39th European Association of Remote Sensing Laboratories Symposium & 43rd General Assembly

EARSeL

DIGITAL | EARTH | OBSERVATION

BOOK OF ABSTRACTS

www.zgis.at/earsel2019

BOOK OF ABSTRACTS

DIGITAL I EARTH I OBSERVATION

EDITORS - University of Salzburg, Z_GIS / AUSTRIA

Barbara Riedler
barbara.riedler@sbg.ac.at

Stefanie Lettner
stefanie.lettner@sbg.ac.at

Stefan Lang
stefan.lang@sbg.ac.at

Dirk Tiede
dirk.tiede@sbg.ac.at

SCIENTIFIC COMMITTEE

THANK YOU TO ALL OUR SPONSORS

CONTENT

(e-)Learning with Open Geo- and Remote Sensing Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
henning.aberle@bkg.bund.de

Henning Aberle[1], Michael Hovenbitzer[1],

[1] Federal Agency for Cartography and Geodesy, Development and Remote Sensing, Germany

Keywords: Open data, eLearning, Geo-information, Copernicus, Remote sensing

Abstract

Today, more and more public and private actors provide geodata for unrestricted public use. This results in huge data sets that are available for scientific use or implementation in university teaching modules. One of the UN Sustainable Development Goals (UN-SDGs) is the establishment of quality education and guaranteed access to learning opportunities and the acquisition of knowledge, where open data can contribute. The goal of this project is to make these open and always new data sets accessible to a broader user community, to teach them the means to deal with the data and how they should take open data for granted. The potential user group includes not only scientists, but all interested users. While the project "Open Data for Teaching and Research in Spatial Studies" (German: "Offene Daten für Lehre und Forschung in raumbezogenen Studiengängen") (short: OpenGeoEdu) focuses on students from courses that have a spatial connection such as (bio-)geography, cartography, geoinformatics, agricultural and forest sciences, it also supports lecturers and encourages them to contribute their ideas and concepts. In this way, the OpenGeoEdu project presented here also addresses the UN-SDGs.

OpenGeoEdu is a joint project funded by the Modernity Fund (mFUND) of the Federal Ministry of Transport and Digital Infrastructure. The project addresses the identified needs and current issues of modern learning concepts and offers a variety of geodata-related topics on a web-based learning platform. Besides the Federal Agency for Cartography and Geodesy, other project partners within this project are the Leibniz Institute for Ecological Spatial Development and the German Biomass Research Centre. The Chair of Geodesy and Geoinformatics at the University of Rostock is responsible for coordinating and implementing the project. On a joint online platform (www.opengeoedu.de), freely available learning units are created as a Massive Open Online Course (MOOC) where case studies designed by the project partners in their fields of expertise are used to demonstrate the possible uses of open geodata. The Federal Agency for Cartography and Geodesy is responsible for implementing lecture materials and exercises on remote sensing and the use of open data from the European Union Earth observation programme Copernicus. The course language is currently German and English parts and case studies will be implemented in the future to reach a wider audience on an international level.

OpenGeoEdu consists of three parts: (1) a so-called portal of the geoportals, (2) lectures and (3) practical exercises and assignments. The thematic modules cover a wide variety of areas relating to openness in society, administration, economy and science as well as data availability and open geodata. In addition to lectures as videos, scripts and tutorials with content on open data or geo-information systems, contemporary socially relevant topics such as electromobility, biomass potentials,

land monitoring and remote sensing are also addressed. As planned, the OpenGeoEdu-MOOC was successfully launched in the winter semester 2018/2019 at the University of Rostock, and updates are applied continuously. At the end, OpenGeoEdu aims (1) to demonstrate the potential of open data by providing best-practice examples and (2) to provide eLearning offers that can be integrated into courses on spatial studies and used by everyone who is interested.

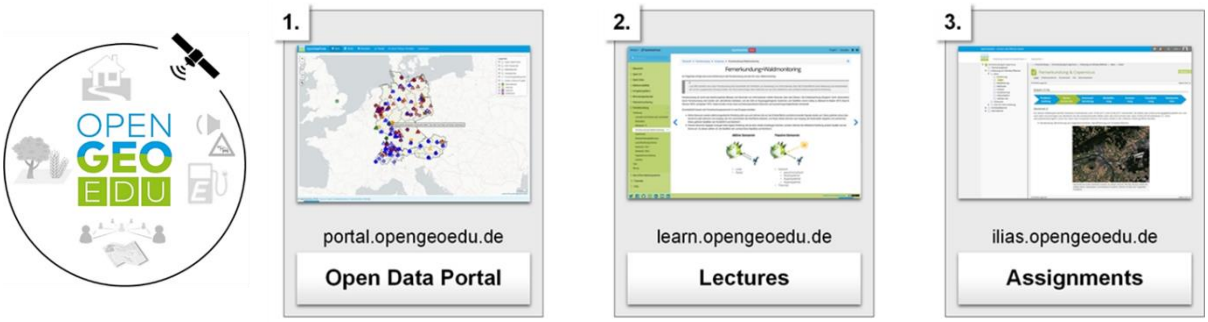


Figure. 1 The joint project OpenGeoEdu (www.opengeoedu.de) offers freely accessible e-Learning material on the utilization of open geodata. The Massive Open Online Course covers a variety of topics and consists of the geoportal, lectures and assignments. The latter contains practical exercises of different difficulty and spatial levels.

Web Service for EO-Based Rapid Mapping of Landslides

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
florian.albrecht@sbg.ac.at

Florian Albrecht[1], Daniel Hölbling[1], Elisabeth Weinke[1], Mario Hernandez[2]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria
[2] International Society for Photogrammetry and Remote Sensing, Geneva, Switzerland

Keywords: Web service, Landslides, Rapid mapping, Earth observation, Copernicus

Abstract

Worldwide, landslides and debris flows result in numerous deaths and significant damages each year. Between 1995 and 2014, Europe experienced 476 fatal landslides with an average economic loss of 4.7 billion Euro per year. Literature also reveals that landslides are even more relevant globally, with 55,997 fatalities in total from 2004 to 2016. After triggering events, authorities have an urgent need for a fast and (close to) accurate assessment of the landslide-affected area. Landslide maps allow them to prioritize their effort on the locations with the most severe problems. This supports their emergency response activities and helps organizing fast and efficient restoration of infrastructure.

Currently, authorities mostly collect landslide information by fieldwork with the additional use of aerial images and very high resolution satellite images. For major events, eligible authorities can trigger the Copernicus Emergency Mapping Service (EMS). It provides Earth observation (EO)-derived information for emergency response for different types of disasters. However, since its start of operation in 2012, the EMS had 16 activations because of landslides (counting the activations until March 2019). Most often, floods were the cause for EMS activations, i.e. 116 times out of 314 activations in total.

While several applications have shown the value of EO-based landslide mapping for other purposes like landslide documentation, for rapid mapping, there remain specifically two challenges: (1) EO-based landslide information extraction itself is challenging because the appearance of landslides in EO data is very variable, and (2) the delivery of information products for rapid mapping is highly time-critical. Therefore, a rapid landslide mapping service requires a reliable and fast provision process. All workflow components from EO data acquisition and access over image interpretation to landslide information delivery have to work well together. In addition, an appropriate integration of the information products into the user workflows is essential.

Consequently, we developed a concept for an EO-based rapid landslide mapping service to support emergency response. The idea for this service originated from the research project Land@Slide (http://landslide.sbg.ac.at). The project included a user requirements analysis that identified rapid mapping as one of the relevant use cases, next to landslide documentation and monitoring of known landslides. Additionally, in this project, we developed a first version of a pre-operational landslide mapping service (Figure 1). The web service provides functionality for access to, integration of and processing of EO data and for visualisation of results. Specifically, it is capable of semi-automatically classifying satellite images to extract landslide information. A comparison with other geodata allows accuracy assessment and the identification of affected infrastructure.

Here we present an improved concept that emphasises the particular requirements of the rapid mapping use case. These requirements are information delivery within a short time frame and ease of information use for time-critical decisions in stressful situations. Therefore, further technological development ought to focus on achieving a high degree of automation in the delivery chain for landslide information and on simplifying the user interaction with the service. An essential step is the direct linkage of the web service with the existing Copernicus data to ease the integration of Sentinel-1 and Sentinel-2 data. Moreover, the inclusion of machine-learning algorithms for landslide information extraction would limit the need for user input and thus lead towards fully automated landslide detection. The web service provides landslide information as a digital map product with an appropriate easy-to-understand cartographic design that is suitable for situational awareness during emergencies. The landslide detection process provides polygons that enclose the areas affected by the landslides. Depending on the user needs for infrastructure information, they become part of a map that identifies affected roads, train tracks, pipes, human settlements, electric cables, etc. The final information product presented to the end user will reflect the accuracy and completeness of the data.

While the concept is technologically sound, its technical feasibility needs to be tested. Apart from implementing critical technological components, this includes a testing of the user interaction with the service. This has to be based on a clear understanding of the use case of rapid mapping that thoroughly describes the process how the landslide maps support first responders in their workflows. Consequently, an associated validation procedure is necessary that provides feedback for service improvement and ensures the usefulness of the landslide maps in practice and their capability to improve emergency response.

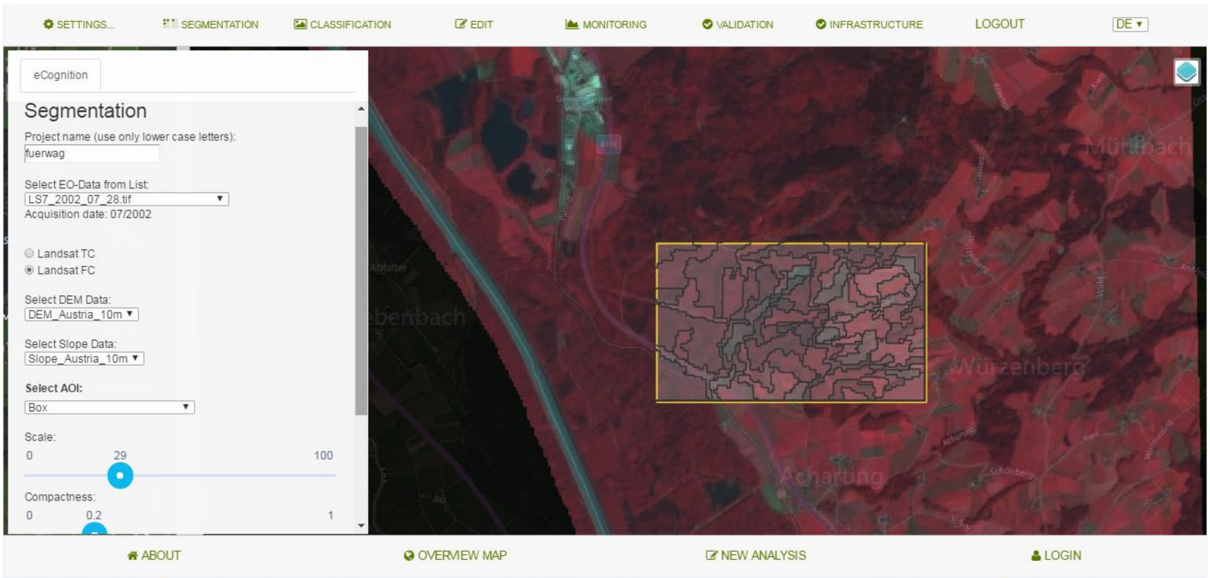


Figure 1. User interface of the interactive landslide mapping service developed in the Land@Slide project

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
d.hadjimitsis@cut.ac.cy

The Benefits for Joining Forces in the Mediterranean Region in Earth Observation: The Mediterranean Regional Information Network (MedRIN)

Vincent Ambrosia[1], Diofantos Hadjimitsis[2], Giannis Gitas[3], Ioannis Manakos[4], George Zalides[3], Chariton Kalaitzides[5], Mora Brice[6], Jana Albrechtova[7], Tapete Deodato[8], Nektarios Chrysoulakis[9], Eyal Ben Dor[10], Arnon Karnielli[11], Harry Kontoes[12], Levent Genç[13], Aziz Koru[14], Kyriacos Themistocleous[2], George Papadavid[15], Andreas Christofe[2], Christiana Papoutsa[2], Stavros Stagakis[10], Georgia Kouta[2], Silas Michaelides[2], Garik Gutman[16], Christodoulos Mettas[2], Georgia Kouta[2], Silas Michaelides[2]

[1] NASA-Ames Research Center, USA
[2] Department of Civil Engineering and Geomatics, School of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus
[3] Aristotle University of Thessaloniki, Greece
[4] xCentre for Research and Technology Hellas, Information Technologies Institute, Thessaloniki, Greece
[5] MAICH, Chania, Crete, Greece
[6] Communications & Systèmes, Toulouse, France
[7] Charles University, Faculty of Science, Czechia
[8] Scientific Research Unit, Italian Space Agency (ASI), Rome, Italy
[9] Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology, Greece
[10] Tel Aviv University, Israel
[11] Ben-Gurion University, Israel
[12] National Observatory of Athens, Athens, Greece
[13] Çanakkale University, Turkey
[14] Tubitak Uzay, Turkey
[15] Agricultural Research Institute, Cyprus
[16] NASA, Land-Cover/Land-Use Change (LCLUC),

Keywords: Earth observation, Synergies, Mediterranean Regional Information Network (MedRIN)

Abstract

Following a series of discussions with European, African and American colleagues, a new regional information network for the Mediterranean Region has been already initiated and established as Mediterranean Regional Information Network (MedRIN) on July 2018. .MedRIN would be a network, which may be coupled upon our joint decision and a formal request, with the framework of the Global Observations of Forest Cover and Land Dynamics (GOFC-GOLD; http://www.fao.org/gtos/gofc-gold/), and would serve as a liaison between land-cover/landuse change remote sensing scientists and stakeholders in the Mediterranean region. The Mediterranean Regional Information Network (MedRIN) will keep its members abreast with the latest advancements in Earth Observation applications based on NASA and ESA satellite data and data products. The Network will support tackling regional and local challenges, as described by the United Nations' Sustainable Development Goals (SDGs). MedRIN will not replace existing networks in the region but will leverage additional networking capacity and build on the existing networks and systems with actions and ways that may only be of support to a peaceful

utilization of Earth Observation in citizen's everyday life. Specifically, the objectives may include (and to be discussed further at the meeting):

a) Better coordination and linkage of monitoring systems and databases across Mediterranean,
b) Strengthening and upgrading regional/national EO networks,
c) Alignment of multi-modal and multi-source data compliant to international norms,
d) Utilization of Copernicus and relevant freely distributed services in the region by end users,
e) Contribution to free publicly-available data through interoperable databases and services.

These will be enriched and fine-tuned based on your experiences, wishes and needs for the MedRIN. The additional benefit of the further promotion of the MedRIN network will be the synergies coming out of the collaborative efforts. One of the first tasks of the MedRIN network is the creation of an inventory of capacities and achievements from the members of the network, in order to seek synergistic collaborations. The network should be accessible to any entity and individual in the region, in terms of products and services produced. There are existing networks, such as GEO-CRADLE, and collaborations so one of the objectives is to try to join forces for the benefit of the Med region. The following focus priorities of the network have been already finalized: Urban and built-up areas (wildland urban interface, population dynamics and how that affects landscape); Rural areas / Agriculture, Forestry and wildlands (monitoring dynamic landscape changes), Hazards (fires including agricultural fires, earthquakes, floods, etc.), Soil and water resource management (Irrigation/Hydrology, Soil degradation, Desertification). Training will be a major component of all proposed priorities.

Sentinel-2 Semantic Data and Information Cube of Austria

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
hannah.augustin@sbg.ac.at

Hannah Augustin[1], Martin Sudmanns[1], Dirk Tiede[1], Christian Werner[1], Jakob Schmollgruber[1], Stefan Lang[1], Andrea Baraldi[1,2]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria
[2] Italian Space Agency (ASI), Italy

Keywords: Remote sensing, Big Earth data, Data cube, Semantic enrichment, Sentinel-2

Abstract

The expanding ecosystem of Earth observation (EO) is quite different than even a few years ago, posing new challenges and opportunities to providers, users and technological infrastructure. The rapidly increasing volume, accelerating velocity and growing variety of available EO data sources are generating new possibilities for innovation, but more specifically, (semi-)automated information production. One such innovation is the use of data cube technology within the EO domain. The term "data cube" has become increasingly associated with innovative EO solutions for storage, access, analysis and more, yet the term was being used as early as the 1980's. Data cubes are a promising methodological development to handle the big EO data challenge, which has led to the development of a growing number of operational EO data cubes, such as EarthServer, Digital Earth Australia or the Swiss Data Cube.

Data cube technologies can offer more to EO than improved data storage and access; they can establish reproducible analytical environments for queries and information production. Possibilities for semantic content-based image and information retrieval are brought within reach by the ability to store image-derived information, such as categorical or continuous variables (e.g. scene-classification map, greenness index, generic spectral rule-based preliminary classification (in addition to data within an EO data cube (see Figure 1). If coupled with image understanding systems, semantically enriched data cubes can facilitate direct information querying in domain language. This means that users are able to access and analyse not only the original EO data provided in an analysis-ready format, but also compose queries on a higher semantic level (i.e. based on at least basic land cover units and encoded ontologies). The Sen2Cube.at project is endeavouring to exceed current state-of-the-art EO data cube implementations by building an Austrian data & information cube (i.e. semantic data cube), primarily utilising free and open Sentinel-2 data.

Satellite data requires additional interpretation or conversion into information layers to provide support for any kind of decision-making-process. Information derived from satellite sources has the potential to be multi-temporal and explicitly geographic when based on such EO data sources. The potential of the European Copernicus programme's Sentinel-2 satellites to provide image-derived information is large. Yet, the greatest challenge for EO analytics working at this volume and velocity remains: producing timely, operational and comprehensive information products and services using systematic and automated workflows, without requiring human-machine-interaction.

The two Sentinel-2 satellites acquire high-resolution imagery at a significantly higher spatial resolution and temporal frequency than any comparable free and open initiative to date. Each Sentinel-2 satellite produces a data volume of more than 1.3 Terabyte (TB) daily, depending on the data processing level. The result of this large volume and high velocity is the acquisition and provision of several hundred scenes every day across the Earth's land surface. At the time of writing, more than 6 million scenes (i.e. 3.1 Petabyte), have been acquired and made available for download. At least 7300 of the existing, acquired scenes cover part of Austria from mid-2015 until January 2019, cumulating in a total volume of ca. 4.8TB.

The potential of semantic EO data cubes is just beginning to be explored and only prototypical work and proofs-of-concept exist. The broader goal of the Sen2Cube.at project is to demonstrate that semantic content-based image and information retrieval is possible in big EO image databases, such as the Austrian data and information cube. On top of the generic semantic data cube, multiple services are being developed towards this aim as prototypes within the scope of the project, including: (1) semantic content-based image retrieval; (2) generation of cloud-free mosaics/composites; (3) location-based queries through time; (4) polygon-based/object-based land cover change analysis through time. A closer look at the development of these services and the Austrian data and information cube will be made, both from theoretical and praxis-oriented perspectives.

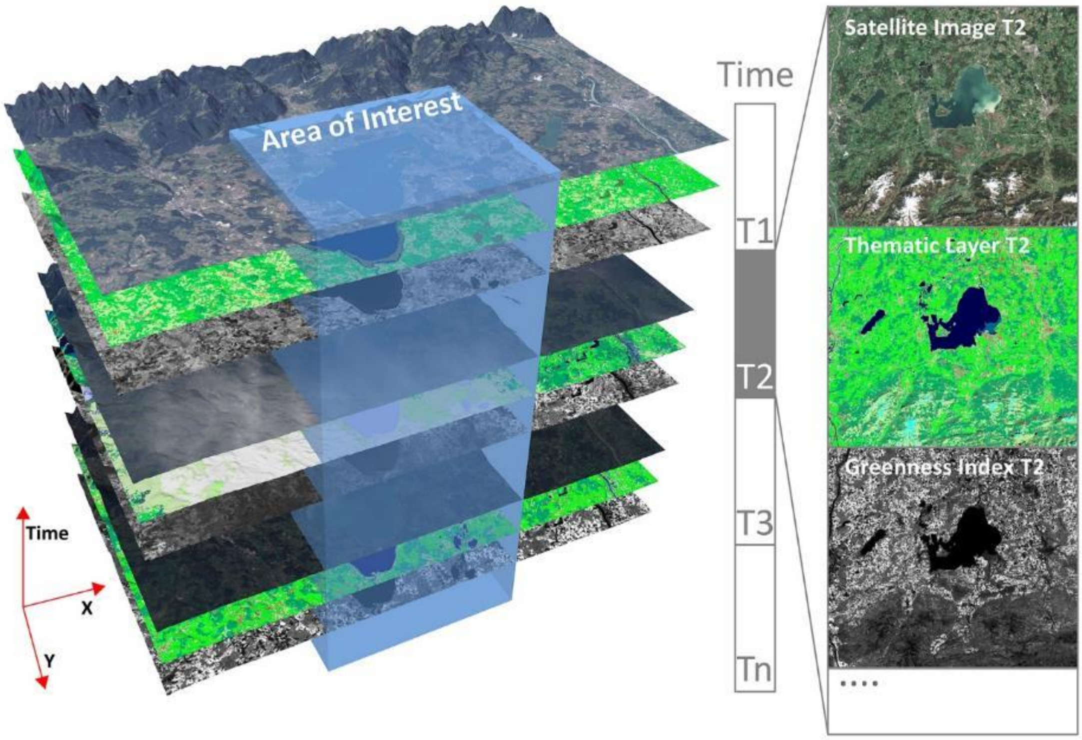


Figure 1. Automatically generated information layers are linked to Sentinel-2 data ready for spatio-temporal semantic queries using a user-defined area-of-interest and timespan (from Tiede et al. 2017).

Protecting Pixels:
Fine Grain Access Control
for Earth Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
baumann@rasdaman.com

Peter Baumann[1,2], Dimitar Misev[1,2]

[1] Jacobs University, Department of Computer Science and Electrical Engineering, Bremen Germany
[2] rasdaman GmbH, Bremen, Germany

Keywords: Access control, Array, Datacube

Abstract

With high-volume, function-rich Web services on spatio-temporal raster data on the rise there is a growing need for adaptive access control. While the datacube paradigm has proven suitable for large-scale raster services appropriate access control is unsolved. In this contribution we provide a model which extends the SQL datacube query language, SQL/MDA, with array -aware access control.

Web services offering scientific data, such as satellite imagery and weather/climate data, are emerging in increasing numbers. While open data are emphasized access often has to be controlled tightly, such as in industrial and security /privacy critical governmental services. Even scientists enjoy protection of their data for some grace period to publish any findings first. "All or nothing" access is not adequate in face of multi-Petabyte Earth data; rather, access protection of spatial and/or temporal regions must be considered. For example, the European Centre for Medium- Range Weather Forecast (ECMW F) offers long time series of climate data. While the long tail of data is free the most recent two weeks are priced. We propose array–aware access control based on a declarative array query language. SQ L triggers serve for defining constraints on array access and processing. Such triggers are always applied to queries, except when the user firing the query has been exempted by the administrator.

User privilege management in standard databases is done through Role-Based Access Control (RBAC), although without array support. The MongoDB No SQL system offers privileges listing allowed operations, but no fine-grain access control inside its objects. The SciDB Array DBMS defines access control only on sets of array s which is too inflexible and coarse-grain. Earth data services (including satellite imagery and climate / weather archives) typically resort to ad- hoc implementations unaware of fine-grain access control, rather relying on file granularity . In the widely used OPeNDAP Hyrax server access control is a known open issue. A family of systems, including the Australian Geoscience Data Cube, offers python APIs with access on file basis and without array - specific authorization.

To make RBAC array -aware we enhance the existing SQL RBAC and triggers with array expressions, plus some novel application mechanisms. First, we introduce two predicates, ACCESSED(A) and MODIFIED(A) where A is some array -valued expression. The result is a Boolean array of the same size as A where each cell contains true if this cell in A gets accessed by the query under consideration, or modified, respectively. Next, we connect triggers to users and roles. As normally a trigger is always checked we need to remove – i.e.: deactivate – it. To accomplish this we enhance the SQL GRANT statement with an option EXEMPTION FROM to exempt a user or role from a particular trigger. This yields a safe model for restrictions: in the first place, constraints always hold; they need to be explicitly and consciously disabled.

The following use cases have been spotted initially, although we feel that there are many more to come: Protecting along time and space; protecting arbitrary areas; protecting by mask; quota; upfront cost estimation. The following example may illustrate this. The following trigger protects sub-datacube region S from access, where S might characterize "the last two weeks":

```
CREATE TRIGGER Latest_2_weeks_disallowed
SELECT ON ERA5
WHEN MDANY( ACCESSED(  ERA5[ S ] ) )
BEGIN EXC EPTION "Error: no access rights on this area." END
```

Let P be given as a vector polygon over some area, ex pressed in W KT (Well -Known Text).

Then, the following query will disallow access to the P area:

WHEN conditions may contain any predicate allowed in the query language, including combi nations of the above mechanisms.

```
CREATE TRIGGER Quota_ on_ Access
SELECT ON ERA5
WHEN MDCOUNT _TRUE( ACCESSED( ERA5 ) ) > 1000000
BEGIN EXC EPTION "Error: data access volume exceeded."
END
```

For "Big Data" privacy and security, service attack protection, general housekeeping such as quota, etc., we propose "trigger as guardian" as a natural RBA C enhancement. To the best of our know ledge there is no other approach published which conveys the same power, flexibility, and ease of use. Array triggers are implemented in rasdaman. Preliminary experiments have shown that they do not impose a particular extra workload. Checking query costs a-priori, something impossible for procedural, interfaces (e.g., the python-based Australian Data Cube), is done by the rasdaman estimator. Currently we are applying triggers in several projects (such as BigDataCube and Land support) and with various rasdaman operators from industry and academia to gain further experience.

Evaluating Methods for Built-Up Area Estimation in Refugee Camps using Sentinel-2 Data - A Case Study

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
riccardobirlla23@gmail.com

Riccardo Biella[1]

[1] Lund University, Department of Physical Geography and Ecosystem Science, Lund, Sweden

Keywords: Remote sensing, Humanitarian, Sentinel-2, Refugee, Refugee camp

Abstract

The determination of the built-up area of a refugee camp is an important task and it can be used for estimating the population. While high resolution satellite imagery can be costly, since 2015 Sentinel-2 data has become freely available through the European Space Agency. the Sentinel-2 satellite program provides world coverage multiband, 10 m resolution, data every few days. In this study three methodologies are compared for the purpose of estimating built-up area using Sentinel-2 imagery: Index Based (using the IBI, or Index-based Built-up Index); Supervised classification; and Digitization. The IBI was selected for the Index Based Method due to its effectiveness at determining built-up areas, also in low density suburban areas. The Supervised Classification was selected as it lends itself very well to Sentinel-2 data, due to the coarse resolution and multi spectral nature of the data. The Digitization Method was selected following a previous paper (Wendt et al, 2017) and for its simplicity. The study areas chosen for this study are Nyarugusu Refugee Camp, in Tanzania, and Kutupalong Refugee Camp, in Bangladesh. The Sentinel-2 data is downloaded as Top-Of -Atmosphere (L1C) and is corrected to Bottom-Of-Atmosphere (L2A) using the plug-in Sen2Cor of SNAP. This is necessary for the Index Based Method and the Supervised Classification Method, but not for the Digitization Method, as it can be performed on L1C data. Nevertheless, from 2019 L2A data can be downloaded directly from the ESA's browsers.

In the first part of this study, an accuracy assessment of the three methodologies is carried out. This is performed by using as ground-truth the built-up area obtained digitizing high-resolution images of the two camps. The ground truth is then compared to the built-up area obtained using the different methodologies on Sentinel-2 images from around the same period. A confusion matrix is created, and the kappa value is calculated as indicator of the accuracy. Of the three methodologies the Digitization showed the greatest accuracy (with kappa over 0.8 for both study areas). The digitization is mostly affected by type II error, especially in areas with vegetation in between the dwellings. The Supervised Classification is the second-best (with kappa just below 0.7) and is mostly affected by the same type of errors as for the previous method. The Index Based Method yields the worst results (kappa as low as 0.3) and is mostly affected by type I error as it fails to distinguish bare soil from built-up. While the Digitization Method yielded the best accuracy, the other two methodologies could still be useful, as a combination of all three could yield better results.

In the second part of the study, the three methodologies are used in creating a time series analysis to investigate their potentials to track the development of the built-up area of a refugee camp. The total built-up area over time is correlated to the population of each camp over the same period. This is performed on the assumption that a growth in population corresponds to the camp expanding rather than densifying and therefore that the built-up area can be used as proxy for the population. Once again, the Digitization Method proves itself to be the most accurate of the three methodologies explored. A strong correlation (above 0.8 for both camps) is found between built-up area and population using this method. Nevertheless, the correlation is carried out with too few points to draw any strong conclusion.

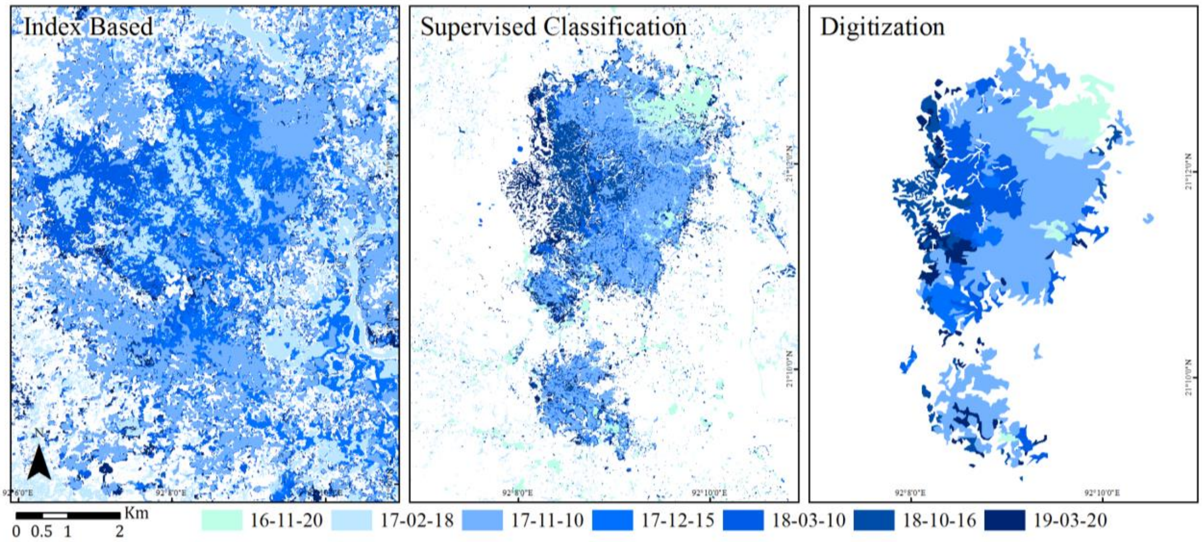


Figure 1. Time-series of Kutupalong Refugee Camp between November 2016 and March 2019. The camp grows southwards from an original nucleus in the northeast. The Digitization Method produced the most accurate results. It can be observed how the area grows suddenly between February and November 2017.

Refugees Under the Radar – Assisting Humanitarian Work with Persistent Scatterer Interferometry

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
an.braun@uni-tuebingen.de

Andreas Braun[1]

[1] University of Tübingen, Department of Geography, Germany

Keywords: Humanitarian relief, Synthetic aperture radar, Persistent scatterer interferometry, Refugees

Abstract

Around 700.000 people of the Rohingya minority in Myanmar were reported to have fled from Rakhine state to Bangladesh because of racial discriminations and clearance operations by the Myanmar's security forces in August 2017. The massive influx of refugees caused overcrowding of the reception camps which are ran by the government and various international humanitarian organizations. In early 2018, Kutupalong officially became the largest refugee camp in the world, hosting a total population of nearly 550.000 people. To relieve pressure on these sites, the government of Bangladesh prepared the relocation of around 100.000 people on Thengar Char, an uninhabited island with a size of 300 square kilometres, located approximately 20 kilometres off the coast in the Bay of Bengal. The United Nations Refugee Agency, Human Rights Watch and Amnesty International severely criticized these plans because the island is regularly flooded during the monsoon season and has no infrastructures or flood protection measures. Despite public resistance, construction works are ongoing since February 2018 and the relocation was officially ordered.

Apart from the described flood risk, the island consists of sparsely covered marsh soils which are believed to sink from the heavy machinery and construction work, but this cannot be measured without field inspection. Furthermore, because of the moist and mainly featureless surface, traditional radar interferometry is impossible due to temporal decorrelation.

As an alternative, this study uses persistent scatterer technique to describe the surface changes on this island since the beginning of construction work in February 2018. 32 Sentinel-1 images acquired in ascending orbit at intervals of 12 days were used to identify persistent scatterers on the island, mostly along the roads and infrastructures. Phase changes were investigated at these points to derive surface changes along the line-of-sight. Their spatial distributions as well as the subsidence rates were analysed at a temporal and spatial scale (Fig. 1).

First results indicate a clear pattern of subsidence concentrated around the construction areas and one cluster of uplift in the south-eastern part of the island, with annual subsidence rates of up to 40 millimetres. Their spatial distribution clearly suggests that they are related to the construction works but more analysis has to be conducted (e.g. comparison with measurements from data of descending orbit). Unfortunately, coverage of images from descending orbits stopped in December 2018 according to the S1 observation scenario, making a comparison of both orbits impossible at the long term. Furthermore, the temporal profile indicates that the subsidence did not proceed gradually but started in the middle of 2018 after some months of stability.

To be able to link the subsidence patterns to the construction work, it is necessary to put the findings into a broader context, for example by the integration of geotechnical calculations or a simultaneous observation of neighbouring islands. Yet, the results support the indication that the surface of the island is subject to specific subsidence patterns, putting the relocated people at an even higher risk. Further information sources and longer time-series have to be included to enhance the results.

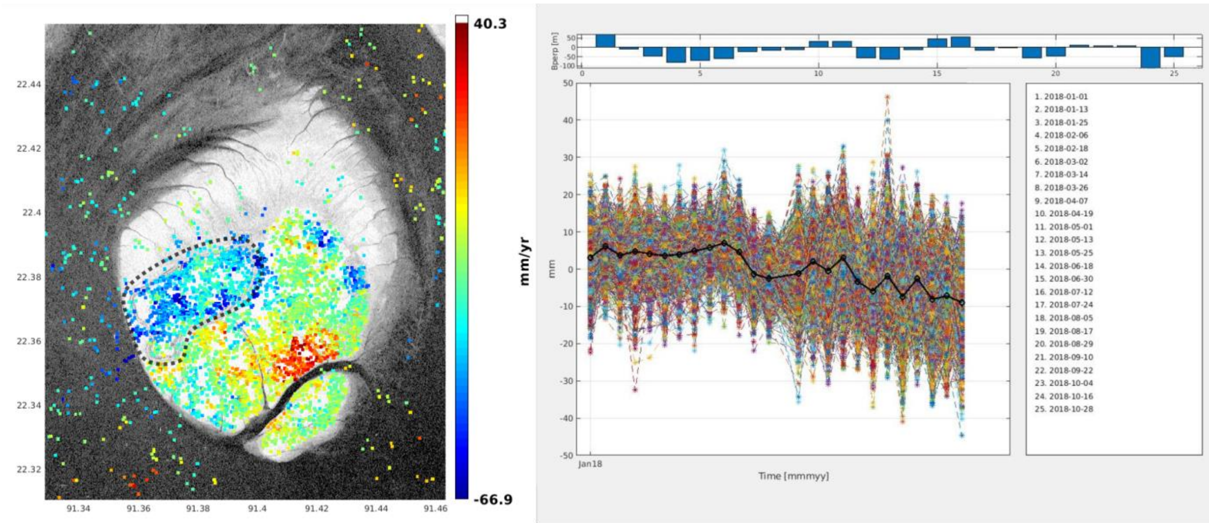


Figure 1. Spatial (left) and temporal (right) representation of surface changes on Thengar Char Island since January 2018 (construction area indicated by the dashed line)

The GROW Project, Interoperability between In Situ Sensors, Citizen Science and Crowd Sourced Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author: aecobley@dundee.ac.uk

Andy Cobley[1], Mel Woods[1], Drew Hemment[1], Rianne Giesen[2]

[1]University of Dundee, United Kingdom
[2]HydroLogic Research BV, Netherlands

Keywords: Citizen science, Remote sensing, Earth observation, Interoperability

Abstract

Citizens' observatories (COs) connect people, science and technologies to create collaborative data, knowledge and action around environmental challenges, both local and global. The GROW Observatory (GROW) sets out to demonstrate an operational CO system for sensing soil. Soil moisture in particular plays an important role in regulating climate, and in climate events such as floods, droughts, heat waves, desertification and wildfires. GROW attempts to monitor this key parameter for science at a continental scale over an extended period through a CO methodology. The resultant data set provides a mechanism to ground truth Sentinel-1 satellites of the EU's Copernicus Earth observation. In addition soil moisture dataset is accessible and presented in visualisations that can improve decision-making for improved soil health across stakeholders.

Technically, GROW builds on existing state-of-the-art, both in platforms and components. Established and standard methodologies are applied for collecting and analysing data on soil and land cover/land use using mobile applications, consumer sensors (Flower Power) and open hardware, open software sensors (Smart Citizen Kit 2.0 with soil moisture probe and shield) with a 'data muling' infrastructure for cloud storage. Currently, there are more than 2,500 Flower Power (FP) sensors operating and returning data across 9 focus areas. Called GROW Places they are selected on the Köppen-Geiger climate classification to cover most of climatic homogeneity within the area of Europe. Flower Power (FP) Sensors have undergone validation for accuracy and reliability of data through physical placement in the field alongside professional calibrated probes across two sites, and in laboratory conditions, measuring real values of water content in a range of soil types. In addition, deployment protocols designed by scientists have been tested in extreme seasonal conditions, with training provided to citizens through field notebooks and social learning facilitated by Community Champions.

Data from the FP sensor is stored in the cloud and indexed on the GROW platform which also provides an access point data formats for citizens. Data is then transferred to the Hydronet (https://www.hydronet.com/) platform which packages the data for retrieval by scientists via an API (https://docs.google.com/document/d/1e3Mertig8iJjVi6WG63gjqXO3Vv1sv8DfY72cwe0xVs), for analysis and integration with datasets from Copernicus. The platform implements Open Geospatial (OGC) standards which translate internal data formats into the OGC Sensor Observation Service (SOS) standard (https://www.opengeospatial.org/standards/sos) to allow data integration with other COs and additional sensors.. This interface implements extension "Get Feature of Interest" to facilitate easier integration with responsive user interfaces.

The GROW system integrates heterogeneous platforms, and creates a geographically dispersed system with no dependencies, using cloud providers AWS, Google Cloud, Microsoft Azure, as well as in-house data centres provided by consortium partners. Figure 1 illustrates the pipeline and access points for Citizen Scientists, scientists, policy makers and other stakeholders interested in accessing and visualising data for information services and decision-making.

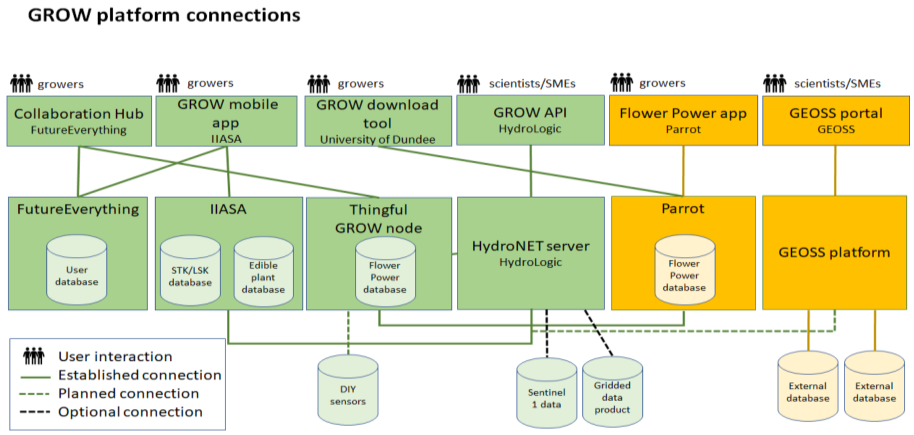


Figure 1. The GROW data platform with established, planned and optional connections to external applications and tools

A GROW 'collaboration hub' provides citizen participants access to simple visualisations e.g. maps, and graphs about their own data (https://growobservatory.org/). The GROW Observatory mobile application both registers each sensor and collects covariates through a land survey, and this data is integrated with FP sensor soil data. Citizen Scientists can query and format data, as .csv files and with appropriate consent can build on shared datasets that allows small scale geospatial data analysis for communities. In one example a GROW Place in Quinta do Vale da Lama, Portugal has used Github (https://github.com/ludwa6/Analysing-SSM) to share and provide analysis on soil moisture for crop growing using python Jupyter Notebooks.

Programmers with appropriate access keys (https://github.com/growobservatory/GrowNodeExample) can retrieve all sensors and time series data in JSON or XML format, for integration with other datasets using Application Programmers Interfaces (API's) to build applications. An application gives scientists the ability to select data geographically, temporally and by data type. These data are also discoverable through the GEOSS Portal (http://www.geoportal.org/), where Earth Observation data from archives all over the world can be searched. A challenge remains to demonstrate that these interfaces are sufficient for all data consumer needs. To this end, those interfaces, in particular the OGC SOS interface will be tested during an Open Data Challenge starting in 2019 by WeObserve (H2020 CSA) to build innovative data-driven applications.

In conclusion, GROW has built a data pipeline to integrate CO data in environmental monitoring systems and for applications in agriculture and climate services, providing data to different stakeholders in a form that is most appropriate for use. GROW is demonstrating that COs can be interoperable with each other and other data sets. This underpins the wider ambition in GROW, namely, to demonstrate that data and knowledge derived in collaboration between community food production networks, soil and satellite scientists, and policy makers can contribute value and impact in food security, climate action, and life on land.

Laplacian of Gaussian and Gram-Schmidt Image Fusion Using Airborne APEX Hyperspectral and WorldView-2 Panchromatic Image

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
zahra.dabiri@sbg.ac.at

Zahra Dabiri[1], Stefan Lang[1], Peter Hofmann[1,2]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria
[2] Deggendorf Institute of Technology, Institute for Applied Informatics, Technology Campus Freyung, Germany.

Keywords: Feature extraction, Image pansharpening, Image noise reduction, Airborne prism experiment (APEX) hyperspectral imagery

Abstract

Image fusion is used for combining multiple images of a scene to obtain a single composite image from that scene. A fused image provides more useful information that can be used for feature extraction, image analysis, and computer vision to name a few. In recent years, fusion of hyperspectral imagery (HSI) with other available data sources gain lots of attentions. HSI provides detailed spectral information that can be used for feature extraction and classification. However, hyperspectral imageries are characterized by low spatial resolution. To incorporate more detailed spatial information to HSI, we assessed image fusion between airborne HSI and very high-spatial resolution panchromatic image, using Laplacian-of-Gaussian (LOG) and Gram-Schmidt algorithms. The Laplacian filter is a second-order derivative, which highlights rapid intensity changes in the image $f(x,y)$ by $\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$. However, it is known that the second-order derivatives are very sensitive to noise therefore, the input image was first smoothed using the Gaussian filter. The enhanced image was achieved using: $g(x,y) = f(x,y) + c[\nabla^2 f(x,y)]$, where $g(x,y)$ was the intensity improved image, $f(x,y)$ was the Gaussian smoothed input image, and c is a constant and it was set to $c = -1$, because the Laplacian-subtraction function was used. The mentioned strategy was applied on a very high spatial resolution WorldView-2 (WV-2) panchromatic image. The enhanced image was used as input to HSI data fusion using Gram-Schmidt algorithm. Two images were used: The WV-2 panchromatic image with spectral coverage ranging from 450 nm to 800 nm, and spatial resolution of 0.5 m, captured on 09 July 2011, and the airborne prism experiment (APEX) image, characterised by 267 spectral bands (ranging from 413 nm to 2451 nm), and spatial resolution of 2.5 m ground sampling distance (GSD), captured on 29 June 2011; APEX data pre-processing including radiometric and atmospheric corrections were done using MODTRAN4 algorithm, by the experimental central data processing centre (CDPC), and the data was delivered by VITO (Flemish Institute for Technological Research).

We applied the following workflow for data fusion: (1) spatial subset to improve computational efficiency; (2) the APEX hyperspectral image re-projection from lat/lang to UTM, zone: 33-N; (3) normalization of WV-2 panchromatic pixel-intensity values to range from 0 to 1; (4) image co-registration, in order to create spatial overlapping between both images (5) HSI spectral band selections to match the spectral coverage of the panchromatic image (450 nm to 800 nm); (6) creating successive smoothed WV-2 panchromatic images, using the low-pass Gaussian filter; the Gaussian function's sigma parameter (σ) was set to 0.7, and it was increased with $k\sigma$, where $k = \sqrt{2}$ (i.e., σ_1=0.7, σ_2=1, σ_3=1.41, σ_4=2, σ_5=2.8); a kernel size was set to 5x5, (7) performing LOG on each successive

smoothed WV-2 panchromatic images (8) image fusion between the enhanced WV-2 panchromatic image and the APEX HSI, using Gramm-Schmidt algorithm. Moreover, for validation purpose, data fusion was similarly performed using the original WV-2 panchromatic image without any image enhancement and the APEX HSI. Figure 1 illustrates an example of data fusion results on two target features: (a) buildings, and (b) a forested area. In general, applying LOG before Gramm-Schmidt image fusion strengthened values around edges. A visual comparison of results between two strategies, (a) data fusion using original WV-2 panchromatic image versus (b) data fusion using the enhanced WV-2 panchromatic image, revealed that the latter preserved feature boundaries more effectively, especially for man-made features such as buildings. However, further research is needed to assess and evaluate the results. Further research on this topic will focus on (a) performing quality assessment using quantitative measures, and pansharpening quality assessment protocols, and (b) to assess capabilities of this approach on different targeted features.

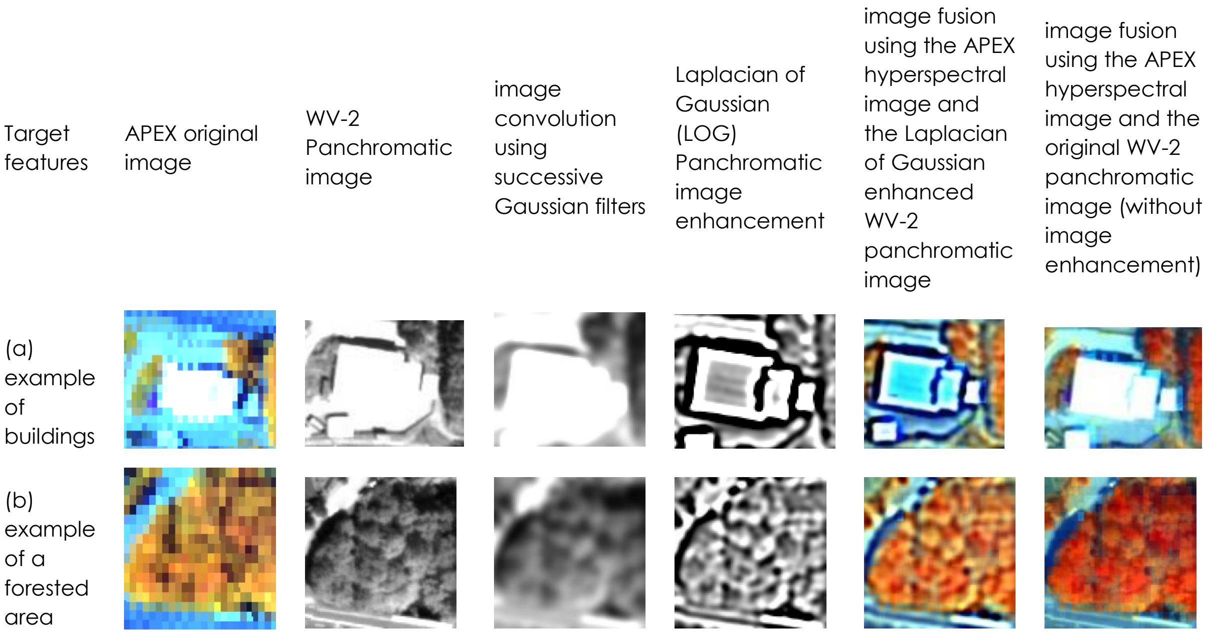


Figure 1. An illustration of data fusion for two targeted examples: (a) buildings (second row), and (b) a forested area (third row). Applying successive Gaussian filter resulted in smoothing out noise in the WV-2 panchromatic image. We applied then the Laplacian of Gaussian to intensify edges on the WV-2 panchromatic image; the result of LOG-enhanced WV-2 imagery was used as an input for image fusion with APEX HSI imagery using Gram-Schmidt algorithm.

Establishing a Strategic Research Infrastructure Unit to Monitor Natural Hazards in the Eastern Mediterranean Region via Integration of Space-based Techniques: The Case of CyCLOPS

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
chris.danezis@cut.ac.cy

Chris Danezis[1], Diofantos G. Hadjimitsis[1], Michael Eineder[2], Ramon Brcic[2], Kyriacos Themistocleous[1], Christiana Papoutsa[1], Evangelos Mendonidis[1], Marios Nikolaidis[1], Marios Tzouvaras[1], Andreas Christofe[1], Christodoulos Mettas[1]

[1] Cyprus University of Technology, Department of Civil Engineering & Geomatics, Cyprus
[2] German Aerospace Center, Remote Sensing Technology Institute, Germany

Keywords: GNSS, SAR, Geohazards, SENTINEL, Cyprus

Abstract

The Cyprus Continuously Operating Natural Hazards Monitoring and Prevention System, abbreviated CyCLOPS, is a research project funded by the European Regional and Development Fund, the Republic of Cyprus and the Research Promotion Foundation in the framework of the RESTART 2016 – 2020 programme under the grant agreement RPF/INFRASTRUCTURES/1216/0050. The project consortium is comprised by the Cyprus University of Technology and the German Aerospace Center (DLR) and has the support of the Department of Lands and Surveys (DLS) and the Geology Survey Department (DSG).

The main objective of CyCLOPS is to found and maintain a novel integrated strategic research infrastructure (SRI) unit for solid earth processes and natural hazards monitoring in Cyprus and the Eastern Mediterranean region. This objective will be achieved by means of the establishment of a novel deformation monitoring and analysis infrastructure; the development of a state-of-the-art early warning system based on the integration of space-based derivatives and novel geospatial information and communication (ICT) infrastructure. The later will be realised via the establishment of strong international partnerships and essential synergies with the local stakeholders. The incentive for this research derives from the unique geodynamic and geotechnical regime of Cyprus, which is attributed to its geographic location, geology and weather. Initially, the unit will focus on earthquakes, and landslides. CyCLOPS will fill the lack of a dedicated, continuously operating system for monitoring these geohazards, and will augment and co-operate with existing infrastructure, such as the Tier-3 GNSS CORS Network of Cyprus (CYPOS) and the national seismological network operated by DSG. Furthermore, CyCLOPS will promote the use of modern Earth Observation (EO) constellations, such as Sentinel-1, COSMO SkyMed and TerraSAR-X, which is limited and has yet to be fully exploited in Cyprus by means of national-wide products, and in terms of the accuracy of the deformation output.

CyCLOPS will consist of two main components (see Figure 1); a novel multiparametric network (MPN) of sensors, and the operation center (OC). The MPN will, in-turn, consist of two segments; the permanent and the mobile segment. The permanent segment will include cutting-edge Tier-1 high-rate permanent GNSS receivers, established at specific sites, on top of highly stable monuments (made of concrete or steel) attached to bedrock, and hence being fully aligned with IGS and EPN guidelines. These stations will co-locate with specifically designed SAR corner reflectors along with a multitude of sensors, such as weather stations, tiltmeters and in most cases with seismographs of the national seismological network.

In this way, estimation of ground deformation and velocity will take place on a continuous basis by means of an integrated processing chain utilizing data from all the aforementioned sensors. Furthermore, CyCLOPS will exploit the latest European space missions, i.e. Galileo and Copernicus programs. The co-located configuration of permanent receivers and corner reflectors will be established and installed in such way as to be compliant with (a) all current GNSS constellations (GPS, GLONASS, Galileo, BeiDou) and (b) the Copernicus Sentinel-1 and the TerraSAR-X EO SAR sensors. The design, installation and calibration of the system will be carried out in close cooperation with the German Aerospace Center (DLR). The mobile segment will consist of the same grade of GPS/GNSS receivers along with airborne and terrestrial mapping sensors, such as UAS and laser scanners.

Finally, the OC will handle the management, processing and storage of the incoming information. It will be comprised of three components; (a) the processing server, which will perform intensive GNSS/SAR processing and calibration operations, (b) the storage server, which will handle the storage of the raw observations and imagery along with auxiliary data required in the processing cycle (i.e. IGS precise products, atmospheric models etc.) and (c) the management server, which will include all the network configuration and control activities, and will host real time services, such as GIS services, Atmospheric Monitoring, and Episodic Event notification modules. Through this system and its unique co-located configuration (array of corner reflectors and GPS/GNSS CORS), Cyprus will be rendered a dedicated calibration site for present and future EO Space missions, within a framework fully compliant with European and National priority axes, thereby promoting civil protection and public safety in the south-eastern Mediterranean region.

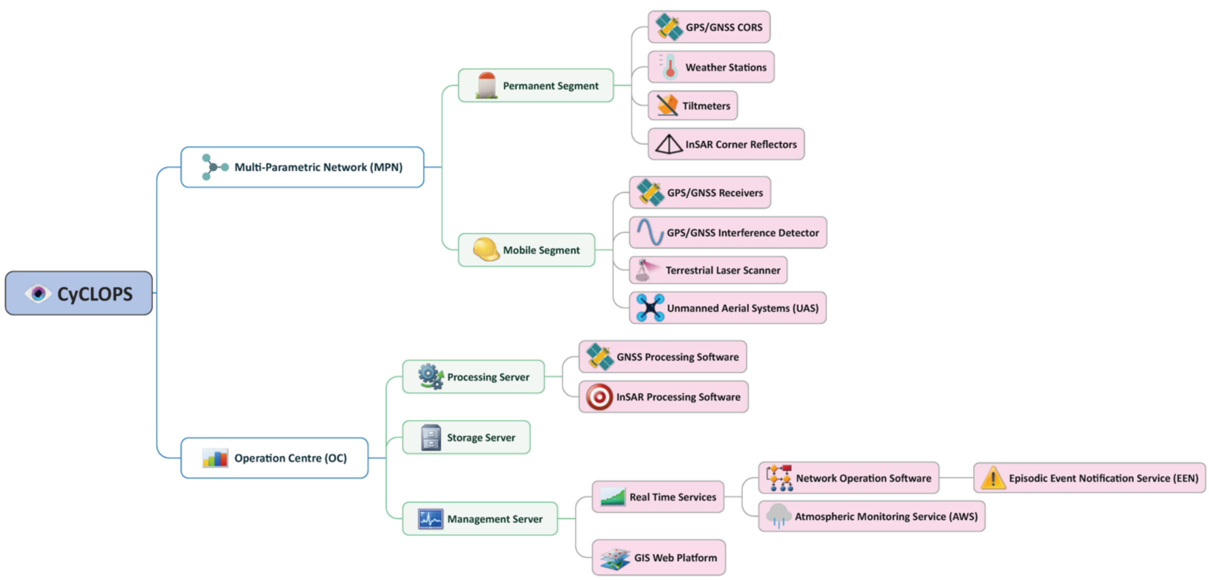


Figure 1. The base architecture of CyCLOPS

InSAR Norway: A National Ground Motion Service Based Upon Sentinel-1

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author: john.dehls@ngu.no

John F. Dehls[1], Yngvar Larsen[2], Petar Marinkovic[3], Tom Rune Lauknes[2], Daniel Stødle[2], Dag Anders Moldestad[4]

[1] Geological Survey of Norway, Norway
[2]NORCE, Norway
[3] PPO.labs, Netherlands
[4] Norwegian Space Agency, Norway

Keywords: InSAR, landslides, subsidence, Sentinel-1, Copernicus

Abstract

A public national ground motion service, based on Copernicus Sentinel-1 data, was launched in Norway in November 2018, as part of Norway's collaborative ground segment. The service provides government, industry, scientists, and the general public with a consistent free and open InSAR based ground motion data source. The data are publicly available in a web browser interface, with tools for simple data analysis, as well as download. Using Persistent Scatterer Interferometry (PSI) software developed by our team, along with over 4000 Sentinel-1 images each year, over 2 billion measurement points are provided, with full deformation time series.

The ground motion service has been built as part of Norway's collaborative ground segment. The main motivation was to aid in the management of natural hazards, such as subsidence and landslides, as well as to help monitor critical infrastructure. In a country like Norway, with over 300,000 km2 of sparsely populated, mountainous landscape, earth observation obviously plays a crucial role. Ground motion data is critical throughout the process of natural hazards mapping and monitoring. In case of Norway, two prominent topics addressed by this service are unstable slopes, and urban subsidence. While these were the driving motivation for building the service, there are many other applications, including scientific studies of surface processes and geodesy.

Ground motion maps are used to identify moving slopes which are then assessed to determine the main process driving the movement, whether that is landsliding, or other surficial processes. During the hazard and risk classification stage, movement rates are fed into a semi-quantitative assessment process. Finally, medium- and high-risk sites are monitored over the long term, using both in situ instrumentation and InSAR data. In particular, for snow-covered areas, all high-risk unstable mountain slopes are equipped with snow protected corner reflector (CR) networks.

While landslides represent the largest potential risk to lives, subsidence may be the natural hazard with the greatest economic impact, due to its impact on critical infrastructure. Rising sea levels threaten coastal cities around the world. In Norway, postglacial isostatic rebound is ongoing, and counteracts the effects of rising oceans. However, many of the coastal cities have expanded, building out into the sea on anthropogenic fill. In most of these areas, subsidence rates far exceed the rate of isostatic rebound, resulting in an increased threat from sea level rise.

Data from the national ground motion service is already being used for several scientific applications. One example is within the field of geomorphology, where active slope processes can now be studied with unprecedented detail and scale. We will soon be integrating the InSAR based ground motion data with national GNSS data, enabling several geodetic applications.

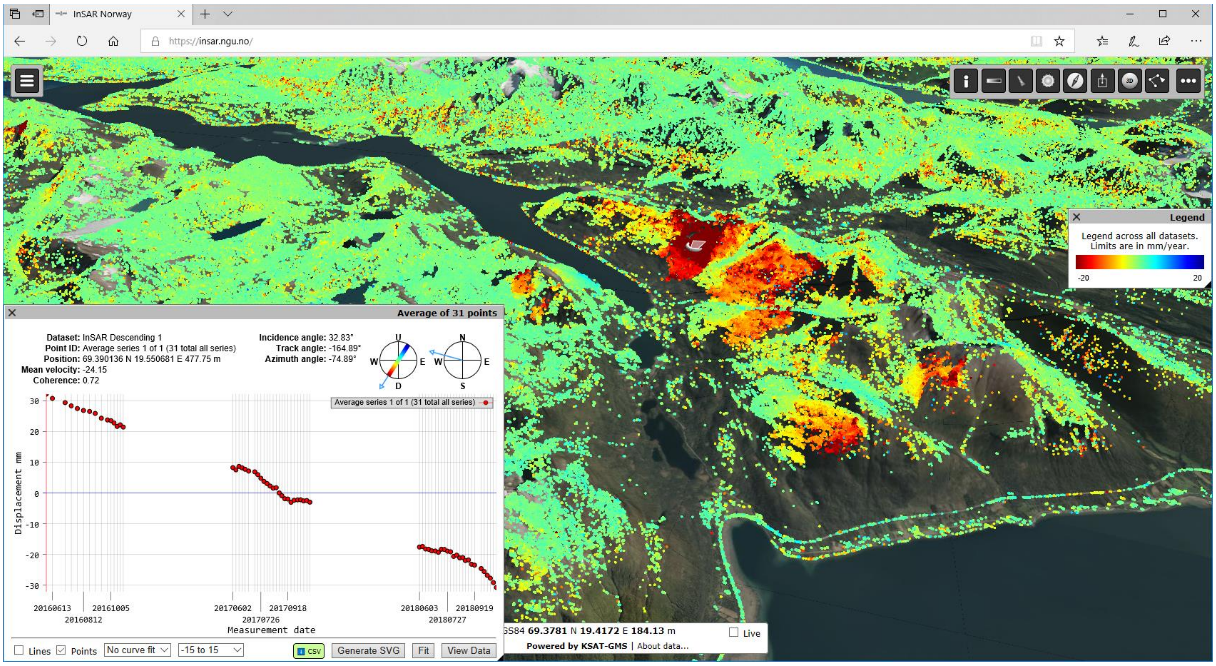


Figure 1. Example of ground motion data in an area of active landslides in Northern Norway. The service presents data in a 3D view, with the ability to see the deformation history of one or more selected point. Data download is also available. Contains modified Copernicus Sentinel data (2018)

Using Time Series of Sentinel-2 Data to Improve Alpine Forest Map Products

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
janik.deutscher@joanneum.at

Janik Deutscher[1], Martin Puhm[1], Andreas Wimmer[1], Klaus Granica[1], Mathias Schardt[1],

[1] Joanneum Research, DIGITAL-Remote Sensing and Geoinformation, Austria

Keywords: Copernicus, Sentinel-2, Forest monitoring, Near real-time, Tree species, Tree cover density

Abstract

A number of EO based forest products are available for the Alpine region, such as the Copernicus High Resolution Layers (HRL Forests), the Global Forest Watch data sets and national forest products. Many products focus on forest cover changes, tree cover density and forest type information - but at different spatial resolutions. None of these data sets currently allows for a frequent periodical mapping of Alpine forests – some are updated on an annual basis (GFW), some every 3 years (HRL Forests) – and most are the result of classifications based on single images or temporal mosaics.

Here we present new forest products at 10m spatial resolution that are computed from time series of Sentinel-2 data. Intra-annual time series of EO data are especially helpful for distinguishing between forest types and tree species as the phenological stages can be used to separate individual species. The presented products include a tree species classification, a forest type classification, a tree cover density map and a near real-time forest change product. These products are part of a Sentinel-2 online forest service prototype that was set up for the Austrian federal state of Styria in the frame of the "AlpMon" project. The prototype covers S-2 granules 33TWN and 33TVN. For 33TWN, average cloud cover is ~55% and cloud free S-2 observations are available every ~15 days on average (http://eo-compass.zgis.at/#/granulestat/33TWN). This roughly corresponds to the 14-day period for initial forest damage reporting by federal forest administrations.

A three year time series (2016-2018) of Sentinel-2 data (10m and 20m bands) forms the basis for all products. This time series is pre-processed to bottom-of-atmosphere (BoA) reflectance with Sen2Cor. Cloud masks are calculated from the Sen2Cor classification including high, medium, low and cirrus clouds to which morphological operations are applied. We then perform a topographic normalisation based on an adjusted Minnaert correction. We also calculate a summer image mosaic for each year based on the medoid of all summer images (May-September). This medoid mosaic can be used to fill cloud gaps in individual images.

The tree species product distinguishes between spruce, larch, pine, beech and mixed classes, such as broadleaf/coniferous mixed, broadleaf mixed and coniferous mixed. About 450 tree species reference plots were selected from aerial CIR imagery or mapped during field campaigns. The reference plots are used to train and validate a Random Forest classifier. In order to identify the best input data combination, different input data sets were used during classification: a) a summer medoid image (10 bands), b) a stack of three summer images (30 bands), and c) a stack of 10 Sentinel-2 images (100 bands) with low cloud cover from the 2017 and 2018 vegetation season (mid-April to October). 20% of the reference data was used as validation samples during Random Forest classification. While the

resulting confusion matrix does not provide an area based accuracy estimate, it can be used to compare the classification accuracies of the different input data sets. Overall accuracies were highest for the 10 image stack (c). The forest type product is aggregated from the tree species map and distinguishes between broadleaf, coniferous and mixed forests.

The tree cover density product is derived from a summer image of 2017 with cloud holes filled by the medoid of the summer 2017 images. The tree cover density is estimated by a k-nearest neighbour algorithm that relates the spectral values of individual pixels of four selected S-2 bands (Green, Red, RedEdge[6], SWIR[12]) with tree cover density values derived from 10-year old laser scanning data. In total, 20.000 randomly selected Sentinel-2 pixels, or 0.02% of all pixels, were used to train the classifier. As the laser scanning data is outdated, we remove all training plots with a high probability of tree cover density changes. Pixels that show tree cover density differences larger than 15% between two classification runs are removed from the final training data set.

The forest change product tracks spectral changes in the forest layer in near real-time. A historic harmonic model at single pixel level is derived from the pre-processed time series (2016 + 2017). The harmonic model parameters and the new observations (2018) are then used as input to a Kalman filter which can better account for phenologic differences among individual years (e.g. later bud break in spring). Changes in individual images are flagged by calculating a statistical deviation between new observation and Kalman filtered model. If changes are detected in consecutive new observations, these changes are confirmed on single pixel level. Changes can then be categorized based on change intensity, time and direction. The target categories for forest change are clear cuts and storm damages.

Preliminary accuracy validation results based on stratified random sampling plots show high overall accuracies >85% for near real-time forest change detection and >80% for tree species classification. Comprehensive validation results will be presented at the conference.

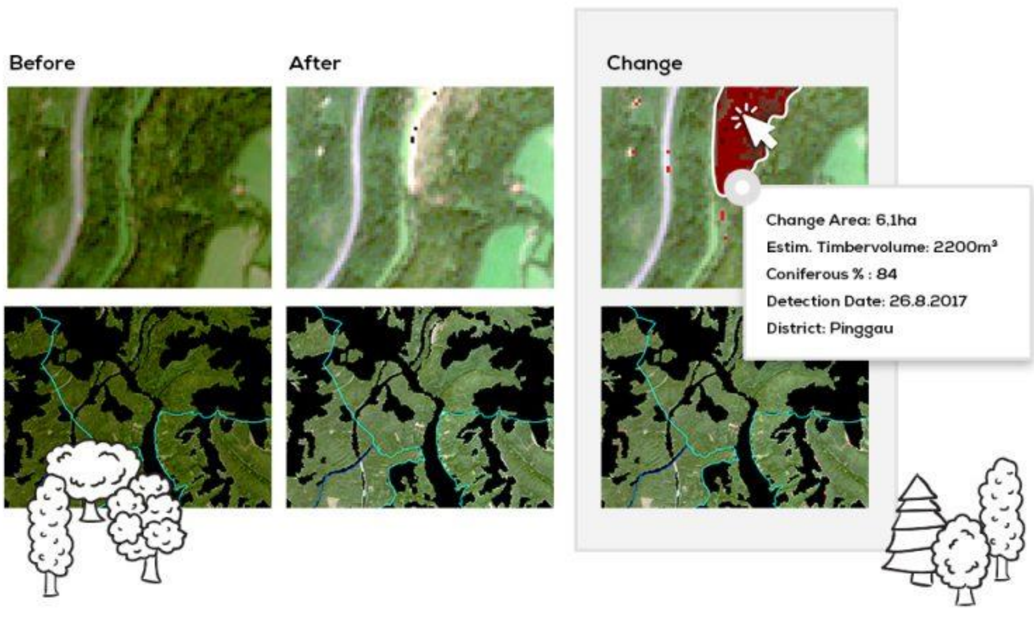


Figure 1. Example of a detected storm damage event and statistics provided by the AlpMon service.

1x1 and Useful Hints How to Use Cloud-Based (DIAS, AWS, …) Live Copernicus Data in ArcGIS

EARSeL 2019
Digital I Earth I Observation
Abstract
Günter Dörffel:
GDoerffel@esri.com

Guenter Doerffel[1], Stanisław Dałek[2], Abhijit Doshi[3]

[1] Esri Inc., European Office, Rotterdam, Netherlands
[2] CloudFerro, Warsaw, Poland
[3] Esri Inc., Sharjah Office, Sharjah, UAE

Keywords: Copernicus, Sentinel, AWS, DIAS, Python, ArcGIS, RasterFunction, CloudFerro, CREODIAS, Esri

Abstract

Today's cloud-based offerings of Copernicus data are still primarily scene based. While this approach allows search and retrieval of suitable 'slices' in time and space, the final use in many custom scenarios benefits from a seamless collection or service. Creating these custom collections, enriching them with predefined function chains and publishing them as services can be done with direct reference to the cloud-based data (no download), given that access is granted. Based on a Proof of Concept defined/conducted together with CREODIAS, this rather technical presentation will summarize the requirements and then provide the know-how and python-based tools to quickly and easily set up dynamic custom data collections and provide them as MosaicDatasets and REST based Image Services. Multiple Trade-offs between Performance, correctness and analytical flexibility can be made/implemented. These include data-caching to reduce the number of returns to the server, format conversions, limited band retrieval and adding ad-hoc selectable process chains to the data compilation. At the same level, deep learning models can be added as analytical processes to be called on demand or automated. Large scalable analytics in elastic environments are enabled by using auto-scaling features provided by the computing platform. The examples for clients/applications shown during the presentation will be web-based and python (notebook) based and include several index based visualizations, time-based selection and classification.

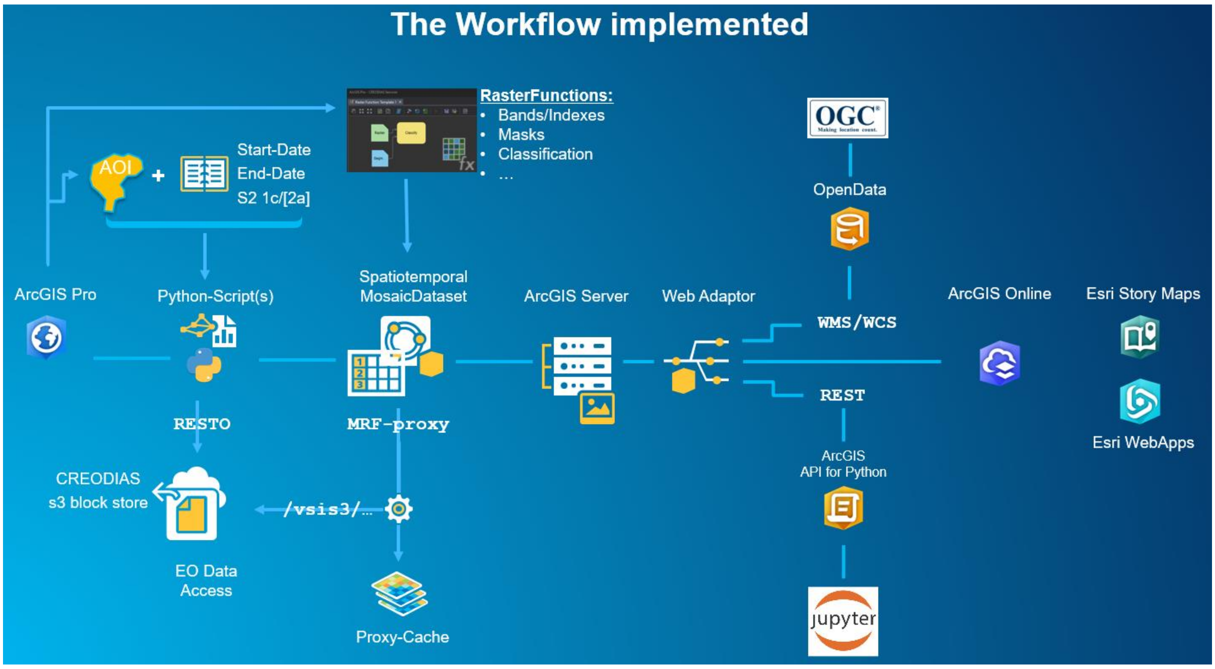


Figure 1. Generic workflow description for python based instant service creation on CREODIAS architecture

The Role of Remote Sensing in Land Degradation Assessments: Opportunities and Challenges

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
odubovyk@uni-bonn.de

Olena Dubovyk[1]

[1] Center for Remote Sensing of Land Surfaces (ZFL), Geography Institute, University of Bonn, Germany

Keywords: Land degradation, Multi-scale analysis, Sustainable development goals, Earth Observation, Sustainable land management

Abstract

Land degradation is taking place in all agro-ecological zones and has long-lasting impacts on people and the environment. Despite the importance of the problem of LD and its acknowledgement at a global level, to date no consensus has been achieved on systematic and standardised approaches that can be utilized for its assessment and monitoring at different spatial scales. Furthermore, the absence of accurate up-to-date spatial information on the extent of LD as well as on its triggers, forestalls implementation of land rehabilitation measures, which in turn threatens environmental sustainability and people's livelihoods. The provision of spatially explicit information on degraded land and identification of the LD factors would make it possible to indicate areas for targeted mitigation efforts and to prioritize those in need of immediate policy attention at different spatial scales. Consequently, there is a pressing need to improve (rather than develop new approaches and methods), calibrate and consolidate existing methods for derivation of the accessible and accurate measurements on the extent of degradation at multiple spatial scales to satisfy environmental and natural resource management, policy and research needs.

The herein presented paper has also pointed out the existing research needs. The concept of ecosystem services is adopted for LD definition in most of remote sensing studies. Accordingly, LD is measured as a 'loss of ecosystem productivity' and uses vegetation cover and productivity loss over time as a proxy of LD. Degradation of valuable resources, such as biodiversity, may not necessarily result in productivity loss, while some LD manifestations such as bush encroachment, often result in gain of vegetation cover and productivity. Therefore, an accurate calibration of remote sensing based information against field data including vegetation cover and productivity, soil fertility, and soil compaction is an issue that should not be overlooked. Another important consideration refers to a difficulty to disentangle productivity changes attributable to proximate causes from those, which may have been caused by underlying causes of LD, such as policy decisions favouring one crop versus another, market access, technological change, or shifts in import/export opportunities. Therefore, there is a need to link generated spatial information and a variety of environmental and socio-economic data in one integrative framework for comprehensive LD assessment.

From a research perspective, the integrative mapping approaches comprising the synergetic use of multiple remote sensing perspectives and different types of observations could be one way forward in remote sensing based LD assessment. This is not only important for mapping applications, but also for correctly attributing the factors of the changes for a better-informed decision-making. This paper also emphasized the importance of the multi-scale and cross-scale analyses based on multi-source remote

sensing datasets to respond to the needs of the potential users, and to fill the gap between the scales of environmental and socio-economic processes and the spatial and temporal resolution of satellite images. The inherent challenge of remote sensing based multi-scale and cross-scale assessments refers to the mismatch between spatial and temporal resolution of currently available satellite imagery and other geospatial datasets, and the required scales for LD assessment along with fast and slow variables (with emphasis on the latter) that trigger these processes.

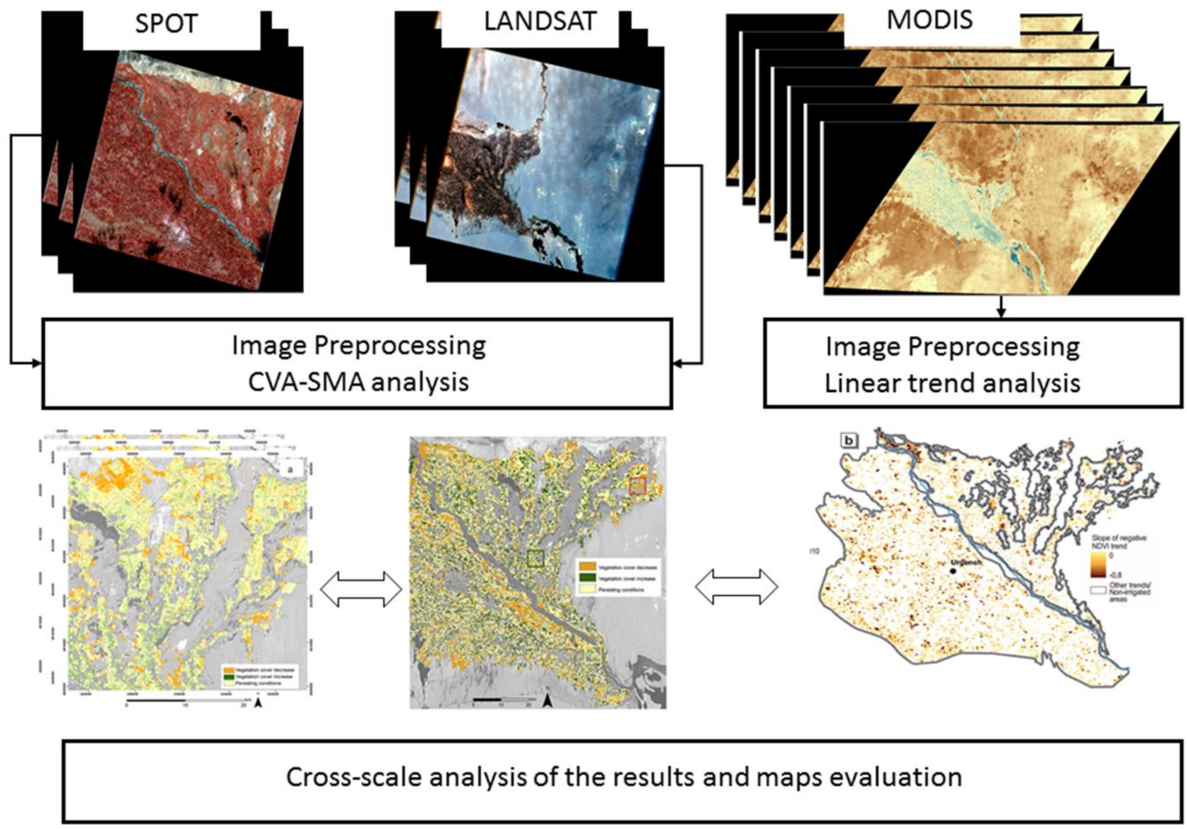


Figure 1. The workflow of the satellite image analysis to derive multi-scale information on vegetation cover changes in the study area in Uzbekistan.

Utilizing Earth Observation & Crowdsourcing for Rapid Assessment of Disaster Events

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
refiz.duro@ait.ac.at

Refiz Duro[1], Tanja Gasber[2], Aynabat Anyyeva[1], Kuo-Yu Chuang[3], Sebastian Sippl[1], Gerald Schimak[1], Volodymyr Andryachenko[3], Alexandra-Ioana Bojor[1], Peter Kutschera[1]

[1] AIT Austrian Institute of Technology GmbH, Austria
[2] GeoVille Information Systems and Data Processing GmbH, Austria
[3] GeoThings Inc., Taiwan

Keywords: Earth Observation, In-situ data, Crowdmapping, Disaster management

Abstract

Natural disasters such as floods, earthquakes, tsunamis and wildfires all substantial impact human societies. Most importantly, human lives are lost, but the significant economic burdens associated with the destructive powers by such disasters that require rebuilding efforts can have crippling effects on the societies over longer periods of time. To minimize the losses and effectively respond to these devastating events, it is necessary to establish decision making grounded on reliable and timely available information, which is primarily based on collecting and evaluating the data from the affected area. Moreover, high levels of reliability and accuracy is required, and to minimize the errors that potentially can lead to wrong decision making and misplaced spending of resources, today's state of the art technologies (e.g., crowdsourcing, satellite observations) can be deployed to assist already existing procedures and tools. Therefore, we see that the use of remote sensing methods in crisis and disaster management (CDM) has gained increasing significance over the past few years. Likewise, the accessibility of information and communication technology (ICT) results in immense quantities of citizen-generated, geolocated data, which can be explicitly initiated by the practice of crowdsourcing having a wide range of possible configurations for CDM [3]–[5]. There are, however, still challenges and a lack of optimized solutions addressing (near) real-time situation assessment for responding to crisis events through combining in-situ and remote sensing data and reports, but that are also financially accessible and designed for rapid deployment.

The approach we present includes very high-resolution (VHR) Earth Observation (EO) satellite technologies and methods to provide the data and imagery from a high vantage point covering large areas with a spatial resolution of a sub-meter level. These initial results will contain some tolerable errors but will nevertheless provide a quick first impression of the situation on the ground, and thus allow crisis managers to initiate further data collecting activities on the ground, i.e., in-situ activities in form of crowd-tasking that involve volunteers being assigned different data-collection tasks (e.g., confirm/reject information from acquired EO data, supply subject-specific data such as building height, provide photos from a specific location). These tasks come to complement and to bypass some real EO limitations such as lacking information on buildings due to viewing angles, sparse temporal coverage due to satellite re-visit times, or limited view due to unfortunate weather conditions.

Our approach has been successfully demonstrated in the "921 International Disaster Prevention Drill" in Taiwan in 2018 with the focus on a magnitude 7.0 earthquake, which is a simulation of the massive "921

Earthquake" that occurred in 1999 and killed more than 2000 people. The crisis response coordination took place at the premises of the Fire Department Central in Hsinchu County, and several volunteers participated in executing the assigned crowdsourcing tasks in the affected areas of the nearby Zhubei city. One important note related to the drill event, is, however, that we did not detect earthquake damages, but changes in urban development. There are two interrelated reasons for this: Taiwan's excellence in quick recovery after a disaster and the lack of satellite images while the damages are still visible. Thus, available pre- and post-event images showed no significant changes, as everything was rebuilt and brought back to the pre-event conditions. We therefore used a proxy for detecting changes, but now considering urban development in an area where this type of activity was very active for a certain period. The method and the approach, however, yield the same results – detecting changes.

The crisis response using the solution included the following steps, and concluded with the quick assessment of the situation in the field:

1) earthquake damages are detected using a rapid assessment, change detection system, which is highly automated processing chain for supporting CDM, and which is applied on pre- and post-event VHR-satellite images for a first assessment of the situation on the ground (e.g., collapsed buildings, etc.), all geo-located and presented as polygons. For the selected pilot site in the Hsinchu city, we used at least two 4-band colour (RGBI) orthophoto 50cm VHR Pléiades (1A or 1B) images, which covered 30.11.2013 (pre-event) and 21.12.2017 (post event) scenes.
2) based on that first damage assessment, and the type and extent of the damage, crisis managers created tasks for the volunteers who are available and near the target area. The tasks included requesting confirmation of the damages and to supply additional data (e.g., number of floors of the damaged building, building construction material, categorization of the area – residential or commercial, etc.).
3) volunteers use dedicated smartphone apps to gather the requested data in form of, e.g., answers to specific questions and images.
   finally, all collected remote sensing and crowdsourcing information is correlated using firstly an automated process establishing where, e.g., the damage locations are at densest, followed by visual expert assessments by crisis managers/responders to create an action plan (e.g., where to distribute resources and response forces).

For all the steps, a dedicated and disaster type-adjustable system was used including a rapid system assessment component for the EO data and images, crowd-tasking smartphone apps and a dynamic crisis mapping system that fuses the data and visualizes the crisis situation in (near) real-time. Visualization features such as the classified data categories (e.g., sent task, received task, EO detection, etc.), or heatmaps identifying critical areas is necessary for decision making and reporting (see Figure 1).

We present our approach and the results of the demonstration from the Taiwan Drill, showcasing a great potential for near real-time disaster management, specifically impacting the decision making, response times, allocation of resources, and distribution of response personnel.

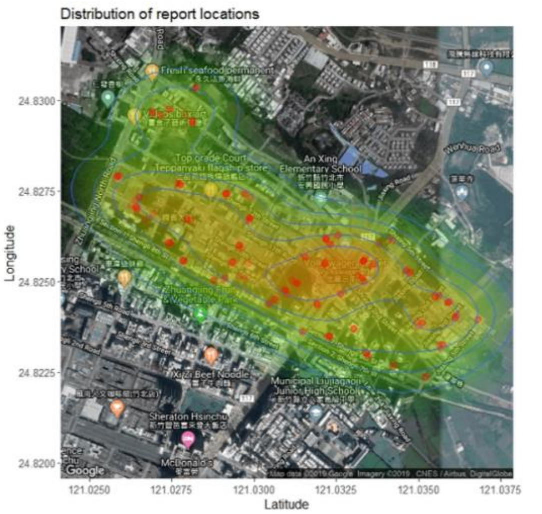


Figure 1. Distribution of crowdsourcing reports' locations in Hsinchu, Taiwan. e

Earth Observation and Machine Learning for Geomorphological Mapping at Regional Scale

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
eisank@grid-it.at

Clemens Eisank[1], Sebastian d'Oleire-Oltmanns[2], Volker Wichmann[3]

[1] GRID-IT, Austria
[2] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria
[3] Laserdata, Austria

Keywords: Geomorphology, Landform mapping, Machine learning, Sentinel-2, TanDEM-X DEM, OBIA, Optimization

Abstract

Previous studies demonstrated the value of Earth Observation (EO) and machine learning for geomorphological and geological applications. Data acquired by recent satellite missions such as the Sentinels and TanDEM-X are well suited for extracting geomorphological features such as landforms and earth surface processes. Especially the following characteristics make these data useful for regional geomorphological mapping: global coverage, data consistency, spatial resolution of about 10 m, and provision free-of-charge. Machine learning provides a fast and efficient way to analyse the vast amount of satellite data. So far, in geomorphological mapping, machine learning approaches mainly focussed on extracting features in per pixel approaches.

We present an innovative approach for geomorphological mapping at regional scale through the application of machine learning within an object-based framework. The research was implemented in the project MorphoSAT (FFG ASAP, No. 859727).

The geodatabase included Sentinel-2 multispectral images, TanDEM-X DEM and a plethora of DEM derivatives such as slope and terrain wetness index. All datasets were collected/computed for a 100 km x 200 km study area in the Alps, and resampled to 10 m spatial resolution. Additionally, we gathered a large set of reference polygons for the training and validation of the selected geomorphological features. Selected features were glaciers, rock glaciers, landslides and debris cones. We split the reference data into a 25% training and 75% validation set. It is important to note that the reference represented a compound dataset that was created by merging data from four different institutional providers. Each provider used different data and techniques for digitizing the polygons. For the training polygons, we computed numerous polygon-specific image/morphometric data statistics as well as shape metrics. In total, we derived 324 variables. We employed several methods to reduce the variable space and to select the sets of variables with the most predictive power for the classification task. We identified ideal variable sets for multi-class mapping and for single-class extraction. The identified sets of training variables in combination with the training polygons were used to train five classifiers: random forest, classification and regression tree, support vector machines, k-nearest neighbours and naïve bayes. This resulted in a total of about 150 trained models.

Selected layers of the geodatabase were segmented using region-growing segmentation with different settings. Statistical optimization was performed to select three optimal segmentation scale levels out of

the many scales that have been produced. For the segments in these three levels, we computed the values of the variables required for prediction. The trained models were applied to the three segmentation levels to produce regional geomorphological classifications. In total, we generated about 200 polygon datasets with classified segments (Figure 1). Number- and area-based accuracy metrics, as well as visual analysis were the basis for assessing the quality of the geomorphological mapping results and the following degrees of freedom in the mapping system: classifier, number of training variables, size of training set, segmentation scale, single-class vs. multi-class mapping, software.

We are currently in the process of analysing the vast amount of derived metrics to evaluate and quantify the impact of the above-mentioned parameters. Eventually, we will be able to propose a set of parameters, which is ideal for regional geomorphological mapping based on machine learning and EO.Visual analysis of the results showed most promising results for glaciers followed by rock glaciers and debris cones. The most problematic class was landslides. Landslides were largely under-estimated or missed during the mapping. Obviously, the spectral and spatial data properties of landslide areas cannot be well distinguished from the data characteristics of other geomorphological features.

The results of the MorphoSAT project demonstrate that geomorphological features can be mapped at regional scale with acceptable quality, if variables with high predictive power can be found which in turn largely depends on the geodatabase. Since the proposed MorphoSAT mapping system relies on globally consistent EO data, the approach may be transferred to map geomorphological features in every region of the world. Moreover, global application is feasible with adequate processing infrastructure. The required EO data is already out there.

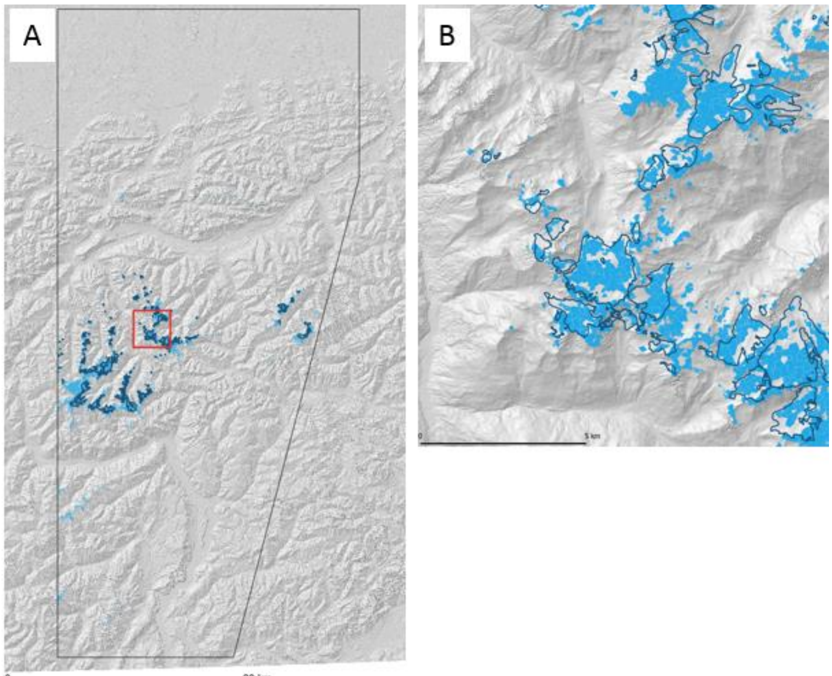


Figure 1. (A) Regional map of glaciers for the defined Alpine study area. Results produced by a random forest classifier that was trained with seven variables. Dark blue outlines show the boundaries of validation polygons. (B) Detailed presentation of results for the area inside the red rectangle in A.

Schematic Identification of Rice Crops Using Parcel-Based Sentinel-2 Data Series for the Monitoring of the Common Agricultural Policy in Murcia

EARSeL 2019
Digital I Earth I Observation
Abstract
manuel.erena@carm.es

Manuel Erena[1], Francisco J. López[1], Carlos Esteban [2], Águeda Soriano [2], Zaida Hernández [1], Joaquín F. Atenza [1], Antonio Saura [1], José A. Domínguez [3]

[1] GIS and Remote Sensing, IMIDA, Murcia, Spain
[2] General Directorate of Agrarian Funds and Rural Development, CARM, Murcia, Spain
[3] Crop Research Institute, VURV, Prague, Czech Republic

Keywords: Rice, Monitoring, Common agricultural policy, Sentinel 2, OpenSource,

Abstract

This work analyses a Sentinel-2 based rice crop identification methodology for the monitoring of the Common Agricultural Policy (CAP). In this regard, we implemented and evaluated a parcel-based pattern recognition scheme to produce accurate crop mapping in a smallholder agricultural zone in Calasparra, Murcia, Spain.

A parcel-based Sentinel-2 MSI time-series approach is using for the construction of the feature space. Sentinel-2 products are being processed with the SNAP desktop tool using the Sentinel-2 Toolbox, and we carried out atmospheric correction using Sen2Cor. The images used model the growth stages of the rice crop using indices such as the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI). The local Land-Parcel Identification System (LPIS), which provides the geospatial input for rice crop delineation, and local farmers' declarations, as part of their CAP subsidy applications, were employed for the object partitioning of the images and the supervised classifiers' training (, in QGIS. The most significant part of the CAP budget is managed and controlled through its Integrated Administration and Control System (IACS), to safeguard the CAP finances and help the farmers to submit their declarations.

The IACS implemented at the regional level through Paying Agencies (PA). Lastly, we performed a compliance check analysis for the CAP requirement to showcase the scheme's capacity for effective decision making within the context of the control of CAP subsidies. During the first phase, the full value of the developed EO products and processing system is being evaluated through a regional-scale demonstration during the year 2019. Regional PA users can visualize the geographic, data and figures information, and all information was generated during the processes using the QGIS model (2017-2018). Short time series of NDVI and NDWI allow determining if the different growing steps and finding the relation of each rice field with its yield. NDVI minimum data coincide with NDVI maximum data because it coincides with the flood time at the medium and the end of May. Spectral indexes data are because the minimum NDVI is low but positive and the maximum NDWI is high but adverse both show us the wetland rice areas. During telling the state, el NDVI shows us high vigour vegetation and NDWI indicates the crop has water. The analysis of the spectral indices together tells us the rice plants are healthy. A vector input layer by means is calculating from spectral indices, and it is possible to use through a friendly GIS viewer. The GiS viewer was developed on MapStore2 technology (https://opengeo-pro-gis.carm.es/mapstore/#/viewer/openlayers/222).

The first step or demonstration of our project was carried out in the operational environment of regional PA. The second phase of the project is coordinating by the Joint Research Centre (JRC) and the national PA and uses the Copernicus Data and Information Access Services (CREODIAS) accounts to support the processing requirements for Sentinel 2 L2A data. In the second step, it is necessary to develop fast tools to access image library while the different applications are processing the images and generating data to increase the database and statistics in the shortest time.

CREODIAS infrastructure offers applications such as PostgreSQL, PostGIS, Python, Apache HTTP Server, Docker, Jenkins, SNAP, GDAL libraries and statistical suite R commander. They also have the EO Data Hub service that offers catalogue services, real-time processing, scripting environment (Python/JavaScript), image conversion tools and WMS services configurator. All tools are being teaching by mean of substantial planning of courses and training for creating the capacity to transfer of the developed products and services to the regional PA. The aim is that everybody maybe uses the remote sensing images and information that it is possible to generate in real time.

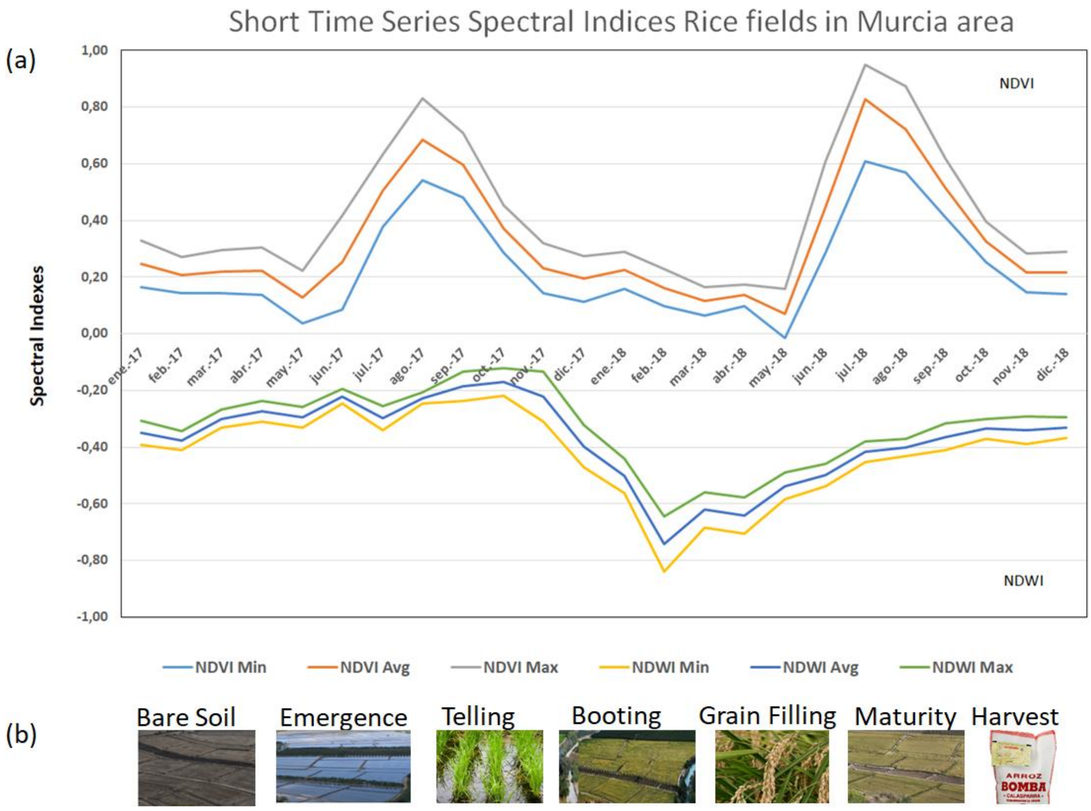


Figure 1. (a) Biannual evolution of the NDVI and NDWI (b) state of rice development

Using Google Earth Engine and Free Satellite Data for Forest Mapping, Assessment and Monitoring in S. Miguel Island (Archipelago of the Azores, Portugal)

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
manuferu@gmail.com

Manuel Fernández Urrutia[1,2], João Madruga [2,3], Artur Gil[1,4]

[1] Ce3C – Centre for Ecology, Evolution and Environmental Changes, Azorean Biodiversity Group, University of the Azores; Ponta Delgada, Portugal
[2] Faculty of Agrarian and Environmental Sciences, University of the Azores, Portugal
[3] IITAA - Instituto de Investigação e Tecnologia da Agronomia e Meio Ambiente, University of the Azores, Portugal
[4] Faculty of Sciences and Technology, Department of Biology, University of the Azores, Portugal

Keywords: Forest inventory, Land cover mapping, Vegetation monitoring, Azores islands.

Abstract

The Azorean Regional Forest Inventory constitutes the core tool for forest planning and management and also the most accurate and reliable official land cover map in the Azores Autonomous Region (Portugal), being widely used by local and regional authorities for supporting both spatial planning and forestry policies purposes. The current Azorean Regional Forest Inventory was produced in 2007 by the DRRF (Forest Regional Department) staff through the combination of Geographical Information Systems (GIS) based on-screen photointerpretation of very high spatial resolution aerial imagery (with a minimum spatial unit of 1 hectare) and exhaustive field campaigns for survey and validation. As the overall cost of this methodological procedure is very high (in both human, logistics and data resources) and time consuming, the periodic update of this cartographic product is not performed as frequently as needed for spatial planning and forest management purposes. Satellite remote sensing has shown to be an appropriate tool to assess and monitor large-area forest attributes with reasonable accuracy levels. The use, integration and combination in the current Forest Inventory's methodological procedure of free-of-charge Copernicus remote sensing data provided by Sentinel-1 (C-band SAR) and Sentinel-2 (multispectral) sensors will significantly improve the regional decision-support system and successfully contribute to develop a more suitable and cost-effective operational system for mapping, inventorying, monitoring, assessing and managing natural (both native and invaded) and production forest areas in the Azores. For this purpose, a remote sensing framework (Figure 1) based on the Google Earth Engine platform (Figures 2 and 3) is under development in order to: (1) accurately map Azorean forest areas through semiautomatic supervised classification; (2) detect changes in forest cover by applying the change vector analysis (CVA); and (3) assess vegetation greenness and moisture status by computing and comparing several spectral indices (e.g. NDVI, SAVI, EVI, NDWI). The development and implementation of a Sentinel-based forest monitoring framework able to support decision-making in spatial planning and to strengthen law enforcement by public authorities, will constitute an important step towards an effective promotion of cost-effective forest management and land use sustainability awareness among decision-makers, land owners/managers, further stakeholders and the general public. In fact, the development of a forest management approach strongly supported by an effective assessment of current resources, complemented by the detection and monitoring of the most relevant forest changes and land cover trade-offs might be able to mitigate the main negative ecological (e.g. loss or degradation of native vegetation areas, increase of areas invaded by alien plant species) and socio-economic impacts (e.g. loss or degradation of production forest; increase of bare soil and

impervious areas). This remote sensing-based framework will be fully aligned with multi-sectorial regional policies and legal instruments related to Forestry planning and management (Azorean Forestry Strategy), Land Management (Regional Decree-Law 26/2010/A and 14/2000/A), Invasive Alien Species control (Government Council Resolution 110/2004), and Nature Conservation (Regional Decree-Law 15/2007/A and 7/2007/A). Furthermore, it will also strongly contribute for all three strategic priorities of the first pillar of the Azores RIS3 (Regional Research and Innovation Strategies for Smart Specialization): "Agriculture, Livestock and Agroindustry". With the expected increase of available free satellite data (especially Sentinel data), there is a growing need for cloud-based data storage and web-based visualization and processing services. The Google Earth Engine platform is currently the most suitable platform to implement this framework, in order to combine this satellite information with further valuable data from field surveys and very high-resolution UAV campaigns periodically undertaken by DRRF, fostering therefore the operationalization of a powerful multi-source decision-support system.

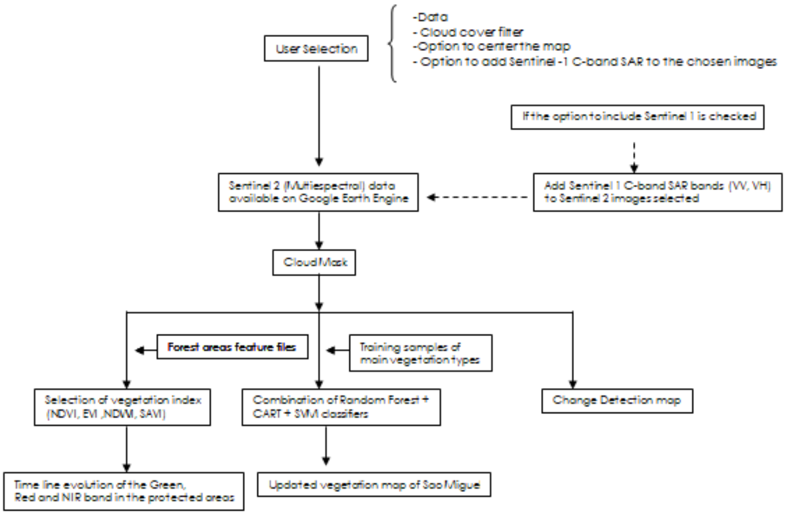


Figure 1. Methodological flowchart of the remote sensing-based framework

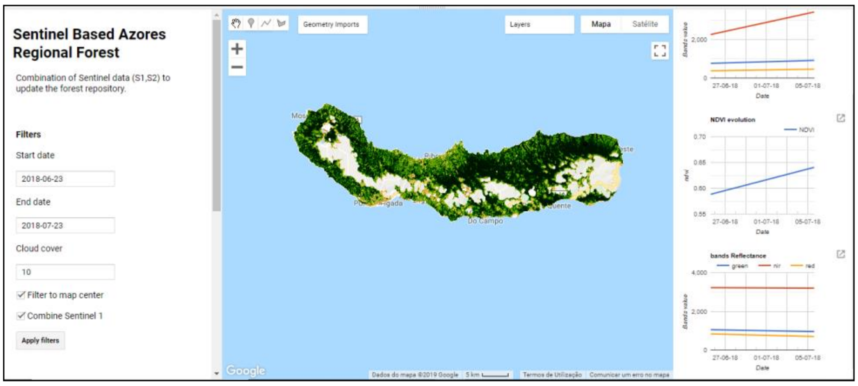


Figure 2. Overview of the GEE-based tool allowing the spectral and vegetation indices' comparison and assessment among different Sentinel-2 images

Contribution of Remote Sensing and GIS to Support Risk Assessment for Sustainable Urban Planning in Tunisia

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
fila@iabg.de

Konstanze Fila, Felicitas Bellert[1], Michael Hagenlocher[2], Mostapha Harb[2], Davide Cotti[2], Matthias Garschagen[2], Rainer Malmberg[1], Sonia Ayed[3]

[1] IABG mbh, Germany
[2] United Nations University, Institute for Environment and Human Security (UNU-EHS), Germany
[3] Municipality of Monastir, Tunisia

Keywords: Disaster risk reduction, Flash floods, Erosion, Remote sensing, Risk assessment, GIS

Abstract

Urban growth and climate change are leading to an increase in urban disaster risk in many places around the globe. These developments result in a rising need for tools that enable efficient disaster risk management (DRM). In this context, remote sensing methods can help stakeholders to make information-based decisions to ensure risk-informed, sustainable urban planning. Within the context of a pilot project entitled "Urban disaster resilience through risk assessment and sustainable planning (UD-RASP)" in Monastir (Tunisia), remote sensing data and methods were applied by to create relevant inputs for an integrated urban multi-hazard risk assessment.

As an initial step, the nomenclature of the "European Urban Atlas" was applied to conduct a standardized mapping of the study area based on multi-temporal remote sensing data (Landsat) for the years 1975 to 2017. Archives of historical satellite and aerial imagery were explored to conduct a retrospective analysis of the urban development in the city. A semi-automated workflow was then applied to perform a land use and land cover (LULC) classification, based on WorldView3 and Landsat data. A differentiation between a wide range of housing classes was made, considering their density, compactness as well as land use classes (e.g. industrial and commercial). The results were subsequently integrated into both urban growth and flash flood modelling.

A hazard analysis with a focus on urban flash floods was conducted. In the process, WorldView 3 imagery (March 2017) was used to generate a digital terrain model (DTM) in high resolution (1m). The DTM and precipitation data of the past 30 years were used as inputs for the flood model (MIKE 21) to detect and localize areas prone to flash floods. To assess exposure to flash floods the absolute population per building block and the transport areas were intersected with the flash flood hazard layer. As a result, the affected population as well as critical infrastructure were identified and mapped in the form of exposure zones. The remote-sensing based hazard and exposure analysis described here was complemented by an indicator-based assessment of social vulnerability and integrated into a flash flood risk analysis.

To support preventive urban planning, a scenario analysis was conducted to identify potential urban risk areas in relation to flash floods up to the year 2030, including hazard, exposure and vulnerability scenarios. Here, a retrospective analysis of urban growth based on multi-temporal remote sensing data has served as an input for the simulation of future urban development and exposure scenarios by means of the SLEUTH urban growth model and GIS. As for the analysis of current risk hotspots, the

outcomes were combined with future vulnerability scenarios, which were developed in the project and integrated into future scenarios of flash flood risk for Monastir.

A GIS system has been implemented in the municipality of Monastir to maintain and update the risk related data. The final geodatabase furthermore serves as a baseline for a web-based information system that is centrally accessible to stakeholders for the respective subject-related decision-making. It presents all information relevant for planning purposes in a spatial context. The tool enables relevant stakeholders to develop mechanisms to cope with the challenges of urban disaster risk in a timely manner. The platform offers a highly integrated method of providing and making available the relevant data for risk-informed sustainable urban planning. To integrate the generated information into the urban planning process, the municipality is planning to conduct regular workshops with the relevant stakeholders to improve communication and further strengthen disaster risk governance. An upscaling of the project from the local to the regional or national level can offer a more comprehensive understanding of risk.

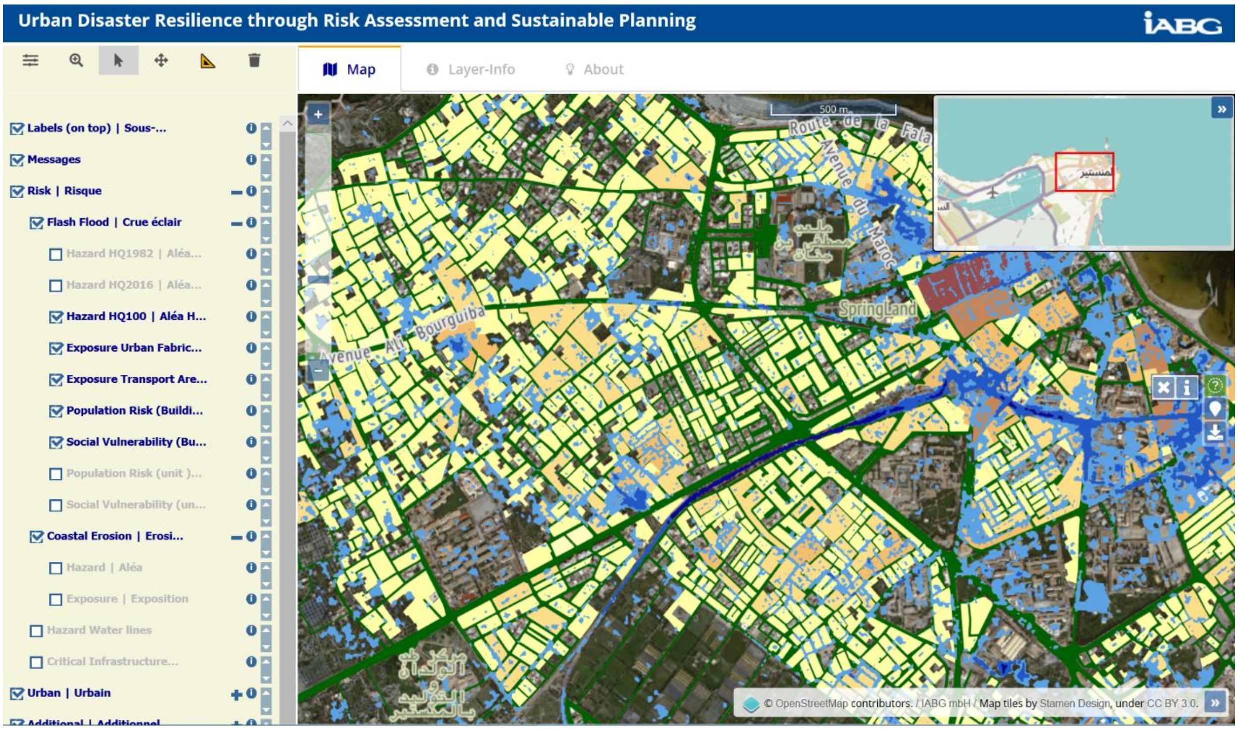


Figure 1. Web-based information platform for risk-informed sustainable urban planning (Source: IABG)

FotoQuest Go: A Citizen Science Approach to the Collection of In-Situ Land Cover and Land Use Data for Calibration and Validation

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
fritz@iiasa.ac.at

Steffen Fritz[1], Tobias Sturn[1], Mathias Karner[1], Inian Moorthy[1], Linda See[1], Juan Carlos Laso Bayas[1], Dilek Fraisl[1]

[1] International Institute for Applied Systems Analysis, Austria

Keywords: Land cover, Land use, In situ data collection, Validation, LUCAS

Abstract

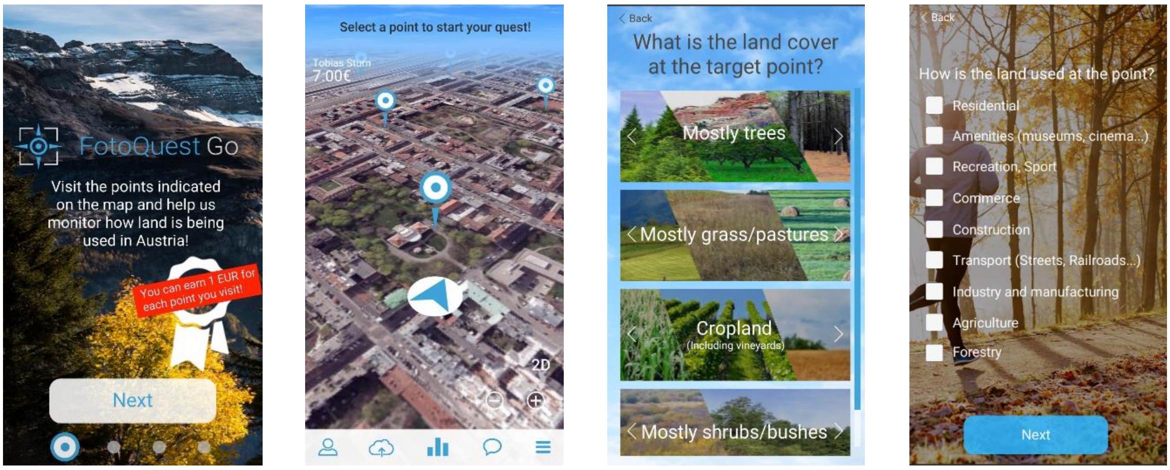
The Land Use/Cover Area frame Survey (LUCAS) is a harmonized data collection exercise on land cover and land use, which employs a systematic sample across EU member countries. The survey is undertaken every three years by trained surveyors and is a rich data set of land use and land cover, including geotagged photographs. LUCAS has been used to validate the CORINE land cover map, which is generated for EU member countries every 6 years, and it represents one of the only publicly available in situ data sets for the calibration and validation of products derived from Earth Observation for Europe. However, the LUCAS exercise is undertaken at a considerable cost to the taxpayer. Given that citizen science is becoming more popular, i.e., the involvement of citizens in scientific research including data collection, we set out to determine whether citizens could help in gathering in situ data on land use and land cover. Advantages of this approach include data collection that is at a denser sample in some areas, the potential for more up-to-date information, since LUCAS is only carried out every 3 years, and as a cost effective way to complement and enrich LUCAS data collection.

To test out this idea of land use and land cover data collection by citizens, the FotoQuest Go app was developed. FotoQuest Go is one of many tools that are part of the H2020-funded LandSense Citizen Observatory for land cover and land use. FotoQuest Go (shown in Figure 1) leads any citizen taking part in our crowdsourcing campaigns to pre-specified locations shown on the map. In some cases, these locations overlap with LUCAS points so that quality assurance can be undertaken, comparing the land cover and land use data from the citizens with that of the professional surveyors. As a location on the map is reached, users are asked to take 4 photographs in 4 cardinal directions away from the location and one at the actual point. The map guides the users, e.g., only allowing them to take a photograph if the compass direction is S, N, E or W, and providing advice regarding how the photos should be taken, e.g. two-thirds land and one-third sky. The citizens are then asked to classify the land cover using a simple, visual decision tree, followed by the land use. The app has been designed to be easy-to-use. For example, it is visually attractive and intuitive as the map interface provides guidance on reaching locations, and the app helps users in taking optimal photographs. The decision tree for determining land use and land cover has also been designed in a simple user-friendly fashion.

A number of different campaigns have been run with FotoQuest Go, where incentives for participation have ranged from prizes at the end of the campaign to small, monetary rewards for each point captured that was deemed to be of sufficient quality. These gamification elements have helped to motivate the crowd and make the crowdsourcing experience more fun. An analysis of the data

showed good agreement between the citizens and the surveyors at the LUCAS locations when considering high level land cover classes, e.g. forest, urban, water, etc., i.e., accuracies greater than 80%. Thus, using an app such as FotoQuest Go, citizens can collect land cover and land use data that could be used for calibration and validation of land cover and land use maps. Moreover, many geotagged photographs have been collected, which could additionally be interpreted and used for calibration and validation purposes.

More recently, the main functionality contained within FotoQuest Go has been moved into the PAYSAGES mobile app for crowdsourcing data on land cover and land use. The idea is to involve citizens in the validation and improvement of the French land cover map developed by the French Mapping Agency (IGN). The PAYSAGES app has been developed within the H2020 LandSense Citizen Observatory as part of a demonstration case in urban areas. The app will be used in data collection campaigns during the summer of 2019.



(a) (b) (c) (d)

Figure 1. The FotoQuest Go mobile application for in situ data collection of land cover/land use showing (a) the front screen (b) locations of points on the map (c) classification of land cover and (d) classification of land use

Sentinel-2A MSI and SPOT 5 Data for Urbanization Monitoring and Environmental Impact Analysis in Stockholm

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
yifang@kth.se

Dorothy Furberg[1], Yifang Ban[1], Andrea Nascetti[1]

[1]Division of Geoinformatics, KTH Royal Institute of Technology, Stockholm, Sweden

Keywords: Sentinel-2A MSI, SPOT 5, Object-based SVM Classification, Stockholm, Urban Growth, Environmental Impact Analysis

Abstract

Over the past decade, there has been substantial urban growth in Stockholm, Sweden, now the largest city in Scandinavia. The Swedish government has recently taken steps to ensure sustainable management of its green and blue resources in urban areas by requiring all counties to draw up regional action plans for their green infrastructure. Capitalizing on the new research opportunities afforded by the availability of Sentinel-2A MSI data, this research investigates and evaluates the evolution of land cover/use change in Stockholm County between 2005 and 2015 with a particular focus on what impact urban growth has had on protected green areas, green infrastructure and urban ecosystem service provision. Some previous studies have analysed urban growth and environmental impact over the Stockholm metropolitan area based on 20/30m resolution data, but very few have examined the entire county landscape and this is one of the first to utilize 10m resolution Sentinel-2A MSI data and SPOT data for the purpose.

One scene of Sentinel-2A MSI imagery acquired on August 23, 2015 and ten scenes of SPOT 5 acquired during 2005 - 2008 vegetation seasons over Stockholm County were selected for this research. These images are classified into 10 land cover categories using object-based image analysis and a support vector machine algorithm. Training samples were gathered for 19 different classes initially which were subsequently aggregated. Several spectral, textural and geometric input features to the SVM classifier were tested; mean and standard deviation of the spectral bands, Asymmetry, Roundness and Rectangular fit of object polygons, and Gray-Level difference vector entropy texture information were selected as inputs. The classification results were subsequently improved to reduce confusion between agriculture, golf courses and urban green space in particular using neighbourhood treshholding rules and ancillary data masks, such as Statistics Sweden's urban centre dataset. Accuracy assessments were performed using at least 1000 validation sample vector points for each land cover class and both classifications reached accuracies of approximately 90%. The results are used in calculations and comparisons to determine the impact of urban growth in Stockholm between 2005 and 2015, including generation of land cover change statistics, urban ecosystem service provision bundles which include spatial configuration information and evaluation of impact on legislatively protected areas as well as ecologically significant green infrastructure networks. This study employs a complementary dual-level analysis approach: at the landscape regional level, yielding an estimation of overall impacts on ecosystem service provision for the whole region, combined with more specific analysis pertaining to green infrastructure that highlights impacted areas which are localized manifestations of the regional trends.

The results indicate that non-urban land cover/use (green structure and agricultural areas) decreased and urban areas increased by just over 2% of the county land area or approximately 116 km^2. Urban areas increased by 15% while non-urban land cover/use decreased by just under 4%. The results suggest that urban areas may soon overtake agricultural areas to become the second largest land cover category in the county landscape after forest. The largest increases in urban areas and significant losses of green structure occurred mainly in the northern outskirts of the county in the rural-urban fringe. However, the most significant environmental impact registered south of Stockholm City where urban expansion increasingly overlapped several types of the region's protected and ecologically important green infrastructure.

In terms of ecosystem service provision, loss of forested areas led to a notable decrease in global climate regulation, but the increase in proximity of urban areas to forest was the main cause of decreases in the provision of temperature regulation, air purification, noise reduction as well as recreation, place values and social cohesion. Urban areas within a 200m buffer zone around the Swedish EPA's nature reserves in Stockholm County increased by 16% over the decade, with several examples of new urban areas constructed along the boundary of nature reserves. Urban expansion also overlapped with the deciduous ecological corridor network and green wedge and core areas to a relatively small but increasing degree. The results of this study can assist policymakers and planners in their efforts to ensure sustainable urban development and natural resource management for the Stockholm region. This study in general can provide a helpful applied example of environmental and green infrastructure monitoring for other regions and nations looking to meet their national and international sustainability goals.

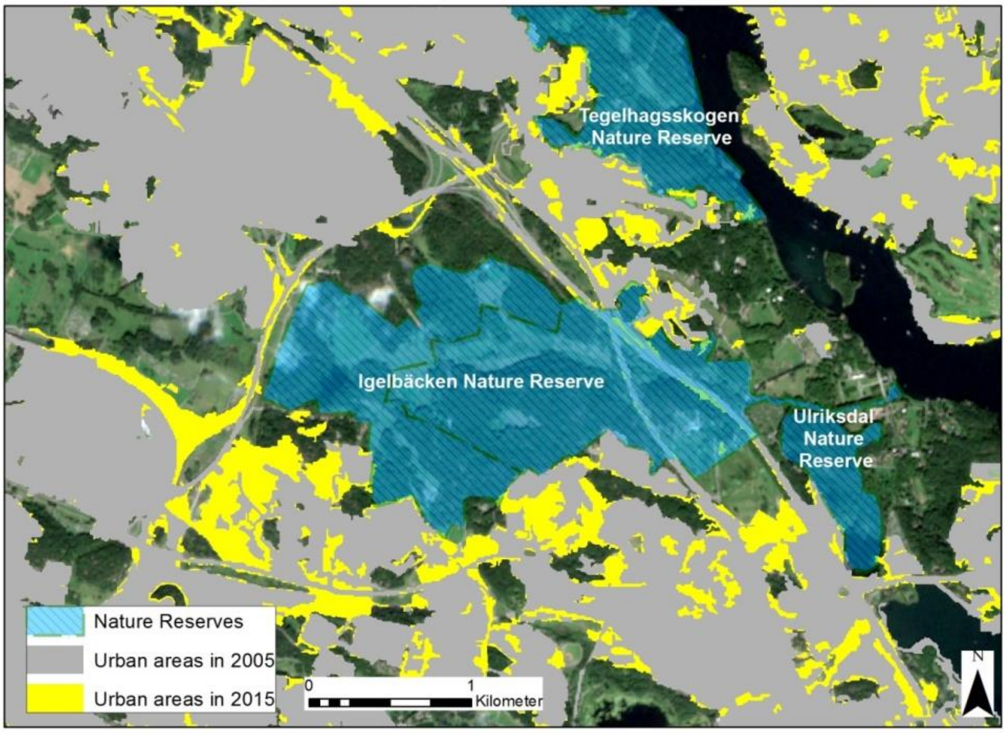


Figure 1. Urban growth between 2005 and 2015 in proximity to nature reserves north of Stockholm City

Post-Disaster Recovery Assessment Using Multi-Temporal Satellite Images with a Deep Learning Approach

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
s.ghaffarian@utwente.nl

Saman Ghaffarian[1], Norman Kerle[1]

[1]University of Twente, ITC, Department of Earth System Analysis, Netherlands

Keywords: Post-disaster recovery assessment, Multi-temporal, Satellite images, Deep learning, Multi-patch, CNN

Abstract

Natural disasters cause massive problems for affected communities, societies, and economies, with devastating impacts on infrastructure, business sectors, and people in the affected region. Recovery starts after the immediate post-disaster response phase, mainly search and rescue operations, have concluded. Compared to the relatively short-lived response phase recovery can then take years or even decades, and is the most poorly understood phase of the disaster management cycle. It comprises reconstruction of buildings, which is easier to detect using direct physical assessments, as well as recovery of the functions of the affected area, such as schools and factories, which are harder to detect and usually are approached using proxies. Remote sensing (RS) as an effective and rapid tool for monitoring large areas is essential to acquire geospatial data. RS techniques have been extensively used for different aspects of the Disaster risk management (DRM), from quantification of vulnerability to rapid damage assessments, and numerous image analysis methods have been developed. Conversely, the recovery phase has seen very little research. Most of the existing studies have been mainly making use of manual information extraction or have used comparatively outdated image processing techniques. The final recovery assessment is usually done via change analysis of the extracted multi-temporal information.

Recently developed deep learning methods, in particular, convolutional neural network (CNN), tend to outperform existing RS data processing methods. Recent studies have already demonstrated the efficiency of deep learning approaches in extracting damaged areas from satellite and aerial images. However, those studies employ mono-temporal RS data, detecting damaged areas from the images acquired immediately after a disaster. In addition, deep learning approaches have not yet been adequately assessed for multi-temporal image analysis in computer vision researches, and no connection to recovery assessment has been made yet. In this study, we develop a new patch generation model that concatenates multi-temporal satellite images from before the disaster, right after the event, and later post-disaster images to be used as input for deep learning approaches (Figure 1). The concatenation is done by vertically and horizontally merging the equal size initial patches that belong to the same area in one patch/image rather than concatenating images as different bands. Then, the final patches for each area are used as training samples in the deep learning approach. In this study, a CNN approach with fully connected layers and backboned by VGG-16 is used to classify the images into recovered or not-recovered areas. The developed model was tested for recovery assessment in Tacloban, the Philippines, which was hit by Typhoon Haiyan in 2013. Very high-resolution (Pansharpened/0.5 m) satellite images acquired from different platforms (e.g., Pleiades, Geoeye and

Worldview2) were employed to generate the training samples. Since it is even visually hard to determine the recovered or not-recovered areas by comparing the multi-temporal satellite images, the training areas that their recovery ratios have been visually determined less than fifty percent were selected as not recovered samples and the rest including not-changed ones were considered as recovered. A total of 989 training samples were generated, and 10% of them were randomly selected to conduct the accuracy assessment. The developed model produced 89% accuracy in distinguishing the test data/images to recovered and not-recovered classes.

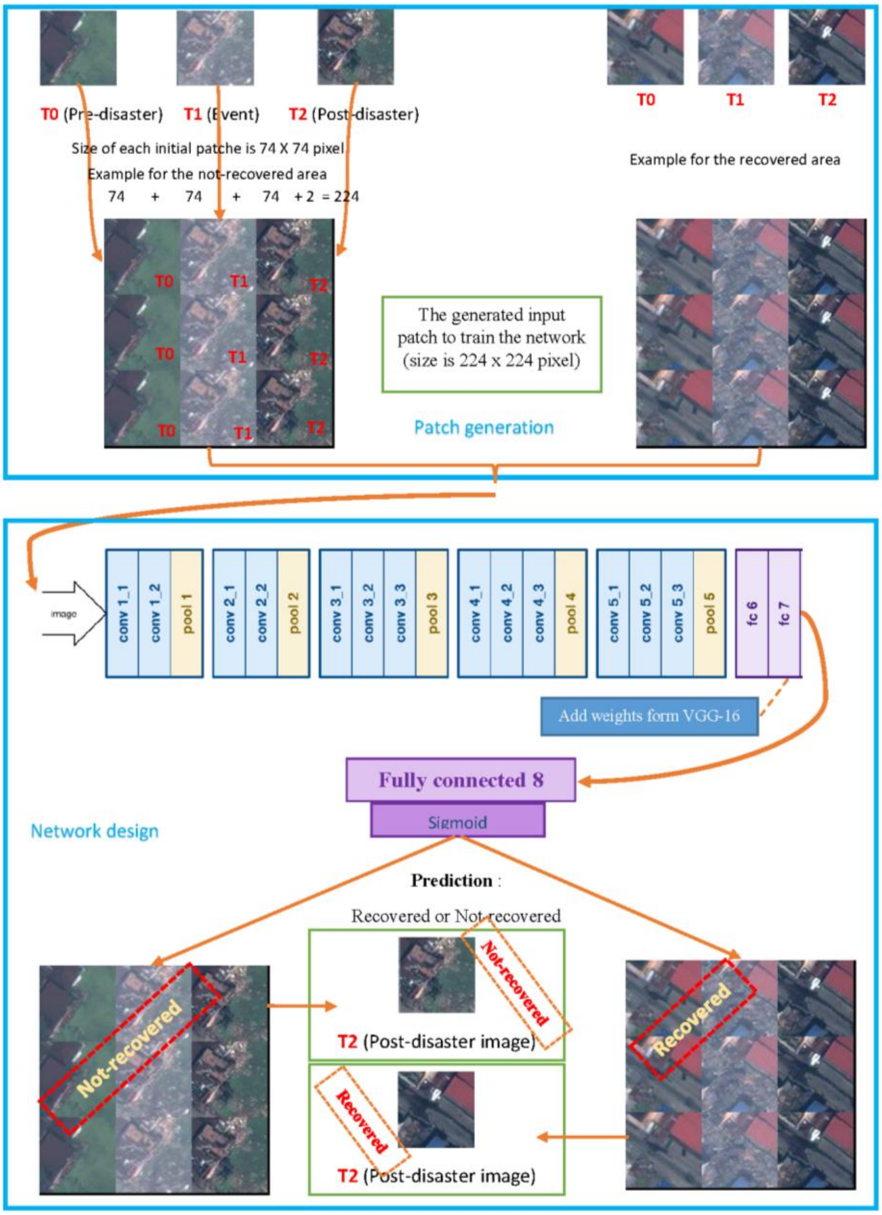


Figure 1. The developed deep learning approach for post-disaster recovery assessment from multi-temporal satellite images.

Remotely Sensed Time Series for Drought Monitoring: Testing Multisource Data in Two Countries

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
gghazary@uni-bonn.de

Gohar Ghazaryan[1], Javier Gonzalez[1], Olena Dubovyk[1,2]

[1] University of Bonn, Center for Remote Sensing of Land Surfaces (ZFL), Germany
[2] University of Bonn, Remote Sensing Research Group (RSRG), Germany

Keywords: Drought impact monitoring, Crop, Leaf area index, NDVI, MODIS, Sentinel

Abstract

Timely monitoring of agricultural production and early yield predictions are essential for food security. Crop growth conditions and yield are related to climate variability and extreme events. One of the extreme events having an impact on crop production are droughts which bear food and water security concerns globally.

Remotely sensed time series, such as the leaf area index (LAI) and vegetation indices, such as Normalized Difference Vegetation Index (NDVI) can be used to study the drought-induced changes in crop growth. However, the choice of remotely sensed data is still an issue, as different datasets have different spatiotemporal characteristics. Thus, our primary goal was to study the impact of different remotely sensed time series for crop condition monitoring. Specifically, we aimed to capture spatiotemporal patterns of crop growth under different agro-climatic conditions in drought-prone areas in the US and South Africa.

As the primary data source, Moderate Resolution Imaging Spectroradiometer (MODIS), 4-day LAI (MOD13Q1 product) and 16-day NDVI datasets were selected (2002 – 2018). In addition, Sentinel-2 time series were used in order to study the intra-pixel heterogeneity of course scale datasets followed by downscaling of MODIS LAI and calculation of the 10m-resolution vegetation indices (2016-2018). Furthermore, ancillary datasets were used to explore the relationship between different remotely sensed variables. Specifically, The Climate Hazards Group Infrared Precipitation with Station (CHIRPS) dataset and Land Surface Temperature (LST) data based on MODIS (1km) and Landsat (30m) were integrated. Lastly, we used Soil Moisture Active Passive (SMAP) soil moisture product for describing the moisture conditions through estimating Standardized Soil Moisture Index. Random Forests (RF) regression was applied for downscaling the MODIS LAI data. Crop phenological indicators were calculated based on NDVI and LAI time series for both Sentinel and MODIS scale datasets. Specifically, the start of the season (SOS), end of the season (EOS) and timing of the peak of the growing season were derived using TIMESAT, following the smoothing of time series with Savitzky-Golay function and thresholding based on percentages of the annual amplitude.

Results showed that some drought events (2015/2016) were well captured by LAI in major crop types in Eastern Cape. In the case of Missouri river basin, LAI was more sensitive to drought-induced crop stress than NDVI, identifying drought events in 2003, 2007 and 2012. We observed significant differences in both timing of the peak and maximum of NDVI and LAI between growing seasons with different agroclimatic conditions for both study areas. Crop yield statistics were integrated for the validation of the remotely sensed derived crop condition. Within the data rich study case in the US, it was confirmed,

that the use of consistently acquired land cover data improved derived agricultural drought information by reducing the uncertainties caused by crop rotation. Additionally, some differences were found among the LAI responses of the different cultivars suggesting crop specific sensitivity to drought events. The use of multi-resolution data allowed the adequate assessment of the heterogeneous agricultural landscapes in selected study regions. Sentinel scale data retained the spatial detail and allowed intra-field level assessment of phenometrics.

This approach is promising for the downscaling of MODIS LAI data and generation of temporally dense LAI time series with improved spatial resolution. Synergistic use of multisource remotely sensed time series gives more information on varying crop condition from the national to the local scale. Remotely sensed time series and derived crop condition metrics can further support decision making for farming activities. Furthermore, these metrics can be used as an input for crop models for reliable early yield estimations and assessment of factors affecting crop yields.

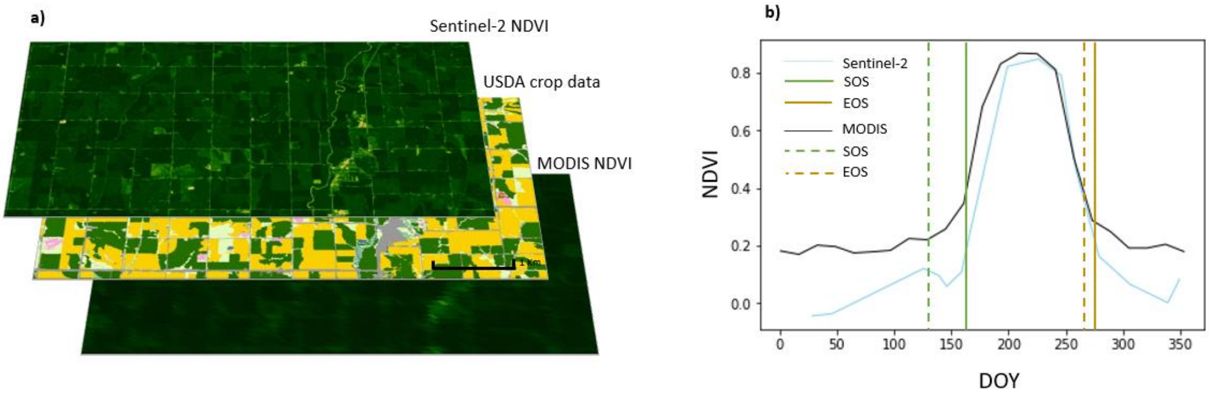


Figure 1. (a) Multiresolution data and (b) Phenometrics derived from Sentinel-2 and MODIS

Convolutional Neural Network (CNN) for Dwelling Extraction in Refugee/IDP Camps

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
omid.ghorbanzadeh@stud.sbg.ac.at

Omid Ghorbanzadeh[1], Dirk Tiede[1], Lorenz Wendt[1], Martin Sudmanns[1], Stefan Lang[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Deep neural networks, WorldView-3, Mean intersection-over-union (mIOU), Humanitarian crisis

Abstract

Both human-made and natural disasters are the main reasons of population displacement, and refugee / IDP (internally displaced people) camps are often the first accommodation for people who have been forced to flee their home. There is a growing availability and usage of optical very high spatial resolution (VHR) satellite images for efficient support of camp planning and humanitarian aid. These satellite images have significant potential to provide humanitarian organisations with critical information to have a deeper and better understanding of the camp situation. Therefore, VHR satellite images are considered as the primary source of information including number, type and size of dwellings and an estimated number of refugees for tasks demanding such high-level information. However, processing the satellite images to the production of useful high-level information is a challenging task. The extraction and categorisation of different dwellings is a demanding process, because a large variety of dwellings exist with various colour, sizes, and multiple placement positions. Several adequate studies implemented object-based image analysis (OBIA), template-matching and (semi-)automated workflows for dwelling extraction and classification. These workflows are mostly expert-knowledge-based rule-sets, which are easily transferable to different camps.

Several neural networks (NN) and other machine learning methods have been used in different studies for VHR satellite image classification. During the past decade, deep neural networks and in particular convolutional neural networks (CNN) marked a new epoch in the application of the NNs in computer vision and image understanding. Because of the current state-of-the-art achievements of CNNs in image analysis tasks and the vast availability of labelled VHR satellite images, there is a growing desire for using CNN for object detection, image classification, scene annotation and so-called semantic segmentation. The CNN methods are supervised multilayer feed-forward neural networks that are tailored to specific image analyses.

Even though CNN models have reached high accuracies for some object extraction aims in VHR satellite images, e.g., detection of vehicles, roads and aeroplanes, the potential and challenges of using these models for dwelling extraction in refugee/IDP camps are not fully explored. In this application, we face some specific challenges including non-uniform and a variety of shapes, and very small objects compared to the spatial resolution of the usable (satellite) imagery.

In this study, we evaluate a specific CNN model using Trimble's eCognition software environment based on Google TensorFlow library for extracting different dwelling types of a refugee camp in Cameroon. In this regard, we used a training data set of labelled images obtained from an operational service for humanitarian mapping at the University of Salzburg, Interfaculty Department of Geoinformatics (Z_GIS).

The input data include four spectral bands of a WorldView-3 image captured on 12th of April 2015, namely blue (450–510 nm), green (510–580 nm), red (630–690 nm), and near-infrared (770–895 nm). We considered and used different input window sizes based on the various sizes of the different dwelling types. To deal with different generated sample patch sizes, our eCognition-based CNNs were structured in different layer depths. The integration in an OBIA software will allow the integration of the CNN results in knowledge-based analyses in future studies.

In order to precisely validate the resulting dwelling extractions, the mean intersection-over-union (mIOU) and a manually labelled test dataset were used. The mIOU is a validation metric which is widely used in the field of computer vision mostly to measure the accuracy of the results of object detection models. It is a general validation metric where any method that produces bounding polygons can be validated by using mIoU based on a precise test dataset of target polygons. It is described as the mean of the following equation (1):

$$IOU = (\text{Area of Overlap}) / (\text{Area of Union}) \quad (1)$$

The mIOU value was calculated based on the resulting true positive (TP), false positive (FP), and false negative (FN) for each dwelling extraction.

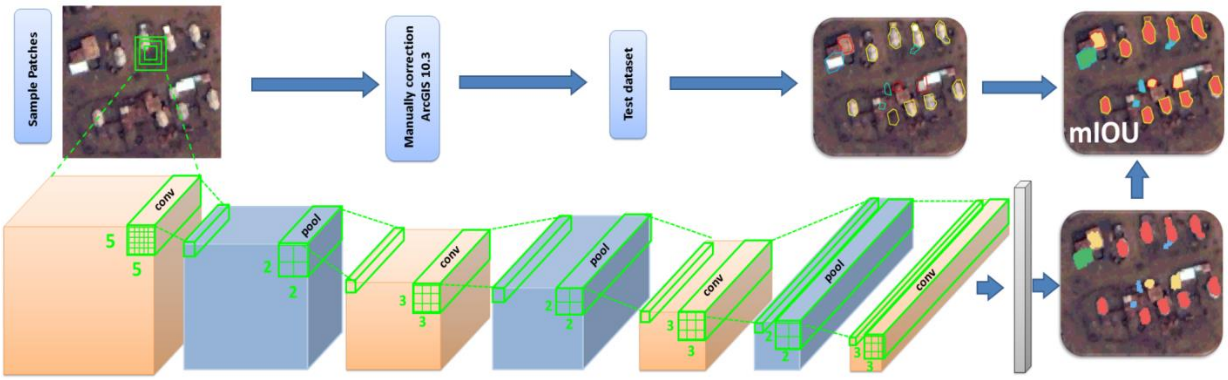


Figure 1. Illustration of the seven-layer depth CNN architecture.

Evaluation of Minimum Noise Fraction Transformation and Independent Component Analysis for Dwelling Annotation in Refugee Camps Using Convolutional Neural Network

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
sepideh.tavakkoli-piralilou@stud.sbg.ac.at

Omid Ghorbanzadeh[1], Zahra Dabiri[1], Dirk Tiede[1], Sepideh Tavakkoli Piralilou[1], Thomas Blaschke[1], Stefan Lang[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Deep learning, Dwelling extraction, Data augmentation, Spectral complexity reduction, WorldView-3.

Abstract

Up-to-date information on the areas affected by a conflict situation or a natural disaster is essential to the coordination of humanitarian relief. The capacity to monitor such areas is also essential in the context of human rights starting from primary information generation, such as the number of people who have been forced to flee their home. Refugee camps are often considered as the earliest accommodation for these displaced people. However, conflict monitoring and gaining access to the refugee camps for conducting ground-based documentation of human rights violations or population estimation are too limited or dangerous in most cases. Therefore, Earth observation (EO) data, including very high resolution (VHR) images, are widely considered as the most accessible source providing timely and detailed information necessary for supporting humanitarian response. The VHR satellite images have a significant potential for providing humanitarian organisations with essential insights into conditions on the refugee camps, including type, number and size of dwellings and consequently an estimated number of displaced people.

Although annotation and classification of different dwellings in immense size and complex refugee camps is a challenging task, some workflows such as object-based image analysis (OBIA) used in full- and semi-automatic information extraction showed good results (see, e.g. Witmer, 2015). These computer-assisted workflows are mostly expert knowledge-based rule-sets that make it possible to transfer it to another refugee camp; nevertheless, often adaptation of the rule-sets is necessary. This study aims to develop an alternative approach for refugee camp mapping with convolutional neural networks (CNNs). Although many studies using CNN models resulted in higher accuracies as compared to conventional neural networks and machine learning models such as support vector machine, the CNN models require much more labelled training dataset for efficient training performance. Preparing such large training datasets can be expensive in practice. Thus, some augmentation techniques have been developed to increase the training dataset artificially. The potential impacts of using different data augmentation techniques on the final accuracy are not clear from the literature. However, they are believed to have a high potential as supportive techniques for improving the training performance of the CNNs. The data augmentation techniques used are also known as data distortion because they use specific deformations to multiply the volume of the training dataset artificially. Moreover, some deformations are more common such as rotation, randomly mirroring, translation the image and window shifting. All of these techniques may have particular pros and cons and have implemented to improve model performance.

In this study, we used the CNN model implemented in Trimble's eCognition software environment based on the Google TensorFlow library. We increased the spectral feature space to assist the learning procedure in our CNN workflow. The added spectral features were derived from the complexity reduction techniques. We compared the results with those achieved from using only the original spectral bands. Our study comprises the following main steps: (1) applying spectral complexity reduction techniques, including the minimum noise fraction transformation (MNF), the principal component analysis (PCA) and the independent component analysis (ICA); (2) training and testing the CNN model with the augmented data set and the original data; (3) using multiple parameters for assessing the relevance of the proposed strategy by comparing between with and without data augmentation.

The MNF transformation is a linear transformation method used for the reduction of spectral bands. The process of MNF transformation consists of two separate principal components analysis rotations; at first, the PCA is used to de-correlate and rescale the noise in the data, resulting in transformed data in which the noise has unit variance and no band-to-band correlations. The second rotation uses the PCA to derive components from the original image data after they have been noise-whitened by the first rotation. The result of an MNF transformation is a group of projected components based on their variance, where the first component contains the highest variation and, hence, has the highest information content. The information content decreases as the number of components increases. The second dimensionality reduction technique used in this study is ICA. It is an unsupervised feature extraction method and is applied to separate components, with the assumption that each band is a linear mixture of independent components. The main difference between the ICA transformation and the MNF transformation based dimensionality reduction techniques is that in the ICA transformation, the assumption of normal distribution is not necessary. We applied PCA, MNF, and ICA transformations on a WorldView-3 satellite image captured in 12th April 2015. A visual inspection of the dimensionality reduction results revealed that ICA is more supportive for data augmentation and dwelling annotation in combination with the CNN model.

The accuracy assessment on CNN approach was based on three kinds of classified objects, namely, true positive (TP), false positive (FP), and false negative (FN).

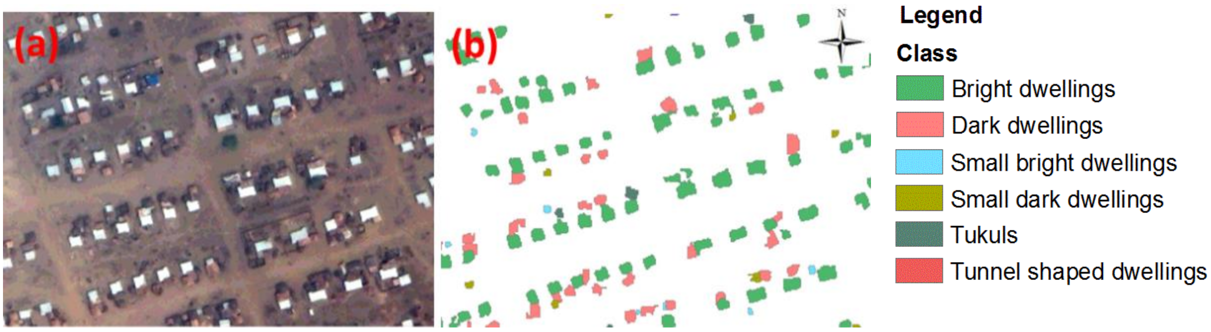


Figure 1. An illustration of a subset area from a) WorldView-3 satellite image, b) labels, c) false colour composite of first three-MNF components, d) false colour composite of first three-ICA components.

OBIA4RTM: Towards an Operational Tool for Object-Based Plant Parameter Retrieval from Sentinel-2 Imagery Using Radiative Transfer Modelling

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
lukas.graf@stud.sbg.ac.at

Lukas Graf[1], Levente Papp[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Object-based Image Analysis (OBIA); Plant parameter retrieval; Radiative Transfer Modelling (RTM)

Abstract

Plant physiological parameters provide valuable information required in a broad range of geo-scientific domains. Generally, these parameters are retrieved from optical satellite imagery using radiative transfer modelling (RTM). RTM establishes a physically or statistically based relationship between a set of predefined plant biophysical and biochemical parameters and a corresponding spectrum. To retrieve plant parameters from a given satellite spectrum an inversion strategy is used by either minimizing a cost function between simulated and observed spectra or by employing machine learning techniques. Machine learning approaches consist mainly of hybrid models where a regressor (e.g. neural network) is trained to reproduce the relationship between a set of plant parameters and corresponding spectra. However, most but not all the proposed plant parameter retrieval strategies are based upon per-pixel approaches. Only few studies included additional spatial constraints or object-based image analysis. Object-based image analysis (OBIA) has successfully demonstrated to overcome certain disadvantages of pixel-based approaches in a broad range of remote sensing applications by generating more tangible as well as tailored information. In the few studies available, the combined use of OBIA and RTM has revealed remarkable improvements in the quality of plant parameter retrieval. Furthermore, to the author's best knowledge no attempts for a combined OBIA-RTM approach in an operational context exist.

To overcome this gap, the OBIA4RTM tool is introduced. OBIA4RTM aims to bridge object-orientated concepts and pixel-based plant parameter retrieval using RTM. Therefore, a sophisticated workflow is established that makes use of existing open-source software tools and (spatial) databases as shown in Figure 1. Figure 1 illustrates the two pillars of the OBIA4RTM concept. The concept consists of the OBIA part to retrieve meaningful image objects and the RTM part to generate synthetic reference plant spectra. The focus is on Sentinel-2 imagery as this platform allows for plant parameter retrieval with reasonable high temporal and spectral resolution - an essential prerequisite in an operational context. In particular, Sentinel-2 imagery in L2 processing-level obtained from the freely available Sen2Cor tool-box could be divided into image regions by e.g. mean-shift segmentation or using existing cadastre data. We hereby acknowledge that the choice of traceable and temporally stable segmentation strategies is a crucial aspect that might require further research effort. The resulting image segments are assigned to land use classes by either applying a classification routine or by using Copernicus land monitoring data (OBIA part). Consequently, RTM parametrization per distinct land use classes present within a given imagery is performed. The translation from land use classes to sets of plant parameters is based on empirical data available from field campaigns (e.g. SPARC) and compilation of existing literature. Using

those parametrizations, the model is run in forward mode to generate synthetic plant spectra (RTM part). Both, the image object – characterized by its inherent spectral properties - as well as the simulated spectra are stored in a spatial database. Storing both parts in a database allows for memory and computational efficient storage and processing of data as well as fast mapping of plant parameter output by applying an inversion strategy – e.g. minimizing the root mean squared error between simulated and object-derived spectra - directly in the database. Using a spatial database also allows for integrating the proposed workflow into upcoming Big Earth Data processing workflows and infrastructures such as data cubes.

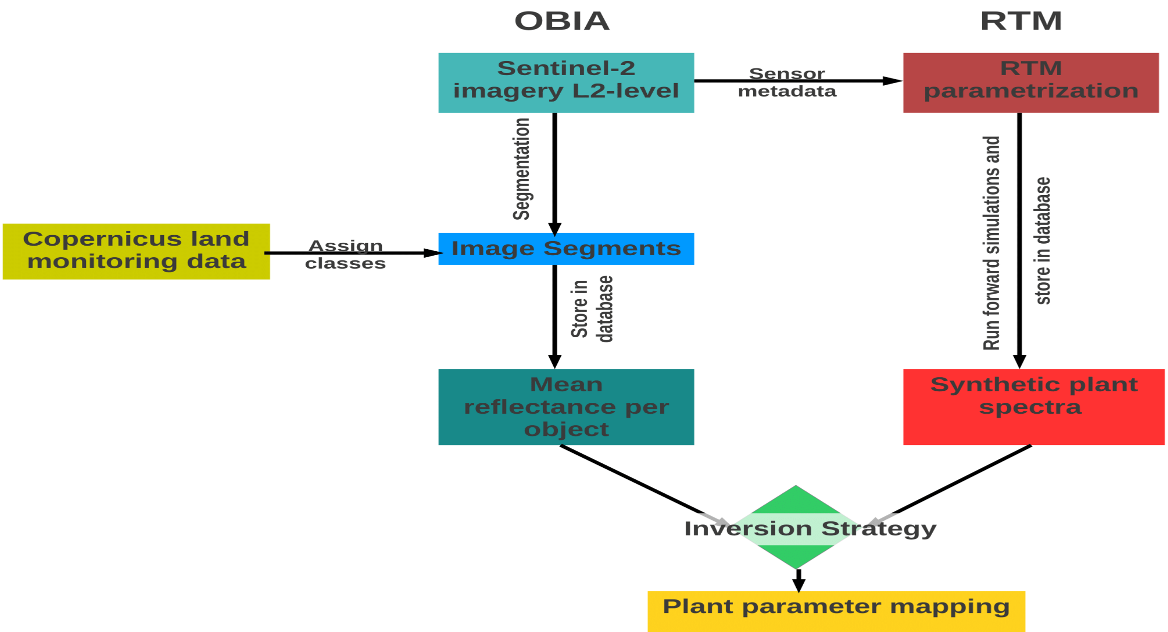


Figure 1. Workflow of the OBIA4RTM tool showing the main steps involved for object-based retrieval of plant parameters.

Educational Activities Under the CopHub.AC Project in Cyprus

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
d.hadjimitsis@cut.ac.cy

Diofantos G. Hadjimitsis[1], Georgia Kouta[1], Marios Tzouvaras[1], Christiana Papoutsa[1], Kyriacos Themistocleous[1], Stefan Lang[2], Marinos Papadopoulos[1]

[1]Department of Civil Engineering and Geomatics, School of Engineering and Technology, Cyprus University of Technology, Cyprus
[2]Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Copernicus, CopHub.AC, Educational activities, Cyprus, Schools

Abstract

The CopHub.AC project has received funding from the European Union's Horizon 2020 research and innovation program. The project's consortium consists of 12 Copernicus Academy members representing the academia, the industry and European associations from 8 countries, and is led by the Z_GIS – Paris-Lodron University Salzburg. The vision of the project is to establish a long-term Copernicus hub to consolidate and sustain the Copernicus Academy as a knowledge and innovation platform. It will focus and link ongoing Research & Development activities in Copernicus-relevant academic fields, and to sustain the innovation process from academia to businesses on the highest possible scientific and technical level, with a clear commitment to a full thematic and geographic coverage for a Europe-wide boost in space uptake.

During the two years of the CopHub.AC project's lifetime, several events will be organised by the project partners with the ultimate goal to promote Copernicus services, transfer knowledge and facilitate networking and synergies between Copernicus Academy and Copernicus Relays members. Eratosthenes Research Centre (ERC) at the Cyprus University of Technology is a partner of CopHub.AC project and responsible for the raising of awareness as a Copernicus Academy in Cyprus.

In the context of the project, ERC has created an elaborate educational programs initiative with a scope to educate young students on the benefits of the Copernicus Services and raise awareness on the programme. The initiative includes visits of ERC scholars to schools and delivery of information presentations in order to foster awareness and build a knowledge culture on remote sensing and Earth Observation. Another part of the educational activities of ERC includes organised school visits at the premises of the University where students get acquainted with the latest technology in remote sensing and Earth Observation. This creates a broader network of collaboration between Universities and secondary education and paves the way for the capitalization of knowledge in the near future.

Moreover, ERC is involved in developing publications and lectures, as well as educational material on Copernicus data and information exploitation drawing on case studies from its own projects on subjects like Cultural Heritage, Marine Spatial Planning and Atmospheric/Climate Studies.

Last but not least, as per the primary objectives of the CopHub.AC project, ERC has been instrumental in developing a robust synergic relation with a Copernicus Relays network here in Cyprus, as well as with other key stakeholders from the Government, the Industry and the Civil Society. Indeed, as a Copernicus Academy member, we encourage students during their first contact with research, science and technology and disseminate up to date Copernicus material translated in Greek. This will promote inter alia, the goals of CopHub.AC domestically and will contribute to raising awareness about Copernicus towards all potential user communities, therefore leading to the development of the ecosystem that the European Commission is building around space data and information.

Based on the schools' engagement, a structured questionnaire is developed and will be distributed during school visits to analyse the impact and the students' understanding regarding Copernicus services and earth observation. Evaluation indicators are also used to evaluate the impact that the events have. Some of them are: Number of participants; Number of use-cases presented; Number of promotional/communication material distributed; Number of Media and Social Media outreach channels.

Figure1. (a)Presentation of the CopHub.AC project to young students who visited the premises of the University in late January 2019 (b) School visit in Paphos, Cyprus in mid-January 2019

Sentinel-1 SAR Data for Agricultural Applications

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
heintz@cropix.ch

Dietrich Heintz[1], Luca Gatti[2]

[1] cropix, Switzerland
[2] sarmap, Switzerland

Keywords: Sentinel-1, SAR, Vegetation index, Precision farming, Crop insurance, Crop monitoring

Abstract

Sentinel-1 SAR satellites are specified as well for agricultural use. With a ground resolution of 20x20 m it is suitable to monitor cropland in areas, where the average plot size is above 2 ha. The temporal resolution of 6 days for Europa and 12 days for all other continents is suitable for a continuous monitoring. Since SAR data is independent from atmospheric disturbances it is ideal to build stable time-series for statistical analysis and for change detection e.g. after a hazard like drought, flood, frost, hail or storm. The granularity of Sentinel-1 SAR data is suitable to show the relative change in crop development and can help to pass management decisions on local, regional and national levels.

From the data of the two polarizations VV/VH we derive a vegetation index that we call ESVI (enhanced SAR vegetation index) It shows the temporal and spatial variability within a value range from 0-100 valid for all crops and seasons. This vegetation index can be seen as a proxy for fresh biomass since SAR sensors measure the structure and humidity of cropland. Beside other map products like change maps after an event or colour composites for visual monitoring, the ESVI enables us to visualize relative changes. For these map products we see three fields of interest in the agricultural industry.

Precision farming: Nowadays farms underly an increasing cost pressure, which can be approached rather with cost efficiency than with yield increase. Regulations like the amending fertilization law in Germany goes into the direction of sustainable agriculture. This includes as well site-specific applications where the technical development makes this possible. Nowadays agricultural machinery is enhanced with positioning devices and are capable for precision farming. This applies for site specific fertilization as well as for variable rate seeding. Increasingly as well for irrigation and for measures in plant protection. Concerning harvest big farms and contractors have logistical challenges, which can be supported with remote sensing data.

Crop insurance: Concerning crop insurance schemes loss assessments create huge costs, which have to be covered with the premium income. Due to cost pressure an intensive assessment is often impossible. The result of the ordinary assessment is normally not repeatable. This leads to customer dissatisfaction and often ends in an arbitration process, which raises additional costs. Satellite imagery will support by identifying zones of different impacts. Those zones can be assessed and the results will be extrapolated over different plots of the same crop-type. Satellite imagery will allow identifying winterkill before closing of subscription. Pre-damages and variations in growth dynamic can be identified by underwriters and farmers. SAR data is especially useful to identify frost, drought and flooding. Not always, but often hail-

and storm damages can be identified and zoned. SAR data will enable crop insurers to develop new index-based insurance products. With a combination of weather- and satellite data it is possible to define a benchmark from the weather station and from the satellite data spatially differentiate the damage extend and intensity. This will result in lower costs for the premium and reduce loss assessment costs drastically. Such schemes promise more transparency for the customers and repeatable results.

Crop monitoring: Where information is needed on a broader scale to observe the performance of cropland, remote sensing is the primary choice. Only remote sensing can acquire such information in nearly real time. Such information is important for early warning of national disasters and to plan appropriate measures in time, to keep the consequences for the public on a low level. That applies to any region in the world where national catastrophes often threaten many people.

Examples from Argentina: For a case study in Santa Fé Province we generated a time-series from Sentinel-1 SAR data. The overview map shows the area, where three farms are located, that participate in a field study. The ESVI shows the vegetation intensity reflecting fresh biomass. The legend indicates ESVI units, which range between 0-100. ESVI is derived from single date dual polarized SAR data and has to be calibrated regionally. After calibration the formula can be applied over the whole season and different years.

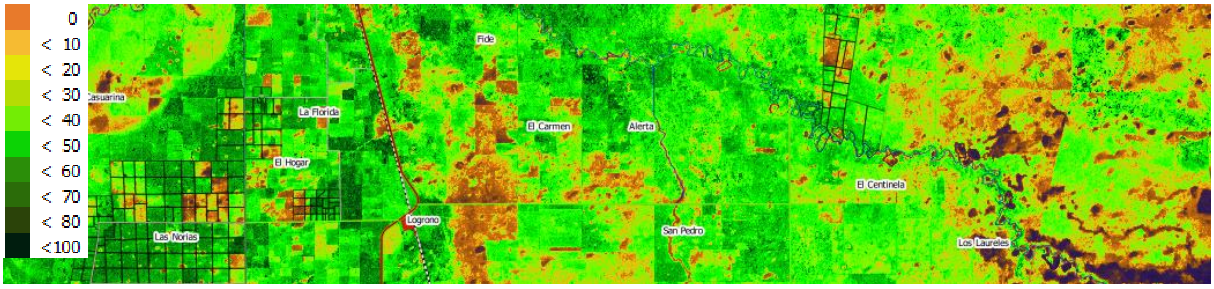


Figure 1. (a) ESVI (enhanced SAR vegetation index) derived from Sentinel-1 SAR data 2019-01-18

The flood map is derived from multi-temporal single polarized SAR data and indicates the evolution of the flood event. The legend indicates zones in different colours. The meaning of the colours corresponds to the duration of the flooding and reflects, if the particular site was flooded at one single acquisition or over the period of several acquisitions. Where the area was flooded for several acquisition dates, we can assume that crops were destroyed. This example demonstrates that stable and reliable time-series data is essential, where the evolution of a natural process needs to be analysed and finally displayed in a map.

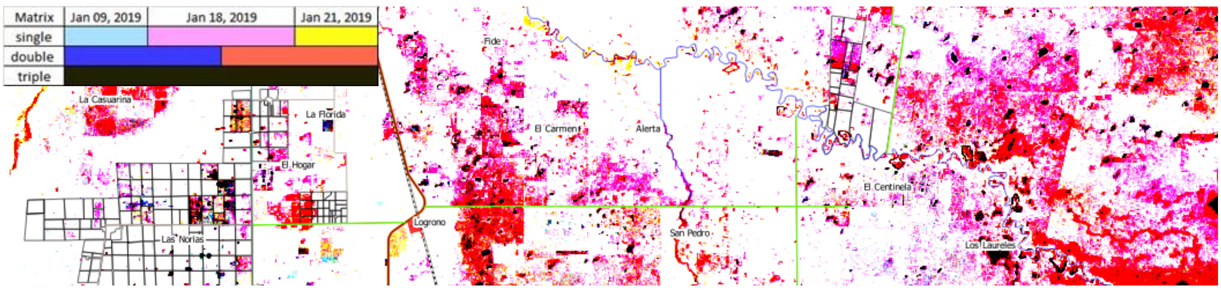


Figure 2. (b) Flood map derived from multi-temporal Sentinel-1 SAR data 2019-01-09, 2019-01-18, 2019-01-21

Research Advances in Digital Earth to Support Human and Environmental Security

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
mariohernandezvaldes@gmail.com

Mario Hernandez[1], Wang Changlin[1]

[1] International Society for Digital Earth (ISDE), hosted by the Chinese Academy of Sciences, Beijing, China

Keywords: Digital earth platform, UN Sustainable development goals, EO data

Abstract

The UN Agenda 2030 will require a full scientific interdisciplinary international and national effort. The data gathered by the different scientific experts will need to be integrated in order to make overall interdisciplinary assessments. A Digital Earth Platform will be required in order to store, access-retrieve, visualize and understand all this data. A big challenge is that the users are scientific experts, decision makers and the general public. This wide range of audiences poses new challenges as far how the final results should be presented.

The European Union Joint Research Center for Digital Earth defines: "*Digital Earth is a concept of an interactive digital replica of the entire planet that can facilitate a shared understanding of the multiple relationships between the physical and natural environments and society. To do so, it needs to be accessible globally from multiple platforms (mobiles, tablets, computers); be able to display information in ways that are easily understood by multiple audiences (the public, decision-makers, scientists); and be constantly updated with data coming from sensors (space-based, airborne, in-situ), citizens, and both public and private sectors*".

Such a Digital Earth platform must also be able to assess changes (from the past, to present and future) and thus include not just data but also the outcomes of models and simulations to enable a wider understanding of the consequences along the time of human action on the environment, and of environmental change on society.

We will require a Digital Platform or even better "Digital Platforms" interconnected. They must include information and services for citizens and business provided by national and local governments (e-government infrastructures, and more recently open data initiatives and portals), dedicated infrastructures for scientific information and data (research e-infrastructures), and the many platforms developed by the private sector to find and share information among the public at large, including social media.

The full concept of "Digital Earth" requires technologies, data, standards, interdisciplinary expertise and interdisciplinary knowledge that can transform data into information. EO derived products are without question a necessary set of datasets for Digital Earth. However EO data is not sufficient. Data from other scientific disciplines, in particular socio-economic data is mandatory. During the past few decades, technologies such as remote sensing, geographical information systems, and global positioning systems have transformed the way the distribution of human population is studied and modelled in space and time.

While assessments of land use change can be obtained (e.g. weekly) using satellite data at a 30m resolution, this is by far not the case for socio-economic changes. Current advances in EO data processing are enabling an improved assessment of human settlements location. However, the counting of individuals remains constrained by the logistics of censuses and surveys of the population.

Crucial to the success of the UN Sustainable Development Goals will be strong government statistical systems that can measure and incentivize progress across the goals. A Digital Earth platform will be require in order to manage this unprecedented rate of innovation in data collection techniques and technologies and the capacity to distribute data widely and freely. The adoption of the UN-SDGs presents a strategic opportunity to build on the momentum of the data revolution and demonstrate the centrality of data for development.

The paper presents the current discussions at the International Society for Digital Earth, the concept of the Digital Earth platform as oriented to support the UN Sustainable Development Goals. Special emphasis will be given to the important role of EO data. Main purpose is to encourage a discussion among EARSeL members in order to invite them to consider working jointly with other scientific disciplines as well as to consider how EARSeL could contribute towards Digital Earth.

Figure 1. "The Sustainable Development Goals, a reason to develop a Digital Earth platform". EO is an essential component of the "Digital Earth platform", however socio-economic data is also another essential component. The divide between EO data and Socio-economic data is tremendous, to be able to implement the UN SDGs we will need to reduce this gap.

Employing Copernicus Data and Time Series Analysis for the Identification and Promotion of Underutilised Lands for Bioenergy Production

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
manuela.hirschmugl@joanneum.at

Manuela Hirschmugl[1], Carina Sobe[1], Cosette Khawaja[2], Rainer Janssen[2], Dominik Rutz[2], Marie-Alice Budniok[3], Alfonso Calera[4], David Cifuentes[4], Marco Colangeli[5], Michela Morese[5], Mathias Schardt[1], Lorenzo Traverso[5]

1 Joanneum Research Forschungsgesellschaft mbH, Austria
2 WIP Renewable Energies, Germany
3 European Landowners' Organization, Belgium
4 Universidad de Castilla – La Mancha, Spain
5 Food and Agriculture Organization of the United Nations, Italy

Keywords: Copernicus, Time series, Bioenergy, Underutilized land

Abstract

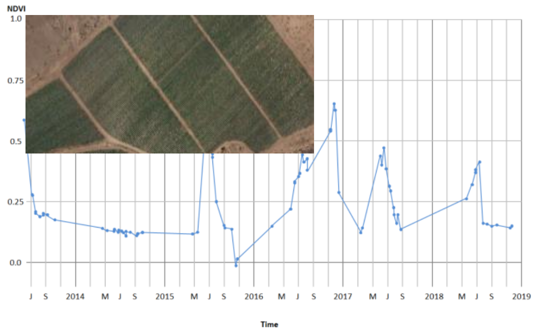
The overall objective of the BIOPLAT-EU project is to promote the market uptake of sustainable bioenergy in Europe using marginal, underutilised, and contaminated lands for non-food biomass production through the provision of a web-based platform that serves as a decision support tool. The Renewable Energy Directive (REDII) identifies six core areas of action among which key action number 5 is concerned with the strengthening of sustainability of bioenergy production and use in the EU. Marginal, Underutilised, and Contaminated lands (MUC) cannot be used for food/feed production or for recreational and conservation purposes, but in some cases, they still retain the potential to produce non-food biomass for bioenergy purposes. The results of previous EU-funded projects demonstrated the viability of using these lands in selected case study regions in the EU for sustainable bioenergy production. In order to expand the geographical outreach of the concept to all European and neighbouring countries, the project BIOPLAT-EU will produce a tool and a database that will be instrumental in assessing environmental, social as well as techno-economic sustainability on MUC lands through a web-based platform.

In this paper, a description of the work and the expected results of the project will be highlighted with a special focus on the GIS and remote sensing part. This part concerns mainly the generation of a database of maps of MUC lands in Europe, which will be created and generated based on high resolution spatial data. For this purpose, in the first step, all existing maps, specifically Copernicus high resolution layers (HRLs) are evaluated for their use to identify MUC lands. This data search led to four possible uses of existing data:

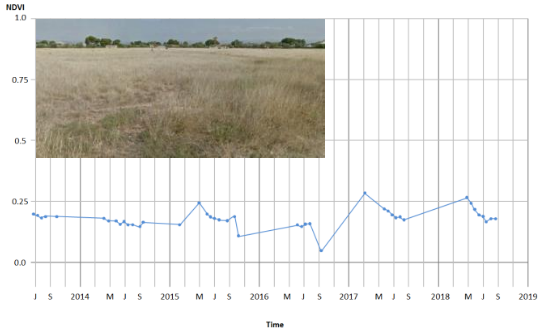
1) the direct use of areas, which are MUC lands (e.g. the map of contaminated lands generated by JRC or marginal lands as classified within the SEEMLA project);
2) the use of areas as training data for follow-up time series analysis (e.g. previous project results on specific areas or the LUCAS point data);
3) the use of areas, which are definitely not MUC lands (e.g. Natura2000 areas from EEA or settlement or forest areas from Copernicus HRLs) and

4) the use of land use and land cover information as explanatory features in the classification process for MUC lands (e.g. Corine land cover).

In addition to existing map data, an online data collection tool has been developed, which will be used to collect additional data. The European Land Owners' Organization is primarily collecting this kind of national and local data. While for "marginal" and "contaminated" lands, satellite data is not very well suitable, we thus have to rely on other data sources (Sallustio et al., 2018; Toth et al., 2015). However, "underutilized" land can be detected with time series analysis, if sufficient training data is available. The definition for "underutilized land" within BIOPLAT-EU is that of FAO: "land, that does not show signs of human interaction for the last five years". Employing time series data for the last five years, we see a clear difference in the temporal trajectory between used and underutilized grass- or cropland as was previously shown on MODIS data over Eastern Europe (Alcantara et al., 2013; Estel et al., 2015). In order to map also areas smaller than the MODIS pixel size, we employed Landsat8 data from 2013 – 2018. Due to the launch of the first Sentinel-2 only in 2015, we cannot solely rely on Sentinel to fulfil the definition given above. However, we intend to also include Sentinel data at a later stage. In this early stage of the project, currently first results are available for Spain. These initial comparisons in the time series show the difference of used (Fig. 1a) and underutilized lands (Fig. 1b). It is even visible in Fig. 1a, that the used land has been left to fallow during 2014. Using the standard deviation over time, we can well distinguish between used and underutilized areas. Clearly, this differentiation is easier in Spain than in other parts of Europe due to the water scarcity and the related larger difference in vegetation cover between the two classes. Further assessments and tests in other European ecoregions are currently ongoing.



(a)



(b)

Figure 1. NDVI Time Series for used (a) and underutilized land (b) for the last five years. Same areas shown in Google Earth (a) and Google Street View (b)

In parallel, a public user-friendly tool (STEN: Sustainability Tool for Europe and Neighbouring countries) is developed to assess the environmental, social and techno-economic sustainability aspects of scenarios and value chains with respect to specific economic and non-economic conditions for bioenergy production on MUC land. When linked with the GIS maps, the tool will allow any stakeholder to search for MUC lands in Europe at a sub-national level. It will give the user some specifications about these lands such as agronomic and climatic specifications and consequently what type of biomass can be planted on these lands. The tool will then allow assessing the environmental, social and techno-economic sustainability aspects of the defined value chain if the user enters the required data specified in the tool. By demonstrating the use of the tool on specific case studies, the BIOPLAT-EU project will have solid and practical material to be shared with the stakeholders during working groups and workshops to mobilise them and encourage them to start their own projects. Communication with local and regional authorities is an important activity within the project as it will help to remove legal or political market uptake barriers. This project has received funding from the European Union's H2020-LCE research and innovation programme.

Mini-MOOCS on Earth Observation - the Impartation of Remote Sensing in Schools in Times of Global Change

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
henryk.hodam@rub.de

Henryk Hodam[1], Carsten Jürgens[1], Claudia Lindner[1], Annette Ortwein[1], Johannes Schultz[1], Fabian Selg[1], Andreas Rienow[1]

[1] Ruhr-University Bochum, Department of Geomatics, Germany

Keywords: Education, MOOCs, Earth Observation, Schools, eLearning

Abstract

Educating the public about the benefits and potentials of remote sensing is of ever growing importance since few people know about the impacts this technology already has on their everyday lives and how it is going to change the way we see our planet as the amount and the quality of the data we collect from space increases. One of the many possibilities available to enhance the general knowledge of remote sensing principles is addressing the topic more frequently in schools. Remote sensing as an interdisciplinary field of application and research is predestined to be used in every STEM (Abbr. for Science, Technology, Engineering, Math) subject to teach pupils and teachers alike how environmental data is collected by satellites and how it is applied in addressing the world's most pressing problems like climate change as well as everyday tasks like weather reports.

Since there is no way around using computers in schools when it comes to working with digital images, one task of the "Remote Sensing in Schools" project is to facilitate the use of digital learning material by constantly looking for recent developments in eLearning. Massive Open Online Courses (MOOCs) are around for some years now and while not being quite the revolution that was announced they certainly enriched the eLearning landscape and proved digital videos to be an efficient way to reach a large audience. Because a school lessons cannot be compared with a massive open online environment, the MOOC concept as a whole does not seem to be applicable here at first glance.

To benefit from the opportunities of digital video content nevertheless, we reduced the course structure into a MiniMOOC and concentrated on short and appealing digital video material on remote sensing topics that are both useful as parts of a course and also as a single learning resource that can be used in different educational setups. This way not only school lessons can be enriched by a different approach on teaching, but basically every learning situation in which no prior knowledge of remote sensing can be expected may profit from didactically well-structured and visual appealing digital learning material.

This increasingly gains important since the Copernicus program makes satellite data and software freely available for users that so far ruled out the use of satellite data for cost reasons, and are now in need of accessible entry level information. Open archives and the free software SNAP are provided by ESA in that regard. Therefore, the Mini-MOOCs of FIS-III (German Abbr. of "Remote Sensing in Schools") shall make use of Sentinel satellite data as much as possible. Albeit the videos are primarily targeting German schools, an English translation is already under way.

The submission shows the underlying concept of modularity comprising non-proprietary technologies and a platform independency. The topics and structure in terms of media, technique, text, interdisciplinarity, and sustainability will be demonstrated and crucial parts of the production process will be explained. Furthermore, it will be shown how the contents are used and implemented in different learning environments and situations. The overarching umbrella 'global change' provides the possibility to address curricula topics, integrate natural science and humanities point of view, and allow for the integration of a broad spectrum of topics which can be taught based on remote sensing digital imagery processing. In doing so, the presented MOOCs are open for addressing the Copernicus services in terms of capacity building in the sectors of spatial planning and ecosystem analysis.

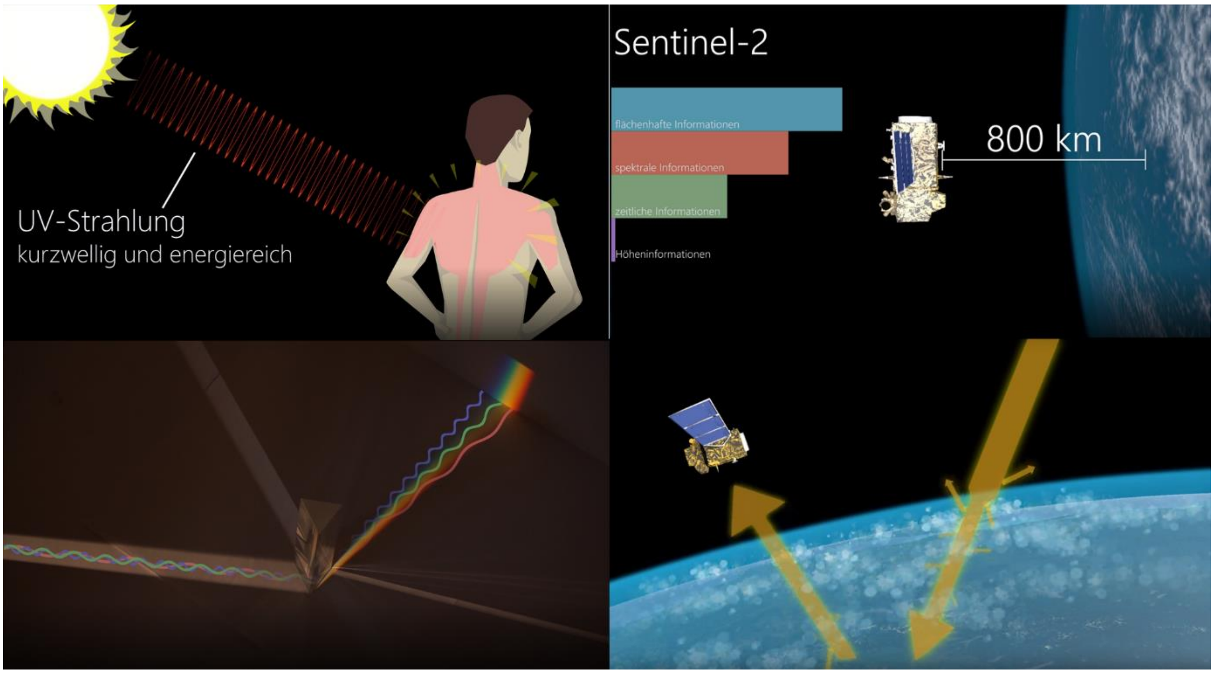


Figure 1. Screenshots of learning videos on earth observation and the basics of the electromagnetic spectrum

Mapping Burned Area with Harmonic Model Using Time Series Sentinel-2 Imagery in Conifer Forests of Sweden

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
xikun@kth.se

Xikun Hu[1], Puzhao Zhang[1], Andrea Nascetti[1], Yifang Ban[1]

[1]Division of Geoinformatics, KTH Royal Institute of Technology, Stockholm, Sweden

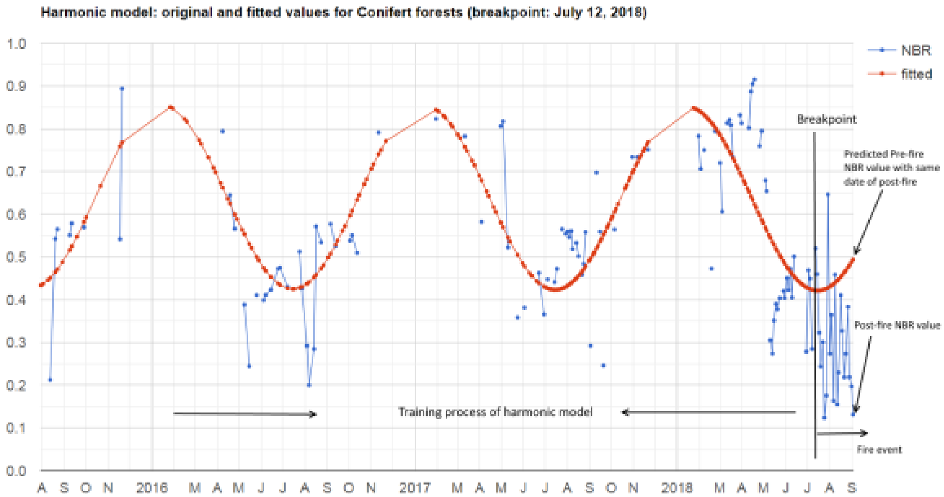
Keywords: Burned area, Sentinel-2 time series, Harmonic model, Conifer forests

Abstract

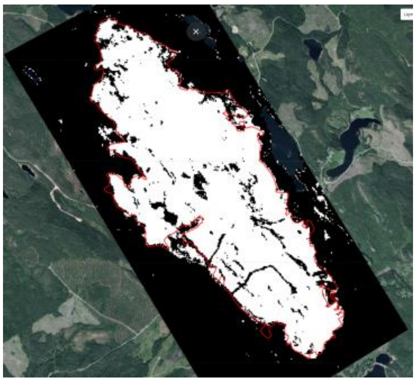
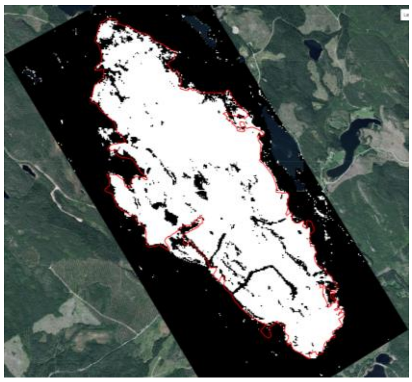
Warm and dry weather caused quick-moving forest fires across Sweden in the summer of 2018. Remote sensing tools have proven useful to accurately estimate fire-affected area. Timely burned area mapping is also essential in post-fire management. In Sweden, different from the California wildfires always with cloudless sky across the shrub and grass area, continuous cloudy weather above the conifer forests in Sweden during the wildfire events makes the useful data acquisition process difficult. Normalized Burn ratio difference (dNBR) has been widely used to asses landscape-scale post-fire effects through detecting the change between pre-fire images. But the well-timed acquisition of pre-fire image is still a challenging task. If the cloudless image of two month ago or even longer is chosen as the pre-fire image, natural biomass change and seasonal effects during this interval period will contaminate the dNBR performance. In this case, predicting a suitable pre-fire image based on the mathematical harmonic model would be a possible solution.

The abstract assesses spatio-temporal harmonic patterns of biomass change and burned of Brattsjo and Trangslet forest fires in Sweden, which occurred during the July of 2018, from a time series of all available history Sentinel-2 MSI images over three years based on Google Earth Engine. The abstract provides a novel way to predict the pre-fire image on the same day of post-fire acquisition to minimize the systematically seasonal change as Figure 1 (a) showed. At present the main issue is to remove the side effects of deforestation during the time series before the fire, which will be clustered into burned area.

Secondly, a new thresholding method is proposed to classify the burned and unburned area based on the pixel-wise standard derivation (STD) map of dense time series. Preliminarily, the STD shows the high potential to replace the manually dNBR thresholding operation with the similar accuracy as Figure 1 (b) and (c) illustrated. For the Brattsjo wildfire all covered by conifer forests, the kappa coefficient (overall accuracy) of manual thresholding and STD-based method are 0.87 (93%) and 0.88 (94%), respectively. Regarding the Trangslet wildfire with two-third conifer forests, the kappa coefficient (overall accuracy) of manual thresholding and STD-based method are 0.86 (93%) and 0.85 (93%), respectively.



(a)

(b) (c)

Figure 1. (a) The blue points are NBR values in the baseline period (training process) and fire event period, the red curve is the harmonic model fitted in the baseline period and predicted in monitoring period (after fire event) with the random 20 pixel-wise samples of conifer forests land type in Trangslet wildfire area; (b) the burned area detection result using dNBR manual thresholding corresponding to the Brattsjo wildfire (threshold: 0.15); (c) the burned area detection result using STD-based method corresponding to the Brattsjo wildfire (magnification of STD: 0.8)

openEO – an API for Standardised Access to Big Earth Observation Data in a Landscape of a Growing Number of EO Cloud Providers.

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
alexander.jacob@eurac.edu

Alexander Jacob[1], Edzer Pebesma[2], Markus Neteler[3], Wolfgang Wagner[4], Jan Verbesselt[5], Matthias Mohr[2], Jeroen Dries[6], Roberto Monsorno[1], Prateek Budhwar[1], Christian Briese[7], Luca Foresta[7], Matthias Schramm[4], Miha Kadunc[8], Pieter Kempeneers[9], Noel Gorelick[10]

[1] Eurac Research, Italy
[2] University of Münster, Germany
[3] Mundialis GmbH and Co. KG, Germany
[4] Vienna University of Technology (TU Wien), Austria
[5] Wageningen University and Research, Netherlands
[6] VITO, Belgium
[7] EODC GmbH, Austria
[8] Sinergise, Slovenia
[9] JRC, Italy
[10] Google Switzerland GmbH, Switzerland

Keywords: API, Big data, Online processing, Open source, Interoperability

Abstract

With the opening of global archives of Earth Observation data streams from satellites we have arrived at a richness of operationally available observations over the whole globe, starting from the Landsat series of satellites and now the plethora of available data coming through Copernicus and its series of Sentinel satellites, that has never been available before. This created huge opportunities for research and businesses, being able to exploit the temporal domain of those observations in a powerful manner, but also poses challenges in terms of data management and processing capacities. As a consequence, a growing number of cloud services and customized solutions in various research centres have been developed, leading to processing workflows optimized for specific system architectures and back-end infrastructures. As such this is limiting portability and reproducibility of workflows across back-ends, both for science and business applications.

OpenEO, a Horizon 2020 project (grant 776242), addresses this problem by defining an API between service provider back-ends and client applications. This API can be seen as a common language that defines interfaces for finding, accessing, processing and retrieving data, and only requires that a back-end architecture specific driver and corresponding client libraries are used when defining the workflows. The project however does not stop at simply defining an API, but also provides implementations for a number of different back-end solutions, ranging from a file-based storage system with processes running in individual containers, over data cubes exposed via OGC web services to GRASS GIS, the Google Earth Engine and the Sentinel-hub. On the client side, libraries are developed in python, R and javascript, leaving space to develop applications based on Earth Observations with very different requirements, from web visualization to extensive time series analysis in a research setting. In addition to a large set of simple processes, user-defined functions allow users to submit more complicated processes as python or R code, e.g. for dedicated time series models, to be run on the imagery data.

All drivers both on client and back-end site are developed as open source software and can be found on the project's Github group (https://github.com/Open-EO). This enables everybody to peek into the available implementations and develop own adaptations based on what is needed for specific back-end solutions. There is also no limitation to define new client libraries in other languages or develop plugins for common software such as QGIS or the Sentinel Toolboxes. A proof of concept showing the successful interaction and processing of different clients and back-ends has been published (http://openeo.org/openeo/news/2018/03/17/poc.html).

During the EARSeL Symposium, details about the concept and the current status of the development will be presented, together with examples from use cases implemented with openEO.

openEO API provides definitions for data discovery, processing and especially chaining of defined processes integrated with user defined functions, data and result access via download and for commercial implementations a framework for managing user content and billing.

openEO's API development and the definition of supported core processes is driven be the expertise of the project consortium members and a set of use cases comprising typical analytical challenges for environmental monitoring based on earth observation data. A hackathon event and user workshop added additional feedback to that. Further such events are planned also for later this year.

Currently the version 0.4 has been released providing a first attempt of defining core processes and back-end. Developers are working on the implementation of this core functionality, following the latest spec. Data discovery has been closely linked to other emerging standards like the spatial temporal asset catalogue STAC (https://github.com/radiantearth/stac-spec) and the web feature service in it's latest development version 3.0 (WFS 3.0 - https://github.com/opengeospatial/WFS_FES).

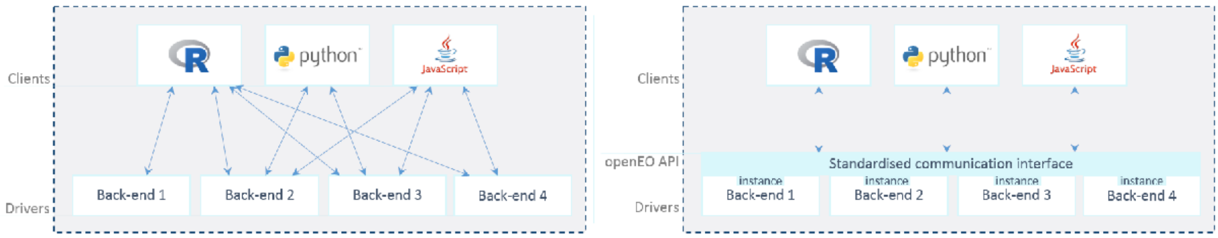


Figure 1. Communication between clients and back-end drivers. Left: common many–to–many communication; Right: many–to–one communication, using the openEO API.

Height Models Based on CORONA Images

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
Jacobsen@ipi.uni-hannover.de

Karsten Jacobsen [1], Rolf Rüdiger Ludwig[2]

[1] Leibniz University Hannover, Germany
[2] Federal Institute for Geosciences and Natural Resources (BGR), Germany

Keywords: CORONA, Height model, Earth observation

Abstract

Bangladesh has a sustaining very high urbanization rate. For example the population of Dhaka expanded 35 times since 1975. In growing amount developing areas arise in marsh lands on few meter high artificial sand deposits to minimize the danger of flooding. Indications of former waters and depressions are covered. Due to the often flooding the water courses changed their location strongly. For city planning these former locations are important to reduce required building foundation and construction cost. Old aerial images and height models are not available, so the use of CORONA images from April 1972 is a solution. Some CORONA KH-4B stereo pairs are covering the area of a Bangladesh-German technical cooperation. The US CORONA images from the beginning of the satellite technology are inexpensive and a frequent used information. Not only active watercourses which can be identified in CORONA images, also former watercourses which only can be identified in a digital surface model (DSM) are important.

The available CORONA KH-4B stereo pairs, taken in April 1972, are from the two panoramic cameras in the satellite having a 30° angle of convergence. Their field of view is 5.1° in flight direction and 70° across. The original analog film of 6cm x 85cm is distributed as scanned version in four overlapping parts with 7µm pixel size. For the image orientation and the generation of height models the four image parts of any full image have been transformed together by tie points due to independent scan of the four image parts. Publications about stereoscopic use of CORONA images are usually limited to the handling of single image parts, so the bending of the long film format could be covered by the orientation. The image deformation was also caused by the location of the film on a cylinder during imaging. The images at the side have strip marks which can be used for determination of the bending which has a size up to 0.7mm. The bending of the backward image is opposite to the forward view, changing the x-parallax by the sum of both image deformations.

In addition to this correction a transformation of the panoramic images to perspective geometry is required, to simplify the further processing. The imaging by the rotating optics takes approximately 1.2 seconds. The influence of the imaging over approximately 8.3km satellite movement in the orbit is nearly compensated by a gimble, used also for the forward motion compensation. Nevertheless the comparison of the generated CORONA DSM with the free ALOS World 3D DSM (AW3D30) shows a periodic height deformation (figure 1). This can be explained by a not perfect gimble rotation or by a satellite scintillation which we partially have also for modern satellites also as e.g. by WorldView-2 after fast rotation. This effect was compensated by a rough fit to the AW3D30 (figure 2). Commercial orientation programs do not have such correction possibilities, requiring own software development.

Depending upon the distance from the image center, the ground sampling distance (GSD) has a size between 1.8m and 2.1m. Together with the base to height relation b/h = 1:1.9 at least a relative standard deviation of the height of 3.4m can be reached. This is satisfying for the identification of watercourses in the generated height models as visible in figure 3. The root mean square difference between the fitted CORONA DSM and the AW3D30 is in the range of 5m with a relative accuracy of nearly neighbored points of 3.5m. This is also strongly influenced by the accuracy of the AW3D30 and the today quite higher amount of trees.

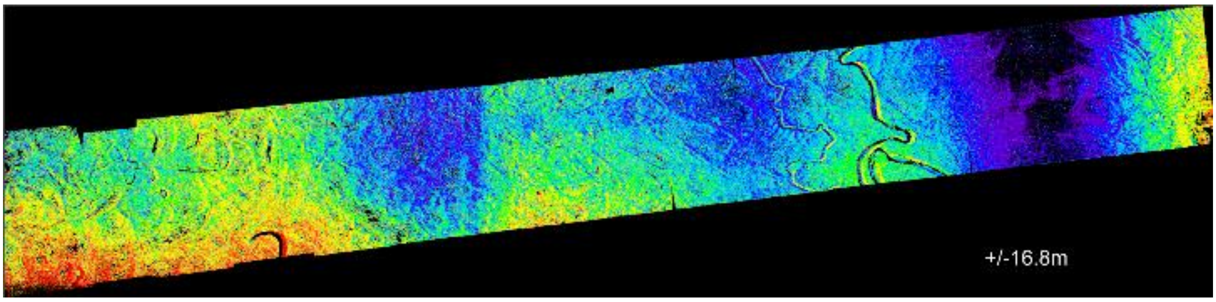


Figure 1. Colour coded height differences CORONA DSM – AW3D30

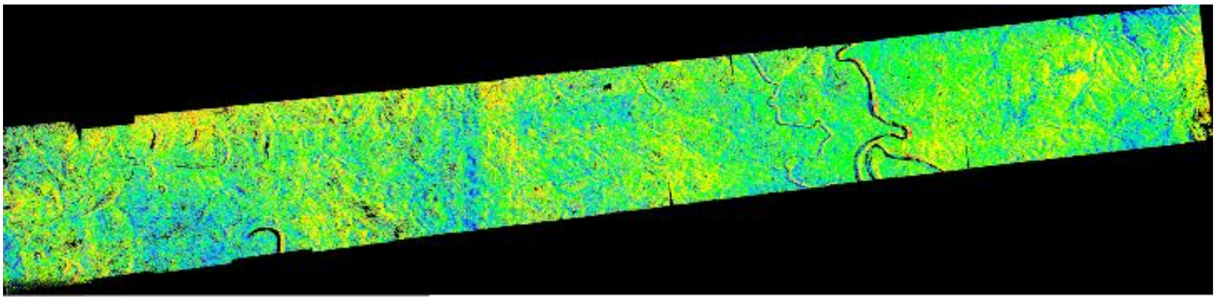


Figure 2. Color coded height differences improved CORONA DSM – AW3D30 with same colour scale as figure 2

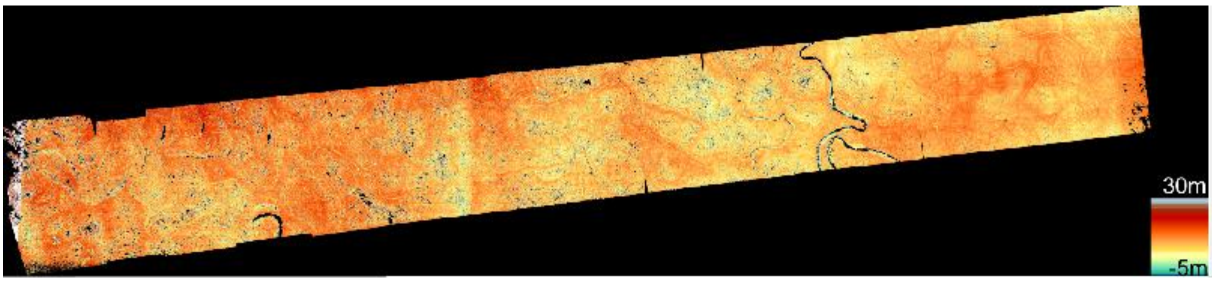


Figure 3. 50% of CORONA DSM

Using UAV Spectral Vegetation Indices for Estimation and Mapping of Biophysical Variables in Winter Wheat

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
GJelev@space.bas.bg

Georgi Jelev[1], Petar Dimitrov[1], Ilina Kamenova[1], Iliana Ilieva[1], Eugenia Roumenina[1], Lachezar Filchev[1], Alexander Gikov[1], Martin Banov[2], Veneta Krasteva[2], Viktor Kolchakov[2], Milena Kercheva[2], Emil Dimitrov[2], Nevena Miteva[2]

[1] Space Research and Technology Institute – Bulgarian Academy of Sciences, Department of Remote sensing and GIS, Bulgaria
[2] Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Poushkarov", Bulgaria

Keywords: Unmanned aerial vehicle, Red-edge band, Regression models

Abstract

In the recent years, data obtained by Unmanned Aerial Vehicles (UAV) are intensively tested for operational applications in agriculture. Advantages of UAV, such as flexibility of image acquisition and high spatial resolution, are particularly important in precision agriculture where timely, within-field crop characterisation is desired. In particular, the on-demand very high resolution (VHR) data from satellite sensors may not suits the farmer needs in terms of exact time of acquisition because the needs of many users must be balanced during the acquisition plan preparation. Moreover, few VHR satellite sensors with red edge band are available (e.g. WorldView-2 and -3). UAV may be easily customised by mounting a camera with the needed spectral bands. As with the other types of remote sensing images, however, an information extraction strategy is needed to derive quantitative parameters of the imaged crop.

In this study a *senseFly eBee Ag* drone with multispectral camera *Sequoia* was tested for estimation and mapping of dry Above Ground Biomass (AGBd), fresh Above Ground Biomass (AGBf), Nitrogen content (N), Nitrogen uptake (Nup), Canopy Chlorophyll Content (CCC), Leaf Area Index (LAI), fraction of Absorbed Photosynthetically Active Radiation (fAPAR), and fraction of vegetation Cover (fCover). The *Sequoia* multispectral camera acquire images in four spectral bands: green (550 nm), red (660 nm), red edge (735 nm), and NIR (790 nm).

A simple information extraction strategy was adopted based on spectral Vegetation Indices (VIs) and regression analysis. The ground data used for regression models calibration and validation were collected from winter wheat fields (*Annapurna* variety) located near the town of *Knezha*, north-western Bulgaria. Four field campaigns were carried out during the 2016/2017 growing season: November 2016, March 2017, April 2017, and May 2017. The 2016/2017 data (n=48) were used for model calibration and for leave-one-out cross-validation. In addition, data from April 2018 (n=15) were available for independent validation. Simultaneous with the ground measurement aerial images were acquired by the SUAV. The prediction capability of each VI was assessed based on the Root Mean Square Error (RMSE). Based on simple linear regression and the lowest cross-validation RMSE, the best VI was selected for each biophysical variable. For AGBf, N uptake, LAI, fAPAR and fCover the best performing index was reNDVI (red-edge Normalised Difference Vegetation Index = (NIR-red edge)/(NIR+red edge)). For AGBd and CCC the best index was CIre (Chlorophyll Index red edge = (NIR/red edge)-1). Both, reNDVI and

CIre use the red edge band in their formulae. The nitrogen content was most strongly correlated with DVI (Difference Vegetation Index = NIR-red). The corresponding models had the following relative RMSEs (the RMSEs from the independent validation are shown in parentheses): AGBf: 21% (20%); AGBd: 21% (42%); N: 32% (40%); N uptake: 49% (37%); CCC: 30% (33%); LAI: 29% (29%); fAPAR: 13% (23%); and fCover: 16% (28%). The best performing regression models (RMSE ≤ 21%) are those for AGBf, AGBd, fAPAR, and fCover. Exponential regression models were also examined but, in general, they did not improve the estimation accuracy.

Note that when some of the models are applied to the independent dataset from April 2018 the errors are higher than those obtained by the cross-validation procedure. This emphasises the fact that multi-year datasets with higher number of observations are highly desirable and would permit better model calibration by accounting for between-season variability. At the other hand, even with the small dataset used in this study it was possible to develop quite stable models for AGBf and LAI. Figure 1 shows an example of high resolution (~30 cm) AGBf map derived by the empirical equation. It illustrates that Test Unit 1 is characterised with higher AGBf values. The same situation was observed in the field. The difference is due to the fact that the crop in Test Unit 1 has higher density and height and is more homogeneous. It also is characterised with more intensive tillering and more advanced development phase compared with the other two Test Units.

In conclusion, the regression method seems promising for deriving biophysical variables of winter wheat from UAV multispectral images, in particular, when data in the red edge band is available. This potential should be further evaluated with the ultimate goal of providing operational methods for quantitative crop characterisation by UAV data in precision agriculture.

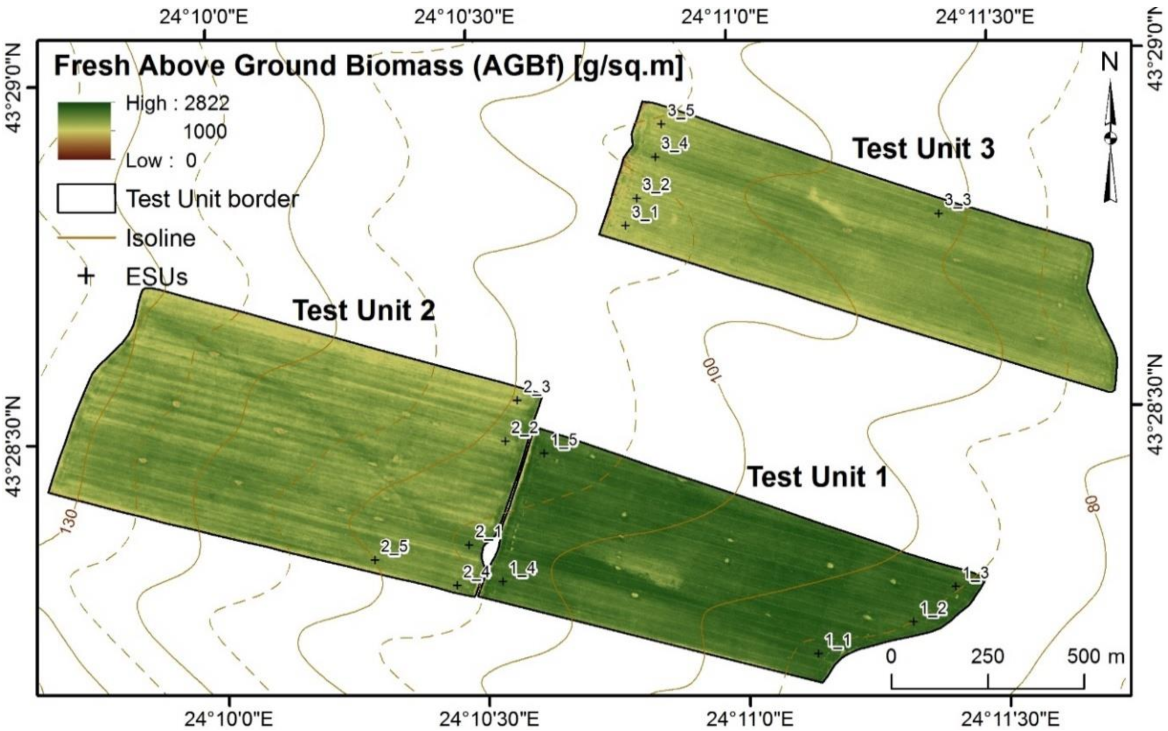


Figure 1. Map of above ground biomass (fresh weight) derived from SUAV data acquired during the April 2018 field campaign. The location of the Elementary Sampling Units (ESUs) where ground data was collected is also shown.

Automation Opportunities of EO Tasks for Humanitarian Purposes

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
petermichael.jeremias@sbg.ac.at

Peter Michael Jeremias[1], Stefan Lang[1], Dirk Tiede[1], Gina Maricela Schwendemann[1], Petra Füreder[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Earth observation, Humanitarian action, Python, GDAL, ArcGIS generic toolbox;

Abstract

Time and precision are two major criteria in utilizing Earth observation for humanitarian aid. A fast analysis with high quality results can be a lifesaving factor in emergency situations. The analysis of satellite images for humanitarian purposes is a key service, which is provided by the Department of Geoinformatics - Z_GIS at the University of Salzburg, supported by its spin-off company Spatial Services GmbH, for different NGOs working in this field. In a well-established partnership with Doctors Without Borders (MSF - Médecins Sans Frontières), up to date imagery is analysed and information for different purposes is provided. Besides image pre-processing, damage assessments, environmental analyses and groundwater resource monitoring, the most commonly requested analysis refers to population estimation in refugee/IDP (internally displaced people) camps and informal settlements. Thereby single dwellings are automatically extracted from VHR imagery using, a.o. object-based image analysis (OBIA), followed by manual refinement, to provide indicators for population estimations. In 2018, 79 requests of this type were handled by the operational component of this information service. Depending on the size of the camp or settlement, the number of extracted dwellings varies from a few hundreds to over one-hundred thousand. Besides the creation of automated algorithms and heuristics for information extraction, the automation of certain analysis steps with a high degree of redundancy in manual activities can considerably reduce the overall production time to provide fast, reliable and consistent information. Our current work investigates how critical elements of this workflow can be supported by the automated routines. The workflow (Figure 1) reveals numerous repetitive tasks, which are needed for every analysis. Satellite imagery with a reasonable quality regarding cloud cover and suitable spatial detail has to be searched, purchased and pre-processed. This includes pre-processing for subsequent analysis, tiled imagery preparation for the NGOs and the creation of purpose specific metadata. The availability of recent images has to be documented to facilitate the work for infield analysts of NGOs. Extracted settlements are analysed regarding type and number for spatio-temporal analysis. With the implementation of script based processes and tools, manually conducted procedures are taken over in a standardized way with consistent results. The provision of analysis-ready data follows standardized workflows (including calibration, ortho-rectification, pan-sharpening, metadata documentation), with slight variations depending on sensor type and data provider. Automation scripts (usually Python scripts in conjunction with GIS software and standalone Python scripts) are written based on common libraries, suitable for analysis processes in the spatial context, for example GDAL. Graphical user interfaces are used to ease the use in an automated workflow. This helps to run all pre-processing tasks without further action (see Figure 1) not requiring further programming skills and deeper knowledge of the specific tool's syntax. Continuous monitoring tasks can be accomplished without

periodical reminders to feed databases and servers manually. Scheduled calls of preliminarily implemented script are used to process footprints of the satellite data acquired and update their availability for the NGOs as a web feature service. Infield experts in emergency areas do not necessarily require a powerful network connection or the required device performance to access satellite images with high resolution due to the file sizes. Automatic image tile creation can help to reduce the data load for quicker and easier access of the required data to the partners in the field. This and further processes are implemented to enforce the degree of automation of repetitive and standardized tasks. Using this approach, GIS analyses for humanitarian purposes can be fulfilled with a reduced risk of manual work-based errors and inconsistencies, as well as reducing the processing times, which may lead to a faster response of NGOs to infield challenges.

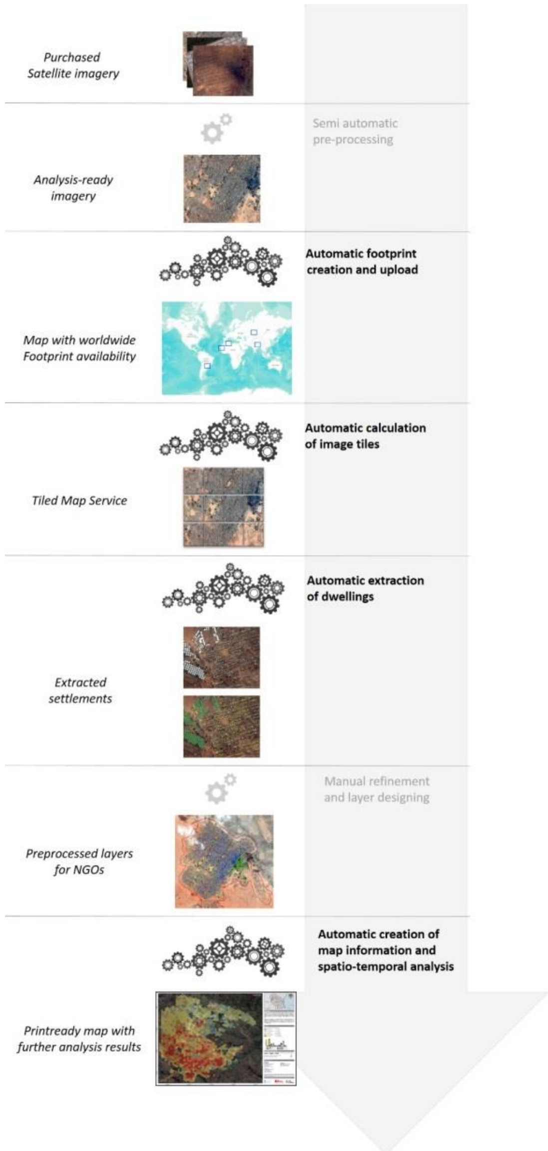


Figure 1. Request handling workflow, showing the manual, semi-automatic and automated tasks

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
ilina.kamenova@space.bas.bg

Evaluation of Sentinel-2 Vegetation Indices for Prediction of Biophysical Variables of Winter Wheat in Bulgaria

Ilina Kamenova[1], Petar Dimitrov[1]

[1] Space Research and Technology Institute at Bulgarian Academy of Sciences, Department of Remote sensing and GIS

Keywords: Sentinel-2, Winter wheat, Vegetation indices, In situ data, Biophysical variables

Abstract

For this study, in situ data for biophysical variables of winter wheat are available from test fields in a study area near Knezha, Bulgaria. The study area is located ca. 100 km northeast of Sofia in the Danubian plain. Six field campaigns were conducted in the framework of the project "Testing Sentinel-2 vegetation indices for the assessment of the state of winter crops in Bulgaria". Four of the field campaigns were conducted in 2016-2017 growing season and two in 2017-2018 growing season. Different biophysical and biochemical variables of winter wheat were sampled; in this study, we used data for LAI, fAPAR and fCover only.

During both seasons, three of the test fields were sown with winter wheat *Enola* variety and three fields were sown with winter wheat *Annapurna* variety. The plot size was approximately 20 by 20 meters. AccuPAR LP80 was used for measuring LAI, fAPAR and fCover in three subplots placed on the plot's diagonal. The final value at plot level was the average of the three subplots. In addition, field spectrometry measurements were made using ASD FieldSpec spectroradiometer on the same subplots. The ASD spectroradiometer provides spectral data in 2151 channels from 350 to 2500 nm. For four of the field campaigns, cloud free Sentinel-2 images were available. They were acquired on 31 Oct. 2016, 19 Apr. 2017, 31 Oct. 2017, and 30 Mar. 2018. The dates of the image acquisitions depart from the field campaigns are in-between 3 and 11 days. Atmospheric correction was applied using Sen2Cor module within Sentinel Application Platform (SNAP). The Sentinel-2 reflectance values were extracted from the pixel with the closest centroid to the plot centre. Part of the spectral bands of Sentinel-2 used in this study have 20 m resolution. Resampling of these bands to 10 m was not considered, because it was preferred to retain the original spectral information. For two of the field campaigns, no cloud free images were available and the field spectrometric measurements were used to simulate reflectance in the Sentinel-2 spectral bands. The weighted averages of the ASD measurements within the Sentinel-2 bandwidth intervals were calculated with the spectral responses of Sentinel-2 MultiSpectral Instrument (MSI) used as weights. Forty vegetation indices (VI) were calculated using Sentinel-2 bands with 10 m and 20 m resolution. The vegetation indices were selected based on a literature review. Special emphasis was placed on the VIs that used bands from the red edge spectral region. Also, three soil adjusted VIs were calculated, Perpendicular Vegetation Index, Transformed Soil Adjusted Vegetation index, and Soil Adjusted Vegetation index 2 (SAVI2). The soil lines were derived empirically using manually selected pixels with bare soil or crop residue land cover.

We used two approaches to compare the potential of different VIs for prediction of biophysical variables. First, the association of each biophysical parameter with each VI was visually assessed using

scatterplots. The second, quantitative approach was based on the regression analysis. All VIs were systematically evaluated by fitting linear and exponential models with each biophysical variable being dependant variable. The Root Mean Square Error (RMSE) was calculated for each model using the leave-one-out method. The RMSE was a criterion for the performance of the VIs. The regression analysis showed that the best linear models for LAI are those with either of the following VIs: SR3 (Simple Ratio 3 = B07/B06), CIg8 (Chlorophyll Index green 8 = (B08 / B03) – 1), CIg7 (Chlorophyll Index green 7 = (B07 / B03) – 1), or CIre8A (Chlorophyll Index red edge 8A = (B08A / B05) – 1). These indices perform very similarly yielding RMSE between 1.00 and 1.04 m^2 m^{-2}. Clear non-linear relation exists between many of the VIs and LAI. The exponential models with gNDVI (green Normalized Difference Vegetation Index = (B08 – B03) / (B08 + B03)), GIPVI (Green Infrared Percentage Vegetation Index = B08/ (B08 + B03)) and NDRE1 (Normalized Difference Red Edge 1 = (B07 – B05) / (B07 + B05)) have RMSE between 1.02 and 1.04 m^2 m^{-2}, which is comparable with that of the best linear models. The scatterplots suggest that, for fAPAR and fCover, a linear model may be appropriate when the explanatory variable is either SR4 (Simple Ratio 4 = B07 / B05), CIre7 (Chlorophyll Index red edge 7 = (B07 / B05) – 1), CIre8A, CIg7 or CIg8, in all cases resulting in a RMSE of 0.10 (for fAPAR) and 0.12 (for fCover). However, exponential models with gNDVI, NDRE1, and GIPVI achieve lowest errors; the RMSE is 0.08 for fAPAR and 0.11 for fCover whichever of these three VIs is used.

Based on the above comparison we selected SR3 and a linear model as the best option for LAI prediction and gNDVI and an exponential model as the best option for prediction of fAPAR and fCover with the Sentinel-2 data. The regression models are depicted in Figure 1. Note that the LAI regression chart shows higher deviations with increasing LAI. In this dataset this appears to be related with some winter wheat variety effects. In particular, the points with highest deviation from the regression line (those outside the 95% prediction interval shown in brown) are from plots with *Enola* variety. Differences in canopy's structural and spectral characteristics between the two winter wheat varieties may play a role here. Such differences would be more prominent at higher LAI. This may indicate the need for separate regression model for each variety. More data is, needed to verify this assumption. The fAPAR and fCover relations, shown in Figure 1, experience saturation at higher values. This suggests that predictions may be more inaccurate with the advance of the growing season. In general, however, this study shows that at least several VIs calculated from Sentinel-2 bands (B03, B05-08 in particular) have a good potential for predicting LAI, fAPAR, and fCover in winter wheat.

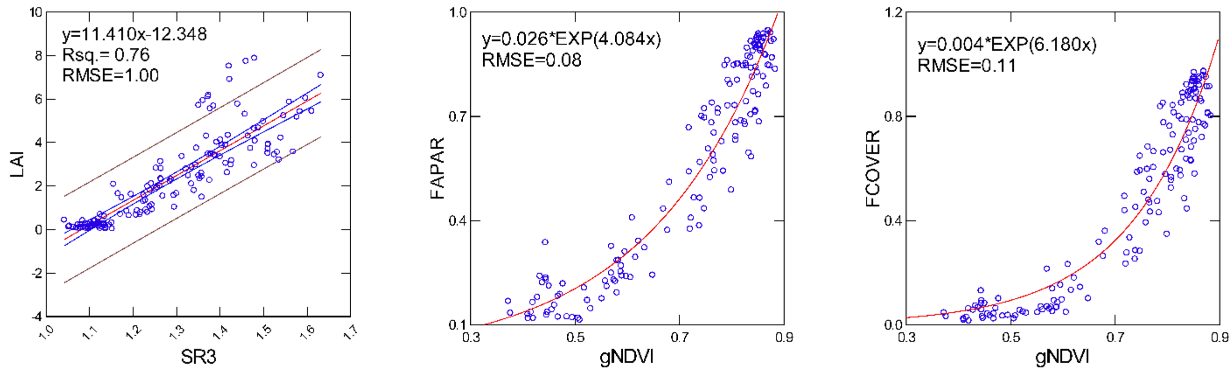


Figure 1. Regression models of LAI, fAPAR and fCover with selected VIs from Sentinel-2

Exploring the Spatial and Seasonal Distributions of the European Vegetation Growth Limiting Factors with Earth Observation Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
karnieli@bgu.ac.il

Arnon Karnieli[1], Noa Ohana-Levi[1], Micha Silver[1], Tarin Paz-Kagan[2], Natalya Panov[1], Dani Varghese[1], Nektarios Chrysoulakis[3], Carl Beierkuhnlein[4], Antonello Provenzale[5]

[1] The Remote Sensing Laboratory, Institutes for Desert Research, Ben Gurion University, Israel
[2] Agriculture Research Organization, Volcani Institute, Israel
[3] Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology - Hellas (FORTH), Heraklion, Greece
[4] Department of Biogeography University of Bayreuth, Germany
[5] Department of Earth System Sciences and Environmental Technologies, National Research Council, Italy

Keywords: MODIS, LST, NDVI, Pan-European biomes, Boosted regression trees

Abstract

In terrestrial ecosystems, vegetation growth limiting factors are thresholds that confine biological response to appropriate environmental conditions. Among others, energy and water limiting factors are well recognized as the primary factors. Respectively, air temperature and precipitation can be measured on the ground and interpolated to larger scales. However, earth observation datasets of biophysical satellite-derived products, such as Land Surface Temperature (LST) and the Normalized Difference Vegetation Index (NDVI), enable the modelling and prediction of productivity and community composition with the ability to cover large areas worldwide. It has been established that LST successfully mimics air temperatures and NDVI can represent water availability variation. The overarching goal of the current project is threefold: (1) to demonstrate the spatial distribution of LST-NDVI relations as indicators for vegetation growth (energy and water) limiting factors on a Pan-European scale; (2) to explore the relative contribution of climatic and environmental variables on the LST-NDVI relations; and (3) to relate the LST-NDVI relations to the European biomes by mapping regions of significantly positive and significantly negative LST-NDVI correlation. LST-NDVI relationships for assessing water vs. energy limiting factors, can be computed from several space systems such as the NOAA-AVHRR, MODIS, and Sentinel-3.

The current project is based on long-term (2000-2017) MODIS data of LST and NDVI. The study is focused on the growing season (March-August), and subdivided into two seasons March-May and June-August to explore the seasonality changes in the LST-NDVI relations and their consequences.

Main results reveal that the LST-NDVI relations change in space in time over the European domain (Figure 1). For the entire growing season (March-August), the northern biomes have significant positive correlations, and only the Mediterranean forests, woodlands, and scrubs, as well as the Desert and xeric shrublands, have significant negative correlations. During the beginning of the growing season, March-May, all the biomes show significant positive correlations, but at the mid-growing season (June-August) the correlations of most of them turned to significant positive except the Tundra and Boreal forests/taiga that keep significant positive correlations. During this season, large areas are characterized by non-significant correlations. Boosted Regression Trees (BRT) analysis shows that three climatic and

environmental variables mainly contribute to the variation of the LST-NDVI relation. These are solar radiation, water vapour pressure, and distance from the ocean.

The main conclusion of the study is that LST and NDVI relations can be used to map the spatial and seasonal variabilities of the main vegetation growth limiting factors, i.e., energy and water, over the European domain. These limiting factors determine the distribution of the different biomes over Europe.

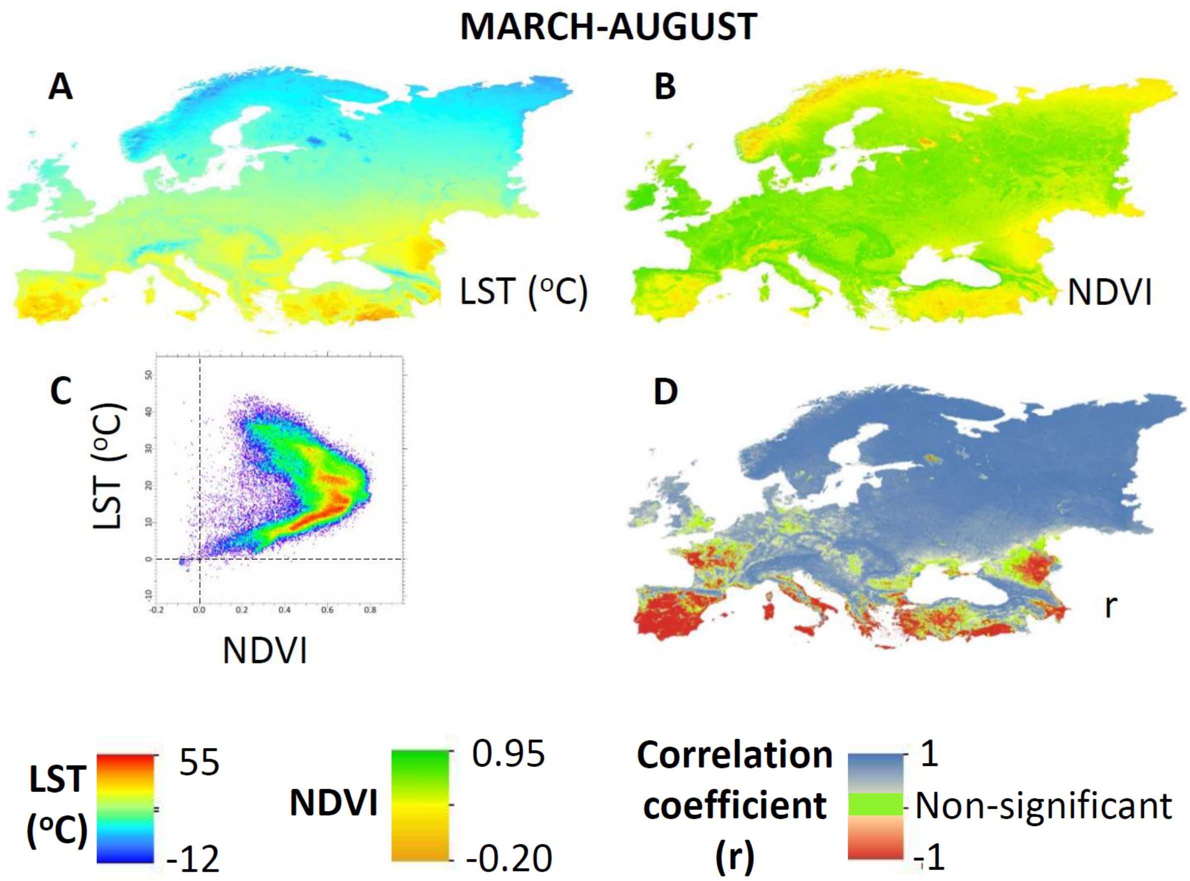


Figure 1. (A) average land surface temperature (LST) during March-August; (B) average normalized difference vegetation index (NDVI) for March-August; (C) LST-NDVI scatterplots for March-August; (D) correlation coefficients map for LST and NDVI.

CopHub.AC Citizen App - The Window to Copernicus Knowledge & Innovation

EARSeL 2019
Digital I Earth I Observation
Corresponding Author:
markus.kerschbaumer@spatial-services.com

Markus Kerschbaumer[1], Peter Zeil[2], Kerstin Kulessa[3], Peter Baumann[4], Diana Vaiciute[5], Martynas Bucas[6], Valerio Tramutoli[7], Monica Miguel-Lago[8], Giorgio Saio[9], Christoph Schröder[10]

[1-3]Spatial Services GmbH
[4]rasdaman GmbH
[5,6]Klaipeda University
[7]Università degli Studi della Basilicata
[8]European Association of Remote Sensing Companies
[9]Geographical Information Systems International Group
[10]University of Málaga

Keywords: CopHub.AC App, Copernicus, Application, Sentinel, Satellite data, Participation

Abstract

The Copernicus application and web service will provide information about the Copernicus Academy to interested people. 'All you need to know' about the Copernicus Ecosystem will be available on 'your' device anytime. The user will be able to see who the network partners are and what they can provide (gateway, knowledge landscape).

The focus of the CopHub.AC Citizen App is to spread information about Copernicus and the Copernicus Academy. Beyond this rather "dry" information, some playful and interactive ways are needed to gain the interest of the users. To this end, an interactive web map will show the broad public which information is freely available and therefore creates interest for the Copernicus services. Like Google Maps, different layers will be able to show the current state of the users surrounding environment, which is located by the persons device using GPS (Galileo). The information provided, will consist of different Copernicus Service information layers such as temperature, soil moisture, air quality, aso. The displayed layers are implemented as a WMS. For the first prototype, two layers of common interest will be implemented to show what the application can achieve.

The information layers are provided through the Copernicus Services (www.copernicus.eu) by using the fleet of Sentinel satellites, contributing missions, dedicated sensor-webs and in-situ observations. Europe and partly global-wide information consisting of surface, atmosphere, and marine parameters of e.g. water bodies (lakes and wide rivers), soil moisture or different land cover types (cropland, grassland, forest, built-up areas, transport network, etc.) can be shown to the interested users. These information layers shall attract interest to the Copernicus Services and the facility of the Copernicus Academy with the objective to stimulate awareness of free and open information available of the user's surroundings.

The users can communicate questions about layer information by indicating their position directly on the map. Copernicus Academy members of the dedicated thematic working groups will then answer these questions visible to everyone. As an easy alternative, a moderated forum could be used; however, this option would have the disadvantage of losing the explicit location of participants.

The CopHub.AC Citizen App is not targeting to a specific user segment - everyone who is interested in earth observations should be able to use the website and application. Although for design purpose, pupils and students in the age range of 15 to 25 years are presently used. The objective is to keep the website and application short, simple and entertaining.The focus will be state-of-the-art progressive web apps, which combine features offered by most modern browsers with the benefits of a mobile experience. Advantages of this approach are that only the website is coded and it will appear to the user as traditional applications or native mobile application for Android and iOS – thus there is no need to design web services for three different platforms.

There are many other possibilities that can be implemented with this application. For example a time sequence of each layer can be built up that demonstrates the changes of the different information layers. This will help to show the public different outlooks and the continuity of information services. Another idea is to use the information provided in those layers to calculate different scenarios using indicators. These raster calculations can be carried out for different circumstances, which will (1) bring more information to the users and (2) provide insights and understanding of earth related science.

Figure 1. Mockup of the future CopHub.AC Citizen Smartphone application

Effect of Distance from Hot Spots on the Relationship of LST with Enhanced Vegetation Index and Road Density

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
khandusa@rediffmail.com

Sumit Khandelwal[1], Rohit Goyal[2], Nivedita Kaul[1]

[1]Associate Professor, Department of Civil Engineering , MNIT JAIPUR, India
[2]Professor, Department of Civil Engineering, MNIT JAIPUR, India

Keywords: Land surface temperature, Road density, Hot Spots

Abstract

Urbanization causes conversion of natural surface into built-up surface which has significant impacts on local environment (both local weather and climate) including increase in local temperatures. This leads to a warmer thermal climate compared to surrounding non-urbanized areas and this phenomenon is referred as Urban Heat Island (UHI).

The UHI effect is not restricted to large metropolitan areas only and has even been detected in cities with populations less than 10,000. Major effects of UHI include increase in energy demand and reduction in air quality levels. Land surface temperature (LST) of Earth's surface has been shown to be affected by vegetation, land-use, land-cover, percentage impervious surface area (%ISA), normalized difference built-up index (NDBI), road density (RD), elevation, soil moisture etc. UHI intensity over a city depends on city size.

The aim of the present study is to analyse the relationship of different parameters with LST for different regions of a city. 8 day LST and 16 day enhanced vegetation index (EVI) images of MODIS Aqua for five years have been utilized with digitized road density (RD) map. All LST images have been aggregated using UHIindex and pixels corresponding to consistent high temperatures have been analysed to identify centroid of hot spots (HS) for Jaipur city, India. Three boundaries at distance of 7, 14 and 21 km from HS have been marked. LST-EVI and LST-RD relationships have been investigated for regions falling within these boundaries. Coefficient of correlation of mean LST-EVI relationship varies between 0.91 to 0.94 for different regions while it varies between 0.80 to 0.88 for mean LST-RD relationship. The governing equations for all the relationships are different which indicate varying effect of different parameters on LST depending on distance from HS. This varying relationship can be utilized in developing master plan of a city to mitigate/minimize the UHI effect.

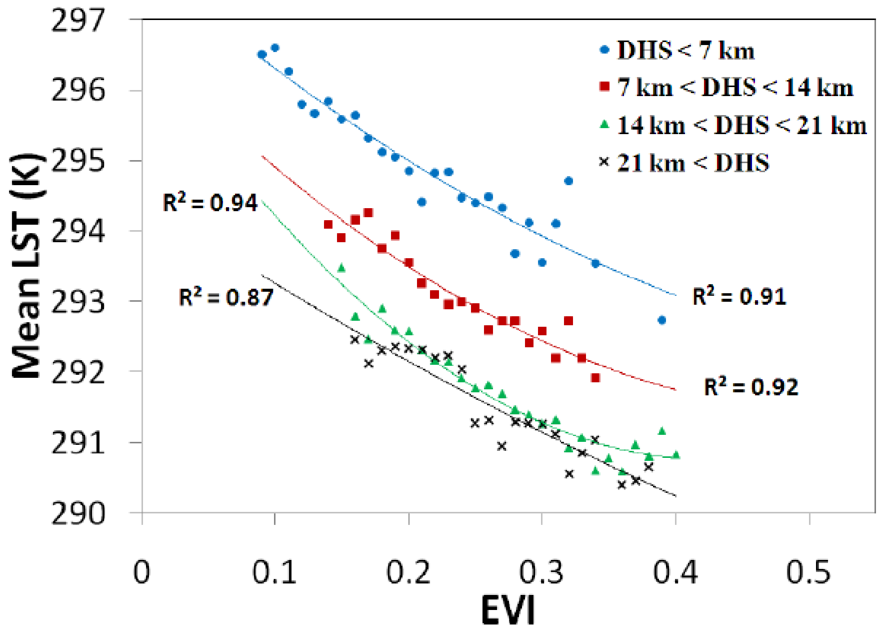


Figure 1. Mean LST and EVI relationship for different regions formed on the basis of distance from hot spots (DHS)

Multi-Sensor Remote Sensing Data Fusion and Machine Learning for Regional Scale Mountain Permafrost Distribution Modelling

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
simonkoenig@uni-bonn.de

Simon König[1]

[1] University of Bonn, Department of Geography, Germany

Keywords: Mountain permafrost, Environmental modelling, Data fusion, Machine learning

Abstract

Permafrost, i.e. ground with a temperature remaining at or below 0 °C for at least two consecutive years, is an integral part of alpine environments with a high hydrological and hazard-related relevance. Mountain permafrost existence and properties are influenced by a large number of environmental variables, distinguishable into different levels. This includes macroclimatic conditions such as latitude and large-scale wind patterns as a first grade, modified by the complex topography of mountainous terrain on a second level, where e.g. altitude and aspect modulate temperatures and energy input by radiation. Thirdly, local ground properties such as lithology or hydrology again alter these topoclimatic conditions. Some influences – e.g. snow cover – even span all three levels, and all of them interact with each other and result in a complex, nonlinear system. This results in large temperature distances over short distances and a very heterogeneous distribution of permafrost in areas of high mountains. Permafrost is facing degradation in the light of accelerated climate change in alpine regions, resulting in increasing frequencies of mass movements at different magnitudes, which endanger infrastructure and human security especially in densely populated mountains like the European Alps. Besides, as a thermal phenomenon mountain permafrost is not directly visible, and during summer its surficial layers thaw and form the *active layer* which is not automatically identifiable as permafrost. Direct measurements typically require drilling and hence are time- and cost-expensive.

All these properties – spatial heterogeneity, hazard potential and elaborate recognition of mountain permafrost, document the relevance of modelling its distribution. A number of approaches to this task exist, from simple, evidence-based thresholds to advanced energy flux models. Most models rely on empirical-statistical relationships between areas of known permafrost existence and various explanatory variables. This study is based on the same idea and models mountain permafrost abundance for the *Hohe Tauern National Park* in central Austria. Past models mainly focussed on using digital elevation models for deriving parameters like altitude, aspect and slope. They scarcely used remote sensing imagery however, especially in the optical domain, and hence we aim at integrating more earth observation products into the modelling process. Our goal is to identify if the integration of remote sensing-based explanatory variables improves model accuracy, and which parameters are most suitable in this context.

Imagery from different sources is used, including Sentinel-1 and -2 as well as Landsat-8. While an airborne laser altimetry digital elevation model provides morphometrical parameters, these spaceborne sensors implement estimations of other environmental variables' yearly development. The complete archives of Landsat-8 and Sentinel-2 are exploited and a radiometrically as well as spatially consistent dataset of both is created. This includes quality flags like cloud cover and poor illumination conditions.

From this dataset, multispectral indices are derived, including the *Normalized Difference Vegetation Index* (NDVI) and the *Normalized Difference Snow Index* (NDSI). The resulting NDMI/NDSI time series for every pixel are then aggregated to statistical derivatives such as mean, maximum and minimum in order to create raster layers that can serve as model input. Likewise, a series of Sentinel-1 images provides backscatter-based estimations of snow cover development.

A published inventory of rock glaciers, i.e. ice-containing forms of debris that creep downslope is used as evidence of permafrost presence and absence. Intact rock glaciers are commonly used indicators of permafrost presence, while relict specimen not containing any ice represent its absence. According to their activity status, they are used as a binary response variable and all other parameters are extracted for the respective rock glacier polygons. The resulting dataset is binarily split into training and test data. For the modelling itself, different statistical and machine learning approaches are applied individually, and their results compared. This includes logistic regression, random forest regression as well as support vector machines. Ultimately, the accuracy of these approaches' output is assessed by calculating the root mean squared error of the predictions if compared to the assumed binary values of the rock glacier inventory.

The study results in different maps of the likelihood of permafrost abundance with a spatial resolution of 10 m. The synergetic use of digital elevation information plus spaceborne remote sensing imagery achieves high accuracies, especially when used with machine learning techniques: random forest regression for example is highly capable of correctly predicting the occurrence of both active and relict rock glaciers (Figure 1). The use of both morphometric and remote sensing parameters increases model accuracy if compared to using both individually. Ultimately, the integration of additional remote sensing imagery into mountain permafrost models produces promising results thus to be further elaborated and used in continuous monitoring of permafrost conditions.

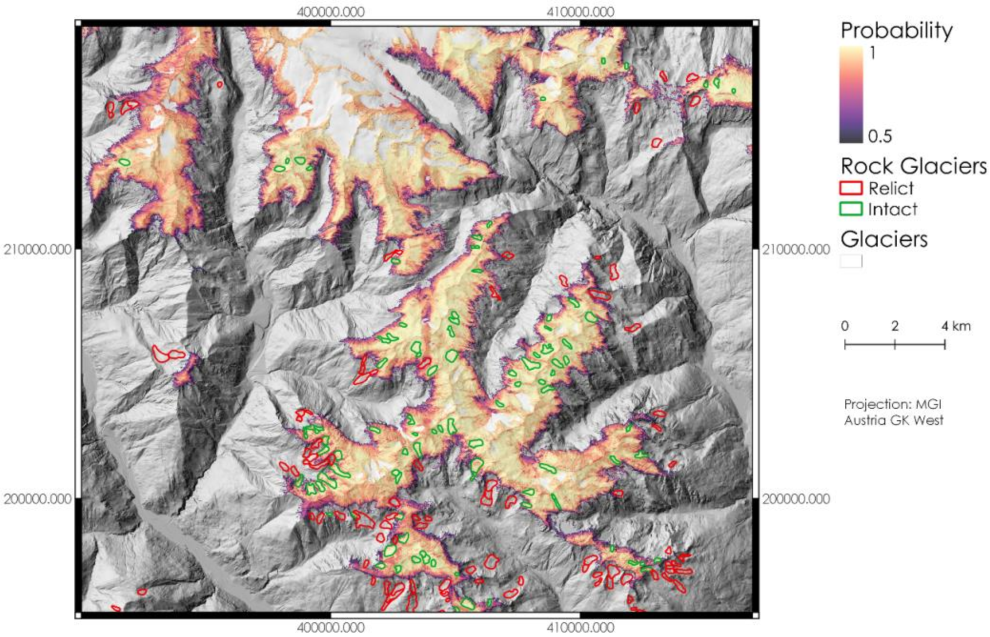


Figure 1. Example of the results. Permafrost abundance probability for the *Schober mountain group* in the southern part of the park as well as parts of the *Glockner mountain group* in the park's centre. This map is based on random forest regression and using both morphometric and remotely sensed parameters. Intact rock glaciers are almost exclusively located in areas likely to be underlain by permafrost, where relict specimens are mostly located outside.

Forest Mask Delineation Using Sentinel-1 Synthetic Aperture Radar for Forest Wind-Throw Assessment

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
stuart.krause@thuenen.de

Stuart Krause[1,2,3], Jan-Peter Mund[2], Tanja GM Sanders[1]

[1] Thünen Institute of Forest Ecosystems, Germany
[2] Eberswalde University for Sustainable Development, Germany
[3] University of Bonn, Department of Geography, Germany

Keywords: SAR, Storm damage, Sentinel-1, Forest mask

Abstract

In the last two years (2017-2018) storms caused severe damage to forests in Germany. According to projections from Swiss Re, such trends are likely to increase in magnitude in the future. The rapid assessment of affected forest directly after a storm is essential for sustainable forest management as well as the appraisal for financial compensation from governmental agencies or insurance companies.

Already well established in Europe, the use of publicly available multispectral remote sensing platforms such as Landsat and Sentinel-2, allow for the acquisition of imagery at high temporal resolutions for the purpose of quantifying changes in forest cover. Multispectral Satellite imagery however, is subjected to cloud cover which can be particularly problematic in regions with continuous cloud cover and publicly available datasets are limited to a spatial resolution of 10 m pixel size (Sentinel-2). Active remote sensing platforms such as Sentinel-1 Synthetic Aperture Radar (SAR), have a high potential for forest change detection and are not inhibited by cloud cover while providing data of the earth's surface in a rapid and cost-effective manner. Since 2014, SAR (Sentinel-1) coverage for Germany is available with both VV and VH polarizations at a revisit time of up to 3 days and even less when images from different orbits and scanning directions are implemented. Such high temporal and spatial resolution datasets can aid in detecting even the slightest variations in forest cover which could otherwise be difficult to be detected due to the presence of leaves and needles still intact on fallen trees.

With the analysis of statistical differences (e.g. minimum, maximum, average and standard deviation) in C-Band SAR backscatter intensity, variations in land cover, in particular forest cover over particular time periods were classified. In order to enable a reliable classification of forest cover change the forested area itself was required to be delineated to remove all non-forested areas which otherwise complicated classification procedures. The integration of for example the Corine Land Cover as a forest mask for wind-throw detection applications was found to be too coarse as finer variations in forest edges could be overlooked (see Figure 1) and out of date. It is expected that an up-to-date high resolution forest mask will improve classification procedures for the purpose of wind-thrown forested areas.

In this study, Sentinel-1 SAR data is implemented for the creation of a forest mask of the Barnim, Brandenburg region in north-east Germany. The statistical analysis of C-Band SAR backscatter is implemented to detect forest edges and delineate forest area. A 5-year old Light Detection and Ranging (LiDAR) dataset (12 pt/m^2) as well as RTK GNSS and UAV-based ground truthing were used to validate the SAR-derived forest mask. RTK GNSS in situ measurements as well as UAV-based

photogrammetric products provided reliable forest boundaries in selected areas however would be impractical for the validation of a forest mask at the regional level. The LiDAR-based forest mask created by means of thresholding of the Canopy Height Model, showed probably the most reliable results as a validation method, however recent selective harvesting procedures could not be accounted for due to an outdated dataset. Results show a strong correlation between the SAR-derived forest mask and the reference LiDAR-derived forest mask in terms of the validation of forest edges however smaller (< 1 ha) non-forested areas were more challenging to validate.

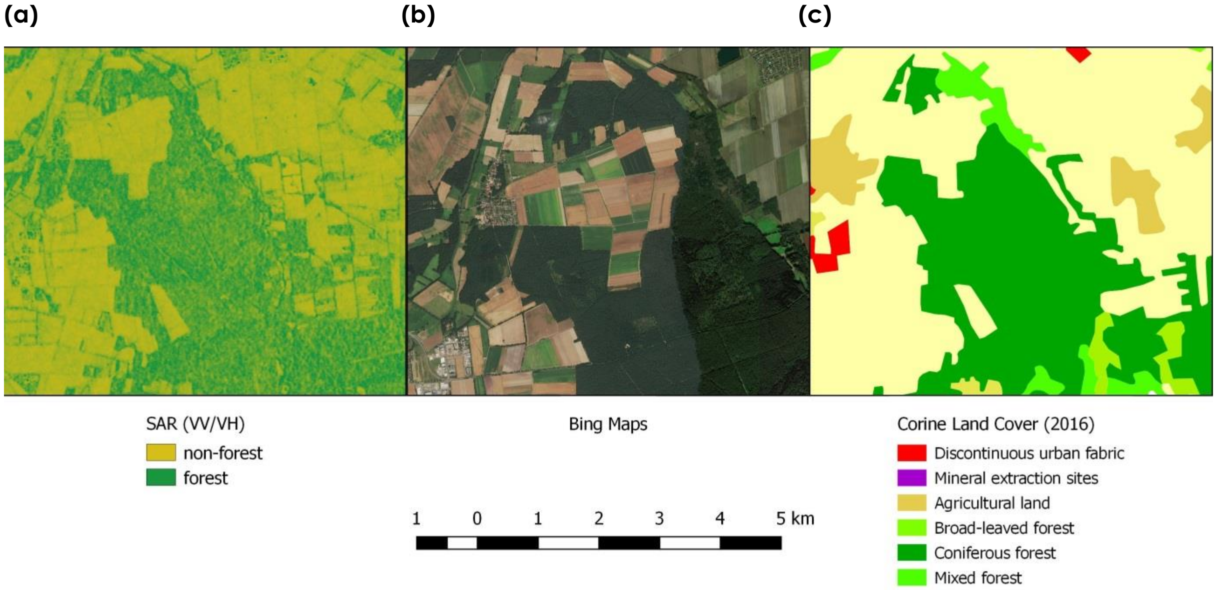


Figure 1. (a) Forest mask created with the statistical minimum of Sentinel-1 C-Band SAR backscatter using both VV and VH polarizations (b) Bing Maps imagery for referencing (c) Coarse forest cover of 2016 Corrine Land Cover

The Potential of Remote Sensing to Estimate the Population of Invisible Spaces in Support of the SDG Slum Indicator

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author: m.kuffer@utwente.nl

Monika Kuffer[1], Claudio Persello[1], Karin Pfeffer[1], Richard Sliuzas[1], Vinodkumar Rao[2]

[1] University ITC, University of Twente, Enschede, The Netherlands
[2] SPARC - (SDI affiliate), Mumbai, India

Keywords: SDG indicator, Slums, informal settlement, Deprived areas, Population estimation, Dasymetric modelling

Abstract

According to UN-Habitat, around one billion people live in slums. This figure is reported for the SDG indicator 11.1.1, on the proportion of urban population living in slums, informal settlements or inadequate housing, here termed population living in deprived areas. However, this number comes with many uncertainties. For several countries, estimates are not available, while for other countries reported data do not accurately reflect the population living in deprived areas. The few existing independent surveys on such areas report dramatically higher numbers of deprived populations as compared to official statistics. Reliable and up-to-date data are urgently required, for planning and service provision, humanitarian response or to address dramatic differences in health outcomes (such as the much lower life expectancies in deprived as compared to better-off areas).

The main question, addressed in this research is: what is the capability of remote sensing to quantify the population living in deprived areas, which is often only partially accounted for in official statistics due to underreporting and the inability of population surveys (e.g., census) to cover all areas (e.g., temporary area) and all inhabitants (e.g., sub-renting tenants). Thus, the paper provides a showcase to locate such invisible spaces, areas that are omitted by official statistics, supported by remote sensing. We use the case of Dar es Salaam in Tanzania to show how a combination of data extracted from remote sensing (e.g., Pleiades and UAV images) combined with locally available data (e.g., OpenStreetMap) and non-official data (e.g., from NGOs such as Slum Dwellers International (SDI)) allow quantifying the degree of uncertainty about city-level population estimates of deprived areas, using dasymetric mapping. Generally, dasymetric mapping allows disaggregating spatial data (e.g., aggregated census ward population) to smaller spatial units employing ancillary data (e.g., building outlines or land use data), resulting in a detailed spatial representation of the population distribution. To estimate the amount of deprived population, we extracted a city-level average of the roof area (in m^2) per person (occupancy ratio) living in deprived areas. The roof area is extracted from building footprints that were generated using UAV images. To estimate the occupancy ratio, one estimate is based on a household survey and a second using publicly available SDI data (Table 1). To exclude non-residential and planned areas, a locally available land use map is used (reference year 2010), updated with recent Pleiades images.

The result of the bottom-up dasymetric model provides an estimate per building (located within deprived areas) on how many people live under a specific roof. As the target unit is not individual buildings and to smooth variations, an aggregation to larger units (e.g., showing an estimate on

neighbourhood scale) is necessary to provide an area based estimate (Figure 1). For the city of Dar es Salaam, the estimates based on the census data indicate that around 3 million of its inhabitants are living in deprived conditions. In contrast, a combination of household surveys, settlement level estimates from Slum Dweller International and rooftop outlines extracted from unmanned aerial vehicle (UAV) images estimates the deprived population to be around 5 million. Assuming that the inhabitants of formal areas are well captured, this result suggests that the total population of Dar es Salaam is beyond 6 million with around 80% living in deprived conditions. This should not be understood as the final truth, but showing the high degree of uncertainties when estimating the population of deprived areas, indicating that we may overlook many people in need (e.g., for planning and provision of basic infrastructure and services). This raises the question of how much, on a global level, do we underestimate the number of people living in deprived areas and shows the potential of remote sensing to shed light on this neglected issue. Therefore, in a next step, this methodology will be transferred to other cities in the Global South to assess its generalization potential.

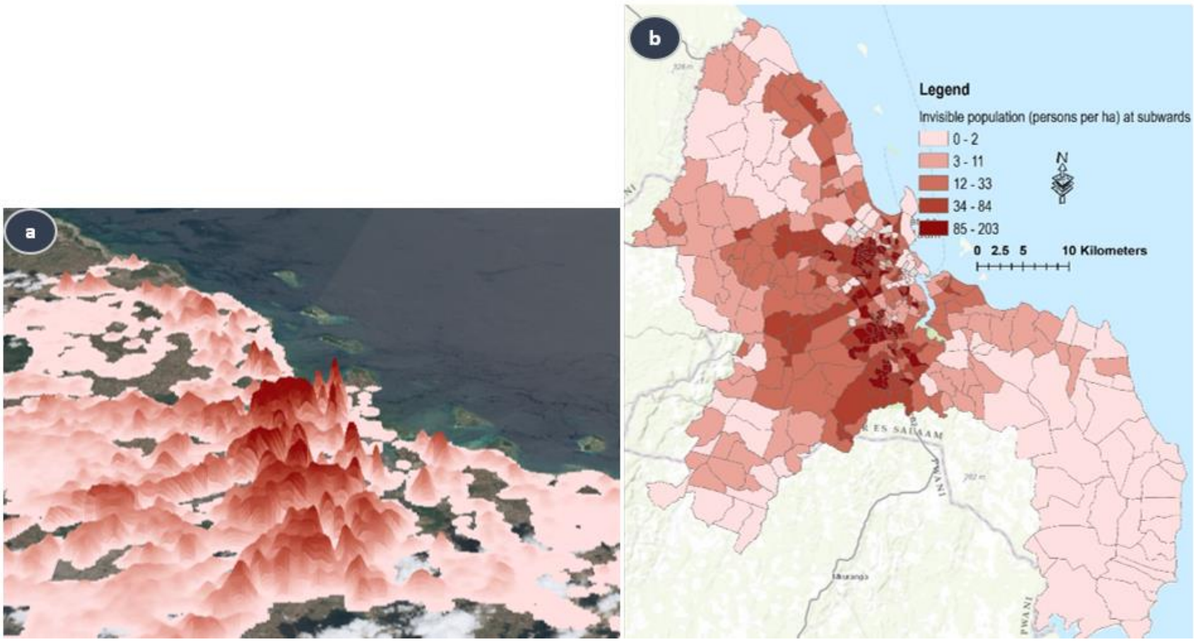


Figure 1. (a) Kernel density estimate of deprived population across the city of Dar es Salaam, Tanzania (shown on top of a Sentinel-2 image), and (b) Difference of local (bottom-up) estimates and census-based estimates of deprived population per ha, Dar es Salaam, Tanzania (shown on top of a topographic base map: Source ESRI).

Table 1. Estimates of the slum population in Dar es Salaam

	Roof Area per person in m²			**Slum population estimates (persons)**			
	Census	HH survey	SDI samples	Census	HH survey	SDI samples	Combined estimate
Total area	19.07						
Informal areas	16.85	9.84	10.57	3,055,179	5,232,405	4,868,623	5,043,903
Formal areas	24.25						

(HH: Household, SDI: Slum Dwellers International)

Mapping of *Rumex obtusifolius* in Native Grassland using Unmanned Aerial Vehicle: From Object-Based Image Analysis to Deep Learning

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
LH@hsrw.eu

Olee Hoi Ying Lam[1], Bethany Melville[1], Marcel Dogotari[1], Moritz Prüm[1], Hemang Narendra Vithlani[1], Corinna Roers[2], Rolf Becker[1] and Frank Zimmer[1]

[1] Hochschule Rhein-Waal, Faculty of Communication and Environment, Germany
[2] Naturschutzzentrum im Kreis Kleve e.V., Germany

Keywords: Weed mapping, Image segmentation, Neural network, UAV, RGB-imagery

Abstract

Weed control is one of the biggest challenges in organic farms or nature reserve areas. In order to understand and quantify the location of the invasion, weed mapping needs to be achieved either by detailed ecological monitoring or by field walking. Considering the large areas to be surveyed and the poor accessibility of certain areas, traditional field mapping is both labour and time-consuming. Recent advancements of remote sensing and airborne technologies provide opportunities to use unmanned aerial vehicles (UAVs) to support environmental monitoring and management. However, current studies mostly rely on object-based image analysis (OBIA) and proprietary software to perform weed classification, which not only requires extensive ground truthing to validate the results, but also creates a barrier for small-and-medium-sized organic farmers and conservation organizations to use semi- or fully-automated processes. This work shows the early results of an experimental approach in using open source software to perform OBIA and to assist the development of a deep learning based automatic weed detection system using UAV RGB-imagery of native grassland. The aim is to develop a repeatable and robust system for early weed detection, with minimum human input.

As a case study, the weed species targeted in this work is *Rumex obtusifolius* (*R. obtusifolius*), a common non-cultivated weed in Europe. Because of its broad-leaved and wide-spread nature, this weed is competitive with the native pasture species and could reduce grass yield substantially if not controlled. Since the nutritive value of *R. obtusifolius* is less than that of grass, it is preferably removed in organic dairy farms or conservation areas with cattle.

The UAV imagery was acquired using a DJI Phantom 3/4 Pro at a nature reserve area near Kleve in North Rhine-Westphalia, Germany, throughout the vegetation period from April to September 2018, with various altitudes: 10, 15, and 30 meters. To ensure the flight tiles could be effectively georeferenced and mosaicked, a total of twelve ground control points and the Reach RS+ RTK GNSS receiver were used. Furthermore, a sequence of 80% forward-overlap and 72% side-overlap images were collected in each flight mission. Images were then processed using Agisoft PhotoScan to produce orthomosaics and digital surface models.

Image segmentation was carried out in order to identify *R. obtusifolius* in the created orthomosaic. Image enhancement and an initial segmentation were performed by a Python script based on the spectral properties of the orthomosaic. The output binary mask was further processed using QGIS, an open source geographic information system application, where the geometric properties of the segments were considered and used to create a series of rulesets for extracting the targeted weed. The

resulting segments were individual *R. obtusifolius*'s leaves which were projected onto a 0.5 x 0.5 meters grid to indicate the presence of the weeds (Figure 1). The resulting segments were compared with the output generated by a hand-crafted ruleset in eCognition as a performance comparison. Visual inspection indicated that the initial result of the proposed open source approach had a comparatively accurate extraction, and was a more time-efficient methodology.

To verify the accuracy of the extractions, the resulting segments were to be compared with the ground truthing provided by a local expert. Field experiments had been setup in early field season in 2019 to collect further field and ground truthing data, and the generated image objects were planned to be used as labelled data to train a convolutional neural network (CNN) as an image classifier, which could be used in an automated detection and mapping process.Despite the lack of relevant studies in classifying invasive weed species from grassland imagery using CNNs, their potential had been proven in the authors' previous work based on handheld RGB camera images at the same field site. There the highest recognition rate of the trained VGG16 model was 72.83% using only 100 images of the targeted weed species and 200 images of the other type of vegetation.

This work is part of the SPECTORS project with project number 143081, which is funded by the cooperation program INTERREG Deutschland-Nederland. The authors would like to acknowledge the support of Wageningen University & Research in the collection of field data.

Figure 1. (a) The density of *R. obtusifolius* using the proposed approach and (b) the zoomed-in of the orthomosaic of the field site flown with DJI Phantom 3 Pro at 10 meters height, the red colour outlined the resulting segment objects. Resolution of the orthomosaic is 4.5 mm per pixel.

Noise Reduction and Signal Retention of Hyperspectral Data Based on Orthogonal Wavelet Transform Basis Functions

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
george.leblanc@nrc-cnrc.gc.ca

George Leblanc[1]

[1]Flight Research Laboratory, National Research Council of Canada, Ottawa, Canada

Keywords: Hyperspectral imaging, Wavelet transform, De-noising

Abstract

Hyperspectral data collection is not unlike other data collection activities where the measurement is composed of both the signal of interest as well as signal that is not of interest – the noise. This noise component is often highly variable in contribution and as such is difficult, if not practically impossible, to totally eliminate. While considerable effort has been, and is being, spent on elimination of noise in fields such as speech processing, visual cueing and general signals analysis, hyperspectral data users in the remote sensing community often suffer from the lack of advanced tools to separate their signal from noise.

The wavelet transform is an orthogonal basis operator that has the advantages of locating signals in time as well as in space domains, with near arbitrary localization and the sampling theorem's fundamental tenant of independent identically distributed (i.i.d.) random variable. These conditions afford the user the flexibility of developing methodology to eliminate variable-scaled and variable-timed (frequency) artefacts in the data that are deemed to be noise. Further, it is important to note that spectroscopic data conforms to the condition of i.i.d. data as, even though there is a high degree of correlation between adjacent spectral samples, each sample does not rely on the value of the preceding sample. Indeed, this is also the case with the vast majority of 2-D spatial hyperspectral images.

This work applies a 1-D Discrete Wavelet Transform (DWT) de-noising process to the actual spectroscopic data collected within each pixel of a hyperspectral image so that any subsequent 2-D analysis of the pixel/spatial-based imagery will be performed on the noise-eliminated data. The methodology is based upon previous work in de-noising aeromagnetic data and relies on the elimination of random non-white noise (i.e. noise that is present at specific frequencies or a range of frequencies). The DWT converts a spectra of N samples into j+1 corresponding wavelet levels via the relation $N=2^j$. As an example, 256 spectral channels corresponds to j = 8 therefore, the energy of the signal is partitioned into 9 wavelet levels. From this point, the values of the independent wavelet level thresholds are derived by first calculating the Donohoe noise estimator (DNE) for the lowest wavelet (finest scale) detail level. Taking this point as an anchor, the method applies a linear soft thresholding operator to the subsequently higher wavelet coefficient detail levels up to the level that is related to the feature of interest – e.g. if an arbitrary feature of 8 data points (corresponding to the 3rd detail level, 2^3) was selected as a target noise source, then the coefficients of the1st wavelet detail would be thresheld to the value of the DNE. The 2nd wavelet level would be thresheld to a value ½ way between the DNE and zero. The third detail (representing our target noise feature of 8 points wide) would be thresheld to zero.

The method was applied to 288 channel airborne hyperspectral radiance data within the 372-1061nm range. The data were collected as part of a project to assess the validation of ground and airborne spectroscopy using large (10m x 5m) calibration tarps of varying reflectance. The noise source was selected as an 8-point feature related to removing general spurious artefacts in the spectra. A typical result of the method (over 50 spectra were used in the analysis) is shown in Figure 1 and it is evident that the wavelet approach has effectively remove spurious high frequency noise and features of the noise target. Finally, a significant advantage of using the wavelet transform over other de-noising methods, e.g. low-pass filtering, resampling, splining, etc, is that the resulting de-noised data is the actual data of the signal and not a splined interpolation of the measured data.

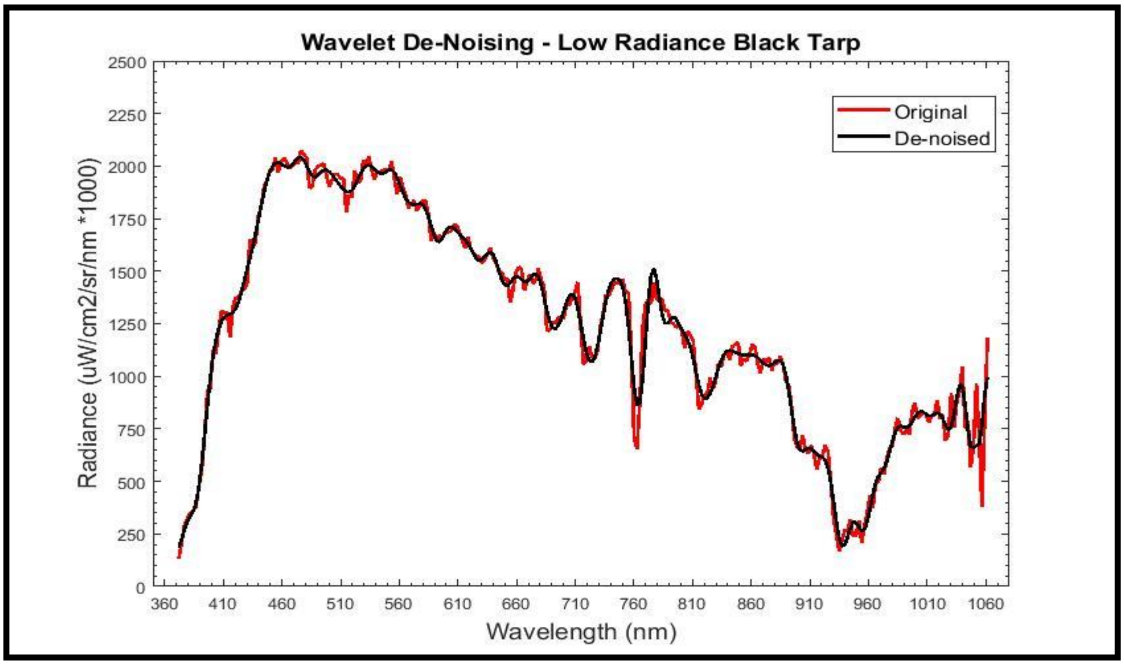


Figure 1. The red line indicates the original radiance data for one pixel collected by an airborne hyperspectral imaging system. The black line represents the results of using the wavelet transform method as outlined in this work and shows significant reduction in spurious data (noise) as well as retention of the useful part of the signal.

Band-to-Band Registration of Kompsat-3 AEISS

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
changno@seoultech.ac.kr

Changno Lee[1], Jaehong Oh[2]

[1] Seoul National University of Science and Technology, Department of Civil Engineering, Korea
[2] Korea Maritime and Ocean University , Department of Civil Engineering, Korea

Keywords: Kompsat-3, AEISS, Band-to-band registration, Sensor model

Abstract

The Kompsat-3 Advanced Earth Imaging Sensor System (AEISS) camera provides a 0.7-m Ground Sampling Distance (GSD) panchromatic image and 2.8-m GSD multispectral image data. The configuration of the Kompsat-3AEISS sensor is shown in Fig. 1(a). Blue, PAN1, PAN2, Green, Red, and Near-Infrared (NIR) channels are aligned in the uni-focal camera system at a certain distance, so that individual CCDs capture the same ground point at different times. Therefore, images from individual CCDs need to be co-registered for following processing and applications, such as pan-sharpening, change detection, spectral signature based classification, etc.

Band-to-band registration can be achieved through image-based or geometry-based methods. The geometry-based method is based on the collinearity equation to eliminate the misalignment effect. The reference band pixels are projected to their ground positions by using the provided sensor alignment and ephemeris data and digital elevation model. The obtained ground positions are then re-projected back to the target band. These methods are robust since they use the rigorous sensor model. The image-based method does not require the knowledge of sensor alignment and ephemeris data. Band-to-band registration is achieved by identification of conjugate points through matching. The image-based method is dependent on the accuracy and reliability of image matching. Therefore, it is likely to fail with images over highly undulated terrain areas and areas without many man-made and natural features.

In this paper, we present a band-to-band registration with a high-resolution panchromatic image and a low resolution multispectral image at the same geographical location. We use the collinearity equation to eliminate the misalignment effect between the reference panchromatic band and the target multispectral band. The band-to-band registration consists of three sequential processes.

First, the image points of the target band are extracted for the reference band pixels on a center image line with the precisely calibrated CCDs alignments and the provided ephemeris and attitude data. Flat target terrain was initially assumed. Co-registration residuals are still remained with less than a pixel in the first process because of the variation of the satellite attitude along the image scan line.

Second, we investigated the relationship between the satellite attitude and the coordinate differences of the tie points. We plotted the residual coordinate differences of the grid of tie points with respect to roll, pitch, and yaw angle differences. The column and row differences are linearly modelled using the attitude changes along the scan lines.

Finally, Shuttle Radar Topography Mission (SRTM) elevation data used to remove terrain elevation effects. The row differences were linear with respect to the terrain height, whereas the column differences are negligible. Even though the SRTM elevation has a coarse resolution, it is freely available for the entire world and the accuracy of DEM is not very critical for the relative shift between the bands. After applying all the processes including terrain elevation effects, the registration residuals were less than 0.2 pixels. An experiment with a Kompsat-3 image produced successful results and displayed negligible image discrepancy between panchromatic and multispectral images.

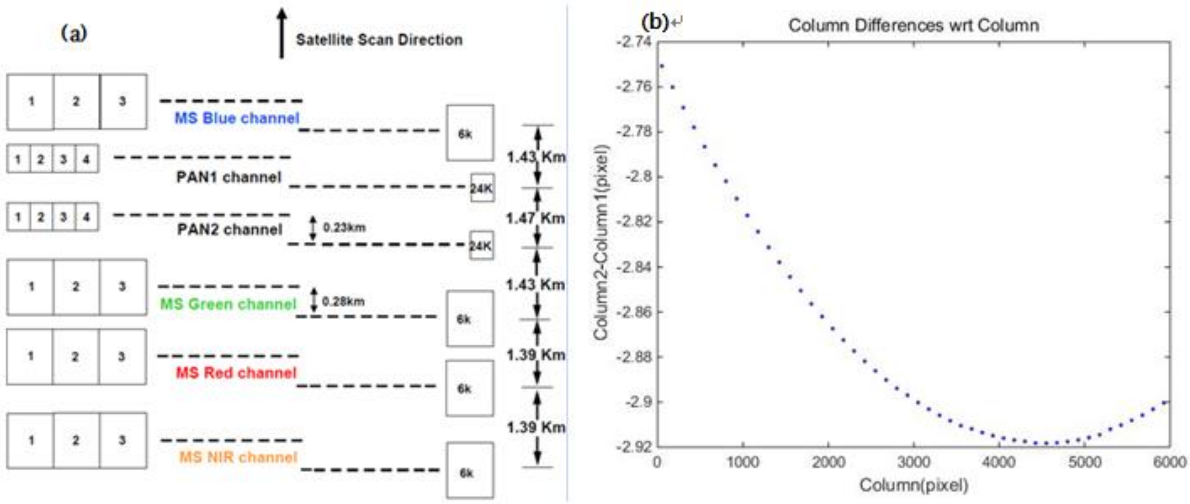


Figure 1. (a) Kompsat-3 AEISS Sensor (b) column differences between PAN and NIR

On the Potentiality of UAV Multispectral Imagery to Detect Oak Wilt Disease Using Convolutional Neural Network

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
hslee89@inha.edu

Hwa-Seon Lee[1], Won-Woo Seo[1], Kyu-Sung Lee[1]

[1] Inha University, Department of Geoinformatic Engineering, Republic of Korea

Keywords: UAV, Multi-spectral, Oak wilt disease, CNN

Abstract

Oak wilt disease, a fungal disease caused by Raffaelea quercus-mongolicae, has been a serious threat to oak trees which is the second dominant species in Korea. Despite the huge efforts to manage oak wilt disease, damaged area by the disease have been continuously reported since 2004. As the early symptom, the leaves begin to wilt and the leaves quickly discolour into the reddish brown as the disease progresses. Thus, it is critical to detect the locations of damaged trees as early as possible to prevent further spreading into healthy trees. Unmanned aerial vehicle (UAV) is becoming an effective alternative for monitoring forest disease. UAV provides very high spatial resolution imagery to detect individual damaged trees since it could be operated at very low altitudes. With the development of sensor technology, various types of UAV image have become available, ranging from natural colour to multispectral or hyperspectral imagery. Convolutional neural network (CNN) is a deep learning algorithm optimized for image processing because it uses multiple convolution filters that can generate various spatial features. CNN has shown outstanding performance in object detection and classification of image. In remote sensing area, CNN also has been effectively used for detecting tree damaged tree and tree species (ex: oil palm, shrub, and weed) and have shown improved performance than machine learning.

In this study, we aim to detect oak wilt disease with different disease progresses from multispectral imagery acquired with UAV using CNN. The study area is located at Gwan-mo and Sang-ah Mountains located in Incheon, Korea with an area of 370ha. UAV multispectral imagery was obtained with a MicaSense RedEdge-M sensor mounted on assembled hexacopter on 4 June 2018. Several pre-processing tasks including mosaic, ortho-rectification, and converting to reflectance from radiance were applied. UAV multispectral imagery has reflectance value in B, G, R, RE, and NIR bands with a spatial resolution at 20cm. Various vegetation indices such as NDVI, GNDVI, NDRE, MTCI, NWI, and CIRE were calculated. Fieldwork was carried out between June and August 2018. By the field work and image interpretation, 170 wilted trees (WT) representing the early symptoms and 230 discoloured trees (DT) representing the advanced symptoms were found within the entire image. Also, there were many healthy trees (HT) within the image. Within the entire UAV multi-spectral image, plot A and plot B were used separately for training and test. For training CNN, Image patches were generated for three classes (WT, DT, HT) by the 42x42 size of pixels from plot A (Figure 1-(a)). Initially, we had 100 WT points, 140 DT points, and 700 HT points for the training area, plot A. For increasing the number of training dataset and solving the imbalance of training dataset, data augmentation by image rotation was applied. Consequently, a total of 2100 patches (700WT, 700DT, 700HT) were generated. CNN architecture was

designed to have three convolutional layers, pooling layers, and two fully-connected layers (Figure 1-(b)). The trained CNN was applied for test area, plot B, by moving window approach.

To evaluate the detection accuracy for oak wilt disease, recall, precision, and F1 values were yielded. First, the detection accuracy by CNN was compared to that by support vector machine (SVM) which is a machine learning method. SVM with radius basis function kernel was trained using training dataset for plot A and then applied for test area, plot B. For DT, CNN showed improved performance than SVM. Both methods produced similar recall (>90%) but different precision (CNN ≈60%, SVM≈20%). Secondly, the utility of various vegetation indices in the detection of damaged trees was compared. For DT, CNN using both 5 bands and vegetation indices as input yielded 70% F1 with 92% recall and 56% precision. While CNN using only 5 bands yielded relatively lower F1 due to the lower precision. Further, we analysed the cause of a false alarm. The false alarms occurred were mainly found in the backgrounds consisting of soil and shadow between tree crowns. This is because they have similar features on both surface reflectance and shape compared to DT. As described in the results DT was detectable, while WT was very difficult to detect by any methods. The detection accuracy on WT exhibited very low F1 below than 20%. Since WT reflectance is mixed together with wilted leaves, branch, shadow, and soil, it might be too similar to distinguish from HT. The utilization of multi-spectral UAV image using CNN showed great potential for detecting damaged trees by oak wilt disease.

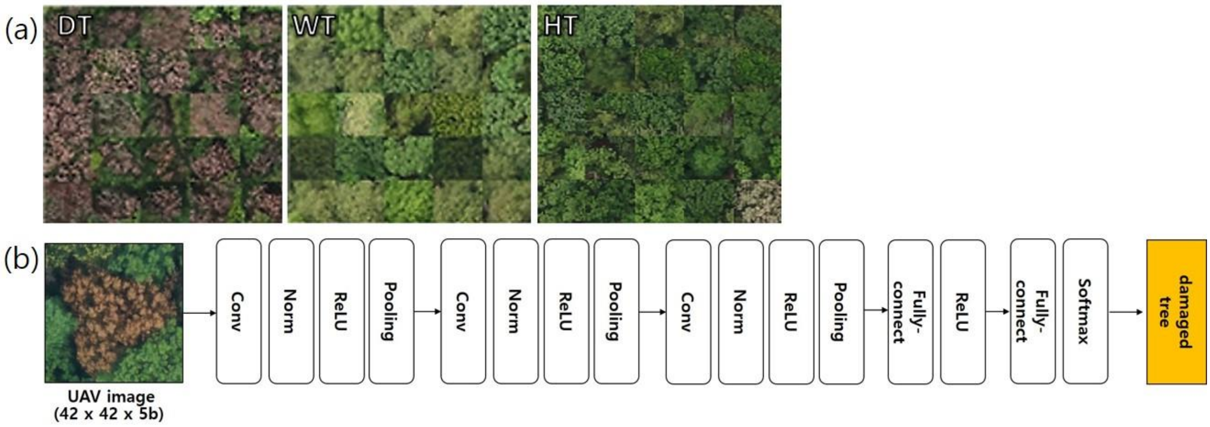


Figure 1. (a) Example of image patch used for training CNN for three classes and (B) CNN architecture

Comparison of the Surface Water Dynamics in Different Climate Regimes, Czechia and Romania, Using Long Time Satellite Imagery Series

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
ionut.sandric@geo.unibuc.ro

Ales Letal[1], Ionut Sandric[2,3], Renata Pavelkova[1], Radu Irimia[2], Zenaida Chitu[4,5]

[1] Palacky University Olomouc, Faculty of Science, Department of Geography
[2] University of Bucharest, Faculty of Geography, Romania
[3] Esri Romania, Romania
[4] National Institute of Hydrology and Water Management, Romania
[5] National Administration of Meteorology, Romania

Keywords: Landsat, Sentinel-2, Surface water, Satellite time series

Abstract

Inland surface water is highly influenced by the climate and human activity and it's one of the main sources for drinking water in Europe. The climate change from the last decades had a significant impact on these water surfaces' dynamics. This impact is mostly visible during severe drought seasons (2014-2018) and during the big flood events (1997, 2002, 2009, 2013). Recent studies approached the long term response at global scale (Liao et al., 2014; Pekel, Cottam, Gorelick, & Belward, 2016) or continental scale.

Our study is focused on assessing both the short- and long-term surface water dynamics in two different climate regions from Europe, in areas from Czechia and Romania. Even though the climatic conditions are not homogeneous across the countries, we focused on assessing at country level to have a more complex and detailed assessment of how surface water is changing in the current global climate changes.

To assess the water surface dynamics, we used the entire Landsat archive available from 1974 up to 2019, for both countries. The reference point in time was the first full cover with surface water for both countries. Because of the different cloud cover percent, this point in time is spread across a few years. Due to the launch of Sentinel-2 A and B from the latest years, a detailed analysis was possible to achieve for the severe drought season from 2014-2018 period. Image processing was performed using Landsat and Sentinel-2 image services present in the ArcGIS Online cloud-gis offered by ESRI, Python programming language and deep learning solutions (TensorFlow, CNTK). For each season (summer, autumn, winter and spring), despite the year, with available satellite images, we classified the water surface with the biggest and the smallest extend for both countries. Non-parametric statistical tests were performed to compare the loss and gain of the surface waters between Czechia and Romania and correlation with climate conditions were performed. Besides these short-term changes, we also looked on the long-term changes by assessing the loss and gain for a period of at least 5 years for each country. By the time of the conference, the results will be available online at https://water.geo-spatial.ro.

Sentinel-2 Based Monitoring of Change Dynamics in a Large-Scale Refugee Camp – the Example of Kutupalong (Bangladesh)

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
stefanie.lettner@sbg.ac.at

Stefanie Lettner[1], Lorenz Wendt[1], Stefan Lang[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: OBIA, SIAM™, Camp monitoring, Outline detection, Sentinel-2

Abstract

Refugee and IDP (internally displaced people) camps are highly dynamic in their development, wherefore a regular monitoring of such camps is of interest for humanitarian aid organisations. So far, a precise dwelling extraction for deriving population estimations is done based on very high resolution (VHR) imagery which involves additional costs and is available on demand only. Such services, like the dwelling extraction, are provided for example by the Humanitarian Services EO4Hum of the Department of Geoinformatics (Z_GIS) at the University of Salzburg.

Through the Copernicus Sentinel-2 mission of the European Commission and operated by the European Space Agency (ESA), free and regular access to high-resolution, high-frequency optical satellite imagery is facilitated. Here we investigate the potential of Sentinel-2 imagery to provide an automated monitoring of change dynamics of the camp extent of large refugee camps over time, using the example of the Rohingya refugee camp Kutupalong in Bangladesh. This is done in order to provide a frequent monitoring possibility of change dynamics of large refugee camps. The developed tool is not intended to replace detailed dwelling extraction, for the resolution of Sentinel-2 imagery would not be sufficient for this task. Rather it provides a regular pre-analysis in order to support decision making of services like EO4Hum, if whether or not a detailed dwelling extraction and therefore the purchase of a VHR satellite imagery is needed.

In a first step, the Satellite Image Automatic Mapper (SIAM™) (Baraldi,2006) software was used in a first step to (pre-)classify the Sentinel-2 scenes. SIAM™ is a remote sensing image understanding system (RS-IUS) which works fully automatic and is applicable to multi-source and multi-resolution images. The results of the SIAM™ pre-classification contains 33 different spectral categories as can be seen in figure 1b. In total 33 categories are available out of which five were used for further camp extent extraction. The relevant categories were evaluated in a subsequent analysis by intersecting the pre-classified imagery with a validation data set of camp dwellings. In a second step, an OBIA rule set was developed in eCognition to extract the camp extent according to the relevant SIAM categories. A camp footprint layer was generated representing only the relevant SIAM categories. In order to distinguish the refugee camp from ordinary villages in the surrounding area, a 20x20 meter density layer was generated above the camp footprint layer. This was done based on the assumption that refugee camps, at least visually, appear denser over a larger area than ordinary settlements. If the area of the camp footprint was covering the 20x20 raster by more than >50% it was considered as camp area. On the basis of the density layer and object based neighbourhood relations the camp extent could be

extracted. In totally this procedure was done for three scenes of three different time stamps, i.e. 2017-11 (T1), 2017-12 (T2) and 2018-02 (T3)and the results can be seen in figure 1c. The results of the eCognition camp extent extraction rule set were transferred into ArcGIS Pro and converted into hexagons in order to provide information on camp growth which is visualised in figure 1e. By comparing the camp extent of T1 with T2 a camp growth of 2,86 km² was calculated and is shown as bright red hexagons in figure 1c. The comparison of camp extent T2 with T3 showed a camp growth of 3 km² and is visualised as dark red hexagons in figure 1c. In order to verify the reliability of the eCognition rule set, the extracted camp extents were compared to the polygon validation data (see figure 1d) of the same time stamps provided by the EO4Hum service. The polygon validation data showed a change of camp area of 2,3 km² and 0,4 km² respectively, therefor it can be said that the model is overestimating and needs to be further improved.

In a future step, the extracted camp extents could be implemented in a web GIS for automated and continuous camp growth monitoring.

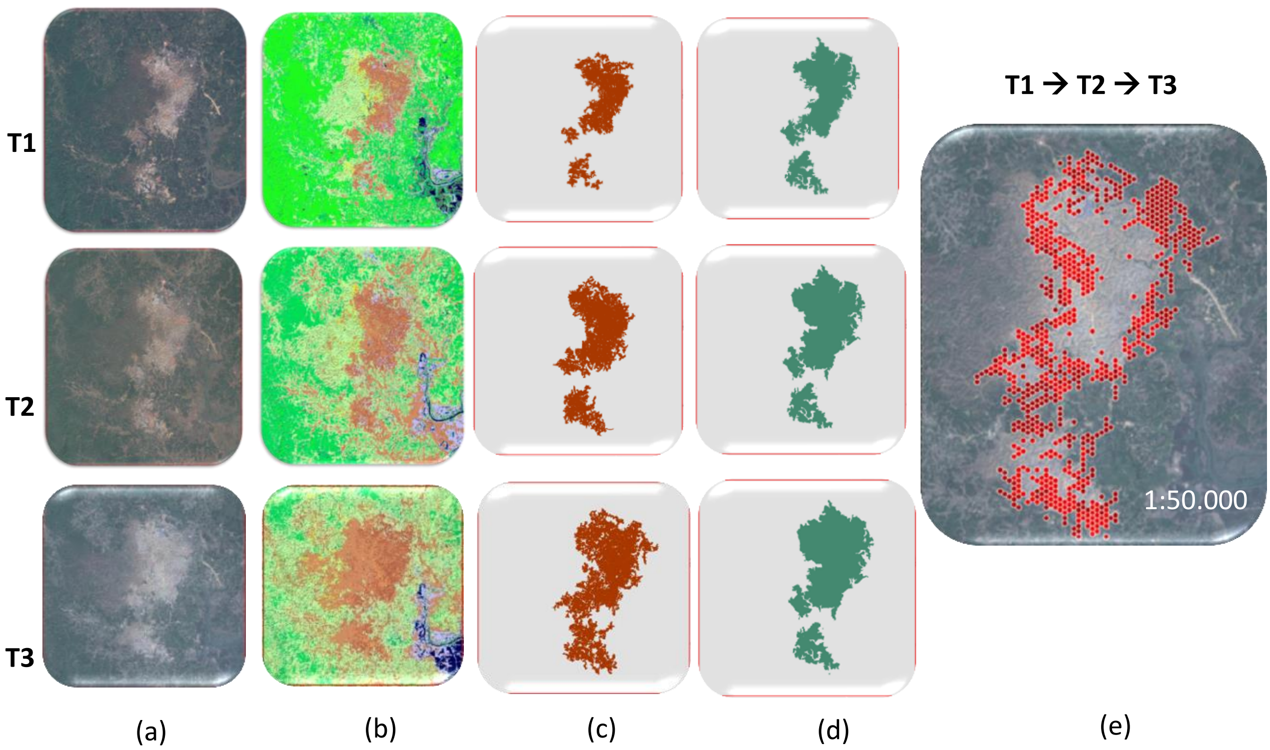


Figure 1. (a) Sentinel-2 imagery of Refugee Camp Kutupalong for the time stamps 2017-11-10 (T1), 2017-12-20 (T2) and 2018-02 (T3); (b) SIAM™ pre-classification; (c)The extracted camp extent by the eCognition rule set for the three different time stamps; (d) The validation data showing the camp extent as polygons for the three different time stamps; (e) Final change layer map; hexagons in bright red indicate areas of camp growth from November to December 2017, hexagons in dark red indicate areas of camp growth from December 2017 to February 2018. The hexagons have an area of 1ha and camp growth is defined as > 0,5 ha.

Deep Learning for Fusion of Hyperspectral and LiDAR dDta for Tree Species Classification

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
wenzhi.liao@ugent.be

Wenzhi Liao [1]

[1]University of Ghent, TELIN-IMEC, Belgium

Keywords: Forest remote sensing, Deep learning, LiDAR data, Hyperspectral image

Abstract

Recent advances in the remote sensing technologies as well as in machine learning algorithms facilitate sustainable forest managements (e.g., tree species composition, stand diversity, forest vitality and timber volume). In particular, hyperspectral (HS) imagery, covering the visible, near-infrared and shortwave-infrared bands with wavelength ranging from 0.4µm to 2.5µm, can be used for detailed quantitative analyses, e.g., determination of chlorophyll or water content in leaves, thus to discriminate tree species. Light Detection And Ranging (LiDAR) data, offering the three-dimensional position of each reflecting point, can be applied straightforwardly to estimate tree height or parameters like biomass. However, fusion of these multi-sensor data for tree species mapping remains challenging. Current deep learning architecture (see Figure 1 (a)) for multi-sensor data fusion might not always perform better than single data source, especially for the fusion of hyperspectral and LiDAR remote sensing data for tree species mapping in complex, closed forest canopies. In this work, we present a new deep fusion framework to integrate the complementary information from hyperspectral and LiDAR data for tree species mapping.

Our method exploits a two-stage deep fusion framework to learn joint features of HS and LiDAR data for tree species mapping, Figure 1(b) shows the flowchart. In particular for the first stage, we use each raw data source and its neighbours (within a sliding window) as the pre-trained layer to obtain individual possibility maps for each data source. In the second stage, both obtained possibility maps and their neighbours are concatenated as the inputs to learn the joint feature representation using stacked auto-encoder.

We also provide a solution to estimate the crown size of tree species by the fusion of multi-sensor data. Experimental results on fusing real APEX hyperspectral and LiDAR data (study area is located in the forest reserve Wijnendale in the western part of Belgium, dominated by 7 tree species) demonstrate the effectiveness of the proposed deep fusion framework. Compared to using only single data source or current deep fusion architecture, our proposed method yields improvements in overall and average classification accuracies ranging from 82.21% to 87.10% and 76.71% to 83.45%, respectively.

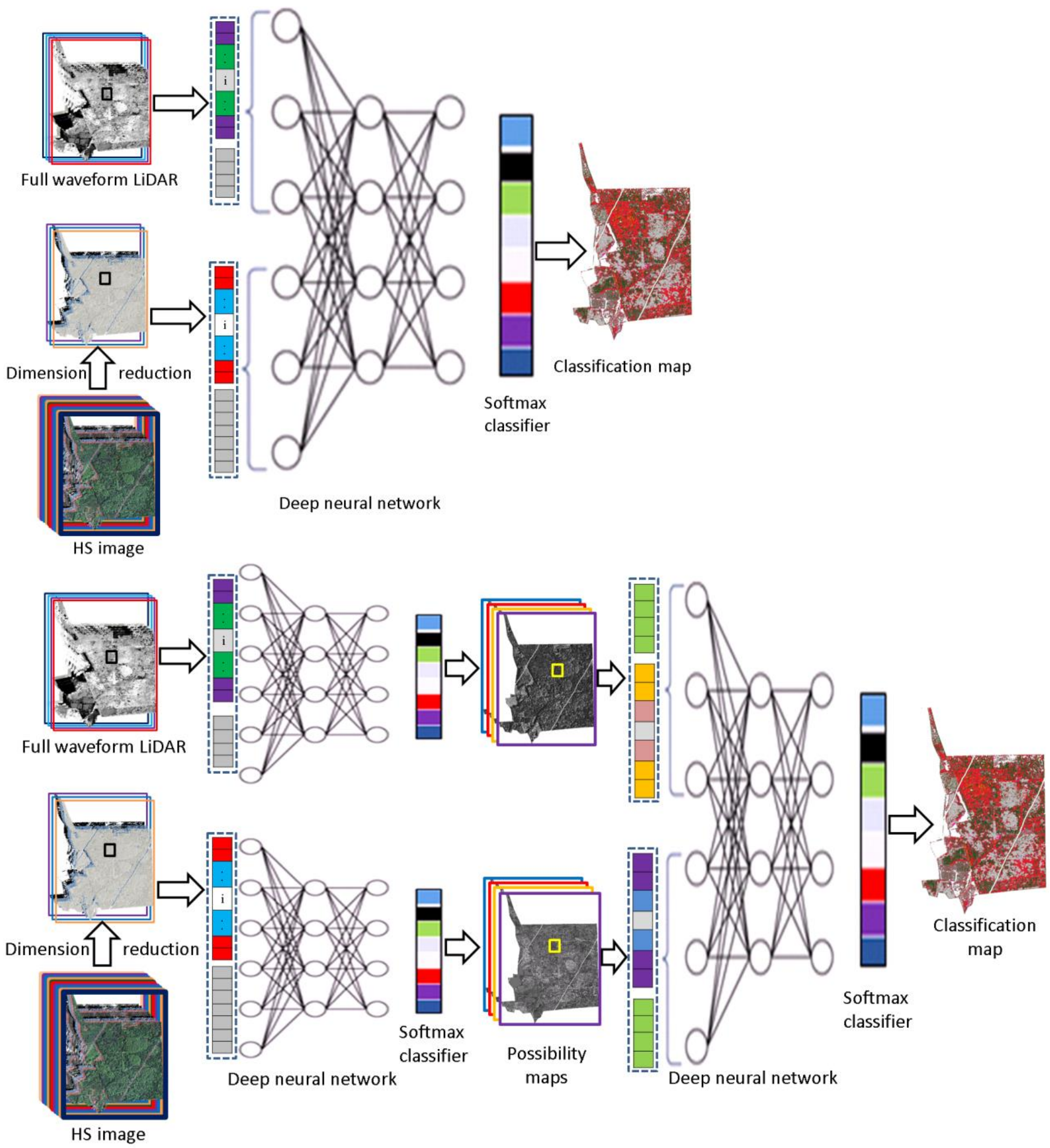


Figure 1. Joint feature representation by deep learning. (a) Current deep feature fusion framework and (b) proposed two-stage deep fusion framework.

Augmenting Reality with Hyperspectral Data from the ISS – a Learning App in Unity

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
claudia.lindner@rub.de

Claudia Lindner[1], Henryk Hodam[1], Carsten Jürgens[1], Annette Ortwein[1], Johannes Schultz[1], Fabian Selg[1], Andreas Rienow[1]

[1] Ruhr-University Bochum, Department of Geography, Germany

Keywords: Augmented Reality, Hyperspectral, ISS, HICO, Education

Abstract

Despite good working and career conditions in many STEM (Science, Technology, Engineering, and Mathematics) fields in Germany, few pupils decide to take up a higher education or training and subsequently pick a career in these fields. The result is a STEM worker shortage on all education levels in Germany that is projected to increase in the coming years and affects the scientific community as well. Several root causes were identified, among them inadequate IT infrastructure in schools and a lack of interest in STEM by the pupils. The project KEPLER ISS takes both of these problems up with the use of the pupils' smartphones for Augmented Reality (AR) applications using real data from ISS-borne earth observation experiments. The ISS is especially suited to motivate pupils as manned spaceflight is still one of the very few STEM-related career dreams of children and earth observation from it is fascinating, informative, and has a variety of real-world applications.

However, pupils lack the background knowledge and schools the necessary IT infrastructure to analyse or even visualise EO imagery in regular classes. Smartphones, while available anywhere, anytime, do not have the necessary requirements to process large amounts of data. The main challenge is to put the EO data to actual use, instead of simply visualising it as pretty pictures, but teaching pupils how to apply scientific methods to the images and deduce qualitative and quantitative information from them, all the while working around the restrictions of ubiquitous technology.

The project has published four AR apps for android smartphones so far (the iOS equivalent is planned). They feature videos from the HDEV experiment aboard the ISS, additional maps, Landsat and Sentinel-2 time series and 3D simulations. Each app is accompanied by a worksheet for the pupils and standard solutions, background information, and lesson planning recommendations for the teachers. The packages are available for free on the project's predecessor's website columbuseye.uni-bonn.de/. The topics covered by the app-worksheet combinations are tropical cyclones, the Aralkum (formerly Aral Sea), light pollution and energy consumption, and gravity in the Earth-Moon System.

The most recent app in the project features a video from the ongoing HDEV experiment and hyperspectral data from the concluded HICO (Hyperspectral Imager for the Coastal Ocean) experiment. The area of interest is Lake Erie with its massive algae bloom in 2011 that was observed with the help of HICO data. Pupils can experiment on hyperspectral data by combining different spectral bands in an RGB image via sliders (see Fig. 1). Spectral signatures were extracted from the original images from different, pre-selected locations in the image. Pupils can compare these different spectral signatures and the NDVI to determine the surface materials and discuss the natural and man-made causes as well as the effects of the algae bloom in the accompanying worksheet.

HICO hyperspectral data requires preparation via scripts and highly specialized and expensive array data visualization tools. Few GIS-tools are able to visualize hyperspectral data at all and these are not suited for use in school due to complexity and due to IT infrastructure requirements. The HICO-based learning app is developed to be easy to use on a smartphone and not use too many resources. This comes with several restrictions. The app is programmed in Unity, which is a software for game development but is increasingly used to visualise scientific data in Augmented and Virtual Reality. The programming language used is C#, which is not specialised on array data visualization, like e.g. IDL or MATLAB, and thus requires the programmer to solve image processing differently. E.g. to reduce capacity utilisation, the RGB images are not calculated, but simply a red, green, and blue coloured, semi-transparent image each on top of each other, allowing for the user to see the result of changing bands immediately. This contribution will thus not only present the educational benefits of the AR app, but also details on how to program an Augmented Reality app on image processing on a beginner level. A short outlook on evaluating the app in the subject "Geography-Physics" in a real-life school lesson is given.

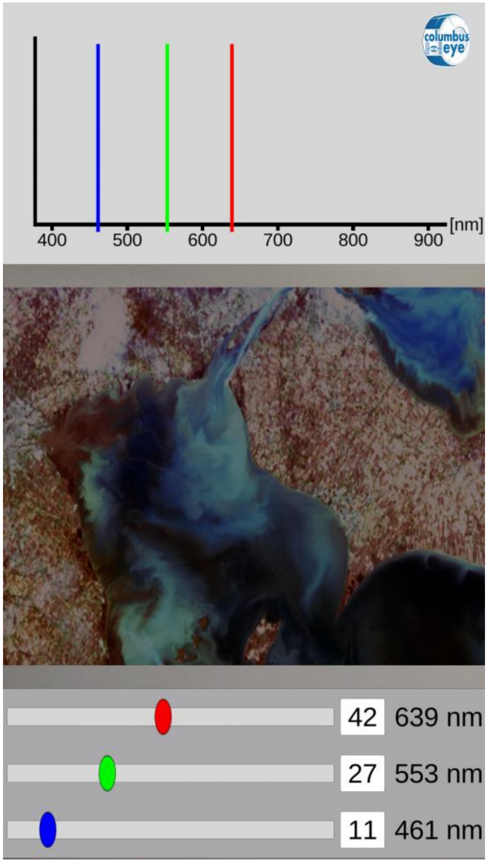


Figure 1. Preview of the Hyperspectral Viewer in the new AR app. Top: Spectral signatures of selected locations in the HICO image will be displayed. Centre: A HICO scene from 2011-03-06 of Lake Erie in the RGB bands is displayed. Bottom: Users can pick the spectral bands to be displayed on a Slider or an InputField and read the according wavelengths.

Vegetation Mapping Using Sentinel-1 Images in Arid Area

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
sahraa62@yahoo.com

Saeideh Maleki[1], Nicolas Baghdadi[2], Vahid Rahdari[3], Ahmad Pahlevanravi [1]

[1] University of Zabol, Department of Natural resources, Iran
[2]University of Montpellier, Montpellier, France
[3] University of Zabol, Hamoun international wetland research institute, Iran

Keywords: Sentinel-1, Support vector machine, Hamoun wetland, Double bounce effect

Abstract

Although, high revisit time, free access and new capabilities to map the earth surface have made the Sentinel-1 Synthetic Aperture Radar (SAR) the favourable data source in the most recent studies but its role in arid regions has been neglected. Hence, in this paper, the Sentinel-1 images were applied to map the vegetation classes in an arid area. This paper is a part of a project to map waterbirds habitat in Hamoun wetland, and the Sentinel-1 images were assessed to map the vegetation cover as one of the habitat factors. The study area is the Hamoun-e-Hirmand wetland lying in Sistan Plain on the Iran-Afghanistan border. Following severe droughts and the blockage of water flow by Afghanistan, the wetland experiences frequent inundation and drought periods even during one year. Hence, the vegetation cover was mapped in inundation and drought periods of Hamoun-e-Hirmand using Sentinel-1 images.

Field studies were run in inundation and drought periods to determine the vegetation classes in the study area. The land cover classes in inundation period include open water, flooded vegetation, and wet meadow. Flooded vegetation contains three subclasses: dense emergent, sparse emergent, and submergent. The vegetation class in the dry period can be divided into three subclasses: dry grass, shrub and bare land. Stratified random sampling method was applied to collect 220 samples within the land cover classes. The geo-localization of each field observation was registered using the Global Positioning System (GPS).

The pre-processing steps including radiometric calibration, orthorectified and the Lee speckle filter 5*5 were done. To investigate the behaviour of Sentinel-1 SAR backscatter for each vegetation class, polygons corresponding to homogeneous areas around the samples collected during the field campaigns were created and a mean backscattering coefficient was calculated for each class. Also, to map the vegetation classes the wetland land-cover maps were created using Sentinel-1 images. The support vector machine (SVM) method was implemented to classify the images in inundation and dry periods. Then the accuracy of the obtained maps was assessed.

Based on the result of accuracy assessment the accuracy of the created maps in inundation and dry periods is 88% and 82% respectively with Kappa coefficient equal to 0.85 and 0.80. These results confirm the accuracy of created maps. Thus Sentinel-1 can separate the land-cover and vegetation classes in a wetland in arid area. Figure.1 illustrates the Hamoun-e-Hirmand land cover maps in inundation (a) and dry (b) periods. As seen, the flooded vegetation is presented in three subclasses. Based on these results dense emergent, sparse emergent, and submergent are separable by Sentinel-1. Figure1.a,

confirmed the ability of C-band to map vegetation classes in a wetland which is covered by grasses and shrubs. This paper introduced the Sentinel-1 (C-band) a favourable tool to map vegetation classes of a wetland in arid area. Based on the backscattering analysis, VH is better than VV for discriminating between emergent vegetation and wet meadow because the difference between σ° of emergent vegetation and wet meadow is higher in VH (at least 10 dB) than in VV (~ 5 dB). In addition, both VV and VH polarizations can be beneficial for differentiating submergent vegetation from dense and sparse emergent vegetation. In dry period (figure 1.b), the dry grass class is differentiated from shrub class which is not dry. It shows the ability of Sentinel-1 to distinguish between these two classes which is important in arid area to manage the shrubs and design the conservational schemes for dry plants. In arid area, the life of a large group of residences during dry period is depend on vegetation. Thus, the vegetation map that shows the situation and location of plants is valuable. Also, with the advantage of high revisit time of Sentinel-1 and independency from the weather, it is possible to create time-series vegetation maps to monitor the management measures during dry period. This paper assessed and confirmed the capability of Sentinel-1 image to map the vegetation in arid area during inundation and dry period. Hence, both achieved maps were applied in the waterbirds habitat mapping project. Because vegetation is an important habitat factor and Sentinel-1 image is useful to separate and map vegetation classes.

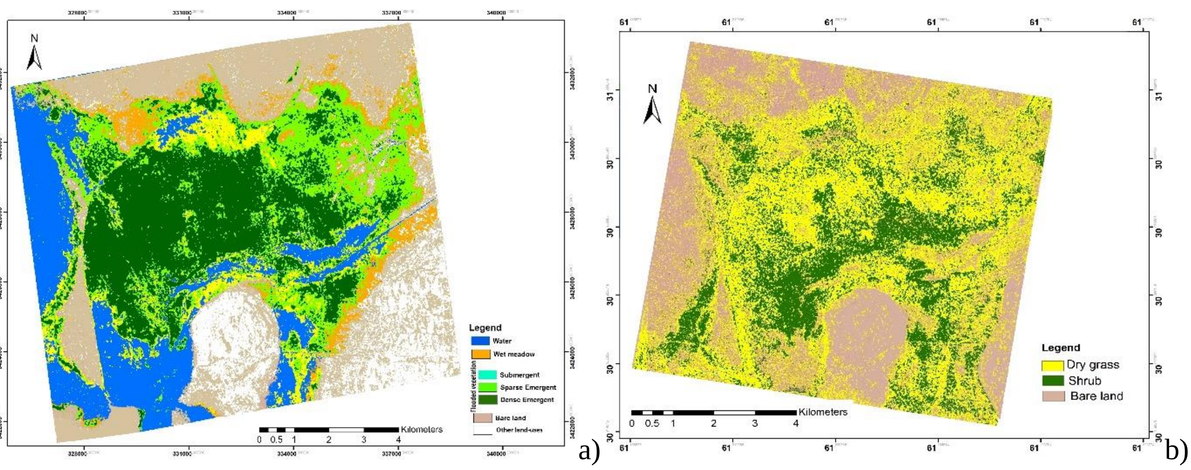


Figure 1. Hamoun-e-Hirmand land-cover map in (a) inundation and (b) dry periods using Sentinel-1

Citizen Science and Conventional Earth Observation Interaction

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
joan.maso@uab.cat

Joan Masó[1], Chrysovalantis Tsiakos[2], Athanasia Tsertou[2], Angelos Amditis[2], Steffen Fritz[3], Dahlia Domian[3], Uta Wehn[4], Andy Cobley[5]

[1] Ecological and Forestry Applications Research Centre, Spain
[2] Institute of Communication and Computer Systems, Greece
[3] International Institute for Applied Systems Analysis, Austria
[4] IHE Delft Institute for Water Education, The Netherlands
[5] University of Dundee, United Kingdom

Keywords: Citizen science, Remote sensing, Earth observation

Abstract

The widespread adoption of mobile devices and social media platforms, coupled with the development of low-cost sensors, has made it easier for the citizens to contribute to scientific research and Earth observation monitoring. The active collection of data by members of the public that contributes to new scientific knowledge, is known as Citizen Science. The European Commission is promoting Citizen Observatories that should complement official, traditional in-situ and remote sensing Earth observation data sources in many application areas. Governmental entities around the globe are supporting these activities as a way to include citizens in informed decision making and increase scientific literacy. Despite the proliferation of citizen science campaigns, only few projects really have succeeded in connecting citizen science data with conventional in-situ or remote sensing sources. Common reasons for this are the different nature of cheap sensors used, the lack of data continuity, the difficulty in discovering and accessing data created by citizens and the different methodologies for data quality assurance.

The goal of the "Citizen Science and conventional Earth Observation interaction" workshop which is held in the framework of this symposium is to explore success stories where citizen science data are combined with conventional sources of Earth observation data, including both remote sensing and in-situ. One way of ensuring Citizen Science success is to direct the observations to cover gaps in conventional Earth sensing by measuring variables that cannot be covered by existing monitoring networks or drastically increase the number of observations both in space and time allowing for the discovery of patterns that are not visible at the resolution obtained only with conventional data. We can find examples in observation of natural environment, such as natural species distribution or phenological observation in a density that cannot be covered by professional natural scientists. Pollution density in cities is conditioned by many factors including traffic, local weather and the actual building structure. While scientists can accurately measure air quality only in a few stations, citizens can literally wear sensors while commuting to work providing invaluable information about the air quality distribution and pollution hot spots. Citizen science data need to pay attention to quality control procedures and clearly document data uncertainties: as any other dataset, its application is limited to the purposes that can tolerate its uncertainty levels. In the previous example, normally, air quality

stations offer better absolute thematically accuracy, while wearable sensors might have more absolute uncertainties but still can be useful when the relative accuracy is on acceptable parameters. The migration of disease vector insects is another example of citizens contributing information to help scientists to observe and understand the impact of climate change in human health (see figure 1).

The workshop, organized by the H2020 coordinate and support action WeObserve, will start by demonstrating best practices, arising from the activities of four current H2020 Citizen Observatories (LandSense, SCENT, GROW, Ground Truth 2.0) but is open to any other project that can illustrate the integration of Earth observation and citizen science data for improved environmental monitoring. Particular emphasis will be given in the field of Land Use and Land Cover (LU/LC), harnessing the power of citizens to create actionable knowledge for participatory governance and policy making. In addition, bottlenecks and barriers related to the utilization of citizen science data in Earth observation enabled applications will be discussed with the participants, targeting to the identification of potential solutions and promotion of policy adoption.

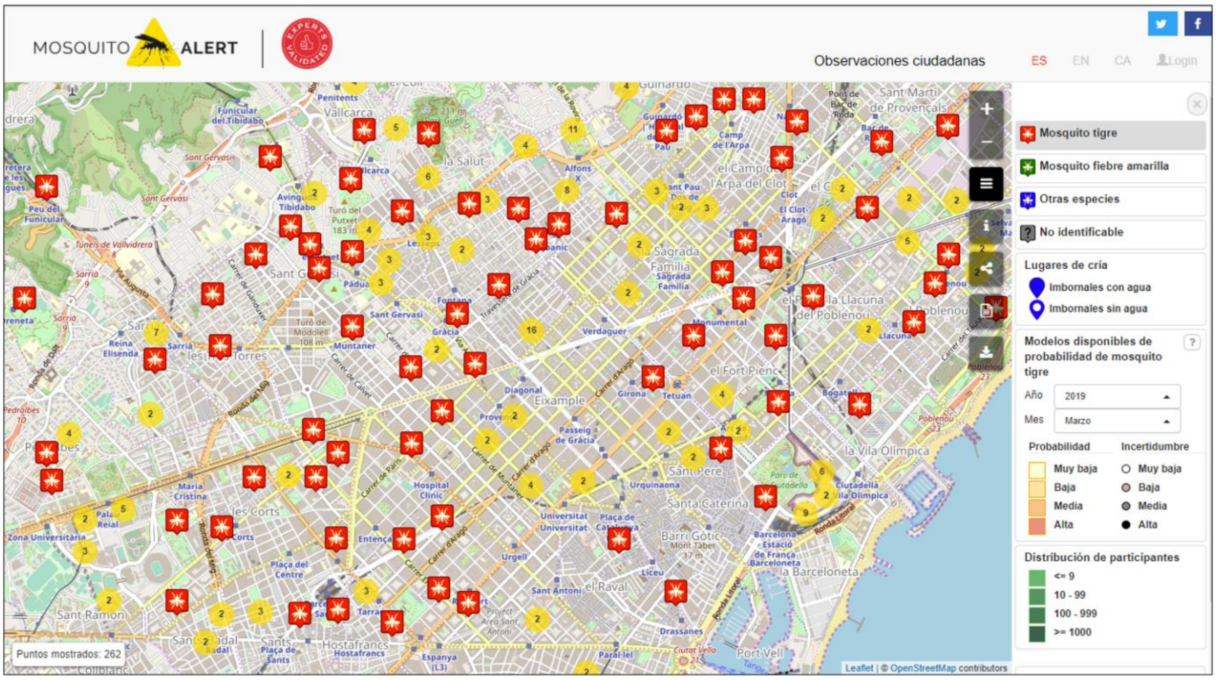


Figure 1. Citizen science observations used to investigate and control disease-transmitting mosquitoes

How Ground Truth 2.0 Citizen Observatories are Enhancing Earth Observation

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
joan.maso@uab.cat

Joan Masó[1], Uta Wehn[2], Ester Prat[1]

[1] Ecological and Forestry Applications Research Centre, Spain
[2] IHE Delft Institute for Water Education, The Netherlands

Keywords: Citizen science, Remote sensing, Earth Observation

Abstract

Ground Truth 2.0 is a 3-year European Union funded project that is setting up and validating six citizen observatories in real conditions. The methodology of the project allows citizens to take on a new role in decision making and cooperative planning by gathering, sharing and analysing data about their environment. Earth Observation is the way citizens have to enforce transparent government and evidence based decision making. The thematic focus of Ground Truth 2.0 is on flora and fauna, as well as water availability and water quality, for land and natural resources management.

The work presented in this abstract focus on eliminate four barriers that prevents the use of Citizen Science data in combination with other Earth Observation products coming from official sources: First, the project promotes the idea of having clearly defined data models behind the data capturing systems that are unambiguous and provide the necessary richness of information that scientific data requires. Data capture is structured in fields clearly described in terms of variable types, units of measure and consistency and helps to identify the equivalent variables coming from more official Earth Observation source. Secondly, information about the uncertainties of the data is also collected at the same time and aggregated into data quality indicators to facilitate comparison with other similar dataset to determine fit for purpose. In addition, the adoption of interoperable web services to share data make possible that the citizen science datasets can be found and utilized with the same tools than the conventional sources of data. Then citizen science data becomes a valuable information that users are able to discover them in the same way that they discover remote sensing data distributed by space agencies, statistical data distributed by the administrations as well as observational data produced by the Earth Observation scientific networks. Finally, the project promotes the adoption of data management principles that increases transparency in the data processing, recognition of the original sources of the observations as well as guaranteeing the preservation of the observations for the posterity.

One way of ensuring Citizen Science success is to direct the observations to cover gaps in conventional Earth sensing by measuring variables that cannot be covered by existing monitoring networks or drastically increase the number of observations both in space and time allowing for the detection of patterns that are not visible at the resolution obtained only with conventional data. In Ground Truth 2.0 water quality is frequently measured by citizens that take samples in regular campaigns in Sweden to discover eutrophication hot spots. In Mechelen (Belgium) citizens are measuring pollution density in unprecedented spatial resolution and with sensors that produces data that is calibrated with official air

quality stations (see figure 1 top right). In cities, pollution concentration distribution depends on many factors including traffic, local weather and the actual building structure. While scientists can accurately measure air quality only in a few stations, citizens can literally ware sensors while commuting to work providing invaluable information about the air quality distribution and pollution hot spots. In Sweden, water quality is regularly sampled by citizens (see figure 1 top left). For the natural environment and climate change effects monitoring, phenological observations are collected in Catalonia reaching remote areas that scientist cannot cover alone (see figure 1 bottom). These studies can be complemented studying long time series of remote sensing NDVI products. In Kenya and Zambia, citizens are creating observation networks that are almost inexistent providing first hand observations of their territory.

Ground Truth 2.0 project is now at the last stage looking for ways for sustaining the observatories and transferring them to the stakeholder networks that decided how the observatories should be in the first place. The experience of the project in terms of the co-designing methods applied, combining the necessary technological advances and adopting methods to ensuring the sustainability of different citizen observatories will be recorded in a methodology that will expressed in a general way that can then be applied to many other existing and future citizen science projects.

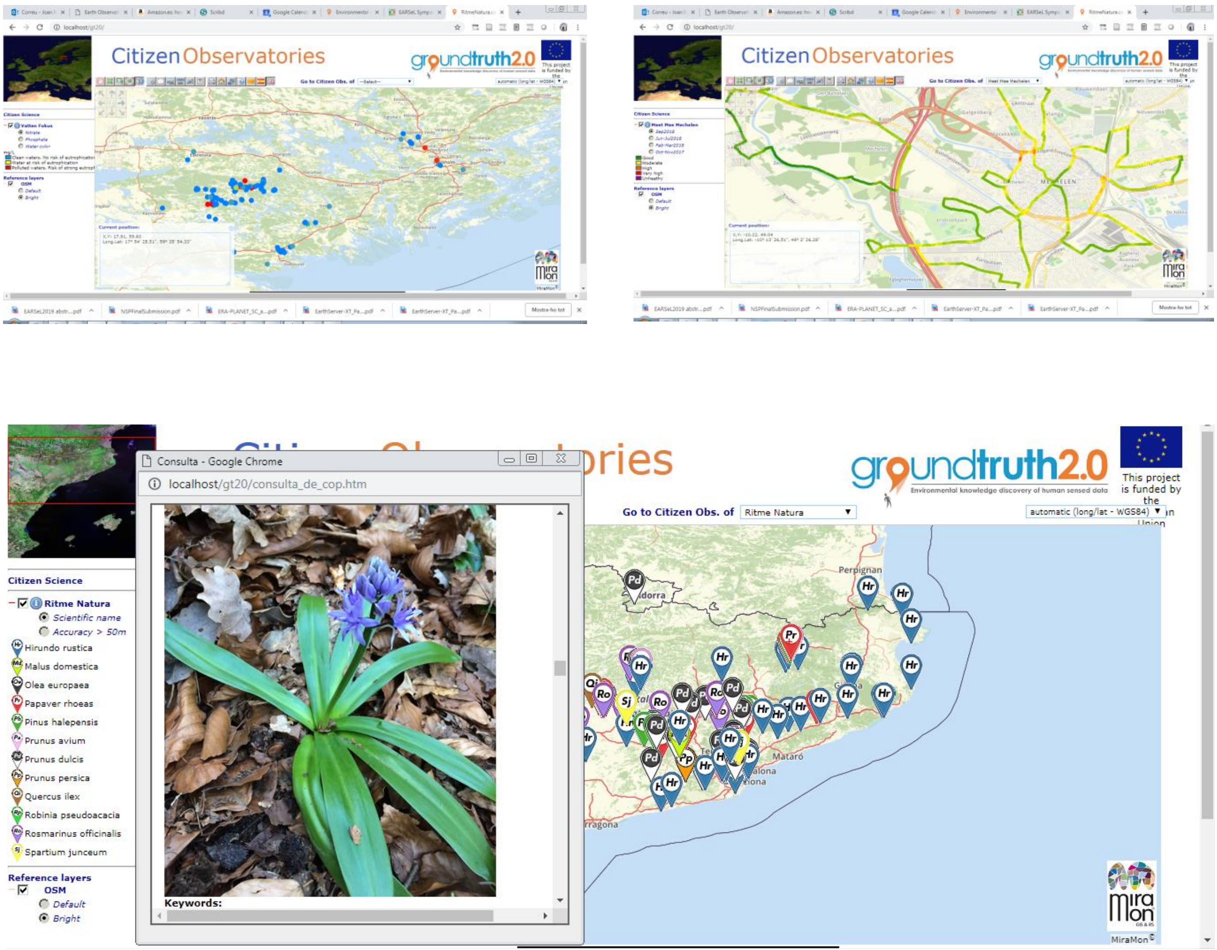


Figure 1. Examples of the Ground Truth 2.0 Citizen Observatories Earth Observation data (Sweden, Belgium and Spanish) integrated in a single portal.

Digital Cameras Calibration for Cultural Heritage Documentation: The Case Study of a Mass Digitization Project of Religious Monuments in Cyprus

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
christodoulos.mettas@cut.ac.cy

Christodoulos Mettas [1], Evagoras Evagorou [1], Athos Agapiou [1], Kyriacos Themistocleous [1], Diofantos Hadjimitsis [1], Spyridon Papavasileiou [2]

[1] Cyprus University of Technology, Department of Civil Engineering and Geoinformatics
[2] Holy Bishopric of Limassol, Cyprus

Keywords: Camera calibration, Cultural heritage, Self-calibration, Photogrammetric calibration, Lens distortion

Abstract

Innovative digital applications in the field of protection and enhancement of cultural heritage, as well as the threats to archaeological and cultural remnants of the past, create important, innovative requirements and challenges of protecting cultural wealth of a country. “Digital Imprint of Hagionymous Islands” is an ongoing research project aiming to acquire 3D digital datasets of mass historic religious monuments and artefacts in the areas of the Archdiocese of Crete in Greece and the Holy Bishopric of Limassol in Cyprus.

The project’s proposed digital service requires the development of a digital infrastructure and its enrichment with culturally digital evidence and documentation data, in order to serve as an information hub for the management and promotion of ecclesiastical cultural heritage. The methodology for the mass digitization will be based on advance methods, aiming for fast but accurate processing. Therefore, the digital documentation record includes close range photographs, stereopairs, UAV images, point clouds from terrestrial laser scanners etc., both internally and externally of facades and relics of selected monuments The project’s data will be also explored so as to create a geo-database linked with a Geographical Information System (GIS) platform, which will act as the digital atlas of the religious monuments.

Bearing in mind the importance of the photographic equipment calibration which shall take place them for photogrammetric purposes, a calibration of the lens has been made. The applied methodology is summarized, in this paper, to evaluate the accuracy of digitization ecclesiastical monuments in three-dimensional computer vision form. The calibration procedure has been applied using two-dimensional “chessboard” images taken from the CANON EOS M5 and SONY DSC-HX400V digital cameras. As a part of the research, the calibration procedures of both cameras were tracked taking into account the relative analysis of the results. A set of images was taken by each camera and used to determine the eight calibration parameters - horizontal and vertical focal length (fx, fy), principal point coordinates (x0, y0), radial distortion coefficients (K1, K2) and tangential distortion coefficients (P1, P2). These parameters were calculated and a comparison of the results of each software took place. The internal calibration parameters have been estimated. Upon the calibration procedure, 3D texture models were created with the Agisoft commercial software using: (a) the above

mentioned calibration parameters and (b) the self-calibration process. Then a direct comparison between the two different 3D models was performed. The overall accuracy (TRMS and RMS) between these models comparing known georeferenced GCP is presented. The results shows that the calibration parameters of the digital camera used for documentation purposes is essential and thus this process will be systematically implemented through the lifetime of the project.

In the future the validation of other techniques with various equipment will be applied in order to further evaluate the extracted 3D metric information. The procedures of camera calibration and the methodologies used will be recorded in order to provide information about processes of optimization or even to accelerate the producers of Digital documentation of monuments without decreasing the desired accuracy or completeness.

Improving Cloud Detection in Satellite Imagery using a Citizen Science Approach

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
moorthy@iiasa.ac.at

Inian Moorthy[1], Tobias Sturn[1], Matej Batič[2], Linda See[1], Grega Milčinski[2], Steffen Fritz[1]

[1] International Institute for Applied Systems Analysis, Austria
[2] Sinergise Laboratory for Geographical Information Systems, Ltd, Slovenia

Keywords: Cloud detection, Earth observation, Citizen science, Computer vision

Abstract

The aim of this paper is to show how citizen science could potentially be used to improve cloud detection algorithms for satellite imagery in the future. This work is being undertaken within the framework of the H2020-funded LandSense Citizen Observatory on land cover and land use. One of key areas of interest in LandSense is making best use of data from Earth Observation. A number of different cloud detection systems and algorithms are available, including Sentinel Hub's CD (s2cloudless) system developed by Sinergise. This system has high cloud detection rates and lower misclassification rates of land and snow as clouds compared to other popular cloud detection algorithms. However, the cloud detector could still be improved, e.g., detection over bare areas. Hence augmenting the training data set with additional data, including misclassified pixels from certain scenes, is one way to improve the classifier performance.

Although Sinergise already has a sophisticated system for collection of training and validation data for the cloud detection system, a more simplified approach for data collection could run in parallel using a citizen-science based application such as Picture Pile. This is a mobile and online tool for rapid image assessment that is part of the LandSense Citizen Observatory. Picture Pile (shown in Figure 1) works in a very simple way. Users are provided with a satellite image and are then asked one question. In this example, the question is: Is more than half of the image cloudy? If the answer is yes, the user swipes the image to the right on mobile devices (or uses the cursor keys on the browser version). If the answer is no, the image is swiped to the left, and if users are unsure, they can swipe the image downwards. In this way it is possible to classify images very rapidly. At present the application does not ask users about cloud shadows but future questions could be added to the application that do. Also users could be trained to distinguish between clouds and cloud shadows. Picture Pile has some similarities to other applications, e.g., Cerberus, which is an online game for land cover mapping of continuous areas and includes the mapping of clouds as one feature type. However, this is online game with missions rather than a rapid image assessment tool. Another similar application is Missing Map's MapSwipe, which shows users a continuous area rather than a sample of images. The user swipes through this continuous landscape looking for features of interest, tapping once when a feature is found, twice if maybe and three times for cloud covered images. Hence the data from both Cerberurs and MapSwipe could potentially be used as additional inputs to the cloud detection algorithm. The Google captcha tool for image annotation could also be used to collect data on clouds if Google chose this as one of their image annotation tasks but it would be highly unlikely that we could obtain these data from Google.

To date, the first pile of 27,021 unique images was classified 271,523 times in Picture Pile by 82 volunteers. The campaign was advertised through Twitter and via emails to previous campaign participants and via the wider Geo-Wiki and LandSense networks. In this instance, there was no need to advertise further as we have established a volunteer group interested in using the application. The quality control procedure in Picture Pile has two elements. The first is to give the same images to more than one volunteer. In this case, 92.6% of the images were classified by more 1 person, with some images classified up to 9 times by different volunteers. Of the images sorted, 61% of the images had complete agreement, 35.5% had some disagreement, in which case we use a majority rule, and 3.5% had some answers in the 'maybe' category, indicating that they were difficult to classify. Hence these images will either be checked manually by experts or deemed unusable for classification purposes. The second element of the quality control is control points, i.e., a subset of images classified by experts, which are randomly shown to the volunteers. When the volunteers make mistakes, they lose points, which encourage them to interpret the images carefully. These types of gamification elements have proven to be successful in previous Picture Pile campaigns.

Having managed to mobilize a crowd to complete this task, the next stage of the process would be to improve the data set needed by Sinergise's s2cloudless system. This could either involve modifying the task in Picture Pile, by asking participants to identify areas as cloud, non-cloud or partial-cloud, e.g. 9 pixels from Sentinel 1 shown as a 30 m block. Another approach would be to use these results from Picture Pile in another application called Picture Paint, in which the users would delineate areas of cloud on the images. This would make the data more useful as training data for the s2cloudless system. These efforts are ongoing.

Picture Pile is also being employed in other use cases within the LandSense Citizen Observatory, e.g., in validating night time lights imagery, for identification of oil palm, and rapid assessment of damage after a natural disaster. The browser version of the Picture Pile application can be found at the following link: https://geo-wiki.org/games/picturepile/, while the mobile application can be downloaded from the Google PlayStore and Apple AppStore.

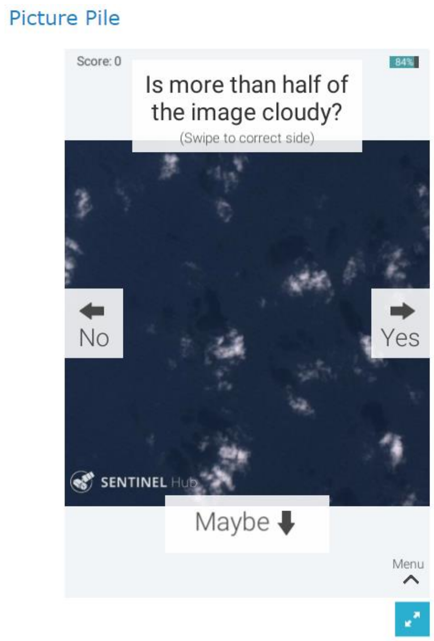


Figure 1. The Picture Pile tool for rapid image assessment of cloud presence

Remote Sensing and Participatory Mapping for Clean Energy Provision

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
jmuro@uni-bonn.de

Javier Muro[1], José Jara[2], Esteban Calderón[2], Richard Resl[3], Leo Zurita[3], Carlos García Lanchares[1], Valerie Graw[1]

[1] University of Bonn, Center for Remote Sensing of Land Surfaces, Germany
[2]Tratrural, Ecuador
[3] University San Francisco de Quito, Ecuador

Keywords: Renewable energy, Participatory mapping, Compositing, Google Earth engine

Abstract

Sustainable Development Goal (SDG) number 7 aims at granting universal access to modern energy services (i.e. electricity, cooking and heating). However, isolated indigenous communities from the Amazon region are often left behind in national electrification plans because of the higher costs of expanding the electricity grid to remote areas. Although they aren't necessarily stricken by poverty, their remote location keeps them away from the rest of the society, making them vulnerable to diseases, extreme climatic events, food shortages, etc. Indigenous communities in the Amazon are also especially vulnerable to the expansion of extensive oil and mineral extraction, and also logging activities. The project SE4Amazonian is developing rural electrification plans based on remote sensing imagery combined with participatory mapping that will feed a GIS-based suitability analysis of decentralized renewable energy power systems. This methodology aims to speed-up decision making by providing rapid, cost-effective and spatially explicit information on energy needs.

Using inputs from different freely available remote sensing sensors and participatory mapping we are estimating the size, location and distribution of the communities that are off-the-grid. This allows us to translate their development needs into energy needs. First, the shape of communities defines the type of electrification. For instance, solar microgrid is more suitable for concentrated communities, and individual solar systems are better for highly scattered households. Second, knowing people's real development needs we can calculate the energy demand to power appliances such as refrigerators to store medicines, light to read at night, or power mills for post-processing agricultural activities. In turn, this will support other SDGs such as health improvement or education. At the end, decision makers will have a planning tool to elaborate techno-economic analysis of electrification plans incorporating indigenous people viewpoints and needs.

Through capacity building workshops we are training a team of local technicians that will gather spatially-based information from communities with and without electricity. The training is given by AmazonGIS.net (http://amazongis.net) a network that support indigenous communities to manage their own territories using spatial technologies. The information collected by the field technicians through participatory mapping includes: number houses, number of people living per household, infrastructures available (health centre, school, workshop, etc.). This information determines the electricity needs and

potentials of each community, and we are using it to build a GIS-based model that can extrapolate the electricity needs of unsurveyed communities using satellite information.

The Amazonia is one of the cloudiest parts of the planet. This makes it very difficult to get cloud-free and updated optical images. It is important to have current images (with a margin or 5 years) because sometimes these communities can move, be forced to move, or grow. To overcome the challenge imposed by persistent cloud cover, we are generating our own cloud free composites of Landsat and Sentinel-2 imagery. Sentinel-2 provides multispectral information at 10-20m spatial resolution. However, its cloud mask is still imperfect when compared to the fmask of the Landsat constellations. Thus, we have generated coarser Landsat-based maps at 30 m resolution showing the location of these communities. Using Sentinel-2 imagery we are estimating the size and distribution of the communities. Using the information provided by the field technicians on electricity needs we are modelling the kW needed in each community and the optimal way to deliver it (solar microgrid, solar individual, or mini-hydropower.

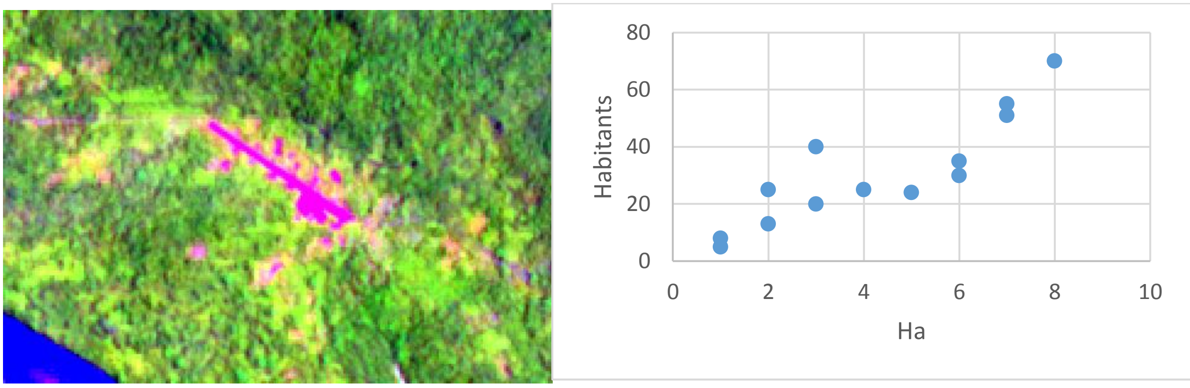


Figure 1. (a) Distribution of an isolated community. Multi-temporal Sentinel-2 composite RGB 12, 8, 4 (b) Example of relation between community size and number of residents, which along with the participatory mapping determines the energy needs.

The resulting maps are uploaded to Geofarmer, an app developed by the University of Salzburg (https://www.geocitizen.org/home/). The app acts as a platform used to support the improvement of quality of life of communities by involving directly their residents. This is achieved by sharing, reporting, discussing proposing and voting about the concerns of their members, and using geospatial technologies and social media to achieve solutions and draw on best practices. The platform is being used also to validate the remote sensing based products and how they adjust to the needs of the communities.

Monitoring of Winter Vegetation on Arable Land Based on Satellite Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
magdalena.ochsenbauer@stmelf.bayern.de

Magdalena Ochsenbauer[1], Wolfgang Ehbauer[2], Franziska Brohmeyer[3], Monika Prasch[4], Florian Ebertseder[4]

[1] Bavarian State Research Center for Agriculture (until April 2019), Bavarian State Ministry for Food, Agriculture and Forestry, Department of ICT, Germany
[2] District Government of Lower Franconia, Department Nutrition and Agriculture, Germany
[3] VISTA Geoscientific Remote Sensing GmbH, Germany
[4] Bavarian State Research Center for Agriculture, Germany

Keywords: Remote sensing, Sentinel-2, Water & erosion conservation, Catch crops

Abstract

An important measure of water and erosion protection on agricultural area (AA) is land cover throughout the year. Cultivation of one-year crops on arable land (AL) can lead to longer periods without vegetation cover, especially during wintertime. The cultivation of so-called catch crops (CC) is only captured if it is part of the area based subsidies and considered for the application of the farmer (e.g. agro-environmental measures (AEM), greening). In addition, however, where in winter the ground is covered is not known. Based on the analysis and interpretation of satellite data (Sentinel-2 data) and data from the agricultural administration, a study was carried out to determine the extent and intensity of winter vegetation on arable land in Bavaria. The validations show that the leaf area index (LAI) derived from the satellite data is a good indicator of the degree of winter soil cover. The average weighted LAI figures for the whole of Bavaria are still relatively high in October 2017, to decline more or less sharply in the period from November to February 2018.

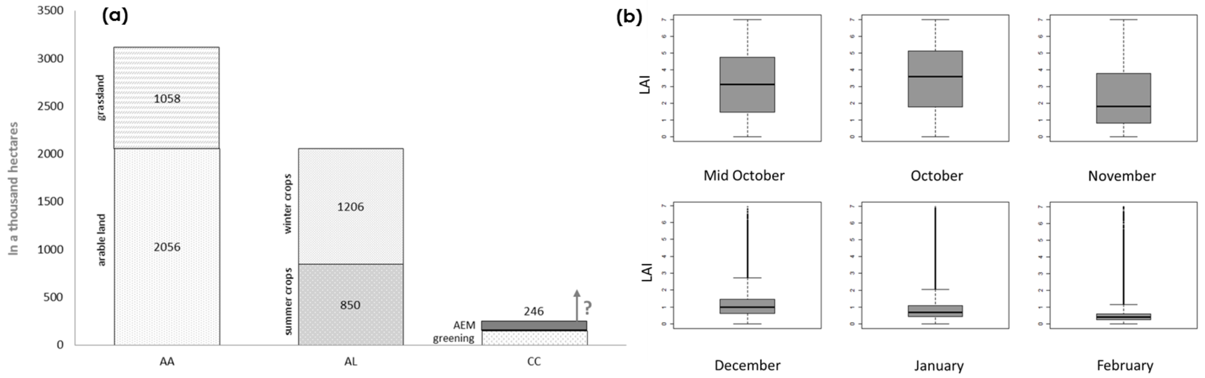


Figure 1. (a) Land Use in Agriculture for the year 2017 in Bavaria (data basis: Bavarian agricultural report 2017/2018; IACS 2017,2018); (b) Development of the average LAI value for areas with catch crops grown under the Greening in Bavaria (data basis: Sentinel-2; IACS 2017,2018)

Investigating Dense Time Series of Optical and SAR Earth Observation Data for Crop Type Classification

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
aiym.orynbaikyzy@dlr.de

Aiym Orynbaikyzy[1], Benjamin Mack, Ursula Gessner[1], Christopher Conrad[2,3]

[1] German Aerospace Center (DLR), German Remote Sensing Data Center, Wessling, Germany;
[2] University of Würzburg, Würzburg, Germany;
[3] University of Halle, Halle, Germany;

Keywords: Sentinel-1, Sentinel-2, Multi-sensor fusion

Abstract

Accurate and timely delivered crop type maps are one of the most needed and important data sources for studies in agricultural monitoring. Remote sensing, as one of the rapidly growing fields of science, offers advanced methods and technologies for land cover and land use monitoring. Notably, the progress in sensor technology together with free and open available remote sensing data boosted an interest in the usage of multi-sensor earth observation data for land monitoring applications. Compared to single-sensor approaches, the combination of optical and radar remote sensing data is promising for improving crop type classification. Due to the different wavelength domains in which optical and synthetic aperture radar (SAR) sensors work they provide complementary information for a better discrimination of crops. Rapid growth of research literature on the topic of optical-SAR remote sensing data fusion indicates shows the high relevance of this research area.

In this study, we evaluate the performance of optical (Sentinel-2) and SAR (Sentinel-1) data combination for crop type classification. The fusion of data from optical and SAR sensors is performed at the feature level. Nonetheless, the performance of each individual sensor is also assessed and compared to the multi-sensor fusion approach. The random forest algorithm is used to perform a pixel-based classification. Furthermore, the contribution to the accuracy of various features, such as vegetation indices, spectral information, VV and VH data, polarization ratio and texture data are investigated. The comparative analysis of the overall, user's and producer's accuracies is evaluated to assess the quality of various feature group combinations. Additionally, the classification performance for specific crop types (e.g. winter barley) and crop groups (e.g. winter cereals) is analysed. Moreover, classification results from dense virtual time series data (linear interpolation between clear-sky observations for 2 weekly dates) are compared to the usage of statistical metrics calculated based on different temporal periods (e.g. monthly medians, seasonal percentiles, etc.).

The study site is located in northern Germany (Figure 1). Earth Observation data from Sentinel-2 and Sentinel-1 missions are employed for the entire year of 2017.for the full year 2017 is used. As reference we use Land Parcel Information System (LPIS) data for the federal state of Brandenburg. It consists of field boundaries and corresponding crop type representative for the year 2017.

In view of the growing contribution of the remote sensing domain to applied agricultural studies and specifically to the crop type identification, the important research objective of this study is to evaluate the efficiency of optical-SAR data fusion. This research shows the capacity of fused data to perform the classification with higher overall accuracy compared to single source remote sensing data. The implementation and assessment of a multi-source, object-based hierarchical classification approach is the subject of future research.

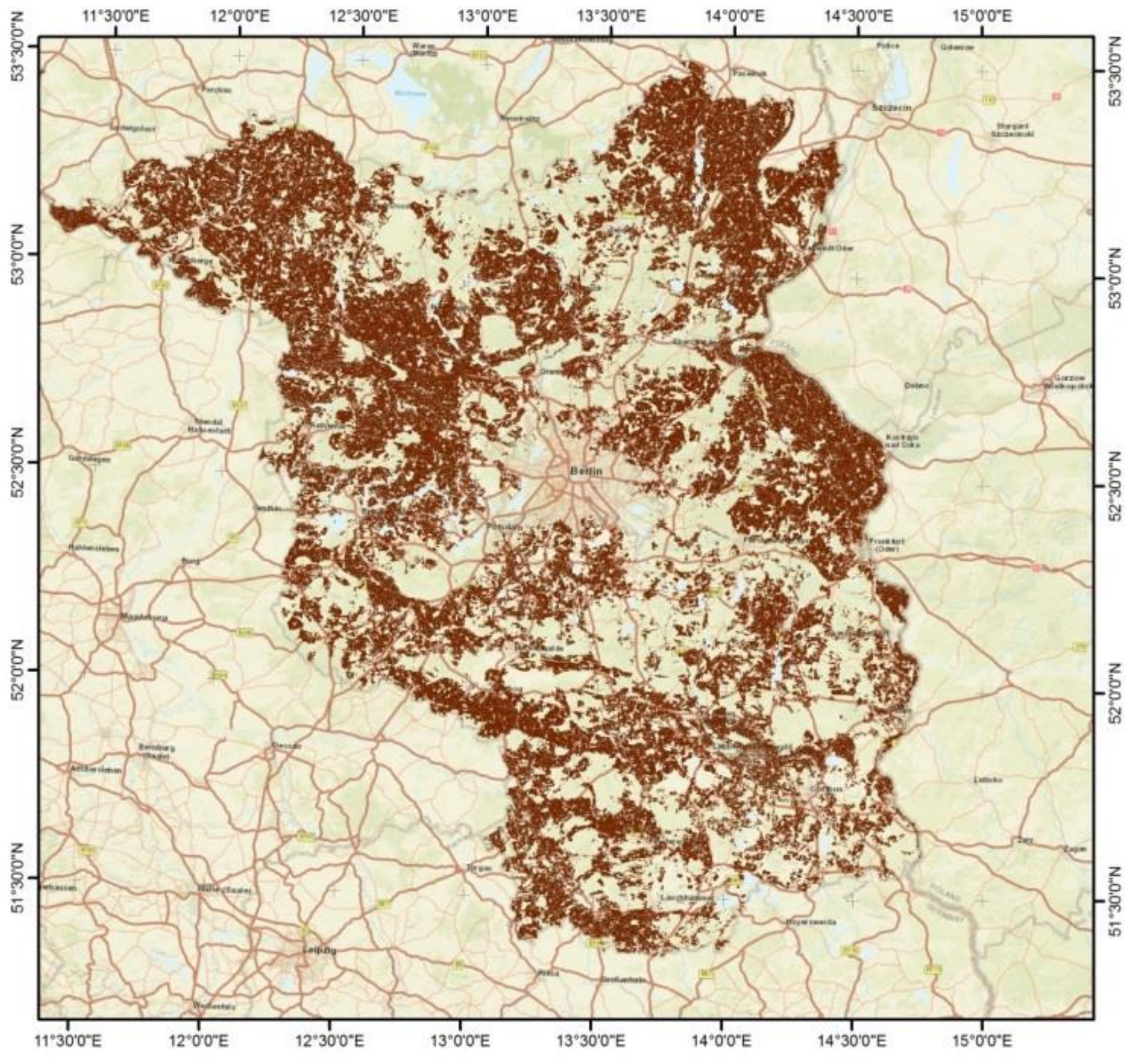


Figure 1. Geospatial Aid Application data showing agricultural fields for the study site located in Northern Germany (Brandenburg).

Lithological Mapping using Landsat 8 OLI and ASTER Multispectral Data in Imini-ounilla District South High Atlas of Marrakech

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
ourhzifz@gmail.com

Zouhair Ourhzif[1], Ahmed Algouti[1], Abdellah Algouti[1], Fatiha Hadach

[1]University of science Semlalia, Department of Earth Science Laboratory 2GRNT, Marrakech

Keywords: Lithological mapping, Landsat OLI, ASTER, Mountainous semiarid

Abstract

This study exploited the multispectral Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Landsat 8 Operational Land Imager (OLI) data in order to map lithological units and structural map in the south High Atlas of Marrakech. The method of analysis was used by principal component analysis (PCA), band ratios (BR), Minimum noise fraction (MNF) transformation. We performed a Support Vector Machine (SVM) classification method to allow the joint use of geomorphic features, textures and multispectral data of the Advanced Space-borne Thermal Emission and Reflection radiometer (ASTER) satellite. SVM based on ground truth in addition to the results of PCA and BR show an excellent correlation with the existing geological map of the study area. Consequently, the methodology proposed demonstrates a high potential of ASTER and Landsat 8 OLI data in lithological units discrimination. The application of the SVM methods on ASTER and Landsat satellite data show that these can be used as a powerful tool to explore and improve lithological mapping in mountainous semi-arid.

Satellite remote sensing data: This study used the level 1B ASTER and Landsat 8 OLI data. The images have been already pre-georeferenced to UTM zone 29 North projections with WGS-84 datum. The crosstalk correction (Iwasaki and Tonooka, 2005) was applied to the images data. Fast line-of-sight atmospheric analysis of spectral hypercubes (FLAASH) was used for atmospheric correction on the images data.

Discriminating Capability of ASTER and OLI: The Landsat OLI sensor has two SWIR bands that may be used to predict alteration mineral associations (Rowan et al., 1977; Sultan, 1987; Knepper and Simpson, 1992; Spatzm and Wilson, 1994; Sabine, 1997). However, OLI SWIR bands have difficulty in differentiating types of clays, sulfates, and carbonates effectively (Perry, 2004). In contrast, the ASTER instrument offers six SWIR bands and five thermal bands, which can enhance the lithologic and mineral information extraction. Few publications exist on ASTER techniques applied to mineral exploration and lithologic mapping at this time. The classification study described above has proved that ASTER data is more powerful than OLI for lithologic mapping. This section will explore the relative utility of ASTER and OLI data for lithologic information extraction based on separability of various band selections.

SVM Classification results: For optimized lithological classification of the study area from remote sensing data, we experimented by training SVMs using various combinations of input data selected from ASTER and OLI images.

ROIs covering different lithological units are selected using the aerial images for the google earth and the preexisting geological map. After the classification the evaluation of the accuracy is achieved by calculating the confusion matrix by comparing pixel by pixel the result of the classification and the geological map.The review of the confusion matrix shows an overall accuracy of 97.2775% for OLI and 74.8885% for ASTER, with kappa coefficients of 0.97 and 0.71, respectively.

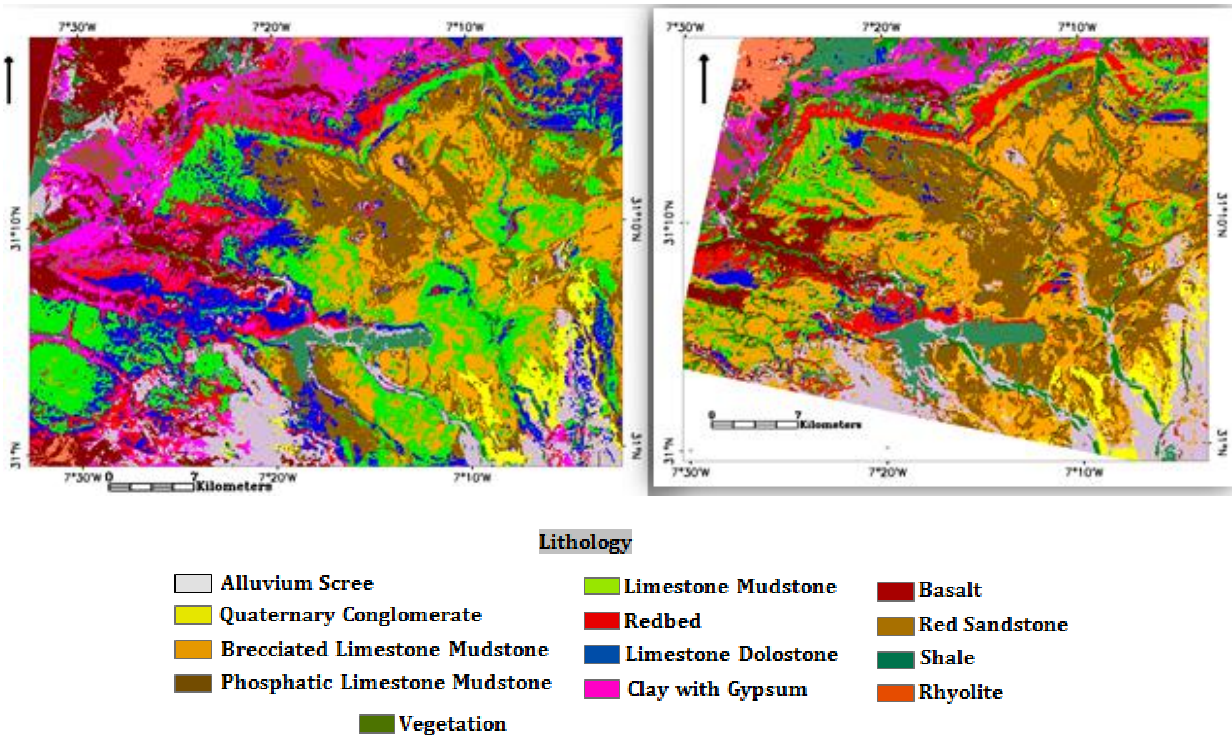


Figure 1. Results of SVM classification of ASTER (a) and OLI (b)

The diagnostic of the diagonals of confusion matrixes shows that the ASTER sensor gave better results than the OLI sensor, especially discriminating the basalt of Trias (Bt), sandstone–mudstone very micaceous (Sd-mud), Limestone dolostone of CT , the red bed of infracenomanien and the differenciation between the phosphatic and brecciated Limestone of Eocene . On the other hand, the shale (Sh), sandstone (Sd),clay , rhyolitics rocks , and alluvium are classified better in the OLI result. Moreover, the generalization in the production of geological maps and the synthetic nature of the boundaries between lithological units also influenced the overall accuracies obtained.

Improving Awareness and Usage of the Information Provided by the Copernicus Earth Observation Programme in the Republic of Cyprus

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
mp.papadopoulos@edu.cut.ac.cy

Marinos Papadopoulos[1], Christodoulos Mettas[1], Diofantos Hadjimitsis[1]

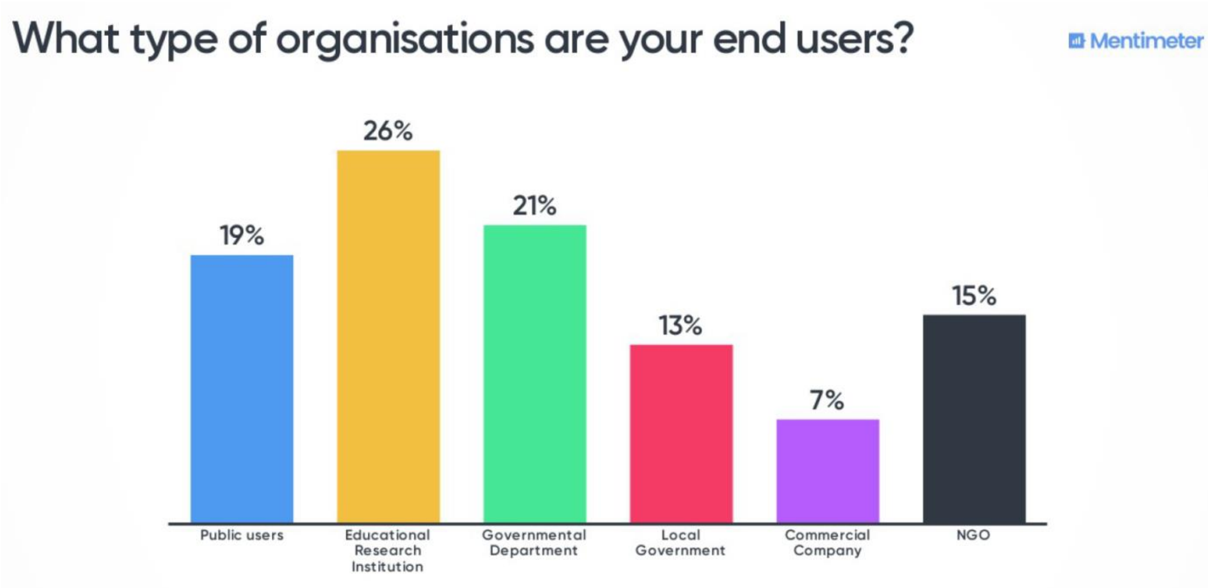
[1] Cyprus University of Technology, Department of Civil Engineering and Geomatics, Cyprus

Keywords: Copernicus, Earth Observation programme, Cyprus

Abstract

Copernicus is the European Union's Earth Observation Programme. It offers information based on satellite Earth Observation and in situ data and can be classified in six services. The service of atmosphere focuses on Air quality and atmospheric composition, Ozone layer and ultra-violet radiation, Emissions and surface fluxes, Solar radiation, Climate forcing. Marine service, which deals with observations and forecasts produced by the service, supports all marine applications, including Marine safety, Marine resources, Coastal and marine environment, Weather, seasonal forecasting and climate. Land deals with systematic monitoring of biophysical parameters, Land cover and land use mapping, thematic hot-spot mapping, Imagery and reference data and European Ground Motion. The Climate change service concerns with information about the past, present and future climate in Europe and the rest of the World. The Emergency sector concerns the mapping component and early warning component and finally the Security service deals with the information on Border surveillance, Maritime surveillance and Support to EU External Action.

The aim of this research is to identify how information, provided by the European Union's Copernicus Earth Observation Programme, can be effectively utilised in the Republic of Cyprus. The information was gained via targeted questionnaires on how Copernicus is effectively used by various international and national bodies. The participants of an international conference (Seventh International Conference on remote sensing and Geoinformation of Environment) were asked to fill an online questionnaire with fourteen targeted questions. The collated information from both, national and international questionnaires were analysed to identify whether Copernicus information is being underutilised. There were responders from educational institutions, governmental departments and non-governmental organisations. The results revealed that organizations use data from the six Copernicus services (i.e.: 16% Atmosphere, 15% Marine, 36% Land, 18% Climate change, 2% Security and 13% Emergency). The answers to questions related to training, education and training material were very interesting since it seems that the responders believe that their organizations lack of training and educational material regarding Copernicus data. 20% of the users they were not aware of any available training material.


What type of organisations are your end users?
Mentimeter
19%
26%
21%
13%
7%
15%
Public users
Educational Research Institution
Governmental Department
Local Government
Commercial Company
NGO

SBAS and DInSAR Technique Integration for Mining Subsidence Monitoring in the Rydułtowy Mine in Poland

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
kamila.pawluszek@upwr.edu.pl

Kamila Pawluszek[1], Andrzej Borkowski[1],

[1] Wroclaw University of Environmental and Life Sciences, The Institute of Geodesy and Geoinformatics, Poland

Keywords: Subsidence, SBAS, Dinsar, Interferometry

Abstract

Underground coal exploitation affects land subsidence, which can cause severe damages to urban structures and infrastructures located in the area of coal exploitation. Mining-related subsidence in the region of active exploitation is usually fast and is characterised by a high nonlinearity. Because of that, the monitoring of such a phenomenon using InSAR is challenging. Since, the traditional Differential Interferometry (DInSAR) exploits interferograms that are differences between at least two SAR images, the accuracy of this approach is restricted by elements connected with spatial and temporal decorrelation, signal delay as a result of atmospheric artefacts as well as orbital or topographic errors. In order to overcome abovementioned limitations, various approaches which exploit time-series interferometric SAR analysis have been proposed. Among them, Small BAseline Subset (SBAS) proposed by Berardino in 2002 is probably one of the most extensively used technique for deformation monitoring. SBAS technique offers great advantages to eliminate DInSAR limitation, e.g. filtering of atmospheric phase component. However, due to the ambiguous nature of the observation, this technique has the incapacity to detect "fast" deformations. Actually, if the differential deformation phase between two subsequent acquisitions exceeds – π to π, the real defamation rate cannot be entirely captured. Also, a substantial limitation of SBAS techniques is the necessity to predefine a deformation model in order to extract proper interferometric components. Mostly, the linear deformation model is applied. Unfortunately, coal-mining related subsidence is characterized by high speed and nonlinearity. Thus, additional errors may occur in final results when the predefined model does not fit the real deformation pattern.

Having considered the above-mentioned aspects, in the presented study, the integration of DInSAR and SBAS techniques is proposed. The goal of this integration is utilizing of advantages and reduction of disadvantages of both methods. The main objective of this work is to generate, as complete as possible, the deformation map over the study area that is located on the surrounding area of the Rydułtowy mine in Poland, in southern-western part of Upper Silesian Coal Basin.

For these purposes, consecutive DInSAR and SBAS processing have been performed for ascending and descending orbits. 106 ascending and 112 descending Sentinel-1 images have been processed by DInSAR and SBAS techniques. These images cover the time span from the 4th of January 2017 up to the 8th of October 2018 and from the 1st January 2017 up to the 4th of November 2018 for ascending and descending orbit, respectively. For SBAS, in total 442 and 463 differential interferograms have been generated for ascending and descending geometries. This corresponds in average to 5 interferograms per acquisition. Afterwards, DInSAR results have been corrected by atmospheric components extracted from the SBAS processing for both geometries. The maximum displacement which has been detected using SBAS technique was around -44cm in Line of Sight (LOS) for the time span 1.1.2017-8.10.2018. For

the same time, DInSAR technique detected maximum displacement of -87cm (LOS). Afterwards, LOS deformations have been re-projected into the vertical and east-west displacement components. Re-projected results for DInSAR and SBAS have been fused completely by means of regularized spline (CRS) within radial basis function interpolation for both deformation components (vertical and east-west). CRS method creates a smooth, gradually changing surface with values that may lie outside the sample data range. Practicably, points from SBAS processing and DInSAR results have been used for surface generation. Due to the atmospheric artefacts, DInSAR points have been used only within the subsidence basins, where SBAS approach failed with displacement estimation. Finally, two complete deformation map in vertical and east-west direction have been generated (Fig.1).

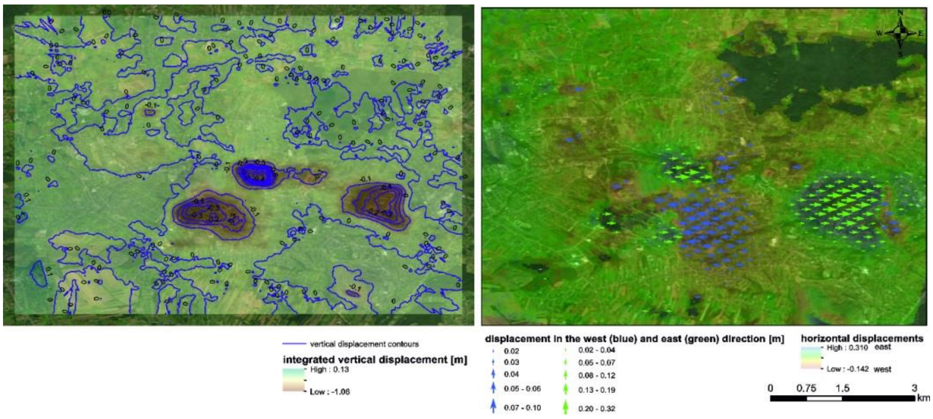


Figure 1. Vertical deformation components (on the left) and east-west deformation components (on the right) extracted from integrated SBAS and DInSAR approaches.

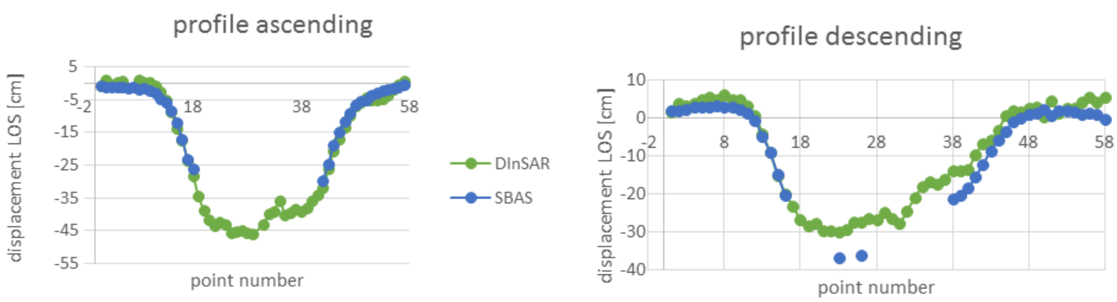


Figure 2. Subsidence profile for ascending and descending orbit

Assessments of achieved results have been performed internally and externally by the comparison with geometric levelling data of four profiles. In one levelling profile, interferometric approach underestimates the subsidence deformation rate. Results indicated that integrated data of DInSAR and SBAS can be effectively applied to monitor mining-related terrain deformations. Additionally, we have compared deformations of DInSAR and SBAS along the chosen profiles. One example for ascending and descending orbit modes are demonstrated in fig 2. A good agreement between SBAS and DInSAR results in the areas of moderate subsidence indicates that SBAS technique seems to be reliable for the monitoring of residual subsidence which surrounds subsidence basins while DInSAR is more suitable for fast deformation estimation in the centre of subsidence basin.

Using Multiple Along and Across Track Pléiades Stereo Images for Improved Digital Surface Model Generation

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
roland.perko@joanneum.at

Roland Perko[1], Manuela Hirschmugl[1], Janik Deutscher[1], Mathias Schardt[1], Markus Hollaus[2], Peter M. Roth[3]

[1] Joanneum Research, Institute for Information and Communication Technologies, Austria
[2] Technical University of Vienna, Department of Geodesy and Geoinformation, Austria
[3] Graz University of Technology, Institute of Computer Graphics and Vision, Austria

Keywords: Digital surface model, Along and across track stereo, Pléiades satellites

Abstract

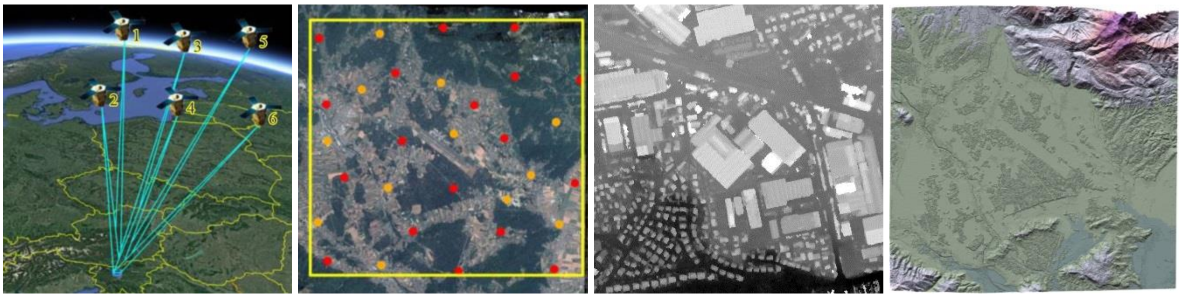
In airborne photogrammetry it is common sense to collect many images with high overlap both in along and in across track direction when a highly accurate digital surface model should be generated. Such highly redundant data aids the processing chain as inaccuracies or gross outliers resulting from one stereo pair can be minimized or even corrected by other stereo data in the fusion process. In satellite remote sensing, however, data is mostly collected with lower redundancy due to acquisition costs, downlink capacity, and data size. Nowadays novel satellite sensors like the Pléiades constellation are able to collect stereo and tri-stereo data in one single overflight, leading to redundant information in along track direction. Since the Pléiades sensors are also able to steer in across track direction they can collect images over the same scene on ground from different orbits yielding also across track stereo pairs. Such photogrammetry-like multi-overlap satellite images were never jointly processed, although the underlying potential is certainly worth being investigated.

This work presents an empirical study with multiple view geometry Pléiades data. It discusses the methodologies that are needed to process such data and describes the pros and cons of the proposed strategy. An effect often discussed in literature is that a single along track stereo acquisition with an across track angle (oblique look angle orthogonal to the flight path) causes problems because occlusions occur in this specific across direction. This issue is, for example, present in forestry applications and in city modelling. Having another stereo set from an adjacent or opposite orbit may solve this occlusion problem. The presented topic is scientifically motivated and there are also some drawbacks and constraints in such a data acquisition process. First, weather should be stable over the days of data collection (especially cloud free images are hard to acquire). Second, multiple stereo sets from multiple orbits result in higher data acquisition costs. Third, there might be acquisition conflicts, which may result in a priority tasking, again raising the data costs. The latter can, however also be the case for simple stereo pairs. On the other hand, such data sets may become cheaper over time or even freely available as known from other missions.

In order to investigate this issue, an empirical study is conducted based on multi view Pléiades data that depicts a scene from multiple orbits and multiple incidence angles. In particular three along track stereo datasets acquired from adjacent orbits within three days were chosen. They observe the same region on ground (cf. Figure 1). Highly accurate reference data exist, consisting of terrestrial measured ground control points, independent check points, LiDAR reference digital surface model, digital terrain

model, and image coordinate measurements of control points. The terrain height of the core region of interest ranges from 345 to 1900 meters a.s.l., and the scenes covers about 400 km^2 consisting of agricultural land, managed forest, villages, the airport Brnik, and mountainous areas.

First, an accuracy analysis of the 2D and 3D geo-location performance is elaborated showing that ground control points can be modelled with a root mean square residual error below 30 cm in East, North, and height. Second, digital surface models are generated from all possible stereo pairs and are additionally fused in the multiple view geometry sense. The proposed fusion is based on a statistical model which determines the mode of the probability distribution of all given height values in a spatial local neighbourhood. It is shown that employing more data increases the accuracy of the resulting digital surface model while reducing the amount of the non-reconstructed regions. As expected, the images acquired under a large across track angle contribute less to the final digital surface model.



		1	**2**	**3**	**4**	**5**	**6**
	Date	2013 07 27	2013 07 27	2013 07 28	2013 07 28	2013 07 29	2013 07 29
	Time	10:10:09	10:10:51	10:03:43	10:04:21	9:55:04	9:55:50
Incidence Angle [°]	along	-12.12	12.36	-7.39	14.78	-10.20	16.91
	across	-1.98	-8.59	9.36	3.95	22.31	16.90
	overall	14.9	12.3	15.3	11.8	24.1	23.3

Figure 1. (top-left) The multi view dataset showing the satellite's position over the study area in Slovenia, (top-right) an orthophoto overlaid with GCPs (red) and ICPs (orange) over the common region (yellow), (centre-left) detailed view of the resulting DSM for a region of 800x800 m^2 with heights ranging from 390 to 430 m, (centre-right) the resulting DSM depicted as painted relief, and (bottom) the main acquisition parameters of the six images.

A Combined Use of In-Situ and Remote Sensing Data for the Monitoring of Soil Moisture in Wallonia, Belgium

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
s.petit@issep.be

Sophie Petit[1], Odile Close[1], Laura Van de Vyvere[1], Benjamin Beaumont[1], Eric Hallot[1]

[1] Institut Scientifique de Service Public – ISSeP, Belgium

Keywords: Soil moisture estimates, Optical and radar remote sensing, In-situ data

Abstract

Global warming induces more occurrences of extreme events such as droughts, floods and heat waves which have an impact on agriculture, water resources, ecosystems, economy and human welfare. The potential of soil moisture to improve flood and drought modelling have numerously been highlighted. Soil moisture plays an important role in maintaining life on earth by modulating many physical, chemical and biological processes. The estimation of soil moisture finds its applications at different spatial and temporal scales (from local to global scales and from short to long term). On a regional and local scale, soil moisture is particularly useful for the agricultural sector and for flood management in addition to flow measurements and surface water tables. From a global perspective, through exchanges with the atmosphere via evapotranspiration, knowledge of soil moisture is also a key component in weather forecast models via general circulation models. Over long periods of time it gives an overview of climate changes. In this context, the Global Climate Observing System recognized soil moisture as an essential climatic variable.

This study investigates the potential of a combined use of in-situ, remote sensing and ancillary data for monitoring soil moisture in Wallonia, Belgium. It also describes the design, implementation, calibration of an in-situ soil moisture measurement network for environmental monitoring. On the one hand, in-situ measurements have the advantage of being precise and providing direct measurements that can be performed at different depths but gives estimates of soil moisture at a given local point. On the other hand, remote sensing makes it possible to study soil moisture at different scales, from local to global, but only gives soil moisture estimation of the near-surface zone, the latter being the first 5 cm of the unsaturated soil zone. Our methodology is assessed on two different test sites where in-situ soil moisture measurements are performed. These sites have been selected for their characteristics that are representative of the two main land use of interest in the region: one in agricultural fields and one in grasslands. The first part of the work aims at investigating the performance of time-domain reflectometry (TDR) probes and capacitance sensors in the context of the regional mapping of soil moisture. As a second step, we seek to investigate the combined use of the in-situ measurements, remote sensing and ancillary data in order to obtain an overall estimate of soil moisture on the Walloon territory. Indeed, while remote sensing can provide an effective methodology for mapping surface moisture content at a regional scale, it must be calibrated with in-situ quantitative measurements of soil moisture and used as a proxy to interpolate soil moisture at any location. To this end, the capabilities of original Sentinel-2 optical data and Sentinel-1 radar data, made available by the European Copernicus programme, are

evaluated. Furthermore, ancillary data such as soil properties, geological and geomorphological characteristics of the territory as well as precipitation data are included. By analysing and merging the different type of data, we put forward a first estimation map of soil moisture at the Walloon scale.

Ultimately, this study will draw recommendations regarding (1) the performance of both types of soil moisture probes, (2) the implementation, in Wallonia, of a measurement network, its maintenance and data retrieval, (3) the combination of remote sensing with in-situ and ancillary data and, (4) the more adequate modes of data acquisition, processing, storage and sharing necessary to obtain first soil surface moisture estimation map. This project will help to cope with the increasing number events and will provide support to water resources management and agricultural sector.

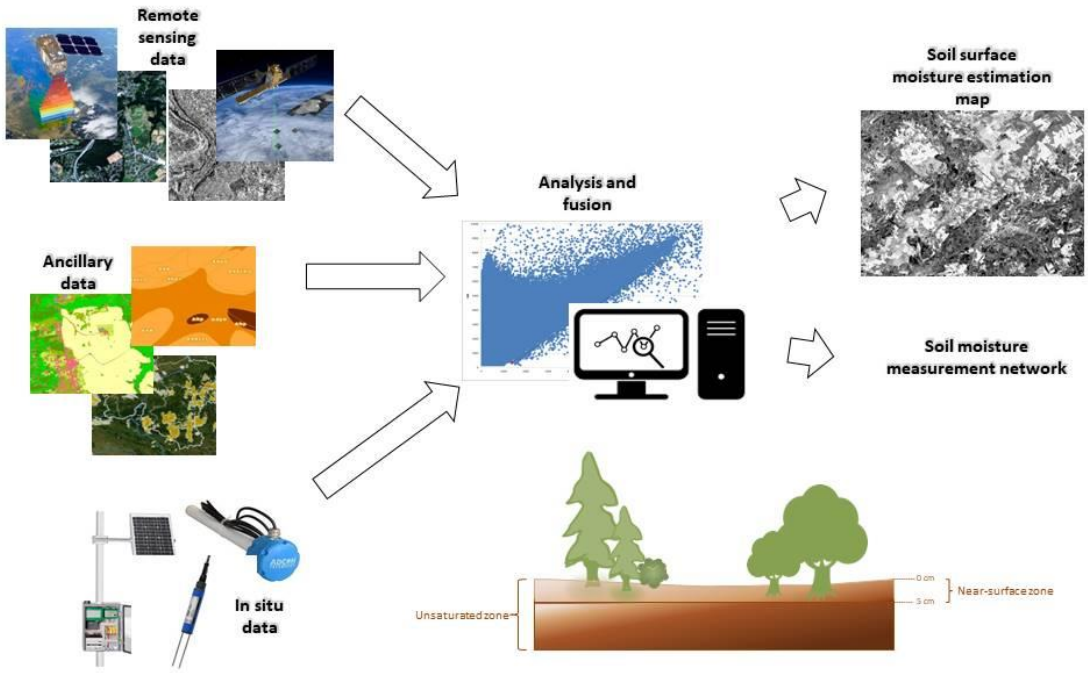


Figure 1. Combination of data for a soil surface moisture estimation map

Near Real-Time Change Detection in Forest Areas using Kalman Filtering

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
martin.puhm@joanneum.at

Martin Puhm[1], Andreas Wimmer[1], Mathias Schardt[1]

[1] Joanneum Research, DIGITAL-Remote Sensing and Geoinformation, Austria

Keywords: Forest monitoring, Near real-time, Time series, Kalman filter

Abstract

Current Earth observation missions employing spaceborne optical sensors acquire a vast volume of data. Through high-quality geo-referencing of the satellite images it is possible to create dense time series of measured grey values for any given spectral band at pixel-level. Several state-of-the-art algorithms use regression models based on trigonometric functions to capture the intra-annual variations of the spectral signatures caused by the phenological cycle. Consequently, newly available images may be compared to model-based forecasts. Abrupt changes of the spectral signature, possibly linked to a forest disturbance, are indicated by statistically significant deviations between new observations and the forecast.

With the same basic concept in mind, this work explores the applicability of the Kalman filter for change detection. Kalman filtering denotes a parameter estimation technique which yields optimal estimates in a statistical sense. In general, the Kalman filter approach requires the definition of a dynamic model and an observation model. The observation model on the one hand defines the relationship of the measurements to a set of state variables which cannot be observed directly. For a time series, the state variables usually represent the series' additive decomposition into trend, seasonal, and long-term cyclical components. The dynamic model on the other hand describes the expected temporal evolution of the state variables. By formulating the dynamic model in continuous time, the problem of gaps in the time series due to persistent cloud cover can be addressed. The Kalman filter operates recursively from one point in time to the next. Each recursion may be divided into two steps. In the time-update step, the states' temporal evolution is *predicted* based on the dynamic model. It is followed by the measurement-update step, where the predicted state estimate is *enhanced* by incorporating newly available observations.

Thus, the Kalman filter framework has some interesting properties regarding its application to remote sensing time series. Since the state variables are continuously updated, the underlying model can adapt to variations in the seasonal cycle, which may be present due to different climatic conditions compared to the previous year. This is a key advantage over simple regression models. Moreover, the ability to make model-based forecasts including confidence intervals is an inherent part of the technique. Occasional outliers in the time series due to un-masked clouds or cloud shadows can be identified if the caused deviation from the forecast is significant. In that case, the measurement-update step is bypassed so that the state estimate remains unbiased. If significant deviations occur temporally aggregated, an abrupt shift of the spectral signature caused by a change event is likely and the

affected pixel is flagged. Long time-gaps (e.g. 2+ months) between consecutive observations have an adverse effect on the level of uncertainty of the state predictions. While the chance of detecting persistent disturbances of a certain minimum magnitude (e.g. ≥5% abs. reflectance change) is still high, more subtle disturbances or cases where the forest regenerates quickly are more likely to be missed. The applicability of the approach hinges on the availability of a dense time series covering at least one full year, which is necessary to train the model and subsequently set the initial state of the filter.

A first operational version of the Kalman-filter-driven change detection algorithm outlined above has been developed over the course of the last year. We are currently assessing the performance in several test sites distributed over Europe and would welcome the opportunity to present and discuss the results at the conference.

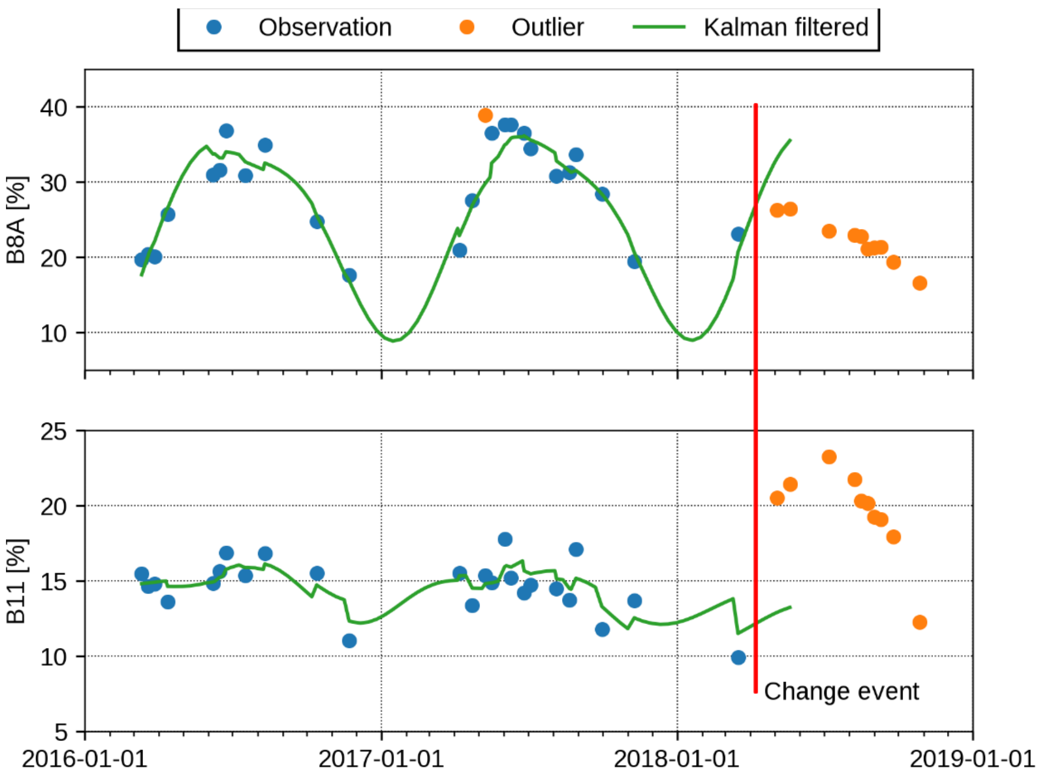


Figure 1. Single-pixel time series (coniferous forest) of Sentinel-2 surface reflectance observed for the bands B8A (near infrared) and B11 (short wave infrared). Observations are labelled as "Outlier" if a statistically significant deviation to the Kalman filter forecast occurs. Note the temporal aggregation of outliers after the change event.

Preserving Natural Reserves using Images from Satellites and RPAS EARSeL 2019 Digital I Earth I Observation

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
paulina.raeva@fsv.cvut.cz

Paulina Raeva[1], Karel Pavelka Jr.[1], Karel Pavelka[1]

[1] Czech Technical University in Prague, Faculty of Civil Engineering, Department of Geomatics, Czech Republic

Keywords: RPAS, Remote sensing, Natural reserve, Vegetation index

Abstract

This study aims at presenting a method for forest monitoring in the national nature reserve Božídarské rašeliniště. The purpose of the study is to provide with a suitable application of remote sensing along with close-range aerial photogrammetry techniques in observing the vegetation changes which take place in nature reserves.

The study area is located in the Krušný mountains in the Carlsbad Region, Czech Republic. It is located at a 940 – 1115 m altitude above sea level with an approximate area of 930 ha. Božídarské rašeliniště has been a natural reserve since 1965 where turf has been extracted till the beginning of WWII. It was decided to monitor and analyse the current state of the vegetation in the resort by using satellite images and images from Remotely Piloted Aircraft (RPA). The authors used satellite data from the Copernicus Sentinel 2 from June/July 2017. The image processing resulted in a classified map with vegetation classes. The authors would like to classify two types of plants and distinguish them from the wet areas in the region. For a more detailed approach, the area has been mapped twice with a VIS and NIR sensor from an in 2015 and 2017.

The results of the study will be focused on mapping the surface waters and the terrestrial and structural changes caused by the acid fluids which are registered in the area. Various vegetation indices have been applied in order to distinguish the vegetation from the wet ground spots. For example, the Normalized Difference Vegetation Index is a suitable indicator not only for discovering the vegetation status but also for determining surface waters. Having gathered multi-temporal satellite and photogrammetric information, a Geographic Information System (GIS) will be created indicating the influential changes in the natural reserve.

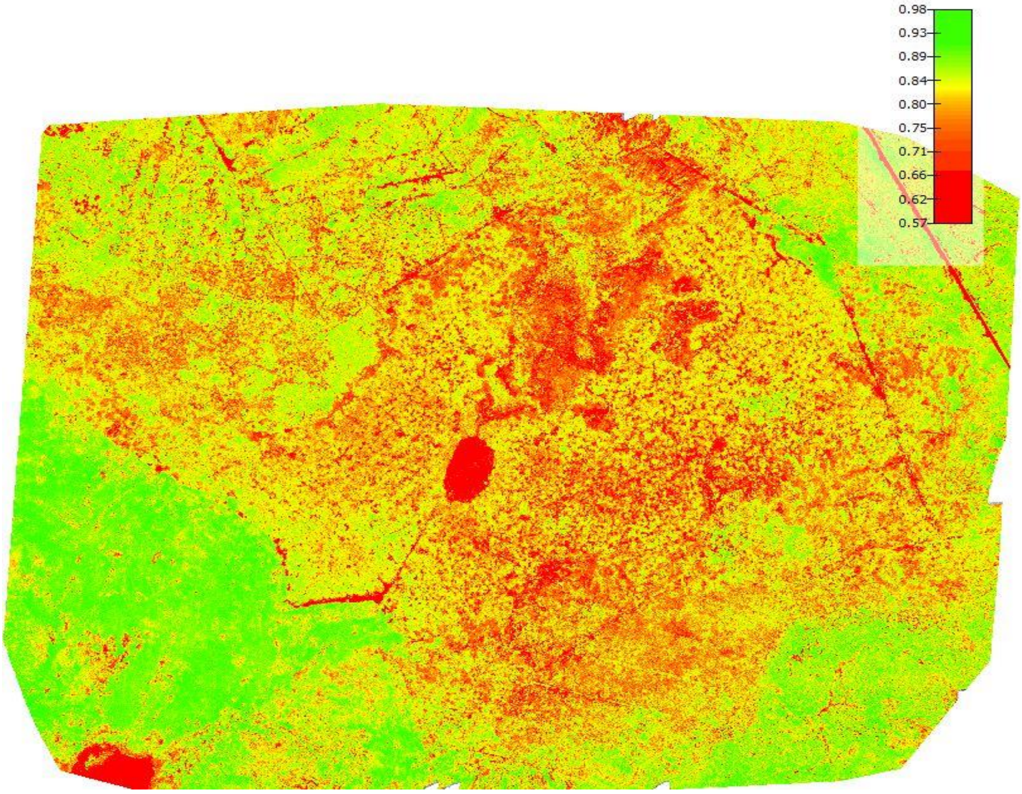


Figure 1. NDVI classification of the natural reserve Božídarské rašeliniště indicating wet ground spots (in the middle) and water routes. The results are based on NIR images captured by RPAS borne sensor take in June 2017

.

Using Satellite Data (sentinel 1) in Water Resource Management and Water Quality Prediction

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
vahid_rahdary@yahoo.com

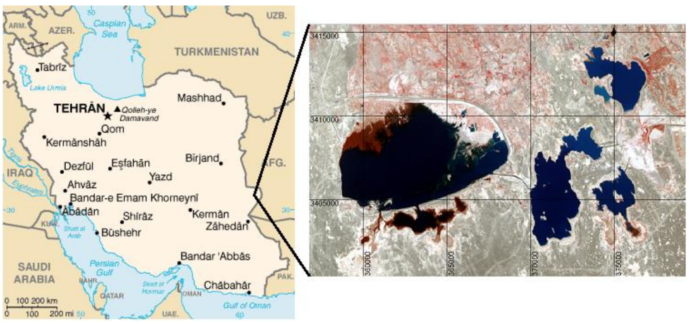
Vahid Rahdari[1], Saeideh Maleki[2]

[1]University of Zabol, Hamoun international wetland institute, Iran
[2] University of Zabol, Department of Natural resources, Iran

Keywords: Sentinel 1, Water quality, Image classification, Water quality model, Chah nimeh

Abstract

Satellite images provide valuable data source to produce land use/cover maps. The advantage of satellite images makes them an important data source for earth surface observation. Large area coverage, providing a collection of data over a variety of scales and resolutions, ability to acquired time Seri images, time and budget saving are the most important advantage of these images. In recent years, new technologies have leaded to develop the satellites with new capability. Sentinel2 is one of these satellites which monitors variability in land surface conditions. One of the study subject is monitoring water bodies during the time which is very important problem to control water reservoirs conditions. Main object of this study is monitoring water quality of Chah nimeh water reservoirs in Sistan region which is located in south-east of Iran. Chahnimeh water reservoirs are only water source in this area. Figure 1, shows Chah nimeh location in Iran.



Figure, 1. Chah nimeh location in Iran

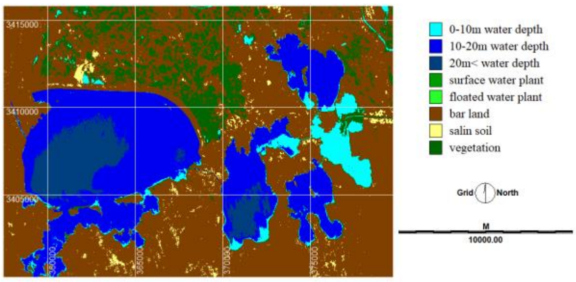
Recently in dry season, especially during summer, algae grow in low depth water body. These vegetation, decrease water quality especially they made smell in drinking water. In this study, sentinel2, images were used to produce data for water quality modelling. These data were applied to determine the algae blooming condition. In this order satellite data was prepared for each month in the same time of water sampling. For producing water quality model, when incoming water from Hirmand river came to end, in the end of 17 October 2017, water quality samples, water depth and some climatology data was collected in 14 sites which their locations were recorded in GPS. Satellite images were collected for preparing some water parameters like depth and algae area. Therefore, for each month in the same time of water sampling till 15 October 2018, totally 13 images from Sentinel2 were selected as table 1.

Table 1, Sentinel 2, selected images date

Tile number	T 41 RLQ			
17/10/2017	14/11/2017	19/12/2017	13/01/2018	15/10/2018
17/02/2018	14/03/2018	13/04/2018	18/05/2018	
17/06/2018	12/07/2018	16/08/2018	15/09/2018	

For image classification, field study was done and land covers around lakes were determined and their locations were recorded using GPS. Land covers types were determined by field study and literature review. By considering water depth measurements, water depth re-classed in to 3 classes as first: 0-10m, second: 10-20m and third: more than 20m. Training sites were prepared and using supervised image classification method and minimum distance approach, images were classified in to 8 classes. Figures 2 a and b, show land cover map in mid of Jun and October as a sample and table 2, shows their land cover area as Hectare.

Images classification accuracy assessment was don with calculating kappa coefficient and total accuracy which in all results were more than 0.83 and 87%. In produced maps algae which is in the surface of water or flouted in the water, were determined for each month. Satellite images classification has shown that in the middle of July algae blooming has happened and increased with very high rate in the surface and interior of water, especially in August and as result drinking water take smell. Produced maps have shown that increasing rate continued till middle of October and water algae increase in the lake to 838 hectares in this time. After that, algae area become stable and water smell decreased. Results of this study have shown that sentinel 2, images with capability of mapping some water quality parameters can be useful for water reservoir monitoring. Produced maps and field studies have shown that farmland and fishery activities around lakes are most important source of water which with decreasing water volume they concentrate in water.



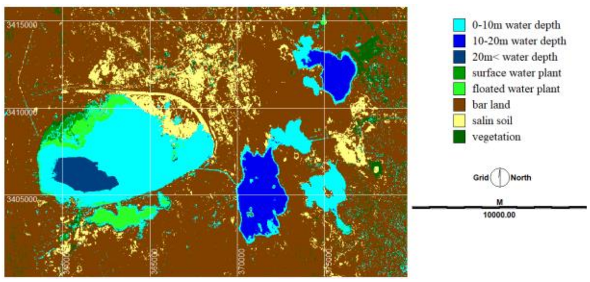


Figure 2a. Land cover map for October 2017 **2b**. Land cover map for October 2018

Table 2. land cover classes area (Hectare)

Class	0-10m water depth	10-20m water depth	20m< water depth	Surface water algae	Floated algae	Bare land	Saline soil	Vegetation
October 2017	1494	7632	2054	-	-	19588	546	3258
Jun 2018	5084	1387	521	176	662	23917	2985	1076

For producing water quality model, results of table 2, and other image classification results will used as dependent variable and then using multiple regression between algae area in water and water samples results, weather parameters measurements and water body area, water quality model prediction will prepare.

Use of Remote Sensing to Monitor Agricultural Projects for Economic Security in Humanitarian Context

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
yrebois@icrc.org

Rebois Yann[1], Maria Alejandra Arango[1], Sabrina Vatanshoeva[1], Thao Ton That Whelan[1]

[1]The International Committee of the Red Cross, Geneva

Keywords: Satellite imagery, ICRC, EcoSec agriculture, Crop monitoring, Sentinel, Micro-satellite, Rainfall anomalies

Abstract

The ICRC mainly uses satellite images in urban contexts for water network rehabilitation, but recently started to use them to also monitor agricultural projects. In our presentation we show examples on how optical and Radar satellite imagery and geospatial information were used by ICRC's Economical Security Unit EcoSec for planning and decision making in various projects.

Before approving a donation of seeds and materials to the victims of a conflict, the EcoSec team generally prepares assessments such as nutrition, livelihoods and market prices surveys in the affected villages. Preliminary work starts with sampling methodologies for the selected villages extracted and formatted out of a global worldwide geodatabase, consolidating gazetteers and locations collected in the field. This list could be a reference for the whole institution, as nowadays the surveys are made with Mobile Data Collection (MDC) solutions which use the geoanalysis as a base line. This allows the team to collect and analyze the needs quickly and as a consequence their response is more effective. A combination of layers depicting the varying contexts, such as security incidents (e.g. Armed Conflict Location & Event Data Project ACLED) , the situation of stress (e.g. the Fews Net, Famine Early Warning) , the combination of the local information and the information from external providers about climatology and anomalies, market accessibility and price variation and regular aerial views helps the team in the field to operate and to deliver the adequate help. This leads to the question of which remote sensing methodologies – mainly in the field of satellite imagery – would be most suitable for the monitoring of agricultural production projects in conflict zones?

Remote sensing for crop monitoring in Mozambique: A pilot project that the ICRC is carrying out using the advantages of remote sensing is to estimate the evolution of crops in an agricultural season and to evaluate the agricultural land use from 2017 until 2019 in Gorongosa and Maringue, Mozambique, which are areas affected by waves of violence. Remote sensing allows reduction of the field activity normally carried out as well the ability to obtain a global picture of less accessible places in the area. It is standard practice for ICRC EcoSec to provide maize seeds to farmers and, as per local customs of inter-cropping, these are commonly mixed with seeds of other crops (sorghum, butter beans and cowpeas) prior to planting. This crop mixture combined with different vegetative timing (growth rate) obviously results in a non-uniform plant distribution which can be observed by remote sensing. Parameters aimed to be assessed during implementation of the project are the time comparison of

crop growth in various locations as well as productivity in order to estimate the quality distribution. Proper detection of the farming plot, monitoring of crop development, estimation of productivity and comparison with previous ICRC distributions as well harvest forecasting are possible with the use of remote sensing data. Furthermore, relevant observation of environmental factors can be monitored. As a plan of action, mid resolution satellite images (Sentinel, 10m) and high resolution (tasked SkySat, 0,8 m and Worldview-2, 0.5 m) in combination with field data were used. Using satellite images with various resolutions in combination with ground-truthing work means NDVI analysis can be performed in attempting to map different crops and mixtures. Using classification (supervised and unsupervised) and vegetation ratios allows generation of automatic crop maps identifying what is growing when, where and in how much land.

Figure 1. Observation of agricultural activity in study area in Mozambique (left: 09 Jan 2019, right 25 Dec 2018): parts of the field are being cultivated © SkySat, Planet

Through utilization of data with different resolutions and frequencies, the analysis of this project provided the possibility to evaluate the pros and cons of different sources of data. And although the suitability of the use of drones under actual ICRC working conditions has yet to be defined, ideally they could provide complementary data that would allow synergy with satellite data.

Immersive Virtual Reality Coral Reef Visualization Based on Remote Sensing and Biodiversity Information

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
rainer.ressl@conabio.gob.mx

Rainer Ressl[1], Florian Hruby[1]

[1] National Commission for the Knowledge and Use of Biodiversity (CONABIO), México

Keywords: Coral reef, Virtual Reality, Immersion, Virtual ecosystem,

Abstract

Virtual reality (VR) technologies are enjoying increasing popularity, not only in the video game industry, but also in a variety of new applications. VR techniques have a great potential for the visualization of scientific content, e.g. for the illustration of complex relationships or for the procurement of information difficult to access in space. In this project, we use immersive VR for the visualization of biodiversity information, in particular of ecosystems that are not easily accessible, e.g. mangrove forests, deep sea or coral reefs.

In contrast to various other "virtual ecosystems", we aim to map the ecosystem as accurately as possible in terms of geography and biological content. Hence, our development of the virtual coral reef is based entirely on real data gathered via remote sensing techniques, GIS datasets and in-situ information. An area of about 12 km^2, located south of Cancun in the Mexican Caribbean, has been modelled.

A highly realistic representation of natural environments makes the development demanding and expensive, since this requires a comprehensive inventory of the natural resources (e.g. topography / bathymetry, benthic habitats, flora and fauna) and their exact replication in VR-space. For a detailed bathymetry of the coral reef and associated benthic habitats World-View-2 satellite data were classified. The data was first corrected for atmospheric disturbance. Then, the influence of the water column on the backscattered signal measured by the satellite was retrieved using a bio-optical model, resulting in a "clean" signal for the subsequent classification process. Due to the high transparency of Caribbean coastal waters we were able to derive the bathymetry up to a depth of about 20 m. Thus, we could cover the entire reef and the surrounding ecosystems. 7 benthic classes (corals, degraded corals, octocorals, macroalgae, seagrass, mixed vegetation class, sediments) were derived from the satellite data, with an accuracy across all classes of 71%. The classification was then filtered, aggregated into objects and converted into a thematic habitat map. For details on habitat and bathymetry mapping also cf. Cerdeira-Estrada et al. (2012).

Further, modelling of caustic effects of water is essential for a realistic perception of the virtual underwater environment. For this purpose, water turbidity and light refraction was rendered with respect to real water depth, which was derived indirectly through the bathymetry map. Particles were added to simulate turbidity of seawater and to reflect visibility in terms of distance.

For the VR-replication of the natural habitats, in-situ data from field work were used as well as information provided by the National Information System on Biodiversity (SNIB) of the National Commission for Knowledge and Use of Biodiversity (CONABIO). Field data about biological parameters

such as height, density, texture, presence and abundance of the species were a valuable source for modelling the ecosystems. From the large number of registered fauna species, a short-list was created to reduce the number of necessary 3D models. Priority criteria for this selection were abundance (fish), uniqueness and / or endemism and also charismatic characteristics of the species (e.g., turtle, seahorses). The current VR version contains about 20 fish species, 12 corals, 4 seagrass species as well as various invertebrates and crustaceans. All objects were modelled using open-source modelling and animation software *Blender*. For rendering the principal habitats, the 7 class benthic map was used as spatial reference. The ecological and biological communities of the individual habitats were represented on the basis of the mentioned in-situ photo and video recordings. Initially, individual 3D grid models were created in high geometric resolution for all fauna species. The number of geometries is dynamically adjusted with respect to viewing distance / proximity of objects to optimize rendering time. Great emphasis was placed on highly detailed textures, derived from photos and videos as well as from various species databases. Subsequently, so-called scenarios were created via blueprint programming in Unreal Engine. These scenarios define all components of the virtual ecosystem. Through the use of metric coordinates, a nearly true-to-scale modelling of the biotopes was strived for. Corals, macro-algae, fish, invertebrates were scaled in terms of their real size in nature. Species composition and density was also realized with respect to the in-situ data.

For the interactive "exploration" of the virtual coral reef “feature cards" provide information on the distribution, biology, habitat and potential threats of the individual species. This information is made visible in the virtual space through floating symbols and can be retrieved interactively in text or audio format.

Currently, we are working on artificial intelligence (AI) based algorithms to model the collective movement of fishes in swarms. In a next step, we plan to apply AI not just to model the movement, but also the behaviour of VR agents, e.g. to realistically simulate also higher-order interactions between flora and fauna (e.g. predator-prey relationships). To facilitate a highly immersive experience, the Oculus Rift head-mounted display is the target hardware our VR app is currently developed for. Parts of the project results are being published also in less- or non-immersive formats.

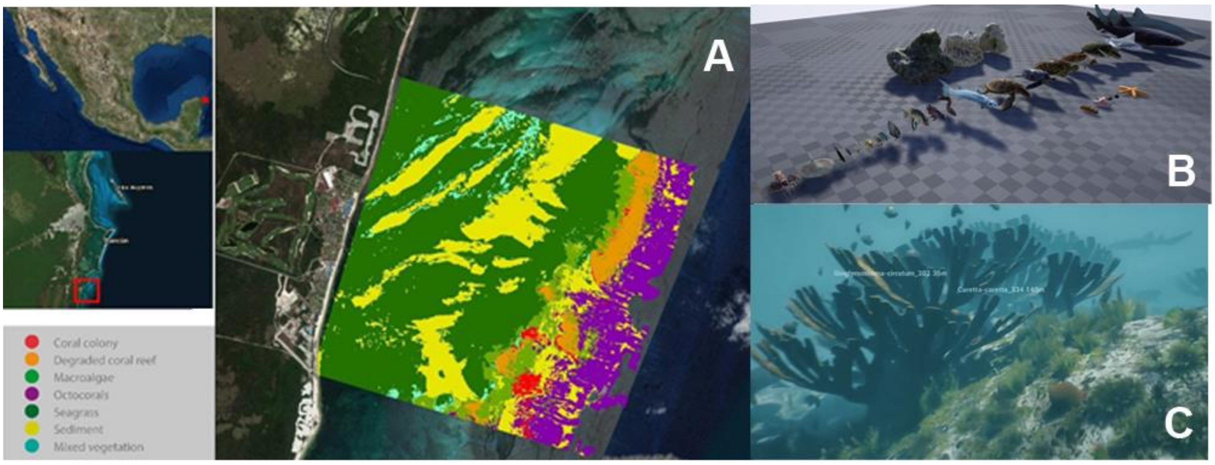


Figure 1. (a) Benthic habitat map derived from the classification of World-View-2 satellite data. (b) modelled species. (c) modelled virtual coral reef ecosystem

Research Capacity for Uptake and Evolution of Copernicus

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
barbara.riedler@sbg.ac.at

Barbara Riedler[1], Stefan Lang[1], Peter Zeil[2], Nefeli Politi-Stergiou[3], Monica Miguel-Lago[4], Christoph Schröder[5], Valerio Tramutoli[6]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria
[2] Spatial Services, Austria
[3] Evenflow, Belgium
[4] EARSC, Belgium
[5] University of Malaga, Spain
[6] University of Basilicata, Italy

Keywords: Copernicus Academy, CopHub.AC, Copernicus services, Innovation hub, Knowledge landscape, Research briefs, Taxonomy

Abstract

The earth observation programme Copernicus provides freely available satellite and in-situ data and derived information products in its various service domains atmosphere, marine, and land monitoring, as well as climate change, emergency management and human security. The use of such data and services facilitates innovative solutions for challenges faced by the society. For such innovation to be realized, inventions from research need to be validated as robust and relevant through the adoption by user communities.

The network of the Copernicus Academy with 150 members from research institutions is an invaluable pool of experts and application know-how from different domains and nations – in- and outside of Europe. The member's capacities and knowledge should be exploited to facilitate the search for expertise by location, thematic area and types of activities, to recognize and explore synergies, and to open the Academy for the general public.

To sustain the Copernicus Academy, increase its visibility and encourage research cooperation, the H2020 project CopHub.AC intends to create a knowledge and innovation hub. It will support the Copernicus Academy by dedicated activities such as mapping and monitoring activities, and liaising between its members in regard to initiatives of interest for the network, such as events and educational opportunities. As a second important function, the foreseen Copernicus Academy hub is to foster and link ongoing R&D activities in all Copernicus-relevant academic fields and thematic areas, as well as strengthen the evolution of Copernicus services and their uptake by industry and public authorities. Thereby the thematic working groups have a moderating, monitoring and advisory function within the hub.

To realize the above mentioned functions four technical components of the hub are foreseen: the CopHub.AC Gateway, Research Briefs 2.0, Knowledge Landscape and the CopHubCitizen App (Fig.1). The CopHub.AC's Gateway – the searchable inventory of the Copernicus Academy – facilitates the sharing of institutional information, educational offers and experiences between the members. The CopHub.AC's Research Briefs 2.0 provide the highlights of Copernicus-related research outputs, their

potential and existing application fields, the methodology used, key results, the innovative impact and readiness level to enable the process to innovation. The used taxonomies are not only a process of naming and classifying EO services but a tool to improve the understanding between communities. Links will be established to the emerging EO/GI Body of Knowledge (see www.eo4geo.eu) with respect to concepts and methods being used and the EARSC thematic taxonomy (https://bit.ly/2UG4axB) in terms of the applications and users, relating products and services that might help for the monitoring and reporting of the sustainable development goals (SDGs). To illustrate the distributed capacities – application and method-wise - within the Academy, CopHub.AC develops a Knowledge Landscape. Built on the information collected in the gateway and research briefs, distributed experience and capacities are illustrated and through combined search options are user-specific retrievable. Thus not only the collaboration within the ecosystem is stimulated but the interactive landscape also opens the door for non-scientists to be informed about the benefits of space-derived information. Finally, the CopHubCitizen App makes the knowledge landscape and the research capacities accessible for the interested public.

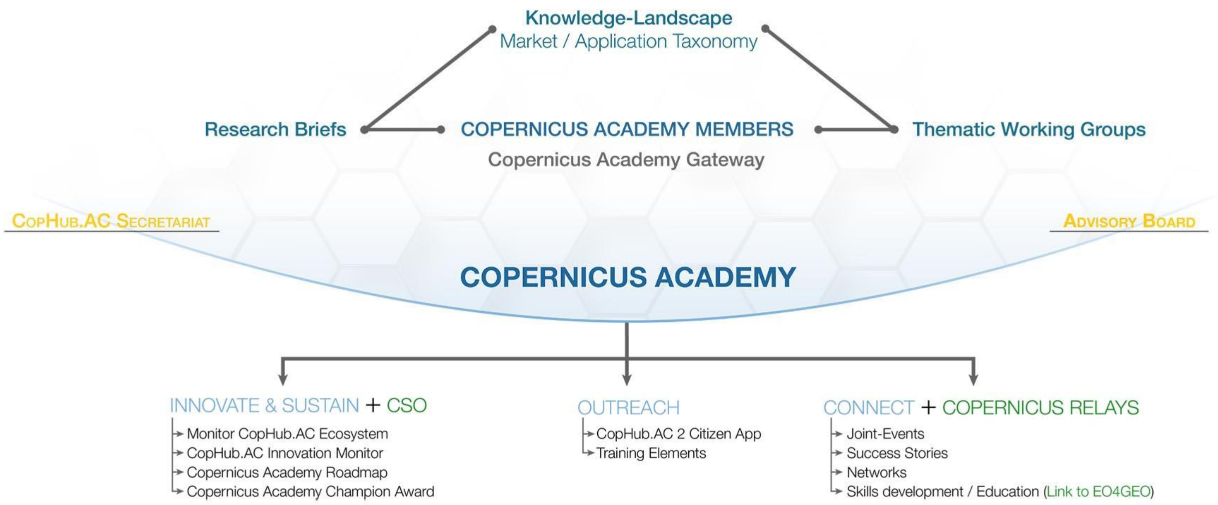


Figure 1. Elements to strengthen and sustain the Copernicus Academy

Spatially-Explicit Modelling of Slum Growth with an Urban Cellular Automaton – Three Scenarios of Lagos 2035

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
andreas.rienow@rub.de

Andreas Rienow[1], Olabisi Badmos[2], Carsten Jürgens[1]

[1] Ruhr-University Bochum, Department of Geography, Geomatics Research Group, Germany
[2] Center for Development Research, Germany

Keywords: Artificial intelligence, Cellular automata, Urban growth, Slum growth, Sentinel-2, RapidEye

Abstract

The lagoon metropolis Lagos (Nigeria) is often referred to as city that won't stop growing. Between 2000 and 2017 Lagos nearly doubled. The social impact is that more than 70% of her residents presently resides in slums. This study contributes to body of knowledge on slum growth monitoring by deriving land use maps based on object-oriented classification of Sentinel-2 and RapidEye data and the application of intensity analysis. Furthermore, pattern and process of slum growth are and analysed and statistically linked in order to provide the data base for the prediction of future slum growth based on the implementation of the cellular automata SLETUH. The results of this study show that slums in Lagos increased spatially between 2009 and 2015 gaining a land area of 9.14 km^2 heavily influenced by in-migration as main driving force of slum development in Lagos. However, the intensity analysis reveals slum as an active land-use category, losing some of its land area but also gaining new land area during this period. The annual gain and loss was 10.08% and 6.41%, respectively, compared to the uniform intensity of 3.15%. A systematic process of transition was observed between slums and other urban areas and open space in the interval studied, and this process was mainly influenced by the Lagos state government. The transition from slum to other urban land-use categories is attributed to gentrification and demolition processes, while the transition from other land-use categories to slum is due to poor maintenance of existing buildings and encroachment on available spaces in the city. Beside other urban areas and open spaces, riparian areas were converted into slum areas both the land as well as the water side.

The historic pattern trends and the socioeconomic as well as geobiophysical factors driving the processes of slum growth, served as main input for the cellular automata (CA) SLEUTH (abbr. Slope, Land Use, Exclusion, Urban, Transport, Hillshade) – an artificial intelligence technique. The CA was calibrated, validated, and implemented in order to spatially explicit explore the future of slum growth in Lagos for the year 2035. It is the first time that SLEUTH was tested to simulate and predict spatial dynamics and patterns of slum growth. In-situ surveys were conducted in order to assess the influence of residential choices of slum dwellers. In doing so, a probability map was created spatializing the outcome of the residentials' decision making and reflecting their location choices. An overall accuracy of 79.17% and a relative operation characteristics value of 0.85 were achieved during the validation of the model. Three growth scenarios have been implemented for the city in 2035: scenario 1 was business as usual, scenario 2 was based on the future population projection for the city, while scenario 3 was based on limited interference by the government in slum development. Scenarios 1, 2 and 3 predicted that the slum area

will increase by 1.18 km², 4.02 km² and 1.28 km², respectively, in 2035 through further densification of the existing slums and new development at the south-eastern fringe of the city. The limited growth is due to the high population density in the city, and thus it is assumed that new slums will probably develop in the neighbouring cities due to spill over of the Lagos population to other local government areas of Lagos state. The study concludes with further perspectives of how the scenario-based results of slum growth in the future metropolitan area of Lagos can act as decision support for the cities' administration.

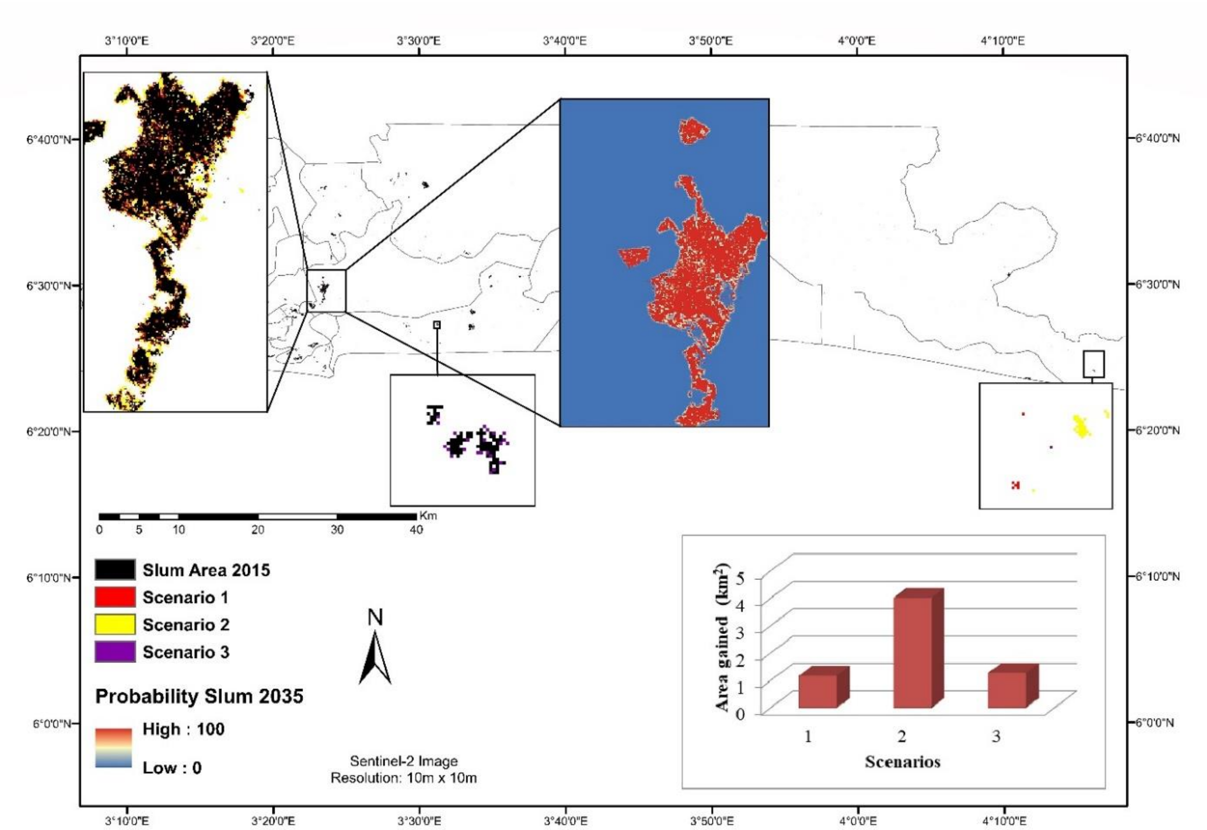


Figure 1. (a) Simulation of slum development in Lagos in 2035: the figure shows the three scenarios as well as the probability of slum growth after 100 iterations of SLEUTH in Lagos state and its local government areas (simulation based on classified Sentinel-2 data).

.

Commercial Cloud and EO Services usage: Opening the Gates to the Research Community Open Clouds for Research Environments (OCRE)

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
a.romeo@rheagroup.com

Antonio Romeo[1], Jose Manuel Delgado Blasco[1], Andres Steijaert[2], Joao Fernandes[3], Sara Pittonet[4], Marc-Elian Begin[5], Geoff Sawyer[6], Lefteris Mamais[7,]

[1] RHEA Group, Italy
[2] GÉANT, The Netherlands
[3] CERN, Switzerland
[4] Trust-IT, Italy
[5] SixSq, Switzerland
[6] EARSC, Belgium
[7] Evenflow, Belgium

Keywords: Cloud, Earth Observation, service procurement, service provision for scientists, European Open Science Cloud

Abstract

Cloud and Earth Observation (EO) based services offer the European Research community a wealth of powerful tools. However, for many researchers these tools are currently out of reach. It is difficult to find and select suitable services. Establishing agreements with cloud and EO service providers and ensuring legal and technical compliance requires specialist skills and takes an inordinate amount of time. Equally, service providers find it difficult to reach and meet the needs of the research community in technical, financial and legal areas.

The Open Clouds for Research Environments consortium (OCRE) will put in place an easy adoption route for researchers to Cloud & EO services through the European Open Science Cloud accelerating cloud adoption in the research community. In the autumn of 2019, OCRE will run a pan-European tender and establish framework agreements with service providers who meet the requirements of the research community. 10.000 European research and education institutes will be able to directly consume these offerings via the European Open Science Cloud service catalogue, through ready-to-use agreements. They will not have to run a tender of their own. In addition, to stimulate usage, OCRE will make available 9.5 million euro in service credits (vouchers), through adoption funds from the European Commission.

The OCRE consortium consists of GÉANT (consortium coordinator), CERN, RHEA and Trust-IT with the contribution of SixSq, as technology provider, together with EARSC and Evenflow, as support to outreach activities, and receives funding from the European Commission, as part of the European Open Science Cloud.

This presentation will introduce the benefits of the Open Clouds for Research Environment for providers and for researchers. It will also address how OCRE aggregates community demand and requirements and applies these into a pan-European call-for-competition, for commercial service providers to respond to. This tender which will be launched in Q3 of 2019, will result in procurement-compliant

framework agreements with suitable suppliers. In the presentation OCRE will talk about how providers can respond to this opportunity.

In addition the presentation will touch upon how researchers, affiliated/not affiliated to institutions will be able to consume the services through ready-to-use contracts, without the need to run their own tender and how OCRE will stimulate usage through an adoption fund.

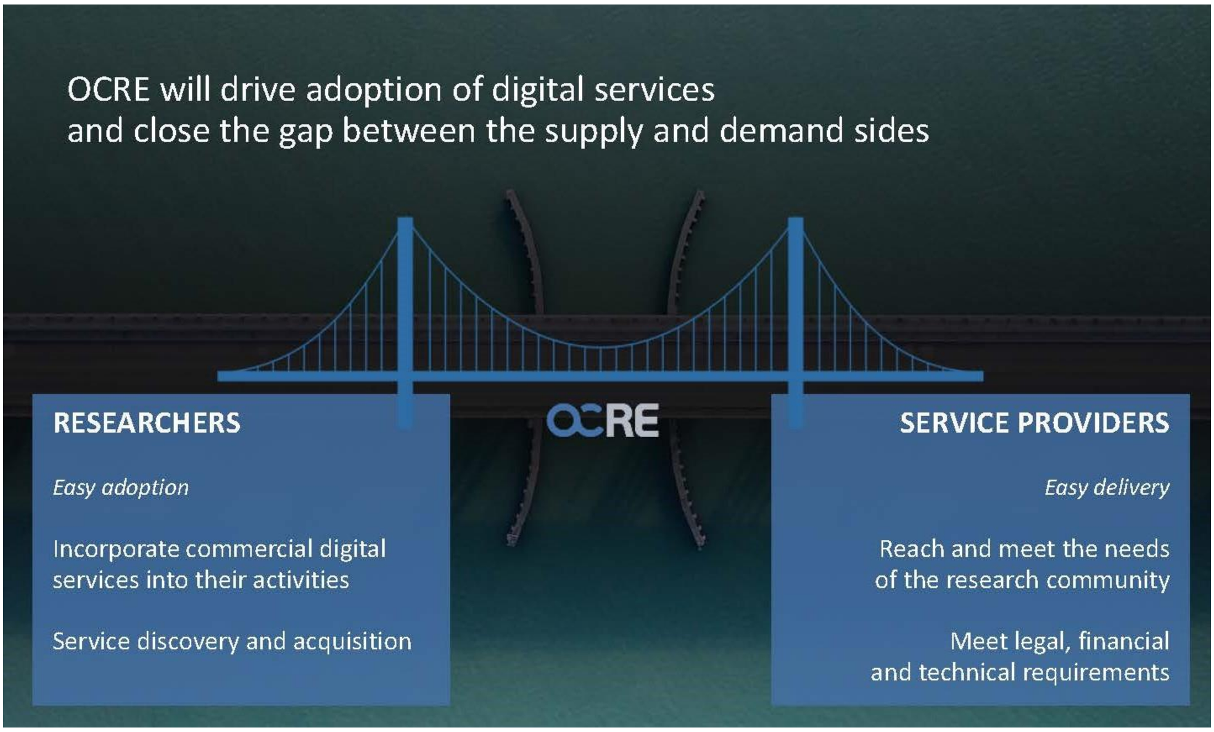


Figure 1. OCRE main purpose

Fire Monitoring and Analysis for Climate Change Mitigation and Improved Fire Management: The firemaps.net Platform Approach

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
gruecker@zebris.com

Gernot Ruecker[1], Dejan Popovíc[1], David Leimbach[1], Joachim Tiemann[1]

[1] ZEBRIS GbR, Munich, Germany

Keywords: Sentinel Copernicus missions, Fire, Greenhouse gas emissions, Climate change mitigation, Infrared remote sensing, EO platforms

Abstract

Vegetation and peat fires contribute substantially to global emissions of greenhouse gases (GHG). According to latest estimates, net fire emissions (i.e. the part of fire GHG not balanced by regrowth) amount to 6% of global fossil fuel GHG emission. Improving the management of fires in frequently burning ecosystems can help reduce GHG emissions and thus contribute to mitigation of climate change. In order to implement, monitor and document success in fire management, timely and accurate data on fire extent and impact, as well as weather and burning conditions is needed.

Monitoring and analysis of fires over large and often remote areas is only feasible with the help of Earth Observation (EO) satellites. Over the last decades, availability of free EO data has increased enormously, as has the availability of computing power, network speed and web based geospatial visualization and analysis technologies. Thermal sensors on geostationary or polar orbiting sensors (Meteosat, MODIS, FireBird, S-NPP VIIRS) make it possible to estimate the intensity of burning up to every 15 minutes, while sensors in visible to short wave infrared wavelength on the Sentinel and Landsat satellite series enable the production of burned area maps with up ~20 m spatial resolution every week. Since collected raw data is being frequently updated and often requires extensive processing for the extraction of information, there is a demand for a solution to simultaneously handle data pre-processing, analysis, and dissemination of results to be able to provide quick, reliable and user-friendly statistical information to assist decision-makers in different levels of management.

Firemaps.net was designed to meet the fire information needs of natural resource and conservation managers. It was developed in cooperation with users in Africa, South America and South East Asia, and interaction with users their requirements shaped the platform.

Key features of the firemaps.net platform are: Near real time monitoring of fire activity and carbon fluxes, weekly updated burned areas, daily analysis and forecast of relevant weather parameters, long time series of fire emissions to calculate baselines, fire risk and vulnerability maps and tools to monitor success of fire management planning and implementation. As a use case, we present the coupling of remote sensing data with weather information and fire spread models which enables forecasting and detailed hindsight analysis of the behaviour of wildfires. Rate of spread and fire intensity are key parameters to understand effects of fires on affected areas and to support management planning. To develop a new information product to analyse fire intensity, we assessed fire spread and fire radiative energy release rate (fire radiative power) over savanna fires using infrared sensors with different spatial,

spectral and temporal resolutions, focusing on sensors providing a spatial resolution higher than 500 m. The sensors used offer either high spatial resolution (Sentinel 2, Landsat 8) for fire detection with low temporal resolution, moderate spatial resolution and fire radiative power retrievals with moderate temporal resolution over selected sites (FireBird satellites), or moderate spatial resolution, high temporal resolution, but no fire radiative power retrievals (S-NPP VIIRS I-band active fire product), or moderate to low spatial resolution and fire radiative power retrievals at high temporal resolution (MODIS and geostationary satellites such as Meteosat, GOES or Himawari-8).

We extracted fire fronts from Landsat and Sentinel 2 (using the Shortwave Infrared bands) and used the available fire products for S-NPP VIIRS, MODIS and Meteosat. From these results we derived metrics on fire behaviour in our study areas. We relate our results to outputs of fire behaviour models and to results to published values. The presentation also covers processing workflows and challenges, as well as an overview of the implemented technologies to develop a modern geospatial information platform for monitoring wildfires.

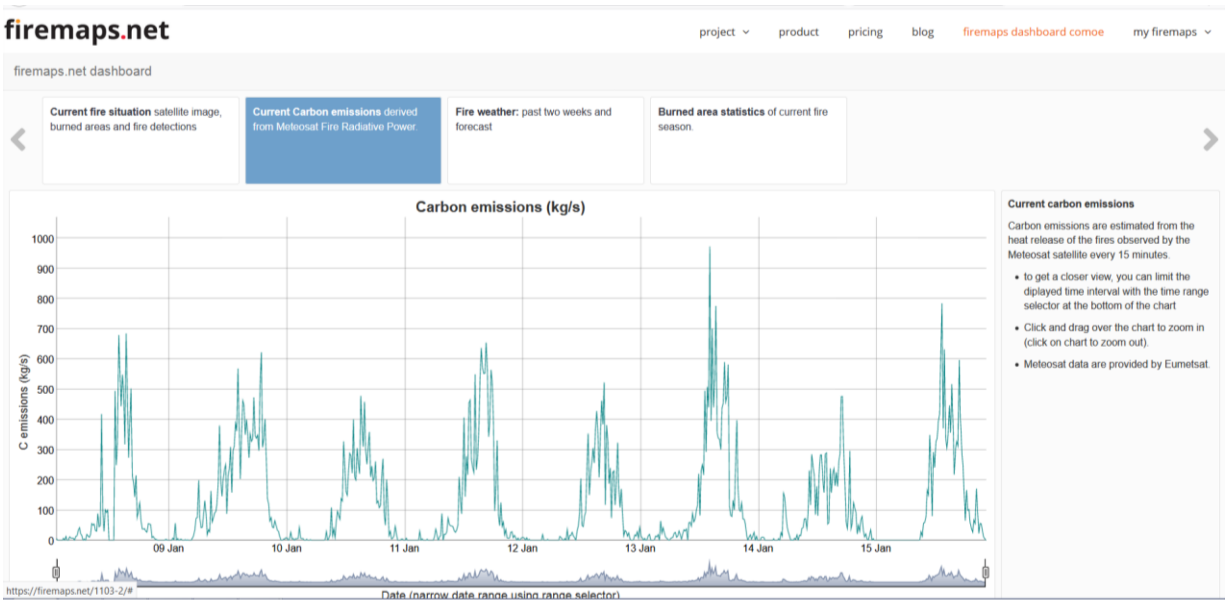


Figure 1. firemaps.net dashboard with near real time estimate of carbon emissions over a West African savanna landscape

Landslide Features Mapping with Ultra-High Aerial Images and Deep Learning

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
ionut.sandric@geo.unibuc.ro

Ionut Sandric[1,2], Marta Jurchescu[3], Radu Irimia[1], Zenaida Chitu[4,5], Viorel Ilinca[6], Francisc Senzaconi[7]

[1] University of Geography, Faculty of Geography, Bucharest, Romania
[2] Esri Romania, Romania
[3] Institute of Geography Romanian Academy, Romania
[4] National Administration of Meteorology, Romania
[5] National Institute of Hydrology and Water Management, Romania
[6] Geological Institute of Romania, Romania
[7] General Inspectorate for Emergency Situations, Romania

Keywords: Convolutional Neural Network, Landslides, Aerial images, Mapping, Digital Elevation Model

Abstract

With the increasing availability of data with very high and ultra-high spatial resolutions, the need to automate processes for mapping natural hazards has also increased. More and more applications are using deep learning algorithms to extract, track and classify valuable information from aerial images, satellite images or aerial geocoded videos. Our study is focused on an experiment consisting in mapping in detail the features of a landslide, aiming to identify elements like scarps (main and secondary), waves, lakes, toe and other landslide features. One of the main challenges we have is related with the fact that landslides are areas with a high number of objects with different shapes and high spectral variability. Also, landslides are in a continuous change in their active period, constantly changing the location and the shape of their features.

To accomplish the task of automated mapping of landslide features, several test sites in Romania were chosen. Each site has different environmental conditions in order to cover as many possible scenarios as possible. Only slides and earthflows are present in these sites. All the sites are covering hilly areas starting from Curvature Subcarthians up to the Getic Subcarpathians and counting about 15 different landslides. Each landslide has been flown with a DJI Phantom 4 quadcopter for at least one time, and some of the landslides have been flown for 6 times. The flights were made at spatial resolutions ranging from 5 to 10 centimetres and both nadir and oblique images were taken. As mapped features, we used only four classes for landslide features: scarps, ridges, water ponds and lobes. Because there weren't enough training images, we generated random noise (jitter) on the training images and we were able to multiply them from hundreds to thousands of images (over 2000). Combinations between spectral information and various terrain parameters, like hillshade, curvatures and slope, were used to enhance the training samples and improve the overall accuracy. We trained the model with tensorflow deep learning framework on five landslides and once the model was fully trained, we applied the model on ten different landslides.

Even though, the methodology is not yet complete, satisfactory results (Figure) have been achieved and landslides features were successfully mapped on various landslides. An overall accuracy of about 90% was achieved on the test data set. The model must be tested on other landslide types and in more different environmental conditions.

Figure 1. Automated identification of landslide scarps

DIEGO - A Multispectral Thermal Infrared Sensor on the International Space Station

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
schultz@giub.uni-bonn.de

Johannes Schultz[1,2], Andreas Rienow[2], Carsten Jürgens[2]

[1] University of Bonn, Department of Geography, Germany
[2] Ruhr-University Bochum, Department of Geography, Germany

Keywords: International Space Station ISS, Bartolomeo, Thermal remote sensing, Land surface temperature, Fire radiative power

Abstract

The International Space Station (ISS) is the greatest object on the Earth's orbit, with a weight of more than 450 t. Onboard of the ISS different experiments are carried out covering different scientific fields such as medicine, life sciences and material sciences. In 1998 when the first parts of the ISS reached space, there was no focus on ISS based Earth Observation and the sun-asynchronous inclined equatorial orbit seemed less suitable for Earth observation than the polar orbit most Earth observing satellites systems have. Nowadays the ISS has become a multiple instrument Earth observation satellite collecting a variety of parameters at different spatial resolutions, but with simultaneous acquisitions. So far 60 Earth remote sensing experiments have been conducted or are planned for the future. The main drivers for ISS based Earth Observation are new sensor technology, the unique and low ISS orbit (400 km) and the opportunity to have easy and relatively inexpensive access to space with external non-commercial and commercial platforms. External platforms like the "Japanese Experiment Module – Exposed Facility" (JEM-EF) with 10 payload slots outside the Japanese Kibo module or the commercial "Multi-User-System for Earth Sensing (MUSES)", developed and operated by Teledyne Brown Engineering, allow to host different sensors simultaneously. Several sensors for Earth Observation were recently installed or will be installed in the near future. For instance: a laser altimeter (Global Ecosystem Dynamics Investigation GEDI), ECOSTRESS (Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station), the OCO-3 (Orbiting Carbon Observatory 3") -all three are from NASA- or the hyperspectral sensor DESIS run by German Aerospace Agency (DLR)

Here we present the DIEGO (Dynamic Infrared Earth Observation on the ISS Orbit) sensor system that is planned to be mounted onboard the ISS and will collect high-resolution, multispectral data in visible, near infrared (VNIR), and mid-wavelength infrared (MWIR), as well as long-wavelength infrared (LWIR) often referred to as thermal infrared (TIR) of the Earth's surface. The DIEGO consortium run by University of Bonn and Ruhr-University Bochum, plans to install the system on the external Bartolomeo platform. Bartolomeo – currently developed and manufactured by Airbus Defence and Space (ADS) - will be attached to the European Columbus laboratory in 2019.

The sensor has in MWIR and LWIR a ground sampling distance (GSD) of less than 60 m and 20-30 m in VNIR. The DIEGO sensor will consist of different sensor heads, one is a cooled mega-pixel detector matrix for multi-spectral thermal IR observations and several heads with uncooled Si-detector arrays for visible (VNIR) imaging. All sensor heads, as well as the two star trackers and the Inertial Measurement Unit

(IMU), will be mounted and co-aligned on one common optical bench and provide in total 11 co-registered spectral bands, 3 for VNIR (0.52 – 0.86 µm), 2 for MWIR (3.6 – 3.9 µm) and 6 for LWIR (8.1 –11.65 µm). Additionally, DIEGO is equipped with a high resolution swivel video camera, coregistered with all bands, which can be used to derive 3D models, night images or to observe low light phenomena like read sprites, blue jets (large-scale electrical discharges that occur high above thunderstorms) or Meteors entering Earth atmosphere.

DIEGO will be able to deduce essential climate variables such as fire disturbance (via fire radiative power), land surface temperature and sea surface temperature (LST, SST). LST and SST are considered to be the most important variables for understanding local to global processes of energy budget. The state of the art sensor design and the unique advantages of the ISS orbit, enabling Earth Observation at different day and night times, are especially beneficial for thermal remote sensing and will allow to address numerous environmental topics such as: urban heat islands, global water cycle (e.g. desertification), monitoring of agricultural areas, thermal monitoring of volcanoes and emissions resulting from natural and anthropogenic fires. DIEGO is going to provide high-resolution (< 60 m), multi-spectral data from VNIR to LWIR wavelengths for more than 16 scientific fields. The DIEGO mission data will be made available to the scientific community via web GIS and data hubs. Besides the DIEGO sensor specifications, first simulated data examples are shown on the poster.

Furthermore, DIEGO will support ESA's supported education office "ESERO Germany" (European Space Education Resource Office) by disseminating learning resources on TIR remote sensing in STEM subjects and deepening the knowledge about key technologies of space flight and Earth observation in school lessons to break new ground in digital education and experiential learning.

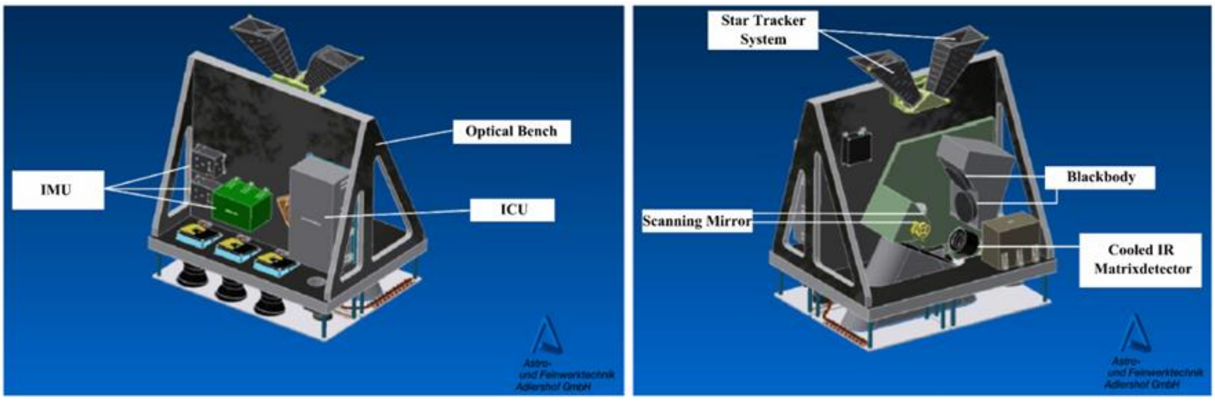


Figure 1. Diagram of the DIEGO sensor system

A Multi-Scale Model for the Detection and Structure Description of Fog Geo-Ecosystems in the Chilean-Peruvian Coastal Desert

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
siegmund@ph-heidelberg.de

Alexander Siegmund[1, 2], Julia Schumacher[1], Anne Schneibel[1], Camilo del Rio[3],

[1] Department of Geography – Research Group for Earth Observation (rgeo), Heidelberg University of Education
[2] Heidelberg Center for the Environment, Institute of Geography, Heidelberg University
[3] Instituto de Geografía, Pontificia Universidad Católica de Chile

Keywords: Fog ecosystem, Atacama desert, Tillandsia ssp., UAV, Chile, Peru

Abstract

The Chilean-Peruvian coastal desert is one of the most extreme geo-ecosystems worldwide. In its core zone, the average annual precipitation in the form of episodic rainfall events falls below 1 mm. Hence, plant growth is limited to so-called fog oases, where ecologically specialized plants cover their entire water demand by combing out water from the coastal fog that regularly occurs from the Pacific Ocean during night. In consequence of their strong dependency on the coastal fog, these fog geo-ecosystems are highly vulnerable to changes in its frequency and intensity as well as changes in the dominant wind direction. Their development could therefore directly reflect such regional climatic changes and might serve as a bioindicator for those. Yet, the main dynamics of these fog geo-ecosystems, locally known as lomas or lomas formations, are still poorly understood. This is especially true for the monospecific lomas of *Tillandsia* spp., though their sensitivity to climatic changes is assumed to be even higher than that of plurispecific lomas (i.e. lomas formed by several different species).

Against this background, a multi-scale remote sensing approach for the detection, analysis and monitoring of the distribution patterns of the *Tillandsia* lomas in the Chilean-Peruvian coastal desert was developed. WorldView-3 data were used to develop semi-automated algorithms to detect the spatial extent of the *Tillandsia* lomas in the entire study area (regional level). The study area covers the coastal desert from the Loa river (21°25'S) in northern Chile up to the city Chala (15°50'S) in southern Peru, i.e. the part of the distribution area of the *Tillandsia* lomas where, in most of the years, fog is the only form of precipitation. On a local level, selected ecosystem sites in northern Chile were then examined in more detail. Data from unmanned aircraft systems were used to create orthomosaics and digital surface models with a spatial resolution in the sub-decimeter range. From these products, several structural characteristics (e.g. coverage ratio, cover patterns) of the plant stands were derived, which allow a systematic and quantitative spatial description. Additionally, in cooperation with the Centre for Organismal Studies (COS) Heidelberg, the endemic *Tillandsia landbeckii* was examined regarding vitality and genetic diversity, in order to detect structural characteristics that reflect the condition of the *Tillandsia* lomas. The relationship between the distribution of the *Tillandsia* lomas and the coastal fog (occurrence, frequency, intensity) were analyzed via a correlation with remotely sensed stratocumulus cloud detections and on-site fog water yields, which were measured by standard fog collectors and additional climatic sensors. Finally, the results of the local plant stand analyses were extrapolated to the regional level via WorldView-3 data and topographical models.

The presented method is an integrative approach of several remote sensing products with multi-level hierarchy, complemented by in-situ observations (see Fig. 1). The results contribute to a better understanding of the interaction between atmosphere and biosphere in the Chilean-Peruvian coastal desert and may serve as the basis for protecting the fog geo-ecosystems and their endemic species. Moreover, the method allows for a systematic detection and monitoring of future changes in the distribution patterns of the *Tillandsia lomas* as well as for the estimation of using fog water as local sustainable water resource.

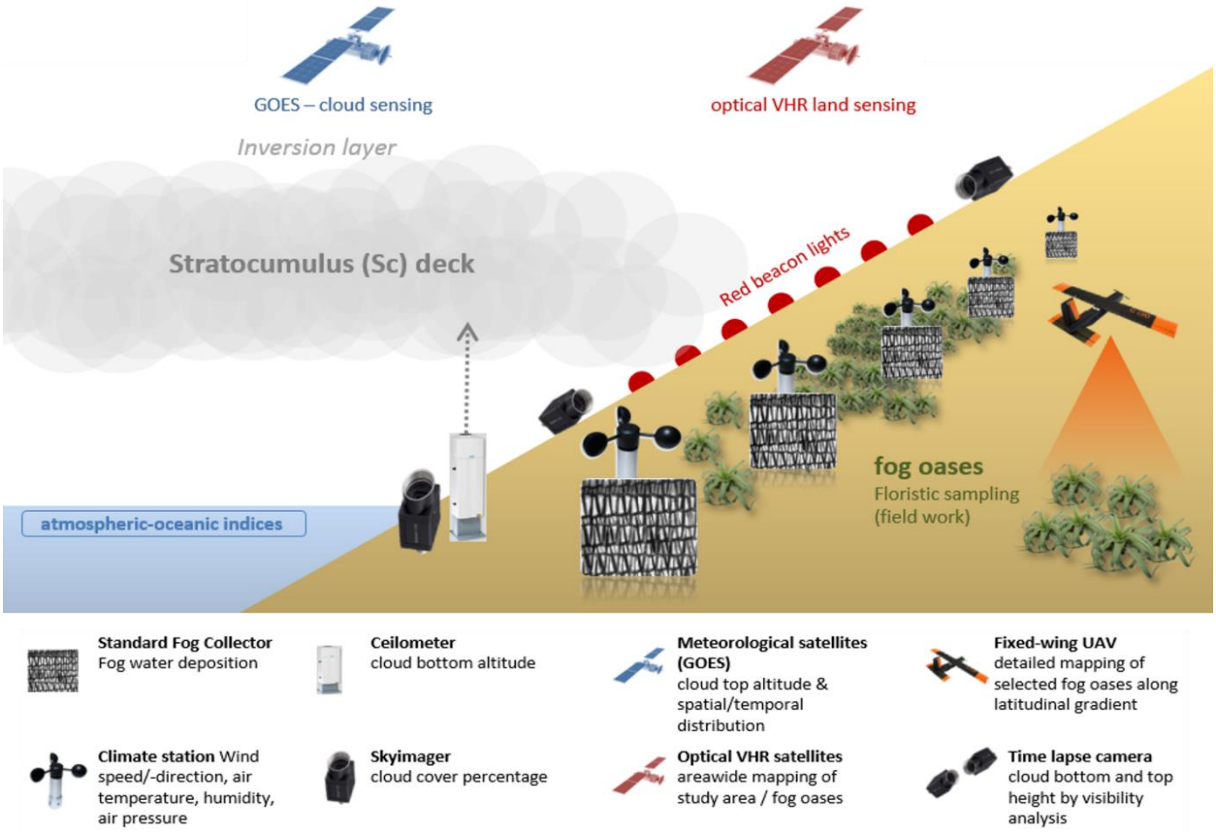


Figure 1. Design setup for the detection and description of fog ecosystems

Living Earth: Interactive E-learning Modules on geo:spektiv to Explore Living Habitats by Remote Sensing

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
siegmund@ph-heidelberg.de

Alexandra Siegmund[3], Alexander Siegmund[1, 2], Julia Schumacher [1, 3]

[1] Heidelberg University of Education, Research Group for Earth Observation (ʳgeo), Department of Geography, UNESCO Chair on World Heritage and Biosphere Reserve Observation and Education, Germany
[2] Heidelberg University, Heidelberg Center for the Environment (HCE) & Institut of Geography, Germany
[3] Siegmund: Space & Education gGmbH, Gaiberg, Germany

Keywords: Remote sensing education, Geospektiv, BLIF

Abstract

The project “Living Earth – Utilization of satellite data for Earth Observation of habitats by adolescents” provides interactive e-learning modules to discover explore and explain climate and environmental processes through remote sensing methods by students. The modules are based on the existing e-learning platform geospektiv (www.geospektiv.de), which provides an adaptive e-learning technology and a responsive design for a wide range of user devices and browser interoperability. Geospektiv is already used by hundreds of school classes and is regularly evaluated. Furthermore, the platform is linked with the easy-to-use web-based remote sensing application BLIF (www.blif.de). By using the integrated application, students can edit, analyse and classify satellite images independently. The application offers a wide range of common processing functions like true- and false-colour composites, indices such as the NDVI or RVI, unsupervised and supervised classification as well as change detection functions.

The web-based learning modules of “Living Earth” are specifically designed for 9th and 10th grade students (about 14-15 years old) and their teachers. By using the “bird’s eye” perspective, pupils get new impressions and knowledge about the distribution, characteristics of and potential threats to selected ecosystems and habitats of animals, especially birds. Due to the variability of usable satellite data (e.g. Landsat, Sentinel, RapidEye), students can choose an individual case study, depending on their interest. By analysing and processing satellite images in an interactive format from their own region, and thus have a reference to their everyday life. The assessment and classification of ecosystems or habitat types with varying spatial scales facilitate the students to evaluate how their own region changes over the years. During the class, teachers have the option to manage, monitor and evaluate the process of learning. Later, results can be illustrated and compared if desired. In addition the modules of “Living Earth” offer a target group-oriented introduction to the basics of Earth Observation and image processing. Due to the adaptivity of the e-learning platform geo:spectiv different educational levels can be addressed. This important feature offers personalization of the learning modules content depending on the abilities or interests of the user.

The developed problem-oriented learning modules of "Living Earth" and practical application offer a considerable contribution to the competence development of students and support the promotion of young talents in the space sector in general. The project "Living Earth" is funded by the German Space Administration (DLR) and implemented by an innovative public private partnership between the Department of Geography – Research Group for Earth Observation (ʳgeo) and die Siegmund: Space & Education gGmbh.

Figure 1. Living Earth modules on remotely sense based analysis of living environments by students, based on the adaptive e-learning platform geo:spektive (www.geospektiv.de)

Assessment of Least Mean Square Multivariate Kriging Regression for Spatial Downscaling of MODIS Thermal Imagery

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
khandusa@gmail.com

Kul Vaibhav Sharma[1], Sumit Khandelwal[2]*, Nivedita Kaul[3]

[1] Research Scholar, MNIT JAIPUR, Department of Civil Engineering , India
[2] Associate Professor, MNIT JAIPUR, Department of Civil Engineering , India
[3] Associate Professor, MNIT JAIPUR, Department of Civil Engineering , India

Keywords: Spatial downscaling; Thermal imagery, Image sharpening

Abstract

High-resolution thermal images (spatial resolution up to 200 meter) are needed very frequently for various earth science applications like surface energy estimation, thermal comfort, forest fire and estimation of Land surface temperature (LST) etc. The current remote sensing setup has limited resources to fulfil the requirement of high spatial resolution thermal images at high temporal resolution as well. Hence, it may be important to build a link between remote sensing data from different platforms to monitor surface energy-related applications. The present study attempts to downscale MODIS satellite thermal images (spatial resolution of about 1000 meter but temporal resolution of one day) using different land use spectral indices as auxiliary data. Terra MODIS day time and Aqua MODIS night time LST/Emissivity product (MOD11A1/MOD11A2) and VNIR product (MOD09GQ) at 1000 m and 250 m spatial resolutions, respectively have been used as input data. The Landsat 8 TIRS Band 10 data as a single spectral thermal band has been used for LST estimation. The operational path angle and overpass time difference between both the satellites vary from 12° to 25° and around 3 to 5 hours, respectively, throughout the study area.

The study has proposed a novel Least Mean Square Multivariate Kriging (WLMSK) method by optimizing fine resolution Indices for different land covers. The proposed method has been evaluated using three downscaling algorithms, sharpening thermal imagery (TsHARP), local neighbourhood model and Multiple Linear regression model (MLR). MODIS LST at 1000 m resolution has been downscaled to 400, 300, 200, and 100 m resolution using regression models. The downscaled MODIS LST values have been compared with available Landsat 8 LST at matching scale and of close overlapping periods. The results have shown that LST downscaling technique performance varies over climate, surface feature and earth surface moisture conditions. The downscaled MODIS LST imagery has been analysed at three focal size (3x3; 5x5; 7x7) pixels. The Relative dimensionless global error (ERGAS) values has varied from (1/4, 1/2, 3/4 and 1) in each spectral quality assessment parameters.

The results show that the proposed thermal band downscaling algorithm has given reasonable accuracy at spatial resolution of 200 m. The root mean square error (RMSE) in LST estimation from 100 m spatial resolution to 200 m and 100 m resolution has been observed as 0.38 °C and 1.45 °C, respectively. The proposed downscaling approach has outperformed other conventional image fusion methods in both the urban and rural areas. The aim of the study to develop a robust LST downscaling algorithm for MODIS data at finer resolution presents a good predictive performance.

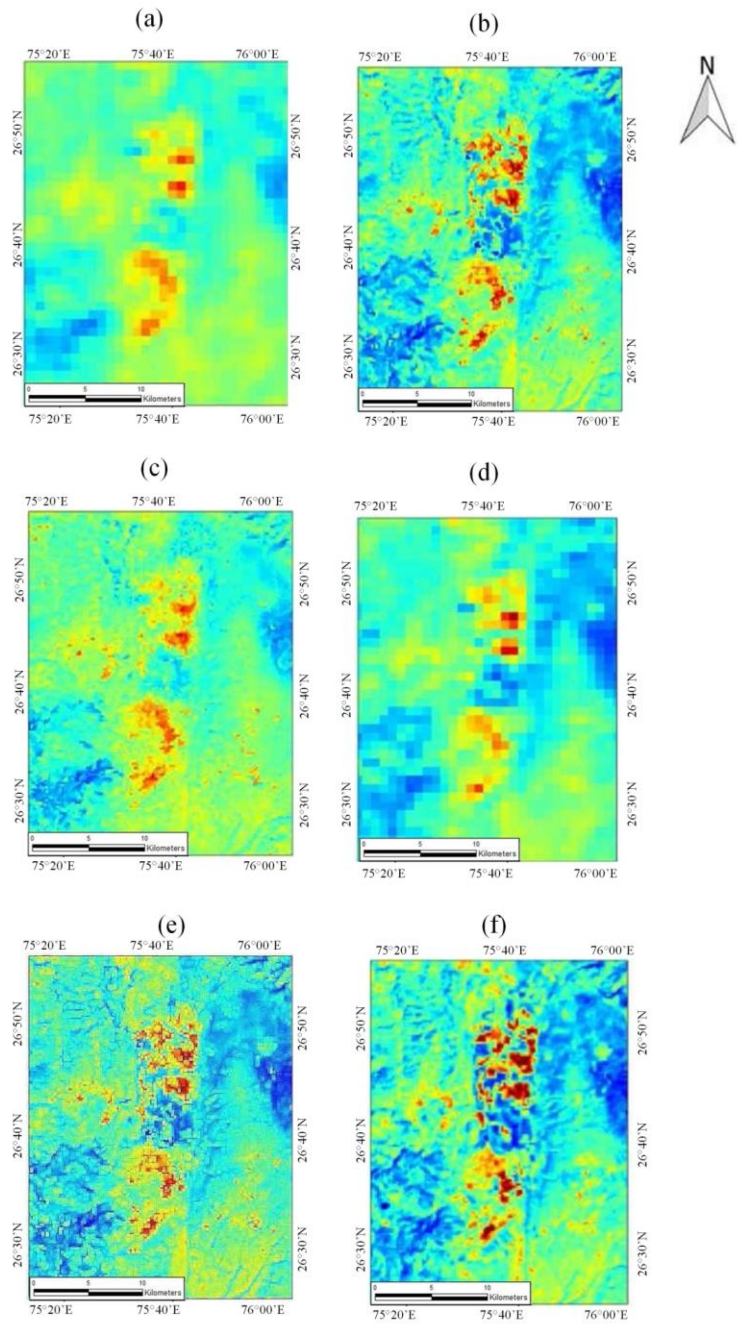


Figure 1. (a) MODIS LST at (1000 m), (b) Landsat 8 LST(100 m) (c) Local Neighbourhood Model downscaled image (d) TsHARP downscaled Image , (e) MLR downscaled and (f) WLMSK downscaled Image at 100 M resolution

Bidirectional Modified PCA Fusion of MODIS and Landsat 8 Data for Downscaling of Coarse Scale Thermal Imagery

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
khandusa@gmail.com

Kul Vaibhav Sharma[1], Sumit Khandelwal[2]*, Nivedita Kaul[3]

[1] Research Scholar, MNIT JAIPUR, Department of Civil Engineering , India
[2] Associate Professor, MNIT JAIPUR, Department of Civil Engineering , India
[3] Associate Professor, MNIT JAIPUR, Department of Civil Engineering , India

Keywords: Fusion, PCA, Kalman filter, Image sharpening

Abstract

Image fusion method is used in remote sensing applications for blending various satellite data for image enhancement purposes. High spatial resolution thermal data at daily temporal resolution is required for a variety of applications, especially research primarily over urban areas. Availability of freely available thermal data at both high spatial resolution as well as high temporal resolution is limited. Thermal images at spatial resolution of 1000 m (MODIS images) and 100m (Landsat images) are available at 1day and 16 days time interval, respectively. Data fusion from different satellites passing over same geographical location can eliminate the gap between the spatial and temporal resolution trade-off. The objective of the present study is to spatially downscale the MODIS thermal bands. Terra MODIS LST product (MOD11A1) at 1000 m spatial resolution and surface reflectance VNIR product (MOD09GQ) at 250 m spatial resolution has been used for downscaling. The Landsat 8 TIRS Band 10 data as a single spectral band has been used for LST estimation. The operational path and overpass time of MODIS and Landsat satellites is discrete through the study area.

Surface emissivity, atmospheric transmittance and effective mean thermal reflectance are key parameters of input thermal bands. Kalman filtering technique has been presented for pre-processing of thermal bands in fusion scheme. The input bands have been substituted with principal components (PC1-PC4) having maximum relative information. Figure 1 shows that the fused imageries are strongly correlated with the Landsat 8 Land surface temperature (LST) values from PC1 ($R^2 > 0.98$) to PC4 ($R^2 > 0.90$). The Root mean square error (RMSE) between the retrieved and the downscaled LST has been observed to be 0.03 K.

The proposed algorithms have been compared with probabilistic and non-probabilistic multisensory fusion methods, like Neuro-Fuzzy method (NF), Wavelet Transform (WT) and Contourlet Transform (CT). The fusion results have shown that Kalman filter can effectively eliminate outliers between the different spatial resolution thermal bands. The bidirectional PCA gets rid of sensor's bias due to different operation path at finer scale. The proposed MODIS thermal band sharpening method may be applied to detect surface temperature, fire detection, volcanic activity, radioactive exposure to nuclear power plants at 24 hours interval.

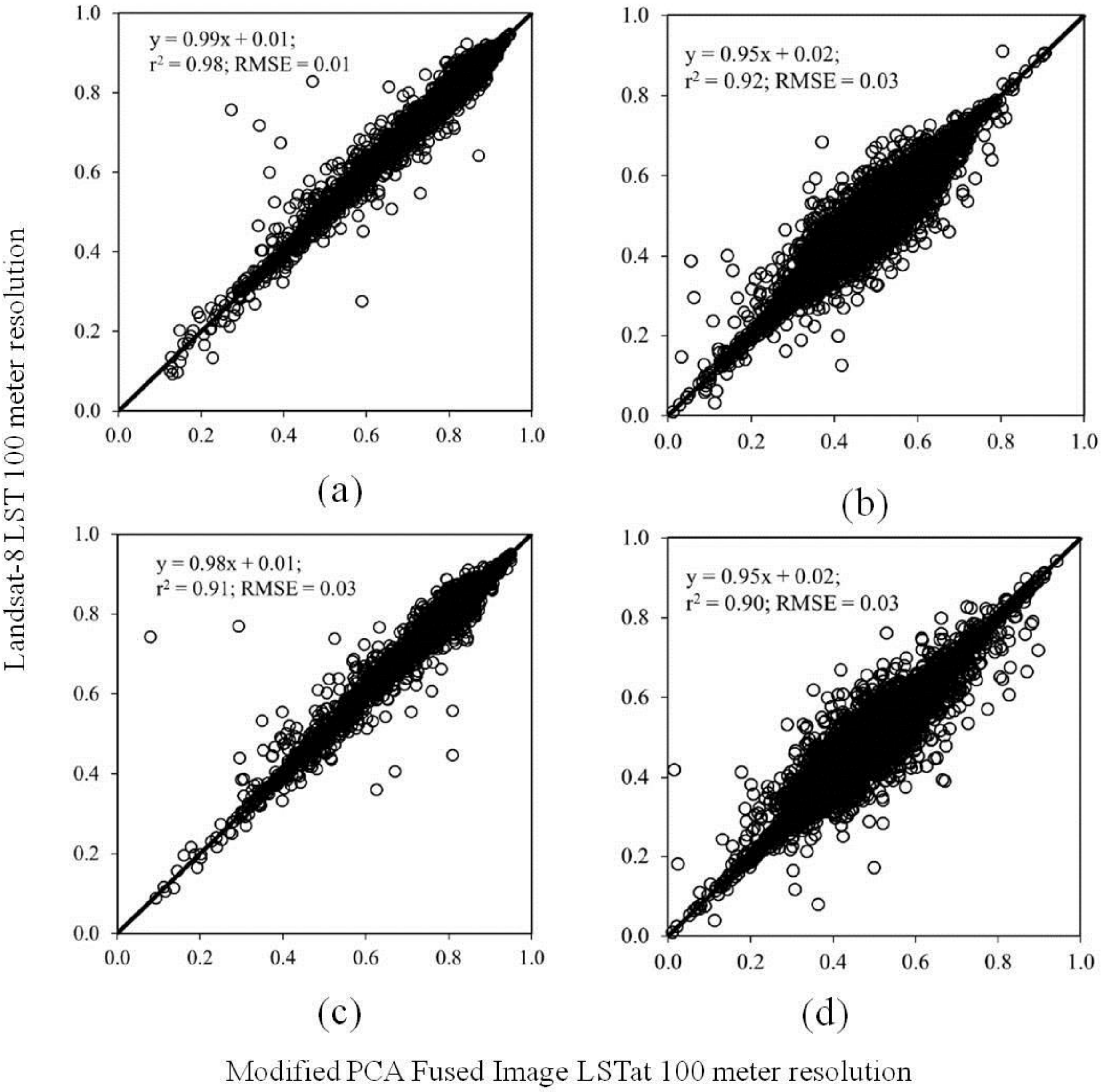


Figure 1. Scatter Plot between Enhanced MODIS Images Using (a) PC1, (b) PC2, (c) PC3 and (d) PC4 and Original Landsat 8 Land surface temperature (LST)

Mapping Fluvial Ecosystems in Mountainous Regions using Spectral Mixture Analysis

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
lstancic@zrc-sazu.si

Liza Stančič[1], Žiga Kokalj[1,2], Krištof Oštir[3]

[1] Research Centre of the Slovenian Academy of Sciences and Arts, Institute of Anthropological and Spatial Studies, Department of Remote Sensing, Slovenia
[2] Centre of Excellence for Space Sciences and Technologies, Slovenia
[3] University of Ljubljana, Faculty of Civil and Geodetic Engineering, Slovenia

Keywords: Water-related ecosystems, Mountain regions, Optical earth observation, Spectral mixture analysis, Sub-pixel mapping

Abstract

Earth observation provides ample opportunities for augmenting environmental monitoring, also in relation to the UN Sustainable Development Goals (SDGs). Increasing spatial and temporal resolutions as well as data accessibility enable timely detection of changes over a wide area. Various global-level products are already available but their coarse spatial resolutions may lead to inaccuracies in spatially fragmented areas. Mountainous regions are an example of such a landscape where features often occupy less than several hundred m^2. This makes them difficult to detect using freely and openly available remote sensing data. In order to overcome this limitation, a sub-pixel precision mapping approach using spectral mixture analysis is proposed.

This study focuses on SDG target 6.6 "By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes". The main aim of the analysis is to map the land cover of water-related ecosystems. In particular, fluvial gravel bars are the central focus of the study. As an ecotone between aquatic and terrestrial habitats, gravel bars host diverse, specialised and endangered species, including plants, invertebrates, fish and birds. Several of these species have evolved to depend on gravel bars for their survival, for instance for egg hatching. Additionally, gravel bars have an important role in water filtration, ground water infiltration, river bank erosion mitigation as well as the river's attractiveness for recreation. Anthropogenic factors such as dam construction, and natural events such as increased precipitation and resulting higher river discharges are reported to have a substantial effect on gravel bar location and extent. Being sensitive to changes in hydrology, gravel bars are thus considered important indicators of fluvial ecosystem disturbances.

Upper reaches of the Soča river watershed in the Julian Alps in north-western Slovenia are chosen as a study area. Three distinct spectral endmembers are selected, representing the main land cover types of interest, namely gravel bars, water and vegetation. The analysis focuses on the fluvial ecosystem up to the first geomorphological change i.e. up to the first fluvial terrace. The spectral endmembers are selected as central pixels in an area of uniform land cover. Processing is carried out in free and open source software including SNAP, R and QGIS. Linear spectral mixture analysis is done using an implementation of a non-negative least squares solver. Landsat imagery with a 30 m spatial resolution, and Sentinel-2 imagery with a 10 m spatial resolution are used as input data.

The outcomes are validated using PlanetScope imagery with an approximately 3 m spatial resolution, and aerial orthophotos with a 0.25 m spatial resolution.

Images from July 2015, October 2017 and October 2018 are analysed. The first two dates coincide with aerial orthophoto availability while the third allows an inter-annual outcome comparison. The results of spectral unmixing clearly demonstrate the differences between pixels containing a single land cover, and mixed pixels. Fractional maps provide additional land cover information and enable a higher exactness of ecosystem mapping. The comparison between unmixing Sentinel and Landsat imagery shows that spatial resolution of the input image plays an important role in the clarity and precision of mapping results. This is due to the fact that the input data pixel size dictates the size of the unit for which land cover percentages are reported. Frequent cloud cover in this mountain barrier to moist air masses from the Adriatic Sea is one of the main limitations for using optical remote sensing for ecosystem mapping in the study area.

Future work includes intra-annual comparisons to determine the seasonal dynamics of gravel bar extent, inclusion of longer time series to extend the analysis into the past and examine the effects of dam construction, and application of the approach to a different study area.

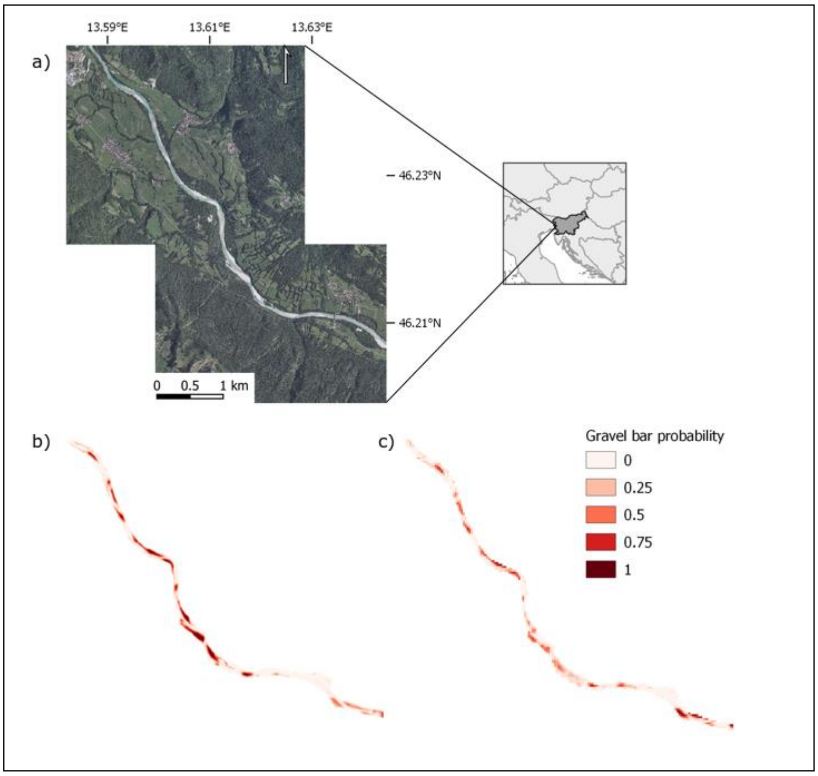


Figure 1. (a) A section on the study area in the Upper reaches of the Soča river between the settlements Kobarid and Tolmin. (b) Results of spectral unmixing of a Sentinel-2 image acquired on 4th July 2015. (c) Results of spectral unmixing of a Landsat image acquired on 17th July 2015. Results indicate the probability that gravel land cover is present within a certain pixel based on the input endmember spectral signatures. Probability calculation is carried out using the Multiple Endmember Spectral Mixture Analysis technique with a non-negative least squares solver.

Preprocessing Very High Temporal Resolution Night-Lights Data for Noise Removal

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author: pbaltas@uth.gr

Stathakis Demetris[1], Baltas Pavlos[1], Liakos Leonidas[1]

[1] University of Thessaly, PRD, Spatial Analysis, GIS and Thematic Mapping Laboratory, Hellenic Republic.

Keywords: Night lights, Noise removal, Optical data, Pre-processing, Urban areas

Abstract

In remote sensing, it has become a standard to classify imagery based on the spatial resolution of the pixel in the following categories, although there is no universal consensus on the exact class breaks:

Spatial resolution class	Pixel size (m)	Sensors (indicative)
Coarse Resolution	500 or more	AVHRR
Medium Resolution	30 - 500	MODIS
High Resolution (HR)	30 - 5	LANDSAT, SPOT, SENTINEL
Very High Resolution (VHR)	5 or less	IKONOS, WORLDVIEW-2, PLEIADES

An analogy is starting to appear regarding the temporal resolution of night-light data. The criterion in this case is how frequently the imagery is recorded. The following broad classes can be formed:

Temporal resolution class	Update interval (days)	Sensors
Coarse temp. Resolution	365	OLS, VIIRS (annual composites)
Medium temp. Resolution	30	VIIRS (monthly composites)
High temp. Resolution (HtR)	7	VIIRS (weekly composites)
Very High temp. Resolution (VHtR)	1-5	VIIRS or International Space Station imagery

The spatial resolution of public domain night-lights satellite data has been improved from 1km pixel in DSMP/OLS to 0.75km in VIIRS. But this improvement is relatively small and only marginally affects applications for time series analysis. However, the corresponding temporal resolution has been rapidly increasing. Starting from coarse temporal resolution (annual) DSMP/OLS data, covering the period 1992-2014, to medium temporal resolution (monthly) based on the Day/Night Band (DNB) sensor on-board the Visible Infrared Imaging Radiometer Suite (VIIRS) satellite since 2012. Recently, using the same sensor, very high temporal resolution data, obtained every night ("daily"), became available.

Temporal resolution improvement has a profound impact on widening the range of possible applications using night-lights. As in the case of substantially increasing the spatial resolution of optical data in the past two decades, and of radar data in the past decade, the exploration of night-lights' applications that were recently impossible, has commenced. The new generation of Very High temp. Resolution (VHtR) data are providing for the first time the actual capacity to study human settlements as living organisms or 'daily urban systems'. The conventional perception, based on the assumption that each human settlement has a fixed-state blue-print of the ground, is changing. The activity in a city within a year, a month, a week, as well as from one day to the next, flows in space for various reasons including commuting to work, trips for leisure and recreation, holidays etc. Using day-time optical data,

this urban phenology is impossible to be captured. But, via night-lights which are a valid proxy of the human activity flux, it is possible to realize short term patterns. These patterns are missed using conventional day-time data that primarily focus on fixed structures of the city, largely regardless of the currently ongoing activity.

Perhaps the strongest aspect of night-lights is that processing is quite straightforward. Complex classification techniques are typically not required. Human activity is correlated to night-lights in a quite straightforward way. The side-effect of using night-light data, especially VHtR imagery, is data volume that amounts to big data. A further implication with using VHtR data is that substantial preprocessing is required in order to form a reasonable coherent time series. The sources of noise include (a) the variation of ambient light in the night due to the phase of the moon, i.e. lunar irradiation (b) degrading quality of the image towards the edge of the swath i.e. bow-tie and edge effect (c) removing pixels with several specific flags in the data signifying low quality, i.e. malfunctions, snow coverage, active fires etc. (d) the presence ephemeral lights such as forest fires, power black-outs, transient ships and aircraft etc. and (e) clouds present in the scene, removed using a cloud mask.

In this paper we discuss preprocessing steps used to correct DNB data for the greater area of Athens (capital of Greece). This metropolitan region, with over four million people, is studied with preprocessed VHtR data that cover one year (2017). Based on the results the analysis of how the urban area is functioning is possible.

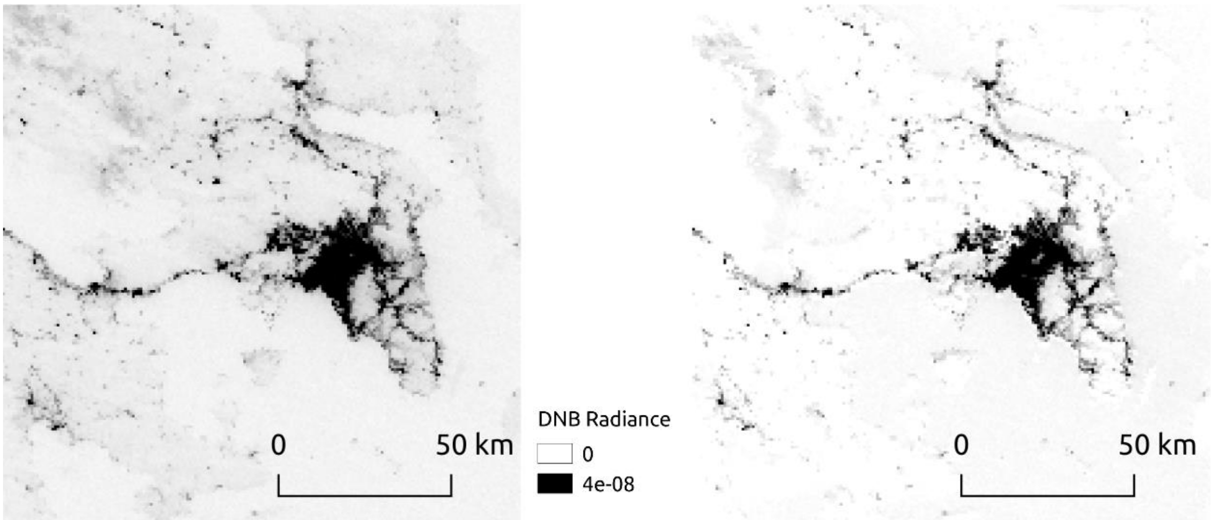


Figure 1. VIIRS DNB data (10.JUNE.2017) for Athens, before (left) and after correction (right). Colors inverted here for display. Radiance in Watts per square centimetre per steradian.

Phenological Spectral Knowledge for Alpine Biotope Type Mapping Derived from Sentinel-2 Satellite Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
thomas.strasser@sbg.ac.at

Thomas Strasser[1], Stefan Lang[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Alpine ecology, Multi-source remote sensing, Multi-temporal, Expert-based knowledge, Land surface phenology

Abstract

Alpine plant communities are sensitive indicators reflecting specific environmental parameters (such as climate, soil type, and topography), effects of human disturbances, and aspects of temporal changes. While alpine plant communities are adapted to extreme climatic conditions (e. g. short growing season, low air temperature, frost, high solar radiation and wind speed), climate warming drives plant communities towards species compositions of lower altitudinal zones and may ultimately lead to the loss of adapted specialists. Thus, monitoring the distribution and status of alpine plant communities, respectively biotope types is of high relevance. However, the large extent of alpine study areas, the steep and undulating terrain, a short vegetation and snow free period, as well as the extreme and fast changing weather conditions limit continuously repeated in-situ surveys, which results in high time and cost efforts.

Recent satellite remote sensing technologies with a high temporal, spatial and spectral resolution (such as Sentinel-2) are well suited to complement and direct in-situ surveys by providing temporal information over large and in particular inaccessible areas. However, specific strategies are needed to cope with seasonal variations of phenology, snow coverage and land utilization, which bias satellite image analysis. Using standardized classification systems, e. g. revealing aggregated spectral signatures in distinct (vegetation) categories, enables 1) a fast interpretation and investigation of the different spectral behaviour of plant species communities within seasons and 2) the development of transferable classification rules based on the derived knowledge of temporal changes. Figure 1 illustrates the comparison of 3 out of 50+ alpine biotopes in the study area Fuschertal valley (Salzburg, Austria) and their changes within the seasons represented by time-steps of early (June) – mid (August) – and late (October) season. First adequate Setinel-2 satellite images (provided in top-of-atmosphere reflectance values, Level-1C), were selected and classified into categorical information using the pixel-based *Satellite Image Automated Mapper*™ (SIAM™). In a second step, spectral categories for biotope types and the information on snow coverage were extracted from the (pre-)classified images using spatial explicit in-situ reference data. In-situ surveys were performed following the biotope type definitions of the Austrian Red List. Last, biotope types were analysed by their differences and/or similarities of spectral categories and specific seasonal changes to derive temporal distinct classes of biotope (type) groups. Additionally the duration of the snow coverage – one of the critical factors leading to the occurrence of alpine plant communities – is used to determine specific biotope types covered more than 7-9 months with snow. Challenges in biotope type analysis and classification remain considering non-regularly temporal effects, such as the near-infrared intensity decrease due to grazing. These effects can be determined via object-based image analysis methodology if changes occur within a localized

area, in a short time-period and are uncoupled to the seasonal effects (e. g. small fenced off areas), while slow changing processes (like grazing in large unfenced areas) are still vague.

Finally, the derived expert-knowledge of spectral and temporal distinct groups of biotope types are used for the implementation in a remote sensing based multi-temporal and multi-source monitoring approach, combining high with very high resolution satellite imagery and airborne laser scan data. Thereby, the satellite-based analysis focuses first on mid-season analysis, which is then enriched with the additional information from early and late seasons. Remaining insufficient defined areas are reviewed by visual interpretation and if necessary in-situ inspections. Whereas the concept of satellite-based alpine habitat monitoring approach is primarily depended from satellite data availability and quality, the most important development is to transform the complexity of biotope type interpretation into a knowledge-based machine-readable format. Thus, implementing the expert-knowledge about the real world conditions and their underlying dynamics, with broader and quasi universal categories, provides a generic and transferable ruleset pertaining the validity of the extracted information irrespective to the uncertainties occurring at the most detailed level. Exemplarily *Rich pastures* are mainly distinguishable to *Blueberry heathland* and *Grassland above alkaline soil* by categories HR_1 and HR_2 in June, while in August and October a high overlap in categories is observable (Figure 1). Conversely, *Blueberry heathland* will be addressed by multiple temporal conditions of the categories HR1_10 and HR1_11 (in June), as well as HR6_23 and HR6_24 (in October), whereas information enrichment leads to higher class stabilities.

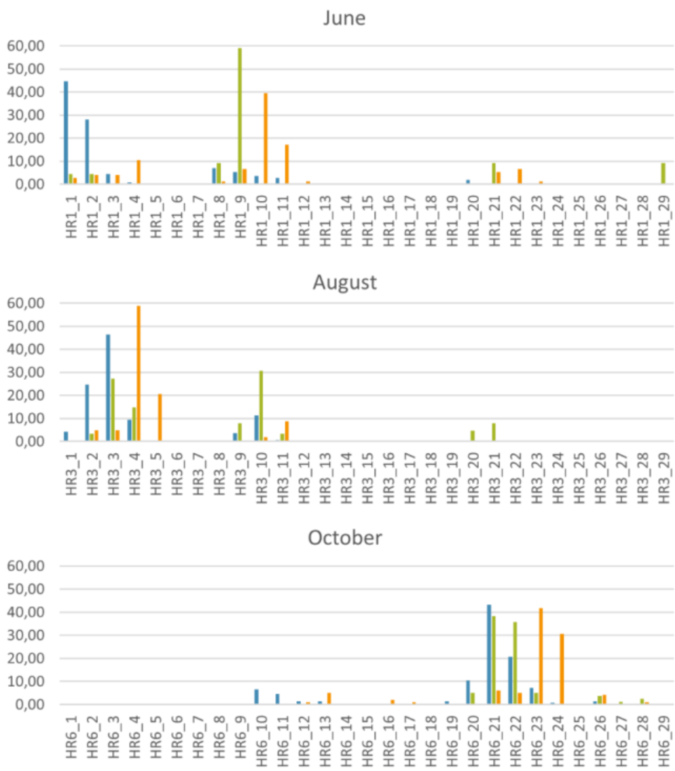


Figure 1. Seasonal changes from June to October of three biotope types revealed by categorized spectral signatures. Biotope types: *Rich pastures* (blue), *Grassland above alkaline soil* (green), *Blueberry heathland* (orange); Spectral categories 1 – 29 (in percentage) of three selected high resolution (HR) Sentinel-2 satellite imagery

The Greenland-Paradox: Time Series Analyses in the Big Earth Observation Data Era

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
martin.sudmanns@sbg.ac.at

Martin Sudmanns[1], Dirk Tiede[1], Hannah Augustin[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Big Earth data, Sentinel-2, Metadata analysis, Data coverage, Data suitability

Abstract

Earth observation data acquisitions are not homogeneously distributed over the Earth. Every location has its own unique characteristics, which is dependent on the latitude, decisions on acquisition scenarios such as those expressed in the Sentinel High Level Operations Plan (HLOP), and climate zones, which are affecting the cloud contamination. Several resources report on this, including our previous work accessible through the Web application EO-Compass (http://eo-compass.zgis.at). In the context of big Earth data, time series analyses are becoming increasingly popular. A short search in Google Scholar shows that every third publication about "big Earth data" [330] explicitly deals with the concept of time series [119 with: "Big Earth Data" AND ("Time Series" OR "TimeSeries")]. With evidence indicating prolific and operationally applied time series analysis techniques, the community should not forget that the examination of the underlying data distribution is essential to meaningfully interpret results and ought to be the first step in any time series analysis. We argue that big Earth data requires evaluating the (temporal) distributions of the underlying datasets in an analysis in order to select appropriate (time series) analyses methods.

The example what we call the "Greenland Paradox" perfectly shows how important this can be: Our statistical analysis of all Sentinel-2 Level 1C scenes covering Greenland in 2017 reveals that only a minority (~10%) of scenes can be considered cloud-free, if we define cloud-free as having less than 10% cloud contamination. While this is not surprising given the climate conditions in Greenland, the same analyses show that the average acquisition time between two cloud-free images is usually only a few days. The two numbers are not contradictory, but they simply do not properly reflect the data distribution. Especially in Greenland, which was a prioritised acquisition target for a long time, the situation is complex and cannot be expressed using simple statistical indicators. The simplest indicator, which is a "global acquisition every 5 days", is not meaningful in this case.

In higher latitudes, such as the Arctic regions, but also Antarctic, acquisitions of optical images is particularly challenging:

- The dense revisit time (e.g. overlapping orbits). While each of the Sentinel-2 satellites passes the equator at around 10-11am every five days, in high latitudes we can find multiple acquisitions per day with only a few hours difference between them.
-

- The continuous illumination during the summer months (polar day) allow acquisitions at any time of the day, even at night. This is in contrast to the rest of the Earth, where Sentinel-2 ascending orbits are on the night side and therefore acquisitions are not possible for the optical sensor. On the other hand, during the winter months (e.g. polar night) no acquisitions are possible.

A detailed look at the individual acquisitions shows that although the majority of acquisitions in Greenland are cloud-contaminated, if there is a day with good weather conditions, multiple acquisitions (up to 4) are possible during that day. Therefore, even with weeks of cloud-contaminated acquisitions, the average is only a few days and simple statistical indicators fail because the times series is completely irregular and biased.

This contribution aims to start a discussion to find better approaches to identify, describe, and quantify whether data are fit-for-purpose within a given application context with focus on time series analysis. This includes (1) identify several types of data distribution and data characteristics; (2) show how they can affect analyses; (3) group different regions of the world with similar characteristics as represented in the Sentinel-2 archive (see Figure 1); and (4) find more sophisticated methods to investigate the underlying data distribution.

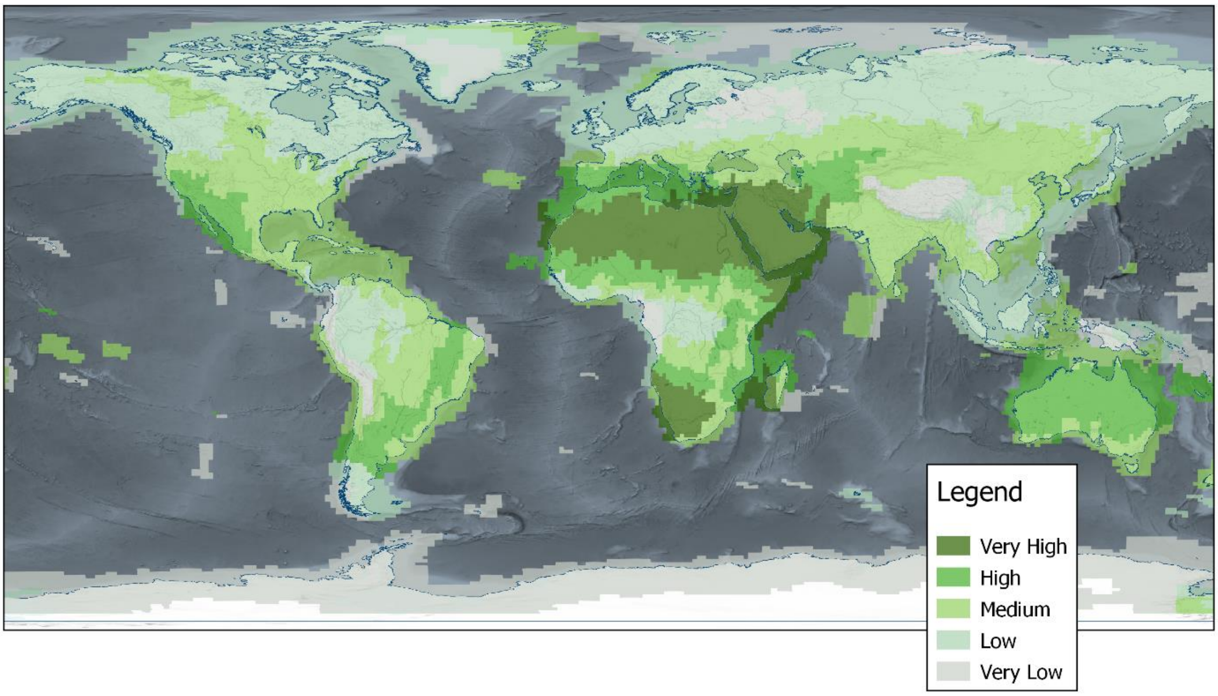


Figure 1. Regions with similar data characteristics, grouped into categories indicating the feasibility of large-scale analyses. The legend indicates categories ranging from "Very High", i.e., high frequency and less cloud contamination on average to "Very Low", i.e., fewer acquisitions frequency with few cloud-free images. This is a general-purpose indication as a starting point, which might be refined as suitability for a particular application and method.

How can Copernicus Data and EO-Based Products Help Germany in the Implementation of the UN-SDGs?

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
patrick.knoefel@bkg.bund.de

Gopika Suresh[1], Christian Schweitzer[2], Patrick Knöfel[1], Michael Hovenbitzer[1]

[1] German Federal Agency for Cartography and Geodesy, Frankfurt am Main, Germany
[2] German Environment Agency, Dessau-Roßlau, Germany

Keywords: Sustainable development, UN-SDGs, Copernicus, Earth observation, EO4SDG, GEO

Abstract

The Sustainable Development Goals (SDGs) provide a framework to make life on our planet better and more sustainable for our future generations. They consist of 17 goals, divided into 169 targets and 232 indicators relating to all realms of society and spheres of life, both on land and underwater. Much of social and economic sustainability lies in improving the quality of human life while preserving and efficiently using our natural resources such as forests and water. To assess and observe whether the SDGs have actually been achieved, an Inter-Agency Expert Group on SDG Indicators (IAEG-SDGs) commissioned by the United Nations Statistical Commission (UNSC), and in collaboration with the national statistical offices, has developed a global set of indicators for reviewing the progress of the SDGs in individual countries. The indicators have also been assigned to Tier classes I, II or III where Tier I represents indicators with globally available data and methods and Tier III representing indicators for which both data and methods are missing. For Germany, the Federal Statistical office is responsible for reporting the status of the SDGs and work with other federal agencies and institutions to acquire data for calculating the SDGs. The 232 indicators of the SDGs are mainly collected and reported based on demographic and statistical data or using data from models or surveys. More recently, the use of Earth observation (EO) data for monitoring and supporting the implementation of the SDGs, targets and indicators is being more frequently used and encouraged by the UN. Most EO datasets have the advantage that they are freely available, global and can enable more timely statistical outputs while providing a consistent means to report and measure the SDGs.

The Federal Agency for Cartography and Geodesy (BKG) actively researches the use of Copernicus data and EO-based products for calculating the SDGs. Feasibility studies regarding the use of national datasets derived from EO datasets such as the German Land Cover model (LBM-DE) and German Digital Terrain Model (DGM-DE) for calculating the indicators 11.7.1, 15.4.2 and 15.1.1 were conducted in collaboration with the Federal Statistical office. The indicator 15.4.2 expresses the relationship of the vegetation-covered mountain landscapes to the entire mountain landscape. Using the BKG products DGM-DE and the LBM-DE, data regarding elevation and land cover were extracted and used to calculate the percentage of vegetation on mountains as per their height and inclination. The analysis showed that in 2018 96.23% of the mountains in Germany are covered with vegetation.

Simultaneously, the use of Copernicus data for estimating the SDGs is being researched within the Cop4SDGs project. The Cop4SDGs (Copernicus for SDGs) project was launched in July 2018 between the German federal Office of Cartography and Geodesy (BKG) and the German Environment Agency (UBA). The project aims at closing data gaps in the national reporting process. Funded by the German Federal Ministry for Environment, Nature conservation and Nuclear Safety (BMU), Cop4SDGs also aims to develop methods for calculating the SDG indicators using Copernicus and EO data. The developed research and methods could, in the future, aid policy making and the adaptation of other strategies.

The Federal Statistical Office publishes a detailed indicator report every two years in which the indicators are reported. The latest indicator report from July 2018 was analysed in detail to understand which SDG indicators and targets were not reported. 118 indicators were not reported in July 2018, either because these indicators were not applicable to Germany or because data to report these indicators were unavailable (27 Tier I, 41 at Tier II and 50 at Tier III indicators). Indicator 6.6.1 regarding the change in the spatial extent of water ecosystems was not reported in this report. The use of Copernicus products such as the Corine Land Cover and High Resolution Layer: water and wetness for calculating this indicator was analysed recently and will be presented.

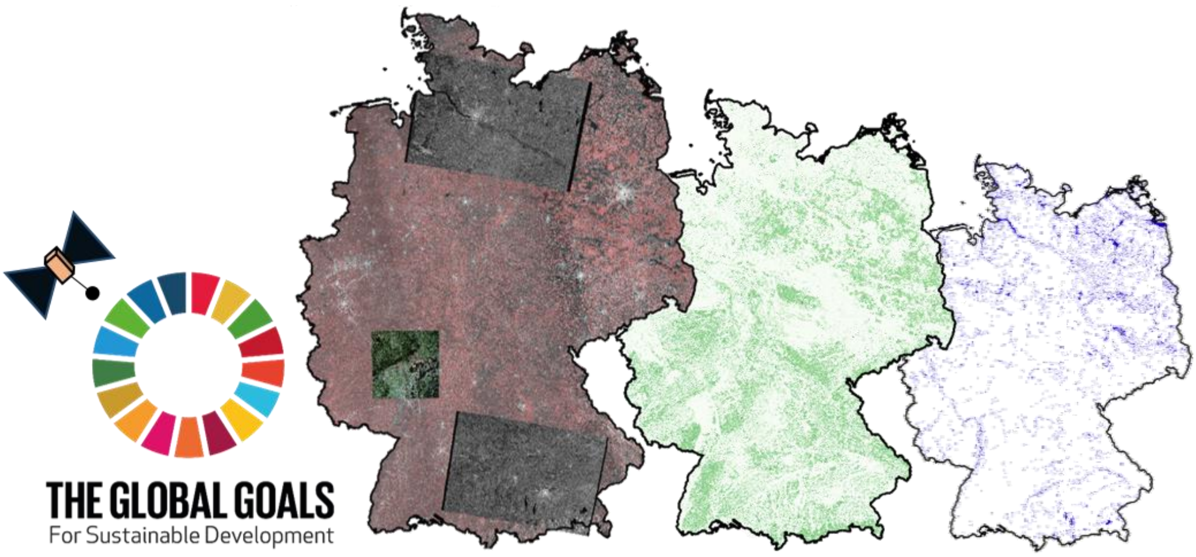


Figure 1. Visual illustration of the Cop4SDGs project showing how the Copernicus data and products can be used for monitoring and reporting of the SDGs. The illustration contains left: two S-1 images from 2017 and one S-2 image from 2018 displayed on a Sentinel-1 VV mosaic of Germany from June 2016; the Copernicus High resolution layer Forest type (middle) and water and wetness status maps (right). The logo for the SDGs is from the United Nations.

RefCampApp – Automation Support for Refugee Camp Analysis Based on Very High Resolution Satellite Data

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
dirk.tieder@sbg.ac.at

Dirk Tiede[1], Petra Füreder[1], Linda Menk[1]

[1] Interfaculty Department of Geoinformatics - Z_GIS, University of Salzburg, Austria

Keywords: Expert-system, Refugee camp analysis, Dwelling extraction, Human computer interaction, GOFAI

Abstract

Expert systems using (human-) knowledge-based algorithms within logic/decision rules in combination with object-based approaches are at the moment the state-of-art in automated analysis of refugee or internally displaced person (IDP) camps for humanitarian relief support based on very high resolution (VHR) satellite data. Such expert systems for image analysis are often difficult to produce and tend to get very complex. However, they can integrate common sense/logic and prior knowledge to abstract/generalize, which is one of the human qualities machine learning systems often fail to achieve. To tackle the general lack in flexibility and scalability of complex expert systems, we developed an application for automated refugee camp mapping (*RefCampApp*) implemented in Trimble's eCognition software. Similar to agile software development, knowledge is transferred to rule-sets starting from tasks, which are easier to accomplish automatically, and improve the algorithms step-by-step. This has the advantage that working code/rule-sets are further developed until a certain threshold is reached, which can be a time constraint (e.g. disaster situations) or reasonable balance between the endeavour made and the result obtained (e.g. automation vs. manual interpretation). An interconnection with interactive (human) expert input is implemented, which improves the transferability to other areas/camps of different complexity or to react – by manual intervention – on data quality problems or similar. The interactive environment enables also basic users of object-based image analysis rule-sets to extract relevant information (here: dwellings in refugee/IDP camps or buildings in urban settlements) in a short time frame to avoid manual interpretation/extraction for clearly visible structures.

The *RefCampApp* has seven main components for object-generation, object-classification, object-manipulation and computer support for manual digitizing. For the classification of different structures, besides knowledge based-rules, also different machine learning algorithms are implemented (e.g. Support Vector Machine, Random Forest), which are working with very small number of samples due to the stratification of the algorithms to potential dwelling objects only (exclusion of non-camp areas). Different tools are implemented to support manual refinement of the result regarding object-delineation and object-classification. For example, objects can be automatically delineated based on operator-defined seed points or automated support is provided in merging and cutting of insufficient delineated objects. Optionally the extracted objects are automatically converted in regularized dwelling footprints and a camp extent can be calculated based on dwelling count/dwelling density. The App (and the knowledge-based rule-sets behind) is designed in a way, that for simpler camp structure a full automation of the dwelling extraction and camp delineation can be reached. For more complex camps or a transferability to different areas and sensors, the intervention of the human operator

increases accordingly, but newly set thresholds are logged to increase automation for repeated monitoring tasks.

The *RefCampApp* has been tested by differently skilled users on 11 sites with 45 hectares each. The sites included refugee/IDP camps and settlements with different complexities regarding dwelling types (different colours with high to low contrast), settlement structure and dwelling densities. Despite of partly high complexities, the *RefCampApp* provided results in short time frames. Number and area of automated dwelling extraction were compared with pre-existing manual digitized dwellings. Overall there is a good agreement of total numbers and areas as over- and underestimations during classification to some degree balance each other out. A site-specific analysis revealed that in more complex camps on average 20 % of dwellings were not detected, whereas ~30% of dwellings were falsely identified as dwellings (e.g. bare soil which is very similar to brownish dwellings). For the majority of test sites, the accuracies of the number of dwellings was higher than for the extracted area of dwellings. Especially dwellings with low contrast to surroundings could often only be partly delineated, leading to an underestimation of the area. For less complex sites, the *RefCampApp* revealed quite high accuracies compared to manual interpretation as well as in comparison with a deep learning model trained on thousands of training samples (see Ghorbanzadeh et al., 2018 for a detailed description of the results).

All in all, the *RefCampApp* can provide fast results in less complex camp situations especially for non-expert users and is mainly useful for large camps and settlements to support manual interpretation in operational settings.

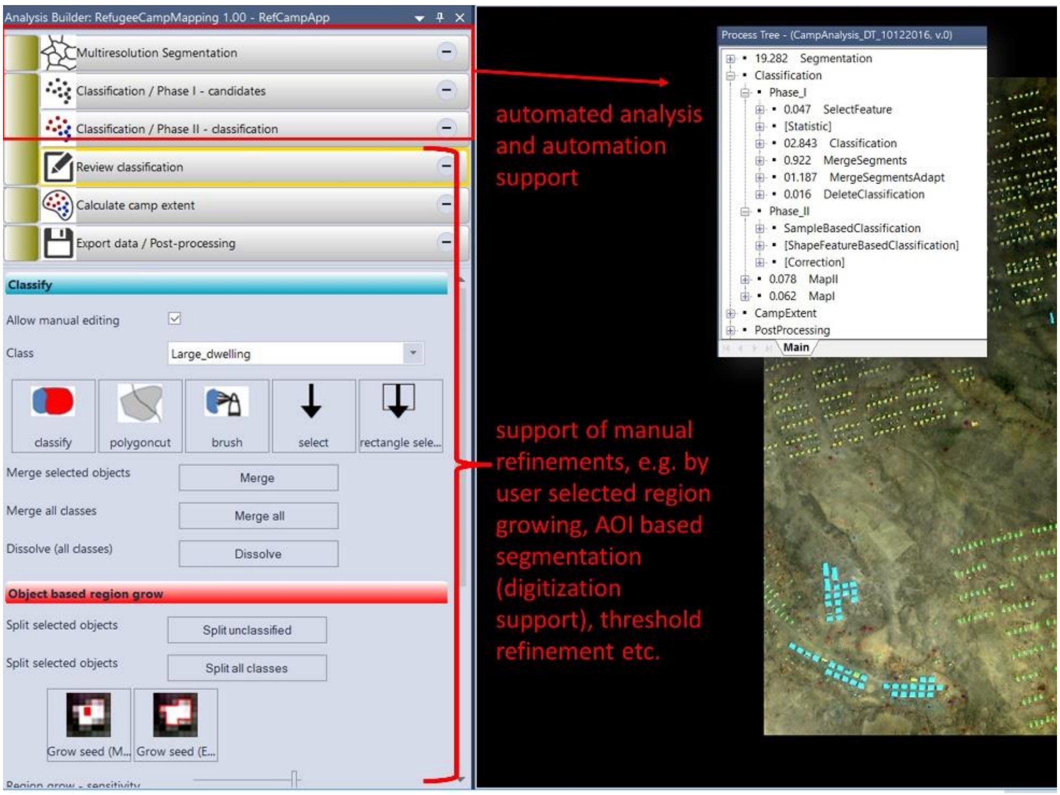


Figure 1. Interactive human-computer interaction: Knowledge-based rule-sets are combined with an interactive expert interface to control user input when necessary.

Leveraging Citizen Science and Machine Learning for Improved Land Cover/Land Use maps

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
valantis.tsiakos@iccs.gr

Chrysovalantis Tsiakos[1], Yannis Kopsinis[1], Maria Krommyda[1], Athanasia Tsertou[1], Angelos Amditis[1]

[1] Institute of Communication and Computer Systems, Greece

Keywords: Machine learning, Land cover, Earth observation, Citizen science

Abstract

The aim of this paper is to showcase novel approaches, resulting from the H2020 SCENT (Smart Toolbox for Engaging Citizens into a People-Centric Observation Web) project, focusing on the combination of earth observation with citizen-generated data for improved environmental monitoring (https://scent-project.eu/). More specifically, SCENT provides an integrated toolbox of smart collaborative and innovative technologies that augment costly in situ infrastructure, enabling citizens to become the 'eyes' of the policy makers by monitoring Land Cover and Land Use (LC/LU) changes in their everyday activities and related environmental phenomena, such as floods by crowdsourcing relevant information. An important element of the SCENT Toolbox lies on the development of a machine learning-based automated engine aiming at creating maps that have well defined regions characterized and annotated with a predefined subset of the SCENT land-cover descriptor taxonomy (e.g. river bank, coniferous trees, etc.), which is based on the CORINE taxonomy but is also enriched to include elements needed for flood management.

To automatically characterise land cover/ land use of level 2 and 3 of CORINE and/or SCENT taxonomy is a challenging task. When comes to 'micro structures' that occupy lower than 100m width or length, such as buildings and canals, then high-resolution satellite imaging is a necessity. Machine learning is the framework of choice for automatic aerial scene classification and/or for pixel-wise LC/LU segmentation of satellite images. The advent of Deep Neural Networks (DNN) dominated the field leading to enhanced segmentation performance. However, only recently DNN learning technologies found their path in LC/LU field leading to significant improvements in performance. The vast majority of the relative works so far concern satellite map tiles classification, meaning that small tiles from the satellite images are classified according to certain LC/LU classes in isolation from the whole map. These developments were propelled by the a large collection of relevant tile-based annotated datasets of 0.3-0.5 square meter resolution satellite data, such as the Aerial Image Dataset (AID) consisting of 30 classes with 200 to 400 images per class, (forest, river, pond, stadium, port, baseball field, etc.) and the WHU-RS19 dataset, (50 images per classes, up to 0.5m resolution, airport, beach, farmland, forest, industrial area, meadow, pond, residential area, river).

In SCENT, state-of-the-art Deep Neural Network technologies have been employed and properly adjusted to the satellite imaging peculiarities in order to build an effective satellite map segmentation tool, appropriate for certain SCENT land cover/land use taxonomy items of the project, that aims (i) to assign a semantic class (SCENT taxonomy) to each pixel, (i.e. convert the raw data to a semantically meaningful raster map), (ii) to convert SCENT taxonomy annotated points into annotated areas on the

satellite/aerial maps and, (iii) to characterize whole areas for which a land-cover/use description is not available.

More specifically, a VGG16 deep NN pretrained with ImageNet (ImageNet. http://www.image-net.org) had its last 6 layers retrained with annotated tile-based open data choosing classes relevant to the SCENT taxonomy. The open data were reshaped (if necessary) to 224x224 tile size. Then the fully connected part (last three layers) were finally trained with the SCENT data. In addition to the conventional VGG16, attention layers were added in order to weight higher the central pixels of each tile. For the implementation, Keras with TensorFlow backend was used.

Crowd-sourced data, consisting of images of LC/LU and other important environmental parameters that are being collected and annotated by volunteers through a dedicated application, constitute an important source of training data for the development of the DNNs in the project. These data have been collected and validated (through different components of the SCENT toolbox) in the context of two large scale pilot demonstrations that have been conducted so as to showcase the usefulness of the toolbox in real conditions; the urban case of the Kifisos river in Attica, Greece and the rural case of the Danube Delta in Romania.

In addition, satellite imagery of very high spatial resolution from the Copernicus Contributing Missions are utilised, so as to allow the identification and segmentation of the SCENT taxonomy elements and the production of improved land cover/ land use maps. In particular For Kifisos catchment, Standard (2A) / Ortho Ready Standard (OR2A) high resolution optical satellite imagery products of Worldview 3 were employed (https://earth.esa.int/web/guest/-/worldview-3-full-archive-and-tasking). Specifically, the 4-band pan-sharpened product (Blue, Green, Red, NIR) was used, with a pixel resolution of 40cm, so as to allow capturing of the elements of the SCENT taxonomy. For the Danube Delta pilot, Pleiades high resolution imagery were used and specifically pansharpened colour image products (Blue, Green, Red, NIR) at 0.5m resolution (http://www.intelligence-airbusds.com/files/pmedia/public/r49228_9_pleiades_product.pdf).

The output of the tool is a semantically meaningful raster map represented as a taxonomy layer on top of the acquired satellite maps. The later would be obtained automatically covering not only the areas were crowdsourced annotations would be available but the whole available map. The automatic map segmentation tool is embedded in the SCENT platform and it will be capable to get appropriately re-trained and operate with LC/LU taxonomy classes different than those trained for the SCENT piloting program as well as for satellite maps different than those used.

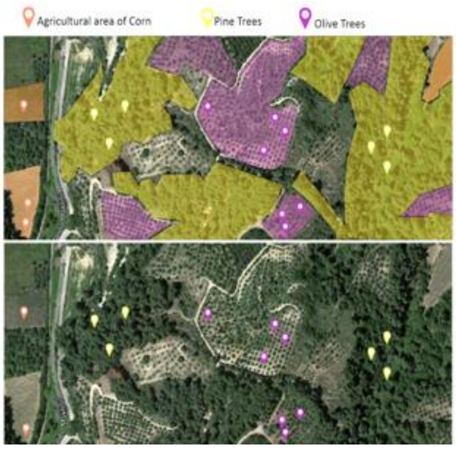


Figure 1. Example of SCENT map segmentation and characterisation

Efficient Transport Planning and Port Operation/Management in the Eastern Mediterranean through Geo-informatics

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
marios.tzouvaras@cut.ac.cy

Marios Tzouvaras[1], Diofantos G. Hadjimitsis[1], Marinos Papadopoulos[1]

[1] Department of Civil Engineering and Geomatics, School of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus

Keywords: Transport planning, Port management, Decision-making, Copernicus, Geo-informatics

Abstract

Nowadays, countries on a macroscale and cities/neighbourhoods in a microscale, face many challenges associated with high population density and the protection of the environment. Transportation planning is one challenge that is directly linked to congestion-oriented problems such as traffic delays, greater fuel consumption, air pollution, investments in new infrastructure and is somewhat connected directly with our everyday life. One of the fundamental aspects that is always studied at the early stages of transportation planning is land use/land change. This affects transportation in general but more specifically in terms of transport planning, it affects greatly the stages of "trip generation" and "trip distribution", i.e. the number of trips that is generated at and attracted by a specific area under study. Changes in land use or changes in distribution of land use in cities over time can lead to changes in transportation/traffic trends. Obtaining information regarding the evolution of land use over time in a specific area of interest has become easier lately with the new Copernicus Sentinel missions, as data are obtained on a regular basis as optical or SAR satellite images and can be processed and used in the benefit of the greater good. In Cyprus and the eastern Mediterranean in general, due to their geographic location, many cloud-free optical satellite images are available. In the present study, archived and more recent images from the Sentinel missions were employed to show how the changes of land uses have affected transportation over time.

In the case of maritime logistics, transport planning affects wider regions, as Europe's ports are vital gateways, linking its transport corridors to the rest of the world. Approximately 74% of goods entering or leaving Europe are transported by sea. The operation of ports depends on many factors that characterise them. Therefore, in the area of maritime transport some concepts, such as productivity and reliability, are very important as they determine the dynamic of ports. Different stakeholders such as decision makers, users, port authorities and port cities are affected of the port´s use and thus port performance is of great importance. It is usually measured via a comprehensive set of Key Performance Indicators (KPIs) that cover substantially all port characteristics. There appears to be a variety of KPI systems in the literature used in research projects. During the present study, a comparison of six KPI systems is carried out. The nature of indicators and the methodology applied are investigated in each case to identify their strengths and weaknesses regarding the calculation of ports performance and efficiency. To have a common basis for comparison, a "universal" set of 5 KPI categories was defined and all KPIs were classified, based on their nature and description, accordingly, to the respective KPI categories. More specifically, these indicator categories are: (a) Environmental /Sustainability, (b) Financial /Economic, (c) Governance, (d) Operational and (e) Traffic. Collection of quantitative data

for the financial/economic; governance; operational; and traffic indicators is more accurate through questionnaires, however most of the environmental information, such as air pollution, COx emissions, etc., can be collected via optical or SAR satellite images, which are nowadays widely available through the Sentinel missions.

Geographic Information Systems (GIS) were employed in order to give a valuable mapping representation of all the different parameters and collected data, providing a spatial representation of the various findings of the evaluation procedure (see Figure 1). This spatial representation could also justify strengths and weaknesses for ports, as well as opportunities for future growth. The findings may further develop our understanding of transportation requirements, logistics and port operations. These data can be used not only to showcase the present status of ports and transportation networks in the eastern Mediterranean region, but they can be included in the decision-making process by port operators/authorities, transport system managers and many other public authorities.

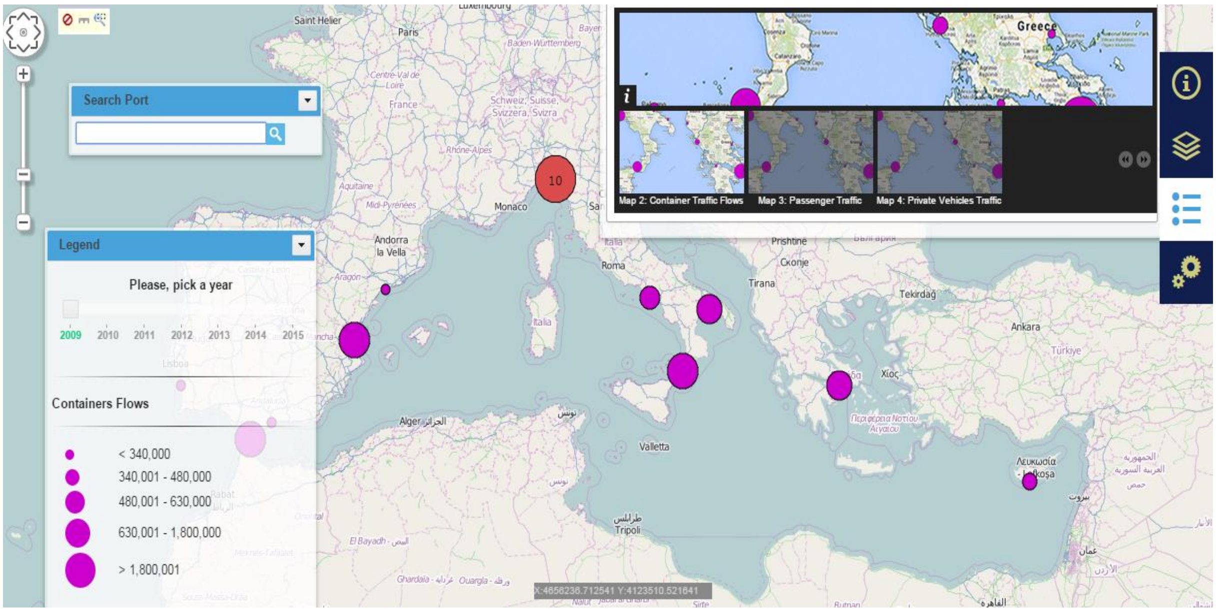


Figure 1. Container flows per year in GIS environment

Earth Observation Services for Smart Airports Operational Management

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
l.vandevyvere@issep.be

Laura Van de Vyvere[1], Olivier Dubois[2], Nicolas Hanse[3], Benjamin Beaumont[1], Eric Hallot[1]

[1] Institut Scientifique de Service Public (ISSeP), Remote Sensing and Geodata Unit, Belgium
[2] OSCARS, Belgium
[3] ESNAH, Belgium

Keywords: Airport management, remote sensing, Automated process, Data fusion

Abstract

Fourteen million flights are expected in 2035 in Europe alone. As highlighted by Eurocontrol, unless new sources of capacity are added to Europe's increasingly capacity-constrained hubs, 1.9 million flights will not be accommodated in 2035, resulting in about 120 million passengers being unable to fly. This may lead to delays for passengers, more time wasted in the air and on the ground, more fuel being unnecessarily burnt and more carbon dioxide and other noxious and greenhouse-gas forming emissions being released.

To increase airport capacity and cost-efficiency, optimisation at every stage of the process chain must be carried on: next to increasing runway and airport throughput, heavily studied in SESAR (Single European Sky ATM Research) projects, ESA (European Space Agency) Smart Airports projects aims at minimizing rotation time on apron side and smoothing real-time airport operations. In this regard, space technologies and Earth Observation in particular can be a valuable asset to support Advanced-Surface Movement Guidance and Control System (A-SMGCS) surveillance and safety support services as well as helping airport manager to maintain high quality and complete knowledge of their airport assets.

The Earth Observation (EO) objectives of the project are twofold. Firstly, produce a high-resolution, accurate, and up-to-date airport map to enhance ground situation awareness. Secondly, Smart Airports aims at defining relevant indicators for airport management that would meet the user's operational requirement and proposing Earth Observation-based temporal change detection methodologies. Eventually, cost-efficiency analysis will be performed to assess the feasibility and economic sustainability of the different technical solutions identified (Strenghts, Weaknesses, Opportunities, and Threats). Liege airport (Belgium), currently the eighth largest European cargo airport (European center of TNT Airways and future Alibaba Group European logistics platform), has been chosen as demonstration use case for the project.

The use of satellite EO has first been introduced to airport management as a tool to enhance wildlife monitoring on airport surroundings (AMMO and WAMMO projects). In Smart Airports, data from multiple sensors (optical, radar, thermal, hyperspectral) and platforms (satellite, airborne, RPAS) are combined with non-EO data sources (eg. Airport AIXM mapping database) to significantly improve airport knowledge. On the one hand, thanks to their very high spatial resolution, VHR satellite data (such as Pleiades), airborne and RPAS-embedded imagery complemented with pre-existing semantic attribute and spatial geometries can be used to precisely map the airport, using segmentation, supervised classification, and ultimately fusion techniques. On the other hand, thanks to their very high temporal

resolution, Copernicus data (both Sentinel-1 and Sentinel-2) can be valued as a monitoring tool providing up-to-date situation of the airport to improve operational efficiency. With this regards, indices such as runway rubber cover or vegetation state can be computed. The types of changes and suitable indices are derived from user needs.

The feasibility study aims at identifying the optimal combination of data and process for the three types of operations foreseen: the creation of the first high resolution airport map and the automated change detection process, the classic map update of after release of a new base product (eg. the annual Walloon aerial imagery), and the event-triggered map update following significant change detection. The feasibility study will highlight the value brought by space-based data in airports.

As a perspective, the ongoing development and research on High Altitude Pseudo Satellites (HAPS) opens new prospects for an intermediate data scale and tailored mission to complement satellite and local services on airports.

This research is carried out under a programme of, and funded by, the European Space Agency. The information and views expressed in this publication lies entirely with the authors and does not reflect the official opinion of the European Space Agency.

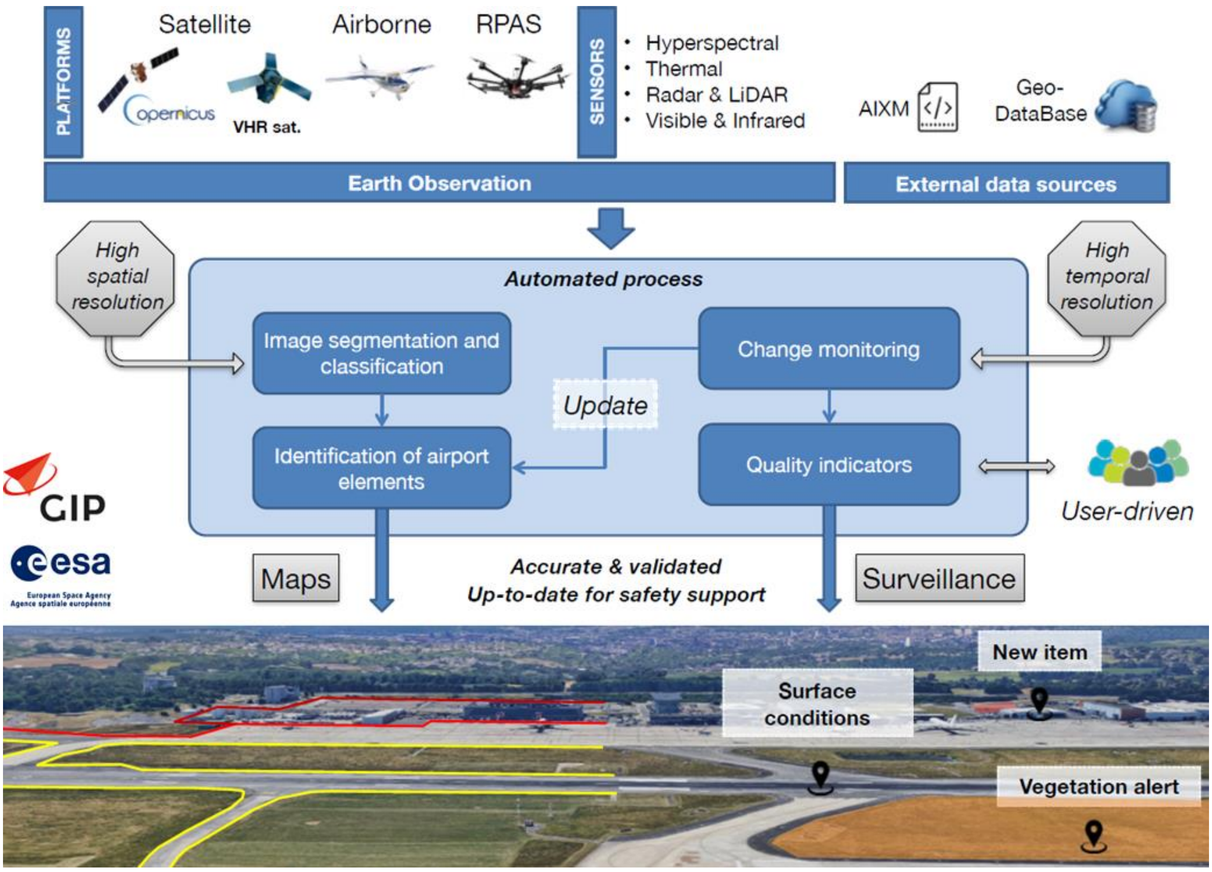


Figure 1. Earth Observation strategies as part of ESA Smart Airport project

Classification of PolSAR Crop Time Series with Missing Values using Recurrent Neural Networks

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
nicolas.wagener@esa.int

Nicolas Jakob Wagener

[1] European Space Agency, ESRIN, Italy

Keywords: PolSAR, Machine learning, Recurrent Neural Networks, LSTM

Abstract

Crop type classification is an important application of remote sensing data, for example in the context of food security or agricultural policies. Polarimetric Synthetic Aperture Radar (PolSAR) has the advantage of daytime and weather independence and lends itself for this purpose. However, the differentiation of crop types with similar physiognomy is difficult based on a single PolSAR scene alone. The solution is to add together multiple scenes over a longer period of time and making use of the different growth and harvest times for different crops. Since the polarimetric covariance matrices implicitly contain information about the scattering contributions of soil and vegetation, different growth stages and harvest times can be clearly distinguished.

With the current trend towards near real-time and large-scale remote sensing applications, one issue that arises, however, is that of unequal time series length (i.e. varying numbers of acquisitions / missing values). This is especially relevant in large scale operational agricultural monitoring where data from different satellite swaths or regions with different numbers of satellite overpasses should be compared.

For this work, 34 fully-polarimetric, ascending path RADARSAT-2 Fine-Quad images of an agricultural area in the Flevoland Province in the Netherlands were used that were obtained during the AgriSAR 2009 campaign. The scenes cover different satellite ground swaths which are shown in figure 1. This leads to the fields in the centre of the area of interest having more acquisitions than the fields in the periphery.

This represents a problem for most machine learning algorithms, since they require the input data sequences to be of equal length. In these cases a pre-processing step is necessary, to enforce this requirement. Commonly, the data is either truncated, which leads to the loss of possibly valuable information, or artificial substitute values are added to replace the missing values (so-called imputation), which can induce significant bias and uncertainty to the results. Recurrent Neural Networks, in particular Long-Short-Term-Memory (LSTM) networks, are a promising approach to overcoming this issue. They consider the temporal relationship and dependency of the input and have therefore been used extensively for time-series classification and regression. Furthermore, they have a great potential for the classification of time series with different sampling rates since they can handle input sequences of varying length.

In this work, a comparison is made between different approaches to classifying PolSAR time series of unequal length using LSTM networks. In particular, two approaches are compared:

- Omitting missing values and feeding the time series as-is to the network
- Filling the missing values using the last observation regulated by a decay function

The results are compared with a baseline machine learning algorithm using imputation and truncation with regards to classification accuracy and generalisation capabilities. The proposed approach has the advantage that the input data can be of any shape and generally does not need to be pre-processed. This enables more flexible processing architectures especially for large-scale, operational agricultural monitoring. Furthermore, the generalization capabilities of the proposed approach are shown using cross-validation and validation on other datasets. Finally, this work investigates the impact of varying numbers of acquisitions on the classification results.

Figure 1. Radarsat-2 ground swaths over area of interest.

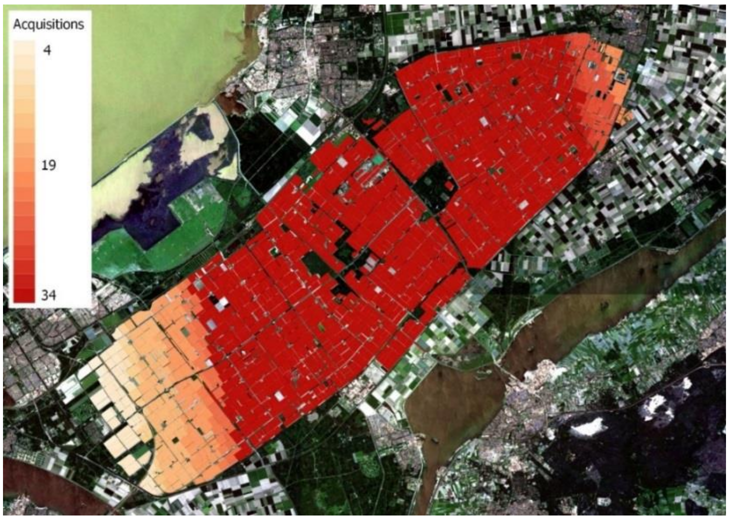


Figure 2. Number of acquisitions per field in the area of interest (Flevoland, NL).

digital@bw: Working with Optical Satellite Data within a Public Authority

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
maryse.wampach@lgl.bwl.de

Maryse Wampach[1], Franziska Wild-Pfeiffer[1], Marius Rokus[1]

[1]State Office for Spatial Information and Land Development Baden-Wuerttemberg (LGL), Germany

Keywords: Sentinel-2, Mosaicking, Classification, Change detection

Abstract

In 2017, the federal state government of Baden-Wuerttemberg decided to invest in the development of digital techniques in the social, the economic and the administrative sectors. To fulfil this aim, several so-called digital@bw projects were launched. Five of these projects were established within the State Office for Spatial Information and Land Development (LGL).

In this contribution, the current status of the digital@bw project “Kompetenzfeld Satellitendaten” is presented. The main goals are the development of expertise in the field of processing satellite data and thus the extension of the existing remote sensing capacities in the LGL (e.g. airborne remote sensing). Furthermore, the requirements for the development of a technical infrastructure for the permanent provision of satellite data in Baden-Wuerttemberg are assessed. The conjoint Copernicus programme of the European Commission and ESA provides free available and accessible satellite data of the Sentinel fleet for everyone. For this reason, the investigations conducted in the project are based on Sentinel-2 data.

In a first step, two pilot use cases were defined; the first one focuses on the pre-processing of the Sentinel-2 data (in particular on carrying out atmospheric corrections and applying cloud masking tools) and subsequently on the mosaicking of the 10 Sentinel-2 tiles covering the state of Baden-Wuerttemberg. For further investigations such as classification applications, the cloud masking of the data is mandatory. In this step, cloudy areas are replaced by so-called “No data” areas. Different cloud masks were investigated, “fmask” turning out to bring the best results in eliminating clouds and cloud shadows. As requested by the agricultural department, the mosaicking of the data is done in a 14-day time period for the whole state, which allows a tight monitoring of the agricultural vegetation cycle (taking into account the possibility that no cloud-free scene could be found in this time period). One of the main goals of this use case is to provide pre-processed, ready-to-use satellite data to other public authorities, small and medium-sized enterprises (SMEs), the public sector and citizens. Band combinations of the original Sentinel-2 data as well as additional indices such as NDVI, NDWI, etc. computed to mosaics of 10m or 20m spatial resolution are provided. The products are made available via WMS in the IT-infrastructure of the LGL.

The atmospheric corrected mosaics also serve as input data for the second use case: the land cover classification of Baden-Wuerttemberg. This study is carried out with respect to a decision of the Working Committee of the Surveying Authorities of the states of the Federal Republic of Germany (AdV), which prescribes that every state of Germany should be able by 2023 to deduce land cover out of remote sensing data. In the project, additional geospatial data of the LGL were introduced in the classification workflow besides the satellite data (i.e. digital terrain models, digital elevation models). Reference data for the classes were generated for each mosaic individually and based on the digital topographic model. The classification focuses primarily on the five main classes defined by AdV: agriculture, forest, water, urban areas and non-vegetation areas (defined as large rocky or pebbly areas, for example vegetation-free mountain areas or beaches). As classification algorithm, the Random Forest classifier is chosen. Each mosaic is analysed with the same routine. Up-to-date the overall accuracy of the classification is 94.9%.

Before the end of the project, a third use case will be analysed: the change detection of land cover based on the classifications of two different time periods with similar phenological appearances (e.g. changes between April 2017 and April 2018). The main goal of this study is to update the existing geospatial products of the LGL. For example, the orthophoto production is carried out in a cycle of three years in the LGL. With information gained in the change detection process based on Sentinel-2 data, it is possible to purchase specific high-resolution satellite data (e.g. WorldView-3 data) and update older orthophotos on a regular basis.

The current project will end in December 2019. To transfer the findings into the daily operational business of the LGL, a follow-on project of further two years is intended. The corresponding application is currently under review.

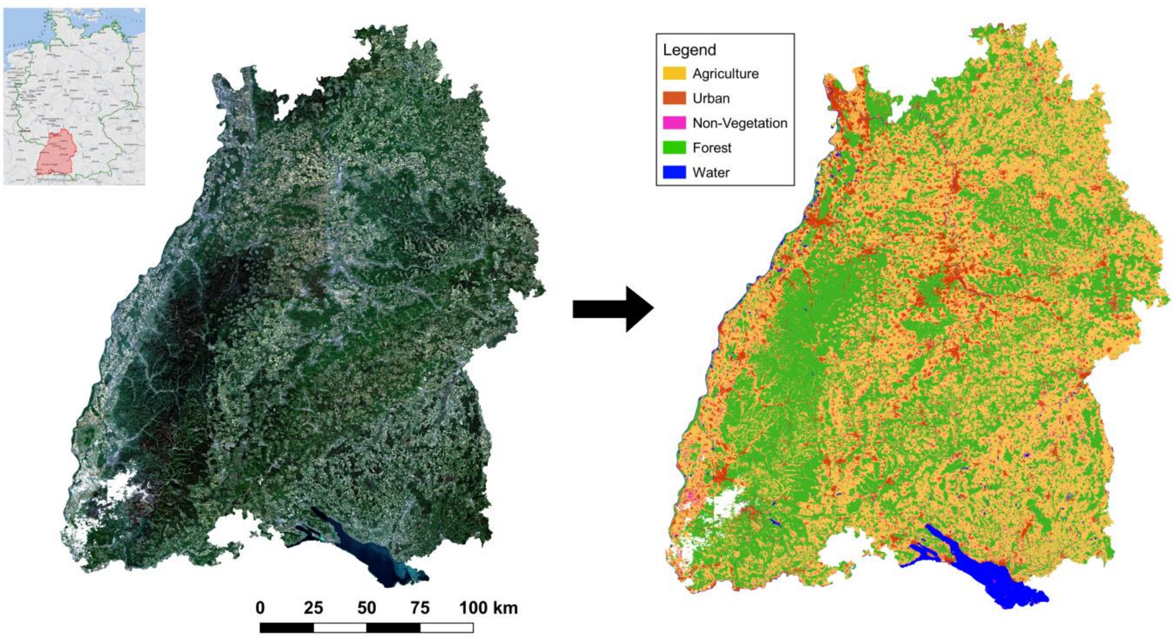


Figure 1. Two use cases of the digital@bw project "Kompetenzfeld Satellitendaten". First, atmospheric corrected mosaics of Baden-Wuerttemberg are generated with "No Data" areas where no cloud-free scenes could be found (left). Based on this product, a land cover classification is performed (right).

The Role of ISDE for Promoting the Vision of Digital Earth

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
wcl@aircas.ac.cn

Changlin Wang[1], Zhen Liu[1]

[1]Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences,China

Keywords: ISDE, Digital earth, Big earth data

Abstract

Digital Earth, a concept being proposed 20 years ago as a global initiative, aimed at harnessing the data and information resources of Earth to quantitatively describe and represent the planet and further a tool of monitoring, measuring, and forecasting natural and human activities on Earth so as to assist in addressing the problems humans are facing, such as global climate change, natural disasters, sustainable development, and so on. In response to this global initiative, the International Society for Digital Earth (ISDE) was founded with the mission of promoting the vision of Digital Earth worldwide. As a non-political, non-governmental and not-for-profit international organization, ISDE principally promotes academic exchange, science and technology innovation, education, and international collaboration towards Digital Earth. By far, ISDE has organized 10 symposia and 7 summits in 11 countries. The society also publishes two journals: *International Journal of Digital Earth (IJDE)*, and *Big Earth Data* journal. With the new development of earth observation, cloud computing, big earth data and associated data acquiring and processing technologies, the vision of Digital Earth is evolving as well.

ISDE is devoting to the development of Digital Earth. In 2012, a workshop was organized for discussing the vision of Digital Earth towards 2020 with two publications on IJDE and PNAS. Currently, ISDE is going to publish a *Manual of Digital Earth* at the 11th International Symposium on Digital Earth which will be held on 24-27 September 2019, in Florence, Italy and will develop a strategic plan for the development of the society. In this presentation, we will address our understanding to Digital Earth, Digital Earth related research work, and the activities of the ISDE. Therefore, we will present the role of ISDE in promoting the vision of Digital Earth.

CSEOL: Catalysing the Potential of Citizen Science for Earth Observation Into Concrete, Achievable Projects

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
u.wehn@un-ihe.org

Uta Wehn[1], Cathy Cotton[1], Elizabeth Gil-Roldán Little[2], Joan Masó[3]

[1] IHE Delft Institute for Water Education
[2] Starlab
[3] Ecological and Forestry Applications Research Centre, Spain

Keywords: Citizen science, Earth observation, Validation, Exploitation, Innovation

Abstract

The potential of using Citizen Science (CS) approaches and new digital technologies in a suitable setting for experimenting and generating new EO products and services is faced by social, scientific, technical and economic challenges. This requires a dynamic approach in which the facilitation of interactions amongst actors, incl. citizens, the wider public, NGOs and non-Space sector actors, takes centre stage in accelerating EO (Earth Observation) data-related innovations and their use.

The approach of the Citizen Science Earth Observation Lab (CSEOL) is firmly based in the open innovation paradigm (i.e. the co-creation of innovation beyond organisational boundaries) and on best practices for creating multi-stakeholder involvement in the innovation process. Specifically, LivingLabs provide an enabling environment to support the innovation process for all involved actors and stakeholders and allows to take into account their motivations.

The principle idea behind the CSEOL methodology is to create an innovation channel which drives the process of generating many ideas on how to explore the potential of CS to exploit EO data towards concrete, implementable projects. The CSEOLab will serve as a central place for idea generation and the co-design of CS EO projects.

Following a competitive Call for Ideas, ending 5 May 2019 to the CS and EO community, CSEOL will generate and fund a number of pilot projects with the purpose of demonstrating the potential of CS for the exploitation of EO. The Call will include collaboration with a range of innovation events, the resulting ideas providing initial insight into the range of participants and types of ideas that this kind of call can generate, an aggregated overview of which will be presented to the EARSeL audience.

The thematic focus of the pilots is proposed to be based on existing ESA programs (e.g. CCI, EO4SD, Copernicus services, Sentinel missions) and usual EO data nomenclature (Data levels), relating to the use and exploitation of EO for a) ESA missions, b) Climate change & sustainable development, and c) Downstream services. This is complemented by topics on how CS can be used for EO exploitation in terms of links with science, society, business and policy/decision making.

These innovative CS EO projects require a supportive yet flexible set up to allow creative exploration of innovative ideas about the use of EO data (e.g. new products and services, new mission concepts, public education, story telling) with a diverse range of actors (citizens, established CS communities, SMEs and private sector players, etc.) and using diverse and emerging digital technologies.

In the short run, CSEOL will result in greater awareness of citizens and participation of CS and non-space actors in using and exploiting EO data in four pilots, taking advantage of new and emerging digital technologies. In the long run, CSEOL will generate a continuous stream of ideas and new CS projects that support the exploitation and validation of EO and help shape ESA missions and concepts by involving the general public, Citizen Scientists and a wide range of non-space actors.

Spatial Analysis of Ecological Impacts of Global Change on Dry lands and their Implications for Desertification in Algeria.

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
z_ahmed65@yahoo.fr

Zegrar Ahmed[1], Bentekhici Nadjla [1], Mansour Djamel [1], Naima Benshila[1], Ghabi Mohamed [1]

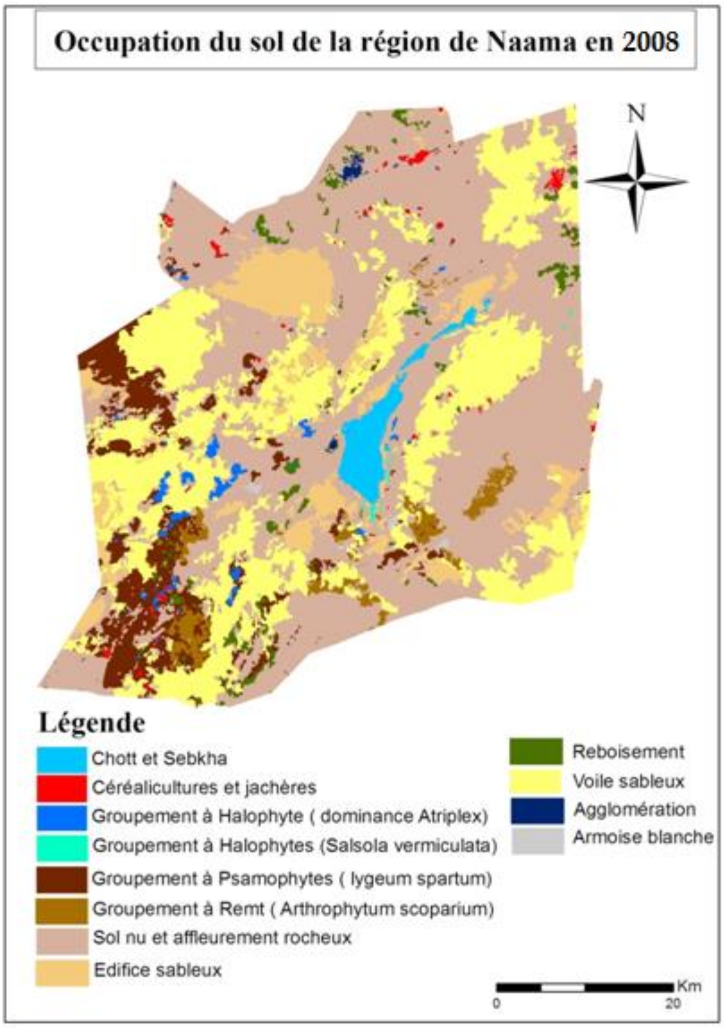
[1]Centre of Spaces Techniques, Algeria

Keywords: remote sensing, Alsat data, Semi arid Land, Desertification, Land Use changes.

Abstract

The degradation of arid and semi-arid ecosystems in Algeria has become a palpable fact that only hinders progress and rural development. In these exceptionally fragile environments, the decline of vegetation is done according to an alarming increase and wind erosion dominates and soil degradation. The ecosystem is subjected to a long hot dry season and low annual average rainfall. The urgency of the fight against desertification is imposed by the very nature of the process that tends to self-accelerate, resulting when human intervention is not forthcoming. In this study, the work is mainly based on the criteria for classification and identification of physical parameters as vegetation and soil characteristic for spatial analysis and multi-sources to determine the vulnerability of major steppe formations and their impact on desertification.

We used Land sat data (2008, 2011, 2014, 2017) in period November, and ALSAT (Algerian satellite) data with March 2010 in order to determine the changes in land cover, sand moving and land degradation for the diagnosis of the desertification phenomenon. The choice of two dates of images of different physical vegetation period, March and November is to differentiate between annual and perennials vegetation in relation to chlorophyll activity in a semi arid environment. The application, through specific processes, including the supervised classification was used derive index (NDVI, RVI) to characterize the main steppe formations. An analysis of the vulnerability of plant communities was conducted to assign weights and identify areas most susceptible to desertification. Vegetation Indices and brilliance index are used to characterize the steppe formations to determine changes in land use.


Occupation du sol de la région de Naama en 2008
N
Légende
Chott et Sebkha
Céréalicultures et jachères
Groupement à Halophyte (dominance Atriplex)
Groupement à Halophytes (Salsola vermiculata)
Groupement à Psamophytes (lygeum spartum)
Groupement à Remt (Arthrophytum scoparium)
Sol nu et affleurement rocheux
Edifice sableux
Reboisement
Voile sableux
Agglomération
Armoise blanche
Km
0
20

Feature Sensitivity to Scale Parameter and Image Segmentation Evaluation on Aeolian Desertified land

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
zhanglei@radi.ac.cn

Lei Zhang

[1] Key Laboratory of Digital Earth Science, Aerospace Information Research Institute, Chinese Academy of Sciences, China

Keywords: Segmentation, Object based image analyses

Abstract

Image segmentation is a basic and critical procedure in the object-based identification and classification of remote sensing data. Optimal scale parameter (SP) selection is a huge challenge in terms of complex landscape and uncertain feature changes over segmentation SP. This study used heterogeneous features of the inter- or intraimage objects to explore optimal SPs and evaluate feature sensibilities. Two 1.8 m high-spatial-resolution Worldview-2 images were used to perform successive multiscale segmentations. Optimal segmentation scale is defined as high homogeneity within an object and high heterogeneity among objects, the four features, namely, the local and global variances of brightness (MLV_B, GV_B) and normal difference vegetation index (MLV_{NDVI}, GV_{NDVI}) were calculated and evaluated.

The graphs indicate that the feature variations of MLV_B, MLV_{NDVI}, GV_B, and GV_{NDVI} were dependent on the segmentation SP (Fig. 1). The MLV_B and MLV_{NDVI} values increased rapidly with the increase in the segment size in fine SPs and increased slowly in coarse SPs both in in test sites 1 and 2. At the initial object segmentation, spatial adjacent objects had similar spectral values, the objects with small size were merged more easily than in coarser SPs, thereby resulting in a significant increase in the MLV_B value in fine SPs. Although the SP increased, the spectral difference among spatial adjacent objects also increased, and objects were became difficult to merge in the same increase in SP, thereby leading to an insignificant increase inMLV_B. Ideally, object boundaries preserved along a number of scale levels represent an optimal scale section, which slows down the general increase or does not change the LV_B. The object merging rate of various land covers was not the same with the increase in SP, however, MLV_B is the mean value of all objectLV_B, which caused the smoothed effect of LV_B. Therefore, the steady (or no change) section of the MLV_B curve over SP is difficult to measure. Therefore, MLV_B or MLV_{NDVI} may not be able to estimate the image segmentation quality accurately.

GV_B and GV_{NDVI} yielded different results (Fig. 1). GV_B curves showed an evident peak at the SP of 25 in test site 2 and several peaks at the SP of 30, 80, and 150 in test site 1. These peaks can be the candidate indicator of the optimal scale. Theoretically, the initial object merging yielded low GV_B, while adjacent objects had similar spectral values. In this situation, a real-world polygon is often matched to many image objects in the over segmentation stage. Low GV_B also occurred in coarse SP, while an image object generally covered many real-world polygons. Hence, only suitable scale generates high variance among the objects and results in GV_B peaks. The GV_{NDVI} curves had trends similar to those of GV_B curves.

However, extremely low amplitudes showed oscillation change or quick descending trend. Hence, the peaks cannot be distinguished from SP. NDVI was sensitive to the change in vegetation but also filtered other spectral information. Therefore, GV_{NDVI} is a weak indication of optimal scale compared with GV_B. A number of peaks and peak positions of GV_B in the two test sites suggested that landscape categories and cover size determined the GV_B curve shapes.

Test site 1 covered various vegetation types and sandy land, thereby forming multiple GV_B peaks. Meanwhile, sandy land was dominant in test site 2, thereby producing a single GV_B peak.

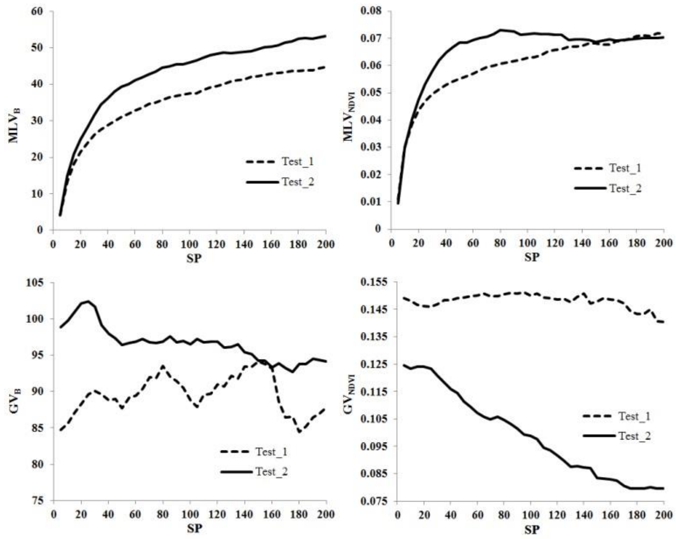


Figure 1. Feature changes in MLV_B, MLV_{NDVI}, GV_B, GV_{NDVI} with the increase in scale parameter in two test sites.

Results demonstrated that the peaks of the global variance of brightness curve over SP had the goodness of fit to the optimal segments regardless of the landscape patterns. This feature was proven robust in measuring appropriate SPs. Other heterogeneous features had obscure responses to optimal SPs.

Random Forest Based Automated Crop Mapping in Small-Scale Farming using Stacked Multitemporal Sentinel 1 and Sentinel 2 Satellite Imagery: A Case Study for Croatia

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
iziza@oikon.hr

Ivona Žiža[1], Ivan Tomljenović[1], Branimir Radun[1], Alen Berta[1], Zrinka Mesić[1], Vladimir Kušan[1]

[1] Oikon Ltd. Institute of Applied Ecology, Zagreb, Croatia

Keywords: Radar satellite imagery, Multispectral satellite imagery, Agriculture, Automated classification, Random forest

Abstract

Various remote sensing techniques have been actively applied in Croatia within forestry, land and topographic surveying over the past decades. Such an approach has never been applied in the agricultural field of study. With our approach, we wanted to apply remote sensing data and machine learning techniques to test its feasibility for our project needs. Through the project “Determination of less-favoured areas for agricultural production in Croatia”, we wanted to use available free source satellite imagery data provided by the European Space Agency (ESA) to map agricultural land cover classes. The main aim of our study was to use the Random Forest (RF) classifier to classify various agricultural crops, explore best vegetation periods for each crop to get a seasonal pattern and to find the most suitable vegetation indexes for crop mapping.

The entire process was handled with the use of SNAP and R-studio environment. The main processing steps included pre-processing of Sentinel 1 (radar) and Sentinel 2 (multispectral) raster imagery. Among others, these steps included orbit corrections, calibration, thermal noise removal, terrain correction and multi-temporal speckle filtering for Sentinel 1 images along with spatial resampling (10m pixel resolution) for Sentinel 2 imagery. Processing and imagery classification was done within R-studio environment.

The selected approach was tested on the area of Bjelovar-Bilogora County (264 000 ha). The input data used for classification was a set of polygons representing each of the sixteen specific crop classes obtained from the Croatian database of agricultural parcels (LPIS). About 70 % of input data was used to train and the rest to validate the RF algorithm. The classification was done using a combination of multi-temporal (April to October) Sentinel 1, Sentinel 2 imagery and specific vegetation indices (SAVI, NDVI, CCCI, CIgreen, CIrededge, LCI).

The challenges recognized with this approach, apart from necessary processing power and data storage, were mainly related to input data accuracy. Agricultural input data contained small parcels, with defined uniform use. After manually inspecting the input data, we concluded that most of the training polygons weren’t homogeneous, and the land use mentioned in the LPIS did not refer to the real land use on some parcels. Due to that, the input data was photo-interpreted and corrected by means of visual identification. Also, we recognised the importance of including forest, water and build-up classes. Although these are not agricultural classes, they significantly affect crop mapping accuracy. Another important finding was made regarding the use of the CCCI (Canopy Chlorophyll Content) index. It causes significant problems in the interpretation of crops by generating high salt and pepper noise effect and we deem it inappropriate for use.

After correcting the input data, the RF algorithm was tested, and the classification accuracy of 92.2 % was achieved. Time spread between April and October has shown to be the appropriate choice for multi-temporal analysis while the addition of water, build-up and forest classes increased the accuracy of the entire approach. The next step includes the application of the chosen approach on a countrywide level.

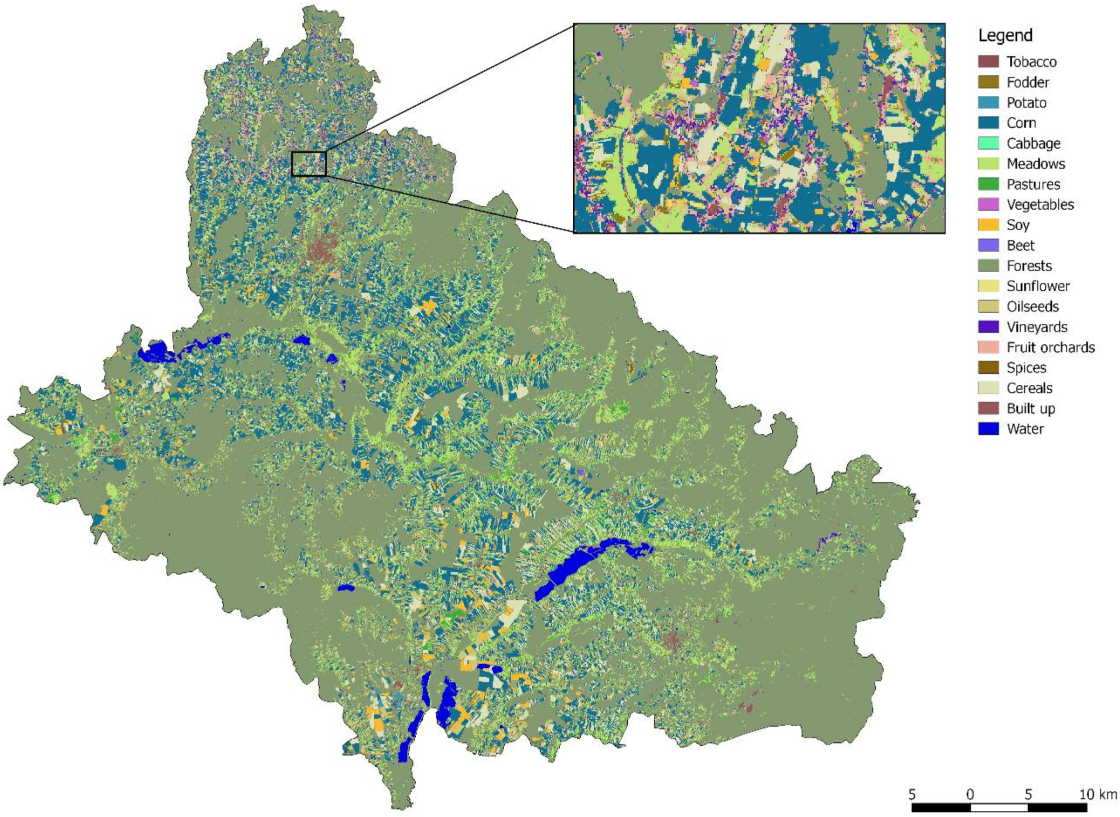


Figure 1. Classification for the area of Bjelovar-Bilogora County done used with proposed method

Using Earth Observation and Open-source Information to Monitor Environmental Dimensions of Armed Conflicts

EARSeL 2019
Digital I Earth I Observation
Abstract
Corresponding Author:
zwijnenburg@paxforpeace.nl

Wim Zwijnenburg[1]

[1]PAX/Bellingcat, the Netherlands

Keywords: Earth Observation, Environment, Conflict, Open-source

Abstract

Research on wars and armed conflicts has often failed to address the acute and long-term impacts on the environment. This gap of knowledge on these dimensions was often the result of lack understanding on the consequences of environmental damage, lack of access to conflict areas due to security reasons, other priorities in terms of funding and perceived needs for research and the absence of tools to undertake monitoring. Often, only conflicts where environmental impacts were clearly visible such as the 1991 Gulf War, where Saddam Hussein's army set fire 600 oil wells in Kuwait, will gain traction from the general public and media. With the rise of internet access, mobile phones and accessible satellite imagery, a wealth of data became available for journalists, researchers, academics and civil society organisations to actively monitoring conflicts and support tracking human rights violations, war crimes, behaviour of armed groups, but also humanitarian needs and environmental impacts. This development of open-source information (OSINT) and combing it with remote sensing tools is paving the way for improving our understanding how wars and armed conflict can have short and long-term impacts on environment and health.

In the last 4 years, PAX and Bellingcat have applied these novel opportunities to document a range of these impacts, starting with the war in Syria and damage to urban areas in the western part, to the target of oil industries and related pollution problems in the eastern part of Syria, while also affecting agriculture. Through high and medium resolution imagery, we identified over 330 cluster of artisanal oil refineries through the governorates of Hasakah, Raqqa, Deir ez Zor, Aleppo and Homs. At each cluster, there can be a handful or hundreds of oil refineries, often employing children that work in dangerous conditions, and that are based near environmental sensitive locations such as water sources. Toxic residues from oil refining and air pollution can affect the local environmental health conditions, while the storage of crude oil and tar waste in makeshift reservoirs pose further risk through large spills or impacting local soil conditions.

In Iraq, the so-called Islamic State destroyed water irrigation infrastructure, built makeshift oil refineries, attacked oil pipelines and set fire to oil wells and a sulphur dioxide storage. Their actions and the fight to defeat them lead to further environment impacts that will echo into the future if not documented and tackled through proper reconstruction policies. Through remote sensing and OSINT, PAX managed to establish a database with over 90 potential environmental hotspots between 2015 and 2018, and provide this information to the Iraqi government and UN Environment, who, with funding from Norway, started to identify the environmental damage in areas retaken from ISIS.

Our mapping turned out the have a 66 % accuracy rate in finding significant pollution on site, solely through OSINT. This saved time and money that could be directed towards further research such as sampling and remediation of affected sites.

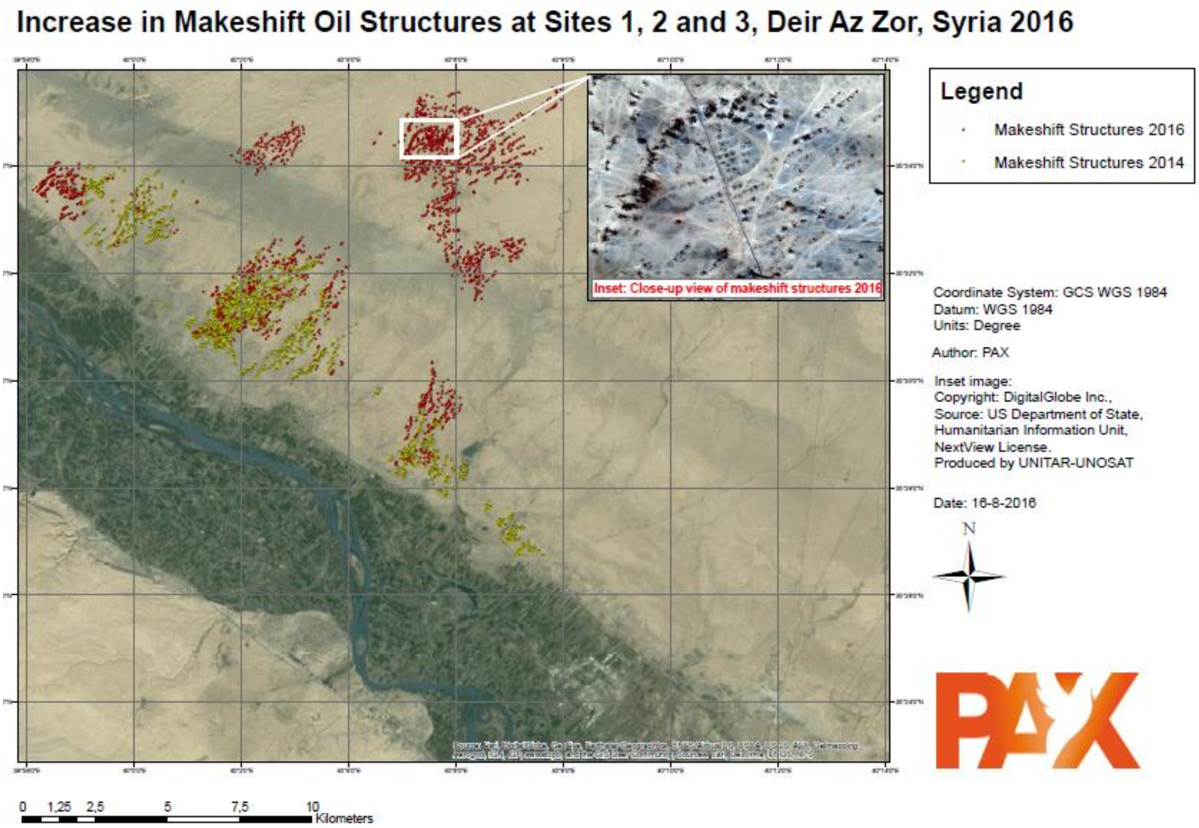


Figure. 1 Two data sets from 2013 and 2016 show increase of artisanal oil refineries in Deir ez Zor, Syria.

These are just a few examples of how OSINT and remote sensing can support in conflict situations. There are huge opportunities for the remote sensing community to contribute to a better understanding of the environmental impacts of conflicts, e.g. how agriculture is affected by ongoing fighting, change in land use, or if there is increase (or decrease) of deforestation in conflict zones, how biodiversity is changing or how toxic remnants of war can pose a threat to the environmental health of communities.

This data on the environmental dimension of armed conflicts can deepen our understanding of conflict dynamics, improve humanitarian response and post-conflict environmental assessments, have more effective and efficient reconstruction and rehabilitation results and i overall contribute to building more accountability of states and non-state actors of the environmental damage caused by military activities.


UNIVERSITY of SALZBURG
Z_GIS
esa
European Space Agency
Copernicus Academy
CopHub.AC
Malvern Panalytical
a spectris company
Trimble
LAND SALZBURG
GEOSYSTEMS
THE GEOSPATIAL EXPERTS
spatialservices
WHERE GEOINFORMATION MEETS TECHNOLOGY
FFG
Forschung wirkt.