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# GEOBIA2018 COMPTE-RENDU QUALITATIF de l'OPERATION

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## COMPTE-RENDU QUALITATIF de l'OPERATION

### Conférence

GEOBIA2018 (Geographic Object-Based Image Analysis). 7e occurrence

### Description synthétique du déroulement de la conférence

Site web <https://www.geobia2018.com/>

Plusieurs unités de recherche régionales (TETIS, EspaceDev, CESBIO et ONERA) ont postulé pour obtenir la localisation de la session 2018 en France et obtenu la possibilité de réaliser, à Montpellier, du 18 au 22 juin 2018, le Colloque **GEOBIA2018** (Geographic Object-Based Image Analysis).

Le thème de l'édition 2018 « GEOBIA in a changing world. *From pixels to ecosystems and global sustainability* » positionne les développements de la communauté de traitement d'images et d'Information Géographique face aux enjeux mondiaux actuels.

C'est la première fois que cette manifestation se déroule en France après Salzburg (2006), Calgary (2008), Ghent (2010), Rio de Janeiro (2012), Thessaloniki (2014) et Enschede (2016). Ce colloque a reçu le soutien de l'International Society for Photogrammetry and Remote Sensing et de la Société Française de Photogrammétrie et de Télédétection.

Cet évènement souligne et conforte la pertinence des synergies mises en place entre les pôles de Toulouse et de Montpellier qui constituent aujourd'hui, avec un appui toujours renouvelé de la région, une communauté de référence à l'échelle Française et Européenne, et de rayonnement mondial.

Ce colloque a permis de mettre en valeur les travaux récents dans le domaine de l'Orienté Objet pour les UMR organisatrices mais aussi pour toutes celles développant des méthodologies innovantes (techniques de segmentation d'images multi-niveaux, algorithmes de classification par objet, fusion de données, traitement de données massives etc.) appliquées à divers domaines d'application comme l'agroécologie, la biodiversité, la foresterie mais aussi la fragmentation des paysages et la croissance urbaine. La forte volonté des organisateurs de se tourner vers les collègues du Suds correspond bien à la spécificité régionale d'ouverture vers nos partenaires du Maghreb mais aussi de l'Afrique ou de l'Amérique latine. Cette ouverture répond aussi au positionnement du projet I-Site Muse.

### Thèmes de la conférence

Remote sensing has faced a paradigm shift in the last years. GEOBIA activities have defined a new framework for image analysis and for participating activities towards stakeholders. Technological and user driven evolution in remote sensing image analysis have tremendously changed the usual per pixel spectra model. Geographic Object-Based Image Analysis community needs to be fostered in order to facilitate dissemination of new evolving related principles, methods and tools.

New sensors capacities and increasing user's demand need to be highlighted through exchange and collaboration perspectives for various global issues like food security, crop yield modelling and other global changes issues.

The image processing techniques addressed by the GEOBIA community contribute to increase the potential of remote sensing data for land use mapping and other applications. The research groups which are active in this field in Montpellier and Toulouse, have long used remote sensing for tropical research in developing countries, so that they propose to widen the scope of the event and also address such applications as monitoring and managing resources for development and food security. Moreover, image-based indices handled by the GEOBIA community can be meaningful in landscape ecology to describe either urban, rural or natural landscapes and therefore contribute to understanding and modeling complex ecosystems.

GEOBIA'18 should bring together scientists, professionals and users, academia, industry, the public sector and government around the world.

GEOBIA'18 will continue to be a platform for presenting research and development on traditional themes: theory / concepts, methods / algorithms and OBIA applications. Particular attention will be given to the current challenges of large data integration, open source solutions, Cloud analysis, semantics and knowledge integration.

Promoting the event towards our colleagues from the South, 2018 GEOBIA will offer an opportunity for exchange and collaboration perspectives for various global Earth issues facing climate change impacts. South and North teams would find during this session the opportunity to present their work regarding worldwide challenges such as agro-system, forestry and natural resources monitoring, food security or crop yield modelling, risks management or urban applications (densification, Landuse-Landover change processes ...).

Agriculture	Big Data
Artificialization	Cloud analysis
Biodiversity	Semantic and knowledge
Environment	Multisensors integration
Forestry	New sensors
Urban	Time series
Littoral	
Ice sheet and Glacier	

### Soumission et processus de sélection

Soumission 168 issus de 28 pays

Acceptation : 34 acceptées Taux de rejet : 20%

Présentations orales : 34 (30 minutes par présentation)

Posters : 18 ; 2 séances

Technical session : 1 session (Trimble)

## 5 keynotes

- Cláudia Maria de Almeida – Senior researcher, National Institute for Space Research (Brazil)
- Marguerite Madden – Director, Center for Remote Sensing and Mapping Science, Department of Geography, University of Georgia (USA)
- Thomas Blaschke – Professor for Geoinformatics, Deputy director Department of Geoinformatics, University of Salzburg (Austria)
- Geoffrey Hay – Associate Professor Geography, ISEEE Fellow, Department of Geography, University of Calgary (Canada)
- Christian Heipke - Professor for photogrammetry and remote sensing and head of the Institute of Photogrammetry and GeoInformation (IPI), Leibniz Universität Hannover, (Germany)

## Thèmes des présentations sélectionnées

Aspects Méthodologiques : 4 sessions (fusion et intégration, extraction de connaissances, séries temporelles et Big Data/deep learning)

Thématique : Agriculture, foresterie, urbain, archéologie

## Publication des actes

Les communications scientifiques abstracts seront déposés sur HAL, les papiers long révisés seront déposés et disposerons d'un DOI, enfin un numéro spécial de la revue International Journal of Geo-information (open access) est en cours de finalisation [http://www.mdpi.com/journal/ijgi/special\\_issues/GEOBIA](http://www.mdpi.com/journal/ijgi/special_issues/GEOBIA).

### Scientific Committee (local)

Christiane WEBER - Conference-Chair (UMR TETIS, Montpellier)  
Frédérique SEYLER - Co-Chair (UMR ESPACE-DEV, Montpellier)  
Laurent POLIDORI - Co-Chair (UMR CESBIO, Toulouse)  
Xavier BRIOTTET - Co-Chair (ONERA DOTA, Toulouse)  
Laurent DURIEUX - PHD colloquium (UMR ESPACE-DEV, Montpellier)  
Pierre-Yves VION - PHD colloquium (AgroParisTech)  
Raffaele Gaetano Tetis, France  
Laurent Durieux EspaceDev, France  
Stéphane Dupuy Tetis, France  
Pedro Luiz Oliveira de Almeida Machado (Embrapa Labex Europe)

Jordi Inglada CESBIO, France

Guerric le Maire Eco&Sol France

Valentine Lebourgeois Tetis France

Samuel Alleaume Tetis, France

Christophe Revillon, EspaceDev, France

Nicolas Bagdadi Tetis THEIA, France

Kenji Ose Tetis, France

Camille Lelong Tetis, France

### Organizing Committee

Annie Huguet (UMR TETIS, Montpellier)

Christophe Révillion (UMR ESPACE-DEV, La Réunion)

Véronique Rousseau (UMR ESPACE-DEV, Montpellier)

## Indicateurs de réalisation

Nombre de participants : 106 inscrits

Taux d'internationaux : 68% de 28 pays différents

Taux de chercheurs français : 21%

Taux de chercheurs : 60%

Taux d'étudiants (doctorants, post doctorants) : 40%

Nombre de posters : 18 (2 sessions)

Nombre de stands (entreprises/associations/autres acteurs non académiques / acteurs académiques) : Société Trimble, PCI Geomatics Enterprises Inc., publications de l'IRD, Pôle de données surfaces continentales THEIA)

## Déroulement

- **PhD Colloquium 18 et 19 juin 2018**

Un jour et demi de formation a été mis en place pour des jeunes chercheurs (doctorants, post-doctorants, jeunes collègues) diverses interventions ont été réalisées

- par COPERNICUS Programme and the Research and Users Support Service (<https://rus-copernicus.eu/portal/>) pour présenter le programme européen Copernicus et les services associés.
- Par la société TRIMBLE (<https://www.trimble.com>) société spécialisée dans le traitement de données spatiales pour les ressources naturelles, l'agriculture, les transports etc...) avec des sessions théoriques et pratiques.

Parmi ces jeunes collègues, 5 ont été sélectionnés (sur 17 candidatures) sur dossiers pour obtenir une bourse couvrant le voyage, le logement, l'inscription au colloque et à la formation. Les jeunes collègues ayant bénéficié d'un support financier venaient de : République Démocratique du Congo, Nigéria, Comores, Gabon, Inde et Pakistan ; 3 femmes, 2 hommes). *Malheureusement deux défections pour cause de visa du Pakistan.* (Annexe 1 Book PhD)

*Une évaluation a été faite sur la formation.*

- **Présentations 20 au 22 juin 2018**

Le colloque a rassemblé une centaine de personnes venant de 24 pays différents, nous avons eu des défections pour cause de grève des transports (beaucoup) et problème de visa avec des collègues venant du Maghreb ou d'Afrique. (Annexe 2 Abstracts Book)

Il s'est tenu sur 2 jours et demi avec des sessions plénières et des sessions parallèles et une « panel session » de discussion entre les personnes invitées (Keynotes) et la salle le vendredi en fin de matinée. Cette « panel session » a permis d'aborder la thématique de l'innovation dans une vague de transition numérique et les développements futurs des traitements orientés objets (IA, profusion de capteurs, besoins des utilisateurs, arrivée sur le marché de fournisseurs privés d'images).

### **Jeunes collègues ayant bénéficié du support financier d'Agropolis fondation ( 5 sélectionnés sur 15 demandes)**

Prune C. KOMBA MAYOSSA , Gabon

Paul GBETKOM, Cameroun

Samuel AKANDE Nigeria (retenu après la defection de M TRIPATHY)

Artadji ATTOUMANE Comores

Bismay Ranjan TRIPATHY Inde \*

Sumaira ZAFER Pakistan \*

*\*Ne sont pas venus pour des problèmes de visa, la somme allouée nous a permis de prendre l'ensemble des frais en charge.*

# Programme

	Monday 18	Tuesday 19	Wednesday 20	Thursday 21	Friday 22
8:30			<b>AGROPOLIS International</b>		
8:30 9:00		Maison de la Télédétection	<b>REGISTRATION</b>	<b>AGROPOLIS International</b>	<b>AGROPOLIS International</b>
9:30		PhD and Young researchers Colloquium	Opening Sessions	Thomas Blaschke	Geoffrey Hay
9:30 10:30			Christian Heipke	Andrea Baraldi	Pierre Maurel - GEOSUD
10:30			break	Khelifa Djerriri	Nicolas Baghdadi - THEIA
10:30 10:45		break	break	break	break
10:45 11:15		PhD and Young researchers Colloquium	Rémi Cresson/Julien Michel	Nuria Sanchez Lopez	Andrea Baraldi
11:15 11:45			Sébastien Lefèvre	Josselin Aval	Dino Ienco - Deep learning
11:45 12:15			Sébastien Lefèvre	Masroor Hussain	Stefan Lang
12:15 12:45			Ovidui Csillik	<b>Poster Session</b>	Discussion
12:45 13:15		Lunch	<b>Poster Session</b>	Lunch	Lunch
13:15 14:30			Lunch	Lunch	Lunch
14:30	Maison de la Télédétection	PhD and Young researchers Colloquium	Marguerite Madden	Claudia de Almeida	
14:30 15:00			C.V. Angelino		
15:00 15:30	PhD and Young researchers Colloquium		Mostefa Kouachi/George Mitri	TRIMBLE	
15:30 16:00			Anne Osio		
16:00 16:30			break	break	
16:30 17:00	break	break	Didier Josselin	Luigi Magnini	
17:00 17:30	PhD and Young researchers Colloquium	PhD and Young researchers Colloquium	Lynda Khiali	Artadji Attoumane	
17:30 18:00			Nicholus Mboga	Peter Hoffmann	
18:30			<b>ICE BREAKER - Salle Vanille</b>		
20:00				<b>DINNER</b>	
			<b>Parrallel Session</b>	<b>Parrallel Session</b>	
10:45 11:15			Khelifa Djerriri	Dawa Derksen	
11:15 11:45			Zahra Dabiri	Sébastien Lefevre	
11:45 12:15				José Valéro	
12:15 12:45					
14:30 15:00			Lisa Landuyt		
15:00 15:30			Wimila Van Iersel		
15:30 16:00			Dirk Tiede		
16:00 16:30			break	break	
16:30 17:00				Marjolein Vogels	
17:00 17:30				Prune C. Komba Mayossa	
17:30 18:00				Ursa Kanjir	

## Communication

Annexe 3

- les documents édités avec le logo régional

Site web

Kakémono

Books

## Liste des participants

Voir Annexe 4

## **Annexe 1**

PhD Book



# GEOBIA 2018

GEOBIA in a changing world

From pixels to ecosystems and global sustainability

June 18-19, 2018, Maison de la Télédétection, Montpellier

## PHD PROGRAM



[www.geobia2018.com](http://www.geobia2018.com)





# GEOBIA 2018

GEOBIA IN A CHANGING WORLD

18 – 22 Jun 2018  
Montpellier (France)



## GEOBIA 2018

### PhD and Young Researchers Colloquium – 18-19 June 2018

#### New Ways of Satellite Image Acquisition and Operational GEOBIA processing using eCognition

The 2018 GEOBIA conference will be enriched by a 1½ day PhD and Young Researchers Colloquium jointly organized with AgroParisTech, Copernicus program and Trimble. The purpose of the Colloquium is to help doctoral students interested or working in the field of GEOBIA to develop an effective research and career plan in this domain. The focus of the colloquium will be on discussions and mentoring, as well as sessions to find together adequate solutions to specific GEOBIA problems posed by the participants. The Colloquium will benefit from the GEOSUD platform facilities to be in direct contact with a spatial image acquisitions infrastructure and by the presence of Copernicus Program representative, AgroParisTech researchers and technician and Trimble technical team. Participation fee to the colloquium is 50 Euro, Tuesday lunch and refreshments are included. However, participants wishing also to participate in the GEOBIA conference must register (see <https://geobia2018.sciencesconf.org/resource/page/id/1> ; a student rate is available). We also ask interested Phds or postdocs to provide a short CV and motivation letter that includes details about their current research, and specific interest in GEOBIA. Basic concepts in remote sensing are a prerequisite to the participation to the PhD colloquium.

The colloquium will be divided in two sessions:

- Images Acquisition: from the satellites to your screen
- eCognition

This first session on image acquisition will allow you to:

- Practice the entire image acquisition chain SPOT, from the command to the reception of the data;
- Discover the richness of the Copernicus programme, how to process image data flows and the other services delivered by the Research and User Support (RUS).

A presentation of the GEOSUD-THEIA spatial data infrastructure will show you how to order a SPOT 6/7 image. From the operations room located at the House of Remote Sensing, the operators will then explain how your order is programmed and followed, and finally how your image is produced. And you will live in real time the acquisition of an image at the foot of the antenna of the receiving station GEOSUD.

The Copernicus programme, thanks to its constellation of Sentinel satellites and thematic services, renews the offer in data by types / resolutions / frequencies of acquisition. This flow of data requires the development of new treatments adapted to large volumes and the continuous supply of new data. In order to meet this objective, the RUS Service, which is the “New Expert Service for Sentinel Users” has been funded by the European Commission. It is managed by the European Space Agency, and operated by CS SI and its partners.

The main objectives of the RUS Service are:

- To promote the **uptake** of Copernicus data;
- To support the **scaling up** of R&D activities with Copernicus data

These new perspectives and methodological issues will be presented and discussed.

The second session on eCognition (TBD)

We anticipate a group of ca. 20 students including 5 invited PhD students or young researchers from developing and transition countries thanks to a call directly accessible from the GEOBIA 2018 conference Website. The colloquium will end with a wrap-up discussion of how lessons from the colloquium can be applied to achieving scientific results and at the same time an effective work-life balance..

**Schedule:**

Monday, 18/06/18., 13:30 – 18:30.

Tuesday, 19/06/18., 9:00 – 18:30.

**How to apply:**

☑ Register via the form at <https://www.geobia2018.com/>

☑ Upload a short CV (max. 2 pages)

☑ Also upload a short motivation letter (max. 1 page) that includes details about your current research, and specific interest in GEOBIA.

**Detailed Schedule**

Monday, 18 June 2018 (13:30-18:30)				
Start	End	Activity	Main facilitator	Notes & details
13:30	13:40	Welcome		Intro & overview of event
13:40	14:20	Introduction by participants		1 minute each, background, research challenges
14:20	15:00	Spot Image Acquisition Chain		
15:00	16:00	GEOSUD Infrastructure Visit		Antenna and Operations Room Visit
<b>16:00</b>	<b>16:30</b>	<b>Coffee break</b>		
16:30	17:00	The Copernicus Programme		
17:00	18:30	The RUS services		
Tuesday, 19 June 2018 (9:00-17:45)				
Start	End	Activity	Main facilitator	Notes & details
9:00	10:30	eCognition		
<b>10:30</b>	<b>11:00</b>	<b>Coffee break</b>		
11:00	12:30	eCognition		
<b>12:30</b>	<b>14:00</b>	<b>Lunch</b>		
14:00	15:30	eCognition		
<b>15:30</b>	<b>16:00</b>	<b>Coffee break</b>		
16:00	17:30	eCognition		
17:30	18:30	Reporting / discussion		Discussion of how to apply the colloquium lessons and outcomes

# GEOBIA 2018

## GEOBIA IN A CHANGING WORLD

### From pixels to ecosystems and global sustainability

June 18-22, 2018 - Agropolis International – Montpellier

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MONITORING OF ACACIA XANTHOPHLOEA SPP USING OBJECT BASED TIME SERIES:-A CASE STUDY OF LAKE NAKURU NATIONAL PARK.

#### SUMMARY OF PHD THESIS

In recent times, the yellow barked *acacia xanthophloea* tree species along Lake Nakuru has been suffering from moisture stress. This was due to the effect of the flooding on the lake's riparian reserve. It was therefore important to monitor the degradation of the *acacia xanthophloea spp* since it is a habitat and feed for animals within the National Park.

The year 2000 map of Lake Nakuru National Park was used as baseline to capture the spectral signatures of the different riparian vegetation and to detect the changes that occurred on the riparian reserve of the lake from 2010 to 2016. The class '*sand & mudflats*' had the highest spectral reflectance, followed by '*chloris gayana*' grasslands. Among all the vegetation classes, *acacia xanthophloea* had the lowest spectral reflectance. Different satellite imageries from various satellite sensors were also used for the analysis of datasets. Landsat8OLI and Landsat5TM which were pre-processed by subsetting, pan-sharpening (by IHS method), radiometric and geometric corrections.

To get the results, softwares that were used to analyse the datasets were ARCGIS 10.4, Erdas Imagine 2014 and eCognition Developer 9.2 and Open source Weka Software. Other pre-process technique entailed the conversion of raw DN values into Top-of-The Atmosphere (TOA) reflectance which made possible the calculation of vegetation Indices which is a measure of vegetation vitality. It was also possible to import the pre-processed images into eCognition Developer 9.2 for OBJECT based classification of vegetation species. The possibility of creating rulesets within eCognition Defiens allows for big data processing at the shortest time

possible. Before classification, segmentation at different scales were carried out on the imageries.

Accuracy assessment was carried out on the different classified images using algorithms J48, Naïve Bayes, Binary Support Vector (SMO) and Random forest. Random forest emerged the best classifier with a Kappa statistic of 1.0 followed by J48 with a Kappa statistic of 0.92. It was worthy to note that the accuracy of classification carried out in Weka software depend on the number of instances entered into its environment.

It was noted that the lake had flooded the riparian reserve since the year 2011 the area covered by the lake was 860 pixels while 1024 pixels in 2016. The area covered by acacia before the flooding (2010) was 891 pixels but in 2016 it had reduced to 465 pixels.

NDVI maps and values were generated from the pre-processed imageries. The general NDVI values captured from the 2010 Landsat 5TM imagery ranged between -0.19 to +0.63 while in 2016 it was noted that NDVI on the 2016 Landsat8OLI ranged between -0.32 to +0.16 indicating that there was a general degradation of vegetation species within the park.

eCognition Defiens software was solely used for the segmentation and classification processes on each imageries. It was not possible to retrieve attribute data from Defiens meaning that the maps (in form of shapefiles) had to be generated in eCognition Software together with the attributes stored as CSV files had to be exported to ARCGIS 10.4 for retrieval, viewing and further manipulations.

Within the ARCGIS environment Thematic re-classification is made possible whereby pixels were able to be identified and attached to their relevant classes. At this point the accuracy of classification would always depend on eye judgement of the analyst. The drawbacks of thematic reclassification in ARCGIS falls into being when the cluster based algorithm in ARCGIS (ISODATA) is used in this case. This interferes with the classification accuracy of the same map that was exported from eCognition Defiens to ARCGIS 10.4.

In conclusion, there is need for the creation of GEOBIA solutions that would incorporate all of the processes that were carried out within the four Softwares (ARCGIS, ERDAS IMAGINE, eCognition Defiens and WEKA).

# GEOBIA 2018

## GEOBIA IN A CHANGING WORLD

### From pixels to ecosystems and global sustainability

June 18-22, 2018 - Agropolis International – Montpellier

#### PHD RESEARCH TOPIC

### GESOPATIAL ASSESSMENTS OF COASTAL VULNERABILITY IMPACTS, AND ADAPTATION TO EXTREME WEATHER EVENTS IN NORTH-ATLANTIC COAST.

#### Background Information

Climate change is one of the most urgent issues of our time with widespread implications for the earth's ecosystems, global sustainability, and human development across sectors. There are evidences of climate change all over the world, these include sea level rise, global temperature rise, warming oceans, extreme weather events, ocean acidification, etc.

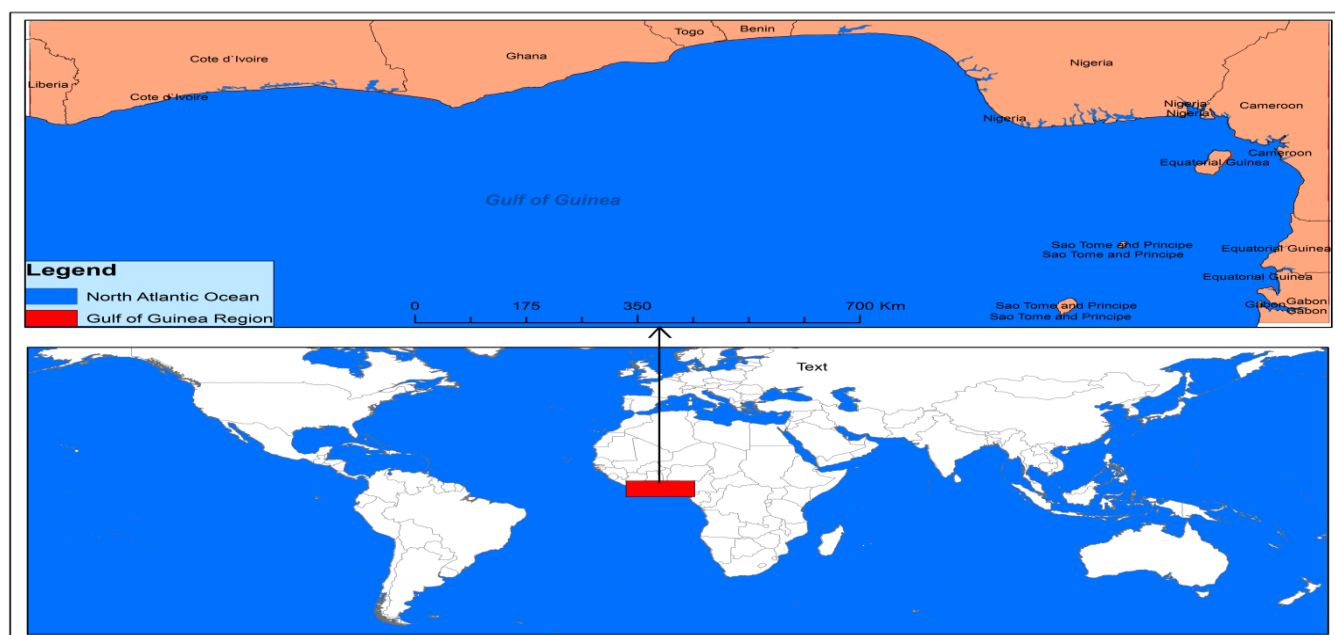
#### Aim of the research study

The aim of this research is to identify climate change influences on West African coastal region with a view to determining its impacts, vulnerability and adaptation strategies.

#### Objectives of the research

The objectives of this research are to

- i. investigate changes in climate and extreme weather events in the West African coastal region.
- ii. assess the vulnerability of coastal communities to sea level rises.
- iii. assess the coastal morphological changes as a result of climatic and oceanic activities
- iv. determine the appropriate adaptations approach towards coastal spatial planning under future climate change
- v. make recommendations for the implementation of 17 SDGs



Map of the Study Area (Author's Research, 2017)

#### Data Collection and Research Methodology

The proposed project data will be obtained from both primary and secondary sources (as shown in Table 1) The first stage of the data analysis will include results associated with vulnerabilities and impacts of climate change on environmental hazards in Nigeria. This will be followed by the acquisition of secondary datasets (as listed in Table 1) These datasets will be pre-processed by several software packages such as SEPAL, IDL, ArcGIS, Erdas Imagine, Idrisi Tersset, Modflow , Geomatica etc.

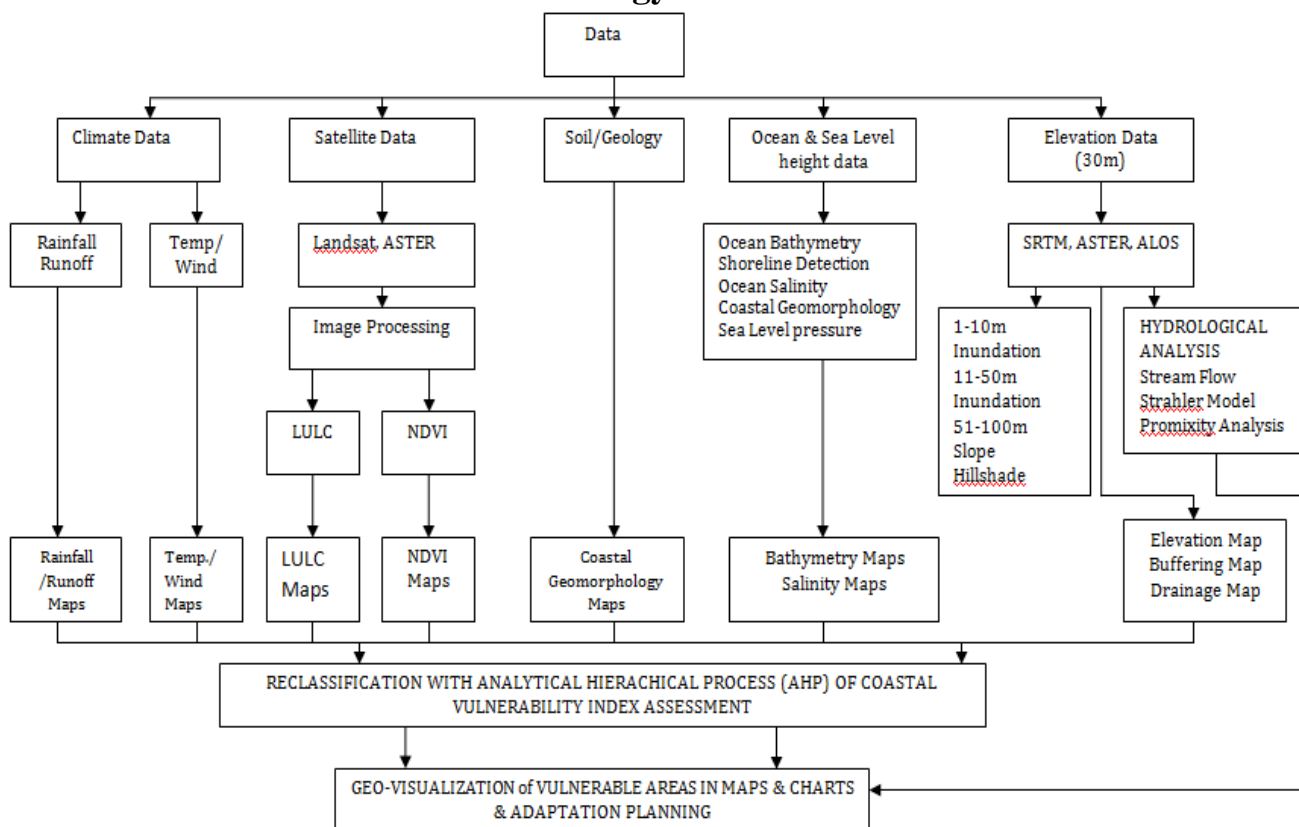
Extensive field reconnaissance will be carried out to identify vulnerable areas to environmental hazards, using field measurements obtained from spectro-radiometer, Real Time Kinematic GPS, air quality analyzers etc. The fuzzy-Analytical Hierarchical Processing (Fuzzy AHP) and holistic mapping approaches would be used to develop a final composite vulnerability index. This would be used to identify and visualize the areas of high and low vulnerability along the Nigeria coast.

This attribute will include the topographical data derived from Light detection and ranging (LiDAR) and ALOS PALSAR data, high spatial resolution multispectral imagery, and also spatial modelling techniques. The method of Object-based Image Analysis (OBIA) will be used in the satellite image pre-processing, segmentation, (object-based) classification, post-classification, and accuracy assessment. The image pre-processing will include radiometric, geometric, registration and atmospheric corrections, while image segmentation will be used to determine the spectral, geometric, contextual, morphologic, and temporal attributes of the objects.

The multi-temporal high-resolution satellite images would be used to elaborate land use polygons in order to analyze changes that have taken place. ArcGIS 10.5 would be used to digitalize the land use and this is hoped to be verified on the field. The area analyzed in each case extended from the coastline to 30 km inland.

The pixel-based classification (both unsupervised and supervised) will be performed by Sentinel S2A and Landsat images. For the unsupervised classification, the K-means clustering method will be used with 6-8 classes, which include urban built-up area, water body, vegetation, bare surface, mangrove forest, etc.

### Methodology Flow Chart



### Expected Outcome and Contribution of the Research

The research will provide information on applicability of optical and radar satellite images for mapping coastal ecosystems and meteorological processes. It will also enhance capacity and knowledge of governments and other decision-makers to make better preparation towards to climate change adaptation and resilience; provide information on how coastal hazards and damages could affect socioeconomic variables such as ecosystem services, population and gross domestic product (GDP) of the West African countries.

# **GEOBIA 2018**

## **GEOBIA IN A CHANGING WORLD**

### **From pixels to ecosystems and global sustainability**

June 18-22, 2018 - Agropolis International – Montpellier

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#### **Remote sensing and Object-based Image Analysis: methods and approaches for the creation of archaeological standards**

Luigi Magnini

In recent years, the field of remote sensing experienced an incredible growth thanks to the increasing quality and variety of sensors and the reduction of instrumental costs. The benefits for archaeology were soon apparent. However, so far, data interpretation remains essentially a prerogative of the human operator and is mediated by his skills and experiences. The continuous increase of datasets volume, i.e. the Big Data Explosion, and the increasing necessity to work on large scale projects require an overall revision of the methods traditionally used in archeology.

In this sense, my PhD research aimed to assess the limits and potential of object-based image analysis (OBIA). The work focused on the definition of OBIA protocols for the treatment of three-dimensional data acquired by airborne and terrestrial laser scanning through the development of a wide range of case studies, used to illustrate the possibilities of the method in archeology.

The archaeological remains are in various state of post-depositional and post-abandonment processes, involving an increasing loss of information and spatial, physical or functional transformations. Numerous sources of impact - from re-forestation, pedogenesis and relic hunting to building activities - hamper the proper recognition of archaeological features to such extent that they can be easily confused with different natural or man-made entities.

Such an intrinsically fragile surface is now particularly 'equivocal' and the embedded archaeological scenario must be fully isolated, recognized and enhanced by using the best scientific, intellectual and ethical practices. Remote sensing, combined with geophysics and ground surveys, seems to offer the best opportunities to detect, protect and monitor the vanishing historical heritage in the direction of 'minimum tillage' or 'no-collection' policy (aimed at minimizing the archaeological footprint/ impact).

The results of the PhD project include a new, automated approach to identify, map and quantify traces of the First World War landscape around Fort Lusern (TN, Italy) and the recalcified osteological tissue on the skulls of two burials in the protohistoric necropolis of Olmo di Nogara (VR, Italy). Moreover, the method was employed to create a predictive model to locate "control places" in mountainous environments; the simulation was built for the Western Asiago Plateau (VI, Italy) and then re-applied with success in basin of Bressanone (BZ, Italy).

The accuracy of the results was verified thanks to respectively ground surveys, remote cross-validation and comparison with published literature. This confirmed the potential of the methodology, giving reasons to introduce the concept of Archaeological Object-Based Image Analysis, used to highlight the role of object-based applications in archaeology.

A particular emphasis was also devoted to discuss the increasing need of standard protocols and shared rule-sets libraries to be (semi)automatically implemented for archaeological investigations (especially time-series mapping/ monitoring or remains quantification). This is topic is of general interest for the OBIA community, but should be considered particularly important for further increasing the role of object-based applications in archaeology, as most of the operators have a humanistic background and, thus, longer learning times.



# GEOBIA 2018

## GEOBIA IN A CHANGING WORLD

### From pixels to ecosystems and global sustainability

June 18-22, 2018 - Agropolis International – Montpellier

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#### Multi-scale representation of high spatial hyperspectral and radar imagery using object-based image analysis

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#### Supervisors:

Assoc.- Prof. Stefan Lang

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Landscapes are complex systems that require a multi-scale approach to fully understand, manage, and predict their behavior (Hay et al. 2001). Increased availability of new high-spatial synthetic aperture radar (SAR) and hyperspectral imagery (HSI) provide unique opportunities for development and classification methods that effectively exploit unique characteristics of data, for habitat and biodiversity mapping at multiple scales. In the other hand, there are scientific and methodological challenges such as advanced data pre-processing, automated information extraction, and transition between mapping schemes and semantic interoperability just to name a few (Lang et al. 2014). This PhD project focused on developing a robust theoretical and methodological framework for linking multi-scale representation of high-spatial resolution HSI and SAR and hierarchical structure of landscapes. A main methodological framework was developed upon the geo-object-based framework that integrate high-spatial resolution imagery, hierarchy, and scale-space theory (SST) (Hay 2014; Blaschke et al. 2014; Chen et al. 2018), and scale invariant feature transformation (Lowe 1999). The objectives of this PhD project are:

- To develop a robust model for multi-scale representation of high-spatial resolution remote sensing data, using airborne hyperspectral imagery and SAR data
- To develop multi-scale object delineation
- To develop linkage among the objects within different scales

The main challenges are:

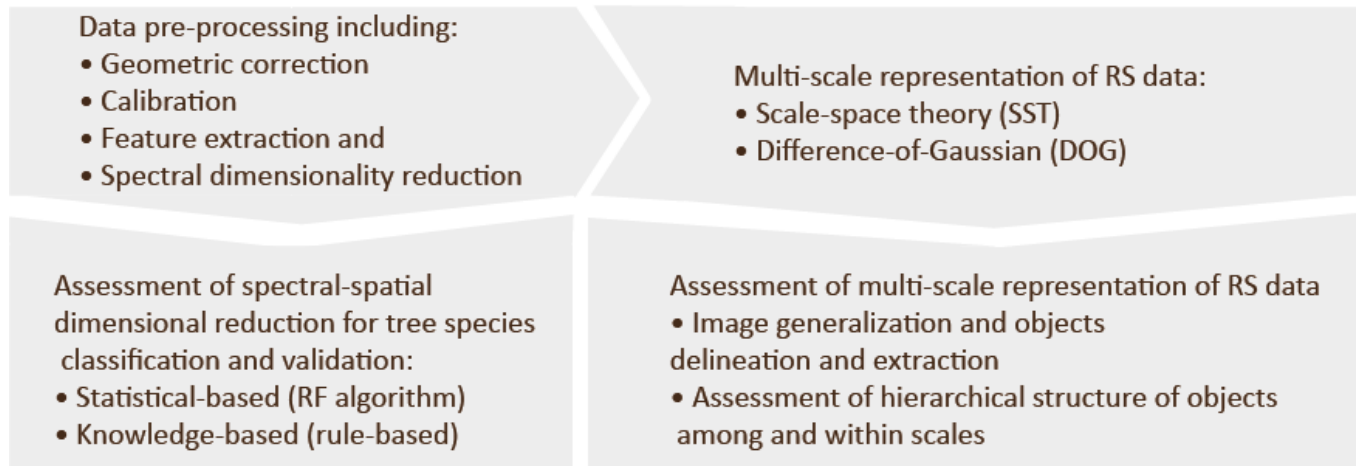
- Loosing edges in the multiscale representation of an image using SST
- Data integration (remote sensing image and in-situ data)
- Statistical-based versus rule-based (or knowledge-based) classification
- Ground verification and product validation
- Feature extraction using HSI
- Presence of speckle and distortion effect, like shadowing and layover in SAR data

#### Datasets

- Airborne Prism Experiment (APEX) hyperspectral imagery, 288 spectral bands (413 nm to 2451 nm), 2.5 m ground sample distance (GSD) for Salzach floodplain, Salzburg, Austria.

- Airborne AISA Eagle VNIR hyperspectral imagery, 66 bands (400 nm to 1000 nm), and 0.6 m GSD, Taita-Hill Kenya
- Temporal Terra SAR-X imagery, single HH polarization, StripMap with 3 m GSD, Salzach floodplain, Salzburg, Austria

## General workflow



## Intended results

This PhD projects intended to create a bridge between some of already existed concepts and theories related to landscape ecology and complex systems, computer-vision, and GIScience with the new remote sensing data sets, such as airborne HIS and high spatial resolution SAR imagery, to enhance methods and tools for a better modelling of landscape structure at multiple-scales.

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**Nuria Sanchez-Lopez**

#### **Forest stand-replacing disturbance history: A GEOBIA-LiDAR approach**

Spatial and temporal contextualization of stand-replacing disturbances is essential for forest ecosystem modeling. Earth observation optical satellite data offers a unique opportunity for systematic monitoring of recent disturbances but discriminates poorly between stands of different age, as spectral response of optical data saturates on closed canopy forests. Therefore, its potential for reconstructing the forest disturbance history is limited by the time series of suitable data (starting with the launch of Landsat-1 in 1972).

Even-aged forest stands are characterized by homogenous structural vegetation parameters that have often been used as a proxy of stand age. Consequently, performing Geographic Object-Based Images Analysis (GEOBIA) on Light Detection and Ranging (LiDAR) data has the potential to detect historical stand-replacing disturbances. GEOBIA would enable the delineation of disturbed stands, providing representative units of analysis, and LiDAR data would provide information on the 3-dimensional structure of the vegetation to accurately identify the forest stands boundaries and date them according to Time Since Disturbance (TSD). The potential of LiDAR to reconstruct the disturbance history of forest stands is currently constrained to small areas where airborne data are available. The forthcoming LiDAR satellite mission, the Global Ecosystem Dynamics Investigations (GEDI), will provide structural data of almost all tropical and temperate forests, opening a new era in the use of LiDAR at large scales. Because of the technical characteristics of the mission, research

is needed to assess whether GEDI data would be a suitable substitute of airborne LiDAR and could be used for estimating TSD on historical disturbances.

This Ph.D. thesis project investigates the suitability of using GEOBIA on LiDAR data to contextualize historical stand-replacing disturbances spatially and temporally, as well as the requirements of GEDI data to be used at the stand level to estimate TSD. The study is divided into three objectives: 1. delineating stand-replacing disturbances using GEOBIA techniques on airborne LiDAR data; 2. estimating TSD at the stand level using airborne LiDAR data; 3. and contextualizing TSD of historical stand-replacing disturbances using GEDI simulated data.

The research presented in the GEOBIA meeting under the title ‘a semi-automated LiDAR-GEOBIA methodology for even-aged forest stand delineation based on a two-stage evaluation strategy’, corresponds to the first objective. Results show good delineation of even-aged forest stands, including stands harvested more than 50 years ago that are generally challenging to detect with optical data. Thus, the estimation of TSD using LiDAR data and machine learning techniques on identified disturbed stand shows promising preliminary results at the decadal level considering a study-based period of 100 years.

# **GEOBIA 2018**

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My name is Betül Şallı and I graduated from Geomatics Engineering Department of Istanbul Technical University and I am a graduate student in the same department. I am working in Istanbul Technical University Research and Application Center for Satellite Communications and Remote Sensing (ITU CSCRS) for 11 months. My primary research topic is about geographic object based image analysis with several resolutions. In my master's thesis, I am planning to study about;

- ❖ By using object based image analysis, pointing out possible approaches for classifying remote sensing imagery that can be found in various spatial and spectral resolutions to acquire thematically and geometrically accurate land cover/use (LCLU) maps
- ❖ Identifying required landscape metrics for interpretation of urban structures and forms
- ❖ Identifying the relation between LCLU maps that derived from distinct satellites' imagery and landscape metrics.

# **GEOBIA 2018**

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#### **Optimizing flood mapping from Synthetic Aperture Radar imagery**

Floods are a threat of increasing concern, causing major fatalities and economic losses. Within the framework of both improving flood forecasts and assessing flood damage, remotely sensed observations are of great importance. While flood mapping through optical imagery is often hampered by the presence of clouds, Synthetic Aperture Radar (SAR) sensors are capable of sensing in all weather conditions during both day and night. Moreover, recently launched missions such as the Sentinel-1 and COSMO-SkyMed constellations provide improved temporal and spatial resolutions, thus even further increasing the potential of SAR for systematic flood mapping and monitoring.

Following the increasing availability of SAR imagery, a broad range of flood mapping approaches have been developed. Frequently used algorithms include histogram thresholding, active contour models and pixel-based change detection methods. However, improved classification techniques based on object-based image analysis (OBIA) have not yet been fully explored within the framework of this classification problem. These object-based approaches allow taking into account spatial context, as well as some other relevant properties such as object shape, proximity and homogeneity. Moreover, most of the existing flood mapping approaches make use of a single SAR image or image pair only, sometimes complemented with topography information for post-processing. However, a number of additional information sources exist that could be included in an object-based approach to further refine the obtained classifications. These include SAR time series, different SAR polarisations and land cover information.

This PhD project aims at exploring the potential of OBIA for SAR-based flood mapping. First, a range of established pixel-based approaches is assessed and compared, considering both accuracy and robustness. Next, an object-based approach is developed and evaluated by comparing its performance with those obtained by pixel-based approaches. The added value of including spatial context as well as additional information sources will be investigated. At last, the uncertainty on the obtained flood observations will be assessed, so that they can be included in hydrodynamic models and thus lead to improved flood predictions.

## **Spatio-temporal analysis of soil degradation in Swiss alpine grasslands**

Lauren Zweifel, University of Basel      Advisor: Christine Alewell

Alpine grasslands are seriously affected by soil degradation due to various forms of soil erosion, amplified by the extreme prevailing topographic and climatic conditions. Climate change is expected to have a strong impact on the alpine region causing not only an increase in temperature but also a change in frequency and increase in intensity of precipitation events as well as strongly altered snow dynamics. Combined with changing land-use practices, an increase in soil degradation is anticipated. Historically and due to the different tools and methods used, scientific studies focus mostly on one or two types of soil degradation processes (e.g., either on landslides or on live-stock trails or rill or inter-rill erosion). Here, we present a holistic approach to identify and monitor all different types of processes causing soil degradation in alpine grasslands.

High-resolution aerial images taken between 1993 and 2015 are analysed to identify soil degradation at catchment scale at selected sites in the Swiss Alps (Urseren- and Piora Valley). The mapping of the degraded soil areas (bare and low vegetation cover) is carried out with an object-based image analysis (OBIA) rule-set developed with the software eCognition Developer. The mapped degraded soil for the respective years is further used to identify increasing, decreasing, fluctuating as well as permanently degraded sites during the investigated time period. Additionally, the mapped soil degradation sites are classified into the different occurring processes. The temporal investigation over several decades allows for the differentiation of fast developing processes as well as gradually developing processes. The results provide a comprehensive understanding of the occurring degradation processes over time as well as their spatial distribution and as such may improve our understanding of the status and trends of alpine grassland soil degradation.

As the project is part of a “Big Data” research program and was designed for an interdisciplinary setting (environmental science, computer science) it addresses data collection, integration of heterogeneous sources, and data analysis. The final goal is to automate the mapping procedure (using Deep Learning methodology) to achieve a processing pipeline, which is able to map soil degradation sites on a larger scale within the Alps (large amount of data) in a faster and less observer-dependent manner.

The existing datasets consisting of aerial images and geographic data are also enriched with user-provided data from citizen scientists (via smartphone application). These users will have the possibility to access information on degraded soil sites and help us verify the mapped sites as well as observe the temporal development of these sites by providing us with photographs taken in the field.

# *PhD project: Josselin Aval*

## Toward an automatic mapping of urban trees thanks to remotely sensed data

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This project is funded by the French Aerospace Lab (ONERA), Toulouse, France, and the region Occitanie, France. The work is supervised by Xavier Briottet, Sophie Fabre (ONERA), Emmanuel Zenou from the National Higher French Institute of Aeronautics and Space (ISAE-SUPAERO), David Sheeren and Mathieu Fauvel from the National Institute of Agricultural Research (INRA).

With the expansion of urban areas, air pollution and heat island effect are increasing, leading to state of health issues for the inhabitants and global climate changes. In this context, urban trees are a valuable resource for both improving air quality and promoting freshness islands. On the other hand, canopies are subject to specific conditions in the urban environment, causing the spread of diseases and life expectancy decreases among the trees. This thesis explores the potential of remote sensing for the automatic urban tree mapping, from the detection of the individual tree crowns to their species estimation, an essential preliminary task for designing the future green cities, and for an effective vegetation monitoring. Based on airborne hyperspectral, panchromatic and Digital Surface Model data, the first objective of this thesis consists in taking advantage of several data sources for improving the existing urban tree maps, by testing different fusion strategies (feature and decision level fusion). The nature of the results led us to optimize the complementarity of the sources. In particular, the second objective is to investigate deeply the richness of the hyperspectral data, by developing an ensemble classifiers approach based on vegetation indices, where the classifiers are species specific. Finally, the first part highlighted to interest of discriminating the street trees from the other structures of urban trees. In a Marked Point Process framework, the third objective is to detect trees in urban alignment. Through the first objective, this thesis demonstrates that the hyperspectral data are the main driver of the species prediction accuracy. The decision level fusion strategy is the most appropriate one for improving the performance in comparison the hyperspectral data alone, but slight improvements are obtained (a few percent) due to the low complementarity of textural and structural features in addition to the spectral ones. The ensemble classifiers approach developed in the second part allows the tree species to be classified from ground-based references, with significant improvements in comparison to a standard feature level classification approach. Each extracted species classifier reflects the discriminative spectral attributes of the species and can be related to the expertise of botanists. Finally, the street trees can be mapped thanks to the proposed MPP interaction term which models their contextual features (alignment and similar heights). Many improvements have to be explored such as the more accurate tree crown delineation, and several perspectives are conceivable after this thesis, among which the state of health monitoring of the urban trees.



# **PROJET DE RECHERCHE DOCTORALE GBETKOM PAUL GERARD**

## **Titre du projet**

### **ETUDE DE LA VULNERABILITE DES RIVES CAMEROUNAISES DU LAC TACHAD A LA DESERTIFICATION**

Travaux encadrés par :

- Pr Sébastien GADAL, laboratoire CNRS ESPACE 7300, Aix Marseille Université ;
- Pr. Ahmed El ABOUDI, Laboratoire de Botanique, Mycologie et Environnement, Faculté des Sciences, Université Mohammed V Rabat.

## **Introduction**

L'augmentation de la fréquence et de l'intensité des catastrophes naturelles, des régimes de précipitations soumis à une plus grande variabilité ainsi que la montée du niveau moyen des mers sont les conséquences du changement climatique. La désertification dont on peut craindre un grand impact sur les moyens de subsistance de nombreuses sociétés, en particulier dans des régions arides caractérisées par un haut niveau de pauvreté et de vulnérabilité, figure en bonne place parmi les conséquences de ces changements en milieu subsaharien. En réponse à ces perturbations, le mode d'adaptation des populations se traduit par l'augmentation des pressions sur les ressources naturelles.

Le but final de cette thèse est de questionner, par l'intermédiaire d'une étude, des facteurs et des indicateurs de désertification, pour comprendre l'ampleur du processus de désertification au niveau du lac Tchad en général et sur les rives Camerounaises en particulier. En effet, l'on admet que l'étude du processus de désertification passe par une bonne analyse des facteurs qui l'implique (anthropiques et naturels) auquel s'accompagnent la quantification et la caractérisation des indicateurs de ce phénomène. A cet effet, les liens de causalité entre les dégradations environnementales découlant de la manifestation

des facteurs de désertification sont à établir. La section suivante livre un aperçu de cette problématique.

### **Problématique générale**

De manière simple, la désertification désigne un processus de mise en place progressive des conditions caractéristiques des déserts. Elle s'accompagne de la diminution de la productivité biologique et partant, une réduction de la biomasse végétale, de la capacité utile des terres pour l'élevage, des rendements agricoles et une dégradation des conditions de vie de l'homme. Selon l'Union Européenne (2000), c'est d'abord dans la région du sahel en Afrique occidentale, qu'ont été identifiés les processus de désertification. Pourtant, la dégradation des terres arides est un problème à l'échelle planétaire. Et il est désormais reconnu que toutes les régions d'Afrique, d'Asie, d'Amérique latine et de la Méditerranée sont affectées par la sécheresse et les pressions sur les terres. Selon le secrétariat de la CCNUD (Convention des Nations Unies sur la Lutte Contre la Désertification), la désertification affecte presque 30% de la surface des Terres et 70% des terres agricoles émergées, environ 250 millions de personnes sont directement impliquées et environ 1 milliard est à risque. A cet effet, 46% des terres africaines sont vulnérables à la désertification selon l'United State Departement of Agriculture (2003).

Aujourd'hui il est principalement question de renforcer les connaissances de base et développer des systèmes d'informations et d'observations systématiques pour les régions exposées au processus de désertification et à la sécheresse. En effet, les études dédiées à l'évolution de la désertification et menées à des échelles diverses ont révélées certaines divergences sur la connaissance de l'ampleur géographique du phénomène mais ont apportées d'importantes informations sur leur évolution et leurs processus. Cependant, un des obstacles scientifiques le plus persistant pour l'étude du phénomène de désertification est la très grande difficulté dans la quantification soignée de la nature et l'extension

du problème (F Bazzani, 2009). En effet, malgré la modernisation des moyens d'observation par l'utilisation de l'imagerie satellitaire, il subsiste de nombreuses incertitudes à différent niveau d'échelle sur l'origine, l'extension, et la gravité des phénomènes de désertification (FAO, 1993). Ces incertitudes constituent autant de contraintes pour les gestionnaires des ressources naturelles en générale et dans les régions arides en particulier dans leur planification de décisions.

### **Contexte du lac Tchad**

Avant de discuter des objectifs de la recherche, les paragraphes suivants décrivent succinctement le contexte dans lequel va se réaliser la partie empirique de cette étude.

Les populations des régions sahéliennes constituées en majeure partie d'éleveurs d'agriculteurs et dans une certaine mesure de pêcheurs, dépendent essentiellement des biens et services fournis par les forêts, les savanes et les pâturages. Cependant, durant ces dernières décennies, les contraintes liées à la faible disponibilité en eau, aux longues périodes de sécheresse, couplées à la démographie galopante et à la pression du bétail sur les forêts, ont favorisé le déboisement et l'amenuisement du couvert végétal. A ces contraintes s'ajoutent celles liées aux mauvaises politiques de gestion des terres, à la mauvaise gouvernance, aux problèmes de propriétés foncières et à la gestion non rationnelles de ces ressources.

Le Lac Tchad et ses écosystèmes sont d'un intérêt stratégique immense pour toute la région. Ils procurent en effet de l'eau et un moyen de subsistance à plus de 30 millions de personnes, dont la majorité vit de l'agriculture, de l'élevage et de la pêche. Le lac contribue de manière significative à la sécurité alimentaire d'un arrière-pays qui s'étend sur un rayon d'environ 300 km dont la population est estimée à 13 millions d'habitants et pourrait atteindre plus de 35 millions

d'ici 2050 (Lemoalle et al, 2015). Comparées aux espaces sahéliens environnants, les densités démographiques du lac Tchad sont relativement élevées et se chiffrent environ à 50 hab/km<sup>2</sup> (Magrin et al, 2014).

L'évolution de la disponibilité en eau du lac contraste avec la pression humaine de plus en plus grandissante à laquelle celui-ci doit faire face. Car en effet, au niveau du bassin du lac Tchad, la pêche est l'activité économique la plus importante car elle rapporte environ 45.1 million US\$ aux ménages. Les cultures de décrue représentent 26.6 million US\$ par an, l'élevage 14.7 million US\$, les petits périmètres irrigués 10.8 million US\$ et 9.4 million US\$ pour les grands périmètres irrigués (UICN, 2008). Par ailleurs, une grande partie des sols du bassin du lac Tchad sont à présent considérés comme étant profondément dégradés et des espaces de terroirs dédiés à l'agriculture se sont réduits à hauteurs de millions d'hectares de terrain en raison de cette dégradation (PNUD, 2014). L'amenuisement du couvert végétal entraîne le cuirassement des sols qui à son tour cause la réduction de l'infiltration des eaux et augmente les décharges, le ruissellement diffus et l'érosion. Avec la diminution de la couverture végétale, on assiste à la formation de nebkas et de nappes de sables qui évoluent et occupent les territoires exondés. Il en résulte une diminution de la productivité des sols et une augmentation de la pauvreté (PNUD, 2014). Ces phénomènes ont pour principale résultat de favoriser la mise en place et l'expansion des principaux facteurs de désertification et par conséquence d'accroître l'exposition du lac (principalement ses rives) à la désertification. De ce fait, l'Homme se sent directement concerné par toutes modifications de la disponibilité des ressources naturelles présentes au sein du lac et dans ses alentours. Car l'assèchement annoncé du lac auquel sera combiné l'augmentation démographique prévue, menacera les moyens de subsistance des millions de personnes et aura forcément un impact environnement et socio-économique important (CBLT, 2015).

Cependant, depuis les années 1990 et jusqu'à récemment, l'hypothèse d'une tendance régressive progressive condamnant l'existence du lac à brève échéance sous l'effet du changement climatique s'est diffusée. Elle n'est pas confirmée par les travaux scientifiques les plus récents, qui considèrent le lac actuel comme un Petit lac Tchad relativement stable depuis 1973 (CBLT, 2015). Les chercheurs soulignent le dynamisme économique particulier lié à la valorisation des potentiels de décrue offerts par ce Petit lac Tchad, tout en reconnaissant la fragilité de ce système et sa vulnérabilité face à la pression démographique, l'incertitude climatique et les tensions politiques (Bazzani, 2009).

### **Objectifs de recherche**

L'objectif de cette thèse est d'évaluer l'ampleur du phénomène de désertification sur les rives camerounaises du Lac Tchad et les conséquences qui en découlent dans le contexte global des effets du changement climatique. Dans ce contexte de détérioration graduelle de l'environnement les intérêts spécifiques seront portés sur l'analyse multicritère des facteurs de désertifications et la cartographie des différents indicateurs de désertification agissant sur les rives Camerounaises du lac.

**Volet 1.** L'analyse diachronique et corrélationnelle des facteurs et des indicateurs de la désertification.

**Volet 2.** La modélisation de l'état de la désertification au-dessus des rives camerounaises du lac Tchad.

### **Méthodologie et démarche**

Dans cette section est détaillée la démarche méthodologique envisagée pour cette étude. Elle se résume en deux points. Le premier concerne la méthodologie de modélisation de la vulnérabilité à la désertification et l'analyse multicritère des facteurs de désertifications, et le second examine la méthode de collecte de donnée auprès de la population.

L'analyse des facteurs de désertification va consister en l'identification des processus de dégradation des ressources naturelles (principalement eau, sol, végétation), et l'étude des interactions entre ces différents facteurs. En effet, la question de la désertification sera appréhendée dans cette étude en se basant sur la démarche systémique qui propose d'étudier le système dans son ensemble en tenant compte de la nature des relations entre les différents composants ou acteurs et les échanges avec l'environnement. Pour cela, les indicateurs tels que la rugosité du sol, la topographie, l'évapotranspiration, l'humidité du sol, l'indice de végétation entre autres seront fortement sollicités. L'objectif est de repérer et faire une hiérarchisation spatiale des zones vulnérables à la dégradation des ressources naturelles. Ensuite, étudier les causes le fonctionnement et les mécanismes majeurs telles que la surexploitation des terres arables, le déboisement, le surpâturage, les pratiques agricoles qui contribuent directement à cette dégradation. L'évolution spatio-temporelle de l'état de dégradation sera également mesurée à l'aide des outils de sciences d'observation. L'utilisation des SIG nécessaire dans le cas de l'étude des milieux dont le fonctionnement est complexe va nous permettre de mieux comprendre les interactions entre les différents facteurs et d'avoir une cartographie de l'état de la dégradation.

Au vu de nos objectifs, la collecte des informations auprès de la population se fera selon une approche qualitative. L'approche fondée sur des méthodes qualitatives ou de type ethnographique permet d'avoir une bonne compréhension des perceptions individuelles des changements environnementaux. La manière d'appréhender le risque et les processus de décisions qui y sont associés ne peuvent être analysés comme étant des mécanismes purement rationnels. Ils se rapportent plus à des processus subjectifs, chargés de valeur et ancrés dans un contexte social spécifique. La prise en considération de ces aspects est donc centrale pour saisir les

comportements des personnes exposées à des détériorations naturelles (Grothmann and Patt 2005; Mortreux and Barnett 2009). En outre, les approches qualitatives posent généralement moins de problème (quant à l'accès aux données, aux biais statistiques, aux moyens financiers, etc.) que les approches quantitatives

Les méthodes de récolte et d'analyse des données mises en œuvre seront les entretiens semi-directifs, les analyses de documents et l'observation participante. L'ensemble de cette démarche devrait nous permettre de réaliser les objectifs de recherche et d'avoir une compréhension approfondie du phénomène étudié.

#### - **Entretiens semi-directifs**

Les entretiens semi-directifs seront effectués avec plusieurs catégories d'acteurs. La première catégorie est composée des individus exposés aux processus de dégradation environnemental au sein de la communauté.

Par rapport à un questionnaire, la plus-value des entretiens est de pouvoir mener à une compréhension approfondie de la perception et de la représentation que les individus ont des manifestations des changements environnementaux auxquelles ils sont exposés afin de pouvoir décrire et expliquer les différents choix réalisés en terme d'adaptation et en particulier lorsque la surexploitation des ressources en fait partir. Etant donné que le terrain est prévu en trois missions réparties sur trois ans, nous espérons pouvoir tirer profit de ces différents séjours pour saisir l'évolution des comportements face aux dégradations environnementales qui tendent à s'accroître au cours des dernières années.

La deuxième catégorie comprendra des « experts » qui, de par leur activité (employés d'administration, d'instituts nationaux de statistiques, d'ONG et experts académiques : dans le domaine des sciences sociales ainsi que dans le domaine des sciences naturelles) sont à même d'apporter un éclairage pertinent sur la problématique qui nous concerne.

### - **Analyses de documents**

Cette partie vise en particulier à acquérir des connaissances du contexte dans lequel prend place le phénomène étudié, par exemple l'implication des gouvernements locaux dans la politisation croissante des impacts du réchauffement climatique. Plusieurs types de documents seront analysés : des articles universitaires et de journaux, des émissions de télévision et de radio ainsi que des textes de lois.

### - **Analyse paysagère et traitement spatialisé des données**

Il s'agit de l'identification des unités paysagère par la réalisation d'inventaires d'habitats et percevoir les dynamiques paysages et de la biodiversité. De la représentation graphique des dynamiques d'occupation du sol identifiées en relation avec la structure et l'organisation de l'espace. Des outils de télédétection dédiés seront mis en œuvre pour atteindre ces objectifs.

## **Planning de travail**

La durée de cette recherche est estimée à trois ans à compte de la date d'inscription.

- **Première année :** il est prévu de poursuivre l'élaboration du cadre théorique – problématique et hypothèses – ainsi que la méthodologie et la démarche. D'une durée de un à deux mois, ce premier terrain que l'on pourrait qualifier de « repérage » poursuit de nombreux objectifs. Du point de vue de la construction de la démarche de recherche, cette première immersion aura pour but de tester la robustesse et la pertinence du cadre théorique et des grilles d'entretiens. Du point de vue de l'organisation de la recherche, ce stage permettra de renforcer le réseau d'acteurs nécessaires à la concrétisation de cette recherche.

- **Deuxième année :** commencer la rédaction de l'analyse sur la base des premiers matériaux récoltés. L'objectif est aussi de réinterroger le cadre d'analyse et la démarche de travail, afin de les optimiser en vue du deuxième



séjour de terrain. C'est en effet au cours de cette seconde mission que la majeure partie de l'enquête devrait être réalisée. La durée de cette mission sera plus longue que la précédente ; nous l'estimons à trois ou quatre mois.

- **Troisième année :** principalement vouée à l'analyse des entretiens et questionnaires et consacré aux travaux de synthèse et de rédaction. Au cours de cette année, un dernier stage de terrain (de un à deux mois) pourrait être planifié afin de pouvoir compléter si nécessaire et d'approfondir le contenu de l'analyse.

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<http://www.unccd.int>

- Mediterranean Desertification and Land Use

<http://www.cru.uea.ac.uk/projects/medalus/>

- Food and Agriculture Organisation

<http://www.fao.org/>

- United State Departement of Agriculture

<http://www.encyclopedia.com/>

## VALORISATION DES RESULTATS DE RECHERCHES

### 1. Article soumis

#### CARTOGRAPHIE ET SUIVI DE L'EVOLUTION DE LA ZONATION DE LA VEGETATION DU LAC TCHAD A PARTIR DES IMAGES LANDSAT - PERIODE 1981-2015

**RESUME** : Cet article traite de l'évolution de la dynamique de la zonation végétale au sein du lac Tchad. Il est principalement question d'analyser, grâce à la télédétection l'évolution des zones de végétations en lien avec les variabilités du climat. Le but du travail est de ressortir les éventuelles corrélations qui peuvent avoir eu lieu entre les paramètres climatiques et l'état de la végétation dans le lac Tchad depuis les années 1980. Le travail est mené sur la base d'images satellitaires multi-dates et multi-sources. Les données utilisées sont les images CHIRP'S depuis 1981, les images MODIS (références : h18v07 et h19v07) de NDVI et de température de surface correspondant à la période 2000 à 2015 et les images Landsat (Path/row : 184/051, 185/050, 185/051, 186/050) de 1984, 2014 et 2015. La méthodologie adoptée consiste à réaliser des courbes d'évolution des différents paramètres utilisés (précipitations, températures, indices d'aridité de De Martonne, SPI, NDVI), ensuite d'identifier les années d'extrême sécheresse et les années d'extrême humidité pour faire les corrélations entre les paramètres climatiques étudiés et l'état de la végétation dans le lac Tchad. Les résultats obtenus mettent en lumière l'influence de la répartition spatiale et de l'évolution inter annuelle des indices de sécheresse sur la répartition des classes de végétation. Nous avons également réussi à faire ressortir le rôle joué par la quantité et la répartition des pluies sur l'état de la végétation. A cet effet nous avons noté que les pluies influencent l'état de la végétation un ou deux mois après les averses, que cette influence est fortement liée aux quantités de précipitation et à la nature écologique des mois pluvieux.

**Mots clés** : lac Tchad, zonation végétale, paramètres climatiques, images satellitaires

### 2. Articles en cours de préparation

#### - MAPPING OF BUILT UP AREAS IN THE CAMEROONIANS SHORES OF LAKE CHAD AND ITS HINTERLAND THROUGH BASED OBJECT CLASSIFICATION OF SENTINEL 2 DATA

**ABSTRACT**: The Lake Chad is now one of the major territories of concentration of people in the central Sahel region of Africa now. Since the beginning of the 21st Century, the strong human settlements, especially built-up area, have expanded as a spontaneous adaptation to the upsurge of border conflicts; the main purpose being the

access to best lands for agriculture, cattle farming and fishing. Nowadays, the Cameroonian side of the Lake Chad and its hinterland constitute a growing habitable space where we find few towns and numerous hamlets. However there is no updated map of the built-up sprawl. Therefore, the aim of this study is to bring out the built up areas distribution in that space through orientated-object classification. The methodology implemented combines statistical and spectral processing's: The first component of Principal Component Analysis (PCA) which contains 87% of information, Normalized Difference Built-up Index (NDBI) and Urban Index (UI), performed on sentinel 2 images of April 2017. These neo-bands are stacked with originals bands to generate a composite image. The new image obtained is then segmented and classified by Support Vector Machines (SVMs) algorithm and submitted to a threshold analysis in an image on which the built-up areas are clearly separated from the others spatial classes. The final results obtained is the delineation the built-up areas, that is the distribution and the structure of the housing space in the Cameroonians shores of Lake Chad and its hinterland.

**Keywords:** built-up areas; Support Vector Machines; Cameroon; Lake Chad.

## - MAPPING CHANGE DETECTION OF LULC ON THE CAMEROONIANS SHORES OF LAKE CHAD THROUGH AN INTER-SEASONAL AND MULTISENSOR APPROACH

**ABSTRACT :** The aim of this study is to evaluate the land use/land cover (LULC) inter-seasonal changes along the Cameroonian shores of Lake Chad using four Landsat sensors images of MSS, TM, ETM+ and OLI. The generation of land use/land cover inter-seasonal changes is based on classification by Support Vector Machines (SVMs) algorithm. Three categories of land use/land cover are identified to analyze the evolution of the Cameroonian shores of Lake Chad: open water and marshland, vegetation, and bare soils. The results show that, among these three categories, bare soils has the most important percent. Moreover, land use/land cover change from one season to another or from one decade to another can be closely linked to evolution of climate conditions. Concerning variation of land use/land cover on the Cameroonian shores of Lake Chad, open water and marshland surfaces varies little compared to variations of other categories. Vegetation has the most important variation compared to others categories. In addition, the proportions of bare soils that varies between rainy seasons are different between dry season.

**Key words:** Inter-seasonal changes; LULC; Support Vector Machines; Lake Chad.

### 3. Poster : présenté au salon CNRS Innovatives SHS les 17 et 18 mai au Parc Chanot à Marseille.



## DETECTION ET L'ANALYSE DES CHANGEMENTS DANS L'OCCUPATION DU SOL AU SEIN DU LAC TCHAD (1976-2015)

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#### Problématique

L'étude traite de l'évolution du lac Tchad par télédétection spatiale multi-dates. L'objectif est de montrer que la dynamique des principales classes d'occupation du sol au sein du lac Tchad a évolué avec le temps de manière quantitative et qualitative. Situé au cœur de l'Afrique et partagé par le Cameroun, le Tchad, le Niger et le Nigeria, le lac Tchad est une étendue d'eau douce peu profonde et endoréique qui couvre une superficie estimée actuellement à 1 350 km<sup>2</sup> (banque mondiale, mars 2014). La superficie du lac a évolué dans le temps et dans l'espace sous l'influence conjuguée des facteurs humains et naturels (GRIP, décembre 2014). C'est dans cette perspective que nous réalisons cette étude, question de faire un état des lieux et percevoir les variations de l'occupation du sol dans cet espace à travers les outils d'observation de la terre.

#### Méthodologies et données

Nous utilisons pour cela les méthodes d'analyse par télédétection spatiale pour étudier l'évolution de l'occupation des sols du lac et détecter les changements intervenus durant les 40 dernières années. Le travail d'analyse est mené sur la base d'images satellites prises durant les saisons sèches des années 1976, 1987, 2001 et 2015. Après classification des images satellites Landsat TM, ETM+ et OLI par maximum de vraisemblance, nous avons effectué des comparaisons en post-classification pour caractériser plus finement les changements et mettre en relation les différents types d'occupation du sol. Les résultats montrent de manière générale une tendance à l'assèchement du lac. Parmi les changements détectés, nous constatons de façon générale le recul de la végétation au profit des classes des sols nus témoignant ainsi de l'amenuisement du couvert végétal et de l'augmentation des superficies des sols nus (sables fins en majorité).

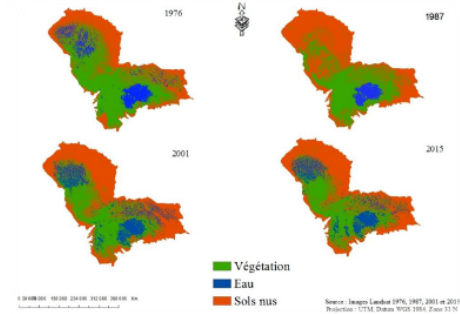


Figure 1 : Occupation du sol du lac Tchad en 1976, 1987, 2001 et 2015

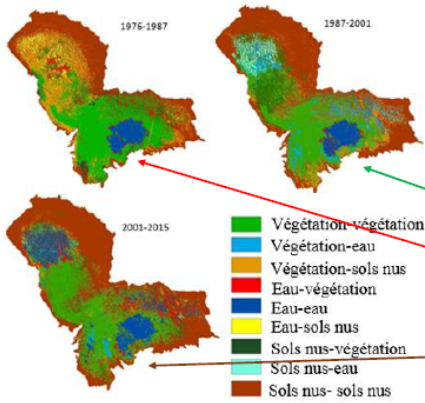


Figure 2 : Changements de l'occupation du sol entre 1976 et 1987, 1987 et 2001 et entre 2001 et 2015

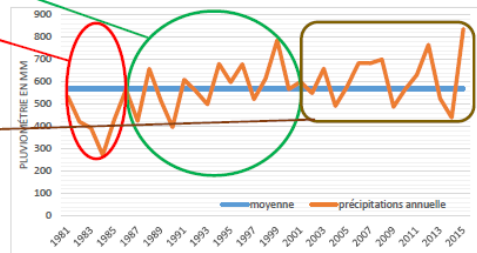


Figure 3 : Evolution des précipitations de 1981-2015

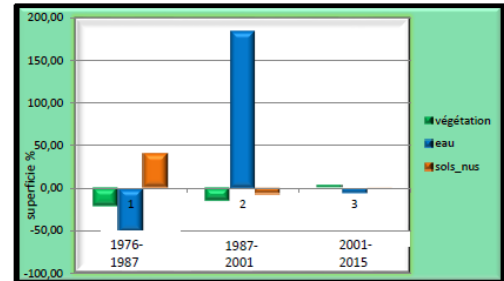


Figure 4 : Evolution de l'occupation du sol pour les différentes périodes

#### Résultats

Au terme de ce travail plusieurs résultats ont été obtenus et des enseignements importants relatifs aux comportements des classes d'occupation du sol ont pu être tirés.

En 1976 la végétation occupe 49 % de la superficie du lac (1307738 hectares), les eaux occupent 10 % (283536 hectares) et les sols nus s'étendent sur 1069350 hectares (40 %). En 1987 la superficie de la végétation est de 1026485 hectares (38%), les eaux sont à 138080 hectares (5%) et les sols nus à 1495939 hectares (56%). En 2001 la végétation couvre 32 % (869818 hectares), les eaux 15 % (392627 hectares) et les sols nus 52 % (1398059 hectares). En 2015 la végétation s'étale sur 895958 hectares (33%), les eaux couvrent 13 % (370415 hectares) et les sols nus occupent 1394252 hectares (52 %).

Durant la période 1976-1987 17,11 % de la superficie du lac est passé de végétation à sols nus, 2,63 % d'eau en végétation et 1,39 % d'eau en sols nus. Les changements entre 1987 et 2001 sont de l'ordre de 26 %, soit 8 % de végétations devenus sols nus, 6,3 % de végétation devenus eau, 8 % de sols nus devenus végétation et 3,7 % de sols nus devenus eau. Pour l'intervalle 2001-2015, les superficies des différentes classes d'occupation n'ont pas beaucoup variées : + 3,01 % pour la végétation, -5,66 % pour l'eau et -0,27 % pour les sols nus.

- 1976-1987 correspond à une période d'assèchement du lac ;
- l'intervalle 1987-2001 convient à une période de retour des eaux ;
- 2001-2015 est marquée par une stabilité dans l'occupation du sol du lac.

# **IMPACT OF LANDUSE/LANDCOVER CHANGE ON STREAMBED OF MALIR RIVER BASIN**

Karachi is the biggest city of Pakistan with a continuous population growth, industrialization, and urbanization. With this growth, the city of lights is facing multiple issues including environmental, social and economic challenges. One of the major environmental problems in Karachi since last several years is localized flooding. Although Karachi used to have an extensive natural drainage system, the system has now lost its original form. The natural drainage network of Karachi has three (03) major river systems including Hub, Lyari and Malir with their tributaries. The increasing planned urban development, unplanned settlements, slums, illegal and informal settlements, and encroachments on the old river beds have severely changed the landuse, land surface characteristics, and drainage capacity of topsoil and drainage system. The change in the drainage capacity of soil and drainage system have caused the localized floods in Karachi after heavy rainfalls.

In Karachi, two of three main rivers – Lyari and Malir with their tributaries – play a major role in draining storm water of Karachi city. Now these rivers are severely affected by urbanization and insufficient watershed management that caused obstructions in the streams beds at many locations. This research aimed to investigate the changes of landuse/landcover (LULC) and their impacts on the hydrology of natural drainage system of Malir River basin over the past 23 years and to model floods for major rainfall events. The geospatial techniques are used to examine LULC changes in Karachi. Satellite images of Landsat 5, 7 and 8 were used to analyze these changes. The SRTM (Shuttle Radar Topographic Mission) Digital Elevation Model and topographic sheets of 1975 (1:50000) are used to demarcate natural drainage network and streambeds using Geographical Information System (GIS) software tool Arc Hydro. Historical rainfall data from 1985 to 2014,

acquired from Pakistan Meteorological Department (PMD), are used to simulate runoff using Hydrologic Modeling System (HEC-HMS) and its geospatial extension (GeoHMS). Rainfall-runoff simulations and flood extent/depth of five major rainfall events of 1992, 2003, 2007, 2009 and 2013 were modeled using hydrologic and hydraulic models (HEC-HMS and HEC-RAS). GIS overlay analyses combined the LULC and river drainage layers to identify the blocked area and to quantify the specific LULCs that were causing the river blockades. The results of the study showed that the changing land into urban dwellings has altered the hydrological characteristics of the soil. Maps of blockages and flood extent, prepared in this study, can further be utilized to support future initiatives leading to the revival of natural drainage network and flood mitigation and preparedness in the study area. The beneficiaries of this study may include, but not limited to, the local disaster risk management, planning, and development authorities.

Keywords: Flood, Geospatial techniques, Natural drainage, Satellite data, Urbanization

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Keywords: Flood, Geospatial techniques, Natural drainage, Satellite data, Urbanization

## Water and health in the Comoros Archipelago: a geographic approach to target populations at highest risk.

### Water and health

In 2015, "more than 600 million people around the world will still use non-potable water sources," UN Secretary-General Ban Ki-moon recently warned. Several diseases are associated with water and have been classified into four classes according to Bradley, (White *et al.* 1972):

1. **Water borne**, water bound, passively waterborne infection (e. g. salmonellosis, typhoid fever, cholera, amoebas, rotavirus, diarrhoea, hepatitis, polio);
2. **Infections whose frequency decreases with increasing water availability (Water washed)** (e. g. Conjunctivitis, diarrhoea, skin infections)
3. **Diseases for which the causative agent has a cycle with a mandatory aquatic phase (Water based)** (eg. schistosomiasis, moat);
4. **Diseases whose vector reproduces or stings near water (Water related)**
  - a. Mosquitoes: malaria, dengue fever, chikungunya, yellow fever...
  - b. Glossines: trypanosomiasis.
  - c. Simulations: onchocerciasis.

Among these diseases, malaria remains a main cause of illness with 212 million cases in 2015, and 429,000 deaths according to the WHO World Malaria Report. By 2015, more than 90% of malaria cases and deaths have occurred in Sub-Saharan Africa. Children under 5 years of age are particularly at greater risk of illness than adults. The efforts made over the past 15 years have led to a reduction in the global epidemic. Between 2010 and 2015, the incidence of malaria fell by 21% in exposed populations and the mortality rate by 29%. The malaria control strategy aims at reducing mortality and cases to less than 90% and eliminate malaria in 35 countries worldwide by 2030 (WHO, 2015).

### Geographical presentation of the Comoros

Located at the northern entrance of the Mozambique Canal between the east coast of Africa and Madagascar, the Union of the Comoros is composed of three islands: Grande Comore (1,147 km<sup>2</sup>), Anjouan (424 km<sup>2</sup>) and Mohéli (360 km<sup>2</sup>). They are located geographically between 43°11' and 45°19' East longitude and 11°20' and 13° South latitude.

The total population of the Union of the Comoros was estimated at 671,009 inhabitants in 2010, including 45,089 in Moheli (123.33 inhabitants per km<sup>2</sup>), 285,707 in Anjouan (574.8 inhabitants per km<sup>2</sup>) and 345,213 in the Greater Comoros (258.2 inhabitants per km<sup>2</sup>). More than half of the population lives below the poverty line (54.7% in 2003). Without any economic growth, the poverty rate is likely to reach 93% of the population by 2015 (UNDP 2003).

The Comoros islands have a tropical climate marked by two seasons: a warm and rainy season between November and April characterized by monsoon winds and the dry season marked by tradewinds between May and October. The annual rainfall averages range from 1398 mm to 5888 mm per year. This geographical location conditions highly sensitive areas that are favourable to water-related diseases and infections such as Leptospirosis.

## Malaria status of Comoros

The Union of the Comoros has high morbidity and mortality associated with malaria, diarrhoeal diseases, respiratory diseases, gastrointestinal parasites (Ouledi et al. 2012). Malaria has been a major public health problem since 1923 (Ouledi, 1995) when the first, more lethal malaria epidemic occurred in the Comoros archipelago. This disease remained for several years the leading cause of consultation and morbidity in health facilities in the Union of the Comoros and has greatly affected the state of health of the Comorian population (Commisariat au Plan, 2014). In recent years, the Union of the Comoros has experienced a major reduction in malaria cases, which has led to it being classified in 2015 as one of the African region's countries in the control phase and therefore capable of eliminating malaria (Toyb et al., 2016). The regression of malaria in the Union of the Comoros is strongly associated with mass treatment by combination therapy of Artemisinin (ACT) in the entire population of the Comoros [6]. This is an Artequick-based treatment that is a combination of 62.5 mg artemisinin (artemisinin-piperacin) (ART) and 375 mg piperaquine (PQ) put in place by a Chinese team from Guangzhou Medical University (Deng et al., 2014). This treatment is aimed at removing it as quickly as possible from the reservoirs of malaria parasite (*Plasmodium falciparum*) in the population.

Malaria in the Comoros is transmitted by *Plasmodium falciparum* (98.11%), *Plasmodium vivax* (1.25%) and *Plasmodium malariae* (0.63%) (Silai et al., 2007). The transmission of these parasites is ensured by two species of anopheles; *Anopheles funestus* and *Anopheles gambiae* (Blanchy et al., 1987). These vectors develop particularly in household cisterns, mosques' ablution basins, blocked estuaries and areas of very sunny vegetation (Blanchy et al., 1999). Meteorological conditions and the ecological environment are the determining factors in the spatial transmission of malaria between islands. The relief of the islands offers many wetlands throughout the national territory, which can help maintain malaria parasite in the environment and explain the existence of the disease at the national level. Socio-environmental conditions also seem to favour the transmission. The investigation of these social, behavioural and environmental factors is the subject of this thesis.

## Problematic and research questions

The geographical approach of this thesis raises several questions regarding the risks of transmission of malaria:

- are these risks related to environmental factors?
- are they related to socio-economic factors?
- are they related to the behaviour of populations?
- have they evolved with anthropogenic pressures and their impact on ecosystems?
- are they the same on all three islands?

Thus, this thesis attempts to balance the environmental factors of the diseases in question (which contribute to hazard) with the exposure and vulnerability factors of populations in order to understand the risk of transmission. The study will then attempt to understand:

- What are the most favourable areas for malaria?
- in and near these areas, what are the populations or people exposed to malaria?

The thesis focuses on:

- A geographical characterization of disparities linked to hazard (environmental approach) and population exposure (proximity to hospital, etc.).
- The analysis of landscape evolution (based on archived satellite images) and epidemiological dynamics).
- A statistical modelling of the risk of transmission of malaria.

## Methodology

The thesis is organized in three steps:

### 1- Analysis of environments favorable to malaria

The study focuses first on the characterization of the land use and land cover over the three islands, Ngazidja (Grande Comore), Mwali (Moheli) and Ndzuani (Anjouan), through a remote sensing analysis of high spatial resolution optical images (SPOT 5 at 2.5 meters in panchromatic and 10 meters in multispectral modes). These land use/land cover maps were used to calculate landscape metrics at different scales: island, health districts and village's buffers (percentage of surface area covered by each land use class, the patch and edge densities). These indices help to characterize the heterogeneity of the living environments of populations exposed to malaria. They are integrated into spatial analyses for the identification of factors associated with malaria.

### 2- Water use and care use surveys

Population surveys were conducted in April-May 2017 at different sites on the three islands. The general objective is to assess the geographical and human factors that condition people's vulnerability to water-related diseases (mainly malaria). The survey is conducted on households in the islands of Ngazidja, Mwali and Ndzuani in the Union of the Comoros. This investigation has allowed a: representation of each island (for inter-island comparisons), representation of urban and rural populations and spatial distribution of survey locations (to measure geographical factors). Spatial analyses are carried out to assess geographical and human factors conducive to the transmission of malaria and other water-related disease.

### 3- Modeling the risk of transmission of malaria

Statistical analyses were carried out to describe the spatial epidemiology of malaria and to identify environmental indicators through a geographical approach at different scales (islands, health districts, villages, urban areas and rural areas). These analyses aim at identifying the landscape indicators of malaria maintenance that could be used to predict its distribution. The distribution of malaria cases was also compared to the mapping of malaria control actions (distribution of Long-Lasting Insecticide-treated Nets) to see their efficiency, but also to make recommendations for the prevention of these diseases. Spatial autocorrelation analyses allowed the identification of spatial clusters between the different spatial units. These clusters provide information on the most exposed populations.

## Results achieved

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- **Attoumane, A.**, Silai, R., Bacar, A., Cardinale, E., Pennober, G., & Herbreteau, V. (2015): Towards the elimination of malaria in the Union of Comoros: geographical insight on control actions and maintenance factors, 2<sup>nd</sup> South Africa malaria research conference, University of Pretoria, 31 July-02 August 2016, South Africa.

## Thesis Committee

The thesis committee brings together members of different structures:

- Gwenaëlle Pennober (PU Univ Réunion - UMR ESPACE-DEV), thesis director / remote sensing
- Vincent Herbretou (CR IRD - UMR ESPACE-DEV) / health geography
- Eric Cardinale (DVM, HDR Cirad – UMR ASTRE) / animal epidemiology,
- Rahamatou Silai (Programme National de Lutte contre le Paludisme – Ministry of Health of the Union of the Comoros) / human epidemiology

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# **GEOBIA 2018**

## **GEOBIA IN A CHANGING WORLD**

### **From pixels to ecosystems and global sustainability**

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Remote Sensing Derived Building Structure and Parameters for Urban Planning Applications

Arthur Lehner

In recent years, the developments of smart cities and the comprehensive digitization within cities' administrations in general were embossed by research findings of different fields, global economic trends (e.g. car sharing, electromobility, big data etc.), and political guidelines. The operational use of object-based image analysis (OBIA) for urban planning purposes appears to be within reach. However, OBIA-based applications regarding the urban structure on an operational level are still missing. Additionally, dealing with urban areas of different sizes, locations, and cultures, demands repeatable and transferable solutions. Nevertheless, no standardized framework for urban structural analysis exists, which limits the actual operational application of remote sensing and object-based image analysis. The abstraction of structural parameters of urban artefacts and their objectification in general by means of OBIA principles could foster the application of OBIA for tasks in urban planning and would allow for standardization of urban structure types (USTs). This PhD encompasses the analysis of the operational use of remote sensing within municipalities and strives for the identification of remotely sensed indicators for urban planning applications and for the sustainable development of urban areas.

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Anderson Soares  
National Institute for Space Research – INPE

The development of autonomous systems that reproduce the capabilities of the human visual system is of great interest in several areas of knowledge. One of the main ones is the Computer Vision that studies and develops techniques for extracting information from objects in a digital image. According to Ballard and Brown (1982), Computer Vision is dedicated to the construction of explicit descriptors, so that they provide meaning to the objects contained in an image. To that, several steps are taken, among which, segmentation is one of the main ones.

According to Soille (1999), segmentation can be defined as the process that divides a digital image by grouping its pixels according to a similar attribute, such as the grey level. Ideally, the line dividing two segments is represented by a border. At the end of this process, the resulting segments must produce uniform areas with respect to the analysed attribute.

According to Felzenszwalb and Huttenlocher (2004), segmentation algorithms must be able to detect global relationships between pixels, that is, the context in which a pixel is inserted. According to Gurney and Townshend (1983), the spatial context is linked to the spatial relations between the pixels of the scene, or the object formed, something that is fundamental for GEOBIA, and being crucial to improve, in some applications, the accuracy of the classification (BLASCHKE, 2010).

The Bayesian approach can be applied as a basis for energy-based segmentation algorithms. The energy is a pseudo-metric defined by a cost function (Arbeláez and Cohen, 2004), which has drawn attention in the last decade, since it has a solid mathematical and theoretical background, and is based on a priori information about the data. It favours the segmentation of images that have non-deterministic content, which is a challenge to the traditional methods (Vantaram and Saber, 2012).

The techniques based on this approach deal with the neighbourhood of a pixel directly, the main reason why it makes them so interesting to model the spatial context in images. They rely on statistical inference and on a priori it is extensively favoured for segmenting images that contain non-deterministic content such as textures and statistical noise. Different models, such as Markov Random Fields (MRF) and Conditional Random Fields (CRF), have been used for the segmentation of remote sensing images.

We propose an energy-based segmentation approach for high-resolution remote sensing images which involves local and long-range information in an energy function. We use well-known and simple techniques to create this algorithm, aiming to label disjoint regions that have similar characteristics, which is a common problem of high-resolution images.

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PhD project description of Zsofia Koma “Reconstructing the 3D ecosystem structure from LiDAR data for animal ecology at regional to continental scales”

One of the main challenges in biodiversity science is to quantify the 3D ecosystem and habitat structure at continental scales. However, with the increasing availability of openly accessible Airborne Laser Scanning (ALS) point clouds new opportunities have emerged that allow overcoming these bottlenecks by quantifying the fine-scale distribution and structure of ecosystems and habitats. This PhD project will take advantage of LiDAR (Light Detection and Ranging) technology to characterize the 3D structure of habitats for use in bird distribution modeling at regional and continental scales and for different habitat types. Within this PhD project, I will investigate the robustness of LiDAR metrics at global settings across different point cloud characteristics and find an optimized way to extract information related to the 3D structure of vegetation. I will focus on wetland birds within the Netherlands to explore the ecological relationship between the derived predictors and bird species presence–absence and abundance data. I will also expand this methodology to forest habitats with the aim to model species distributions of European forest birds. This requires to upscale LiDAR-derived metrics across countries and different datasets and to develop appropriate analysis tools. The outcome of my PhD study will provide a better understanding of the interaction of specific wetland and forest bird species with their 3D habitat structures, which can be used to improve conservation planning in the future.

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**Title: Food security and water availability in data-poor regions: Monitoring and modelling land-use dynamics**

*PhD candidate:*

*Marjolein Vogels*

*Department of Physical Geography, Utrecht University, The Netherlands*

In the Horn of Africa both the economy and the population are growing rapidly, which results in changes in land use. For instance, in Ethiopia, forests and grazing land have been converted into cropland, affecting both land degradation and water availability. Conversion of vegetated land to nearly bare agricultural cropland results in less infiltration and more surface runoff. As a result, soil erosion increases and the base flow of Blue Nile tributaries lowers, threatening food supply and access to water. Agriculture is mainly rain-fed, which means that the local population fully relies on precipitation for both water and food. In the Horn of Africa, precipitation is influenced by the El Nino/Southern Oscillation (ENSO) conditions in the Pacific Ocean, resulting in temporal and spatial differences. Climate change is anticipated to affect annual precipitation and its seasonality within the next decades. This may further enhance land degradation, resulting in loss of agricultural land, and reduce groundwater recharge, resulting in even lower water availability.

The work of land-use and water managers is frustrated by the absence of reliable information on current land use and land-degradation status. Up-to-date information could be obtained from satellite images. These can provide actual and detailed information on land- and water use. This knowledge is vital to keep the ecosystem services delivery at the desired level. The objective of this thesis is to create automated approaches to map land- and water use in complex data-poor regions in the framework of food security and water availability.

## Object-based Change detection: tracking landscape dynamics with objects

Due to rising population pressure and changing climate, natural and anthropogenic landscapes are facing important challenges as to sustainability, biodiversity conservation and provision of ecosystem services. It is not only important to understand how these landscapes function and change, but also to quantify and map these functions and changes. Hence, spatially explicit information is prerequisite to study the impact of landscape changes on ecosystem processes. Remote sensing change detection is the technology of choice for this purpose and allows for quantification of landscape status and change on a range of geographical and temporal scales. Recently, the technological advancement of both remote sensing sensors (multispectral, hyperspectral, thermal, RADAR, LiDAR) and platforms (mounting platforms, UAV, air and space platforms) has gained momentum, and offers a tsunami of new opportunities to more accurately detect landscape changes, with diminishing costs and processing time. Remote sensing based monitoring systems are therefore expected to play an increasingly prominent role in landscape management, environmental policy and decision-making. At the same time, the advent of high spatial and temporal remote sensing data calls for new image processing techniques and opens opportunities to detect changes based on image objects, i.e. **Object-based Change Detection – OBCD**. Image objects are aggregates of spatially connected pixels representing real world entities, which contain next to spectral information also textural, geometrical, contextual characteristics as well as interrelations across scales. It is hypothesized that these additional object features will improve the identification and hence monitoring of subtle landscape changes. Gradually, this new concept of image objects representing meaningful entities or scene components has been maturing and **OBIA – Object-Based Image Analysis** became an evolving paradigm within Remote Sensing and GIScience. OBIA utilizes principles from spatial reasoning, and hence human perception can be considered as the ultimate benchmark. While our visual perception of the environment is a spontaneous experience, it is quite a challenge to translate this in words or formally in rule sets. As such, in spite of its strengths, the development of OBCD monitoring techniques still faces numerous **methodological challenges**. Until today, the most pressing questions are: (1) how can we appropriately quantify changes between objects, and (2) how do we evaluate the accuracy of object-based change results?

This project has three main objectives:

- (1) Establishment of an online OBCD benchmark database,
- (2) Development of object-based metrics for change identification, and
- (3) Development of new measures to assess the accuracy of objects and their change status.

# GEOBIA 2018

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Organization: IRSTEA

Supervisors: Maguelonne Teisseire and Dino Ienco (IRSTEA)

Period: 2015/2018

Title: Data Mining from Satellites Images Time Series

Keywords: data mining, machine learning and spatial data.

#### Abstract:

Remotely sensed satellite images constitute a rich source of information that can be leveraged to support several applications including food risk prevention, land use planning and mapping, natural habitat monitoring, land cover classification and many other several tasks [1]. Advanced satellite technology and high frequency image acquisition result into huge amount of data, thus needing effective and efficient analytical approaches. In fact, standard tools are not suitable for dealing with this large amount of spatio-temporal data. In this context, data mining techniques have shown their capabilities and adequacies to extract valuable information and support remote sensing analysis on both single and time series satellite images [2, 3, 4, 5].

The work carries out during my thesis is about the development of new data mining approaches especially tailored for OBIA representation. We are particularly interested in the analysis of satellite image time series with the purpose to identify and characterize the evolutions of natural and semi-natural areas. Recently, [6] proposes an object-oriented approach that track spatio-temporal phenomena and extract their evolution. Based on this approach, we are exploring the potential of unsupervised and semi-supervised machine learning approaches to mine spatio-temporal phenomena in the satellite image time series [7].

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## **Annexe 2**

Abstracts Book



# GEOBIA 2018

GEOBIA in a changing world

From pixels to ecosystems and global sustainability

June 18-22, 2018, Agropolis International, Montpellier

## Program



[www.geobia2018.com](http://www.geobia2018.com)

# GEOBIA 2018

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GEOBIA'18 is expected to gather scientists, professionals and users, from academia, industry, the public sector and government from all over the world.

GEOBIA'18 will continue to be a platform to present research and development on the traditional topics: theory/concept, methods/algorithm and OBIA applications.

Special focus will cover today challenges as big data integration, open sources solution, cloud analyses, semantic and knowledge integration.

GEOBIA'18 will offer an opportunity for exchange and collaboration perspectives for various global Earth issues facing climate change impacts.

Southern and Northern teams would find during this session the opportunity to present their work regarding worldwide challenges such as agro-system, forestry and natural resources monitoring, food security or crop yield modelling, risks management or urban applications.

## Program

GEOBIA 2018 start on **June 18, 2018**

**June 18 and 19** will be reserved for two days of training workshop and for the presentation of PhD and young researchers working with GEOBIA.

**June 20, 21 and 22** will bring together the keynote speakers the technical and scientific sessions :

**Technical sessions** : big data integration, open sources solutions, semantic and knowledge integration, time series, multi sensors integration, open data challenges, new satellite data

**Thematic sessions** : crop monitoring, urban application, forestry, marine and coastal environment

### Scientific Committee

**Christiane WEBER** - Conference-Chair (UMR TETIS, Montpellier)

**Frédérique SEYLER** - Co-Chair (UMR ESPACE-DEV, Montpellier)

**Laurent POLIDORI** - Co-Chair (UMR CESBIO, Toulouse)

**Xavier BRIOTTET** - Co-Chair (ONERA DOTA, Toulouse)

**Laurent DURIEUX** - PHD colloquium (UMR ESPACE-DEV, Montpellier)

**Pierre-Yves VION** - PHD colloquium (AgroParisTech)

### Organizing Committee

**Annie Huguet** (UMR TETIS, Montpellier)

**Christophe Révillion** (UMR ESPACE-DEV, La Réunion)

**Véronique Rousseau** (UMR ESPACE-DEV, Montpellier)



# Program

	Monday 18	Tuesday 19	Wednesday 20	Thursday 21	Friday 22
8:30					
8:30-9:00			<b>AGROPOLIS International</b>	<b>AGROPOLIS International</b>	<b>AGROPOLIS International</b>
9:30-10:00		Maison de la Télédéttection	<b>REGISTRATION</b>	Thomas Blaschke	Geoffrey Hay
9:30-10:30		<b>PhD and Young researchers Colloquium</b>	<b>Opening Sessions</b>	Methodological aspects Chairman : Sébastien Lefèvre	Pierre Maurel - GEOSUD
10:30-10:45		break	Christian Heipke	break	Nicolas Baghdadi - THEIA
10:45-11:15			break	Forest Analysis Chairman : Andrea Baraldi	break
11:15-11:45		<b>PhD and Young researchers Colloquium</b>	Methodological aspects Chairman : Didier Josselin	Poster Session - Hall Bananier	Big Data & IA Issues Chairman : Laurent Durieux
11:45-12:15			Poster Session - Hall Bananier	Lunch	Discussion
12:15-12:45		Lunch	Lunch	Lunch	Lunch
12:45-13:15					
13:15-14:00					
14:00-14:30	Maison de la Télédéttection		Marguerite Madden	Claudia de Almeida	
14:30-15:00	<b>PhD and Young researchers Colloquium</b>	<b>PhD and Young researchers Colloquium</b>	Forest Analysis Chairman : Stefan Lang	TRIMBLE	
15:00-15:30			break	break	
15:30-16:00			Methodological aspects Chairman : Christophe Révillion	Urban Analysis and Health Issues Chairman : Sébastien Gadal	
16:00-16:30					
16:30-17:00	break	break			
17:00-17:30	<b>PhD and Young researchers Colloquium</b>	<b>PhD and Young researchers Colloquium</b>			
17:30-18:00					
18:30			<b>ICE BREAKER - Salle Vanille</b>		
20:00				<b>DINNER</b>	
			<b>Parallel Session</b>	<b>Parallel Session</b>	
10:45-11:15			Forest Analysis Chairman : Rahim Aguejad	Methodological aspects Chairman : Laurent Polidori	
11:15-11:45					
11:45-12:15					
12:15-12:45					
14:30-15:00			<b>Wetland Analysis</b> Chairman : Frédérique Seyler		
15:00-15:30			break	break	
15:30-16:00					
16:00-16:30					
16:30-17:00					
17:00-17:30				Agriculture Analysis Chairman : Stéphane Dupuy	
17:30-18:00					

## Keynote Speakers



### **Professor Marguerite Madden**

Director, Center for Remote Sensing and Mapping Science,  
Department of Geography, University of Georgia



### **Cláudia Maria de Almeida**

Senior researcher and a permanent professor of the Graduate  
Program in Remote Sensing of the National Institute for Space  
Research (INPE), Brazil



### **Professor Thomas Blaschke**

Professor for Geoinformatics, Deputy director Department of  
Geoinformatics, University of Salzburg



### **Professor Geoffrey Hay**

Associate Professor Geography, ISEEE Fellow, Department of  
Geography, University of Calgary



### **Professor Christian Heipke**

Associate Professor Geography, ISEEE Fellow, Department of  
Geography, University of Calgary

20 juin - 10h00 - 10h30

*Christian Heipke, Keynote speaker "Remote sensing in the age of deep learning – and the role of ISPRS"*

20 juin 2018 - 10h45 - 11h15

Methodological aspects

### Large Scale Segmentation Algorithm for Object Based Image Analysis suitable for HPC architectures in hybrid distributed-shared memory context

Rémi Cresson<sup>\*1,2</sup>, Julien Michel<sup>\*3</sup>, Arnaud Mallen<sup>4</sup>, Pierre Lassalle<sup>3</sup>

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<sup>2</sup> Territoires, Environnement, Télédétection et Information Spatiale (UMR TETIS) - Centre de Coopération Internationale en Recherche Agronomique pour le Développement : UMR 91, AgroParisTech, Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture - Maison de la Télédétection - 500 rue Jean-François Breton - 34093 Montpellier Cedex 5, France

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The amount of remote sensing images is constantly growing due to the increasing amount of satellites with Very High Resolution or very short revisiting time. In this context, exact large scale OBIA segmentation algorithms have been proposed to process remote sensing images of arbitrary size [1,2], to overcome the memory limitation issue. It is important to note that in this context, The word *exact* means that algorithm ensure resulting segments to be identical to those obtained without tiling, while using a tiling strategy with a proper stability margin. However those solutions have been proposed for sequential execution, and current implementations can use only one single processing unit on one single computer. Thus the execution time can be very important, which still prevents those approaches to be used for OBIA processing in an operational context. Meanwhile, resorting to High Performance Computing (HPC) is becoming a common practice to tackle the computational complexity in Earth Observation information extraction, since it provides environments and programming facilities able to speed-up processes.

In this paper, we focus on the parallelization of segmentation algorithms to process large images in areas on a short time, using HPC techniques. Our approach consists in a generic strategy of parallelization using the Message Passing Interface (MPI) standard with the concept of remote window. While MPI enables the scaling through multiple processing nodes, threaded parallelism is used in the shared memory context to optimize core algorithms. A specific attention has also been paid to IO operations which is a well known bottleneck in HPC environments. We have successfully applied our method to two state of the art segmentation algorithms commonly used in remote sensing images processing, namely the Generic Region Merging [2] and the Mean Shift Smoothing based segmentation [1]. The hybrid distributed-shared memory approach enables algorithms to benefit from both multiple CPUs of one processing node, and also multiple nodes connected through network thanks to the MPI. As our aim is to enable those algorithms for operational applications, we have implemented our approach for the two segmentation algorithms cited above in the OrfeoToolBox, a well known open-source library for geospatial images processing [3].

In the final paper and presentation, trends of execution times for different configurations of real remote sensing in put data and HPC ressources will be presented and discussed. The source code corresponding to the application presented in this paper is available for download[4], and will be integrated in the forth coming releases of the OrfeoToolbox[5].

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Lassalle, P., Inglada, J., Michel, J., Grizonnet, M., & Malik, J. (2015). *A scalable tile-based framework for region-merging segmentation*. IEEE Transactions on Geoscience and Remote Sensing, 53(10),5473-5485.

Grizonnet, M., Michel, J., Poughon, V., Inglada, J., Savinaud, M., & Cresson, R. (2017). *Orfeo ToolBox: open source processing of remote sensing images*. Open Geospatial Data, Software and Standards,2(1),15.

LSOBIA:<https://github.com/RTOBIA/LSOBIA>

OrfeoToolBox:[www.orfeo-toolbox.org](http://www.orfeo-toolbox.org)

**Keywords:** Segmentation, computer vision, HPC, high performance computing, large scale, OTB, orfeo toolbox

## Combining multiple segmentations through a flexible framework

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<sup>2</sup>INRIA Sophia-Antipolis Méditerranée – Institut National de Recherche en Informatique et en Automatique, Institut National de Recherche en Informatique et en Automatique – France

<sup>3</sup>Dynamiques Forestières dans l'Espace Rural (DYNAFOR) – Institut National Polytechnique (Toulouse), Institut National de la Recherche Agronomique : UR1201, Ecole Nationale Supérieure Agronomique de Toulouse – France

The Object-Based Image Analysis (OBIA) paradigm strongly relies on the concept of segmentation, i.e. partitioning of an image into regions or objects that are further analyzed (e.g., described and classified). This segmentation step is thus critical, while remaining a challenging issue since there is no (and probably will never be) perfect segmentation technique yet. Indeed, various segmentation criteria as well as input data can be exploited to derive a unique segmentation that could serve for further analysis.

In order to alleviate the sensitivity of the OBIA process to the segmentation step, we consider here that a set of segmentation maps can be derived from remote sensing data. Such various segmentations can be obtained through several segmentation algorithms, multiple parameter settings, or even complementary remotely-sensed observations of a given scene (possibly coming at different spatial scales). Inspired from the boosting paradigm, we thus propose a novel framework for combining multiple segmentations maps. The combination leads to a fine-grained partition of segments (superpixels) that is built by intersecting individual input partitions.

More importantly, each segment is assigned a segmentation confidence score that directly relates to the correlation of the different individual segmentation inputs regarding this segment. Furthermore, each input segmentation can be assigned some local or global quality score based on expert assessment or automatic analysis. These scores are then taken into account while computing the confidence map resulting from the combination of segmentations process. It helps the process not being too much affected by incorrect segmentation inputs either at the local scale of a region or at the global scale of a map.

Some experiments conducted on the ISPRS 2D Semantic Labeling dataset (made of VHR color/multi-spectral optical image and DSM) have been conducted to assess the relevance of the proposed framework. Results show that confidence map is a valuable information that can be produced when combining segmentations. Furthermore, the segmentation map is used to perform object-based supervised classification based on random forests. To do so, we consider several strategies in order to exploit the confidence map, either through direct thresholding or as an intermediate image on which a final segmentation is applied. A comparison with individual segmentations shows our framework is able to effectively combine various segmentation maps in order to improve the subsequent classification. From a user perspective, this approach is also able to provide a confidence map related to the geometry of the classified objects, in addition to the probability-based uncertainty map related to their semantics.

**Keywords:** Segmentation, fusion, remote sensing

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\*Speaker

## GEOBIA at the Terapixel Scale: From VHR Satellite Images to Small Woody Features at the Pan-European Level

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While the GEOBIA paradigm has led to significant improvements in the analysis and understanding of remote sensing images thanks to the processing of objects (i.e. regions) instead of pixels, it still requires to identify the objects (or segment the image into regions) before applying rules for classifying the extracted objects. This segmentation step is not straight forward and relies on user expertise or empirical tuning to be adapted to each new scene to be processed. Thus, it cannot be used for Big GeoData where large-scale analyses require methods that are both very efficient and robust to the wide variety of scenes to be observed.

We address here these multiple issues by relying on a multiscale image representation that embed in a tree structure, with no need of parameter tuning, the different (nested) objects to which a pixel can belong. Computation of such a stack of segmentations benefit from some recent scalable implementations that make realistic their very fast extraction from large-scale image datasets. Once the tree structure has been extracted, further image analysis is conducted at a very low computational cost, and relies on Differential Attribute Profiles (DAP). These state-of-the-art features describe a pixel by the properties of the objects it belongs to. We apply these profiles to both the original multispectral bands and some derived features such as NDVI or textural information. We then apply the Random Forest classifier on the extracted DAP features, or more precisely on only the most relevant features. We benefit from the efficiency of the different steps (tree construction, feature extraction, training, prediction) to propose a semi-supervised strategy where we retrain the model for each kind of landscape, thus allowing to tackle the great variety in appearances of objects at a very large-scale (e.g. VHR imagery at Pan-European scale). Due to the low computational cost (e.g. a few minutes for a Pleiades or WorldView-3 scene), a user can then interactively improve the classification by updating the reference samples used for training the model.

The proposed scalable solution fully relies on open source components (Orfeo ToolBox, Boost, GDAL, Shark, Triskele OTB remote module) and so can be used in any GEOBIA applications.

To illustrate our methodology, we consider here the Mapping of Small Woody Features (SWF), that is to be included as part of a new High-Resolution Layer (HRL) covering the whole of Europe from Iceland to Turkey within the Copernicus pan-European component of the land monitoring service. SWF represent some of the most stable vegetated linear and small landscape objects providing numerous ecological and socio-cultural functions related to soil and water conservation, climate protection and adaptation, biological diversity and cultural identity. Extracting these objects over such a large area (almost 6 million sq.km) from VHR imagery brings numerous challenges: large amount of data (greater than 100TB), large number of individual image scenes (greater than 25,000), diversity of the European landscapes, and the need to process these data in a timely manner whilst ensuring a satisfactory degree of precision.

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**Keywords:** Big data, scalability, multiscale analysis, land cover mapping, differential attribute profiles, random forest, open source

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# Automated object-based satellite image time series classification using dynamic time warping

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Satellite image analysis can support efficient monitoring of crops by providing timely and relevant spatial and temporal information products and tools. However, there are challenges analyzing satellite image time series (SITS), such as: few available samples, irregular temporal sampling of images, and temporal variability of the phenomena of interest. The Dynamic Time Warping (DTW) method is able to address these challenges by comparing the similarity between two temporal sequences, finding their optimal alignment and providing a dissimilarity measure between the evaluated temporal sequences. In this paper, we present an automated implementation of DTW for processing Sentinel-2 SITS within an object-based image analysis framework, implemented as a ready-to-use parameter-free algorithm in eCognition software. By adapting the DTW to be object-based, we solve one of the main challenges of DTW, namely a reduction in computational time. We tested the developed tool on Sentinel-2 SITS in south-eastern Romania, using 11 images of 5192x4367 pixels. The 10m spatial resolution red, green, blue and near-infrared bands were used in the segmentation process. To speed up the segmentation, we used SLIC superpixels for an initial oversegmentation of the images, and then applied multiresolution segmentation on the resulted superpixels using the ESP2 tool with an automated selection of scale parameter. We used 30 training samples per class, with five classes of interest (wheat, maize, sunflower, forest, water), to extract the NDVI temporal pattern to be used in DTW. The tool compares the temporal pattern of an object with the training temporal patterns, classifying the object into the class to which it had the minimum DTW dissimilarity value.

The overall accuracy for resulted classification was 90.27%, with kappa index of 0.87. Besides the categorical classification of SITS, the tool delivers also a map of DTW dissimilarity values, which is useful to understand which objects have a strong similarity with the assigned class (values closer to 0) or can have a doubtful assignment to one of the five classes used (the largest values). This tool represents the first operational implementation of the DTW method at the object-level. Therefore, it can benefit agricultural management and monitoring agencies at different scales towards designing and implementing sustainable agricultural practices. The availability of this kind of operationalized approaches dedicated to turning data into information are increasingly necessary as we move into imagery-dense workflows with satellite constellations providing increasing spatial and temporal resolutions.

**Keywords:** Sentinel 2, eCognition, DTW, OBIA, satellite image time series, land use/land cover mapping, superpixels, segmentation, crop mapping

## **Poster Session - 12h45 - 13h15**

- **An unsupervised segmentation algorithm for remote sensing images** - Anderson Soares, Thales Körting, Leila Fonseca
- **Feature selection and its impact on orbital imagery classification accuracy** - Camila Anjos, Claudia Almeida, Marielcio Lacerda, Paulo Ruiz
- **Assessment of classifiers through decision tree in urban areas using Worldview-2 image** - Bruna Maria Pechini Bento, Hermann Johann Heinrich Kux, Thales Sehn Körting
- **Mapping of built up areas in the Cameroonian shores of Lake Chad and its hinterland through based object classification of Sentinel 2 images** - GBETKOM Paul Gérard, GADAL Sébastien, El ABOUDI Ahmed, NGANDAM Homère
- **Using the OpenStreetMap database to improve an object-based classification process. Application to a landcover product on small islands in the Indian Ocean** - Christophe Révillion, Vincent Herbreteau
- **FT and LMT decision trees applied to WV-3 imagery for a detailed urban land cover classification** - Paulo Roberto da Silva Ruiz, Cláudia Maria de Almeida, Camila Souza dos Anjos Lacerda
- **From ice-wedge polygons to pan-Arctic landscapes: Automated characterization of ice-wedge polygons from very high-resolution remote sensing data** - Chandi Witharana
- **OBIA and template matching for transferable detection of water crowfoot** - Fleur Visser
- **Mapping of urban temperatures by TRISHNA : precision of the land surface temperature according to the spatial resolution** - Aurélie Michel, Karine Adeline, Xavier Briottet



## Unsupervised post-fire assessment of burned areas with free and open multispectral data using Obia

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This paper presents a new unsupervised workflow to assess the extension of the burning damages due to wild fire events. The workflow make use of open access medium and high resolution multispectral images from the Landsat-8 and Sentinel-2 satellites, together with open access low resolution products provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Visible Infrared Imaging Radiometer Suite (VIIRS) missions. In particular, the proposed workflow considers strong variations in the Normalized Difference Vegetation Index (NDVI) between two observation dates in order to detect burning damages. The changes in NDVI not related to the wildfire effects are filtered thanks to the MODIS and VIIRS hotspot detections occurred during the same observation period. To this aim, an Object-Based Image Analysis (OBIA) approach is employed. In fact, the proposed false positive filtering method is based on object features such as 'overlaps with' and 'distance to' detected hotspots. Experimental results on the Vesuvius, Southern Italy, wildfires of July 2017, show the effectiveness of the proposed method.

**Keywords:** Sentinel-2, Landsat-8, MODIS, VIIRS, multi- spectral data, SWIR, burned area evaluation, hierarchical segmentation, hierarchical classification, OBIA, NDVI

## Mapping the distribution of endemic *Abies numidica* and *Cedrus atlantica* in Mount Babor, Algeria using Object-Based Image Analysis

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Mount Babor is the most imposing (2004 m a.s.l) and the best-preserved area in the little Kabylie region, Algeria. It hosts very rich biodiversity with a high number of endemic and threatened species such as the Algerian fir (*Abies numidica* de Lannoy ex Carriere) and the Atlas cedar (*Cedrus atlantica* Manetti ex (Endl)) listed as 'Critically Endangered' and 'Endangered' in the IUCN Red List of Threatened Species, respectively. These two forest species are of high ecological value, as they constitute a habitat to many other protected species e.g. the Algerian nuthatch (*Sitta ledanti* Vielliard) and the Barbary macaque (*Macaca sylvanus* Linnaeus).

The precise mapping of the spatial distribution of both conifer species across the study area (2367 ha) is considered as an essential element towards improving the management and conservation of species within their existing natural landscape. Accordingly, this work aims at developing and testing a reliable method for mapping the distribution of endemic forest species.

The methodology involved the use of spectral and contextual information for mapping Algerian fir and Atlas cedar with an object-based image analysis approach. Sentinel-2 imagery was employed in combination with topographic and field data.

A total of 157 ground reference points was collected in the field between April and June 2016. Field plots were determined taking into account the physiognomic, floristic and ecological homogeneity criteria. Lower and upper elevation limits for both species were also determined.

Image objects were created at different segmentation levels for use in the classification and a classification scheme was developed accordingly. This allowed for better representation of multi-scale forest patches that are present within the study area. Image object training samples were produced using the collected ground truth data. The Nearest Neighbor classifier was employed in the classification process with the involvement of spectral information from the multi-spectral Sentinel-2 data (10 m resolution) in addition to topographic parameters.

An accuracy assessment of the classification results was conducted using ground truth points. The produced and validated maps are expected to serve in 1) providing tools for improved management of existing natural landscape and 2) establishing advanced phyto-sociability studies.

**Keywords:** Object Based Image Analysis, Sentinel 2, Endemic species, Mediterranean conifer forests, Atlas cedar, Algerian fir

## OBIA-based Monitoring of Riparian Vegetation Applied to the Identification of Degraded *Acacia Xanthophloea* along Lake Nakuru

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The Lake Nakuru (Kenya) faces flooding since 2010, thus interfering with the growth of riparian vegetation, and requiring automated image analysis to monitor the effect of flooding on the Lake Nakuru Riparian Reserve vegetation species. The vegetation specie that was affected by the flooding lake is *Acacia Xanthophloea*, i.e. a habitat and feed for many animal species within the National Park. In this study, we explore how riparian vegetation classification can ease the detection of degraded *Acacia Xanthophloea* spp.

To overcome the limitations of pixel-based analysis (e.g. salt and pepper effect in the classification map), we have conducted object-based image analysis on satellite imagery (Landsat-5TM and Landsat-8OLI) acquired at different dates: a baseline consisting of an image acquired in 2000 (i.e. before flooding), and several images acquired in 2010, 2012, 2014 and 2016. Such Landsat Earth Observation satellites provide information in the visible, near-infrared and shortwave regions of the electro-magnetic spectrum, which are of utmost importance to assess vegetation vitality.

The OBIA methodology employed here consists in several steps: i) some pre-processing (georeferencing, radiometric corrections, geometric corrections, pan-sharpening, ortho-rectification) is applied on each image ; ii) objects are extracted from each image by eCognition segmentation tool ; iii) spatial and spectral information were combined on riparian reserve vegetation to extracting information about land cover classes ; iv) vegetation was extracted through NDVI thresholding based on visual analysis with eCognition ; v) thematic re-classification and feature extraction was performed with Arc-GIS ; vi) supervised classification was achieved for each input image using Weka (an open source data mining software) considering several algorithms, including Na'ive Bayes classifier, J48 pruned tree, CART, Random Forests and Random Tree; vii) relevant changes were identified as objects that were classified as *Acacia Xanthophloea* in the baseline, but not anymore in the more recent images. The classification accuracy was evaluated using cross-fold validation and a reference dataset of 232 instances and 8 attributes, and reaches 92% assuming 9 land cover classes (Cynodon/Chloris/Themada grasslands, Olive and Teclea forest, sedges and rashes, Lake Nakuru, Chloris Gayana, Sporobulus Spicatus and *Acacia* woodland). Furthermore, we were able to identify important features and to define rulesets to be used in a GEOBIA framework.

Our study thus shows that: i) from a thematic point of view, GEOBIA was able to identify *Acacia Xanthophloea* from Landsat satellite imagery, and comparing the resulting classification maps allows us to achieve monitoring of this specie through time; ii) from a software point of view, it might be necessary to involve several different tools (both proprietary or open source) since there is still some missing functionalities in the existing GEOBIA software solutions.

**Keywords:** Remote Sensing, OBIA, Change Detection, Vegetation Monitoring, Landsat Imagery, Thematic Classification

## Areal Unit Problem

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GEOBIA has to deal with several issues which can be considered as “burning research questions, research need and outlook” as expressed in the book edited by T. Blaschke, S. Lang and G. J. Hay in 2008 [2]. Related to quality in a general meaning, one of them is the reliability of the statistics used to find the correct objects boundaries, that finally reflects on objects comparability in a given spatial partition. Indeed, since the number of pixels can strongly change at a given scale, and due to the major advantage of GEOBIA to find objects with different size and shape, any statistical indice describing those objects must be used with a particular caution. Contrary to what is claimed in the chapter 1.4 of this book, “object-based approaches represent viable solutions to mitigate the modifiable areal unit problem (MAUP, Openshaw, 1984 [8]), since they focus analysis on meaningful geographical objects rather than arbitrary defined spatial units i.e., individual pixels” (p. 81), or “image-objects are less sensitive to MAUP than units that do not keep a correspondence with the structure of the phenomenon under study” (p. 83), GEOBIA is neither a solution to the MAUP, nor a way to reduce its effects. As a matter of fact, MAUP is not only a question of object meaning for a given observed phenomenon. Its is also a low level (re)sampling problem related to pixels variance in each object and between each other. Because scale is one of the key dimensions in delineating spatial objects, results obtained from GEOBIA, such as from any clustering processes, can be impaired by the MAUP [7], and beyond, by any problem related to change of scale: Robinson’s ecological inference [9] in sociology, aggregation inference fallacy [3,5] in environmental science or statistics, Simpson’s paradox in economy, etc. All those issues can be comprised within a conceptual umbrella: the Change Of Support Problem (COSP [4,6]). In this paper, using current GEOBIA algorithms, we show on a set of images segmented at different scales that statistical indices and descriptors related to both objects and sets of pixels encompassed in those are strongly subject to the MAUP. Subsequently, object quality and consistency are not comparable, even in a same spatial partition, due to some size effect of the pixel samples. For instance, GLCM homogeneity, entropy, variance of the pixels and compactness, perimeter/area ratio are studied according to scale. Then we propose different ways to assess and to take into account this issue by introducing some constraints on the objects size to reorientate segmentation algorithms such as the well-known method proposed by Baatz and Schape [1]. We finally discuss on the alternative point of view about dealing with two facets of the MAUP: using similarly shaped objects (close to pixels or pixel aggregates) to fix the statistical scale-dependent problem versus variously shaped objects (entities drawn from OBIA) to focus on the nature of the observed object in its context.

**Keywords:** GEOBIA, relationship, MAUP, discussion, consistency, comparability

## Multi-annual Satellite Image Time Series Analysis using an Object-Oriented Approach

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Satellite images are an important data source for land monitoring. They allow us to depict the dynamics of the areas. In this paper, we present an unsupervised method to analyze multi-annual Satellite Images Time Series (SITS). Our approach aims to track areas evolution and characterize them with patterns. The proposed method combines an object-oriented analysis with a clustering approach to characterize the evolutions of SITS data. First, it detects the spatio-temporal entities to track. Second, it illustrates their evolution through a graph-based representation. Finally, it applies a clustering algorithm on them to highlight spatio-temporal entities that evolve similarly. An inter-site analysis is carried out on two study areas the Lower Aude Valley and the Pic Saint Loup. The results show that the proposed method highlights different evolution types according to the different land covers.

**Keywords:** Satellite image time series, Object-oriented image analysis, Clustering, Graph Analysis, Inter-site analysis.

## Fully convolutional networks for the classification of aerial VHR imagery

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Remote sensing images provide the capability to obtain information of various land cover classes. This information is useful to the process of urban planning, socio-economic modelling and population studies. There is a need for accurate and efficient methods to obtain this information, particularly in regions where there is a scarcity of reference data. In this work, we develop a methodology based on fully convolutional networks (FCN) that is trained in an end-to-end fashion using aerial RGB images only as input. The experiments are conducted on the city of Goma in the Democratic Republic of Congo. We compare the results to a state-of-the art approach based on a semi-automatic Geographic object image-based analysis (GEOBIA) processing chain. State-of-the art classification accuracies are obtained by both methods whereby FCN and the best baseline method have an overall accuracy of 91.24% and 89.34% respectively. The maps have good visual quality and the use of a FCN skip architecture minimizes the rounded edges that is characteristic of FCN maps. Finally, additional experiments are done to refine FCN classified maps using segments obtained from GEOBIA. This resulted in improved edge delineation in the FCN maps, and future work will involve explicitly incorporating boundary information from the GEOBIA segmentation into the FCN pipeline in an end-to-end fashion.

**Keywords:** Fully convolutional networks, deep learning, very high resolution aerial imagery, GEOBIA

## Extraction of Specific Land-Cover Class Using Deep Features and SVM One-class Classification

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During the past decades significant efforts have been made in developing various methods for very high spatial remotely sensed images classification; most of them are based on handcrafted features. Recently deep learning-based techniques have demonstrated excellent performance in remote sensing applications. However, for many applications, users may only be interested in a specific land class in an image such as extracting burned areas in forest, urban vegetation or cars in streets. This could be referred to as a one- class classification problem. In this paper, we test the usability of deep features and one- classification for the extraction of a specific land-cover type. The features of the class of interest are extracted using a pre-trained convolutional neural network, which works on square patches. The feature vectors are classified using SVM one-class classification technique. The performance of the proposed model is validated by an experimental comparison on a set of available remote sensing datasets. The obtained results show the effectiveness of the proposed approach, and could be a promising quick and efficient way for extracting a specific land class from high spatial resolution images.

**Keywords:** Object Based Image Analysis, SVM One-class Classification, Convolutional Neural Networks, Deep Feature

## Dimensionality reduction and scale-space analysis of APEX hyperspectral imagery for tree species discrimination

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Hyperspectral imagery has high potential for tree species classification. However, high-spectral dimensionality poses computational complexity, such as the Hughes phenomena (a.k.a., the “curse” of dimensionality). The aim of this study was two-fold: a) to assess spectral dimensionality reduction, for classification of uniform tree stands, in a case of lesser training samples and b) to assess the potential of difference-of-Gaussian for multi-scale representation of tree stands, on dimensionality reduced hyperspectral imagery. A minimum noise transformation was applied on an airborne prism experiment (APEX) image, and 10 MNF-derived components were selected. Multiresolution segmentation and random forest algorithms were used for tree species classification.

To assess multi-scale representation, MNF-derived components were convoluted with successive Gaussian filters, and difference- of-Gaussian of each consecutive image were created.

A contrast-split-segmentation was used to assess potential tree stands at multi-scales. The classification results using MNF-derived components yielded 93% of overall accuracy on object level, and 0.910 measure of kappa coefficient. A visual inspection of the classification results showed a better performance in a comparison with the classification results of original hyperspectral imagery. Additionally, utilizing DOGs for spatial complexity reduction resulted not only in a spatially simplified image, but also dominant features at different scales were preserved as blobs.

**Keywords:** Scale space analysis, Gauss filter, minimum noise fraction transformation (MNF), object-based image analysis (OBIA), random forest, APEX hyperspectral imagery, multi-scale analysis, tree species classification, automatic blob detection



## The potential of OBIA for SAR-based flood mapping

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In our changing world, floods are a threat of increasing importance causing major fatalities and economic losses. Within this perspective, flood extent mapping is of great importance for both damage assessment and improving flood forecasts. While flood mapping through optical imagery is often hampered by the presence of clouds, Synthetic Aperture Radar (SAR) sensors are capable of sensing in all weather conditions during both day and night. Moreover, recently launched missions such as the Sentinel-1 and COSMO-SkyMed constellations provide improved temporal and spatial resolutions, thus even further increasing the potential of SAR for systematic flood mapping and monitoring. Due to their specular reflectance properties, open water surfaces typically appear dark and homogeneous on SAR images. Classification of these images is generally performed using a pixel-based approach. Frequently used algorithms include histogram thresholding, active contour models and pixel-based change detection methods. The use of object-based approaches for SAR-based flood mapping remains rare, although a couple of studies have worked with a segmentation step. However, pixel-based approaches suffer from quite some drawbacks. Especially thresholding typically results in classification products that still include a large number of dispersed misclassified pixels, thus requiring a post-processing step. Although computationally more expensive, active contour models mostly lead to higher accuracies, which indicates the importance of spatial context. An object-based approach allows taking into account this spatial context, as well as some other relevant properties such as object shape, proximity and homogeneity. Moreover, it is possible to include some additional information sources such as elevation data, land cover data and optical imagery. This study aims at further investigating the potential of OBIA for SAR-based flood mapping applications. A range of established pixel-based approaches will serve as a benchmark. Preliminary results demonstrate the benefit of both segmenting the image into objects as well as incorporating additional information sources.

**Keywords:** Synthetic Aperture Radar (SAR), floods, image segmentation

## Monitoring floodplain vegetation change at river-reach scale

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Floodplain vegetation has important implications for flood safety, food supply, biodiversity and recreation. Because of river restoration projects, floodplain vegetation is becoming more heterogeneous in space and time.

To evaluate and document the development of floodplain vegetation, frequent monitoring is necessary. For monitoring, the detection of changes in vegetation type is a major objective, because of the potential consequences on hydraulic roughness or habitat availability. Manual photo interpretation is a common method to document these changes, but it is time-consuming and expensive. Moreover, interpretation errors can influence the accuracy. Hence, it is preferable to detect change without classification of the RS data. Change detection based on trend deviation or threshold exceedance (multitemporal spectral analysis) is complicated for floodplain vegetation and requires the use of a single type of sensor data, which limits the frequency of available data. Furthermore, the atmospheric corrections will influence the accuracy of the change detection.

The aim of this study is to present a method that quickly detects changes (i.e. where did changes occur?) and allows focussed analysis of change identification (i.e. how did it change?). Rather than classification or multitemporal spectral analysis, we compare object attribute values within specific classes at a single moment and detect outlier objects. If objects are identified as outlier multiple times, we consider them as changed. The basic assumptions for this approach are that 1) objects belonging to the same class have similar attribute values; 2) classes differ from each other for (some) attribute values; 3) the majority of objects does not change class within the monitoring period.

The method is tested in the floodplains along a 100-km river section along the River Waal in the Netherlands. Frequent and open remote-sensing data is available on the Google Earth Engine, such as Landsat, Sentinel, airborne imagery and surface models. A classified vegetation polygon map based on high resolution airborne imagery from 2008 is used to extract the zonal statistics from the multisensor and multitemporal data. These object statistics are used to detect the outliers at each time step and to monitor them. Changed objects are validated with yearly high resolution airborne imagery.

In short, this study evaluates whether sequential deviation of a vegetation object from the average (e.g. spectral) value of its class can be used for change monitoring and whether our basic assumptions are correct. The advantages of this approach are 1) the high frequency of remote-sensing data, because any available spectral/LiDAR/RADAR dataset can be used, allows close monitoring of changes; 2) the independence of classification or multitemporal spectral analysis, which are problematic due to the small (e.g. spectral) differences in vegetation and (3) it allows for fast processing.

**Keywords:** floodplain vegetation; monitoring; Google Earth Engine; change detection

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\* Speaker

## Object tracking through time: the example of a rock avalanche on a glacier

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Within this study, we investigate a specific methodological topic of object-based image analysis (OBIA), namely the tracking of (in this case slow) moving objects through time based on different optical satellite images. We are focusing on a large rock avalanche in Iceland, which occurred in 1999 in the southeastern part of the Vatnajökull ice cap. Debris from this event was deposited on the Svöludalsjökull outlet glacier. The extent of the debris cover on the glacier is automatically delineated using object-based rule-sets on different Landsat images of the last ~18 years. Building on a strategy to link moving objects geographically between different images based on directional overlap and a space-temporal model of the candidate object class, we estimate the speed of the debris and the change in size of the debris deposit.

Results are compared to a glacier velocity estimation using SAR offset tracking with TerraSAR-X data. Such an automated change analysis of rock avalanche deposit transportation on a glacier will not only help in documenting the rock avalanche-fate itself, but also provides an alternative for glacier velocity estimation in situations where only cross sensor images are available hampering for example velocity estimation based on image correlation approaches.

**Keywords:** Object-linking, moving objects through time, object-based image analysis (OBIA), remote sensing, rock avalanche, object-fate, Iceland, glacier velocity

## **AutoCloud+, a “universal” single-date multi-sensor physical and statistical model-based spatial context-sensitive cloud/cloud- shadow detector in multi-spectral Earth observation imagery**

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To contribute toward systematic European Space Agency (ESA) Earth observation (EO) Level 2 product generation at the ground segment, requiring a cloud/cloud-shadow quality layer detection in operating mode, but never accomplished to date by any EO data provider, this work presents the research and technological development (RTD) of an innovative AutoCloud+ approach. Designed and implemented to be “universal”, i.e., robust to changes in multi-spectral (MS) imaging sensor’s spatial and spectral resolution specifications, AutoCloud+ aims at cloud/cloud-shadow detection in multi-sensor single-date MS imagery without human-machine interaction. Sensitive to spatial topological and spatial non-topological information components in addition to MS color properties in compliance with an object-based image analysis (OBIA) paradigm, AutoCloud+ adopts a hybrid (combined top-down/physical model-based and bottom-up/statistical model-based) CV workflow. The AutoCloud+ software prototype was tested starting from a 10 m resolution Sentinel-2 MS imagery, in comparison with alternative cloud/cloud-shadow detectors in operating mode, specifically, the single-date ESA Sentinel-2 (atmospheric) Correction Prototype Processor (Sen2Cor) and the multi-date CNES/CESBIO/DLR MACCS-ATCOR Joint Algorithm (MAJA). In this difficult test case affected by several error-prone situations, AutoCloud+ ran automatically with high accuracy, qualitatively affected by few false positives and few false negatives.

**Keywords:** Color naming, color constancy, object-based image analysis (OBIA), physical and statistical data models, radiometric calibration, spatial topological and spatial non- topological information components, vision.

## Object-based image classification by One-dimensional Convolutional Neural Networks

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Thanks to GEOBIA approaches it is possible nowadays to shift from low dimension pixel domain to high dimension objet domain. Various machine learning classifiers have been proved their effectiveness to classify objects issues from segmentation. Rule-based classifier, Random forest, Support Vector Machine and K-Nearest Neighbors are the most used ones. Recently deep learning through convolutional neural networks (CNN) has been intensively used in remote sensing field. Obtained Geographic objects can be viewed as one-dimensional (1-D) signal formed of the computed features during the characterization step, which led us to suggest the using of 1-D version of CNN for the classification of these objects.

In this work, we perform object-based classification experiment, where multi-resolution segmentation is applied and the obtained segments are characterized using spectral, spatial and textural features. The classification results over the high spatial resolution Zurich summer benchmark dataset demonstrate that the proposed solution achieves a superior classification performance than most of the state-of-the-art machine learning methods.

**Keywords:** Object Based Image Classification, Machine Learning, Segmentation, 1D Convolutional Neural Networks

## A semi-automated LiDAR-GEOBIA methodology for forest even-aged stand delineation based on a two-stage evaluation strategy

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Forest stand delineation is rapidly evolving from traditional photointerpretation to semi-automated GEOBIA techniques. To obtain a good correspondence between image objects and geographic objects, GEOBIA techniques require user decisions considering input data, segmentation algorithms, and classification strategies. GEOBIA applications in forestry have relied mostly on optical remotely sensed data, focusing on the spectral properties of vegetation to identify forest stand boundaries. A limitation of this approach is that optical data have limited sensitivity to forest structural parameters which are the main driver of stand boundaries in even-aged forests. Active sensors such as Light Detection and Ranging (LiDAR) are an alternative, providing a direct estimation of forest structure (e.g. height, density) and potentially leading to more accurate stand maps. In this paper, we propose a semi-automated methodology for even-aged stand delineation using LiDAR data and a two-stage GEOBIA evaluation strategy, combining both unsupervised and supervised evaluation methods to select a suitable segmentation output. The study area is located in the Clear Creek, Selway River & Elk Creek watersheds (~ 54,000 ha) in Northern Idaho (USA), where available LiDAR data was collected in 2009 (Clear Creek watershed) and 2012 (Selway River & Elk Creek). Additionally, a reference dataset of stand-replacing disturbances consisting of yearly clearcut maps compiled from timber harvest records were also available from 1950 as part of the US Forest Service FACTS (Forest ACTivity Tracking System). The proposed methodology involves: (1) image segmentation of several airborne LiDAR metrics using the multiresolution segmentation algorithm implemented on the eCognition software varying consistently the scale, compactness and shape parameters; (2) selection of the best set of parameters for segmentation for each tested LiDAR metric, applying an unsupervised evaluation method based on measures of spatial autocorrelation. This stage ensures that the selected segmentation has the highest possible intra-object uniformity and inter-object heterogeneity; (3) selection of the most suitable LiDAR metric for the segmentation, applying a supervised evaluation method based on measures of area-based dissimilarity, selecting the segmentation with the maximum degree of similarity in size and shape to FACTS reference dataset; and (4) validation using as reference data forest stand perimeters independently derived from visual interpretation. The results show good delineation of even-aged forest, including stands harvested more than 60 years ago that are generally challenging to detect with optical data, because the spectral response of forest canopy saturates at high levels of canopy closure. On a methodological level, the proposed two-stage procedure allows not only accurate image objects delineations but also allows to select the most suitable input data that assure that the image objects are spatially matching with the ground objects. This workflow could be implemented in other studies where different segmentation strategies (e.g., different segmentation algorithms, parameters or resolutions), input data (e.g., Landsat data) or target features (e.g., land cover types) need to be assessed.

**Keywords:** GEOBIA, LiDAR, even aged forest stand, delineation, multiresolution segmentation, evaluation

## Individual street tree detection from airborne data and contextual information

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With the current expansion of cities, 5 billion citizens and 1.2 millions km<sup>2</sup> more by 2030, urban trees have an important role for preserving the health of its inhabitants. With their evapotranspiration, they reduce the urban heat island phenomenon, by trapping CO<sub>2</sub> emission, improve air quality. Urban tree structures including street trees and park ones do not have necessarily the same functions/roles in the urban context. In particular, street trees or alignment trees, create shade on the road network, are structuring elements of the cities and decorate the roads. Street trees are also subject to specific conditions as they have little space for growth, are pruned and can be affected by the spread of diseases in single-species plantations. As a case in point, a pruned lime tree (*Tilia*) has a life expectancy of 150 years against 800 years without constraint. Thus, their detection, identification and monitoring are necessary. In this study, an approach is proposed for mapping these trees that are characteristic of the urban environment. Three areas of the city of Toulouse in the south of France are studied. Airborne hyperspectral data and a Digital Surface Model (DSM) for high vegetation detection are used. Then, contextual information (from Geographic Information System (GIS) data) is used to detect the vegetation canopies close to the streets. Afterwards, individual street tree crown delineation is carried out by modeling the contextual features of individual street trees (hypotheses of small angle between the trees and similar heights) based on Marked Point Process (MPP). Compared to a standard individual tree crown delineation method based on region growing, our method logically provides the best results with F-score values of 91%, 79% and 85% against 70%, 41% and 20% for the three studied areas respectively. These results are illustrated in the figure 1. Our approach mainly succeeds in identifying the street trees. In addition, the contribution of the angle, the height and the GIS data in the street tree mapping has been studied. The results encourage the use of the angle (alignment), the height and the GIS data together. However, with only the angle and the height, the results are similar to those obtained with the inclusion of the GIS data for the first and the second study cases with F-scores values of 88%, 79% and 62% against 91%, 75% and 85% for the three study cases respectively. Finally, it is shown that the GIS data only is not sufficient. This study highlights the interest of taking into account the contextual characteristics of the studied objects. As an urban manager, this type of information is useful for a specific urban planning and a specific monitoring. Moreover, it can be integrated in species classification schemes in order to improve the accuracy in single species-plantations.

**Keywords:** Street tree, Urban remote sensing, Hyperspectral, Digital Surface Model, Geographic Information System, Individual tree crown delineation, Marked Point Process

## Integrating Geographic Object Based Image Analysis with the Open Data Cube for multi-resolution, multi-sensor hyper-temporal image analysis using CCDC for deforestation monitoring in Canada

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Deforestation is a permanent land use change, caused by the direct human-induced conversion of forest land to other land uses. Land cover changes such as forest clearings due to harvesting as part of sustainable forest management, or due to natural disturbances, are not deforestation, as they are usually temporary and followed by forest re-growth. Current pixel based change detection techniques are sensitive to tree cover change and specific sensor characteristics and are, therefore, ill-suited for automated land use change classification. With a limited number of temporal observations, Geographic Object Based Image Analysis (GEOBIA) has been widely used for deforestation mapping in projects such as REDD+, but has not yet been implemented within a data cube architecture, such as the Open Data Cube (ODC).

The purpose of this research project is to use analysis ready data (ARD) acquired by the Land- sat Program and Sentinels 1 and 2 over Canada, to detect deforestation using the ODC with a GEOBIA data abstraction layer. Using both SAR and optical observations, the Continuous Change Detection and Classification (CCDC) algorithm is then applied on a per segment basis to characterize historic land use versus current land use, and to identify the resulting change date.

To generate a quality layer for the ODC, a pixel based spectral pre-classification delineating spectral classes such as cloud, haze, shadow, water, snow, dark bare soil, bright bare soil, herba- ceous vegetation and woody vegetation, is applied to every image. A reference object layer is generated from segmented Sentinel 2 10m resolution imagery acquired in summer of 2017 by incorporating multi-date acquisitions until all segments have been formed from clean data. For the analysis, only segments are used which do not contain any cloud, shadow, haze, or snow pixels. In the time series for each segment, when a discontinuity in pixel based class mixtures is identified, the segment is split along the discontinuity boundary. In the ODC, once segments have been established across the full time series, and spectral/textural features have been calculated for each segment, CCDC is used to characterize the phenology of each segment. Abrupt changes in phenological behavior can be identified with given break points. When the land cover classes on each side of the temporal divide are identified, they can be used to determine if the non-forest land cover reverts back to forest or not. This will distinguish between land cover change and land use change. Only a change in land use is flagged as true change, and this can then be used to assist in deforestation monitoring.

The study area is situated in northeastern Alberta, Canada, and is historically subjected to frequent deforestation activities, mainly attributed to oil sands mining and fracking. Using manual image interpretation techniques, the Canadian Forest Service has recorded deforestation in a systematic sampling design at frequent intervals for the small events, and by a complete coverage for large events. This highly accurate reference data is used to validate the performance of automatic deforestation mapping techniques developed in this study.

**Keywords:** Open Data Cube, hyper, temporal image analysis, CCDC, deforestation



## **Poster Session - 12h15 - 12h45**

- **Mapping Brazilian Savanna Physiognomies using WorldView-2 Imagery and Geographic Object Based Image Analysis** - Cesare Di Girolamo Neto, Leila Maria Garcia Fonseca, Thales Sehn Körting, Anderson Reis Soares
- **Crop type detection based on Sentinel-1 multi-temporal data** Aleksandrowicz S., Wozniak E., Kofman W., Rybicki M., Lewinski S., Łaczyński A., Milewski T., Niszczota S., Slesiński P.
- **Automatic tuning of segmentation parameters for tree crown delineation with multispectral data** - Camile Sothe, Clàudia Almeida, Marcos Schimalski, Veraldo Liesenberg
- **From land use status to landscapes. Field and object-based treatment in two communes of the Ranomafana-Andringitra-Ivohibe forest corridor, South-Central Madagascar** Avisoatolona Andrianarivo, Eric Delaitre, Anne-Elisabeth Laques, Samuel Razanaka, Dominique Hervé
- **Monitoring reforestation with UAV images and OBIA** - Bos Debusscher
- **Object-based classification of a high spatial resolution satellite image (IKONOS) using spatial autocorrelation and semivariogram metrics in a rural NATURA 2000 deltaic area** - Nikos Koutsias, Ioanna Voukelatou
- **Hierarchical Object Based Image Analysis of Unmanned Aerial System (UAS) imagery for species level mapping of Himalayan treeline vegetation** - Niti Mishra, Bharat Shrestha
- **Multi-scale object-based measurement of plant community structure** - Lei Zhang
- **Mapping Date Palm Structure and Age Using UAV Imagery** - Kasper Johansen, Samir Al-Mashharawi, Yoann Malbeteau, Bruno Solorio, Matteo Ziliani, Matthew McCabe

21 juin - 14h00 - 14h30

*Cláudia de Almeida, Keynote speaker " GEOBIA: Retrospective overview & prospective reflections "*

21 juin 2018 - 14h30 - 16h00



**Workshop "Highlights in eCognition 9.3 - point cloud analytics, Deep Learning and the world in between"**

21 juin 2018 - 16h30 - 17h00

**Urban Analysis and Health Issues**

## **Archaeology and Object-Based Image Analysis: potential and issues for the application of semantic models**

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In recent years, the field of remote sensing experienced an incredible growth thanks to the increasing quality and variety of sensors and the reduction of instrumental costs. The benefits for archaeology were soon apparent. So far, data interpretation remains essentially a prerogative of the human operator and is mediated by his skills and experiences. However, the continuous increase of datasets volume and the increasing necessity to work on large scale projects require an overall revision of the methods traditionally used in the archaeological field.

With the progressive diffusion of OBIA in archeology during the last few years, it is now essential to find a shared language and a common protocol of investigation (ideally passing from operational practice to operational routine), necessary to allow the comparability of data.

This presentation will offer a general review on the topic considering both the results published in the literature and new case studies developed by the author and his research group, which will be used to illustrate the possibilities of the method in archeology. The case studies will comprise object-based procedures for the treatment of aerial/satellite imaging, such as VHR multispectral data, and digital elevation models acquired by airborne and terrestrial laser scanning.

These data will serve as a starting point to discuss the limits and the potential of OBIA in the archaeological field, with specific reference to the prospects for the future in light of the recent developments in other disciplines such as environmental and biomedical sciences.

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\*Speaker

The objective is therefore to examine a series of crucial methodological issues linked to the residuality of the archaeological remains, also through the exemplification of practical results. In fact, the archaeological remains are always affected by post-depositional processes which have progressively altered, with different degrees of impact, their original characteristics, leading to a high variability within the same category of evidences. Diachronic semantic models were thus developed to fine-tune the classification tree and obtain a better accuracy of the results. For the same purpose, a systematic integration of OBIA and targeted ground surveys seems to be the best option of a cross-validation of the results, in order to achieve an appropriate balance between processing speed and reliability of data.

**Keywords:** Archaeology, Digital Elevation Models, Aerial/ Satellite Imagery, Diachronic Semantic Models

## Mapping of urban temperatures by TRISHNA : precision of the land surface Malaria and Environment: Search for specific landscape indicators of its distribution in the villages of Grand Comore

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<sup>3</sup> CIRAD, UMR ASTRE – Centre de coop ration internationale en recherche agronomique pour le d veloppement [CIRAD] : UMR15 – 2, Rue Maxime Riviere, F97491 Sainte Clotilde, France

Malaria has long been endemic in the Union of Comoros. Grande Comore has experienced the highest rates of malaria among the Comorian islands for 90 years. Between 2010 and 2016, more than 82% of reported malaria cases were reported to the Grande Comore. Maintaining a high incidence rate of malaria on the island of Grande Comore, unlike the remaining islands, intrigues malaria control leaders in the Union of the Comoros. This study aims at describing the spatial patterns of the epidemiology of malaria and at identifying environmental indicators through a geographical approach in Grande Comore. Monthly cases, as reported by the "Programme National de lutte Contre le paludisme" (PNLP) in 2016, were geo-referenced in the island of Grande Comore, at two different scales: by health district and villages. Using SPOT 5 satellite images of Grande Comore, we described and classified the land use by an Object-Based Image Analysis (OBIA) method. We used this classification to calculate landscape metrics within 1km, 1.5km and 2km radius of each village (percentage of surface area covered by each land use class, the patch and edge densities). We realized statistical and spatial analyses to show the relationships between malaria and environmental information. We applied the Global Moran's I and the Anselin Local Moran's I to test spatial correlation of malaria incidence between villages. In 2016, 1,372 malaria cases were recorded in 116 villages. The average incidence of all the villages was 301 cases per 100,000 inhabitants. We observed significant and positive correlation between malaria incidence with grassland (RR=0.03,  $p < 0.01$ ) and significant and negative correlation with forest (RR=0.03,  $p < 0.05$ ) and mean altitude (RR=0.03,  $p < 0.01$ ). Malaria incidence was correlated with the patch density (RR=0.14,  $t=3.1$ ,  $p < 0.01$ ) and the edge density (RR= 0.09,  $p < 0.05$ ) in the health district of Centre. In the health district of Oichili Dimani, malaria incidence was correlated with shrub cover (RR=0.13,  $p=0.047$ ). The Global Moran's I reveals spatial autocorrelation of the malaria incidence in Grande Comore villages ( $I=5.5$ ,  $p < 0.000001$ ). The Anselin Local Moran's I shows spatial autocorrelation between health districts.

This study allowed characterizing the spatial distribution of malaria in Grande Comore and revealed a strong autocorrelation by village and health district. Based on the fine scale of villages, it has mainly helped to identify landscape indicators of malaria maintenance that could be used to predict its distribution in areas where data are incomplete.

**Keywords:** Malaria, spatial analysis, remote sensing, OBIA, autocorrelation, landscape metrics, Grande Comore

\* Speaker

## 3D Hyperspectral and Thermal Analysis of Forest Trees Focusing on Bark Beetle Infestation

Peter Hofmann<sup>\*1</sup>, Martin Hais<sup>2</sup>, Marco Heurich<sup>3,4</sup>, Rainer Pöschl<sup>1</sup>, Stefan Kunze<sup>1</sup>, Milan Novák<sup>2</sup>, Petr Dolžal<sup>2</sup>, Stanislav Grill<sup>2</sup>, Markéta Davidková<sup>2</sup>, Miloš Prokyněk<sup>2</sup>, Martin Stary<sup>5</sup> Wolfgang Dorner<sup>1</sup>

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Disturbances caused by bark beetles are a massive problem for forestry in the northern hemisphere. Especially the central part of the national parks Bavarian Forest (Germany) and Šumava (Czech Republic) are often affected by bark beetle infestations. Recently, an early stage detection of bark beetle infestation is only possible by terrestrial inspection, which is labor intensive and costly. Thus, effective methods allowing an early-stage detection of bark beetle infestation of larger areas are needed. The joint project BarkBeeDet aims at investigating the detection of trees infested by bark beetle at an early stage (green-attack-stage) using methods of UAV (Unmanned Air Vehicle)-based imaging with LiDAR, hyperspectral and thermal IR sensors. The data of the different sensors is used in conjunction for image analysis, whereas methods of 3D object-based image analysis are applied. The paper present outlines first results of imaging and 3D object-based image analysis and concludes the potential of this method for an effective detection of bark beetle infestation.

**Keywords:** LiDAR, Hyperspectral, Bark Beetle, Forestry

## Multi-Scale Superpixel Neighborhoods For Contextual Features For Land Cover Mapping With High Resolution Satellite Image Time Series

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Contextual features are known to be key descriptors for distinguishing certain land cover classes, for instance, different levels of urban density. Superpixel methods place themselves in between the usual sliding-window and the object based methods for contextual features. By offering neighborhoods that are adaptive to the image content, they maintain the possibility of including diverse pixels in the same segment by imposing size and compacity constraints, which enables the calculation of pertinent contextual features. In this paper, a novel method is presented, in which each pixel is described by a series of features calculated in the superpixels containing it, thus at several different scales. The focus of the paper is the comparison of different contextual features in the frame of high resolution image time series as the ones provided by Sentinel-2, where a pixel is described by 10 spectral bands with acquisitions every 5 days. The two groups of features, image statistics and semantic features, are compared on their ability to improve the classification of a Sentinel-2 time series, on a land cover problem with 14 classes including urban, agricultural, and natural cover classes. Overall, it is shown that including contextual features in superpixels increases accuracy when compared to pixel-based classification, and that semantic features are best able to capture long-range information. It is also shown that superpixel neighborhoods do not smooth high spatial frequency areas.

**Keywords:** Contextual features, OBIA, Superpixel, Classification, Time-series

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\*Speaker

## GEOBIA at the Terapixel Scale: From VHR Satellite Images to Small Woody Features at the Pan-European Level

François Merciol<sup>1</sup>, Loïc Fauqueur<sup>2</sup>, Bharath Bhushan Damodaran<sup>1</sup>, Pierre-Yves Rémy<sup>2</sup>, Baudouin Desclée<sup>2</sup>, Fabrice Dazin<sup>2</sup>, Sébastien Lefèvre<sup>\*1</sup>, Christophe Sannier<sup>2</sup>

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While the GEOBIA paradigm has led to significant improvements in the analysis and understanding of remote sensing images thanks to the processing of objects (i.e. regions) instead of pixels, it still requires to identify the objects (or segment the image into regions) before applying rules for classifying the extracted objects.

This segmentation step is not straight forward and relies on user expertise or empirical tuning to be adapted to each new scene to be processed. Thus, it cannot be used for Big GeoData where large-scale analyses require methods that are both very efficient and robust to the wide variety of scenes to be observed.

We address here these multiple issues by relying on a multiscale image representation that embed in a tree structure, with no need of parameter tuning, the different (nested) objects to which a pixel can belong. Computation of such a stack of segmentations benefit from some recent scalable implementations that make realistic their very fast extraction from large-scale image datasets. Once the tree structure has been extracted, further image analysis is conducted at a very low computational cost, and relies on Differential Attribute Profiles (DAP). These state-of-the-art features describe a pixel by the properties of the objects it belongs to. We apply these profiles to both the original multispectral bands and some derived features such as NDVI or textural information. We then apply the Random Forest classifier on the extracted DAP features, or more precisely on only the most relevant features. We benefit from the efficiency of the different steps (tree construction, feature extraction, training, prediction) to propose a semi-supervised strategy where we retrain the model for each kind of landscape, thus allowing to tackle the great variety in appearances of objects at a very large-scale (e.g. VHR imagery at Pan-European scale). Due to the low computational cost (e.g. a few minutes for a Pleiades or WorldView-3 scene), a user can then interactively improve the classification by updating the reference samples used for training the model. The proposed scalable solution fully relies on open source components (Orfeo ToolBox, Boost, GDAL, Shark, Triskele OTB remote module) and so can be used in any GEOBIA applications.

To illustrate our methodology, we consider here the Mapping of Small Woody Features (SWF), that is to be included as part of a new High-Resolution Layer (HRL) covering the whole of Europe from Iceland to Turkey within the Copernicus pan-European component of the land monitoring service. SWF represent some of the most stable vegetated linear and small landscape objects providing numerous ecological and socio-cultural functions related to soil and water conservation, climate protection and adaptation, biological diversity and cultural identity. Extracting these objects over such a large area (almost 6 million sq.km) from VHR imagery brings numerous challenges: large amount of data (greater than 100TB), large number of individual image scenes (greater than 25,000), diversity of the European landscapes, and the need to process these data in a timely manner whilst ensuring a satisfactory degree of precision.

Extracting these objects over such a large area (almost 6 million sq.km) from VHR imagery brings numerous challenges: large amount of data (greater than 100TB), large number of individual image scenes (greater than 25,000), diversity of the European landscapes, and the need to process these data in a timely manner whilst ensuring a satisfactory degree of precision.

**Keywords:** Big data, scalability, multiscale analysis, land cover mapping, differential attribute profiles, random forest, open source

## Multispectral image classification from axiomatic locally finite spaces-based segmentation

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Geographical object-based image analysis (GEOBIA) usually starts defining coarse geometric space elements, i.e. image-objects, by grouping near pixels based on (a, b)- connected graphs as neighbourhood definitions. In such an approach, however, topological axioms needed to ensure a correct representation of connectedness relationships can not be satisfied. Thus, conventional image-object boundaries definition presents ambiguities because one-dimensional contours are represented by two-dimensional pixels. In this paper, segmentation is conducted using a novel approach based on axiomatic locally finite spaces (provided by Cartesian complexes) and their linked oriented matroids.

For the test, the ALFS- based image segments were classified using the support vector machine (SVM) algorithm using directional filter response as an additional channel. The proposed approach uses a multi-scale approach for the segmentation, which includes multi-scale texture and spectral affinity analysis in boundary definition. The proposed approach was evaluated comparatively with conventional pixel representation on a small subset of GEOBIA2016 benchmark dataset. Results show that classification accuracy is increased in comparison to a conventional pixel segmentation.

**Keywords:** GEOBIA, inter-pixel element, finite spaces, oriented matroid, SVM classification



## Mapping irrigated agriculture in complex landscapes using object-based image analysis

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In developing countries, irrigated agriculture is key to achieve domestic food security and mitigate poverty. The often complex landscapes dominated by traditional smallholder farming (fields  $\sim$  1 ha) pose a challenge with regard to mapping irrigated agriculture. Irrigation mapping efforts are complicated by the spectral overlap between irrigated crops, rainfed crops and other land cover. Efforts to identify smallholder irrigation are often too coarse, and, generally the area under smallholder irrigation is underestimated. This study presents an object-based approach for mapping irrigated agriculture in complex landscapes for both smallholder farming as well as modern large-scale agriculture. The aim here is twofold: 1) a proof-of-concept of irrigation mapping in a case study in the Central Rift Valley, Ethiopia, using SPOT6 imagery and 2) upscaling of the mapping to the Horn of Africa using Sentinel-2 imagery.

Our assumption is that the application of irrigation has a positive effect on the crop throughout the field, following the field's borders. Next, we hypothesise that the use of shape, texture, neighbour and location features in addition to spectral information is beneficial for the classification of irrigated agriculture. The case study area is located in the Awash River basin and contains two irrigation schemes serving both traditional smallholder farming as well as modern large-scale agriculture. Three SPOT6 images spanning the dry season were acquired. Objects were generated at the field level on the basis of similarities in vegetation behavior (NDVI change) assuming that this matched the response of the crop on receiving irrigation water. The resulting map shows whether and where fields received irrigation water in between the three satellite acquisition moments and whether it belongs to traditional smallholder farming or modern large-scale agriculture.

The object-based classification had an overall accuracy of 94% and a kappa coefficient of 0.85 and showed an improvement for mapping irrigated agriculture compared to a pixel-based classification (overall accuracy of 88% and a kappa coefficient of 0.69). Producer's and user's accuracies of individual classes were generally higher for the object-based approach compared to the pixel-based classification. Type of agriculture (i.e. smallholder or modern large-scale) was mapped with an accuracy of 95% and a kappa coefficient of 0.88. The addition of shape, texture, neighbour and location information in the object-based approach proved essential for the identification of cropland plots, irrigation period, and type of agricultural system.

For the upscaling we use Sentinel-2 imagery as they are available with the highest spatio-temporal resolution among publicly-available imagery. The 10-meter resolution and 5-day revisit time has tremendous potential for mapping smallholder irrigation in complex landscapes. At the moment we are processing the data. A mosaic of best-cloud-free images acquired in the dry season (October to March) is segmented at field level. Monthly NDVI composites, combined with shape, texture and neighbour information are used to map irrigated agriculture. The output will be a map showing the spatio-temporal distribution of irrigated agriculture, for both smallholder farming and modern large-scale agriculture, for the Horn of Africa.

**Keywords:** Smallholder irrigation, Field level analysis, Data poor regions, Agriculture, Horn of Africa

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\*Speaker

## Spatial structure analysis of olive landscape in Congo basin using Landsat images

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Congo basin is the world's tropical forest outside of the Amazon. With an important biodiversity, this forest plays a central role in global warming. These forests divide up on six countries, one of which is Cameroon. Tropical Congo basin forests are a vital element in the economic development of these countries and are prone to spoilage. Agricultural and urban expansion is among the causes of forest cover degradation in this area (Geist and Lambin, 2001). Agricultural development induces urbanization processes (Gourade and Bruneau, 1983). Our work aims to study cover forest structure evolution linked to oil palm cultivation in Cameroon. The studied oil palm cultivation is the SOCAPALM industrial palm grove, located in Kienkí'e, South of Cameroun. We developed a method to describe and characterize processes and transformations that induce covert forest degradation. For that purpose, we studied the link between forest, urban frame and oil palm areas evolution. The first step is about mapping of land use from Landsat5 TM and Landsat8 OLI images, from 1988 to 2017. For Land use mapping, because of mixed pixels (Komba Mayossa and Gadai, 2016), usual methods of automatic and supervised classification didn't allow a good discrimination of land cover features. Thus we use a method based on supervised classification of Landsat segment images extract. These method consists of: (i) spatial segmentation using thematic masks; (ii) after extraction, we classify each segment using maximum likelihood algorithm; (iii) classified segments are merged to obtain a final map land use in 1988 and 2017; (iv) map accuracy evaluation using confusion matrix method; (v) we extract forest, urban frame and oil palm areas to study their evolution between 1988 and 2017. The last step is to extract landscape structure using contextual operator such as edge analysis. For that, we compute Principal Component Analysis (PCA) from spectral layers of Landsat sensors. First components PC1988 and PC2017 containing respectively 90% and 85% of spectral information were selected. From these components we make directional filters in 3x3 sliding window pixels. In this way we extract olive Landscape structure. The experimental results of this study shows that cartographic method proposed allows a good mapping of land use features. That claim is justified by the good values of Kappa indices, 0.98 in 1988 and 0.87 in 2017. The proposed method involves a logic allowing understanding the systemic link between trends in urban frame, palm grove areas and forest structure. The study of areas evolution shows a decrease of forest cover (from 60% in 1988 to 40% in 2017), on the benefit of palm grove (from 25% to 35% in 2017) and urban frame (from 15% to 20% in 2017). At the same time the analysis of landscape structure shows the appearance of new urban structures such as roads and buildings inside and near agricultural surface, decreasing forest cover.

**Keywords:** Olive landscape, spatial structure, mapping.

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\* Speaker

## Sentinel-2 time series based automatic detection of agriculture land use anomalies

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The common agricultural policy (CAP) is one of the oldest policies of the European Union; however, the latest reform will reshape the agriculture land use control processes from the selected risk fields-based into an all-inclusive one, fostering the use of Sentinel-2 data. In this paper, we present the suitability of the Breaks For Additive Season and Trend Monitor (BFAST Monitor) method in combination with the customization of parcel-based temporal (NDVI) profiles, to automatically detect and verify changes that correspond to anomaly observation in permanent meadows and crop fields, using Sentinel-2 images. The validation of these land use anomalies was performed with the information on declared land annual use and field controls, obtained in the framework of subsidy granting. The proposed approach proves efficient for permanent meadows monitoring and can be introduced to help the process of agriculture land use control within CAP activities.

**Keywords:** Crop monitoring, Sentinel-2, time series analysis, crop temporal profiles, change detection, land use anomalies, EU CAP (EU Common Agricultural Policy)

22 juin - 9h00 - 9h30

Geoffrey J. Hay, Keynote speaker "Visualizing Urban Energy Efficiency: My Story of GEOBIA Commercialization"

22 juin 2018 - 9h30 - 10h30



GEOSUD - Pierre Maurel



THEIA - Nicolas Baghdadi

22 juin 2018 - 10h45 - 11h15

Big Data & IA Issues

## Earth observation big data analytics in operating mode for GIScience applications The (GE)OBIA acronym(s) reconsidered

Andrea Baraldi<sup>1,2\*</sup>, Stefan Lang<sup>1</sup>, Dirk Tiede<sup>1</sup>, Thomas Blaschke<sup>1</sup>

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Pre-dated by spatial context-sensitive image classification algorithms, developed by the remote sensing (RS) and computer vision (CV) communities as viable alternatives to traditional pixel-based image analysis since the late '70s, in year 2006 the geographic information science (GIScience) community introduced terms "object-based image analysis" (OBIA) and geographic OBIA (GEOBIA) to "bridge the gap between geographic information systems (GIS) and RS". Following year 2000, two driving forces working in closed-loop fostered the emergence of a GEOBIA subfield within the GIScience community. On the one hand, a portion of the GIScience community adopted de-facto the eCognition commercial image processing software toolbox, brought to market in year 2000, as a CV system reference standard. On the other hand, the GIScience community lacked communication with the multi-disciplinary realm of cognitive science, encompassing philosophy, psychophysics, neuroscience, machine learning-from-data, artificial general intelligence (AGI), which includes CV as superset of Earth observation (EO) image understanding, and GIScience. One fundamental proof of the self-referential syndrome affecting the GEOBIA community is that, to date, the mainstream RS and CV solutions ignore standard GEOBIA algorithms and vice versa. Unequivocal true-facts about biological

\*Speaker

vision and primate visual perception recommend reconsidering the relevance of acronyms OBIA/GEO-BIA. Acknowledged that “science progresses one funeral at a time”, to successfully cope with EO big data analytics characterized by the five Vs of volume, velocity, variety, veracity and value, the GEOBIA community is wished to gather sufficient intellectual fortitude to change its own name into a more exact one, such as EO for GIScience (EO4GEO), meaning EO big data analytics in operating mode for GIScience applications, constrained by 2D (retinotopic, spatial topology- preserving) image analysis in cognitive science (2D-EO4GEO).

**Keywords:** Hybrid (combined deductive and inductive) inference, object-based image analysis (OBIA), physical and statistical data models, radiometric calibration, spatial topological and spatial non-topological information components, vision, world model.

22 juin 2018 -11h15 - 11h45

Big Data & IA Issues

## Dino Ienco - Deep learning in the OBIA context

22 juin 2018 - 11h45 - 12h15

Big Data & IA Issues

### Towards a GEOBIA 2.0 manifesto – achievements and open challenges in information & knowledge extraction from big Earth data

Stefan Lang<sup>\*1</sup>, Andrea Baraldi<sup>1,2</sup>, Dirk Tiede<sup>1</sup>, Geoffrey J. Hay<sup>3</sup>, Thomas Blaschke<sup>1</sup>

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The primary aim of collecting earth observation (EO) imagery is to turn scene content into geo-based knowledge/information. In Geographic Information Science (GIScience), the term “object-based image analysis” (OBIA) was tentatively introduced in 2006. When it was re-formulated in 2008 as GEOBIA, the primary focus was on integrating multiscale EO data with GIScience and computer vision (CV) solutions to cope with massive volumes of EO imagery. A principal objective of this article is to (re-) emphasize the role of space/geospatial in image analysis, supported by recent trends, such as big data analytics in the form of a GEOBIA 2.0 manifesto. The following key aspects of multi-source EO image analysis are emphasized: (1) EO image enhancement and interoperability/harmonization at the radiometric and semantic levels of analysis; (2) big raster data storage and exploitation, affected by ongoing limitations in tackling spatiotemporal information in vector format; (3) deep (multi-scale) distributed CV systems (e.g., artificial neural networks); (4) hybrid (combined deductive/top-down and inductive/bottom-up) inference, (5) structured CV system of systems design, based on a convergence of spatial and color evidence, (6) consistency of CV with human visual perception; and (7) semantic content-based image retrieval. This plea for a GEOBIA 2.0 manifesto is supported by illustrative examples from the field of GIScience.

**Keywords:** (Geographic) Object-Based Image Analysis; Computer Vision; big data analytics; GIScience; spatiotemporal information.

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\* Speaker

## An unsupervised segmentation algorithm for remote sensing images

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Geographic Object-Based Image Analysis (GEOBIA) provided the potential for exploiting geographical information, such as spatial context or object shape. Because of that, image segmentation became a fundamental and a necessary task on the GEOBIA processing chain, though that already was a traditional operation in Remote Sensing and a fundamental problem of image processing. Regardless of the good results obtained by some algorithms, the correct partitioning of an image is still an unsolved problem. In this paper, we propose a new unsupervised context-based segmentation algorithm, which uses some concepts of the Bayesian approach, to do image partition for high-resolution remote sensing images. We use well-known and simple techniques to create this algorithm, aiming to label disjoint regions with similar characteristics and to reduce the computational cost by simplifying the energy function, thus facilitating information fusion through long-range interaction. The algorithm was tested on a WorldView-2 multispectral image with 98 reference objects and its results were evaluated with 6 quality measures, that analyse precision, recall, f1-score, the agreement to size, shape and positional adjustment. In addition, we compared the results of the proposed algorithm with those produced by the Multiresolution Segmentation algorithm, which is commonly applied by the GEOBIA community, the Meanshift algorithm, and a Region Growing segmentation algorithm. For the metrics of precision, recall, f1-score and size, the Multiresolution obtained the best results, while our proposed algorithm outperformed the others, on the metrics of positional adjustment and shape agreement.

**Keywords:** Image Segmentation, Segmentation Comparison, Remote Sensing

## Feature selection and its impact on orbital imagery classification accuracy

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Currently, the large availability of orbital, airborne and UAV-borne multispectral and hyperspectral imagery has fostered an increasingly wide scope of applications. Likewise the sensor systems, image classification approaches have been continuously evolved. In order to produce an accurate discrimination of targets in the process of classification, the employed methods need to be able to deal with a massive quantity of input data. The literature demonstrates that the use of images together with thereof derived attributes increases classification accuracy since they help to differentiate the classes of interest in a more effective way. Handling big data normally implies the use of data mining, aiming to extract amidst a huge volume of information what is actually relevant to the user's goals. Regardless the application, it is known that relevant information is always followed by superfluous content. In this context, feature selection is an alternative to be considered, so as to filter the most meaningful attributes and to exclude redundant or irrelevant information. In the accomplishment of the present work, a WV-3 multispectral image with 16 spectral bands (VIS, NIR and SWIR) together with the following attributes: Principal Component Analysis (PCA), Minimum Noise Fraction (MNF), Normalized Difference Vegetation Index (NDVI) and Soil-adjusted Vegetation Index (SAVI) were employed in the analyses. The data pre-processing comprised the atmospheric correction, with the parallel conversion of DN values to surface reflectance, followed by feature selection. In this stage, data mining was initially executed in the software WEKA (Waikato Environment for Knowledge Analysis) by the application of three different feature selection algorithms (Wrapper, Correlation-based Features Subset (CFSSubset) and Relief), what resulted in four data sets, one of them complete, and the three remainder ones deriving from the feature selection process. For classifying these four data sets, Random Forest (RF) and Support Vector Machine (SVM) were used. Such methods allow the inclusion of a great number of explanatory variables (attributes) with no a priori concern as to their relevance for classification. The accuracies of the classifications generated with the complete and the three previously filtered data sets were assessed considering the two classifiers. The results attained in this work, supported by findings reported in the peer-review literature, confirm that the data sets subject to feature selection did not provide results with a superior performance in relation to that obtained by the complete dataset. This can be ascribed to the fact that the current classification methods are able to deal with a bulky amount of features, besides handling well with weak explanatory variables.

**Keywords:** Feature Selection, Data Mining, Random Forest, Support Vector Machine.

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## Assessment of classifiers through decision tree in urban areas using Worldview-2 image

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GEOBIA (Geographic Object-Based Image Analysis) allows the simulation from the view of a human interpreter using knowledge models expressed by semantic networks. The construction of knowledge models is a complex task which demands an extensive time. Data mining techniques have been widely used as a support tool for the construction of the semantic network. In this sense, the aim of this study is to analyze the performance of the CART and C4.5 algorithms, which use decision trees, to classify urban land cover. It uses both cognitive approaches and data mining. A WorldView-2 image from São José dos Campos – SP (Brazil) was used for this analysis. Both algorithms presented a good accuracy. The C4.5 algorithm accuracy presented average values slightly higher than the CART algorithm. Regarding the tree models obtained in the experiments, the C4.5 algorithm showed a better generalization capacity in the formulation of the attribute rules. The C4.5 algorithm was supported by other software for the execution of the analyses. This posed a challenge to the researchers for data integration, data format conversion, knowledge of the utilized software and also file replication. Albeit this study covered a reduced geographic area, it presented a high number of objects.

From the findings one concludes that, in a large scene, the data volume may represent a big barrier. On the other hand, the CART algorithm tested is part of an integrated GEOBIA platform, which benefits the user reducing the time spent to execute all the image analysis steps.

**Keywords:** Remote Sensing, WorldView-2, GEOBIA, Data mining, C4.5 Algorithm, CART



## Mapping of built up areas in the Cameroonians shores of Lake Chad and its hinterland through based object classification of Sentinel 2 images

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The Lake Chad is now one of the major territories of concentration of people in the central Sahel region. Since the beginning of the 21st Century, the strong human settlements, especially built-up area, have expanded as a spontaneous adaptation to the upsurge of border conflicts; the main purpose being the access to best lands for agriculture, cattle farming and fishing. Nowadays, the Cameroonian side of the Lake Chad and its hinterland constitute a growing habitable space where we find few towns and numerous hamlets. However, there is no updated map of the built-up sprawl. Therefore, the aim of this study is to bring out the built up areas distribution in that space through orientated-object classification. The methodology implemented combines statistical and spectral processing's: The third and sixth component of Principal Component Analysis (PCA) which contains respectively 87% and 11 % of information, Normalized Difference Built-up Index (NDBI) and Urban Index (UI), performed on Sentinel 2 images of April 2017. These neo-bands are stacked with originals bands to generate a composite image. The new image obtained is then segmented and classified by Support Vector Machines (SVMs) algorithm and submitted to a threshold analysis in an image on which the built-up areas are clearly separated from the others spatial classes. The results obtained is the delineation the built-up areas, that is the distribution and the structure of the housing space in the Cameroonians shores of Lake Chad and its hinterland.

**Keywords:** Built-up areas; Support Vector Machines; Sentinel 2 images; Lake Chad.

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\* Speaker

## Using the OpenStreetMap database to improve an object-based classification process. Application to a landcover product on small islands in the Indian Ocean

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The southwest of the Indian Ocean comprises numerous islands of less than 3000 sq km (Comoros, Seychelles, Mascarene Islands). These small island territories have very fragmented and diversified environments. Satellite imagery and products at low and medium spatial resolution (usually from 4 kilometers to 250 meters) are not or poorly suited to the study of these areas. This is particularly the case for ecological studies such as the study of vector-borne diseases where the evaluation of interactions at a fine scale is critical to understand their spatial dynamics.

To overcome this need, we realized a homogeneous land cover mapping of these small islands, by analysing SPOT 5 satellite images acquired between July 2013 and July 2014 by SEAS-OI Station. We used an object-based image analysis method to identify the 12 major classes of land cover / land use of these tropical islands.

To improve the results of this classification, we used some data from the free and participative OpenStreetMap (OSM) database as training data. These data were first checked and even completed to ensure their quality. This information helped us in particular to improve our results on agricultural areas (sugar cane, market gardening) and to define more precisely the main roads. This methodology together with a good knowledge of the field has enabled us to achieve an overall accuracy of 85%, making it an operational product.

In return, we fed the OSM database by integrating the classes for which we had the best accuracy (mangrove, surface water and forest). Indeed, OSM is a particularly interesting platform for releasing and disseminating land use data.

**Keywords:** Free geographic data, landcover, remote sensing, object-based image analysis

## BFT and LMT decision trees applied to WV-3 imagery for a detailed urban land cover classification

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This study aims to compare urban land cover classifications based on the use of two decision trees - Best First Tree (BFT) and Logistic Model Tree (LMT) - for two different legend levels. The legend level 1 presents 11 urban land cover classes and the legend level 2 presents 42 classes. A WorldView-3 image was used, with 16 multispectral bands and a spatial resolution of 0,31 m. The study area corresponds to a transect within the campus of Campinas State University, São Paulo, in the Southeastern Region of Brazil. At the legend level 1, the classifications achieved very similar accuracies, showing global accuracy indices around 76% and 82%. At the legend level 2, on its turn, the accuracies were very different. The results obtained by the BFT algorithm presented a global accuracy index of 64%, while this index reached 78% for the result produced by the LMT algorithm. The comparisons between classifications accomplished at the same legend level were performed by means of hypothesis tests. The comparisons revealed that at the legend level 1 the performance of the algorithm was significantly the same in both scenes. However, at the legend level 2, the LMT algorithm performed better than the BFT algorithm. Thus, one can conclude that the greater spatial and spectral refinement of the WV-3 sensor contributed to the improvement of the classification accuracy in the more detailed legend level.

**Keywords:** Remote Sensing, Data Mining, Urban Land Cover Classification, WorldView-3

## From ice-wedge polygons to pan-Arctic landscapes: Automated characterization of ice-wedge polygons from very high-resolution remote sensing data

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A multitude of field measurements across the Arctic have documented ice-wedge degradation resulting in low-centered polygons (LC) transforming into high-centered (HC) polygons in less than a decade. The microtopography associated with ice-wedge polygon types controls many aspects of ecosystem, permafrost, and hydrologic dynamics from plot-to-local scales and landscape and regional scales, primarily due to the role of polygon type on the flow and storage of water. Overall goal of this multidisciplinary research is to understand the complex and interlinked processes responsible for the evolution of the pan-Arctic ice-wedge polygon tundra landscape by combining field measurements from nine Canadian, Russian, and Alaskan field sites, numerical modeling, and very-high spatial resolution (VHSR) satellite imagery that has recently become available for the entire Arctic tundra domain. While Polar geosciences stands at the precipice enabled by the petabytes of sub-meter imagery, the distribution of ice-wedge polygons is still largely unknown. There are currently no automated methods to map ice-wedge polygonal ecosystems, including polygon type (LC and HC), ice-wedge degradation/stabilization stage, and wedge-ice content that can operate at the pan-Arctic scale. We aim to develop computationally efficient workflows to characterize ice-wedge polygons and address methodological and implementation challenges in deploying large-scale imagery resources now available for the Arctic from Polar Geospatial Center. Our combined approach of automated mapping, local field measurements and numerical modeling will allow us to capture the spatial patterns and temporal dynamics of polygonal tundra processes from the individual polygon to pan-Arctic scales. Findings of this study will help identify key mechanisms affecting the resilience of ice wedges to climate change, and the effects of ice-wedge degradation on watershed hydrology, while also providing the first pan-Arctic map of ice-wedge polygons that is key for future efforts in scaling up to the pan-Arctic domain.

**Keywords:** Arctic, Imagery, Tundra, Ice, wedge, Remote Sensing

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\* Speaker

## OBIA and template matching for transferable detection of water crowfoot

Fleur Visser\*<sup>1</sup>

<sup>1</sup> University of Worcester – United Kingdom

*Ranunculus* spp. , subgenus *Batrachium* (*Ranunculus fluitans*, *R. penicillatus* ssp. *penicillatus*, *R. penicillatus* ssp. *pseudofluitans*, and *R. peltatus* and their hybrids) are characteristic vegetation of many river channels in the UK. The plants can modify water flow, promote fine sediment deposition, and provide shelter and food for fish and invertebrate animals. Our understanding of their functioning is, however, limited by our ability to monitor their spatial and temporal distribution dynamics. Ongoing research is showing how ultra-resolution imagery of small clearwater rivers in combination with Object Based Image Analysis (OBIA) provides a means to rapidly monitor and map the presence of submerged aquatic vegetation. This poster demonstrate how the use of expert knowledge and template matching techniques enable the development of a detection method for specifically *Ranunculus* spp., which is transferable through space and time, as demonstrated by applications of the approach on images taken over a range of years from various locations.

**Keywords:** *Ranunculus* spp., OBIA, Template matching, Submerged Aquatic Vegetation

## Mapping of urban temperatures by TRISHNA : precision of the land surface temperature according to the spatial resolution

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54% of the world population lives in urban areas and a raise is expected to 66% by 2050. Moreover, in a critical scenario, a recent study published in 2017 has shown that urban temperatures could rise up to 7°C by 2100 (Estrada et al, ). This rising is due to global warming but is accentuated in cities by the Urban Heat Island (UHI) effect, which is the air temperature difference between the urban area and its surrounding rural areas. In remote sensing, the key-parameter is the land surface temperature which is indirectly retrieved from radiance measurements in the infrared domain. TRISHNA (Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment) is a joint mission between both CNES and ISRO (National Space Center and Indian Space Center respectively). TRISHNA is expected to be a multispectral mission with spectral bands in the VNIR and TIR ranges with a high temporal repetitivity (1 to 3 days) and a high spatial resolution (50m in the TIR range). The project CATUT aims to quantify the surface temperature accuracy from simulated spaceborne measurements for the TRISHNA instrumental and spatial characteristics for urban applications. In order to do so, the processing tool STRASSS (Surface Temperature Accuracy Retrieval With Spaceborne Sensor Simulations) has been developed : it computes TOA (Top of Atmosphere) radiances from DESIREX airborne measurements over the Madrid city (4-m spatial resolution for the Airborne Hyperspectral Scanner), performs spatial aggregation to 60 meters, adds the instrumental noise and retrieves the surface temperature with two algorithms called Split-Window and TES (Temperature Emissivity Separation). The Split-Window is performed over two spectral bands between 10 and 12  $\mu\text{m}$  and the TES is performed for three or four spectral bands between 8 and 12  $\mu\text{m}$ . Both Split-Window and TES have been calibrated on a specific database : the algorithm error is 0.97 K for the Split-Window and 0.013 or 0.012 for the emissivity for the TES algorithm (three or four spectral bands respectively). The land surface temperature retrieval accuracy is given according to the spatial resolution from 4 meters to 60 meters (4 meters, 8 meters, 16 meters, 32 meters, 60 meters). A comparison with a 7-band TES applied on the airborne measurements is performed (Rosa Oltra-Carrio, 2014) as well as a comparison with in situ measurements from validation sites. This study shows the degradation of the accuracy according to the spatial resolution and helps considering unmixing methods to improve the land surface temperature retrieval.

**Keywords:** Spatial resolution, multispectral remote sensing, TRISHNA, land surface temperature, urban heat island

## Mapping Brazilian Savanna Physiognomies using WorldView-2 Imagery and Geographic Object Based Image Analysis

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Brazilian Savanna, or just “Cerrado”, is considered one of the 25 hotspots for biodiversity conservation priority in the world. Cerrado occurs on the central part of Brazil and has three major natural formations: Grasslands, Savannas and Forests. However, the challenge on mapping Cerrado relies on the division of these major formations into specific physiognomies. Distinguishing each of these physiognomies is an important task to better evaluate smaller ecosystems, access carbon storage with greater precision and improve the exactitude of greenhouse gases emissions. Thus, the aim of this work is to evaluate the potential of very high spatial resolution imagery in order to improve the classification of 8 Cerrado physiognomies: Rocky Grasslands, Open Grasslands, Shrub Grasslands, Shrub Savanna, Typical Savanna, Dense Savanna, Flooded Plains with Palmtrees and Evergreen Forest. A WorldView-2 image was used for a protect area with over 30 thousand hectares of preserved Cerrado vegetation. Features such as surface reflectance, vegetation indices, tasseled cap transformation and spectral linear mixture models were used on the automatic classification. Random Forests algorithm was used with a 10-fold cross-validation. The Global Accuracy was of 67.7%. Values above 70% of User’s Accuracy were obtained for classes such as Rocky Grasslands, Open Grasslands, Typical Savanna and Evergreen Forest. On the other hand, Flooded Plains with Palmtrees were omitted from the classification. Omission errors were also noticed for the classes of Shrub Savanna and Dense Savanna; they were sometimes misclassified as Typical Savanna which has a similar vegetation structure and tree cover percentage. The use of very high resolution images provided advantages on distinguishing Cerrado physiognomies on an automatic classification procedure. The detection of some classes was very precise and, despite the obtained misclassifications, it is an advance to distinguish some physiognomies that lower spatial resolution sensors are, hardly never, capable of distinguishing.

**Keywords:** Data Mining; Random Forests; Image Classification; Very High Resolution Images; Cerrado; Carbon Storage; Remote Sensing.

## Crop type detection based on Sentinel-1 multi-temporal data

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Sentinel-1 proved to be a good and reliable source of data for various applications. In this study we use multi temporal data for classification of crop types on the area of Warmińsko – Mazurskie voivodeship in Poland. We are looking for a number of crop types from four categories: Cereals (eg. Maize, Rye), Leguminosae (e.g. Bean, Clover, Lentil), Meadows and Tubers (e.g. Beet, Potatoes). Around 20 SAR images were acquired in 2016 in order to elaborate classification. Each one of them was processed using polarimetric methods: coherence matrix and H/Alpha decomposition. This gives around 60 input layers for the classification process. As a base for the object creation we use LPIS vector layer. Only agricultural field are selected from land parcels imported into eCognition environment.. They are next re-segmented using mosaic of cloudless Sentinel - 2 optical images and Lambda parameter layers were calculated using H/Alpha decomposition on SAR images acquired at different dates during the vegetation season. This step assures that objects properly delineate extent of crop fields even if two or more types of crop were sown on a given land parcel. Next, we use field samples to learn classifier. For this study we tested efficacy of four classifiers: Support Vector Machine (SVM), Random Forest, Decision Trees and K-Nearest Neighbors. Validation done using declarations from farmers shown that SVM classifier resulted to be the most accurate. It is also sensitive to the S-1 acquisition dates used for classification.



## Automatic tuning of segmentation parameters for tree crown delineation with multispectral data

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Studies with the purpose to identify and remotely classify native tree species play a strategic role in management, surveillance, administration, and conservation of these species, contributing to assess their cover extent and spatial distribution in a faster way. In this sense, the greater detailing attained by the spatial resolution of the latest generation sensors is crucial for this end, since their images enable the detection and delimitation of individual trees crowns (ITC). In this case, a tree is represented by a group of pixels that refer to smaller portions of the target of interest, presenting a great variability of spectral responses. Hence, it is preferable to merge them by means of segmentation, so as to make each segment corresponding to an ITC. However, in order to have a segmentation algorithm that generates segments accounting for meaningful image objects, such as an ITC, its parameters ought to be properly tuned. Conventionally, this stage supposes a time-consuming trial and error procedure. In this context, some initiatives for the automatic search of segmentation parameters have been developed. Among them, the stochastic optimization method is to be mentioned, which searches within the parameters space those values that maximize the level of agreement between a set of reference segments, manually defined by the user, and the segmentation result. This level of agreement is assessed by a metric that compares the segmentation result with the reference segments. In face of this, the objective of this work is to automatically estimate the segmentation parameters of different segmentation algorithms, and by means of suitability functions, identify the best fit for the delimitation of trees crowns belonging to the native species *Araucaria angustifolia*, located in an area of the subtropical Atlantic Forest in Southern Brazil. In order to achieve this goal, two datasets were compared: a WorldView-2 scene with eight spectral bands, pansharpened with the panchromatic banda (0.5 m of spatial resolution); and an orthoimage with three spectral bands and 0.39 m of spatial resolution. Initially, the trees were in-situ geocoded. After this stage, some crowns were manually delimited in the image with the aid of the orthoimage, so serve as reference segments. These segments were then subdivided into two sets: training (70%) and test (30%), and drove the software Segmentation Parameter Tuner (SPT 3.9). In the optimization stage, the optimization function Nelder-Mead was employed to accomplish the automatic search of parameters for the Region Growing, MeanShift and Graph-Based algorithms. The Precision & Recall ( P&R) metric was used to assess the segmentation quality. Preliminary results with the Region Growing (Multiresolution) algorithm applied on the orthoimage presented a P&R value of 0.13. The result showed that the crowns were well delineated, since the closer to zero the value of P&R, the greater the agreement between the reference and the segmentation result. This study is committed to advance the research in the delimitation of ITCs using VHR multispectral imagery, and hence, contribute to the object-based classification of tree species in subtropical forests.

**Keywords:** Individual tree crown, image segmentation, object based image analysis, optimization algorithm

## From land use status to landscapes. Field and object-based treatment in two communes of the Ranomafana-Andringitra-Ivohibe forest corridor, South-Central Madagascar

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The enhancement of satellite images that are increasingly spatially resolved will make it possible to monitor land use on a parcel scale. The control of the interpretation of the classes of objects given by the geomatician forces, on the ground, to cross disciplinary points of view, the «states» of occupation of the soil of the agronomist, the «habitats» of the ecologist, the «landscapes» of the geographer. A dialogue is organized to have a common nomenclature of the homogeneous land-use units observed in the field and the classes of objects discerned on satellite images, translating states into landscape components and defining indicators that can be computed from the types of landscapes granted in common. This interdisciplinary method is applied at two sites in the Fianarantsoa rainforest corridor, in the Androy communes on the western outskirts of Ranomafana and Ambohimahamasina Park, north of Andringitra Park. The treatment is done in two stages. First, the classification of images by an object-oriented approach. Then landscape metrics calculations from landscape ecology are applied to the land cover maps from the classification. In the commune of Androy, the matrix is forest and the landscapes translate the degree of opening by the clearing on the slopes of the ricefields in bottom; in the commune of Ambohimahamasina the matrix is herbaceous and the landscapes associate with these herbaceous slopes rags of eucalyptus at the top or of village arboriculture. The same landscape palette is combined differently, reflecting a distinct landscape evolution. 6 land cover conditions, 10 landscape components, combine into 5 different landscape types at both sites. This characterization of landscapes gives rise to a quantification of indicators specific to the issues addressed and a generalization to decision-making spaces in terms of spatial planning, the region and the forest corridor.

**Keywords:** Land, use, object, oriented, landscape, landscape metrics

## Monitoring reforestation with UAV images and OBIA

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Monitoring reforestation projects in dense forested areas can be a cumbersome operation if done by means of ground measurements. While remote sensing techniques could simplify forest monitoring, traditional remote sensing platforms have shown to be costly and low in flexibility. In recent years, the technology behind Unmanned Aerial Vehicles (UAV) and mountable sensors has advanced enormously, lowering the cost of data collection and delivering very-high resolution image-products (cm to dm pixel-size). This paper focusses on the use of automated OBIA processing of UAV-derived data to assist reforestation management. The study site is a reforestation project of Mindo Cloud, in the north of Ecuador. UAV-image data is available for 24 terrains in three different strata (montane, pre-montane and coastal biotopes) at two different flight altitudes. Ground measurements with respect to tree location, tree height, diameter and species are available in subplots on each terrain. Six different species have been planted at the start of the reforestation project. This paper evaluates the effects of UAV image quality and orthophoto-processing artefacts on the OBIA process. The raw UAV data is processed using Agisoft Photoscan, which results in a 3D-model and a rectified (RGB) orthophoto of the terrain. These outputs are used in an OBIA process to segment the image. Preliminary segmentation results for tree crown delineation through multi-resolution segmentation are promising and form a good basis to allow differentiating species based on spectral (RGB) responses and textures. While the advantages of operational application of UAV data in reforestation management are numerous (very high spatial resolution, potential for high temporal resolution, insensitivity for cloud cover, potential for 3D image generation, relatively low cost ...), this technology also has its limitations (low spectral resolution, low software automation, sensitivity to atmospheric conditions ...). Another disadvantage is the poor geometric and radiometric performance, which results in image artefacts and image blurs on the UAV-orthophoto after the rectification process. In this paper, we discuss how these artefacts affect the performance of the segmentation process and the level of consistency we can expect compared with traditional RS products.

**Keywords:** OBIA, UAV images, monitoring

## Object-based classification of a high spatial resolution satellite image (IKONOS) using spatial autocorrelation and semivariogram metrics in a rural NATURA 2000 deltaic area

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Kalamas Delta belongs to Natura 2000 network. Most part of delta consists of agricultural land. Remote sensing and GIS are important tools to map and identify agricultural crops among others. The aim of our study is to map permanent agricultural crops in the plateau of Kalamas Delta using IKONOS satellite data by considering the spatial arrangement of the radiometric values of the pixels.

The spatial pattern was estimated using the Moran's I spatial autocorrelation index and semivariance, which is the one-half the average squared difference between data values separated by the lag distance.

The satellite data used in the analysis were geometrically corrected and enhanced by applying various multivariate data analysis methods. Additionally we studied the effect of the size and shape of the sampling area used to estimate the autocorrelation statistic as well as the orientation of the parcels when trying to detect and characterize the spatial patterns of the crops. The classification of satellite data was implemented using object-based classification techniques. The segmentation algorithm applied (segments) was based originally on the spectral and spatial characteristics of the IKONOS image. Afterwards, the classification of the segments was based, not only on their spectral and spatial characteristics, but also on the spatial arrangement of the radiometric values of the pixels of the image expressed by the autocorrelation and semivariance metrics.

The various agricultural parcels, except the unique spectral characteristics, are also characterized by their spatial characteristics determined from the spatial patterns of the crops. This information when considered in the classification process together with their spectral and other spatial characteristics increased the final accuracy of the classification results from 60 to 73%. Concluding, it seems that permanent agricultural crops are distinct areas in high spatial resolution satellite images with particular spatial characteristics that are determined by the type of crop in relation to the spatial resolution of the satellite image.

**Keywords:** Agricultural crops, OBIA, satellite imagery

## Hierarchical Object Based Image Analysis of Unmanned Aerial System (UAS) imagery for species level mapping of Himalayan treeline vegetation

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Situated between montane forest and alpine vegetation, treeline ecotone represents the upper limit of forest on a mountain. The Himalayan region in south Asia has the highest and biologically one of the most diverse treeline ecotone in the world. The impact of climate change is projected to be disproportionately high along Himalayan treeline ecotone due to their high sensitivity to changing temperature and precipitation patterns, leading to significant ecological changes. This study analyzed multi-spectral imagery acquired using Unpiloted Aerial Systems (UAS) and plot level field collected data at treeline ecotone in Langtang National park, Nepal to examine the suitability of the ecological proxies derived from UAS imagery for mapping of tree line vegetation at genus level in a spatially explicit manner. The UAS images were pre-processed using Structure from Motion (SfM) algorithms and resulting reflectance maps were analyzed following semi-automated Object Based Image Analysis Approach to develop homogeneous objects at multiple segmentation scales and derive spectral and textural features. Following a hierarchical classification approach, decision tree algorithm was utilized first, to semi-automatically derive vegetated and non-vegetated parts in the imagery and at the second hierarchical level, four woody vegetation genus types were mapped. Results showed that mapping accuracy varied not only between hierarchical levels of classification but also among different species types.

The results highlight potential and limitations of UAS acquired imagery and object based image analysis for detailed mapping of vegetation properties in a data scarce Himalayan region and enable understanding of ecological patterns and the underlying processes along treeline ecotone.

**Keywords:** UAV, vegetation mapping, species mapping, treeline ecotone, Himalaya, OBIA

## Multi-scale object-based measurement of plant community structure

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The measurement of plant community structure provides an extensive understanding of its function, succession, and ecological process. The detection of plant community boundary is rather a challenge despite in situ work. Recent advances in object-based image analysis (OBIA) and machine learning algorithms offer new opportunities to address this challenge. This study presents a multi-scale segmentation OBIA approach to accurately identify the boundaries of each vegetation and plant community for mapping plant community structure. Initially, a very high resolution Worldview-2 image of a desert area is hierarchically segmented from scale 2 to 500.

Afterward, the peak values of the standard deviation of brightness and normalized difference vegetation index (NDVI) across the segmentation scales are detected to determine the optimal segmentation scales of homogeneous single vegetation and plant community boundaries. A multi-scale classification of vegetation characterization with features of multiple bands, NDVI, grey-level co-occurrence matrix entropy, and shape index is performed to identify desert vegetation types. Finally, the six vegetation structural features on the diversity, richness, and morphology are calculated within the plant community boundaries and classified into plant community categories. Comparing the results with the object fitting index of the reference data, the validation indicates that the optimal segmentations of tree, shrub, and plant communities are consistent with the identified peak values.

**Keywords:** Multi-scale, object, based, plant community

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\* Speaker

## Mapping Date Palm Structure and Age Using UAV Imagery

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Dates are oval-shaped sweet fruits growing on date palms. Date palm plantations in Saudi Arabia contribute 8.8% of the world's dates. Saudi Arabia is the third largest date producer in the world. However, date productivity in Saudi Arabia is still relatively low e.g. due to overaged trees, use of low-quality cultivars and reduced date quality caused by suboptimal management and harvesting practices and losses from pests and diseases. Remotely sensed derived information has the potential to significantly contribute to increasing yield and quality of date production. It is important to determine the date palm density, structure and age to optimize management and production practices and to determine if mechanized harvesting methods are feasible. Narrow spacing between date palms has been linked to reduced yield and date quality and increased likelihood of spreading Red Palm Weevils, which is a major pest. Date palms usually die if they are exposed to several overlapping generations of Red Palm Weevils. Mapping date palm age is important for managing infestations, as about 75% of infested date palms are 6-15 years old. The objectives were to: (1) automatically delineate individual date palms for density mapping based on multi-spectral UAV imagery; and (2) to map structural parameters (crown projective cover, perimeter, width, area, height) and age groups. Our study area was located in the Al-Qaseem region of Saudi Arabia. Field data were collected of crown projective cover, perimeter, width, length, area and height. The age of palm trees were determined based on grower information and assessment of Google Earth time-series imagery. A multi-spectral camera mounted to a DJI Matrice-100 platform was used to collect imagery with 5 cm pixels in the visible and near infrared parts of the spectrum at three selected sites each including approximately 1000 date palms. The eCognition Developer software was used to automatically delineate date palms by first mapping their extent and then using an averaging filter on the binary extent map to identify the likely location of date palm center points. A region-growing algorithm was then used to grow date palm center points outwards to include associated palm leaves. More than 98% of all date palm trees were correctly identified. Crown projective cover showed good correlation with spectral vegetation indices ( $r^2 > 0.75$ ). Image derived measurements of perimeter, width, length and area of date palms corresponded well with field derived measurements, although these perimeters were in some cases over- or underestimated for date palms with leaves overlapping those of adjacent palms. Height of date palms was measured using Structure-from-Motion. The height measurements corresponded to field derived measurements, although height estimates were underestimated for sites with narrow spacing between date palms. The perimeter, area and height of individual date palms could be used to estimate age up to approximately 20 years, beyond which no significant relationship was observable. These findings may contribute to improved management practices and production of dates in Saudi Arabia. Future work will focus on scaling up the mapping result to cover larger areas based on multi-temporal satellite imagery.

**Keywords:** Date palms, multi, spectral, UAV, Saudi Arabia, density, structure, age

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\* Speaker

## Notes



## Notes

# GEOBIA 2018

June 18-22, 2018, Agropolis International, Montpellier

## Practical information

### Conference location

Agropolis International, 1000 Avenue Agropolis,  
34000 Montpellier, France.  
<http://www.agropolis.fr>

### Oral sessions

The oral sessions take place in the amphitheatre and the parallel sessions in the Badiane room. Speakers have to test and upload their Powerpoint (via USB) directly on the PC available in the amphitheatre.

### Poster sessions

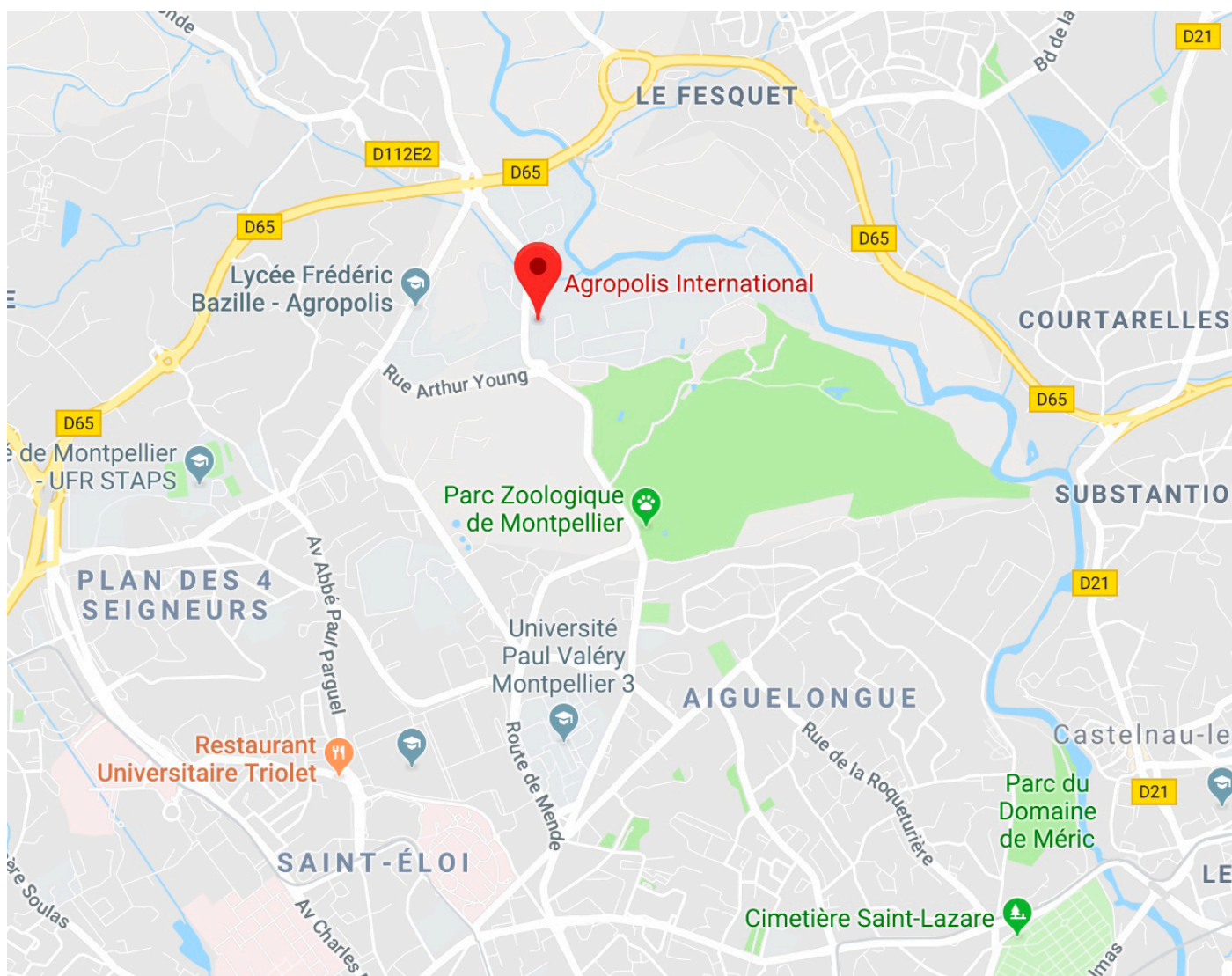
The poster sessions take place in Grand Hall "Bananier".  
You must display your poster as soon as you arrive.

### Coffee breaks

Coffee breaks are served during the morning and the afternoon in the Mezzanine.

### Lunches

Lunches are served in the Vanilla Room.



## Annexe 3

### Site Web &

### PHOTOS

#### Site Web





Kakémono

## **Annexe 4**

Liste des participants