ABSTRACTS

7TH BELGIUM GEOGRAPHY DAY

17th November 2017

LIÈGE université

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Urban, Economic and Rural Geography S74 (B4- Amphi. Europe)	Climatology R53 (B4-Amphi. Europe)	Physical Geography Spork (B11- Dept. Geog.)	Geomatics R54 (B4-Amphi. Europe)
8h15-9h00 - Registration (B11, Dept. Geog.)			
9h-9h20 - Keynote Speakers			
Contested entangled geographies: challenges and relevance of belgian human-geographical research, M. van Meeteren (VUB)	*Climate future projections vs weather forecast,* F. Massonet (UCL)	*Why Geomorphology matters?* J. Poesen (KUL)	*Big Data and Geomatics : towards a new management of spatial information,* J.P. Kasprzyk & P. Hallot (ULg)
Cities	**General Climatology**	**Geo-Hazard**	**Remote Sensing**
Urban geography at the heart of the urban transition, J.-M. Halleux (ULg)	*Future climate change impacts: an introduction,* N. van Lipzig (KUL)	*Geo-hazards: Research Achievements, Challenges and Perspectives,* M. Kervyn (VUB)	*The last decades revolutions in Remote Sensing : example of implications for Earth Science,* F. Kervyn (MRAC, Tervuren)
A. Bortolotti et al. P. Dethier et al.	C. Wyard H. Wouters et al.	M. Bruwier et al. G. J. Gracius, P. Ozer	Q. Glaude et al. B. Gobbi et al.
10h-10h15 - Coffee break			
K. Fung-Loy et al. G. Montero et al. R. G. Sanul	A.J. Henrot et al. I. Jacquemin et al. A. Belleflamme et al.	K. Mertens et al. T. Mugaruka Bibentyo L. Nibigira	F. Priem et al. B. Smets et al. J. Wellens, A. M. Sallah et al.
11h-11h20 - Poster Presentation			*Cartesius. be,* R. Kurk (NGI)
11h20-12h50 - Poster session (B11, Dept. Geog.)			
12h50-13h30 - Lunch (B11, Dept. Geog.)			
Southern Countries	**General Climatology**	**Long-term geomorphology**	**Data acquisition**
How to introduce environment in a migration model? S. Henry (UNamur)	I. Vanderkelen et al. D. Gharbaoui	*Constraining landscape evolution over 10 yr, 10 ky and 1 my time scales,* V. Vanacker (UCL) et al.	*Precise positioning with smartphones running Android 7 or later,* R. Warnant (ULg) et al.
A.N. Gadiaga et al. N. Karimi et al. S. Mossoux et al. V. Rodriguez Garcia et al. C. Zickgraf	**Cryophere** *Why studying the cryosphere ?* X. Fettweis (ULg) C. Amory C. Lang et al.	N. Broothaerts et al. B. Campforts et al. F. Clapuyt et al. L. Lamair et al. J. Robinet et al.	C. Deprez et al. A. Dille et al. H. Hendrickx et al. F. Poux et al. N. Vanhaeren et al.
14h55-15h10 - Coffee break			
Landscape & Environment	**Cryophere** *(follow-up)*	**Contemporary geomorphic processes, land degradation, soil water conservation**	**SIG**
What does "smart" mean in rural development? S. Schmidt (ULg)	A. Gossart et al.	*Challenges and opportunities regarding land degradation and soil conservation,* C. L. Bielders (UCL)	*GIS: from systems over science towards technology,* N. Van de Weghe (UGent)
V. Beckers et al. L. Bruckmann C. Chaiban et al. M. Cox et al. W. Gruijthuijsen et al.	C. Agosta C. Kittel S. Sun et al. B. Van Liefferinge et al.	I. Alomia Herrera et al. A. Birhanu et al. A. Peeters et al. R. Rousseau et al. S. Rubin et al.	A. Adam et al. S. Bourrelly R. Neuville S. Trabelsi et al. L. Zwartjes
16h35 - Reception & Best Poster Award (B11, Dept. Geog.)			

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Geomatics Session

Oral presentations

BIG DATA AND GEOMATICS : TOWARDS A NEW PARADIGM IN SPATIAL INFORMATION MANAGEMENT

Jean-Paul Kasprzyk and ***Pierre Hallot****

Université de Liège, Belgium

During the last decade, the technological advances allowed a massive acquisition of digital data whose volume grows exponentially. Going from location-based social networks to smartphones, users produce huge amounts of data that are located in space and time. The various exploitations of these large and heterogeneous datasets have created a new field called “Big Data”. As most of these data are characterized by spatial and temporal components, it has become the next challenge to handle for geomatics researchers within the next incoming year.

In this presentation, we provide an overview of the main domains in geomatics that are impacted by big data. Related fields are among other things: terrestrial spatial data acquisition where the rise of powerful laser scanners, that can acquire millions of points per second in order to precisely represent built heritage in 3D, revolutionized topography; Global Navigation Satellite Systems (GNSS), powered by the European constellation Galileo, imply original researches able to increase the position accuracy of a simple smartphone user; remote sensing is now enriched by a wide open access capability thanks to Copernicus satellites which provide timely information for the management of the environment. In order to effectively manage and analyse information related to each of these revolutions, Geographical Information System (GIS) research uses innovative data storage strategies based on CityGML for 3D data, semantic web linked-data and non-structured databases (NoSQL) for the integration of heterogeneous information, data warehouses and OnLine Analytical Processing (OLAP) for decision support. The presentation is based on concrete applications about smart cities, remote sensing, firefighting…

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THE LAST DECADES REVOLUTIONS IN REMOTE SENSING : EXAMPLE OF IMPLICATIONS FOR EARTH SCIENCE

François Kervyn*

Royal Museum for Central Africa, Department of Earth Sciences, Natural Hazards and Cartography Unit, Belgium

The last decades revolutions in Remote Sensing : example of implications for Earth Science. The RMCA has been using satellite remote sensing since the 1980s, particularly for applications related to Earth Sciences. It was initially limited to the interpretation of the imagery of the first optical satellite sensors LANDSAT-MSS and SPOT-1 to understand and map the geological processes of regions of Africa still poorly known. Today, the RMCA with its Belgian and Luxembourg partners coordinates various projects focused on the study of natural risks or on mapping in Africa. Over the past thirty years, Earth Observation techniques have undergone several revolutions in various dimensions and at various scales. In the spectral domain firstly with the improvement of optical sensors whose bands have diversified but also and especially in the field of microwaves; radar remote sensing has taken a dramatic rise, particularly with interferometry (InSAR) for the detection and monitoring of ground displacements. In the space domain also, the ever-increasing image refining has considerably changed the vision of the world and opened up new fields of application by reaching metric or sub-metric values. In the temporal domain, the technological evolution of sensors and the multiplication of spatial platforms coupled with policies of open access to data allow diachronic studies of a wide variety of natural phenomena or anthropogenic activities. In addition to this spatial approach, it is necessary to add the complementarity of airborne techniques and in particular UAVs which seem to offer infinite possibilities for studies at the local scale. Moreover, Remote Sensing is today intimately related to cartographic tools such as positioning satellites (GPS, GLONASS, GALILEO ...) and Geographic Information Systems (GIS), geomatics is nowadays present in a very wide variety of domains.
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CRATERNET : A FULLY CONVOLUTIONAL NEURAL NETWORK FOR LUNAR CRATER DETECTION BASED ON REMOTELY SENSED DATA

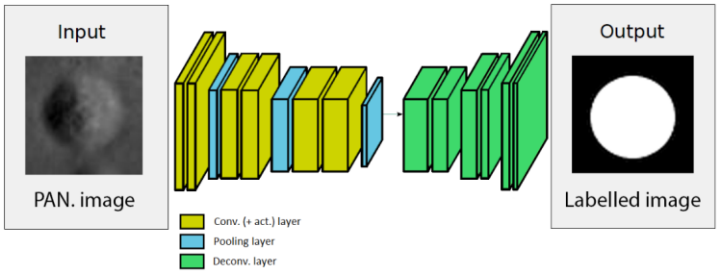
Quentin Glaude*, Yves Cornet

University of Liège, Belgium

The craters are important topographic objects on the surface of planets. They give useful information to researchers about their geology and the history of geomorphological process. Moreover they are witnesses of space particles density and inform about presence of allochthonous materials. In addition, these topographic elements are crucial in the case of exploratory space missions. Some probes are not designed to safely land on these objects. Moreover, craters are structuring elements on the surface of planets that guide local illuminations conditions by producing shadows which can reach several kilometers. Indeed, energy produced by the sun is extremely important for the survival of a mission. Finally, craters constitute landmarks for space navigation.

All these scientific applications require crater detection algorithms (CDAs). The problem of crater detection is not new. First, it was solved by manually locating craters on images. With finer remotely sensed data produced, that task became deprecated. Then, many scientists tried to develop supervised or unsupervised algorithms in order to automatically perform the task. Nevertheless, though much effort has been made, we still don't have an unanimously accepted solution.

With recent advances in deep learning associated to image processing, we wanted to try a new attempt considering the case of the Moon. Deep learning advances proved to be highly efficient in various classical tasks such as image classification. More recently, deep learning techniques are used in fields where no clear answer exists to see if recent advances in artificial intelligence can solve the issue. The hypothesis developed in this brief is based on the idea that the benefits of deep learning techniques can be applied to the task of crater detection. In this master thesis, we proposed a semantic segmentation using deep learning techniques to produce a quick and efficient CDA. The model employed is a deep network of autotuned convolution and deconvolution layers classifying an input panchromatic image into a binary mask representing craters.



After that, we were looking for data to train our model. Unfortunately, no dataset met our needs. Then came the question of how to create our learning observations. In this context, we created a Cytomine project and we integrated some lunar images from the LRO space probe. Cytomine enabled us to create a fairly large number of annotations necessary to our CDA.

Doing so, we contributed somehow to the research in crater detection by making an entire crater dataset available to the scientific community. This dataset consists in more than 11 000 manually selected annotations of craters and crater-free areas in two types of data sources. The first one is the NAC CDR image available in the NASA's LROC archive. The second one is the ortho-rectified images produced by the Arizona State University. This dataset responds to a lack of lunar training data when trying to implement some supervised models and will be useful to researchers focusing on crater detection.

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TRACKING FOREST DEGRADATION WITH HIGH-RESOLUTION 3D FOREST MAPS

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Remote sensing studies have mainly concentrated on quantifying deforestation, the conversion from forest to pastures or agricultural lands. The process of forest degradation has often been overlooked because degradation may be harder to detect from space. Forest degradation is reflected in more subtle and subjective changes compared to forest conversion.

Subtropical dry forest in Latin America are experiencing among the world highest deforestation rates. From 2000 to 2012, 8.3% of the dry forests of Latin America of the total area have been lost. These rates have been attributed to the important deforestation rates of the Chaco region. The Chaco ecosystem expands over 1.000.000 km² in Bolivia, Paraguay, Brazil and Argentina. Remaining forests are degraded from selective logging, cattle and charcoal production.

Using unpiloted aerial systems (UAS), we acquired aerial photographs from 20 plots of forested landscapes. The plots are located in areas with different use and with a different number of trees per hectare. We selected the plots in areas with different types and degrees of disruption: protected areas with cattle degradation, private areas with cattle degradation, private areas with some forestry extraction processes and forests with sylvopastoral use. The forested plots we selected with a number of trees varying from 40 to 250 trees per hectares. Two different cameras were mounted on the drone. The first is the standard camera of the Phantom 3, aerial pictures from this camera have been taken to reconstruct canopy height based on UAS-SfM techniques. The second is a Parrot sequoia multispectral sensor who captures 4 discrete spectral bands, in green, red, red edge and near infrared to map vegetation indexes, like NDVI.

In this presentation, we will show the first results from the forest mapping, including 3D images of the canopy of subtropical dry forests.

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USING SENTINEL-2 AND IMAGING SPECTROSCOPY FOR SUB-PIXEL MAPPING OF URBAN AREAS

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Sentinel-2 is a state-of-the-art multispectral sensor from ESA that allows monitoring the Earth's surface with a well-balanced trade-off between spatiotemporal coverage and spatial-spectral resolution. Application of this sensor to sub-pixel mapping or spectral unmixing of the urban environment is still largely unexplored. An important challenge that must be addressed is the need for efficient workflows that can be used for standardized sub-pixel mapping of Sentinel-2's fast growing image archives. Another challenge, particularly with regards to urban unmixing, is the difficulty to acquire reliable mixed training data describing the spectral variability of the urban environment. In this research, we propose the use of a hyperspectral library, synthetic mixing and ensemble machine learning regression to perform urban unmixing. The proposed outline is applied to Vegetation-Impervious-Soil unmixing of a Sentinel-2 urban scene covering Brussels. To better frame the outcome of the research, a comparison is made with a traditional approach for acquiring mixed training data. Results indicate that the proposed workflow is not just feasible but also outperforms traditional training approaches for unmixing. The presented research may contribute to the development of operational mapping schemes for urban areas with Sentinel-2.

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COMBINING SATELLITE, AIRBORNE AND GROUND-BASED REMOTE SENSING TECHNIQUES TO STUDY THE LAVA LAKE ACTIVITY OF NYIRAGONGO VOLCANO (NORTH KIVU, D.R. CONGO)

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Nyiragongo volcano, in the western branch of the East African Rift system, is among the most active volcanoes on Earth, and one of the most hazardous African volcanoes. Its flank eruptions in 1977 and 2002 triggered disasters, affecting a population that already suffers from years of socio-political instability. The main eruptive activity of Nyiragongo corresponds to the presence of a persistent lava lake in its summit crater. This lava lake can be seen as an interesting opportunity to monitor the activity of the volcano, as its level variations may translate volume and pressure changes in the upper volcanic plumbing system. The lava lake could consequently provide precursory signals associated with an upcoming flank eruption. In order to study the lava lake activity of Nyiragongo, we combined different remote sensing techniques, based on synthetic-aperture radar (SAR) satellite imagery, and photographs acquired during helicopter flights, drone surveys and ground-based campaigns. These techniques are complementary and provide an overview of the different types of lava lake level variations observed at Nyiragongo. Mono- and stereo-photogrammetry are used to measure minute to day-scale lava lake level variations and surface movements, through ground-based multi-view time-lapse image acquisitions in the Nyiragongo crater. Structure-from-Motion photogrammetry with images acquired during helicopter flights and drone surveys allows monitoring major changes in the Nyiragongo crater, by measuring volume changes and ground deformation associated with the lava lake activity. Photogrammetric ground deformation measurements correlate with those performed by SAR interferometry. Finally, long-term lava lake level monitoring and trend change detection are obtained using shadow measurements on SAR amplitude images coming from ENVISAT, RADARSAT-2, TanDEM-X, Cosmo-SkyMed and SENTINEL-1 satellites.

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A BATCH-PROCESSING ASSESSMENT OF AQUACROP PLUG-IN FOR MAIZE AND WINTER WHEAT USING CROWD-SOURCED AND SATELLITE DERIVED FCOVER DATA

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The integration of crop growth models with remote sensing has presented great potential in (regional) crop yield forecasting; although so far few field-level applications exist. Based on crowd/farm-sourced observations (phenological stages and yield measurements) and a basic assimilation procedure using satellite (DMC and Sentinel-2) and digital hemispherical pictures (DHP) derived green fractional cover data (fCover), the AquaCrop plug-in model was assessed for maize and winter wheat fields in Belgium. A semi-automated R-environment was developed to simultaneously run, assess and evaluate the ensemble of field-level simulations. The root mean square errors (RMSE) were 1.50 ton/ha for maize and 0.84 ton/ha for winter wheat. It was concluded that the presented approach might be promising for large scale field-level yield forecasting.

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PRECISE POSITIONING WITH SMARTPHONES RUNNING ANDROID 7 OR LATER

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For many years, low-cost GNSS receivers have been providing meter-level positioning to the mass-market. In particular, most smartphones are nowadays at least GPS-enabled but many high-end devices are also GLONASS- and Beidou-enabled. At the present time, only a few smartphones are Galileo-enabled.

During its "I/O 2016" held in May 2016, Google announced that the raw GNSS measurements collected by devices running Android 7 would be made available to users. Up to Android 6, only position fixes and limited satellite information (PRN, azimuth, elevation, …) were available. This announcement opens new opportunities. Indeed, the development of new data processing strategies might lead to decimeter-level positioning capabilities allowing the emergence of new applications, in particular in the field of location-based services.

The paper analyses the raw GNSS measurements (GPS, GLONASS, Galileo, Beidou) provided by the (Galileo-enabled) Huawei Mate 9 smartphone which is running Android 7, also called Android N or Android Nougat.

In order to collect the raw measurements, we used the "GnssLogger" application kindly provided by Google. This application creates '.txt' data files which contain different information: GPS time of measurement, constellation, satellite number, carrier-to-noise-density ratio, time of emission which together with time of emission allows to compute code pseudorange, code range rate (coming from Doppler), phase pseudorange, information about cycle slips, multipath, ….

In a first step, we collected raw data samples on the roof of our building where we are operating 6 geodetic receivers which are connected through 2 splitters to 2 Trimble choke ring antennas allowing a comparison between smartphone and geodetic GNSS data. Then, other scenarios like pedestrian and car navigation are analyzed. Finally, we assess the added value of these new data for more precise positioning with smartphones.

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PRECISE POSITIONING IN MULTI-GNSS MODE

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Over the last decades, GNSSs have seen their importance always increasing in the frame of many fields of applications including geophysical applications, such as crustal deformation monitoring, or more practical applications, namely, unmanned vehicles systems, precision farming or even road charging systems, to name but a few. With various expectations in terms of precision, ranging from a few meters to the millimetre-level precision, these recent developments are facing similar issues:

- The number of visible satellites, which may be too small to achieve proper positioning in particular time and space, and which also impacts satellite geometry, might degrade the precision of the estimated position
- The phase observable ambiguity resolution, achieved over many epochs, suffers from cycle slips
- The multipath, which is environment dependent, may highly degrade the solution

Nonetheless, the recent development of additional GNSSs, such as BeiDou (Chinese) and Galileo (European), as well as the modernization of the GPS (USA), appears as very promising at improving satellite positioning.

On the one hand, these state-of-the-art spacecraft broadcast a new range of frequencies, more resistant to multipath and presenting a reduced observation noise. Their navigation payload has also been improved with very precise atomic clocks. Exploiting these new signals should improve the accuracy and the reliability of instantaneous real time positioning, in particular, in difficult environments, such as in urban canyons.

On the other hand, the combination of the different GNSS will lead to increased redundancy and to better satellite geometry.

This paper describes this performance improvement. New issues related to inter-system differences are also addressed and a proper handling of these inter-system biases is presented.

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A MULTI-SENSOR APPROACH TO CHARACTERIZE LANDSLIDE DYNAMICS IN A TROPICAL URBAN ENVIRONMENT

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Landslides represent one of the main hazards in dissected landscape, resulting every year in fatalities, structural and functional damage to infrastructures and serious disruptions of the organisation of societies. Loss of lives associated with landslides has been shown to be concentrated in less developed countries, particularly in tropical areas where a combination of active tectonics, steep topography, intense rainfall and high population density is found. In most tropical regions, however, landslide process characterisation relevant for hazard assessment and urban planning remains rare.

In the framework of a PhD research, we aim to increase our understanding of the ground deformation processes in the urban and peri-urban environments of the rapidly expanding city of Bukavu (DR Congo), situated on the southern shore of Lake Kivu in the western branch of the East African Rift. The combined presence of natural triggers (heavy rainfall, tectonic activity…) and predisposing factors (steep topography…) make this city very prone to landsliding; slope instabilities being there responsible for a continuous degradation and destruction of houses, buildings and roads, but also of the water networks and sewerage infrastructures in several districts of the town.

To characterise the ground deformations, a combination of remote sensing (space-borne Synthetic Aperture Radar (SAR) and Very High-Resolution optical sensors) and field-based (targeted UAV acquisitions, ground-based time-lapse stereo-photogrammetry and LiDAR, as well as repeated DGPS measurements) data and techniques adapted to the deformation dynamics, landslide characteristics (exposure condition and size) and the land cover context are being applied. Firsts InSAR results validated through DGPS data already allow us to detect various deformations patterns and landslide processes. It is expected that such multi-sensor, multi-scale and multi-temporal study will provide information that will help us to distinguish the signatures and trends of distinct landslide parameters and hence to precisely characterise the mechanism at play. The construction of displacement time series will be of great value for the understanding of the effect of environmental drivers (climate, seismicity, ect.) on the landslide dynamics. These outputs will also contribute to the update of the landslide inventory that serves as a basis for the assessment of the landslide susceptibility, hazard, and risk over the city of Bukavu.

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USING UAV AND SFM TO UNDERSTAND THE GEOMORPHOLOGICAL DYNAMICS ON PERIGLACIAL TALUS SLOPES

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Using UAVs and the Structure-from-Motion techniques to obtain high resolution Digital Elevation Models (DEMs) is recently being used in many different fields. This method is relatively cheap in comparison with for example terrestrial laser scanning. Moreover, an orthophoto can be produced besides a high resolution DEM. Although applying this method in mountainous areas can be difficult due to large topographic differences and quickly changing weather conditions, it was successfully applied in two talus slope areas in the Valais (Swiss Alps). Talus slopes are one of the most common landform in high mountain environments and an important debris storage. Therefore, they are often subjected to mass wasting processes. Both areas have a variety of geomorphological landforms, such as debris flow channels, small rock glaciers, solifluction, evidence of rock fall and landslide activity. Located on an elevation in between 2300 – 2800 m, different permafrost conditions can be found.

The goal of the UAV surveys is to obtain detailed topographic information, and by repeating this measurements, gaining an insight in the dynamics of these landforms, from volumetric changes to horizontal displacements. These dynamics could then be linked to the potential permafrost distribution. In order to obtain the needed photogrammetric data, flight lines were programmed in QGIS. The flight height was set at 70 to 100 m above the surface of interest and minimum overlap between the flight lines was at least 70%. The software 'Mission Planner' was used to write this data on to a Hexacopter DJI F550 drone. A 16MP camera was mounted on the drone in order to obtain the desired resolution. Ground Control Points (GCPs) were placed in the area of interest, with at least one GCP every 200 m. After surveying, data was processed with Agisoft Photoscan. The results are a DEM and orthophoto with an average resolution below 5 cm. In addition, permafrost state will be assessed using year round temperature data and geophysical methods. By doing so, this study will contribute to a deeper understanding about geomorphological process dynamics and will try to conceptually assess the potential impact of climate change on these periglacial talus slopes. First preliminary results of the fieldwork conducted in the summer of 2017 will be presented.

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FROM 3D PHYSICAL DATA TO 3D INTELLIGENT POINT CLOUDS

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Tools and methods to capture the 3D environment are a great way to document a 3D state of the context at a given time. Specifically, point clouds are an exhaustive representation of the real world but the integration, the maturation state as well as the link between semantic and spatial information is still limited. Concepts and tools that simplify this process are rare, which complicates the merging of different experts' perceptions. Bridging effective 3D data capture and semantics assimilation through ontologies, we developed a new concept: the Smart Point Cloud. It allows to bring intelligence to point clouds and creates a connection between available knowledge and classification procedures to allow reasoning from the data itself.

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UAVS AND 3D MODELLING IN SOUTH AMERICA

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Nowadays, 3D modelling is a popular technique for scientific research. 3D modelling can contribute to the registration, documentation and visualisation of objects, sites and larger research areas. Moreover, using the 3D models in a geographic information system (GIS) can be of great value in scientific research.

The three-dimensional environment is reconstructed based on unstructured images using computer vision techniques. To capture high resolution infrared and RGB images of the area, the cameras are mounted on an unmanned aerial vehicle (UAV). Additionally, images are taken by hand. These images are processed using Agisoft Photoscan to create a 3D model of the area. The model can be oriented globally or locally using measurements of targets and/or control points with GNSS and/or total station.

In Mexico (Edzna) and Honduras, the 3D models and derivative end products were used for archaeological research. More specifically, RGB and infrared orthophotos were analysed to detect subsurface archaeological structures based on the difference of reflection values of vegetation. The results will be used for further archaeological research, detection, excavation and conservation of the remains.

In Ecuador, on the Galapagos Islands, the intertidal area of Puerto Ayora on the was modelled in cooperation with the Department of Applied Ecology and Environmental Biology. These products will be used for research on fish populations and sediment deposits in this region.

In Ecuador, the three-dimensional environment is reconstructed for the evaluation of a reforestation project of Bos+. Since 2011, forests were replanted on plots with different characteristics (height, land use…). For this project, a monitoring method will be developed in cooperation with the Department of Forestry and Water Management and Bos+ to evaluate the success of the reforestation.

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GIS: FROM SYSTEMS OVER SCIENCE TOWARDS TECHNOLOGY

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For many years, GISystems play a central part in the research and the applications in geography and geomatics. Besides the systems, the “S” in GIS is more and more linked to science; GIScience being the part of information science that handles geographical information. The central goal of GIScience is to optimise geographical information systems (GISystems). Now and then the "S" is even extended to the "T” of technology, standing for all technologies that cannot be called a GIS s.s. but are typically used to build, manage, process, present, integrate and/or communicate about geographical/spatial data. In this talk, a brief overview is given of the key questions and challenges that ‘live’ in these

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REVISITING THE INTERNAL STRUCTURE OF BRUSSELS WITH MOBILE PHONE DATA AND SOCIO-ECONOMICS VARIABLE: DO WE CONVERGE?

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With the advent of Big-data, new mathematical methodologies are currently used and developed to decompose a deluge of data into simple information. Applied to spatial datasets, they open new avenues for urban analyses by depicting the internal organization of cities and by measuring their spatio-temporal variations.

We here use **mobile phone** calls to delineate interaction patterns within the metropolitan area of Brussels; the Louvain Method is applied on almost 20 million mobile phone calls collected in April – May 2015. Using the origin and the destination of the calls, we detect **communities** of antennas that are tightly linked in terms of number of calls, during work and non-working hours and, with the introduction of a parameter in the Louvain method, these spatial groups are decomposed into sub-communities and further analyzed. The robustness of the results in terms of data and the methods are in-depth discussed. Moreover, the antenna are individually characterized in terms of the socio-economic conditions and the time dimension of the calls are hence considered.

Communities of mobile phone calls are compared and further discussed. Does the socio-economic conditions of places influence the organization of communities? Are some areas more active than others? Results show that (1) surprisingly, the communities of calls follow quite well the expected composition of the Brussels Capital Region and, (2) the socio-economic conditions around the antennas allow to characterize the interaction patterns within the metropolitan area of Brussels. This work shows that combining new and classical analyses for interpreting Big-Data allow to depict the urban complexity and open new avenues for future research.

Keywords: Mobile phone calls, Community detection, Time dimension & Cluster analyses

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GEOGRAPHY, STATISTICS AND LCA: COMBINE AND INTERFACE METHODS TO MAP TERRITORIAL INEQUALITIES OF ENVIRONMENTAL IMPACTS ARISING FROM LAND USE PLANNING DESIGNED BY PUBLIC POLICY

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Context: Life Cycle Assessment (LCA) is the scientific field, which assesses the environmental consequences of human activities. A LCA analysis comprises four phases: Scope & Goal definition, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA) and Interpretation. Many interdisciplinary frameworks have been recently developed; giving rise to many methodological advancements. Territorial LCA (TLCA) is one of these new frameworks. TLCA was created by integrating in LCA the concept of territory as well as basic methods of spatial analysis, used in Geography.

Question: the purpose of a TLCA is estimating the environmental consequences of goods and services rendered by a land use planning. Even though researches in TLCA have made an important step forward, an open research question remains: how to perform TLCA at sub-regional decisional scales (i.e. territorial scales). This methodological research question tackles two issues: i. how to handle the output parameters provided by the recent spatial LCA models; ii. how to create explicit meaningful decisional supports from regular statistical mapping methods?

Purpose: I briefly present a methodological & software guideline for combining statistics, geography and LCA to perform spatially differentiated TLCA and return explicit statistics, charts and maps.

Objectives:
Scope & Goal. I explain how this guideline helps to complete spatially differentiated TLCA case study, i.e. to perform: i. a Spatial Territorial Life Cycle Inventory (STLCI) that foresees the main chemical emissions generated by the fertilisers applied in 108 328 agricultural parcels; ii. a Spatial Territorial Life Cycle Impact Assessment (STLCIA) that estimates their impacts on ecosystems for the 116 communes of the Luxembourg in 2008. STLCI. I provide details to inventory the quantities of ammoniac, nitrous oxide, nitrogen oxides in air and phosphate, nitrate, phosphorus in water released - from an agricultural land use planning, parameters of spatial LCI models and GIS tools**.** STLCIA. I provide details to aggregate and transform these chemical emissions in the major impacts of the agriculture - from parameters of spatial LCIA models and GIS tools**.** Interpretation. I present i. map results for demonstrating the ability of spatially differentiated TLCA to study the spatial inequalities; ii. spatial analysis results for identifying which types of agricultural land uses contribute the most to the air acidification, eutrophication of fresh waters and global warming – at the scale of communes.

Discussion: I open the discussion with three strange findings when one attempts to interpret the: i. results in relation with the European data; ii. total impacts in proportion with population living in communes; iii. correlation coefficients with socio-demographic spatial indicators.

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VIEWPOINT MANAGEMENT FOR AN OPTIMAL 3D VISUALIZATION

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The current advances in computer sciences and the increasing number of acquisition techniques led to significant improvements in the 3D visualisation. Nowadays, 3D models are widely used by numerous applications: e.g. urban planning, environmental management, indoor navigation… With the emergence of 3D environments, new visualisation issues appear like the viewpoint management. Indeed, unlike in a 2D environment, the viewing direction is not only oriented in a top down direction in 3D. A non-optimal camera location means a poor 3D representation in terms of relayed information. To address this issue, we propose a new method based on the analysis of the computational display pixels that determines an optimal viewpoint. It maximises the visibility of objects selected by semantic queries. The method is finally implemented into a prototype developed in WebGL, a JavaScript API for rendering 3D graphics. The tool directly allows semantic extraction and visualisation of pertinent information for the end users. It leads to efficient communication between actors by proposing optimal 3D viewpoints as a basis on which interactions can grow.

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ON MEASURING "GREEN": A COMPARATIVE ANALYSIS OF FOUR DATABASES IN NAMUR (BELGIUM)

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The (further) development of green spaces in urban areas has become a trending topic in the last decade. Studies on hedonic pricing, environmental and ecosystem benefits and human health issues, all consider such factor from different perspectives.

An interdisciplinary systematic review on the measures of green spaces conducted within the GRESP-HEALTH research project (Trabelsi et al. 2016) shows that a wide range of datasets and measures are to be found in the literature.

In this work, we aim at looking at and identifying different typologies of urban, peri-urban and rural areas by means of four different land use databases on the same study area. For this purpose, we look into land use information provided by Corine Land Cover, Urban Atlas, NDVI, and a self-developed database from Google Earth Images and Google Car Images. The study is conducted on the area of Namur, a city of 100.000 inhabitants in Belgium with urban and rural features.

We use descriptive statistics to compare the information provided by the four databases, to assess the variance and the gap among them.

The comparison of the four databases is subject to the choice/definition of a common classification of the landuses, as the data is provided in different formats (i.e. vector, raster; surface, percentage…). Six common main classes of land uses are defined: built up, agricultural and pasture, road and rail, water, general green areas, other landuses. These six classes have then sub-classification according to the detail level of the database.

First results show both a great variation in the percentage of surface identified by each database for some land uses (i.e. built up), but also consistency in surface for some other classes (i.e. agriculture and pasture), due to the level of aggregation. But the total surface hides the information on the number, size and dispersion of the patches, which is a relevant element when studying accessibility or proximity to green areas, for example.

Our work looks into the four databases and aims at understanding where the limitations of each lie and whether a finer resolution database can be created using wisely the data available.

The four databases show to have advantages and flaws: Corine Land Cover and NDVI are easily accessible and available for big and a bigger number of areas, but lack in definition of data and detailed analysis of the location; Urban Atlas is freely available and has a rather good quality of data but is only available for some European cities; Google Earth has the finest definition of the data but is a time consuming process of data creation and highly subjected to the choices of the "author" concerning the data classification.

Outcomes will provide a reflection tool for selecting the most appropriate database according to the study needs.

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GI LEARNER: DEVELOPING A LEARNING LINE ON GISCIENCE IN EDUCATION

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GI Learner is a three years Erasmus+ KA2 strategic partnership project, aiming at integrating geospatial literacy, geospatial thinking and GIScience into schools. Although it is seen as one of the most important sectors in the economy it is seldom really taught in secondary schools.

GI Learner aims to respond to this by the development of a GIScience learning line for secondary schools, so that integration of spatial thinking can take place.

A first step was translating results of an extended literature review into a list of spatial and other competences and learning objectives. The different levels of complexity used hereby, referring to the taxonomy of Bloom, take into account age and capabilities of students. For each of the competencies lessom materials are now being produced, thus facilitating the implementation in education on short term.

The developed learning line will increase the importance of geospatial smart thinking and help produce the workforce we need now and for the future and geospatially literate citizens.

The GI Learner project website (http://www.gilearner.eu) shows already the first results: a state-of-the-art literature review and the developed learning line with selected competencies. Linked to the website an online course platform is being developed that will include all lesson materials.

Keywords: GIScience, geospatial literacy, learning line, education

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Geomatics Session

Poster presentations

ESTIMATION OF FOREST BIOMASS USING REMOTELY SENSED DATA IN NORTHERN PART OF MONGOLIA

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Information on forest volume, forest coverage and biomass are important for developing global perspectives about *CO2* concentration changes. Forest biomass cannot be directly measured from space yet, but remotely sensed greenness can be used to estimate biomass on decadal and longer time scales in regions of distinct seasonality, as in the north. Hence, in this research, numerical methods were used to estimate forest biomass in higher northern regions. A regression model linking Normalized Difference Vegetation Index (NDVI), to forest biomass extracted from SPOT/4 VEGETATION data. Landsat data was used to validate forest coverage. Statistical tests indicated that the regression model can be used to represent the changes of forest biomass at high latitude regions over years 2000-2016. This study suggests that the implementation of estimation of biomass based on SPOT-4/VEGETATION data could be detected over a range of land cover change processes of interest for global biomass change studies.

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SOIL ORGANIC CARBON PREDICTION IN CROPLANDS BY AIRBORNE APEX IMAGES USING LUCAS TOPSOIL DATABASE

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The quantitative prediction of soil properties using the first generation of hyperspectral satellite sensors is hampered by the very low signal to noise ratio (SNR) in the SWIR region for Hyperion imagers on board of the NASA EO-1 platform or by the restricted spectral range (415–1050 nm) for the Compact High Resolution Imaging Spectrometer (CHRIS) on the European Space Agency's PROBA platform. In the near future at least five satellites equipped with hyperspectral imagers are due to be launched: the German Environmental Mapping and Analysis Program (EnMap), the Italian PRecursore IperSpettrale della Missione Applicativa (PRISMA), the U.S. NASA Hyperspectral Infrared Imager (HyspIRI), the Japanese Hyperspectral Imager Suite (HISUI) and the China Commercial Remote-sensing Satellite System (CCRSS). A calibration/validation protocol is necessary to investigate the potentiality of these forthcoming hyperspectral imagers. In this regard, the PROSOIL project aims to exploit the potential of new generation of hyperspectral imagers, developing a standardized multivariate calibration approach valid for large areas and that requires minimal user inputs. For these purposes, LUCAS topsoil database was used to calibrate robust multivariate prediction models for the prediction of the OC content of 146 topsoil samples collected in croplands in Central Belgium and Gutland-Oesling region (Grand Duchy of Luxembourg). The predicted OC values at the sampling points were joined with hyperspectral remote data in order to predict OC over all bare soils of the two study areas.

A subset from LUCAS database was created selecting only the samples collected on croplands (LUCAS_agri). This subset was spilt into 7 classes, for this purpose, a matrix composed of all the soil variables of the LUCAS_agri database was clustered using the k-means algorithm and the optimal number of clusters was chosen through the ‘gap’ method. In order to make possible the comparison between the spectra acquired according with LUCAS protocol and those acquired with a new protocol 5Belgium and Luxembourg), we scanned again 153 samples of the LUCAS_agri dataset, transforming the LUCAS spectra into “new protocol” spectra by means of the External Parameter Orthogonalization (EPO) method.

The classified soil spectra of the LUCAS_agri were used as training data to classify soil spectra of the samples collected in Belgium and Luxembourg using an artificial neural network (ANN). After the class assignment, a partial least square regression (PLSR) model was carried out for each class of the LUCAS_agri dataset, which was used to predict OC content of the samples of the two study areas belonging to the same class. The predicted OC values obtained by the LUCAS_agri models were joined with airborne APEX hyperspectral data to obtain the OC maps of 90 fields. The APEX sensor was used as the new generation of hyperspectral satellites are not yet launched. The next step of the PROSOIL project will concern the simulation of satellite images starting from APEX data to test if the OC prediction from hyperspectral satellite sensors of new generation is feasible.

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EXPLORING THE EVOLVING STRUCTURE OF THE SOUTHEAST ASIAN AIR TRANSPORT NETWORK DURING 1979-2012

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This paper offers a novel approach to investigate and understand the evolving structure of the Southeast Asian air transport network (SAAN) over the period of 1979-2012. It captures the main topological and spatial changes in the network system from different dimensions of complex network theory, demonstrating a relatively stable topological structure and constantly changing multilayer structure. A statistical analysis indicates that the SAAN is a scale-free network with a decentralization trend in the overall connectivity. It has been characterized with small-world property since 1996 when the characteristic path length was surpassed by that of a same-size random network (RN) while the average clustering coefficient has significantly outstripped the value of the comparable RN all the time. Furthermore, the SAAN shows a more and more explicit disassortative mixing pattern and a growing global efficiency to transport passengers over time. A decomposition analysis encapsulates the SAAN into three layers, i.e., core, bridge and periphery, to give new insights into the multilevel structure in the complex network system. The core layer, containing capital cities of each country, most economic vibrant secondary cities, and famous tourist destinations, is densely connected with a focus moving towards the west half of Southeast Asia. The periphery layer, comprised of cities in remote areas, sustains low significance with decline in internal connections and passengers despite a slight rise in cities. The bridge layer lies in between presents a high volatility over time. The connections and passengers between different layers exhibits an overall increase, especially those between core and bridge after 1996.The changes are generally coupled with a series of socio-economic and political dynamics in Southeast Asia.

Keywords: Complex network; air network; topology; multilayer structure; Southeast Asia

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SOIL MOISTURE ANALYSIS USING MULTISPECTRAL DATA IN MONGOLIA

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Long term moisture data sets on a regional scale could provide reasonable information about climate change and global warming specific regions. Moisture is most important variable in climate change especially drought. Soil moisture (SM) content is one of the most important environmental variables in relation to land surface climatology, hydrology and ecology. The annual evaporation is 150~250 mm in the steppe zone and over 150 mm in desert steppe and deserted zones. This research work will be divided two parts which means long-term moisture analysis in central part of Mongolia and soil moisture modelling in target area. The study area is included seven provinces which as agricultural area and situated central part of Mongolia. Its situated between approximately 589 and 2788 meters and there are thirty-eight climate stations in seven provinces. The aim of this research work is to develop a SM model using multispectral satellite data and long-term moisture mapping in central part of Mongolia. In addition to this, land surface temperature (LST) and normalized difference vegetation index (NDVI) from Landsat satellite images were integrated for the assessment. A digital elevation model (DEM) from ASTER satellite image with 30 m resolution along calculation aspect and slope maps was used. We collected ground truth measurement of soil moisture in Tuv provinces for the validation. The most accurate method to estimate SM is gravimetric sampling. The soil sample from the field has to be immediately measured by putting the sample for 24 to 48 h in a drying oven at 105 °C, to measure the mass of the dry soil. Further soil bulk densities are required to convert gravimetric (water mass per soil mass) to volumetric values (water volume per soil volume). On the long-term analysis, the satellite-derived products can be providing moisture indices events. We interpolated precipitation data into raster imagery from May to August for the 2000-2013 over Mongolia using 127 climate stations. The potential evapotranspiration (PET) was estimated from MODIS data and NDVI was calculated two bands which are near infrared (NIR) and visible red (RED) from SPOT data during the growing season from May – August for the 2000-2013 was acquired. The method of Lewis (1999) was chosen to determine the moisture index (MI) using spectral information from Landsat satellite data and Mathew Tybersky (2008) using derived from precipitation and PET. Regression analysis is used to develop the model. The model shows how SMI from satellite depends on LST, NDVI, DEM, Slope and Aspect in the agricultural area. For the long-term moisture mapping to accurate using NDVI. The result of moisture mapping was compared with NDVI. According the results that moisture of previous months directly affected to vegetation growth of next months. The results of the model were correlated with the ground SM data in Mongolia and indicate that there is 0.65 correlation between output SM and SM of ground truth for the agricultural area. The soil moisture indices based on climate stations measurements could not completely reveal the natural zone effects.

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USING OF EUROPEAN'S SATELLITE IMAGES, SENTINEL-2 AND HYDROMETRIC DATA FOR MONITORING THE SURFACE WATER ABSTRACTION, FOR AGRICULTURAL PURPOSE, IN THE SUB-BASIN UPPER-COMOÉ, BURKINA FASO

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Water shortages frequently cause conflicts between water users in the upper Comoé sub-basin, Burkina Faso, during the dry season, particularly between farmers (Roncoli & al., 2009). Farmers are always accusing each other to misuse the available water. However, no one knows exactly the amount of water that is removed from rivers and waterbodies, by the three principal groups of farmers (rice producers, vegetable farmers and sugar cane industry), and the volume of water that must really be withdraw (Etkin & al., 2015). Knowing the areas cultivated by each user during the dry season, is a good way to determine exactly the amount of water that must be remove by users, for agriculture purpose, thus, identifying guilty farmers.

Several maps have been made using remote sensing techniques, in the context of Upper-Comoé basin, characterized by smaller plots (Wellens, & al., 2013; Traoré, & al., 2013), but high resolution purchased satellites images were needed, on the one hand, aerial photographs on the other hand.
The availability, since 2015 of European's satellite images Sentinel-2, which are free of charge with high temporal and spatial resolutions, is an opportunity to address the lack of information about water and land uses in this basin.

To achieve the above objective, Sentinel-2 images classification has been made, using Support Vector Machines algorithms, firstly (Mountrakis & Ogole, 2011). Secondly the combination of the results of the classification with hydrometric data collected from 2015 to 2017, permit us to determine and compare discharges withdrew and needed by each group of farmers at a given time.

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CARTESIUS.BE
THE WORLD IN OLD MAPS, AERIAL PHOTOGRAPHS AND DRAWINGS ONLINE IN YOUR CLASS ROOM…

Rink W. Kruk*

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Already for centuries land, water and society is being mapped, drawn and photographed, properties are being inventoried and captured on paper. They are carefully p Never before you could search through and view these rich cartographic collections with only one mouse click. The collections comprise famous maps – like those by Ferraris, Mercator, Vandermaelen – the topographic maps of the NGI, primitive cadaster plans, landscapes, battle scenes, unique noble and legal archive pieces and so much more. Thanks to Cartesius.be you will get a fresh insight in how the landscape looked like hundreds of years ago and what was happening in it.

The innovative approach of the Cartesius portal is the geographical search function, in fact the most important way to search through the collections. It means that you can indicate the area of your interest on a modern map, and the search engine will display the documents that are in that area designated by you. The convenient thing about this is that, unlike a classic catalog, you do not have to worry about changing place names, the language or writing of place names, or even the absence of place names in the description of these old documents. Think for example of Liège, which is also known as Liège (French), Lüttich (German), Lieja (Spanish), Liegi (Italian) and Leodium (Latin). Neither do you have to worry about what “Liège” in fact stands for: is it the city, the agglomeration, the province, the diocese or the prince-bishopric? It is important, therefore, that a search is done on the basis of geographical coordinates, in practice on the geographic footprint of the cartographic documents. It is therefore that for each document, the footprint of the old map on a modern map is defined by us. This "footprint" Is used by the search engine to match your area of interest and will be displayed on the modern map in the results of a search.

With myCartesius, the public cloud application of the portal, you can get started with the old maps, aerial photos and maps yourself, and make your own atlas. The possibilities are manifold. Merging, sharing, compiling, editing, and embedding them in a blog or social media ... or develop a web app that you can use on your tablet or phone, using your GPS and walk around with an old map from 1873 for example. It looks like some kind of geo-facebook.

MyCartesius is ideally suited to build your classes on. The first geography teachers have already put some geography lessons online, and we sincerely invite you to build more packages with us, and why not, also with your colleagues of history, classical languages, economics, etc.?

Old and new maps, aerial photographs, cityscapes, landscapes, they have been appealing to the peoples imagination for centuries. In the past, it was the domain of kings, emperors, noblemen and a single surveyor, today you can use them in class and outside, thanks to Cartesius.be! The history of people, society, property and land is made visible by tens of thousands of historic witnesses in their spatial context. More than 60,000 old maps and aerial photographs are already unlocked online by the National Geographic Institute, the Royal Library of Belgium, the National Archives and the Royal Museum for Central Africa. This number continues to grow as we find it important to make our heritage accessible to the public.

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Physical Geography Session

Oral presentations

WHY DOES GEOMORPHOLOGY MATTER?

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Geomorphology is the science that studies the origin and development of landforms and how those landforms combine to form landscapes (Tooth and Viles 2016). As such, it makes a critical contribution to the earth sciences by answering important questions related to the global environment and how this operates and changes. Understanding how landscapes operate and change is crucial for a full understanding of the Earth System and for enabling better environmental management. Geomorphology Interfaces with, and contributes to, many different aspects of the earth, environmental and social sciences: e.g. global change, geology, environmental engineering, archaeology, ecology, planetary science, geotourism, environmental policy and management. Several examples will be given to illustrate that geomorphology really matters.

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GEO-HAZARDS: RESEARCH ACHIEVEMENTS, CHALLENGES AND PERSPECTIVES

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Geohazards include geological and geomorphological processes that represent a direct threat to human lives, infrastructures and livelihoods. Although generally restricted to short-onset processes of geological origin such as earthquakes, landslides, volcanic eruptions or tsunami, geohazards in the broadest sense also encompass geomorphological events such as severe soil erosion, gullying, ground subsidence or other types of physical and chemical degradation of the environment. Impacts of these processes on human society keep on increasing but the responsibility of human actions in enhancing these hazards or their consequence is frequently overlooked. Major scientific advances over the last decades have enabled to better understand the factors controlling the spatial distribution, frequency and rate of these processes, and to model their long-term impacts on landscape evolution. Newly available methods make it possible to document these processes with ever increasing spatial and temporal resolution, as well as to quantify physical processes thanks to a combination of laboratory experiments, field observations, a range of remote sensing techniques and numerical models. This short contribution will review some of these major advances contributed by several Belgian research groups for European and tropical environments. Specific challenges, including the one of upscaling the results of existing case studies and empirically-derived models as well as the forecasting of geohazard event will be highligted. Future perspectives to improve the relevance of these research to contribute to more sustainable land management and reduction of geo-hazard on human communities will be discussed. This includes inter-disciplinary research accounting for the economic valuation of geohazard impacts and mitigation measures, the modelling of georisk accounting for elements at risk and their respective vulnerability, and participatory research to document geohazard and raise awareness on appropriate risk reduction strategies. This contribution will serve as a contribution to the specific research contribution in the geo-hazard session of the 2017 Belgian Geography Days.

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TO WHICH EXTEND INUNDATIONS ARE INFLUENCED BY URBAN PATTERNS?

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Urbanization changes flood risk in many regards: reduction of the infiltration of water, modification of the inundation flow, increase of the exposure of elements-at-risk, etc. Today, few researches have investigated the influence of urban configurations on inundation flow, while urban characteristics such as road width, road length or location of buildings may impact the discharge distribution between the roads and hence the flow depths and velocities.

In this project, an original methodology was set up to investigate systematically the influence of nine urban characteristics (average road length, road base orientation, road curvature, major and secondary road widths, parcel mean area, side and rear building setbacks, and building footprint) on inundation depths. Varying the values of these urban characteristics, a procedural model generated randomly a set of 2,000 quasi-realistic building layouts over a horizontal 1 x 1 km^2 urban domain. Next, inundations were computed over the 2,000 building layouts for identical steady hydraulic boundary conditions. The simulation of such a large number of inundations was made possible through the use of a porosity-based hydraulic model. Such a porosity model enables a strong reduction of the computational time by increasing the size of the computational cells while maintaining to some extent the subgrid topographic information through porosity parameters. A storage porosity is defined at each cell to reproduce the available volume of water within this cell while the conveyance porosity of an edge mimics the impact of subgrid obstacles on the flux terms. Finally, statistical analyses were performed to investigate the relations between the building layouts and the inundation depths.

The results show that while the building footprint has logically a major influence on the inundation depths, the urban characteristics controlling the conveyance of the flow, like the distance in-between the buildings and the spatial distribution of the buildings, may play also a significant role. This is of high relevance for future flood-proof urban planning since the augmentation of inundation depths due to urbanization could be mitigated by a suitable location of the buildings.

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« CAP-HAÏTIEN » OR « HOW TO ‘CONSTRUCT’ A FLOOD RISK IN A DECADE »

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Cap-Haïtien is a town situated in northern Haiti that is experiencing an unprecedented increase in flooding. While some observers are tempted to blame the flooding to the consequences of climate change, we try here to demonstrate that it is the total lack of urban planning, environmental degradation, lack of good governance and rural exodus which are the main components creating this exceptional risk. The objectives of this paper are to analyze the evolution of urban expansion in two wetlands (Haut-du-Cap river and the mangroves in Petite-Anse) from 2004 to 2016 and to assess the perception of flood risk by local people. The urban expansion dynamics is analyzed using 23 images with very high spatial resolution available in open access on Google Earth since 2004 and surveys were administered to 50 respondents living in newly parceled zones during a field mission in April 2016. Our results show that recent urban sprawl is mainly carried on embankments in the estuary of the Haut-du-Cap river or to the detriment of the mangrove. Consequently, these new residents are periodically flood victims. Questioned on the ground, it appears that 80% of these people are coming from rural exodus and have settled in Cap-Haïtien in the last decade. 82% and 60% of the people live respectively bellow the poverty line (< 2 USD / day) or in extreme poverty (<1 USD / day), and 42% are illiterate. Therefore, the ignorance of flood risk, poverty and low education levels are all parameters involved in the vulnerability of these new inhabitants. Thus, 78% of respondents claim to have been dramatically impacted by flooding at least three times since their arrival (i.e. since 2004). Field surveys revealed that most of the newly settled people in some areas highly exposed to the risk of flooding in Cap-Haïtien come from neighboring rural areas. Their movements are motivated by the aspiration of "a better life". However they were quickly disillusioned because the recurrent floodings plunge these populations in an aggravated state of insecurity. As for the authorities, they are guilty of not applying the national standards for construction in flood risk areas and the lack of regional planning policy endangers the survival of hundreds of households per year. In this case, it seems evident that the most frequent flooding is not due to climate change but rather that chaotic governance creates all conditions for the "construction" of the risk because of the inhabitability process.

Keywords: Flood, vulnerability, maladaptation, urban sprawl, Cap-Haïtien, Haïti

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LAND TRANSACTIONS TO CHANGE RISK EXPOSURE? LANDSLIDES, LAND MARKETS AND SOCIAL NORMS

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Some big landslide disasters in the Global South have been termed class disasters because they disproportionally hit the poor and powerless. Often this is a consequence of the poor being pushed towards more marginal land.

In our case study on smallholder farmers in a rural community in Uganda we find a different trend. While there are inequalities in wealth, measured by the amount of land owned, between farmers, as well as in exposure, measured by the average landslide susceptibility on the plots owned by the farmers, these inequalities do not necessarily overlap. They are not constant, either, as they change over the lifetime of a farmer. We find that farmers that are initially more exposed to landslides manage, over time, to reduce their average exposure by acquiring plots outside landslide prone areas. This goes at a cost, as farmers that are initially highly exposed acquire less land than farmers that have a lower exposure at the beginning of their independent life. Over a lifetime, in our case study, land transactions therefore have a levelling effect on inequality in exposure to landslide susceptibility, but increase the inequality in land ownership.

We propose, but do not conclusively confirm yet, an explanation for this observation, which is not in line with the 'class disasters' that have been observed in the Global South. It should be noted that the land transactions in our case study do not always consist of monetary transactions in a capitalist sense, but also include gifts and exchanges. In a close community, the occurrence of a landslide that severely affects one of the members of the community to a point that this person needs assistance, has serious consequences for the community as a whole. We therefore hypothesise that social norms and traditions could exist within the community of farmers in our study area which push towards transactions and exchanges that allow the poor to be less exposed to the risk of serious landslide shocks. While such a process has an equalizing effect on exposure to landslide risk, it could have long term consequences for inequality within the community.

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ANATOMY OF NYAKAVOGO LANDSLIDE (BUKAVU, DR CONGO): INTERPLAY BETWEEN NATURAL AND ANTHROPOGENIC FACTORS

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There are few data on the interactions between human factors and landslide processes in tropical environments such as those found in the mountains around Lake Kivu in DR Congo. This study focusses on the analysis of the spatial and temporal variability of natural and anthropogenic factors in and around Nyakavogo landslide (city of Bukavu). It combines data from field survey, aerial photographs, satellite imagery and archive analysis. This landslide, in contact with a river, occurred far before 1959. It affected the whole hillside. The significant reduction of the forested parts in favour of cultivated areas and grassy vegetation, increasing number of houses and earthworks, concentration of surface runoff at the main escarpment and seismic activity is the combination of factors that has probably contributed to its instability from 1959 to 1997. In 1997, the deep rotational movement which affected the entire landslide is the most important reactivation known. The river reorganization after the dam created by the reactivation of 1997 and the erosion accentuated by exploitation of building materials in the riverbed have played an important role in the reactivation of 2000 that affected the foot of the landslide. Currently, movements still occur, mainly in the reactivated area of 2000, but a stabilization trend is observed. Reforestation of recent years probably plays a role. Nevertheless, overloading of part of the main escarpment could reverse this dynamic. This study provides useful information for the management of areas affected by landslides in the city of Bukavu.

Keywords: landslide, natural and anthropogenic factors, reactivation, land use, tropical environment.

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GEOHAZARDS AND FLOOD RISK ASSESSMENT IN BUJUMBURA / BURUNDI: CONTRIBUTION OF NUMERICAL MODELLING

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A multi hazard assessment was performed for Bujumbura, straddling the western branch of the East African Rift. Based on remote sensing and field measurements, a landslide modelling using the Universal Distinct Element Code (UDEC) has been developed to perform a back analysis as well as a landslide dam formation along the Kanyosha river. Results revealed that a fifteen-meter-high landslide-induced dam may occur, resulting in over 60.000 m^3 of water impoundment. Finally, the effects of the dam on the hydrodynamic behavior of the Kanyosha river and especially on the risk of flooding were investigated. For this, we used WOLF software, a powerful device, including a physically based hydrological model, a 1D flood routing and a 2D shallow-water solver. The resulting 2D floodplain and flow velocity maps for different scenarios highlight the importance of a multi hazard approach for a better risk assessment. These findings are of a great interest to the population in general and policy makers in particular, especially for sites in a multi-risk environment.

Keywords: flood; landslide; modelling; East African Rift; Bujumbura

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CONSTRAINING LANDSCAPE EVOLUTION OVER 10 YR, 10 KY AND 1 MY TIME SCALES

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Constraining erosion rates, patterns and processes is essential to understand how Earth's topography evolves, how hillslope processes determine sediment fluxes to the oceans, and how river incision can drive slope adjustment through landsliding.

In this talk, I will give a brief overview of recent methodological advances in geomorphometry and dating techniques for investigating rates and dates of geomorphological processes. A selection of these techniques has been applied in Belgian sites in the past two decades to constrain topographic evolution of the Belgian Ardennes and Northern Belgium.

The presentation will review recent work on landscape evolution of the Belgian Ardennes and Northern Belgium, and put it in perspective of topographic evolution of low-relief landscapes over 10 yr, 10 ky and 1My timescales.

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QUANTIFYING LONG-TERM HUMAN IMPACT IN CONTRASTING ENVIRONMENTS: A PALYNOLOGICAL AND STATISTICAL APPROACH

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Reconstructing and quantifying human impact is an important step to fully understand human-environment interactions in the past. Quantitative measures of human impact on the landscape are needed to fully understand long-term influence of anthropogenic land cover changes on the global climate, ecosystems and geomorphic processes. Nevertheless, quantifying past human impact is not straightforward. In this study, statistical analysis of pollen data was used to characterize vegetation changes and to extract quantitative data on human impact. Fossil pollen records were included in a multivariate statistical analysis (cluster analysis and non-metric multidimensional scaling (NMDS)) together with modern pollen data and modern vegetation data. The information on the modern pollen and vegetation dataset can be used to get a better interpretation of the representativeness of the fossil pollen records, and can result in a full quantification of human impact in the past. This methodology was applied in three contrasting environments: Central Belgium, SW Turkey and Central Spain. For each region, fossil pollen data from different study sites were integrated, together with modern pollen data and information on modern vegetation. In this way, arboreal cover, grazing pressure and agricultural activities in the past were reconstructed and quantified. The data from Central Belgium shows the gradually increasing human impact from the Bronze Age onwards (ca. 3900 cal a BP), except for a temporary halt during the Migration Period (ca. 1900-1600 cal a BP). The data from SW Turkey provides new integrated information on changing human impact through time in the Sagalassos territory, and shows that human impact was most intense during the Hellenistic and Roman Period (ca. 2200-1750 cal a BP) and decreased and changed in nature afterwards. Finally, the data from Central Spain show that the evolution of human impact through time differs along an altitudinal gradient, with a decrease in arboreal cover during the Roman and Visigoth periods (2000 – 1240 cal BP) at low altitudes and only during the Christian/Feudal period (850 – 500 cal BP) at high altitudes. Overall, the presented examples from three contrasting environments shows how cluster analysis and NMDS of modern and fossil pollen data can provide quantitative insights in anthropogenic land cover changes. Our study extensively discuss and illustrate the possibilities and limitations of statistical analysis of pollen data to quantify human induced land use changes.

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FROM LANDSLIDE TO ALLUVIAL FAN: A PROCESS BASED MODEL TO EVALUATE THE INFLUENCE OF SEDIMENT PRODUCTION AND TRANSPORT ON LANDSCAPE EVOLUTION

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Landscape evolution models (LEMs) have successfully been used to unravel the interplay between different forces shaping the earth surface. Notwithstanding the successful application of LEMs on geological timescales, applications at shorter (millennial to concurrent) timescales are hampered by (i) the lack of field data to constrain landscape evolution models and (ii) the lack of landscape evolution models which are capable of simulating earth surface processes over different timescales.

In this contribution, we start by answering a fundamental question: does a river incision driven model designed to simulate landscape evolution over geological timescales allows to simulate spatially varying erosion rates at a millennial timescale? We selected the highly transient Paute catchment in the Southeastern Ecuadorian Andes as a study area to answer this question. We found that our model (TTLEM) is indeed capable to better explain the spatial patterns of ca. 30 Cosmogenic Radio Nuclide (CRN) derived catchment wide erosion rates in comparison to a classical statistical approach. Notwithstanding the success of this first approach, long-term LEMs lack some components to be operational on shorter timescales in regions where the interaction between sediment production and sediment dynamics plays an important role. Therefore, we developed an updated version of our open-source landscape evolution model (TTLEM_Sed) and illustrate how the formation of landslides and the transport of sediments influence the overall behaviour of landscape evolution under different environmental settings.

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LONG-TERM EROSION RATES IN AN EARTHFLOW-AFFECTED WATERSHED IN THE CENTRAL SWISS ALPS

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Tectonic and geomorphic processes drive landscape evolution. In mountainous environments, river incision resets hillslope gradients and drives hillslope adjustment through mass wasting and surface erosion. The mobilisation and transport of sediment within mountain basins can be synthetized as a sediment cascade, where erosion of material, sediment transport, deposition and remobilisation of sediment control sediment discharge. Mass movement processes, i.e. stochastic events, are mobilizing and reorganizing loose sediments on slopes while gravity and water are transporting material into rivers. However, the space and time scale of sediment cascades is still subject to debate, and will be explored in this presentation.

In the foothills of the Central Swiss Alps, we selected a watershed affected by an active earthflow in its intermediate part and rockfalls in its upper part. We sampled river sediments in order to quantify CRN-derived long-term erosion rates. Our data show that CRN-derived denudation rates are high in the rivers that are directly connected to mass-wasting phenomena, i.e. first-order rivers, which suggests that the landslide-derived material is rapidly entering the river network. However, in higher-order rivers, denudation rates are systematically lower and similar to denudation rates measured in adjacent watersheds. Our data suggests that there is a clear time lag between sediment mobilization by mass-movement processes and transportation of mobilized sediment into lower reaches of watersheds.

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USING LACUSTRINE SEDIMENTS TO RECORD PAST NATURAL HAZARDS: THE CASE OF FUJI FIVE LAKES (JAPAN)

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In this presentation, we will focus on the Fuji Five Lakes region. Since 2013, Mt. Fuji and the Fuji Five Lakes area (Lake Motosu, Lake Shoji, Lake Sai, Lake Kawaguchi and Lake Yamanaka) are added on the world heritage list of UNESCO. Mt. Fuji is a main touristic attraction in Japan bringing each year 300 000 tourists. The Fuji Five Lakes are located at the foot of Mt. Fuji Volcano close to the triple junction where the North American Plate, the Eurasian plate and the Philippine Sea Plate meet. Therefore, the region can be impacted by Mt. Fuji volcanic eruption as well as by large magnitude earthquakes. Additionally, nearly every year, Japan is hit by strong winds, heavy rains with flood, landslides and high waves. These natural hazards may affect the Japanese economy by causing casualties and infrastructure damage. In the regions frequently affected by natural disasters like Japan, it is crucial to have a better knowledge of the recurrence times of such disasters in order to refine the probabilistic models. For that purpose, lacustrine sediments are often used. Lacustrine sediments retrieving by coring offer several advantages compared to onland drilling: the method is cheaper, the cores are easier to take and they have longer temporal span. Lacustrine sediments are generally good archives to record past natural hazards. However, each lake has its own particular setting and a different sensitivity to record paleohazards. Coupling geophysical data, sedimentological analysis and historical records is often required to identify natural paleohazards in the sedimentary records and to define the threshold sensitivity of the lake. Here, we will used Fuji Five Lakes as natural laboratory for the recording of paleohazards (typhoons, earthquakes and volcanic eruptions) and will discuss the sedimentary record of Lake Motosu, Lake Sai, Lake Yamanaka and Lake Kawaguchi over the last ca. 6000 years regarding their geomorphological characteristics.

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IMPACTS OF THE CONVERSION OF FOREST TO ARABLE LAND AND LONG TERM AGRICULTURE PRACTICES ON THE WATER PATHWAYS IN SOUTHERN BRAZIL

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Stormflow and runoff pathways are affecting many environmental processes such as movement and distribution of solutes and nutrient, sediment transportation or chemical weathering. Land use change (LUC), and more specifically forest conversion to arable land, is one of the various controlling factors of water fluxes at the hillslope or catchment scale. Still, the long term effects of forest conversion and subsequent agricultural activities in (sub-) tropical environments have been relatively understudied. The objective of our study was therefore to investigate the impact of deforestation and multi-decadal land degradation through agriculture in a sub-tropical area in Southern Brazil.

We selected two small catchments with contrasting land use (LU) (agriculture vs. natural forest) in a subtropical region in the south of Brazil. A smaller sub-catchment of the agricultural one was also studied. The conversion of forest to arable land in the agricultural catchment started at the beginning of the 20th century. Stream-, pore-, subsurface- and rainwater were monitored, sampled and analyzed for Dissolve Silicon concentration (DSi_c) and $\delta^{18}O$ signal.

Both forested and agricultural catchments were highly responsive to rainfall event. For both LU types, only 2 runoff components contributed to the stream discharge: a baseflow and a peak flow components. The DSi_c of the peak flow component was low in both catchments. The $\delta^{18}O$ signal of the peak flow component in the agricultural catchments was closely related to the $\delta^{18}O$ signal of the rainfall. This was not the case for the forested catchment, where the $\delta^{18}O$ signal of the fast component corresponded to a seasonally averaged $\delta^{18}O$ signal. In the agricultural catchments, the peak flow mainly consists of surface runoff and deliver fresh rainwater to the stream. This is not the case for the forested catchment where the peak flow water must be derived from a mixed reservoir, allowing the $\delta^{18}O$ to average out between rainfall events. The low DSi_c of the fast component in the forested catchment suggests that this mixing cannot have taken place in the soil matrix as the soil pore water contains high DSi_c. Instead, the mixing must take place in a reservoir with a relatively short residence time that is, to some extent, isolated from the soil matrix. The dense channel network left behind by decayed roots in the forest soil above the clay-rich water-impeding B horizon is the most likely candidate. Visual observations confirmed that a large fraction of the peak flow in the forest was indeed delivered through these root channels. Contributions of other, deeper reservoirs are unlikely given the quick response time of the catchment.

The change in water pathways caused by land use change evidently affected solid fluxes as the surface runoff on agricultural land causes soil erosion. Dissolved fluxes are less likely to be strongly affected by the change in water pathways as, in both catchments, the peak flow component had low solute concentrations. Land use change effects on dissolved loads are likely to be more impacted by the change in water balance caused by forest removal, which leads to a higher water surplus.

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CHALLENGES AND OPPORTUNITIES REGARDING LAND DEGRADATION AND SOIL CONSERVATION

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After a brief review of the main degradation processes affecting land in Belgium, this presentation will highlight some remaining challenges and new opportunities regarding the study of soil erosion processes (gully erosion, pipe erosion, erosion by harvest of root crops, ...) and the approaches needed to mitigate their on- and off-site effects.

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ENVIRONMENTAL FLOW ASSESSMENT IN ANDEAN RIVERS OF ECUADOR, CASE STUDY: CHANLUD AND EL LABRADO DAMS IN THE MACHANGARA RIVER

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The high Andean rivers of Ecuador provide most of the water for irrigation, and through hydroelectric plants generate electricity for the country. The environmental flow is a management tool to mitigate the impact of a dam on ecosystems. The Ecuadorian law requires that the environmental flow remains 10% of mean annual flow in old hydroelectric stations, however advances on this area suggest this is not adequate. The objective of this research was to assess the impacts of a 10% release and establish environmental flow recommendations in the Machángara and Chulco rivers which have been dammed by the Chanlud and El Labrado hydroelectric plants, in the watershed of the Machangara River (southern Ecuador).

During twelve months physical and chemical parameters and aquatic macro-invertebrates were recorded in twelve sampling points. Data collected included: the flow (by channel geometry), temperature (with a thermometer), and dissolved O_2 (DO, electrometric method). In the laboratory of ETAPA the data collected included: pH (pH meter), NO_3^-–N concentration (spectrophotometer), and soluble reactive P (SRP) (spectrophotometer). Macro-invertebrates were considered suitable biological indicators in the absence of others such as native fish. Shannon–Wiener and BMWP índices were calculated.

The analysis found significant differences in some parameters, indicating a decline in ecosystem condition and relations were found between the flow, the diversity of macro-invertebrates and the concentration of dissolved O_2 (DO). Decreased flows reduce re-oxygenation due to the slow movement of water. A low and constant flow in dammed rivers (10%) causes low DO concentration, especially in the dry season. However, determining whether these impacts are unacceptable is difficult because Ecuador does not have established criteria for required ecological condition.

This deterioration in ecological conditions can be minimized by applying more modern methods of environmental flow assessment such as the basic flow methodology (BFM) that allows the variability of the river flow. In the Machangara River (3000–4000 m.a.s.l.) an environmental flow of 27–51% of the mean annual flow for the rainy season and 29–42% in the dry season were determined by using BFM. Whereas the environmental flow for the Chulco River was 15–45% of the mean annual flow for the rainy season and 15–36% for the dry season (3000–4000 m.a.s.l.).

These results partly coincide with the global estimates calculated by Pastor, Ludwig, Biemans, Hoff, & Kabat (2014), who suggested keeping between 20 and 50% of the annual mean flow. Other research in high Andean-rivers like the Chinchina, Las Piedras and El Manso in Colombia indicated that environmental flows should be greater than 25% of the annual mean flow (Boodoo, McClain, Vélez Upegui, & Ocampo López, 2014; Casanova & Figueroa, 2015; Pinilla-Agudelo, Rodríguez-Sandoval, & Camacho-Botero, 2014).

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IMPACTS OF LAND USE AND COVER CHANGES ON THE HYDROLOGY OF GUMARA CATCHMENT, ETHIOPIA

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Land use and cover changes (LUCC) are continuous phenomena often driven by natural or anthropogenic factors. In Ethiopia, a conversion of forest and grass lands into cultivated and urbanized lands has been reported. While such changes are known to have multidirectional impact on river flows, erosion and sedimentation, environment and socio-economic situation within a catchment, there is a lack of assessment on the scale and rate of these changes, and consequent impacts. This study quantifies the rate of LUCC in the Gumara River catchment (1413 km^2), an important tributary to Lake Tana in northwest Ethiopia. The Landsat images of three years (1986, 2001 and 2015) were processed, and a supervised classification method was used for the LULC classification. An extensive field survey generated over 150 ground truth points, used in the classification and accuracy assessment process. Then, a conceptual rainfall-runoff model (HBV) was applied to assess the impact on water balance components - evapotranspiration, soil moisture and groundwater recharge, and runoff. A reasonably reliable LULC classification was achieved, with overall efficiency of 90%. In 1986, the area under forest and grass land was about 11% and 18%, respectively, which reduced to 5% and 10%, respectively, in 2015. In contrast, cultivated land increased from 70% in 1986 to 72% in 2015. The successfully calibrated and validated HBV model, against observed streamflow, indicated only a slight change in the water balance components (±5%). In general, the observed LULC changes seemingly caused an increase in soil moisture and recharge, and a decrease in evapotranspiration. Consequently, streamflow showed a slight increase, though not as significant as expected in the light of LULC changes. The uncertainties involved in the LULC impact modelling process are also discussed in this paper. This application also highlighted the limitations of conceptual models, like HBV, that represent LULC in a much simplified manner, in adequately simulating the hydrological response under LULC change scenarios.

Keywords: Land use and cover changes, LULC change impact, Hydrology, Gumara catchment, Conceptual hydrological model, uncertainties

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WEIR IMPACTS ON SEDIMENT TRANSPORT AND GEOMORPHIC RESPONSE TO THEIR REMOVAL IN THE BOCQ RIVER (BELGIUM)

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Bedload transport is an important component of the ecological equilibrium of rivers. Artificial features such as dams or weirs interrupt the continuity of sediment transport, causing river habitat degradation. These barriers are numerous in the Bocq catchment (233 km²), with an average of one barrier every 1.8 km. They consist of old weirs (1-3 m high) related to ancient uses (watermill, iron factory, irrigation system).

Since 2009, the Bocq catchment has been subjected to a large-scale restoration project (EU LIFE+ project Walphy) including weir removal, resulting in the re-establishment of bedload continuity, and thus in an improvement in river ecological quality.

Before undertaking sustainable rehabilitation work, an assessment of hydromorphological and sedimentological conditions was conducted on several weirs, based on the identification of impacted areas (upstream influence on water level and bedload transport) and on the evaluation of the trapping efficiency of bedload material. The latter rests on the characterisation of the weir structure and the sediment storage quantification. Particle size measurements and the use of Passive Integrated Transponder (PIT) tags have demonstrated different scenarios of bedload trapping, from absence to partial trapping.

The Spontin weir removal was combined with an appropriate assessment of the hydromorphological and geomorphological impacts. The surveys carried out pre- and post-removal have shown an improvement of hydromorphological conditions on the upstream reach, with shallow, fast-flowing habitats, more suitable for salmonid species. Geomorphic responses to the weir removal were quick in relation to the 11-year flood that followed. The release of the trapped sediment was studied using topographic surveys and PIT-tagged pebbles. We thus highlighted the development of a new point bar and a moderate stream bed aggradation downstream.

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SPATIAL ENVIRONMENTAL DETERMINANTS OF THE RISK OF TICK-BORNE DISEASES IN WALLOON PASTURES

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Ticks present a major threat for both human and animal health because they transmit diseases that affect these populations. Risk of vector-borne diseases results from the combination of hazard and exposure. Hazard represents the strength of the zoonotic transmission cycle and is determined by the ecological conditions that influence the life cycles of the pathogens, the vectors and the hosts. Exposure represents the intensity of contacts that susceptible human or animal populations have with places where infected ticks are present, in relation to their activities and preferences. It is largely determined by land use, for example, the accessibility and attractiveness of places where infected hosts/vectors are found. Landscape has thus an influence on both hazard and exposure.

Tick borne diseases are infectious diseases affecting humans but also domestic animals. Bovines can be infected by tick-borne pathogens, such as *Anaplasma phagocytophilum*. This bacterium causes bovine anaplasmosis, a disease associated with influenza-like symptoms and decreases the production of milk. Knowing the environmental characteristics of a pasture that favors the presence of this disease is thus important for the agricultural sector.

In 2010 and 2011, the ARSIA (Association Régionale de Santé et d'Identification Animale) tested one cow in 2,088 different Walloon herds for the presence of IgG antibodies to *A. phagocytophilum*. A positive test indicates that the cow has been in contact with the pathogen. However, a negative test does not necessarily indicate an absence of the pathogen in the entire herd. It was then impossible to consider this information as "presence/absence" data. Instead, we used the presence of a positive cow has an indication that the pasture occupied by the herd is located in a suitable environment for the tick-borne disease system. The different pastures are geolocated so it allows the creation of a spatial gradient of risk for each pasture in Wallonia, based on the pastures where known infected cattle graze. This gradient was used as the dependent variable in the assessment of the effects of environmental variables on the risk of bovine anaplasmosis in pastures.

The results of this study were then compared with those from a previous study assessing the influence of landscape-level environmental variables on human-ticks contacts during scout summer camps in Wallonia (de Keukeleire et al., 2015). These two studies used different datasets but were analyzed according to the same set of independent variables extracted from the same source meaning that the results were directly comparable, unlike most of what is found in the literature because of the use of heterogeneous data sources on the landscape, with different semantic contents on land cover, different resolution, and diverse landscape indicators. The comparability between studies undergone in the same area can improve the assessment of the risk of tick-borne diseases.

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CLIMATE AND ENVIRONMENT IN BIOLOGICAL THEORY

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The Earth planet as a living unitary system and the climate as its phenotype are foundational for a theory of bio-environments. While many theories of bio-environments have been focused on Life and Earth co-evolution (adaptationist programme of natural selection), thermodynamics optimization (Maximum entropy production) and homeostasis (nonlinear dynamical system theory and cybernetics' regulation and control), here we propose a biological-centered approach based on biological structural organization theory and theory of categories. By applying a minimum set of key categories to climate system to certain ongoing biogeochemical cycles (water, carbon, nitorgenous, and others) and resources (including sunlight radiation, atmosphere, cryosphere, lithosphere, pedosphere and others) catalyzed by Earth's microbial and macrobial network, a favorable mapping with a biological unity is obtained. Our results indicate that biological activity produce and constitute more than co-evolve or optimally control a bio-environment and its climate. Implications on climate and environmental theory and models are of interest.

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Physical Geography Session

Poster presentations

VULNERABILITE AUX INONDATIONS DANS LE CONTEXTE DES CHANGEMENTS CLIMATIQUES A NEW- BELL NGANGUE, UN QUARTIER PLANIFIE DE LA VILLE DE DOUALA, CAMEROUN

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Cette recherche se propose d'analyser la vulnérabilité aux inondations dans un contexte des changements climatiques en prenant comme cas d'étude New-Bell Ngangué, l'un des quartiers planifiés de la ville de Douala. Les réflexions formulées sont issues d'une méthodologie combinant deux approches. L'une dite « top down » dans laquelle les données pluviométriques journalières ont été utilisées pour l'étude de l'aléa en tant que facteur prépondérant à la survenue de l'inondation, et une autre, dite contextuelle dans laquelle une enquête de terrain, des interviews et des observations directes ont été utilisés pour l'évaluation de la vulnérabilité ainsi que des stratégies d'adaptation. Les résultats indiquent une fréquence accrue des inondations dans la ville de Douala ainsi que le nombre de jours pluvieux entre 2009 et 2013. Cette fréquence sera probablement accompagnée d'une augmentation de l'intensité des précipitations extrêmes de l'ordre de 0 à +10 % d'ici 2050. Ce facteur climatique couplé aux facteurs physiques, socioéconomiques, infrastructurels, comportementaux et institutionnels contribuent à augmenter la vulnérabilité des différents ménages du fait des mauvaises voire de l'absence des stratégies appropriées de gestion des inondations. Les lacunes répertoriées dans ces différentes mesures invitent à un retour au respect des normes d'urbanisme et au renforcement des capacités de réponse pour rendre le quartier résilient à l'inondation.

Keywords: Inondation, changement climatique, vulnérabilité, adaptation, Douala, Cameroun

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A DATA-BASED LANDSLIDE SUSCEPTIBILITY MAP OF AFRICA

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Studies on landslide risks and fatalities indicate that landslides are a global threat to humans, infrastructure and the environment, certainly in Africa. Nonetheless our understanding of the spatial patterns of landslides and rockfalls on this continent is very limited. Also in global landslide susceptibility maps, Africa is mostly underrepresented in the inventories used to construct these maps. As a result, predicted landslide susceptibilities remain subject to very large uncertainties. This research aims to produce a first continent-wide landslide susceptibility map for Africa, calibrated with a well-distributed landslide dataset.

As a first step, we compiled all available landslide inventories for Africa. This data was supplemented by additional landslide mapping with Google Earth in underrepresented regions. This way, we compiled 60 landslide inventories from the literature (10817 landslides) and an additional 7236 landslides through mapping in Google Earth (including 1414 rockfalls). Various environmental variables such as slope, lithology, soil characteristics, land use, precipitation and seismic activity, were investigated for their significance in explaining the observed spatial patterns of landslides. To account for potential mapping biases in our dataset, we used Monte Carlo simulations that selected different subsets of mapped landslides, tested the significance of the considered environmental variables and evaluated the performance of the fitted multiple logistic regression model against another subset of mapped landslides.

Based on these analyses, we constructed two landslide susceptibility maps for Africa: one for all landslide types and one excluding rockfalls. In both maps, topography, lithology and seismic activity were the most significant variables. The latter factor may be surprising, given the overall limited degree of seismicity in Africa. However, its significance indicates that frequent seismic events may serve as in important preparatory factor for landslides. This finding concurs with several other recent studies. Rainfall explains a significant, but limited part of the observed landslide pattern and becomes insignificant when also rockfalls are considered. This may be explained by the fact that a significant fraction of the mapped rockfalls occurred in the Sahara desert. Overall, both maps perform well in predicting intra-continental patterns of mass movements in Africa and explain about 80% of the observed variance in landslide occurrence. As a result, these maps may be a valuable tool for planning and risk reduction strategies.

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LES STRATEGIES D'ADAPTATION FACE AU RISQUE D'INONDATION DANS LES ZONES D'HABITAT SPONTANES DE OUAGADOUGOU, BURKINA FASO

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A Ouagadougou (Burkina Faso), les difficultés économiques d'accès à la terre conduisent des populations à occuper des zones d'habitats spontanés comparables à des bidonvilles (zones aussi appelées « non loties »), dépourvues d'équipements publics. Ces quartiers furent durement touchés par l'inondation du 1er septembre 2009 en raison de la nature précaire des matériaux de construction. Cette étude analyse l'impact des stratégies d'adaptation locales sur la résilience de ces populations soumises au risque d'inondation. Au niveau individuel, la migration reste le meilleur moyen pour augmenter durablement la résilience, mais en son absence, la protection de l'habitat est privilégiée. Au niveau collectif, ce travail souligne l'importance du secteur associatif, de l'entraide collective entre voisins et des actions de sensibilisation, qui viennent comme complément indispensable à l'assistance fournie par la mairie. Ces formes d'adaptation ne semblent cependant pas durables en raison du manque de moyens financiers dont dispose chaque acteur. Une réinstallation organisée par l'Etat semble par ailleurs être une prévention efficace, à condition que les populations concernées soient inclues dans un processus de concertation, afin de ne pas répéter les mêmes erreurs que celles commises lors de la relocalisation des sinistrés de 2009.

Keywords: Inondation, adaptation, relocalisation, Ouagadougou, Burkina Faso

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RISK MANAGEMENT IN IVORY COAST: CASE STUDY OF POPULATION EVICTIONS IN PORT-BOUËT, ABIDJAN

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Beginning in 2011, the State of Ivory Coast decided to evict populations in risk zones of the Autonomous District of Abidjan in order to reduce the impacts of natural disasters. The last major eviction operation concerned the cleansing of the coastline in the Port-Bouët commune, threatened – acccording to authorities – by the advancement of the sea. This paper aims to analyse the evolution of the coastline in the commune of Port-Bouët during the period 2001-2016 and to measure the surface area of zones evacuated by the authorities in October 2014. The coastal dynamics and the surface area of the evacuated coastal zone have been analysed using high resolution spatail images available in Open Access on Google Earth between 2001 and 2016. The diachronic comparison of 29 satellite images shows that the coastline was broadly stable throughout the commune of Port-Bouët over the past 15 years. The eviction at the end of 2014 covered a zone of 10,4 km. The most densely populated area is the destroyed stretch between the main road and the beach, which varies in width between 63 and 289 m. The total surface of evictions is 124 ha. Eviction is synonymous with forced displacement, violent and authoritarian that has direct and indirect consequences on the health, economic and social wellbeing of affected populations. Additionally, the justifications given for the evictions were the threat imposed by coastal erosion in Port-Bouët and the construction of a highway connecting Abidjan to Grand Bassam. However, our analysis proves that the coastal dynamics have been relatively stable over the past 15 years. The government's arguments are therefore unsubstantiated. What's more, the forced displacement of these populations should respond to a number of requirements, such as the Kampala Convention (ratified by Ivory Coast) that guarantees the protection of people internally displaced by natural disasters, development projects or armed conflicts. The Ivory Coast has therefore agreed to « carry out a just and equitable compensation, and to provide forms of reparation, if need be, to displaced persons for the damages resulting from displacement ». Clearly, this has not been respected.

Keywords: Shoreline erosion, maladaptation, population displacement, Abidjan, Ivory Coast

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ASSESSING THE IMPACTS OF FARMING PRACTICES AND SOIL AND WATER CONSERVATION MEASURES ON SOIL EROSION IN SOUTH-KIVU, EASTERN D.R. CONGO

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In South-Kivu (eastern DR Congo), soil erosion by water is a major cause of land degradation, but farmers' attitude toward this problem may vary depending on their living contexts. A better understanding of farmers' knowledge regarding soil erosion and soil conservation measures is a prerequisite for implementing resilient erosion control measures. A survey was conducted in four territories in the highlands of northern South-Kivu to assess farmers' knowledge of soil erosion, to document existing soil and water conservation measures, and to identify adoption constraints. The study was based on a semi-structured questionnaire involving 720 respondents. Data were analysed using descriptive statistics, correspondence analysis, analysis of variance, and quantile regression. Results show that more than 60% of farmers distinguished six or more erosion indicators, among which the most important were presence of gullies, decrease of topsoil thickness and loss of organic matter. In spite of their more common occurrence, rills were seldom perceived as important erosion indicators at all studied sites. Farmers were largely unaware of the potential impact of their crops and cropping practices on erosion, but the perceived impacts depended significantly on their living places (p<0.0001). Most SWC measures identified by farmers were perceived as little to moderately efficient. In spite of their awareness of some SWC measures, the level of adoption was very low (21%). Small farm size, insufficient access to credit and labour, and unsuitable equipment (e.g., hand-hoe and machete) were the main constraints for adoption. Finally, we observed that the lower the soil fertility, crop productivity or SWC measures indexes, the higher the erosion index. Future interventions need to raise awareness among farmers regarding their role in soil degradation, to carefully consider the experimentation and adaptation of new technologies and finally, and to create a policy and institutional environment that stimulates widespread adoption of SWC techniques.

Keywords: Cropping practices, eastern DR Congo, soil erosion, SWC measures, South Kivu, watershed

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VULNERABILITE ET ADAPTATION DES COMMUNAUTES LACUSTRES AUX INONDATIONS A SO-AVA DANS LA BASSE VALLEE DE L'OUEME AU BENIN

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Les inondations qui se sont produites sur les rives du Lac Nokoué (sud du Bénin) au cours de ces dernières années ont occasionné des destructions sans précédent. Si les dégâts matériels sont souvent considérables, la santé des populations est également sérieusement affectée du fait de la résurgence des maladies hydro-fécales, du paludisme et d'infections diverses. Cette étude évalue la vulnérabilité des populations lacustres de la commune de Sô-Ava et leur capacité d'adaptation aux inondations. La démarche méthodologique utilisée a consisté à la recherche documentaire et à la réalisation d'enquêtes en milieu réel. L'analyse des résultats a été effectuée par l'application du modèle d'analyse FFMO. Cette démarche a permis d'appréhender les facteurs naturels et anthropiques qui aggravent la vulnérabilité des populations lacustres aux inondations dont les conséquences se manifestent par les crues de la rivière Sô et du lac Nokoué, les pluies intenses, le comblement du lac, l'utilisation d'engins de pêche d'acadia prohibés, l'installation grandissante des populations dans des zones impropres à l'habitation, etc. Face à cette situation, les populations de Sô-Ava ont développé des méthodes endogènes pour réduire leur vulnérabilité aux inondations. Cependant, il appert que ces stratégies d'adaptation relèvent d'actions momentanées et non durables. Pour cette raison, ce travail propose une approche de gestion intégrée des crues et des inondations dans la commune de Sô-Ava afin de réduire les vulnérabilités des populations lacustres.

Keywords: Inondation, populations lacustres, vulnérabilité, adaptation, Sô-Ava, Bénin

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SOCIAL MULTI-CRITERIA EVALUATION TO IDENTIFY APPROPRIATE LANDSLIDE RISK REDUCTION MEASURES: APPLICATION FOR THE RWENZORI MOUNTAINS, UGANDA

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In 2015, the Sendai Framework for Disaster Risk Reduction (DRR) urgently called for more investment in DRR because the global exposure of persons and assets to natural hazards, like landslides, has increased faster than that vulnerability has decreased over the past decades. Recent study has exposed the lack of scientific evaluation data for selecting landslide risk reduction measures, e.g. in the form of cost-effectiveness, cost-benefit or multi-criteria analysis. The objective of this article is to develop a participatory methodology framework for identifying appropriate landslide risk reduction measures based on shared local and scientific knowledge. More specifically, this article proposes a two-phased social multi-criteria evaluation which combines a participatory multi-criteria analysis with an institutional analysis for its design and a discourse analysis for interpreting its outcomes. This article provides results from the field testing of this methodology framework in the Rwenzori Mountains region (Uganda) to illustrate both its usefulness and practical challenges. This article contributes to the scientific literature on decision-making for disaster risk reduction as it proposes a social multi-criteria evaluation to support decision-making. It also contributes to the understanding of landslide risk management in the Rwenzori Mountains as it presents the first attempt to identify appropriate landslide risk reduction measures for the region.

Keywords: disaster risk reduction; decision-making; mass movements; multi-criteria analysis

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GULLY EROSION IN KINSHASA: HYDROMORPHOGENIC DYNAMICS AND DEVELOPMENT OF PREVENTION TOOLS

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Soil erosion has multiple linkages to land planning, environment changes and urbanization in developing countries. Gully erosion is also reported as an emerging hazard connected with the rapid development of Sub Saharan towns in Africa. Since the start of urbanization at the end of the 60s', the high town of Kinshasa (DR Congo) has been the place of an important gully erosion. Here we show that in 2007, Kinshasa is affected by 308 mega-gullies having 94.7 Km of cumulated length. The accumulated length evolution between 1957 and 2010 is exponential. The gully density varies from 0.4 to 2 Km/Km². The average depth and width are 7 and 21 m respectively. The causal relationship between urbanization and gullying shows that gullies develop with a delay of less than ten years after the built up of urban sectors lacking an adequate drainage system. There are nearly no gullies outside of the urban zones. Analyzing the gully distribution and morphology with regard to the local topography and the road network, we found that the spatial occurrence of the mega-gullies (width≥5m) in this newly urbanized environment is controlled by two factors. First, there is a topographic control, given by the relation $S= 0.00008A^{-1.459}$, with S being the slope gradient (mm^{-1}) of the soil surface at the gully head and A the drainage area (ha) above the head. There is also a 'road' control, expressed by $S= 22.991Lc - 1.999$, with Lc being the cumulated length of roads in the basin above the gully head. The co-existence of both controls reflects the fact that the local sands are highly permeable and hence roads are the most important generator of continuous runoff. The S–A relation noted above should not be applied outside the town where the road network is less dense. In contrast, the S–Lc relation may be used in both the town and rural areas underlain by porous soils where roads are the only generators of continuous runoff. We further conclude that the high town of Kinshasa is one of the most vulnerable places for gullying, and gullying can potentially transform the town into badlands. As last step in our investigation, we assess, through field-based measurements, site- and rainfall-specific runoff coefficients to be expected for a given period of the year in the trigger zones of the gullies. We show that different land use/land cover reply in a different way to rainfall characteristics and that these differences due to vegetation cover disappear gradually with decreasing slope. Currently, the critical rainfall for gullying in the high town of Kinshasa is 24.9 mm with a mean intensity of 21.8 mm h-1. Roads generate by far most runoff and, therefore, are considered as the primary reason for gullying. The other soil uses lead most of the time to much smaller runoff coefficients, but their relative contribution to the supply of gullies grows with rainfall increase in height and intensity. The results provide material for gully management and adaptation strategies and open perspectives for the development of an early warning system in the region of Kinshasa.

Keywords: Kinshasa, urbanization, topographic control, rainfall intensity, runoff, gully erosion

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KARSTIC PHENOMENA OF THE BOUKADIR-CHLEF. GEOLOGICAL, HYDROGEOLOGICAL AND MINERALOGICAL CHARACTERIZATION

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Calcareous environments occupy 10% of the surface of the globe (continents and seas),. The fragility, dissolution and rapid evolution of these formations constitute, in addition to the occurence of the karstic forms, a major risk and a potential hazard for the equilibrium of these grounds and more specifically for the infrastructures.

Carbonate rocks are also present in the Mediterranean Basin and represents, depending on the country, about 30 to 70% of the surface area.

The karstic formations also occur in Algeria. Among the best examples observed across the national territory are the ones found in: Tlemcen (karstification well developed at depth) and Saida (karstification well developed at the surface), the calcareous ridge of Djurdjura, Jijel...

The region of Boukadir situated in the northern piedmont of Ouarsenis is the location of karstic forms and has witnessed the occurence a large collapse of the national road RN4 linking the wilaya of Algiers to Oran in 1988. However, this region has never been defined as a karstic region.

For a better understanding of these phenomena, it’s essential to catalog and create an inventory of karstic forms developed in this region, to analyze in detail the geology and hydrogeology, using different tools such as : geological maps, drilling and different stratigraphic logs, aerial photography, hydrogeological and piezometric data, and of course, confirm all with a mineralogical study which is based on a morphoscopic analysis of thin sections and a diffractometric examination (DRX) of the samples collected around this locality.

The Analysis and evaluation of this hazard is therefore dependent on the knowledge and study of the geology and hydrogeology of these lands, and especially the detection of the location of this phenomenon.

Keywords: Algeria, Boukadir, Karstic region, Geology, Hydrogeology, Mineralogy

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UNDERSTANDING WATER LEVEL FLUCTUATIONS IN (SEMI)CLOSED MARGINAL GRABENS UNDER A FAST GROWING IRRIGATION DEVELOPMENT OF NORTH ETHIOPIA

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Water resources safeguard livelihoods of pastoralists and farmers at the western margin of the Rift Valley in north Ethiopia. However, poor knowledge of water resources and their availability hampers good governance in the closed basins. Therefore, this study investigated the condition of water resources in the marginal grabens. We monitored and analyzed the water level of observational wells (n= 46) springs (n=80), river baseflow (n=14) and endorheic lakes (n=3); from 2015 to 2017. The study shows that the western escarpment stretching from Aba'ala to Kobo basins are the main recharge areas to the marginal graben bottoms well beyond the eastern horsts. Western mountains showed a higher concentration of springs and river flows (95%). Moreover, the baseflow at the outlet of the Kobo sub-graben (573 km2) and Aba'ala graben (553 km2) are 185x106 m3 and 18332 m3 respectively. Unlike the outlet of Aba'ala, baseflow at the Mehoni-Alamata and Kobo basins flows through out the year. This indicates that the volume of baseflow is greater at the outlets of basalt grabens than the limestone grabens. Groundwater, springs, streams/rivers and closed lakes also showed rapid fluctuations in water level as a response to human abstractions and high evapotranspiration in dry seasons. To conclude, surface and subsurface water resources in the marginal grabens showed variability both in time and space, and this could severely challenge the future livelihoods of the marginal graben communities. Thus, integrated catchment management is required to support the present fast growing irrigation agricultural development in the marginal grabens of north Ethiopia.

Keywords: springs, baseflow, diver, hydrograph, escarpment, Ethiopia

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CONTEXTUAL ANALYSIS OF ALGERIAN FLOODS BETWEEN 1921 AND 2016

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By 2050, 80% of the population will be an urbanized population that will request the expansion of urban territories to new areas, especially peri-urban areas. In Algeria, the population has grown (increased) from 11 million in 1961 to 41 million habitants in 2016 with a prediction of 54.5 million habitants in 2050. In a space territory exceeding two million km², its occupation is completely heterogeneous and it is characterised by a polarity in the north of the country. 1.9% of the territory which represent the coastal strip is occupied by 36.5% of the Algerian population [National office of statistics, RGPH 2008], which involves either a densification of the urban fabric or an urban expansion. These two phenomena are the cause of a high vulnerability to hazards. In our case, floods, the first listed hazard by its direct impacts on the population, causing the largest losses and injuries recorded in Algeria (870 deaths during the exceptional event of November 2001 in Algiers). Therefore, the management of this risk in urban area is necessary. Our proposition consists to find solutions for a proper risk area management by looking for the problem at the sources. This finality depends first on a good contextual analysis of recorded events between 1921 and early 2017.

Keywords: Algeria, floods, population, urban area.

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RECENT EVOLUTION OF THE COASTLINE IN THE GULF OF GUINEA. EXAMPLE OF TOGO AND BENIN (2000-2015)

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The land-sea interface is an extremely fragile environment. On a global scale, coastlines are threatened by a multitude of factors sometimes natural and mostly anthropogenic. Thus, in addition to the disruptions to coastal areas by port facilities, dams, sediment sampling on the beach or urban sprawl, there are the consequences of climate change, including rising sea levels. The objective of this study is to assess recent trends (between 2000 and 2015) of the coastline in Togo and Benin where more localized studies show that sandy beaches are experiencing major changes (accretion or erosion) in recent decades. Coastal dynamics are analyzed using very high spatial resolution images available in open access on Google Earth; the coast is studied by section of 1 km on a coastline of 170 km (pk1 to pk170) by calculating the average change in meter per year since 2000. Analysis of coastal Togo and Benin shows that only 34% of the coastlines (often protected) are stable and that accretion is recorded only upstream of harbor infrastructures (14%). Elsewhere, coastlines undergo erosive processes (52%), sometimes exceeding annual average retreats of 10 m / year. In such conditions, villages have disappeared during the past decade and a large number of people have been displaced.

Keywords: Shoreline erosion, maladaptation, population displacement, Togo, Benin

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REMOVAL OF IMPURITIES RELEASED FROM PHOSPHOGYPSUM WASTE IN AQUATIC ENVIRONMENT USING BENTONITE

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Phosphogypsum (PG), CaSO4,2H2O, is an acidic residue derived from the phosphate industry produced in very large quantities. Phosphogypsum is mainly calcium sulfate dihydrate, it contains elevated amount of impurities that originated primarily from the phosphate rock used for the production of phosphorus fertilizers. Large quantities are produced world-wide and are being thrown out on the seas, thus causing adverse effects on marine environment. It is known that PG causes disturbances, mainly chemical pollution of the aquatic environment (e.g. phytoplankton efflorescence and continuous regressions of *Posidonia herbarium*).

In order to fully understand the environmental impact of phosphogypsum, it is necessary to understand the geochemical processes that control the composition of phosphogypsum leachates and the attenuation of environmentally sensitive chemical species when these leachates enter aquatic environments. The aim is also to use natural adsorbent as raw bentonite to reduce the impact of the acidity and heavy elements on the environment. For that purpose, XRD, XRF, LOI and ATD/TG analyses were performed on raw bentonite (B). Afterwards, in distillated water, we mixed 10g of different proportion of PG and bentonite ($0\% \leq PG/B \leq 100\%$) in order to follow the characteristics of the liquid phase (pH, conductivity, chemical composition ...).

The results indicate that the pH of the solutions containing only PG remain constant, however, for the PG and bentonite mixtures, the environment became more alkaline. A proliferation of algae starts to be observed in the mixture 5PG/5B, and after a long stay in natural conditions, a proliferation of algae is observed in all the mixtures. We note the absence of algae when only the phosphogypsum or bentonite is put in contact with water. Overall, the preliminary results show that the mixture "PG + bentonite" has two important effects: (1) fertilization of the aquatic environment, (2) depollution by trapping of the chemical impurities released by the PG into the solution.

Keywords: Phosphogypsum, Bentonite, Waste recycling, Valorization, Aquatic environment.

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RECENT ROCK FALLS ON MT BAKER, RWENZORI MOUNTAINS (UGANDA, D.R. CONGO): AN EXAMPLE OF LANDSLIDE RECONSTRUCTION IN A REMOTE, RUGGED, DATA-POOR MOUNTAIN ENVIRONMENT

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Landslides are a common process in many tropical humid regions, where intense rainfall, associated with steep topography, can lead to severe erosional rates and mass wasting. This often results in high vulnerability to natural hazard, notably through crop, property and infrastructure destruction, as well as casualties. Yet, field-based research on landslide dynamics remains a challenging effort in these regions, owing mostly to limited access to funding and to geopolitical and accessibility barriers. For the same reasons, direct, observations of landslides and related processes are often sparse and limited, leaving scientists, in their effort to inventory events and understand their dynamics and impacts on the environment, with an *a posteriori* descriptive and reconstructive approach. This is especially true in Equatorial Africa, where the Rwenzori Mountains (RM), located at the border between Uganda and the Democratic Republic of Congo, represent a striking example of this situation. With heights of 4-5 km and with rainfall exceeding 2000 mm per year, RM are subject to recurrent landslides of various forms. RM also host some of the last African glaciers. The latter being sensitive indicators of regional and global climate change, their >80% recession during the last 100 years sheds light on a major climatic shift, with potentially significant geomorphic consequences. With the aim to better assess the potential links between surficial mass movement and climate change in the upper Rwenzori Mountains, we report here on trajectory modelling of rock falls observed on Mt Baker, one of the last glacierized mountain peaks. For the purpose of our work, a high-resolution digital elevation model of the affected terrain was produced by combining UAV and photogrammetrical methods. Landslide pathways and dynamics are discussed in the light of run-out results from STONE, a 3-D physically based landslide model, and of recent glacier trends on Mt Baker.

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MODELLING BLANKET PEATLAND HYDROLOGY AND HOLOCENE PEATLAND DEVELOPMENT IN NORTH-EASTERN SCOTLAND

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Peatlands cover only three percent of the Earth's surface, but contain one third of the global soil carbon stock. Therefore, they are an important element of the terrestrial carbon cycle. However, there are still large uncertainties regarding peatland development and their carbon fluxes and dynamics. To study the long-term peatland processes and feedbacks, different models have been developed in recent years. Unfortunately, these modelling efforts have been mostly restricted to peat bogs in arctic and boreal regions, but for other peatlands types, such as blanket peatlands in temperate climates, the insights in the dynamics are lacking. Hydrology is fundamental to peatland development and an improved representation and understanding of the relationships between climate, hydrology, land cover and peat growth is crucial to better understand the effects of environmental change on peatland evolution and the carbon balance.

Here, a new spatially explicit process-based peat growth model is presented for blanket peatlands, which couples a detailed 2.5D-hillslope hydrology model with a peat accumulation and decomposition module. The resultant model allows to study the hillslope hydrology and blanket peatland development along topographically complex hillslopes over a Holocene timescale. Calibration and validation of the model parameters is based on a dataset of more than 250 peat thickness measurements along several hillslope transects in the headwaters of the river Dee (Cairngorms National Park, north-eastern Scotland). The Holocene land cover evolution was reconstructed based on pollen data, which were converted to land cover fractions using the REVEALS model.

The model results show that the topography-driven hillslope hydrology has a strong influence on the resultant peat development along the hillslope, stressing the need for spatial models in studying peatlands. Model simulations for the studied area result in peat growth initiation dates situated mostly in the period 9000 – 7000 a BP, which corresponds largely to basal calibrated radiocarbon dates for peat deposits in central and north-eastern Scotland. The simulated blanket peat growth initiation occurs before the mid-Holocene forest cover decline. These results indicate that, for the studied area, the blanket peatland development is largely driven by the early-Holocene increases in temperature and precipitation, rather than by an alteration of the hillslope hydrology due to a declining forest cover. The model allows to study the sensitivity of blanket peatlands to changes in environmental factors such as land cover, temperature and precipitation, providing a new tool to study the response of blanket peatlands to the future environmental changes under different climate change scenarios.

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ANALYSE SPATIO-TEMPORELLE DE LA VULNERABILITÉ DE LA POPULATION FACE À L'ALÉA VOLCANIQUE: LE CAS DE GOMA, RÉPUBLIQUE DÉMOCRATIQUE DU CONGO

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Lors de ses deux dernières éruptions, les coulées de lave émises par le volcan Nyiragongo se sont répandues près de Goma en 1977 et dans la ville de Goma en 2002. Pendant ces deux éruptions, les coulées de lave étaient très rapides (plusieurs dizaines de km / h) et ont emportées des centaines des vies humaines. Le nombre très élevé de victimes est le résultat de la grande vitesse de la lave, de sa fluidité et de l'émission des coulées près des zones habitées. De plus, en raison de l'absence de stratégies efficaces de réduction des risques de catastrophe, les conséquences économiques de cette éruption ont été significatives et ressenties sur le long terme, dans cette région densément peuplée qui reste menacée par de nouvelles éruptions.

La ville de Goma est en expansion, tant démographique que spatiale, dans des zones où les aléas volcaniques pourraient constituer à l'avenir un grand danger. En outre, l'étalement urbain, le sous équipement des quartiers périphériques, le manque de capacité financière dans des ménages, etc. accentuent l'augmentation de la mobilité des personnes.

Dans un contexte de rareté des données de localisation de la population et de localisation des ressources essentielles pour la vie (eau, sante, aliments, éducation, etc.), notre étude cherche à discuter de la **distribution spatio-temporelle de la population** et à examiner la **vulnérabilité de la mobilité** de la population menacée par une coulée de lave volcanique.

Le travail a permis en première estimation, de réaliser des mesures de variations d'effectif de la population de Goma, lesquelles se distribuent irrégulièrement sur la journée de la semaine et de manière différente encore le dimanche.

Pour examiner la vulnérabilité de la mobilité, il faut un réseau des routes capable de sélectionner les itinéraires les plus favorables. Pour ce faire, le réseau des routes openstreetmap de Goma nécessitent une validation de type de mobilité, une connectivité des tronçons et une connaissance de l'évolution des vitesses probables sur les tronçons de routes. .

L'étude porte également sur les voies d'évacuation et sur la relation entre le réseau de routes et le bâti et l'expansion urbaine.

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EXPOSITION ET VULNERABILITE FACE AUX RISQUES D'INONDATION AU BURKINA FASO : CAS DE LA VILLE DE DORI

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La ville de Dori, située à la lisière du Sahara, connait fréquemment des inondations dues à des stagnations des eaux de pluies à l'intérieur de la ville et du débordement de la grande mare. Certaines mesures structurelles sont prises par la ville pour réduire la vulnérabilité aux inondations à l'intérieur de la ville mais il n'en demeure pas moins que ces mesures sont insuffisantes au regard du risque de débordement des eaux que cette grande mare qui ceinture la ville à 75% de son périmètre et l'expose encore aux risques d'inondation. L'objet de cette étude est d'analyser les causes des inondations dans la ville de Dori, d'évaluer sa vulnérabilité aux inondations au travers d'indicateurs pertinents qui interagissent à la fois entre les facteurs de vulnérabilité d'exposition, de susceptibilité et de résilience et les composantes de la vulnérabilité sociale, économique, environnementale et physique. Une autoanalyse de la vulnérabilité par les populations par zone à risque d'inondation dans la ville est réalisée pour mieux explorer les spécificités de la nature de la vulnérabilité de ces zones exposées aux risques d'inondation. Cette analyse a permis de mettre en exergue une conjonction de phénomènes environnementaux, climatiques et surtout anthropiques à l'origine des inondations à Dori. Ce couplage – en plus d'être une méthode d'analyse de la vulnérabilité – donne un avantage de comprendre, au-delà des indicateurs globaux entrant dans la détermination de l'indice de la vulnérabilité aux inondations de la ville, les spécificités des zones à risque et les stratégies individuelles et collectives de réponses face aux inondations. L'évaluation de vulnérabilité aux inondations à travers diverses méthodes utilisées permet aux décideurs de comprendre la vulnérabilité sociale, économique, environnementale et physique afin de mieux cibler les actions de mitigations à travers une gestion intégrée des risques d'inondation par des approches mixtes et contextualisées aux réalités des villes moyennes pour tendre vers des villes sures et résilientes dans un contexte de transition démographique accentué par la décentralisation.

Keywords: Inondation, indice de vulnérabilité, résilience, Dori, Burkina Faso

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CONSTRAINING EXPOSURE AGE AND EROSION RATES OF THE KEMPEN PLATEAU OVER THE LAST 1 MA

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The Kempen plateau (N-E Belgium) is a high-standing plateau built of fluvial sediments. This area is in erosive regime since the last 0.5 to 1 Ma. The inverted topography of the plateau is the result of differential erosion, and the positive relief can be used as proxy to reconstruct topographic evolution of the surrounding Kempen region over the last 0.5 to 1Ma. The aim of the research is to constrain surface exposure age and past erosion, along with potential burial episodes, of the Kempen plateau over the last 1Ma. Further questions will ask whether erosion of the Kempen Plateau was triggered by opening of the English Channel and whether uplift of the Ardennes enhanced erosion at the eastern its eastern margin.

To do so, cosmogenic radionuclide (CRN) datings are applied. Exposure age and denudation rate of the surface will be constrained based on ^{10}Be depth-profiles. Three lithological units (Zutendaal Gravels, Lommel sands and Winterslag sands) were sampled on the Kempen Plateau. Depth profiles contain > 10 depth-integrated samples. The CRN concentration of the sediments will be measured at the AMS facility of ETH-Zurich.

A Bayesian inversion of ^{10}Be concentration depth-profiles is performed to infer the couple erosion rate-exposure age, along with inherited ^{10}Be. Addition to Bayesian inversion model of other CRN concentration-influencing parameters are also developed. These parameters are investigated in a physically-based model encompassing several CRN production pathways and dynamically adjusting CRN concentrations as a function of variable denudation, burial, density and exposure duration. This allows the development of scenarios on complex post-depositional histories. Sensitivity analysis is performed on the model to identify the parameters that significantly influence the CRN concentration, which are then implemented in the Bayesian inversion.

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EFFECTIVENESS OF PLANT ROOTS IN CONTROLLING RILL AND GULLY EROSION: A CASE STUDY ON VEGETATION COMMUNITIES ON RIVER DIKES

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An important ecosystem service of plant roots is their potential to control concentrated flow erosion rates. The objectives of this study are: i) to explore the overall trends in soil erosion reduction as a function of root density (RD, kg m^{-3}) and root length density (RLD, km m^{-3}) based on a meta-analysis of experimental data and ii) to use these trends to assess the effectiveness of 5 dike vegetation communities in controlling soil erosion rates during concentrated runoff. The latter is of great importance as predicted climate change, and the associated sea level rise, poses an increased threat of flooding due to wave overtopping events at sea and river dikes, possibly resulting in erosion of these dikes.

The decrease in soil detachment ratios (SDR; i.e. the ratio of soil erosion rates of a root-permeated soil sample and a bare soil sample) as a function of RD and RLD could be best described by a Hill curve model. As a large scatter in the experimental data is observed, uncertainty ranges were calculated using a Monte Carlo approach. The application of the resulting relationship between RLD and SDR to the selected dike vegetation communities showed that there were large differences in the erosion-reducing potential of these vegetation communities. These can be attributed to large differences in RLD due to the presence or absence of *U. dioica* which has thick rhizomes. As a result, concentrated flow erosion rates of the topsoil (0-0.05m) are likely to be reduced to only 22-30% of the erosion rates for root-free topsoils if *U. dioica* (i.e. nettles) is present compared to 13-16% for vegetation communities without *U. dioica*. This study illustrates that the overall trends in soil erosion reduction based on root characteristics can be used to assess the likely erosion-reducing effects of vegetation communities.

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SPATIAL DISTRIBUTION OF ROCK FRAGMENTS IN PURPLE SOIL IN THREE GORGES RESERVOIR AREA

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The existence of rock fragments is one important features of purple soil. However, the variation in rock fragments on purple soil-mantled hillslope is poorly understood. In order to understand the spatial distribution pattern of rock fragments in purple soil, a typical catena which contained both a relatively steep slope and a relatively gentle one was selected. Ten pedon pits on hillslope from crest to foot were selected and the content and size of rock fragments of soil layers varied in depth at different position of hillslope were investigated. Results show that: (1) the rock fragment content of purple soil varied in 0.4%~50%. The small rock fragments with diameter of 5~20 mm and medium rock fragments with diameter of 20~76 mm were the main components. (2) With increasing depth of soil layer, the total content of rock fragments increased as soil layer deepened and the equivalent diameter of rock fragment enlarged. (3) On the relatively steep slope, the content and equivalent diameter of rock fragments increased from crest to foot. On the relatively gentle slope, the content and equivalent diameter decreased from crest to foot. We can concluded that vertical distribution of rock fragments within soil column was determined by pedogenic process and the depth of soil layer significantly influence rock fragment content, rock fragment size and content ratio of rock fragments with different diameter, while slope-scale variation of rock fragments depended on dominant hillslope transport process, i.e. water erosion processes or gravity erosion process.

Keywords: Rock fragment content; Rock fragment size; Vertical variation of rock fragment; Slope-scale variation of rock fragment

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THE AFRICAN ANTHROPOCENE: LAND-USE HISTORY IN THE CENTRAL RIFT VALLEY OF KENYA BASED ON ANALYSES OF CLAY MINERALS, PARTICLE SIZE AND CHARCOAL IN A CONTINUOUS LAKE-SEDIMENT RECORD

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The dramatic rise of human impact on the Earth's natural environment has encouraged introduction of the Anthropocene as a new formal unit in the geological time scale. Yet it is unclear since when humans have been modifying geological processes in such a way that stratigraphic signatures of the Anthropocene differ significantly from those of the preceding Holocene. In the 'early Anthropocene' scenario, it coincides with the onset of extensive land-cover change marking the historical spread of agriculture and animal domestication. At the other end of the spectrum, the 'Great Acceleration' scenario stresses the strong mid-20th century increases in human population, alteration of natural processes, and the spread of new synthetic materials. Defining the Anthropocene is complicated by great variability in the onset of significant human impact among continents and regions. Moreover, in several regions such as East Africa, precious little is known about the history of human impact on natural ecosystems, making definition of the Anthropocene's 'base level' even more difficult. We conducted high-resolution, multi-proxy analyses on the sediment record of Lake Bogoria in central Kenya to unravel both the timing and relative magnitude of historical land-use change in its 700 km^2 rift-valley catchment. Lake Bogoria is one of the few Kenyan lakes that did not dry out during the severe late-18th and early-19th century Mahlatule drought, and hence its sediment record provides an uninterrupted archive of past environmental change. This presentation focuses on evidence of past vegetation clearance and soil erosion, deduced from the stratigraphic distribution of clay minerals, the size of clastic particles and charcoal along with well-constrained data on dry-sediment accumulation rates supported by ^{210}Pb, ^{137}Cs and ^{14}C dating.

From the early 17th century to ~AD 1800, dry climatic conditions prevailed (De Cort et al. 2017 *Sedimentology*), rendering the Lake Bogoria region unattractive to both farmers and pastoralists. The dominant sediment source during this period were relatively coarse-grained, well-drained catchment slopes with illite clays immediately surrounding the lake. After the 'Mahlatule' drought ended in the early-19th century, farmers started to clear forest and woodland areas for cultivation by setting fire. This destabilized clay-rich smectite-kaolinite soils in headwater areas of the catchment, through which the Sandai-Waseges river flows before entering Lake Bogoria. River inflow thus became the dominant sediment source, reducing the importance of riparian catchment slopes; however, human activity was still too low to significantly alter total sediment accumulation. Also the magnitude of anthropogenic biomass burning at that time, while substantial, did not exceed natural variability at the multi-decadal time scale. Following ~60 years of relatively stable land use with little biomass burning, at the start of the 20th century both charcoal fluxes and sediment accumulation start to increase gradually. Both accelerated from AD 1970 onwards, presumably triggered by the land redistribution following Kenya's Independence in 1963. Since the early 2000s sediment accumulation has increased further to >10 times its base level, reflecting the severe land degradation and soil erosion associated with intensified land use, whereas biomass burning has fallen back to early 20th-century levels.

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CONTRIBUTION DES SYSTEMES D'INFORMATION GEOGRAPHIQUE POUR LA CARTOGRAPHIE DES ZONES A RISQUES D'INONDATION A YAOUNDE

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La ville de Yaoundé est exposée à une gamme de risques naturels au rang desquels les inondations sont importantes. La fréquence de celles-ci est très élevée. En effet, de 1970 à 2016, 171 inondations ont été recensées. Ces inondations ont causé de nombreux dégâts matériels, environnementaux et plus de 70 pertes en vies humaines. Au cours de cette même période, on a enregistré une diminution de la pluviométrie annuelle de 9,2 % (-146 mm) tandis que la surface imperméabilisée par le bâti a été multiplié par dix entre 1956 et 2010 (de 3,16 à 31,53 km²). Ceci suppose que le rôle de l'homme s'est amplifié dans la genèse des inondations, principalement à travers l'urbanisation et ses corollaires (occupation des zones inondables, dysfonctionnement des ouvrages d'évacuation des eaux, etc.). Le but principal de ce travail est d'utiliser les possibilités qu'offrent les Systèmes d'Information Géographique pour cartographier et quantifier les zones inondables ainsi que les enjeux humains menacés. Pour atteindre cet objectif, une approche méthodologique par combinaison multicritères des cartes dérivées du MNT et de l'hydrographie a été opérée grâce au Model Builder d'ArcGIS. Il ressort que 86,17 km², soit 30,5% de la superficie de la ville, se retrouvent dans les zones à fort et très fort risques d'inondation, tandis que 9,23 km² (26%) du bassin versant du Mfoundi est exposé au même niveau de risque. La quantification des enjeux menacés a été effectuée à travers le croisement des couches de données et les requêtes spatiales, donnant un bilan de 62 126 bâtiments potentiellement inondables, soit une population à risque de 186 378 habitants en considérant 3 peronnes par ménage. En outre, 318 km de routes et des centaines d'équipements socioéconomiques ont également été répertoriés dans les zones potentiellement inondables. Face à ces menaces, des mesures de prévention, de protection et de préparation ont été déployées par la Communauté Urbaine de Yaoundé, les ONG, et les populations à risque pour gérer les inondations. Ces aménagements très localisés dans l'espace et le temps n'ont fait que réduire les risques temporairement. En effet, la défaillance des ouvrages d'assainissement pluvial et d'évacuation des eaux, la carence de l'entretien régulier des ouvrages hydrauliques, et le laxisme de l'Etat dans les politiques d'occupation des zones inondables sont autant de maux qui viennent s'ajouter aux facteurs naturels pour amplifier les risques d'inondation.

Keywords: Inondation, cartographie, SIG, Yaoundé, Cameroun

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Urban, Economic and Rural Geography Session

Oral presentations

CONTESTED ENTANGLED GEOGRAPHIES: CHALLENGES AND RELEVANCE OF BELGIAN HUMAN-GEOGRAPHICAL RESEARCH

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One of the classic contradictions in geographical thought is that all regions are unique, yet these regions are produced and sustained by geographical processes that are not unique at all. In Belgium, this contradiction is compounded: not only have the Belgian regions (Flanders Wallonia, Brussels) been produced by economic-, political-, and cultural differentiation; the spatial interactions and processes that shape regions in Belgium are inter-regional, thoroughly entangled, and tend to change over time. As metropolization dynamics have intensified since the early 2000s, Brussels once again shows symptoms of being an integrative force of a profoundly Belgian space-economy. However, Belgian society has produced a set of regional institutions that have solidified boundaries at regional scales. This enduring focus on regionalization is somewhat in tension with these renewed centripetal tendencies and commonly result in distinctive Belgian geographical patterns of union-in-diversity. More problematic from a research perspective is that regional institutions have created sets of statistics and knowledge structures that tend to obscure distinctively Belgian geographies to see the light of day as we are discouraged to collect data, think and map processes on the Belgian scale. Critically inclined human geographers have a duty to reduce the amount of illusion in the world and in the case of Belgium that means we have to be creative in research questions, research methods, data collection and analysis to depict the Belgian scale for those processes in which it is relevant.

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URBAN GEOGRAPHY AT THE HEART OF THE URBAN TRANSITION

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The global South is now in the heart of its urban transition. This evolution brings great challenges and knowledge arising from urban geography can definitely contribute to the management of a mutation that will strongly impact the future of Mankind. It is in this perspective that we will present the "making room paradigm" formalized by Shlomo Angel and that we will analyse how the work of urban geographers can be integrated into this framework.

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WHO'S THE 'GREEN' FOR? THE SOCIAL INCLUSION/EXCLUSION OF URBAN RENEWAL PROJECTS: THE CASE OF THE 'ABATTOIRS D'ANDERLECHT', BRUSSELS

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Over the past decade, the concepts of 'green' and 'circular' economy have increasingly gained traction in public discourses, programs and policies in Europe. Based on the idea of boosting economic growth while solving major environmental problems, these concepts were translated into diverse urban development projects, having distinct impact on the economic and sociospatial structure of these cities.

The site of the Abattoir and food market of Anderlecht - a 10-ha remnant of the industrial past located in a poor inner-urban neighbourhood of Brussels - represents one of these 'urban (re)development projects' attracting a lot of interest and generating debate for many years now. The private company who owns the site has benefited of EU and Regional funding (the ERDF - European Regional Development Fund) for the implementation of an ambitious masterplan which pro-poses a global reorganisation of the site: relocation of the existing slaughterhouses into a new mixed-use building hosting various other activities related to the food sector, creation of a large public 'playground', promotion of sustainable real estate developments, creation of an urban roof-top farm based on 'smart' agriculture…. The company's foremost concern is to enhance greening as well as openness and adaptability of the site.

On the other hand, the food market held on the site, by far the largest and cheapest one in Brussels, keeps up a long-existing complex network of formal and informal relationships among its users. It enables market vendors, immigrants, low qualified workers and volunteers to equally engage in a variety of economic and social activities ranging from selling to recovering and recycling food and goods, while the surrounding neighbourhood of Cureghem offers a shelter and home to newly arrived immigrant families. In this respect, the Abattoir site represents a truly inclusive and hospitable place, particularly to disadvantaged or marginalised population groups.

A main question thus arises: how may the restructuring of the area, promoted under the label of EU policy strategy for a 'smart, green and inclusive' development, affect this complex but vulnerable social network? In how far may the upgrading process weaken the site's capacity to host, invite, allow or ease less formalised activities and its appropriation by different population groups? How, in return, may the stakeholders in charge of the Abattoir site better integrate and even in-crease the level of social justice by taking into account this complex 'ecosystem' and by developing new planning approaches which address urban change and the major environment and re-source issues without undermining the existing social fabric?

My aim is to present the results of a transdisciplinary investigation (made through a series of fieldworks, interviews, etc.) led on the Abattoir site in order to question its potentially changing inclusive character (for people and uses). This critical analysis crosses the environmental policies that underlie urban transformation processes with the realities embedded in this complex urban 'ecosystem'.

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GAMES TO UNDERSTAND URBAN PLANNING

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Planning is not anymore seeing as a neutral concept. During a long period planning has been conducted as a technical activity only. Nevertheless, space "*is no longer a neutral category as it was between the 1960s and the 1980s that is viewed as a container for economic and social processes, but is rather the result of social relations among people living in a certain area or region where culture and cultural influences play a crucial role*"(Knieling & Othengrafen, 2009, p. xxiii). Planning is indeed deeply depending on cultural context of a country and a region. Since the 1990s, the term planning culture covers comparative spatial planning research. This concept can be define as "*the collective ethos and dominant attitudes of planners regarding the appropriate role of the state, market forces, and civil society in influencing social outcomes*" (Sanyal, 2005, p. xxi).

To date, planning culture literature concentrates on listing the observations and expert analyses. Our goal is to operationalise this concept as a set of values and attitudes shared by a particular group of people. For this purpose, we use experimental economics to gain empirical evidences on planning practices.

Our presentation will be structured in three parts. At first, we will develop the concept of planning culture and illustrate it by the comparison of planning in Belgium and in the Netherlands. Despite many common characteristics, planning in those two countries strongly differs. On the one hand, both countries are densely populated and their territories are relatively similar. Although, on the other hand, their urban form are highly contrasted. Indeed, Belgium is characterized by an extreme sprawl whereas Netherlands has controlled the sub-urbanization processes.

The second part of our presentation will be dedicated to the explanation of experimental economics. Experimental economics are experiments motivated by economics questions. "*Experiments are a controlled data generation process. 'Control' means that most factors which influence behaviour are held constant and only one factor of interest (the "treatment") is varied at a time*"(Croson and Gächter, 2010, p. 124). To illustrate the field, we will realise an experiment in real time with the audience.

Finally, we will finish our presentation by presenting some results of our current research that intends to objectify the role of planning culture in urban development. Based on experimental economics, our research aims to study the risk aversion as well as the importance of trust and cooperation in the development of partnership. To do so, we have organized four experiments with urban planning stakeholders in three different countries: Belgium, the Netherlands and Norway.

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DETECTION AND SIMULATION OF URBAN SPRAWL AND SOCIAL SEGREGATION IN PARAMARIBO, SURINAME (1987-2030)

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In this paper a method is proposed to assess and analyze the urban expansion and the corresponding social segregation within the Greater Paramaribo Region, Suriname. The Built-Up expansion between 1987 and 2015 was assessed via remotely sensed Landsat images. To gain insight into the population within this urban system, a visual analysis of Google Earth images was conducted. Based on a differentiation of spatial characteristics, the residential Built-Up area was categorized into the categories 'Rich', 'Middle', 'Middle to low', and 'Poor' residences. An assessment was done about where different residential groups end up within the urban landscape. By means of an entropy indicator the social segregation was measured. Through logistic regression modeling, a business-as-usual scenario for the year 2030 was simulated, where the future built-up expansion and the type of residential built-up area were assessed.

The results show that the urban expansion between 1987 and 2015 consisted of mainly 'Middle' and 'Middle to low' income residences. These categories were present in all the resorts of the whole Region. Categories 'Rich' and 'Poor' became more segregated throughout the landscape, with the majority of their area lying in resorts in the district Paramaribo. Resort Blauwgrond experienced the most growth in 'Rich' during 1987-2015. Resort Latour had the largest increase in 'Poor' during this time. This segregation of 'Rich' and 'Poor' in Paramaribo is likely to remain, based on the business as usual projection of 2030. Entropy measures of the spatial mixing of the different groups show that the entropy is decreasing pointing at an increasing clustering of social groups. In 1987, Paramaribo had an entropy index of 0.94, while in 2000, 2015, and 2030 the entropy index was 0.72, 0.76, and 0.77. Only the districts of Wanica and Commewijne showed an increasing entropy index which is points at a better mixing of the different social groups.

Overall we can conclude that urban expansion in the Greater Paramaribo Region has not yet led to an extreme social segregation such in many other developing countries but there is a clear trend towards further segregation whereby the north of the city is getting richer and the south is getting poorer. The models developed in this study show that policy makers have some handles to steer the future development of the city by means of road construction or upgrading and the provision of utilities and services.

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ON URBAN BORDERS: THREE METHODS, THREE SOLUTIONS FOR BRUSSELS

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Delineating the urban border is a challenging and important topic for researchers and planners: empirical analyses highly depend on the delineation of the study area and the limits of the cities are of particular interest as they change over time and space (sprawl). Urban governance can't be conducted in an efficient way if urban boundaries are not clearly defined.

Many scientific methods exist to delineate urban borders. They are mainly based on functional and/or morphological criteria. We here limit ourselves to morphological analyses using the footprint of the built-up as sole input. The first two methods deal with "complex theory" and use respectively the **Morpholim methodology** - a geographical application of the fractal theory (Tannier et al., 2011) and, the **Natural Cities methodology** - a topological application of the complex network theory (Jiang and Miao, 2015). The third method is a more classical one using the Euclidean approach: a **Local Density Index**.

Each method leads to specific results (i.e. a different delineation of the urban space). The goal of this analysis is to measure and understand each methodology and where/why are the differences. What do they do exactly and what do they show? Specificities and biases are identified and illustrated using theoretical cities and an empirical analysis is provided on the Brussels Metropolitan Area in Belgium.

Morpholim methodology measures a distance threshold showing a break in the organisation of the built-up at different scales and without any *a priori* delineation of the structure. The presence of a diffuse peri-urbanisation and/or the presence of a built corridor between two distinct urban structures deeply influence Morpholim results. The absence of contiguity in the Natural Cities methodology, and the use of the centroid of ground surface area of the buildings instead of the cadastral details, explain why the Natural Cities methodology ends up with urban spaces that correspond to the clustering of minimum three centroids. The Density methodology is subject to the well-known "Modifiable Area Unit Problem" and is unable to measure the geographic organisation of the footprints of the buildings.

The application of the methods on the Brussels Metropolitan Area allows to confirm that morphologically Brussel sprawls out of its administrative boundary and that each method leads to a different delineation. We already know that the delineation of functional cities deeply depends on the data/method used and that morphological delineations are different from any functional ones (Thomas et al., 2012). This paper further proofs and reminds that method matter for morphological delineations as well and that one is not better than the other; they are simply measuring other things. Indeed, cities can be seen as (1) "hot spots" of buildings (*Natural Cities*), (2) uniform organisations of built-up footprints among heterogeneous patterns (*Morpholim*) or (3) simply as high-density occupation of the space (*Density Index*).

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ORDERING EVERYDAY LIFE CULTURE IN ISTANBUL: PUBLIC MORAL INTERTWINES WITH NEOLIBERAL RESTRUCTURING

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The recent transformation of Istiklal Avenue, known as the cultural hub of Istanbul, has received a widespread attention from media. A great number of newspaper articles highlighted urban transformation while documenting the theatres, movies and bookstores which have been closed down since the last decade of Justice and Development Party (AKP). In this context, questions about the freedoms over lifestyles attracted the attention more than ever before by attaching importance to the analyses situated at the intersection of urban transformation and cultural policies. In this context, this paper explores the ways in which AKP rule shapes the everyday life culture in and around Istiklal Avenue of Istanbul. Therefore, by adopting a semiotic-practical approach to the culture, this research investigates the practices and the forms of visibility created by Beyoğlu Municipality.

Informed by the conceptual vocabulary derived in the empirical work of Dikeç (2012) on French urban policy which refers to the Rancierian notions of 'aesthetic regimes' and 'the partition of the sensible' this paper reflects on what is made visible in Istiklal Avenue. The findings highlight the narrative of 'our culture' introduced by AKP order which tends to position the contemporary art practices as a contested form of the urban culture. Moreover, this paper reveals that spaces of everyday life culture is shaped through the marriage of neoliberal restructuring with the design of a system of moral values legitimised by AKP order with the concept of 'public moral'. This legitimisation therefore allows us to discern the invisible part of the everyday life culture in Istiklal Avenue.

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HOW TO INTRODUCE ENVIRONMENT IN A MIGRATION MODEL ?

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It is now generally accepted that living in a risky environment can lead to migration as well as living under environmental stress causing livelihood scarcity. Defining « the environment » is a source of confusion in migration-environment research. Some results emanate from exploration of the relationships existing between "actual environment" and migration. Others explore the "perceived environment", but they are faced with the numerous challenges to measure perceptions. Finally, the environment can also be seen as a social object that incorporates social data and natural elements with the cultural dimension as central. Emotions that people experience every day in their interaction with their environment are considered here. Three empirical studies will be presented to illustrate the "actual environment", the "perceived environment" and emotions in a migration-environment research.

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TYPOLOGY AND DISTRICTS MAPPING AS WELL AS CONTEXTUAL RISK FACTORS

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Previous work on urbanization in Dakar has highlighted its uncontrolled nature, the growing of spontaneous neighbourhoods and its resulting environmental, health and social problems. In this context, census data are essential for a better understanding of urban dynamics as they provide detailed information on household living conditions at fine spatial scales. The objective of this study is to carry out the mapping and the typology of the districts of Dakar. A principal component analysis based on the 2002 and 2013 census data was conducted on habitat characteristics, education levels, household structure and occupational activity of their members. Overall, the spontaneous habitat covers 30% of the inhabited area of the region and increases from the city centre (3% in the department of Dakar) to the suburbs (e.g. 42% in the department of Pikine). The typology of districts shows an east-west opposition regarding land use, household equipment, access to basic social services and educational levels. The most equipped and wealthiest households are located in the west, in the city centre; while the economically weak are located in the east, in deprived neighbourhoods of the suburbs. However, this classic opposition between downtown area and the suburbs is hampered by the persistence of shantytowns in the historic districts of the east. This study demonstrates the usefulness of census data in the study of spatial heterogeneities and thus the analysis of health risks in urban areas.

Keywords: Dakar, health risks, census data

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ADAPTIVE CAPACITY ASSESSMENT OF WATER MANAGEMENT IN SEMI-ARID AREA AND DETERMINATION OF THE UNCERTAINTIES IN THE SANANDAJ REGION, IRAN

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Iran is experiencing a serious water shortage which is increasingly viewed as a major crisis faced by local communities (Masih, 2011). This includes, but is not limited to, rising water demand, shortages, declining groundwater levels, deteriorating water quality, and increasing ecosystem losses as result of rapid population growth and the unbalanced spatial distribution of the population, inefficiencies in the agricultural sector, mismanagement and desire for development. It is commonly believed that the current crisis is temporary during frequent drought years, climate change, and the international embargo. However, the dramatic water scarcity issues of Iran are rooted in decades of weakening planning policies under a structural-based paradigm (Madani, 2014). This paradigm generally focuses on structural cure of the problem rather than on practical adaptation initiatives that tend to focus on risks caused by a combination of water shortage and other environmental and social stress factors. It is clear that without immediate action, the situation could become more critical in the near future.

The current circumstances of controversy and disagreement on water management in Iran and particularly in the Kurdistan region requires a systematic approach that allows to integrate different points of view of stakeholders (Macharis, 2012) which is a prerequisite for targeting interventions to reduce the adverse impacts of water shortage (Vincent, 2006). The paper suggests that adaptive capacity is a crucial factor in resolving the impact of water scarcity that is associated predominantly with vulnerability and resilience framework (Brook et al, 2004; Nathan, 2011). The main purpose of this paper is to assess adaptive capacity, particularly with respect to identify opportunities for advancing the measurement and characterization of adaptive capacity in light of recent water shortage that are practical at the local level in sanandaj region.

It is important to acknowledge that adaptive capacity is drawn upon a range of uncertainties of variables and actors, not least in terms of scale (Vincent, 2006). Therefore, a theory driven analysis of data is employed to present a set of vulnerability indicators and actors dealing with water scarcity at the level of the local communities. The assessment is based on a multiactor-multicriteria framework in which adaptive capacity is viewed in terms of outcome, and is a function of the vulnerability of governance, institutions, and management. The analysis will include qualitative and quantitative criteria of the various objectives of the multiple stakeholders (Macharis, 2012) in the city of Sanandaj (Kurdistan province, Iran). Eventually, uncertainty is described across different scales of analysis. We will conclude that the central elements of adaptive capacity, based on stakeholders' collective responses are common at different scales, although the structure of each index is scale-specific (Vincent, 2006). Hence the findings of the analysis will form the basis for validating points of leverage for policy intervention in order to raise resilience and the adaptive capacity to the risks posed by water scarcity.

Keywords: adaptation, adaptive capacity, water resilience, community-level, scarcity

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ESTIMATING EXPOSURE TO LAVA FLOW HAZARD ON NGAZIDJA ISLAND (COMOROS)

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Located northwest of Madagascar, Ngazidja Island is the most western island of the Comoros archipelago. On this active volcanic island, urban areas as well as smaller settlements are surrounding the Karthala volcano. As such the chance of population being affected by lava flow during a next eruption is high. Since a few years, a lot of effort has been done to better understand lava flow hazard on Ngazidja Island. A model has been developed to define the probability on the island for a next vent opening and to forecast the potential path taken by the lava flow. But what is the risk for the Comorian population regarding lava flow hazard? Due to limited budget and more urgent priorities in the Comoros, which is considered as one of the poorest countries in the world, the last population survey dates of 2003. Hence there is a strong need to obtain up-to-date information on population numbers and distribution.

In this study, we propose a remote sensing based approach, applied to Ngazidja Island, to estimate population at the neighborhood level from high resolution remotely sensed imagery. In our approach, it is assumed that the number of inhabitants per house can be related to the type of dwelling, characterized by its roof type. High resolution remote sensing images (Pléiades) are used to manually locate the houses and automatically identify their roof type. Due to the limited spectral resolution of the images and the high confusion between the spectral characteristics of dwellings and their surroundings, a segmentation of the scenes is done, prior to image classification, increasing the amount of information available for the classifier. Knowing the location of the houses and their roof types, the number of inhabitant is estimated at the neighborhood scale by combining remotely sensed output with data collected during a field survey reaching over 1000 households. In this contribution, we present the results of the population estimation for the whole Ngazidja Island, and confront these with the lava flow probable inundation areas defined during a previous study.

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LINKING LAND USE DISPLACEMENT, AGRICULTURAL INTENSIFICATION AND FOREST TRANSITIONS - A CONTRIBUTION TO THEORY DEVELOPMENT IN LAND SYSTEM SCIENCE

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Land constitutes a nexus between the current environmental and societal challenges. Balancing these tradeoffs and synergies is the focus of Land System Science (LSS). Within this frame, we analyzed three central issues of contemporary land systems: land use displacement through international trade, forest transitions – i.e. shifts from net deforestation to net forest recovery- and agricultural intensification. Current geographic and economic theories focus either on international trade or on local land change processes but they rarely link the two. We established operationalizable hypotheses of causal mechanisms linking these three processes at cross-country level based on a set of theories (including environmental Kuznets curve, ecological modernization, comparative advantage, new economic geography, pollution haven, and theories on forest transition). We then compiled data on socio-economic and policy factors (from World Bank, ILO, World development Indicators, as well as variables on environmental attitudes), trade data (from United Nations, COMTRADE, FAOSTAT) and land use change data, to build cross-country structural equation models using panel data econometrics.

The results will contribute to fill the gap of LSS in theory development and move forward a new generation of LSS. This information will also serve policy makers when making decisions on land management at global and local scales under the current context of growing demand for land.

Keywords: Land System Sciences, trade, land use displacement, forest transitions and agricultural intensification.

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COASTAL EROSION, MIGRATION AND IMMOBILITY: EVIDENCE FROM COMOROS

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This paper presents evidence from fieldwork conducted on the island of Grande Comore in the volcanic archipelago of Comoros located in the Indian Ocean. Specifically, this paper looks at the impacts of coastal erosion on migration decisions, including the decision to stay. Academic research, grey literature, policy circles, media and public discourse tend to highlight migration and displacements as rather inevitable outcomes of sea-level rise, floods, droughts, environmental disasters, and coastal erosion, while neglecting the great majority of people who stay in areas affected by sudden and gradual environemntal changes. In this work, we instead privelige the perspectives of those who are at least partially immobile, considering a spectrum of (im)mobility and agency in migration decision-making processes, and the impact of migration on coping strategies and adaptive capacities *in situ*. In one of the world's poorest countries, we examine not only financial resoures as migration costraints but also the relative influence of social, political, and demographic influences on (im)mobility outcomes. The contribution presents the theoretical foundation of the research, its conceptual grounding within the literature on the links between environmental change and migration, the methods of study, before presenting insights from fieldwork conducted in September 2017. Findings come from four villages in Grande Comore that are among the most severely affected by coastal erosion: Ikoni, Mbachilé, Chindini, and Bandamadji. Finally, the paper situates this research in the broader project, which includes case studies previously conducted in the Mekong Delta of Viet Nam and the northwestern coast of Senegal.

Keywords: Coastal Erosion, Adaptation, Immobility, Migration, Displacement, Indian Ocean, Small Island Developing States, Comoros

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WHAT DOES "SMART" MEAN IN RURAL DEVELOPMENT?

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For more than a decade, "smart development" is a leitmotiv in both the literature and political discourse. Besides the integration of ICT in everyday life, “smartness” seems to include many approaches, which are sometimes in contradiction. Based on a systematic literature and internet review; this introduction scrutinizes the use of the fuzzy concept in rural development studies and questions the fate of geography in regard of this “marketing” development.

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SPATIALLY EXPLICIT FARMER POPULATION MODELLING IN BELGIUM

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The pressure of globalisation on farmers worldwide has resulted in a continuous decrease of the number of farmers in many parts of the world. Uncompetitive farmers are forced to end their activities or do not find a successor after their retirement. This allows remaining farmers to upscale their activities by taking over the land of their former competitors. In developed countries, the decades-old continuous decrease in agricultural employment and the increase in average farm size accompanied by specialization and new management techniques strongly impacted agricultural landscapes and the ecosystem services they provide. A deeper insight of the mechanisms that drive this decreasing number of farms is required to better understand these trends and their impact on the land use and environment.

In order to do so, the model ADAM (Agricultural Dynamics through Agent-based Modelling) was created. The model simulates the evolution of a farmers' population and their farms at the level of individual parcels for the whole of Belgium. The model starts from an initial farmer population that cultivates a set of parcels. For each farmer, a performance-indicator is assessed based on the farm size, the location and the quality of the parcels and the cultivated crops. On a yearly basis, less-productive farms dropout. The available parcels can be taken over by competitive farmers or be abandoned. The model was calibrated for the period 2000-2015. The results show that ADAM is able to simulate the gradual decrease of the farmer population in Belgium and the gradual scale increase and specialisation of the remaining farms. Finally, we intend to develop the model further to simulate future agricultural dynamics in Belgium under alternative policy scenarios such as increasing or decreasing EU-CAP support.

The presentation will describe the ADAM model, the results currently obtained for running the model from 2000 to 2015 for Belgium and the potential ways for policy makers to use the model in their decision-making process.

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RIVER, PEOPLES AND UNCERTAINTIES: A SOCIO-ECOLOGICAL RESILIENCE OF MIDDLE SENEGAL RIVER VALLEY

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In Senegal river basin, large dams were built during the 1980's to secure water resources after a decade of water scarcity in the 1970's: Manantali in the upper basin with a reservoir of 12km3 and Diama close to estuary to avoid saltwater intrusion during dry season. Senegal river water resources are known under the supervision of Senegal River Basin Development Organization (OMVS), which defines water allocation between different goals (electricity, irrigation, flood-recession agriculture).

The Senegal river valley, located on northern part of the basin (with low precipitation < 300 mm), deals with different socio-ecological changes, following thirty years of dam management. Hydrological changes are characterized by a new hydrological regime, especially by a higher irregularity of annual flood. The main change is the development of an irrigated agriculture along the floodplain, and the valley is a strategic place for national rice production. In these context livelihoods are particularly affected by change and uncertainties around climate change, hydrology and economy. The agricultural landscape is currently remodeled around irrigation, where traditional activities are still included and combined.

The aims of this communication is to determine the influence of both changes, socio-economic and hydro-climatic, in the reorganization of the agricultural landscape of the middle Senegal river valley, and especially the way they interact together. Water management at different scales (basin level versus local level), diversification of agriculture and socio-demographic dynamics are some important factors of the socio-ecological resilience of the middle Senegal river valley to uncertainties and mutations.

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MODELLING EMERGING INTENSIVE POULTRY SECTOR AT FARM-LEVEL IN WESTERN KENYA

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Intensification of livestock production occurs in each part of the world, although at different speeds. However, it comes with many environmental, health and societal impacts. Assessing these impacts requires to know the geographical distribution of livestock. Therefore, understanding underlying spatial patterns of livestock distribution and its evolution with intensification is essential to further explore how these distributions may be associated with zoonotic disease risk, for example. The spatial distribution of farms and the factors influencing it, tend to vary between production systems (extensive backyard household vs commercial larger intensive farms). Extensive systems are generally homogeneously distributed and correlated to rural populations, especially in developing and transition economies. Intensive farms tend to cluster and to be more closely associated to accessibility to inputs and markets than to land resources. However, factors influencing the distribution of intensive farming are poorly known, especially at fine scales, and their assessment suffers from a lack of spatially explicit data sets with precise farm locations and characteristics. This is particularly true in developing countries, where farm locations are not recorded formally. Although extensive backyard systems still dominate in Kenya, an intensive poultry sector is emerging. We aimed to characterize the different farm types of this emerging commercial chicken sector and to determine their spatial distribution. For that purpose, we collected data on all commercial farms (50-1000 birds) in western Kenya, in an area of 40km diameter at the intersection of Busia, Bungoma and Kakamega counties. A cluster analysis will be used to characterize the different types of farmers of the early stages of intensification process using both individual characteristics (chicken breeds raised, feed types and destination of output types) and contextual variables (access to market and access to city). We will also test if the numbers of animals well represent intensification level of a farm, a hypothesis assumed in previous works at broader scales. Finally, spatial determinants of farm types in western Kenya will be investigated to identify which characteristics make some areas more suitable for the establishment of the different types of farm. This study will allow the understanding of the factors encouraging farmers to start a commercial activity. This will in turn help further modelling of chicken populations at farm-level, i.e. predicting farm location and size.

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FOSTERING SYSTEMS THINKING IN SECONDARY GEOGRAPHY EDUCATION: EFFECTS OF AN INTERVENTION STUDY

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An increasing interconnectedness of people and goods enhances the complexity of many geographical problems. For students to understand geography, systems thinking is a promising approach. It helps to understand increasing complexity by looking at the entire system and at the interconnectedness between the elements in the system. Encouraging students to use tools to handle complexity may help them to understand that complexity. In this study students were enquired to elaborate causal diagrams based on original texts and graphs of complex geographical issues. Causal diagrams are expected to support the development of students' systems thinking ability. A quasi-experimental design is used in which the systems thinking ability of students working with causal diagrams is compared to a control group with students not working with causal diagrams. Teachers of the experimental group participated in the design process and in a learning community to evaluate the use of causal diagrams. Pretests, posttests and exam questions were taken by 552 students in the experimental group and 195 students in the control group. Quantitative results from both tests show a positive impact of the intervention. The experimental group has a significantly higher mean score on the posttest and on the exam questions. This means that they are better in systems thinking itself but they also acquired a better content knowledge. Qualitative observations do reveal a deeper reasoning by students while constructing a causal diagram. However, the processing of the information in the texts, graphs and maps in order to select variables and to understand the connections in the systems is rather difficult for some students. Differences in study program have an impact on their systems thinking ability. Particularly in study programs with a higher success rate in higher education a higher ability to create causal diagrams was observed in the pretest. Despite these positive effects observed in the intervention, some concern has risen about the attention students have for spatial patterns and spatial embeddedness of the variables. Indeed, students seem not to be aware of the fact that some variables can cause effects elsewhere, nor that this effect is on a global or a local level. In future research, more attention should be paid at embedding a spatial and temporal component in the study of the variables.

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"SEASCAPES" FOR CONTEMPORARY VISITORS OR TOURISTS: A CHALLENGE?
CASES: DUTCH AND BELGIAN SEASIDE TOWNS

Wesley Gruijthuijsen*, Dominique Vanneste

In an increasingly interconnected world characterized by a mobile population, the Dutch and Belgian coast is probably not the first destination that (Dutch and Belgian) holidaymakers think of when it comes to planning their next holiday. This is in strong contrast to the period around the beginning of the 19th century, which can be characterized as the golden era of tourism at the Dutch and Belgian coast. But this does not necessarily mean that the coast is completely written off. For short breaks, the coast can still be considered as an interesting destination. But we should not forget that the competition for short breaks has increased during the last decades. Therefore it is important for destinations to offer a competitive product. The main goal of this research was to get more insight in the way in which the Belgian and Dutch coast could satisfy the needs and wishes of the contemporary visitor or tourist.

A survey was carried out to gain more insight into the perspective of the tourist and visitor, while interviews were carried out to gain more insight into the supply and policy side of the tourism product. To capture the uniqueness of place in more detail, four cases were chosen: Scheveningen and Zandvoort in the Netherlands and Ostend and Blankenberge in Belgium. To realize a successful repositioning, it is important to know more about the current state and the historical development. Therefore, the 'tourism area life cycle' was used to gain a detailed view on the development and current position of these seaside towns. The results illustrate that the visitors are, in general, satisfied with their visit. Besides of sun, sea and sand, more traditional aspects as 'to have a walk', 'relaxing' and 'catering' are still considered important. Nevertheless, modernization (of the public area) is required. The local governments and suppliers of the touristic product emphasize the need for more distinctiveness and improvement of the quality. They are aware of certain challenges to remain competitive or the need to improve the competitiveness. Based on the efforts by the municipalities and entrepreneurs, it seems appropriate to talk about a re-orientation phase. Nevertheless, there are differences in the way of dealing with the planning and implementation of tourism policy across the cases. But something that almost all stakeholders have in common is the focus on efforts to increase the tourism numbers. While this is probably not surprising, further research is needed into the carrying capacity and the use of for example the TALC as planning tool. At the same time it should be stressed that tourism is often not incorporated in broader strategies across sectors and policy domains. There is a need for a more holistic and integral vision, especially when one thinks about future challenges as climate change. This asks for further research into (sustainable) development tools for tourism.

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Urban, Economic and Rural Geography Session

Poster presentations

POLITICAL FRAGMENTATION OF EUROPEAN INTERMEDIATE CITIES: A SPATIAL APPROACH

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Local authorities are central actors in the governance of European intermediate urban regions. In this paper, we propose a methodology to analyse the fragmentation of local authorities within 119 urban regions. We tested several European databases to create indicators of fragmentation and to develop a typology of fragmentation within cities. Our results show that the Eurostat Cities programme gives a consistent spatial definition of urban regions and that their fragmentation is mainly influenced by national contexts. The developed methodology is a contribution to the debate on territorial reforms and urban governance transformations.

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A SMART CITY POLICY IN BRUSSELS?

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'Smart Urbanism' has become a major trend in the 2010s. 'Smart' policies are now nearly inescapable for all mid- to large scale cities. But how does a city concretely develop and implement such a policy locally? Which discourses support its integration into policy agendas? What (colations of) actors produce these discourses and/or take part in their fulfilment? How is urban space actually affected? Those are the questions we try to answer for the case of Brussels through public document analysis and semi-directed interviews with stakeholders.

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UNCONVENTIONAL FERTILITY TIMINGS IN URBAN AREAS: SOCIOECONOMIC OR CONTEXTUAL INFLUENCE?

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Introduction

The shifts in values and attitudes affecting partnership, reproduction and family (second demographic transition, Lesthaeghe and Van de Kaa, 1986), and the shift from incidental to planned parenthood, partly consequent to the availability of modern abortion and contraception methods (Bajos & Fernand, 2006; Knibiehler, 1997), contributed to easier completion of ideal fertility plans; in what timing is an important variable (Moguérou et al., 2011). Our societies extolling individual autonomy, self-realisation and social recognition shaped a new collective representation of an ideal family and family formation pattern. Teenage and late mothers are often stigmatised for having made a non-normative choice. One could argue even scientific literature isn't objective naming them 'early' and 'late' pregnancies, as in "happening before" or after an expected time.

Few cross-country studies tackle fertility timing at the local level, and this one acknowledges an urban specificity, gathering the non normative fertility patterns. This paper then study whether this is solely due to a compositional effect or also partly explained by a specific local fertility norm.

Literature review

The communication portrays the scientific literature dealing with teenage and “late” fertilities and their influencing factors in the western world especially. A double observation can be made. First, too often these fertility timings are socially and/or economically perceived as problematic if not considered as a health issue (Kearney & Lenive, 2012 ; Hobcraft & Kiernan, 2001 ; Mc Culloch, 2001). Secondly, too often they miss spatial outlook at the local level.

Among the factors cited in the literature: siblings and social environment are believed to influence one's fertility project and its fulfilment (Lyngstad & Prskawetzo, 2010 ; Bernardi et al., 2007) and eventually contribute to the transmission of a local norm. We understand these local norms to be spatially defined: could it be because of the environment socio-economic composition; the socio-cultural inertia (Lesthaeghe & Neels, 2002) affecting ideal family representations; or constraints, may they be legislative (abortion laws), economic or material (housing stock).

Data, methodology and results

We start by mapping the spatial distribution of non normative fertility timings at different level in North-western Europe. Using Crossroads Bank for Social Security individual data on women between 15 and 49 years old in 2010, this study then profiles who are the women giving birth before their twenties or after the age of 35. But we aim to go further the sole description by testing comprehensive hypothesis; here the existence of local norms stigmatising and/or directing fertility habits, and eventually leading to spatially differentiated family formation timing ideal. We thus analyse age specific fertility rates through neighbourhoods after composition adjustment (e.g., for equal ethnic and economic background).

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VULNERABILITE SANITAIRE ET ENVIRONNEMENTALE DANS LES QUARTIERS INONDABLES DE LA COMMUNE DE CAP-HAITIEN, HAITI

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Face aux risques sanitaires persistants et très souvent aggravés lors des évènements climatiques désastreux dans la commune de Cap-Haitien, une étude sur la vulnérabilité sanitaire et environnementale a été menée dans ce contexte afin de pouvoir contribuer à la réduction des risques sanitaires essentiellement liés à la dégradation de l'environnement dans cette ville. Partant des données cliniques du centre de traitement du choléra et des diarrhées aigües de l'hôpital universitaire Justinien de la commune de Cap-Haitien, données compilées dans Excel et importées dans un système d'information géographique (Arc GIS 10.1), des entretiens avec les autorités ainsi que des enquêtes transversales socio-environnementales auprès des ménages ont été menés afin de mieux cerner le problème, l'évaluer et formuler quelques recommandations pour en améliorer la prévention ainsi que la gestion. Il ressort de l'évaluation des facteurs de risques liés à la dégradation de l'environnement dans ces zones, densément peuplées et à urbanisation incontrôlable, l'insuffisance – voire la quasi absence – des services vitaux notamment du système de gestion de l'assainissement, 71% de notre population d'étude ne disposent pas d'installation hygiéniques, il n'existe aucun plan opérationnel de gestion des eaux usées et des déchets solides pour la ville. Tout finit par être jeté le long de la rivière ou de la mer, sur les voies publiques et dans les canaux de drainage en violation avec les textes de lois existants. Le système d'approvisionnement en eau potable n'est pas fonctionnel depuis près d'une décennie, laissant ainsi ce secteur aux acteurs privés à 81%, sans aucun système régulier de surveillance de la qualité. Quant à l'inaccessibilité aux soins de santé de qualité, il appert que – malgré la bonne couverture de la ville en structures médicales – les frais exorbitants de consultation et d'examens de laboratoire poussent la population enquêtée à recourir dans 67% de cas à l'automédication en première instance face à une maladie. Le syndrome pseudo palustre et les maladies diarrhéiques ont été notés dans les deux semaines précédant notre enquête avec une prévalence respective de 42 et 27%. A ceux-ci s'ajoutent les infections de la peau, les infections urinaires, etc. dont la prévalence élevée est notée pendant les périodes de fortes précipitations. L'analyse qualitative rapide des risques de diarrhées aigües à la suite de toutes les données et résultats de cette enquête transversale à l'aide de la grille de Zepeda modifiée est d'une importance capitale dans l'analyse de la vulnérabilité sanitaire et environnementale au Cap-Haïtien. Les inondations de plus en plus fréquentes sont non seulement des vecteurs des risques sanitaires mais constituent également des événements traumatisants dont les impacts sur la santé mentale nécessitent d'intégrer une sensibilisation des victimes et des intervenants médicaux et secouristes aux conséquences psychologiques des catastrophes naturelles pour une prise en charge précoce. Face à l'incapacité criante, l'inapplication des lois existantes ou l'abandon des gouvernants, les capacités limitées de faire face de cette population nécessitent un encadrement et une éducation adéquate au changement de comportements afin de limiter la dégradation de l'environnement et réduire ainsi les risques sanitaires.

Keywords: Inondation, risques sanitaires, précarité, gouvernance, Cap-Haitien, Haïti

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ON THE SCALING OF URBAN LAND AND POPULATION DENSITY PROFILES IN MONOCENTRIC MODELS

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Urban scaling laws with respect to total population have become a major field of research in urban studies. They particularly constitute novel opportunities to develop parsimonious models of cross-sectional data. However, the scaling properties of the population density profiles resulting from the monocentric models of urban economics are still unclear. This paper fills in this gap by introducing scaling laws in Alonso's seminal monocentric model.

First, conditions are derived under which the resulting population density profile matches the empirical homothetic scaling of European cities recently uncovered by Lemoy and Caruso (2017)[1]. This theoretical development consistently integrates both intra- and inter-urban analyses. Second, a functional form of the model is proposed using an exponentially decreasing profile of housing land-use. Both the housing and population density profiles are then calibrated using the empirical profiles of Lemoy and Caruso (2017).

From a theoretical perspective, the results show that the monocentric model is consistent with a three-dimensional homothetic scaling of the population density profile, and that it infers a scaling power of 1⁄3 that matches empirical evidence. To achieve this, an approximate scaling of the housing profile was assumed but the resulting error remains lower than city-specific fluctuations. The proposed model also infers the non-existence of agglomeration costs, although it is shown that alternative formulations of transport cost could easily fix it. From an empirical perspective, the proposed functional model turns out to be a satisfactory representation of the European average profiles. Consequently, it constitutes an original and particularly parsimonious model of population density profiles, which can represent any European city just by rescaling its axes by the cube root of the total city population.

Keywords: Monocentric model, population density, scaling laws, agglomeration economies

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[1] Lemoy, Rémi and Geoffrey Caruso (2017) "Scaling evidence of the homothetic nature of cities", arXiv: 1704.06508.

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ANALYSE DU RISQUE DE DEPLACEMENT DE POPULATIONS LIE AU PROJET DE DEVELOPPEMENT MUNICIPAL ET DE RESILIENCE URBAINE (MDUR) : CAS DE LA COMMUNE DE CAP-HAÏTIEN, HAÏTI

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Les catastrophes naturelles, les chocs politiques et les projets de développement sont les principales causes de déplacement de populations un peu partout dans le monde comme en Haïti. Au Cap-Haïtien, dans le cadre du projet d'aménagement du littoral vers l'aéroport, l'Etat haïtien a démoli une centaine de maisons et a délocalisé des centaines de personnes. Aussi, cette recherche a été effectuée dans le but d'analyser le risque de déplacement encouru par les personnes affectées par le projet (PAPs) de Développement Municipal et de Résilience Urbain (MDUR) de Cap-Haïtien et les personnes des quartiers vulnérables tels que Fougerole, Fort Saint-Michel, Blue Hills. Cette analyse a permis d'orienter et de proposer des perspectives liées à tout plan d'action de réinstallation y compris celui du projet MDUR. Les résultats de l'analyse de la carte d'occupation du sol présentent des zones de construction concentrées près des cours d'eau (bassin Rhodo) et de la mer, et des terrains vides ou non construits à l'est de Cap-Haïtien. Les analyses des images de Google Earth prises entre 2007 et 2015 montrent que des personnes au niveau du littoral de Cap-Haïtien ont été déplacées. Les enquêtes de terrain relatent que les personnes affectées par le projet MDUR veulent partir car elles sont dans l'immobilité forcée et le déplacement vers des voisins, des amis ou des membres de familles est leur unique forme d'adaptation aux catastrophes naturelles. Les autorités sont conscientes de la nécessité de relocaliser ces personnes et de gérer adéquatement les déchets dans la commune de Cap-Haïtien. Toutefois, les mesures appropriées tardent encore à venir en raison d'une mauvaise gouvernance, de l'inapplication du plan d'aménagement du territoire et des textes de loi y relatifs. Les autorités des communes limitrophes ne sont pas prêtes à collaborer et à coopérer dans le cadre d'une éventuelle relocalisation des personnes des quartiers vulnérables de Cap-Haïtien. Par contre, la perception des habitants de ces communes est à l'extrême opposé de celle des autorités. Les résultats préliminaires ont été présentés à la population concernée et aux autorités afin de mieux appréhender ce travail. C'est plus qu'une nécessité de trouver des zones susceptibles d'accueillir en toute sécurité avec les services de base les personnes affectées par le projet MUDR et celles des autres quartiers inondables.

Keywords: Inondation, vulnérabilité, adaptation, déplacement de population, relocalisation, Cap-Haïtien, Haïti

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CULTURAL FACILITIES AND URBAN DEVELOPMENT: WIELS CONTEMPORARY ART CENTRE AND THE TRANSFORMATION OF A WORKING-CLASS NEIGHBOURHOOD

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The opening in 2007 of the first contemporary art centre in Brussels in the lower part of the municipality of Forest, which is characterised by an industrial urban fabric and socioeconomic insecurity, seems to have marked a new era for this neighbourhood. WIELS is located in a building in a former brewing site and can be seen from a distance: its impressive and recently renovated Art Deco architecture, the flag on top of the building and the imposing titles of exhibits on the windows attract attention from the surrounding streets. In addition to these striking visual elements, there are activities for creation (artists' residencies), diffusion (temporary exhibits) and mediation (educational and/or social and artistic activities) organised by the art centre. Beyond these visual and symbolic dimensions, we seek to understand through the WIELS case how cultural facility is anchored - or not - in its territory, and hence, to what kind of "cultural-led urban development" it contributes.

Based on international literature, a typology of the socio-spatial rationales underlying the establishment of a cultural centre in a working-class neighbourhood has been proposed. This one, articulated around four ideal types, constituted the first grid of analysis for a field investigation. During the latter, we have differentiated the logics of production, studied at the outset of the strategies of actors, from the logics of operation, studied from three angles: the evolution of interactions with the inhabitants, with a real estate developer identified as a key player of the WIELS project, and finally with metropolitan dynamics, and particularly through the formation of a cultural and/or creative cluster.

While the four models help to structure the analysis, in the end, the field study revealed the existence of a hybrid cultural venue whose relationship with the territory has evolved with the strategies of actors and urban dynamics. Although WIELS was initially caught in a conflict between land and property development – a "showcase space" - and openness towards its neighbourhood – a "community space", certain tangible and discursive elements might now prompt us to consider WIELS as one of the components in the formation of a new creative metropolitan centrality – a "creative space" - without abandoning the rationales of the previous two models. Thus, in 2017, the social and spatial perspectives with respect to the interactions between WIELS and its neighbourhood overlap and borrow elements from the different models.

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PEOPLE MOVED AND WILL MOVE AGAIN

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Compiling several case studies in different developing countries, we arrive at some 'general trends' on the links between climate / environmental change and migration / displacement of populations. A series of complementary papers exemplify this assessment.

(i) No direct relationship between the scale of climate impacts and migration impacts

☐ Small perturbations can have big effects on migration

☐ Big changes do not always mean big effects on migration

☐ Do not assume climate hotspots are migration hotspots

☐ Small and big quantitative migratory outcomes can be big in terms of permanence or temporality

(ii) Climate change at 2°C, 4°C or 6°C will make migration different (not just about scale)

☐ Non-linear changes

☐ Immobility

(iii) Climate tipping points do not equal migration tipping points

☐ Perceptions about climate change can alter migration responses

☐ What is the lag time between perceptions and intentions? Between intentions and actions?

(iv) The conjuncture of social inhabitability and climate inhabitability:

☐ Resilience

☐ Maladaptation.

Keywords: climate change, environmental change, maladaptation, human migration, population displacement

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LES EFFETS PROBABLES DE LA LOI 034/2009 RELATIVE A LA SECURISATION FONCIERE RURALE AU BURKINA FASO SUR LES MIGRANTS AGRICOLES DES GRANDES SECHERESSES DES ANNEES 1970 ET 1980

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En 2009, le Burkina Faso a adopté une loi sur la sécurisation foncière en milieu rural dont la finalité est entre autres la reconnaissance et l'enregistrement des droits coutumiers sur les terres rurales. L'Etat burkinabè a exprimé sa volonté d'assurer un accès équitable à la terre à l'ensemble des acteurs ruraux à travers cette loi. L'objectif de cette étude est d'évaluer, dans le cadre de l'application de cette loi 034/2009, le niveau de vulnérabilité des migrants agricoles. Ces derniers se sont majoritairement déplacés suite à la « grande sécheresse » des années 1970 et 1980. Ils ont quitté les localités où ils avaient un droit coutumier sur les terres pour s'installer dans des zones plus favorables à l'activité agricole mais en utilisant les terres agricoles sous forme de prêt à durée indéterminée selon la logique du tutorat. Les enquêtes menées dans des localités des communes de Solenzo et de Balavé (province des Banwa), fortement colonisées par des allochtones, ont révélé que la majorité des migrants agricoles sont arrivés dans la zone pendant la période des grands déficits pluviométriques entre 1969 et 1990. Il est aussi ressorti que ces migrants agricoles exploitent surtout les terres agricoles sous forme de prêt à durée indéterminée. Avec l'application de la loi 034/ 2009, le risque d'une perte totale ou d'une réduction considérable des superficies cultivées par les migrants agricoles est très élevé car 67% des propriétaires coutumiers des terres envisagent de louer aux migrants les parcelles qu'ils cultivent actuellement après la sécurisation foncière et 11% voudraient récupérer certaines parcelles pour leur propre exploitation. Dans le même temps, 76% des migrants agricoles comptent toujours sur une générosité des autochtones pour leur faire des prêts car ils ne disposent pas de moyens suffisants pour acheter ou louer les terres. Par ailleurs, ils ne peuvent pas non plus quitter la zone pour plusieurs raisons : pour certains, les membres de leur ménage sont devenus si nombreux qu'ils ne peuvent ni avoir des superficies suffisantes dans leurs zones d'origine ni à ailleurs pour répondre à leurs besoins et pour d'autres, parce qu'ils n'ont plus de véritable attache avec la zone d'origine. Le risque que ces migrants agricoles se retrouvent dans une situation de migration circulaire et/ou forcée pour les uns ou d'être piégé parce que le besoin de partir se fait sentir mais incapable de pouvoir le faire pour les autres, est élevé. Pour réduire ce risque, il est souhaitable de procéder à une révision de la loi pour permettre à l'Etat de s'impliquer conséquemment dans la renégociation des droits des migrants agricoles dans les zones d'accueil. Cela afin d'éviter toute aggravation des tensions sociales qui peuvent menacer la stabilité socio-politique et économique du pays.

Keywords: Sécheresse, migration, législation foncière, conflits, Burkina Faso

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STAYING ON: PEASANT FARMER'S LIVELIHOOD STRATEGIES AND LAND USE CHANGE IN A RURAL SMALL TOWN IN TURKEY

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Rural areas in Turkey have experienced dramatic changes in the past half a century. Urbanization, industrialisation and modernization have increased the socio-economic polarisation between urban and rural areas, stimulating rural-to-urban migration at a massive scale. Resultantly, agricultural communities have lost population and human and social capital. To curb migration and decrease rural-urban disparities, Turkey's strategic development plan (2001-2023) highlights rural development, including agricultural restructuring/modernization and socio economic development.

In this paper, we analyse the impact of these changes on peasant families' livelihood choices in Aglasun. Aglasun is a rural small town in Southwest Turkey. Whereas having experienced outmigration and economic decline over the past decades, new temporary residents have entered the community, from college students (a university college was moved to the town as a rural development strategy) to second home tourists from nearby cities.

Household surveys were conducted in 2016 with 221 peasant farmer households (1/4 of all farming households), investigating socio-economic variables (demographics, income, family assets,…) and livelihood and land use choices. We analyse how different profiles of households combine off-farm income and migration strategies with land use strategies in different combinations to try to meet their specific needs in a changing rural environment. We show how, apart from demographic differences, land ownership structures and distribution of land across the village territory affect livelihood choices. We conclude by spelling out the consequences of these findings for Turkey's rural development strategies.

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INCORPORATION DES DISPOSITIFS INTERNATIONAUX ET REGIONAUX EN MATIERE DE REDUCTION DES RISQUES DE CATASTROPHE ET DE PROTECTION DES DEPLACES, DANS LE CADRE DE LA LEGISLATION INTERNE. LE CAS DU BURKINA FASO

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Depuis une dizaine d'années, une dynamique d'inondations, parfois occasionnées par des précipitations loin d'être exceptionnelles, s'est progressivement installée à Ouagadougou avec comme corollaires à chacune d'elles, des impacts socio-économiques importants. Dans la capitale burkinabé, les inondations sont d'une part fonction (1) des changements climatiques provoquant ainsi une mauvaise répartition spatiale et temporelle des précipitations et, d'autre part (2) des caractéristiques topographiques, pédologiques et hydrographiques de la capitale, ces dernières résultant à leur tour de pressions anthropiques : démographie et urbanisation. Quant à la vulnérabilité au risque d'inondation à Ouagadougou, elle est étroitement liée à la manière d'occuper l'espace. En conséquence, Ouagadougou et les autres villes du Burkina Faso ne seront résilientes que si elles s'investissent réellement dans la réduction des risques d'inondation comme le recommande les priorités du Cadre de Sendai. Rendre ses villes moins vulnérables et plus résilientes suppose également la délocalisation des populations les plus vulnérables des zones à haut risque, cette alternative étant encadrée par la Convention de Kampala qui reconnaît la responsabilité des gouvernements dans la protection des personnes déplacées notamment par des catastrophes naturelles, et l'adoption de mesures pour limiter ces déplacements. Cependant, malgré la ratification du Cadre de Sendai par le Burkina Faso, les inondations persistent à Ouagadougou et continuent d'engranger chaque année son même lot de conséquences socio-économiques. Quant à la Convention de Kampala, son degré d'incorporation dans les plans nationaux des États parties, et ce malgré les nombreuses ratifications et mesures entreprises par l'Union Africaine et la CEDEAO, reste, à ce jour, particulièrement faible. Ces éléments ne témoigneraient-ils finalement pas d'une mauvaise prise en compte de ces deux dispositions, internationale pour l'une et régionale pour l'autre, dans le droit interne du pays ? Cela ne serait-il pas le signe d'une gouvernance défaillante de la part de l'État burkinabé face à ces deux enjeux ?

Keywords: Inondation, vulnérabilité, Cadre de Sendai, Convention de Kampala, Ouagadougou, Burkina Faso

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TERRITORIALISATION OF SOCIAL CAPITAL IN THE PERSPECTIVE OF TOURIST DESTINATIONS' DEVELOPMENT

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All too often one forgets that tourism destinations are territorial entities with a particular (additional) planning and management dimension due to tourism (as an economic sector) and the presence of tourists (with impact on the environment and the local community). Such territorial entities face the challenge of maximizing benefits (from tourism) while limiting negative impacts (from tourism). Thus, enhancing a destination to attract the desired types and quantities of international visitors, matching local development goals, is a major aim. Tourist destinations sometimes comprise vast territories and sometimes small entities depending on the kind of resources that are turned into a tourism product. This implies institutional interrelations at different geographic levels, making destinations' development and management specially challenging, and even conflictive. From a governance perspective, destinations are usually multilayered structures that facilitate or complicate tourist experiences. Therefore, the complex relationships between governments, firms and host communities at different territorial levels, determine how stakeholders participate, and ultimately, benefit (financially such as the tourism industry but also gain experience such as hosts and guests).

Additionally, a destination's territory may vary depending on the perspective. For the local actors, their destination is defined by political boundaries, ranging from a country, a region, or even a specific local attraction. All can be promoted as a 'destination'. However, for visitors, the destination might have a different territorial structure, mixing diverse resources. The visitors' destination could indeed match a political boundary (e.g. the city of Brussels), but can cut across boundaries along a route (e.g. non-European visitors travelling through 'Europe', e.g. from Amsterdam to Rome via Brussels and Paris).

Within this multilayered and dynamic context, if host societies expect benefits through tourism, there is the necessity for coordinated participation from actors at different locations and from different sectors. Therefore, positive Social Capital (SC), understood as the capacity to act together towards common goals, is a key resource to enhance local actors' capacity to self-determine their development path. SC explains how independent resources can be mobilized for common purposes and influence determinant conditions for international market access.

Based on SC literature and several cases from the Cajas Massif Biosphere Area in southern Ecuador, we introduce an assessment matrix to reflect on how to enhance SC at the destination level. It identifies three key dimensions to study SC as a process and as an outcome simultaneously, emerging from a group of actors; and three levels of scope to guide the study of a destination's collective action at different aggregation levels.

We conclude that a collective action is more determined by internal collective capacities, than by external conditions. Locally empowered facilitating actors are key for SC's enhancement in which 'local actor' might refer more to participation than to physical proximity. Therefore a 'destination' needs to go beyond a set of politico-administrative and spatial boundaries; it needs dynamic boundaries that change according to the interacting actors that facilitate the tourism experience and visitors' as well as facilitators' needs.

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WILL WINTER SPORTS TURN INTO SUMMER SPORTS? THE EFFECTS OF CLIMATE CHANGE FOR TYROLEAN SKI RESORTS

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Climate change is also felt in mountain areas, which are especially susceptible to even the smallest change in climate as a result of their extremely vulnerable ecosystem. Climate change has consequences for tourism as well, since the tourism sector in mountain areas is very much climate-dependent, oriented towards winter and ski tourism. **Therefore, the main question is how to preserve a sustainable tourism sector and destination in mountain areas and how to mobilise resilience towards a climate change that none of the individual tourism resorts can stop nor influence.**

In our research, we focused on the Tyrol since every year, millions of tourists spend their winter holiday in the Tyrolean mountains. Over the last decade, climate change has caused a precipitation decrease and a temperature increase, combined with a larger climatic variability. This has resulted in uncertain snow conditions during the winter sports season and more than once in a snow deficit. Although much scientific research has been dedicated to what ski resorts can do in case of a snow deficit –we know that they seek a solution in e.g. the use of artificial snow- only little research has been conducted into the question if and how stakeholders within the winter sports industry and destinations perceive climate change on a long term, the kind of (collaborative) actions they prepare and the resilience they show.

The aim of our current research was to look at how different stakeholders within the Tyrolean tourism industry position themselves within the climate change issue, which mitigation and adaptation strategies they adopt, at which institutional levels such strategies are formulated, and how these levels and other stakeholders collaborate. Our mean methodology was based on qualitative research, with interviews conducted with the following stakeholder groups: ÖHV (the Austrian Hotelier Association), Tirol Werbung (the Tyrolean Tourism Office), WKO (the Tyrolean Chamber of Commerce), Innsbruck University (Division of Geography), Stubaier Gletscher and Serfaus-Fiss-Ladis Tourism Office. Both desk research and interviews showed as an alarming result that most stakeholders reject the climate change issue, argue that there is no such thing as climate change, and as a result, that no consequences for the Tyrolean winter sports industry should be expected. This has resulted in a completely decentralised approach to several short-term mitigation strategies, of which artificial snow is and stays the most popular one. More sustainable long-term adaptation strategies are not likely to be implemented in the near future, as most stakeholders are very persistent in their rejection of climate change and its consequences, which complicates the implementation of a clearly formulated climate change strategy. Very little collaboration can be detected while the local differentiation of resorts (located above 2000 metres and therefore with guaranteed snow versus below 2000 metres) seems to result rather in a survival of the fittest attitude than mutual efforts to cope with the problem. Some other solution such as summer tourism is developing but many practical issues (operation of ski lifts etc.) are hindering its development.

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CLIMATE CHANGE AND MIGRATION IN THE MIDST OF ELUSION

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Despite progress in the understanding of the complex links between climate change and migration, the so called 'climate change-migration nexus' occludes more than it reveals. On one hand, academic and policy analysis often tend to focus on the biophysical impacts of climate change as 'push' factors, naturalizing migration drivers, simplifying their impacts, and eluding the ways in which climate change politics and migration discourses are (re)shaping access to fundamental natural assets. On the other hand, in the burgeoning literature on land and green grabs, displacement and migration remain relegated to a secondary level of consideration, often depicting migrants as little more than passive victims of capitalism. This talk will analyse the variegated and complex interactions between climate change politics, resource grabs, and migration by drawing on case studies conducted in two very different socio-political contexts: Senegal and Cambodia. In so doing, it will show how and why powerful framings on causes, impacts, and solutions translate into interventions that often increase, rather than alleviate, the very pressures that they intend to redress.

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WHAT HAPPENED TO THE BRUSSELS FINANCIAL SECTOR SINCE THE 2008 CRISIS?

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Before the financial crisis of 2008, Brussels concentrated half of the national employment in financial services, which represents 64.000 people. Since then, Brussels lost about 9.000 jobs in the financial sector. Paradoxically, its weight in the national economy remained stable. Beyond what could be interpreted as a usual rise of productivity – employing less people to create the same value – these dynamics invite us to interrogate how the restructuration of the financial sector has shaped up. We hypothesize a change in working practices which translates unevenly over the sector. Depending on the type of stakeholder, certain activities are being removed or outsourced, other new activities being developed, with implications on the profile of employees needed. What are the reasons driving this reorganisation? To approach these issues, we first establish the financial sector profile in Brussels. We map the financial institutions employment dynamics, with changes and migrations between 2008 and 2014. Second, we analyze reports from financial institutions, professional associations, trade unions and press releases to understand how employment dynamics are narrated in the case of large banks in Brussels. The combination of both approaches allows to characterize which stakeholders are undergoing transformations and where ; detect which activities are reorganised and how this reorganisation is framed. These inputs will provide the necessary material to constitute a case-study to be deepened further with interviews in the banking sector, professional associations, trade unions and eventually researchers.

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FIRM PERFORMANCE AND MULTI-SCALE TERRITORIAL RESOURCES IN WALLONIA: TOWARD A MODEL USING BUSINESS ACCOUNTING

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The research project aims to explore the relationships between firm performance and their territorial and/or location specific resources. By territorial resource, we mean the specific features of the territories that affect the ability of companies to develop their business. Our ambition is to compare different categories of territorial resources: accessibility at both, the micro and the macro level: the "prestige" of place; the economic environment; the size and the quality of workforce… The main goal is to measure the differences in terms of scales and intensity of these territorial resources. We postulate the existence of three structuring scales around the firm internal perimeter: the Walloon scale, the sub-regional scale and the scale of the site where the firm is located.

This PhD project is structured in four parts: The first part relates to the literature review, with the aim to explore three main topics: the concept of firm performance (what kind? For whom?), the territorial resources, and the economic geography of Wallonia. For the second part, we plan to develop a model using business accounting data in order to quantify the impact of territorial resources on firm performances. In the third part, the results of the business accounting model will be compared to a hedonic model aiming to assess the impact of territorial resources on property values. Finally, in the fourth part, surveys will confront the results of the models with the perception of businessmen and regional development specialists. New knowledge established through the project will be communicate to the scientific community through academic publications as well as to key stakeholders in order to influence political and administrative decisions in relation to the economic redeployment of Wallonia.

This proposal of poster presents the first model of this PhD project, using the business accounting data. First, we expose the State of Art related to the territorial resources to select variables. These variables are linked with the available data from European, Belgian and Walloon sources. Then, we lay out the methodology of this model, explaining the added value created by the Walloon firms thanks to internal factors of the Walloon firms (measured by accounting data) and to the territorial resources. Finally, we expose the data used as well as our first results.

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HOW SENSITIVE ARE MEASURES OF POLYCENTRICITY TO THE CHOICE OF 'CENTRES'? A METHODOLOGICAL AND EMPIRICAL EXPLORATION

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In the literature dealing with measuring polycentricity, relatively little attention has been paid to the choice of what constitutes a 'centre'. In this research, we assess the sensitivity of these measures to one particular aspect of this selection of the units of analysis: using the case of 'polycentric urban regions', we empirically examine the sensitivity of the 'level' of polycentricity to the number of cities included in the analysis. Based on a two-mode firm-city data source, we do so by stepwise measuring the polycentricity of the Yangtze River Delta (YRD) as cities are added to the analysis (i.e. measuring 'stepwise polycentricity'). The result suggests that the measure of polycentricity is indeed highly sensitive to the choice of the number of cities. We propose that the analysis of the sensitivity of polycentricity can help researchers to (i) investigate the different role of cities in shaping polycentric structures of urban regions and (ii) identify mono- or poly-centric structures of urban regions. Analyses of the trend of the 'stepwise polycentricity' of the YRD and other seven urban regions along the Yangtze River Economic Belt serve to illustrate.

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Climatology Session

Oral presentations

CLIMATE PREDICTION: WHERE ARE WE?

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The evolution of the atmosphere beyond weather time scales is governed, on the one hand, by variations in the so-called "slow" components of the climate system such as the ocean, the sea ice cover or land. On the other hand, changes in atmospheric composition (from natural or anthropogenic origins) are key drivers of long-term climate variability. The emerging area of climate prediction bridges these two aspects by studying to which extent key climate phenomena are predictable a few months to a few decades in advance, given initial and boundary conditions. Predicting fluctuations of a non-stationary system characterised by strong nonlinearities is a challenging task. This is why General Circulation Models (GCMs) are valuable tools to perform climate predictions. Using GCMs for prediction is, however, non trivial: the models like to evolve in their preferred state, are computationally expensive to integrate and their predictions are not always obvious to verify.

During this presentation, I will review the field of GCM-based climate prediction, a young but very active branch of climate sciences which calls upon a wide range of topics, from mathematics to physics through statistics, informatics and even sometimes social sciences. By going through specific cases (El Niño/Southern Ocean oscillation, Arctic sea ice, Northern Atlantic Oscillation), I will discuss the possible reasons explaining the significant gap between potential and actual skill, present ongoing related ongoing activities in Europe and briefly explain how such predictions could eventually benefit society through the provision of climate services.

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FUTURE CLIMATE CHANGE IMPACTS: AN INTRODUCTION

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Climate change is one of the key challenges of the 21st century impacting society in many ways. Climate change refers not only to a change in global means: It are often the extremes that are more relevant for climate impact than the average changes. Moreover, climate change does not encompass temperature only but also refers to changes in the hydrological cycle (including precipitation, evaporation and evapotranspiration) and the wind. Regional variations in the climate change patters are driven by atmospheric dynamics and/or feedbacks acting on regional or local scale. These feedbacks are often related to the land cover which include natural surfaces (snow and ice, vegetation, desert, ..) and anthropogenically modified surfaces (cities, croplands, …). In this introductory talk, I will give an introduction of the 'state-of-the-art' in climate modelling, I will discuss climate change impact research – with a focus on the impact studies addressed in this session (i.e. agronomy, biosphere, vegetation, human migration, epidemiology, ..) - and I will discuss some key challenges that the climate modelling community is facing.

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USING THE REGIONAL CLIMATE MODEL MAR TO PROVIDE HIGH RESOLUTION METEOROLOGICAL DATA FOR 'PRECISION FARMING' AGRONOMICAL MODELS

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There is a need in agriculture for further improving both quality and quantity of the productions, while reducing and optimizing the usage of fertilisers and pesticides (e.g. insecticides, fungicides, herbicides) for economical and environmental reasons. To achieve this, different types of agrometeorological models, which are used at the scale of the parcel, or even at an infra-level, are under development. Some models are used to forecast the phenological stages and the expected yield to improve the timing of the use of fertilisers. Other models are developed to predict the appearance of plant diseases and thus, to optimize the use of pesticides. Since the progression of the phenological stages, the effectiveness of the fertilisers and pesticides, as well as the outbreak of plant bugs and fungal diseases are strongly conditioned by the weather conditions, these agrometeorological models have to be constrained by reliable high resolution meteorological data.

In this context, we adapt the regional climate model MAR (for "Modèle atmosphérique régional"), developed at the laboratory of Climatology of the University of Liège to the needs of the high resolution agrometeorological models developed by AgrOptimize. In fact, the use of a regional climate model like MAR has two advantages. First, it allows a dynamical downscaling taking into account topographical effects and land use to reach a much higher resolution than global models. Second, some meteorological variables that are usually not provided by global models but are important for agronomical aspects (e.g. sunshine duration, evapotranspiration), can be developed and implemented in MAR. In this project, we use MAR in two ways. On one side, we force it with the ERA-Interim reanalysis to produce hindcasts over the last years (2010-2017), that can be used to calibrate and evaluate the agromet models. On the other side, MAR will be forced by the GFS global forecasting model to provide high resolution weather forecasts at 5 days that can be used to drive the agromet models in real time.

The MAR model is run at 7.5 km horizontal resolution with outputs every hour over western and central Europe. Hourly data are necessary to take into account subdaily processes such as temperature inversions or cold pools in depressions which appear during clear nights and vanish at sunrise. For the same reasons, we will develop a statistical downscaling scheme to further increase the horizontal resolution to 1 km. Moreover, an important aspect of this project will be to develop and validate a moisture model to forecast the time span leafs are covered by rain or dew. In fact, this issue is very important, since it strongly influences the outbreak of plant diseases. Finally, an automated quality control procedure will be set up on the basis of SYNOP station data.

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CLIMATE CHANGE AS DRIVER OF HUMAN MOBILITY IN THE PACIFIC REGION

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This paper presents a general review of the current trends related to climate-induced human mobility in the Pacific region. After a basic introduction to the impacts of climate change on the region, it reviews the existing body of knowledge on migration, displacement, and planned relocation induced by slow and rapid-onset environmental drivers. Climate change is further exacerbating the natural features of the Small Islands, which are by nature already extremely exposed and sensitive to extreme environmental events. Migration has been used by Islanders for generations in order to cope with the adverse environmental impacts. The paper addresses some detailed accounts of the latest trends in particular countries of the Pacific and makes use of recent studies to outline those trends. Finally, it illustrates specific examples of recent disaster-induced displacement and planned relocation in the region.

Keywords: Climate Change, Adaptation, Human Mobility, Migration, Displacement, Relocation, Pacific region, Small Island States.

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SIMULATING THE EFFECT OF RECENT CLIMATE CHANGE ON THE DISTRIBUTION OF ATLAS CEDAR IN MOROCCO USING THE REGIONAL CLIMATE MODEL MAR AND THE DYNAMIC VEGETATION MODEL

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It appears today established that climate change will alter biodiversity, since the migration speeds of many species, especially plants, are presumably too small to follow climate change. Mountain ecosystem floras of Mediterranean regions are particularly vulnerable to the climatic threat, because they combine high ecosystem diversity and large proportion of endemic species, with the risk of reaching the summits of the mountains, which would limit their migration. Moreover, these environments are often strongly impacted by man. Being able to identify and predict the areas favourable to the species – microrefugia - becomes crucial in view of the fragmentation of the space devoted to their conservation. The microrefugia could be identified by using regional climate models (RCM) and dynamic vegetation models (DVM). RCMs allow a dynamic downscaling of the climatic scenarios produced by the global climate models. High resolution climate simulations can thus be performed over a given region, in order to study the effects of climate change at a scale approaching the microclimate scale. These high resolution climate scenarios can then be used to constrain the models describing the flora, i.e., the DVM.

In the framework of the international VULPES project (VULnerability of Populations under Extreme Scenario, https://vulpesproject.wixsite.com/vulpes), we used the regional climate model MAR (Fettweis et al., The Cryosphere, 7 :469-489, 2013) to downscale ERA -interim reanalysis at 5 km resolution over Northern Morocco. MAR simulation results are evaluated against measurements collected at several meteorological stations in Morocco. The MAR climatic outputs are then used to force the CARAIB DVM (Dury et al., iForest - Biogeosciences and Forestry, 4:82-99, 2011) to simulate the evolution over the last thirty years (1981-2010) of the distribution of *Cedrus atlantica*, an endangered species of the North African mountains. CARAIB results in terms of biomass and net primary productivity (NPP) are evaluated against data coming from forest inventory and leaf area index (LAI) measurements.

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HIGH-RESOLUTION SIMULATIONS OF NATURAL AND AGRICULTURAL ECOSYSTEMS OVER BELGIUM WITH THE CARAIB DYNAMIC VEGETATION MODEL

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CARAIB (for CARbon Assimilation In the Biosphere) is a state-of-the-art dynamic vegetation model (DVM), initially designed to study the role of the vegetation in the global carbon cycle and the vegetation behavior as a function of climate and soil. Motivated by the requirements of ecosystem management and land use planning studies, CARAIB was recently improved so as to deal with both natural and agricultural ecosystems and at a high resolution of 1km over Belgium. A new module, for crops and meadows, was added in the model, which deals with the specific processes (phenology) and management (sowing, harvesting…) of these ecosystems. The spatial and temporal validation was carried out with different data sources: agricultural statistics, eddy-covariance site, field measurements, etc. The addition of the crop module has led to the improvement of the surface scheme, from now on including dynamic land use and land cover information.

Describing the evolution of both physical and biological processes, CARAIB has become an interesting tool to assess the sustainability under climate change of the ecological systems, in particular by the approach of the ecosystem goods and services. Indeed, if some model outputs can be directly read as quantitative indicators of ecosystem services (e.g. carbon sequestration), we have translated some of them to get, e.g., the crop yield (from net primary productivity) or an estimation of soil erosion for simulations at the parcel level (from runoff and parcels characteristics).

But whether focusing on ecosystem services or land use planning studies, the crucial point for CARAIB is landscape dynamics, which is not considered by the model, in the absence of anthropogenic, economic and societal factors in the system. In order to overcome this lack, CARAIB is now coupled with an agent-based model (ABM), to compose a land surface dynamics (LSD) module. The productivity and growth of natural and managed vegetation is provided by the DVM to the ABM, which determines the shifts in land use and land cover. The LSD module is able to represent the mutual interactions between ecological and socio-economic systems and thus, to assess the sustainability of the different climate and socio-economic scenarios tested. This work is performed in the framework of the MASC project within the BRAIN-be program of Belgian Science Policy (BELSPO).

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PROJECTING THE FUTURE LEVELS OF LAKE VICTORIA

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Lake Victoria directly sustains 30 million people living in its basin and 200 000 fishermen operating from its shores. As the one of the two sources of the Nile River, it also supports natural resources that impact the livelihood of over 300 million people living in the Nile basin. The outlet to the Nile is controlled by two hydropower dams. The water balance of Lake Victoria is controlled both by climatic conditions (precipitation and evaporation) and human management (dam outflow).

Future climate simulations with a high resolution coupled lake-land-atmosphere model project decreasing mean precipitation and increasing evaporation over Lake Victoria. As these two are important factors in the water balance of Lake Victoria, these projected changes may induce a drop in future levels of Lake Victoria. Moreover, as Lake Victoria is also a relatively shallow lake, lake surface area may decrease as well.

Here we present a water balance model for Lake Victoria that provides lake level and extent as output. We first force our model with observational input (new satellite products providing high quality precipitation and evaporation data) and evaluate it using measured lake levels. The skill of the model is subsequently assessed by forcing it with present-day regional climate simulations (CORDEX evaluation simulations). In a third step the future lake levels of Lake Victoria are simulated by forcing the model with CORDEX projections under RCP4.5 and 8.5. Finally, the role of human decisions regarding future dam outflow are investigated.

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HEAT STRESS INCREASE UNDER CLIMATE CHANGE TWICE AS LARGE IN CITIES AS IN RURAL AREAS

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Urban areas are usually warmer than their surrounding natural areas, an effect known as the urban heat island effect. As such, they are particularly vulnerable to global warming and associated increases in extreme temperatures. Yet ensemble climate-model projections are generally performed on a scale that is too coarse to represent the evolution of temperatures in cities. Here, for the first time, we combine unprecedented long-term (35-year) urban-climate model integrations at the convection-permitting scale (2.8km resolution) with information from an ensemble of general circulation models to assess temperature-based heat stress for Belgium, a densely populated mid-latitude maritime region. We discover that the heat-stress increase towards the mid-21st century is twice as large in cities compared to their surrounding rural areas. The exacerbation is driven by the urban heat island itself, its concurrence with heatwaves, and urban expansion. Cities experience a heat-stress multiplication by a factor 1.4 and 15 depending on the scenario. Remarkably, the future heat-stress surpasses everywhere the urban hot spots of today. Our results demonstrate the need to combine information from climate models, acting on different scales, for climate-change risk assessment in heterogeneous regions. Moreover, these results highlight the necessity for adaptation to increasing heat stress, especially in urban areas.

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WINTER SEASON CHANGES IN BELGIUM: THE MAR MODEL CONTRIBUTION TO THE CORDEX.BE PROJECT

Coraline Wyard*

In the framework of the CORDEX.be project funded by Belspo, most universities and research institutes of Belgium have worked together in order to gather existing and ongoing Belgian research activities in the domain of climate modelling to create a coherent scientific basis for future climate services in Belgium. The Laboratory of Climatology of the University of Liège has performed climate simulations using the regional climate model MAR ("Modèle Atmosphérique Régional" in French) at a resolution of 5 km over the period 1900-2014. This research aims to study the evolution of several variables computed by MAR during the winters of the last century. Results show a significant decrease in snow cover and in the length of the snow season. A slight increase in precipitation extremes is also computed by MAR.

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WHY STUDYING THE CRYOSPHERE ?

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In this introducing presentation, we will see i) what is the cryosphere and its different components (sea ice, ice sheets, ...), ii) what are its particularities, positive feedbacks and unknowns in respect to the other climate components, iii) how the ice sheets work (mass balance) and iv) the different issues between the North Pole and the South Pole. We will finish by an quick overview of what are the main researches in cryosphere performed in Belgium.

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ANTARCTIC CLIMATE PROJECTIONS : WHICH CONSEQUENCES ? WHICH UNCERTAINTIES ?

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Climate and water cycle changes in Arctic and Antarctic is a major threat for coastal areas via ice-sheets input to sea-level. Moreover, interactions between ice-sheet, atmosphere, ocean and sea-ice are still poorly understood while they are involved in major circulation changes impacting both polar and mid-latitude regions.

In Antarctica, significant atmospheric circulation changes happened in the last decades, affecting the ocean which in turn destabilised the ice-sheet, increasing the ice flux through the ocean. We will see that few global climate models are able to correctly represent the present climate circulation over Antarctica. Although climate models predict consistent trajectories in the future, we will wonder in which extend we can rely on them and we will point out the main uncertainty sources in climate projections.

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MODELLING THE SURFACE MASS BALANCE OF POLAR ICE SHEETS

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The Greenland and Antarctic ice sheets together contain more than 70% of the world's freshwater trapped in ice and snow. The evolution of these huge natural reservoirs under a changing climate is among major environmental challenges, particularly in terms of sea level rise. Estimations of their contribution to sea level require accurate knowledge of the accumulation/ablation conditions at their surface, i.e., the surface mass balance. This information can be obtained locally from field measurements (stake-lines, radar stratigraphy, ice cores). However, due to the wideness, the remoteness and the harsh environment of polar ice sheets, field measurements are scarce in space and time and have to be complemented by numerical models adapted to polar climate specificities (detailed snowpack module, polar clouds, cold atmopshere, etc.). We propose an assessment of the surface mass balance of the Greenland and Antarctic ice sheets for the recent period (1979 – 2015) using the regional climate model MAR, specifically developed for polar regions.

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A LONG-TERM HINDCAST SIMULATION WITH COSMO-CLM² OVER ANTARCTICA

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The surface mass balance (SMB) of the Antarctic ice sheet (AIS) is crucial to understand Antarctica's contribution to 21st century sea level rise. Therefore, it is essential to understand both the large scale atmospheric processes that affect accumulation as it is the only source term of the ice sheet. In addition, local effects such as snowdrift can result in a gain or loss in the local surface mass balance and need to be better constrained.

Given the scarcity and low spatial coverage of observations over the AIS, the regional climate modeling approach, which is not very common over Antarctica, is the adequate tool to gain insights in AIS SMB. In this respect, COSMO-CLM 5.0 was coupled to the Community Land Model (CLM4.5) and adapted for Antarctic conditions. The model was first executed using ERA-Interim as its initial and lateral boundaries for a time period of 1 year (excluding 3 months of spin-up time) at a resolution of 0.22° by 0.22° over the whole Antarctic continent in order to identify possible lackings in the model representation of basic climatic variables such as temperature and wind speed. Changes in the turbulence scheme, the location of the tropopause were executed in COSMO-CLM, as well as several modifications to the Community Land Model (e.g. snow metamorphosis, wind dependent compaction,...).

Here, we present the results of COSMO-CLM² adapted for Antarctica, for a 30-year historical hindcast simulation (1987-2017; same specifications as above) executed on the new Flemish supercomputer (Tier1). We compare the results with other state-of-the-art climate models and the scarce amount of observations that is available. Our main focus lies on the different components of the SMB. These components are currently predominately estimated by climate models. COSMO-CLM² contributes as an extra member to this ensemble. Furthermore, our setup uses the CORDEX domain, and therefore COSMO-CLM² also contributes to the POLAR-CORDEX international initiative.

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COUPLING AN ATMOSPHERIC MODEL TO AN OCEAN MODEL TO STUDY AIR-ICE-OCEAN INTERACTIONS IN ANTARCTICA: CHALLENGES AND APPLICATIONS

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Interactions between atmosphere, ice sheet and ocean play a crucial role in the Antarctic climate. For example, sea-air exchanges in leads and polynyas can strengthen cyclonic activities by warming and water vapour loading of air masses while associated sea heat loss and brine rejection modify water density and contribute to the dense water formation. Due to the harsh weather conditions in Antarctica, climate and ocean models appear as suitable tools to complement the scarcity of observations and to study the Antarctic climate. Nonetheless, only few models are able to represent typical processes found at high latitudes such as katabatic winds, drifting snow for the atmosphere or sea ice formation, accretion and deformation for oceans. Furthermore, due to their high non-linearity, those processes are difficult to model as they occur at different spatial and temporal scales. Current models are often forced by outputs: atmospheric conditions are provided to ocean models and ocean models outputs are used as surface conditions in atmospheric models meaning air feedbacks on ocean (or inversely) are muted. One can think models should be coupled at each time steps to take into account instantaneous interactions. Nonetheless, this method involves (too) high computational costs. The main challenge of this coupling is to take into account air-ice-ocean interactions and the temporal scale of associated processes in order to define an appropriate coupling time step. We will present both ocean and ice-atmosphere processes relative to polar climates and the specificities of the two models as well as technical coupling aspects.

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STABILISATION OF THE PRESENT SURFACE MASS BALANCE OF SVALBARD IN RELATION TO SUMMER ATMOSPHERIC CIRCULATION

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Svalbard is a Norwegian archipelago located in the Arctic (74 –81°N, 10–35°E), halfway between mainland Norway and the North Pole and is covered by more than 2000 glaciers and ice caps over 60% of its surface (~62 000 km2). It is located less than 1000 km west of Greenland, which has broken melt record after melt record since the second half of the 2000's and regularly makes headlines in the media. The Arctic sea ice also forms later and later in the year and its minimum extend has often been significantly lower than average in the past 10 years.

On the contrary, the regional climate model MAR (Modèle Atmosphérique Régional) showed that the surface mass balance (SMB, mainly the difference between accumulation from snowfall and ice loss from meltwater runoff) of Svalbard had very negative values at the beginning of the 2000's, with a record in 2004, but then stabilised and had values much closer to equilibrium and around the 1960–2016 average. This stabilisation of the SMB is in agreement with observations and Svalbard therefore seems to be less sensitive to the observed Arctic warming than the other Arctic regions. This apparent stabilisation of the Svalbard SMB has been attributed to a recent change in summer atmospheric circulation in the Arctic. Over Svalbard, the mean 1979–2005 summer 700 hPa ERA- Interim atmospheric circulation was a westerly or west–southwesterly flow. After 2005, however, the circulation changed as a result of more frequent North Atlantic Oscillation (NAO) negative phases in summer, resulting in northwesterly flows over Svalbard and more anticyclonic conditions over Greenland. Consequently, a summer temperature increase breaking melt records has been observed over Greenland since 2006. Over Svalbard, on the contrary, the northerly flow brings colder air and the surface mass balance modelled by MAR has remained stable over the period 1979–2012. In summer 2013, however, the 700 hPa summer atmospheric circulation was again a westerly flow and could not oppose Arctic warming anymore and the MAR SMB broke the last 35 years's record (-23.4 Gt) whereas Greenland's SMB was higher than average. The 2014 and 2015 Svalbard SMB were very close to the 1960–2016 average but the 2016 SMB was as negative as the 2013 one (-23.1 Gt). The amount of surface meltwater runoff in 2016 was higher than in 2013 (56 vs 51 Gt) but was partly compensated by significantly higher than average precipitation, resulting in the same SMB values in 2013 and 2016. This record melt happened despite a summer northwesterly flow over Svalbard, similar to the 2005–2012 summer atmospheric circulation. However, this northerly flow still mitigated the warming over Svalbard, which was much lower than in most regions of the Arctic.

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BASAL MELT RATE VARIABILITY ACROSS ICE-SHELF CHANNELS IN DRONNING MAUD LAND, ANTARCTICA

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Basal mass balance variability of Antarctic ice shelves is of significant interest because ice shelves buttress the grounded ice and are directly affected by ice-ocean interaction. ApRES (Autonomous phasesensitive radio-echo sounder) measurements have been conducted at a series of sites on the Roi Baudouin ice shelf (RBIS), Dronning Maud Land, East Antarctica. Vertical strain and basal melt rates are inferred from displacements of internal reflecting layers and the base. Radar sites were allocated across ice-shelf channels between the grounding line and the ice front, where the highest basal melt variability was suspected (Berger et al., 2017). Repeat visits were made on these sites over periods of several weeks in January 2016. Melt rates range from -0.09 ± 0.06 m a^{-1} at the flank to 7.77 ± 0.28 m a^{-1} in the channel trough, and the magnitude and variability in melt rates decreases with distance from the grounding line. The spatial variability of basal melting is coherent with the pattern inferred from spaceborne remote sensing. At two sites, continuous measurements were made over a whole year, from which the seasonal trend and short-term variability was derived. Although our measurements are still sparse, the spatial variability shows a high correlation between basal melt rates and the topography of the ice shelf base. From the annual observations, we have confidence that basal melting is significantly sensitive to ocean warming and tides.

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TRANSIENT THERMODYNAMICAL MODELLING TO EVALUATE BASAL TEMPERATURES IN DIVIDE REGIONS OF THE ANTARCTIC ICE SHEET OVER THE LAST 1.5 MILLION YEARS

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The quest for oldest ice in Antarctica has recently been launched through an EU H2020 project (Beyond EPICA - Oldest Ice) and aims at identifying suitable areas for a potential future drilling. Retrieving an ice core of such age is essential to understand the relation between orbital changes and atmospheric composition during the mid-Pliocene transition. However, sites for a potential undisturbed record of 1.5 million-year old ice in Antarctica are difficult to find and require slow-moving ice (preferably an ice divide) and basal conditions that are not disturbed by large topographic variations. Furthermore, ice should be sufficiently thick but cold basal conditions should still prevail, since basal melting would destroy the bottom layers. Therefore, ice-flow conditions and thermodynamic characteristics are crucial for identifying potential locations of undisturbed ice. Van Liefferinge and Pattyn (2013) identified suitable areas based on a pan-Antarctic simplified thermodynamic ice sheet model and demonstrated that uncertainty in geothermal conditions remain a major unknown. Here, we use a transient thermodynamical 1D model to obtain an ensemble basal temperatures for the whole interior Antarctic Ice Sheet over the last 1.5 million years in order to calculate the geothermal heat flux (GHF) allowed to avoid any subglacial melting, in other words, the GHF required to reach the pressure melting point at the base of the ice column. Our calculated GHF values are statistically compared with the cumulative distribution functions (CDF) calculated from GHF uncertainties (Fox-Maule et al., 2005; Puruker, 2013; Shapiro and Ritzwoller, 2004). The resulting probability distribution of ice remained frozen over the last 1.5 Myrs obtained are analysed and compared with new high resolution survey of Dome Concordia and Dome Fuji.

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INITIALISING A GREENLAND ICE SHEET MODEL THROUGH A NUDGING APPROACH

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The sea level will be rising over the next centuries in response to the increase in greenhouse gas concentration. This is partly accounted for by the freshwater input arising from the melting of the Greenland ice sheet. Accurate projections of the sea level change therefore require a good knowledge of the evolution of the Greenland ice sheet. This evolution is simulated thanks to ice sheet models driven by different sets of boundary conditions that represent different forcing scenarios. In addition to the boundary conditions, a good estimate of the initial state is required in order to properly simulate the evolution of the ice sheet. The Greenland ice sheet is monitored by remote sensing and in situ measurements. Nevertheless, these observation datasets are often incomplete and are not fully consistent with the model equations. In this context, data assimilation techniques constitute an adequate tool to bridge the gap between model and observations. The present research work aims at systematically test different data assimilation techniques with the VUB Greenland Ice Sheet Model (GISM-VUB) in order to compute an optimal initial state of the ice sheet that is consistent with both the model and the observations. All the data assimilation methods implemented here rely on a nudging approach applied to different model variables (the surface velocity, the surface elevation and the ice thickness). The benefits and the limitations of each method are discussed and the results are compared to the ones obtained with another initialisation technique previously used with the GISM-VUB.

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Climatology Session

Poster presentations

INVESTIGATING THE ANTARCTIC ORIGIN OF MELTWATER PULSE 1A

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During the last glacial termination, a phase of abrupt global sea-level rise called Meltwater Pulse 1A took place around 14 500 BP. Although the timing and the magnitude of this event have become better constrained, a causal link between the MWP-1A and an accelerated ice loss from the Antarctic ice sheet has still not been proven. Understanding the origin of this meltwater pulse is of the highest importance when considering the current uncertainty surrounding a potential collapse of the Antarctic ice sheet in response to present-day climate change.

We simulated the evolution of the Antarctic ice sheet over the last 40 kyr using the ice-sheet model f.ETISh (Pattyn, 2017). A large ensemble of 54 runs is used to calibrate the model to modern and geologic data and determine a best-fit simulation. Moreover, a sensitivity analysis is carried out to assess the conditions for the occurrence of significant melting of the Antarctic ice sheet. With the best-fit simulation, the influence of an accentuated oceanic melting coincident with Meltwater Pulse 1A is tested to evaluate the likely contribution of Antarctica to this event. For the Antarctic ice sheet to have made a meaningful contribution to the Meltwater Pulse 1A, a sufficient sea-level equivalent ice volume must have existed at the Last Glacial Maximum. Then, this ice volume must have been discharged at the correct time and at a rate fast enough to contribute to this rapid sea-level rise (Golledge et al., 2014).

Results reveal that a sufficient ice volume has existed at the Last Glacial Maximum in Antarctica. However, abrupt rises in seal-level and air temperatures, characteristic of the last glaciation termination, do not, on their own, trigger rapid retreat of the modelled ice sheet. For the Antarctic ice sheet to have made a meaningful contribution to the Meltwater Pulse 1A, a specific interaction between the ice sheet and its surrounding ocean –independent of the atmospheric forcing -seems to be necessary. More specifically, rates of freshwater flux from the Antarctic ice sheet are highest when, by a still undetermined mechanism, an episode of accentuated sub-shelf oceanic melting occurs. This latter instigates a positive feedback that further accelerates retreat of marine-based sectors of the Antarctic ice sheet. Under these conditions, a contribution of nearly 1.2 meters of sea-level equivalent from the Antarctic ice sheet is predicted at the time of MWP-1A, representing a meaningful but still minor (between 5 and 10%) contribution to this event. Even forced by such a substantial accentuation of sub-shelf melting, the Antarctic ice sheet can therefore not be considered as the major contributor of MWP-1A.

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IMPROVING KNOWLEDGE ON MALARIA EPIDEMIOLOGY USING URBAN CLIMATE MODELLING

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During past decades, strategies for mitigating malaria have been designed without considering the impact of urbanization. Yet urban population is expected to represent 75% of Africa's total population by 2050, hence supporting the need of understanding malaria transmission in cities. In response to this issue, The REACT project aims at developing an index for malaria risk assessment among and within sub-Saharan African cities. Therefore, inter- and intraurban variability of the malaria epidemiology has to be described.

As the impact of urban areas on climate has been thoroughly demonstrated (Oke, 1982; Grimmond and Oke, 1999; Arnfield, 2003), it is supposed that local climate in cities will correlate with malaria mosquito presence. For now, one domain is being studied over the African Great Lakes, focusing on Kampala, Uganda. The regional climate is considered as tropical and interactions between the Lake Victoria and its surroundings have been identified (Thiery et al., 2015). Since malaria depends on typical climatic factors such as precipitation, relative humidity, wind speed and temperature, the first part of the project aims at defining a proper downscaling methodology that will allow for better representation of those factors at regional to urban scales.

Hence, 11-year simulations will be performed at 12 and 2.8 km horizontal grid resolution using the COSMO-CLM model coupled with the urban canopy model TERRA_URB. The latter is activated only at 2.8 km resolution. For representing the intraurban variability of the landscape and its related morphological parameters, the Local Climate Zone scheme (Stewart and Oke, 2012) is employed. Indeed, former studies (Brousse et al., 2016; Wouters et al., 2016; Alexander et al., 2016) demonstrated its applicability for urban climate modelling and its usefulness over data-scarce regions.

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MODELLING PAST AND PRESENT DISTRIBUTIONS OF TROPICAL AFRICAN BIOMES AND SPECIES USING A DYNAMIC VEGETATION MODEL

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In the framework of the AFRIFORD project (Genetic and paleoecological signatures of African rainforest dynamics: pre-adapted to change?, http://www.ulb.ac.be/facs/sciences/afriford/), we used the CARAIB dynamic vegetation model to simulate past and present distributions of tropical African vegetation at the biome and species levels to better project and understand future dynamics. We studied individual species (*e.g.*, *Afzelia africana*, *Pericopsis elata*, *etc*) for which we determined climatic requirements and gathered specific traits.

To perform palaeovegetation reconstructions, we used outputs of snapshot climate simulations (*e.g.*, CNRM-CM5, FGOALS-g2 and MRI-CGCM5 global climatic models) from the PaleoModelling Intercomparison Project (PMIP3, https://pmip3.lsce.ipsl.fr/) for the mid-Holocene (6 ka) and the Last Glacial Maximum (LGM, 21 ka). These global climatic outputs were downscaled at a 0.45° spatial resolution over Equatorial Africa using the MAR regional climate model (RCM). For current conditions, the RCM was nested in different historical climate datasets.

We compared modelled species distributions with species occurrences from different databases for present and with palaeorecords for past periods. MAR regional climate simulations notably allow CARAIB to reproduce the Dahomey Gap separating the Upper and Lower Guinean forests in West Africa in present biome distribution. The vegetation model also simulates LGM rainforest distribution in agreement with hypothetical glacial rainforest refuge areas inferred from palaeorecords.

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DROUGHT CHARACTERIZATION BASED ON GRIDDED DATASET IN CENTRAL ASIA

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In drought prone regions like Central Asia, drought characteristics are of uttermost importance for drought risk management. In this study, therefore, the spatiotemporal drought characteristics are analyzed over Central Asia in the past half centrury, based on the Climatic Research Unit (CRU) dataset. Drought events, as well as their frequency, duration, severity, intensity and preferred season, are studied by using the Run theory and the Standardized Precipitation Evapotranspiration Index (SPEI) at 3-month, 6-month and 12-month timescales. Variable patterns of drought characteristics are found in Central Asia. Such as, Hexi Corridor region and the southeastern part suffered from more short-term drought occurrences which mostly occurred in summer while the northeast part experienced fewer occurrences with longer duration and larger severity. A general wetting trend between 1966 and 2015 with a drying switch since 2003 is found in Central Asia based on the Sen's slope and Modified Mann-Kendall method (MMK). Six subregions are identified based on the Principle Components Analysis (PCA) and varimax rotation method. At regional scale, the continuous wetting trend was found in the north Kazakhstan while a consistent drying in the Aral Sea and Hexi Corridor region was observed in the last half century. For 2003-2015, a significant drying pattern is detected in most Central Asia except the northern Kazakstan. According to the cross wavelet transform analysis, the drought variation was mainly dominated by 16-64-month periods. In addition, significant coherences between subregional drought variation and large-scale climate pattern (i.e. North Atlantic Oscillation, Siberian High and El Niño-Southern Oscillation) are also found based on cross wavelet coherence. The results of this study may serve scientific references for policy design in the framework of water resources management and drought mitigation in Central Asia at a sub-regional scale.

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DEFINING SPATIOTEMPORAL CHARACTERISTICS OF CLIMATE CHANGE TRENDS FROM DOWNSCALED GCMS ENSEMBLES: HOW CLIMATE CHANGE REACTS IN XINJIANG, CHINA

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The fragile ecosystem and scarce water resources of Xinjiang, China make it especially vulnerable to climate change combined with limited resilience. A reliable analysis of climate change trends is needed to formulate regional adaption strategies and support sustainable development of this region. Therefore, two statistical downscaling (SD) methods and the combination of Mann-Kendall trend test with Co-Kriging interpolation method were used to investigate the spatiotemporal features of climate change in Xinjiang based on the ensemble of 37 General Circulation Models (GCMs) in 2021–2060. The reliabilities of single run and ensemble downscaling results of GCMs were evaluated by 69 meteorological stations over the reference period (1965–2004). The correlation coefficients (CC) with the observational data series for precipitation and temperature ranged between 0.4–0.8 and 0.9–0.99 in the reference period, respectively. CC improved to 0.87 and closed to 1 after downscaling, respectively. A pronounced increase of ca. 0.27–0.51 °C decade^{-1} was projected overall, and especially for RCP8.5 in northern Xinjiang. In general, the precipitation changed by −1.66–6.83% decade^{-1} while varying seasonally and spatially; a declining tendency emerged in the western regions of Xinjiang during summer. More extreme rainfall events are predicted to occur in summer and autumn months, while more warm extremes would be concentrated in August. The reference evapotranspiration was predicted to increase at a rate of 0.33–2.16% decade^{-1} owing to a drastic increase in temperature. The climate in Xinjiang will continue to be warmer and wetter. Nevertheless, western Xinjiang will experience a warmer and drier climate in summer and autumn. These projections of climate change in the near future are able to provide useful information for the development of potential mitigation measures and adaptation strategies.

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REEMERGENCE OF ANTARCTIC SEA ICE PREDICTABILITY AND ITS LINK TO DEEP MIXING IN GLOBAL CLIMATE MODELS

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Unlike the rapid sea ice losses reported in the Arctic, satellite observations show a small overall increase in Antarctic sea ice extent (SIE) over the period 1979–2015. However, this upward trend needs to be balanced against the recent pronounced SIE fluctuations occurring in the Antarctic. In the space of three years, the SIE sinks from its highest value ever reached in September 2014 to record low in February 2017. Multiple mechanisms have been proposed as potential drivers of the Antarctic sea ice cover changes over the last decade. As yet, none of them has provided a single and fully satisfactory explanation.

Thanks to this study, we determine if state-of-the-art climate models can be useful to predict the recent natural fluctuations of sea ice occurring in the Antarctic. We shed light on this critical issue by looking at the seasonal prediction properties of the Antarctic sea ice with six general circulation models (GCMs), which are ECEarth2.2, ECHAM6-FESOM, GFDL CM3, HadGEM1.2, MIROC5.2 and MPI-ESMLR.

Understanding the evolution of the Antarctic sea ice turns out to be more complicated than for the Arctic for two reasons: the lack of observations and the well-known biases of climate models in the Southern Ocean. That is the reason why we considered idealised ensemble experiments rather than real ensemble experiments to assess the initial-value predictability of the Antarctic sea ice on seasonal to interannual timescales. Those experiments were generated within the APPOSITE project.

The limits of the initial-value predictability are estimated thanks to the potential prognostic predictability (PPP). This metric basically compares the variance of the ensemble predictions (which gives a idea of the ensemble spread) to the variance of some reference forecast, chosen in this case as the control simulation variance. Thus, it gives a measure of the uncertainty of the ensembles.

We applied the PPP to the ice edge location and the ocean heat content. This study reveals that the ice edge location can potentially be predicted up to three years in advance in some models. However, the predictability is limited to autumn and winter months. The connection between two consecutive predicting seasons is provided by the ocean through its large thermal inertia. The information about sea surface conditions is stored at depth at the end of the winter and influences the sea ice advance the following year as the mixed layer deepens. The effectiveness of this mechanism is found to depend upon the depth of the mixed layer.

Caution must be exercised in interpreting the magnitude of the potential predictability results that we got, as there is evidence that the Antarctic sea ice predictability is promoted by deep Southern Ocean convection. We therefore suspect models with excessive convection to show better sea ice potential predictability results due to a wrong representation of the Southern Ocean.

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ADDED VALUE OF CONVECTION-PERMITTING SCALE IN SIMULATING FUTURE CHANGE IN EXTREME PRECIPITATION

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Owing to computational advances, an ever growing percentage of regional climate simulations are being performed at convection-permitting scale (CPS, or a horizontal grid scale below 4 km). One particular area where CPS could be of added value is in future projections of extreme precipitation, particularly for short timescales (e.g. hourly). However, recent studies that compare the sensitivity of extreme hourly precipitation at CPS and non-convection-permitting scale (nCPS) have produced mixed results, with some reporting a significantly higher increase of extremes at CPS, while others do not. Important to note is that the domains used in these studies differ significantly in orographic complexity, and include both mountain ranges as well as lowlands with minimal topographical features.

This study investigates the added value of CPS for future extreme precipitation projections, by performing and analyzing three sets of 30 year climate simulations (hindcast, control and end-of-century RCP 8.5) at both nCPS (12 km resolution) and CPS (2.5 km resolution), using the regional climate model COSMO-CLM. The study area is Belgium and surroundings, and is comprised of lowland in the north (Flanders) and a low mountain range in the south (Ardennes). These two distinct topographical regions are separated in the analysis, allowing for an assessment of the influence of topographic complexity.

Results show that the added value of CPS in simulating future extreme precipitation depends on both timescale and topography. Despite a background of general summer drying in our region caused by changes in large-scale circulation, our CPS simulations predict a significant increase in the frequency of daily and hourly extreme precipitation events, for both the lowland and mountain areas. The nCPS simulations are able to reproduce this increase for hourly extremes in mountain areas, but simulate a significantly lower increase or even a decrease for (a) hourly extremes in lowlands and (b) the most extreme parts of the daily extreme precipitation range (60-100 mm/day) for both lowlands and mountain areas. A possible explanation for the regional dependence of our results is a difference in triggering mechanism. Convective activity over lowlands is mainly triggered by differential surface heating and synoptic scale weather fronts, whereas in mountain areas, orography plays a role as well. These results suggest that nCPS simulations match and possibly even overestimate future increases in extreme precipitation linked to orography, while simultaneously underestimating the increase associated with the other triggering mechanisms.

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THE DOMINANT ROLE OF CLIMATE CHANGE IN DETERMINING CHANGES IN EVAPOTRANSPIRATION IN XINJIANG, CHINA FROM 2001 TO 2012

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Water resource is a critical limiting factor for the sustainable development of economics for the Xinjiang Uyghur Autonomous Region of China, which is located deep inside the Eurasian continent and is characterized by extreme low precipitation and high temperatures. Evapotranspiration (ET) is the highest outgoing water flux in the hydrological cycle and, is a primary determinant of water availability in Xinjiang. Besides, Xinjiang has experienced significant land cover and climate change since the beginning of the last decennia. However, a reasonable simulation of ET and its response to environmental factors are still unclear. Land surface models (LSMs) provide a possible resolution for simulating ET and quantifying the contributions of various environmental factors on ET. However, most global LSMs underestimate ET within arid/semi-arid regions, because the model cannot capture the form and structure of desert plants and related root functions. Vegetation in dry land regions has evolved into rich and deep root systems and high root/shoot ratios, which could mitigate the effect by arid circumstances. When soil water is limiting, most species within dryland ecosystems do not suffer from water stress. Besides, most LSMs also cannot account for irrigation effects on ET for cropland.

For this study, to simulate ET and its response to climate and land cover change in Xinjiang, China from 2001 to 2012, we used the Common Land Model (CoLM) by adding irrigation effects for cropland and modifying root distributions and the root water uptake process for shrubland. Our results indicate that mean annual ET from 2001 to 2012 was 131.22 (± 21.78) mm/year and demonstrated no significant trend (p = 0.12). The model simulation also indicates that climate change was capable of explaining 99% of inter-annual ET variability; land cover change only explained 1%. Land cover change caused by the expansion of croplands increased annual ET by 1.11 mm while climate change, mainly resulting from both decreased temperature and precipitation, reduced ET by 21.90 mm. Our results imply that climate change plays a dominant role in determining changes in ET, and also highlight the need for appropriate land-use strategies for managing water sources in dryland ecosystems within Xinjiang.

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