What can Remote Sensing do for the Conservation of wetlands?

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Abstract book

Publishers
Javier Mª Bustamante Díaz
Ricardo Díaz-Delgado
Alfredo Huete
Patricia Kandus

Avd. Américo Vespucio. Isla de La Cartuja. 41092 Sevilla (Spain)

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Summary

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Javier Bustamante
Chairman
Seville, 21 September 2015

Introduction

Wetlands are fragile and dynamic ecosystems sensitive to changes in climate and land-use, and rich in biodiversity. For centuries they were considered to have little or no value, and most have been drained or transformed. In 1971 the first international convention for the protection of Wetlands, the Ramsar Convention, was signed to promote their conservation and sustainable use. Now it is recognized that wetlands provide fundamental ecosystem services, such as water regulation, filtering and purification, as well as scientific, cultural, and recreational values. Wetlands constitute an extensive array of ecosystems ranging from lakes and rivers to marshes and tidal flats. An increasing number of wetlands have some kind of legal protection, and many wetlands are monitored and actively managed.

Remote Sensing (RS) can provide useful information about wetlands. Earth Observation (EO) satellites can be used to delineate flooded areas, and can provide information on wetland location, limits and extent. They can also be used to monitor changes in water quality (e.g. cyanobacterial blooms, trophic status, inputs of terrestrial Carbon), or to map habitat types, vegetation communities or ecosystem services. Since the launch of Landsat 1 in 1972 there has been an exponential increase in the number of sensors aboard satellites providing valuable information about wetlands. EO satellites provide periodical information that is essential for dynamic ecosystems such as wetlands. However, the amount of information EO satellites can provide is currently much more than scientists can process or managers are aware of.

Compared to other areas of research, wetland ecology has lagged behind in the use of information provided by satellites. RS is used extensively in meteorology and climate, geology, oceanography, land use change or terrestrial vegetation dynamics. Research groups using RS techniques to study wetlands are to date small and dispersed. There is, up to our knowledge no regular scientific meetings on the topic "Remote Sensing of Wetlands". Wetland ecologists and experts in remote sensing usually attend different meetings and publish their findings in different journals, limiting scientific interaction. While wetland research tends to be based on short-term projects and on measurements at point locations, EO satellite data allows to extend the observations in time, in space and in the spectral domain. We hope that this International Symposium: What can Remote Sensing do for the Conservation of Wetlands? will be a first step to set up such regular meetings facilitating the contact between wetland ecologists interested in RS techniques and RS experts, in an interdisciplinary manner.

Javier Mª Bustamante Díaz
Ricardo Díaz-Delgado
Alfredo Huete
Patricia Kandus

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Javier Bustamante, Estación Biológica de Doñana-CSIC, Spain
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Alejandro Rodríguez, Estación Biológica de Doñana-CSIC, Spain
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Oral Communications and Posters Summary

Invited lectures

Remote sensing of wetland dynamics, functioning, and resilience to human and climate impacts

Alfredo Huete

Abstract

Wetlands provide critical ecosystem services to societies and play important roles in storing terrestrial carbon and safeguarding biodiversity, yet they are highly endangered and degrading and/or disappearing at alarming rates. Here we review major satellite Earth Observation developments and achievements in mapping the current extent, health, as well as declines of the world's wetlands, and discuss some of the major unresolved challenges in understanding wetland functioning that are crucial to their future conservation. New and upcoming remote sensing tools as well as some case studies are also presented. The temporal dynamics of wetlands at seasonal and inter-annual scales are important to better understand their functioning, resilience and vulnerabilities to inter-annual climate variability, environmental disturbance, and human impacts. Current knowledge of wetland functional responses to seasonal drivers and controls are limited and insufficient for accurate ecosystem model representations needed to predict current and future climate and environmental change impacts. Key questions on climate, hydrology, and soil controls on structure and function of coastal- and inland-wetlands remain largely to be explored. We focus on current remote sensing developments and challenges in addressing wetland temporal dynamics, seasonality/ phenologies, and their biologic, meteorologic, and environmental drivers. An understanding of seasonal controls on wetland function thus becomes prerequisite to advance predictions of wetland response to future climate and environmental change. The seasonality question, observable with satellites, thus provides an important threshold test for wetland conservation.

Alfredo Huete
http://www.uts.edu.au/staff/alfredo.huete
University of Technology, Sydney
Australia

The contribution of remote sensing for the conservation and management of wetlands: A view from South America

Patricia Kandus

Abstract

Wetlands cover a significant portion of South America, with an estimated 20% of the territory, well above the global values of 5-8%. They can be expressed as landscapes with wetlands, which contain wet patches in terrestrial matrices, or true wetland landscapes, such as the extensive fluvial and coastal macrosystems. They provide a wide range of ecosystem services to society, in particular related to the supply and storage of freshwater water. Although South American wetlands have been considered to be in relatively good state of conservation, the increase in productive development of the last decades has put substantial pressure on the area´s natural resources, particularly on wetlands. This compromises the ecological integrity of wetlands with continuous deterioration caused by pollution, coverage degradation, overuse, loss of biodiversity, and net losses due to their conversion into terrestrial land as a result of filling or draining, or into aquatic system as a result of dredging. In this context, remote sensing has emerged as a critical tool for wetland conservation in three main areas of interest: wetland inventory, development of protocols for monitoring their status, and quantitative assessment of ecosystem services provision. Examples of these uses across South America will be illustrated. Nevertheless, the wide range of spatial scales where wetlands are expressed and their intrinsic heterogeneity associated with eco-hydro-geomorphic characteristics and temporal variability, pose challenges to the use of remote sensing products. Technical and conceptual advances need to be elaborated in conjunction in order to move forward.

Patricia Kandus
Universidad Nacional de San Martín
Argentina

Oral Communications

Application of spectral indices including Landsat tasseled cap transformation to estimate wetlands under natural and regulated hydrological regime changes and direct human impact in the Volga-Akhtuba floodplain.

Maria Vladimirovna Kozlova. Principal contact for editorial correspondence.
Olga Vladimirovna Gorelits
Anna Alexandrovna Sapozhnikova
https://www.researchgate.net/profile/Maria_Kozlova4
State Oceanographic Institute. Russian Federation. Information System Lab. (ISysLab), Researcher, PhD

Alexander Vladimirovich Kozlov
Lomonosov Moscow State University, Russian Federation.
Faculty of Mechanics and Mathematics, Navigation and Control Lab. Researcher, PhD

Igor Vladimirovich Zemlianov
State Oceanographic Institute, Russian Federation
Information System Lab. (ISysLab), Head of the Department, PhD

Abstract

In the unified ecosystem comprising the Volga river basin - Volga-Akhtuba floodplain (VAF) – Volga delta – Caspian Sea, the Lower Volga is a unique natural territorial complex with intrazonal ecosystems located within arid lands. The spatial and temporal ecosystem dynamics of the VAF are mostly characterised by seasonal and long-term variations in the hydrological regime. Since the mid-20th century the Lower Volga hydrological regime is regulated by the Volzhsko-Kamskiy hydroelectric power station (HEP) cascade. The downstream Volzhskaya Hydro-Electric Power Plant is situated at the top of the VAF. Local field observations of land cover reveal the activation of desertification processes, gradual loss of original wetland ecosystems and their replacement by arid ecosystems in recent years. To evaluate the scale of these changes, accurate monitoring of the VAF region is necessary in order to localize and quantify the desertification processes, estimate the state of wetland plant cover, its seasonal and annual dynamics, so that the hydrological regulation strategies can be adapted to conserve wetland ecosystems and prevent their loss. In this case remote sensing data is extremely useful for monitoring the VAF. Simple band math indices –NDVI and NDWI or MNDWI calculated from Landsat data– are useful because of the ease of calculation, low demands for computational resources and appropriate results for common analyses of land cover feature dynamics. To improve this data we also applied a fundamentally distinct approach to analyze key scenes – tasseled cap transformation techniques (TCT). Although it is time consuming, TCTs are powerful methods for plant cover detection and also provide valuable information about soils and water bodies. We found these methods to be the most appropriate for detecting changes in the VAF wetland plant communities in terms of soil wetness and water body dynamics. These data assays are combined with an analysis of lower spatial but higher temporal resolution data (SeaWifs and MERIS FAPAR products). Our results indicate that vegetation activity may vary greatly depending on the type of ecosystem, its location in the VAF, Volga and Akhtuba water runoff, precipitation, human activities, etc. Our findings from remote sensing data on land cover in the VAF produce reliable conclusions for significant fluctuations of vegetation activity in the floodplain territory and allow the development of proposals for operational strategies on the hydrotechnical facilities which characterise the Lower Volga wetland hydrological regime. The study is vital for the conservation of the VAF's unique ecosystems and biodiversity.

Mapping and monitoring semi-arid wetland surface water dynamics through spectral mixture analysis of a time series of Landsat satellite images (1984 – 2011)

Meghan Andrea Halabisky
University of Washington, United States. College of the Environment, School of Environmental and Forest Sciences, PhD Student. Principal contact for editorial correspondence.

L. Monika Moskal
http://faculty.washington.edu/lmmoskal/
University of Washington, United States. College of the Environment, School of Environmental and Forest Sciences, Associate Professor

Abstract

Wetlands are among the most biodiverse ecosystems in the world, due largely to their dynamic hydrology. The hydroperiod, which can be defined as the timing and duration of flooding within a wetland, is an important factor in determining wetland habitat types and the species that they support. Despite the importance of the wetland hydroperiod, it is not well understood, in part because it is time-consuming and expensive to monitor changes in wetland hydrology using field measurements. We used a high resolution wetland classification and spectral mixture analysis (SMA) of 230 Landsat satellite image scenes to reconstruct surface water dynamics for 750 wetlands in Washington State, USA, from 1984 to 2011. SMA identifies the fractional abundance of spectrally distinctive and physically meaningful materials, known as spectral endmembers, which comprise a mixed pixel, and provides sub-pixel estimates of surface materials. Endmembers for water and sage steppe were selected directly from each image date in the Landsat time series while endmembers for salt and wetland vegetation were derived from a mean spectral signature of selected dates spanning the 1984 – 2011 timeframe. This method worked well (R^2=0.98) even for small wetlands (<1800 m^2, or 0.18 ha) providing a wall-to-wall dataset of reconstructed surface-water dynamics for wetlands across our study area. Our method differs from others by providing detailed hydroperiod data at the individual wetland scale while still covering a broad landscape. Our results can be used both to monitor human impacts to wetlands across the landscape and as inputs for forecasting changes to wetland surface water dynamics under a changing climate. This knowledge is being used to inform the development of strategies to conserve the biodiversity supported by these systems, and prioritize and/or help stratify wetlands for further study and conservation action.

Past, present and future use of remote sensing for wetland conservation in Spain

José Antonio Domínguez Gómez
Spain
Principal contact for editorial correspondence

Abstract

Introduction: The use of remote sensing to study wetlands in Spain began in the 80's, with studies on the water quality of the Albufera de Valencia. The environmental problems that occurred in the 80's and 90's, such as the excavation of gravel ponds in the Jarama valley, makes this area near the city of Madrid a convenient pilot area to study wetlands produced by the extraction of gravel. An agreement between the Community of Madrid and CEDEX, a civil engineering research agency, helped to establish remote sensing as a tool for wetland management in Spain. In the beginning of the 21st century this technique was consolidated for wetland monitoring and proposed to ESA in the First International Wetland Symposium (2006), in which Spanish papers focused on using remote sensing for monitoring Wetlands in Spain or in a particular wetland area, such as Doñana. From 2006 to 2012 the Spanish Ministry of the Environment invested heavily to consolidate remote sensing as a tool to support official planning for integrated water cycle. A manual for determining the water needs of wetlands was eventually developed. However, subsequent economic and political conditions in Spain and the crisis paralyzed many of these plans, including the use of remote sensing as a management tool which was dependent on and refined by the General Directorate of Water (Ministry of Agriculture, Food and Environment). However Life, CDTI and other projects have allowed UAV to be used to study wetlands. The aim of this presentation is to describe the Spanish experience in the use of remote sensing to study and manage wetlands, and the challenges presented by new sensors and platforms.

Data and Methods: Years of experience in: (1) processing all kinds of images for the study of wetlands: (a) Spatial resolutions: low (MERIS; 300m), medium (Landsat; 30m), high (ATM, CASI, AHS; 3.44m), hyper-high (UAV; 3cm), ultra-hiper-high (UAV; 3mm). (b) Spectral resolutions: panchromatic, multispectral, hyperspectral and thermal. (c) Time resolutions: changes and times series; and in (2) field data campaign: spectroradiometer, thermal sensor and laboratory analysis. The methodology has been standardized in the following phases: planning, implementation, results and final report. This methodology is followed in each part of the project as a certified quality system (ISO): field data campaign, image processing (atmospheric correction, algorithm development, checking and thematic mapper), operating system.

Results: The years of field work have generated a specific spectral library of several Spanish wetlands, such as La Albufera de Valencia, Las Tablas de Daimiel, Doñana, Sanabria, Monegros, Hito, Parque de Peñalara, Parque del Sureste de Madrid, etc. This experience also allowed an operating system to be built that was used by the General Directorate of Water from 2008 to 2012 using Landsat 5 and MERIS images, as well as the development of predictive models of water bodies, monitoring the number of gravel pit ponds, flood surface area, agricultural uses, as at La Albufera de Valencia, or monitoring the phreatic level (Puebla de Beleña wetland). In addition, predictive models for NDVI and temperature were used to study the behaviour of the phenological state of the palustrine vegetation, which can be used as an indicator of the wetlands' state.

Conclusion: Our experience in using remote sensing to study and to preserve Spanish wetlands is significant, but insufficient because much data remains unprocessed and coordination is necessary to analyze all the information available and make it accessible for research and management. The future presents new challenges such as the Sentinel satellites. Past experience will help us to obtain further results. However, for other platforms, such as UAV, we will have to develop new methodologies in order to understand millimetre information, time series, etc. If the information provided by remote sensing is not properly understood or used by managers, the effort being made is useless. We must also therefore investigate how to make remote sensing a useful tool for the conservation of wetlands.

Investigating variations in flood areas of seasonal lagoons in the La Mancha Húmeda Biosphere Reserve, Spain, using remote sensing and data mining

Carolina Doña Monzó.
Department of Earth Physics and Thermodynamics, Faculty of Physics, Spain
Principal contact for editorial correspondence.

Ni-Bin Chang
Department of Civil, Environmental, and Construction Engineering, United States

Vicente Caselles
Department of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Burjassot, Valencia, Spain

Juan Manuel Sánchez
Department of Applied Physics, University of Castilla-La Mancha, Almadén, Ciudad Real, Spain

Antonio Camacho
Cavanilles Institute of Biodiversity and Evolutionary Biology, University of Valencia, Burjassot, Valencia, Spain

Abstract

La Mancha Húmeda has been designated a Biosphere reserve since 1980. It is a wetland-rich area located in central Spain that includes several dozen temporary lagoons, whose seasonal water level fluctuates. Water inflows into these lagoons come from both precipitation/runoff from very small catchments and, in some cases, from groundwater, although some also receive waste water from nearby towns. Most of them lack surface outlets and behave as endorheic systems, with water loss mainly resulting from evaporation causing salt accumulation in the lake beds, which makes most of these lagoons saline. In order to accomplish the goals set out in the European Water Framework Directive and the Habitats Directive, management plans are being developed. These directives establish that all EU countries have to achieve a good ecological status and a favourable conservation status at these sites, and especially for their water bodies. A core task required to carry out these management plans is to develop an understanding of the hydrological trend in these lagoons with a sound monitoring scheme. To this end, an estimation of the temporal evolution of the flood area for each lagoon, and its relationship with the hydrological patterns and the seasonal effect can be achieved by using remote sensing techniques. This study aims to develop a remote sensing methodology to estimate the change in water coverage areas in each lagoon from satellite images with the aid of the ground-truth data sets. Landsat-5, 7-8 and Deimos 1-2 images were used to fulfil this goal. In this analysis, unsupervised classification methods and genetic programming were applied. Results were compared with ground-truth data and the classification errors were evaluated by means of the kappa coefficient. Findings indicate that the ISODATA and genetic programming models both presented acceptable kappa values. Both methods were then compared with flood areas of lagoons measured in situ by GPS concurrent with the satellite overpass. We were therefore able to study the hydrological pattern of these lagoons which in turn provides information about the hydrological trends of water bodies on a seasonal scale. Lastly, the linkage of water area variations over time with precipitation, air temperature, wind, and ET is presented.

Semi-Automatic Delineation of Peatland Drains

John Connolly
http://jcresearch.wix.com/johnconnolly
Independent Researcher. Ireland

Abstract

Global peatland contain about 25% of the terrestrial soil organic carbon. This carbon stock is vulnerable to ecosystem disturbance such as drainage, which is usually the first step in the modification of peatlands. Drained peatlands are significant hotspots for carbon dioxide (CO_2) emissions Between 1990 and 2008, global CO_2 emissions from drained peatland increased by about 20% from 1,058 Mt to 1,298 Mt. In recent years, there has been a concerted effort to understand the effects of drainage and subsequent drain blocking on ecosystem functions and dissolved organic carbon (DOC) dynamics, particulate organic carbon (POC) dynamics and net C flux. Given the potential impact that drains have on peatlands there is a need to identify drained networks for conservation assessment. Peatlands are spatially extensive and determining the location and density of drains is a difficult and expensive task. In this work Object Oriented Image Analysis (OBIA) was tested to in an effort to extract the spatial extent of drains on a low level Atlantic blanket bog in the west of Ireland. A geo- and ortho- rectified Geoeye-1 image was acquired for the study area. The spatial resolution of the image was 2m and it was pan-sharpened to 0.5 m using the Brovey transform in ArcGIS. Feature Analysis (FA), an add-on to ArcGIS was used for the OBIA. FA is a black box method where the user defines some parameters. The training data consisted of 23000 m of digitised drains throughout the study site. Five validation areas were selected covering 12% of the study site. Within these areas all drains (76,634 m) were manually digitised by selecting the centre line of a drain. The results show that the process accurately delineates the spatial extent of peatland drains. The OBIA FA process extracted just under 500,000 m of drains throughout the study site. Two accuracy assessment methods were used: 1. The error matrix (EM) and 2. The measures of completeness, correctness and quality (CCG)) to assess the validation area and withi five sub-areas. For the entire validation area the EM method produced an overall accuracy of 94%, with a Producer's and User's accuracy for drains ranging from 60% and 83% with a Kappa of 66%. The CCG method yields results of 85%, 85% and 71% respectively. This method would be very useful in detecting and mapping peatland drains over large areas across the globe.

Monitoring the ecological state of small coastal wetlands by remote sensing in the Albufera de Valencia Natural Park (Spain)

Juan Miguel Soria García. Principal contact for editorial correspondence.
José Flor Izquierdo
Sara Calvo García
Susana Romo Pérez
Dep. Microbiología y Ecología. Fac. Ciencias Biológicas. Universidad de Valencia, Spain

Abstract

The Albufera de Valencia Natural Park is a wetland that includes, among other aquatic ecosystems, small wetlands named "malladas". They are located in the coastal dunes that separate the Albufera lagoon from the Mediterranean Sea. The dune ponds are small (0.1 – 3.6 ha), shallow (less than 3 m in depth) and mainly temporary. We studied the hydrological and ecological status of these systems using remote sensing from previous and up-to-date images. Additionally, this study also reports on the changes in the complex dune ecosystem during the restoration projects carried out from 1986 to 2008. The images analysed were obtained by satellites Landsat 4, 5, 7 and 8. The flood phases, water surfaces and the vegetation in the wetland were studied by means of the near-infrared band, PCA and NDWI index and the IsoData classification. The results were calibrated complementarily with field data from other wetlands in the Park. Surfaces of a pixel size were analysed together with water layers over two centimetres (in vegetation-free zones) and pond sediment surfaces that were free of vegetation during the initial flooding phases. After processing the images, we could observe the changes and dynamics of the water level and hydrological cycles in some of the temporary and permanent ponds. Some of these changes were related to the alternative periods of flooding after heavy rains and drying taken place for several years. These alternating phases are inherent to temporary systems; they drive the biological rhythms of most of their species and determine patterns of high biodiversity in this type of ecosystem. This type of ecological study which is based on time-series from remote sensing, improve our knowledge about the functioning of aquatic ecosystems; in this case, small dune ponds located within complex, highly diverse coastal wetlands. Overall, in the Iberian Peninsula they represent unique and interesting wetlands, located in transitional zones between the sea and the coastline, often under great urban and human pressure. Today, in the Mediterranean, they are becoming infrequent and isolated ecosystems, where remote sensing can monitor long-term changes, as well as inform us about ecological events and the success of restoration and conservation projects. The results show that it is an excellent complementary tool for the management of coastal wetlands.

What do wetland conservationists require from remote sensing based wetland monitoring? User engagement and service cases in the context of the H2020 project "Satellite-based Wetland Observation Service"

Christoph Schröder
http://www.etc.uma.es/index.php?option=com_contact&view=contact&id=12:christoph-schroeder-
European Topic Centre - Universidad de Málaga, Spain. GIS and Environmental researcher
Principal contact for editorial correspondence.

Dania Abdul Malak
European Topic Centre - Universidad de Málaga, Spain. Director of ETC-UMA

Eleni Fitoka
Mouseio Goulandri Fysikis Istorias, Greek Biotope Wetland Centre, Greece

Stephan Flink
Wetlands International, Netherlands

Anis Guelmani
Foundation Tour du Valat, France

Lammert Hilarides
Wetlands International, Netherlands

Christian Hüttich
Friedrich-Schiller-University Jena, Germany

Eric Mino
Unité Technique du SEMIDE / EMWIS, France

Christian Perennou
Foundation Tour du Valat, France

Kevin Smith
IUCN, United Kingdom

Susanne Thulin
Brockmann Geomatics Sweden AB, Sweden

Kathrin Weise
Jena-Optronik GmbH, Germany

Abstract

The H2020 project SWOS ("Satellite-based Wetland Observation Service") brings together high-level institutions in wetland monitoring with the aim of developing a monitoring and information service for wetland ecosystems that complements the MAES process under the EU Biodiversity Strategy to 2020 by supporting the maintenance and restoration of wetland ecosystems and their services. SWOS will provide the required Earth Observation data and indicators to explore the conditions of the wetland ecosystems and detect on-going changes. This will permit preparation of conservation and restoration measures that will allow us to maintain the provision of the most relevant ecosystem services and biodiversity. The service will

deliver a basis for political decisions and protection measures. As wetlands are key ecosystems and hotspots of biodiversity, the service will contribute to assessing their role in the water cycle and climate regulation as well as the status of our planet's biodiversity. The service provided by SWOS will be key input to the management of very fragile ecosystems such as wetlands, especially within the Natura 2000 network as many selected wetlands are part of this EU-wide network of nature protection areas. The most important objective of SWOS is to prepare and install a service with users for users. The aim is a service, tailor-made to answer to user and policy needs, that it is easy to use and demonstrates how existing and new Earth observation information can be used for improved management and the conservation of wetlands as a significant part of a broader natural resources policy. The service will be connected to the Global Earth Observation System of Systems (GEOSS) and support the development of a Global Wetland Observation System in close collaboration with the Group on Earth Observations (GEO) and other international partners like the Ramsar Convention on Wetlands. This paper provides an overview of the SWOS approach and gives insights into how the project envisages the engagement of users of the proposed SWOS products through the establishment of user groups and development of service cases. A key part of user activities is the identification of stakeholders and potential users working at different levels. This will be achieved by undertaking stakeholder and user mapping and will form a key part of the Science-Policy Interface (SPI) strategy of SWOS. Once the stakeholders and users are identified their requirements will be acquired based on prior drafted potential service cases for targeted users. After analyzing user requirements the final service cases for the detailed service demonstration and map production will be selected and described. The SWOS service cases will serve as demonstrators for improved management and decision making. They will show how the service can support national reporting obligations and implementation of international and European agreements and directives, provide information such as indicators to inform wetland management decisions, assess wetland related ecosystem functions and services, and monitor degradation and fragmentation of individual wetlands.

Remote sensing, wetlands and agriculture

Carmen Castañeda del Álamo. Principal contact for editorial correspondence.
Juan Herrero Isern
http://www.eead.csic.es/
Estación Experimental de Aula Dei, EEAD-CSIC, Avenida Montañana 1005, 50059 Zaragoza, Spain
Consejo Superior de Investigaciones Científicas. CSIC

Manuel Márquez Fernández
Concepción 16, 3ºA, 50008, Zaragoza, Spain

Abstract

Agricultural policies have shifted in recent decades from encouraging agricultural production to agricultural sustainability. Worldwide, many wetlands have been lost and degraded by agricultural intensification, and losses might increase in the future. The continuous degradation of wetlands in agroecosystems is more intense in dry regions where modern agriculture involves far-reaching landscape transformation due to farm consolidation and the development of large irrigation projects. As an example, the Spanish Government launched a project to irrigate over 60,000 ha in southern Monegros, NE Spain, a territory containing Ramsar sites. Its uniqueness has already been recognized for bird and plant protection under EU Directives. The irrigated lands available will deal with two new circumstances; the modification of wetlands hydrology and soils characteristics. However, their consequences for habitat preservation have not been evaluated. A major threat for Monegros saline wetlands is flooding by fresh and polluted water from irrigated lands, which can destroy existing habitats and extinguish extremophiles and/or endemic organisms, and finally, lead to eutrophication. Meanwhile, smaller wetlands have been plowed and surviving wetlands are suffering extensive perimeter loss. Scientific understanding of the role that wetlands play in the ecosystem has increased appreciation for them in arid environments. One of the problems in monitoring and preserving arid wetlands is the scarcity of records. For this reason, remote sensing was applied early to wetland monitoring in order to identify their hydrological cycles. However, soil management is key to preserving bio- and edaphodiversity in arid lands and to reconciling agriculture with habitat conservation in Monegros. In Monegros, we used remote sensing for the delimitation of agricultural soils in dry-farmed lands with low or nil production due to their aridity and soil composition. Distinctly colored decametric patches with different soil properties and crop (winter cereal) development are dominant in the landscape. Gypsum- and carbonate-rich soils are spread throughout the dry-farm area in relation with the limestone and gyprock substrate; gypsum rich areas are known as very low production areas. White color patches are discriminated with Landsat, Aster and Quickbird images. Post-harvest summer maps were produced from unsupervised classified images of the different sensors, with spectral signatures interpreted using field data. The summer maps showed the distribution of vegetation subclasses (stubble, fallow, and volunteer plants), bare soil subclasses based on different humidity, and white patches. The maps of low production areas derived from Quickbird data are suitable for agricultural management at the scale of agricultural plot. Within white patches, gypsum rich areas were differentiated from carbonate rich areas using the spectral signatures and band ratios, and comparing them with mineral spectra and data composition from soil surface. NDVI maps from spring images together with yield data showed the decrease in crop production in the areas, especially in years with a good development of winter cereal. Identifying low-production areas around wetlands and their fringes can avoid the intensive plowing being seen today and the destruction of native vegetation, as well as decrease chemigation and water use.

Change Detection in Wetlands using Multi-layer fusion Markov Random Field

Maha Shadaydeh
Distributed Events Analysis Laboratory, Computer and Automation Research Institute, Hungarian Academy of Sciences. Hungary. Principal contact for editorial correspondence.

Andrea Manno-Kovacs
Hungary

Tamas Sziranyi
Hungary

Abstract

Remote sensing through multiple time series can help to monitor changes in inaccessible wetland areas. The supervision of these wetlands may provide multiple ecosystem services such as flooding water retention, water quality maintenance, wildlife habitat, and soil erosion control. Concern about changes in the size and quality of many of the world's wetland systems has been growing, as more and more wetlands are affected by human activities and natural phenomena. Classifying and detecting changes in wetlands is an important remote-sensing image analysis task for improved resource protection and management. In this paper, the multi-temporal fusion Markov Random Field (fMRF) model previously proposed by the authors is adapted for classification and change detection in wetlands. The proposed change detection method consists of the following main steps. First, stacks of pixel feature vectors from multi-temporal layers (two or more images) are collected for clustering on the fused layers. Finding the clusters can be achieved either by using unsupervised methods such as the K-means algorithm, or by choosing the characteristic training areas manually. MRF segmentation on the fused layer data and the multi-layer cluster parameters is then applied resulting in multi-layer labelling. This map of multi-layer labelling is used as a training map for MRF segmentation of each single layer. Finally, the consecutive image layer labels are compared for post-classification change detection maps. To further enhance the estimation of the land cover cluster parameters, a new improved statistical cross-layer similarity measure is developed and added to the stack of the layers' pixel feature vector in the fused layers in the clustering and segmentation steps. Experiments have been conducted on multi-sensor multi-temporal aerial images of the wetlands in the Tiszadob area, Hungary, and compared to other state-of-the-art methods. The advantages of the proposed method can be summarized in the following points: 1. The method can be used for different image modalities, such as optical or multi-spectral images; in the latter case, an optimal selection of the characteristic spectral bands can be performed prior to multi-layer clustering for better identification of different wetland classes. 2. The use of noise-tolerant cross-layer similarity measure helps to better identify some classes where radiometric values are dubious. 3. Since the outcome classes of the multi-layer segmentation is used later in the training of each single layer, similar classes are automatically given similar labels in all layers. Hence the post-classification change detection approach in the proposed method defines the location as well as the type of change and thus can be used to monitor wetland dynamics in remote sensing time series.

Satellite data for assessment of biomass, humidity conditions and carbon balance

Katarzyna Dabrowska – Zielinska. Principal contact for editorial correspondence.
Monika Tomaszewska
Maria Budzynska
Martyna Gatkowska
Institute of Geodesy and Cartography Remote Sensing Center, Poland
Remote Sensing Center

Abstract

Wetland ecosystems are very complex since wetland dynamics depend on links between climate, soil and vegetation. Wetland restoration is therefore an important issue in the proper management of water resources. Frequent monitoring of the area is needed to examine the exchange of energy, water and carbon. The study was conducted in the Biebrza Wetlands in Northeast Poland, with a total area of 59,233 ha. The wetlands consist of 25,494 ha of peatland which is unique in Europe because of its marshes and peat areas, many biodiversity-rich plant habitats, as well as its highly diversified fauna, especially birds. The Biebrza Wetlands were designated a wetland site of global significance in the NATURA 2000 Network and since 1995 has been under the protection of the RAMSAR Convention. Terrestrial carbon sequestration is limited by rates of vegetation growth and its accumulation. Spatial estimations of potential carbon sequestration or release are difficult to conduct. The aim of the research was to find out the CO_2 flux for wetlands in order to examine how much carbon is sequestered or released under different wetland conditions, mainly formed by the hydrological processes examined. The drainage processes may release a significant amount of carbon. Satellite data was applied for the study which included: ENVISAT ASAR and MERIS, ALOS PALSAR and PALSAR-2, TerraSAR-X, NOAA.AVHRR and Terra MODIS data. Optical and TerraSAR-X images were used for the classification of wetland communities and calculation of vegetation indices. Heat fluxes such as latent heat and sensible heat were applied for calculations of the soil moisture index. Microwave images were also used for the assessment of soil moisture. For each of the classified wetland vegetation habitats the relationship between soil moisture and the backscattering coefficient was examined. In addition, daily data acquired from NOAA.AVHRR and Terra MODIS were taken and the correlation between NDVI calculated from these data and in-situ measurements of biomass (LAI) were examined. This approach was used for calculations of biomass which was then presented spatially for the whole area of wetlands. Heat fluxes were related to radar signals from different satellites.

Remote sensing for mapping the fraction of green cover in Monegros saline wetlands, NE Spain

Manuela Domínguez-Beisiegel
Todo sobre mi madre 7, 3º, 50019 Zaragoza, Spain

Carmen Castañeda del Álamo
http://www.eead.csic.es/
Estación Experimental de Aula Dei, EEAD- CSIC, Spain
Consejo Superior de Investigaciones Científicas, CSIC
Principal contact for editorial correspondence.

Abstract

A goal of European Habitats Directive is to protect biodiversity through the conservation of habitats (Council Directive 92/43/EEC). This task requires data about the distribution of vegetation and its conservation status. Remote sensing, coupled with field data, is helpful to identify the vegetation cover and to assess its degradation. In arid areas, with sparse vegetation, the spectral reflectance of ground surface includes a mixture of background reflectance from vegetation and soil. For this reason, it is crucial to establish a relationship between spectral data and vegetation cover, type, and phenological state. We have developed a methodology to monitor the habitat 1420 ("Mediterranean and thermo-Atlantic halophilous scrubs") at the inland saline wetlands of southern Monegros (NE Spain). *A. macrostachyum* and *Suaedetum Braun-blanquetii* are the most representative plants, together with bare soil, from the point of view of the surface cover. Sampling points of soils and vegetation were collected in 11 saline wetlands as representative samples of different soil and vegetation cover density. Two field surveys were performed in the dry season in 2007 and 2008, based on the field map of vegetation. Field spectra were recorded with two different spectroradiometers (Cropscan and Ocean Optics). First, we established the relationship between green cover and spectral data obtained from proximal sensors. Second, spectral field information was related to Quickbird bands using homogeneous samples and pure pixels of soil and vegetation. Third, satellite imaging was classified using a decision tree classifier. We established 10 classes representing ranges of ground cover and soil moisture: six for vegetation, from rare vegetated to dense vegetated, three for soil moisture, and water. The classified Quickbird image closely matches the field map of vegetation though the vegetation cover obtained from satellite is always lower in density, indicating underestimation. The difficulties of quantifying the total biomass are caused by shadows, the occurrence of dry, senescent and green parts in these perennial plants; the influence of soil colour; and the presence of efflorescence. Moreover, the effects of spatial and spectral resolution on the identification of vegetation were analyzed by comparing Landsat and ASTER summer images with Quickbird and field spectral data. ASTER and Quickbird data show a good correlation with field spectral data, whereas the relationship using Landsat drops severely. Field data on the spectral characteristics of soil and vegetation are essential in the validation and classification of satellite images. The implementation of these methods with object-oriented classifications, and the use of panchromatic bands across the fused images can be of interest to delimit the vegetation cover and soil classes in arid environments.

LiDAR as a data source for the 2020 biodiversity strategy: overview, case studies and future directions for wetland conservation mapping

András Zlinszky
http://okologia.mta.hu/en/node/5091
Balaton Limnological Institute Centre for Ecological Research Hungarian Academy of Sciences, Hungary
Department for Hydrobiology. Research Fellow

Abstract

European-level policy has made strategic commitments to biodiversity protection, including most recently the European 2020 Biodiversity Strategy. This strategy aims to reach quantitative goals with respect to a well-defined baseline, through a set of strategic targets. These include enhancing the implementation of nature legislation, restoring ecosystems and establishing green infrastructure, sustainable agriculture and forestry, sustainable fisheries, combating alien invasive species and contribution to averting global biodiversity loss. Many of these targets require affordable, up-to-date spatially explicit information, not only on vegetation types but also patterns, processes, structures and environments. The LiDAR coverage of Europe is rapidly increasing, both through national or regional-level scan campaigns and through smaller targeted surveys. LiDAR has proved itself as a versatile data source, and especially through advancements such as radiometric calibration and full-waveform recording, has allowed applications similar to earlier multi-sensor campaigns. This data source has high potential especially for the following sub-targets of the biodiversity strategy:

-Fully implement the Birds and Habitats Directives

-Improve and streamline Natura 2000 monitoring and reporting

-Maintain and restore ecosystems and their services

-Ensure no net loss of biodiversity and ecosystem services

-Improve knowledge of ecosystems and their services (including mapping and assessing ecosystem services within each member state)

-Increase the contribution of agriculture to biodiversity (especially within payment for environmental public goods schemes). We provide an overview of the main features, capabilities and costs of LiDAR compared to other sensors. We also show a number of these in case studies, which include reed wetland vegetation and health mapping from low-density LiDAR, mapping alkali wetland and grassland habitat quality from high-density full-waveform data and finally merging LiDAR and Pleiades data to create a time series for change detection. We introduce a new approach to sensor-based vegetation mapping: instead of collecting sensor data and field references, and processing the data to a map afterwards (which is currently the norm), we propose airborne-assisted fieldwork and a classification software solution that allows sensor-based mapping to be initiated during the field campaign, directing effort to locations and categories that improve accuracy in an optimal way. Finally, we deliver a brief overview of LiDAR data availability in Europe, and conclude that LiDAR is emerging as a cheap and reliable data source with information content sufficient for automatic classification. Especially in wetlands, where pixel-based methods are appropriate and canopy penetration is essential, LiDAR has potential to significantly advance the purpose of the 2020 biodiversity strategy.

Landsat 8 data and image classification and interpretation techniques to estimate wetland characteristics in three different Natura 2000 network areas in Greece

Charalampos Topaloglou. Principal contact for editorial correspondence.
Ioannis Chronis
Aristotle University Thessaloniki, Greece

Georgios Efthimiou
Technological Educational Institute of Sterea Hellas, Greece

Abstract

Landsat 8 Operational Land Imager (OLI) is the newest Earth Observation System in the Landsat series. Its main differences with Landsat 7 ETM+ are: 1) OLI has two new spectral bands, an ultra-blue which is useful for coastal and aerosol studies and a short-wave infrared useful for cirrus cloud detection, 2) a Thermal Infrared Sensor (TIRS) consisting of 2 bands providing more accurate surface temperatures. Landsat scenes combined with other image data have been widely used in recent years for mapping wetlands or wetland characteristics. On the other hand, Greece has more than 400 large and small wetlands covering a total of 210,000 ha in spite of the heavy losses over the last two generations. The most common wetland types are: rivers, estuaries, deltas, lagoons, shallow lakes and shallow marine formations, marshes. Many of them belong to the Natura 2000 Network and 10 of them are protected under the Ramsar Convention. The aim of this paper is therefore to investigate characteristics from three different types of wetlands in Greece using various remote sensing methods and satellite scenes from Landsat 8 OLI. The first test site was Spercheios river and its deltaic system in Central Greece which was included in the NATURA 2000 network with code GR2440002. Anthropogenic interventions in the delta area have influenced its natural habitats. In this regard, a post-classification and computer aided photo-interpretation methods were used to map and monitor differences in wetland habitats and especially the loss of riparian forests. Also, landscape metrics are calculated in order to investigate changes in landscape characteristics. The second test site was the Epanomi Lagoon in Northern Greece (NATURA code: GR1220012), a wetland which is considered to be an important breeding, feeding and wintering ground for more than 186 species with 12 habitat types and two priority types: coastal lagoons and (1150) and *Poseidonia Beds – Poseidonia oceanicae* (1120). In this test site we managed to estimate the lagoon hydroperiod and its inundated vegetation using temporal Landsat 8 images. Most importantly, we mapped lagoon water area in the high and low tide seasons and detected changes in the surface roughness and waterline with the aid of short-wave infrared band. Water appeared smooth with no reflection contrasting with mud and vegetation. Also, inundated vegetation was mapped using a pseudo–color image of tasseled cap transformation. The third test site is Lake Karla in Central Greece (NATURA code: GR1430007). In 1964 it drained completely. After many years, the former lake area has flooded partly, creating ideal habitats for many wetland species. The water volume was estimated using field measurements with the depth of lake and its surrounding reservoirs and wetness component of tasseled cap transformation produced with Landsat 8 data.

Posters

Geomatics and non-native Mangrove Nypa fruticans (Arecaceae) van wurmb invasion in the Rio del Rey Estuary, Cameroon

Jean-Hude Ekindi Moudingo
Geomatics Lab, University of Ngaoundere, Cameroon.
Principal contact for editorial correspondence.

Abstract

Nypa fruticans (the Nipa Palm) is a native species from Indonesia that was introduced into Nigeria in the early 1900s. The species has spread from the site it was first introduced into and has reached the Rio del Rey Estuary, a proposed protected ecosystem, with wetlands and mangroves. The invasion of Nypa is altering the local ecosystem and causing serious problems. However, recent studies on mangrove vegetation showed that it has colonised and is competing with native mangrove species (Rhizophora spp. and Avicennia spp.) as it follows suitable sites and tidal regimes. Little or inadequate attention has been paid to revealing the distribution of this non-native species. Hence, basic information and baseline data on N. fruticans were lacking: specifically the extent of invasion and distribution, georeference data and a thematic map of mangrove species. Primary and secondary approaches were used. These include observation and ground-truth (GPS) data acquired on foot and boat in strategic areas of interest, based on information from key informants. Extracted coordinates were projected into Google Earth. In addition, we conducted a review of literature and a detailed description of the intra- and interspecies pattern. Some specific results are presented in the summarized tables, maps and graphs. Our study shows that Nypa has spread in all areas and along river banks (mangrove estuary; Kombo Itindi; Upper Rio del Rey; Upper Ndian; Upper Andokat; Upper Meme and coastal lowland forest) on the Rio del Rey with moving edge or landward growth at the estuarine mouth at Cape Bakassi toward creeks and upstream systems on the main rivers. Most of the sites, except the coastal lowland forest, are accessible only by water (boat). We established that Nypa is found near to, or not far from settlements and most often found in patches, clustered or isolated stands. Using the GPS approach is insufficient to see the distribution and extent of the surface occupied by this species since we can move around each plant in the site at ground level. However we maintain that the Nypa invasion can be efficiently studied in combination with satellite imagery in order to conduct an intensive time series analysis (Landsat images for example). More in-depth research is needed to check the extent of Nypa in the mangrove ecosystem in Cameroon. It is therefore essential to use geomatics data as a tool (satellite images) to monitor non-native mangrove.

ECOPOTENTIAL: a framework to monitor ecosystem services in protected wetlands with remote sensing

Pere Serra Ruiz
Universitat Autònoma de Barcelona (UAB), Spain. Department of Geography, UAB, Lecturer
Principal contact for editorial correspondence.

Alaitz Zabala
Universitat Autònoma de Barcelona (UAB). Department of Geography, UAB, Lecturer

Xavier Pons
Universitat Autònoma de Barcelona (UAB). Department of Geography, UAB, Lecturer

Javier Bustamante
Estación Biológica Doñana (CSIC). Department of Wetland Ecology

Ricardo Díaz-Delgado
Estación Biológica Doñana (CSIC). Department of Wetland Ecology

Antonello Provenzale
Consiglio Nazionale delle Ricerche (CNR). Institute of Geosciences and Georesources

Abstract

Terrestrial and marine ecosystems provide essential goods and services to human societies. In the last few decades, however, anthropogenic pressure has produced a loss of ecosystem services that can seriously affect human wellbeing and climate processes at a local and regional scale. In order to improve ecosystem benefits, knowledge-based conservation, management and restoration policies are urgently needed. Fundamental to all these is effective monitoring of the state and trends in ecosystem conditions and services. New monitoring methodologies are now available, combining approaches in geo- and bioscience, earth observation data, and *in situ* data. This work synthesizes the objectives and methods of the ECOPOTENTIAL project, a European Horizon 2020 project started in June 2015, which has been designed to achieve significant progress beyond the state of the art on ecosystem services. The project focuses its activities and pilot actions on a targeted set of internationally recognized protected areas (PA) in Europe, European Territories and beyond, over a broad range of habitats, ecosystems and landscapes, including wetlands ecosystems, among others. ECOPOTENTIAL addresses the entire chain of ecosystem-related services, by:

(a) Making extensive use of Earth Observation (EO) data in combination with *in situ* monitoring. Data from existing archives and new missions (in particular, Sentinel sensors and VENµS) are considered.

(b) Developing an ECOsystem data service for COPERNICUS (ECOPERNICUS): a new open-access, smart and user-friendly geospatial data/products retrieval portal and web coverage service using a dedicated online server, will be created, coherent with the Global Earth Observation System of Systems (GEOSS) data sharing principles.

(c) Creating a corpus of innovative, field-tested, peer reviewed and documented monitoring methodologies to define the ecological status of current and future protected areas, based on EO and *in situ* data.

(d) Developing a conceptual framework guiding the integration of data, models and scenarios towards a new vision of ecosystem structure, change and services. This objective includes the concept of Essential Biodiversity Variables (EBV), EOV (Ocean), ECV (Climate) and defines an overarching EV approach

combining these with new EWV (Water), EGV (Geo) and ESEVs (Social and Environmental), as well as the crucial issue of cross-scale interactions in the framework of Macrosystems Ecology,

(e) Finally, estimating current and future ecosystem services and benefits, combining ecosystem functions (supply) with beneficiaries' needs (demand).

Wetland ecosystems are negatively affected by the impact of human activities, leading to a loss of biodiversity, reduced abundance of species, damage to habitats and loss of ecological functions and ultimately, ecosystem services. Countering these threats is only possible through sustained monitoring and development of indicators to inform policy makers and managers. Seven wetlands ecosystem sites, including two Large Marine Ecosystems, are analyzed: Doñana National Park, Spain; Wadden Sea with Dutch Delta, The Netherlands; Camargue regional park, France; Danube Delta, Romania; Curonian Lagoon, Lithuania; and the Mediterranean Sea Large Marine Ecosystem and Caribbean Large Marine Ecosystem. In short, ECOPOTENTIAL will address the data-to-information-to-decision-making process for ecosystem services, making significant progress beyond the state of the art, using novel approaches of Earth System and Natural Sciences.

Authors summary

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