remote sensing

Editorial

Editorial for Special Issue "Remote Sensing for Coastal and Aquatic Ecosystems' Monitoring and Biodiversity Management"

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Abstract: Most of the papers published in this Special Issue were presented at the international conference EUCOMARE-2022 in the framework of the European Jean Monnet Chair European Spatial Studies of Sea and Coastal zones with the support of the ERASMUS+ Programme of the European Union.

Keywords: remote sensing; coastal and aquatic ecosystems; biodiversity management

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1. Introduction

Environmental management and the preservation of biodiversity are widely considered priorities in the context of accelerating global changes affecting the physical and biological resources of our planet. This Special Issue focuses on "Coastal and Aquatic Ecosystems". The coastal region is a transition area between terrestrial and marine ecosystems. This transition area is now considered an important component of the biosphere, in terms of ecosystem diversity, and the provision of resources and services. Moreover, the coastal region is home to a significant number of distinct biological communities, including coral reefs, mangroves, salt meadows and wetlands, phanerogam meadows, kelp forests, estuarine assemblages or coastal lagoons, forests, and grasslands. The diversity of coastal ecosystems is directly threatened by human activity. It is estimated that 60% of the world's population lives on or near the coast, and economic development stresses the coastal environment. Coastal ecosystems are undergoing permanent changes in production rates, organism abundance, and community structure.

Achieving sustainable coastal zone management poses particularly significant challenges as the pressures of a growing human population, multiple development pressures, pollution from land-based sources, and unsustainable exploitation of natural resources are felt on many of the world's coasts. Remote sensing meets this challenge by offering a wide range of standard products on environmental coastal conditions, thanks to various state-of-the-art sensors. The development of innovative methods based on integrating multi-source, multi-resolution, and multi-temporal images offers promising prospects for considering the different scales of ecosystems. Consequently, the products derived from remote sensing contribute to the development of temporal and spatial indicators for better knowledge and management of coastal and aquatic ecosystems. This Special Issue includes original environmental research using satellite data processing—optical or radar—addressing coastal and aquatic ecosystem monitoring on different spatial and temporal scales.

2. Overview of Contributions

The following is the synthesis of results obtained in each paper published in the SI "Remote Sensing for Coastal and Aquatic Ecosystems' Monitoring and Biodiversity Management".

G. Xie and S. Niculescu [1] propose a methodology to map two main winter crops (winter wheat and winter barley) in the northern Finistère region with high-resolution Sentinel-2 data and, in a second step, the monitoring of winter crop phenology with Sentinel-1 C-band SAR data using the Google Earth Engine (GEE) platform. In the first part of the research, pixel-based classification (PBC) and object-based classification (OBC) methods are proposed and evaluated. The results showed that OBC achieved better accuracy in mapping croplands, and PBC was more accurate in extracting winter crops. In the second part of the research, the objective was to synthesize the temporal behavior from sowing to harvesting, identifying three important phenological states (germination, heading and maturation, including harvesting) from the VV and VH polarizations as well as the VH/VV ratio.

W. Diruit et al. [2] focus their study on intertidal macroalgal habitats on the rocky coast of Porspoder (Western Brittany, France). The authors studied the distribution of macroalgae using field sampling and airborne hyperspectral mapping by drone over 17,000 m^2. Twenty-four sampling points, according to four bathymetric levels were proposed to characterize the dominant macroalgal cover and sessile fauna at low tide. These data were later used for comparison with the results of hyperspectral image processing (seven classes of algae, including five different species of Fucales). Two classification methods were implemented: the maximum likelihood method (MLC) and the spectral angle method (SAM). MLC was more accurate in classifying the main dominant species (overall accuracy (OA) 95.1%) than SAM (OA 87.9%) at the site scale.

G. Silva et al. [3] evaluate the impact of the January 2018 Montecito Debris Flow on the Carpinteria Salt Marsh Reserve California, a 93 ha reserve consisting of upland vegetation, high marsh, mid marsh, open channels, and mud flats. Using Sentinel-2 data, they calculated fractional cover, and two spectral vegetation indices prior to, immediately following and for several years after the debris flow. Fractional cover, SVIs and LiDAR data were used to train a Random Forest classifier to map changes in cover. Classification accuracies ranged from a Kappa of 0.911 in January 2018, immediately following a disturbance of 0.993 in November 2017, just prior to the disturbance. The most immediate impact of the debris flow was a decrease in both marsh classes and an increase in bare soil. Post-disturbance analysis demonstrated a rapid recovery with the vegetation extent approaching pre-disturbance levels by November 2020, but also showed a transition of high-marsh to mid-marsh vegetation in areas that showed initial increases in bare soil.

Timmer et al. [4] use a field spectrometer to evaluate the relative merits of Near-Infrared (NIR) and red-edge reflectance for the detection of submerged Bull kelp (*Nereocystis luetkeana*). Under clear-sky conditions, they measured kelp reflectance from 325–1075 nm at varying depths from the surface to a depth of 100 cm at 10 cm intervals. Field spectra were convolved to WorldView 3 bands and wavelengths sampled by the Micasense RedEdge-Mx sensor, a sensor deployed on an unoccupied aerial vehicle (UAV). Surface kelp showed higher NIR reflectance than red-edge reflectance. Submerged kelp resulted in two narrow peaks, one in the NIR, the other at the red edge, with higher reflectance observed in the red edge. SVIs calculated using red-edge bands were able to detect the presence of kelp deeper in the water column.

Bertin et al. [5] explore the potential of using a structure from motion (SfM) photogrammetry deployed from an RTK quadcopter to map the complex topographic variation typical of coastal beach environments in the rapidly changing intertidal zone. A key objective was to map topo-morphological features at submeter resolutions, while also being constrained to a two-hour period at low tide and using a minimum number of ground-control points (GCPs). Working at two coastal sites, they found that the addition of a single GCP produced global precision equivalent to traditional GCP-based photogrammetry; the highest accuracies were achieved using five GCPs and imagery at its native resolution. These findings offer promise for the rapid, accurate monitoring of coastal environments over large areas.

Qiu et al. [6] propose a new approach for mapping sea ice in the Yellow River Estuary, China, using multispectral data. They argue that sea ice map accuracies in this area are often low, due to the confounding effects of high variability in suspended particulate matter

(SPM) in the adjacent water. They developed a sea ice spectral information index that can be adapted to different levels of turbidity, combined with textural information and applied multi-scale image segmentation to map sea ice using the OTSU method. The approach was applied to Gaofen-1 (GF1), Sentinel-2 and Landsat 8 achieving accuracies above 93%, 5% higher than accuracies using Support Vector Machines (SVM) and K-Means.

Letard, M et al. [7] illustrate the usefulness of topo-bathymetric lidar data for mapping coastal and estuarine habitats by categorizing multispectral data to generate three-dimensional maps of 21 different types of land and sea cover at a very high resolution. To find characteristics that are unique to certain environments, the whole waveform data from a green lidar is analyzed. Random forest classifiers employ these characteristics as predictors with infrared intensities and altitudes, and their individual contributions to classification accuracy are evaluated. The research shows that combining green waveform information with infrared intensities and heights improves classification accuracy. Our segmentation accuracy on the dual-wavelength lidar dataset improves to 90.5% with this setup. In the end, we generate an original mapping of a coastal site in the form of a point cloud, which paves the way for the 3D categorization and administration of land and sea covers.

D. James et al. [8] improve very high resolution (VHR) habitat mapping/classification using Pleiades-1 derived topography, its morphometric by-products and Pleiades-1 derived images over the Emerald Coast in Brittany, France. In their study, the authors use a tri-stereo dataset to obtain nine 0.50 m pixel digital surface models (DSMs). Four morphometric predictors derived from the best of the nine generated DSMs were computed: slope, aspect, topographic position index (TPI) and TPI-based landform classification (TPILC). These morphometric predictors were added to the Red–Green–Blue reference. The best combination of TPILC added to RGB + DSM resulted in a 13% gain in OA, reaching 89.37%.

A. Le Quilleuc et al. [9] generated a very high-resolution (VHR) bathymetry and habitat mapping digital depth model (DDM) in Mayotte island waters (Indian Ocean) by fusing 0.5 m Pleiades-1 passive multispectral imagery and active ICESat-2 LiDAR bathymetry. In particular, along the ground track of the satellite ICESat-2, the RMSE of a DDM calibrated using ICESat-2 data was 0.89 m or around 6 percent of the maximum depth collected by ICESat-2. There was an overall accuracy of 96.62% and a coefficient of 0.94 for the classification performed by ML utilizing the Blue and Green spectral bands and the three geomorphic predictors. A slope geomorphic predictor was added to the SVM classification using blue, green, and red spectral bands, and the resulting model showed an overall accuracy of 96.50% and a coefficient of 0.95.

M. Jaud et al. [10] present light, easily-implemented, in-situ methods, using only two Spectralon® and a field spectrometer, to correct "vignetting effects" in the sensor and to convert digital numbers (DN) collected by the hyperspectral camera to reflectance, taking into account the time-varying illumination conditions. A portion of the dataset gathered above the pioneer mangrove-colonized mudflats in French Guiana is radiometrically corrected. The comparison of HyperDRELIO image spectra with an in situ spectrometer readings made high above the intertidal benthic biofilm and mangroves is used to evaluate the efficacy of the radiometric adjustments. Spectral angle mapper (SAM) distance was 0.039 above the benthic biofilm and 0.159 above the mangroves, and spectral shape remained similar throughout. Given the importance of benthic biofilm and mangroves in coastal food webs, biogeochemical cycles, and sediment stability, the results offer new perspectives for measuring and mapping these features at the scale of the Guianese intertidal mudbanks system.

E. Gairin et al. [11] investigate the historical evolution of the French Polynesian island of Bora Bora's classification and position from 1955 to 2019. The evolution of the island's shoreline was brought to light through the processing of a time series of ultra-high resolution aerial imagery. In the period between 1955 and 2019, the length of natural coastlines, which includes beaches, declined by 46%, while the length of man-made coasts, which includes seawalls, expanded by 476%, and now accounts for 61% of the coastline. This research illustrates the effects of man-made buildings on erosional processes and highlights the need for sustainable coastal management strategies in French Polynesia by recording the changes to the Bora Bora shoreline over time.

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