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Editorial

Editorial for the Special Issue "Remote Sensing of the Oceans: Blue Economy and Marine Pollution"

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Citation: Buono, A.; Li, Y.; Paes, R.L. Editorial for the Special Issue "Remote Sensing of the Oceans: Blue Economy and Marine Pollution". *Remote Sens.* **2021**, *13*, 1522. https://doi.org/10.3390/rs13081522

Received: 7 April 2021
Accepted: 13 April 2021
Published: 15 April 2021

Oceans represent an extraordinary source of resources that needs to be preserved while being exploited. The blue economy lies at the basis of the future of human society because it aims at developing a sustainable and renewable economy, getting benefits from the ocean while reducing pollution and waste. Hence, improving our understanding of ocean processes and their changes, as well as how ocean resources are affected by anthropogenic activities is crucial.

Within this framework, the continuous, updated, and synoptic monitoring capabilities provided by Earth observation instruments play a key role. Nowadays, an unprecedented amount of large-scale and long-term information is available that can support decision makers, environmental agencies, business companies, and local authorities in the management of ocean resources. Remote sensing tools operating on different platforms (e.g., satellite, airborne, unmanned aerial vehicle (UAV), shore-based) at different frequencies (e.g., microwaves, infrared, visible) provide the unique chance of generating added-value products, retrieving geophysical parameters of interest, and boosting the knowledge of ocean processes and marine awareness.

In this special issue, several topics have been addressed that deal with the remote sensing of the ocean for blue-economy-supporting and marine-pollution-monitoring purposes. The articles published in this special issue cover:

- Detection of targets such as marine raft aquaculture, moving vessels, and the shoreline [1–3];
- Observation of spatio-temporal pattern of oil spills and coastal marine litter [4–6];
- Study of natural sea processes, including typhoon-induced storm surges, sub-mesoscale eddies and migration of the along-slope counter-flow [7–9];
- Analysis of scattering and spectral properties of the sea surface [10,11].

Those goals have been pursued using multi-platform and multi-frequency remote sensing tools together with theoretical models, numerical simulations, and in-situ measurements. Most of the study exploited satellite data, including microwave–synthetic aperture radar (SAR) imagery collected in single-, dual- and quad-polarimetric imaging modes, radar altimeters [1–5,7,11], and optical–spin-scanning radiometers and spectroradiometers [7,8]. Other studies used airborne or shore-based sensors, including UAV cameras and high-frequency (HF) coastal radars [6,9]. Numerical tools and simulations were also considered in [3,4,8–10], while in-situ information was exploited in [5,7,8].

Further details on material and methods addressed in the articles published in this special issue, together with the main outcomes those studies achieved in the context of blue economy and marine pollution, are presented as follows:

In [1], single-polarization (under vertical transmit) C-band Sentinel-1 SAR satellite data are exploited to detect marine raft aquaculture in coastal areas. To this aim, a segmentation network combined with a non-subsampled contourlet transform is proposed to extract the sea area covered by the raft aquacultures. It was pointed out that interferences due to significant sea waves can reduce the effectiveness of the proposed method.

In [2], the problem of shoreline extraction is addressed by means of single-polarization (under horizontal transmit) C-band spaceborne Radarsat-2 SAR images. An improved geometric active contour model is proposed, which resulted in a fast, stable and accurate extraction of the land/sea boundary.

In [3], a new method to improve the refocusing of moving vessels under high sea state conditions is proposed. Experimental results, performed on C-band Gaofen-3 SAR satellite imagery, showed that the adaptive time-frequency analysis based on the particle swarm optimization results in an increased and faster global convergence and better processing effectiveness and robustness.

In [4], the monitoring from space of marine pollution due to oil spills is addressed. Simulated compact-polarimetric SAR data are considered for the analysis and were collected from Alos PalSAR-1 (L-band), Radarsat-2 and SIR-C/X (C-band) satellites over ocean slicks of known origin. A set of polarimetric parameters is investigated to identify actual oil spills of natural origin and to distinguish them from oil look-alikes as biogenic films. It was shown that scattering-based features are effective in oil spill detection and that, even though the slant linear compact-polarimetric mode results in better detection performance, the circular compact-polarimetric architecture is to be preferred to preserve the integrity of the detected oil spill.

In [5], the problem of oil pollution is also considered. A novel approach, based on a convolutional neural network and simple linear iterative clustering superpixel, is proposed to classify sea oil spills from quad-polarimetric SAR measurements collected on C-band by Radarsat-2 and SIR-C/X satellite missions. It was found that the simple linear iterative clustering superpixel method significantly improves the classification accuracy, especially for oil emulsion, and that, among the polarimetric features considered in the study, the scattering model-based parameters derived from the four-component Yamaguchi decomposition results in the highest classification performance.

In [6], the pollution of marine coastal areas due to anthropogenic debris, including plastic and metal objects, is investigated. The spatial and temporal patterns of marine debris accumulation along the beaches are analyzed by means of cameras on-board a UAV. Results showed that the equilibrium of the accumulation process depends on the season and on the size of the debris and that it can be significantly affected by extreme events, such as floods. A fairly good agreement between the UAV observations and the standard manual counting is found for medium-/large-size litters, while discrepancies were found for small-size objects, which is likely attributed to the transparent, buried, or hidden nature of such debris.

In [7], a study on the spatiotemporal variations of the along-slope counter-flow off northeastern Taiwan is investigated by means of satellite data and in-situ observations. A synergistic approach is followed, which integrates geostrophic velocity from radar altimeter data from the Archiving, Validation, and Interpretation of Satellite Oceanographic data, sea surface temperature measurements from the moderate-resolution imaging spectroradiometer, the re-analysis ocean data from the assimilative global Hybrid Coordinate Ocean Model, and horizontal velocity records from a mooring acoustic Doppler current profiler. It was observed that the along-slope counter-flow in the subsurface layer was remarkably uplifted and lowered with this phenomenon that was closely linked with the Kuroshio intrusion.

In [8], the impact of tropical cyclone size on storm surges in semi-enclosed areas is addressed. Typhoon information from meteorological satellites, data from tide stations, and simulations performed according to a finite-volume coastal ocean model were considered for the study. It was found that the size of the tropical cyclones is a key parameter that must be accounted for when predicting marine-economic effects and risk assessment. The highest storm surges occur at maximum wind speeds of 40–45 m/s, while the radius of maximum wind only affects the inner area of the typhoon. The peak surge values have been found to approximately follow a linear trend with respect to the seven-level wind circle range.

In [9], HF coastal radar observations of the sea surface current velocity field are used to detect sub-mesoscale eddies in an unsupervised way. A novel algorithm is proposed to overcome the drawbacks due to the high non-geostrophic winds of the observed sea surface currents, therefore resulting in the detection of eddies characterized by significant asymmetry. It was shown that the proposed method allows estimating the eddy boundary profiles and spatial distribution effectively.

In [10], theoretical advancements on the scattering mechanisms of the sea surface when observed by HF and very HF airborne radars are presented. Once the sea surface height has been expressed as the superposition on linear and non-linear wave heights, numerical models are used to simulate the sea surface normalized radar cross section according to the small perturbation method under different environmental and radar imaging parameters and to derive the first- and second-order sea-echo Doppler spectra. The proposed model gives further insights on the sea surface scattering and the wave height spectrum, also providing a theoretical baseline to design a potential airborne radar for ocean surface remote sensing.

In [11], C-band Sentinel-1 satellite SAR measurements are exploited to analyze the spectral signatures of low-backscattering sea areas. The latter can be due to several natural and anthropogenic phenomena, such as oil spills, algal blooms, and low-wind areas. A physically-based approach that relies on the inherent synthetic aperture radar imaging characteristics of the sea surface with and without slicks is proposed to evaluate the signatures of low-backscattering sea areas in terms of the auto-correlation function estimated along the azimuth direction. Results showed that the presence of a low-backscattering area at sea modifies the shape and the width of the azimuth auto-correlation function with respect to the reference sea surface, and that oil spills result in the largest departure.

Acknowledgments: We want to thank all the authors who contributed towards this Special Issue on "Remote Sensing of the Oceans: Blue Economy and Marine Pollution", as well as all the kind reviewers who provided constructive comments and useful suggestions to the authors.

Conflicts of Interest: The authors declare no conflict of interest.

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