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Editorial

Editorial for Special Issue "Advances in Satellite Altimetry and Its Application"

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Received: 3 December 2019; Accepted: 5 December 2019; Published: 5 December 2019

Abstract: This special issue compiles studies from different disciplines presenting recent advances in the field of radar and laser altimetry including new and future altimetry missions and their applications. It comprises eight research papers as well as one review paper, and covers method development as well as applications, which target diverse Earth systems (oceans, coastal regions, sea-ice, inland) as well as the Moon.

Keywords: satellite altimetry; remote sensing of the oceans; ocean currents; Polar Regions; inland altimetry; Earth systems

1. Introduction

Since 1978, numerous satellite altimetry missions have observed the Earth with different orbital configuration, sampling characteristics, sensors, and measurement principles. Currently, eight satellites provide elevation and elevation change observations of the hydrosphere, solid Earth, and cryosphere. Since 2010, SAR altimeters (also known as Delay Doppler mode) have provided better signal-to-noise characteristics as well as highest spatial resolution, opening up avenues for new application targets such as coastal regions.

The operational, accurate, homogeneous, absolute, and near-global observation of the sea surface is a critical component in ocean modeling and ocean dynamics on different scales from global mean sea level change to internal waves and tidal modeling. Today, satellite altimetry missions provide reliable observations as close as a few hundred meters off the coast, clearly surpassing the altimeter missions of the previous two decades, which were basically limited to 2–20 kilometers offshore. In addition, satellite altimetry allows for monitoring of water level variations of inland water bodies as well as height/thickness variations of sea ice, ice sheets, and mountain glaciers. Geodetic applications such as gravity field modeling, unification of height systems, and monitoring of vertical land motion are other examples of the wide range of altimetry applications.

In this Special Issue, researchers from different disciplines present recent advances in the field of radar and laser altimetry including new and future altimetry missions and their applications in spatio-temporal monitoring of Earth systems (including the Moon) on different scales.

2. Contributions

The contributions of this special issue are sorted along their application area: the first paper [1] handles method development applicable to various regions of the Earth. Afterward, oceans [2,3], polar regions [4,5], coastal areas [6,7] and inland waters [8] are addressed. The last paper [9] deals with the Moon's topography. All relevant satellite radar altimetry measurement techniques are covered:

from Low Resolution Mode (LRM) [4–6] to Synthetic Aperture Radar (SAR) [1,2,4,5,7,8] and SAR in mode [7] to SWOT [3] as well as laser altimetry [1]. In the following, each paper is briefly summarized.

Guccione et al. [1] proposed a new approach to exploit the full information of high pulse repetition frequency (PRF) radar altimeters following the so-called fully-focused (FF) concept. Special focus was put on reducing the computational effort by adapting the 2D frequency domain Omega-Kappa focusing algorithm for SAR to high PRF altimeters. The effectiveness of the proposed algorithm was demonstrated using simulated data, and the approach was successfully applied to CryoSat FBR data over a transponder.

Santos-Ferreira et al. [2] demonstrated that the SAR altimeter on board the Sentinel-3A satellite is able to detect short-period internal solitary waves (ISWs) with scales of the order of kilometers. Their detection method is mainly based on analyzing the radar backscatter coefficient, assuming that the along-track footprint is sufficiently small to capture radar power fluctuations over successive wave crests and troughs. The detection method was validated using cloud-free sun glint Ocean and Land Colour Instrument (OLCI) images.

Using a high-resolution coastal model, Ma and Han [3] explored the potential for reconstructing the surface inshore Labrador Current from high-resolution sea surface height (SSH) measurements of the upcoming Surface Water and Ocean Topography (SWOT) satellite mission. SWOT-like data were simulated and used to reconstruct half-day SSH fields, which were averaged to weekly fields. The model results were evaluated against in situ data from tide gauges and nadir altimetry for the period from June to October, 2010. Moreover, comparisons to the model revealed an average normalized root-mean-square difference of 0.26 for the inshore Labrador Current.

Rose et al. [4] presented a complete and precise overview of sea level change in the Arctic Ocean, which was obtained after evaluating 1.5 billion radar measurements of various altimetry satellites from ERS-1 to CryoSat-2. A major challenge for a comprehensive analysis is the presence of sea ice, which covers vast areas of the Arctic Ocean and obscures the ocean surface underneath. A sea level rise of 1.54 mm/year from September 1991 to September 2018 was estimated. ERS-1 data were found to not be as reliable as data from the following missions and if ignoring ERS-1 data, the sea level trend increased to 2.22 mm/year. Evaluating the sea level anomaly trends in five year intervals shows a clear steepening of the trend around 2004.

The paper by Quartly et al. [5] reviewed various approaches that had been used to improve satellite altimetry results in the Arctic, especially the initial classification and subsequent retracking over diverse polar surfaces, showing examples from both LRM and SAR altimeters. Moreover, issues concerning geophysical corrections were discussed, and perspectives on future developments are provided.

Wang et al. [6] developed a new subwaveform retracker for coastal applications, especially for regions that exhibit heterogeneous sea surface roughness such as slicks. They proposed an algorithm that considered the possible effects of various corruption sources through the automatic adjustment of the length of the estimation window. In contrast to other approaches, not a single waveform is used, but the footprint size with homogeneous sea surface roughness is taken into account, using spatial restriction conditions in echograms. The method was applied to seven years of Jason-2 altimeter data over the Sulawesi Sea of Indonesia and compared with results from Adaptive Leading Edge Subwaveform (ALES) retracker [10] and sensor geophysical data record (SGDR) products.

In order to estimate vertical land motion (VLM) along the Norwegian coast, Idžanović et al. [7] combined 7.5 years of CryoSat-2 satellite altimetry and tide-gauge data at 20 tide gauges. They found a coastal average land motion rate of 2.4 mm/year. The estimated VLM rates from 1 Hz CryoSat-2 and high-frequency tide-gauge data confirmed the amplitude of coastal VLM as provided by an independent semi-empirical land-uplift model.

Gao et al. [8] assessed the performance for Sentinel-3 inland water level products. They focused on the minimization of the land contamination over small- to medium-sized water bodies (down to 130 m). Three specialized algorithms, together with a new waveform portion selection method, were evaluated to minimize land contamination in the waveforms and to select the nadir return associated with the water body. No significant difference was found in the results of the three retrackers. However, waveform portion selection using Digital Elevation Model (DEM) information greatly improved the results.

While most of the papers of the Special Issue are focused on the Earth, Li et al. [9] presents an improved method to estimate a DEM for a region of the Moon, namely the Mons Rümker region, based on the combination of datasets from different laser altimeter missions.

Acknowledgments: The Guest Editors of this Special Issue would like to thank all authors who have contributed to this volume for sharing their scientific results. In addition, special thanks go to the reviewers for their valuable inputs. The Remote Sensing editorial team is gratefully acknowledged for its support to successfully complete this volume.

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

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