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Editorial

Editorial for the Special Issue "Remote Sensing of Water Quality"

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Received: 10 September 2019; Accepted: 16 September 2019; Published: 19 September 2019

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Keywords: water quality; remote sensing; ocean color; bio-optical modeling; atmospheric correction; spatial variability; optical complexity; end-user engagement

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The importance of monitoring, preserving, and, where needed, improving the quality of water resources in the open ocean, coastal regions, estuaries, and inland water bodies cannot be overstated. Remote sensing of ocean color from spaceborne and airborne systems has become an indispensable tool for monitoring water quality. Recent advances in sensor technology and algorithm development have made it possible to move beyond mere estimates of biomass abundance and into quantitative measures of complex biophysical and biogeochemical processes. For instance, the development of spaceborne hyperspectral sensors, such as the upcoming Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission, will provide unprecedented spectral information at a global scale that can be used to quantitatively estimate the biogeochemical composition of water, detect pigment assemblages, and monitor ecological functional groups.

Nevertheless, challenges remain in generating data products that are consistently accurate and can be routinely used for operational water quality monitoring. Atmospheric correction, though successful for open-ocean waters, is still a challenge for coastal, estuarine, and inland waters because the widely variable and complex optical conditions encountered in these waters invalidate some basic assumptions in typical atmospheric correction models. Though hyperspectral data provide a wealth of spectral information, the retrievals—particularly, the retrievals of ancillary pigments—are subject to uncertainties due to sensor noise, radiometric calibration, and atmospheric correction. Developing bio-optical algorithms that perform consistently well under varying water types is an ongoing challenge. The spatial, spectral, and temporal resolutions of current sensors are often found to be inadequate to capture the scales of bio-optical variability, especially in coastal, estuarine, and inland waters. Inconsistencies in the acquisition, processing, and quality control of in situ and remote sensing data and differences in sensor characteristics across multiple remote sensing missions and projects complicate efforts to achieve the consistency and continuity of data products required for long-term monitoring. Finally, research efforts in developing water quality products need to be coordinated with the needs of the end-user community that is actually engaged in water quality monitoring. A robust engagement with the end-user community is required to identify the community's needs and develop efficient tools for water quality product generation, data dissemination, capacity building, and citizen education.

In light of these and many other challenges, a special issue of Remote Sensing of Water Quality has been dedicated to address the current status, challenges, and future research priorities for the remote sensing of water quality.

Huang et al. [1] developed an empirical near infrared-red band ratio for estimating particulate organic carbon (POC) content in Taihu Lake using Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery. The near infrared-red band ratio algorithm was applied to a time series of

MODIS data from 2002 to 2014. The results showed the importance of riverine input and algal growth in POC distributions.

Lobo et al. [2] studied the effects of various intensities of gold mining on the bio-optical properties of rivers in the Brazilian Amazon. The authors showed that increased mining activity resulted in increased concentrations of suspended sediments in water and a shift from an absorption dominated light environment to a scattering one.

Carswell et al. [3] provide a robust intercomparison of atmospheric correction methods for MODIS data over the west coast of Canada and the United States using a 13-year time series. Their results suggest that the Management Unit of the North Seas Mathematical Models (MUMM) algorithm with an additional modification using the short-wave infrared (SWIR) band (MUMM + SWIR) is the most appropriate algorithm for the region, with reflectance biases less than 20% and improved chlorophyll retrievals.

Toming et al. [4] tested the performance of the recently launched Ocean and Land Colour Instrument (OLCI) using the standard Case 2 processing chain for the Baltic Sea. Results suggest that the atmospheric correction performs well in non-bloom conditions, while the inherent optical property (IOP) component of the processing chain requires additional training with data from the Baltic Sea.

Roberts et al. [5] developed an empirical relationship between in situ data and Landsat and MODIS imagery to describe suspended particulate matter (SPM) dynamics in Sahelian Mali, an area with scarce in situ data and limited knowledge of factors controlling SPM. They then used this imagery to describe the seasonal patterns, spatio-temporal variability, and forcing mechanisms responsible for the observations.

Renosh et al. [6] addressed the management need for forecasts of vertical profiles of turbidity at a variety of temporal and spatial scales with a combination of modeling, statistics, and remote sensing data. Experiments with satellite-derived SPM (from SeaWiFS, MODIS, MERIS, and VIIRS) did not significantly improve results relative to those with just model output based on barotrophic currents and significant wave height. The authors suggest that satellite data with higher temporal resolution (~1 h), such as data from future geostationary systems, may improve results.

Making use of remote sensing imagery obtained under sub-optimal sky conditions was the objective of the Göritz et al. [7] case study at Lake Stechlin, Germany. Water constituent retrievals were performed under a variety of illumination conditions from full sun to complete overcast. Results suggest that reasonable retrievals can be made under variable cloud cover, potentially expanding conditions under which remote sensing imagery can be utilized.

McCarthy et al. [8] used a remotely sensed turbidity product to study the environmental factors most responsible for variations in water quality among 11 Gulf of Mexico estuaries for a time-series and extreme events. Using the 645 nm channel of MODIS with 250 m resolution, 15 years of turbidity measurements were analyzed at multiple temporal scales (weekly, monthly, seasonal, and annual) and statistically compared to a suite of environmental forcing functions (precipitation, wind speed, river discharge, etc.). Wind speed was found to be the most consistent driver of turbidity for both time-series and extreme events.

Kratzer and Moore [9] offered improvements for the retrieval of chlorophyll, colored-dissolved organic matter (CDOM) and SPM in the Baltic Sea through improved parameterization of the specific inherent optical properties (sIOPs) used in spectral inversion models. Generally, the contribution of CDOM was underrepresented, while chlorophyll and SPM were overrepresented relative to reference datasets (NOMAD/COLORS). These regional parameterizations are needed to maximize the value of ocean color archives and future data for management uses.

Pahlevan et al. [10] attempted to produce internally consistent remote sensing reflectances among the three most recent Landsat sensors (TM, ETM+, and OLI) for the purpose of product development and retrospective analysis of coastal and inland waters. The authors show reasonable agreement but stress that there are high levels of uncertainty in the heritage Rrs products, which indicates that they are appropriate for only certain applications.

Together, these papers show a subset of the vast and varied ways that remote sensing data, particularly ocean color data are being used to understand water quality dynamics in coastal and inland waters. Model development, regional parametrization, studies of underrepresented areas, atmospheric corrections, and the utilization of historical time series are all needed to advance our understanding of the remote sensing of water quality.

Author Contributions: The authors contributed equally to this editorial.

Funding: This work was supported by the Office of Naval Research under Naval Research Laboratory (NRL) projects 72-1C02-09 and 72- 1L28-09.

Acknowledgments: The authors wish to thank the authors and reviewers who made this special issue possible. This is contribution NRL/JA/7230-19-0461.

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

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