MULTI-SENSOR SATELLITE TIME SERIES OF OPTICAL PROPERTIES AND CHLOROPHYLL A CONCENTRATION IN THE ADRIATIC SEA

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Abstract

Advanced remote sensing techniques and algorithms are combined to produce and analyse an improved 12-year multi-sensor time series of bio-optical properties for the Adriatic Sea. First, a multi-sensor series of normalized water-leaving radiance is created with an optically-based merging technique applied to SeaWiFS and MODIS data. Then, two empirical algorithms, embedded in a dynamic algorithm selection scheme, serve to compute the concentration of chlorophyll a (Chla), and distributions of inherent optical properties are obtained with a semi-analytical bio-optical model.

Keywords: Adriatic Sea, Ocean Colours, Remote Sensing, Chlorophyll-a

Introduction

The potential of satellite ocean colour for monitoring and studying marine ecosystems could be better exploited in coastal and marginal seas if the uncertainties associated with satellite products could be reduced. Moreover, the creation of a long-term satellite data record needs to address the combination of satellite products derived from different space missions. This work aims at generating and presenting a time series of improved quality-assessed bio-optical products for the Adriatic Sea using advanced remote sensing techniques and specific algorithms.

Satellite Data Merging

Building on previous work [1, 2], an optically-based technique is proposed to merge L_{WN} from SeaWiFS and MODIS by averaging sensor-specific values after wavelength differences are corrected by a band-shift correction scheme. The resulting 12-year series of L_{WN} serves to generate derived products of optically signifiant constituents. Field measurements collected at the Acqua Alta Oceanographic Tower (AAOT) located in the North Adriatic [3] provide a unique data set for validation of the merged L_{WN}. Uncertainty estimates decrease from 28% at 412 nm to 10% between 490 and 555 nm.

Development of Derived Products

A single empirical algorithm for calculating Chla is unlikely to produce a data set with a consistent level of uncertainty across the optical diversity of the Adriatic basin. The approach adopted here, based on the novelty detection technique [4], is to distinguish two dominant water types, representing offshore waters (Class 1) and coastal regions (Class 2), and dynamically blend the outputs from the associated algorithms [5, 6] according to the probability of the input L_{WN} of belonging to a specific optical class. The optical classes are defined by bio-optical datasets made of globally-distributed measurements representative of offshore clear waters and the data collected at AAOT. The Chla dataset is completed by inherent optical properties obtained with a semi-analytical algorithm [7]. Uncertainties for these optically significant constituents are estimated with field data collected at the AAOT site. For instance, the RMS difference computed for log-transformed Chla amounts to 0.15.

Applications

A 12-year budget shows that 66% and 8% of the basin are classified as Class 1 and 2, respectively. Most of the points that are left un-classified have optical properties located along the gradient (in optical space) between Classes 1 and 2. The areas classified as Class 2 are mostly located in the northwest Adriatic and along the Italian coast. Average values for north, central, and south Adriatic are, respectively, 0.58, 0.21 and 0.18 mg m^{-3} for Chla, 0.023, 0.013 and 0.012 m^{-1} for phytoplankton absorption at 443 nm, 0.074, 0.040 and 0.035 m^{-1} for absorption due to chromophoric dissolved organic matter and non-pigmented particles at 443 nm, and 0.0054, 0.0029 and 0.0026 m^{-1} for particle backscattering at 555 nm. Finally, the temporal variability of the time series is analysed with statistical techniques distinguishing seasonal and trend components [8]. A significant amount of interannual variations are found, particularly in the North and Central Adriatic, with Chla values that tend to be higher at the beginning of the data record.

Conclusion

The Adriatic basin displays a significant diversity in optical water types, and has thus served as a testbed for new approaches. Combining these led to the definition of a multi-sensor 12-year record for optically significant constituents, particularly a much-improved time series of Chla. The applicability of this framework to other European seas depends on several factors, including the optical properties associated with the considered region, and the in situ data available to statistically model these properties, and the uncertainties associated with the primary ocean colour product that is L_{WN}.

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