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Estimation of Chlorophyll-a Concentration in Inland, Estuarine, and Coastal Waters using Aircraft and Satellite Data

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A three-band model and a two-band model, which use reflectances in the red and near Infrared (NIR) wavebands that match the spectral channels of MODIS and MERIS, were tested for estimating chl-a concentration in turbid and productive inland, estuarine, and coastal waters using remotely sensed aircraft and satellite data. The NIR-red models were first tested with data collected by field spectrometers from inland, estuarine, and coastal water bodies with widely varying biophysical characteristics, from different geographic locations. The models showed a very close and steady relationship with chl-a concentration ($r^2 > 0.9$), effectively accounting for variations in other constituents such as suspended solids and dissolved organic matter. The high accuracy and stability obtained with the field spectrometer data lent to the development of algorithms that can be applied to aircraft and satellite data. When applied to multi-temporal data from the aircraft sensor, AISA, the output from the two-band NIR-red model, with wavebands that match the MERIS spectral channels at 665 nm and 708 nm, had very close relationships with chl-a concentration ($r^2 > 0.87$) for each image. But the slope and offset of the linear relationship varied between the images due to non-uniform atmospheric effects. A relative atmospheric correction of the AISA images resulted in conformity of the slopes and offset. The two-band MODIS NIR-red model and the two-band and three-band MERIS NIR-red models were applied to MODIS and MERIS images. Four different atmospheric correction schemes were tried for MODIS data and two schemes for MERIS data. The two-band and three-band MERIS NIR-red model values, when applied to MERIS images, had a very close and steady relationship with chl-a concentration ($r^2 > 0.95$). Data collected in four different campaigns on Azov Sea and Taganrog Bay in 2008 were used to calibrate and develop MERIS NIR-red algorithms that were validated with data collected in 2009. The two-band MERIS NIR-red algorithm was more accurate (RMSE = 3.65 mg m^{-3}) than the three-band algorithm (RMSE = 5.02 mg m^{-3}). The slope and offset of the algorithms closely matched the corresponding figures obtained from field spectrometer data. The results obtained present a significant step towards achieving a spectral algorithm, particularly, the two-band MERIS NIR-red algorithm, for estimating chl-a concentration from satellite data routinely acquired over inland, estuarine, and coastal waters around the globe. The issues and challenges in developing such a satellite algorithm are also discussed.

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