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Remote sensing retrieval of suspended sediment concentration in shallow waters

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Monitoring the dynamics of coastal lagoons and estuarine areas and the description of the interaction of their biological and physical processes require observations over a wide range of spatial scales (indicatively 1 m-10 km). Remote sensing techniques can overcome the spatial limitations of traditional in situ point observations and potentially allow access to the desired range of scales. The application of remote sensing in shallow waters, however, can be affected by errors in the retrieval of the signal caused by the influence of bottom reflection and by the variability of the optical properties of the matter suspended in the water column. The possibility of accurate remote sensing retrievals, e.g. of suspended particulate matter (SPM) concentration, must thus be tested against in situ observations, and methods must be produced to assess the uncertainty associated with the estimates produced. We present here a method to estimate SPM concentration in lagoon/estuarine waters by use of a simplified radiative transfer model. We calibrate the model parameters using observations from a network of turbidity sensors in the Venice lagoon and from several multispectral satellite sensors (LANDSAT, ASTER and ALOS AVNIR). We then apply a cross-validation technique and use bootstrap resampling to provide a statistically sound determination of model parameters and an evaluation of the uncertainty induced by their inaccurate determination as well as by the uncertain knowledge of the bottom sediment reflectance.
The bootstrap and cross-validation procedures employed show that consistent estimates of SPM concentration can indeed be retrieved from satellite remote sensing, provided that sufficient in situ ancillary information for appropriate calibration is available. The quantification of the estimation uncertainty shows that retrievals obtained from remote sensing are accurate, robust and repeatable. The SPM concentration maps produced show a general coherence with known features in the Venice lagoon and, together with suitable biological information, point to the role played by benthic vegetation in the stabilization of the bottom sediment.