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Filling the temporal gap in remote sensing observations by hydrodynamic modelling

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Remote sensing has recently become a powerful tool for water quality monitoring. Satellite-borne remote sensing information about water quality indicators of inland water bodies has limited availability. Due to cloudy weather or satellite instrument unavailability, time periods without remote sensing scenes may vary from several hours to several weeks. This is often unacceptable for operational end users.
To overcome this problem we propose an idea of assimilating satellite observations into hydrodynamic model. In our study, we use MODIS-retrieved total suspended matter (TSM) distribution across the lake, processed with the Modular Inversion and Processing System (MIP). This scalar value is a vertically integrated quantity and has to be converted to information about TSM distribution in modeled water column. Besides TSM concentration, also optical penetration depth (z90) can be derived from MODIS satellite images. This quantity sets the lower integration boundary for integrated TSM concentration from the whole water column. Based on field studies with CTD profiler, satellite borne integrated TSM and z90, we reconstruct a TSM profile structure. Reconstructed TSM profiles are systematically (as far as MODIS acquisition is possible) assimilated to hydrodynamic model. Assimilation is based on weighted average between modeled (from Delft3d) and reconstructed (from satellite observation) TSM profiles. Averaging weights come from pixel quality information which is retrieved from satellite image during atmospheric correction.
As a study site, Lake Constance has been chosen. Thanks to its large dimensions, it was possible to monitor it using the Moderate Resolution Imaging Spectroradiometer (MODIS). Another advantage of this study site is that in spring Lake Constance experiences also the mixing of inflowing, highly turbid, cold Alpine Rhine water and transparent warmer lake water. This phenomenon is highly related to hydrodynamic (wind induced and density-driven) currents and can be monitored with satellite-borne remote sensing.
For hydrodynamic modeling, a three dimensional Reynolds averaged Navier-Stokes hydrodynamic model (Delft3D) was used. Inflowing glacier particles were assumed to be a passive tracer, transported by advection according to simulated water currents. Despite strong physical background hydrodynamic models still encounter problems with results quality. Together with data from boundary conditions (ex. wind shear stress, sun heat flux), models assimilate also errors and uncertainties which make model results unreliable for longer prediction time.
This idea of data fusion from remote sensing and hydrodynamic modeling leads to more reliable hydrodynamic transport model results and more frequent data availability (in compare to pure remote sensing).
This research shows new possibilities in overcoming hydrodynamic transport model uncertainty constraints and new application field for remote sensing water quality products.