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Combining Envisat type and CryoSat-2 altimetry to inform hydrodynamic models

Raphael Schneider (1), Peter Nygaard Godiksen (2), Heidi Villadsen (3), Henrik Madsen (2), and Peter Bauer-Gottwein (1)

(1) Technical University of Denmark, Department of Environmental Engineering, Kgs. Lyngby, Denmark (rasch@env.dtu.dk), (2) DHI, Hørsholm, Denmark, (3) National Space Institute, Technical University of Denmark, Kgs. Lyngby, Denmark

Hydrological models are developed and used for flood forecasting and water resources management. Such models rely on a variety of input and calibration data. In general, and especially in data scarce areas, remote sensing provides valuable data for the parameterization and updating of such models. Satellite radar altimeters provide water level measurements of inland water bodies. So far, many studies making use of satellite altimeters have been based on data from repeat-orbit missions such as Envisat, ERS or Jason or on synthetic wide-swath altimetry data as expected from the SWOT mission. This work represents one of the first hydrologic applications of altimetry data from a drifting orbit satellite mission, using data from CryoSat-2.

We present an application where CryoSat-2 data is used to improve a hydrodynamic model of the Ganges and Brahmaputra river basins in South Asia set up in the DHI MIKE 11 software. The model's parameterization and forcing is mainly based on remote sensing data, for example the TRMM 3B42 precipitation product and the SRTM DEM for river and subcatchment delineation. CryoSat-2 water levels were extracted over a river mask derived from Landsat 7 and 8 imagery. After calibrating the hydrological-hydrodynamic model against observed discharge, simulated water levels were fitted to the CryoSat-2 data, with a focus on the Brahmaputra river in the Assam valley: The average simulated water level in the hydrodynamic model was fitted to the average water level along the river's course as observed by CryoSat-2 over the years 2011-2013 by adjusting the river bed elevation. In a second step, the cross section shapes were adjusted so that the simulated water level dynamics matched those obtained from Envisat virtual station time series.

The discharge calibration resulted in Nash-Sutcliffe coefficients of 0.86 and 0.94 for the Ganges and Brahmaputra. Using the Landsat river mask, the CryoSat-2 water levels show consistency along the river and are in good accordance with other products, such as the SRTM DEM. The adjusted hydrodynamic model reproduced the average water level profile along the river channel with a higher accuracy than a model based on the SRTM DEM. Furthermore, the amplitudes as observed in Envisat virtual station time series could be reproduced fitting simple triangular cross section shapes.

A hydrodynamic model prepared in such a way provides water levels at any point along the river and any point in time, which are consistent with the multi-mission altimetric dataset. This means it can for example be updated by assimilation of near real-time water level measurements from CryoSat-2 improving its flood forecasting capability.