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Assimilation of CryoSat-2 altimetry to a hydrodynamic model of the Brahmaputra river

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Remote sensing provides valuable data for parameterization and updating of hydrological models, for example water level measurements of inland water bodies from satellite radar altimeters. Satellite altimetry data from repeat-orbit missions such as Envisat, ERS or Jason has been used in many studies, also synthetic wide-swath altimetry data as expected from the SWOT mission. This study is one of the first hydrologic applications of altimetry data from a drifting orbit satellite mission, namely CryoSat-2. CryoSat-2 is equipped with the SIRAL instrument, a new type of radar altimeter similar to SRAL on Sentinel-3.

CryoSat-2 SARIn level 2 data is used to improve a 1D hydrodynamic model of the Brahmaputra river basin in South Asia set up in the DHI MIKE 11 software. CryoSat-2 water levels were extracted over river masks derived from Landsat imagery. After discharge calibration, simulated water levels were fitted to the CryoSat-2 data along the Assam valley by adapting cross section shapes and datums.

The resulting hydrodynamic model shows accurate spatio-temporal representation of water levels, which is a prerequisite for real-time model updating by assimilation of CryoSat-2 altimetry or multi-mission data in general. For this task, a data assimilation framework has been developed and linked with the MIKE 11 model. It is a flexible framework that can assimilate water level data which are arbitrarily distributed in time and space. Different types of error models, data assimilation methods, etc. can easily be used and tested. Furthermore, it is not only possible to update the water level of the hydrodynamic model, but also the states of the rainfall-runoff models providing the forcing of the hydrodynamic model.

The setup has been used to assimilate CryoSat-2 observations over the Assam valley for the years 2010 to 2013. Different data assimilation methods and localizations were tested, together with different model error representations. Furthermore, the impact of different filtering and clustering methods and error descriptions of the CryoSat-2 observations was evaluated. Performance improvement in terms of discharge and water level forecast due to the assimilation of satellite altimetry data was then evaluated. The model forecasts were also compared to climatology and persistence forecasts. Using ensemble based filters, the evaluation was done not only based on performance criteria for the central forecast such as root-mean-square error (RMSE) and Nash-Sutcliffe model efficiency (NSE), but also based on sharpness, reliability and continuous ranked probability score (CRPS) of the ensemble of probabilistic forecasts.