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The impact of the assimilation of SWOT satellite data into a large scale hydrological model parametrization over the Niger basin.

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Satellite measurements are used for hydrological investigations, especially in regions where in situ measurements are not readily available. The future Surface Water and Ocean Topography (SWOT) satellite mission will deliver maps of water surface elevation (WSE) with an unprecedented resolution and provide observation of rivers wider than 100 m and water surface areas above 250 x 250 m over continental surfaces between 78°S and 78°N. The purpose of the study presented here is to use SWOT virtual data for the optimization of the parameters of a large scale river routing model, typically employed for global scale applications. The method consists in applying a data assimilation approach, the Best Linear Unbiased Estimator (BLUE) algorithm, to correct uncertain input parameters of the ISBA-TRIP Continental Hydrologic System. In Land Surface Models (LSMs), parameters used to describe hydrological basin characteristics are generally derived from geomorphologic relationships, which might not always be realistic. The study focuses on the Niger basin, a trans-boundary river, which is the main source of fresh water for all the riparian countries and where geopolitical issues restrict the exchange of hydrological data. As a preparation for this study, the model was first evaluated against in-situ and satellite derived datasets within the framework of the AMMA project.

Since the SWOT observations are not available yet and also to assess the skills of the assimilation method, the study is carried out in the framework of an Observing System Simulation Experiment (OSSE). Here, we assume that modeling errors are only due to uncertainties in Manning coefficient field. The true Manning coefficient is then supposed to be known and is used to generate synthetic SWOT observations over the period 2002-2003. The satellite measurement errors are estimated using a simple instrument simulator. The impact of the assimilation system on the Niger basin hydrological cycle is then quantified. The optimization of the Manning coefficient using the BLUE algorithm from June 2002 to December 2003 leads to a significant improvement of the water levels over the river, and also at the 8 locations with gages. Indeed, the relative bias of the water level is globally improved (a 30 % reduction) and the amplitude of the water level is closer to the truth with assimilation than without assimilation. The relative bias of the Manning coefficient is also reduced (40% reduction) and the Manning coefficient globally converges towards an optimal value despite potential problems related to equifinality. The discharge is also improved by the assimilation, but to a lesser extent than for the water levels (7%). Moreover, the method allows a better prediction of the occurence and intensity of flood events in the inner delta and showed skill in simulating the maxima and minima of water storage anomalies in several continental reservoirs, especially the groundwater and the aquifer reservoirs, for which its evolution is difficult to observe. Finally, the study shows that the method is useful for hydrological forecasting over longer time periods than those of the calibration.