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Discharge forecasting using MODIS and radar altimetry: potential application for transboundary flood risk management in Niger-Benue River basin

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Flooding is one of most widespread natural disasters in the world. Its impact is particularly severe and destructive in Asia and Africa, because the living conditions of some settlements are inadequate to cope with this type of natural hazard. In this context, the estimation of discharge is extremely important to address water management and flood risk assessment. However, the inadequate monitoring network hampers any control and prediction activity that could improve these disastrous situations. In the last few years, remote sensing sensors have demonstrated their effectiveness in retrieving river discharge, especially in supporting discharge nowcasting and forecasting activities. Recently, the potential of radar altimetry was apparent when used for estimating water levels in an ungauged river site with good accuracy. It has also become a very useful tool for estimation and prediction of river discharge. However, the low temporal resolution of radar altimeter observations (10 or 35 days, depending on the satellite mission) may be not suitable for day-by-day hydrological forecasting. Differently, MODerate resolution Imaging Spectroradiometer (MODIS), considering its proven potential for quantifying the variations in discharge of the rivers at daily time resolution may be more suited to this end. For these reasons, MODIS and radar altimetry data were used in this study to predicting and forecasting the river discharge along the Niger-Benue River, where severe flooding with extensive damage to property and loss of lives occurred. Therefore, an effective method to forecast flooding can support efforts towards creating an early warning system. In order to estimate river discharge, four MODIS products (daily, 8-day, and from AQUA and TERRA satellites) connected at three sites (two gauged and one ungauged) were used. The capability of remote sensing sensors to forecast discharge a few days in advance at a downstream section using MODIS and ENVISAT radar altimetry data was addressed as well. The results confirmed the effectiveness of the MODIS sensor to assess river discharge. Performance indices are, on average, for the two sensors equal to 0.96 and 0.97 in terms of coefficient of correlation and Nash-Sutcliffe efficiency, respectively. For the forecasting of river discharge with a lead time of 4 days, both altimetry and MODIS provide satisfactory results with a coefficient of persistence equal to 0.99 and 0.80, respectively. If altimetry is more accurate in the retrieval of river discharge, the higher temporal resolution of MODIS guarantees a temporal continuity of the forecasts that is highly required to address operational activities.