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A Feasibility study on satellite derived aerial precipitation to extend simulation modeling in lake Chad basin

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Spatial estimate of rainfall derived from good network of gauging station are widely used as input to hydrological models. However, gauging station are sparsely located within the drainage basin of lake Chad, therefore the spatial estimate of rainfall and subsequently the model prediction is likely to be unreliable. The basin covers an area of 2,434,000 square km and expands across Saharan, Shelian and Sudanese zone. It is an endorheic transboundary basin that transects seven countries and houses extensive floodplains.
Three datasets that provides spatial estimates of rainfall viz. TRMM3B43, GPCP 1DD and RFE2.0 were compared based on: a) Pair wise comparison between estimates from satellite and gauged data, and b) Error propagated through hydrological model. The Terrestrial Hydrological Model with Biogeochemistry (THMB) (Coe et al., 2001) which simulates the flux of water in rivers, floodplain and lakes was used. The pair wise comparison of satellite estimated rainfall against a network of 26 gauging station shows that the estimates form entire satellite datasets overestimated the rainfall. However, estimates from RFE2.0 and TRMM are closer to gauged data as compared to GPCP. The bias and RSME between network of gauged data and TRMM is 1.8 and 26.2 mm/day, and between gauged and REF is 4.2 and 27.2mm/day, and between gauged and GPCP is 19.2 and 44.6 mm/month respectively.
The CRUTS2.0 gridded rainfall datasets that is available for the period of 1901 till 2002 and widely used in the pas for hydrological modeling of lake Chad basin was also selected as a reference gridded data to compare satellite estimates. The spatial R2 static between CRU and satellite data reveals a stronger linear relationship between CRU and GPCP as compared to TRMM datasets. Both satellite underestimated the values in the eastern and south Alps, whereas they overestimated the values elsewhere. The overestimation of satellite data in the study region can be attributed to abundance of aerosol content in air mass, and higher cloud base (Mc Collum et al., 2000). The above specified satellite datasets (a common period 1998-2002 between CRU and satellite estimates) were independently fed into the hydrological model calibrated with CRU data and subsequent error propagated through hydrological model was used to compare satellite estimates. The Bias in an aerial average estimate are 3% and 29% for TRMM and GPCP respectively, whereas the average simulated flow of Chari river at N'djamena was overestimated by 17 and 53% as compared to CRU indicating that the response of lake Chad basin is sensitive to the satellite rainfall products. Furthermore, the simulation results (1998-2002) at three interior locations and lake level are markedly improved with TRMM estimates as compared to CRU and GPCP.
Satellite data are available only for a short period of time than generally required for hydrological model calibration, so we combined the satellite data with CRU data that spans from 1901-2002 using the spatial relationship identified from common period of CRU and satellite datasets. The performance of model simulation evaluated against stream flow at a number of interior gauging stations and water surface elevation of lake reveals that historical data concatenated with regridded TRMM and next estimated from the functional relationship between the common period of CRU and GPCP resulted in better model simulation.

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