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Streamflow data assimilation into a large scale hydrologic-hydrodynamic model in the Amazon

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Recent extreme events in the Amazon River basin and the strong dependence of local population to water resources bring the need of hydrological forecast systems in this region. Due to the size of the Amazon and its large flood wave travel times, uncertainty on model initial conditions (ICs) may play an important role for discharge forecasts using large scale hydrological models, even for large lead times ($\sim$ 1 to 3 months). In this direction, data assimilation (DA) methods may provide an interesting way of merging different types of observations with models to estimate optimal ICs. We present results from first experiments on streamflow data assimilation into a large scale hydrologic and hydrodynamic model of the Amazon River basin. We use the conceptual and physically based MGB-IPH model. It uses the Penman Monteith for evapotranspiration and the Moore and Clarke model for soil water storage. River dynamics is simulated using full Saint-Venant equations and a simple floodplain storage model. We implemented a DA scheme based on the Ensemble Kalman Filter (EnKF) to assimilate daily discharge from in situ gauge stations. All model state variables were updated at each analyses time step. Model state variables errors were generated by perturbing precipitation forcing field from original value, using log-normally distributed, time and spatially correlated errors fields. Streamflow observation errors were modelled considering spatial and temporal uncorrelated normally distributed errors. Since the hydrodynamic model is vulnerable to large corrections, which may lead to model instability, we use a combination of two approaches to avoid the divergence of the DA scheme. First, if the solution of a given ensemble member diverges we substitute it by another member sampled from the ensemble. Then, to avoid lots of ensemble members to diverge, we use what we call an inertia approach, where the final analyses solution is the weighted combination of the analyzed and forecasted state variables using a time variable weight. In this first experiment, we considered that standard deviation of stream flow errors is 2%, we used an ensemble with 200 members and simulations were conducted during the 1998 (spin-up), 1999 and 2000 years. We assimilated discharge data from 14 stations located in the main rivers and used other 104 stations for validation. Agreement between model and observations increase in main Amazon Rivers when compared with simple model simulations. For example, in a validation site at Amazon River, Nash and Suttcliffe index increases from 0.77 to 0.97 and root mean square error (RMS) decreases 67%. RMS values generally decrease at gauges located at the large Amazon tributaries and close to gauges used in the DA scheme. On the other hand, we observed an increase of errors in smaller tributaries. Finally, future improvements of this DA scheme include the investigation of the source of errors in small rivers, assimilation of remotely sensed observations such as river water levels derived from satellite altimetry data and its evaluation for streamflow forecasts.