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Proof-of-concept for the assimilation of multi-mission remote sensing data for large-scale discharge estimation

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The understanding and prediction of the variability of the hydrological state of watersheds across the planet is growing, as water is a fundamental human need and therefore important for science and society. In the last 20 years, significant advances have been made toward hydrological modeling of large river basins, and also continental to global-scale land areas. Remote sensing has been widely used in hydrology because, in addition to being a clear advantage in regions with a poor monitoring network, it has proven to be suitable for use in global and continental hydrological applications.

The estimation of river discharge is of paramount importance, as it is considered an aggregator of all water cycle processes in the basin. On the one hand, estimates of discharge solely from space remain limited because they are not the primary focus of current satellite missions. On the other hand, simulations of hydraulic variables have been performed with large-scale hydrologic and hydrodynamic models, but the accuracy of their estimates can be improved with recent techniques such as data assimilation (DA). DA techniques have been developed to use remotely sensed datasets to obtain the best estimate of the current state of a system by optimally combining observations and large-scale hydrological models. Recent studies have also demonstrated the advantages of assimilating several types of datasets at the same time, which can help to further constrain the model state variables to be more physically representative.

Thus, the main objective of this research is to develop a proof-of-concept for estimating hydraulic variables such as discharge and water level by assimilating multiple remotely sensed datasets into a large-scale hydrologic and hydrodynamic model. Experiences on the assimilation of different mission datasets into a large-scale hydrological model are discussed, including radar altimetry-derived water level from JASON, ENVISAT and Sentinel missions, terrestrial water storage from GRACE mission, flooded area extent from SWAMPS database and soil moisture from the SMOS mission.

To develop our proof-of-concept, the Amazon as the study area. We used the hydrologic-hydrodynamic MGB model and the Local Ensemble Kalman Filter as the DA method as it has been commonly used in hydrologic models. Different localization and multivariable assimilation techniques were implemented to improve the effectiveness of the DA.

The results indicate that the multi-mission assimilation approach is able to smooth/average the improvement of the state variables of the model, such as discharge and water level anomaly, compared to the experiment of assimilating the mission datasets individually. This proof-of-concept allows us to spatialize the improvement of the dynamics of hydrological-hydrodynamic variables based on large-scale hydrologic modeling and DA from global remote sensing sources only, without requiring in-situ data. As our proof-of-concept is based on datasets globally available and a hydrologic-hydrodynamic model that can be applied almost everywhere, it is fully replicable in any region of the world and represents a great potential for regional to continental studies.