Geophysical Research Abstracts
Vol. 18, EGU2016-4966, 2016
EGU General Assembly 2016

Creation of Spatially and Temporally Consistent Discharge Records in Global Basins through the Assimilation of SWOT Observations

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The Surface Water and Ocean Topography (SWOT) mission is designed to provide global estimates of water surface elevation, slope and discharge from space. This mission will provide increased spatial and temporal coverage compared to current altimeters. However, the temporal sampling is less frequent than current in-situ discharge observations. Thus, there is a need for methods that can utilize spatially and temporally inconsistent observations of discharge to reconstruct fields that are consistent in time and space.

Using the Inverse Streamflow Routing (ISR) model of Pan and Wood [2013], discharge records are derived for a set of large river basins using data assimilation with a fixed interval Kalman smoother. ISR utilizes observed (or future SWOT retrieved) discharge values at discrete (gauge) locations to generate spatially and temporally distributed fields of runoff by inverting a linear routing model. These runoff fields are then routed to produce river discharge estimates throughout the basin.

Previous work has shown that the ISR assimilation method can be used to effectively reproduce the spatial and temporal dynamics of discharge within the Ohio River basin: however, this performance was strongly impacted by the spatial and temporal availability of discharge observations (particularly for the case of assimilating theoretical SWOT observations.) In this study, we further investigate the sensitivity of the ISR model to the data availability by applying it to a number of other other basins with different geometries and crossing patterns for the future SWOT orbit. For each basin, three synthetic experiments have been carried out to evaluate assimilating future SWOT observations. The experiments are: (1) assimilating in-situ gauges only, (2) using in-situ gauges and SWOT-retrieved “gauges”, and (3) using SWOT-retrieved “gauges” only. Results show that that the model performance varies significantly when using temporally and spatially sparse data, which will be provided by SWOT. However, we are still able to recover significant information about the discharge within a given basin. Additionally, by optimizing the locations and timing of observations used in the assimilation, or providing a small number of in-situ gauges, we are able to increase our model performance without large increases in computational cost. By carefully considering the data availability the ISR-SWOT assimilation approach will provide useful discharge estimates, especially in sparsely gauged regions where spatially and temporally consistent discharge records are most valuable.
Pan, M; Wood, E F 2013 Inverse streamflow routing, HESS 17(11):4577-4588