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Upstream Satellite Remote Sensing for River Discharge Forecasting: Application to Major Rivers in South Asia

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In this work we demonstrate the utility of satellite remote sensing for river discharge nowcasting and forecasting for two major rivers, the Ganges and Brahmaputra, in southern Asia. Passive microwave sensing of the river and floodplain at more than twenty locations upstream of Hardinge Bridge (Ganges) and Bahadurabad (Brahmaputra) gauging stations are used to: 1) evaluate their use in producing stand-alone river flow nowcasts, and forecasts at 1-15 days lead time; and 2) how they can be combined to improve the skill of an ongoing ensemble weather forecast-based flood forecasting system. The pattern of correlation between upstream satellite data and in situ observations of downstream discharge is used to estimate wave propagation time. This pattern of correlation is combined with a cross-validation method to select the satellite sites that produce the most accurate river discharge estimates in a lagged regression model. The results show that the well-correlated satellite-derived flow (SDF) signals were able to detect the propagation of a river flow wave along both river channels. The daily river discharge (contemporaneous) nowcast produced from the upstream SDFs could be used to provide missing data estimates given its Nash-Sutcliffe coefficient of 0.8 for both rivers; and forecasts have considerably better skill than autoregressive moving-average (ARMA) model beyond 3-day lead time for Brahmaputra. Due to the expected better accuracy of the SDF for detecting large flows, the forecast error is found to be lower for high flows compared to low flows. Overall, we conclude that satellite-based flow estimates are a useful source of dynamical surface water information in data-scarce regions and that they could be used for model calibration and data assimilation purposes in near-time hydrologic forecast applications.

The paper concludes by explore the utility of the SDF's in improving the skill of the existing Climate Forecasting Applications for Bangladesh (CFAB) forecast system, which over the last decade has been providing operational probabilistic forecasts of severe flooding of the Brahmaputra and Ganges Rivers as part of a humanitarian effort to mitigate the impacts of these events on the country of Bangladesh. The CFAB system developed utilizes weather forecast uncertainty information provided by the European Centre for Medium-Range Weather Forecasts (ECMWF) ensemble weather forecasts, rain gauge and satellite-derived precipitation estimates from NASA and NOAA, along with near-real-time river stage observations provided by the Flood Forecasting and Warning Centre of Bangladesh. We compare the skill of both the SDF- and CFAB-derived flood forecasts individually, and examine the overall skill of an optimal combination of both systems within the unique context of the ongoing flood forecasting effort for Bangladesh.