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A Hydrodynamics and Remote Sensing based Framework for Establishing Virtual Streamflow Measurement Stations in Scantily-gauged River Reaches

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Streamflow is the fundamental variable for any hydro-informatics based decision making to manage catchment-scale water resources. However, with the significant reduction in the number of streamflow gauging stations in many world-rivers, emphasis has now been shifted toward obtaining river discharges along the ungauged / scantily-gauged river reaches using innovative hydroinformatics tools. Many rivers which were gauged in the past, are now ungauged. In this context, this study considers a typical real-river, namely, the 48 km Bolani-Gomlai reach of the Brahmani River in eastern India, where a few historical concurrent streamflow hydrographs are available at the upstream and downstream gauging stations, which are defunct at present. Therefore, the main focus of this study is to generate spatially distributed high-frequent daily-scale river discharges along the selected ungauged river reach using the real-time optical remote sensing (RS) based imageries. To achieve this objective, the MIKE11 hydrodynamic (HD) model is setup and used in the selected reach to route the past streamflow records, available at the upstream section, so as to obtain the corresponding spatially distributed past discharges at 1 km resolution downstream. These routed historical streamflow records at each 1 km interval form the observed flow database for that specific RS-based virtual streamflow measurement station (VMS). For establishing the VMSs at each 1 km interval to estimate daily-scale river discharges, an RS-based methodology has been advocated that uses the spectral reflectances of the fused MODIS and Landsat satellite imageries and the MIKE11-HD derived corresponding routed past streamflows for calibration and validation. The different spectral behavior of land (C) and water (W) pixels in the near infrared of the electromagnetic spectrum is exploited by computing the (C/W) ratio of the fused imageries between two pixels located within (W) and outside (C), but close to the river. The values of C/W increase with the presence of water and, hence, with discharge. Moreover, in order to reduce the noise effect, an exponential smoothening filter is applied to obtain C/W_*. Finally, the real-time filtered pixel ratios are used in the RS-based framework to estimate recent high-frequent streamflows in the ungauged river reach. The results reveal that the developed model has a very good potential which can be extended for high-frequent discharge estimation at any ungauged world-river reaches.