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Daily precipitation merging from multi-source information based on double geographically weighted ridge regression kriging

Shilei Chen

Wuhan University, School of Water Resources and hydropower engineering, Depart of hydrology and water resources, China (chenslwater@126.com)

Precipitation estimation with high-accuracy and spatiotemporal resolution is the key for distributed hydrological modelling. Gauge-satellite precipitation merging provides an effect way to improve the spatial precipitation estimation. In spite of the encouraging outcomes of gauge-satellite merging, it is quite a challenging job to derive precipitation appropriate for distributed watershed hydrological modeling when facing the following problems: (1) the spatial resolution of satellite-based precipitation product is much coarser than the modeled one; (2) the spatial distribution information of daily/sub-daily precipitation input to distributed hydrological models cannot be well captured by a single satellite-based precipitation product. In allusion to these problems, a two-step strategy for multi-source information merging was proposed in this paper to improve the spatial resolution and accuracy of daily precipitation estimates. The strategy is based on geographically weighted ridge regression kriging (GWRRK) with emphasis on dealing with non-stationarity and local collinearity in the regression context. Firstly, several individual satellite-based precipitation products, e.g., Tropical Rainfall Measuring Mission (TRMM) Multisatellite Precipitation Aanlysis (TMPA) 3B42RT, Climate Prediction Center MORPHing technique (CMORPH), Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN), and Global Satellite Mapping of Precipitation (GSMaP), were downscaled to 1km by employing the relationships between precipitation and other environmental factors such as topography and vegetation. And then, all these downscaled products were merged with gauge observations. Considering the strongly skewed distribution of daily precipitation, Box-Cox transformation was carried out prior to the GWRRK approach to give a more normal distribution. To our knowledge, this is the first research to downscale satellite-based precipitation product at daily scale using geographically weighted regression method and to merge gauge observations and multiple satellite-based precipitation products. The two-step merging strategy was applied to an experiment conducted in Xijiang Basin of China from 2010 to 2017. Results showed that: (1) the regression relationships in spatial downscaling and gauge-multisatellites merging were strongly spatially non-stationary; (2) local collinearity existed in both steps: this problem was not serious in spatial downscaling but serious enough to be the main barrier for the application of geographically weighted (GWR) in gauge-multisatellites merging; (3) the spatial trend of the downscaled data was consistent with that of the original data for all the four satellite-based daily precipitation products; (4) the merging of gauge observations and multiple satellite-based precipitation products provided more accurate estimates than the merging of gauge observations and a single satellite-based precipitation product. The GWRRK-based two-step merging strategy presented in this study has provided an efficient way to derive daily precipitation with high-accuracy and spatiotemporal resolution.