Geophysical Research Abstracts
Vol. 18, EGU2016-2480, 2016
EGU General Assembly 2016

Evaluating the present annual water budget of a Himalayan headwater river basin using a high-resolution atmosphere-hydrology model

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Understanding the present water budget in Himalayan basins is a challenge due to poor in-situ coverage, incomplete or unreliable records and the limitations of coarse resolution gridded dataset. In the study, a two-way coupled implementation of the Weather Research and Forecasting model (v3.5.1) and the WRF-Hydro hydrological modeling extension package (WRF/WRF-Hydro) was employed in its offline configuration, over a 10-year simulation period for a mountainous and topographically complex Beas river basin (up to Pandoh) in North India. A triple nest is employed, in which the innermost nest domain had an atmospheric model grid spacing of 3 km and a grid spacing of 300 meters for the hydrological routing components. Two microphysical parameterization schemes are quantitatively evaluated in the study to reveal how sensitively and differently microphysical parameterization (MP) influence orographic-related precipitation, and in turn, how it impacts hydrological responses. Two sensitivity experiments of the surface-flow parameter and glacier wastage were also tested for uncertainty analysis in the study.

The WRF-Hydro modeling system shows reasonable skill in capturing the spatial and temporal structure of high-resolution precipitation and the resulting stream flow hydrographs exhibit a good correspondence with observed streamflow at monthly timescales, although the model tends to generally underestimate streamflow amounts. The Thompson scheme fits better to the observations than the WSM3 schemes in the study. More importantly, WRF showed that for high altitude precipitation, the Beas River exhibits a high ‘bias’ in winter precipitation from both MPs, which is about double to triple that as estimated from valley-sited rain gauges, and remotely sensed precipitation estimates from both TRMM and APHRODITE. While the distribution of simulated daily discharge values agrees well with the gamma distribution from observed discharge. This correspondence suggests that the major regional hydroclimatic forcings and responses are reasonably reproduced. Given the full annual cycle of pattern and amount in high altitude precipitation and the statistical correspondence in discharge, it is concluded that coupled modeling system shows potential for explicitly predicting the atmospheric-hydrology cycle of ungauged or poorly gauged basins.