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Implementation of new sub-grid runoff parameterization within the Weather Research and Forecasting (WRF) modeling system

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Runoff is an important component of the water cycle in land surface parameterization schemes, whose estimation is very difficult because of its dependence on rainfall, soil moisture, and topography, which vary temporally and spatially. In this study, two different methods of sub-grid parameterization of runoff are tested within the WRF numerical weather forecast model. The land surface scheme originally used in WRF is NOAH, in which runoff is parameterized based on the probably distributed function (PDF) of soil infiltration capacity. The river discharge calculated from WRF-NOAH simulated runoff and routed using total runoff integrating pathways (TRIP) model for three sub-basins of Karoon River, in the southwestern Iran, including Soosan, Harmaleh and Farseat is compared with observations for the winter 2006. WRF-NOAH extremely underestimates the discharge in the Karoon River basin, probably because of uncertainties in the runoff parameterization, which is in turn due to unavailability of soil infiltration data needed to estimate the shape and parameters of the PDF of the infiltration capacity. For this reason, we modified NOAH (NOAH-SIM) by substituting the infiltration capacity dependent runoff parameterization with a parameterization based on the PDF of the topographic index, following the philosophy used in the simplified TOPMODEL. As the topographic index is scale dependent, high resolution of topographic indices (10 m) are derived from digital elevation data model in low resolution (1000 m) by using a downscaling method. Evaluation of stimulated discharge by the two land surface schemes (NOAH-SIM, NOAH) coupled in WRF, with observed discharge proves improved runoff simulation by NOAH-SIM in all the three sub-basins. Compared to NOAH, NOAH-SIM simulated discharge has lower bias, smaller mean absolute error, higher efficiency coefficient, and a standard deviation closer to that observed. Coupling NOAH-SIM with WRF not only improves runoff simulations, but also feeds back to the atmosphere and changes the simulated precipitation. The mean and variations of precipitation simulated by the WRF is closer to that observed at selected stations in the basin. The main reason for the increased precipitation, despite the decreased surface evaporation, can be the increase in the calculated surface temperature and hence stronger instability and enhancement of surface moisture flux convergence.