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Effect of lateral terrestrial water flow on land-atmosphere feedbacks: A comparison between WRF and WRF-Hydro simulations for the Heihe river basin in China

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Consideration of lateral water flow in land surface modeling can significantly impact the terrestrial water balance at a variety of spatial and temporal scales. It potentially affects the atmospheric convection through soil moisture and evapotranspiration feedbacks. In mountainous areas, characterized by heterogeneous land surface and climate conditions, the impact of lateral redistribution of soil moisture on land-atmosphere feedbacks is not well known yet. In this study we perform a fully coupled atmospheric-hydrological modeling of the Heihe river basin with the hydrologically enhanced version of the Weather Research and Forecasting model WRF (WRF-Hydro). The Heihe river basin is an endorheic drainage basin in China with complex terrain and heterogeneous natural features, located at the edge area of the Asian Summer monsoon region and reaching elevations up to 5500 m above sea level. Our WRF-Hydro modeling system is configured with a horizontal resolution of 3 km for atmospheric modeling and a 300 m fine sub-grid for lateral hydrological processes. ECMWF operational analysis is used for driving the model for a 3-year period from 2008 to 2010. A control simulation with WRF is also performed in order to assess the effect of lateral terrestrial water flow on model results. The water- and energy budgets from WRF and WRF-Hydro are evaluated with ground measurements for both the rainy and dry season including Eddy-Covariance station measurements. We compare the diurnal cycle of surface energy fluxes and quantify the differences for various elevations and ecosystems in the Heihe river basin. It is found that the lateral hydrological processes have a clear effect on the water and energy budget and increase the soil moisture content in the mountainous area. There is only a slight increase of quantified precipitation recycling ratio, in both WRF and WRF-Hydro it is around 1% during the rainy season.