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Modifications in the land surface model ORCHIDEE and application in the Tarim basin

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Land surface modeling in regions mixing high mountains and arid deserts remains a great challenge due to the inadequate representations of physical processes in atmospheric forcings , runoff generation, evaporation and river routing. A few key improvements were analyzed within ORCHIDEE (Organising Carbon and Hydrology in Dynamic Ecosystems) to better understand these limitations as well as quantify their influence on the water cycle over Tarim basin (TRB). The TRB is a representative endorheic basin in center Asia, with glacier and snow melting, limited precipitation but strong evaporation, high spatial heterogeneity and intensive human interference, thus challenging any land surface model. National observations on daily precipitation from China Meteorological Administration (CMA) were used to correct precipitation inputs on the basis of WATCH forcing datasets. The independent glacier melting simulation by HYOGA2 was added to the forcing to overcome the lack of glacier module in ORCHIDEE. Improvements in the snow scheme provided more accurate simulations of the soil temperature which restrict the infiltration process when the soil is frozen. In addition, a novel routing scheme with finer spatial resolution from 50km to 1km was developed based on HydroSHED map. It improves the descriptions of catchments boundaries, the flow direction and the water residence time within sub-basins that make significant difference especially for the mountainous area and flat plains. Model results with these modifications were compared through various atmospheric and hydrological variables (i.e. evaporation, soil moisture, runoff and discharge).

In conclusion, the correction by the precipitation observations and involvement of glacier melting simulations increase the water input to the basin by 37.2% and 8.4% respectively, which in turn increases evaporation, soil moisture and runoff to different extents. The new snow and soil freezing scheme advance in time the spring high-water in the hydrograph and induce a decreasing in the flow peaks during summer. The changes reduce the annual evaporation by 6.7%, with the ratio between evaporation and precipitation decreasing from 0.73 to 0.68.

All the modifications improve the model performance in terms of the similarity between modeled discharge and the observations. However, large biases still exist which could be attributed to the human influence (i.e. irrigation or dams regulation which are not included in the current model) and other modules in ORCHIDEE. Further efforts should be made to optimize evaporation estimation as well as the relevant human processes.