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Simulations of Mississippi river basin streamflows by the land surface model ORCHIDEE. Sensitivity to the forcing resolution and parameters.

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The land surface community had shown motivation in the development of runoff routing schemes during the last decade to simulate streamflow. It is essential for our models because it integrates at large scale all the land surface hydrology processes and it is easily compared to observations for validation. It is a good challenge for the land surface model (LSM) coupled with ocean-atmosphere to close the global water cycle. Before coupling the LSM with a GCM, an evaluation offline of these routing processes is essential to understand them precisely. Therefore, this work explore the sensitivity of the LSM ORCHIDEE (Organising Carbon and Hydrology In Dynamic EcosystEms) integrating a routing scheme, for two atmospheric forcings differing in resolution, spatially (1° to (1/8)°) and temporally (6 hours to 1 hour), through streamflow variations which are compared to observations (River UCAR and USGS). The forcing data used are NCC (NgoDuc & al., 2005) and NLDAS (Cosgrove & al., 2003) over the Mississippi river basin during a common period 1997-1999. First, we have compared the atmospheric inputs between the forcings. Both give similar mean climatic conditions over the basin (precipitation in particular) excepted the solar radiation. In order to have similar input for the model, a comparison of the downward shortwave radiation is performed between the forcings and FLUXNET data. It shows an agreement between NCC data and measurements but a systematic overestimation (spatially and temporally) of about 25% during the year for the NLDAS data comparing to NCC. Therefore, a basic correction of the NLDAS downward shortwave radiation is performed and the result shows its expected decrease and its similarity with NCC. The first result is the response of the streamflow simulated by ORCHIDEE to the decrease of the NLDAS shortwave radiation. The seasonality is not affected by this modification but the magnitude is increased of about 30% at Vicksburg station during all the period. However, the correlation between the streamflow simulated and the observations is very bad. Secondly, the main result points out the high sensitivity of the streamflow seasonality to the spatial resolution (the temporal resolution has not an impact with this hydrological model). With the NCC resolution, the peak of streamflow reaches the period in agreement with the observations whereas it is hugely shifted with the high resolution. We explain this difference by the time constants of routing reservoirs in ORCHIDEE which were only calibrated with the NCC resolution. With a high resolution, we have to put a lower value of time constant for the stream reservoir which should represent a water amount routed more quickly. When we divided by a factor 10 the time constant of this reservoir and the routing time step, the seasonality of the streamflow at Vicksburg is found back and similar to NCC. Furthermore, with this calibration, we show that streamflows are correctly represented over many stations over the basin during the three years, with both forcings. We also compare ORCHIDEE to four other models which have performed the same simulation with NLDAS (Lohmann & al., 2004). For the five stations of the Mississippi river basin studied in this paper, we compare their measured streamflow variations to the simulated ones. We notice a large difference between five models. ORCHIDEE and NOAH are the most similar and able to represent the peaks accurately. Finally, we point out the good ability of the model ORCHIDEE to simulate streamflow but also the incertitude in its seasonality due to calibrated parameters such as time constant and routing time step. Overall, this study shows the necessity to find a general law to switch over spatio-temporal scale to another in a same LSM.