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Investigation of land-atmosphere interaction with a multi-model coupling approach

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Two Atmospheric General Circulation Models (AGCMs), COLA AGCM and the NCEP GFS, are each coupled to three different land surface schemes (LSSs), SSiB, CLM3.5, and Noah (six different model configurations in total). A series of experiments with them are performed to study the role of different model components and different action processes in land-atmosphere interaction and climate variation. When coupled to the same AGCM, the three LSSs produces significantly different surface fluxes over most of the land. The influence of LSS uncertainties on the simulation of surface temperature is stronger in dry regions/seasons, and its influence on daily maximum temperature is stronger than on minimum temperature. For the six model configurations, the choice of AGCMs is the main reason for the substantially different precipitation variability, predictability, and land-atmosphere coupling strength among the configurations. The impact of different LSSs is secondary. For the same AGCM, coupling to different land models or prescribing subsurface soil moisture does not change the global pattern of precipitation predictability and variability very much. However, the regional impact of soil moisture can shows very different patterns for the three LSSs. Further, climate change experiments of doubled CO2 and associated oceanic changes with one AGCM coupled to three different LSSs are performed. It is found that the implemented LSSs can greatly impact the spatial distribution and amplitude of the simulated warming over land. In warm regions, the different descriptions of local land processes and their associated feedbacks are responsible for about half of the inter-model spread. In cold regions, almost all of the spread is caused by the circulation differences triggered by LSS differences, and the local land processes have little direct impact. On the other hand, as the annual global-average land surface warmings are very close no matter which LSS is coupled, this study suggests that the LSS has little impact on projections of annual global-average temperature change, despite strong regional impact in warm regions.