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The impact of water table dynamics on climate

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The water cycles in the atmosphere and in the land make up a fundamentally coupled system, with complex interactions among all reservoirs (atmosphere, soil-vegetation, groundwater and rivers). The focus of the present work is to study the role of groundwater on climate and to stress the integrated nature of the water cycles in the land and the atmosphere. For this purpose, we incorporate water table dynamics and river processes into the Regional Atmospheric Modeling System (RAMS) with a domain covering the whole North American continent. In our approach, the water table acts as lower boundary for the soil columns of the soil-vegetation model of RAMS and the relatively long timescales of evolution of the water table contrast with a fast evolving atmosphere interacting from the top. To obtain initial water table depths we examine thousands of groundwater observations throughout the continent and find that topography is the main factor determining horizontal distribution of groundwater depth. We perform experiments of the fully coupled atmosphere-hydrology model for a relatively dry summer season and compare results to simulations without the hydrology part. Results show that the presence of the water table affects significantly soil moisture dynamics in the areas where groundwater is within a few meters from the land surface. In particular, in a dry season groundwater supplies an important fraction of moisture to the root zone to sustain evapo-transpiration. Relatively shallow water tables are found over large areas of the North American continent, especially east of the Rocky Mountains, and therefore North American soil moisture horizontal distribution is largely affected by the position of the water table. Energy fluxes in the land surface, the atmosphere, and therefore climatic conditions are also significantly impacted by groundwater. The fully coupled model includes river flow as a natural product of the calculations and allows us to close the water budget in the soil and atmosphere simultaneously and validate results with routine hydrological observations.