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Impact of a prescribed groundwater table on the global water cycle in the IPSL land-atmosphere coupled model

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The main objective of the present work is to study the impacts of the water table depth on the global water cycle and the physical mechanisms responsible for it through analysis of land-atmosphere coupled numerical simulations. The analysis is performed with the LMDZ (standard physics) and ORCHIDEE models, which are the atmosphere-land components of the IPSL (Institut Pierre Simon Laplace) Climate Model. Results of sensitivity experiments with groundwater table (WT) prescribed at 1m (WTD1) and 2m (WTD2) are compared to the results of a reference simulation with free drainage from an unsaturated 2m soil (REF).

The precipitation and evaporation are significantly impacted by WT with the largest difference found between REF and WTD1. Saturating the bottom half of the soil in WTD1 induces an increase of soil moisture. Evapotranspiration increases over water-limited regimes due to increased soil moisture, while it decreases over energy-limited regimes owing to the decrease of downwelling radiation and the increase of cloud cover. Consequently, the land-atmosphere coupling strength is weakened in WTD1 over the water-limited regimes. The tropical (25°S-25°N) and extratropical areas (25°N-60°N and 25°S-60°S) are significantly impacted by the WT with an increase of precipitation. This can be explained by more vigorous updrafts due to the uneven distributed change of evaporation, which transports more water vapor upward causing a positive precipitation change in the ascending branch. Transition zones like the Mediterranean area and central North America are also impacted, with strengthened convection resulting from increased evaporation (recycling). Over the West African Monsoon region, the rainfall belt moves northward. The more intense convection and the change of large scale dynamics (increased meridional temperature gradient) are responsible of this change. Despite the model dependence, these results with the ISPL climate model are consistent with the ample body of literature regarding the sensitivity of the simulated climate to soil moisture increase.