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Impact of soil hydrology formulation on water budget and phenology over the Amazon basin. Sensitivity of simulated hydrology to the dry-season length.

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The role of soil moisture in controlling evapotranspiration (ET) is important over the Amazon basin, and particularly in south Amazonia, where a high rate of water recycling is sustained through transpiration. Thus, soil moisture parametrization in Land Surface Models (LSMs) plays a critical role in accurate modeling of the hydro-climatology and CO_2 fluxes. Multilayer schemes have been introduced in LSMs to better describe the water diffusion through the soil. The main question we address here is "Does the use of a soil diffusion scheme, rather than a simpler bucket-type scheme, improve the simulation of water storage dynamics and water fluxes?". For the first time, we compare two soil models embedded in ORCHIDEE coupled to the same river routing scheme and interactive phenology/carbon cycle module: a simple 2 layer soil scheme with a bucket topped by an evaporative layer (2LAY) and an 11 layer soil diffusion scheme (11LAY). We tested their different impacts on the estimated Amazonian water budget and carbon flux dynamics, which are compared with several datasets, at the scale of the five major tributary sub-basins. The use of the 11LAY did not significantly change the Amazonian water budget simulation when compared to the 2LAY. However, the higher water holding capacity of the soil and the physically based representation of runoff and drainage in the 11LAY resulted in higher dynamic of soil water storage variations and improved simulation of the total terrestrial water storage when compared to GRACE satellite estimates. The greater soil water storage within the 11LAY resulted in increased dry-season ET in the southeastern sub-basins such as the Xingu. Lower plant water stress simulated by the 11LAY led to better simulation of the seasonal cycle of photosynthesis (GPP) when compared to a GPP data-driven model based upon eddy-covariance and satellite greenness measurements. Simulated LAI was consequently higher with the 11LAY but exhibited too low a variation when compared to a satellite-based dataset. The dry-season length, between 4 and 7 months over the entire Amazon basin, was found to be critical in distinguishing differences in hydrological feedbacks between the soil and the vegetation cover simulated by the two soil models. The use of the 11 layer soil diffusion scheme might become critical for assessments of future hydrological changes, especially in southern regions of the Amazon basin where longer dry season, more severe droughts (Li et al., 2008) and lower minimum river discharge rates (Guimberteau et al., 2013) are expected in the next century.

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Li, W., Fu, R., Juárez, R., and Fernandes, K. (2008): Observed change of the standardized precipitation index, its potential cause and implications to future climate change in the Amazon region, Philos. T. R. Soc. B, 363, 1767–1772