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Subgrid-scale parametrization of groundwater-soil moisture interactions in the ORCHIDEE land surface model: first results at global scale

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Groundwater (GW) constitutes by far the largest volume of liquid freshwater on Earth. The most active part is soil moisture (SM), recognized as a key variable of land/atmosphere interactions. But GW can also be stored in deeper reservoirs than soils, characterized by slow and mostly horizontal water flows towards the river network. These flows end up forming baseflow, with well-known buffering effects on streamflow variability. But they also contribute to sustain high SM in many areas, like in lowland areas surrounding streams, which are among the most frequent wetlands (floodplains and smaller riparian wetlands).

In the standard version of the ORCHIDEE land surface model, the sole effect of GW is on river discharge, using a linear reservoir model to represent GW storage and baseflow in each grid-cell, with no feedback on local SM. To describe the interactions between GW flow and soil moisture, we introduced a new sub-grid fraction, corresponding to the lowland parts of the grid-cell, and acting as a buffer between the upland areas, supplying most GW recharge, and the river system eventually draining GW flow. For simplicity, this fraction is constant in each grid-cell, and prescribed from a global-scale wetland map recently designed to this purpose (Tootchi et al., 2019). The lowland fraction is described as a separate hydrological element, with physically-based water flows relying on a fine vertical discretization. It is effectively wet when/where GW flow is sufficient, in which case a water table can build up, and feeds baseflow to the river, as well as enhanced evapotranspiration compared to the upland fraction.

This new version is called ORCHIDEE-GWF (GW-fed Fraction) and we present here its first evaluation at global scale, both off-line (with prescribed atmospheric conditions from a meteorological forcing dataset) and coupled to the IPSL climate model. Compared to the reference version of ORCHIDEE, the main impacts of this new version relate to SM, evapotranspiration, river discharge, and soil thermal properties. They are quantified spatially, compared to several observation-based products to assess if ORCHIDEE-GWF helps obtaining more realistic simulations, and the sensitivity to key assumptions of this new parametrization ORCHIDEE-GWF is explored (soil depth, baseflow parameters).

Tootchi, A., Jost, A., and Ducharne, A. (2019). Multi-source global wetland maps combining surface water imagery and groundwater constraints, Earth Syst. Sci. Data., accepted, https://doi.org/10.5194/essd-2018-87