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Assessing the Importance of Lateral Groundwater Flows at the Global-Scale

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Most current global-scale hydrological models do not account for long-distant groundwater flow between model cells, i.e. lateral groundwater flows. These models may therefore not fully represent the effects of human water use or climate variability on groundwater depth and river low flows. In this study, we explore the importance of including groundwater flow in large-scale modelling. We used a Global-scale Surface water-Groundwater model that simulates hydrological processes, including lateral groundwater flow, at 5-arcminute resolution at a daily timestep running over 1960-2010. For a naturalized situation, we first quantifying how much water exits a catchment without ever passing through the surface outlet. Second, we quantify the effect of including lateral groundwater flows on discharge estimates by comparing model outcomes to a similar run, but not coupled to the groundwater model. We did the same analysis for a human influenced situation and additionally estimated groundwater depletion. Based on the comparison of these runs we isolate the main hydrogeological and climatological drivers that cause temporal and spatial differences in groundwater flow magnitude and groundwater-surface water interactions. Results showed that upstream catchments often support water budgets of downstream catchments or aquifers and lateral groundwater flow paths are longest and amounts are most significant in magnitude for thick sedimentary aquifer systems. Groundwater depletion estimates improved when lateral flows were included, as well as the effect of abstractions on river discharges due to head declines. These results emphasize that including lateral groundwater flows is essential for water resources analysis at the larger scale, especially when moving to finer resolution and flow between cells gets more significant compared to other fluxes. Our results have wide ranging implications for understanding and modelling changes in the water balance partitioning of large basins and for informing robust future water management.