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The 'Dominant Source Layer' approach to infer long- and short-term water and solute mobilization in a subhumid Mediterranean catchment

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The 'Dominant Source Layer' (DSL) is defined as the riparian zone (RZ) depth stratum that contributes the most to water and solute fluxes to streams. For any given period of time, the DSL position is inferred from the relationship between RZ groundwater table and stream runoff by assuming that lateral fluxes at any given RZ soil depth are proportional to the groundwater table – stream runoff curve. In forest headwaters, the DSL approach can be used to explain timing and amount of water and solute transferred from RZs to streams.

Here, we used the DSL conceptual framework to investigate the potential impact of future climate changes on the long-term mobilization of water and solutes in a subhumid Mediterranean headwater catchment. We used the rainfall-runoff model PERSiST and synthetic temperature, precipitation, and inter-event length scenarios to simulate reference (1981–2000) and future (2081–2100) stream runoff in the catchment. Simulated stream runoff was then used to estimate RZ groundwater tables, and thus, the DSL position, based on the characteristic RZ groundwater table – stream runoff relationship previously established for this catchment. Our simulations indicate that future changes in temperature and precipitation will lead to reductions in stream runoff and water exports, and that the DSL will move down by as much as ca. 30 cm. As a result, shallow organic-rich layers in the RZ may only be hydrologically activated during sporadic large rainfall events predicted for the most extreme inter-event length scenarios. To better understand the transfer of solutes during these large rainfall events, we examined the RZ groundwater table – stream runoff relationship during five large storms for which we had empirical data. We found that this relationship varied among individual storm events depending on antecedent hydroclimatic conditions. Specifically, antecedent drier conditions led to steeper slopes in the RZ groundwater table – stream runoff relationship, which resulted in relatively larger concentrations of dissolved organic carbon (DOC) and nitrate (NO_3^-) in the stream. A steeper slope of the relationship implies that more RZ layers will be hydrologically connected to the stream, increasing the 'thickness' of the DSL and thus the chances for relatively more DOC and NO_3^- to be mobilized.

Overall, we highlight the importance of identifying the layers in the RZ vertical profile that are hydrologically active (i.e., DSLs) and the factors contributing to their temporal dynamics both at long- and short-term scales, to better predict the transfer of water and solutes from catchment soils to forest headwater streams