EGU25-2243, updated on 09 Dec 2025
https://doi.org/10.5194/egusphere-egu25-2243
EGU General Assembly 2025

Drivers of stream and riparian hydrological responses to rainfall events in forest headwater catchments across ecoregions

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Studying hydrological responses to rainfall events at the catchment scale is a foundational approach to understanding water and solute mobilization processes because it provides insights into the runoff generation mechanisms. These responses are reflected not only in variations in stream discharge, but also in shifts in groundwater tables, particularly within hydrologically connected near-stream riparian zones. In this context, cross-ecoregional comparisons offer additional value as they can identify both shared and distinct drivers of hydrological responses to rainfall events across diverse system settings. We analysed rainfall events in four forest headwater catchments spanning four different ecoregions: boreal, temperate, subhumid Mediterranean, and semiarid Mediterranean. We aim to evaluate the role of hydroclimatic predictors, including rainfall event characteristics and antecedent hydroclimate (e.g. soil moisture) conditions, in shaping hydrological responses. These responses include variations in stream discharge and riparian groundwater table, as well as the relationship between these two variables, with particular attention to hysteresis patterns. Our results show that drier antecedent soil moisture was linked to anticlockwise hysteresis loops, where stream discharge responded faster than riparian groundwater tables to rainfall events. This observation was particularly prominent at the temperate site. Furthermore, distinct hydrological response patterns at the Mediterranean sites emerged only during larger events, while the responses observed at the boreal and temperate sites remained consistent regardless of storm size. We will discuss these and further findings in the context of hydrological connectivity, wetness state, and the hydrological conductivity of the riparian layers activated during rainfall events. This approach has the potential to offer valuable insights for both scientific assessments and the management of land-water connectivity across ecoregions with contrasting hydroclimates.