EGU23-1421, updated on 15 Apr 2024
https://doi.org/10.5194/egusphere-egu23-1421
EGU General Assembly 2023

Beyond precipitation: diversity of drivers of high river flows in European near-natural catchments

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High streamflow in rivers can lead to flooding, which may have severe impacts on economy, society and ecosystems. Therefore it is imperative to understand their underlying physical mechanisms. Previous research has illustrated the relevance of several hydrological drivers, such as precipitation, snowmelt and soil moisture. However, the relative importance of these drivers compared with each other is unclear. Moreover, the role of vegetation-related drivers is not well studied. In this study, we focus on high river flows and consider a comprehensive set of potential drivers and analyze their relative importance. This is done with streamflow observations from over 250 near-natural catchments located across Europe during 1984–2007, which are matched with driver data from various observation-based sources. Not surprisingly, we find that precipitation is the most relevant driver of high river flows in most catchments. In addition, and more interestingly, we show that next to precipitation a diversity of other drivers is relevant for high flows, including shallow soil moisture, deep soil moisture, snowmelt, evapotranspiration and leaf area index. These non-precipitation drivers tend to be even more relevant for more extreme high flows. The relative importance of most considered drivers is similar across daily, weekly and monthly time scales. The spatial patterns of the relevance of precipitation, snowmelt and soil moisture for supporting high river flows are controlled by vegetation types and terrain characteristics, while climate and basin area are less important. By analyzing a comprehensive selection of drivers of high river flow in a powerful framework which accounts for co-linearities between drivers, this study advances the understanding of flood generation processes and informs respective model development.