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Spatio-temporal synchronization of heavy rainfall events triggered by atmospheric rivers in North America

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Atmospheric rivers (ARs) are filaments of extensive water vapor transport in the lower troposphere. They are important triggers of heavy rainfall events, contributing to more than 50% of the rainfall sums in some regions along the western coast of North America. ARs play a crucial role in the distribution of water, but can also cause natural and economical damage by facilitating heavy rainfall. Here, we investigate the large-scale spatio-temporal synchronization patterns of heavy rainfall triggered by ARs over the western coast and the continental regions of North America.

For our work, we employ daily ERA5 rainfall estimates at a spatial resolution of 0.25°x0.25° latitude and longitude which we threshold at the 95th percentile to obtain binary time series indicating the absence or presence of heavy rainfall. Subsequently, we separate periods with ARs and periods without ARs and investigate the differing spatial synchronization pattern of heavy rainfall. To establish that our results are not dependent on the chosen AR catalog, this is conducted in two different ways: first based on a recently published catalog by Gershunov et al. (2017) , and second based on a catalog constructed using the IPART algorithm (Xu et al, 2020). For both approaches, we subsequently utilize event synchronization and a complex network framework to reveal distinct spatial patterns of heavy rainfall events for periods with and without active ARs. Using composites of upper-level meridional wind, we attribute the formation of the rainfall synchronization patterns to well-known atmospheric circulation configurations, whose intensity scales with the strength of the ARs. Furthermore, we demonstrate that enhanced AR activity is going in hand with a suppressed seasonal shift of the characteristic meridional wind pattern. To verify and illustrate how small changes of the high-level meridional wind affect the distribution of heavy rainfall, we, additionally, perform a case study focusing on the boreal winter.

Our results indicate the strong sensitivity of the intensity, location, frequency, and pattern of synchronized heavy rainfall events related to ARs to small changes in the large-scale circulation.