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Rainfall extremes, weather and climatic characterization over complex terrain: A data-driven approach based on signal enhancement methods and extreme value modeling

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Weather and climatic characterization of rainfall extremes is both of scientific and societal value for hydrometeorological risk management, yet discrimination of local and large-scale forcing remains challenging in data-scarce and complex terrain environments. Here, we present an analysis framework that separate weather (seasonal) regimes and climate (inter-annual) influences using data-driven process identification. The approach is based on signal-to-noise separation methods and extreme value (EV) modeling of multisite rainfall extremes. The EV models use a semi-automatic parameter learning [1] for model identification across temporal scales. At weather scale, the EV models are combined with a state-based hidden Markov model [2] to represent the spatio-temporal structure of rainfall as persistent weather states. At climatic scale, the EV models are used to decode the drivers leading to the shift of weather patterns. The decoding is performed into a climate-to-weather signal subspace, built via dimension reduction of climate model proxies (e.g. sea surface temperature and atmospheric circulation)

We apply the framework to the Western Andean Ridge (WAR) in Ecuador and Peru (0-6ºS) using ground data from the second half of the 20th century. We find that the meridional component of winds is what matters for the in-year and inter-annual variability of high rainfall intensities alongside the northern WAR (0-2.5ºS). There, low-level southerly winds are found as advection drivers for oceanic moist of the normal-rainy season and weak/moderate the El Niño (EN) type; but, the strong EN type and its unique moisture surplus is locally advected at lowlands in the central WAR. Moreover, the coastal ridges, south of $\sim$3ºS dampen meridional airflows, leaving local hygrothermal gradients to control the in-year distribution of rainfall extremes and their anomalies. Overall, we show that the framework, which does not make any prior assumption on the explanatory power of the weather and climate drivers, allows identification of well-known features of the regional climate in a purely data-driven fashion. Thus, this approach shows potential for characterization of precipitation extremes in data-scarce and orographically complex regions in which model reconstructions are the only climate proxies

References

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