Quantifying the influence of moisture transport on precipitation maxima by an extreme value approach

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Integrated vertical vapour transport (IVT) is a widely used local measure of moisture transport, primarily both for its role as a defining parameter of atmospheric rivers, but also as a precursor of extreme precipitation and because it is much more predictable than extreme precipitation. With all the exceptions, nowadays very well studied, extreme precipitation should scale with temperature in a similar way to humidity, i.e., with a thermodynamic constraint (following Clausius–Clapeyron (CC) equation, approximately 6-7% per degree of temperature). Although moisture transport should also scale according to the CC rate, it should vary depending on the region under study. As IVT has two components (thermodynamic and dynamic), the thermodynamic component of IVT should increase according to the CC rate in a worldwide way, but the dynamic one not necessarily (expansion of the tropics, migration of storm-track towards the poles, arctic amplification...).

In this study, in addition to IVT, we made use of other two interesting measures, namely IWV (integrated water vapour) and IVT/IWV, which are associated to the thermodynamic and dynamic component of moisture transport, respectively. For this purpose, we used data from the ERA-5 reanalysis for the period 1981–2020. A non-stationary Generalized Extreme Value (GEV) modelling was carried out: for each season, a GEV distribution was fitted to the annual precipitation maxima at each grid point, allowing its location and scale parameters to vary linearly with a covariate. Centred and scaled IVT, IWV and IVT/IWV were used separately as a covariate.

Moreover, we computed how the estimated 20-year return level of maximum precipitation varies between a low and a high value of IVT, IWV and IVT/IWV, in order to identify the regions where the corresponding covariate has a relevant influence on precipitation maxima.