Applying a scaling approach for extreme precipitation to disentangle thermodynamic and dynamic contributions to CORDEX-FPS simulations

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The response of the hydrological cycle to global warming is one of the greatest concerns of climate change. Especially, extreme precipitation can lead to severe physical and economic impacts on human and natural systems. Though extreme precipitation is expected to increase over many land areas an important question remains: which factors drive the uncertainty in extreme precipitation? Answering this will help better understand, prepare for, and ultimately, predict future extreme precipitation.

In this study, we use a scaling approach for extreme precipitation events developed by O’Gorman and Schneider (2009) to disentangle the thermodynamic and dynamic contributions to these events. Extreme precipitation is scaled by the vertical integral over the product of the vertical velocity (\(\omega\); dynamic contribution) and the derivation of the saturation specific humidity (\(\frac{d q_s}{d p} |_{\theta^*}\); thermodynamic contribution):

\[ P_e \sim -\left\{ \omega \frac{d q_s}{d p} |_{\theta^*} \right\} \]

We apply this scaling approach to a subset of the CORDEX-FPS ensemble and focus on change signals of seasonal extremes of daily precipitation for two 10-year periods (2090-2099 vs 1996-2005). By keeping either the first term or the second term in the formula constant over the entire time period we obtain the thermodynamic and dynamic signal, respectively. The thermodynamic signal is quite homogeneous over the domain, approximately in the order of Clausius-Clapeyron scaling (~ 7%/K), while the dynamic signal modifies the thermodynamic signal. Thus, the dynamic contribution, which is represented by vertical wind, is key in understanding differences between models and uncertainty in precipitation changes. The vertical wind profiles show, especially for summer, that the vertical winds during extreme events weaken in the future period compared to the historical period. This seemingly counterintuitive result could be due to more downdrafts leading to extreme precipitation in the future period instead of updrafts.
However, a comprehensive interpretation is the subject of ongoing research.

the CORDEX Flagship Pilot Study on Convection over Europe and the Mediterranean – ensemble: Merja Tölle, Thomas Frisius, Susanne Brienen, Sophie Bastin, Heimo Truhetz