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The dynamical context and isotope signature of extratropical airmasses that experience strong and rapid moistening

Franziska Aemisegger (1), Lukas Papritz (1), and Jesper Sjolte (2)

(1) Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland, (2) Department of Geology Quaternary Science, Lund University, Lund, Sweden

Large-scale ocean evaporation is a key mechanism linking the energy and water budgets of oceans and the atmosphere. Because of its efficiency in transferring energy between these two components of the climate system, ocean evaporation plays a fundamental role for the diabatic forcing of the atmosphere. In addition, it is a major contributor to severe weather, for example, by favourably preconditioning the atmosphere for rapid cyclone intensification as well as downstream of the evaporation region in the form of heavy precipitation associated with the subsequent coherent transport of the evaporate.

Studying atmospheric moisture uptake resulting from strong large-scale ocean evaporation (SLOE) on synoptic spatiotemporal scales thus provides important information about the dynamics of the atmospheric water cycle. Here, we present a methodology for an object-based climatological analysis of SLOE. In particular, we focus on transient events with a notable impact on the near-surface atmospheric moisture budget and its isotopic composition. These short-lived intense evaporation events explain nearly a quarter of global annual mean ocean evaporation, even though they occur only 6% of the time in the global average. The presented methodology provides the basis for a general Eulerian moisture source characterization using reanalysis data and can be easily applied to large datasets such as long-term climate simulations to effectively identify hot spots of strong moisture uptake by the atmosphere.

In this presentation, we show three application examples of the SLOE identification scheme. First, the key role of the position of the storm track in shaping the spatial distribution of the occurrence of evaporation hotspots is discussed. Second, we show that during these events, the second order isotope parameter deuterium excess (d) of the marine boundary layer vapour is essentially determined by the evaporation flux signature. And third, a robust process-based dynamical link is established between the variability of d in precipitation and the occurrence of SLOE at the moisture source. Potential implications of our findings for the interpretation of d as a proxy for the location and intensity of storm tracks are discussed.

Overall, our results highlight the importance of transient weather systems in shaping the variability of the atmospheric water cycle at the synoptic to interannual timescales. Furthermore, they contribute towards a better understanding of the link between the dynamical drivers of this variability and stable water isotopes.