From Heat Waves to Thunderstorms: The Impact and Properties of Atmospheric Deserts

Fiona Fix
Universität Innsbruck, fiona.fix@uibk.ac.at

Abstract

Heat waves and extreme thunderstorms can pose a severe risk to human health, infrastructure, ecosystems and economy. Their formation has been investigated increasingly in the recent years. One process that can influence both the accumulation of heat as well as the formation of thunderstorms, is a capping inversion. If a potentially warmer air mass aloft prevents the boundary layer from growing, heat can build up underneath, leading to a heat wave if the situation prevails for long enough. Thunderstorms are typically suppressed by the warm air mass aloft, can, however, erupt violently close to the edges, where the lid is weaker and trigger mechanisms initiate ascent.

One phenomenon that can cause a capping inversion like this, is the atmospheric desert. An atmospheric desert is an air mass that is formed in the hot, dry boundary layer of a semi-arid or desert region. It is then advected across a target region with a cooler, moister boundary layer. In order to identify these air masses we employ a novel approach, tracking the air directly from the source to the target region using the Lagrangian analysis tool (LAGRANTO) together with ERA5 reanalysis data.

In the present work we analyse atmospheric deserts over Europe between May 2022 and April 2024 with respect to their extent, location, frequency, prevalence, modification during the advection, and consequences. In particular, we investigate if and how often atmospheric deserts cause a capping inversion, and how they can be connected to anomalously high temperatures and thunderstorm occurrence.

We find that atmospheric deserts occur in up to 60 % of cell-hours in the Mediterranean, where they prevail on average 1-2 days. In the rest of Europe they are less frequent and last for less than a day on average. In some regions, up to 45 % of the daytime atmospheric desert cell-hours also show a capping inversion, however, the typical duration is short. This also explains why anomalously high temperatures could not be connected to atmospheric desert presence in this study. However, the odds of lightning occurring near the atmospheric desert edge are clearly elevated.