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Looking under the Lid: Understanding the Influence of Atmospheric Deserts on Heat Wave and Thunderstorm Formation

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We introduce the concept of atmospheric deserts, air masses that originated as hot and dry boundary layers in semi-arid or desert source regions. When they are advected to regions with moister and cooler boundary layers, they can cap the local boundary layers, eliminate cloudiness, and lead to the buildup of heat underneath. Heat waves can occur when atmospheric deserts are present over a target region for several days. Thunderstorm formation can be suppressed where the capping lid is strong, but where it is punctured, thunderstorms can erupt violently.

We illustrate this new concept with a case study from mid-June 2022 when an atmospheric desert was advected from its source region in North Africa towards Europe. With the Lagrangian analysis tool (LAGRANTO), approximately 200 million trajectories are traced, tracking the path of the air mass and the development of its properties as it progresses towards and across Europe over the course of 5 days. By the end of the study period the atmospheric desert extends from the Atlantic to Eastern Europe and as far north as Sweden. k-means-clustering identifies four typical pathways that the trajectories follow. Most of the atmospheric desert air is modified along the way, with exception of one pathway for which air remains well mixed and forms an elevated mixed layer.

Thunderstorms erupted along a line parallel to the northwestern edge along the surface temperature front, but were mainly absent in the core region of the atmospheric desert. A heat wave affected large parts of Europe, from the Iberian Peninsula to Central Europe. Temperatures set new records, for example in some parts of Eastern Germany. Potential temperatures in some locations even became as high as the ones of the overlying atmospheric desert air.