Dry air intrusions: climatology and their relevance for extreme weather

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I introduce the research themes in my new group by presenting climatological work on dry air intrusions (DIs), a prominent feature in the atmospheric circulation.

DIs are large-scale equatorward descending airstreams, typically referred to as the coherent airstream in the cold sector of extratropical cyclones. Emerging evidence suggests that DIs are linked to severe surface wind gusts and heavy precipitation. However, there is yet no strict Lagrangian definition of DIs, and so their climatological frequency, physical characteristics as well as their seasonal and spatial distributions are unknown. Furthermore, the mechanistic link between DIs and severe weather is not well understood or quantified.

Here, a Lagrangian definition for DI air parcels is suggested, namely a minimum pressure increase along a trajectory of 400 hPa in 48 hours. Based on this criterion, the open questions are addressed by: (i) a novel global Lagrangian climatology for the ECMWF ERA-Interim reanalysis dataset for the years 1979-2014; (ii) examples for the interaction between DIs and high-impact weather, shown with case studies and a regional numerical weather-prediction model simulation.

DIs are found to occur predominantly in winter. DIs coherently descend from the upper troposphere (its stratospheric origin is small), to the mid- and low levels, where they mix with their environment and diverge. The majority of DIs are associated with anomalously deep boundary layer, accompanied by strong winds, large surface heat fluxes and potential instability. A top-down destabilization mechanism is identified during DI episodes, facilitating the downward-mixing of high-momentum air over large geographical areas. Near cold fronts, shallow convection contributes to wind gusts and intense precipitation locally.