

The link between dry air intrusions and frontal precipitation and winds

Shira Raveh-Rubin

Department of Earth and Planetary Sciences, Weizmann Institute of Science, Israel

Abstract:

The conceptual picture of an extratropical cyclone typically includes warm and cold fronts and various cyclone-related airstreams, including the dry intrusion (DI). The DI is a stream of air descending slantwise from the upper troposphere equatorward behind the cold front. The DI may have a dynamical impact on the cold front and the cold sector behind it, helping to produce instability and potentially convective activity. However, it is not clear how the presence of DIs shapes the characteristics of the front, its environment and impact, in terms of precipitation and winds.

To understand and quantify the link between DIs, fronts and their environment, we combine case studies, feature-based climatologies and composite analysis, based on the ECMWF ERA-Interim dataset for winters during 1979-2014 in both hemispheres. Specifically, a global climatology of DIs, produced using a Lagrangian trajectory analysis, is joined with an objective climatology of cold fronts to quantify the climatological link between the two. In the analysis, a distinction is made between cold fronts trailing from cyclones, and cold fronts that are located away from any cyclone.

Case studies demonstrate the relative positions of the cyclone, DI, front and the associated surface wind and precipitation. Although the DI contributes to drying of the atmospheric column, it created a potentially unstable environment for convection to be triggered. The global distribution of cold fronts linked to DIs indicates that roughly a third of DIs are linked to fronts, while about 20% of fronts are associated with DIs. Generally, fronts that occur with DIs are substantially longer, sharper and more impactful in terms of precipitation and 10-m wind gusts, even when controlled for the front intensity. Moreover, with DIs, trailing fronts occur with stronger SLP dipole, deeper upper-tropospheric trough and enhanced ocean sensible and latent heat fluxes in the cyclone cold sector, compared to similar fronts without DIs in their vicinity.