The linkage of water vapour transport features and extratropical cyclones – with a focus on diabatic Rossby waves

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Several Eulerian and Lagrangian concepts of large-scale water vapor transport features have been established and used primarily to investigate heavy precipitation events. Very likely, these features are also relevant for the dynamics of extratropical cyclones, given that moisture transport towards and vertical motion near cyclones lead to latent heat release, which in turn can strengthen their intensity. The linkage of two of these water transport concepts, the Lagrangian Tropical Moisture Exports (TMEs) and the Eulerian Atmospheric Rivers (ARs), with extratropical cyclones is addressed in this study for cyclones in general and in particular for the sub-category of so-called diabatic Rossby waves (DRWs). TMEs are identified as air parcel trajectories of tropical origin with a strong meridional moisture transport into the extratropics; and ARs are defined here as elongated extratropical features (> 2000 km) with high values of integrated water vapor (IWV > 20 kg m⁻²) and integrated horizontal water vapor transport (IVT > 250 kg m⁻¹ s⁻¹).

Climatologies of TMEs and ARs have been calculated for the Northern Hemisphere using the ERA-Interim data set (1979-2014). TMEs occur slightly less frequently than ARs and the two features temporarily and spatially overlap for less than half of the events. It is then investigated how often a TME and/or an AR co-occurs with the track of an extratropical cyclone. For this analysis cyclones are identified as two-dimensional features bounded by the outermost closed contour of the sea level pressure field, and “hits” are objectively identified as overlaps of cyclone areas and either ARs or TME trajectories. It is found that only a small portion (<10%) of extratropical cyclones, typically those with a relatively southerly track, are affected by moisture supply from TMEs. In contrast, extratropical cyclones occur more often in close contact with an AR, at least once along their track.

Particularly interesting is this linkage between ARs and TMEs for a special category of cyclones: DRWs whose dynamics is strongly driven by latent heating and therefore requires constant supply of low-level moisture and intense baroclinicity. Case study examples show how DRWs profit from the moist environment of ARs. The quantitative climatological examination reveals that the comparatively rare DRWs almost always occur in the vicinity of an AR, which however varies in intensity and shape during the DRW lifecycle. The linkage between DRWs and TMEs will be also quantified.