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Stratosphere-troposphere exchange (STE) in the vicinity of extra-tropical cyclones

Philipp Reutter (1), Bojan Skerlak (2), Michael Sprenger (2), and Heini Wernli (2)

(1) Johannes Gutenberg University, Institute for Atmospheric Physics, Mainz, Germany (preutter@uni-mainz.de), (2) ETH Zurich, Institute for Atmospheric and Climate Science, Switzerland

The exchange of air masses across the tropopause plays an important role for the chemical composition of the stratosphere and troposphere. For instance, the injection of stratospheric air into the troposphere can enhance the ozone concentration significantly in the troposphere, even down to the boundary layer. On the other side, the amount of water vapor can be strongly increased when tropospheric air is transported into the stratosphere.
Stratosphere-troposphere exchange (STE) occurs in different meteorological environments: e.g., near tropopause-level jet streams due to turbulent mixing, associated with the diabatic decay of upper-level cutoff lows, or in overshooting deep convective systems. In this study the importance of STE is quantified in the vicinity of extratropical cyclones, based upon climatologies of cyclones and STE. Previous studies estimated the effects of STE in the vicinity of cyclones through case studies of single cyclones and extrapolated the results to the global scale. The caveat of this method is the uncertain representativeness of a single cyclone.
Therefore, we use in this study 30 years of ERA-Interim data (1979-2011) to count all STE events in the vicinity of cyclones. A Lagrangian approach is used to identify STE events from the stratosphere to the troposphere and vice versa. The tropopause in this study is defined by the 2-pvu isosurface. A sophisticated cyclone identification and tracking tool determines the exact structure of a cyclone at each time step along its lifecycle. Therefore, an STE event can be clearly assigned to a specific cyclone.
With this data set we build a climatology of STE events in the vicinity of cyclones and investigate their spatial and temporal distribution on a global scale and also within a cyclone life cycle. This enables us to study if STE events happen in preferred areas of a cyclone and during preferred phases of its lifecycle. Additionally, the climatology allows to determine if the mass flux through the troposphere is higher when a cyclone is present compared to the geographical mean. Furthermore, we address the question whether the intensity of STE is related to the minimum pressure of a cyclone, i.e. whether intense cyclones are associated with particularly intense cross-tropopause mass fluxes.