EMS Annual Meeting Abstracts
Vol. 10, EMS2013-592-2, 2013
13th EMS / 11th ECAM

Where do the air masses between double tropopauses come from?

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Tropospheric and stratospheric intrusions make important contributions for the exchange of trace components between the stratosphere and the troposphere. Because of the impact that stratospheric intrusions may have in near surface air quality by increasing ozone concentration, and the impact that tropospheric intrusions may have in the transport of water vapour and pollutants into the stratosphere, it is very important to characterize these types of events. Recent works by Olsen et al. (2008), Pan et al. (2009) and Randel et al. (2007) document intrusions of upper troposphere tropical air into the lower stratosphere occurring with the formation of double tropopause structures. Randel et al. (2007) and Castanheira et al. (2012) showed that double tropopause events (DTs) are associated with a reduction of total column ozone. These results suggest that an important mechanism for the formation of double tropopauses (DTs) is the overlapping of the tropical and the extratropical tropopauses, accompanying the occurrence of tropospheric intrusions. However, a recent idealized study by Wang and Polvani (2011) suggested that the air masses that end up between double tropopauses come from higher latitudes.

In this communication we present a systematic study of back-trajectories of the air masses that end between DTs, using the Lagrangian Particle Dispersion Model FLEXPART V.8.2. We studied DT events in January, from 1980 to 2010, as identified in ERA-interim reanalysis. Back-trajectories were calculated for eight geographic locations. At five locations, the tropopause height for single tropopause events (STs) shows values typical of extratropics. At the other locations, ST events have tropopause heights typical of both extratropics and tropics, intermittently. We considered as tropospheric intrusions events where more than 60% of the particles ending up between the DTs are of tropospheric origin.

Results show that significant fractions of DTs, depending on geographic location, are associated with tropospheric intrusions. The fraction of DT events associated with tropospheric intrusions ranges from 9 to 34%. In accordance with this result, the mean latitudes of the back-trajectories associated with DT events are displaced equatorwards with respect to those associated with ST events. At locations where the height of the first tropopause alternates between extratropical and tropical values, the fraction of DTs events associated with tropospheric intrusions does not exceed 18%. Moreover, at those locations, the frequency of DT events is higher than 50% (53 to 64%) suggesting a quasi-stationary structure in the temperature profiles. At this point, our hypothesis is that such a semi-permanent structure is linked to the tropopause inversion layer. Therefore, we may conclude that different mechanisms may contribute to the occurrence of DTs. One of those mechanisms is the intrusion of upper troposphere tropical air into the lower extratropical stratosphere, a process that will be concomitant with a reduction of the total column ozone.

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