MULTIPLE TROPOPAUSE EVENTS: CLIMATOLOGICAL FEATURES AND ANALYSIS OF THE RELATIONSHIP OF THEIR OCCURRENCE WITH CUT-OFF LOW SYSTEMS

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Abstract

This study examines various climatological features related to multiple tropopause events (MT events). The analysis is based on the lapse rate definition of the tropopause and IGRA radiosonde data and builds on previous work describing global statistics of MT events, without reference to their seasonality or geographical distribution. Our results are in moderate qualitative agreement with earlier studies. They reinforce the findings of analysis made by other researchers, though at the same time highlighting important differences in both the number and position of the centres of maximum occurrence of these events. In our study, we found maximums of multiple tropopause occurrence in midlatitudes for both hemispheres, which are coincident with identified zones of maximum ciclogenesis. We also study the relationship between the occurrence of MT events and the development of cut-off low systems.

1. Data

For this work we used sounding meteorological data contained in IGRA (Durre et al. 2006) and the cut-off lows database from Wernli and Sprenger, similar to the used for Wernli and Sprenger (2007) but using ERA-40. The analysis is based upon a 180 stations subset. This is the same one previously used by Añel et al. (2007) after data homogeneization (Añel et al., 2008). The tropopause and MT were computed from individual sounding profiles corresponding to 00 and 12 UTC and using the usual thermal definition (WMO, 1957). To avoid false tropopauses which may be due to low altitude temperature inversions, those cases with first tropopause pressures greater than 500 hPa were removed. Studied period: 1965 - 2004.

2. Results

Figure 1 shows the percentage of seasonal mean of double (left) and triple tropopause (right) (hereafter DT and TT respectively) ocurrences for December-January-February with respect to the seasonal mean of the first lapse rate tropopause (LRT1). The shaded regions mark the zones where the results could be affected by the interpolation because of the lack of stations. The relative spatial distribution of MT events as described above shows a clear maximum located in the midlatitudes, near the subtropical jet stream region.

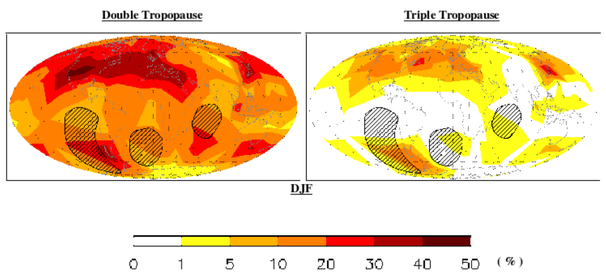

Figure 1: *percentage of seasonal mean of double (left) and triple tropopause (right) ocurrences for December-January-February (DJF) with respect to the seasonal mean of LRT1.*

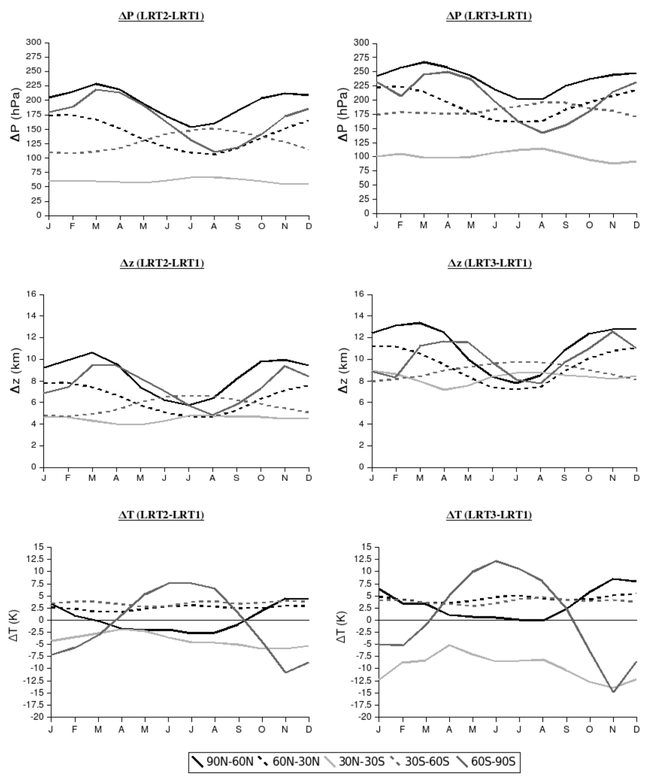

Figure 2: *Intra-annual variation of pressure, height and temperature differences between LRT1 and LRT2 for DT (left) and LRT1 and LRT3 for TT (right). Results are shown split by latitude bands.*

Other features of MT was also studied and they are exposed in Añel et al. (2008). One of them is the intra-annual variation of pressure, height and temperature differences between the last and the first lapse rate tropopause for MT, which is shown in Figure 2. The results were obtained by subtracting the values of the variables for LRT2 and LRT3 from those of LRT1 for the case of double and triple tropopauses, respectively. We call the resulting values for pressure ΔP_{12} and ΔP_{13} and use a similar convention for geopotential height and temperature.

The obtained pattern for MT is very close to the known distribution of cut-off low systems around the globe. Moreover cut-off lows are related with the occurrence of tropopause foldings so it seems clear that it could exist a relationship between our results and this kind of systems. In order to verify it, for each sounding in the studied period we checked the existence of cut-off lows (both stratospheric and tropospheric) in the nearest grid point 12, 24 and 36 hours before the launching of the sonde. Three regions were studied because of their percentages of MT: North America (20°N-60°N, 140°W-40°W), the Mediterranean region (30°N-50°N, 20°W-40°E) and East Asia (20°N-60°N; 120°E-160°E). Tables 1, 2 and 3 show the results obtained for 24 hours. The percentages obtained for 12 and 36 hours are slightly lower.

North America

	ST	DT	TT
Tropospheric Cut-Off Low	2.18	0.97	0.31
Stratospheric Cut-Off Low	9.82	3.88	1.15
Without Cut-Off Low	56.86	20.01	4.82

Table 1: *Percentages of cases with single, double and triple tropopauses respect to the total number of soundings for DJF and classification respect to COL systems. Studied region: North America.*

Mediterranean region

	ST	DT	TT
Tropospheric Cut-Off Low	6.74	2.96	0.98
Stratospheric Cut-Off Low	6.86	2.57	0.52
Without Cut-Off Low	53.13	21.07	5.04

Table 2: *Similar to Table 1 but for the Mediterranean region.*

East Asia

	ST	DT	TT
Tropospheric Cut-Off Low	3.02	0.59	0.14
Stratospheric Cut-Off Low	11.41	3.62	1.39
Without Cut-Off Low	60.27	14.37	4.80

Table 3: *Similar to Table 1 but for East Asia.*

As it can be observed the relationship between percentages is very erratic. While for the Mediterranean region there is not significant differences between the percentages correspondig to tropospheric and stratospheric COLs, in East Asia and North America they are clear. Moreover in this two regions the percentages of DT associated with stratospheric COLs is bigger than the percentage of ST associated with tropospheric COLs. However for all the cases the percentages corresponding to ST are between 65% and 75% and no more than an 8% of the MT is coincident with COLs.

3. TRODIM PROJECT

TRODIM is a collaborative project funded by the Ministry of Education and Science (Goverment of Spain) for the period 2008-2010. It is participated by 7 research centres from 3 countries. TRODIM has five subprojects with different goals:

- ALTRO: study of the interannual variability of the tropopause height.
- TROJET: study of tropopause foldings and jet stream systems.
- PT-DIN: permeability of tropopause.
- TROSAT: caracterization of the tropopause using models and satelite images.
- MATRIMOD: maps of tropopause to identify conceptual models.

LEARN MORE ABOUT TRODIM: http://ft2dc.uvigo.es/trodim

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