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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Morphology of the tropopause layer and lower stratosphere above a tropical cyclone: A case study on cyclone Davina (1999)" *by* F. Cairo et al.

Anonymous Referee #3

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Review of the paper Morphology of the tropopause layer and lower stratosphere above a tropical cyclone: a case study on cyclone Davina (1999)

General Comments

The paper presents observations collected with a high-altitude aircraft in a tropical cyclone which developed in 1999 over the Indian Ocean. The focus is on the tropopause structure change induced by the cyclone and the subsequent water vapour adjustment and tracer gas exchanges across the tropopause. This topic has been addressed by several authors using model results and observations (aircraft, radiosondes,). This is well reviewed in section 1 and 2 of this paper. The main objective of this paper

is to bring new insights into 3 questions: (1) downward transport of O3 into the TTL (2) upward transport of marine air into the TTL, (3) the cloud/water vapour interaction within the TTL. Since the questions are still relevant and since the M-55 high altitude aircraft allows measurement of thermodynamical and chemical measurements up to 20 km, this paper is very welcomed. Looking at the results this paper provides a very interesting discussion of question (3) (dehydration in the upper TTL by cirrus formation) but does not clearly address or bring new information for questions (1) and (2). In fact the second result of this paper is to discuss the potential effect of Davina to promote interaction between the tropical lower stratosphere and mid-latitude. This could be better listed in the initial objectives. So my main concern is that there are very often discussions of either well-known or not very well explained conclusions. For example discussions of the thermal structure is too long and should focus on the colder temperature in the upper TTL (link with dehydration) and cold temperature in the lower stratosphere (400-430 K), discussion of boundary layer air influencing the lower TTL is well known (unless a more quantitative analysis is performed on the mass exchange occurring), discussion of stratospheric intrusion not influencing the TTL is a distraction and too strong considering the limited observations (limited area, end of the cyclone life cycle). So the paper could be shortened and could be focused on the most interesting and new results: (1) dehydration induced by the cirrus forming above the cyclone (2) change in the chemical tracer and water distribution in the lower stratosphere 400-430K due to meridional transport from the mid-latitudes and link with Davina (3) comparison with the data prior and after the cyclone passage to discuss the actual impact on the thermodynamical data

Specific comments

Abstract (see above to highlight the main results)

Section 2 line 21 What is the uncertainty related to this method when trying to separate the level below and above the TTL bottom ? It is not clear what was the area studied, Indian Ocean only ? The full tropical region 15S-15N ? Does it make sense to consider

ACPD

7, S9047–S9050, 2008

the whole year rather than the cyclone season only ? The use of this 3.5 % figure is not clear to me, because it tends to say that the study of cyclones is marginal for the analysis of the water budget of the TTL. Please be more precise about the methodology and discuss the real meaning of the obtained value.

Section 4.2 It is not clear how far was the aircraft from the eye. Could you show the eye and northern edge position on Fig.2 ? The right panel of Fig. 1 is not very useful, Figure 3 could also be removed as the lidar information is not really used or discussed in addition to the backscatter sonde data.

Section 4.3 The discussion of the temperature profiles seems very long and we loose the main points. In fact discussion of the right side of figure 4 is enough to show the cooling in the upper Davina TTL, the warming and lesser thermal stability in the Davina TTL and the cooling in the stratosphere. Contrary to what is stated page 18334 line 27, I do not see a clear change in the altitude of the cold point which remains close to the 17 km (so where the right panel of figure 1 is splitted).

Section 4.3 Although the ozone profile correspond quite well to what is expected (i.e. lower values in the lower Davina TTL reaching the upper TTL value near 375 K), the tropospheric tracer profiles show tropospheric values 10 K higher suggesting that longer lived tropospheric tracer reach the lower stratosphere up to 385 K while boundary layer with low ozone remains in the TTL (meridional advection of tropospheric air near 380 K ?). This could be discussed in the paper in addition to the stratosphere perturbation above 400 K.

Section 4.3 Comparison with non cyclone data is quite useful, but new questions arise when considering non-Davina profile southward of 13°S. Nothing is said about the large difference of the data taken before the Davina passage. The temperature and ozone values are higher and the TTL structure is quite different. Does this mean that before the passage of Davina the region has neither tropical nor mid-latitude characteristics but is intermediate, while Davina makes it more tropical ?

ACPD

7, S9047–S9050, 2008

Section 5 The introduction sentence for this paragraph is odd as it does not correspond to the main observations. The fact that there is not evidence of downward transport of stratospheric air in TTL region above the area studied by the Geophysica does not mean that this process does not happen especially in the southern periphery of Indian ocean cyclone where there is an interaction with mid-latitude troughs.

Section 5.1. To me, it is the most interesting one. The combined analysis of temperature, water and aerosol depolarization is quite convincing. Another area of cirrus clouds was sampled at 7-8°S, did the authors looked at similar mechanisms of dehydration occurring in this area ? Was this observed only for the Davina flight ?

Section 5.1 It is difficult to check in Fig. 6 if the 11 of March profile (2 days after Davina) has similar water distribution in the upper TTL. Is the dehydration still visible and if not why ?

Section 5.2. Again this section is quite convincing when discussing the mid-latitude properties of the air mass seen between 400-430 K. The interaction of the cyclone with the intensity of the meridonal circulation and the efficiency of the subtropical barrier could be a useful addition using for example maps of the potential vorticity.

Minor comments:

P 18333 line 25 use 13°S instead of -13°N

Fig 8 and 11 Not easy to distinguish between the 6 of March and 11 of March data

Figure 3, left panel of figure 4, figure 5 are not very useful and could be omitted if the paper needs to be shortened.

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7, S9047–S9050, 2008

Interactive Comment