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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Commentary on using equivalent latitude in the upper troposphere and lower stratosphere" *by* L. L. Pan et al.

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We appreciate and welcome the comments. These open discussions are what we had hoped for in submitting this commentary to ACP. To clarify the conclusion, we stress whether and when EqLat-θ is a right set of coordinates depends on the specific questions in hand (page 33098, L9-13). In the summary section, we presented specific concerns over the use of EqLat - θ as coordinates for chemical tracer averaging. We do not intend an overall general conclusion that "equivalent latitude or theta coordinates are inappropriate in this particular region".

Response to the major comments:

The reviewer's major comment is that the fragmented air mass, resulted from wave

breaking in the example from Figs 10-12, should be averaged according to its chemical and thermal dynamical property and, in this case, still be considered tropospheric. The reviewer refers to the contrast of using Eqlat as a tracer or a coordinate variable as "thermodynamic or geometric" view. The criticism is that the paper had the two views mixed.

From the authors' perspective, the two views, given in Figures 10-12, are intentionally contrasted. In the case of this example, we agree that the fragmented air mass is still largely tropospheric and there are two possible ways to do averaging. When we said the blob of tropospheric air is "wrongly" classified, it is from the view of including the transport in the resulting zonal mean. If transport is not part of the research interest, a choice can be made to average the chemical field based on the dynamical consistency. We plan to revise the wording to be clearer and be specific on what we mean by "right" or "wrong".

To further motivate this point, we will relate our discussion to a body of research work that uses the PV field to characterize Rossby wave breaking in the context of stratosphere troposphere exchange (STE). There are a large number of papers on the topic. A few good representatives are Postel and Hitchman (1999), Wernli and Sprenger (2007), and Sprenger et al. (2007). The results of these works largely represent our knowledge of preferred locations of STE. Sprenger et al. (2007), in particular, did a detailed analysis of the relationship between PV streamers, cutoffs and trajectory based STE analyses. The result shows that the PV structures (cutoffs and streamers) do have a significant connection with the trajectory calculation based preferred STE location. If we average the chemical tracers based on their PV or EqLat, the STE events related to these PV structures will be all concealed. If we accept that the preferred STE locations based on these PV structure analyses are meaningful ones, the method we use to perform zonal averages of chemical species should account for these events, which are the consequence of these structures. The choice of coordinates, therefore, should be made based on the purpose of averaging. We will include these discussions in the

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revision.

Response to Additional Comments:

The first two comments regarding page 33098 are largely along the same line of the major comments, whether PV should be used as a tracer of transport or signature of reversibility, and whether the air mass displaced by wave breaking is necessarily irreversible. Our response, again, is that the correct method depends on the purpose of the study. If we value the physical processes revealed by the PV structure near the tropopause, it is important to realize that using PV/EqLat as a coordinate to average the air mass will conceal these processes. We will add to the discussions to clarify this point.

For the rest of the additional comments, we hope to emphasize that the perspective of the paper is to bring out potential issues of using EqLat-θ coordinate to aggregate data from the surface to lower stratosphere, aircraft data in particular. There has been a strong voice in the community which advocates for making research aircraft data climatologies using EqLat-θ coordinates. We are giving examples to show what the unintended consequences might be there and why this set of coordinates may not be desirable for certain types of applications. It is within this context we point out that, in Figs 8 and 9, the CO structure associated with negative EqLat is likely connected to the convection, and while EqLat is dynamically more consistent in the LS, it may not represent the chemical structure well in the UT. The reviewer's criticism of "not needing special advice" for these conditions is taking the discussion out of context. The context is not about using EqLat to study convection or representing the troposphere, but about representing the entire range covered by many research aircraft data, which includes the troposphere.

Response to comments on p.33103, l.6-11, RE the asymmetry of the theta coordinate: We do not oppose research works using theta coordinates for pertinent problems. Fig. 5, however, is important for reminding us that the theta coordinate compresses the tro-

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posphere and is not optimal for compiling trace gas climatology if tropospheric chemistry processes are important. The reviewer's comment about this point is taking our discussion out of context.

Response to comments for P33105L15: The references cited there are for a possible mechanism to explain the features shown in Fig. 7. There is no implication that these were studies of intra-stratosphere transport. We will seek to clarify this point in revision.

For the comment on Fig. 8 (adding cross-sections along 120 W to show Ozone-EqLat correlation), we think the point that the ozone field is well correlated with EqLat near the tropopause is well made in Fig. 9.

In terms of Fig. 9, the multiple levels given there are to create a complete picture of tracer-EqLat versus tracer-Lat relationship from mid-stratosphere (600 K, Fig. 4), to right above the tropopause (330 K) and right below the tropopause (290 K). To have all three levels shown is pedagogical and completes the thought process started in Fig. 4. We will make the connection between the two figures more clearly in the revision.

References:

Postel, G. A., and M. H. Hitchman, 1999: A climatology of Rossby wave breaking along the subtropical tropopause. J. Atmos. Sci., 56, 359–373.

Wernli, Heini, Michael Sprenger, 2007: Identification and ERA-15 Climatology of Potential Vorticity Streamers and Cutoffs near the Extratropical Tropopause. J. Atmos. Sci., 64, 1569–1586.

Sprenger, Michael, Heini Wernli, Michel Bourqui, 2007: Stratosphere–Troposphere Exchange and Its Relation to Potential Vorticity Streamers and Cutoffs near the Extratropical Tropopause. J. Atmos. Sci., 64, 1587–1602.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 33095, 2011.