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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.

Anonymous Referee #2

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Review of Pan et al.:

The current paper regards itself as a commentary on the use of equivalent latitude. It provides various examples showing tracers in the geographical as well as equivalent latitude frame work. The utility of PV (Eq. Lat) to remap tracer distributions (CO) is investigated with focus on the tropopause region. In this frame case studies are presented illustrating the relation between PV, potential temperature gradient and equivalent latitude. Comprehensive plots of vertical as well as horizontal cross sections are shown and compared with tracers (CO and ozone) from the WACCM model. For the tropopause region it is concluded that equivalent latitude or theta coordinates are inappropriate in this particular region.

The paper wants to present a 'cautionary note' on the use of adiabatic coordinate

systems and their relation to tracers. Though one could argue about the general sense of such papers without a scientific finding, at least the cautionary note itself should be clear and correct. Unfortunately I see a lot of room for improvements here, since some of the conclusions drawn from the examples result from the fact, that geometrical and (thermo-) dynamic view points are mixed in this paper. The geometrical view is overemphasized and the two view points are not clearly separated, which leads to wrong or incomplete conclusions.

I think this manuscript has the potential to illustrate the strengths and weaknesses of thermodynamic coordinates, but in the current stage it misses this chance.

At least the different view points (geographical versus thermodynamical) need to be clearly separated. This is in particular evident when discussing the last three figures, which I therefore start to comment on below. In the current form I think the paper is not suited to be published in ACP and the points below need to be addressed:

Major comments: Figs. 10-12 show this: Figure 10 shows a low-PV (eq.lat) anomaly entirely surrounded by stratospheric high PV air. From a thermodynamical point of view this blob of air has a more tropospheric signature, which is corroborated by the ozone distribution, which is significantly lower, than its surrounding: O3-tracer and PV (eq.lat.) therefore give the corresponding information. It is stated, that this blob of air is irreversibly transferred into the stratosphere. This might be correct or not, the point is, that both, tracer and the thermodynamic quantity PV indicate, that the air has not yet mixed and still carries its tropospheric signature within the stratosphere. From a thermodynamical and tracer view this is a tropospheric air mass (but located in the stratosphere).

Fig. 11 shows the relation of ozone to latitude and equivalent latitude relative to the dynamical tropopause, respectively. The geographical (latitude) view shows tropospheric ozone in the stratosphere (like the map), the thermodynamic view shows the thermodynamical view of the air parcel shifting ozone back to the tropospheric side. Conse-

quently the same is illustrated in Fig.12 as vertical cross section.

The authors then state (33108, l.3-6) that "...The large scatter of blue points on the positive side of the O3-relative latitude relationship, however, highlights the fact that significant transport of low ozone air mass from troposphere to stratosphere are wrongly classified back to their transport origin if EqLat is used..."

No, they are not wrongly classified, they are still tropospheric in their thermodynamical (and tracer) nature. This is opposed to geographical mapping, which shows, that this tropospheric blob is in the stratosphere. As such equivalent latitude is able to assign the air masses to their thermo dynamical origin as long as this has not yet been irreversibly mixed with the background. The blob as a hole might stay in the stratosphere and therefore irreversibly transported, but the air is still tropospheric from a thermodynamical AND a tracer point of view (I.e. a point measurement within the blob not knowing about your surrounding would indicate tropospheric air, (Homeyer, 2011)). As long as PV has not adopted to stratospheric background, the air parcel has still the potential to return to its original reservoir and is in that sense (!) reversible. At the time of observation we don't know about the future development of the 'blob'.

Additional comments:

There are many additional examples that in the given manuscript itself the different views - mainly the geographical coordinate view and the (thermo-)dynamical viewpoints are not clearly separated in the discussion. Of course one can combine both systems (and indeed should do this): The example below maps thermodynamics to geographical coordinates and thermodynamical coordinates, respectively, but discusses both in the geographical view:

e.g.p.33098, l.20: : "...On the one hand, we identify stratospheric contribution to the troposphere using high PV as a signature..." =Thermodynamical quantity in geographical coordinates "...On the other hand, we use PV-based EqLat to aggregate trace gas species, which in effect removes the contribution of exchanged air mass from the tro-

pospheric average because of their high PV signature..." =Thermodynamical quantity in thermodynamical coordinates"

and then (l.27): "...The example raises a general question that how well EqLat climatologically separates reversible (wave) from the presence of irreversible (wave breaking) transport...". Well - the answer is given in Figs 10-12: It shows it very well: At the time of observation still some air is from a thermodynamical point not mixed and looks tropospheric, but is situated geographically in a stratospheric environment. As such it can't be decided, if the transport at that point in time is reversible or not.

p.33103, l.6-11 With regard to the asymmetry of Theta and z-coordinates "...The relevance of this information to UTLS studies is that often times when potential temperature is used as the vertical coordinate, a layer of 20-30 K above the tropopause is contrasted to a layer of 20–30 K below the tropopause. We want to point out here that, in the geophysical space, the former is a narrow layer 10 of 1–2 km while the latter is often the entire troposphere. The asymmetry makes it less meaningful to compare the STE influence in these two layers..."

Again, the asymmetry argument is based on a purely geographical view: Of course the geometrical altitude extent corresponding to Theta = 30 K in the stratosphere covers a different altitude range than in the troposphere. Using isentropic coordinates the focus is clearly on the stratosphere or (in the case of relative theta coordinates) on the diabatic processes, which which violate adiabatic conservation laws and therefore identify the zones of irreversible transport since this has to be related to diabatic processes in the very end. Therefore it clearly makes sense to investigate STE in thermodynamic coordinates. Thermodynamics determines the exchange not geometry. Following the asymmetry argument above it would not make sense to use pressure (relative) coordinates - the discussion makes no sense to me and I would remove Fig. 5 as well as the discussion.

p.33105,l.15 "...The displacements introduced here by the behavior, however, would

create misrepresentation of transport..." I don't think that any of the cited studies uses equivalent latitude as an indicator of intra stratospheric transport, where long transport time scales exist, allowing PV being diabatically modified on long time scales.

Fig. 8 : Please use or add the same cross section of tracers as in Figs 5./6. Note, how well the ozone field at 330 K and 120 W resembles locally the equivalent latitude cross section in Fig. 6.

p.33105/33106: An analysis of a convective tropospheric CO plume on the basis of equivalent latitude would be rejected by any reviewer, I don't understand that statement here, that's trivial. p. 33106 l.15.: Figure 9 is nice, but do we need a special advice, that PV is not a tropospheric coordinate? Given the Theta = 330K profile in Figure 9 it shows exactly, how equivalent latitude should and can be used: To (thermo-)dynamically separate stratospheric and tropospheric data.

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