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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The water vapour distribution in the Arctic lowermost stratosphere during LAUTLOS campaign and related transport processes including stratosphere-troposphere exchange" *by* A. Karpechko et al.

A. Karpechko et al.

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We thank the Reviewer 2 for the comments. Our answers are given below.

General comments

The comments of the Reviewer on the relative role of turbulence and radiation for stratosphere-troposphere exchange are very valuable. We must accept that our arguments, which we used to neglect possible PV changes due to radiation at the flanks of the anticyclones, are not correct. The text will be modified accordingly.

However, the CTFs near the jet stream, in particularly along the flanks of anticyclones,

are related to our water vapour measurements. Indeed, trajectory calculations suggest that air from the layer of high water vapour, which we observed on 17 February, was already in the stratosphere before the streamer developed. This was mentioned in the manuscript. The streamer did not play any role in transport of water vapour from the troposphere to the stratosphere at the 330K isentropic level which is of interest here. The role of the streamer in this case was transport of air with high water vapour away from the region of strong PV gradients deeper into the stratosphere. Being close to the tropopause a particle can easily cross it back and forth while being transported deeper into the stratosphere by streamer it is more likely to contribute into the irreversible exchange. Therefore, the whole process we are dealing with is a two-step process: first, transport through the tropopause by either turbulence or radiation and, second, transport deeper into the stratosphere by streamer. This point will be more clearly expressed in the revised version. CTFs associated with the streamer itself also take place as we have shown in the manuscript but as long as our observations are concerned they are of secondary importance.

'Do they claim that the turbulence is causing the streamers?'

No. Streamers are caused by breaking of Rossby waves, not by turbulence.

'My suggestion for improving the paper is to actually try to understand which processes are contributing to the evolution of the streamer they are observing, and how much. The remarkable result of figure 4 is that the model is potentially good enough to answer this question. I don't think that CAT or diabatic processes are generating the streamers from the edge of the anticyclone (and neither do the authors, I think). So, I would suggest actually writing the equation for the evolution of PV along a trajectory (in the region of the streamer at some appropriate time) and evaluating the terms (which are mixing of PV into the surroundings by turbulence and diffusion and change in PV by the vertical gradient of diabatic heating).'

Though the suggestions of the Reviewer for improving the paper look very interesting

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we see that implementing them is a demanding task and can easily provide material for a separate paper. Therefore, we reserve them for the future work.

'A less ambitious tack would be to relate the CAT index and change in PV to the streamer of interest at various times.'

It was mentioned in the manuscript that CAT index is relatively weak along the borders of the streamer. However, we are not sure that this excludes turbulence since there could be regions with turbulence on scales less than the resolution of model. More detailed discussion of CAT index along the trajectories will be included in the revised version.

Specific comments

'Abstract: What is the difference between clear air turbulence and 'developed' clear air turbulence?'

No differences. 'Developed' will be taken away from the text in order to avoid misunderstanding.

'Page 4729, line 28 What is LAPBIAT?'

LAPBIAT is the Lapland Atmosphere-Biosphere Facility (LAPBIAT). The campaign acronym (LAUTLOS-WAVVAP) is from the Lapland Atmosphere-Biosphere Facility (LAPBIAT) Upper Tropospheric Lower Stratospheric Water Vapour Validation Project (LAUTLOS-WAVVAP). It will be mentioned in the revised version.

'Page 4736, line 18: Why not show the sounding being discussed?'

There are several breaks in data in this particular flight caused by telemetry problems. Data from this flight is included into statistics of Figs. 1-2 but we would not like to demonstrate this profile separately.

'Page 4739, line 29: '..northeast of the Greenland SEA??' or northeast of Greenland?'

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Here, it is probably more correct to say 'over the Greenland Sea'.

'Page 4739: Specifically it is vertical gradients of diabatic heating that produce changes in PV. It would be useful to go into a little more detail on how diabatic heating changes the PV. I am not certain that it leads only to upward (troposphere to stratosphere) transfer. If the authors choose to make so many assertions about the role of turbulence, we need a sharper discussion of how turbulence changes the PV along a trajectory (it mixes it). This has been a contentious issue in the past, with much controversy about Shapiro's turbulence generating PV mechanism (referred to in Traub and Lelieveld).'

Thanks for this comment. The text will be modified and unjustified statements will be excluded.

'Page 4742, line 21: 'Indeed, there is observational evidence ...' I think it is interesting that both the downward flux and the CAT index have large, correlated variations in Figure 7. The upward flux has much less variation (though it is also correlated, albeit less strongly, with the CAT index). This is intriguing, suggesting (but by no means proving) that CAT drives the downward transport (negative CTF), while the upward CTF is due to some other mechanism.'

Indeed, it looks that the CAT index correlates better with the downward flux than with the upward flux though it is not clear why. This point will be more clearly stated in the revised version.

'With some exceptions (like Figure 6e,f over Greenland), the downward and upward fluxes are right next to each other in long strings. Is some of this due to error in the trajectory approach to CTF (as suggested on page 4741 and line 9 regarding inconsistency in the analyses)? Might it not make sense to smooth the results and come up with a hopefully more believable 'net' flux?'

We do not think that inconsistencies in the analyses can lead to the string-like structures in fluxes. Similar structures appear in the fluxes calculated from forecasted fields.

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Therefore, these structures deserve some credibility. Since the net flux is downward, smoothing the fluxes can shift picture toward downward transport and even result in purely downward transport. Since we are studying upward water vapour transport, this is not desirable here.

There are also several grammar corrections suggested by the Reviewer, which we greatly acknowledge.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 4727, 2006.