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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A multi-model analysis of vertical ozone profiles" *by* J. E. Jonson et al.

Anonymous Referee #2

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General

The presented article "A multi-model analysis of vertical ozone profiles" presents results from the comprehensive model inter-comparison experiment on northern hemispheric tropospheric O_3 as conducted within the framework of the Convention on Long-range Transboundary Air Pollution (LRTAP) and its Task Force on Hemispheric Transport of Air Pollution (TF HTAP). While the focus on previous publications was on surface level ozone, the present article investigates the vertical tropospheric distribution of ozone and distinguishes between contributions from different source regions. The results are presented in three major sections: a) comparison of simulations with O_3 sondes for the full period of the model exercise (2001) at 4 (6) selected sonde stations, b) analysis of 4 events of inter-continental transport at 4 selected sonde stations, c) climatological discussion of inter-continental transport for the year 2001 at

the 4 selected sites.

Major comments

It was not clear to me what the main intention of the article is. Should the focus be on model validation or on the analysis of inter-continental transport of O_3 in the free troposphere? It do not think that either of these issues is adequately covered:

1) For a model validation using sonde data it would be more beneficial to not only take 4 sites into account, but all sonde sites for which model vertical profiles were available (32 according to the authors). This would give a more complete picture of the model performance and might also allow a more detailed analysis of the model shortcomings especially with respect to their limited vertical resolution and possible difficulties to represent stratospheric influence. The authors attempt a difficult task when comparing the sonde measurements (which are point measurements in space AND time) with daily model grid averages. Therefore, they should include as many data as possible and not rely on a rather sparse data base (as stated by the authors themselves P26105, L18-19). It is mentioned in the manuscript that free tropospheric measurements are representative for larger areas than surface measurements. While this certainly improves the comparability with model simulations, comparisons at 4 sites are certainly not sufficient to represent the whole northern hemisphere. The selection of the 4 presented sites was based on their position on the western side of the receptor continent. However, as frequently mentioned in the manuscript, transport in the free troposphere is rather fast and sites at more continental locations might still show clear signals from an up-wind continent. There are several other sonde sites in Europe (for example Hohenpeissenberg and Payerne) that have a very good data coverage and that should therefore be considered in the comparison/validation. Drawn from the current results, the conclusions summarized in the abstract (P26097, L12-22)

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are much to general. In summary I would encourage the authors to extend the model validation as presented in Sec 4.1 to all 32 sounding sites for which model profiles are available. Actually, Taylor plots for two additional sites are already presented in the manuscript, thus I assume these comparisons are readily available for the other sites as well. Similar time series plots as Fig. 2 - Fig 5 could be provided for all sites in the supplement. Summarizing model statistics for all 32 sites might be presented in additional Taylor plots.

2) The discussion of free tropospheric inter-continental transport is again limited to the 4 selected sonde locations. It seems to be of more general interest to also discuss the horizontal distribution of free tropospheric inter-continental transport. So instead of the presented Fig. 12 to 15 I suggest to include an analysis for the 4 receptor/source regions. The influence at the selected sites would still be covered by Fig. 2 - Fig. 5 and within the discussion of the transport events.

3) The selection of long-range transport events is rather questionable since for two of the four examples there is no sonde data available. The interesting question here is how do the observations and model simulations relate to each other in these events. Is it possible to detect long-range transport events of ozone in the sondes? Can the models reproduce such events? And if so how does the source/receptor relationship look in the Lagrangian tracer model. I don't think that the current examples really demonstrate the models ability to reproduce ozone transport events and I would suggest to replace at least the two events where sonde data is missing by other examples.

4) The seasonal comparison for winter is using data for Jan and Feb only. The authors also mention that due to the model spin-up the models might have some difficulties in early Jan. So why not include Dec in the seasonal analysis and skip the first half of Jan?

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5) Structure of the manuscript: Reading the current version of the manuscript I had the impression that certain statements are repeated over and over again. For example there is a statement that transport in the free troposphere is faster and less affected by loss processes in almost every section. Other examples follow below. I suggest condensing part of the introduction, results and discussion to avoid too much redundancy.

Minor comments

P26102: L4-6 and L16-18 give an uncertainty statement for the ozone sondes. Please condense and avoid repetition.

P260104: From L11: Large parts of this have been said in the introduction already. Please shorten.

P26106-26109: There are no paragraph breaks in this whole section. It's therefore rather hard to read and follow the line of discussion. I would insert new paragraphs at: P26107, L6, L12, L21; P 26108, L1; P26109, L6.

P26108, L18-L21: I guess with "inaccuracies stemming from the interpolation" the authors also refer to the coarse grid resolution, which already numerically makes it difficult to transport sharp gradients as found in plumes.

P26109, L6: Why do models not capture the low ozone content in the tropics? Problems with deep convection?

P26109-P26113: Instead of presenting each site in a sub-section (4.2, 4.3, etc) I suggest to use sub-sub-sections (4.2.1 Goose Bay, 4.2.2 Uccle ...) to better distinguish the discussion of the events from the rest of the results.

P26109-P26113 and Fig. 8 - Fig. 11: The figures are much too small. It is almost impossible to identify the details described in the text. Therefore, some of my following

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comments might simply be caused by not being able to see enough details. Furthermore, I was wondering why only results from the EMEP model are presented and not ensemble averages. From some of the profiles it seemed to me as if the EMEP model is not always the best fit to the observations (e.g. Fig 9 above 600 hPa). Instead of ensemble means you might want to show the results for the best fitting model. In which case cases with observational data should be chosen (see above). Each of the Figures e and d are also missing a symbol indicating the sonde location. Finally, I think it would be more appropriate to use the FLEXPART results in a more quantitative way by calculating tracer concentrations as caused by the typical source fluxes in the specific source regions (for example CO emissions multiplied by FLEXPART emission sensitivity).

P26110, L13-15: I actually see the opposite: No influence on the daily maximum but strong influence on the tropospheric column. But as mentioned above, it is difficult to identify the location of Goose Bay on those plots.

P26111-26112: Why not show the FLEXPART footprint for the level with largest influence from EA. The influence at the surface seems to be smallest considering Fig.10b.

Fig.10b: Use different x-axis scale so that differences in the models can be seen. Mention different axis scale as in comparison to Fig 9b. This also applies to Fig.11b.

P26113: From the footprint I don't see the European influence. The presented sensitivities are orders of magnitude smaller for central Europe where emission sources are large. Using the footprints in combination with emissions would allow for a more quantitative assessment in this case.

Technical corrections

P26105, L22: DetailS about ...

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P26105, L23: What is NCL?

P26106, L14: spread in the model results IS caused ...

P26106, L16: ... regions increaseS.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 26095, 2009.

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Interactive Comment