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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A multi-model assessment of pollution transport to the Arctic" *by* et al.

et al.

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We thank both reviewers for their detailed and constructive comments on our paper. We have revised the paper attempting to take into account all the comments raised by both reviewers. We apologize for the delay due to the time required to perform the requested additional analysis and comparisons with observations, to update the prescribed lifetime tracer results, and to allow the many co-authors time to look over the revisions.

Major points:

We appreciate the insight of the reviewer into the results of the Stohl (2006) Lagrangian modeling and the suggestion to compare the transport pathways identified in that study with the results from the HTAP models. The latter are Eulerian models,

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and hence it is not straightforward to examine transport pathways. The reviewer suggested that we examine the standard deviation of the relative contribution of emissions from the various source regions across the model, which we have now done. Rather than average over particular boxes, we have calculated the full spatial patterns for various seasons and levels. The most informative of these, summer and winter surface BC, have been added to the paper along with a discussion (section 4).

As suggested, we have added a description of the transport pathways identified in Stohl 2006 to the introduction. We have also revised the section discussing the comparison between Stohl (2006) and Koch and Hansen (2005) in section 4. We find that indeed the results of the HTAP models are largely consistent with those of Koch and Hansen (2005), and that the relative contribution of Asian emissions versus European emissions to surface BC in the Arctic is substantially higher than that seen in the modeling of Stohl (2006). The transport pathways in the Eulerian models are not obvious, and while some substantial differences across models seem to be present, the standard deviations suggest that the pathways are largely similar in the models with primary uncertainties in how much reaches the Arctic related to how long BC remains in the atmosphere (and hence can be transported to the Arctic). We hypothesize that the difference between these models and the study of Stohl (2006) is instead most likely due to the Langrangian setup of the latter, which could lead to substantial differences in diffusion, or to the lack of removal processes in that study.

Given the contrast between the Stohl (2006) and Koch and Hansen (2005) results, we felt that it would help put the HTAP models into context if a BC simulation with the GISS model were added. We were able to complete simulations including BC at GISS for the HTAP project, using the same GISS GCM as in Koch and Hansen (2005) that was already included in the paper for CO, ozone and sulfate. Dorothy Koch helped on this (and wrote the BC/OC model in the first place), so she has been added as a co-author. The GISS model turns out to have greater transport of BC to the Arctic than any of the other HTAP models. Comparisons with observations are better than for other HTAP

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models, but still relatively poor, especially at Alert. Results throughout the paper have been updated to include this model, but the multi-model mean results typically change little with the addition of a single model.

We wish to point out that there is an issue of process categorization that is important. The influence of transport is not fully separable from that of physical processes such as wet deposition. As the reviewer points out in a useful example: If the Asian airmasses take a different transport pattern to enter the Arctic and do not undergo a strong uplift, that will affect the humid convection and then the microphysics and the wet removal involved in it. So while we can look at the variation across models in the tracers with prescribed lifetimes and emissions to get an idea of how dry transport varies across models, for realistic tracers whose lifetimes vary with location transport and physical processes are inherently coupled. So when we conclude that for aerosols, chemical and physical processing plays a larger role in model-to-model variations than dry transport, this is subject to the definition of physical processing which inherently includes some effects of transport. We have made this point more explicit in section 3.2 (discussion at end of second paragraph), and also in the discussion section of the paper (third paragraph of section 4).

Minor points:

P8388, l 19: We have added a citation to Stohl 2006 as suggested.

P8389, l 15: We agree, and have added text stating that Russian anthropogenic sources are small rather than all Russian sources.

P8390, l13: We now state the rationale for choosing 2001 meteorology, as suggested.

P8391, l11: The lowest model layer is different between the models, depending on their vertical resolution and layer spacing. We have calculated the global mean pressure for this layer, and added this to the text (last paragraph of section 2) to give some idea of how different the lowest layer heights are and we note that this will contribute, though

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modestly, to intermodel variations at the surface.

P8392, l 9: Revised as suggested.

P8392, l 11: Stohl 2006 cited, as suggested.

P8392, l 14: This point is now addressed in the expanded discussion of differences between HTAP/Koch and Hansen (2005) and Stohl (2006) in section 4.

P8395, l 3: Added citation to Law and Stohl (2007).

P8403, l 24 and 28: SA written out.

Table 1: The references to the models are difficult to add concisely as for most of these models different publications discuss the chemistry, aerosol and climate models, all of which are relevant here. We note here that a summary of most of the models included here is included in: A multi-model source-receptor study of the hemispheric transport and deposition of oxidised nitrogen, M. Sanderson et al., submitted to GRL. We have added a statement to the caption that horizontal resolution is in degrees.

Figure 7: We have made the grey lines darker in this figure. Note that how they look when printed often depends on the printer.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 8385, 2008.