

## ***Interactive comment on “Impact of Intercontinental Pollution Transport on North American Ozone Air Pollution: An HTAP Phase II Multi-model Study” by Min Huang et al.***

**Anonymous Referee #3**

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### General Comments

This manuscript presents the first HTAP Phase II findings, expanding on HTAP Phase I by incorporating regional models to estimate the impact of international anthropogenic emissions on U.S. surface ozone. The authors use boundary conditions from three different global models to drive the regional STEM model, and compare the sensitivities of surface ozone in North America to international anthropogenic emissions with those determined from 8 global models. They further compare with an adjoint version of one model, use boundary conditions from a model that assimilated satellite ozone products, and conduct a case study using multiple satellite and ground-based products. This is a major undertaking, as noted by another reviewer. I agree with the other reviewers,

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however, that the paper suffers from some shortcomings. Several of the issues I was planning to cover were discussed at length in the earlier reviews, so I focus below on additional points.

I'd like to see the abstract/conclusions clarify and quantify (e.g., within 10%, 30%, factors of 2?) the conclusions regarding how different the global and regional model estimates are, and how much the RER sensitivity estimates have changed from those reported in the 2010 HTAP report. I agree with Dr. Tonnesen that more emphasis on episodic events would enhance the policy relevance of this work.

Throughout the text, more quantitative and specific language should be used wherever possible, and the paper should be edited carefully for clarity (e.g., incomplete sentence L768). The introduction is quite long and could state earlier on what the point of this study is to provide a context before going into all the details of past work.

Specific Comments L42-45. Elaborate on what this means for drawing conclusions regarding the role of hemispheric transport of air pollution.

L48 'Tagged tracer approach' is mentioned here and elsewhere (e.g. L564); a brief explanation is needed as approaches can involve tagging ozone itself or tagging precursors. I'm not convinced that this study cleanly isolated the role of rising East Asian anthropogenic emissions; see also RC2 comments.

L51 Are the adjoint sensitivities compared to all the global models or just the forward version of GEOS-Chem? Is this the same version as used to provide boundary conditions? (see also L591)

L54-56 Try to quantify this statement: is it off by 20%? Factor of 2?

L57-59 This appears to be a general statement rather than a conclusion drawn from this work and thus does not seem appropriate to include in the abstract.

L96 The first paper to show this was Jacob et al., GRL, 1999: <http://onlinelibrary.wiley.com/doi/10.1029/1999GL900450/abstract>

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L148. Region-dependent, but also time-dependent?

L220-227 Seems relevant to provide BVOC emissions over Asia and North America. How much do North American anthropogenic emissions contribute to global totals?

L233 References could be included in Table 1

L238 Why are boxes shown in Figure 1 if the regions are actually following the political boundaries as indicated in L258?

L276. Given that Lin et al. 2012 estimated Asian ozone pollution transport to the western U.S. using a global model about this resolution, a case needs to be made for why it's appropriate to use a regional model (e.g., allows testing of multiple boundary conditions, and regulatory applications would presumably run at finer scales).

L283. This may be true for the Asian pollution transport, but Lin et al. 2015 indicate that 2010 isn't a particularly high year for stratospheric intrusions reaching surface air over the WUS. <http://www.nature.com/articles/ncomms8105> See their figure 2.

L287-88 Is this just reflecting the warming trend over the 81-00 period? Temperatures and ozone production were even higher in 2011 and 2012 in the eastern US.

L315 How was this downscaling done?

L442 perhaps needs a reference for the HTAP1 work unless this was done as part of this study?

L445-447. It's not clear what the take-away point is here. Are the models underestimating Asian pollution influence or can we not tell because it could be regional transport? Presumably even though the data assimilation fixes this problem, it does not help us to distinguish between these possible sources of error?

L472. How did this study determine that the bias is likely due to overestimated anthropogenic NO<sub>x</sub> emissions? May doesn't look like it has a clear bias whereas July does. How do we know this is associated with anthropogenic sources rather than season-

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ally varying sources like soil NO<sub>x</sub> for example? Are there seasonal variations in the anthropogenic NO<sub>x</sub> emissions?

L481-483. Doesn't this interpretation depend on where the photochemical regime is at in terms of ozone production with respect to NO<sub>x</sub> emissions?

L520 An estimate of how large these biases are and how much bias they introduce into ozone would be useful here.

L541-544. There seems to be model disagreement near the Canadian border, with Oslo for example suggesting high cross-border influence but CHASER suggesting much less.

L544-547. Is Oslo also higher resolution as it looks similar to EMEP in terms of higher influence.

L585-588 Where is this shown?

L612-616. Can you provide estimates of how the ozone lifetimes in the boundary layer differ in the different simulations?

L627-628. There seems to be an assumption that LRT is obvious from satellite data. This isn't the case for ozone. How will LRT be convincingly separated out from other ozone sources?

L658-659. Did all models capture the same events in terms of their timing and approximate regional location?

L661. It would be more convincing to show this as a monthly mean diurnal cycle rather than rely on Figure 2a.

L679-681. I didn't follow this point.

L741-742. Be more specific here.

L744-747. Is there a relationship between the bias and the Asian transport events?

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L747-749. It's not clear how better quantifying stratospheric o3 intrusion helps reduce North American pollution levels and model uncertainties. This statement also implies that stratospheric intrusions are as important as local ozone formation.

L750. How frequent are these episodic sensitivities to East Asian emissions? Are they occurring when measured ozone is highest?

L800-801. These suggestions seem to neglect the important caveat that these approaches assume that model transport is perfect.

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