Response to Anonymous Referee #1 on "The effect of model spatial resolution on Secondary Organic Aerosol predictions: a case study at Whistler, BC, Canada" *by* C. D. Wainwright et al.

Suggestions

1) **Comment**: Regarding the role of lifetime, I wondered if the authors considered looking at the different SOA types (i.e monoterpene-SOA vs isoprene-SOA) as a supporting argument for this? There is a range of lifetime for the different SOA species and one might expect that the differences in this lifetime effect due to resolution would differ as a result. It might be worth investigating.

Response: In the real atmosphere, there may be a significant difference in the lifetimes of SOG and SOA generated from different precursors. However in the model, the factors controlling the lifetime of SOA and SOG dry and wet deposition. In terms of the SOA from different precursor gases (monoterpenes, isoprene and anthropogenics), the removal rates will be the same for each of these (all mixed together in the same aerosol). Regarding SOG from the different precursors, all are assumed to have the same Henry's law constants (whether this is realistic is a separate issue), so their removal rates should be close. It is likely whatever differences there are between species are not large enough to be considered as major contributing factors to variances in lifetime.

2) **Comment**: The impact of resolution on SOA model predictions could be very relevant to interpretation of previous studies. However, these previous studies represent a range of models and environments, and not all may be impacted. For example, the study of Volkamer et al., 2006 (referenced at the end of Section 3.1 and 4) uses a box model and is not subject to resolution errors. The focus here is on the surface measurements (and thus you can certainly point out the implications for any previous surface 3d model-obs comparions), but one question that is raised in my mind is whether this is a relevant issue for aircraft campaigns? One could imagine that simulations aloft could be more (plumes) or less (well mixed) affected by resolution. It would be very interesting to include a version of Fig 6 for the free troposphere (say 5km) and a discussion of these issues.

Response: The results of the simulations were investigated at 5km. The table below shows the ratio of SOA between resolutions for summer and winter. This table has been included in the paper.

SOA change	Summer	Summer	Winter	Winter
	4x5 to 0.5x0.667	2x2.5 to 0.5x0.667	4x5 to 0.5x0.667	2x2.5 to 0.5x0.667
5km	1.51	1.00	1.19	1.05

Surface	1.32	1.19	1.23	1.08

Here is the accompanying discussion that we have added to the paper:

"An additional analysis was done at in the free troposphere at 5 km above the surface. Table 2 shows the ratio of SOA between model resolutions for the summer and winter simulations at 5 km compared to the surface increases. There was a 51% increase between the 4ºx5º and 0.5ºx0.667º for the summer at 5 km (compared to 32% for the surface concentrations). The 2ºx2.5º and 0.5º x0.667º comparisons yielded no increase at 5 km (compared to 19% at the surface). The winter 5 km comparisons were quite similar to the surface with a 19% change between the 4ºx5º and 0.5ºx0.667º (compared to 23% at the surface) and a 5% change between the 2ºx2.5º and 0.5ºx0.667º (compared to 8% at the surface).

Most interesting in the 5 km comparison is that during the summer there is no fractional change in SOA between the 2ºx2.5º and 0.5ºx0.667º, whereas there is a large change between 4ºx5º and 0.5ºx0.667º. This may be due to horizontal concentration gradients at 5 km may be resolved in the model at both the 2ºx2.5º resolution (~200 km spatial scale), but horizontal concentration gradients require higher spatial resolutions at the surface. However, at the 4ºx5º resolution (~400 km) scale, these gradients may not be resolved at either altitude. This is somewhat consistent with work done in Weignum et al. (2012), which uses a measurement based process to estimate carbonaceous aerosol plume sizes in the free troposphere at a median of 113km across (with ranges from 85-155km). 2ºx2.5º-resolution simulations are somewhat close to being able to resolve these plumes. The model is incapable however of resolving plumes of the size mentioned above at the 4ºx5º scale due to spatial limitations."

Minor Corrections/Comments:

1) **Comment**: "Page 16027, line 25-26: I'd suggest a re-phrasing here. It's not clear that the major uncertainty wrt to SOA is purely biogenic. The message of Spracklen et al., 2011 is that there is an important missing source of "anthropogenically-controlled SOA"(with biogenic). So the sentence written is a little misleading.

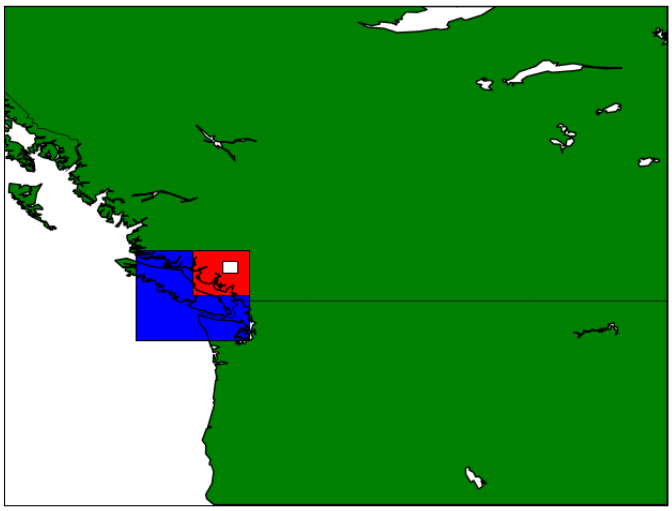
Response: Wording changed to "Spracklen et al., 2011 showed that there are significant uncertainties associated with modeling boundary layer organic aerosol concentrations. Biogenic SOA is a major contributor to boundary layer SOA and is thus important to understand for modeling purposes."

2) **Comment**: Page 16029, line 8: grammar and repetitive use of "during". Suggest: "measurement done during the Whistler Aerosol and Cloud Study (WACS 2010) in July 2010".

Response: Suggestion put in place - second “during” changed to “in”.

3) **Comment**: Figure 1: the boxes around Whistler are hard to see, especially the 0.5x0.67 box. Perhaps you could show a zoom of the region as an inset on the figure?

Response: The figure has been replaced with a zoomed in version which allows a clearer view of all box sizes in addition to keeping the relevant scale of the boxes to the North American coast comparable. This figure can be seen below.



4) **Comment**: Page 16031, line 4: reference for MEGAN2.1 is not Guenther et al., 2006. The best reference here would be for the implementation of MEGAN 2.1 in GEOS-Chem: Barkley et al., 2011.

Response: Reference updated.

5) **Comment**: Page 16031 line 16, page 16032 line 10 and line 18. The authors should avoid citing webpages (not peer-reviewed or permanent record). There should be literature references for these model development/issues.

Response: The webpages with citations available have been updated. Please note the boundary layer fix does not yet have a citation so it has remained unchanged.

6) **Comment**: Page 16033, line 7: suggest inserting text to clarify: "Figure 3a shows the high resolution simulated aerosol".

Response: Text inserted as suggested.

7) **Comment**: Page 16033, lines 12-19: I don't disagree with the author's point that the mixing depth is not likely to be a major factor, but I think the language is a little strong here. This is a VERY qualitative comparison of mixing depth and the figure would suggest that the mixing depth is in fact a little deeper in the model than shown with the lidar obs (i.e consistently ~1.5km in the model and 1+ in the obs). Would be good to acknowledge that, but as stated in the text, that this isn't likely to be a significant error.

Response: Wording changed to "Overall the simulation predicts a boundary layer height similar to the measured data. The model predicts a typical mixing height of ~1.5km, while the observations show a relatively constant mixing height between 1-2km. This comparison gives us some confidence in the ability of the model to handle vertical mixing of aerosols in the region even though upslope and downslope flows along the mountain may be difficult for the model to capture."

8) **Comment**: Page 16034, lines 16-17: what about the role of topography in the region as well as ocean margins? I didn't see any discussion of the challenges associated with mountain flow and meteorological conditions at Whistler.

Response: Added text: "In addition, the topography surrounding the Whistler mountain valley makes it extremely difficult for any low-resolution model to resolve properly. Upslope/downslope mountain winds cannot be resolved properly even by our highest resolution simulations (0.5^{o}x0.667^{o})."

9) **Comment**: Page 16035, line 3: remove "below" (you don't know if in final copy-editing the figure will appear above or below this text.)

Response: Text Removed.

10) **Comment**: Page 16037, lines 10-18: It's not quite clear here what factor leads to a drop in continental monoterpene and isoprene emissions at higher resolution. Could you clarify?

Response: A drop in continental monoterpene and isoprene emissions with increasing resolution could be related to the Leaf Area Index (LAI). In MEGAN, the emissions are determined by product number of factors, one being the LAI. The emissions factor for LAI is sub-linear (negative 2nd derivative) with LAI. This means that increasing the variability in LAI (which would be done if switching to a higher resolution) would result in a lower emissions factor for LAI. Thus, it is possible to get a drop in VOC emissions across NA with increasing resolution.

Added text "Most significantly, within the model parameters, as variability in Leaf Area Index (LAI) increases, emissions decrease. Thus, as we get larger variability with increasing resolution, we see a drop in emissions across NA".