Atmos. Chem. Phys. Discuss., 10, C14234–C14240, 2011
www.atmos-chem-phys-discuss.net/10/C14234/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Satellite observations of aerosol transport from East Asia to the Arctic: three case studies" *by* M. Di Pierro et al.

M. Di Pierro et al.

dipierro@atmos.washington.edu

Received and published: 1 March 2011

The authors describe three aerosol transport events from East Asia to the Arctic in 2007. CALIOP aerosol layers are compared with the GEOS-Chem model in the context of regional meteorological conditions. This manuscript provides a nice description of these events and the transport phenomena, however the larger context is somewhat absent. The transport of aerosols from mid-latitudes to the Arctic is well-known– these basic model/CALIOP comparisons do not further our understanding of this process. If the authors could re-frame these results to generalize aerosol transport to the Arctic from Asia (i.e. how frequent? at what altitudes? how important compared to climatological aerosol loading from local sources?), this study would be more compelling. Some additional comments are included below.

We do agree that transport from mid-latitudes to the Arctic, especially from Europe and N. America, is well known. However, transport from Asia to the Arctic remains poorly understood, with very few observations available to constrain this pathway. Our manuscript demonstrates the value of CALIOP in documenting this transport pathway to the Arctic and in providing constraints to check the performance of models in this region. We acknowledge that our original manuscript would have benefited from more general discussion of transport from Asia to the Arctic. We have followed this reviewer's suggestion by adding such discussion in the revised manuscript. We focus on the contribution of Asian aerosols to total AOD, as well as on the frequency and altitude of these transport events.

Major Comments:

1. Figures 1, 5 and 8: The left-hand panels are very difficult to read. Even zoomed in with the online pdf version, I had difficultly discerning back trajectories from political boundaries (both in black). The CALIOP orbits are almost impossible to see. The size of these figures needs to be increased considerably, and/or the authors might consider only showing 4 panels for each.

The number of panels has been reduced from 5 to 4 in order to increase the size of the panels. Figures have also been re-centered so that the back-trajectories are easier to see.

2. I am somewhat concerned that v2 of the CALIOP retrievals were used for this study. This data was labeled as "provisional" and did not include the suite of QA flags available in the v3 products, which can be used to filter observations as per the recommendations of the CALIOP team. While it may be impractical to repeat the entire analysis with the new data products at this time, I suggest that you do so for one event (and examine the uncertainties in the v3 retrieval). You can thus comment in the text about the robustness of your results to the use of an early data product.

Following this reviewer's suggestion, we have repeated our analysis for the first

case study with the v3.01 data product to examine how this affects our results based on v2.01 retrievals. We find that the aerosol/cloud classification is the same for both versions, except for 2 out of the 23 CALIOP cross sections where v3.01 classifies the features as mostly clouds, while v2.01 classifies then as aerosols. The average aerosol optical depth for the remaining 21 cross sections are 15% lower in v3.01 compared to version 2.01, which gives us confidence about the robustness of our results. The following discussion was added to the text:

"Our results, obtained with version 2.01 of the CALIOP retrieval, do not change much when compared with the more recent version, 3.01. With v3.01, mean plume AOD is 0.030 (compared to 0.037 for v2.01), with mean IVDR 0.029 (0.03 for v2.01) and Color Ratio 0.24 (0.26 for v2.01). We find that the aerosol/cloud classification is the same for both versions, except for 2 out of the 23 CALIOP cross sections, where v3.01 classifies the features as mostly clouds, while v2.01 classifies then as aerosols. "

3. GEOS-Chem reproduces the plume placement observed with CALIOP remarkably well. However in all cases, it does not seem to reproduce the intensity of the observed plumes in Fig 2a, 2b, 7, 10, particularly in the later two cases. It would be preferable to compare these at the same spatial resolution (ie. grid the CALIOP observations to the GEOS-Chem grid) to properly compare these features. Similarly, it was not clear if the total AOD comparisons were made over just the extent of the observed plume (i.e. GEOS-Chem sampled only for where aerosol extinction > 0 was reported with CALIOP) or throughout the model feature/column, compensating for plume diffusion in the model. I suspect the later, given the good agreement between the magnitude of AOD, if so it should be made clear that these are not exact comparisons.

To address this issue we have re-gridded the CALIOP observation to the horizontal and vertical resolution of GEOS-Chem. This leads to a slight improvement in the agreement between model and observations, however in most cases the

model cannot reproduce the intensity of the observed plumes (Figures 4 and 5 in revised manuscript). The total AOD comparison was conducted throughout the feature/column, which does compensate for plume diffusion in the model. This indeed is not an exact comparison. These points have been clarified in the revised manuscript.

4. The text indicates that all three events are associated with precipitation during transport according to the backtrajectories. You showed GEOS-5 precipitation maps, but do not comment on whether these reproduce the regions of precipitation in the backtrajectories. What fraction of aerosols were scavenged in the model as a result?

We have verified that the GEOS-5 and backtrajectories precipitation do compare very well in terms of the timing and location of precipitation. This has now been clarified in the text: *"Both the trajectories and GEOS-5 meteorological fields indicate that precipitation was associated with this lifting between February 25 and February 27 south of 65°N."*

The fraction of aerosols scavenged in the model is address in point 8 below.

5. Why is NCEP-NCAR re-analysis shown to describe the meteorological conditions rather than the GEOS-5 product used in GEOS-Chem?

We used the NCEP-NCAR re-analysis for convenience. However, we did verify that GEOS-5 and NCEP-NCAR geopotential heights and sea level pressure fields are virtually identical in the extra-tropics.

6. The importance of accounting for the CALIOP sensitivity threshold is discussed in 3.1.3 and Figure 2b, but it is unclear if this threshold is therefore applied to all model extinction values in what follows. Please clarify this in the text.

The extinction threshold is applied in case 1 (Table 1) and 3 (Table S1). We have not applied the threshold in case 2, when the misclassification occurs, because we used the CALIOP backscatter instead of extinction.

7. Can you comment on how the CALIOP lidar ratio employed matches with the simulated aerosol types for these events?

We extracted the mean lidar ratio (LR) used in the CALIOP algorithm for all 3 cases, finding 45 sr for the first case study, 42 sr for the second case study and 49 sr for the third case study. The comparison to GEOS-Chem is not straightforward, as these CALIOP LR are based on a cluster-based observational approach (defining representative aerosol clusters) as opposed to a synthetic approach (based on the definition of individual aerosol types, sulfate, sea salt, etc...) as described in Winker et al. (2009). To calculate the GEOS-Chem LR, we need to use the synthetic approach, assuming the following LR for individual species: 70 sr for sulfate, BC, and organic carbon; 40 sr for dust; and 20 sr for sea salt (see section 3.4.2). Based on the GEOS-Chem aerosol composition for these plumes, we find a mean LR of 64 sr for the first two case studies and 66 for the third case study. The GEOS-Chem derived LR are thus 35-50 % higher than CALIOP's. The CALIOP aerosol classification algorithm classifies most of the aerosols poleward of 70N as either "clean continental" (corresponding to a LR of 35) or "polluted continental" (LR of 65). As 75 % of the aerosol layers in our case studies are classified as "clean continental" this leads to relatively low LR. Our model-calculated synthetic LR correspond more closely to the "polluted continental" aerosol type.

8. The discussion of scavenging efficiency on page 25407 is quite interesting. Could you say more about this in your analysis of each event?

For each case study we have added a short discussion of the scavenging efficiency in the model.

Minor comments: 1. Page 25390, line 14: grammar: replace "at daytime" with "during daytime"

Corrected

2. Section 2.1: It would be useful to include some information on the aerosol optical properties used in GEOS-Chem.

This has been clarified in the following:

"The assumed dry aerosol mass extinction efficiencies are: 2.2 m2/g for sulfate, 8 m2/g for black carbon, 2.8 m2/g for organic carbon, 2.4 m2/g and 0.9 m2/g for accumulation and coarse mode sea salt, respectively, and 3.1-0.16 m2/g for dust depending on the size bin. We take into account aerosol growth as a function of the local relative humidity."

3. Page 25395, line 14: how can the vertical range extend to negative values (-0.5 to 20.2 km)?

We replaced -0.5 with 'the surface'.

4. Figure 2a 7: why are multiple overpasses during the same day shown here when the transport events extend over several days with many CALIOP intercepts? i.e. why not match Fig2a to Fig1?

In the revised manuscript, we have improved the match between these figures.

5. Figure 3 is discussed in the text prior to the discussion of Figure 2b - these should be re-ordered.

Done.

6. Page 25406, line 27: these AOD values in the plumes are quite small (i.e. 0.022, and 0.038). Are they significantly different from background or climatological conditions?

These AOD values are obtained by integration along the vertical boundaries of the plume, with a thickness of 1-2 km (what we refer to in the text as 'plume AOD'). The average modeled plume AOD (0.022), is indeed small and is slightly above the corresponding autumn 2-5 km background AOD (0.017). Initially the modeled plume AOD is 2-3 times higher than background, but after 5-7 days of

transport the values decrease to below background values.

7. Page 25407, line 7: you indicate precipitation occurs primarily in the "initial phase" but in your description of the 3rd event you indicated that "precipitation occurred during most of the transport" (page 25406, line 13). Correct inconsistency of phrasing.

We have corrected the inconsistency as following:

"Transport was rapid (3-4 days to reach the Arctic) and precipitation took place in the initial phase of the export near the source region in the two springtime cases and during most of transport, although weakly, in the autumn case."

8. Page 25409, discussion of Figure 11: similar to my point above about the earlier figures, it is very difficult to distinguish the two poles of action on the figure. I had to zoom into the pdf figure.

We have used filled circles to make them more clearly visible in the revised figure.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 25389, 2010.