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Atmospheric Chemistry and Physics Discussions

Interactive comment on "NASA A-Train and Terra observations of the 2010 Russian wildfires" *by* J. C. Witte et al.

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We would like to thank the reviewer for the helpful comments and suggestions. The response to each comment is below. The reviewers comments are repeated in quotes.

" p. 19117, line 14: As you mention, heavy clouds may prevent MODIS from detecting ïňĄres. What about thick smoke plumes? The Russian ïňĄres produced huge amounts of smoke, which probably diminished the number and the intensity of the detected ïňĄres. "

Response: It is certainly true that in addition to clouds, optically thick smoke will obscure MODIS views of the fire activity. We modified the statement to include optically thick smoke.

" p. 19117, line 24: You should also mention the accuracy of the AOT retrieval. "

We added: Levy et al. (2010) compared AOD.55 values with AERONET data from over 300 sites and found a high correlation (R = 0.9) within an expected error envelope of $\pm$(0.05 + 15%).

" p. 19117, line 24: AOT55 $\rightarrow$ AOT.55. "

We made the correction. Thank you.

" p. 19118, line 6: You could add the wavelength information to the SSA term, just like you did with AOT. "

I believe the wavelength information has already been mentioned: "The OMAERUV Collection 3 algorithm uses the top-of-atmosphere radiances at 354 and 388 nm (near-UV region) to derive AI and AOT and SSA (at 388 nm)."

" p. 19118, line 14: Here you should mention that AI depends on the amount of absorption but also on the altitude of the aerosol layer. "

This is true. We updated the following statement in Section 2.2 that addresses main uncertainties in the AI measurement: Two important sources of uncertainty in OMI AI and SSA are sub-pixel cloud contamination due to the large OMI footprint and the dependence on the assumed aerosol layer height (Torres et al., 2007). The effect of sub-pixel cloud contamination is the overestimation of SSA (measure less absorption than actual). OMI AI is less affected by clouds, except that it does not provide a quantitative estimate of aerosol absorption.

" p. 19118, line 26: What is the accuracy of the total column CO? "

We added the following statement: CO_TC has an estimated uncertainty for an individual measurement of 7–8% with standard deviations between $\pm$2 and $\pm$6% (Yurganov et al., 2002).

" p. 19119, line 17/Figure 2: Why did you choose this speciïňĄc domain (33E-53E, 52N- 62N) for the AIRS OLR data? Is it due to the radiosonde locations? This should be clariïňAed in the text. "

Indeed, we wanted to encompass the radiosonde locations, with a focus on western Russia. This region is also quite large, similar that in Figure 4.

We modified the Figure 2 caption to say the following: This domain is shown in Fig. 1c and encompasses all the radiosonde stations in western Russia.

We also added this clarification to the beginning of the second paragraph in Section 3: We calculate the time series of AIRS OLR anomalies (2010 daily values minus the 2003–2009 daily mean) over the box region shown in Fig. 1c. that encompasses the radiosonde locations and includes regions where MODIS observed elevated fire activity.

" p. 19120, line 3/Figure 4: Figure 4d shows that during the episode domains 2,3,6,7 and 10 have clearly lower SSA values. However, in Figure 4c the domains 2,3,6,7 have increased AI values during the episode while domain 10 seems pretty much constant. Do you have an explanation for the difference between the SSA and AI data? It is evident from Figure 4e that domain 10 has signiïňAcantly lower AOT values than the other domains which could explain the difference but could there also be some differences on the altitude of the smoke plumes in these domains? "

As you have mentioned in an earlier comment, the altitude of the aerosol layer is of critical importance to determining OMI AI. For smoke aerosol type, the algorithm assumes an aerosol vertical proïňAle with Gaussian distribution and maximum concentration (peak) at 3 km (Torres et al., 2007). We looked at plume heights using MISR data on-board Terra. This is a good 'first-look' diagnostic tool to determine best-guess estimates of plume heights close to the source (i.e. fire pixels). Where data were available (alas, only three days in August and mostly confined to domains 6 and 7, the lower SSA values we find in the MISR data are consistent with what we see in Figure 4d. Retrieved SSA assumes black carbon and organics are the dominant components in

the smoke aerosol model. This is consistent with Angstrom exponents within the MISR smoke plumes found to be between .8 and 1.2.

From these limited set of MISR observations we observed that smoke plume heights varied from 500m to 3km near the source. This suggests that the height of aerosols assumed by the OMI standard algorithm may miss the actual peak for those smoke plumes below 3km and may explain the underestimation in AI observed in domain 10. SSA is also affected by plume height estimates, although we see a good correlation with aerosol type between MISR and OMI for these cases. Although MISR observations were limited to domains 6 and 7, we can use these results to look at probably causes of discrepancies, such as the reviewer had noticed in domain 10.

" p. 19124, line 1/Figure 6: The selected region in this study seems like the worst-case scenario for 2010 and it made me wonder what would happen to the differences between the years if the region had been selected differently. What do you think, would the difference between 2010 and the other years be as clear if you had selected, for example, the domain 6 from Figure 4 for this analysis? "

There is certain arbitrary aspect to dividing up our domains, although put together we can more easily map the spatial extent of the effect of the fires, as well as the temporal range. Essentially, we used the 2010 data to tell us where the worst of the fires were located and for how long. Thus, we do indeed take the worst-case set of observations against which we calculate the burdens and anomalies relative to the historic data records.

We have added the following explanation of our choice of region and domain division to the first paragraph in Section 5.1 where we first introduce Fig. 4: Our region of interest was chosen based on a preliminary analysis of the location of all the MODIS fires counts during August 2010, when the count and FRP reached a maximum, and the geographic extent of the three-day back trajectories from Fig. 3. Dividing this large region into smaller domains (12 in total) facilitates mapping the spatial extent of the observations affected by the wildfires, their magnitude, as well as the temporal range. In this study, we are taking the worst-case set of observations against which we calculate the contribution of smoke pollution from the wildfires, relative to the historic satellite data records.

For the reviewer's curiosity, on a per year basis, we did a quick calculation of the mean values similar to Table 1 just for Domain 6 and found the following results:

Domain 6

Year, Fire Count, FRP(x10ˆ4), AI, AOT, CO_TC

2010, 8680, 19.0, 1.06, 1.00, 27.49

2009, 1582, 7.7, 0.37, 0.21, 18.35

2008, 2545, 1.1, 0.37, 0.21, 19.06

2007, 2068, 9.0, 0.35, 0.20, 19.85

2006, 906, 3.2, 0.39, 0.22, 21.10

2005, 1635, 5.5, 0.34, 0.16, 19.52

2004, 833, 2.3, N/A, 0.17, 20.26

2003, 92, 0.2, N/A, 0.15, 21.74

2002, 44, 0.1, N/A, 0.22, N/A

These numbers show 2010 is exceptionally high in the data record, further attesting to the severity of the 2010 wildfire event.

" p.19124, line 23: You could mention in the text that in this study the domain is 1x1 degrees. "

We added this statement in the second sentence of Section 5.3 where Figure 7 is first mentioned.

" Figure 6: FNR → FRP "

We made the correction. Thank you.

" Figure 7: The AOT and CO data suggest that the most polluted days in Moscow were between 1 August and 18 August. OMI AI data, on the other hand, has elevated values also on 31 July while the SSA data has clearly lower values from 26 July onward. Can you explain why OMI measurements at the end of July indicate increased absorption by aerosols even though AOT and CO values are still moderate? "

Indeed, at the end of July OMI AI and SSA are high, whereas AOT and CO are not. Unlike CO, AOT or SSA, AI is a qualitative parameter that detects the presence of UV absorbing aerosols, thus it should not be used as a quantitative measure of the absorption. Recall in Figure 6 that the fires ramp up at the end of July. It is likely that OMI AI and SSA are sensitive to the smoke at the height of the plumes. As you mentioned earlier AI is sensitive to the altitude of the aerosol layer. The winds during the last two days in July are coming from the southeast over regions of high fire count and FRP. During the August 1-10 period anti-cyclonic pattern and stagnant conditions are reflected in the elevated levels of AOT and CO. With three different instruments of various footprints, sensitivities, and retrieval limitations; it is quite amazing that we get such a high level of agreement and coherence in time and space.

We have added this observation by the reviewer to the Section 5.3 (2nd paragraph): OMI SSA shows enhanced absorption from 26 July onward and OMI AI increases significantly on 31 July (no data available on 30 July), whereas COTC and AOT.55 show only modest increases. From Fig. 6 we observed that the fires ramp up at the end of July. It is likely that during this time OMI AI and SSA are detecting the peak in the smoke aerosol layer at heights assumed by the OMI algorithm. For smoke aerosol type, the OMI algorithm assumes an aerosol vertical proïňĄle with a Gaussian distribution and maximum concentrations (peak) at 3 km (Torres et al., 2007). The winds during the last few days in July originated from the southeast, over regions of high fire count and FRP.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 19113, 2011.