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Atmospheric Measurement Techniques Discussions

Interactive comment on "Assessing remote polarimetric measurements sensitivities to aerosol emissions using the GEOS-Chem adjoint model" *by* B. S. Meland et al.

Anonymous Referee #1

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General comments This paper investigates the value of remote sensing observations of aerosols by finding the measurement sensitivity to emission perturbations using the GEOS-Chem adjoint model. The concept of coupling remote sensing instrument configuration to aerosol models is tremendously valuable, as most assessments of remote sensing instrument designs are not directly connected with models. Unfortunately, the potential scientific significance of this work is diminished because the choice of instrument configuration, which does not correspond with any existing or planned polarimetric remote sensing instrument. Also, some important aspects of aerosol remote sensing are addressed vaguely, minimally, or not at all. This includes the omission of

the spectral sensitivity of the assessed instrument designs, or the impact of variable surface reflectance on the retrieval. Finally, I found the presentation of the results, particularly the normalized values in figures 4 and 6-9, obscure, rather than clarify the results.

To reiterate, I think this is a potentially important paper, but with implementation flaws. I realize that repeating the entire analysis may not be feasible, but a serious attempt must be made to address the significance of some of the choices that were made in this work, and to present the results more clearly.

Specific comments

1. There are several ways that the simulated polarimetric instruments are not representative of current or planned instruments. In most of these cases the difference between simulated and current/planned instruments is that the latter is sensitive to more information. In this sense, your hypothesis that polarimetric instrumentation is more sensitive to aerosols despite spatial coverage losses still would hold. But I wonder if the differences are so great as to raise more questions than they address. The impact of these differences must be addressed. Some of the differences between simulated and current/planned instruments are:

a. The use of only a single view angle. Except for SGLI, all current and planned polarimetric instruments make multi-angle observations. There is significant information contained in multi-angle observations, which is partially why those designs accept the loss of spatial coverage compared to single view intensity-only observations. The implication of this work is that useful aerosol observations can be made with a single viewing angle, a radical proposition that must be discussed.

b. The use of polarimetry alone, rather than polarimetric + intensity measurements. While this distinction is mentioned several times, why not use both, since that is what real instruments would do? An example of the ambiguity this creates is in the assessment of black carbon. There is no reason to rely on the speculative nature of the

statement “If the sensitivities of the simulated polarimetric and intensity based measurements are combined, the differences in the measuring capabilities of the two simulated satellites would be enhanced.” It would be far better if an actual comparison were to be performed.

2. Some important aspects of the simulation are vaguely defined, and this must be corrected. If an outcome of this work is to guide the design of future instruments, than this must be resolved. Some of the vague elements for me are:

a. Lack of information about simulated instrument spectral characteristics. This is a big omission – I assume the simulated instruments have severable channels at visible wavelengths, but this must be explicitly stated. If only a single channel is used, this is again a major difference with existing instruments (and would be another item to add to #1, above).

b. Lack of information about radiometric and polarimetric accuracy. How do sensitivities compare with these accuracies? This is especially important for polarimetrically sensitive observations, since different designs have different polarimetric accuracies – there is an order of magnitude difference between POLDER and APS.

c. Lack of information about what polarimetric information is used. At several points in the paper the use of the full Stokes vector is mentioned. At other points polarized reflectance is mentioned. What, exactly is being compared? Polarimetric instruments devoted to aerosol and cloud remote sensing do not, in fact, observe the full Stokes vector. Instead, they measure the first three elements of the vector (I,Q,U), meaning they are sensitive to linear, but not circular, polarization. If this work assumes sensitivity to circular polarization this must be modified to be sensitive to linear polarization only. In any case, this issue must be clarified.

3. It is not entirely clear to me the role that retrieval of non-aerosol parameters play in an analysis such as this. I am especially concerned about the surface reflectance. If I understand correctly, the surface reflectance was chosen from the 646nm channel, and

presumably held spectrally invariant (assuming more than one channel is used in the analysis, which is difficult for me to determine). Spectrally invariant surface reflectance would be highly unphysical. No information is given for the source of polarized reflectance, which must be corrected. In an actual aerosol retrieval, surface reflectance must be retrieved along with the aerosol parameters, or at least constrained with external information. The behavior of polarized and intensity surface reflectance is quite different – typically over land polarized reflectance is spectrally grey, while intensity reflectance has strong spectral dependence. This has a significant impact on the retrieval ability of both types of sensors, since less information about the surface is needed for polarimetric measurements. Unfortunately, these details are omitted from this paper, and this must be corrected.

4. This work is actually a comparison for spherical aerosols over land only - this needs to be made clear in the abstract, and introduction.

5. I am having difficulty fully understanding how differences in spatial sampling are addressed. I understand that fewer data points are assessed with the polarimetric vs radiometric sampling schemes – but it seems like a step is missing to see if the sensitivity is statistically significant. Yes, there are fewer data points for the polarimetric analysis, but what is the implication of this? Rather than maps, wouldn’t the best way of assessing sensitivity be to do hypothesis tests for the entire dataset?

6. I’m also concerned that the sampling does not seem to consider the very significant role of clouds in the ability to retrieve aerosol properties. Depending on spatial resolution, roughly three quarters of pixels will be ‘contaminated’ with clouds, meaning that no aerosol properties can be retrieved. Was this taken into account?

7. Figure 1 is mentioned nowhere in the text. It should be discussed.

8. With regards to Fig. 4: What, exactly, is being plotted here? I understand that you are normalizing sensitivity, but why? What is the meaning of vastly different values on different plots?

9. Figures 6-9: Why are these sensitivities normalized? I should be able to glance at these figures, and compare them, to understand the relative sensitivities of different measurement techniques. But since the sensitivities have been normalized, that ability has been taken away – and I'm not sure what I should learn from these plots. I'm also confused why the absolute value of the sensitivity is not used. In figure 7, for example, it is clear that BCPI has a 'negative' sensitivity, compared to 'positivie' for SO4, NH4 and OCPI – but sign is meaningless if the point is to understand if a sensor has sensitivity to a particular species. In this figure, three of the four panels have been scaled 'for clarity', but for me that renders any difference between them invisible. Figures 6-9 need to be redone, using the absolute value of the sensitivity, and a uniform normalization so that actual differences between sensor types and aerosol species can be assessed.

10. Perhaps I missed it, but I am confused on the spatial extent of the analysis in figures 6-10. Are the emissions only in North America? Why are values only presented for North America and parts of Asia?

11. Figure 10 is perhaps more useful, since it is a direct comparison of polarimetric vs radiometric sensitivities. I would like to see the use of a different colorbar that makes explicit which sensitivity is higher – say shades of green for >1 and shades of red for <1 (or some other clear distinction).

12. Section 4.4 notes that the results are functions of 'aerosol microphysical properties, wavelength, and viewing geometry', which is true (although it is also sensitive to aerosol loading and surface reflectance). But then the only the first – aerosol microphysical properties – is addressed. Wavelength, viewing geometry, aerosol loading and surface reflectance must also be assessed.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 5447, 2013.