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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieving aerosol in a cloudy environment: aerosol availability as a function of spatial and temporal resolution" *by* L. A. Remer et al.

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We won't hide our amazement at the level of detail of this reviewer's comments and the pages of suggestions that he/she made the time to write. Thank you! These suggestions and the reviewer's perspective are very much appreciated. In responding to the reviewer's comments we are going to paraphrase her/his points and write those between ***.

***General comments. "[the study]. . . seems to lack some depth and clarity concerning the aerosol availability from a GOES-like geostationary satellite. Both parts should be

better balanced." ***

"The reader seems to be left with unanswered questions: 1) Does geostationary satellites like GOES resolve the diurnal signal? 2) Compared to polar orbiting satellite sensors, does enhanced temporal resolution offset coarser spatial resolution for geostationary sensors? [the conclusion] seems to rely , at the most, on one day of GOES data. . .. can't, therefore, be said in a general sense. 3) Which one between MODIS or GOES-R cloud mask should be used for sufficient aerosol retrieval availability? There seems to be no demonstration, reference or either discussion in this study that shows that one cloud mask is more appropriate than the other in terms of aerosol retrieval."

Response to general comment: These comments are similar to one of Reviewer #2's main points, and together caused us to refine the presentation of the GOES-R results in the paper. It is true that there is only one day of data analyzed for GOES-R and 12 weeks of data for MODIS, causing an imbalance. We regret this, but cannot do anything about it. The GOES data used to demonstrate the GOES-R cloud mask was a special high temporal resolution data set and the demonstration made for only this one day. The analysis cannot be expanded to include more days. This is now stated in the revised paper in Section 6.0. We have added an entire paragraph.

Unfortunately only one day of data is available. GOES data are generally archived at coarser temporal resolution (15 minutes), making this specific day of data unique. Because there is only one day of data, it is difficult to place the results of the GOES analysis on the same par as the seasonal analysis applied to the MODIS data. Still, the GOES analysis provides a glimpse into what might be expected from a geosynchronous satellite in terms of aerosol retrieval availability and the differences in availability between a cloud mask designed for an aerosol retrieval (MODIS) and one designed for cloud retrievals (GOES-R).

We hope this paragraph clearly states the limitations of the data set and the reason for including it in the analysis despite the limitations. In addition we have downplayed the

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role of the GOES-R analysis at the onset of the paper, subjecting it to a "supplemental" role as it is introduced in the Introduction, removing reference to its results in the abstract and removing the word "temporal" from the title of the article.

Response to Question #1. We can see that our answer to this question is ambiguous. The answer is NO, geostationary satellites will NOT resolve the diurnal aerosol signal in a CLOUDY environment. The statement previously made in the conclusions, "... and will be able to resolve the diurnal aerosol signal." has been removed. We stand by the other statement in what is now Section 6. "The answer to that question lies outside the scope of this study. " We feel that the paragraph in the conclusions that explains the tradeoffs of a geostationary retrieval adequately expresses the conclusions now that we have inserted a statement about the limitations of a one-day analysis.

The analysis of the GOES-R cloud mask applied to geostationary satellite radiances from GOES reveal interesting diurnal patterns, but because this analysis is applied to only one day, it is difficult to make firm conclusions. The one day analysis suggests the possibility that regions overcast with clouds at typical polar orbiting satellite overpass times may open up to aerosol retrievals either early or late in the day. The diurnal availability pattern is most significant at the coarser spatial resolutions, suggesting that an aerosol retrieval using 8 km radiance may be almost as available in the early morning as the 1 km retrieval is at midday. This diurnal pattern has some regional and seasonal variation. However, from a scientific perspective the early morning aerosol that can be retrieved may have very different properties than the aerosol that cannot be retrieved. We note that based on this analysis there is little possibility of resolving the diurnal cycle of aerosol properties from satellite if using an instrument with a 4 km or 8 km footprint. The availability at midday is too low. However, the diurnal analysis was limited to just one day, and may not be representative of other conditions. .

Response to Question #2 We do not have sufficient data to properly answer the question as the reviewer expresses it, and as it was set up in the previous introduction. We have removed the sentences in the introduction that suggested that we would be

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able to answer such a question. Now we feel that the above paragraph appearing in the conclusions properly expresses our conclusions, with the appropriate statements of limitations.

Response to Question #3 Although we have no solid proof that one cloud mask is better than the other in protecting an aerosol retrieval, it is obvious to all authors that the MODIS aerosol cloud mask is better because (1) it was designed to be used for aerosol retrieval, and the GOES-R was not, (2) it has a long history of evaluation in an aerosol retrieval context and the GOES-R has not, and (3) we can't imagine a aerosol-centric cloud mask offering over 80% availability under the conditions seen in Fig. 8 for VA and MX. In the conclusions we explicitly state these three reasons for disbelieving the GOES-R cloud mask results in an absolute sense.

Specific comments - aerosol availability should be defined in the introduction. Done

- Define "sufficient" aerosol retrieval availability for any sensor. "Sufficient" is application specific, which is stated in the very beginning of the Introduction.

- Need brief description of MODIS and GOES instruments, aerosol retrievals from both instruments and uncertainties. Descriptions of the instruments have been added. There is no point describing the aerosol products, because these products are not used in the analysis.

- Need table listing the three MODIS cloud masks and the GOES-R cloud mask with corresponding references. Point to table in discussion around Fig. 2 Done.

- GOES-R cloud mask description is confusing and needs more references. We have written 3 paragraphs of description and reference the ATBD and a published paper that is now on-line and accessible. We have updated the reference with a doi number. The reason why there is more description of the MODIS aerosol cloud mask is that the Martins et al., 2002 reference gives the basic idea, but is a decade old and a bit out of date. In contrast the Heidinger et al. 2012 paper is fresh and complete. We are not

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sure what more we can do to satisfy this reviewer or to offer to our readers.

- Rename heading for Section 4.1 Done

- State what was done or not done about bright surfaces (p637); if not done, what is the statement about the snow when discussing Figure 6. This was confusing, and we worked at describing that bright surfaces are sometimes accidentally included in the cloud mask, but for this study we did not explicitly eliminate bright surfaces. We use the words 'accidentally' and 'explicitly' consistently through all relevant sections. See an example in the below paragraph.

In this section we use the MODIS aerosol cloud mask derived from Terra-MODIS Level 1B reflectances to investigate the consequence to aerosol retrieval availability as sensor pixel size degrades from 0.5x0.5 km to 1x1, 2x2, 1x4, 4x4 and 8x8 km. These resolution sizes are nominal, at nadir, and will stretch as view angle increases until they become 4 times the nadir size at swath edge. This is the actual operational aerosol cloud mask derived from MODIS data (Table 1, Martins et al., 2002). The MODIS aerosol cloud mask is not meant to identify clouds. It is meant to protect an aerosol retrieval. Some pixels that are cloud-free, but still inappropriate for an aerosol retrieval may be labeled accidentally as 'cloud' in the mask. Such pixels are bright surfaces, especially snow and sun glint. In this exercise there is no explicit masking of bright surfaces other than what is accidentally included in the MODIS aerosol cloud mask.

- Don't separate sections 4.3 and 4.4 Does August 12 represent the summer? Fig. 6 and 7 should have same y-axis. We prefer to keep local and regional analyses separate and in separate sections. We also prefer to keep the axes, as they are in order to spread out the curves in Fig. 6 for better viewing and then resolving the higher availabilities in Fig. 7 (now Fig. 8) . The seasonal analysis shows how we lose availability as spatial resolution degrades for applications having to do with monthly and seasonal statistics, such as climate. The daily analysis shows us how we lose

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availability for applications having to do with the aerosol situation TODAY, such as air quality forecasting. The local analysis shows us how we lose availability TODAY in our home town, for applications such as local air quality forecasting and field experiment deployments. Each analysis has its place. August 12th is just one day of the summer. It is not meant to represent the summer. It explores the question of what happens to my needs for TODAY if my only available sensor is 4 km instead of MODIS's 0.5 km.

- MODIS and GOES-R cloud masks. The paper should spend more time comparing the two cloud masks and showing that one is better than the other. The two should be compared at the same overpass time and on a daily average. Much of this is addressed above when replying to the reviewer's main comment above. We disagree that the paper should spend more time in comparing the two cloud masks. The bulk of the analysis depends on the established MODIS aerosol cloud mask. The GOES-R cloud mask is introduced as a supplement to look for diurnal patterns in availability and to demonstrate the vast differences in the two results, which are shown clearly in Figure 12. An in depth comparison of the two holds little value for us, because we know that the GOES-R cloud mask is not going to flag marginal clouds. We have added as 3 bullet points in the conclusion to explain our reasoning.

- Figure 11 (now Figure 12) is an attempt to compare MODIS with GOES-R, but it is limited by poor description. Are these diurnal means or matched to the overpass time? We checked to make sure, and all GOES-R values plotted in Fig. 12 are matched to MODIS overpass time. The caption is corrected and more information is given in the text.

- Add quantification of cloudiness in each category along with availabilities. We thought adding cloud fraction an excellent idea, but which cloud fraction? We decided on the fraction calculated by the MODIS aerosol cloud mask defined at 0.5x0.5 km. A column is added to Table 3 (previously Table 2) showing the regional/seasonally mean cloud fraction for each regional domain. To show the same for the 12 Aug domains, including the local areas, a new table is added that includes a column for cloud fraction. Now the

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reader can see how availability at a specific resolution always exceeds cloud fraction.

Technical corrections:

- p 628 L9, Done

- p 628 L17, we don't believe that level of detail is necessary in the abstract

- p 628 L19 and L22, those awkward sentences have been eliminated in the process of moving the GOES analysis to its supplementary position.

- P 629L12, "six" removed

- P 629 L18, 2 references added

- P 629 L26, the sentence is redundant because it sums up the preceding thoughts. Topic sentences and redundant concluding sentences are a writing style that the first author particularly likes and prefers to keep (and wishes that more people in the business followed).

- P 630 L5, Done

- P 630 L7, Done

- P 630 L9, Done

- P 631 L8, Sentence removed in the overall attempt to downplay the diurnal analysis and make the GOES work supplementary to the MODIS

- P 632 L3, Done

- P 632 L9, Done

- P 632 L14, Done

- P 632 L20, then we would have the problem of too many "selective"s in the sentence. We'll keep choosier, although it is informal.

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- P 632 L26, changed it to “perform”. It does more than attempt here, it “makes” the retrieval, or “performs” one.

- P633 L2, We’re not sure how to reword. The aerosol retrieval is both more and less conservative. It is both more daring and more careful. We’re not sure why the reviewer doesn’t like the wording. Without a suggestion we would probably make the wording worse, not better.

- P 633 L25, added some directional words (right and down)

- P 634 L12, added reference to ATBD

- P 635 L2, bright surfaces is self-explanatory. We added sun glint.

- P635, L16- P636, L14 See above. We don’t see what more we can offer besides the 3 paragraphs and references to the ATBD and the 2012 paper.

- P637, L3-6, The sentences are redundant, but this is an important point that we want emphasized by rephrasing the same meaning.

- P637, L10. We added sentences to make it more clear.

- P 637, L17, the definition of availability is now introduced and defined in the last paragraph of the introduction, and redefined here specifically for the 8 km product boxes. The example of 100% availability is given here now.

- P 638 L1, Done

- P 638, L16, Snow is probably mis-identified as cloud in the cloud mask used here. There is no additional de-selection for snow in this analysis. This is discussed above. Text changes have been implemented to clarify the difference.

- P 638 L17, See above.

- P 638, L24, Done.

- P 639, L1, It’s almost 50%!!! We added the word “generally” to account for that one

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counter example.

- P 639, L7, This particular line should stay where it is, but the reviewer's multiple comments concerning the need for greater clarity in explaining what goes into the cloud mask used in this study versus the entire de-selection process of the operational MODIS algorithm are being taken seriously. We have re-written much of the old Section 4.1, now Section 5.1, in an effort to improve clarity.

- P640 L2, Done.

- P 640, L16. Done.

- P 640 title section 5. Done.

- P 640 L 24. Wording changed to reflect more frequent observations at high latitude.

- P 641 L2. Done.

- P 641 L14. Done.

- P 641 L 17. Prefer to keep the redundancy.

- P 641 L 23. Done.

- P 641 L 23. It is 10%. Stated explicitly here, now.

- P 641 L 26. Reworded.

- P 642 L 19. Done.

- P 642 L 27. Done.

- P 642 L 24. "Most" removed.

- P 643 L 4. Inserted, "compensate for the lack of retrievals at the time of polar orbiter overpass"

- P 643 L 4. Sentences were reworded.

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- P 643 L23. Done

- P 644 L4. Done.

- P 644 L7. Done.

- P644 L9. We prefer to keep the redundancy.

- P 644 L10. Done.

- P 644 L14. We now list the 3 reasons leading to the conclusion.

- P 645 L1. We are happy with this wording and prefer to keep it.

- P645 L16. Removed

- Table 1. Information added to the caption.

- Figure 2. Each panel shows different features and it would be hard to make it all consistent and still identify the different features. The wording in the caption was changed, as suggested. -

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/5/C1176/2012/amtd-5-C1176-2012-supplement.pdf

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