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Atmospheric Measurement Techniques Discussions

Interactive comment on "Assessing snow extent data sets over North America to inform trace gas retrievals from solar backscatter" *by* Matthew J. Cooper et al.

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Thank you for your comments.

——- General Comments

Comment 1: "The assessment of different snow cover data sets is carried out for the entire year of 2015. This approach of using the full year data may cause biases in the metrics. The authors admit "All data sets have high accuracy numbers, owing to a high number of true negatives during the summer months" (Line 220). I think that the assessment of the snow cover data sets should be done on a seasonal basis and the

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Discussion paper

metrics for different seasons should be compared. It would be particularly interesting to assess the snow data sets for spring when melting snow occurs."

Response: We have included a table in the Appendix that gives evaluations of the snow data sets by season, and now include the following text on Line 245:

"Data sets were also evaluated by season with similar results (Appendix Table A1). All data sets have weaker performance metrics during the spring melt season, which has been observed in past evaluations (Frei et al., 2012). IMS has the highest F score in winter and autumn but is slightly outperformed by MAIAC in spring."

However, keeping in mind that the goal of this work is to evaluate data sets for informing retrieval algorithms, and as most retrieval algorithms would likely choose a single data set to provide snow information throughout the year, we continue to focus on the full year data.

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Comment 2: "In my opinion, results of the RT simulations shown in Fig. 2 and 3 do not provide new significant information. Effects of surface reflectance on trace gas retrievals have been studied theoretically (see O'Bryne et al., JGR, 2010; Lin et al., ACP, 2015; Vasilkov et al., 2017 and references there). "

Response: We respectfully contend that Figures 2-3 do provide important information here. They illustrate how changes in snow cover affect the observation sensitivity to NO2. Indeed Reviewer 1 expressed interest in Figure 2.

Comment: "Figure 2 of the manuscript (showing the scattering weights for a single solar zenith angle and a single NO2 profile) is not conclusive because the NO2 sensitivity to surface reflectance substantially depends on tropospheric NO2 profiles (see Fig. 13 in Vasilkov et al., AMT, 2017). "

Response: It is true that the column NO2 sensitivity depends on tropospheric NO2 profiles. However, the scattering weights in Figure 2 represent the sensitivity of backscattered radiation to surface reflectance, which is independent of NO2 profile. We have taken care to clarify this in the text (Line 201):

“Figure 2 shows the sensitivity of backscattered radiation (scattering weights) over snow-covered and snow-free surfaces . . .”

Comment: "Figure 3 compares AMFs for snow-covered and snow-free conditions for January 2013. The snow-free conditions are absolutely unrealistic for January. That is why I doubt that useful information can be derived from this comparison."

Response: We clarified that the figure is for the observation geometry of January. The Figure 3 “snow-free conditions” plot shows AMF values in the case that snow is not present during a given observation. It is not meant to suggest that snow is never present in January in North America. As snow-covered scenes are often omitted in retrieval algorithms, the resulting data sets are essentially “snow-free”, and thus a snow-free map of AMF does provide important context.

Comment: "I think that the text and figures related to the RT simulations can be removed without the loss of significant material. To some extent, this is supported by the title of the manuscript because the RT simulations are not mentioned in the title."

Response: We have strengthened the material covering snow and AMFs by including Figure 6, which shows how including snow-covered scenes improves the quantity and quality of retrieval data sets. We have changed the title to reflect this as well. Together with Figures 2-3 we feel that this is new, significant information.

—– Specific comments

Comment: "Line 24. The quantity “F” is not defined here."

Response: We have removed the mention of F here. It is defined later in the abstract.

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Comment: "Line 52. It is worthwhile to mention that uncertainties in surface reflectance also lead to uncertainties in the cloud fraction and pressure retrievals which affect the NO2 retrievals (Vasilkov et al., AMT, 2017). "

Response: We now mention this effect in the introduction (Line 59): "Correspondingly, surface snow may be mistaken for cloud, leading to errors in cloud fraction and pressure estimates used in trace gas retrievals (O'Byrne et al., 2010; Lin et al., 2015; Vasilkov et al., 2017)."

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Comment: "Line 162. Indeed, snow reflectivity is almost spectrally independent in UV/Vis. However, the maps in Fig. 1 include snow-free regions. For such regions, ground reflectivity does depend on wavelength, so reflectivity at 354 nm may not be used for 440 nm.

Response: The snow reflectivity (for 354 nm) is only used when snow is present. Snow-free regions use the MODIS CMG Gap-Filled Snow-Free Products at 470 nm, which are at a wavelength closer to the 440 nm used in the AMF calculation. We have clarified this in the text and in Figure 1.

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Comment: "Line 174. Please clarify "the most reliable source is used". "

Response: As stated, the GHCN-D data set includes information from multiple sources. GCHN-D provides a priority ranking of these sources. We have added a citation to this line which provides additional information.

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Comment: "Line 185. Please explain why the F score is most relevant for TEMPO."

Response: This is now clarified in the text (Line 192) as follows: "The F score balances recall (which accounts for false negatives) and precision (which accounts for false positives) to measure correct classification of snow without the influence of frequent snow-free periods, and therefore is the metric which is most relevant for TEMPO”

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Comment: "Line 190. Where does the OMI cloud fraction come from? How is the cloud fraction determined for snow-covered and partially snow-covered scenes? "

Response: We no longer use the OMI cloud fraction in this work. From line 199: “We assume cloud-free conditions in the AMF calculations, as the impact of surface reflectance on retrieved cloud fractions is beyond the scope of this paper.”

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Comment: "Line 235. Is it correct that the MODIS products perform better at coarser resolution? Table 1 shows F=0.46 and 0.54 for the 4 km resolution while Table 2A shows F=0.45 and 0.53 for the 25 km resolution."

Response: Yes, MODIS products do perform better when regridded to 4km than at their native resolution of 0.05°, where F=0.37 and 0.43. However as pointed out by the reviewer, the benefit of regridding does not continue to improve if the resolution is further decreased. This has been clarified in the text (Line 250):

“. . .MODIS Aqua and Terra products perform better when regridded from their native 0.05° resolution to a 4 km resolution as it reduces the number of grid boxes missing observations due to cloud. . .”

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Comment: "Reference to McLinden et al., ACP, 2014 is missing."

Response: This has been fixed.

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Comment: "Figure 1. The caption states “reflectivity at visible wavelengths”. The 354 nm wavelength (used for the upper panel) is not a visible wavelength. The lower panel is not informative because the color scale is not appropriate for it. "

Response: The figure caption now specifies “UV-Visible” instead of only “visible” wavelengths. We have also changed the colour scale.

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Comment: "Figure 2. The corresponding NO2 profiles should be shown. Surface reflectivities should be specified. What is the viewing zenith angle of observations? "

Response: Surface reflectivities and zenith angles are now included in Figure 2. We have edited the text at Line 201 to better distinguish between the sensitivity of backscattered radiation to lower troposphere NO2 (i.e. scattering weights) and the sensitivity of the NO2 column to lower troposphere NO2 (i.e. AMFs). Figure 2 focuses on how the scattering weights themselves (which do not depend on the NO2 profile) are affected by reflectivity, and thus we do not include the corresponding NO2 profiles for the sake of clarity.

“Figure 2 shows the sensitivity of backscattered radiation (scattering weights) over snow-covered and snow-free surfaces for two locations . . . This shows that satellite observed backscattered radiation is up to five times as sensitive to NO2 in the boundary layer in the presence of snow, due to the increased absorption by NO2 in the lower troposphere when the surface reflects more sunlight.”

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Comment: "Appendix. Please explain why some numbers for the CMC and NISE data sets are slightly different in Tables A1 and A2. The spatial resolution of the data sets is same for both tables."

Response: Thank you for noticing this. There were some errors in the Appendix tables that have been corrected. In Table A3 (previously A2), all products were regridded to a common 25km resolution. For NISE, this is slightly different than its native 25km grid, hence a small difference in its F score (0.51 to 0.52).

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