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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.

Comment: "1. In the section describing IMS-dataset you might want to explain a bit more in detail what instruments the dataset is based on. "

Response: IMS uses an often-changing list of instruments and models to build its dataset. We have added some examples of instruments that are used in Section 2.1.1. Line 100: "The maps are produced by a trained analyst using visible imagery from a collection of geostationary (e.g. GOES, MeteoSat) and polar orbiting (e.g. AVHRR,

MODIS, SAR) satellite instruments, with additional information from microwave sensors (e.g. DMSP, AMSR, AMSU), surface observations (e.g. SNOTEL), and models (e.g. SNODAS) (Helfrich et al., 2007)."

Comment: "2. There is a fractional snow extent product from Globsnow/Sen3app projects that might be also worth a look and included in the comparison. For 2015 it is based on VIIRS (Suomi-NPP) data. The data and information are available here: http://www.globsnow.info/index.php?page=SE or here: http://sen3app.fmi.fi/index.php?page=Fractional_Snow_Cover_Extent_-_NH&style=main "

Response: We have looked at the fractional snow extent product from Globsnow/Sen3app as suggested, and have decided to exclude it from this work. This product does not provide snow cover information when clouds are present in the VIIRS observations. As a result, there is no information on snow cover for approximately a third of the TEMPO domain in 2015. Therefore, the product is not appropriate for the study performed here.

Comment: "3. In the conclusion you write: "However, the lack of confidence in snow identification has previously led many retrieval procedures to omit observations over snow. Increasing this confidence such that these observations could be included would not only improve spatial and temporal sampling, but also allow the inclusion of observations with higher quality information on the lower troposphere." It would be useful to actually demonstrate this with an example or case study, perhaps based on OMI data. I mean, showing one OMI scene/orbit of NO2 retrievals, where the added value of this improved snow information would be visible. For example, an OMI orbit with snow-cover that was filtered out or somehow incorrectly flagged and would be improved using a more accurate knowledge of the snow cover (with the right AMFs and profiles) in the NO2 retrieval. "

Response: Thank you for this suggestion. We have included a figure (Figure 6) that shows how including observations over snow improves sampling and increases AMFs. This is explained in the text on Line 280 as follows: “We next examine the effect on both spatial sampling and sensitivity to the lower troposphere of a retrieval data set if observations with surface snow are included rather than omitted. We use IMS to identify the presence of snow for OMI observations over North America in January 2015. We then use LIDORT to calculate AMFs for these observations using the corresponding snow-free (Sun et al., 2017) or snow-covered (O’Byrne et al., 2010) surface reflectance, and examine the results of either including or omitting snow-covered scenes. Figure 6 shows that including snow-covered scenes results in a significant (factor of 2.1) increase in observation frequency, particularly in the northern US and Canada. Additionally, including snow-covered scenes increases the average AMF by a factor of 2.7 in regions with occasional snow cover. The increase in AMF demonstrates that including snow-covered scenes increases the quality of information about the tropospheric NO2 column by increasing the observation sensitivity to tropospheric NO2.”

Comment: "4. Could you comment on how the increased sensitivity in the PBL might affect NO2 retrievals at relatively higher latitudes (where snow is very often present)? For example, how would those scattering weight profiles in Fig. 2 look like for higher SZA/or a different latitude? It might be less important for TEMPO but it is relevant for OMI/TROPOMI missions to improve retrieval at high latitudes in autumn-winter. "

Response: We have added a scattering weight profile for a high latitude location in Figure 2.

Comment: "5. There is this paper by Vasilkov et al. about BRDF and OMI retrievals you might need to mention/discuss in your paper: Vasilkov, A., Qin, W., Krotkov, N., Lamsal, L., Spurr, R., Haffner, D., Joiner, J., Yang, E.-S., and Marchenko, S.: Accounting for the effects of surface BRDF on satellite cloud and trace-gas retrievals: a new approach based on geometry-dependent Lambertian equivalent reflectivity applied to OMI algorithms, Atmos. Meas. Tech., 10, 333-349, https://doi.org/10.5194/amt-10-333-2017,

2017."

Response: We have added a mention to this paper 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 (Lin et al., 2015; O’Byrne et al., 2010; Vasilkov et al., 2017).” and in the conclusion, as follows (Line 316): “This could potentially include Bidirectional Reflectance Distribution Functions (BRDF) that describe reflection at different viewing angles, as this effect has been shown to have significant impact on retrieved NO2 columns (Vasilkov et al., 2017)”

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