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Atmospheric Measurement Techniques Discussions

Interactive comment on "Remote sensing of aerosols over snow using infrared AATSR observations" *by* L. G. Istomina et al.

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"The paper presents an innovative approach to measure aerosol optical depth over snow-covered surfaces using AATSR infrared dual-viewing observations. The topic is definitely appropriate for AMT, but the authors need to elaborate and explain better several assumptions stated in the manuscript. The authors implicitly present the aerosol IR retrieval technique as a general method that could work for different aerosol types. Based on the restrictive implied assumptions in the application of the method, it seems to me, the technique works best for dust, but it would probably break down for other aerosol types in which the fine aerosol mode may be dominant. Please address the following issues: Pg 36, line 25. Is the snow emissivity variability of less than 5% documented by Hori et al (2006)? If so, please reword to associate the statement on line

25 with the reference. Otherwise, include appropriate reference."

The reference on line 25 is missing, the proper reference should be W. Gareth Rees, Remote Sensing of Snow and Ice. Taylor & Francis, 312 p, 2006. It will be included in the text.

"Pg 37, line 15. The authors assume that the fine and coarse aerosol size modes associated with a smoke event apply equally to dust, water soluble and oceanic aerosols. Is the assumed coarse mode for dust aerosol consistent with AERONET observations? Tables 1 and 2. The model representation of soot aerosol seems unrealistic. Although soot is an important aerosol component, pure soot is rarely present in the atmosphere. The authors should offer some observational evidence of the very low SSA of 'soot aerosols' in tables 1 and 2."

The theoretical study and the RT simulations in Section 3 which resulted in Fig. 1, 2 and Tables 1, 2 are done only to get the impression on the behavior of the phase function, TOA reflectance and SSA of different aerosol components depending on the wavelength and the particle size. These values are not used in the actual retrievals and are to illustrate the similarity of the phase function shapes for all components in the IR even for the accumulation mode. This implies that all possible differences in the TOA reflectance will come from the SSA and will not change the shape of the bidirectional reflectance at the TOA, which is crucial for the proposed usage of the satellite forward view for the retrieval. The soot component taken separately and for such large particles is indeed unrealistic, it is included for the sake of completeness, but still shows valid dependencies on the particle size and the wavelength. This and the above mentioned details will be highlighted in the text of the final version of the manuscript.

"Pg 38, line 26. In the sentence ': : :to employ values of same magnitude: : :', values of what?"

Values of the TOA reflectance. This will be corrected in the final version of the paper.

"Pg 42, line 5. How small must AOT be to justify this assumption?"

In order to obtain Eq (9) from Eq (8), one has to assume that the atmosphere is clear enough to allow the transmittances T1 and T2 be close to unity, which is valid for AOT less than 0.1. The AOT at 3.7 micron is in general case much smaller than that and can be as small as 10^-3.

"Pg 43, line 4. Neither figure 1 nor figure 2 is related to nadir reflectance. I think the authors mean figures 3 and 4."

Indeed, this will be corrected in the final version of the manuscript.

"Pg 43, line 5. Nadir direction for a solar zenith angle of 65 degrees corresponds to a scattering angle of 115 degrees. According to the phase function calculations in figures 1 and 2, equation 12 would only apply to aerosol types where the coarse mode predominates. For aerosol types where the number density of fine mode dominates, equation 12 may yield zero or even negative aerosol reflectance. Please elaborate on the applicability of the approach to the water soluble, oceanic aerosols, or soot containing aerosols."

According to e.g. Twomey, 1977 (S. Twomey, Atmospheric Aerosols, Elsevier Scientific Pub., 302p., 1977) the scattering behavior of an aerosol load in the IR spectral region is dominated by the larger particles, even if they are a few, as smaller particles are not effective scatterers at these wavelengths. So the TOA reflectance of an aerosol load consisting of such particles will tend to zero disregarding of the viewing direction, and depending on the instrument noise and the reflectance reconstruction accuracy will give zero or negative value in Eq (12). These exception values are not used for the AOT retrieval. In current study only accumulation and coarse mode particles are taken into account. Though accumulation mode is generally referred to as fine mode, e.g. Hobbs, 1993 (P. Hobbs, Aerosol-Climate-Cloud Interactions, Academic Press Inc, 240p., 1993) states that accumulation mode particles of polar aerosol are larger than accumulation mode particles of other aerosol types (mean particle radius of around

0.4 micron as compared to around 0.1 micron for background and maritime and less than 0.1 micron for rural, urban, desert dust storm and remote continental). This made it possible to include also accumulation mode into the study along with the coarse mode. The suggested retrieval is not able to estimate the AOT of fine (<0.4 micron) particles. Indeed, this was never mentioned explicitly in the text and will be highlighted additionally.

"Pg 43, line 10. In addition to no angular variability of snow emissivity, equation 12 is also based on the assumption of no angular variability of the aerosol scattering phase function between nadir and off-nadir viewing geometries. Under these assumptions the equation is only valid for dust aerosols. It wouldn't hold for water soluble nor oceanic aerosols, because the larger reflectance at nadir associated with the larger phase function would probably be interpreted as surface contamination."

As Fig 2 shows how similar the phase functions of the accumulation mode of the four components are at 3.7 micron, the question is probably addressing Fig. 1 and the coarse particles reflectance at nadir, with the dust component phase function being slightly deeper at nadir than that of water soluble and oceanic components. It should be noted that none of these phase functions is used in the retrieval, furthermore, none of these phase functions can be encountered in the real case of aerosol pollution event, as they are limited to one certain aerosol component and mode. The real phase function will be a weighted average of the IR phase functions shown in Fig. 1 and 2, with the occasional inclusion of the other aerosol components. Since the presented method only uses one wavelength and is not able to determine spectral aerosol properties, we have no chance to guess the correct aerosol phase function. Therefore the delivered AOT can only be used for a qualitative estimate of aerosol dynamics over snow. The sensitivity of the presented method will indeed depend on the aerosol type, and there are several ways to adjust the algorithm for aerosols which reflect more at nadir, once we know that e.g. a given scene contains such aerosols. In the present version of the algorithm we can expect underestimation of the retrieved AOT for the coarse mode of

oceanic and water soluble aerosol components; the presented correlation plots, however, do not show any systematic underestimation, from which one can conclude that the coarse mode of oceanic and water soluble components is of rare occurrence in the background and haze Arctic aerosols at the given groundbased stations. As the current work is a case study of a dust storm event, we expect all the assumptions to be valid and the provided AOT maps to be applicable for qualitative estimate of the dust plume dynamics for the studied event.

The authors are grateful for the thorough and constructive comments, addressing which will make the manuscript much more clear and concise.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 33, 2011.