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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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"1. This paper addresses an important problem – performing satellite aerosol retrievals over bright snow surfaces. The authors have done a good job developing the theory, and validating the approach for AATSR using coincident, ground-based observations. In my opinion, this paper is appropriate for publication in AMT, though some questions regarding the sensitivity of the method to specific assumptions made in implementing the algorithm might be worth addressing first. 2. P36, line 25. The assumption that variations in snow emissivity at 3.7 micron are < 5% is key to this work. The reference provided, Hori et al. 2006, actually deals only with the spectral range 8-14 microns, and does not indicate the <5% variability even for those wavelengths. In the visible, snow BRDF can be scale-dependent, as sastrugi and other surface texture and shadowing elements affect the angular reflectance signature. I do not have intuition about snow BRDF at 3.7 microns, but it would be reassuring to see some justification for the <5% assumption at this wavelength."

There is a reference missing at the line 25, it will be added. Hori et al. 2006 is applicable to line 23-24. Rees, 2006 (W. Gareth Rees, Remote Sensing of Snow and Ice. Taylor & Francis, 312 p, 2006) states that the emissivity of snow is equal to 0.965-0.99 throughout the whole thermal infrared region, and discusses the effect of the grain size on snow IR reflectance, which is lower than 5% for grain sizes from 10 to 400 micron. This gives the variation of the emissivity 5% depending on the grain size. The same source suggests that since the emissivities of snow and liquid water are similar throughout the thermal IR region, the effect of liquid water can be neglected, which is of course valid as black body assumption also holds for water. As a side remark, however, it should be noted that liquid water in the snowpack rarely comes alone and is often a sign of snow contamination and subsequent melting. Pollution drastically affects snow spectrum at most of the wavelengths, and the black body assumption is no longer valid. However, such a surface is no longer “snow” in its original meaning, and it will be screened out by our cloud screening and snow flagging thresholds.

"3. P37, lines 14-19, and Table 1. How are the results affected when other particle microphysical properties are assumed? In particular, the fine-mode effective radius of 0.64 micron is fairly large, especially for soot, and the resulting visible SSA, 0.38, is very low for particles in the atmosphere. As smaller particles will generally have flatter single-scattering phase functions, could this be significant for the proposed method?"

According to e.g. Hobbs, 1993 (P. Hobbs, Aerosol-Climate-Cloud Interactions, Academic Press Inc, 240p., 1993) 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). In addition, the value provided in the tables 1 and 2 is the effective radius (as opposed



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to modal or mean radius), which tends to be larger than the corresponding mean radius (which is equal to 0.4 micron according to Hobbs, 1993). This made it possible to use the value measured during one particular event for a more general study. However, it should be noted that the algorithm suggested within this work is only capable of detecting large particles – the accumulation and the coarse-mode particles. For the smaller particles the problem is not even the flat shape of the phase function (which would make the forward and nadir view signals less asymmetric, yet, this signal can still be used for AOT retrieval), but the fact that at 3.7 micron the scattering behavior of an aerosol load is determined by the large particles, even if there are very few of them. The TOA reflectance of an aerosol layer consisting of small particles only at 3.7 micron will be under the detection limits disregarding of the viewing angle. As the proposed method can only be used to determine the AOT of the coarse and accumulation modes, no study has been shown for nucleation and Aitken modes. This important remark will be included in the text of the final version of the paper. The very low SSA of the soot component taken separately is indeed unrealistic and only shown for the sake of completeness among the other main aerosol components. It also helps to estimate the dynamics of the integrated aerosol properties (consisting of the four main components) with the increase or decrease of soot in the aerosol. Indeed, provided value would be too low for the real aerosol SSA, but here it is a characteristic of one aerosol component separately and can never be met in reality. The provided value is still useful for the theoretical study of aerosol components separately.

"4. P38, lines 13-28. The challenge of retrieving AOT over snow in the visible stems from the very bright surface, as small percentage errors or variations in surface reflectance can swamp the TOA aerosol signal. The simulations shown in Figures 3 and 4 were done assuming a black surface and an AOT of 0.1. Although the snow surface is darker at 3.7 microns than in the visible, you need to show it is actually dark enough that it does not significantly affect sensitivity. Also, is the AOT 0.1 at 550 nm or at 3.7 microns? AOT is typically 0.1 or less in the mid-visible at high latitudes, and would be lower at 3.7 microns, especially for accumulation-mode particles."



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The AOT mentioned is at 550nm, this will be highlighted in the text. Snow surface at 3.7 micron is generally referred to as an almost perfect black body due to its high density, with the emissivity equal to 0.965-0.99 throughout the thermal infrared region and the reflectance at 3.7 micron being of the magnitude of several percent, around 1 % for dry snow with middle-sized grains (W. Gareth Rees, Remote Sensing of Snow and Ice. Taylor & Francis, 312 p, 2006, Salisbury et al, 1994). Therefore Eq. 12 can be applied to remove the residual surface contamination.

"5. P40, line 9. I think you mean to say: “Conversely, if the TIR criteria: : :” Also, P42, line 1. No need to repeat the definitions of theta and phi."

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

"6. Section 4.2. Given the assumptions required to extract the surface contribution to TOA reflectance at 3.7 microns, it would be helpful to have an actual error budget for the simulation."

The accuracy of the simulated surface reflectance extraction is shown in Fig. 5 for both forward and nadir views and in the worst case it is not exceeding 10%. The effect of this error on the AOT is very much dependent on the actual AOT of the scene and on the chosen LUT, and is therefore hard to evaluate in the general case.

"7. The manuscript could use a little copy-editing; in particular, the definite article is sometimes applied correctly, sometimes not."

The final version of the manuscript will be thoroughly checked by a native English speaker.

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