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Atmospheric Chemistry and Physics Discussions

Interactive comment on "UV albedo of arctic snow in spring" *by* O. Meinander et al.

Anonymous Referee #1

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The manuscript presents results from continuous measurements of broadband UV albedo before and during the snow melting period in an arctic environment. The results are interpreted with respect to observations of physical snow properties, snow height and air temperature. During the snow melting period, a diurnal, reversible change in albedo is observed. This is explained as a daily metamorphosis of the surface of the snow cover.

The work represents probably the first continuous measurements of snow albedo and snow paramters during the melting period in arctic environments, and is such a unique data set and contribution to the understanding of the relation between changes in snow albedo and changes in physical properties of the snow. Radiation measurements in harsh arctic conditions pose great challenges to instrumentation and calibrations. The scientific motivation and conduction of the investigations are sound and clearly presented. However, the interpretation of radiation measurements and the total uncertainties of albedo result should be discussed in more detail.

Comments.

The title "UV albedo of arctic snow in spring" and the discussions related to the snow properties in the vicinity of the measurement site refer to the local snow surface albedo. The snow albedo were measured with two radiometers, one facing a local area 2 m below the radiometers, the other facing the full hemisphere. Hence, the irradiance ratios will be influenced not only by the local snow albedo underneath the radiometers but also the combination of low-albedo and high-albedo surfaces within a large radius. Additionally, the snow albedo may have a specular component (MIE scattering), giving rise to a SZA dependent variation. Please, discuss the results in relation to the heterogeneity of the local and regional surface albedo (location of trees and a nearby building indicated by the photo in Fig. 3), see eg. Kylling et al., "Determination of an effective spectral surface albedo from ground-based global and direct UV irradiance measurements", JGR, 105, 4949-4959, 2000. From the comments further down, the authors may consider reformulating the title, containing the word regional albedo, or diurnal variations in the UV albedo.

Page 4156, lines 25-28, the authors mention reasons (grain size and impurities) why a lower albedo is expected for arctic snow, compared with antarctic snow. However, even for fresh snow and the smallest grain sizes of 0.2-0.3 mm, the observed albedo is significantly lower (max 0.81, average 0.6) than the albedo reported for Antarctic conditions (0.95-1.00, grain size 54 nm to 200 micrometer,Wuttke et al., 2006). What other factors may explain the lower values observed?

Page 4157, lines 6-13. The error sources in the experimental data is only generally mentioned and referenced, but the total uncertainty is not given any place.

Page 4157, line 19 (similar spectral and cosine responses) is in contradiction with the statement on page 4170, lines 10-13 (responses had changed, resulting in U-dependency as a function of SZA). The diurnal irradiance ratios systematically vary

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by a factor of more than 1.5. Could this be explained by differences in the spectral response functions; or the experimental setup with two radiometers seeing different radiance fields?

Page 4158, section 2.2 Multiband data. The NILU-UV potentially could provide spectrally resolved albedo data for the UV and visible, in addition to erythemally effective UVR. However, this more extensive data set is hardly presented, except for the verification of a relative, diurnal change in albedo. A utilization of the full data set, providing spectral albedo on an absolute scale, may have added even more general relevance and could be discussed in relation to spectroradiometric based albedo measurements.

Page 4158, section 2.3 Empirical calibration and the discussion on page 4170. The authors describe the general measurement equation, however, an empirical calibration approach has been chosen. The two calibration options should be discussed in more detail: The general measurement equation requires a thorough characterisation of the two radiometers, but may have removed most of the SZA dependent artefacts from differences in response functions and the influence on total ozone in the observed ratios, and hence utilized a larger portion of this valuable data set. The second method provides a direct comparison of the two radiometer readings, which circumvent detailed characterisation work. However, data within only a small SZA range is utilized; hence the SZA influence of albedo remains unresolved.

Furthermore, error sources related to the empirical calibration should be discussed in more detail: 1) Even if both radiometers had identical spectral and angular response functions, and both readings are normalized for the same orientation at a certain SZA (Table 2), the errors induced by the combination of imperfect response functions and radiance distribution (diffuse and specular, vs. direct and diffuse) may be different for the two radiometer orientations. An assessment of systematic errors from different orientations would require field comparison with a spectroradiometer with almost perfect cosine response, or RT modelling of the two radiance distributions vs SZA. 2) It should also be discussed whether different orientations of the two radiometers may alter the

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internal temperature, and hence affect the responsitivity for the two orientations. 3) What is the influence from shadows from the pole and electronic boxes (AWS) on the measurements from the down looking radiometer? On page 4171, lines 15-20, the fact that no shadowing was detected does not exclude the influence of a pole.

Page 4161 and the rest of the manuscript: All graphic presentations have Julian date as reference, whereas in the text body the date is mostly give as month and day. It would be easier to follow the discussion when the Julian date is given, with day and month given in paranthesis.

Page 4163, section 3.3 snow grain size: The equation gives the snow grain size as function of snow height, max temperature and time. Eq. 4, on page 4168 gives the snow albedo as function of the snow height, but even more relevant would be a discussion on the connection between albedo and snow grain size. In addition, the parameter E in eq. 4 is not defined.

Page 4166, lines 3-17, discussing results from the NILU-UV radiometer. This section may be shortened, as the major findings is a confirmation of a diurnal change in albedo

Comments to Tables and figures: There are a relatively large number of tables and figures, and the authors may consider omitting some that are less relevant.

Table 2: Empirical calibration procedures. Most of the information is already given in the text body, and the table may be removed.

Table 4. A column giving the Julian day number would be informative for the interpretation of the figures.

Table 5: The NILU-UV results presented do not bring anything new with respect to the SL results and may be removed.

Figure 1 and 2: May be omitted, as these response data have not been applied for the calibrations and results shown in Fig. 13 indicate significant differences in the response functions of the two radiometers.

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Figure 6 font size is too small.

Figure 7 font size too small.

Figure 8 Fontsize too small. Missing legends and titles of the two y-axis.

Figure 9 and Figure 10. Could be combined in one figure. Small fontsize and missing legends.

Figure 11 Confirms the observations of diurnal changes in albedo, measured with a pair of NILU-UV radiometers, but the absolute level of albedo within the UVB and UVA is unrealistically different, due to missing calibrations. The figure may be omitted as it does not show anything new compared with SL measurements.

Figure 12 missing legends.

Figure 13 The figure size and fonts are too small to be readable.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 4155, 2008.