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Comment on "Measurements of Erythemal Irradiance near Davis Station, Antarctica: Effect of Inhomogeneous Surface Albedo"

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Smolskaia et al. [1999] (hereafter SNM99) recently presented experimental results concerning the effect of inhomogeneous surface albedo on erythemal irradiance. Measurements were taken near Davis Station, Antarctica, along transects perpendicular to the ice/water boundary. The main findings were a maximum increase of the erythemal irradiance of 10% over the highly reflecting snow surface compared to the ocean under cloudless conditions. The profiles measured along these transects suggested that the erythemal irradiance did not change significantly for distances of more than about 2 km from the coast. Taking into account the albedo contrast between water (0.05) and snow (>0.8) these measurements contradict several experimental and theoretical studies who generally found much larger increases, and changes over longer distances from the coast. Here we discuss possible causes for this seeming discrepancy and give some suggestions on how to improve the usefulness of such experimental studies.

For typical snow albedos of 0.8, e.g. *Kylling et al.* [1999], *McKenzie et al.* [1998], and *Herman and McKenzie* [1998] presented measured and simulated increases of erythemal irradiance of about 40% compared to snow–free conditions, that is, four times the increase reported by SNM99. Furthermore, model studies by *Degünther et al.* [1998], *Ricchiazzi et al.* [1998], and *Kylling et al.* [1999] have addressed the transition region between the two extreme cases. Degünther et al. [1998] showed that even at 20–30 km distance from the ice/water boundary, the irradiance might still differ from its limiting homogeneous value by a few percent. These numbers of course depend on the atmospheric conditions and on the wavelength of the radiation. To allow a direct comparison of the results of SNM99 with modeled data, we present the results of a simulation of erythemal irradiance for the conditions at Davis Station. The input data for the example case, 21 November 1997, are summarized in Table 1. We used a Monte Carlo radiative transfer solver, driven by the UVSPEC model [*Kylling et al., 2000; Mayer et al., 1997*]. Although possible, topography was not taken into account because the region around Davis Station does not have high elevations or steep slopes. Low aerosol was assumed (horizontal visibility 100 km). The boundary between ice and water was approximated by a straight line. The model domain was 200 x 200 km^2 and the irradiance was calculated every 1 km along a transect perpendicular to the ice/water boundary. The erythemal irradiance was calculated by weighting the spectral irradiance with the CIE erythema action spectrum [*McKinlay and Diffey, 1987*] and integrating over the wavelength range 290–400 nm.

Absolute values of the erythemal irradiance as a function of the distance from the ice/water boundary are shown in Figure 1a, for three different land albedos (a value of 0.84 is reported by SNM99 for November 21, 1997). The thick lines are the results for a water surface (albedo 0.05) and a completely snow covered surface (albedo 0.84), calculated by the one–dimensional DISORT radiative transfer solver by *Stamnes et al.* [1988]. The limiting homogeneous value is reached only more than 20 km away from the coast. The ratio of the homogeneous values (ice/water) of 1.44 for a land albedo of 0.84 is very close to that calculated by SNM99 (1.42) using the same UVSPEC model.

Figures 1b and 1c show the normalized results in comparison with the experimental data from Figure 3a of SNM99. As there is no obvious dependence of the data on the measurement date, all data points are plotted here without further distinction. At first glance, all measurements are quite well modeled, assuming a land albedo of 0.6. The measured transects suggest an earlier leveling of the experimental data compared to the simulations. To correctly interpret these data, however, the specified experimental uncertainties and the small number of data points has to be taken into account (see error bars in Figure 3a of SNM99). A possible reason for the discrepancy is the deviation of the coast from a straight line. As the results in Figure 3a of SNM99 seem to be independent of the measurement location and thus of the exact form of the ice/water boundary, this point, however, is probably of little influence. A non–Lambertian snow albedo can also be ruled out as a cause for the differences as *Degünther and Meerkötter* [2000] showed that the use of realistic bidirectional reflectance functions of snow would only introduce a small correction of less than 1% for the down–welling irra-

Table 1. Model input parameters for Nov. 21, 1997.

Parameter	Value
Solar zenith angle	49.15°
Total ozone	368 DU (EP/TOMS)[a]
Land albedo	0.40, 0.60, 0.84 (Lambertian)
Water albedo	0.05 (Lambertian)
Visibility	100 km

[a]Earth Probe TOMS data, http://toms.gsfc.nasa.gov/.

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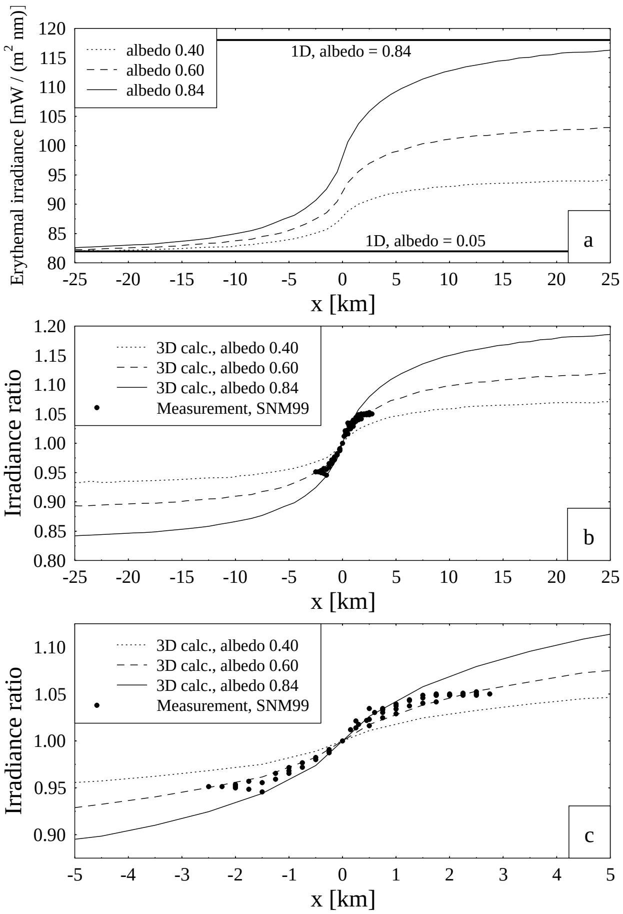

Figure 1. (a) Simulated erythemal irradiance as a function of distance from the ice/water boundary for three snow albedos. The thick lines represent one–dimensional calculations for ocean (albedo 0.05) and completely snow–covered land (albedo 0.84). (b,c) Comparison between measured and simulated data, normalized to the value at the ice/water boundary.

diance under these conditions. Finally, inhomogeneities of the land surface albedo itself may also be a source of discrepancies. Since a land albedo of 0.6 results in distinctly better agreement with measurements than the land albedo values reported by SNM99 (0.84 for November 21, 0.76 for December 4), perhaps the locations of the albedo measurements are not representative of the effective land albedo, as already mentioned by SNM99.

A suggestion to reveal possible reasons for the discrepancy between experiment and theory would be to compare absolute irradiance values, rather than relative differences only (see Figure 1a). As has been shown e.g. by *Mayer et al.* [1997], measurements by a well–calibrated instrument can be simulated within about 5 to 10% if the atmospheric conditions are known, which is the case here. Taking measurements at a distance of around 20 km from the coast, it should at least be possible to confirm whether or not the limits over water and snow are reached.

In summary, it has been shown that the measurements presented by SNM99 are in reasonable agreement with model calculations, provided inhomogeneities of the land albedo reduce its effective value to about 0.6. Nevertheless, the simulations suggest that the erythemal irradiance should still change at distances of more than 2 km from the coast. To find a statistically significant agreement or deviation between experiment and simulation, measurements far away from the coast would be helpful. To improve the usefulness of experimental studies as in SNM99 even more, we would therefore like to encourage investigators to extend the measurements farther away from the coast, at least to one side. This, in combination with comparisons of absolute irradiance values, rather than only relative ones, would further help to validate theoretical studies.

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