

Review of Mary et al. “Retrieval of snow Specific Surface Area (SSA) from MODIS data in mountainous regions”

The authors describe a method that they developed in order to retrieve specific surface area for ice particles in mountain snowpacks using radiance data from MODIS. They attempt to assess their results using modeled grain size from the SAFRAN-Crocus models. One innovative aspect that I appreciated in this paper is their topographic correction of MODIS reflectance data. Otherwise, I had a number of serious problems with it.

The main problem that I have with this paper is that the authors “test” their method using modeled snow grain size (from SAFRAN-Crocus). Testing a model with a model does not validate the results. It is only a comparison. You cite a paper that is in press that shows SSA values from Crocus “were in very good agreement with field measurements” but that is a different study for a different time period and location. The attempt to use model output to verify SSA derived from MODIS is insufficient for validation. At the end of the paper you state that you are pursuing a complete evaluation using ground-based measurements. I suggest that you resubmit the manuscript following your analysis of these field measurements.

The authors motivate their research by stating the significance of snow grain size as a major control on snow albedo and therefore its significance to climate and snow hydrology. To refine and constrain what is meant by snow grain size, they use the term “specific surface area” which is defined as “the ratio between the area of the air/snow interface and the mass of the snow sample, i.e.,  $SSA = S/M = S/(\rho * V)$ , where S and M are the surface area and mass of a snow sample, respectively, V the volume of the ice particles in the sample, and  $\rho$  is the ice density ( $917 \text{ kg m}^{-3}$  at  $0^\circ\text{C}$ .)” While this definition is appropriate for understanding gaseous exchange at the ice-air interface, it is not correct for light scattering. This definition of SSA only considers S to be the surface that is in contact with the air. Thus, it excludes grain boundaries, which serve as scattering interfaces. The SSA that is relevant for snow albedo defines S as the entire surface of the snow grain (here, I term this  $S_{\text{grain}}$ ), not just that portion that is in contact with air (here, termed  $S_{\text{ice-air\_interface}}$ ). Thus,  $S/V$  as used by Warren (1982) is fundamentally different from  $S/(\rho * V)$  as used here (and defined by Legagneux et al. 2002 and used by Domine et al. 2007). Results using stereology and chemical adsorption should be different because they are sampling different surface areas ( $S_{\text{grain}}/V$  vs.  $S_{\text{ice-air\_interface}}/(\rho * V)$ ). While there may be a relationship between  $S_{\text{ice-air\_interface}}/(\rho * V)$  and the optical properties of snow, it remains that the definition is not correct.

In their review of the literature, the authors neglect the early work on grain size and albedo by Wiscombe and Warren (1980), the potential for grain size retrieval from remote sensing by Dozier et al. (1981) and Dozier & Marks (1987), and early successful demonstrations of grain size retrieval by Nolin & Dozier (1993, 2000) and Bourdelles & Fily (1993).

The study is focusing on “the effect of 1/ the local topography, 2/ the anisotropy of snow

and ice reflection, 3/ the shape of snow grains”. There seems to be a scale gap here you go from looking the scale of snow grains (50-1000 microns) to the scale of local topography (0.1-1.0 km) but you neglect surface roughness (0.1-10 m). You consider the case where snow has a Lambertian reflectance and where the snow surface is anisotropic. Please address how surface roughness will affect the anisotropic pattern of reflectance and what this means for your SSA retrievals.

Minor comments:

Line 69: “the grains shape distribution”. This is not grammatically correct and is unclear. Perhaps you mean “the distribution of grain shapes”? Please clarify and correct.

Line 73: Use of the slash character in your numbered list is visually confusing since at first glance it looks like a ratio. Please use a right-parenthesis rather than a slash.

Line 94: “Alpine” should be lower case.

Line 100: “precipitations” should be “precipitation”.

Line 108: “impurities content” should be “light absorbing impurities”

Section 2.2: It would be worth mentioning that, in addition to the other advantages, the MODIS data are freely available for download via ftp.

Line 125 and numerous sentences throughout the manuscript: You use the passive voice and do so in a way that obscures the meaning of the sentence. For instance, you write: “It is illustrated on Fig. 1. SRTM data were assessed by Rodriguez et al. (2005) that the absolute geolocation error is...” When it would be more clear and concise to say: “showed that “SRTM data have an absolute geolocation error of...(Rodriguez et al., 2005)”.

Line 155: “function of” should be “functions of”.

Line 279-280: “high and low albedo corresponds, respectively, to little and large amounts of energy absorbed.” Awkward – please rephrase.

Lines 289 and 298 (and elsewhere): Please use consistent formatting for dates.

Section 4.1.1: It seems that you should perform an optimization study to determine the optimal threshold distance value and set of bands that give the best coverage and least bias. Your selection of bands and spectral distance threshold seem rather *ad hoc* (subjective).

Line 325: You need to report the light transmittance depth for each spectral band. Not only is this dependent on wavelength, it also depends on grain size and density. It would be useful to report this in terms of grain radii thus the reader would have a sense of how many grain radii were sampled for each spectral band (see Nolin & Dozier, 2000; Table 2).

Line 401: “whose anisotropy is less sided than small SSA snow” This doesn’t make sense. Please rewrite.

Lines 444-446: “This suggests that nearly half the RMSD between MODIS and SAFRAN-Crocus SSA originates from the variability of the SSA retrieved from satellite measurements at constant altitude, slope and aspect.” Could this be the result of surface roughness?

Line 525: “The results expressed in optical optical radius are less sided.” Doesn’t make sense.

Line 529: “However, despite SAFRAN-Crocus modelled SSA seems to be very close to field measured values...” Not grammatical, please rephrase.

Figure 1: You need to produce a real map showing the location of the study area in the context of the European Alps. Just putting a rectangle on a DEM is entirely inadequate. Please contact a cartographer for advice or assistance.

Figure 2: This is really confusing. Please redraft or have a professional draft this for you.

Figure 3: The fonts are too small and the date format on the x-axis is difficult to understand and inconsistent with other date formats used in the text.

Figure 6: It is not valid to compute a linear regression with so few points. You should not show the lines.

Figure 7: Again, you have a new date format. Please choose one format and be consistent throughout the paper.