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Influence of snow grain shape on the penetration depth of light within a snowpack

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The surface albedo of snow-covered areas controls the quantity of solar energy that is absorbed by the ground in those regions. The radiative budget of polar and high latitudes regions is governed by the presence of snow, the temporal evolution of snow optical properties, along with the spectral and angular characteristics of the solar irradiance. While the albedo has been much studied, less works were focused on the penetration of radiation within the snowpack. Recent studies have proven that this subsurface deposition of energy can modify the energy budget of the snowpack and consequently have an impact on the surface temperature.
In the framework of the project MONISNOW (French ANR, PI G. Picard), we aim at measuring the spectral penetration depth for various types of snow, in the Alps first, and then in Antarctica. At the same time, a model will be developed to correctly represent the evolution of spectral penetration depth so that it could be better considered in snow and climate models.
For penetration depth measurements, we will use optical fiber buried in the snow and plugged into a spectrophotometer. The extinction of the radiant flux in the snow will provide the depth and rate of deposition of the energy. Simultaneously, the density and specific surface area of each layer of the snowpack will be measured to be used as input of the numerical model.
Modeling will be done using a new fast radiative transfer model that we are currently developing. Although snow is a very complex medium, where grain shape is highly varying, snow grains are often considered in modeling as a collection of spheres. Although spheres cannot be representative either of dendritic fresh snow, or of elongated and faceted hoar crystals, the albedo calculated using the spherical assumption proved to be very similar to the observations. However, this representation is not realistic for the penetration depth. The few studies that tried to confront observations to calculations found that the penetration was too great in the models compared to the in situ measurements. Following some authors that recommend to tackle snow more like non-spherical particles, we believe that spheres have a greater forward scattering than most types of natural snow. Our preliminary results show that using non-spherical particles allows better agreement between modeled and measured penetration depth. Thanks to these future penetration depth measurements, we want to get a representative asymmetry parameter g of the snow that would help the model fits the data.
Once the penetration of light within the snowpack is well represented, it will allow a better representation of the energy deposition in the snowpack and thus could improve the modeling of the snow metamorphism and finally of snow/climate interactions. In Antarctica, the good representation of this penetration can modify the modeled temperatures by a few degrees at large scales. This might have important consequences on the climate such as an acceleration of subsurface melting, or even calving in coastal regions.