Title:

Contact spectroscopy for determination of stratigraphy of snow optical grain size

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Conference Themes:

- Remote sensing systems (microwave, Lidar, (hyper-)spectral, multiangular, thermal, polarization)
- Remote sensing applications to hydrology, carbon cycle, biochemical and –physical cycles, plant ecology, ecosystems, snow, soil moisture, agriculture, natural ecosystems, etc.

Abstract:

We present a technique for *in situ* measurement of the vertical and spatial stratigraphic distribution of snow optical grain size with a coupled contact illumination probe and field spectroradiometer. Accurate measurements of optically equivalent grain size are critical for modeling of radiative properties of snow such as spectral albedo and microwave emission. Here, we refer to grain size inferred from traditional hand lens measurements as TGR (traditional grain radius) and optically equivalent grain radius as OGR (optical grain radius). Given the subjective nature of TGR measurements, it is a poorly defined and as such is not repeatable from observer to observer (S. Colbeck, personal communication). The OGR is well defined as the spherical grain radius required to give the same spectral or spectrally-integrated albedo. OGR may also be represented by the specific surface area (surface area per unit volume ice) for the case of fluxes or albedo for snow or clouds.

Measurements of the spectral reflectance of the snowpit surface are made at 2 cm intervals in the vertical plane under constant illumination and view geometries. We invert the integral of the continuum normalization of the ice absorption feature with maximum at 1.03 μm wavelength for optically equivalent grain size using the validated model of *Nolin and Dozier* (2000) that has accuracy of ±50-100 μm across the grain size range 50 to 900 μm. Results are presented for an alpine site in southwest Colorado across the ablation season and for a Greenland ice sheet site at the onset of snowmelt. These results suggest that only for rounded grains are traditional measurements of grain size from hand lens nearly accurate (R^2 = 0.4, RMSE = 160 µm) for estimating optical grain radius, whereas for polycrystals and faceted grains the hand lens approach is strongly inaccurate (R^2 = 0.03 and 0.24, RMSE = 1206 and 1010 µm, respectively). We demonstrate the order of magnitude improvement in modeling of shortwave spectral albedo and net shortwave flux with contact spectroscopy measurements of grain size stratigraphy

over those from hand lens. The observed differences between OGR and TGR as well as the modeled albedo and net shortwave calculations associated with them suggest that the empirical relationships of snow metamorphism and grain growth currently employed in snow models likely require a fundamental revision and re-parameterization if grain size as calculated by the model is to be validated and useful for remote sensing and shortwave radiation calculations.