In-Situ Probe for Optical Snow Grain Size Measurement

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INTRODUCTION

We have constructed and tested a prototype spectral profiler probe to measure snow grain size stratigraphy in mountain snowpack at up to 5mm vertical resolution, without the need for snow pit excavation.

The probe infers grain size using near-infrared reflectance spectroscopy by inserting into the snowpack an optical package consisting of a light source and fiber optic receiver, which views the snow laterally and sends the collected reflected light to a spectrometer at the surface. The instrument can be easily dismantled and transported in a backpack, and rapidly deployed in the field.

The main contribution of this device relates to the repeatability of the grain size data and the speed at which the measurements can be made. The implications are broad and far reaching, as snow grain size is a critical state variable in remote sensing retrieval algorithms for active and passive microwave remote sensing and in distributed snowpack models. The instrument put forth in this paper will enable rapid grain size measurements and therefore improve spatial and temporal sampling of snowpack microstructure.

DESIGN

The spectral reflectance probe connects via fiber optic cable to a remote light source and spectrometer on the surface. Basic field operation uses a standard snow sampling tube to drill and remove a core, leaving an empty hole into which a windowed sleeve is then inserted. The probe is lowered into the hole inside the sleeve, allowing it to view the snow laterally using a mirror and record spectra along the full profile from surface to ground. A microcontroller and servo motor raise and lower the probe and record depth automatically.

GRAIN SIZE CALCULATION

Grain size is determined by integrating the normalized 1020nm absorption feature in the ice reflectance spectrum and comparing to a look-up table generated from a radiative transfer model (DISORT) of uniform ice spheres. This method was developed for contact spectroscopy of snow pits (Painter et. al., Journal of Glaciology, Vol. 53, No. 180, p-121, 2007.) and for airborne surface measurements (Nolin and Dozier, Remote Sensing of Environment, Vol 74, p-207, 2000).

FIELD TEST RESULTS

Grain size profiles from the probe, along with snow-pit contact spectroscopy and hand lens measurements were gathered and compared during winter and spring 2010 field campaigns in Colorado. Results from the probe agree to within 30% with snow-pit contact spectroscopy measurements, except when thin layers are present which are detected at better vertical resolution by the profiler probe. The results highlight the lateral heterogeneity inherent in most mountain snowpacks, which is impractical to measure with conventional techniques.