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“Exploration of Morphometric Approaches for Estimating Snow Surface Roughness”

Abstract

In cold climates, the snow surface is often the interface between the atmosphere and the earth. Changes in this surface can have important effects on the hydrologic process, but it is difficult to characterize and model these changes. The roughness of a surface influences atmospheric turbulence, and surface roughness length (Z0) is used to understand the flow of water, temperature, and moisture over a surface. Z0 is a critical variable for estimating latent and sensible fluxes at the surface, but most land surface models treat Z0 simply as a function of land cover and do not address the variability of this value due to changing snow surfaces. This is due in large part to the difficulty and cost of obtaining estimates of Z0. The goal of this research is to compare methods for estimating Z0 and test the viability of approaches that do not rely on expensive wind tower instrumentation. We will test and compare both main approaches available to determine Z0. One method, micrometeorological (or anemometric), relies on field observations of wind turbulence movement to solve for aerodynamic parameters included in the theoretical relations derived from the logarithmic wind profile. The anemometric method can be used for any surface or roughness elements, but its disadvantage is the expense and difficulty involved in installing and operating a wind tower to obtain measurements. The second method, morphometric (or geometric), uses algorithms relating aerodynamic parameters to measures of surface morphometry [Grimmond and Oke, 1999]. Geometric methods have the advantage that values of Z0 can be determined without tower instrumentation. However, most geometric methods are based on empirical wind tunnel tests which do not account for changing wind directions and irregular roughness elements like boulders and trees. We will obtain Z0 values from both procedures and use the anemometric approach to verify and validate the geometric methods, knowing the geometric approach is limited by the accuracy of the description of roughness elements and the ability to accurately simulate real€world conditions [Holland et al., 2008]. In order to accomplish these objectives, a meteorological tower will be installed at the CSU Hort Farm at the center of a 25 by 50€m field. The tower will be equipped with a series of cup anemometers and temperature/relative humidity sensors at logarithmic intervals to allow for anemometric calculations of Z0. The field will be plowed prior to snow accumulation to mimic larger surface roughness features such as sun cups or sastrugi. When a fresh snowpack is present, the site will be visited and photographs will be taken to characterize the snow surface. Wind (plus temperature and relative humidity) profiles will be continuously measured at the meteorological tower. The surface will be scanned with a Terrestrial Laser Scanning (TLS) system which will allow for geometric roughness calculations.