Spatial scaling characteristics of snow depth

Ernesto Trujillo and Jorge A. Ramírez
Department of Civil Engineering, Colorado State University

Kelly Elder
Rocky Mountain Research Station, USDA Forest Service, Fort Collins, CO

Abstract. Spectral analyses were conducted for LIDAR (LIght Detection And Ranging) snow depths measured in six of the nine 1-km2 Intensive Study Areas (ISA's) of NASA's Cold Land Processes Experiment (CLPX) in the spring of 2003 (8-9 of April, 2003). The six study areas analyzed are located in the Fraser and Rabbit Ears Mesoscale Study Areas of the project in the state of Colorado. The snow depth power spectra were compared to the spectra of bare ground elevations (topography) and elevations filtered to the top of vegetation (topography + elevation). The log power spectral density of snow depth versus log of frequency presents two distinct slopes with scale breaks at wavelengths between 6 m and 45 m. The average spectral slopes for the study areas range between 0.4 and 1.4 for the low frequencies intervals, and between 2.94 and 3.41 for the high frequencies intervals, indicating spatial self-affinity of the snow depth profiles. Additionally, box-counting fractal dimensions between 1.4 and 1.6 were obtained for the snow depth profiles. The scale breaks observed in the power spectra of snow depth are not present in the power spectra of topography and/or topography + vegetation, and the slopes of the snow depth spectra differ from the slopes of the power spectra of topography and topography + vegetation. The observed breaks in the power spectra of snow depth are not explained by the power spectra of the underlying topography and vegetation. These scale breaks are a product of the switch in the dominant process(es) driving the variability of the snow cover properties at these scales. Physical causes of the scale breaks are presented for each of the sites based on the characteristics of each of these environments. The spatial variability of snow depth at scales smaller than the scale breaks observed is controlled, among other factors, by the interaction of wind, vegetation, and small topographic features. At larger scales, this variability is controlled by precipitation patterns, short and long wave radiation, aspect, slope, and wind, among others. These differences are analyzed to explain the characteristics observed in the power spectra of snow depth.