Comparison of the spatial organization of snow depth between a forested environment and an alpine environment

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Abstract. Marked differences exist in the spatial organization of snow depth above and below tree line in mountain environments as a product of the difference in the dominant processes controlling the distribution of snow. These differences are studied here based upon the analysis of the spatial statistical and scaling properties of LIDAR (LIght Detection And Ranging) snow depths in two adjacent areas of 500 m by 500 m obtained on April 8 of 2003. These two areas are located in the Alpine Intensive Study Area (ISA) of the Cold Land Processes Experiment (CLPX) in the state of Colorado (USA). The forested area is coverer by a fairly dense and uniform coniferous forest, while the alpine area is covered by short vegetation characteristic of a tundra environment. The empirical probability density functions and the two-dimensional correlograms indicate larger variations of snow depth in the alpine environment, although the forested area presents a weaker correlation structure with a faster decay of the correlation function. The power spectra of snow depth in both areas exhibit segmented power law relationships with frequency, with scale breaks at wavelengths of the order of meters for the case of the forested area and tens of meters for the alpine area. These scale breaks can be explained by a switch in the dominant process(es) controlling the variability of snow depth between the small-scale and the large-scale. The spectral slopes of the larger scales intervals vary around 0.7 for the forested area and around 1.1 for the alpine region, while the spectral slopes of the smaller scales intervals vary around 3.5 for the forested area and 2.4 for the alpine area. The box-counting fractal dimensions of the snow depth profiles vary around 1.5 for the forested area and 1.2 for the alpine area. These results indicate that snow depth profiles exhibit self-affine behavior with two distinct scaling intervals, although marked differences exist in the characteristics of the variability between both environments. These differences are explained by differences in the magnitudes of the mass and energy fluxes of the driving processes in each environment. Physical interpretation of these results and implications for the applications of fractal theories in downscaling methodologies of snow depth measurements are discussed.
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