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Characteristics of the turbulent flow in the surface layer of a Tropical Glacier

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Energy balance studies on glaciers mostly use aerodynamic profile methods, assuming hypotheses of Monin-Obukhov similarity theory are valid, in order to compute sensible and latent turbulent heat fluxes. Nevertheless, various turbulence measurements have shown that the turbulent flow in the surface layer is not in equilibrium and stationnary within mountainous rough topography. Few of these studies focus on tropical glaciers, and little is known about the dynamics of the surface layer in these environnments. We thus have deployed an extensive micro-meteorological experiment within the atmospheric surface layer over the ablation zone of the tropical Zongo glacier, Bolivia, during the dry season from July to August, 2007. Stations were installed around 5050 m a.s.l. They included two complete eddy covariance systems at a 2-m mean level and a 6-m mast measuring the mean profiles of air temperature and of wind speed. Data is used to characterize the conditions in the surface layer. Weakly stable conditions prevailed in the first meters above the ice or snow surface. With weak large scale forcing, a katabatic downslope flow with a wind maximum at about 2-m height usually appeared in the middle of the afternoon and maintained itself during most of the night. Profile data is fitted to derive roughness lenghts and characterize their evolution. The study of statistical moments of high frequency wind speed and temperature data shows that the wind regime was highly gusty and irregular. Stationary conditions were rarely encountered. Characteristics and structure of the turbulent flow were studied using spectral analysis. It shows that the observed turbulence cannot be generated only by local shear and that low frequency perturbations interact with the surface layer turbulence and lead to divergence from the classical Kansas surface layer curves. We compare the spectra for different typical meteorological conditions and katabatic wind maximum heights. It gives us insights on the extent of these perturbations regarding to the conditions. We test the influence of the nearness of the wind maximum on eddy covariance measurements and flux divergence in the few meters above the surface.