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Surface roughness heights derived from wind and temperature profile measurements: comparison with eddy correlation. Case study of a high altitude glacier in the Bolivian Andes.

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The turbulent fluxes remain poorly known on tropical glaciers. Different studies based on the bulk method have shown that sublimation can be important during the dry season, reducing the energy available for melting. However, uncertainties on the bulk method are large, especially when the katabatic wind causes a wind speed maximum at low height. Eddy correlation measurements have been conducted at 5050 m elevation on the Zongo Glacier, Bolivia (16°S) in July-August 2007. Concomitant measurements of all radiation components, snow surface temperature and of vertical gradients of air temperature and wind speed were made. The site was approximately level within several hundred meters, with drainage winds prevailing at night and most of the day. The surface roughness heights for temperature and momentum were derived from the profile measurements at the hourly time scale. Results indicate values from 0.1 to 1 cm in rough agreement with terrain observations. However, the uncertainties on the roughness height for temperature are large and the relation of Andreas (1987) can not be thoroughly tested. The results show that in this dry and thin atmosphere, surface temperatures below freezing are maintained with significant cooling of the surface due to sublimation and low long-wave radiation input. The agreement between the bulk and the eddy correlation methods is rather good, except during periods of calm wind when errors are large in both methods. The roughness height for momentum derived from the eddy correlation is also in good agreement with the heights derived from the profile measurements. However, the measurement period of the eddy correlation is short and more work must be done to quantify the errors on the method.