Geophysical Research Abstracts
Vol. 21, EGU2019-9228, 2019
EGU General Assembly 2019

Atmospheric boundary layer dynamics on an alpine glacier: Effect of katabatic flow variation and local heat advection on turbulent exchange processes

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Multiscale interactions between the glacier surface, the surrounding alpine terrain and the overlying atmosphere are highly complex. The heterogeneity of boundary layer processes that couple these systems is responsible for large heterogeneity of energy fluxes and therefore leads to strongly variable melt rates. A comprehensive measurement campaign, the HEFEX (Hintereisferner Experiment), was conducted during three weeks in August 2018. The aim of this experiment was to investigate spatial and temporal dynamics of the near-surface boundary layer and associated heat exchange processes at the glacier surface during the melting season. The experimental setup was designed to capture the spatial characteristics of the katabatic flow across the glacier and influences of warm air advection on local energy flux variability. The measurement network consisted of five 3-m towers, located at an along and an across glacier transect. The instrument set-up at each tower consisted of a wind profile at three heights above the ice surface, and temperature, relative humidity and pressure measurements at a single level. Four towers were additionally equipped with eddy covariance sensors measuring turbulence characteristics at two heights above the ice surface. Furthermore cold-air flow close to the glacier surface was investigated with a thermal camera pointing at a synthetic projection screen reflecting air-temperature fluctuations near-by. Combining the different data sets allowed us to analyze the spatio-temporal variability of the katabatic flow at different locations on the glacier and the effect this has on turbulent heat fluxes contributing to ice melt. Local turbulence profiles of momentum and heat revealed strong differences in the strength and height of the katabatic flow at locations away from the main glacier axis, as well as day-to-day variability. This heterogeneity in the local wind system is responsible for the changes in the importance of local heat advection from the surrounding area.