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Effects of local microclimates on the surface sensible heat flux on a mid-latitude alpine valley glacier using Large-Eddy Simulations

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While the large-scale climate conditions play an important role in shaping the environment in which glaciers exist, the mass and energy balance of each individual glacier are dictated by local conditions. Given the complex mountain topography around alpine glaciers, it is not trivial to find a direct link between the large-scale atmospheric motions and the local-scale weather conditions at an individual glacier. Non-local dynamic effects due to the surrounding complex topography can significantly modify the spatial variability of exchange processes, either by small scale circulations or episodic entrainment of heat and momentum by burst events.

Motivated by the fact that distributed glacier models strongly rely on the quality of high resolution forcing data to adequately represent the glacier wide ablation and accumulation processes, the present study investigates (i) whether non-local topographic effects have a significant impact on the spatial distribution of turbulent sensible heat fluxes (local microclimates) over alpine glaciers, and (ii) how much variability is smoothed out when using linearly interpolated fields together with the commonly used bulk approach. To answer these questions, we perform highly resolved and properly designed case experiments by Large-Eddy Simulations with real topography to determine the impact of topographic flow features on the spatial variability of the surface sensible heat flux and compare the fields with those derived with the bulk approach.

The analysis shows that there is a significant spatial variability of the mean fluxes with values ranging from -10 Wm^{-2} to -120 Wm^{-2}. Since the sensible heat flux can make up to 40% of the total melting on mid-latitude alpine valley glaciers, the heterogeneity of the fluxes can substantially dictate the local melting rates. When estimating the glacier-wide surface heat fluxes on the basis of point-measurements and the bulk approach, a considerable amount of spatial information is lost. All together, the bulk approach underestimates the average glacier-wide sensible heat flux by more than 20%, which might lead to great uncertainties in the calculated glacier-wide ablation rates.