Geophysical Research Abstracts
Vol. 21, EGU2019-10902, 2019
EGU General Assembly 2019

Determination of glacier surface roughness lengths through in situ and remote observation

Noel Fitzpatrick (1), Valentina Radic (1), and Brian Menounos (2)

(1) Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, Canada (nfitzpat@eoas.ubc.ca), (2) Natural Resources and Environmental Studies Institute and Geography Program, University of Northern British Columbia, Prince George, Canada

The roughness length values for momentum, temperature, and water vapour are key inputs to the bulk aerodynamic method for estimating turbulent heat flux. Measurements of site-specific roughness length are rare for glacier surfaces, and substantial uncertainty remains in the values and ratios commonly assumed when parameterising turbulence. Over three melt seasons, eddy covariance observations were implemented to derive the momentum and scalar roughness lengths at several locations on two mid-latitude mountain glaciers. In addition, two techniques were developed in this study for the remote estimation of momentum roughness length, utilising LiDAR-derived digital elevation models with a 1 x 1 m resolution. Seasonal mean momentum roughness length values derived from eddy covariance observations at each location ranged from 0.7–4.5 mm for ice surfaces, and 0.5–2.4 mm for snow surfaces. From one season to the next, mean momentum roughness length values over ice remained relatively consistent at a given location (0–1 mm difference between seasonal mean values), while within a season, temporal variability in momentum roughness length over melting snow was found to be substantial (> an order of magnitude). The two remote techniques were able to differentiate between ice and snow cover, and return momentum roughness lengths that were within 1–2 mm (« an order of magnitude) of the in situ eddy covariance values. Changes in wind direction affected the magnitude of the momentum roughness length due to the anisotropic nature of features on a melting glacier surface. Persistence in downslope wind direction on the glacier surfaces, however, reduced the influence of this variability. Scalar roughness length values showed considerable variation (up to two and a half orders of magnitude) between locations and seasons, and no evidence of a constant ratio with momentum roughness length or each other. Of the tested estimation methods, the Andreas (1987) surface renewal model returned scalar roughness lengths closest to those derived from eddy covariance observations. Combining this scalar method with the remote techniques developed here for estimating momentum roughness length may facilitate the distributed parameterisation of turbulent heat flux over glacier surfaces without in situ measurements.