Dynamics of a small surge-type glacier, St. Elias Mountains, Yukon Territory, Canada: Characterization of basal motion using 1-D Geophysical inversion

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The dynamics of a small surge-type valley glacier are investigated as part of a study to evaluate the modulating role of glacier dynamics on the glacier response to climate in the Donjek Range of the St. Elias Mountains, Yukon Territory, Canada. Surface elevation and ice thickness data were collected on the study glacier between 2006 and 2008 using kinematic global positioning system (GPS) techniques and ice-penetrating radar. These data were used to construct digital elevation models (DEMs) of the glacier surface and bed by kriging. A velocity pole survey was also conducted during three consecutive summer field seasons. The displacements of 12 poles located along an approximate flowline were recorded over a one-month period each year using kinematic GPS techniques. Measured surface velocities range from less than 10 \( \text{ma}^{-1} \) over the lowermost 1500m of the 5 km-long glacier to a maximum of \( 25-35 \text{ma}^{-1} \) over the upper 3500m. The velocities over this upper zone are higher than expected for a surge-type glacier of this size in its quiescent phase, but much lower than typical surge velocities. Basal velocities along an approximate flowline are reconstructed from the measured surface velocities using a 1-D geophysical inverse model. An analytical relationship between the basal velocity, deformational velocity and surface velocity of an ice body flowing in a channel defines the forward model, which is subsequently linearized using a method of longitudinal averaging for variable ice thickness and surface slope. To perform the inversion itself, two different methods are tested through a set of control tests using synthetic input data. The singular value decomposition method (SVD), identified as the most accurate, is subsequently used to invert the measured surface velocities, and sensitivity tests are performed to evaluate the influence of the shape factor, the flow-law coefficient, the longitudinal averaging length and the errors on the data. Inversion of the measured surface velocities yields results that are reasonably robust with respect to uncertain parameters, and shows that basal motion accounts for roughly 50–100% of the total surface motion along the flowline. Such a high contribution of basal motion is characteristic of surging glaciers. The high modelled contribution of basal motion above 1700m along the flowline, the undulation of the glacier surface, the observation of many crevasses, and the fact that the subglacial drainage system appears to be strongly influenced by factors other than topography in this region suggest that the glacier is not in a state of quiescence. In addition, to sustain the measured surface velocities would require a more positive mass balance than has likely been obtained in recent years. Based on the evidence presented in this thesis, we suggest that the glacier may be undergoing a slow surge.