Short-term flow variations under the control of basal conditions in a temperate valley glacier

Shin Sugiyama

Glacier Research Group, Institute of Low Temperature Science, Hokkaido University
Sapporo, Japan

Background

Temperate glaciers flow with two mechanisms, viscous deformation of ice and basal motion. Basal conditions, such as subglacial water pressure, are an important factor to discuss glacier flow variations because they determine both of the flow mechanisms. Not only in small mountain glaciers, temperate bed condition takes key role in ice sheet flow in Antarctica and Greenland as well. It has been suggested that surface flow speed is related to subglacial water pressure by field observations. Detail interaction between basal conditions and glacier flow fields, however, has not been studied based on field data.

Objectives

This thesis studies the influence of basal conditions to flow fields in a temperate valley glacier based on the high temporal resolution measurements of surface flow velocity, internal ice deformation, and subglacial water pressure. Discussion focuses particularly on the following three topics.

(1) Relationship between surface flow velocity and subglacial water pressure

(2) Vertical movement of glacier surface (uplift)

(3) Temporal variations in vertical strain within a glacier

Hypotheses constructed for the field data are verified by newly developed two-dimensional finite-element glacier flow model.

Results

Field study was carried out in Unteraargletscher, Swiss Alps from June to October 2001. Main measurements on the glacier are GPS survey on the surface, water pressure measurement in a bottom reached borehole, and borehole depths measurements. New findings obtained from the four series of continuous measurements, 1-2 weeks for each, are as follows.

(1) Hysteresis in the surface flow speed against the water pressure change

(2) Surface uplift due to vertical straining and volume increase in subglacial water cavities

(3) Diurnal variations in the vertical strain of ice

(1) suggests that flow speed at a point on a glacier is not determined only by basal motion below, but influenced by neighboring basal conditions. (2) indicates uplift can be caused by two different mechanisms. (3) confirms internal ice deformation varies within a short time scale and contributes to short-term glacier flow variations. Numerical investigation shows that basal conditions within a horizontal spatial scale of 10ice thickness are relevant to the glacier flow at a point, which is harmonious to the field measurement results.