High frequency surface strain measurement in Unteraargletscher

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Background

During the ablation season, flow speed of a glacier fluctuates under the influence of melt water. Water drained to the bed of a glacier is considered to enhance basal motion. However, the influence of basal conditions on glacier flow regime is complicated and not well understood.

Field measurements

In summer 2003, glacier surface was surveyed every 1-3 hours with 3 GPS's in Unteraargletscher, Bernese Alps (Fig. 1). This measurement aimed to obtain temporal variations in surface strain rate with high temporal resolution. Surface flow speed measured at the site GPS-3 showed diurnal variations from 10 to 14 July during the period of fine weather (Fig. 2). Figure 3 shows surface strain rate calculated from the GPS measurements at the sites GPS-3, 4 and 5. Each ellipse represents five-day mean strain rate during three hours in each time period of the days. In general, principal axes incline 45 degree to the flow direction because of the shear strain established by the drag of the valley walls. An interesting feature of the temporal strain variation is shear strain enhancement observed twice a day at noon and midnight.

Discussion

Possible interpretation of the two maxima in the strain rate is diurnal migration of basal lubrication in the transverse direction. Early in the morning, bed is not lubricated because of little water input from the surface (Fig. 3a). Towards the noon, melt water starts to lubricate the central part of the bed. Because only the central part of the glacier is accelerated, shear strain shows maximum at this time of day (Fig. 3b). More water is drained into the bed in the afternoon increasing flow speed evenly across the glacier. Shear stress is transfered very close to the margin when basal stress is reduced at the large area of the bed, and the strain rate at the study site decreases (Fig. 3c). In the midnight, lubricated area gets narrow as water input decreases, and the strain rate is enhanced again (Fig. 3d).

Future prospect

To test the above hypothesis, we are planing to analyze strain and stress field in a glacier cross section using a viscous flow model.

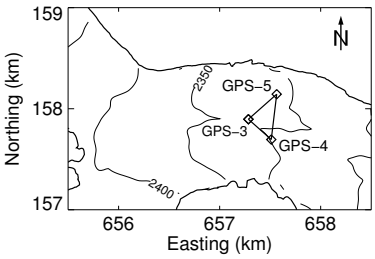

Figure 1: Map of the study area at Unteraargletscher.

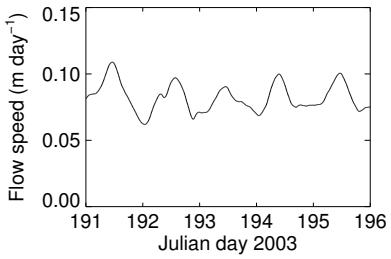

Figure 2: Surface flow speed at the site GPS-3.

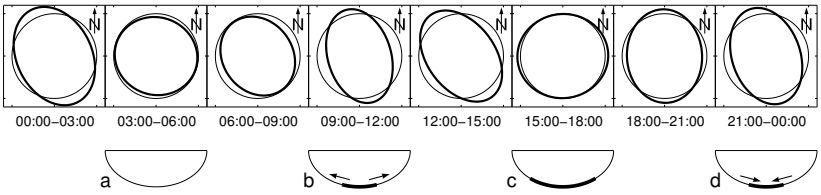

Figure 3: Surface strain rate ellipses calculated from the strain grid GPS3-4-5. The strain rates are exaggerated by a factor of 2.5×10^4*. Schematic diagrams are glacier cross sections showing the hypothesized bed conditions described in the text. Bold line along the bed indicates water lubrication.*