Reconstruction of past accumulation rates in an alpine firn region: Fiescherhorn, Swiss Alps

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Abstract

Knowledge of past annual accumulation rates is an important contribution to our understanding of climatic changes. With a newly developed method for measuring the vertical strain-rate, the accumulation rate history can be reconstructed by determining the thinning rate of ice layers with increasing depth. The theory will be applied to the measured layer thicknesses derived from an ice core from Fiescherhorn glacier, Swiss Alps. The reconstructed accumulation rate history is compared with an earlier method.

Firn and ice layers in polar and high mountain ice masses constitute valuable archives of past climates and the history of chemical composition of the atmosphere. A new ice core was drilled on Fiescherhorn Glacier in December 2002 in the context of the project VITA (Varves, Ice cores and Tree rings: Archives with annual resolution) of the Swiss National Center of Competence in Research (NCCR Climate). One of the purposes of the ice core drilling was the reconstruction of past annual accumulation. The study site (46° 33' north, 8° 4' east) is located in the accumulation area of the Fiescherhorn glacier in the Swiss Alps on a plateau with an area of about 0.5 km² and a mean elevation of about 3900 m a.s.l.

Accumulated annual layers of snow are buried by snow layers of the following year. With increasing depth, the layers become progressively thinner because of plastic compression. With the assumptions that velocity, density and surface elevation are in steady state, and density and mean velocity are functions only of depth below the ice surface, the thinning of annual layers with depth is reconstructed. Interestingly, under these assumptions, information on the density profile is not required anymore.

The assumptions that only the density field is in steady state and only a function of depth below ice surface (Sorge's Law) requires either additional measurements or an additional assumption of ice mass continuity. This case may be generalized to a 3-dimensional field such as a borehole in a sloping region, because the integrated thinning does not depend on the particle path, but only on the starting point at the surface and the point of the ice sample in the borehole. On the other hand, this requires some information on the position where the corresponding ice samples in the borehole were accumulated on the surface.