



## **How well do we know near-surface density when determining mass balance by the geodetic method?**

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From a data set of firn pits in the accumulation area of Hintereisferner in the years 1964 – 2002 the behavior of density and water equivalent was analyzed with a view to estimating the potential errors in the application of the geodetic method. Since annual specific balance ranged from 100 to 3300 mm w.e. the profiles were scaled to total depth. For the uppermost 10% of the annual deposit at a typical location the 1964-2002 mean density would be  $350 \text{ kg/m}^{-3}$  with a standard deviation of  $110 \text{ kg/m}^{-3}$ ; for the 10% layer at the base of the annual snowpack the respective figures are  $510 \pm 30 \text{ kg/m}^{-3}$ .

The normalized long term means of an ensemble of 9 pits ranged from 310 to 380  $\text{kg/m}^{-3}$  in the top layer and from 510 to 540  $\text{kg/m}^{-3}$  in the bottom layer. When one outlier is removed the the range in the bottom layer reduces to 525 to 540  $\text{kg/m}^{-3}$ . This small local variance encourages the use of the geodetic method.

The comparison of elevation models of 1969 and 1997 yields a mass change that agrees very well with the results of the glaciological method provided the volume change is converted to mass with a density of  $900 \text{ kg/m}^{-3}$ . While this may be true for the entire glacier on long terms, it will fail for individual years in the accumulation area. Possible errors are calculated from the data set emphasizing the role of year to year changes of specific balance and accumulation area ratio.