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Is densification of polar firn abnormal ?

M. W. Hörhold, S. Kipfstuhl, F. Wilhelms, and J. Freitag
Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, (Maria.Hoerhold@awi.de)

The high resolution density of 16 firn and shallow ice cores from Greenland and Antarctica was determined by applying the gamma-ray absorption method. Profiles of mean density and density fluctuations (i. e. deviations from the mean) are presented and discussed.

The profiles of mean density show the patterns well known from the numerous firn cores studied so far. However, the density fluctuations appear to behave anomalous insofar, as for a layered medium we expect a direct correlation of the density fluctuations with the increase in density. That means that the deviation from the mean decreases steadily with increasing density, until the density of bubbly ice is reached. But in contrast to the expected steady decrease we observe a relatively fast decrease of the amplitudes in density fluctuations close to the surface. They assume a local minimum for densities between 600 and 650 kg/m$\hat{3}$ (in depths of 20 to 50 meter, depending on accumulation rate and annual mean temperature) but then increase again. Local maxima are obtained for densities between 750 and 850 kg/m$\hat{3}$, leading to increased amplitudes throughout the firn-ice transition. Below the fluctuations decrease again, approaching the values for bubbly ice.

Since the investigated cores reflect different climate conditions with accumulation rates varying from 30 mm water equivalent per year to >1500 mm water equivalent per year and annual mean temperatures from -20°C to -55°C we assume, that the behaviour of the density fluctuations observed in our cores is a fundamental property of polar firn, not discussed much in literature due to the lack of high resolution density profiles. The possible origin and implications of this phenomenon, e. g. for modelling the densification of polar firn or the air enclosure processes, are discussed.