Shallow firn cores from Neumayer, Ekströmisen – A comparison of dating methods, accumulation rates, and stable isotope ratios

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Introduction

Since the pre-site survey for the German Antarctic base "Georg von Neumayer" in 1979/80 glaciological studies have been carried out on Ekströmisen (e.g. Reinwarth et al., 1982, Reinwarth and Graf, 1985), including accumulation stake measurements, snow pit and shallow firn core studies, at first in order to get information about accumulation rates at the construction site for the base, later also for isotope and chemical investigations.
This paper focuses on two firn cores taken 1989 and 1998, respectively, and one of the oldest cores (from 1982) which, being 52m long, is still the deepest one. The lengths of the other cores vary between 10m and 27m.

Data

A stake array was set up to the southeast of the base in 1981. Accumulation has been measured since then with a few exceptions on a weekly base. Snow pits were dug and shallow firn cores taken in unregular time intervals. Snow stratigraphy, chemical properties, stable isotope ratios (in some cases also tritium contents) were investigated. Detailed information about the data can be found in Schlosser et al., 1999. Fig. 1 shows the core B04 taken in 1982. This core was also analysed for tritium, which was used to control the dating. Fig. 2 shows core FB0189, which does not show a very regular isotope stratigraphy, nonetheless the accumulation rates derived from it agree very well with the stake data (Fig.3).

Accumulation rates

In Fig. 4 the accumulation rates from core B04 and FB0198 since 1955 are shown. Both cores show high interannual variations and do not agree very well due to the high spatial variability of accumulation because of the extreme wind influence. Whereas in B04 a decreasing trend can be found between 1892 and 1980 (Fig. 5), FB0198 (Fig. 6) shows almost no trend at all for the time period 1955-1997. The extremely high spatial variability should warn to be careful with the interpretation of the data concerning trends.

Isotope ratios

Fig. 7 shows the mean annual $\delta^{18}O$ for core B04 compared to FB0198 (1955-1982), Fig. 8 for FB0198 (1955-1997). The isotope values of both cores agree much better than the accumulation rates. We assume that this is due to the fact that the isotope ratios are relatively uniform during single precipitation events.
Both cores show increasing $\delta^{18}O$ values during this century until the 1980s, later FB0198 shows rather decreasing values. Neither of those trends can be interpreted climatically, since at Ekströmisen the annual mean $\delta^{18}O$ is strongly dependent on seasonal distribution

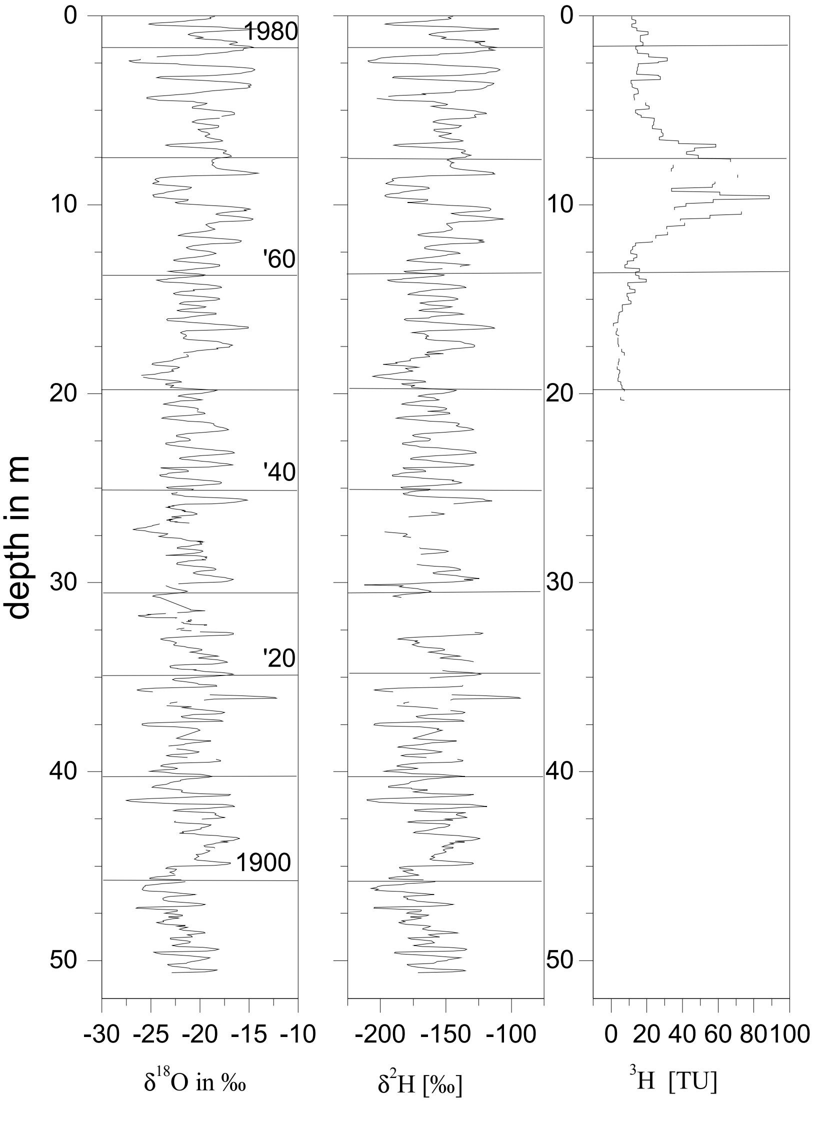

Fig. 1: Firn core B04, taken in Feb.1982 at GvN

of accumulation (Schlosser, 1999) which predominates the temperature effect. For smaller time scales (months, see Pfaff, 1992), the $\delta^{18}O$ is highly correlated to temperature.
Fig. 9 shows the annual mean temperature at Neumayer since 1981, no trend corresponding to the $\delta^{18}O$ trend can be found during the past two decades.

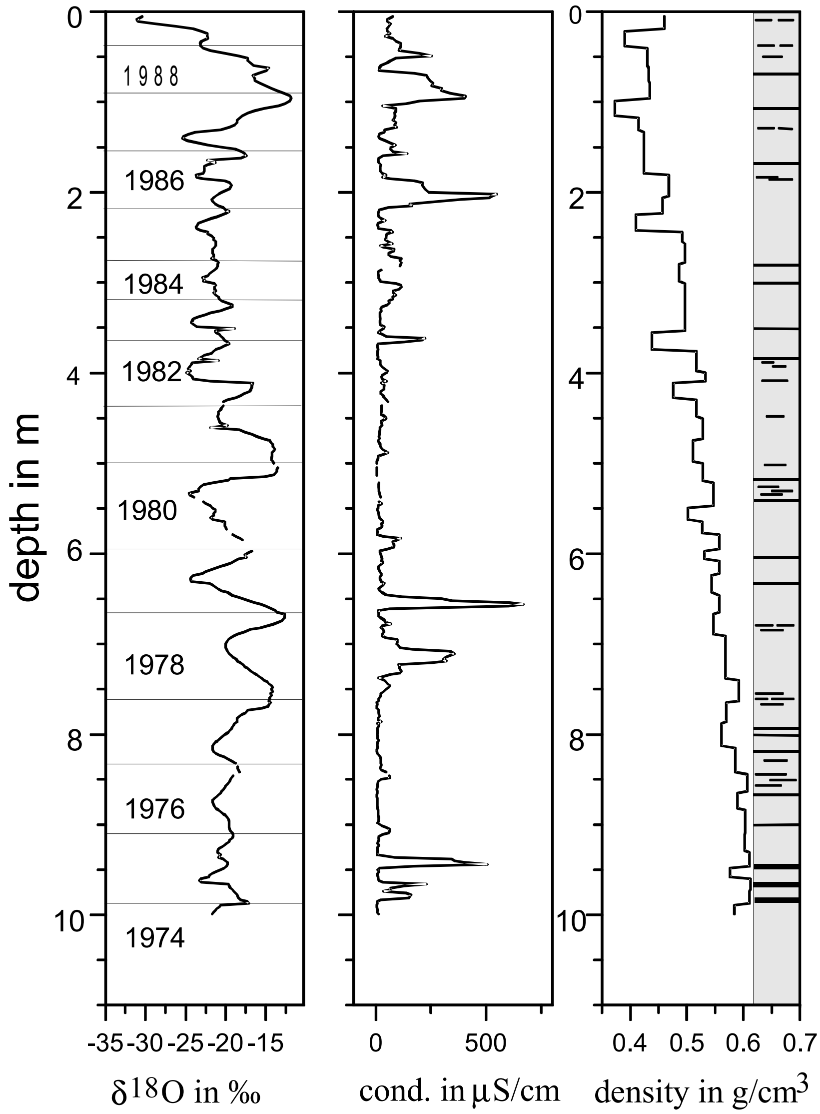

Fig.2: Shallow firn core FB0189, Neumayer, Dec. 1989

Comparison of dating of the cores using stake data, DEP and isotope stratigraphy

Fig. 10 shows the conductivity and $\delta^{18}O$ profiles for core FB0198 together with the corresponding dating. The numbers correspond to the $\delta^{18}O$ dating. 1948 is the last year of the DEP dating. These two dating methods yield different results. For the last two decades the dating could be checked using the stake measurements, which proofed that the $\delta^{18}O$ profile yielded the more exact dating in this case. Differences are largest in those parts of the core where the conductivity is fairly unregular, whereas the isotope profile shows a clear seasonal variation. There are still some uncertainties in the lower part of the core. Unfortunately, the stake measurements did not start before 1981. The difference between the two datings is 7a in 49a or 42a corresponding to an error of 14% and 17%, respectively.

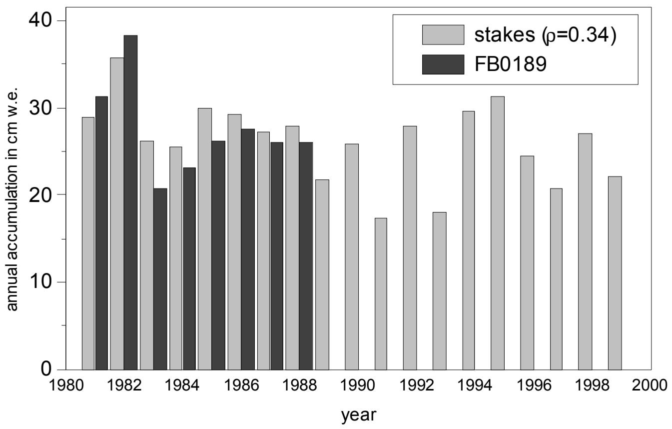

Fig. 3: Mean accumulation rates from stake array and core FB0189

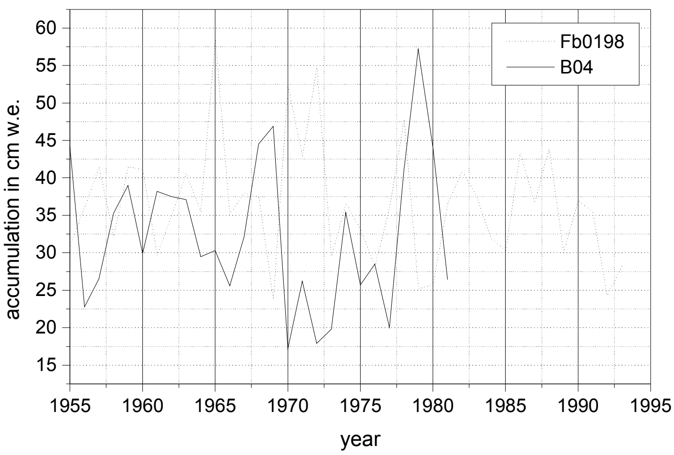

Fig. 4: Annual accumulation rates from B04 and FB0198

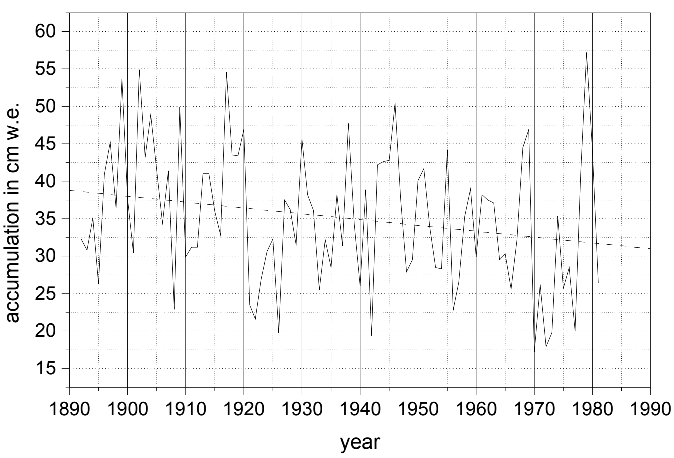

Fig. 5: Mean annual accumulation of core B04

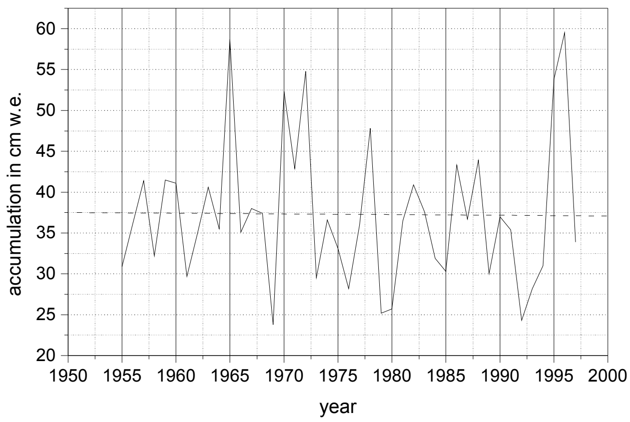

Fig. 6: Mean annual accumulation from core FB0198

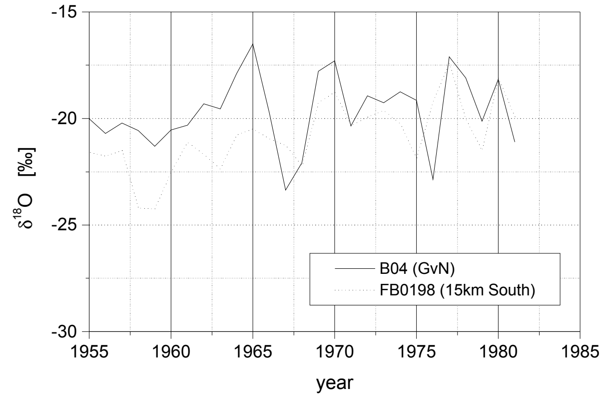

Fig. 7: Annual mean $\delta^{18}O$ from cores B04/ FB0198

Conclusions

Accumulation rates around Neumayer amount to about 360mm. The spatial distribution of accumulation is very uneven due to large wind influence. No trend was found in accumulation rates during the last 50 years. Earlier in the century the accumulation decreased. Trends have to be considered very cautiously because of the extremely high interannual variability of accumulation. In spite of the highly unregular accumulation distribution the stable isotope ratios show less spatial variability, presumably because the isotope ratios are the same over a wider area during one precipitation event. $\delta^{18}O$ values seem to have increased during the 20th century, since the late 80s a decrease is observed. This trend is not related to temperature, since the mean annual temperature at Neumayer shows no significant trend over the last two decades.

A comparison of dating of a core using DEP and isotope stratigraphy shows a difference of about 15% between the two methods for a time period of about 45 years.

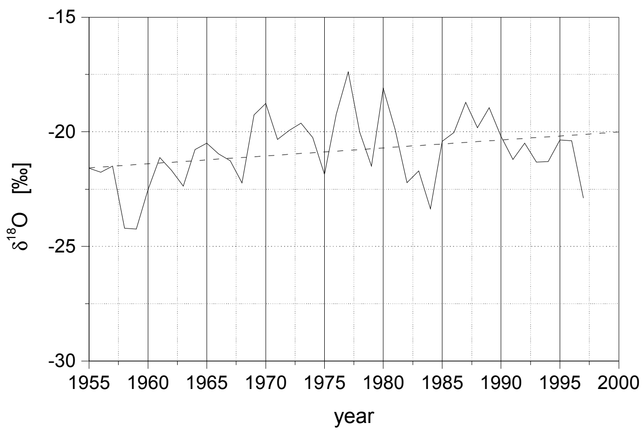

Fig. 8: Annual mean $\delta^{18}O$ from core FB0198

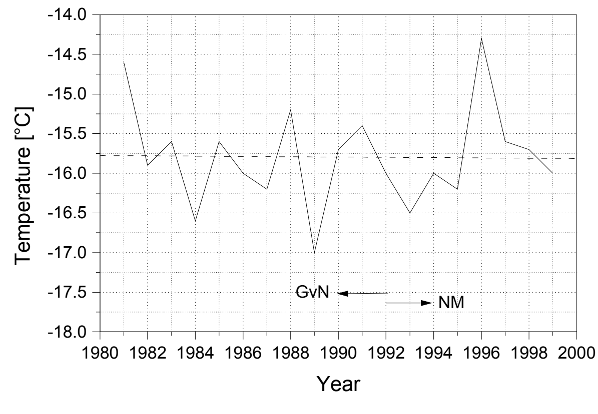

Fig. 9: Annual mean temperature at Neumayer 1981-1999

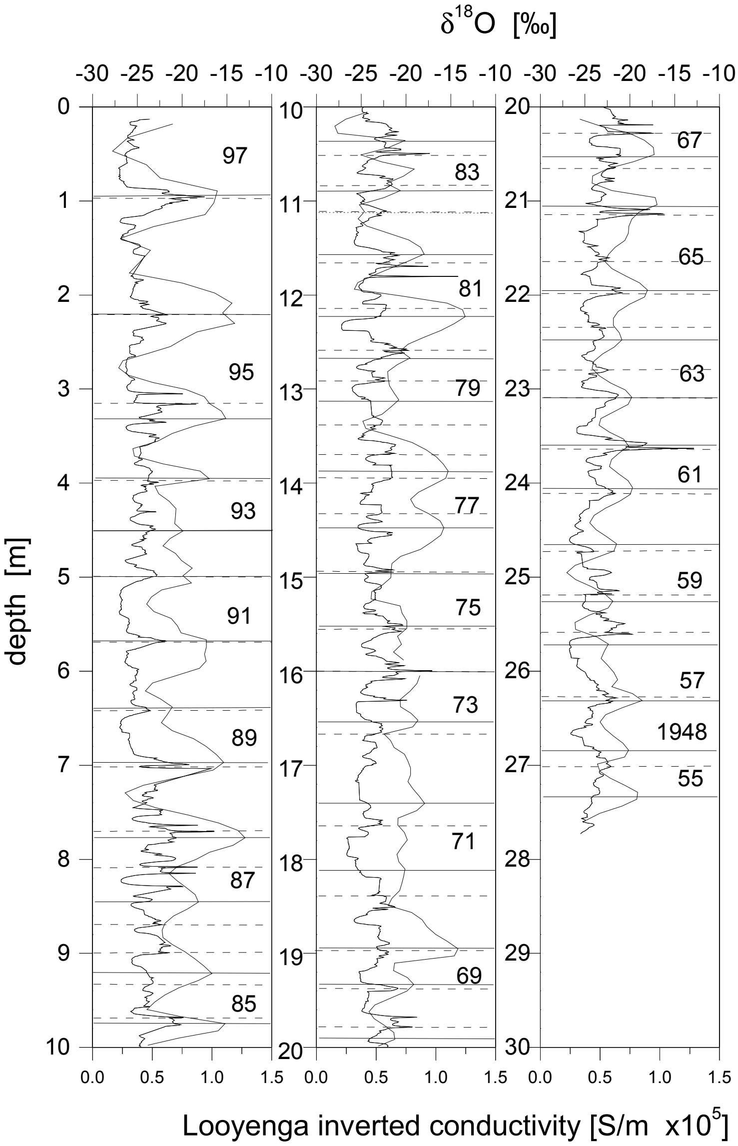

Fig. 10: Core FB0198: Conductivity (bold line) and $\delta^{18}O$ (thin line), and corresponding dating (dashed and solid, respectively), numbers correspond to $\delta^{18}O$, 1948: last year of the DEP dating.

Acknowledgements

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