δ^{18}O records from Berkner Island and Dronning Maud Land, Antarctica

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1 Introduction

New climate and environmental records from ice cores have become available during the last 5 years from Berkner Island and Dronning Maud Land, Antarctica (Fig. 1). The two regions are quite different. Berkner Island is located at the margin of the continent and influenced by the Weddell Sea, whereas Dronning Maud Land on the inland ice is influenced by the Atlantic ocean. The cores were drilled within the British-German Berkner Island project and within the European Project for Ice Coring in Antarctica (EPICA), respectively. Mulvaney (1995) gives an overview of the aims of the Berkner Island project. Preliminary results from ice and firn core analyses are reported by Miners and Mulvaney (1995), Mulvaney et al. (1996), Graf et al. (1997) and Oerter et al. (2000). Results from the analysis of the firn and ice cores from Dronning Maud Land are published by Oerter et al. (1999) and Oerter et al. (2000). This paper focuses on the comparison of the records from the Weddell Sea region and from Dronning Maud Land.

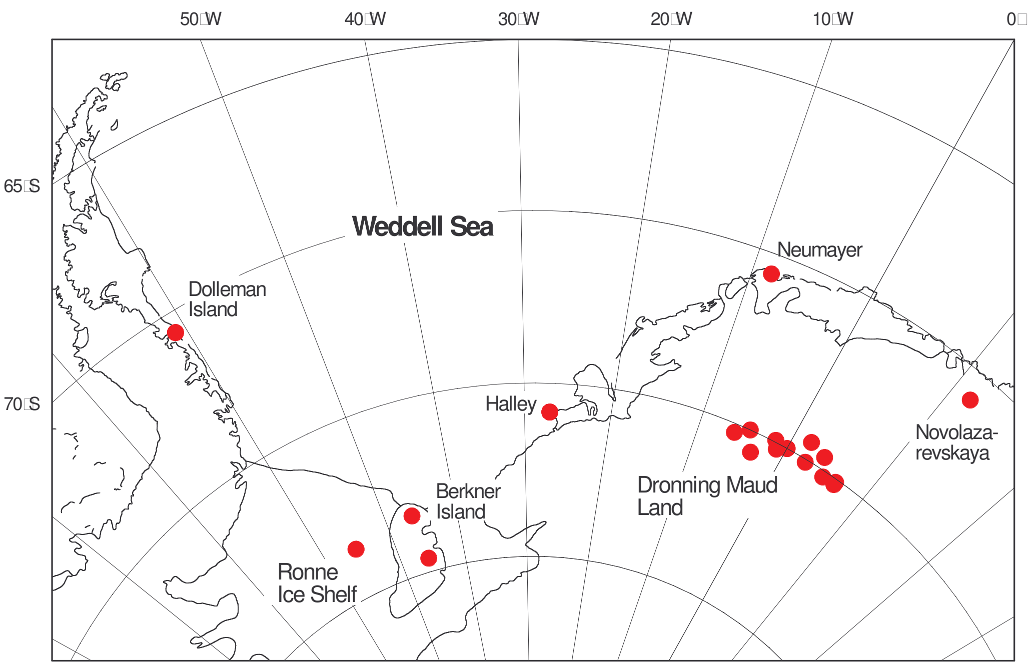

Fig. 1: Map of the Weddell sea sector of Antarctica with the location of stations and drilling sites of ice cores.

2 The firn and ice cores

The characteristics of the drilling sites of the firn and ice cores are summarised in Tab. 1 (see also Wagenbach et al. 1994). All parameters reflect the contrast between the lower altitude, near coastal location of Berkner Island and the continental situation in Dronning Maud Land. Besides the ice cores retrieved at the locations listed, several 10-20 m firn cores were collected on Berkner Island and another ten firn cores (10 m deep) and fifteen firn cores (30 to 40 m deep) were drilled in Dronning Maud Land, which cover the last 200 years. The Berkner cores were dated by ECM (Miners and Mulvaney, 1995), the Dronning Maud Land by using DEP (Wilhelms et al. 1998) and CFA (Sommer et al. 2000). All profiles reflect the chemistry of the firn and ice, and display volcanic horizons like those caused by the eruption of Krakatao (1883), Tambora (1815), an unknown volcano (1810), Kuwae (1458) and El Chichon (1259) as well as seasonal variations of the ice chemistry. Both the seasonal variations and the volcanic horizons were used to date the firn and ice cores. The dating at the horizons is as accurate as the volcanic chronology and the accuracy of the dating in between is about 2% of the time to the next horizon; the accuracy of the depth-time scale and the accumulation rates are also dependent upon the uncertainty of the depth logging.

Tab. 1: Drilling sites on the north and south dome of Berkner Island in 1994/95 and the region in Dronning Maud Land, where fifteen firn cores (30 to 40 m deep) and three ice cores were drilled in 1997/98. The data of Berkner Island South refer to the drilling site which is 5km to the south of the true summit of Thyssenhöhe; see Oerter et al. (2000) for the spatial variability of the parameters.

Drilling site	**Berkner Island**		**Dronning Maud Land**		
	Reinwarth-höhe	**Thyssen-höhe**	**DML07** (Core B31)	**DML05** (Core B32)	**DML17** (Core B33)
Latitude	78° 18' S	79° 36' S	75° 34.89' S	75° 00.14' S	75° 10.02' S
Longitude	46° 17' W	45° 37' W	3° 25.82' W	0° 00.42' E	6° 29.91' E
Elevation (m a.s.l.)	≈ 710	≈ 860	2669	2882	3160
10 m firn temperature (°C)	-24.1	-26.2	-44.3	-44.5	-46.1
Accumulation rate (kg $m^{-2}a^{-1}$)	226	142	59	62	47
^{18}O content (‰)	-23.8	-28.8	-44.9	-45.1	-46.6
Ice core depth (m)	152	182	115	150	130
Age at the bottom of the cores (years)	≈ 600	≈ 1200	≈ 1300	≈ 2000	≈ 1800

3 Records of accumulation rates and stable isotope content

The depth resolution of the measuring profiles is high enough to derive annually resolved records. While records of accumulation rates and at least one of the stable isotope records (^{2}H, ^{18}O) are available from all sites, those of chemical constituents are not yet all available, which could help in the interpretation of the isotopic profile. The records belong to the few climatic records from Antarctica, which document the last 500 years with a high temporal resolution. Mosley-Thompson (1995) could discus only five such records, e.g. from Siple Station, Ronne Ice Shelf, Mizuho, Law Dome and South Pole.

The large number of cores available from Dronning Maud Land offer the opportunity to build a composite record in which the signal-to-noise variance is distinctly reduced in comparison to the individual records. The residual noise variance in the composite 200-year record of accumulation rates from Dronning Maud Land is still high and obscures the short term variations. The noise variance in the ^{18}O series is lower and variations with a period of about 20 years are detectable. Regarding long term variations, both time series display low values at the turn from the 19th to the 20th century, possible caused by variations in the build-up of the snow cover or in temperature (Oerter et al. 2000). This long term variation is the reason for a correlation between both time series. Also, the 1000-year chronologies from DML display remarkable features, e.g. a 300-year period from 1250 to 1550 AD of low ^{18}O values. In the context of the whole 1000-year ^{18}O record, the slight increase of the ^{18}O values in the 20th century seen in the DML core does not seem extraordinary.

Mulvaney et al. (1996) compared the records from the North and South dome of Berkner Island and Dolleman Island. They did not find great similarities between the records, though they observed a similarity in the ^{18}O signal in the 70s in the Dolleman Island and Berkner Island North records, but this was not extended to the record from Berkner Island South. We introduce into our analysis here the records from the Ronne Ice Shelf and Dronning Maud Land and correlate the records. It is well known that the result of a cross-correlation analysis of two time series depends on the time interval considered. Therefore, the relationships between records is much better described by a series of correlation coefficients calculated in a moving window than by a single value.

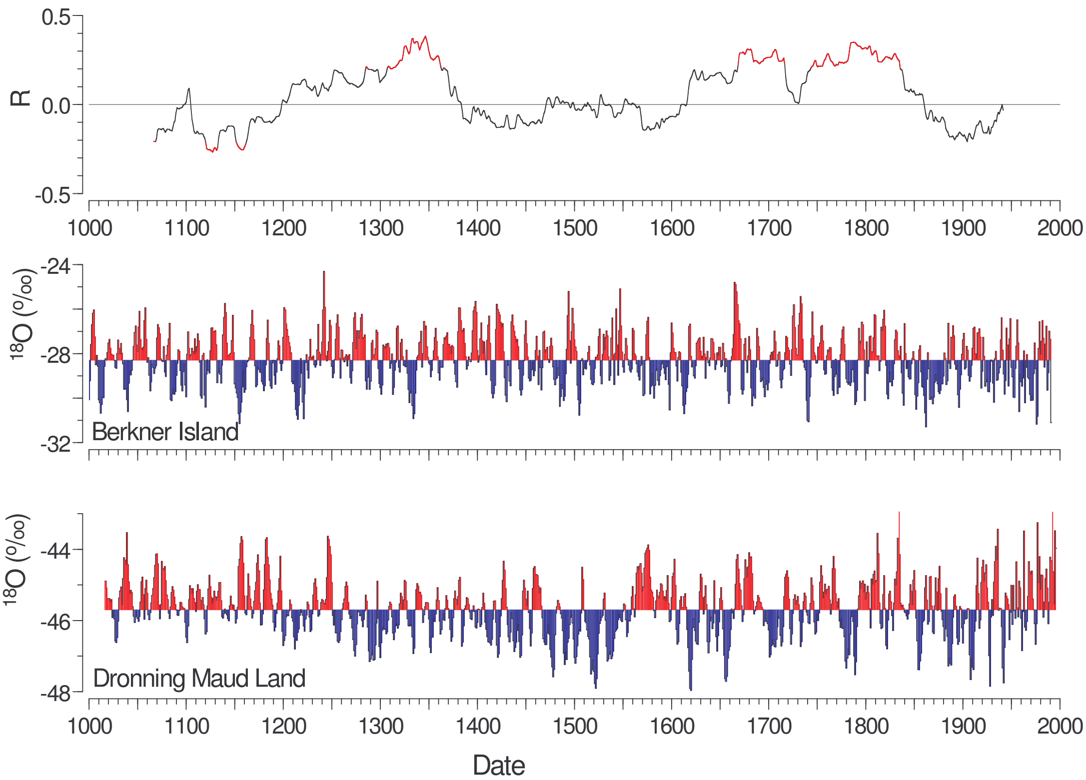

Fig. 2: Annually resolved time series of ^{18}O contents derived from ice cores drilled on Berkner Island South and in Dronning Maud Land. The later record consists of three individual ones. The figure on the top shows the cross-correlation coefficients between these two records calculated in a moving 100-year window.

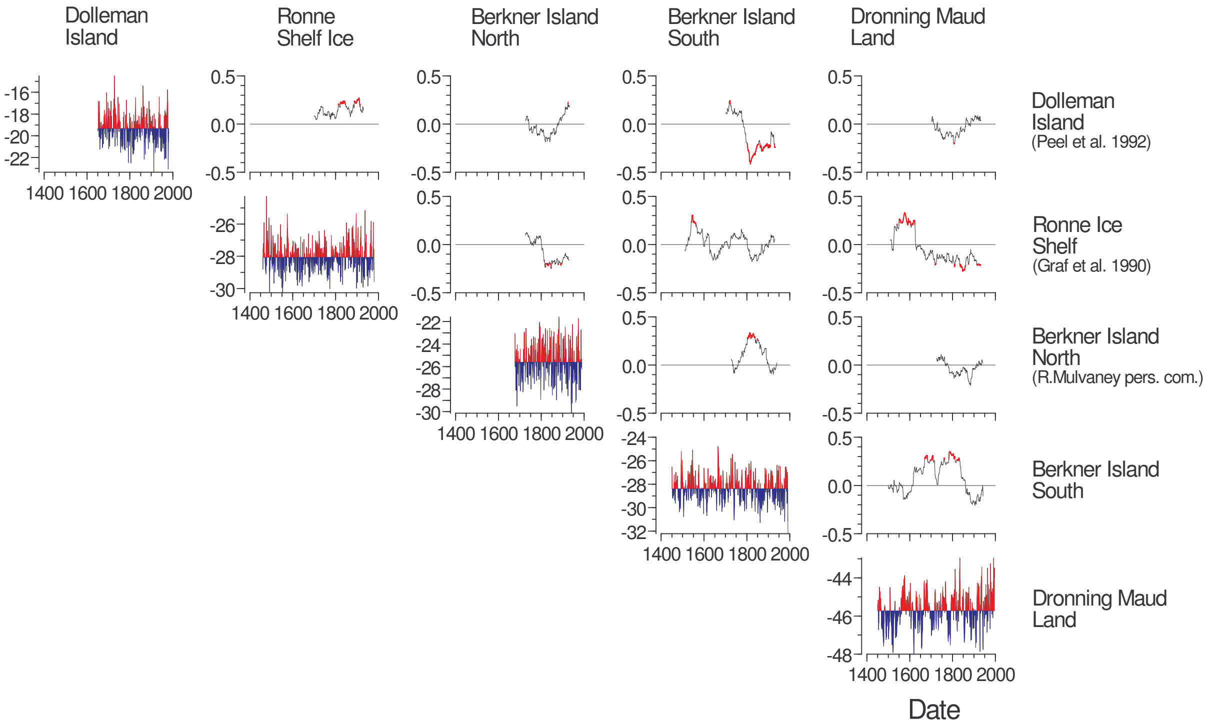

Fig. 3: Cross-correlation between time series from Antarctica. Figures are arranged like a cross-correlation matrix. The diagonal element figures show the time series and the other figures series of cross-correlation coefficients calculated in a moving 100-year window

Coefficients of cross-correlations between the records were calculated in a window of 100 years. With one exception the coefficients oscillate between positive and negative values (Fig. 3). For example, the records from Berkner Island South and Dolleman Island are negatively correlated in the 19th century and positively in the 18th century. The records from Berkner Island South and the Ronne Ice Shelf are longer and allow us to calculate a 420-year series of correlation coefficients. The series is comparable with the former one in the last 300 years and displays variations with a period of about 200 years. The corresponding series from the two Berkner Island records indicates a similar correlation pattern but with a 100-year phase shift. The reasons for these findings in records from locations only 140 km apart are still unclear. Positive and negative correlations can also be seen between the records from Berkner Island South and Dronning Maud Land (Fig. 2).

Differences in the climate history of Antarctic regions are well known. For example, the cold period of the Little Ice Age can be seen at the South Pole, while at Siple Station the same period is characterised by more positive ^{18}O contents (Mosley-Thompson et al., 1995). The new ^{18}O records described here also show climate oppositions; indicating that they exist not only between coastal and central Antarctica but also within the Weddell Sea region. However, climate oppositions are only one side of the story; ^{18}O records here show climate development in the same sense during some periods.

4 References

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