Seasonal and spatial distribution of aerosols between Neumayer- and Kohnenstation

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Introduction

Atmospheric circulations are not only important for the transport of water vapour to different locations in Antarctica but also for the transport of trace elements included in firn and ice. Hence, ionic concentrations in ice cores highly depend on the meteorological conditions at the time of their deposition. Assumed a site where a firn core is drilled has an accumulation high enough to obtain seasonality in the data, atmospheric circulations can be determined from this data. But before this is possible it is important to understand the processes that stand behind the ionic data. Measurements from the vicinity of the Neumayerstation show very high accumulation rates (~600 kg/m²*a, Oerter 2008), so that this location is convenient for this kind of research. Automatic weather stations are distributed at Dronning Maud Land. Therefore, it is possible to analyse meteorological data and relate them to the ionic compositions in different firn cores.

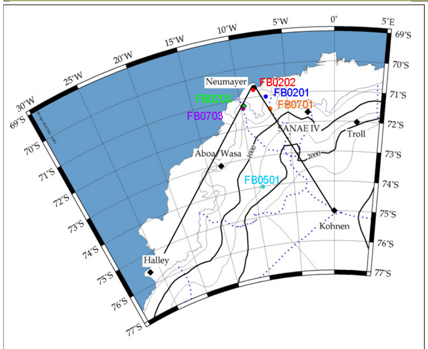

Fig. 1 Map of Dronning Maud Land with the locations of the firn cores discussed (Graphic by D. Steinhage)

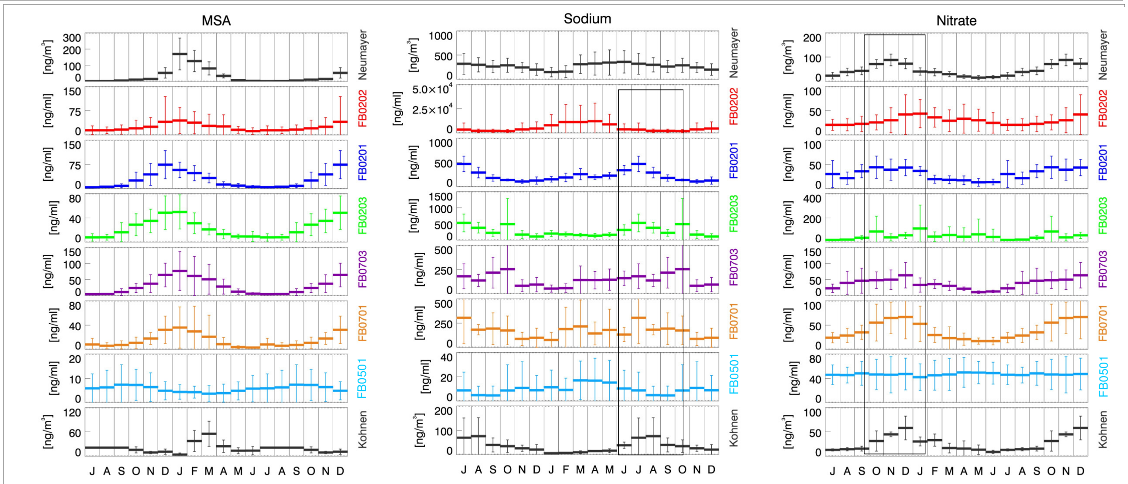

Fig. 2 Seasonal signal of MSA (Methanesulfonic acid), Sodium and Nitrate from the firncores discussed and signal from aerosol measurements at Neumayer- and Kohnenstation. This was obtained by first taking monthly means of the years and second averaging these means. The MSA was used to improve the dating of the core by matching it with the MSA-Signal measured at Neumayerstation. This explains the coherency of their signals. By contrast, the Sodium signal is more coherent with the one measured at Kohnenstation (box). The source region of Nitrate is primarily the stratosphere. This makes its signal less sensitive to near-surface winds and hence matching to Neumayerstation as well as Kohnenstation.

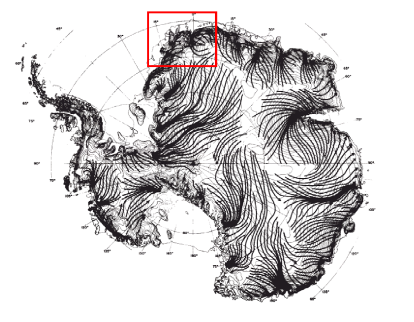

Fig. 3 composite map of observed annnual wind directions. Red box shows the region of interest (Parish and Bromwich, 1987).

- Fig. 3 shows annual means of wind directions in Antarctica. To get a better overview at the area under investigation, Fig. 4 was chosen as a good approximation for the yearly conditions.
- Wind speeds on firn core location are mostly from southwest to southeast (pink arrows)
- At Neumayerstation, easterly winds are dominant (Atka Bay, blue arrow)
- For the cores FB0701, FB0703, FB0201 and FB0203, the Sodium signal is more coherent with the aerosols measured at Kohnen (Fig. 2). The main wind flow comes from a south easterly direction but is highly dependent on the current synoptic conditions.
- Due to the south easterly wind direction it is most likely that the precipitation was transported over the plateau. The particles were not transported directly from the ocean to their place of deposition.
- The topography plays an important role in the distribution of the wind field (see van den Broeke and van Lipzig, 2003)

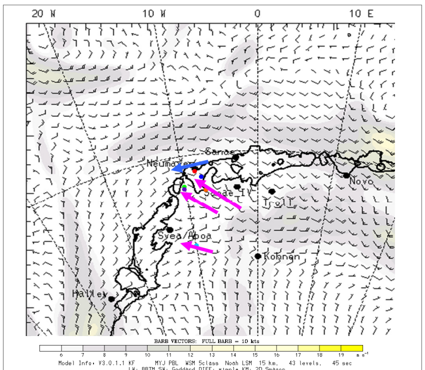

Fig. 4 Wind barbs in DML on 1. April 2010. This is used as a typical condition in the antarctic atmosphere because it is likely to the conditions shown in Fig 3. (http://www.mmm.ucar.edu/rt/amps/ , on 09.04.2010)

- Three of the six firn cores are located on two cross sections (Fig 5), one taken from Halley- to Neumayerstation, and the other one taken from Neumayerstation to Kohnenstation. The firn core on Neumayer is located on both sections.
- The cross section from Halley to Neumayer shows only a small dome where the firn cores are located. Next to the surface some katabatic wind regime can be seen.
- The cross section from Neumayer to Kohnen shows a rising topography. Katabatic winds are present next to the surface (from Kohnen to Neumayer) while the wind in higher altitudes has a north western direction (Neumayer to Kohnen). Due to this the main flow transporting trace compounds deposited in the snow is likely from south eastern directions (down the slope).

Conclusions

It is important to understand atmospheric processes when looking at proxy data in firn cores. In the annual mean as well as in a single event (assumed to be similar to the annual mean), the precipitation transporting wind comes from a south easterly direction. This especially drives the dispersion of trace compounds with a local source like sodium. Hence, firn cores that are drilled too far away from the coast cannot be taken as a proxy for processes related to the coast, e.g. the development of sea ice (see Röthlisberger et al 2010).

This is just a first assumption how trace compounds in firn cores and atmospheric circulations may be related. Even if data from one day in a year looks similar to an annual mean this does not assure that it is the same. To get a better overview, more work needs to be done: Temperature reconstructions need to be made for the firn cores, the surface wind field has to be modeled for the region of interest and backward trajectories should be calculated to determine the source region of trace compounds. Additionally, a longer record from core data would be useful to smooth the ionic data.

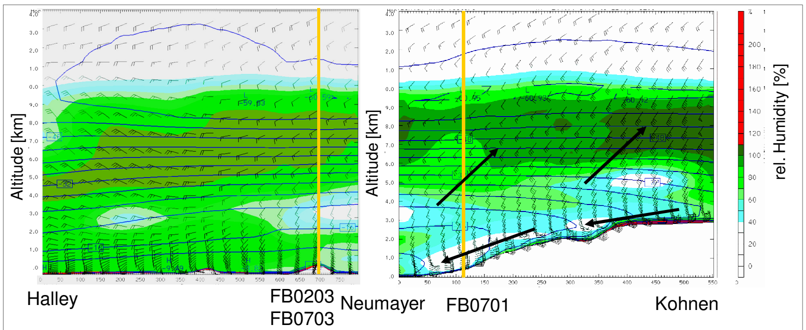

Fig. 5 cross sections with isotherms (blue lines) and wind barbs from Halley to Neumayer and from Neumayer to Kohnen on 1. April 2010. Colours show relative humidity. Black arrows represent the main wind direction (http://www.mmm.ucar.edu/rt/amps/, on 09.04.2010).

Table 1: data of the firn cores used in this study

core	latitude [°]	longitude [°]	elevation [m]	lenght [m]	time period
FB0201	71,21	6,79	~700	16,3	2002 – 1996
FB0202	70,63	8,25	~40	13,8	2002 – 1992
FB0203	71,46	9,86	~700	13,6	2002 – 1997
FB0501	74,13	9,67	~1500	11,5	2005 – 1975
FB0701	71,57	6,67	538	5,9	2007 – 2000
FB0703	71,41	9,92	654	6	2007 – 2002

References

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