Regional and seasonal variability of particle and element-concentrations from snowpits in Antarctica

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Introduction

Mineral dust measured in Antarctic ice cores is a unique tool to reconstruct palaeo-climate variations, but even the knowledge about present day dust in Antarctic snow is still very poor. In this study we analyzed different proxies of mineral dust (particle concentration, size distribution, elemental composition) in snowpits from Berkner Island, a coastal influenced site, and from Kohnen Station located on the plateau, in order to investigate differences in the transport behaviour of dust from the source to its deposition site and how this might change during the year.

Results

Particle concentration

At Berkner Island the particle concentration is low (3.75 ng/ml without any pronounced particle peaks), we find no clear seasonality, but a slightly increase of particle-concentration in winter. There are very prominent peaks at 122-136 cm depth (year 2001), as shown in fig. 4. This event is also detected in elemental composition investigations. At Kohnen the particle concentration is higher (6.7 ng/ml), we found a clear seasonality in the particle-concentration with a maximum in winter (fig. 5).

Chemical composition

Additional the concentration for Fe as a tracer for mostly insoluble mineral dust particles is shown in fig. 4 and 5. For Kohnen station there is a good agreement obvious in the depth range from 16-58 and 57-76 cm.

At Berkner Island are only some few peaks for Fe which reflect the particle distribution. The prominent peaks for particle concentrations at 122-136 cm correspond very well with the distribution for sea salt elements like Na, Mg, Ca (fig. 6). This finding could not be explained yet. It could be an effect of chemical reactions during atmospheric transport whereby insoluble particles are produced.

Experimental

Sampling

The samples were taken in polypropylen tubes, which were pressed into the snowpit walls. For the investigation of elemental composition the tubes were sealed and stored in acid-washed polypropylen bags to avoid contamination. About 0.05 l of the upper 0.1 m of snow was sampled from the snowpit. The samples were processed and measured in cleanroom laboratories at AWI. After melting the initial sample volume was approximately 20 ml. The samples were treated under pressure with a full- acid digestion (HNO3, HF, H2O2) and enriched by a factor of 10 (fig. 3). Trace and ultraelement analyses were carried out with an ICP-MS (ELAN 6000 Perkin-Elmer/Sciex) in combination with a membrane desolvation system MCN 6000 (Cricat) and a 100 µl PFA nebulizer. The instruments setups are shown in table 1 and 2. As internal standard Rh was added to each sample. The method detection limits (MDL) of the measured elements are given in table 4. The flux for sea salt was measured at least three times using a sample volume of 4-10 ml.

Measurements of particle distribution

For the particle concentration and size distribution the samples were measured within 15 minutes after melting with a laser-sensor device (ION770) and after having the samples been dried with ultrapure water. After sampling, the tubes were packed into two polyethylene bags and kept frozen until analysis.

Measurements of elemental composition

For determination of elemental composition the samples were processed and measured in cleanroom laboratories at AWI. After melting the initial sample volume was approximately 20 ml. The samples were treated under pressure with a full-acid digestion (HNO3, HF, H2O2) and enriched by a factor of 10 (fig. 3). Trace and ultraelement analyses were carried out with an ICP-MS (ELAN 6000 Perkin-Elmer/Sciex) in combination with a membrane desolvation system MCN 6000 (Cricat) and a 100 µl PFA nebulizer. The instruments setups are shown in table 1 and 2. As internal standard Rh was added to each sample. The method detection limits (MDL) of the measured elements are given in table 4.

Fig. 2: Laser-sensor-setup, for particle size and-concentration measurements

Concentrations for sea salt elements like Na, Mg, Ca (fig. 6). This concentration at 122-136 cm correspond very well with the elemental composition investigations. At Berkner Island it can be seen that there is a good correlation between these elements and Na and the element ratios (marked by a red cross) in open ocean water agree very well.

This strong variability is also shown for some selected elements (fig. 4-7). There is a clear seasonality in the sea-salt elements at Berkner Island. At Kohnen sea salt aerosol is not the dominating source, but shows also a seasonality with maximum in winter.

Conclusions and Outlook

The plateau position at Kohnen Station has a clear seasonality in the particle concentration. The chemical composition shows that mineral dust is dominating. At Berkner Island the particle concentration and size distribution is dominated by single events, that might not have a local source. A strong influence from the ocean could be observed when looking to typical sea salt trace elements.

For future investigations of deep ice cores it is necessary to take into account at which position the drilling will be carried on. In order to optimize the sampling studies up to now Ca is used as a tracer for anthropogenic dust in continuous flow analyses. This contribution shows that depending on the sampling location Ca has at least two different sources.

In further steps analyses will be carried out for samples from potential sources in the southern hemisphere to identify sources and possible changes during the year. For this analyses the Rare earth element-distribution patterns will be used.

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