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# A 115 year high-resolution ice core record from Severnaya Zemlya, Central Russian Arctic

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## 1 BACKGROUND

Due to its impact on thermohaline and atmospheric circulations, the Arctic plays an important role in the Earth climate system. Climate changes in the Arctic are amplified by several positive feedback mechanisms. Thus, the Arctic is highly sensitive to such changes and a key region for climate change research.

Unfortunately only a few time series of Arctic meteorological measurements back to the 19th century exist. There is a need for additional climate information from proxy data. Among the climate archives available in the Arctic, glaciers and ice caps are most prominent. Ice cores provide unique information about the physical and chemical properties of the atmosphere and are one of the best archives for climate and environmental changes.

Located in the Central Russian Arctic, Severnaya Zemlya (SZ) is the easternmost archipelago with considerable ice caps (see map). A new 724 m long ice core was drilled on Akademii Nauk (AN) ice cap between 1999 and 2001 to gain high resolution proxy data from the Central Russian Arctic (Fritzsche et al. 2002). This ice cap is characterized by summerly melting and infiltration processes, resulting in alteration of the original isotopic and chemical signals. Here we present data of stable isotopes, melt content and major ions (for methods see Fritzsche et al. 2005) from the uppermost 57 m (47,60 m w.e.).

## 4 FINDINGS FROM $\delta^{18}O$

$\delta^{18}O$ in ice cores depends mainly on condensation temperature of water vapour and is commonly used as proxy for local surface air temperature (SAT).

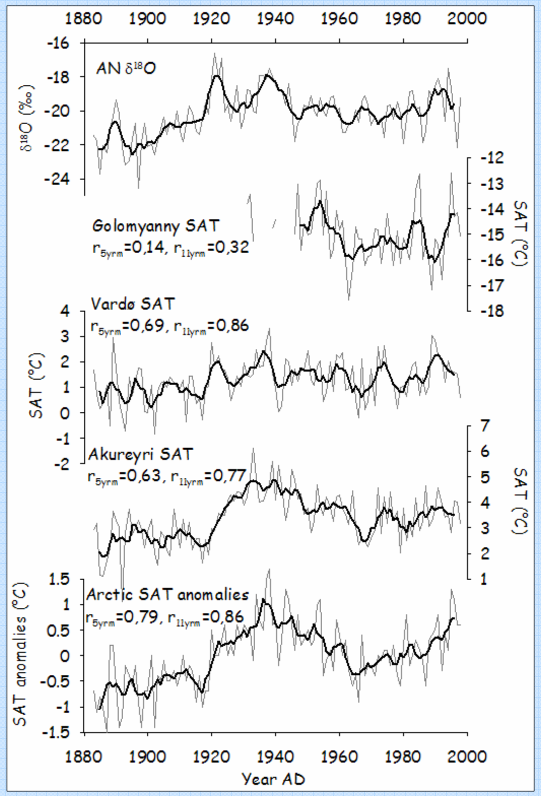



Fig. 2: Time series (annual mean values and 5yrm) of AN $\delta^{18}O$, different (Sub-)Arctic SATs (data: Polyakov et al. 2003a) and correlation coefficients between AN $\delta^{18}O$ and SAT time series (5yrm and 11yrm).

AN $\delta^{18}O$ data show pronounced SAT changes in the last 115 years.

AN $\delta^{18}O$ time series coincides with other (Sub-)Arctic SAT time series.

Strong correlations were found for meteorological stations without sea ice influence (Vardø, Akureyri) as well as for a compilation of Arctic SAT anomalies, indicating a strong Atlantic influence on Central Russian Arctic SATs.

Absolute SAT maximum occurred in the late 1930s in the Eurasian as well as in the whole Arctic.

A strong warming before 1920 is a common feature in all displayed time series, whereas a pronounced 1920s SAT maximum is only visible in the Eurasian Arctic data (AN, Vardø), indicating that this is a specific Eurasian Arctic SAT pattern.

**AN $\delta^{18}O$ - a good proxy for Eurasian Arctic annual mean SAT!**

## 2 STUDY AREA: SEVERNAYA ZEMLYA AND THE EURASIAN ARCTIC

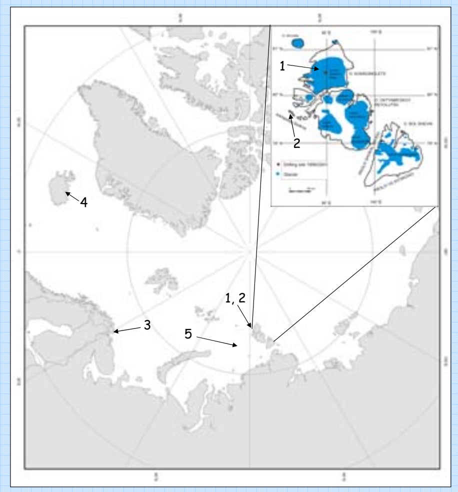
1 Akademii Nauk

2 Golomyanny

3 Vardø

4 Akureyri

5 Kara Sea



## 5 FINDINGS FROM DEUTERIUM EXCESS

The deuterium excess d (d=δD-8*$\delta^{18}O$) depends on conditions in the moisture source region, mainly the sea surface temperatures (SST).

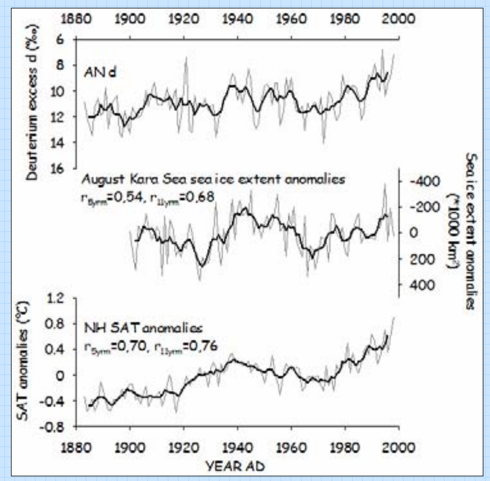



Fig. 3: Time series (annual mean values and 5yrm) of AN d (note reverse scale!), August Kara Sea sea ice extent anomalies (data: Polyakov et al. 2003b) (note reverse scale!), NH SAT anomalies (data: http://data.giss.nasa.gov/gistemp/tabledata/NH.Ts.txt) and correlation coefficients between d and other time series (5yrm and 11yrm).

Due to the strong Atlantic influence on AN $\delta^{18}O$ values and Eurasian Arctic SAT we assume the main moisture source in the North Atlantic region.

Kara Sea sea ice extent anomalies show marked similarities to our AN d record. The Kara Sea could be a minor moisture source or its sea ice extent could be influenced distinctly from the North Atlantic.

Additionally the AN d data show a good correlation with Northern Hemisphere SAT anomalies.

**AN Deuterium Excess – a proxy for large scale SAT changes?**

9 REFERENCES

Fritzsche, D. et al. 2002, Ann. Glaciol. 35, 25; Fritzsche, D. et al. 2005, Ann. Glaciol. 42, 361; Polyakov, I. et al. 2003a, J. Climate 16, 2067; Polyakov, I. et al. 2003b, J. Climate 16, 2078; Weiler, K. et al. 2005, J. Glaciol. 51, 64.

## 3 DATING AND ANNUAL LAYER THICKNESS

Dating of this core section and determination of annual layer thickness were done by using radioactive and volcanic reference horizons (see fig. 5) as well as by counting annual isotopic cycles. This yields to an age of 115 years in nearly annual resolution. The dating error is assumed to be within ± 2 years.

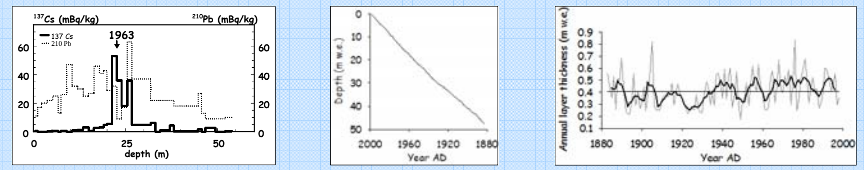



Fig. 1: left: $^{137}Cs$ reference peak, middle: depth-age-relationship, right: Annual mean layer thickness (annual and 5 year running mean (5yrm))

## 6 FINDINGS FROM MELT LAYER CONTENT

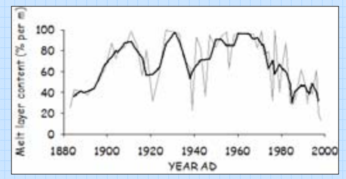



Fig. 4: melt layer content (m and 3mrm)

Melt layer content in AN ice core shows an early 20th century warming trend similar to $\delta^{18}O$.

In the decades after 1920 melt layer content shows signals opposite to that of $\delta^{18}O$, indicating contrary trends in annual mean SAT and summer SAT.

## 7 FINDINGS FROM MAJOR IONS

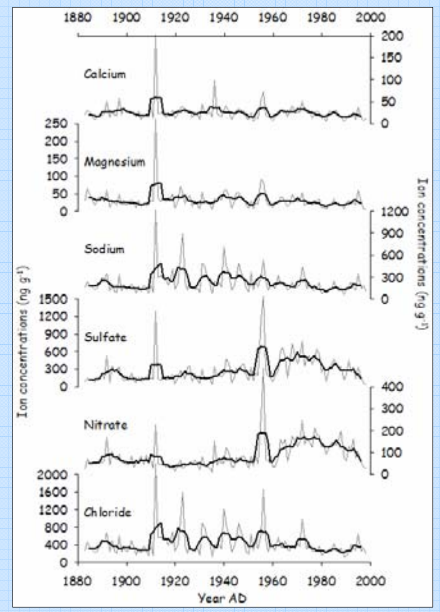



Fig. 5: Time series (annual mean values and 5yrm) of AN major ions

The AN major ion record is superimposed by melting, infiltration and refreezing processes. Seasonal signals seem to be unlikely, but most years seem to be represented by a peak of major ions. Therefore, a depth-age scale can be achieved by counting these peaks (Weiler et al. 2005).

The AN major ion time series show as a common feature sharp peaks in 1956 and 1912. These peaks were interpreted as deposition of aerosols as a result of the large volcanic eruptions of Bezymianny/Kamchatka 1956 (Weiler et al. 2005) and Katmai/Alaska 1912.

The sea salt ions sodium and chloride show a decreasing trend for the 20th century.

In contrast, the time series of sulfate and nitrate show an increase since the 1960s followed by a decrease since the 1980s, which can be attributed to anthropogenic emissions of Eurasia.

**AN major ions reflect volcanic events and anthropogenic emissions!**

## 8 CONCLUSION AND OUTLOOK

**AN ice core provides high resolution climate and environmental proxy data not only for the Eurasian Arctic!**

**Further work will extend this ice core record to about 2500 years!**