CLIMATIC VARIABILITY IN DAVIS SEA SECTOR (EAST ANTARCTICA) OVER THE PAST 250 YEARS BASED ON THE "105" KM ICE CORE GEOCHEMICAL DATA

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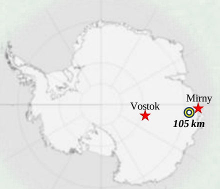
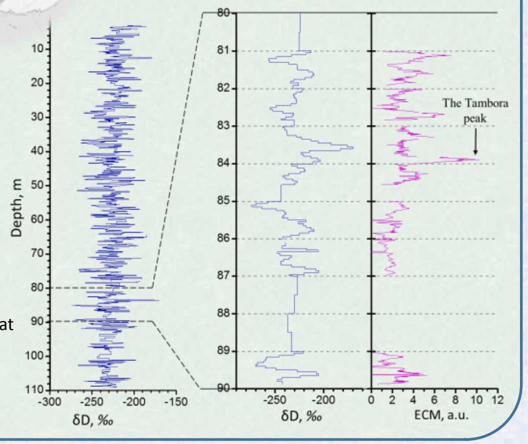
Data and methods

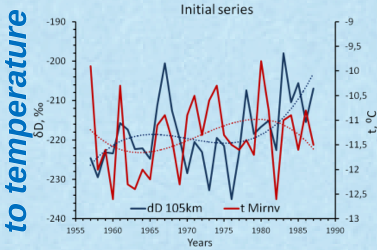


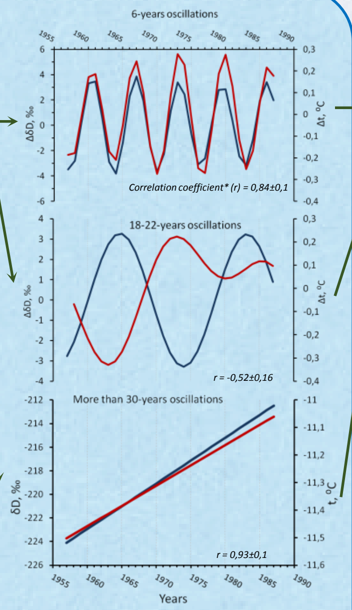
Location: Mirny – Vostok route S67⁰26' E93⁰23'
Elevation of the drilling site: 1470 m
Year of drilling: 1988
Core depth interval: 3-109 m
Dating: annual layers counting + Tambora peak
Age at 109 m: 231±8 years

Isotope content: was measured at CERL (St. Petersburg, Russia) (deuterium and oxygen-18 concentration)
sampling resolution: 5 cm
number of samples: 1524
analyzer: laser analyzer Picarro L1120-i
accuracy: 0,7‰ for δD
ECM: was measured at Vostok glaciological laboratory
Chemistry: was measured at Limnological Institute RAS (Irkutsk, Russia)



From isotopes to temperature



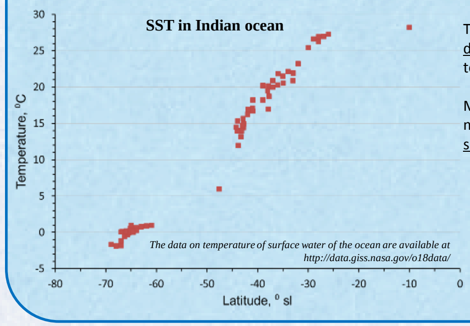


The obtained series of isotopic composition are characterized by a periodical variability.
We divided all the cycles into three groups:
1)high-frequency with a duration of period of about 6 years,
2)18-22-year fluctuations,
3)low-frequency oscillations with a wavelength of tens of years.

In the frames of the short-term and long–term cycles the local temperature is related to the isotopic composition positively. But as for the 18-22-year period, we obtained a negative relationship between the temperature of condensation and the isotopic composition of precipitation.

To explain this negative relationship, we used a simple isotope model (*Salamatin et al., 2004*).
We found out that this situation can occur if the temperature in the source of moisture changes three times more intensively than the condensation temperature.

** All correlation coefficients are significant with likelihood 99%. Method of decomposing: Gaussian filtering (**AnalySeries 2.0.8**)*

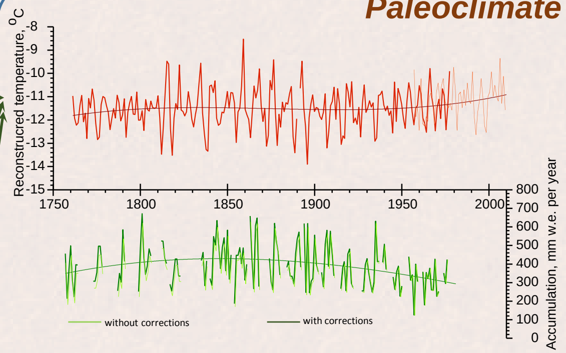


The isotopic composition is related to the difference between source and site temperatures.

More intensive temperature change in the moisture source may be due to the latitudinal shift of the area of air mass formation.

When the source of moisture displaces to the north by a few degrees, the temperature at the source significantly increases, the isotopic composition of precipitation decreases because of the stronger isotopic depletion.

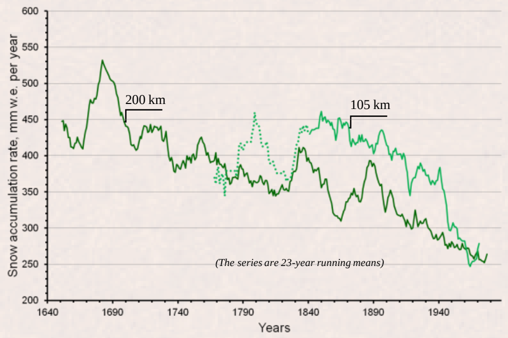
Paleoclimate



The reconstructed temperature series from 1766 to 2010 shows a warming of about 0,5⁰C over the past 250 years.
Interestingly, the 19th century is characterized by increased amplitude of the interannual variations of temperature. It could be related to the change of climatic conditions at the end of the Little Ice Age (eg *Goose et al., 2012*).

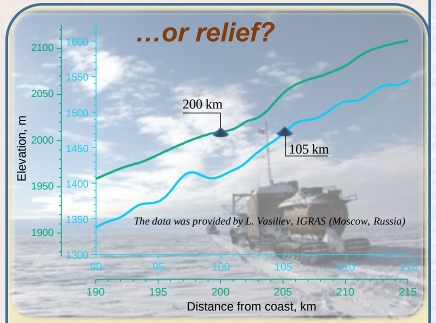
The time series of snow accumulation over the period from 1757 to 1982 was reconstructed using the obtained dating and snow density data. The values of the accumulation and isotopic composition were corrected for thinning of annual layers with depth and advection of ice.
The resulting long-term average snow accumulation (391 mm w.e. per year) is consistent with the data of instrumental observations in 1955-1987 years (*Lipenkov et al., 1998*).

The opposite trends are observed in the reconstructed local temperature and snow accumulation rate which is unusual.



Similar trend is observed at the nearby site "200 km" (*Ekaykin et al., 2000*). So, it could be of climatic origin.

…or relief?

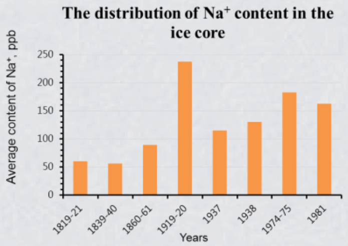


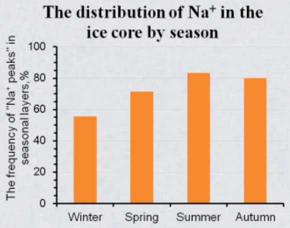
The observed trend of the accumulation rate could be also attributed to the location of the drilling site in a megadune area.

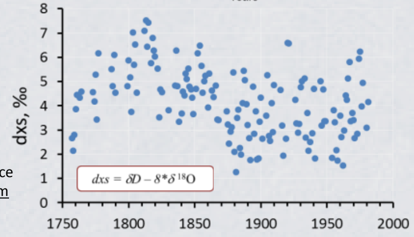
Sea ice

According to the chemical analyses data most of the sodium (80%) seems to be deposited at the summer-autumn period, when the area of the sea ice is the smallest.

This suggests that the concentration of sodium depends positively on the ice-free area of the sea, and thus a reduced sodium content in the XIX century may be considered as the evidence of the increased area of sea ice in the Little Ice Age in the studied region.







Another proof of the increased area of the sea ice in the LIA is the increased value of the deuterium excess until the middle of the XIXth century, compared to the present.

The smaller is the area of the sea ice, the more is the contribution of the cold sea in the evaporation process, the lower is the average weighted temperature of the moisture formation, and as a result, the lower are the values of the deuterium excess.
An increased area of the sea ice in the LIA in Antarctica is confirmed by climatic simulations (*Goose et al., 2012*).

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Unknowns:
1) Why snow accumulation rate and air temperature have being changed in different ways?
2) What is the reason for the increased amplitude of the interannual variability of temperature in XIX century?
3) What is the relationship between marine aerosols and sea ice extent?

Summary:

- We have reconstructed the time-series of temperature and snow accumulation at the site "105 km" over the last 250 years. According to the obtained data the temperature in the area of Mirny station increased by 0,5⁰C while the snow accumulation rate decreased over this time, which may be explained as combined influence of climatic and glaciological factors.
All changes took place with the periods 4-6; 8,5-11; 18-22; 33 and of about 120 years. The separation of the series into frequency components was used in local temperature reconstruction.
The negative relationship between the isotopic composition of precipitation and near surface air temperature was identified in the frame of 18-22-years oscillations and could be associated with latitudinal displacement of moisture source.
We suggest that sea ice area was larger in XIX century in Davis sea sector, according to isotope and chemical data.

References:

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