Conference “Vostok”, 25th of September 2015

Stable water isotope studies in the subglacial Lake Vostok region

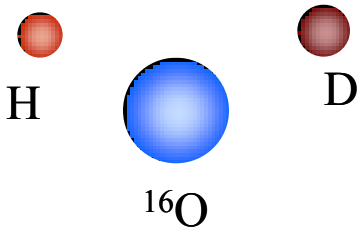
Alexey Ekaykin
and CERL’s team

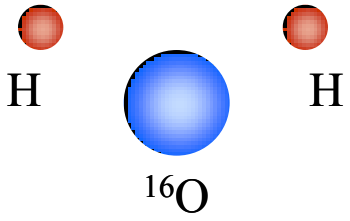
Outline

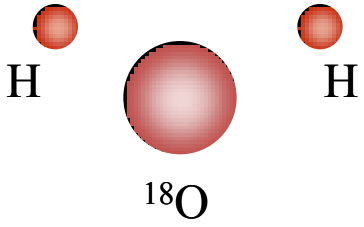
- What is “stable water isotope content”?
- Water isotopes and Paleoclimate
  - Millennial scale
  - Centennial and decadal scale
- Spatial variability of stable water isotopes
  - Continental scale
  - Regional scale (Lake Vostok region)
  - Local scale (mega-dunes)
- Stable water isotopes in Lake Vostok
  - Accreted lake ice
  - Lake water
- Conclusion and Prospective

Stable water isotopes

Изотопы (от греч. ισος — «равный» и τόπος — «место») – элементы, занимающие одно и то же место в периодической системе элементов







$$\delta = \frac{R_{SA} - R_{ST}}{R_{ST}} \times 1000$$

В морской воде (SMOW):

R [$^{1}H_{2}{}^{18}O$] = 2000 ppm
R [$HD^{16}O$] = 310 ppm

δD: от +10 до -500 ‰

$\delta^{18}O$: от +5 до -60 ‰

Stable water isotopes

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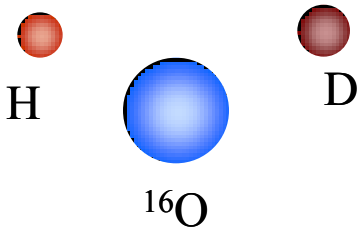
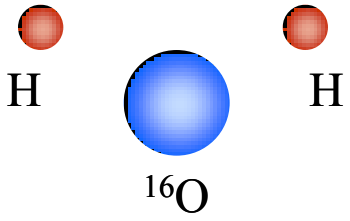
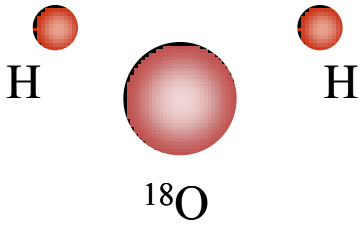
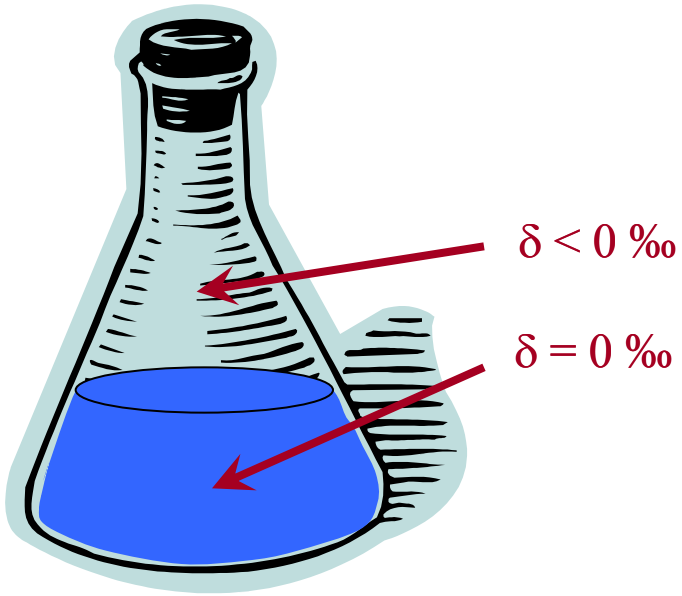




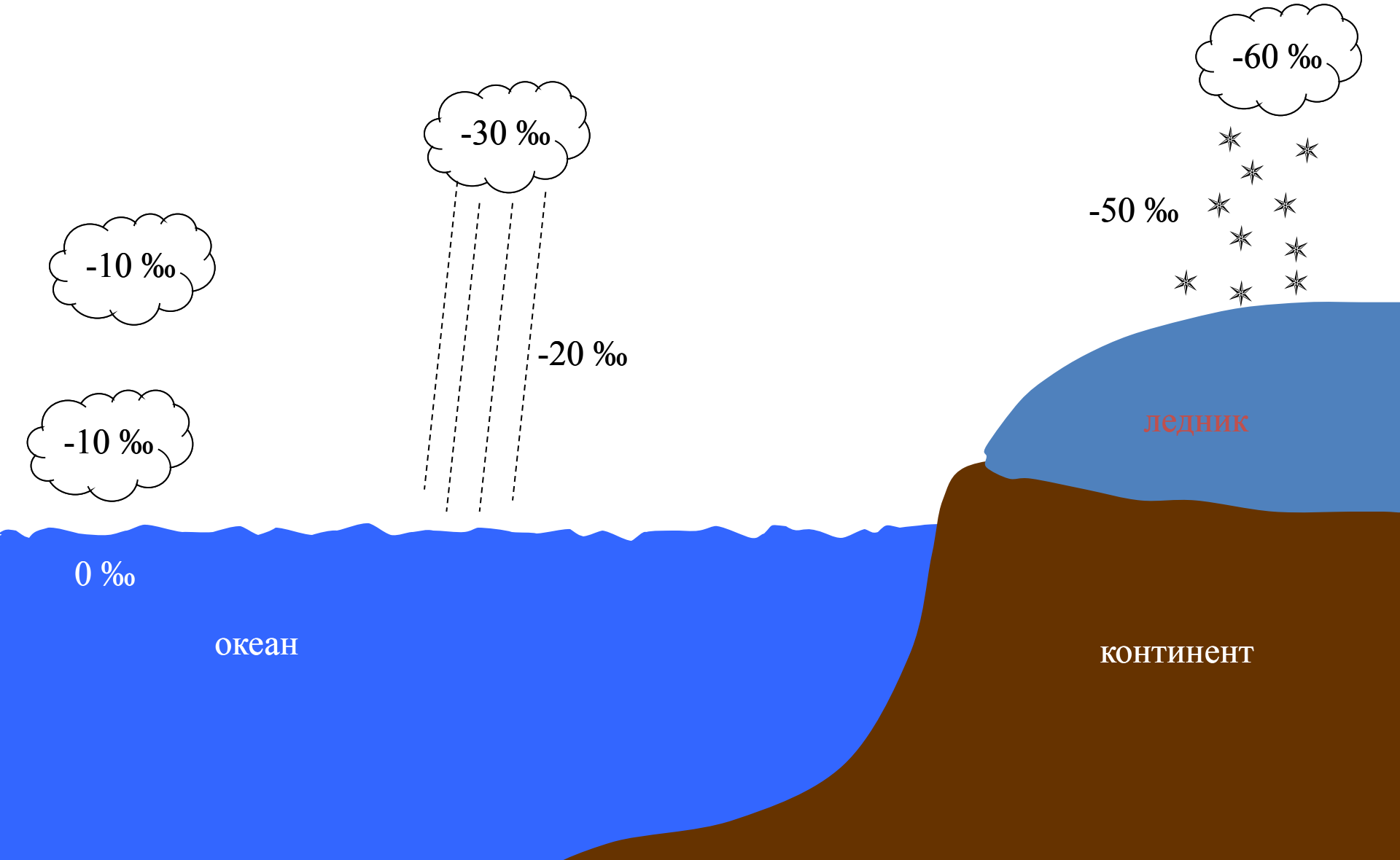


Немного различающиеся физические свойства:

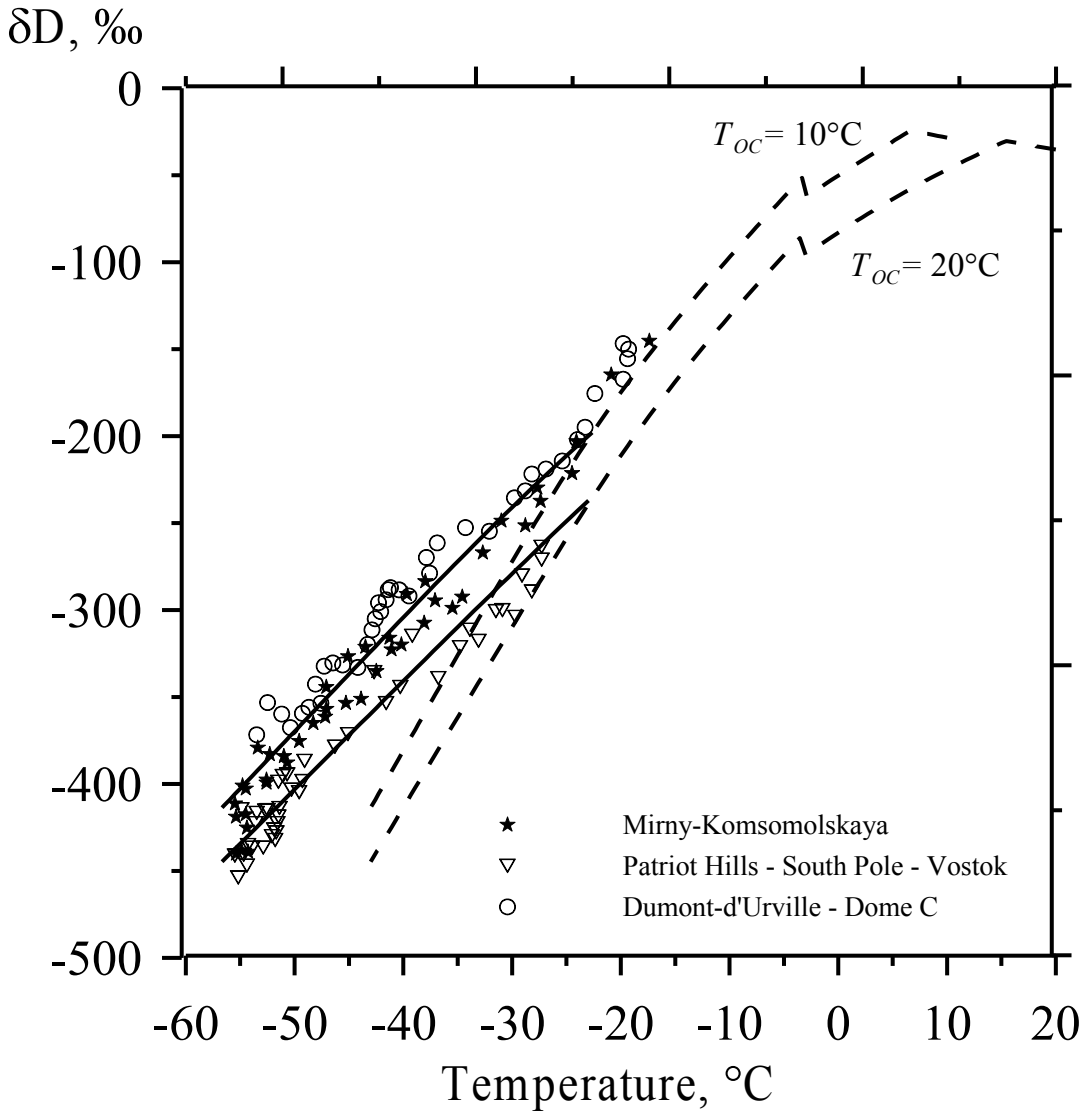
- давление насыщения
- коэффициенты диффузии



Stable water isotopes in global water cycle

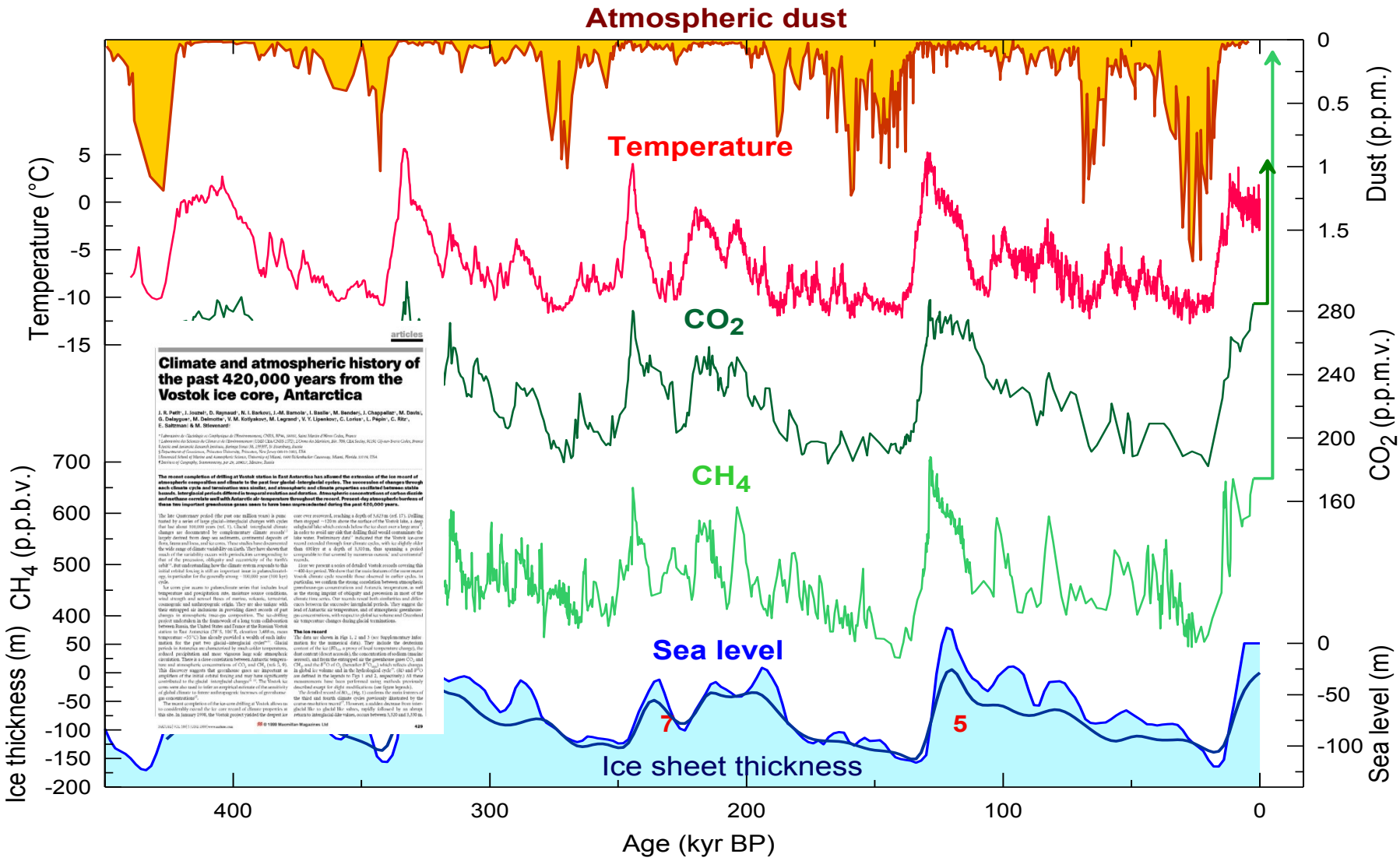


Stable water isotopes *vs* air-temperature: “Isotope paleo-thermometer”



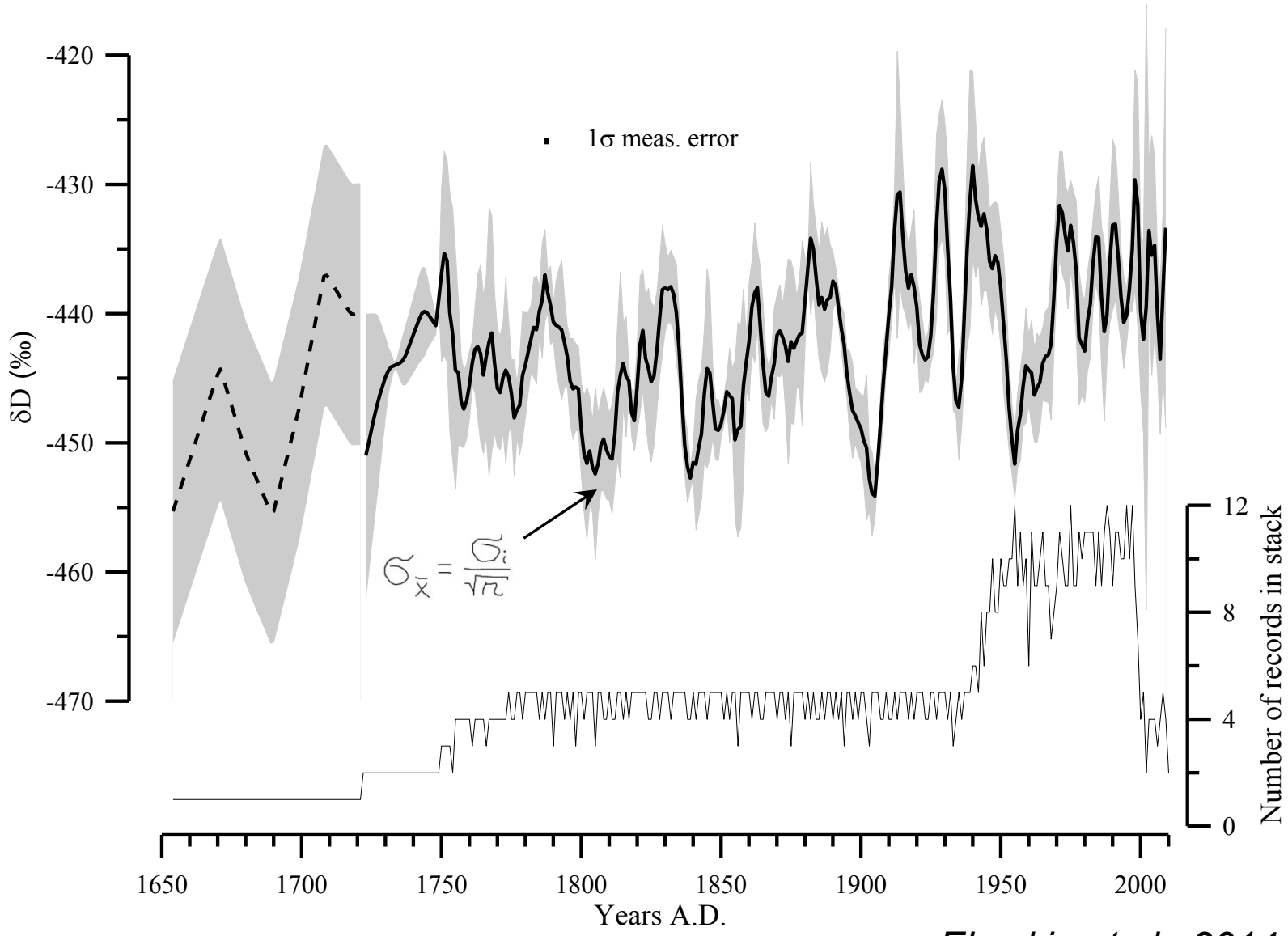
Ekaykin, 2003

Millennial-scale climatic variability



Petit et al., 1999

Vostok climate over the past 350 years



Ekaykin et al., 2014

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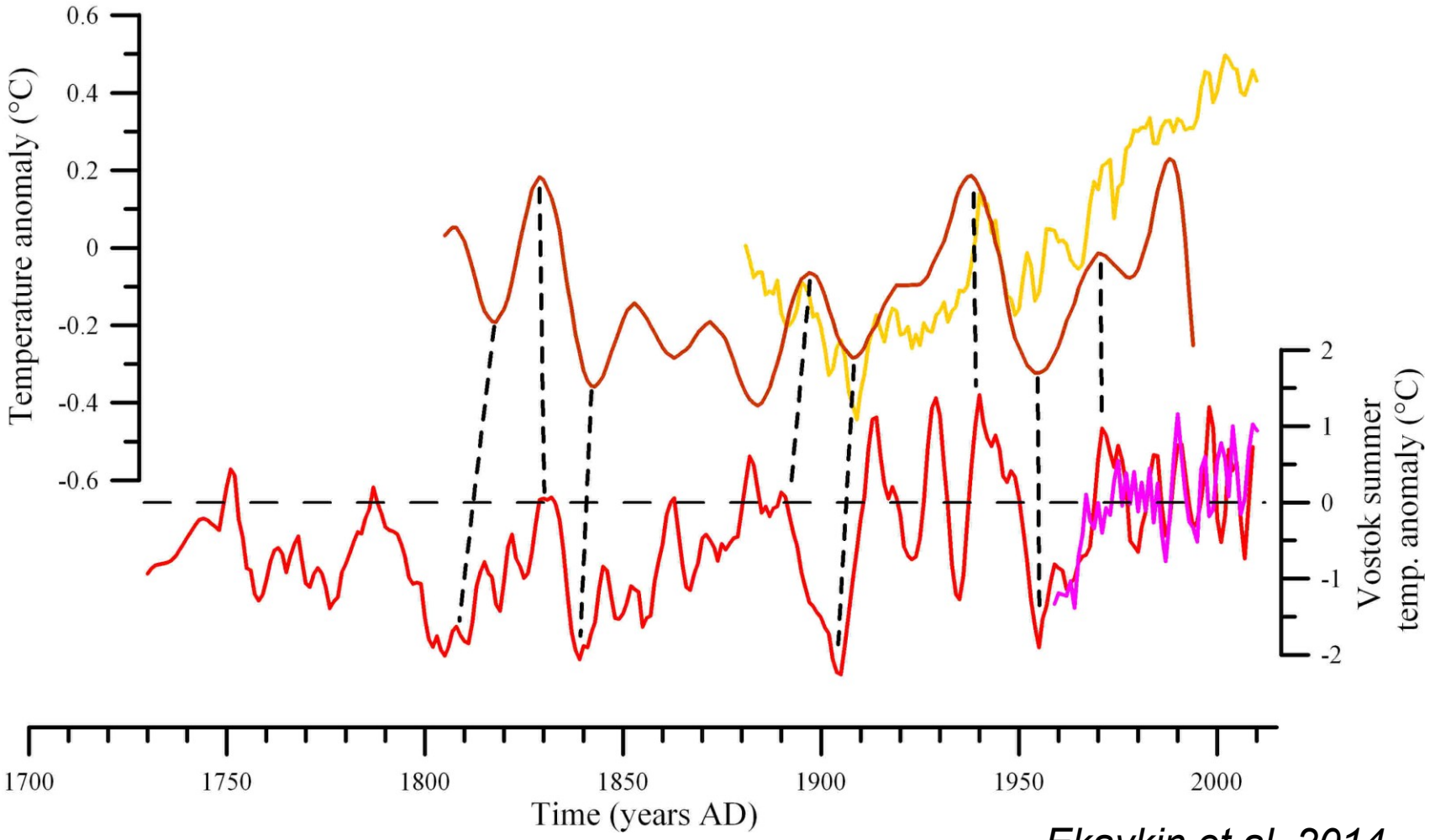


Ekaykin et al, 2014

Stable water isotopes and paleoclimate results

Stable water isotope content is a nice proxy of the air temperature

But! A small signal-to-noise ratio

$\Rightarrow$ One core is not enough! (ok for millennial-scale variability and/or for high-accumulation sites)

For Vostok region:

Over the past 350 years slight warming

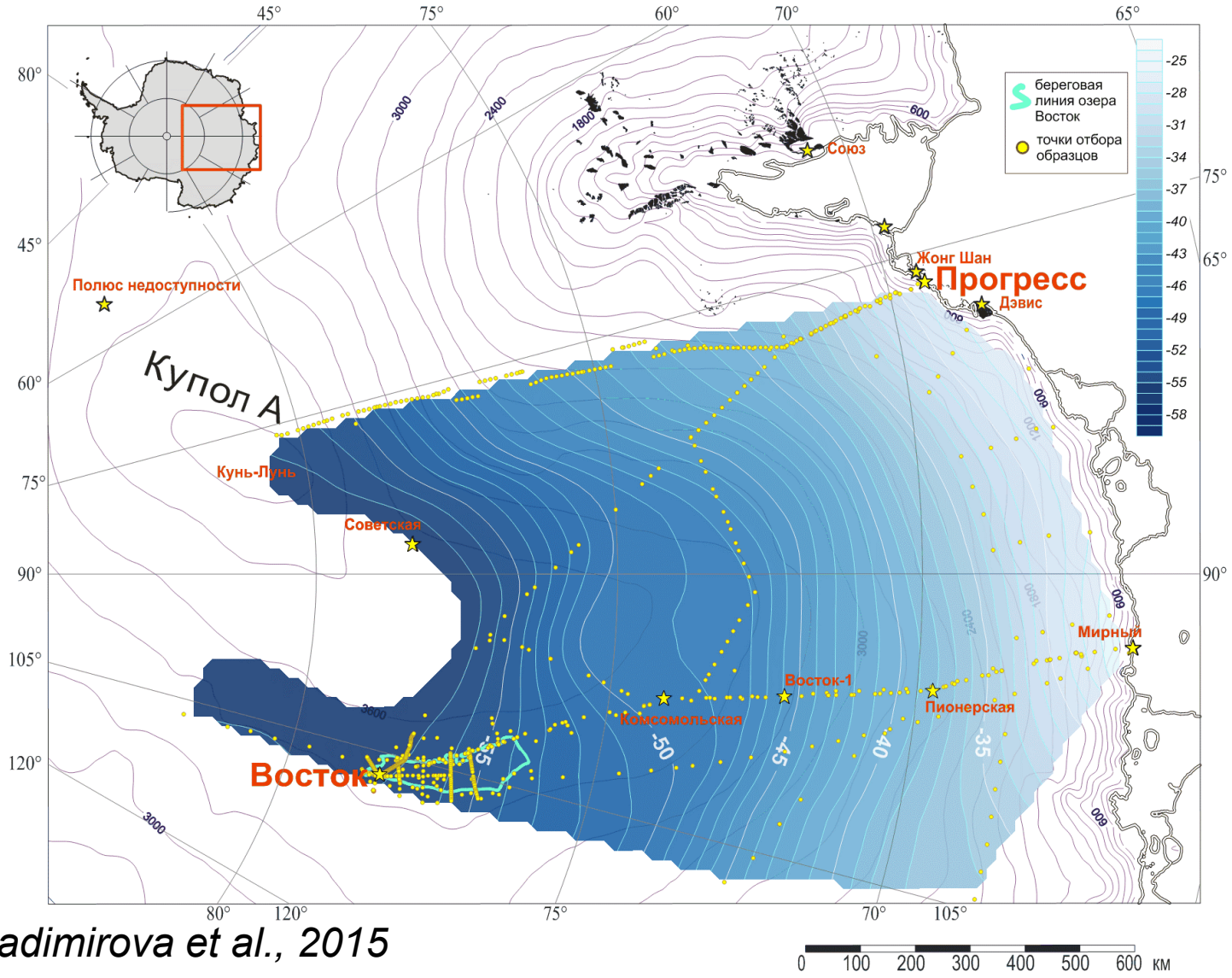
30-60 periodicity

No recent sharp warming

Stronger correlation with summer temperature than with mean annual temperature (post-depositional effects?)

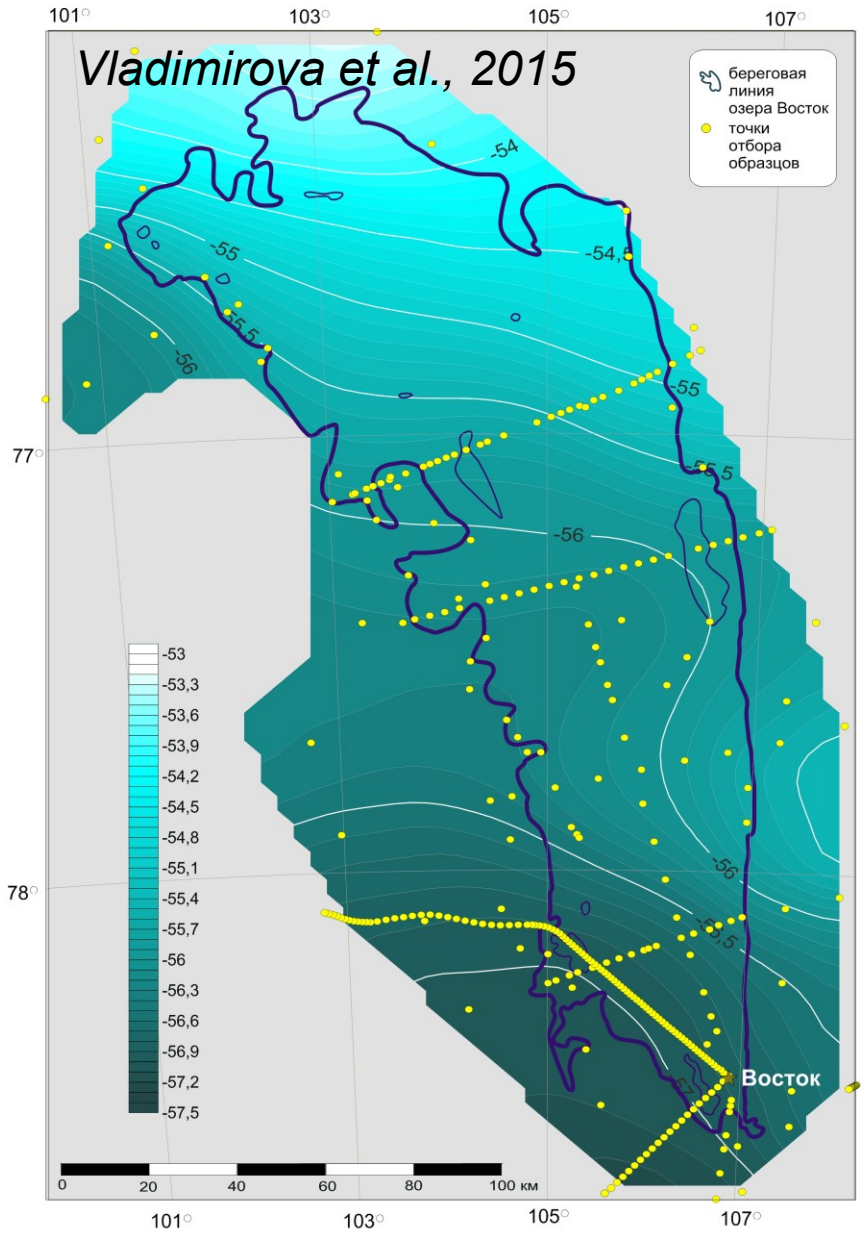
$\Rightarrow$ Revision of the deep ice core data needed?

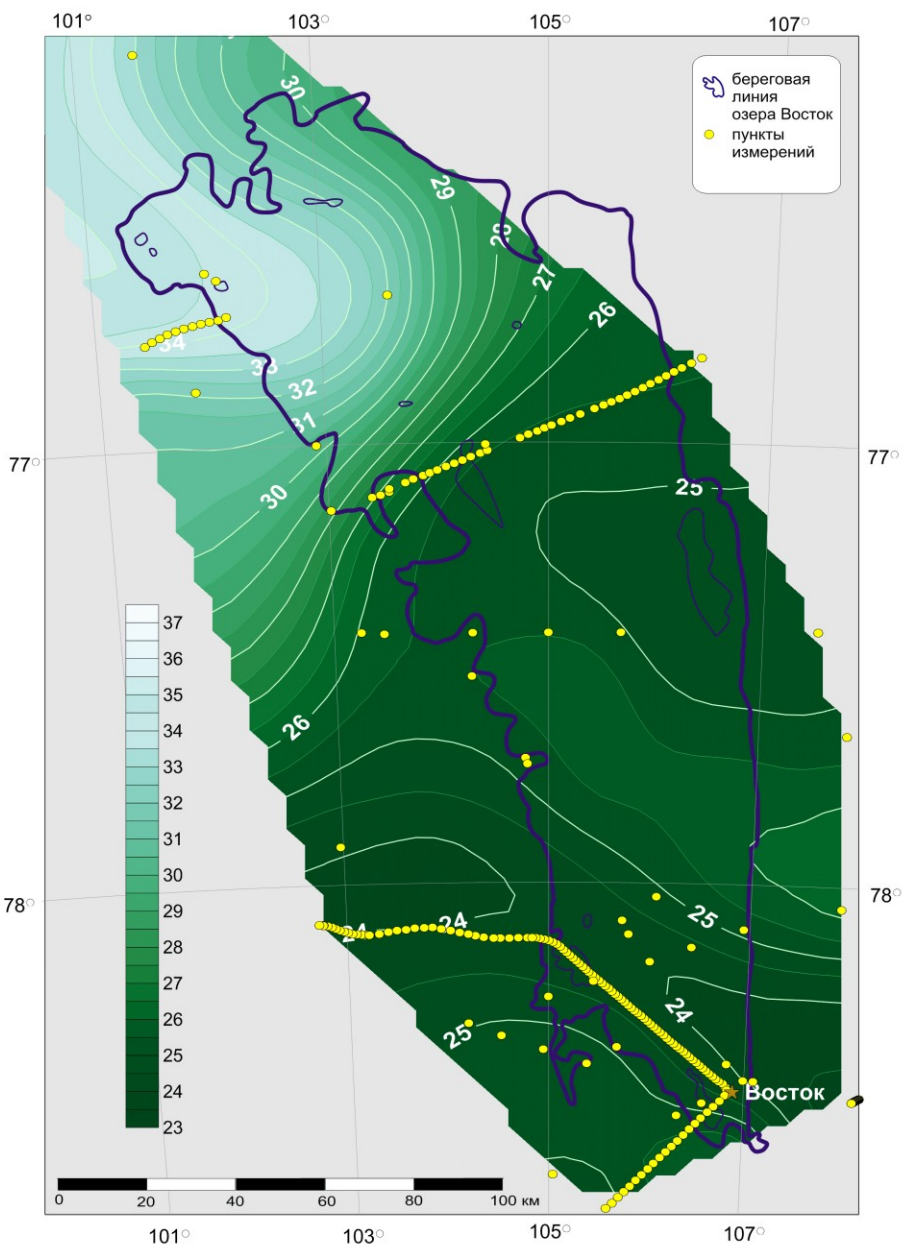
Spatial variability: continental scale



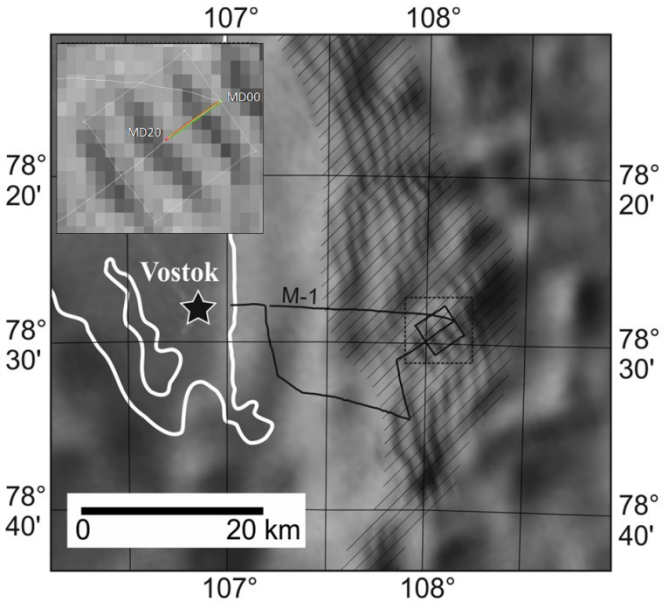
Vladimirova et al., 2015

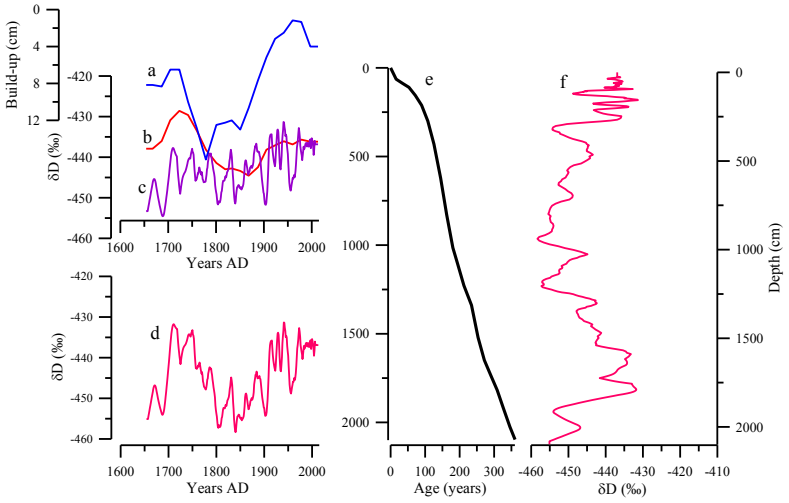
Spatial variability: regional scale



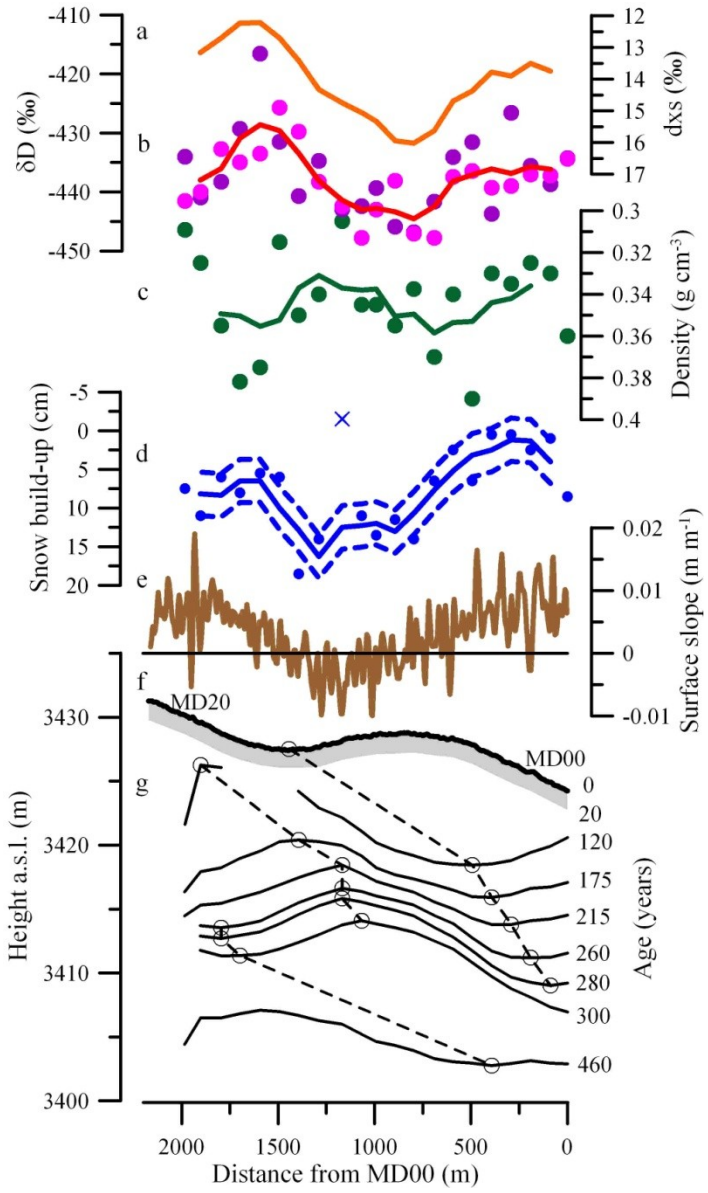


Spatial variability: local scale (mega-dunes)

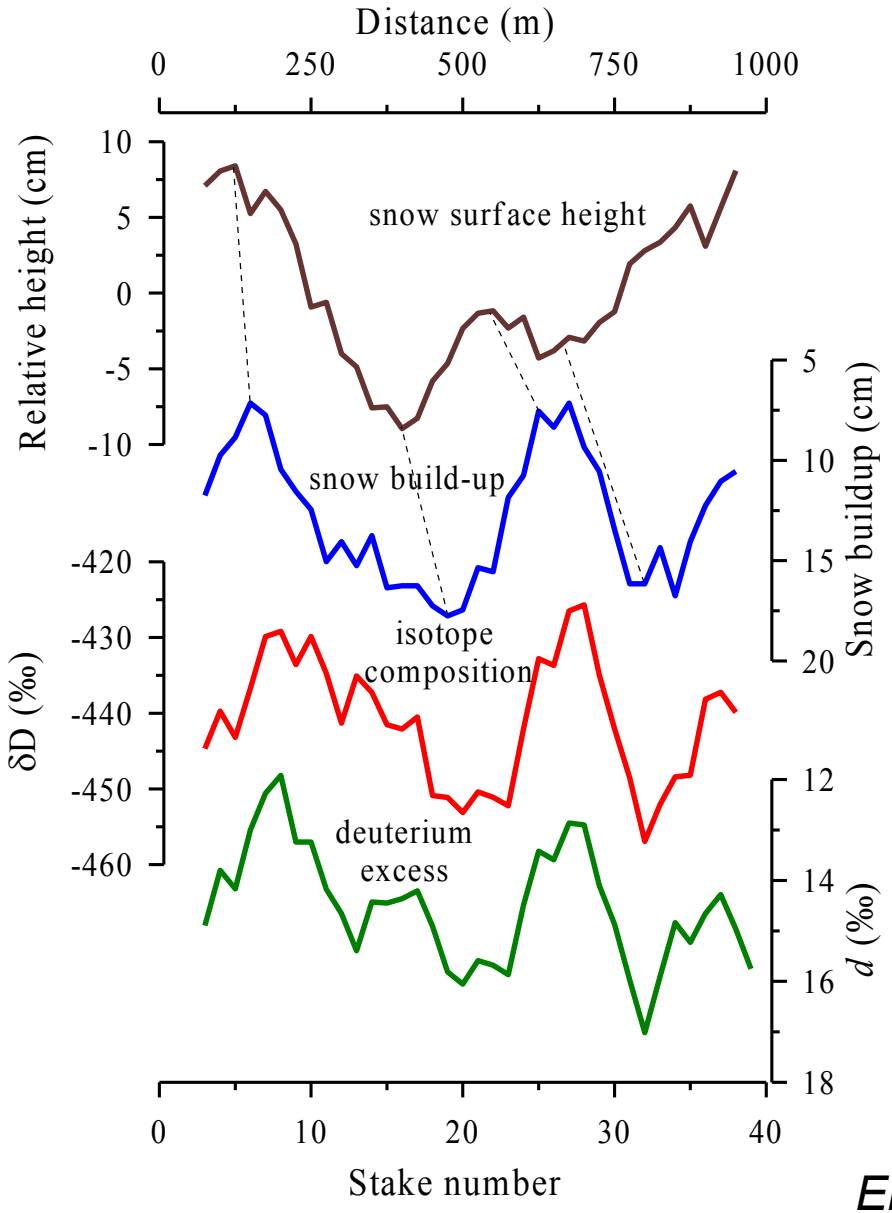




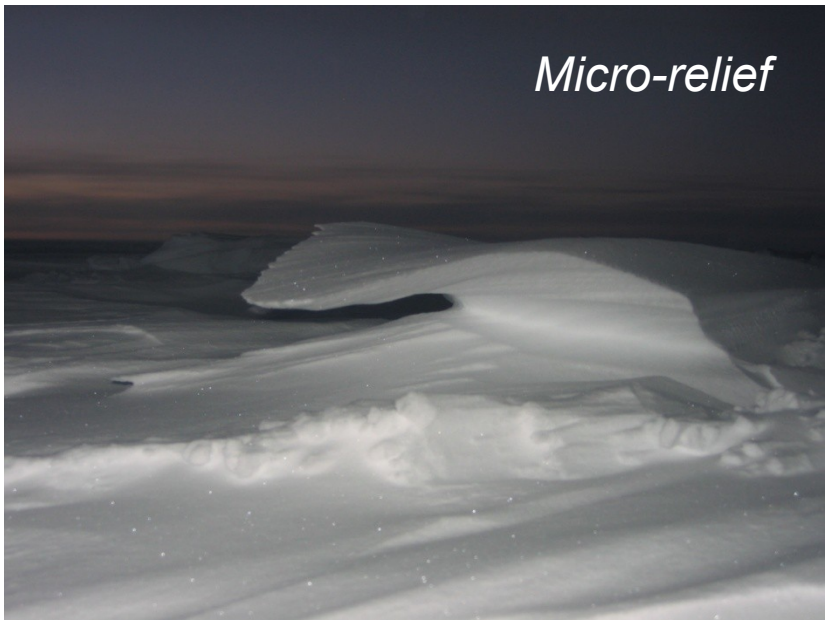
Ekaykin et al., 2014



Spatial variability: even smaller waves?



Meso-dunes



Ekaykin et al., 2002

Spatial distribution of stable water isotopes results

On continental scale:

Latitudinal and altitudinal zonality

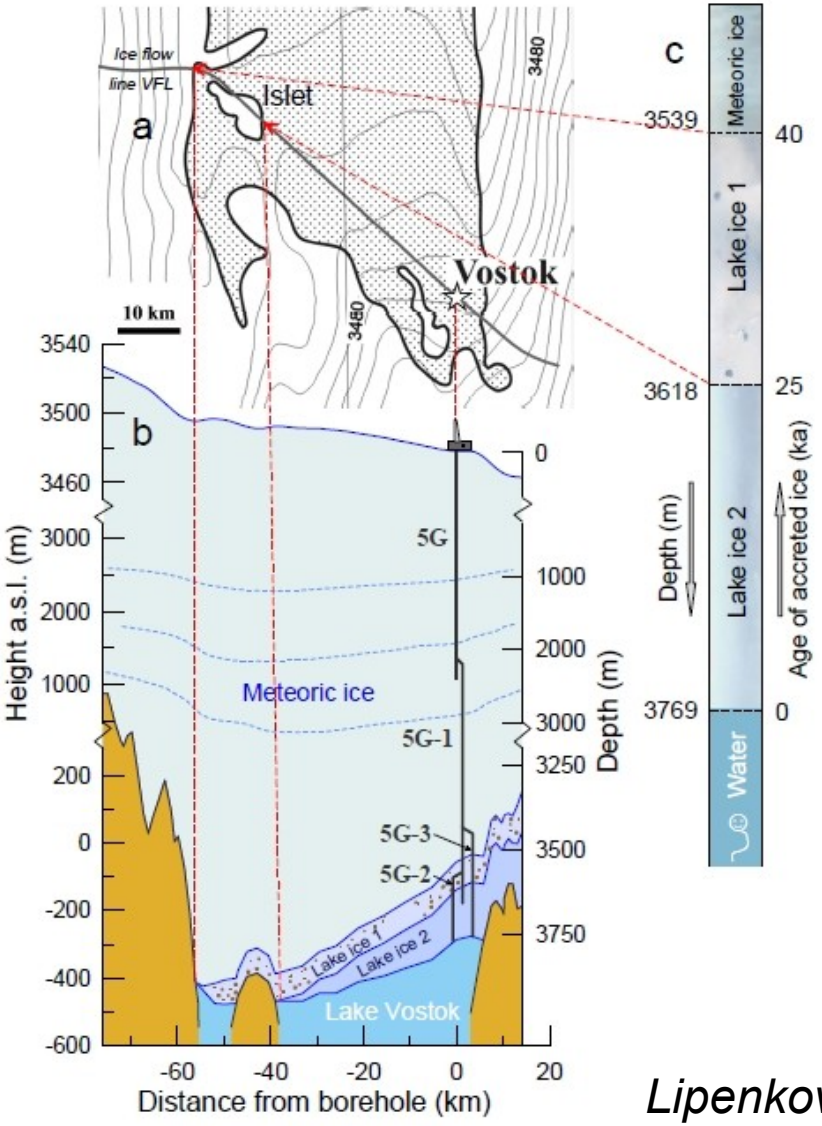
But! Complex behavior in central Antarctic plateau

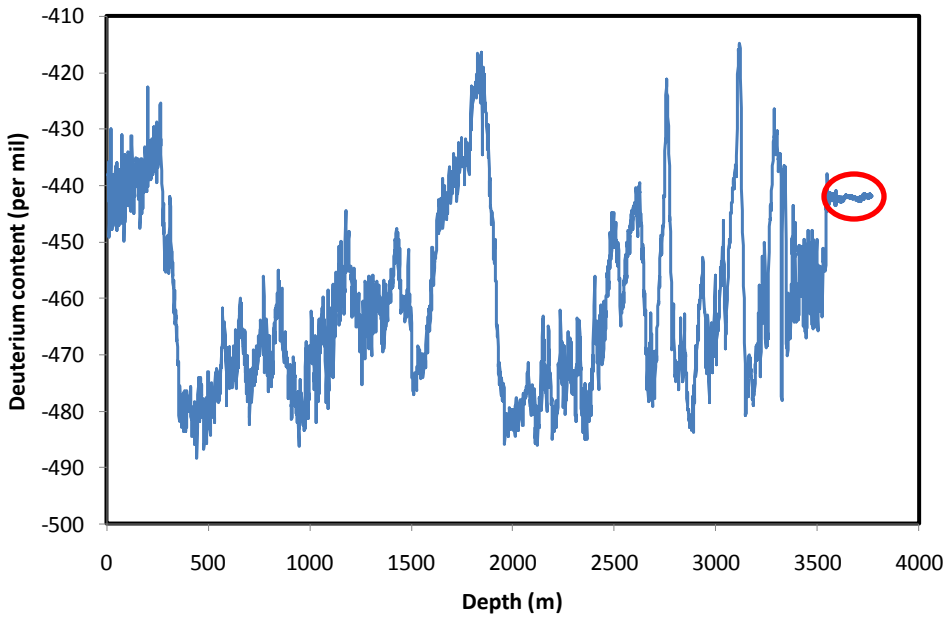
On local scale:

Variety of forms, from mega-dunes to sastrugi (the main reason for the noise in the ice core records)

Spatial waves transform themselves in temporal waves!

Isotopes in Lake Vostok: accreted ice





Lipenkov et al., in press

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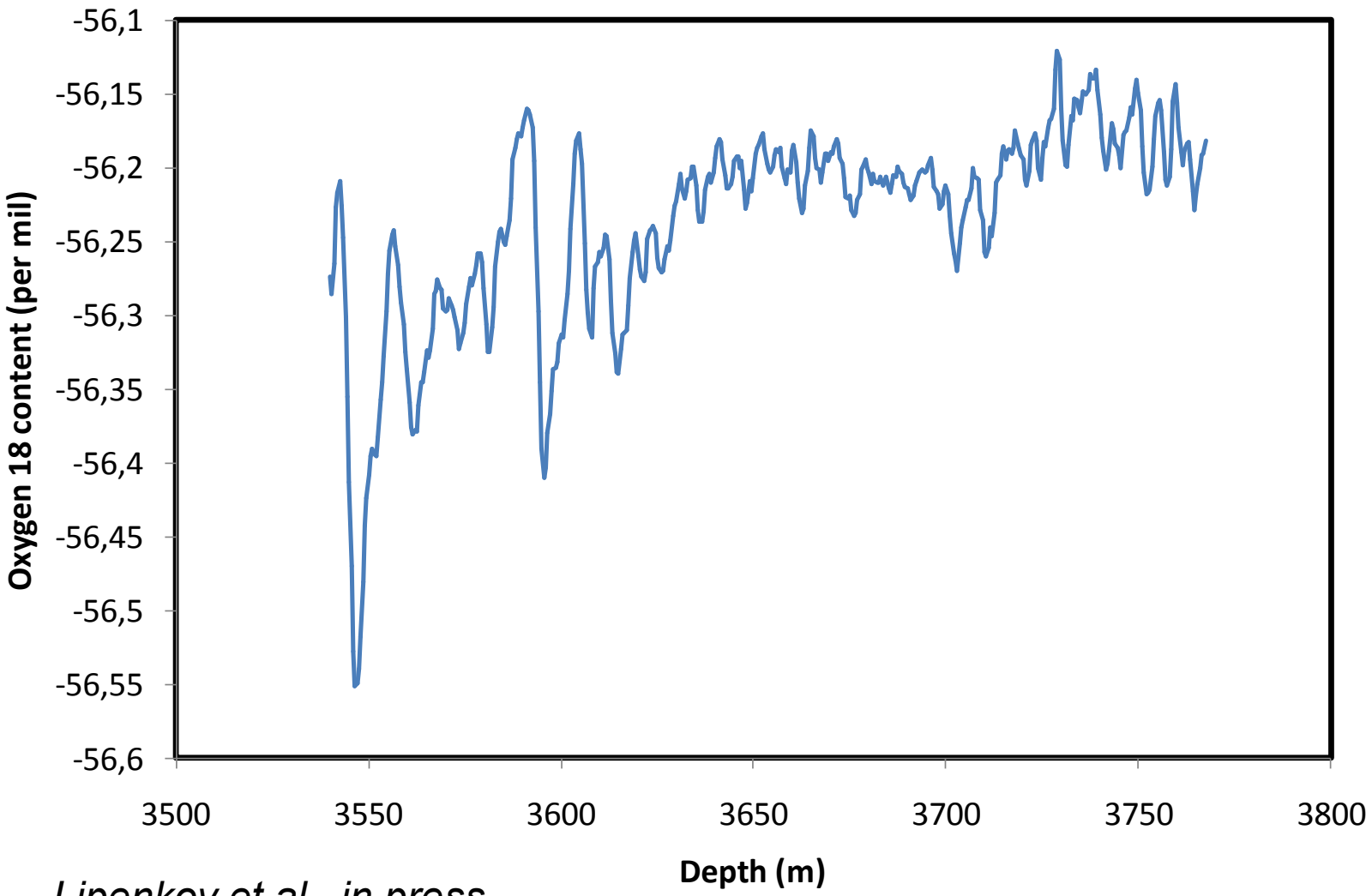

Lipenkov et al., in press

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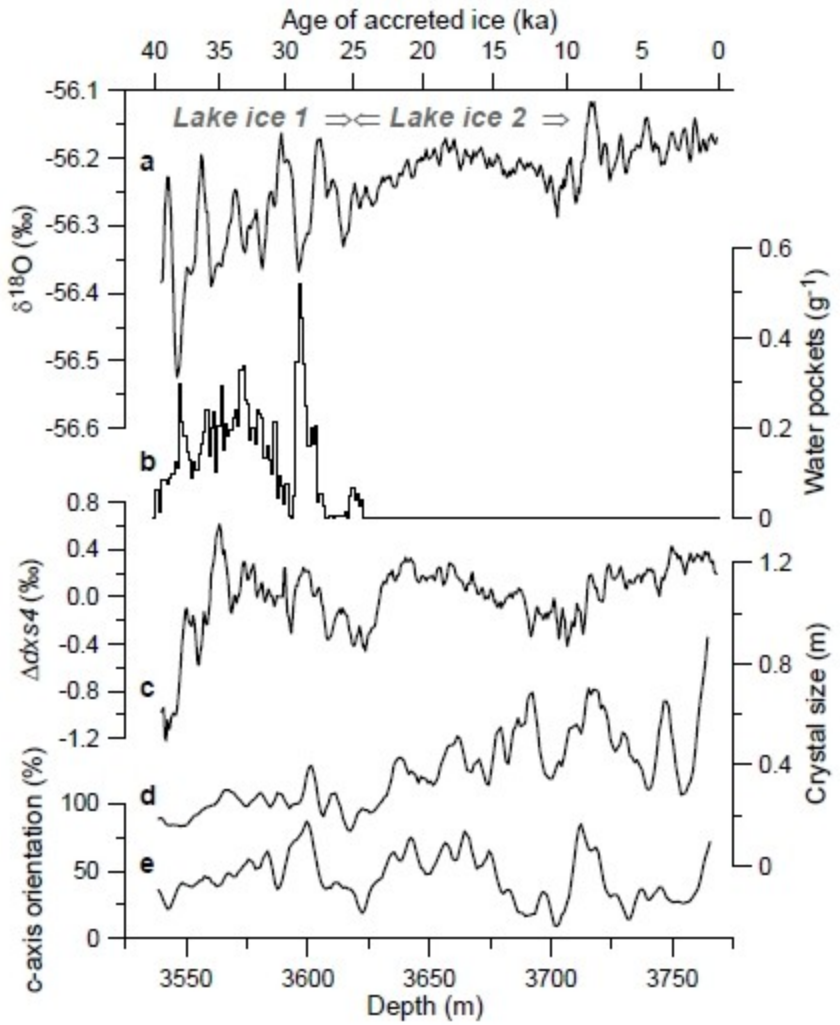


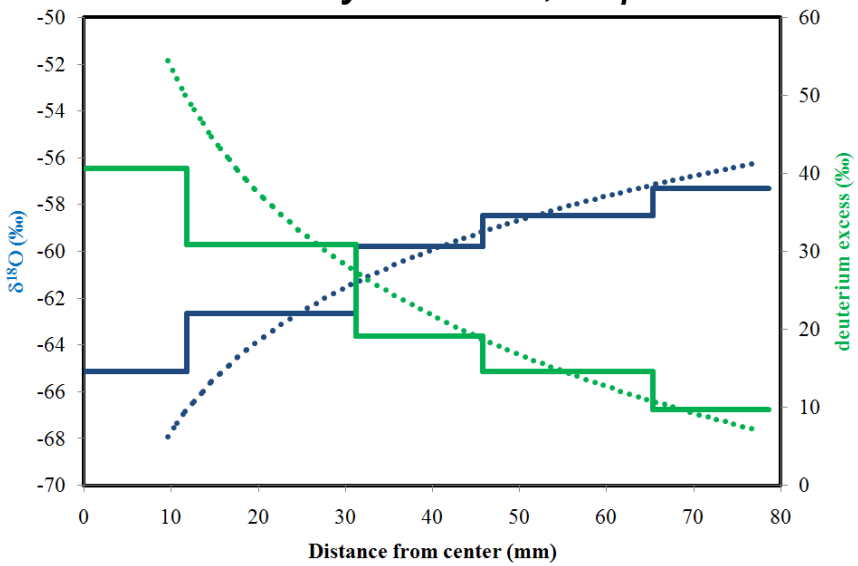
Lake ice 1: capture of water inclusions
Lake ice 2: in equilibrium with lake water?

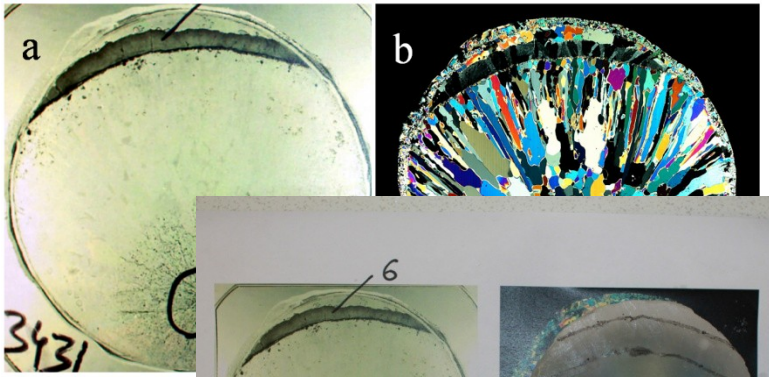
Lipenkov et al., in press

Isotopes in Lake Vostok: lake water

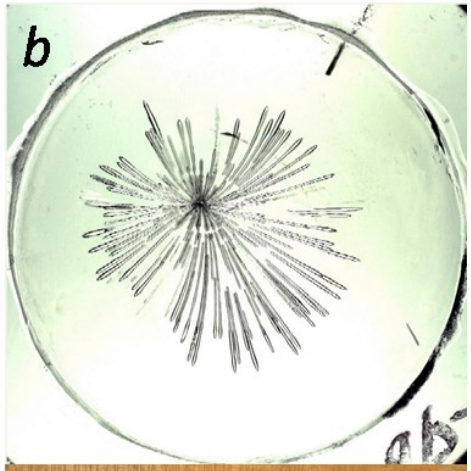
Isotopes in Lake Vostok: lake water

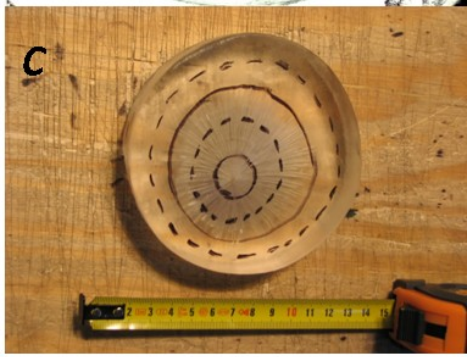
Ekaykin et al., in press

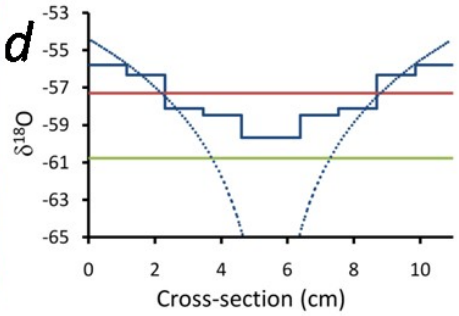


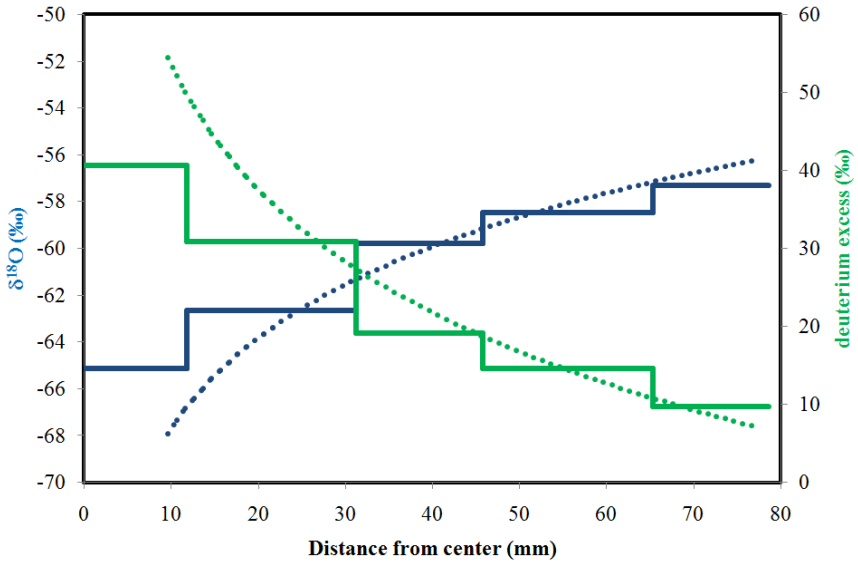


Isotopes in Lake Vostok: lake water









Real core

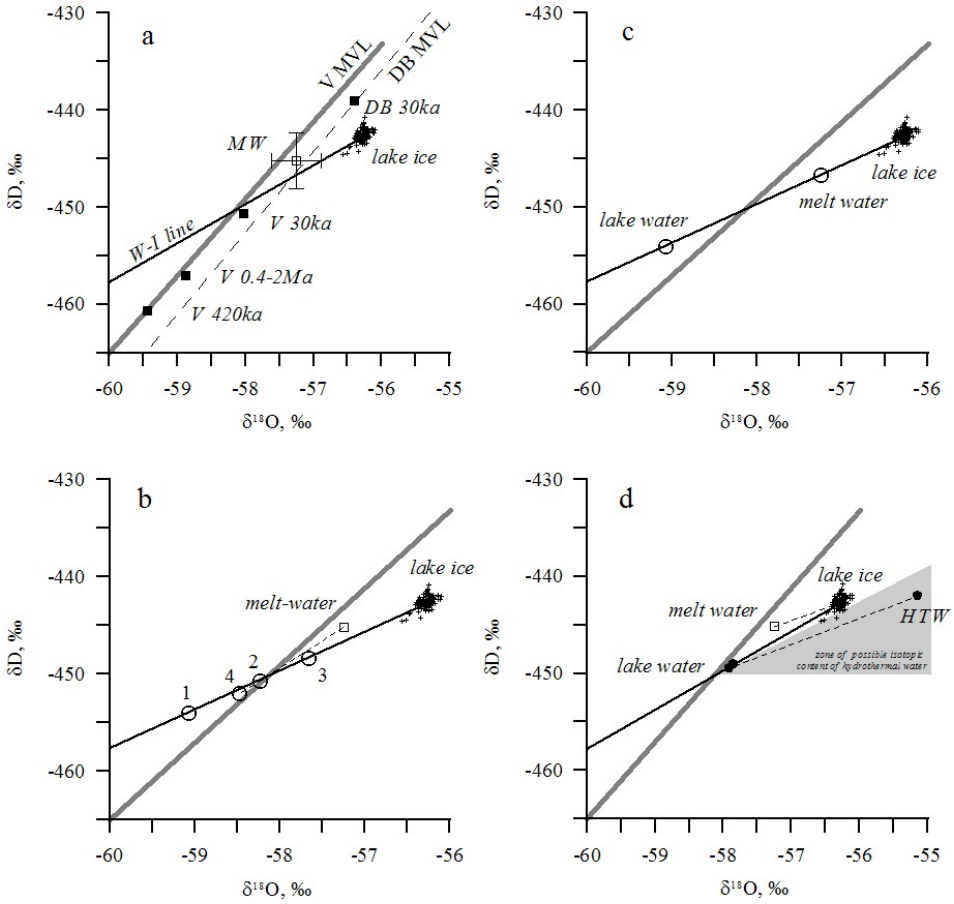
experiment

Ekaykin et al., in press

Isotopes in Lake Vostok: lake water

Lake Vostok water: -59.0 $\delta^{18}O$ and -455 for δD

Good correspondence to the calculated values



Ekaykin et al., 2010

Isotopes in Lake Vostok: results

Two water sources (glacier melt and hydrothermal)

Poor mixing of melt water and resident lake water

Lake Ice 1: capture of water pockets

Lake Ice 2: in equilibrium with lake water

Rapid events in Lake Vostok?

Prospective

Oldest Ice Challenge

Study of post-depositional effects

Stack climatic record for Antarctica

Spatial distribution of stable water isotopes on different scales

Lake Vostok water sampling at different depths

and at different places?

Oxygen 17


Thank you for your attention!