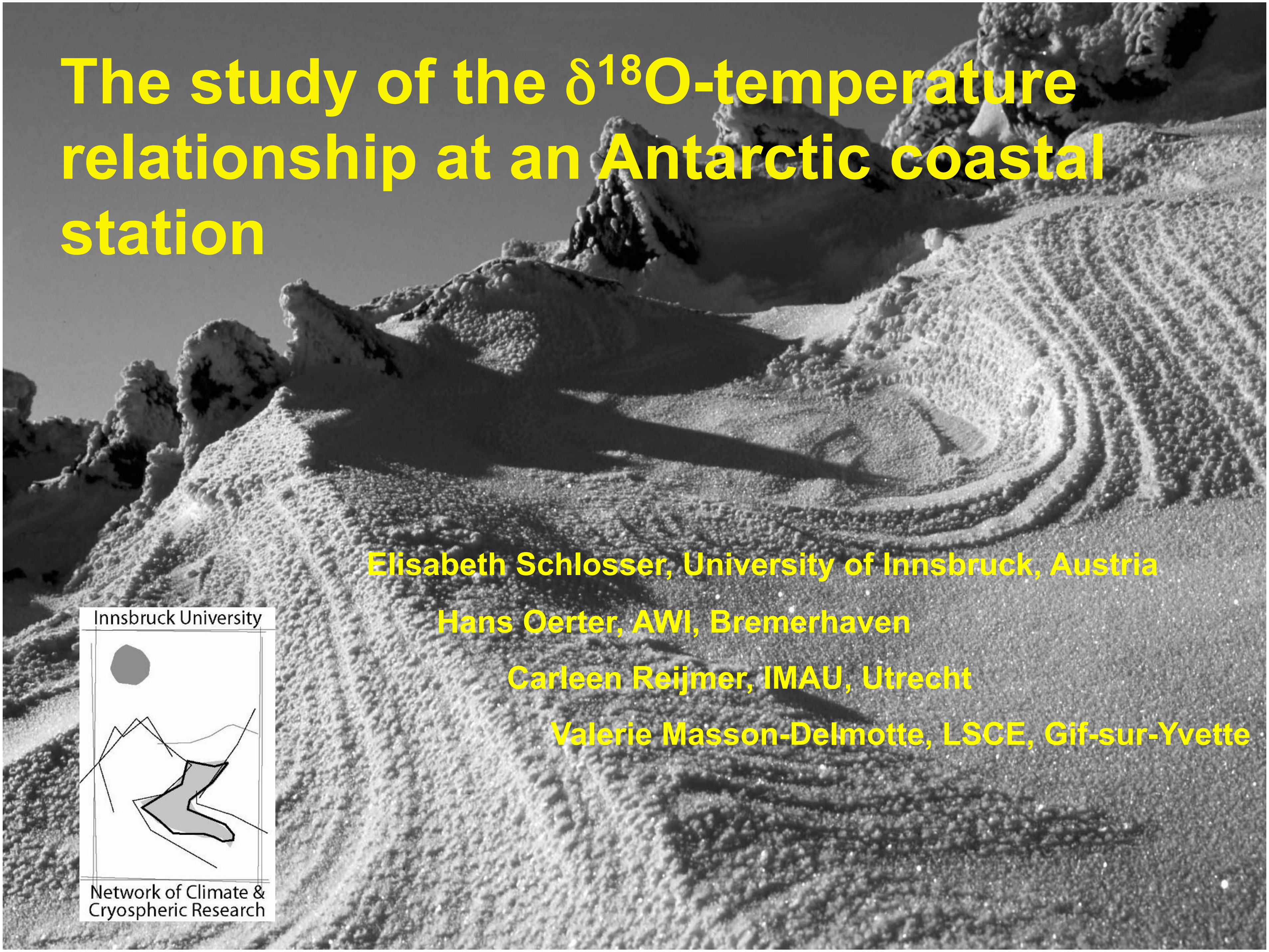

The study of the δ^{18}O-temperature relationship at an Antarctic coastal station

Elisabeth Schlosser, University of Innsbruck, Austria
Hans Oerter, AWI, Bremerhaven
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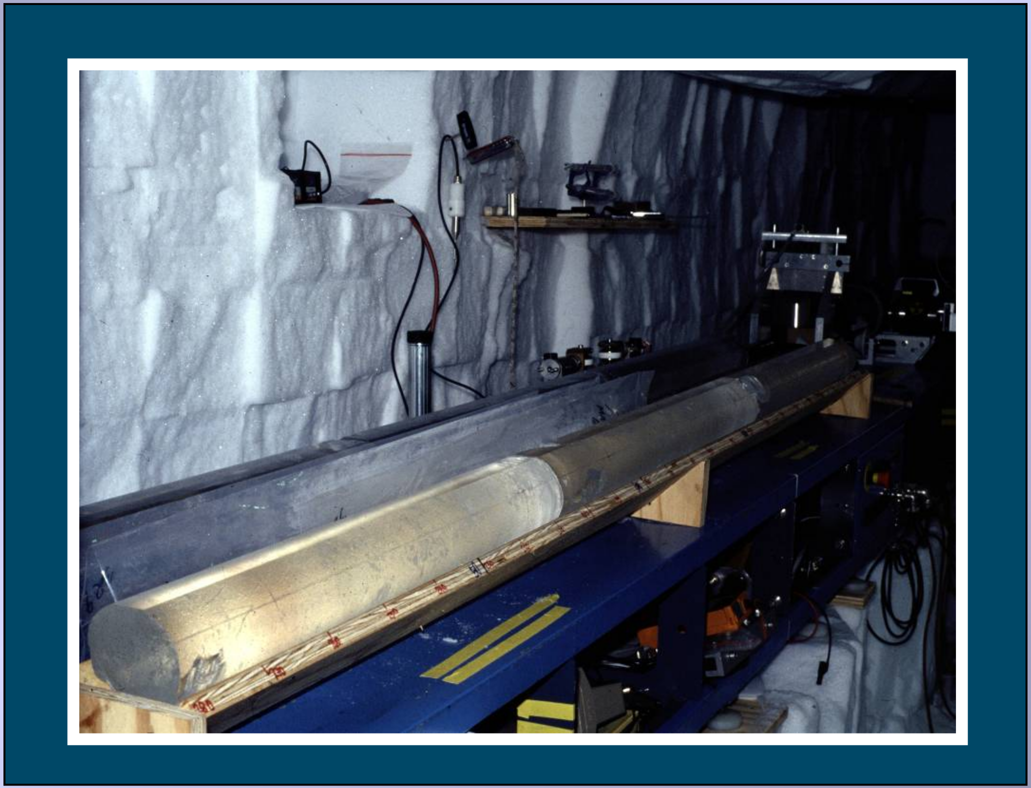
Innsbruck University
Network of Climate & Cryospheric Research

Ice Cores

- very successful in paleoclimatology
- climatic information from Greenland and Antarctica, „EPICA“

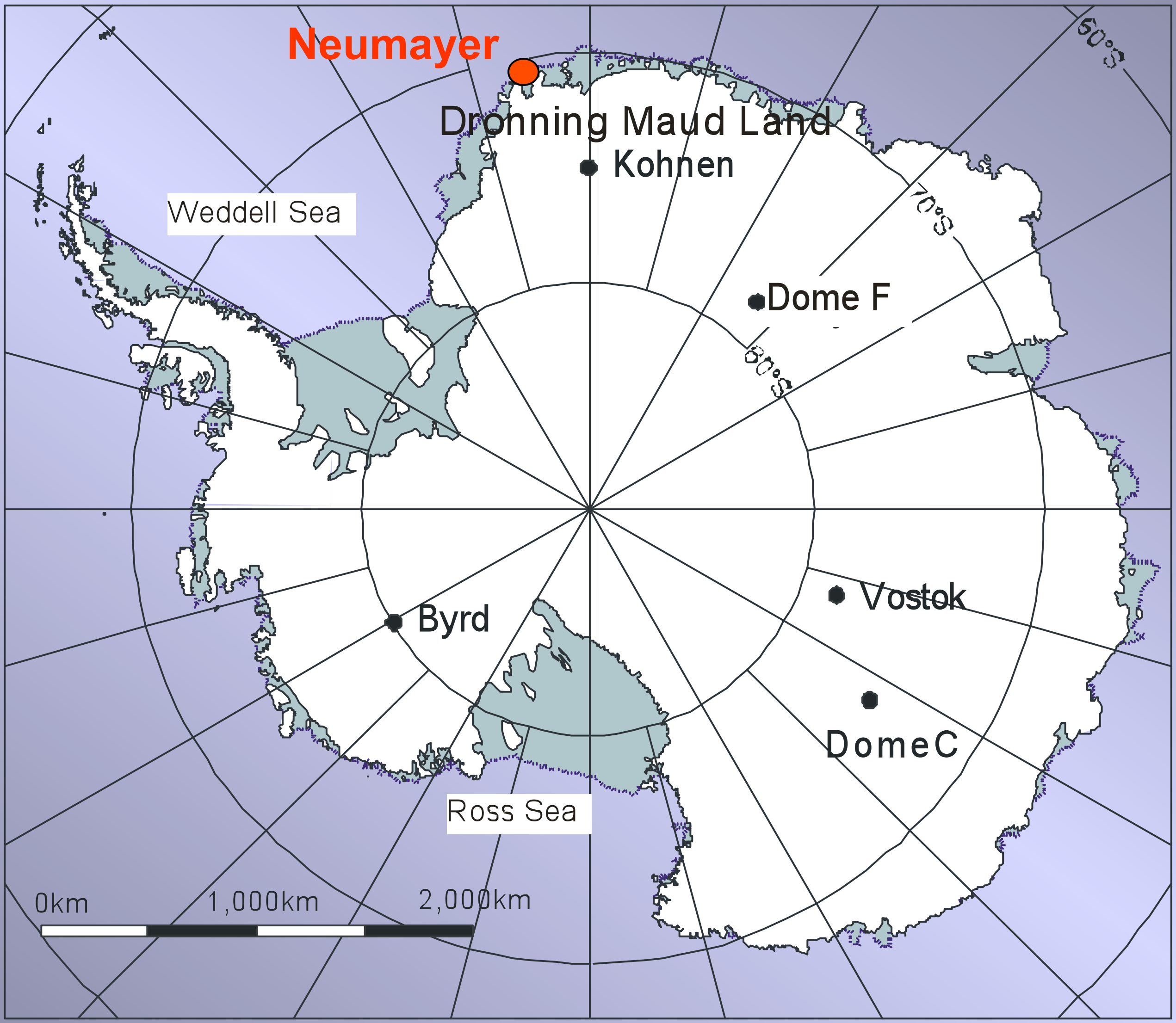


Ice Cores

- different parameters of snow and air bubbles are measured
- stable isotopes: $\delta^{18}O$ – T – relationship not as simple as originally assumed

Ice Cores

- different parameters of snow and air bubbles are measured
- stable isotopes: $\delta^{18}O$ – T – relationship not as simple as originally assumed
- detailed investigation required
- problem: no sufficient data available at drilling locations


Neumayer
Dronning Maud Land
Kohnen
Weddell Sea
Dome F
60°S
70°S
80°S
Vostok
Byrd
DomeC
Ross Sea
0km
1,000km
2,000km

Stable isotopes

- different types of oxygen and hydrogen molecules: ^{16}O, ^{18}O, H, ^{2}H (Deuterium D)

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Stable isotopes

- different types of oxygen and hydrogen molecules: ^{16}O, ^{18}O, H, ^{2}H (Deuterium D)
- ratio of heavy to light molecules changes during evaporation and condensation
- this „fractionation“ depends on air temperature
- H and O behave differently, thus additional information from deuterium excess:

($d = \delta D - 8\ \delta^{18}O$)

Stable oxygen isotopes

$$\delta^{18}O = \frac{({}^{18}O/{}^{16}O)_{\mathrm{Probe}} - ({}^{18}O/{}^{16}O)_{\mathrm{SMOW}}}{({}^{18}O/{}^{16}O)_{\mathrm{SMOW}}}$$

SMOW: standard mean ocean water
(analog für δD)

Georg-von-Neumayer-Station 1981-1992

Georg-von-Neumayer Station during polar night

Neumayer Station 1992-2008

Neumayer and ice cores

Ice shelf station → no long climate data series

but: detailed **parallel** meteorological and glaciological measurements for **more than two decades** at the same site:

accumulation, isotopes, snow chemistry and complete **meteorological data set** including upper air soundings (radiosondes)

This enables us to study the processes that are important for ice core interpretation on small time scales and use the results for the long records.

Data

accumulation from
stake array,
(weekly since 1981)
snow pits, and
shallow firn cores

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δ^{18}O and δD from
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δ^{18}O and δD of fresh snow samples
342 samples (1981-2000)

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meteorological
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5-d-backwards-
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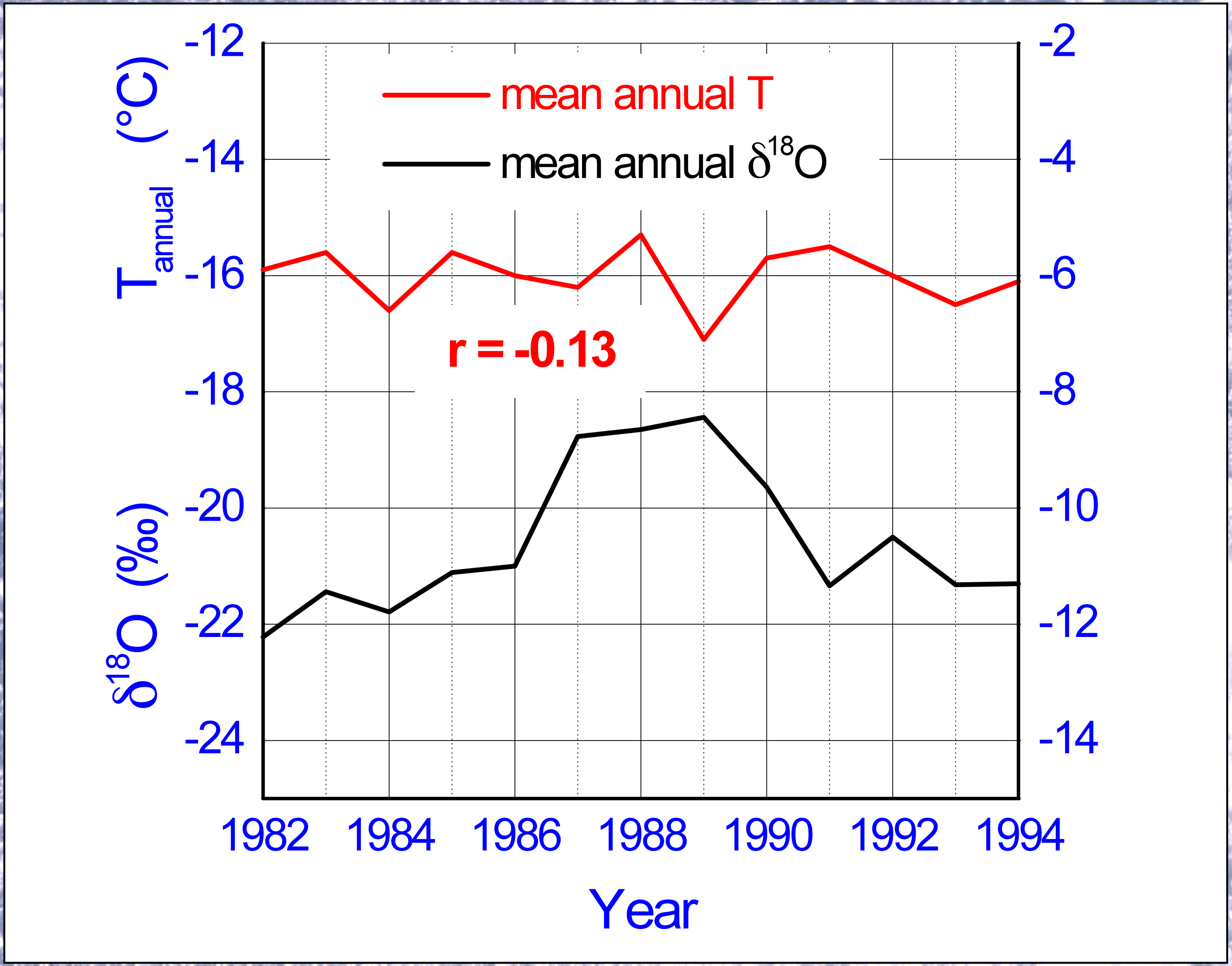
5-d-backwards-trajectories from KNMI-trajectory model (1981-2000)

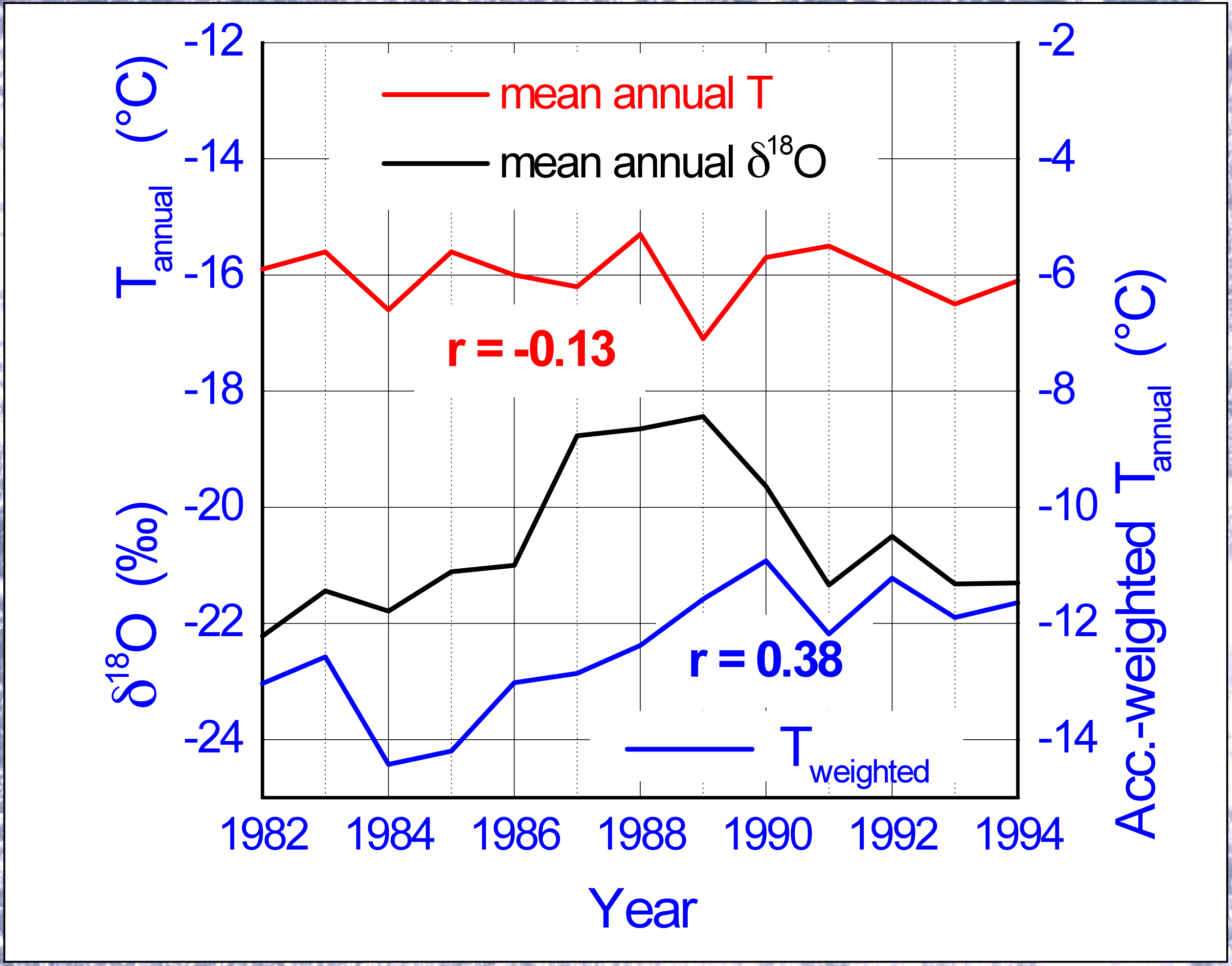
ECMWF-Re-analysis data
500hPa-geopotential height,
surface pressure

$\delta^{18}O$ – T - relationship



annual mean of $\delta^{18}O$ and air temperature

$\delta^{18}O$ – T - relationship



annual mean $\delta^{18}O$ and air temperature

Neumayer

Change in seasonal distribution of accumulation due to interannual changes of *synoptic conditions*

➡ Bias in mean annual $\delta^{18}O$

Deep drillings

Change in seasonal distribution of accumulation due to *Change of General Atmospheric Circulation* at transition from ice age to warm period

➡ Bias in mean annual $\delta^{18}O$ in ice core

Neumayer

seasonal change in sea ice coverage

→ change in storm tracks

→ change in accumulation distribution

→ **change in δ^{18}O without change in T!**

Deep drillings

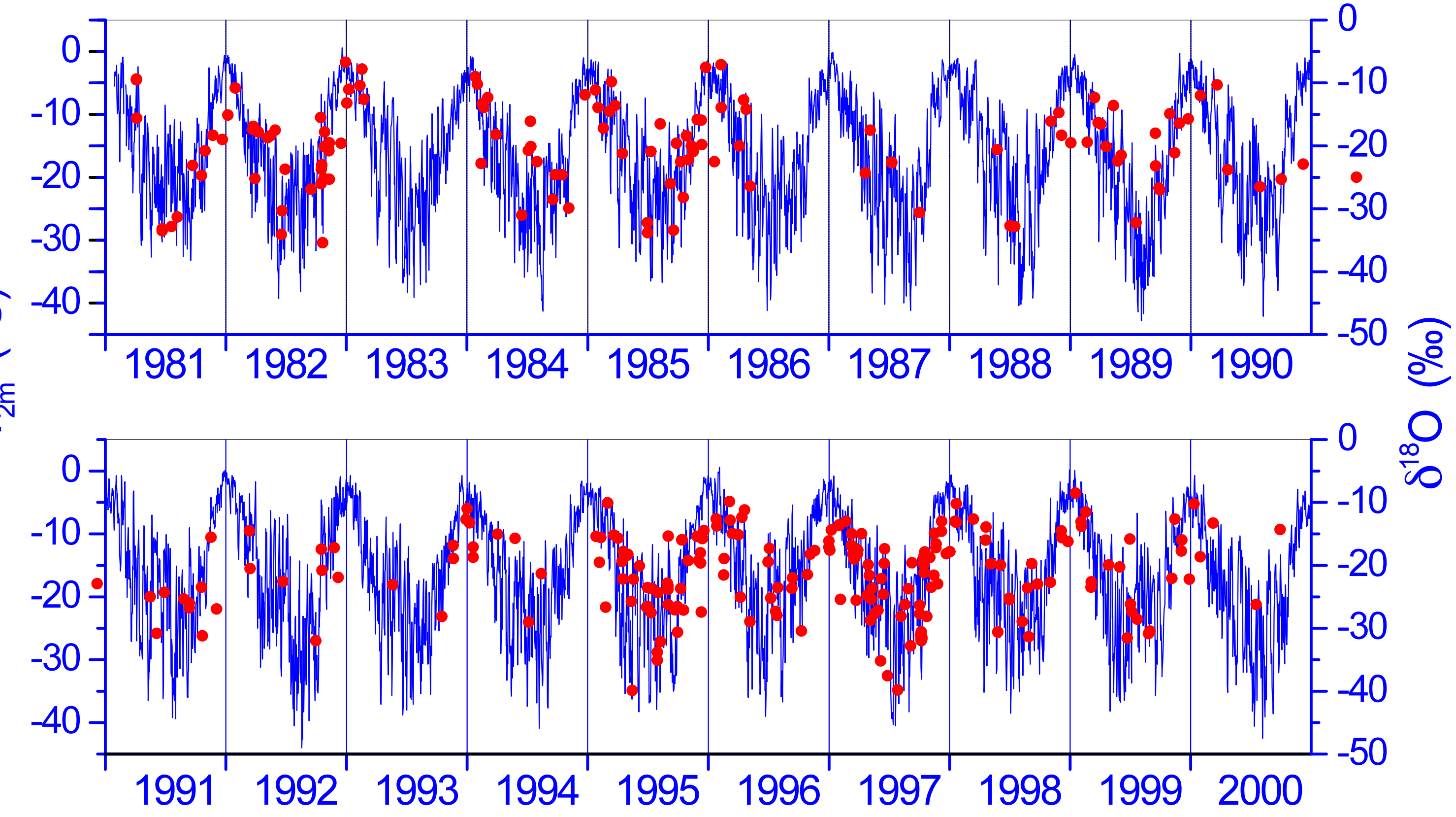
change in mean sea ice coverage at transition ice age - warm period

→ change in storm tracks

→ change in accumulation distribution

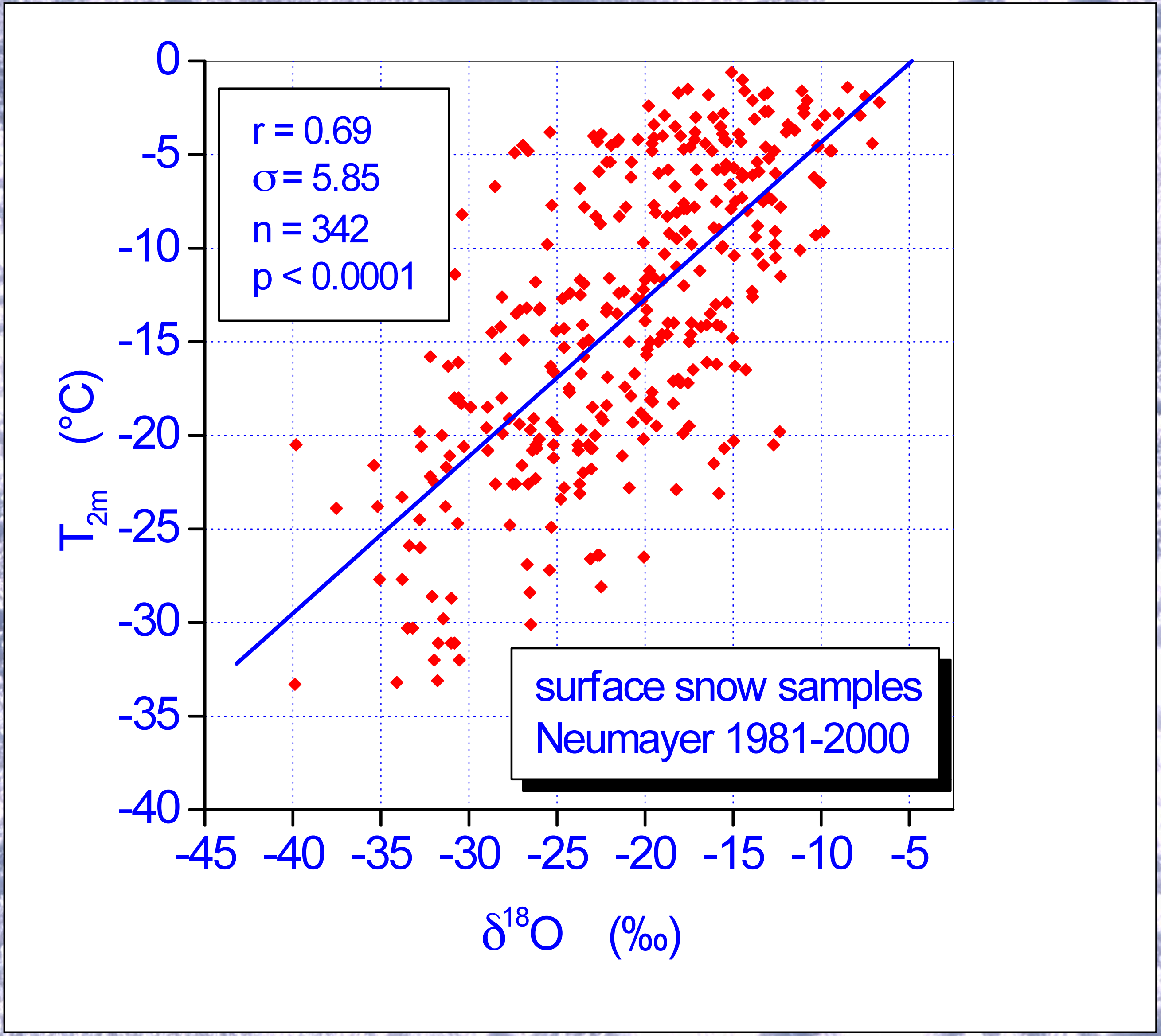
→ **change in δ^{18}O without change in T!**

$\delta^{18}O$ – T - relationship

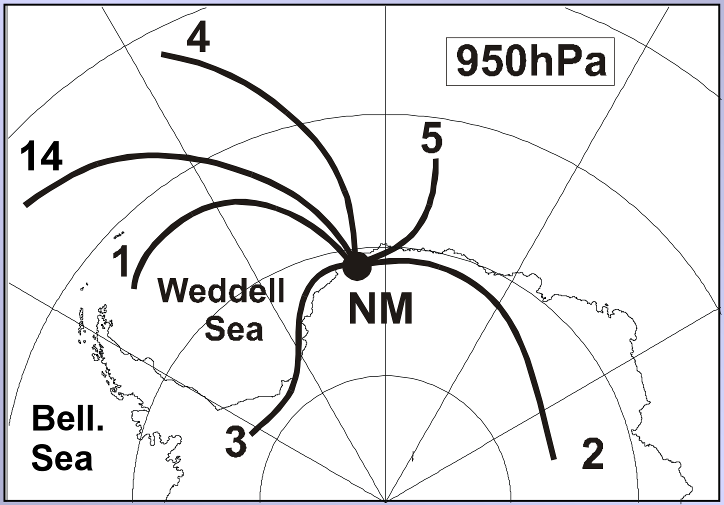


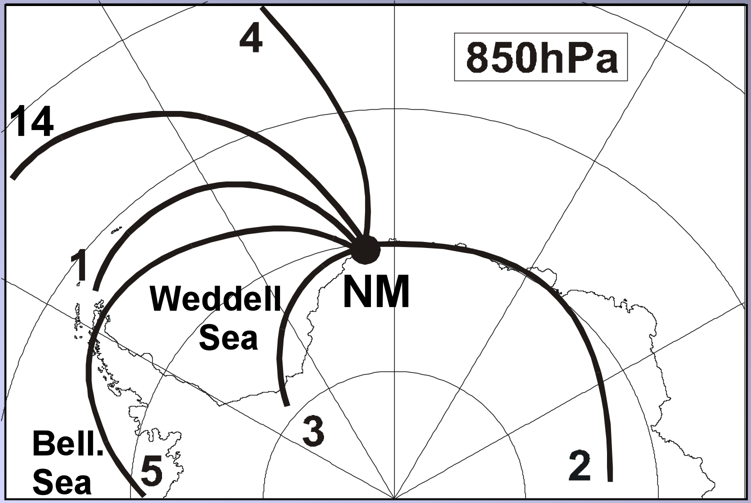
$\delta^{18}O$ from surface snow samples (red dots) and measured 2m-air temperature (solid line) 1981-2000

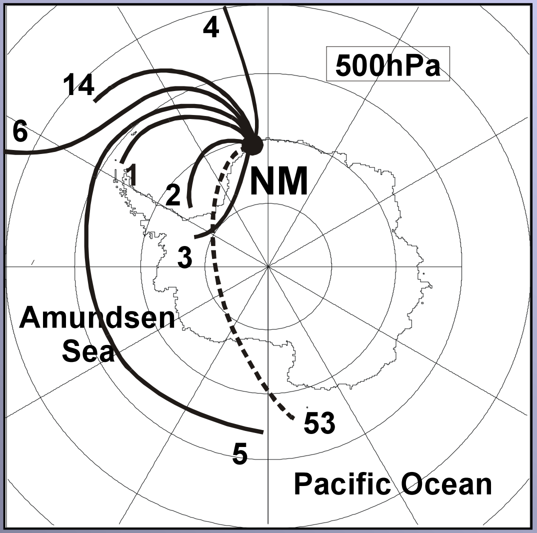
$\delta^{18}O$ – T - relationship



Trajectory model



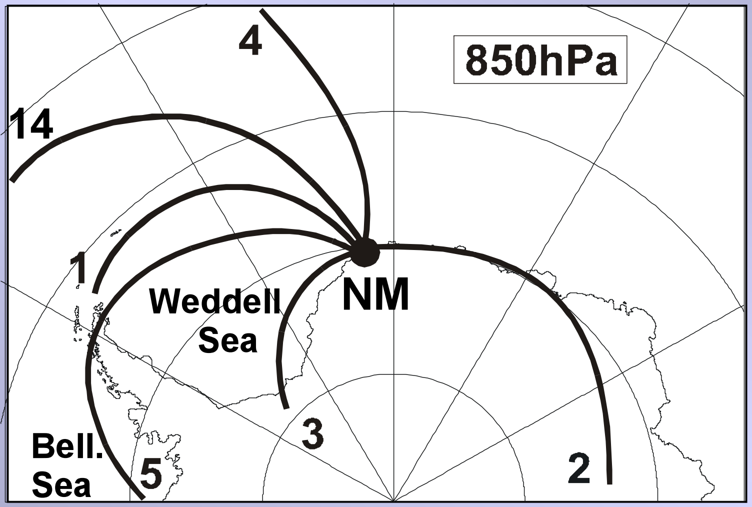


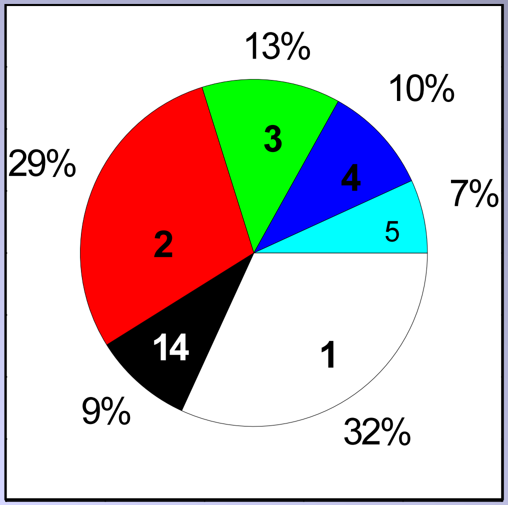


1: Weddell Sea
3: continental S
4: N-NW > 50°S

2: continental E (950 + 850hPa)
5: different for different levels

Trajectory model





1 Weddell Sea

14 north of 60°S, around Weddell Sea

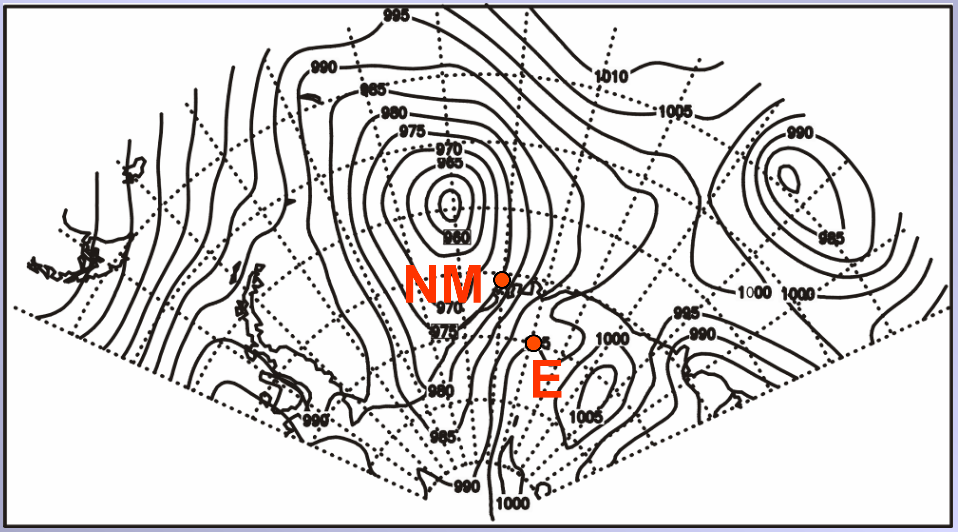
2 cont. E-SE

3 cont. S

4 NW north of 50°S

5 Amundsen-Bellingshausen Sea

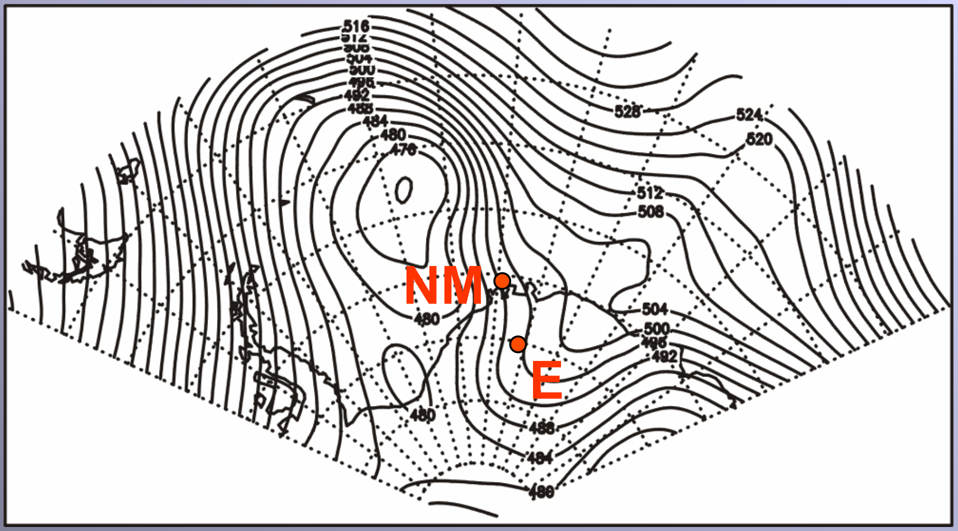
ECMWF-Re-analysis



2. Nov. 1997

Trajectory class 4
(all arrival levels)

surface pressure



500hPa Geopotent. height

NM: Neumayer

E: EPICA Kohnen

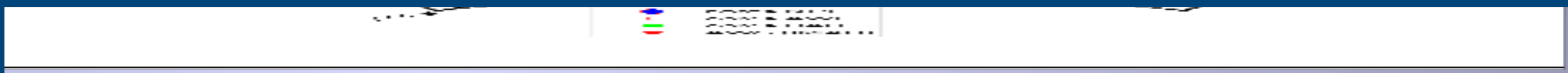
Outlook

- Study with 65 firn cores of Dronning Maud Land
- Study of DML precipitation regime using AMPS
- δ^{18}O for firn cores in relation to synoptic situation and sea ice extent
- Implications for EPICA deep core interpretation

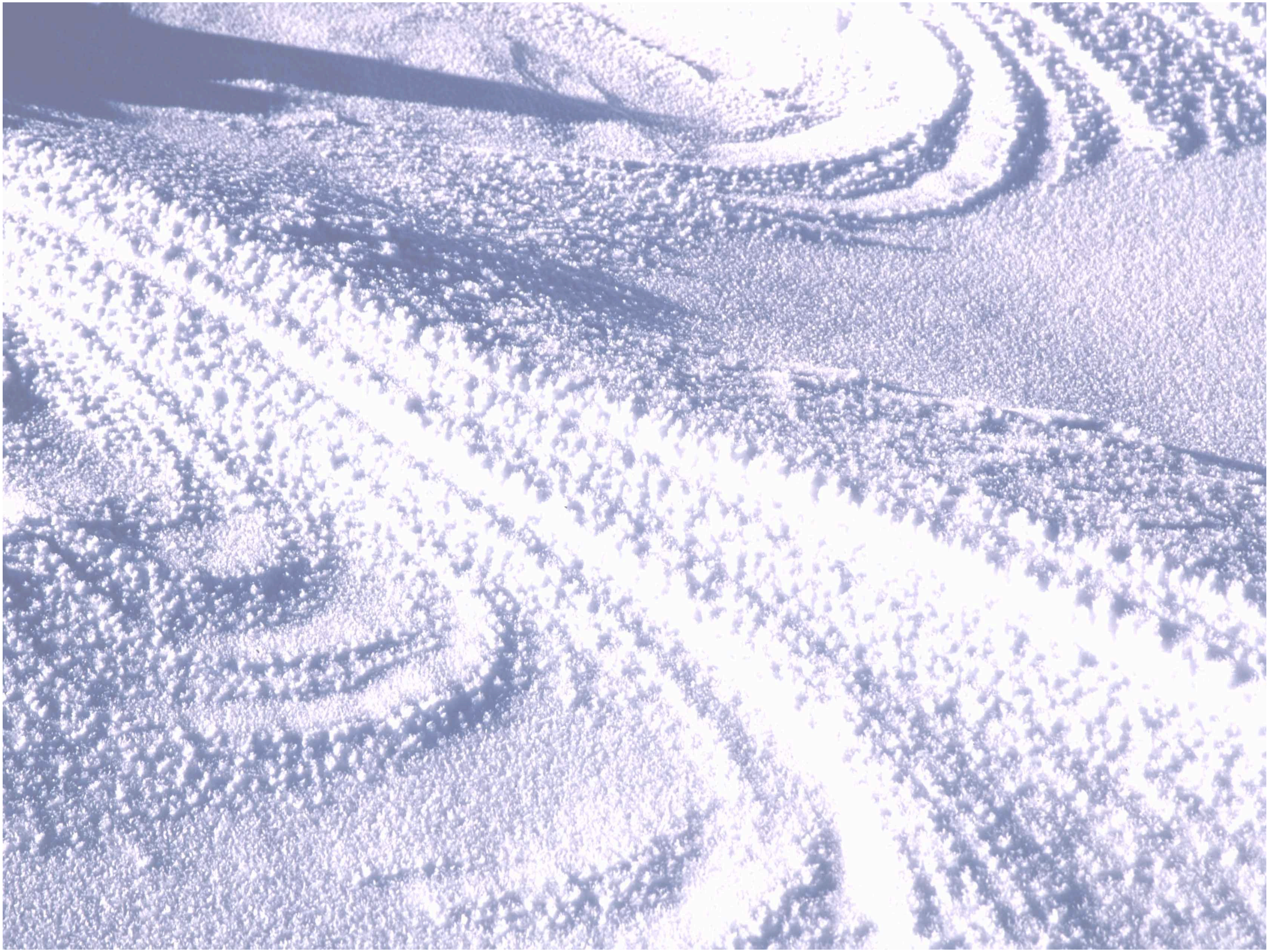
Acknowledgements:

Thanks are due to all Neumayer winterers for doing the field work, to Wolfgang Graf for sample analysis, Alex Gohm for computer support, and the Austrian Science Fund (FWF) for funding.

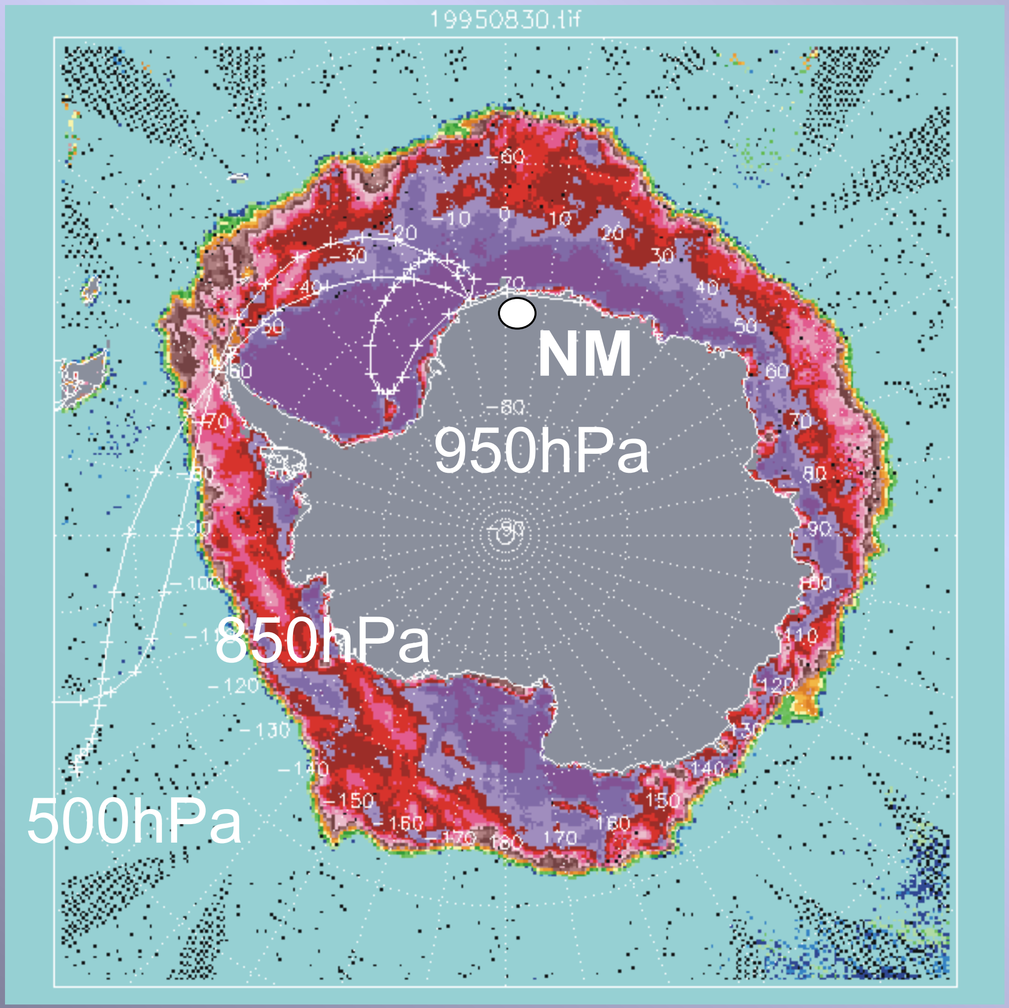
Map of DML



Thank you for your attention!



δ-T – relationship and sea ice



example: 30.8.95

>80% ocean:

no sign. corr.!

>80% sea or land ice:

r= 0.61

(n=76, p<0.0001)

100% ice-covered

Weddell Sea (3 days):

r=0.73 !

(n=38, p<0.0001)

Deuterium excess

$$d = \delta D - 8\ \delta^{18}O$$

depends on : Sea Surface Temp., rel. humidity and wind speed
at source area for precipitation (ocean)
(empirical equations)

physics: 2 different processes of fractionation:
„kinetic processes“:
different *molecular diffusion*
of light and heavy molecules
and „equilibrium processes“:
different saturation vapour pressure
of light and heavy molecules

equilibrium fractionation for D 8-10x larger than for ^{18}O,
kin. effects für D und ^{18}O similar

➡ **rel. contribution of kin. fract. for D smaller than for ^{18}O**

Deuterium excess

$$d = \delta D - 8\ \delta^{18}O$$

Deuterium excess dependent on:

- conditions at first evaporation from ocean
- number and kind of fractionation between first evaporation at the oceanic source and precipitation site

Deuterium excess

Arrival level	950hPa	850hPa	500hPa
Trajectory class	d	d	d
1	8.14	8.94	9.43
14	9.42	6.70	6.06
2	8.41	8.89	-
3	10.79	10.91	11.88
4	5.69	6.15	6.33
5	-	7.80	8.97
53			11.50
6			8.21

Mean deuterium excess d for each class and arrival level, respectively