Università degli Studi di Ferrara

Dipartimento di Studi Umanistici

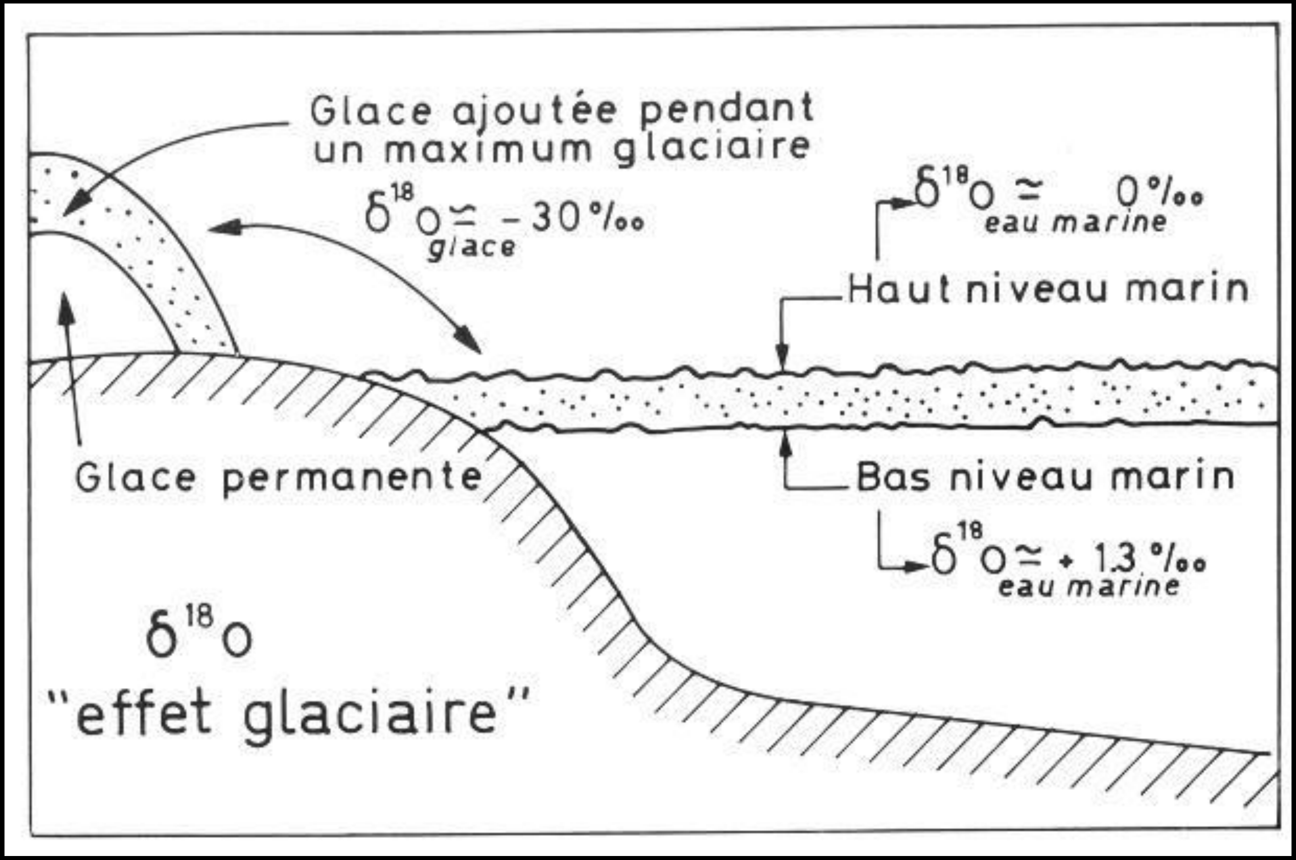
# Ecologia Preistorica

Prof. Marco Peresani

A.A. 2021-2022

## Lezione 4 - Carote di ghiaccio e paleotemperature

# Effetto glaciale



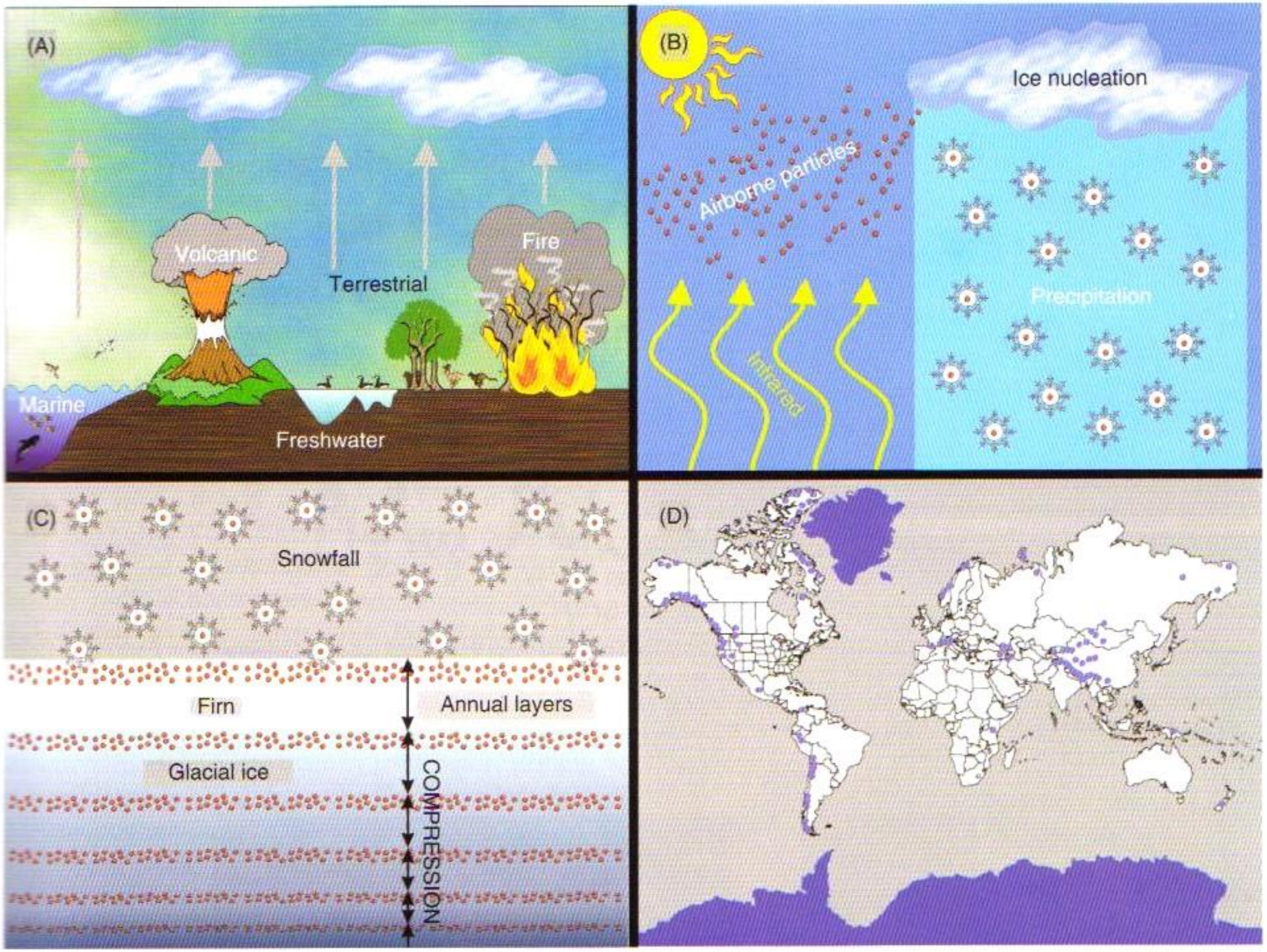
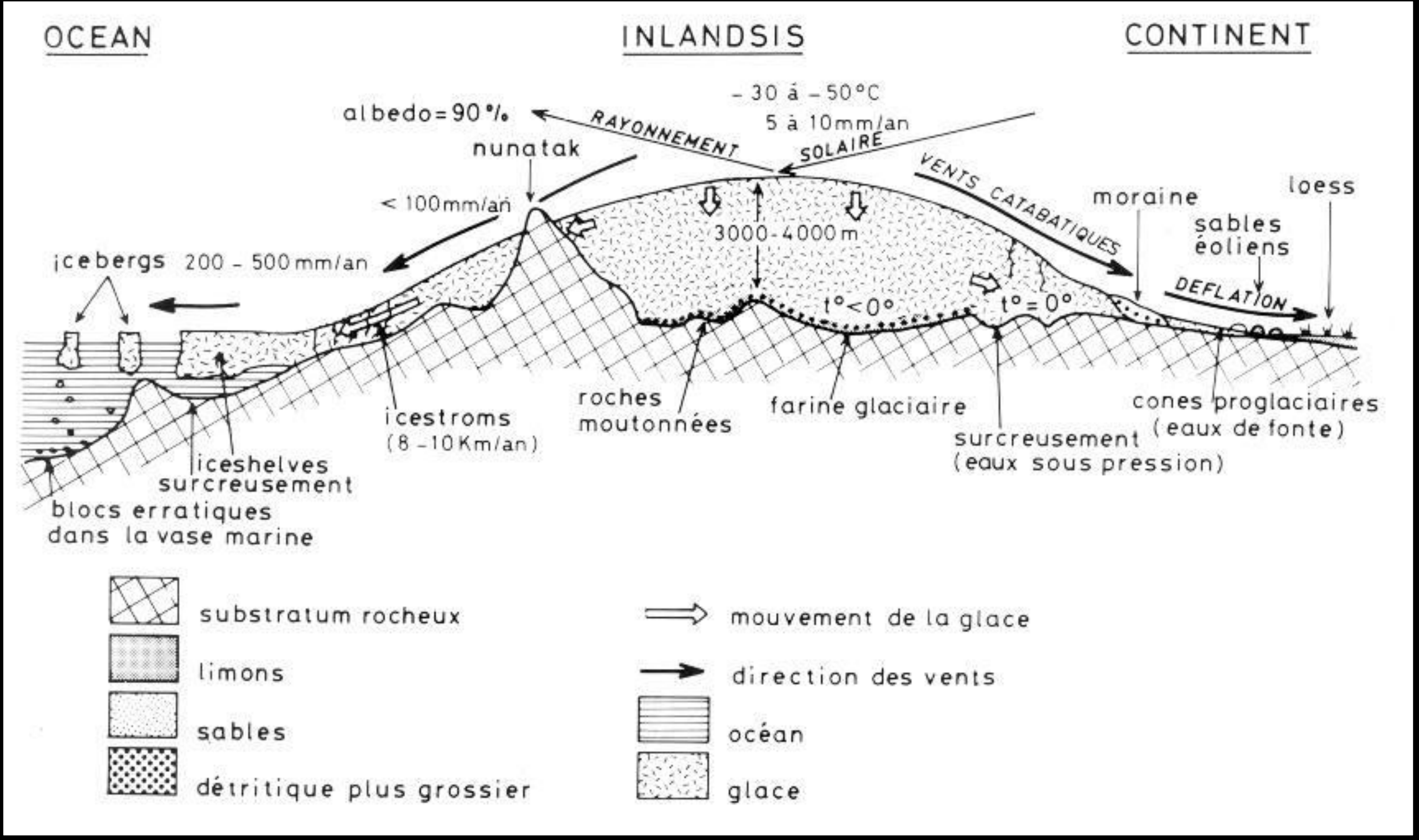
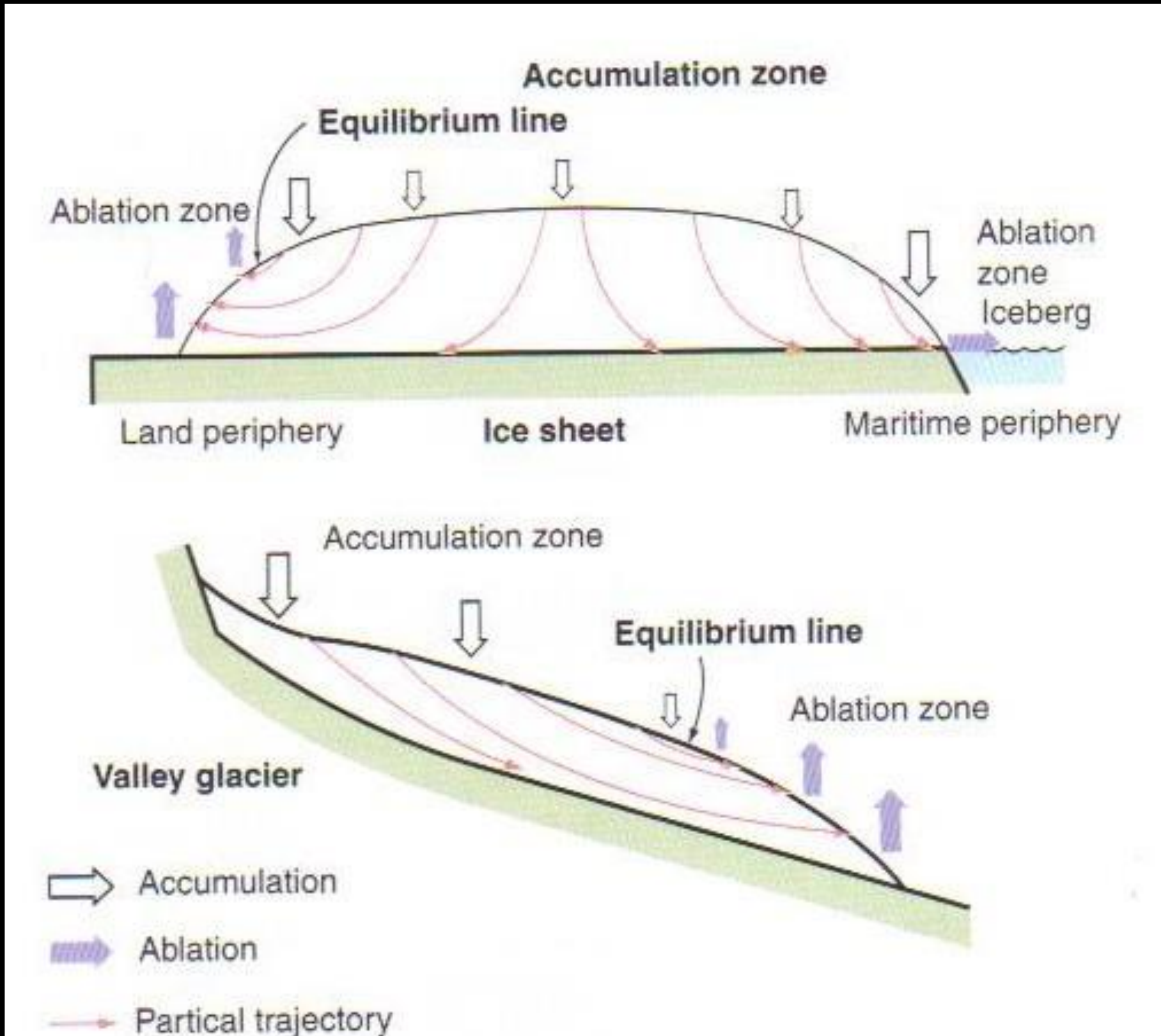
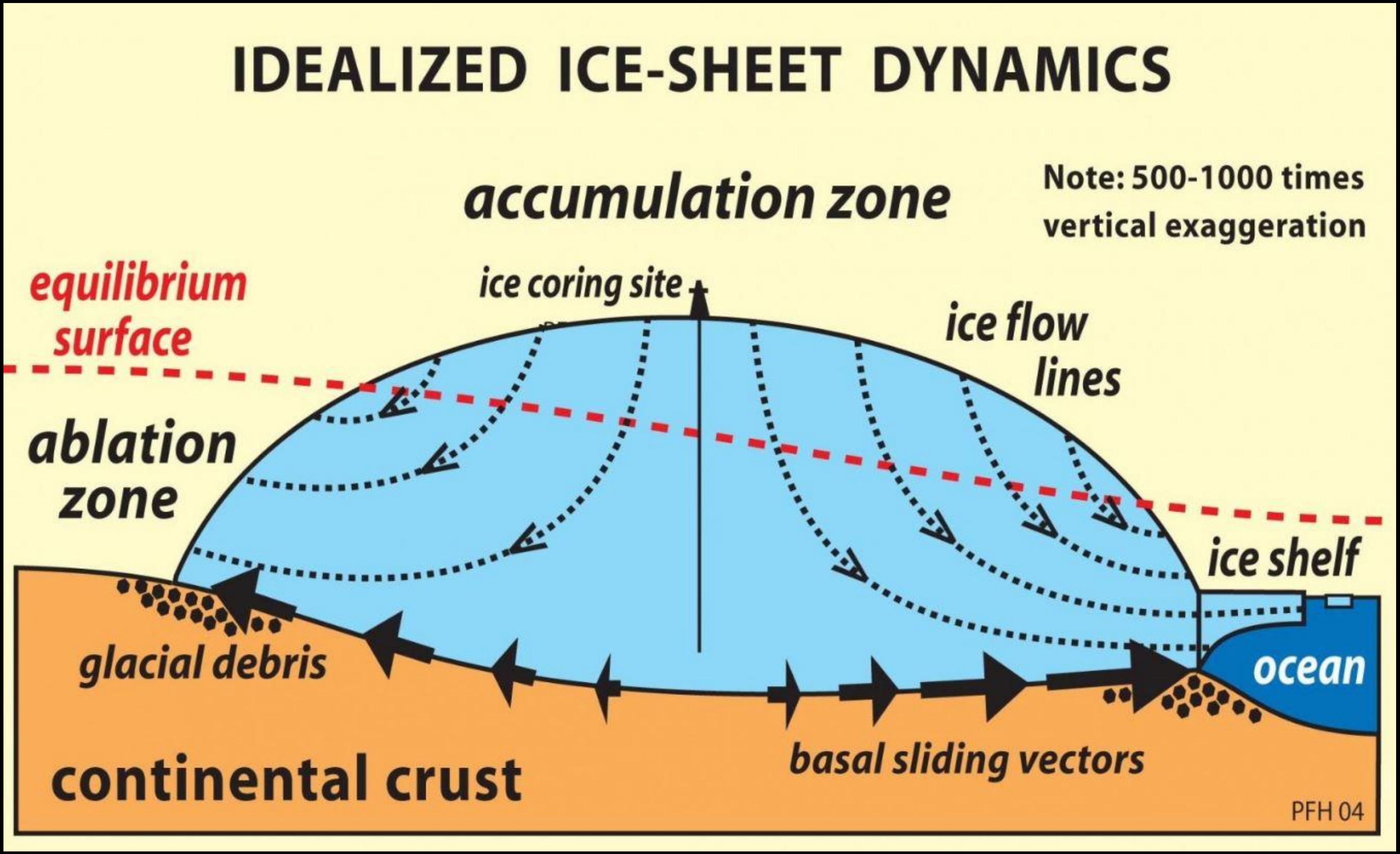



**Figure 1** History of entrapped particles in glacial ice and the present-day distribution of glaciers. (A) Schematic illustrating the range of source environments that contribute particles to the atmosphere. (B) Advective currents, created by solar generated infared radiation, inject surface derived aerosols high in the atmosphere. Such aerosols (red dots) may serve as primary ice nuclei in clouds, and are subsequently precipitated in snowfall or rain. (C) In geographical locations where the annual temperature remains cold enough for snowfall to accumulate annually, particles from the atmosphere are archived in a chronological sequence in firn and glacial ice. (D) Global locations of present-day ice sheets and mountain glaciers (in blue). Each glacial environment is unique, as the nearest ecosystems that would most likely contribute the majority of airborne biological particles are very different. Distribution data based in part on Satellite Image Atlas of Glaciers of the World (US Geological Survey, (2002) Satellite Image Atlas of Glaciers of the World).


OCEAN
INLANDSIS
CONTINENT
- 30 à - 50°C
5 à 10mm/an
albedo=90%
RAYONNEMENT
SOLAIRE
nunatak
< 100mm/an
VENTS CATABATIQUES
moraine
loess
sables éoliens
3000-4000m
icebergs 200 - 500mm/an
DEFLATION
t°<0°
t°=0°
icestroms (8 -10Km/an)
roches moutonnées
farine glaciaire
cones proglaciaires (eaux de fonte)
surcreusement (eaux sous pression)
iceshelves surcreusement
blocs erratiques dans la vase marine
substratum rocheux
limons
sables
détritique plus grossier
mouvement de la glace
direction des vents
océan
glace

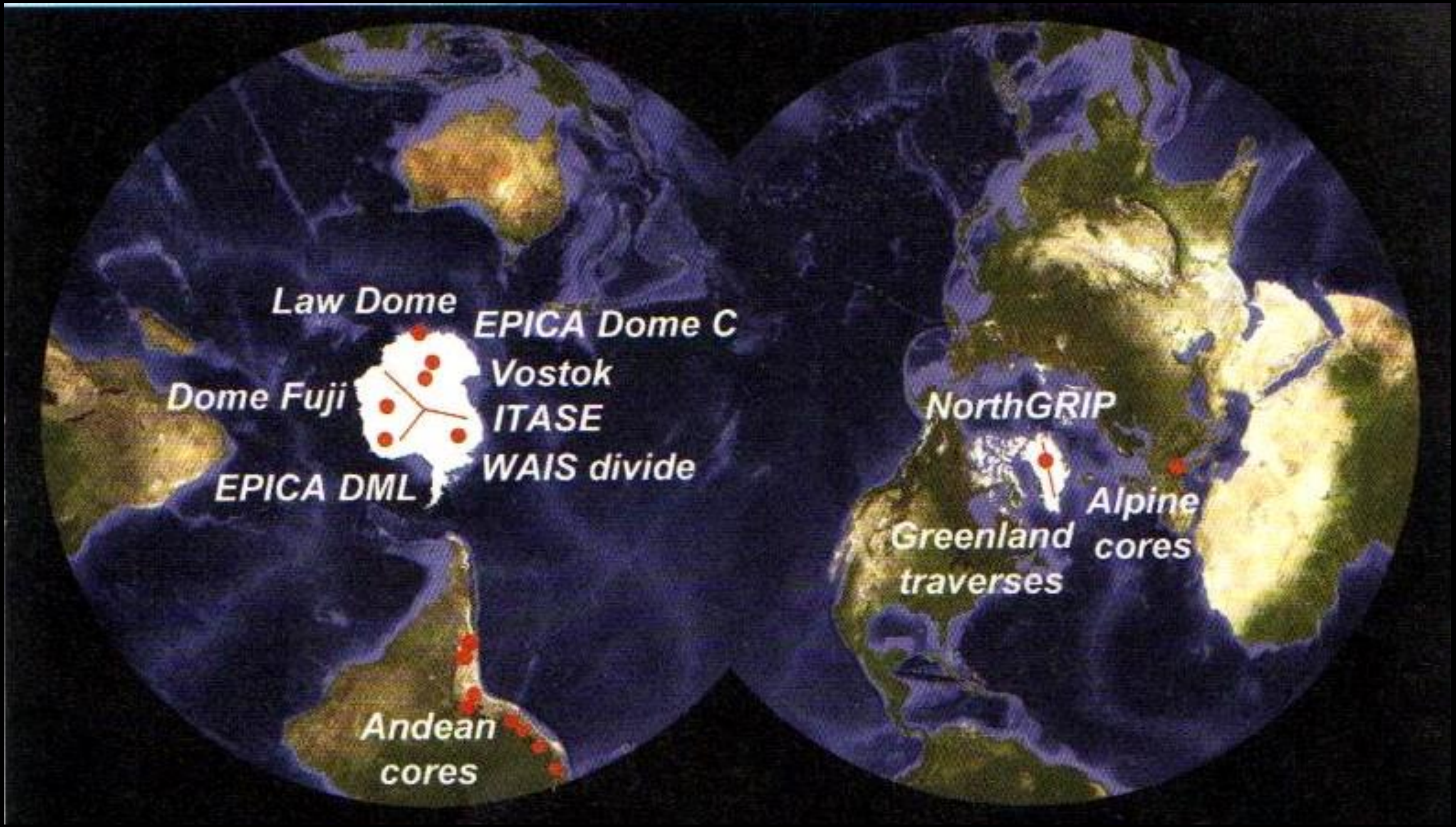

Accumulation zone
Equilibrium line
Ablation zone
Ablation
zone
Iceberg
Land periphery
Ice sheet
Maritime periphery
Accumulation zone
Equilibrium line
Ablation zone
Valley glacier
Accumulation
Ablation
Partical trajectory



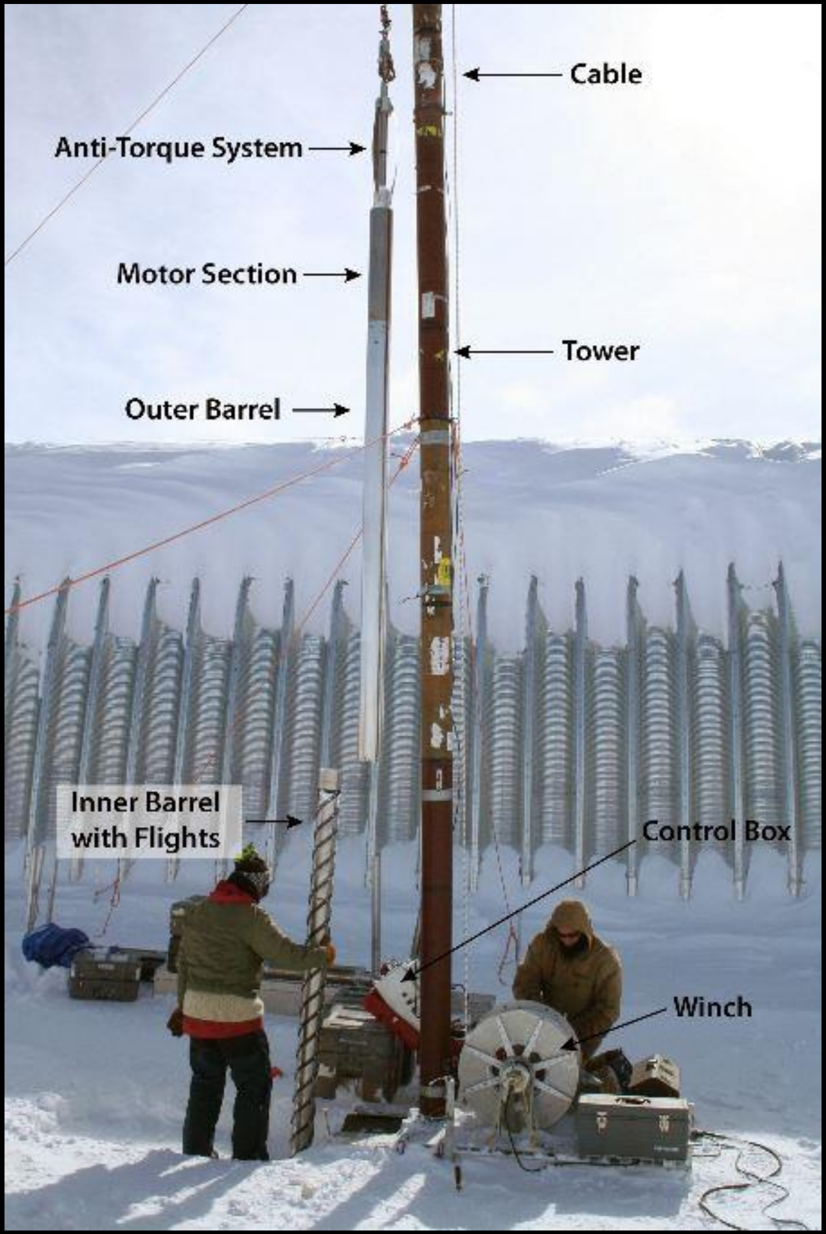
IDEALIZED ICE-SHEET DYNAMICS
accumulation zone
Note: 500-1000 times
vertical exaggeration
equilibrium
surface
ice coring site
ice flow
lines
ablation
zone
ice shelf
ocean
glacial debris
basal sliding vectors
continental crust
PFH 04

The science of ice core drilling originated in the 1950s and the first deep core in Antarctica was at Byrd Station in 1968, during the International Geophysical Year. Since then, numerous deep-coring projects have been completed (blue circles in **a** in the figure). The longest core, at Vostok Station, reaches 3,700 m below the ice surface. The oldest so far, the EPICA Dome C ice core, extends to 800,000 years[1].

The technology for deep ice coring has gradually evolved, with recent developments in larger volume and replicate coring drills, and new access tools that will allow quick sampling of deep ice sections, coring within bedrock and analysis in situ.


Law Dome
EPICA Dome C
Vostok
Dome Fuji
ITASE
WAIS divide
EPICA DML
Andean
cores
NorthGRIP
Alpine
cores
Greenland
traverses

Ice cores are cylinders of ice drilled out of an ice sheet or glacier. Most ice core records come from Antarctica and Greenland, and the longest ice cores extend to 3km in depth. The oldest continuous ice core records to date extend 123,000 years in Greenland and 800,000 years in Antarctica.


Cable
Anti-Torque System
Motor Section
Tower
Outer Barrel
Inner Barrel
with Flights
Control Box
Winch

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# National Ice Core Laboratory

HOME ABOUT NICL SAMPLE ACCESS POLICY INVENTORY NEWS ABOUT ICE CORES

**The Main Archive Freezer at the National Ice Core Laboratory**

Photo credit: National Ice Core Laboratory


USGS

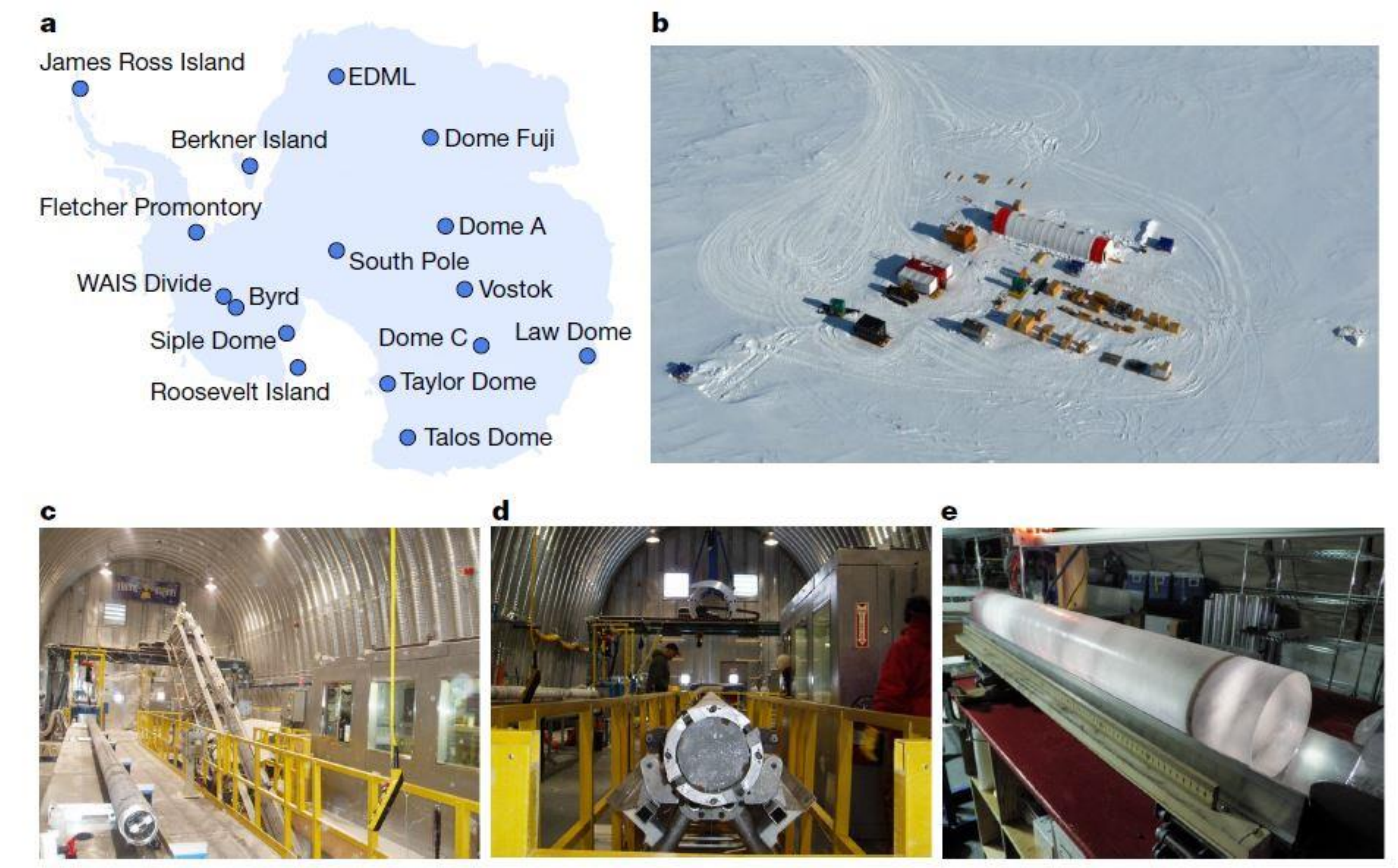

# Antarctic and global climate history viewed from ice cores

Edward J. Brook[1]* & Christo Buizert[1]

The science of ice core drilling originated in the 1950s and the first deep core in Antarctica was at Byrd Station in 1968, during the International Geophysical Year. Since then, numerous deep-coring projects have been completed (blue circles in a in the figure).

The longest core, at Vostok Station, reaches 3,700 m below the ice surface. The oldest so far, the EPICA Dome C ice core, extends to 800,000 years. The technology for deep ice coring has gradually evolved, with recent developments in larger volume and replicate coring drills, and new access tools that will allow quick sampling of deep ice sections, coring within bedrock and analysis in situ. National archive facilities retain samples from all deep ice cores, preserving a unique resource for the scientific community.

At an ice core drilling camp at the South Pole (b), the long arch structure contains the drill. The tipping tower of the US Deep Ice Coring Drill is shown (c). An ice core section in the WAIS Divide Drill (d) is shown immediately after a drilling run. A core section from the WAIS Divide site (e) shows a visible volcanic ash layer. The core is 12 cm in diameter.




# Antarctic and global climate history viewed from ice cores

Edward J. Brook[1]* & Christo Buizert[1]

# Antarctic and global climate history viewed from ice cores

Edward J. Brook[1]* & Christo Buizert[1]

A growing network of ice cores reveals the past 800,000 years of Antarctic climate and atmospheric composition. The data show tight links among greenhouse gases, aerosols and global climate on many timescales, demonstrate connections between Antarctica and distant locations, and reveal the extraordinary differences between the composition of our present atmosphere and its natural range of variability as revealed in the ice core record.

Further coring in extremely challenging locations is now being planned, with the goal of finding older ice and resolving the mechanisms underlying the shift of glacial cycles from 40,000-year to 100,000-year cycles about a million years ago, one of the great mysteries of climate science.

# International launch of the "Ice Memory" project

**When, local time:**
Wednesday, 8 March 2017 - 2:00pm to Friday, 10 March 2017 - 5:30pm
**Where:** France, Paris
**Type of Event:** Category 6-Expert Committee
**Contact:** Peter Dogsé/84098/p.dogse@unesco.org

Mountain glaciers keep a record our climate and our environment, captured in ice. They are the only direct natural records we have of variations in atmospheric composition, a vital contribution to environmental and climate science. However, this memory of our planet's story is disapearing as many glaciers retreat unrelentingly throughout the world, because of climate change.

The Ice Memory project aims to constitute the first world library of archived glacier ice, to preserve this invaluable scientific heritage for the generations to come, when future techniques can obtain even more data from these samples.

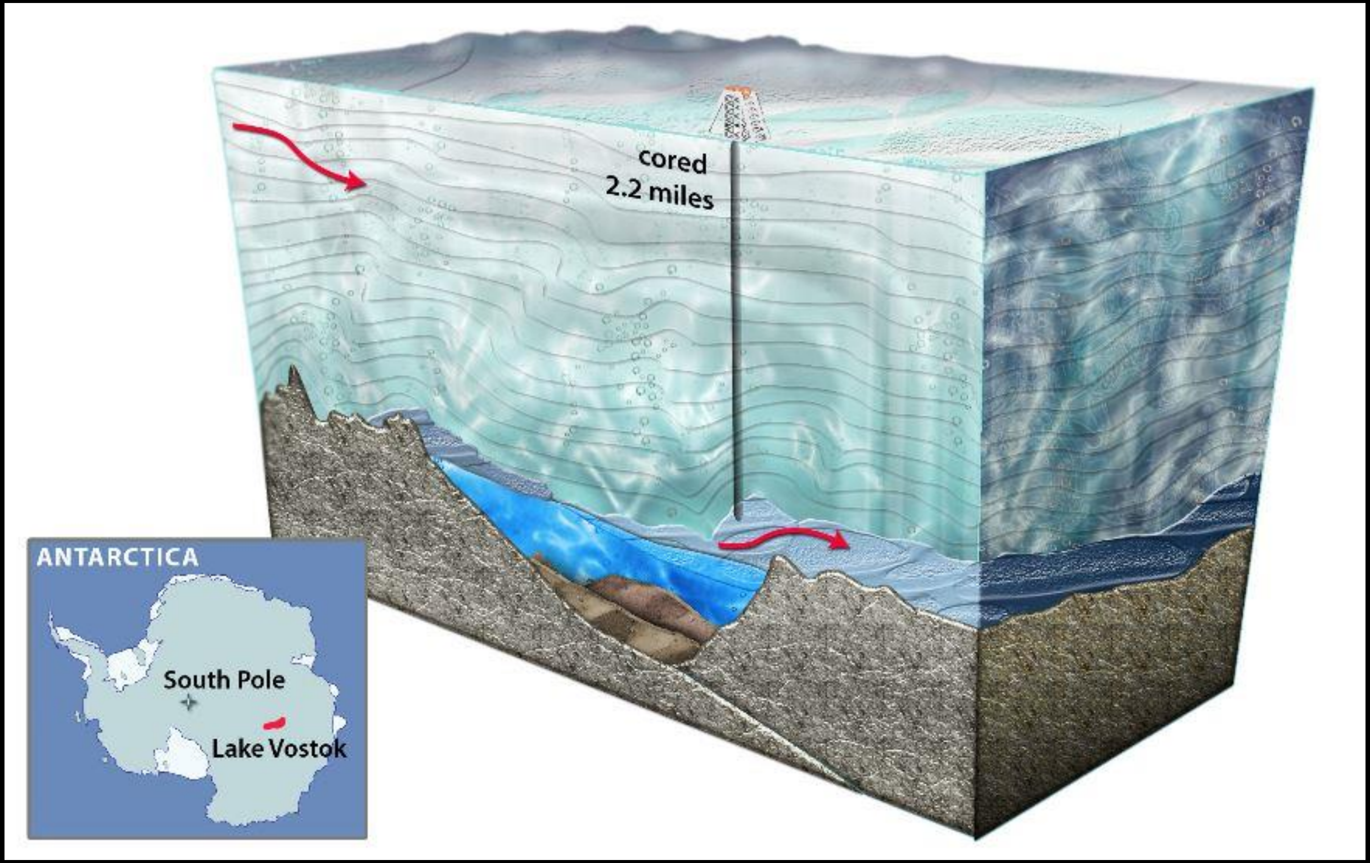
An inauguration ceremony will mark the international launch of the Ice Memory project at UNESCO headquarters on Wednesday 8 March 2017. This inaugural day will be followed by two days of workshops moderated by international experts and UNESCO specialists, to establish a roadmap for the years to come.

This project, managed by the University of Grenoble Alpes Foundation in collaboration with numerous French and Italian partners such as the CNRS or the University of Venice, already benefit from a dynamic international community of scientists and more particularly of glaciologists.

The project is under the patronage of the French and Italian National Commissions for UNESCO.

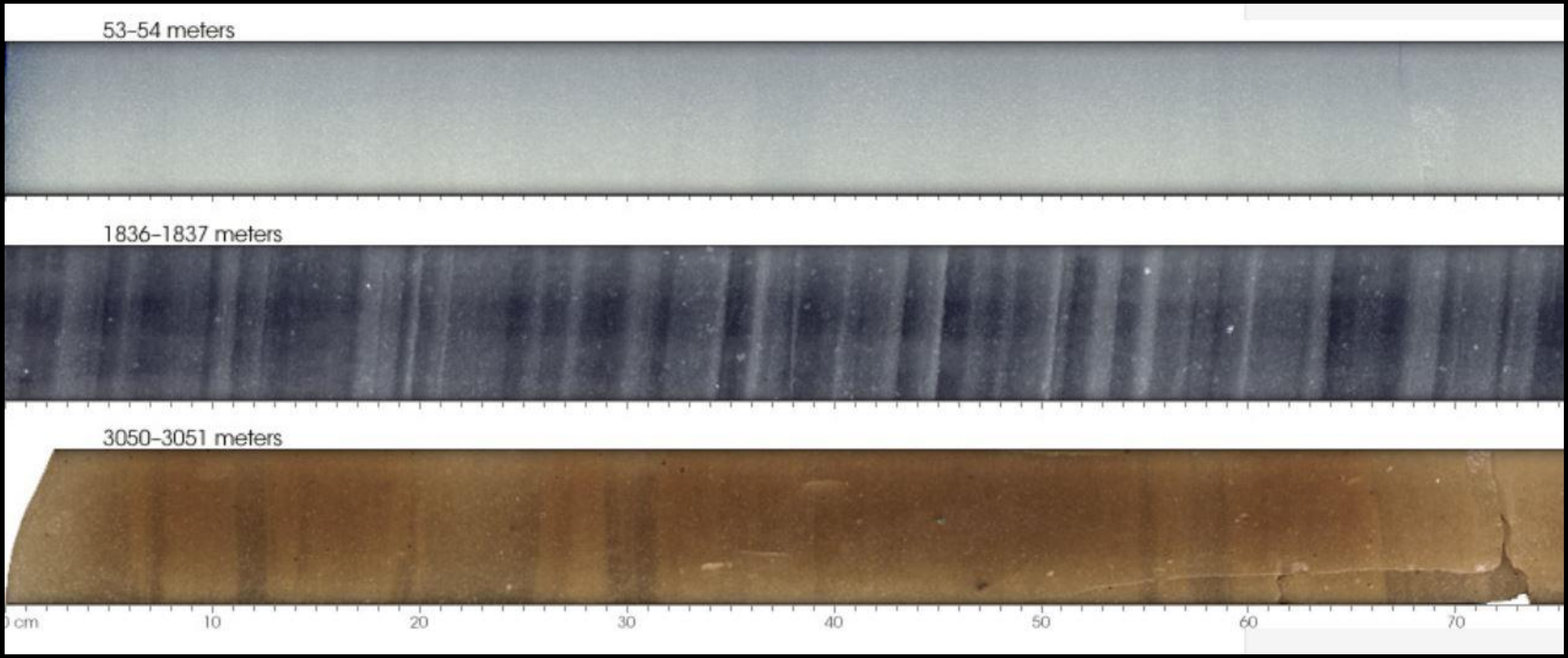
**Links:**
Ice Memory project
Addressing Climate Change

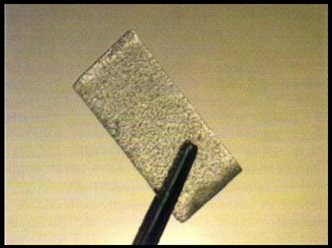
# Vostok Ice Core




From 1995 at Vostok lake
Length of 3.310 meters.
It records 422.766 years of accumulated snow/ice.
It records the last 4 glacial/interglacial climatic cycles

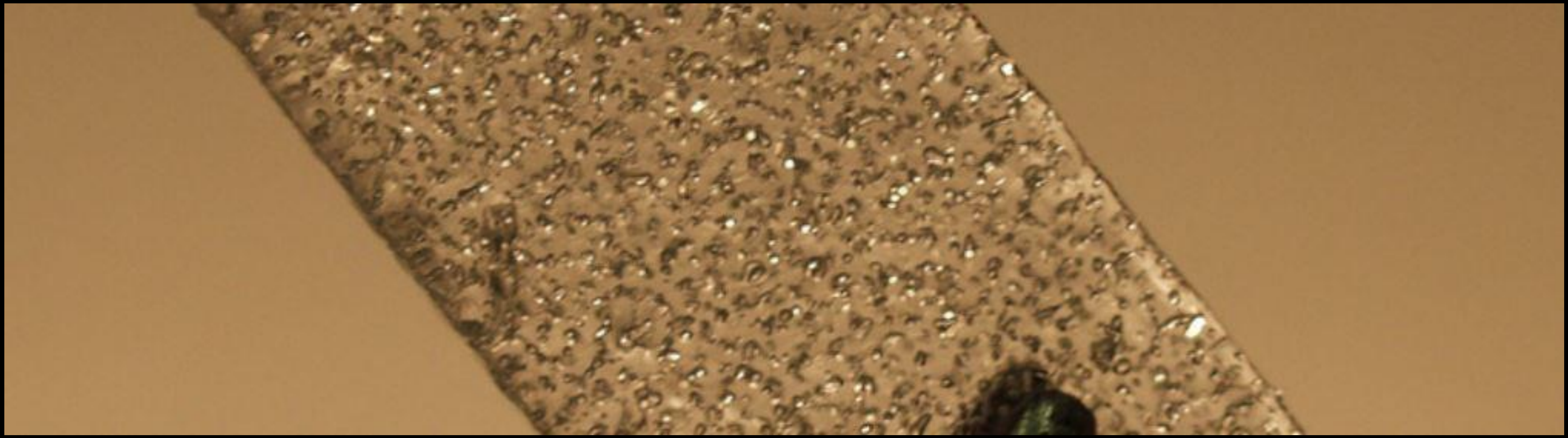
# Vostok Ice Core
## Stato di conservazione del ghiaccio e laminazioni

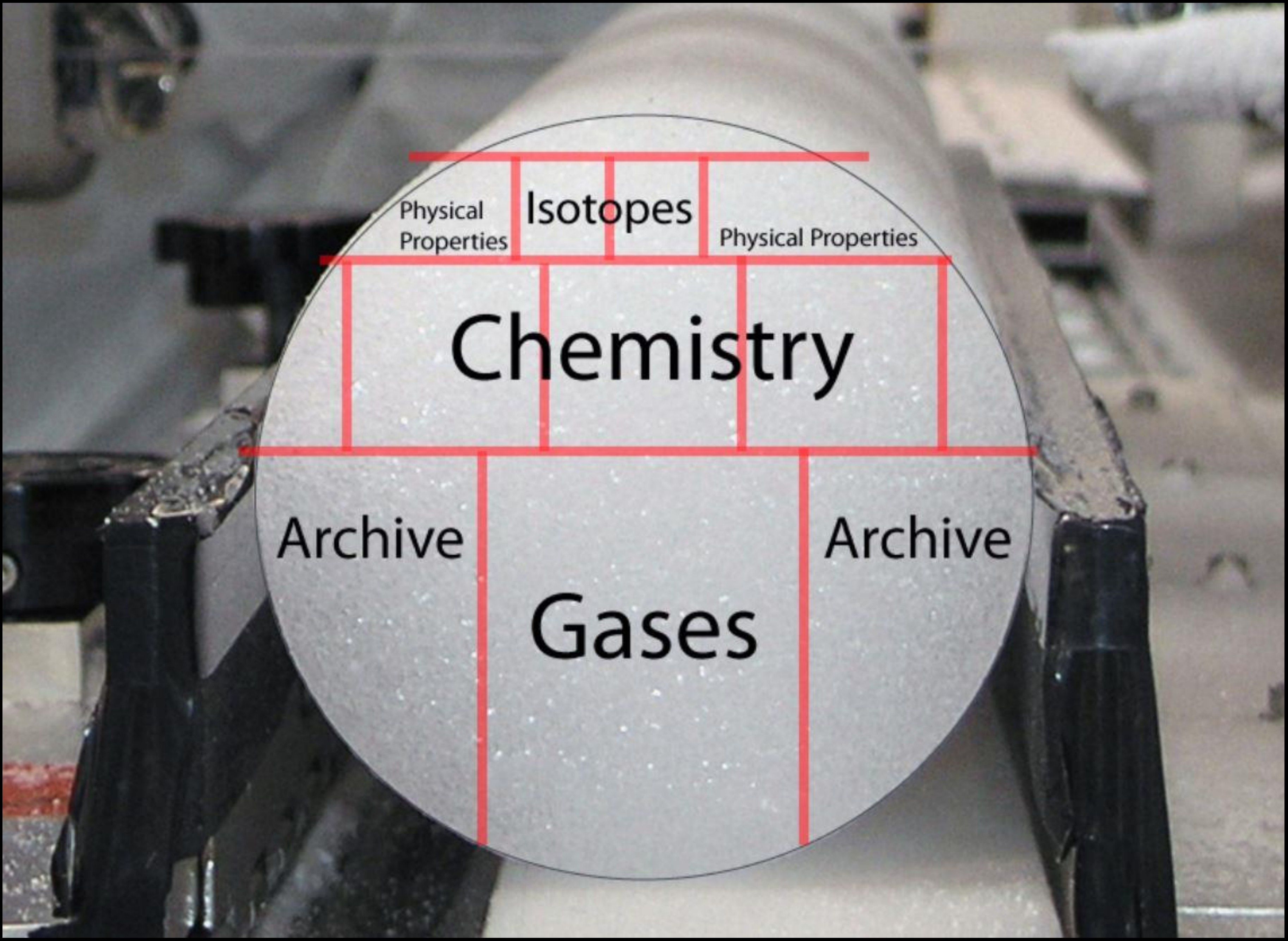




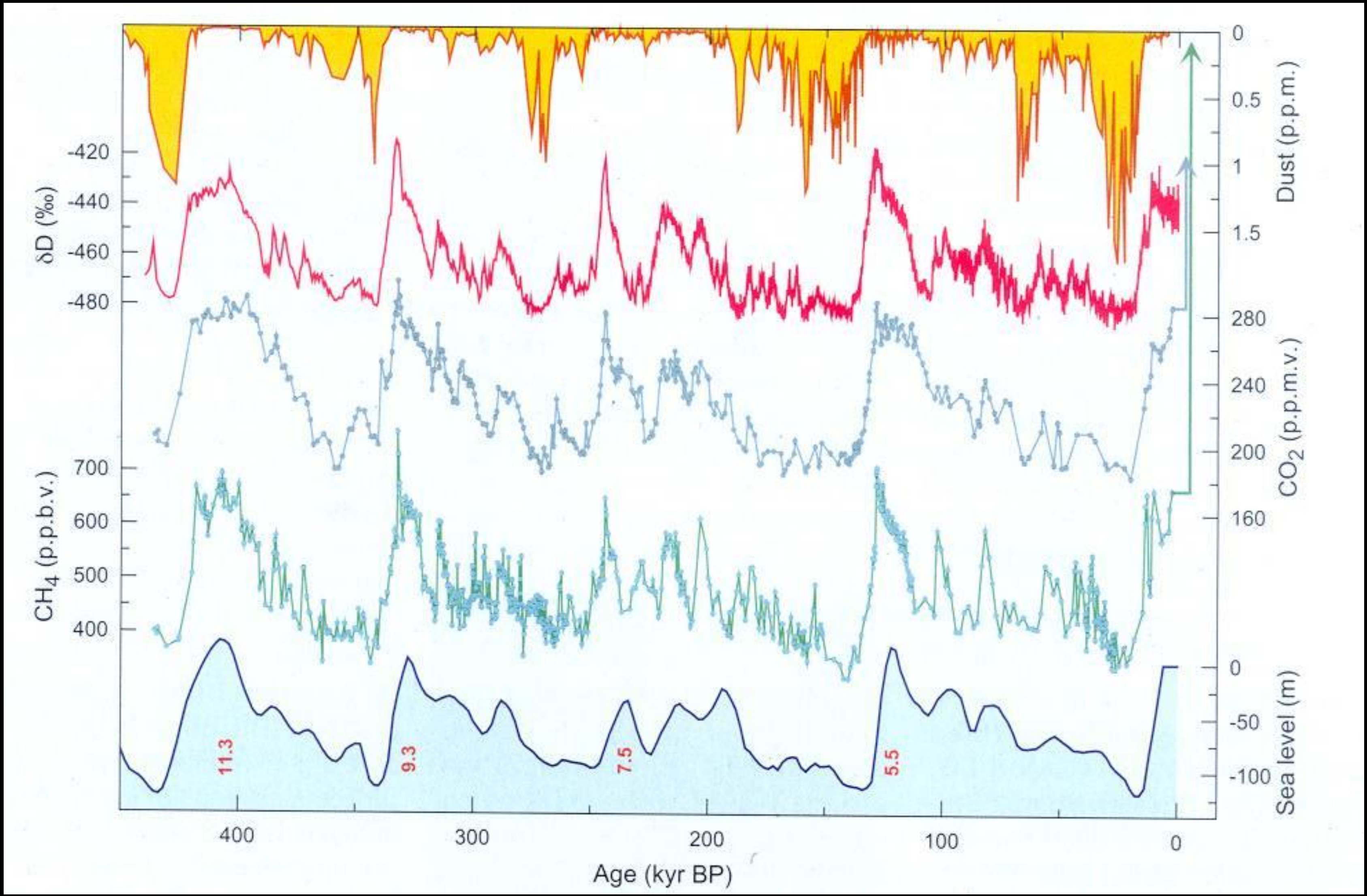
# Vostok Ice Core

## Air bubbles




Physical Properties
Isotopes
Physical Properties
Chemistry
Archive
Gases
Archive

# Vostok ice Core



# Vostok ice Core

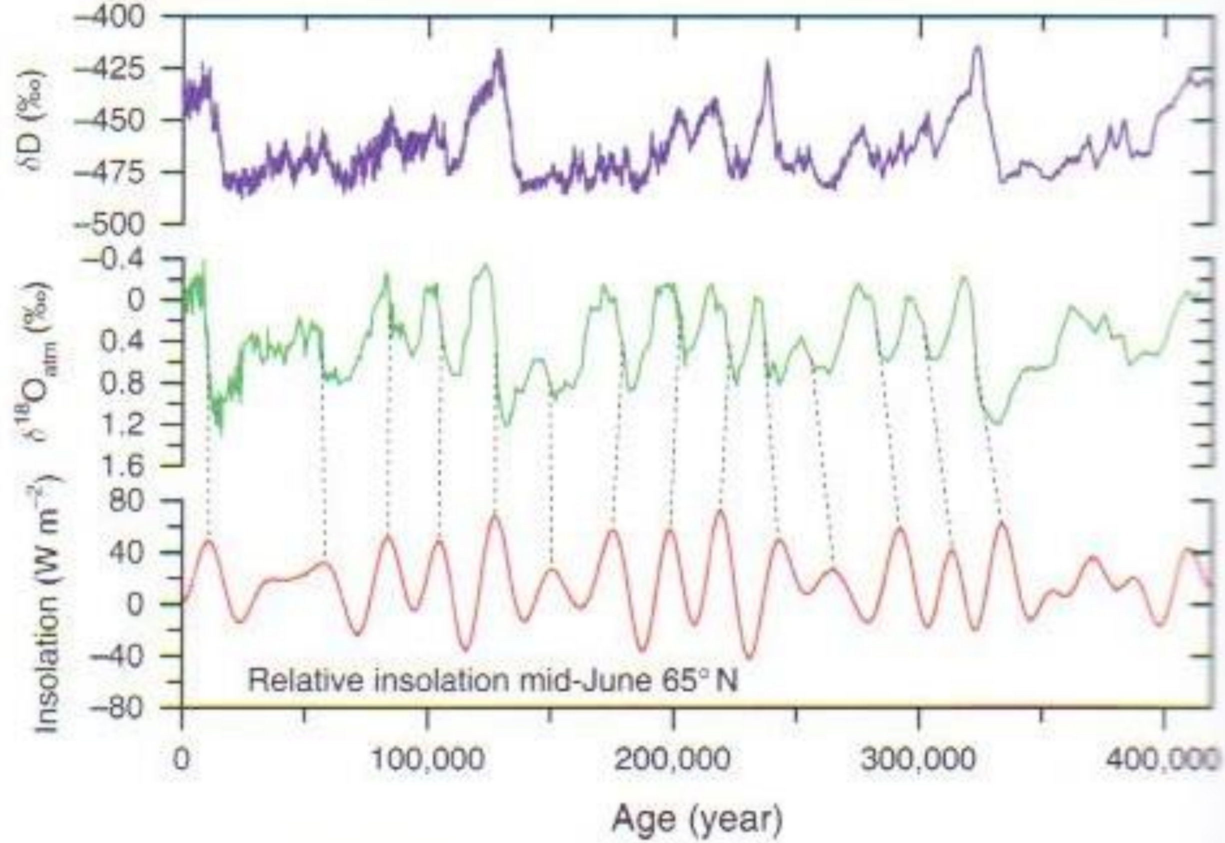



**Figure 6** The $^{18}O/^{16}O$ isotope ratio of the air in the Vostok ice core correlates with the insolation at 65 °N. The stable isotope ratio of the ice ($\delta D$) is a proxy for local temperature.

EUROPEAN SCIENCE FOUNDATION

ARCHIVES





# European Project for Ice Coring in Antarctica (EPICA)

## Summary

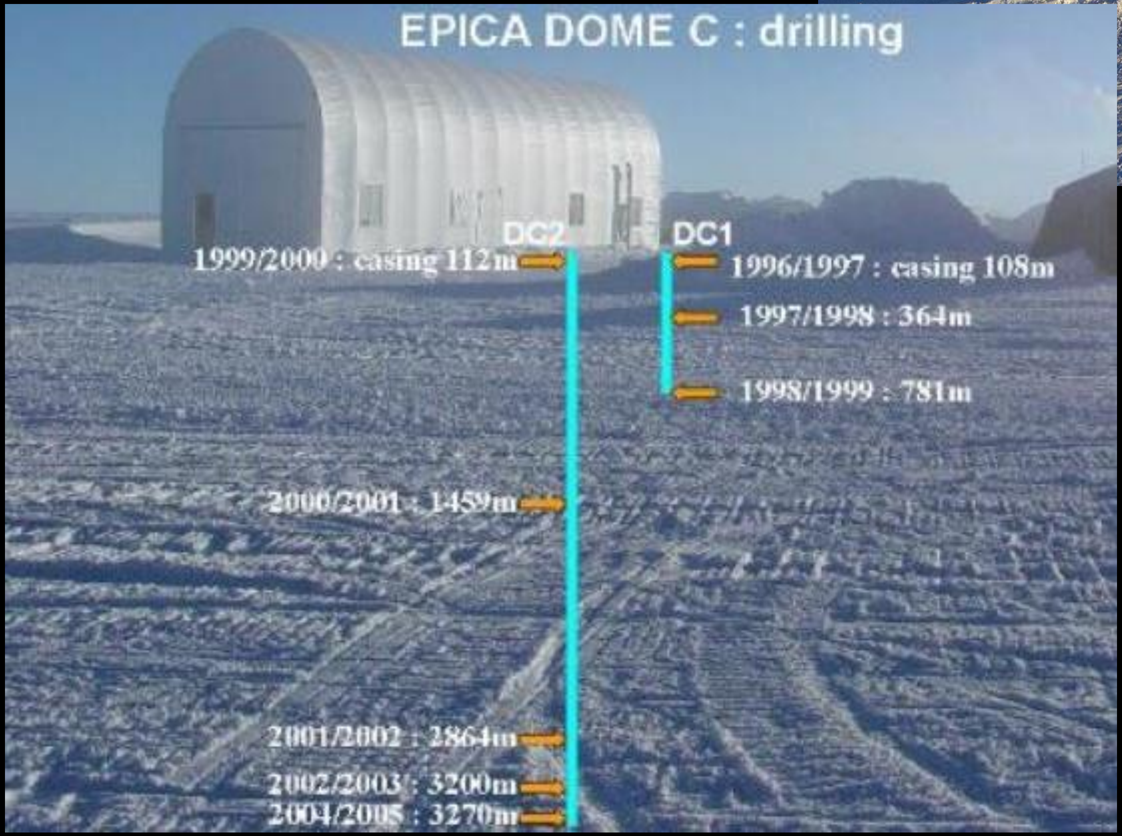
EPICA is a multinational European project for deep ice core drilling in Antarctica. Its main objective is to obtain full documentation of the climatic and atmospheric record archived in Antarctic ice by drilling and analyzing two ice cores and comparing these with their Greenland counterparts. Evaluation of these records will provide information about the natural climate variability and mechanisms of rapid climatic changes during the last glacial epoch. More

**Quick links on this page**

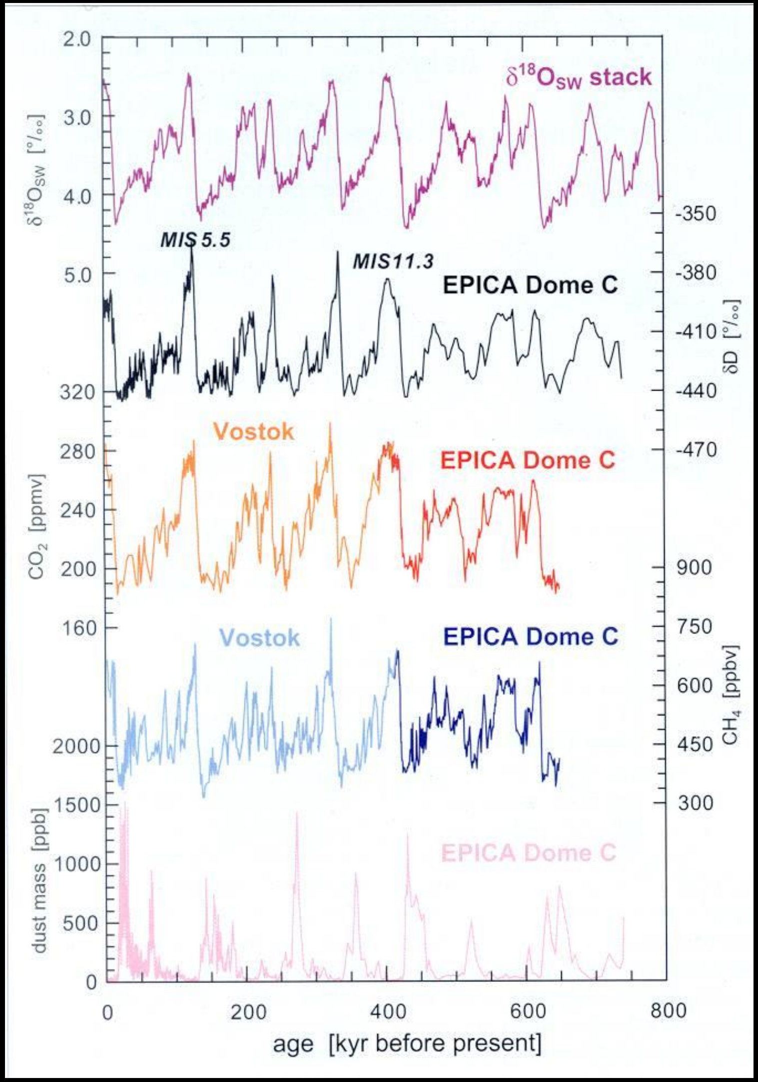
- Summary
- Duration

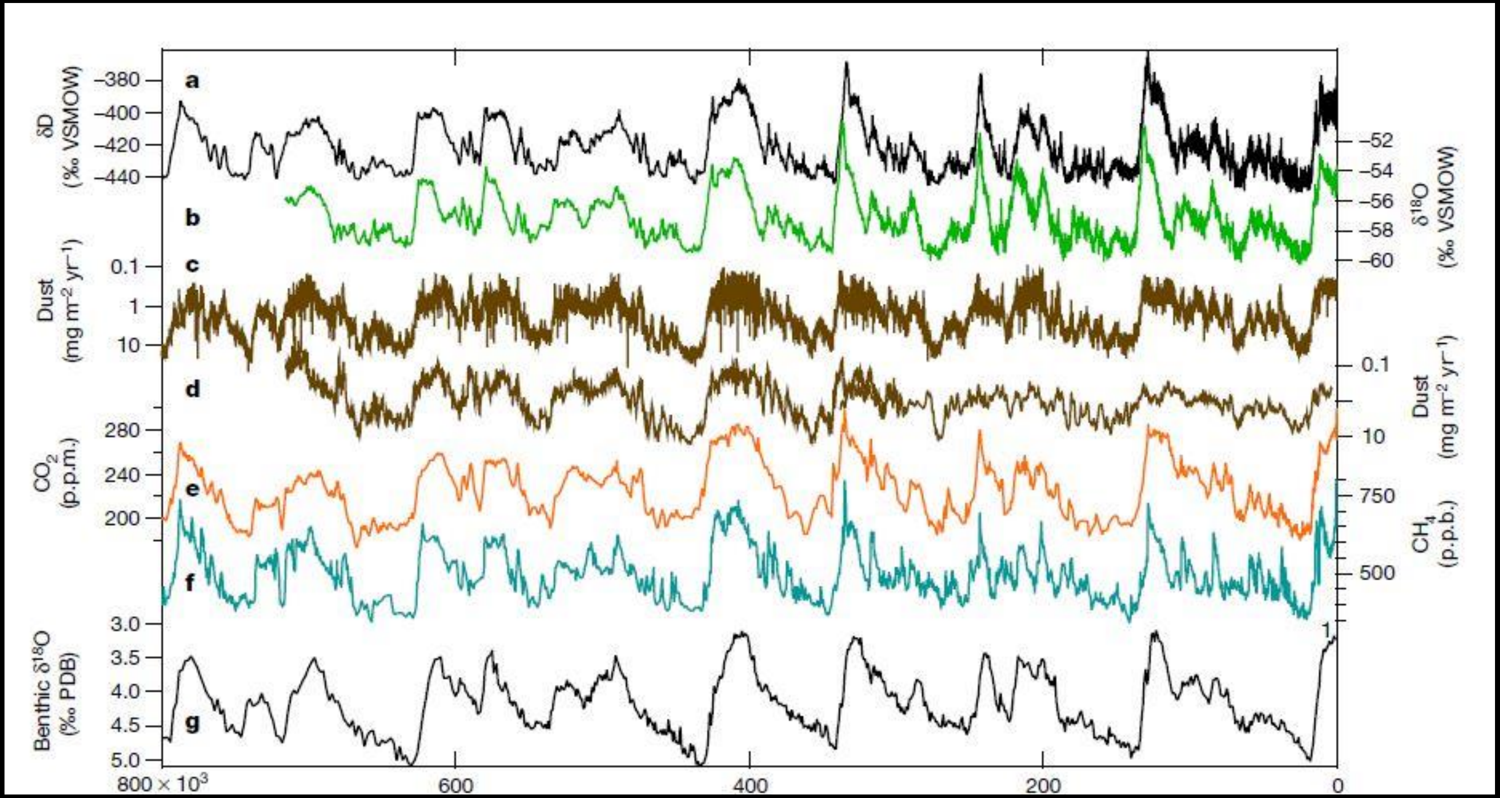
**Further pages**

- Summary
- Steering Committee
- Contributing Member Organisations


EPICA DOME C : drilling
DC2
DC1
1999/2000 : casing 112m
1996/1997 : casing 108m
1997/1998 : 364m
1998/1999 : 781m
2000/2001 : 1459m
2001/2002 : 2864m
2002/2003 : 3200m
2004/2005 : 3270m

# European Project for Ice Coring in Antarctica (EPICA)



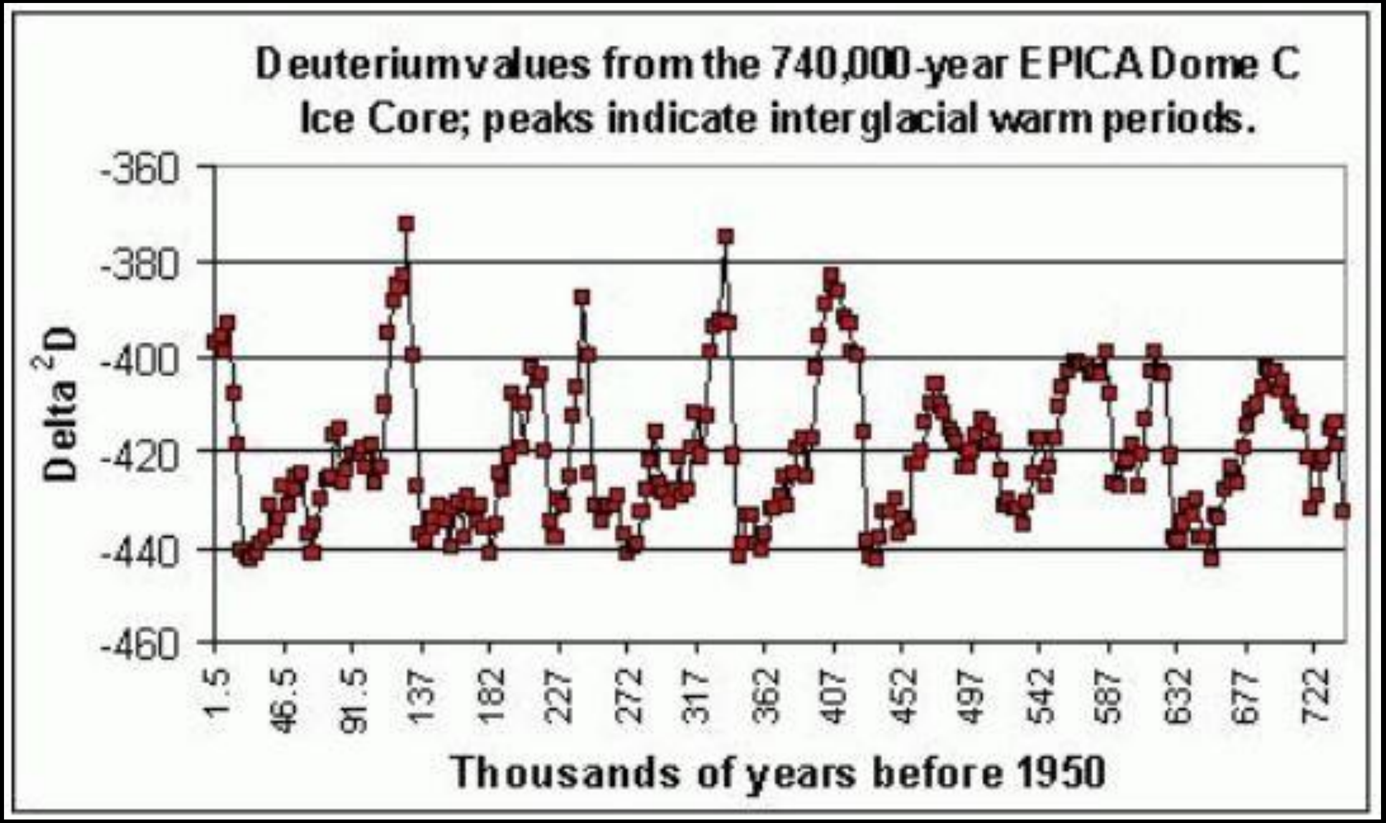

Data covering the last 800,000 years from long Antarctic ice core records, and the benthic isotope stack, a proxy for global glacial–interglacial cycles, with upward direction corresponding to warm interglacial conditions. a, The EPICA Dome C δD (2H/1H isotopic ratio of water). VSMOW, Vienna Standard Mean Ocean Water. b, The Dome Fuji δ18O (18O/16O isotopic ratio of water). c, d, The EPICA Dome C and Dome Fuji dust records. e, f, The EPICA Dome C/Vostok CO2 and CH4 records. g, Benthic oxygen isotope stack. PDB, Pee-Dee belemnite standard.

**Antarctic and global climate history viewed from ice cores**

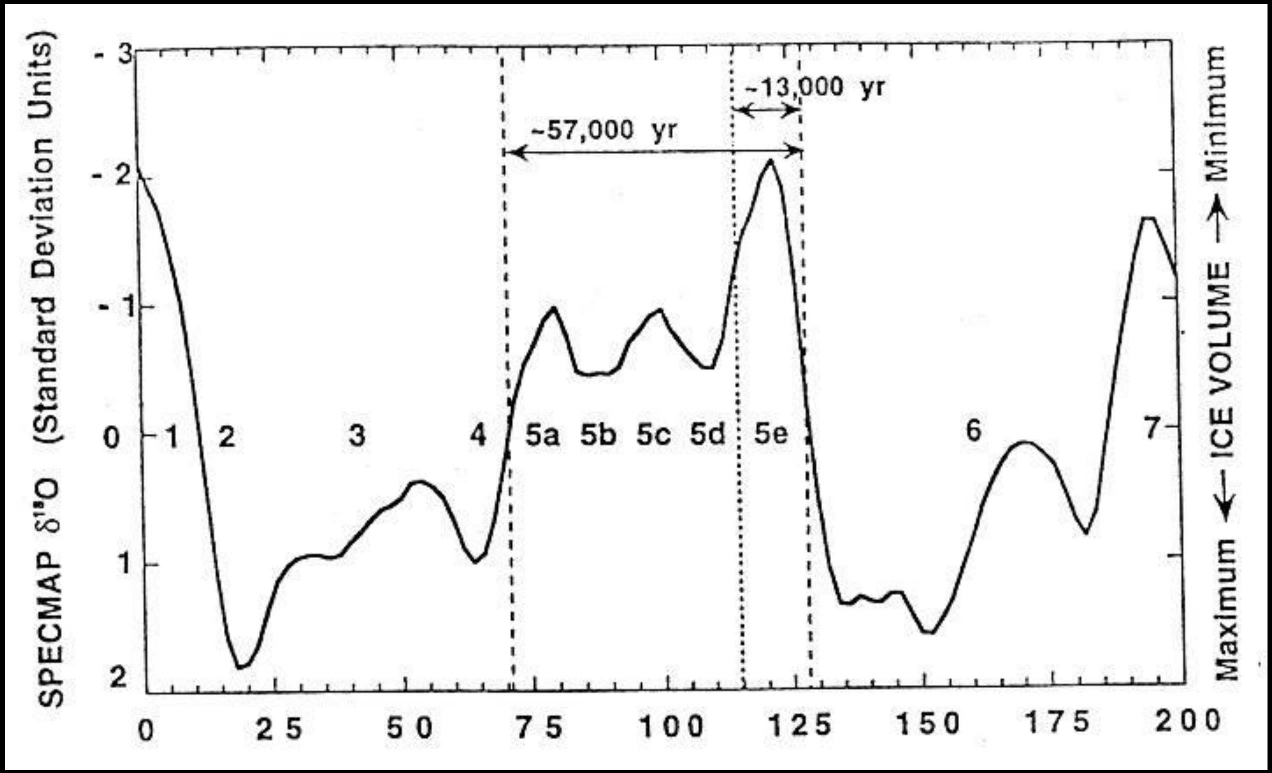
Edward J. Brook[1]* & Christo Buizert[1]

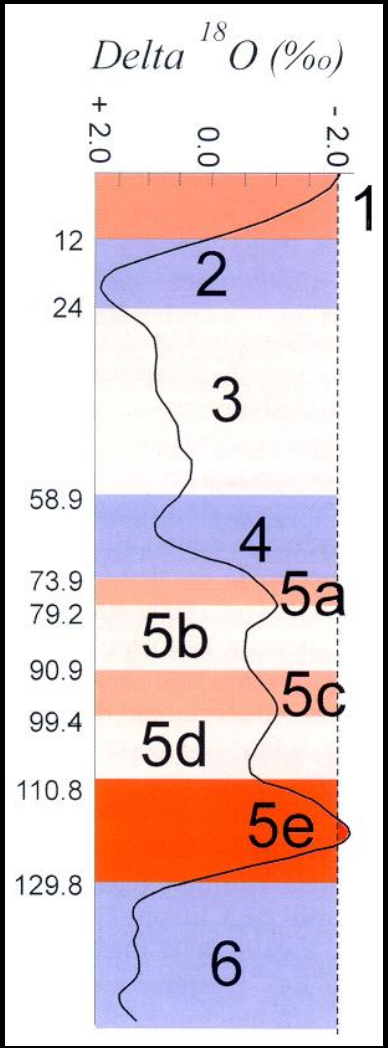

**https://www.youtube.com/watch?v=ls_inIwtAZI**

L'idrogeno possiede due isotopi stabili 1H e 2H (o Deuterio), con abbondanze relative di 99,9844 e 0,0156.



# Pleistocene superiore



# Greenland Ice Cores

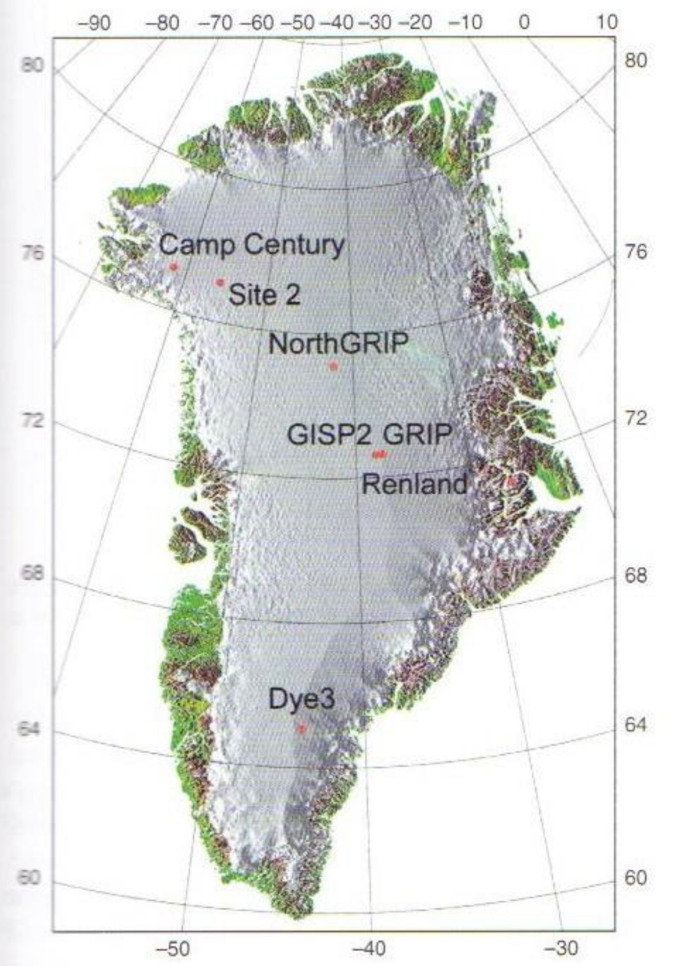
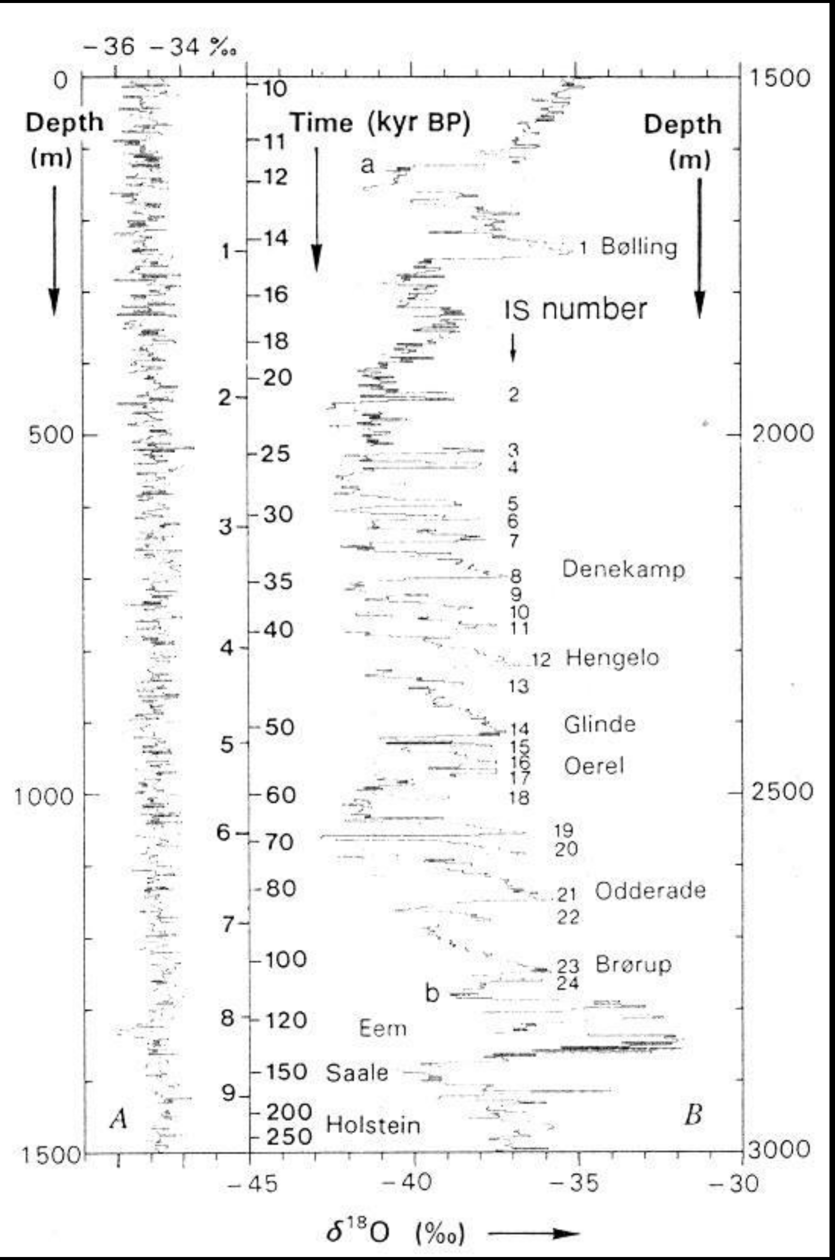


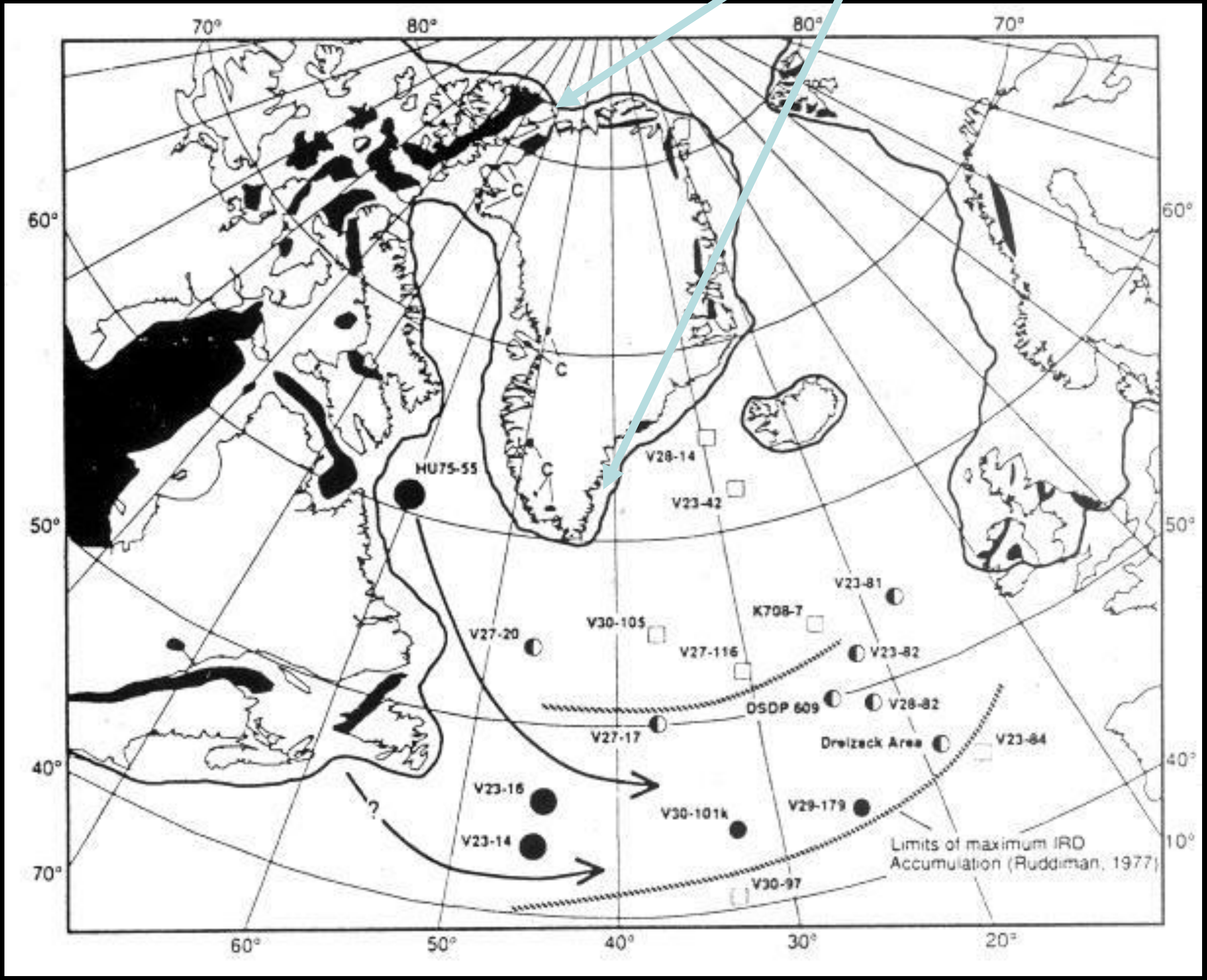

**Figure 1** Locations of selected Greenland ice cores. The Site 2 core was the first ice core drilled in Greenland. The Camp Century, Dye-3, GISP2, GRIP, NGRIP, and Renland cores all contain ice from the Holocene, Glacial, and Eemian periods.

# GRIP Ice Core



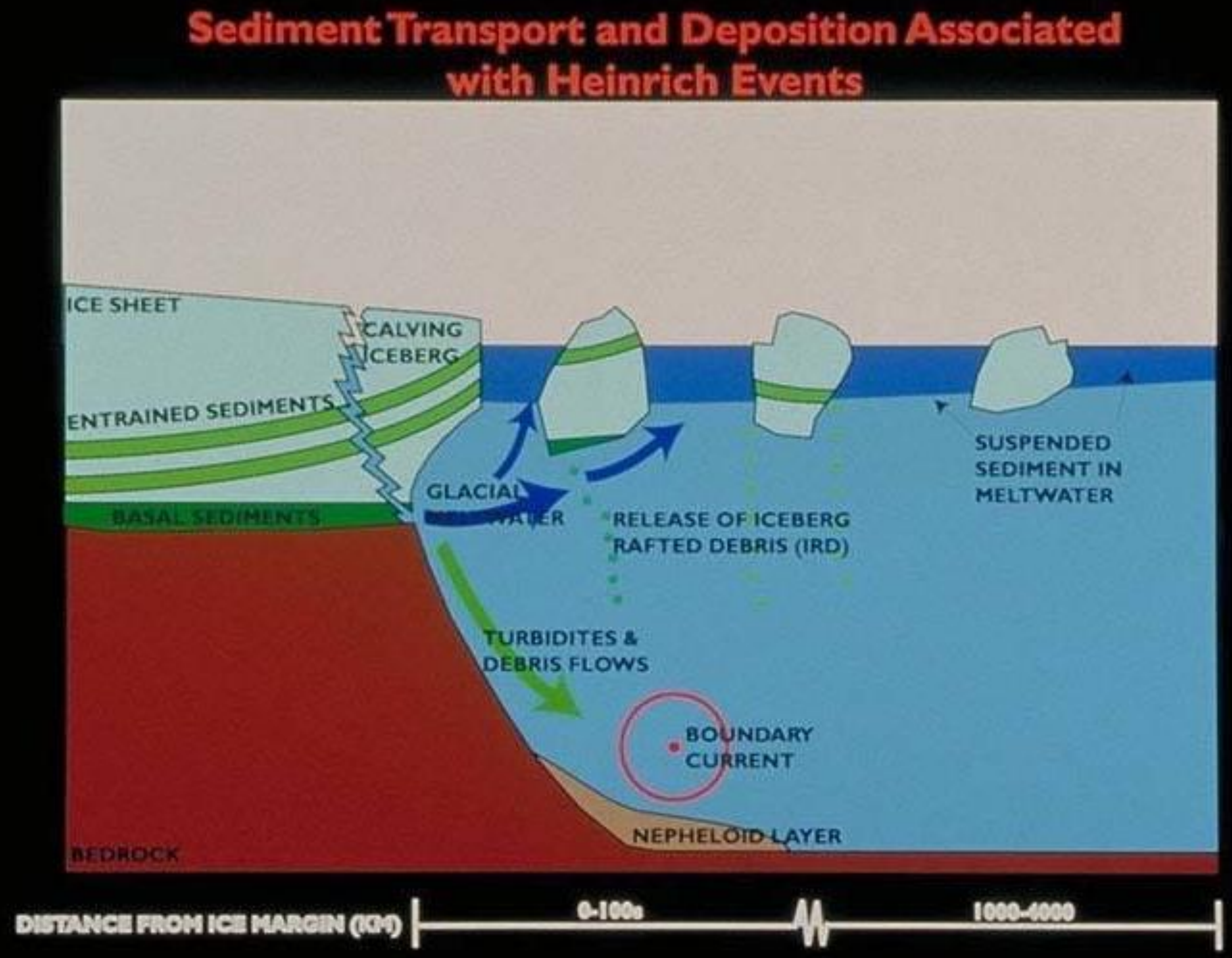
# Eventi Heinrich

Max extention
Laurentide Ice Sheet

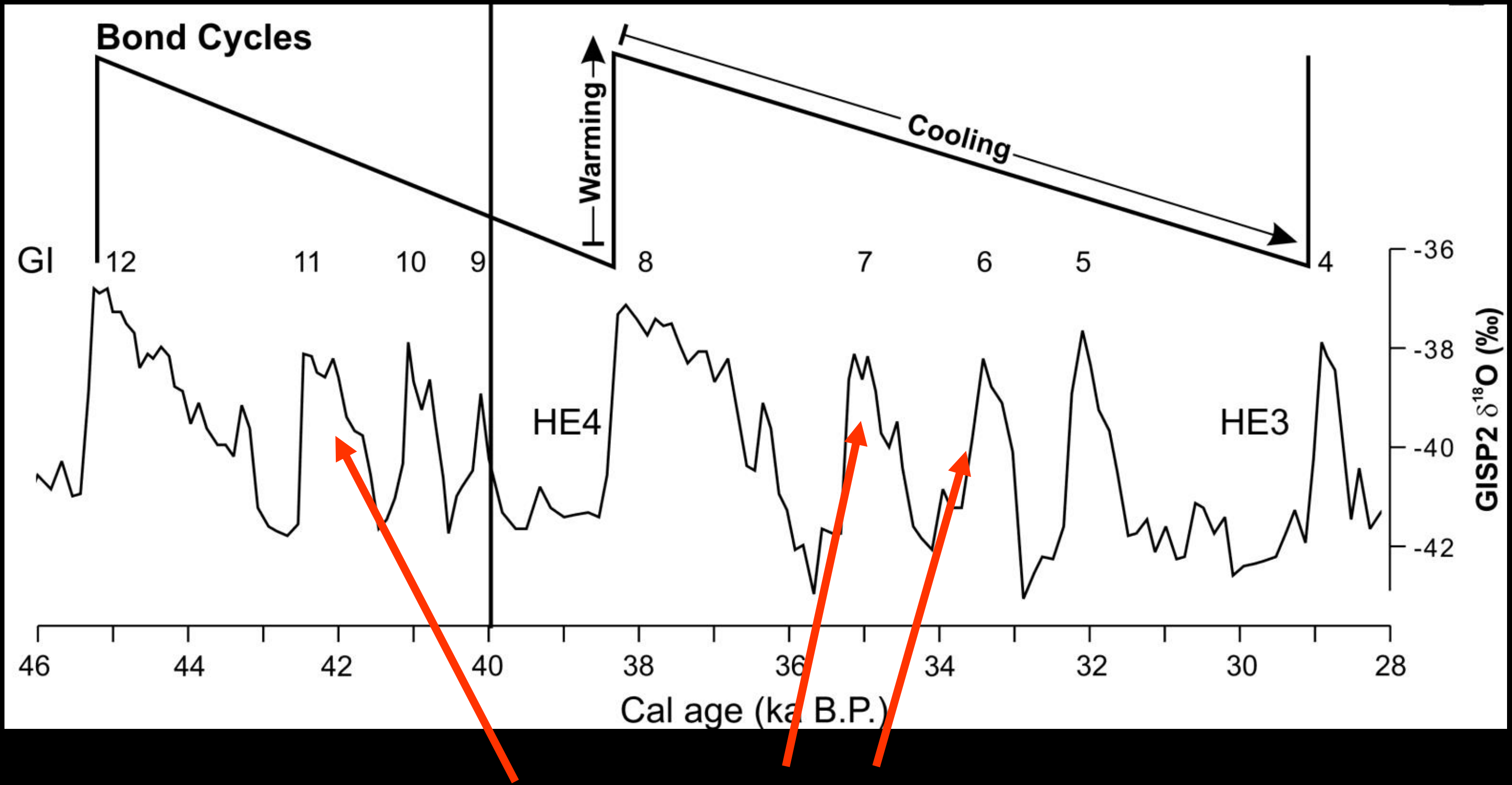



**During the last glacial period, the Laurentide Ice Sheet sporadically discharged huge numbers of icebergs through the Hudson Strait into the North Atlantic Ocean, leaving behind distinct layers of ice-rafted debris in the ocean sediments. Perplexingly, these massive discharge events—Heinrich events—occurred during the cold portion of millennial-scale climate oscillations called Dansgaard–Oeschger cycles,**

# Binge-Purge Model

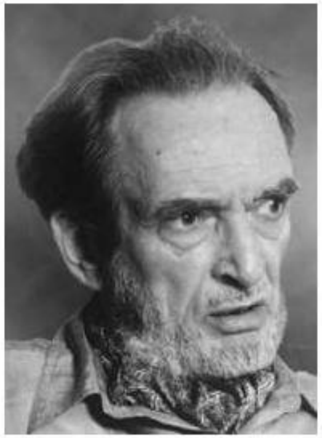


# Cicli di Bond + Eventi Heinrich




Cicli Dansgaard-Oescher (D-O)

WILLI DANSGAARD
(1922-2011)



-Interested in the ratios of Oxygen isotops of rain, sow, ice.

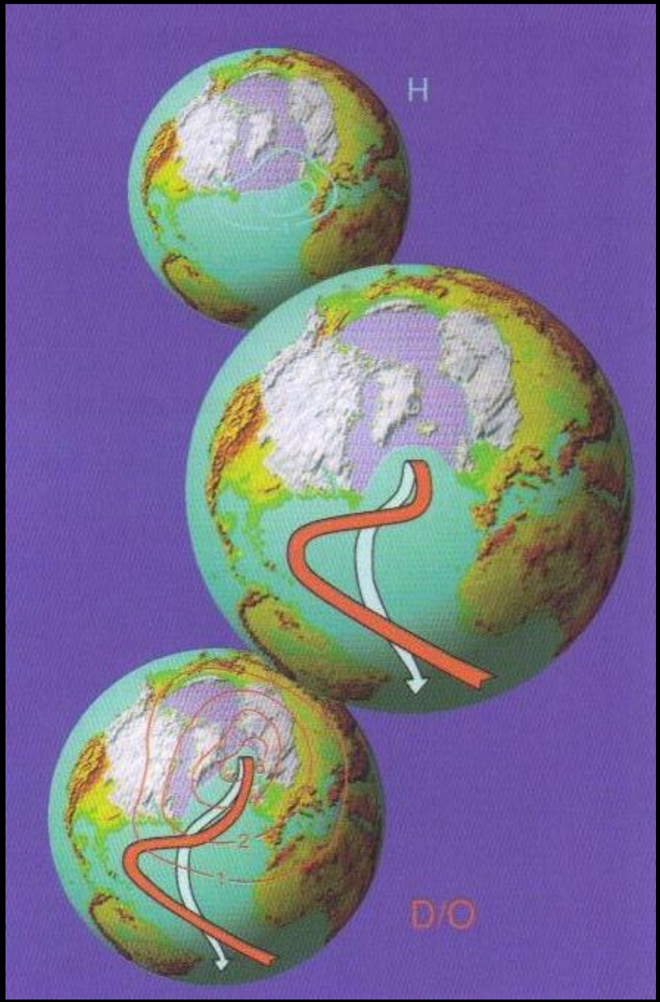
-Isotopic composition of precipitation

↓

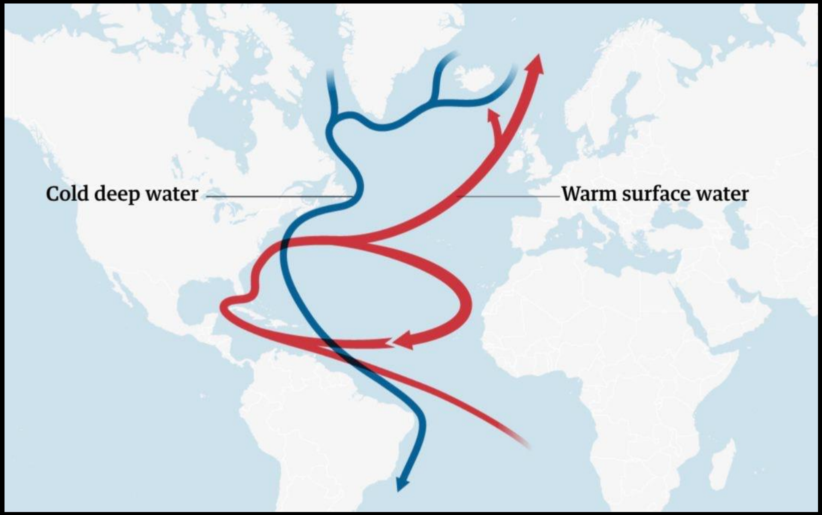
condensation temperature

HANS OESCHGER
(1927-1998)

-Pioneer in measuring greenhouse gases in bubbles trapped in the ice



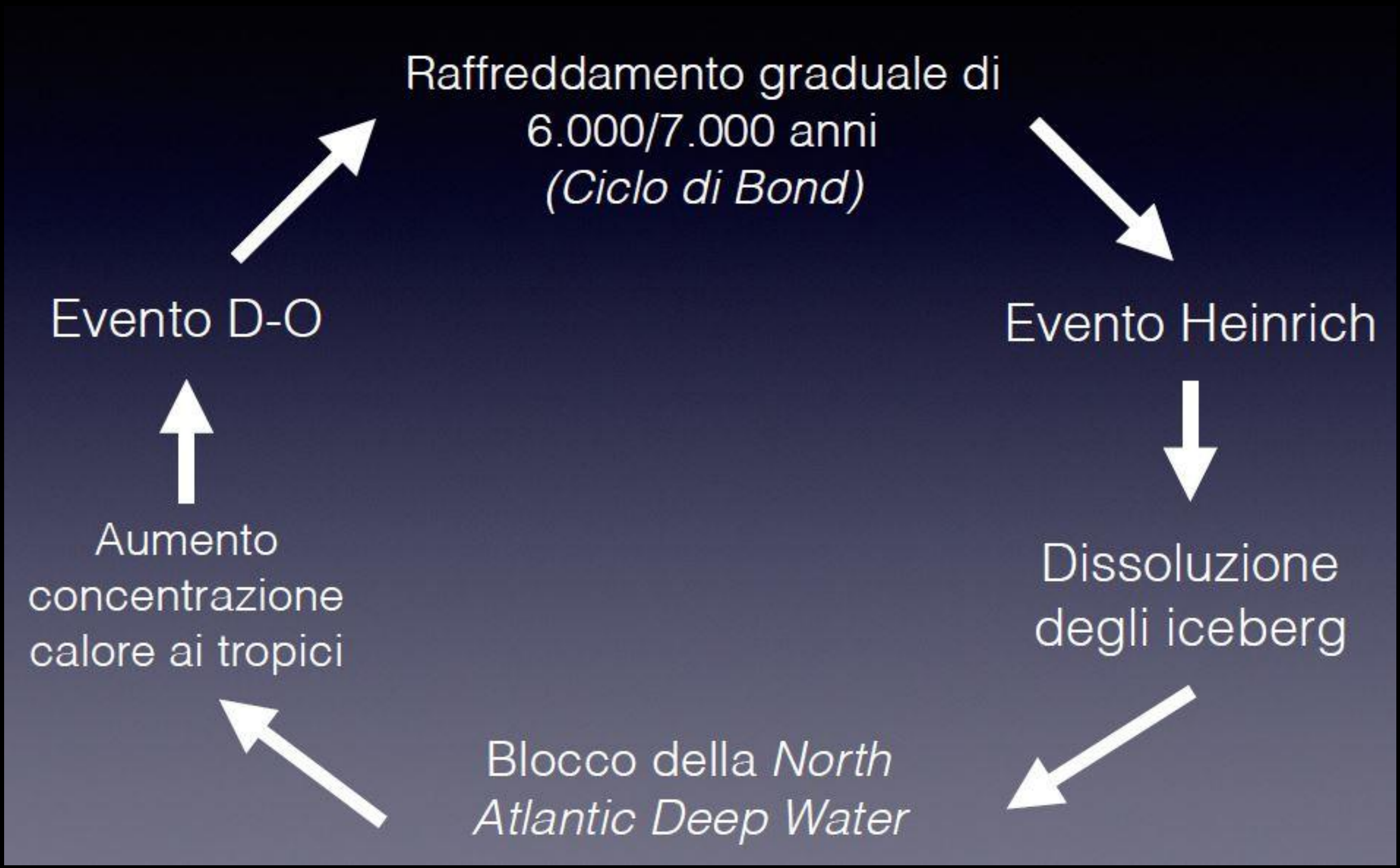

Schematic of three circulation modes of the glacial Atlantic: the prevailing cold mode (middle), the warm mode associated with Dansgaard-Oescher events (bottom), and the «off» mode occurring after Heinrich events (top).




**Role of the thermohaline circulation in the abrupt warming after Heinrich events**

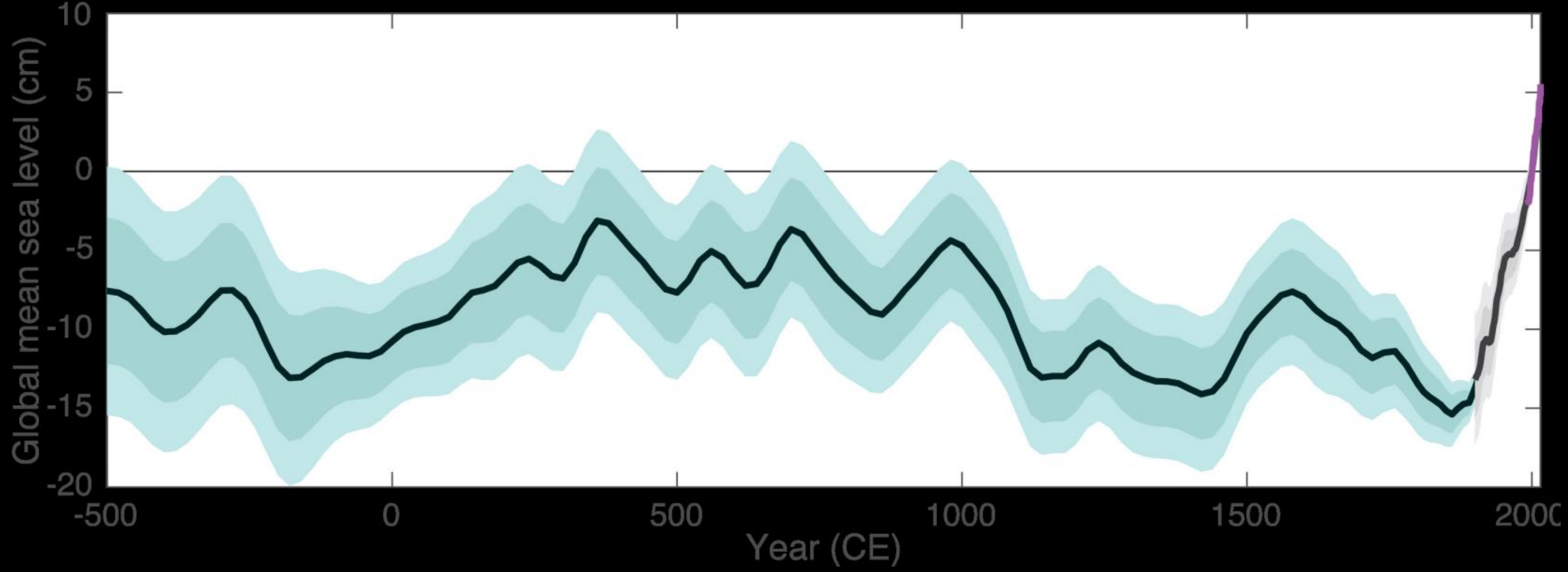
**D. Paillard* & L. Labeyrie†**

# D-O cycles


Raffreddamento graduale di
6.000/7.000 anni
*(Ciclo di Bond)*
Evento Heinrich
Dissoluzione
degli iceberg
Blocco della *North*
*Atlantic Deep Water*
Aumento
concentrazione
calore ai tropici
Evento D-O

# CENTENNIAL TO MILLENNIAL CLIMATE VARIABILITY

As we know, the climate system is complex enough to generate its own internal oscillations, like the El-Niño Southern Oscillations or Dansgaard-Oeschger events. There is no reason not to have such modes in the centennial band.




Global-mean sea level over the last 2.5 ka. Heavy/light shaded regions are 67% and 95% credible intervals.