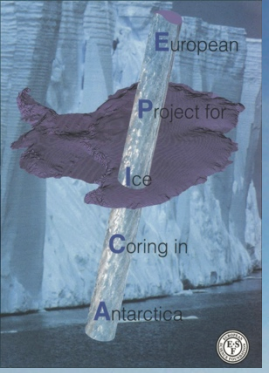


Conferenza nazionale sulla ricerca in Antartide

20-21 ottobre, Accademia Nazionale dei Lincei

European Project for Ice Coring in Antarctica – EPICA

Carlo Barbante & Massimo Frezzotti

(on behalf of EPICA Community)

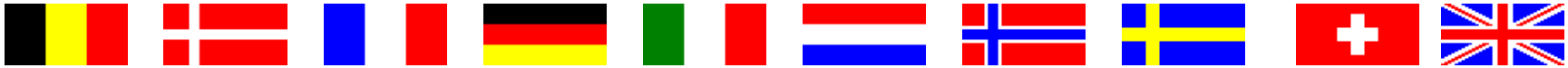
Institute for the Dynamics of Environmental Processes – CNR, University of Venice

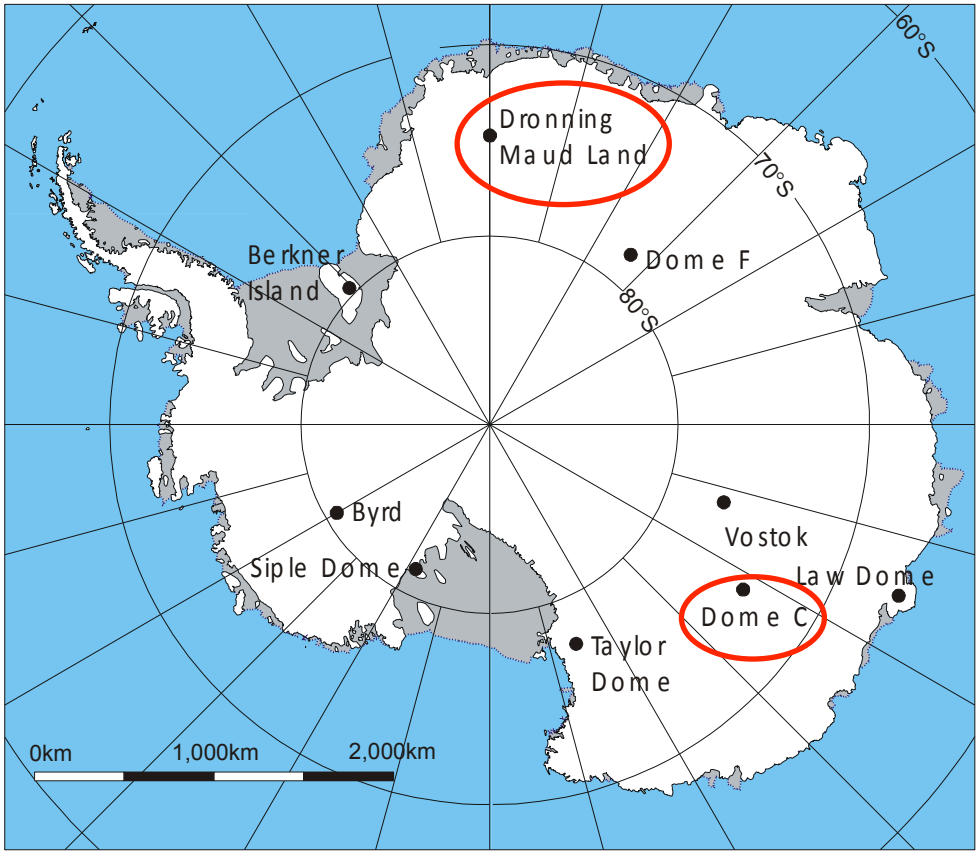
ENEA-Roma

MINISTERO DELL'ISTRUZIONE, DELL'UNIVERSITÀ E DELLA RICERCA

PROGRAMMA NAZIONALE DI RICERCHE IN ANTARTIDE

A great European effort





Dome C

- Recover very old ice for a long and undisturbed climate record
- Sample earths climate in warmer times than today
- Get signals from Indian and Pacific oceans

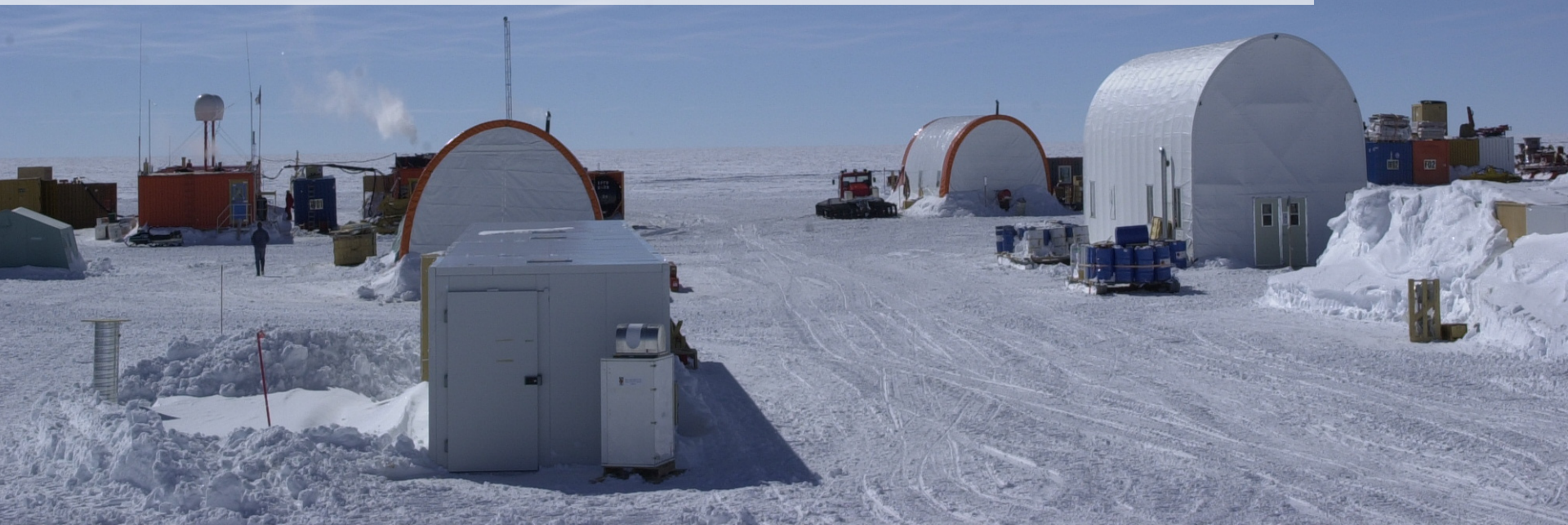
DML

- Recover record with higher temporal resolution than Dome C
- Probe Antarctic ice in a region previously unexplored
- Get signals from Atlantic ocean for optimal interhemispheric comparison

1993 (reconnaissance started) – present (science papers still being produced)

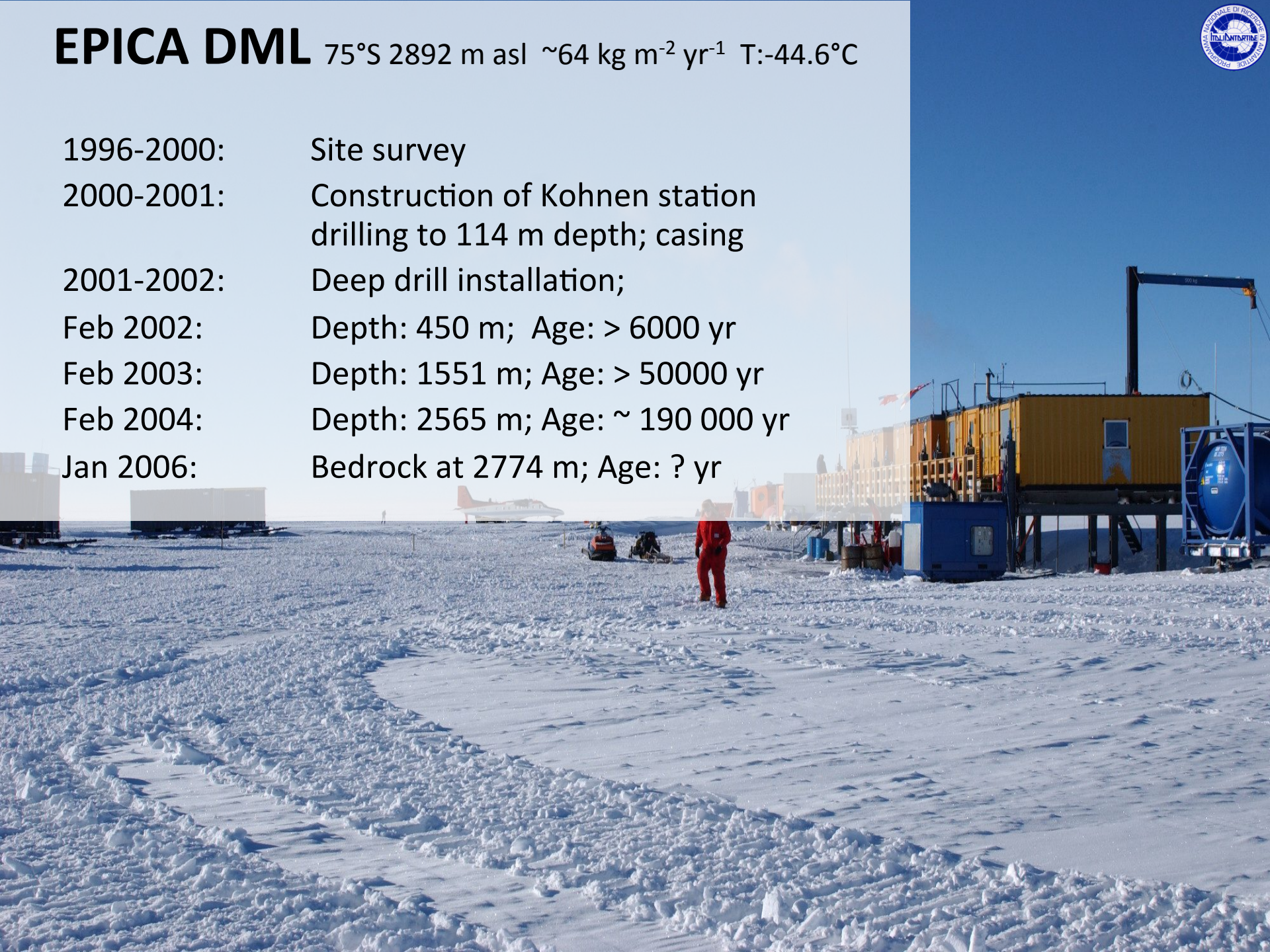
EPICA Dome C 75°S 3233 m asl ~25 kg m^{-2} yr^{-1} T:-54.5°C

1993-95	Site survey
1995-1996:	Camp construction
1996-1997:	Drill installation and start of drilling
Dec 1998:	Drill is stuck in 781 m depth
Dec 1999:	Start 2nd drilling
Jan2001:	Depth: 1459 m; age: >70 000 years
Jan2002:	Depth: 2870 m; age: >500 000 years
Jan2003:	Depth: 3190 m; age: >800 000 years
Jan2005:	Depth: 3260 m; age: ?



EPICA DML 75°S 2892 m asl ~64 kg m^{-2} yr^{-1} T:-44.6°C

1996-2000:	Site survey
2000-2001:	Construction of Kohnen station drilling to 114 m depth; casing
2001-2002:	Deep drill installation;
Feb 2002:	Depth: 450 m; Age: > 6000 yr
Feb 2003:	Depth: 1551 m; Age: > 50000 yr
Feb 2004:	Depth: 2565 m; Age: ~ 190 000 yr
Jan 2006:	Bedrock at 2774 m; Age: ? yr



Summary: a reminder

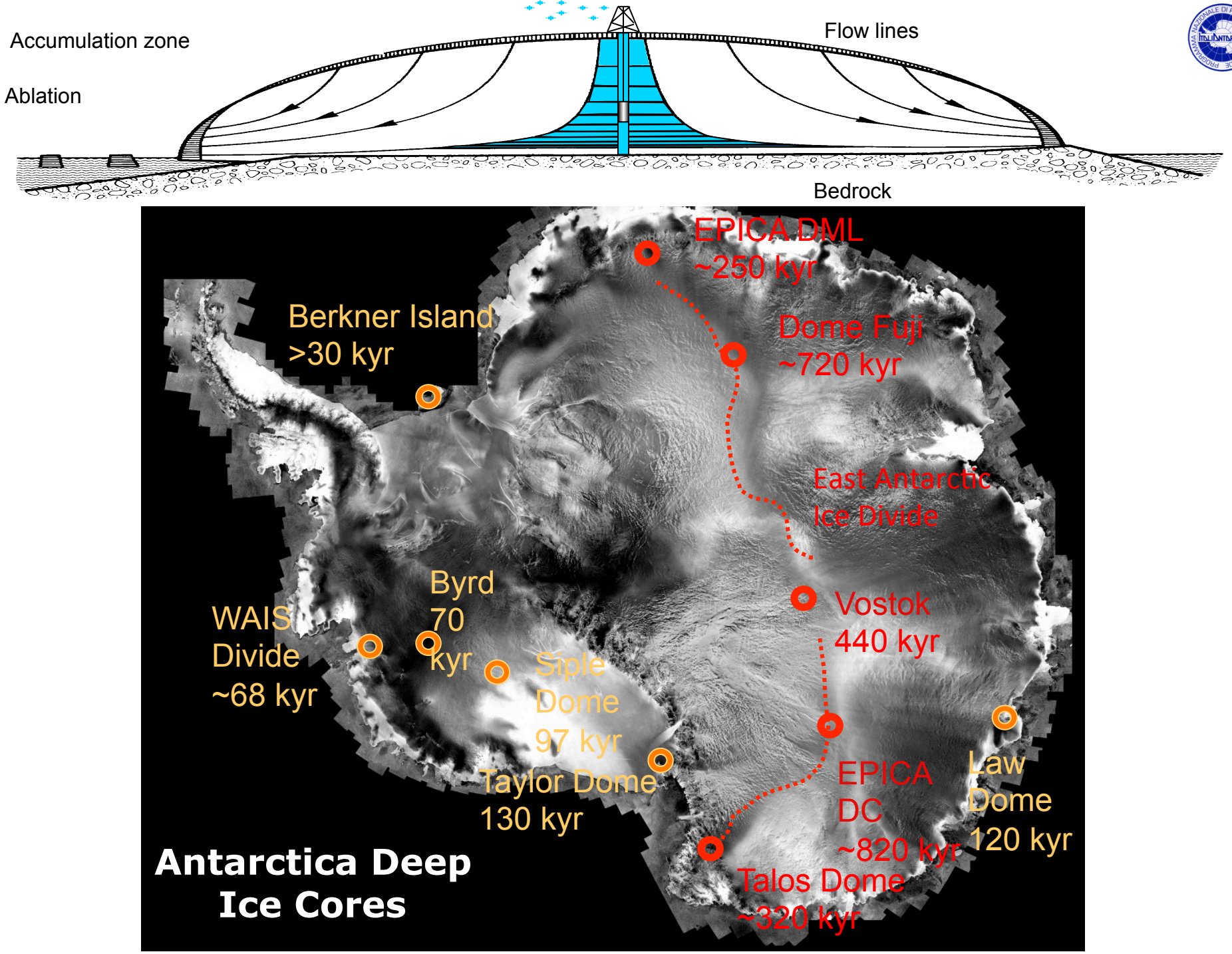
- 820,000 years of climate history
- So far more than 300 peer reviewed papers,
  10 Nature and Science publications
- Iconic data, used in almost every presentation about climate, and extensively in IPCC AR4 and 5
- Provided solid data to put present change in context and to understand e.g. C cycle, climate effects of changes in ocean circulation
- Cemented tremendous links between researchers from different countries
- Educating the scientific leaders of tomorrow:
  ~20 master and ~40 PhD theses
  The data and technical challenge excite young scientists (from school onwards)
- A flagship EU project
- Project only possible with combined efforts of 10 national agencies and EU (part funding)

Descartes Prize, 2007

EPICA (European Project for Ice Coring in Antarctica) receives prestigious 2007 **Descartes Prize for Collaborative, Transnational Research**.

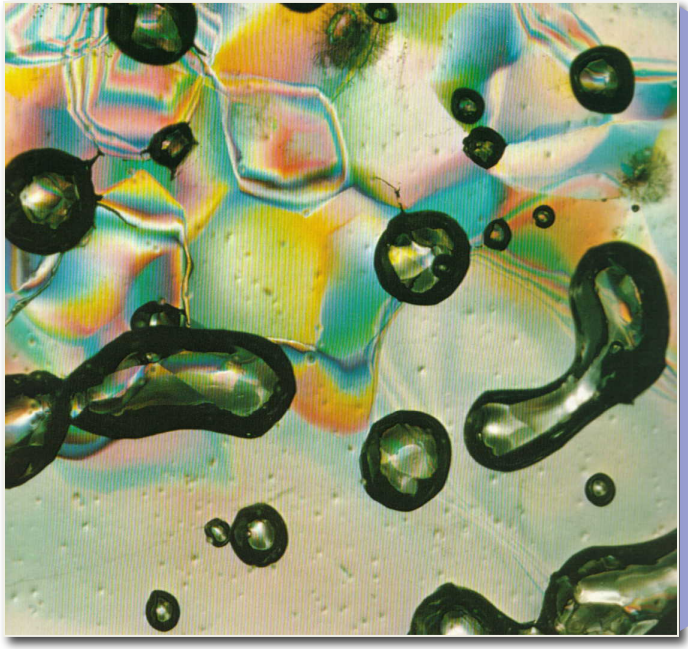
The Descartes Prize for Research was awarded to European teams **for outstanding transnational projects in natural sciences and humanities by the European Union**.

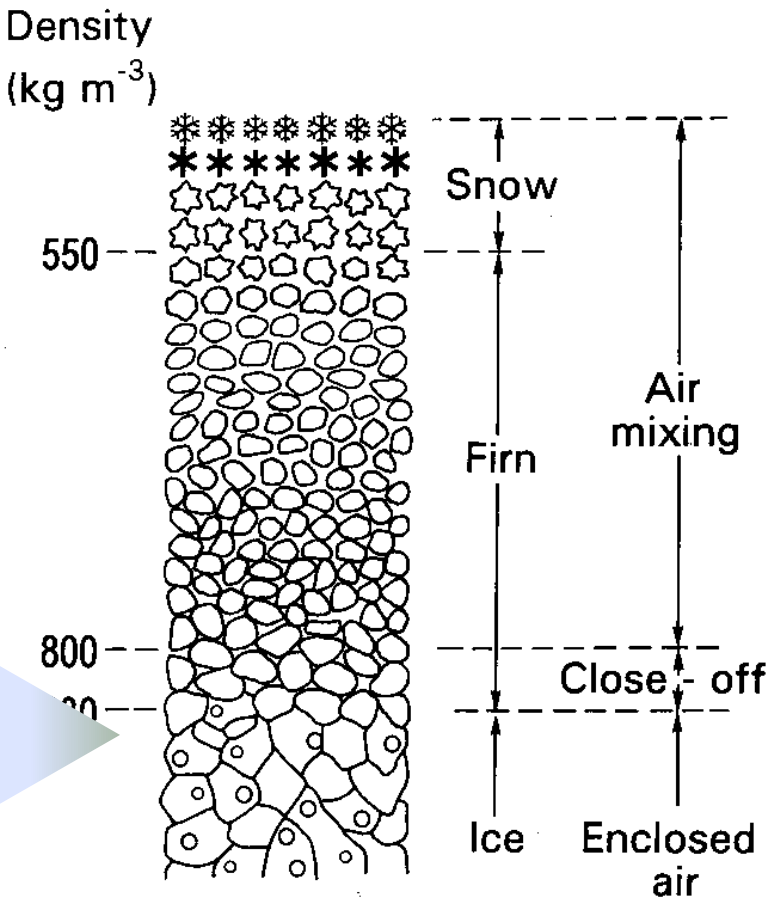
The EPICA project was **successful in retrieving past climate records** of great impact for the assessment of our current climate change.

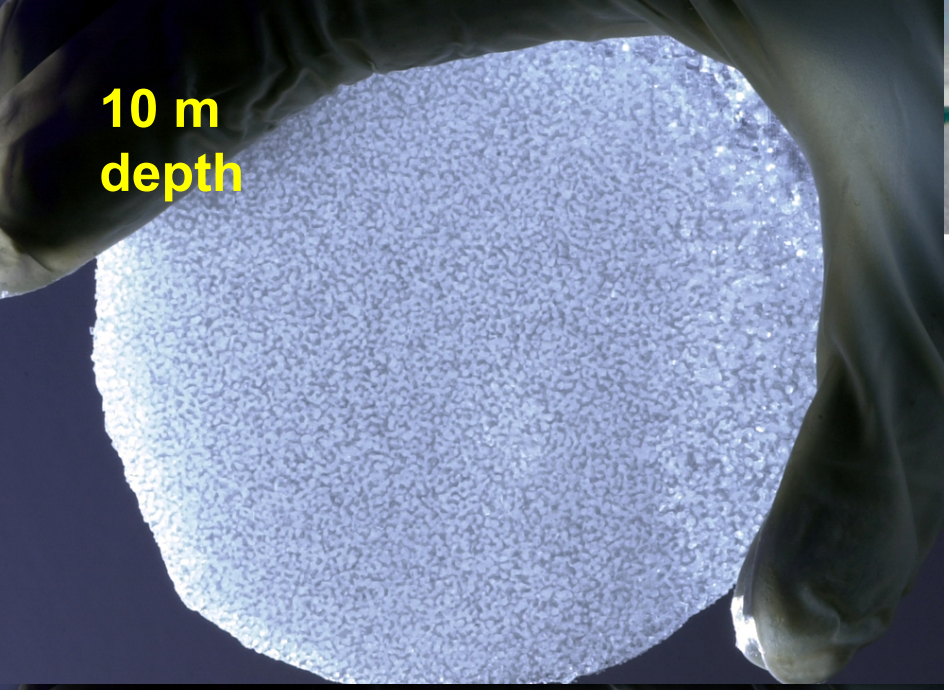

Accumulation zone
Ablation
Flow lines
Bedrock
EPICA DML
~250 kyr
Berkner Island
>30 kyr
Dome Fuji
~720 kyr
East Antarctic
Ice Divide
Byrd
70
kyr
WAIS
Divide
~68 kyr
Vostok
440 kyr
Siple
Dome
97 kyr
Taylor Dome
130 kyr
EPICA
DC
~820 kyr
Law
Dome
120 kyr
Talos Dome
~320 kyr
Antarctica Deep
Ice Cores

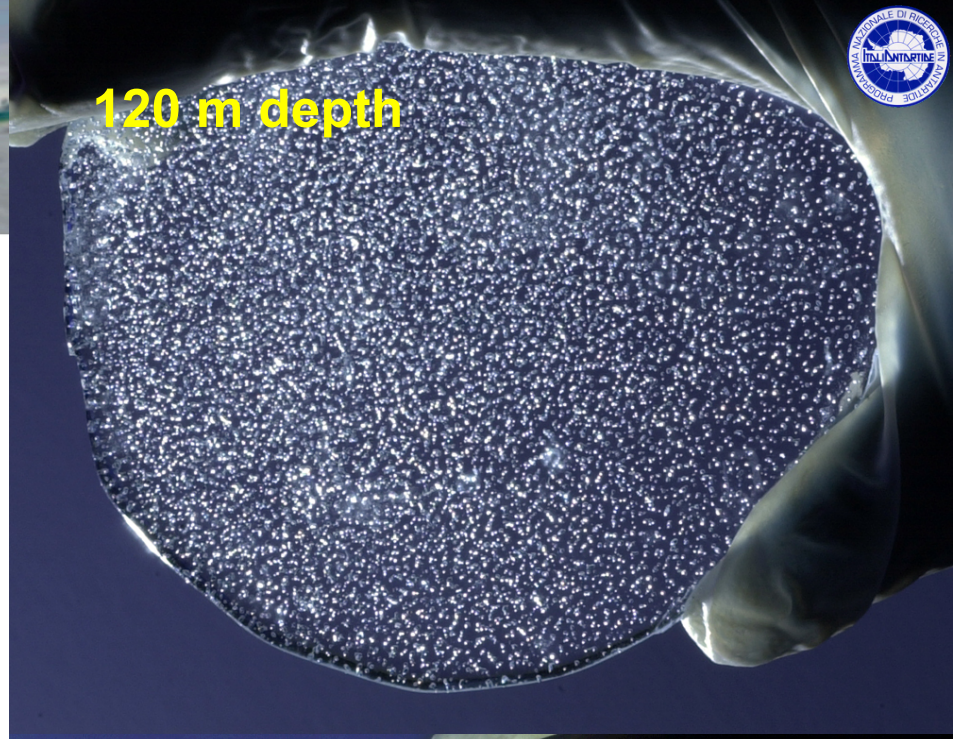
Snow and ice as archives

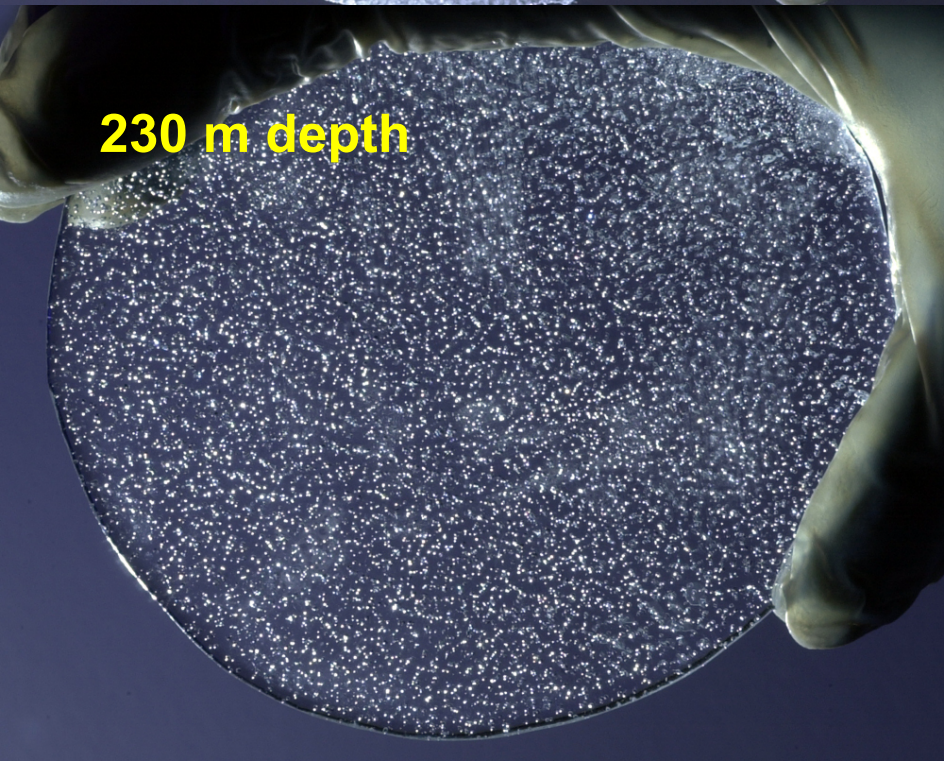
- Ice cores are the key palaeorecord for the atmosphere
- Climate and forcing factors in the same record
- Well resolved
- But mainly limited to polar regions

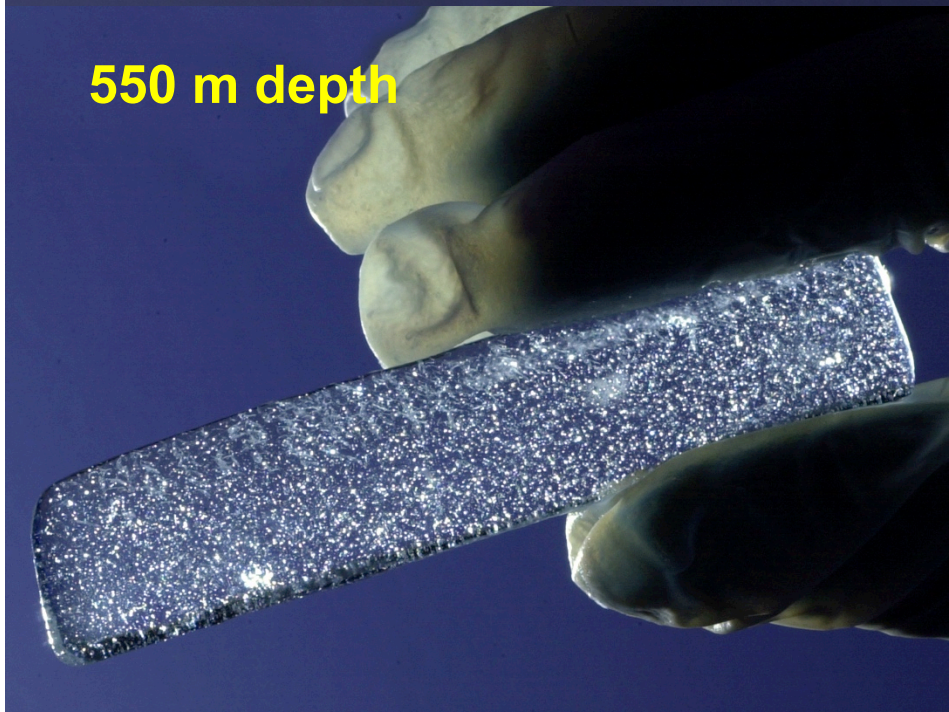




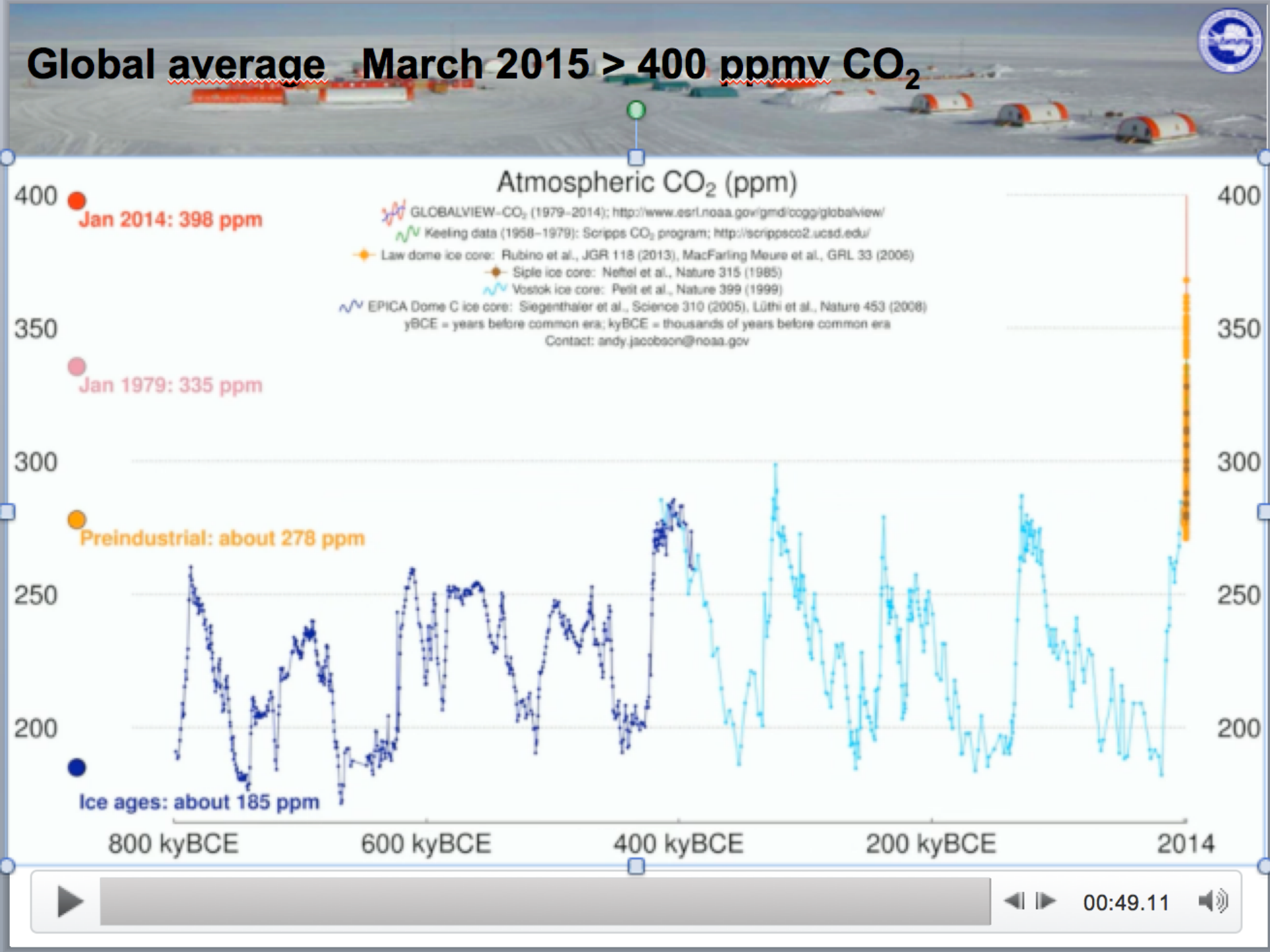

10 m
depth


120 m depth


230 m depth


550 m depth

Global average March 2015 > 400 ppmv CO_2



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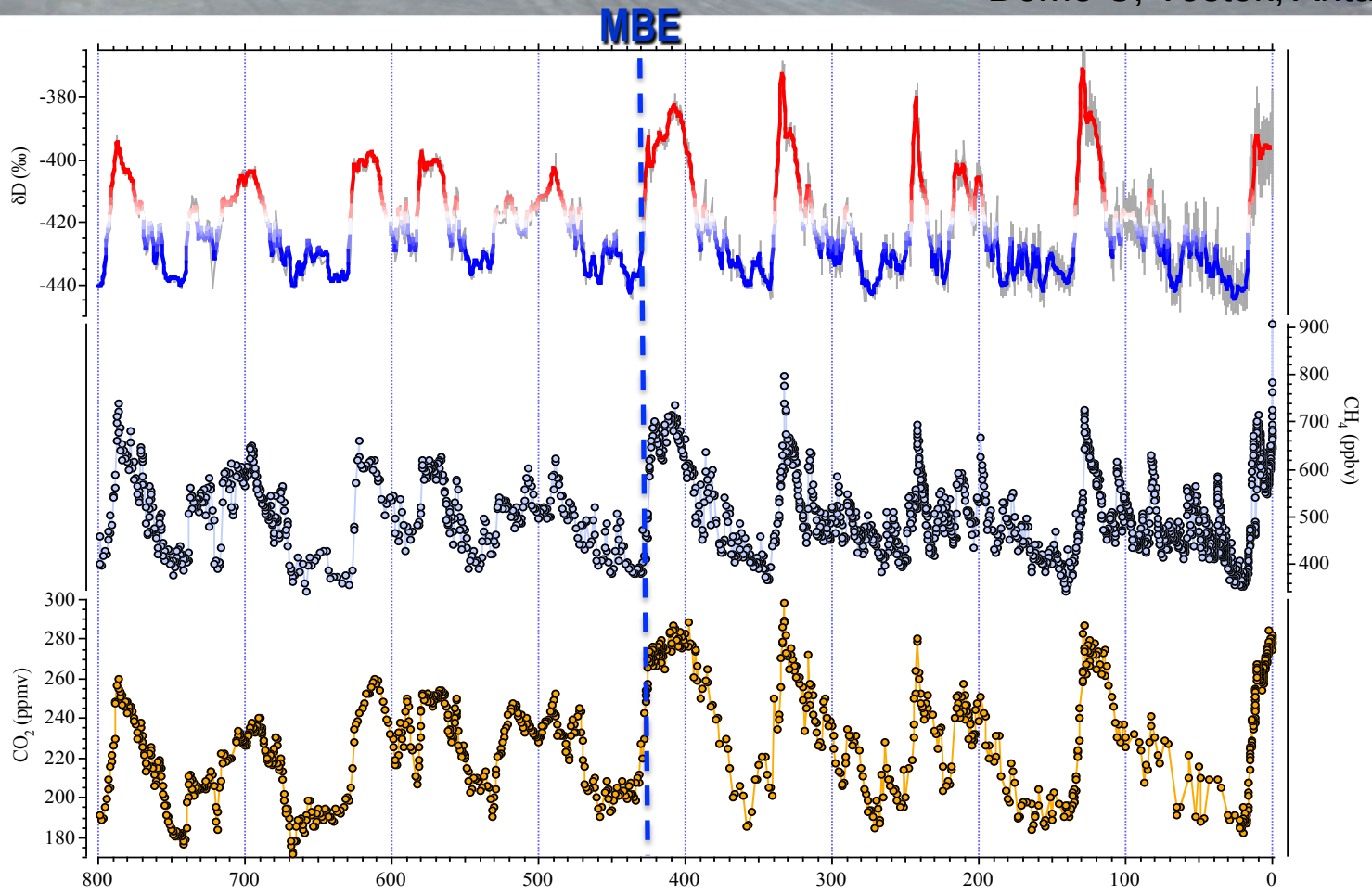
Temperature and GHG – the long-term perspective

Dome C, Vostok, Antarctica

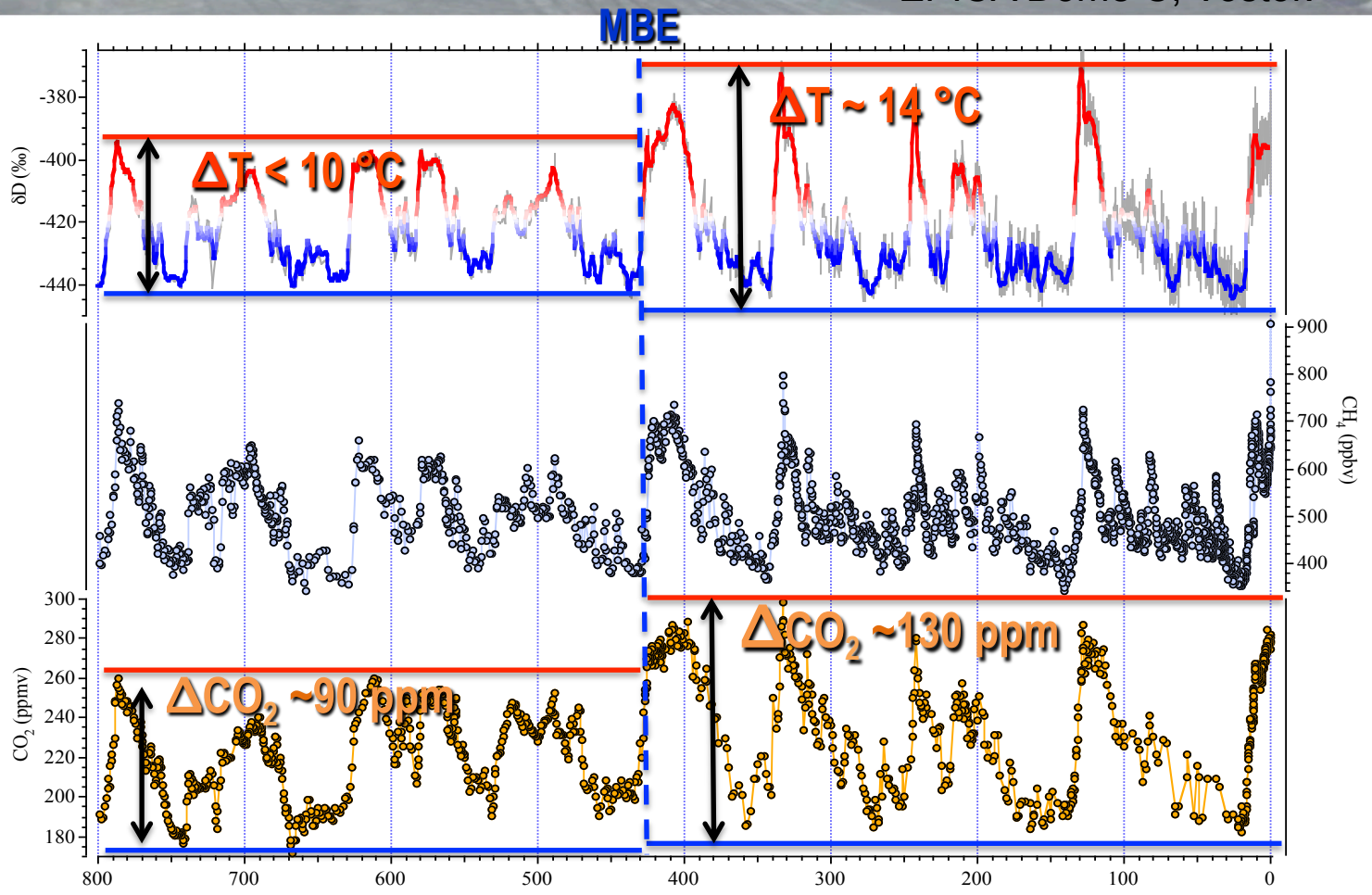


- ~100 ka cycles of warm and cold (warm is short)
- Tendency to stronger cycles in later part of period
- Every warm period is different!
- Temperature and GHG are in phase

Jouzel et al., 2007, Petit et al., 1999, Lüthi et al. , 2008, Loulergue et al., 2008, Schilt et al., 2009; Stenni et al., 2001, 2010

Temperature and GHG – the long-term perspective

EPICA Dome C, Vostok



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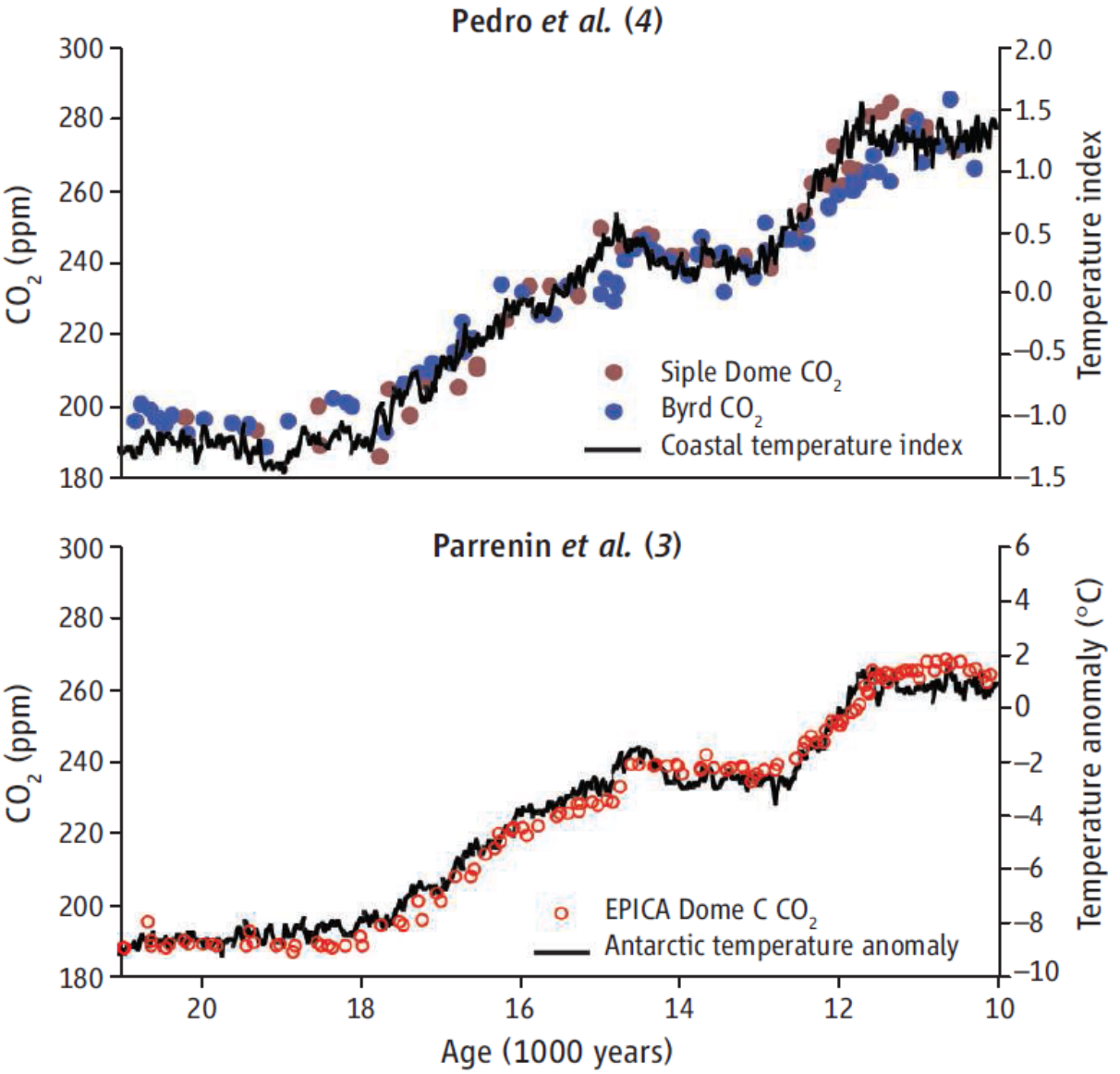
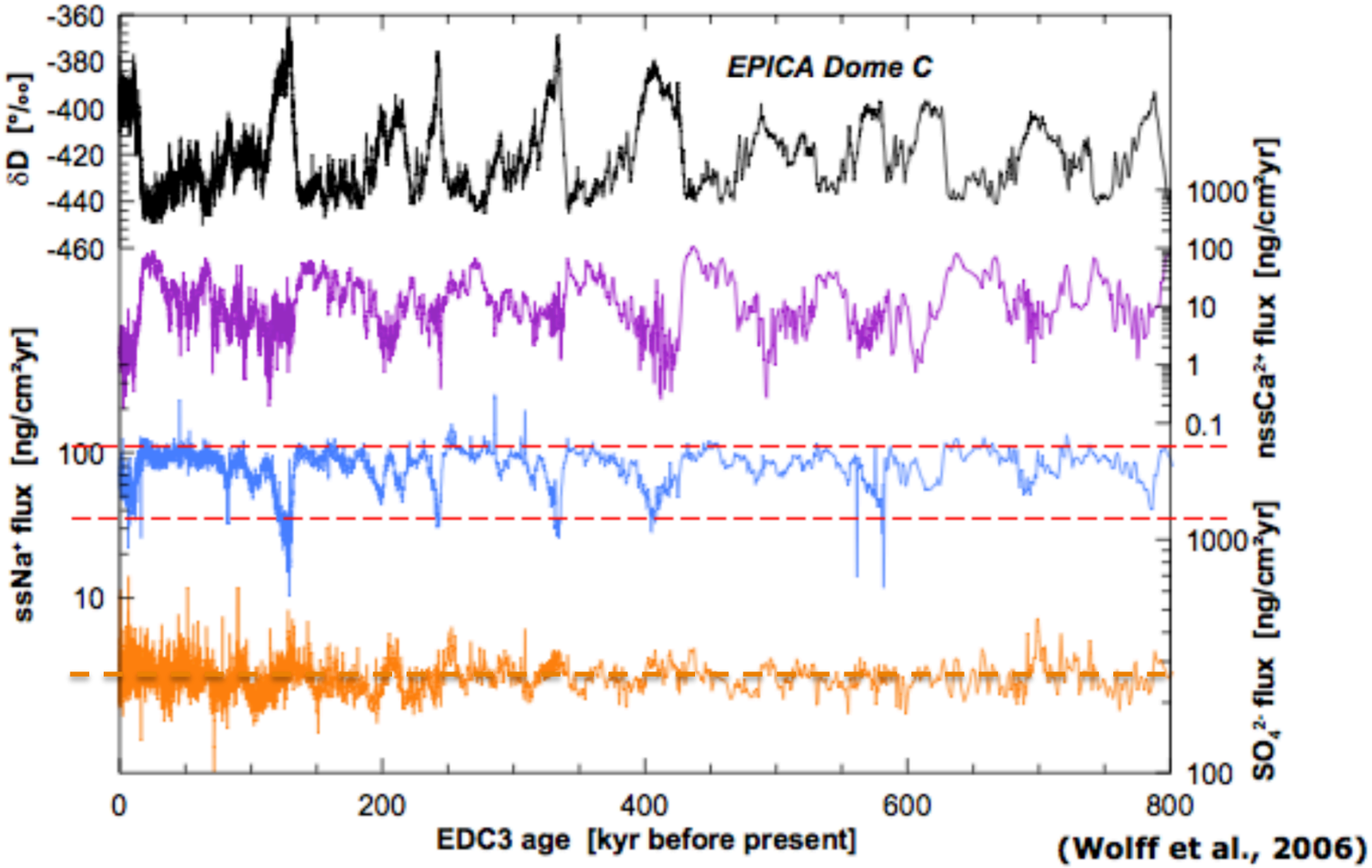
CO_2 Is acting as an amplifier

Latest estimates put CO_2 and Antarctic temperature almost exactly in phase.



Southern Ocean sea-ice extent, productivity and iron flux over the past eight glacial cycles



- 3 times more sea salt in glacial
- Is mainly derived from sea ice and not from the open ocean
- Very little change in marine biogenic sulfur production

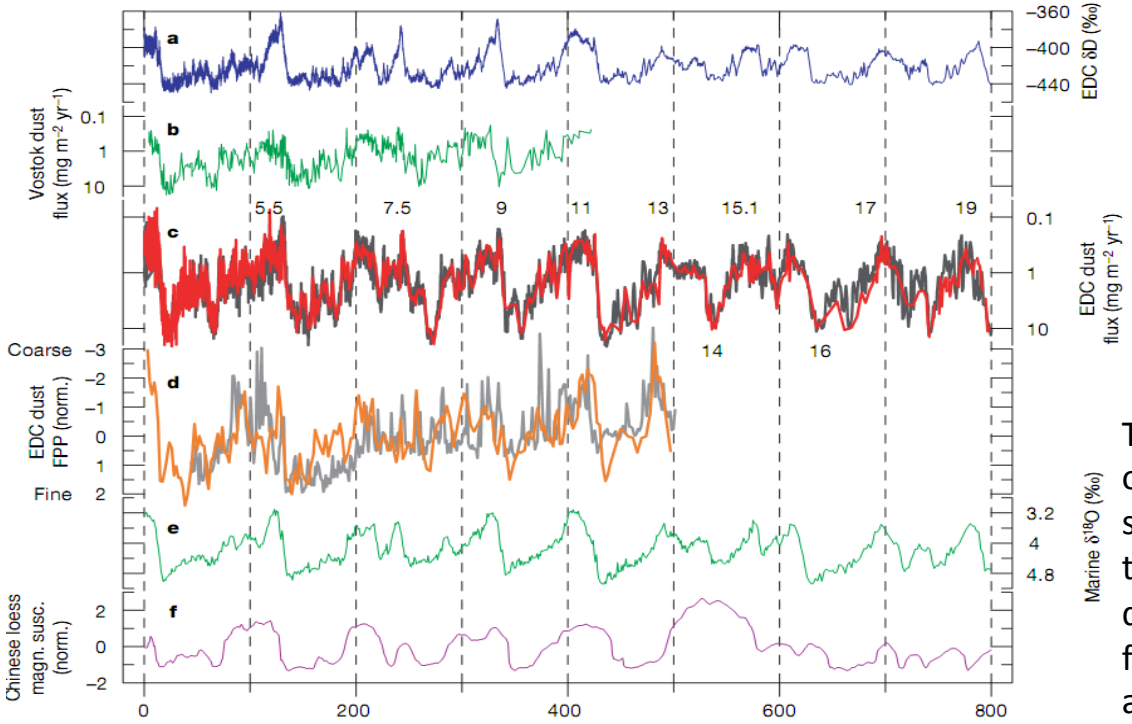
Dust in the ice

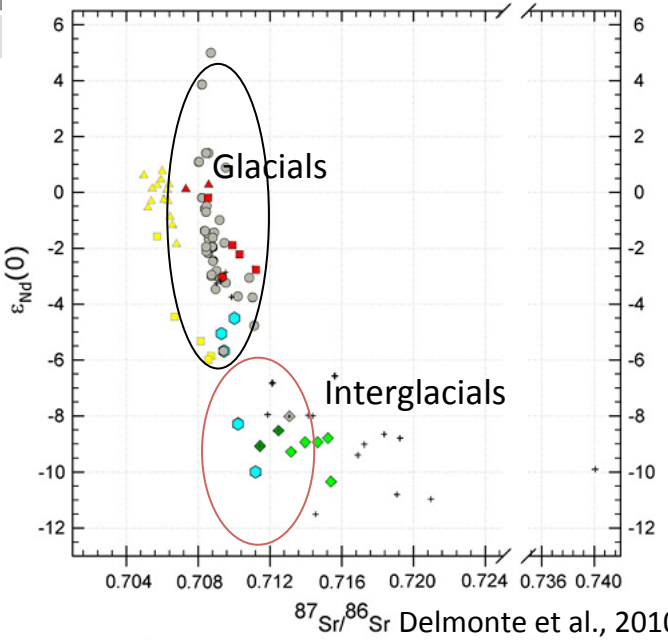
nature Vol 452|3 April 2008|doi:10.1038/nature06763

LETTERS

Dust—climate couplings over the past 800,000 years from the EPICA Dome C ice core

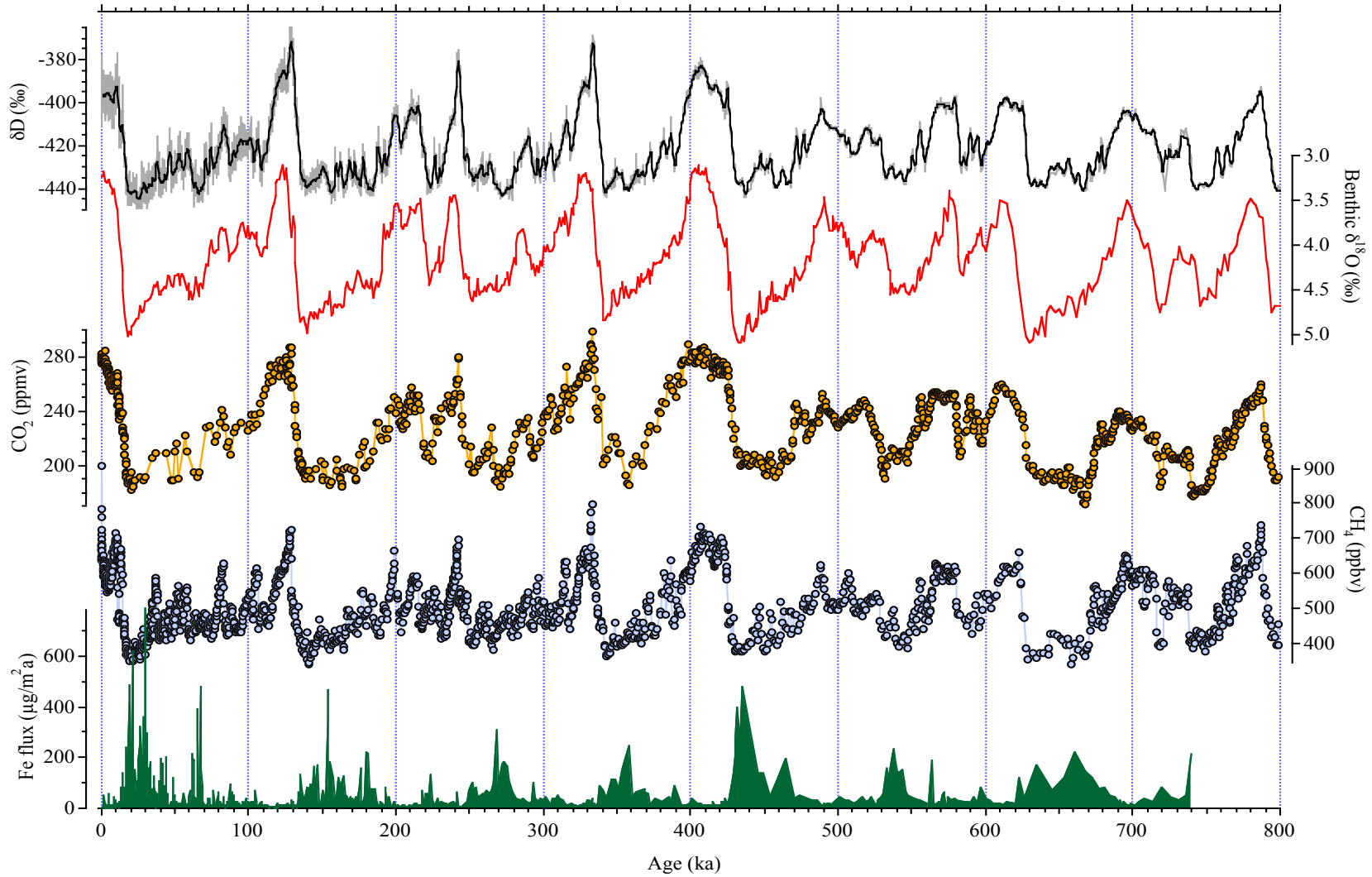
F. Lambert[1,2], B. Delmonte[3], J. R. Petit[4], M. Bigler[1,5], P. R. Kaufmann[1,2], M. A. Hutterli[6], T. F. Stocker[1,2], U. Ruth[7], J. P. Steffensen[5] & V. Maggi[3]





The observed 25-fold increase in glacial dust flux over all eight glacial periods can be attributed to a strengthening of South American dust sources, together with a longer lifetime for atmospheric dust particles in the upper troposphere resulting from a reduced hydrological cycle during the ice ages.

EPICA DOME C – Iron flux Record



Iron data from: *"Southern Ocean sea ice, DMS production and iron flux over the last eight glacial cycles", Nature, 2006, Gaspari et al., 2006*

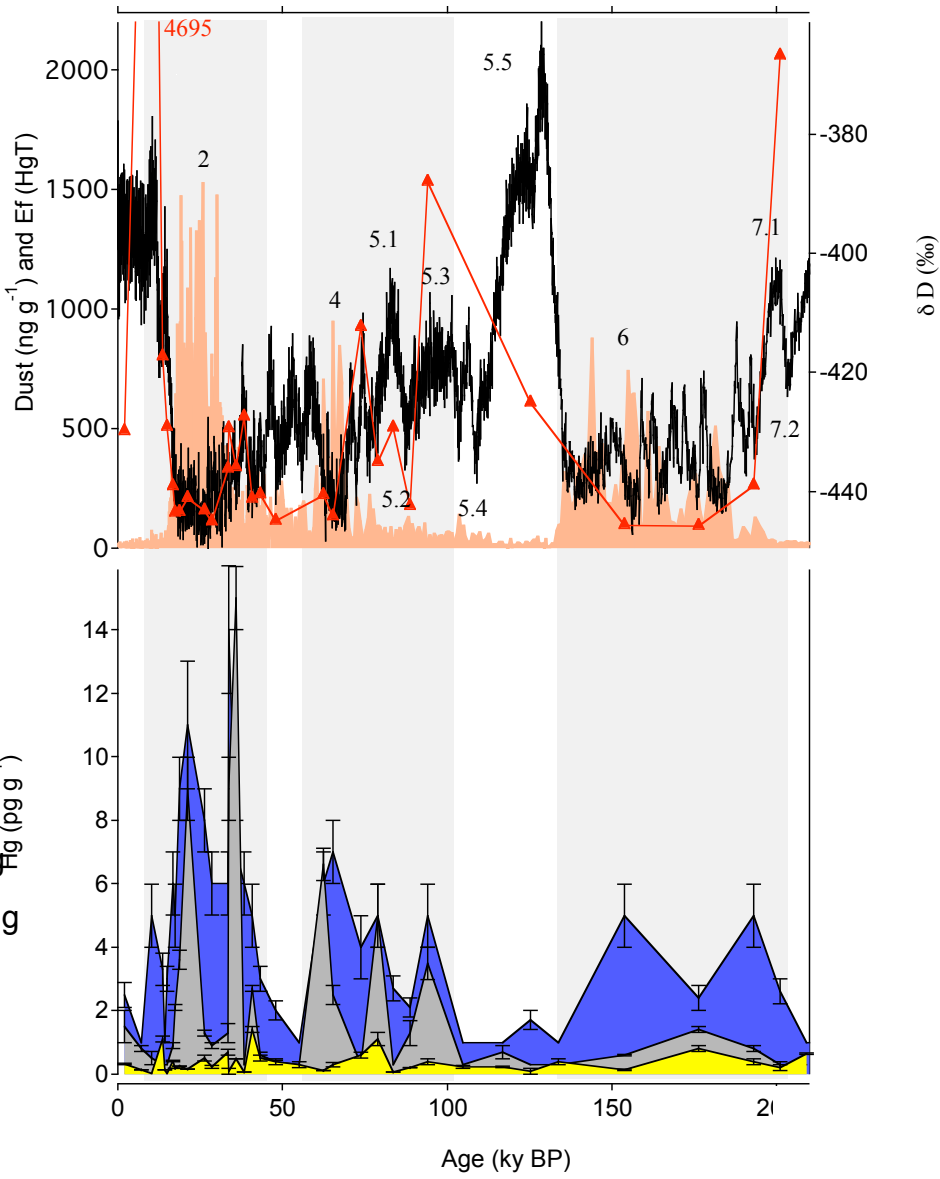
Mercury species in the ice

nature geoscience
LETTERS
PUBLISHED ONLINE: XX MONTH XXXX | DOI: 10.1038/NGEO549

Atmospheric depletion of mercury over Antarctica during glacial periods

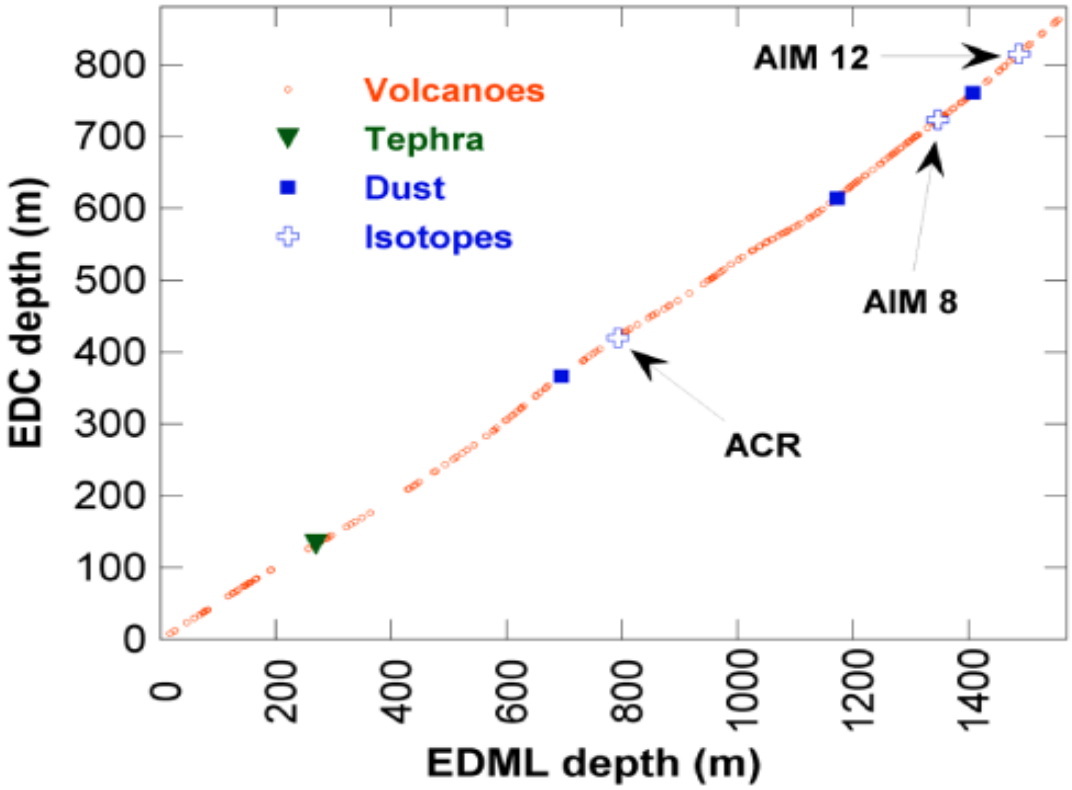
Petru Jitaru[1,2,3], Paolo Gabrielli[1,4,5]*, Alexandrine Marteel[4,6], John M. C. Plane[7], Fréderic A. M. Planchon[1,8], Pierre-Alexis Gauchard[4], Christophe P. Ferrari[4,9], Claude F. Boutron[4,10], Freddy C. Adams[2], Sungmin Hong[11], Paolo Cescon[1,12] and Carlo Barbante[1,12]

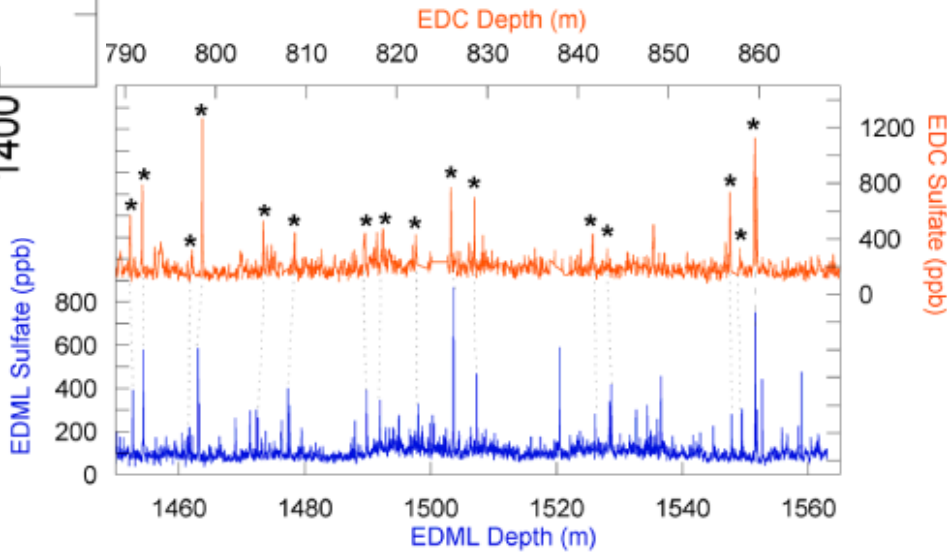
Polar regions acted as a mercury sink during the coldest climatic stages, and that substantial polar deposition of atmospheric mercury is therefore not an exclusively recent phenomenon.



P. Jitaru et al., *Nature Geoscience* 2009

EPICA DC-DML-NGRIP-Vostok-TALDICE synchronisation by volcanic matching

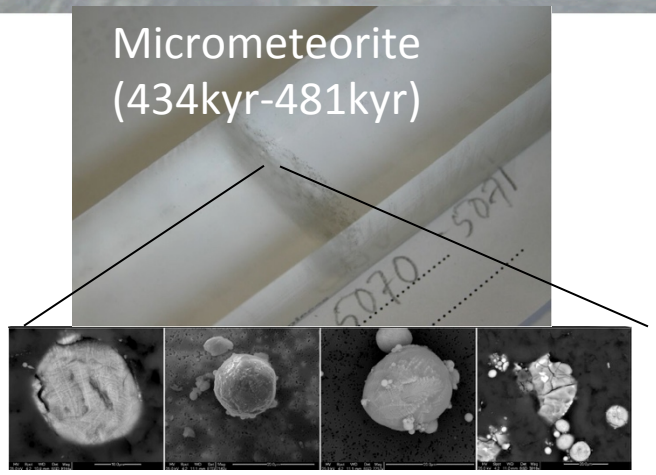


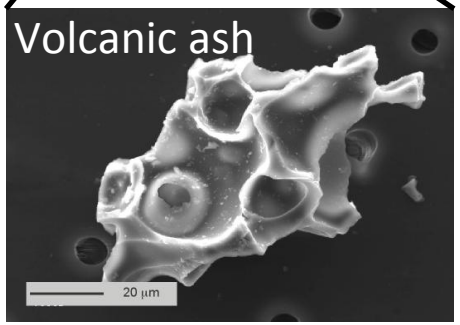


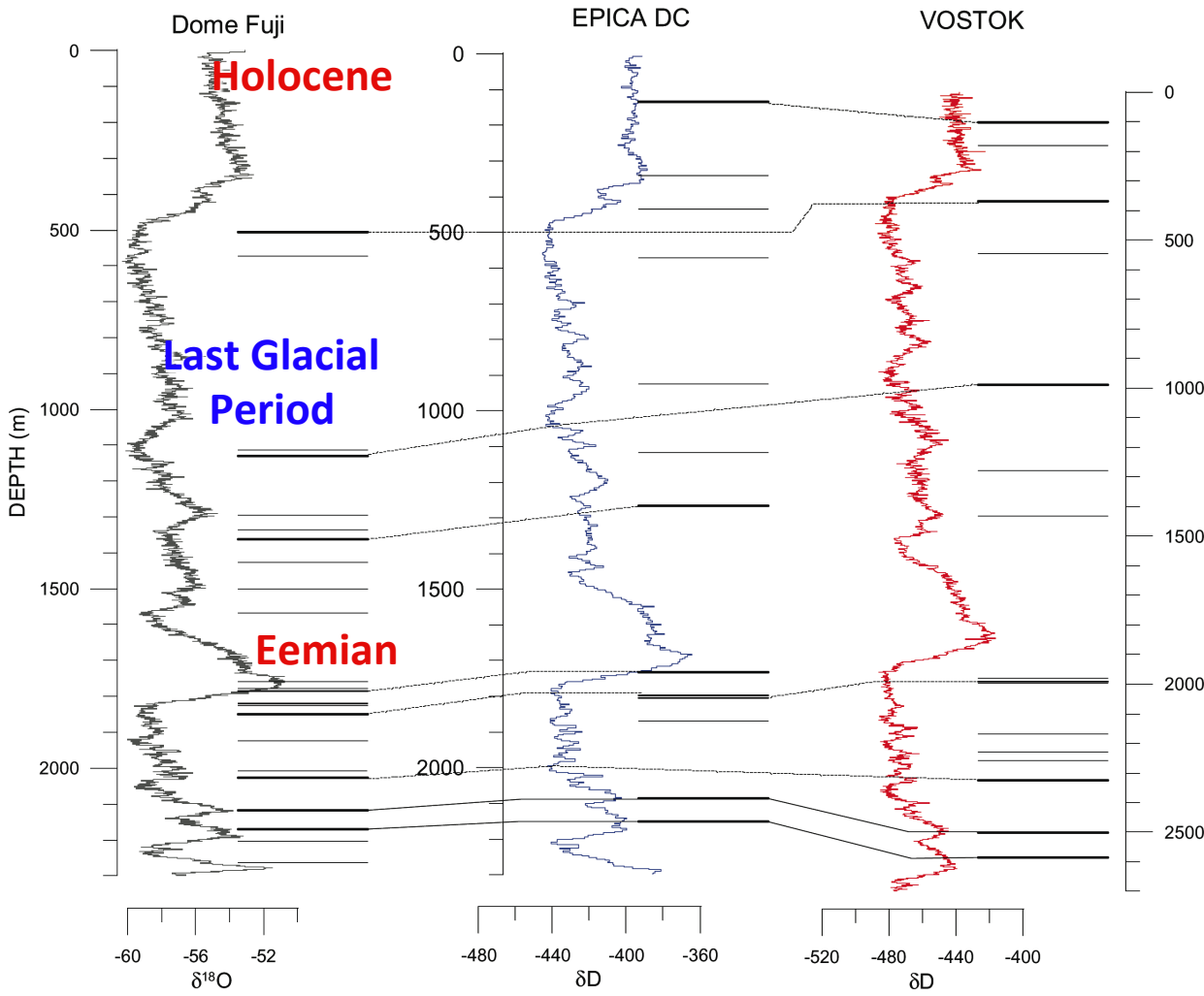
Age scale synchronisation between the EPICA DC-DML-VOSTOK-TALDICE and NGRIP ice cores was carried on through the identification of several common volcanic signatures

Udisti et al., 2004; Castellano et al., 2004; Severi et al., 2007; 2012; Ruth et al. 2007; Parrenin et al., 2012

Volcanic ash and micro meteorite in EPICA core

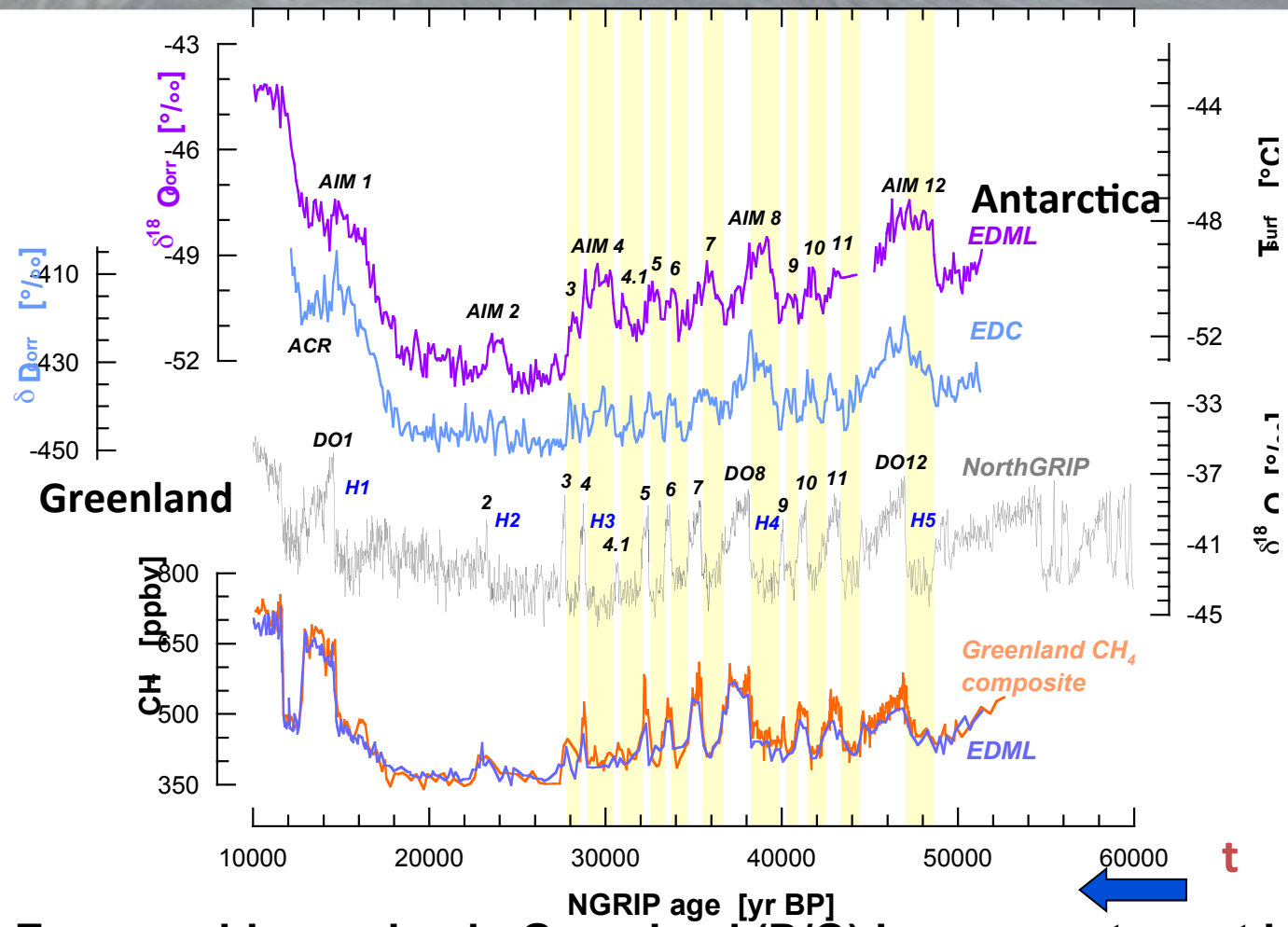


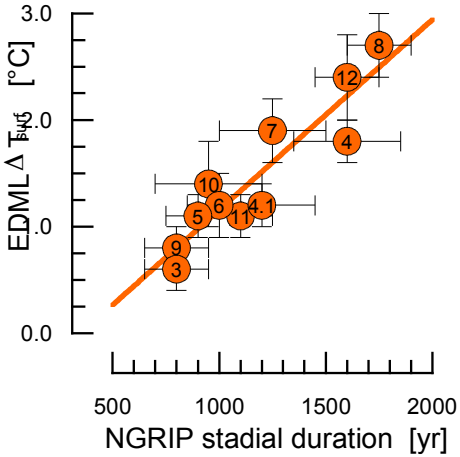




Narcisi et al., 2005, 2006, 2007, 2008, 2010

BIPOLAR SEESAW

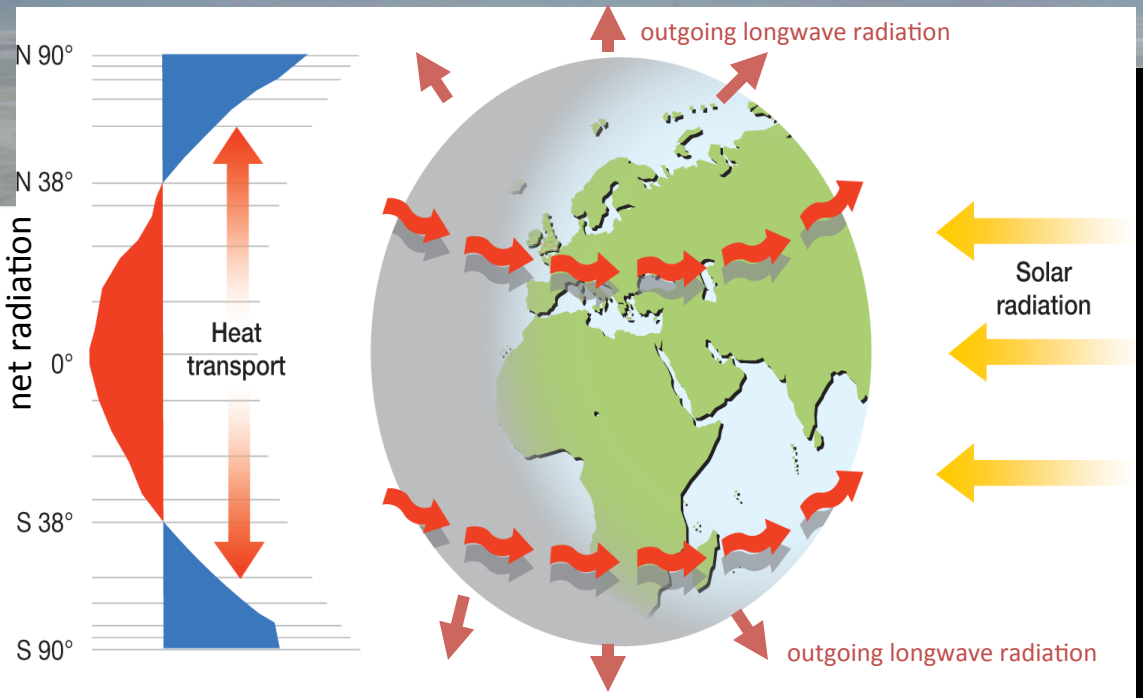


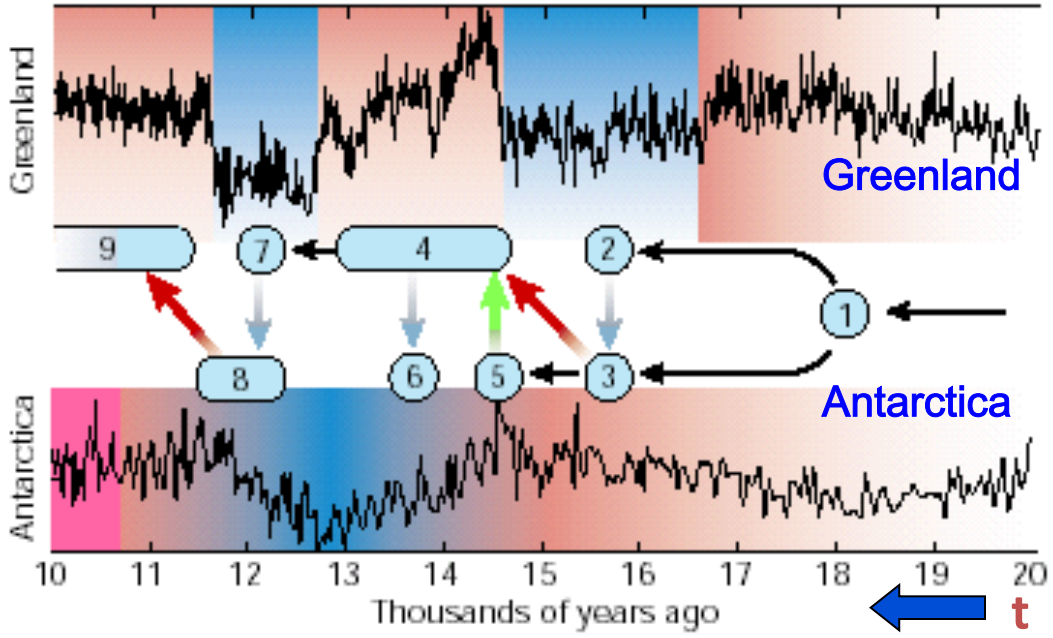


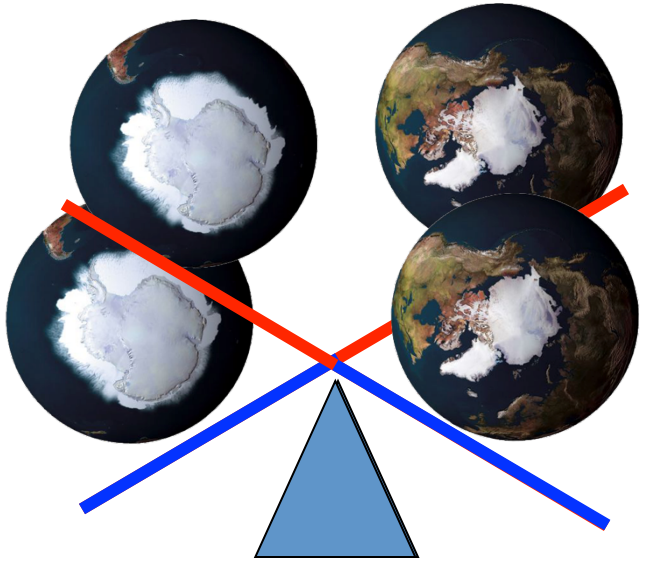
- **Every rapid warming in Greenland (D/O) has a counterpart in Antarctica (AIM)**
- **Antarctica warms up when Greenland is cold and vice versa**
- **Antarctica (AIM) temperature amplitude linearly related to duration of subsequent D/O event**

Barbante et al., 2006

BIPOLAR SEESAW







Stocker, 2003

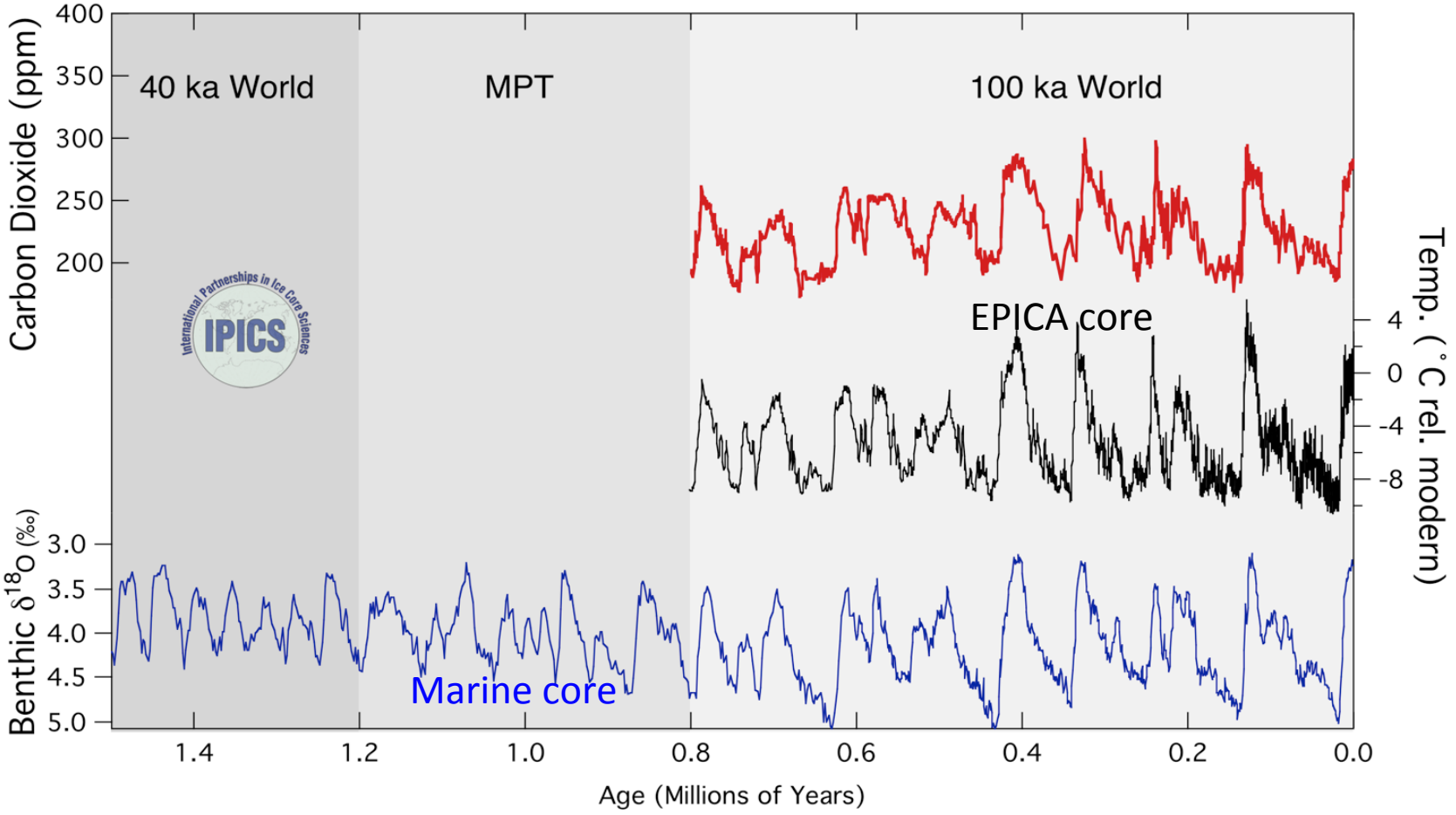
TALDICE

TALosDomeIceCorE

TALDICE is a European ice core research project (Italy, France, Germany, Switzerland, United Kingdom) aimed at retrieving an ice core from the peripheral dome of East Antarctica, reaching back through the previous two interglacials (about 320,000 years), from a peripheral dome of East Antarctica. Logisticl support was provided by the Italian Antarctic Programme (Programma Nazionale di Ricerche in Antartide).

www.taldice.org

Oldest ice

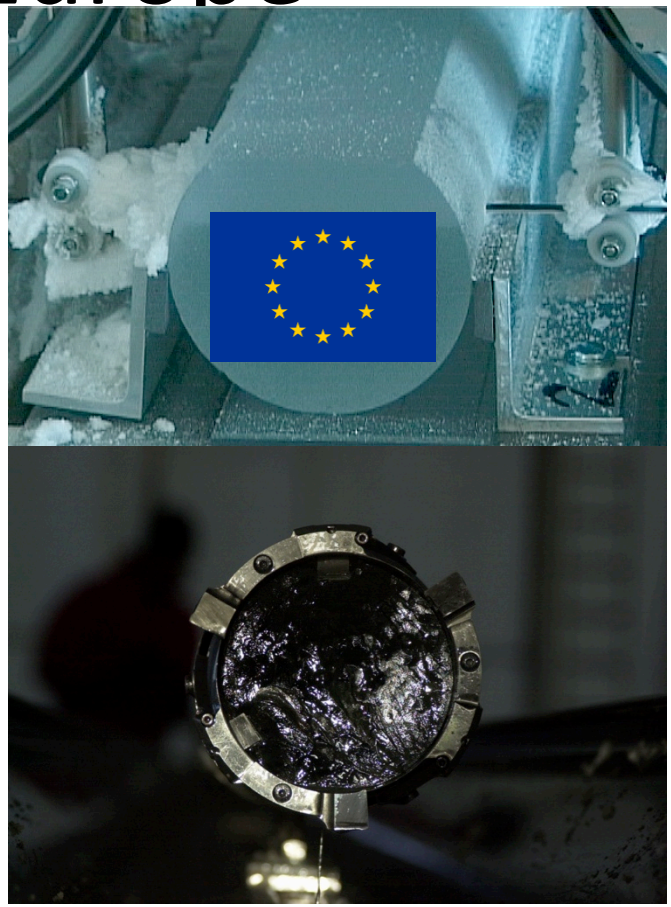

Carbon Dioxide (ppm)
400
350
300
250
200
40 ka World
MPT
100 ka World
EPICA core
Temp. (°C rel. modern)
4
0
-4
-8
Benthic δ18O (‰)
3.0
3.5
4.0
4.5
5.0
Marine core
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Age (Millions of Years)

Underlying science issues

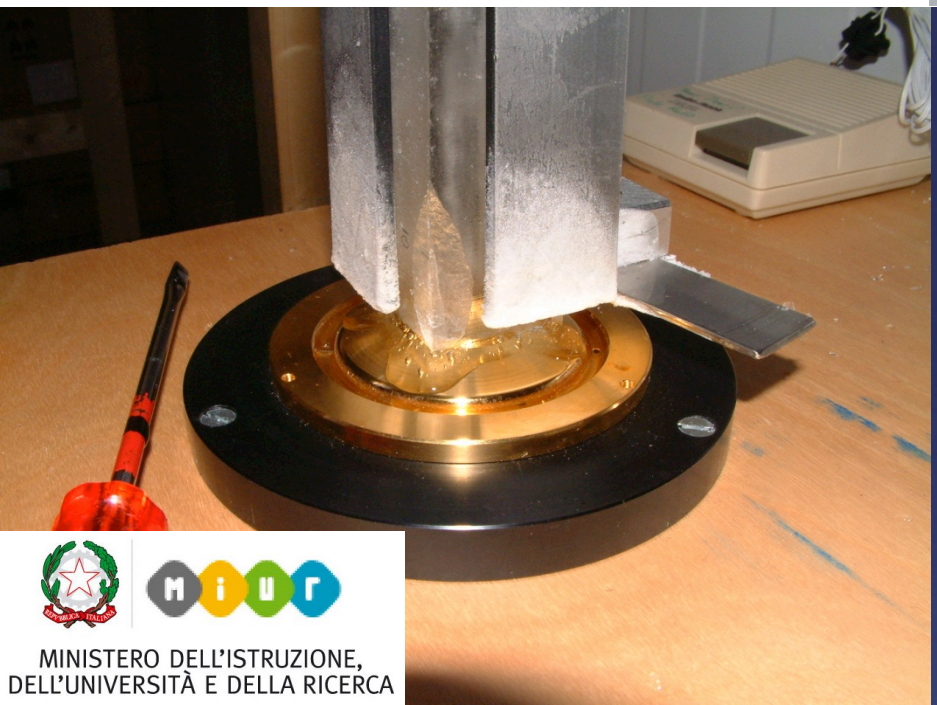
- Unless we understand the transition from 40 ka cycles to 100 ka cycles, we don't really understand current climate
- Why did we have the Mid-Pleistocene Transition (MPT) around 1 Ma ago?
  - What was the role of greenhouse gases in this transition?
- Why do we now live in a 100 ka world?

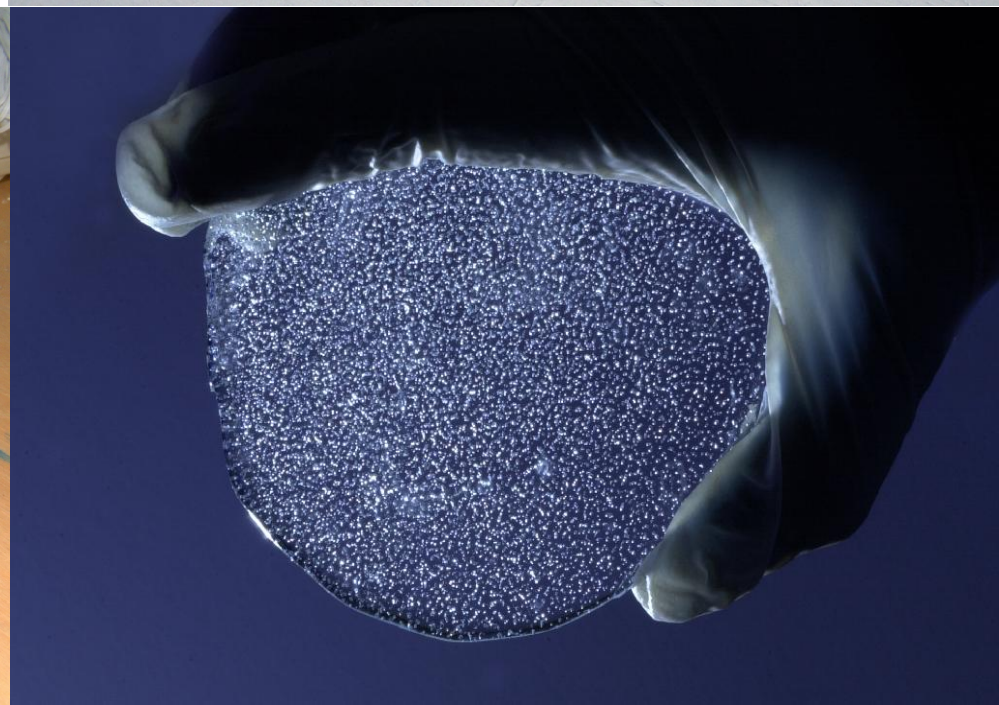
Oldest ice and Europe

- Ambitious "grand challenge" project to drill ice core extending 1.5 million years
- Europe can and should be taking the lead (other nations are not yet ready but would collaborate)
- After meeting in US and workshop in Bremerhaven significant new geophysical and rapid access drilling campaigns are underway to seek the most probable locations
- Logistics and funding agencies are primed! But will need a major coordinated effort on the scale of EPICA, underpinned at EU level



Thank you for your time and attention





MINISTERO DELL'ISTRUZIONE,
DELL'UNIVERSITÀ E DELLA RICERCA