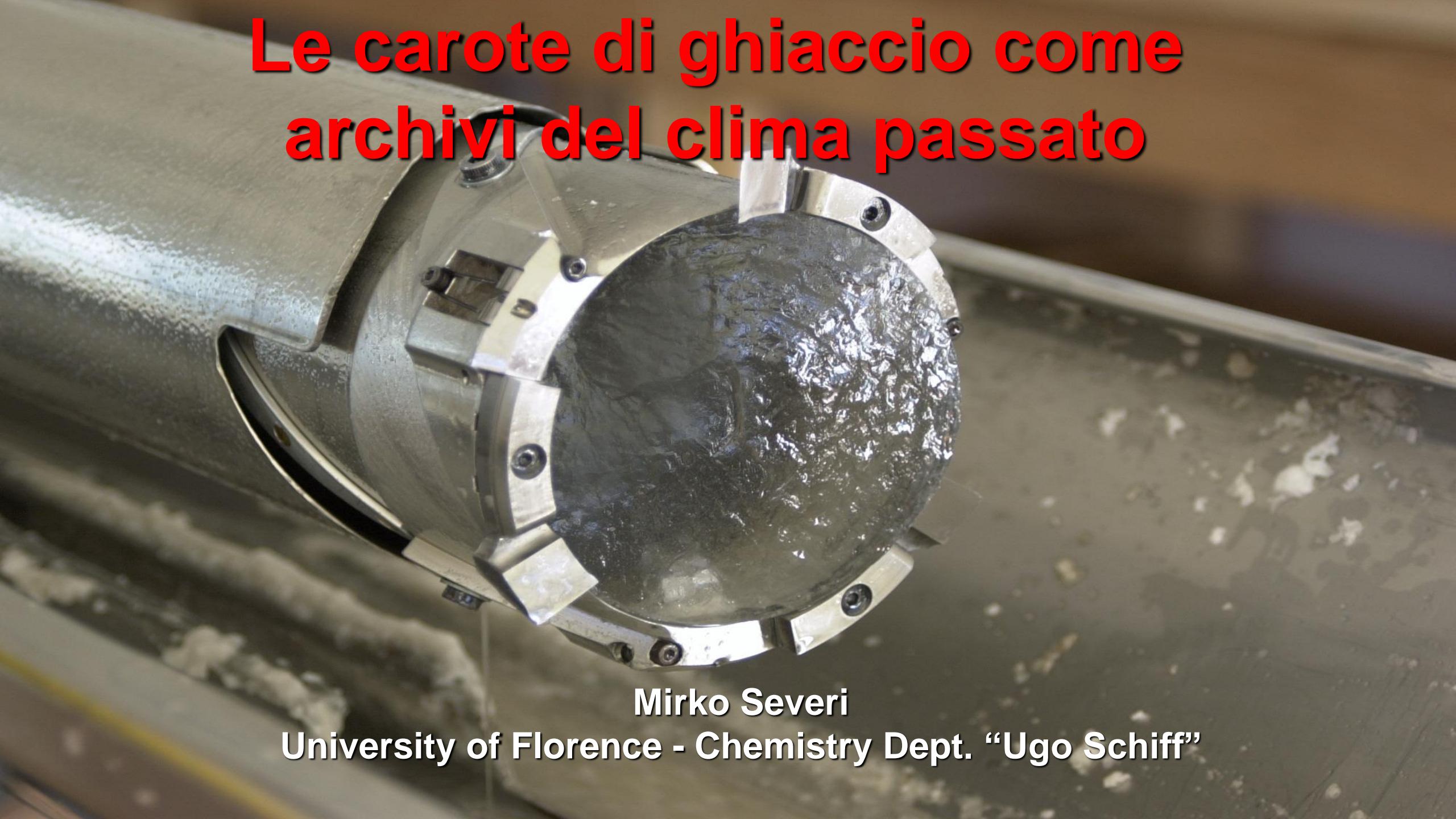


Le carote di ghiaccio come archivi del clima passato



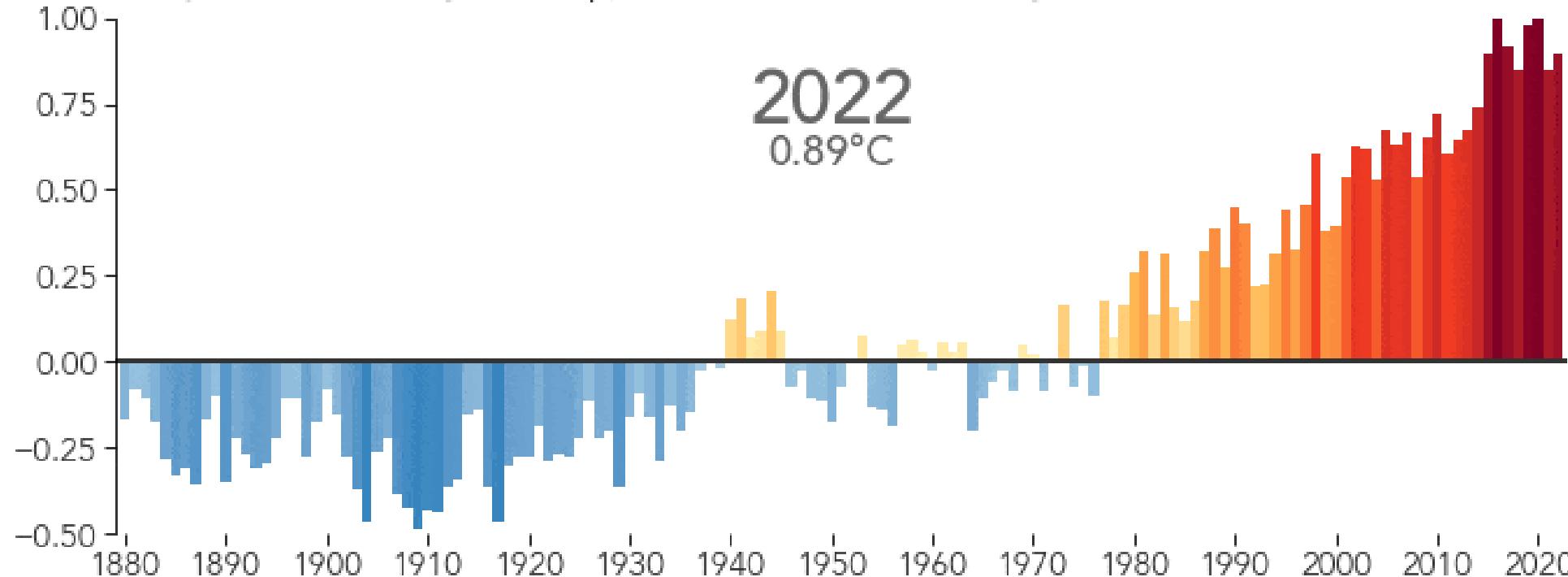
Mirko Severi

University of Florence - Chemistry Dept. "Ugo Schiff"

Il cambiamento climatico non è qualcosa in cui credere, è un fenomeno da comprendere

Last 9 Years Warmest on Record

Global Temperature Anomaly ($^{\circ}\text{C}$ compared to the 1951-1980 average)



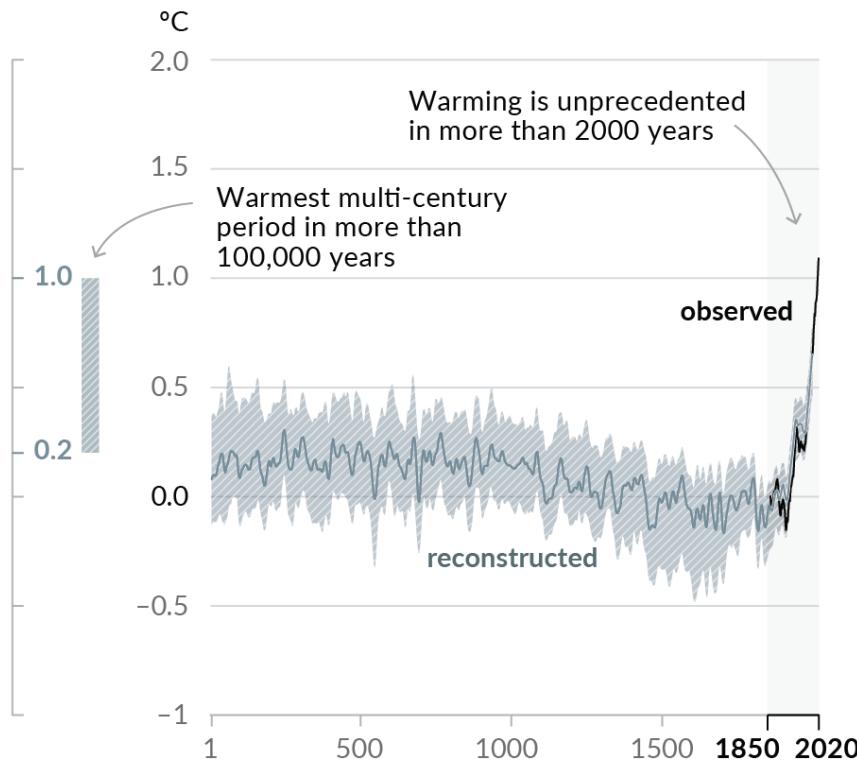
Dal 1880 riscaldamento di 0.06 $^{\circ}\text{C}/\text{decade}$

Dal 1982 riscaldamento tre volte più veloce (ca. 0.2 $^{\circ}\text{C}/\text{decade}$)

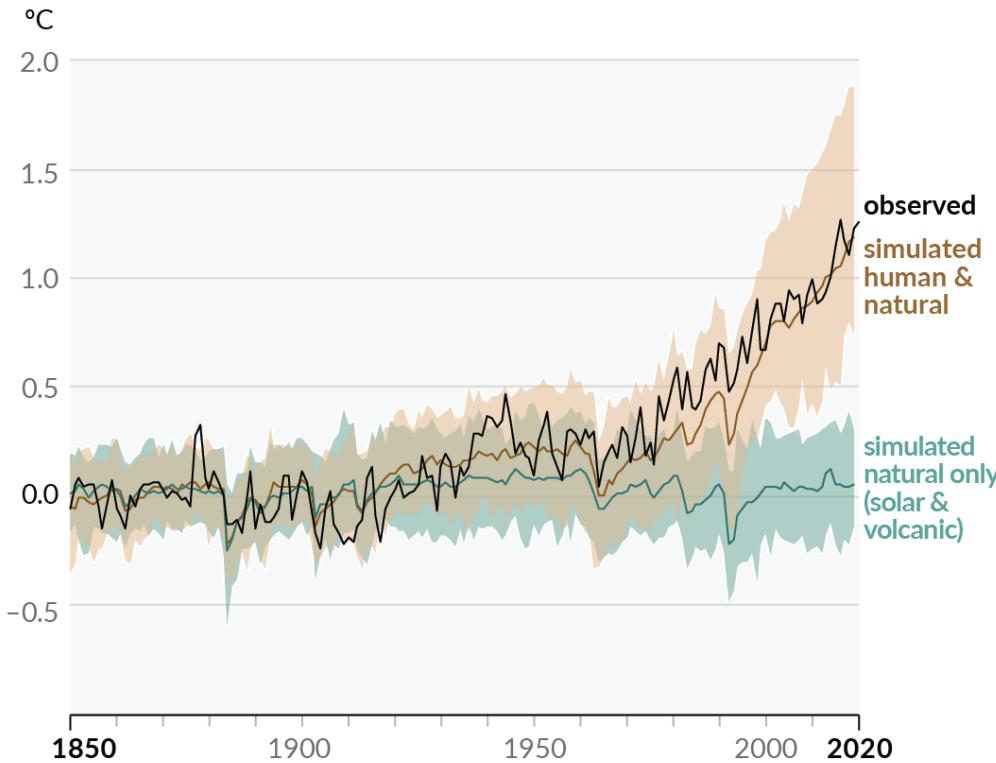
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Changes in global surface temperature relative to 1850–1900

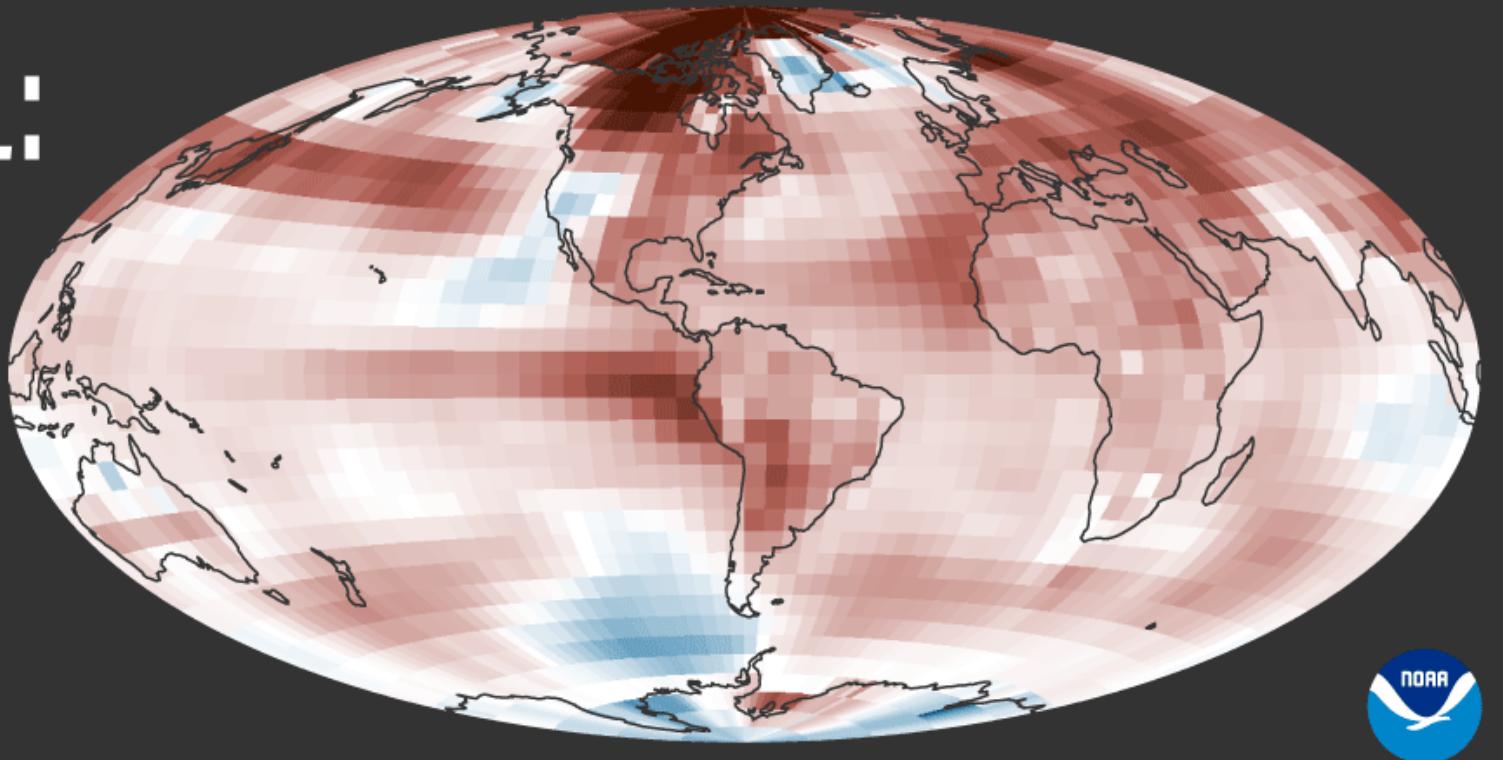
(a) Change in global surface temperature (decadal average) as **reconstructed** (1–2000) and **observed** (1850–2020)



(b) Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850–2020)



IT'S OFFICIAL:



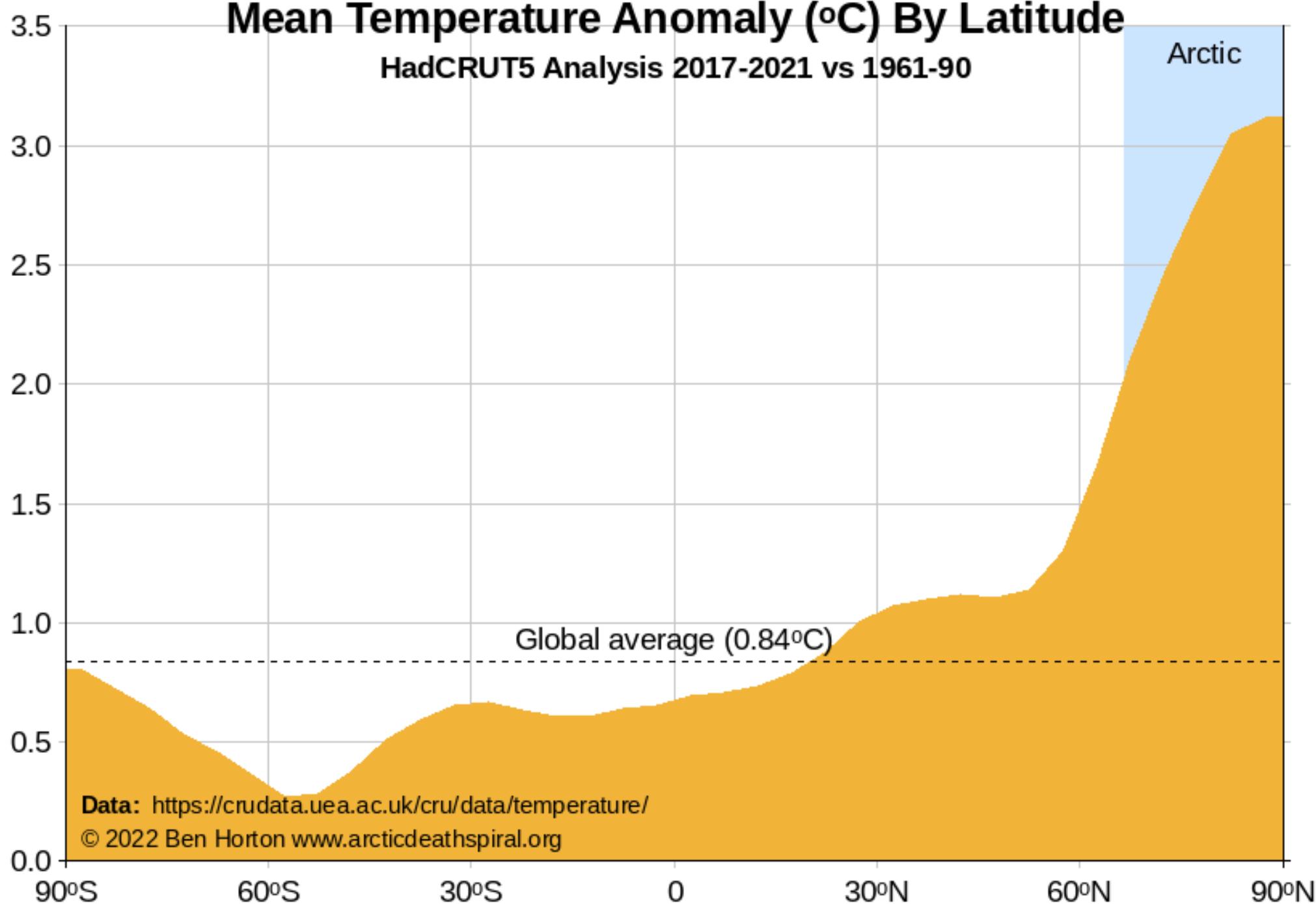
Difference from 1991–2020 average ($^{\circ}\text{F}$)

-5 0 5



Mean Temperature Anomaly ($^{\circ}\text{C}$) By Latitude

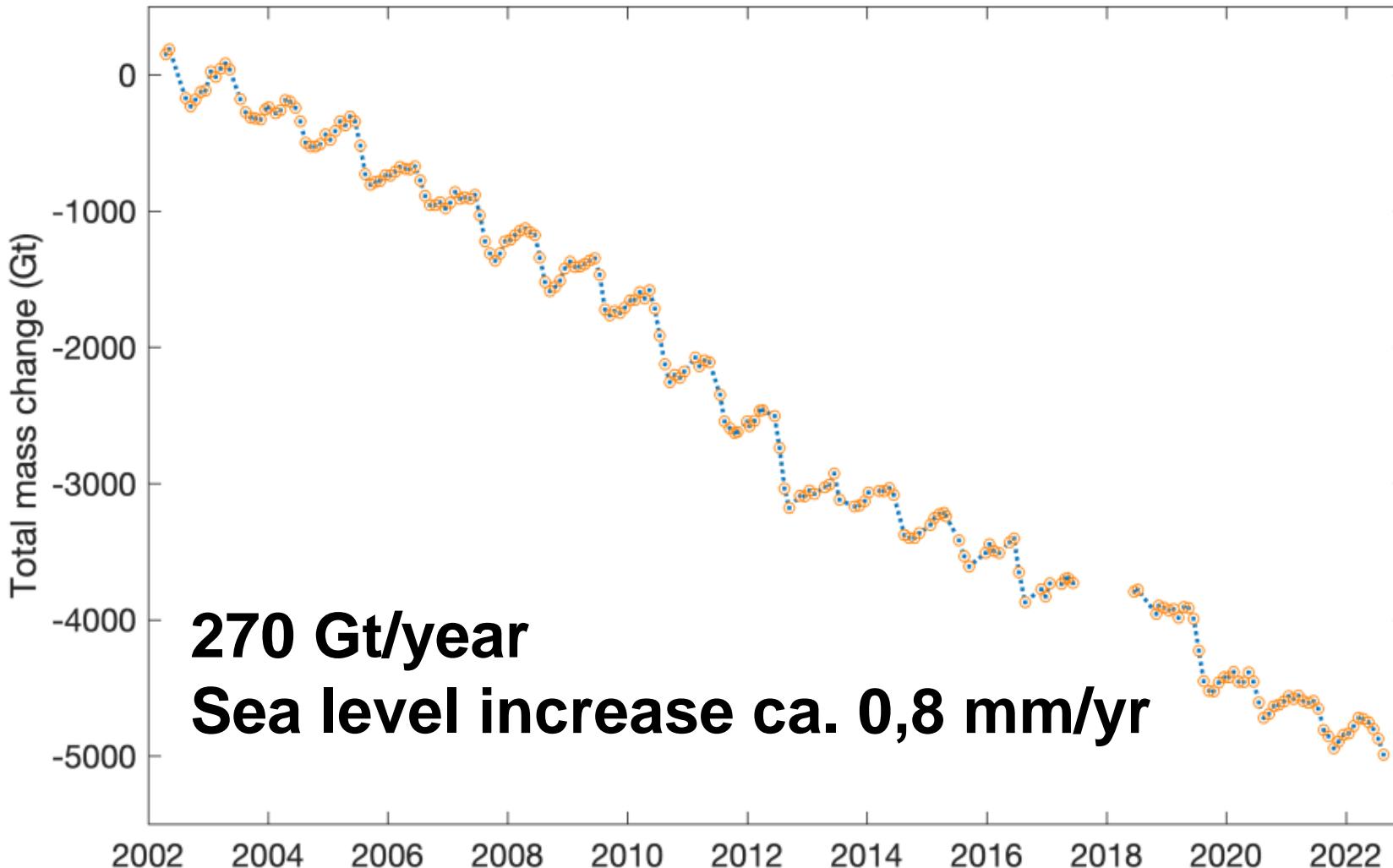
HadCRUT5 Analysis 2017-2021 vs 1961-90



Data: <https://crudata.uea.ac.uk/cru/data/temperature/>

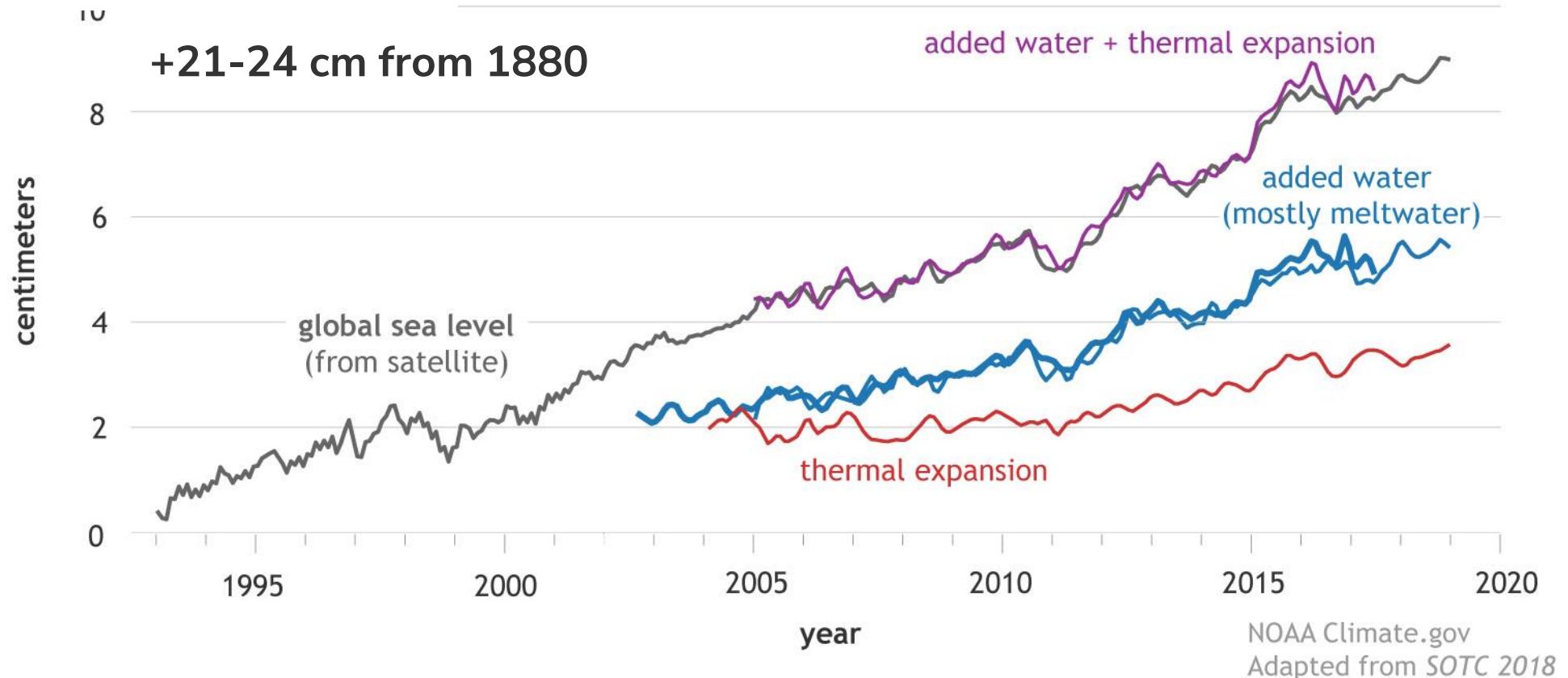
© 2022 Ben Horton www.arcticdeathspiral.org

Greenland ice loss

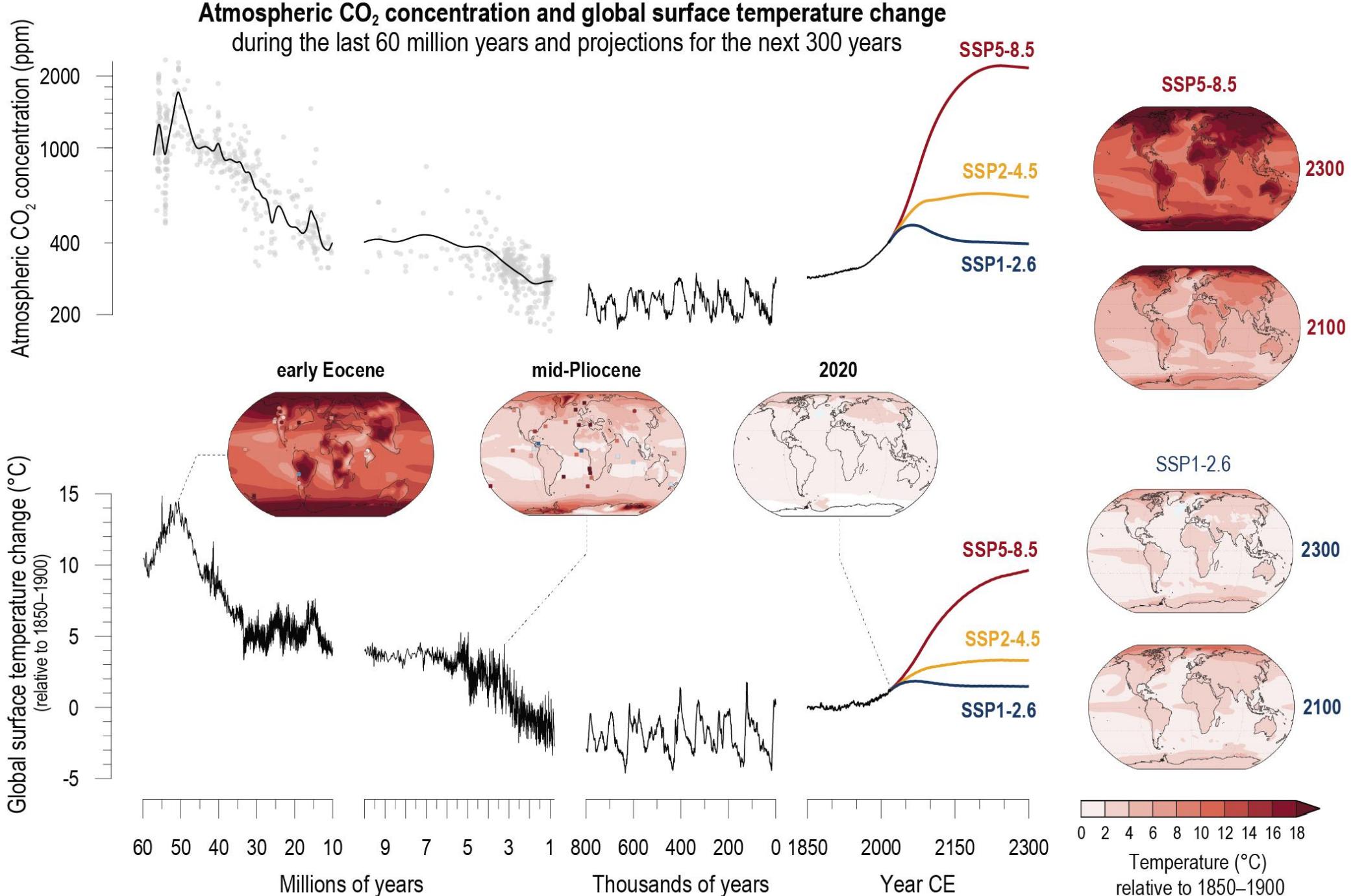


Total mass change (Gt) of the Greenland ice sheet from April 2002 to mid-August 2022 determined from GRACE (2002–17) and GRACE-FO (2018–Present) satellite data.

Global Sea Level

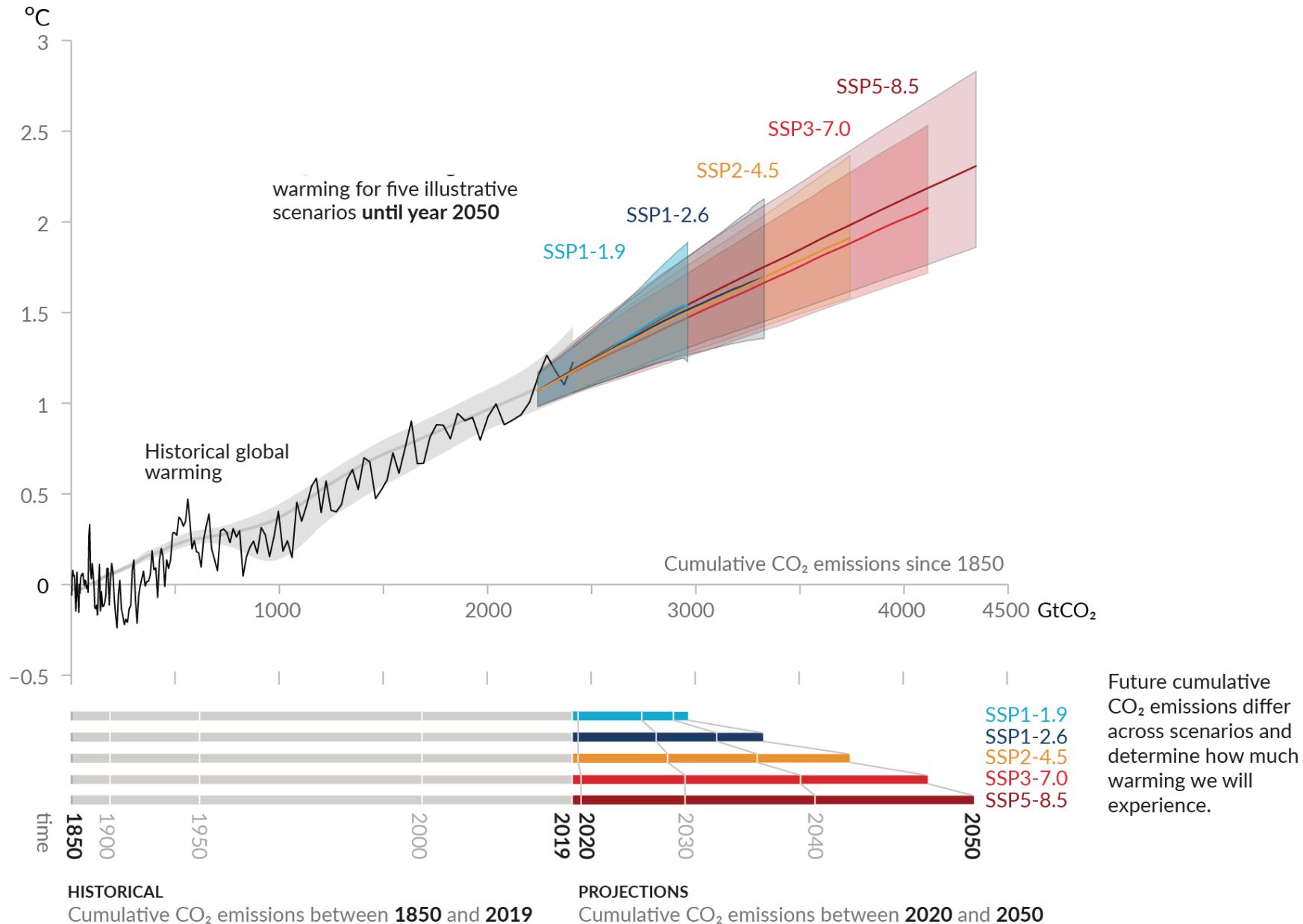


Accelerated from 1.7 mm/year
throughout most of the twentieth
century to 3.2 mm/year since 1993



Every tonne of CO₂ emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)

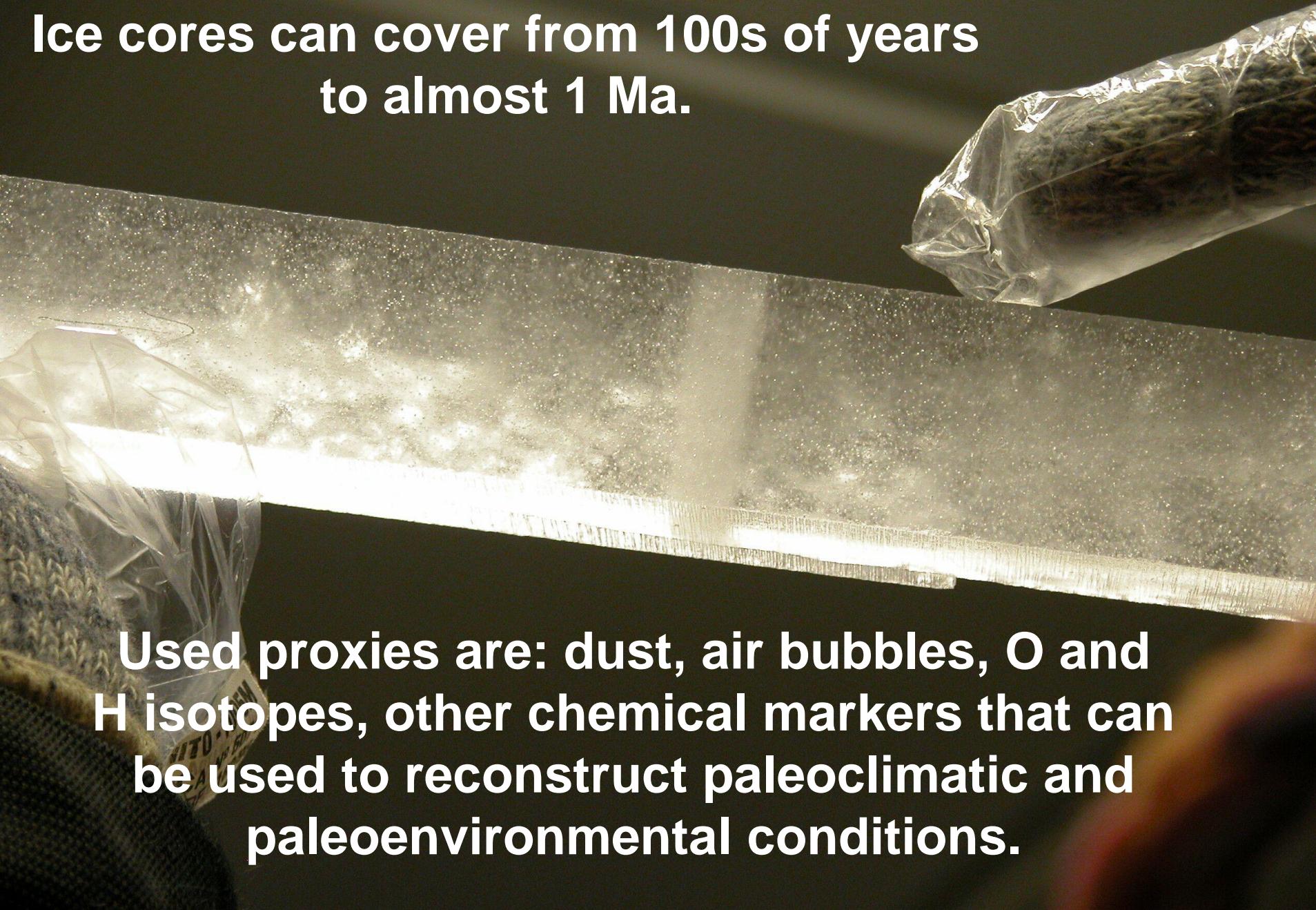


If we want to “read” the elder pages of
the “*Book of Earth’s Climate*” we
need to use something different ...

We need PROXIES

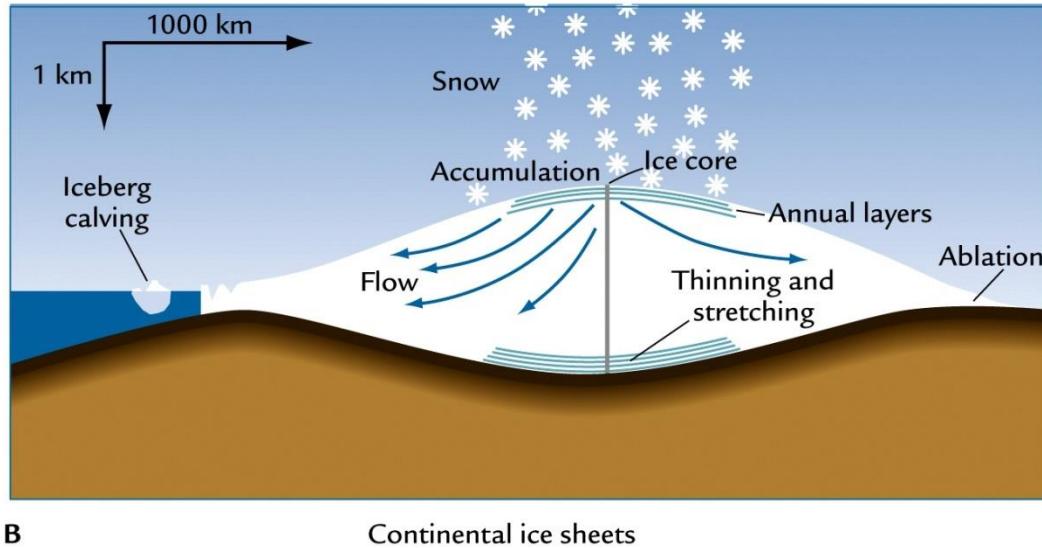


**Ice cores can cover from 100s of years
to almost 1 Ma.**

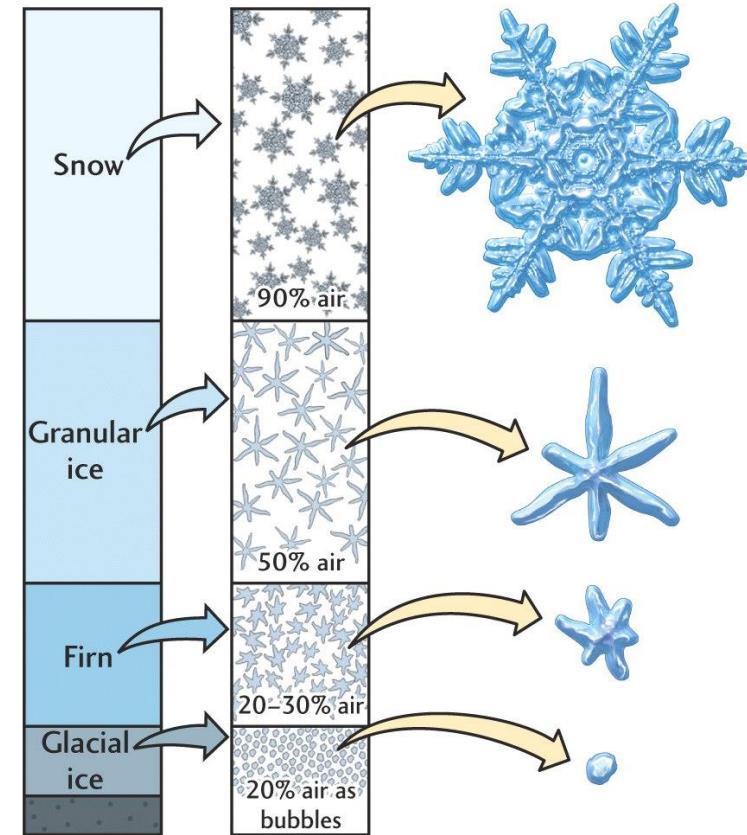


**Used proxies are: dust, air bubbles, O and
H isotopes, other chemical markers that can
be used to reconstruct paleoclimatic and
paleoenvironmental conditions.**

The ice sheets can be used as archives of past atmospheric composition.



Snowfalls accumulate on ice-sheets and slowly become **firn** (compressed snow) and **ice**.



This process excludes air out of the snow and just a small amount of air is finally trapped in the ice.



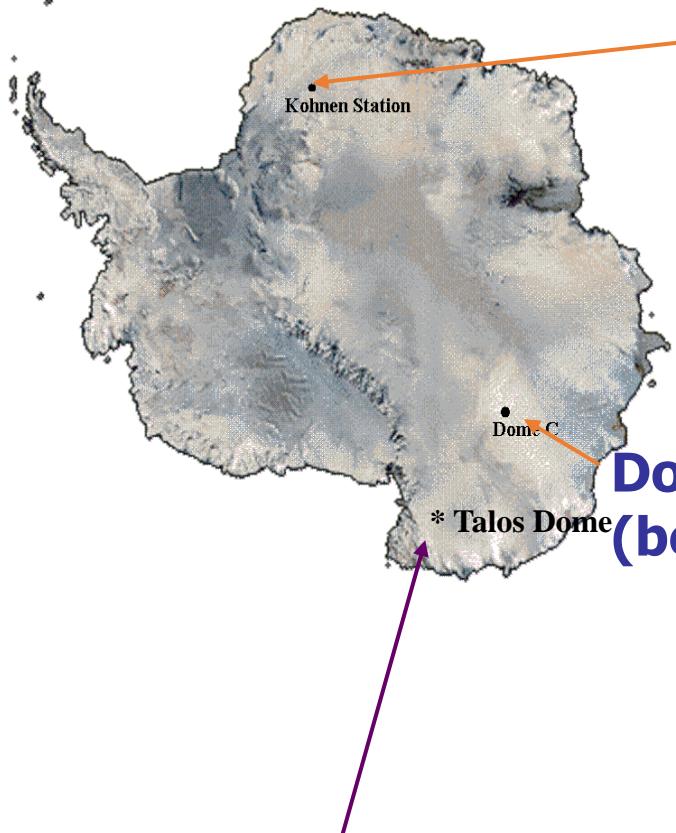
VIESSMANN

BETYOND
EPICA





EPICA Project (European Project for Ice Coring in Antarctica)



Kohnen (DML) – 2750 m (bedrock)



Very high resolution (sub-annual) stratigraphy for the last 150 kyr. Teleconnection between climate and Atlantic thermohaline circulation.

Dome C (Central East Antarctica) – 3270 m (bedrock)



800 kyr high resolution chemical, physical and isotopic stratigraphies

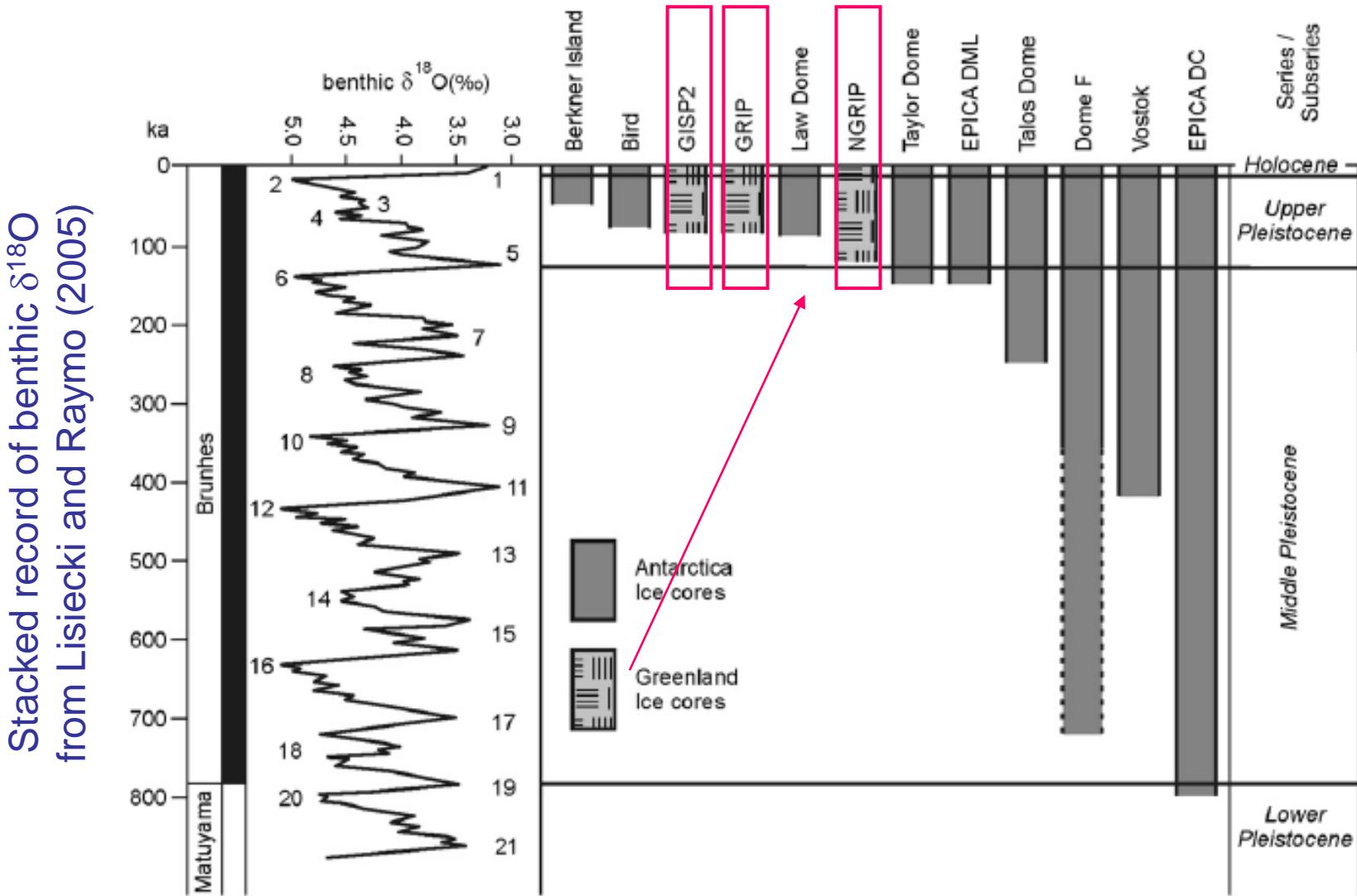
Talos Dome (NVL) – 1625 m

High resolution stratigraphies for the last 320 kyr.

Coastal dome - climatic information from Pacific-Indian sector



The stratigraphic extent reached by the deepest Greenland and Antarctic ice cores



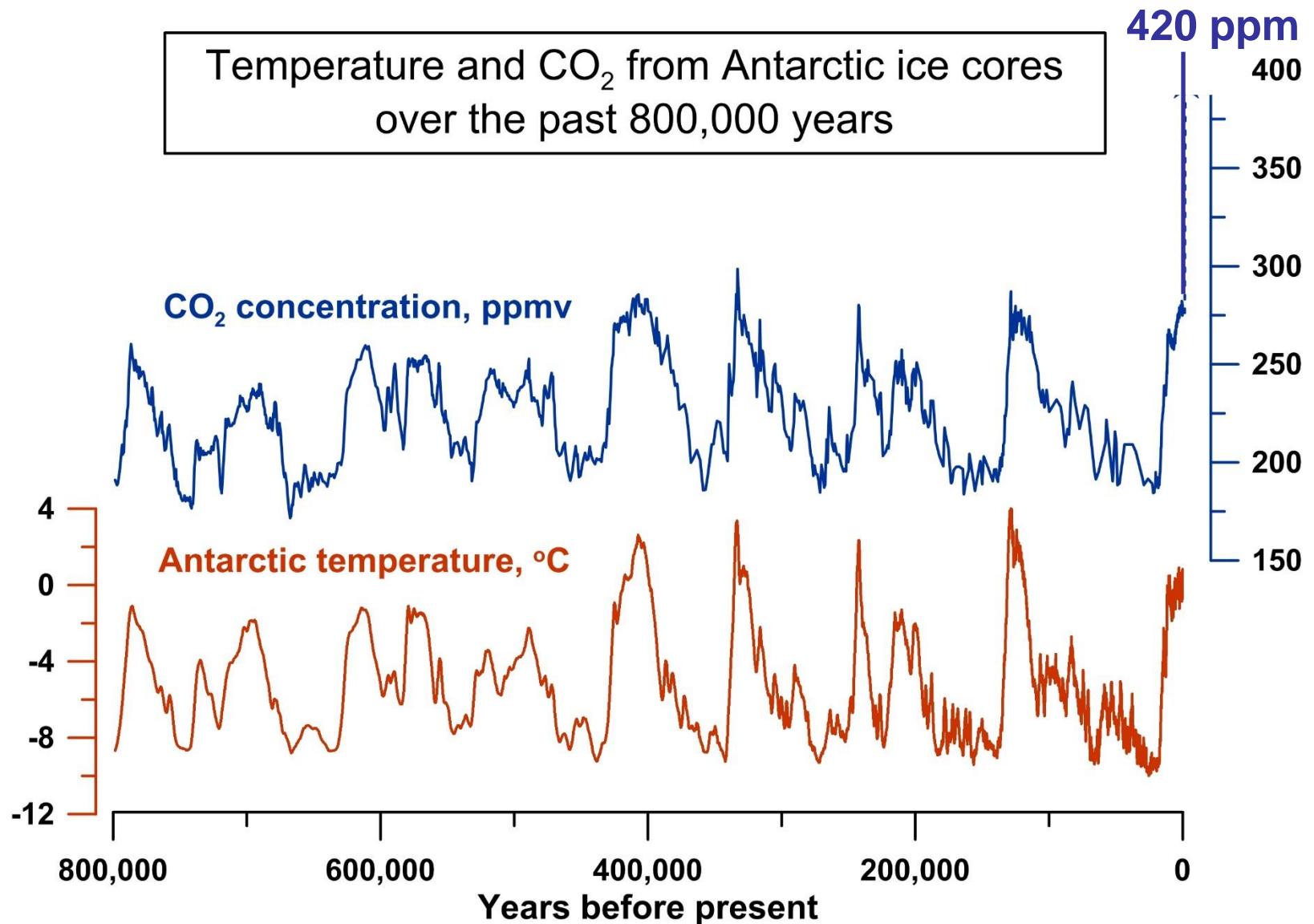
[From: Orombelli et al., 2009 QSR]

- Greenland ice cores cover Holocene and Upper Pleistocene
- EPICA Dome C (Antarctica) goes back to the Lower Pleistocene

DOME C – Summer field

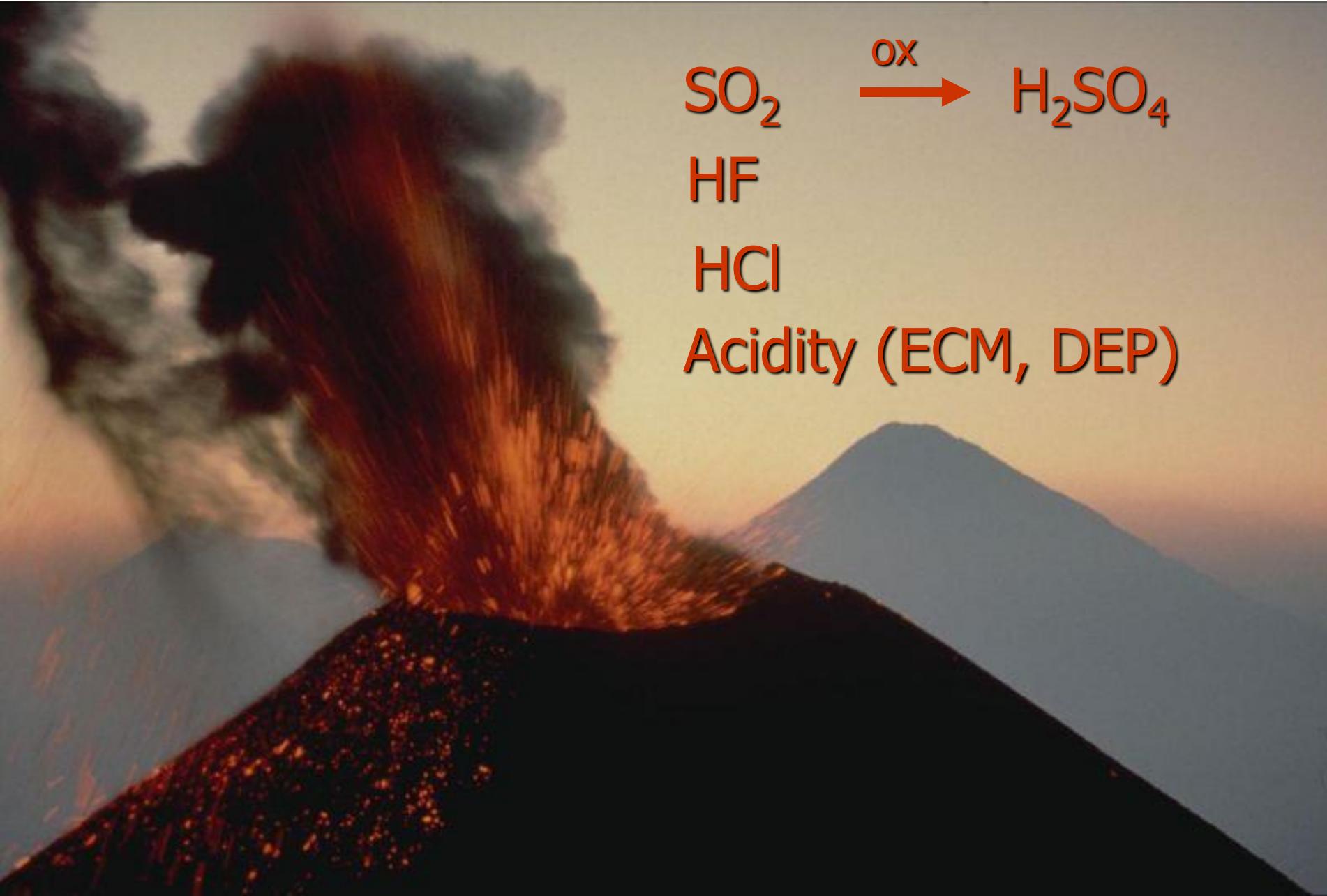


Temperature and CO₂ from Antarctic ice cores
over the past 800,000 years



The 800,000-year record of atmospheric CO₂ from the EPICA Dome C and Vostok ice cores, and a reconstruction of local Antarctic temperature based on deuterium/hydrogen ratios in the ice. The current CO₂ concentration of 392 ppmv is shown by the blue star. (data from Lüthi et al., 2008, Nature, 453, 379-382, and Jouzel et al., 2007, Science, 317, 793-797).

Ice-core markers of volcanic emissions



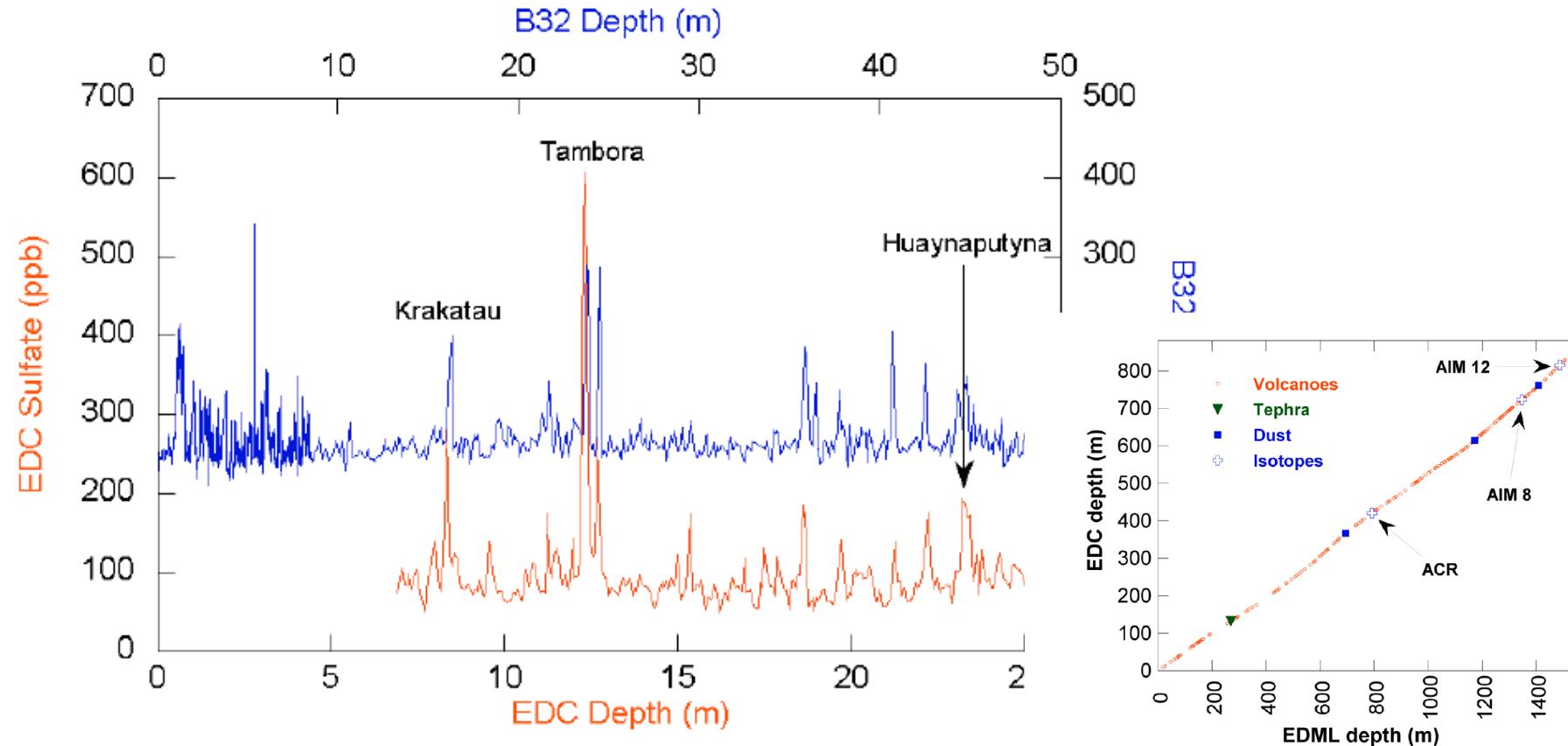
HF

HCl

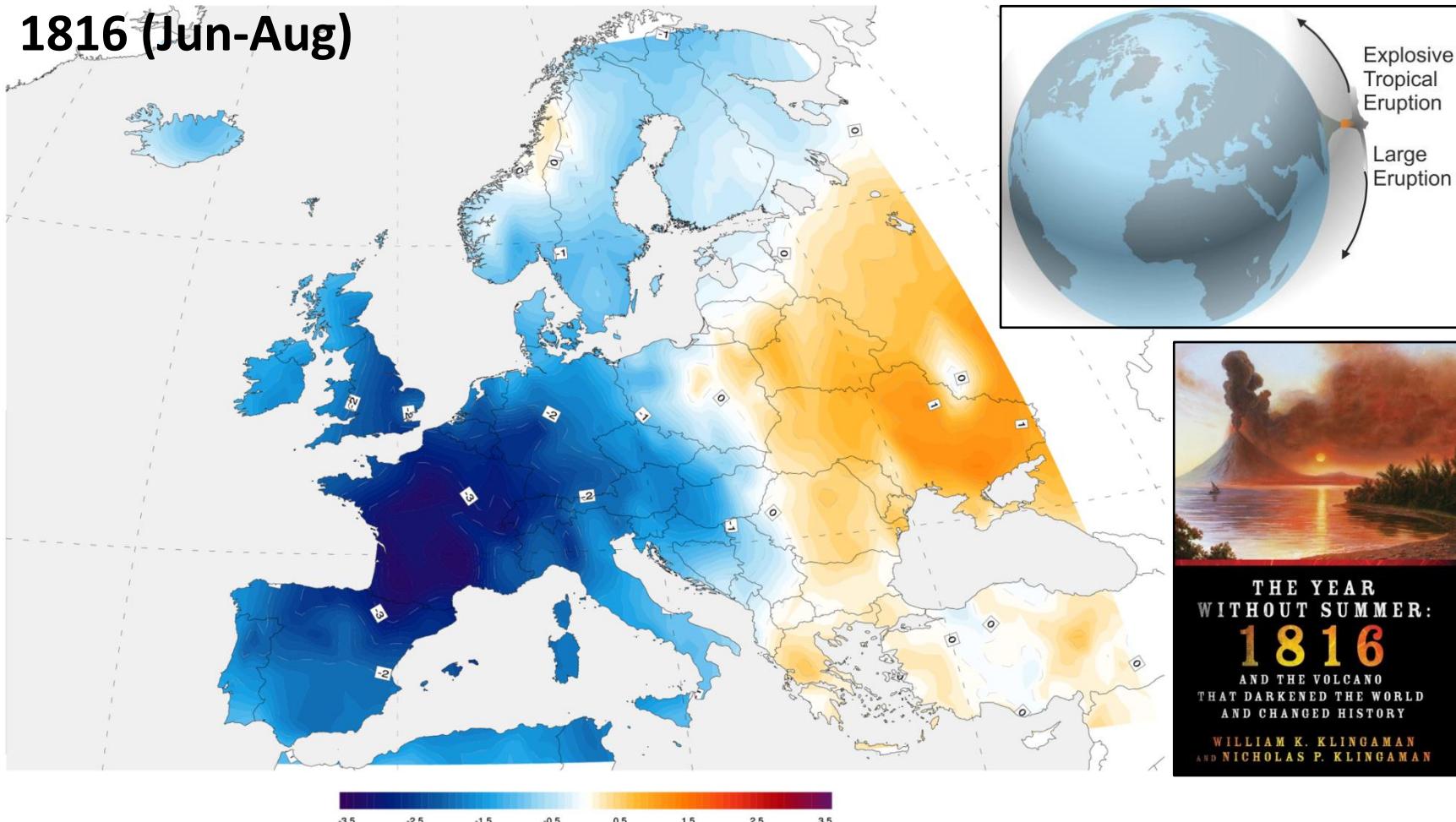
Acidity (ECM, DEP)

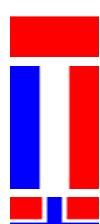
Synchronisation of the EDML and EDC ice cores for the last 52 kyr by volcanic signature matching

M. Severi¹, S. Becagli¹, E. Castellano¹, A. Morganti¹, R. Traversi¹, R. Udisti¹, U. Ruth², H. Fischer², P. Huybrechts^{2,7},
E. Wolff³, F. Parrenin⁴, P. Kaufmann⁵, F. Lambert⁵, and J. P. Steffensen⁶

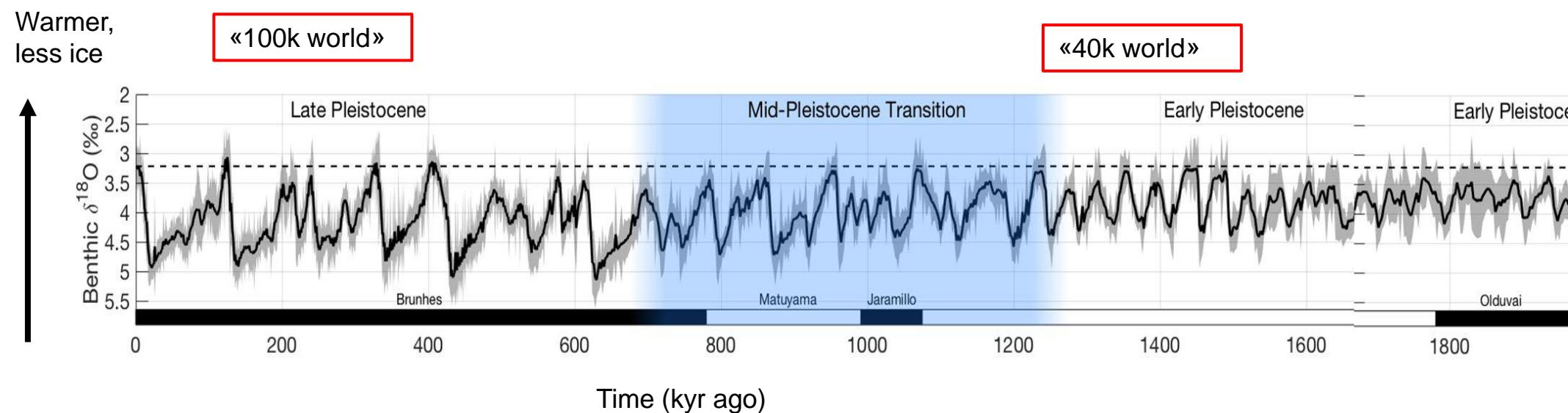


...the “Year without a Summer”



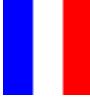
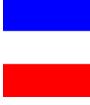


The MPT in Proxy Archives



Climate evolution over the past 3.4 Ma recorded in the oxygen isotope compositions of benthic foraminifera shells [data from Lisiecki and Raymo, 2005]

Berends et al. (2021)

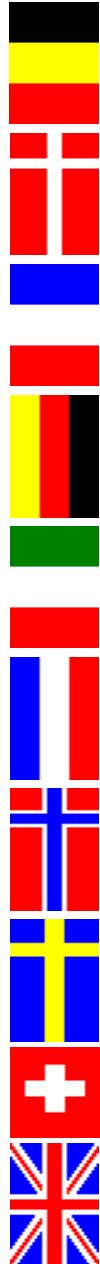


Underlying Science

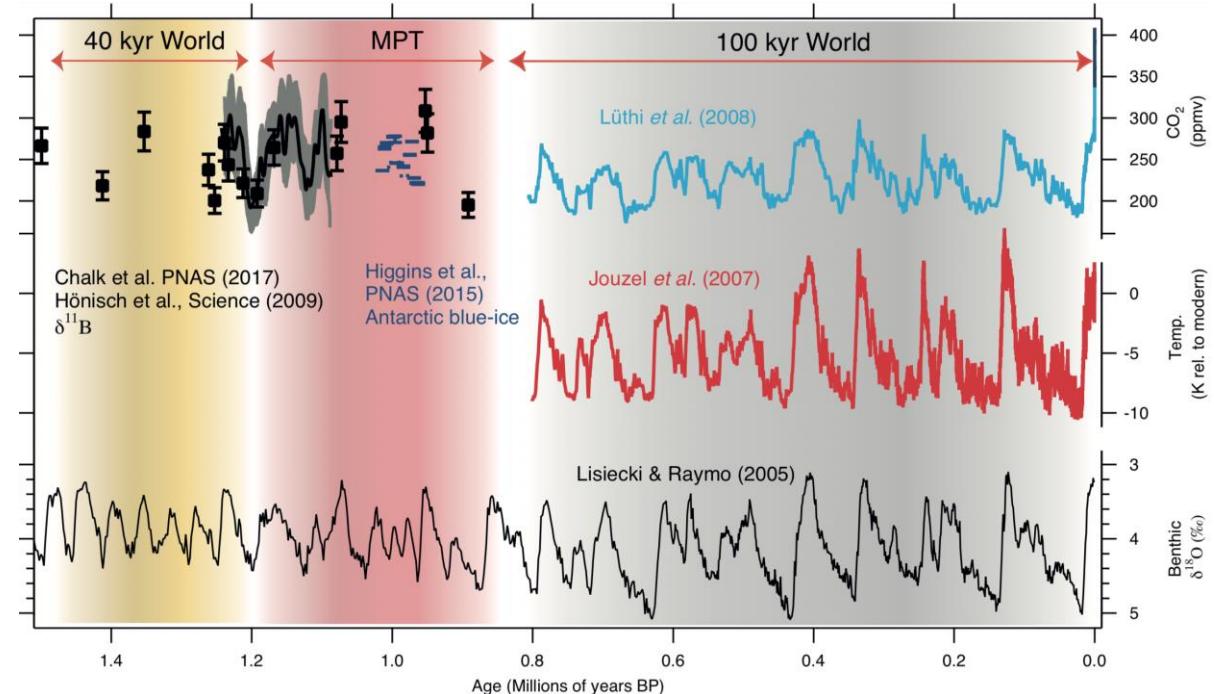
- Se non capiamo cosa sta alla base della transizione da cicli di 40 kyr a cicli di 100 kyr, non possiamo comprendere fino in fondo il clima attuale
- Perchè si è verificata la Mid-Pleistocene Transition (MPT) intorno a 900 kyr fa?
- Perchè viviamo in un mondo fatto di cicli della durata di 100 kyr?

Le carote di ghiaccio possono darci queste risposte!

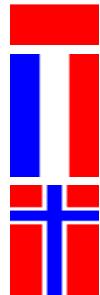




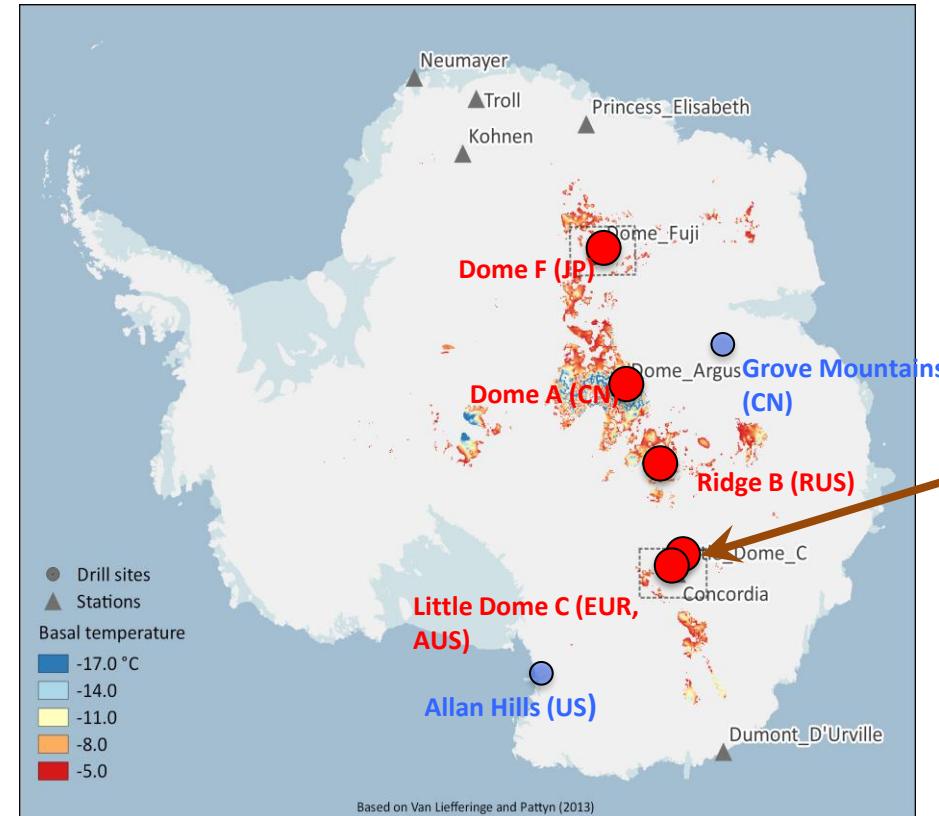
Climate and CO₂ records over the last 1.5 Myr



Marine sediment records (bottom, black line) provide the combined sea level and deep sea temperature record over many million years back in time. Existing ice core record of Antarctic temperature (middle, red line) and atmospheric CO₂ (top, light blue line) going back only 800 kyr. Selected marine and blue-ice proxy records provide time slices of CO₂ at low resolution and precision, but no full continuous record (top left).



Where to find such old stratified ice ?





Grazie per l'attenzione!

