

# Osservazioni di stato e tendenza del sistema climatico terrestre

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**La scienza è fatta di dati come una casa di pietre.**

**Ma un ammasso di dati non è scienza più di quanto un mucchio di pietre sia una casa.**

*-Henri Poincaré-*



**definizioni e impostazione del problema;**



**evidenze della tendenza climatica;**



**problemi;**

# CLIMA E TEMPO METEOROLOGICO

**diversa scala temporale**

**diversità di metodo, dati e formulazioni teoriche**

***tempo meteorologico stato di un sottosistema (in particolare dell'atmosfera) ad un preciso istante.***

***clima stato medio del sistema e sue variazioni nel tempo.***

definizione dello stato e delle sue variazioni  
**monitoraggio**            **indicatori**

previsioni sull'evoluzione del sistema  
**modelli**                    **parametrizzazioni**

**temperatura dell'aria**

**altezza del mare**

**precipitazione, vegetazione, insolazione,  
estensione dei ghiacci, ....**

## temperatura dell'aria ( $h=2\text{ m}$ )

termometri (tempi recenti < 200 anni):

- termometri a mercurio

- termometri a stato solido (termistori)

proxy data (paleoclima):

- anelli di accrescimento degli alberi

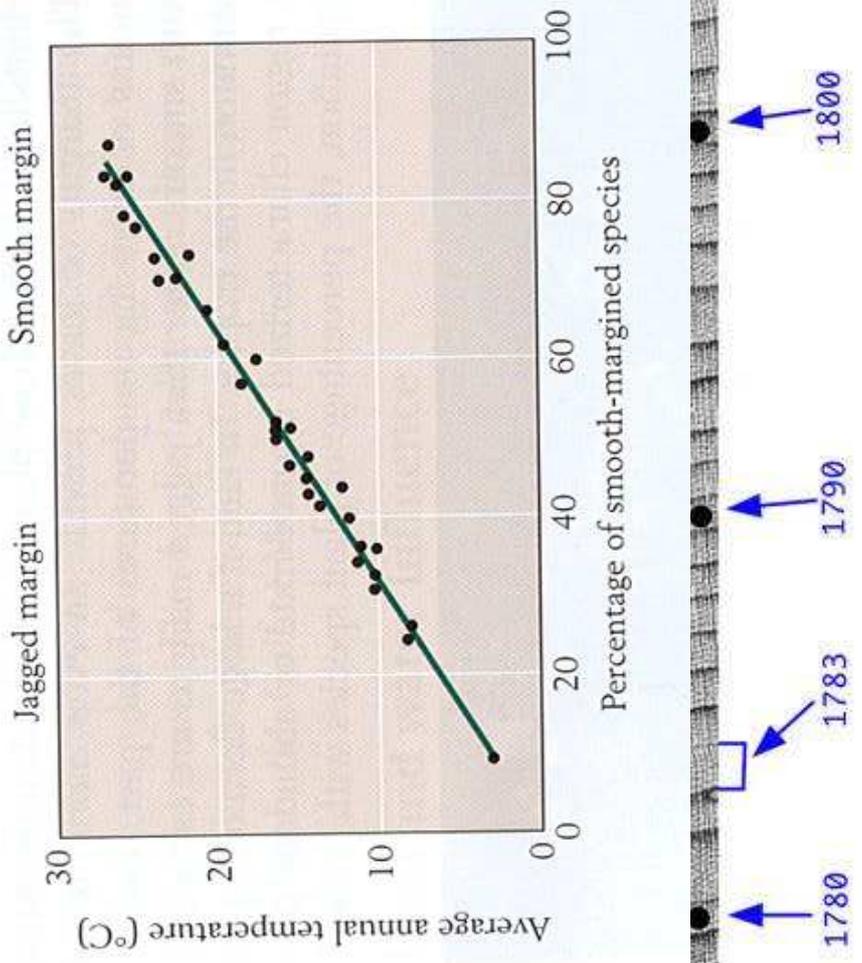
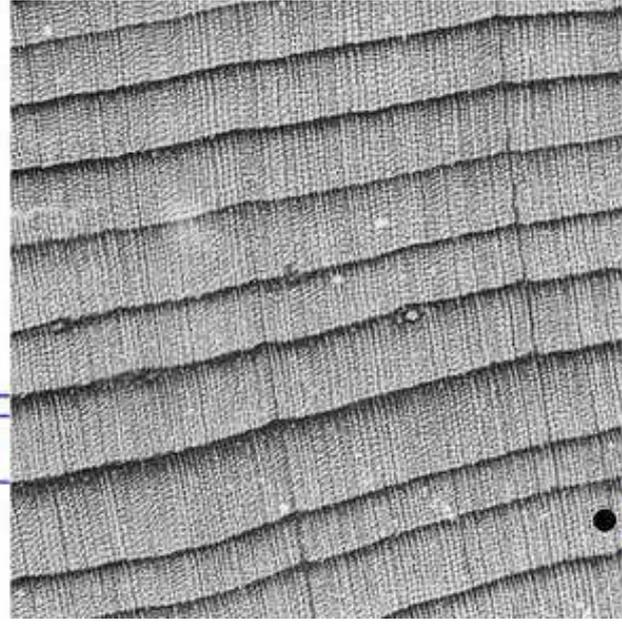
- forma delle foglie

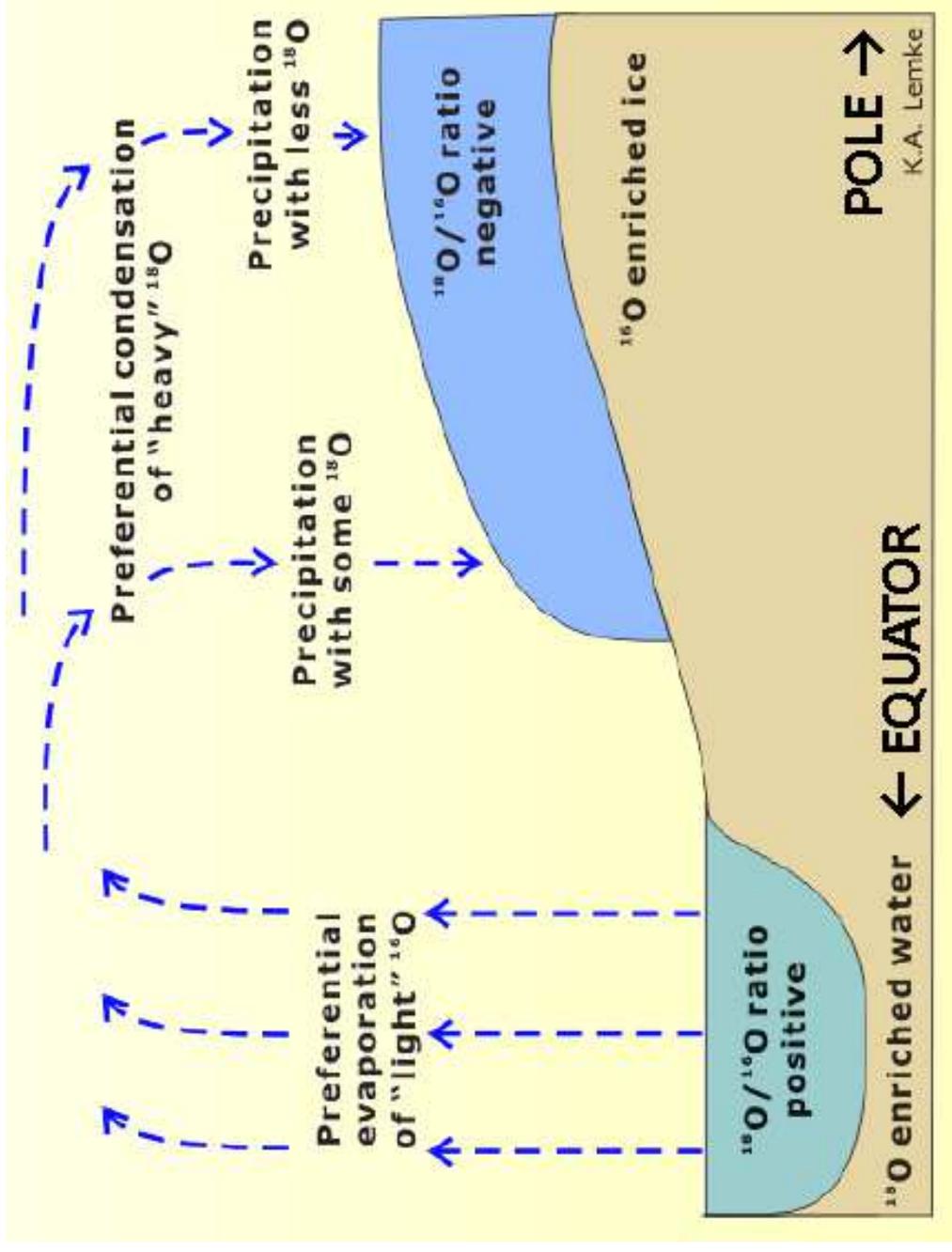
- $O^{16}/O^{18}$

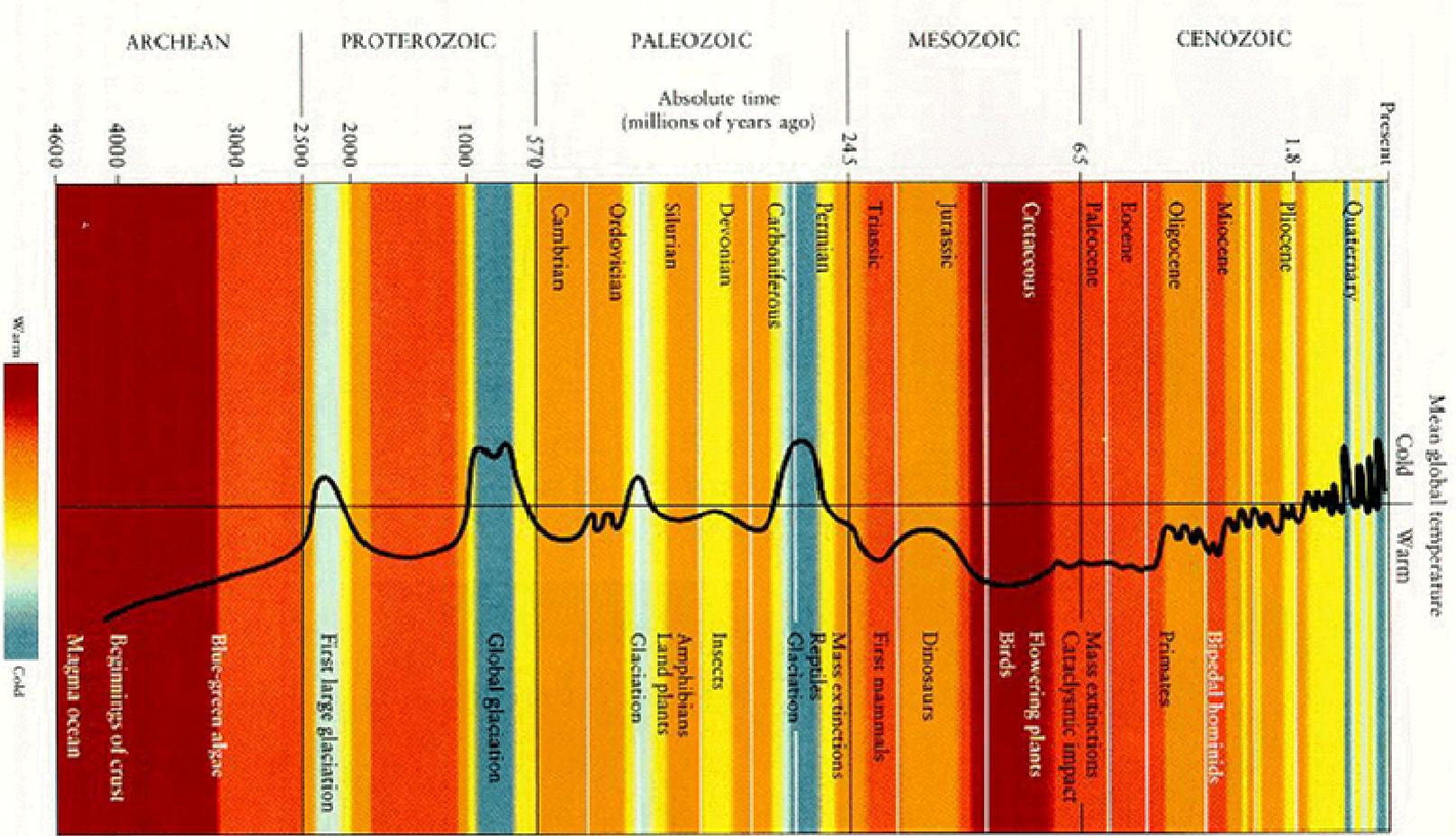
- cronache storiche



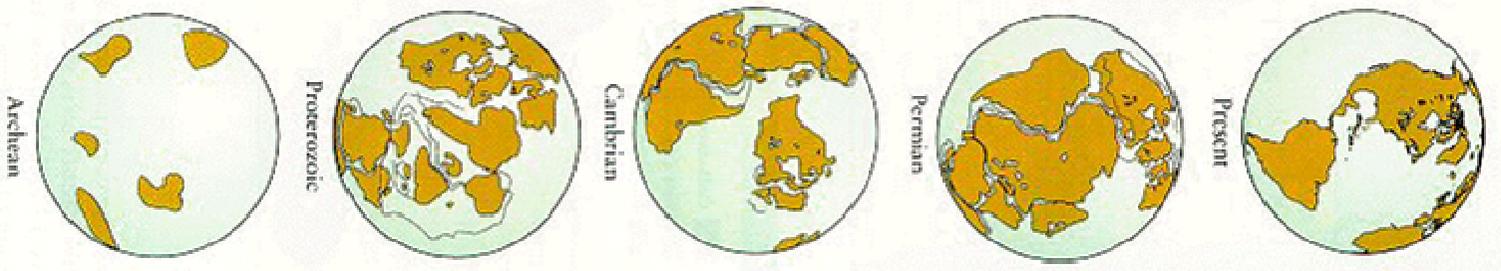
earlywood + latewood = annual



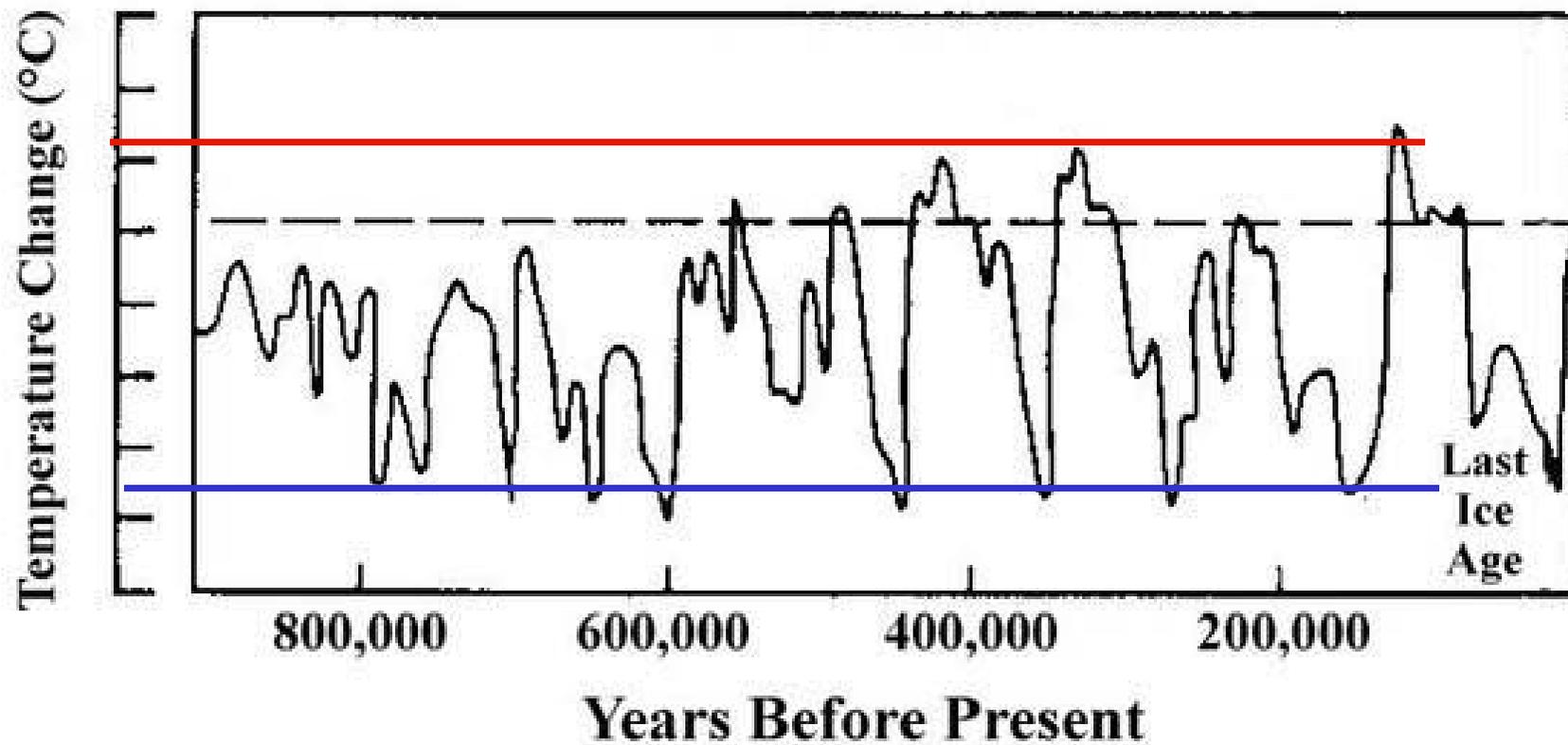




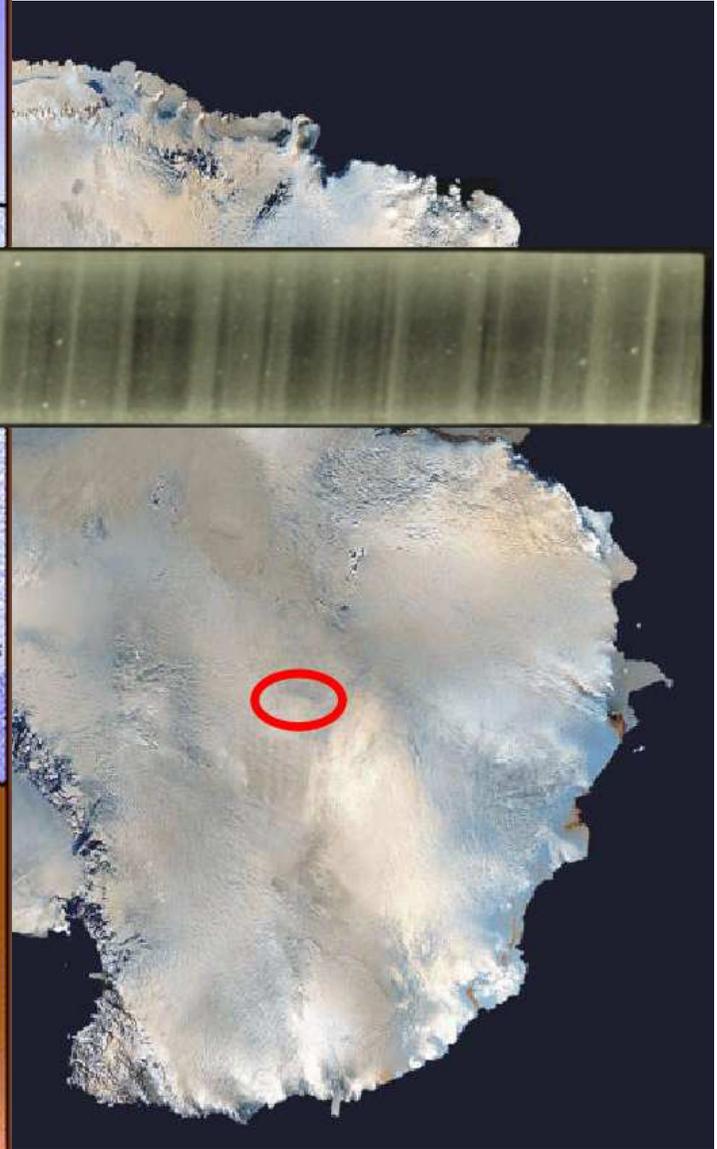
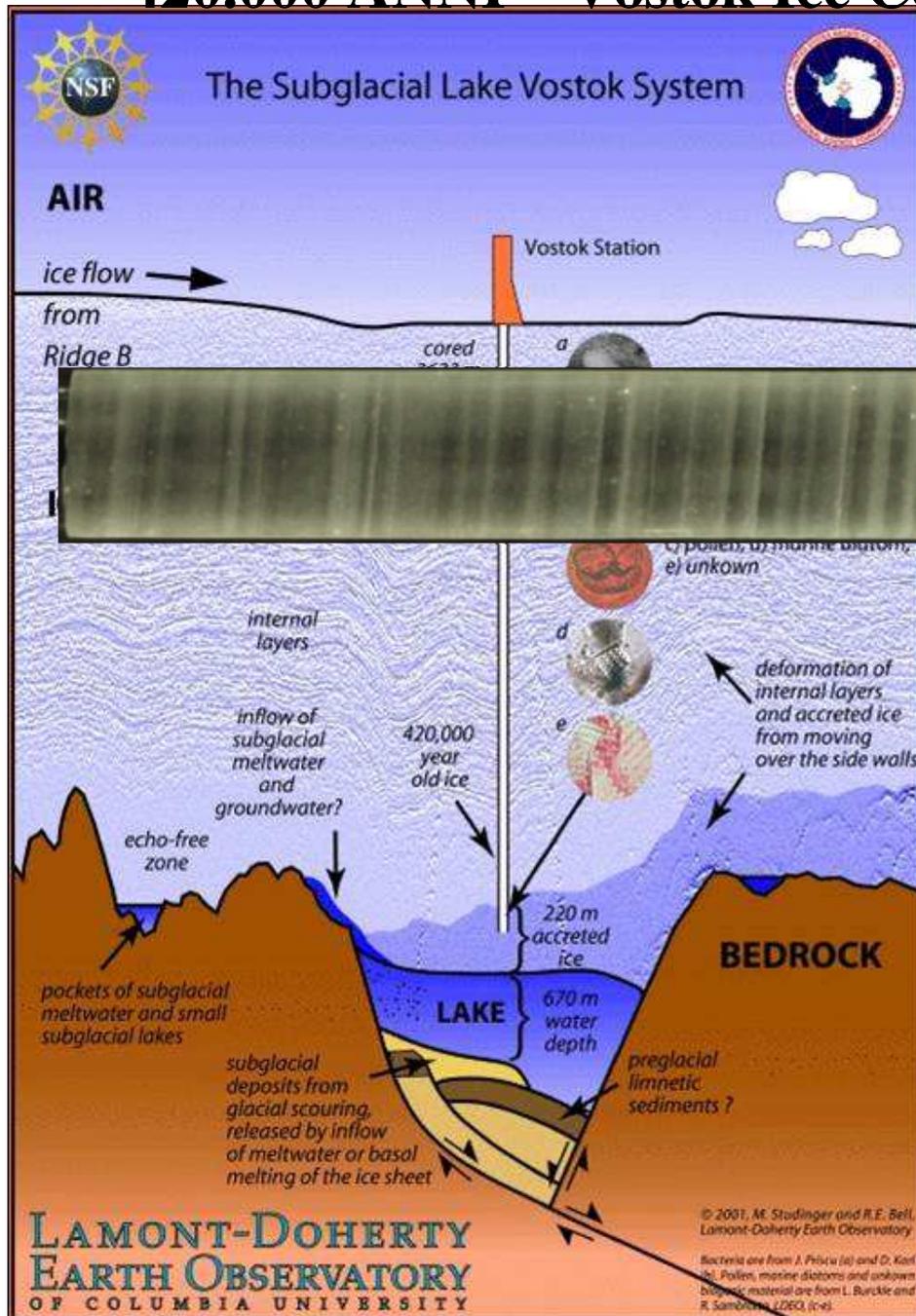
# 4.5 MILIARDI



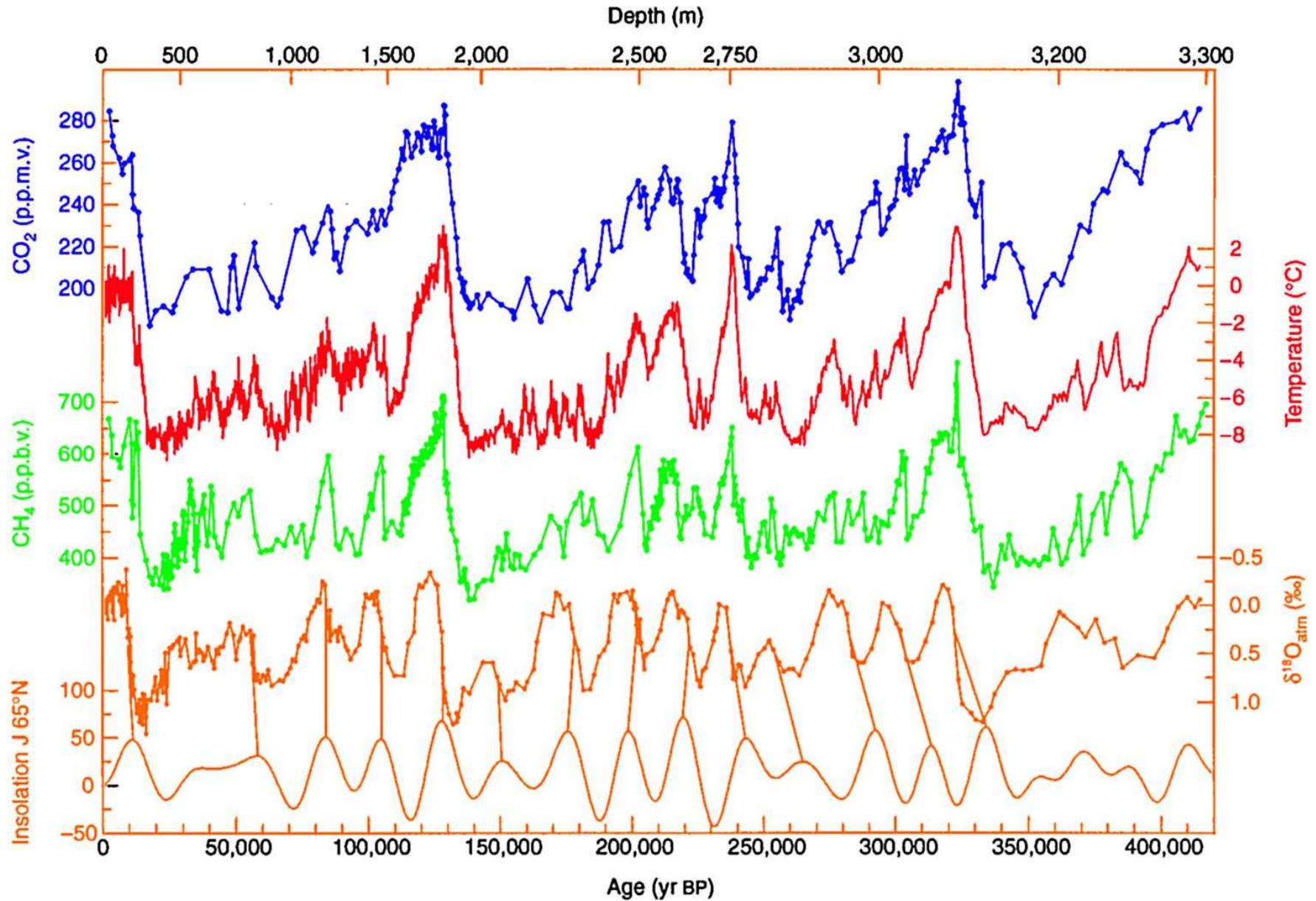
# 1 MILIONE DI ANNI



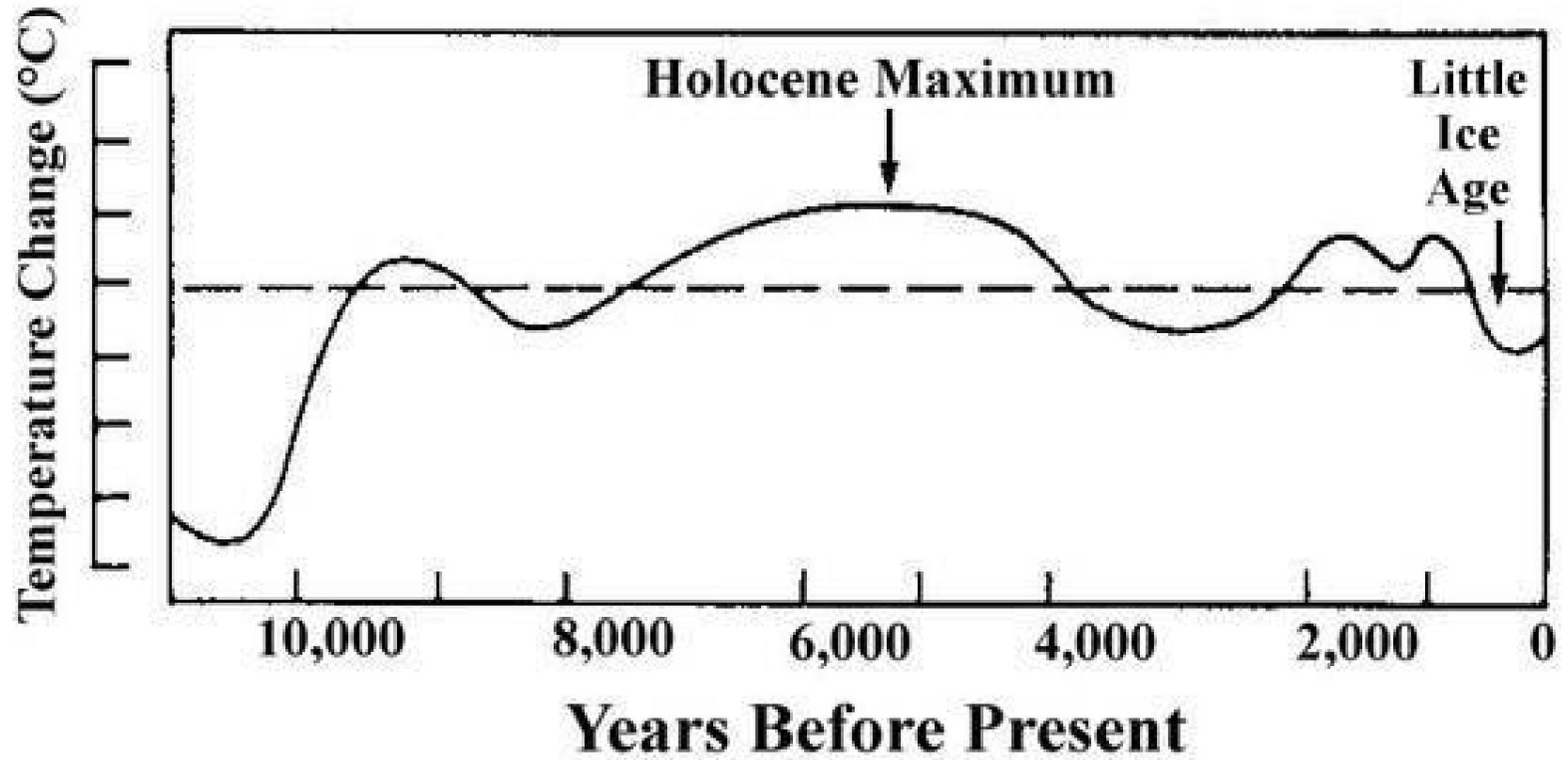
# 420,000 ANNI – Vostok Ice Core



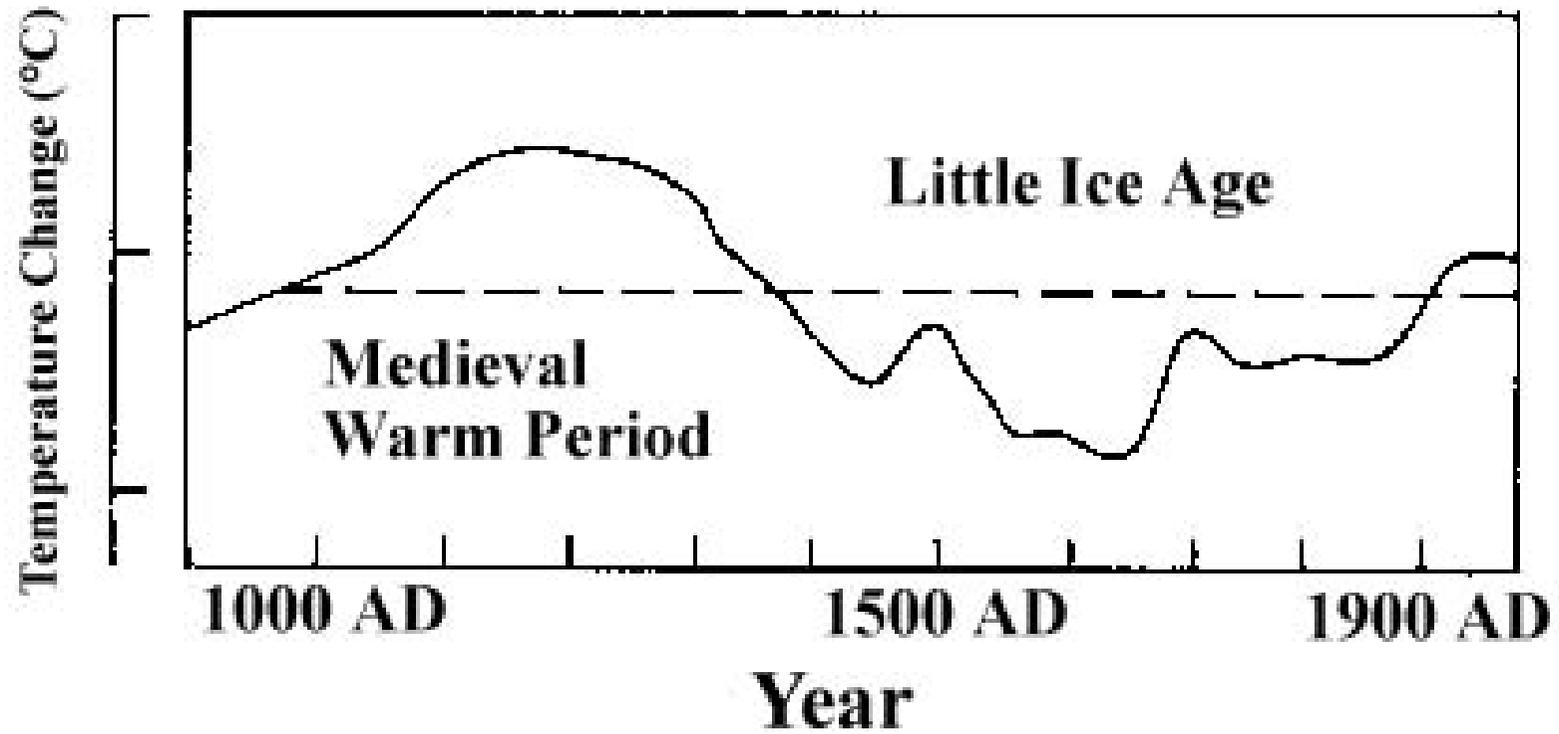
# 420.000 ANNI – Vostok Ice Core



# 10.000 ANNI

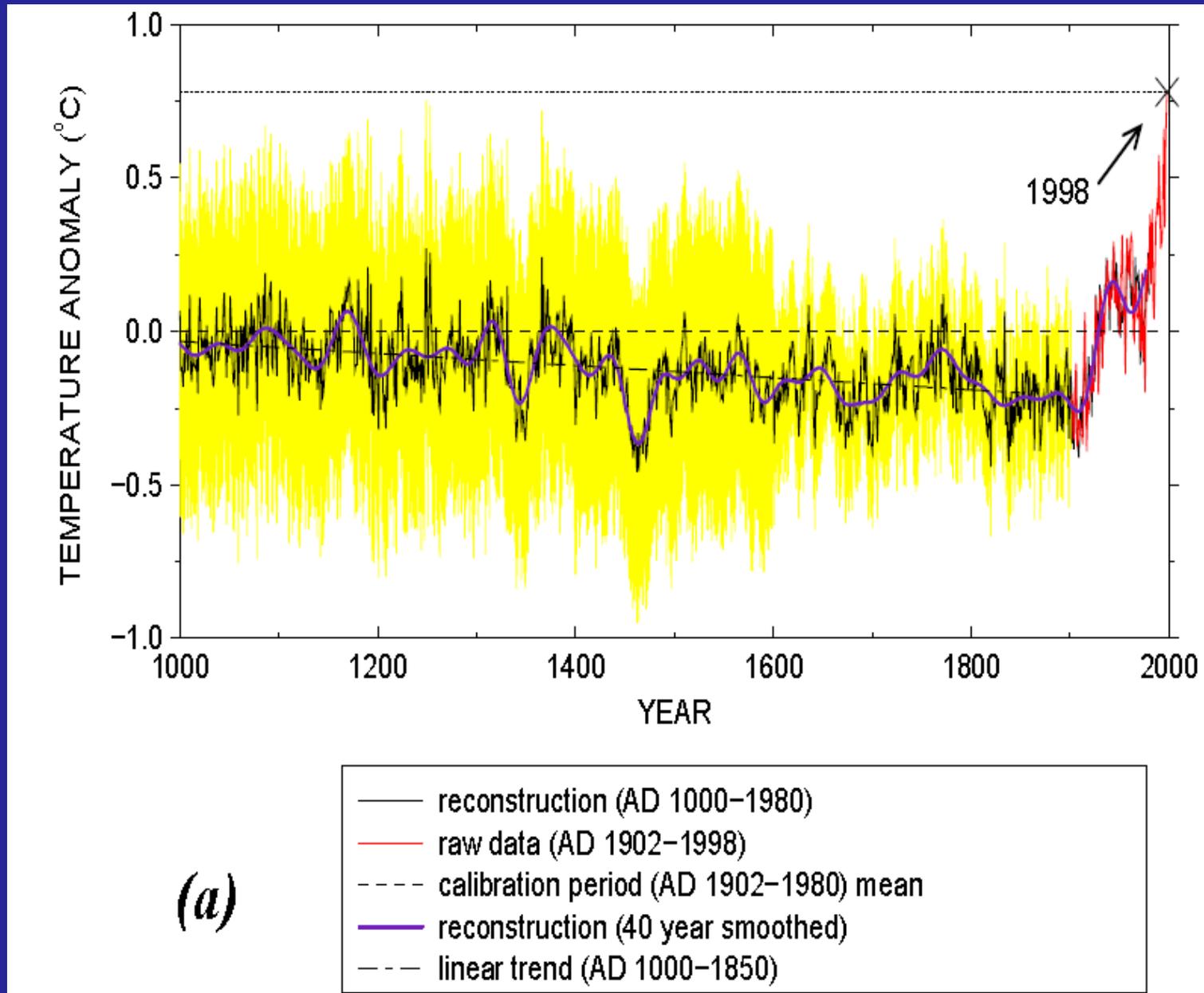


# 1.000 ANNI



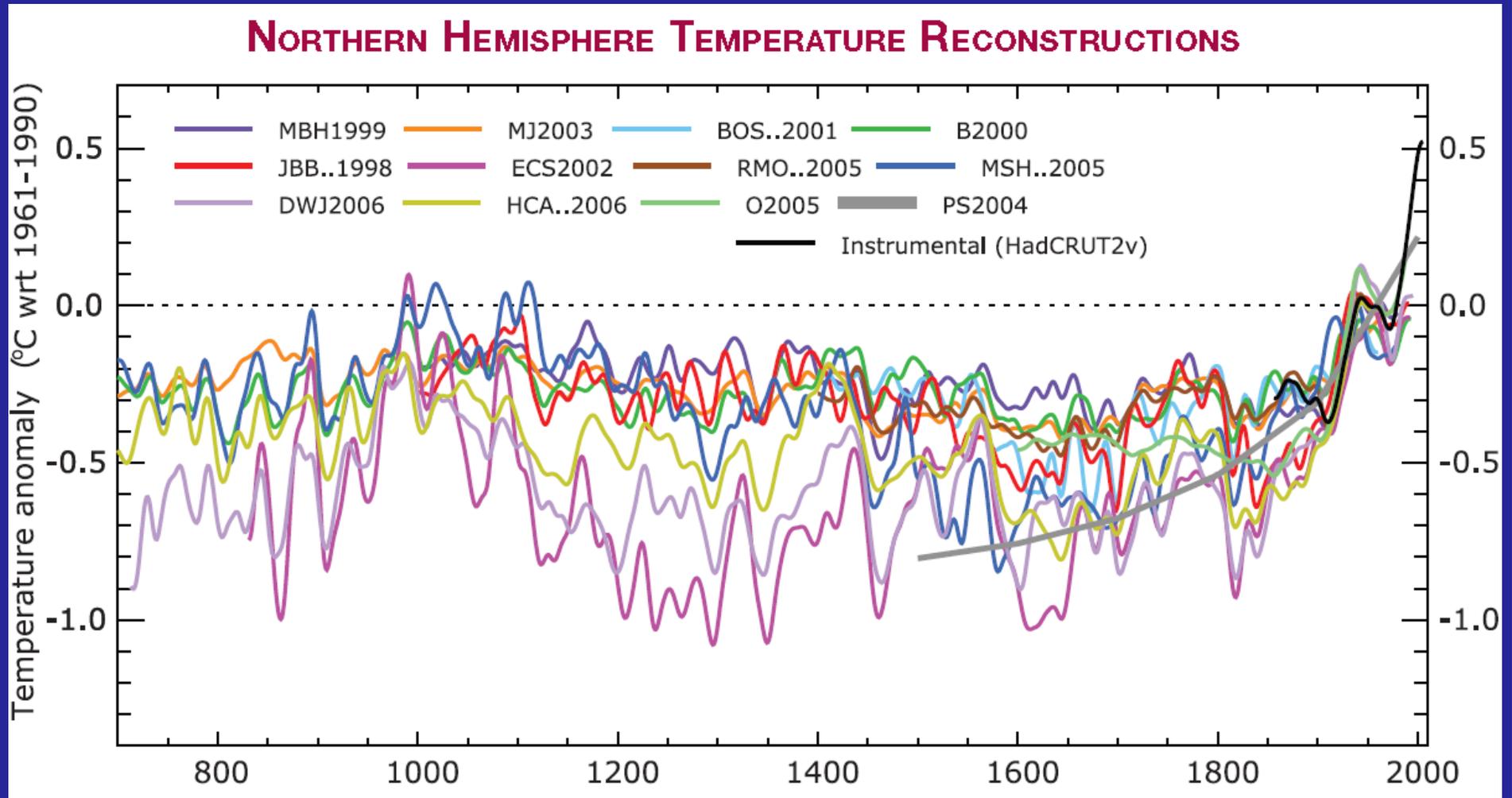
# osservazione delle tendenze I

*hockey stick (Mann, Bradley, Hughes, JGR, 1999)*



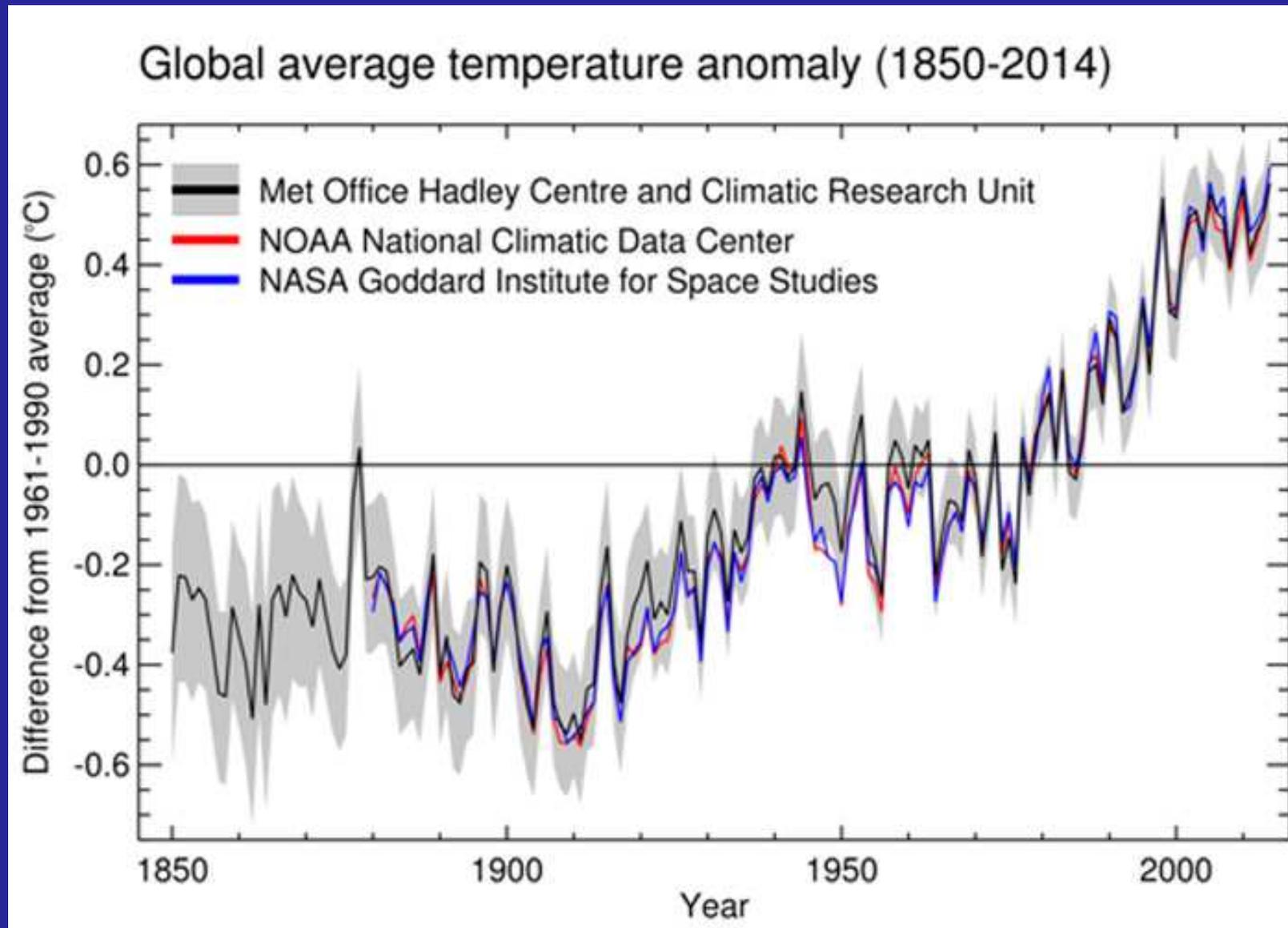
## osservazione delle tendenze II

*stime della temperatura media dell'emisfero nord*



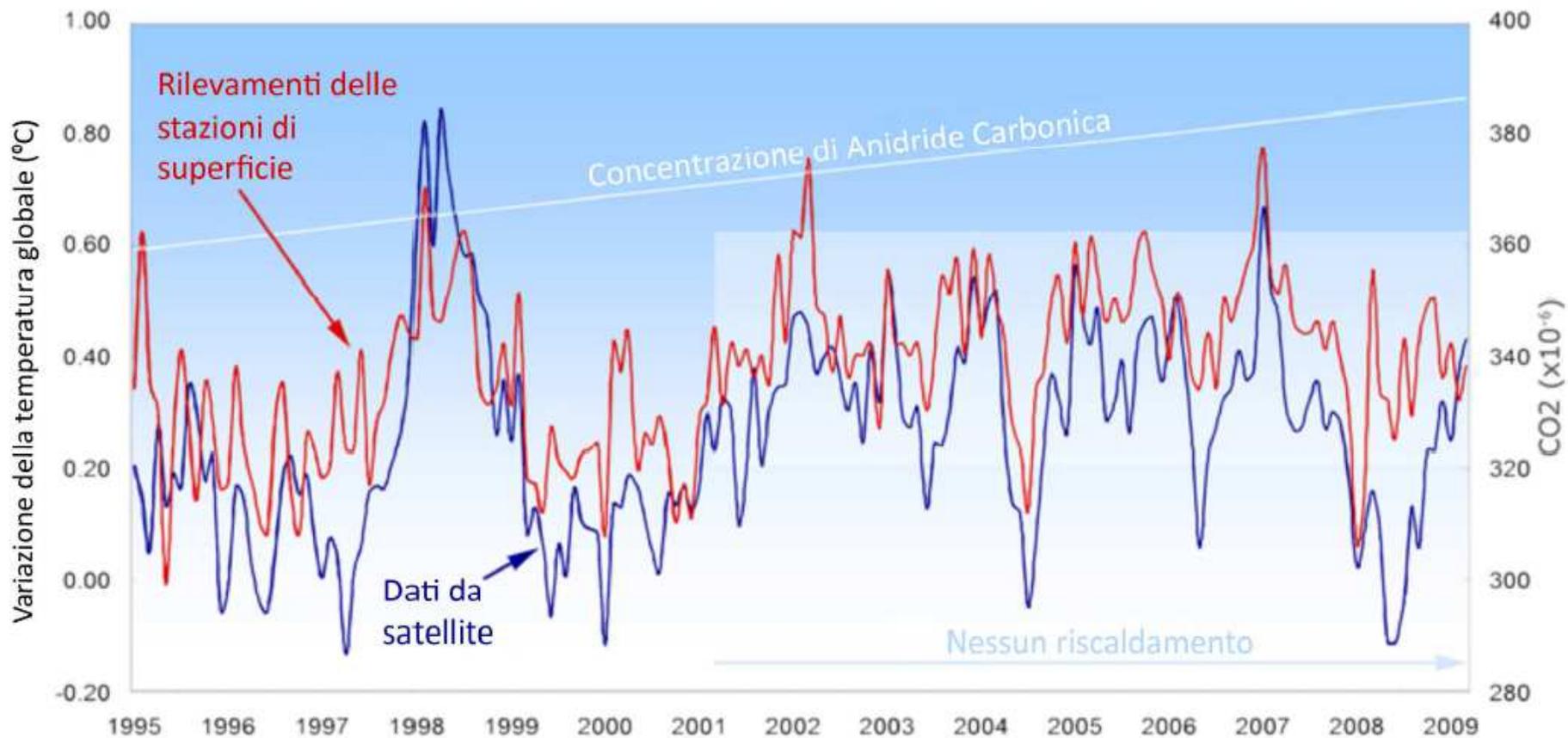
# osservazione delle tendenze III

*ultimi anni*



# osservazione delle tendenze III

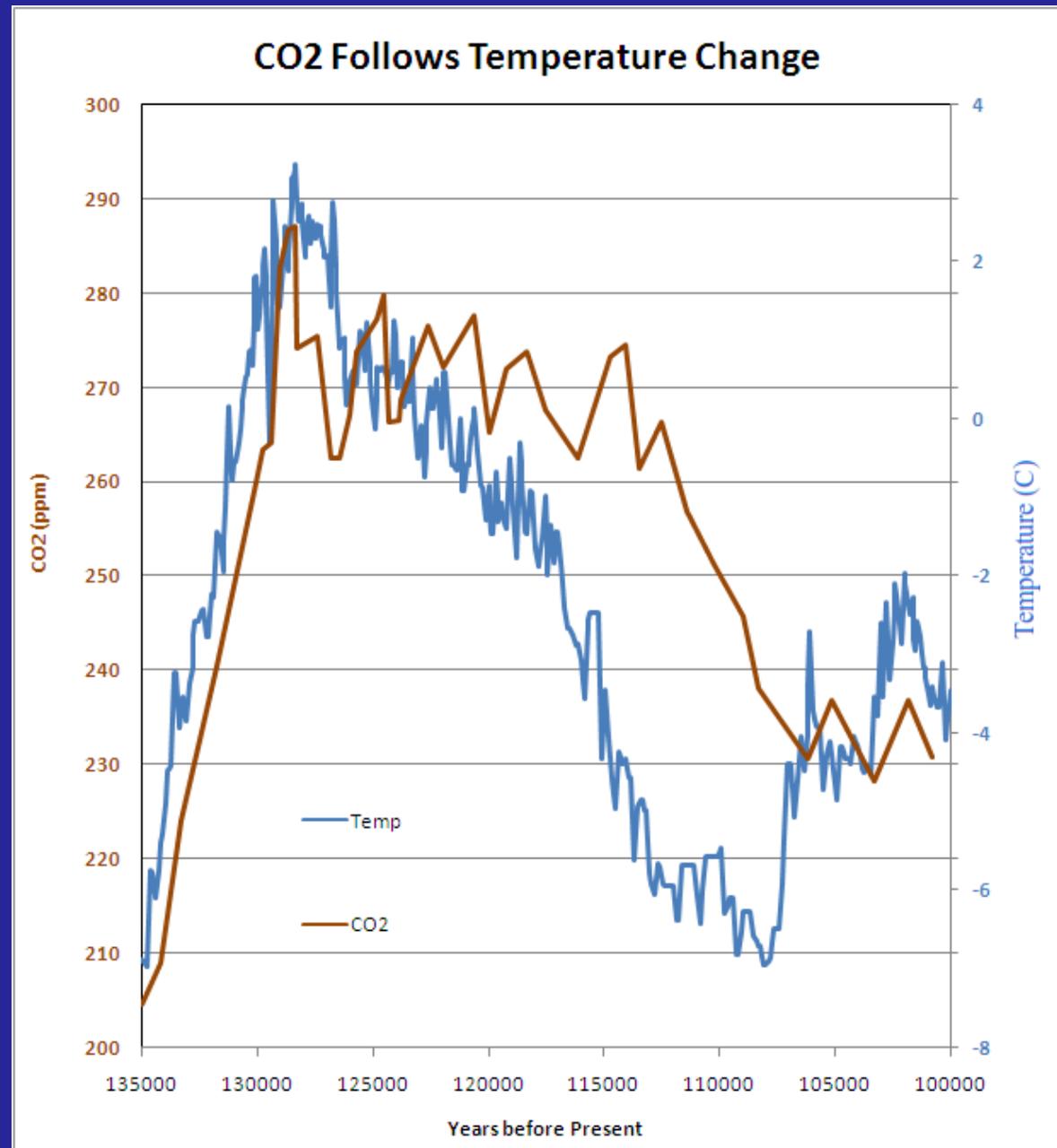
*ultimi anni*



## osservazione delle tendenze IV

*relazione GHG/ $\Delta T$*

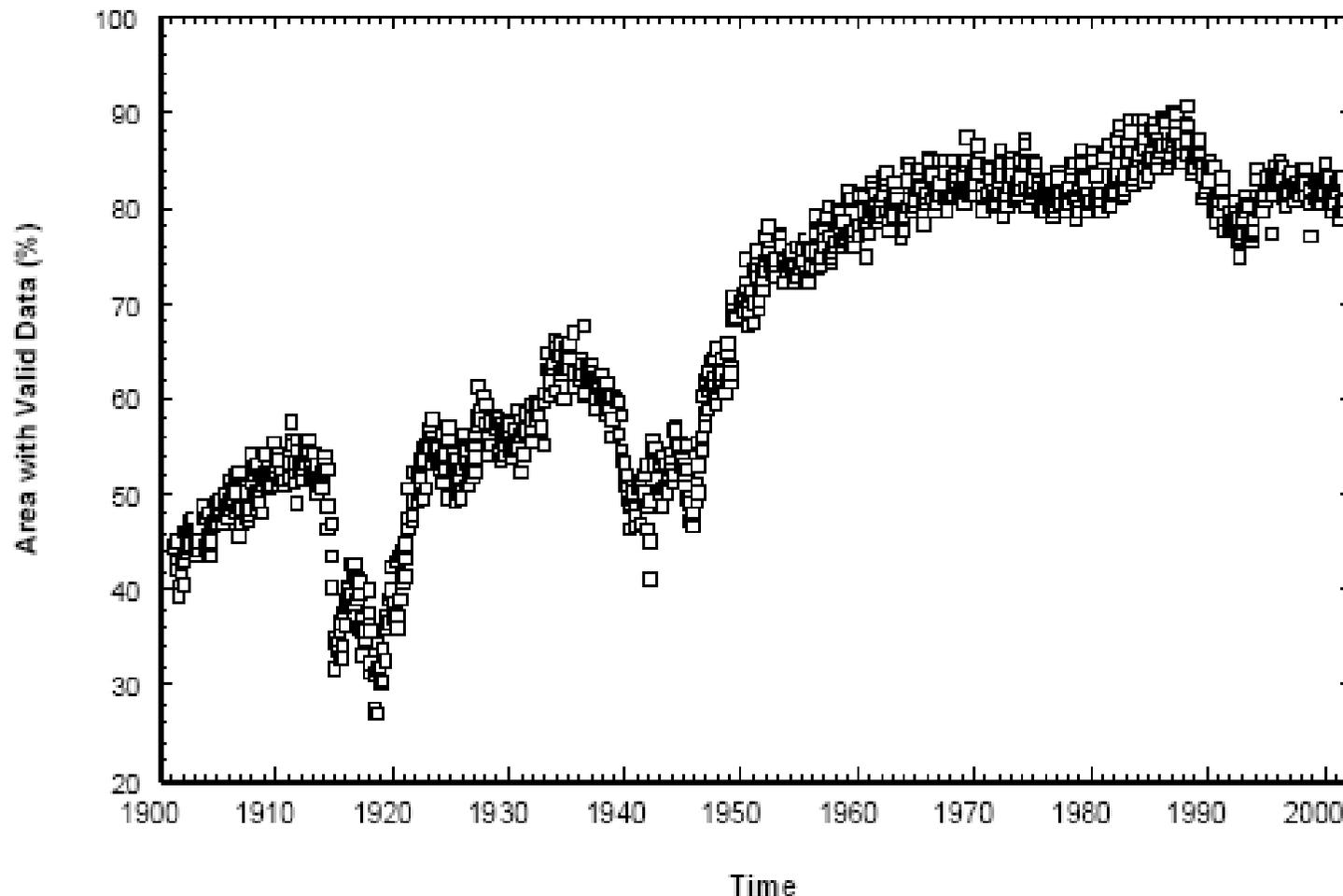
*le variazioni di contenuto di  $CO_2$  seguono di circa 800 anni le variazioni della temperatura*



*Mudelsee, 2001*

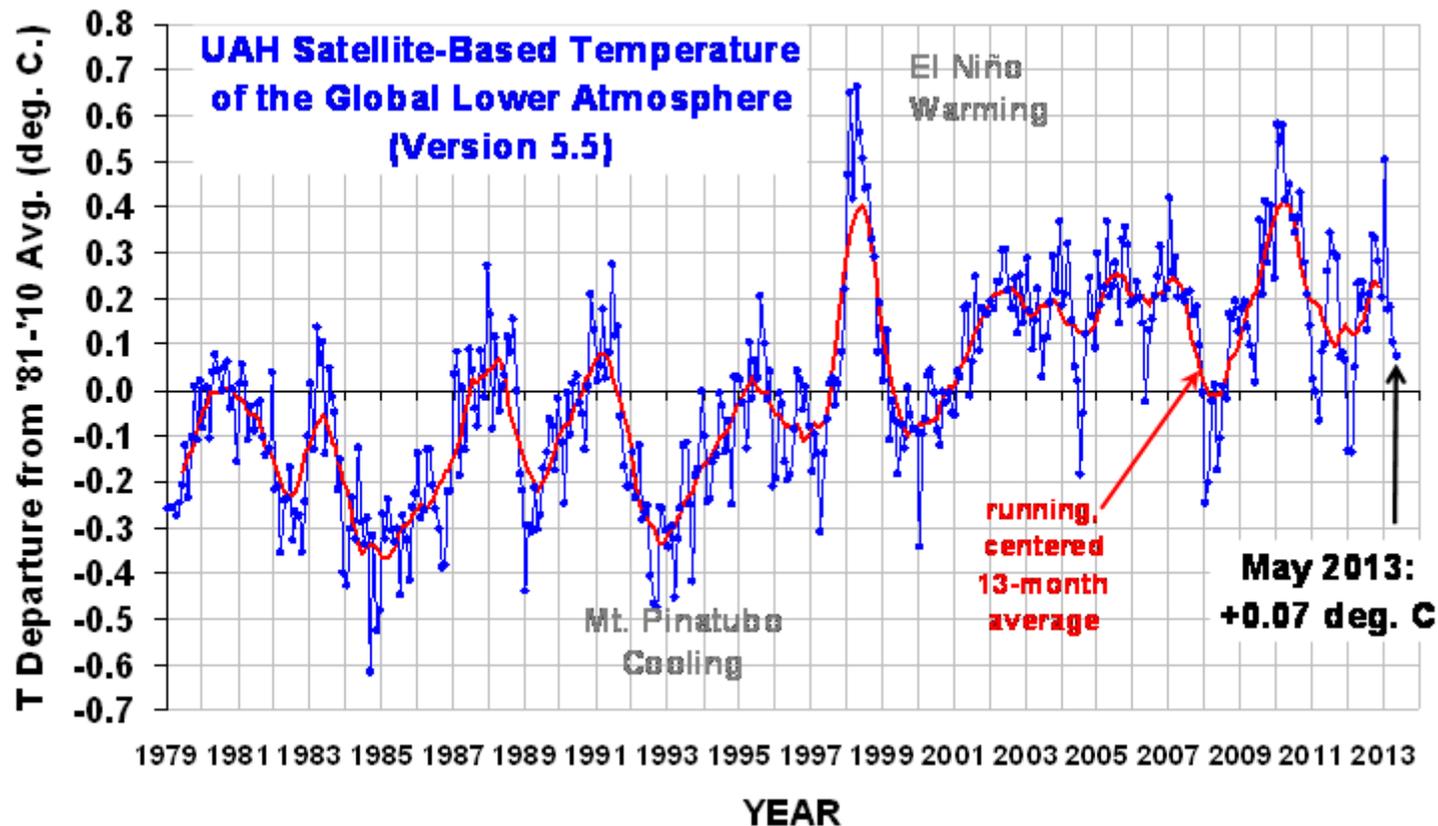
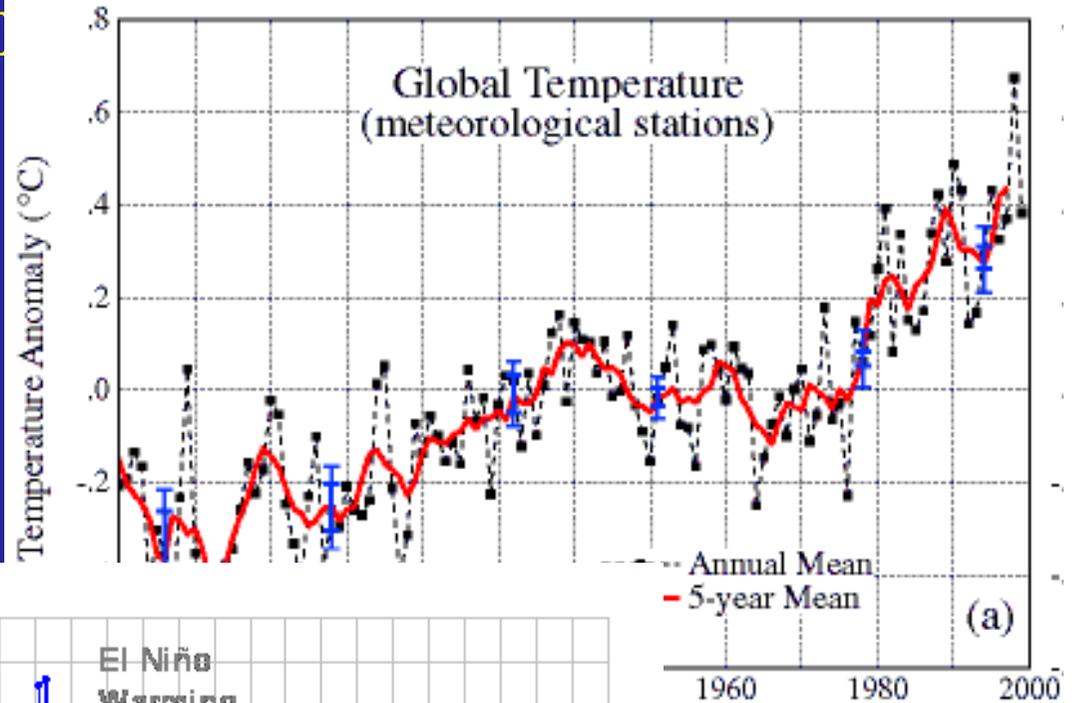
**osservazione delle tendenze V**  
*copertura globale dei sensori*

**la frazione di superficie globale monitorata varia**  
 **$5^\circ \times 5^\circ \sim 550 \times 400 \text{ km}^2$**



**osservazione delle tendenze VI**  
*osservazioni dallo spazio*

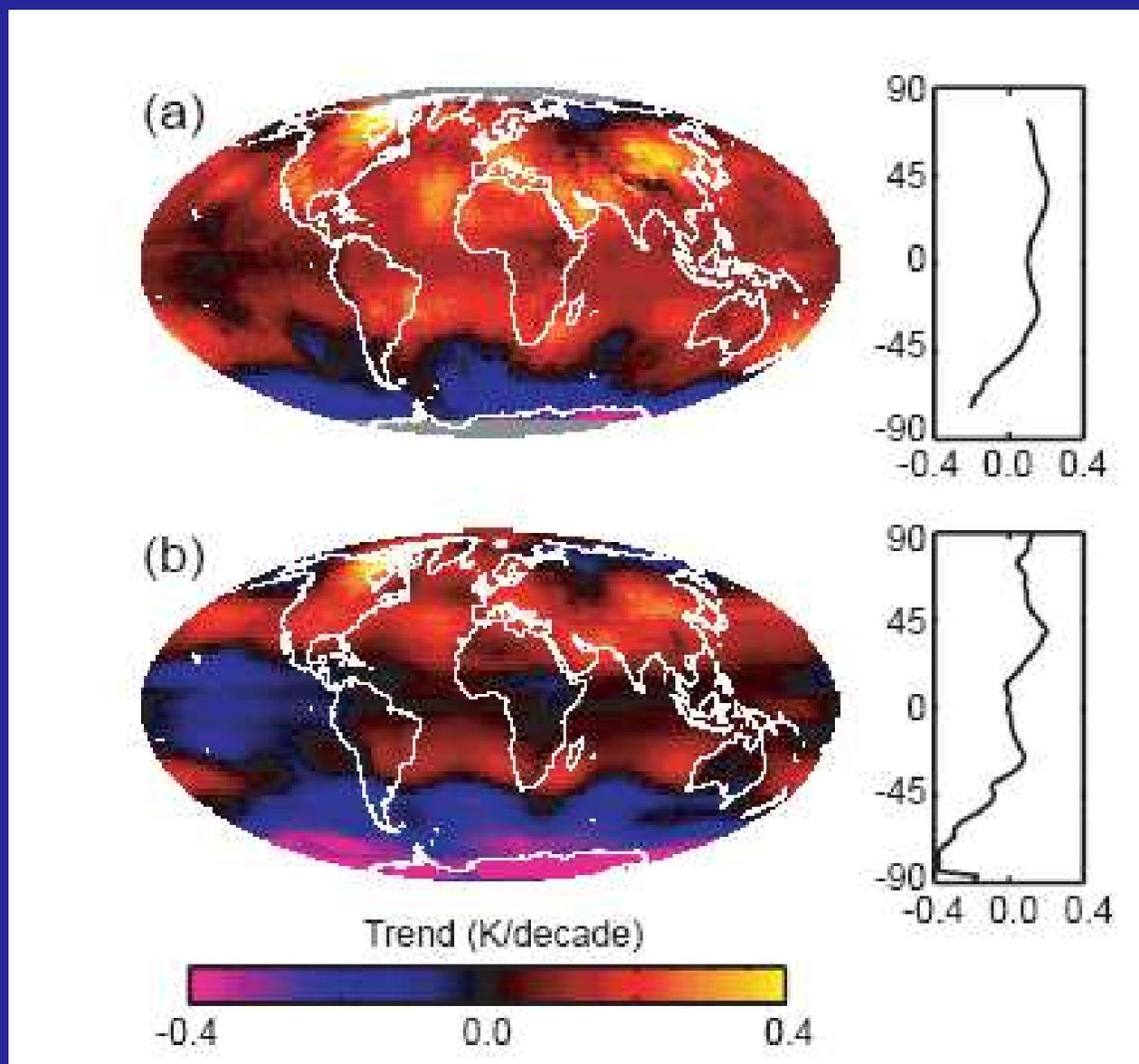
0,2 K/decade ←



0,09 K/decade ←

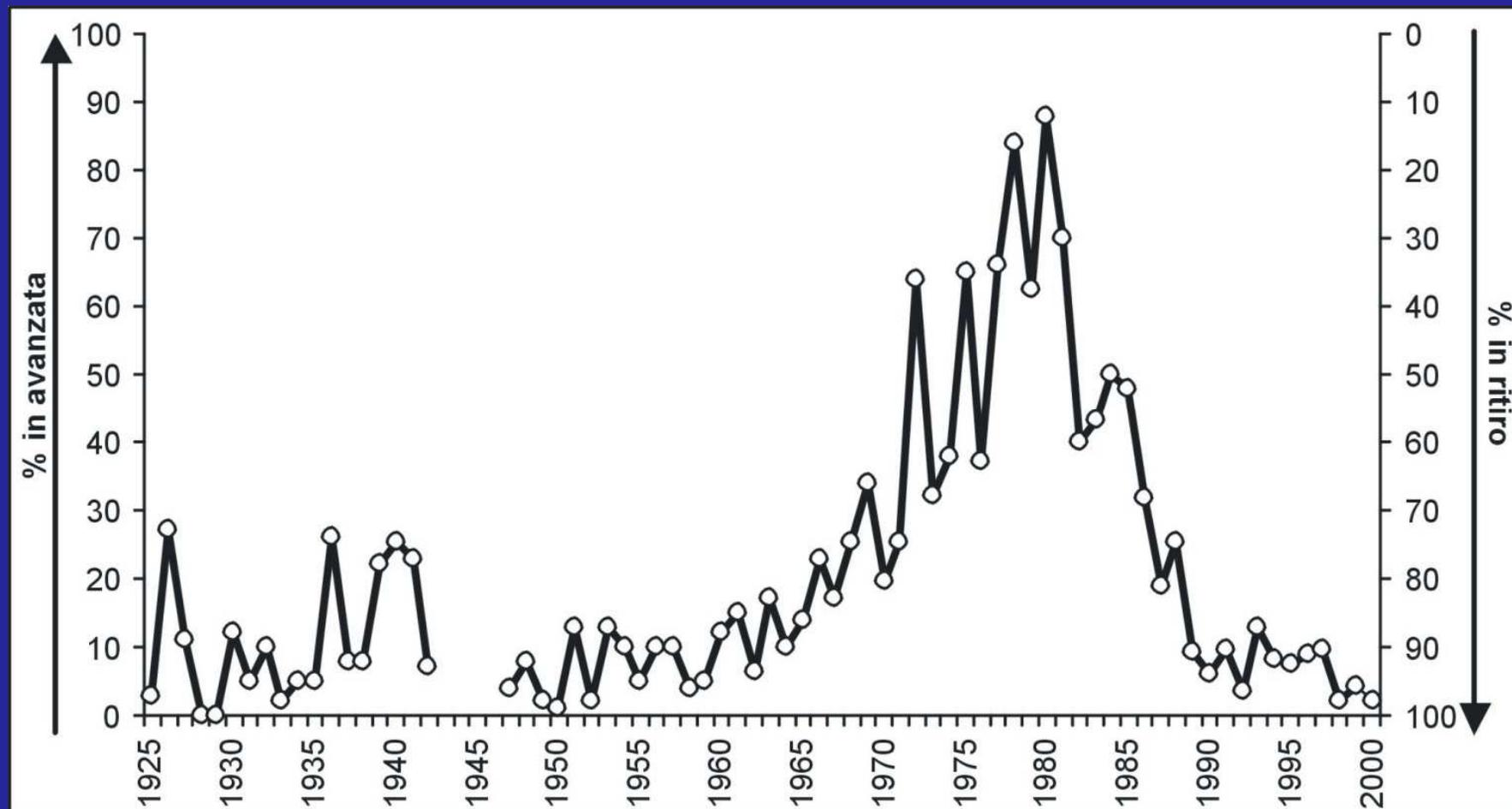
# osservazione delle tendenze VIII

## *Microwave Sounding Unit (MSU)*



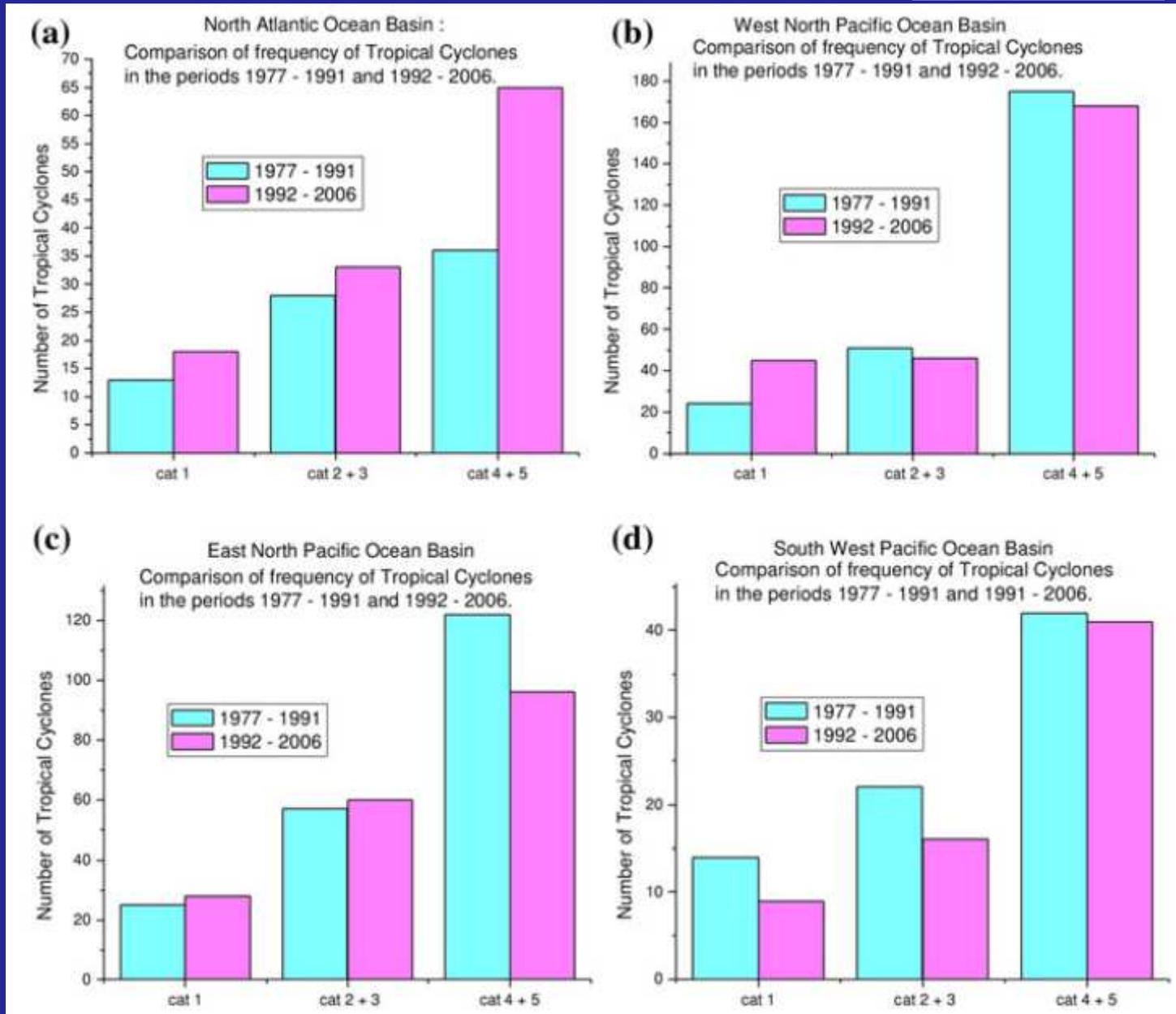
# osservazione delle tendenze IX

*ritiro dei ghiacciai*



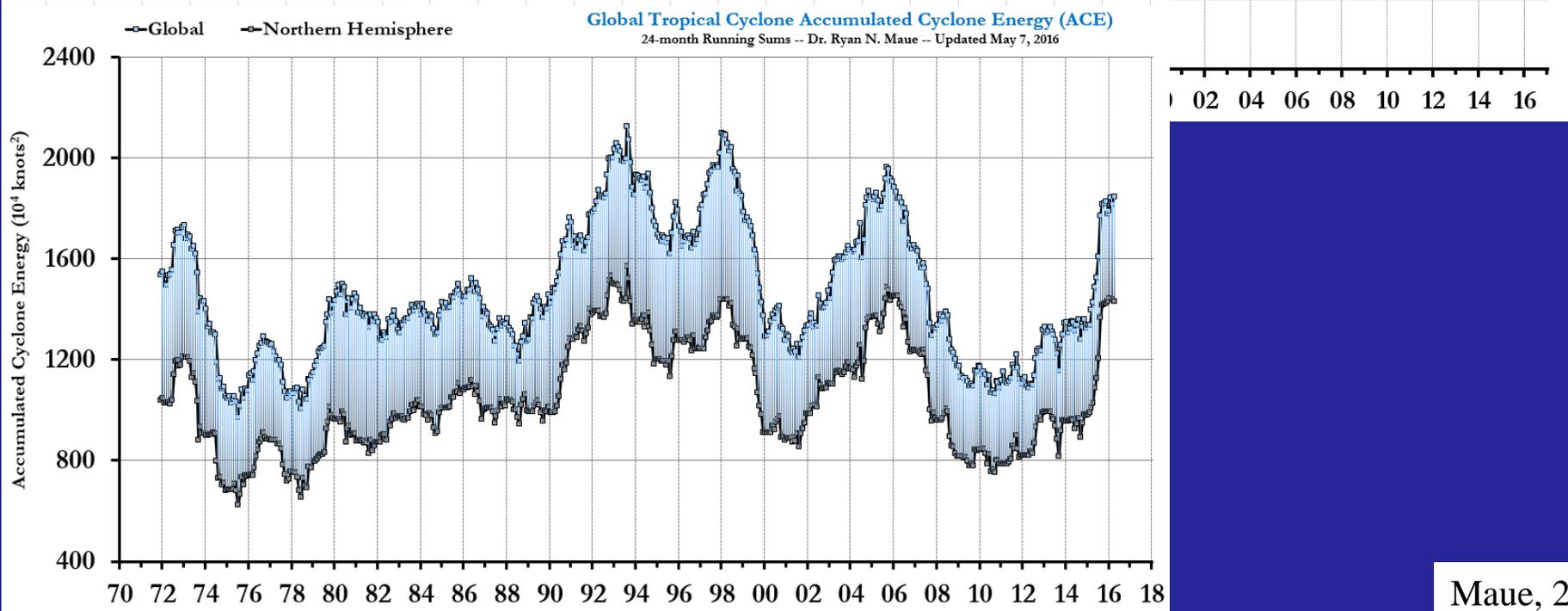
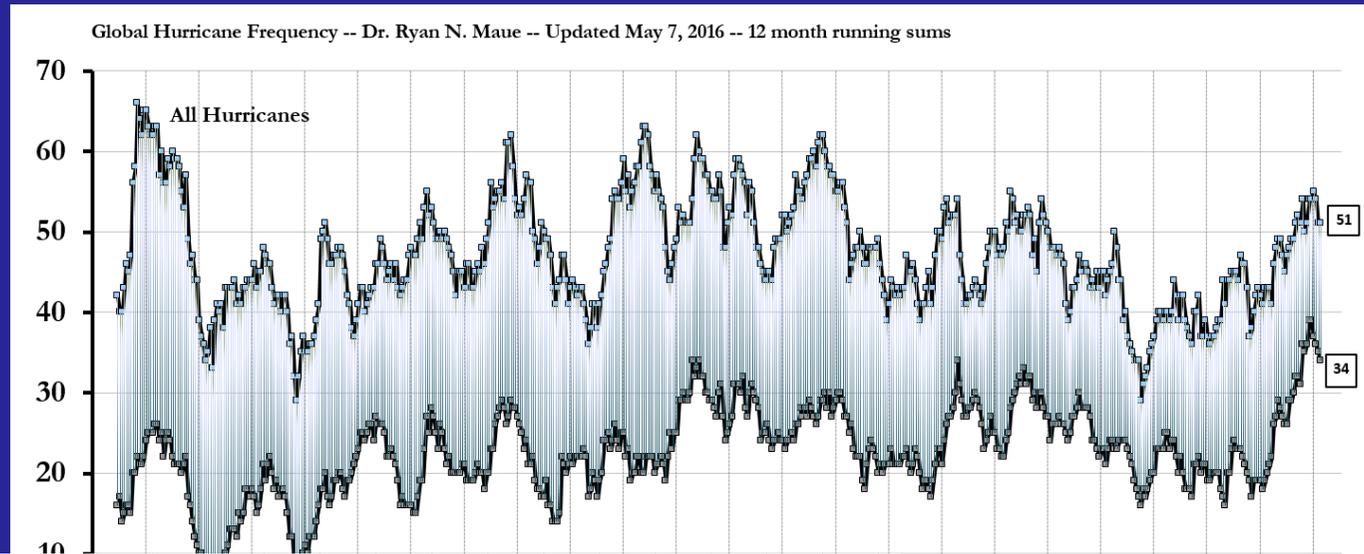
# osservazione delle tendenze X eventi estremi: cicloni tropicali

Deo et al., 2011



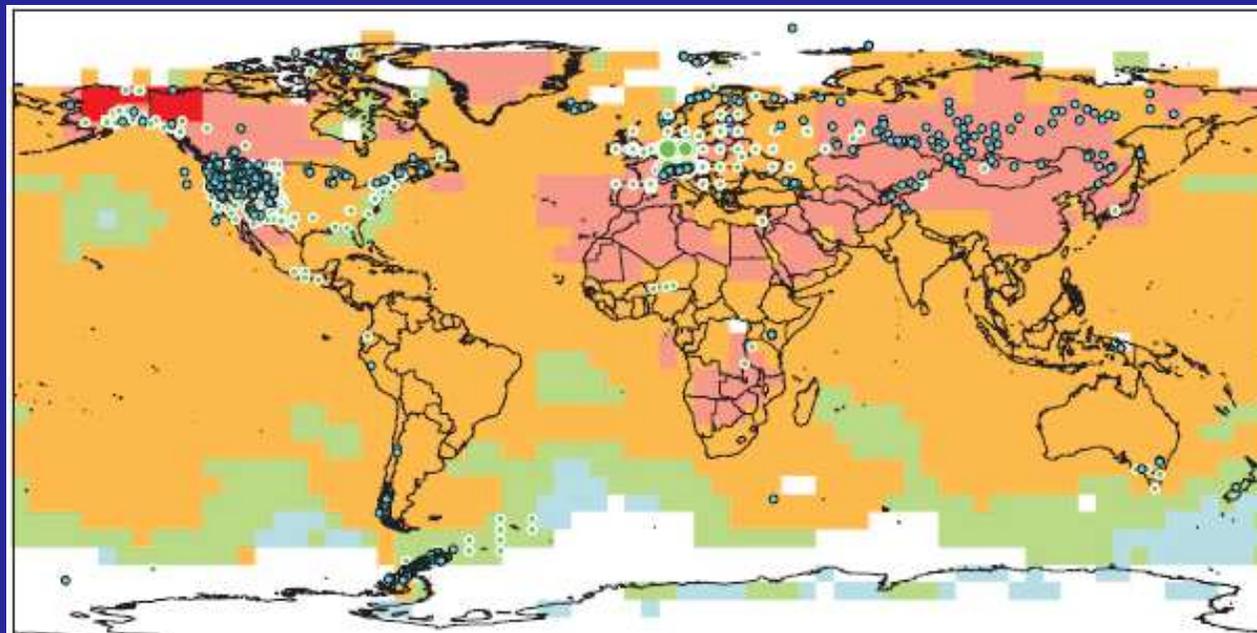
# osservazione delle tendenze X

## eventi estremi: cicloni tropicali



# osservazione delle tendenze XI

*impatto sui  
sistemi fisici e  
biologici*

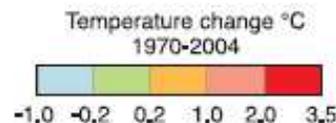


NAM		LA		EUR <sup>28,115</sup>		AFR		AS		ANZ		PR*		TER <sup>28,585</sup>		MFW**		GLO <sup>28,671</sup>	
355	455	53	5	119	28,115	5	2	106	8	6	0	120	24	764	28,585	1	85	765	28,671
94%	92%	98%	100%	94%	89%	100%	100%	96%	100%	100%	—	91%	100%	94%	90%	100%	99%	94%	90%

Observed data series

- Physical systems (snow, ice and frozen ground; hydrology; coastal processes)
- Biological systems (terrestrial, marine, and freshwater)

Europe ***	
•	1-30
○	31-100
○	101-800
○	801-1,200
○	1,201-7,500



Physical      Biological

Number of significant observed changes	Number of significant observed changes
Percentage of significant changes consistent with warming	Percentage of significant changes consistent with warming

\* Polar regions include also observed changes in marine and freshwater biological systems.

\*\* Marine and freshwater includes observed changes at sites and large areas in oceans, small islands and continents. Locations of large-area marine changes are not shown on the map.

\*\*\* Circles in Europe represent 1 to 7,500 data series.