

# A brief outlook to some scientific issues of global warming?

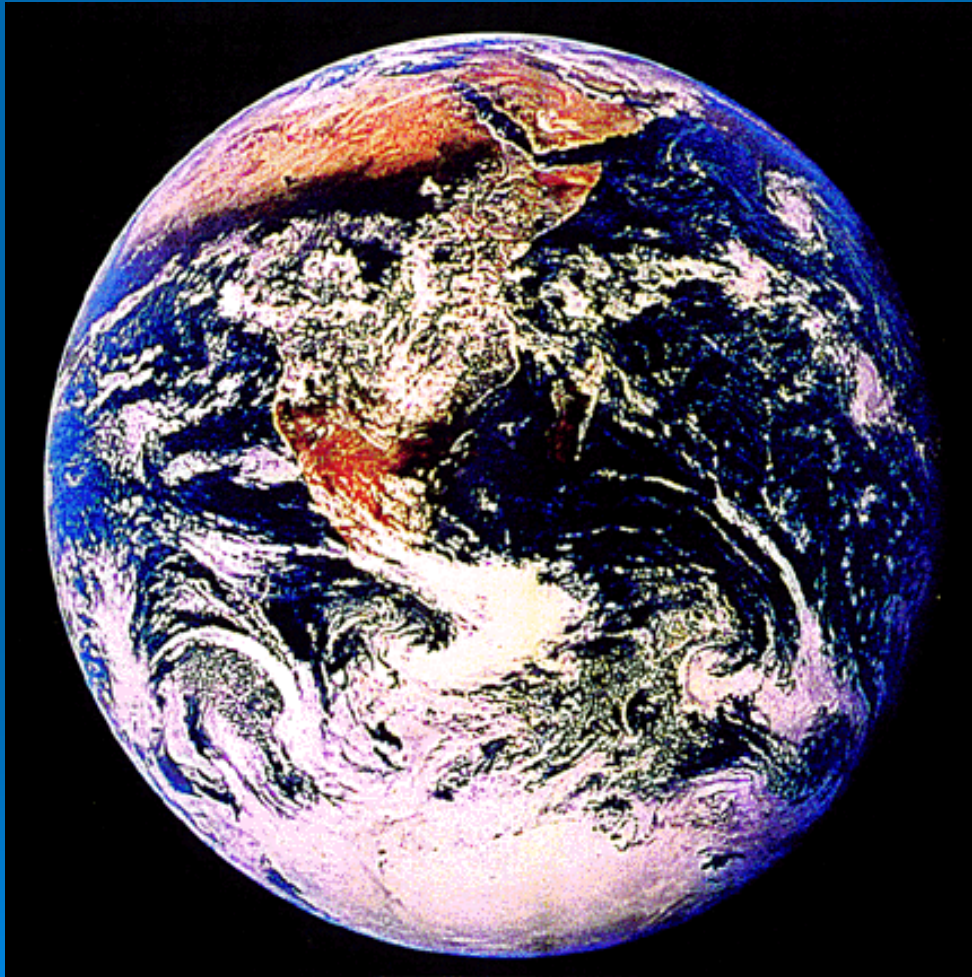
UdG Summer School  
Climate and landscape  
July 9th 2012

Josep Enric Llebot  
Generalitat de Catalunya  
Departament de Física, UAB  
[enric.llebot@gencat.cat](mailto:enric.llebot@gencat.cat); [enric.llebot@uab.cat](mailto:enric.llebot@uab.cat)



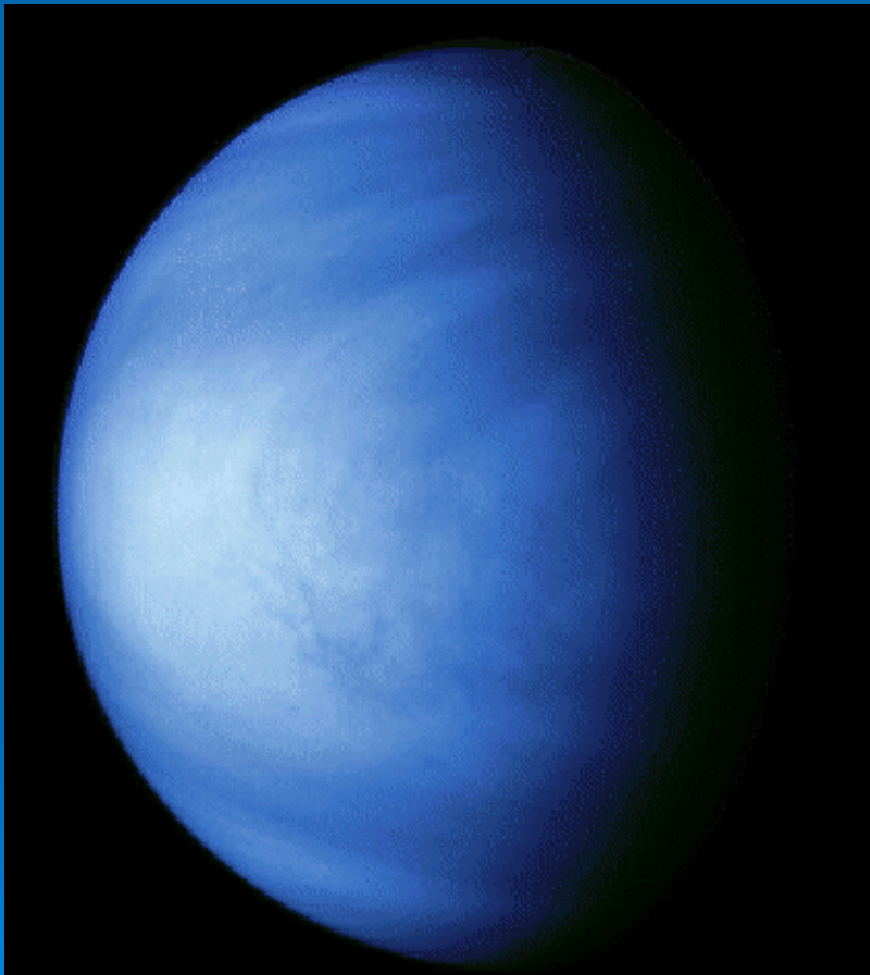
Apollo 8, 1968

# Earth



Radius	6378 km
Surface area	$5.1 \times 10^8 \text{ km}^2$
Mass	$5.974 \times 10^{24} \text{ kg}$
Density	$5.515 \text{ g/cm}^3$
Gravity	$9.87 \text{ m/s}^2$
Escape velocity	11 km/s
Albedo	0.30
Surface temperature	290 K
Day	23 h 56 min
Year	365.25 days
Sun distance	$1.496 \times 10^8 \text{ km}$

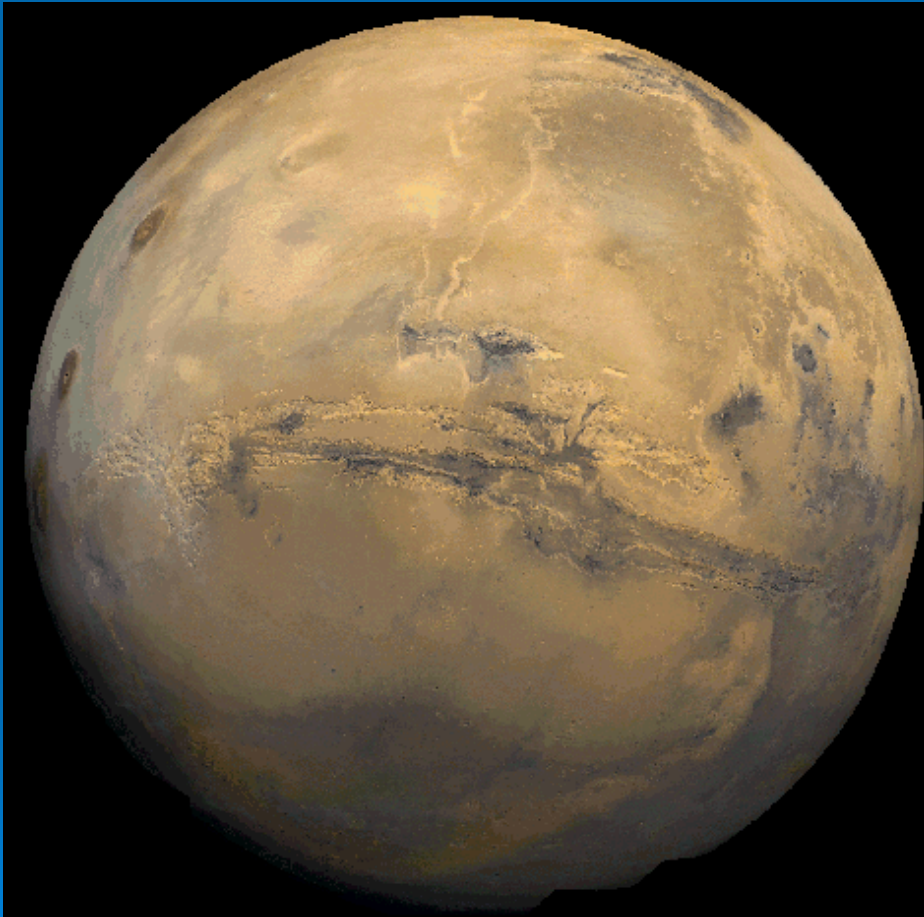
# Venus



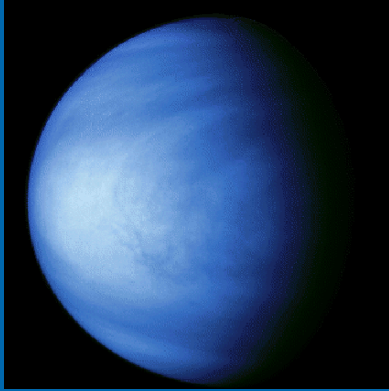
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Radius	6052 km
Surface area	$4.6 \times 10^8 \text{ km}^2$
Mass	$4.87 \times 10^{24} \text{ kg}$
Density	$5.20 \text{ g/cm}^3$
Gravity	$8.87 \text{ m/s}^2$
Escape velocity	$10.5 \text{ km/s}$
Albedo	0.77
Surface temperature	737 K
Pressure	$9.2 \times 10^6 \text{ Pa}$
Day	243.02 days
Year	224.7 days
Sun distance	0.723 AU

# Mars

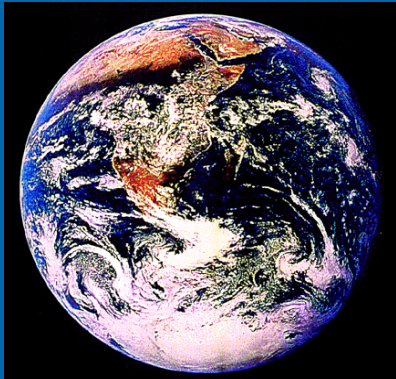


Radius	3397 km
Surface area	$1.4 \times 10^8 \text{ km}^2$
Mass	$6.4 \times 10^{23} \text{ kg}$
Density	$3.94 \text{ g/cm}^3$
Gravity	$3.72 \text{ m/s}^2$
Escape velocity	5.1 km/s
Albedo	0.16
Surface temperature	240 K (day) 210 K (night)
Pressure	700 Pa
Day	686.98 days
Year	24 h 37 min 25 s
Sun distance	1.524 AU



Venus: Solar constant  $2637 \text{ Wm}^{-2}$  albedo 0.77  
( $606,51 \text{ Wm}^{-2}$ ),  $T_e = 227 \text{ K}$  ( $-46^\circ\text{C}$ ),  $T_s = 737 \text{ K}$  ( $464^\circ\text{C}$ )

$\text{CO}_2$  96% pressure 93000 hPa



Earth: Solar constant  $1367 \text{ Wm}^{-2}$  albedo 0.30,  
( $956,9 \text{ Wm}^{-2}$ ,  $T_e = 255 \text{ K}$  ( $-18^\circ\text{C}$ ),  $T_s = 288 \text{ K}$  ( $15^\circ\text{C}$ ))

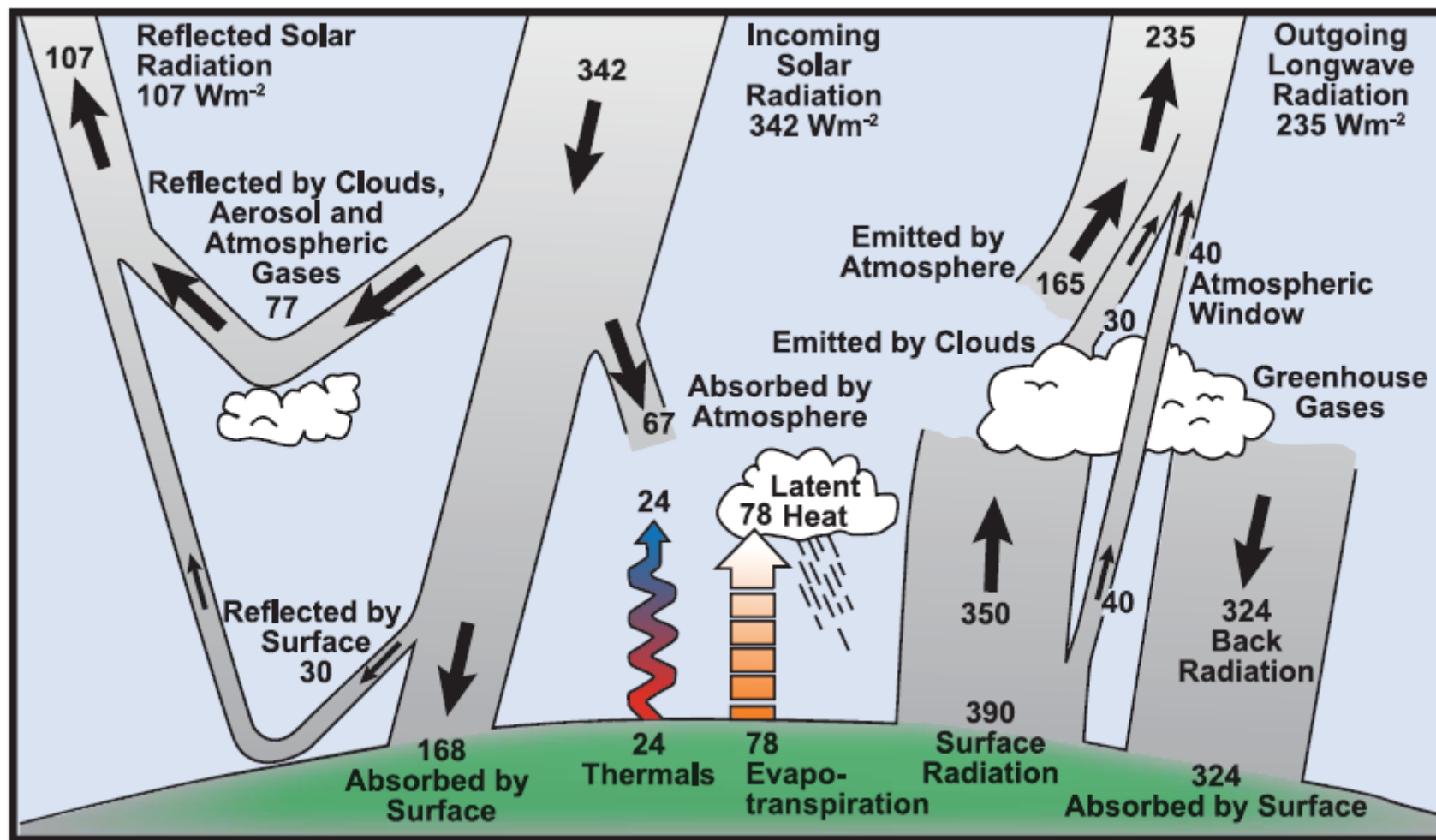
$\text{CO}_2$  0.03% pressure 1013 hPa



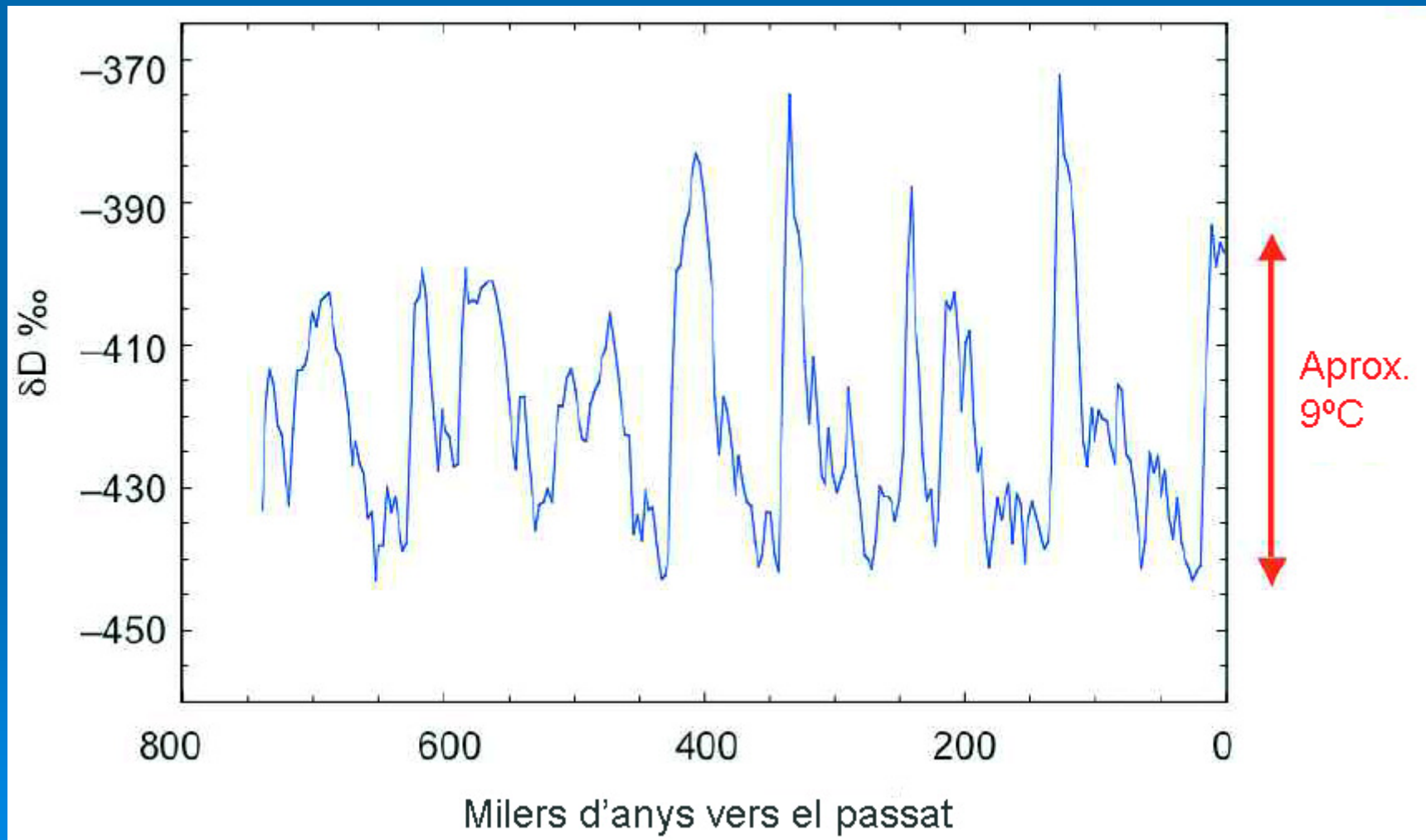
Mars: Solar constant  $592 \text{ Wm}^{-2}$  albedo 0.16,  
( $509,12 \text{ Wm}^{-2}$ )  $T_e = 218 \text{ K}$ , ( $-55^\circ\text{C}$ )  $T_s = 220 \text{ K}$  ( $-53^\circ\text{C}$ )

$\text{CO}_2$  95.3% pressure: 7hPa

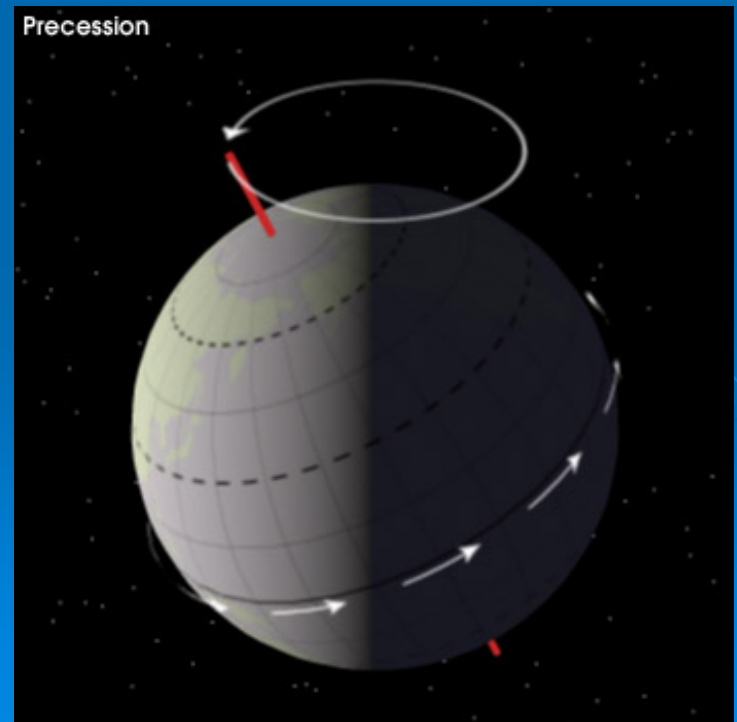
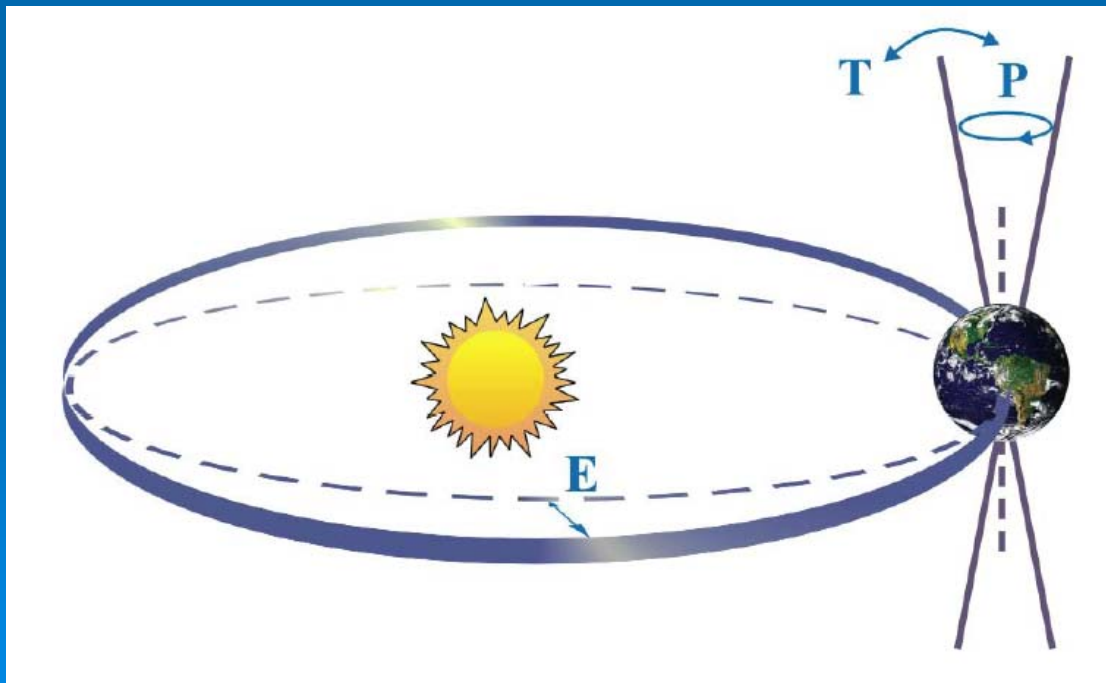
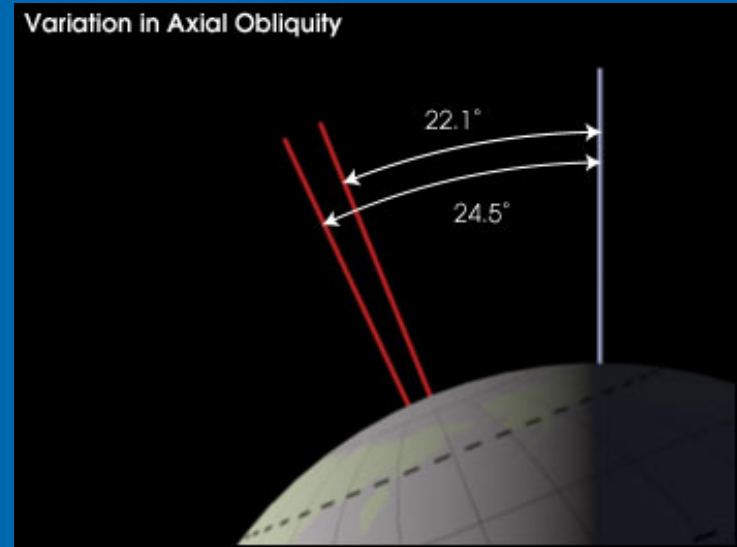
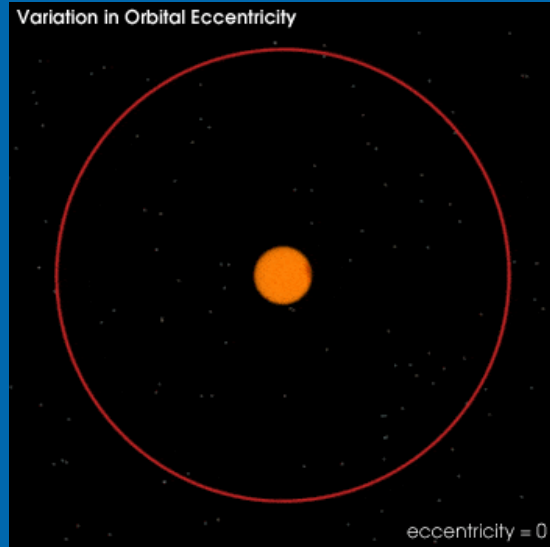
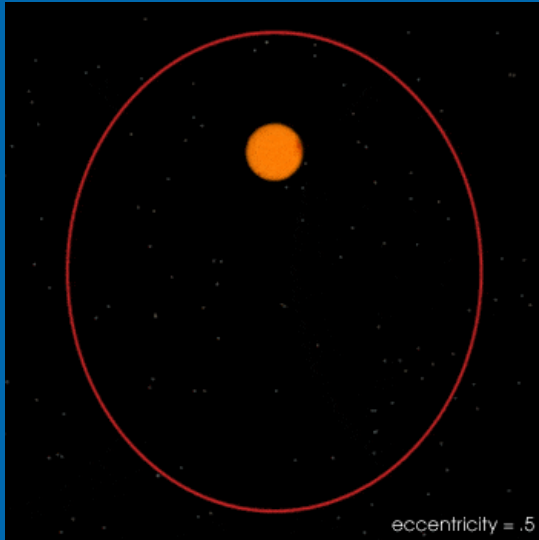
# Earth energy balance



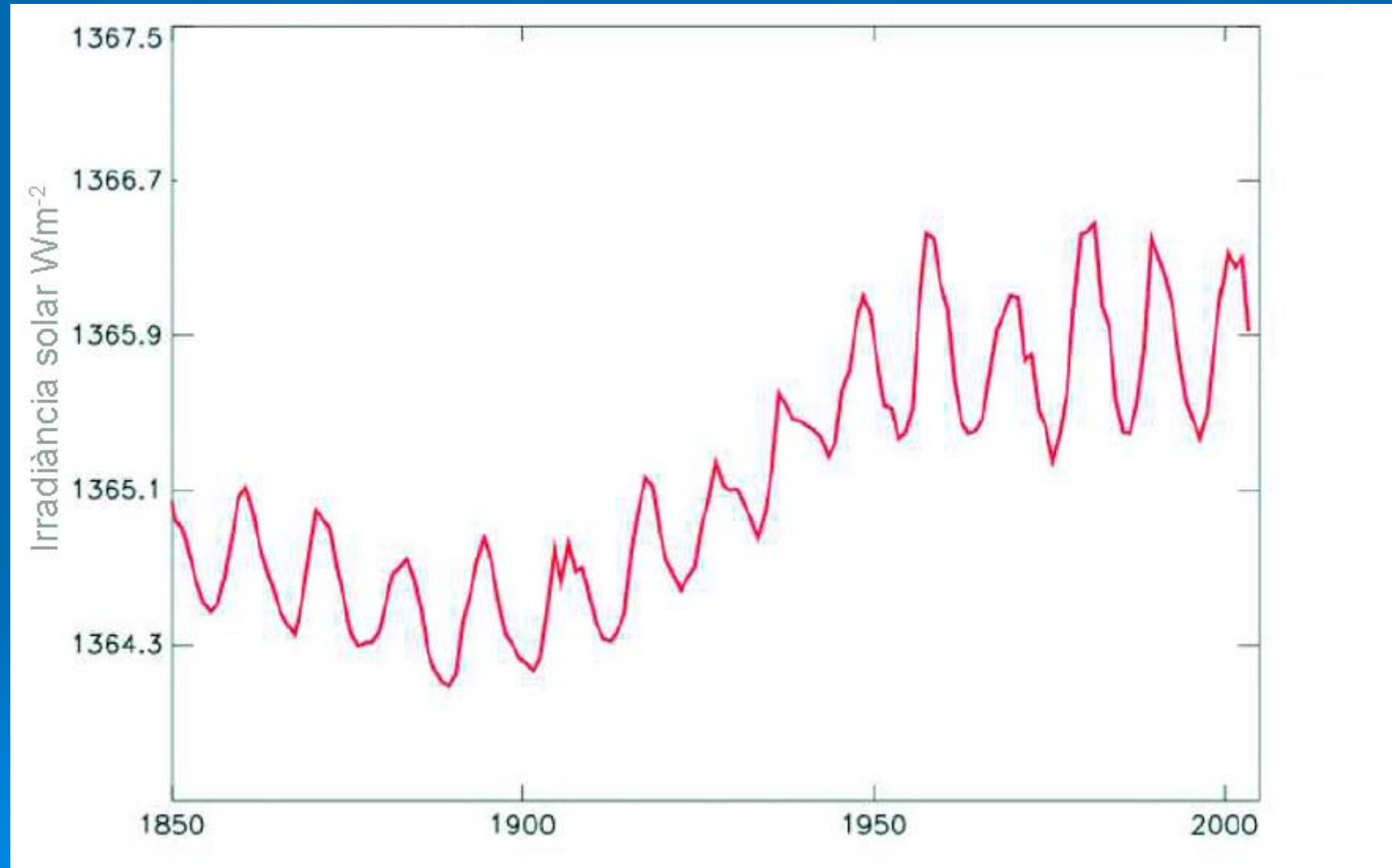
# Earth climate has changed always



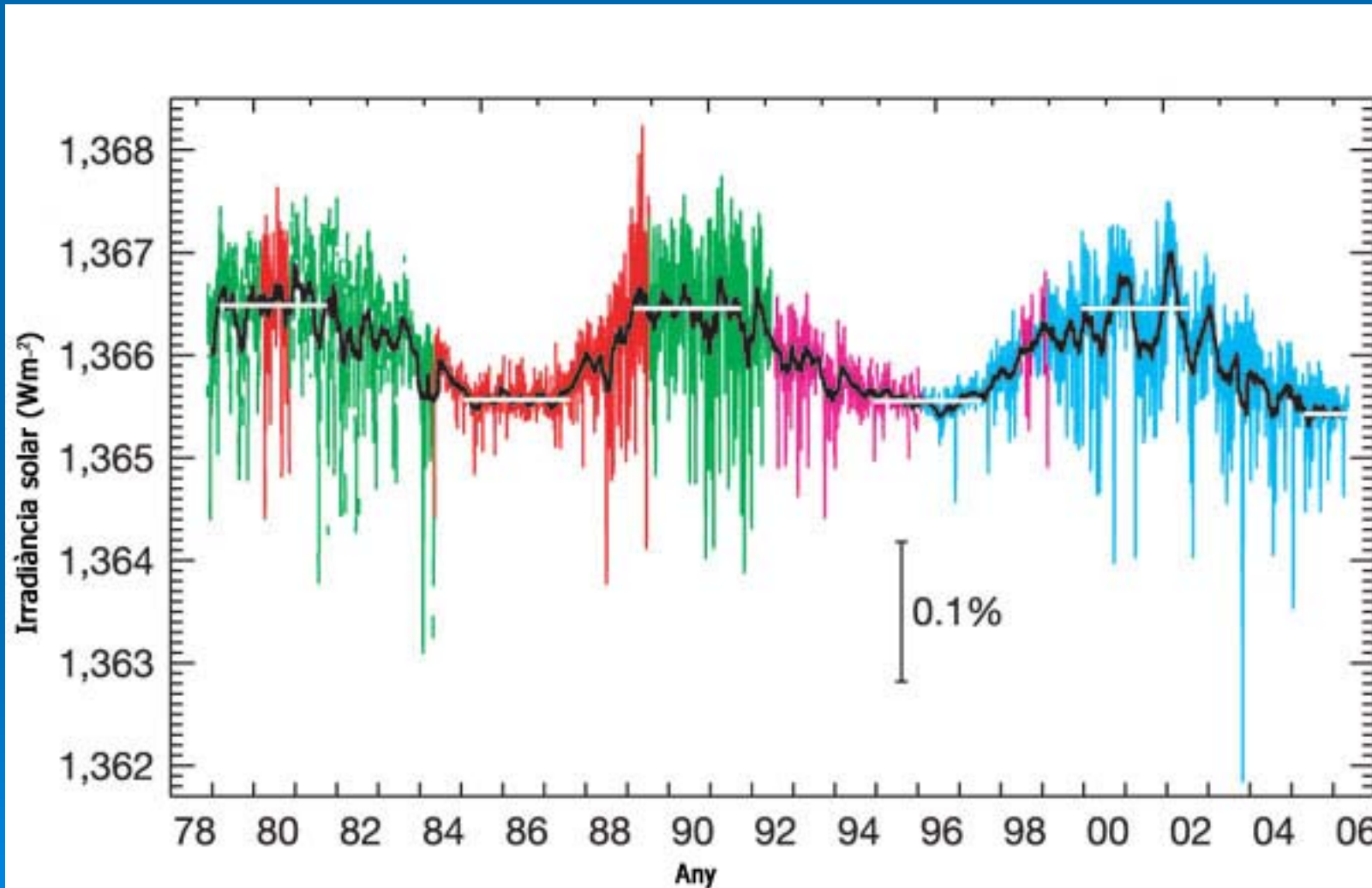




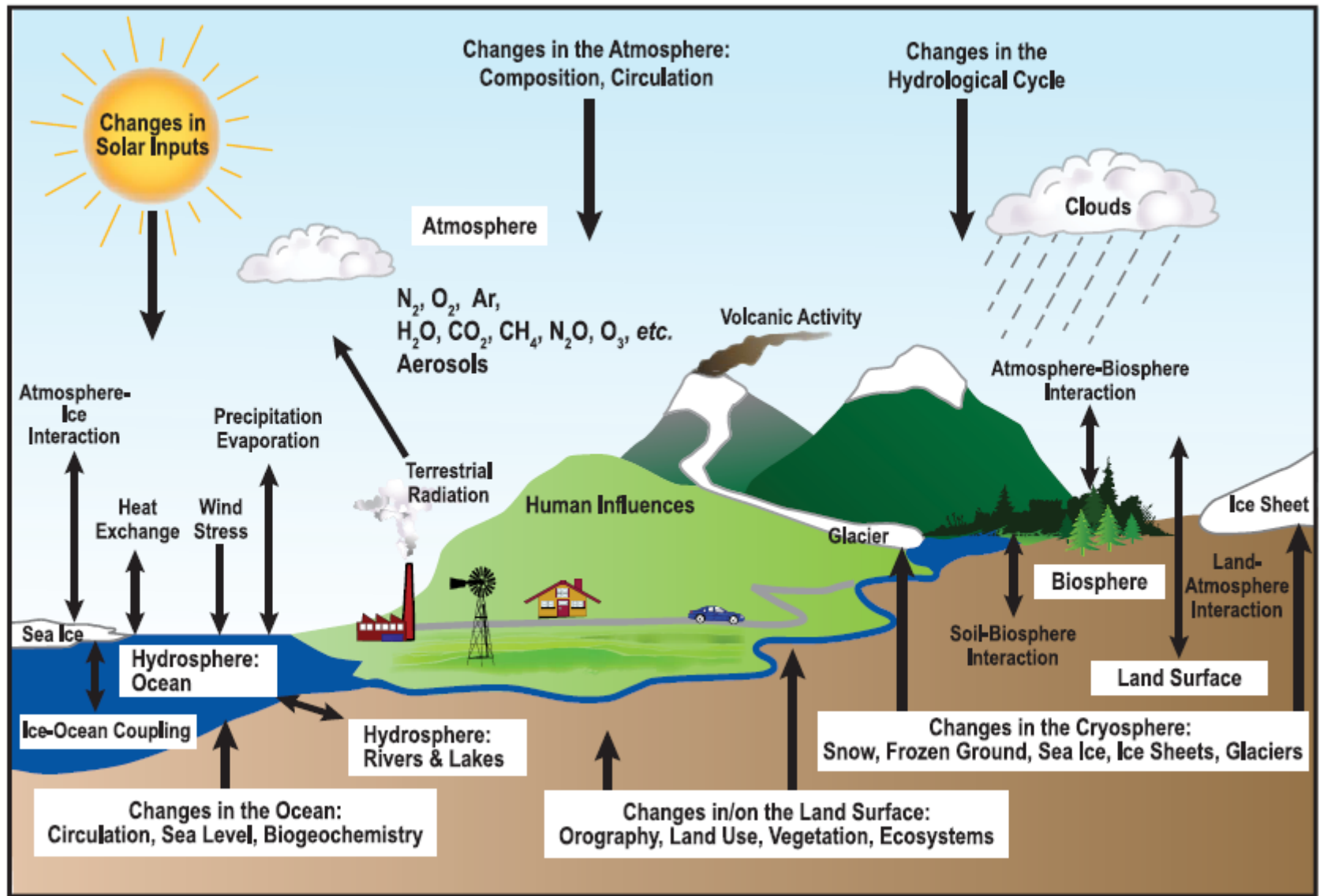
# Sun irradiance $Wm^{-2}$



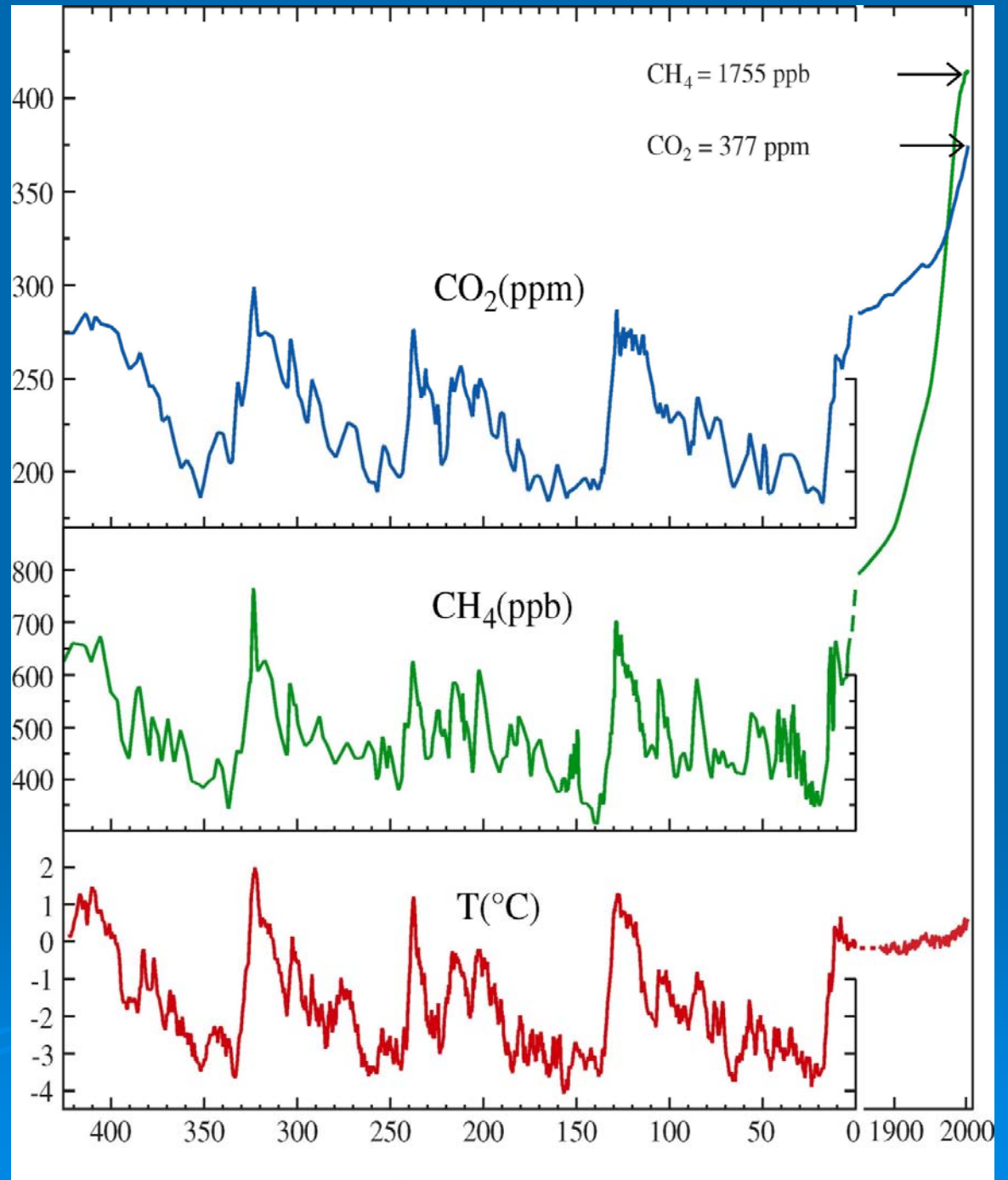
# Sun irradiance $\text{Wm}^{-2}$



Nature (2006)



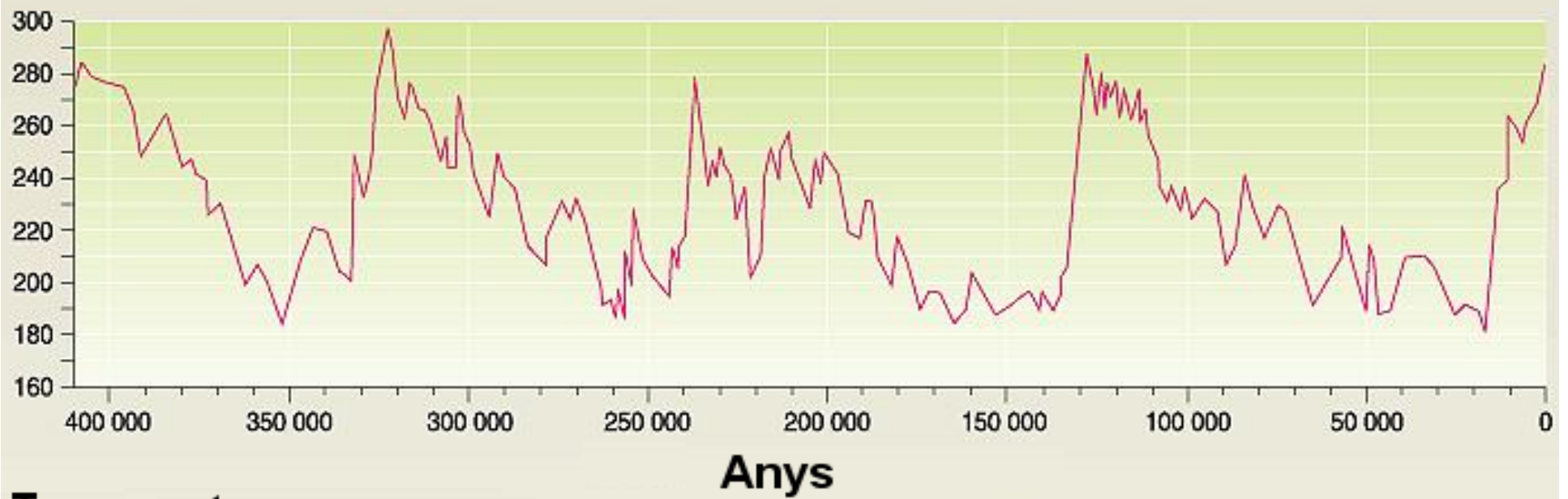
CO<sub>2</sub>, CH<sub>4</sub> & global temperature  
0 = mean (1880-1899)



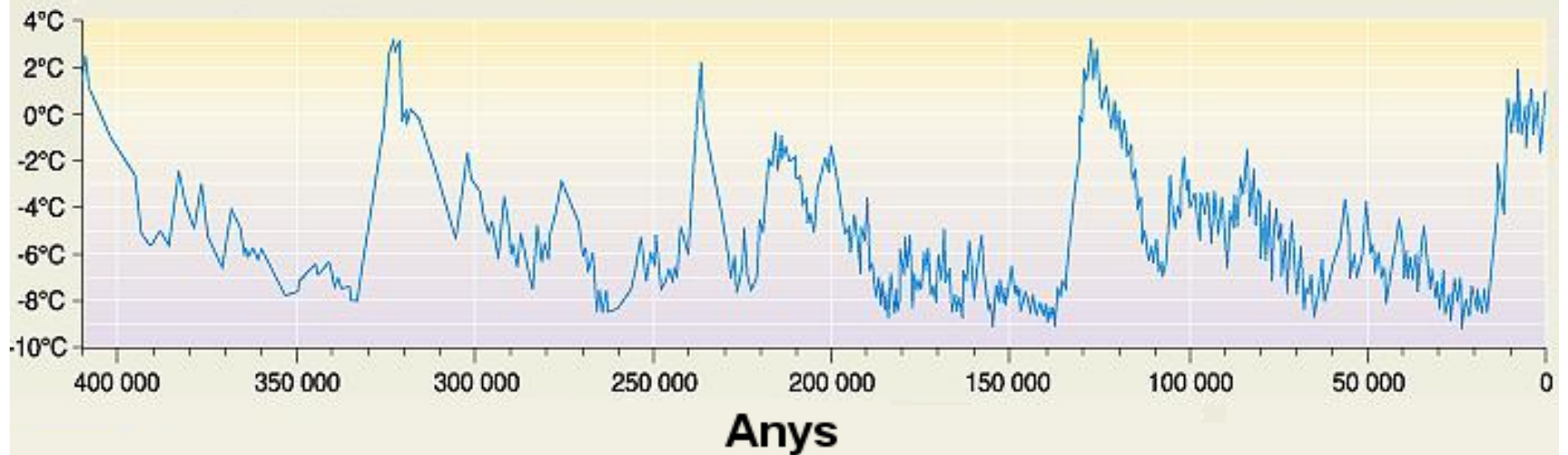
Font: Hansen, *Clim. Change*, 68, 269, 2005.

# Cales de gel de Vostok

## CO<sub>2</sub>



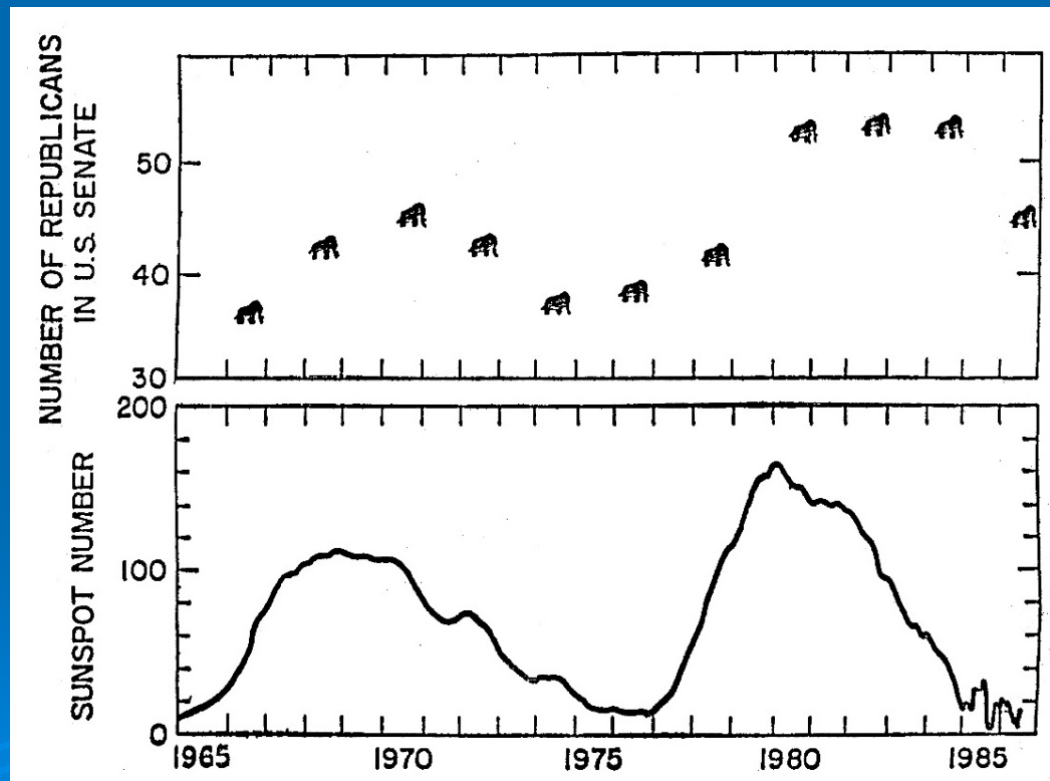
## Temperatura



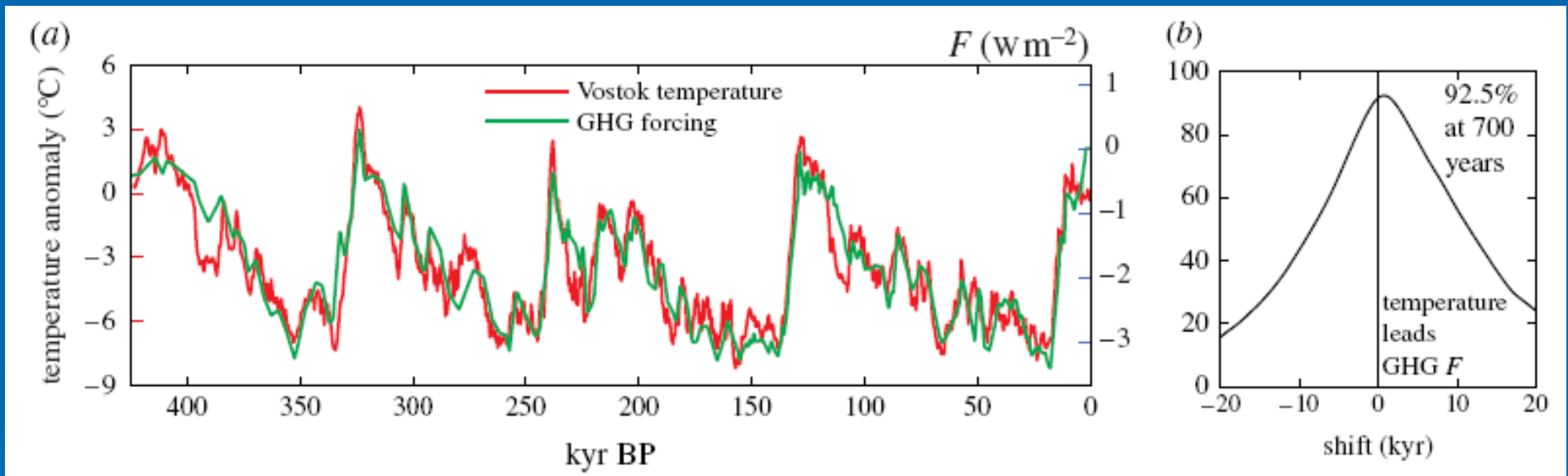
There is a clear attempt to establish truth not by scientific methods but by perpetual repetition!



Richard Lindzen

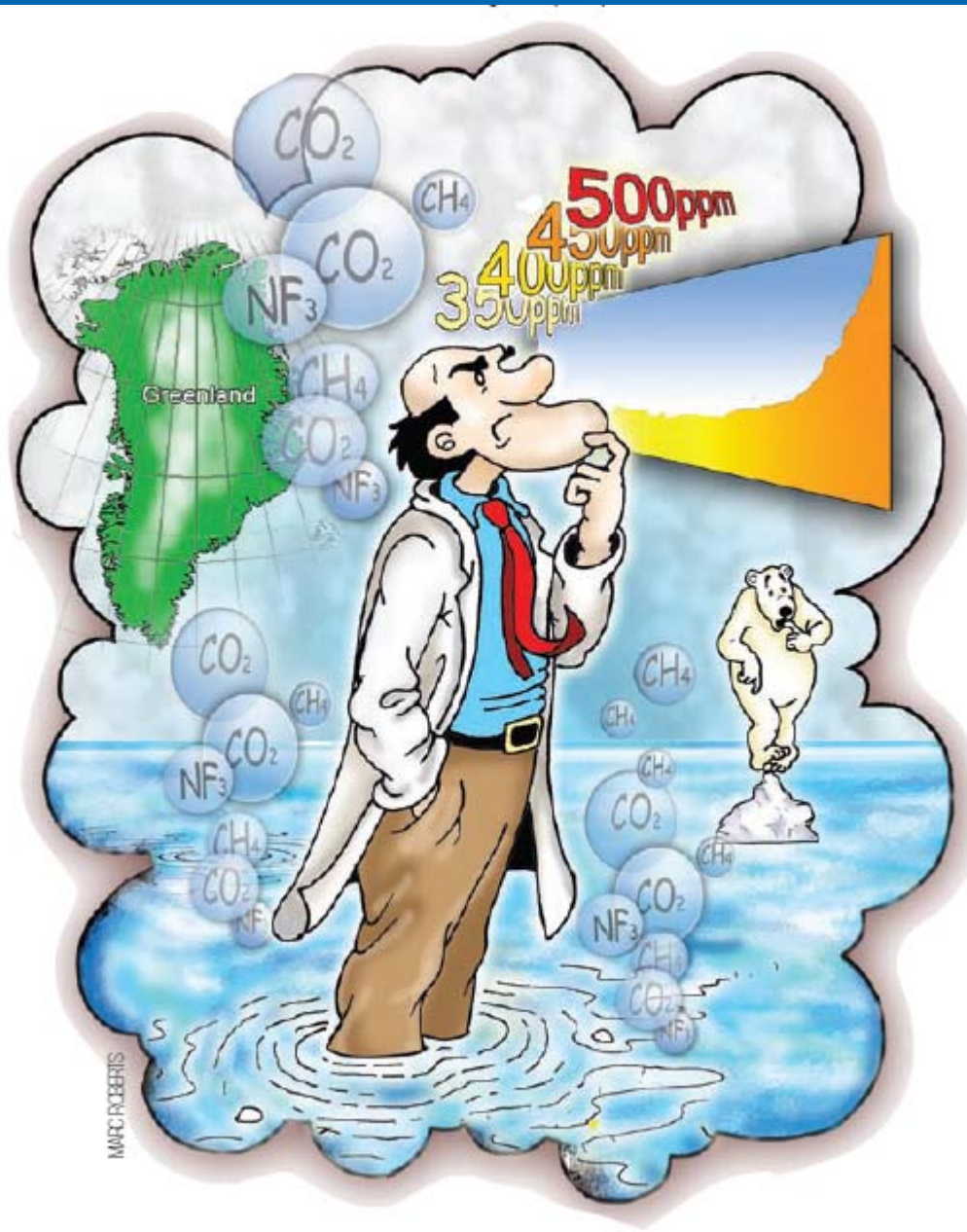


# CO<sub>2</sub> atmospheric concentration and surface temperature



Font: J. Hansen, 2007



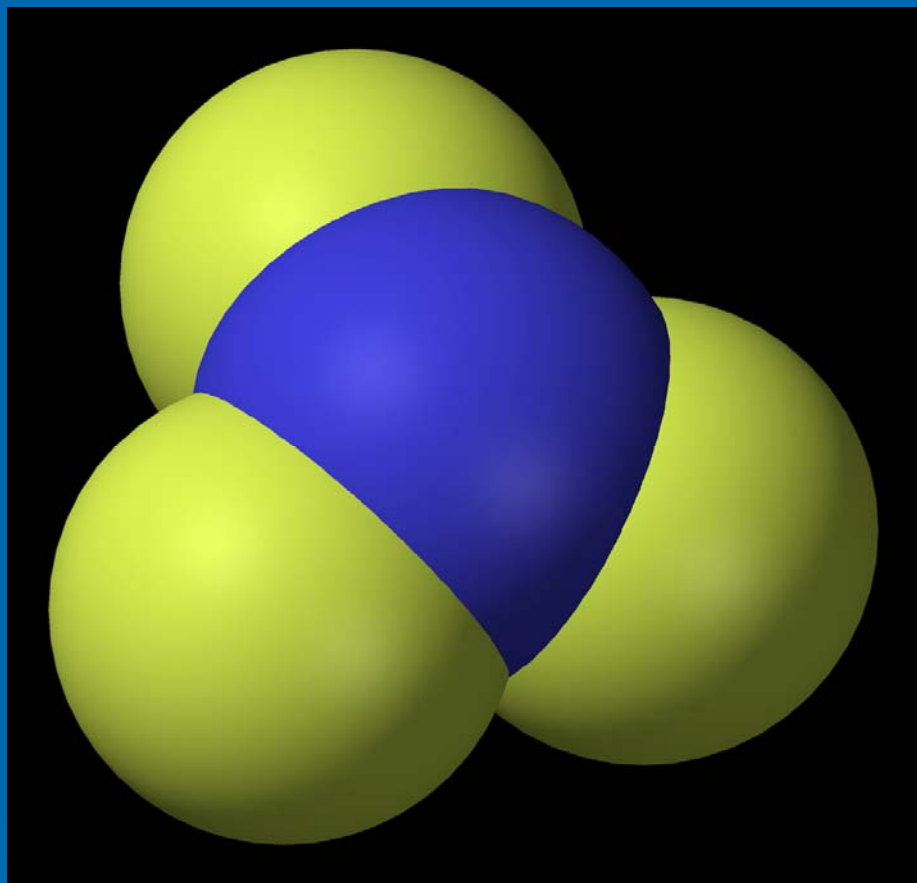


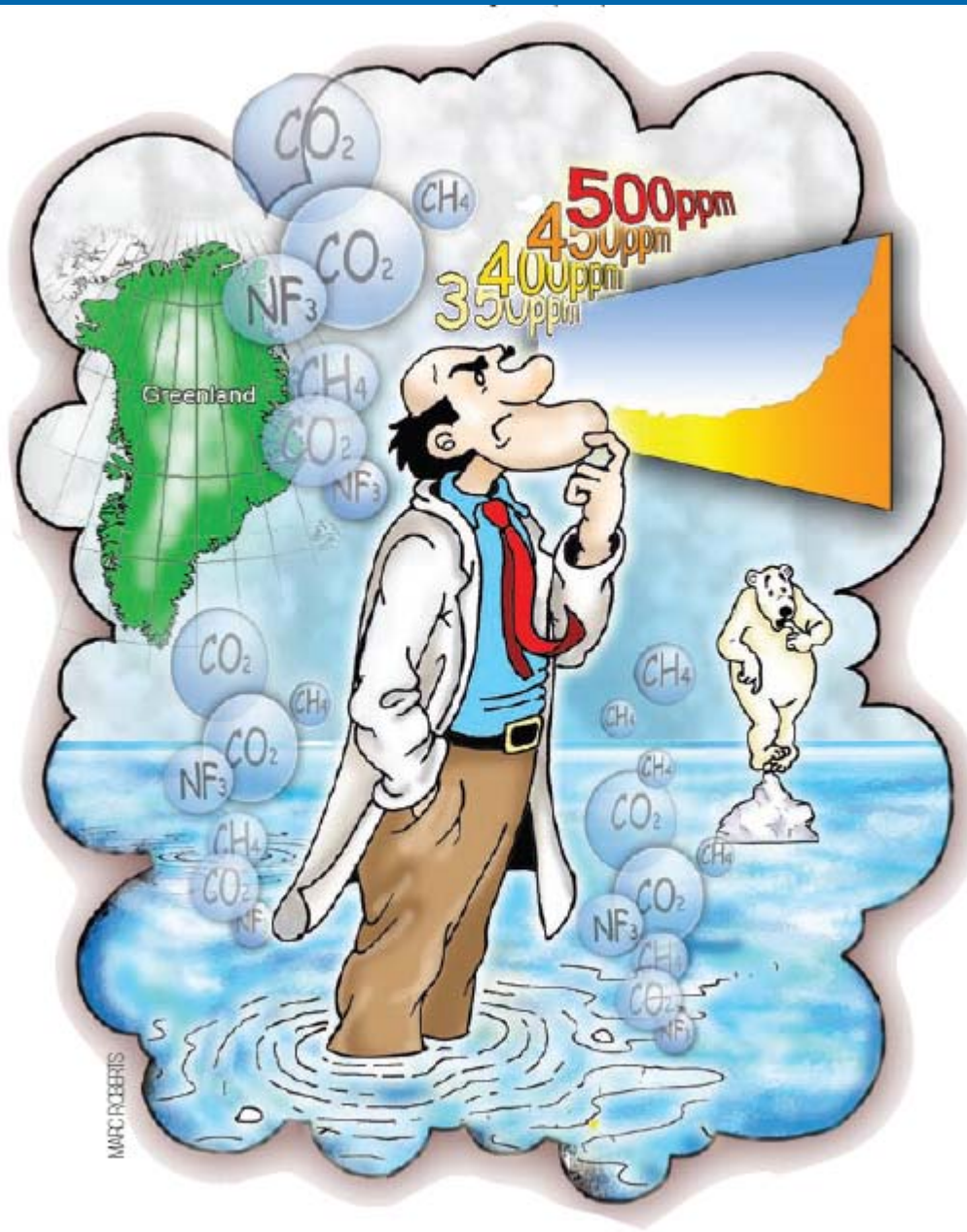
What has been learned recently?

- Other greenhouse gases are worrying
- Arctic summer sea ice is in rapid decline
- Warming is already having an impact
- The hockey stick holds up
- Sceptics are still out there

What we are still working on?

- How much warming and by when?
- Where to stabilize?
- Where the missing carbon is going?
- Does global warming worsens storms
- How fast Greenland is melting?



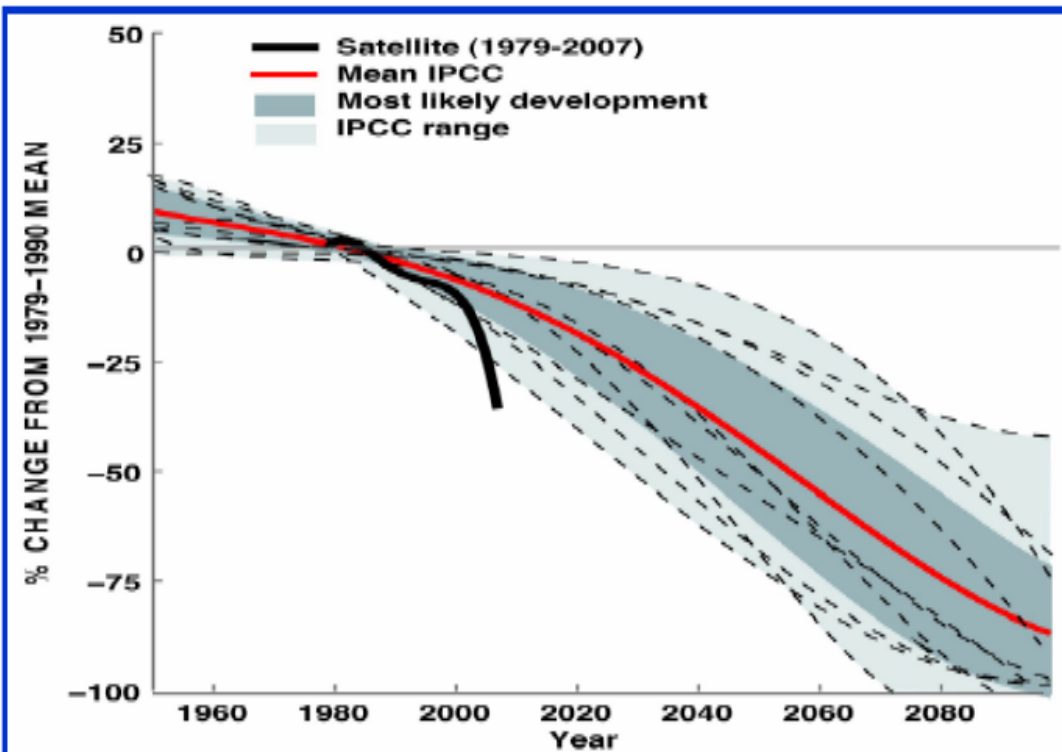


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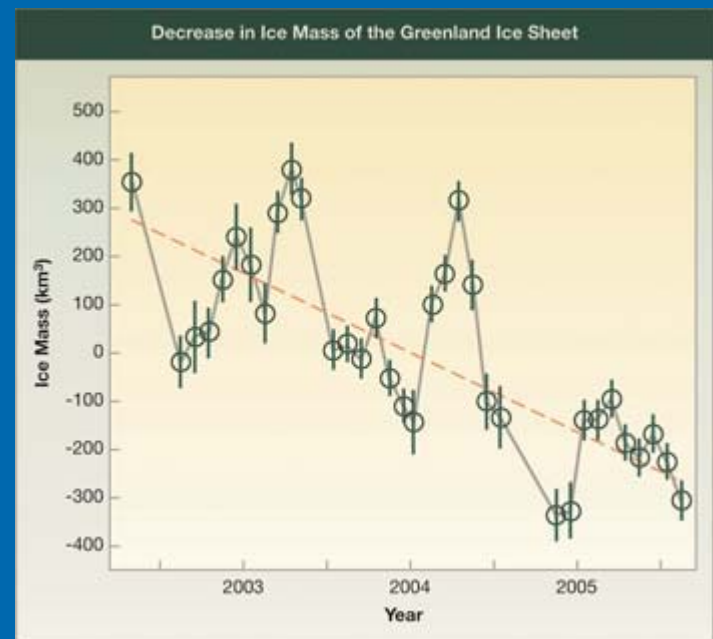
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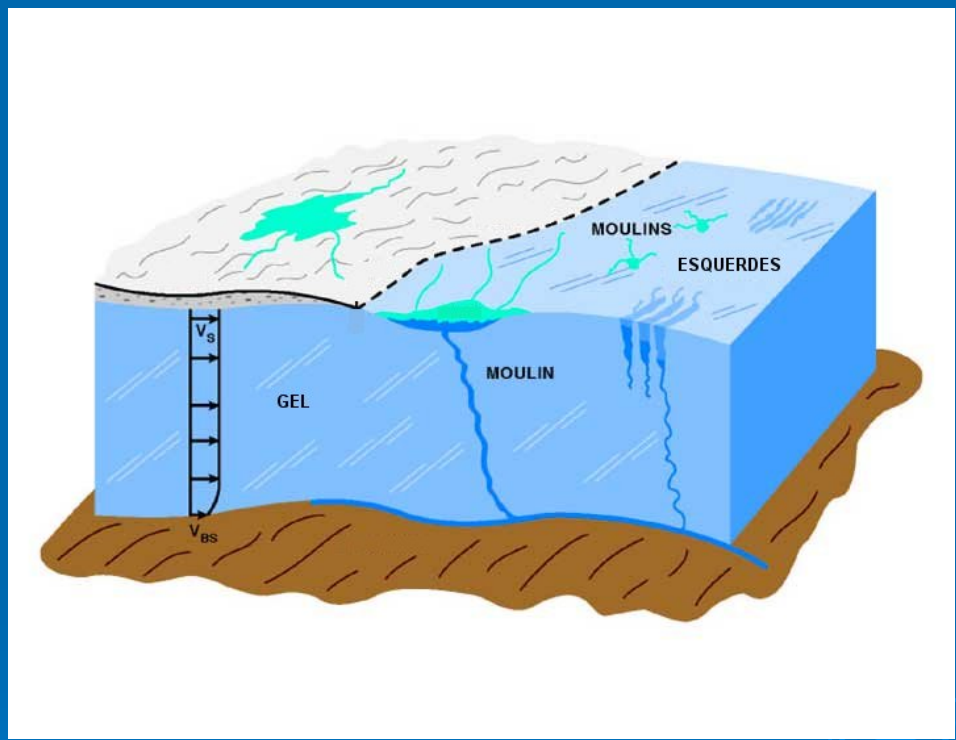
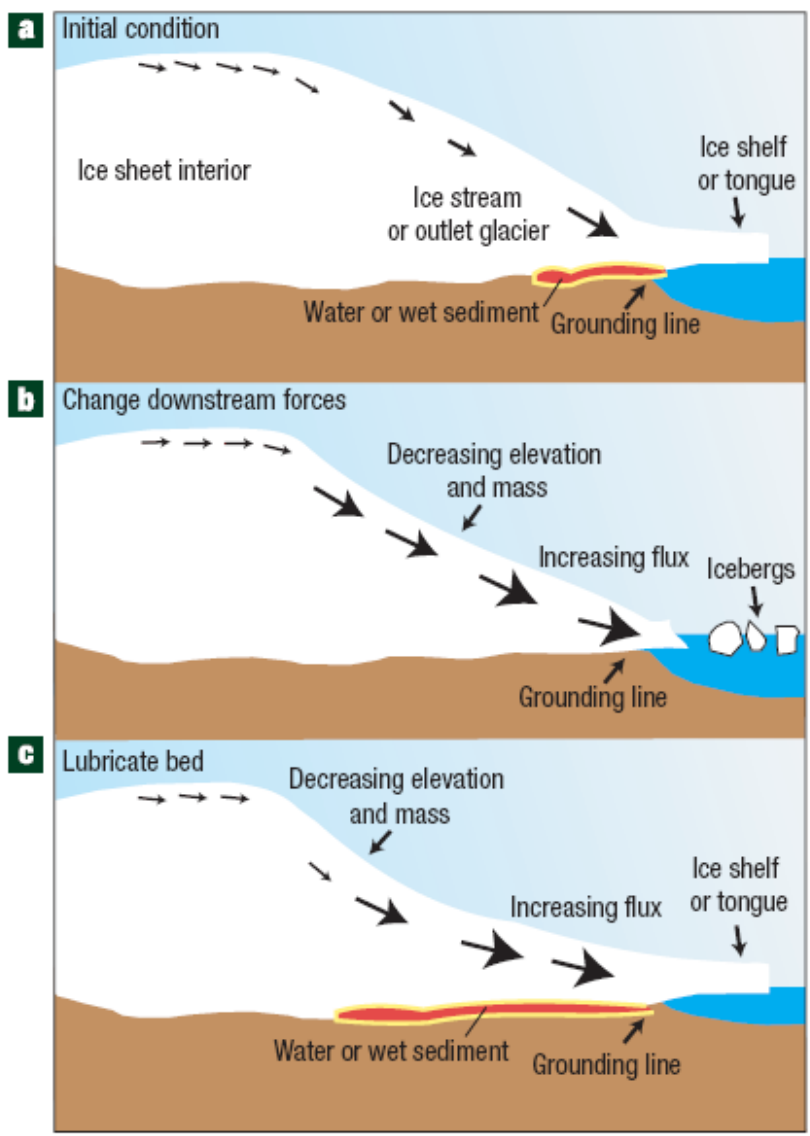
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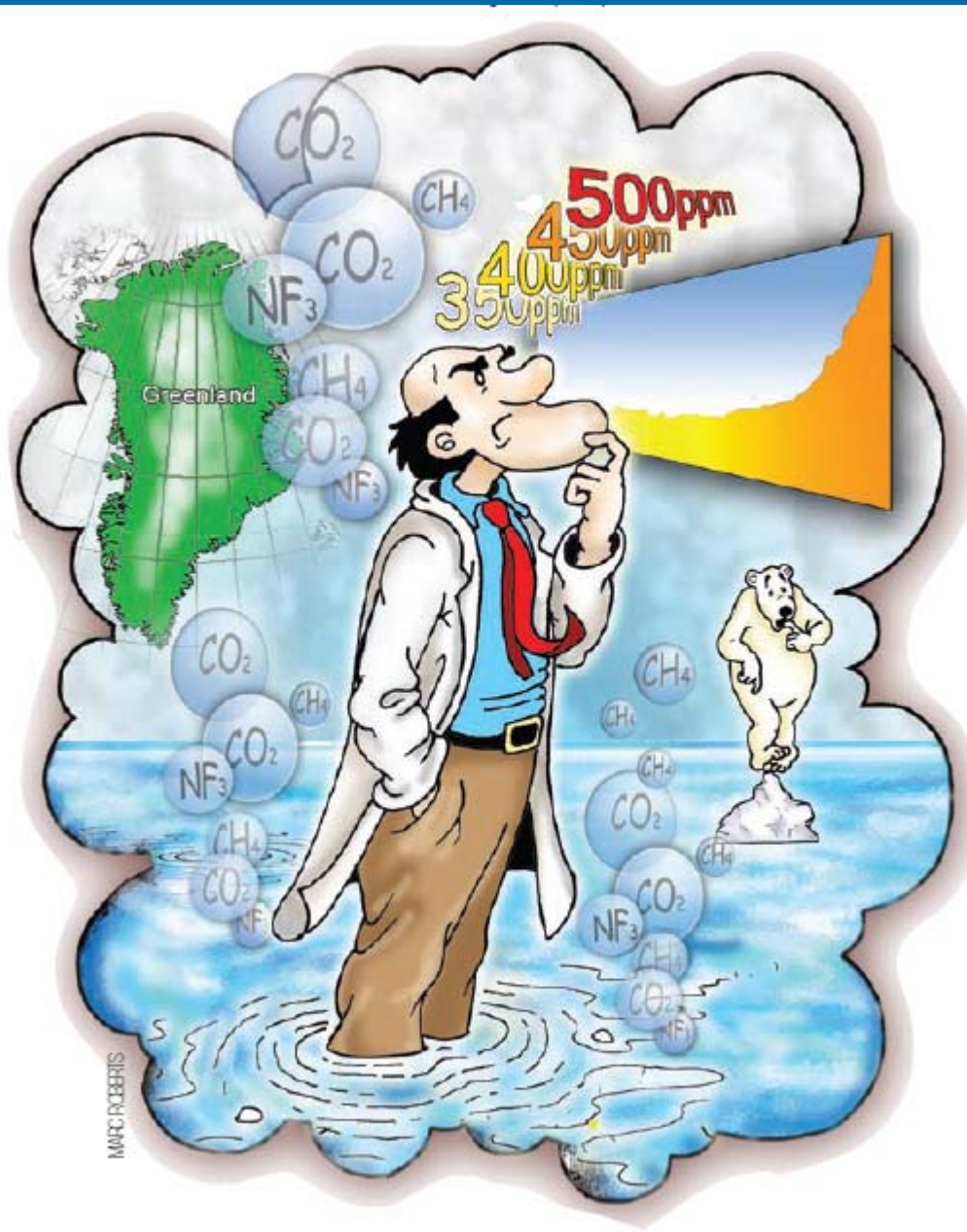
### Arctic sea ice loss compared to IPCC models

Arctic ice extent loss to September 2007 compared to IPCC modelled changes using the SRES A2 CO<sub>2</sub> scenario (IPCC high CO<sub>2</sub> scenario). September loss data from satellite observations. Data smoothed with a 4th order polynomial to smooth out the year-to-year variability. Chart courtesy Dr Asgeir Sorteberg, Bjerknes Centre for Climate Research and University Center at Svalbard, Norway. Date: 23 September 2007 [www.carbonequity.info/images/seaice07.jpg](http://www.carbonequity.info/images/seaice07.jpg)





Font: Robin E. Bell, naturegeoscience 2008



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Josep Peñuelas

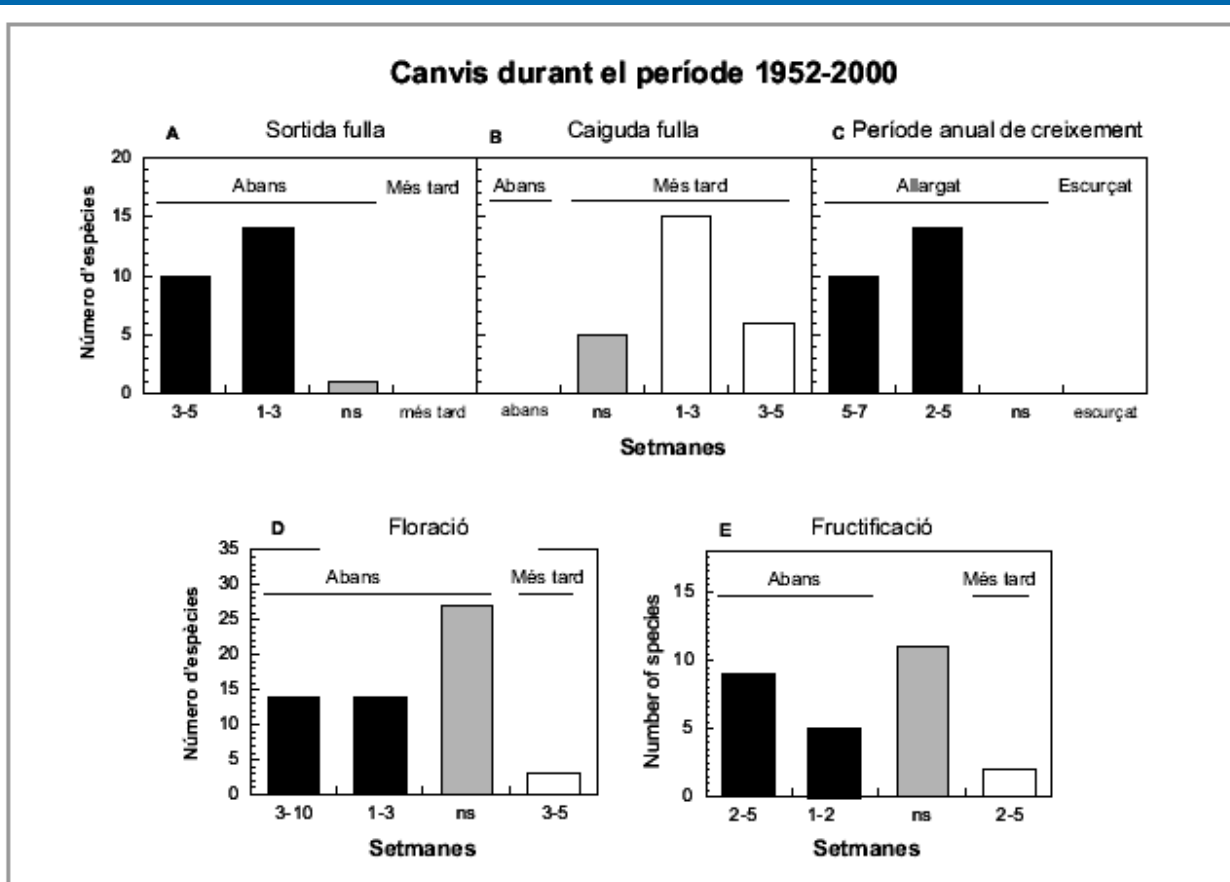
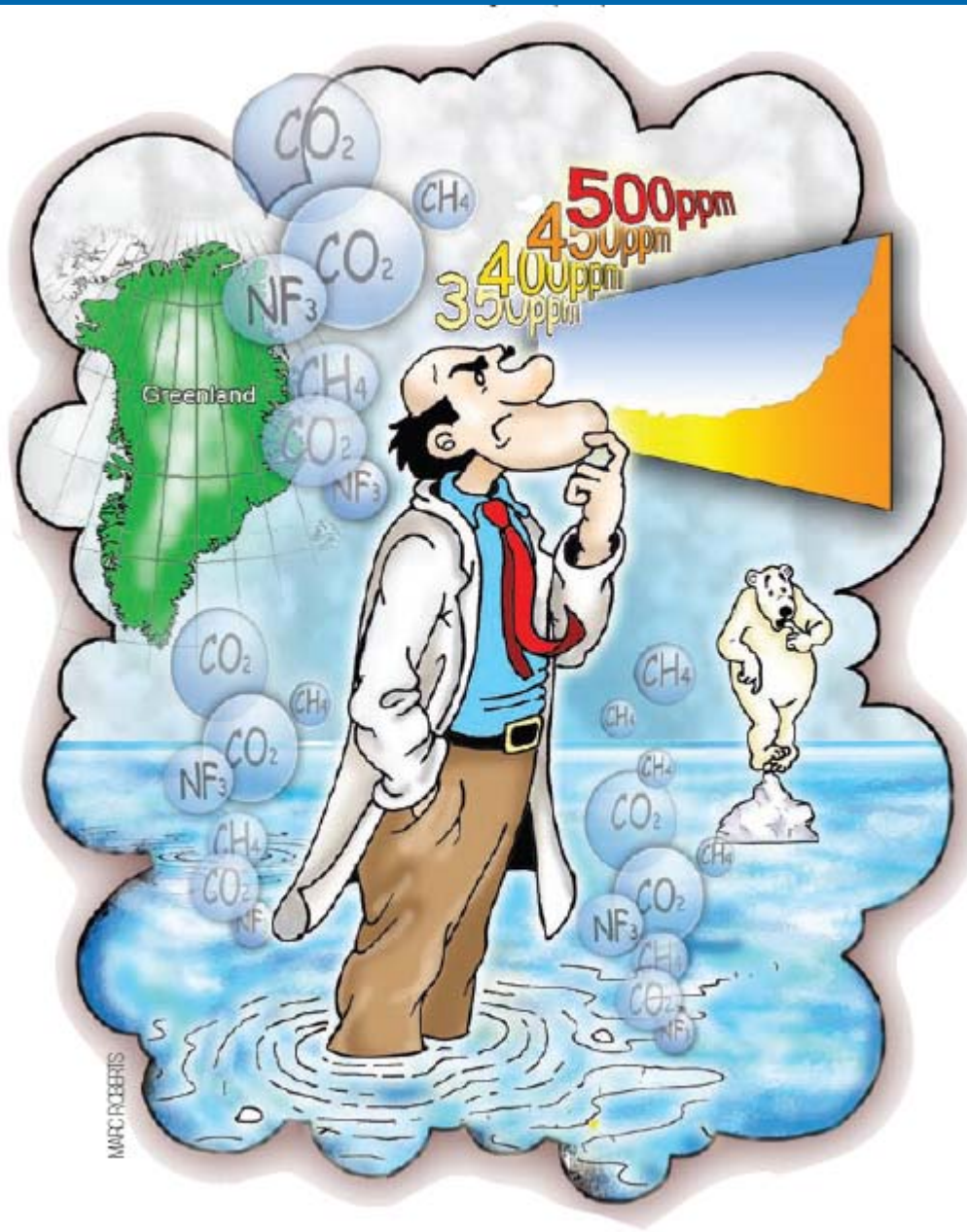


Figura B9.2. Frequència d'espècies vegetals i animals amb fenologia alterada durant les darreres cinc dècades (període 1952-2000) a Cardedeu (Vallès Oriental). Font: Peñuelas et al., 2002.



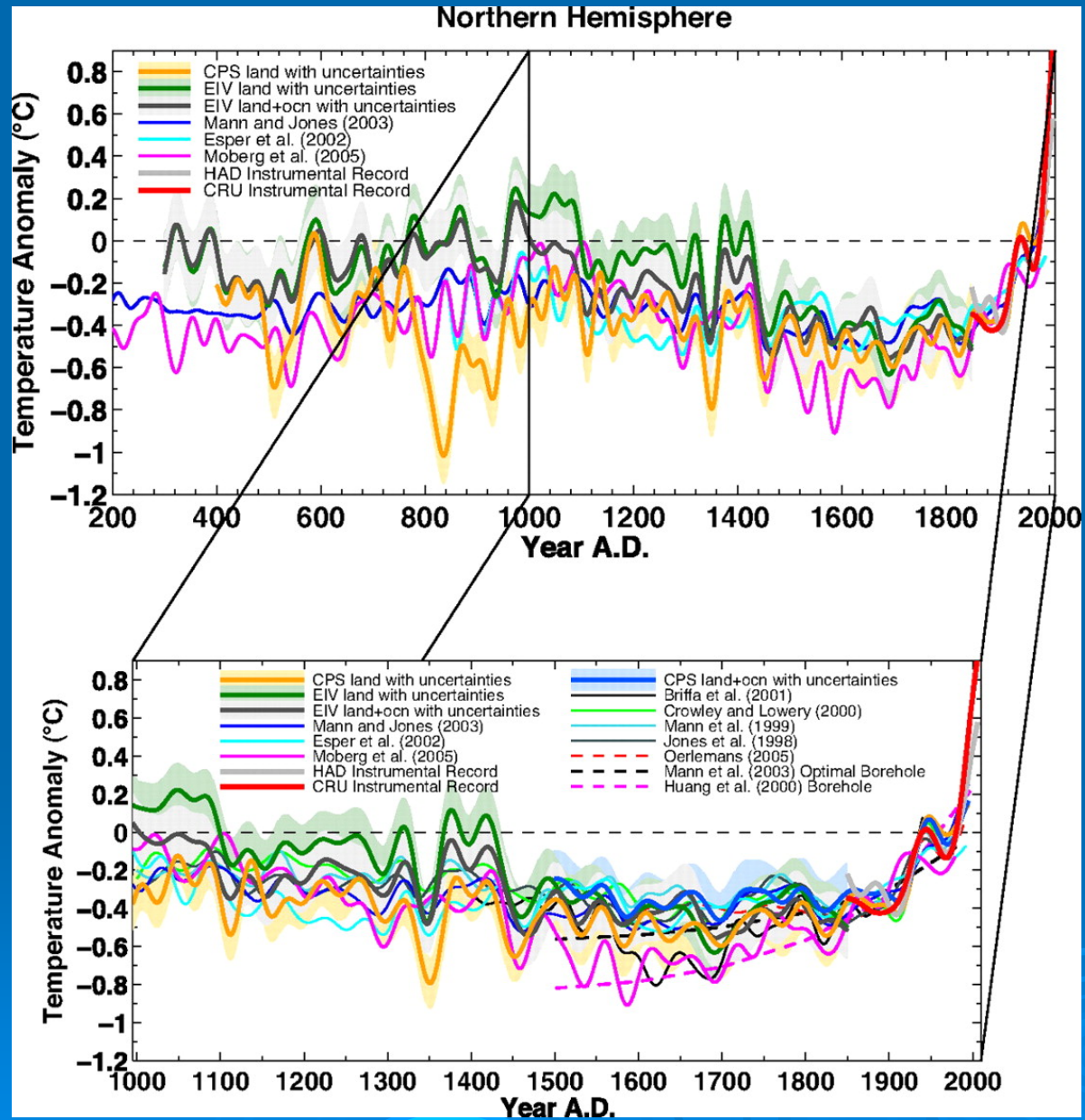
What has been learned in 2008?

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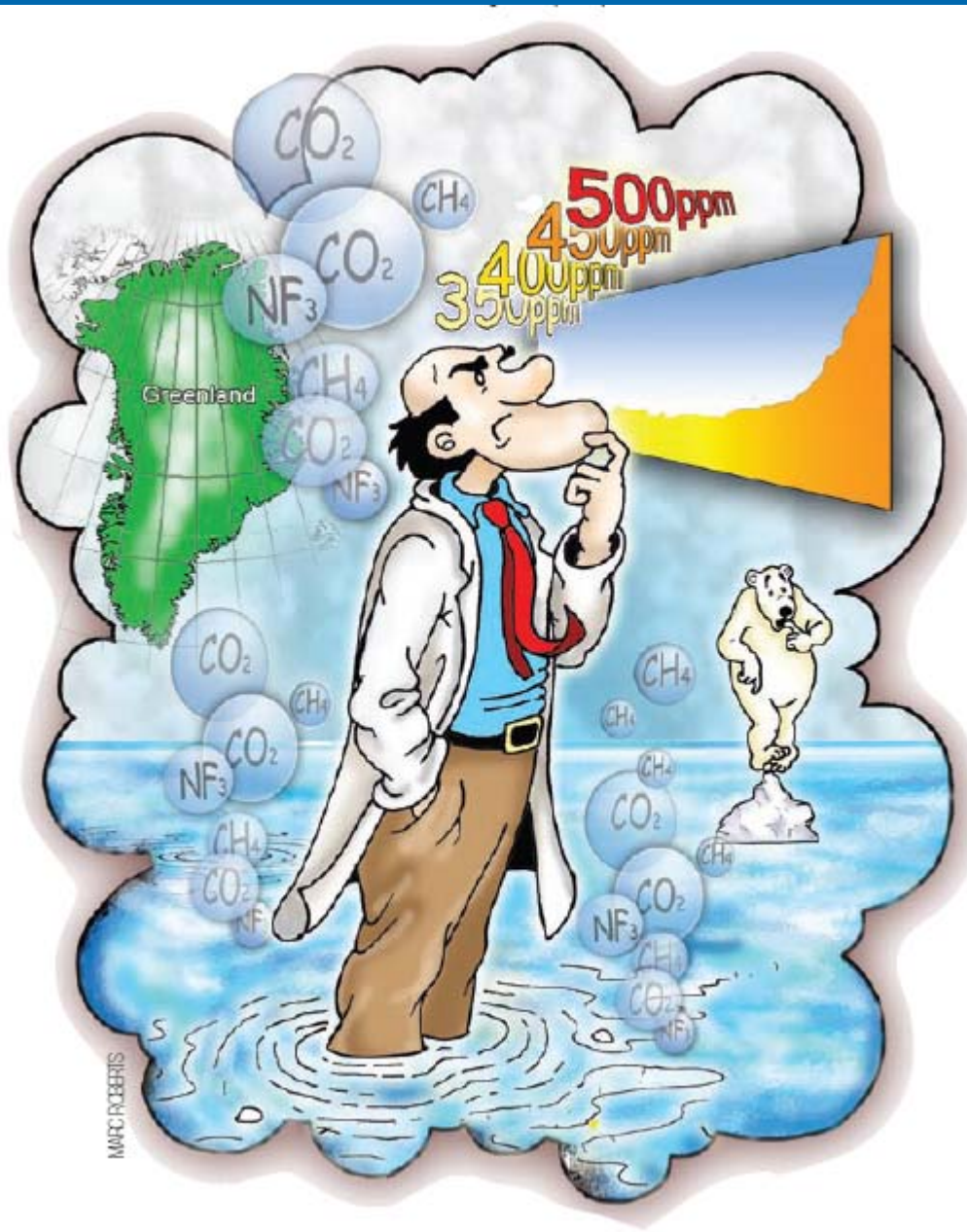
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Mann M. E. et.al. PNAS 2008;105:13252-13257

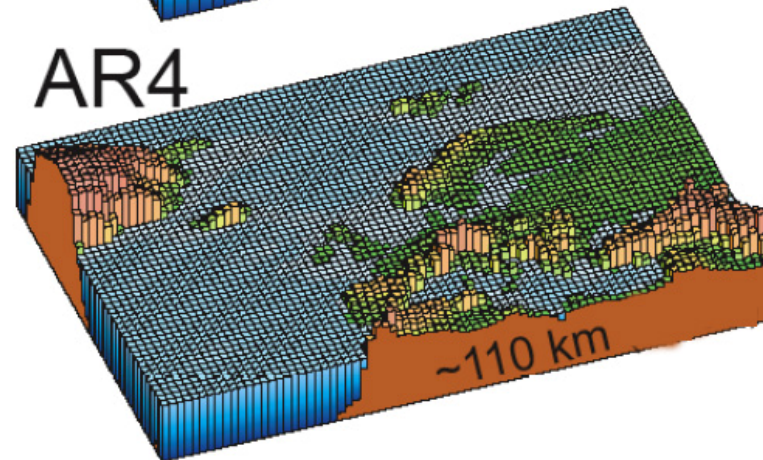
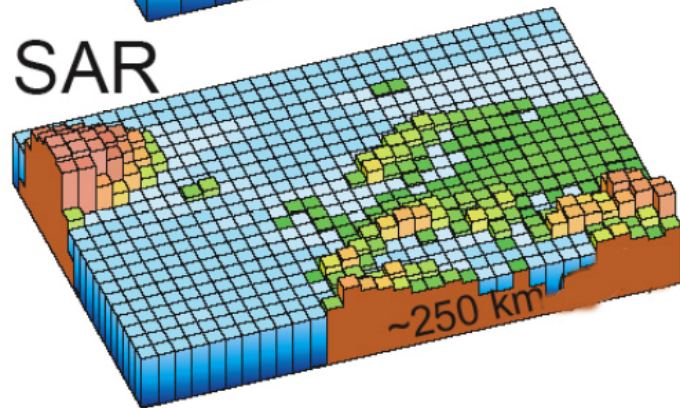
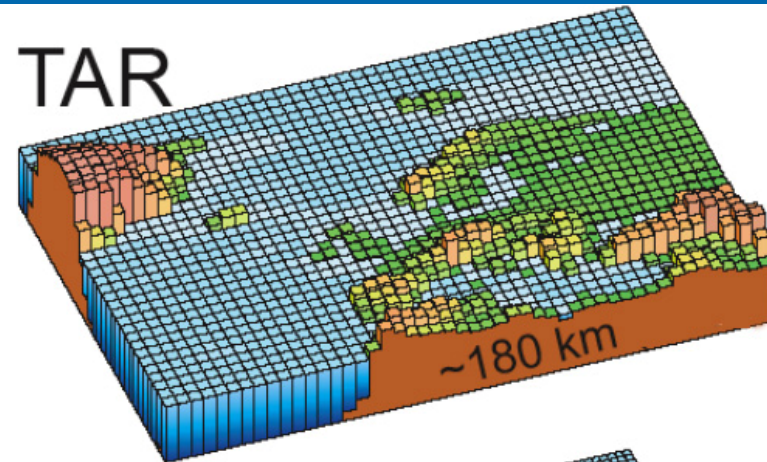
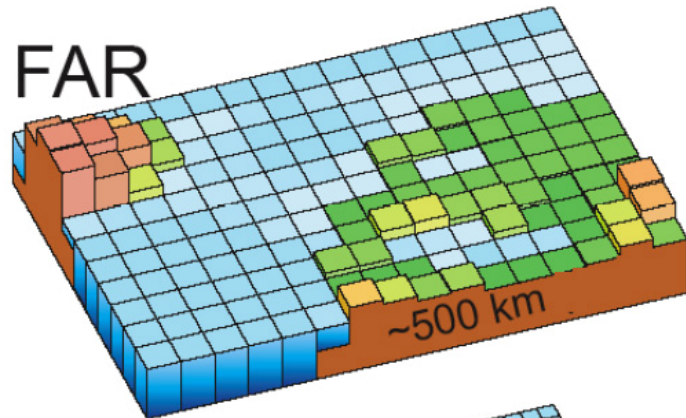


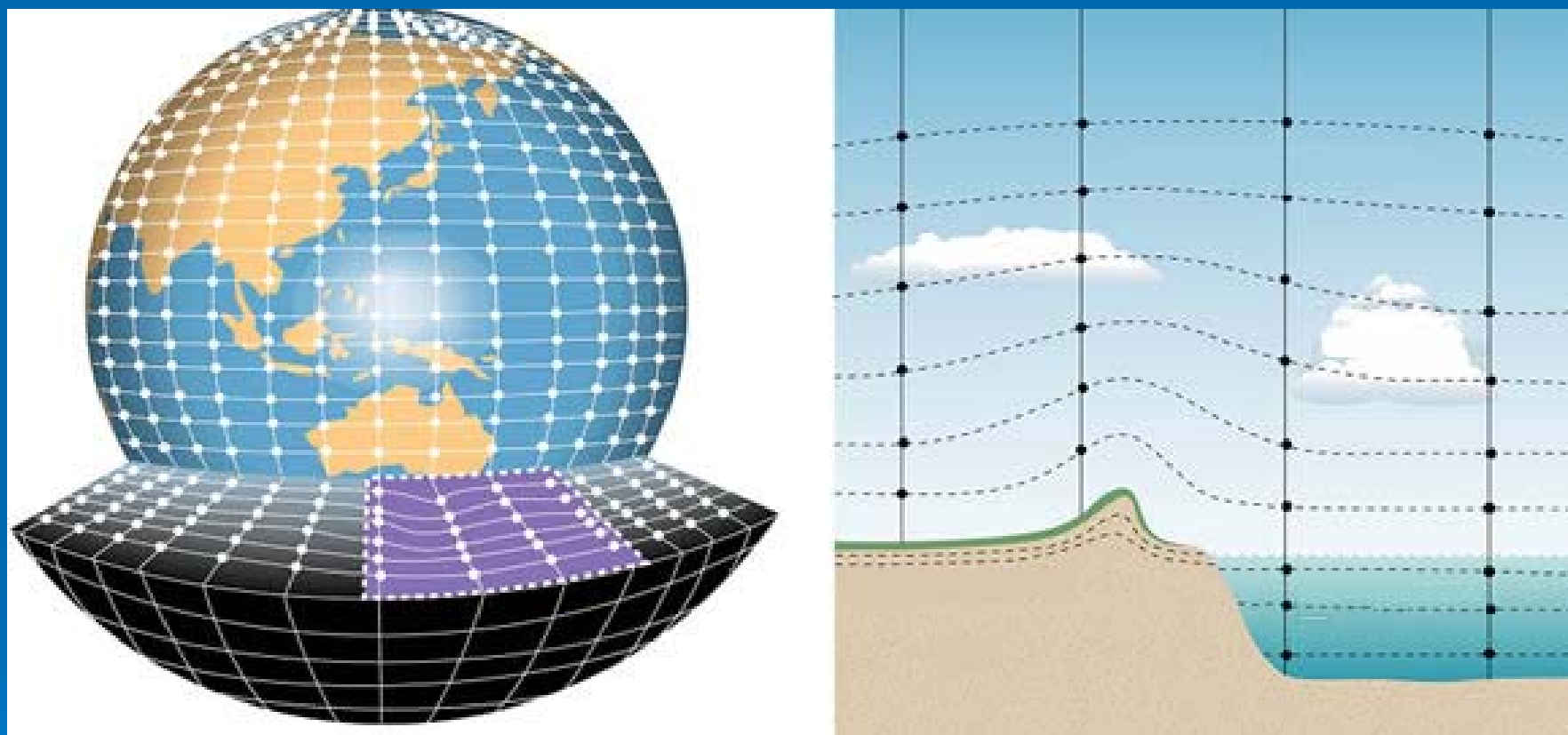
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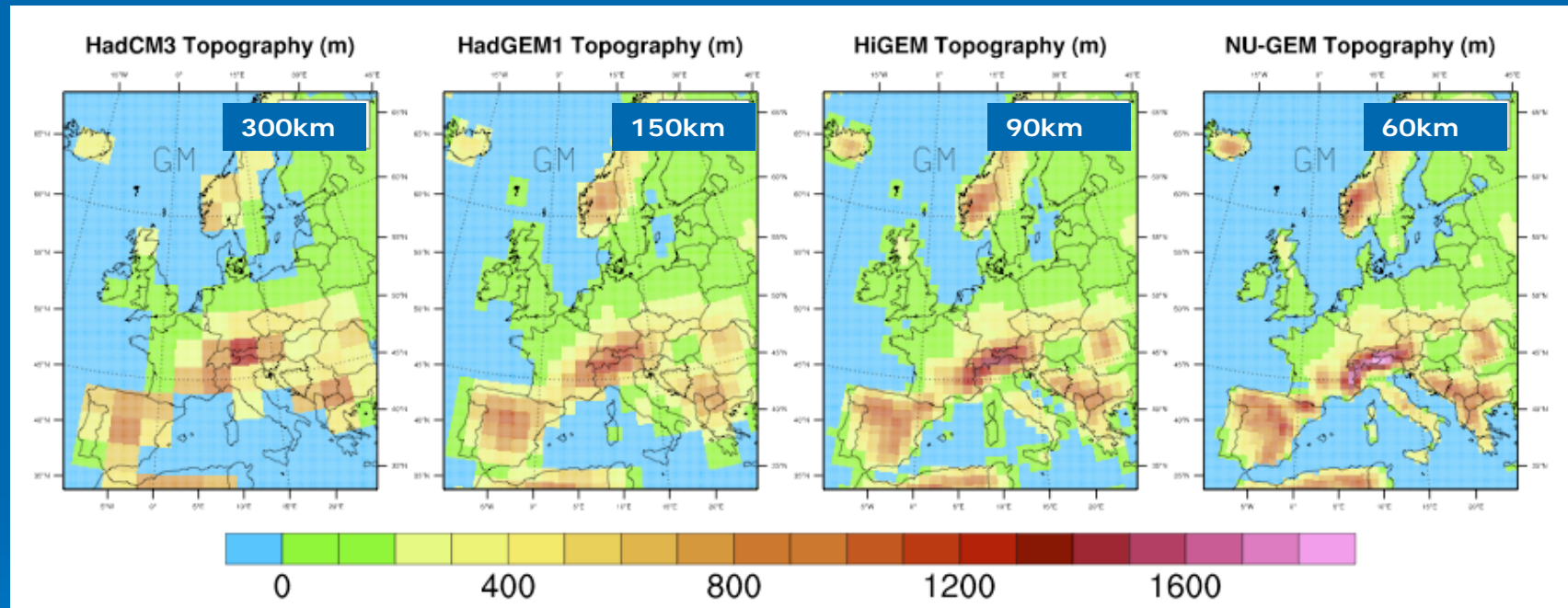
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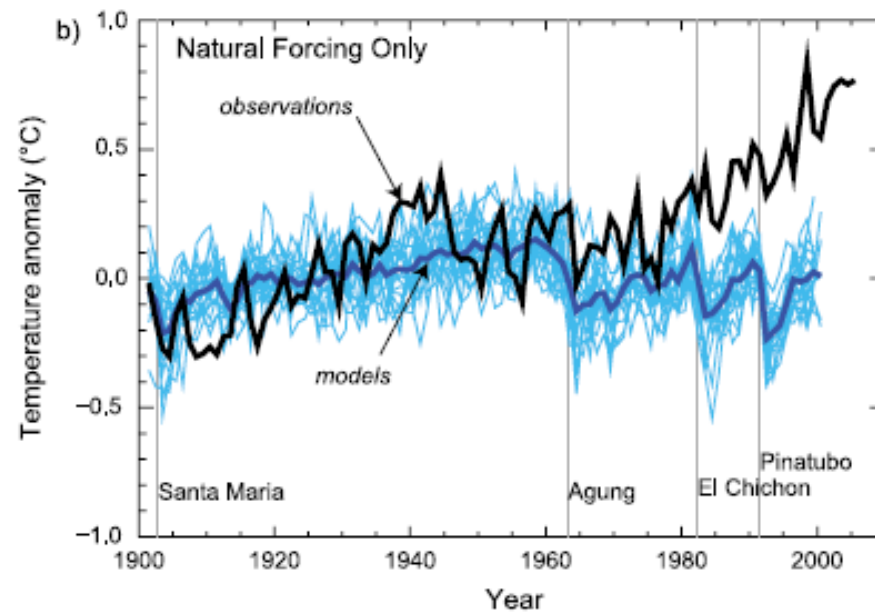
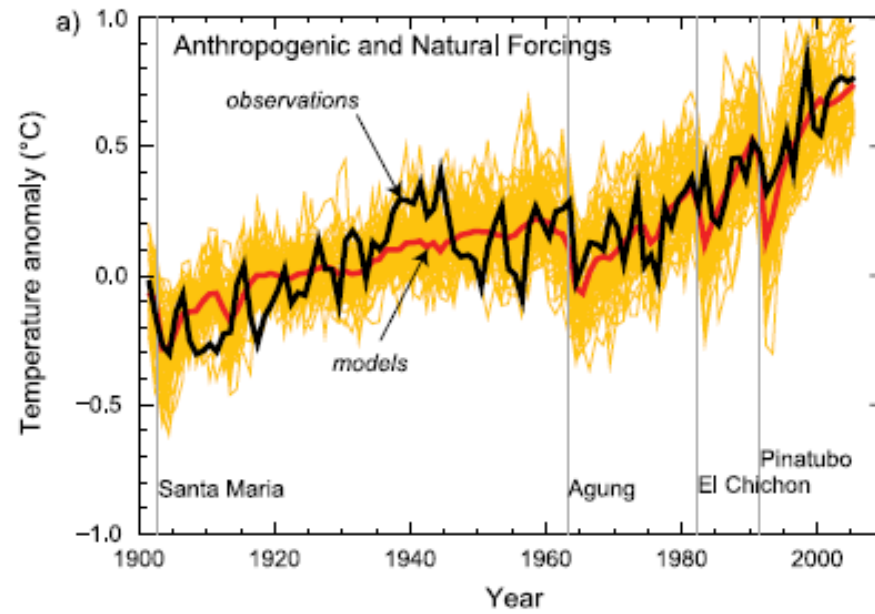
Font: M. Noguera, 2007

# Regional downscaling still in development



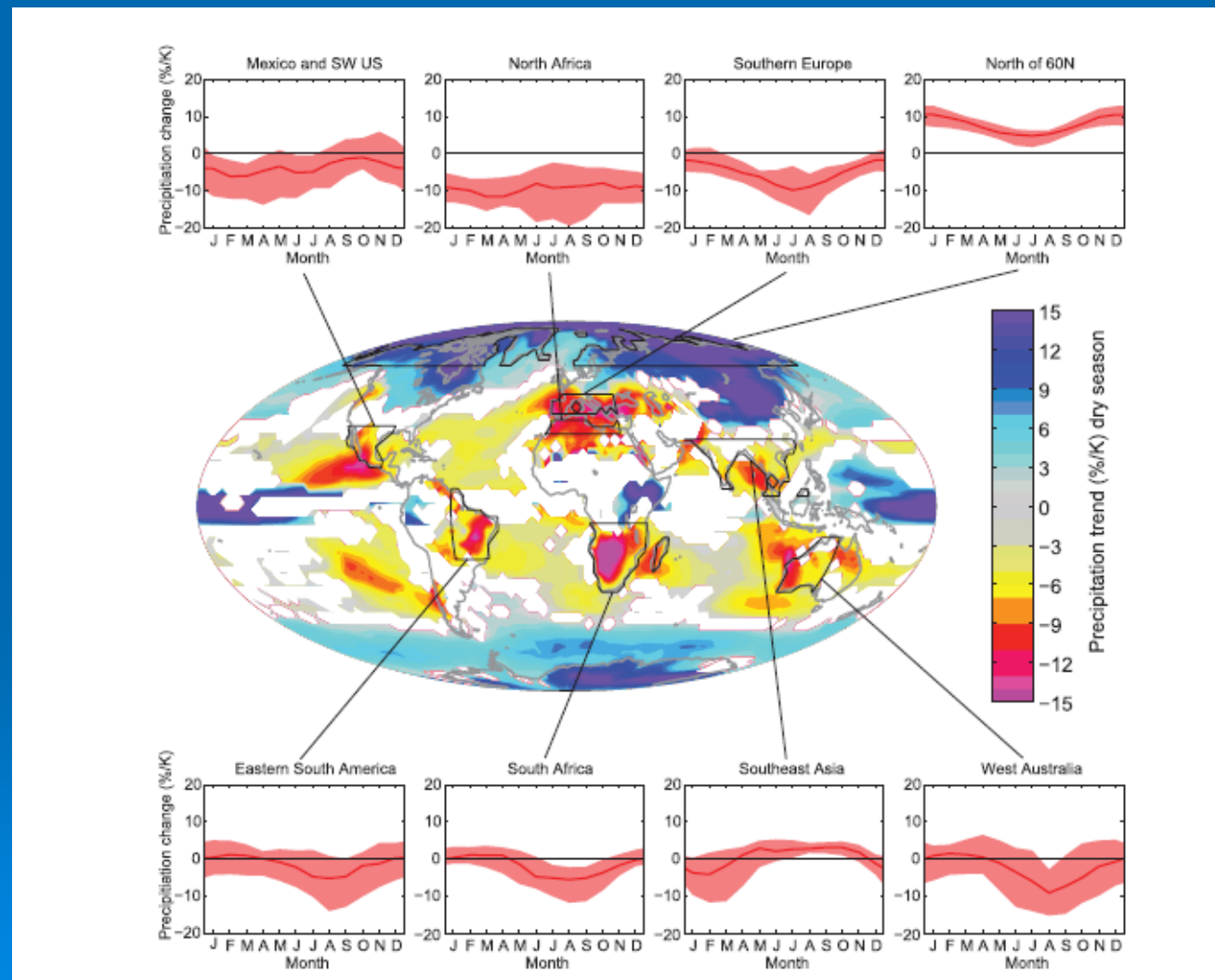
Font: Noguera, 2007

## GLOBAL MEAN SURFACE TEMPERATURE ANOMALIES

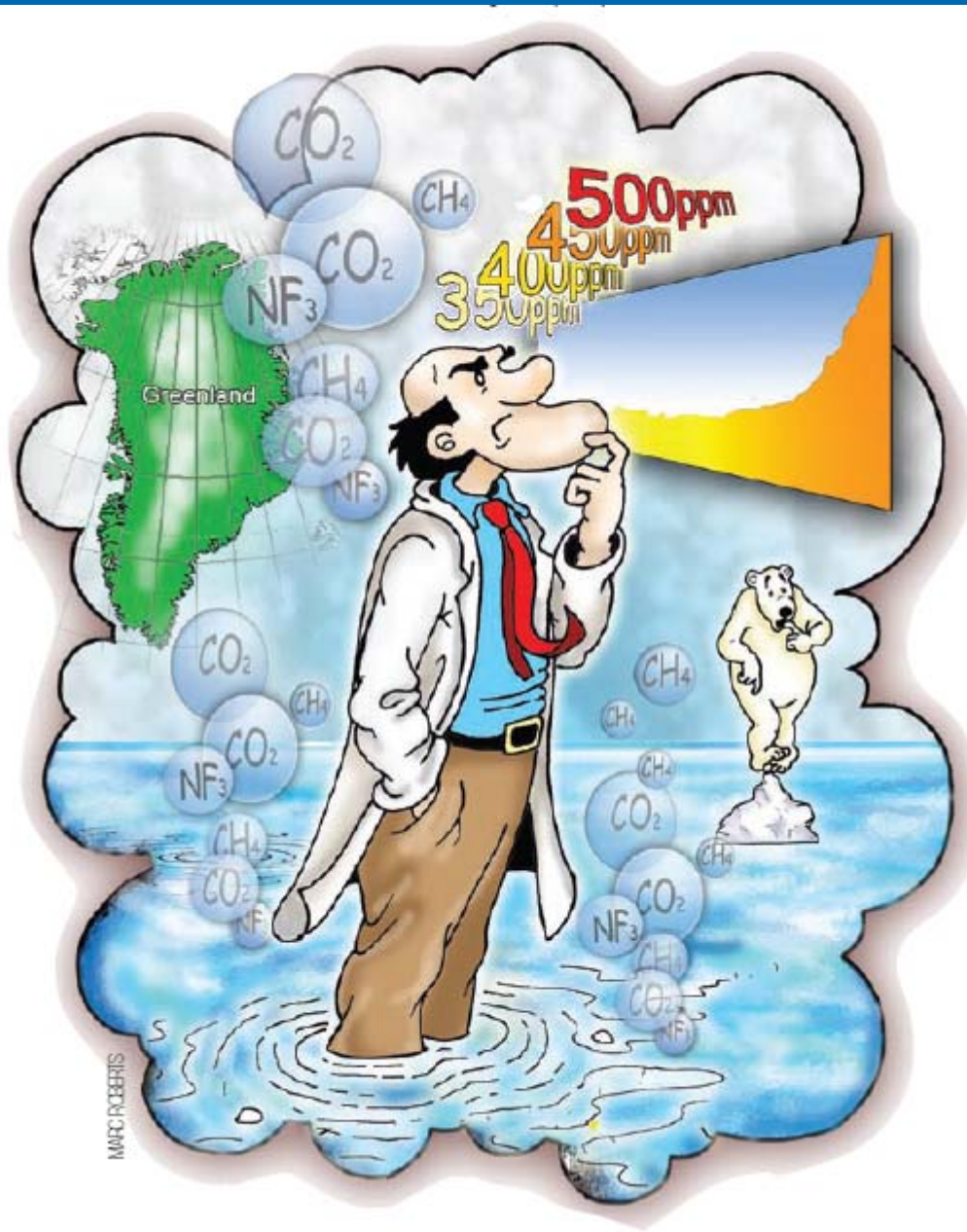


©IPCC 2007: WG1-AR4

# Expected averaged changes in the global distribution of precipitation per degree of warming



Susan Solomon et al. PNAS 2009



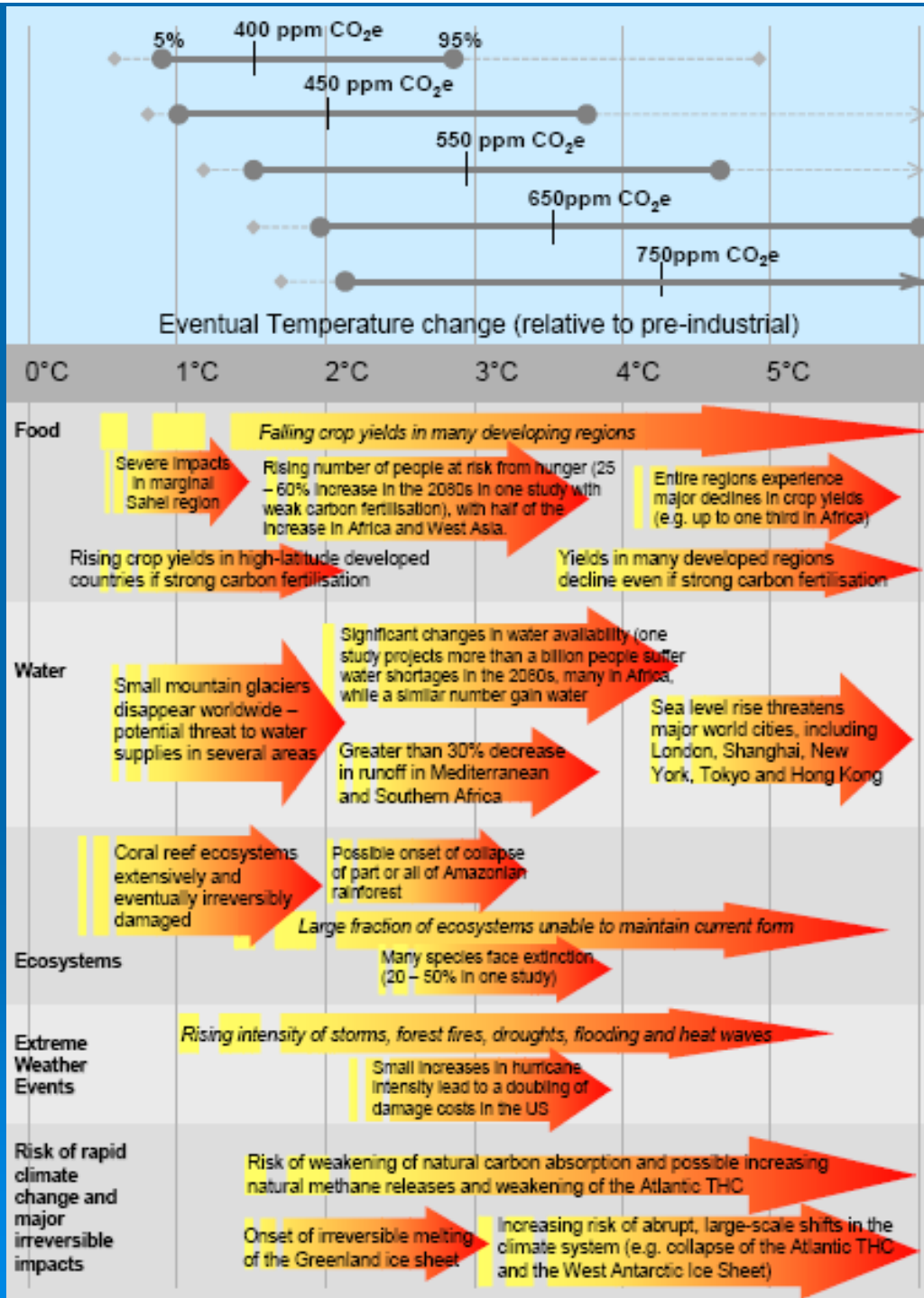
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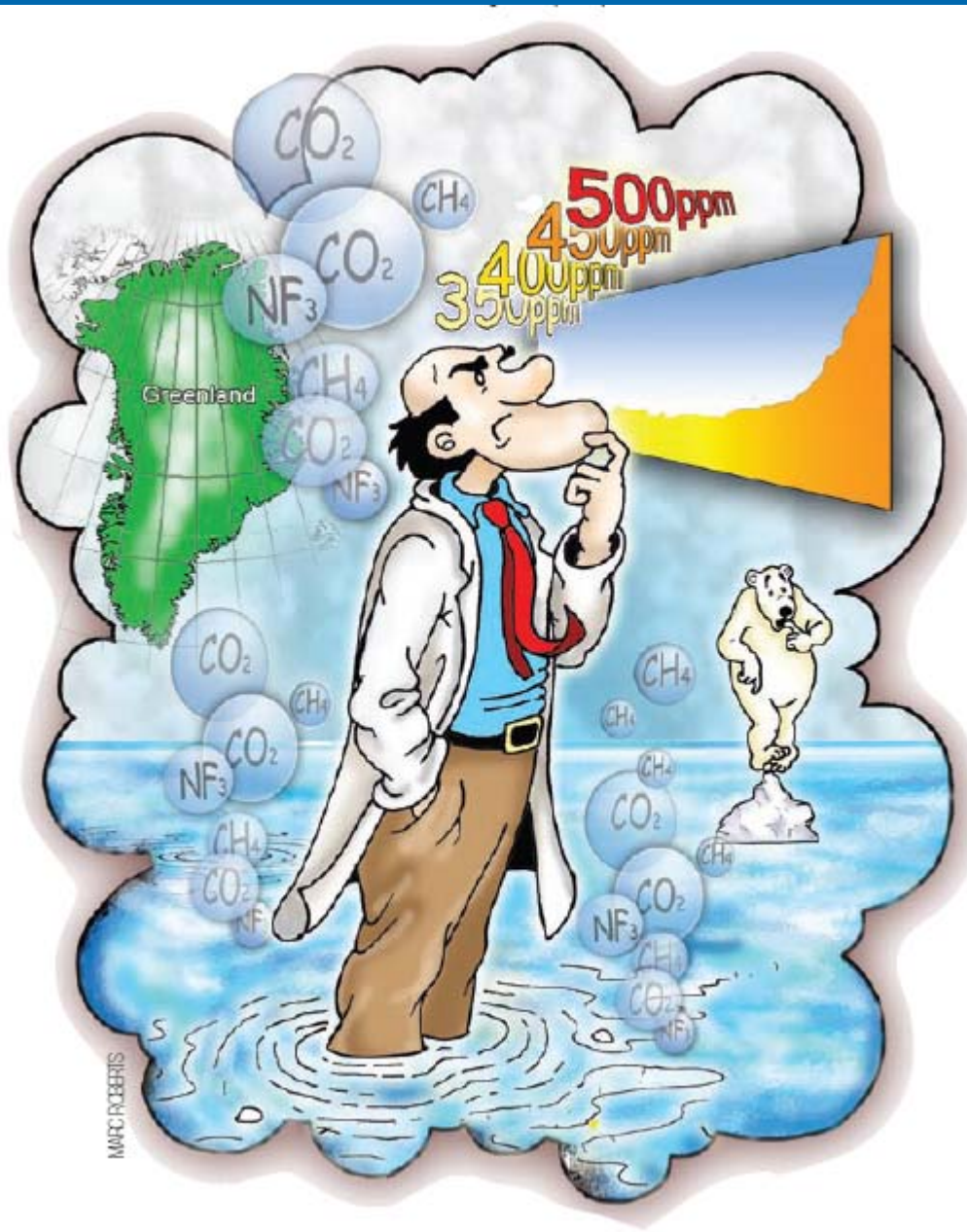
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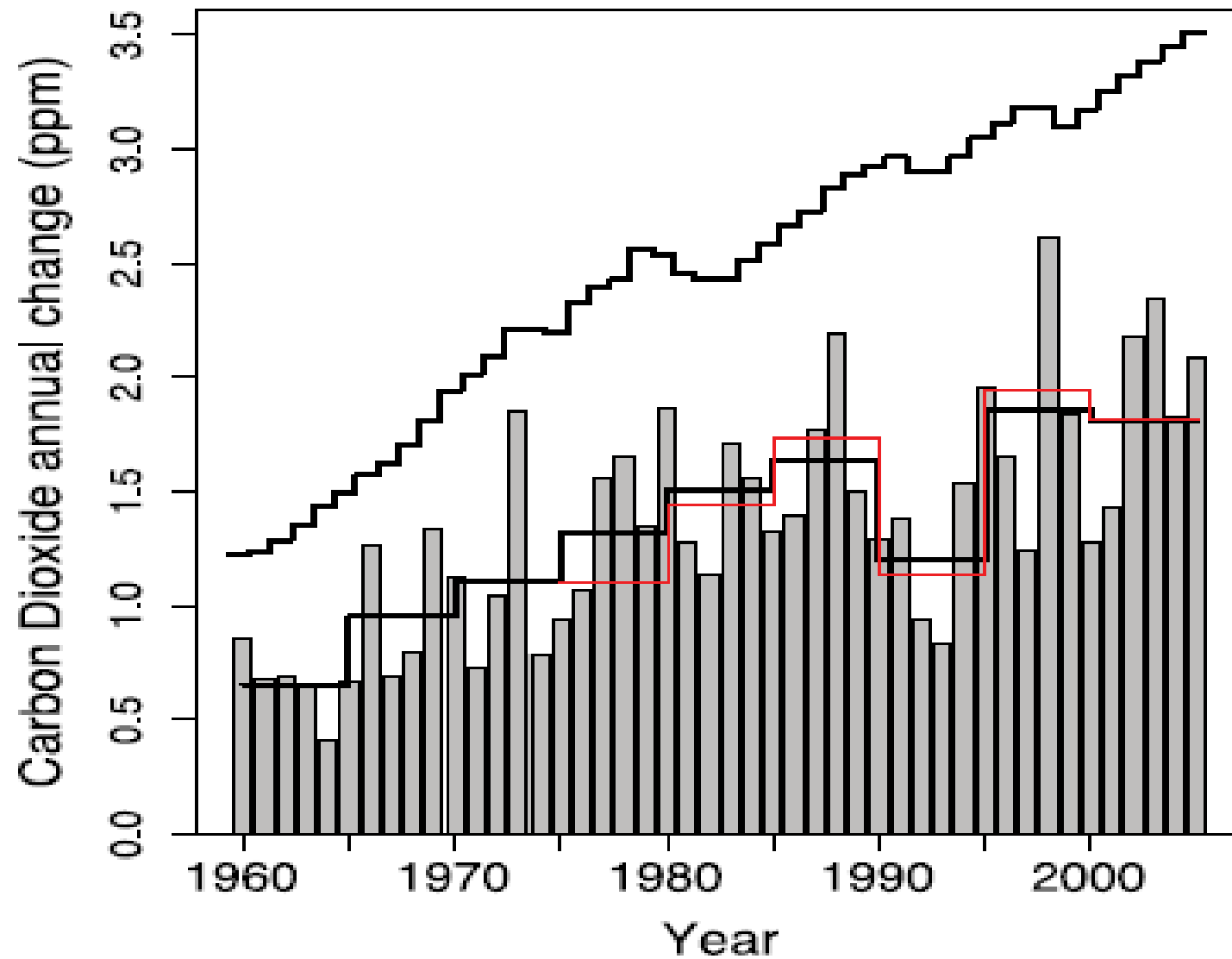
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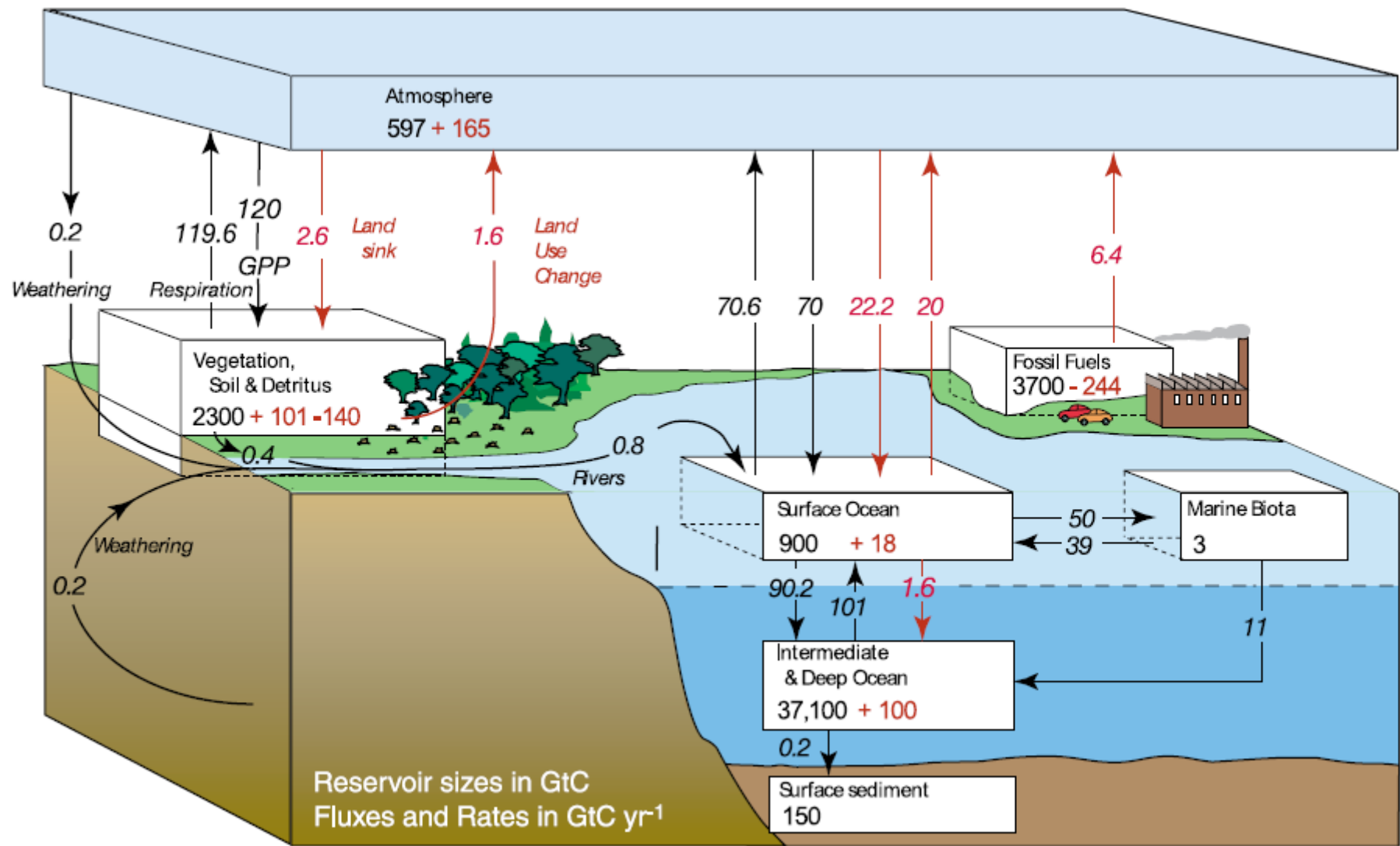
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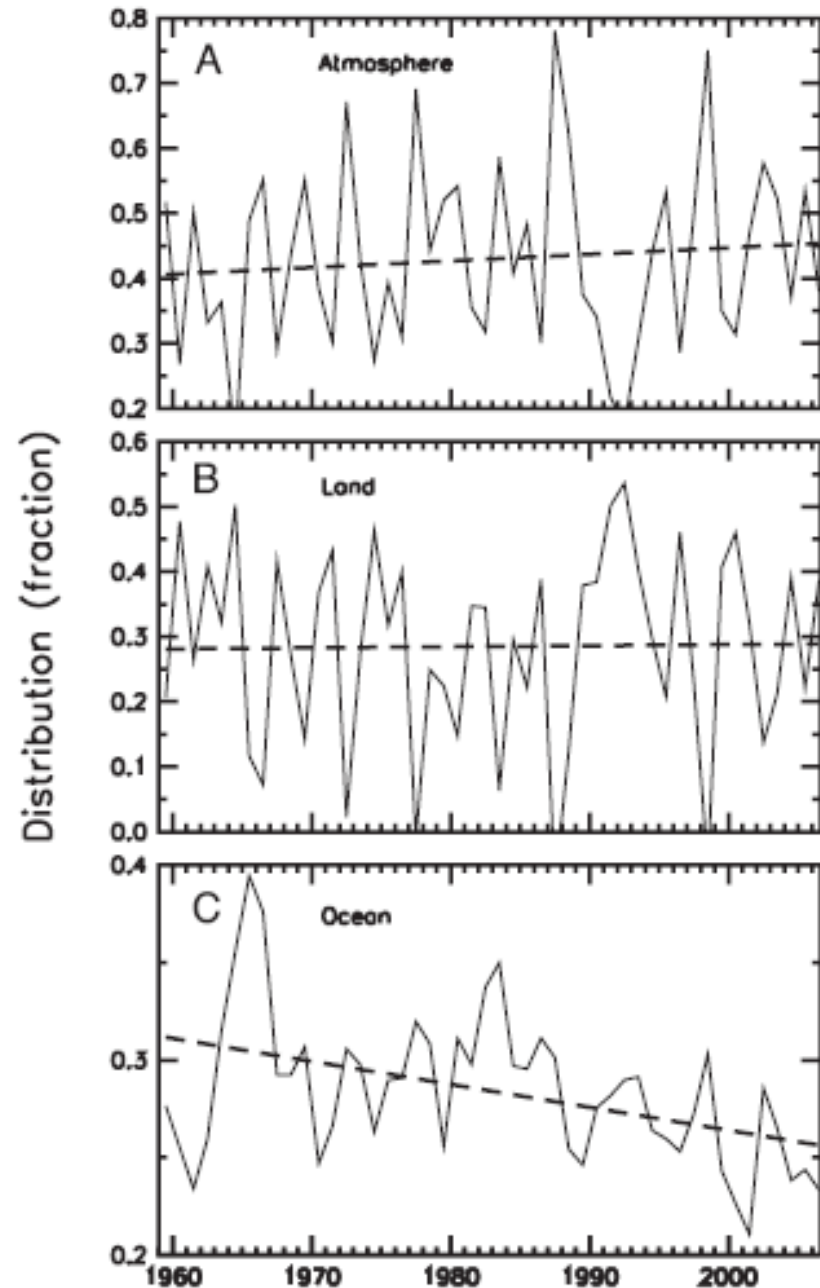
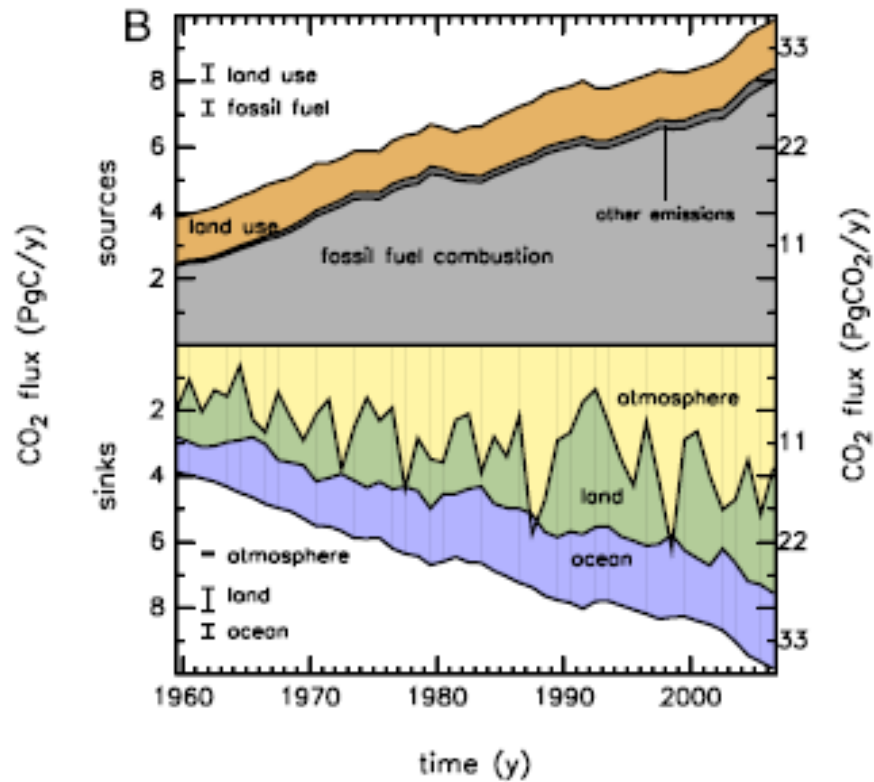
## CO<sub>2</sub> EMISSIONS AND INCREASES



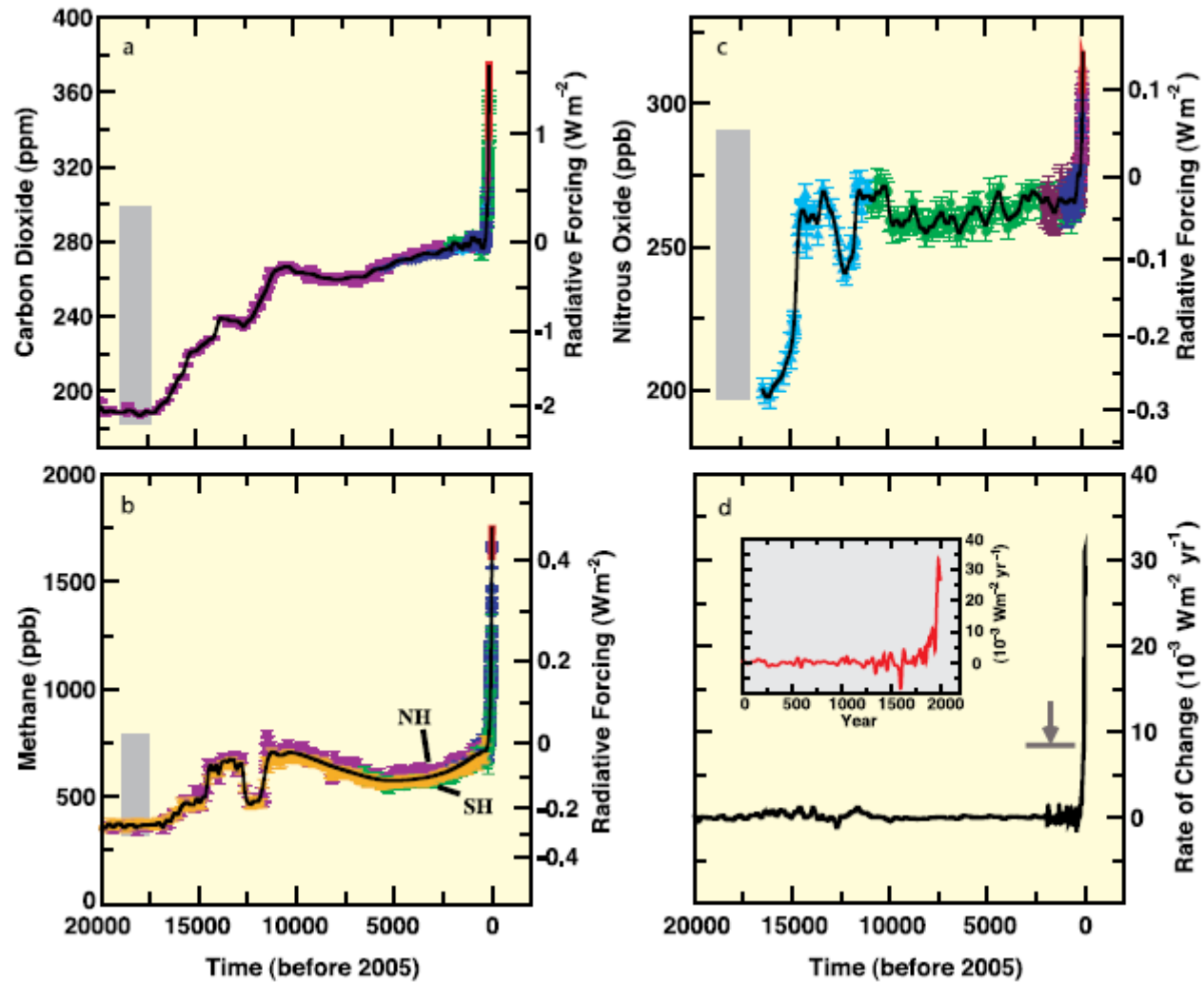


Font: Sarmiento i Gruber 2006

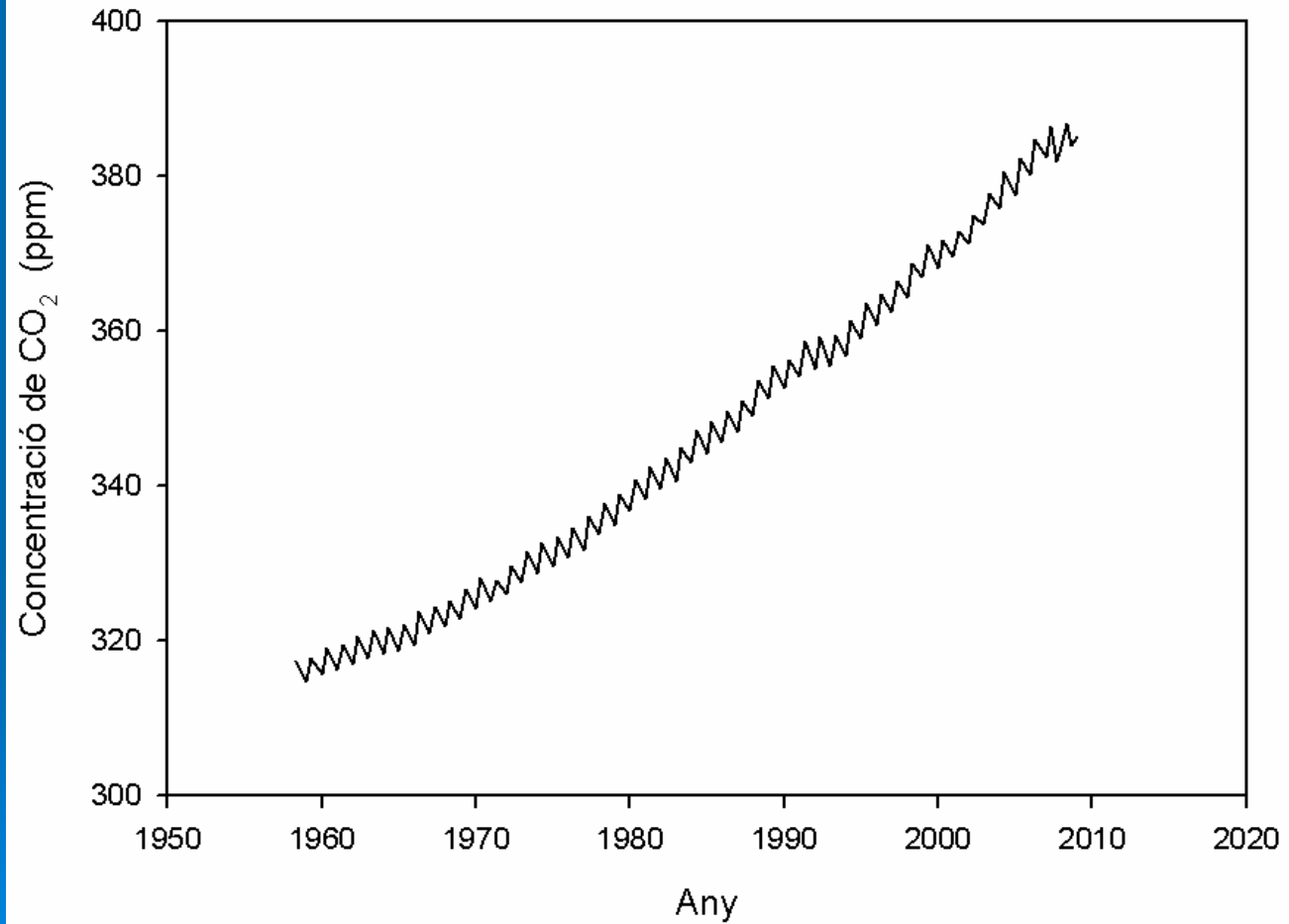
# Efficiency of natural sinks



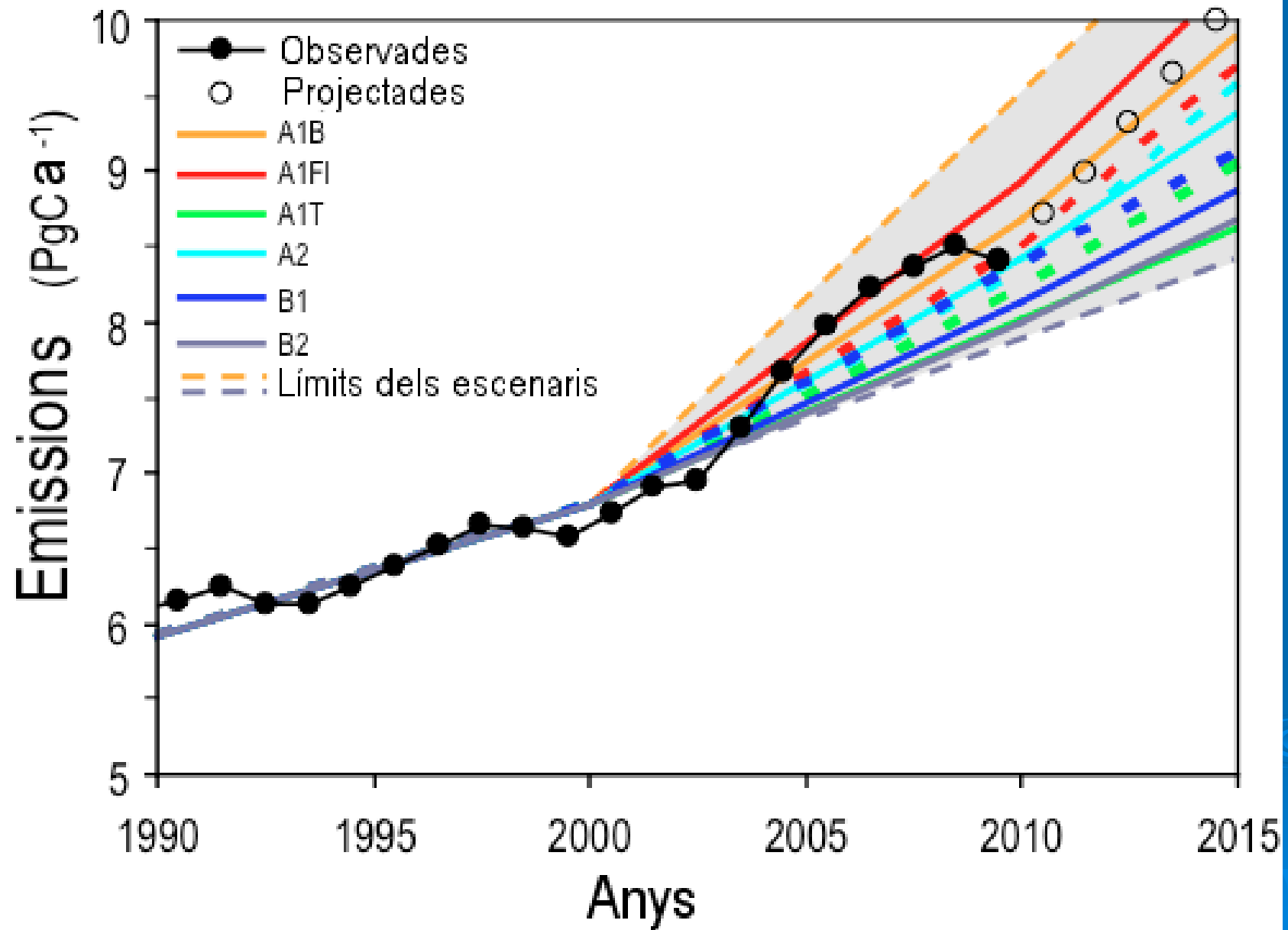
## CHANGES IN GREENHOUSE GASES FROM ICE CORE AND MODERN DATA



### Concentració de CO<sub>2</sub> a Mauna Loa (Hawaii)

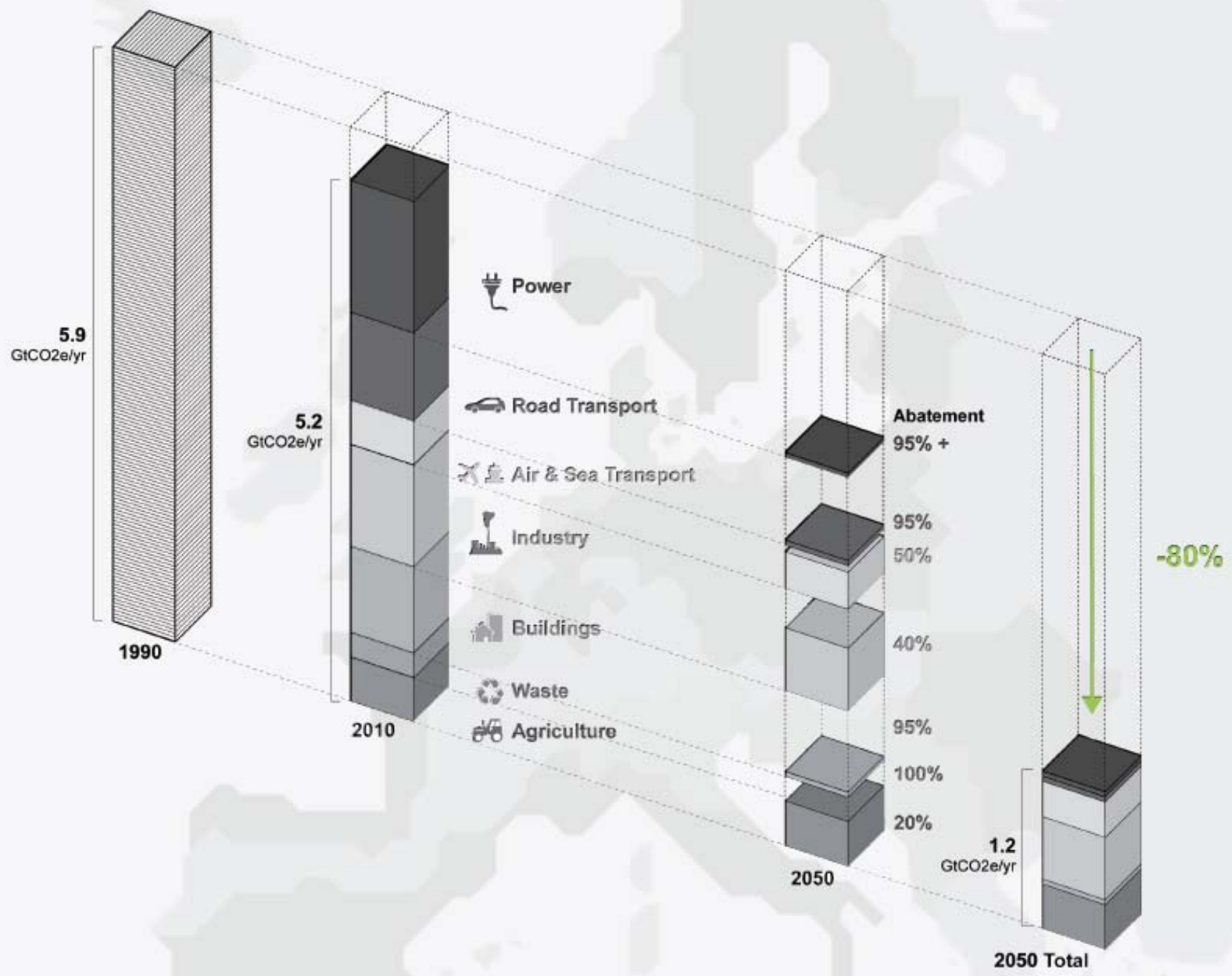


Data: NOAA 2009



Font: Carbon Project 2011, Pep Canadell

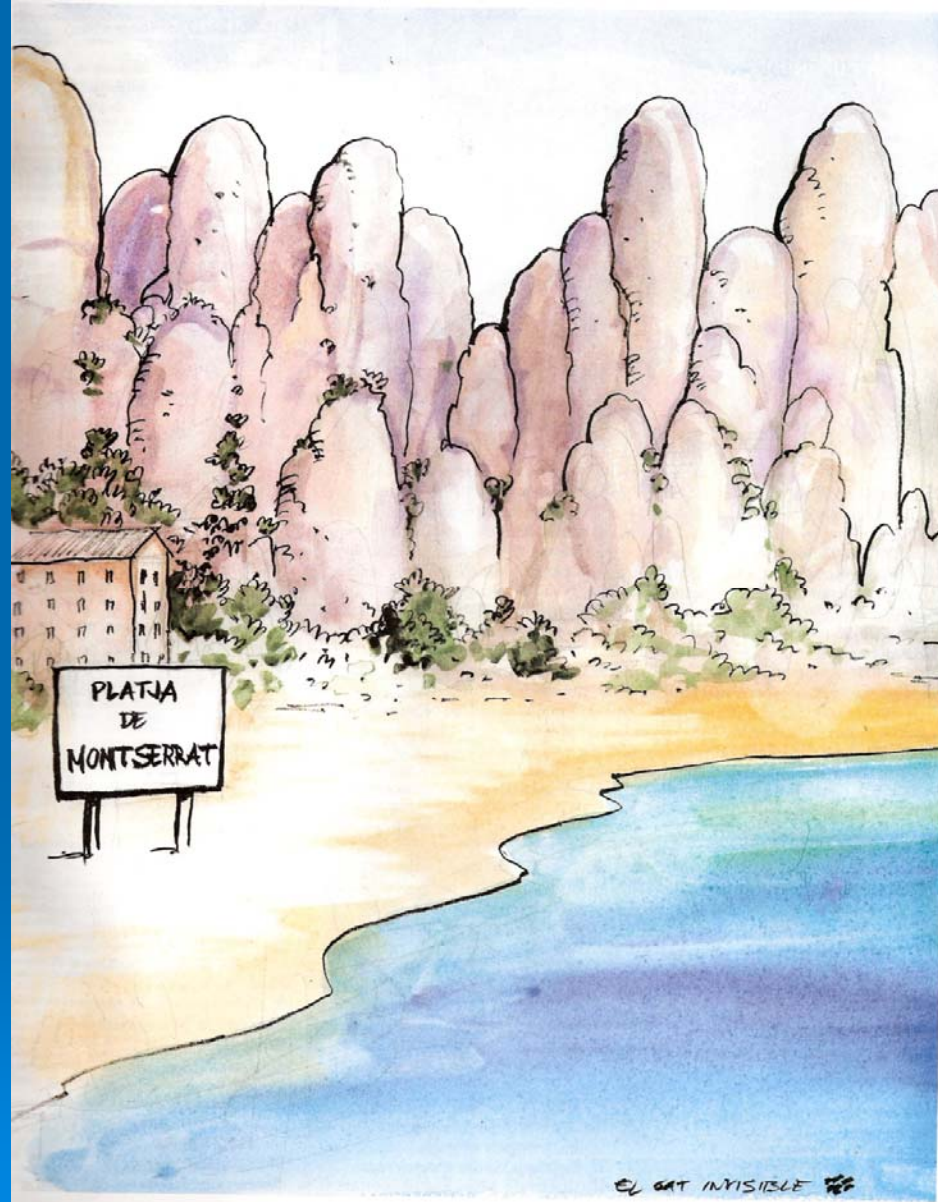




**Everybody believes global warming  
is going on?**



Gatonera



6 DE NOVEMBRE DEL 2007 EL TEMPS 3

El Temps, 6 de nov. 2007





SPECIAL ADVERTISING SECTION

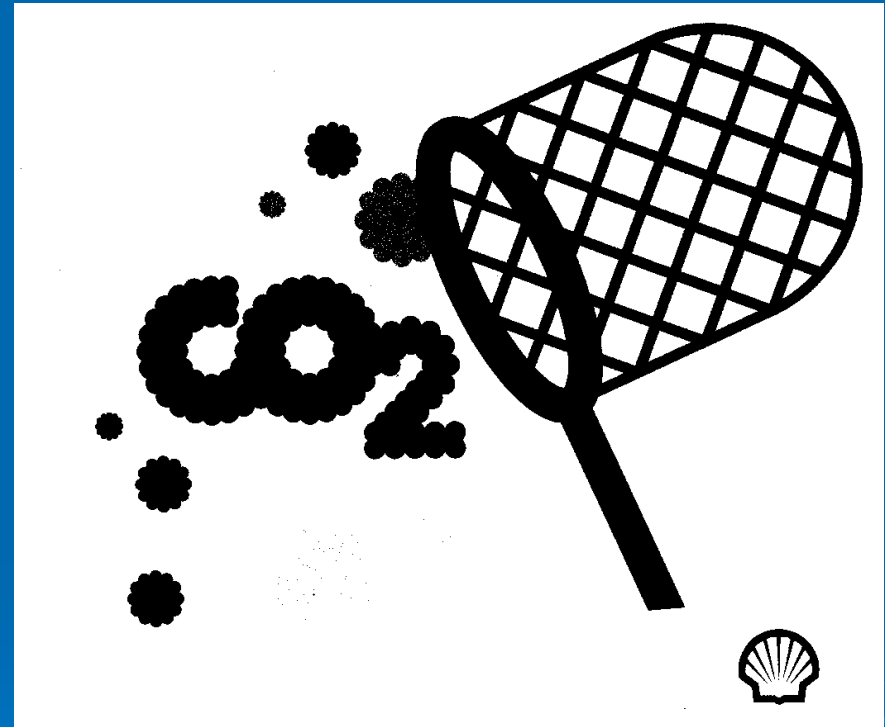
# The Heat Is On

Companies are rushing to find a cure for climate change. Here's what they are doing to help save the planet.



In partnership with:

**CARBON DISCLOSURE PROJECT**



# Climate geoengineering?

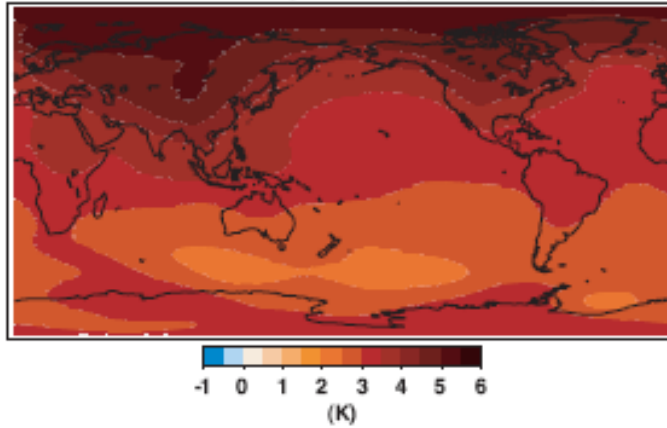


Paul Crutzen

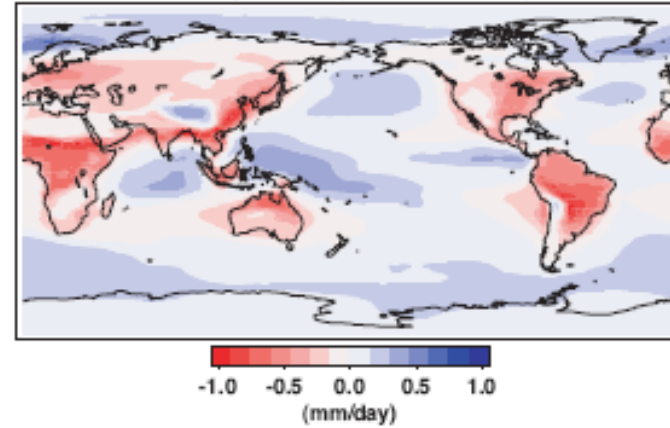


Results from modelling surface air temperature (a i c) and precipitation (b i d) for scenario A2 for 2100 (a b) and with geoengineering (c d)

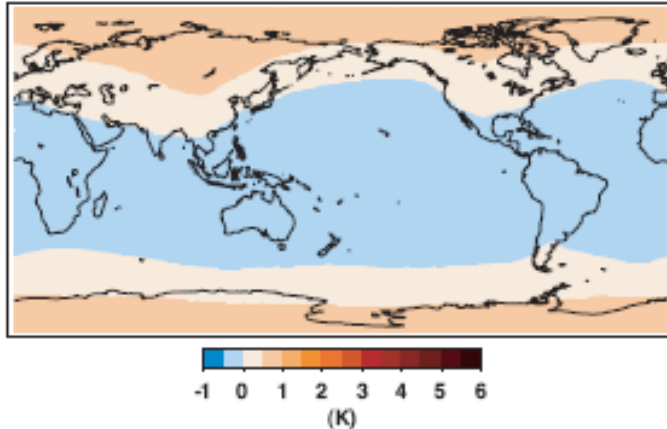
a Surface Air Temperature (A2: 2100-1900)



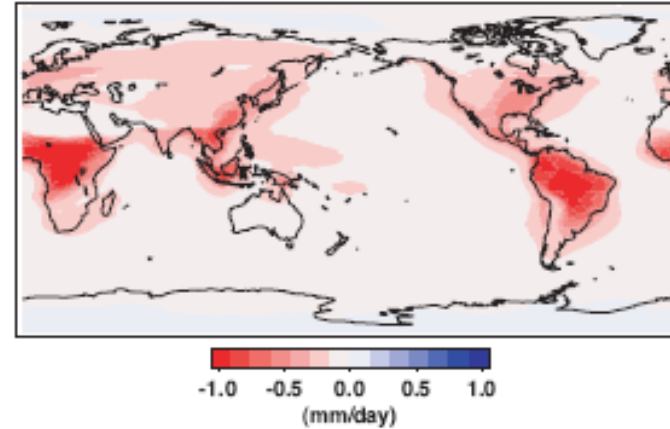
b Precipitation (A2: 2100-1900)



c Surface Air Temperature (GEO: 2100-1900)

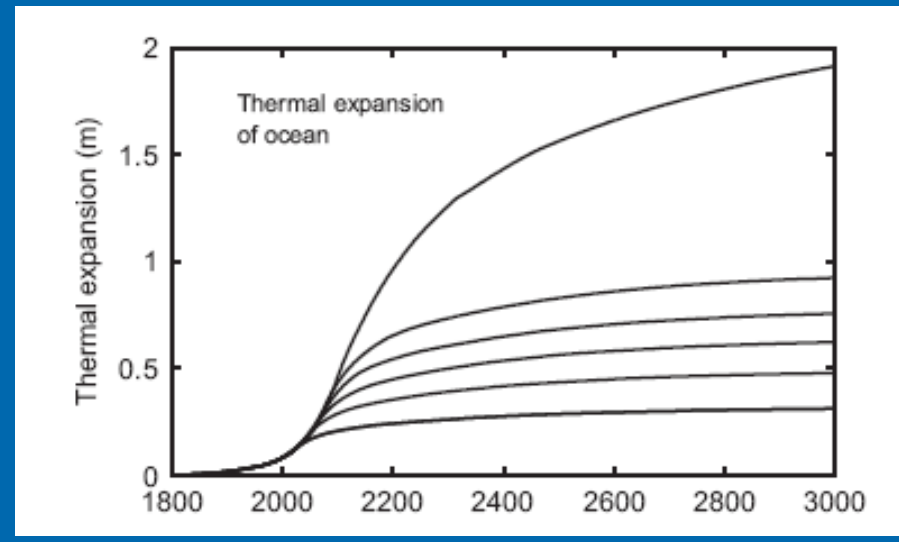
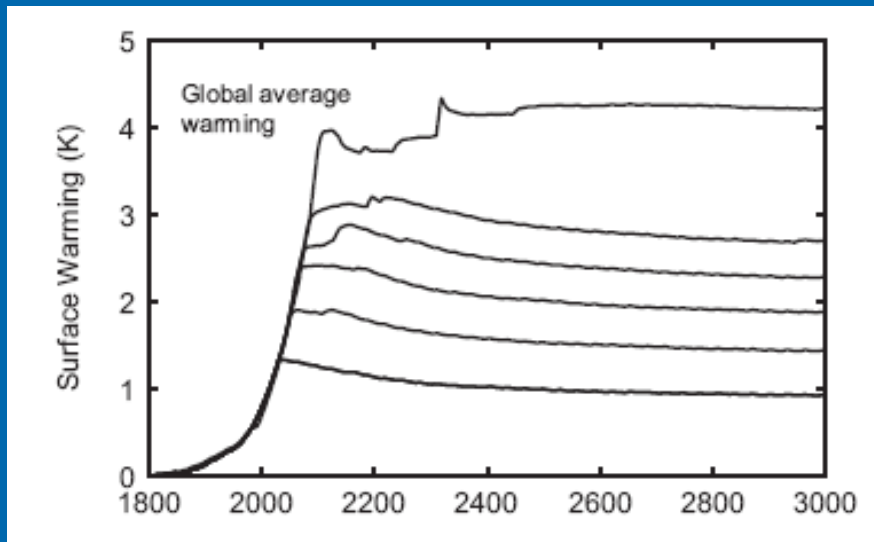
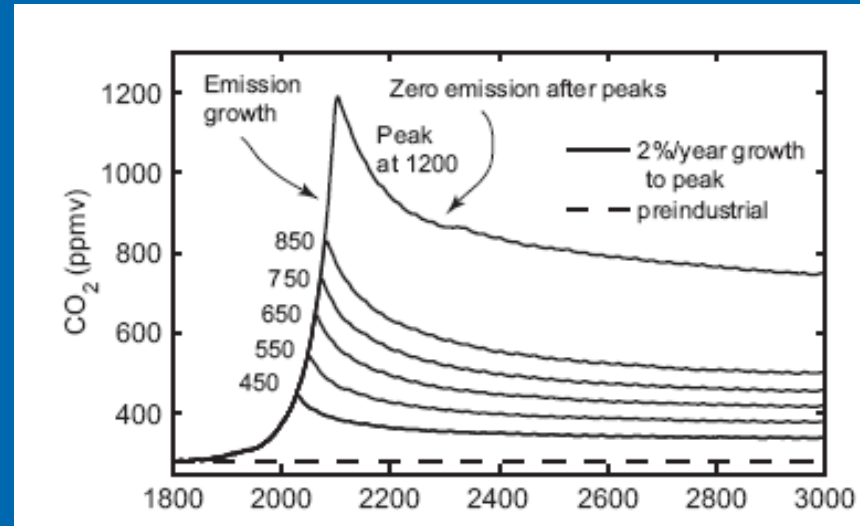


d Precipitation (GEO: 2100-1900)





# Changes are irreversible!



Susan Solomon et al. PNAS 2009