

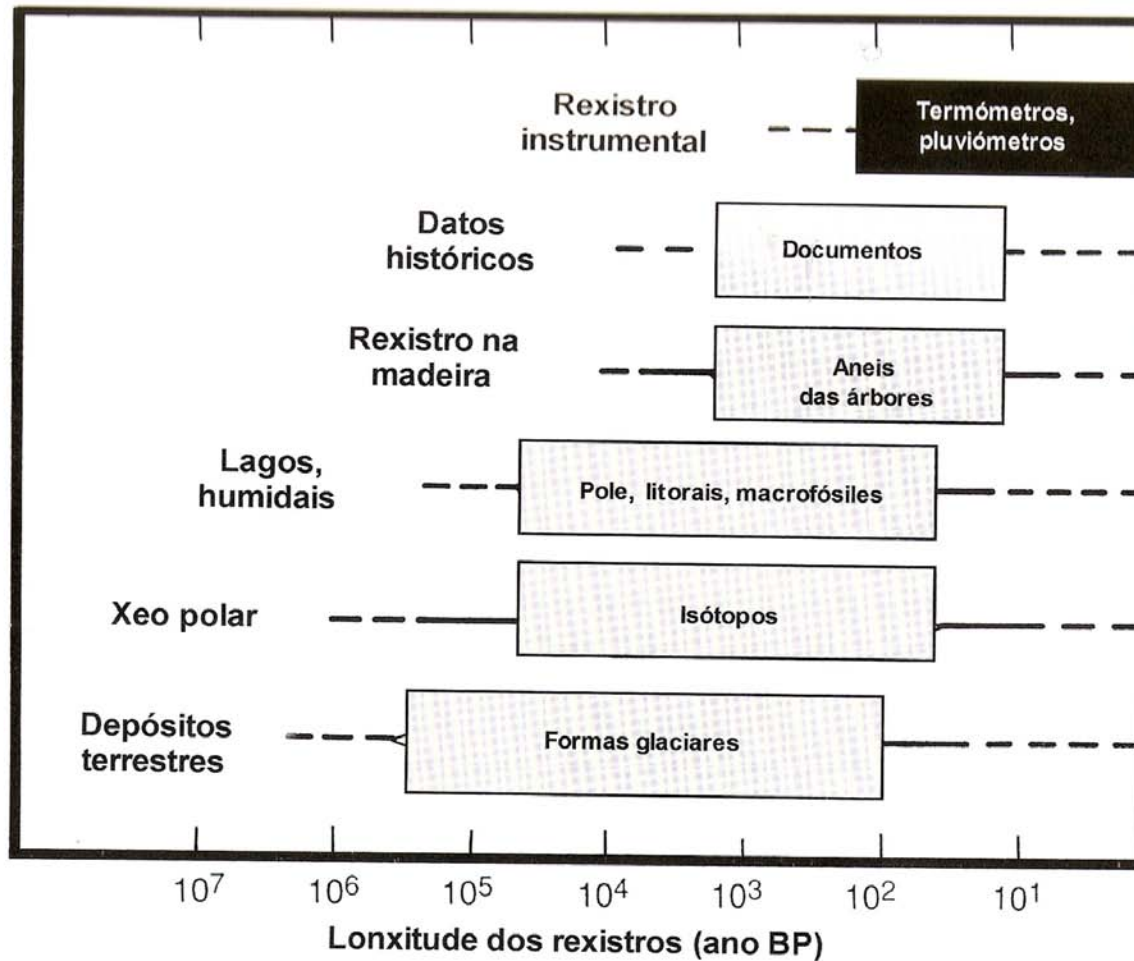
**CUESTIONES FUNDAMENTAIS**

**SOBRE O**

**CAMBIO CLIMÁTICO**

**Francisco Díaz-Fierros Viqueira**

# OS MÉTODOS



# OS MÉTODOS

## Medidas instrumentais

- **FONTES DE ERROS**
  - a) **Dos datos**
    - Calibración dos instrumentos
    - Instalación dos instrumentos
    - Problemas do contorno
    - Representatividade da estación
  - b) **Dos estatísticos**
    - Valores normais
    - Tendencias

# OS MÉTODOS PROXY

## Dendrocronoloxía

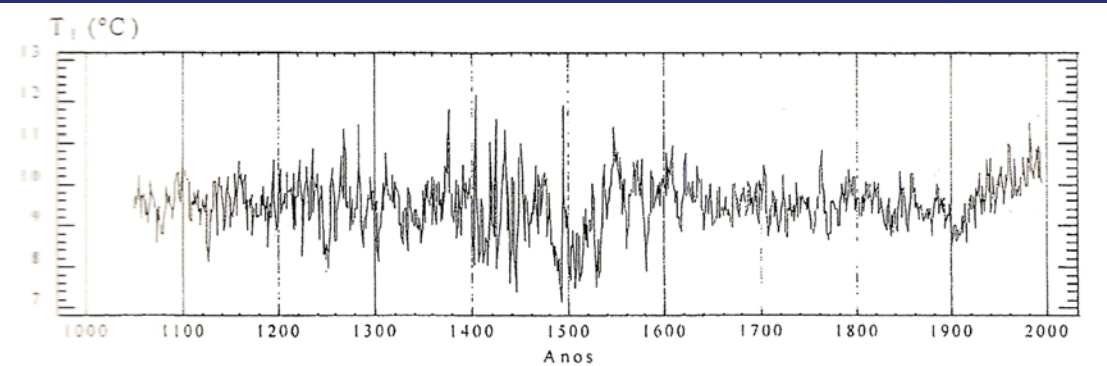
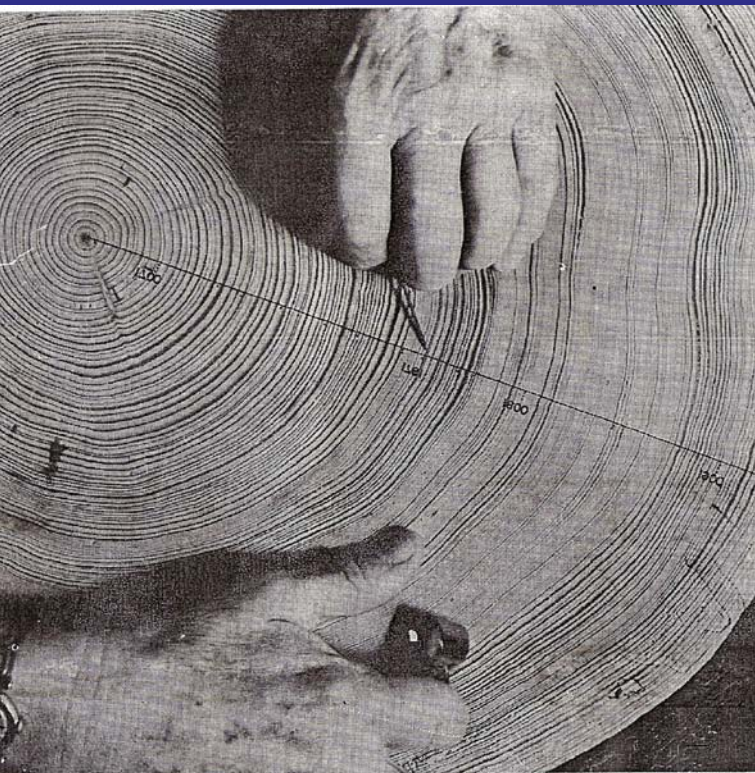
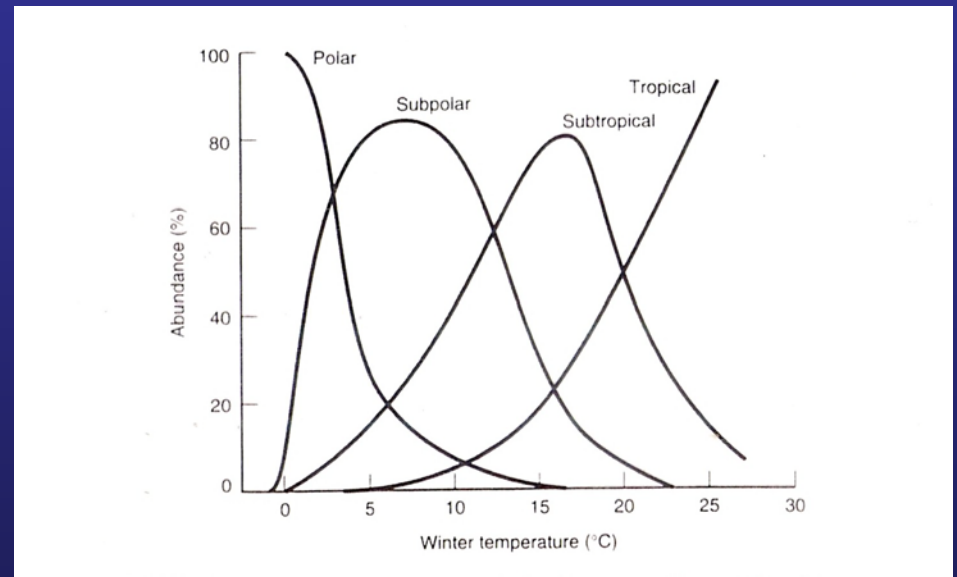
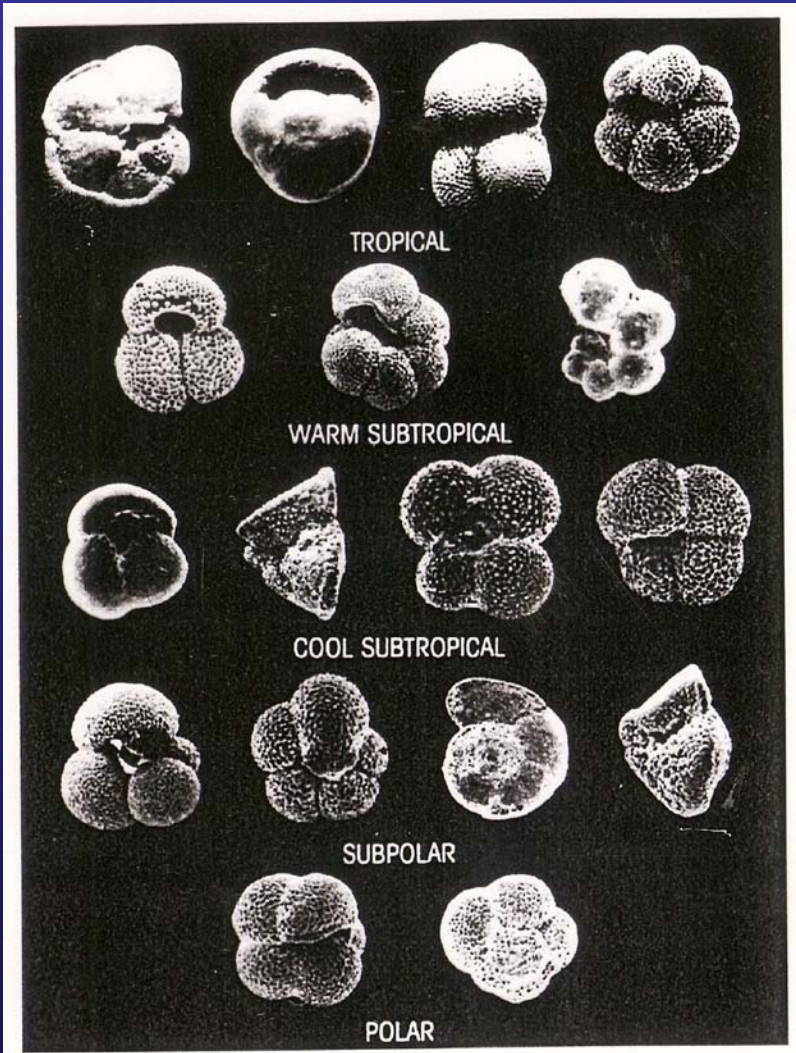


Figura 7.7 Reconstrución dendrocronolóxica para as temperaturas medias de xaneiro do observatorio da Coruña (Fernández Cancio A. e Manrique Menéndez E., 1998)

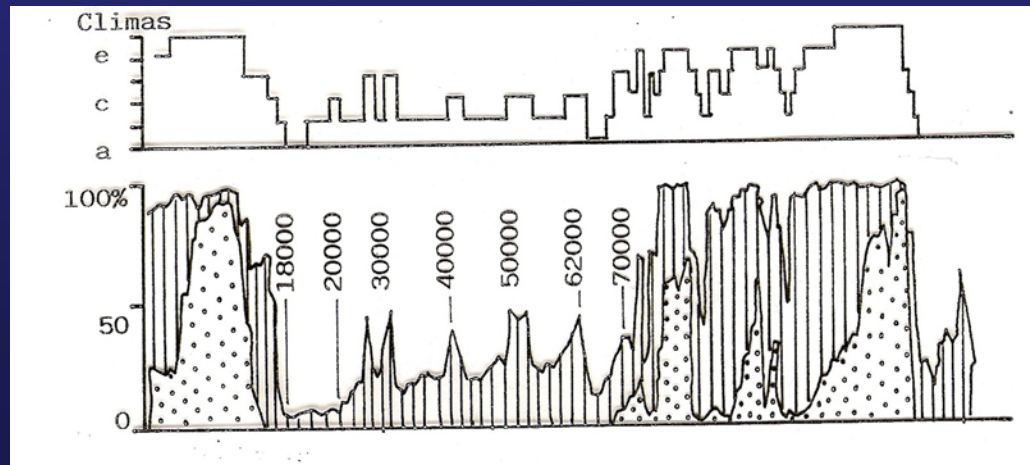
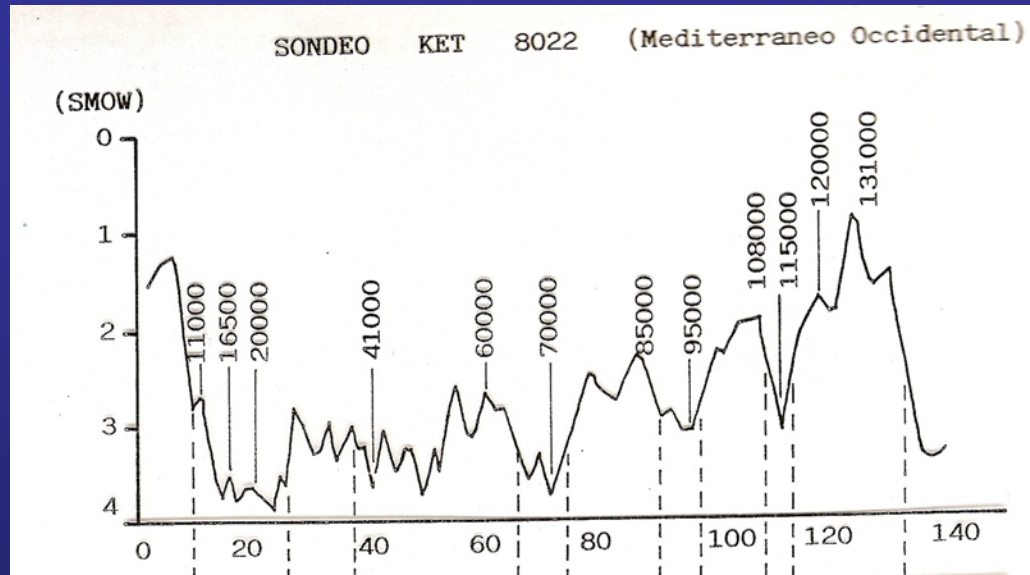
# OS MÉTODOS PROXY 2

## Foraminíferos e diatomeas



# OS MÉTODOS PROXY 3

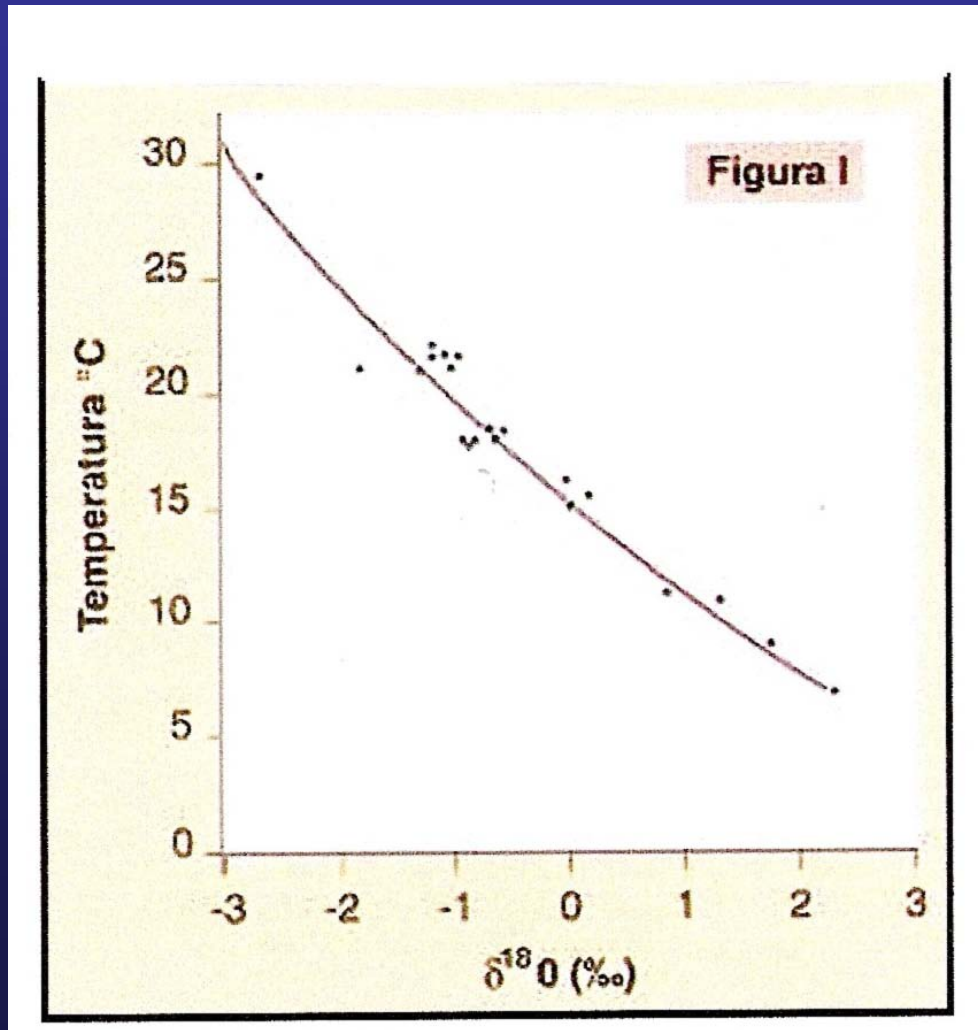
## Palinología



# OS MÉTODOS PROXY 4

## Relaciones isotópicas

- O-18 / O-16



# OS MÉTODOS

## Modelos predictivos

- Modelos deterministas
  - downscaling
- Modelos estocásticos



# Os modelos predictivos

# Secuencia histórica dos coñecementos do clima

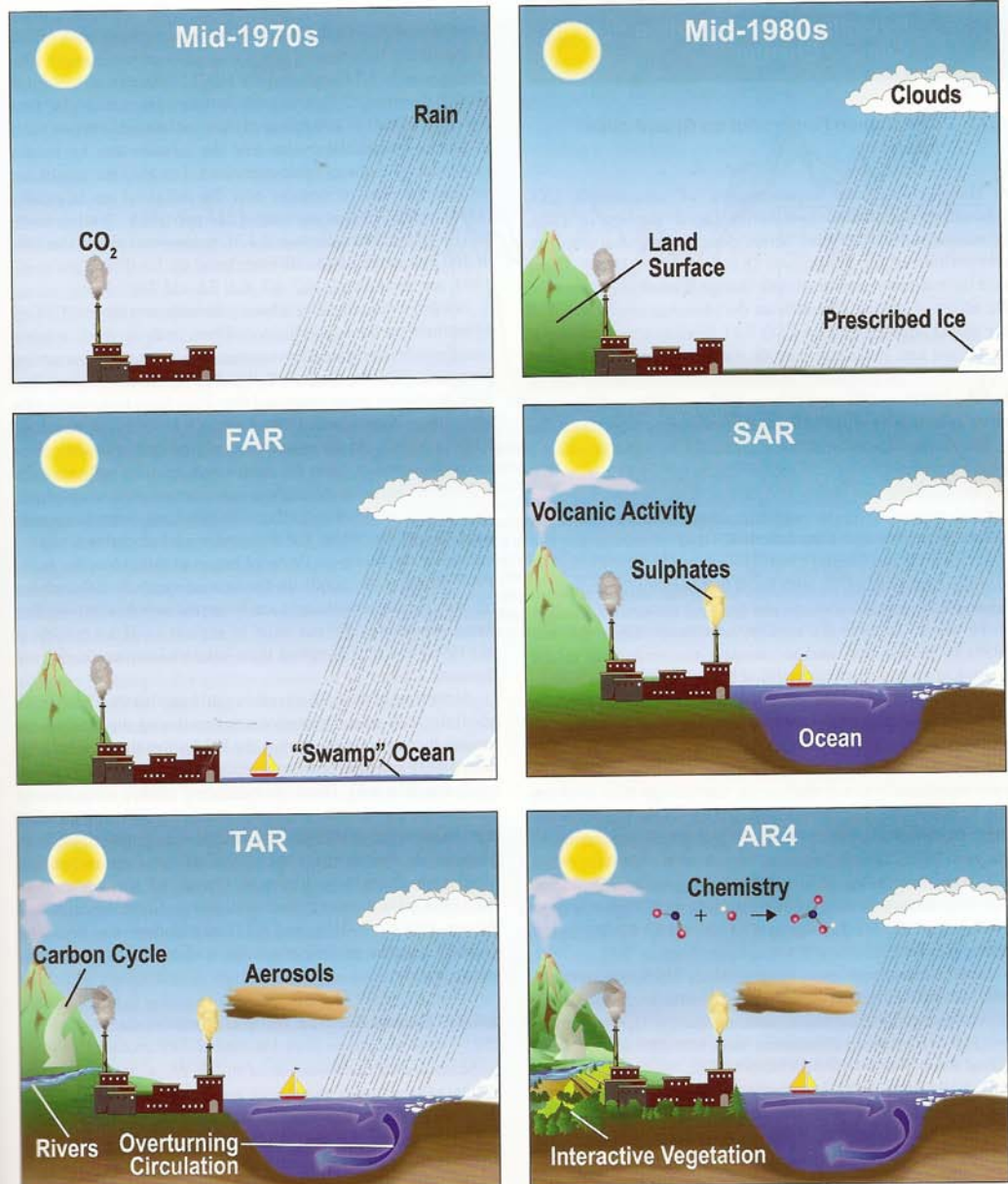
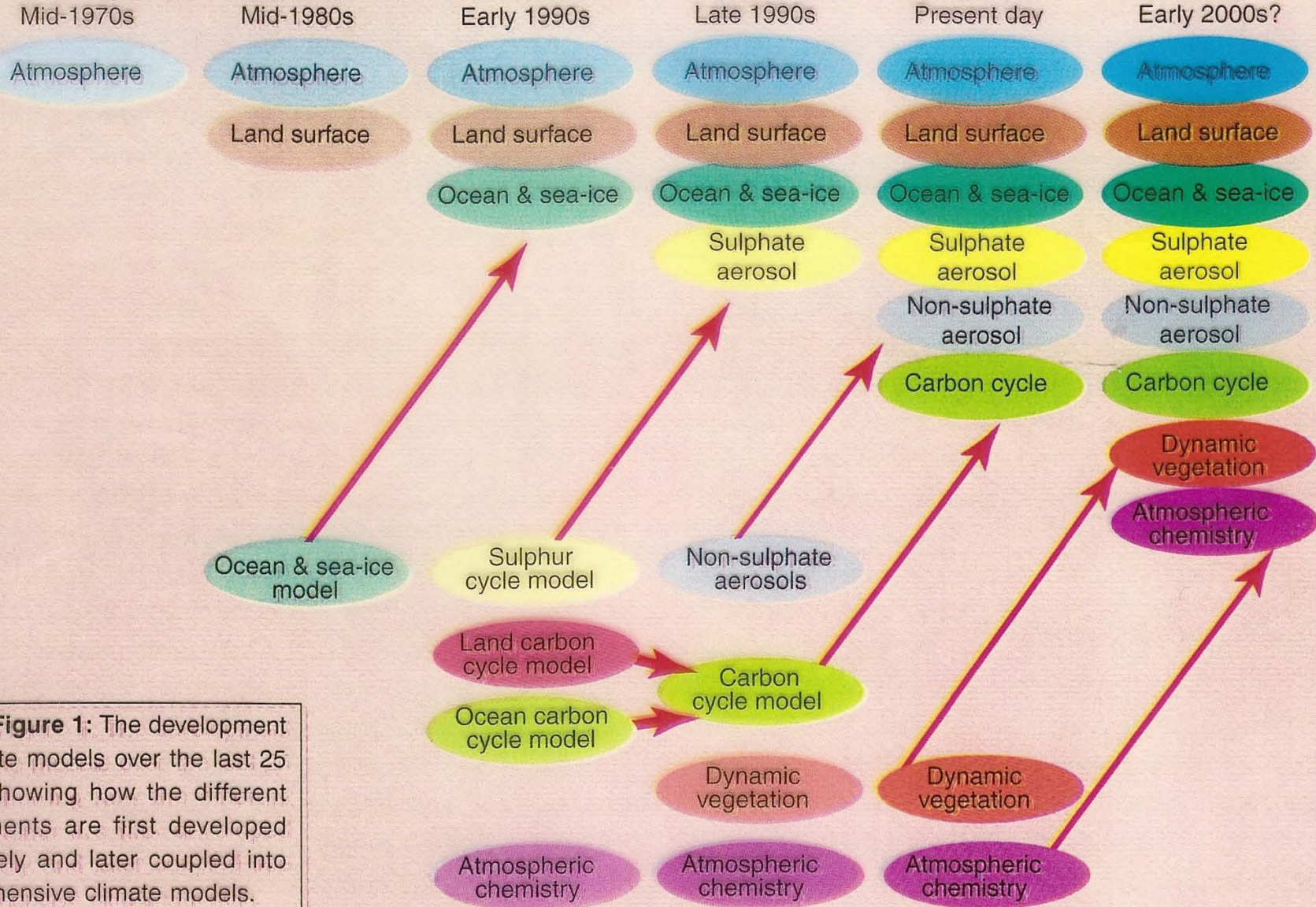


Figure 1.2. The complexity of climate models has increased over the last few decades. The additional physics incorporated in the models are shown pictorially by the different features of the modelled world.

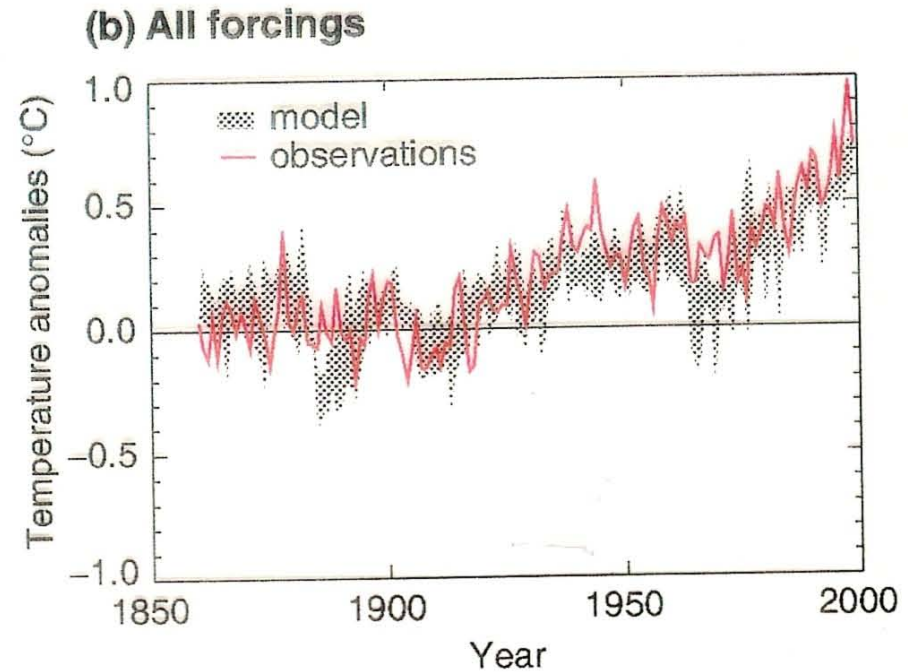
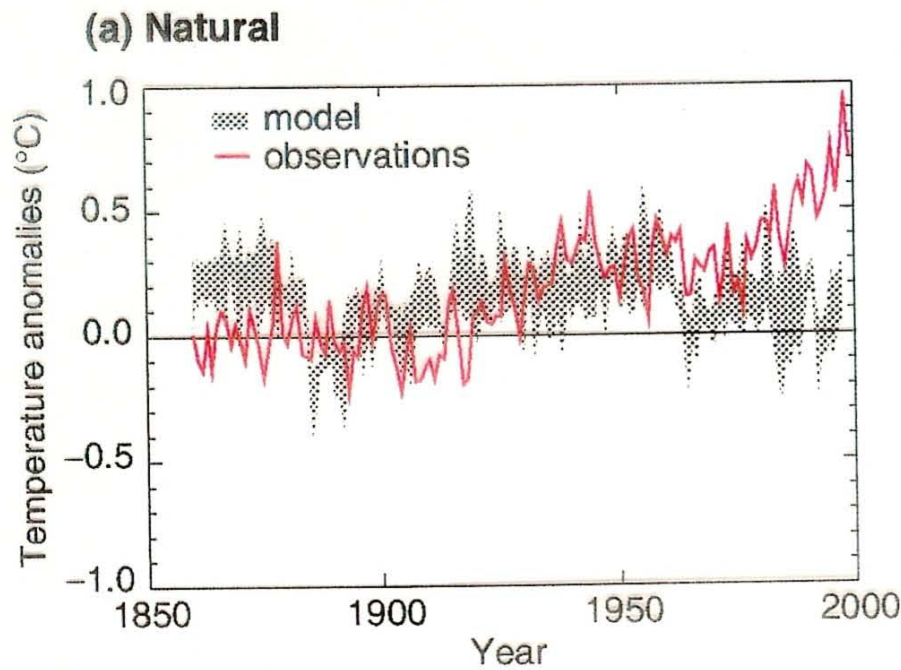
# The Development of Climate models, Past, Present and Future



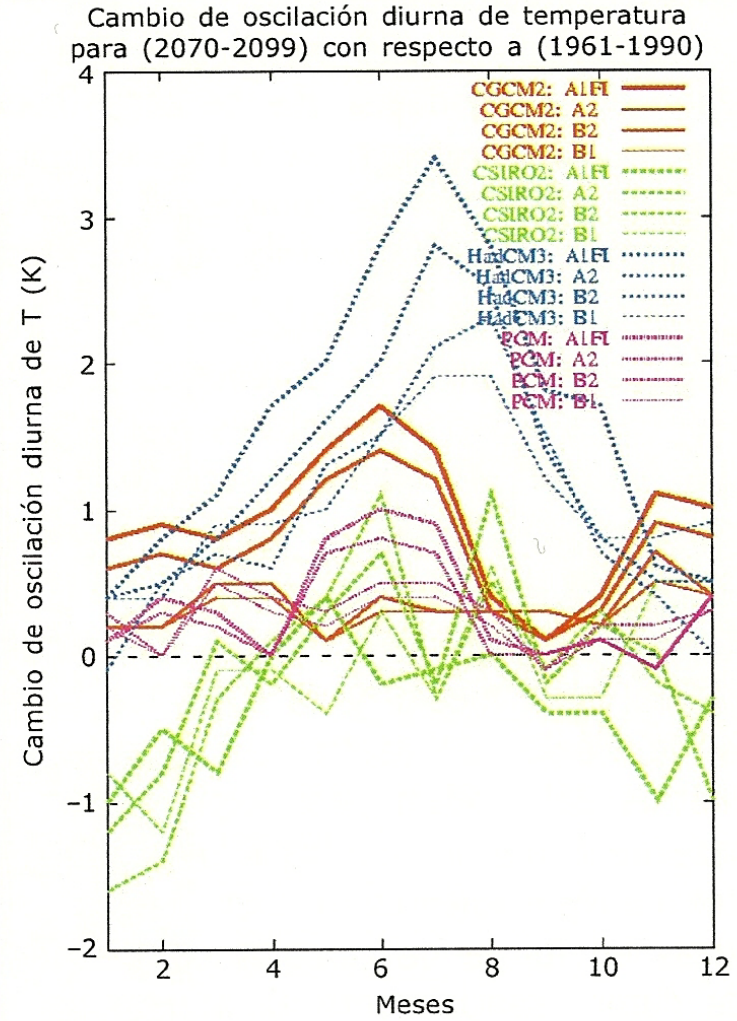
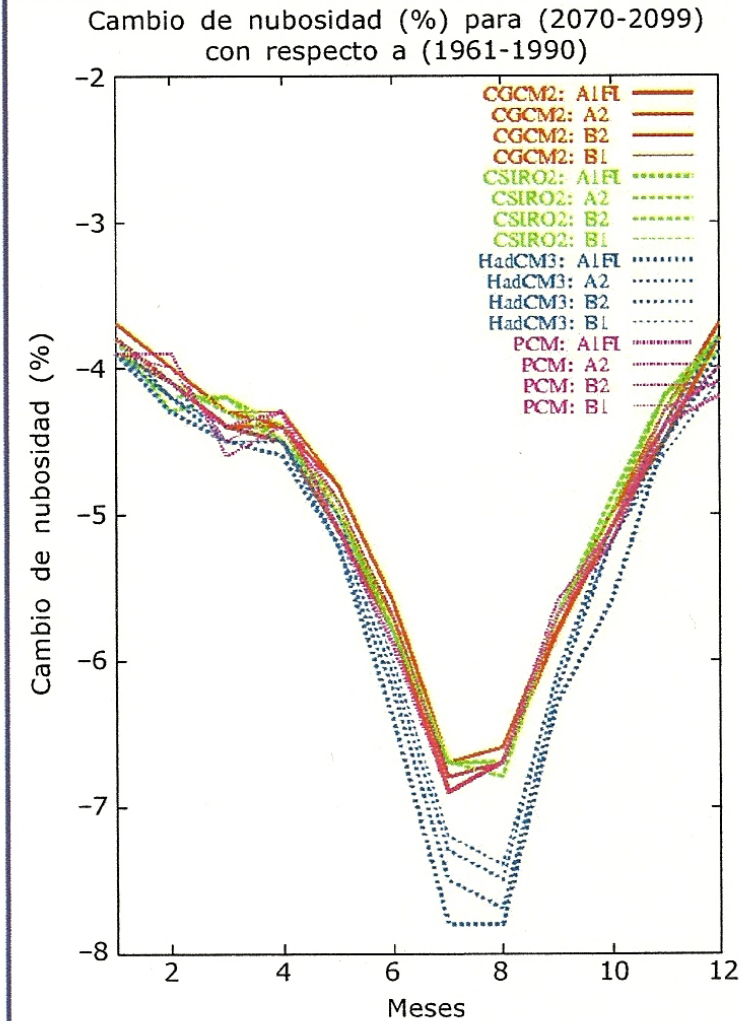
**Box 3, Figure 1:** The development of climate models over the last 25 years showing how the different components are first developed separately and later coupled into comprehensive climate models.

# CALIBRACIÓN DE MODELOS

## Simulated annual global mean surface temperatures



# RESULTADO DOS MODELOS

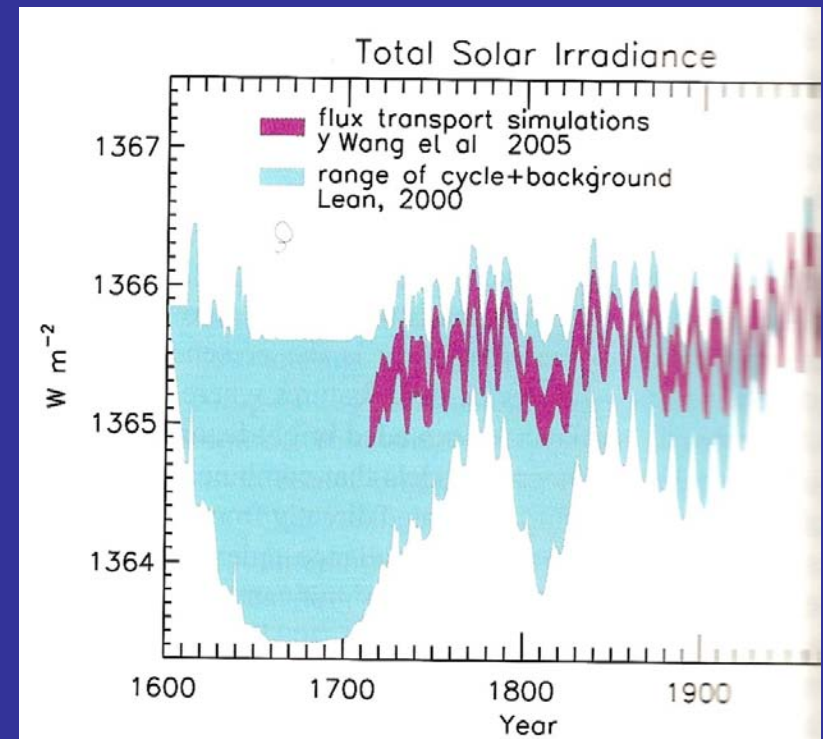
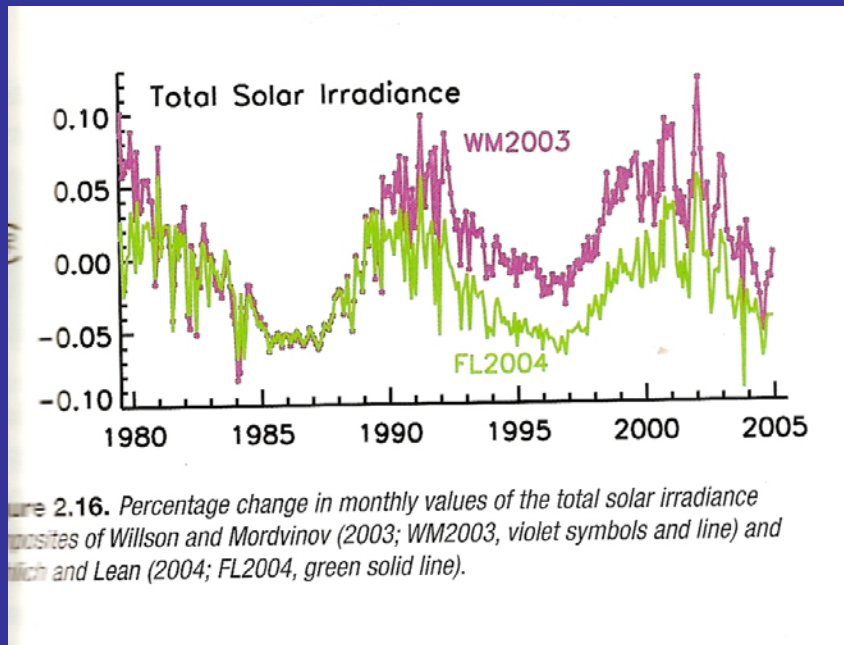


# O MÉTODO COSMOLÓGICO

- Hipótesis múltiples de Chamberlein
- Convergencia e coherencia
- nos resultados múltiples

# A RADIACIÓN SOLAR

- A evolución temporal da irradiancia



- % forzamento radiativo de quecemento : 3.6
- “ “ “ “ : 7.5

# A RADIACIÓN SOLAR 2

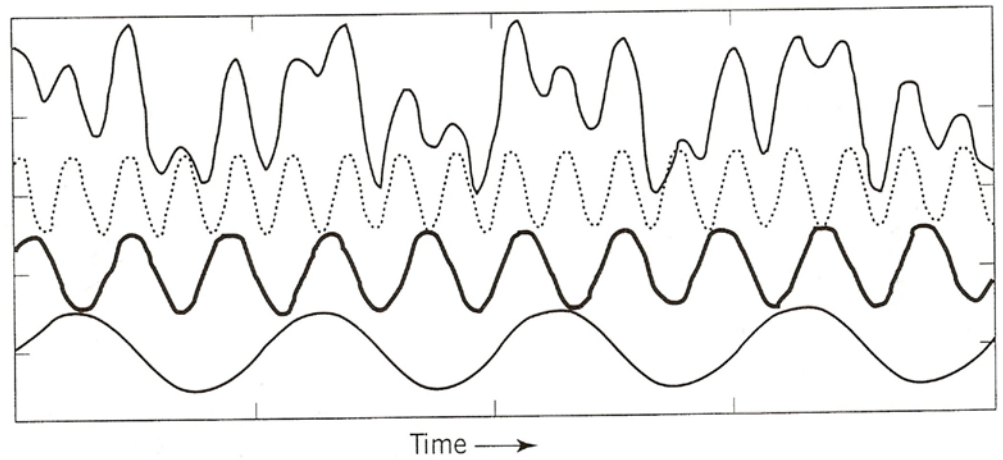
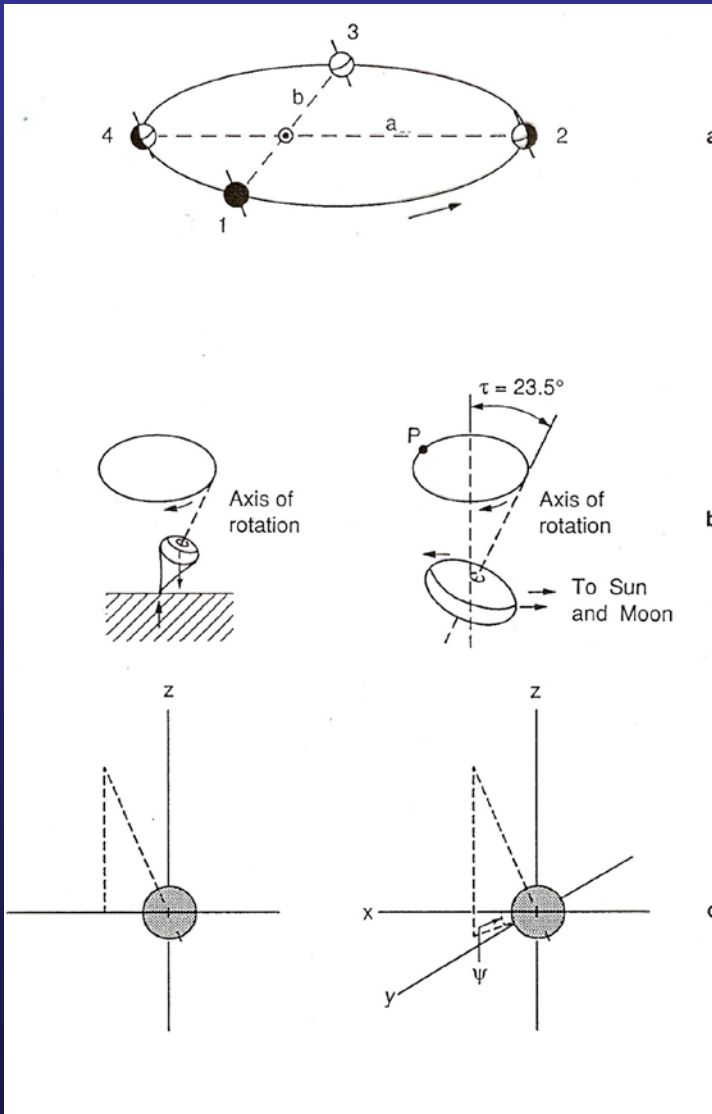
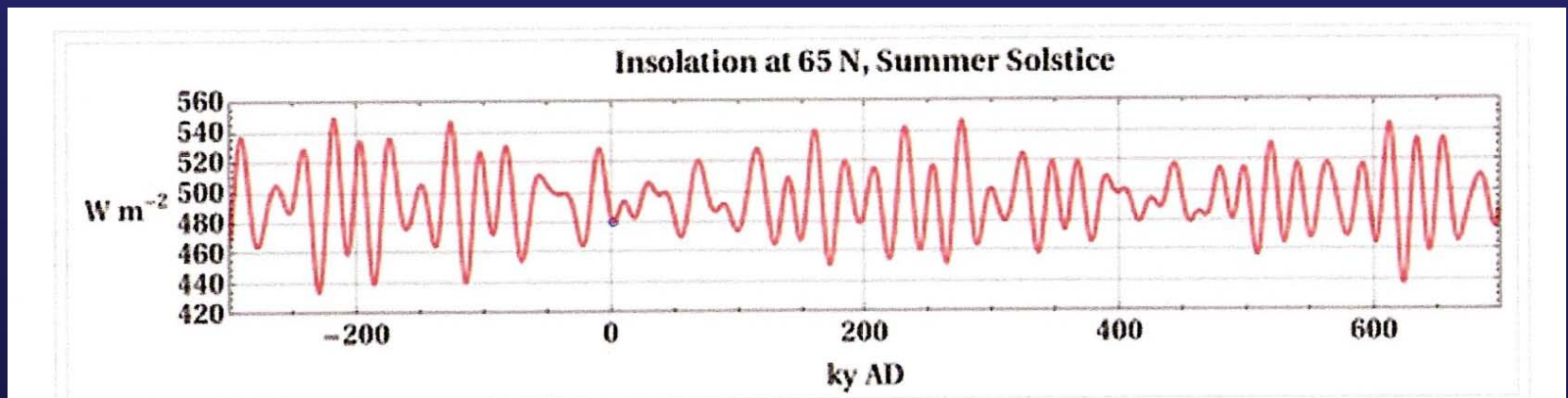
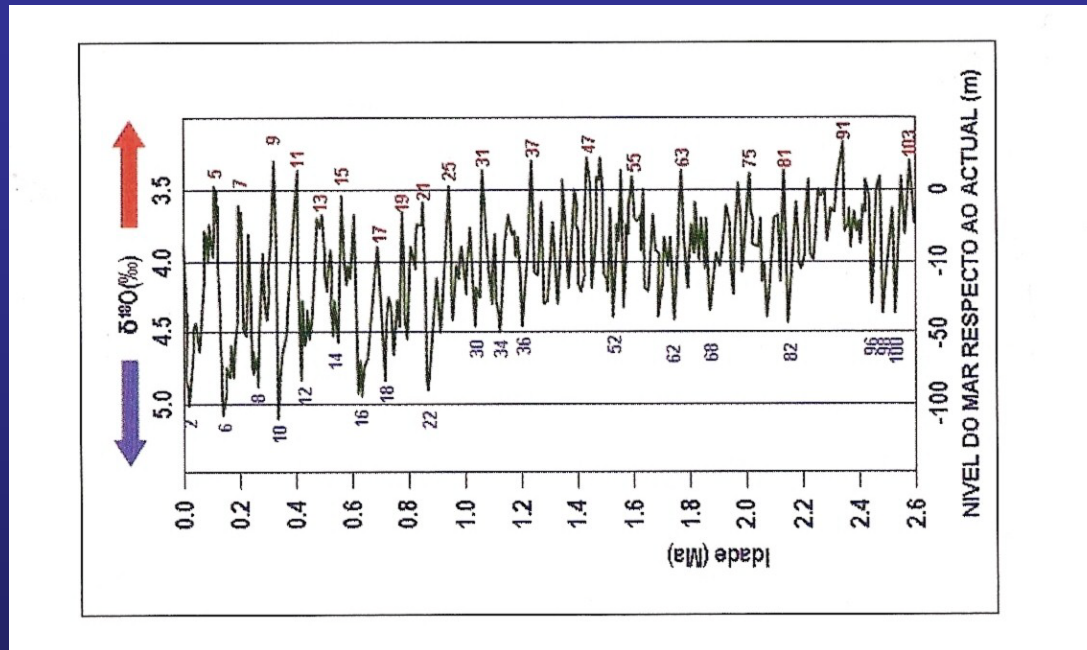


Figure 5.12 Three hypothetical records of solar radiation are shown schematically as a function of time. The bottom solid curve depicts a record with a period of 100,000 years (eccentricity); the heavy solid line depicts a record with a period of 41,000 years (tilt); and the dashed curve indicates a record with a period of 23,000 years (precession). The top curve is the sum of these three records.

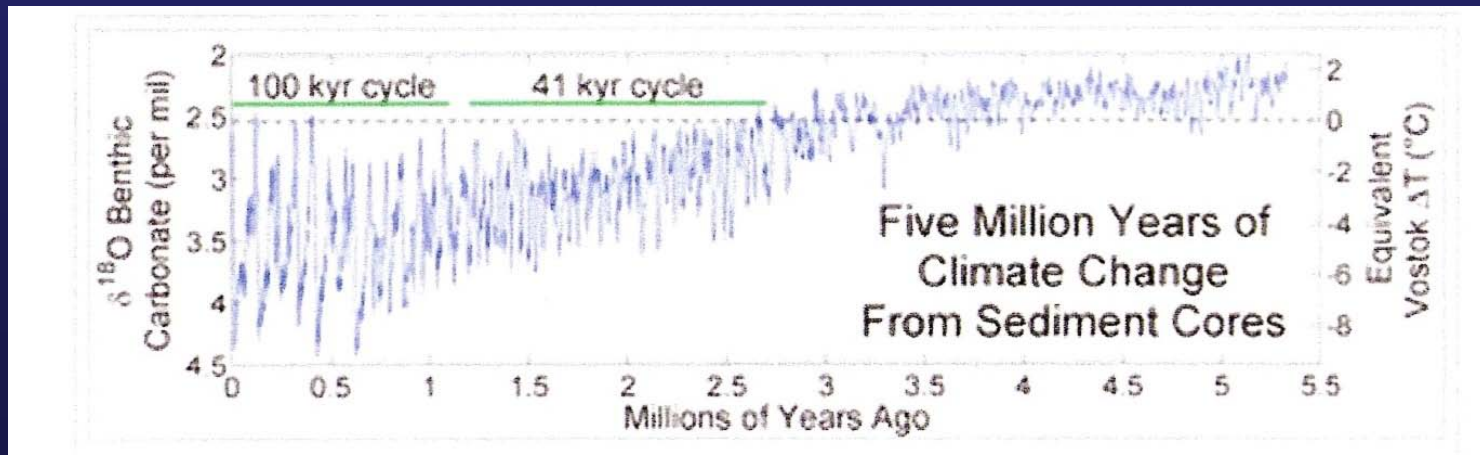
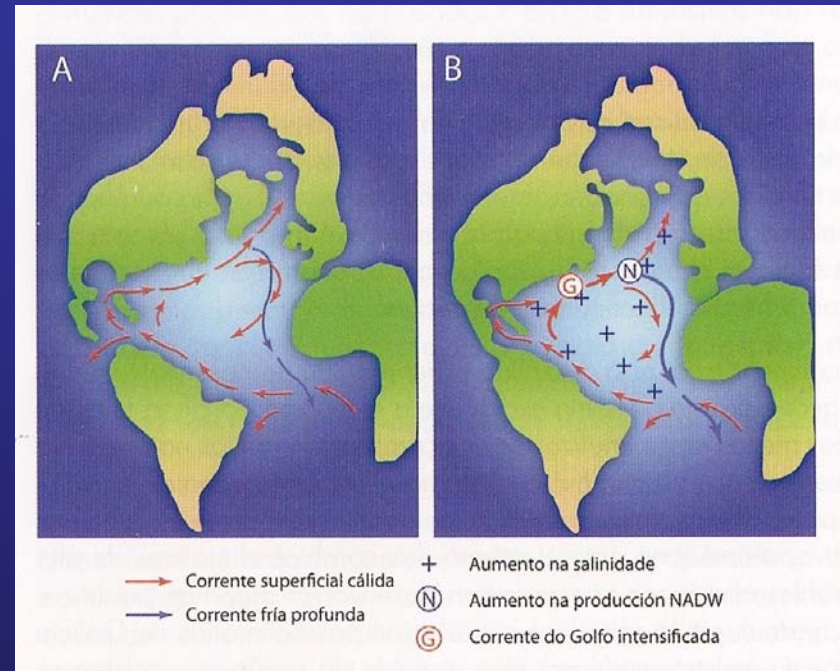
# RADIACIÓN / GLACIACIONES





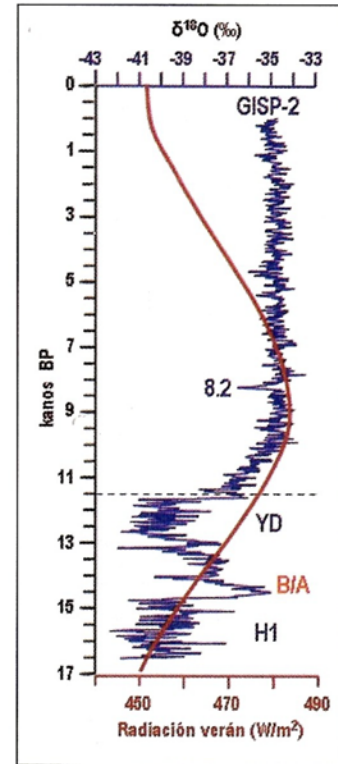
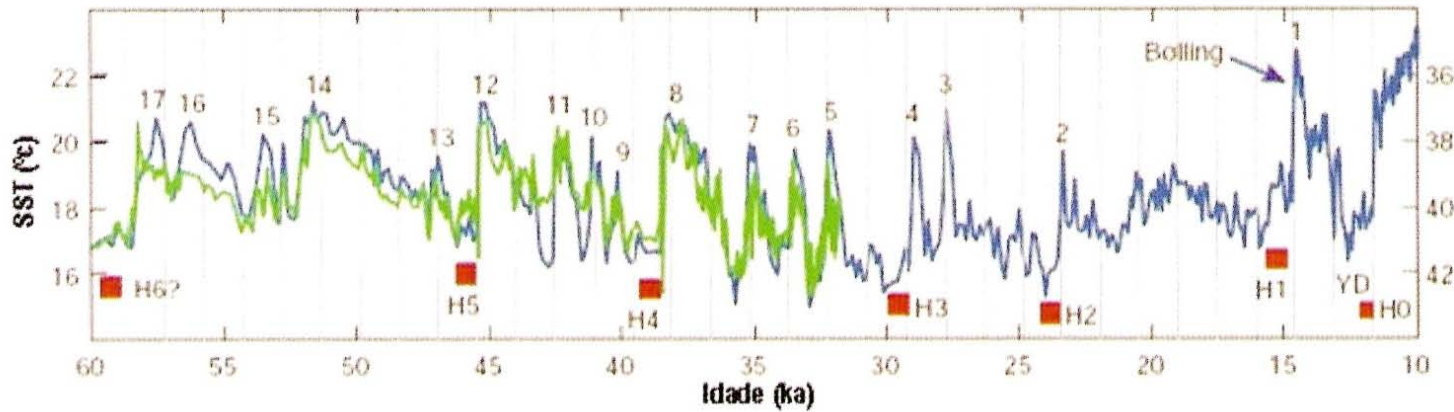
# GLACIACIONES

- Retroalimentaciones
- Corrientes marañas
- Albedo
- CO<sub>2</sub>

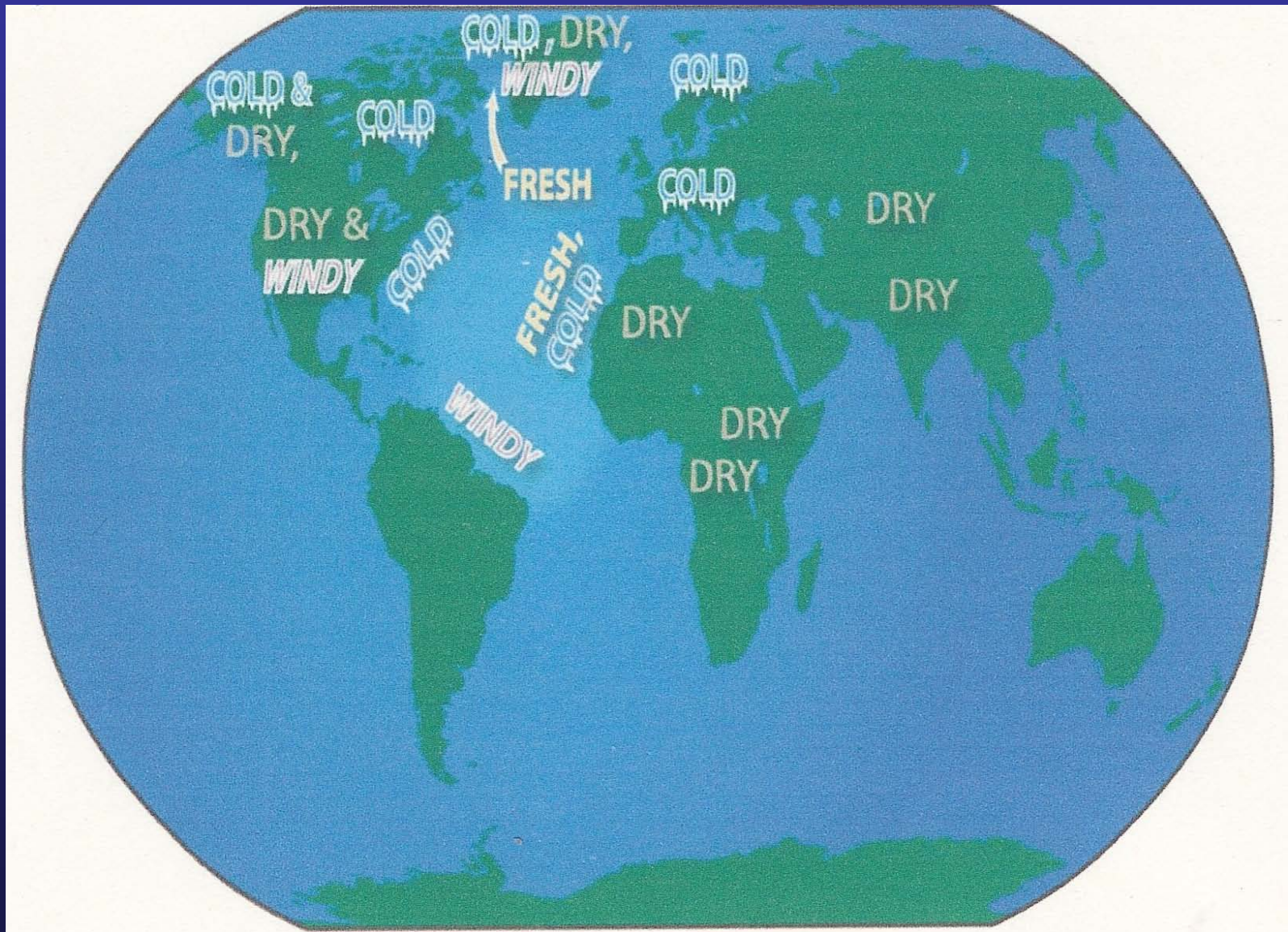


# GLACIACIONES (Wurm)

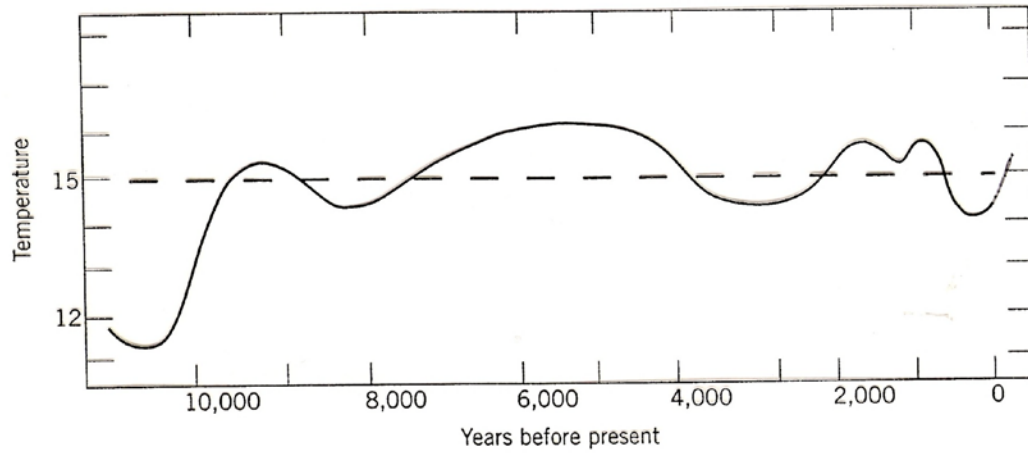
- Cambios climáticos abruptos



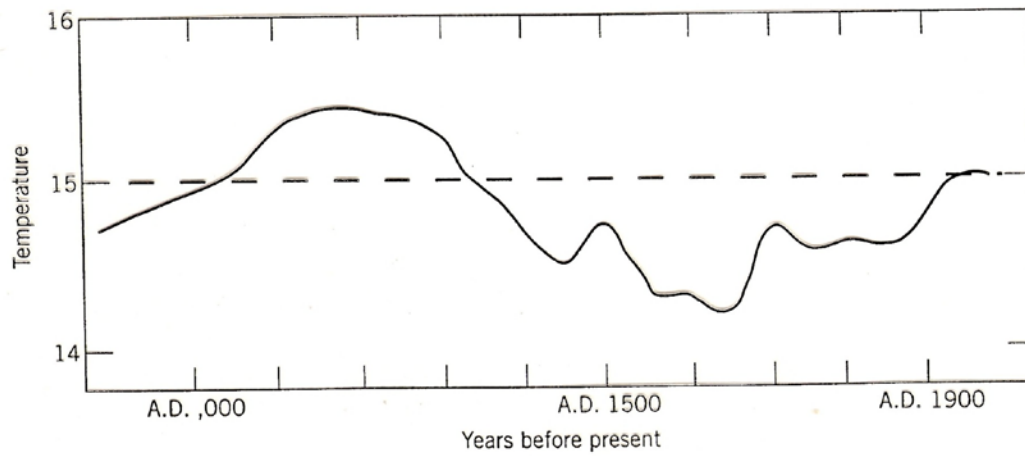
# CAMBIO CLIMÁTICO ABRUPTO (8k)



# HOLOCENO



(b)



(c)

# HOLOCENO (GALICIA)

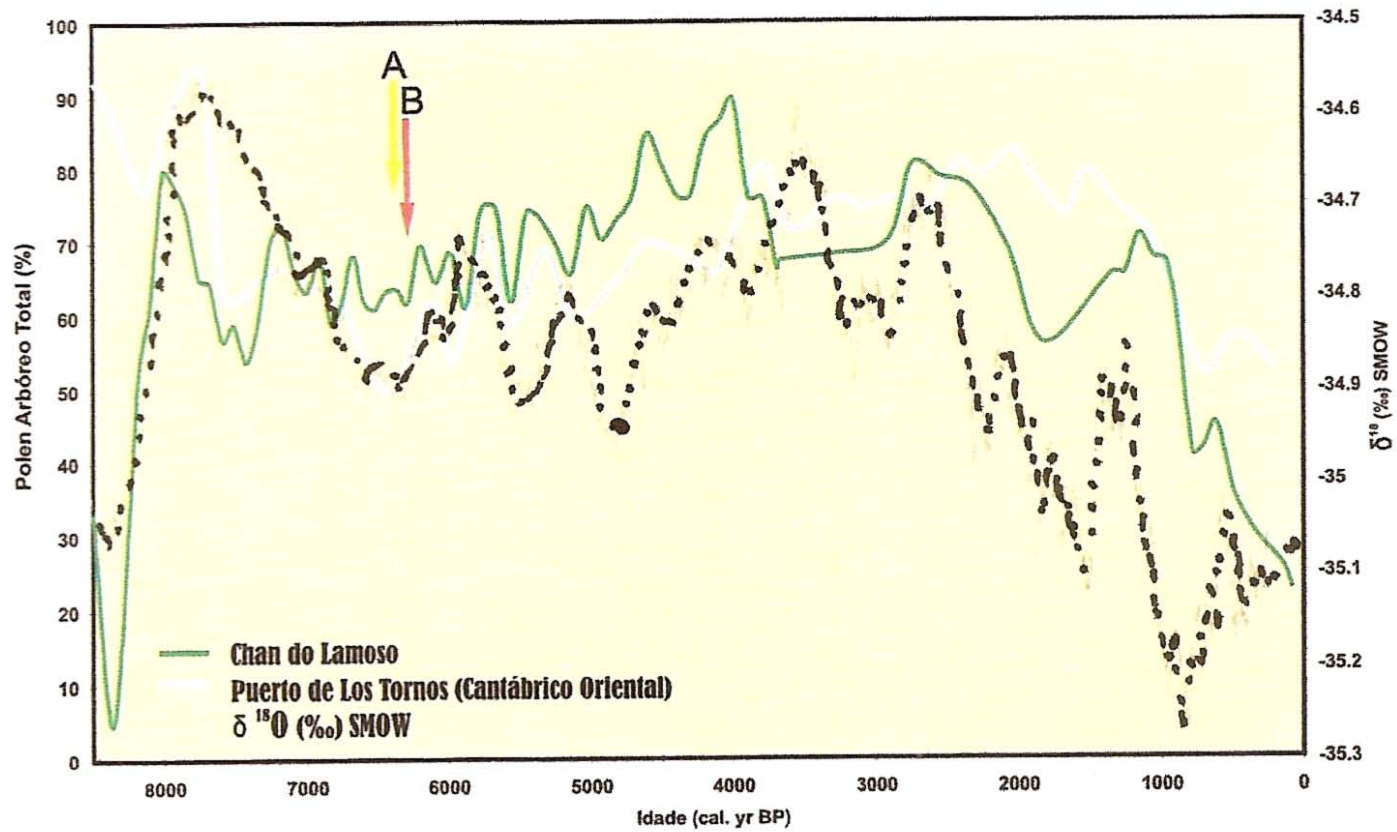
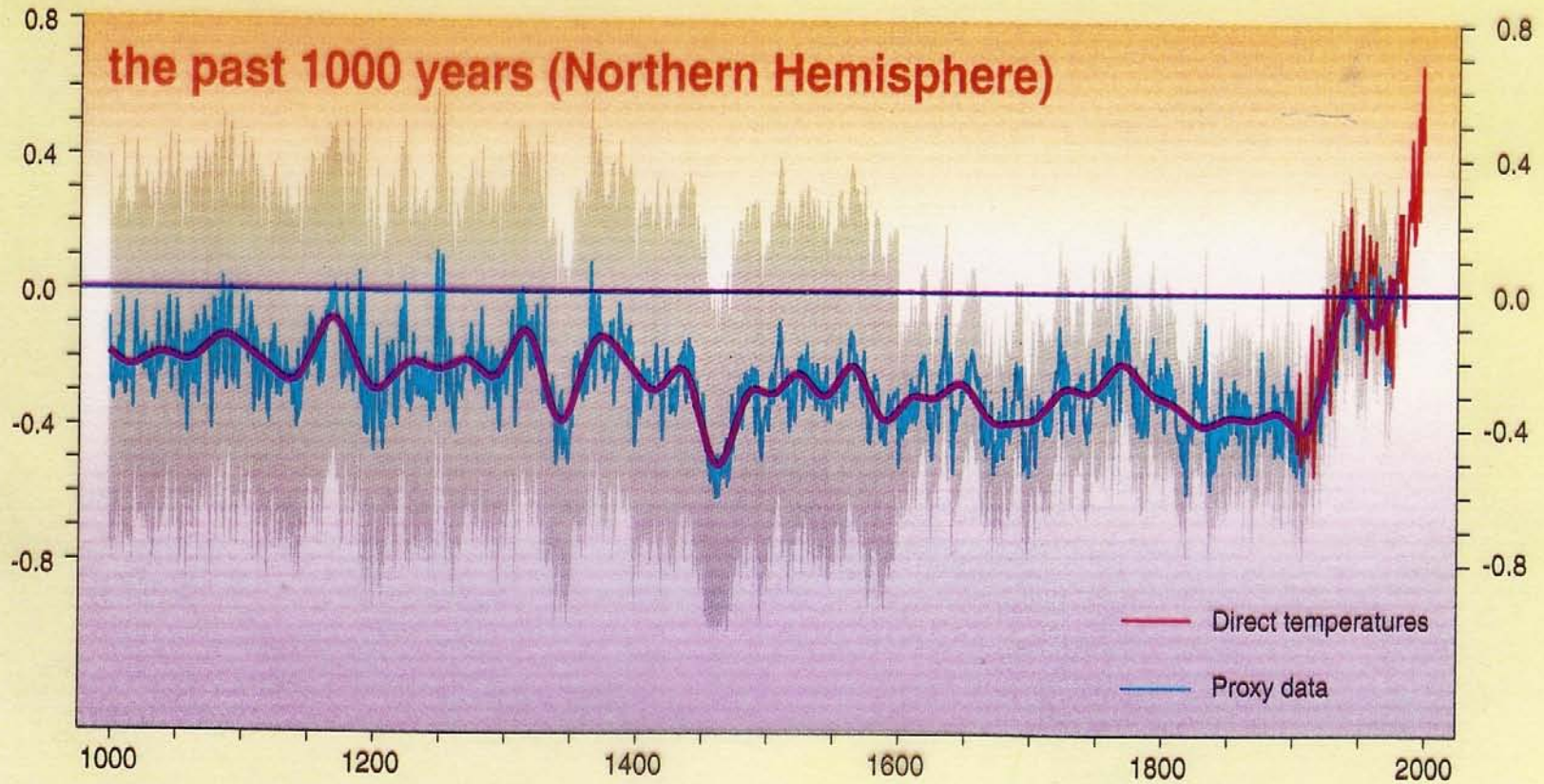


Fig. 2.10. Evolución de la temperatura y de la humedad en el Chan do Lamoso, Ferras de Valdeavea, Lugo. Altitude

# HOLOCENO (“Pau de hockey”)

Departures in temperature in °C (from the 1961-1990 average)



# HOLOCENO-GALICIA (dendrocronoloxía)

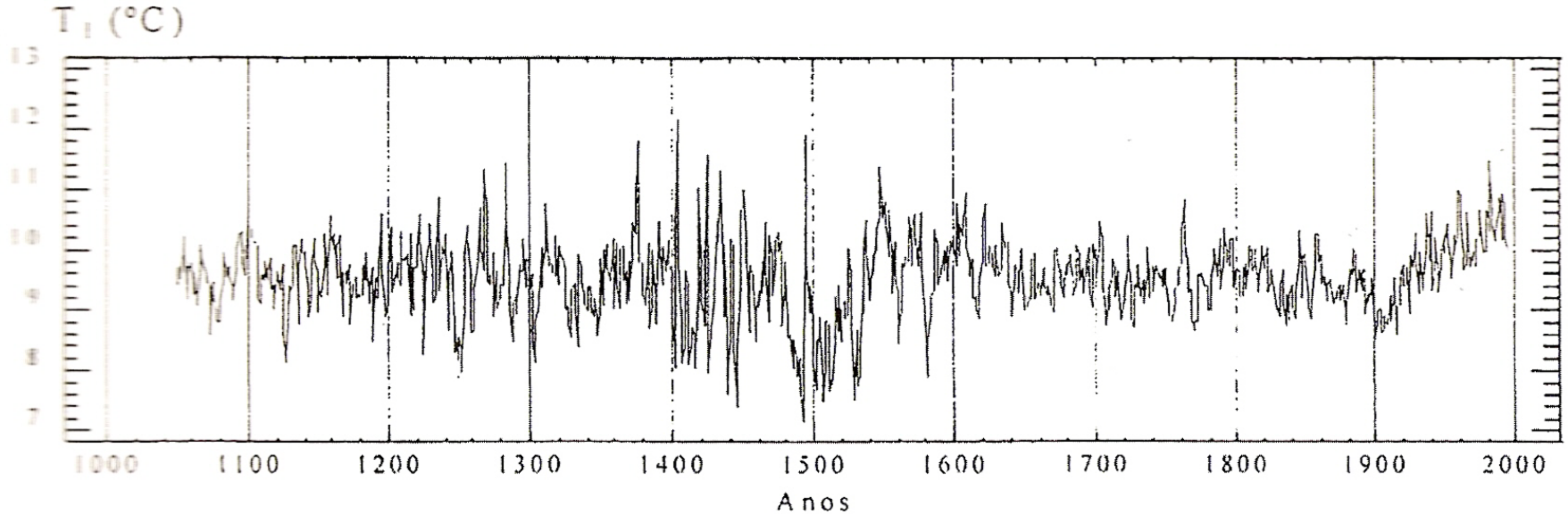
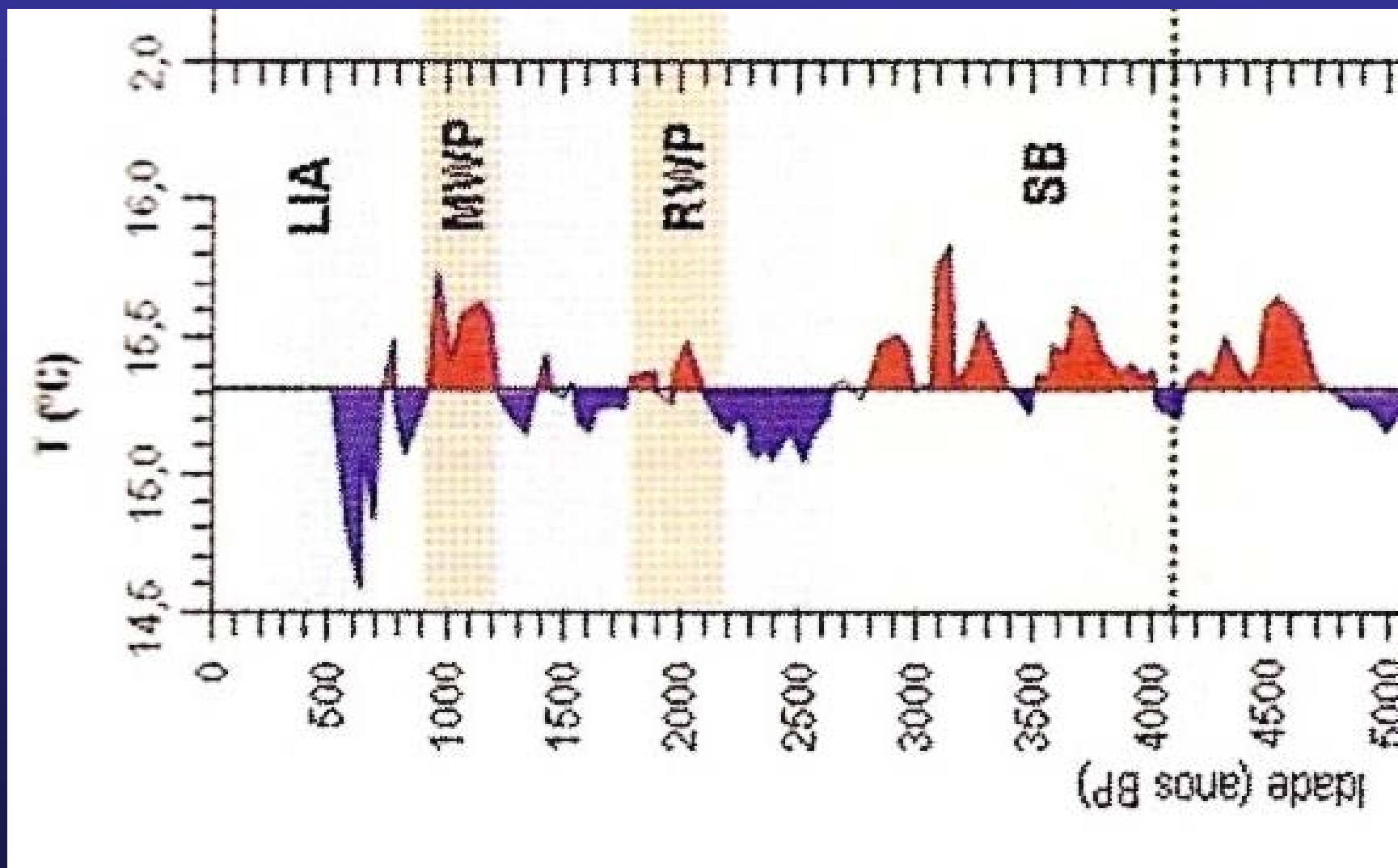


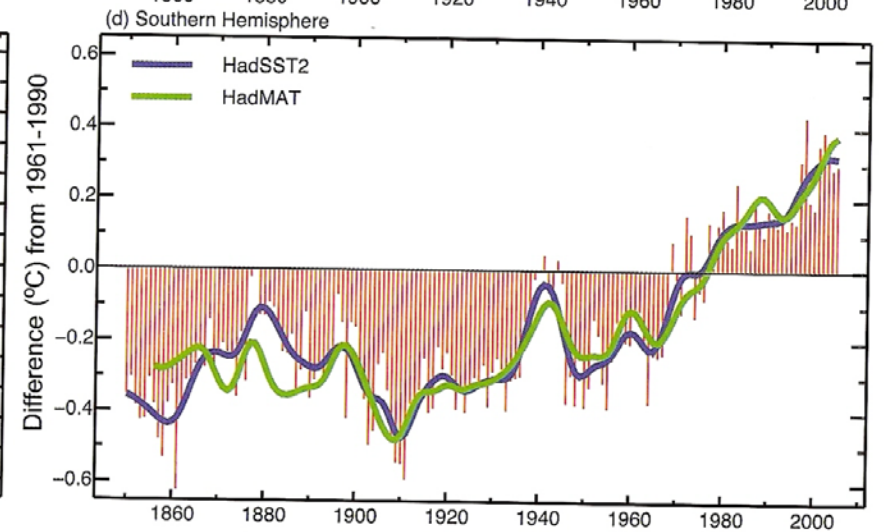
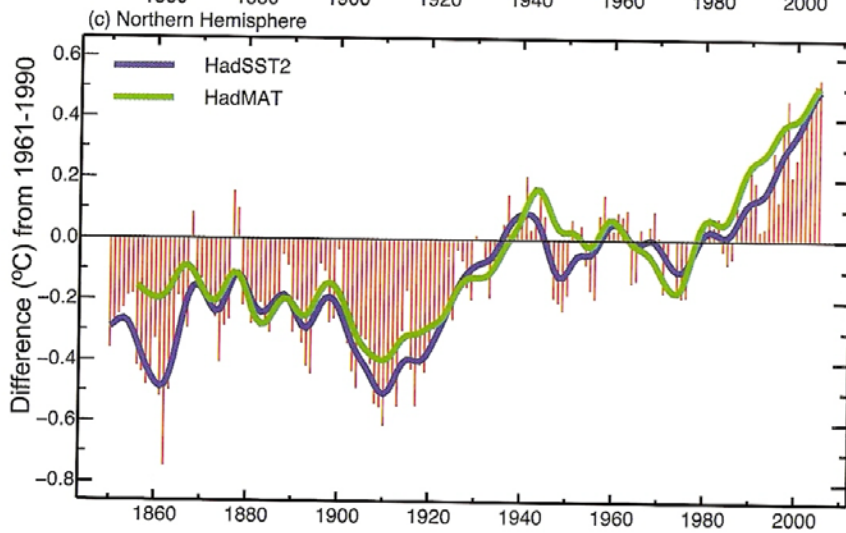
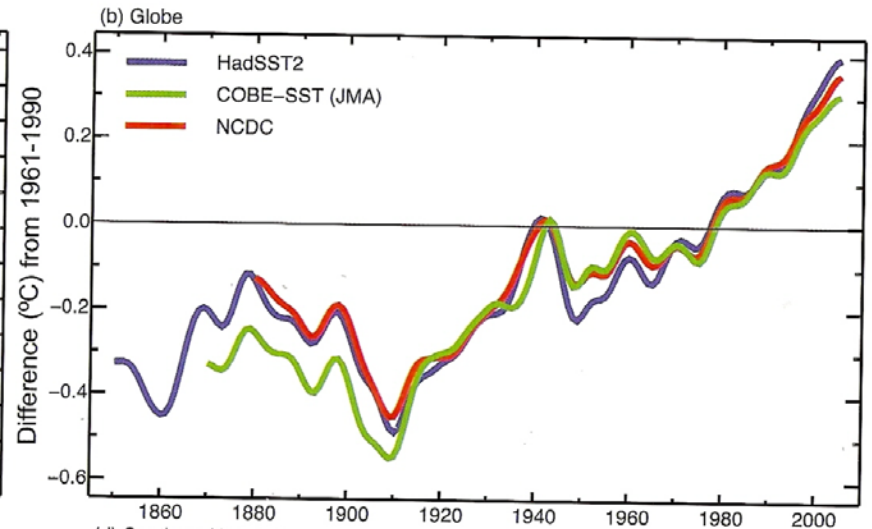
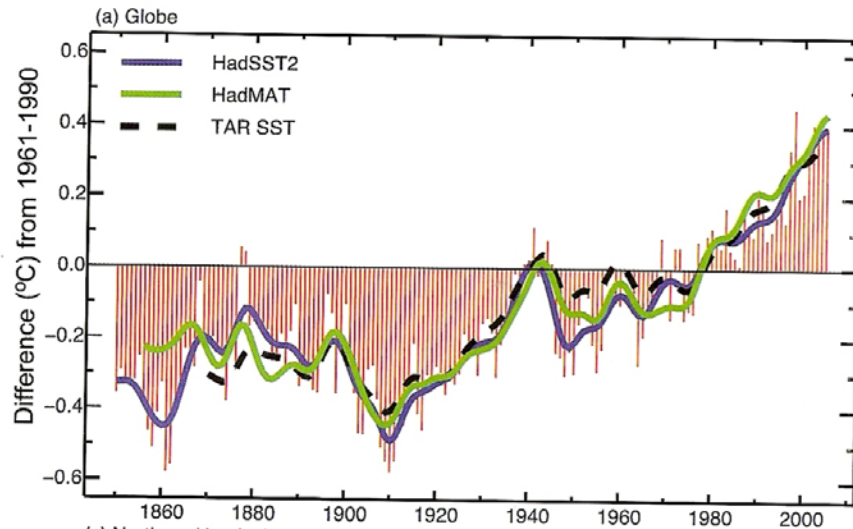
Figura 7.7 Reconstrución dendrocronolóxica para as temperaturas medias de xaneiro do observatorio da Coruña (Fernández Cancio A. e Manrique Menéndez E., 1998)

# HOLOCENO-GALICIA (foraminíferos)

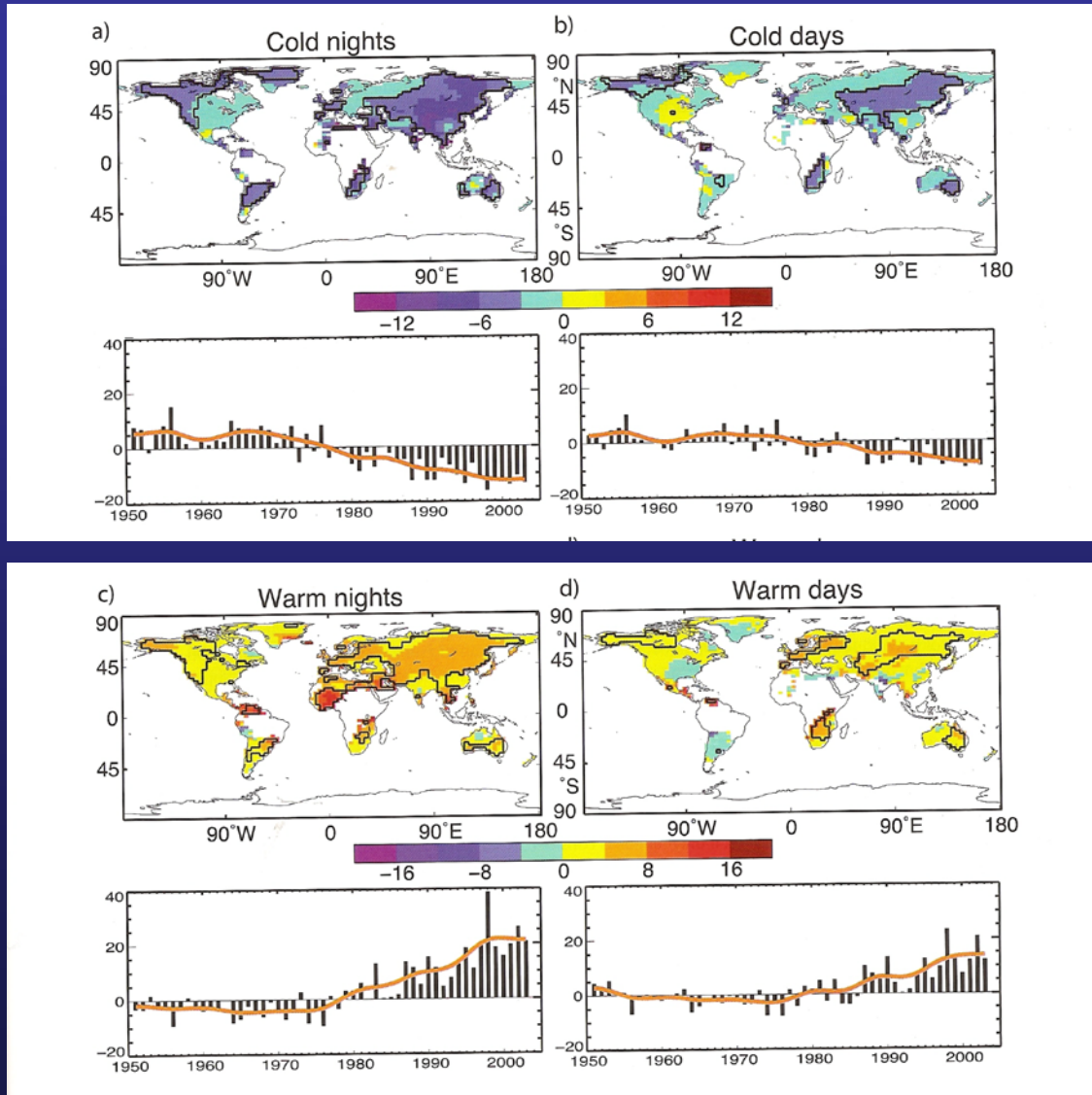




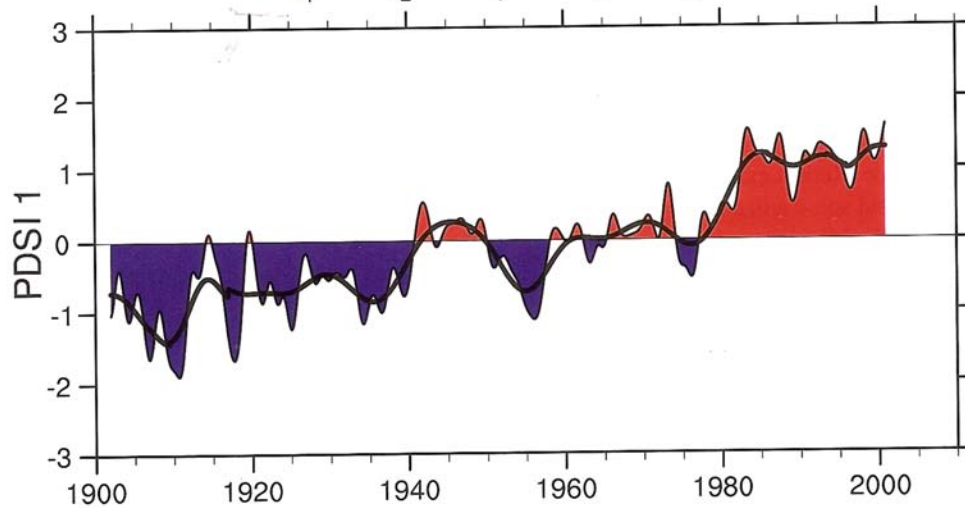
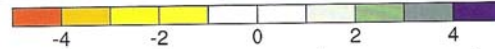
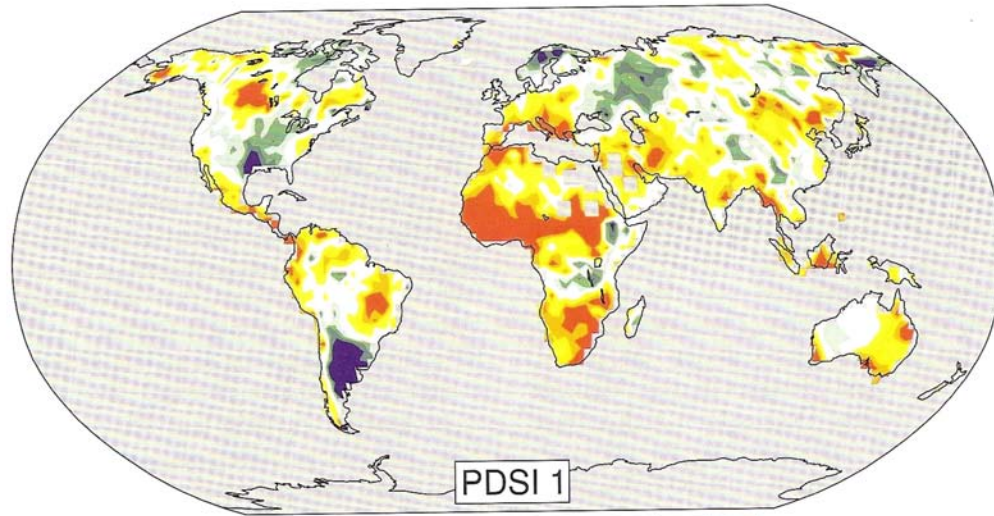
# DATOS INSTRUMENTAIS



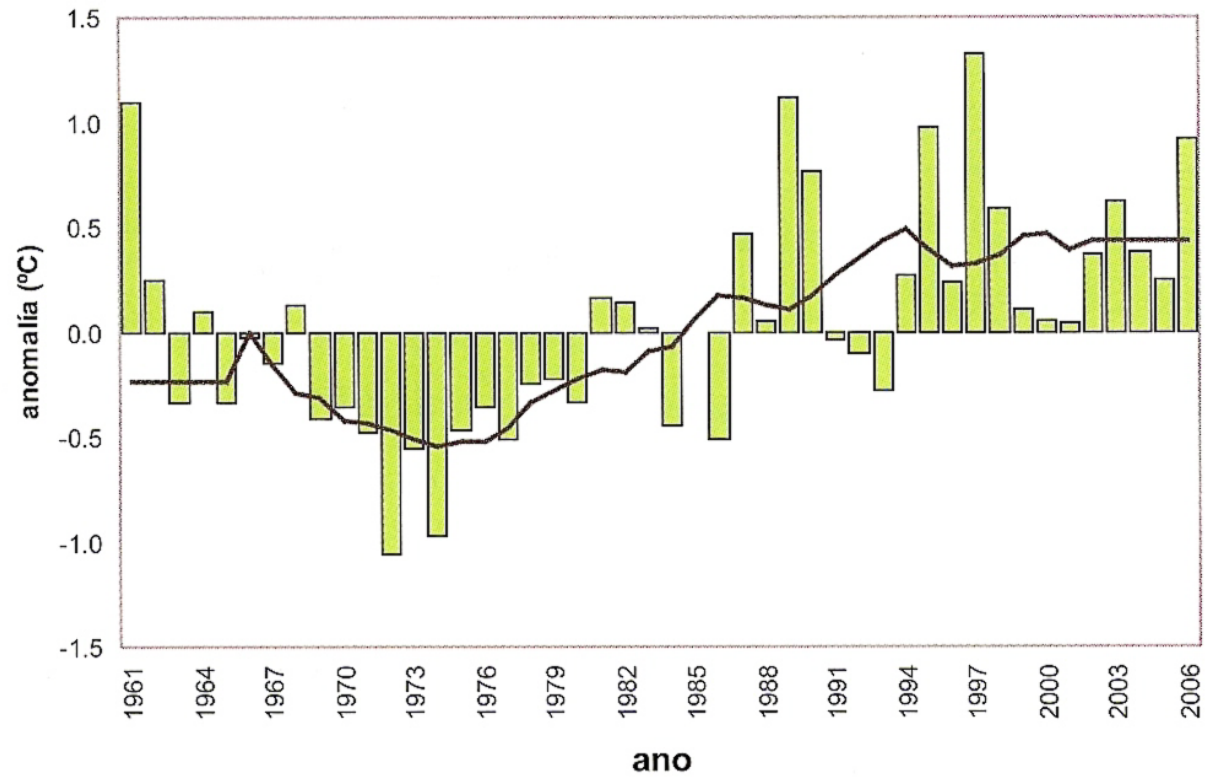
# DATOS INSTRUMENTAIS Extremas



# DATOS INSTRUMENTAIS Secas



# DATOS INSTRUMENTAIS Galicia



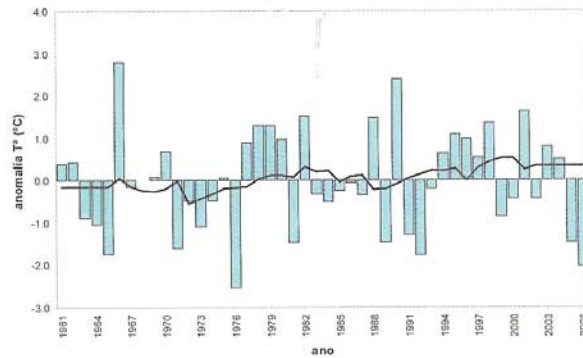
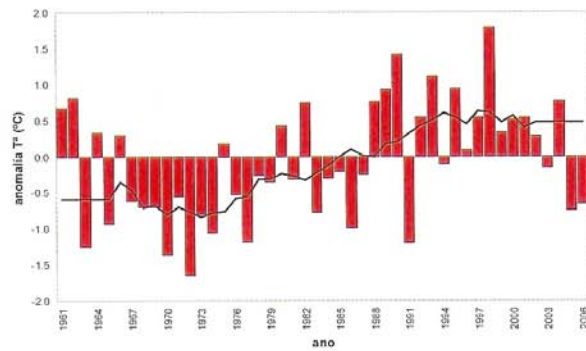
# DATOS INSTRUMENTAIS Galicia extr.



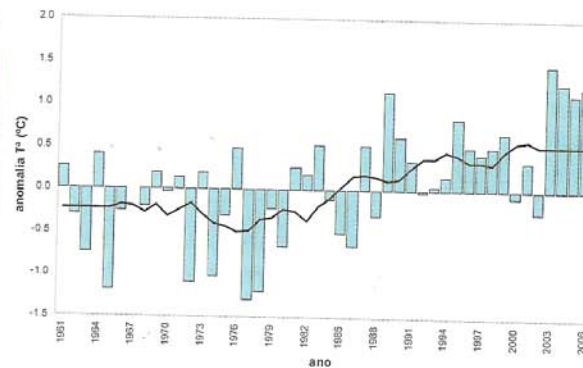
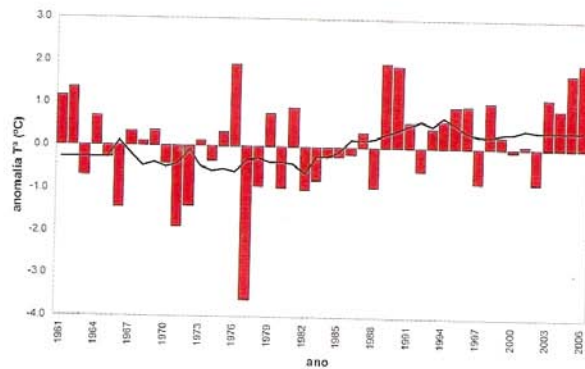
máximas

mínimas

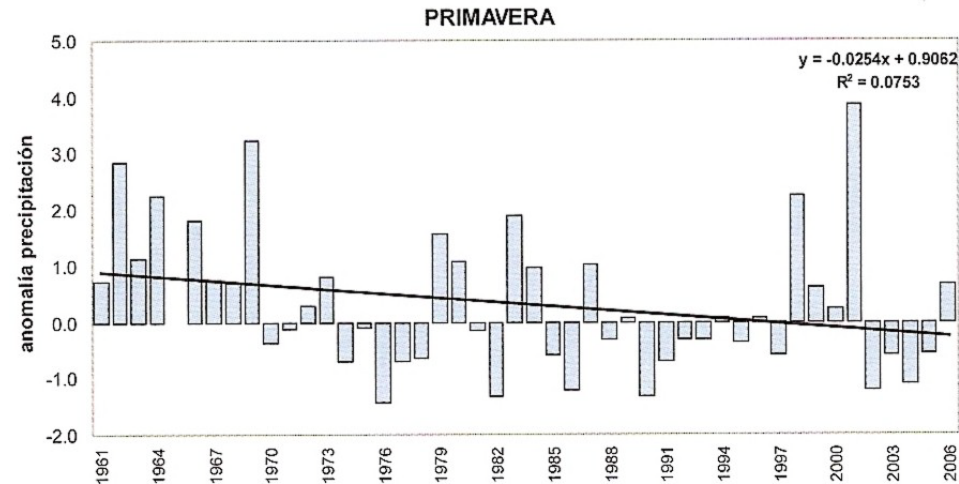
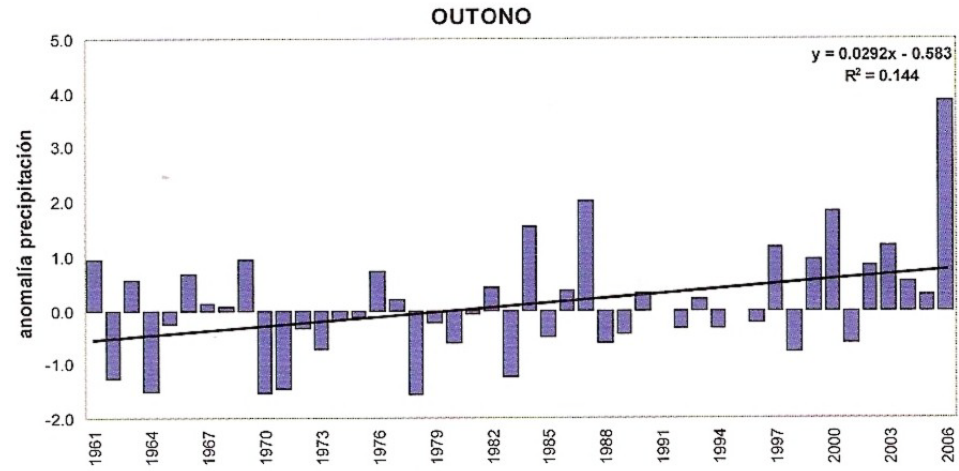
inverno



verán



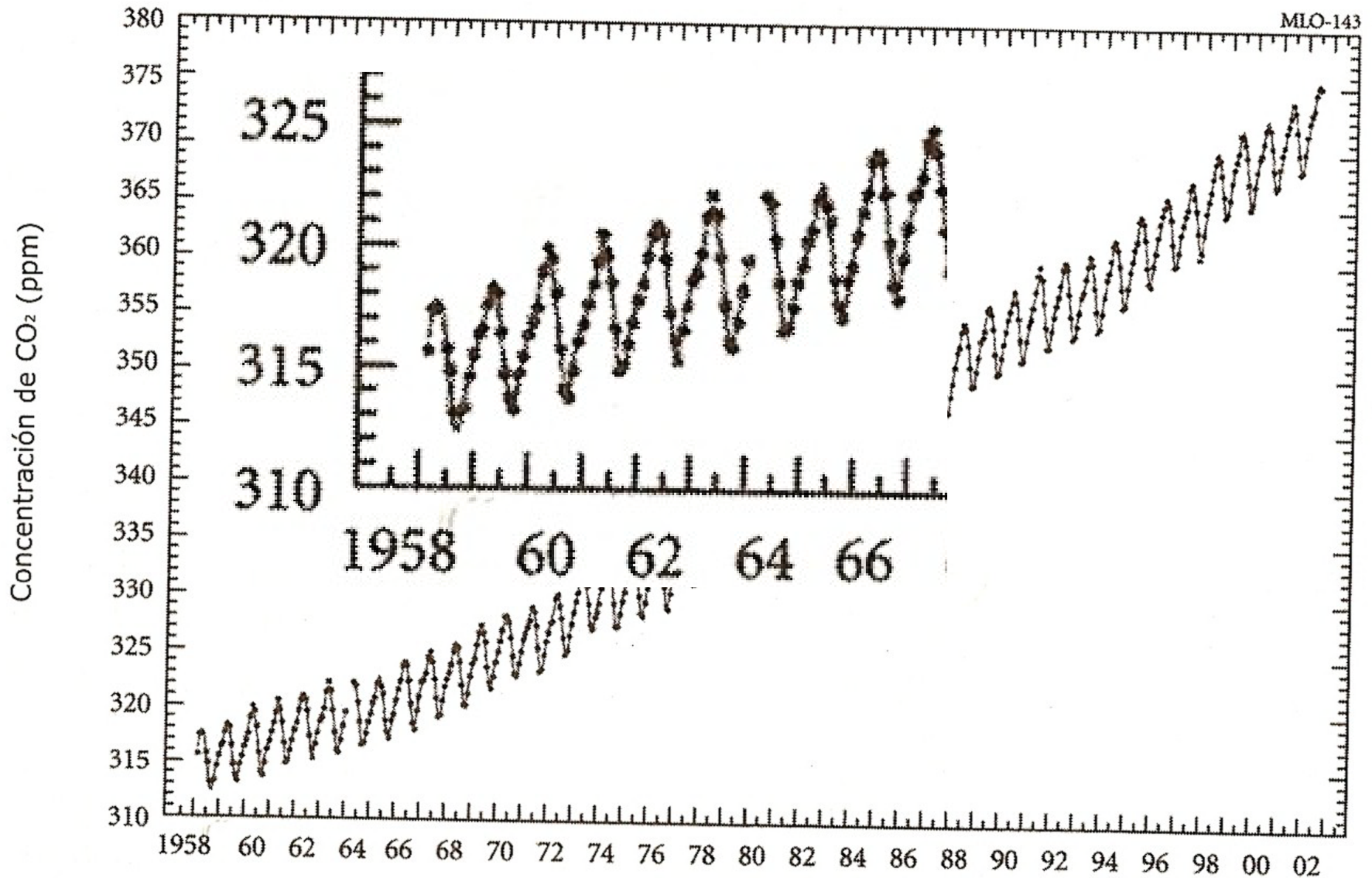
# DATOS INSTRUMENTAIS Galicia prec.



# GASES EFECTO INVERNADOIRO (GEIs)

- 1862 Tyndall :CH<sub>4</sub> e CO<sub>2</sub> opacos aos “raios de calor”
- 1896 Arrhenius: CO<sub>2</sub> + vapor de auga
- 1938 Callendar : (Royal Meteorological Society)
- **OPINION DOMINANTE** : os océanos podían absorber todo o CO<sub>2</sub> emitido (unha atmósfera en equilibrio)
- 1957 Revelle : os océanos non absorven todo o CO<sub>2</sub>
- 1958 Kelling . Observatorio de Mauna Loa
- 1967 Manabe et al x 2 CO<sub>2</sub> aumenta 1.5 – 4.5 °C
- Década dos 70: CFCs e ozono
- 1981 Hansen: aerosois (arrefriamento)
- 1985 Análise das burbullas de aire no xeo

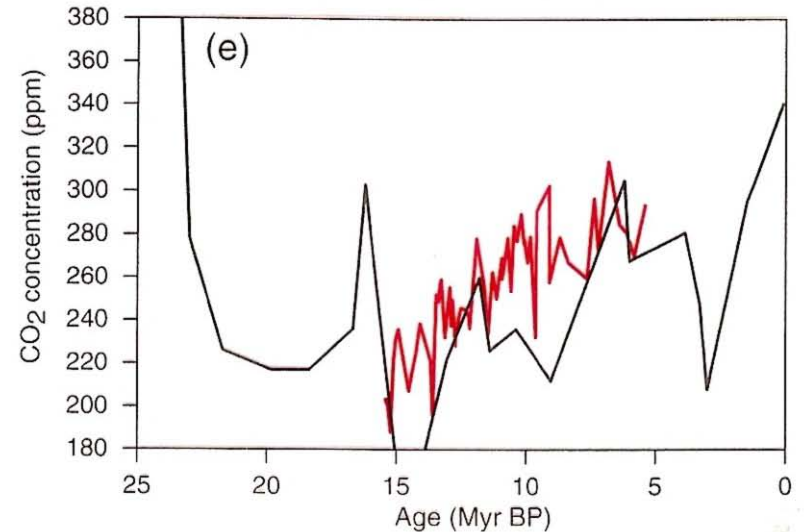
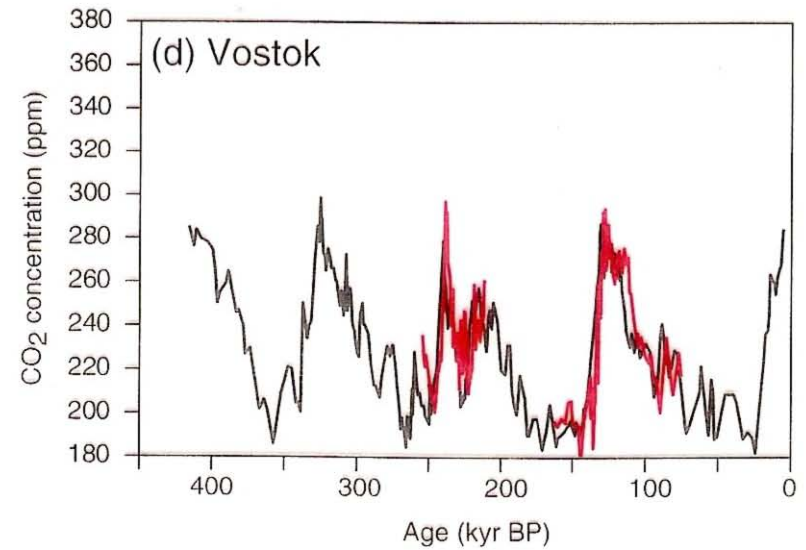
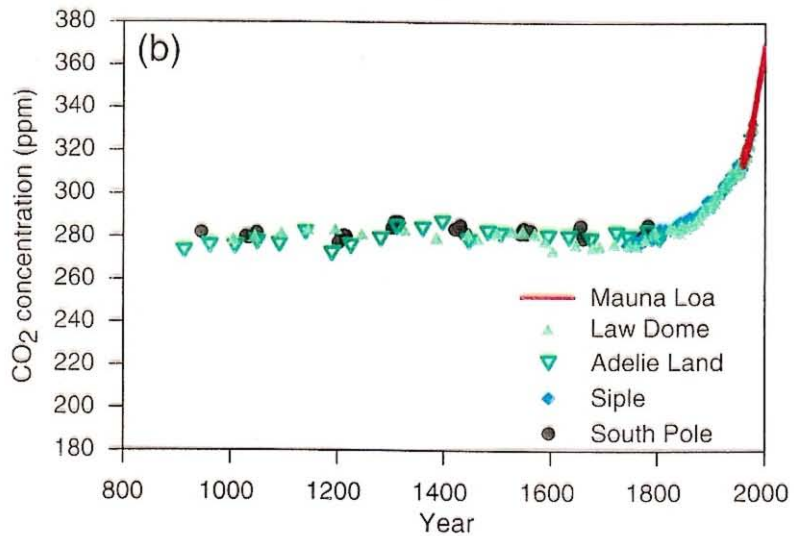
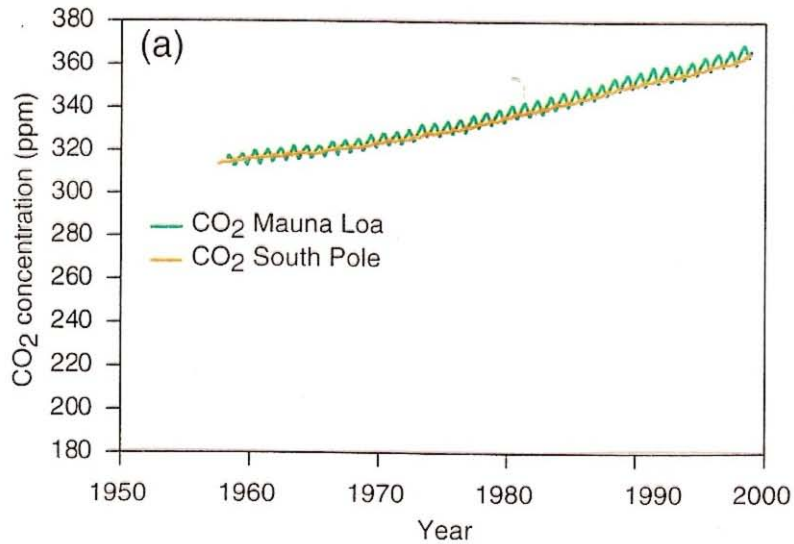
# GEIs Mauna Loa



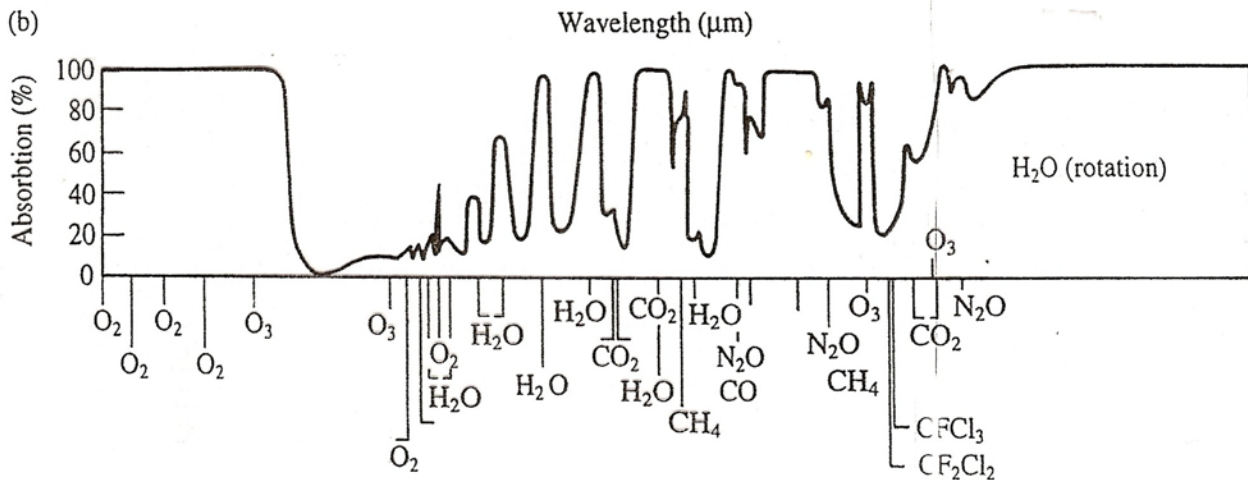
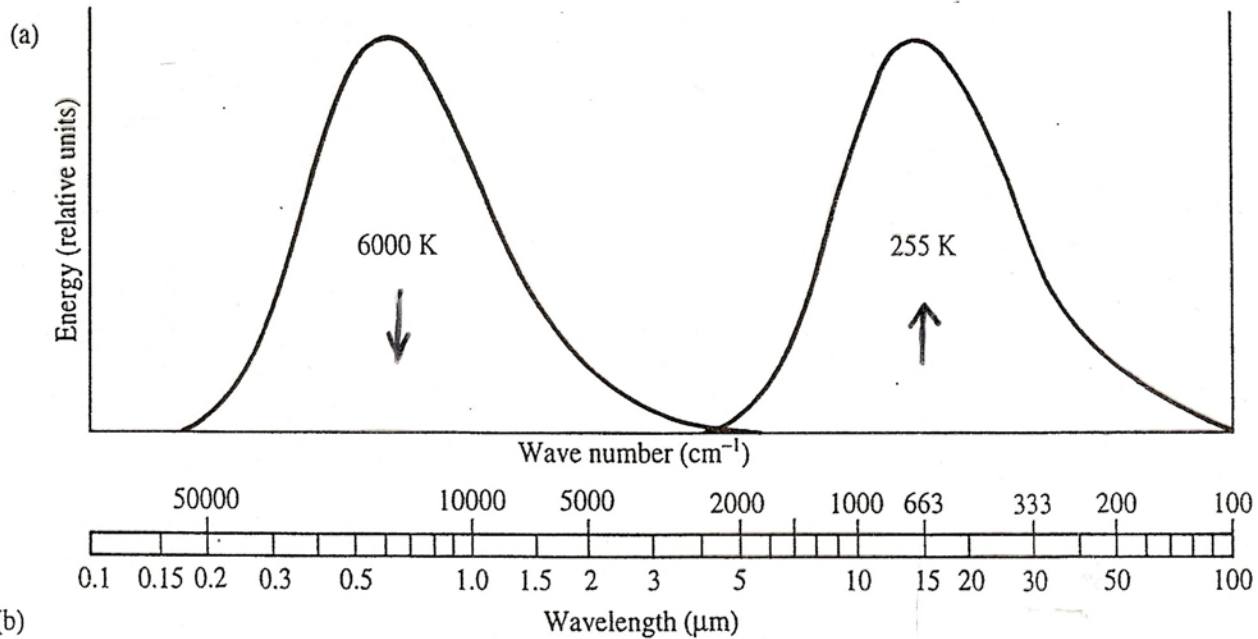


# GEIs Paleoxeoquímica

Variations in atmospheric CO<sub>2</sub> concentrations on different time-scales



# EFEECTO INVERNADERO

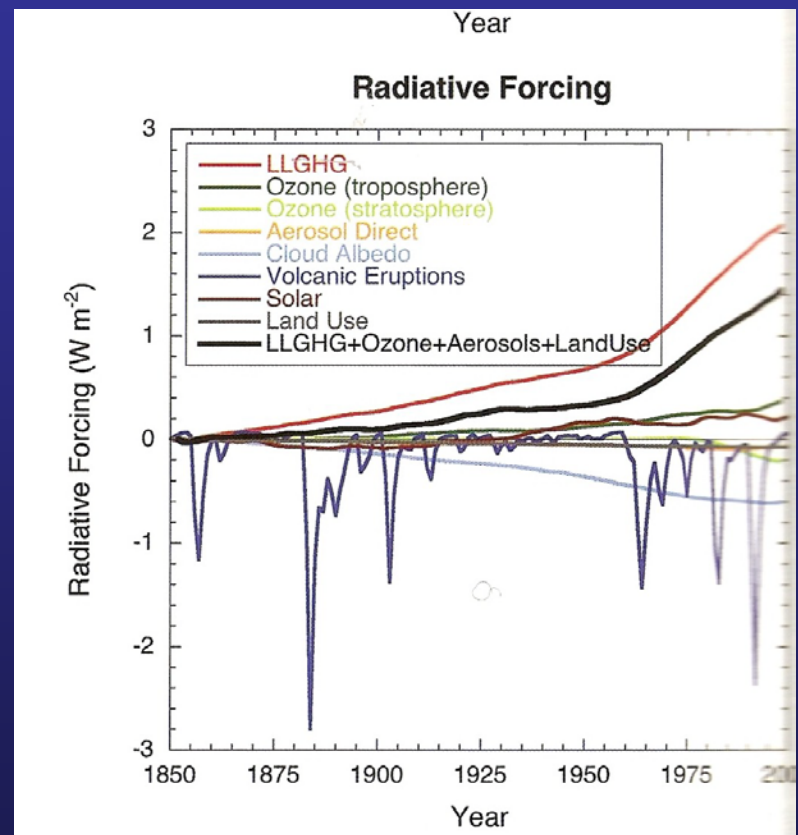
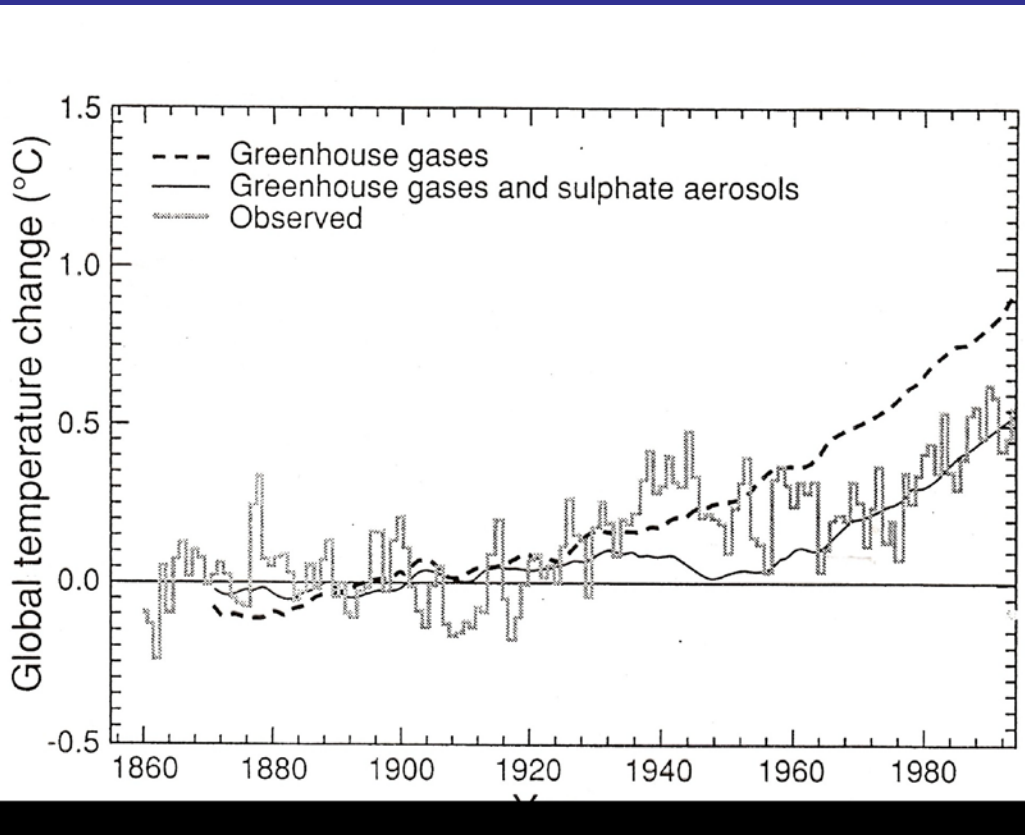


# INTENSIFICACIÓN RADIATIVA

**TABLE 17.1.** Global Warming Potentials and Other Relevant Data for Radiatively Important Gases<sup>a</sup>

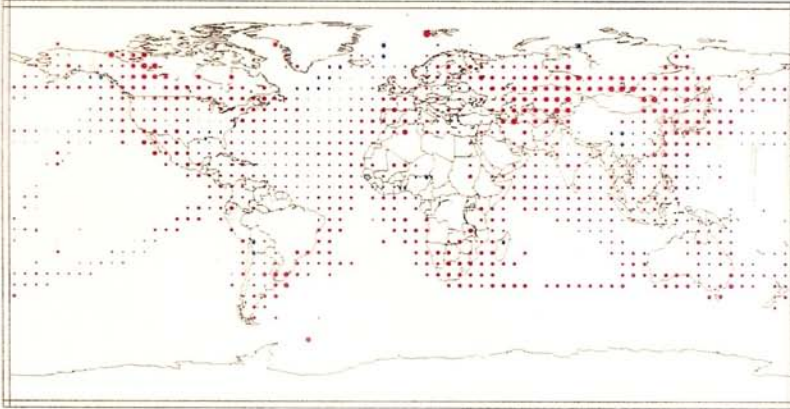
GAS	GWP <sup>b</sup>	1990 EMISSIONS (Tg)	RELATIVE CONTRIBUTION OVER 100 yr (%)	STABILIZATION REDUCTION (%) <sup>c</sup>
CO <sub>2</sub>	1	26,000	61	~60
CH <sub>4</sub>	21	300	15	15-20
N <sub>2</sub> O	290	6	4	70-80
CFCs	3000-8000	0.9	11	70-85
HCFC-22 <sup>d</sup>	1500	0.1	0.5	40-50

# AEROSOLS

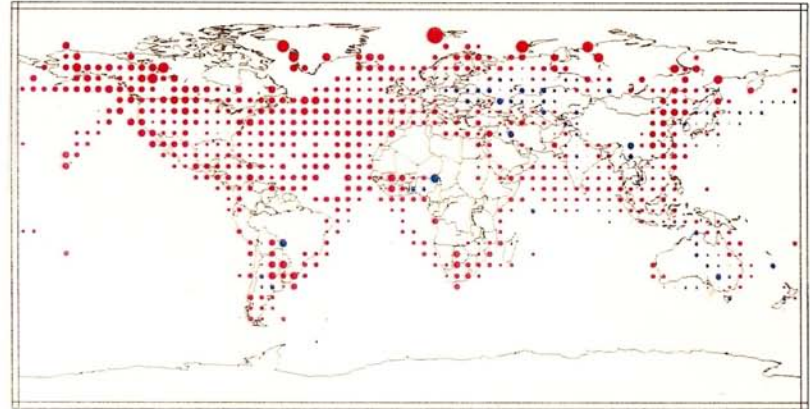


# AEROSOIS (arrefriamento)

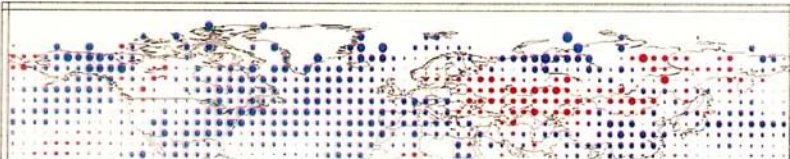
(a) Annual temperature trends, 1901 to 2000



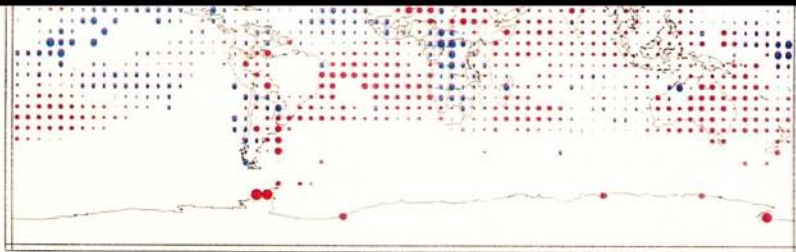
(b) Annual temperature trends, 1910 to 1945



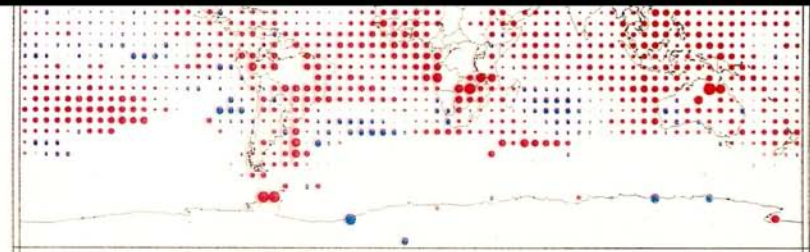
(c) Annual temperature trends, 1946 to 1975



(d) Annual temperature trends, 1976 to 2000



-1 -0.8 -0.6 -0.4 -0.2 0

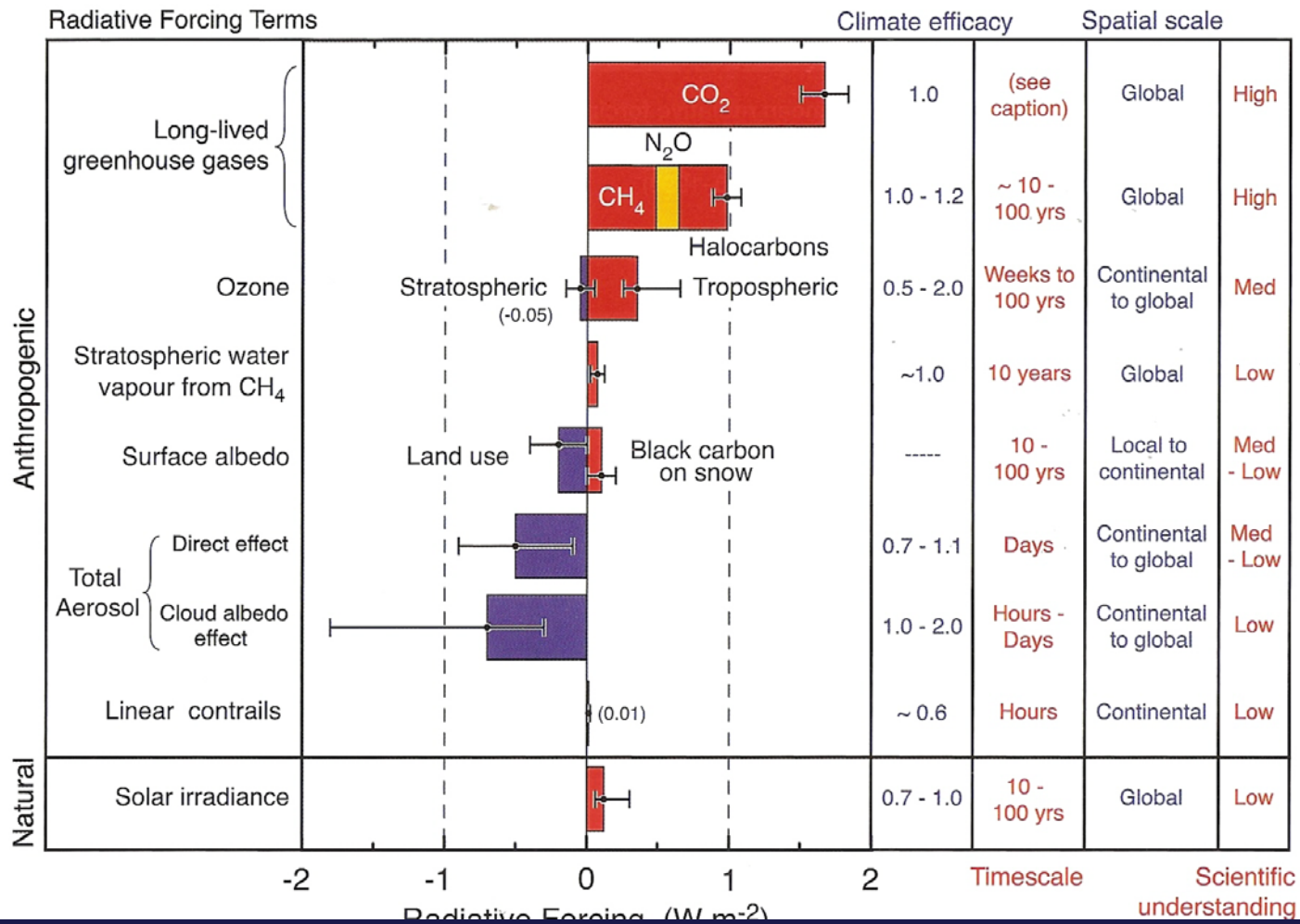


0.2 0.4 0.6 0.8 1

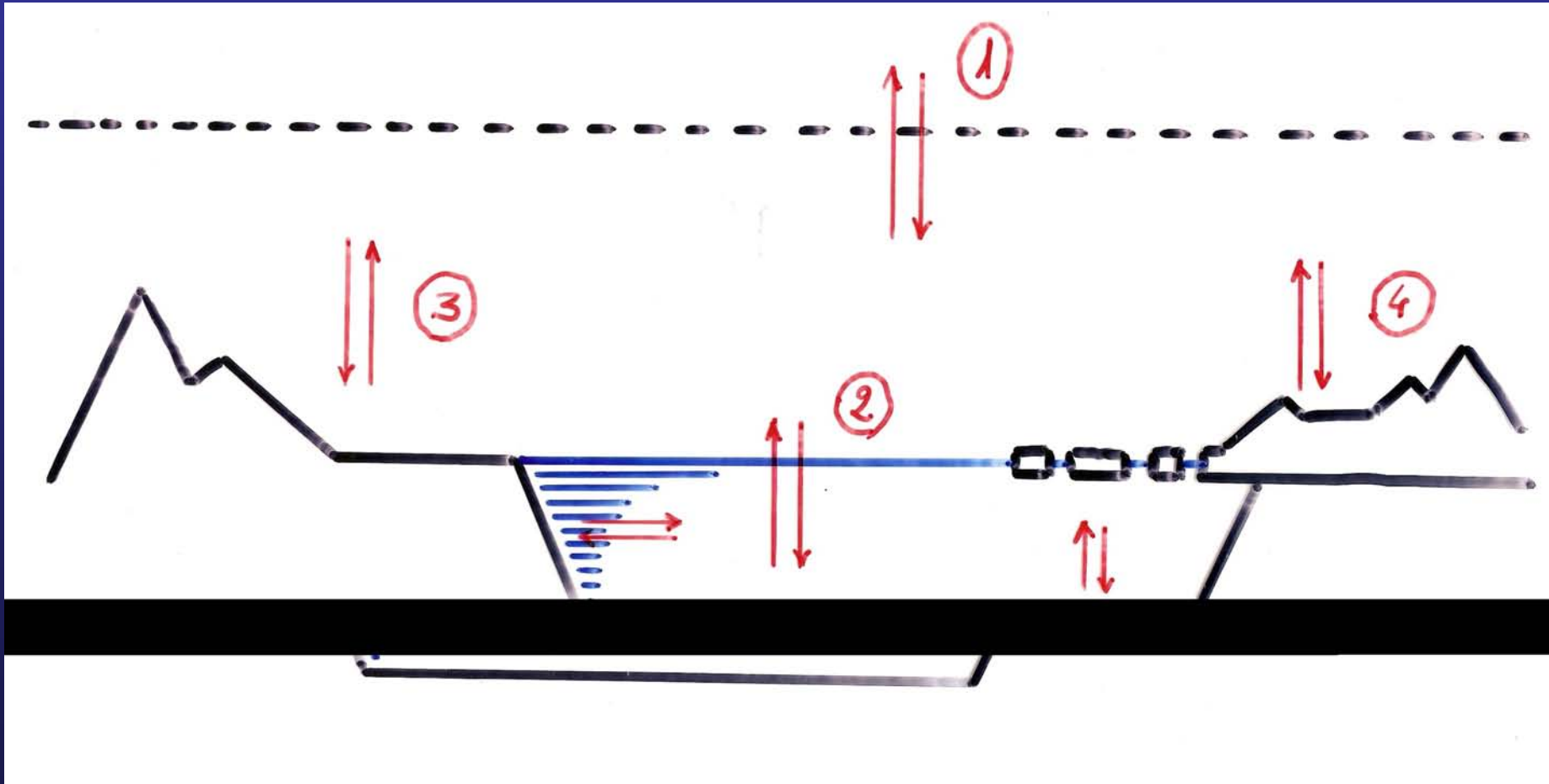
# INTENSIFICACIÓN RADIATIVA TOTAL

A.

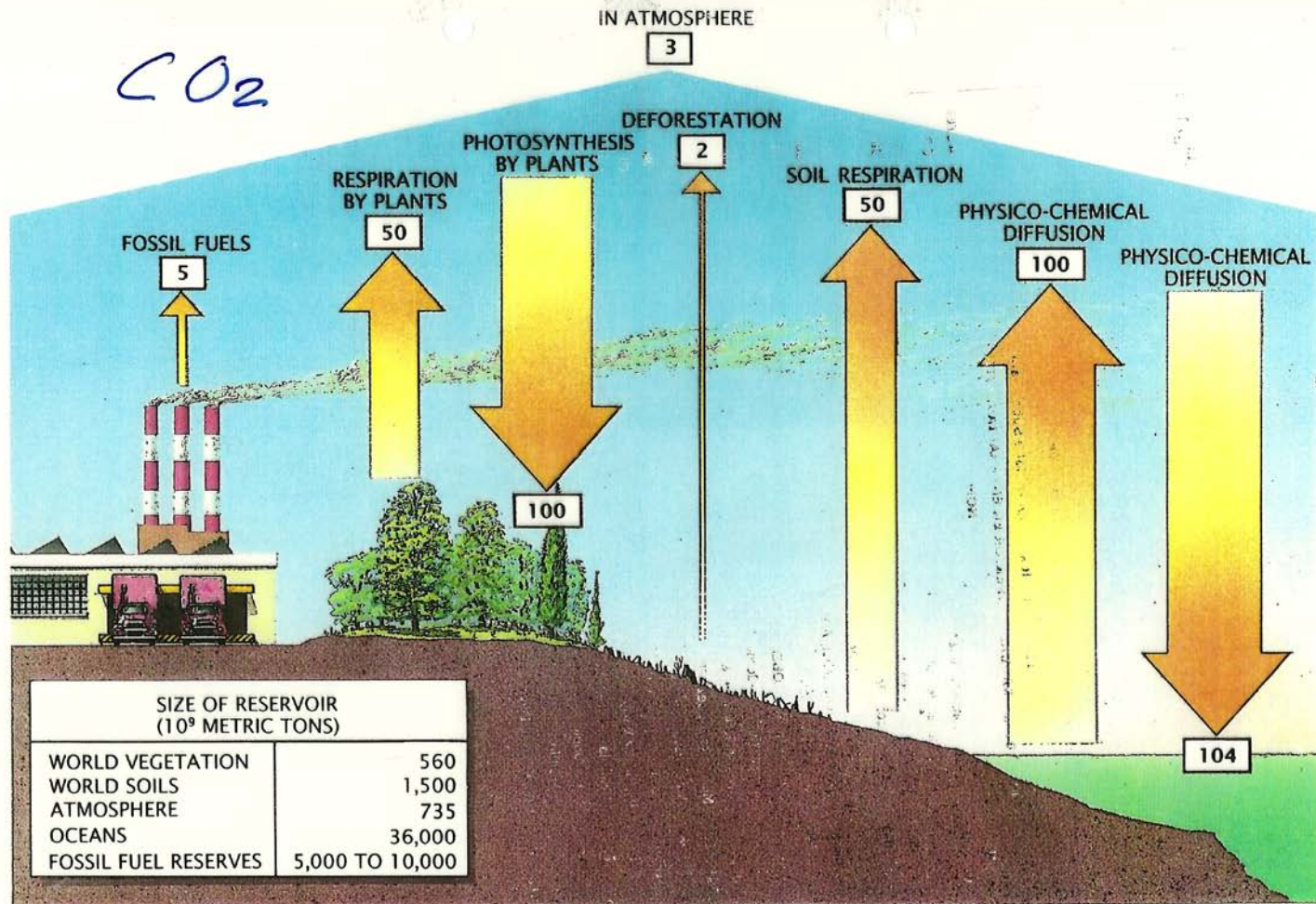
Radiative forcing of climate between 1750 and 2005



# INTERACCIONES NO SISTEMA CLIMÁTICO



# O CICLO DO CARBONO



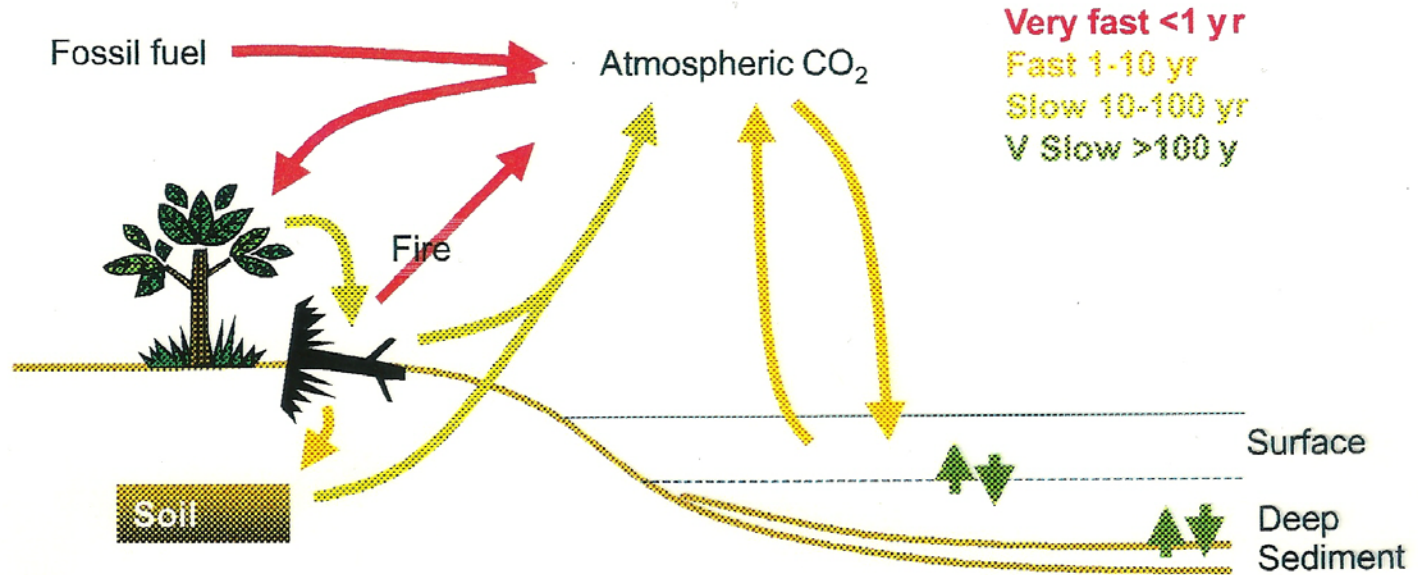
ANNUAL CARBON FLUXES are shown in units of one billion (10<sup>9</sup>) metric tons. Photosynthesis on land removes about 100 billion tons of carbon from the atmosphere annually in the form of carbon dioxide. Plant and soil respiration each return about 50 billion tons. Fossil-fuel burning and deforestation

release into the atmosphere respectively about five and two billion tons. Physicochemical processes at the sea surface release about 100 billion tons into the atmosphere and absorb about 104. The net atmospheric gain is about three billion tons annually. The table lists the world's major carbon reservoirs.

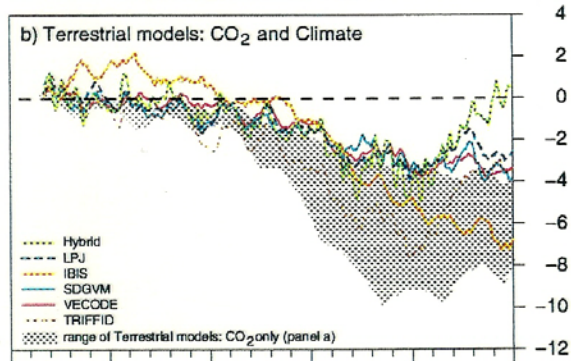


# O CICLO DO CARBONO 2

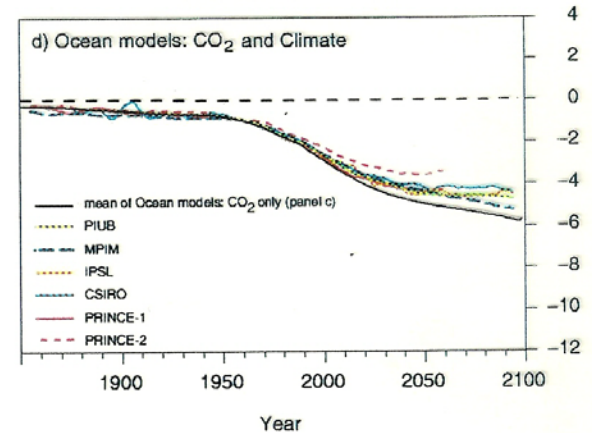
1



Terrestrial C sink

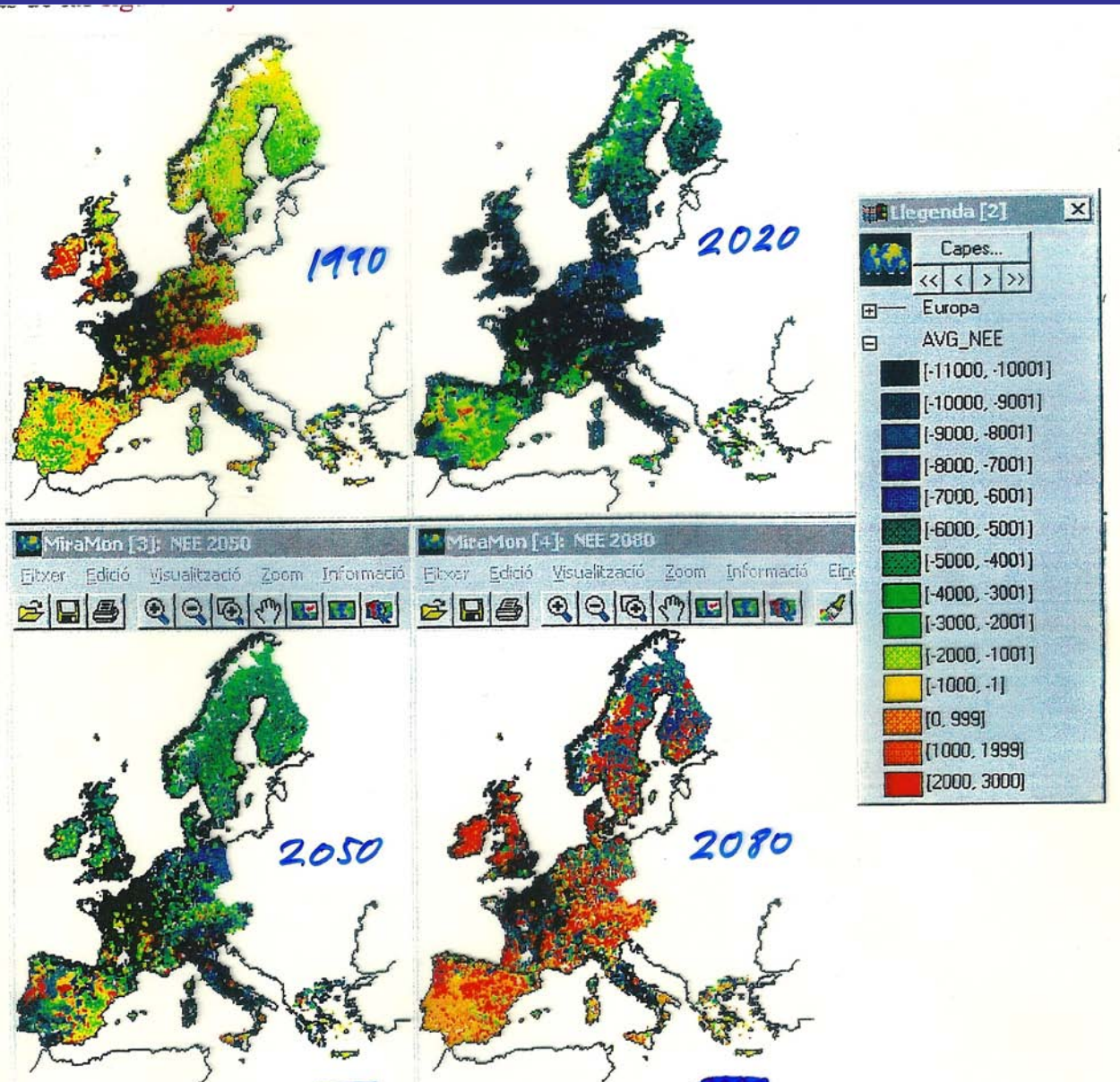


Oceanic C sink

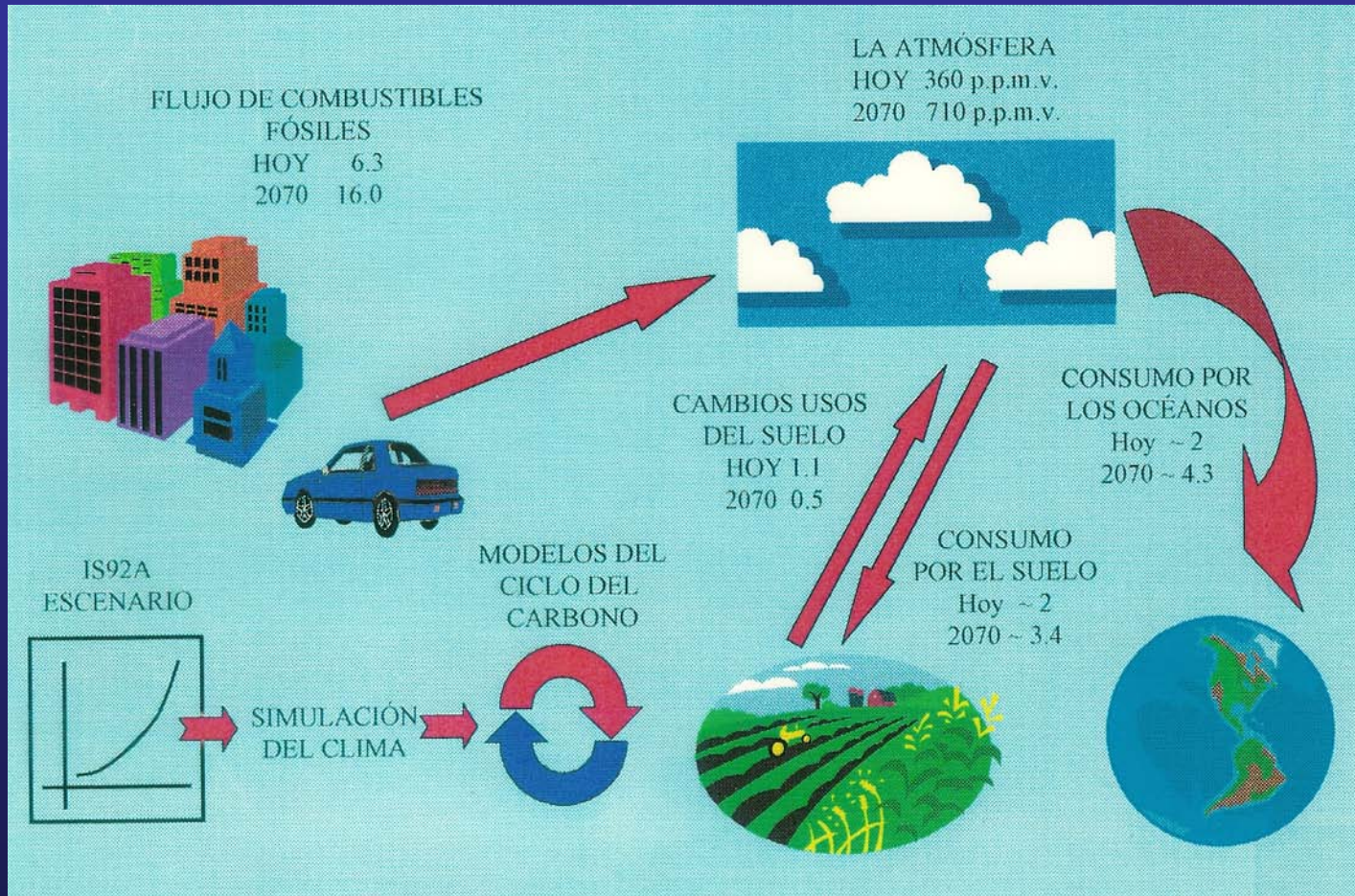


2

# ECOSISTEMAS FORESTAIS



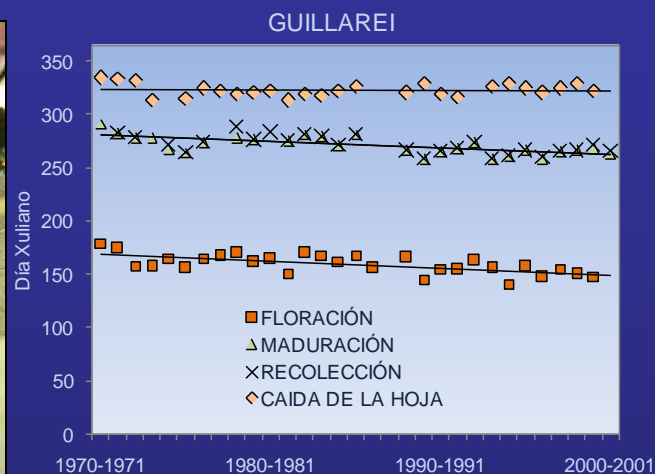
# A ECUACIÓN DO CARBONO



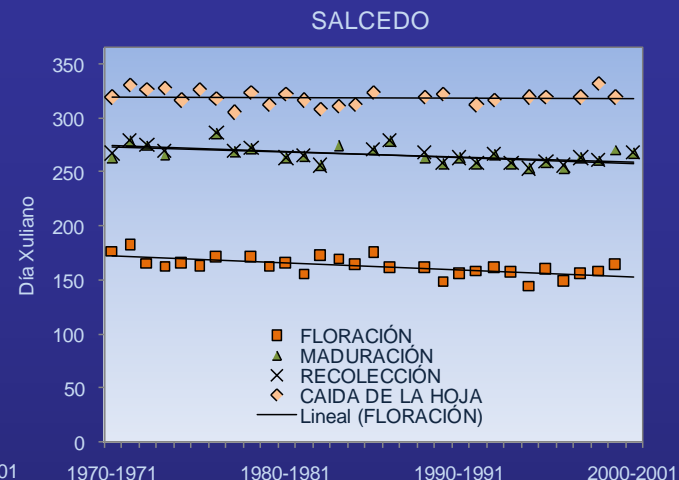
- HOXE  $6.3 + 1.1 - (2 + 2) = 3.4 \cdot 10^{15}$  gramos. ano  $\text{CO}_2$
- 2070 (2x $\text{CO}_2$ )  $16.0 + 0.5 - (3.4 + 4.3) = 8.8$  “ “ “ “

# VIDE

## Evolución das fenofases da Vide (*Vitis vinifera*) desde 1970



**Floración: 19 días en 30 anos**  
**Maduración: 18 días en 30 anos**  
**Colleita: 17 días en 30 anos**  
**Caída da folla: sen cambio aparente**



**Floración: 18 días en 30 anos**  
**Maduración: 18 días en 30 anos**  
**Colleita: 15 días en 30 anos**  
**Caída da folla: sen cambio aparente**

## Cambios nas fenofases da Vide (*Vitis vinifera*) desde 1970

Estación fenolóxica	Fenofase analizada	Día Xuliano promedio	Data promedio	Anos Observados			REGRESIÓN		
				Nº Anos	Desde	Ata	Pendente <sup>(1)</sup>	t <sup>(2)</sup>	Sig.
SALCEDO	FLORACIÓN	163	11-jun	28	1970	2000	-0.624	-4.408	0.000*
	MADURACIÓN	266	22-sep	25	1970	2000	-0.493	-2.991	0.007*
	RECOLECCIÓN	271	27-sep	23	1970	2001	-0.605	-3.896	0.001*
	CAIDA DE LA HOJA	319	14-nov	25	1970	2000	-0.335	-0.335	0.741**
GUILLAREI	FLORACIÓN	160	08-jun	29	1970	2000	-0.656	-4.447	0.000*
	MADURACIÓN	271	27-sep	26	1970	2001	-0.621	-4.503	0.000*
	RECOLECCIÓN	271	27-sep	25	1970	2001	-0.598	-3.78	0.001*
	CAIDA DE LA HOJA	323	18-nov	26	1970	2000	-0.022	-0.174	0.864**

<sup>(1)</sup> Pendentes en días/ano.

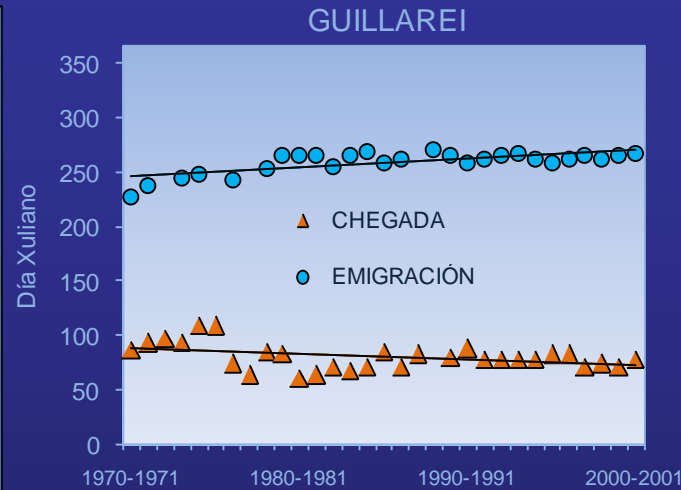
<sup>(2)</sup> Valores dados como unha distribución t de Student.

\* Valores con un 95% de probabilidade de significancia.

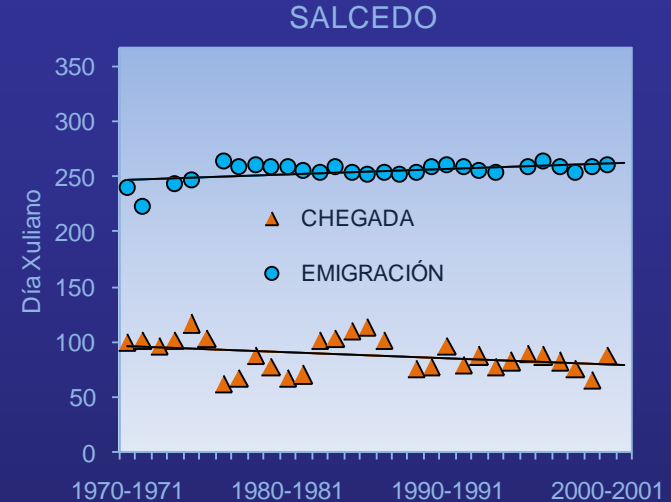
\*\* Valores sen cambio aparente (t entre +1 y -1).

# ANDURIÑA COMÚN

## Evolución da chegada e emigración das Anduriñas (*Hirundo rustica*) desde 1970



**Chegada: 15 días antes en 30 anos**  
**Emigración: 14 días máis tarde en 30 anos**



**Chegada: 14 días antes en 30 anos**  
**Emigración: 24 días máis tarde en 30 anos**

## Cambios na chegada e emigración da Anduriñas común (*Hirundo rustica*) desde 1970

Estación fenolóxica	Fenofase analizada	Día Xuliano promedio	Data promedio	Anos Observados			REGRESIÓN		
				Nº Anos	Desde	Ata	Pendente <sup>(1)</sup>	t <sup>(2)</sup>	Sig.
GUILLAREI	CHEGADA	81	21-mar	30	1970	2001	-0.493	-2.192	0.037*
	EMIGRACIÓN	259	15-sep	27	1970	2001	0.828	4.98	0.000*
SALCEDO	CHEGADA	88	28-mar	30	1970	2001	-0.531	-1.826	0.079*
	EMIGRACIÓN	254	10-sep	28	1970	2001	0.489	3.081	0.005*

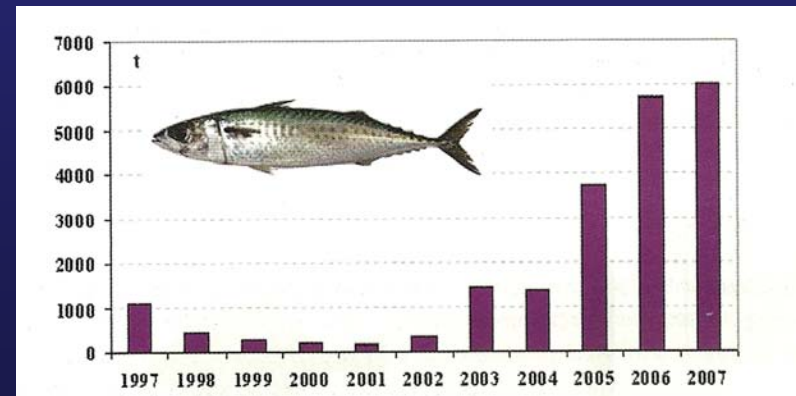
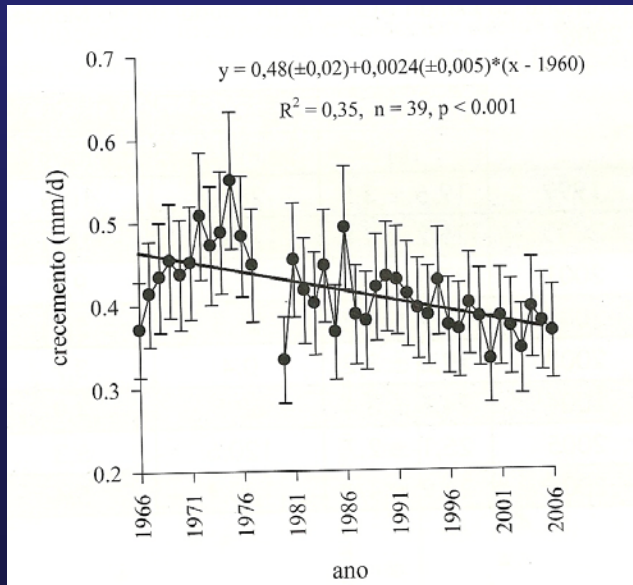
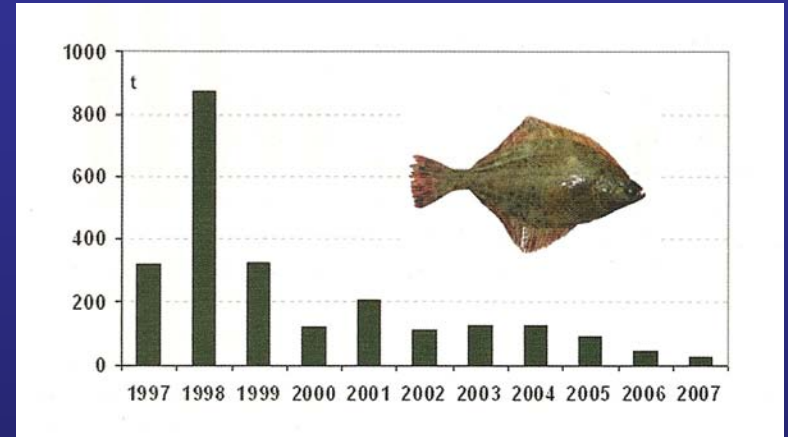
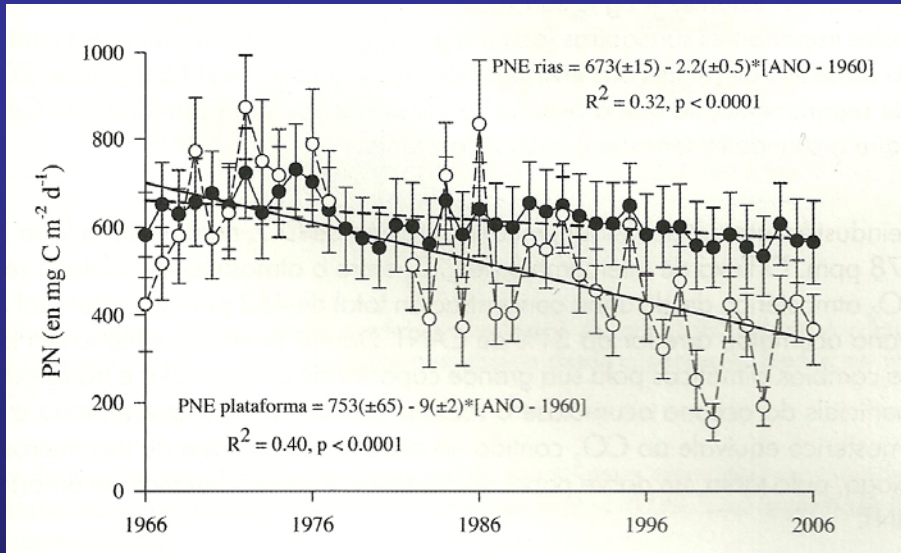
<sup>(1)</sup>Pendientes en días/año.

<sup>(2)</sup>Valores dados como unha distribución t de Student.

\* Valores con un 95% de probabilidade de significancia.

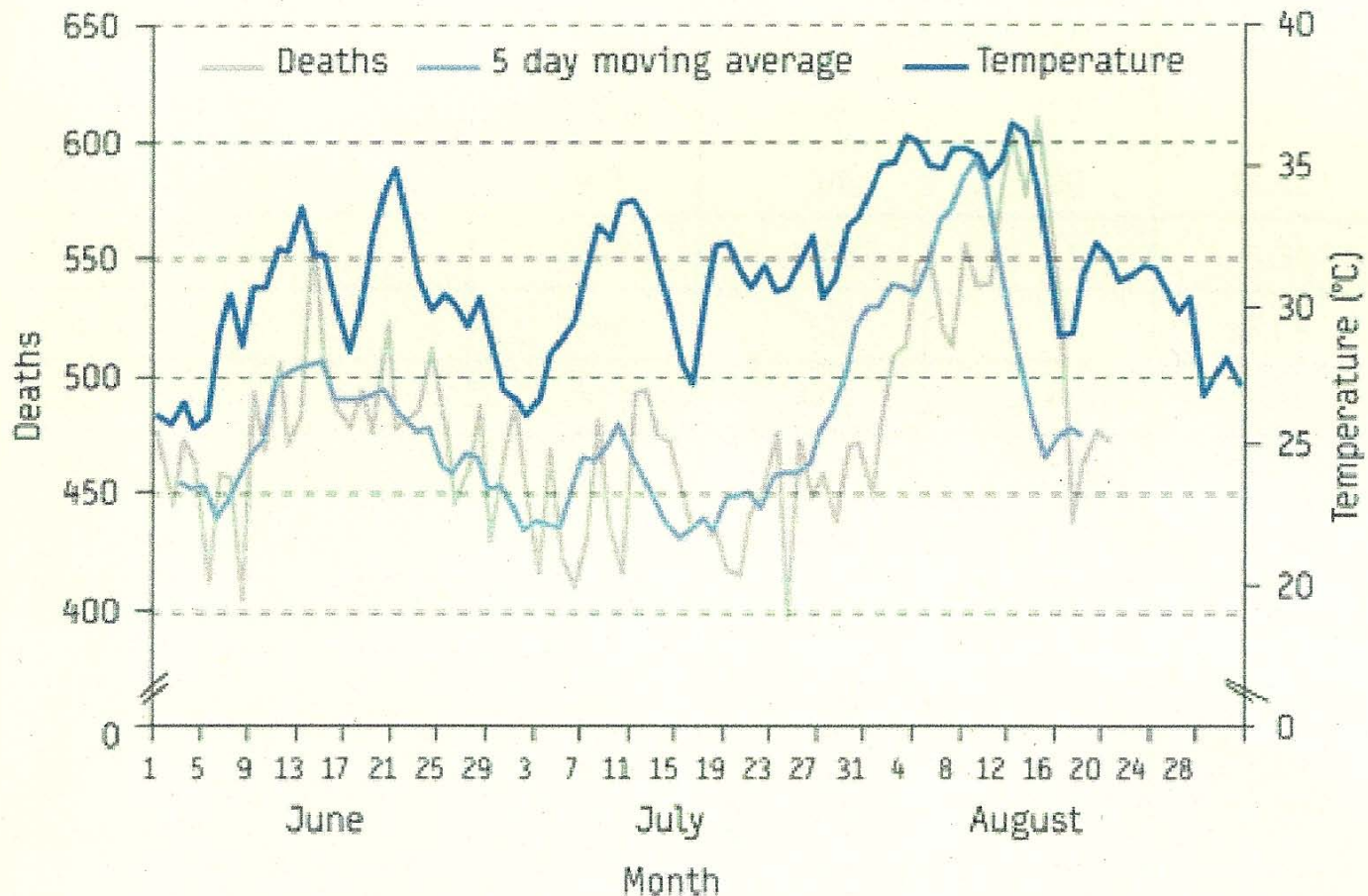
\*\* Valores sen cambio aparente (t entre +1 y -1).

# EVIDENCIAS MARINAS



# SAUDE HUMANA

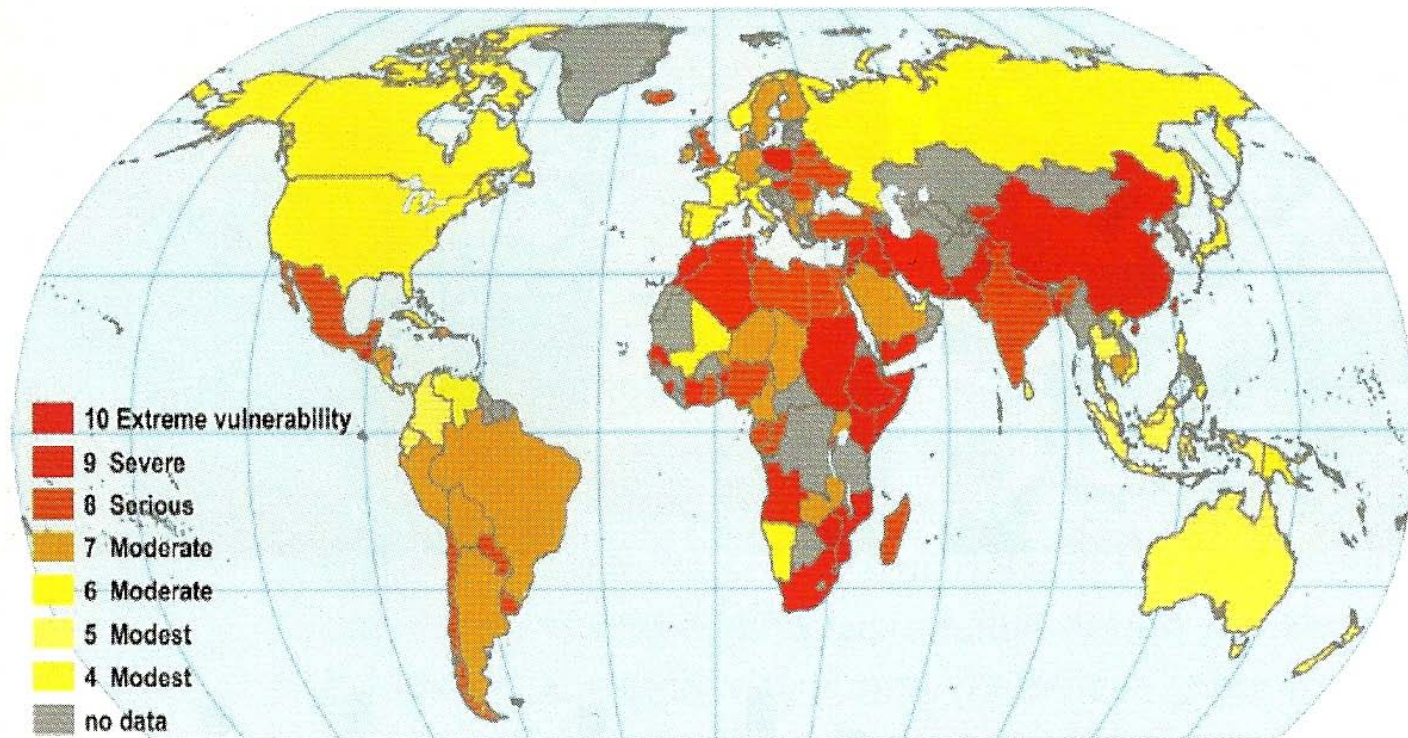
Daily deaths, 5 day moving average and daily mean temperatures for 50 provincial capitals, Spain, June-August 2003



# VULNERABILIDADE

## Global Distribution of Vulnerability to Climate Change

Combined National Indices of Exposure and Sensitivity



Scenario A2-550 in Year 2100 with Climate Sensitivity Equal to 5.5 Degrees C

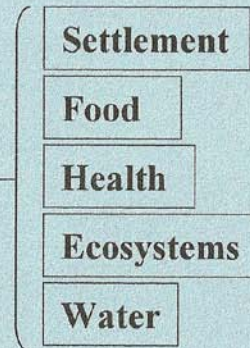
Annual Mean Temperature with Aggregate Impacts Calibration



# VULNERABILIDADE / RESILIENCIA

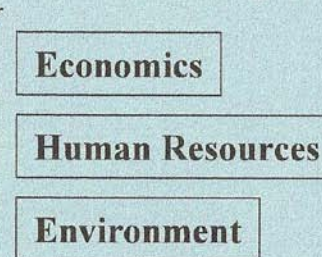
## Quantifying vulnerability and resilience

### Sensitivity sectors



Sensitivity Indicators

### Coping and Adaptive Capacity



Coping-Adaptive Capacity Indicators

Baseline Estimates and Projections of  
Sectoral Indicators,  
Sensitivity and Coping-Adaptive Capacity, and  
Vulnerability-Resilience Response Indicators to Climate Change