La sfida della scienza del clima

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INGV

Aristotele

Raffello, la Scuola di Atene

De Meteorologica

However, all the mouths of the Nile, with t at Canopus, are obviously artificial and not natural. And Egypt was nothing n ebes, as Homer, too, shows, modern though he is in relation to such changes.

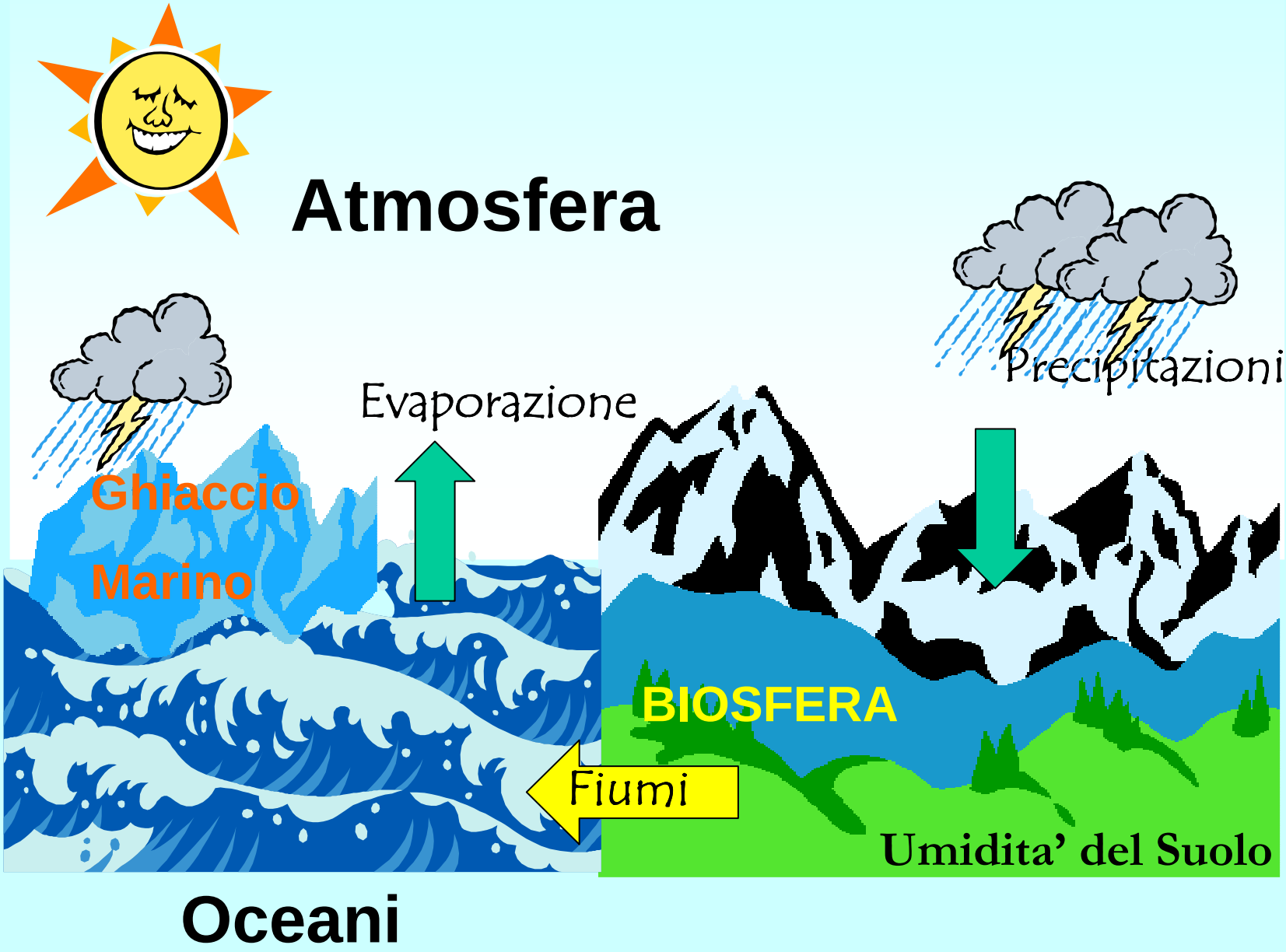
(…)

This happened to the land of Argos and M me of the Trojan wars the Argive land was marshy and could only support a sma land of Mycenae was in good condition. But now the opposite is the case, for the r the land of Mycenae has become completely dry and barren, while the Argi barren owing to the water has now become fruitful. Now the same process th mall district must be supposed to be going on over whole countries and on a la

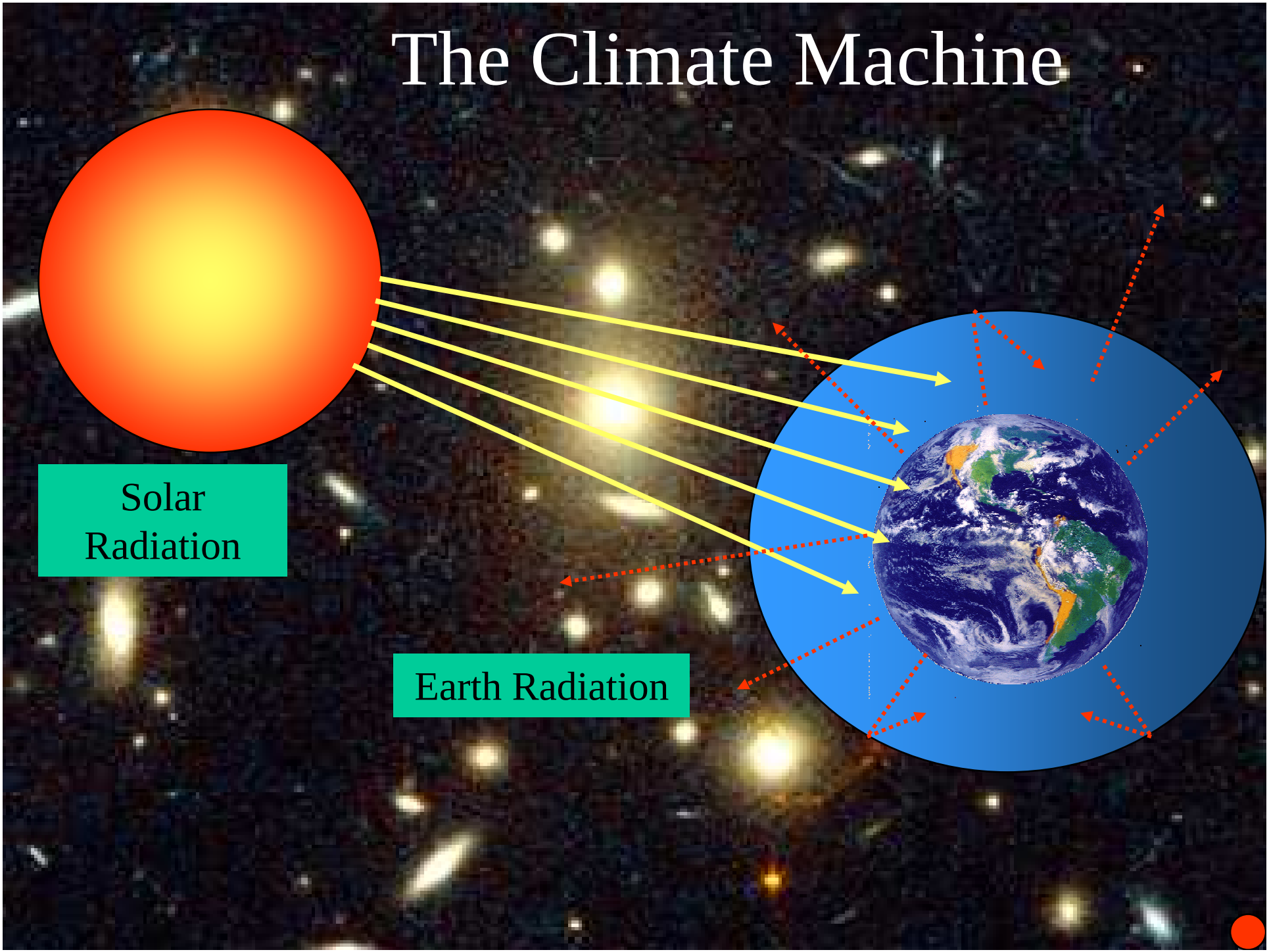
(…)

So it is clear, since there will be no end to nal, that neither the Tanais nor the Nile has always been flowing, but that the regi once dry: for their effect may be fulfilled, but time cannot. And this will be equally true of all other rivers. But if rivers come into existence and perish and the same parts of the earth were not always moist, the sea must needs change correspondingly. And if the sea is always advancing in one place and receding in another it is clear that the same parts of the whole earth are not always either sea or land, but that all this changes in course of time.

Il Sistema Clima



The Climate Machine



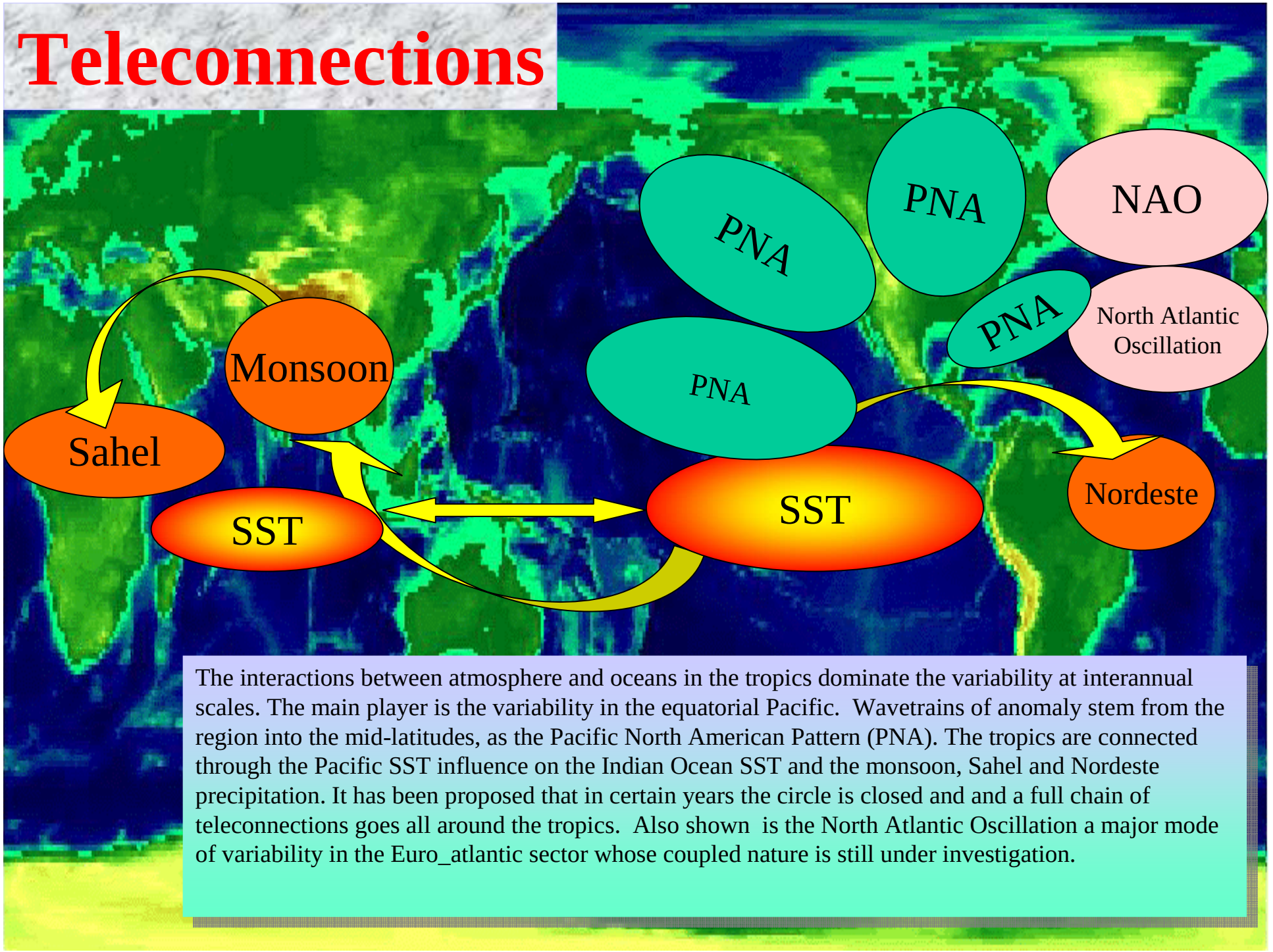
Globalizzazione del Clima

Una serie di carestie senza precedenti, i cui effetti furono moltiplicati dal regime coloniale, colpi l'India nella seconda meta del XIX secolo.(1861,1866,1876-1878, 1897-1901). L'inserimento dell'agricoltura tropical nel sistema europeo mise in rilievo che la carestia, prodotti dai fallimenti della stagione delle piogge, non erano solo limitati all'India, ma si erano verificate anche in Cina e in Brasile.

Lo sforzo di comprendere si allargo'. Jevons, ecoomista e statistico, elabaro' una teoria secondo la quale i cicli delle macchie solari influenzavano i cicli economici e in special modo un ciclo di undici anni tra crisi finanziarie che aveva appena scoperto.

Sir Gilbert Walker, direttore del servizio meteorologico indiano nel … cerco' di prevedere le variazioni interannuali dei monsoni collegate ai disastri. Si imbarco' in una colossale fishing expedition per cercare di trovare relazioni che collagassero i monsoni indiani ad altri fenomeni climatici, coordinando uno sfrozo di raccolta dati senza precedenti. Analizzando i dati che gli arrivavano da tutto l'impero fu in grando di individuare una serie di relazioni a lunga distanza tra la pressione al suolo, di cui la piu' famosa e la piu' importante e' l'Oscillazione Meridionale.

Teleconnections

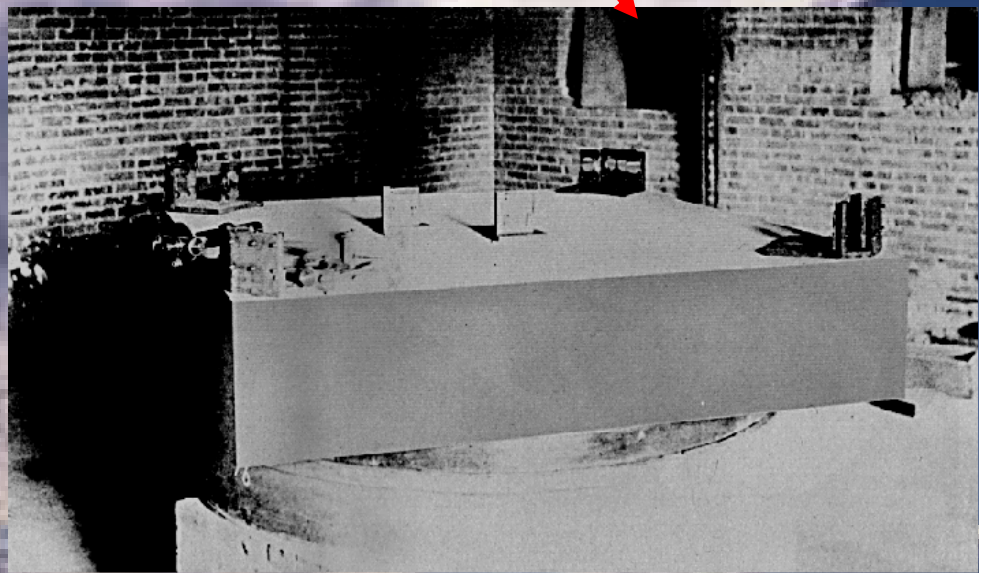


The interactions between atmosphere and oceans in the tropics dominate the variability at interannual scales. The main player is the variability in the equatorial Pacific. Wavetrains of anomaly stem from the region into the mid-latitudes, as the Pacific North American Pattern (PNA). The tropics are connected through the Pacific SST influence on the Indian Ocean SST and the monsoon, Sahel and Nordeste precipitation. It has been proposed that in certain years the circle is closed and and a full chain of teleconnections goes all around the tropics. Also shown is the North Atlantic Oscillation a major mode of variability in the Euro_atlantic sector whose coupled nature is still under investigation.

A scientific consideration of climate (I)

Crucial experiments like the famous experiment of Michelson e Morley are not possible in climate science

How is it possible a scientific investigation of climate ?

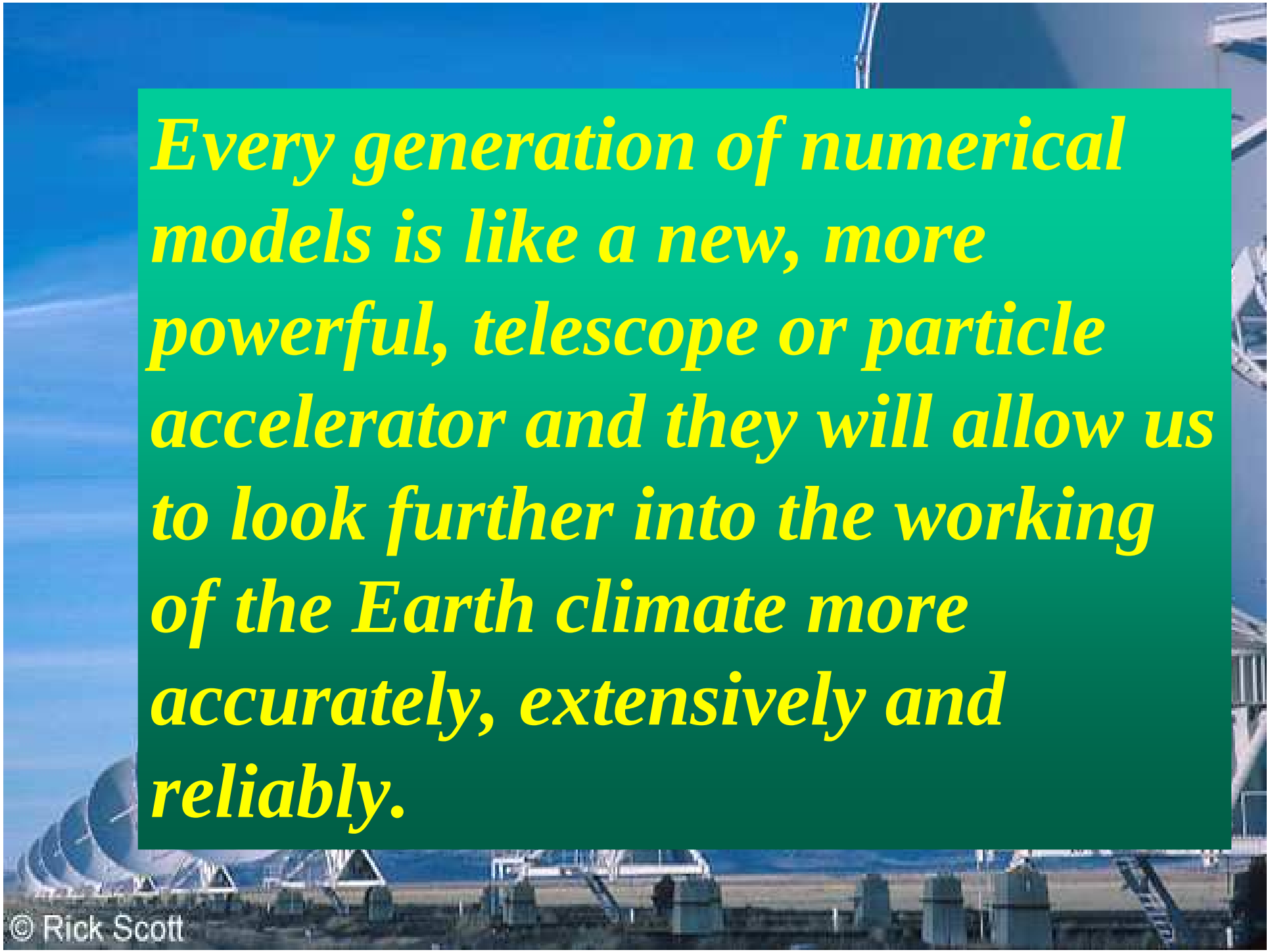


A scientific consideration of climate (II)

We can make experiments if we represent the climate system via a set of mathematical relations: the equation of climate.

The equation of climate are very difficult, but they can be solved by numerical methods.

We can then treat very complex mathematical equations, paying the price of a enormous number of elementary operations.


Every generation of numerical models is like a new, more powerful, telescope or particle accelerator and they will allow us to look further into the working of the Earth climate more accurately, extensively and reliably.
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Numerical Methods

Discretize the atmosphere

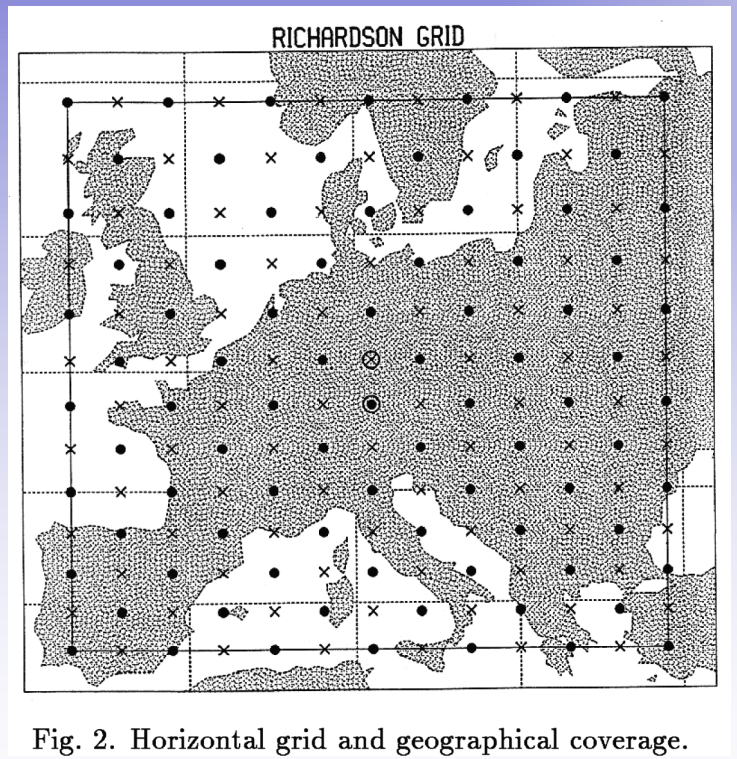
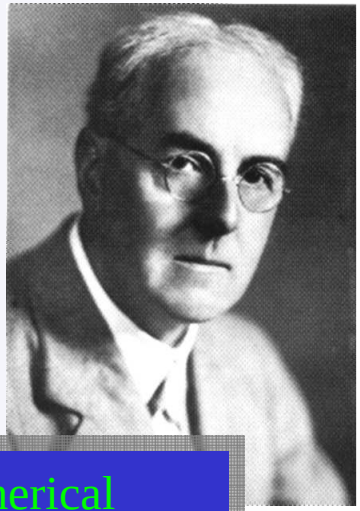
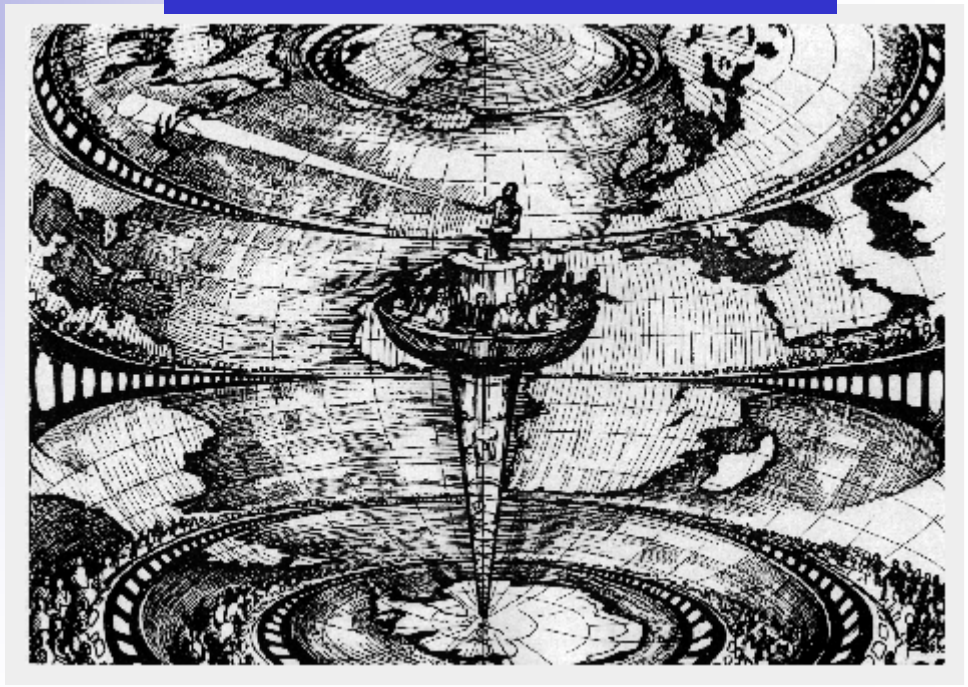


Fig. 2. Horizontal grid and geographical coverage.



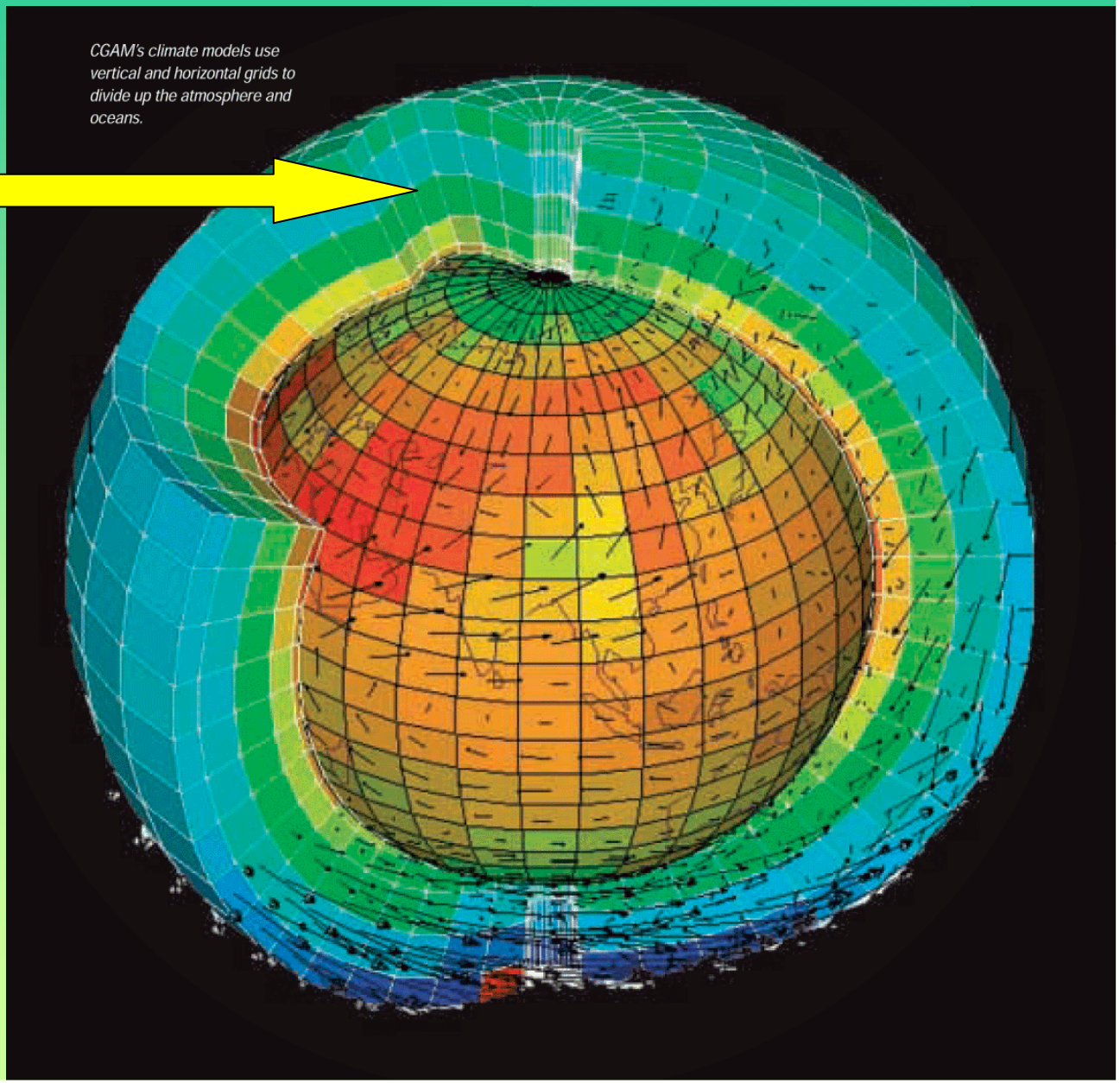
L.F. Richardson, Numerical Weather Forecasts



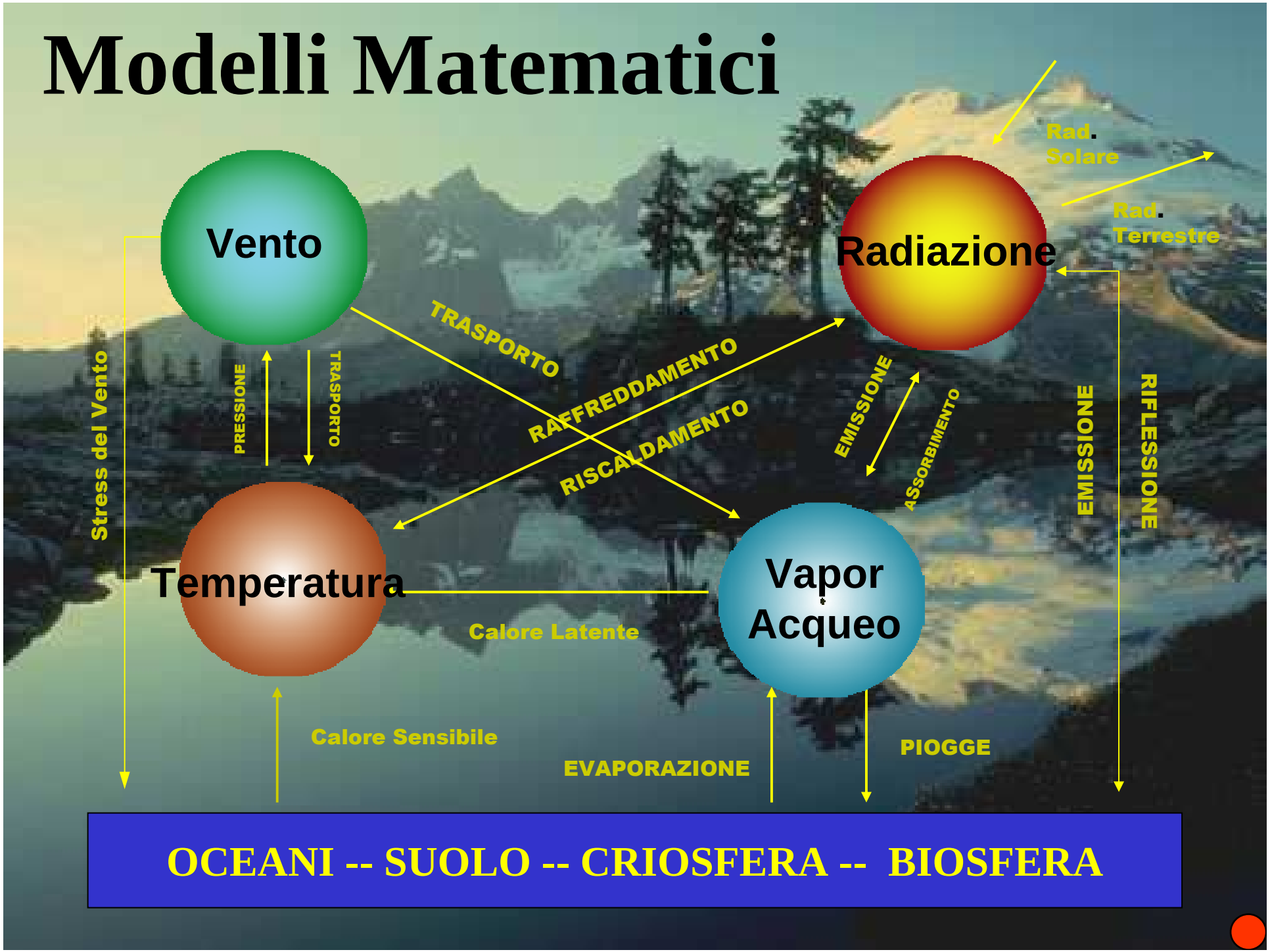
Meteorologists in front of the Electronic Computer Project at the Institute for Advanced Study (Princeton)

Grids for Earth

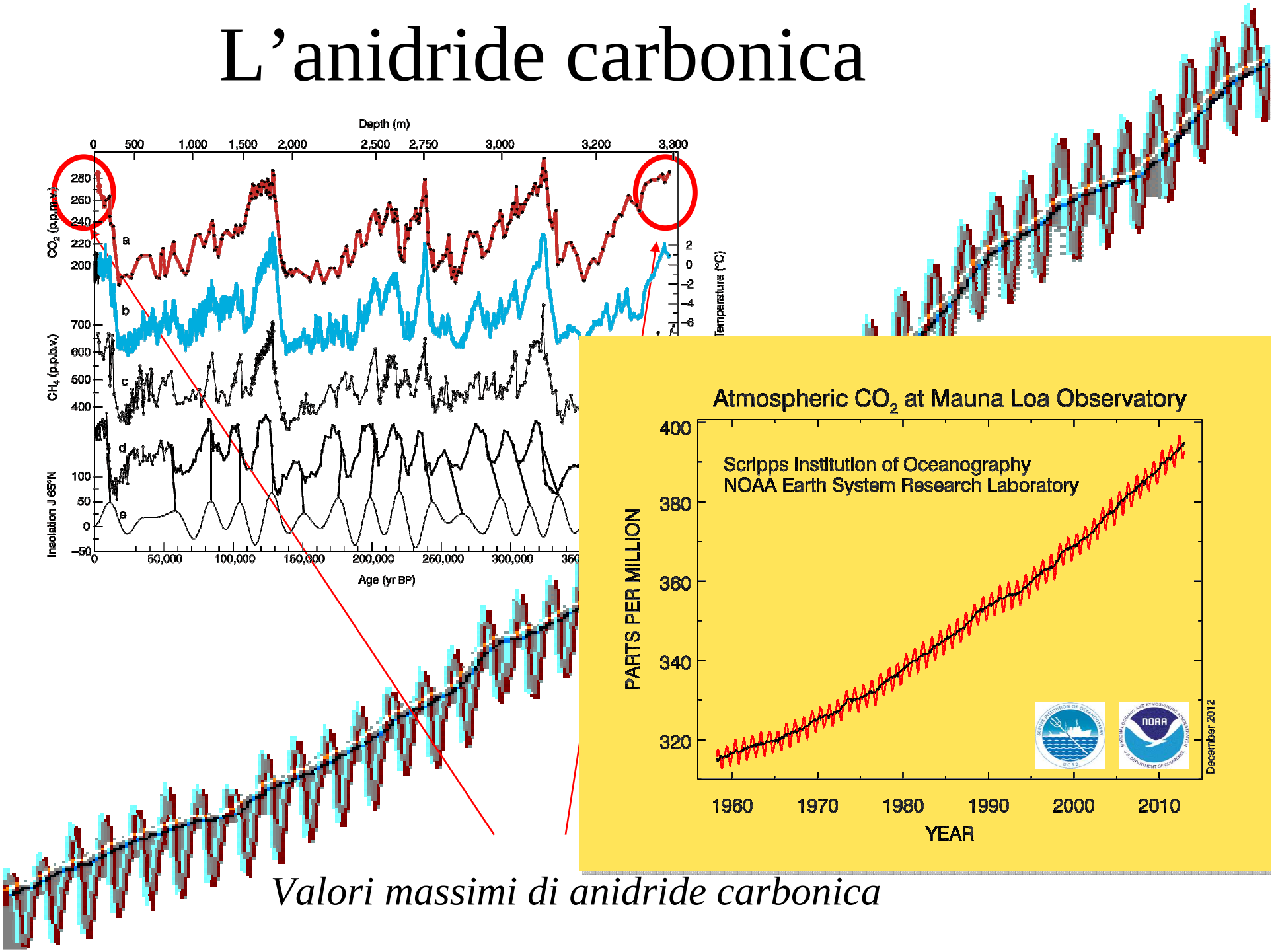
Sort of crowded at the pole



Modelli Matematici

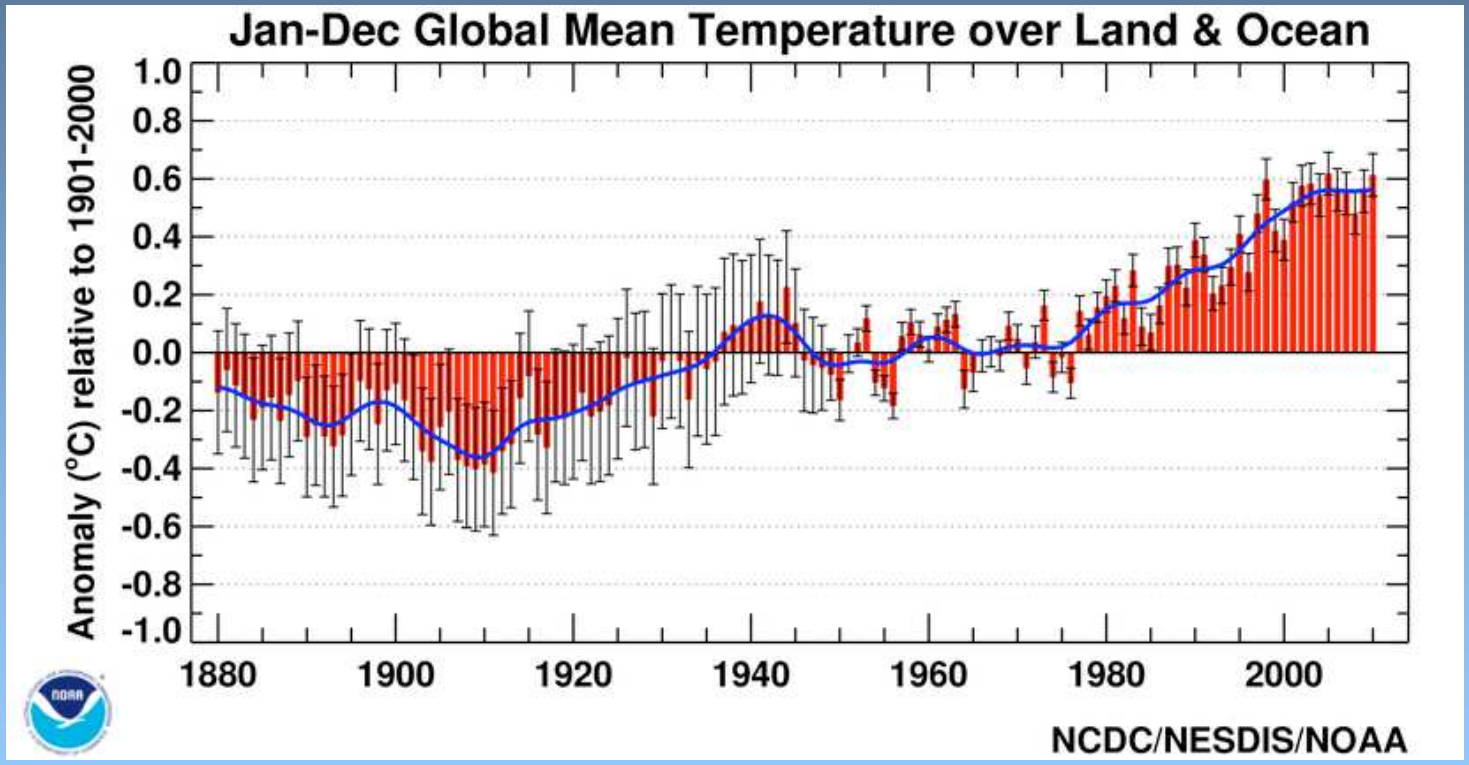


L’anidride carbonica

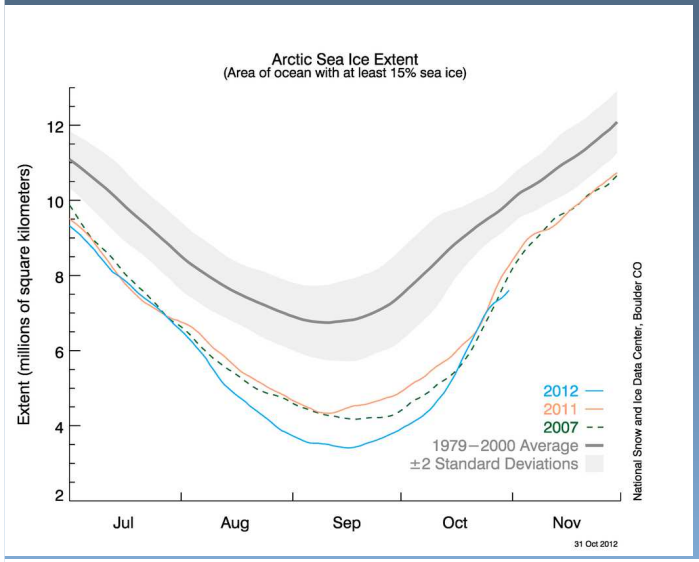


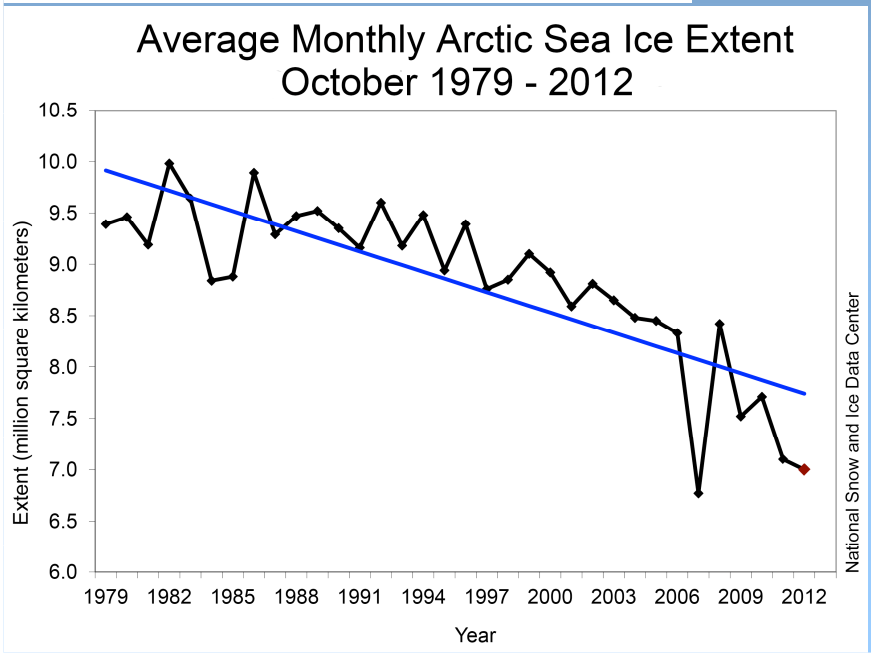
Valori massimi di anidride carbonica

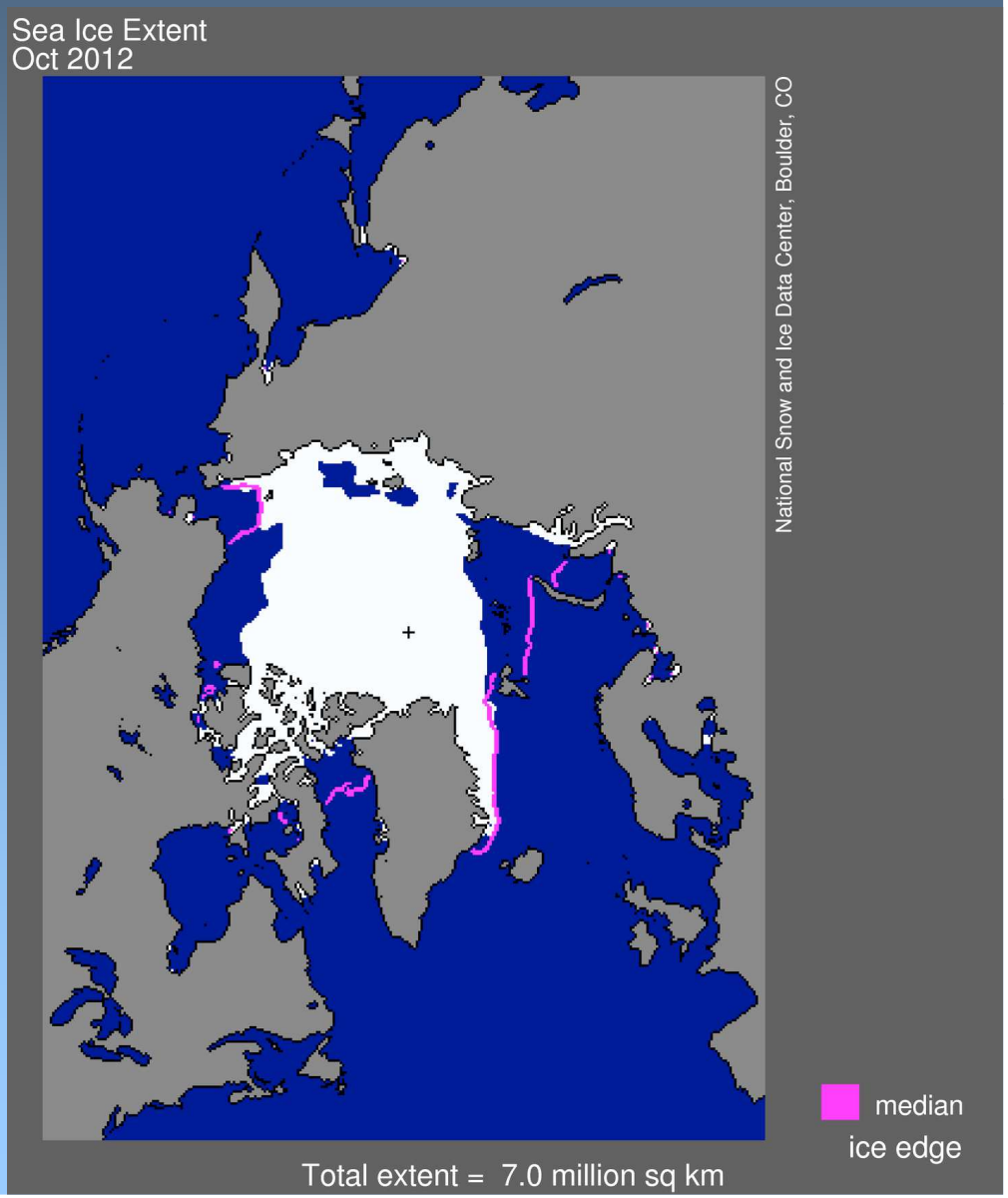
Global Temperature



The climate in 2012:the Arctic

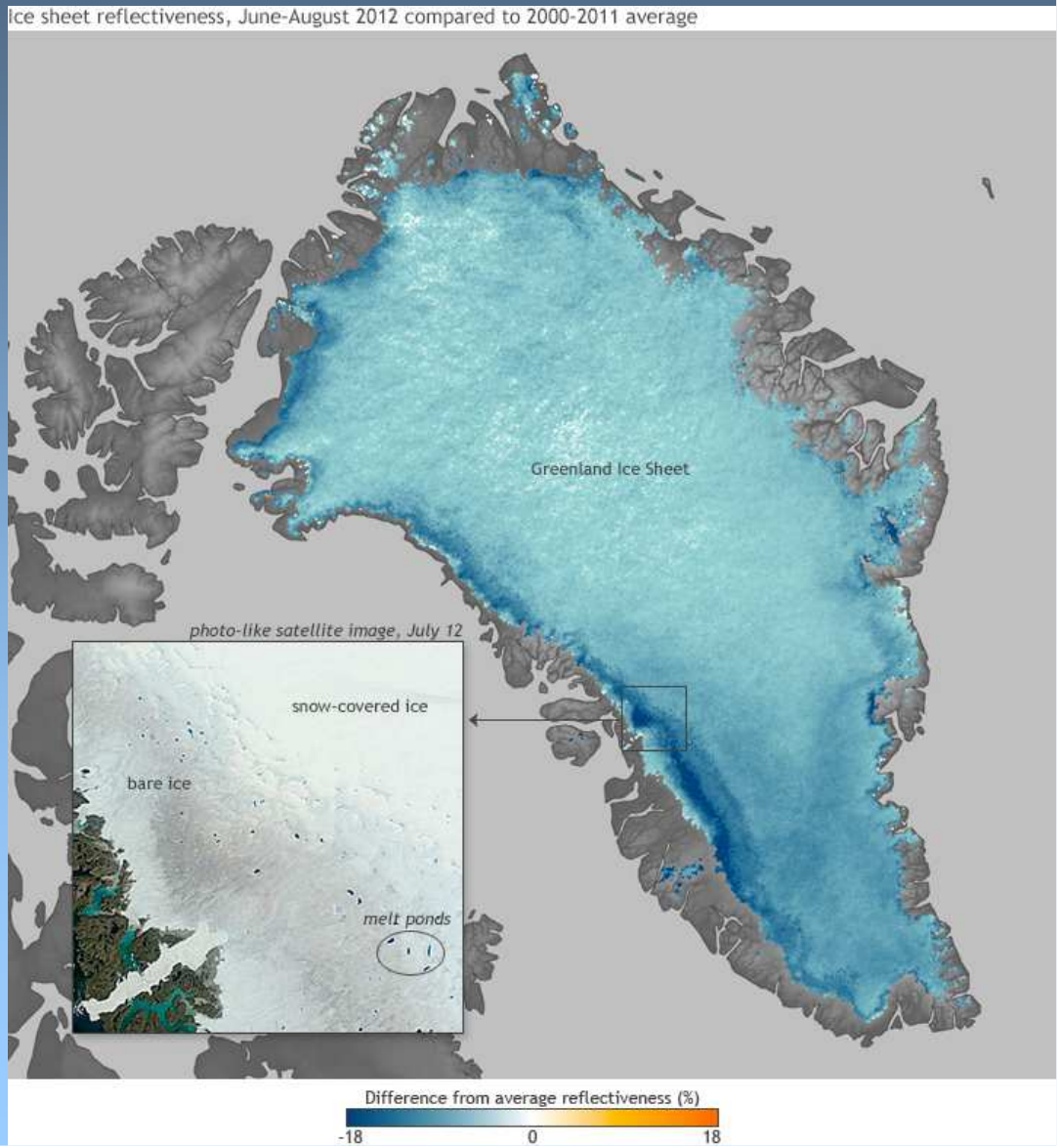




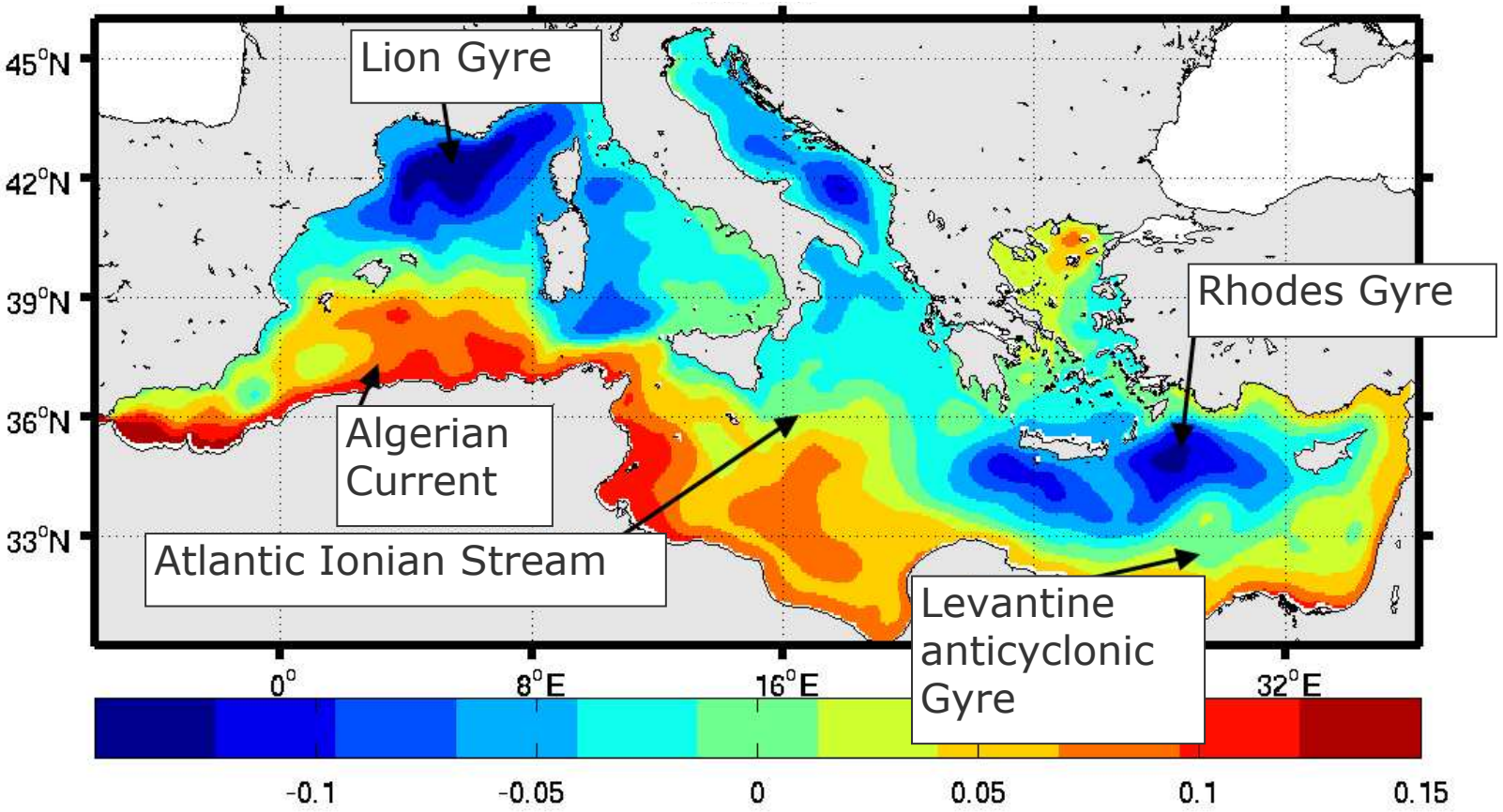


A dark Greenland

The map above shows the percent of incoming sunlight Greenland reflected during June through August 2012 compared to the average of summers from 2000-2011. Blue indicates less sunlight reflected than average, with dark blue indicating nearly 20 percent less sunlight than average reflected back into space. (http://www.climatewatch.noaa.gov)

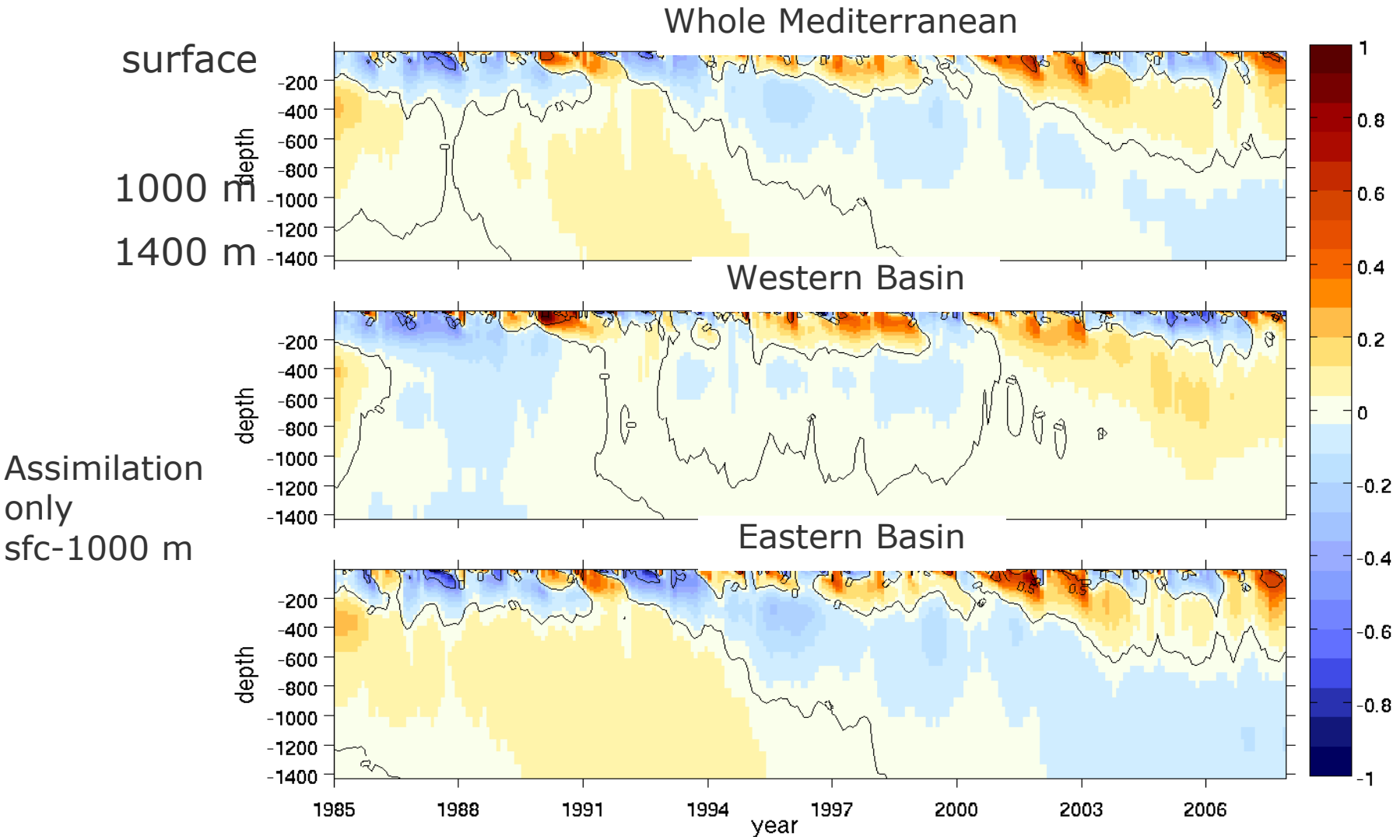


Sea Level 1987-2007 (m) estimated by Circe reanalyses



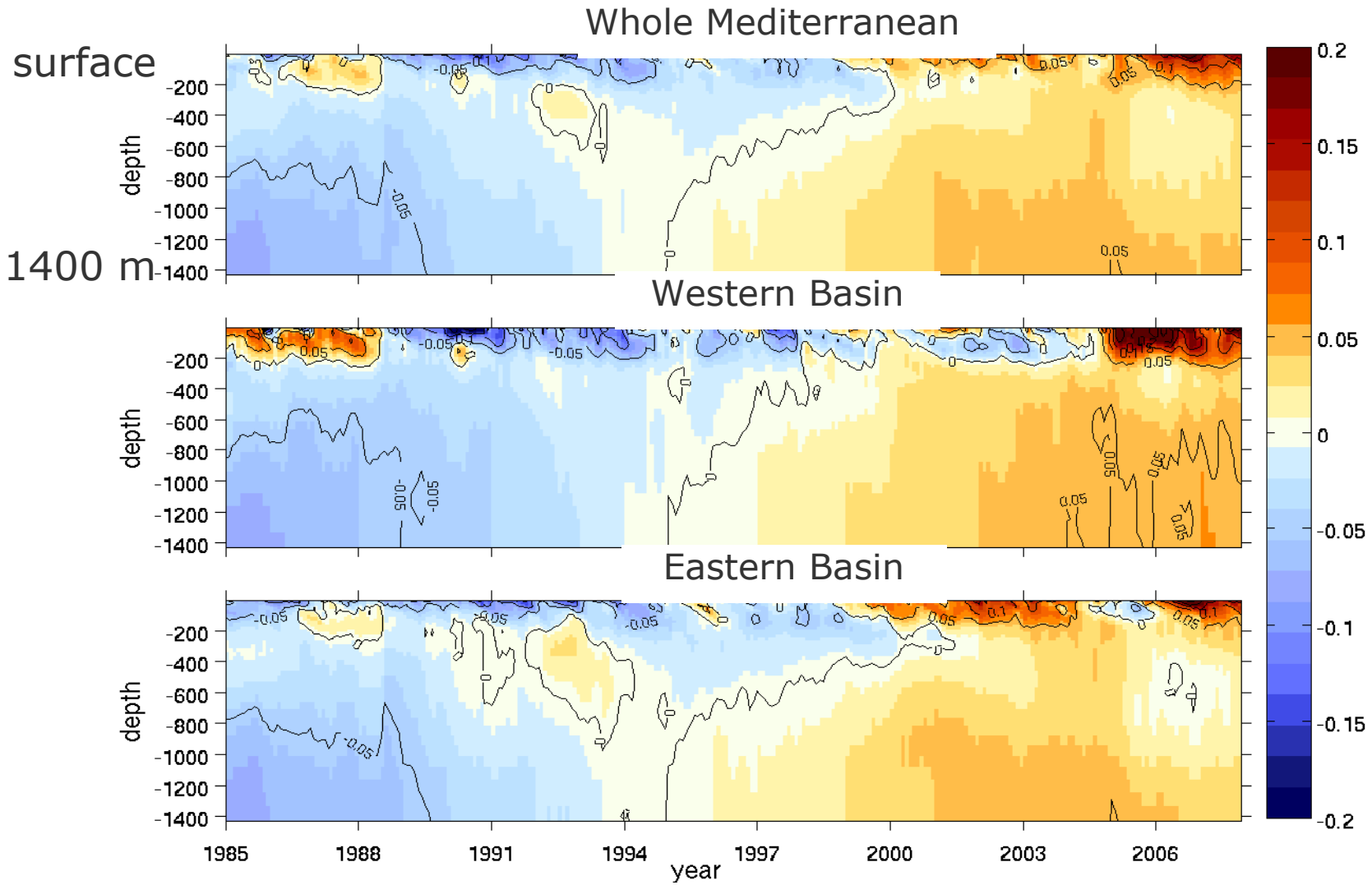
Ocean reanalysis

Temperature in ° C



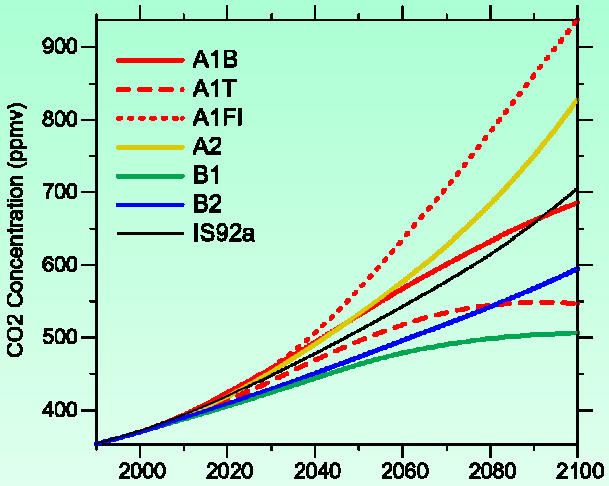
Ocean reanalysis

Salinity in practical salinity units

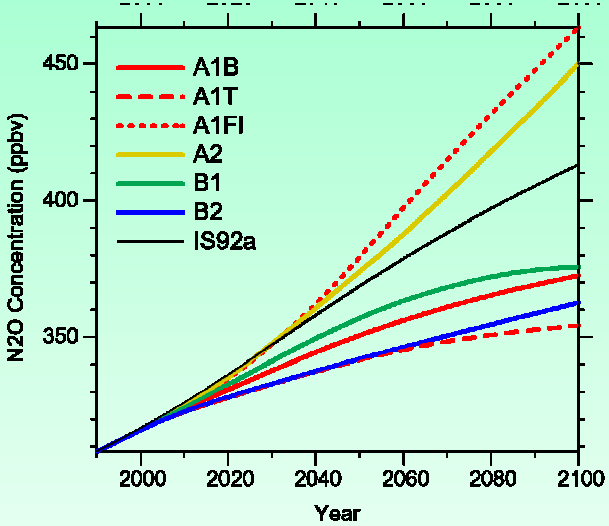


Scenarios

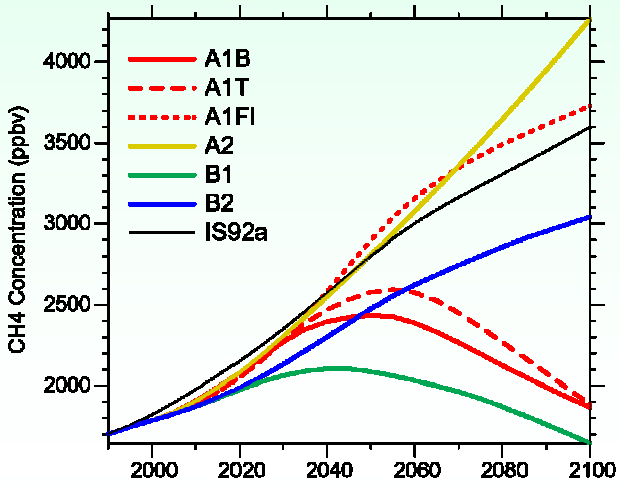
CO2



N2O

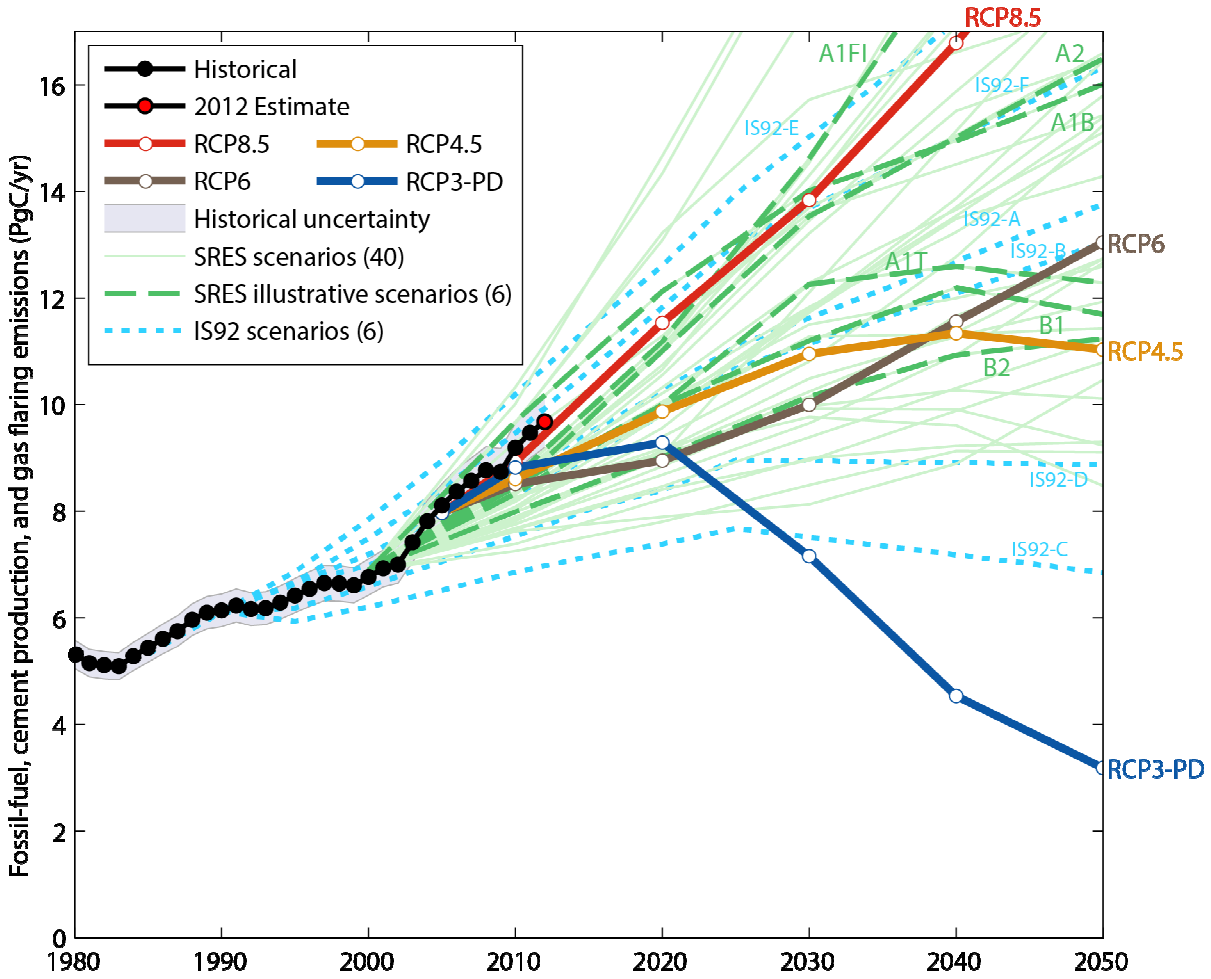


CH4



Observed Emissions and Emission Scenarios

The IPCC has been associated with four generations of emission scenarios



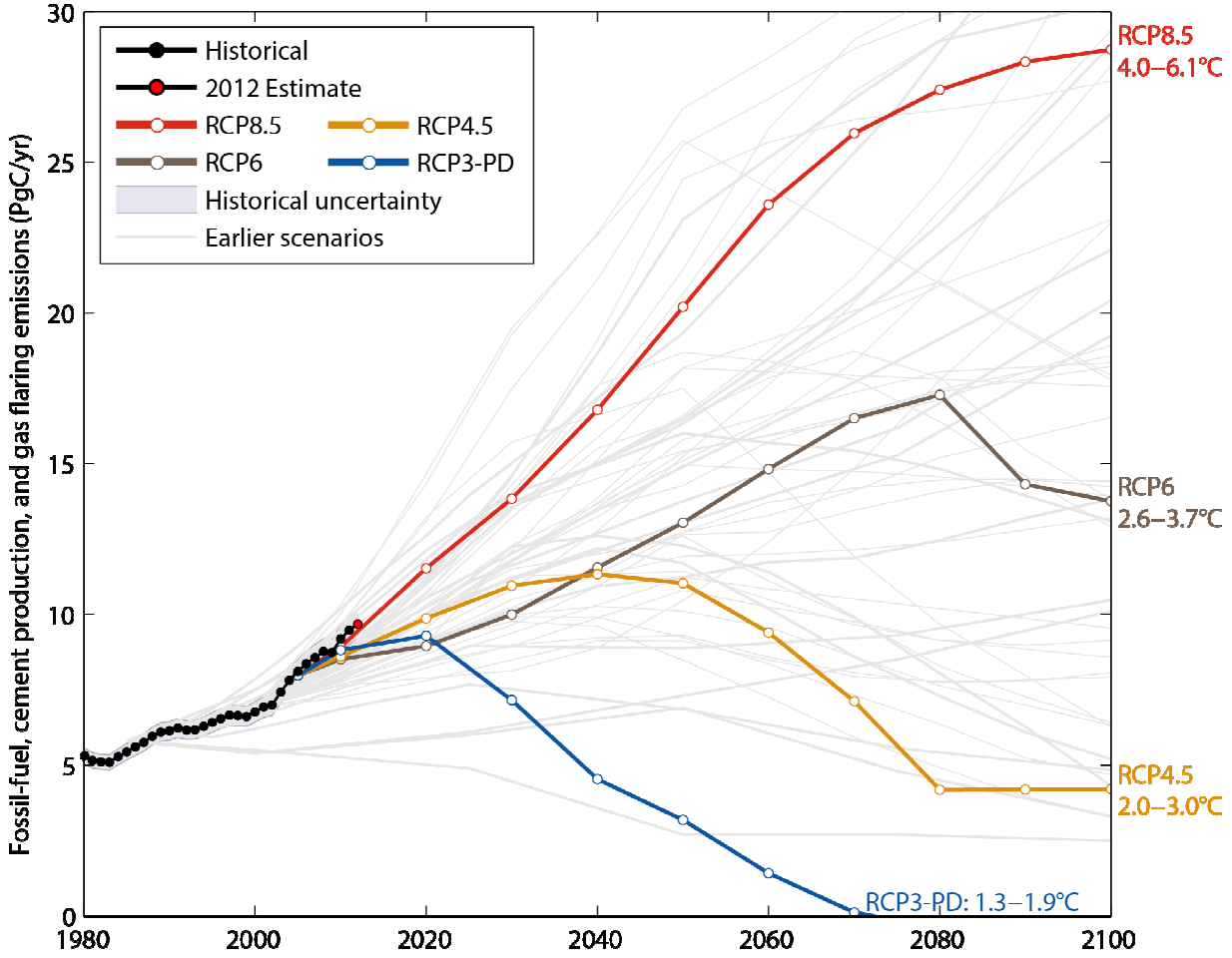
Main periods of use: SA90 (1990-1992, not shown), IS92 (1992-2000), SRES (2000-2012), RCPs (2012+)

Source: Peters et al. 2012a; Global Carbon Project 2012

Observed Emissions and Emission Scenarios

Emissions are heading to a 4.0-6.1ºC “likely” increase in temperature

Large and sustained mitigation is required to keep below 2ºC



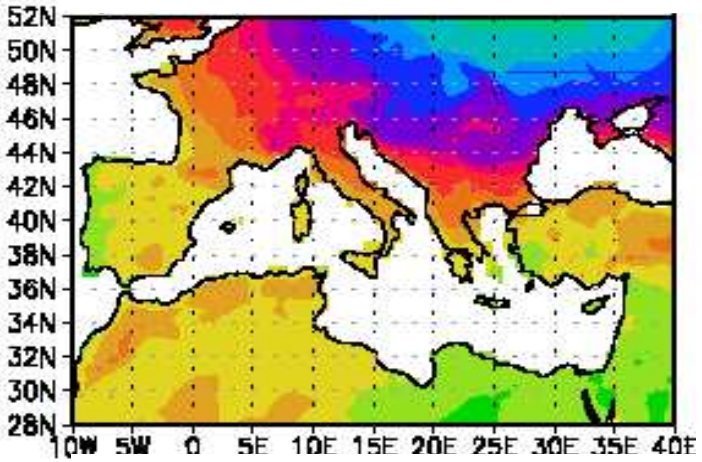
Linear interpolation is used between individual datapoints

Source: Peters et al. 2012a; Global Carbon Project 2012;

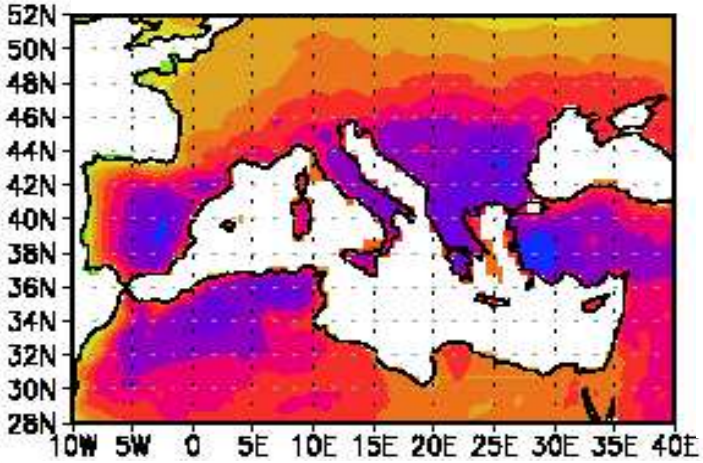
Section 2.2 and Section 2.3: SIMULATIONS OF THE MEDITERRANEAN CLIMATE AND FUTURE PROJECTIONS

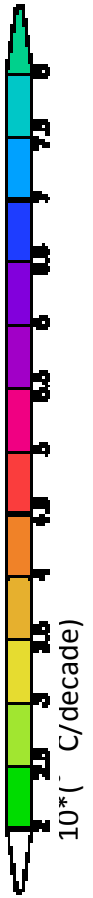
T2m and Precipitation projected trends

T2m trend 2001-2050 DJF

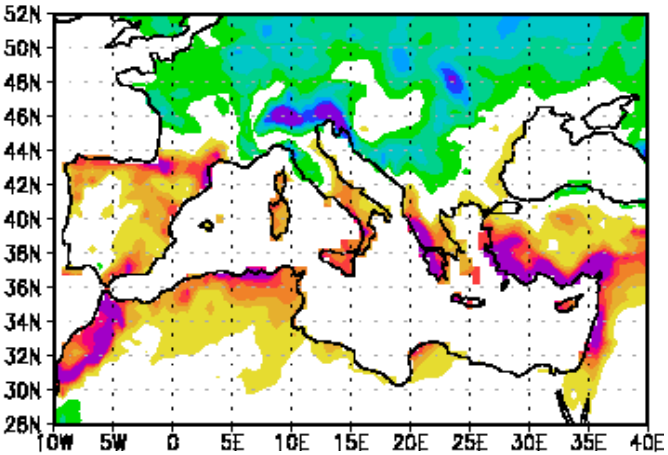


T2m trend 2001-2050 JJA

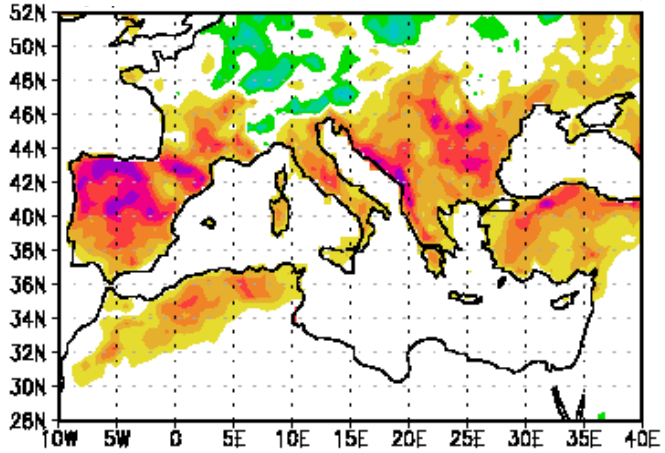


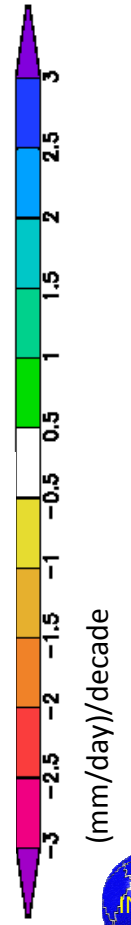


Precip trend 2001-2050 DJF



Precip trend 2001-2050 JJA

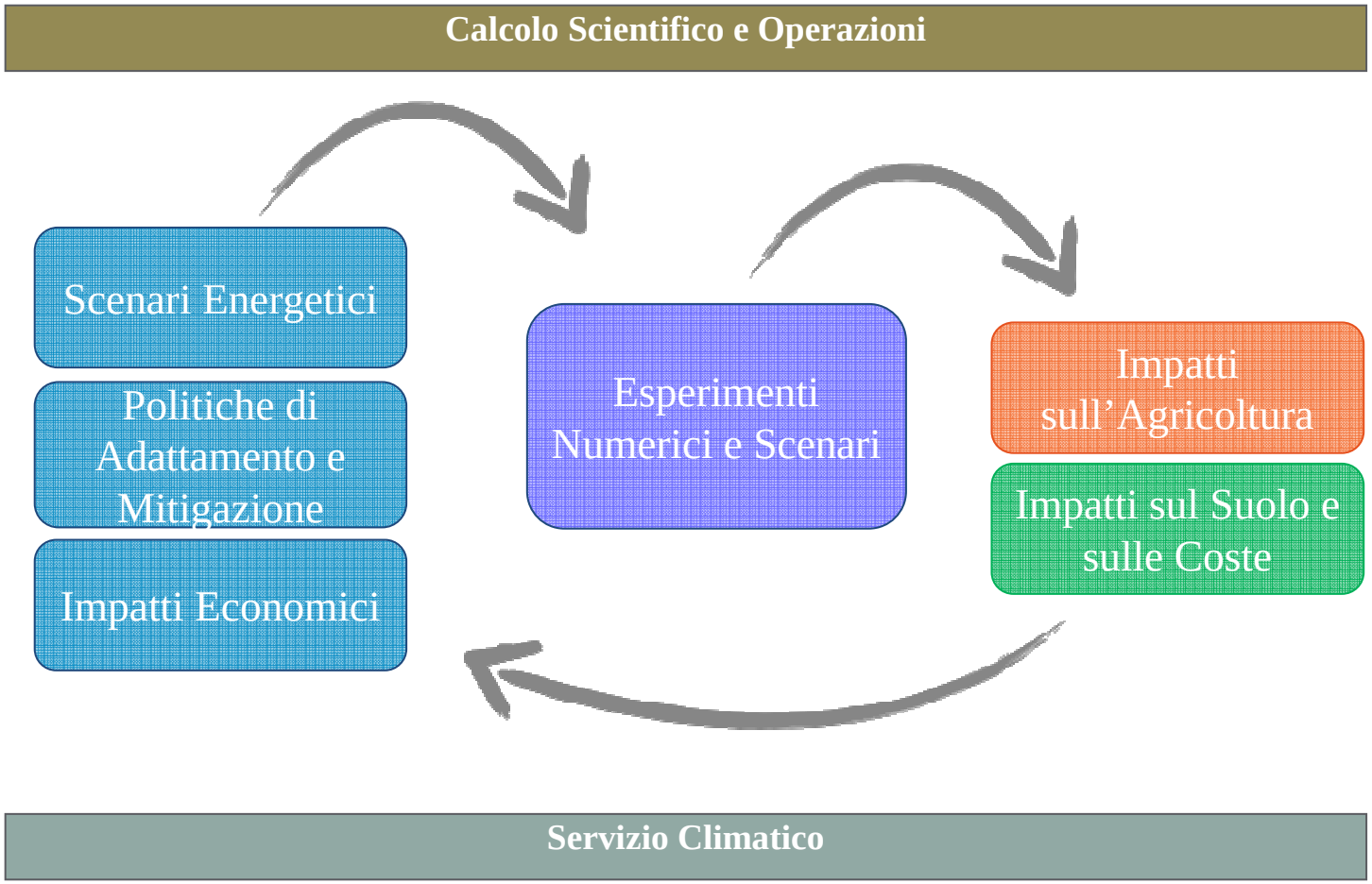




Ci sono dei limiti all'adattamento ?

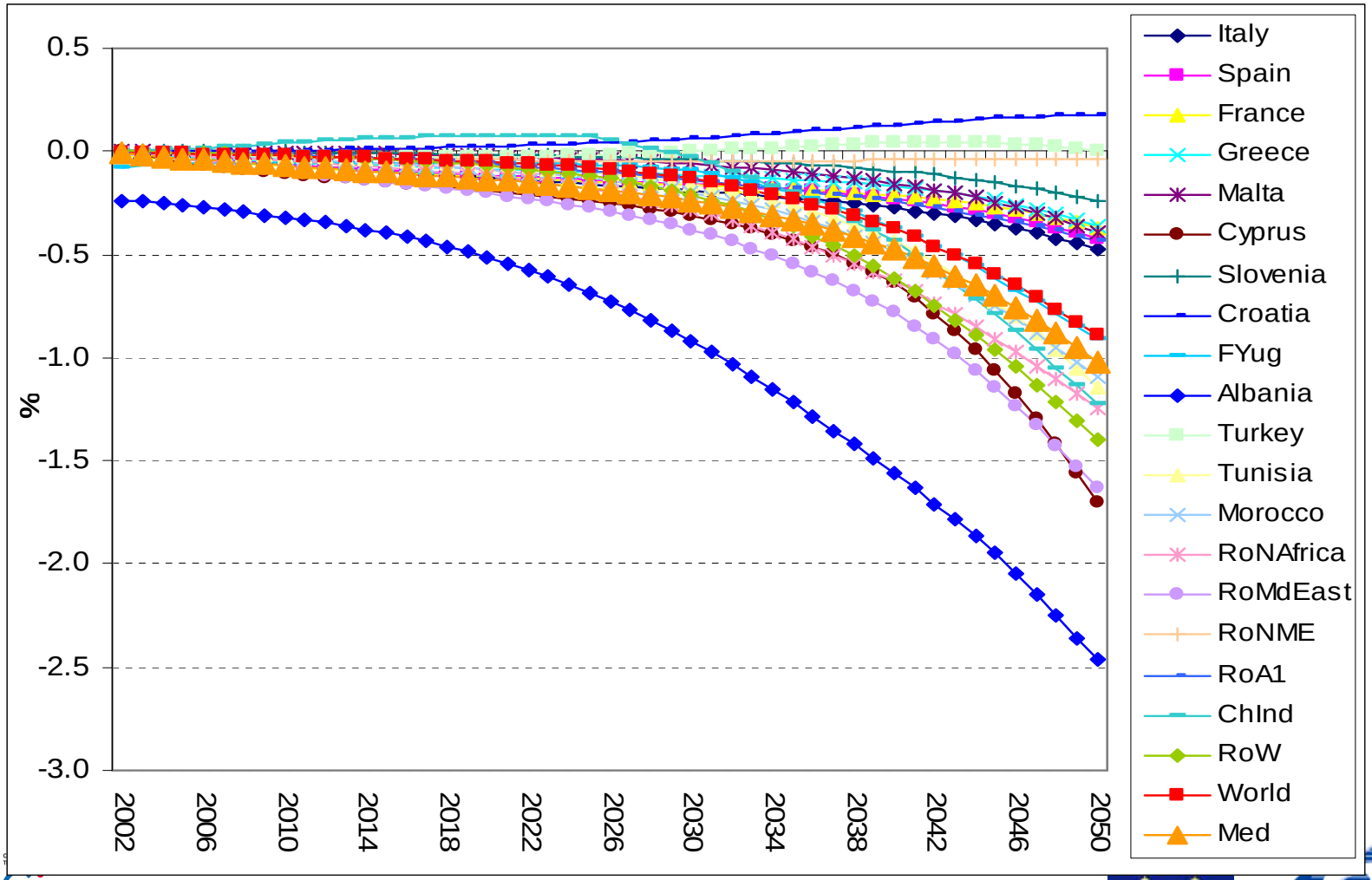
Mucche olandesi,
2100 circa

La Struttura del CMCC



Climate Change Impacts on GDP

% change of GDP wrt no CC baseline



A VOLTE, SFIDARE LA NATURA PORTA A RISULTATI TREMENDI, VECCHIO MIO!
D'ACCORDO CON TE, SATANASSO! ROBA DA FARTI ACCAPPONARE LA PELLE!
FINE