



**Scuola Permanente per l'Aggiornamento
degli Insegnanti di Scienze Sperimentali**

Quali conoscenze di base per comprendere l'innovazione?

XIII Edizione
I modelli nelle Scienze

Dall'osservazione alla previsione.
Che cosa sono e come funzionano i
modelli meteoclimatici.

Selected Significant Climate

GLOBAL AVERAGE TEMPERATURE

June 2019 average global land and ocean temperature was the highest for June since records began in 1880.

ALL-TIME RECORD HIGH
ANCHORAGE, AK

NEW RECORD

90°

OLD RECORD

85°

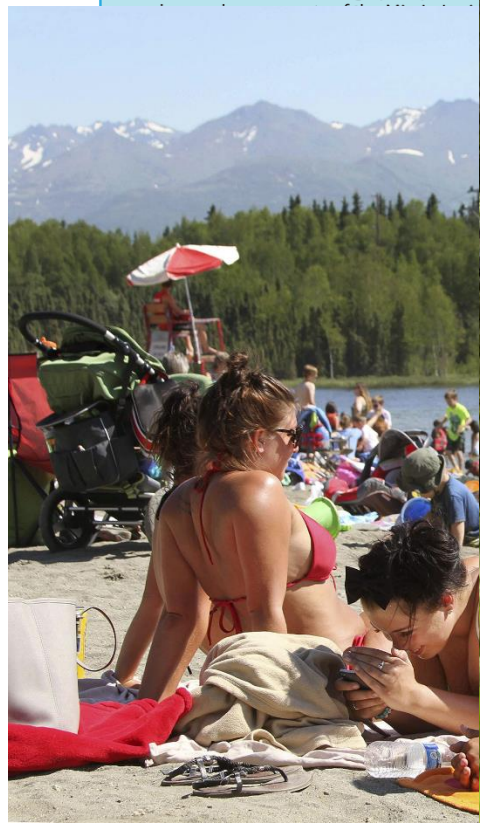
ALASKA

Alaska had its second warmest June since statewide records began in 1925.

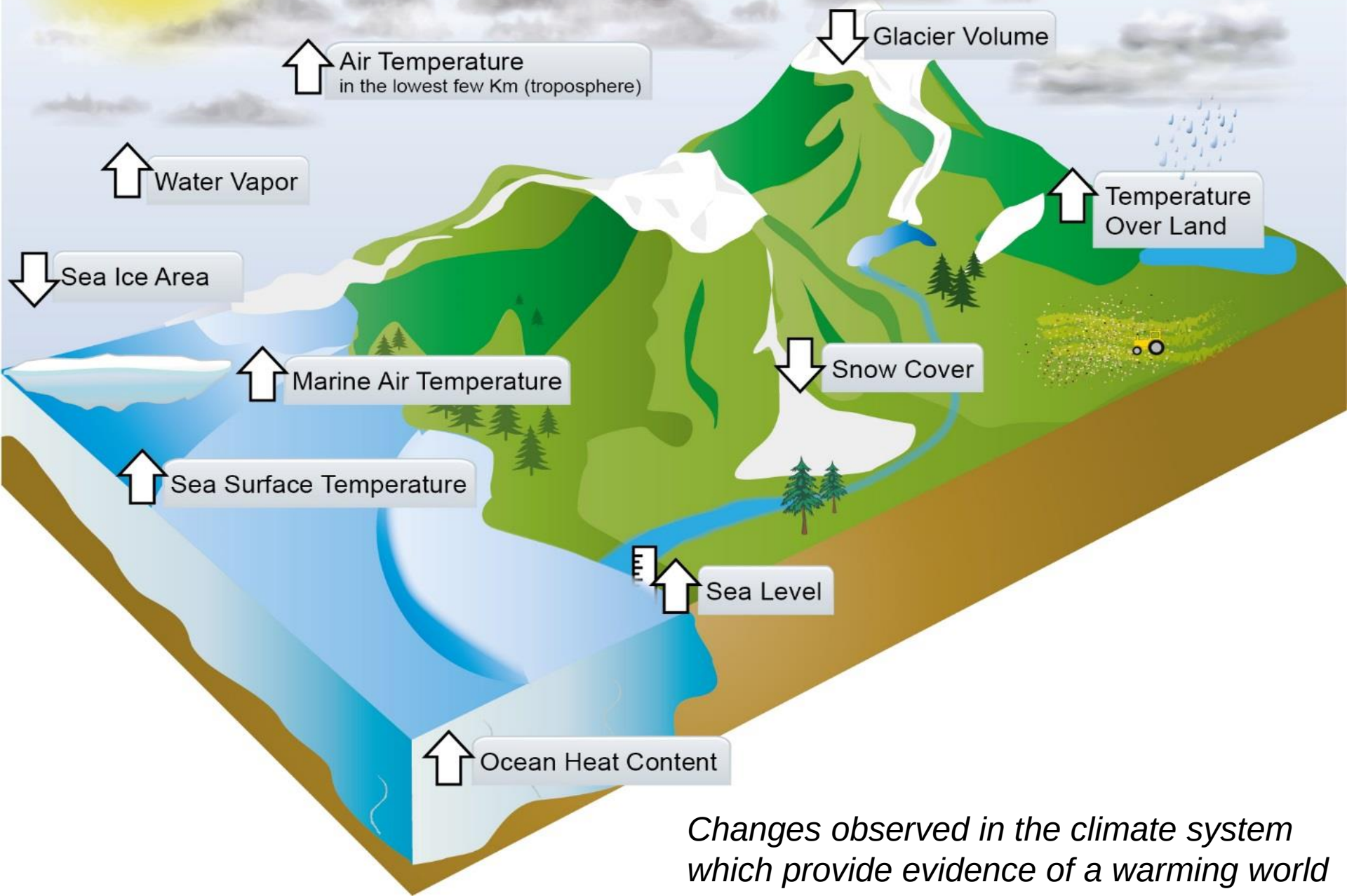


CONTIGUOUS UNITED STATES

Above- to much-above-average precipitation



Signs of a Changing Climate



Changes observed in the climate system which provide evidence of a warming world

Le evidenze del riscaldamento globale

1906



Photo credit: Glacier Bay National Park and Preserve, Alaska. Carroll Glacier, Queen Inlet. 1906. Photographer: C.W.Wright. Source: U.S. Geological Survey Photo Library (<http://libraryphoto.cr.usgs.gov/html/lib/free1.htm>; wcw00335)



2004



Photo credit: Glacier Bay National Park and Preserve, Alaska. Carroll Glacier, Queen Inlet. 2004. Photographer: Brian F. Molnia. Source: U.S. Geological Survey Photo Library (<http://libraryphoto.cr.usgs.gov/html/lib/free1.htm>; mbf00013)

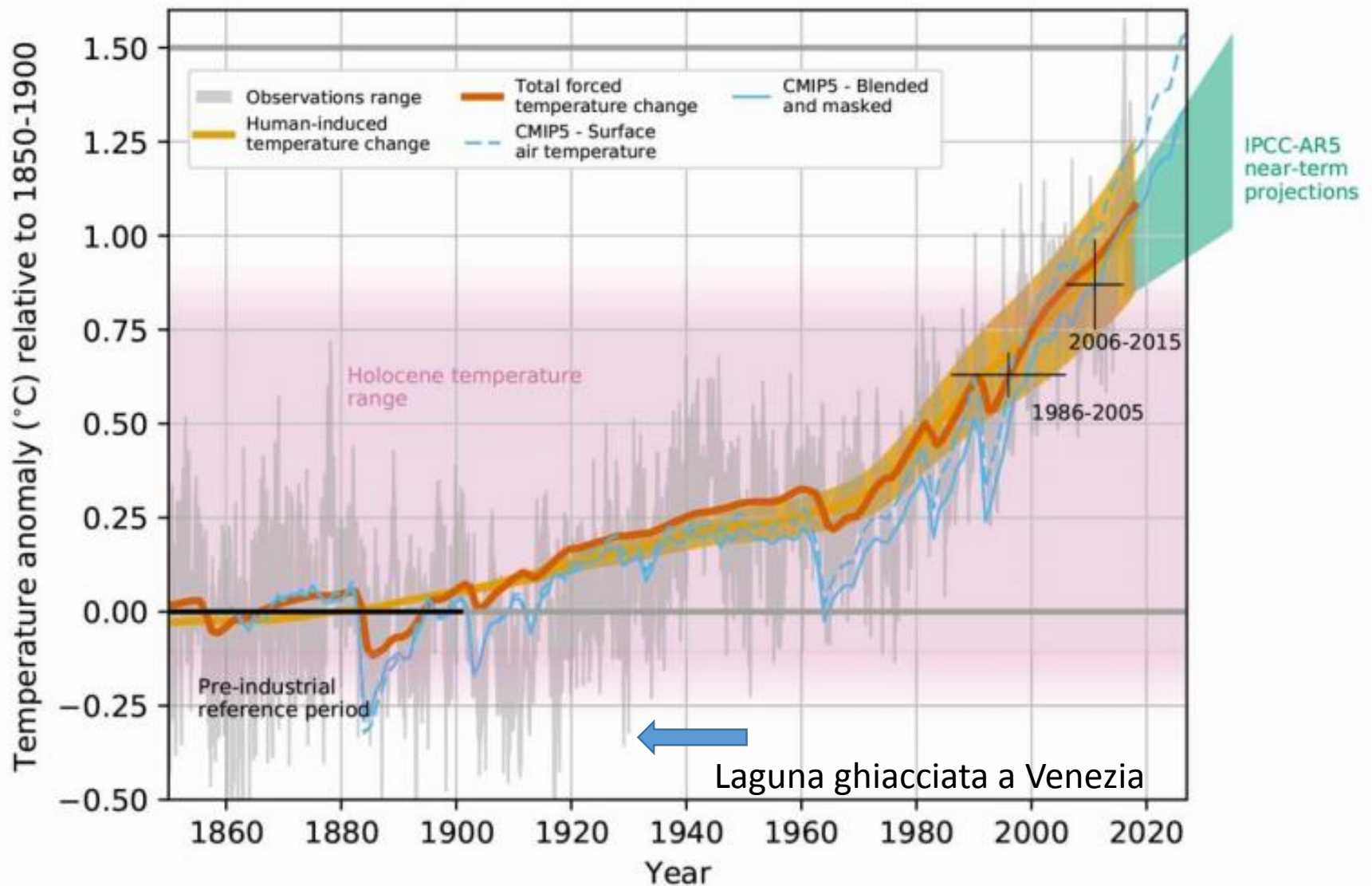


Laguna ghiacciata a Venezia nel 1708 (Anonimo Veneziano)



Laguna ghiacciata a Venezia nel febbraio del 1929





Evolution of global mean surface temperature (GMST) over the period of instrumental observations. Grey line shows monthly mean near surface air temperature over land and sea surface temperature over oceans. Human-induced (yellow) and total (human- and naturally-forced, orange). Thin blue lines show the modelled global-mean surface air temperature (dashed) and blended surface air and sea surface. The pink shading indicates a range for temperature fluctuations over the Holocene. Light green plume shows AR5 prediction for average GMST over 2016–2035.

WEATHER, CLIMATE AND CLIMATE CHANGE

WEATHER -> Tempo meteorologico

Condizioni dell'atmosfera in un determinato luogo e in un preciso momento o comunque in un breve periodo

CLIMATE -> Clima

Media delle condizioni atmosferiche misurate in un intervallo di tempo molto lungo (normalmente oltre 30 anni) su una determinata area

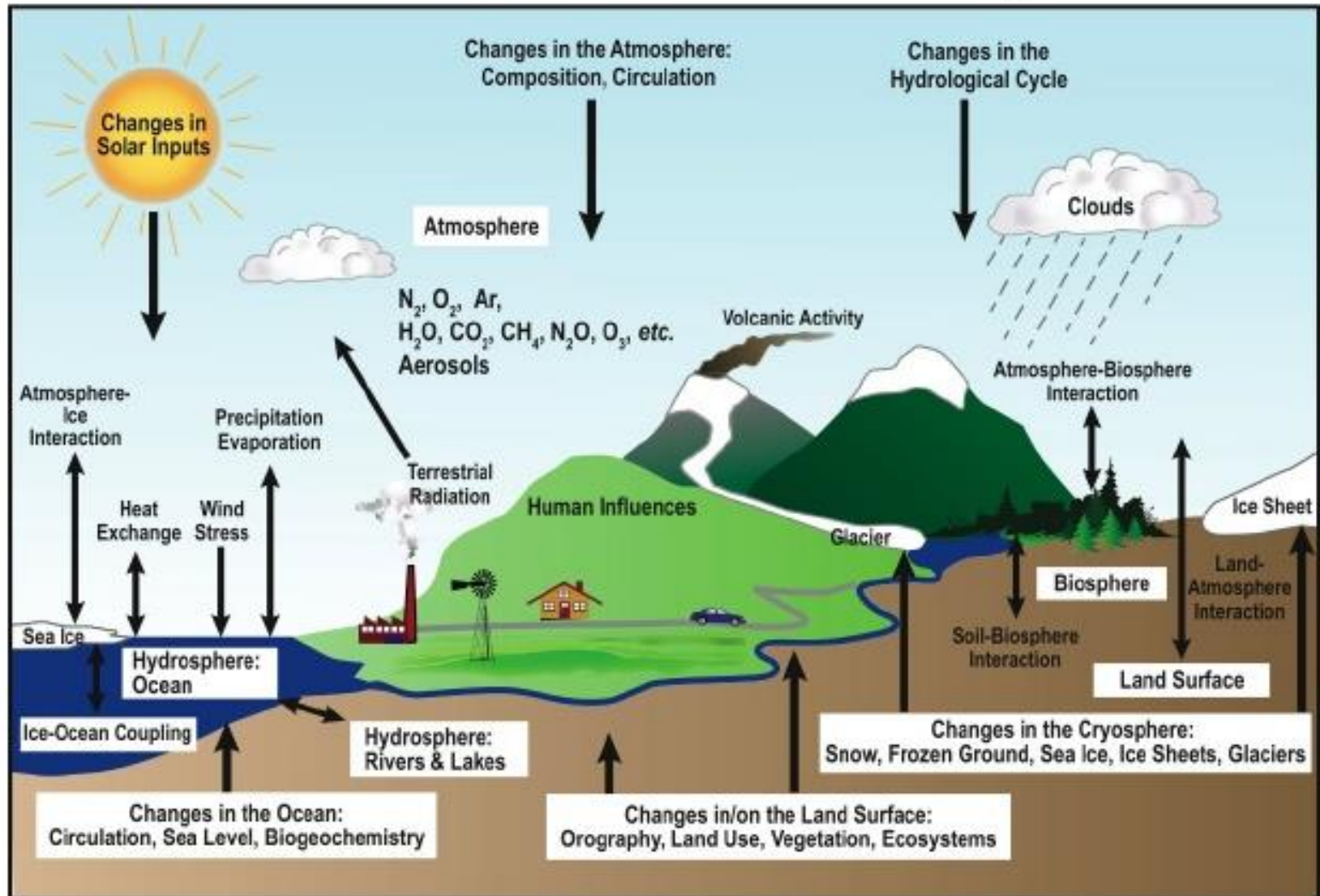
CLIMATE CHANGE -> Cambiamento climatico Difficile da individuare e comprendere, a causa delle lunghe scale temporali e delle diverse aree geografiche in cui si manifesta

CLIMATE FORCING -> Forzante climatica

Fattore in grado di determinare un cambiamento climatico

Thomas Chrowder Chamberlin (1843-1928), Geologo USA è stato il primo a comprendere che non esiste una sola causa (forzante) in grado di determinare il cambiamento climatico. Per Chamberlain il clima è un fattore dinamico in cui il Sole, le orbite terrestri, gli oceani, l'atmosfera, la crosta terrestre, la vegetazione e i vulcani sono parte di un unico Sistema complesso in cui sono le interazioni tra tutti questi fattori a determinare e modificare il clima.

The Earth's Climate System



Atmosphere + Hydrosphere + Cryosphere + Biosphere + Geosphere

Climate change

Causes of Climate change

Internal Natural

Volcanic eruptions

Ocean Currents

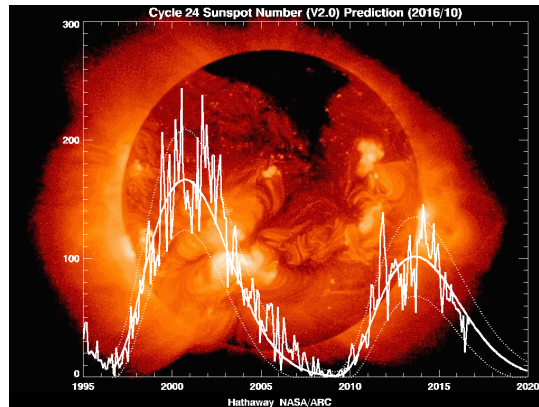


External Natural

Astronomic Cycles

Sunspot and solar cycle

Meteorites



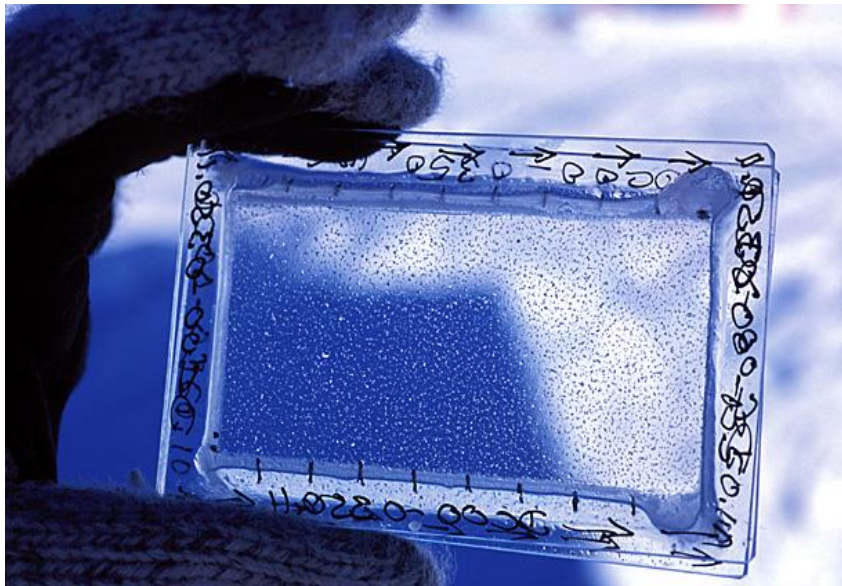
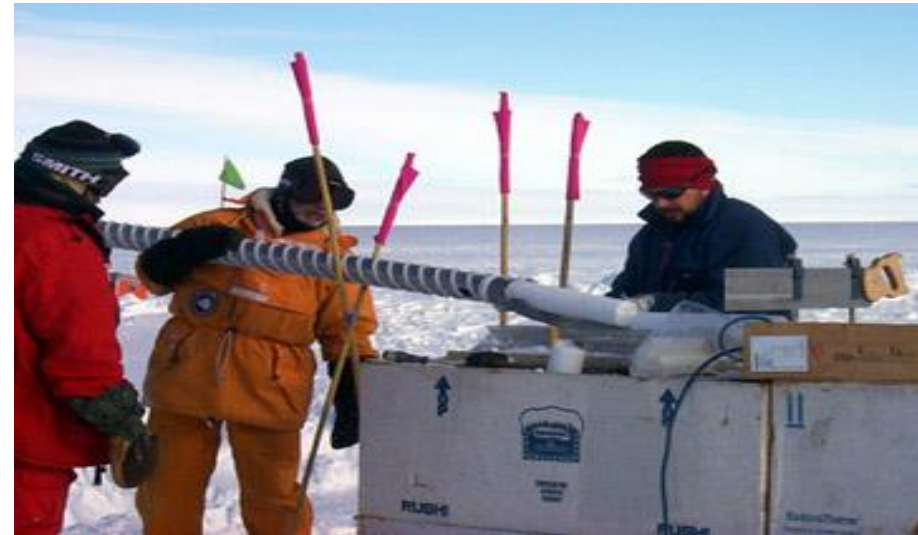
Anthropogenic

Greenhouse gases

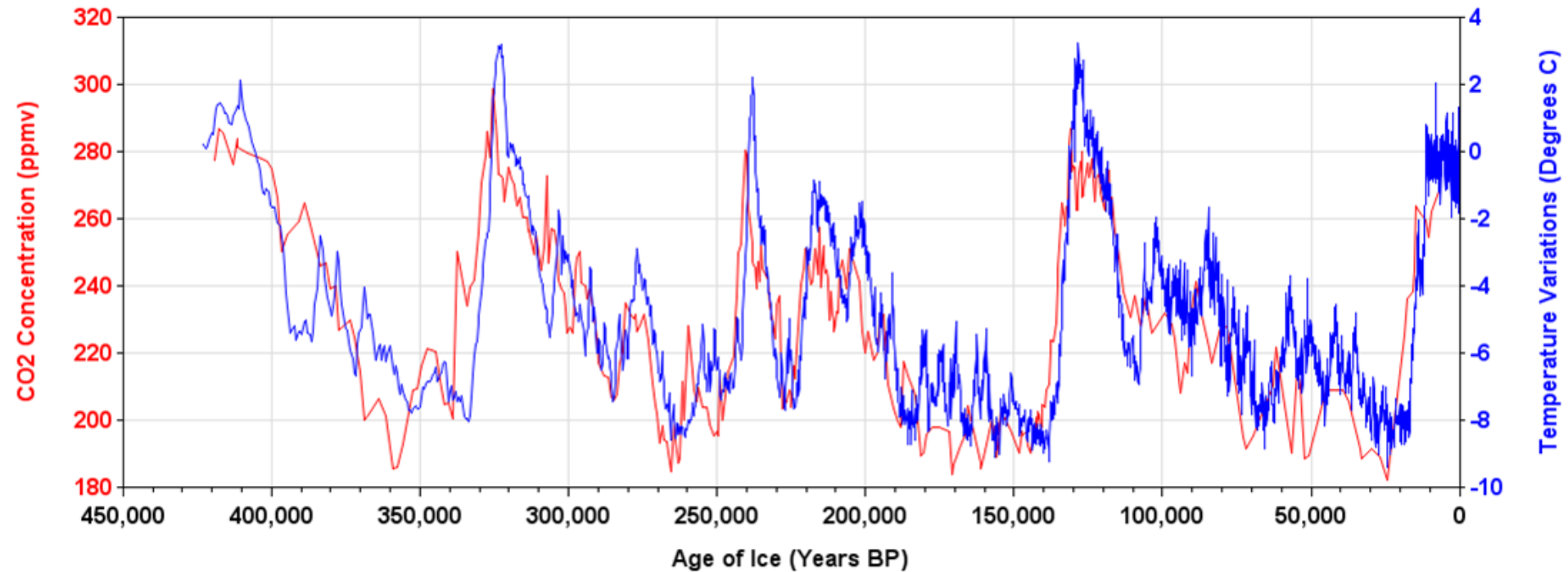
Deforestation



L'archivio climatico terrestre

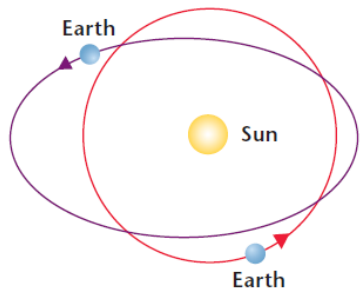


Antarctica Ice-core Data (Vostok)

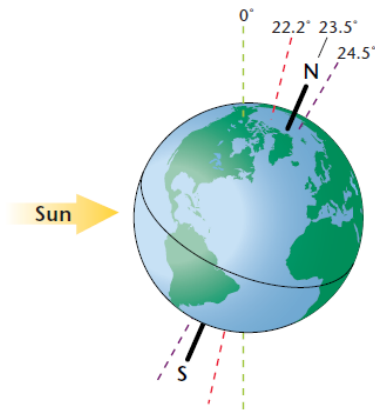


CO2 data Source: Jean-Marc Barnola et al.

Temperature data Source: Petit et al.



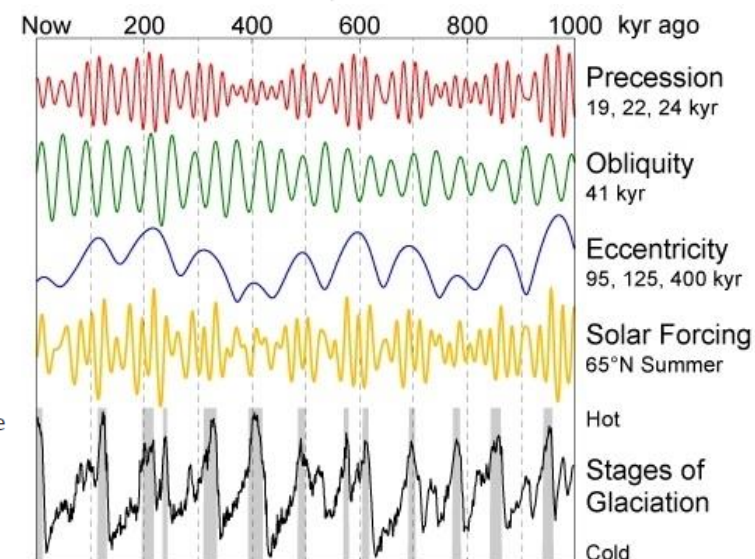
Eccentricity Earth encounters more variation in the energy that it receives from the sun when Earth's orbit is elongated than it does when Earth's orbit is more circular.



Tilt The tilt of Earth's axis varies between 22.2° and 24.5°. The greater the tilt angle is, the more solar energy the poles receive.



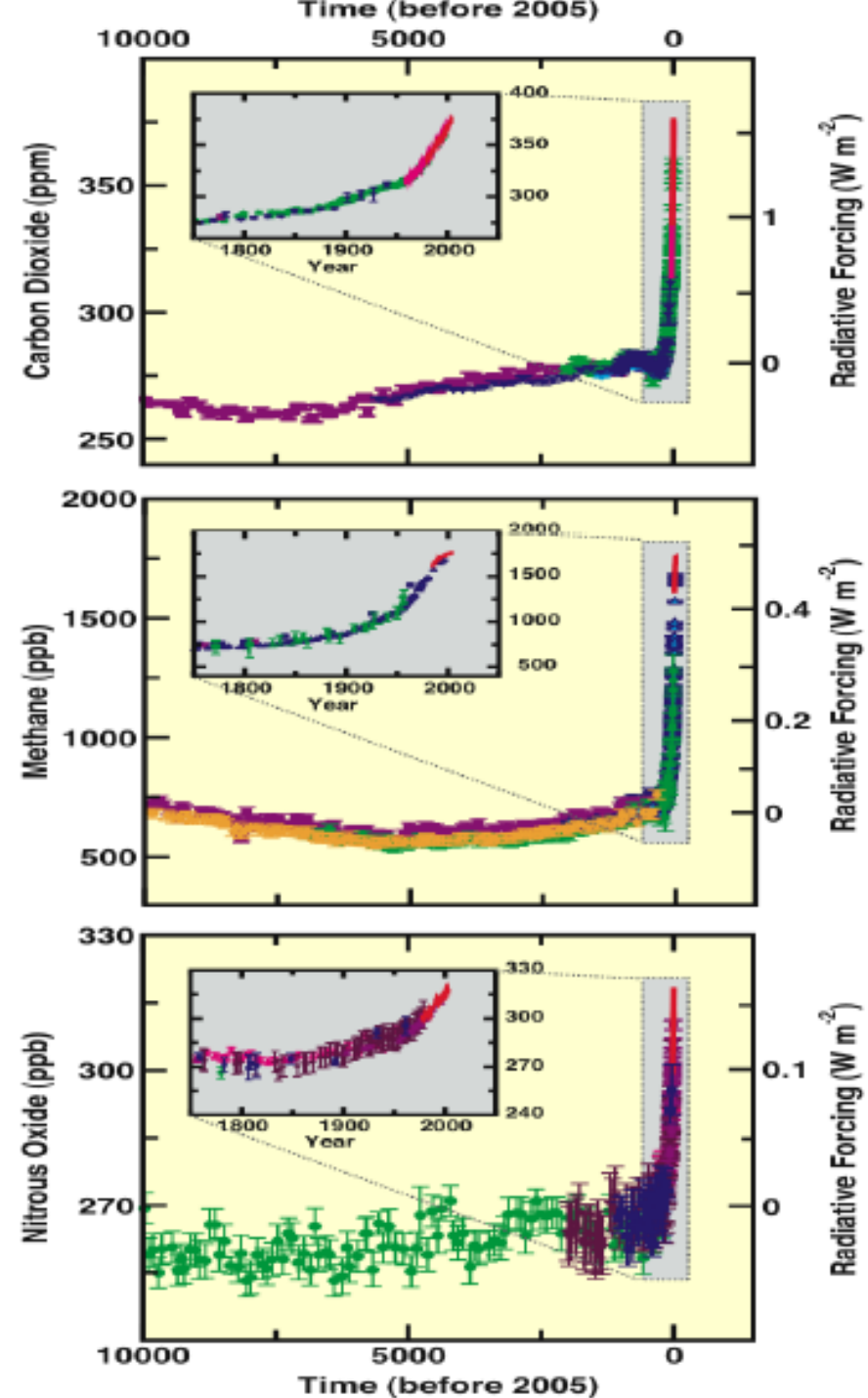
Precession A gradual change, or "wobble," in the orientation of Earth's axis affects the relationship between Earth's tilt and eccentricity.



Modificazione della composizione dell'Atmosfera per cause “antropiche”

Le concentrazioni di CO_2 , CH_4 e N_2O :
-mostrano valori molto superiori
a quelli pre-industriali
-aumentano notevolmente dal 1750
a causa delle attività umane

Variazioni relativamente piccole prima
della rivoluzione industriale



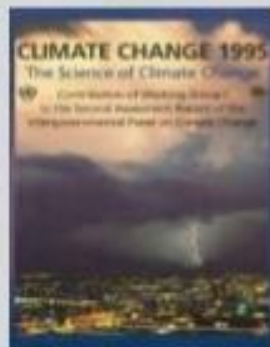
IPCC

Intergovernmental Panel on Climate Change

IPCC Assessment Reports



FAR 1990



SAR 1995



TAR 2001



AR4 2007



Nobel Peace Prize 2007



AR5 WGI 2013



AR5 WGII 2014



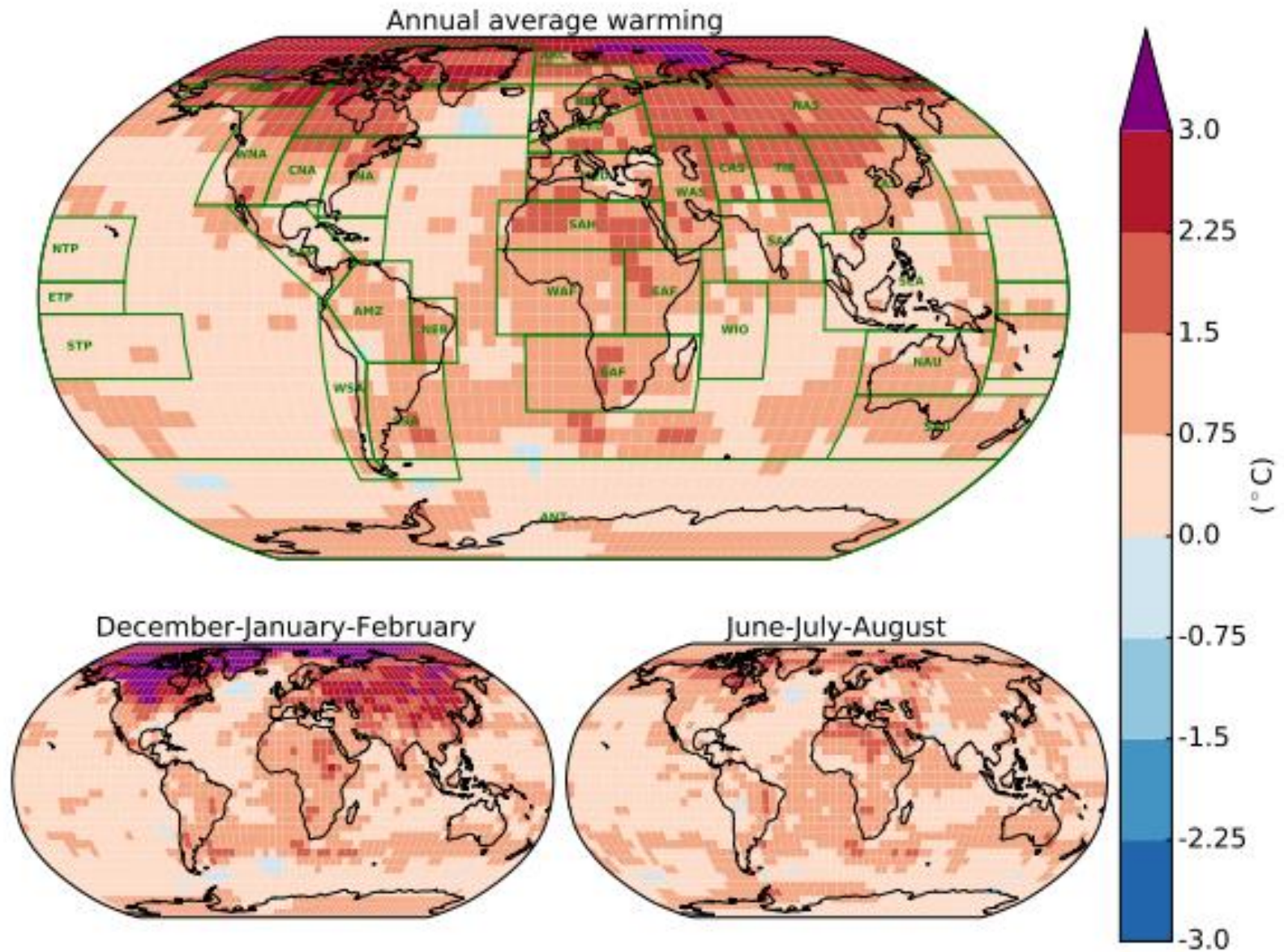
AR5 WGIII 2014



Synthesis Report
2014



Regional warming in the decade 2006-2015 relative to preindustrial



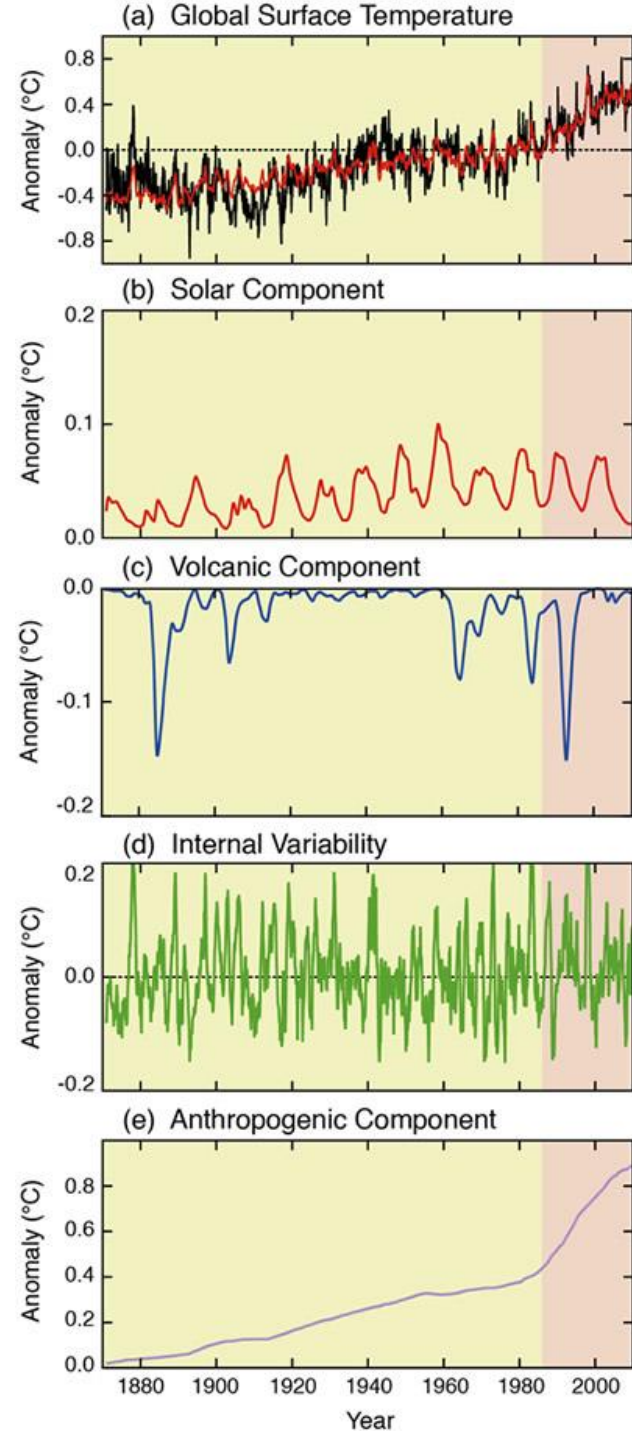
Causes of Recent Changes in Global Surface Temperature

What is Forcing?

Forcing represents any factor that influences global climate by heating or cooling the planet. Examples of forcings are volcanic eruptions, solar variations and **anthropogenic** (human) changes to the composition of the atmosphere.

Taking a longer term perspective shows the substantial role played by **anthropogenic** and natural forcings in driving climate variability on hemispheric scales prior to the twentieth century. It is very unlikely that Northern Hemisphere temperature variations from 1400 to 1850 can be explained by natural **internal variability** alone; - something, such as changes in solar and/ or volcanic activity, must have driven the changes.

*Global surface temperatures from 1870 to 2010, (a) The black line shows global surface temperatures (1870–2010) relative to the 1961–1990 average. The red line shows **climate model** simulations of global surface temperature change produced using the sum of the impacts on temperature from natural (b, c, d) and **anthropogenic** factors (e). Note the different vertical scales.*



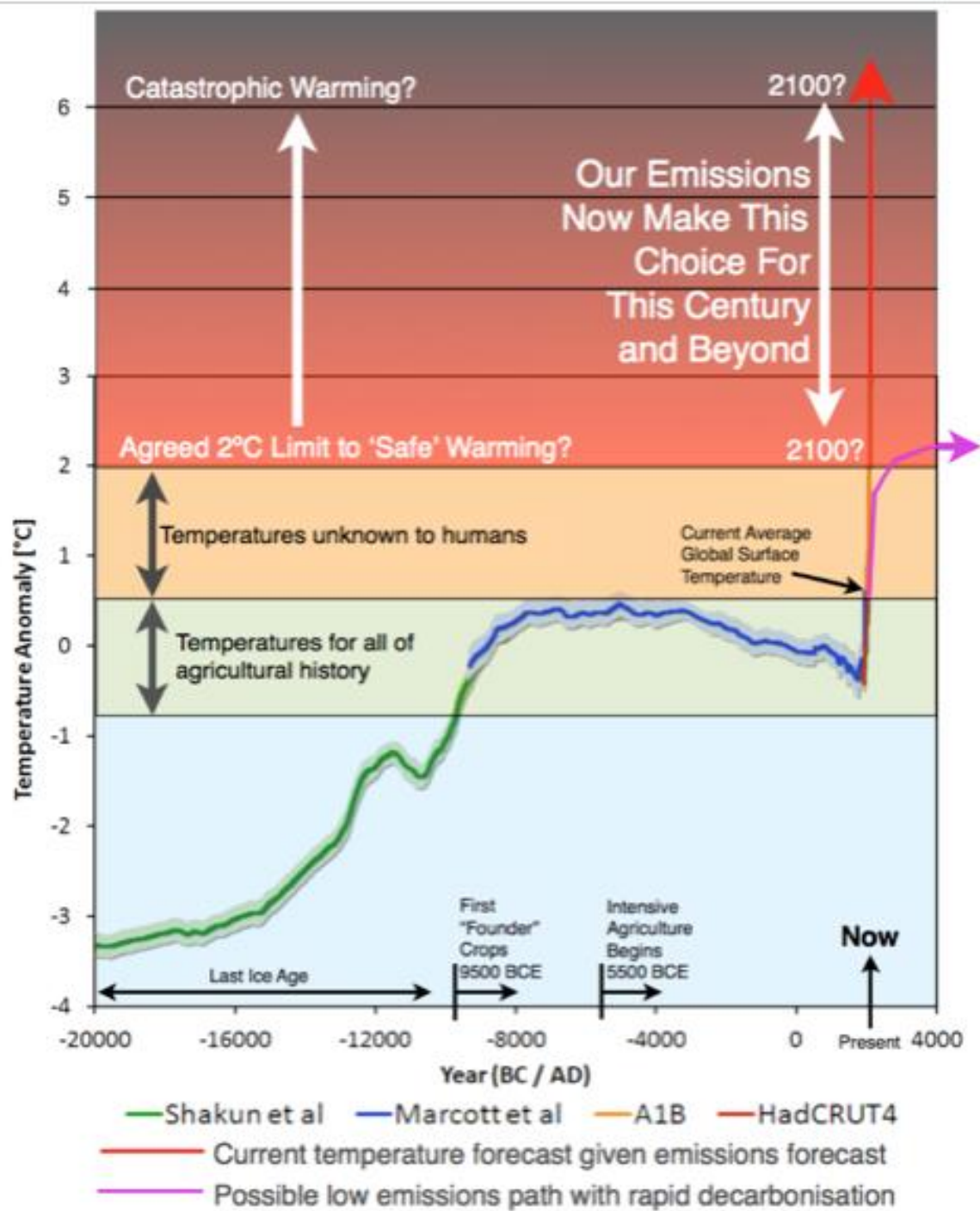
Global Warming of 1.5 ° C

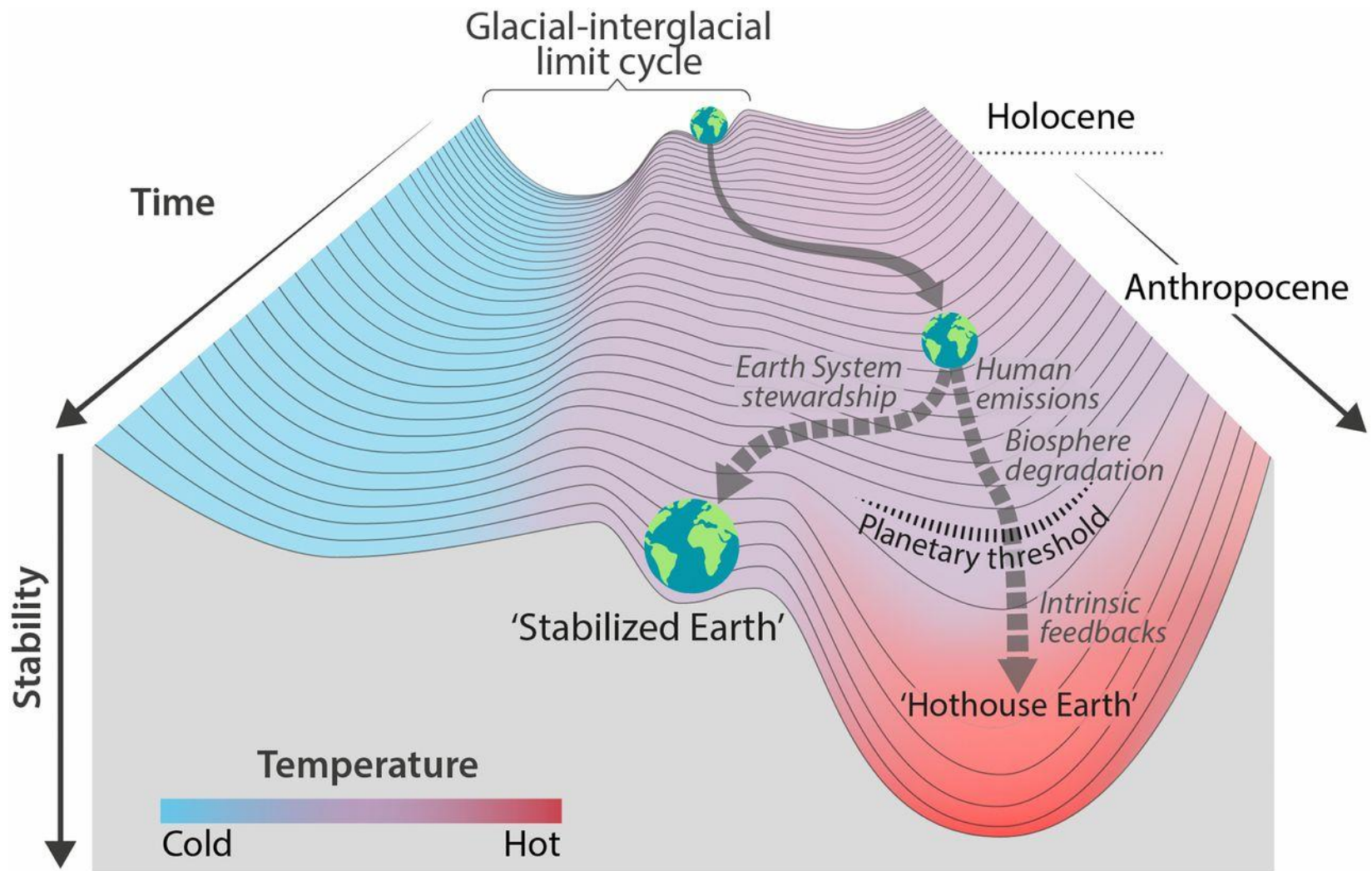
an IPCC special report on the impacts of global warming of 1.5 ° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty



Why are we talking about 1.5° C?

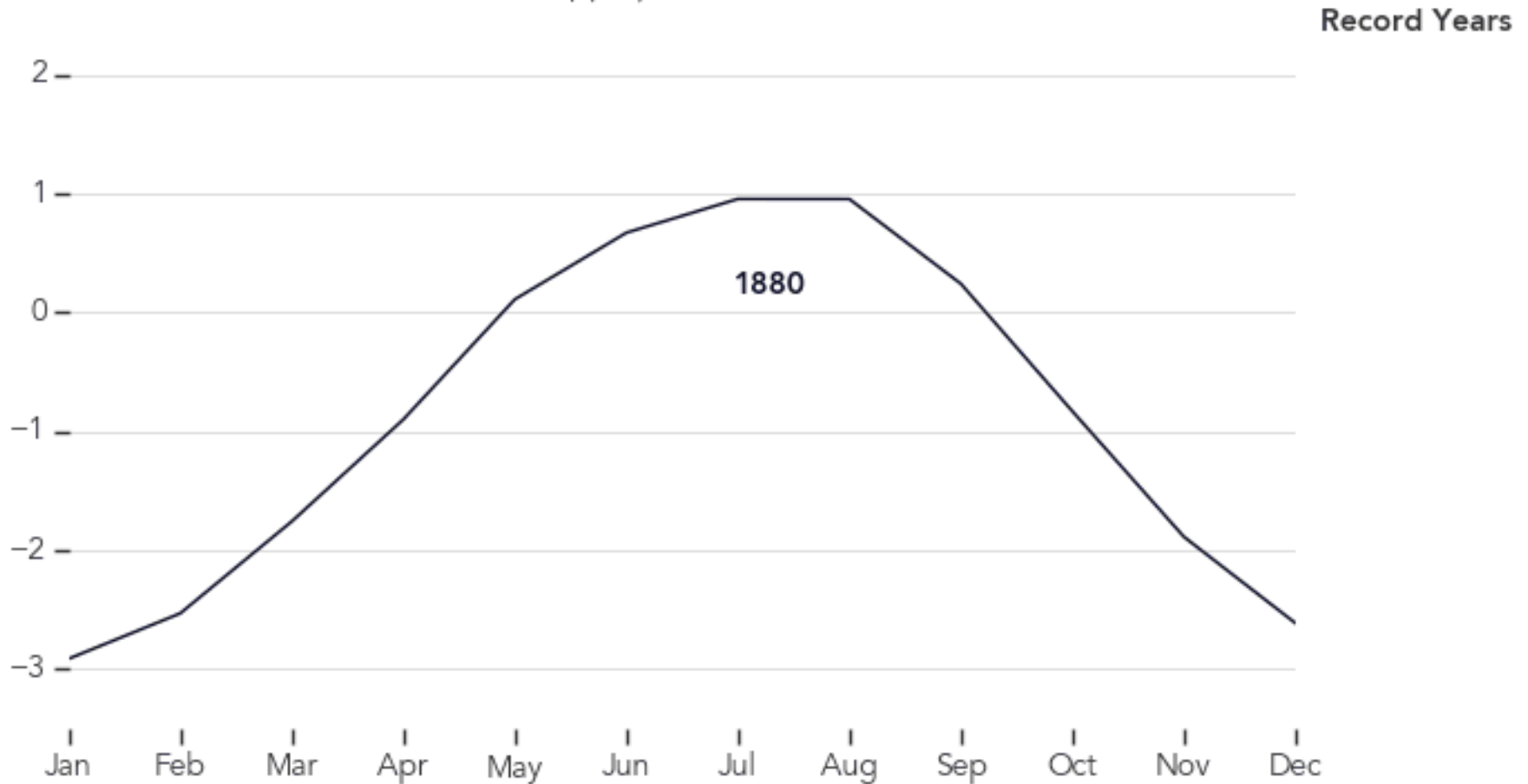
Climate change represents an urgent and potentially irreversible threat to human societies and the planet. In recognition of this, the overwhelming majority of countries around the world adopted the Paris Agreement in December 2015, the central aim of which includes pursuing efforts to limit global temperature rise to 1.5° C. In doing so, these countries, through the United Nations Framework Convention on Climate Change (UNFCCC) also invited the IPCC to provide a Special Report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emissions pathways.





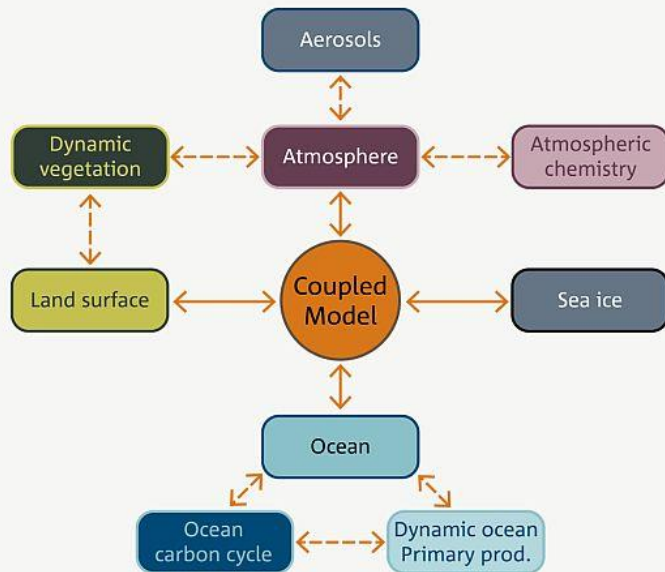
The Present is Warmer than the Past

Difference from 1980-2015 annual mean, ($^{\circ}\text{C}$)



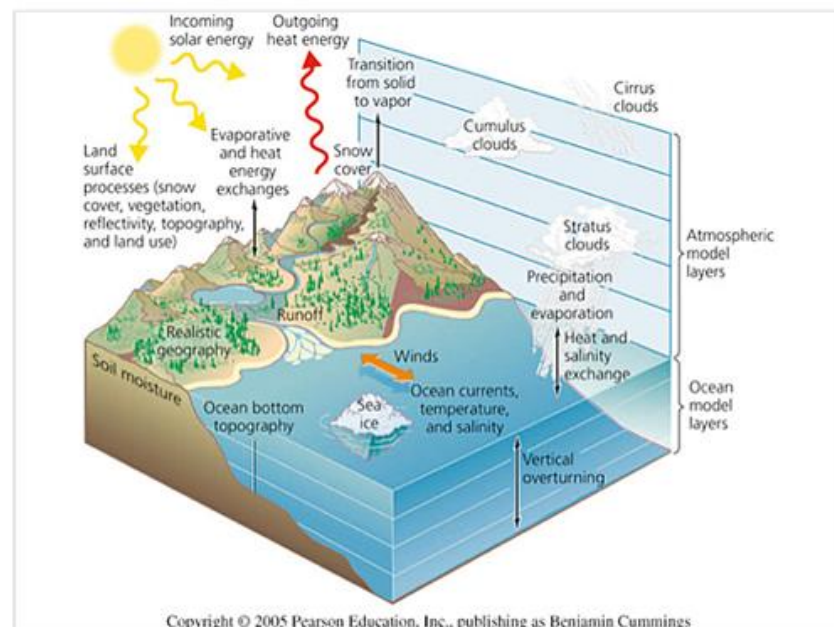
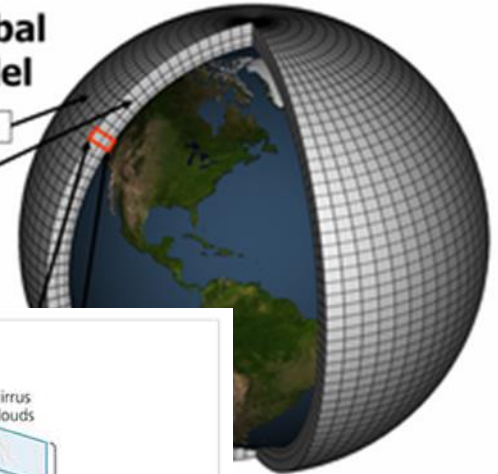
This animated figure shows the seasonal cycle in global temperature anomalies for every month since 1880. Each line shows how much the global monthly temperature was above or below the annual global mean from 1980–2015. The column on the right lists each year when a new global temperature record was set. These seasonal anomalies are drawn from the Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) model run by NASA's Global Modeling and Assimilation Office.

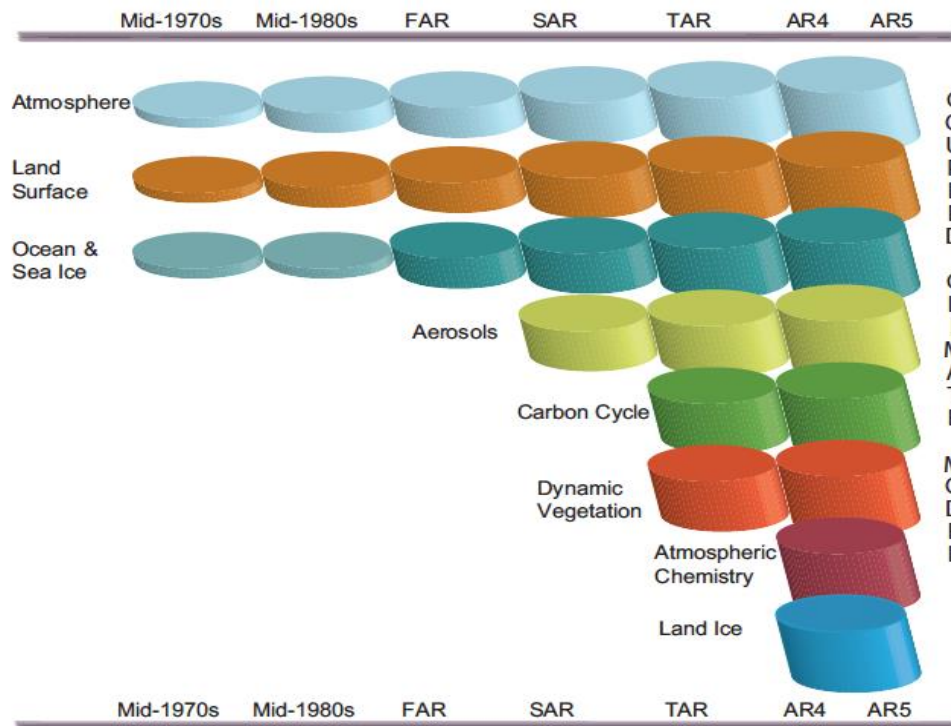
Dall'osservazione alla previsione. Che cosa sono e come funzionano i modelli meteoclimatici.



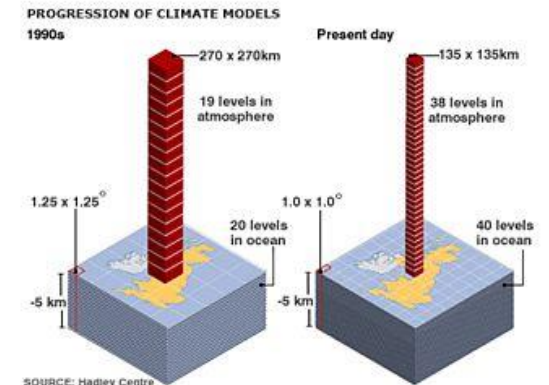
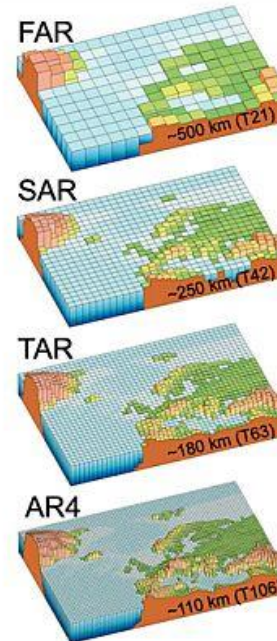
Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)
Vertical Grid (Height or Pressure)

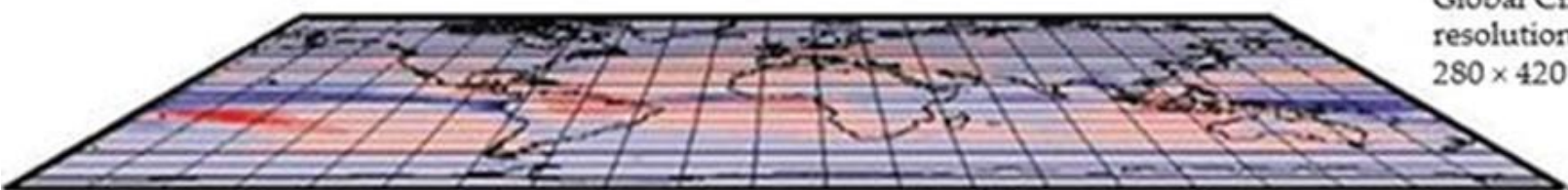




I modelli climatici



AR5: ~70km maximum horizontal resolution; up to 90 layers in the atmosphere and over 60 in the ocean.



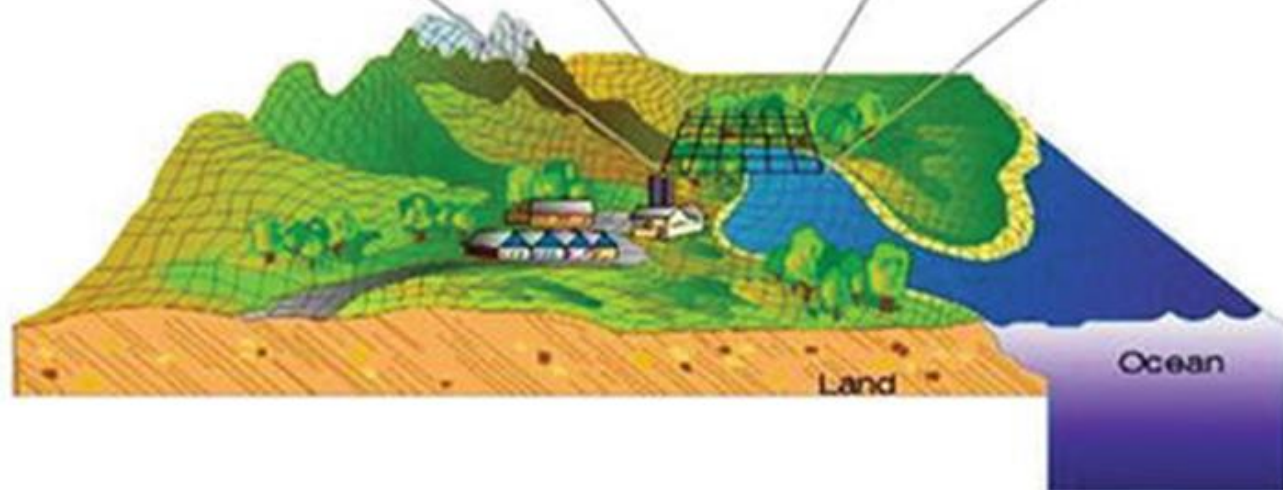
Global Circulation Model
resolution, e.g..HadCM3
 280×420 km



Regional Climate Model
resolution, e.g..RegCM3 25×25 km

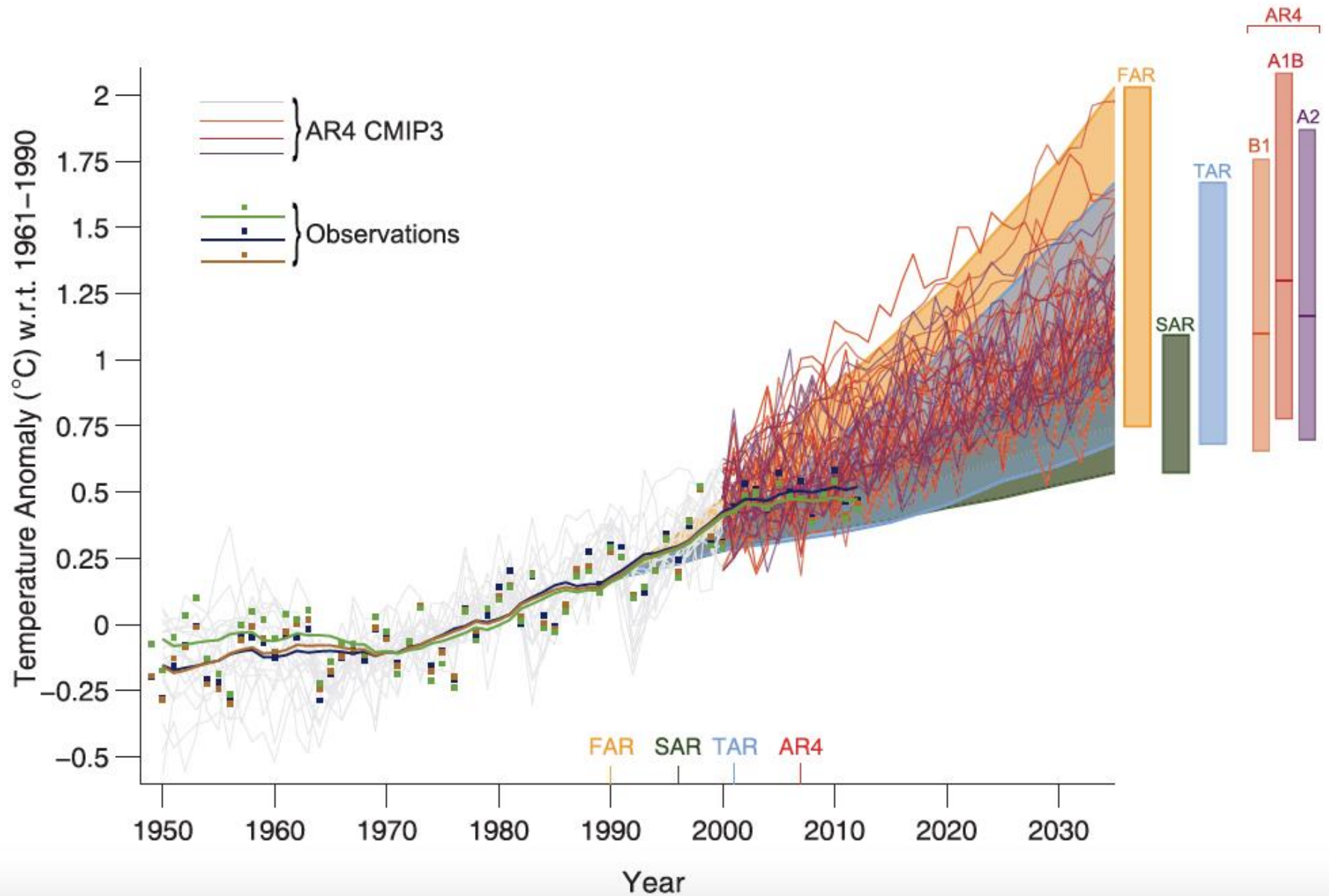


Hydrology
Vegetation
Topography

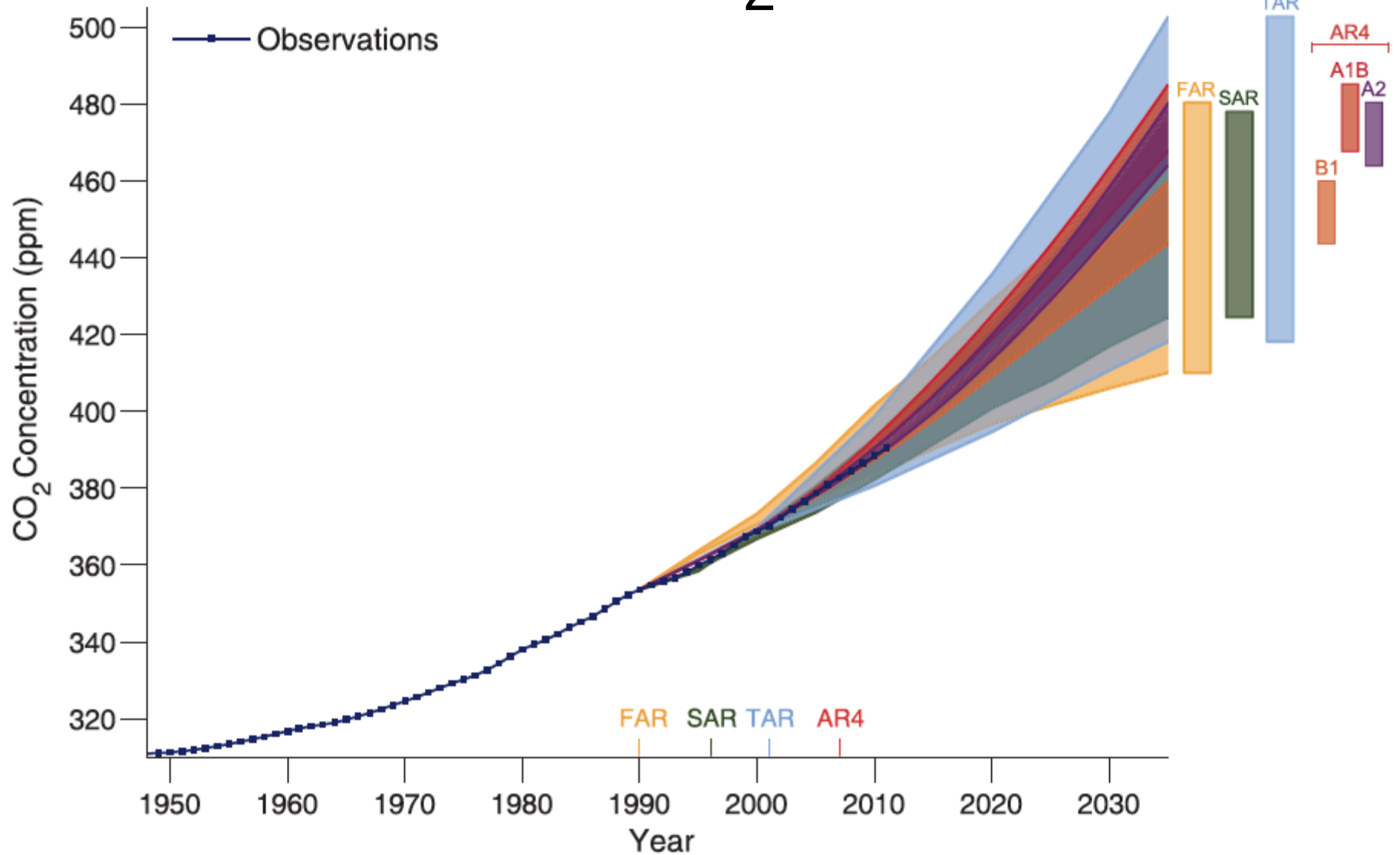


Regional Land Use
Changes
Socio-economic changes

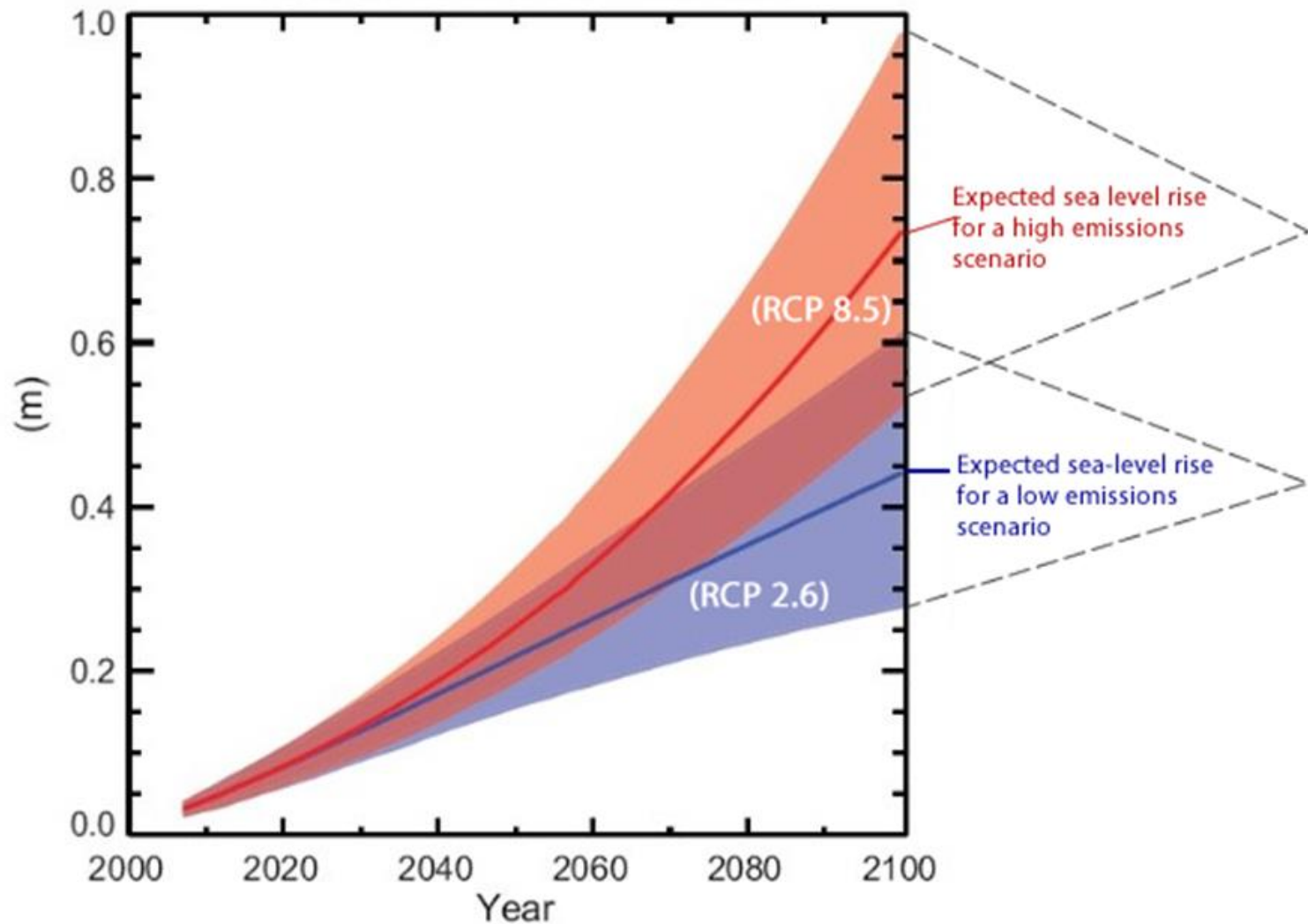
TEMPERATURE



CO₂



Global mean sea level rise



The central line shows the expected sea level rise. The shading indicates a measure of uncertainty about future sea level for two different scenarios.

The low emissions scenario is one where carbon emissions are rapidly cut (blue RCP 2.6)

The high emissions scenario is one where there are no carbon cuts (red RCP 8.5).

Areas in dotted lines indicate a measure of uncertainty in the prediction

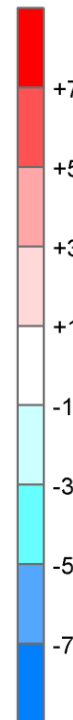
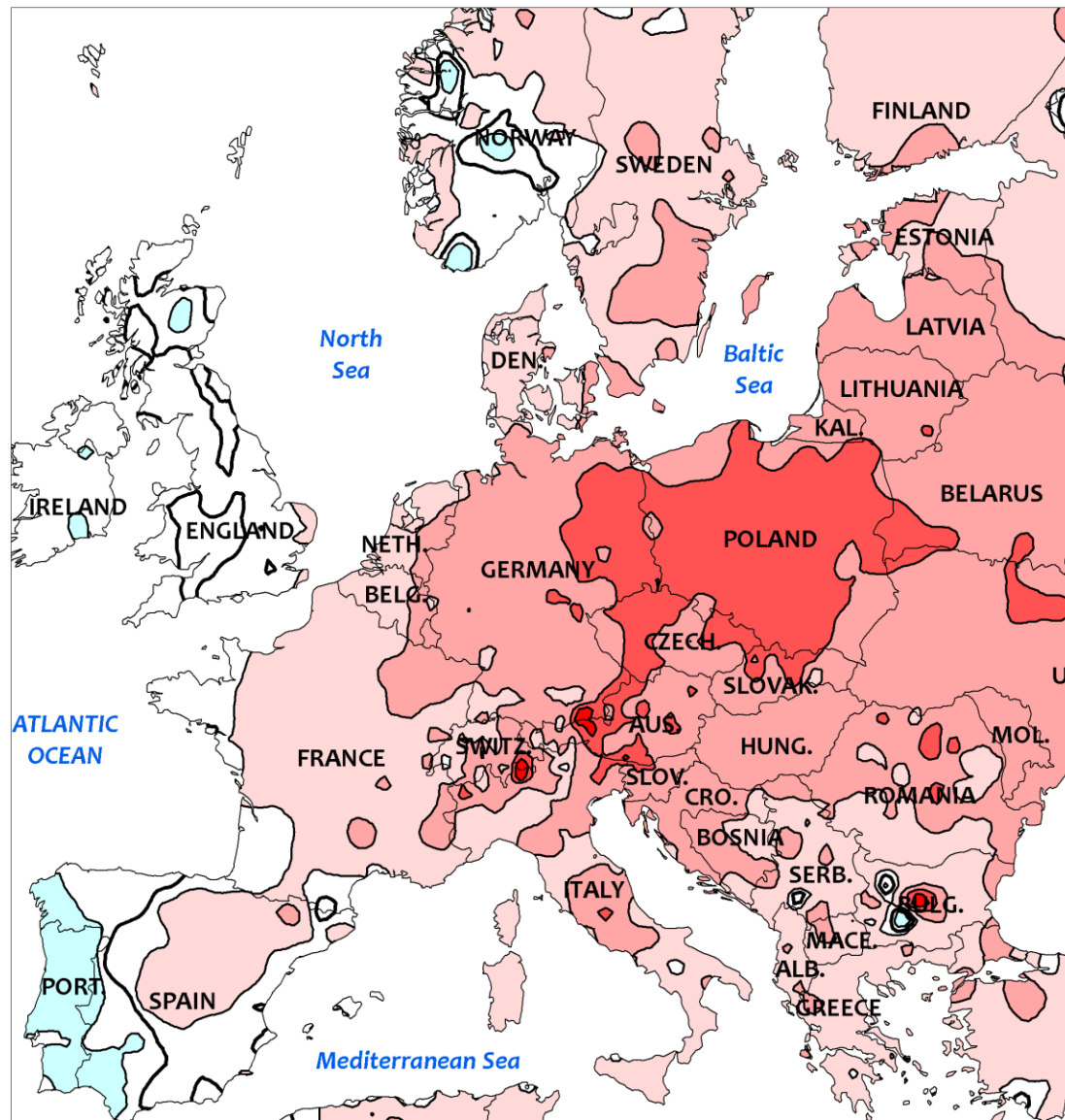
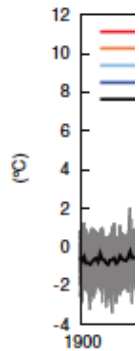


EUROPE

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

June 2019

Temperature chs



CLIMATE PREDICTION CENTER, NOAA
Computer generated contours
Based on preliminary gridded data
Normals based on 1981-2010 gridded data



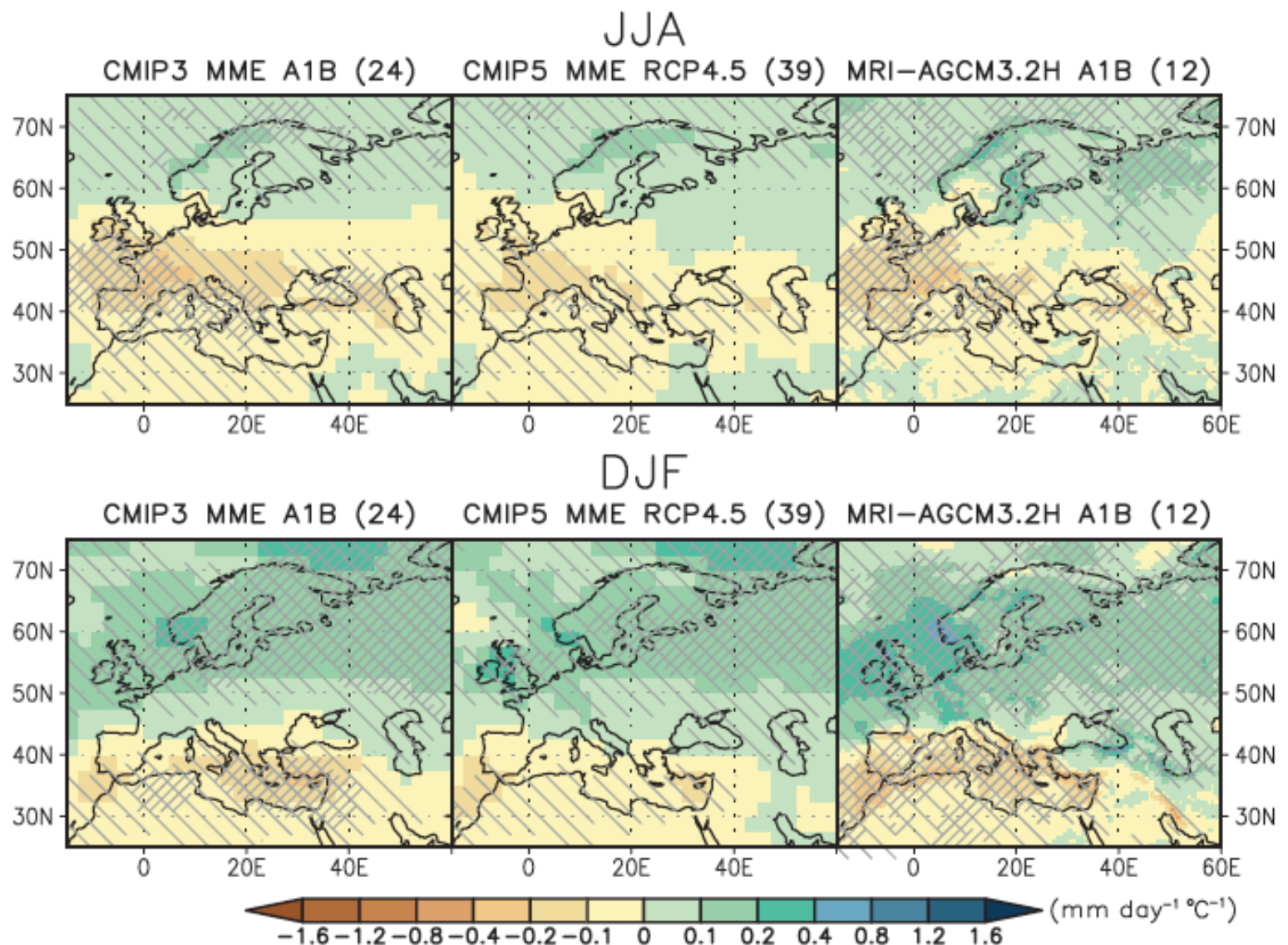
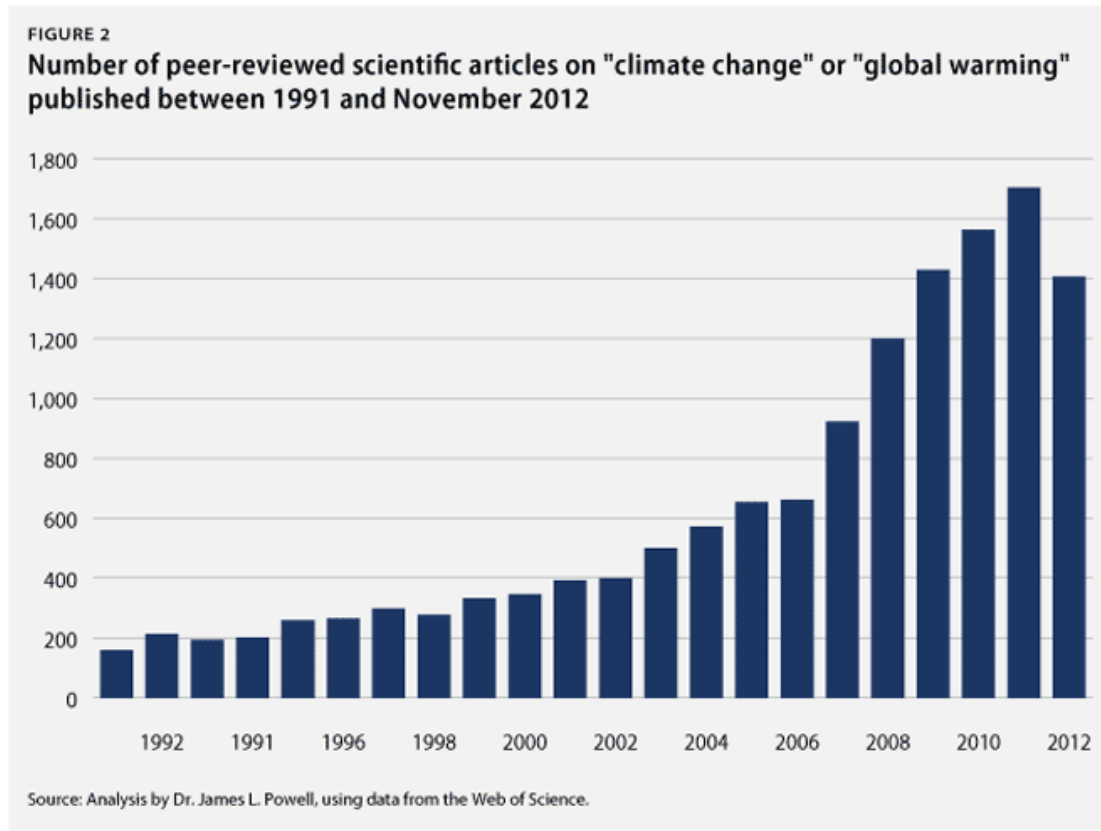
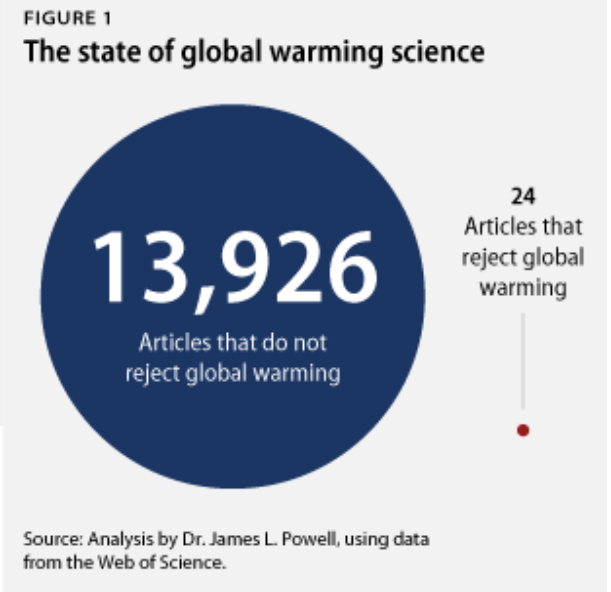


Figure 14.22 | Maps of precipitation changes for Europe and Mediterranean in 2080–2099 with respect to 1986–2005 in June to August (above) and December to February (below) in the SRES A1B scenario with 24 CMIP3 models (left), and in the RCP4.5 scenario with 39 CMIP5 models (middle). Right figures are the precipitation changes in 2075–2099 with respect to 1979–2003 in the SRES A1B scenario with the 12 member 60 km mesh Meteorological Research Institute (MRI)-Atmospheric General Circulation Model 3.2 (AGCM3.2) multi-physics, multi-sea surface temperature (SST) ensembles (Endo et al., 2012). Precipitation changes are normalized by the global annual mean surface air temperature changes in each scenario. Light hatching denotes where more than 66% of models (or members) have the same sign with the ensemble mean changes, while dense hatching denotes where more than 90% of models (or members) have the same sign with the ensemble mean changes.

NEGAZIONISTI contro CATASTROFISTI ??



Scientific Activity



This sculpture made by Isaac Cordal in Berlin,
Germany is called
“Politicians Debating Global Warming”



Questa terra non l'abbiamo avuta in eredità dai nostri padri, ma in prestito dai nostri figli.
(proverbio diffuso tra i popoli indigeni dell'Africa e dell'America)



«I cambiamenti climatici sono un problema globale con gravi implicazioni ambientali, sociali, economiche, distributive e politiche, e costituiscono una delle principali sfide attuali per l'umanità.»

Jorge Mario Bergoglio



Grazie per l'attenzione

DOMANDE??