

Copertina

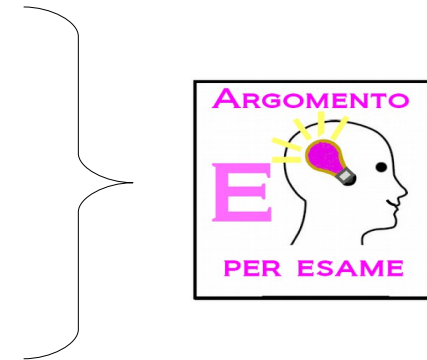
Corso di Fisica dell'Atmosfera

Cenni di climatologia
e
cambiamenti climatici

Giaiotti Dario & Stel Fulvio

Sommario della lezione

- Definizione di clima secondo WMO (strettamente meteorologico)
- Definizione di sistema clima (visione integrata)
- Paleoclima e le sue fonti
- Cambiamenti climatici in atto
- Scenari futuri di clima
- Bibliografia



Cos'è il clima: definizione World Meteorological Organization

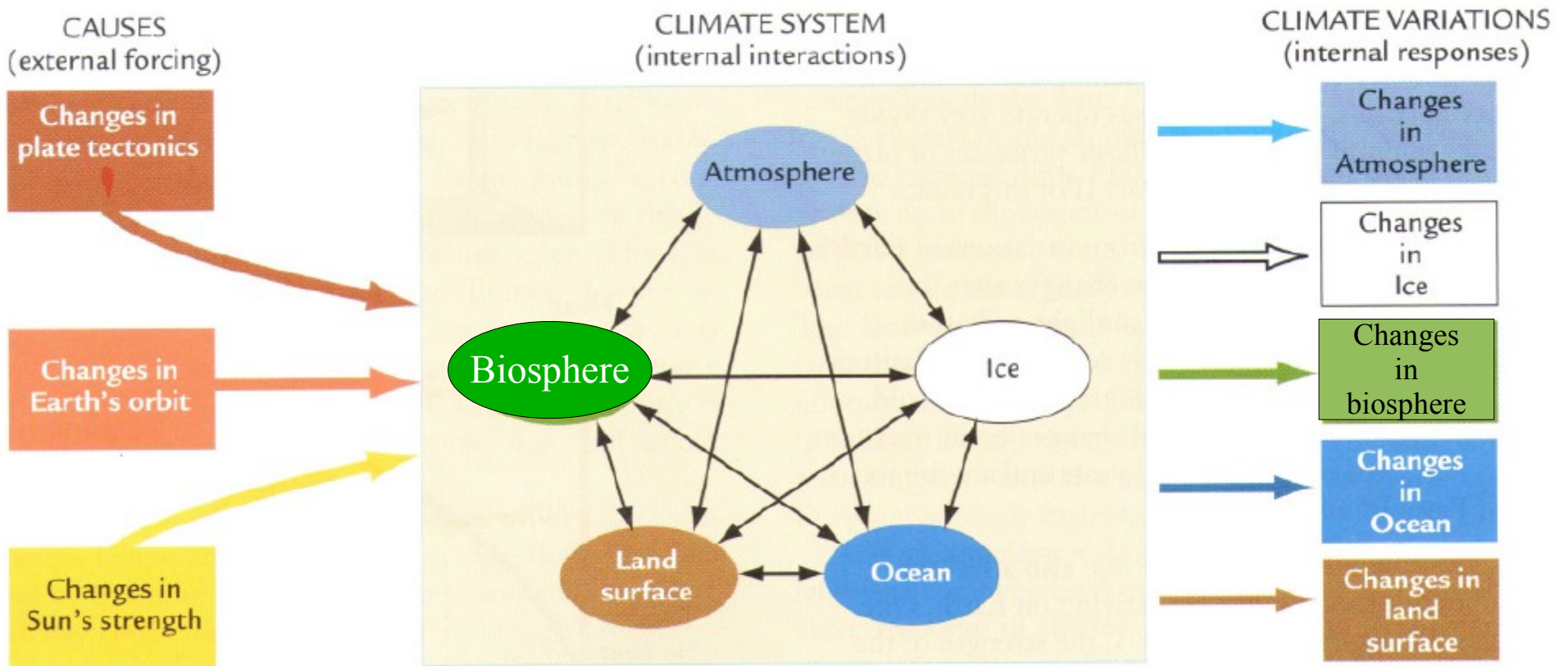
Climate, sometimes understood as the "average weather," is defined as the measurement of the mean and variability of relevant quantities of certain variables (such as temperature, precipitation or wind) over a period of time, ranging from months to thousands or millions of years.

The classical period is **30 years**, as defined by the World Meteorological Organization (WMO). Climate in a wider sense is the state, including a statistical description, of the climate system.

Questa definizione si focalizza sull'atmosfera

Il sistema clima

Una visione più ampia che tiene conto delle interazioni tra tutti i sistemi interagenti con l'atmosfera



Cosa sappiamo del clima passato

- Ci sono evidenze che a Terra esiste da datano l'esistenza della terra a 4.5 Gy
- Non ci sono informazioni disponibili precedenti i 300 My da oggi
- Ci sono evidenze di notevoli cambiamenti del clima passato negli ultimi 300 My

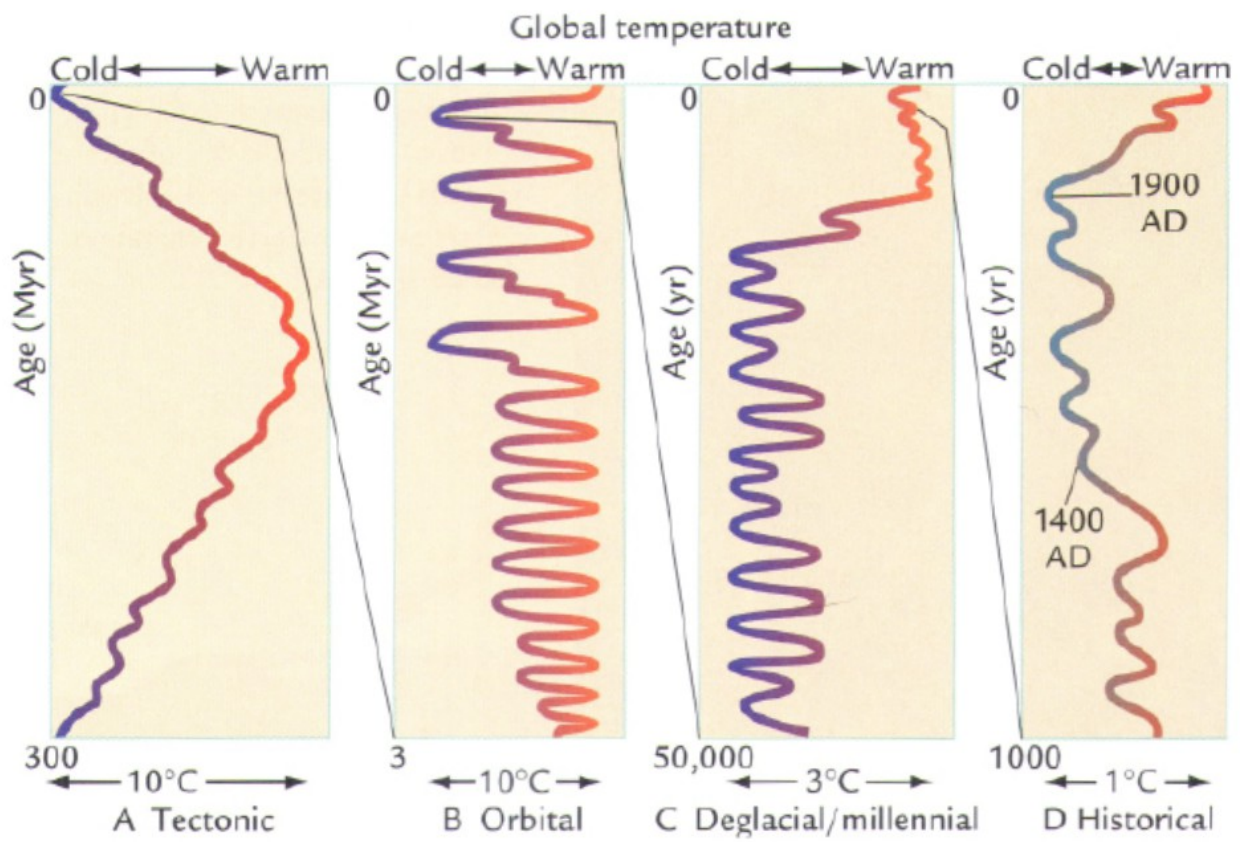


FIGURE 1-3 Time scales of climate change Changes in Earth's climate span several time scales, arrayed from longer to shorter: (A) the last 300 million years, (B) the last 3 million years, (C) the last 50,000 years, and (D) the last 1000 years. Here progressively smaller changes in climate at successively shorter time scales are magnified out from the larger changes at longer time scales.

Tempi di risposta delle diverse componenti del sistema clima alle forzanti esterne

TABLE 1.1 Response Times of Various Climate System Components

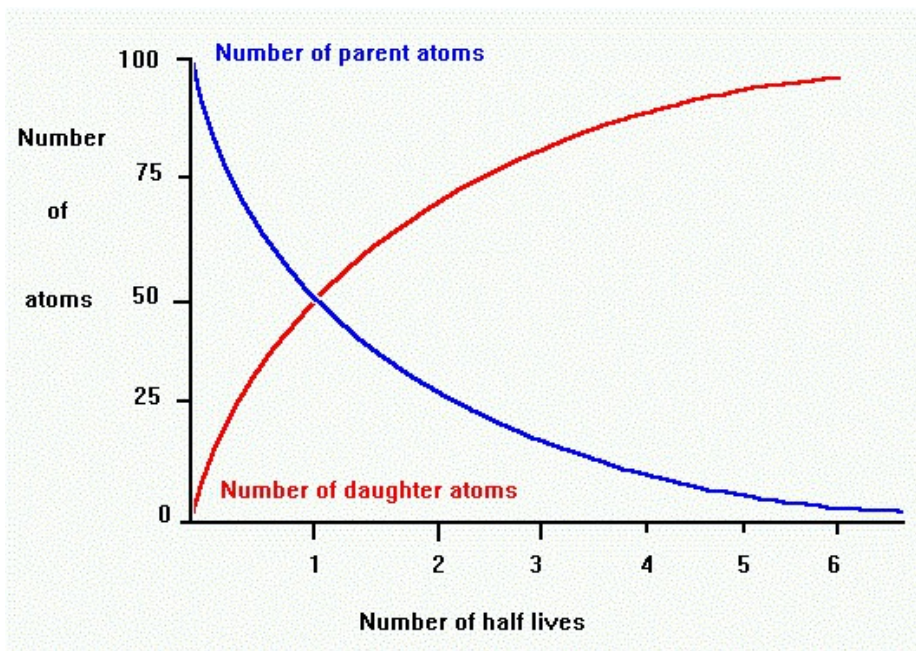
Component	Response time (range)	Example
Fast responses		
Atmosphere	Hours to weeks	Daily heating and cooling Gradual buildup of heat wave
Land surface	Hours to months	Daily heating of upper ground surface Midwinter freezing and thawing
Ocean surface	Days to months	Afternoon heating of upper few feet Warmest beach temperatures late in summer
Vegetation	Hours to decades/centuries	Sudden leaf kill by frost Slow growth of trees to maturity
Sea ice	Weeks to years	Late-winter maximum extent Historical changes near Iceland
Slow responses		
Mountain glaciers	10–100 years	Widespread glacier retreat in 20th century
Deep ocean	100–1500 years	Time to replace world's deep water
Ice sheets	100–10,000 years	Advances/retreats of ice sheet margins Growth/decay of entire ice sheet

Lo studio del clima passato: le fonti

- Fonti storiche e misure moderne
- Coralli
- Pollini
- Carote di ghiacci
- Anelli dei tronchi di alberi
- Sedimenti marini
- Sedimenti nei laghi
- Radio datazione

Radio datazione

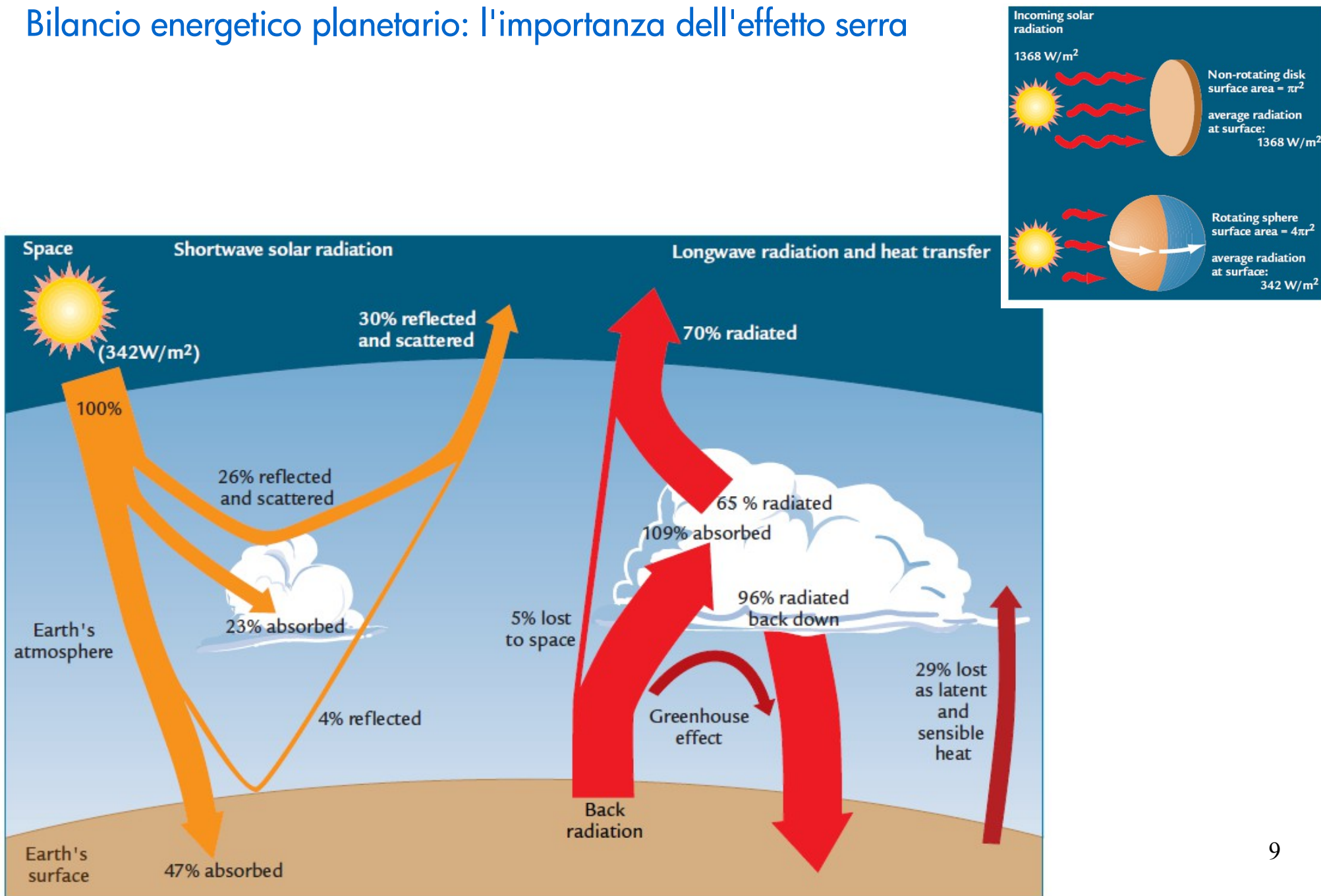
Un metodo usato parecchio negli ultimi decenni per datare campioni è quello della radio datazione che si basa sul decadimento radioattivo di alcuni isotopi naturali



Radioactive Parent	Stable Daughter	Half life
Potassium 40	Argon 40	1.25 billion yrs
Rubidium 87	Strontium 87	48.8 billion yrs
Thorium 232	Lead 208	14 billion years
Uranium 235	Lead 207	704 million years
Uranium 238	Lead 206	4.47 billion years
Carbon 14	Nitrogen 14	5730 years

Ovviamente le incertezze non riguardano solo la misura radioattiva, ma anche il modo in cui il campione ha conservato la massa dei radio nuclei.

Bilancio energetico planetario: l'importanza dell'effetto serra



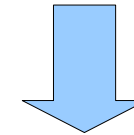
I forzanti climatici

1-5 Climate Forcing

Three fundamental kinds of climate forcing exist in the natural world:

- *Tectonic processes* generated by Earth's internal heat affect its surface by means of processes that alter the basic geography of Earth's surface. These processes are part of the theory of plate tectonics, the unifying theory of the science of geology. Examples include the slow movement of continents, the uplift of mountain ranges, and the opening and closing of ocean basins. These processes operate very slowly over millions of years. The basic processes of plate tectonics are explained in Part II of this book.
- *Earth-orbital changes* result from variations in Earth's orbit around the Sun. These changes alter the amount of solar **radiation** (sunlight and other energy) received on Earth by season and by latitude (from the warm, low-latitude tropics to the cold, high-latitude poles). Orbital changes occur over tens to hundreds of thousands of years and are the focus of Parts III and IV.
- *Changes in the strength of the Sun* also affect the amount of solar radiation arriving on Earth. One example appears in Chapter 3: the strength of the Sun has slowly increased throughout the 4.55 Byr of Earth's existence. In addition, shorter-term variations that occur over decades or longer are part of the focus of Part V.

A fourth factor capable of influencing climate, but not in a strict sense part of the natural climate system, is the *effect of humans on climate*, referred to as **anthropogenic forcing**. This forcing is an unintended by-product of agricultural, industrial, and other human activities, and



Ipotesi antropogenica del
riscaldamento globale

Evidenze di un riscaldamento globale anomalo: l'attuale ipotesi antropogenica CH₄

RG4001

Ruddiman: EARLY ANTHROPOGENIC HYPOTHESIS

RG4001

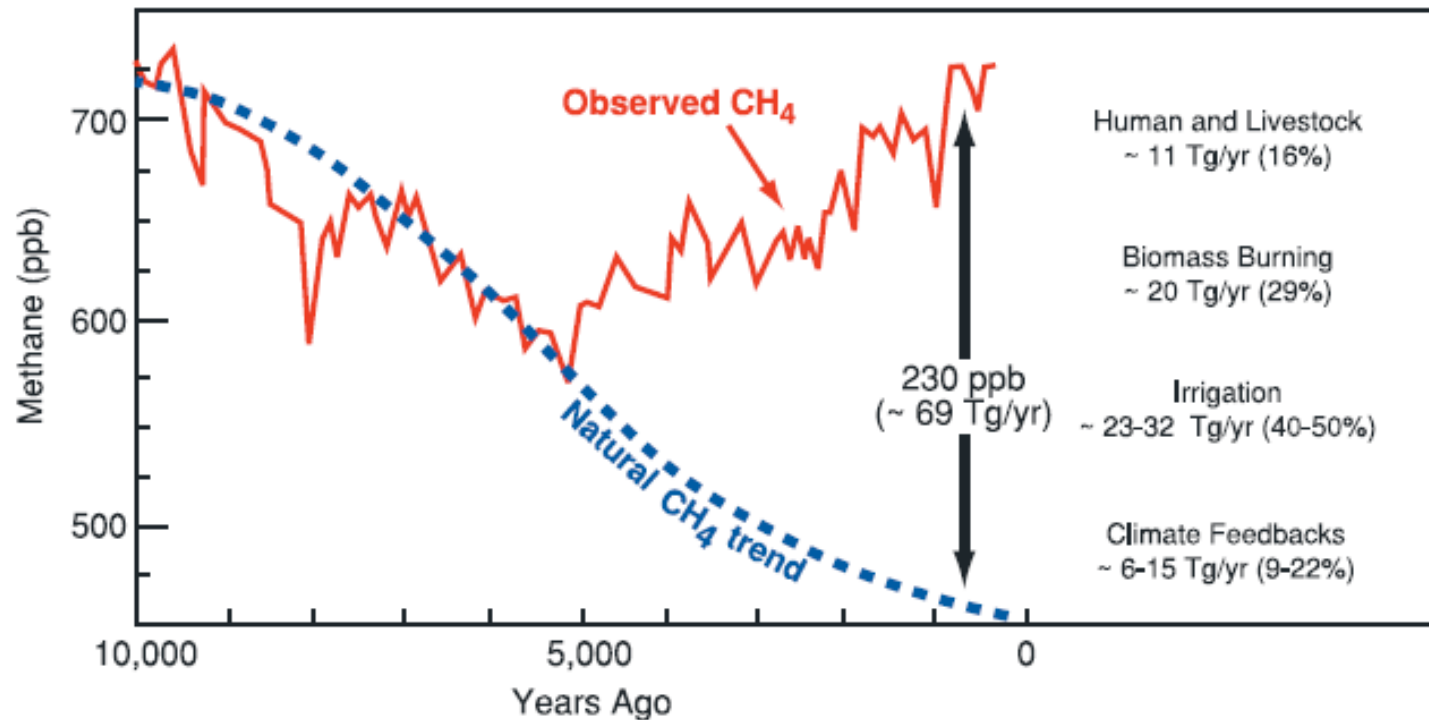


Figure 12. Estimated anthropogenic CH₄ anomaly of 230 ppb in the year 1500 accounted for by contributions from several sources: emissions from livestock and human waste (both linearly tied to human population), disproportionately large emissions from biomass burning and irrigation, and climate system feedbacks.

Evidenze di un riscaldamento globale anomalo: l'attuale ipotesi antropogenica CO₂

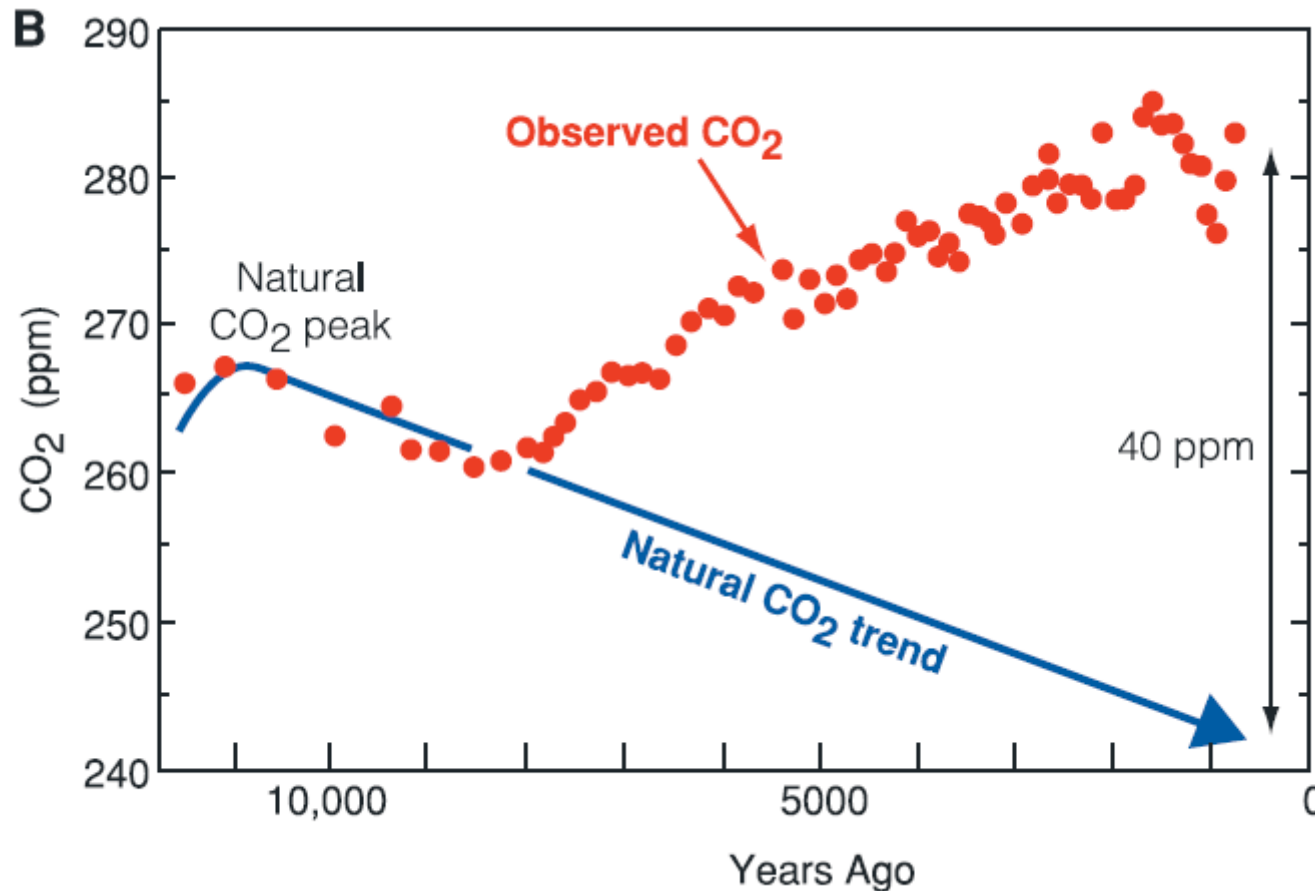


Figure 1. Early anthropogenic hypothesis. Human activities during the late Holocene causing increases in (a) CH₄ and (b) CO₂ in contrast to the downward trends during previous interglaciations. (c) Late Holocene greenhouse gas increases preventing much of the natural cooling that occurred in previous interglaciations.

Evidenze di un riscaldamento globale anomalo: l'attuale ipotesi antropogenica

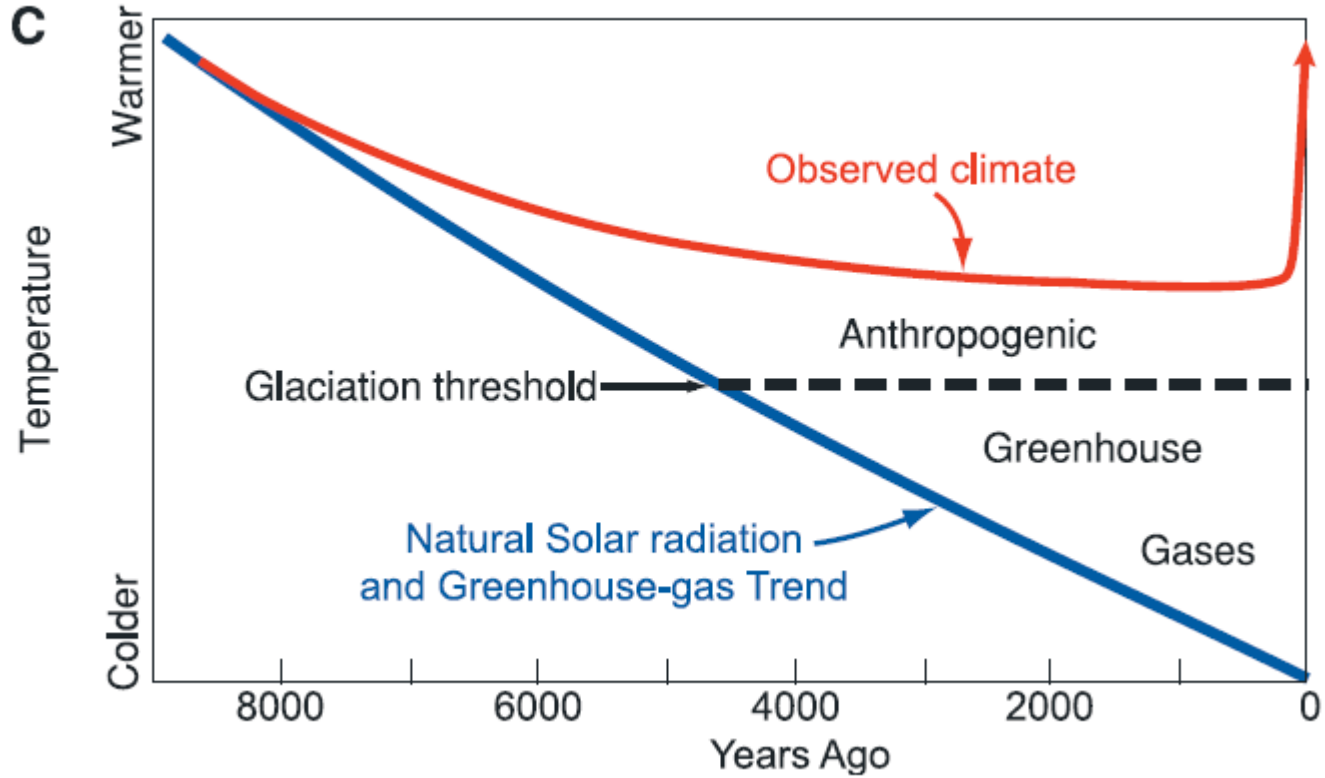
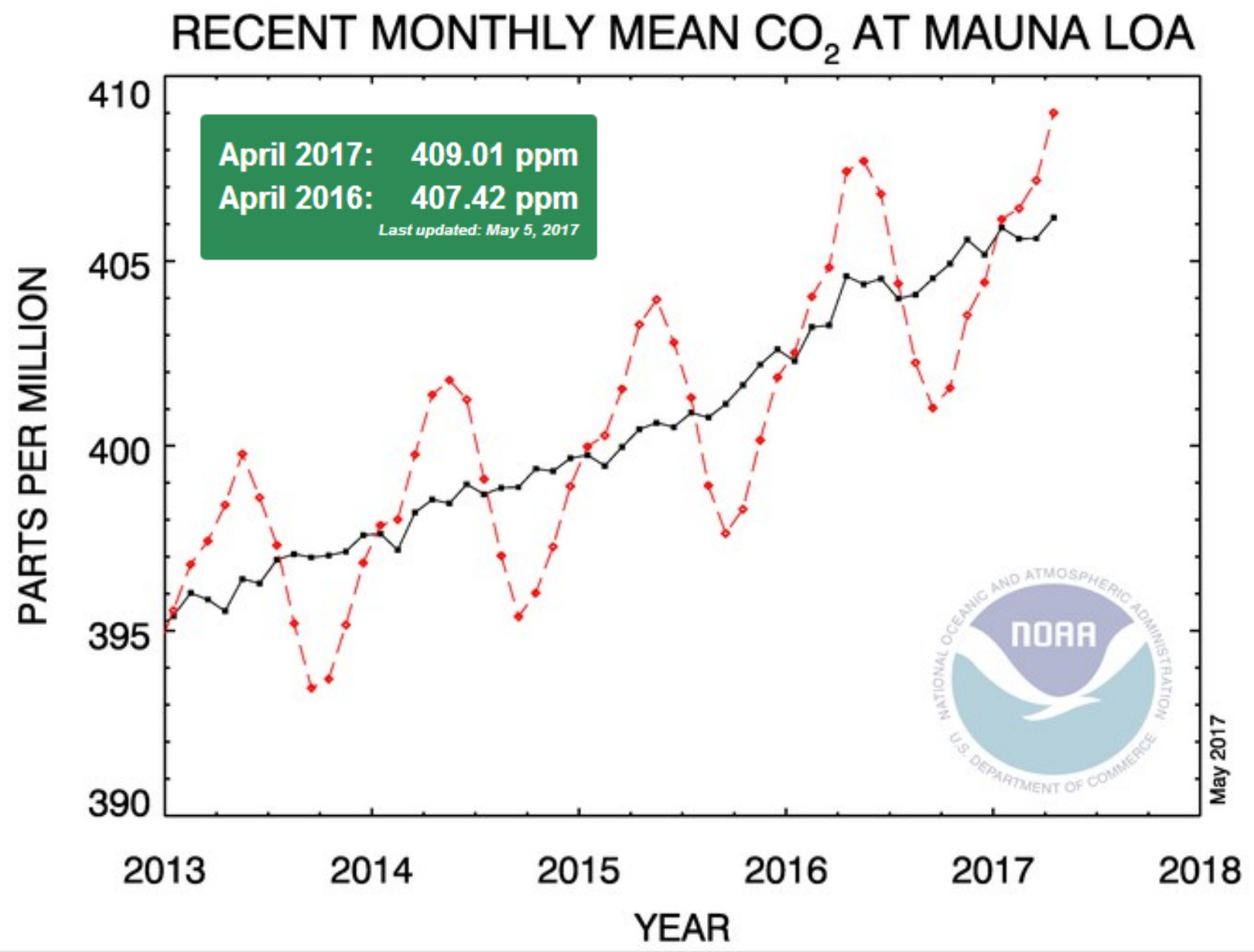
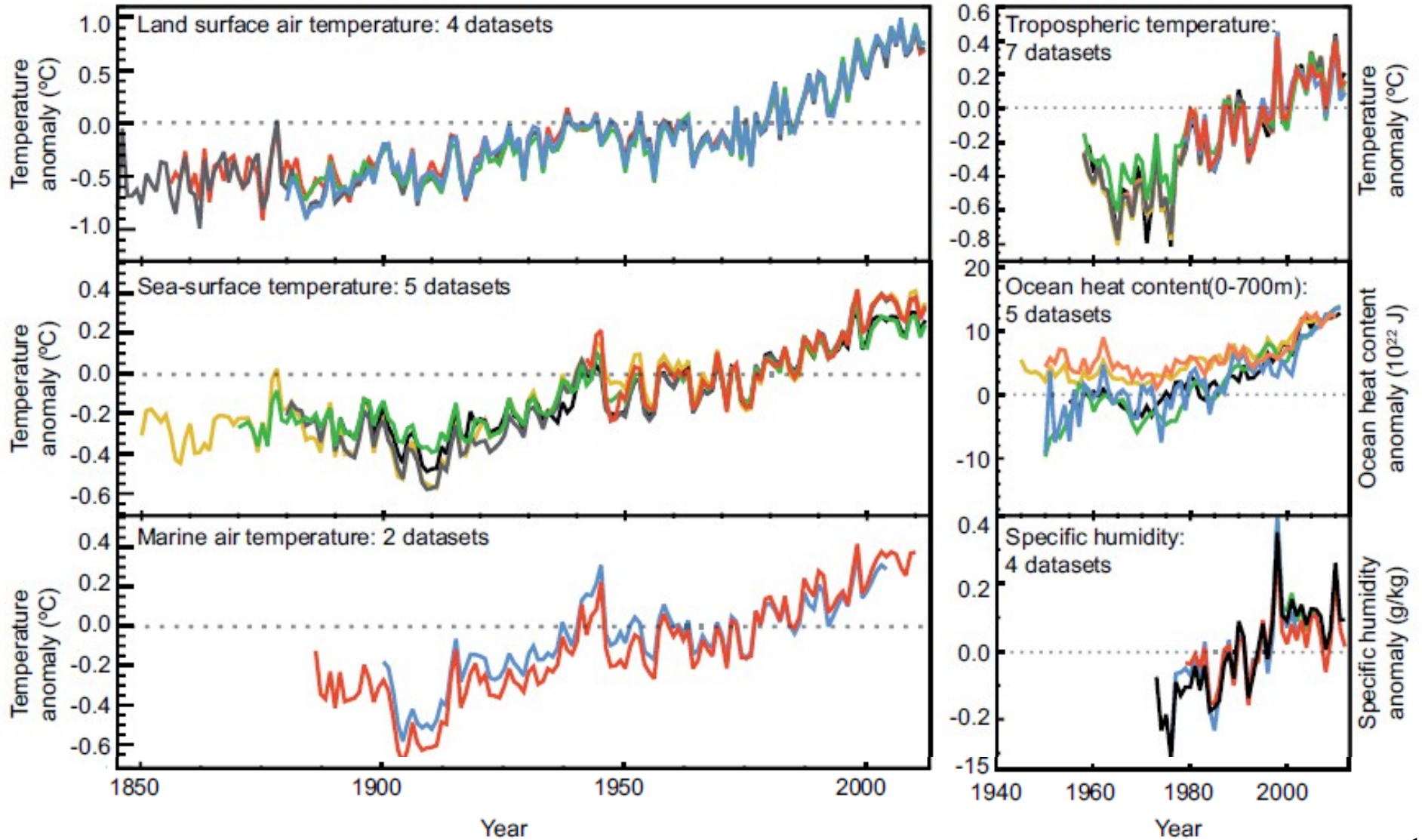


Figure 1. Early anthropogenic hypothesis. Human activities during the late Holocene causing increases in (a) CH_4 and (b) CO_2 in contrast to the downward trends during previous interglaciations. (c) Late Holocene greenhouse gas increases preventing much of the natural cooling that occurred in previous interglaciations.

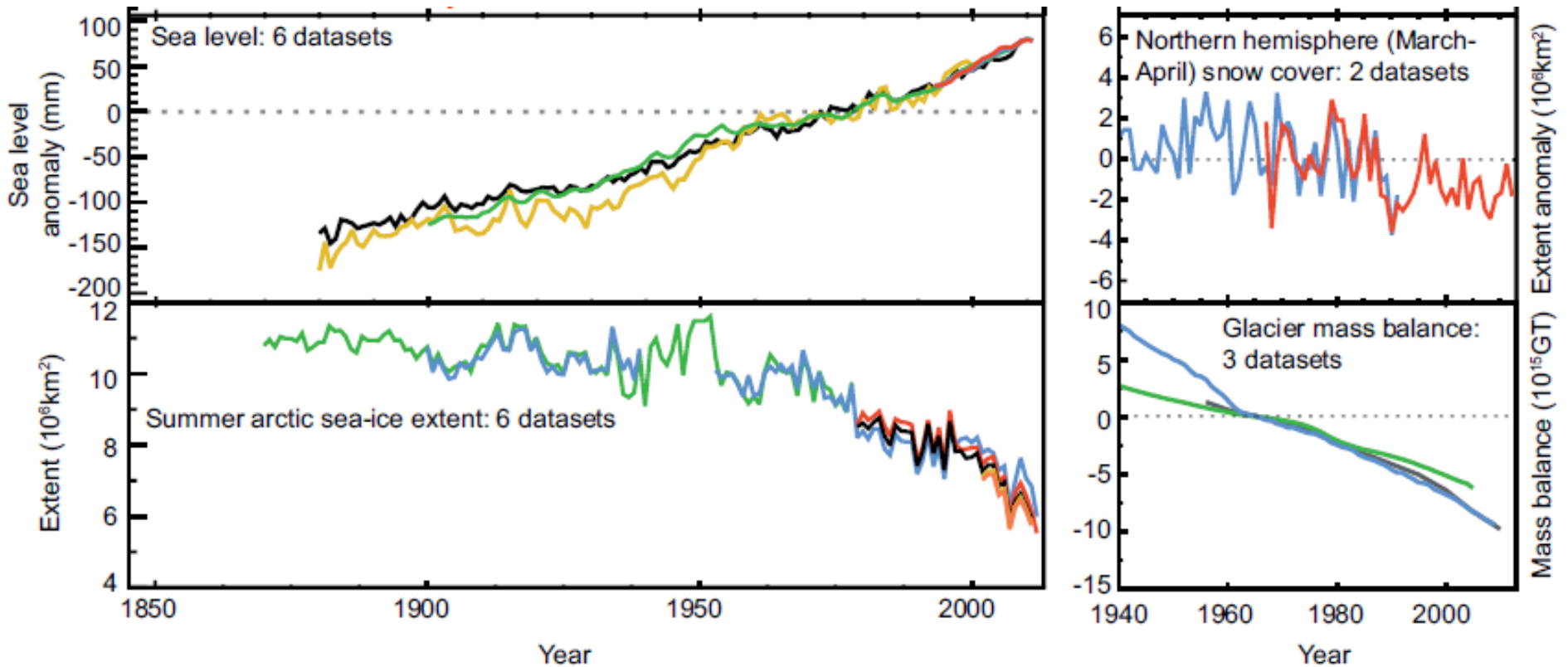
Livelli attuali di CO2



Evidenze dei cambiamenti nell'ultimo secolo

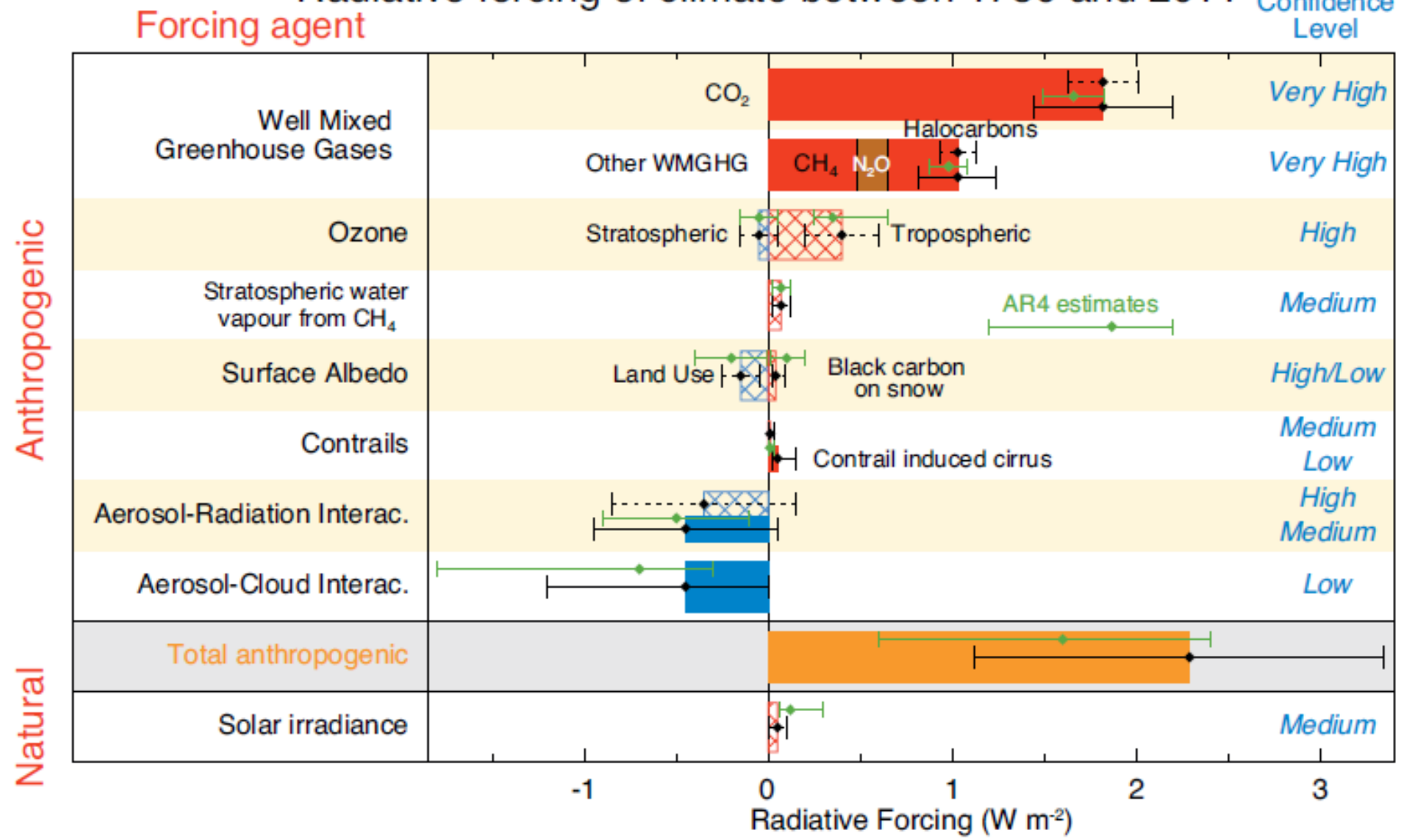


Evidenze dei cambiamenti nell'ultimo secolo

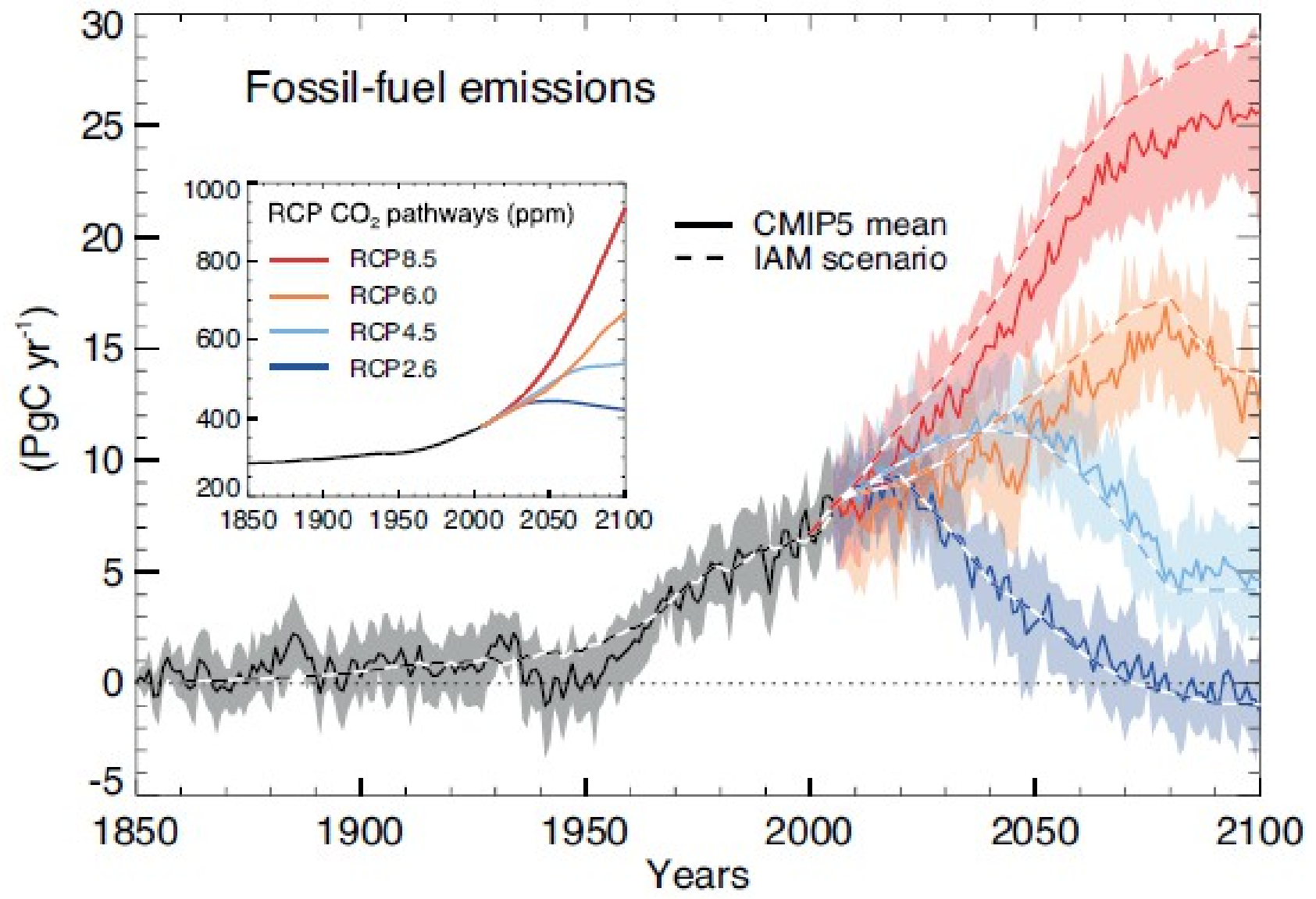


Elementi che agiscono da forzante sul clima

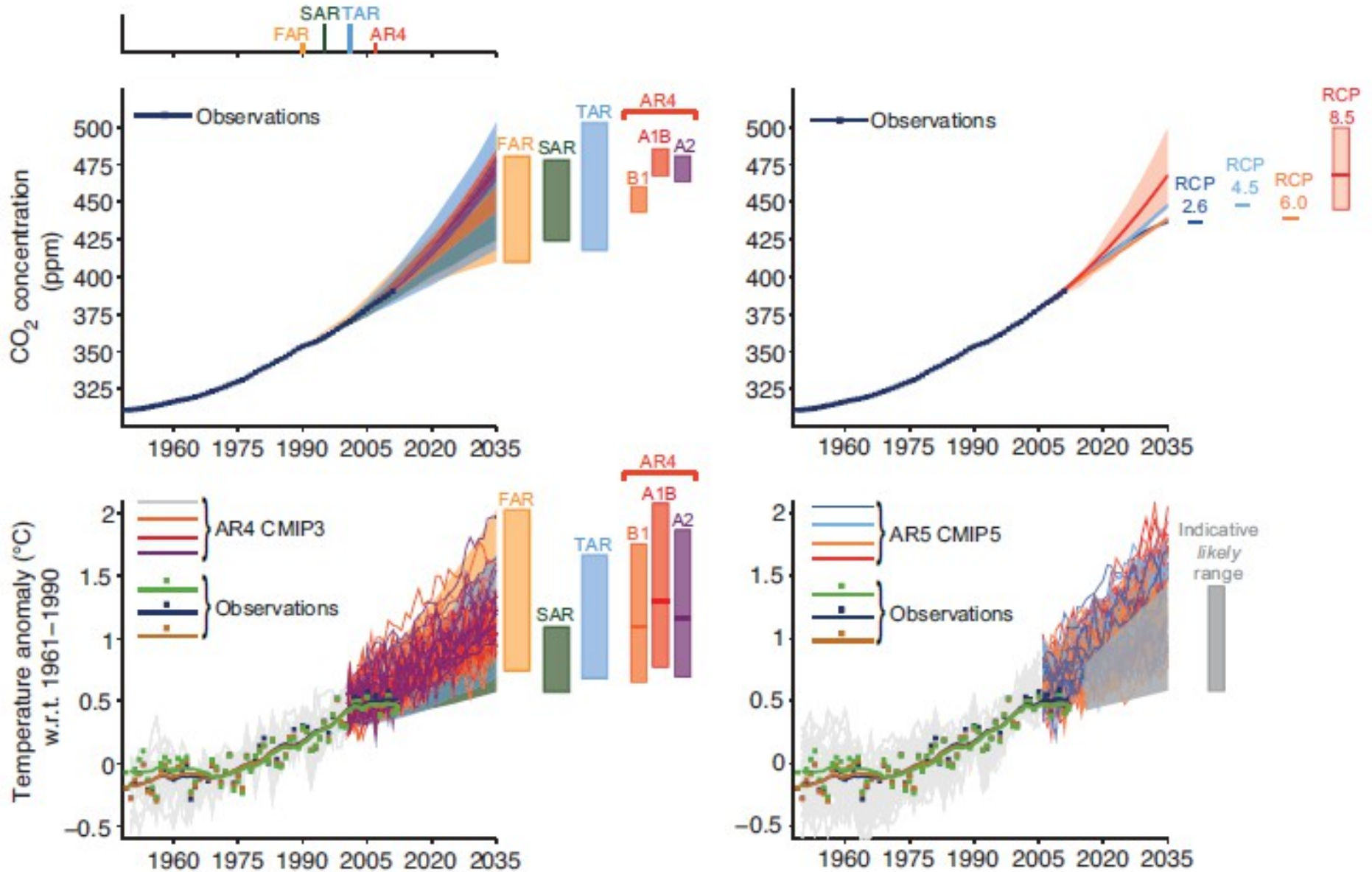
Radiative forcing of climate between 1750 and 2011



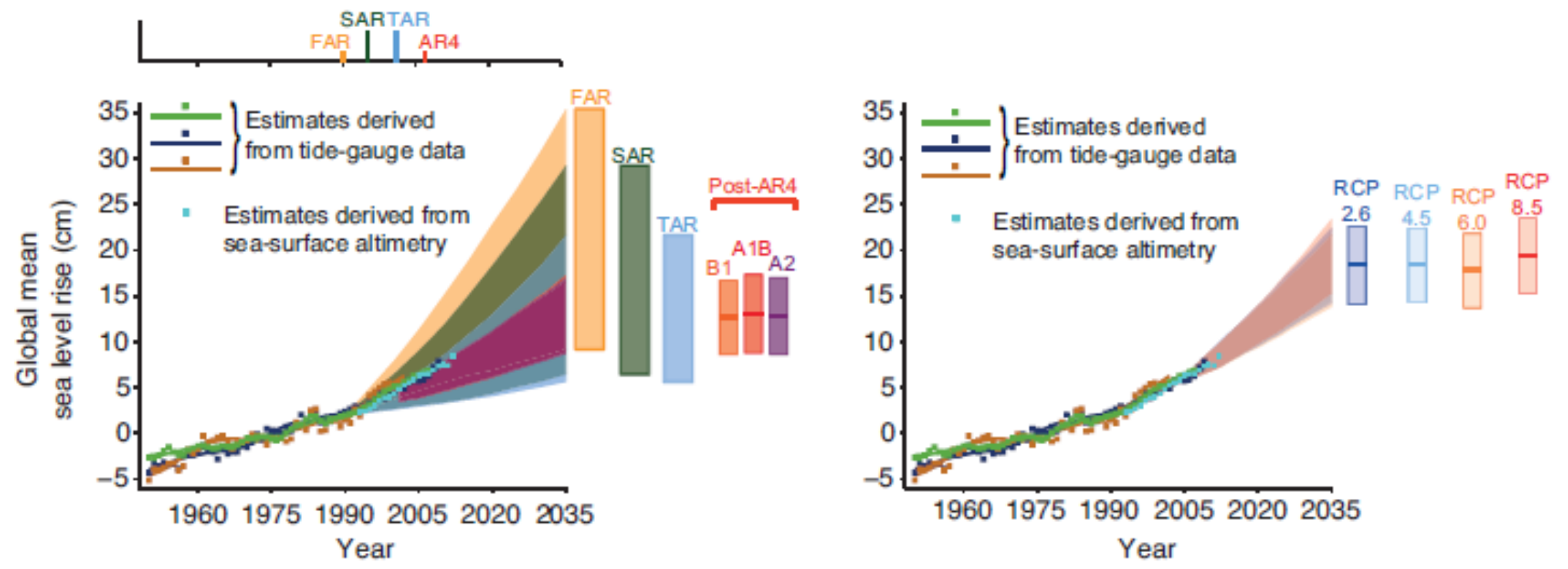
Simulazione delle forzanti sul clima futuro



Scenari di cambiamenti climatici per il XXI secolo

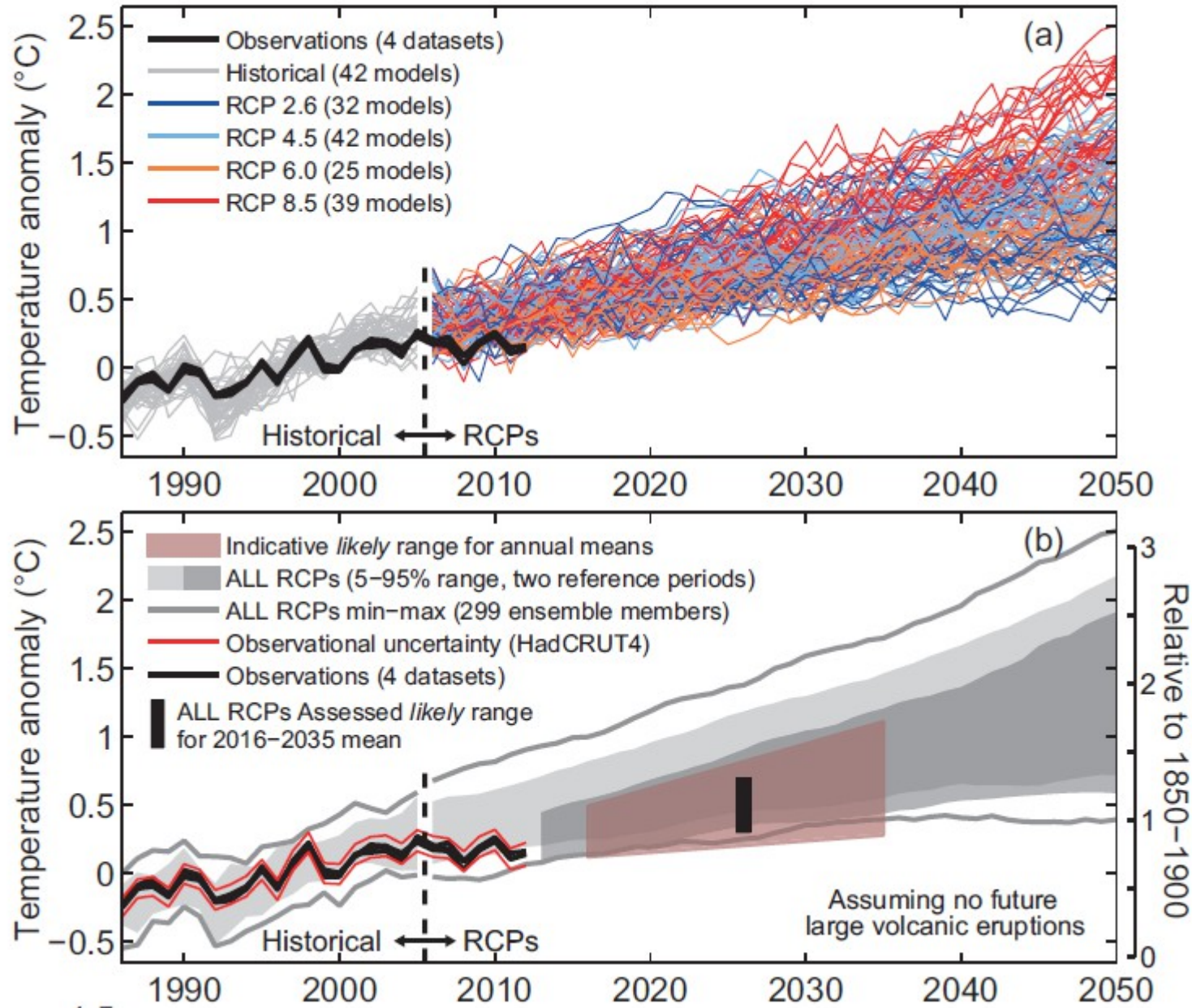


Scenari di cambiamenti climatici per il XXI secolo



Scenari di cambiamenti climatici per il XXI secolo – Valutazione incertezze

Global mean temperature near-term projections relative to 1850–1900



Bibliografia

[1] Earth's Climate – Past and Future (Second Edition), by William Ruddiman, 2008, W. H. Freeman and Company Biblioteca Tecnico Scientifica BS/04/M/0009

[2] Intergovernmental Panel on Climate Change - Fifth Assessment Report (AR5)-
<https://www.ipcc.ch/report/ar5/mindex.shtml>