Luigi Cavaleri

Istituto di Scienze Marine – CNR

Venezia

“L’evoluzione della conoscenza scientifica in materia climatica”

ovverosia

“Dove andiamo col clima? Quello che i giornali e la TV ripetono e quello che non sanno.”

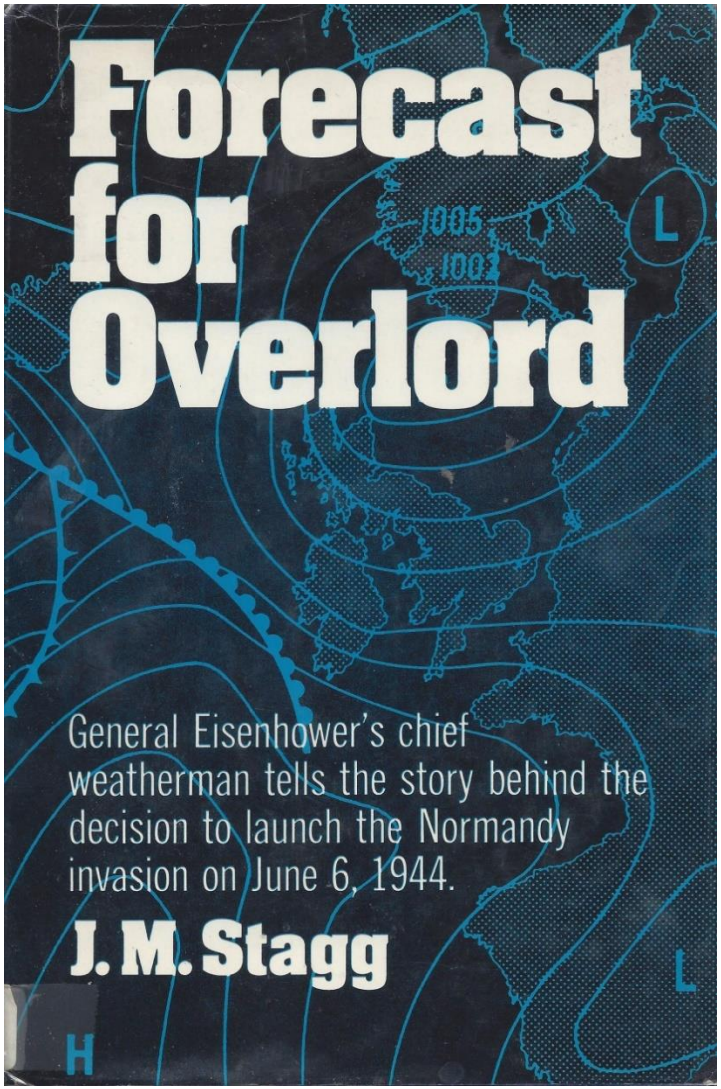
Revisiting the meteorology of June 1944 using a modern analysis and forecasting system

A selection of results drawn from ERA-CLIM reanalyses of the weather and climate of the 20th Century

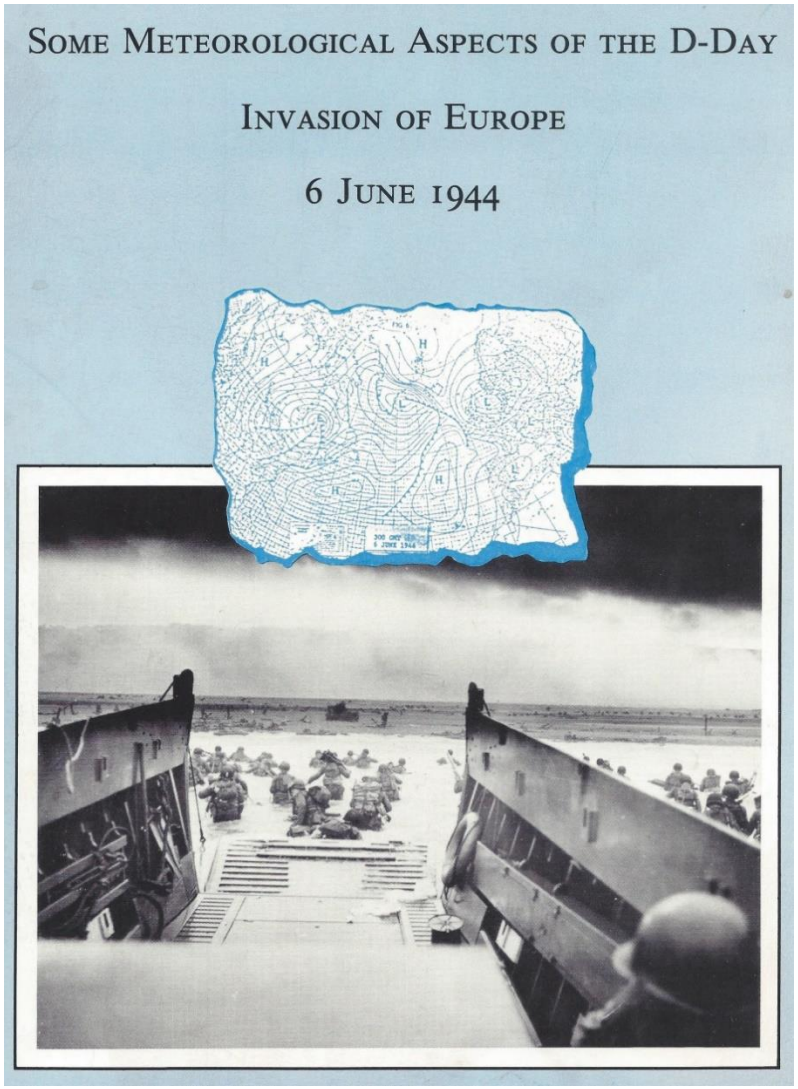
Adrian Simmons, Hans Hersbach, Paul Poli, Jean Bidlot and colleagues
European Centre for Medium-Range Weather Forecasts
(with thanks to Eric Freeman, US National Climatic Data Center)

ERA-CLIM and its follow-on ERA-CLIM2 are ECMWF-led multi-partner projects partly funded by the European Union's Seventh Framework Programme

Principal sources of background information and original charts



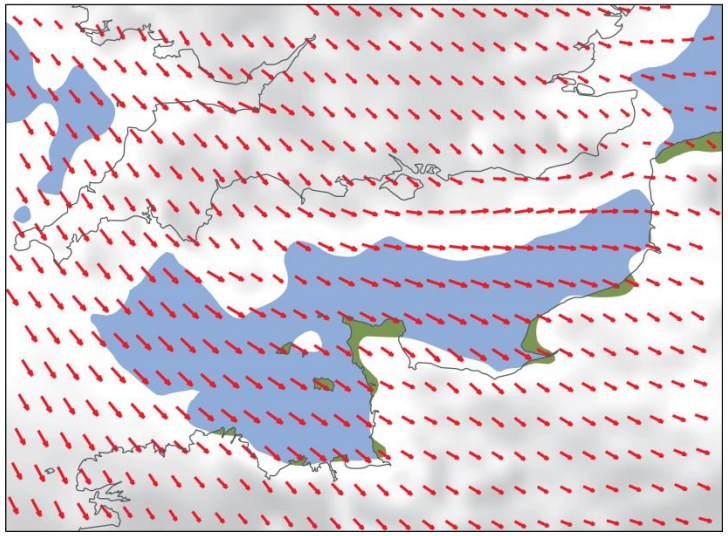
W.W. Norton & Co. Inc., 1971



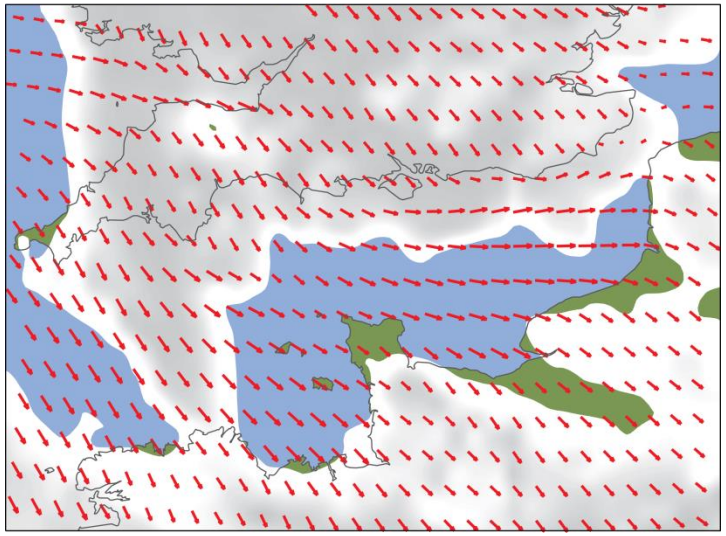
American Meteorological Society, 1984

Cloud cover and 10m wind from short-range high-resolution (~16km grid) forecasts

H+12 valid 12 UTC 6 June 1944



H+15 valid 15 UTC 6 June 1944



Shortly before midday

Tuesday, 6 June:

Late Forenoon	Cloud: Clouds broke and cleared over Channel.
1700	Wind: WNW, Force 4, 5 at times. Cloud: Clear conditions over Channel. Variable amounts of low cloud, mainly 6-9/10 over beachhead and further inland. There was a clear area over the Seine Estuary.
1800	Cloud: At Cherbourg, 4-6/10, base 3-5000 ft.; at Havre, 1-2/10 low cloud, 2-3000 ft., with patchy medium

Pictures from Imperial War Museum

qual’è il mio (nostro) lavoro?

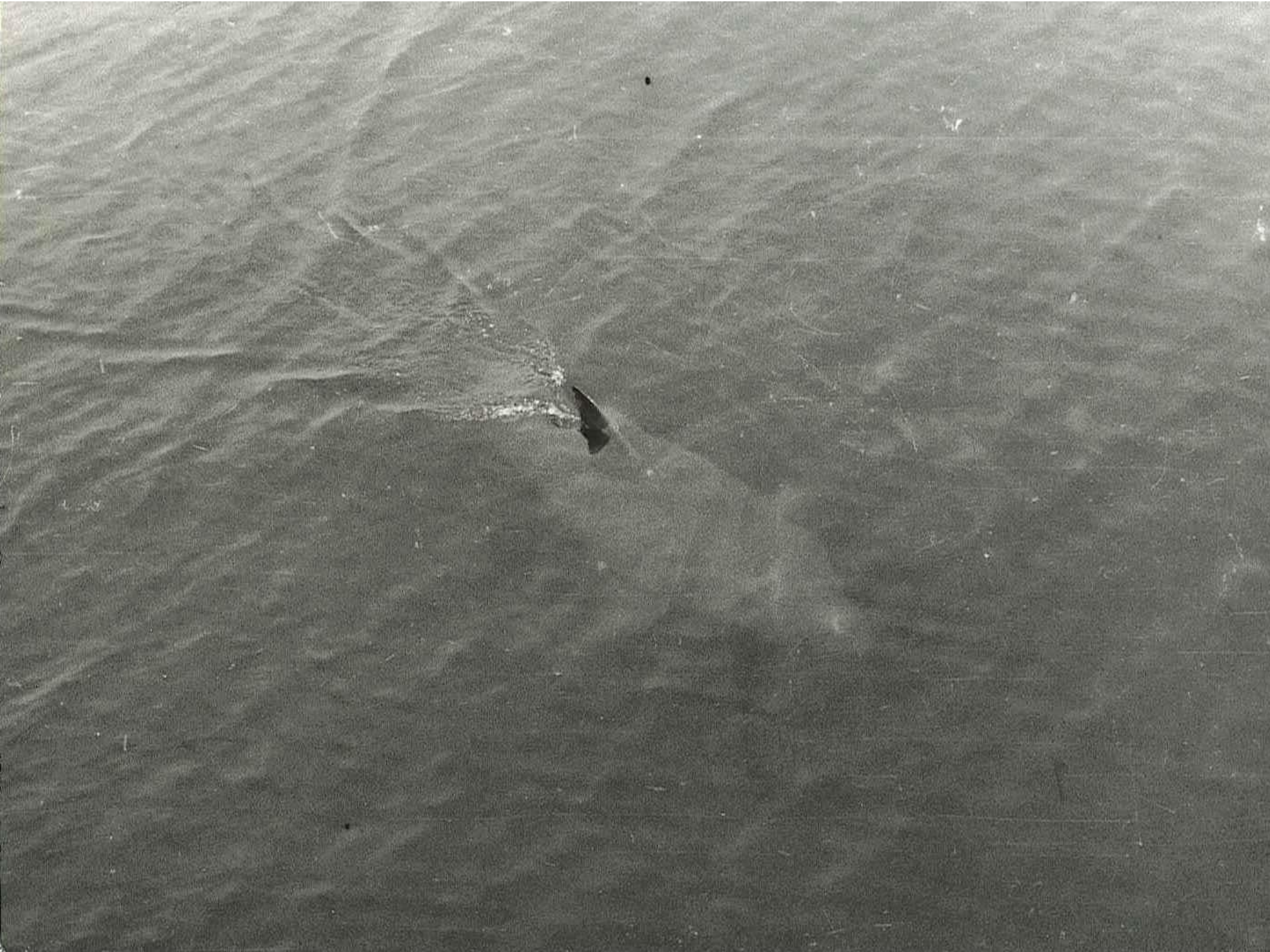
- studio del mare

qual’è il mio (nostro) lavoro?

- studio del mare

in particolare:

- studio e previsione delle onde e delle mareggiate



L’effetto serra: cent’anni di storia
Arrhenius 1896

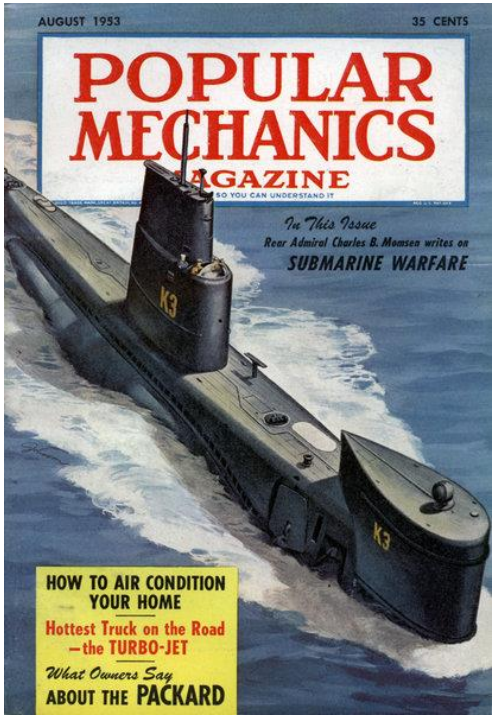
Svante August Arrhenius (1859-1927) chimico svedese, prodigio matematico, premio Nobel per la Chimica 1903. Nel 1896, dopo aver studiato i lavori di Fourier e i primi spettri di radiazione infrarossa prodotti da Langley, fu il primo a sostenere che la temperatura terrestre fosse regolata dalla concentrazione atmosferica di CO_2 (*On the influence of carbonic acid in the air upon the temperature of the ground.* Philosophical Magazine). Sostenne che l’aumento di CO2 di origine antropica avrebbe evitato al mondo la prossima era glaciale e calcolò che un raddoppio di CO_2 avrebbe fatto aumentare la T di 5 C (oggi si stima tra 1,5 e 4,5 C). Al tasso di emissione del tempo, stimò che il raddoppio sarebbe avvenuto entro 3000 anni, in realtà è atteso per il 2050.

Carbon Dioxide Causes Global Warming

(Modern Mechanics, Jul, **1932**)

Carbon Dioxide Heats the Earth

DR. E. O. HULBURT, physicist of the naval research laboratory, Washington, has found conclusive mathematical evidence that the earth's temperature is being warmed by the increased amount of carbon dioxide present in the air. Smoke stacks emit huge volumes of this gas, which is also found in the breath and waste products of humans and animals.



Growing Blanket of Carbon Dioxide Raises Earth's Temperature (Popular Mechanics Aug, **1953**)

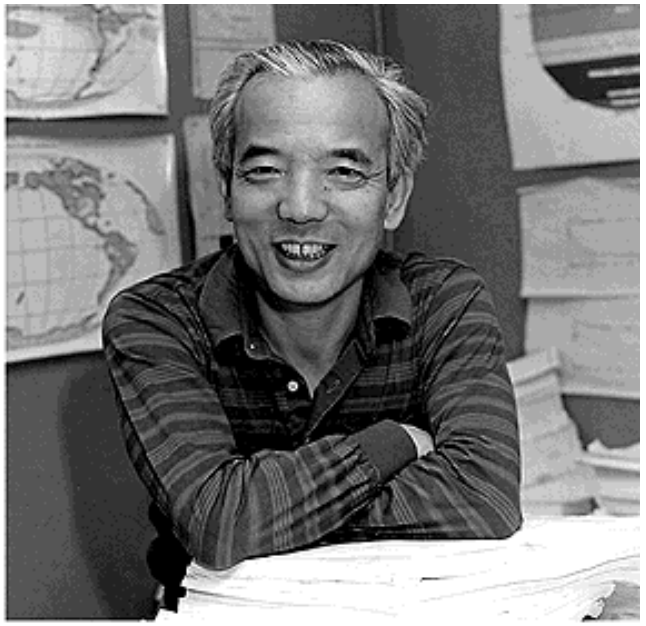
Growing Blanket of Carbon Dioxide Raises Earth's Temperature

Earth's ground temperature is rising 1½ degrees a century as a result of carbon dioxide discharged from the burning of about 2,000,000,000 tons of coal and oil yearly. According to Dr. Gilbert N. Plass of the Johns Hopkins University, this discharge augments a blanket of gas around the world which is raising the temperature in the same manner glass heats a greenhouse. By 2080, he predicts the air's carbon-dioxide content will double, resulting in an average-temperature rise of at least four percent. If most of man's industrial growth were over a period of several thousand years, instead of being crowded within the last century, oceans would have absorbed most of the excess carbon dioxide. But because of the slow circulation of the seas, they have had little effect in reducing the amount of the gas as man's smoke-making abilities have multiplied over the past hundred years.

Syukuro Manabe
Geophysical Fluid Dynamics Lab
Princeton - www.gfdl.noaa.gov

- A **1967** paper with Richard Wetherald of GFDL, published in the *Journal of Atmospheric Sciences,* predicted how increased carbon dioxide levels due to fossil fuel use could warm the earth.

- **IPCC** founded **1988**




OCTOBER 19, 1987
$1.95
TIME
SPECIAL REPORT
Fighting for Global Markets
The Heat Is On
How the Earth's Climate Is Changing
Why the Ozone Hole Is Growing

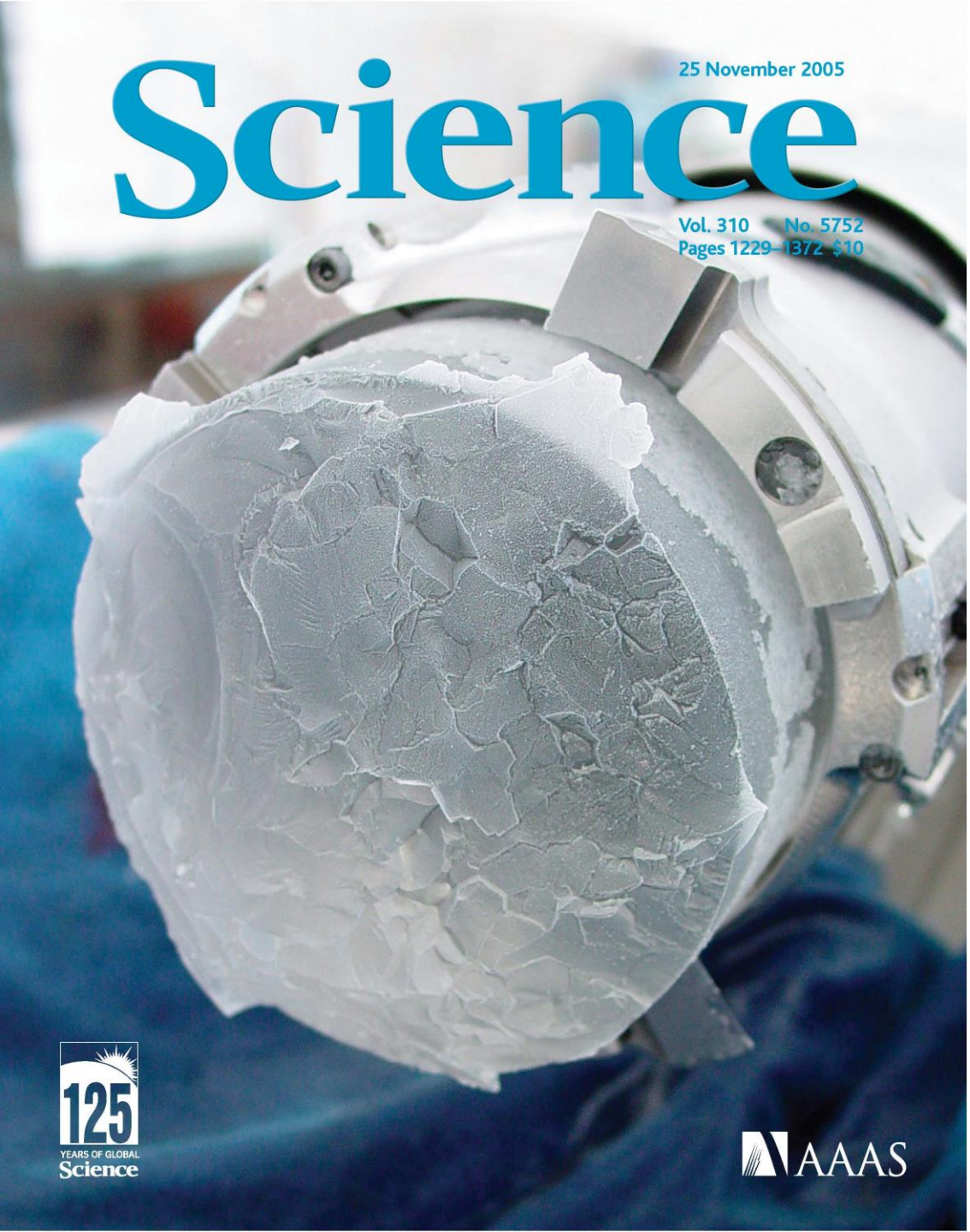

APRIL 3, 2006
www.time.com AOL Keyword: TIME
SPECIAL REPORT GLOBAL WARMING
TIME
BE WORRIED. BE VERY WORRIED.
Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well
EARTH AT THE TIPPING POINT
HOW IT THREATENS YOUR HEALTH
HOW CHINA & INDIA CAN HELP SAVE THE WORLD—OR DESTROY IT
THE CLIMATE CRUSADERS

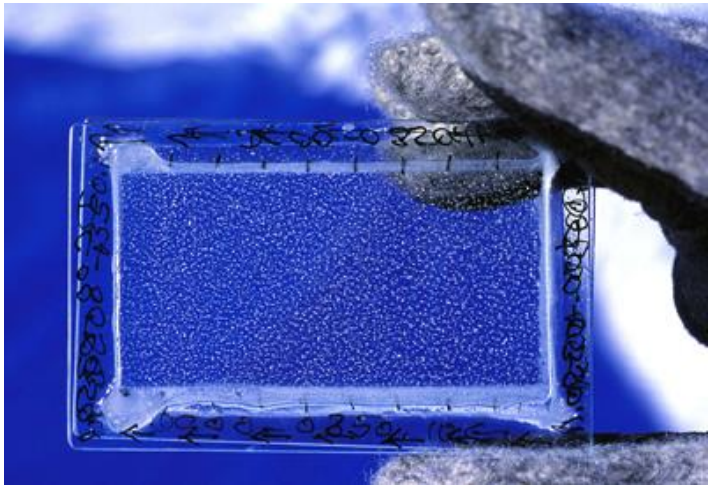
Progetto EPICA - EPICA

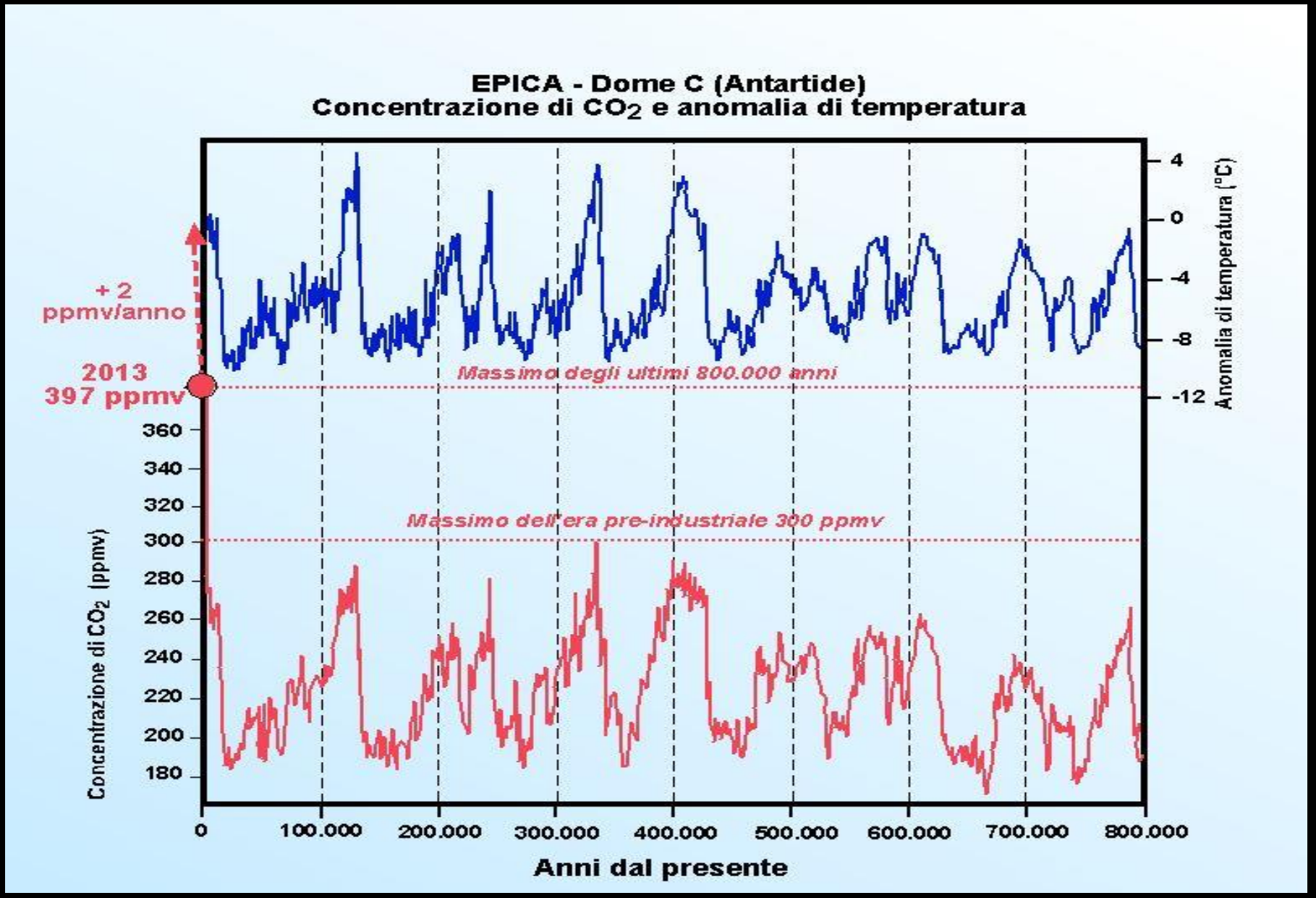
(European Project for Ice Coring in Antarctica)

Stazione italo-francese Concordia, a Dome C - Antartide


EPICA DOME
15-01-2001
DEPTH: 100
00m 30-12-2001
CA DÔME C
3000m
EPICA DÔME C
12 12 2002
3270.20m 21·12·2004

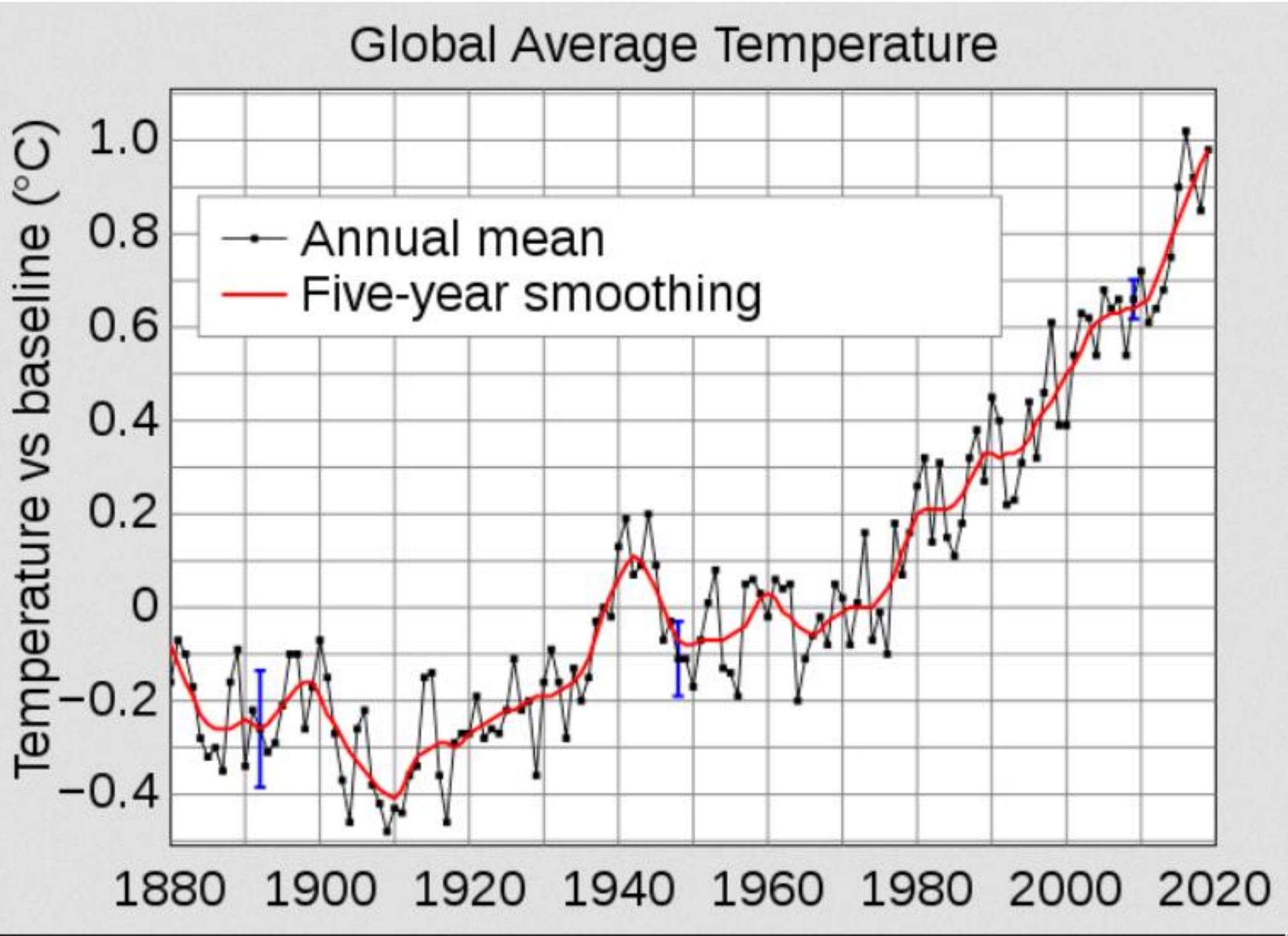

Science
25 November 2005
Vol. 310 No. 5752
Pages 1229–1372 $10
125
YEARS OF GLOBAL
Science
AAAS





Analisi chimica delle bolle d'aria «fossile» intrappolate nel ghiaccio

CO_2 max. concentrazione 300 ppmv

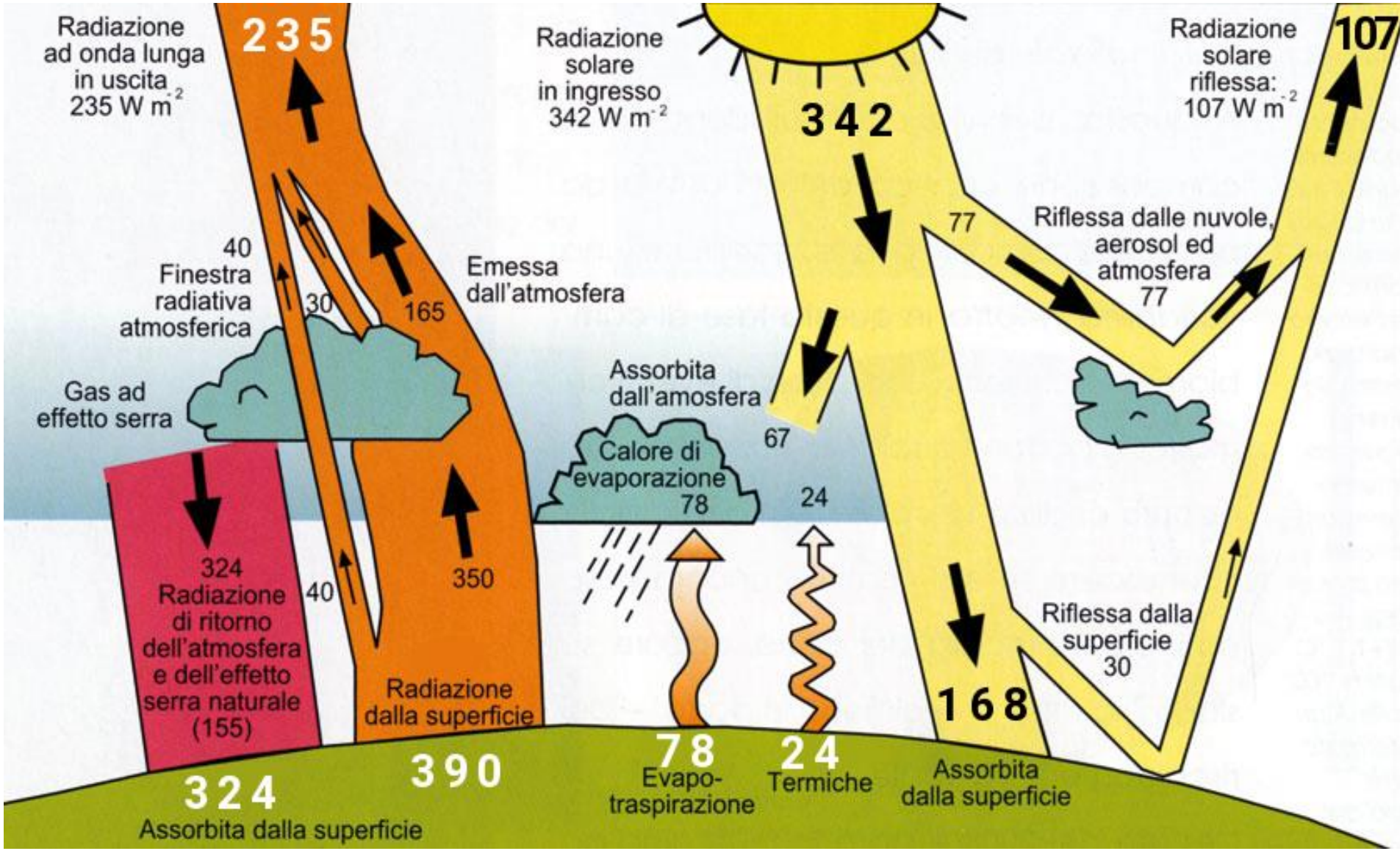

Global Average Temperature
Temperature vs baseline (°C)
1.0
0.8
0.6
0.4
0.2
0
−0.2
−0.4
Annual mean
Five-year smoothing
1880
1900
1920
1940
1960
1980
2000
2020

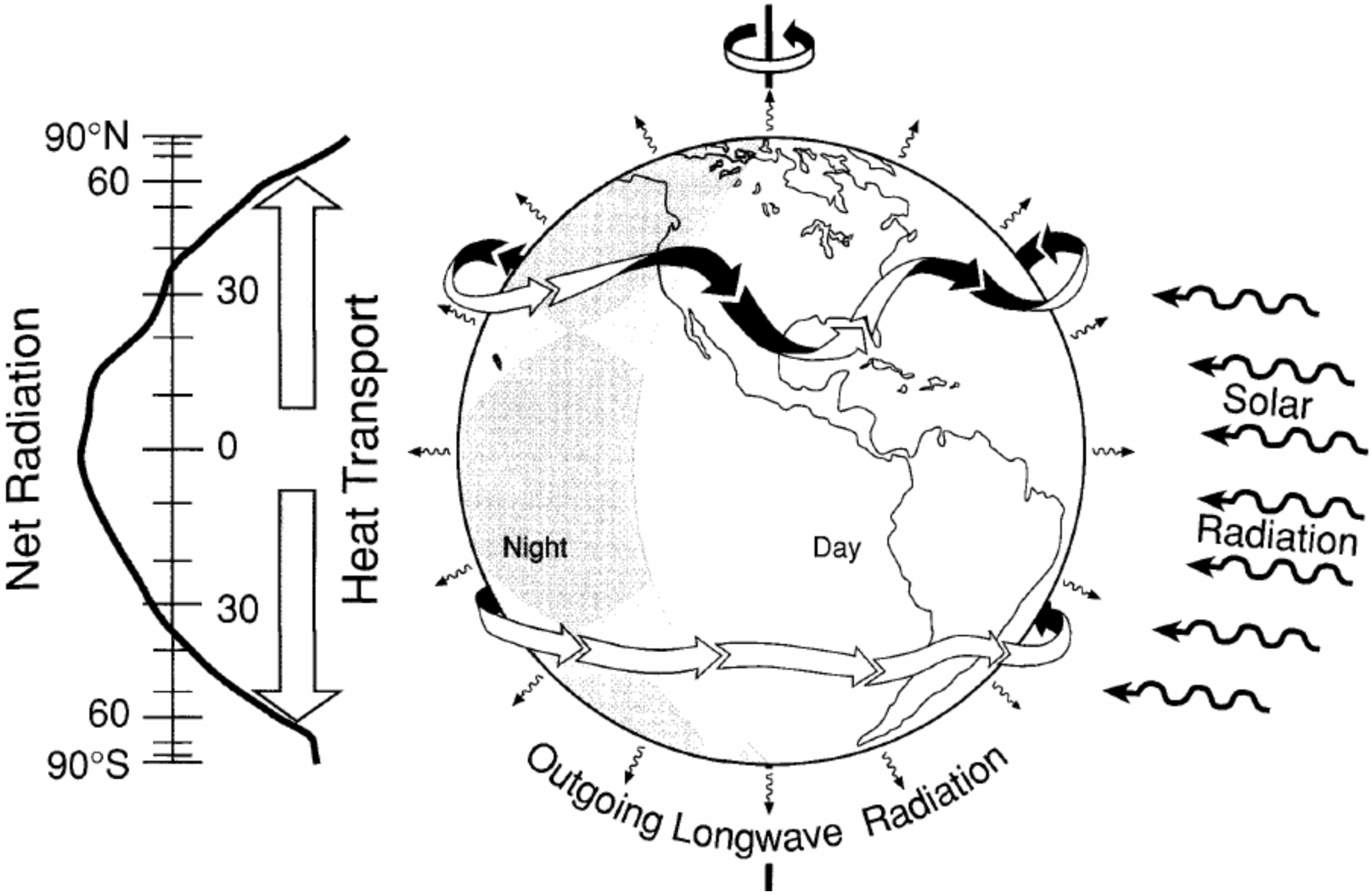
Il riscaldamento globale è tra noi…

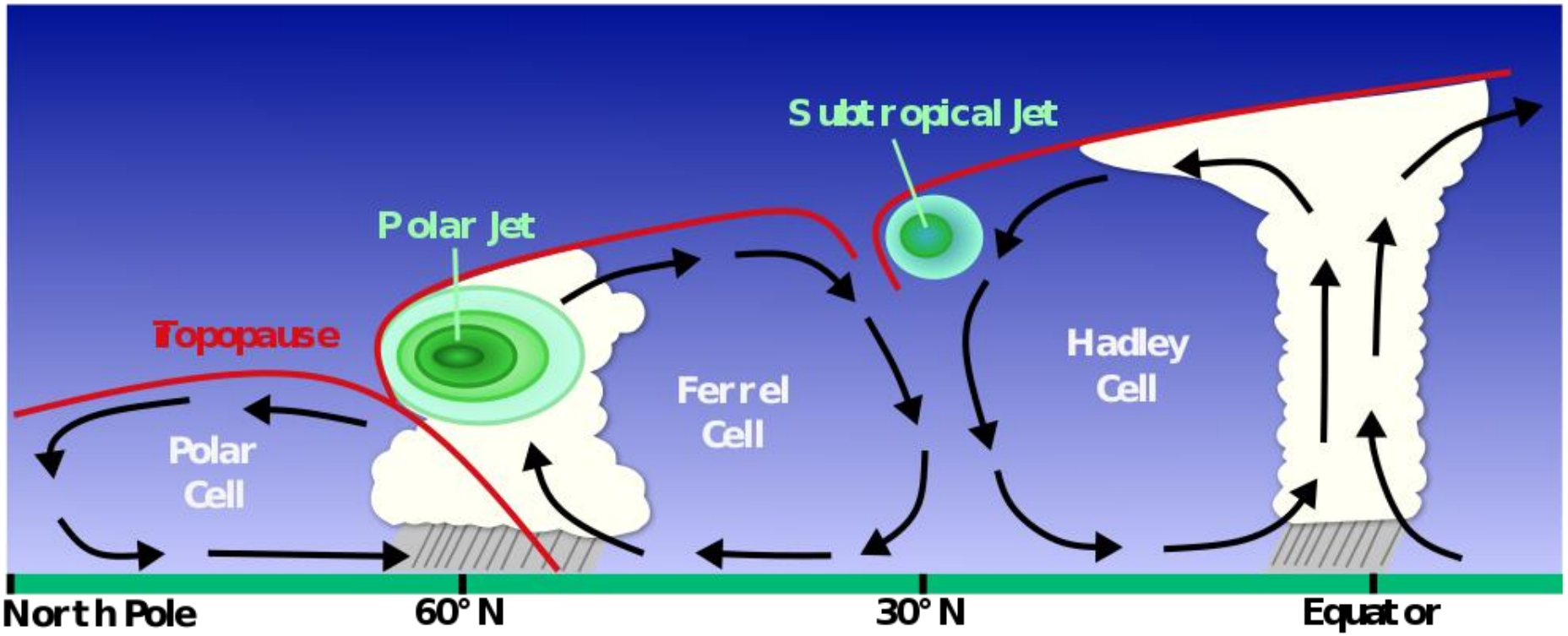
Ghiacciaio occidentale del Carro (Gran Paradiso)

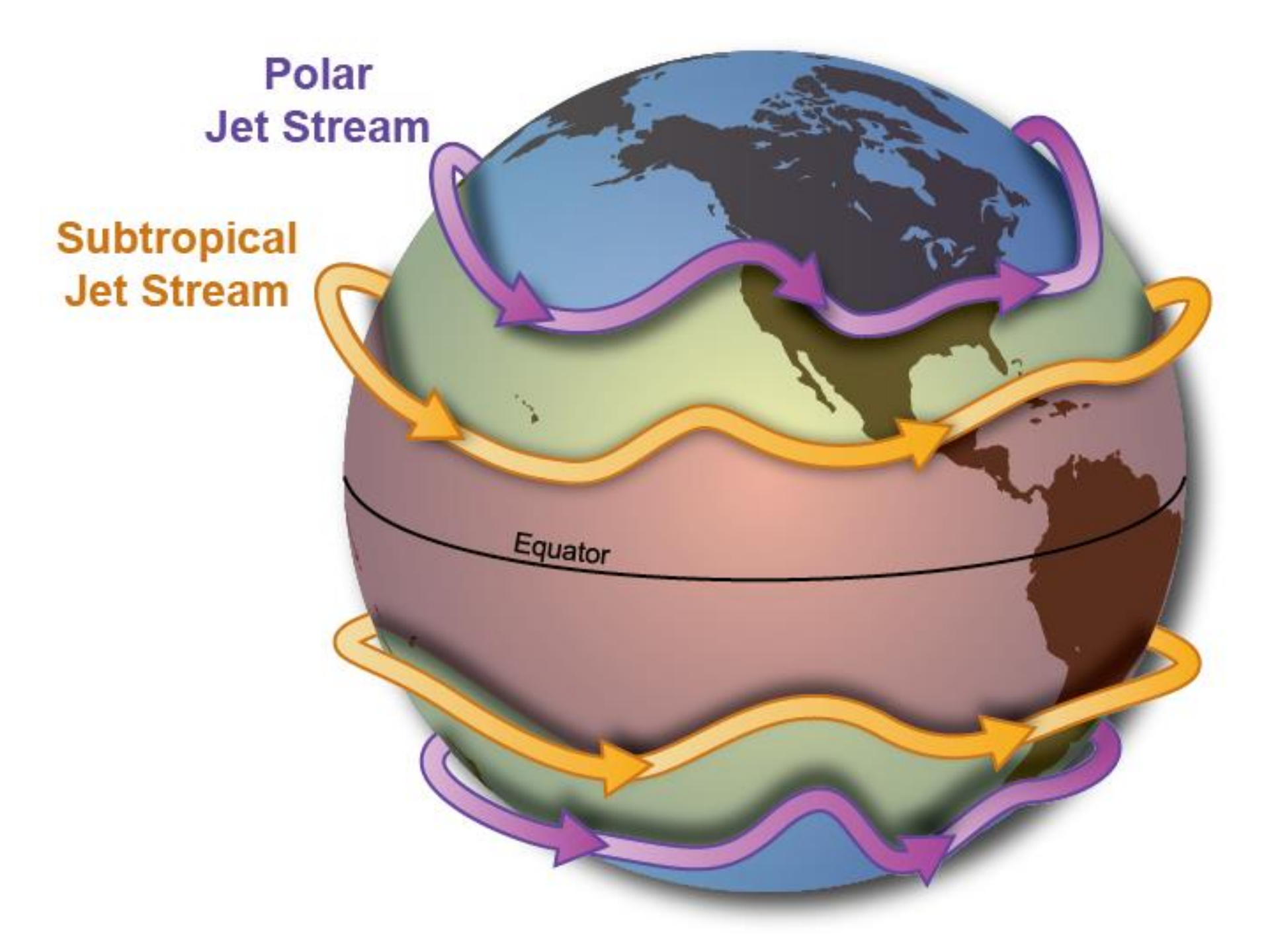

Ruitor 1909

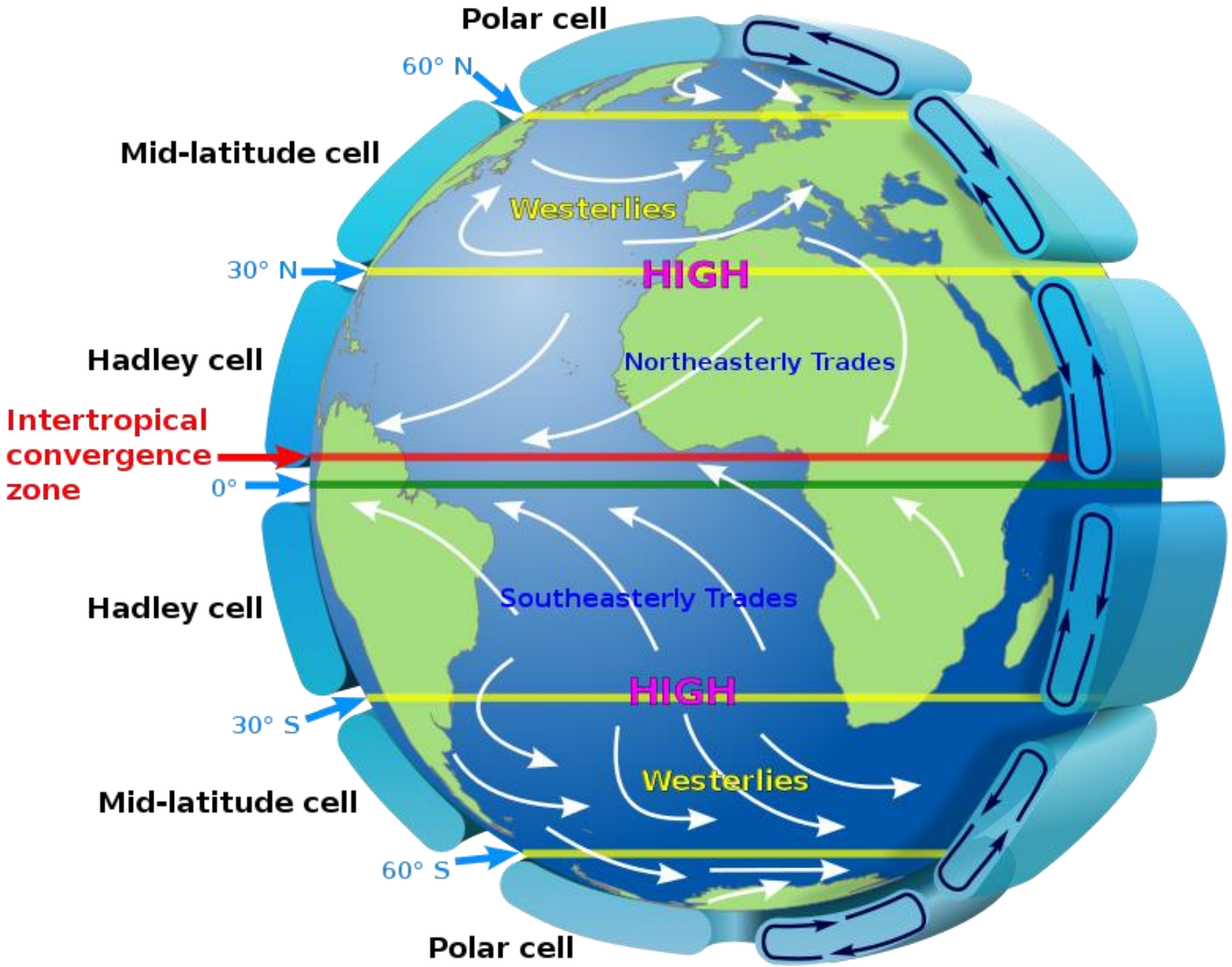

2012

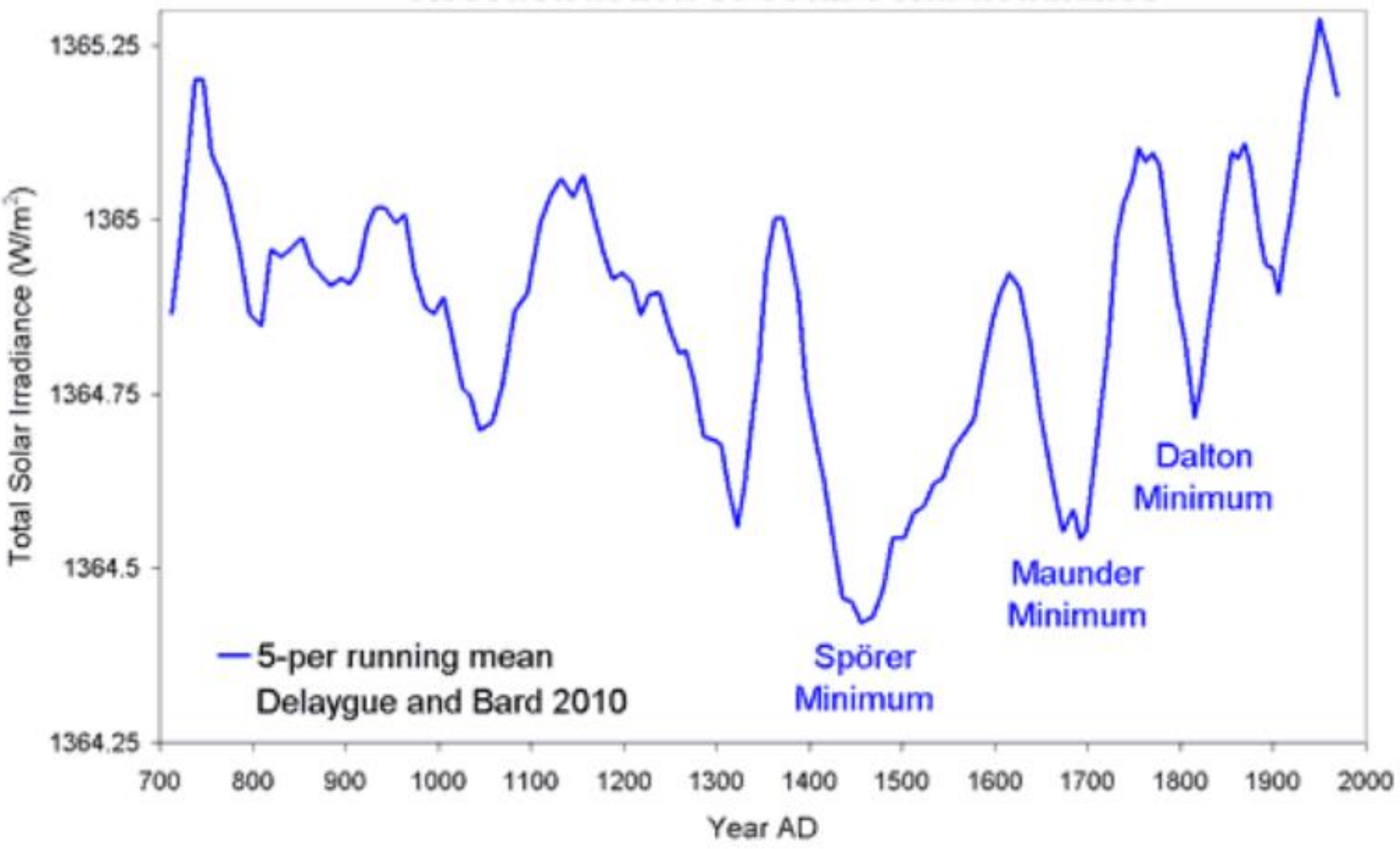

Radiazione ad onda lunga in uscita 235 W m-2
235
Radiazione solare in ingresso 342 W m-2
342
Radiazione solare riflessa: 107 W m-2
107
77
Riflessa dalle nuvole, aerosol ed atmosfera
77
40
Finestra radiativa atmosferica
30
165
Emessa dall'atmosfera
Gas ad effetto serra
Assorbita dall'amosfera
67
Calore di evaporazione
78
24
324
Radiazione di ritorno dell'atmosfera e dell'effetto serra naturale (155)
40
350
Radiazione dalla superficie
Riflessa dalla superficie
30
168
78
Evapo-traspirazione
24
Termiche
390
Assorbita dalla superficie
324
Assorbita dalla superficie

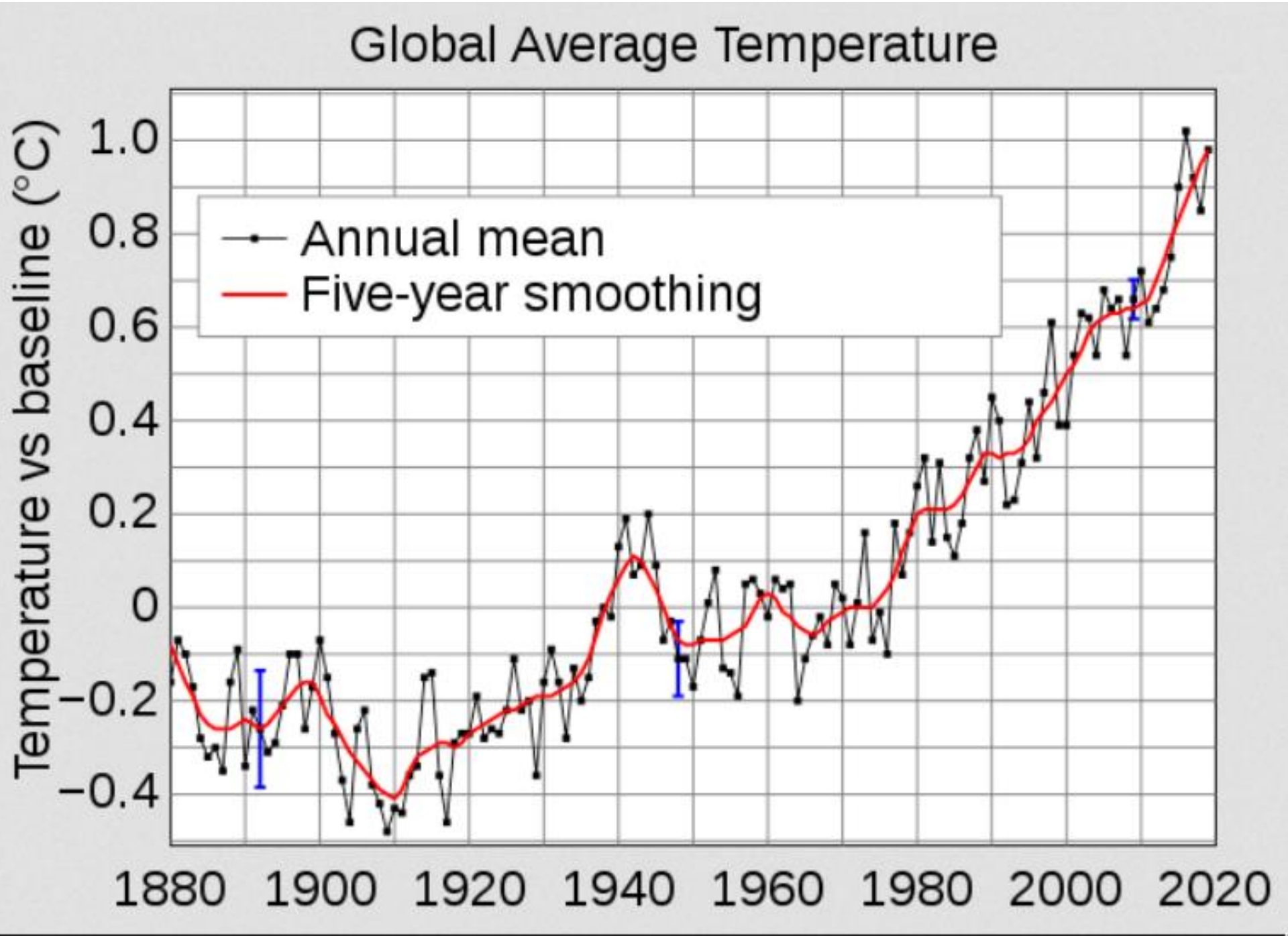

90°N
60
30
0
30
60
90°S
Net Radiation
Heat Transport
Night
Day
Solar
Radiation
Outgoing Longwave Radiation

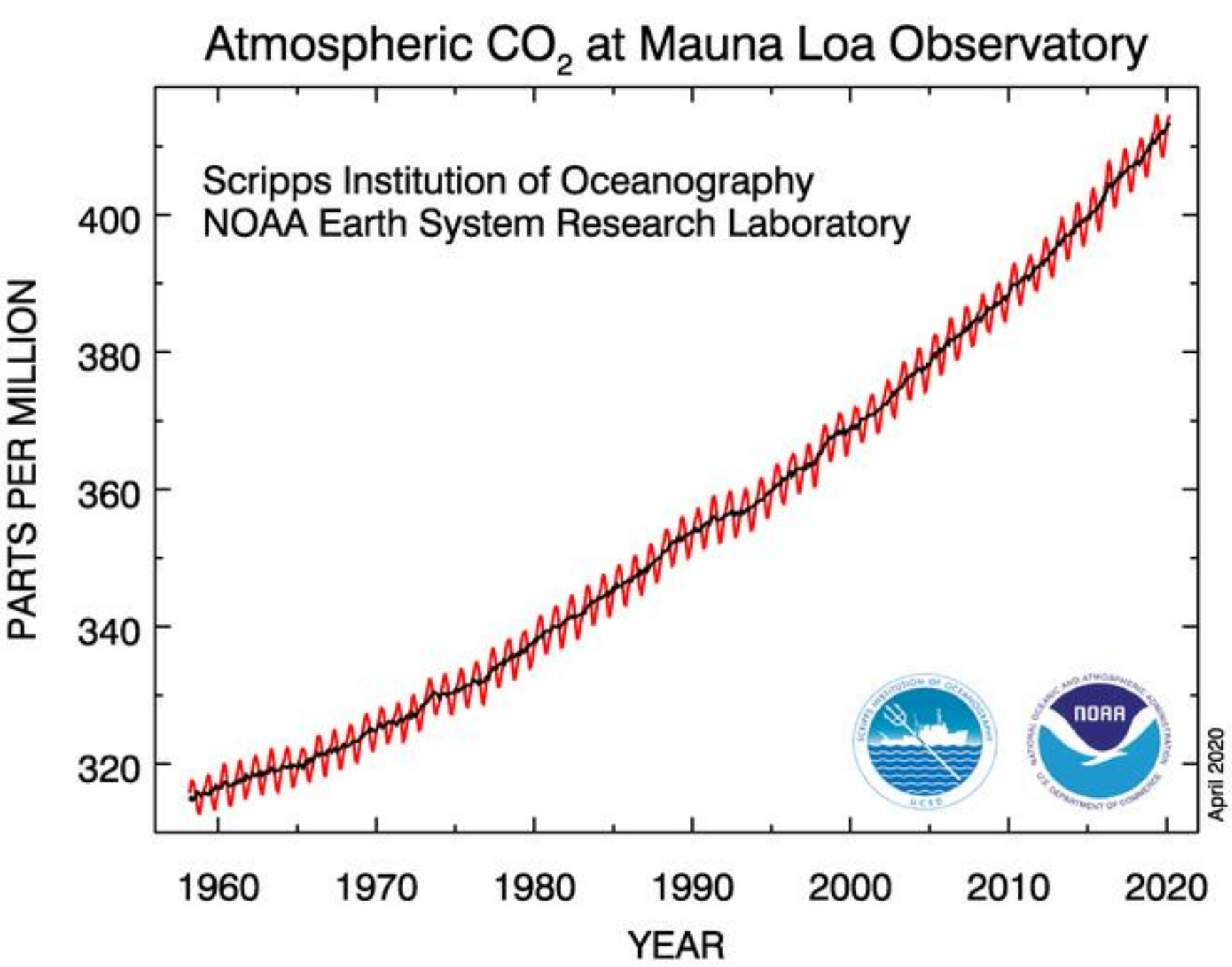

Subtropical Jet
Polar Jet
Topopause
Polar
Cell
Ferrel
Cell
Hadley
Cell
North Pole
60° N
30° N
Equator

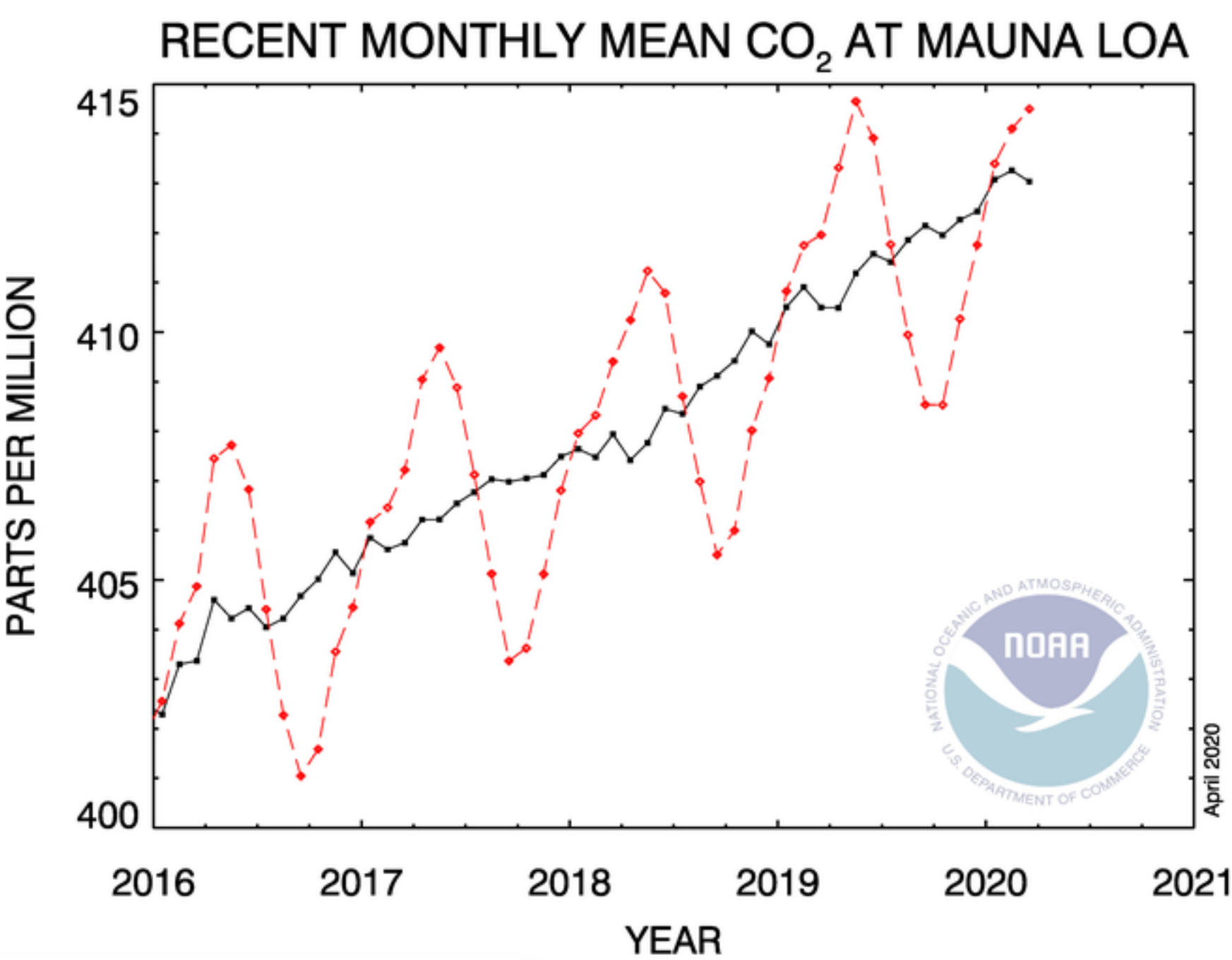

Polar
Jet Stream
Subtropical
Jet Stream
Equator

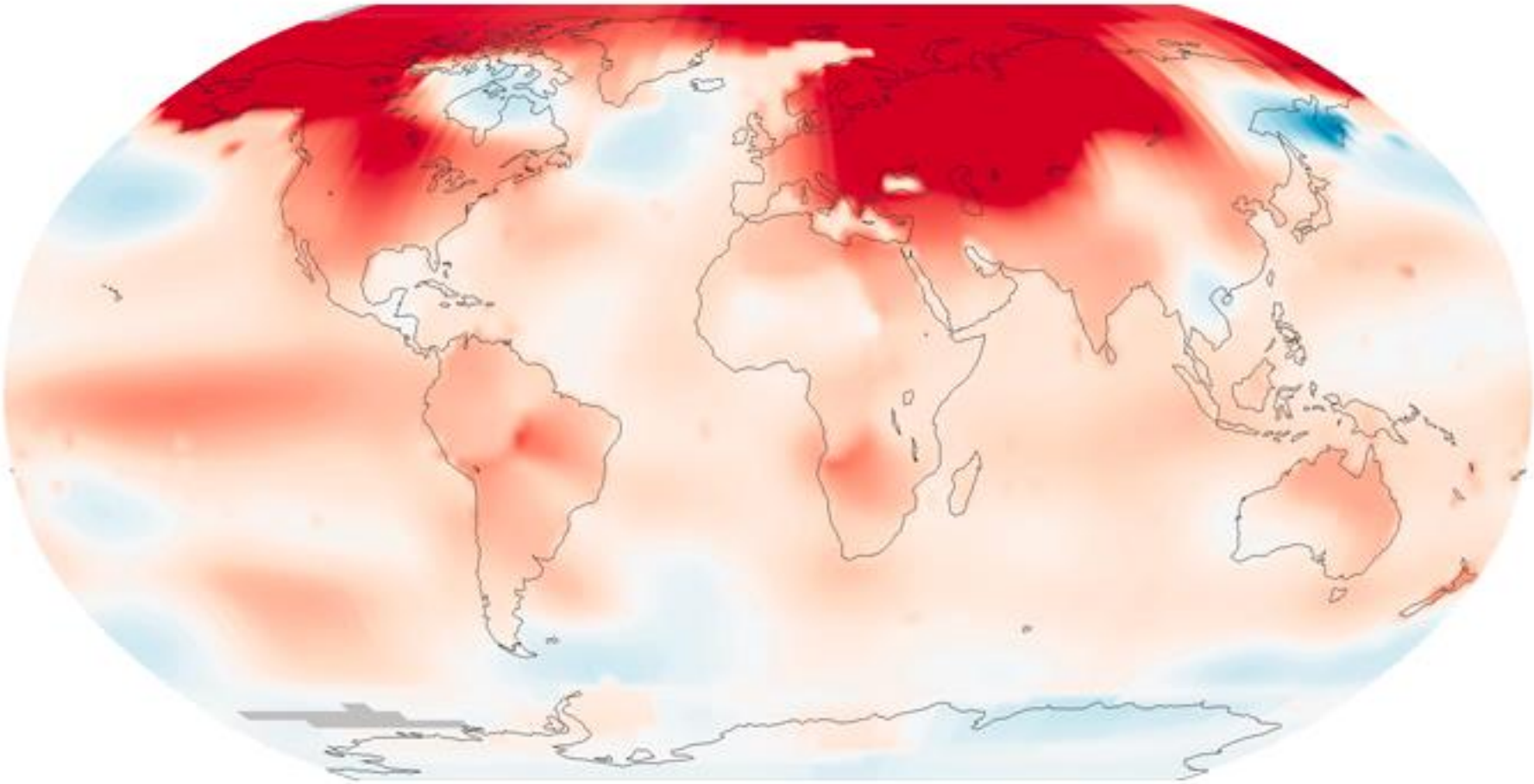

Polar cell
60° N
Mid-latitude cell
Westerlies
30° N
HIGH
Hadley cell
Northeasterly Trades
Intertropical convergence zone
0°
Hadley cell
Southeasterly Trades
HIGH
30° S
Mid-latitude cell
Westerlies
60° S
Polar cell


1365.25
1365
1364.75
1364.5
1364.25
Total Solar Irradiance (W/m²)
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Year AD
5-per running mean
Delaygue and Bard 2010
Spörer Minimum
Maunder Minimum
Dalton Minimum


Global Average Temperature
Temperature vs baseline (°C)
1.0
0.8
0.6
0.4
0.2
0
−0.2
−0.4
Annual mean
Five-year smoothing
1880
1900
1920
1940
1960
1980
2000
2020

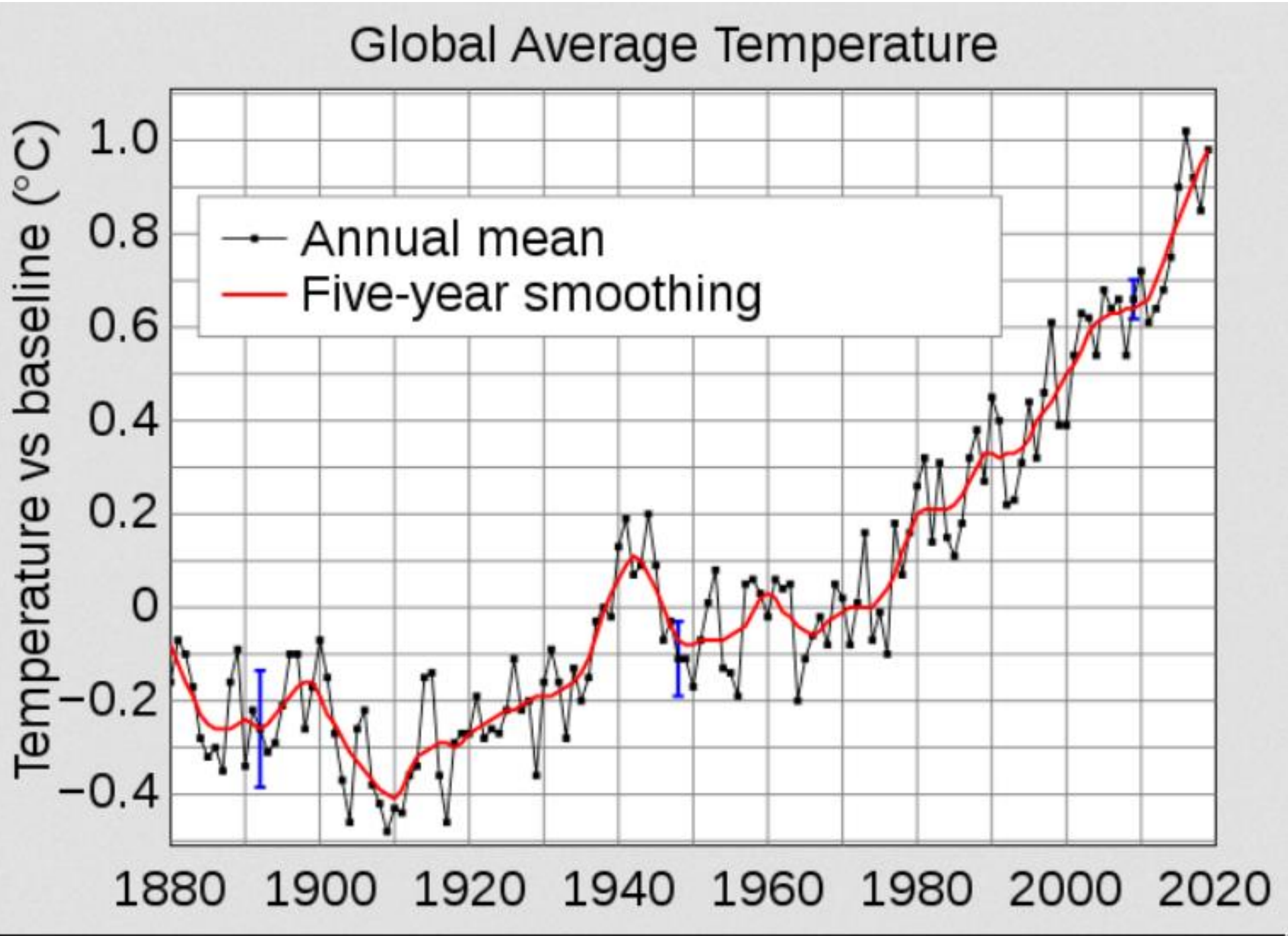

Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
2020
YEAR
April 2020


RECENT MONTHLY MEAN CO2 AT MAUNA LOA
PARTS PER MILLION
415
410
405
400
2016
2017
2018
2019
2020
2021
YEAR
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
April 2020



February 2016 Mean Surface Temperature Anomaly (°C)

-5≤ 0 ≥5


Global Average Temperature
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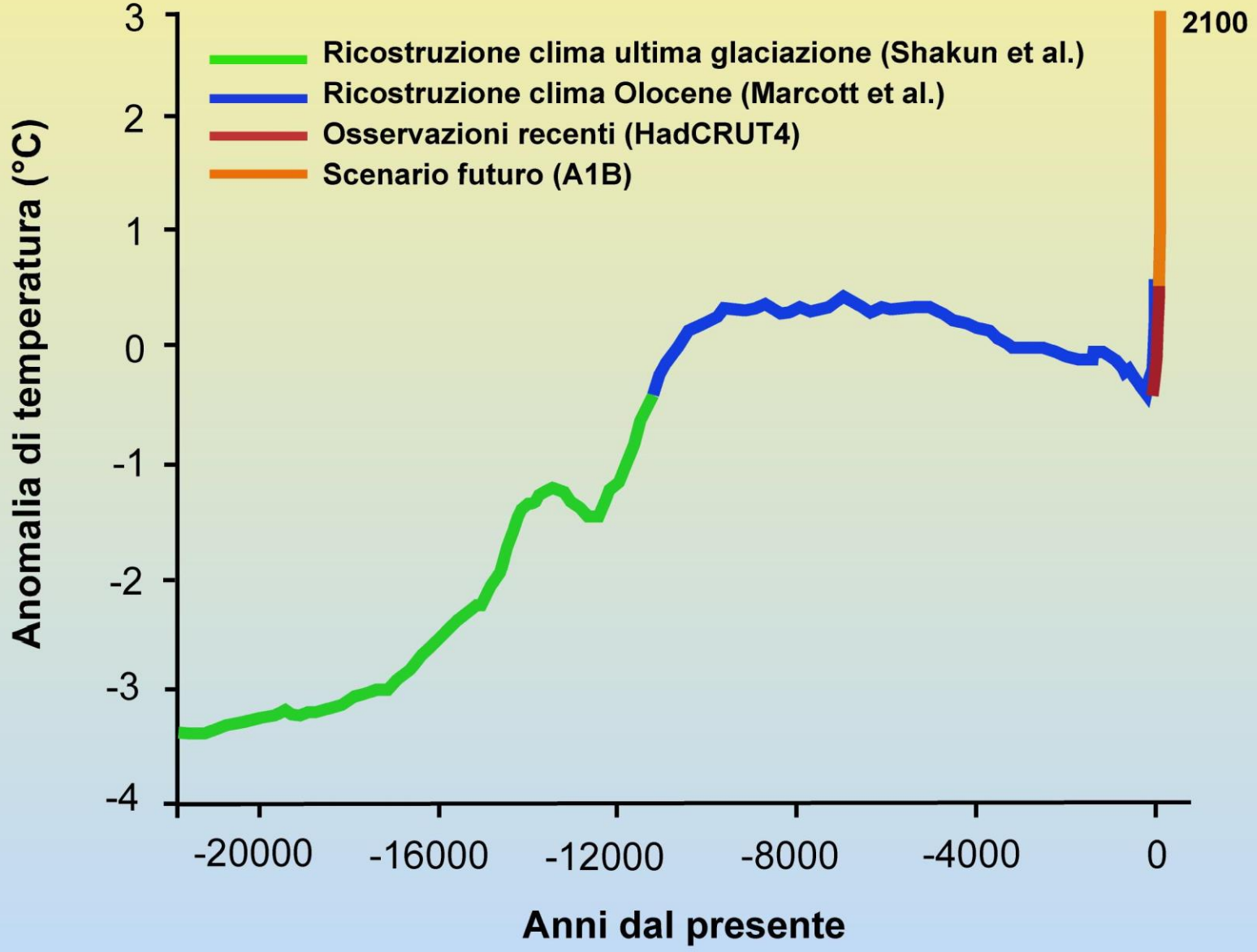
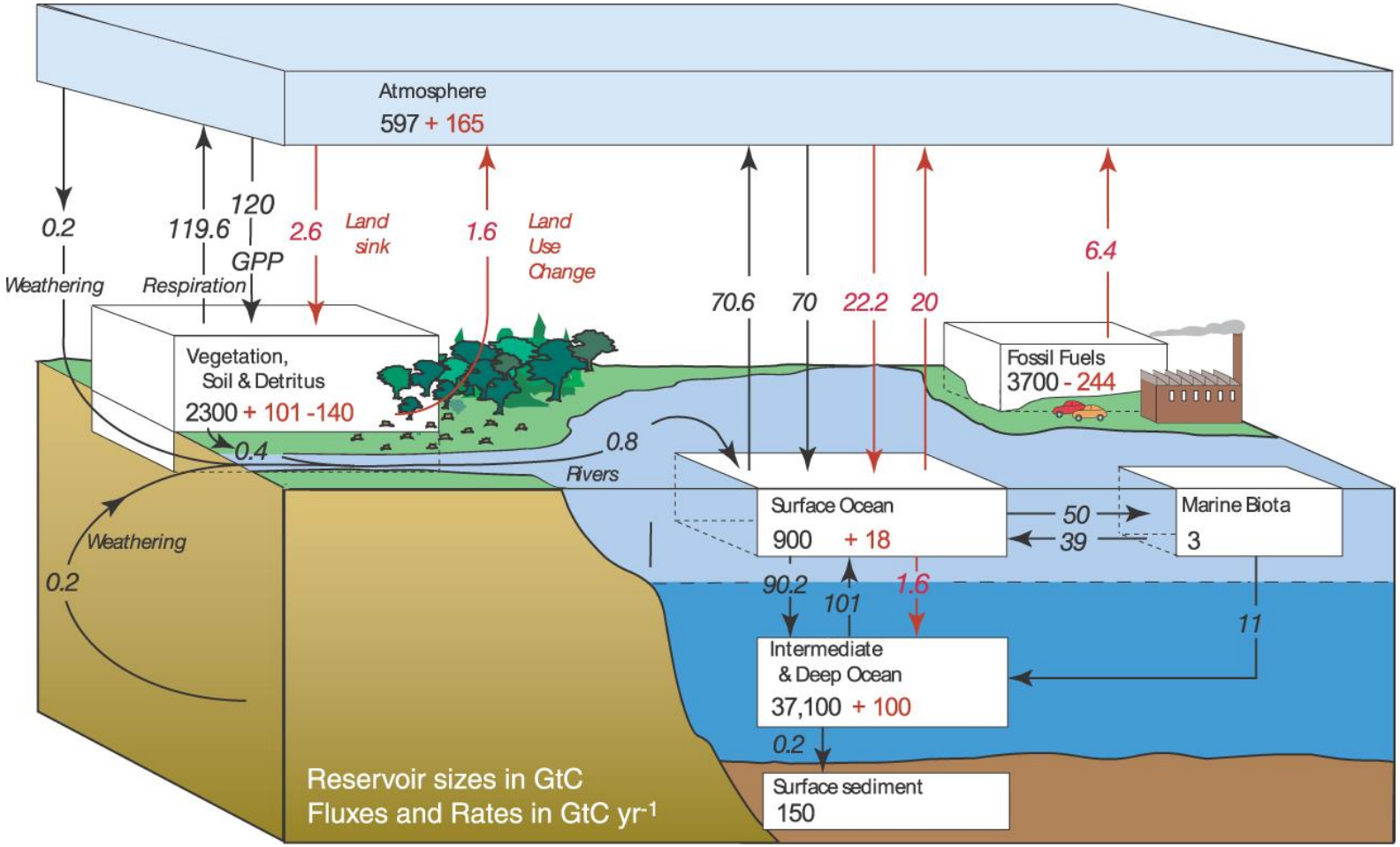
0.4
0.2
0
−0.2
−0.4
Annual mean
Five-year smoothing
1880
1900
1920
1940
1960
1980
2000
2020

Variazioni termiche globali dall'ultima glaciazione e scenario al 2100

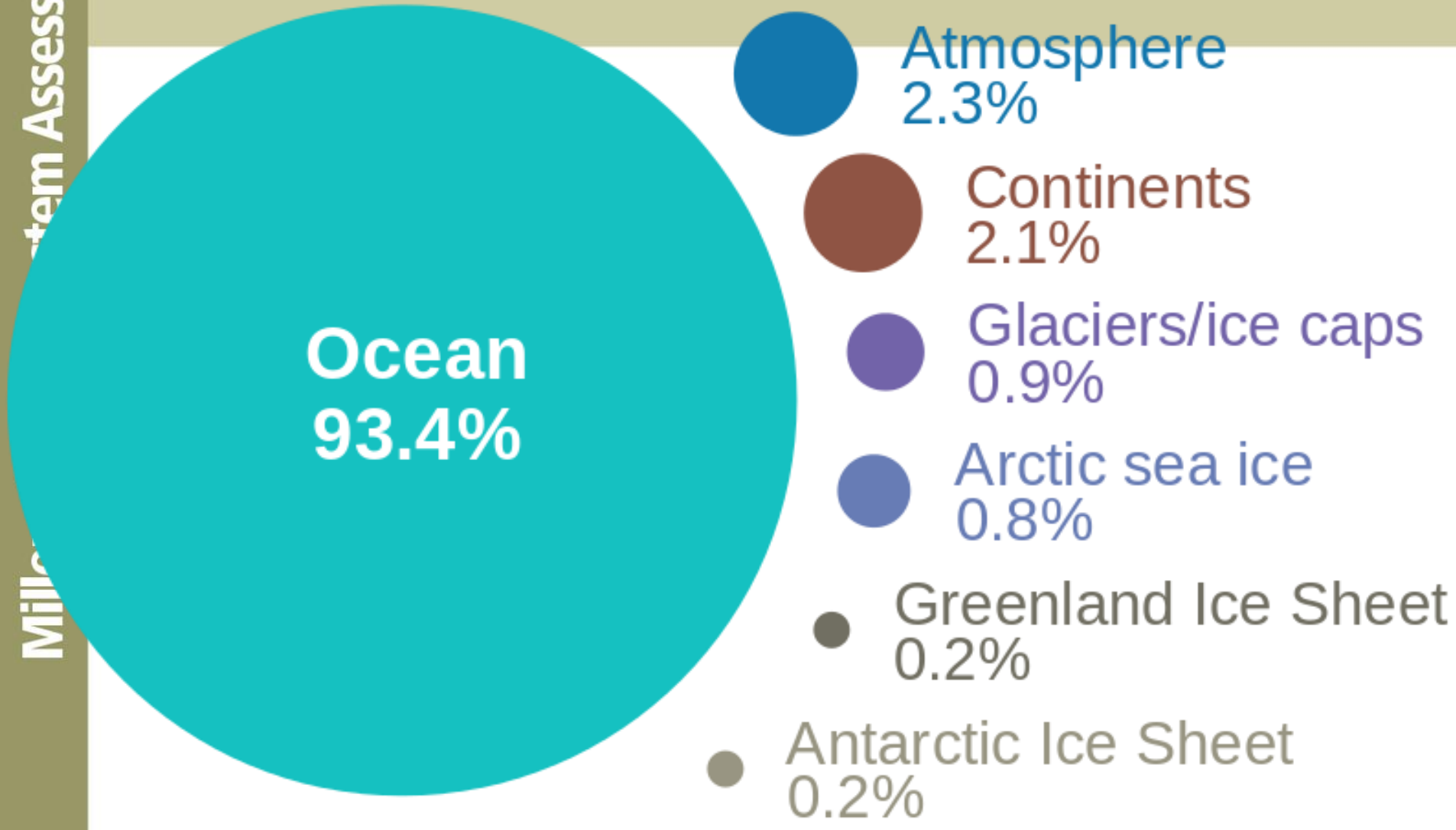


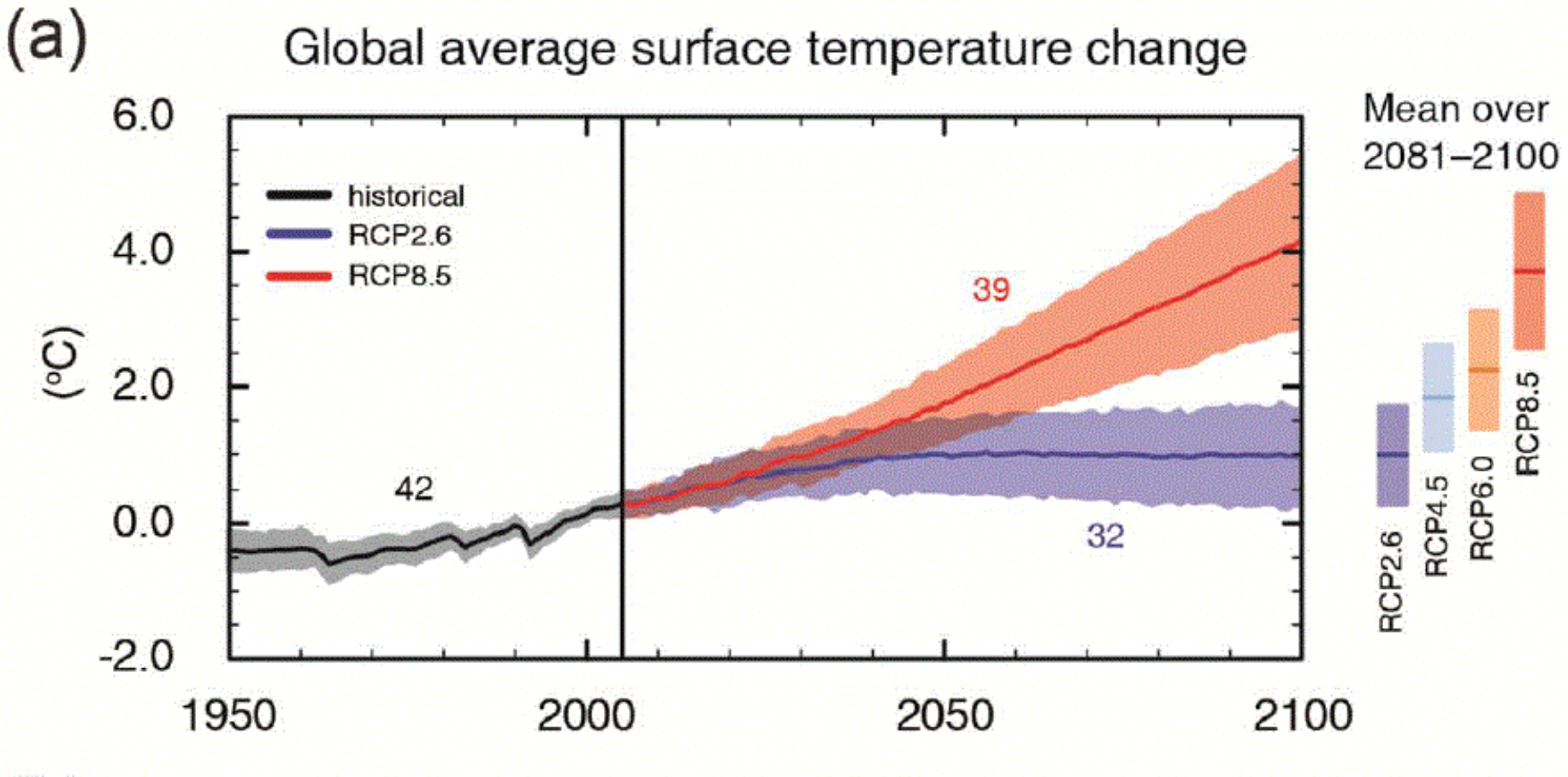
1 petaflop = 10^{15} =

un milione di miliardi di istruzioni/operazioni al secondo


Atmosphere
597 + 165
0.2
Weathering
119.6
Respiration
120
GPP
2.6
Land sink
1.6
Land Use Change
70.6
70
22.2
20
6.4
Vegetation, Soil & Detritus
2300 + 101 -140
Fossil Fuels
3700 - 244
0.4
0.8
Rivers
Surface Ocean
900 + 18
50
39
Marine Biota
3
Weathering
0.2
90.2
101
1.6
11
Intermediate & Deep Ocean
37,100 + 100
0.2
Surface sediment
150
Reservoir sizes in GtC
Fluxes and Rates in GtC yr-1

Where is global warming going?





RCP = Representative Concentrations Pathways, W/m^2

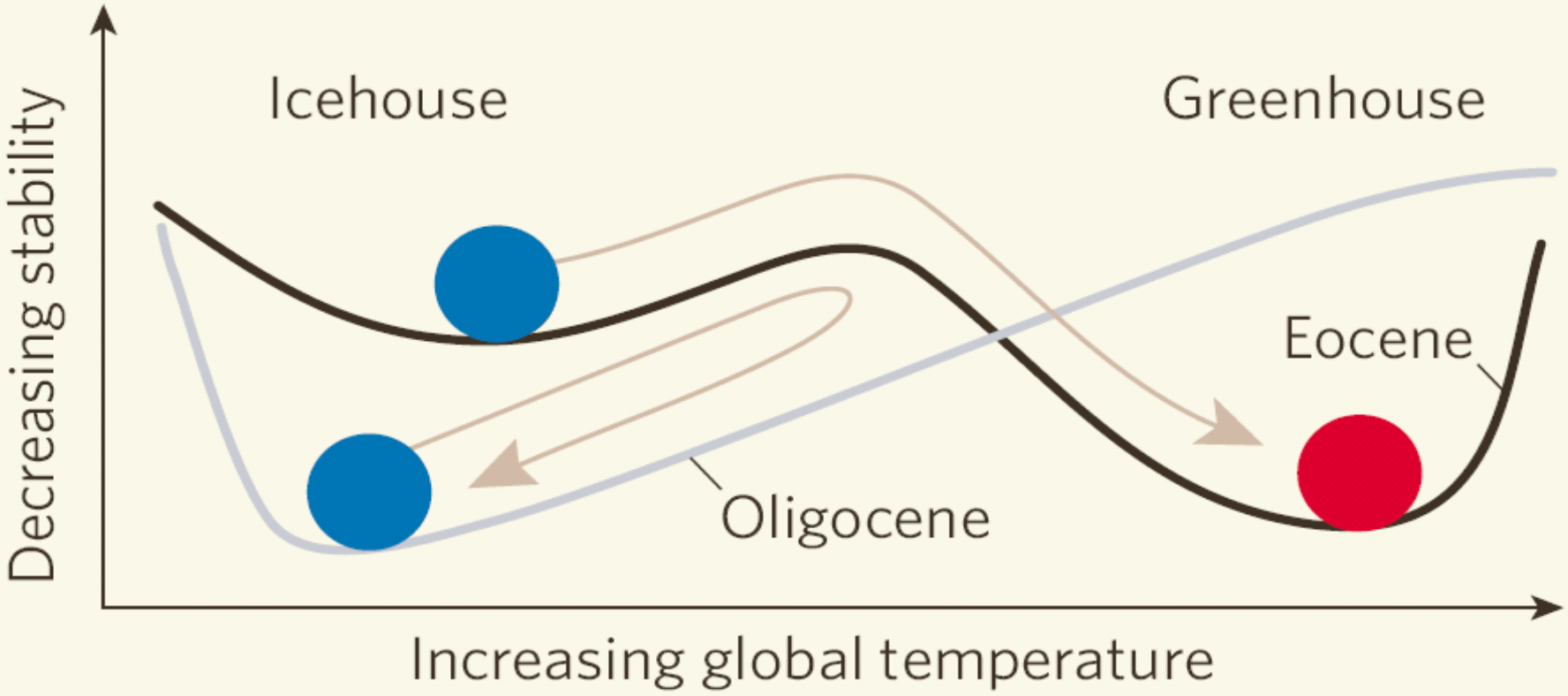
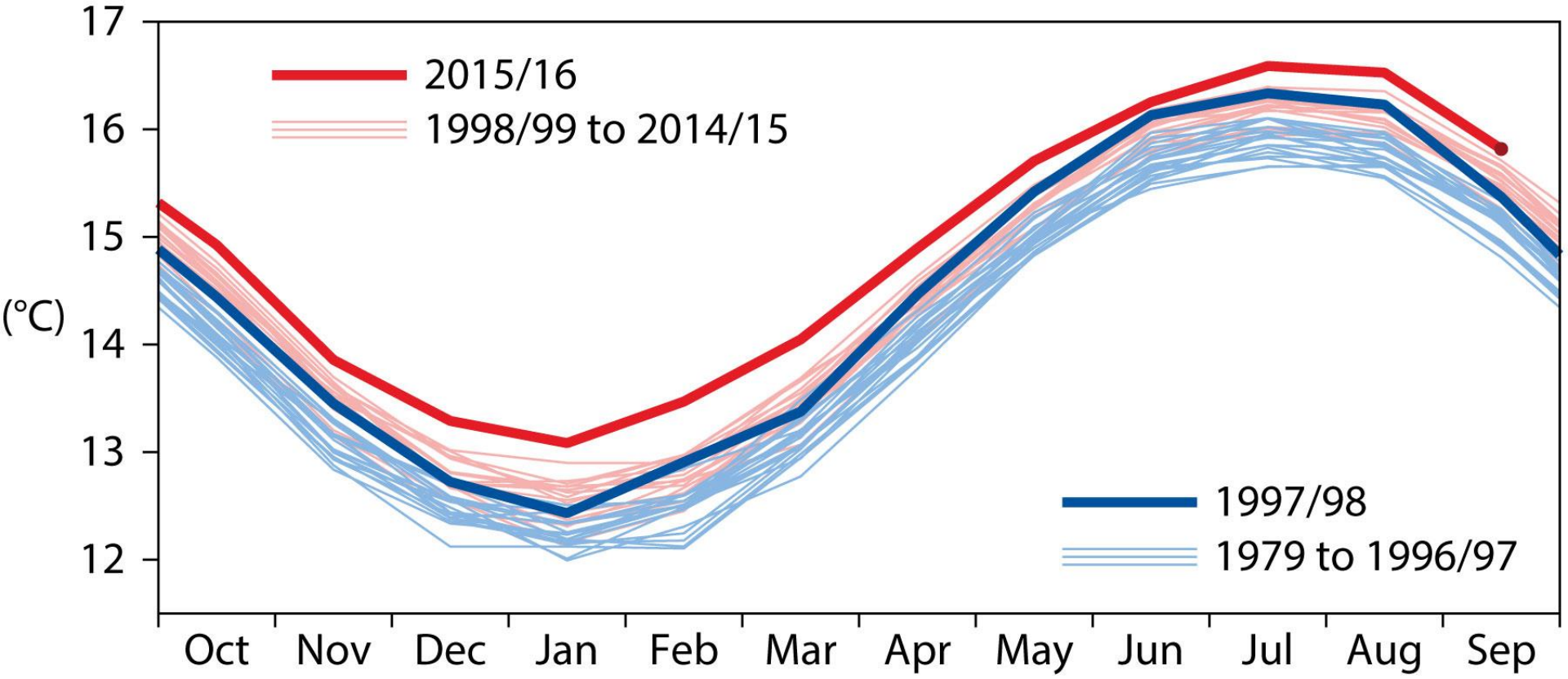
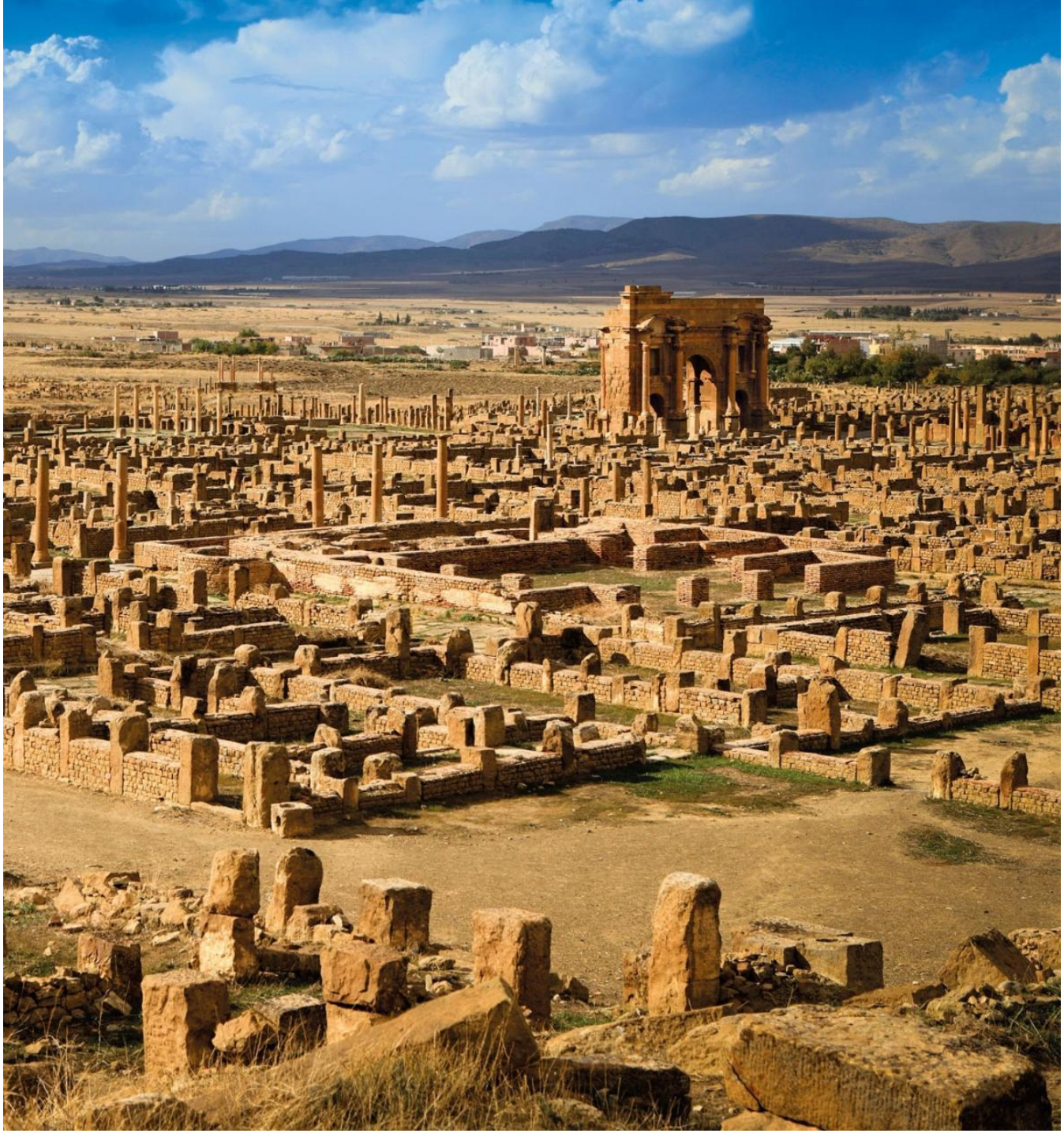
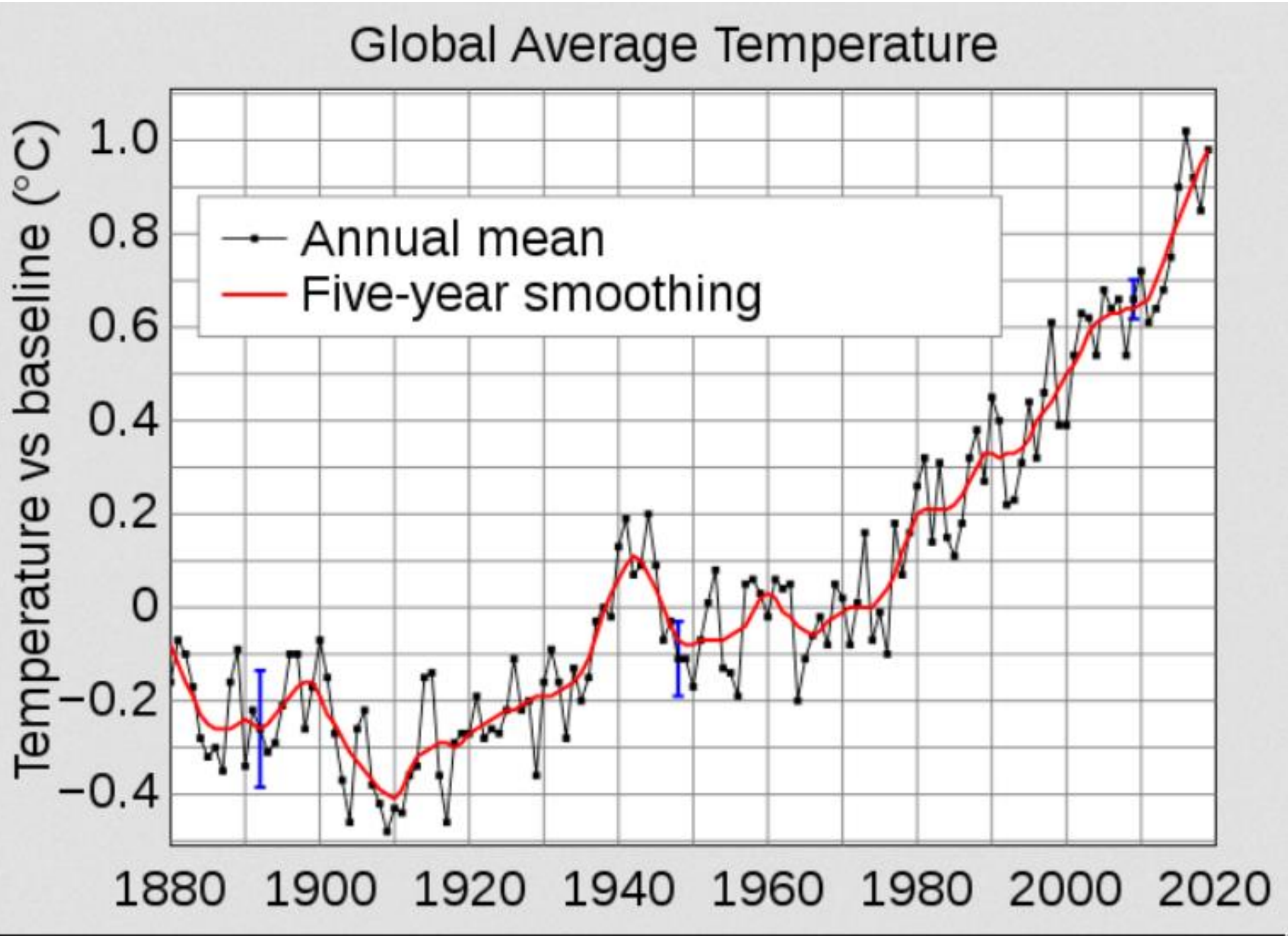


Figure 1 | Glacial stability and instability. Global temperature is indicated by the balls. The findings of


17
16
15
14
13
12
(°C)
2015/16
1998/99 to 2014/15
1997/98
1979 to 1996/97
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep




Global Average Temperature
Temperature vs baseline (°C)
1.0
0.8
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0.4
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0
−0.2
−0.4
Annual mean
Five-year smoothing
1880
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1960
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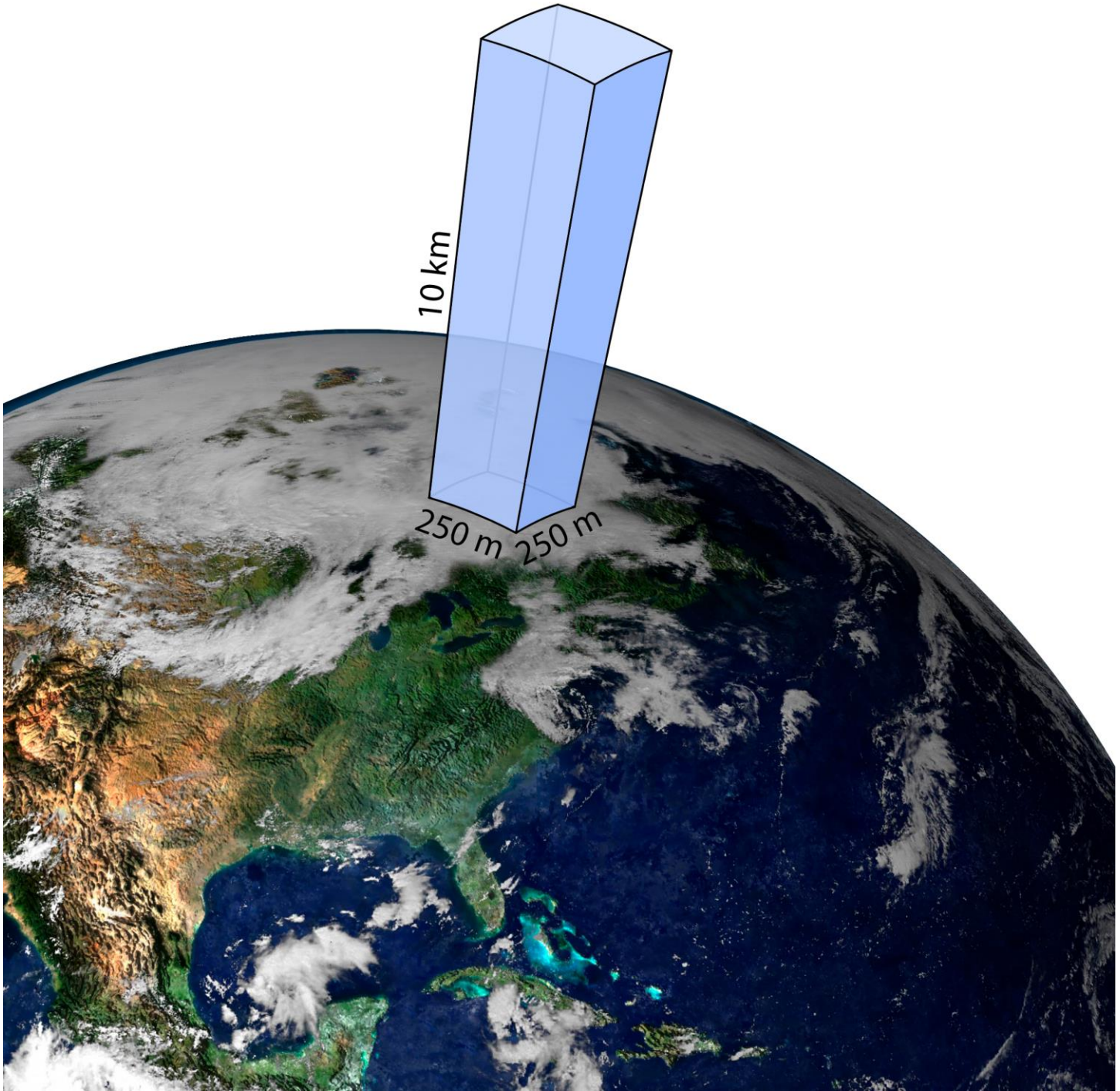
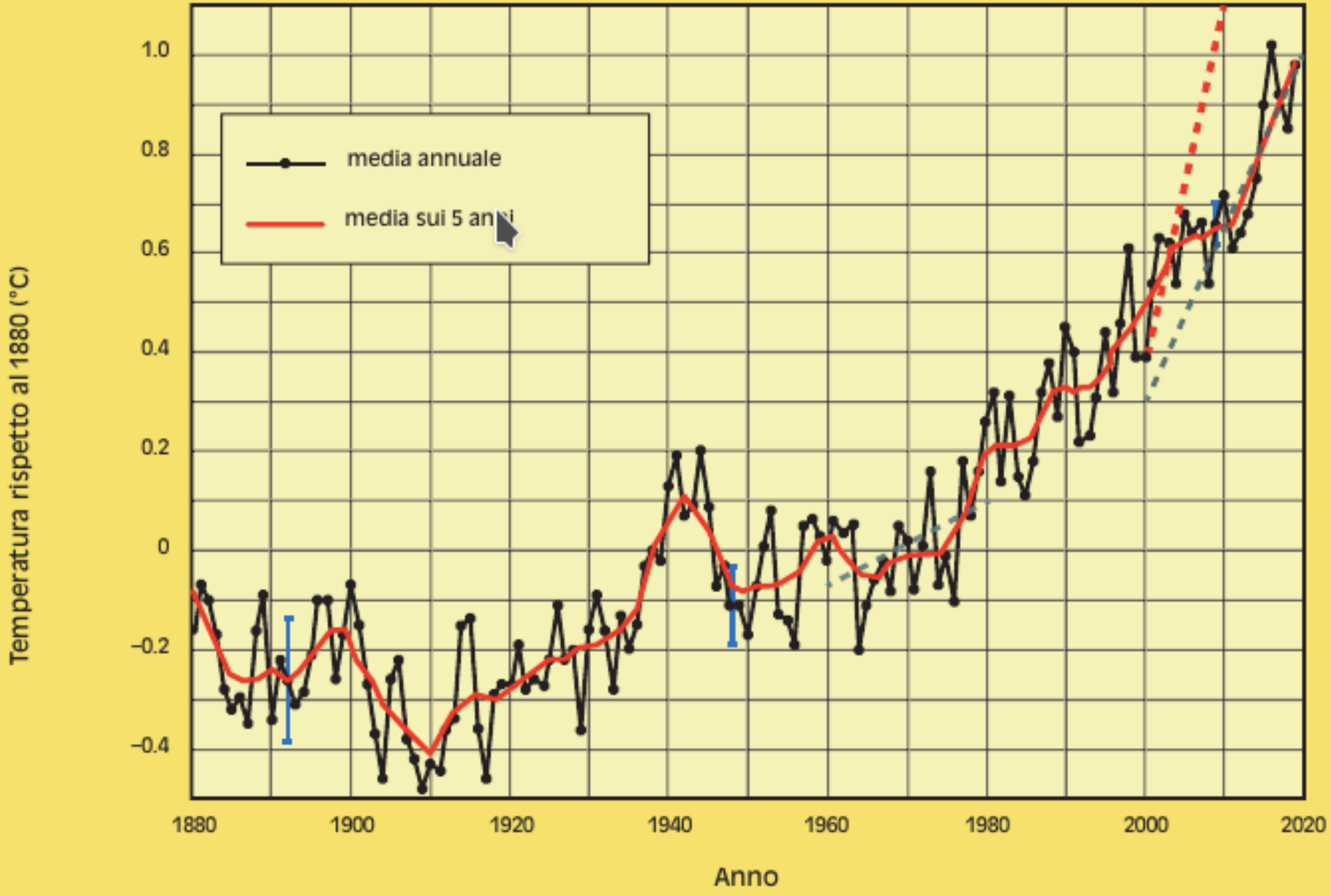
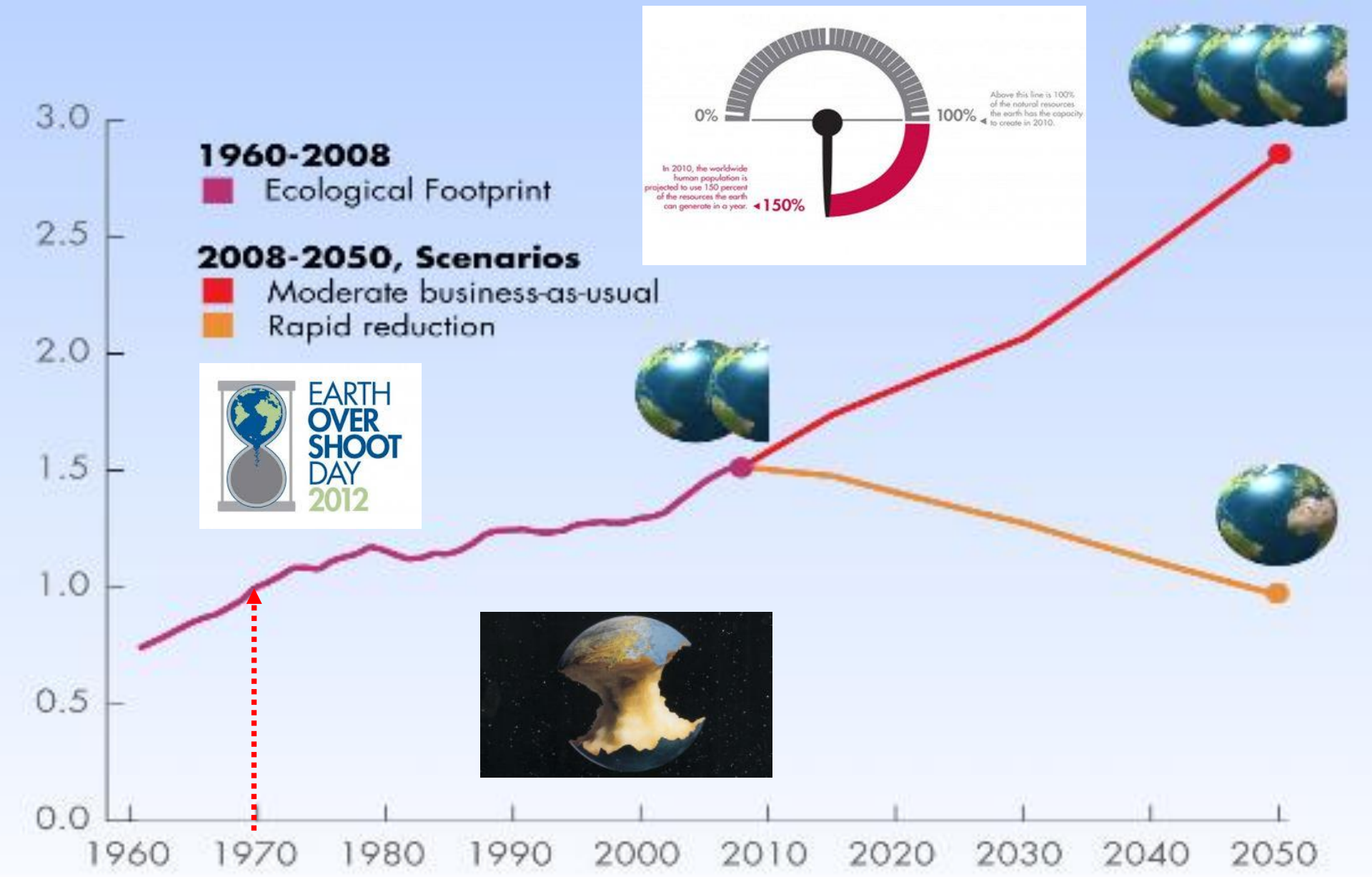
2020


10 km
250 m
250 m

Temperatura media globale




3.0
2.5
2.0
1.5
1.0
0.5
0.0
1960-2008
Ecological Footprint
2008-2050, Scenarios
Moderate business-as-usual
Rapid reduction
EARTH OVER SHOOT DAY 2012
0%
100%
Above this line is 100% of the natural resources the earth has the capacity to create in 2010.
In 2010, the worldwide human population is projected to use 150 percent of the resources the earth can generate in a year.
150%
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
y-axis: number of planet earths, x-axis: years

Luigi Cavaleri

Istituto di Scienze Marine – Consiglio Nazionale delle Ricerche, Venezia

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