

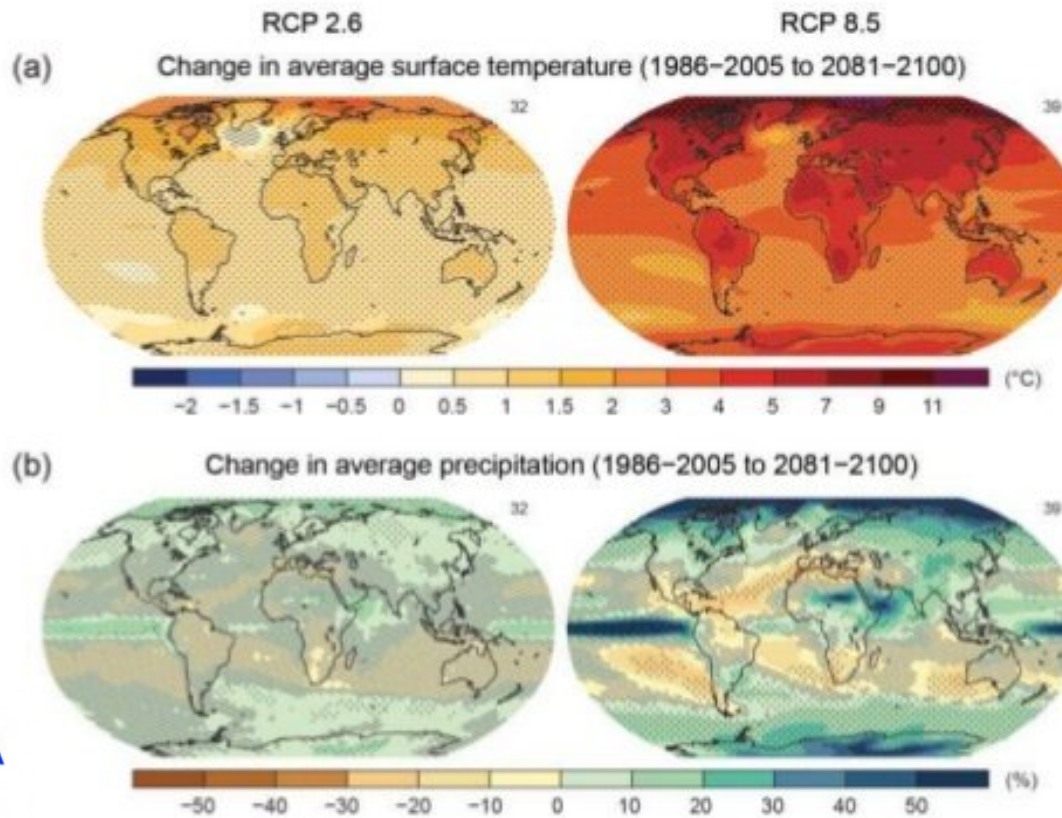
Gli scenari climatici del futuro

Luca Mercalli – Società Meteorologica Italiana
www.nimbus.it

Figure SPM.8a,b

Maps of CMIP5 multi-model mean results

All Figures © IPCC 2013



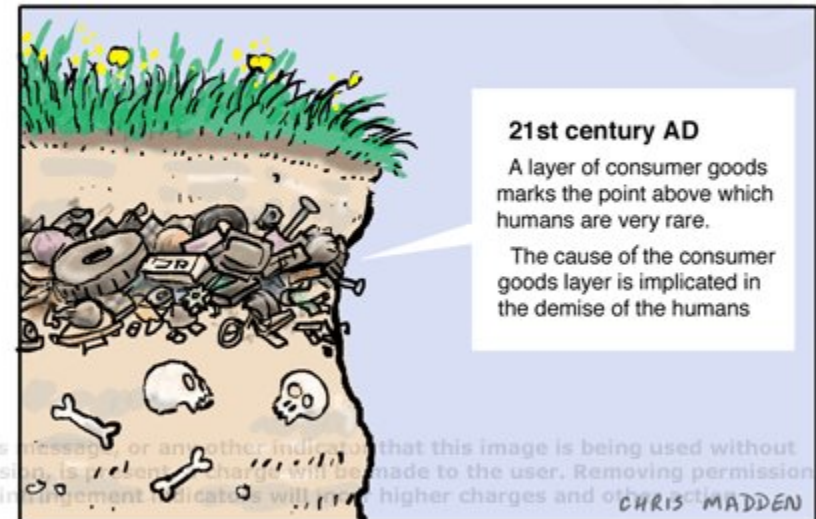
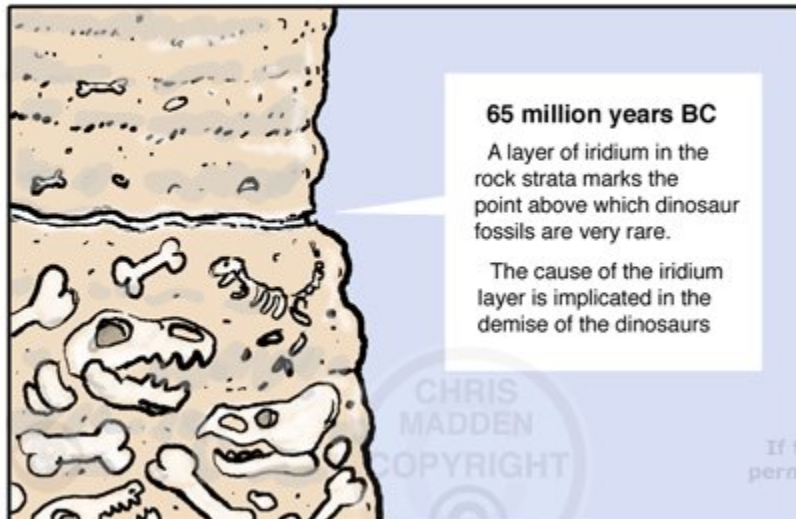
ANTHROPOCENE

approx. 1945 A.D. - present



A new geologic era with no precise start date. Marked by significant human impact on climate and ecosystems. Coined by Paul Crutzen. Rise of agriculture. Deforestation. Cement. Combustion of fossil fuels. Coal, oil and gas roused from the earth. Extraction and emission. Operation Crossroads vaporizes 70 acres of Bikini Atoll. Deep geologic repositories. Pacific Trash Vortex, a swirling gyre of marine litter and plastic. 6.7 billion humans + growing. Palo Verde Nuclear Power Plant. Hull-Rust-Mahoning open pit mine. Three Gorges Dam. Fresh Kills Landfill. Las Vegas. Dubai.

LESSONS FROM THE FOSSIL RECORD

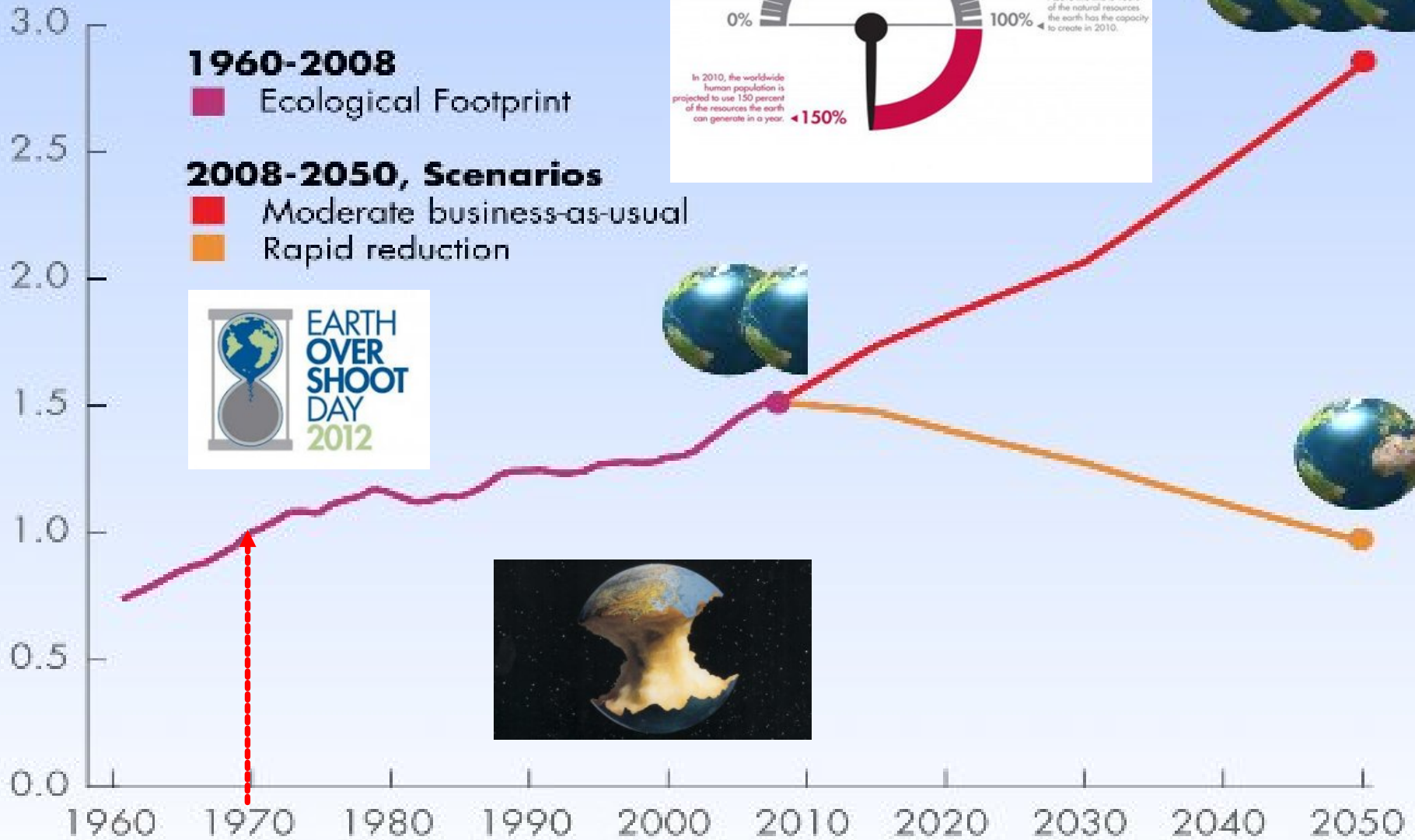
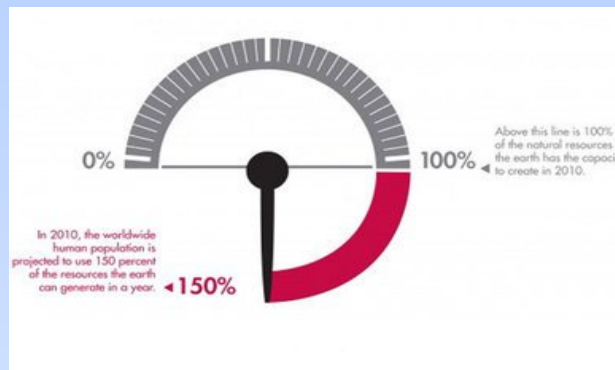


1960-2008

■ Ecological Footprint

2008-2050, Scenarios

■ Moderate business-as-usual
■ Rapid reduction



y-axis: number of planet earths, x-axis: years

FEATURE

A safe operating space for humanity

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.

Rockstrom et al., 2009

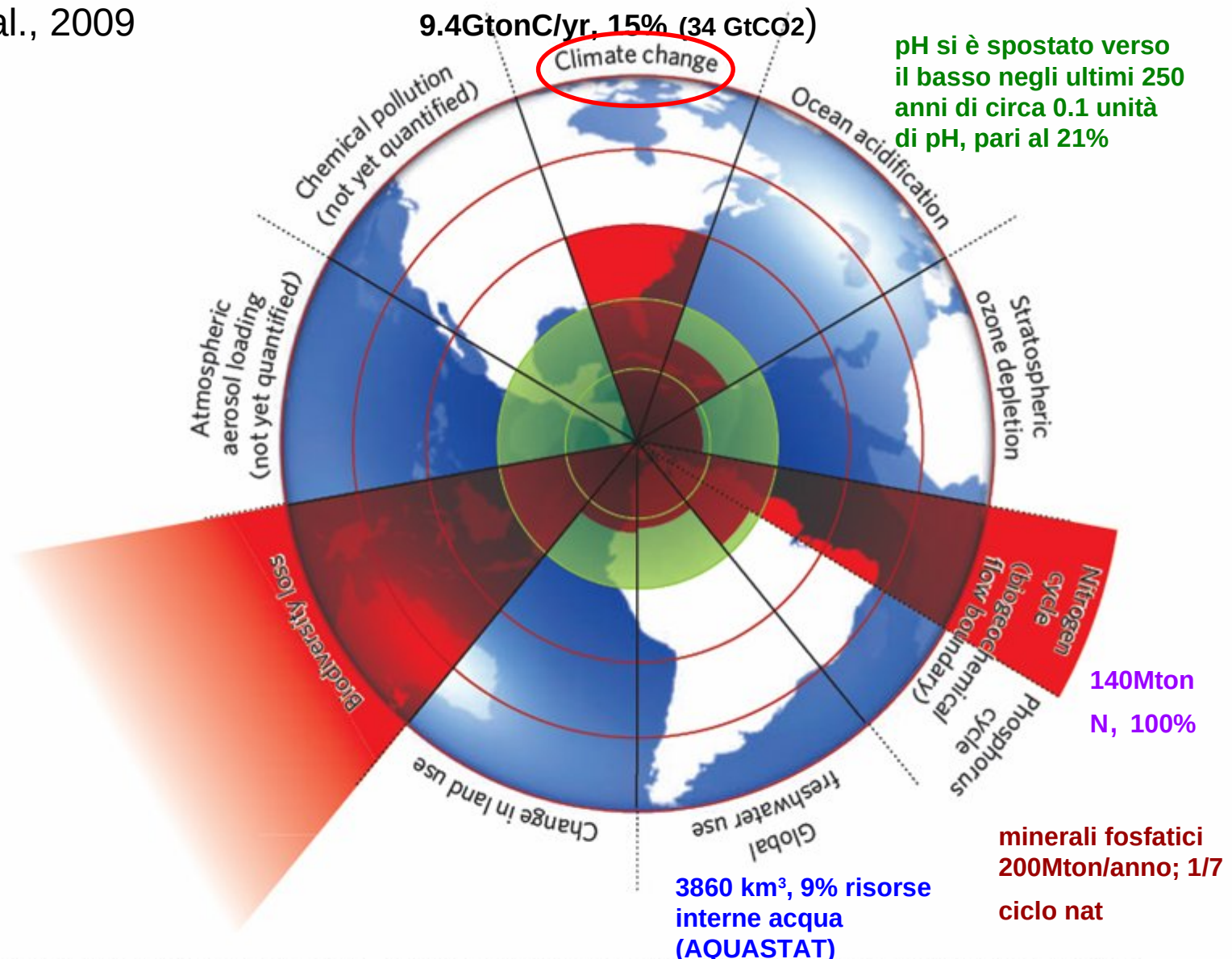
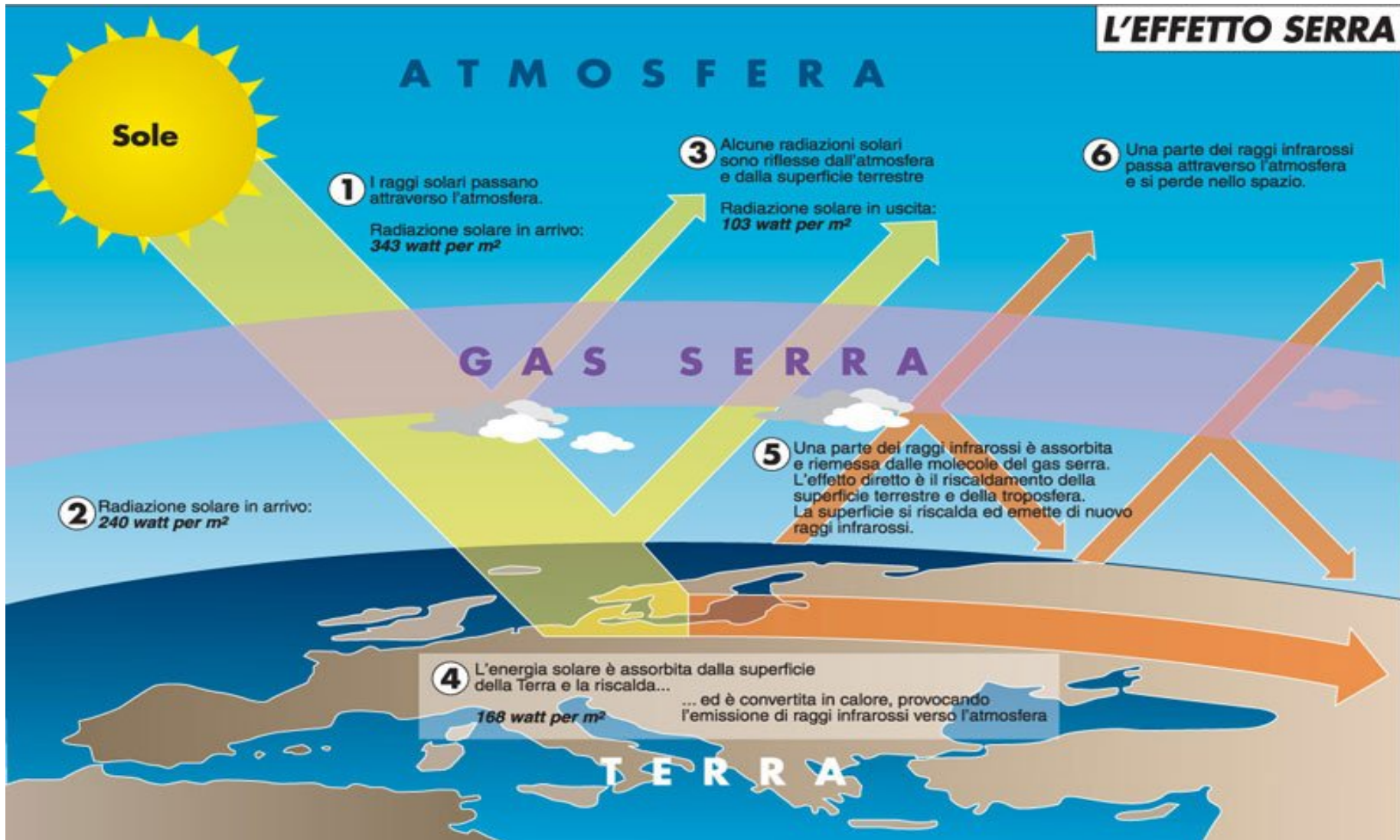


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

Terra senza effetto serra $-18\text{ }^{\circ}\text{C}$ Con effetto serra naturale $+15\text{ }^{\circ}\text{C}$





Tyndall † in particular has pointed out the importance of this circumstance. Another side of this circumstance has attracted the attention of physicists, is this: Is the temperature of the ground in any way influenced by presence of heat-absorbing gases in the atmosphere? Fouri maintained that the atmosphere acts like the glass of a h house, because it lets through the light rays of the sun retains the dark rays from the ground. This idea was elaborated by Pouillet; and Landolt's researches led to the discovery of Carbonic Acid in the Air upon the Temperature of the Ground. By Prof. SVANTE ARRHENIUS.

[FIFTH SERIES.]

APRIL 1896.

XXXI. On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground. By Prof. SVANTE ARRHENIUS.



Svante August Arrhenius
(Nobel prize, Chemistry, 1903)

Developed the hothouse theory for CO₂ in 1896, and in 1905 predicted that raising CO₂ content of the atmosphere would cause an increase in mean global temperature similar in magnitude to modern predictions



CO₂, the greenhouse effect and global warming: from the pioneering work of Arrhenius and Callendar to today's Earth System Models

Thomas R. Anderson^{a,*}, Ed Hawkins^b and Philip D. Jones^{c,d}

^a National Oceanography Centre, European Way, Southampton SO14 3ZH, UK

^b NCAS-Climate, Department of Meteorology, University of Reading, Reading RG6 6BB, UK

^c Climatic Research Unit, University of East Anglia, School of Environmental Sciences, Norwich NR4 7TJ, UK

^d Center of Excellence for Climate Change Research/Dept of Meteorology, King Abdulaziz University, Jeddah, Saudi Arabia

Climate warming during the course of the twenty-first century is projected to be between 1.0 and 3.7 °C depending on future greenhouse gas emissions, based on the ensemble-mean results of state-of-the-art Earth System Models (ESMs). Just how reliable are these projections, given the complexity of the climate system? The early history of climate research provides insight into the understanding and science needed to answer this question. We examine the mathematical quantifications of planetary energy budget developed by Svante Arrhenius (1859–1927) and Guy Stewart Callendar (1898–1964) and construct an empirical approximation of the latter, which we show to be successful at retrospectively predicting global warming over the course of the twentieth century. This approximation is then used to calculate warming in response to increasing atmospheric greenhouse gases during the twenty-first century, projecting a temperature increase at the lower bound of results generated by an ensemble of ESMs (as presented in the latest assessment by the Intergovernmental Panel on Climate Change). This result can be interpreted as follows. The climate system is conceptually complex but has at its heart the physical laws of radiative transfer. This basic, or “core” physics is relatively straightforward to compute mathematically, as exemplified by Callendar’s calculations, leading to quantitatively robust projections of baseline warming. The ESMs include not only the physical core but also climate feedbacks that introduce uncertainty into the projections in terms of magnitude, but not sign: positive (amplification of warming). As such, the projections of end-of-century global warming by ESMs are fundamentally trustworthy: quantitatively robust baseline warming based on the well-understood physics of radiative transfer, with extra warming due to climate feedbacks. These

projections thus provide a compelling case that global climate will continue to undergo significant warming in response to ongoing emissions of CO₂ and other greenhouse gases to the atmosphere.

Introduction

Climate change is a major risk facing mankind. At the United Nations Climate Change Conference held in Paris at the end of last year, 195 countries agreed on a plan to reduce emissions of CO₂ and other greenhouse gases, aiming to limit global temperature increase to well below 2 °C (relative to pre-industrial climate, meaning a future warming of less than 1.4 °C because temperature had already increased by 0.6 °C by the end of the twentieth century). The link between CO₂ and climate warming has caught the attention of scientists and politicians, as well as the general public, via the well-known “greenhouse effect” (Figure 1). Solar radiation passes largely unhindered through the atmosphere, heating the Earth’s surface. In turn, energy is re-emitted as infrared, much of which is absorbed by CO₂ and water vapour in the atmosphere, which thus acts as a blanket surrounding the Earth. Without this natural greenhouse effect, the average surface temperature would plummet to about –21 °C,¹ rather less pleasant than the 14 °C experienced today.

The concentration of CO₂ in the atmosphere is increasing year on year as we burn fossil fuels, which enhances the natural greenhouse effect and warms the planet. To what extent, then, must CO₂ emissions be kept under control in order to restrict global temperature rise to within 2 °C? The projections of complex Earth System Models (ESMs) provide quantitative answers to this question. Run on supercomputers, these models integrate the many processes taking place in the atmosphere, on land and in the ocean. According to the Intergovernmental Panel on Climate Change (IPCC), the latest results of these models indicate

*Corresponding author. Anderson, T.R. (tr@noc.ac.uk);

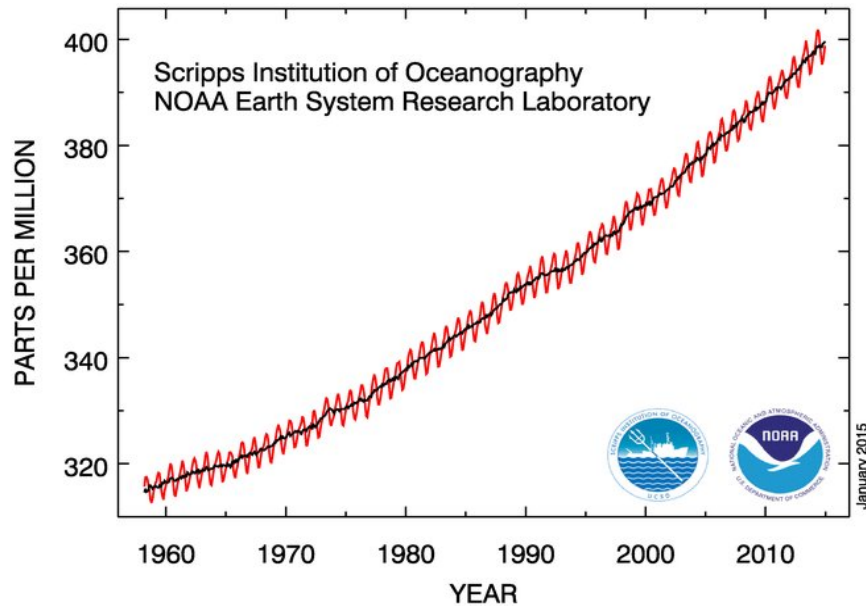
Hawkins, E. (e.hawkins@reading.ac.uk); Jones, P.D. (p.jones@uea.ac.uk)

Keywords: Greenhouse effect; Global warming; Earth System Models; Arrhenius; Callendar.

¹ Andrew A. Lacis, Gavin A. Schmidt, David Rind, and Reto A. Ruedy, “Atmospheric CO₂: Principal Control Knob Governing Earth’s Temperature,” *Science* 330 (2010): 356–59.

Charles David Keeling's first observations, 1958-60

- Unequivocal evidence that CO₂ concentrations are rising steadily



Carbon Dioxide and Climate: A Scientific Assessment

Report to the National Academy of Sciences
Jule G. Charney and co-authors
1979



When it is assumed that the CO₂ content of the atmosphere is doubled and statistical thermal equilibrium is achieved, the more realistic of the modeling efforts predict a global surface warming of between 2°C and 3.5 °C, with greater increases at high latitudes.

- Oceans “could delay the estimated warming for several decades”
- “We may not be given a warning until the CO₂ loading is such that an appreciable climate change is inevitable.”

Progetto EPICA

(European Project for Ice Coring in Antarctica)

Stazione italo-francese Concordia, a Dome C - Antartide



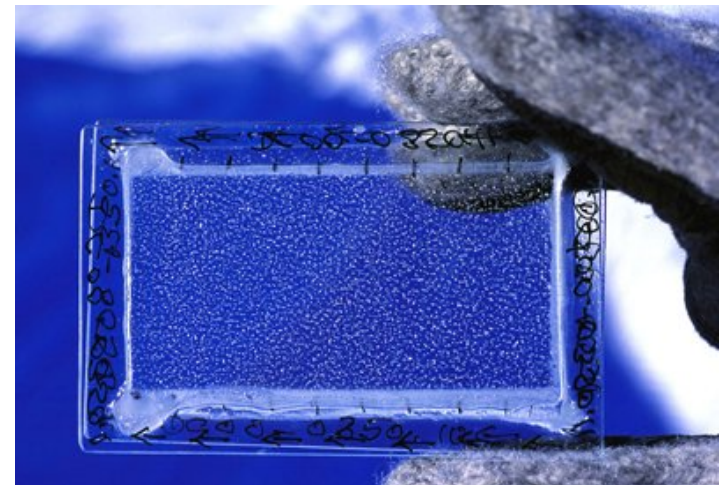
Science

25 November 2005

Vol. 310 No. 5752
Pages 1229–1372 \$10



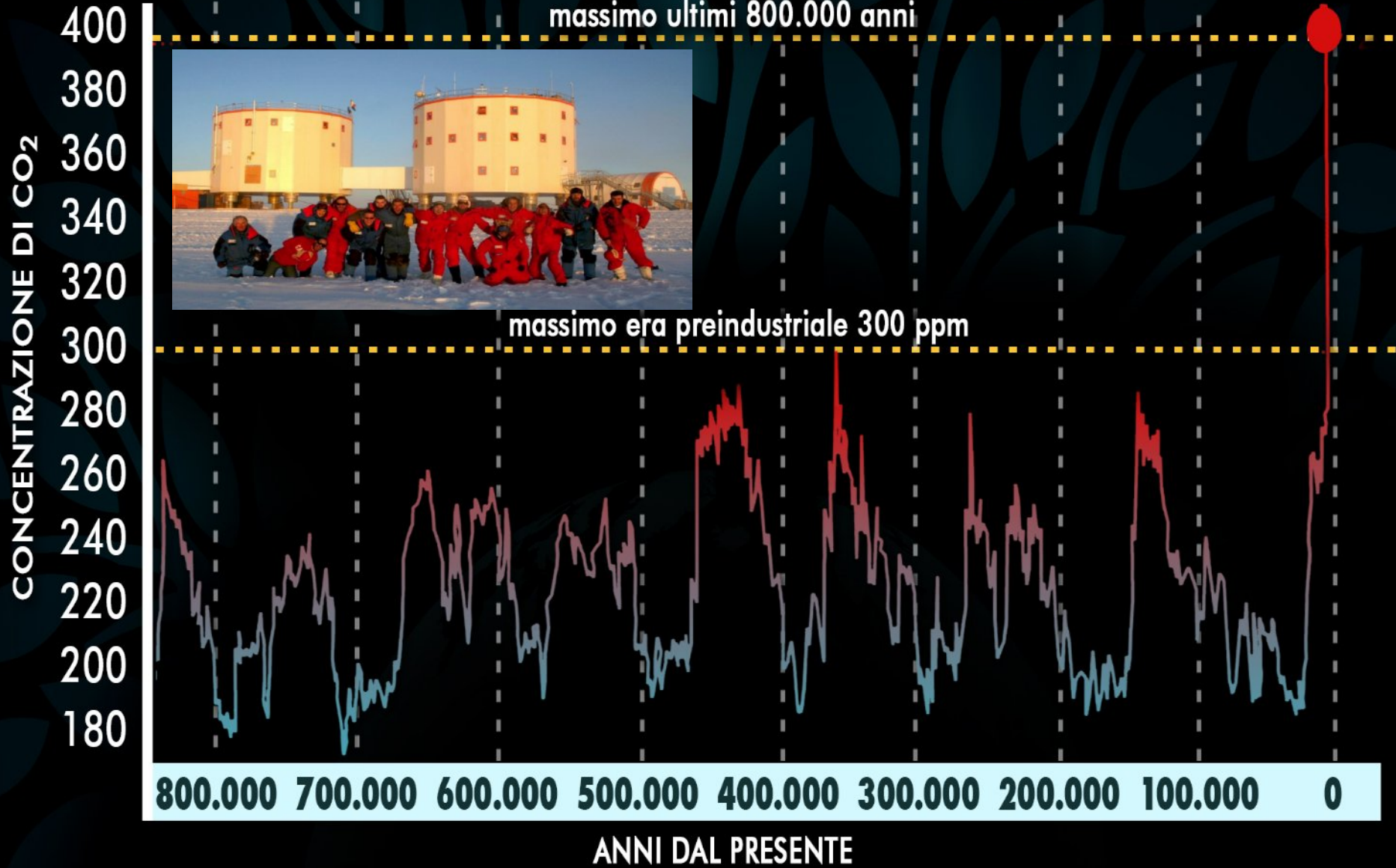
L'analisi delle bolle d'aria sigillate nel ghiaccio permette di ricostruire le concentrazioni storiche di CO₂ e metano



125
YEARS OF GLOBAL
Science

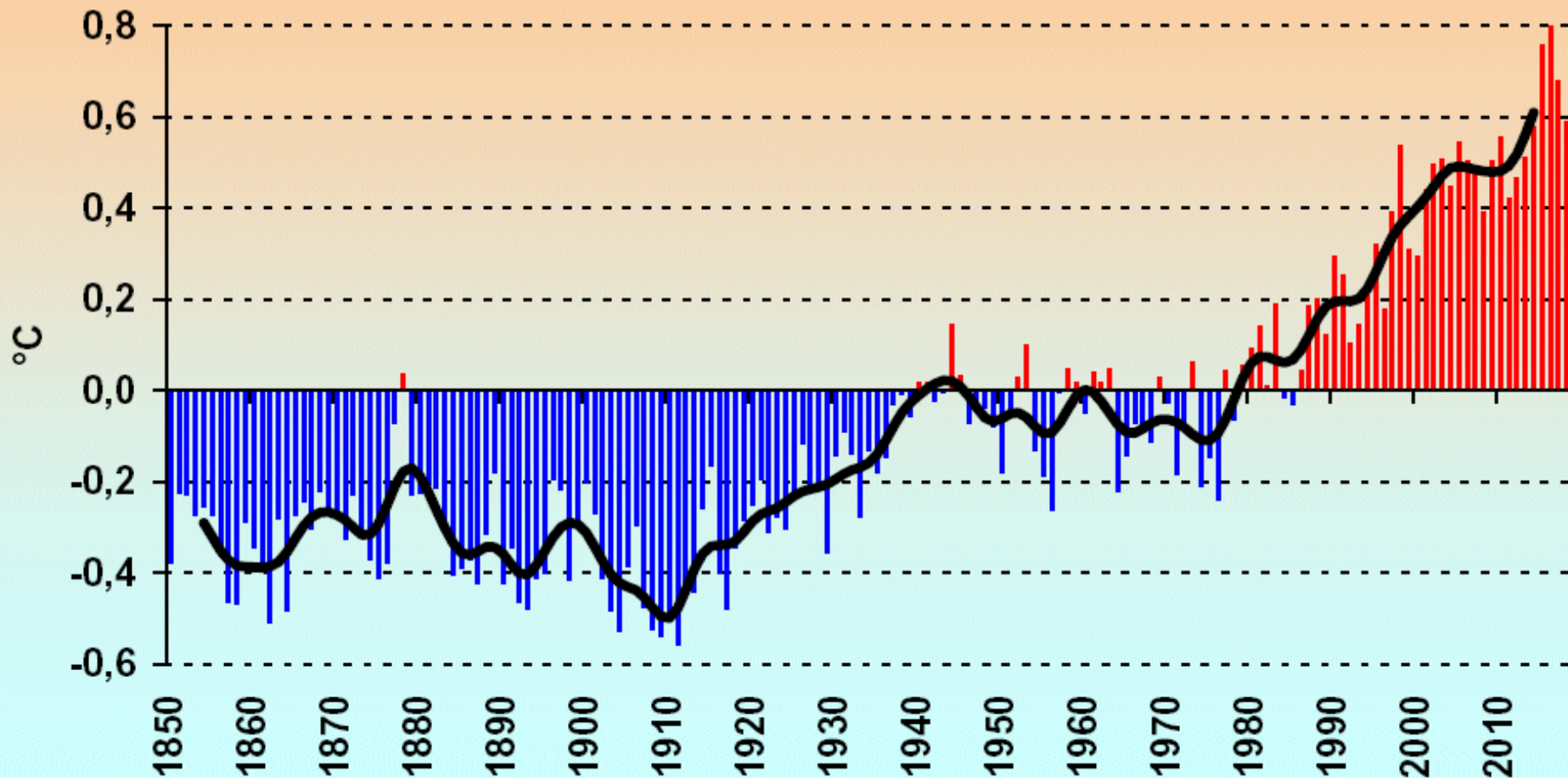
AAAS

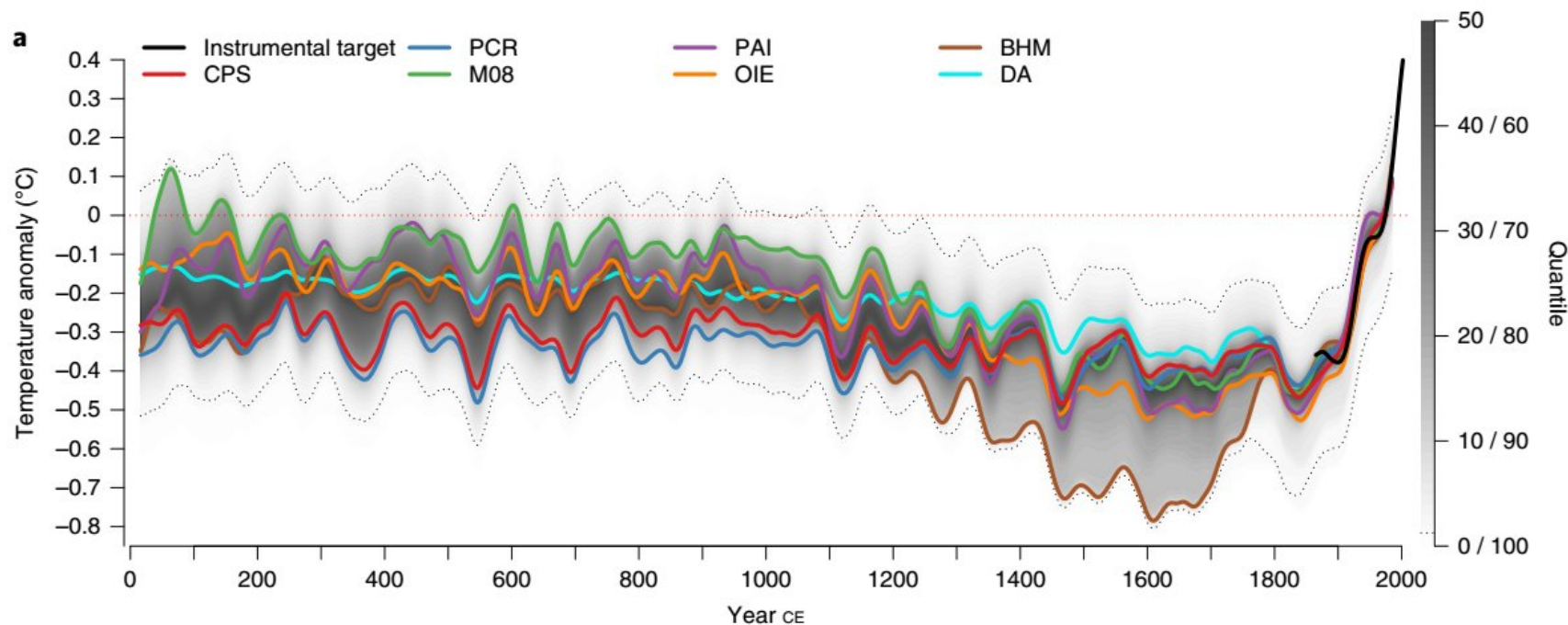
LIVELLO CO₂ NEL TEMPO



Temperatura media globale: +1°C in più nell'ultimo secolo

Anomalie termiche globali 1850-2018
(rispetto a media trentennio 1961-90)
serie MetOffice - Hadley Center





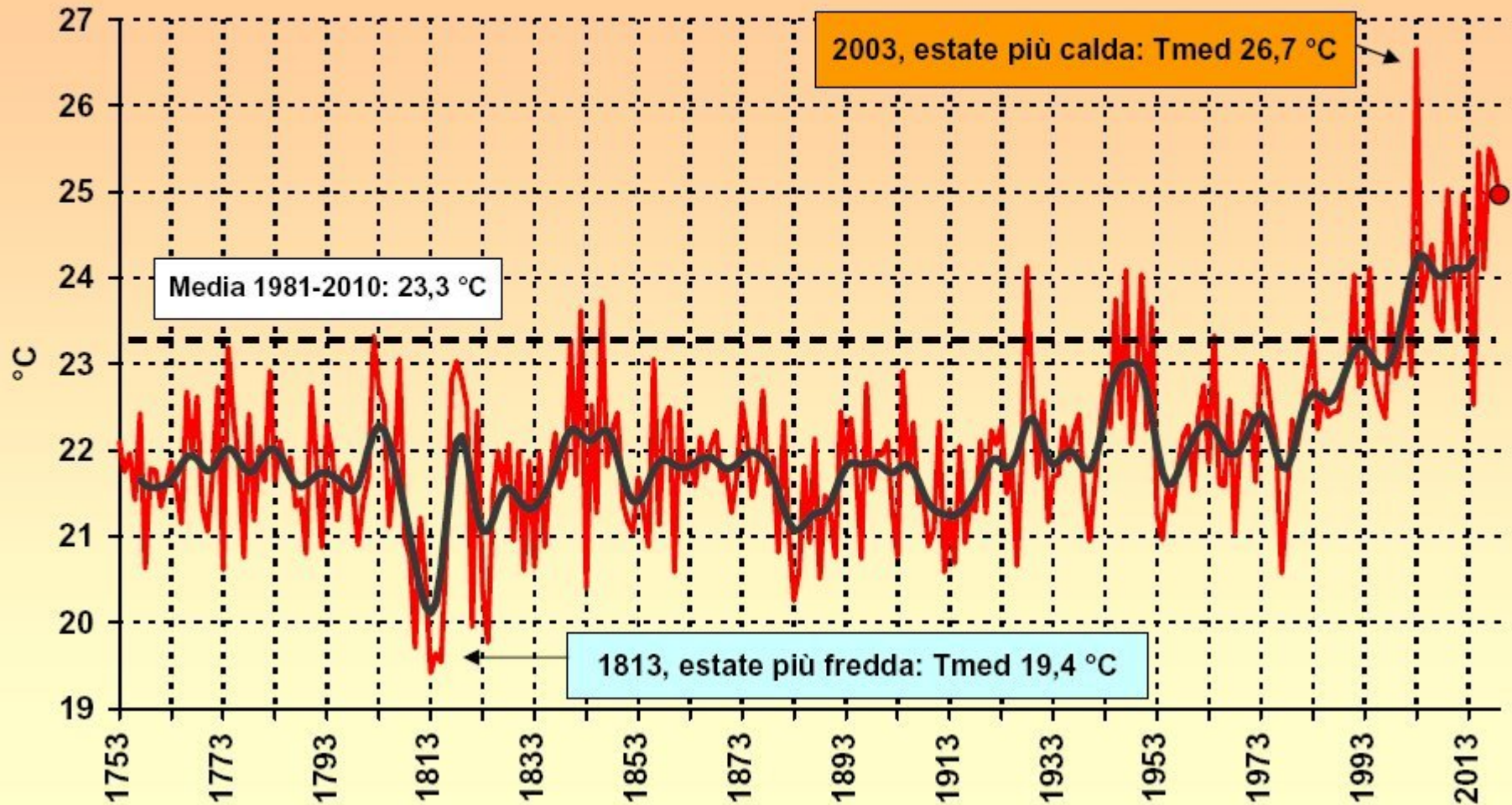
Consistent multidecadal variability in global temperature reconstructions and simulations over the Common Era

PAGES 2k Consortium*

Multidecadal surface temperature changes may be forced by natural as well as anthropogenic factors, or arise unforced from the climate system. Distinguishing these factors is essential for estimating sensitivity to multiple climatic forcings and the amplitude of the unforced variability. Here we present 2,000-year-long global mean temperature reconstructions using seven different statistical methods that draw from a global collection of temperature-sensitive palaeoclimate records. Our reconstructions display synchronous multidecadal temperature fluctuations that are coherent with one another and with fully forced millennial model simulations from the Coupled Model Intercomparison Project Phase 5 across the Common Era. A substantial portion of pre-industrial (1300–1800 CE) variability at multidecadal timescales is attributed to volcanic aerosol forcing. Reconstructions and simulations qualitatively agree on the amplitude of the unforced global mean multidecadal temperature variability, thereby increasing confidence in future projections of climate change on these timescales. The largest warming trends at timescales of 20 years and longer occur during the second half of the twentieth century, highlighting the unusual character of the warming in recent decades.

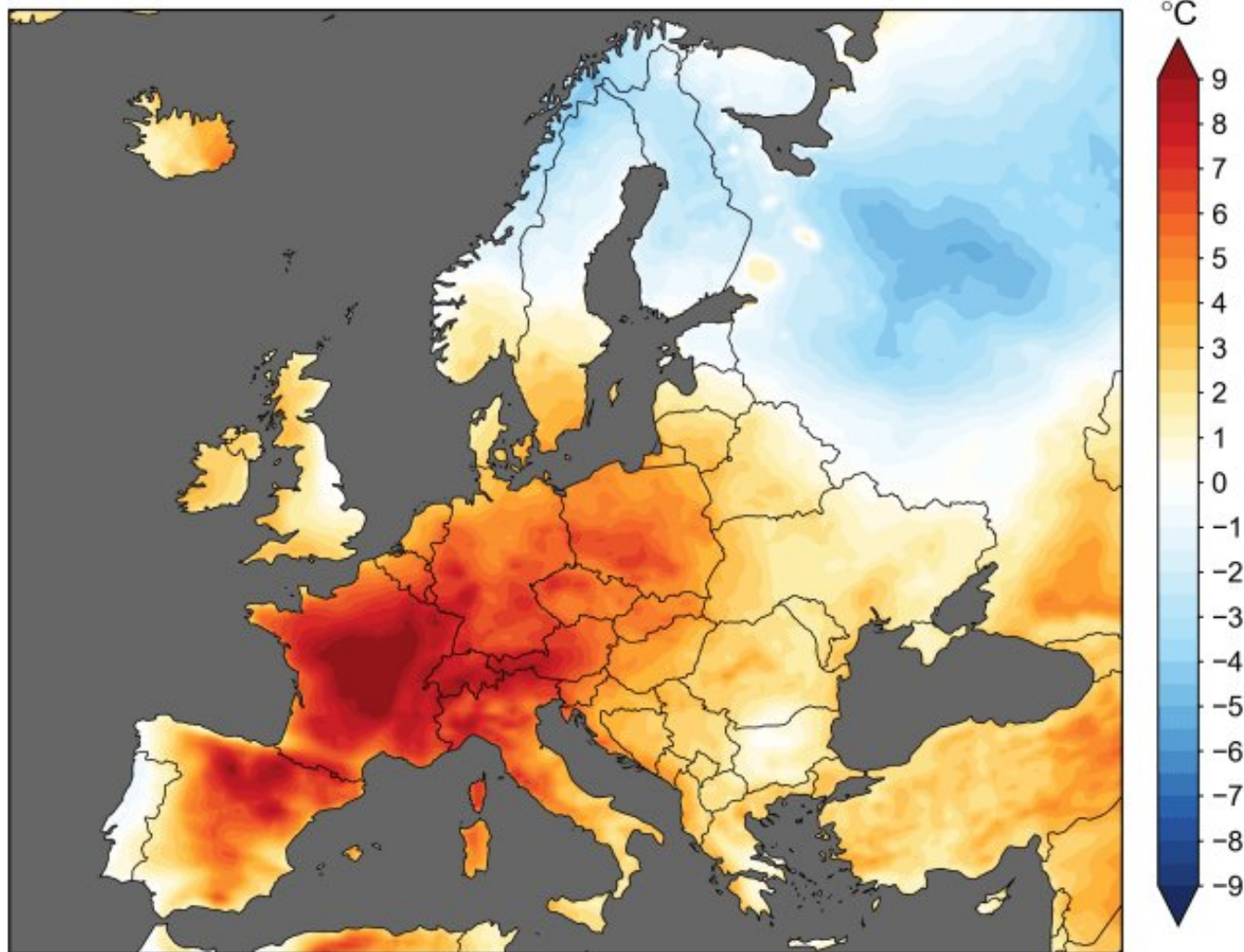
Torino - Temperature medie estive (°C) dal 1753 al 2019

(elaborazione dati: SMI - www.nimbus.it)



9 su 10 delle estati più calde sono successive al 2002

Average 2m temperature anomaly for 25-29 June 2019

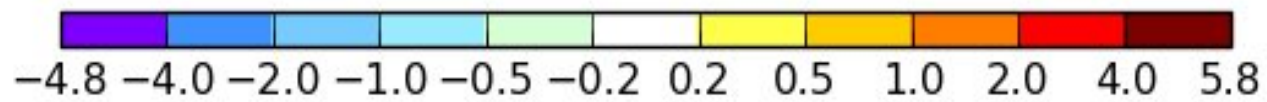
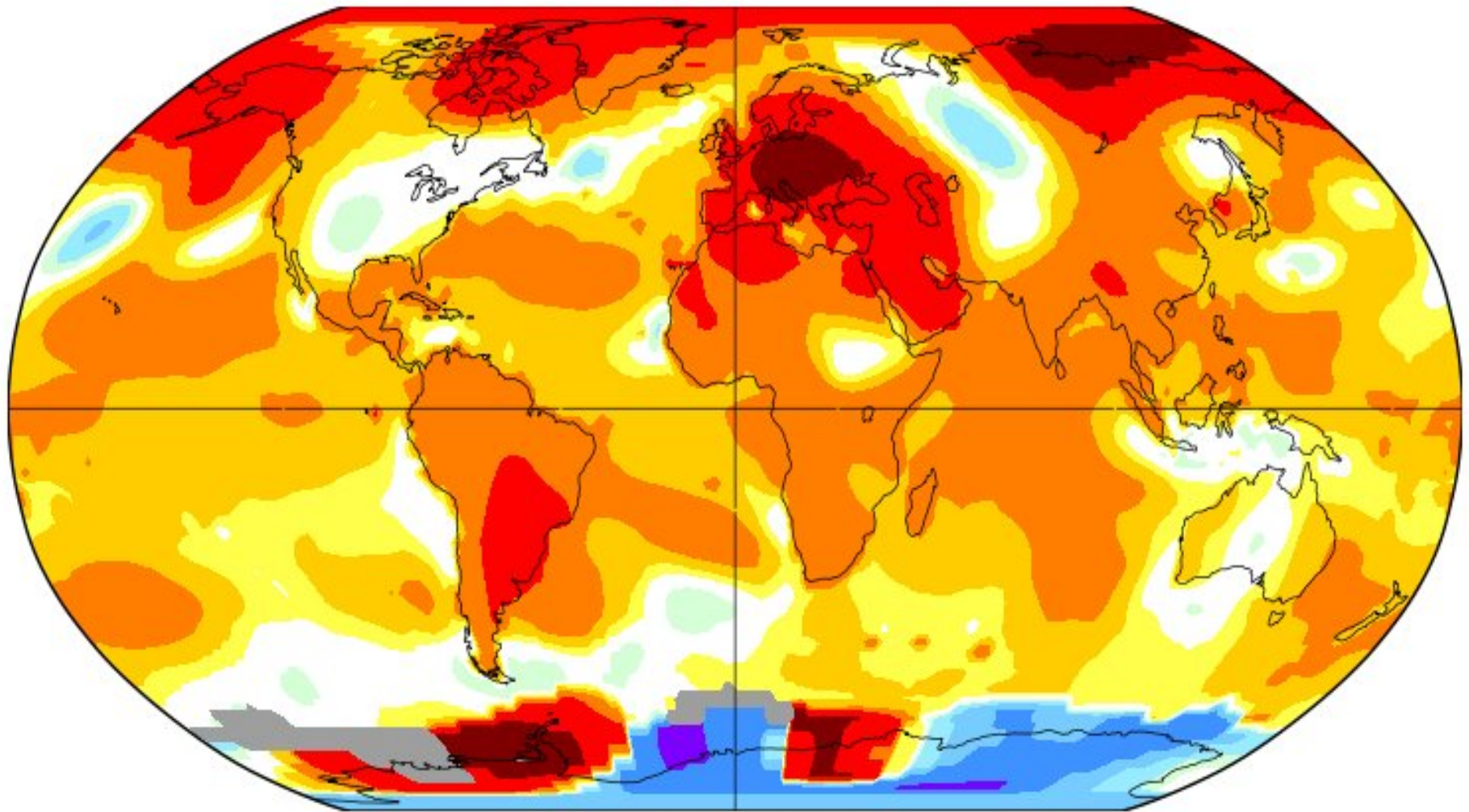


Giugno 2019 è risultato in Europa il **più caldo in assoluto** mai registrato. Mediamente anomalie dell'ordine dei 2°C rispetto al periodo 1981-2010, ma alcune aree, come Francia, Svizzera, Germania e Nord Italia, hanno fatto registrare anomalie anche di 6-10°C nei 5 giorni più caldi dal 25 al 29 giugno.

June 2019

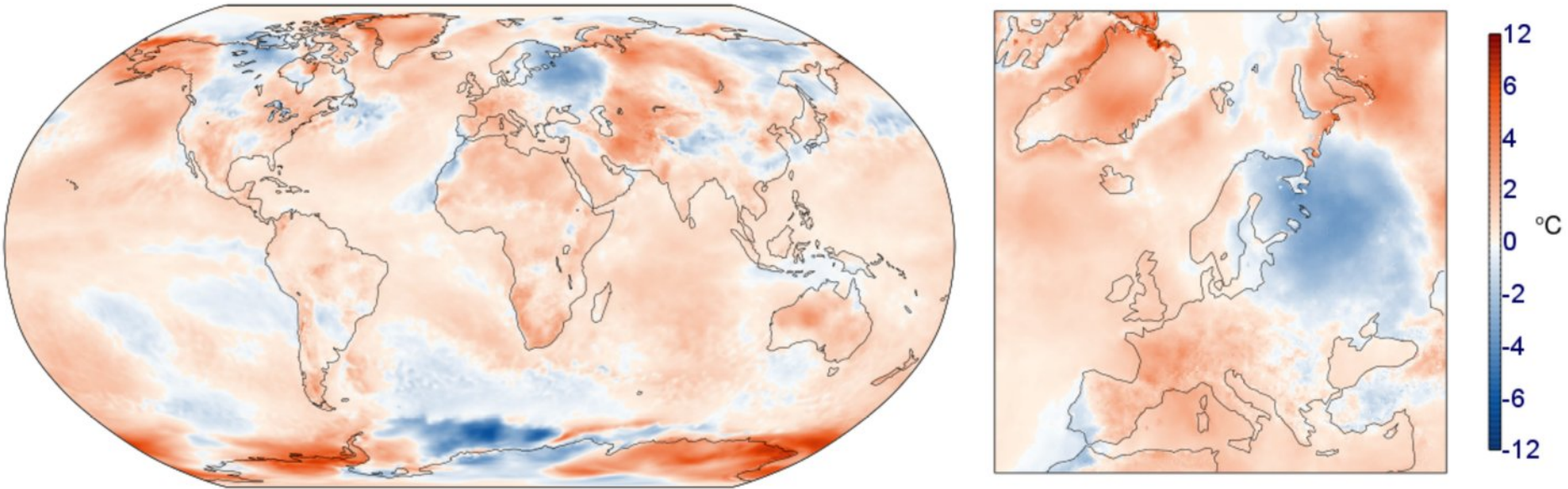
L-OTI(°C) Anomaly vs 1951-1980

0.92



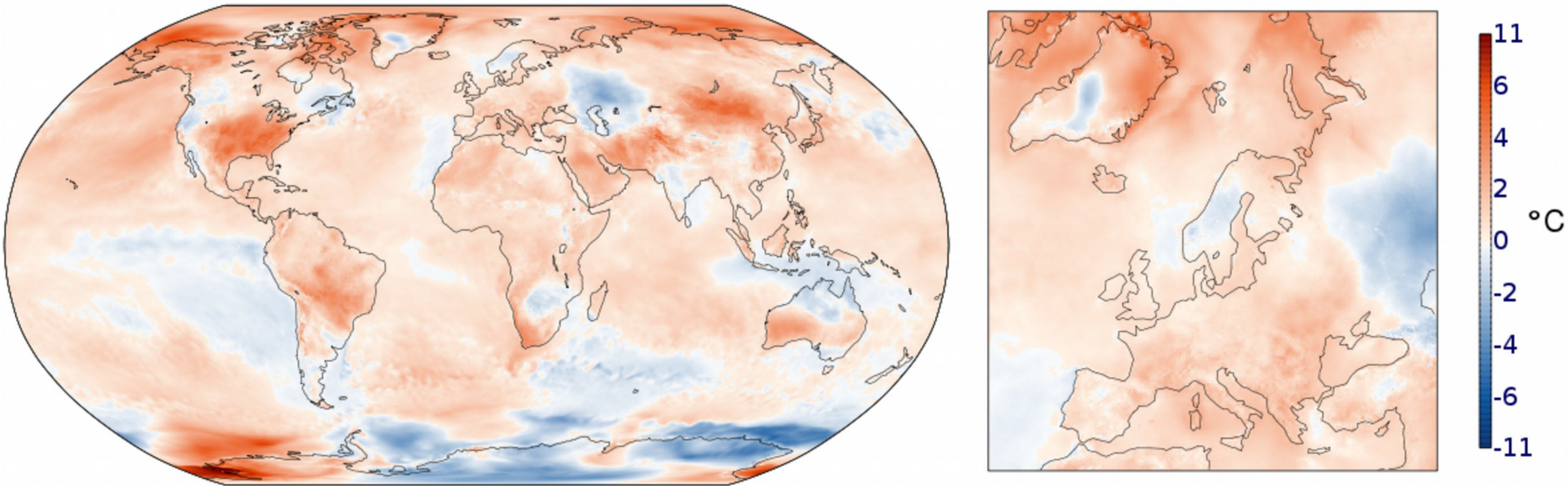
Luglio 2019: il mese più caldo della storia meteorologica terrestre

Surface air temperature anomaly for July 2019 relative to 1981-2010



Settembre 2019: anche questo, il più caldo della storia meteo

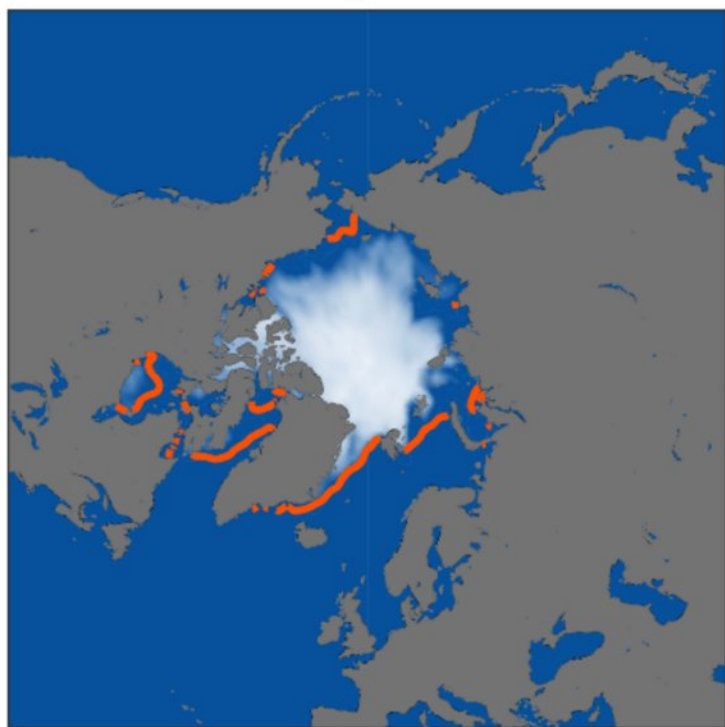
Surface air temperature anomaly for September 2019 relative to 1981-2010



Banchisa polare ai minimi

Arctic sea-ice cover for July 2019

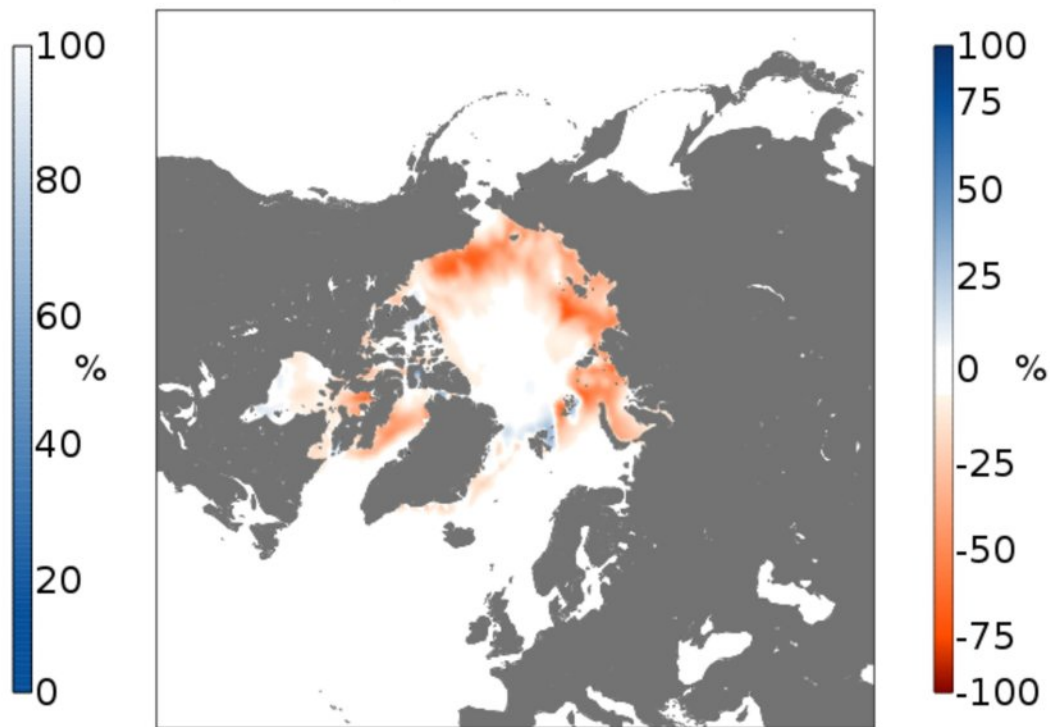
Average cover

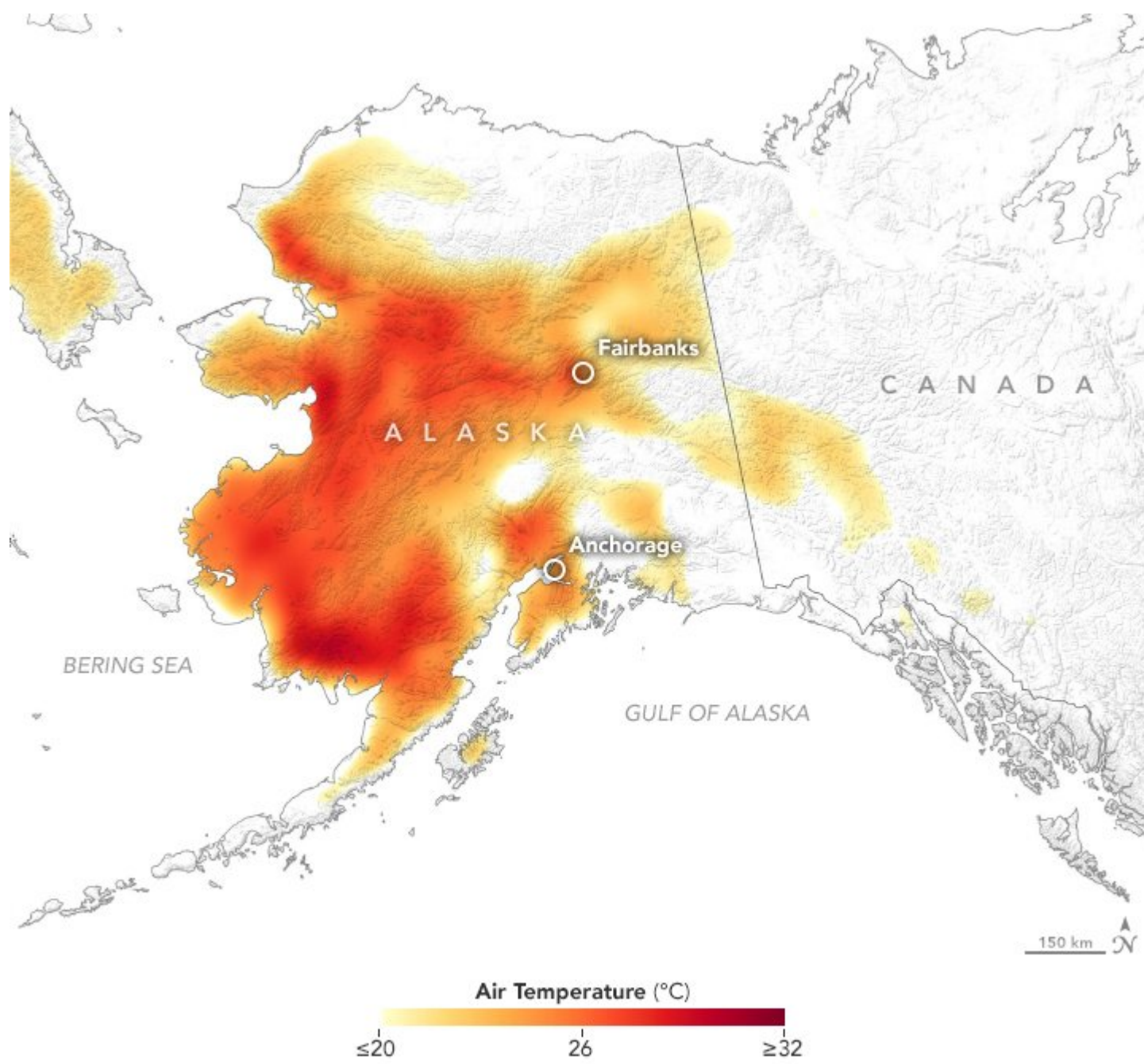


— Average ice edge July 1981-2010

Data: ERA5

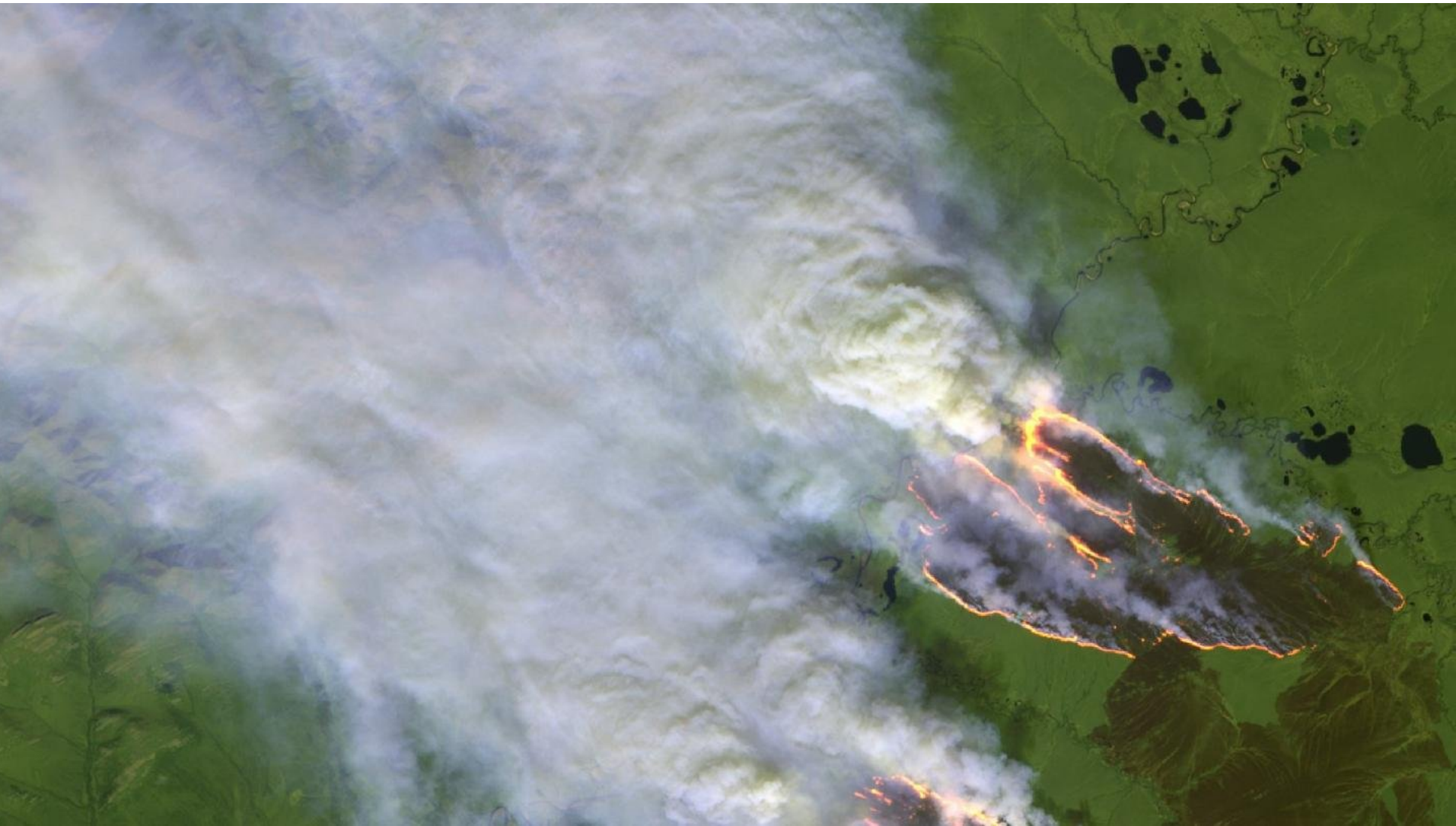
Anomaly relative to 1981-2010





**Record
32°C
Alaska
4 lug
2019**

Epocali incendi in Siberia





1897
(f. Druetti)



2005
(f. L. Mercalli)



2015
(f. S. Jobard)

Ghiacciaio Pré de Bar (Monte Bianco):

ritiro della fronte di oltre 800 m dal 1897 al 2015

I ghiacciai alpini si sono ridotti di oltre il 50% in un secolo

~ 1960

Archivio Pessina,
Domodossola



19.09.2018

f. L. Mercalli



Ghiacciaio
Meridionale del
Sabbione
(Ossola)
dalla diga.

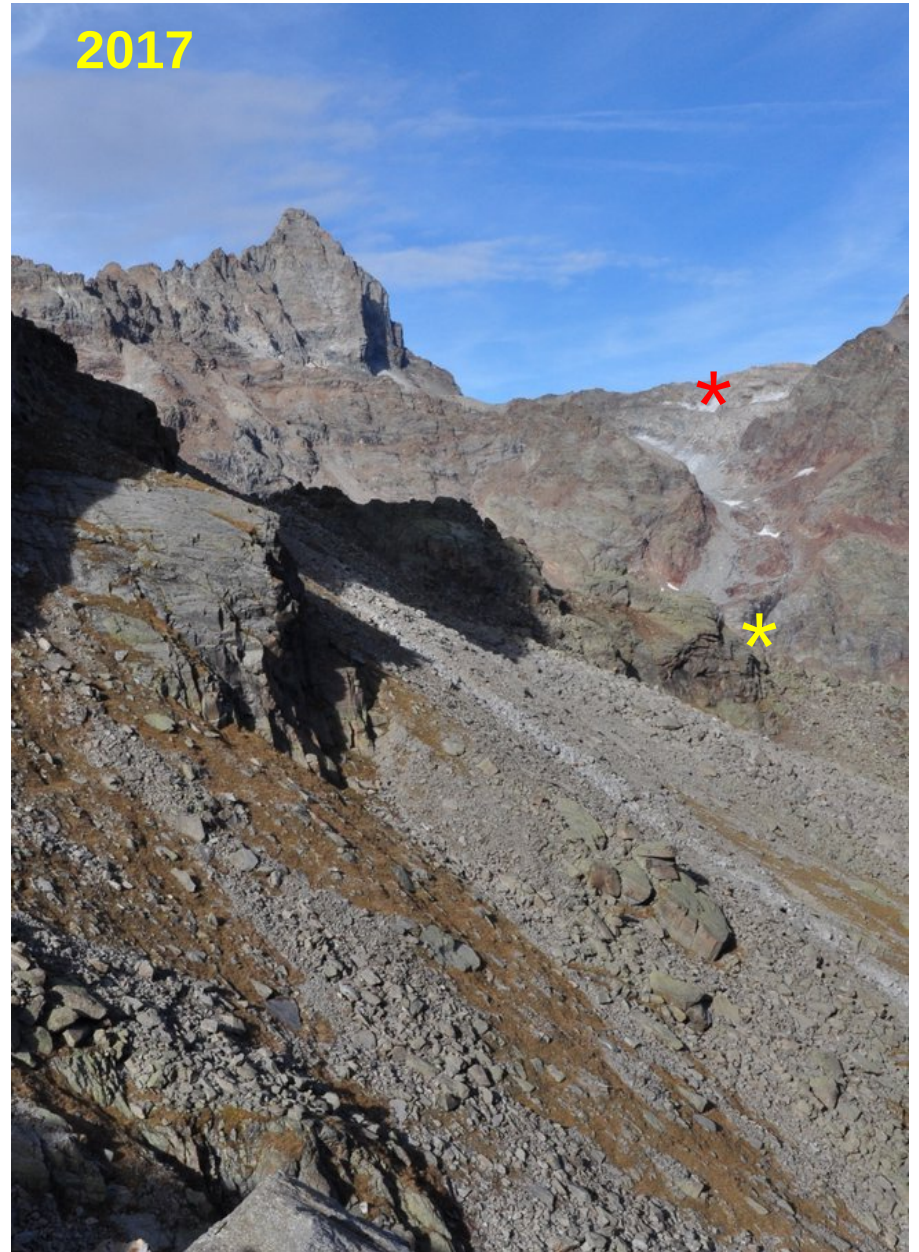
Regresso frontale
circa 1200 m.

1850



LA TOUR DU GRAND ST. PIERRE,
APRES NATURE, PAR M. A. A. REILLY.

2017



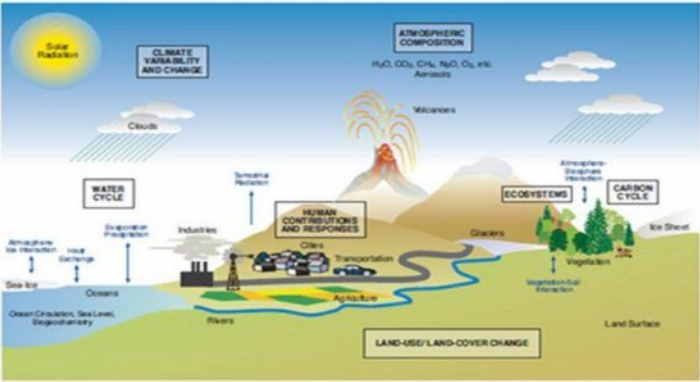
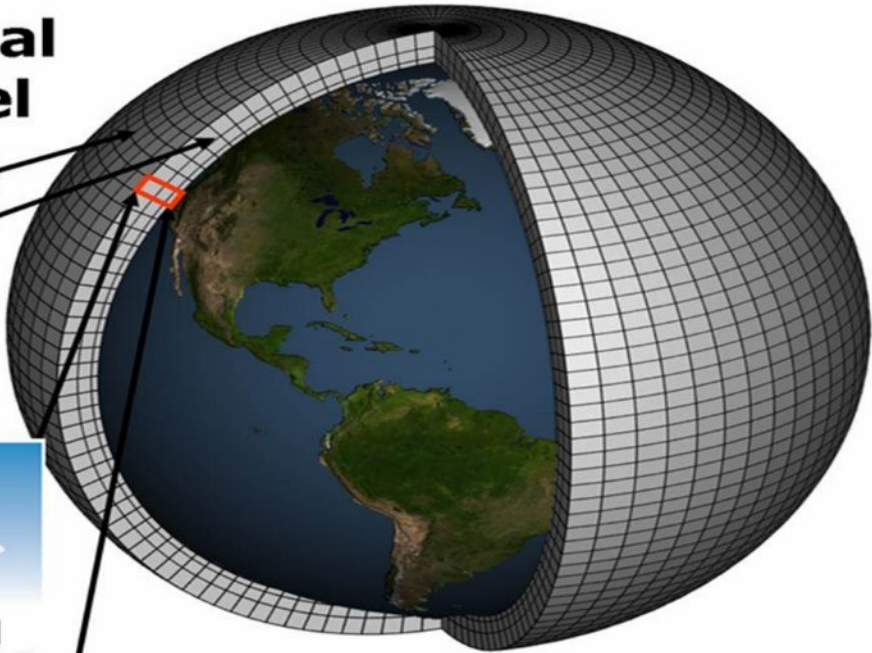
Ghiacciaio di Teleccio (Gran Paradiso)

Global Climate Models

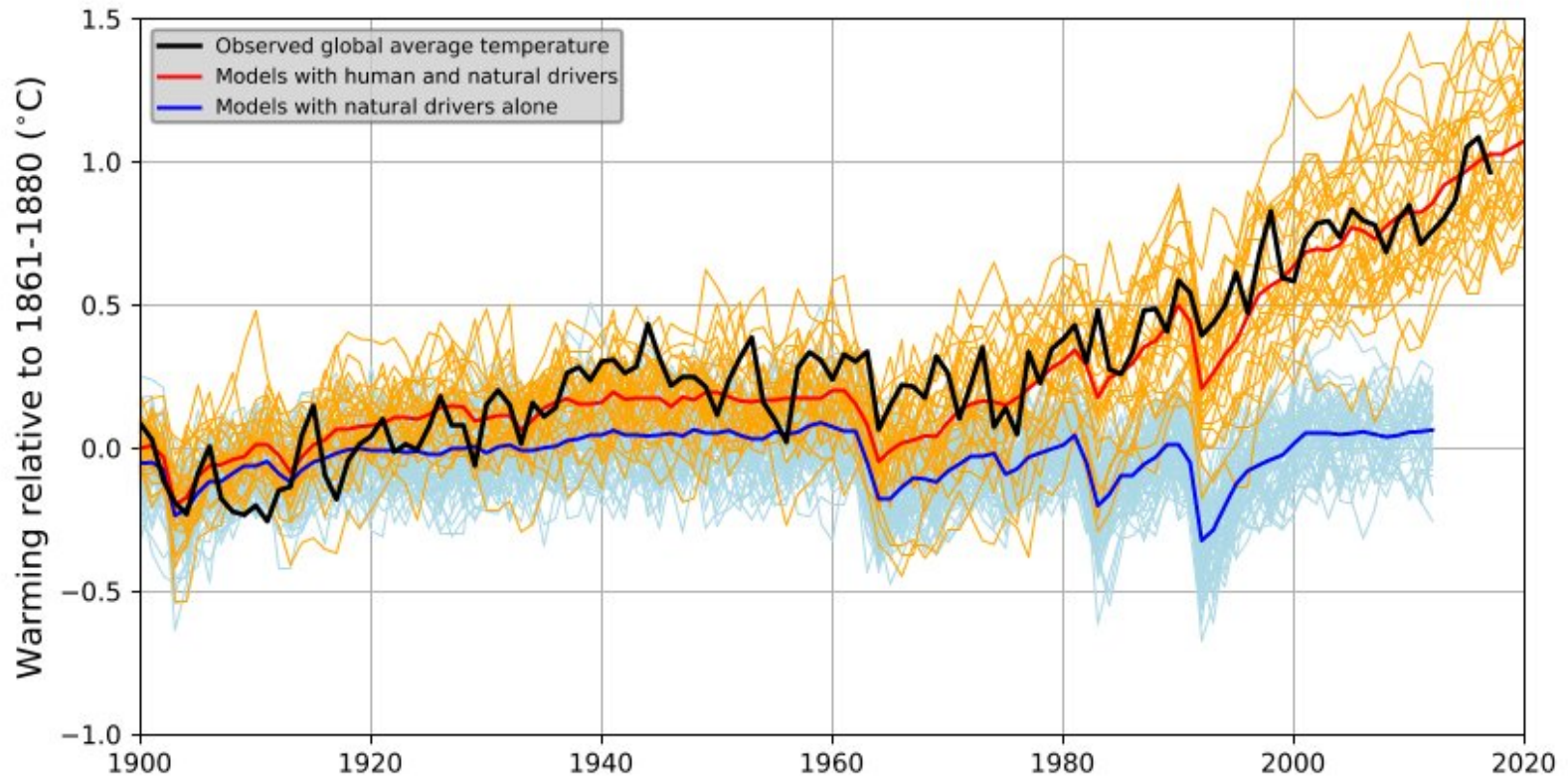
Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)

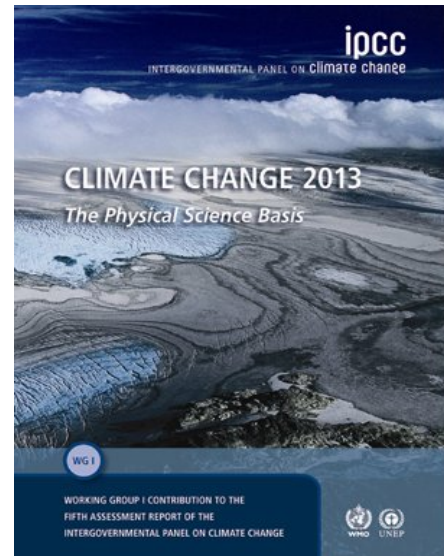
Vertical Grid (Height or Pressure)



Climate models reproduce observed warming only when human influences are included



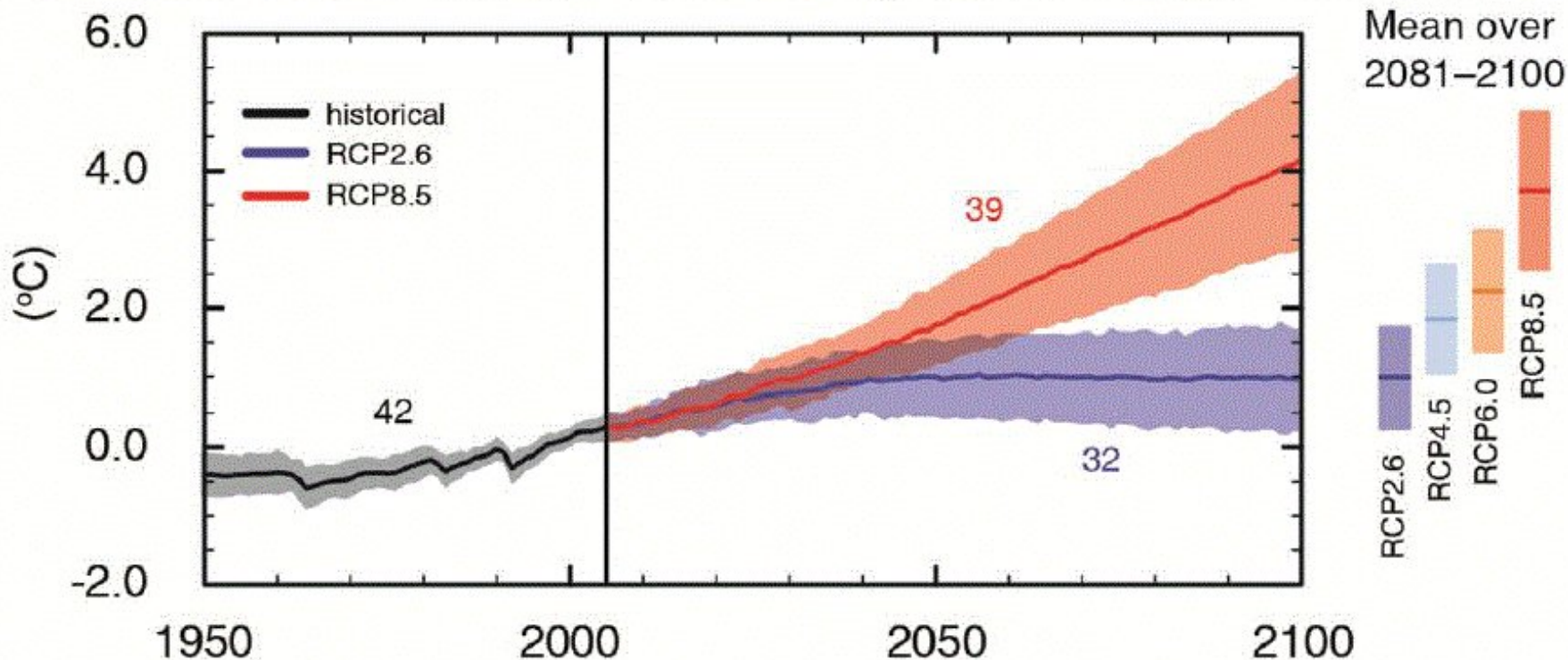
Richardson et al, 2017



Scenari 5° rapporto IPCC (AR5 2013):

+2°C al 2100 se si applica **Accordo Parigi 2015** (linea azzurra), oppure fino a **+5°C** in più con business-as-usual (linea rossa)

(a) Global average surface temperature change



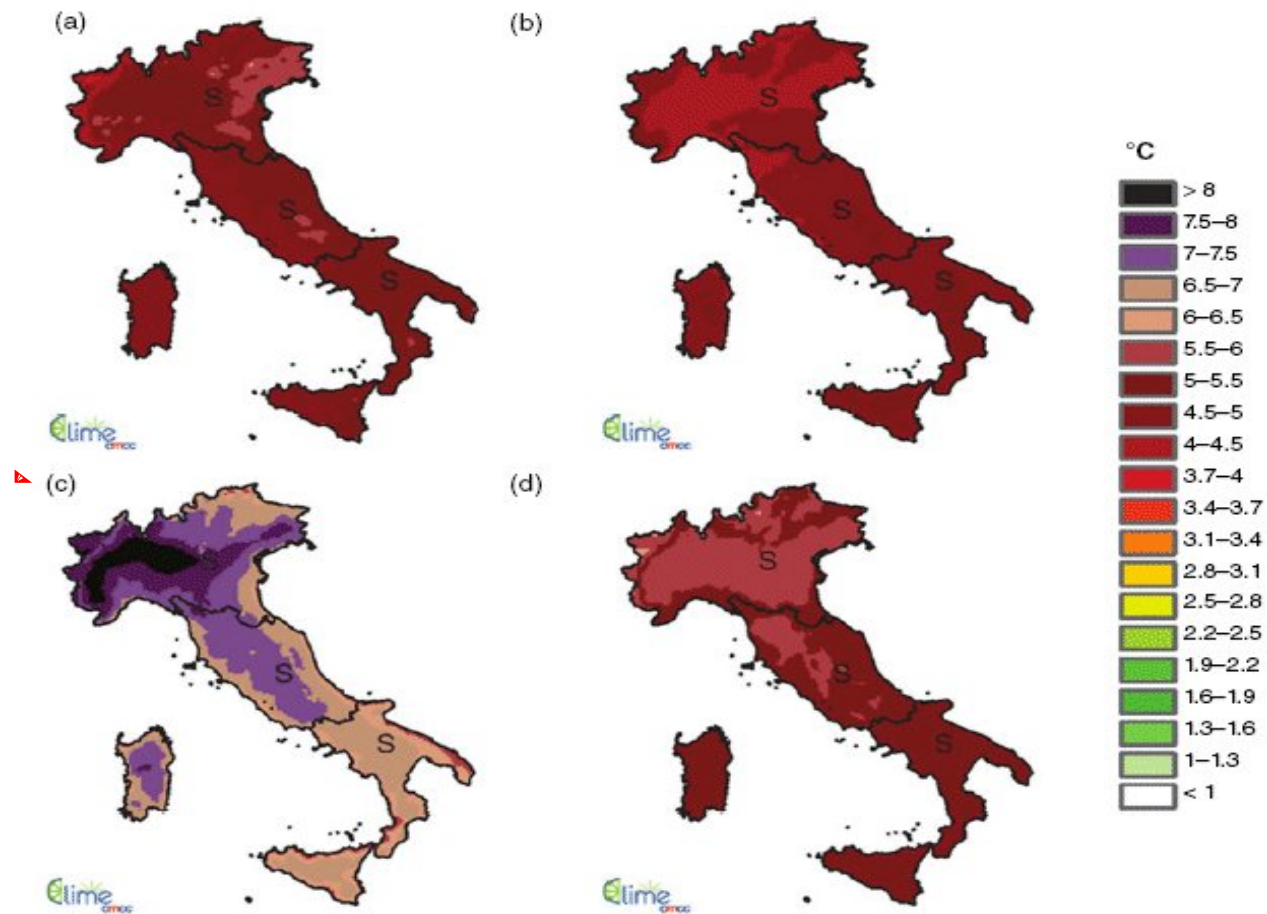


Figure 9. Temperature climate projections, RCP8.5: seasonal differences ($^{\circ}\text{C}$), between the average value over 2071–2100 and 1971–2000 for (a) DJF, (b) MAM, (c) JJA and (d) SON (S, significant; NS, not significant).

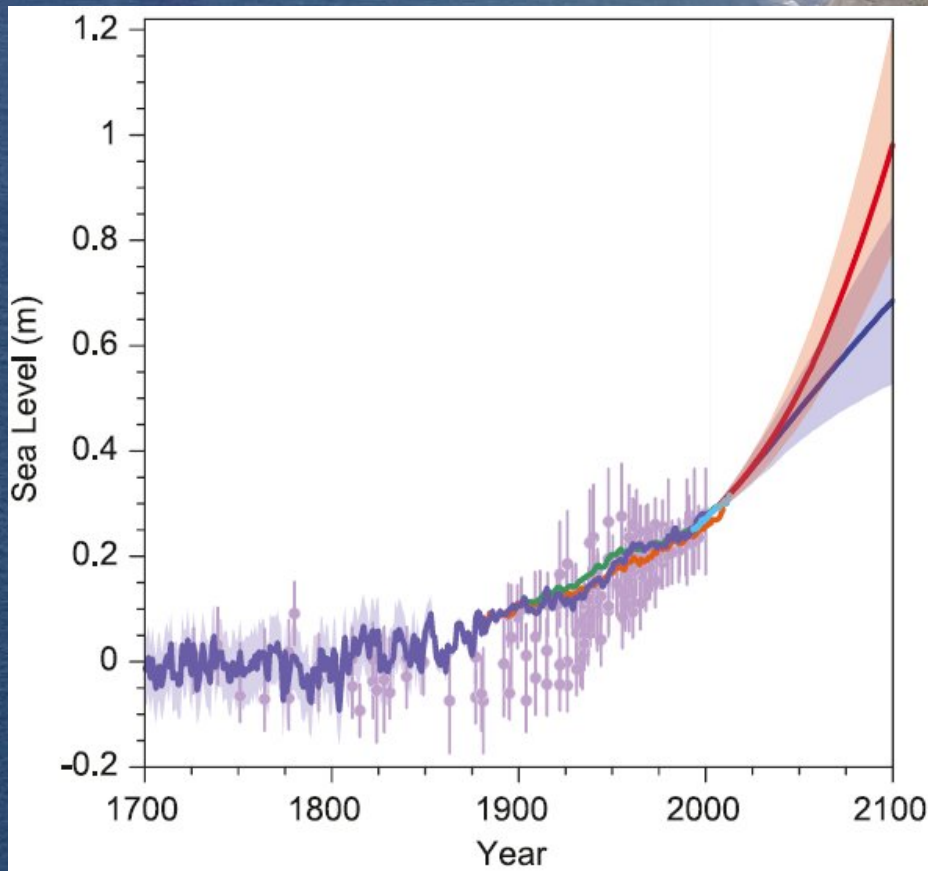
**E se non facessimo nulla? NW Italiano + 8 $^{\circ}\text{C}$ in estate
nel 2100! Torino come Karachi...**

Bucchignani et al. (2015) *High-resolution climate simulations with COSMO-CLM over Italy*, Int. J. Climatol.



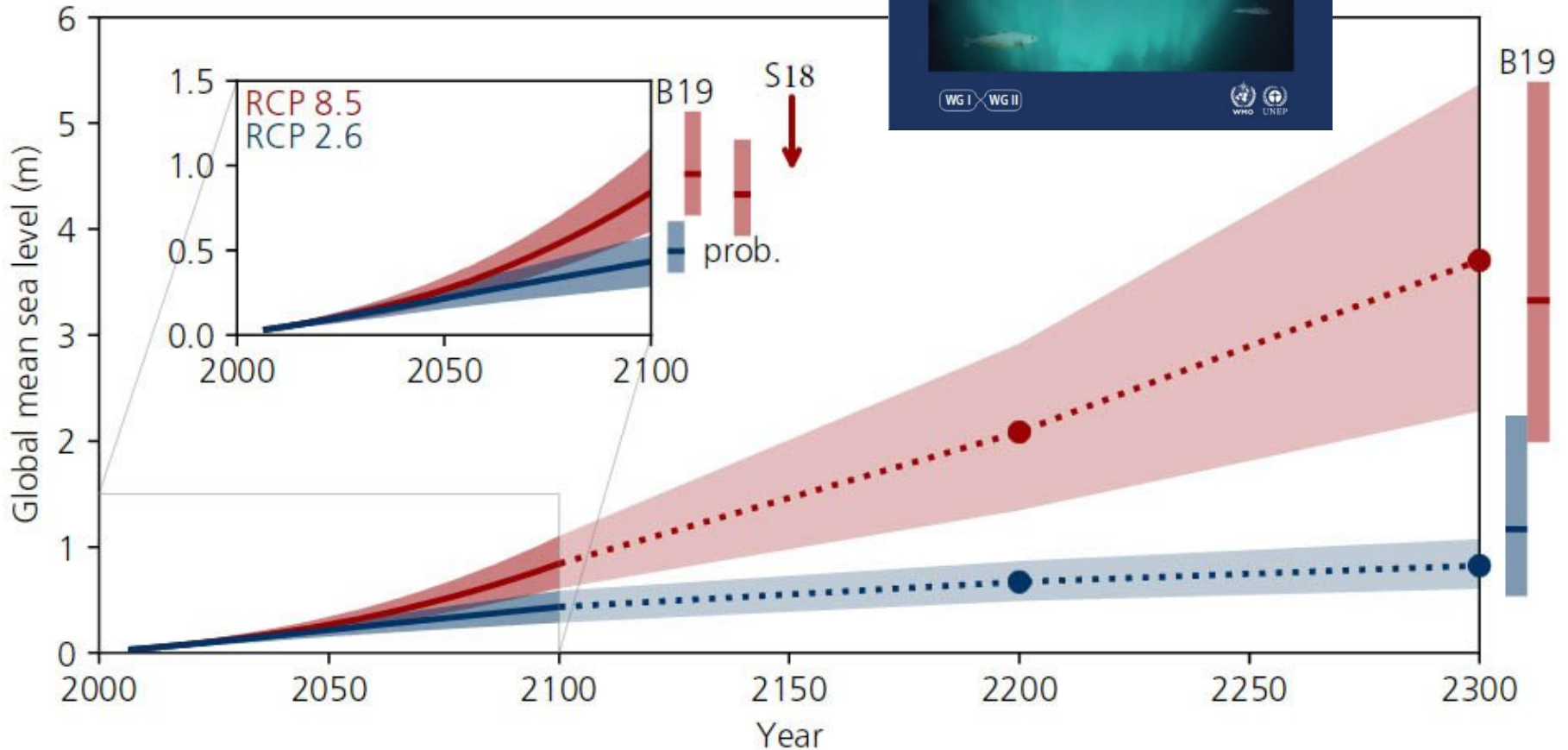
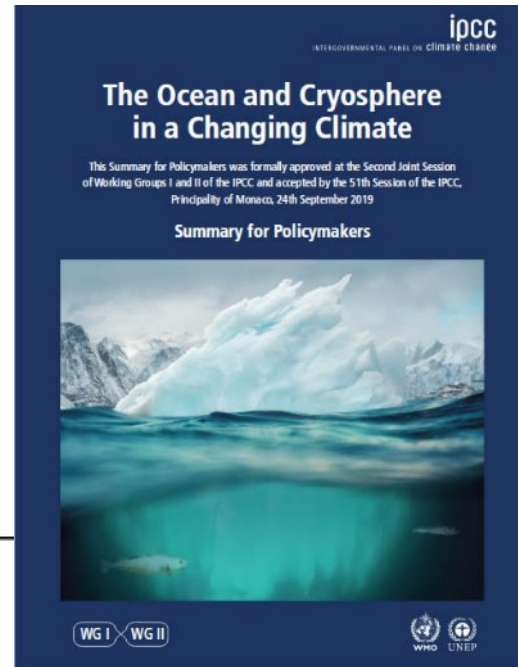
**Aumento livello marino:
a rischio laguna veneta e delta del Po**

Le zone costiere risentiranno dell'aumento del livello marino, e dovranno essere adeguatamente protette (es: Venezia, delta del Po)



Settembre 2019 – Rapporto IPCC Oceano e criosfera

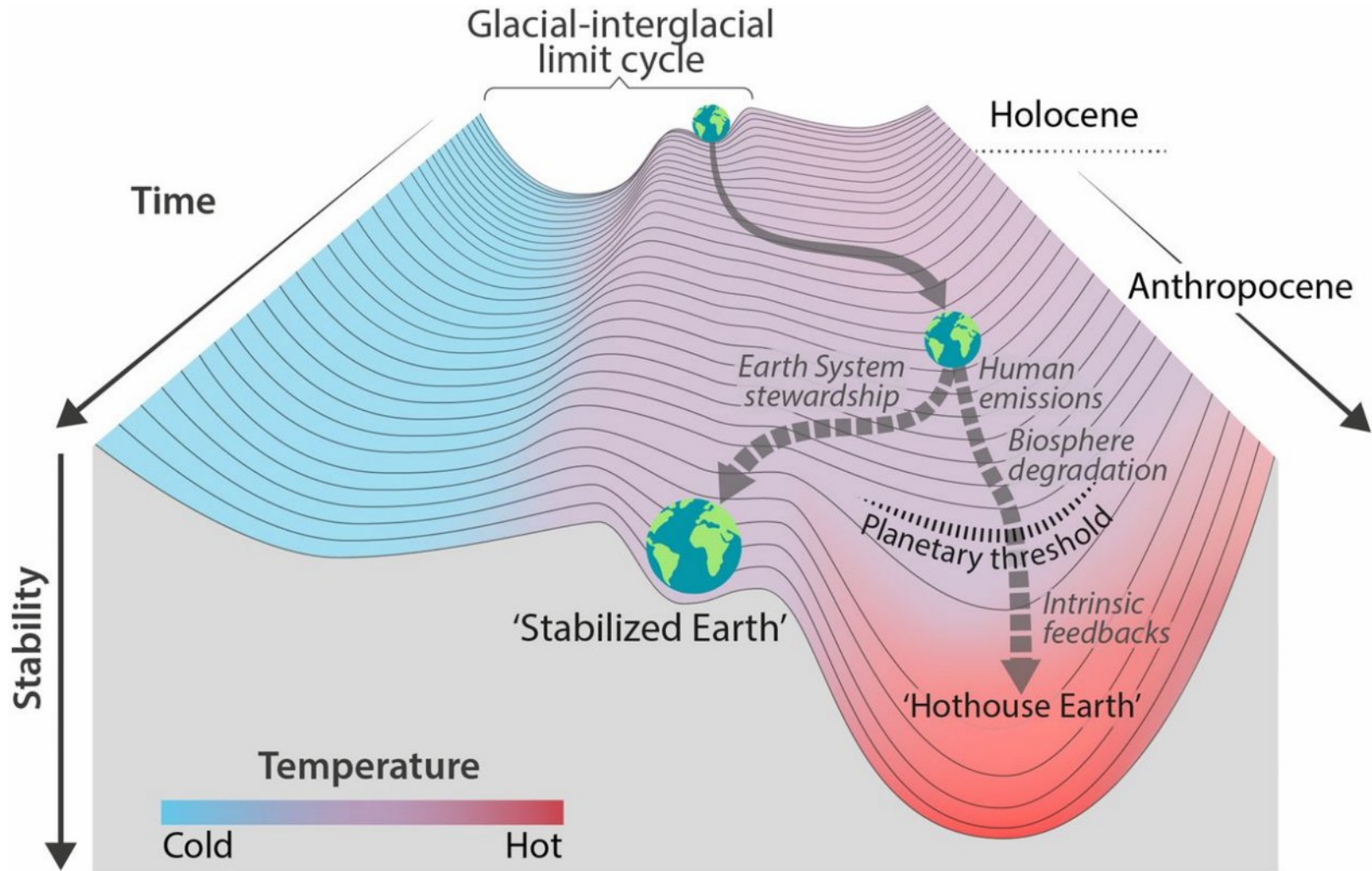
Fino a +5 m di livello marino nel 2300





Dallo studio dell'Enea: nei riquadri, i due valori indicano in millimetri di quanto potrebbe alzarsi il livello del mare sulla base di due scenari (di minore e maggiore gravità) che tengono conto di due fattori: i cambiamenti climatici (l'aumento della temperatura media della Terra e lo scioglimento dei ghiacciai) e le forze geologiche cui è sottoposta l'intera penisola.

Stability landscape showing the pathway of the Earth System out of the Holocene and thus, out of the glacial–interglacial limit cycle to its present position in the hotter Anthropocene.

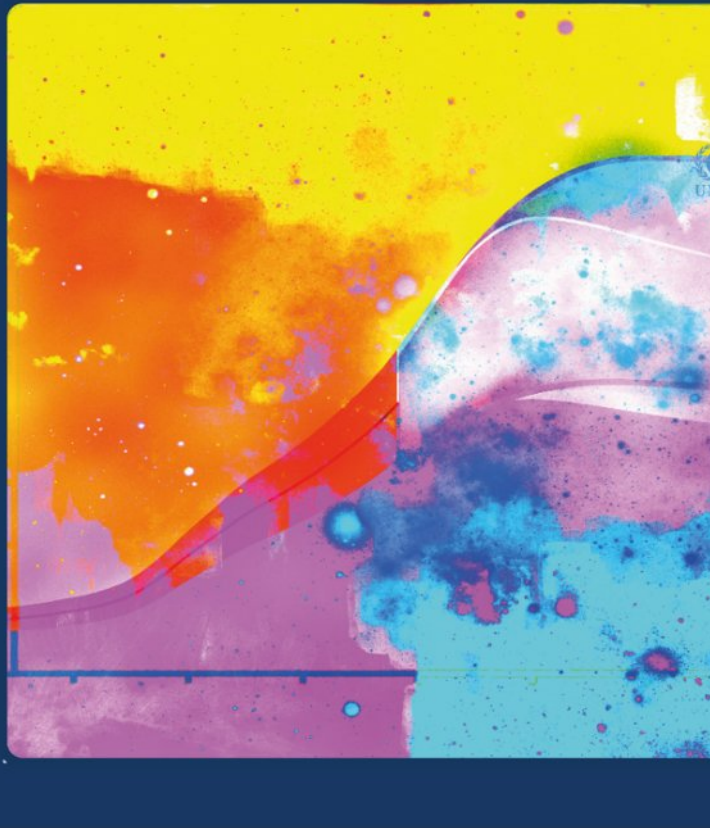


Will Steffen et al. PNAS doi:10.1073/pnas.1810141115

PNAS

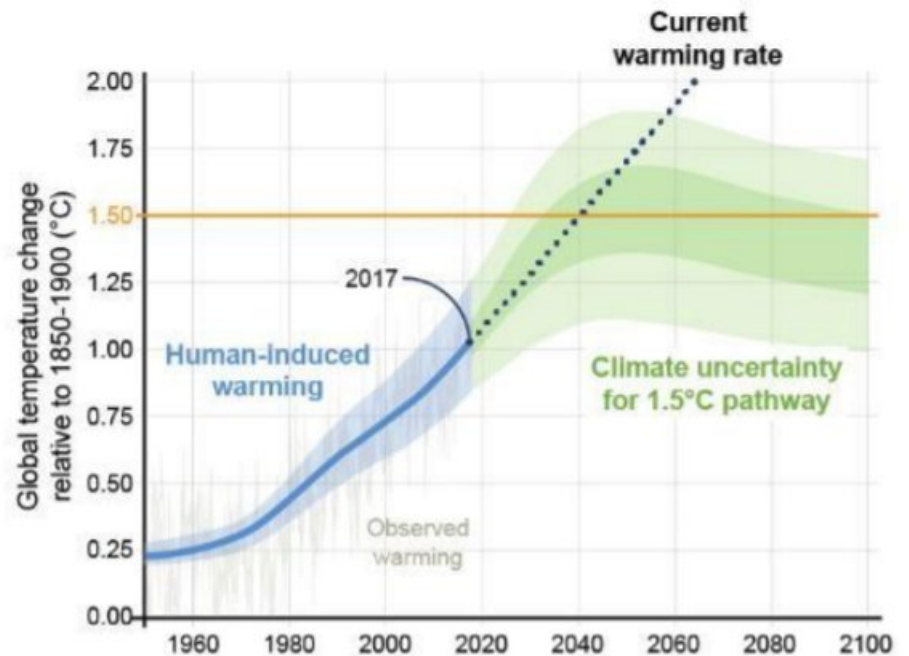
Global Warming of 1.5°C

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.



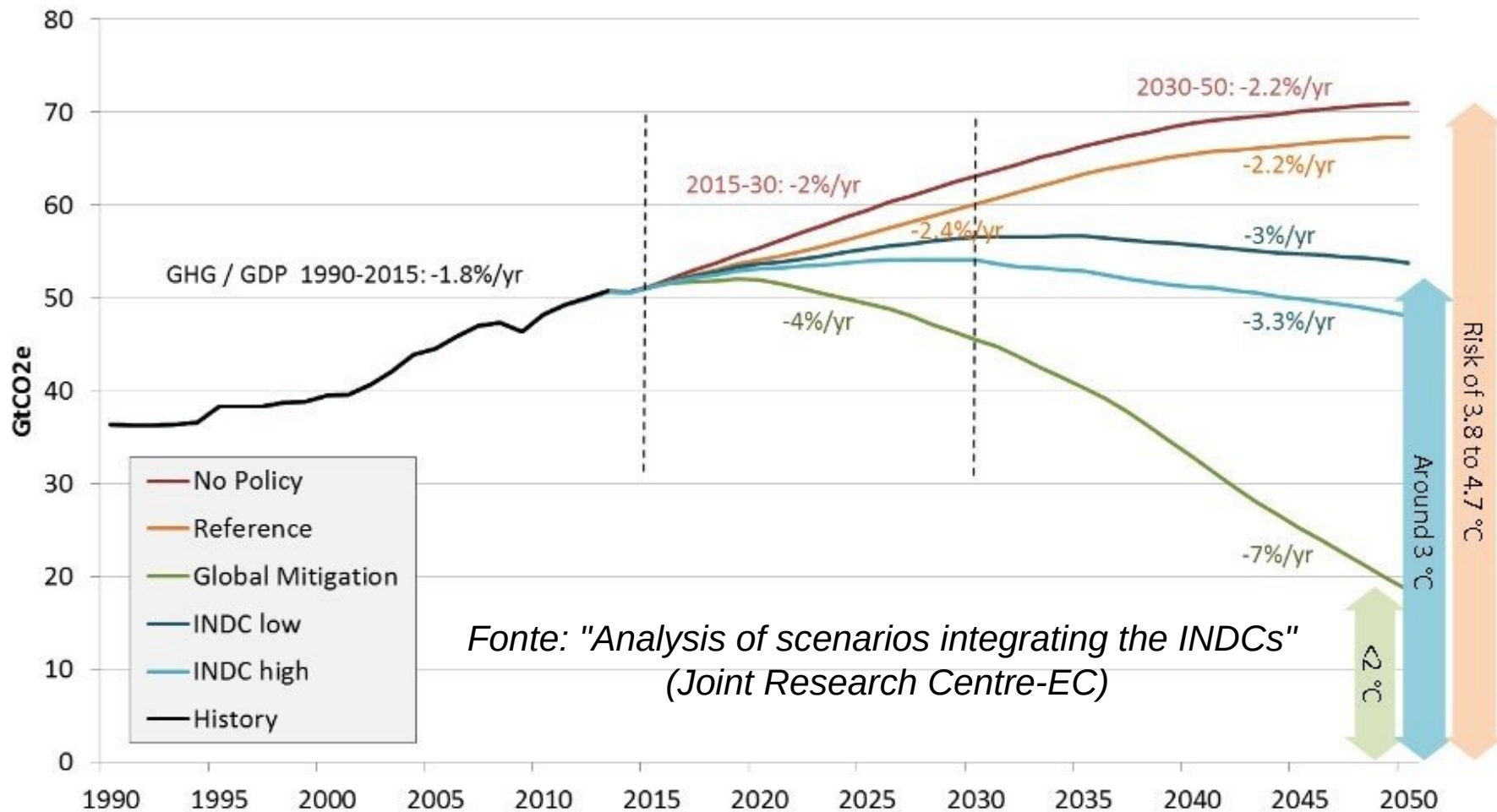
FAQ1.2: How close are we to 1.5°C?

Human-induced warming reached approximately 1°C above pre-industrial levels in 2017

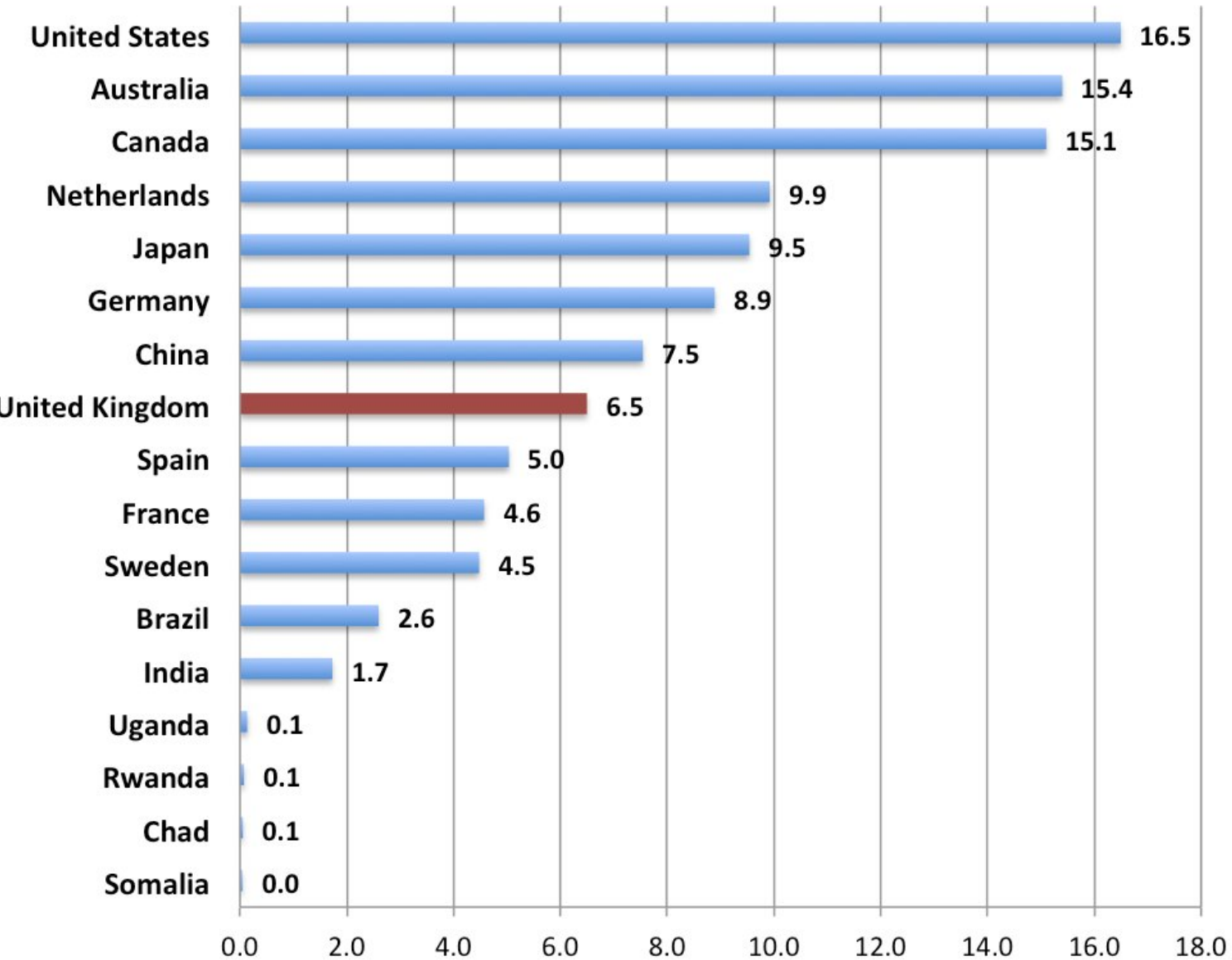


FAQ1.2, Figure 1: Human-induced warming reached approximately 1°C above pre-industrial levels in 2017. At the present rate, global temperatures would reach 1.5°C around 2040.

Promesse ambiziose di riduzione CO₂, ma non bastano: se applicate, circa +3 °C nel 2100 !



CO2 emissions per capita



2014

Italy 5.3 t

EU 6.4 t

Global mean 5.0 t

OIL & GAS SUPPLY AND STRANDED ASSET RISK

How does potential oil and gas supply compare to demand under different global warming outcomes?

B2DS demand

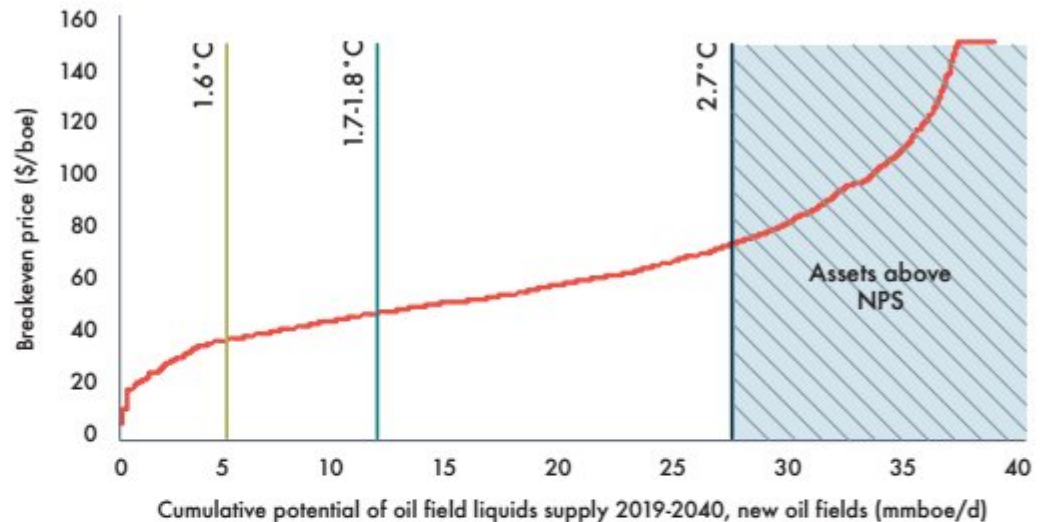
SDS demand

NPS demand

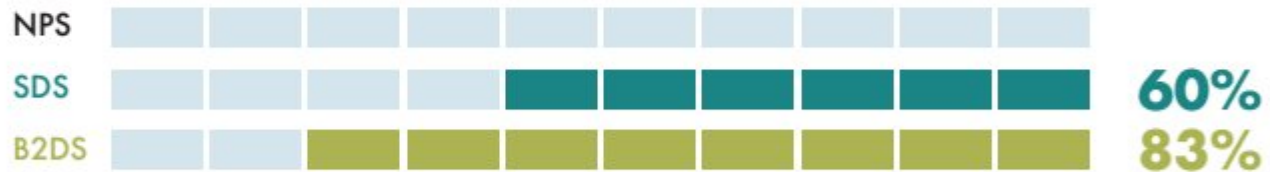
Production from new oil fields 2019-2040

The only way that fossil fuel companies can be "Paris-aligned" is to commit to not sanctioning projects that fall outside the remaining carbon budget constraint.

In the context of the energy transition towards a decarbonised economy, these potential fossil fuel developments risk destroying investor value as well as the climate.



Share of capital expenditure at risk of stranding in each scenario (2019-2030)



1.5°C warming

In a 1.5°C world, no new oil & gas project would be compliant

If no CCS is assumed, 1.5°C warming is delivered by existing projects alone.

The oil and gas in projects that have already been sanctioned will take the world past 1.5°C, assuming carbon capture and storage remains sub-scale. Without a response sufficient to prematurely close existing projects, a warming of a warming of 1.5°C is already effectively locked in, and no new projects are compliant with the low end of the Paris goals.

Oil and gas companies have approved \$50 billion of investment since 2018 in major projects that undermine climate targets and threaten shareholder returns



\$2.2tn
at risk
by 2030

Largest non-Paris compliant projects sanctioned by oil and gas majors since 2018

Carbon Tracker has identified \$50 billion of investment in 19 major projects that are not even consistent with a 1.7-1.8°C pathway and would require oil prices of nearly \$60 per barrel or more to deliver adequate returns. They include:

Resource theme	Project	IOC partners	2019-2030 capex	Country	Scenario compliant
	LNG Canada T1, T2	Shell	\$13 bn	Canada	No No
	Gorgon/Jansz Stage 2	Shell, Chevron, ExxonMobil	\$3.6 bn	Australia	No No
	Aspen Phase 1	ExxonMobil	\$2.6 bn	Canada	No No
	Amoca FFD	Eni	\$1.4 bn	Mexico	No No
	Zinia 2	BP, ExxonMobil, Total, Equinor	\$1.3 bn	Angola	No No

Investment decisions on a further \$21 billion in 12 projects inconsistent with a low-carbon world are due this year.

These projects represent an imminent challenge for investors and companies looking to align with climate goals.

Demand / global warming scenarios:

B2DS	SDS	NPS
1.6°C	1.7 - 1.8°C	2.7°C

The Economist

Iran's dangerous game

Lessons from a Wall Street titan

Why rent controls are wrong-headed

Goddess of the Taiwan Strait

SEPTEMBER 21ST-27TH 2019

The climate issue

1850

1900

1950

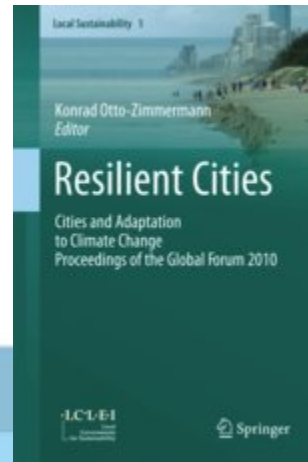
2000

ROTTERDAM RESILIENCE STRATEGY.

READY FOR THE
21ST CENTURY

CONSULTATION
DOCUMENT

Città resilienti e sostenibili



The Risks

As more people and assets become rapidly concentrated in cities and as infrastructure struggles to keep up with rapid growth, the risk from natural disasters and climate change is rising.

collapsed buildings

landslides

broken bridges

brownouts

fires

flooding





**Mitigazione = riqualificazione per efficienza
energetica e minori emissioni**

**Più energie rinnovabili ed
efficienza energetica abitazioni**

Favorire mobilità elettrica



Meno viaggi aerei, meno trasporti
in genere, più telelavoro



Allevamento: vale 15% delle emissioni globali
Ridurre la quota di carne rossa nella dieta e sostenere
agricoltura biologica e a filiera corta



MENO **È MEGLIO**

RIDURRE CARNE E PRODOTTI
LATTIERO-CASEARI
PER UNA VITA E UN
PIANETA PIÙ SANI

Fermare la cementificazione, il suolo non è infinito!

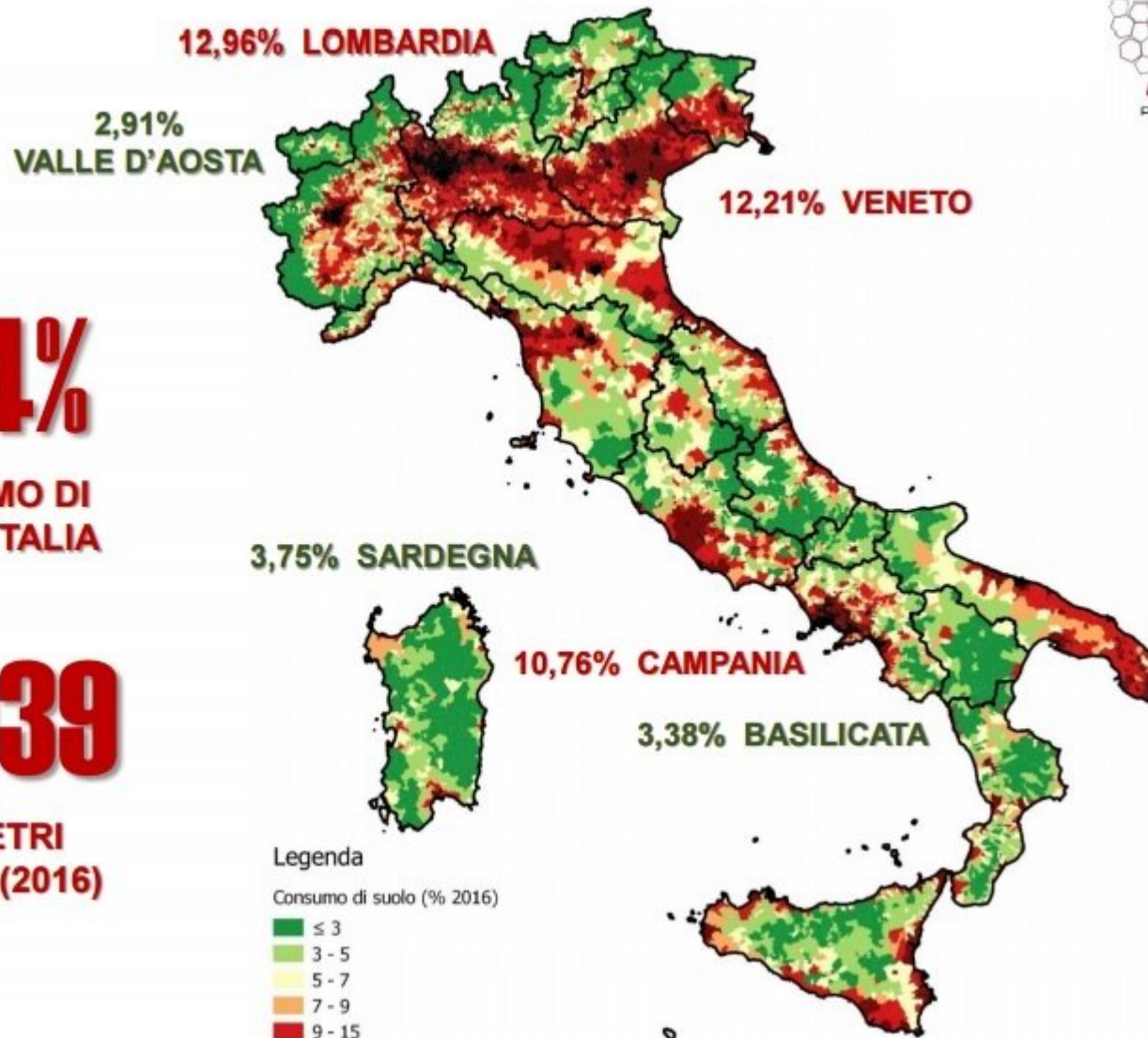


7,64%

**IL CONSUMO DI
SUOLO IN ITALIA**

23.039

**CHILOMETRI
QUADRATI (2016)**



Al lavoro! Gli obiettivi UN dell'Agenda 2030



“The wedding cake” - organizzazione gerarchica dei Sustainable Development Goals (SDGs) - Da Johan Rockström and Pavav Sukhdev - Stockholm Resilience Centre





A RACE WE CAN WIN

“Climate change is the defining issue of our time – and we are at a defining moment.”



António Guterres,
United Nations Secretary-General,
10 September, 2018

“Climate change is moving faster than we are.”

“If we do not change course by 2020, we risk missing the point where we can avoid runaway climate change, with disastrous consequences for people and all the natural systems that sustain us.”



A RACE WE CAN WIN

“ The transition to a cleaner, greener future needs to speed up. We stand at a truly "use it or lose it" moment. ”



António Guterres,
United Nations Secretary-General,
10 September, 2018

SPLENDENDO GENERO



**Il tempo è il fattore critico di successo.
Dobbiamo accelerare la transizione!**

LAT. 45:07:18 - LON. 07:24:30 - ALT. 500 M

The only question is how to communicate the gravity of our situation to the non-scientific public. In the words of Kaisa Kosonen, an observer at the negotiations, “Scientists might want to write in capital letters, ‘ACT NOW, IDIOTS,’ but they need to say that with facts and numbers.”

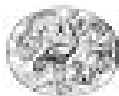
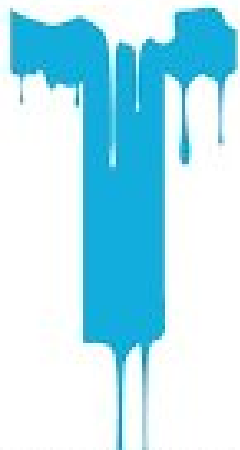
A large, white rectangular sign is positioned in the center of the frame, supported by several thin blue metal legs. The sign features the text 'ACT NOW IDIOTS' in a very large, bold, black, sans-serif font, arranged in three lines. The background is a desert landscape with several palm trees of varying heights and a large, multi-story orange building with arched windows and balconies in the distance. The sky is a clear, pale blue. The ground in the foreground is sandy and appears to be a construction or undeveloped area.

**ACT
NOW
IDIOTS**

LUCA MERCALLI

NON C'È PIÙ TEMPO

COME REAGIRE AGLI ALLARMI AMBIENTALI




È come fermare il tempo che inizia a scorrere per comprendere che quello climatico e ambientale è un'emergenza di cui dobbiamo preoccuparci.

LUCA MERCALLI PREPARIAMOCI

A VIVERE IN UN MONDO
CON MENO RISORSE,
MENO ENERGIA,
MENO ABBONDANZA...
E FORSE PIÙ FELICITÀ



 chiarolettere

LE SCOPERTE • LE INVENZIONI I

IL CLIMA CHE CAMBIA

PERCHÉ IL RISCALDAMENTO
GLOBALE È UN PROBLEMA VERO,
E COME FARE PER FERMARLO

LUCA
MERCALLI

BUR
Rizzoli