Laurea in Ingegneria per l’Ambiente ed il Territorio

CAMBIAMENTI CLIMATICI E ADATTAMENTI NEGLI ECOSISTEMI E NELLE SOCIETÀ

Docenti

Salvatore Pappalardo

Daniele Codato

Alessandro Ceppi (Politecnico di Milano)

Supporto didattico

Edoardo Crescini

- 6 CFU
- 48 ore
- 102 ore di studio individuale

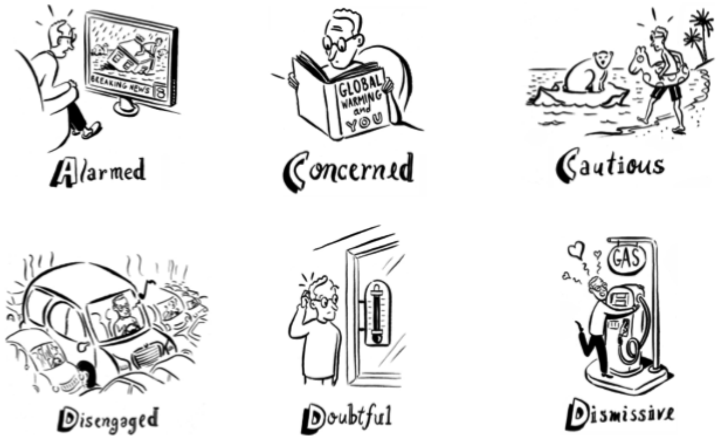
Outline

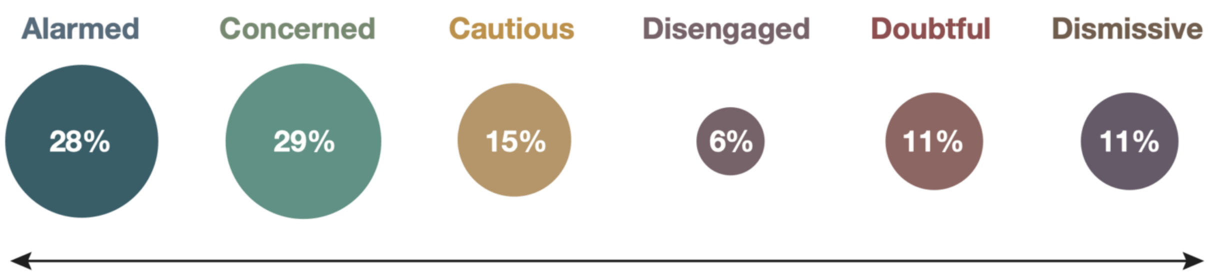
'La cassetta degli attrezzi'

- Quantificare il cambiamento climatico
- Scale spaziali / scale temporali
- Analisi dati meteorologici e climatici (data driven)

Risultati sondaggio "Opinioni e pensieri sui cambiamenti climatici"

https://docs.google.com/forms/d/e/1FAIpQLScBDV2M8cOvqIL5YMVpkb3hcKJyZgii5lBreQgeXsD6y-acww/viewanalytics?pli=1&pli=1





Highest Belief in Global Warming
Most Concerned
Most Motivated

Lowest Belief in Global Warming
Least Concerned
Least Motivated

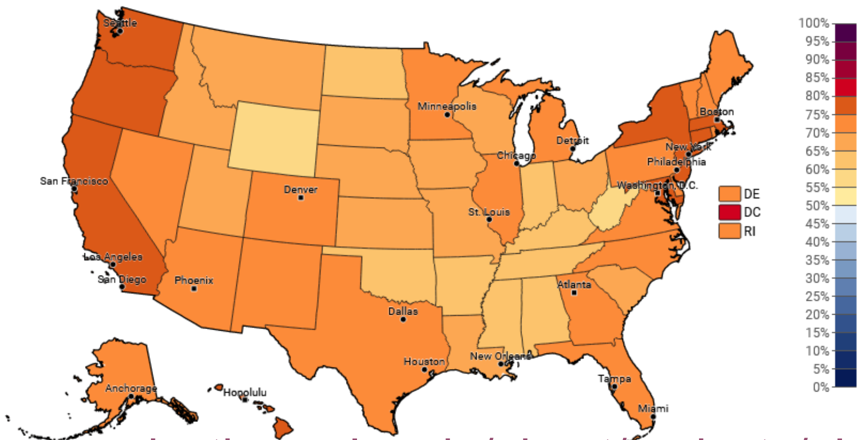
Global Warming's Six Americas, Fall 2023
Base: 1,033 U.S. adults

Source: Yale Program on Climate Change Communication;
George Mason University Center for Climate Change Communication

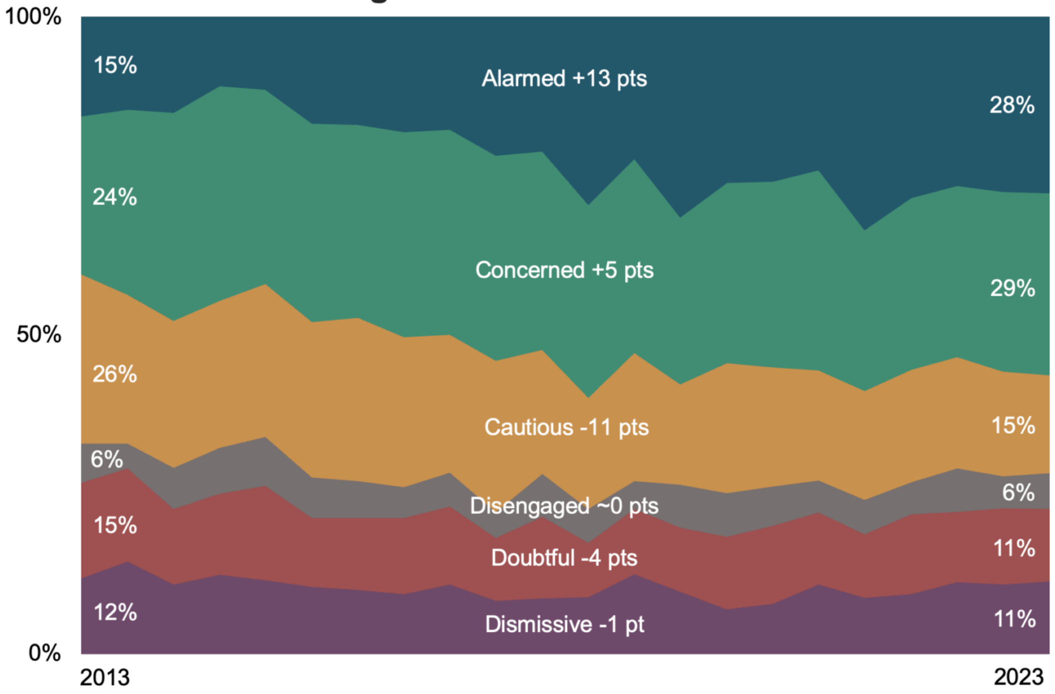
Estimated % of adults who think global warming is happening (nat'l avg. 72%), 2023

Select Question: Global warming is happening
Click map or: Select a State
Absolute Value

National | States | Cong. Districts | Metro Areas | Counties



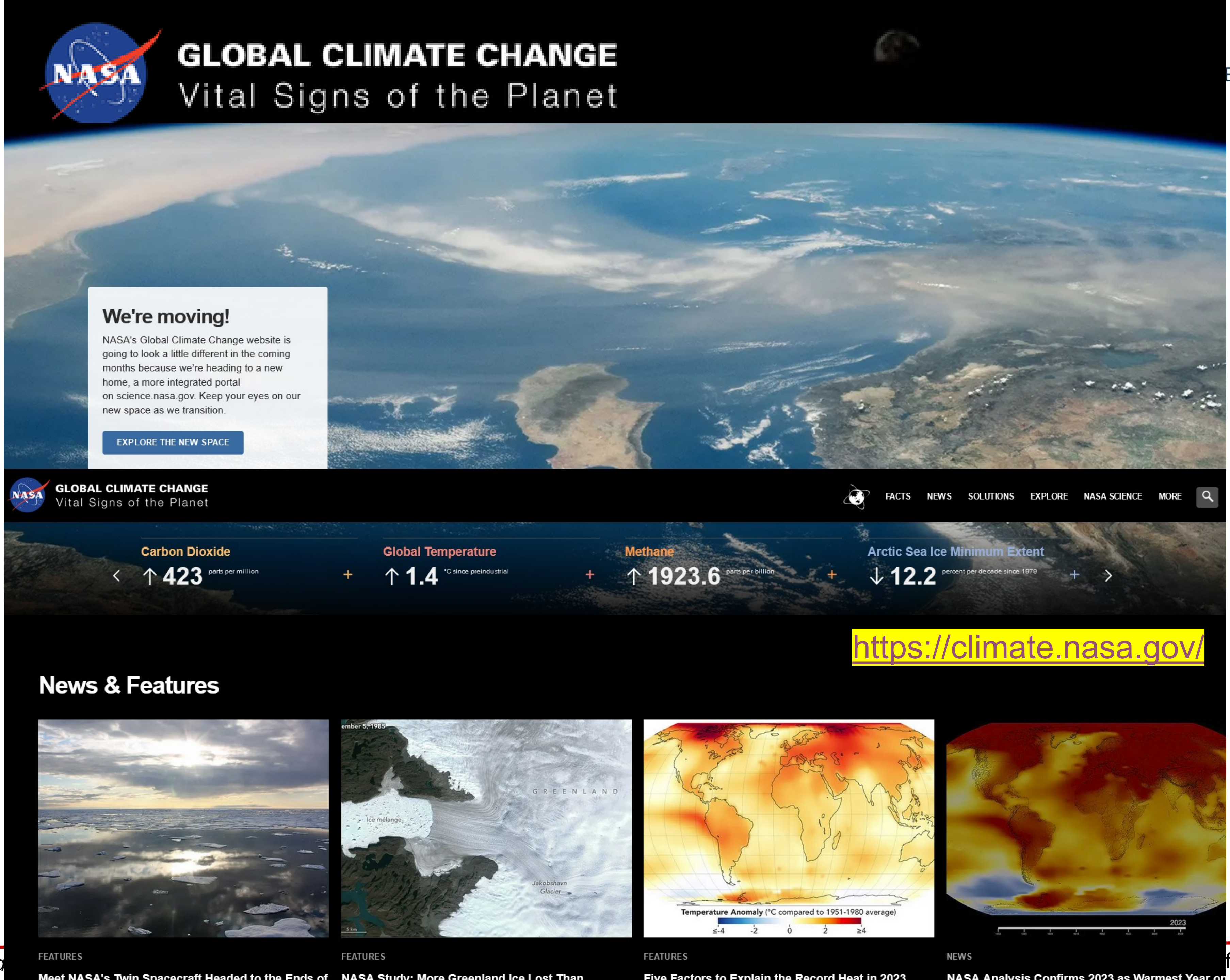
Global Warming's Six Americas Over the Last Decade



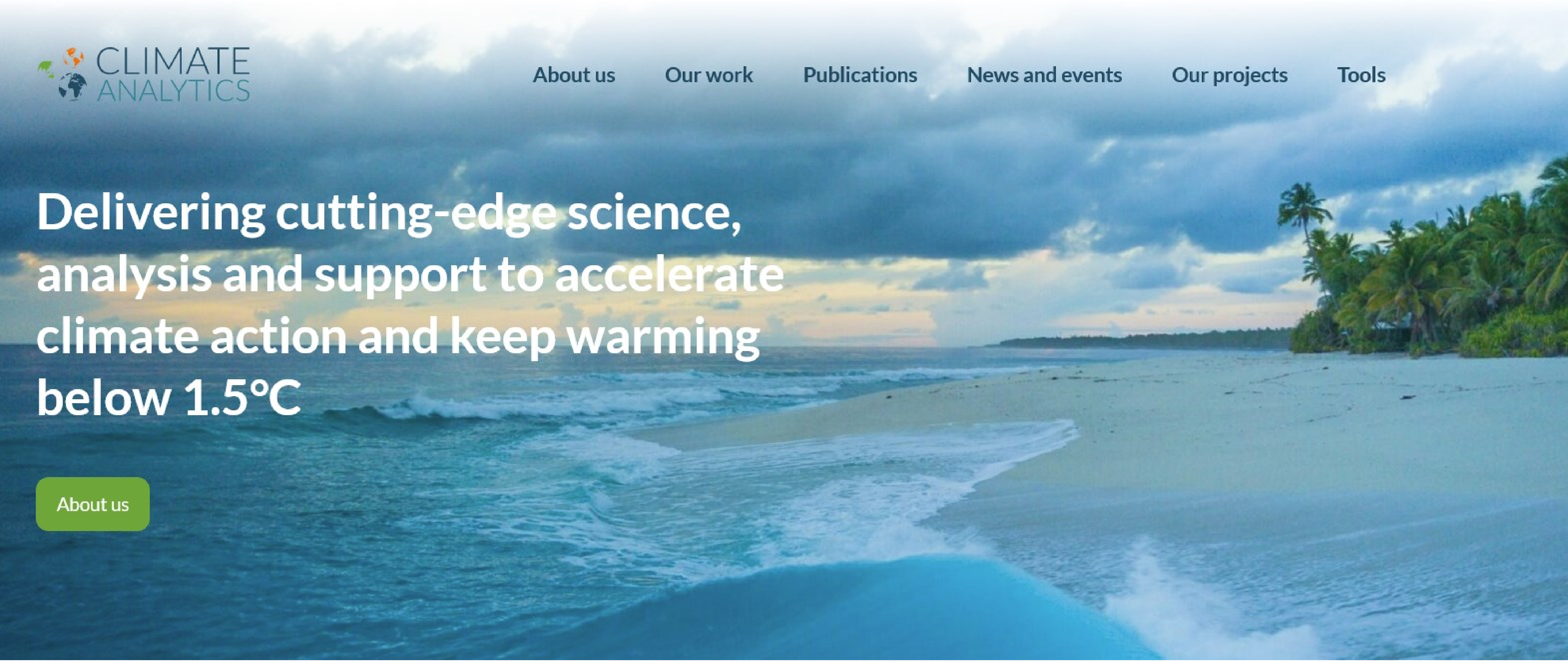
Base: 25,368 U.S. adults. Data include 22 waves of national surveys spanning April 2013 – October 2023.

Source: Yale Program on Climate Change Communication;
George Mason University Center for Climate Change Communication

https://climatecommunication.yale.edu/about/projects/global-warmings-six-americas/


GLOBAL CLIMATE CHANGE
Vital Signs of the Planet
We're moving!
NASA's Global Climate Change website is going to look a little different in the coming months because we're heading to a new home, a more integrated portal on science.nasa.gov. Keep your eyes on our new space as we transition.
EXPLORE THE NEW SPACE
FACTS
NEWS
SOLUTIONS
EXPLORE
NASA SCIENCE
MORE
Carbon Dioxide
423 parts per million
Global Temperature
1.4 °C since preindustrial
Methane
1923.6 parts per billion
Arctic Sea Ice Minimum Extent
12.2 percent per decade since 1979
https://climate.nasa.gov/
News & Features
FEATURES
Meet NASA's Twin Spacecraft Headed to the Ends of
FEATURES
NASA Study: More Greenland Ice Lost Than
FEATURES
Five Factors to Explain the Record Heat in 2023
NEWS
NASA Analysis Confirms 2023 as Warmest Year on

https://www.cmcc.it/it



https://climateanalytics.org/

Istituto di Scienze dell'Atmosfera e del Clima

L'Istituto di Scienze dell'Atmosfera e del Clima (CNR-ISAC) promuove e sviluppa una comprensione scientifica integrata dell'atmosfera, dell'oceano e dei loro processi, tramite un approccio multidisciplinare.

News

01-03-2024

Un approccio più preciso per la stima delle emissioni di CO_2

26-02-2024

7° Bando per Trans-National Access – ATMO-ACCESS

22-02-2024

Al cinema in difesa della foresta amazzonica – Almanacco della Scienza

15-02-2024

L'artico sta perdendo la memoria sul clima

https://www.isac.cnr.it/it

Fonti attendibili per acquisire conoscenze sui cambiamenti climatici:

- 3 a scala globale
- 3 a scala europea
- 3 a scala italiana

Quantificare il cambiamento climatico
Unità di misura

Unità Fondamentali – Sistema Internazionale

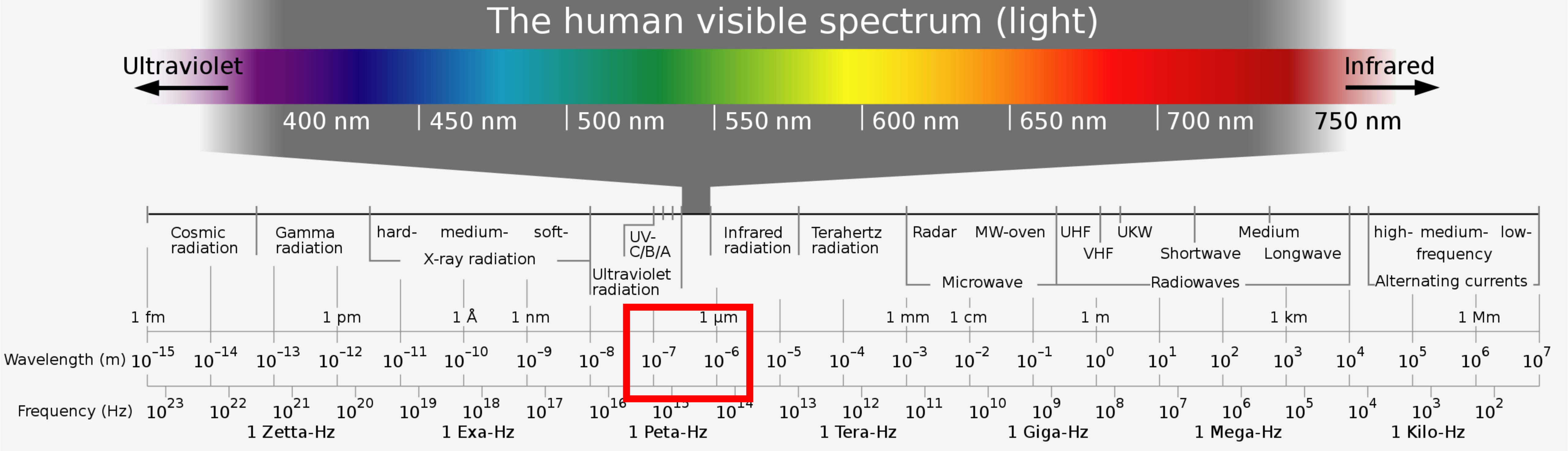
Quantity	Unit	Symbol	Definition
Length	**meter**	**m**	1983, 17th CGPM: The path travelled by light in vacuum during a time interval of 1/299792458 seconds. This fixes the speed of light to **exactly** 299792458 m/s.
Mass	**kilogram**	**kg**	1901, 3rd CGPM: Mass of the platinum-iridium prototype at BIPM in Sevres.
Time	**second**	**s**	1968, 13th CGPM: One second equals 9192631770 periods of the radiation due to the transition between the two hyperfine levels of the ground state of Cesium 133.
Electric current	**ampere**	**A**	1948, 9th CGPM: Given two parallel, rectilinear conductors of negligible circular cross-section positioned 1 m apart in vacuum, one ampere is the electric current which, passing through both of them, makes them attract each other by the force of 2.10^{-7} newtons per every meter of length. This fixes the permeability of vacuum to **exactly** $2\pi*10^{-7}$ H/m.
Temperature	**kelvin**	**K**	1968, 13th CGPM: One degree K equals 1/273.16 of the thermodynamic temperature of the triple point of water.
Quantity of substance	**mole**	**mol**	1971, 14th CGPM: The **amount of a substance** composed of as many specified elementary units (molecules, atoms) as there are atoms in 0.012 kg of Carbon 12.
Luminosity	**candle**	**cd**	1979, 16th CGPM: The candle (or candela) is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540.10^{12} hertz and that has a radiant intensity in that direction of 1/683 W/sr.

Unità derivate e quantità

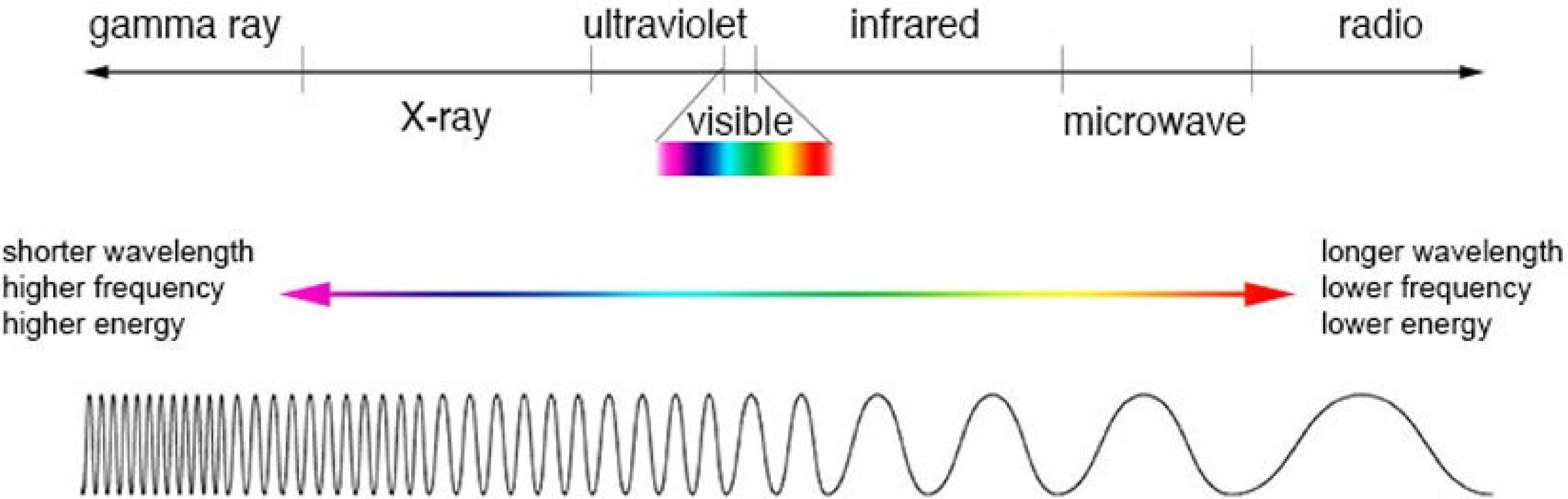
Name	Symbol	Quantity	Expressed in terms of other SI units	Expressed in terms of SI base units
radian	rad	angle		$m \cdot m^{-1}$
steradian	sr	solid angle		$m^2 \cdot m^{-2}$
hertz	Hz	frequency		s^{-1}
newton	N	force, weight		$kg \cdot m \cdot s^{-2}$
pascal	Pa	pressure, stress	N/m^2	$kg \cdot m^{-1} \cdot s^{-2}$
joule	J	energy, work, heat	$N \cdot m$	$kg \cdot m^2 \cdot s^{-2}$
watt	W	power, radiant flux	J/s	$kg \cdot m^2 \cdot s^{-3}$
coulomb	C	electric charge or quantity of electricity		$s \cdot A$
volt	V	voltage (electrical potential difference), electromotive force	W/A	$kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}$
farad	F	electric capacitance	C/V	$kg^{-1} \cdot m^{-2} \cdot s^4 \cdot A^2$
ohm	Ω	electric resistance, impedance, reactance	V/A	$kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}$
siemens	S	electrical conductance	A/V	$kg^{-1} \cdot m^{-2} \cdot s^3 \cdot A^2$
weber	Wb	magnetic flux	$V \cdot s$	$kg \cdot m^2 \cdot s^{-2} \cdot A^{-1}$
tesla	T	magnetic field strength	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
henry	H	inductance	Wb/A	$kg \cdot m^2 \cdot s^{-2} \cdot A^{-2}$
degree Celsius	°C	temperature relative to 273.15 K		K

Prefissi unità SI

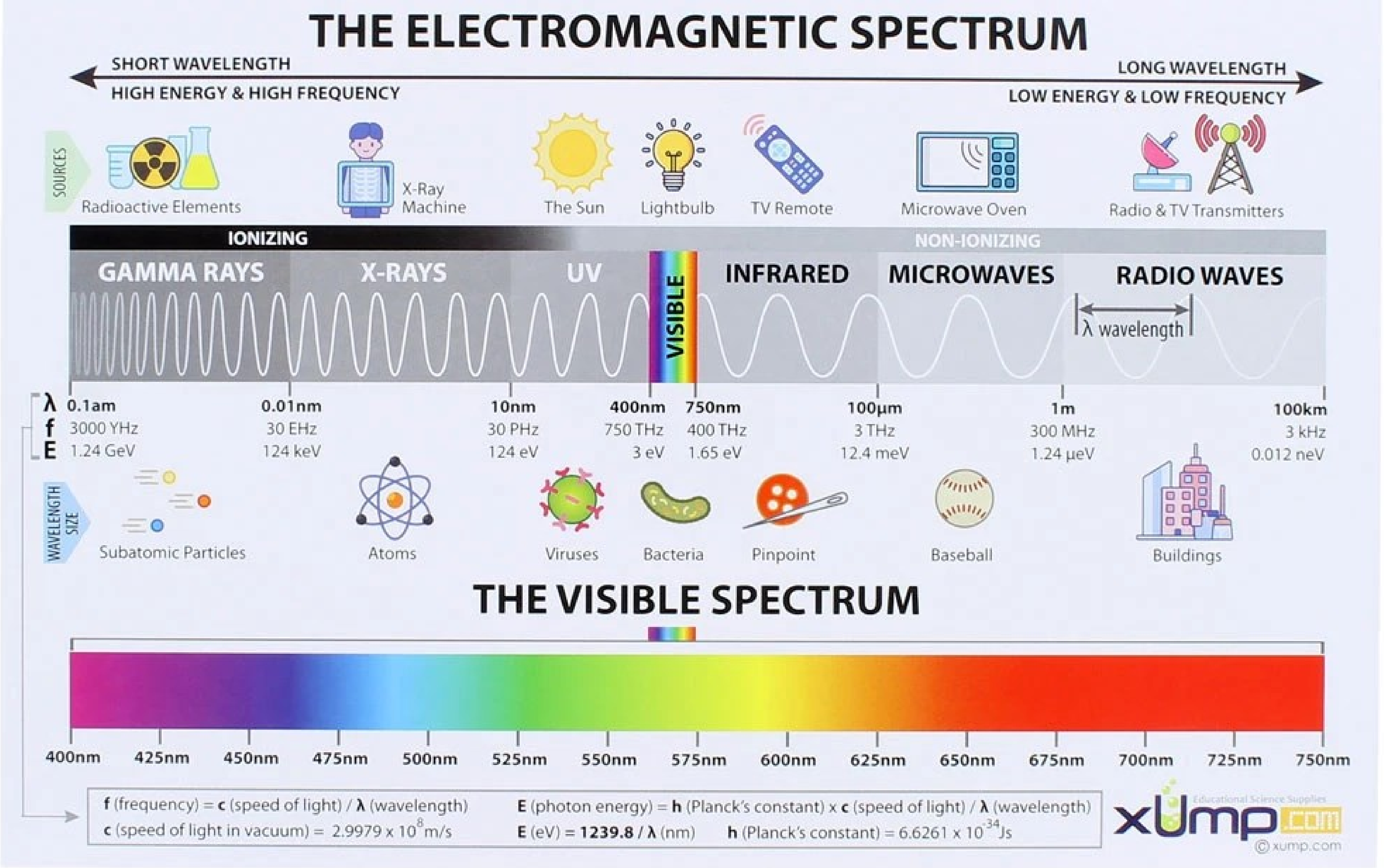
Prefix	Symbol	Factor	Examples of usage	Origin
Yotta	Y	10^{24}	0.2 YW, 1.23Y [W]	Greek 'octo' (eight, 1000^8)
Zetta	Z	10^{21}	3.33 Zs, 3.33Z [s]	French 'sept' (seven, 1000^7)
Exa	E	10^{18}	1.23 Ekg, 1.23E [kg]	Greek 'six' (1000^6)
Peta	P	10^{15}	7.5 Ps, 7.5P [s]	Greek 'five' (1000^5)
Tera	T	10^{12}	0.5 Tm, 0.5T [m]	Greek 'teras' = monster
Giga	G	10^9	1.2 GΩ, 1.2G [Ω]	Greek 'gigas' = giant
Mega	M	10^6	7 MW, 7M [W]	Greek 'megas' = large
Kilo	K, k	10^3	33 km, 33K [m]	Greek 'kilioi' = thousand
hecto	h	100	Deprecated by SI	Greek 'hekaton' = hundred
deca	da	10	Deprecated by SI	Greek 'deka' = ten
deci	d	0.1	Deprecated by SI	Latin 'decima pars' = one tenth
centi	c	0.01	Deprecated by SI	Latin 'centesima pars' = one hundredth
milli	m, k	10^{-3}	22 mm , 1.2m [m]	Latin 'millesima pars' = one thousandth
micro	µ, u	10^{-6}	2.7 uJ , 2.7µ [J]	Greek 'mikros' = small
nano	n	10^{-9}	2.2 nF, 2.2n [F]	Latin 'nanus' = dwarf
pico	p	10^{-12}	1.5 pA, 1.5p [A]	Spanish 'pico' = minimal measure
femto	f	10^{-15}	4.8 fs, 4.8f [s]	Danish and Norvegian 'femten' = fifteen (10^{-15})
atto	a	10^{-18}	1.2 ag, 1.2a [g]	Danish and Norvegian 'atten' = eighteen (10^{-18})
zepto	z	10^{-21}	0.2 zm, 1.2z [m]	French 'sept' (seven, 1000^{-7})
yocto	y	10^{-24}	1 ys, 1y [s]	Greek 'octo' (eight, 1000^{-8})



The human visible spectrum (light)
Ultraviolet
Infrared
400 nm
450 nm
500 nm
550 nm
600 nm
650 nm
700 nm
750 nm
Cosmic radiation
Gamma radiation
hard- medium- soft-
X-ray radiation
UV-C/B/A
Ultraviolet radiation
Infrared radiation
Terahertz radiation
Radar
MW-oven
Microwave
UHF
VHF
UKW
Shortwave
Medium
Longwave
Radiowaves
high- medium- low-
frequency
Alternating currents
1 fm
1 pm
1 Å
1 nm
1 µm
1 mm
1 cm
1 m
1 km
1 Mm
Wavelength (m) 10^{-15} 10^{-14} 10^{-13} 10^{-12} 10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6} 10^{7}
Frequency (Hz) 10^{23} 10^{22} 10^{21} 10^{20} 10^{19} 10^{18} 10^{17} 10^{16} 10^{15} 10^{14} 10^{13} 10^{12} 10^{11} 10^{10} 10^{9} 10^{8} 10^{7} 10^{6} 10^{5} 10^{4} 10^{3} 10^{2}
1 Zetta-Hz
1 Exa-Hz
1 Peta-Hz
1 Tera-Hz
1 Giga-Hz
1 Mega-Hz
1 Kilo-Hz



gamma ray
ultraviolet
infrared
radio
X-ray
visible
microwave
shorter wavelength
higher frequency
higher energy
longer wavelength
lower frequency
lower energy


THE ELECTROMAGNETIC SPECTRUM
SHORT WAVELENGTH
HIGH ENERGY & HIGH FREQUENCY
LONG WAVELENGTH
LOW ENERGY & LOW FREQUENCY
SOURCES
Radioactive Elements
X-Ray Machine
The Sun
Lightbulb
TV Remote
Microwave Oven
Radio & TV Transmitters
IONIZING
NON-IONIZING
GAMMA RAYS
X-RAYS
UV
VISIBLE
INFRARED
MICROWAVES
RADIO WAVES
λ wavelength
λ 0.1am 0.01nm 10nm 400nm 750nm 100μm 1m 100km
f 3000 YHz 30 EHz 30 PHz 750 THz 400 THz 3 THz 300 MHz 3 kHz
E 1.24 GeV 124 keV 124 eV 3 eV 1.65 eV 12.4 meV 1.24 μeV 0.012 neV
WAVELENGTH SIZE
Subatomic Particles
Atoms
Viruses
Bacteria
Pinpoint
Baseball
Buildings
THE VISIBLE SPECTRUM
400nm 425nm 450nm 475nm 500nm 525nm 550nm 575nm 600nm 625nm 650nm 675nm 700nm 725nm 750nm
f (frequency) = c (speed of light) / λ (wavelength)
c (speed of light in vacuum) = 2.9979 x 10^8 m/s
E (photon energy) = h (Planck's constant) x c (speed of light) / λ (wavelength)
E (eV) = 1239.8 / λ (nm)
h (Planck's constant) = 6.6261 x 10^-34 Js
xUmp.com
© xump.com

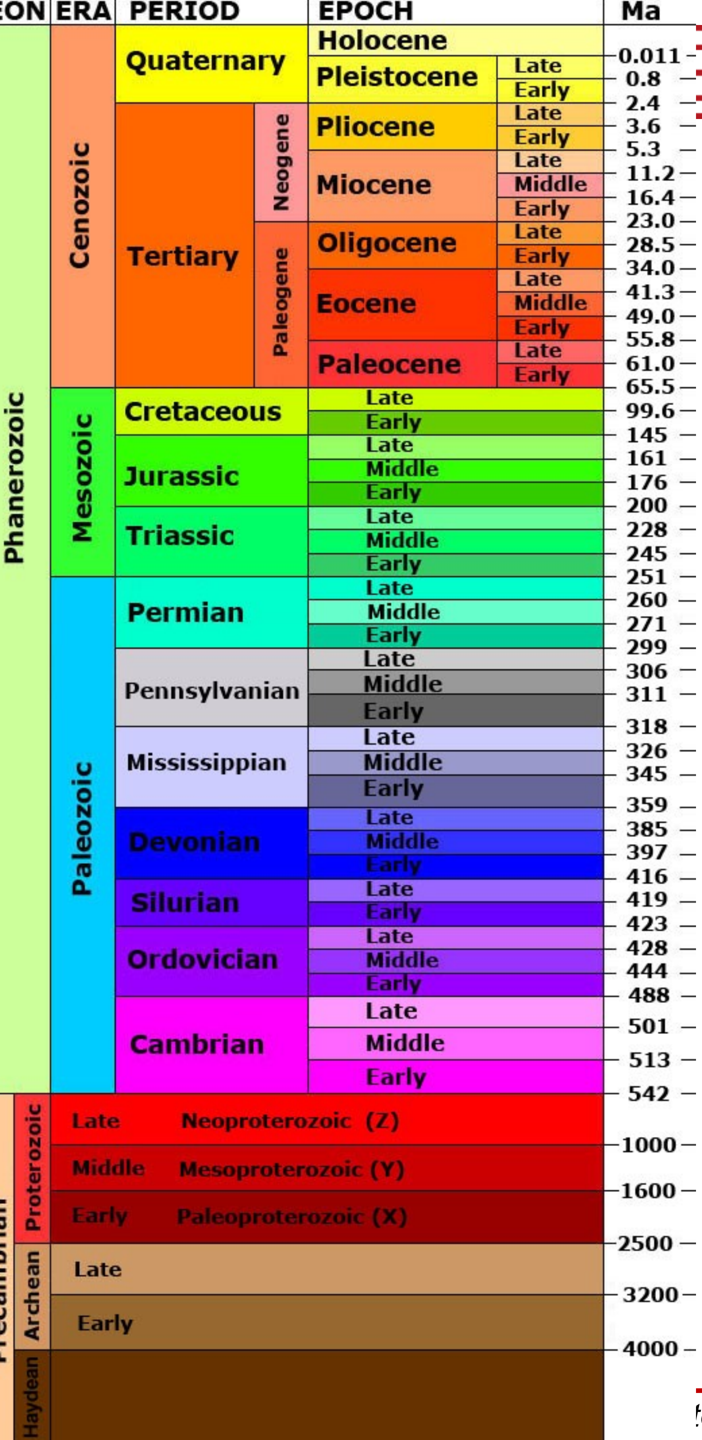
Scale matters. Always.

Scale spaziali
Scale temporali

Meteo e clima
Scale spaziali – scale temporali

Scale spaziali fenomeni meteo-climatici

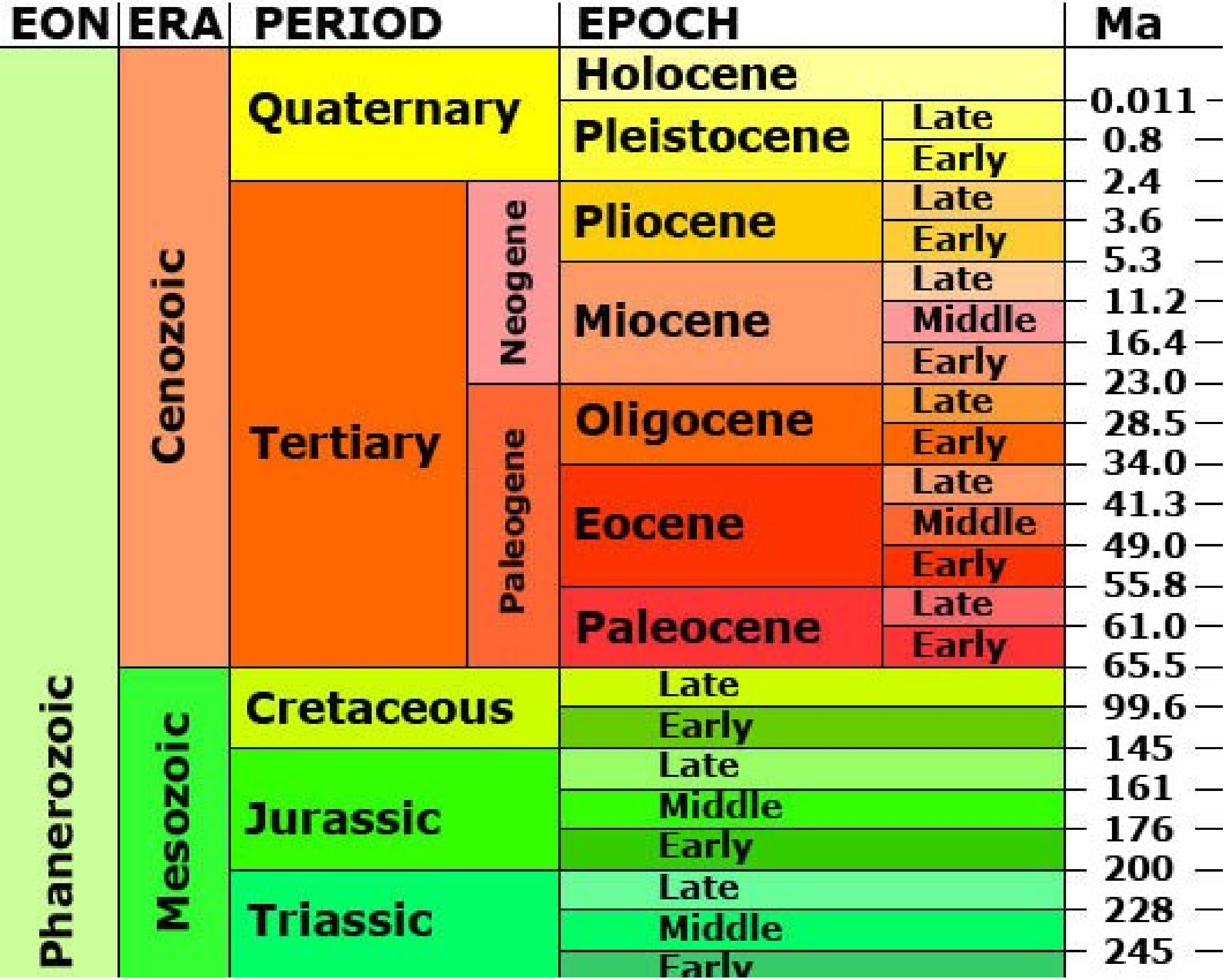
Scala	Dimensione spaziale	Fenomeni (esempi)
Scala planetaria	10.000-20.000 km	Circolazione atmosferica globale
Scala continentale	5.000-10.000 km	El Niño/La Niña
Scala sinottica	1.000-5.000 km	Cicloni tropicali/Ondate di calore
Scala regionale	100-1.000 km	Shift di zone climatiche
Scala locale (meso-scala)	10-100 km	Eventi estremi (nubifragi)
Macroscala	1 m – 1000 m	Microclima, raffiche di vento
Scala microscopica	< mm	Microfisica delle nuvole
Scale amministrative	Regioni/Stati/Confederazioni	



scale temporali

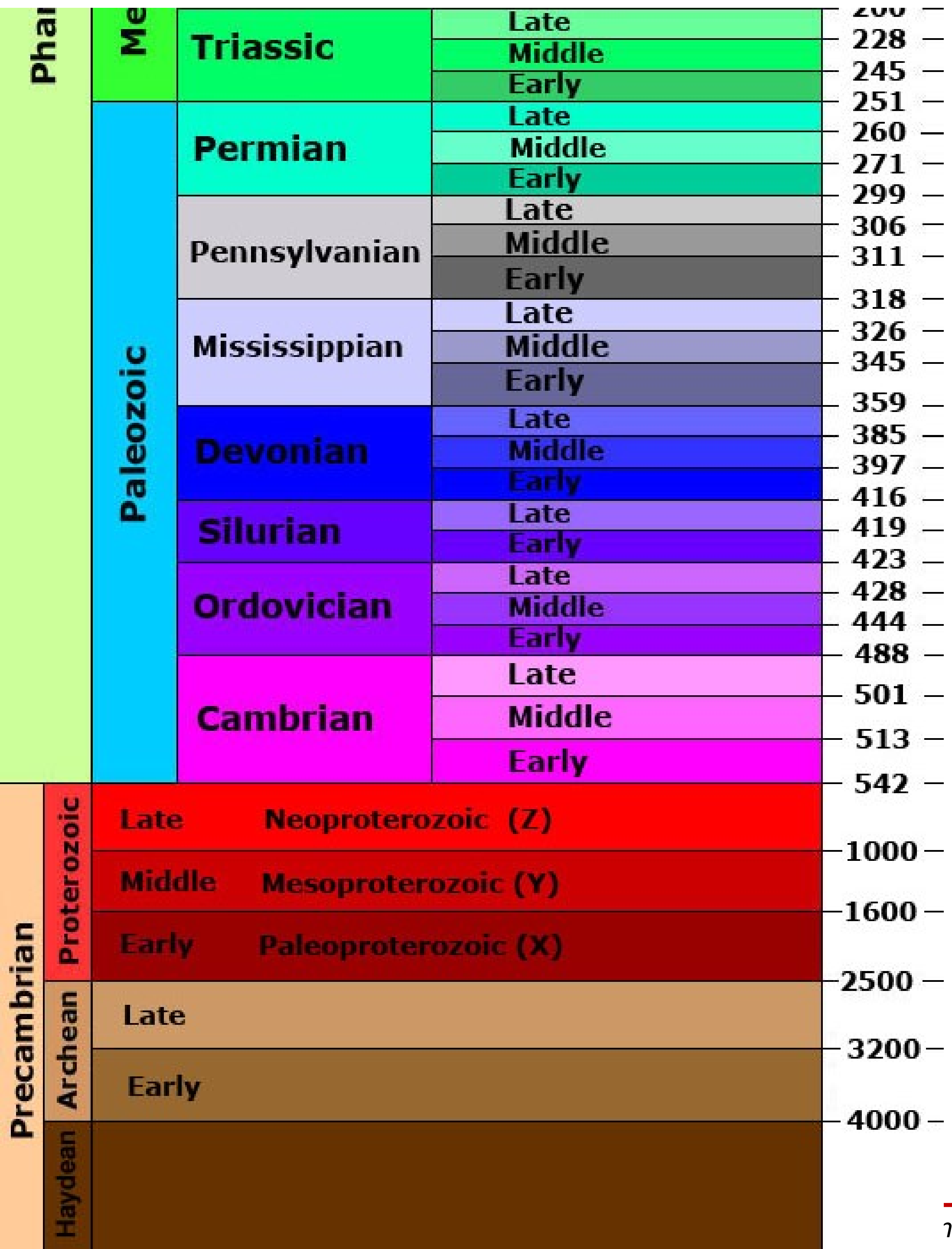
- scale geologiche
- scale umane
- scale anthropogenic *climate change*

- **Eone** miliardi di anni
- **Era** centinaia di milioni di anni
- **Periodo** decine di milioni di anni
- **Epoca** milioni di anni
- **Età** migliaia di anni



scale temporali

- scale geologiche
- scale umane
- scale *climate change*



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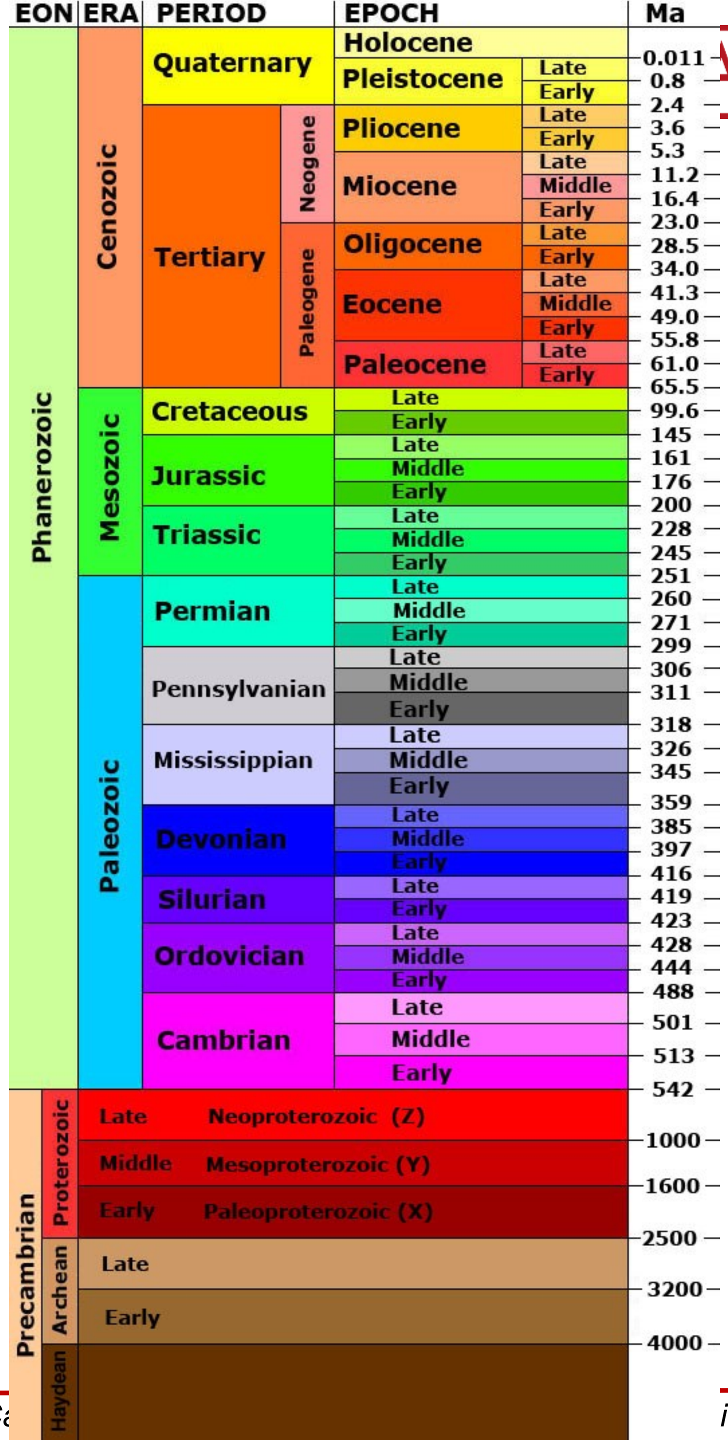
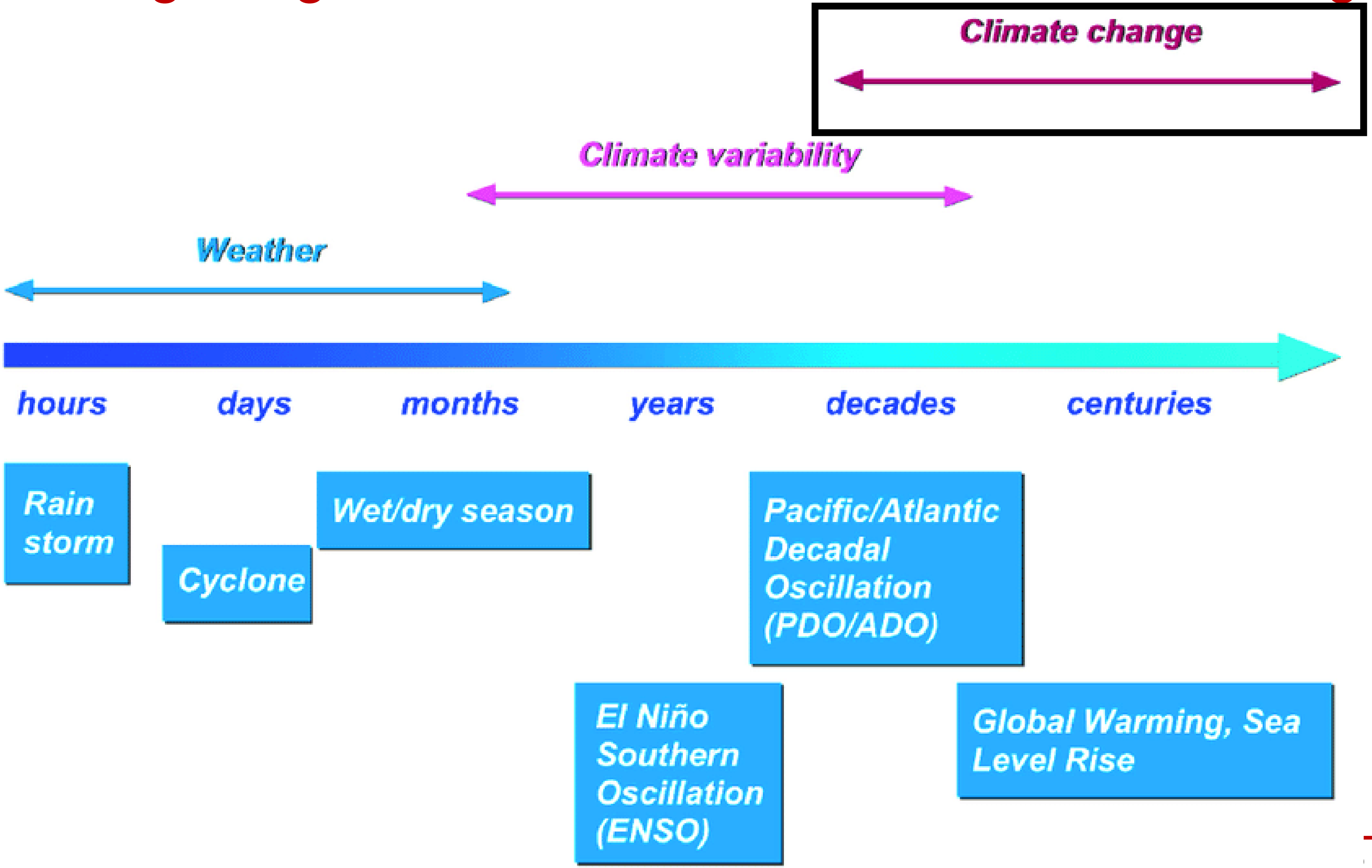
scale temporali

- scale geologiche
- scale umane
- scale *climate change*



Scale temporali

scale geologiche, scale umane, scale climate change



Interpretare il cambiamento climatico: dati, grafici, cartografie

UNIVERSITÀ DEGLI STUDI DI PADOVA

ICEA

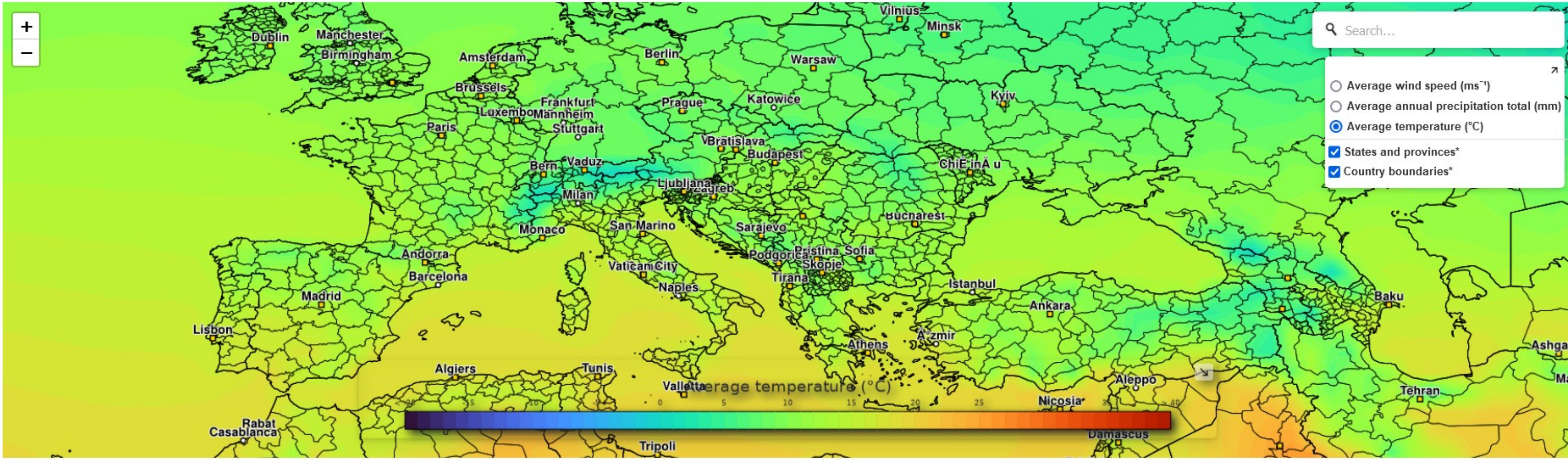
GIScience

Climate Justice Centre of Excellence

Climate Data Store - ERA5 explorer

Click anywhere on the map or search for a city to discover a range of local climate statistics for the period 1979-2020.

This application is driven by ERA5, the fifth generation ECMWF atmospheric reanalysis of the global climate. Inspired by Lobelia's Past Climate Explorer.

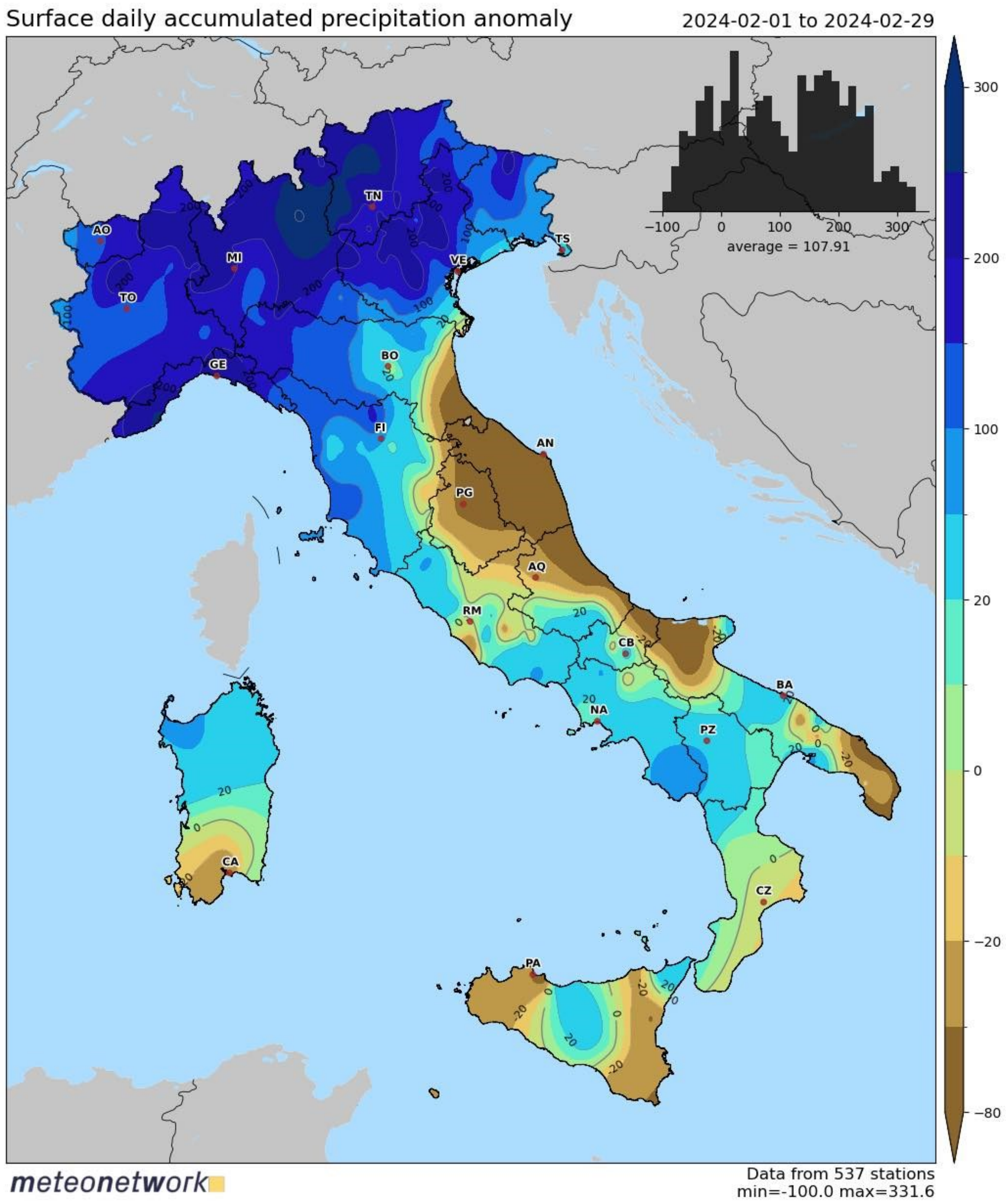


*The designations employed and the presentation of material on the map do not imply the expression of any opinion whatsoever on the part of the European Union concerning the legal status of any country, territory or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

https://cds.climate.copernicus.eu/apps/c3s/app-era5-explorer

https://climateknowledgeportal.worldbank.org/country/italy/climate-data-historical

https://en.climate-data.org/europe/italy/veneto/padua-4354/



GIScience

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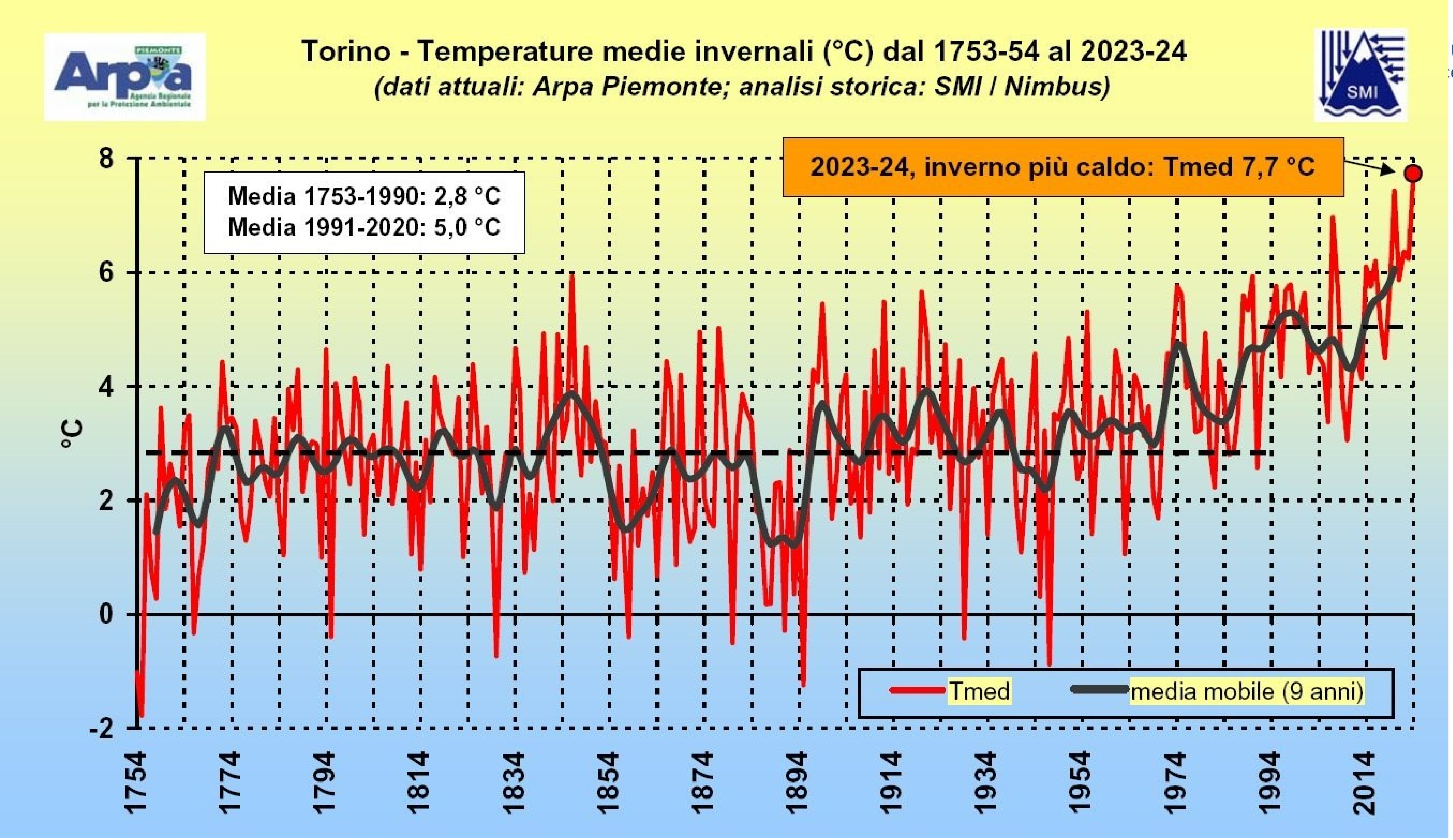
Anomalia pluviometrica di Febbraio 2024

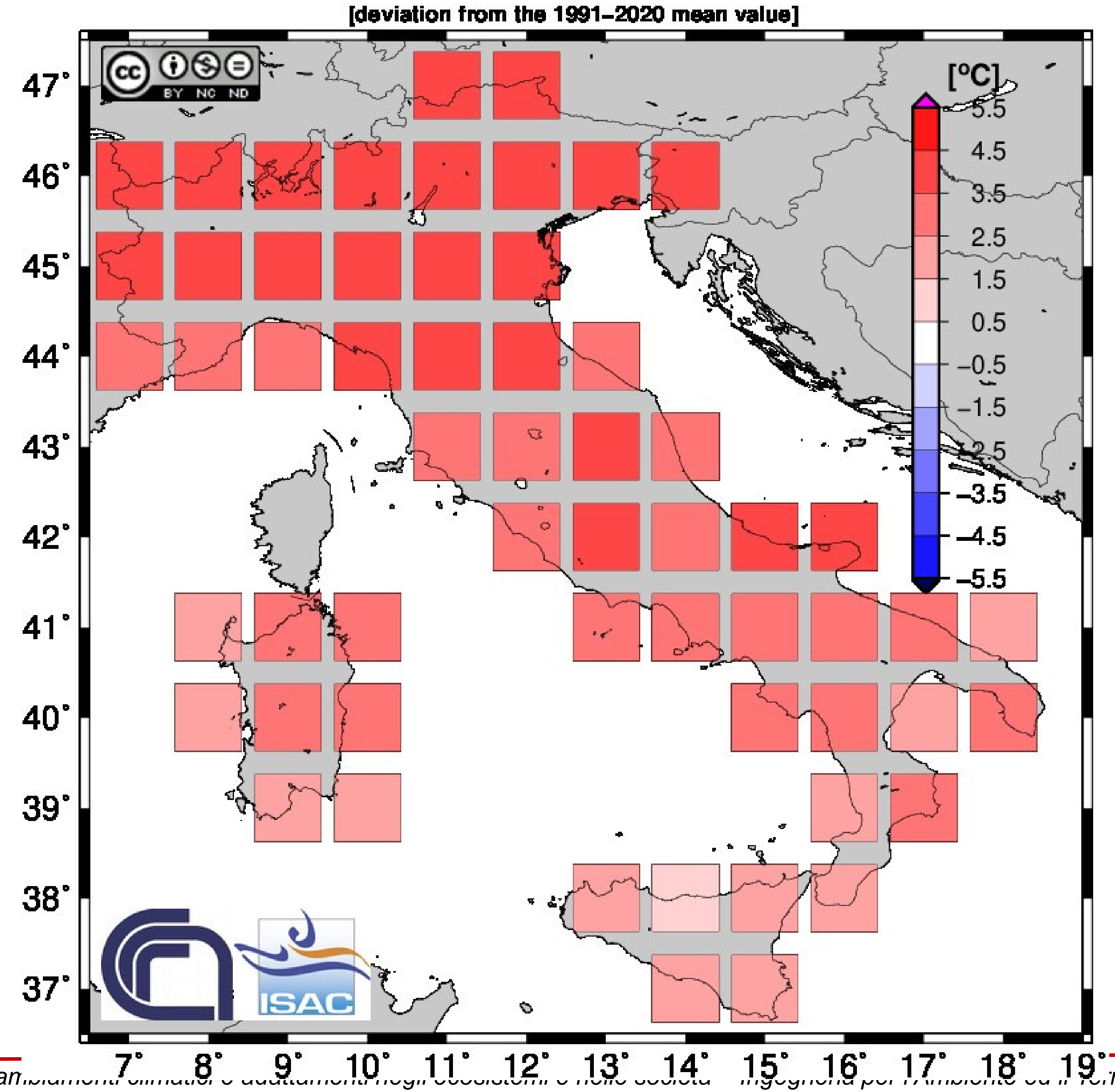
https://www.facebook.com/photo/?fbid=779730384188205&set=a.613478187480093

https://www.meteonetwork.eu/it/mappe



ustice
:ellence

http://www.nimbus.it



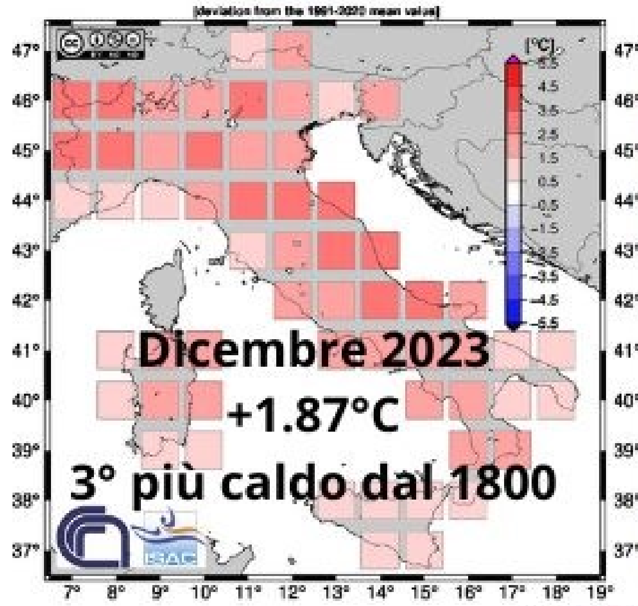
Scala nazionale (amministrativa)

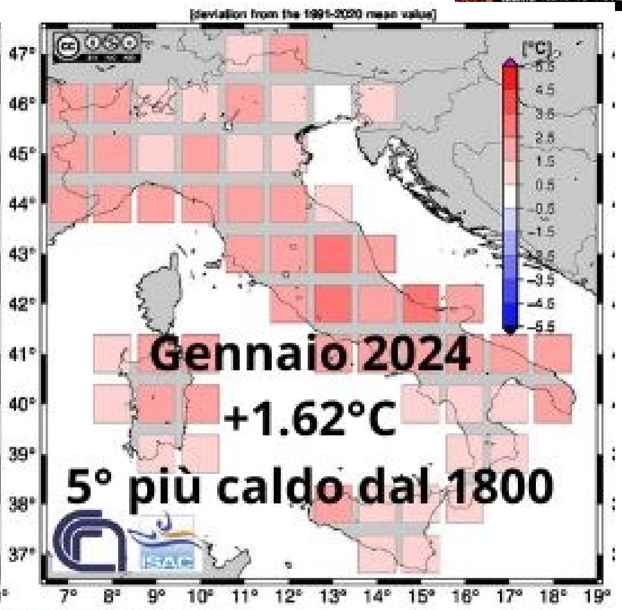
https://www.isac.cnr.it/it

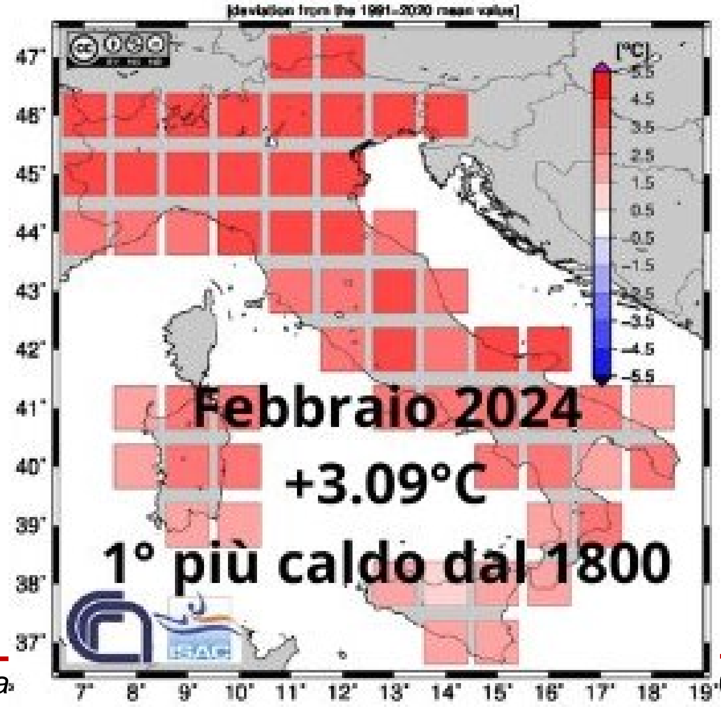
http://isac.cnr.it/climstor/climate_news.html

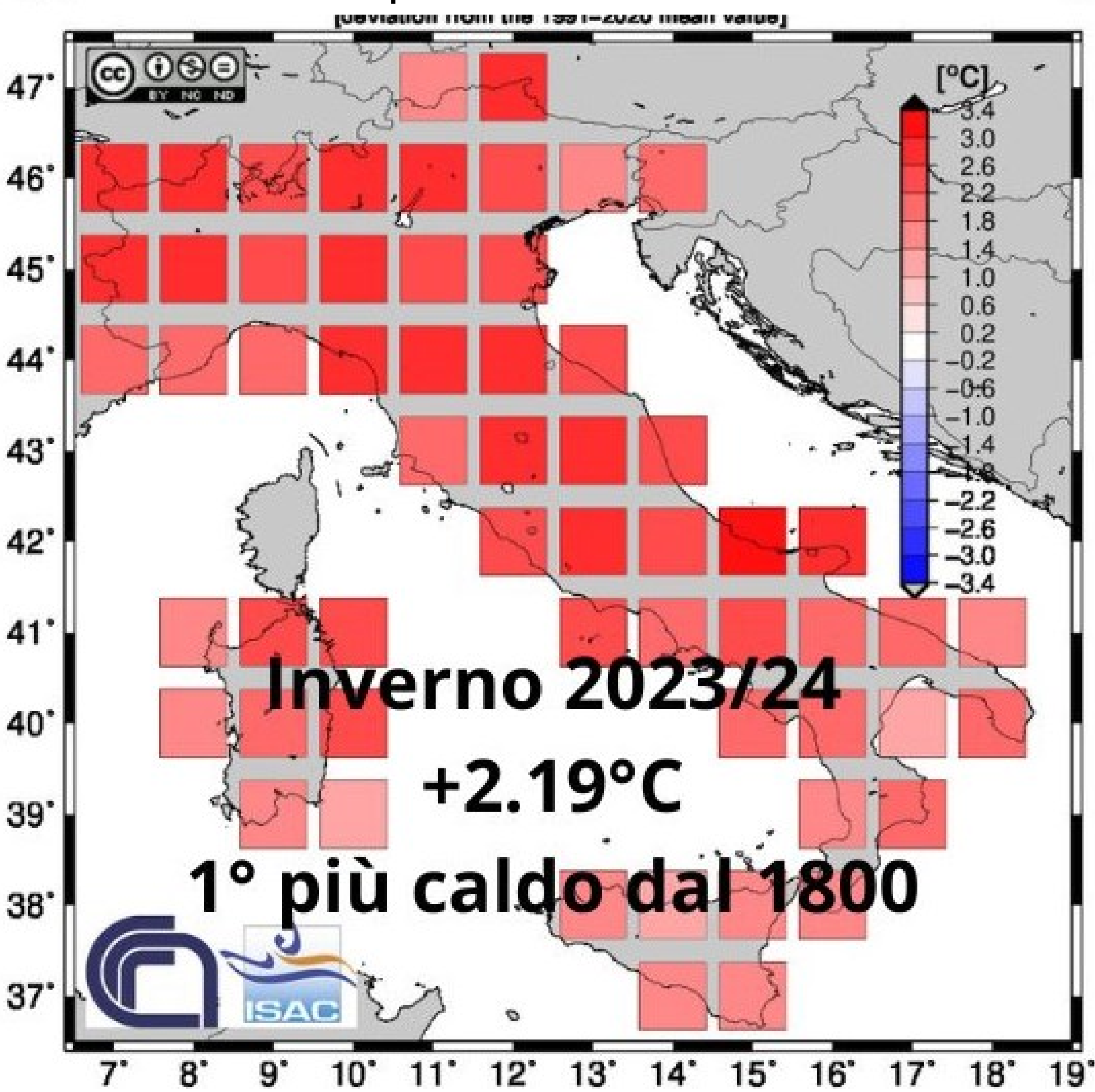
INVERNO 2023/2024

Anomalie rispetto alla **media 1991-2020**









http://isac.cnr.it/climstor/climate_news.html (M. Brunetti 2024)

SCALA GLOBALE

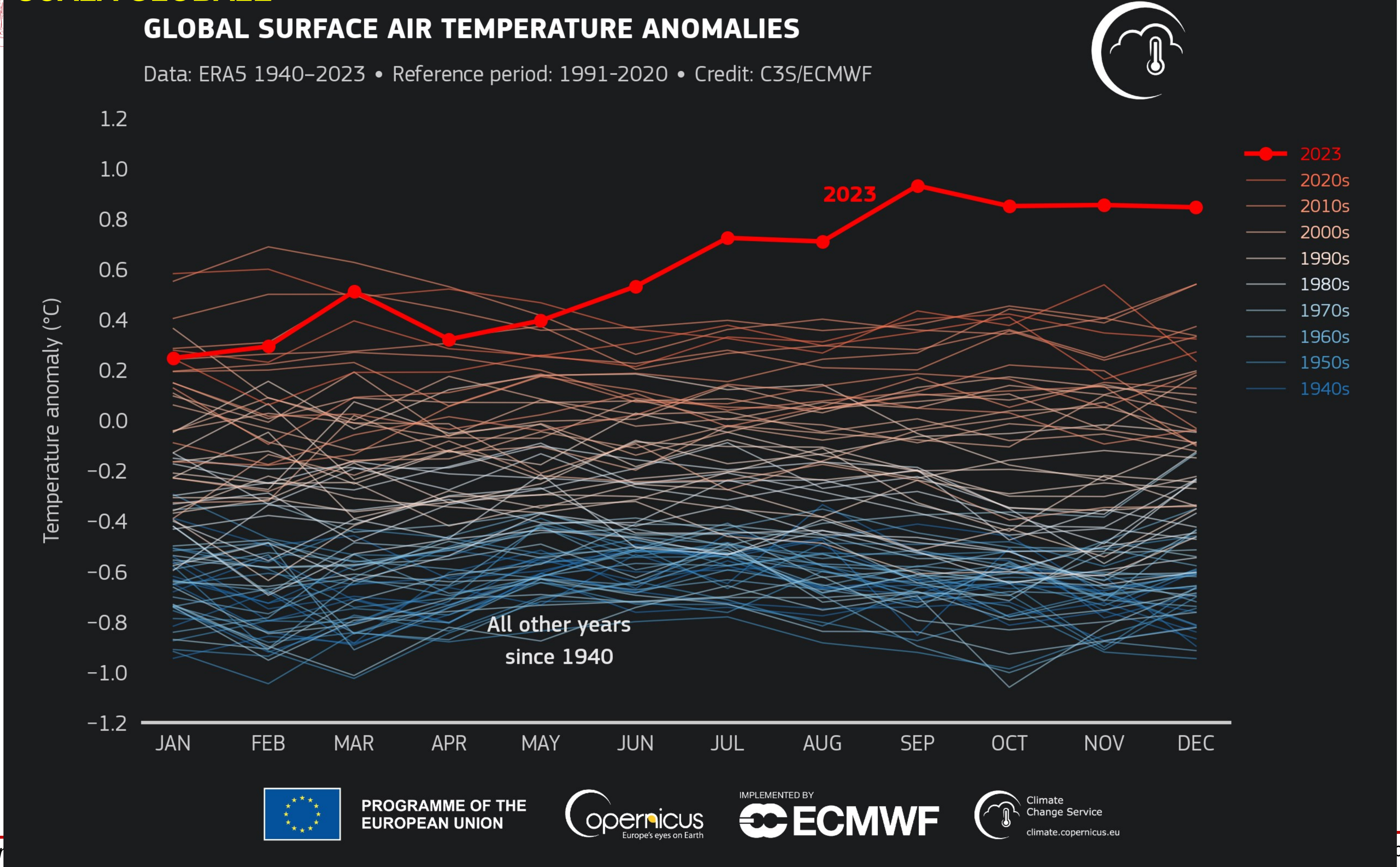
CLASSIFICA DEI MESI PIU' CALDI

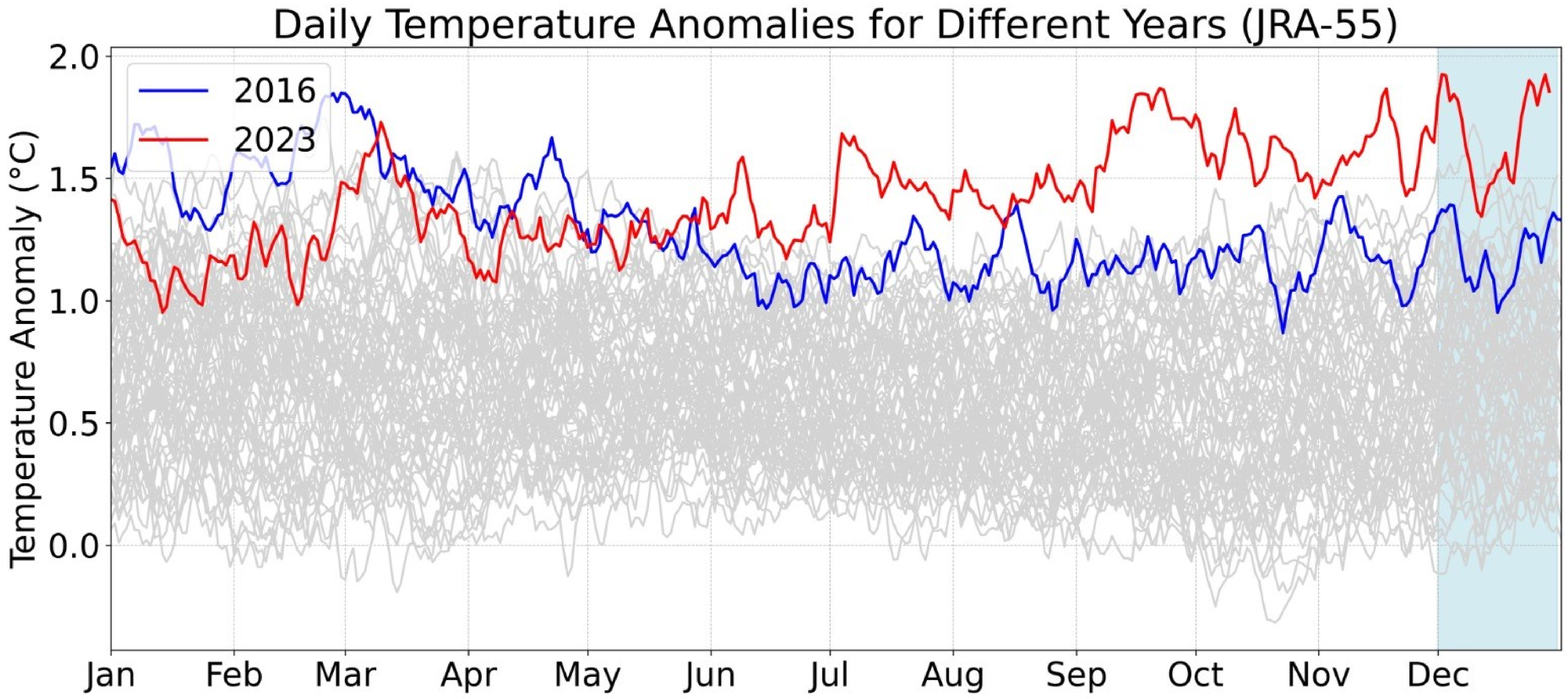
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
	24	18	19	23	13	17	14	22	16	11	20	15	12	10	6	3	5	8	4	2	9	7	1	?
GEN	30	12	15	19	16	22	5	39	18	14	25	28	17	13	8	2	4	10	6	3	11	7	9	1
FEB	28	12	20	14	19	13	15	37	23	10	26	25	18	22	6	1	3	9	5	2	16	7	4	1
MAR	24	9	22	19	15	21	16	14	26	8	18	23	17	13	7	1	5	11	4	3	10	6	2	?
APR	26	19	22	18	14	27	10	24	17	7	15	13	23	9	11	2	5	6	3	1	12	8	4	?
MAG	20	16	19	26	17	23	13	22	15	12	21	11	18	5	9	2	4	8	6	1	10	7	3	?
GIU	23	21	24	27	16	14	19	25	15	12	18	17	11	13	6	7	10	8	4	3	5	2	1	?
LUG	18	14	22	36	15	23	19	17	9	13	11	20	16	21	10	6	8	7	2	5	4	3	1	?
AGO	22	21	18	25	20	12	19	24	14	15	11	16	13	7	9	2	6	10	4	5	8	3	1	?
SET	23	17	18	24	13	15	20	19	14	16	21	12	11	7	8	5	10	9	4	2	3	6	1	?
OTT	24	23	13	21	12	15	22	17	18	14	19	11	16	10	2	8	7	3	4	9	5	6	1	?
NOV	16	23	24	15	14	13	21	18	11	10	22	12	8	19	3	6	7	9	4	2	5	17	1	?
DIC	18	27	12	22	14	10	23	19	15	26	16	21	13	11	2	6	4	5	3	9	7	8	1	?

DATI: NASA GISS SURFACE TEMPERATURE ANALYSIS (GISTEMP V4) | CREDITS: @GALSELO PER CHPDB https://chpdb.it/_climate_dash/

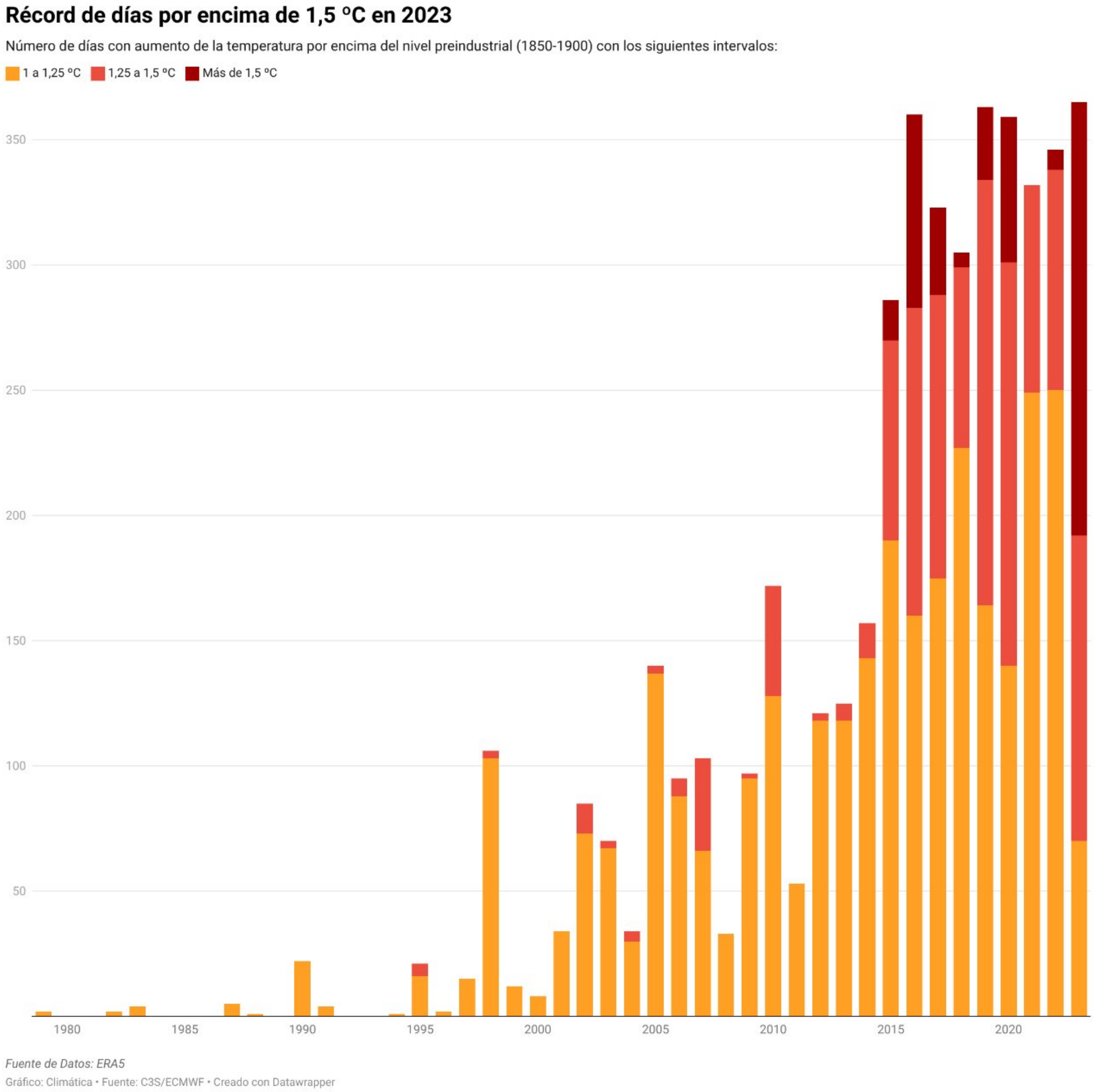
https://twitter.com/galselo

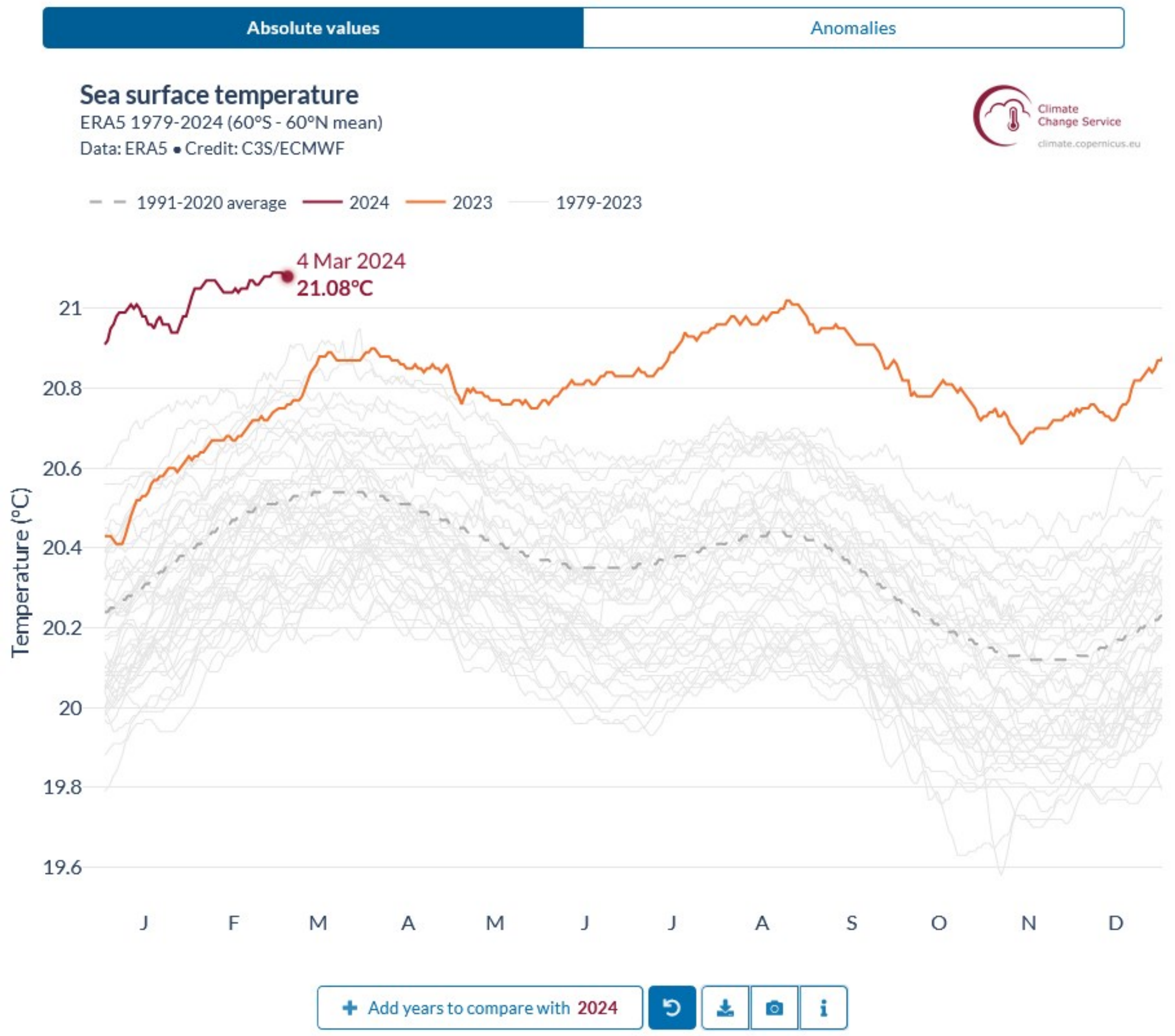
SCALA GLOBALE

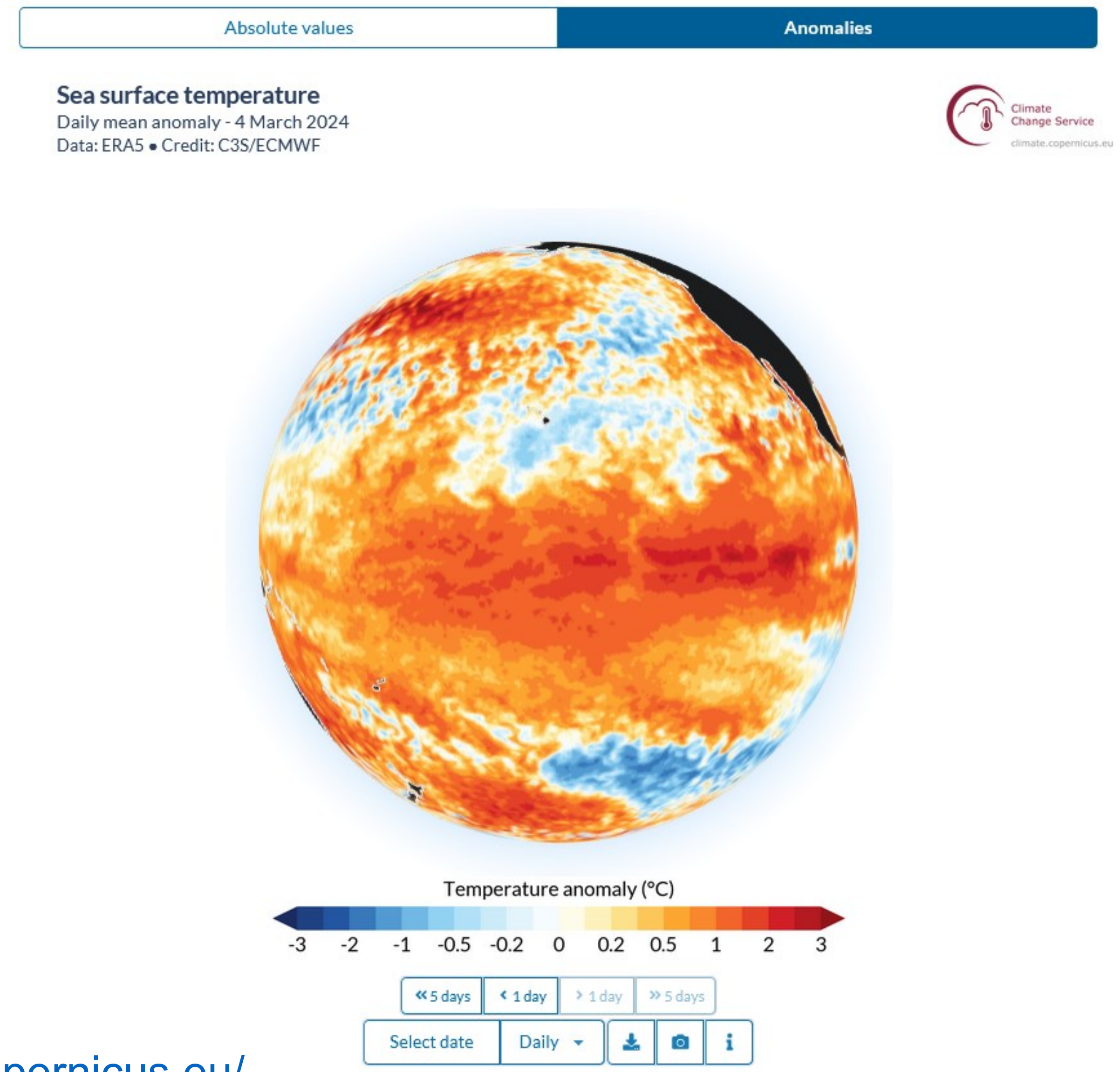



Daily Temperature Anomalies for Different Years (JRA-55)
2016
2023
Temperature Anomaly (°C)
2.0
1.5
1.0
0.5
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

STATISTICHE GLOBALI







https://pulse.climate.copernicus.eu/

Climate Reanalyzer

Climate Change Institute | University of Maine

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Today's Weather Maps

About this page

GFS 2m Temperature (°C)

1-day Avg | Wed, Mar 06, 2024

ClimateReanalyzer.org

Climate Change Institute | University of Maine

2m Temperature

Avg | Clim | Max | Min

2m Temp Anomaly

Precipitation / Clouds

Precipitation / MSLP

Precipitable Water

PWtr Sd Anomaly

10m Wind Speed

Mean SL Pressure

MSLP Sd Anomaly

500hPa Geopot. Hgt

500hPa GPH Anom

500hPa Jetstream

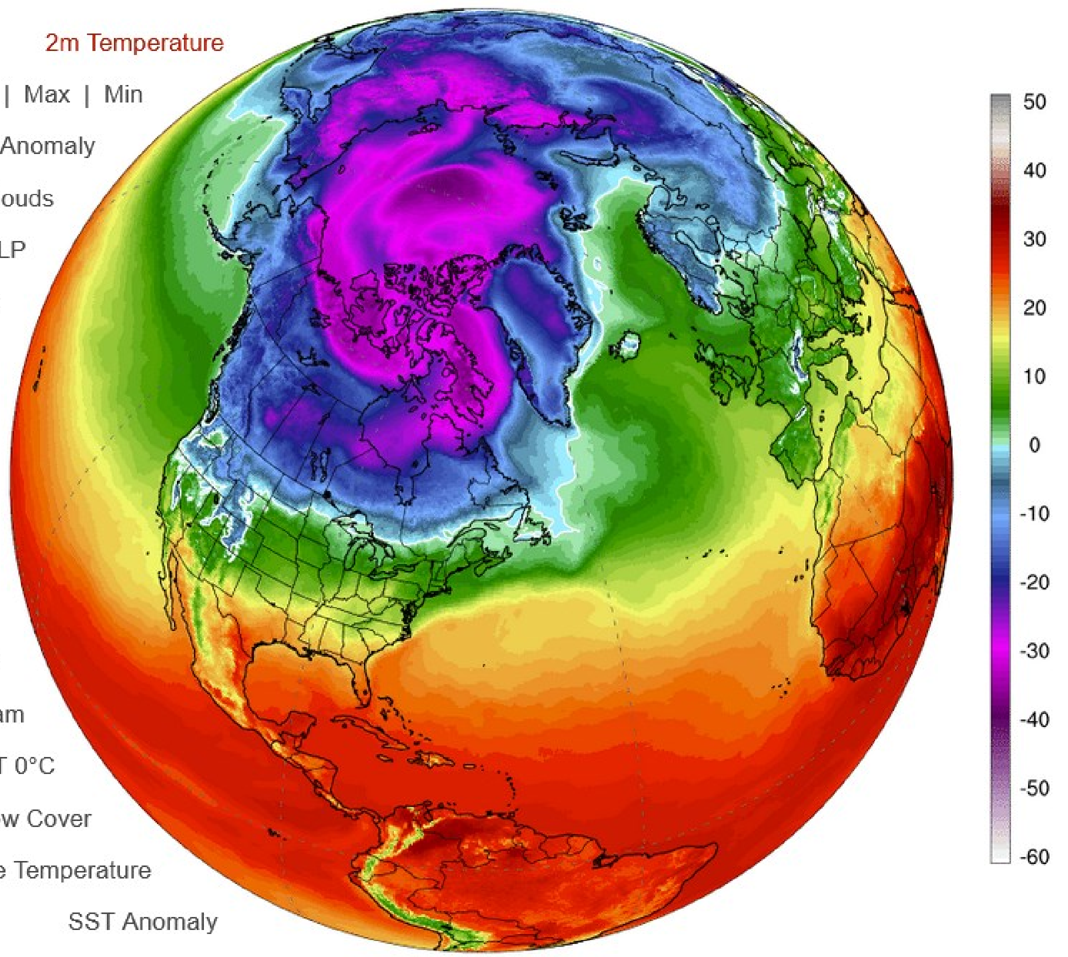
250hPa Jetstream

Snow Depth / T 0°C

Sea Ice / Snow Cover

Sea Surface Temperature

SST Anomaly



Click Map to Change View

https://climatereanalyzer.org/wx/todays-weather/?var_id=t2&ortho=1&wt=1

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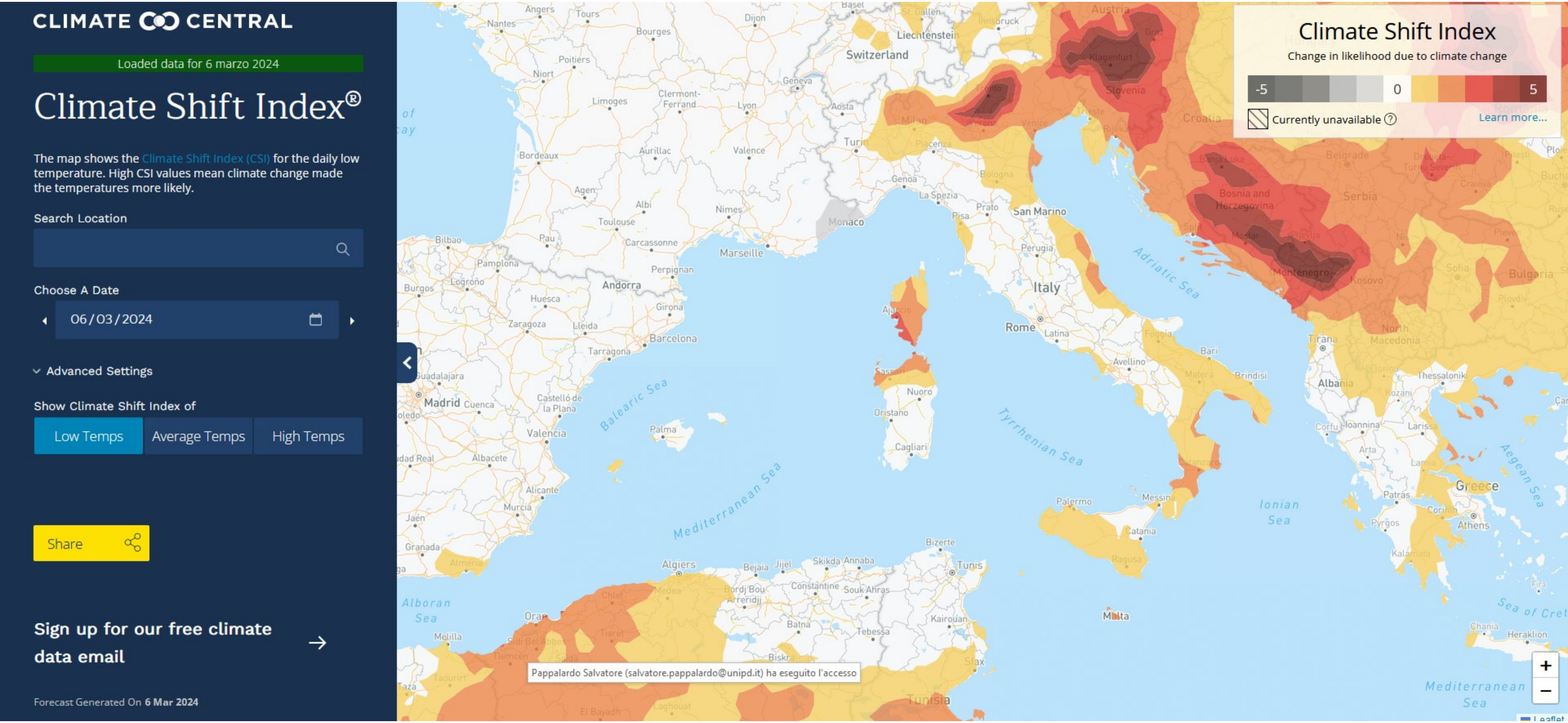


https://csi.climatecentral.org/csi-contour-map/tavg/2024-03-07/

Crollo della Biosfera

Crollo della Biosfera

Negli ultimi 70 anni le attività antropiche hanno modificato gli ecosistemi in termini di velocità ed estensione che in qualunque altro periodo storico dell'umanità.

Tali cambiamenti hanno comportato perdite sostanziali ed irreversibili della diversità della vita sulla terra

Crollo della Biosfera

Gli attuali cambiamenti in termini di diminuzione di diversità e di popolazioni sono legati a processi intrinseci alla vita sulla Terra, prevalentemente da attività antropiche (M.A., 2005).

Il 28% dei *taxa* attualmente conosciuti (42.100 specie) sono al momento minacciati di estinzione (IUCN Red List, 2022)

- cambiamento d'uso dei suoli (*land use change*)
- sovrasfruttamento delle risorse naturali
- introduzione di specie alloctone invasive (*alien species*)
- diffusione di agenti patogeni e contaminanti

⇨ ***Anthropogenic direct drivers***

- **cambiamenti climatici globali**

THE IUCN RED LIST OF THREATENED SPECIES™

More than 42,100 species are threatened with extinction

That is still 28% of all assessed species.

AMPHIBIANS	MAMMALS	CONIFERS	BIRDS	SHARKS & RAYS	REEF CORALS	SELECTED CRUSTACEANS	REPTILES
41%	27%	34%	13%	37%	36%	28%	21%

CYCADS 69%

AMAZING SPECIES

PLANTAE - MAGNOLIOPSIDA — GLOBAL
Holly
Ilex aquifolium
Stable — LC

ANIMALIA - AVES — GLOBAL
Dwarf Ibis
Bostrychia bocagei
Decreasing — CR

ANIMALIA - MAMMALIA — GLOBAL
Grey-faced Sengi
Rhynchocyon udzungwensis
Unknown — VU

ANIMALIA - REPTILIA — GLOBAL
Antsingy Leaf Chameleon
Brookesia perarmata
Decreasing — EN

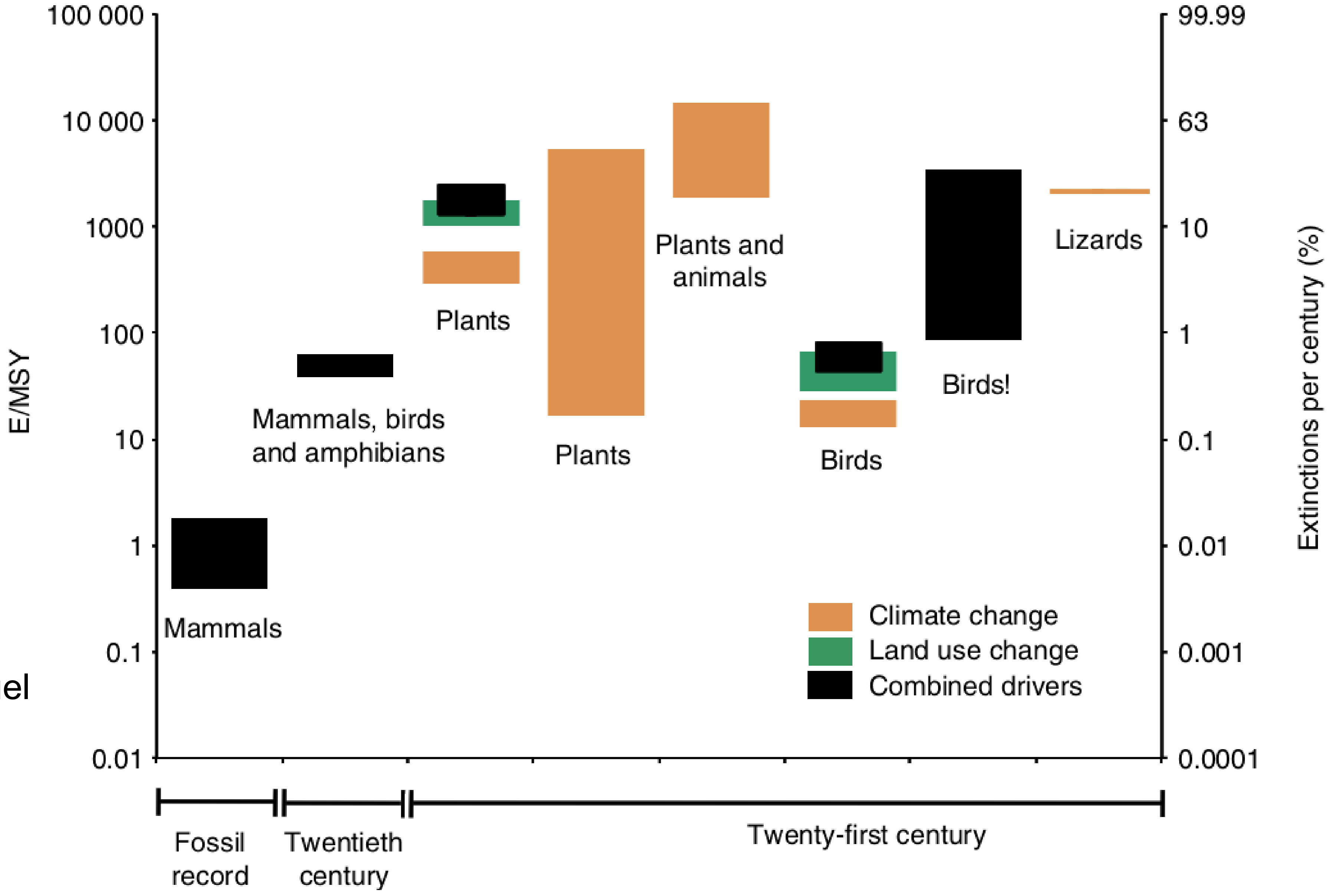
https://www.iucnredlist.org/

"The biodiversity of species and their rates of extinction, distribution, and protection"

(Pimm et al., 2014)

"Comparing Extinction Rates: Past, Present, and Future"

Vania Proenca & Henrique Miguel Pereira (2013)



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Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction

Gerardo Ceballos[a,1], Paul R. Ehrlich[b], and Peter H. Raven[c]

[a]Instituto de Ecología, Universidad Nacional Autónoma de México, 04510 Ciudad de México, México; [b]Center for Conservation Biology, Department of Biology, Stanford University, Stanford, CA 94304; and [c]Plant Science Department, Missouri Botanical Garden, St. Louis, MO 63110

Contributed by Gerardo Ceballos, March 22, 2020 (sent for review December 26, 2019; reviewed by Thomas E. Lovejoy and Jorge L. Soberon)

The ongoing sixth mass species extinction is the result of the destruction of component populations leading to eventual extirpation of entire species. Populations and species extinctions have severe implications for society through the degradation of ecosystem services. Here we assess the extinction crisis from a different perspective. We examine 29,400 species of terrestrial vertebrates, and determine which are on the brink of extinction because they have fewer than 1,000 individuals. There are 515 species on the brink (1.7% of the evaluated vertebrates). Around 94% of the populations of 77 mammal and bird species on the brink have been lost in the last century. Assuming all species on the brink have similar trends, more than 237,000 populations of those species have vanished since 1900. We conclude the human-caused sixth mass extinction is likely accelerating for several reasons. First, many of the species that have been driven to the brink will likely become extinct soon. Second, the distribution of those species highly coincides with hundreds of other endangered species, surviving in regions with high human impacts, suggesting ongoing regional biodiversity collapses. Third, close ecological interactions of species on the brink tend to move other species toward annihilation when they disappear—extinction breeds extinctions. Finally, human pressures on the biosphere are growing rapidly, and a recent example is the current coronavirus disease 2019 (Covid-19) pandemic, linked to wildlife trade. Our results reemphasize the extreme urgency of taking much-expanded worldwide actions to save wild species and humanity's crucial life-support systems from this existential threat.

endangered species | sixth mass extinction | population extinctions | conservation | ecosystem services

that time, we numbered about 1 million people worldwide; now there are 7.7 billion of us, and our numbers are still rapidly growing (21). As our numbers have grown, humanity has come to pose an unprecedented threat to the vast majority of its living companions.

Today, species extinction rates are hundreds or thousands of times faster than the "normal" or "background" rates prevailing in the last tens of millions of years (8–10). The recent United Nations report on biodiversity and ecosystem services estimates that a quarter of all species face extinction, many within decades (11). When a species disappears, a wide range of characteristics is lost forever, from genes and interactions to phenotypes and behaviors (22–27).

Every time a species or population vanishes, Earth's capability to maintain ecosystem services is eroded to a degree, depending on the species or population concerned. Each population is likely to be unique and therefore likely to differ in its capacity to fit into a particular ecosystem and to play a role there. The effects of extinctions will worsen in the coming decades, as losses of functional units, redundancy, and genetic and cultural variability change entire ecosystems (14, 23, 24). Humanity needs the life support of a relatively stable climate, flows of fresh water, agricultural pest and disease-vector control, pollination for crops, and so on, all provided by functional ecosystems (12, 28).

Examples documenting the ongoing biological annihilation are proliferating, each of them underlining the magnitude of the problem and the urgency of taking action. More than 400 vertebrate species became extinct in the last 100 y, extinctions that

https://www.pnas.org/doi/epdf/10.1073/pnas.1922686117

Extinction risk from climate change

Chris D. Thomas[1], Alison Cameron[1], Rhys E. Green[2], Michel Bakkenes[3], Linda J. Beaumont[4], Yvonne C. Collingham[5], Barend F. N. Erasmus[6], Marinez Ferreira de Siqueira[7], Alan Grainger[8], Lee Hannah[9], Lesley Hughes[4], Brian Huntley[5], Albert S. van Jaarsveld[10], Guy F. Midgley[11], Lera Miles[8*], Miguel A. Ortega-Huerta[12], A. Townsend Peterson[13], Oliver L. Phillips[8] & Stephen E. Williams[14]

[1]*Centre for Biodiversity and Conservation, School of Biology, University of Leeds, Leeds LS2 9JT, UK*
[2]*Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, UK, and Conservation Biology Group, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK*
[3]*National Institute of Public Health and Environment, P.O. Box 1, 3720 BA Bilthoven, The Netherlands*
[4]*Department of Biological Sciences, Macquarie University, North Ryde, 2109, NSW, Australia*
[5]*University of Durham, School of Biological and Biomedical Sciences, South Road, Durham DH1 3LE, UK*
[6]*Animal, Plant and Environmental Sciences, University of the Witwatersrand, Private Bag 3, WITS 2050, South Africa*
[7]*Centro de Referência em Informação Ambiental, Av. Romeu Tórtima 228, Barão Geraldo, CEP:13083-885, Campinas, SP, Brazil*
[8]*School of Geography, University of Leeds, Leeds LS2 9JT, UK*
[9]*Center for Applied Biodiversity Science, Conservation International, 1919 M Street NW, Washington, DC 20036, USA*
[10]*Department of Zoology, University of Stellenbosch, Private Bag X1, Stellenbosch 7602, South Africa*
[11]*Climate Change Research Group, Kirstenbosch Research Centre, National*

areas[7–12]. This 'climate envelope' represents the conditions under which populations of a species currently persist in the face of competitors and natural enemies. Future distributions are estimated by assuming that current envelopes are retained and can be projected for future climate scenarios[7–12]. We assume that a species either has no limits to dispersal such that its future distribution becomes the entire area projected by the climate envelope model or that it is incapable of dispersal, in which case the new distribution is the overlap between current and future potential distributions (for example, species with little dispersal or that inhabit fragmented landscapes)[11]. Reality for most species is likely to fall between these extremes.

We explore three methods to estimate extinction, based on the species–area relationship, which is a well-established empirical power-law relationship describing how the number of species relates to area ($S = cA^z$, where S is the number of species, A is area, and c and z are constants)[13]. This relationship predicts adequately the numbers of species that become extinct or threatened when the area available to them is reduced by habitat destruction[14,15]. Extinctions arising from area reductions should apply regardless of whether the cause of distribution loss is habitat destruction or climatic unsuitability.

Because climate change can affect the distributional area of each species independently, classical community-level approaches need to be modified (see Methods). In method 1 we use changes in the summed distribution areas of all species. This is consistent with the traditional species–area approach: on average, the destruction of half of a habitat results in the loss of half of the distribution area summed across all species restricted to that habitat. However, this

https://www.nature.com/articles/nature02121

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RESEARCH ARTICLE | ENVIRONMENTAL SCIENCES

Accelerated modern human–induced species losses: Entering the sixth mass extinction

GERARDO CEBALLOS, PAUL R. EHRLICH, ANTHONY D. BARNOSKY, ANDRÉS GARCÍA, ROBERT M. PRINGLE, AND TODD M. PALMER

https://www.science.org/doi/10.1126/sciadv.1400253

BIOLOGICAL REVIEWS

Cambridge Philosophical Society

Biol. Rev. (2022), 97, pp. 640–663. 640
doi: 10.1111/brv.12816

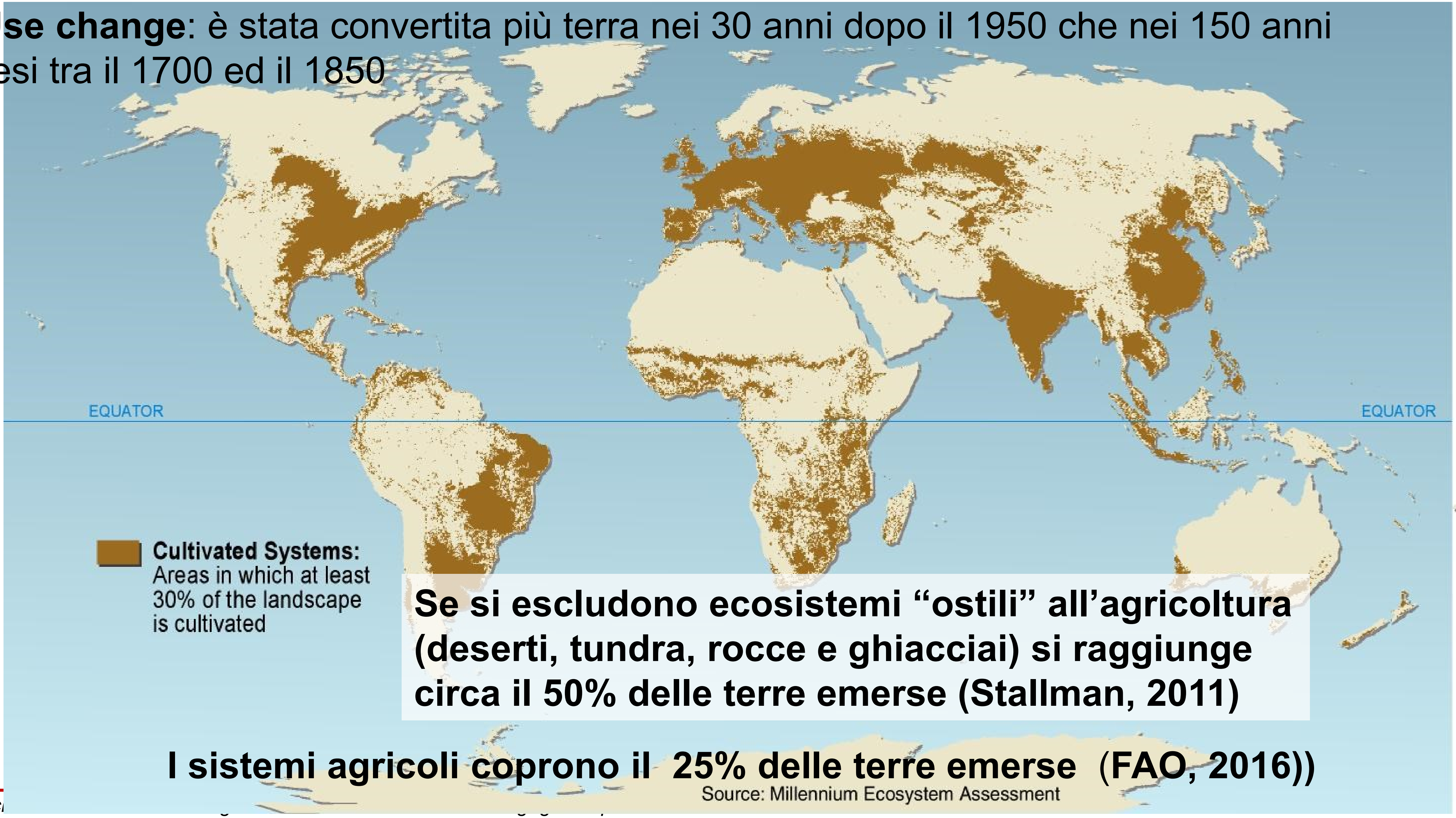
The Sixth Mass Extinction: fact, fiction or speculation?

Robert H. Cowie[1*], Philippe Bouchet[2] and Benoît Fontaine[3]

[1]*Pacific Biosciences Research Center, University of Hawaii, Honolulu, Hawaii 96822, U.S.A.*
[2]*Institut Systématique Evolution Biodiversité (ISYEB), Muséum National d'Histoire Naturelle, CNRS, Sorbonne Université, EPHE, Université des Antilles, 57 rue Cuvier CP 51, 75005 Paris, France*
[3]*UMS 2006 Patrinat (OFB, CNRS, MNHN), Centre d'Écologie et des Sciences de la Conservation (UMR 7204), Muséum National d'Histoire Naturelle, 43 rue Buffon CP 135, 75005 Paris, France*

https://pubmed.ncbi.nlm.nih.gov/35014169/

LandUse change: è stata convertita più terra nei 30 anni dopo il 1950 che nei 150 anni compresi tra il 1700 ed il 1850

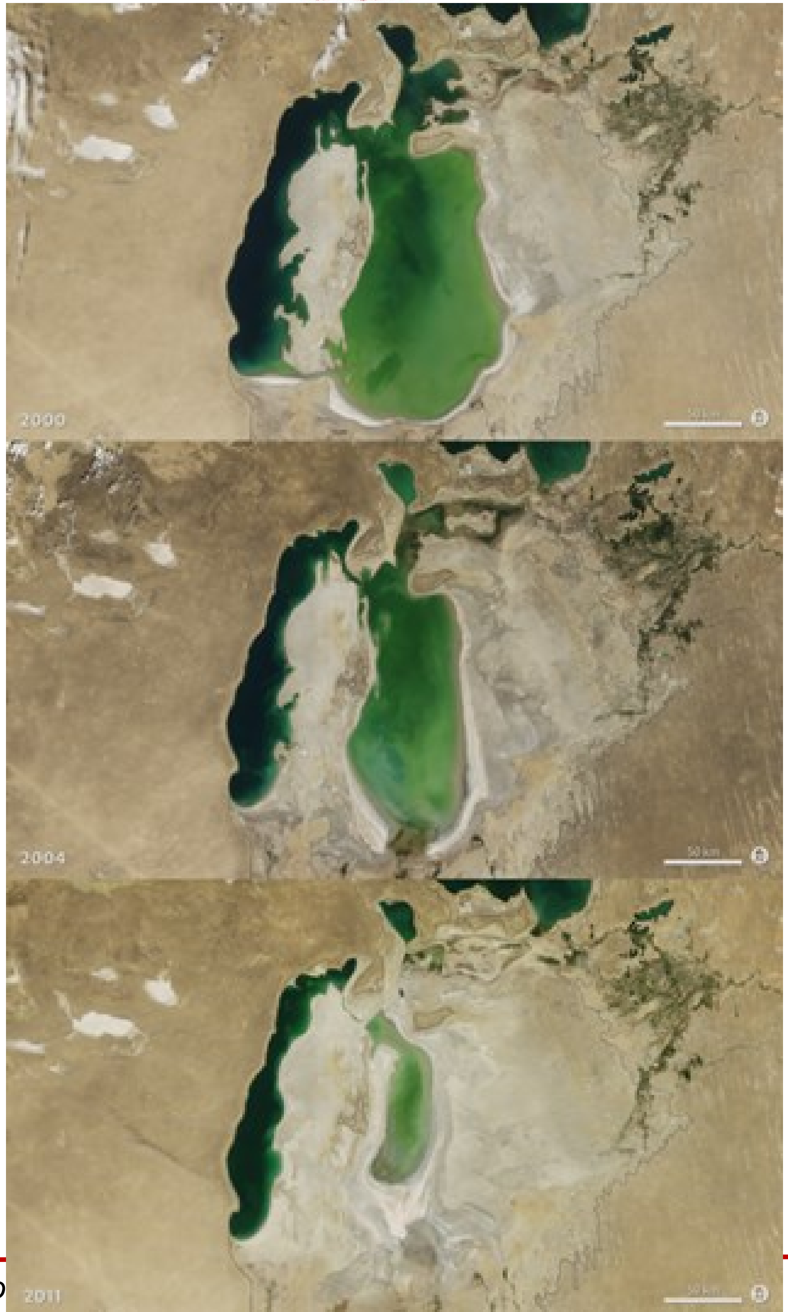


Se si escludono ecosistemi "ostili" all'agricoltura (deserti, tundra, rocce e ghiacciai) si raggiunge circa il 50% delle terre emerse (Stallman, 2011)

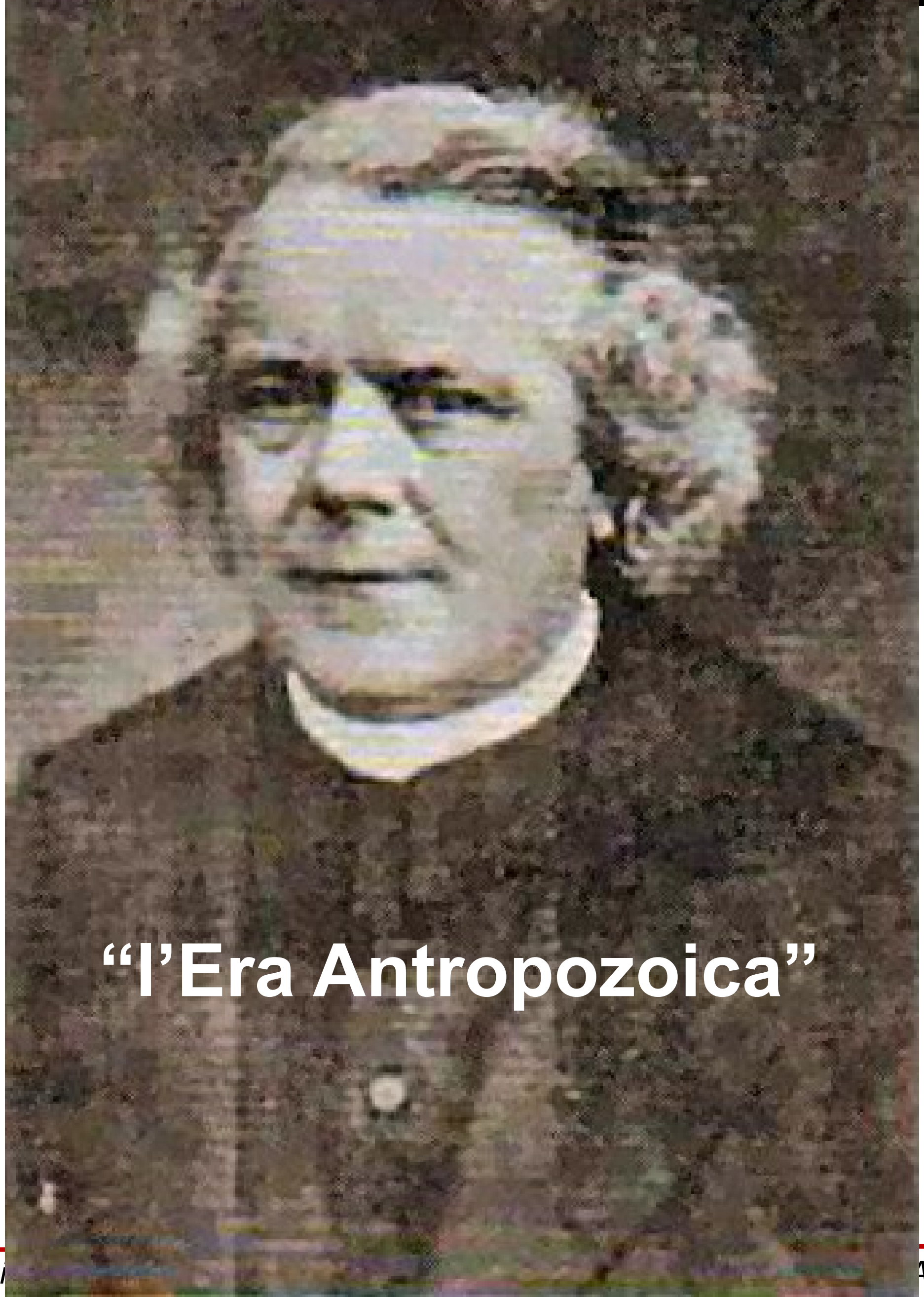
I sistemi agricoli coprono il 25% delle terre emerse (FAO, 2016))

68.000 km^2

3.300 km^2



Antonio Stoppani (1824-1891)



Climate Justice
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"…una nuova forza tellurica che per magnitudo e ampiezza può essere paragonata alle più grandi forze della Terra."
(Corso di Geologia, A. Stoppani, 1873)

2000 IGBP Scientific Committee meeting, Cuernavaca, Mexico

Paul Crutzen (Nobel Prize in Chemistry, 1995)

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REVIEW

The Anthropocene is functionally and stratigraphically distinct from the Holocene

Colin N. Waters[1,*], Jan Zalasiewicz[2], Colin Summerhayes[3], Anthony D. Barnosky[4], Clément Poirier[5], Agnieszka Gałuszka[6], Alejandro Cearreta[7], Matt Edgeworth[8], Erle C. Ellis[9], Michael Ellis[1], Catherine Jeandel[10], Reinhold Leinfelder[11], J. R. McNeill[12], Daniel deB. Richter[13], Will Steffen[14], James Syvitski[15], Davor Vidas[16], Michael Wagreich[17], Mark Williams[2], An Zhisheng[18], Jacques Grinevald[19], Eric Odada[20], Naomi Oreskes[21], Alexander P. Wolfe[22]

+ Author Affiliations

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Science 08 Jan 2016:
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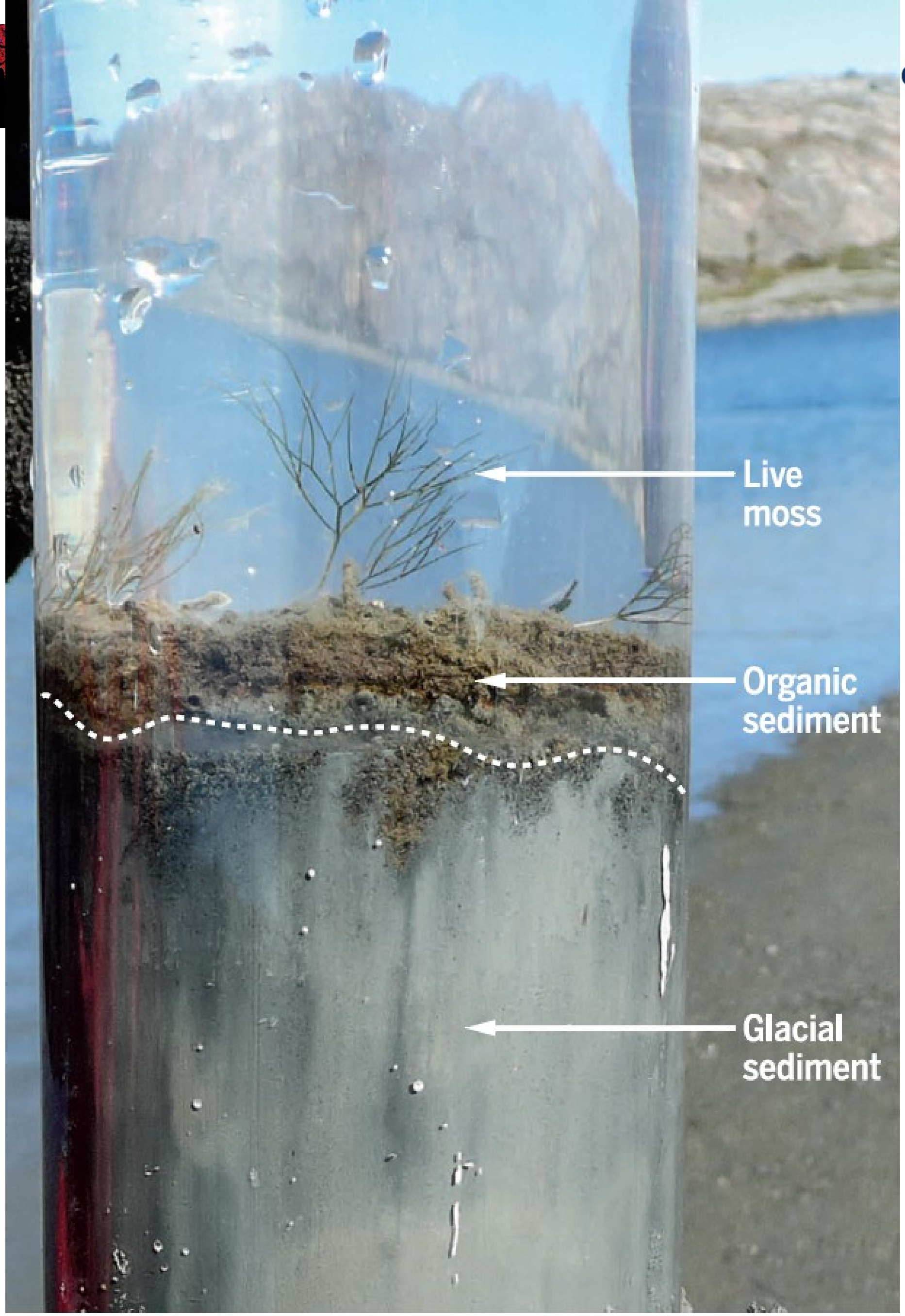
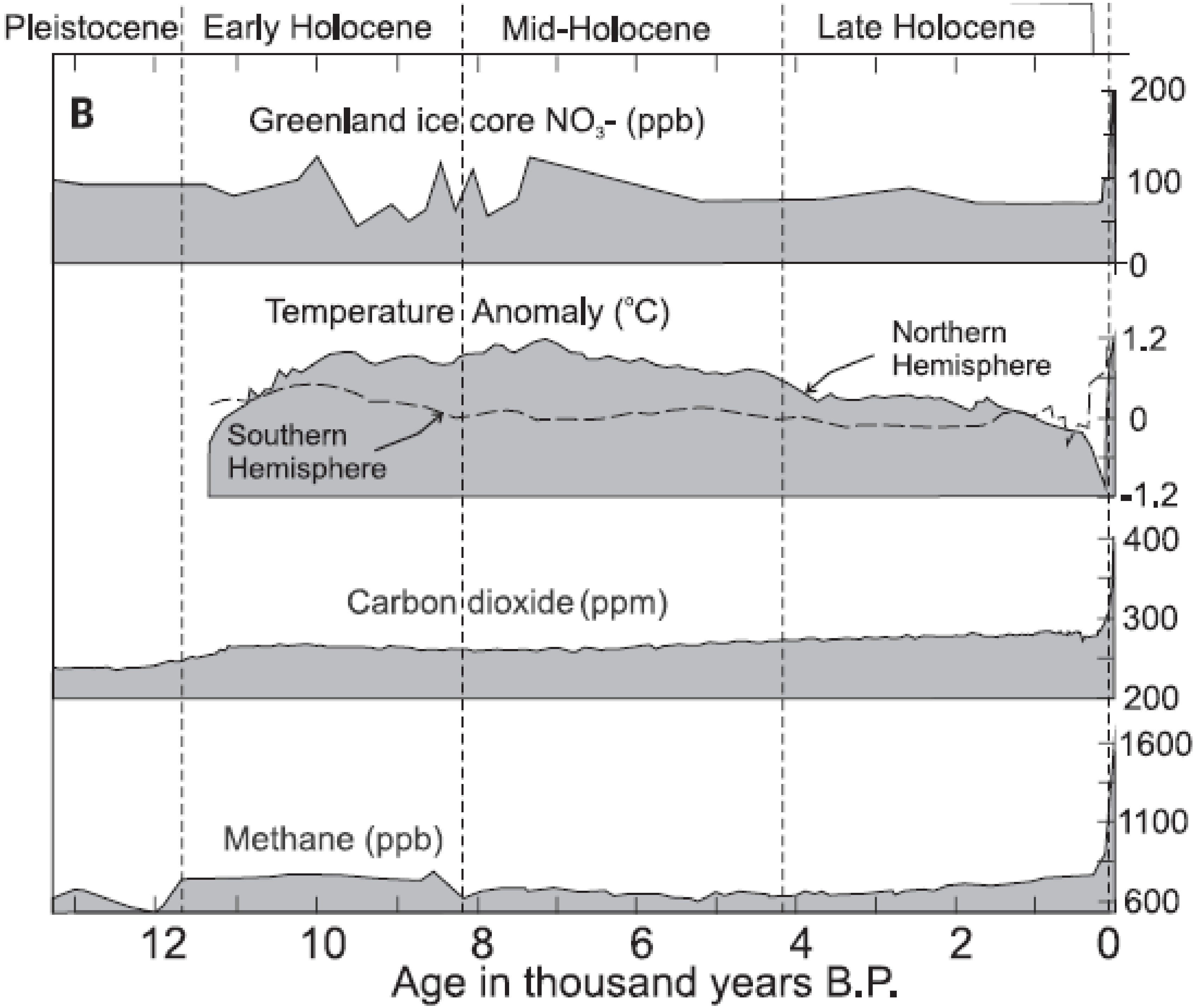
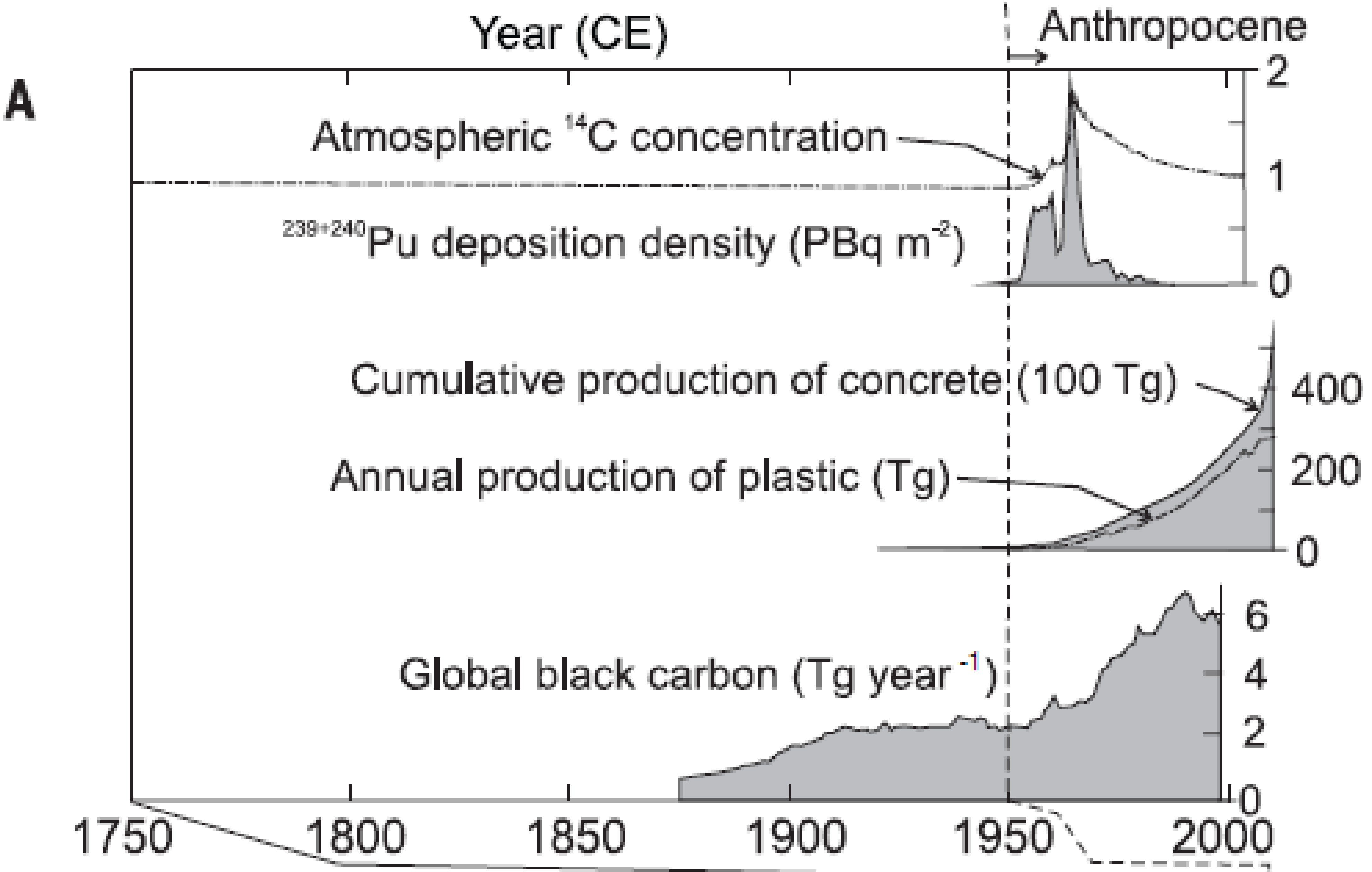
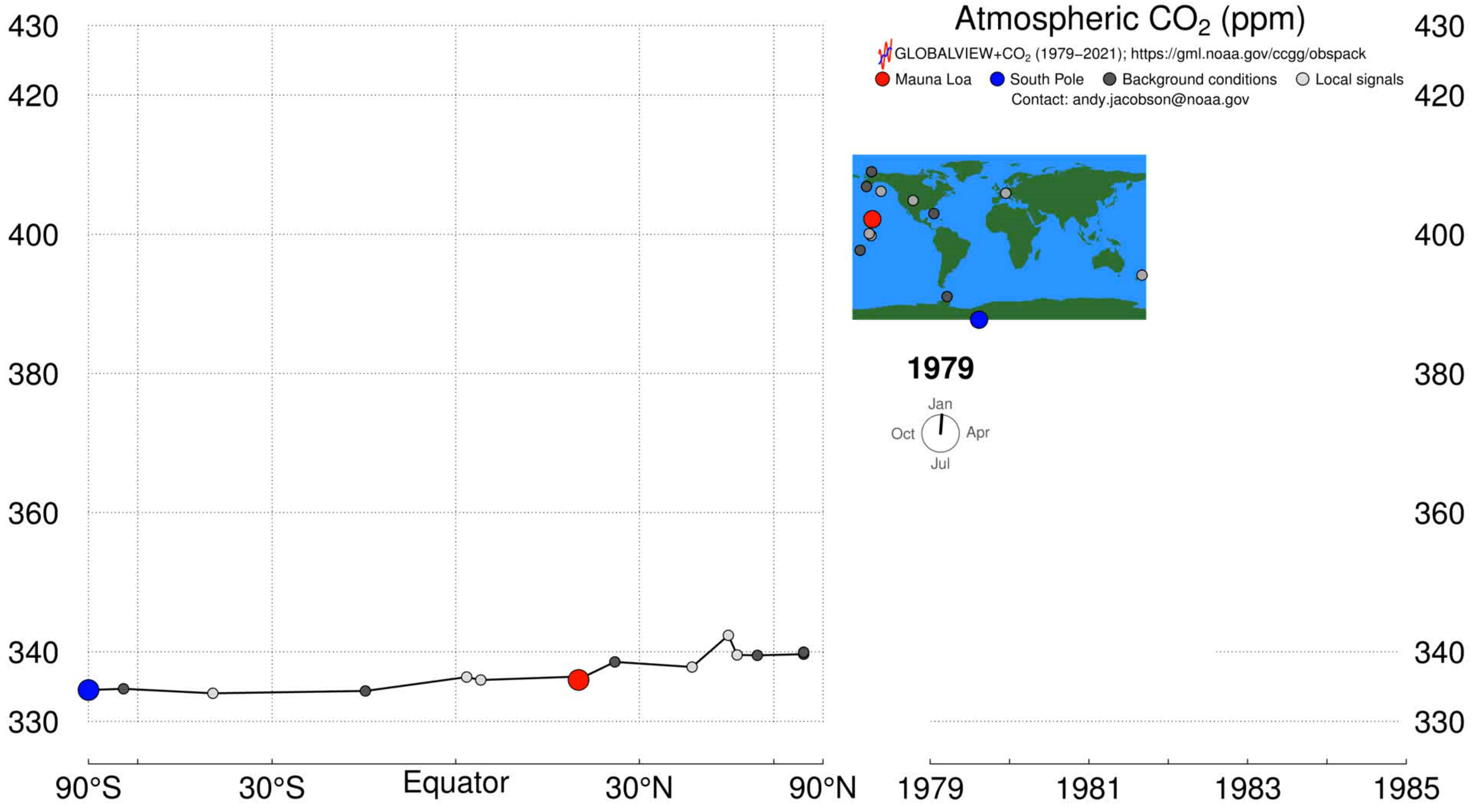
DOI: 10.1126/science.aad2622




Pleistocene
Early Holocene
Mid-Holocene
Late Holocene
B
Greenland ice core NO_3- (ppb)
200
100
0
Temperature Anomaly (°C)
Northern Hemisphere
Southern Hemisphere
1.2
0
-1.2
Carbon dioxide (ppm)
400
300
200
Methane (ppb)
1600
1100
600
12
10
8
6
4
2
0
Age in thousand years B.P.

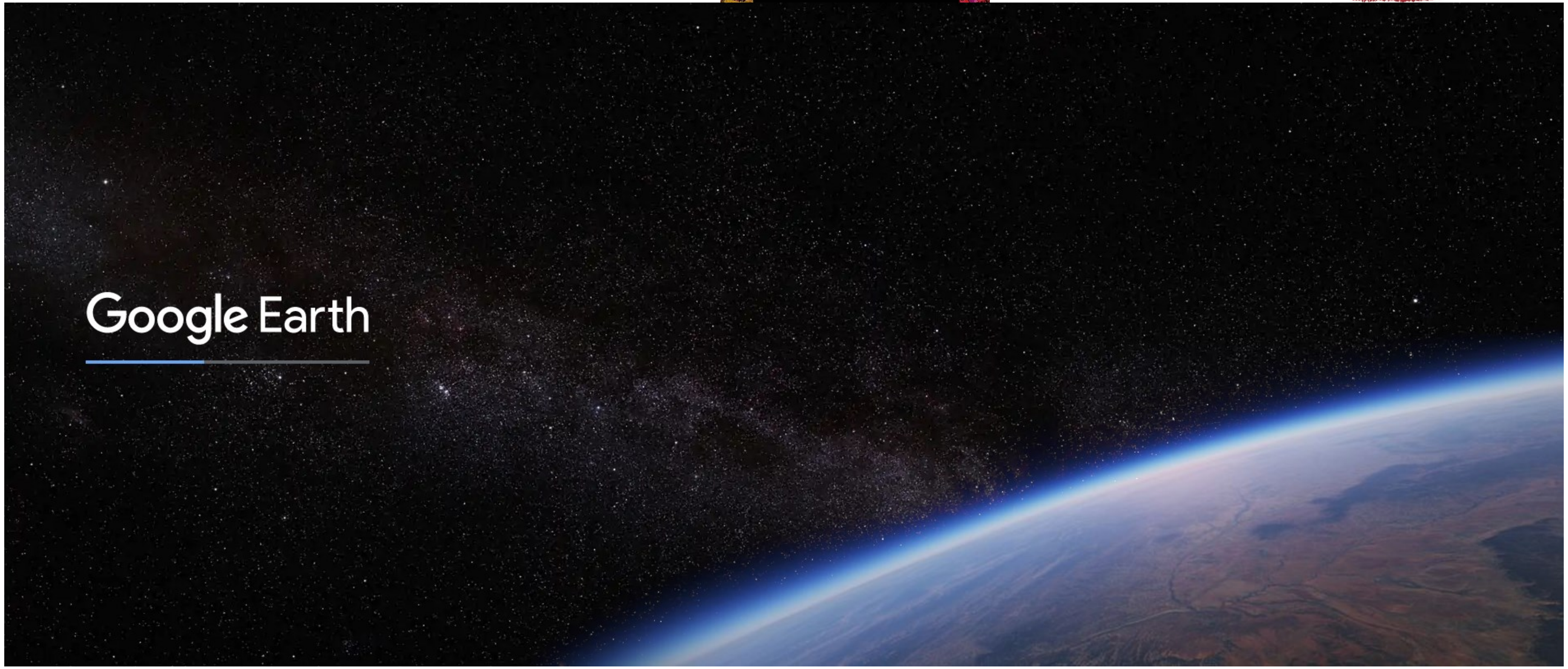

A
Year (CE)
Anthropocene
Atmospheric 14C concentration
239+240Pu deposition density (PBq m-2)
Cumulative production of concrete (100 Tg)
Annual production of plastic (Tg)
Global black carbon (Tg year-1)
2
1
0
400
200
0
6
4
2
0
1750
1800
1850
1900
1950
2000

Time history of atmospheric carbon dioxide (updated January, 2022)



NOAA

https://gml.noaa.gov/ccgg/trends/history.html



https://earthengine.google.com/timelapse/

https://www.google.com/earth/about/gallery/