DEASCUOLA | SOS CLIMA

Passiamo all’azione con l’adattamento e la mitigazione

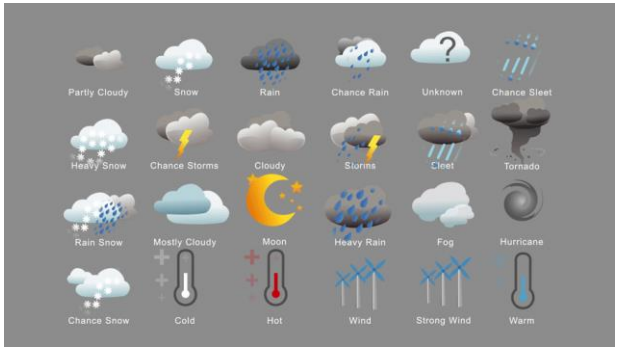
Relatore: Gianmaria Sannino
Direttore Divisione ENEA «Modelli e tecnologie per la riduzione degli impatti antropici e dei rischi naturali»

Moderatrice: Serena Giacomin
Climatologa, Presidentessa di Italian Climate Network

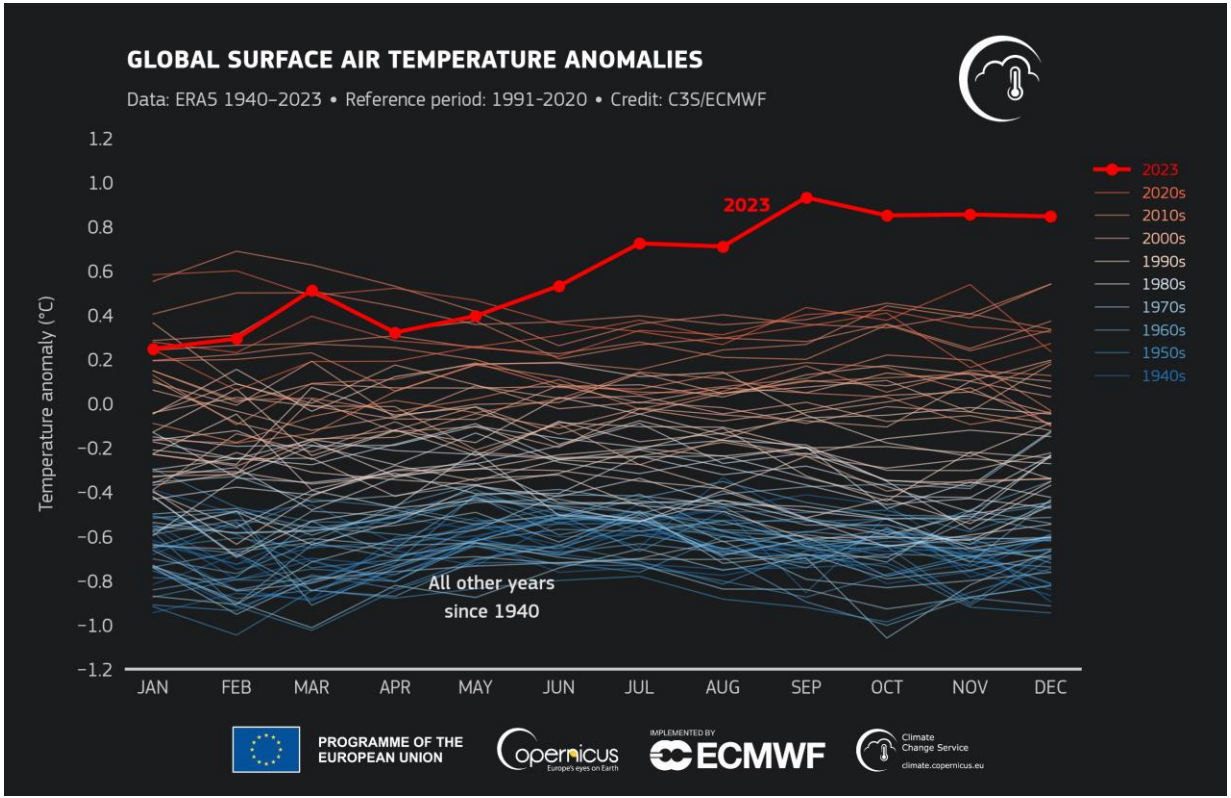
Differenza tra METEO e CLIMA

Il **METEO** è definito come lo stato dell'atmosfera in un certo luogo e in un certo momento, solitamente espresso in termini di temperatura, pressione atmosferica, umidità, velocità e direzione del vento, precipitazioni e nuvolosità. I meteorologi studiano il tempo meteorologico.

Il **CLIMA** è definito in termini di media (valore medio) degli elementi meteorologici (come temperatura e precipitazioni) su un periodo di tempo specificato (30 anni secondo l'Organizzazione Meteorologica Mondiale).

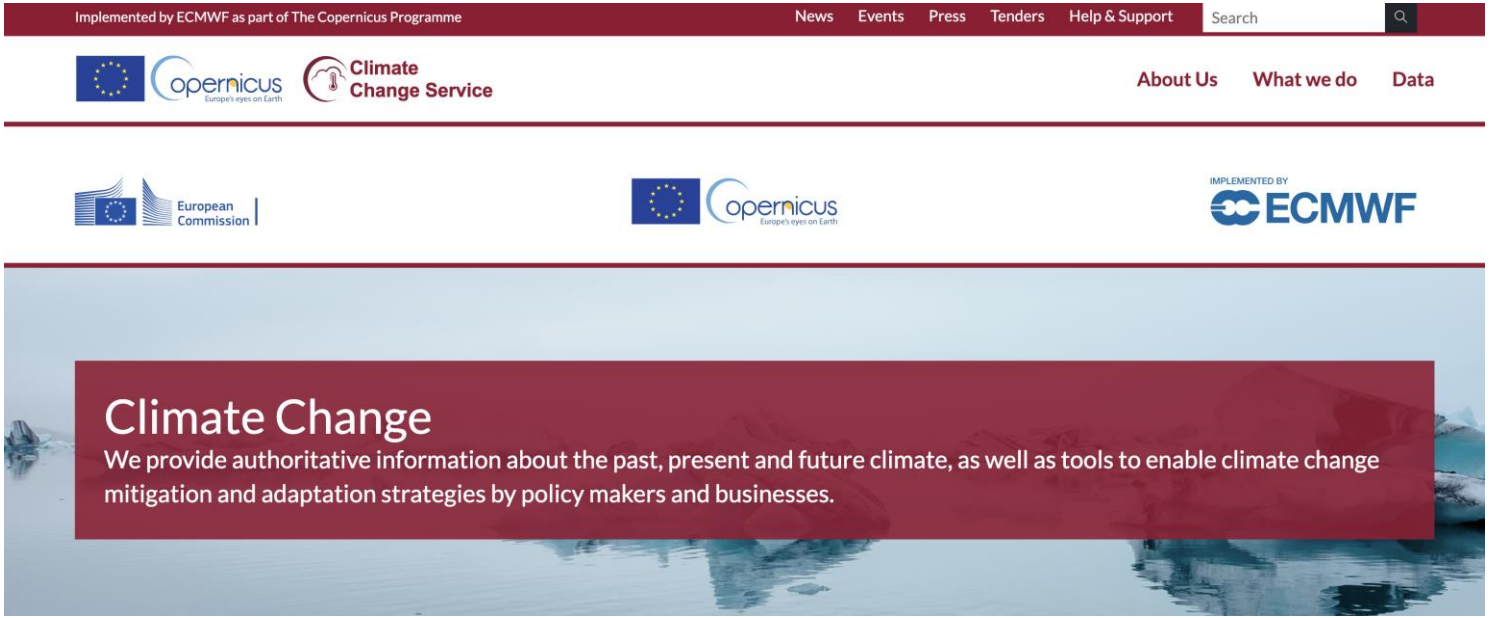


Stato del clima attuale: Copernicus Climate Change

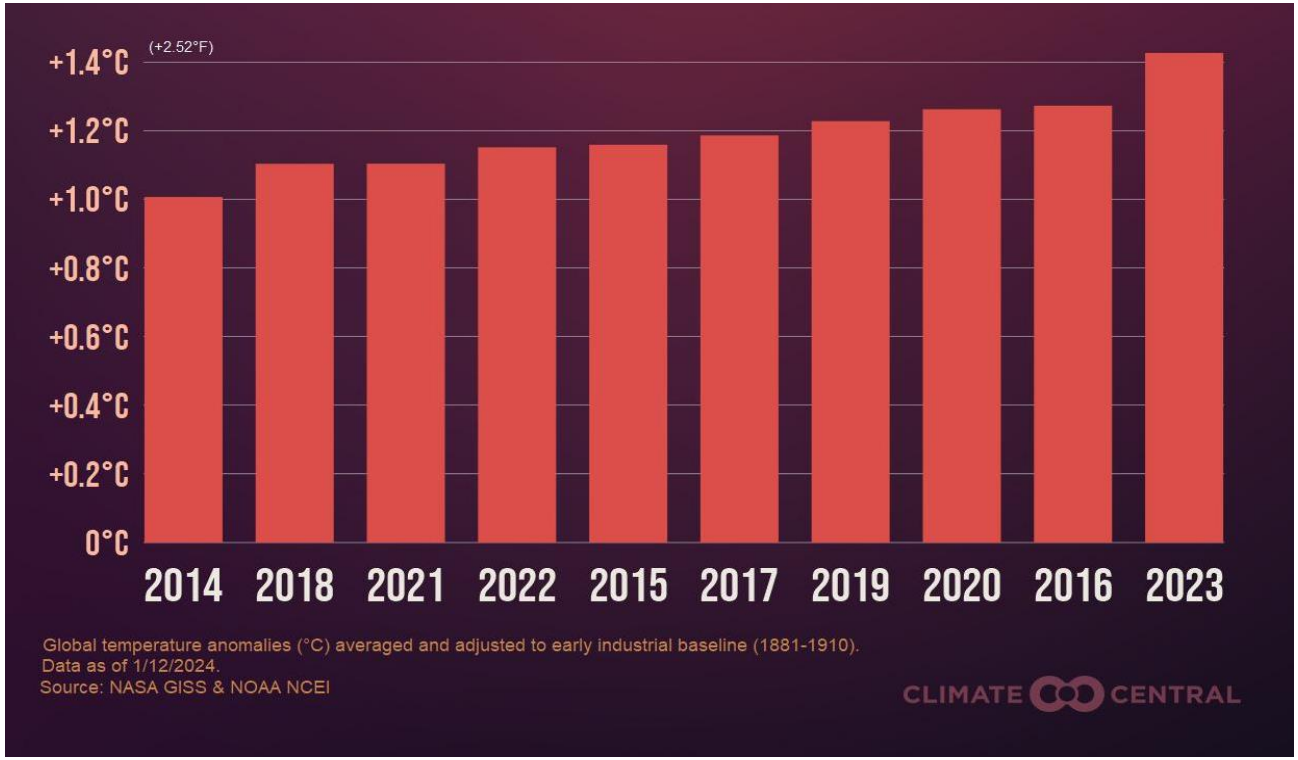


Stato del clima attuale: Copernicus Climate Change

https://climate.copernicus.eu/



I 10 anni più caldi dal 1850



https://www.climatecentral.org

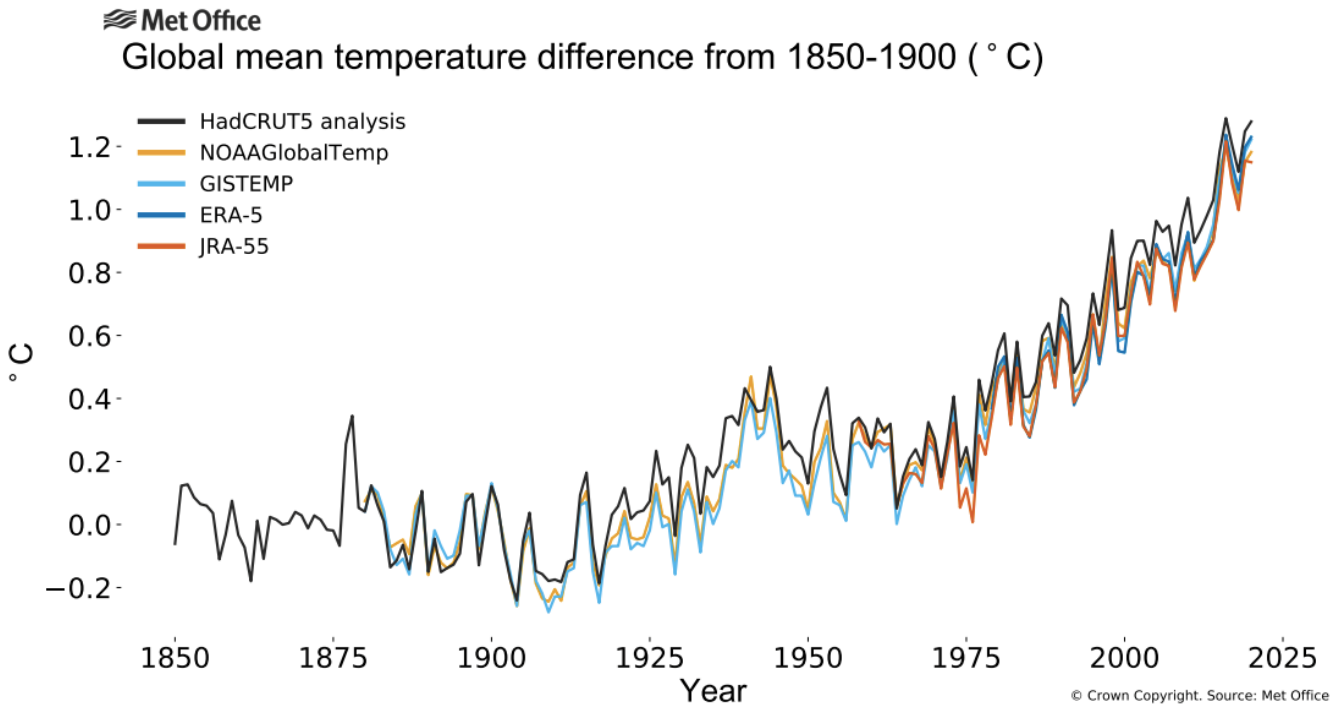
I 10 anni più caldi dal 1850

Rank 1 = Warmest Period of Record: 1850–2023	Year	Anomaly °C	Anomaly °F
1	2023	1.18	2.12
2	2016	1.03	1.85
3	2020	1.01	1.82
4	2019	0.98	1.76
5	2017	0.95	1.71
6	2015	0.92	1.66
7	2022	0.91	1.64
8 (tied)	2018	0.86	1.55
8 (tied)	2021	0.86	1.55
10	2014	0.77	1.39

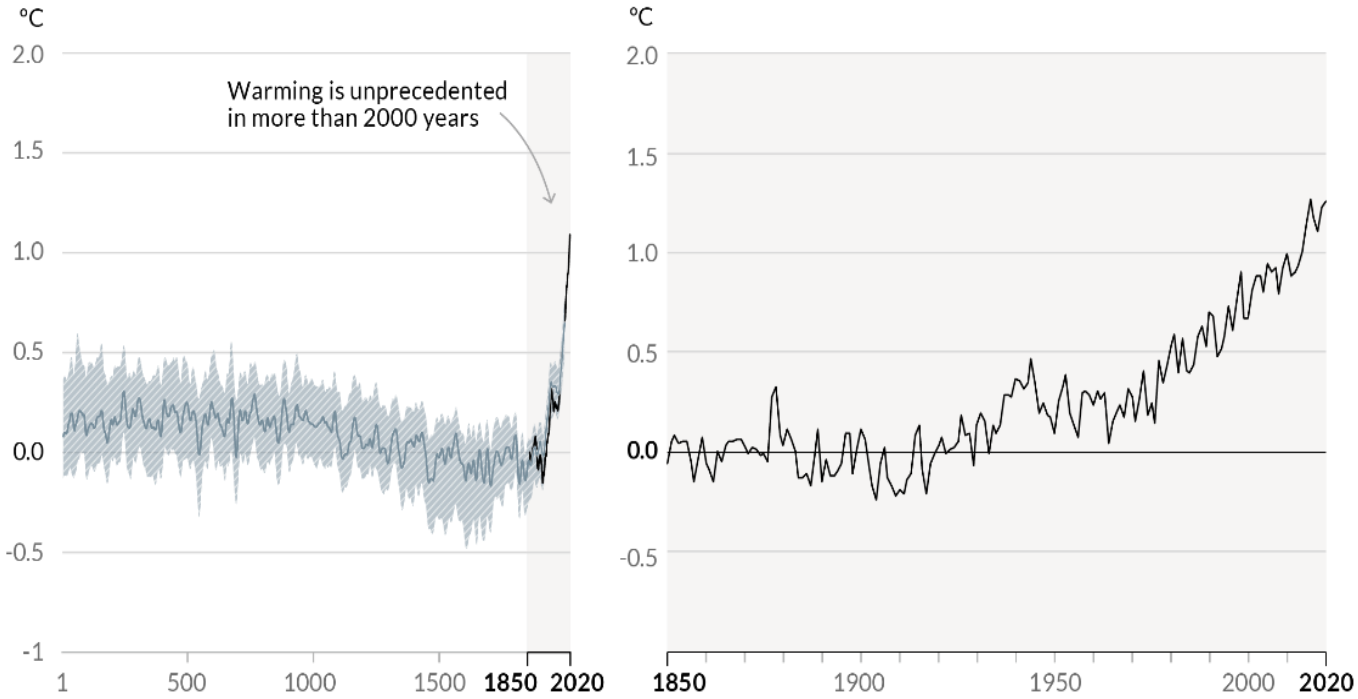
National Centers for Environmental Information
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202313

Temperatura superficiale media globale 1850-2023



Temperatura superficiale media globale



ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

http://ipcc.ch

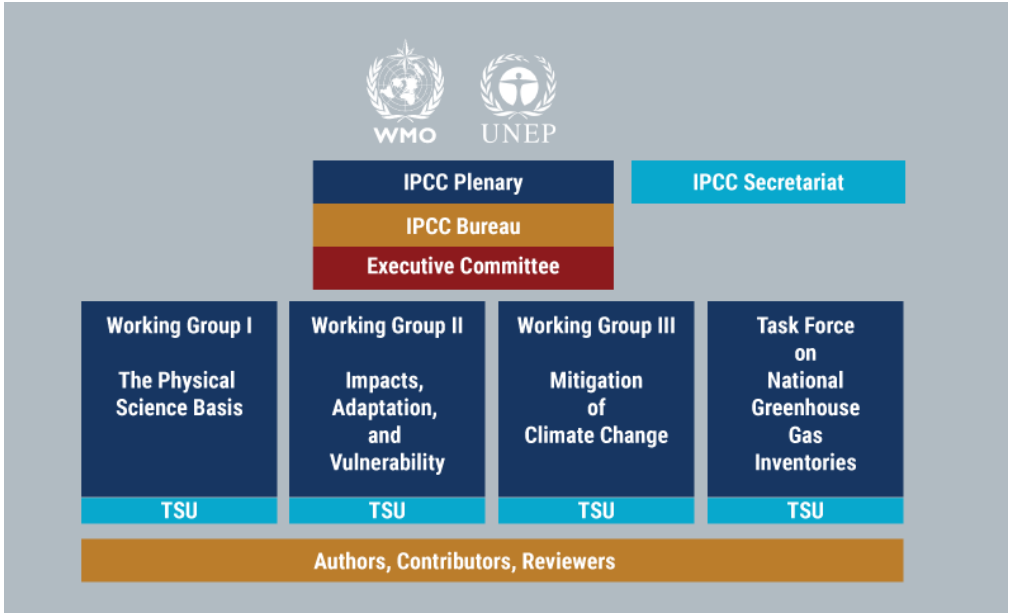
The Intergovernmental Panel on Climate Change

ipcc

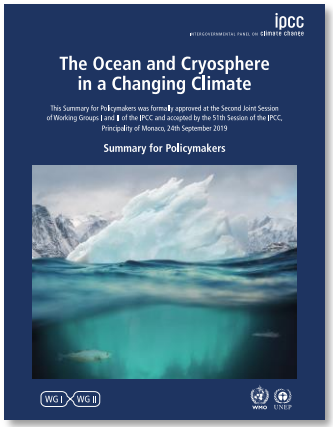
INTERGOVERNMENTAL PANEL ON climate change

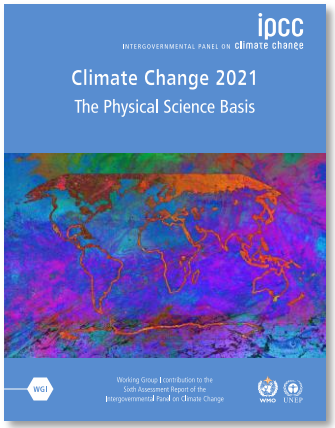
WMO UNEP

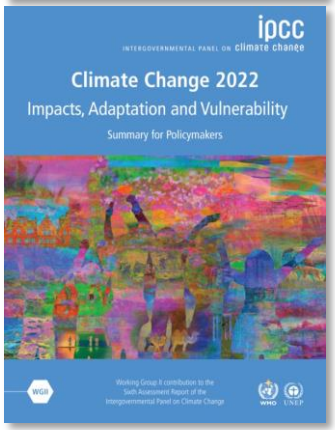
The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.



Il CLIMA e le sue basi scientifiche







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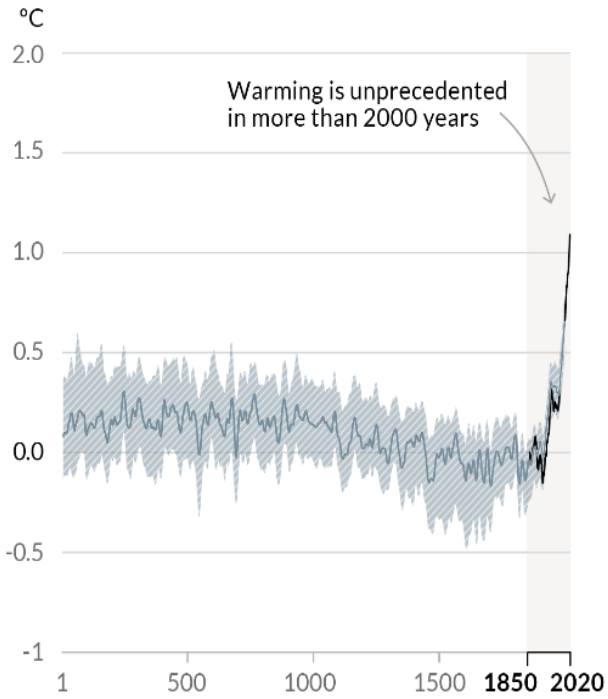
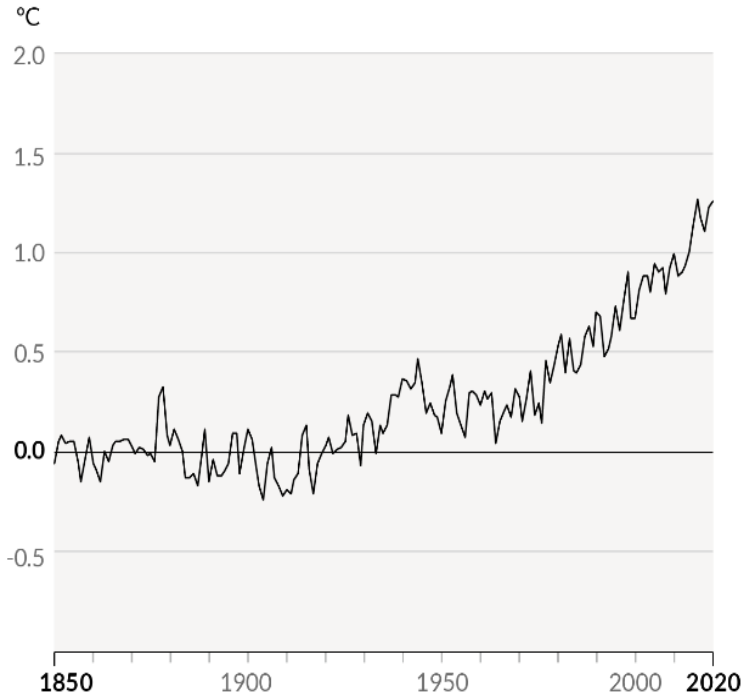
I rapporti dell'IPCC sono redatti e rivisti in più tappe, garantendo così obiettività e trasparenza. Ogni 6-7 anni vengono pubblicati dei rapporti di valutazione scientifica approfonditi; il sesto rapporto di valutazione, è stato pubblicato inizialmente nel 2021 e ha fornito la principale base scientifica agli scienziati e ai responsabili politici. Nel 2022 è stato pubblicato il rapporto del WGII sugli impatti, l'adattamento e la vulnerabilità.

Temperatura superficiale media globale





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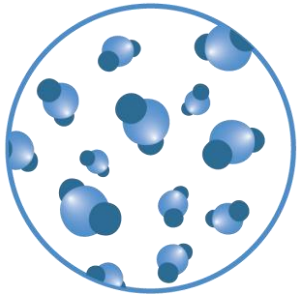
http://ipcc.ch

Effetti del cambiamento climatico

http://ipcc.ch

Concentrazione
CO_2



la più alta
degli
2 milioni
di anni

Innalzamento
livello del mare

il più rapido
degli ultimi
3000 anni

Estensione
ghiaccio artico

il più basso
degli ultimi
1000 anni

Ritiro
ghiacciai

senza
precedenti
negli ultimi
2000 anni

Extreme heat

More frequent

More intense

Heavy rainfall

More frequent

More intense

Drought

Increase in some regions

Fire weather

More frequent

Ocean

Warming

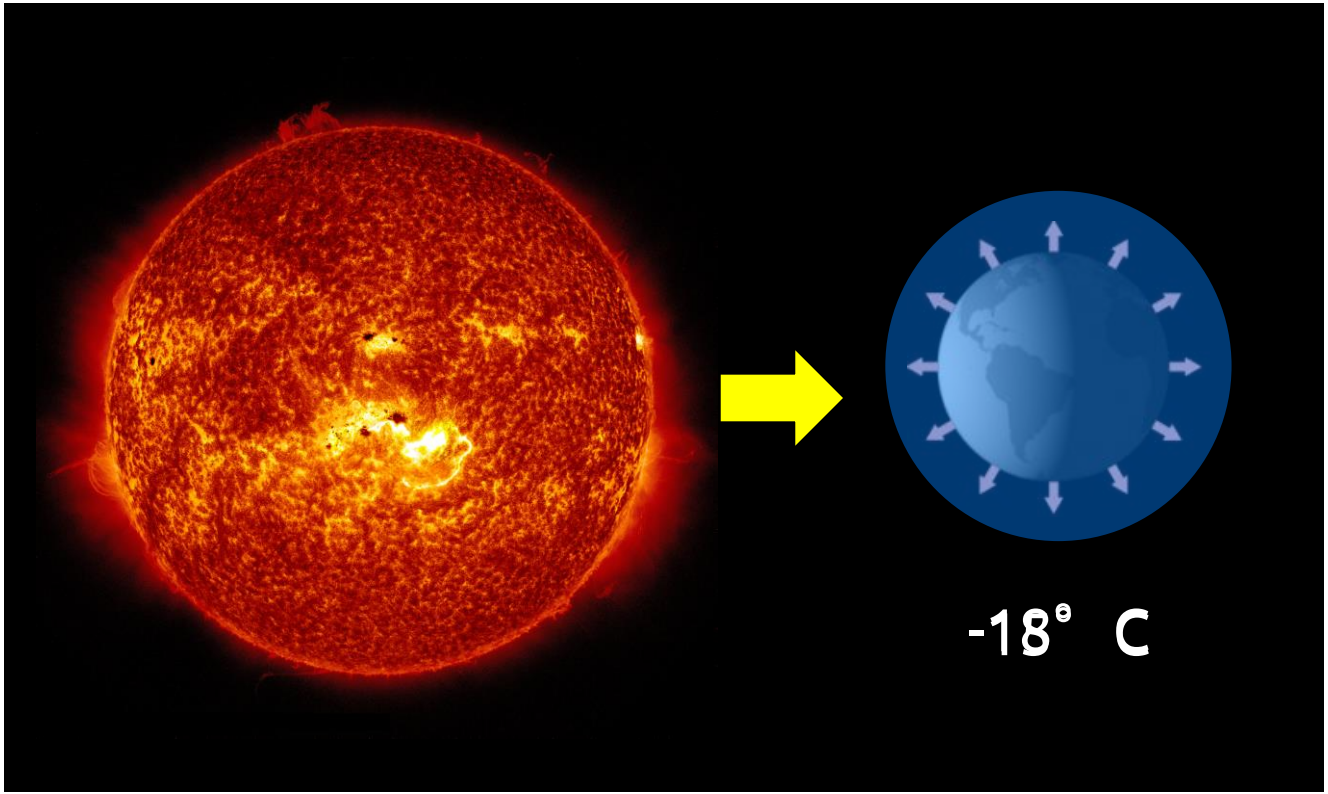
Acidifying

Losing oxygen

Cosa dice l'IPCC

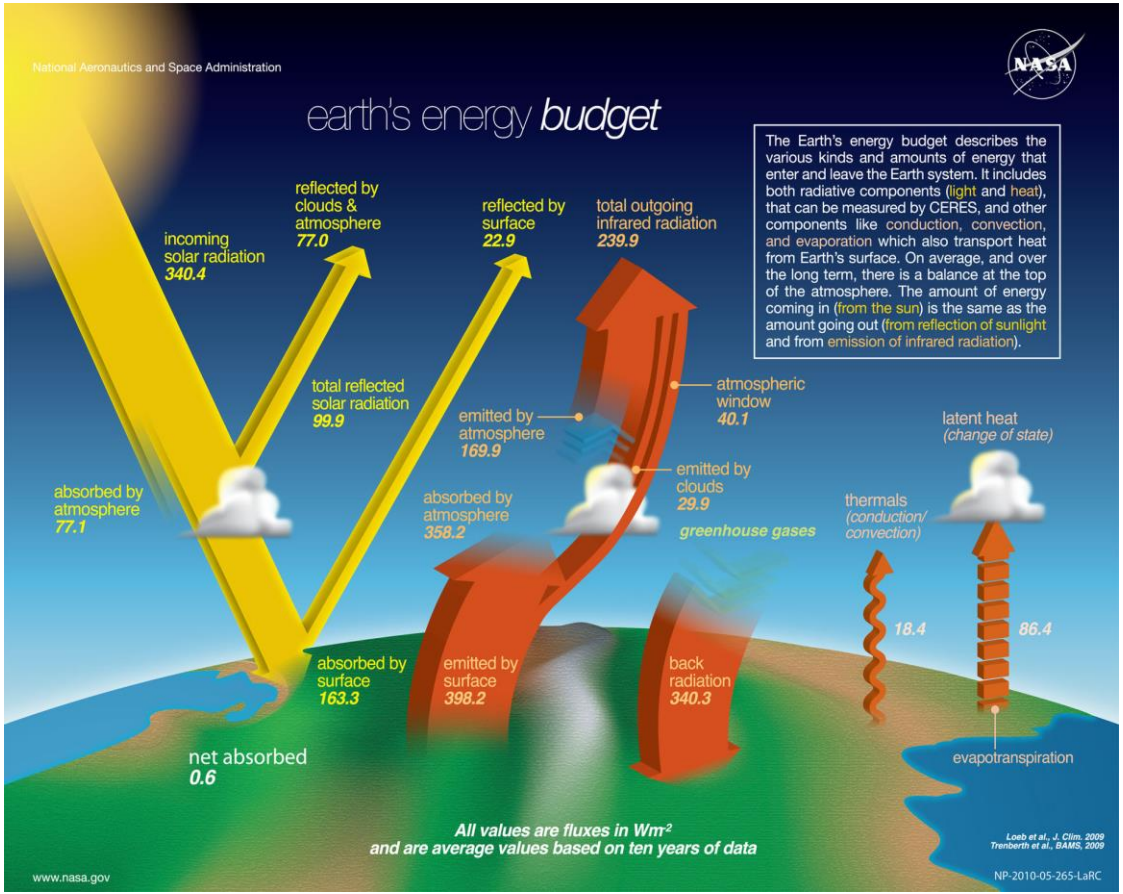
ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Effetto Serra

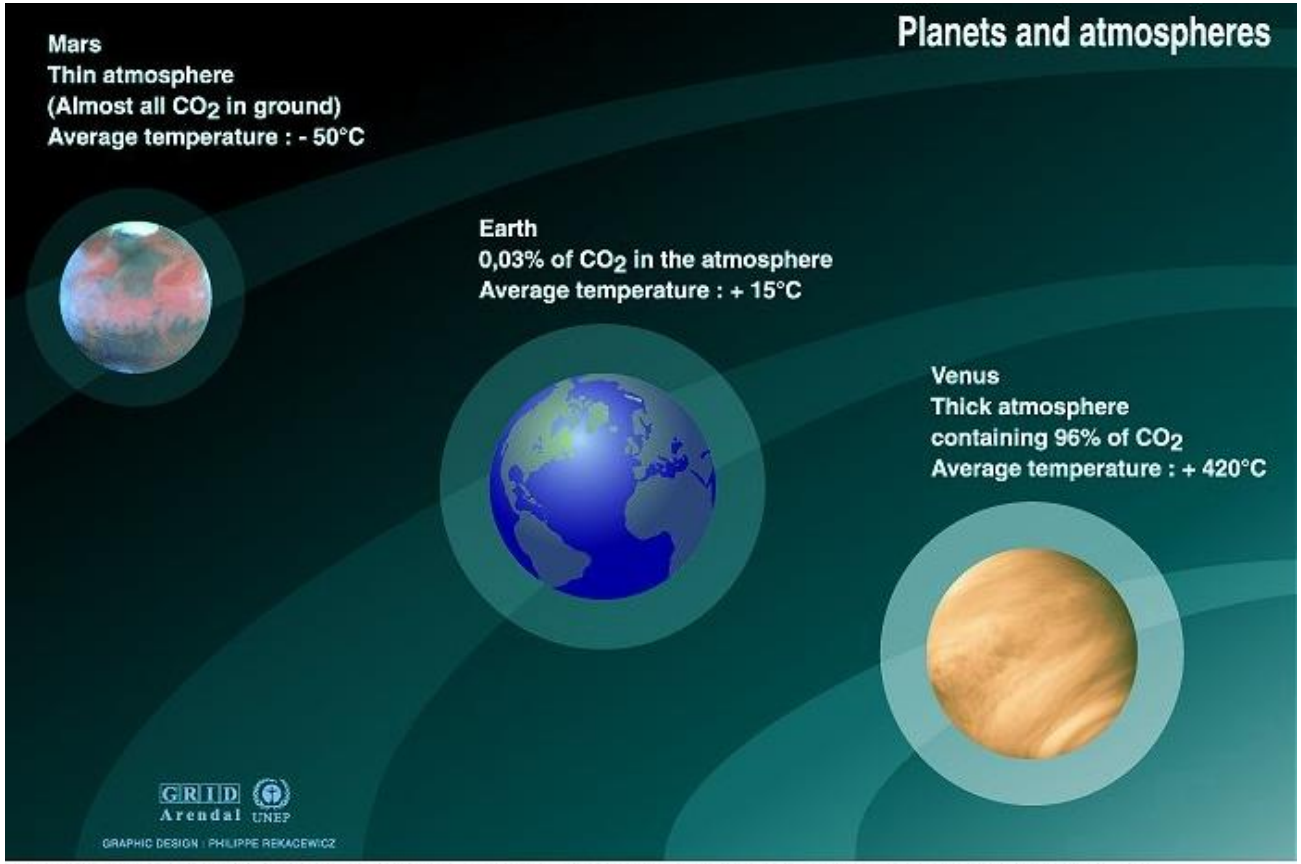


Gas serra contribuiscono a riscaldare la Terra di **33°C**

climate.nasa.gov/

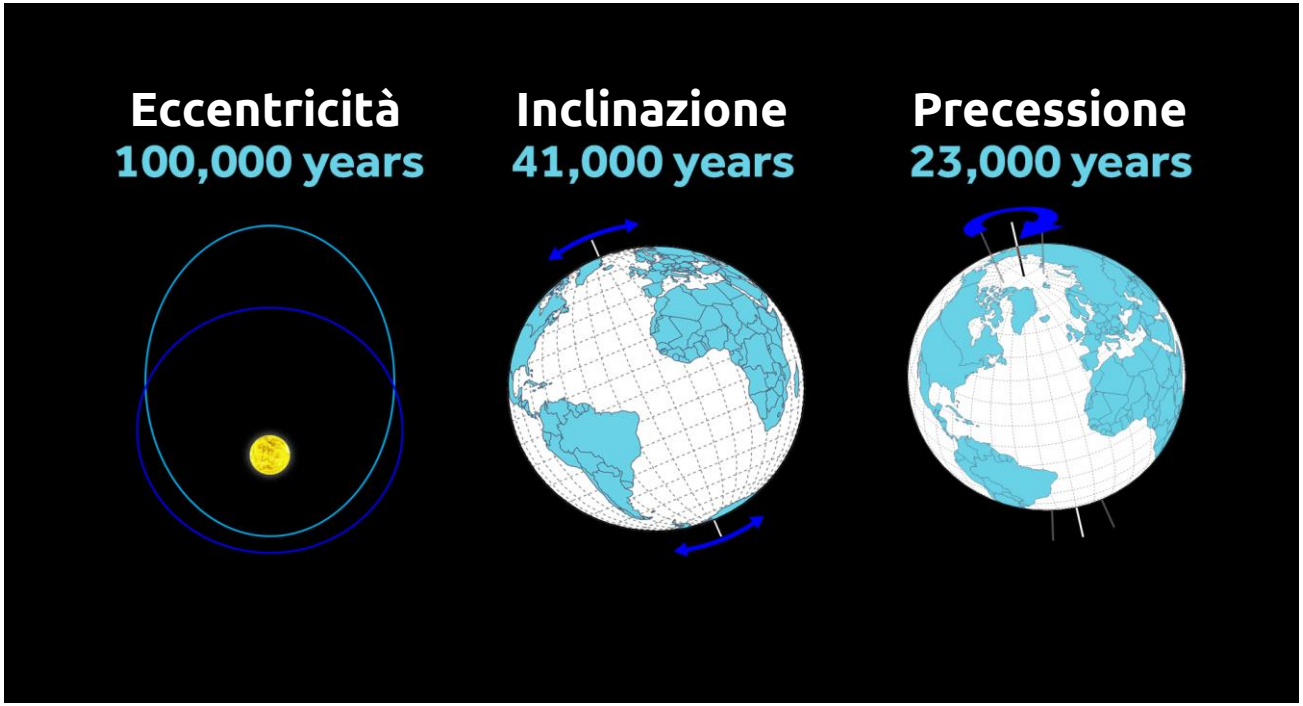


climate.nasa.gov/



Sources: Calvin J. Hamilton, Views of the solar system, www.planetscapes.com; Bill Arnett , The nine planets, a multimedia tour of the solar system, www.seds.org/billa/tnp/nineplanets.html

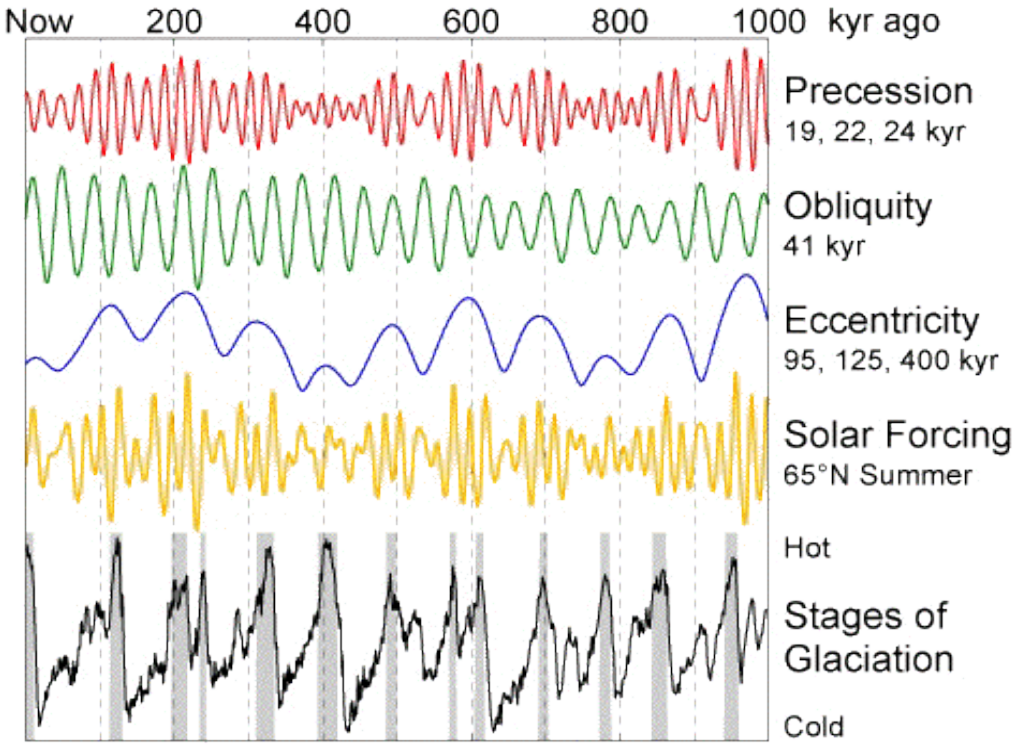
Variabilità naturale del clima: effetti astronomici



Questi cicli modificano la quantità di energia solare assorbita dalla terra.

In gran parte sono responsabili delle passate ere glaciali

Variabilità naturale del clima: effetti astronomici



- La Teoria di Milankovitch spiega i 3 cambiamenti ciclici dell'orbita e dell'inclinazione della Terra che causano le fluttuazioni climatiche che si verificano nell'arco di decine di migliaia di anni fino a centinaia di migliaia di anni

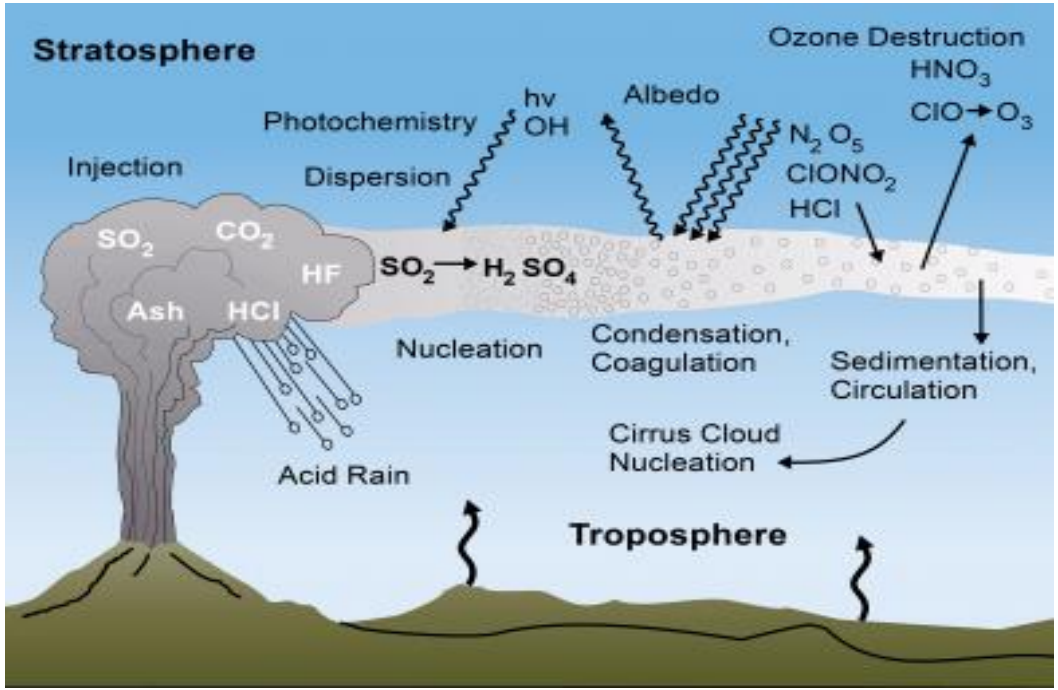
Variabilità naturale del clima: attività solare

Si pensa che una diminuzione dell'attività solare abbia innescato la Piccola Era Glaciale tra il 1650 e il 1850 circa, quando la Groenlandia fu in gran parte isolata dal ghiaccio dal 1410 al 1720 e i ghiacciai avanzarono nelle Alpi.

The Frozen Thames, by Abraham Hondius (c.1625–1691)

Pompenburg with Hofpoort in winter, by Bartholomeus Johannes van Hove (1790-1880)

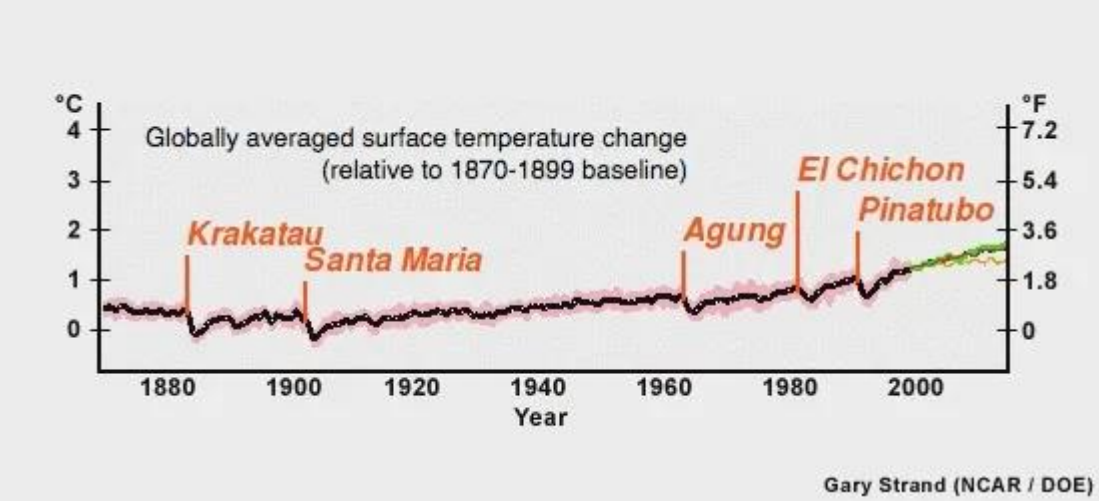
Variabilità naturale del clima: vulcanismo

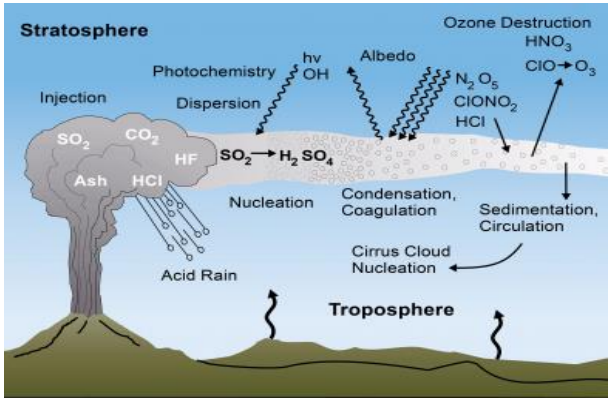


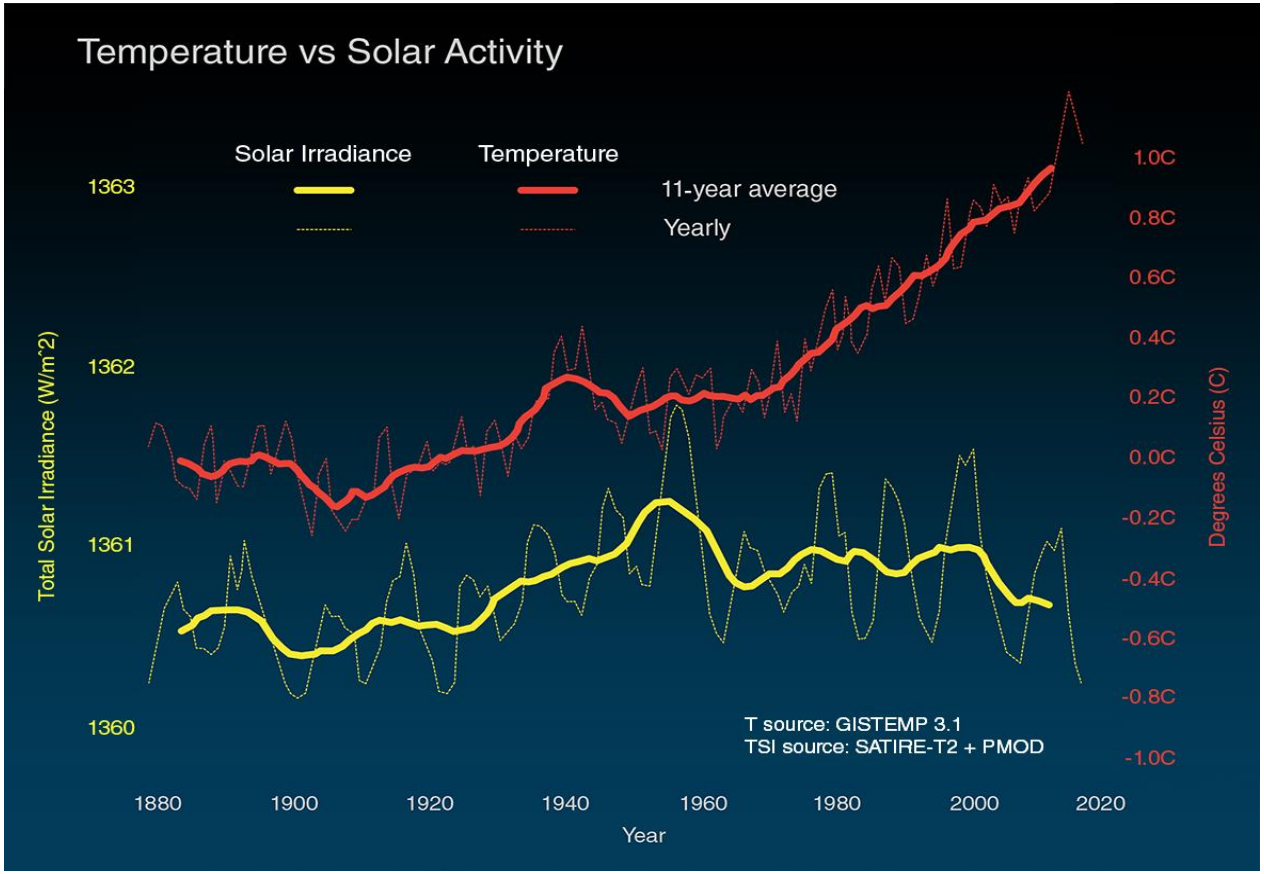
Fonte: https://earthdata.nasa.gov/learn/sensing-our-planet/volcanoes-and-climate-change

Un'eruzione vulcanica emette una enorme quantità di particelle e altri gas che ci proteggono efficacemente dal Sole portando a un periodo di raffreddamento globale

Variabilità naturale del clima: vulcanismo

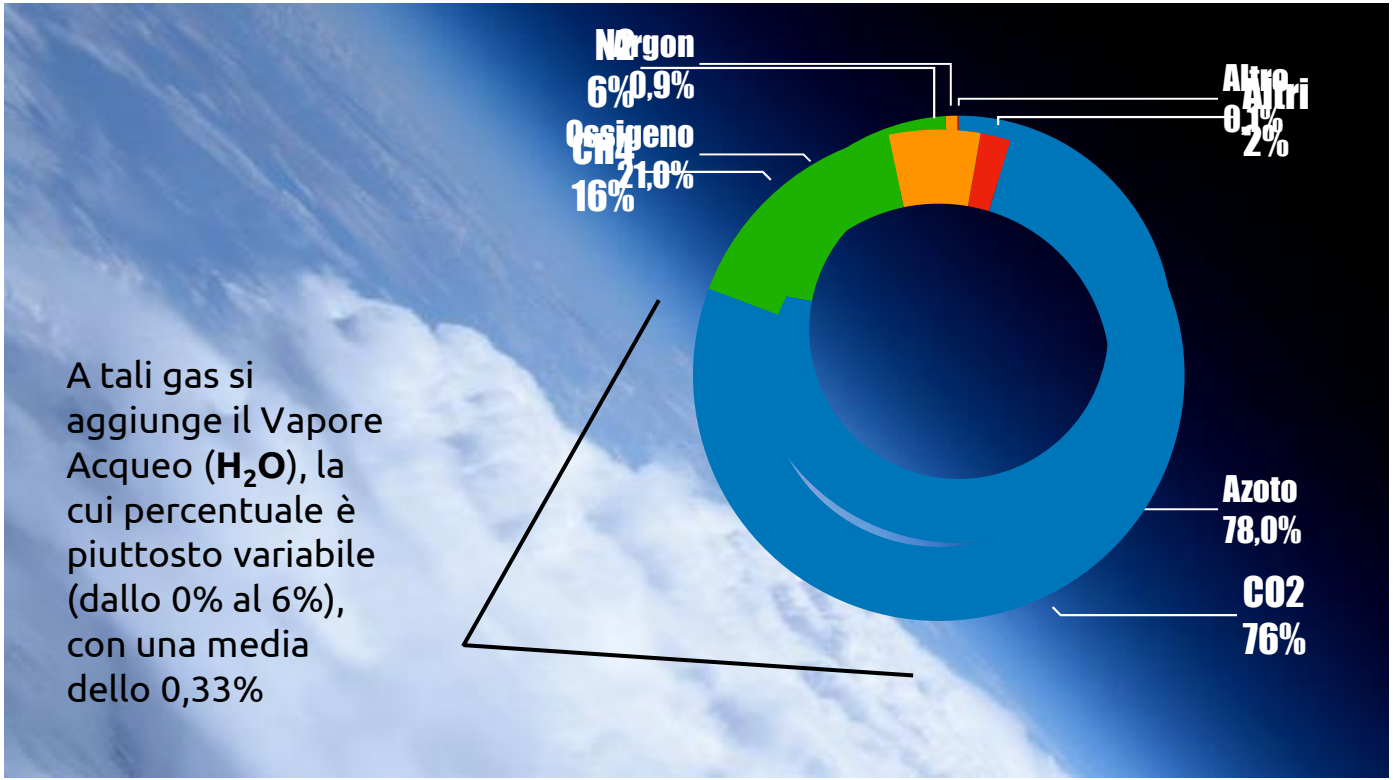






Andamento della temperatura superficiale della Terra in funzione della radiazione solare

Gas atmosferici



A tali gas si aggiunge il Vapore Acqueo (H_2O), la cui percentuale è piuttosto variabile (dallo 0% al 6%), con una media dello 0,33%

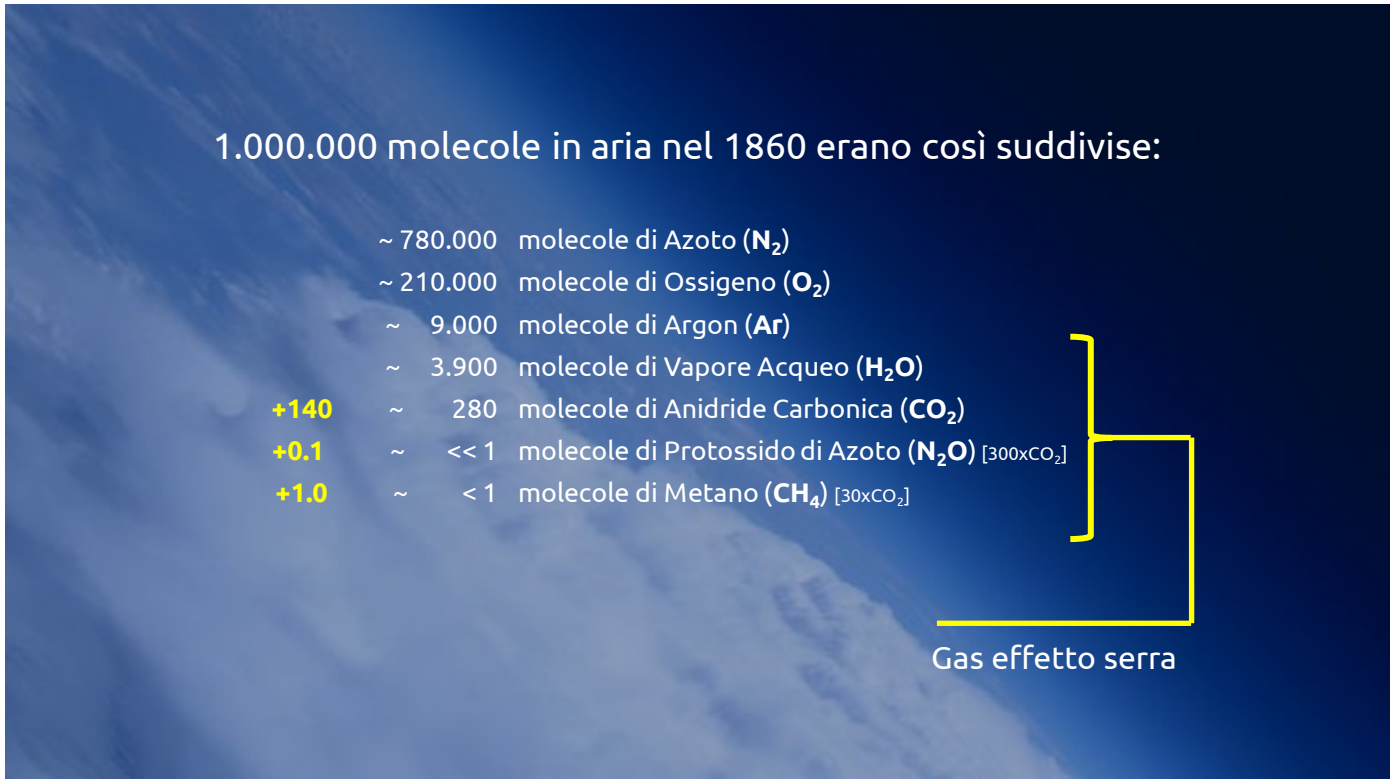
Gas atmosferici

1.000.000 molecole in aria nel 1860 erano così suddivise:

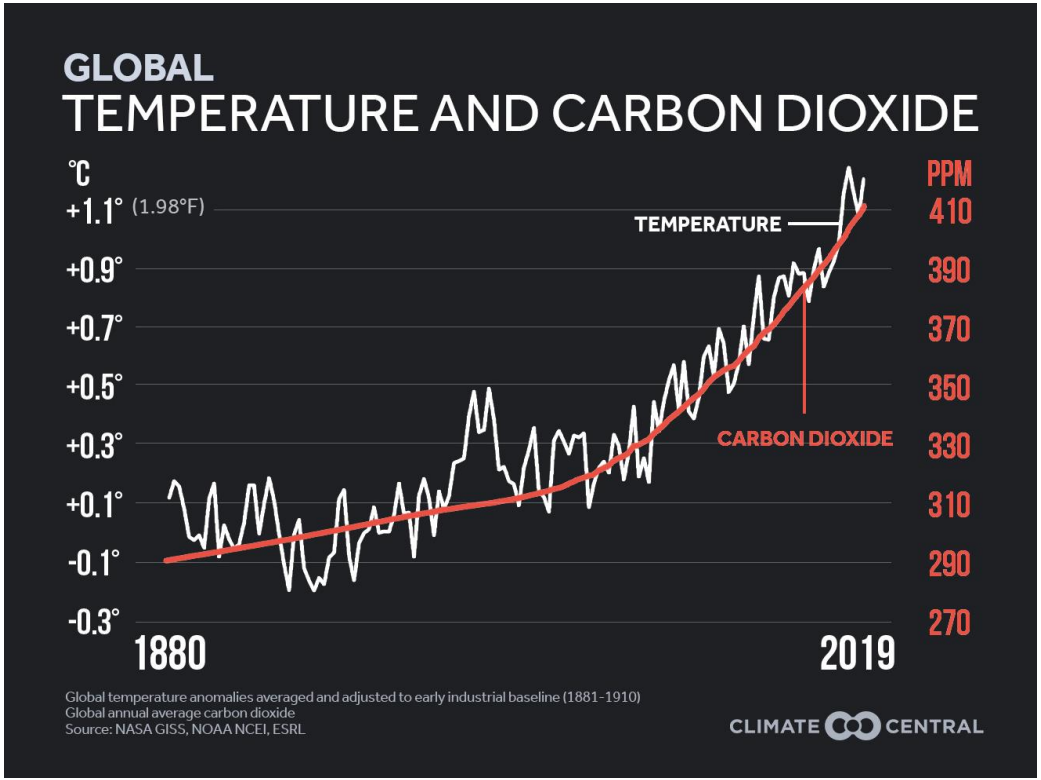
~	780.000	molecole di Azoto (N_2)
~	210.000	molecole di Ossigeno (O_2)
~	9.000	molecole di Argon (**Ar**)
~	3.900	molecole di Vapore Acqueo (H_2O)
~	280	molecole di Anidride Carbonica (CO_2)
~	<< 1	molecole di Protossido di Azoto (N_2O) [300xCO_2]
~	< 1	molecole di Metano (CH_4) [30xCO_2]

Gas effetto serra

Gas atmosferici

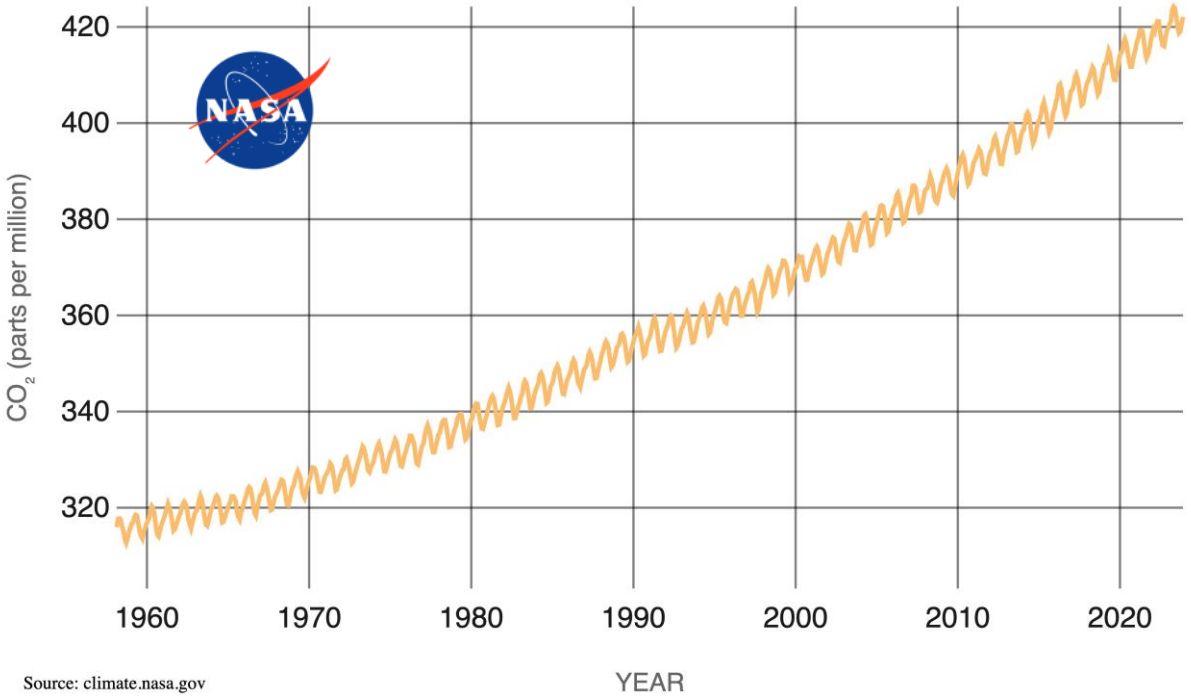


Andamento della temperatura superficiale e CO_2



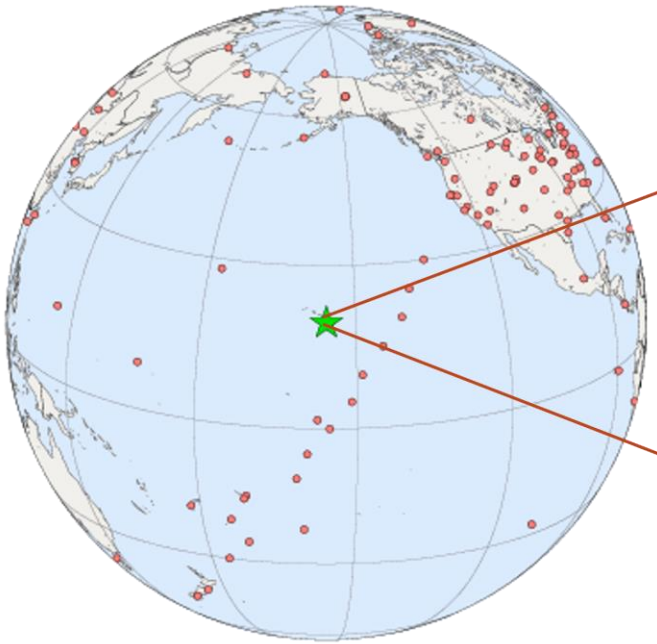
https://www.climatecentral.org/

Andamento concentrazione CO2 in atmosfera



Il grafico mostra i livelli di anidride carbonica atmosferica (CO2) misurati da NOAA presso l'Osservatorio di Mauna Loa, nelle Hawaii, a partire dal 1958.

Prima stazione di monitoraggio della CO2

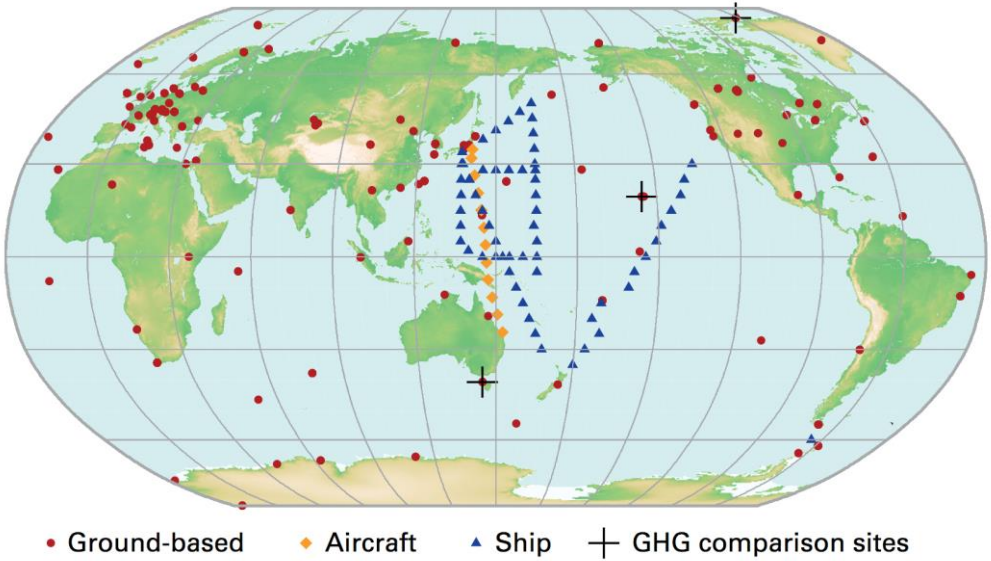


3397 m

Prima stazione di monitoraggio della CO2

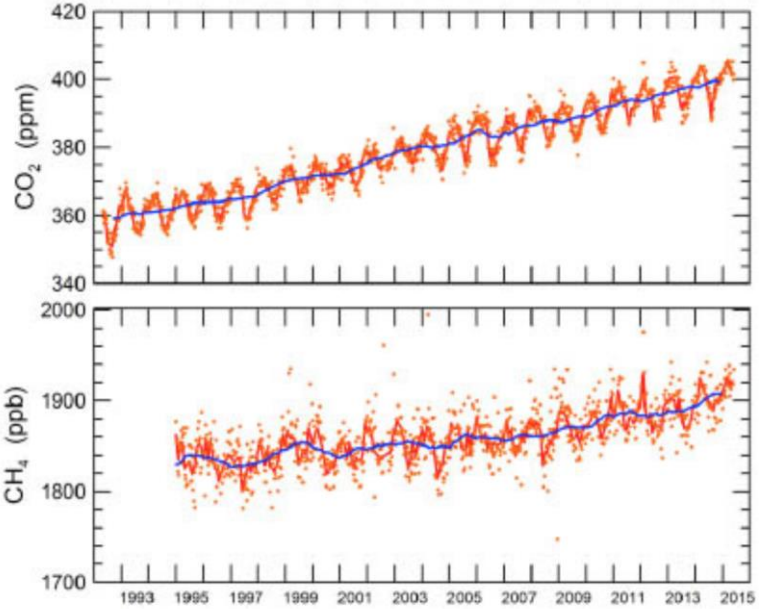
Charles David Keeling
(April 20, 1928 – June 20, 2005)
Agli inizi degli anni ’50 Keeling aveva scoperto una tecnica per misurare con precisione la CO2 presente in atmosfera, facendo installare all’osservatorio di Mauna Loa un dispositivo che ne rilevava il valore.

Stazioni di monitoraggio della CO2



La rete globale *Global Atmosphere Watch* (GAW) per la misura dell'anidride carbonica. La rete per la misura del metano è simile.

Stazione di monitoraggio della CO2 italiana

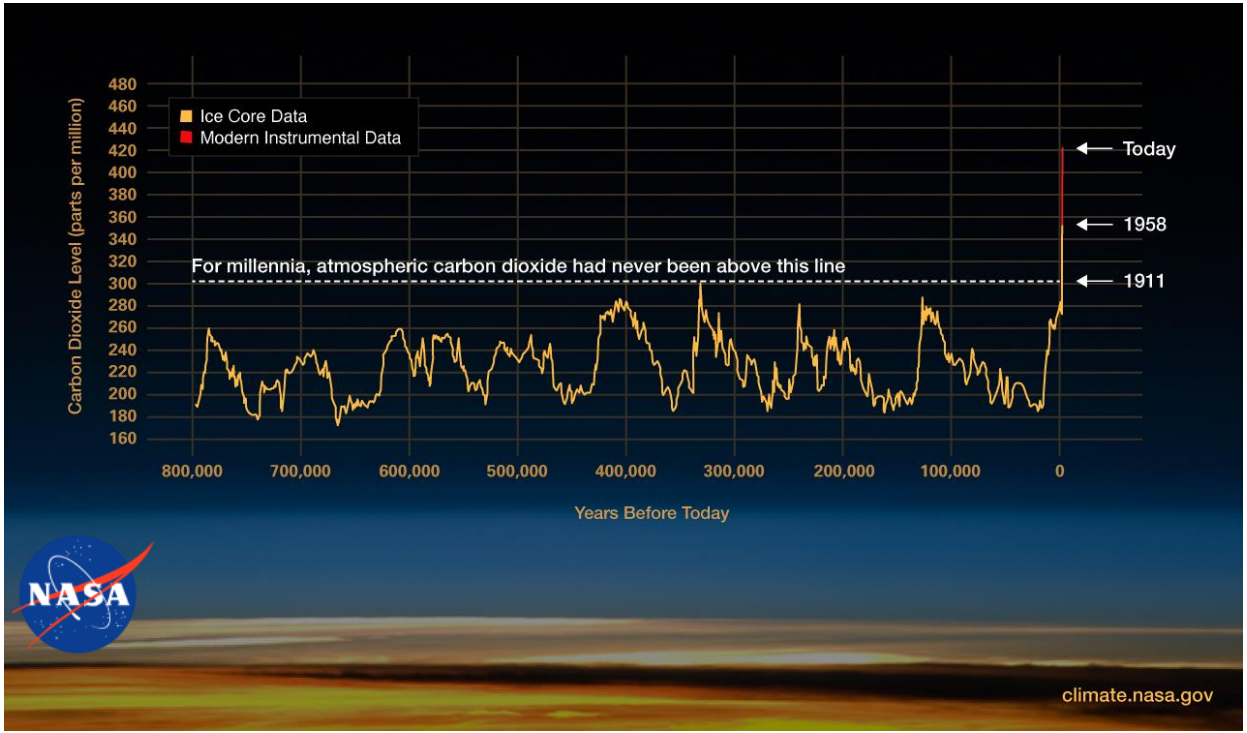


Evoluzione dei valori settimanali (punti arancioni), mensili (curva rossa) ed annuali (curva blu) di CO2 e CH_4 (metano) a Lampedusa

La Stazione di Osservazioni Climatiche dell'ENEA (Roberto Sarao) sull'isola di Lampedusa è un centro di ricerca nel Mediterraneo dedicato alla misurazione dei parametri climatici dell'atmosfera.

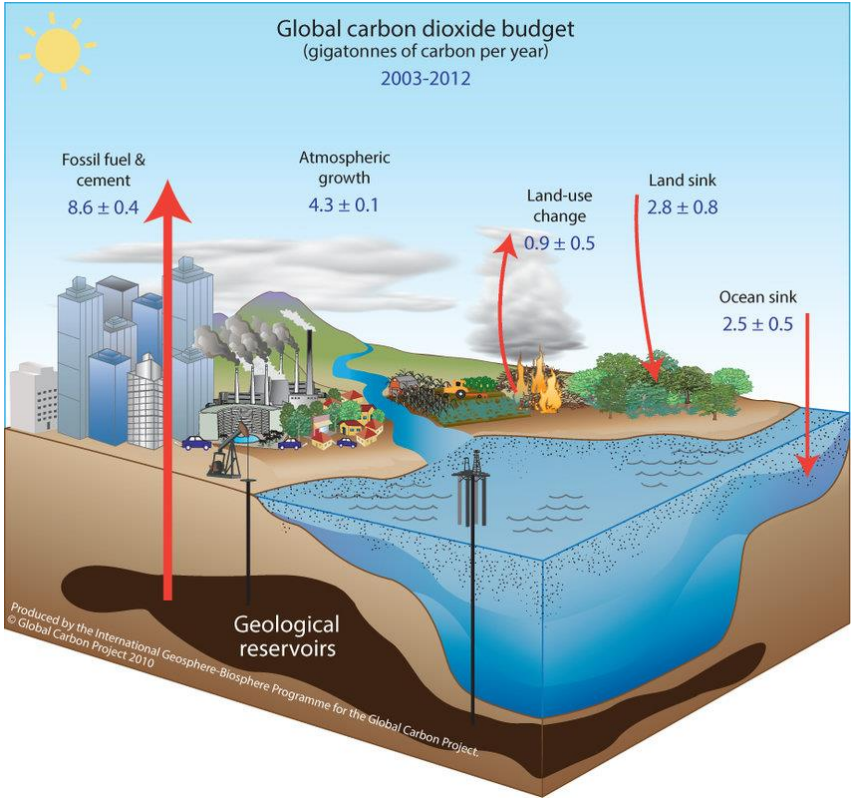
ENEA
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
www.enea.it

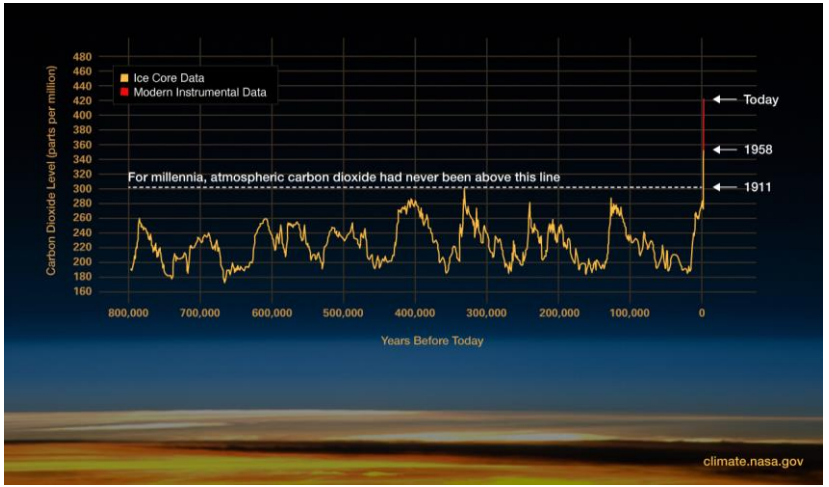
Andamento concentrazione CO2 in atmosfera



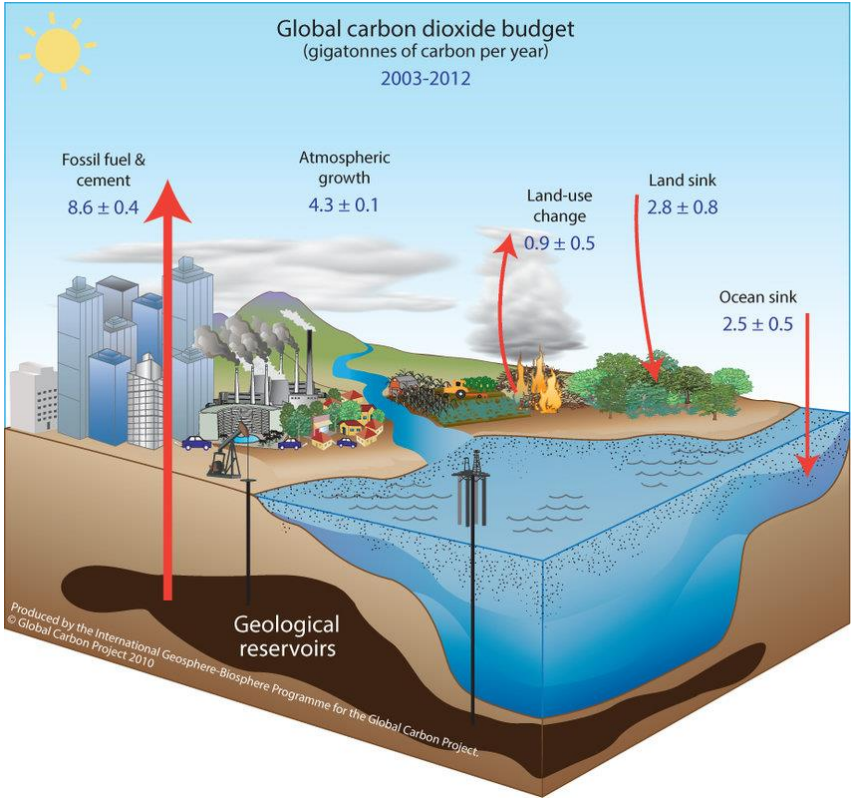
Questo grafico, basato sul confronto tra campioni atmosferici contenuti in carote di ghiaccio e misurazioni dirette più recenti, fornisce prove che la CO2 atmosferica è aumentata dall'epoca della Rivoluzione Industriale.

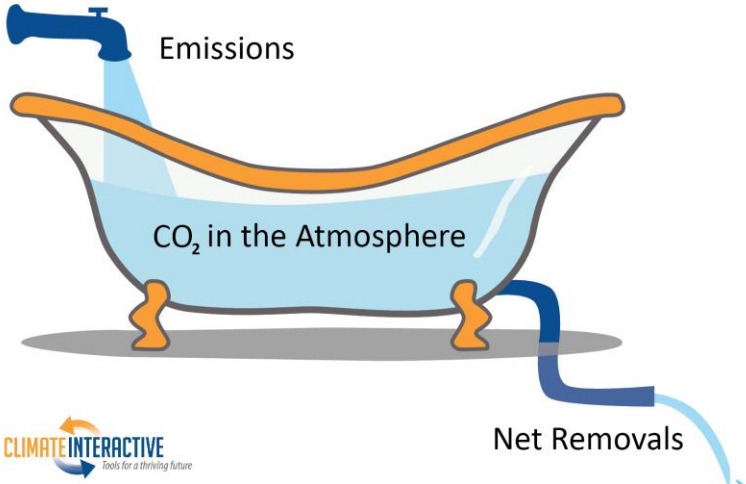
Flussi di CO2





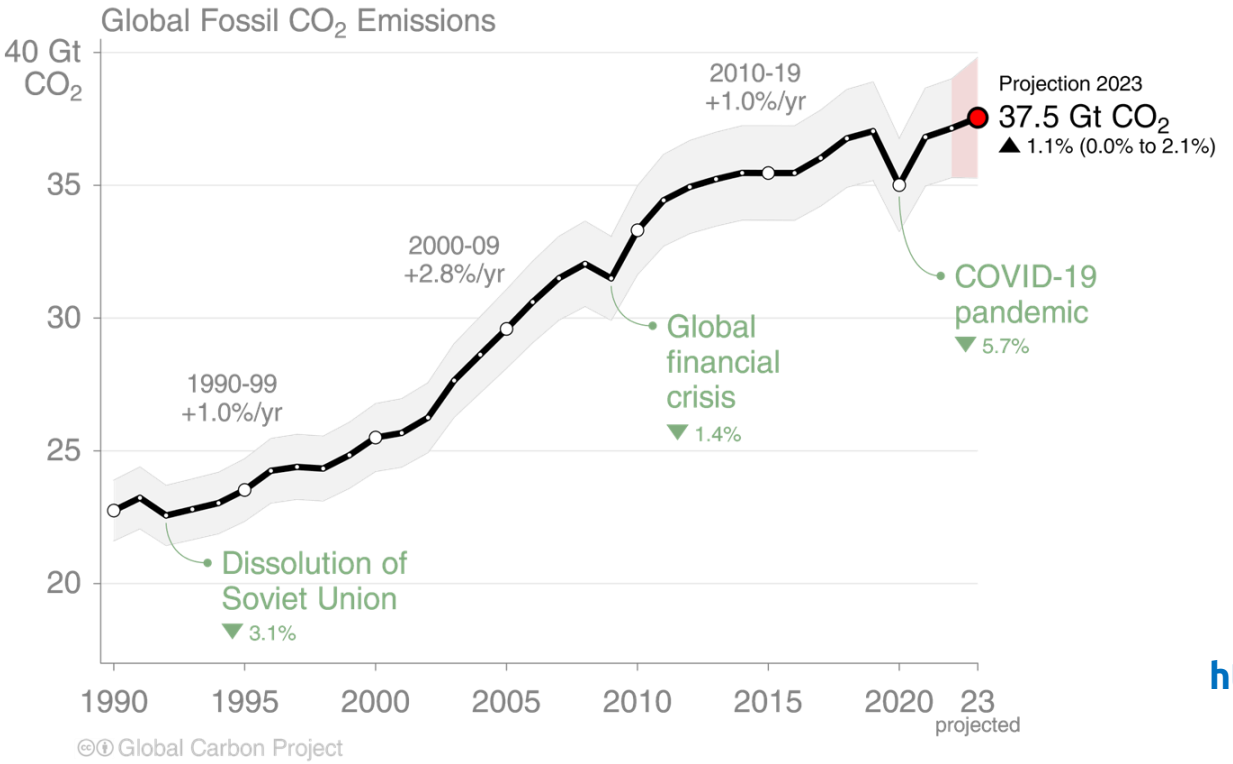
Flussi di CO2





Overall framing by Dr. John Sterman, MIT Sloan

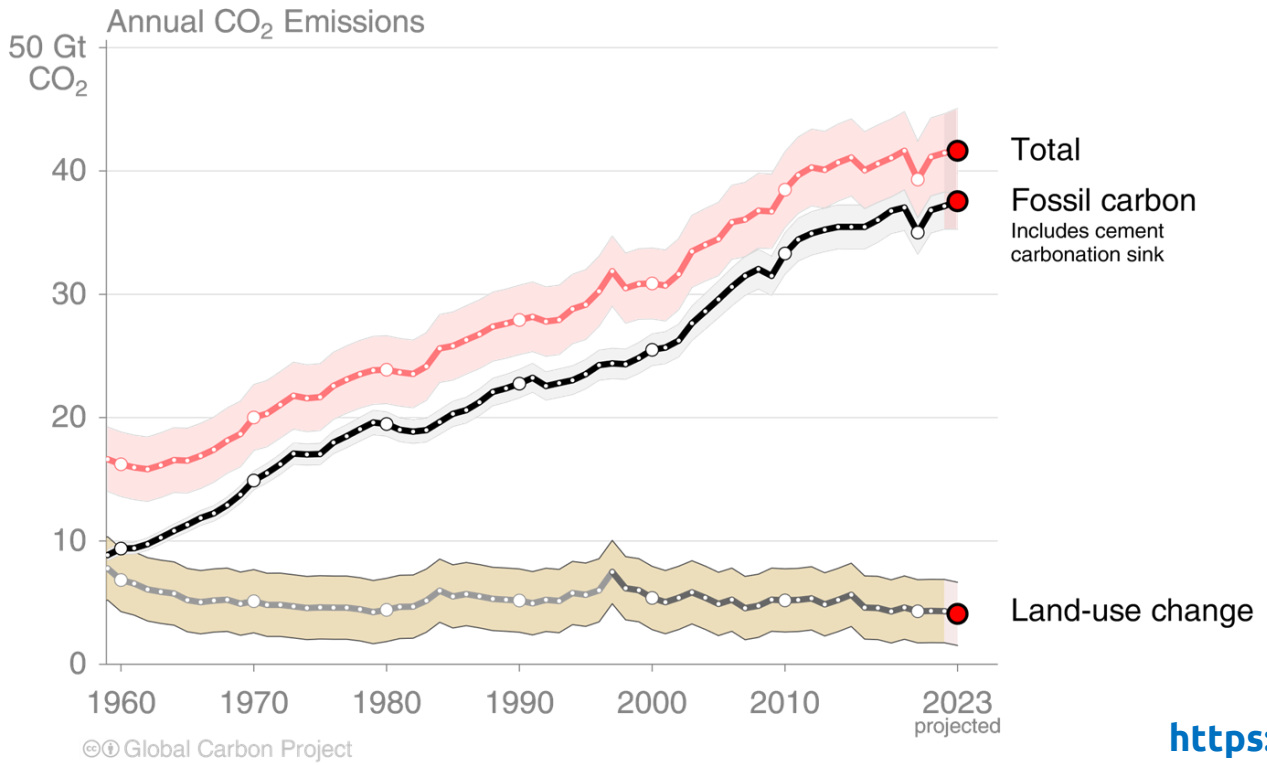
Emissioni globali di CO2 dal 1990 al 2023



GLOBAL CARBON project

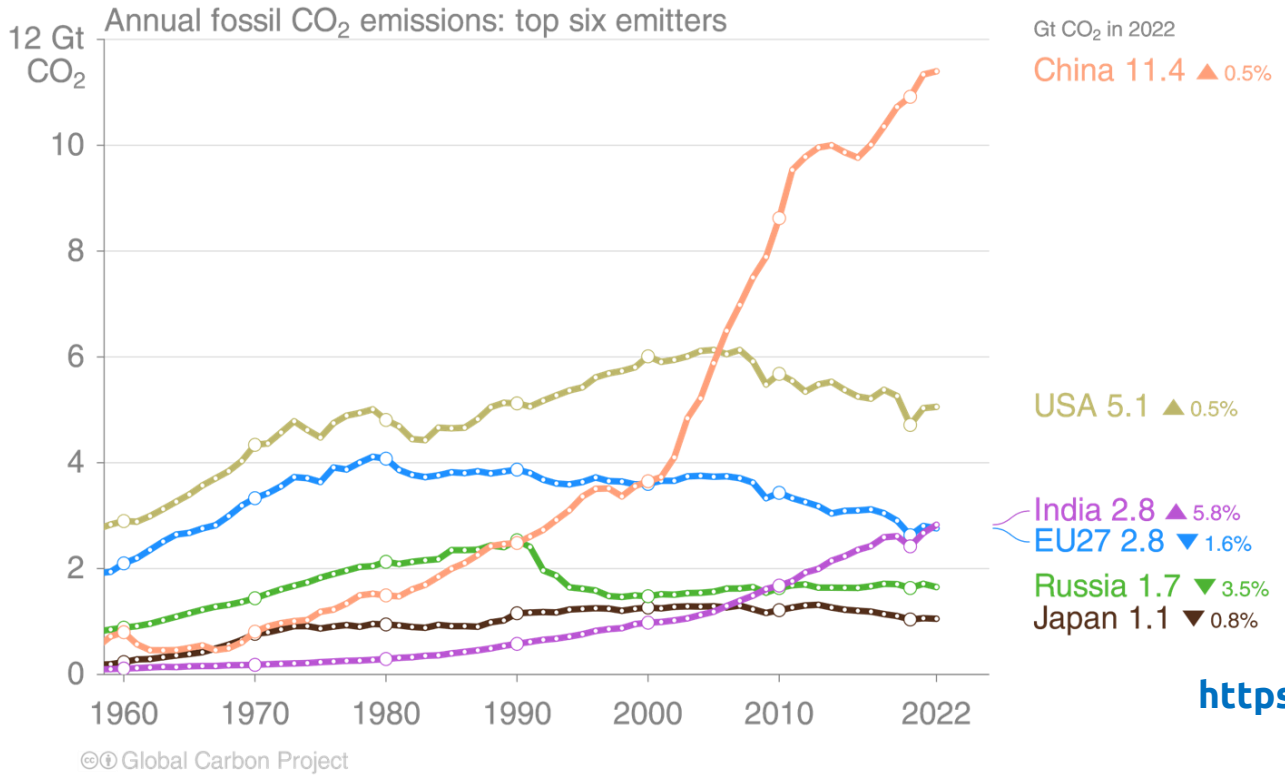
https://globalcarbonbudget.org/

Emissioni globali di CO2 dal 1990 al 2023



https://globalcarbonbudget.org/

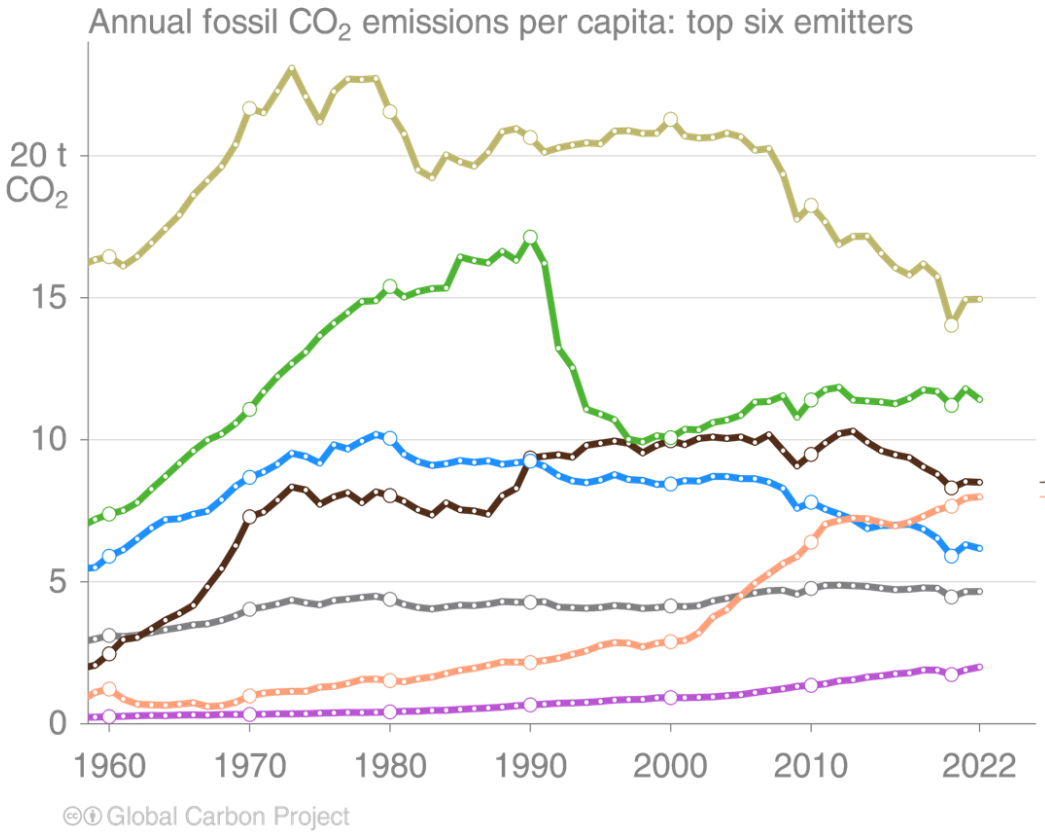
I maggiori emettitori di CO2



GLOBAL CARBON project

https://globalcarbonbudget.org/

Emissioni globali di CO2 pro capite



GLOBAL CARBON project

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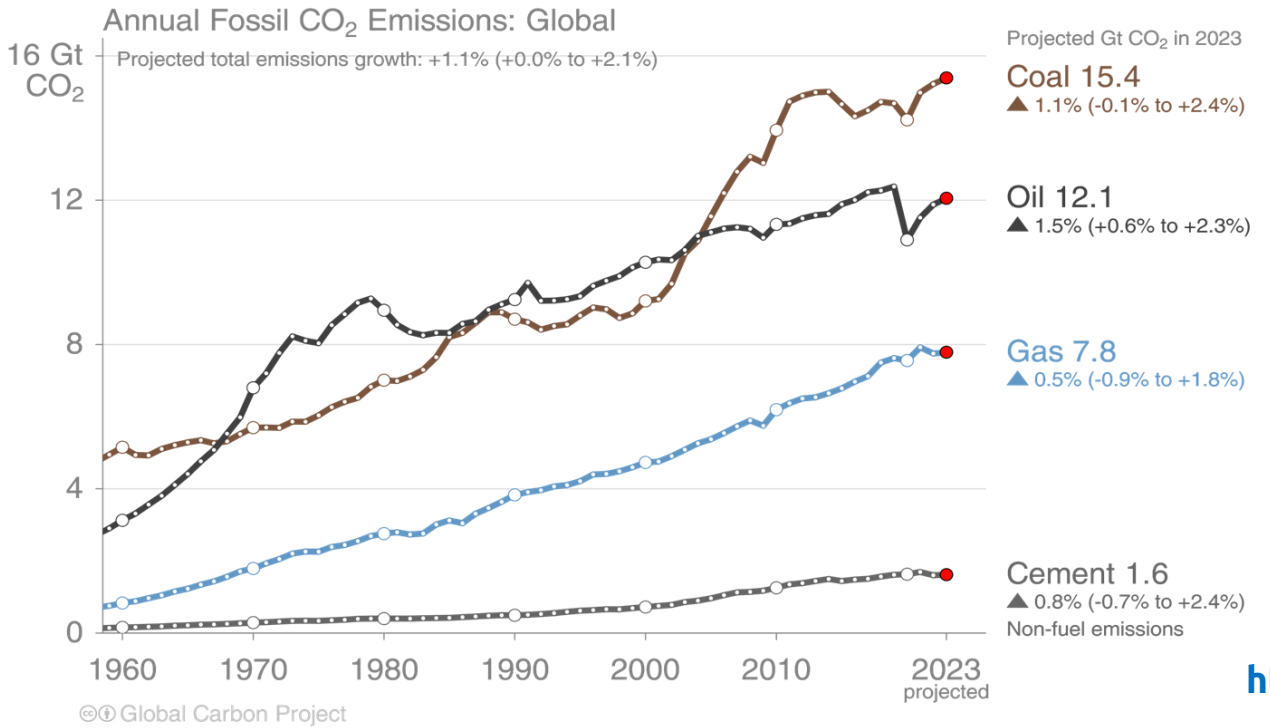
Emissioni globali di CO2 per fonte di energia



GLOBAL CARBON project

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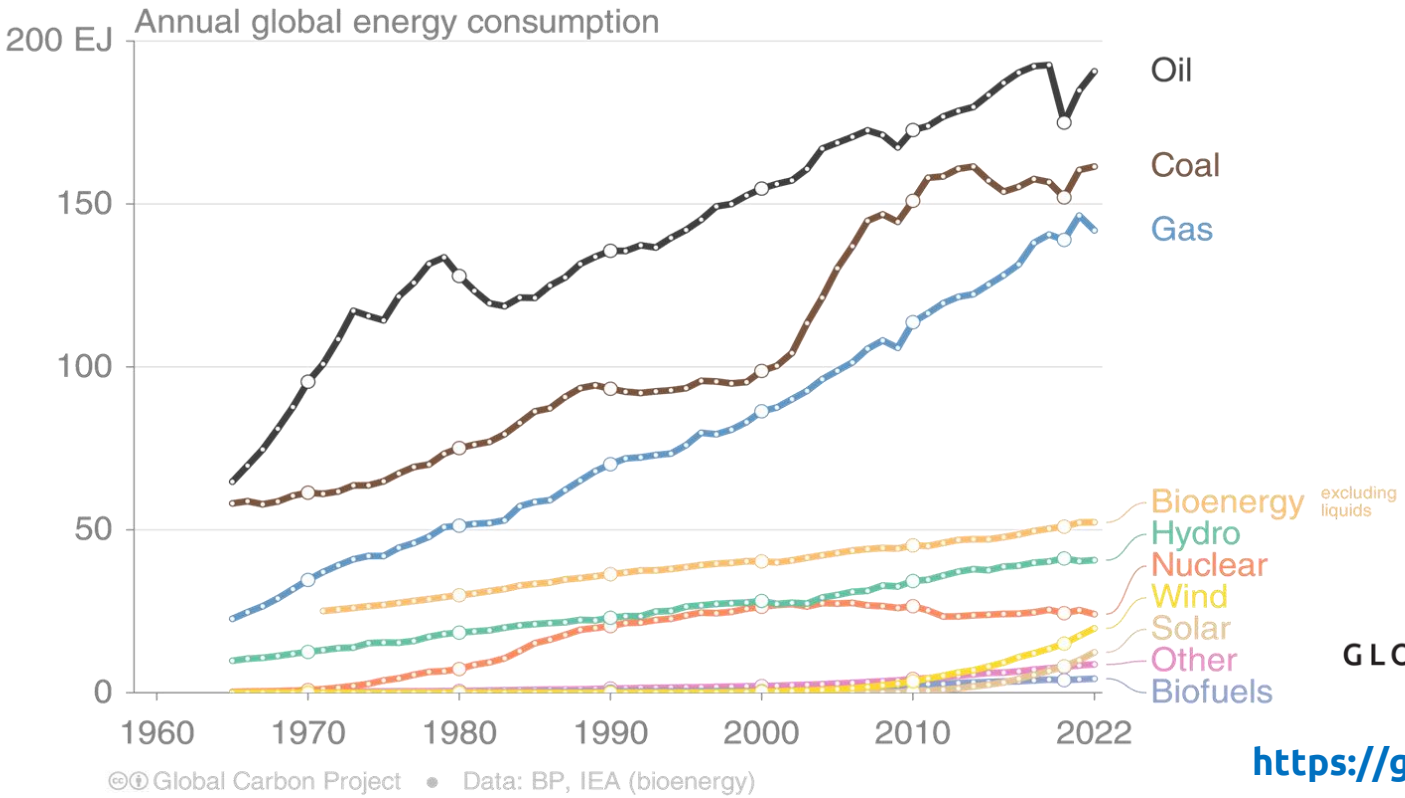
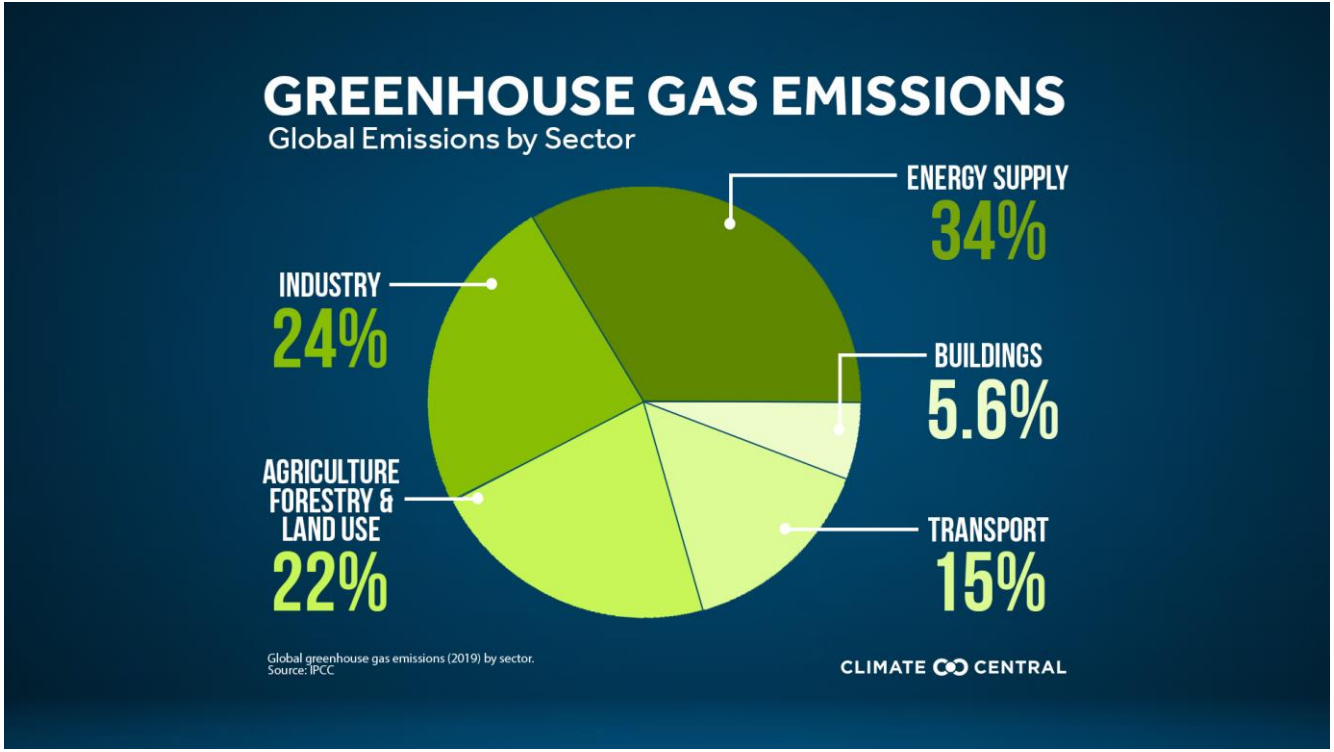
Produzione di energia globale



GLOBAL CARBON project

https://globalcarbonbudget.org/

Emissioni globali per settore



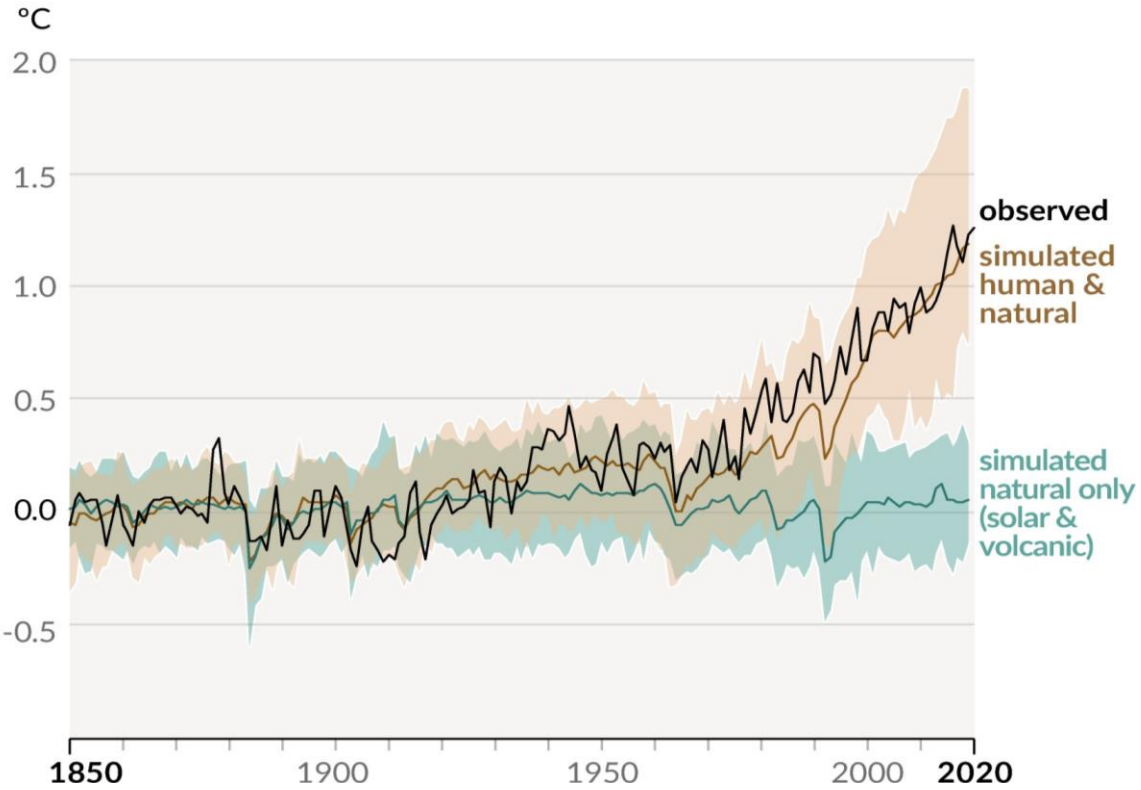
CLIMATE CENTRAL

www.climatecentral.org

Cosa dice l'IPCC

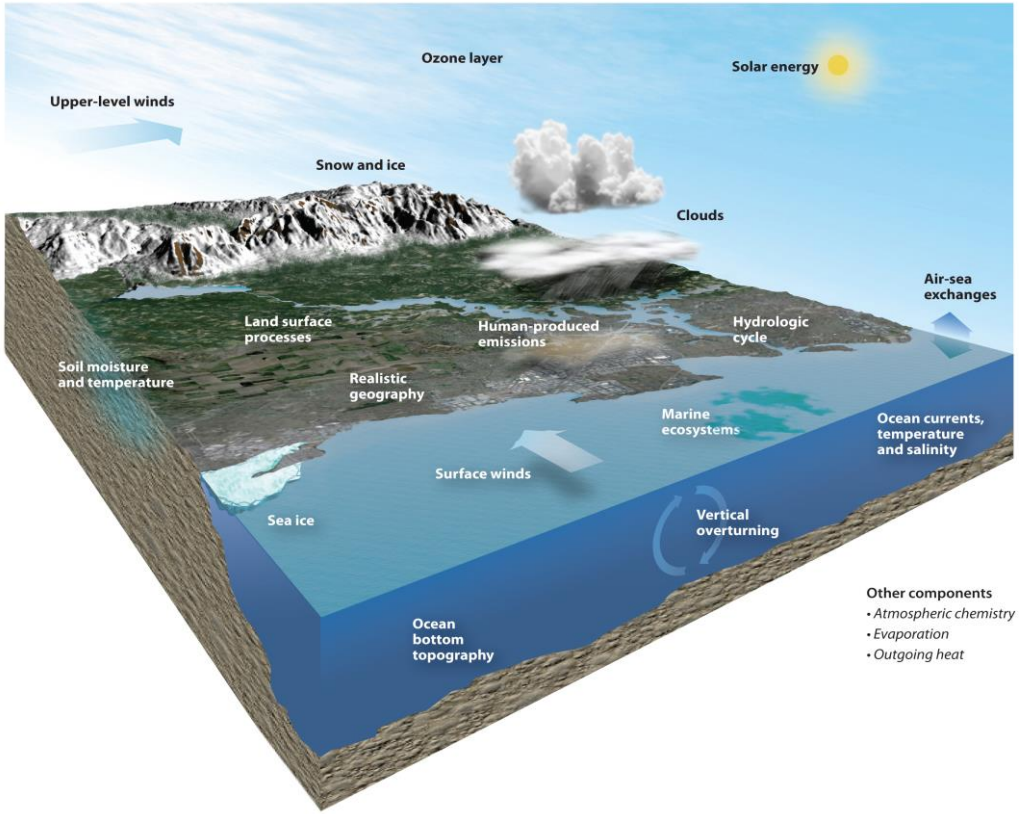
ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Cosa dice l'IPCC



Variazione della temperatura superficiale globale (media annuale) come osservata e simulata utilizzando fattori sia umani che naturali e solo naturali (entrambi per il periodo 1850-2020)

Il Sistema climatico è un sistema complesso



Le Equazioni dell'oceano

$$\frac{1}{\rho}\frac{D\rho}{Dt} + \nabla \cdot \mathbf{u} = 0$$ Conservazione della Massa

$$\frac{D\mathbf{u}}{Dt} + 2\boldsymbol{\Omega} \times \mathbf{u} = -\frac{1}{\rho}\nabla p - g + \nu\nabla^2\mathbf{u} + \text{Forzante esterno}$$ Equazione del momento

$$\rho = \rho(p, S, T)$$ Equazione di stato

$$\frac{DS}{Dt} = \kappa_S \nabla^2 S$$

$$\frac{DT}{Dt} = \kappa_T \nabla^2 T + Q_T$$

Equazione di Avvezione e Diffusione per Salinità e Temperatura

Equazioni di Navier-Stokes

$\frac{D[\ ]}{Dt} = \frac{\partial[\ ]}{\partial t} + \mathbf{u}\cdot\nabla[\ ]$ *derivata Totale*

$\mathbf{u} = [u, v, w]$ *vettore velocità*

ρ *densità*

$\boldsymbol{\Omega}$ *veloc. ang. Terra*

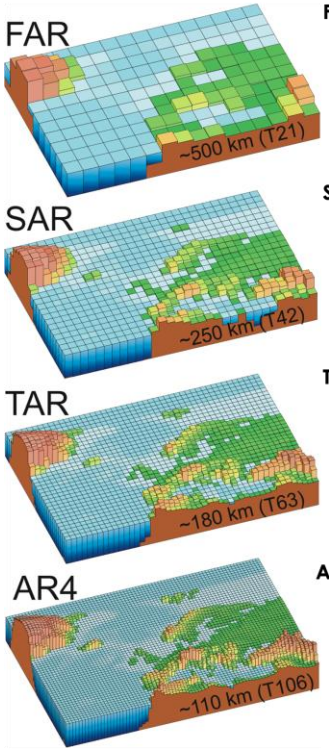
p *pressione*

S *salinità*

T *temperatura*

Q_T *sorgente calore*

κ_T κ_S *coefficienti di diffusione*

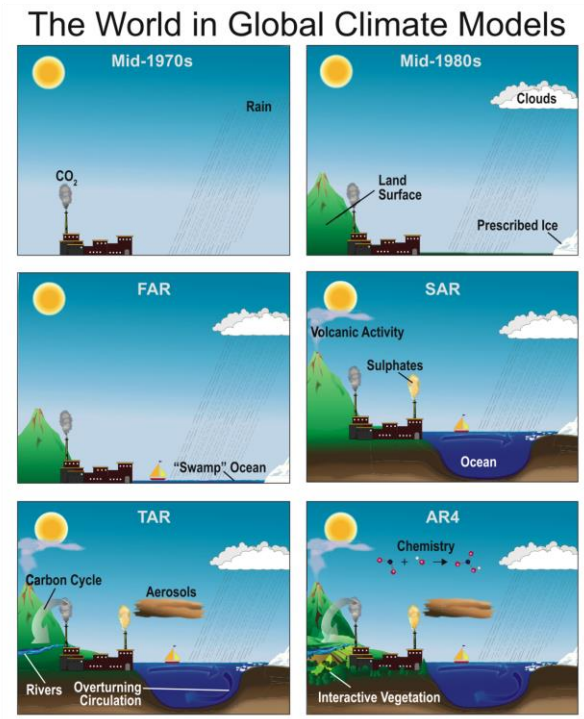


First **A**ssessment **R**eport (1990)

Second **A**ssessment **R**eport (1995)

Third **A**ssessment **R**eport (2001)

Assessment **R**eport **4** (2007)



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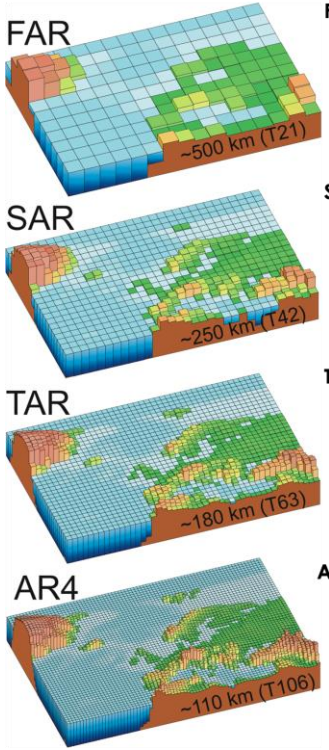

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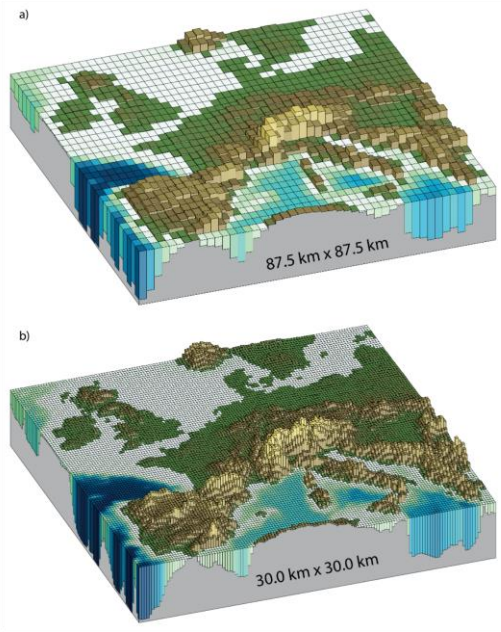

Assessment **R**eport **5** (2014)

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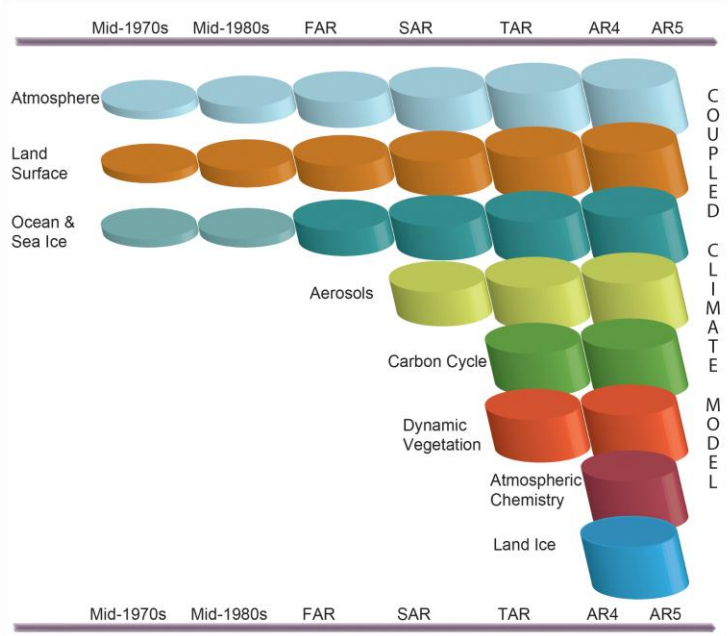

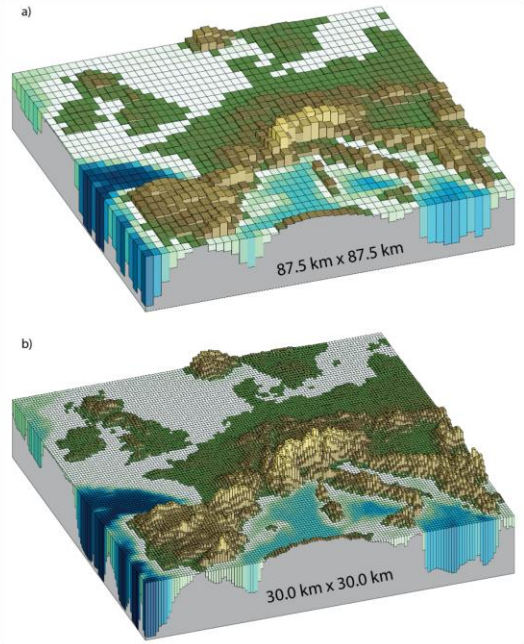

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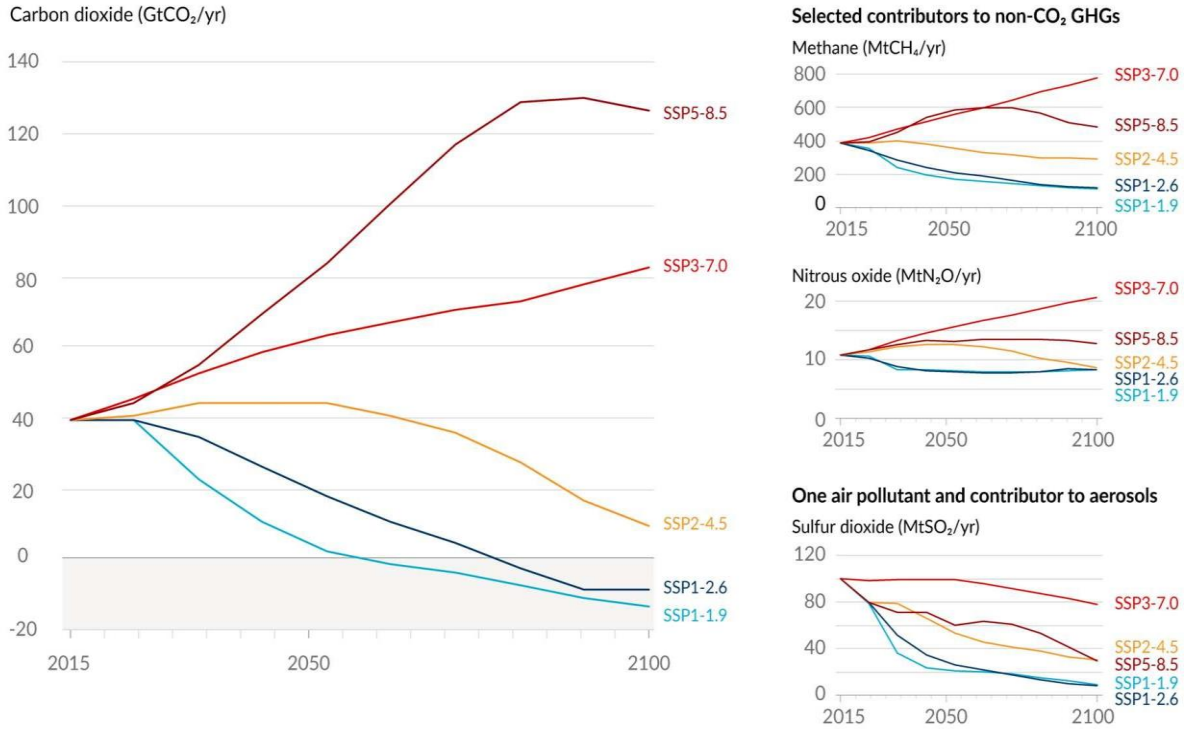
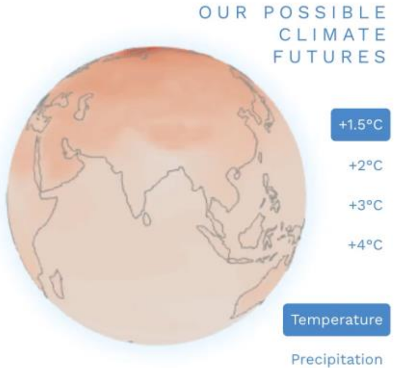
Scenari emissivi futuri

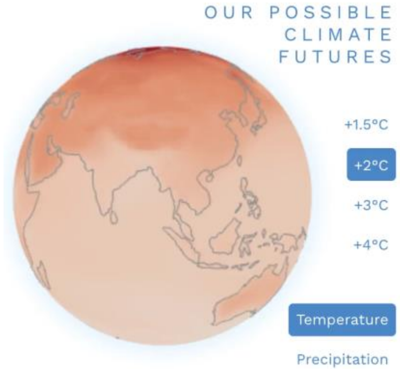
a) Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five illustrative scenarios

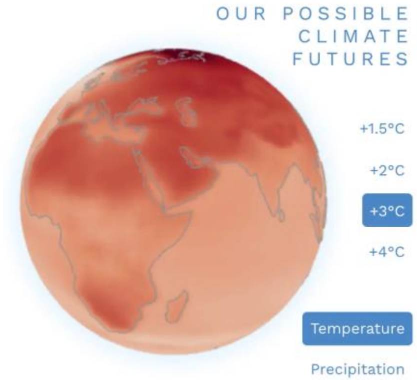


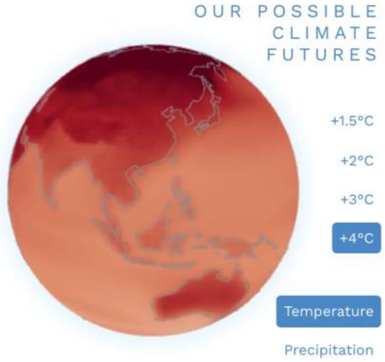
Emissioni antropogeniche dei principali gas e sostanze che contribuiscono al riscaldamento globale e influenzano il cambiamento climatico.

Scenari climatici: temperatura superficiale









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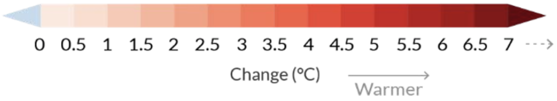
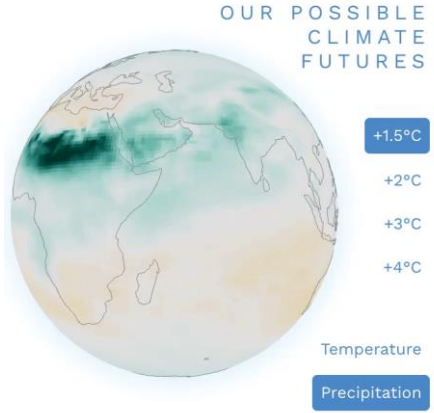
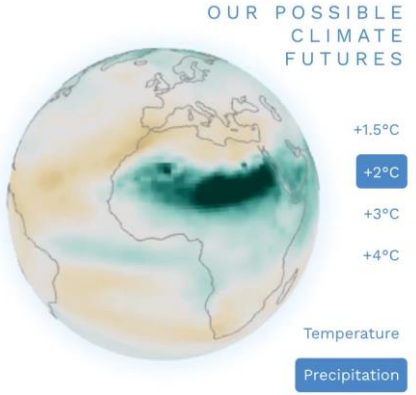
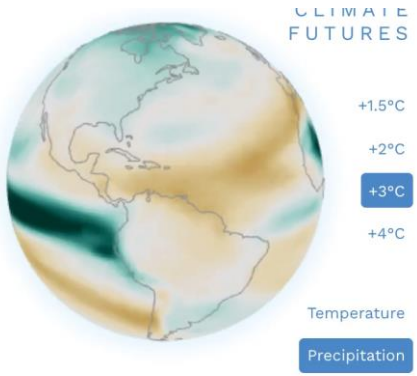
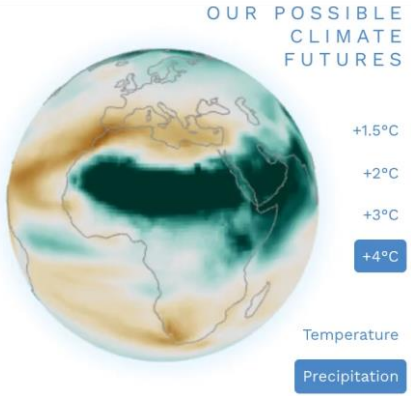


Scenari climatici: precipitazione









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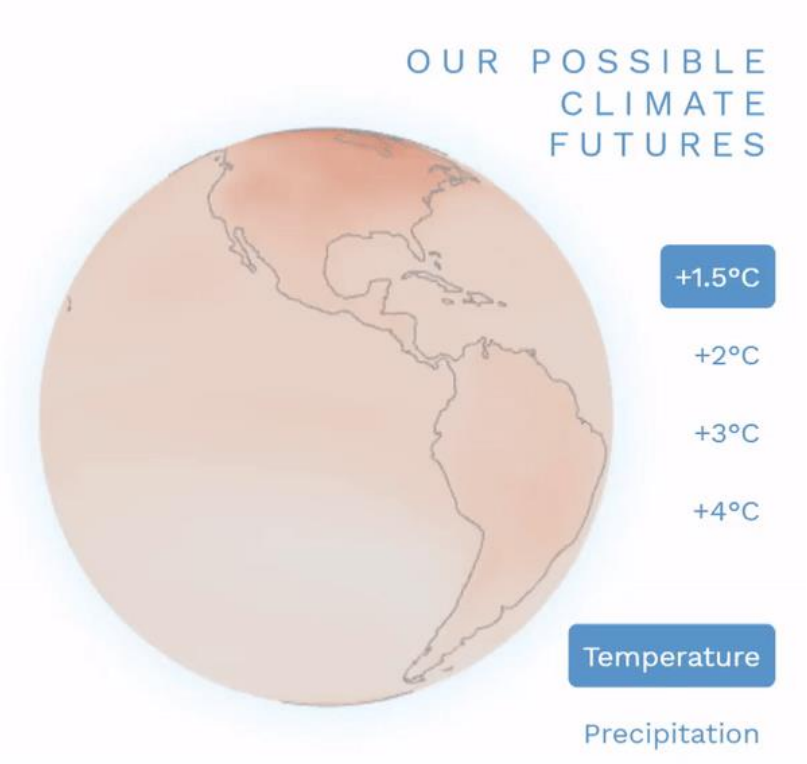
IPCC Atlante Climatico Interattivo



https://interactive-atlas.ipcc.ch/

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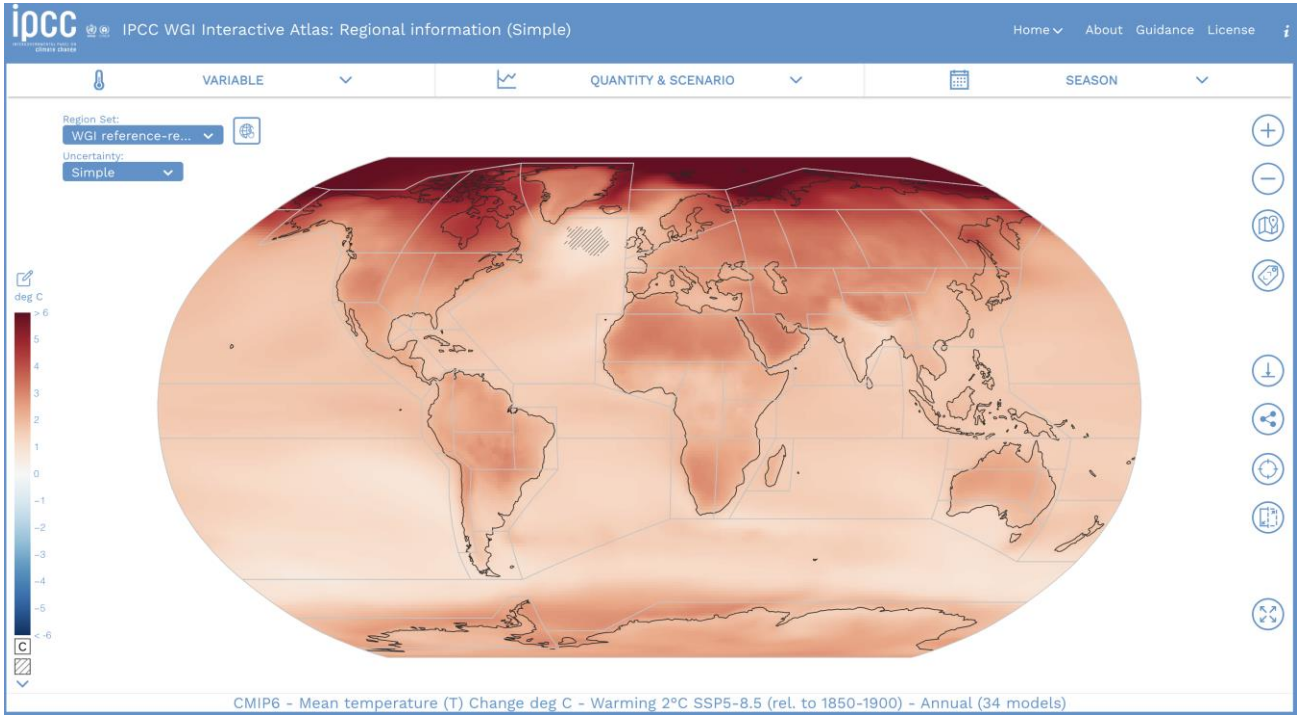

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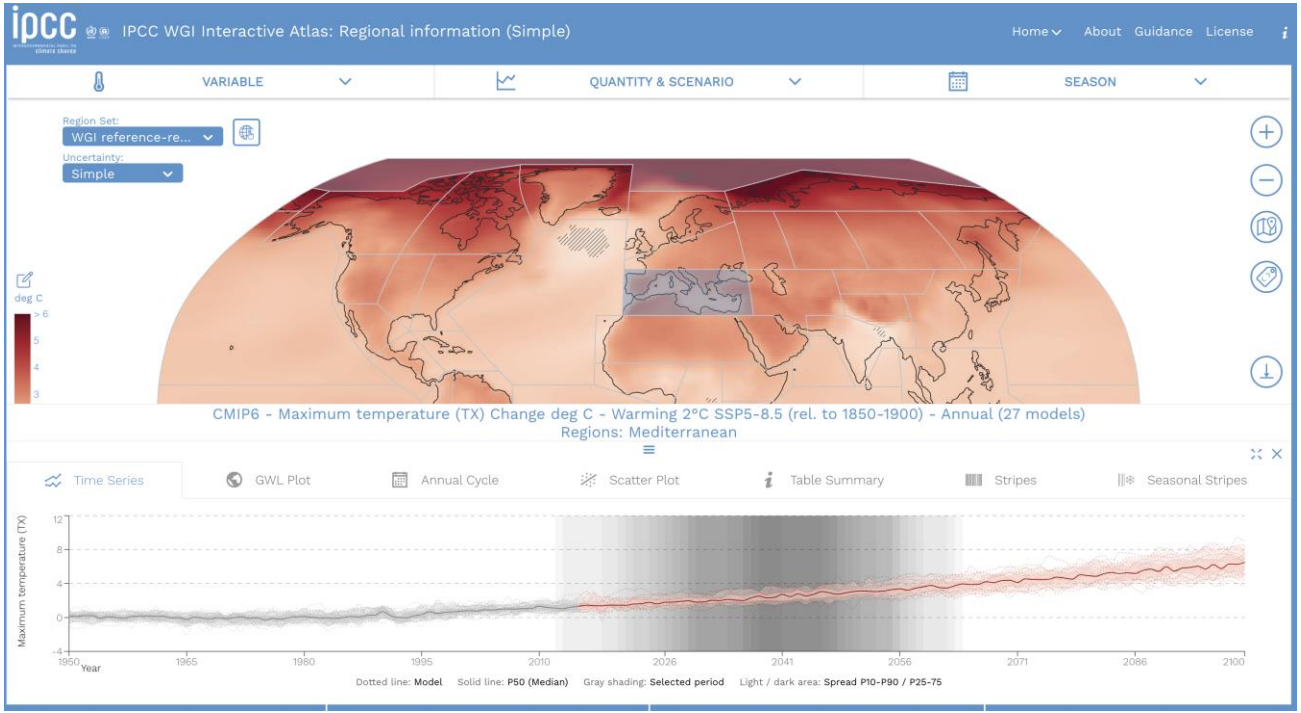
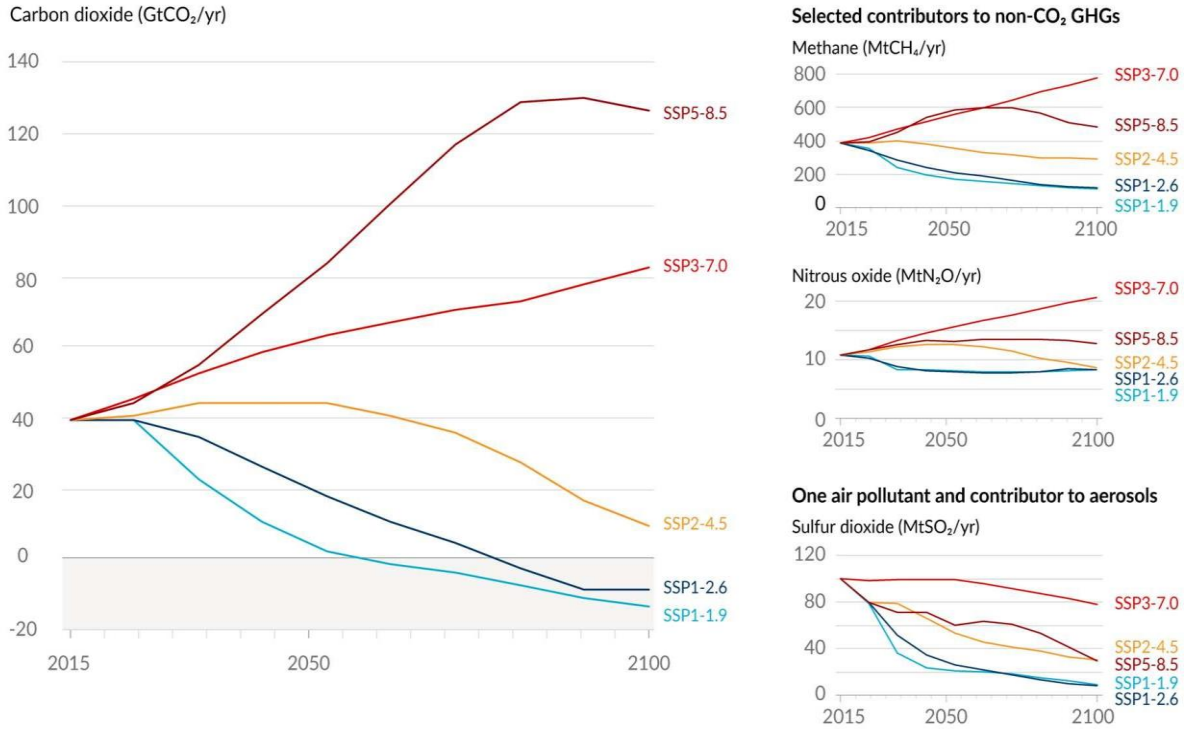


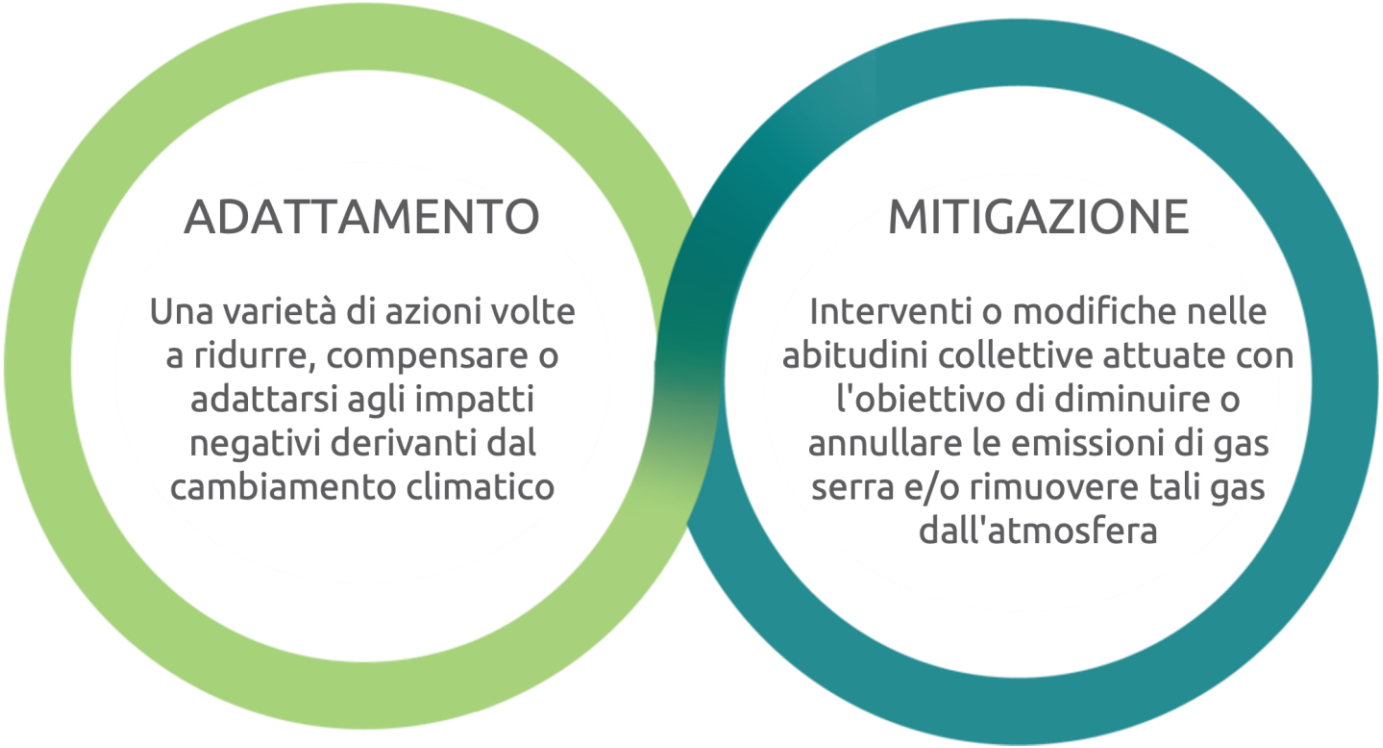
Scenari emissivi futuri

a) Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five illustrative scenarios

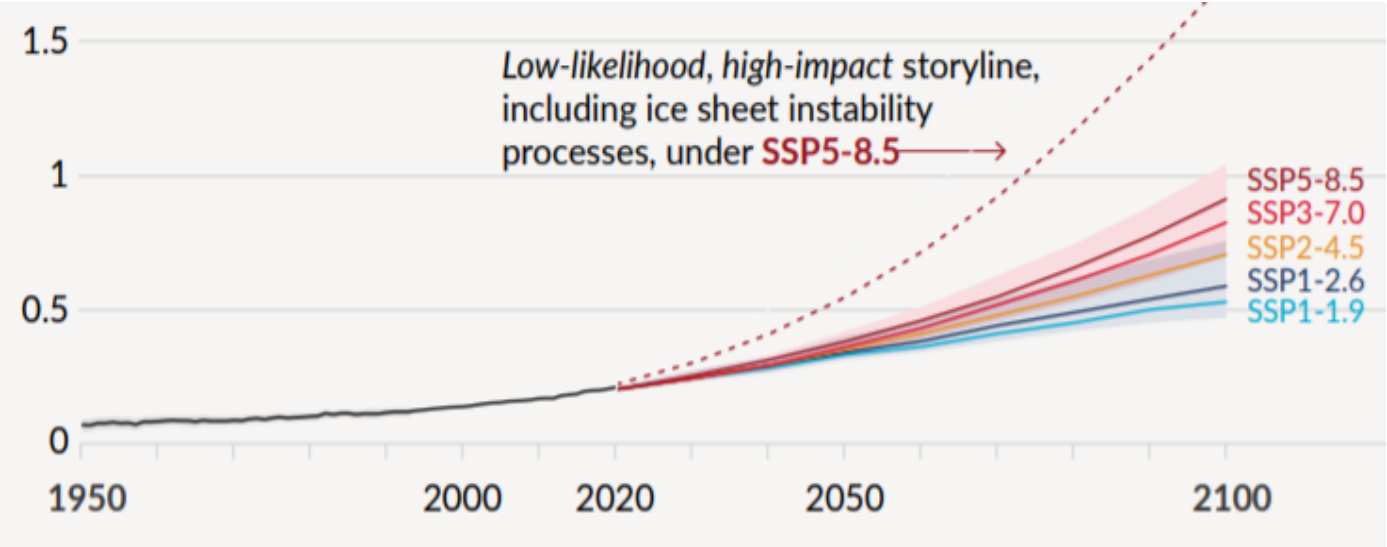


Emissioni antropogeniche dei principali gas e sostanze che contribuiscono al riscaldamento globale e influenzano il cambiamento climatico.

Adattamento e Mitigazione



Scenari climatici: Livello del mare



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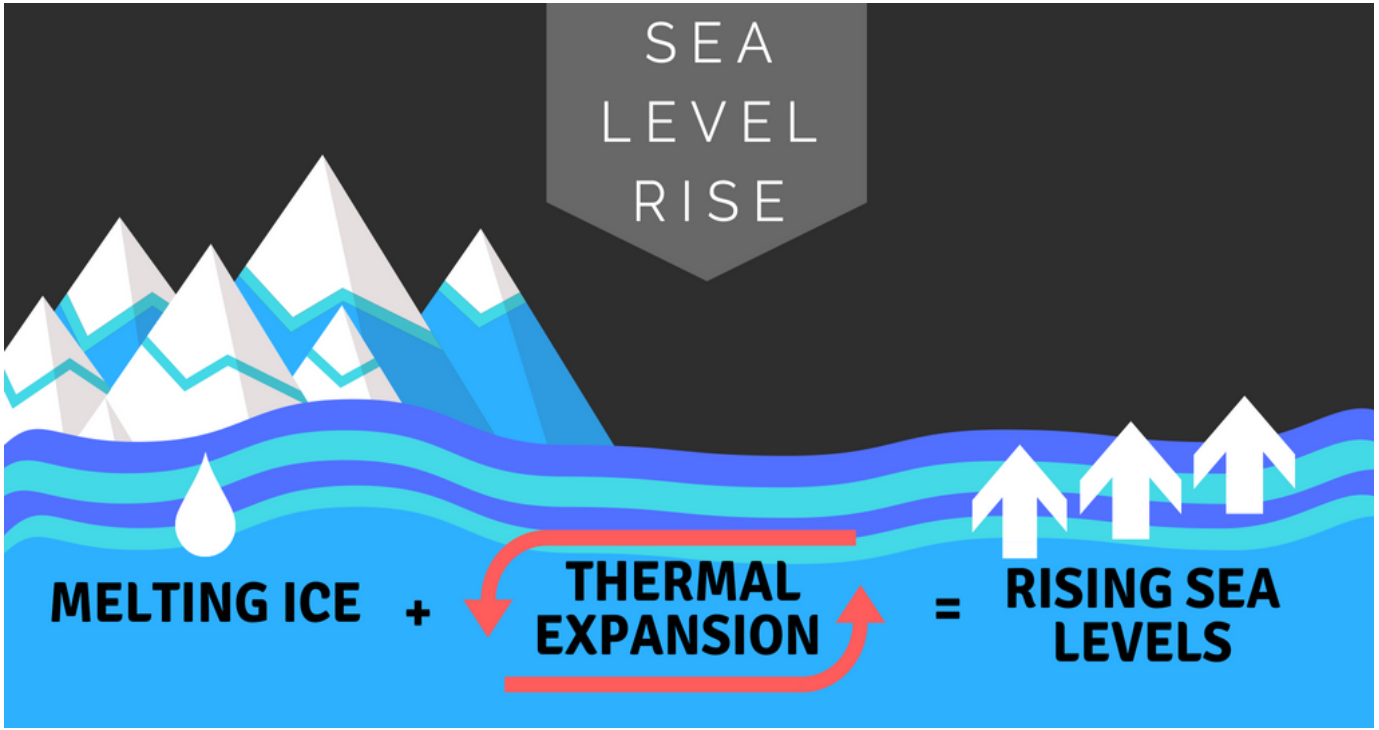
WMO UNEP

Scenari climatici: livello del mare



Scenari climatici: livello del mare

*The **SROCC** estimated regional sea-level changes from combinations of the various contributions to sea-level change from **CMIP5** climate model outputs, allowing comparison with satellite altimeter and tide-gauge observations. Closure of the regional sea-level budget is complicated by the fact that **regional sea-level variability is larger than GMSL variability** and there are more processes that need to be considered, such as vertical land movement and ocean dynamical changes.*

*Since **CMIP6** models are of fairly coarse (typically ~100km) resolution, and even the models participating in HighResMIP (near 10km resolution) do not capture all the phenomena that contribute to coastal ocean dynamic sea-level change, there is low confidence in the details of ocean dynamic sea-level change along the coast and in semi-enclosed basins, **like the Mediterranean**, where **coarse models can misrepresent key dynamic processes**.*

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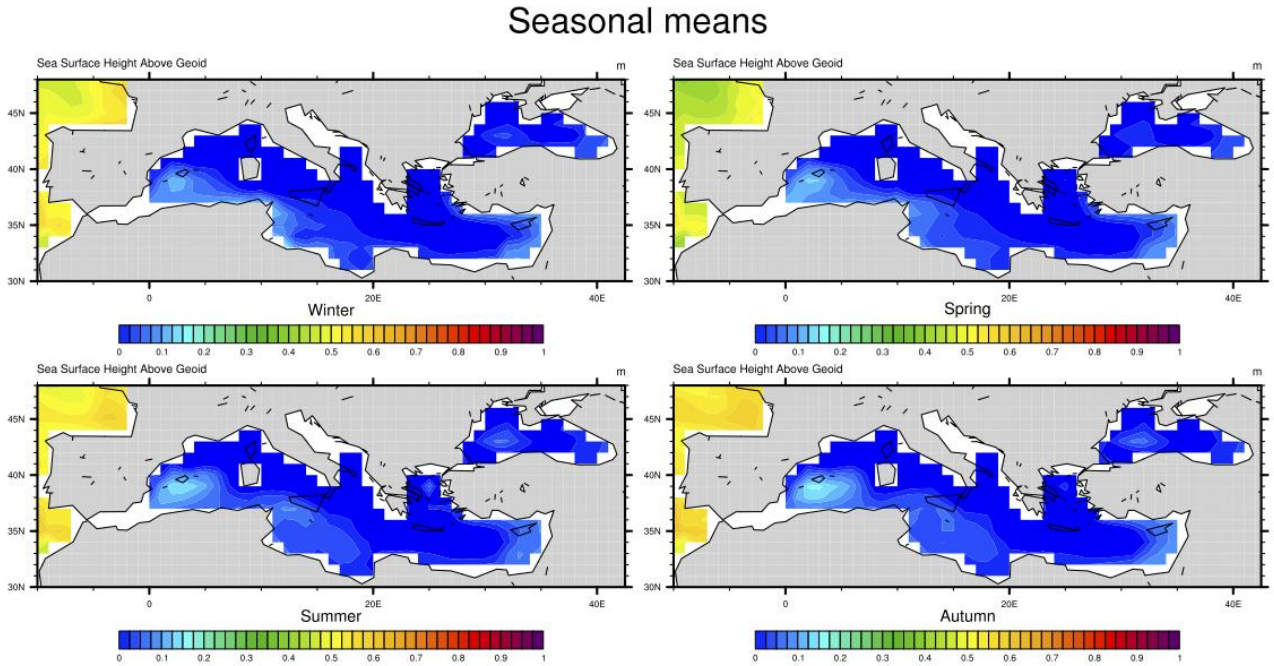
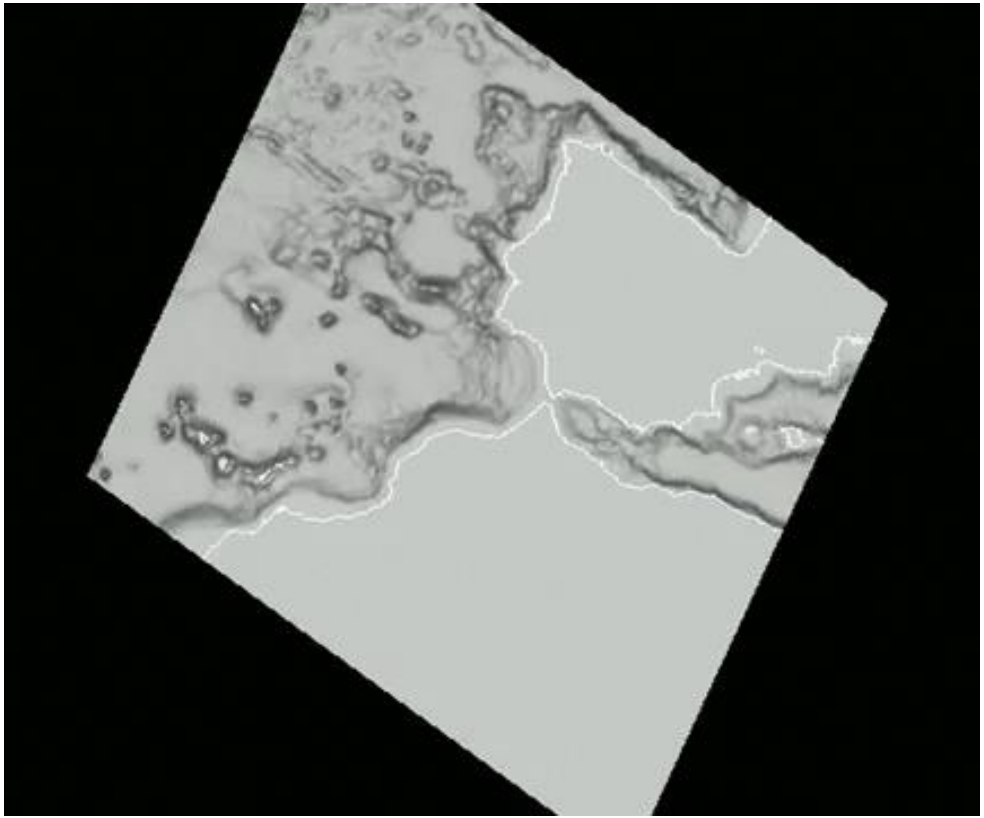
Scenari climatici: livello del mare



Livello attuale del mare Mediterraneo come rappresentato nei modelli di clima globale (CMPI5*)

*Coupled Model Intercomparison Project - https://cmip.llnl.gov/cmip5/

Batimetria dello Stretto di Gibilterra



Batimetria dello Stretto di Gibilterra

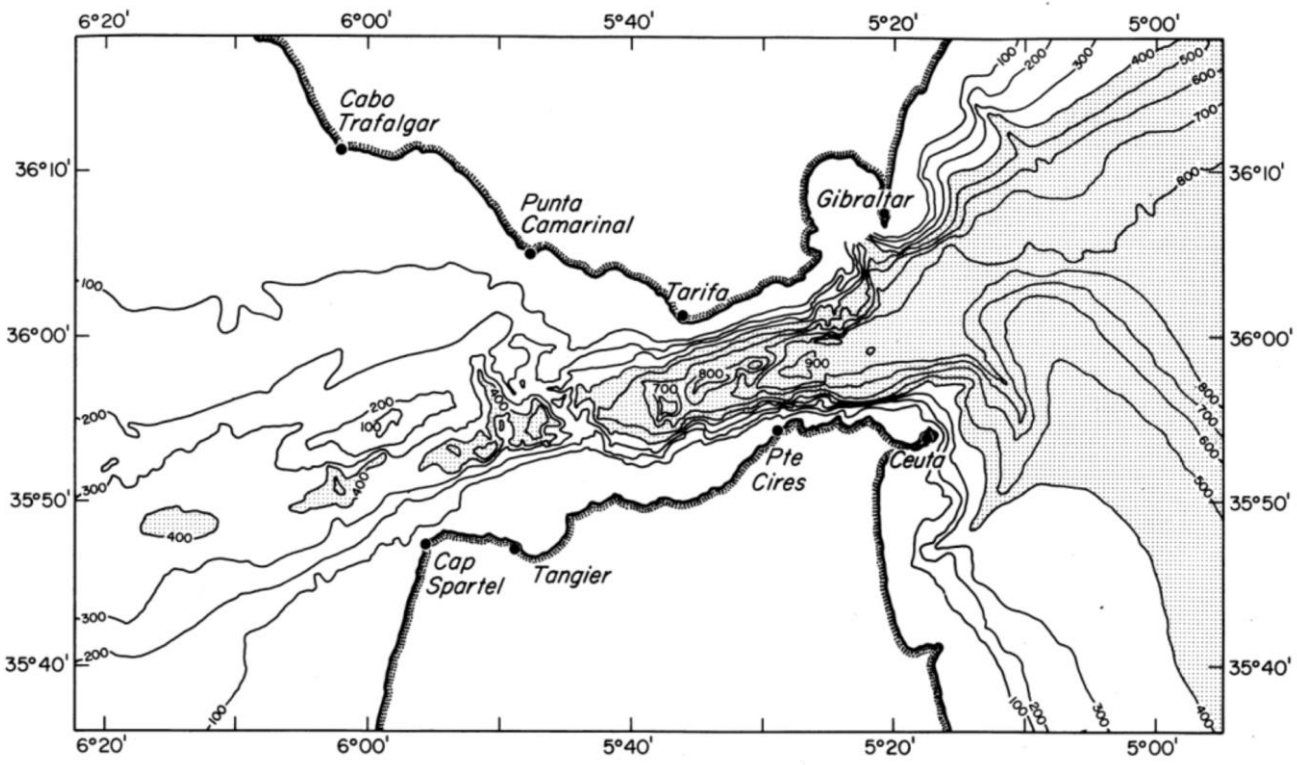


Chart of the Strait of Gibraltar, adapted from Armi & Farmer (1988), showing the principal geographic features referred to in the text. Areas deeper than 400 m

are shaded

Salto idraulico nello Stretto di Gibilterra

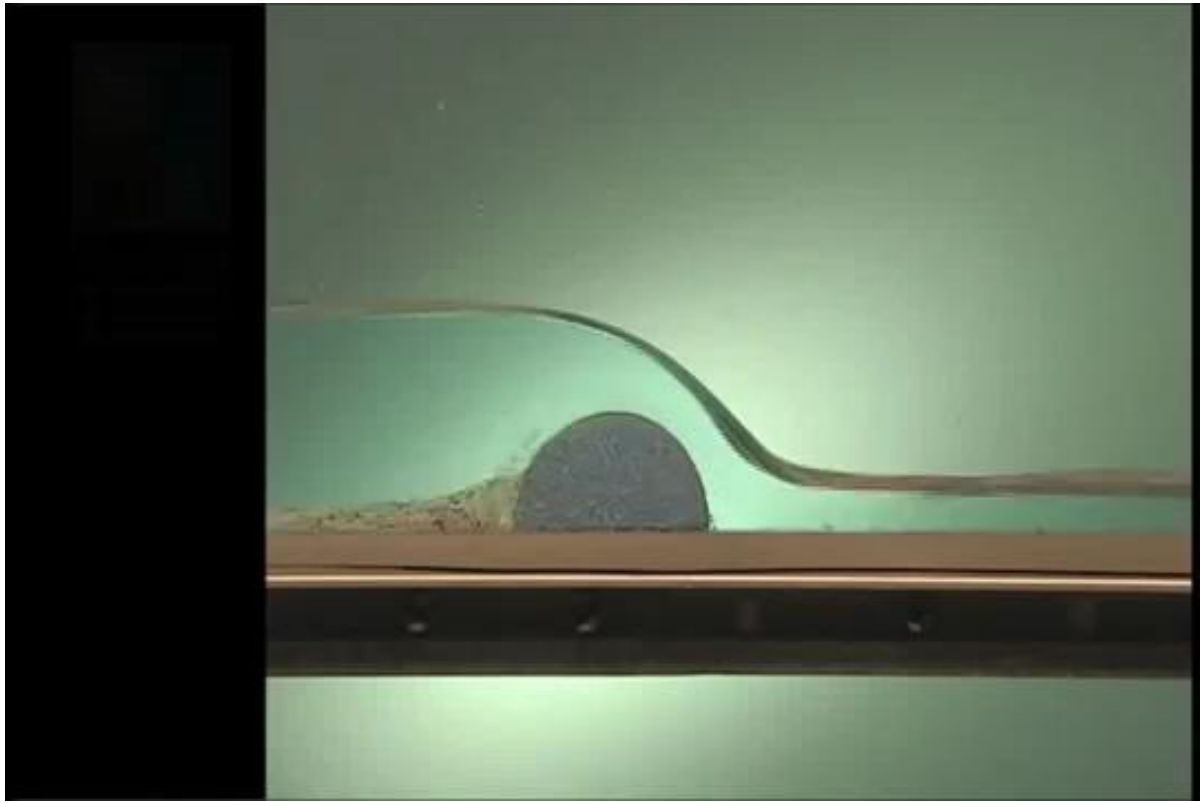


Chart of the Strait of Gibraltar, adapted from Armi & Farmer (1988), showing the principal geographic features referred to in the text. Areas deeper

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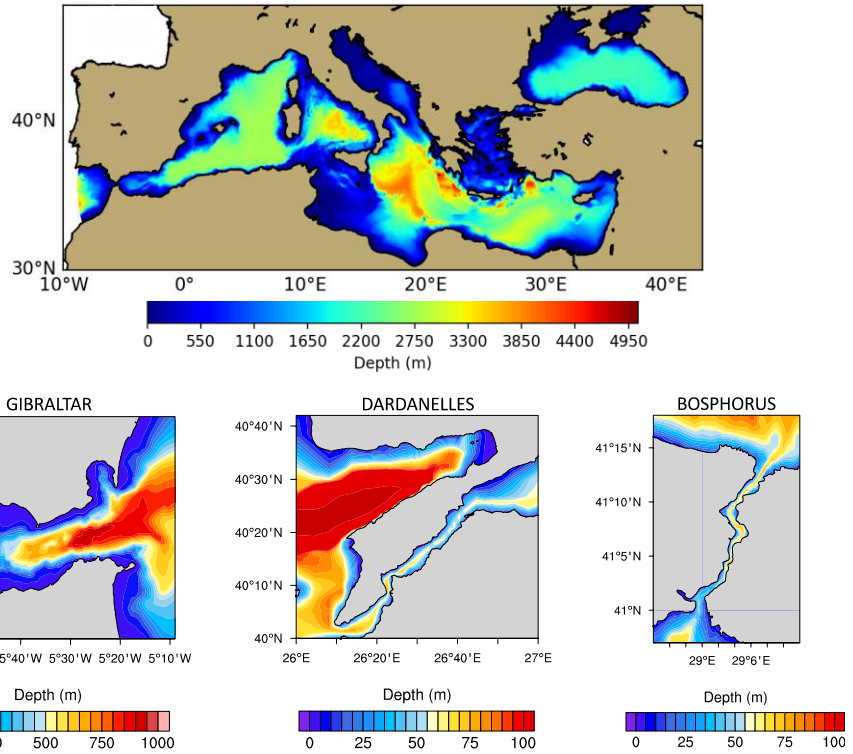
Modello climatico del Mediterraneo: batimetria



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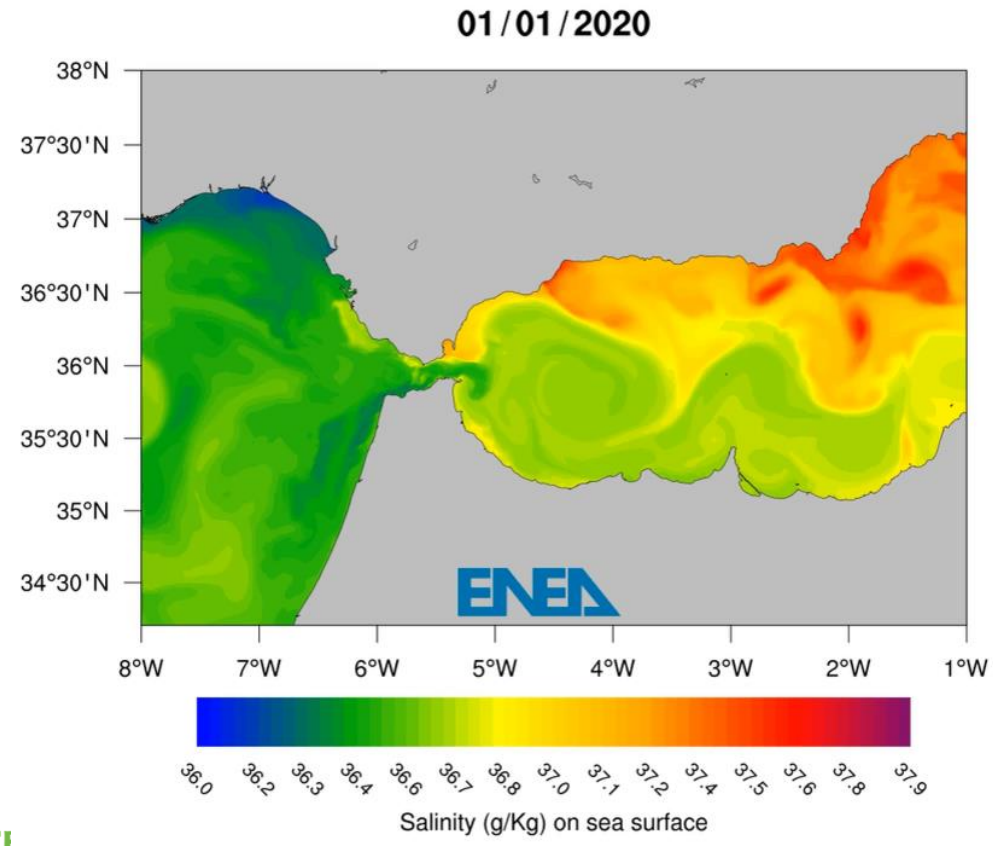
Modello climatico del Mediterraneo



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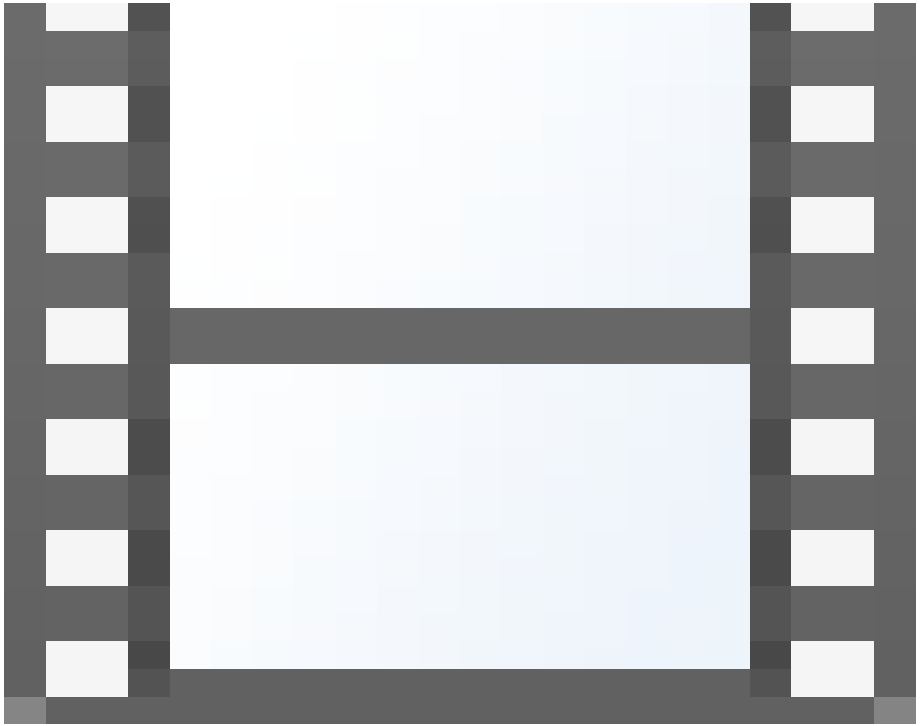

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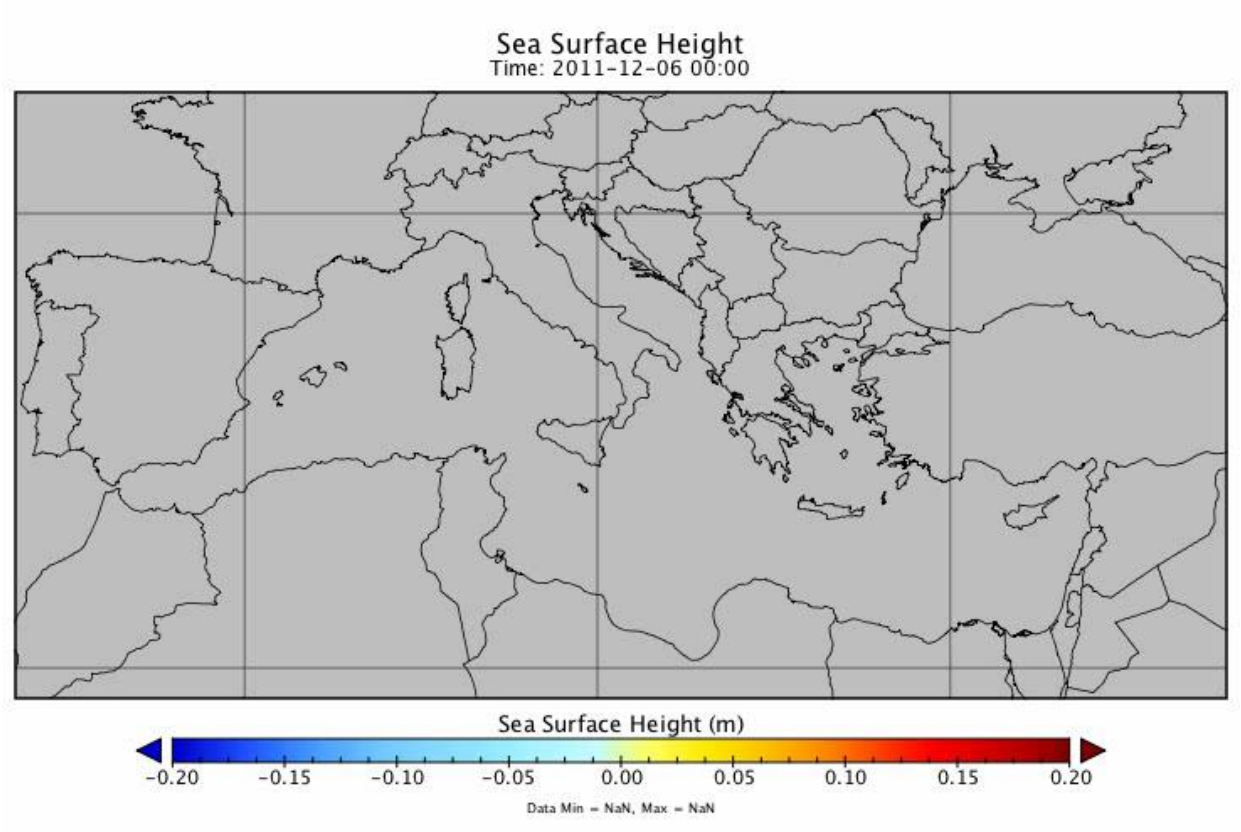

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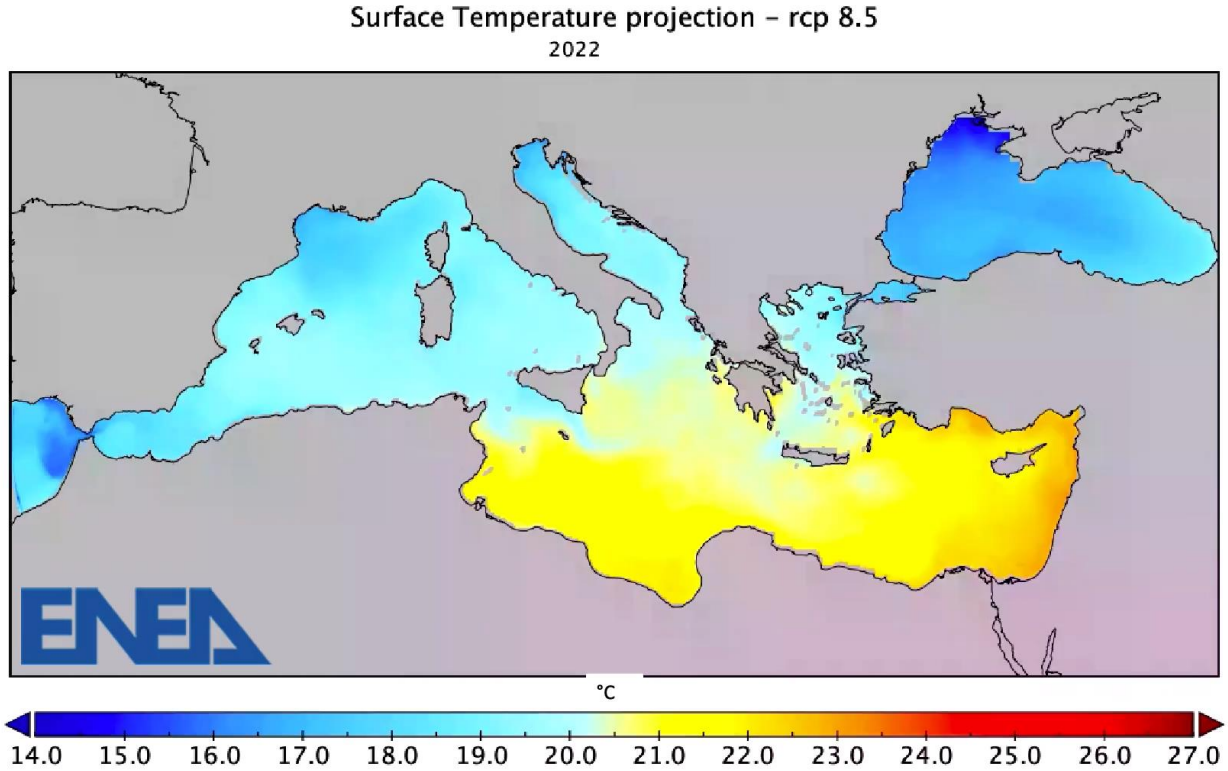
Modello climatico del Mediterraneo: batimetria



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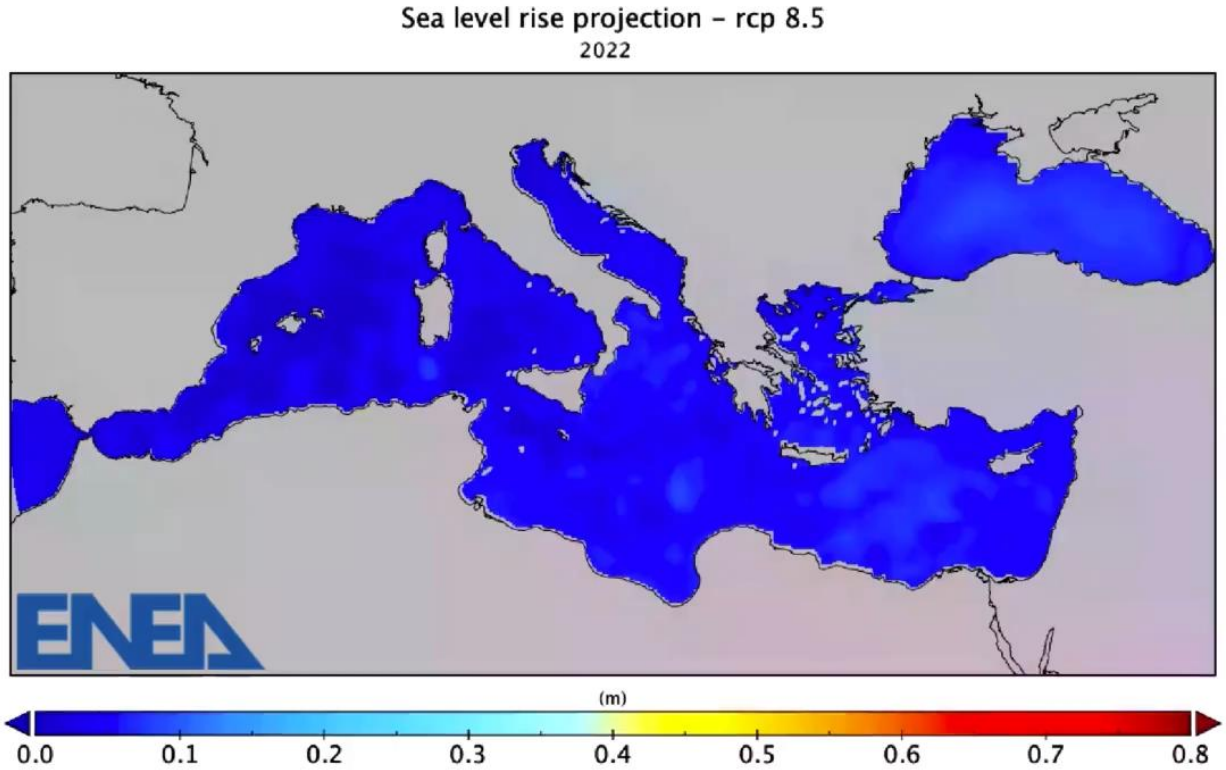
Modello climatico del Mediterraneo: batimetria



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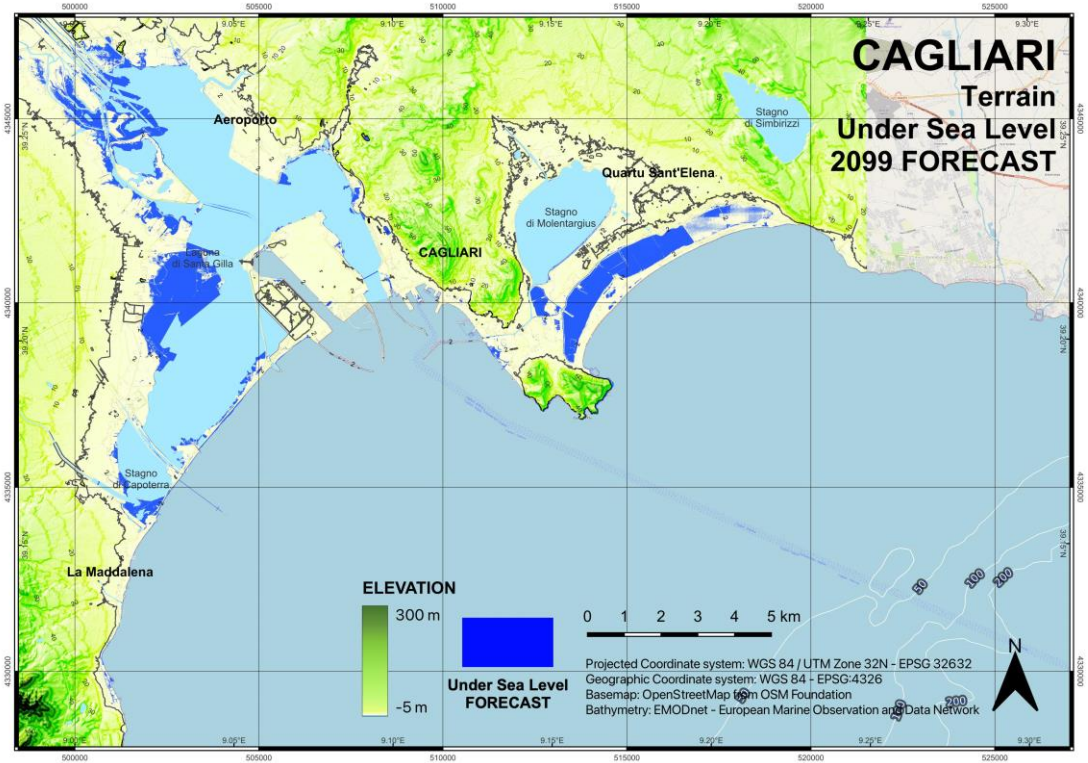
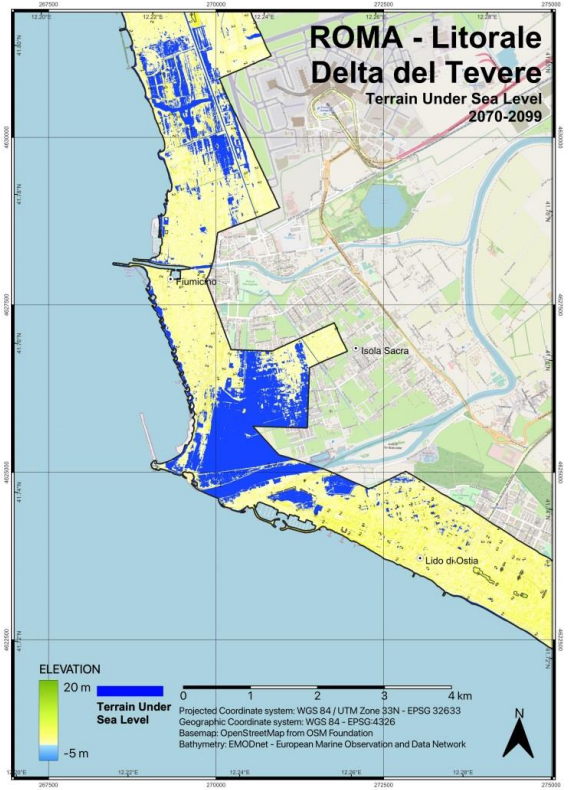

CAGLIARI
Terrain
Under Sea Level
2099 FORECAST
Aeroporto
Stagno di Simbirizzi
Quartu Sant'Elena
Stagno di Molentargius
CAGLIARI
Laguna di Santa Gilla
Stagno di Capoterra
La Maddalena
ELEVATION
300 m
-5 m
Under Sea Level FORECAST
0 1 2 3 4 5 km
Projected Coordinate system: WGS 84 / UTM Zone 32N - EPSG 32632
Geographic Coordinate system: WGS 84 - EPSG:4326
Basemap: OpenStreetMap from OSM Foundation
Bathymetry: EMODnet - European Marine Observation and Data Network
N


ROMA - Litorale
Delta del Tevere
Terrain Under Sea Level
2070-2099
Fiumicino
Isola Sacra
Lido di Ostia
ELEVATION
20 m
-5 m
Terrain Under Sea Level
0 1 2 3 4 km
Projected Coordinate system: WGS 84 / UTM Zone 33N - EPSG 32633
Geographic Coordinate system: WGS 84 - EPSG:4326
Basemap: OpenStreetMap from OSM Foundation
Bathymetry: EMODnet - European Marine Observation and Data Network
N

“What’s the use of having developed a science well enough to make predictions if, in the end, all we’re willing to do is stand around and wait for them to come true?”

— F. Sherwood Rowland (Nobel laureate)

LESSON KIT

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wmo.int/

WCRP World Climate Research Programme

www.wcrp-climate.org/

UN environment

United Nations Environment Programme

www.unep.org/

UNESCO

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

www.ioc.unesco.org/

ipcc
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WMO UNEP

http://ipcc.ch

CLIMATE CENTRAL

https://www.climatecentral.org

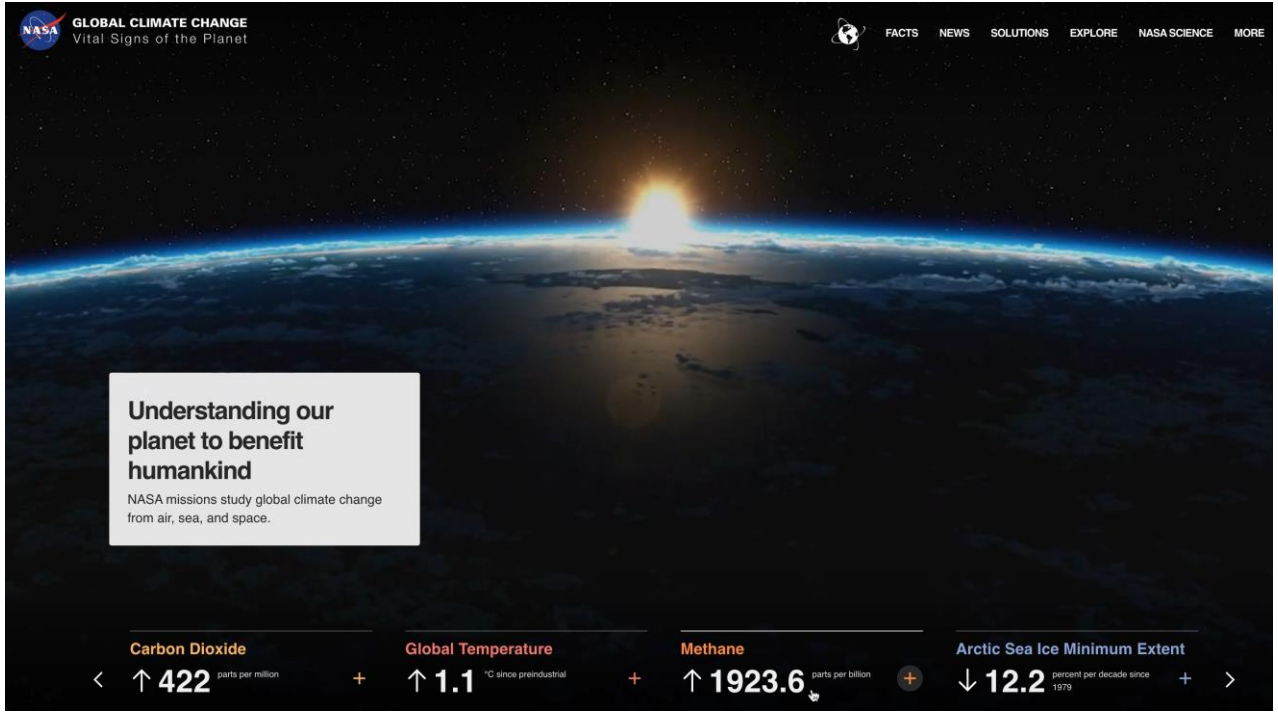
GLOBAL CARBON project

https://globalcarbonbudget.org

copernicus
Europe's eyes on Earth

Climate Change Service
climate.copernicus.eu

NASA Global Climate Change



https://climate.nasa.gov/

Grazie

Spazio alle domande

I prossimi appuntamenti

https://formazione.deascuola.it/sos-clima/