

La ciencia detrás del Cambio Climático

Ricardo García Herrera

Universidad Complutense de Madrid e
Instituto de Geociencias (IGEO, CSIC-UCM), Madrid, Spain
rgarciah@ucm.es

¿QUE ESTÁ OCURRIENDO EN EL PLANETA?

¿POR QUÉ OCURRE ESTO?

¿QUE VA A OCURRIR EN EL FUTURO?

REFLEXIONES

¿Qué está ocurriendo
en el planeta?

Los Gases invernaderos siguen creciendo y la temperatura aumentando

OMM 2022

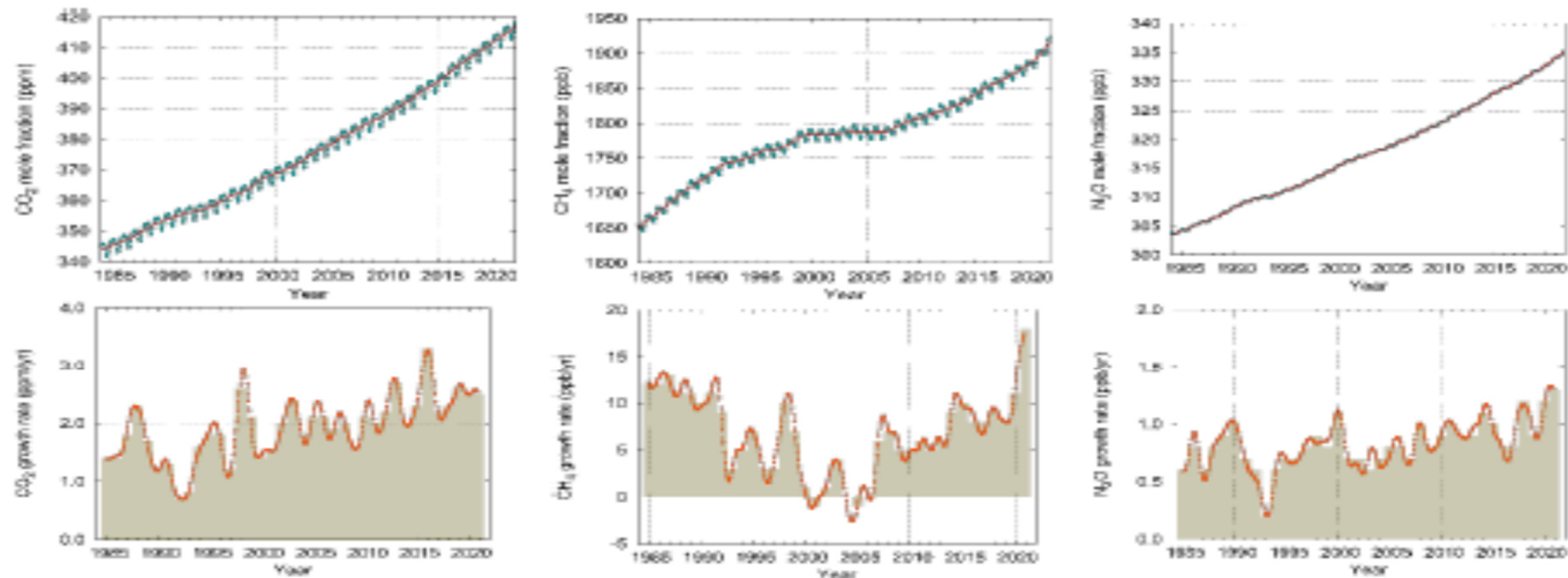


Figure 1: Top row: Globally averaged mole fraction (measure of atmospheric concentration), from 1984 to 2021, of CO₂ in parts per million (left), CH₄ in parts per billion (centre) and N₂O in parts per billion (right). The red line is the monthly mean mole fraction with the seasonal variations removed; the blue dots and line show the monthly averages. Bottom row: the growth rates representing increases in successive annual means of mole fractions for CO₂ in parts per million per year are shown as grey columns (left), CH₄ in parts per billion per year (centre) and N₂O in parts per billion per year (right) (Source: WMO Global Atmosphere Watch).

La Temperatura sigue aumentando

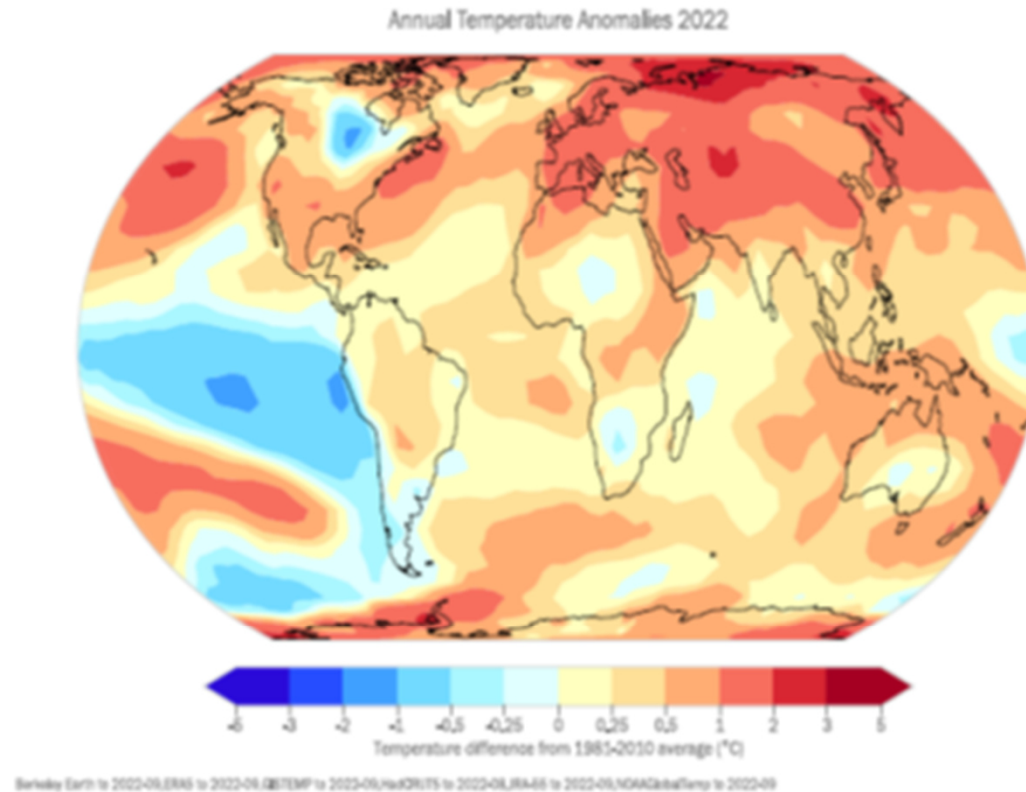


Figure 3: Near-surface temperature differences relative to the 1981–2010 average for 2022 to September. The map shows the median anomaly calculated from six data sets: HadCRUT5, ERA5, JRA-55, GISTEMP, NOAA GlobalTemp and Berkeley Earth.

Sequía

Quantiles, Reference 1951-2000, Jan-Sep 2022

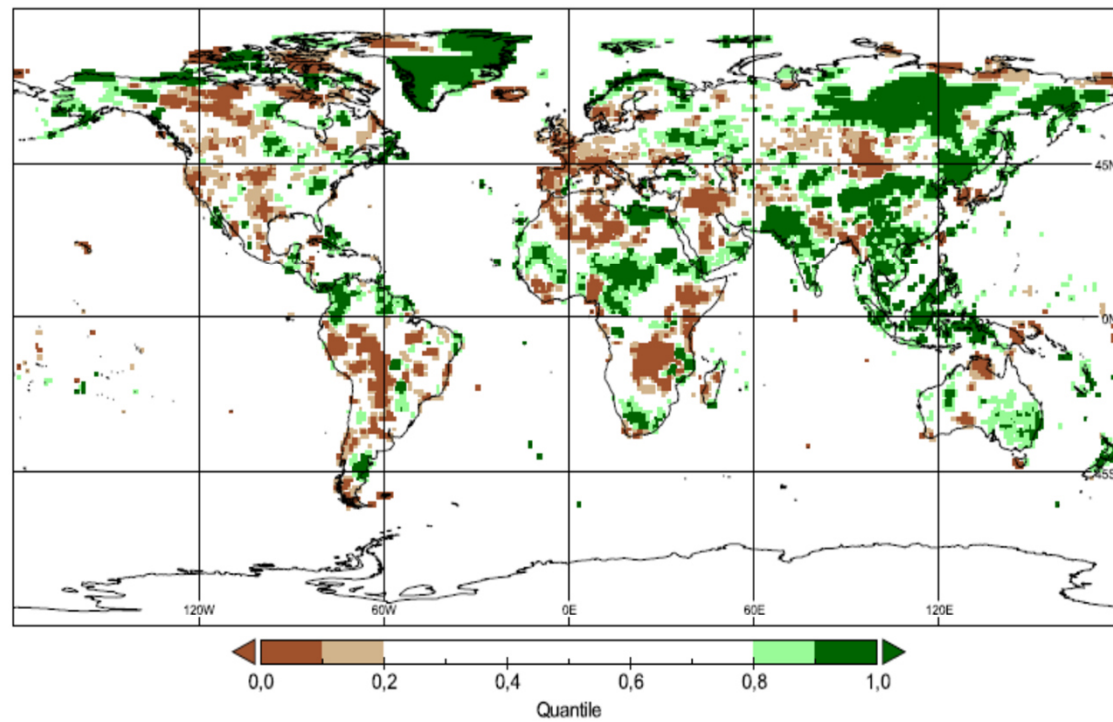
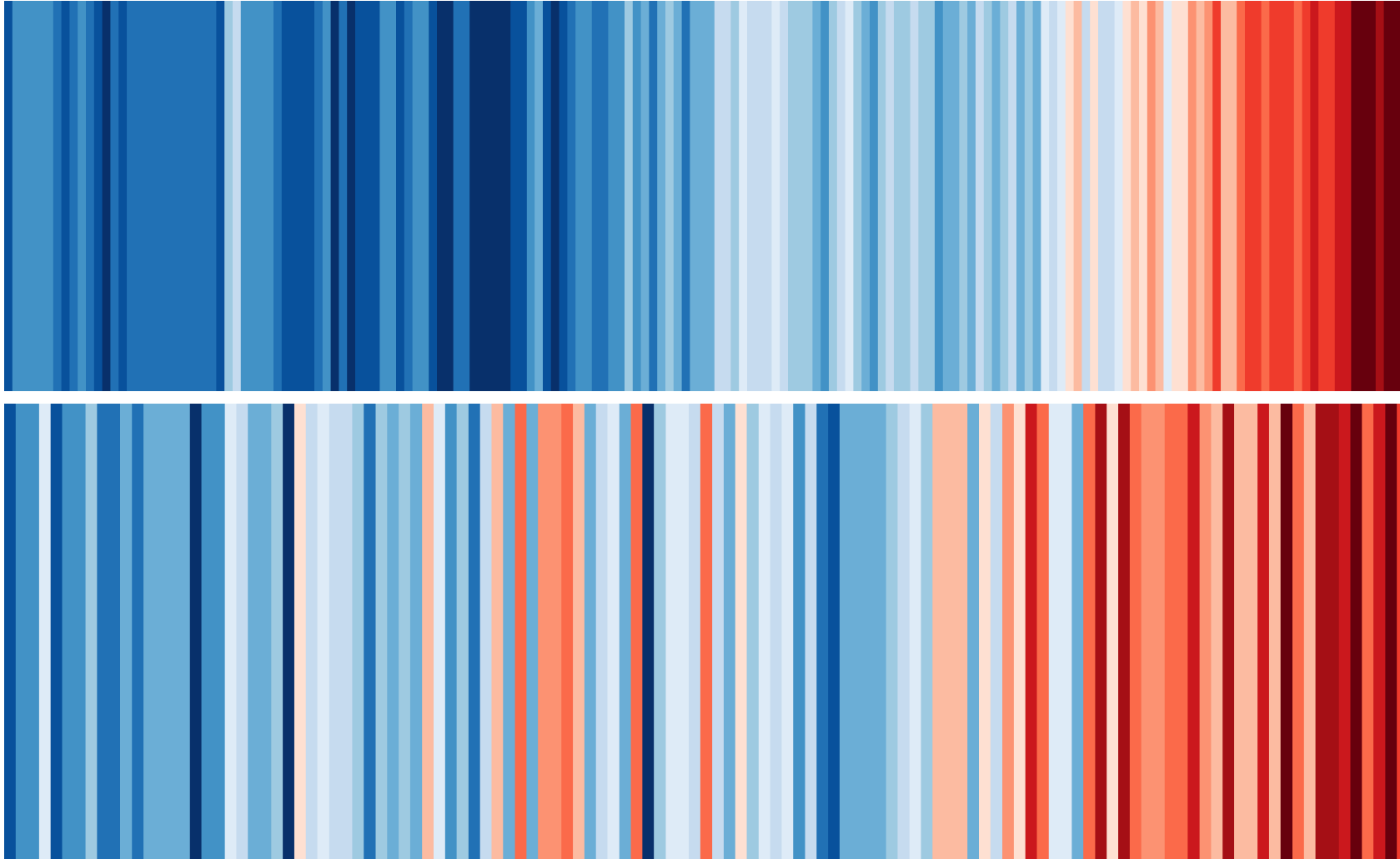


Figure 11: Total precipitation in Jan-Sep 2022, expressed as a percentile of the 1951–2000 reference period, for areas that would have been in the driest 20% (brown) and wettest 20% (green) of years during the reference period, with darker shades of brown and green indicating the driest and wettest 10%, respectively (Source: Global Precipitation Climatology Centre (GPCC), Deutscher Wetterdienst, Germany)

el globo vs España 1850-2021



Hielo ártico

<https://climate.nasa.gov/vital-signs/arctic-sea-ice/>



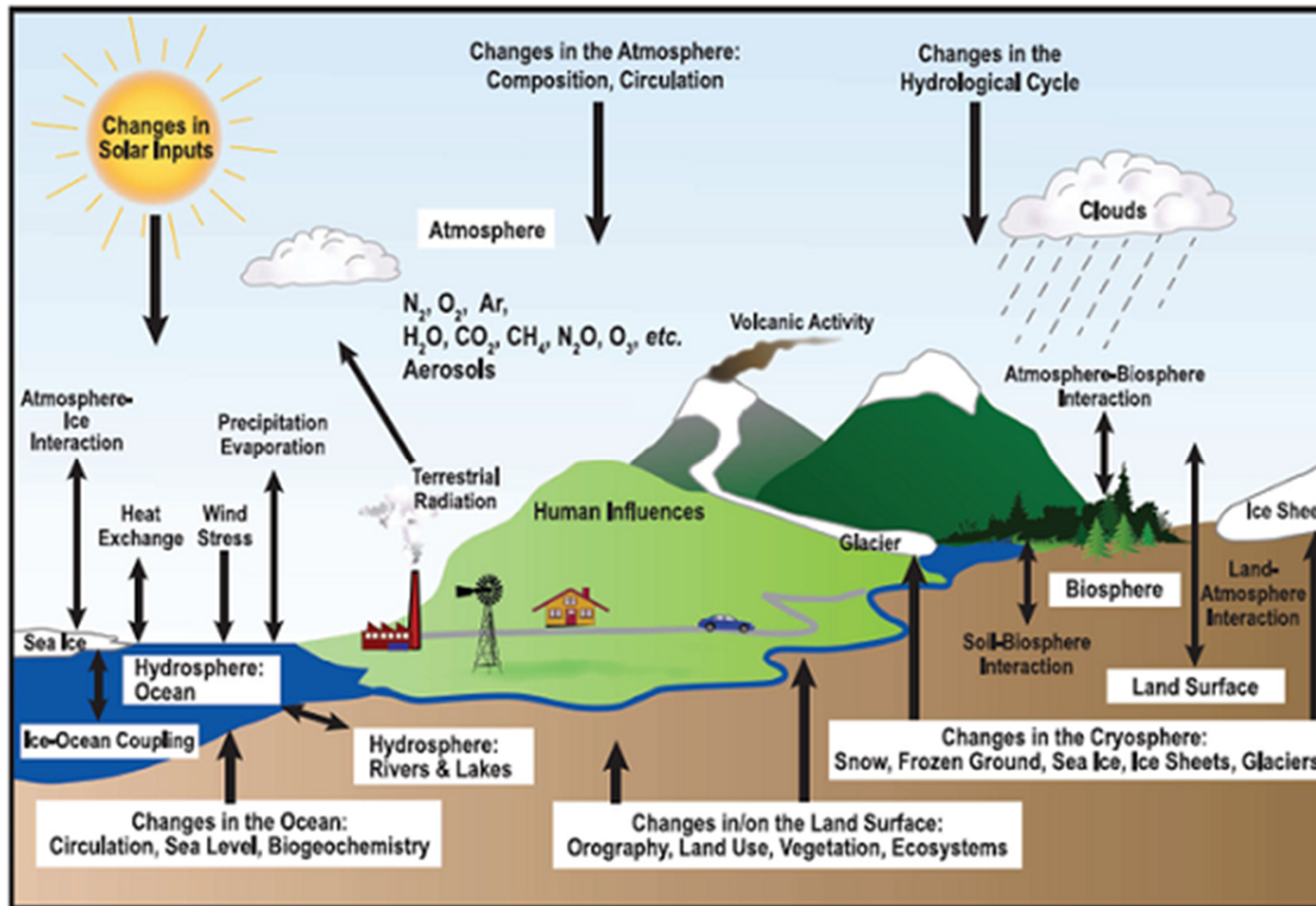
Temperatura

<https://climate.nasa.gov/vital-signs/global-temperature/>

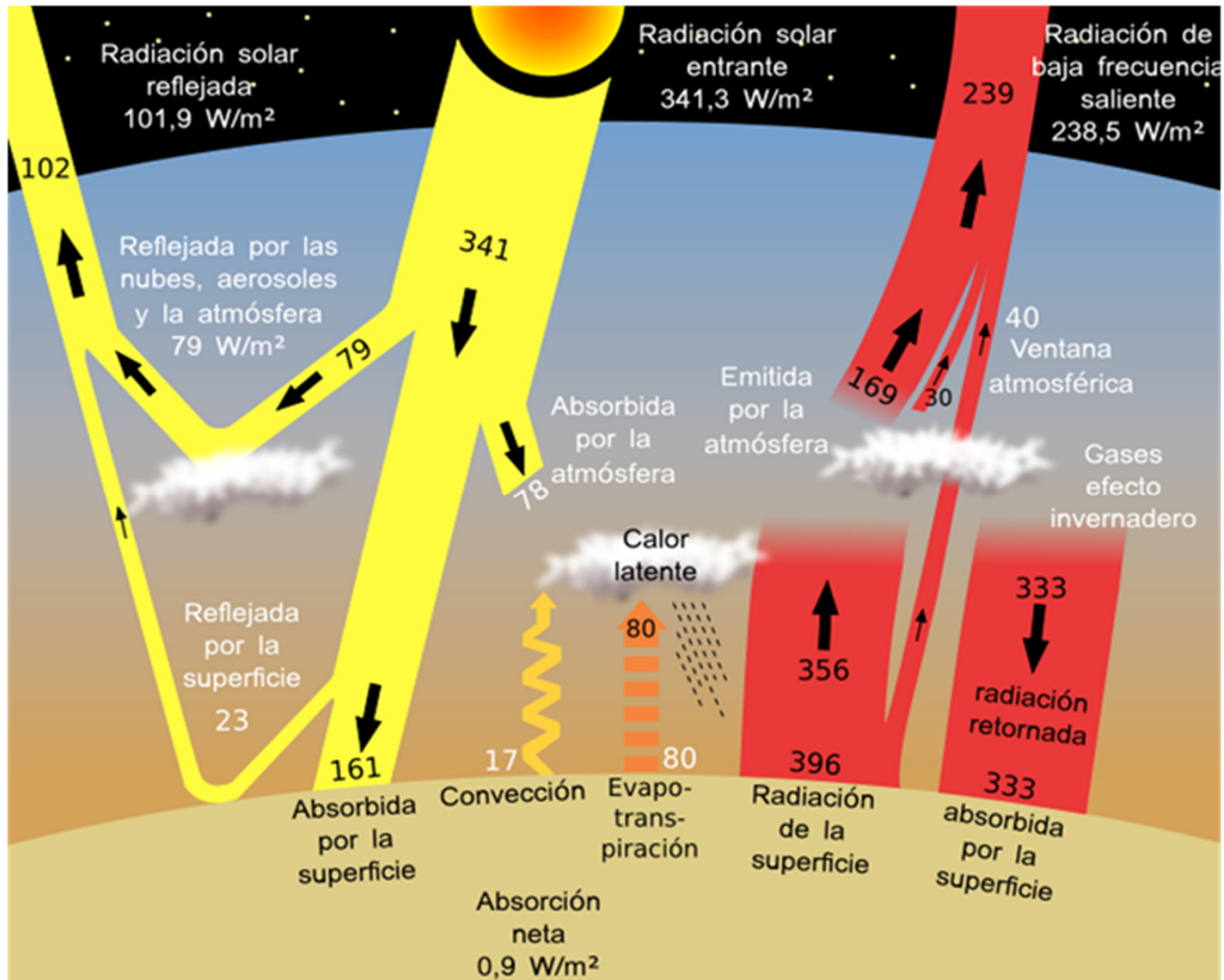


¿POR QUÉ OCURRE ESTO?

El sistema climático

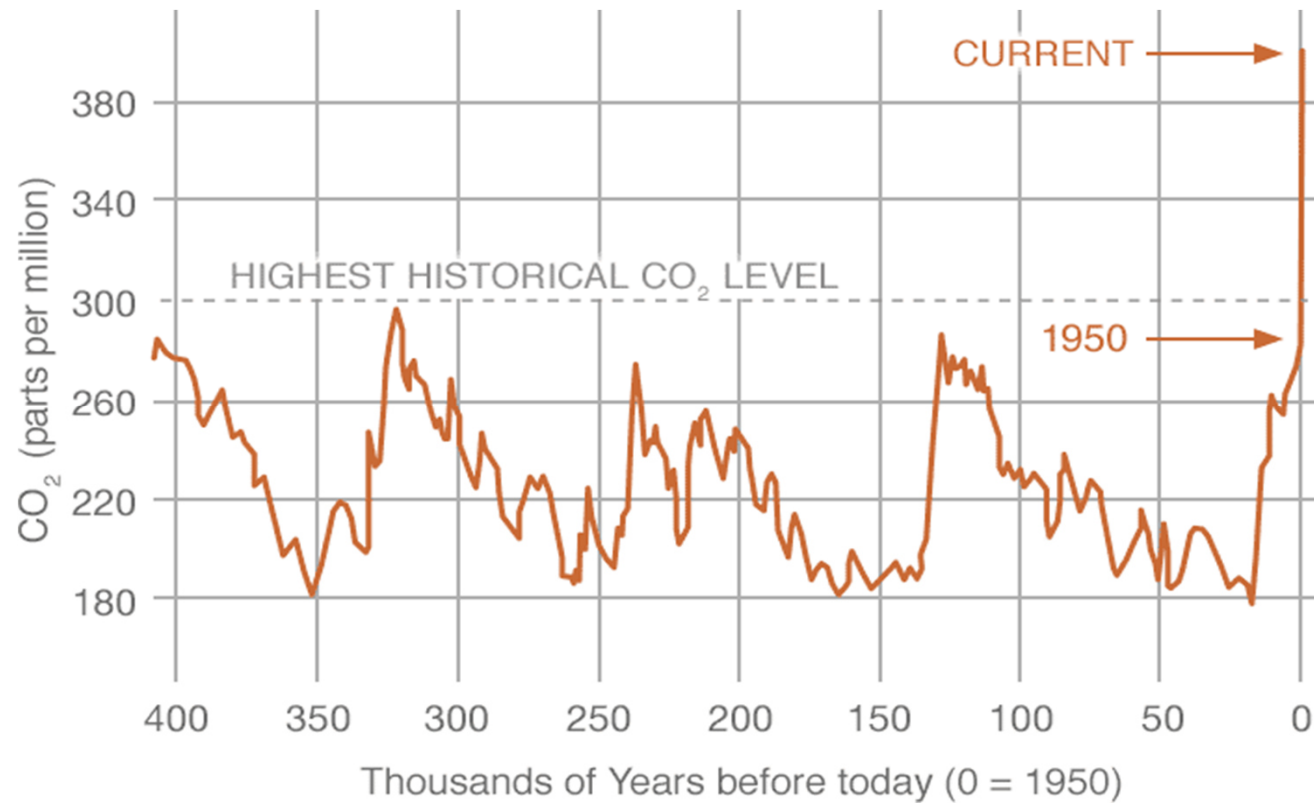


El balance radiativo

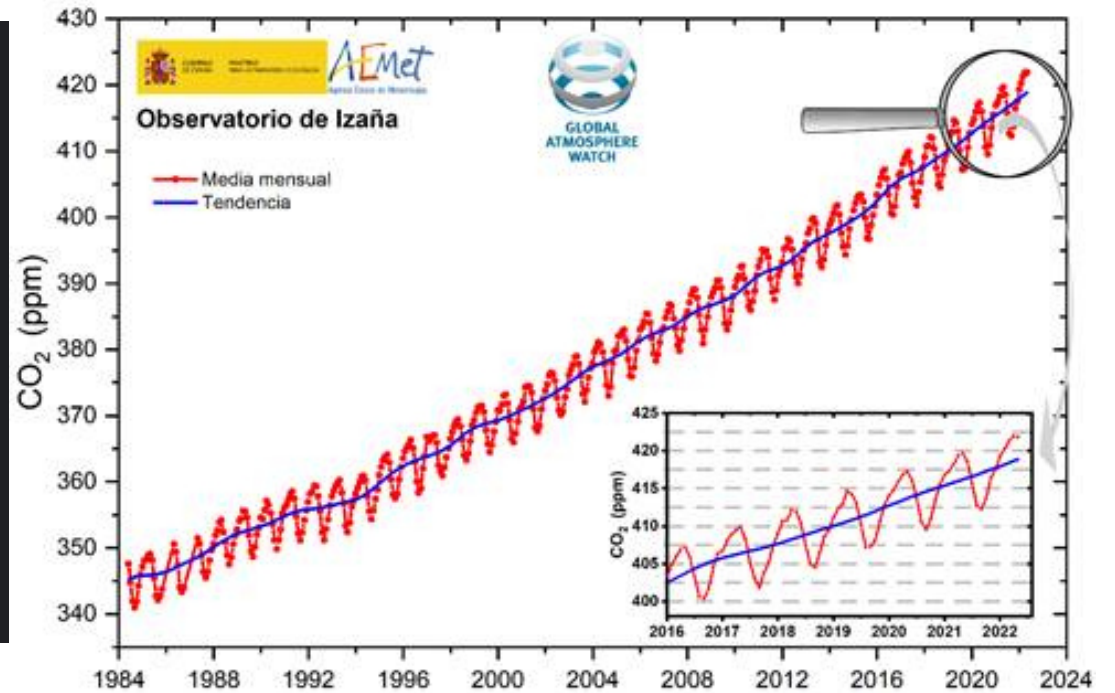
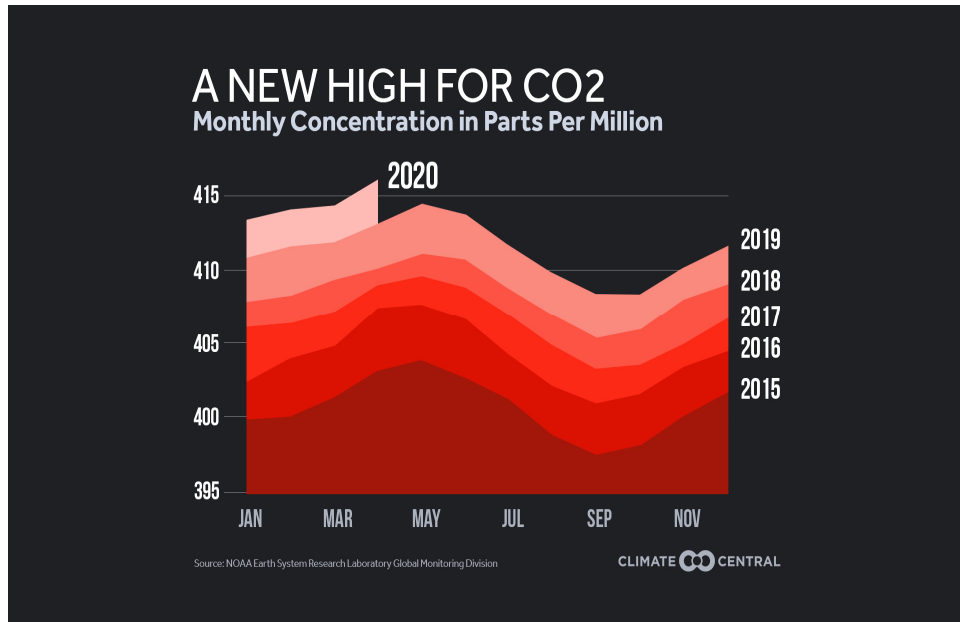


Joseph Fourier
1768-
1830

La evolución del CO₂ hasta los 415 ppm en Mayo 2019



La evolución reciente



Svante Arrhenius 1859-1927
2x CO₂ implica aumento de 5º

¿Qué va a ocurrir en el futuro?

Modelos climáticos

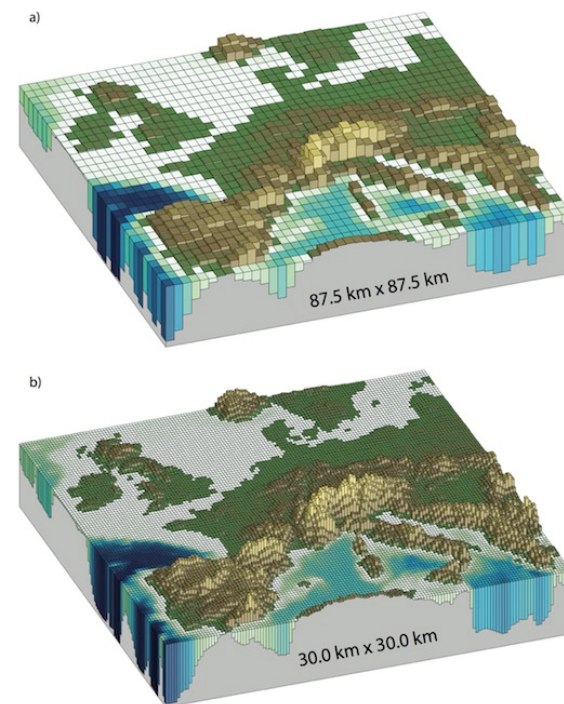
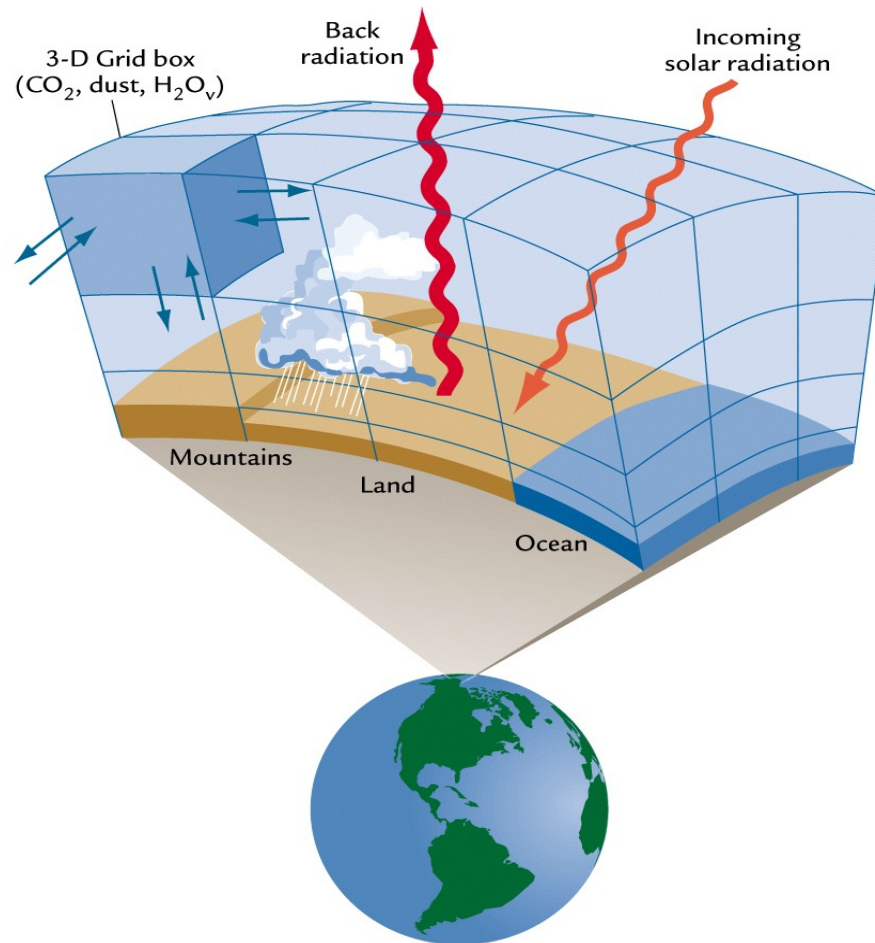


Image Source:
IPCC Fifth Assessment Report, Jan 2014. Working Group 1, Fig 1.14

Y en cada cubito...



$$\frac{\partial p'}{\partial t} - \rho_0 g w + \gamma p \nabla \cdot \mathbf{v} = -\mathbf{v} \cdot \nabla p' + \frac{\gamma p}{T} \left(\frac{\dot{Q}}{c_p} + \frac{T_0}{\theta_0} D_\theta \right)$$

$$\frac{\partial u}{\partial t} + \frac{m}{\rho} \left(\frac{\partial p'}{\partial x} - \frac{\sigma}{p^*} \frac{\partial p^*}{\partial x} \frac{\partial p'}{\partial \sigma} \right) = -\mathbf{v} \cdot \nabla u + v \left(f + u \frac{\partial m}{\partial y} - v \frac{\partial m}{\partial x} \right) - e w \cos \alpha - \frac{u w}{r_{earth}} + D_u$$

$$\frac{\partial v}{\partial t} + \frac{m}{\rho} \left(\frac{\partial p'}{\partial y} - \frac{\sigma}{p^*} \frac{\partial p^*}{\partial y} \frac{\partial p'}{\partial \sigma} \right) = -\mathbf{v} \cdot \nabla v - u \left(f + u \frac{\partial m}{\partial y} - v \frac{\partial m}{\partial x} \right) + e w \sin \alpha - \frac{v w}{r_{earth}} + D_v$$

$$\frac{\partial w}{\partial t} - \frac{\rho_0 g}{\rho p^*} \frac{\partial p'}{\partial \sigma} + \frac{g p'}{\gamma p} = -\mathbf{v} \cdot \nabla w + g \frac{p_0 T'}{p T_0} - \frac{g R_d p'}{c_p p} + e (u \cos \alpha - v \sin \alpha) + \frac{u^2 + v^2}{r_{earth}} + D_w$$

$$\frac{\partial T}{\partial t} = -\mathbf{v} \cdot \nabla T + \frac{1}{\rho c_p} \left(\frac{\partial p'}{\partial t} + \mathbf{v} \cdot \nabla p' - \rho_0 g w \right) + \frac{\dot{Q}}{c_p} + \frac{T_0}{\theta_0} D_\theta$$

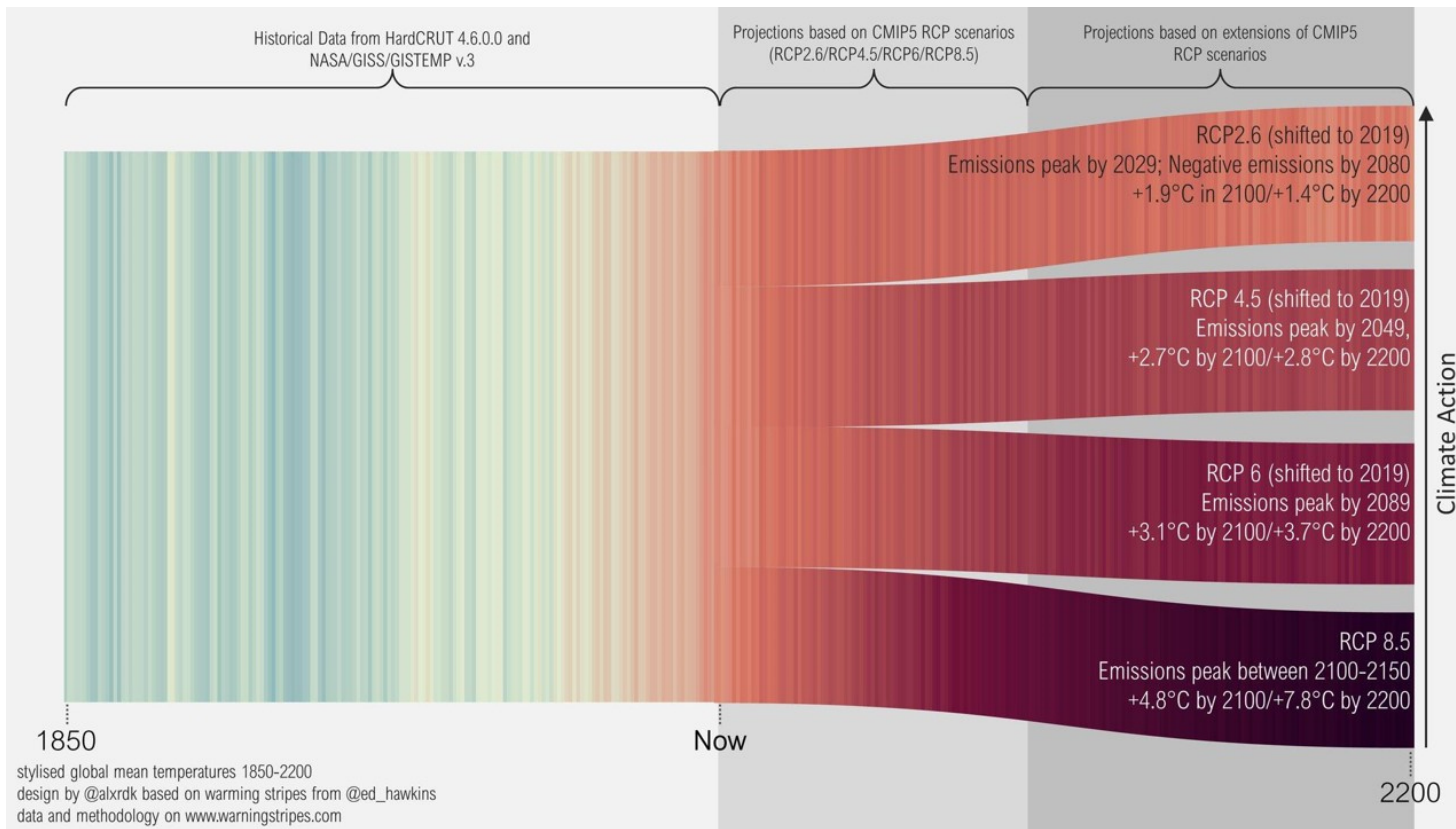
$$\mathbf{v} \cdot \nabla A \equiv m u \frac{\partial A}{\partial x} + m v \frac{\partial A}{\partial y} + \dot{\sigma} \frac{\partial A}{\partial \sigma}$$

$$\dot{\sigma} = -\frac{\rho_0 g}{p^*} w - \frac{m \sigma}{p^*} \frac{\partial p^*}{\partial x} u - \frac{m \sigma}{p^*} \frac{\partial p^*}{\partial y} v$$

$$\nabla \cdot \mathbf{v} = m^2 \frac{\partial}{\partial x} \left(\frac{u}{m} \right) - \frac{m \sigma}{p^*} \frac{\partial p^*}{\partial x} \frac{\partial u}{\partial \sigma} + m^2 \frac{\partial}{\partial y} \left(\frac{v}{m} \right) - \frac{m \sigma}{p^*} \frac{\partial p^*}{\partial y} \frac{\partial v}{\partial \sigma} - \frac{\rho_0 g}{p^*} \frac{\partial w}{\partial \sigma}$$

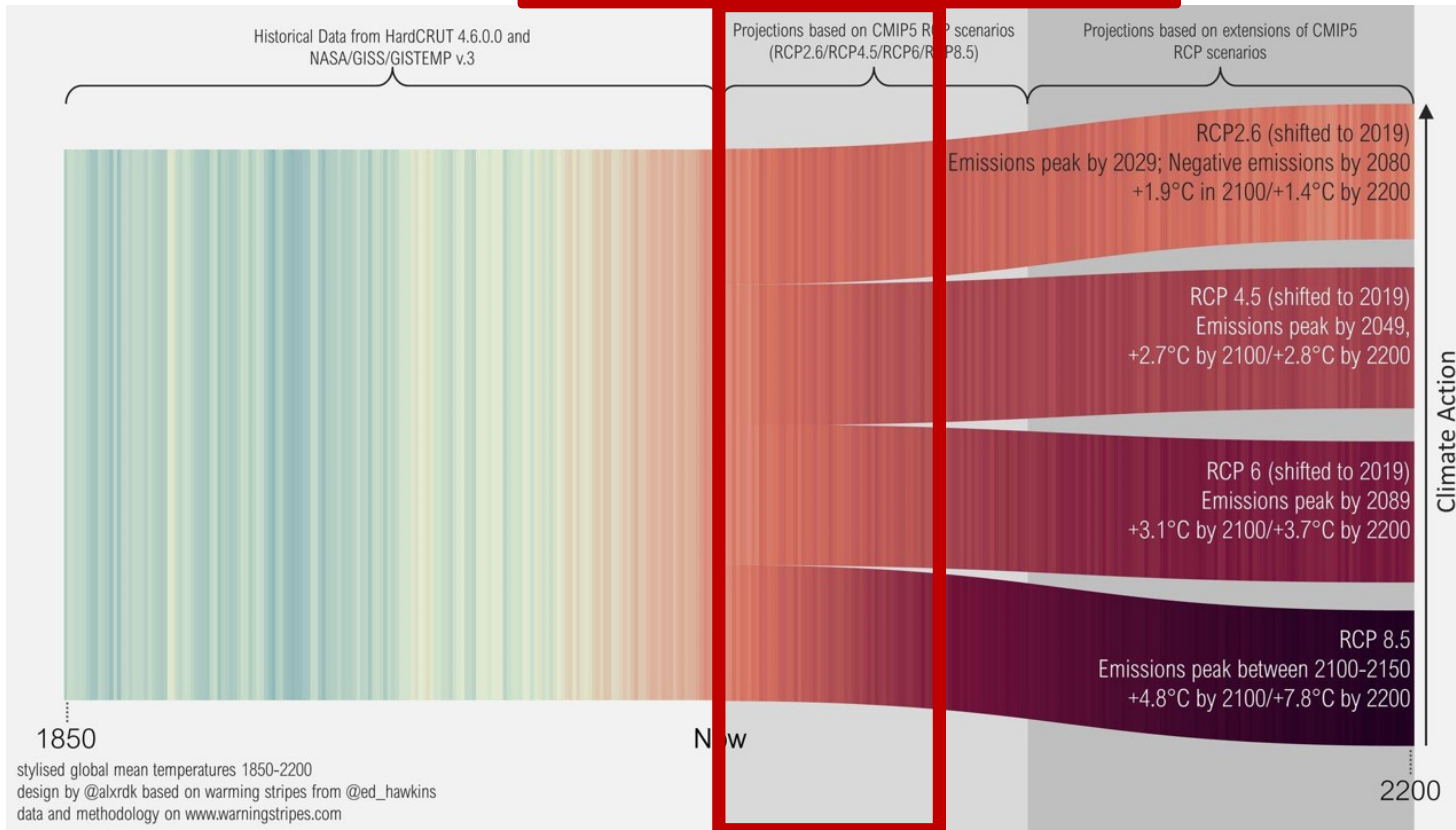
Expansión de algunas expresiones

Proyecciones de Temperatura



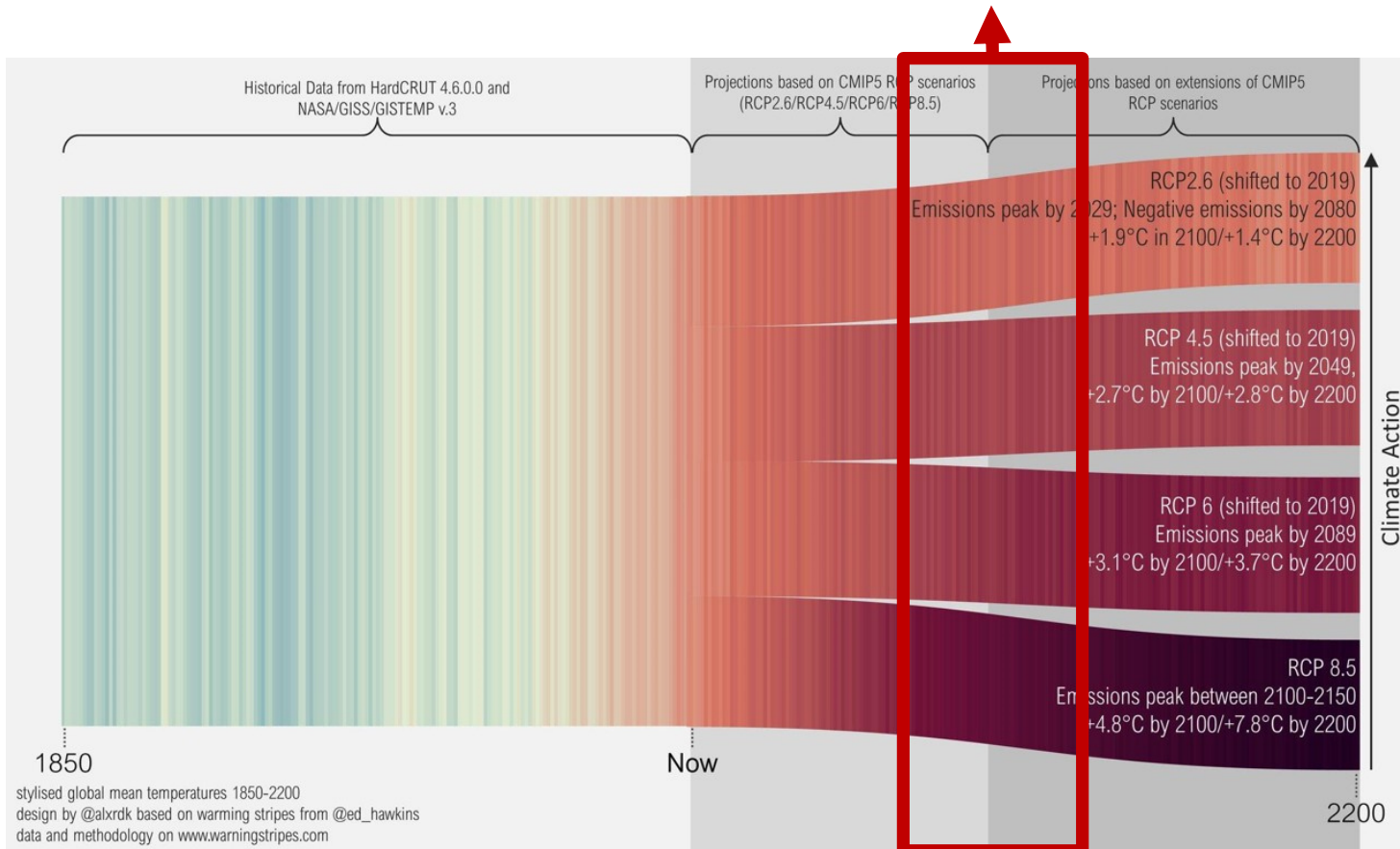
Proyecciones de Temperatura

La trayectoria en los próximos 30 años no va a cambiar independientemente del camino que sigamos

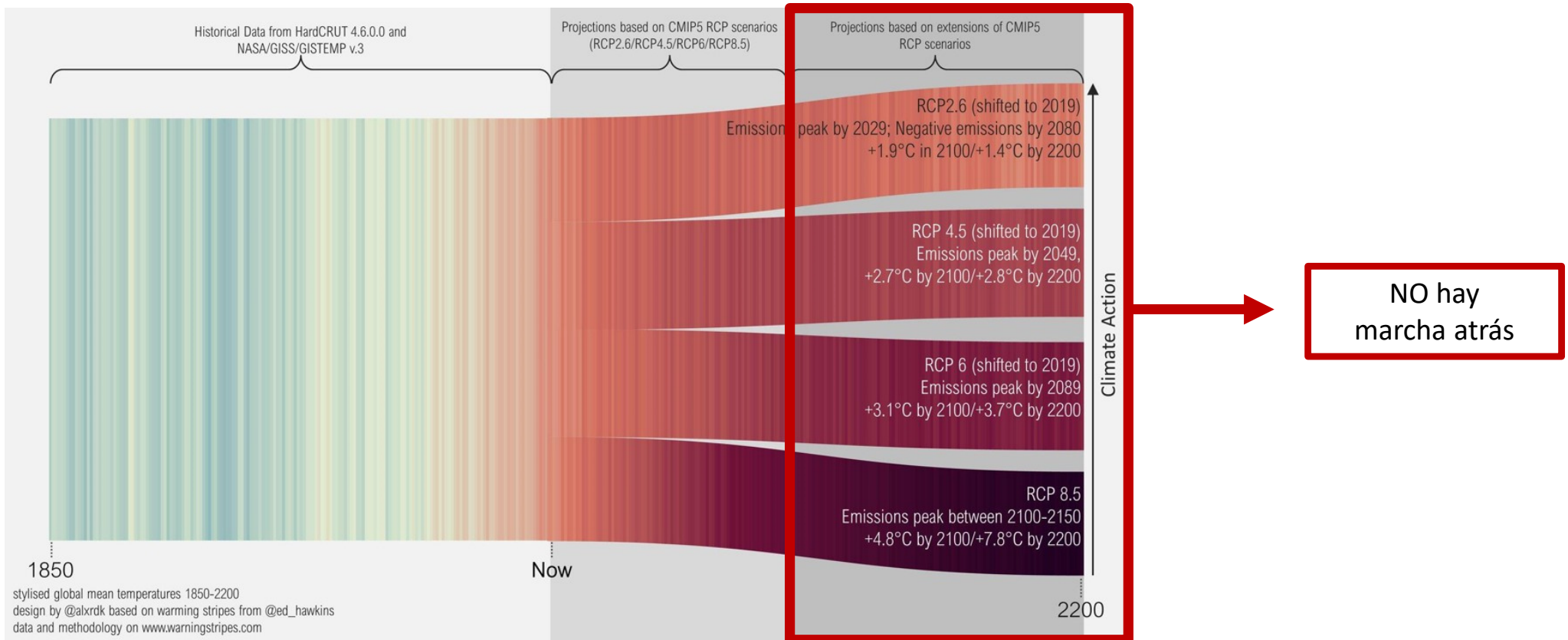


Proyecciones de Temperatura

El sistema climático no se estabilizará hasta al menos finales de siglo



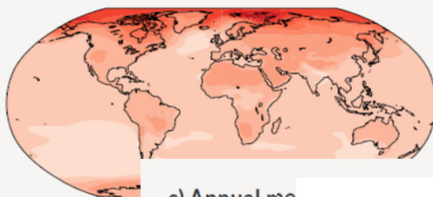
Proyecciones de Temperatura



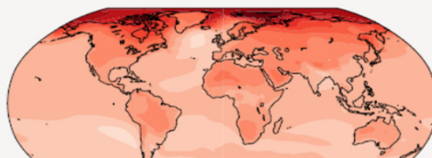
b) Annual mean temperature change (°C) relative to 1850-1900

Across warming levels, land areas warm more than oceans, and the Arctic and Antarctica warm more than the tropics.

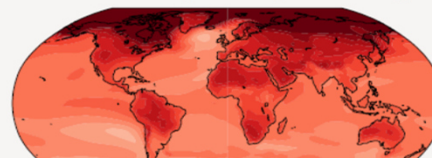
Simulated change at 1.5 °C global warming



Simulated change at 2 °C global warming

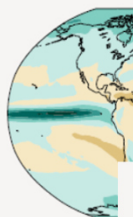


Simulated change at 4 °C global warming



c) Annual mean temperature change (°C) relative to 1850-1900

Simulated change at 1.5 °C global warming

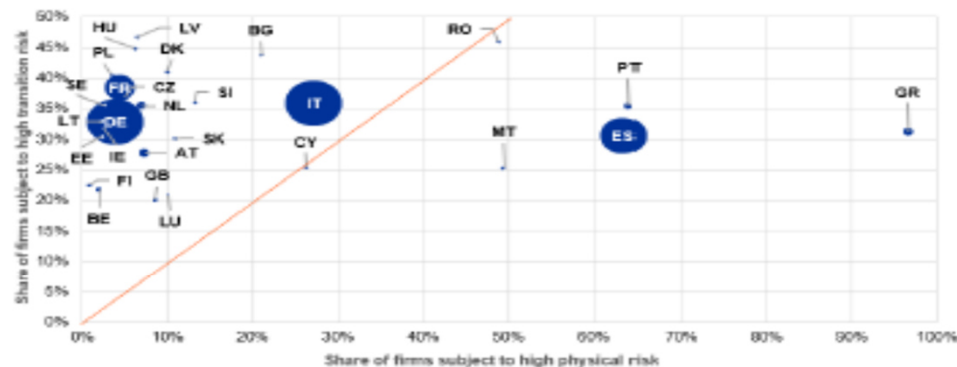


Relatively small absolute changes may appear large when expressed in units of standard deviation in dry regions with little interannual variability in baseline conditions

Chart 17

Share of firms exposed to physical versus transition risk by country

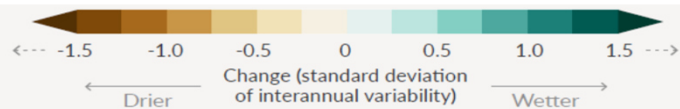
(percentages)



Sources: ECB calculations based on AmecCredit, Urgentem, and Four Twenty Seven data (2018).

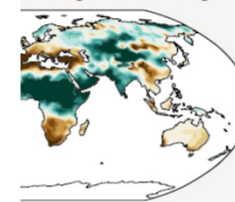
Notes: Firms are subject to high transition risk if their emission intensities fall within the 70th percentile of Scope 1, 2 and 3 relative emissions for the entire sample. Firms are subject to high physical risk if their probability of suffering from a wildfire or a river or coastal flood in a given year is over 1%. The size of the bubbles depicts the exposures at risk, and is proportional to the absolute loan exposure to high-transition and/or high-physical-risk firms in the country of origin as compared with the total exposures of euro area banks in the sample (across countries). In order to facilitate the visualization, the x-axis is not drawn to scale.

Relatively small absolute changes may appear large when expressed in units of standard deviation in dry regions with little interannual variability in baseline conditions



es in

at 4 °C global warming



Resumiendo

- Debido a la inercia del sistema climático, el escenario para los próximos 30 años está trazado y no hay vuelta atrás.
- Muy probablemente alcanzaremos los 1,5° de aumento en la próxima década. La última estimación de Naciones Unidas es que llegaríamos a 2,7°
- Cada décima de grado importa: incremento de la frecuencia e intensidad de extremos

Algunas implicaciones

- Incremento de
 - - Vulnerabilidad
 - - Percepción social del riesgo
 - - Desigualdades
 - - Intensidad y frecuencia de impactos extremos
- Mantener el doble esfuerzo: adaptación a los riesgos crecientes y transición a la descarbonización
- Cambios en la forma de trabajar/vivir
- ¿Fatiga climática? ¿Cómo se gestiona una emergencia de 30 años?

Muchas gracias

rgarciah@ucm.es