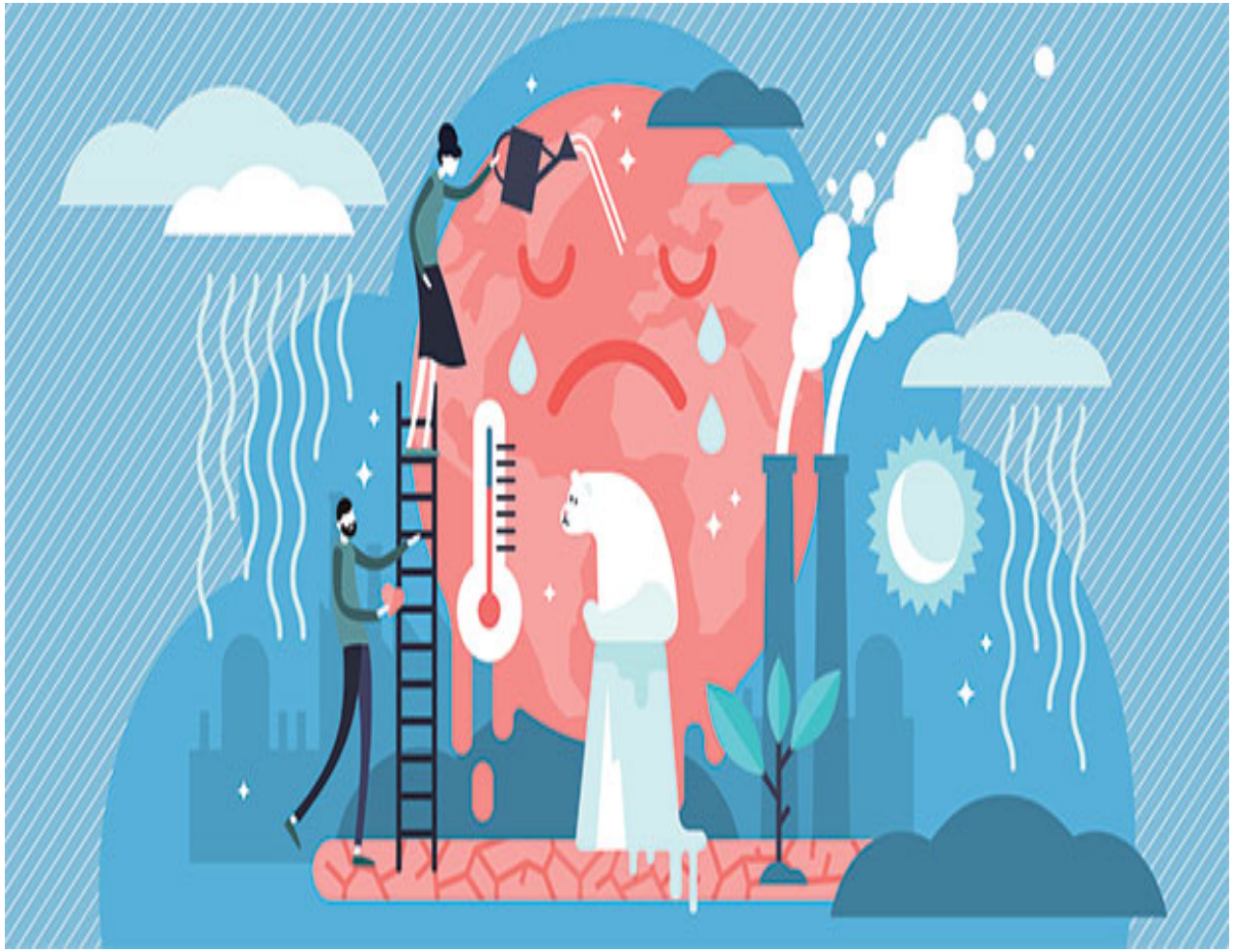
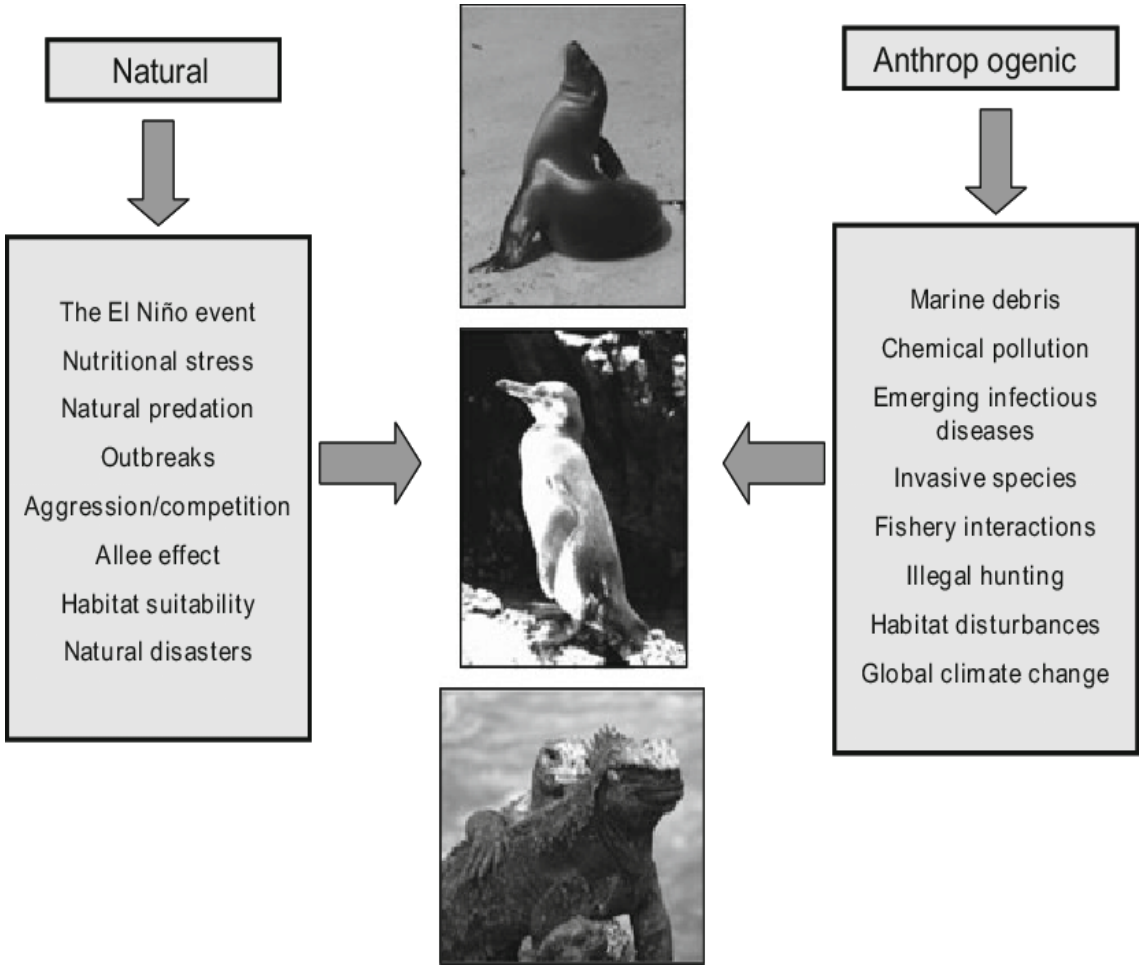


Contemporary Humans and the Environment

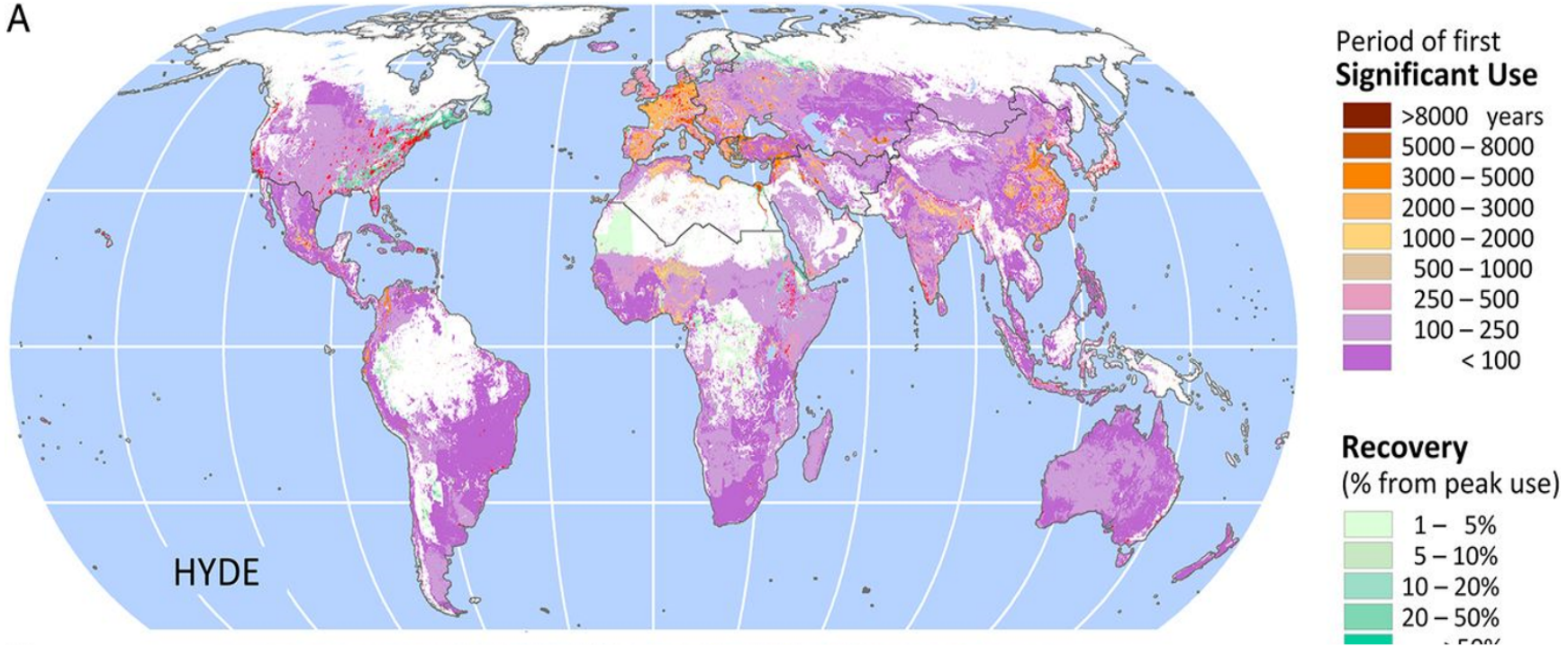
Anthropogenic stressors contribute to change

- **Historical build-up:**
  - hunting and megafaunal extinctions
  - agriculture and domestication
  - urbanization and population growth
- **Current trends (today's topic)**
  - land use change
  - pollution
  - globalization
- **Equivalent to a natural stressor if an organism's response is similar or identical**



Land-use change levels up

- **Before the Anthropocene, human induced land-use change was mostly regional**
  - hunting, agriculture and increased urbanization
  - Thus, habitat modification is not new



Erle C. Ellis et al. PNAS 2013;110:20:7978-7985

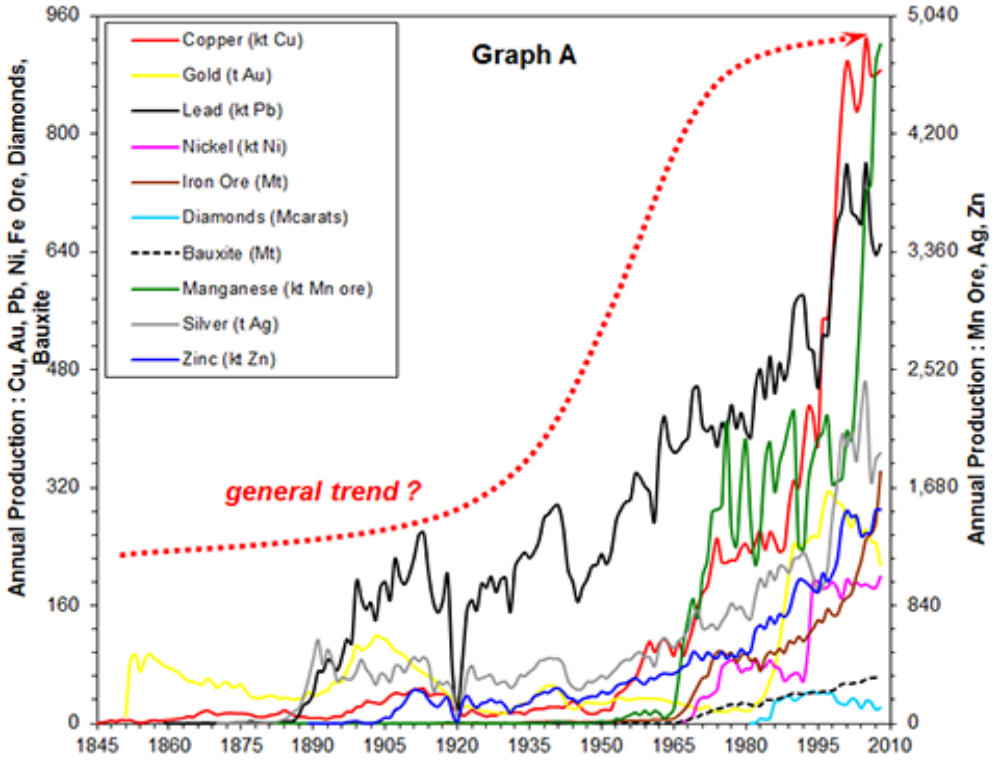
How have humans modfied 75% of the land surface?

- **Agricultural intensity must match demand**

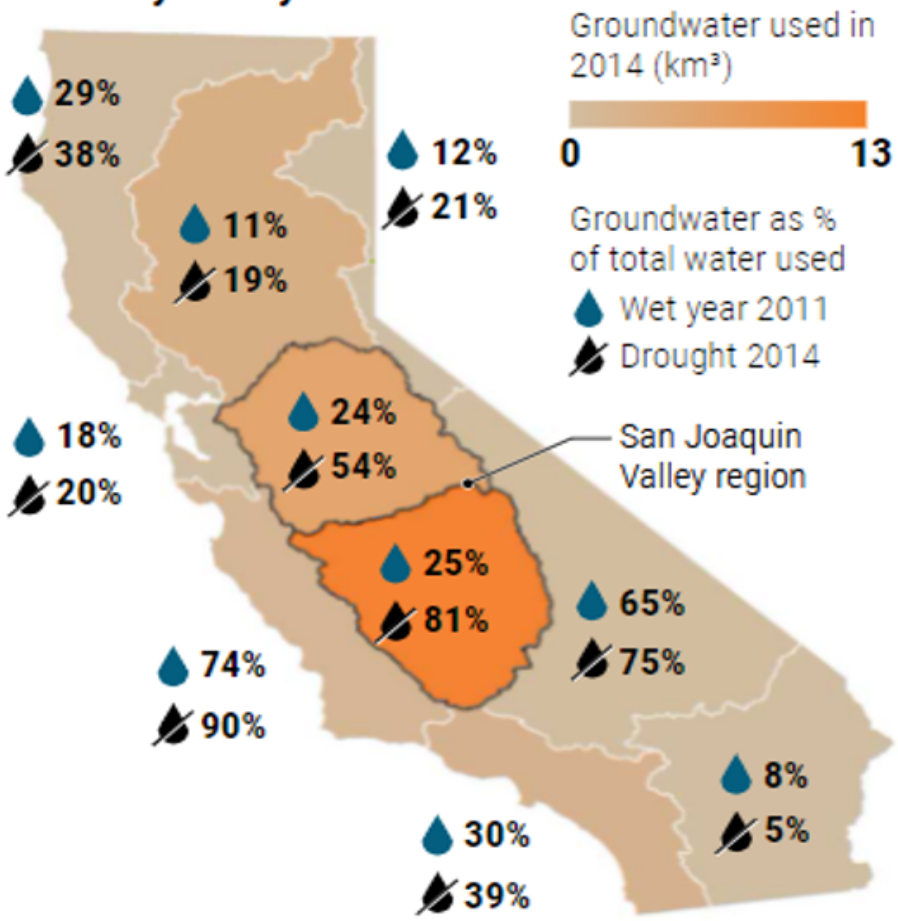
- **Freshwater is a limiting resource**
  - 40% dedicated to agriculture
  - deep water sources are needed
  - water needs to be diverted

- **Minerals and metals are needed for everything**

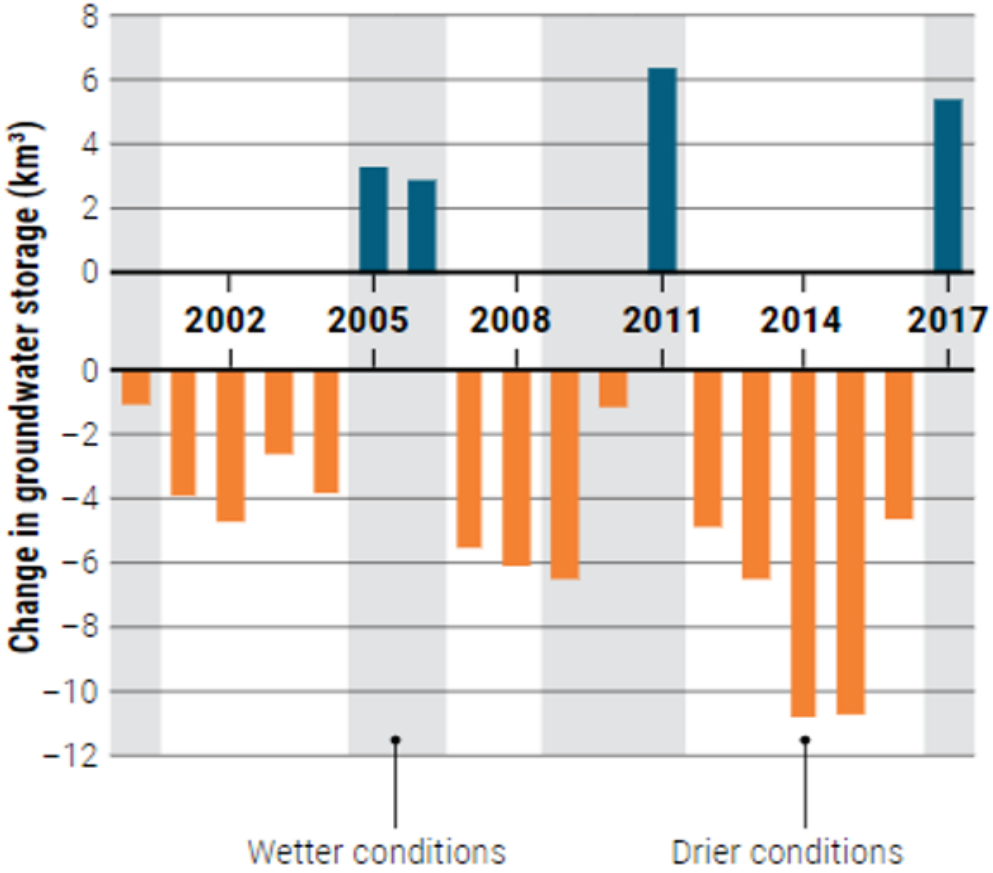
- **Natural ecosystems provide raw materials**
  - and get it the way of urbanization



A thirsty valley



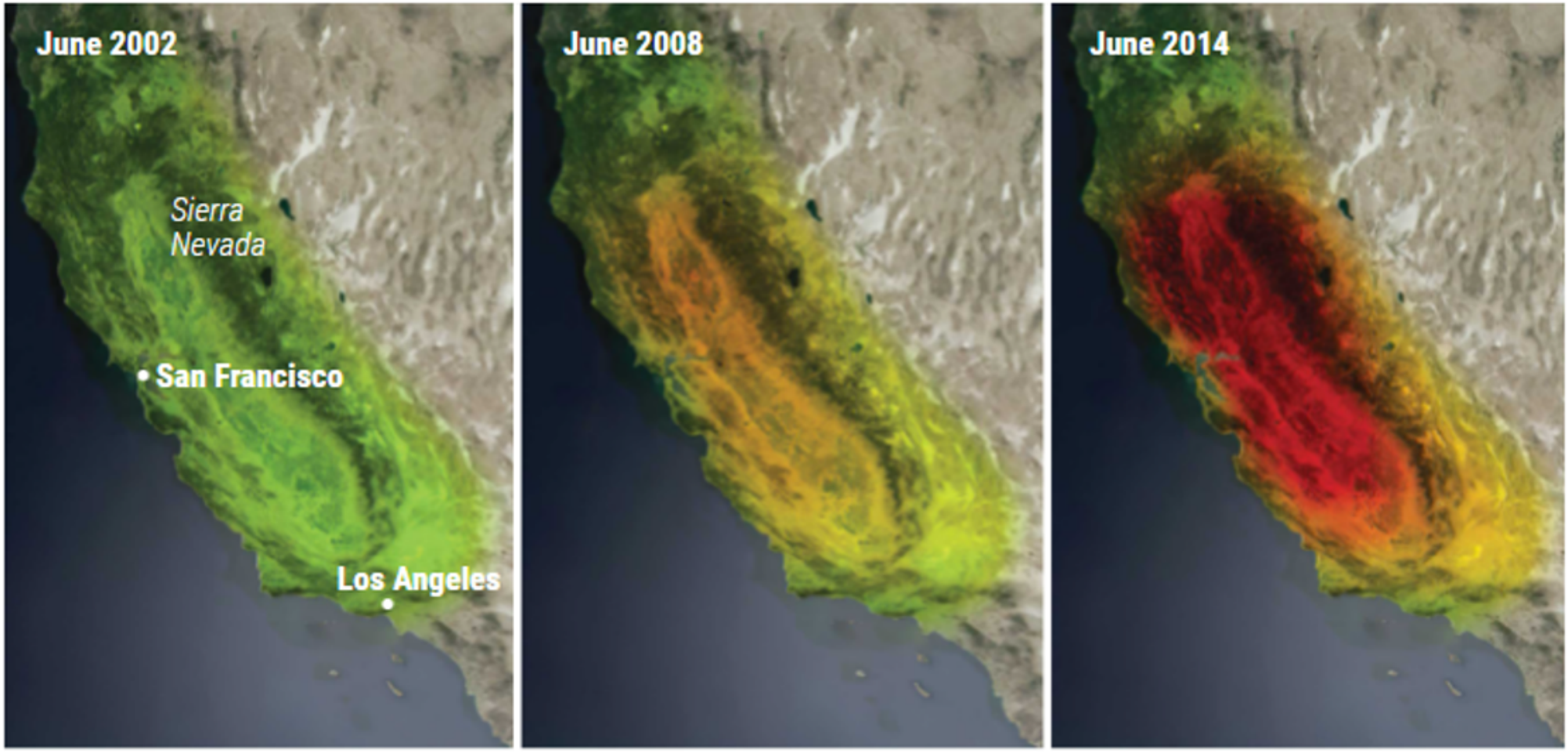
Subtraction outraces addition



(IMAGES) JAY FAMIGLIETTI/NASA JET PROPULSION LABORATORY; CALIFORNIA INSTITUTE OF TECHNOLOGY; UNIVERSITY OF CALIFORNIA, IRVINE; (GRAPHICS) N. DESAI/*SCIENCE*; (DATA) CALIFORNIA DEPARTMENT OF WATER RESOURCES; PPIC

California drying

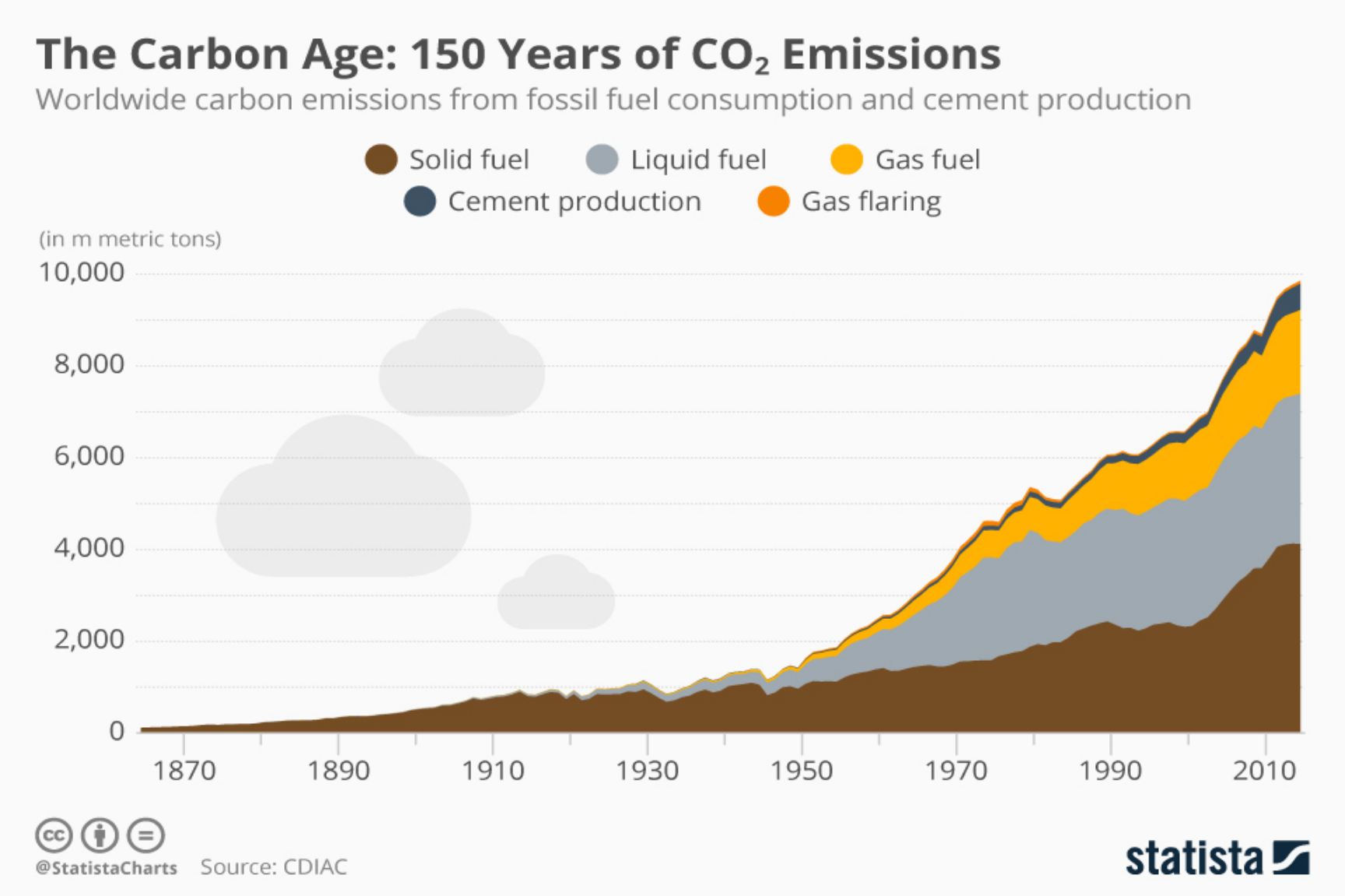
NASA's GRACE satellites detect the gravitational pull of water masses in aquifers, reservoirs, and snowpack. In 2014, GRACE data showing water loss (below, red indicates loss) helped dramatize the draining of aquifers and galvanize state lawmakers to protect groundwater.



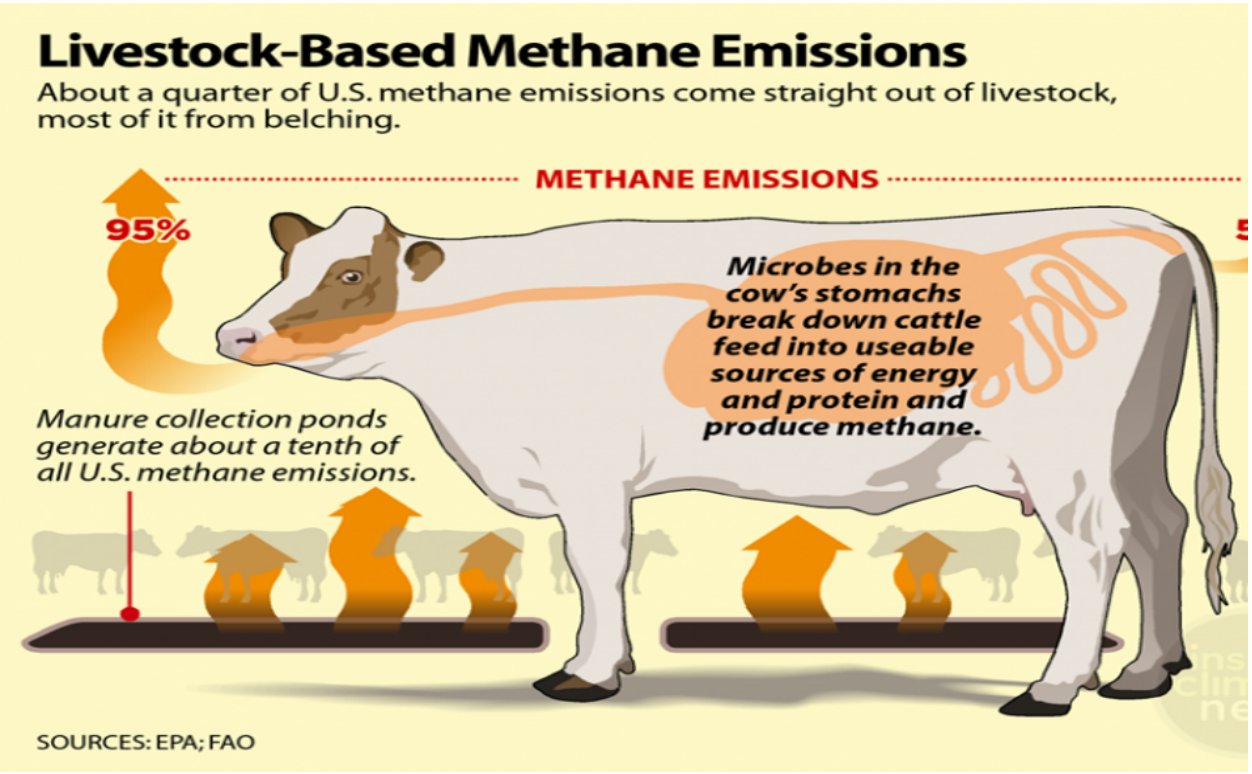
Human activities create contaminants

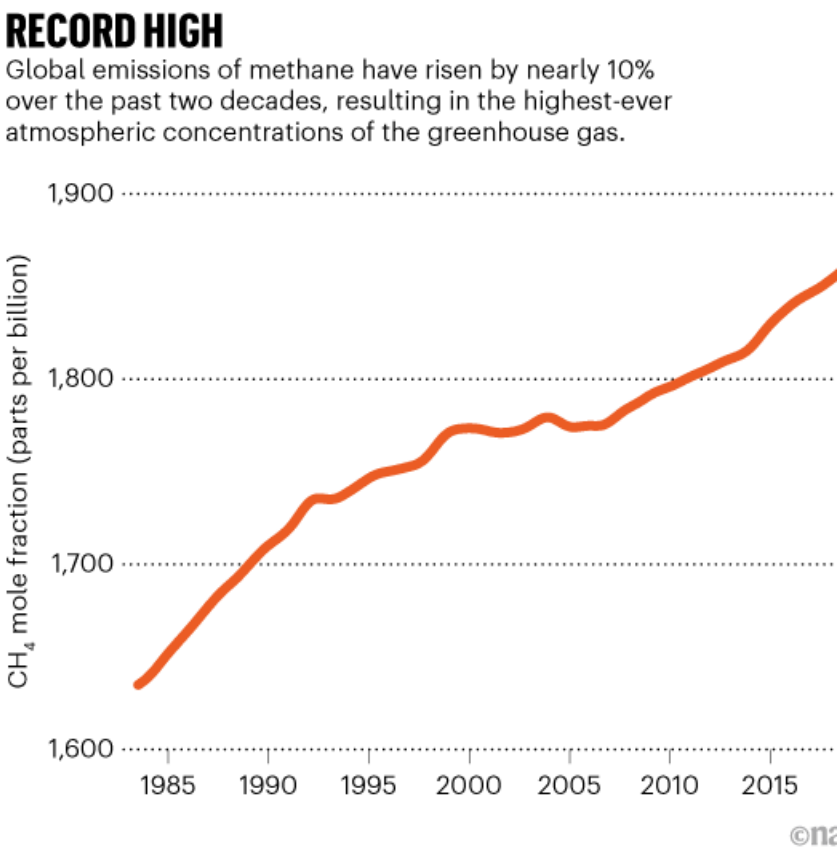
- **From *point* sources to *diffuse* impacts**
  - California oil spill vs. fertilizer run-off in Chesapeake Bay

Human activities create contaminants: Excess carbon dioxide



Human activities create contaminants: Other greenhouse gases



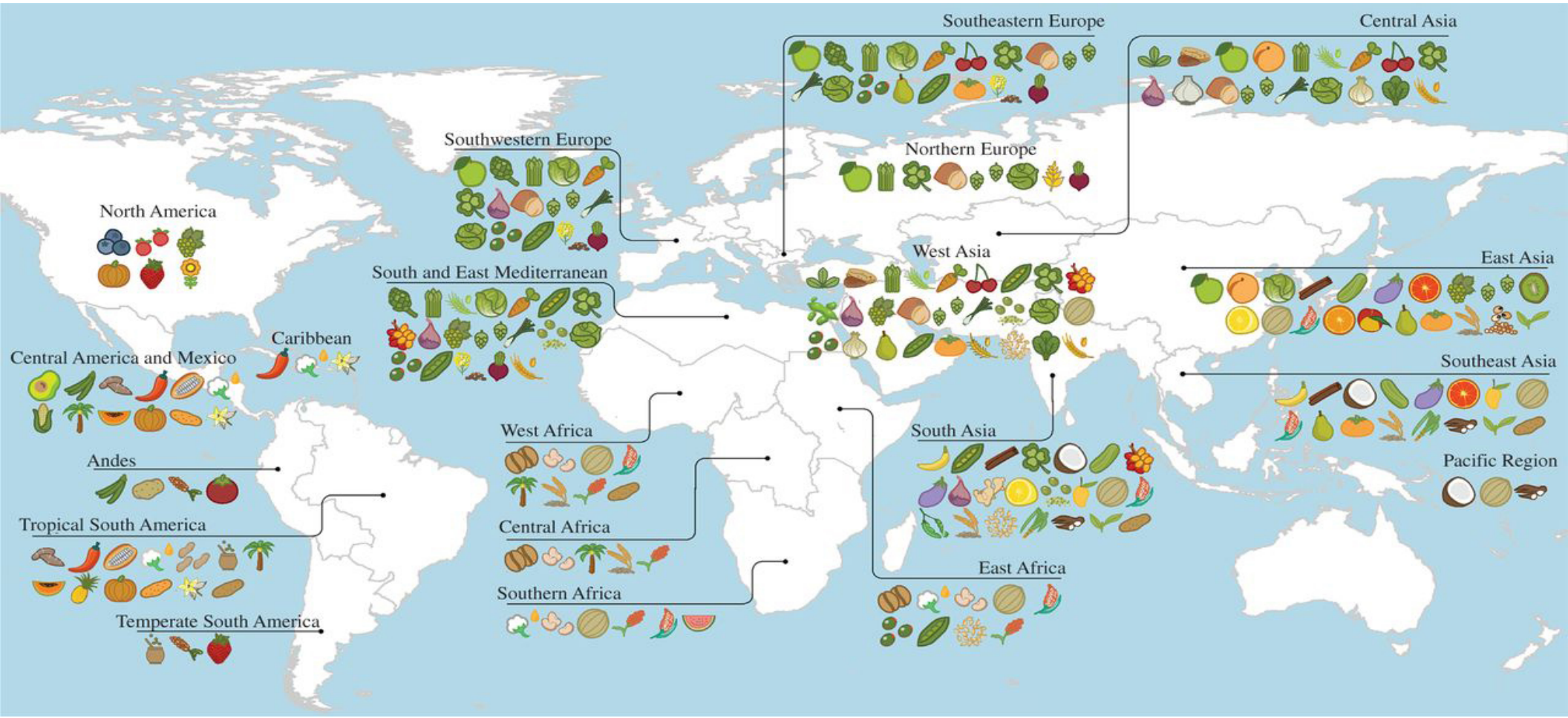


Humans are now connected worldwide

- **The impacts of *globalization* on natural systems is huge**

- **Humans move species around - for better or worse**
  - necessary for food systems
  - unintentional as part of trade (invasive species)
  - intentional with unknown consequences

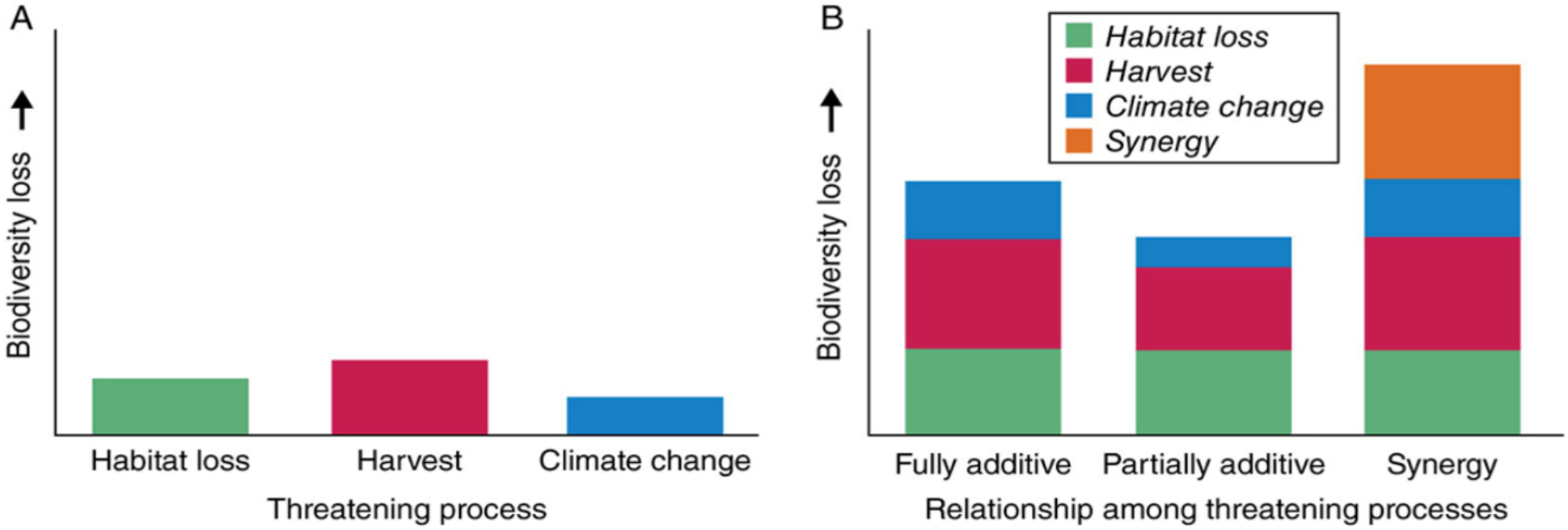
- **Infrastructure of globalization also disrupts natural systems**
  - roads fragment landscapes
  - transportation pollutes
  - politics of trade divides wealth


Southeastern Europe
Central Asia
Southwestern Europe
Northern Europe
North America
West Asia
East Asia
South and East Mediterranean
Caribbean
Central America and Mexico
Southeast Asia
West Africa
South Asia
Pacific Region
Andes
Central Africa
Tropical South America
East Africa
Southern Africa
Temperate South America

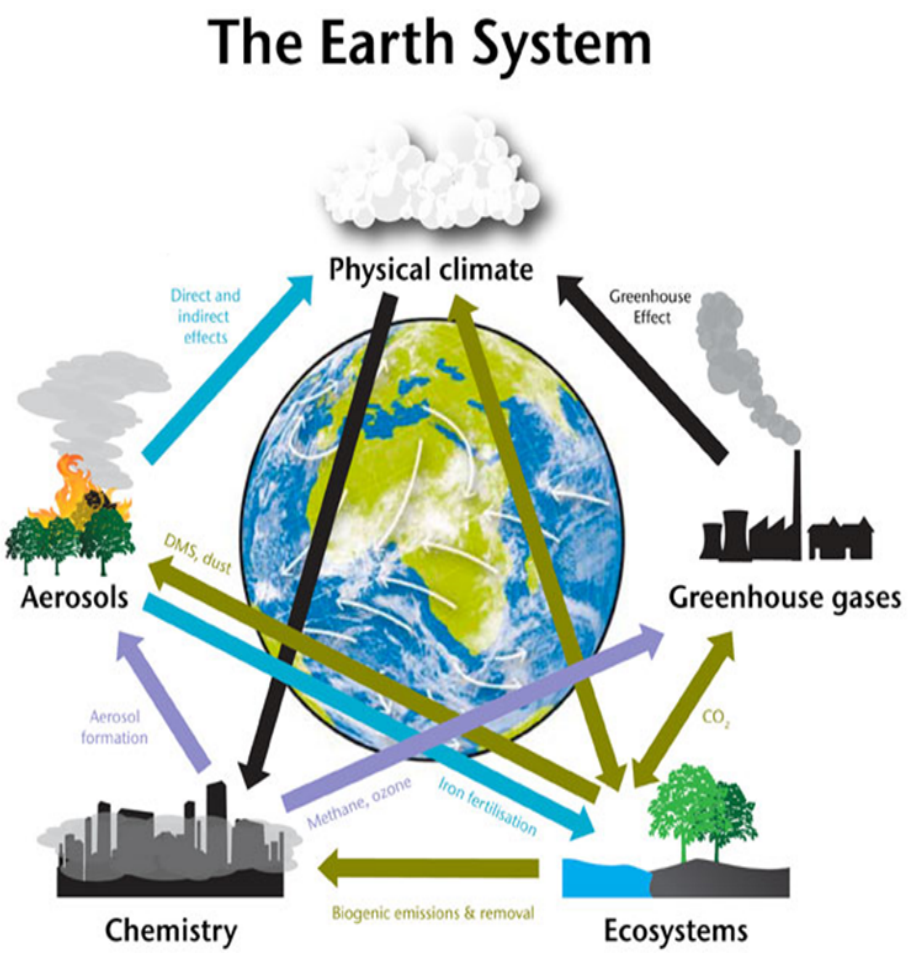
How do stressors interact?

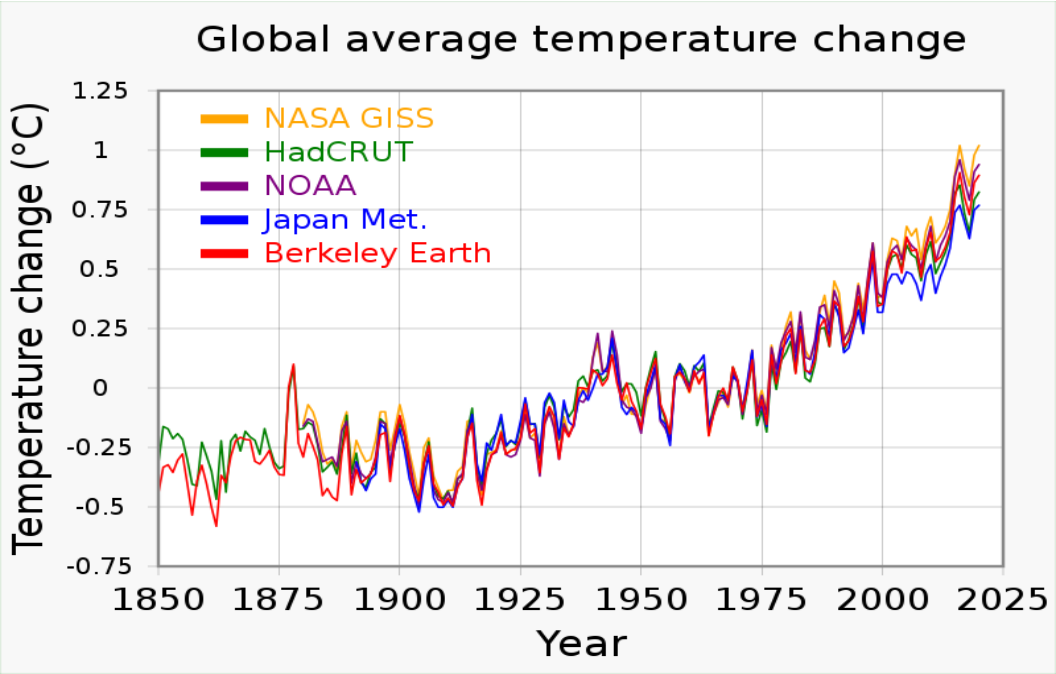
Synergy: when the total effect is *more* than the sum of the individual effects

Partially additive: when the total effect is *less* than the sum of the individual effects

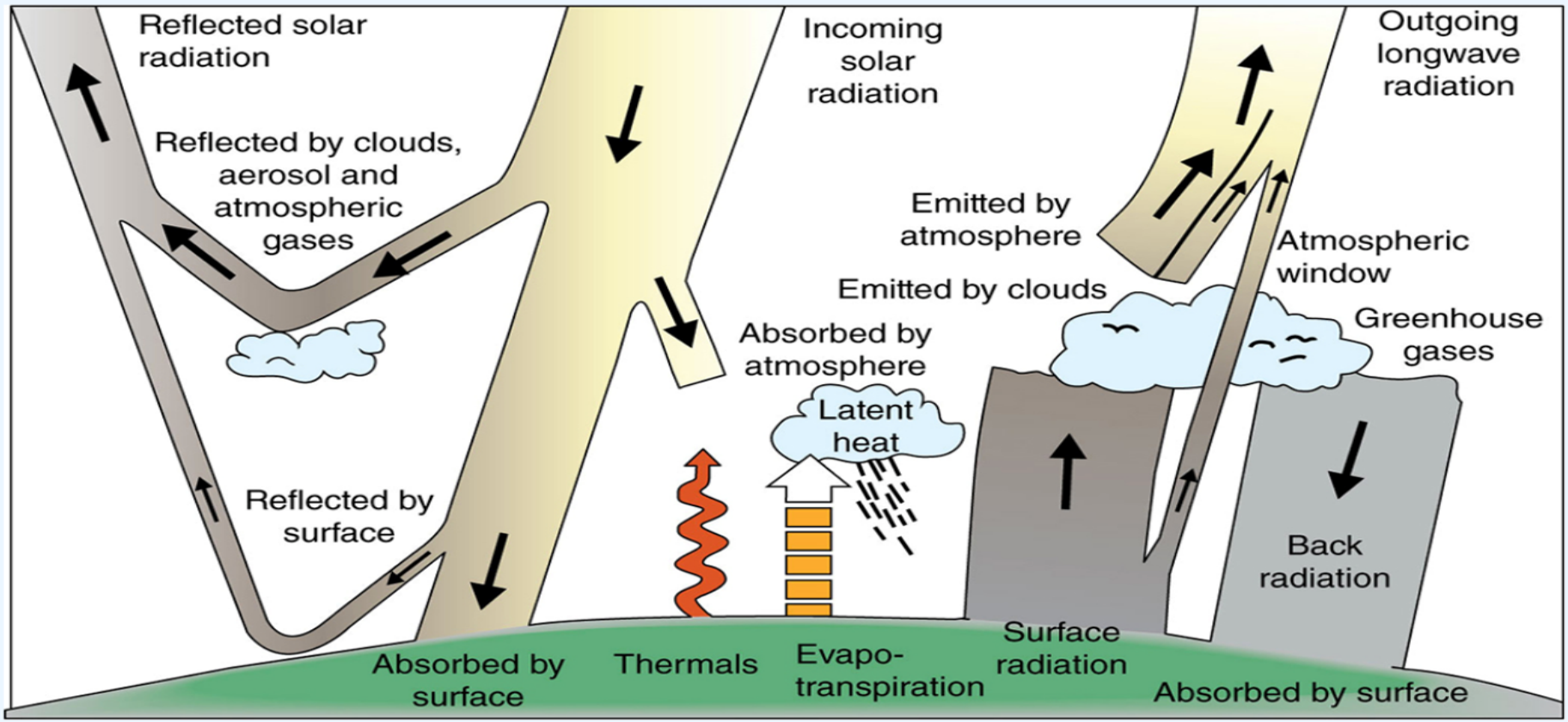


Big picture: These stresses have altered Earth's climate systems



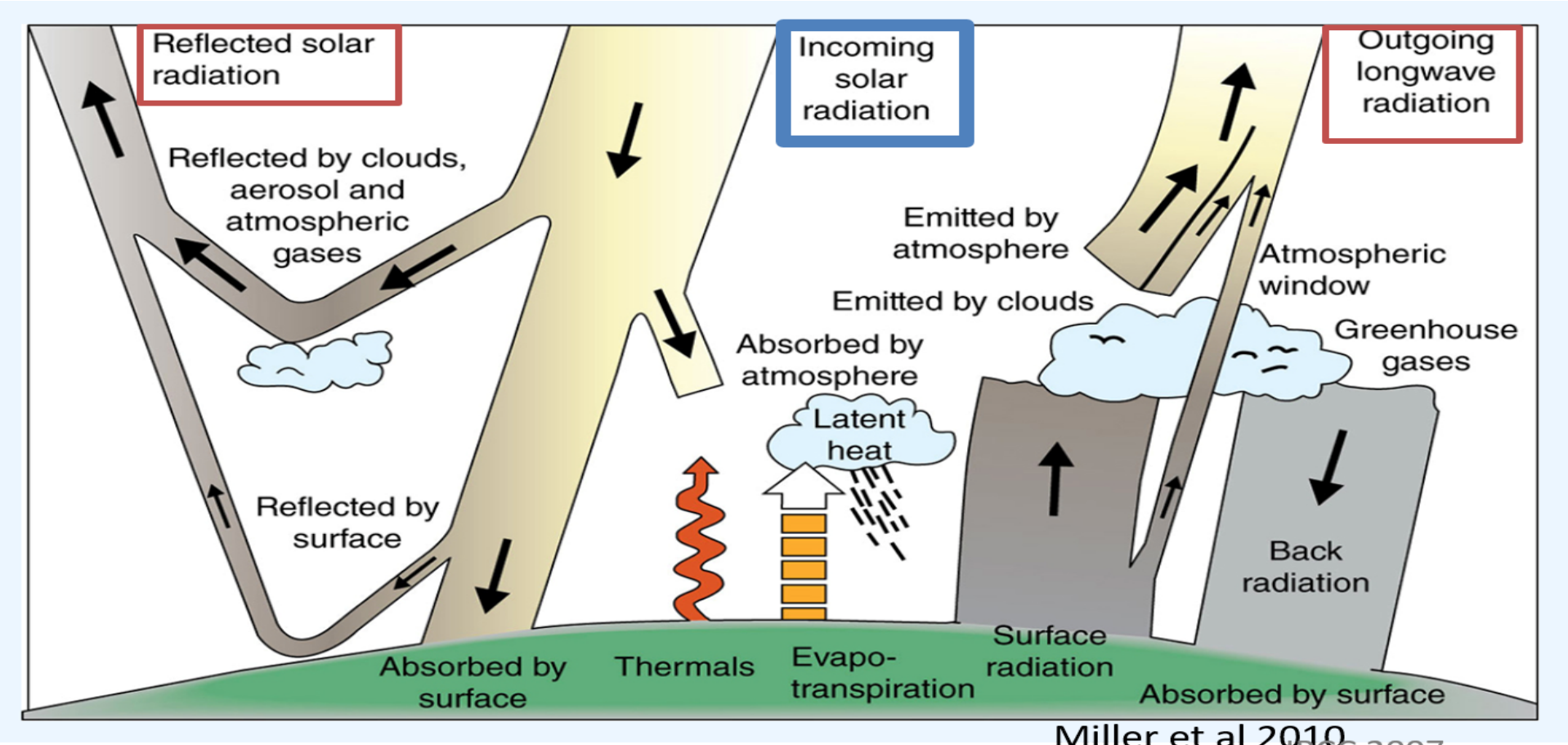


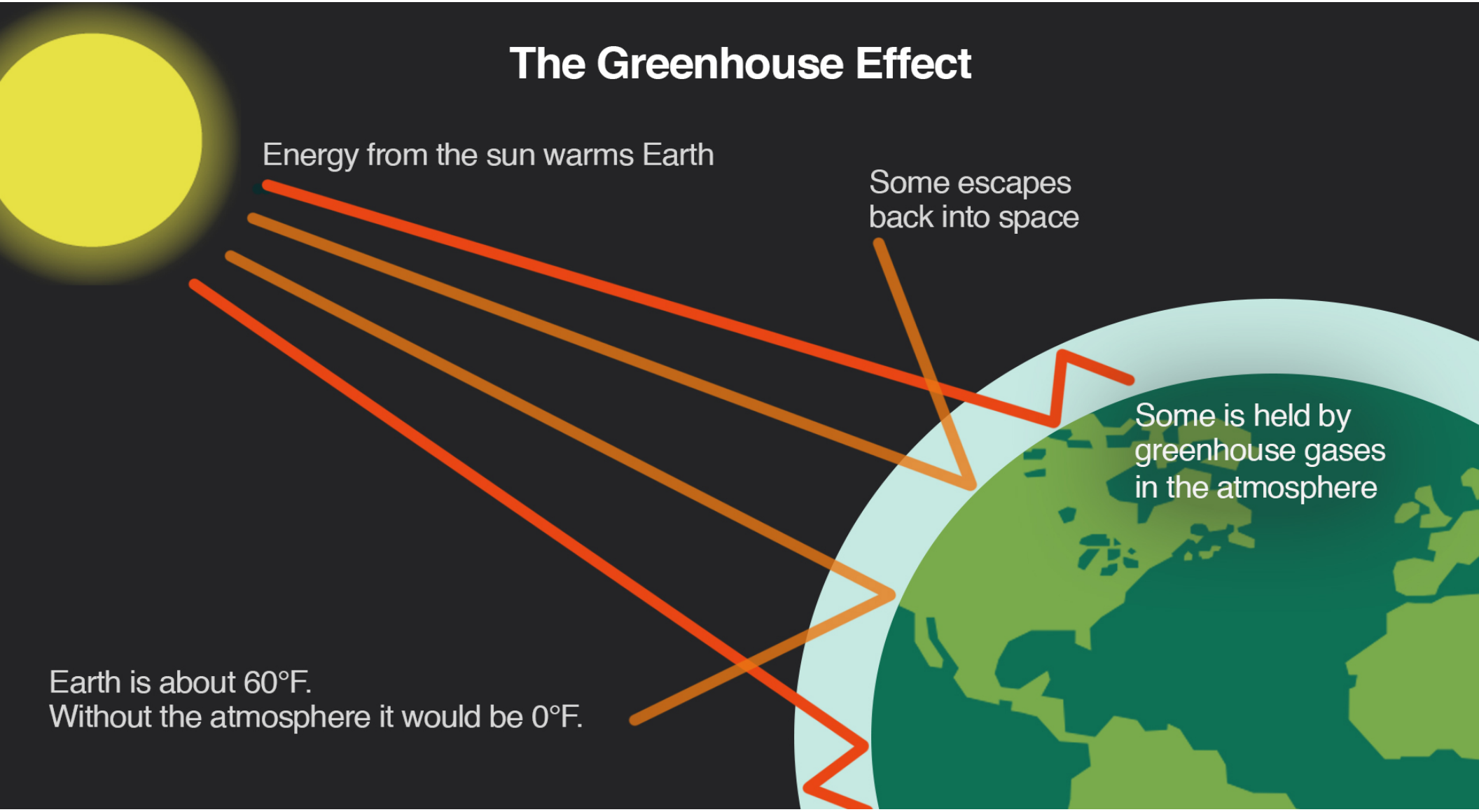
The climate system is powered by solar radiation.



Don’t get lost in details

Incoming solar radiation balanced by outgoing radiation



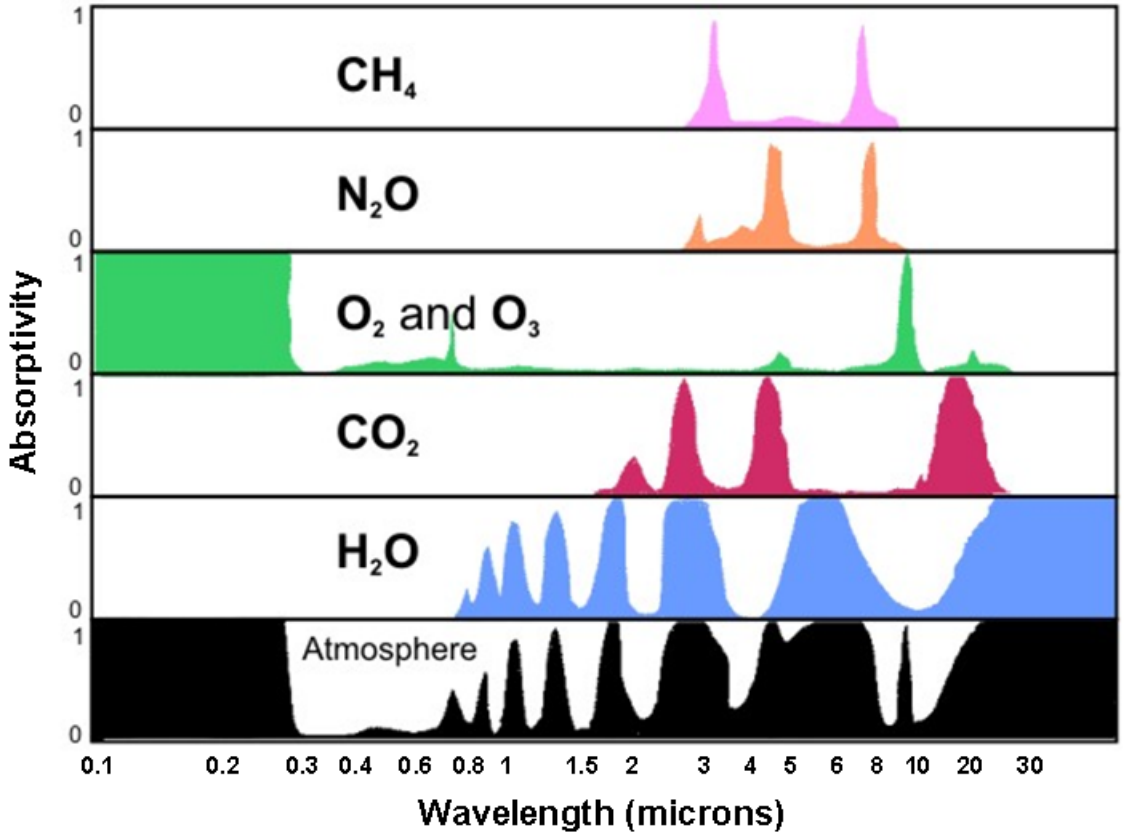

The Greenhouse Effect
Energy from the sun warms Earth
Some escapes
back into space
Some is held by
greenhouse gases
in the atmosphere
Earth is about 60°F.
Without the atmosphere it would be 0°F.

If balance interupted, Earth warms or cools

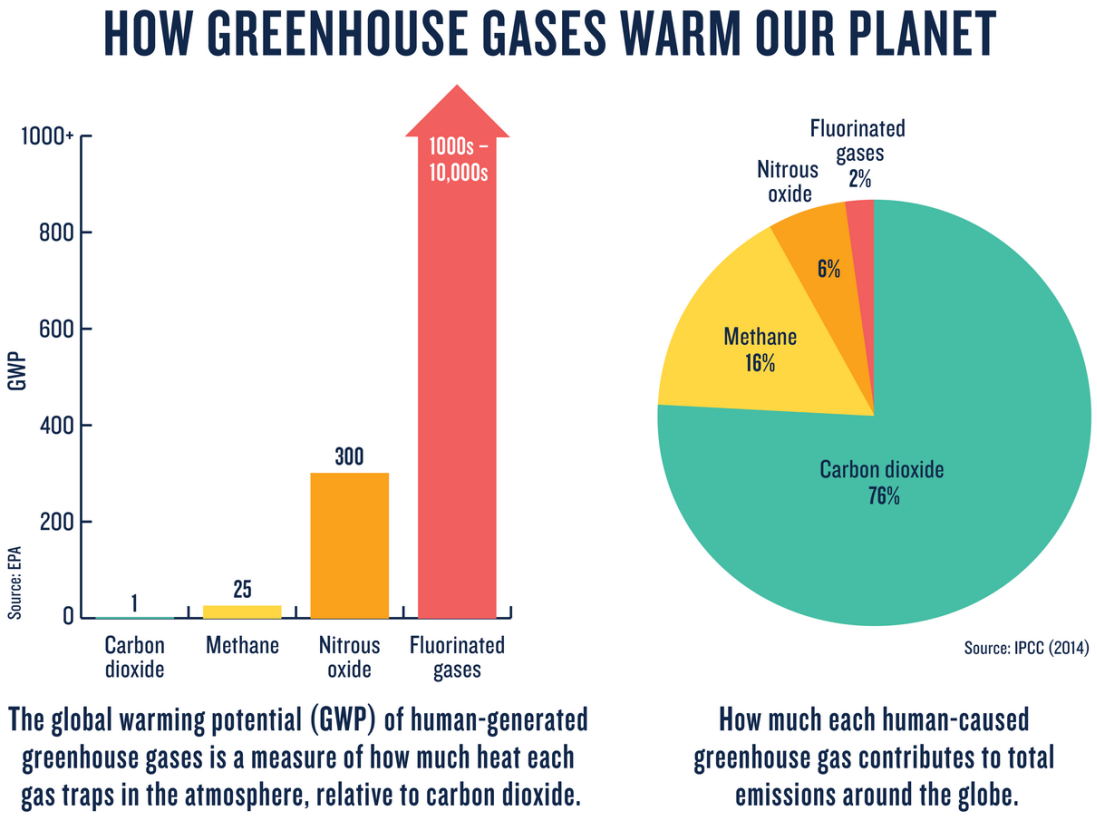
The radiative balance can be perturbed by "forcings'

- **Each 'forcing' can alter:**
  - incoming solar radiation (shortwave)
  - solar radiation that is reflected
  - longwave radiation emitted from Earth

- **Forcings largely a function of greenhouse gases**
  - each absorb longwave radiation

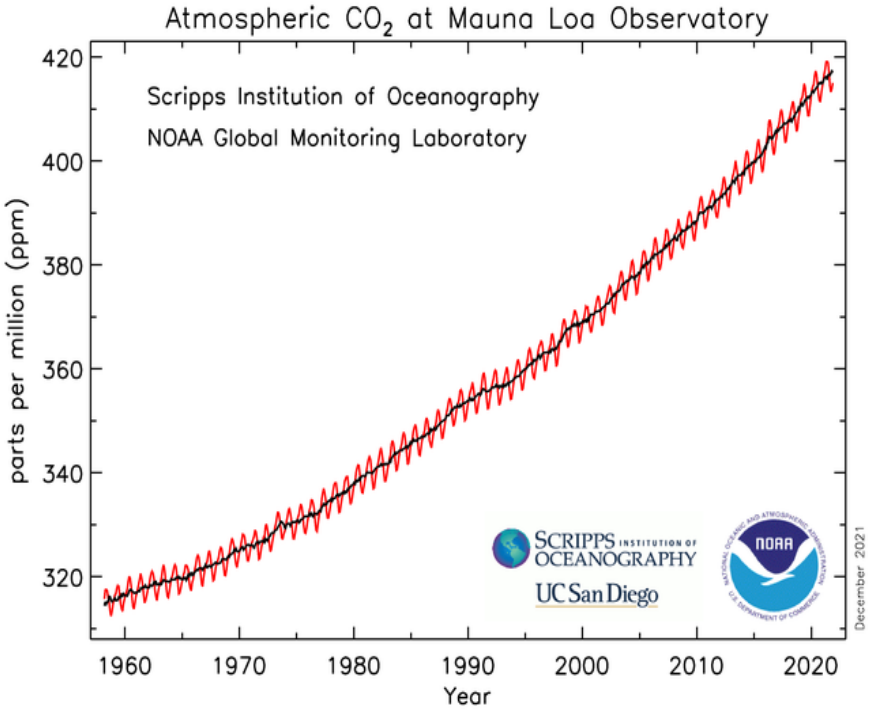


Why does climate change over time?

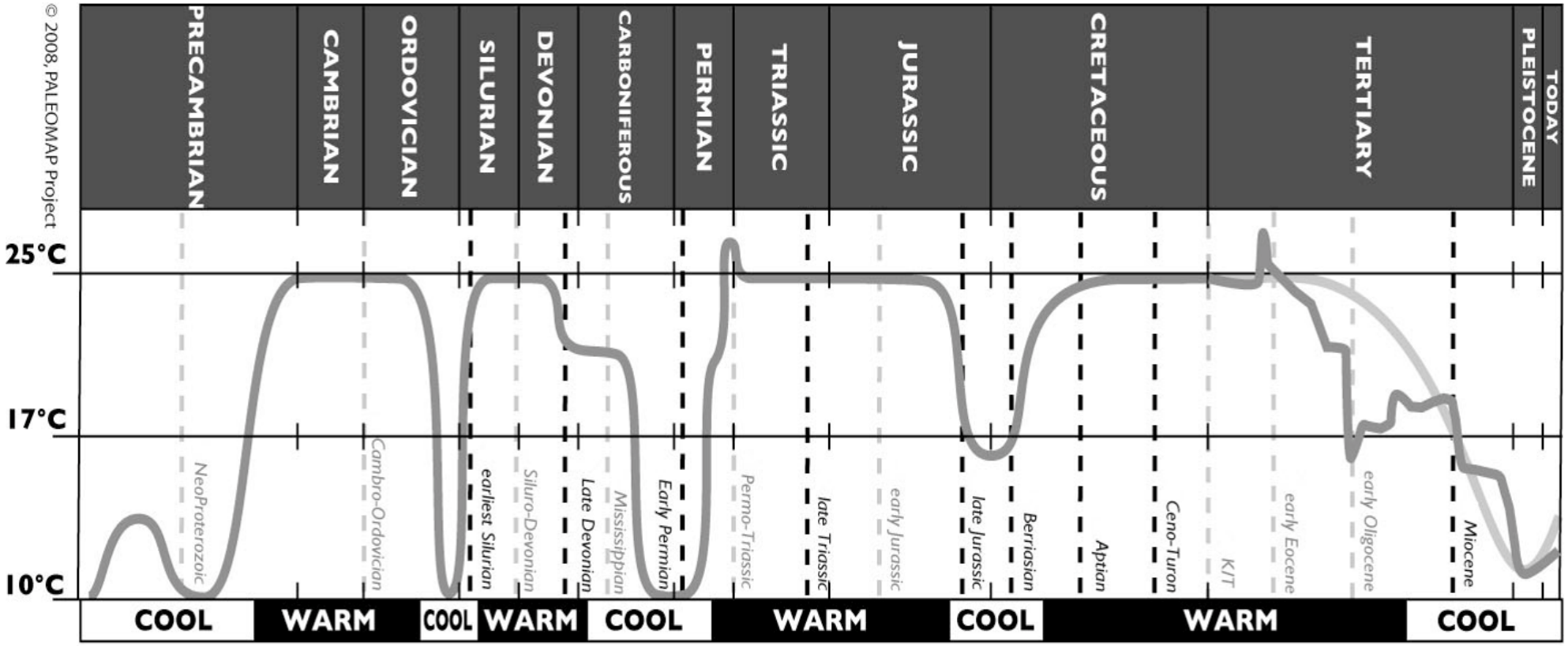


The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.

How much each human-caused greenhouse gas contributes to total emissions around the globe.

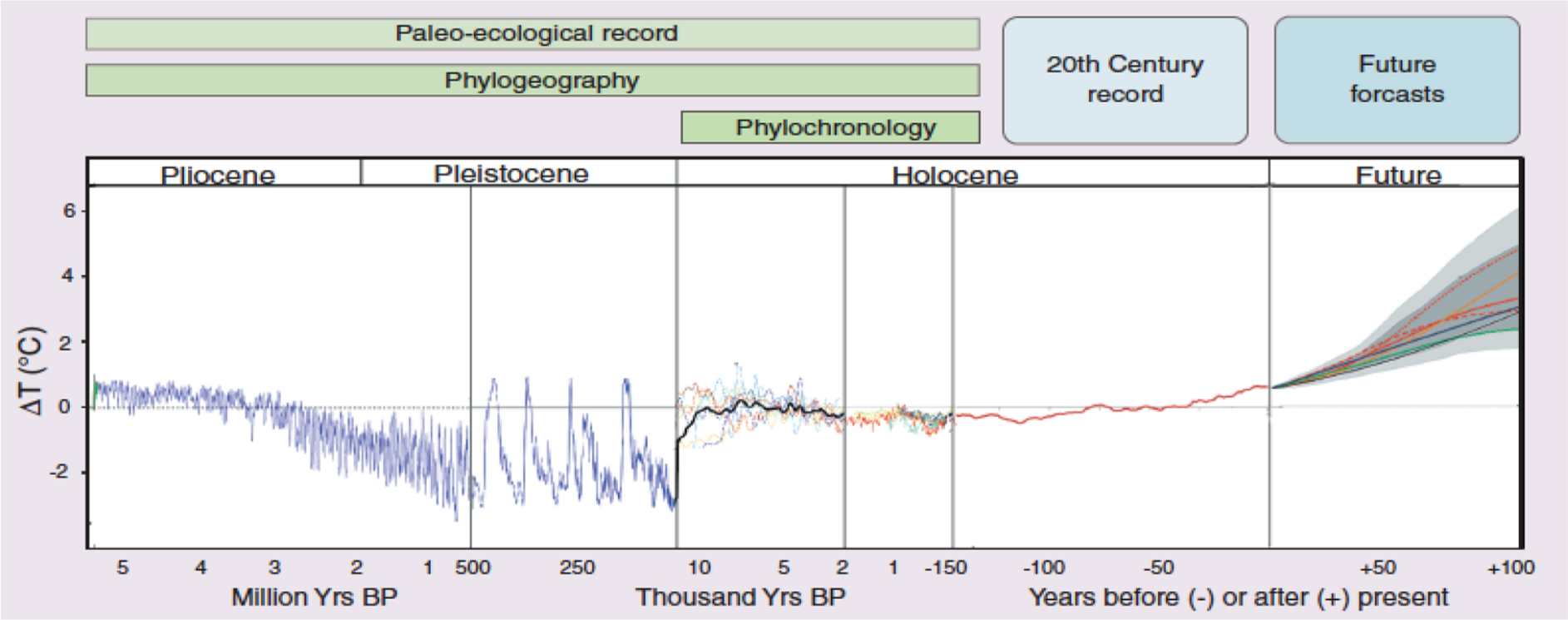


Climate change is not new



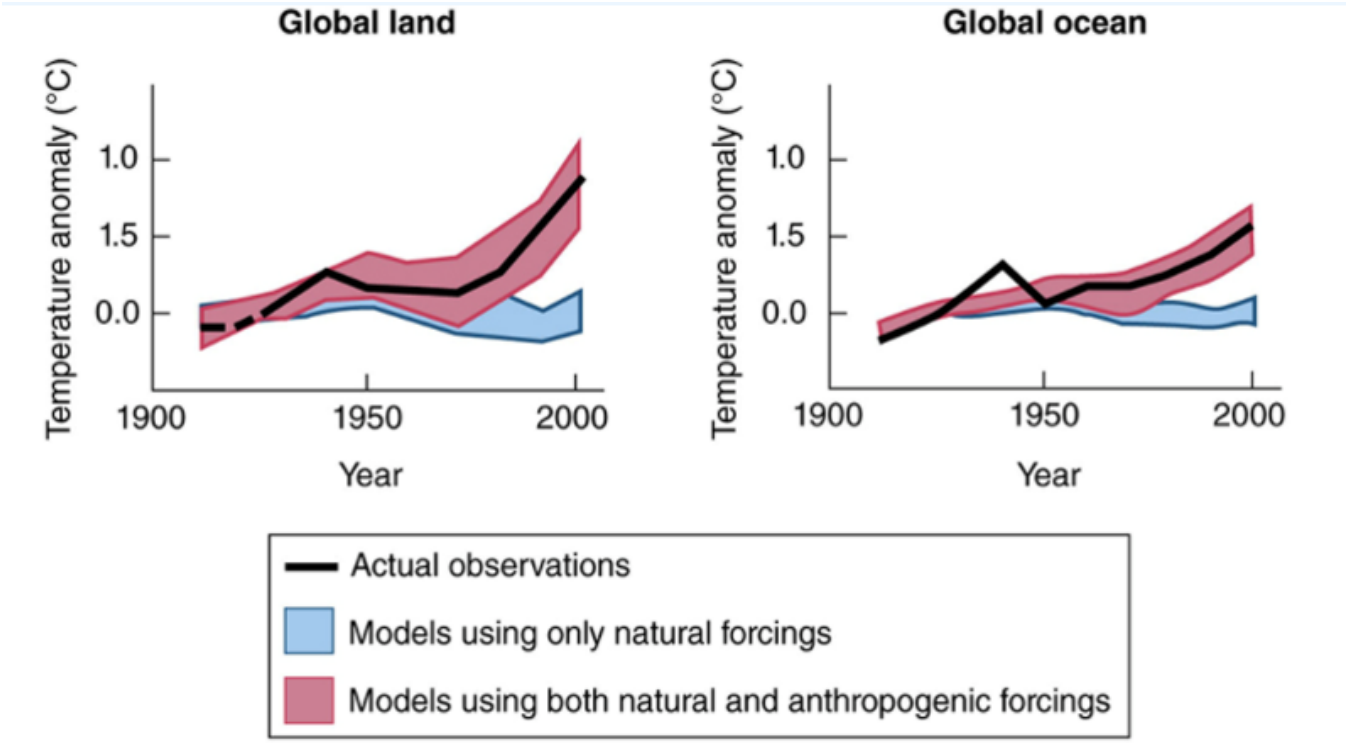
Climate change then versus now…

5°C of “natural” warming took earth from an Ice Age to our modern interglacial world
Took 1600 years!



Climate change then versus now…

Contemporary climate change is different because of anthropogenic causes and velocity
Same 5°C change >10x faster



We measure current change since Industrial age…

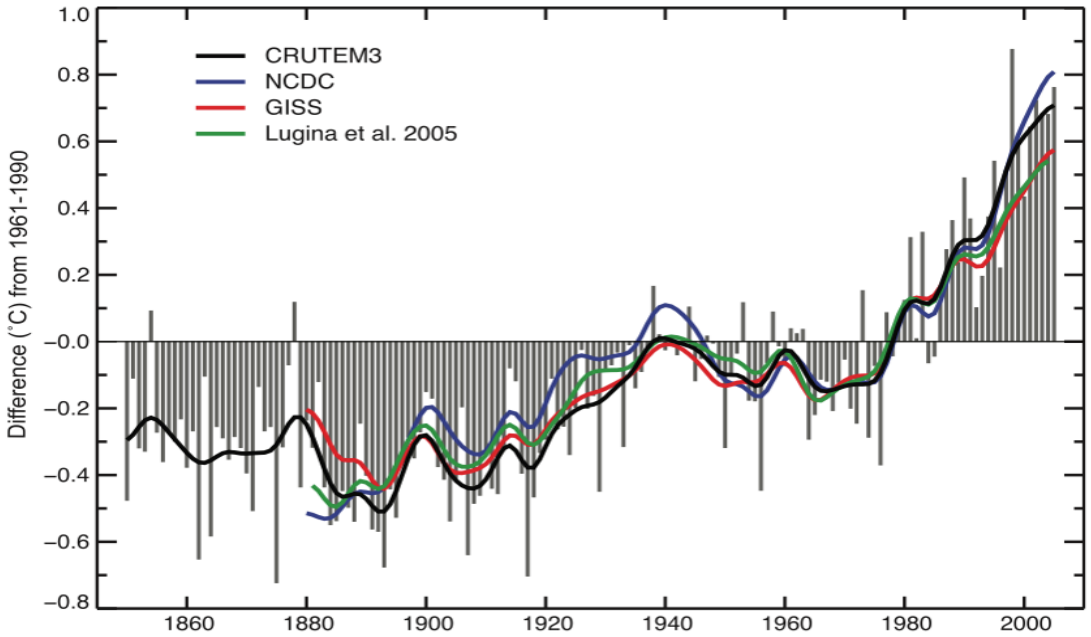
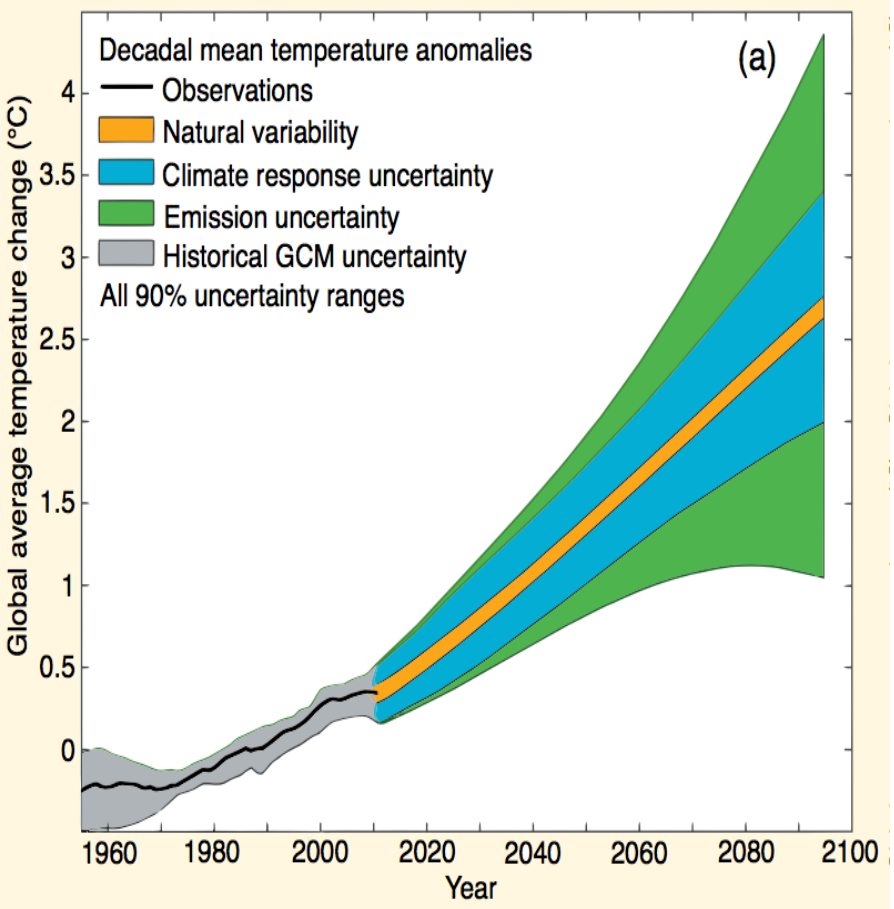


Figure 3.1. *Annual anomalies of global land-surface air temperature (°C), 1850 to 2005, relative to the 1961 to 1990 mean for CRUTEM3 updated from Brohan et al. (2006). The smooth curves show decadal variations (see Appendix 3.A). The black curve from CRUTEM3 is compared with those from NCDC (Smith and Reynolds, 2005; blue), GISS (Hansen et al., 2001; red) and Lugina et al. (2005; green).*

- **Global mean surface temperature has risen ~ 1 degree C over the last 100 years**
- **How much is left to come?**
  - depends on continued forcing
  - we can predict (based on trends)
  - always some uncertainty

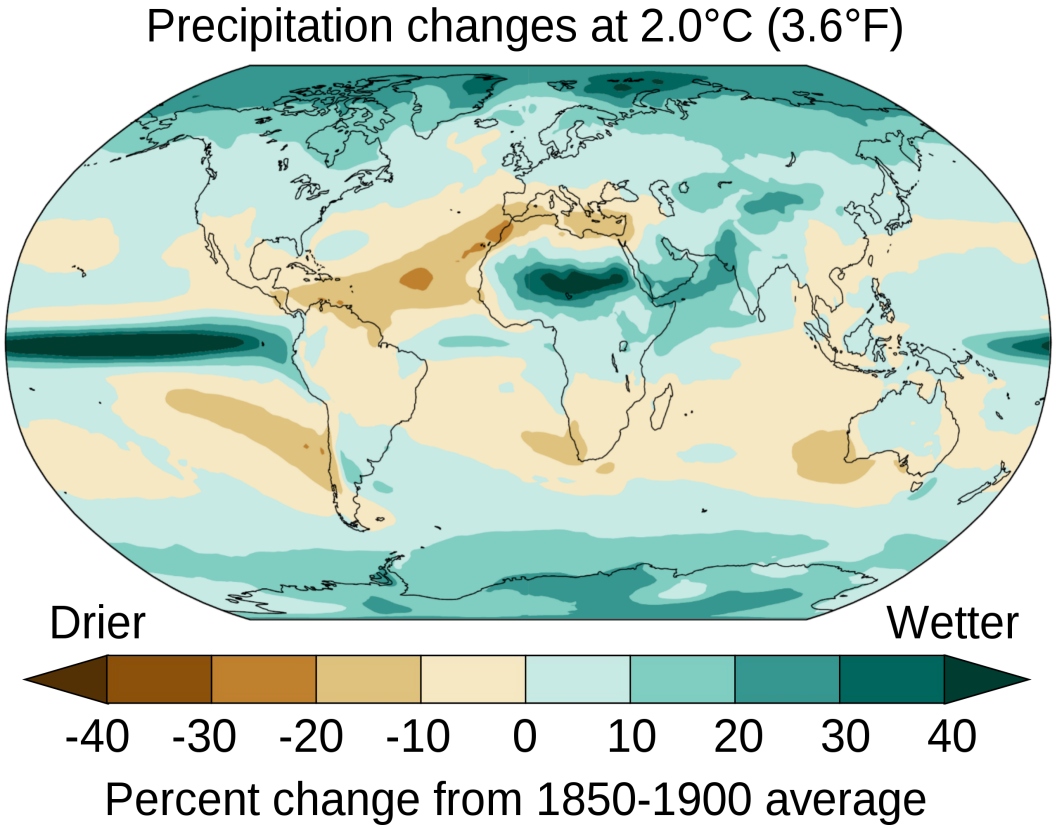
Future climate change is inevitable

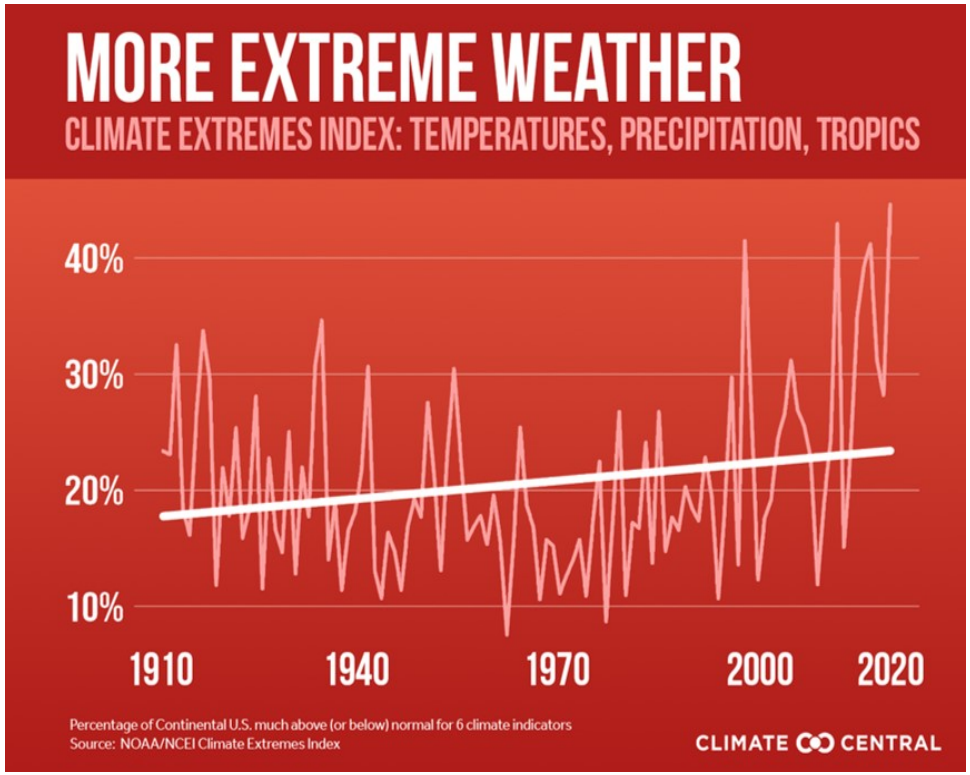


- **Global mean surface temperature has risen ~ 1 degree C over the last 100 years**

- **How much is left to come?**
  - depends on continued forcing
  - we can predict (based on trends)
  - always some uncertainty

Temperature is just one part of Earth's changing climate system





Next up: Exam Time