The Calculus of Climate Change

with Peter Prengaman, AP Climate and Environmental news director, and
with Mark Neikirk, executive director, Scripps Howard Center for Civic Engagement

MAT128, Spring, 2023

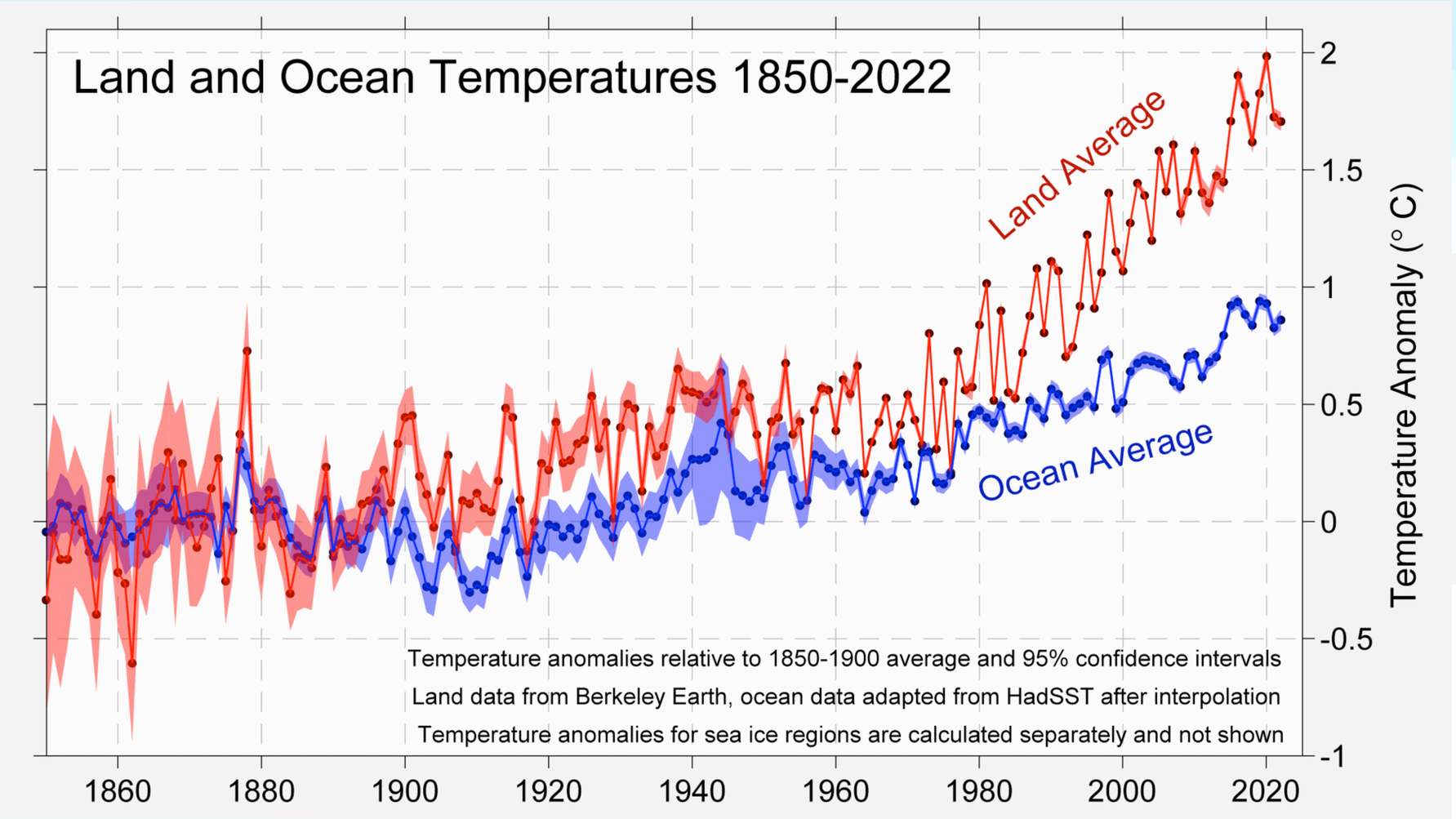
Calculus is about change….

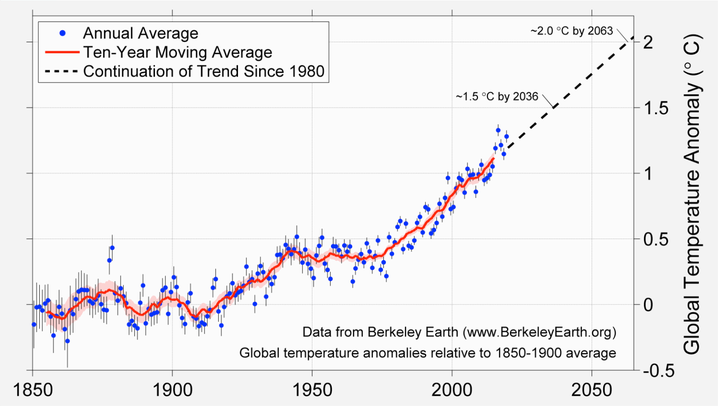
and especially about quantifying/modeling rates of change.

- Climate **change**: if the climate were static, well, Peter here would be looking for a different job; and I could be studying other things. (How I wish it were so.)
  - Is climate changing? (Yes) If so, how fast, and what are the implications?
  - Is the change itself changing (i.e. accelerating)?
  - Ideally climate would **stop changing** -- stabilize -- and then return to the climate of the Holocene, which is (well, perhaps "was") the stable geological epoch and period of climate during which human civilizations evolved.
- Some say that we've entered a new epoch, which many have taken to calling the "*Anthropocene*".

Climate Change is much more than warming

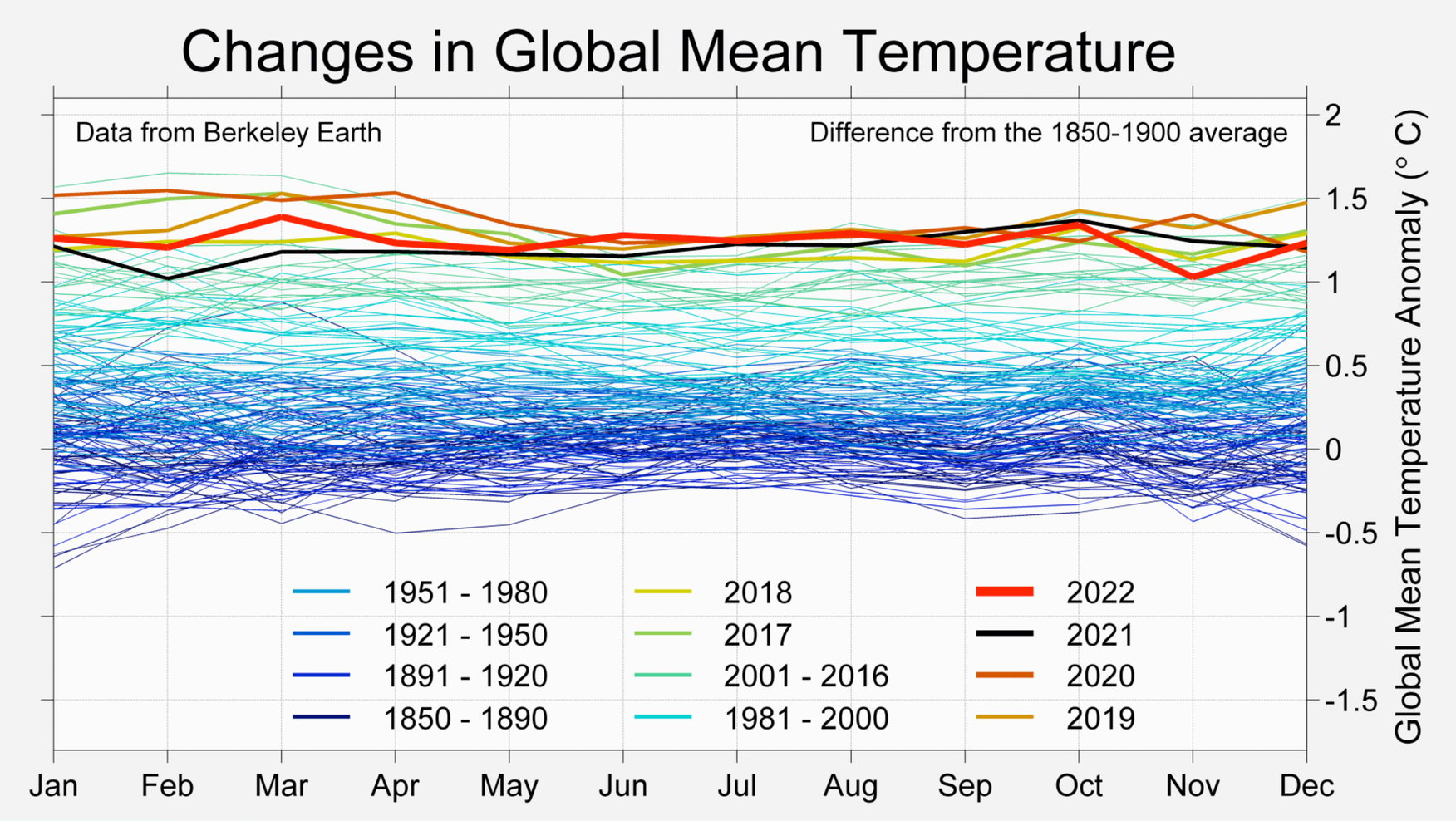
but the Earth is warming, nonetheless:





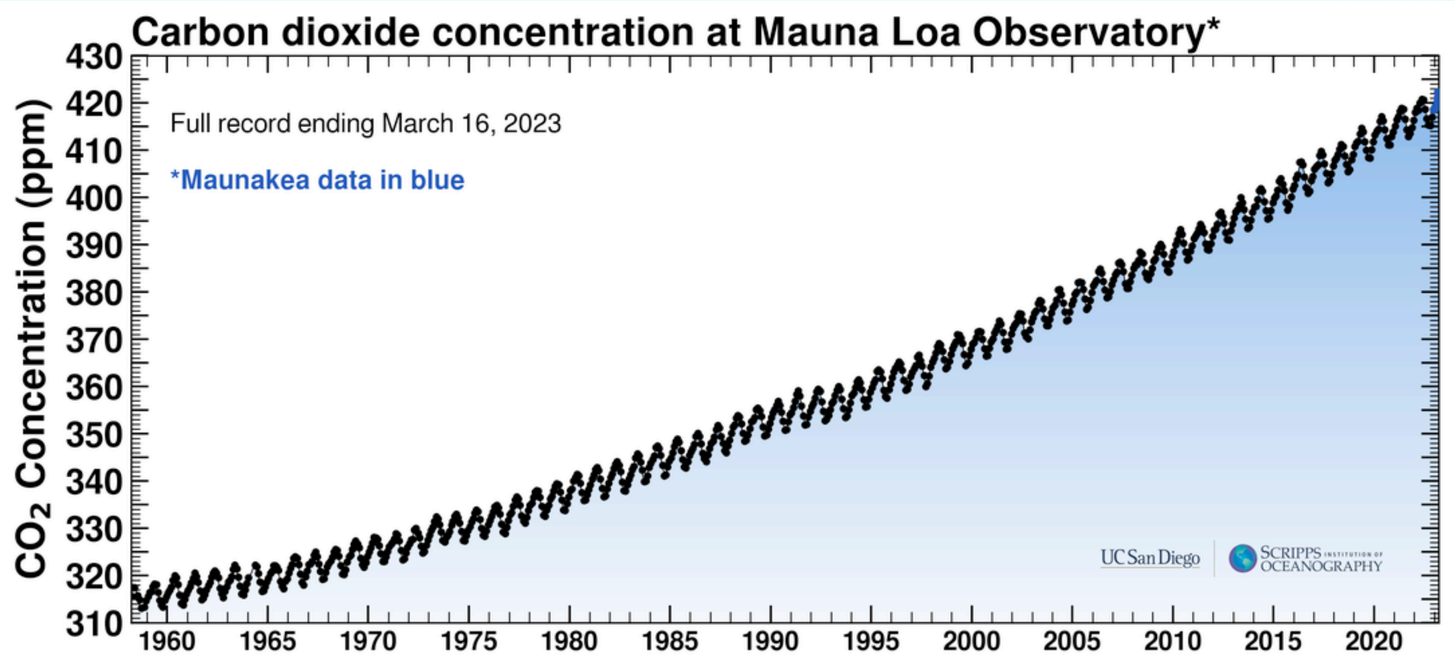
Yes folks, the Earth is warming

Here's another way to look at it; seasonally, across the year:



Why is the Earth warming?

(Charles Keeling, Eunice Foote, and John Tyndall explain)

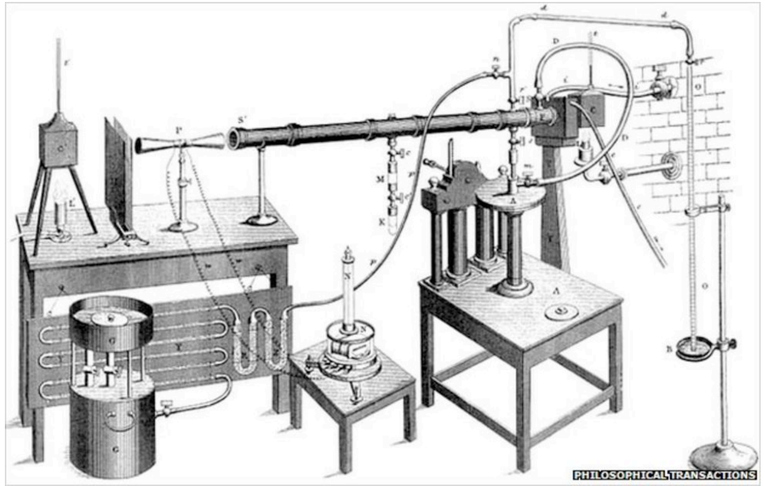


Thirdly. The highest effect of the sun's rays I have found to be in carbonic acid gas.

One of the receivers was filled with it, the other with common air, and the result was as follows:

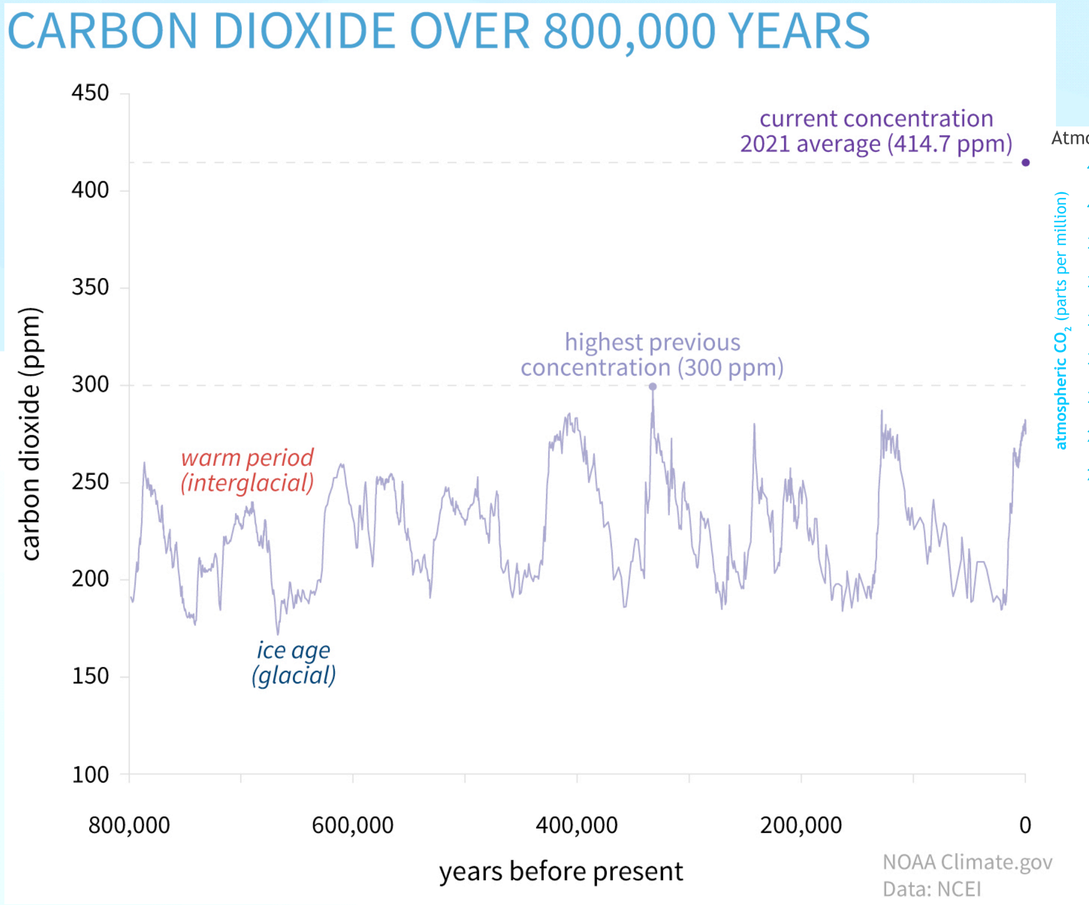
In Common Air.		In Carbonic Acid Gas.	
In shade.	In sun.	In shade.	In sun.
80	90	80	90
81	94	84	100
80	99	84	110
81	100	85	120

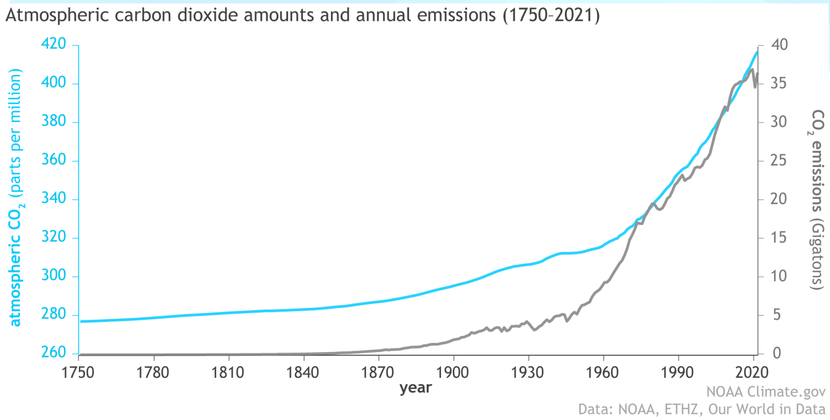
The receiver containing the gas became itself much heated—very sensibly more so than the other—and on being removed, it was many times as long in cooling.



Why is the Earth warming?

Fossil-fuels: fossil carbon spewing into the atmosphere



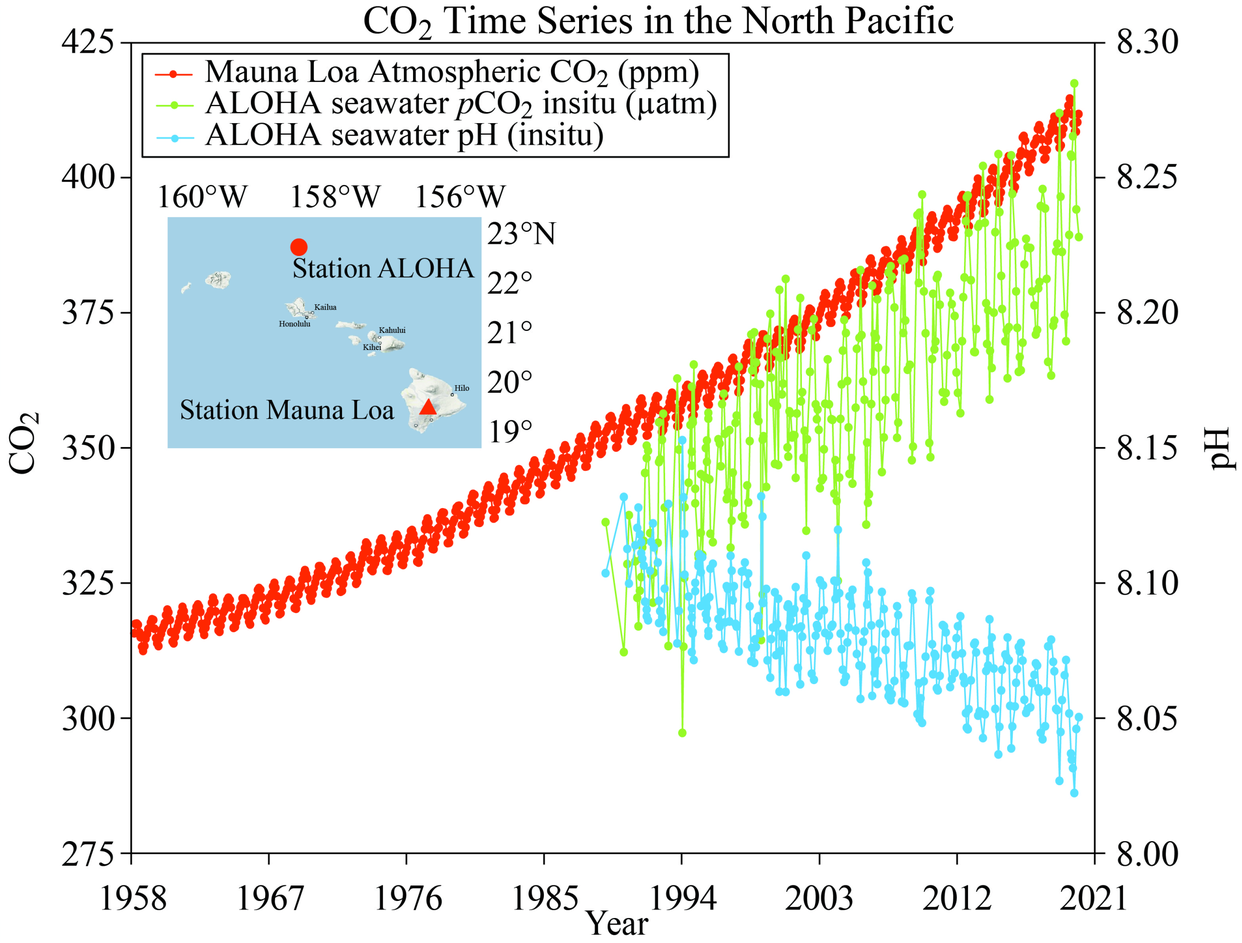


An atmosphere of that gas would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion than at present, an increased temperature from its own action as well as from increased weight must have necessarily resulted.

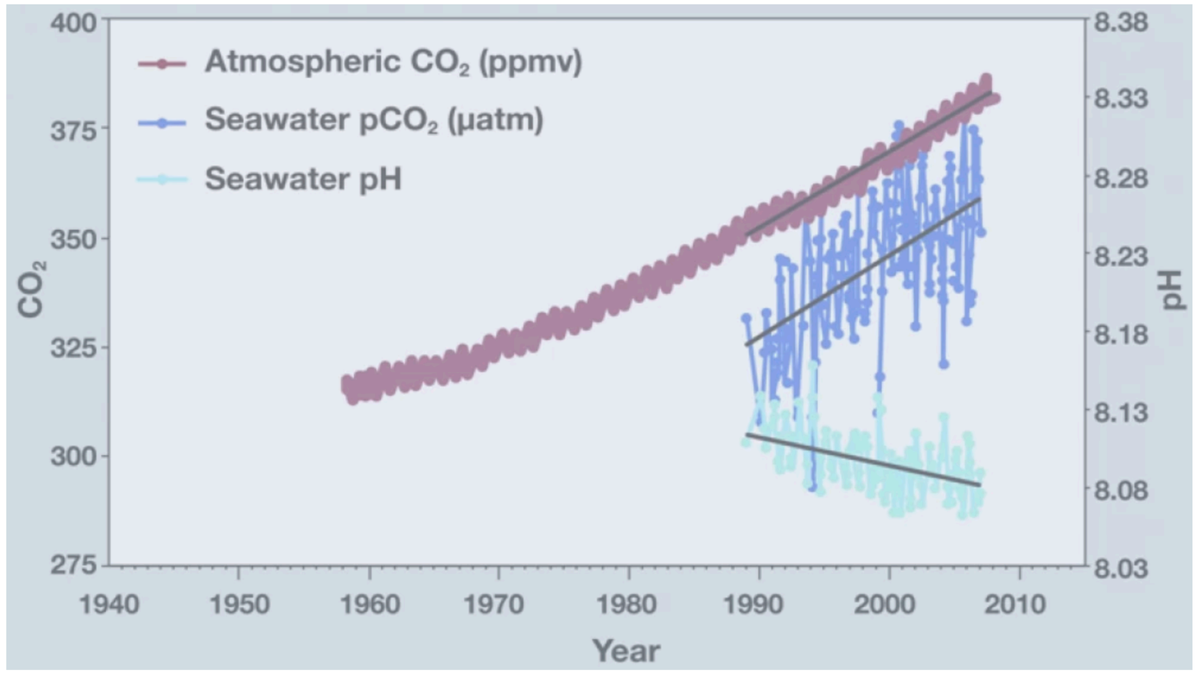
Eunice Foote (1856)

Climate Change is also Ocean Acidification

(The oceans absorb about 30% of yearly CO2 emissions)



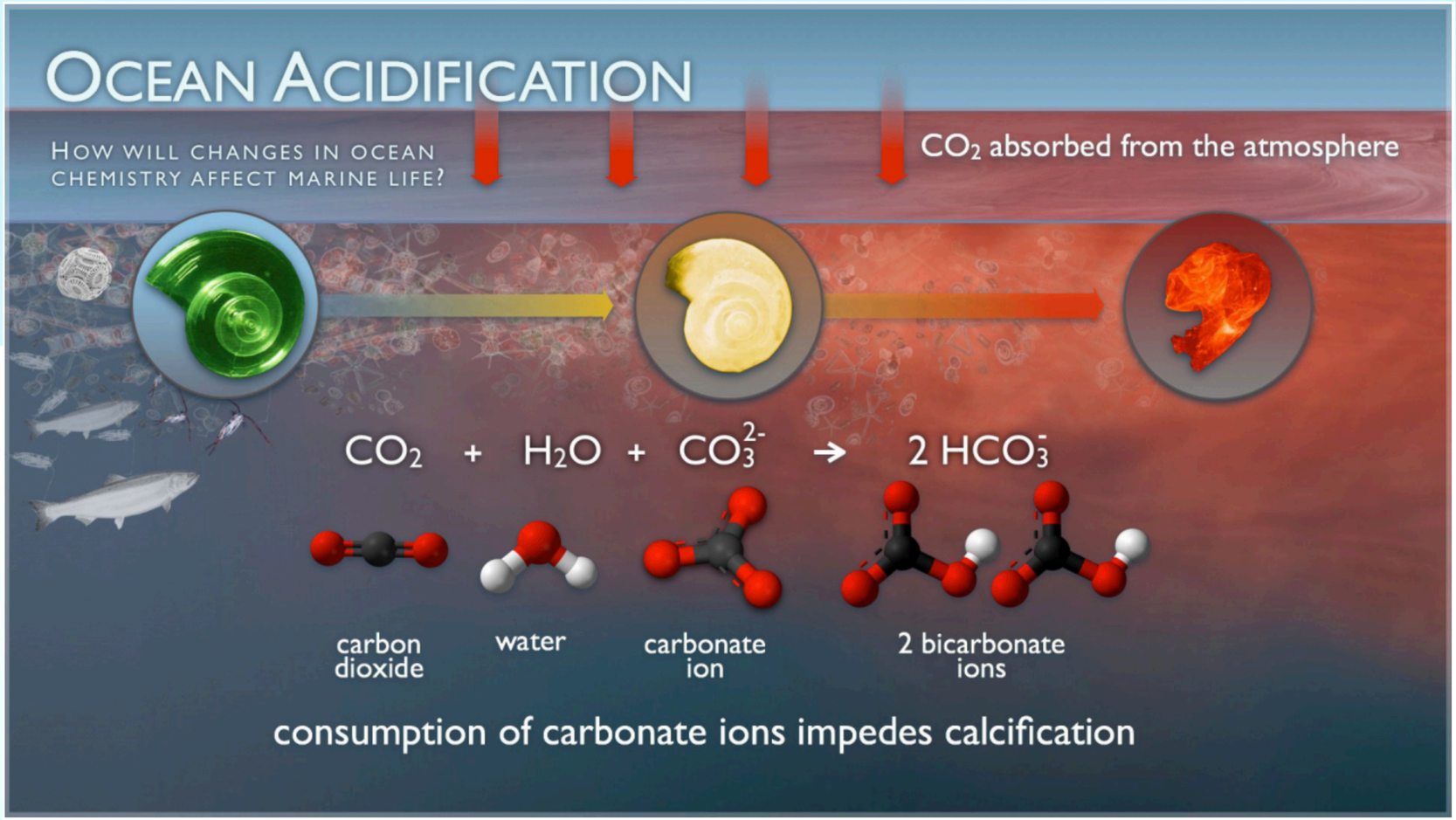
Data: Mauna Loa (ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt) ALOHA (http://hahana.soest.hawaii.edu/hot/hot-dogs/bextraction.html)
ALOHA pH & pCO_2 are calculated at in-situ temperature from DIC & TA (measured from samples collected on Hawaii Ocean Times-series (HOT) cruises) using co2sys (Pelletier, v25b06) with constants: Lueker et al. 2000, KSO4: Dickson, Total boron: Lee et al. 2010, & KF: seacarb



NOAA PMEL Carbon Program (Link)

Climate Change is also Ocean Acidification,

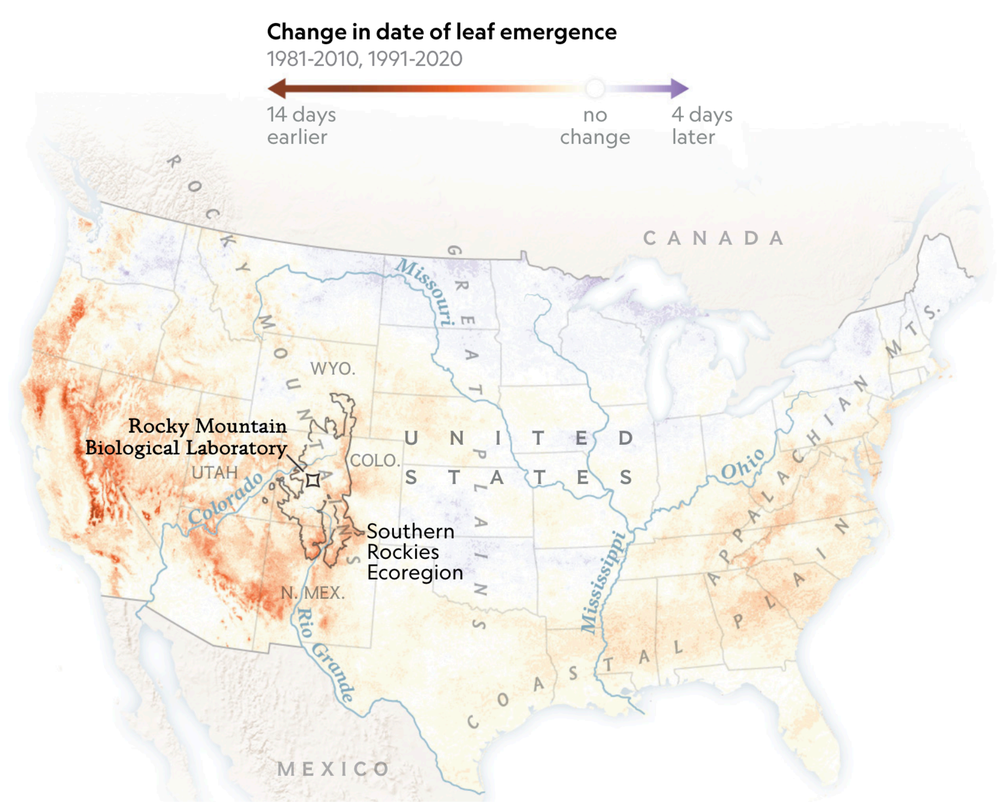
ocean warming, and sea level rise. Some of the consequences:



A pteropod shell is shown dissolving over time in seawater with a lower pH. When carbon dioxide is absorbed by the ocean from the atmosphere, the chemistry of the seawater is changed. (Image credit: NOAA)

Climate Change is also Phenological Change

This from the National Geographic (March, 2023):

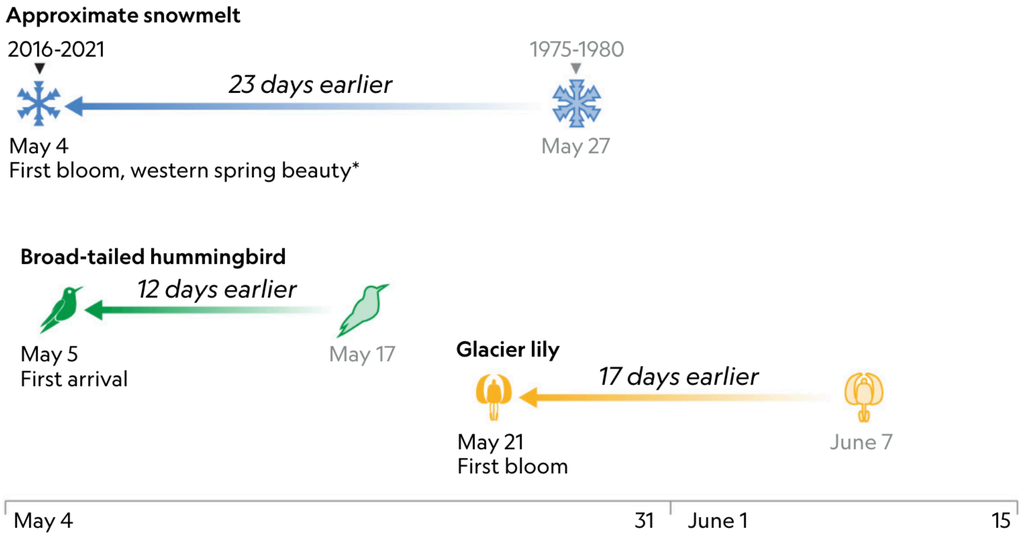


Change of pace

Across much of the United States rising average temperatures are pushing spring to speed up its arrival. Plants and pollinators found at high elevations in the western U.S. are especially affected. To better understand how species are interacting and responding to these changes, scientists are tracking the timing of biological events—a field known as phenology.

Seasonal shifting

Earlier snowmelt in high-altitude meadows has caused many species to adjust to earlier springs. For 50 years researchers at the Rocky Mountain Biological Laboratory in Gothic, Colorado, have collected data showing that plants such as the glacier lily are flowering sooner, and some of their pollinators, including hummingbirds migrating from Mexico, have sped up their arrival schedules.



*The western spring beauty is used by researchers as a proxy for snowmelt.

Lucas Petrin, NGM Staff. Kelsey Nowakowski.
Sources: Brian D. Inouye, Florida State University; Billy Barr; Rocky Mountain Biological Laboratory

Climate change coverage

And the latest, breaking news from the AP

- How do/should we communicate climate change? (Words, visuals, music, protests, ….)
- How has climate change **coverage** changed? And what is the latest?
  - Have we simply moved from denial to delay?
  - Are we going to see dramatic changes in the rates of change (in at least some of these impacts)? Tipping points?
  - Will we be able to bend the climate curves back to the Holocene? If so, how? What are some of the exciting prospects?
  - What is the future of agriculture, green energy, water supply, …?
- Let’s get the discussion going!