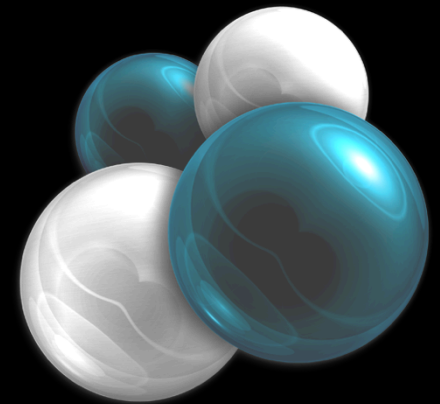
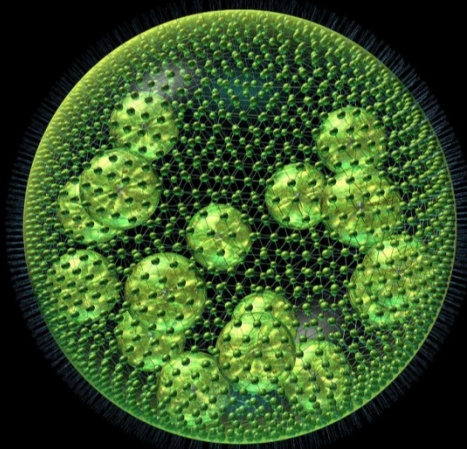
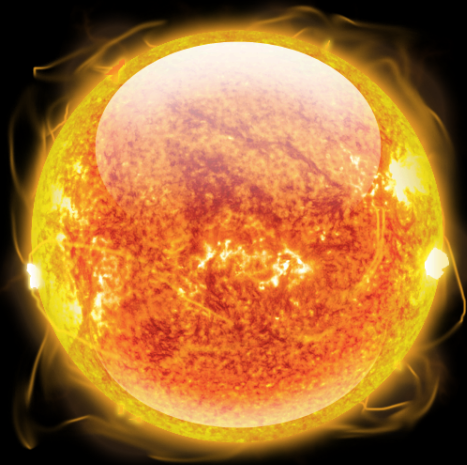


Global change and the Earth System: Exploring causes, consequences, and solutions



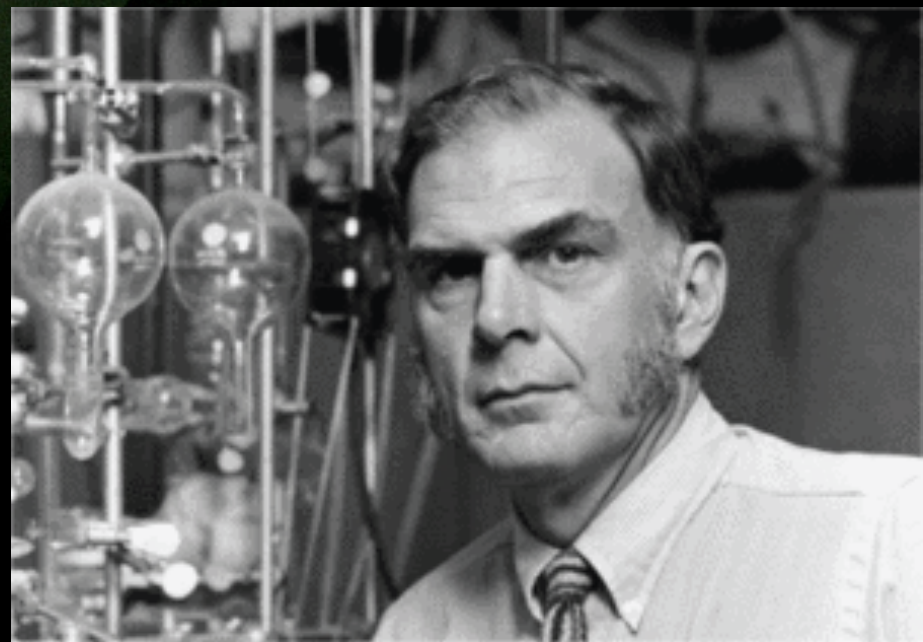
Katherine RM Mackey

Department of Earth System Science
University of California, Irvine

Norman Rostoker Memorial Symposium
25 August 2015



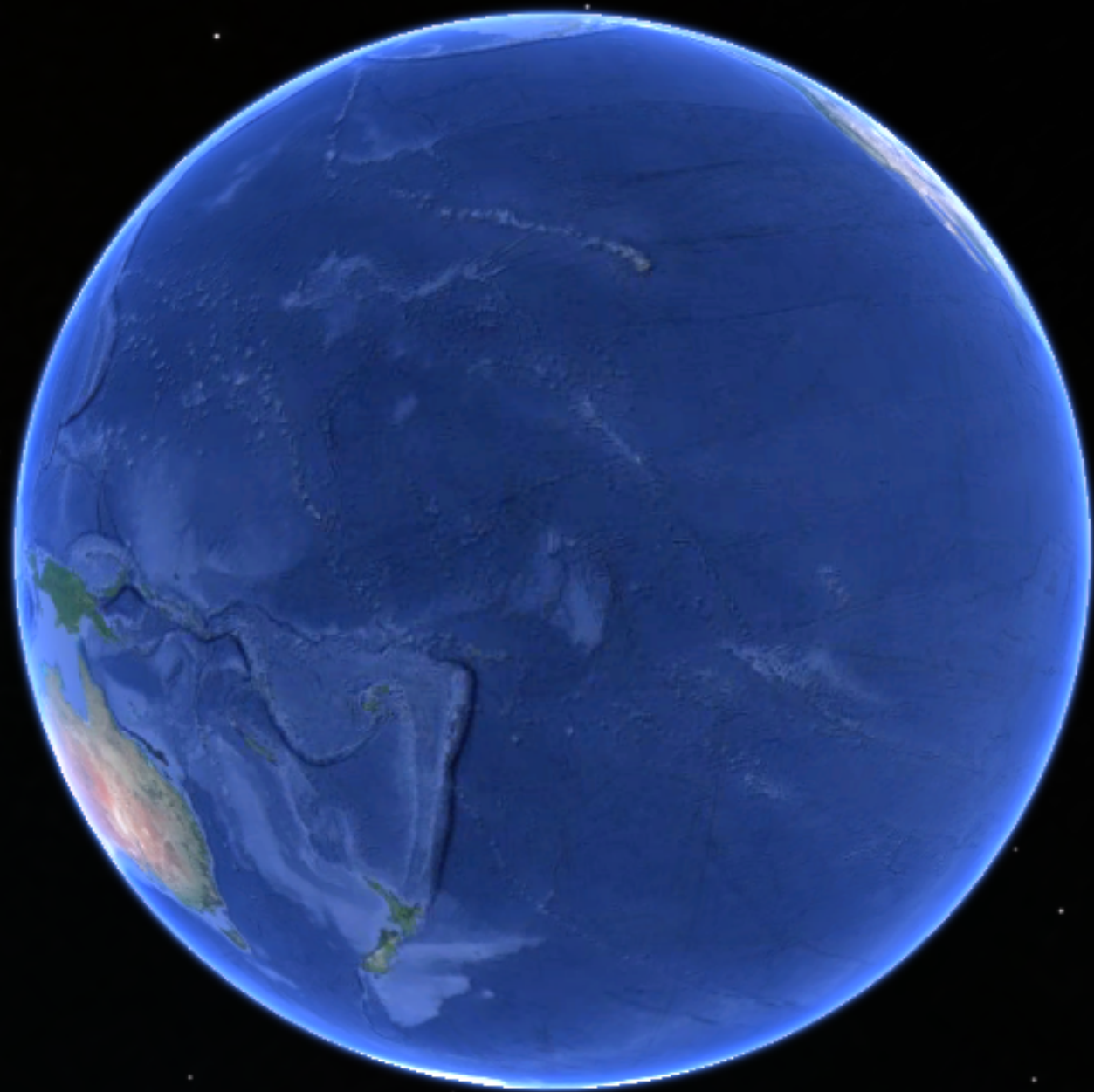
569177493



Earth System Science, UCI

To contribute to a fundamental scientific understanding of the Earth as a coupled system, to train the next generation of Earth scientists, and to inform and educate policy makers and the public-at-large.



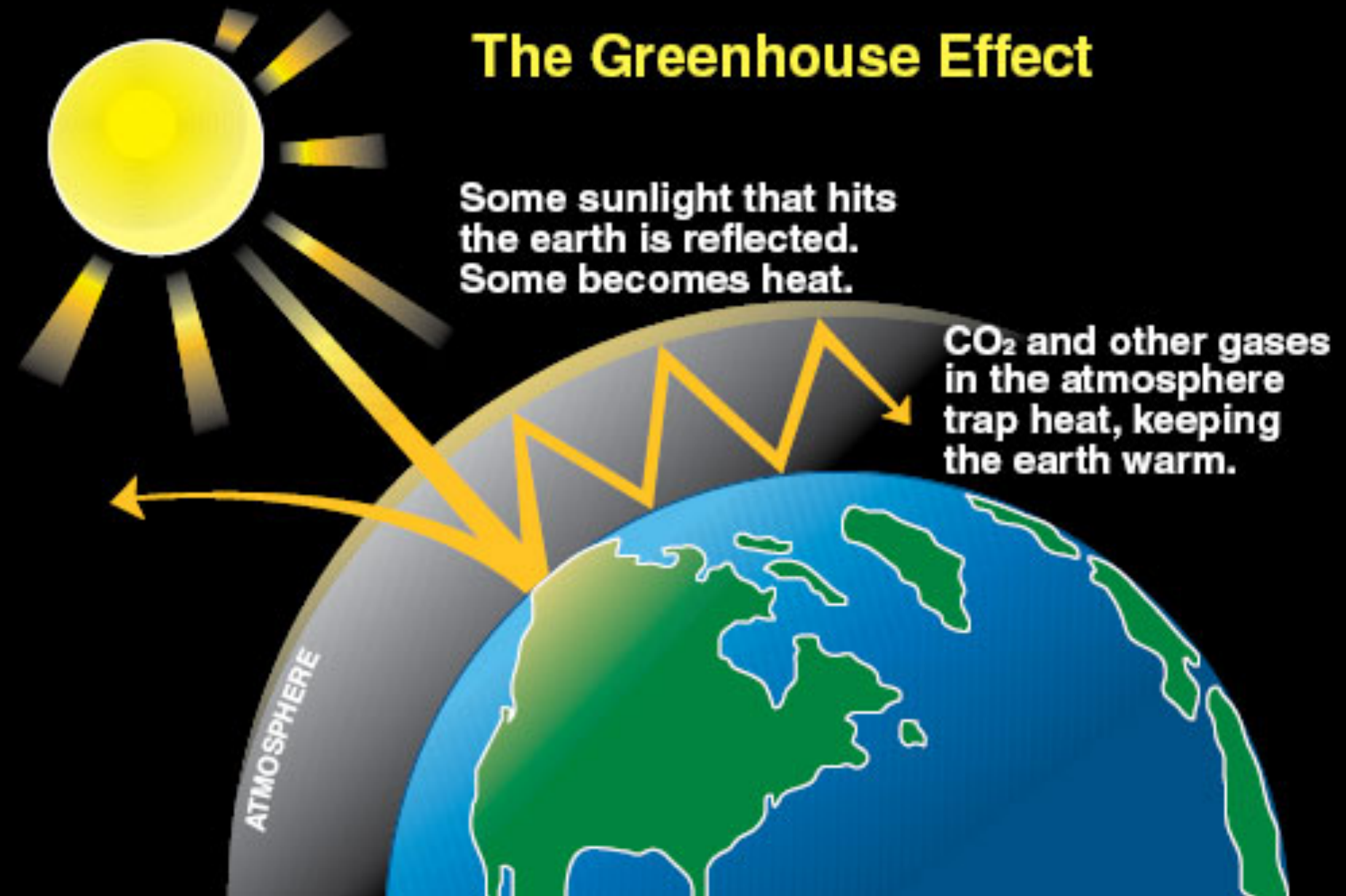


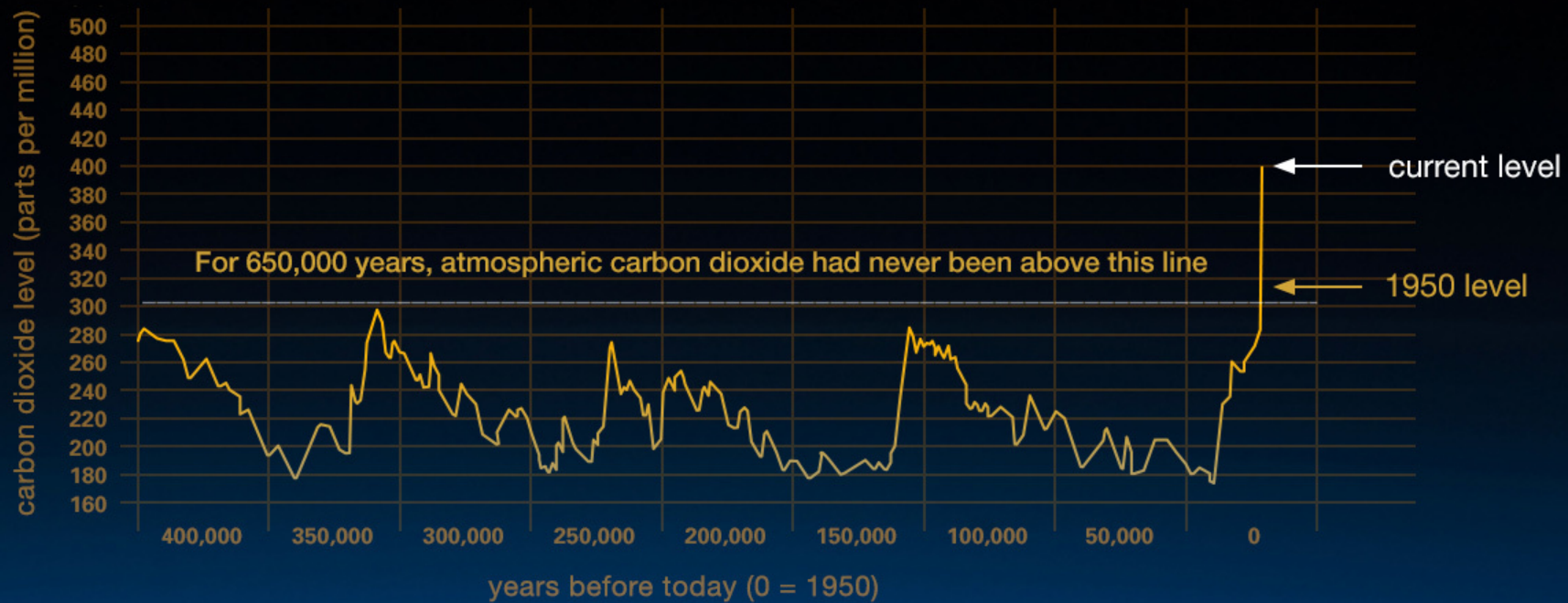
The Greenhouse Effect

Some sunlight that hits the earth is reflected. Some becomes heat.

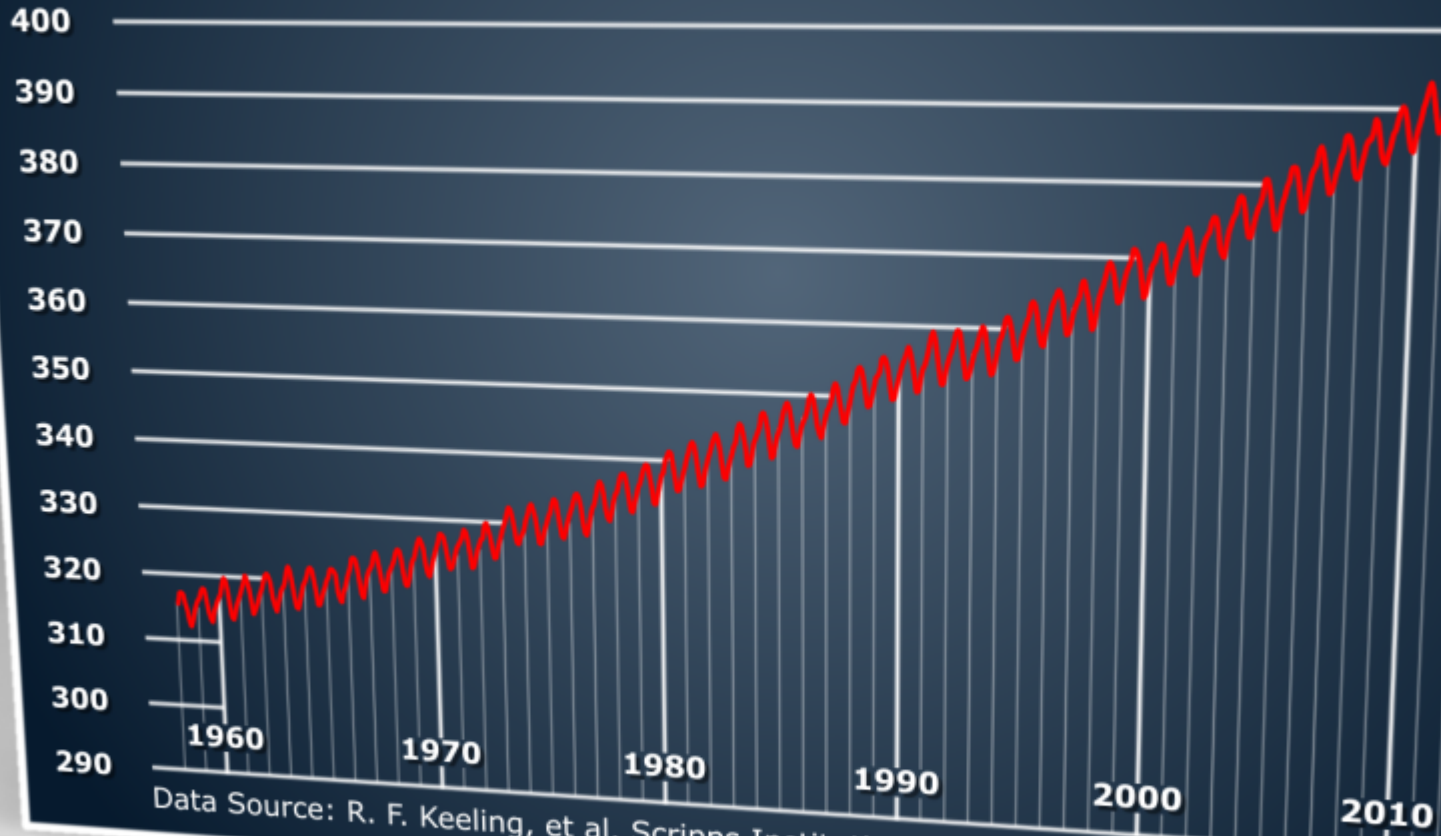
CO₂ and other gases in the atmosphere trap heat, keeping the earth warm.

ATMOSPHERE

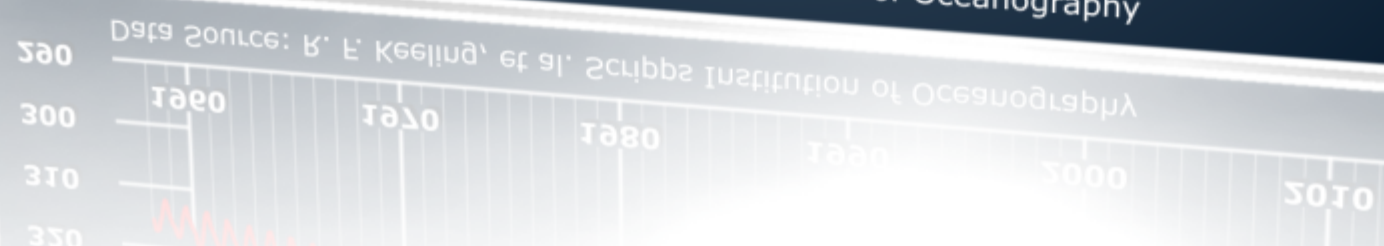




Atmospheric CO₂ (ppm)



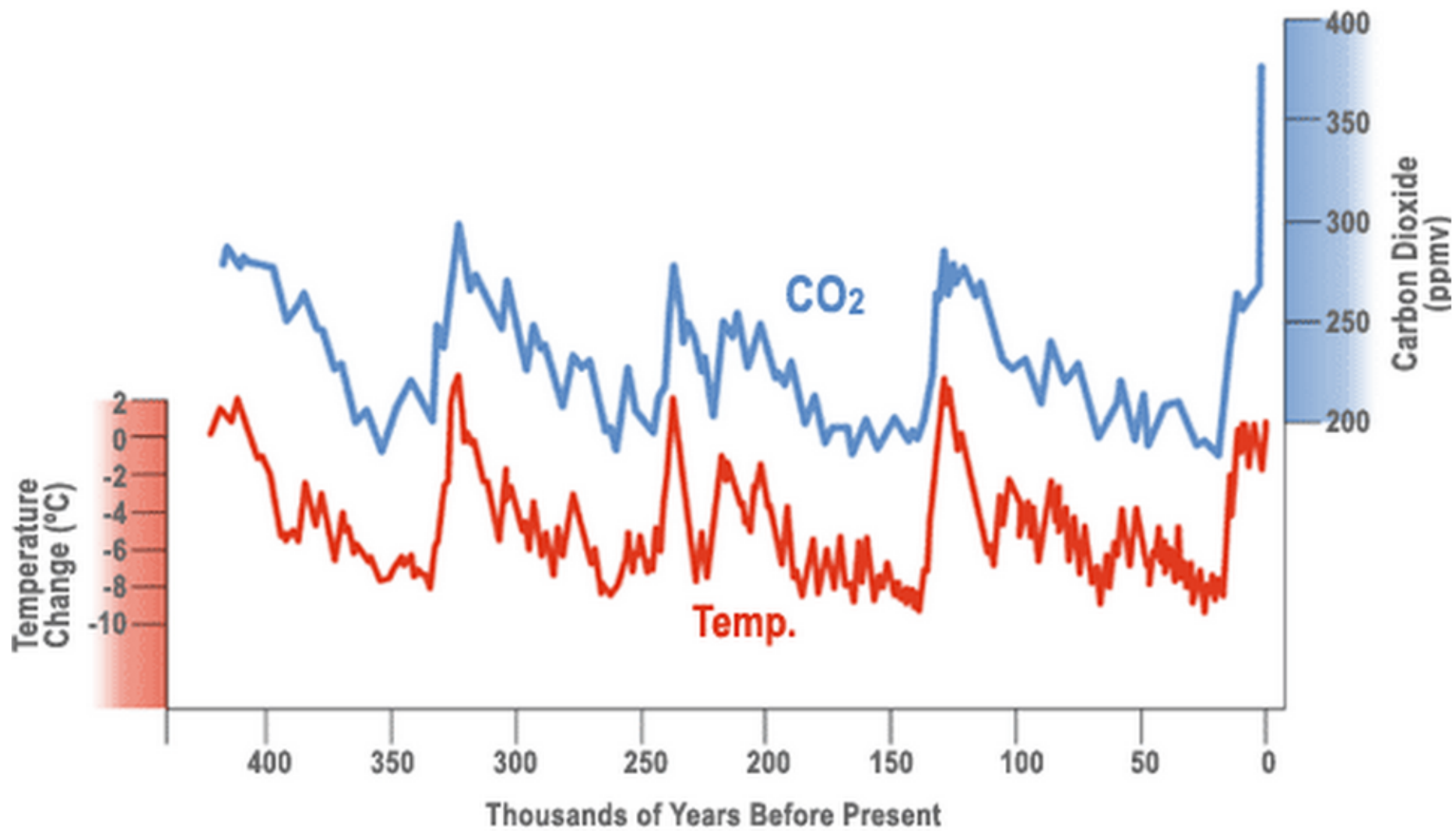
Data Source: R. F. Keeling, et al. Scripps Institution of Oceanography

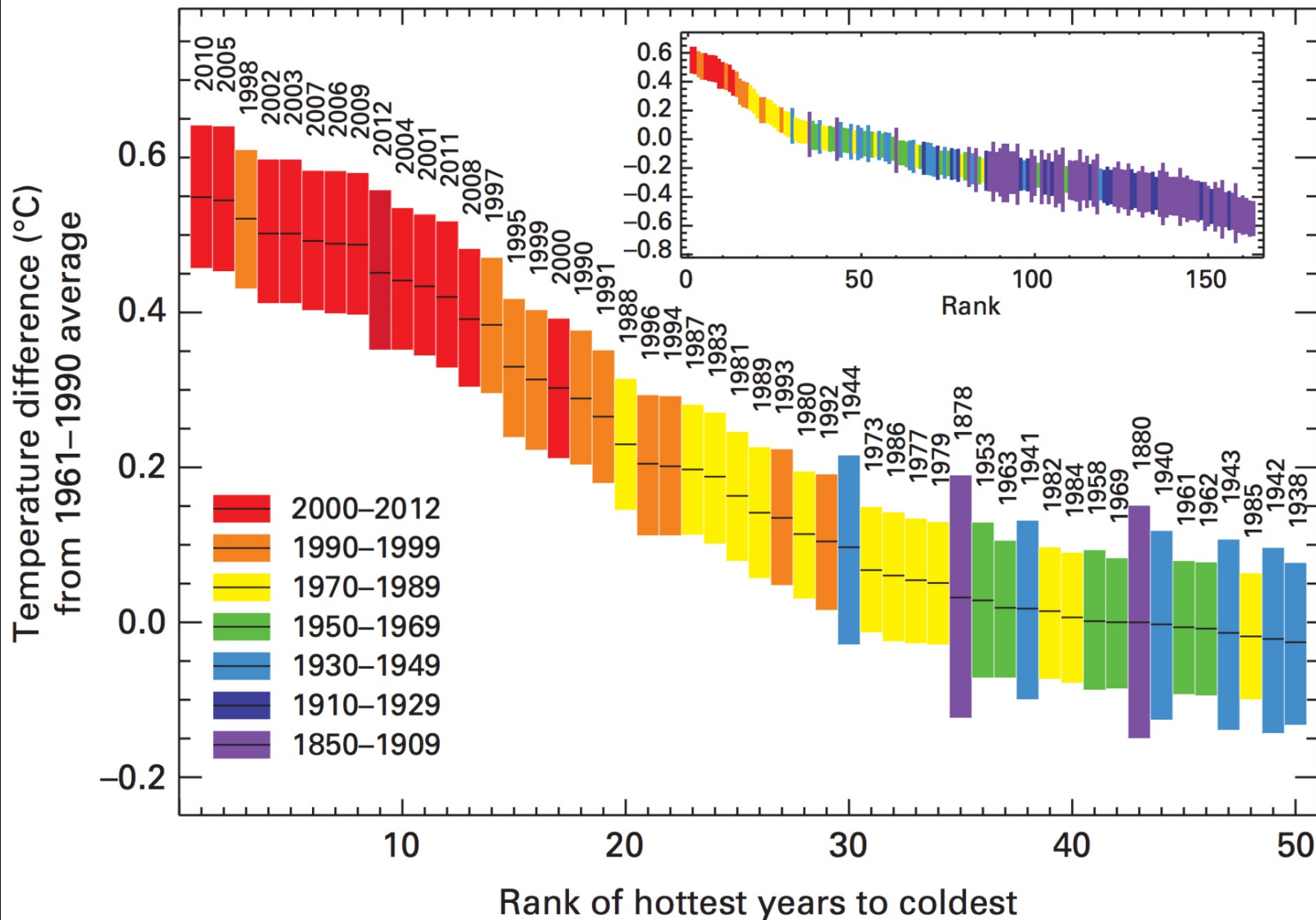


“Business as usual” scenario

750 ppm









↑ Troposphere air T

↓ Glaciers

↑ Air T over oceans

↓ Snow cover

↑ Tree line shifts up and north

↑ Humidity

↑ Sea level

↓ Earlier spring

↓ Ice sheets

↓ Sea ice

↑ Animals move up and north

↑ Sea surface T



The Island Nation of Tuvalu

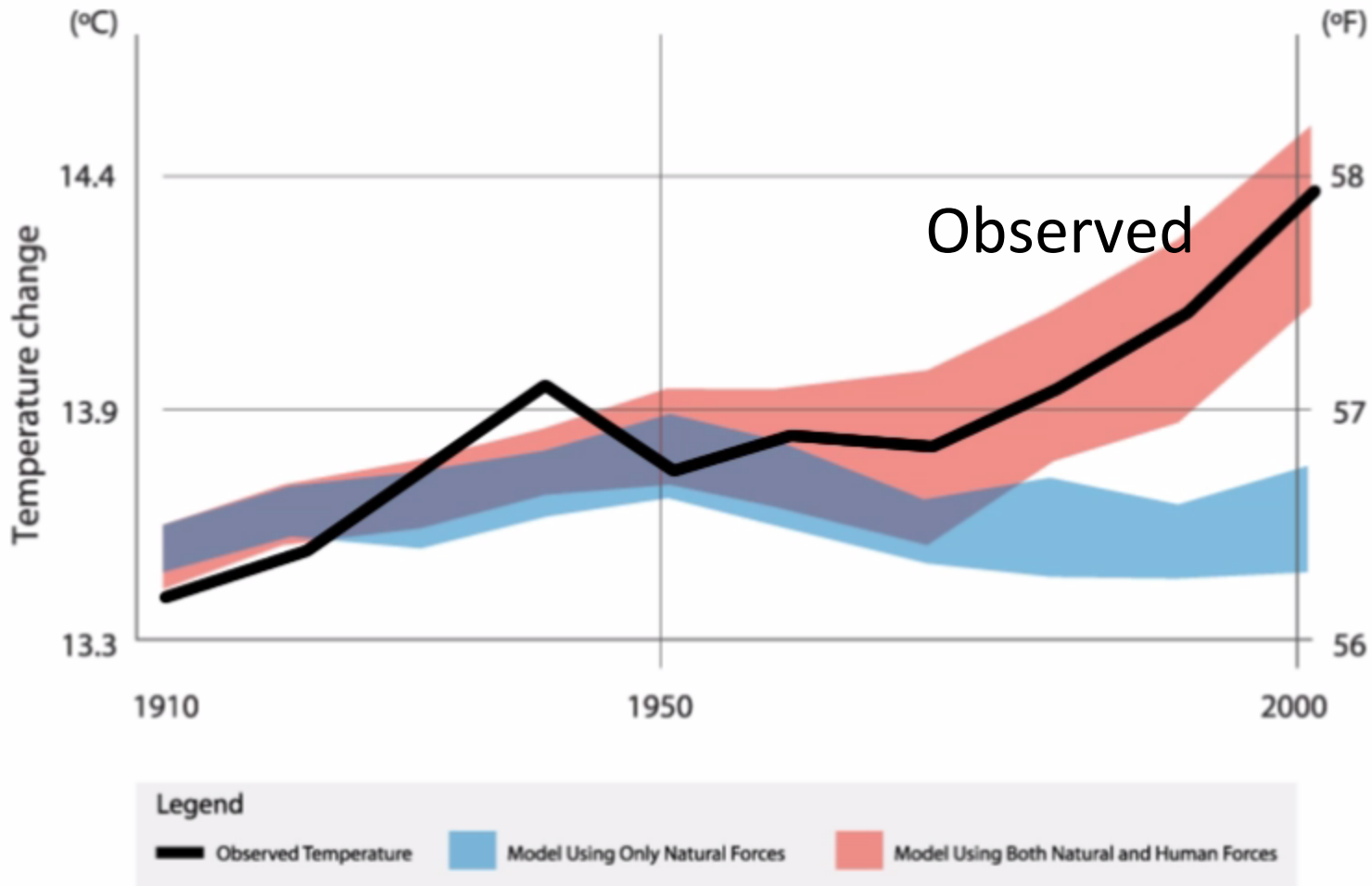


“The Weather on Steroids”





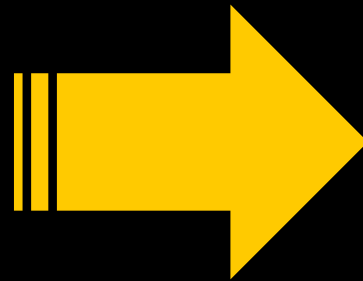
How do we know it's us?



With
human
input

No
human
input





CO_2
 CO_2 CO_2
 CO_2 CO_2 CO_2
 CO_2 CO_2
 CO_2 CO_2

Ocean acidification & Global warming

CO₂

CO₂

CO₂

CO₂

CO₂

CO₂

CO₂

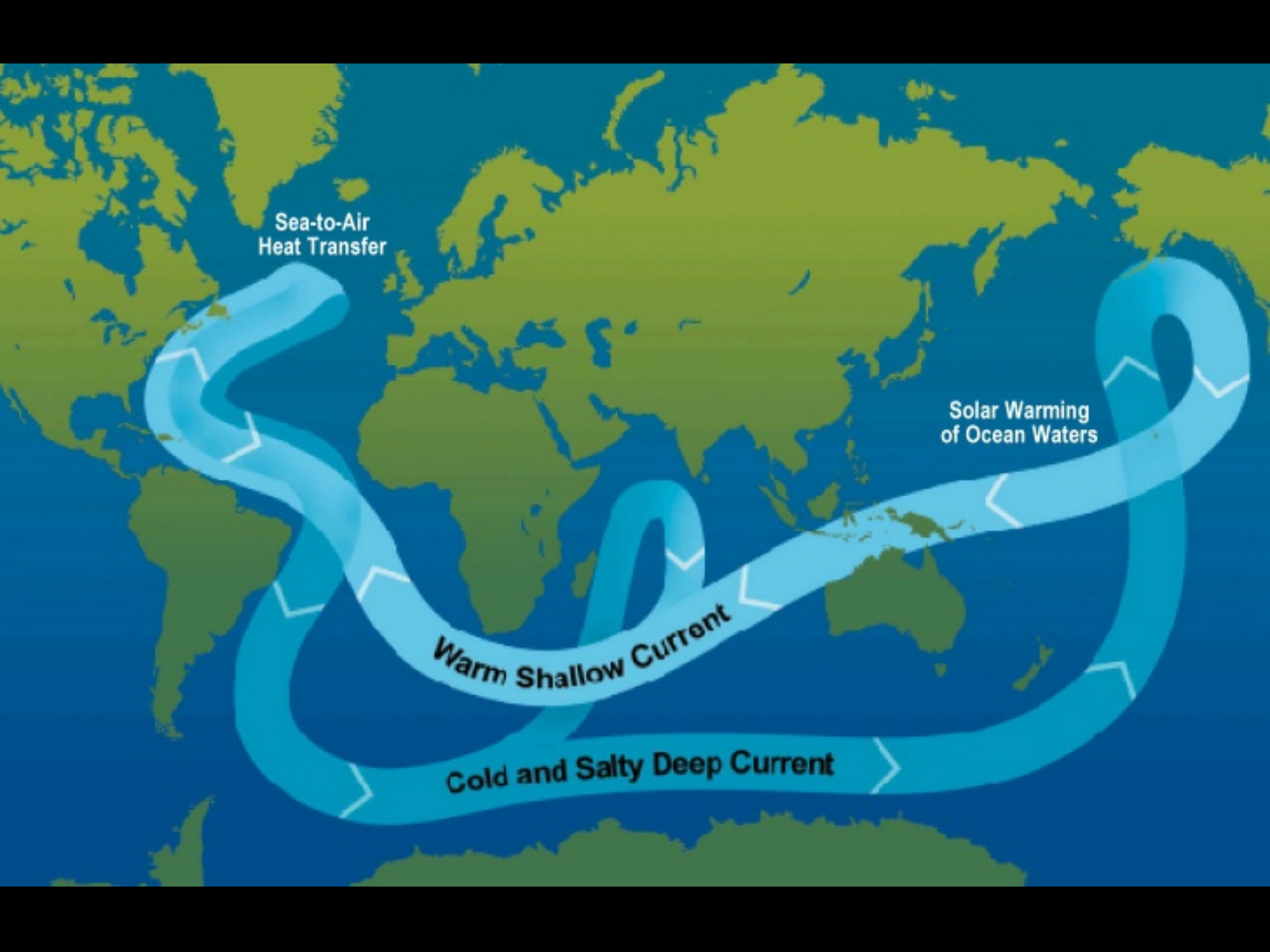
CO₂

CO₂

CO₂



CO₂

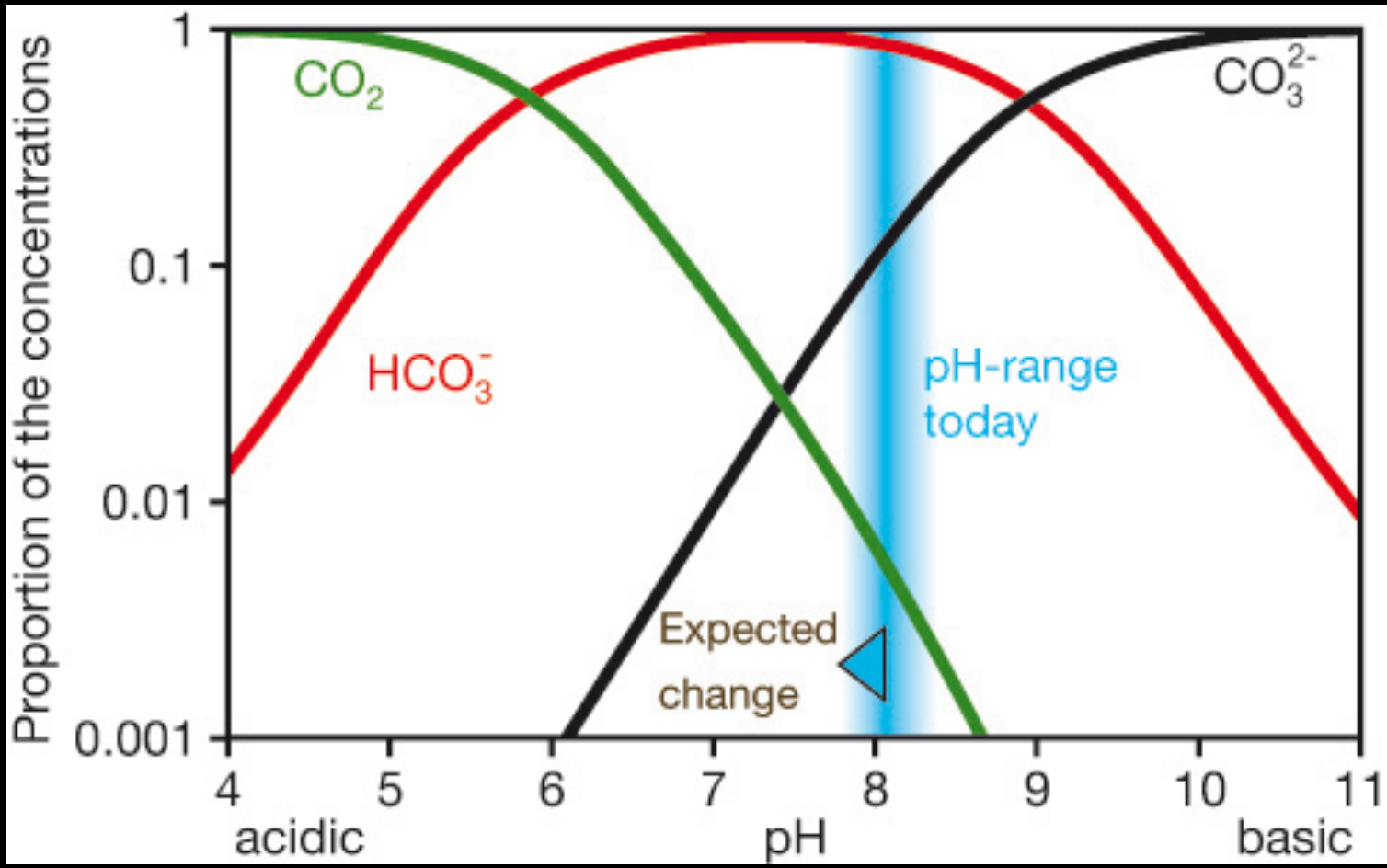
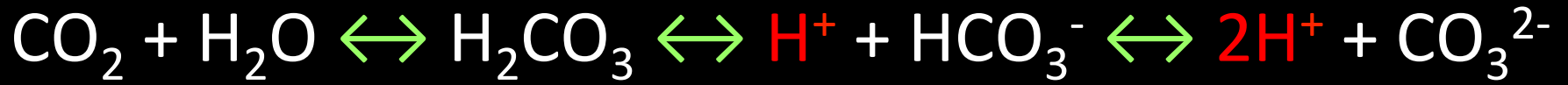


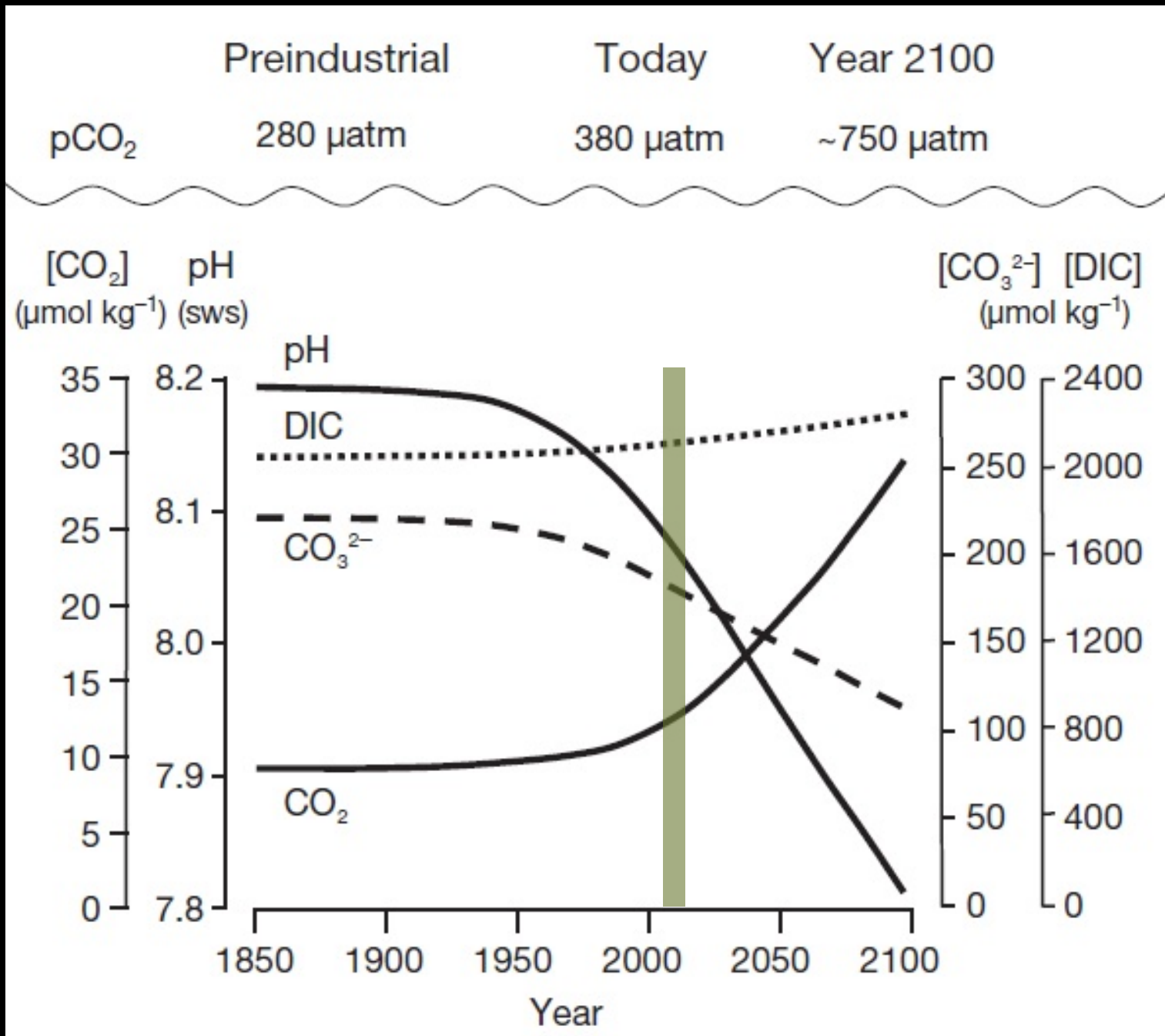
Sea-to-Air
Heat Transfer

Solar Warming
of Ocean Waters

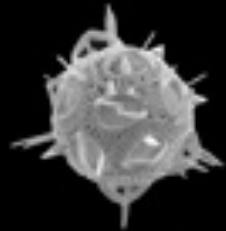
Warm Shallow Current

Cold and Salty Deep Current





Coccolithophores



Gephyrocapsa protohuxleyi (3 variants)



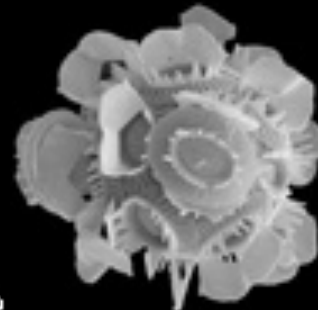
G. ericsonii



E. huxleyi type A



Reticulofenestra parvula



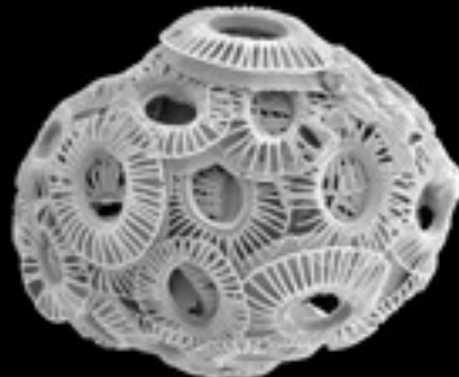
G. ornata



G. muelleriae



E. huxleyi type C



E. huxleyi type B

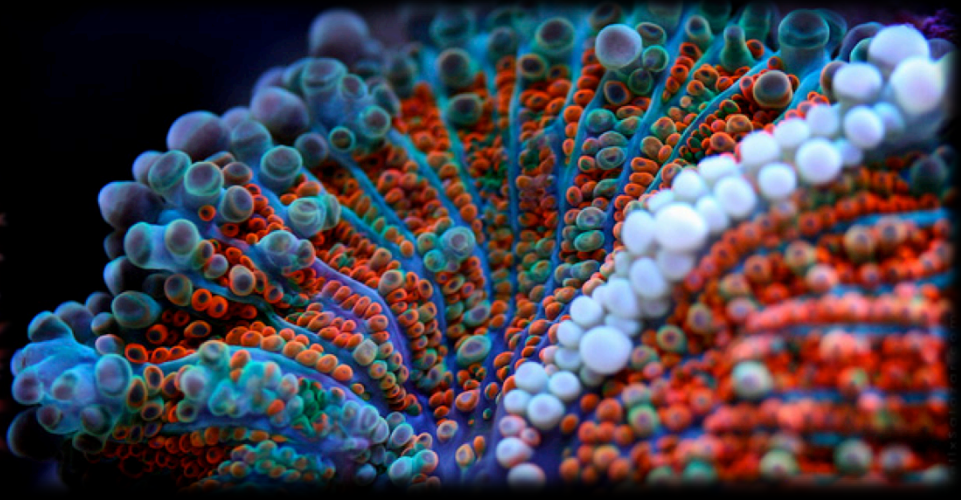
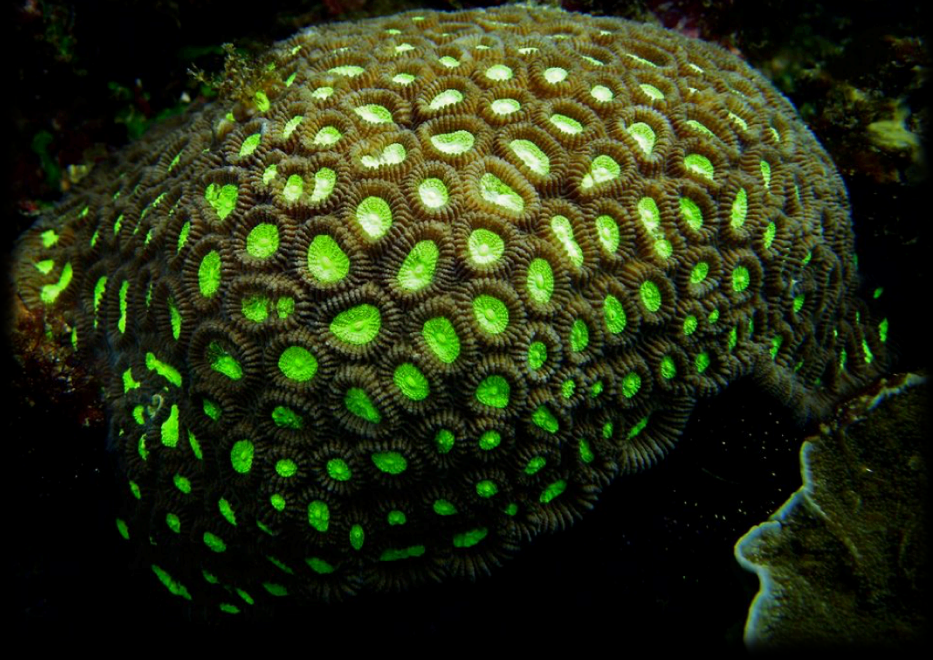


G. oceanica



2 μ m

Coral

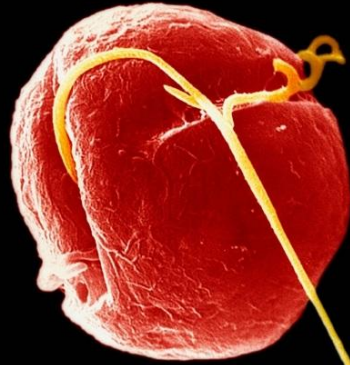


Shellfish Hatcheries

- \$111 million industry in
- 1000s of jobs in OR & WA
- On the verge of collapse in the early 2000s due to acidification
- Early warning system from federal and state investments







9 million jobs
57 million tonnes
of food

Is there hope?





USA



Energy efficiency
in California

Iceland



Geothermal
power

Spain



Renewables

France



Low carbon

Germany



Passivhaus

China



Solar

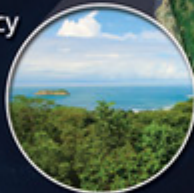
In a few short
years China
has become
the world's
leading solar
manufacturer.

India



Soil conservation

Costa Rica

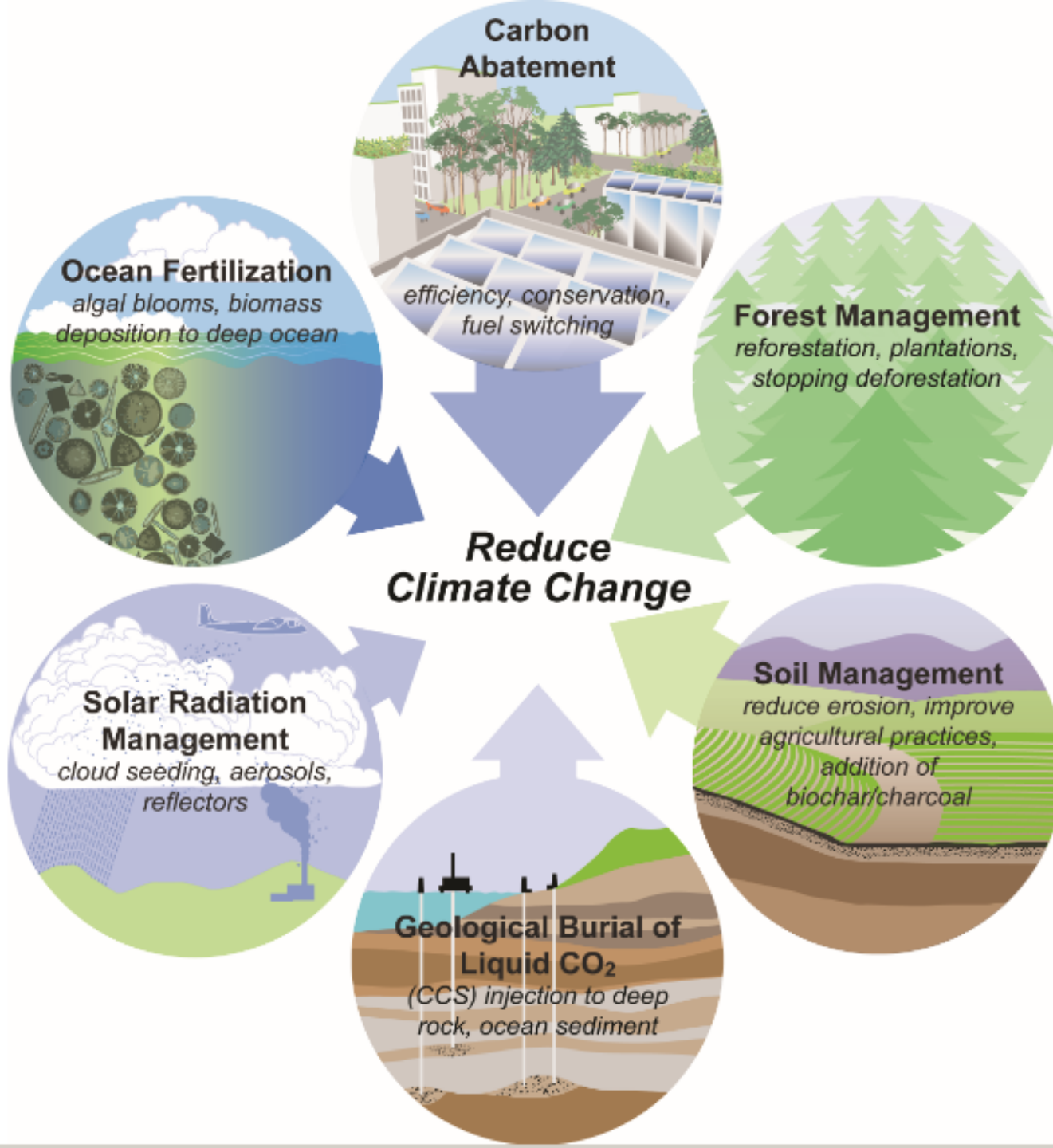


Preservation

Brazil

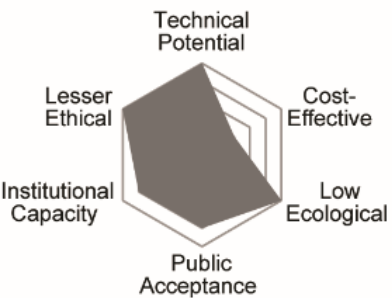


Forest protection

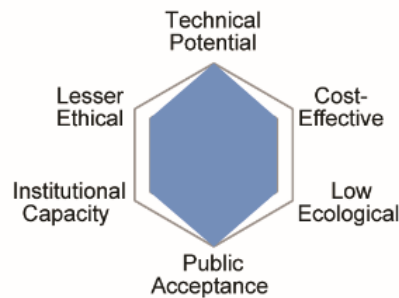


Interdisciplinary Assessment

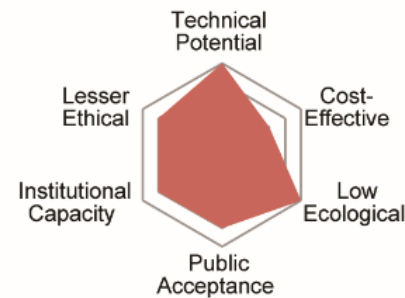
Abatement



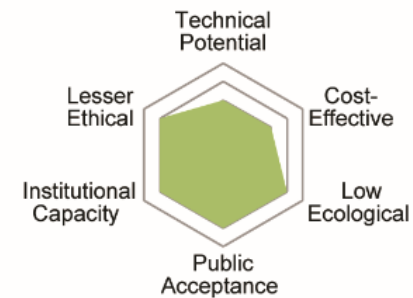
Forest Management



Soil Management



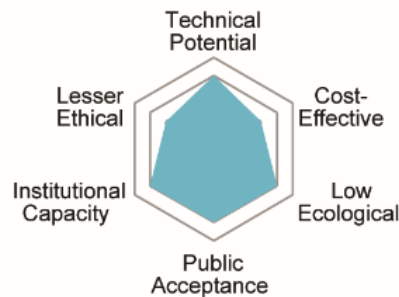
Biochar



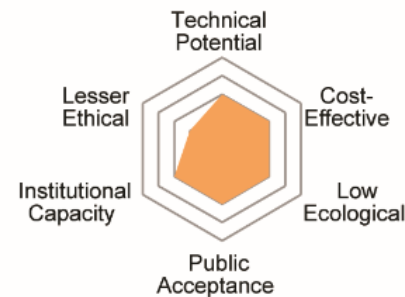
Ocean Iron Fertilization



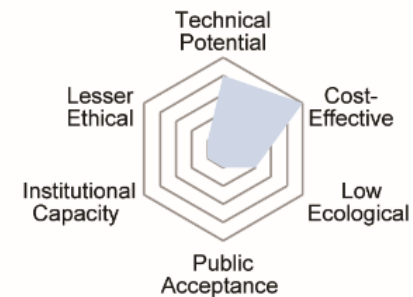
Geological CCS



Ocean CCS



Stratospheric Aerosols



The cover features a bright blue sky with sunbeams and white clouds over a calm blue ocean. The title is in large white letters, and the subtitle is in yellow.

CLIMATE INTERVENTION

Reflecting Sunlight to Cool Earth

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

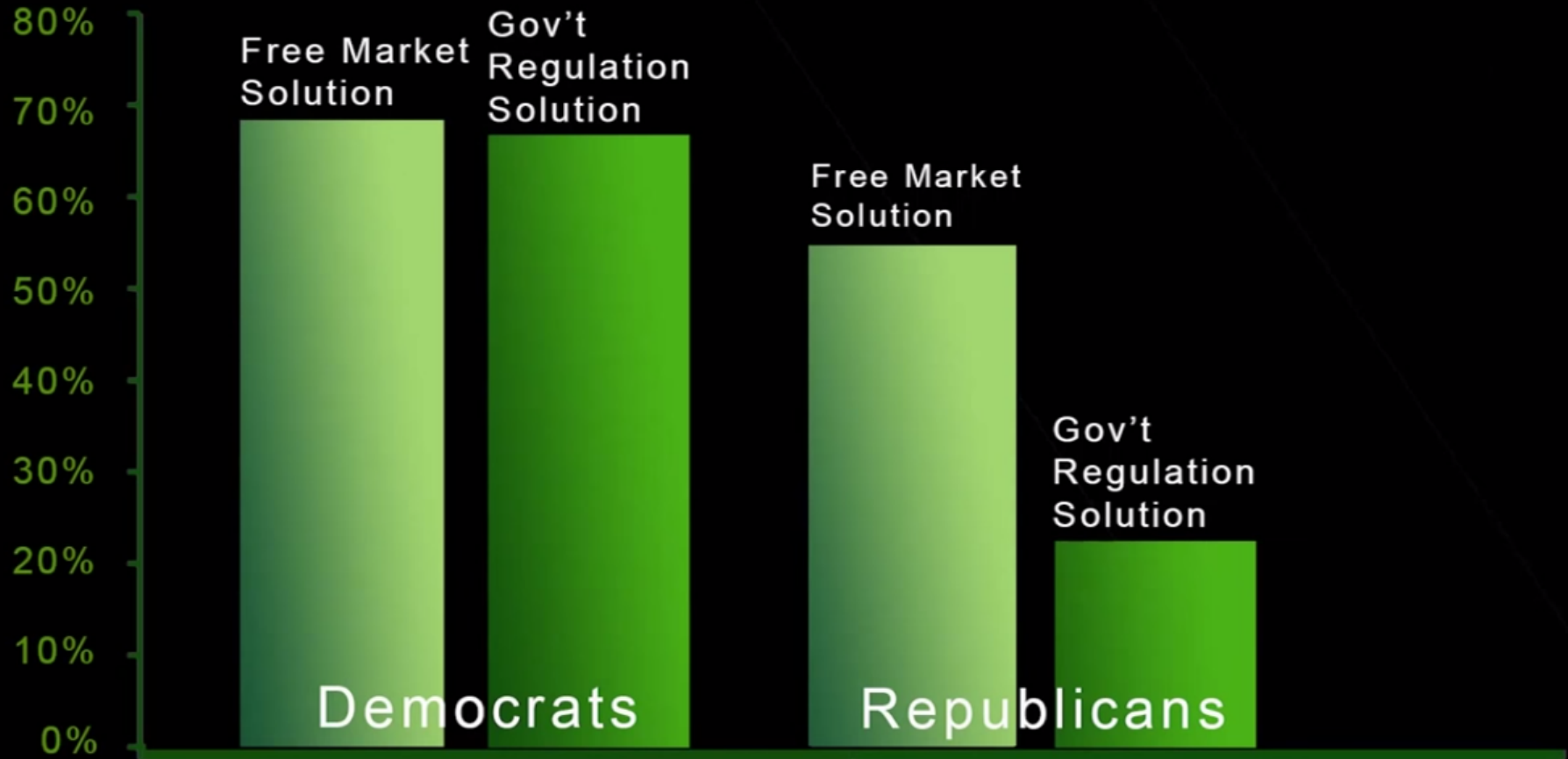
The cover features a green background with leaves at the top, a brown rock formation in the middle, and a blue ocean at the bottom. The title is in large white letters, and the subtitle is in yellow.

CLIMATE INTERVENTION

Carbon Dioxide Removal and
Reliable Sequestration

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Why the debate?



% Agreement with climate change science



It's real.

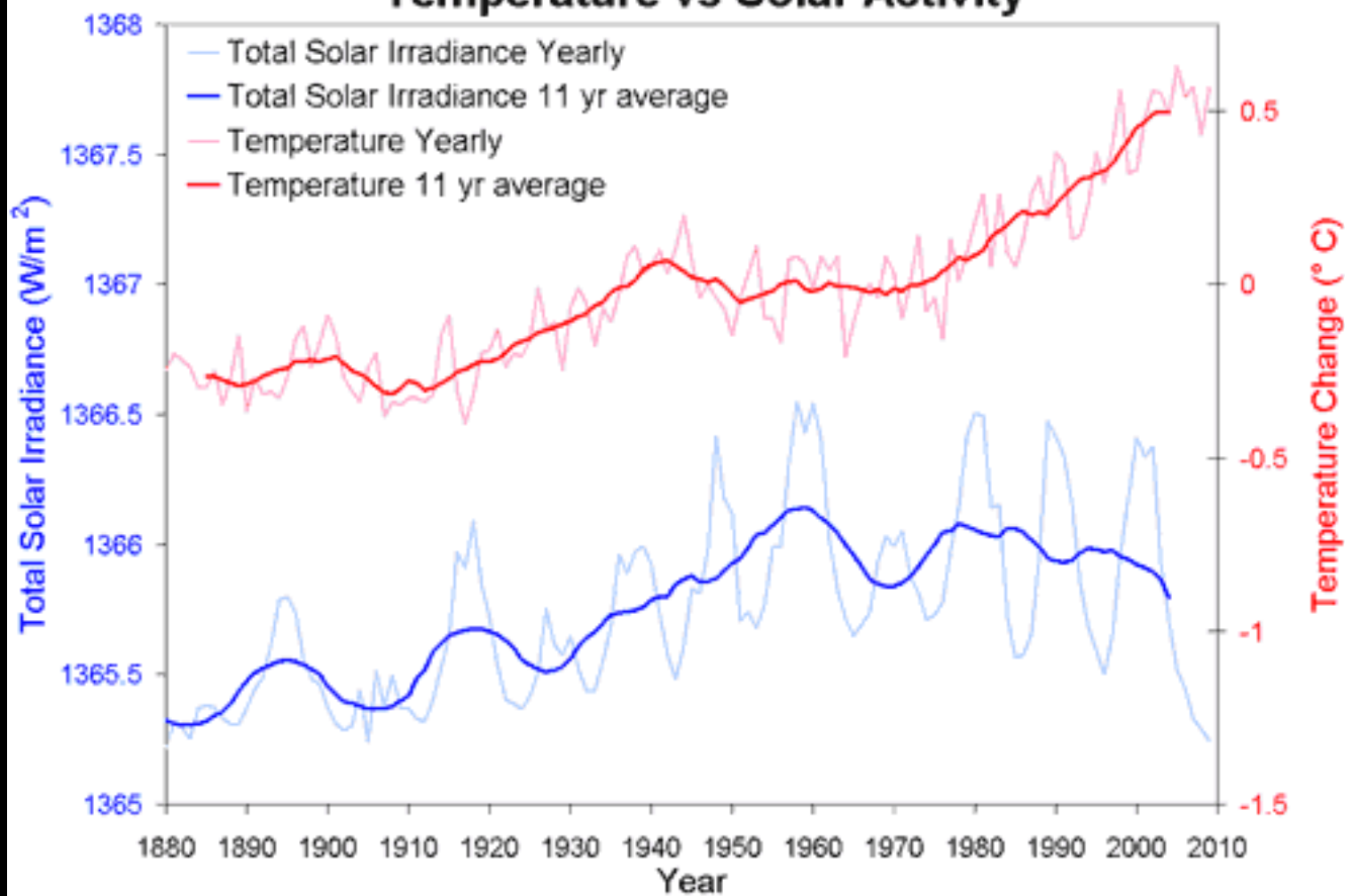
It's us.

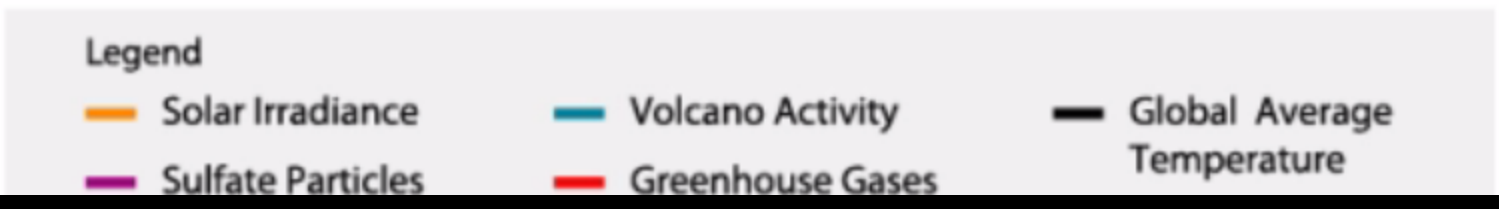
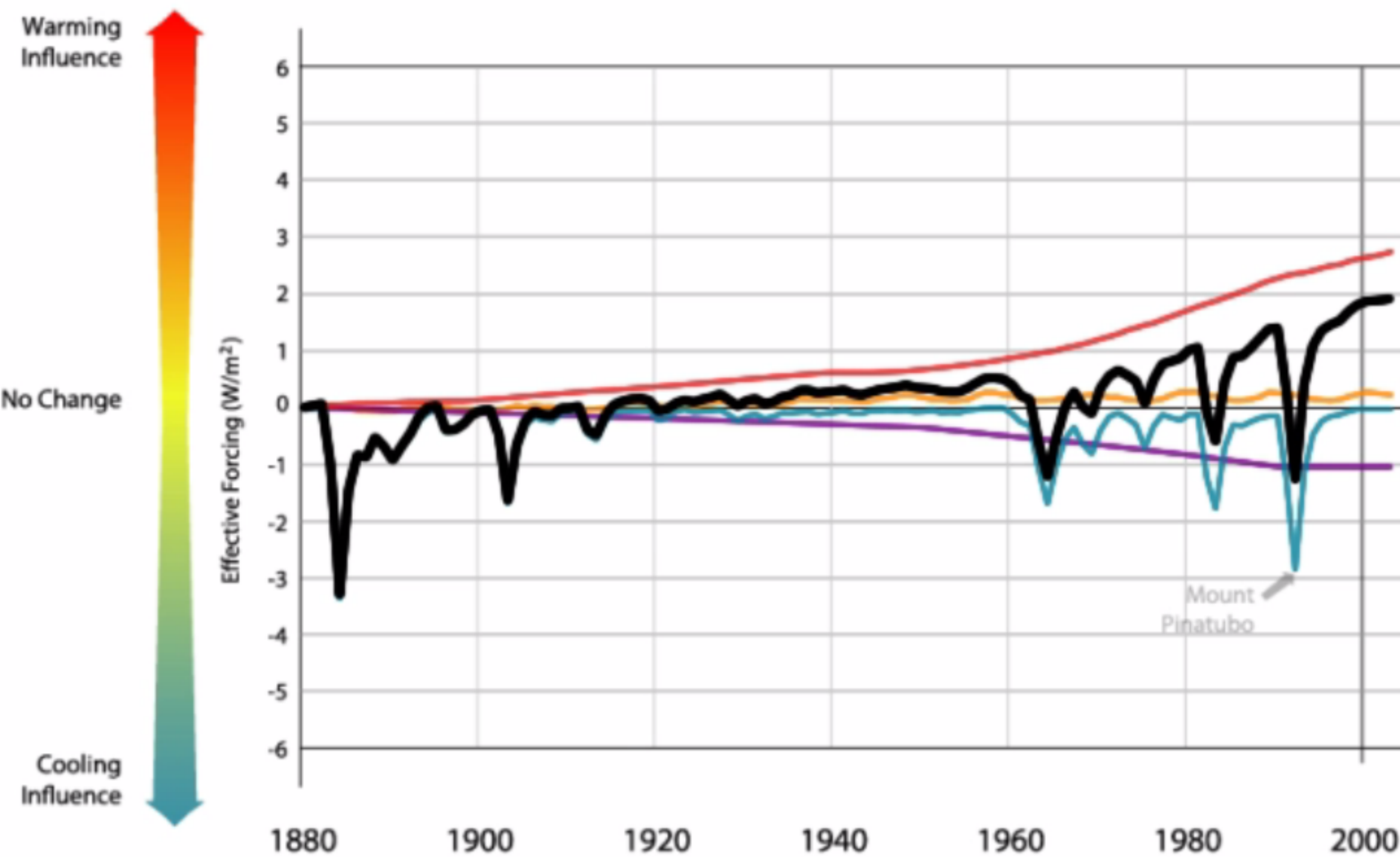
It's bad.

Scientists agree.

There's hope.

Temperature vs Solar Activity







97%

**OF CLIMATE PAPERS STATING A POSITION
ON HUMAN-CAUSED GLOBAL WARMING**

AGREE

**GLOBAL WARMING IS HAPPENING—
AND WE ARE THE CAUSE.**

TheConsensusProject.com

