

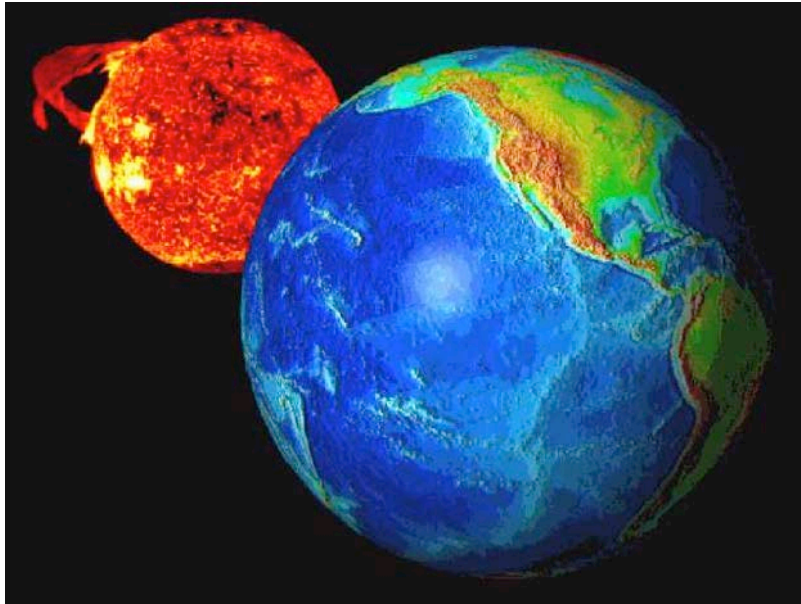
Greenhouse Gases, Climate Change and Sustainability

Why ignorance is not bliss

Jim White,
University of Colorado
INSTAAR



Back to the basics....

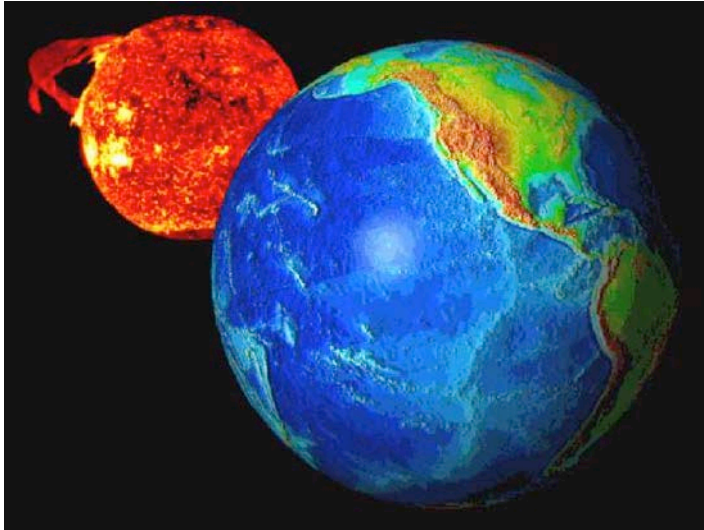


Simple physics:
Global climate depends on three factors

- How much energy we get from the sun
- How much of that energy is reflected back to space (aerosols, ice, etc.)
- Amount of greenhouse gases

OK,
then...

If we add *lots** of
greenhouse gases to
the atmosphere, the
Earth will warm.

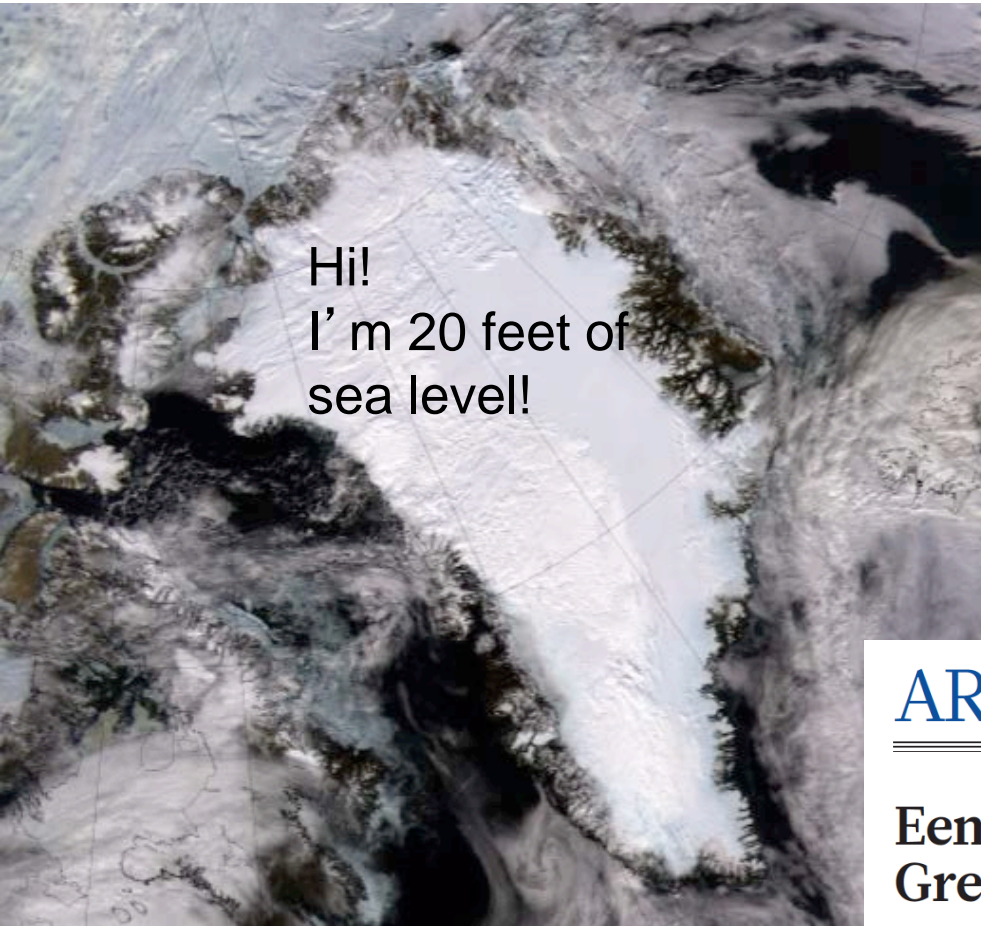


*To expect otherwise
denies simple
physics... and the
next time you feel the
urge to deny simple
physics, try denying
gravity...*

* Lots: 30% more
CO₂ and N₂O, triple
CH₄

Simple physics and sea level

- When our planet warms, sea level rises.
When it cools sea level drops.
- Thermal expansion of water
- Land ice melts
- And there's a powerful reflectivity feedback
- Sea level and temperature is one of the most robust relationships in past climates



Big sea level changes from big ice sheets

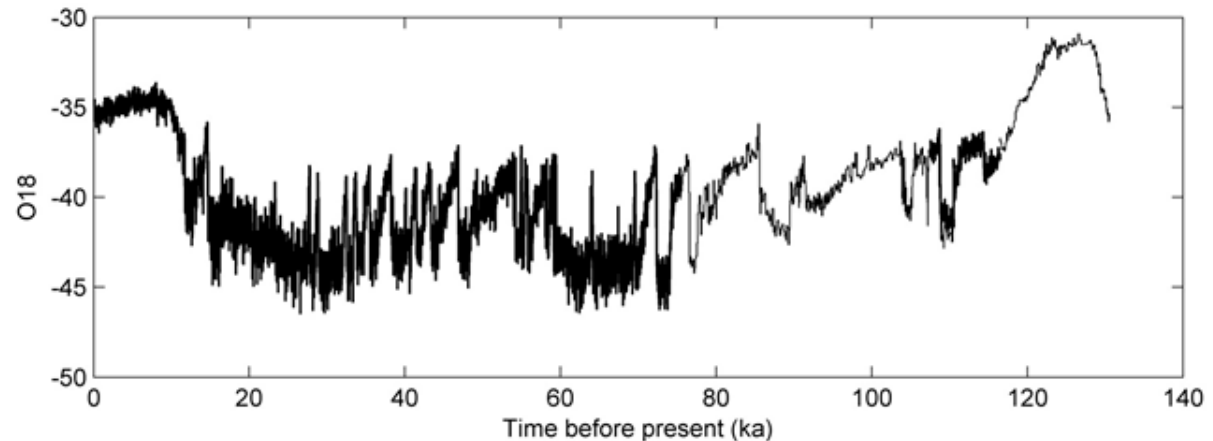
ARTICLE

doi:10.1038/nature11789

Eemian interglacial reconstructed from a Greenland folded ice core

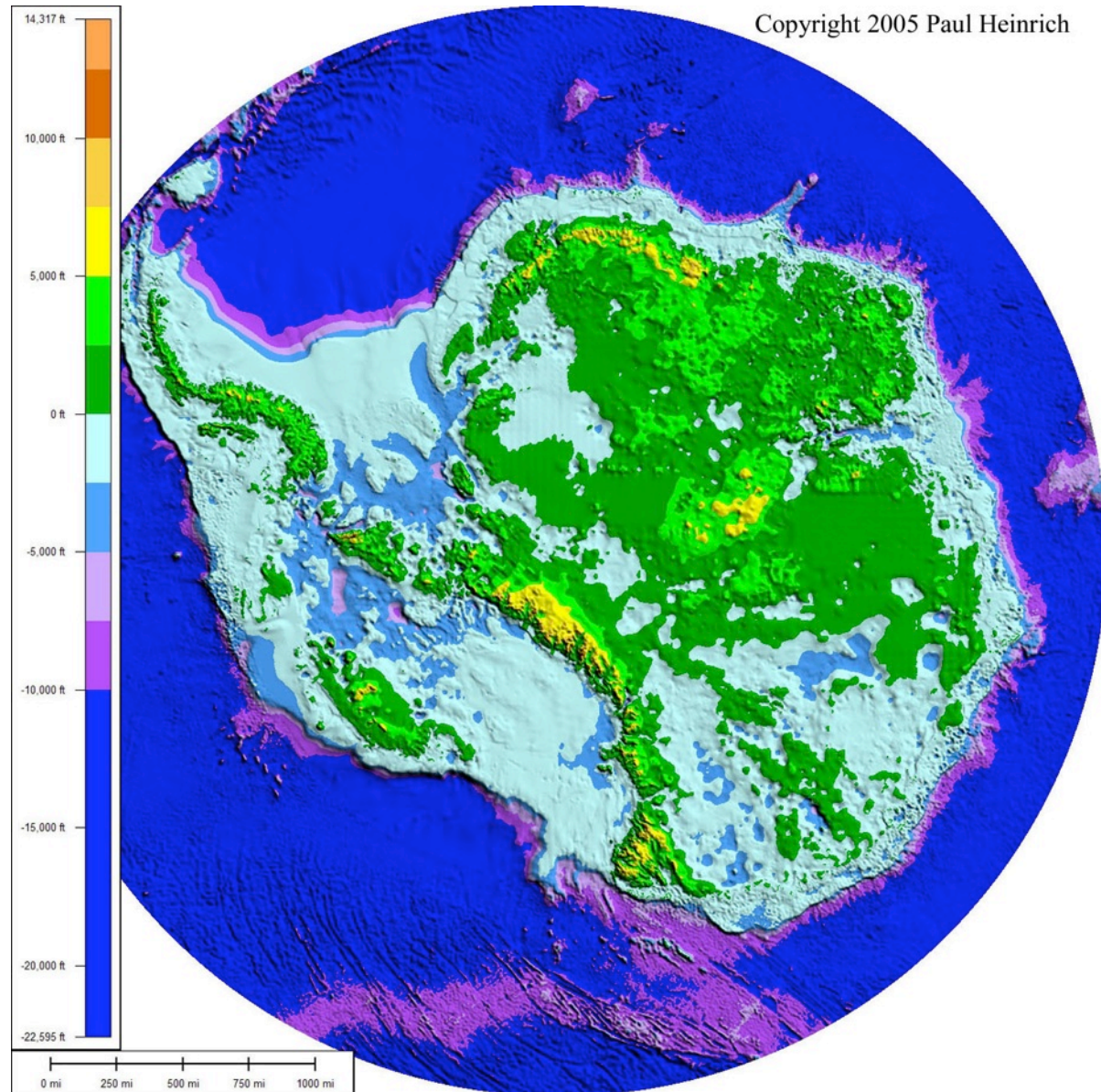
NEEM community members*

- Greenland
- West Antarctica
- East Antarctica



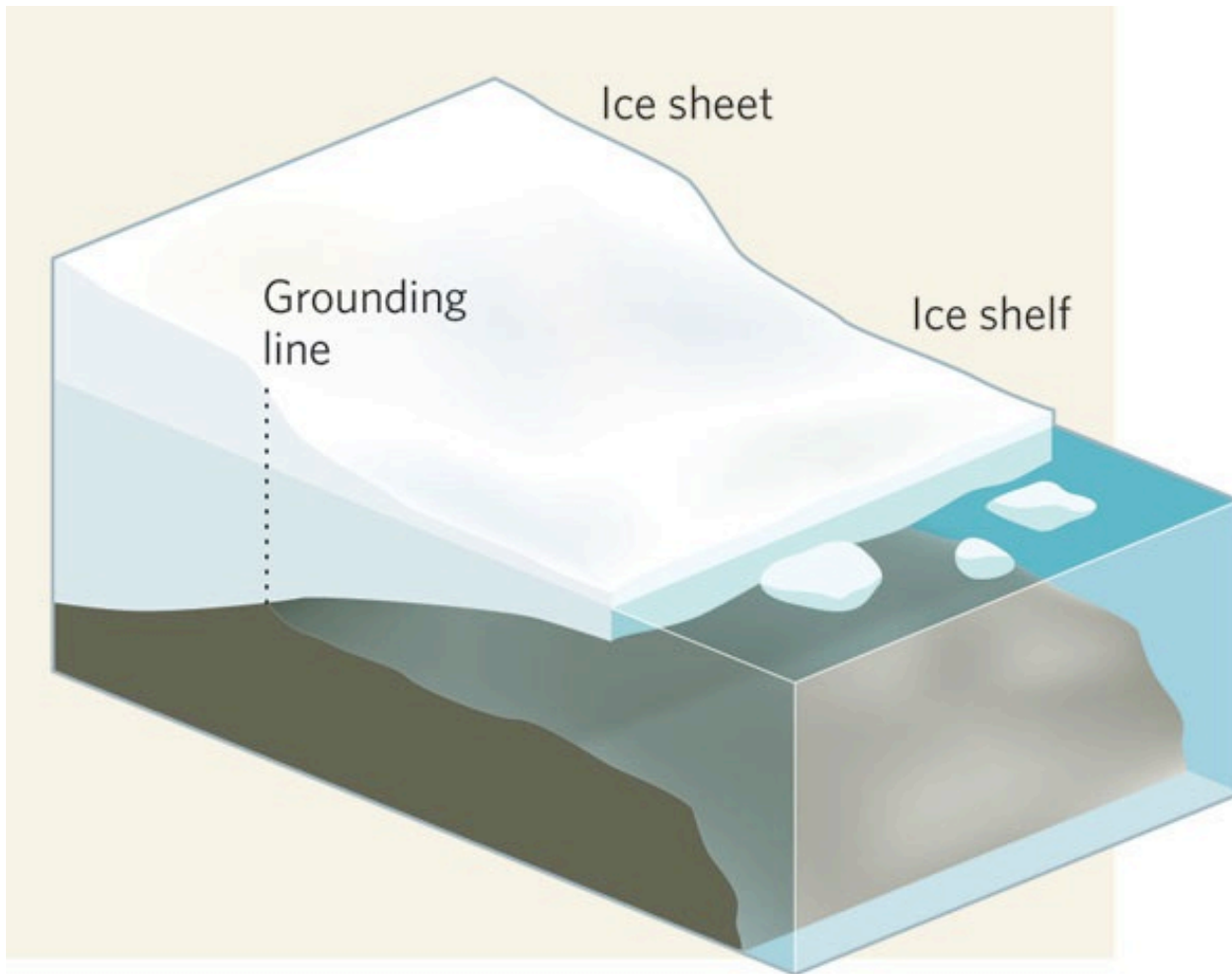
If not Greenland... Antarctica

Copyright 2005 Paul Heinrich



- West Antarctica is a Marine Ice Sheet... its bedrock is well below sea level

Importance of Grounding Line



Sea level and climate

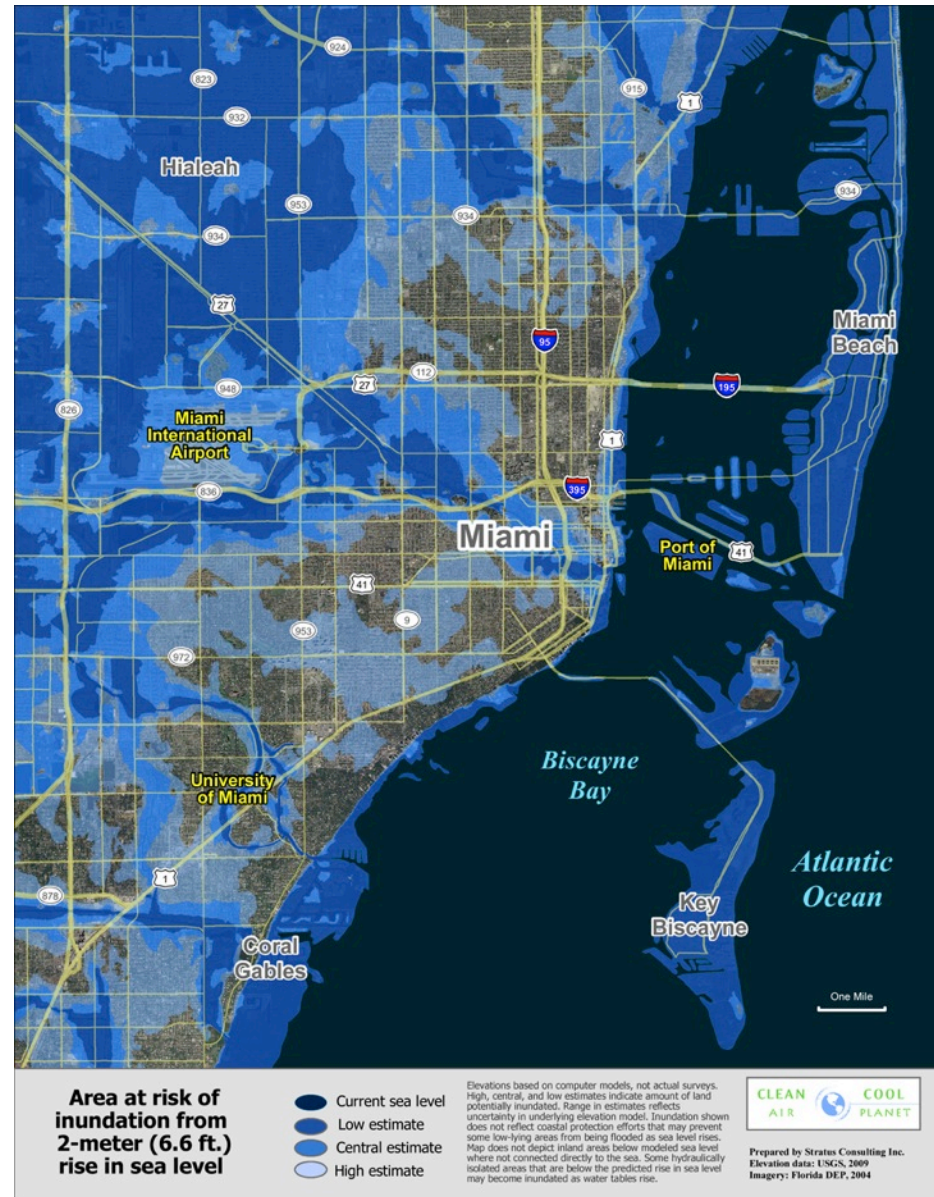
- The question is not IF sea level will rise with a warmer climate...
- But how fast?
- And how far?

Sea level is rising today: 1 meter by the end of this century is current estimate... *and it won't stop there... and that is without West Antarctica collapsing*

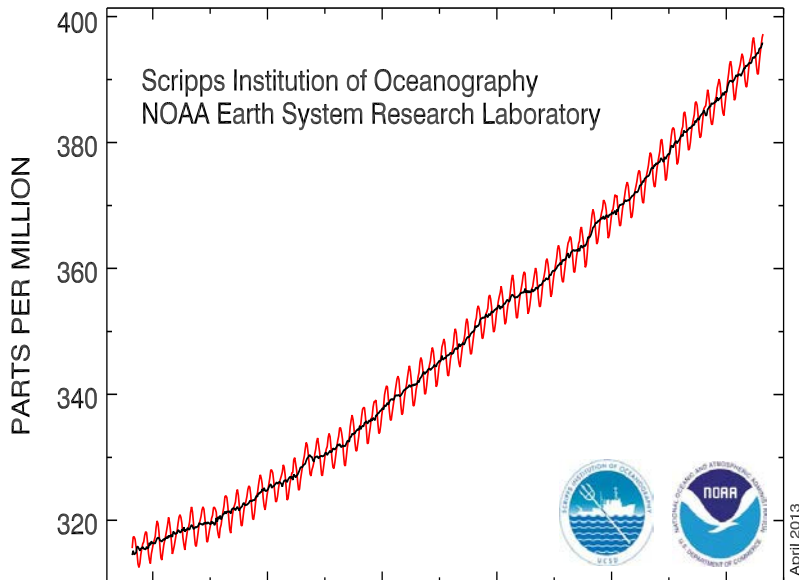


Think about it...

*Miami has no future
much beyond this
century... and
Miami is not alone.*



What does the past tell us?



The last time there was
400 ppm CO₂...

- The Pliocene (3 million years ago):
 - 350 to 400 ppm CO₂
 - 30°F warmer in the Arctic... **trees in the Arctic Circle**
 - less sea ice and land ice
 - *20-25m higher sea level*

“Deep time” sea level and temperature

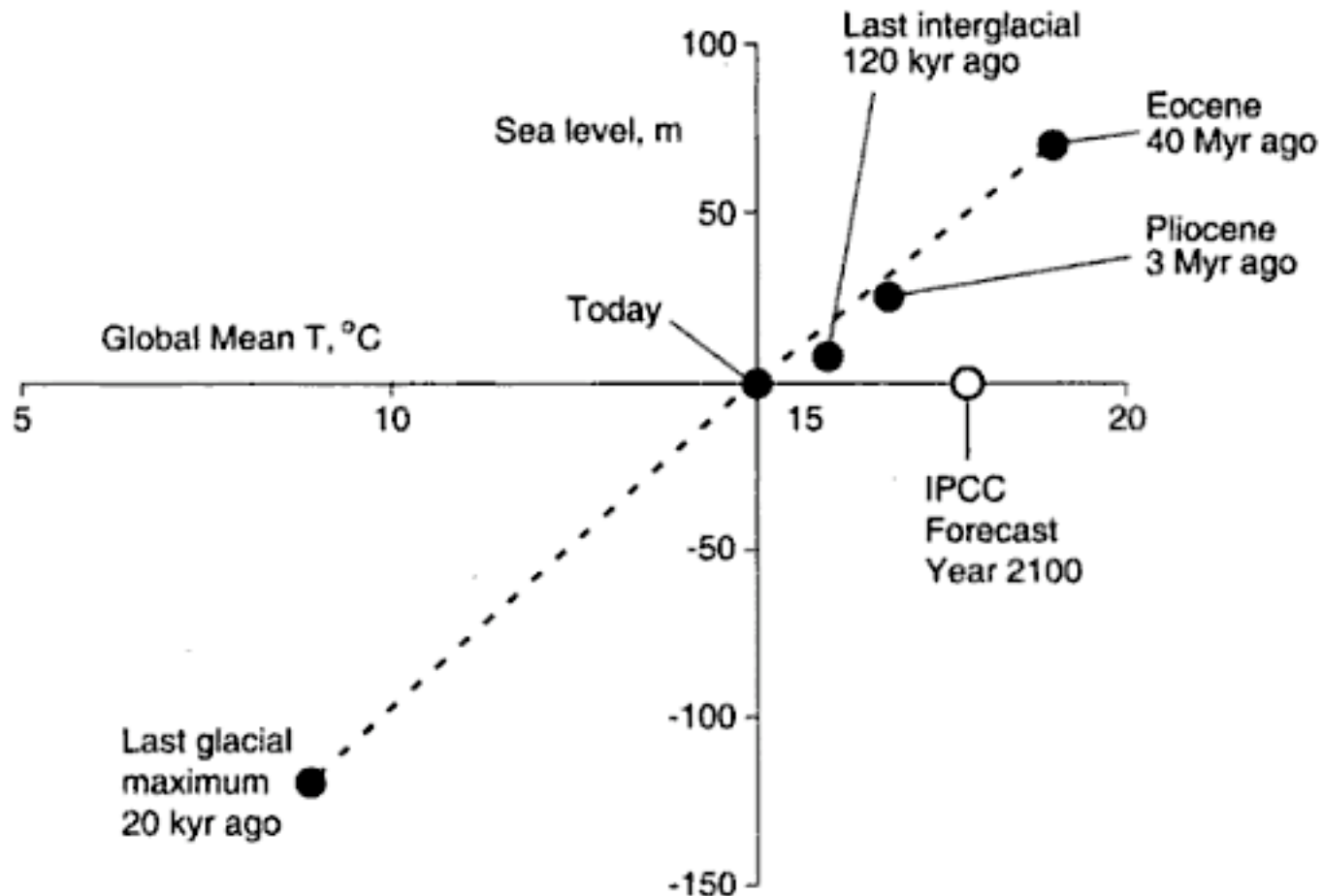
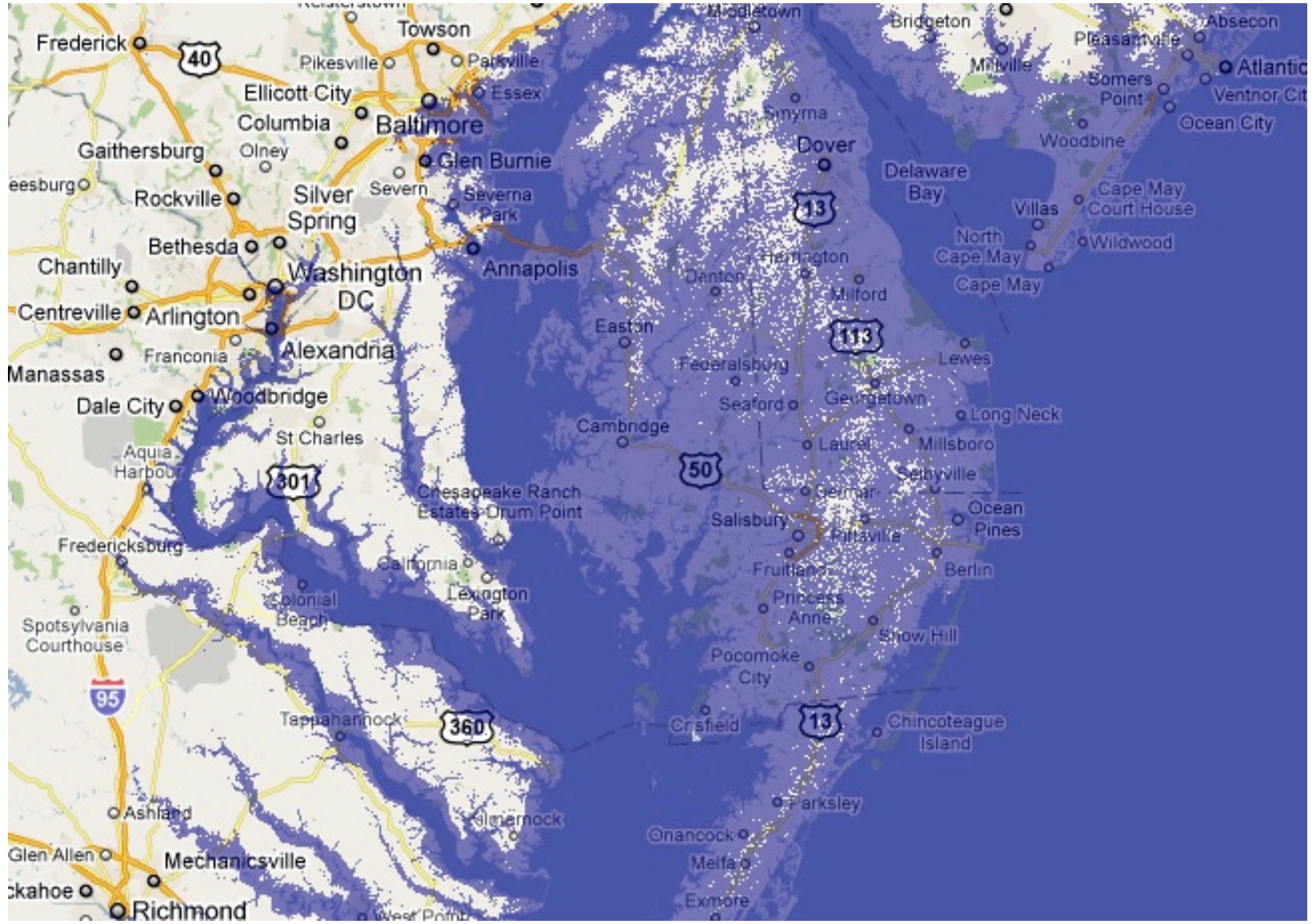
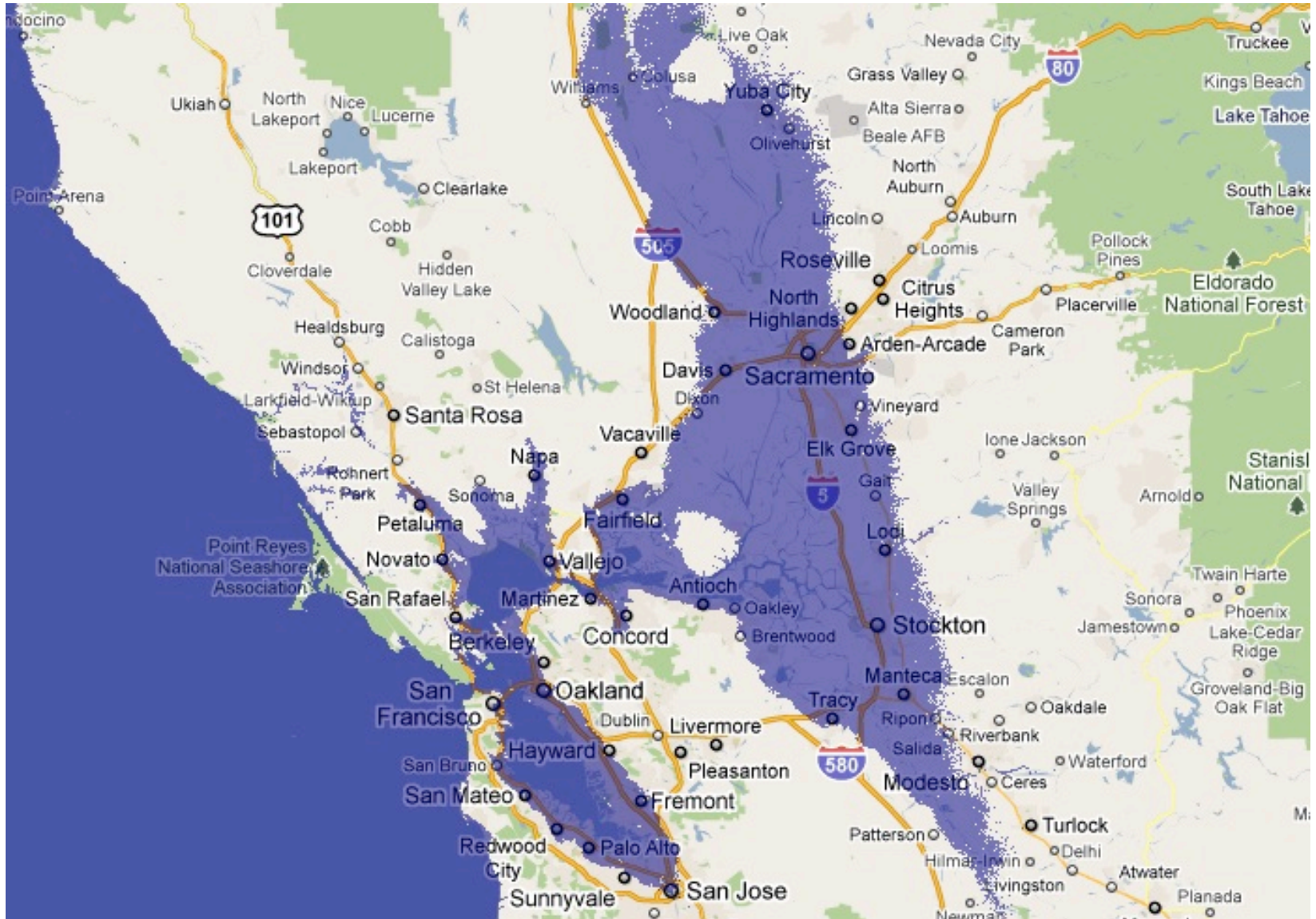


FIGURE 17. Covariation of sea level with global average temperature in the geologic past, compared with the IPCC forecast for sea level rise by the year 2100.

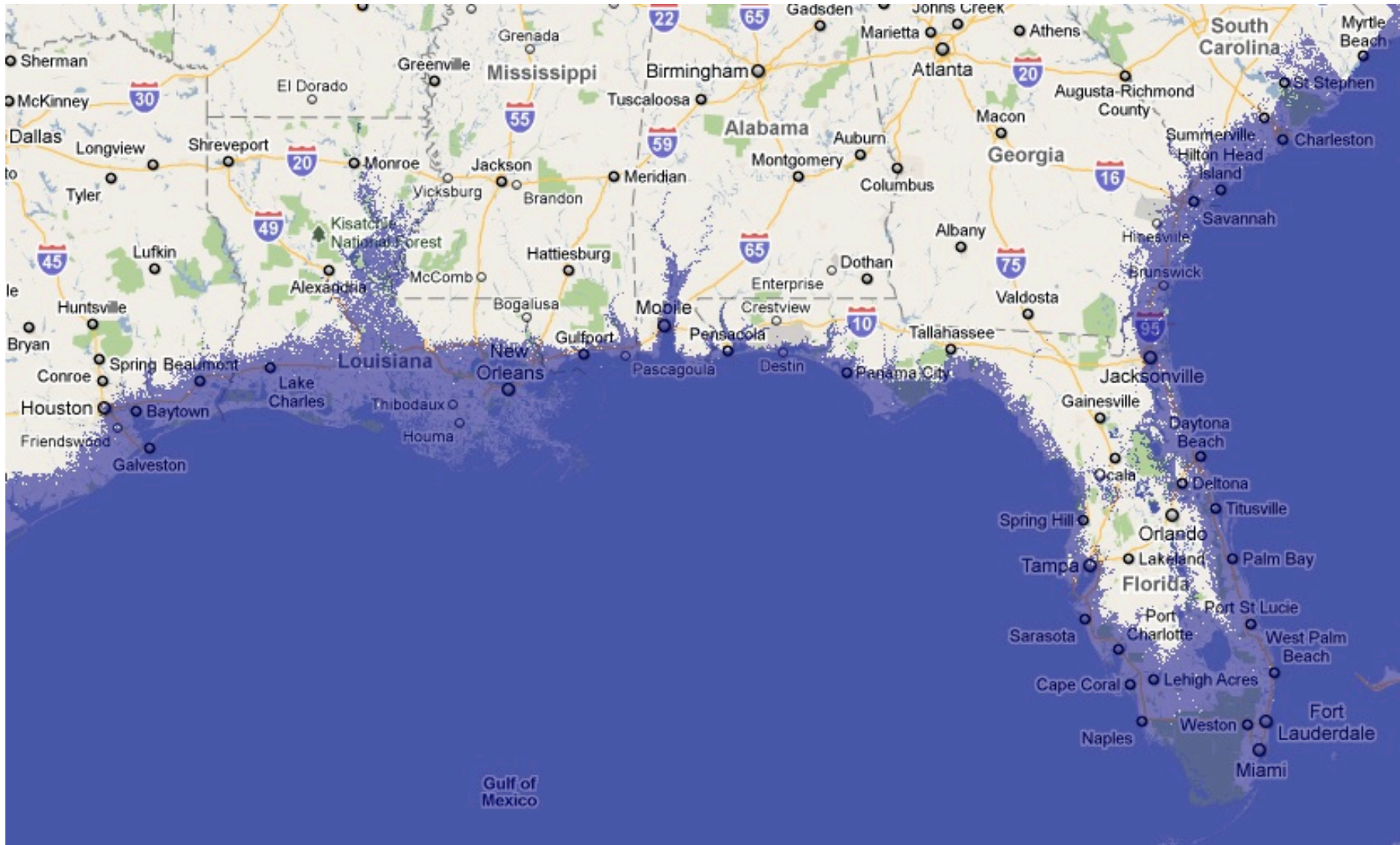
What does 20 meters (65 feet) of sea level rise look like?



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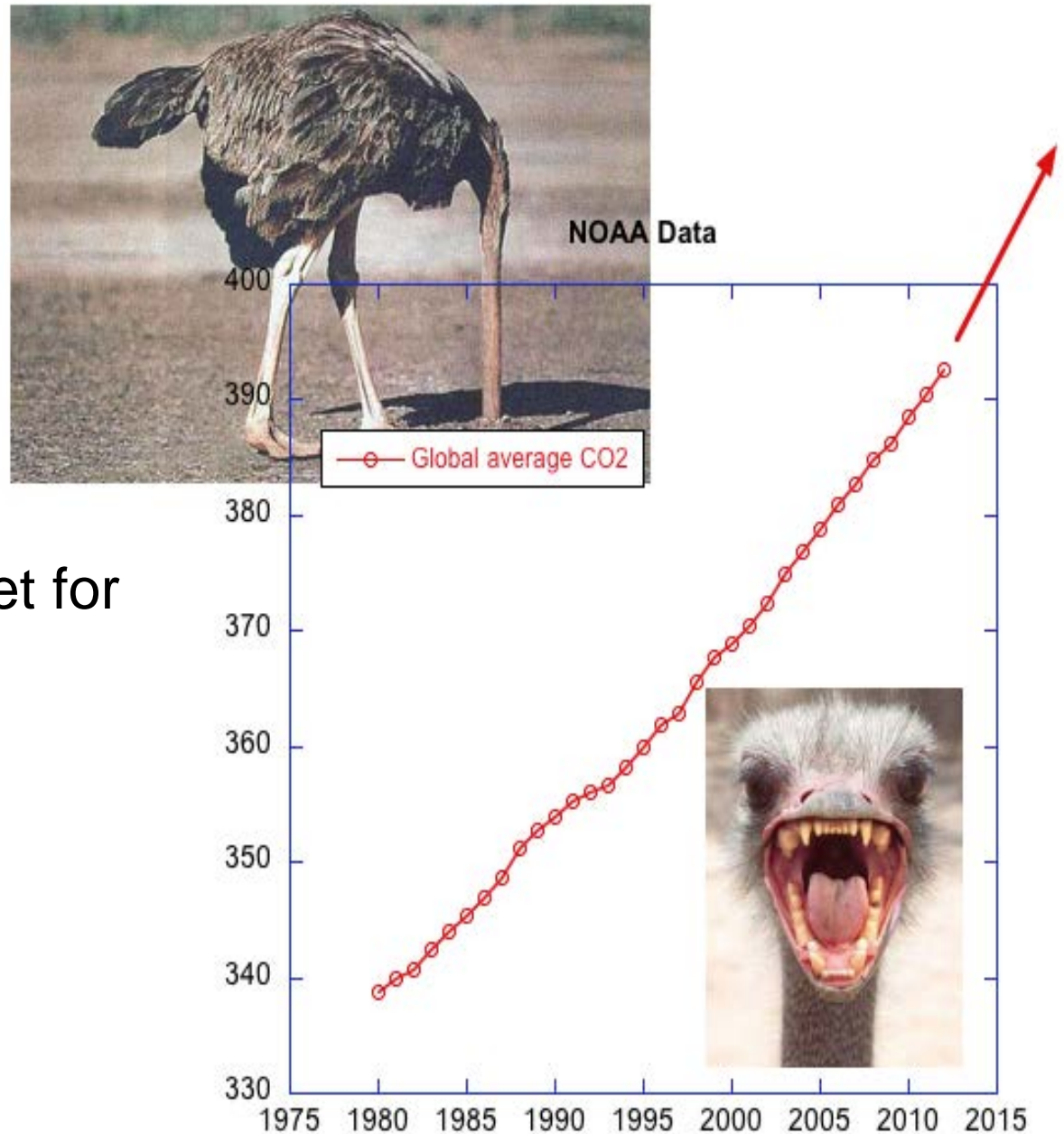


Plot turns?

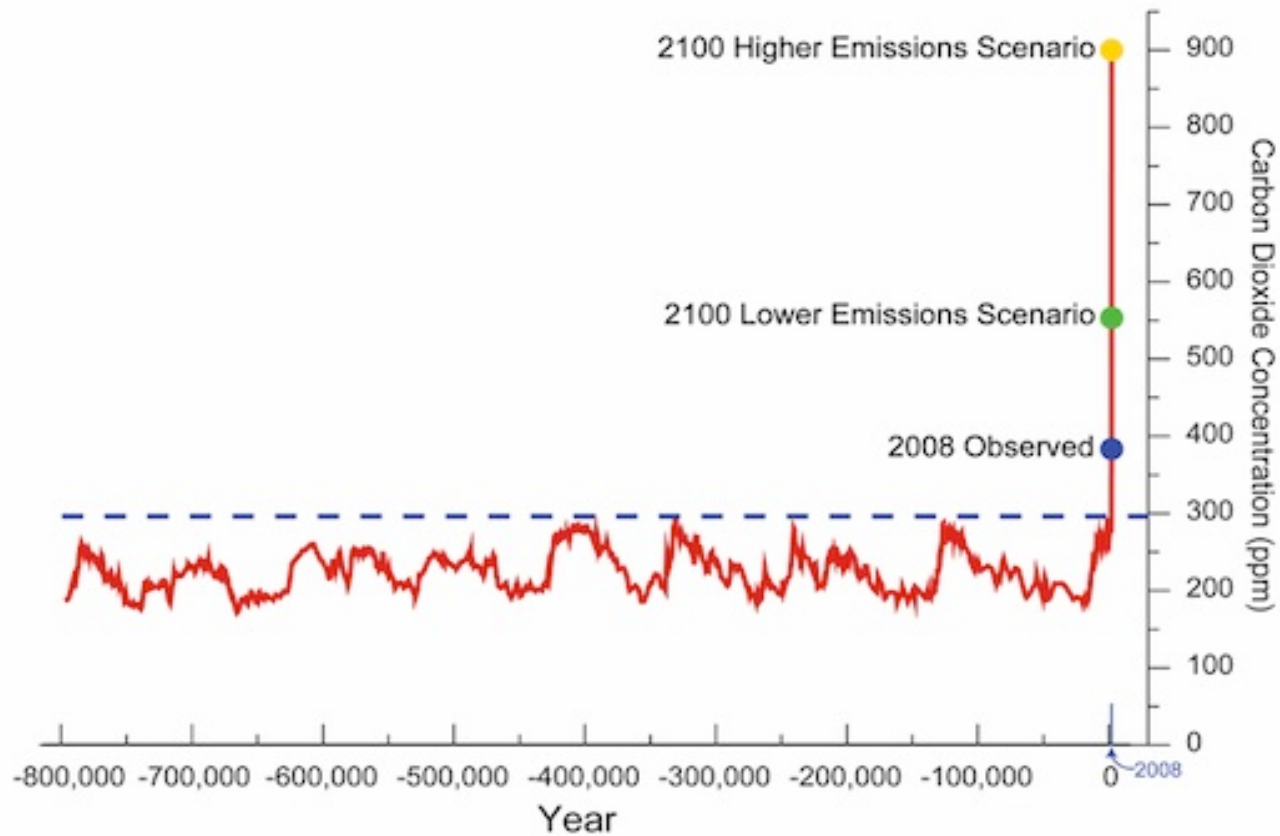
- CH₄ and CO₂ from frozen carbon: yes, but hopefully slow
- CH₄ and CO₂ from clathrates: not likely
- Abrupt changes: yes
- Natural carbon sinks: not failed us yet, but...

So what's our current strategy?

- Cut NOAA's budget for GHGs
- Attack science
- Attack education
- Deny physics



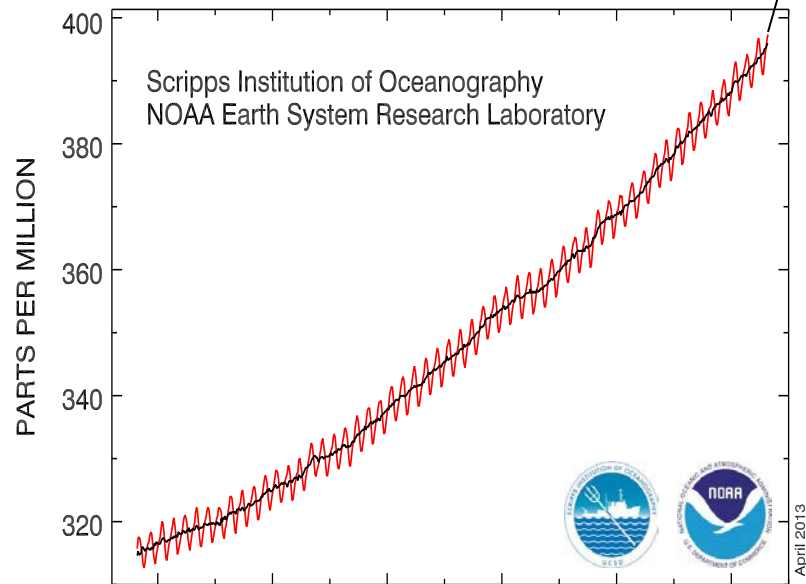
And where are we going?



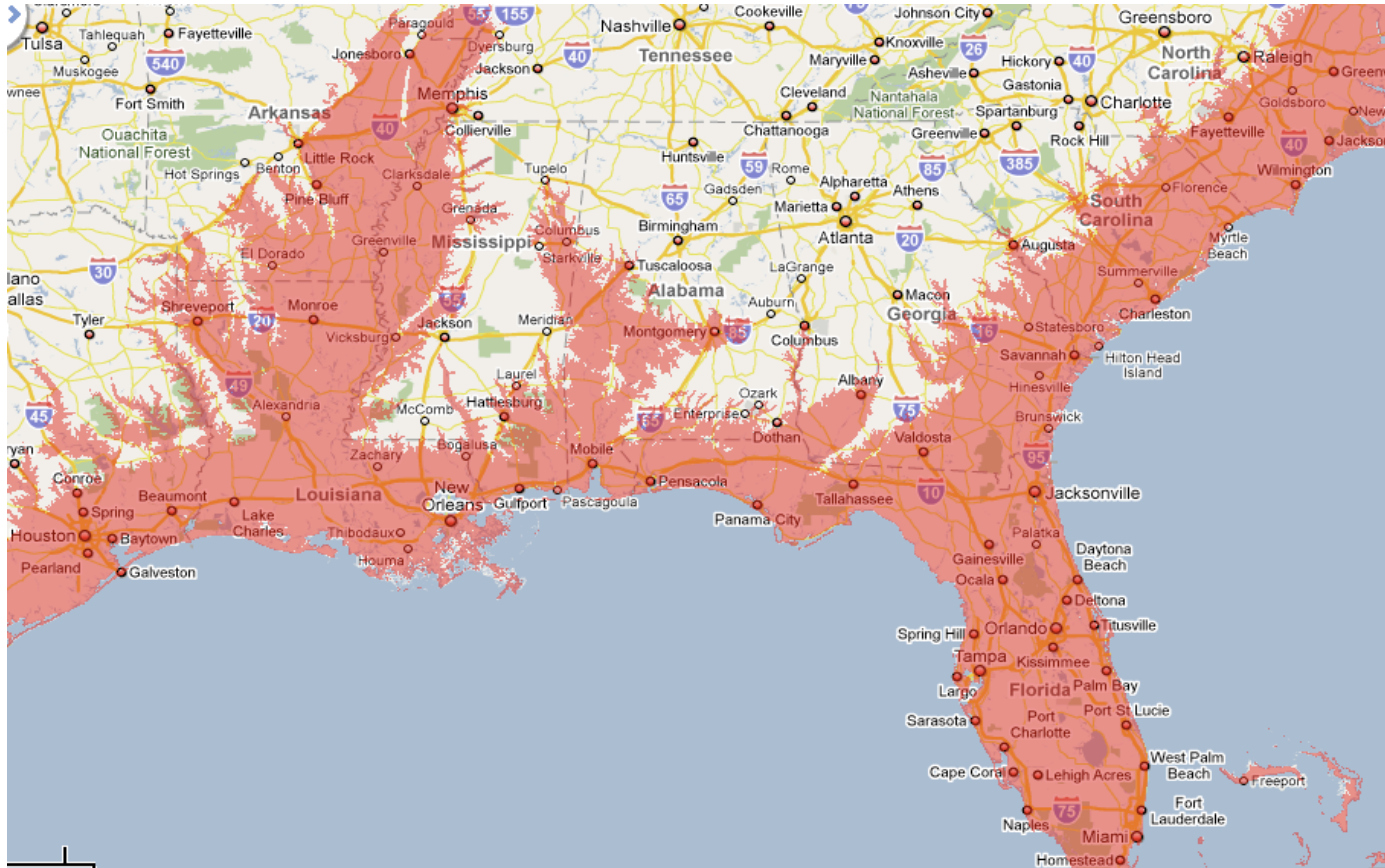
What does the past tell us?

The last time there was 1000 ppm CO₂...

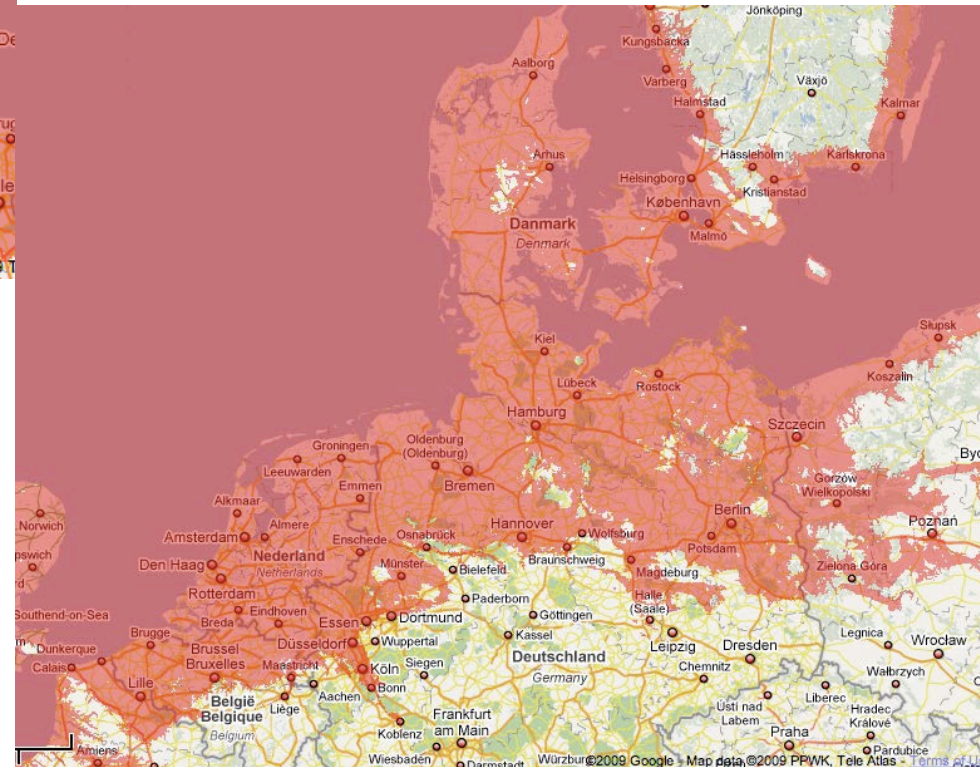
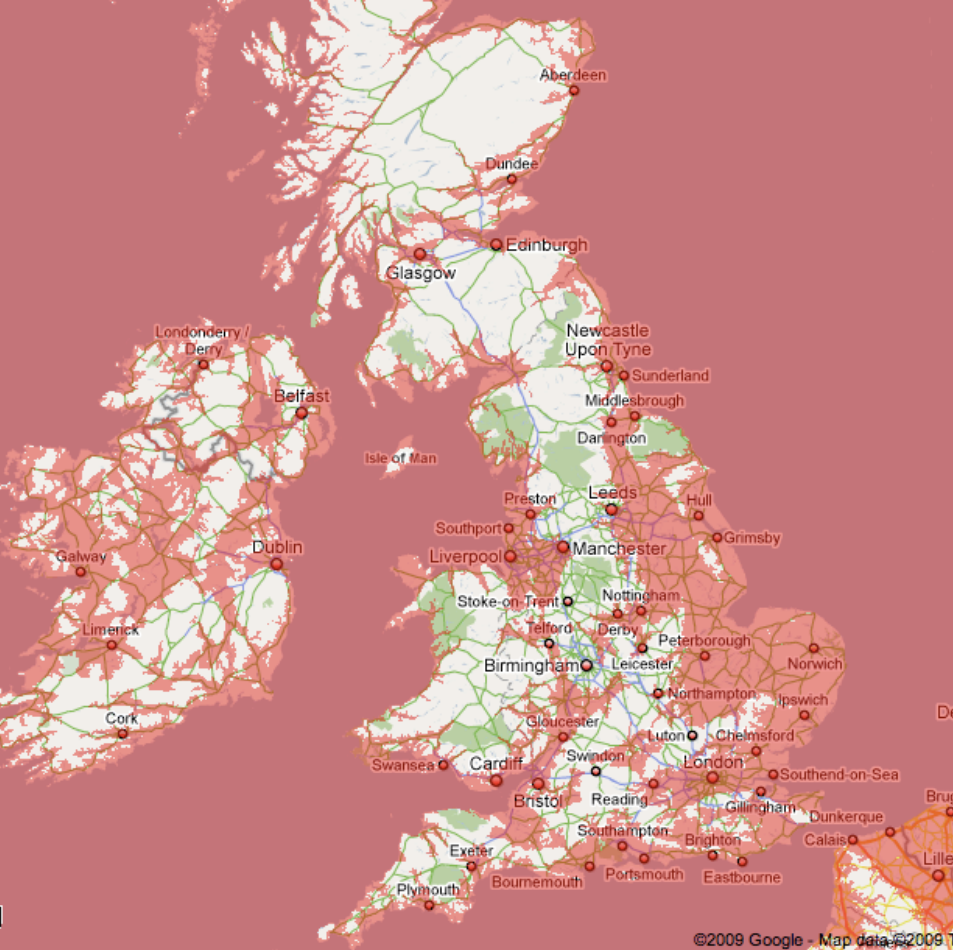
- The Eocene (50 million years ago):
 - No land ice
 - *80m higher sea level*



80m of sea level



80m of sea level rise



Final thoughts...

Its not just about energy

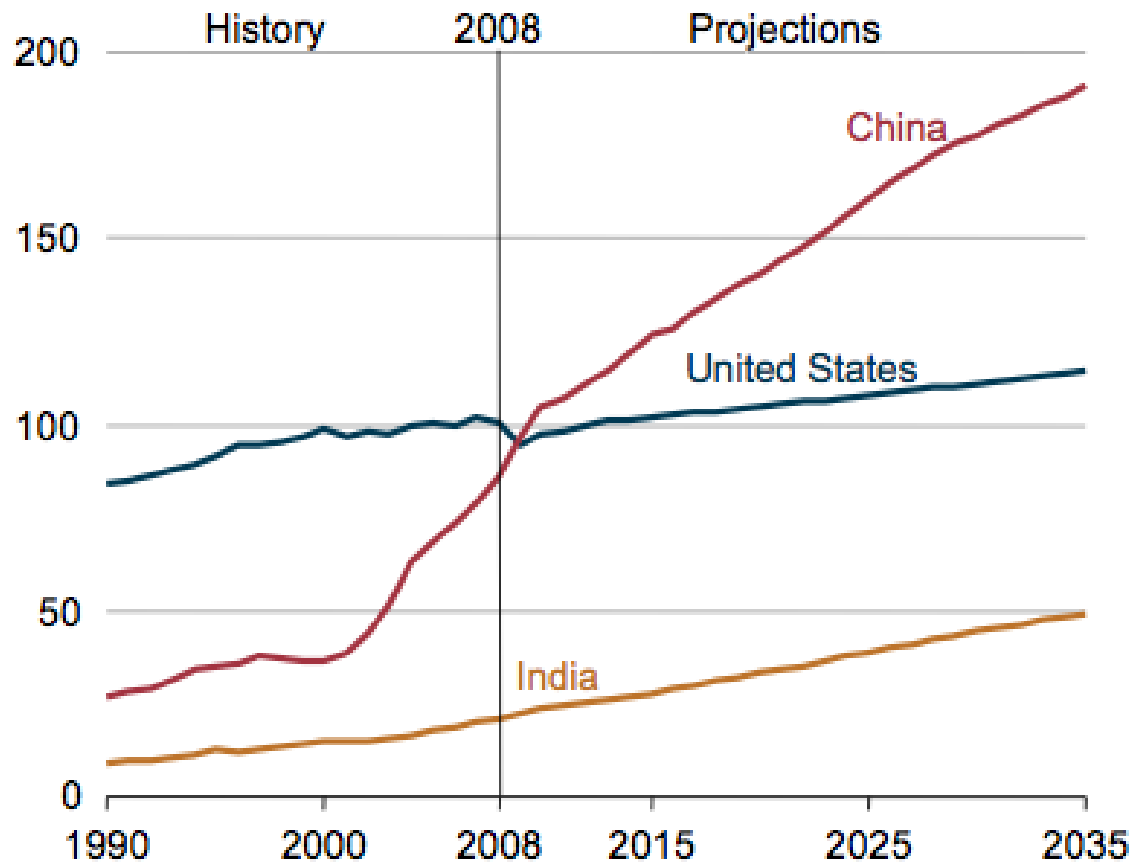
... CH₄ and N₂O are food greenhouse gases... *can we live without fertilizer?*
Rice? Cattle?

Climate change is training wheels for sustainability

The problem is global, requiring global cooperation

From Energy Information Agency, US DOE

Figure 13. Energy consumption in the United States, China, and India, 1990-2035 (quadrillion Btu)



Our children

The impacts come after the causes by 50 years or more: ours is a water planet and it takes time to heat up the water...
if cause and effect are not immediate, its hard to provoke action.

Final comments: Responsibility



The good news!

My 3 simple rules of sustainability:

1. Everything must cycle
2. Population must be controlled (equality of the sexes), and vary inversely with resource use per capita
3. Equity must be considered and acted upon

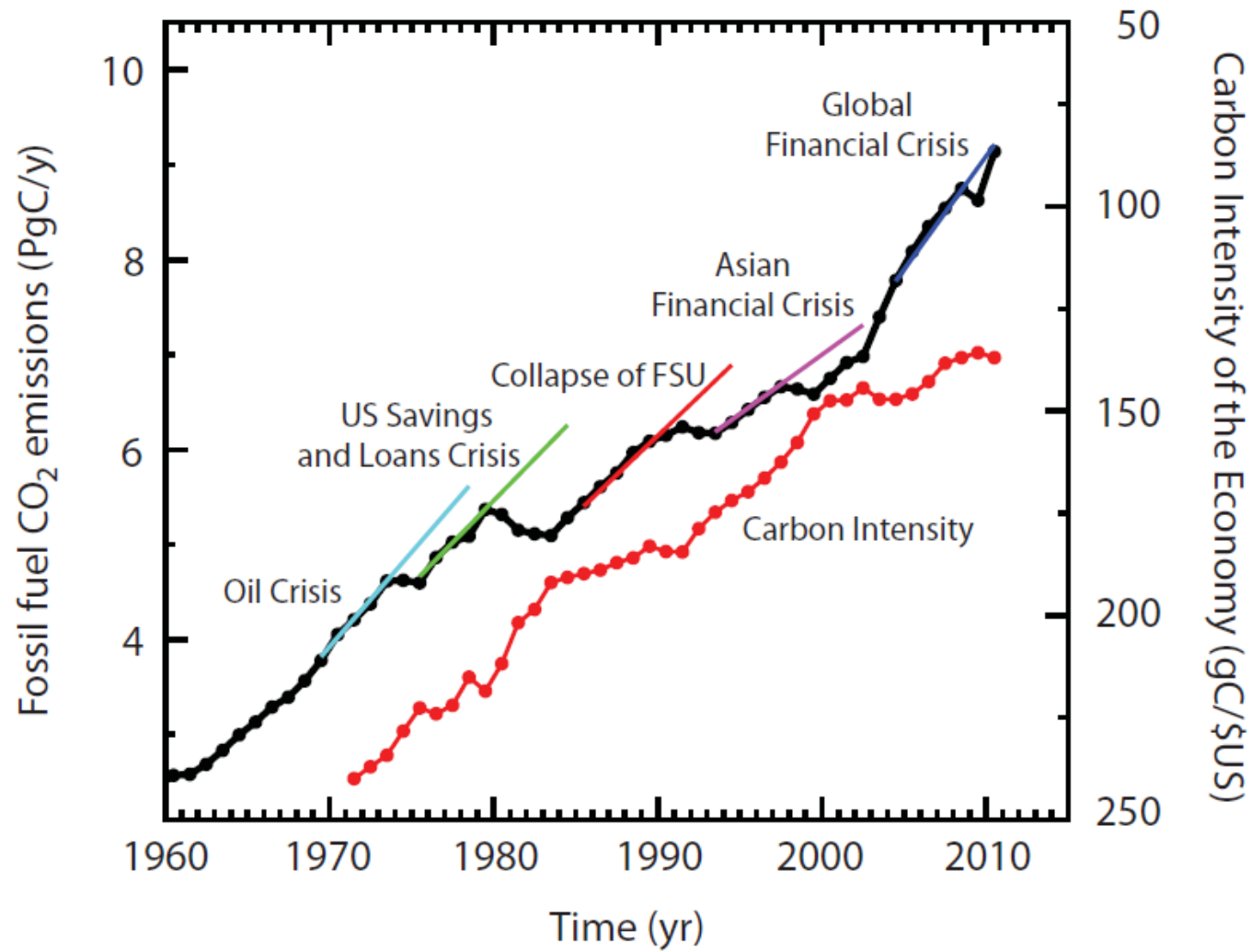
Yes, It's a hard problem that will take many of us to solve it

Why is it hard?

- Its political
- There's a lot of \$ at stake: **the US alone spends about \$1.4 Trillion per year on energy...** but is it all about money?

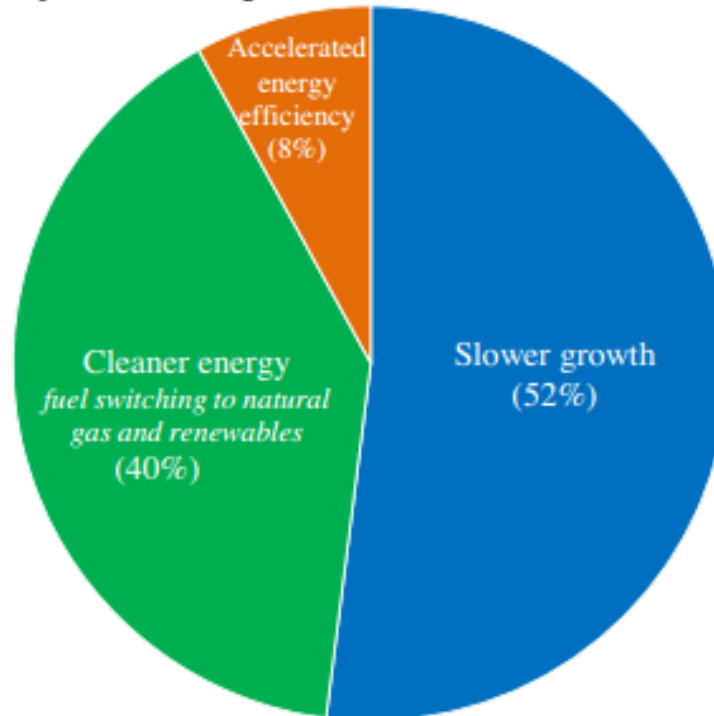
Is it only economics, or is it also ethics, morals and religion?

grow is what we do.



Progress on reducing GHGs

Decomposition of CO₂ Emission Reductions, 2005–2012

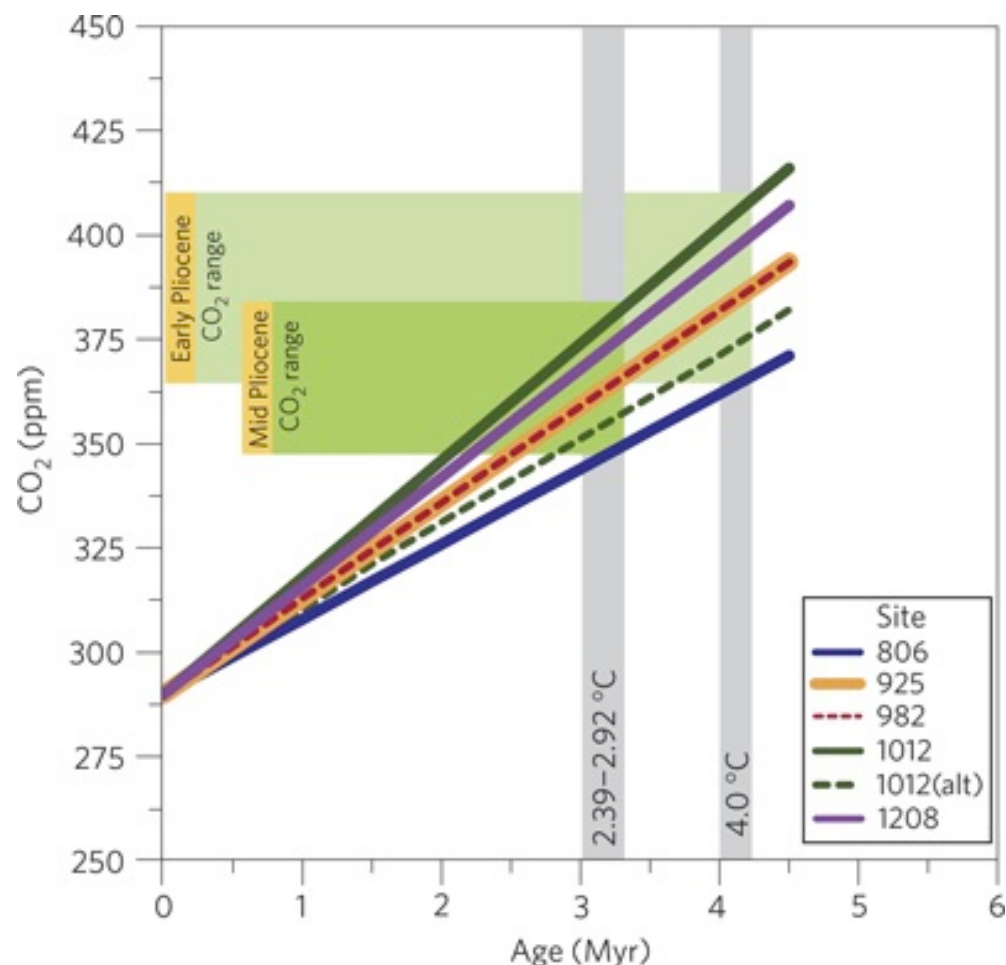


Source: Bureau of Economic Analysis, National Income and Product Accounts; EIA (2013); CEA calculations.

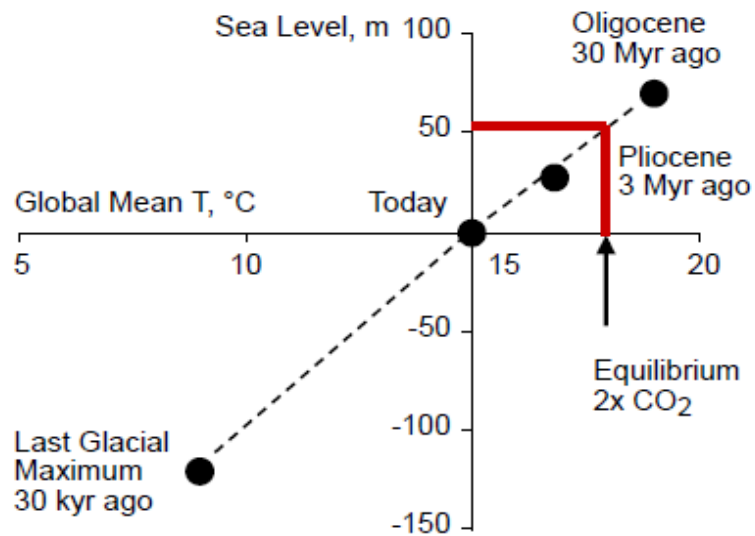
“Here we reconstruct atmospheric carbon dioxide concentrations for the early and middle Pliocene, when temperatures were about 3–4 C warmer than preindustrial values^{3–5}, to estimate Earth-system climate sensitivity from a fully equilibrated state of the planet. **We demonstrate that only a relatively small rise in atmospheric CO₂ levels was associated with substantial global warming about 4.5 million years ago, and that CO₂ levels at peak temperatures were between about 365 and 415 ppm.** We conclude that the Earth-system climate sensitivity has been significantly higher over the past five million years than estimated from fast feedbacks alone.”

High Earth-system climate sensitivity determined from Pliocene carbon dioxide concentrations

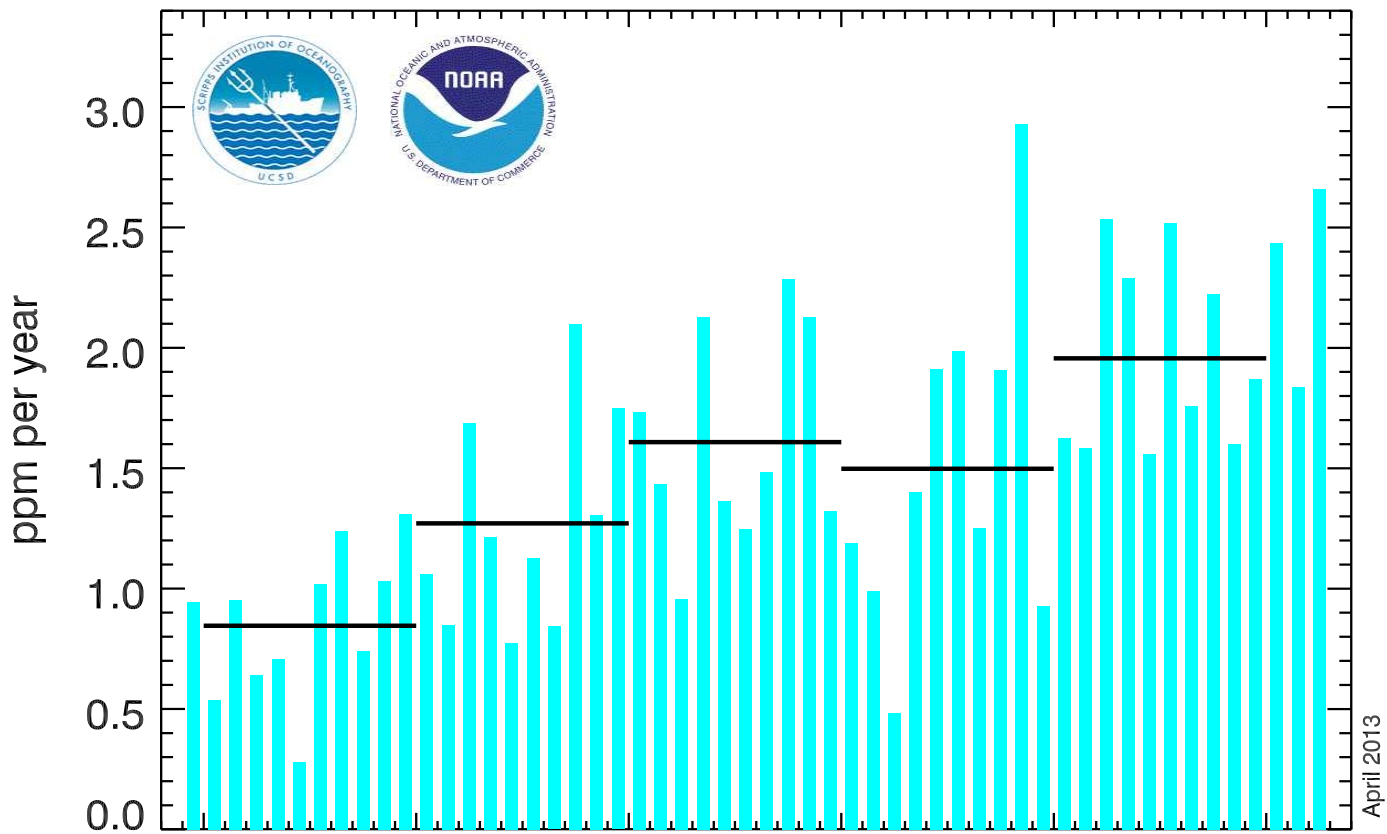
Mark Pagani^{1*}, Zhonghui Liu^{1,2}, Jonathan LaRiviere³ and Ana Christina Ravelo³

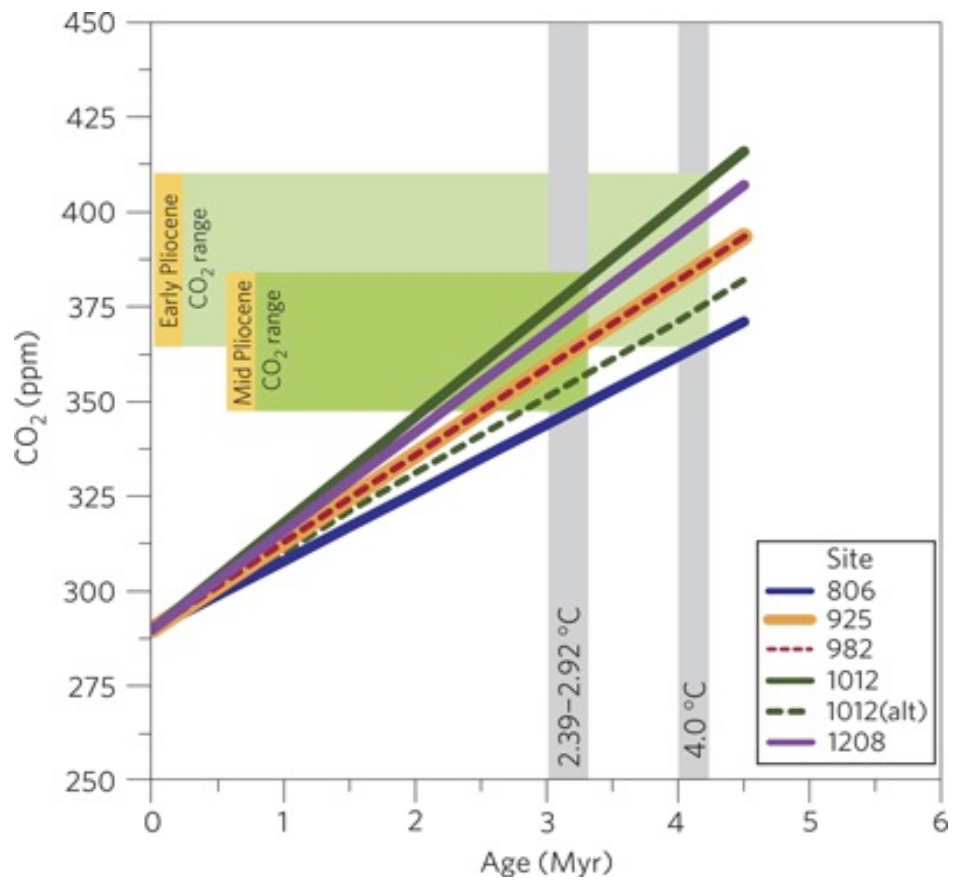


Sea Level and Temperature

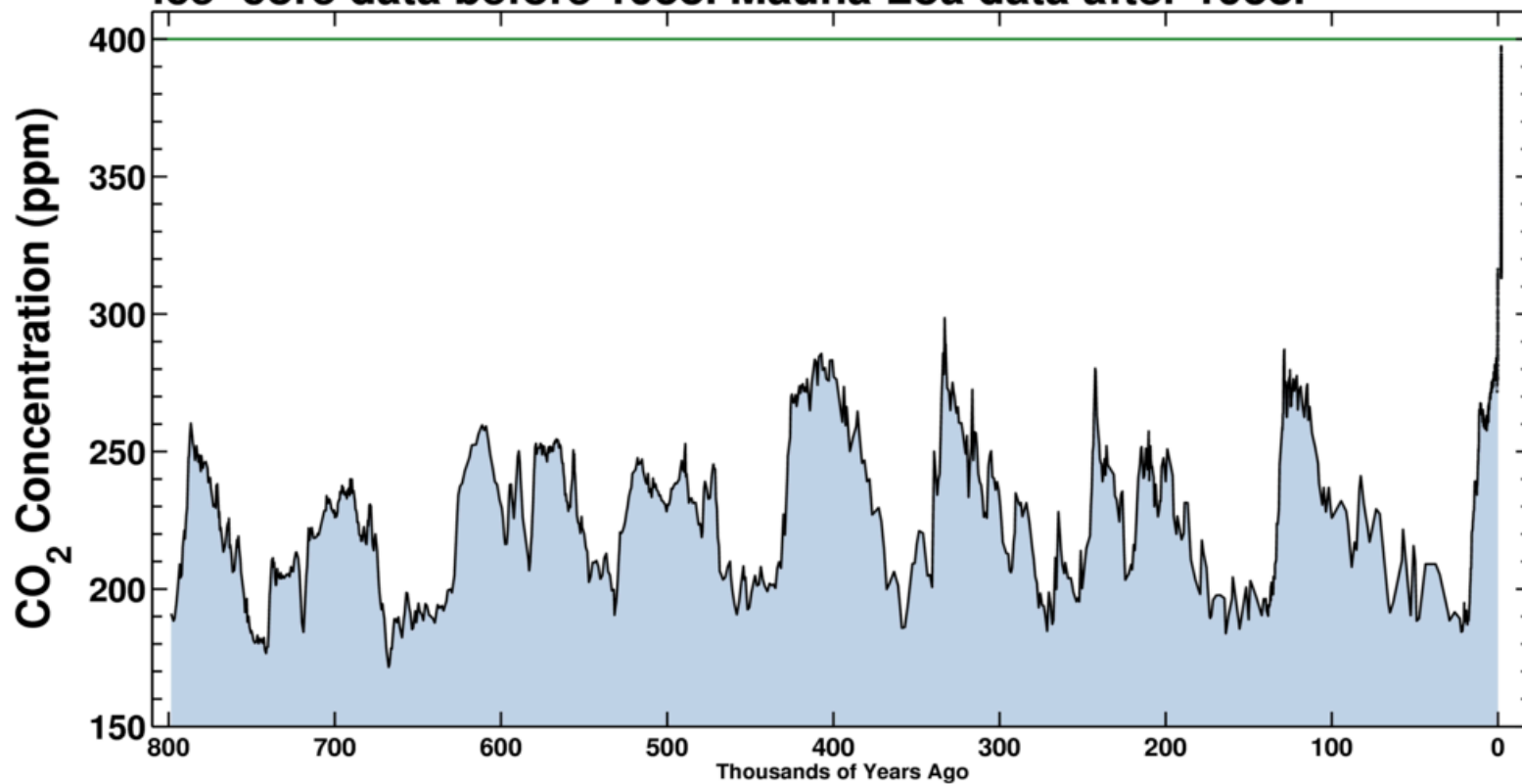


David Archer

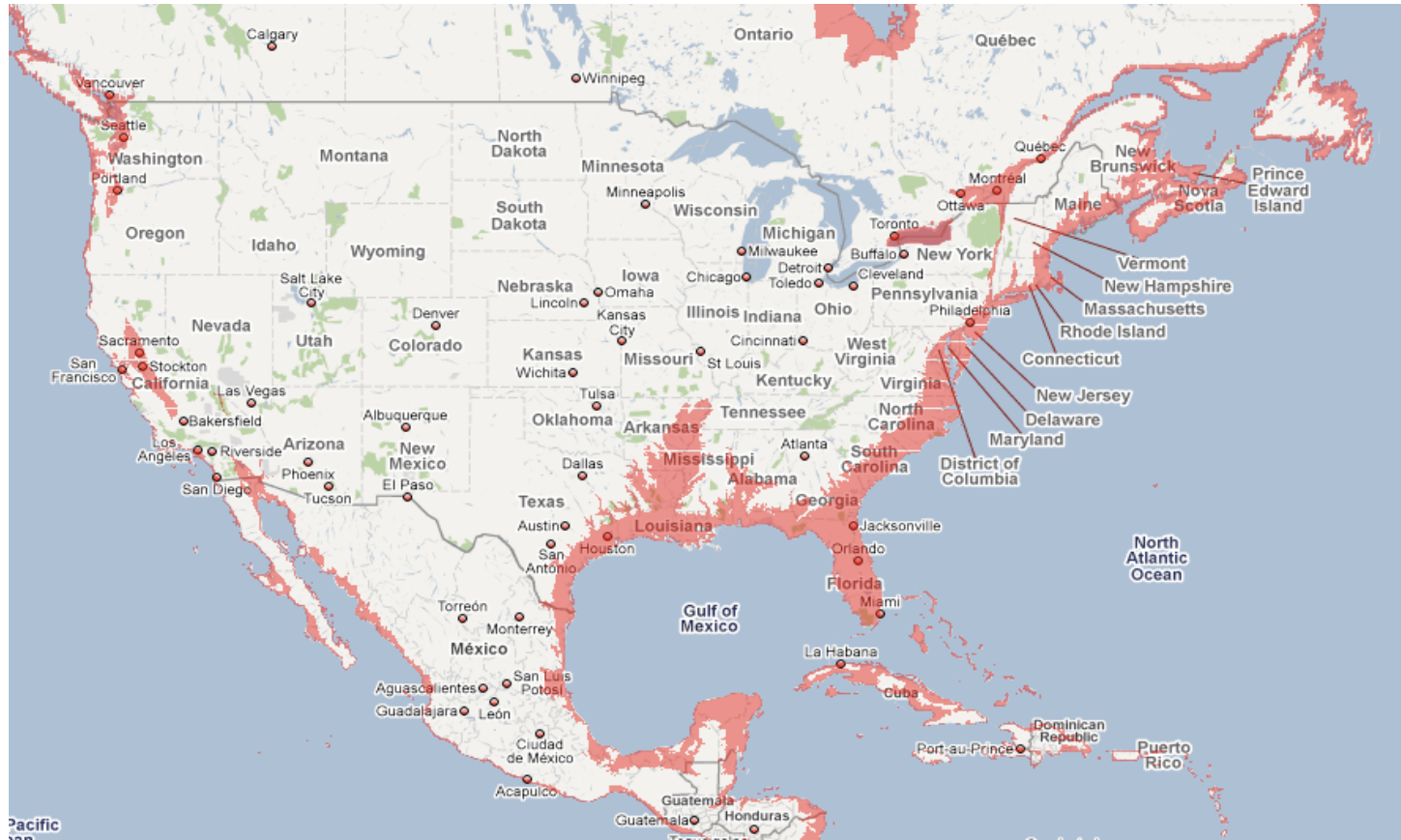


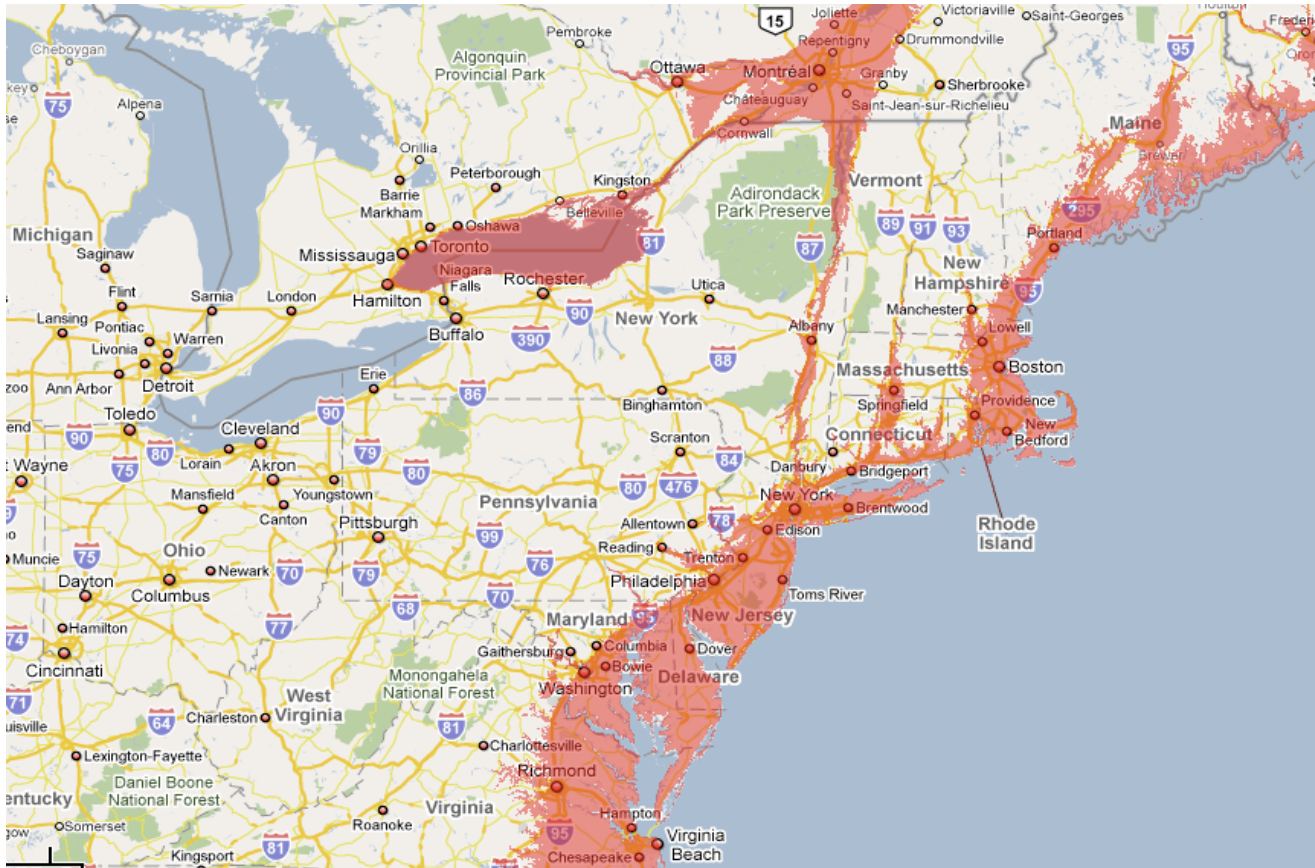


Ice-core data before 1958. Mauna Loa data after 1958.



80m of sea level





Global Temperature Relative to Peak Holocene Temperature

