News from a Warming Planet

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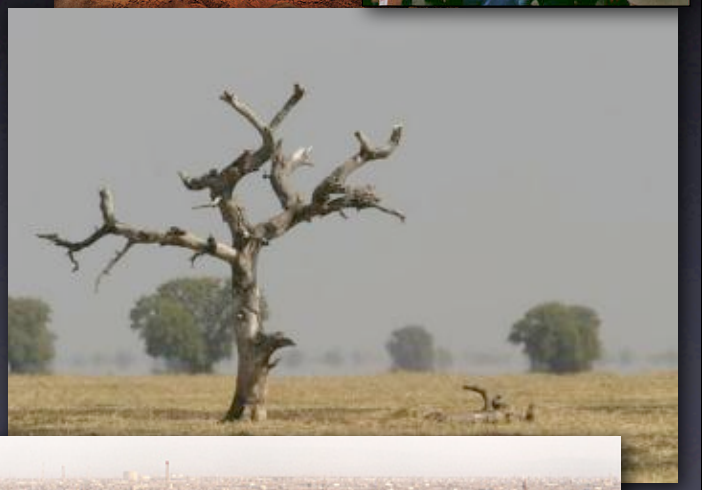
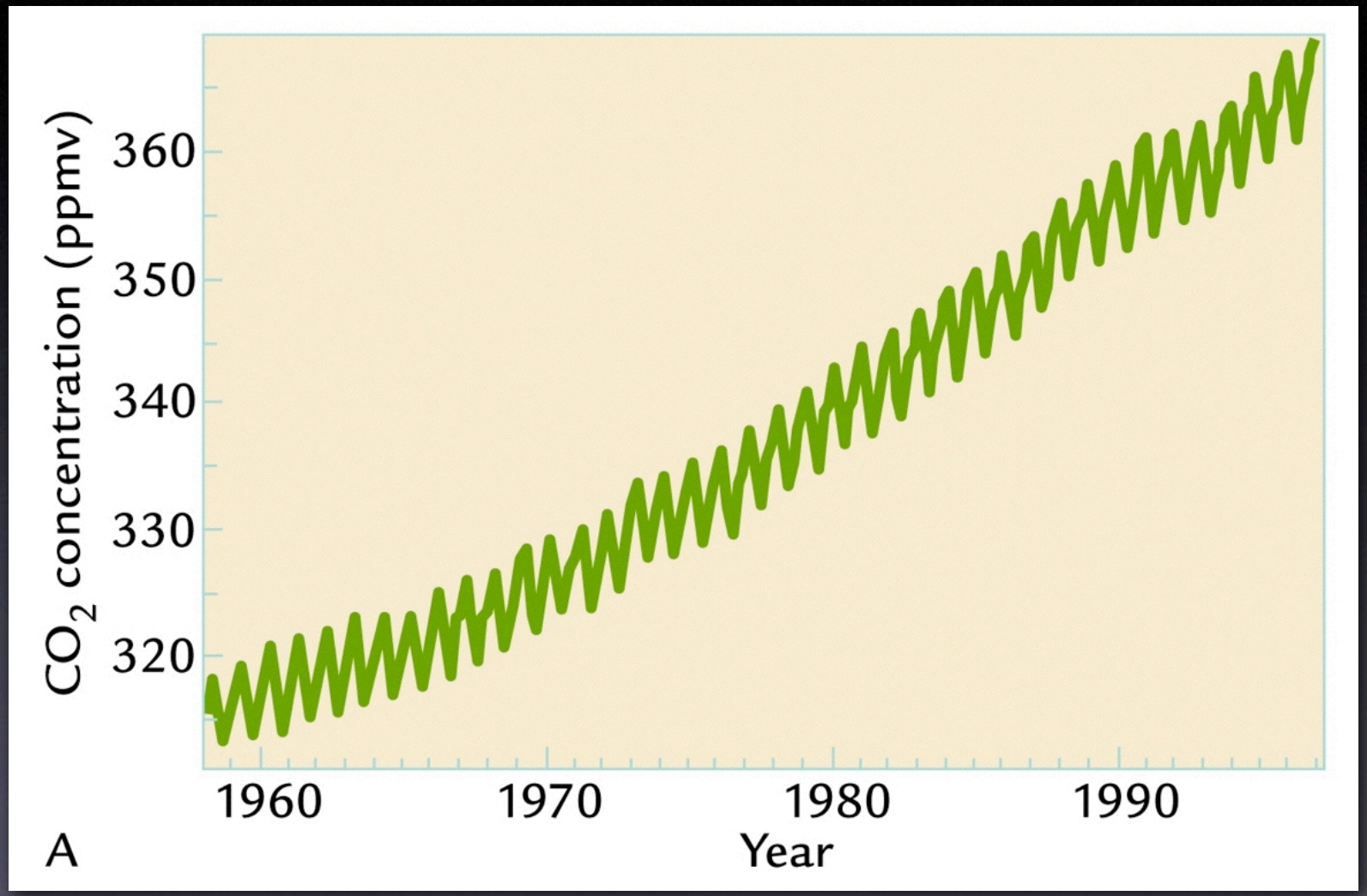
Image: NASA

Recent History of the Globe...

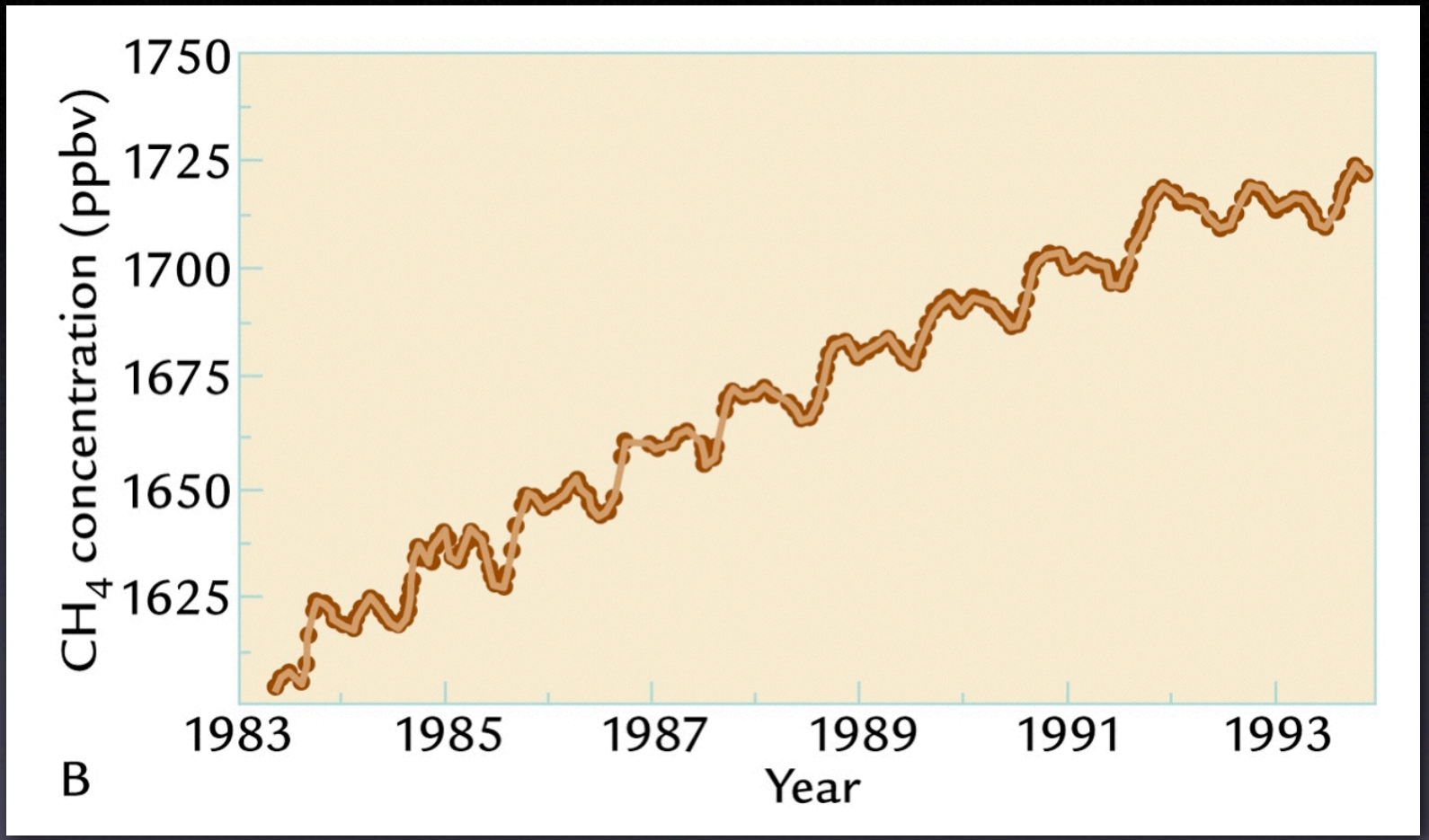
- between 1950 and 2000...
  - *population more than doubled*
  - *economy grew seven-fold*
- massive increase in *agriculture*
  - *food consumption almost tripled*
- and *energy use*
  - *fossil fuel use increased four-fold*
- *the planet has noticed*



Increasing Carbon Dioxide



Increasing Methane

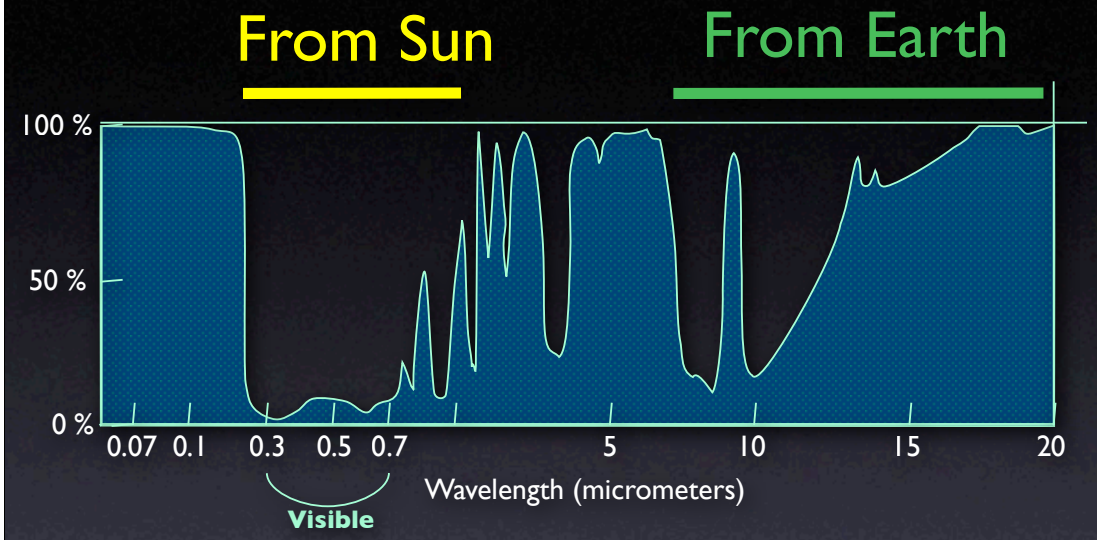


A Warming Planet

You've Heard This Before...

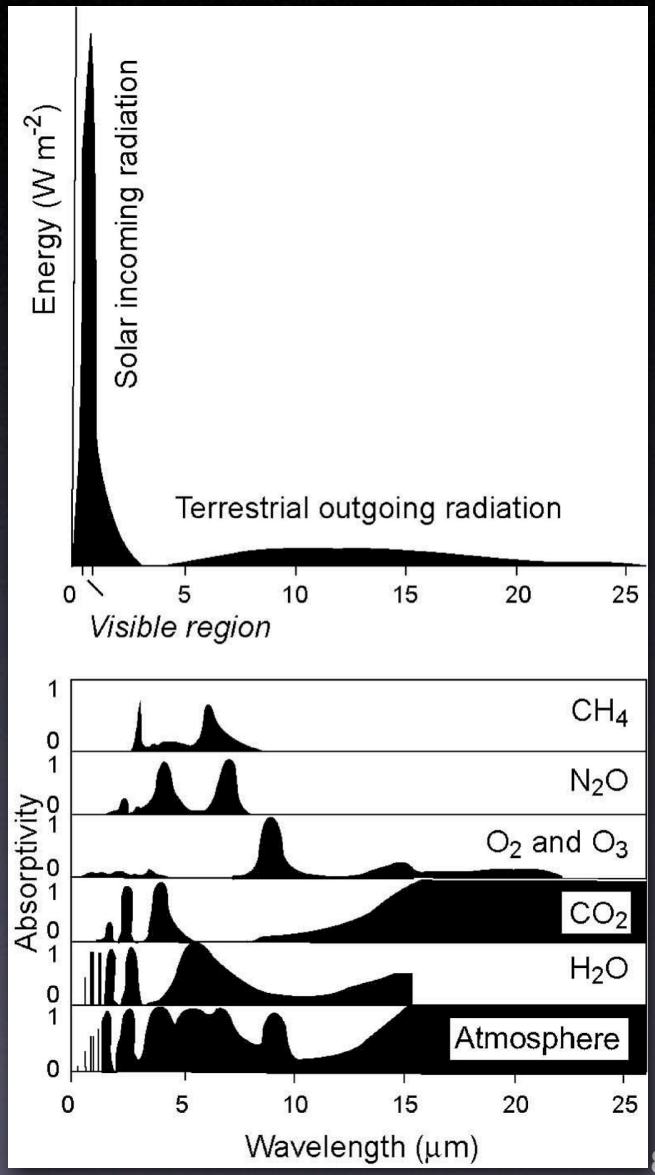
It's Just Physics 101

How Does It Work?

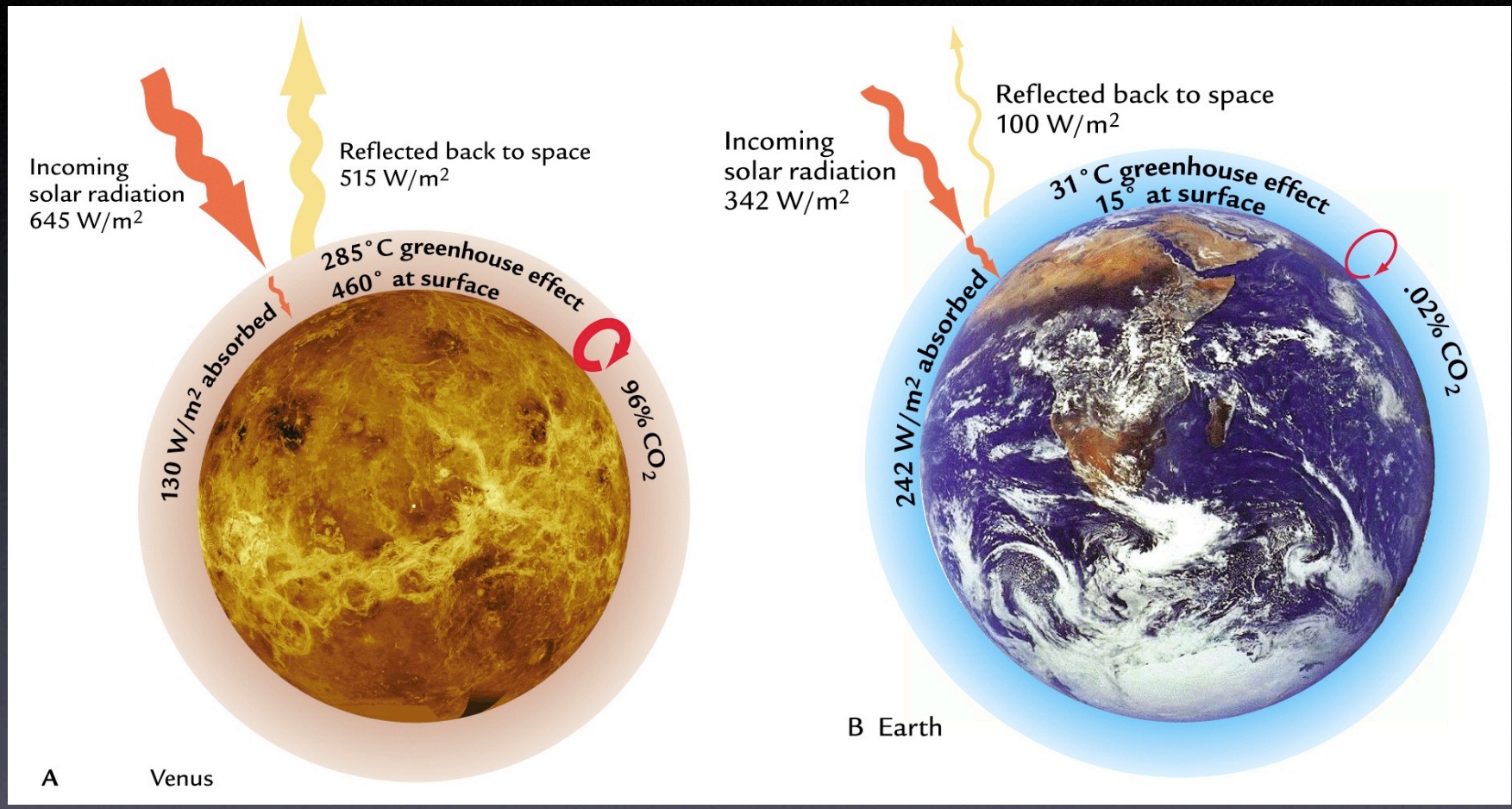


radiation absorbed by atmosphere

greenhouse gases



A Tale of Two Planets



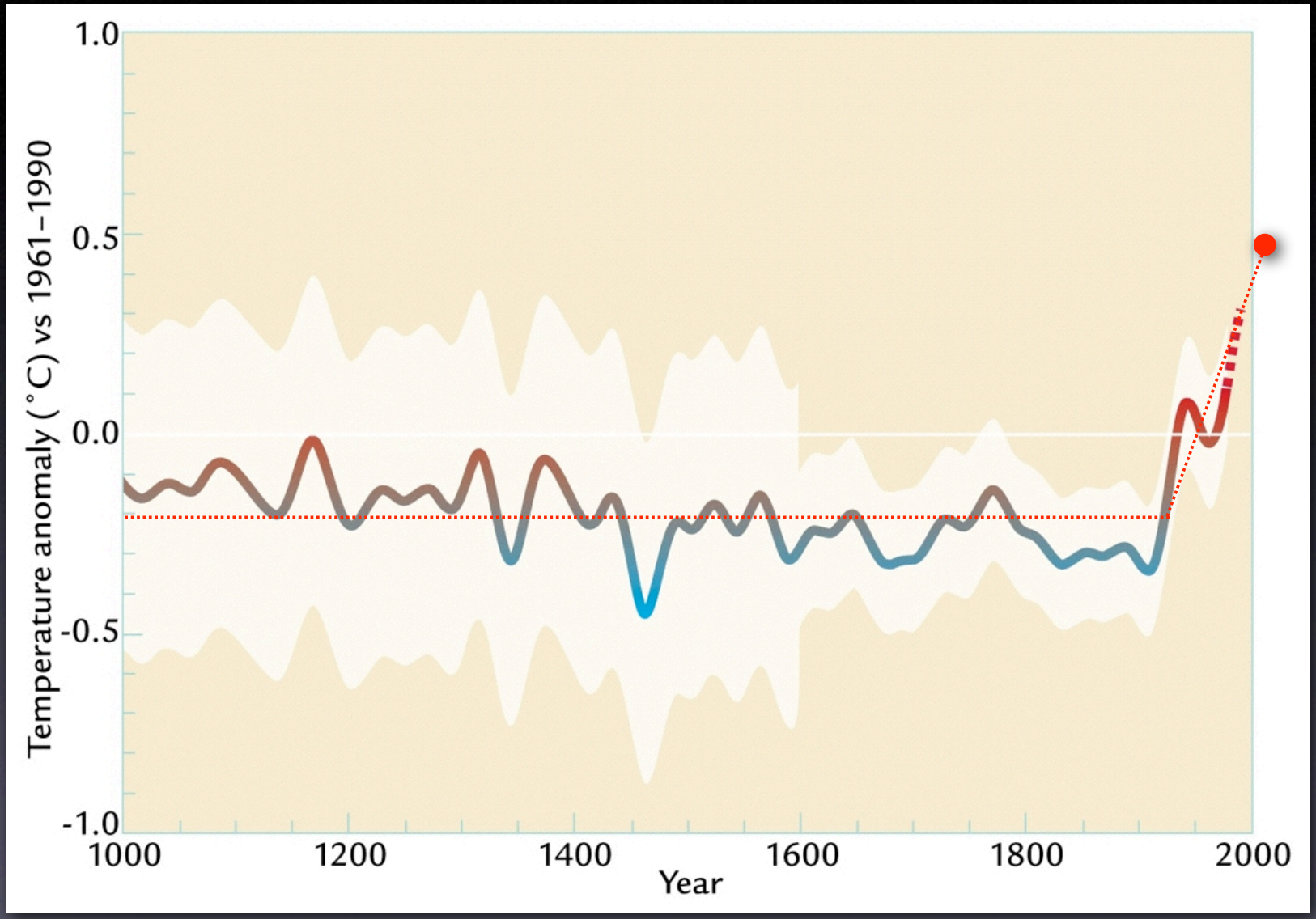
This is *Not* a New Idea

Svante Arrhenius

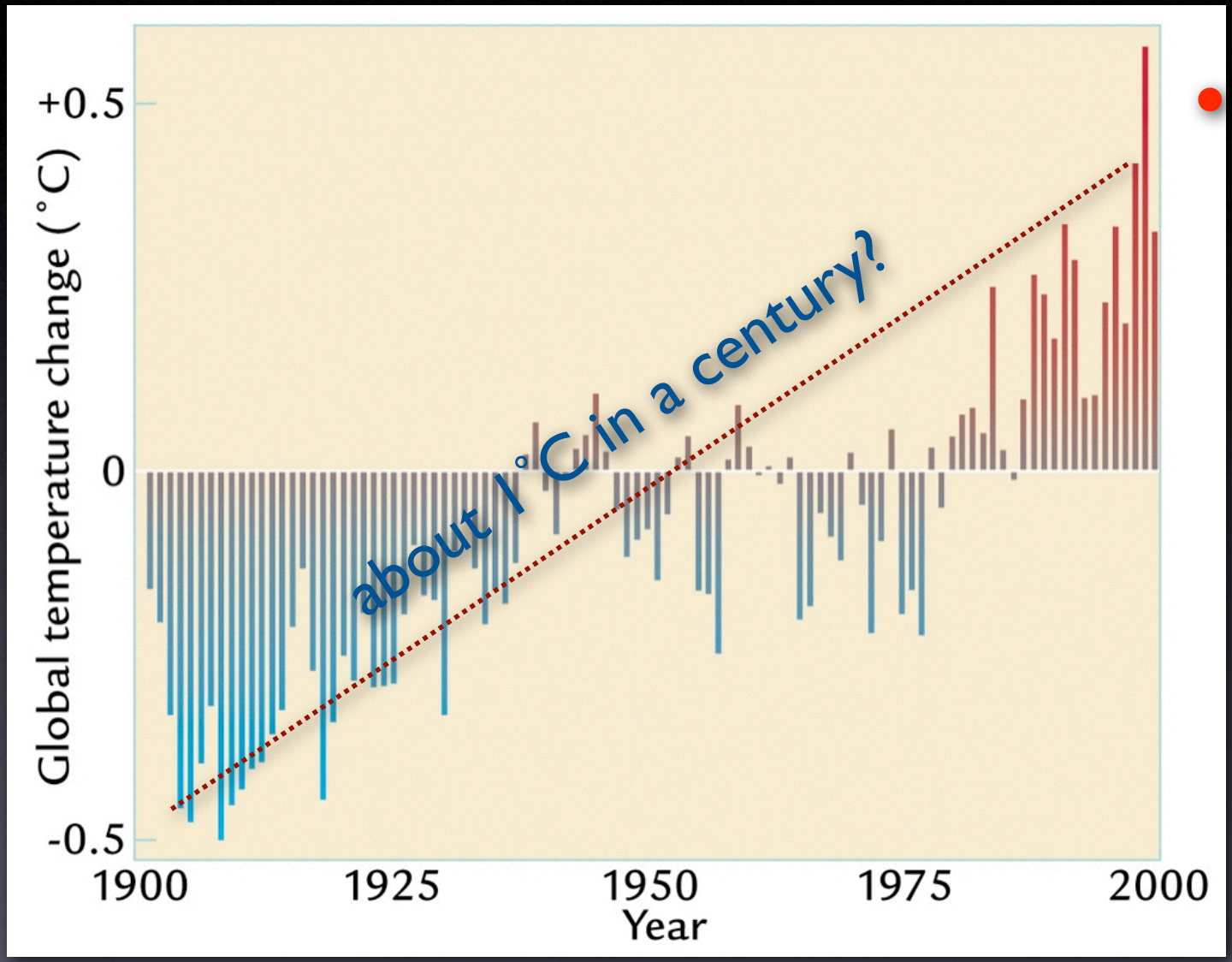
T.C. Chamberlain

The Data

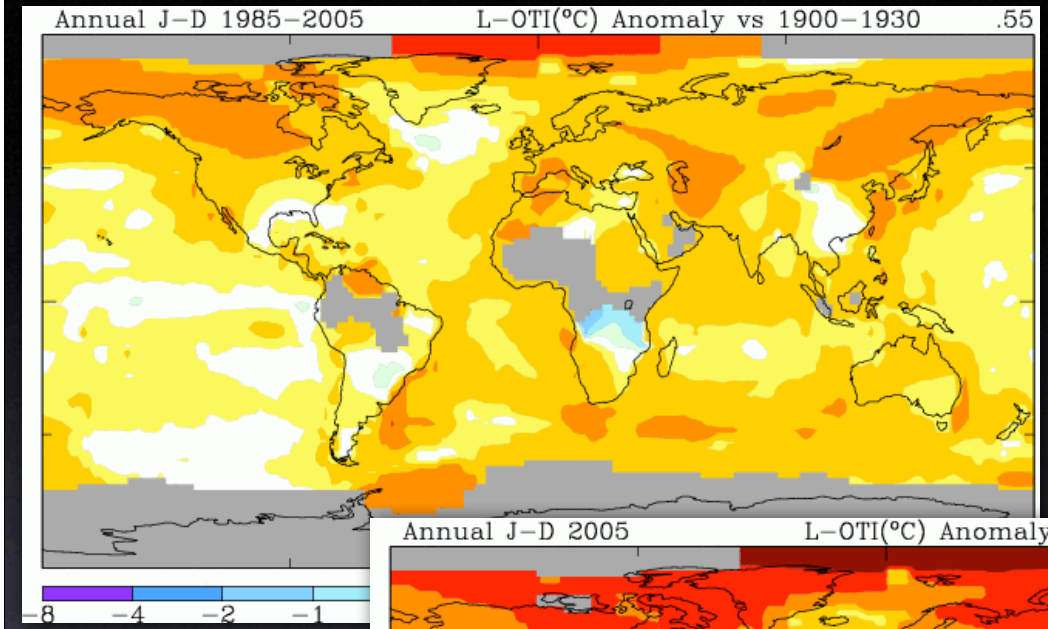
2nd Millennium Climate Record



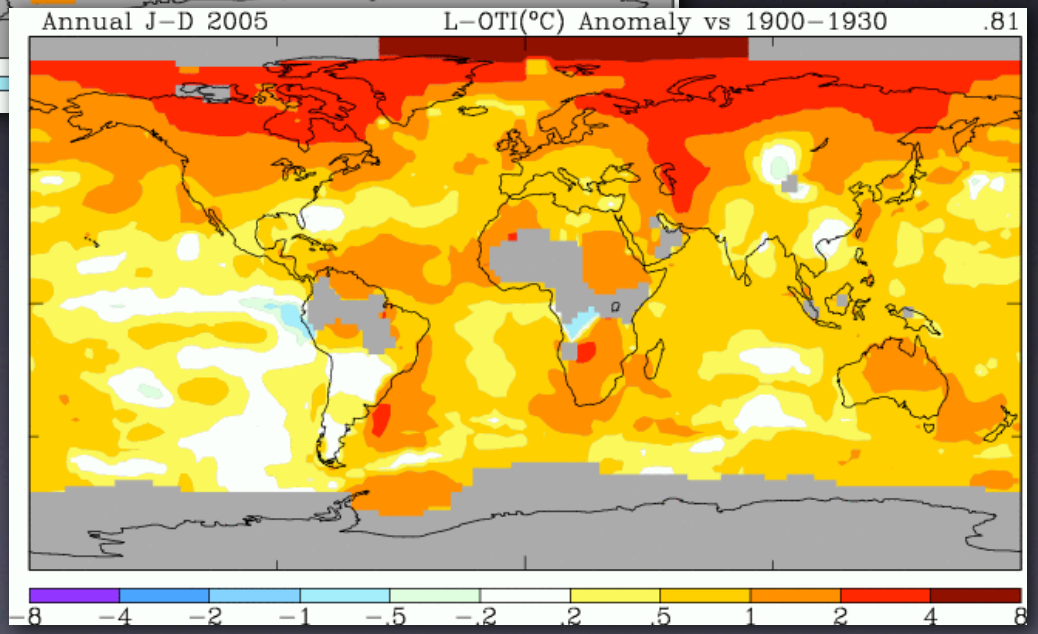
20th Century Warming



Patterns of Warming



1985-2005
compared to
1900-1930



2005
compared to
1900-1930

Image: NASA

Other Evidence

Other Evidence: Glaciers?

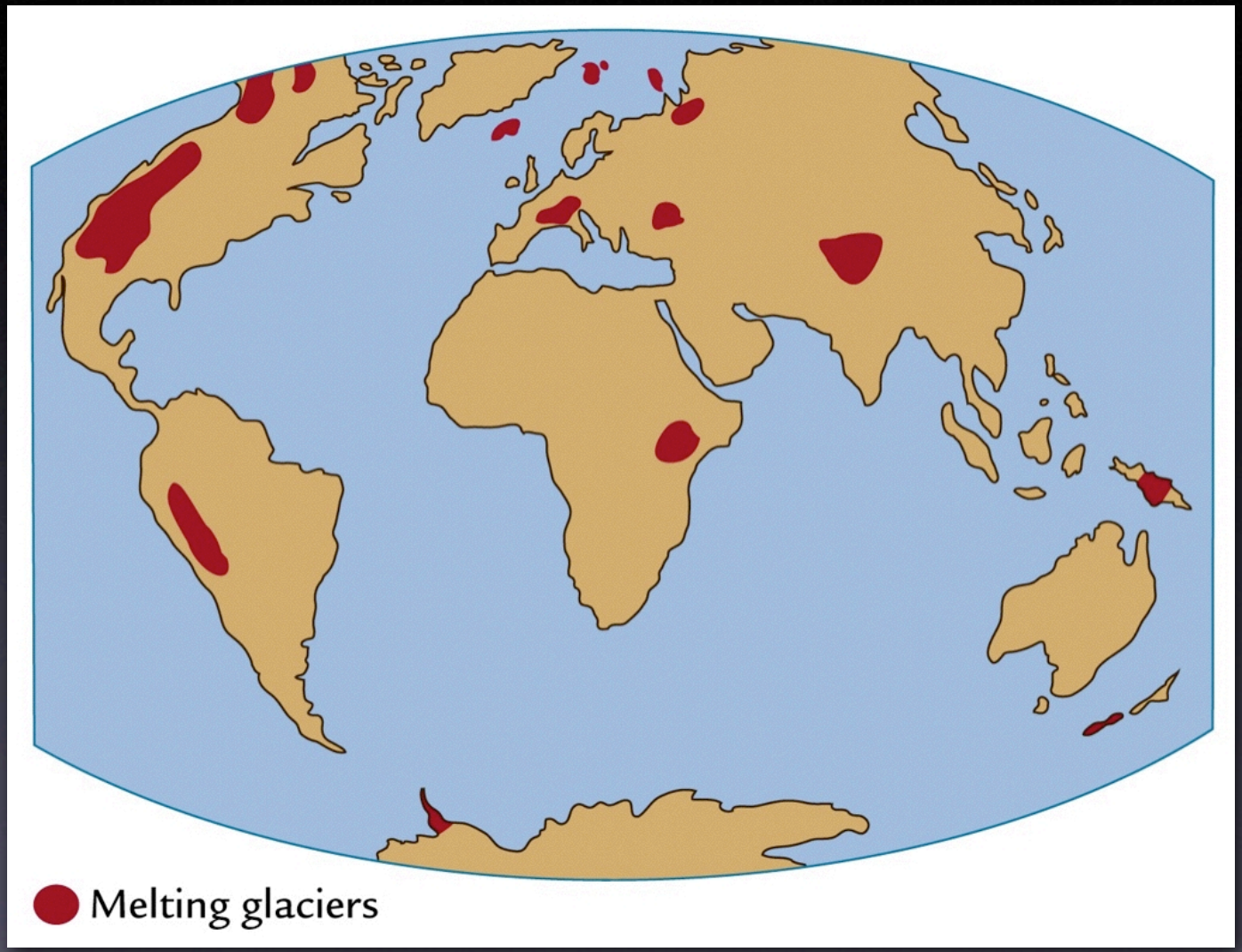
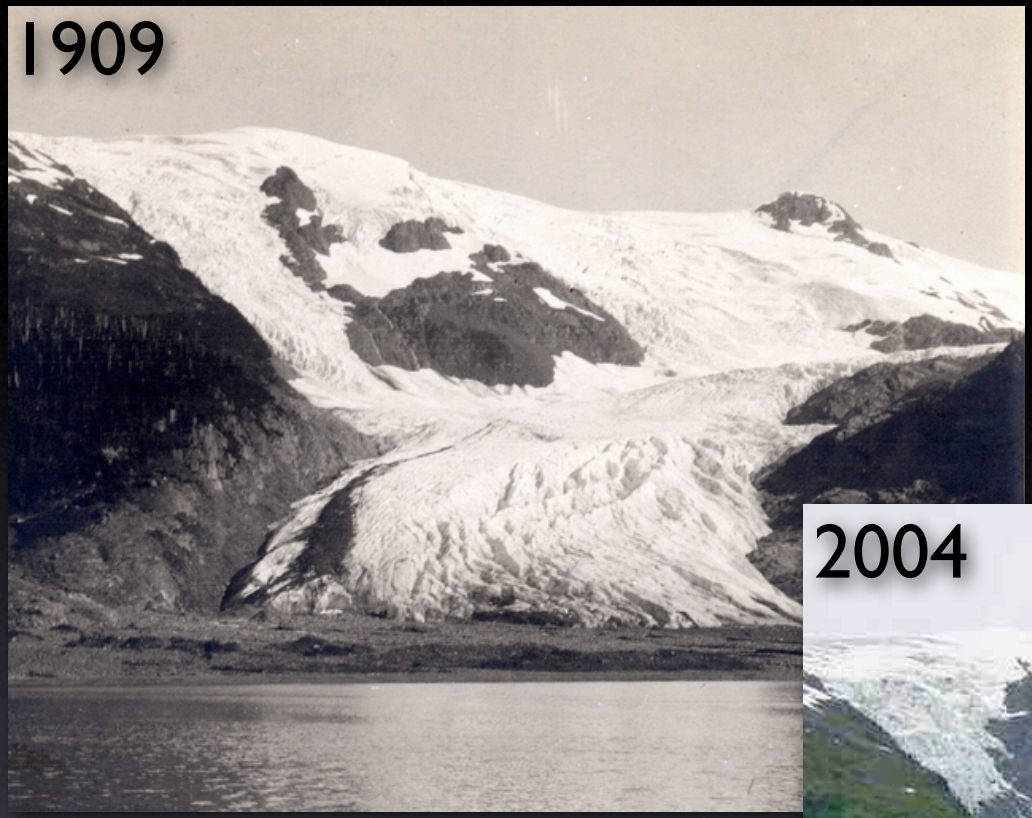


Image: Ruddiman

Muir Glacier, Alaska

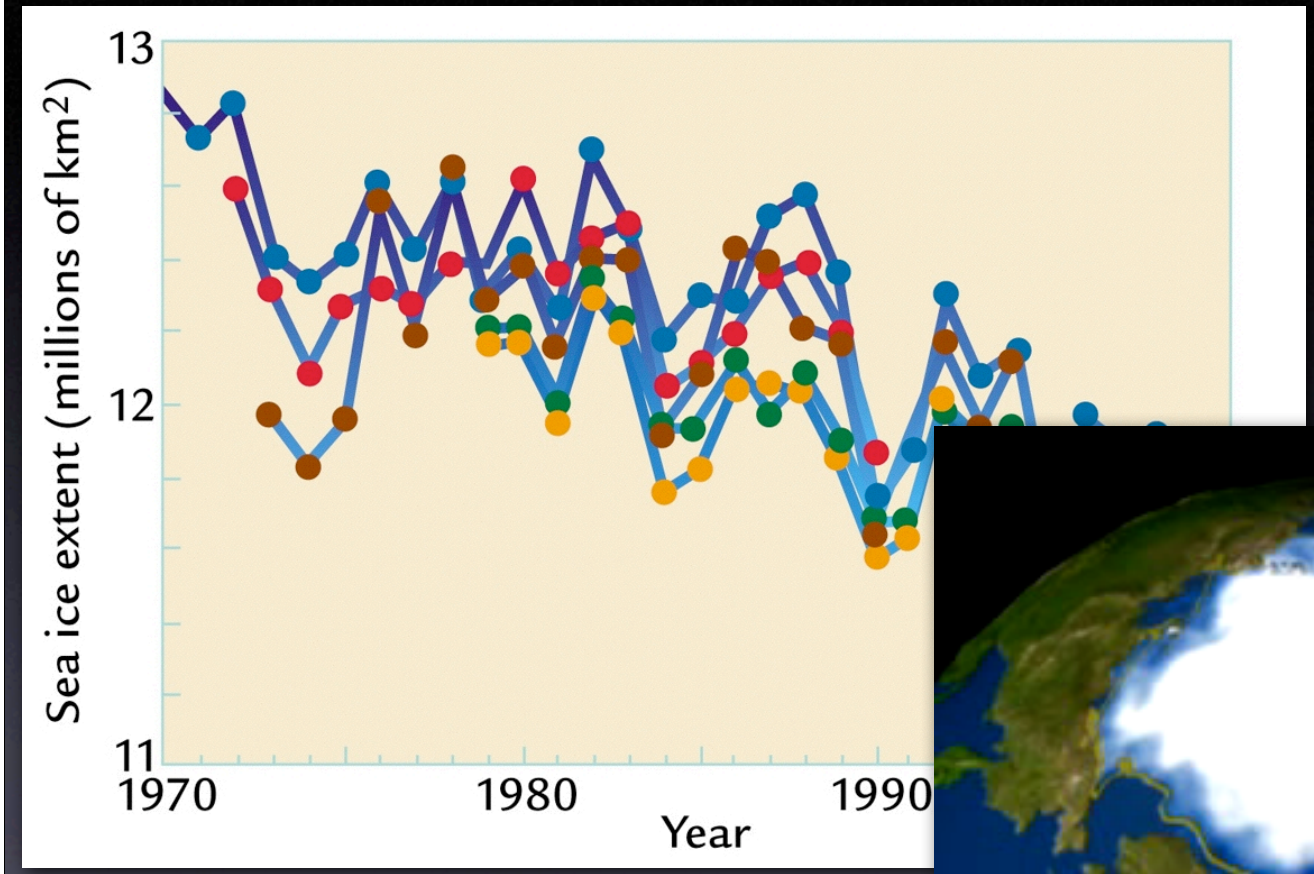
Online glacier photograph database. Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

Toboggan Glacier, Alaska



Online glacier photograph database. Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

Other Evidence: Sea Ice



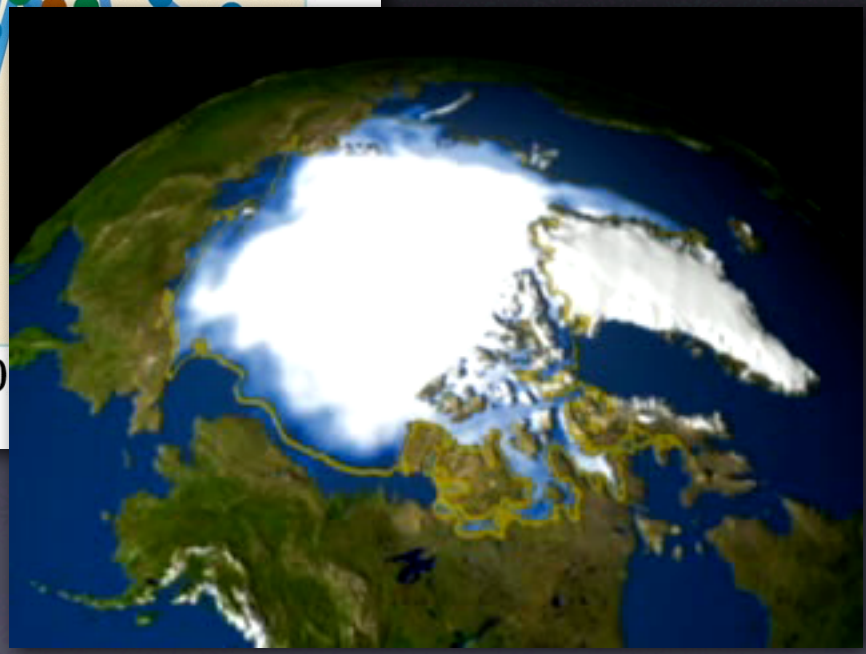
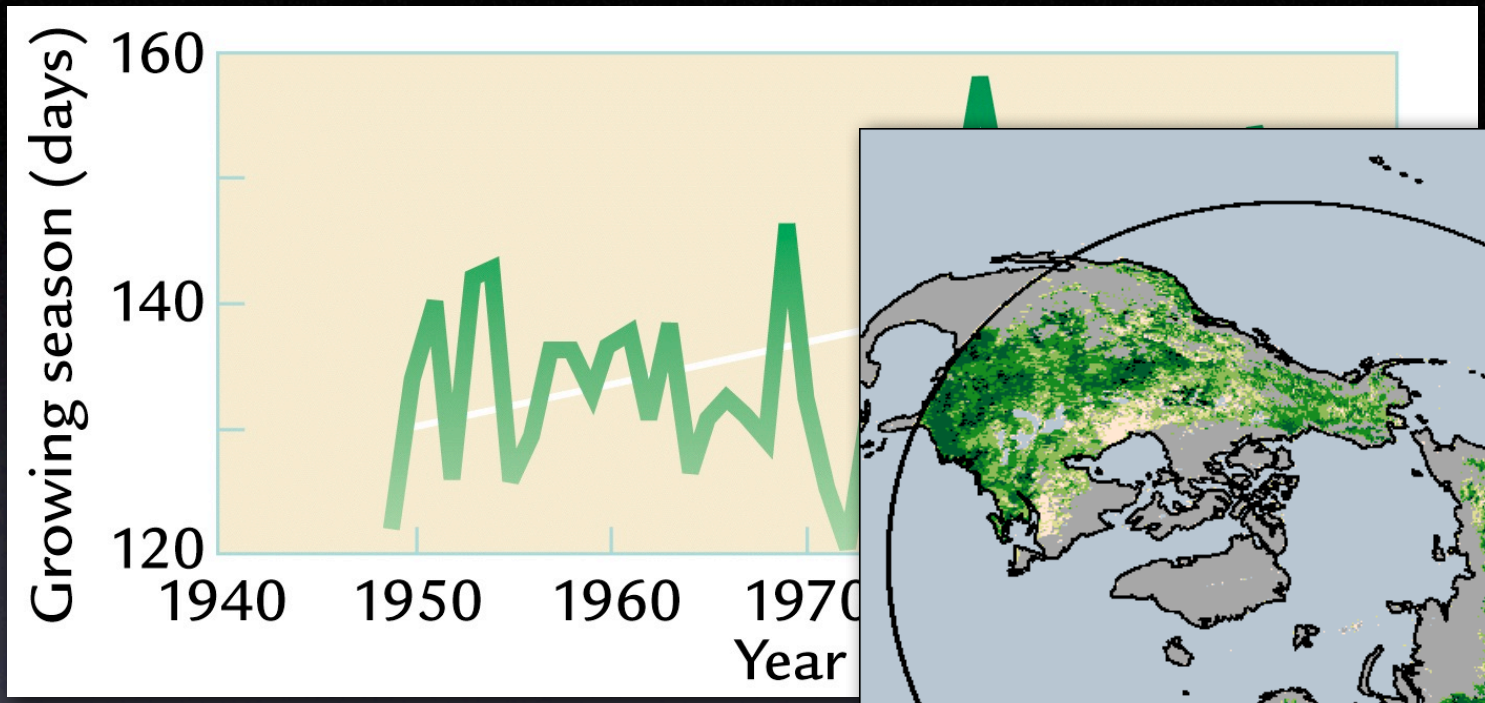


Image: Ruddiman, NASA

Other Evidence: Seasons



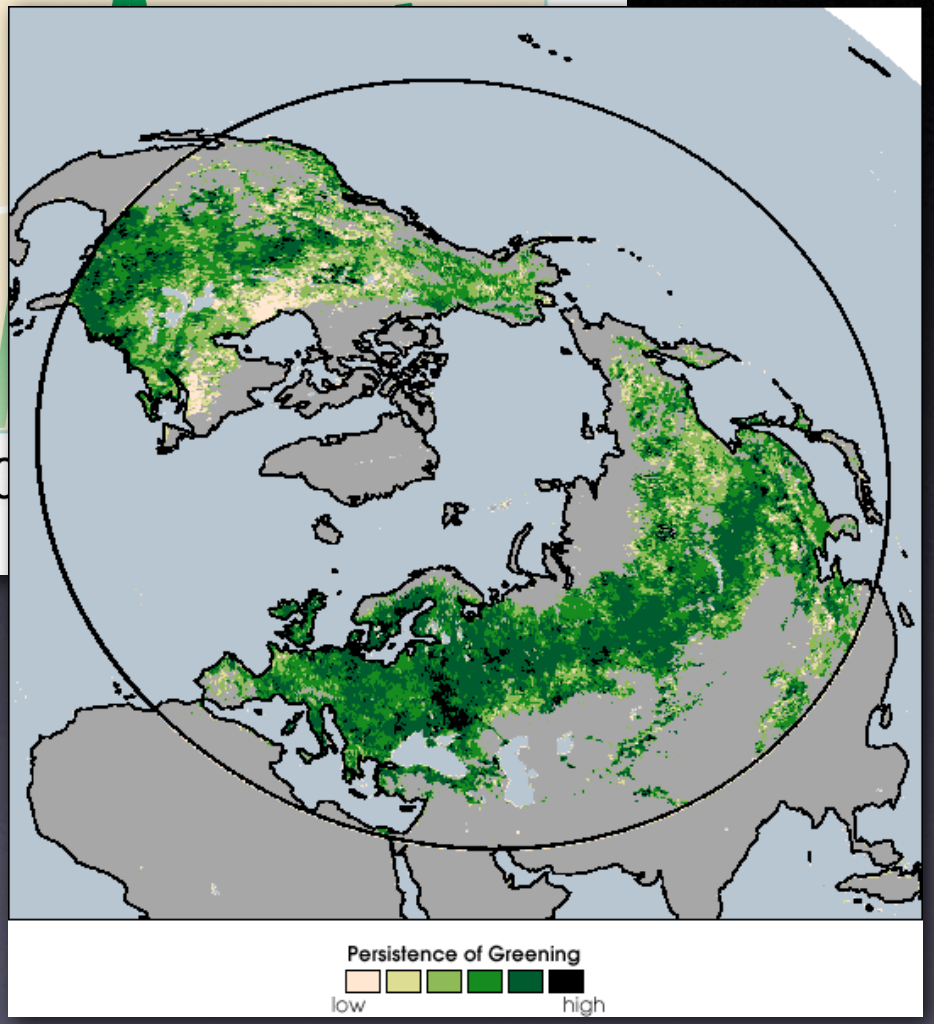


Image: NASA

Myth Busting

Image: Apple

"It's Just a Computer Model"

- *not true*

- I haven't shown you a single computer model
  - *firm basis in real-world observations*

- but guess what? *the models agree with reality*
  - *patterns and timing of warming are basically the same*

"The Scientists Aren't Sure"

- *absolutely not true*
- recent analysis of scientific data *(Oreskes, 2004)*
  - *928 peer-reviewed papers: evidence for human-induced warming*
  - *0 showed otherwise*
- all international scientific organizations agree
  - *IPCC*
  - *AMS, AGU, AAAS, etc...*
- handful of professional "skeptics" -- that's all

"It's a Left-Wing Eco-Conspiracy"

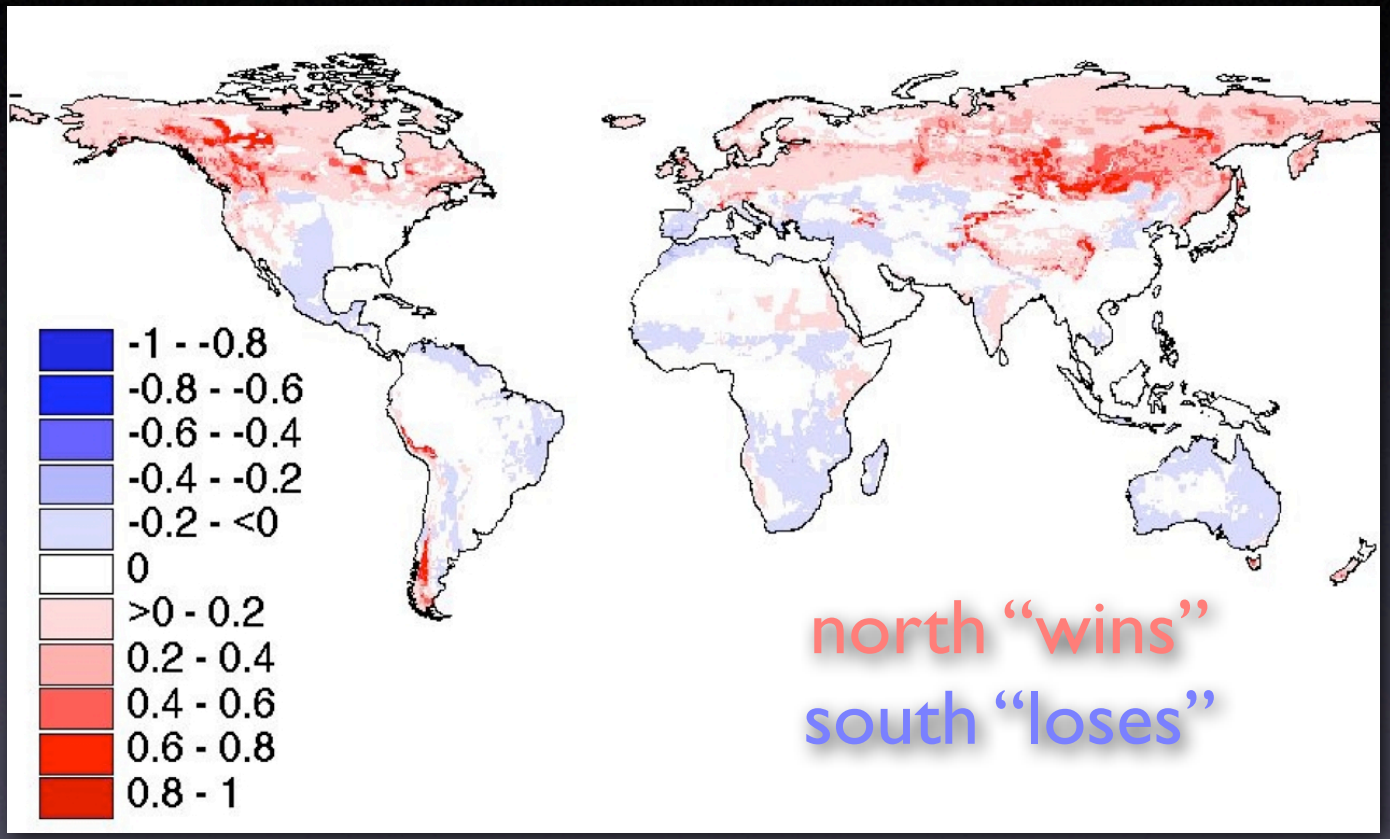
- *this isn't about politics...*

Human Dilemma

Image: Apple

Food Security Impacts

- changes in agricultural production?



Source: Ramankutty et al., 2002

Health Impacts

~150,000 deaths / year *already*

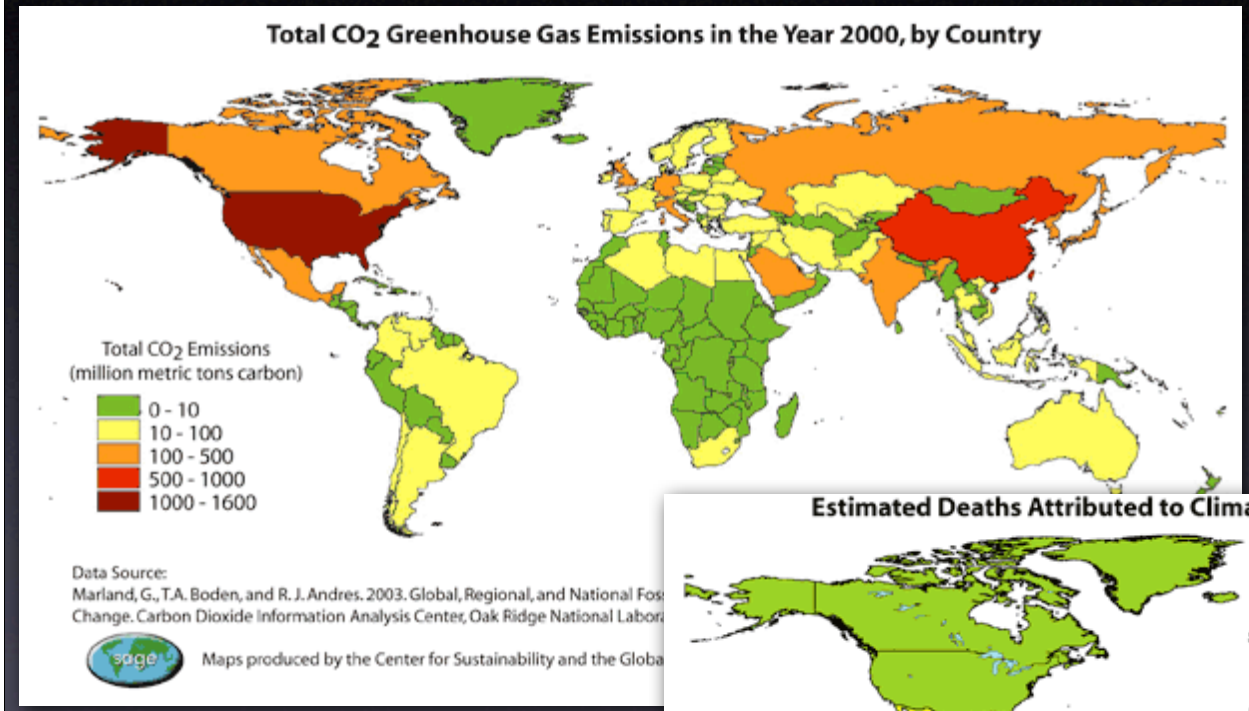
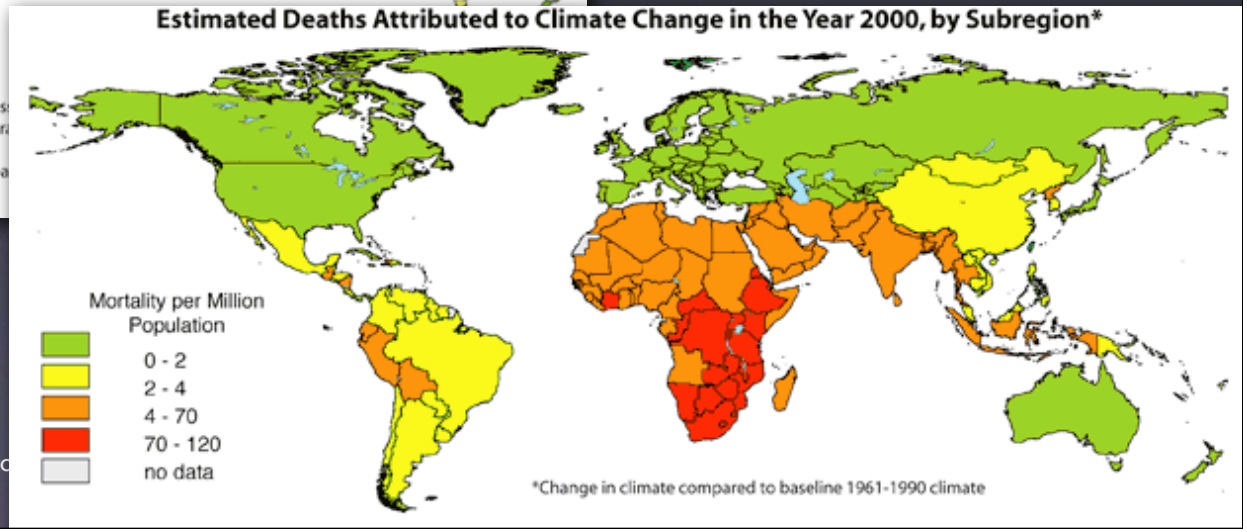


Image: Patz et al., Nature, 2005



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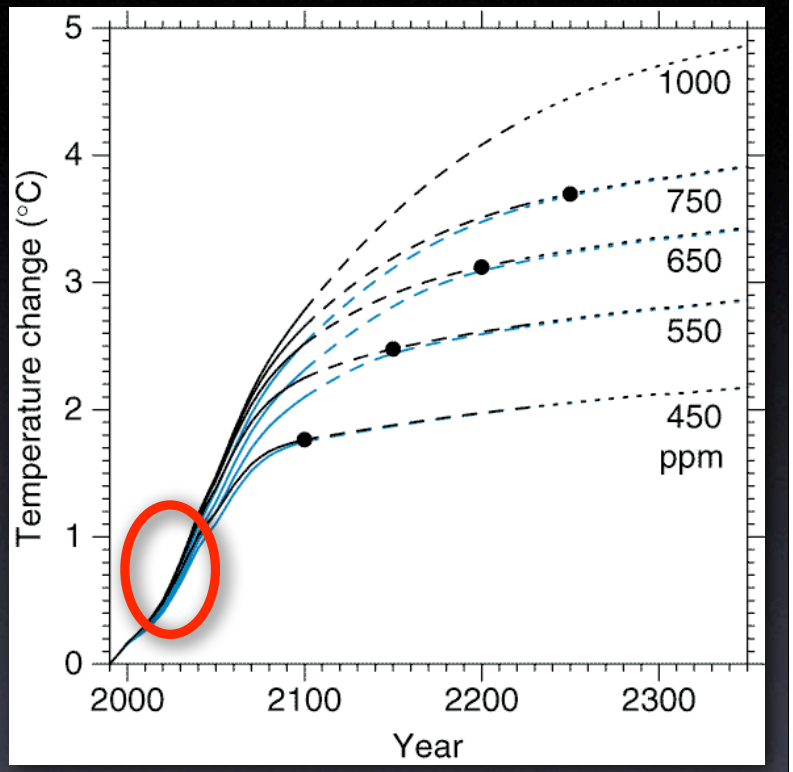
Hardest Hit by Climate Change

- sensitive regions
  - *Arctic, coral reefs, tropics, small island nations, ...*
- major irony: *these people emit little CO_2!*

- strategic threat
- moral issue
- losses will become irreversible, unless actions are taken <u>now</u>
  - *narrow window to prevent catastrophic losses*

Running Out of Time

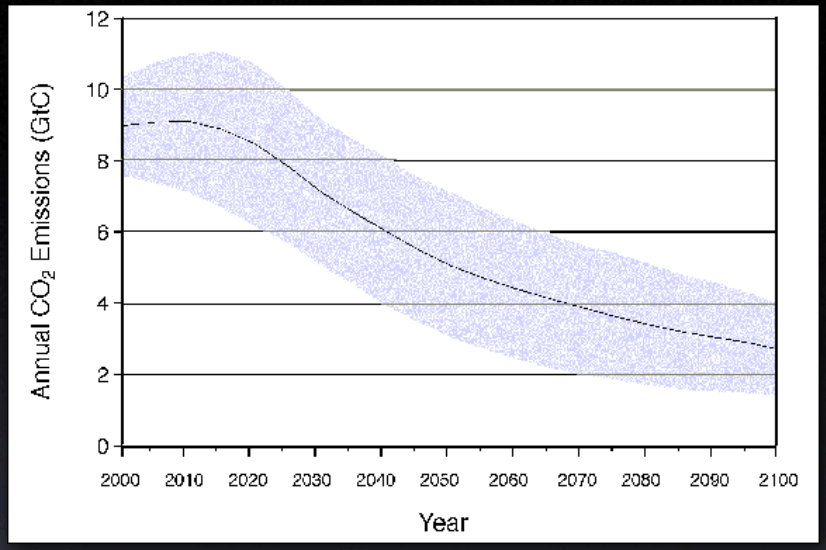
- huge inertia in system
  - *CO_2 in atmosphere ~110 years*
  - *"thermal lag" ~decades*
- we can't wait and then"stop on a dime"
- narrow window to prevent catastrophic losses
  - *if we're lucky, we have a decade -- maybe two -- to get started*



Steps Forward?

Avoid *Dangerous* Change

- what is "dangerous"?
  - *globe > 2° warmer?*



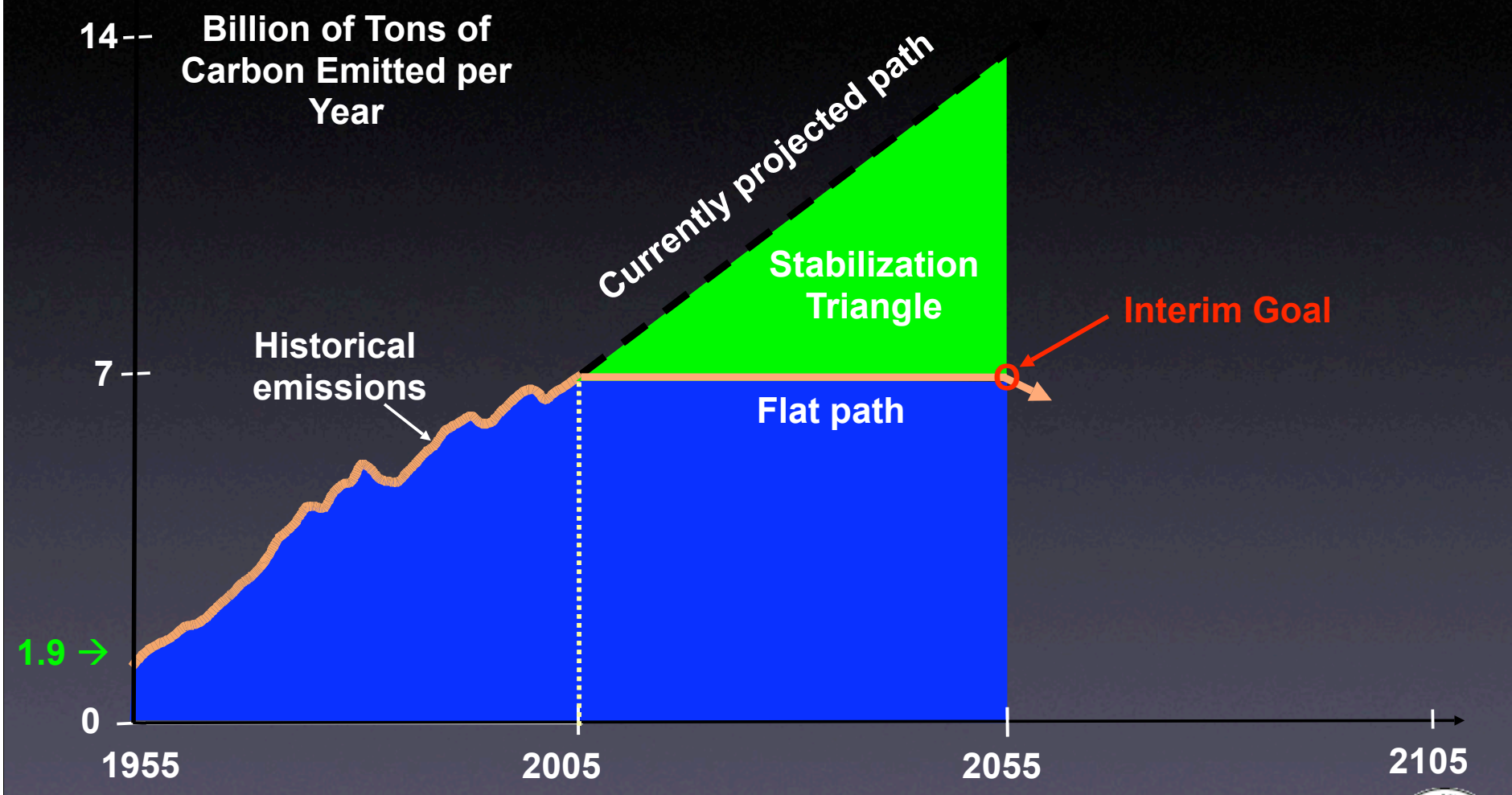
- growing consensus
  - *stabilize CO_2 ~450 ppm*
  - *requires emissions stabilization within 10-20 years*
  - *further emissions reduction within 50-70 years*

- we are *way* off from doing this...
  - *emissions continue to grow every year*

A Good First Step

- *stabilizing* emissions to current (2006) levels now, and hold for next 50 years
- *then* start to lower emissions
- so what can we do about the stabilization problem?

Stabilization Triangle



Images & Data from Robert Socolow, Princeton University

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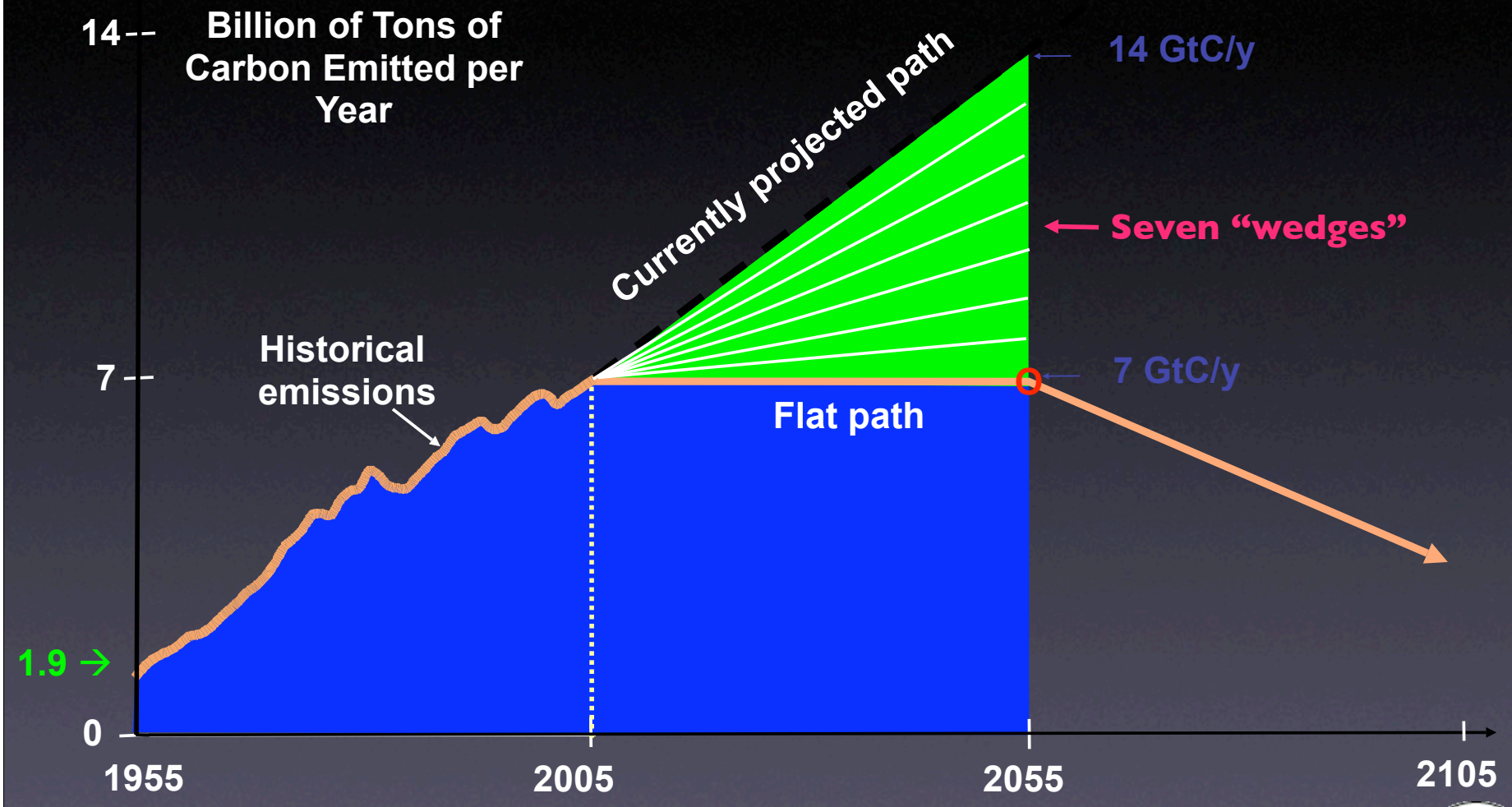
Socolow Wedges



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Carbon Mitigation Initiative

Efficiency and Conservation

transport

buildings

industry

Effort needed by 2055 for 1 wedge:

e.g., 1 billion cars at 40 mpg instead of 20 mpg

power

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Carbon Mitigation Initiative

Wind Electricity

Effort needed by 2055 for 1 wedge:

One million 2-MW windmills displacing coal power.

Today: 40,000 MW (2%)

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Nuclear Electricity

Effort needed by 2055 for 1 wedge:

700 GW (twice current capacity), displacing coal power.

But phase out of current nuclear power plants creates the need for another half wedge.

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Carbon Capture & Storage

The Wabash River
Coal Gasification Repowering Project

Effort needed by 2055 for 1 wedge:

Carbon capture and storage at 800 GW coal power plants.

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14 *Possible* Wedges, Need 7

1. Increase electric efficiency
2. Increase transport efficiency
3. Increase heating efficiency
4. Fuel switching for electricity
5. Fuel switching for heat production
6. Carbon capture and storage for electricity generation
7. CCS for hydrogen production
8. Nuclear energy for electricity
9. Nuclear energy for hydrogen production
10. Wind power for electricity
11. Wind power for hydrogen production
12. Solar electricity
13. Biofuels
14. Natural sinks

Nuclear Power is not "the" Solution to Climate Change

- there is no single "silver bullet"
- but it's potentially *part* of the solution

- still big questions, though...
  - *climate: CO_2 emissions from entire nuclear power life cycle?*
  - *economics: do we really know all of the costs?*
  - *public opinion: is this really going to fly?*


Avoiding Climate
Disruption is
Going to be Hard

But It's a *Good Opportunity* for Wisconsin

First Steps

- goal: cut family emissions by 50%, compared to other Wisconsin households

- offset remaining emissions
  - *planting trees, restoring prairies*
  - *helping conserve energy elsewhere*

we didn't meet our goal

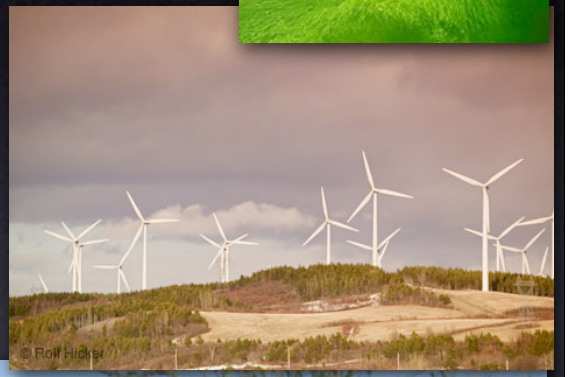
we exceeded it

So, how many Foley's does it take to change a light bulb?

Toyota Prius
50% less CO_2, 90% less NO_x

New Energy Systems

- first generation renewables
  - *wind already cost-effective, solar is getting there*
- new biological systems?
  - *switchgrass ethanol*
  - *bioreactors (wastewater, manure, landfills)*
- energy farms?
  - *Brazil: hydrocarbon exporter by 2015?*
  - *Wisconsin: wind above, grass below?*



Facing the Future

Facing the Future

- won't be easy
- but a major opportunity
  - *technical feasible, only requires vision & leadership*
  - *could be the biggest business opportunity in human history!*
- decades of effort
  - *whole new energy systems*
- we need to be in league with the future
  - *previous generations have done it*

"The Future is up for grabs...

It belongs to any and all who will take the risk and accept the responsibility of consciously creating the future they want."

- Robert Anton Wilson


Thank You