

# Basics of Climate Science

MIT Joint Program on the Science  
& Policy of Global Change - IAP  
Climate Lecture Series 2016

B. B. Cael - 19 Jan 16

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‘a mote of dust suspended in a sunbeam’ - Carl Sagan



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# Overview of week



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TUE • JAN 19

## **BASICS OF CLIMATE SCIENCE**

**E51-315 • 5:30PM–6:30PM • B.B. Cael**

Given the hype and controversy surrounding climate change, we'll start with the basics, surveying the history & fundamentals of climate science, radiation and greenhouse gases, the carbon cycle, and the earth's heat storage.

## **CLIMATE POLICY 101: EVALUATING CLIMATE POLICY OPTIONS**

**E51-315 • 6:30PM–7:30PM • Samantha Houston and Katie Mulvaney**

How can the world respond to what science reveals about climate change? To understand options for climate policy, we'll go over basic economic concepts, climate policy instruments, and tools for evaluating policy.



# Overview of week

WED • JAN 20

## **MECHANISMS OF CLIMATE CHANGE**

**E51-315 • 5:30PM–6:30PM • Mara Freilich**

There are many feedback systems and possible tipping points in the climate system; this nonlinearity makes prediction difficult. We will discuss mechanisms of the climate system; Earth system models; the role of clouds, oceans, land cover, and biology in the climate system; and how extreme weather relates to climate change.

## **CLIMATE POLICY 102: CLIMATE GOVERNANCE**

**E51-315 • 6:30PM–7:30PM • Samantha Houston and Katie Mulvaney**

Climate policy can be enacted at both the international and the domestic level. We will go over the history and status of international climate governance (including the 2015 Paris Climate Negotiations), as well as national forums for climate governance.

# Overview of week

THU • JAN 21

## CLIMATE CHANGE & UNCERTAINTY

E51-315 • 5:30PM–6:30PM • Megan Lickley

In this session we will discuss the sources of uncertainty in climate projections, the range of possible future outcomes, and how that translates into uncertainty in climate impacts both globally and locally. We will cover topics such as the rate of warming, sea level rise, storm activity, and precipitation changes and how uncertainty in these changes make it more challenging to adequately prepare and adapt to climate change.

## CLIMATE POLICY IN ACTION

E51-315 • 6:30PM–7:30PM • Interactive Panel Discussion

Local climate science and policy leaders discuss implementing creative solutions to climate change, from community activism to policy at the local and national scale.



# Overview of week

FRI • JAN 22

## WORLD CLIMATE NEGOTIATIONS SIMULATION

E51-315 • 5:30PM–7:30PM • Interactive Group Project

Designed as part of Climate Interactive's World Climate Project, this activity provides participants with some insight into the challenges of coming to a global climate agreement. Participant groups will represent regions of the world with various goals for mitigation, adaptation, and economic growth, then participate in a mock international climate negotiation. The computer simulation C-ROADS will be used to examine the outcomes of the mock negotiation in real-time.

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Jan 24 - Tu BiShvat Seder for Palestine, Climate, and Racial Justice

Jan 25+6 - From Turbines to Tariffs: Technical & Regulatory Issues for Scaling up Wind Energy

Jan 27 - Symposium: MIT on Climate = Science + Action

Jan 29 - ESI & Climate CoLab Hackathon for Climate

# Overview of today

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- History of Climate Science



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- Radiation & Greenhouse Gases

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Intended Learning Outcome:

Be comfortable discussing the fundamental scientific principles which describe how the climate system can change

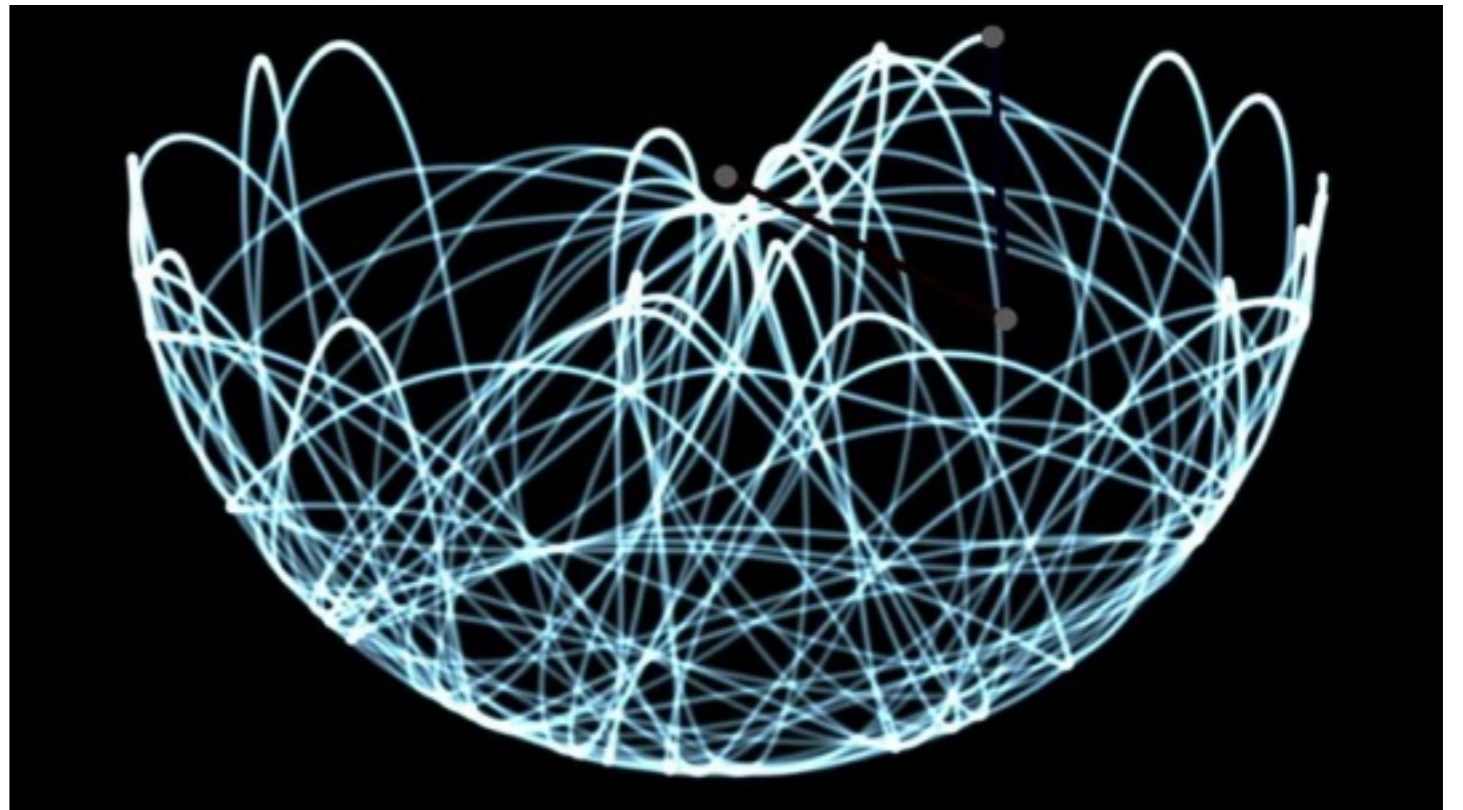
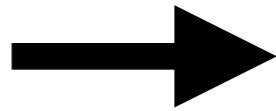
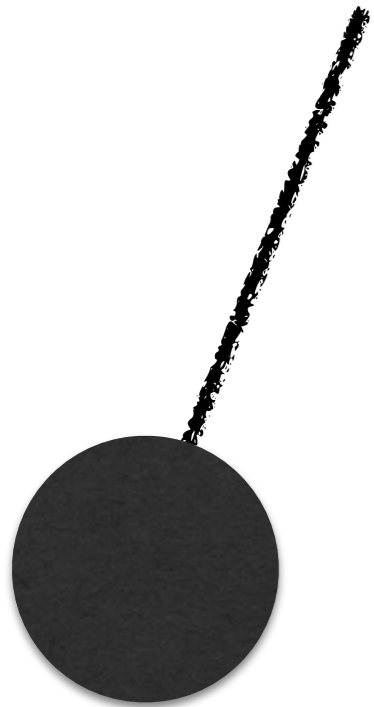
Sound Hard? Not so!

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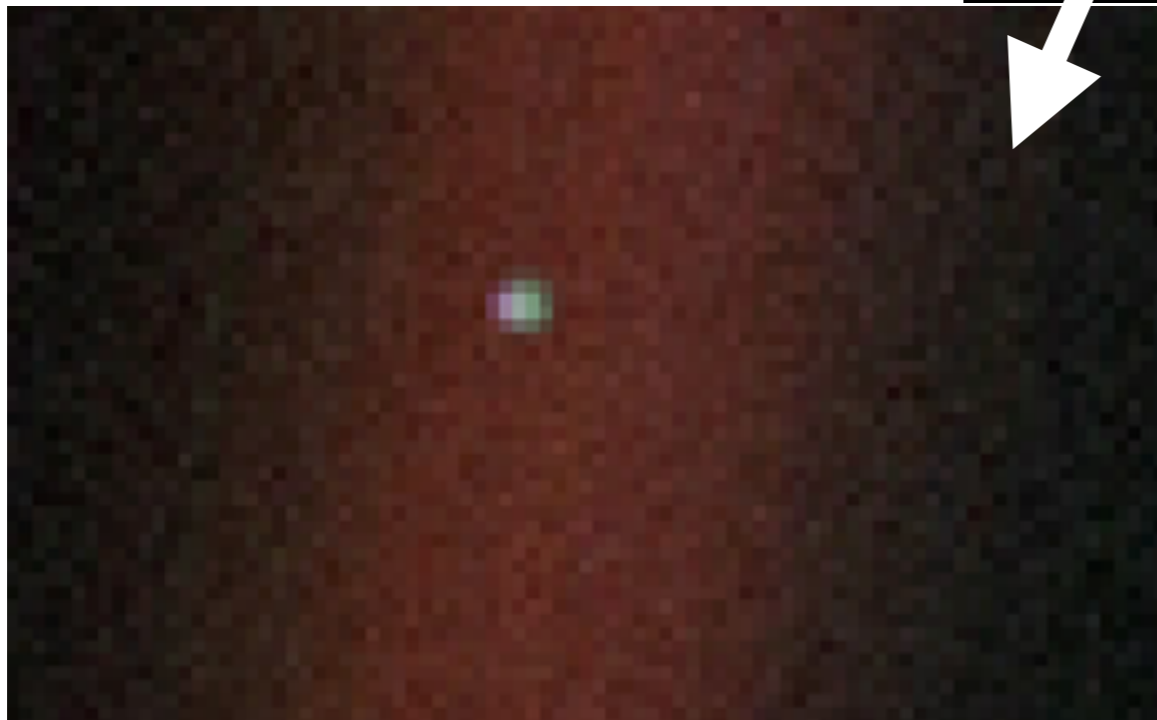
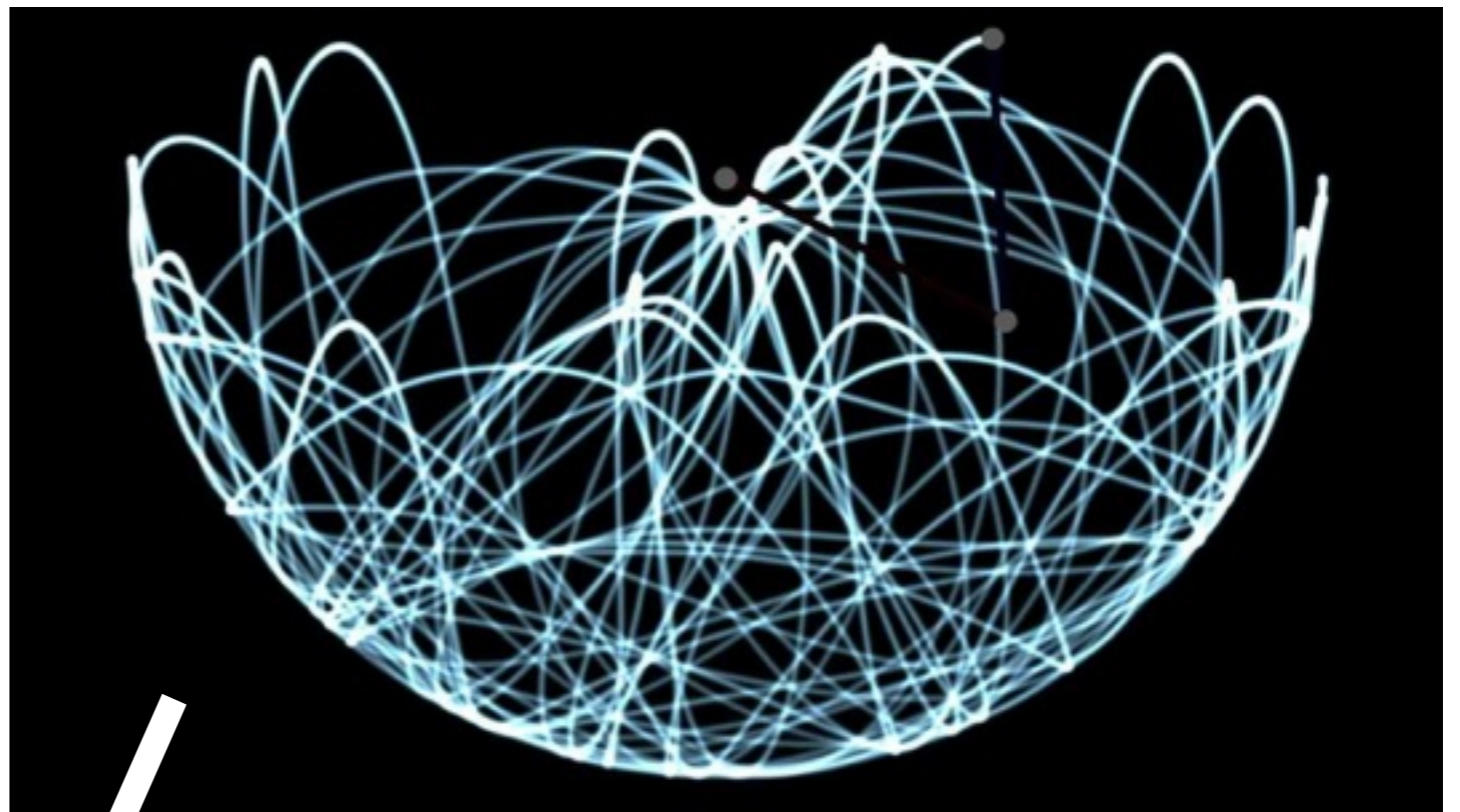
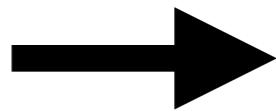




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# What is 'Climate'?

- A. The weather outside today
- B. The difference between the weather here & the weather in Singapore
- C. The average of the weather here over the last year
- D. The average & variability of the weather here over the last 30 years
- E. The range in weather across the history of the earth

# What is 'Climate'?

The statistics [mean & variability] of weather over decadal timescales

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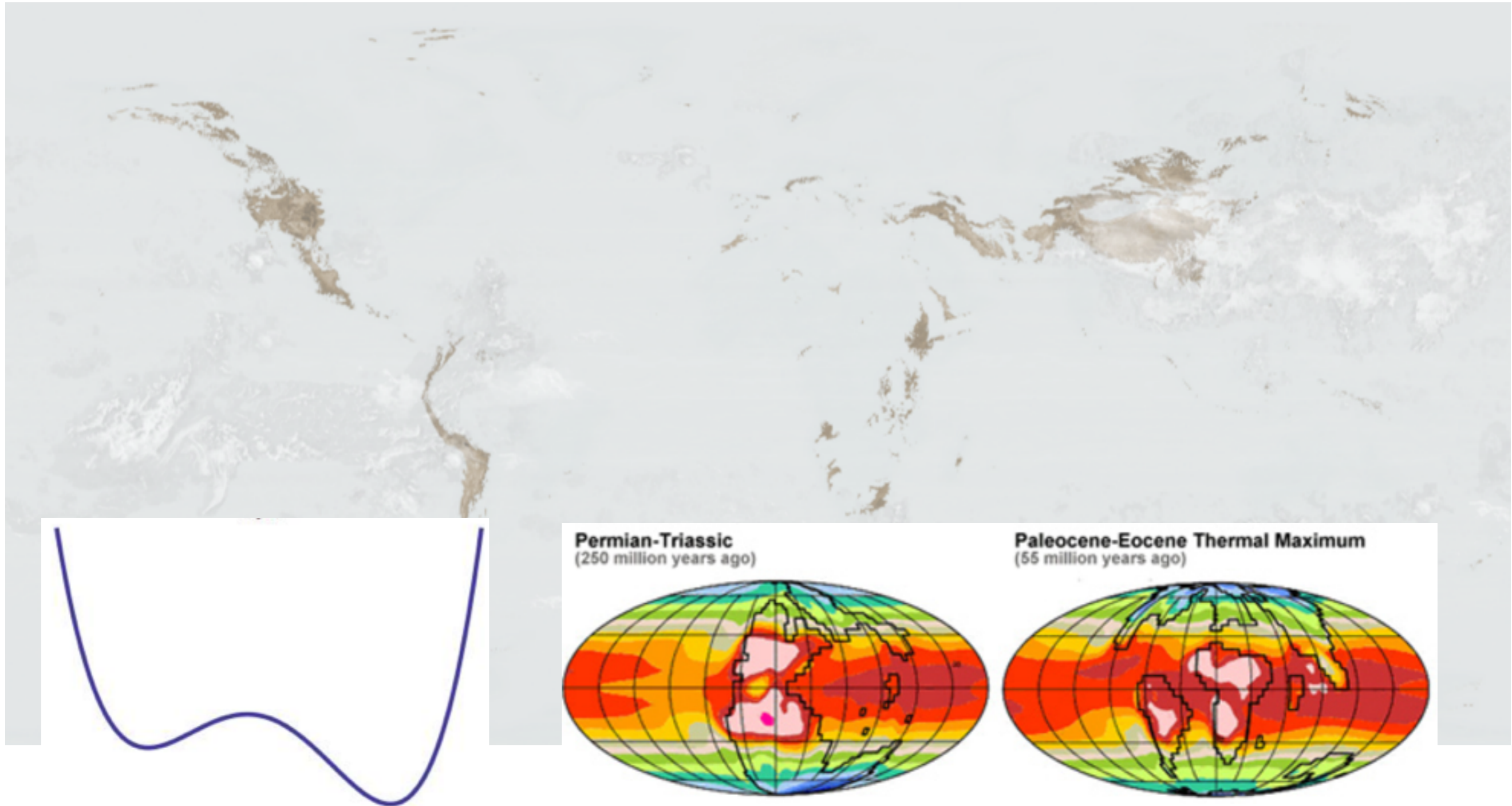
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# What is 'Climate Change'?

Changes in the statistics [mean & variability] of weather over decadal timescales - 'typical states' of the earth are different



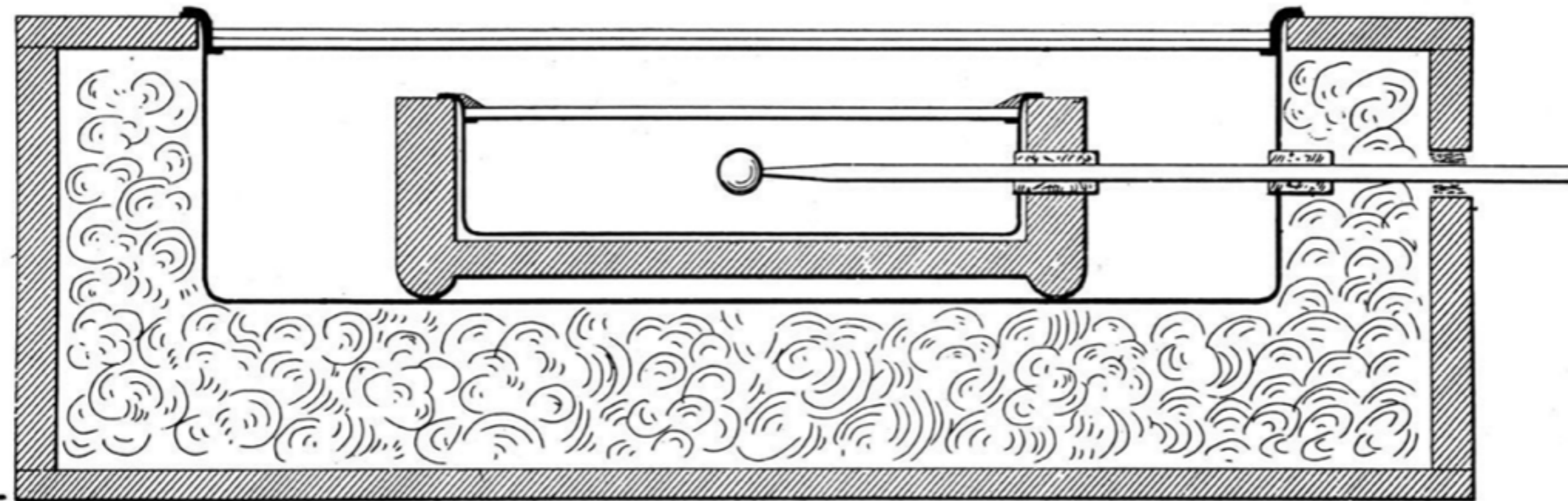
# What is 'Climate Change' for the world as we know it?



What 'Impacts of Climate Change' do we hear about?

# A Brief History of Climate Science

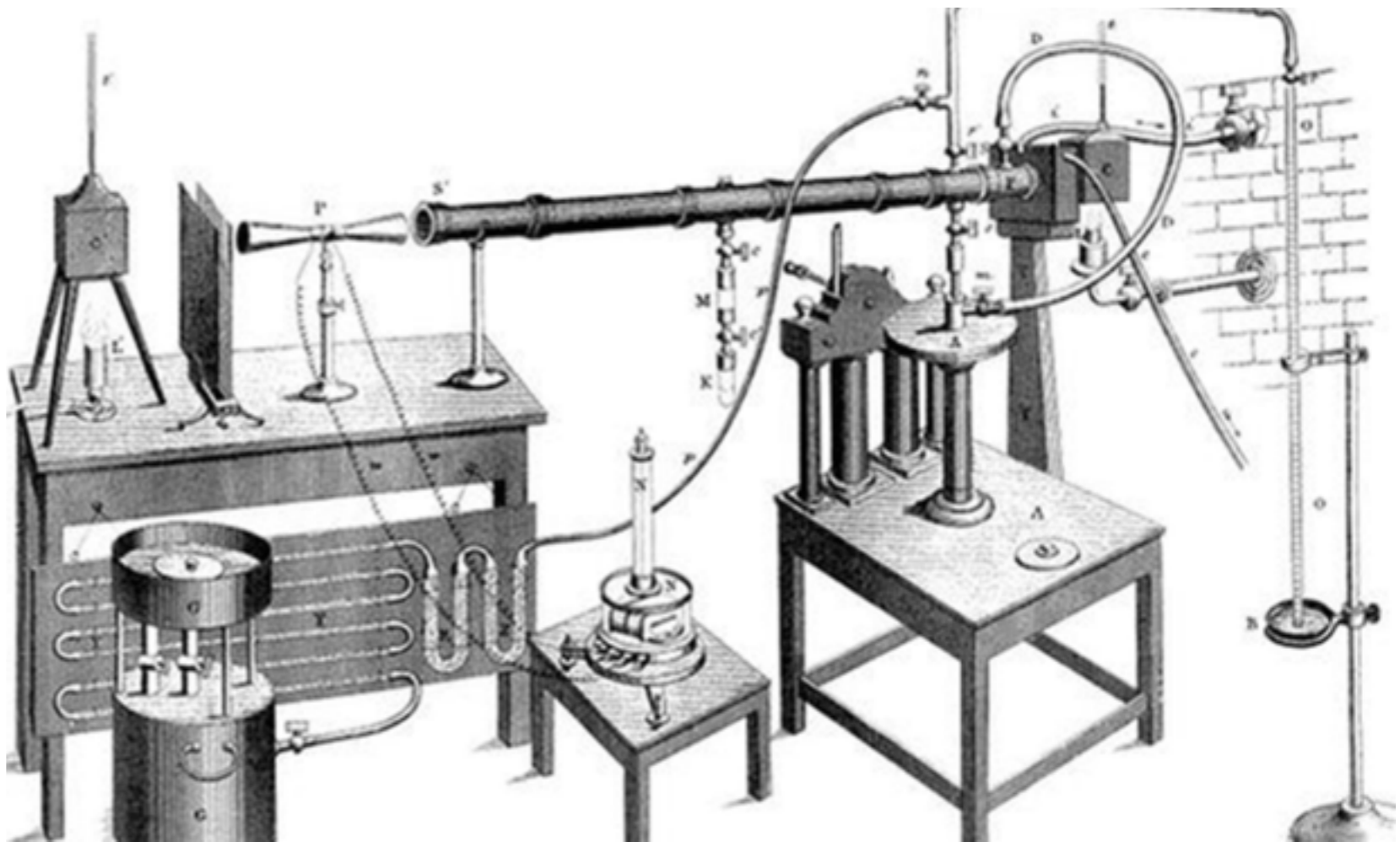
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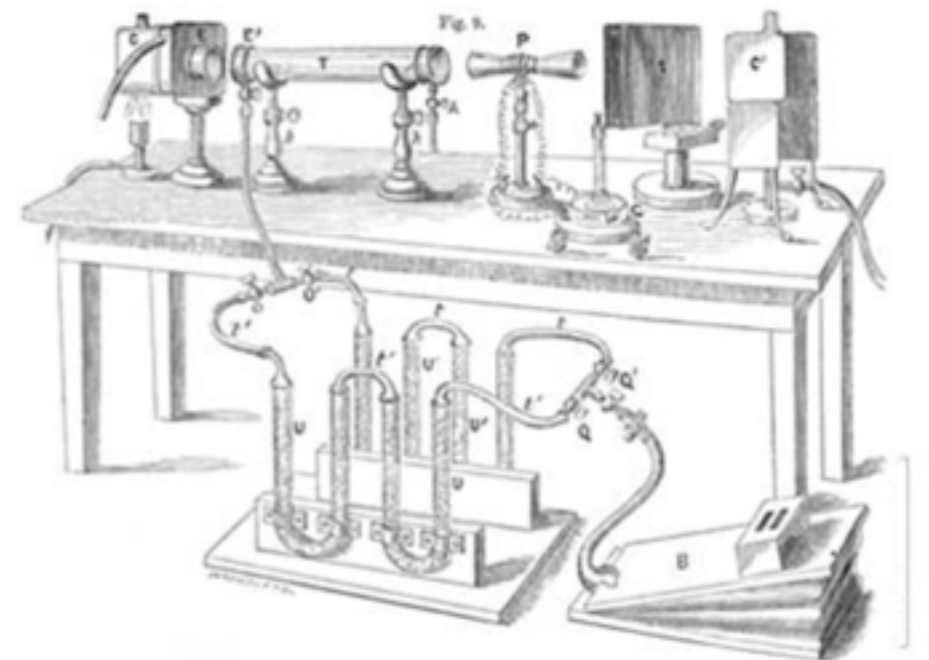
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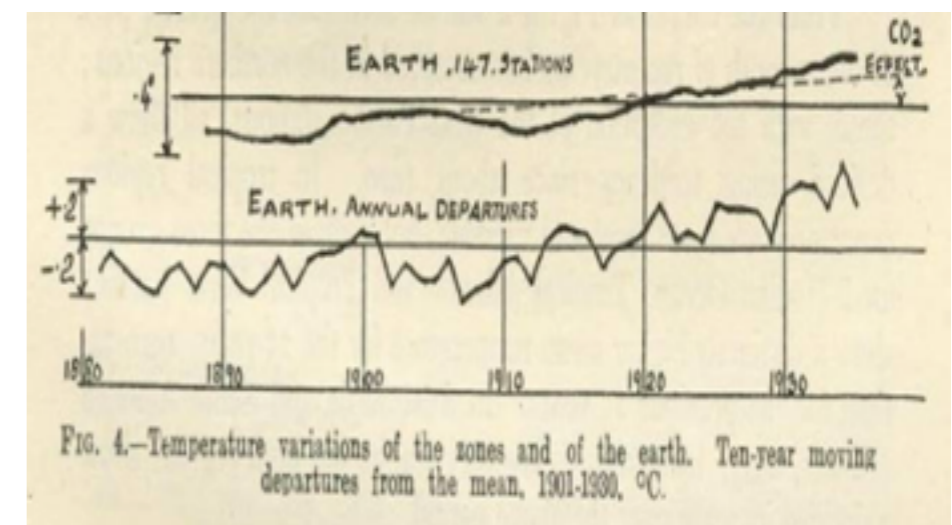
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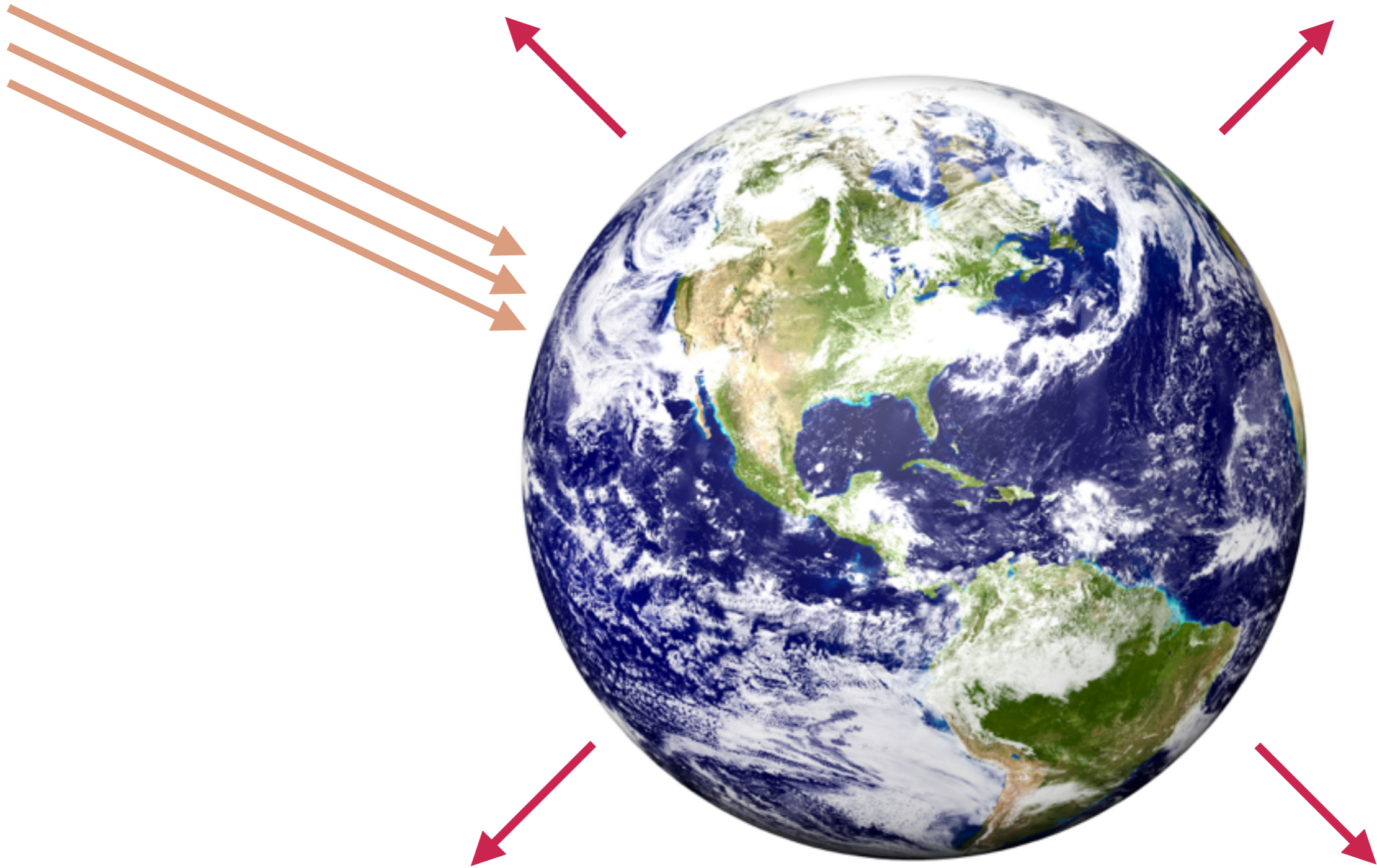
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- 1989: Margaret Thatcher calls for a global treaty on climate change
- Lots more from there

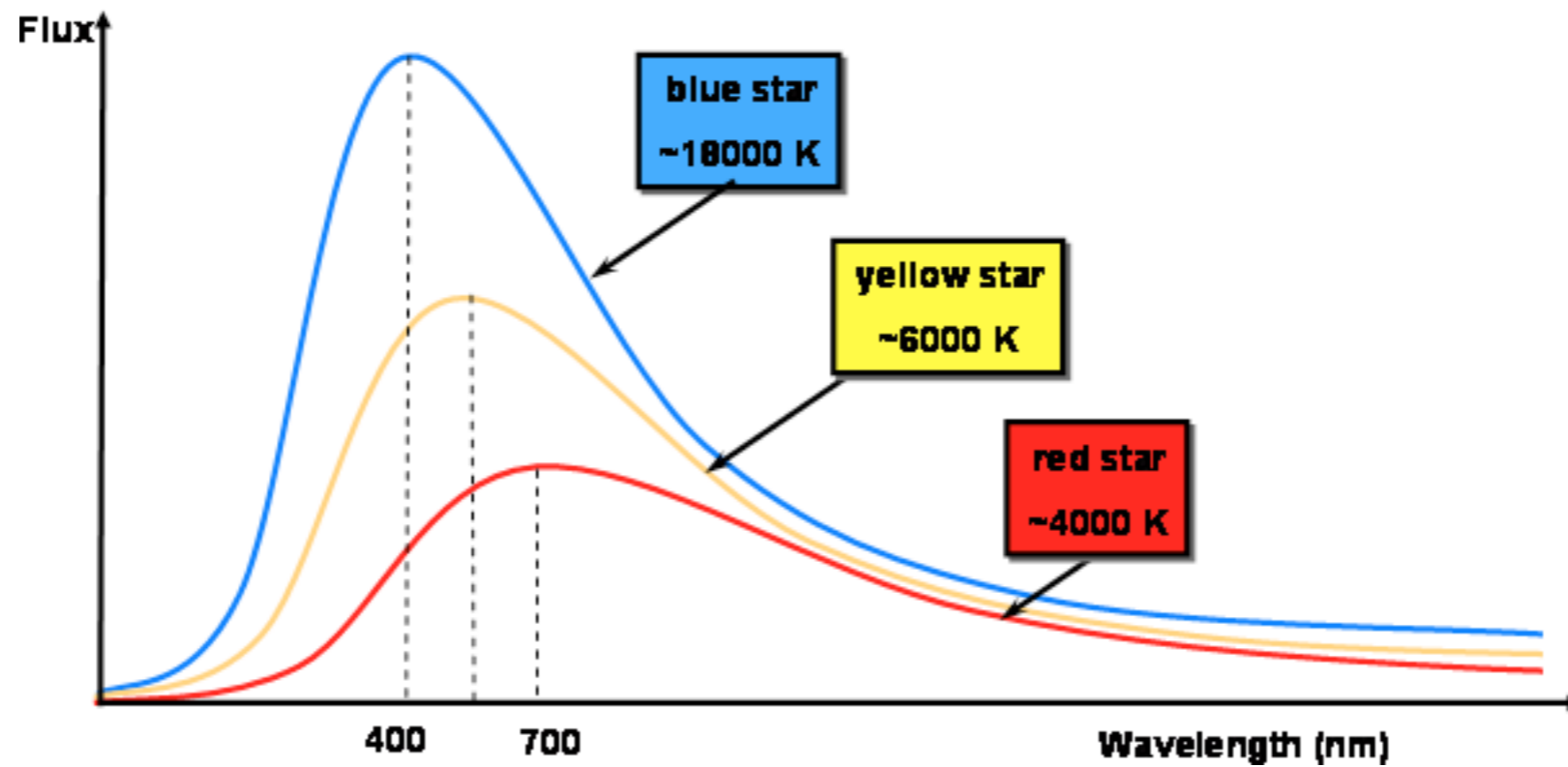




# Energy Balance

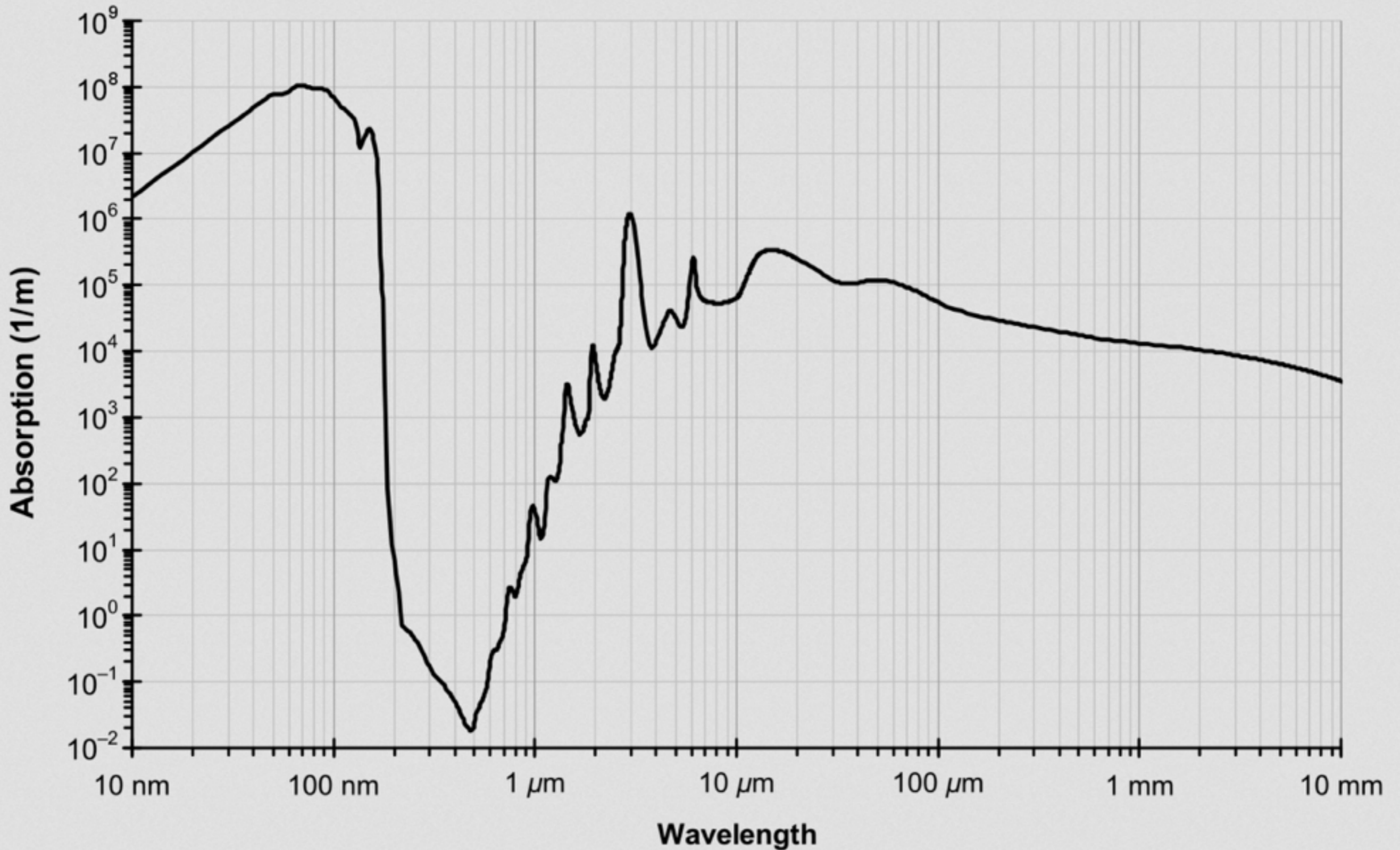


# Black Body Radiation

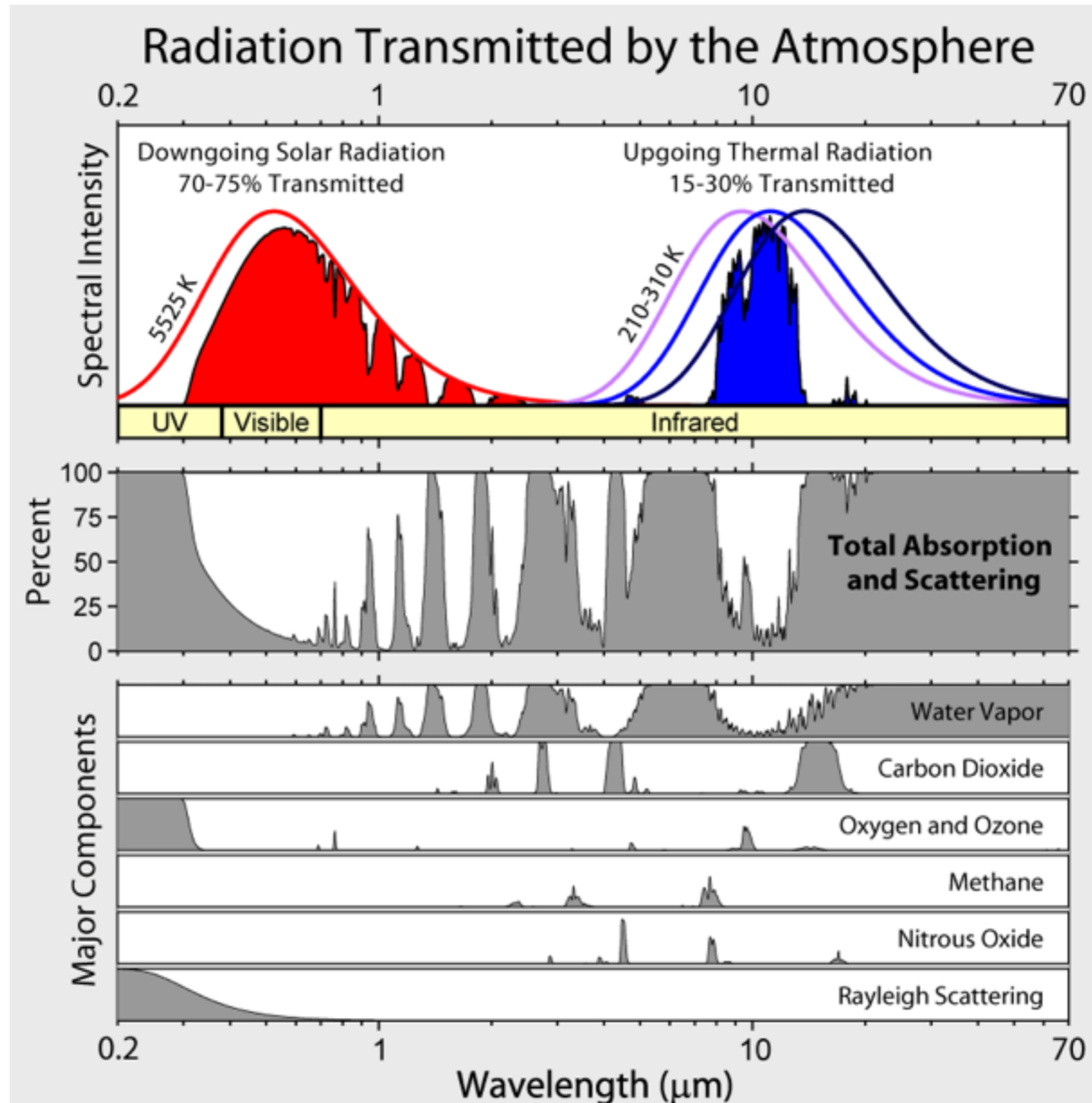




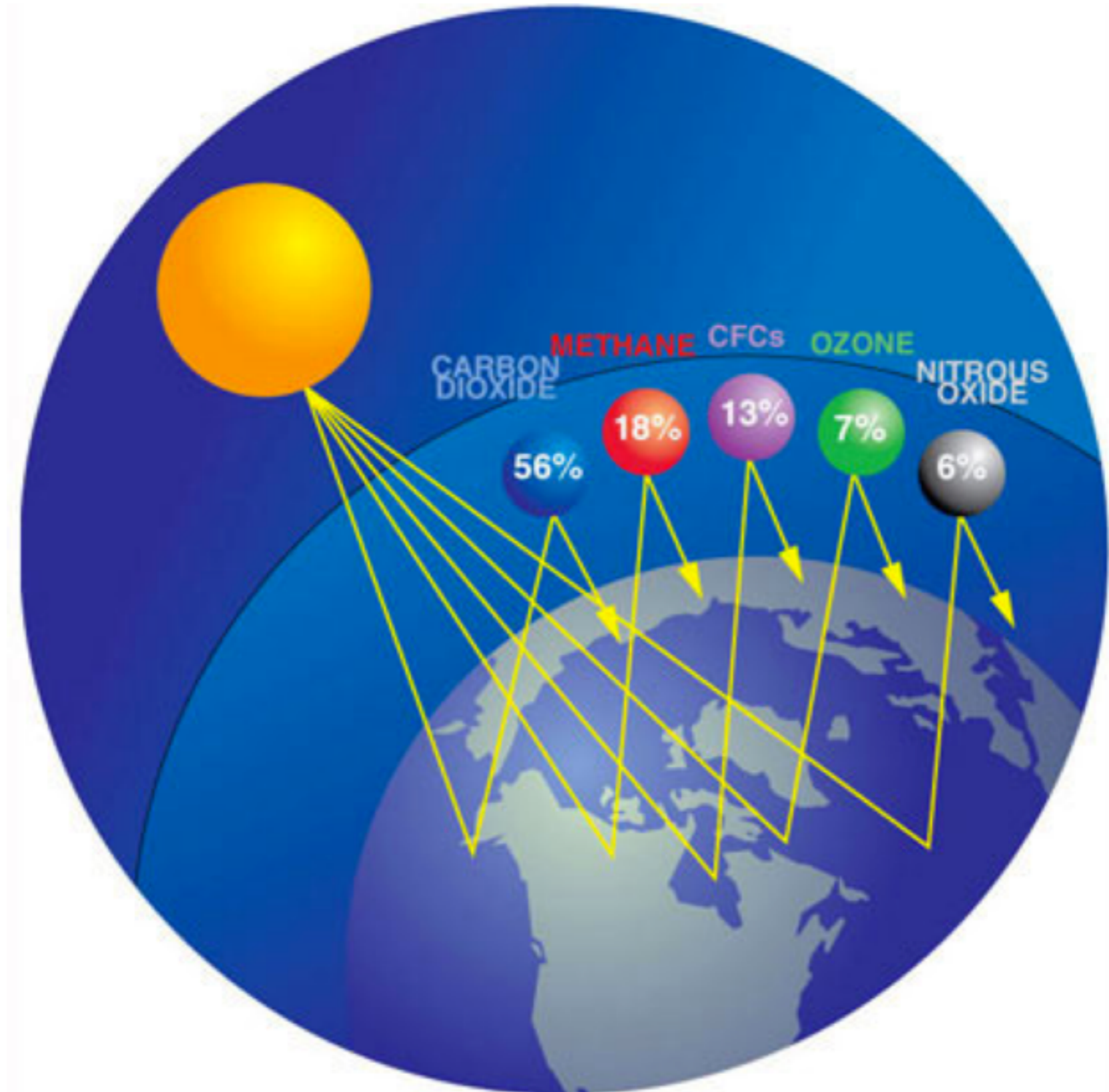
# Absorption



# Black Body Radiation + Absorption

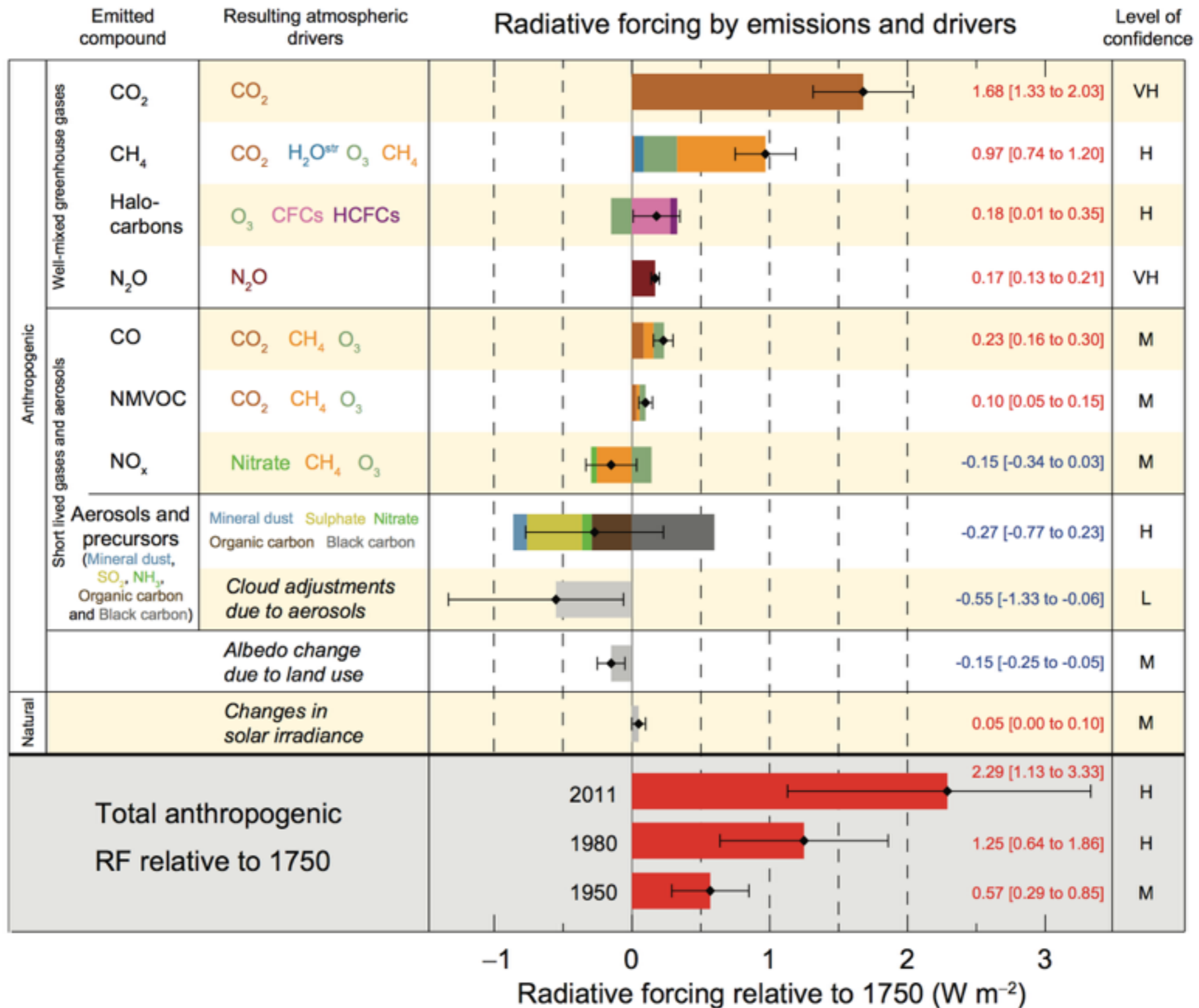


# So a Greenhouse Gas is What?

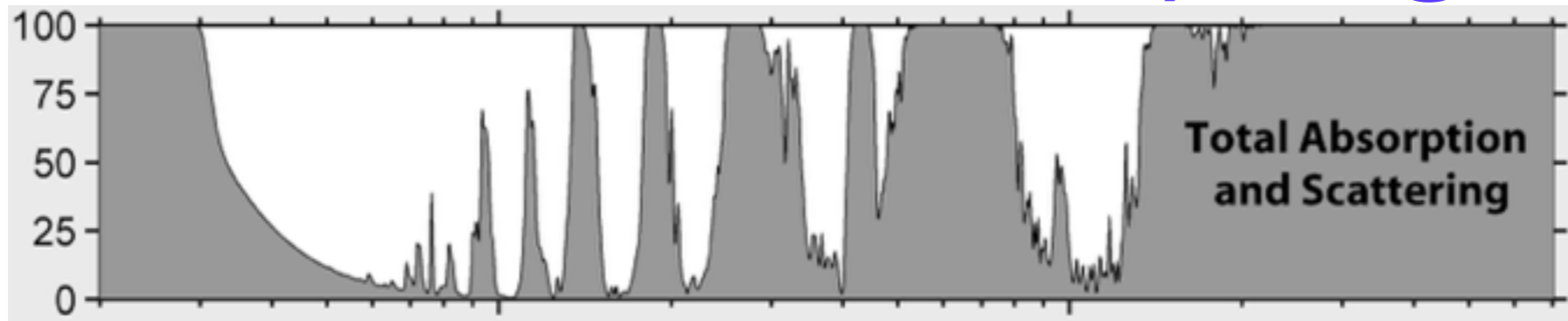




# GhG Bookkeeping



# GhG Bookkeeping



Combination of:

1. Concentration
2. Lifetime
3. Potency
4. Available photons, location...

Concentration  
in 1994

358 000 ppbv

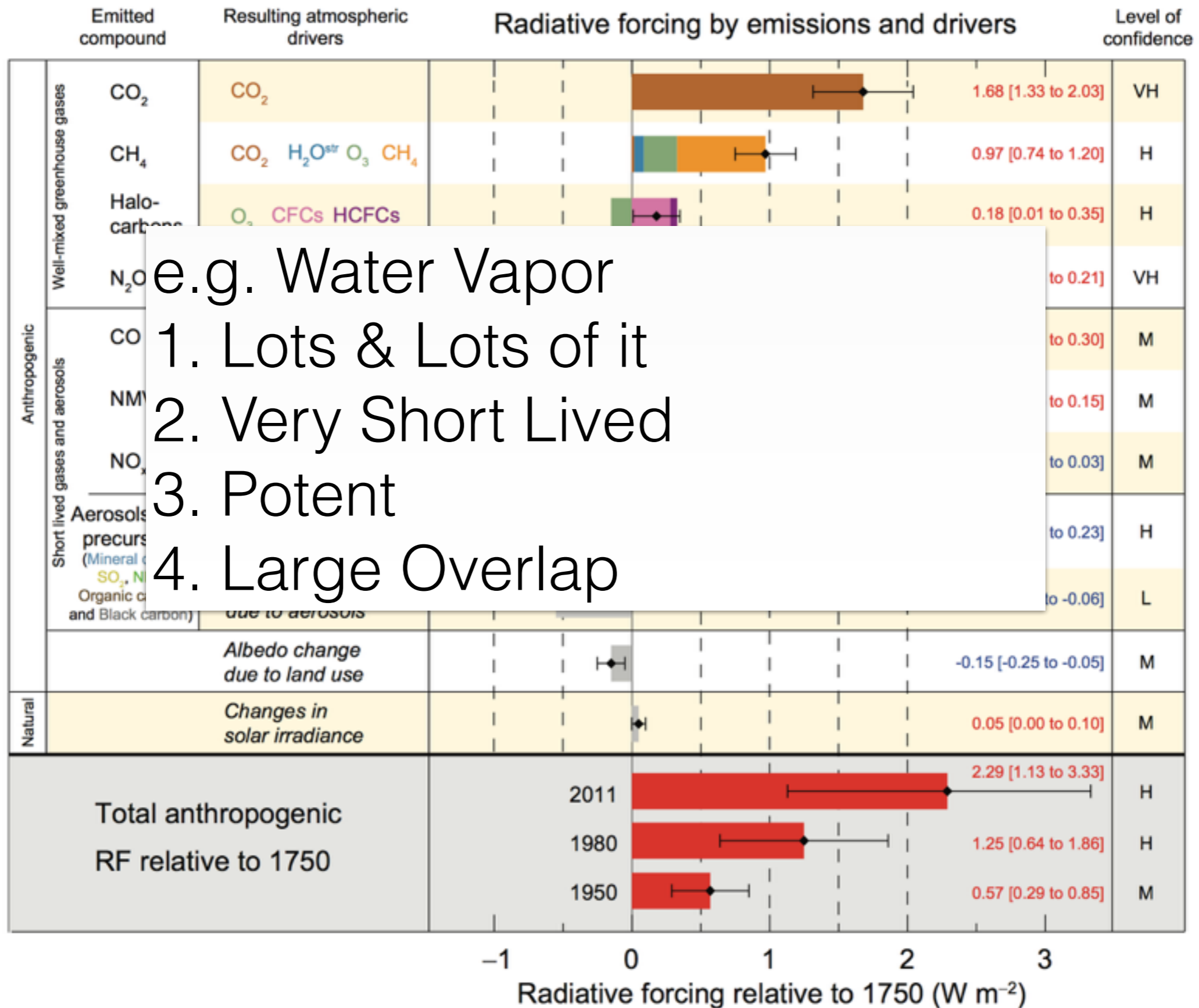
1721 ppbv

311 ppbv

Gas	Atmospheric Lifetime	100-year GWP <sup>a</sup>
Carbon dioxide (CO <sub>2</sub> )	50-200	1
Methane (CH <sub>4</sub> ) <sup>b</sup>	12±3	21
Nitrous oxide (N <sub>2</sub> O)	120	310



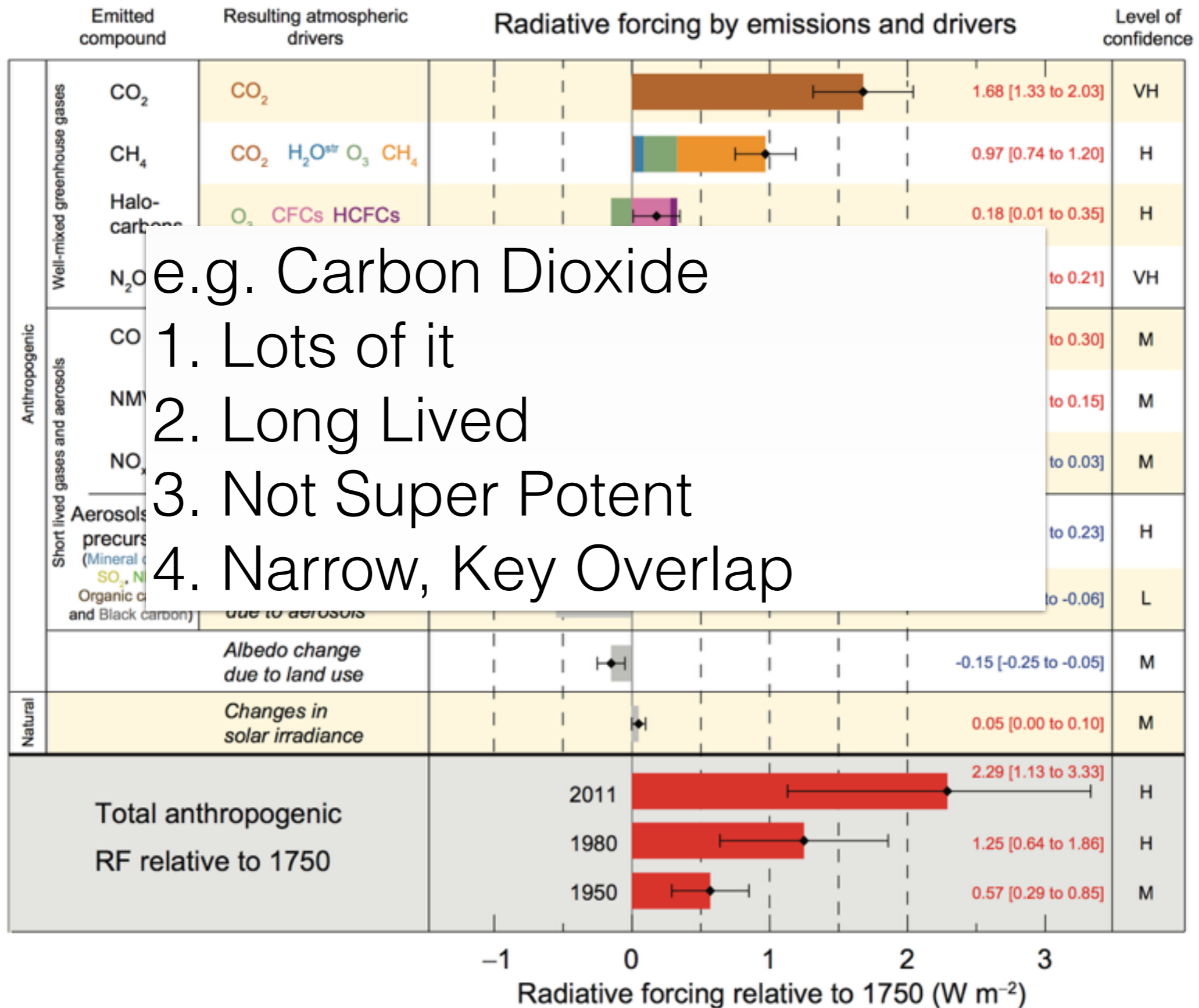
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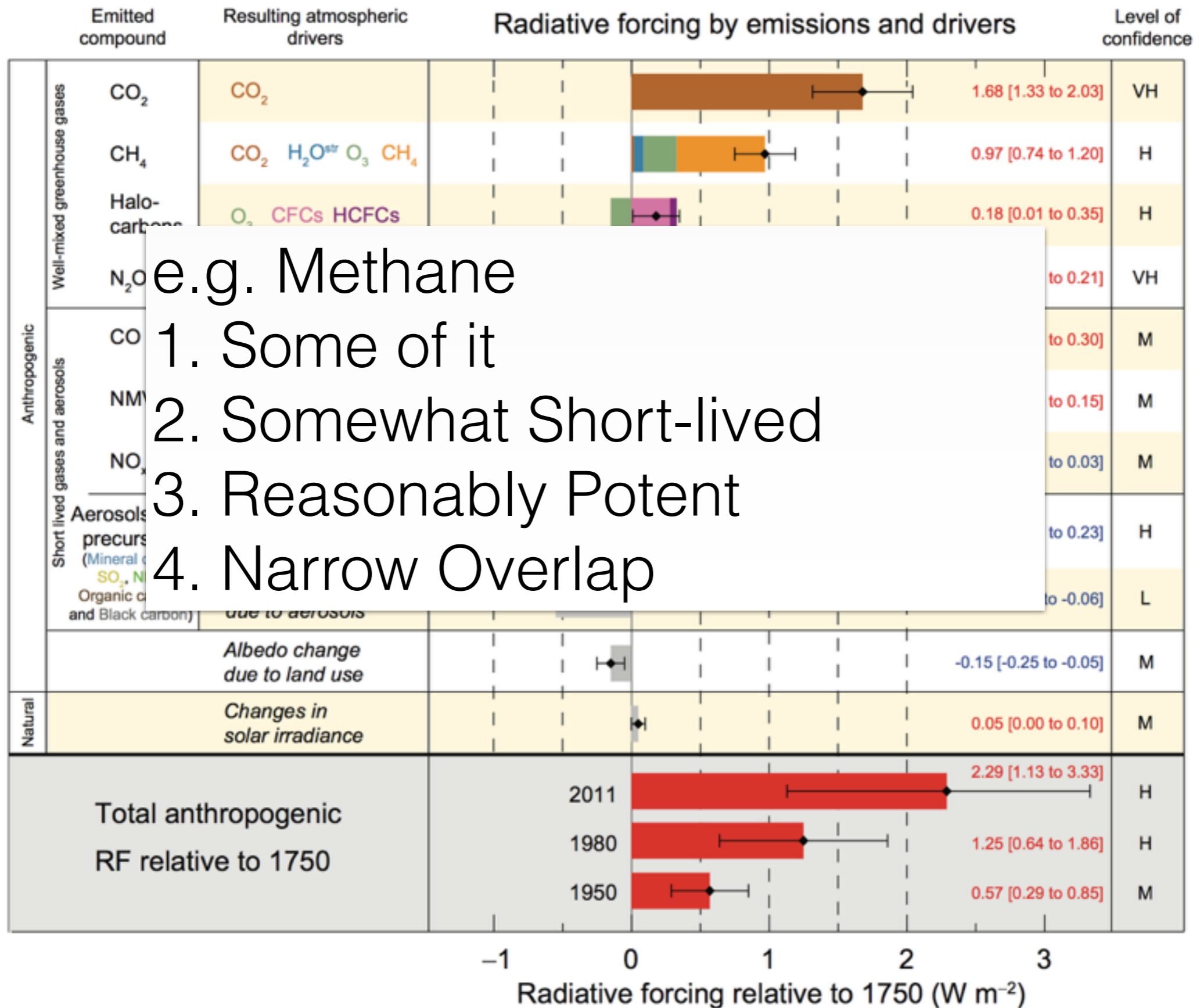
e.g. Water Vapor

1. Lots & Lots of it
2. Very Short Lived
3. Potent
4. Large Overlap

# GhG Bookkeeping



# GhG Bookkeeping



e.g. Methane

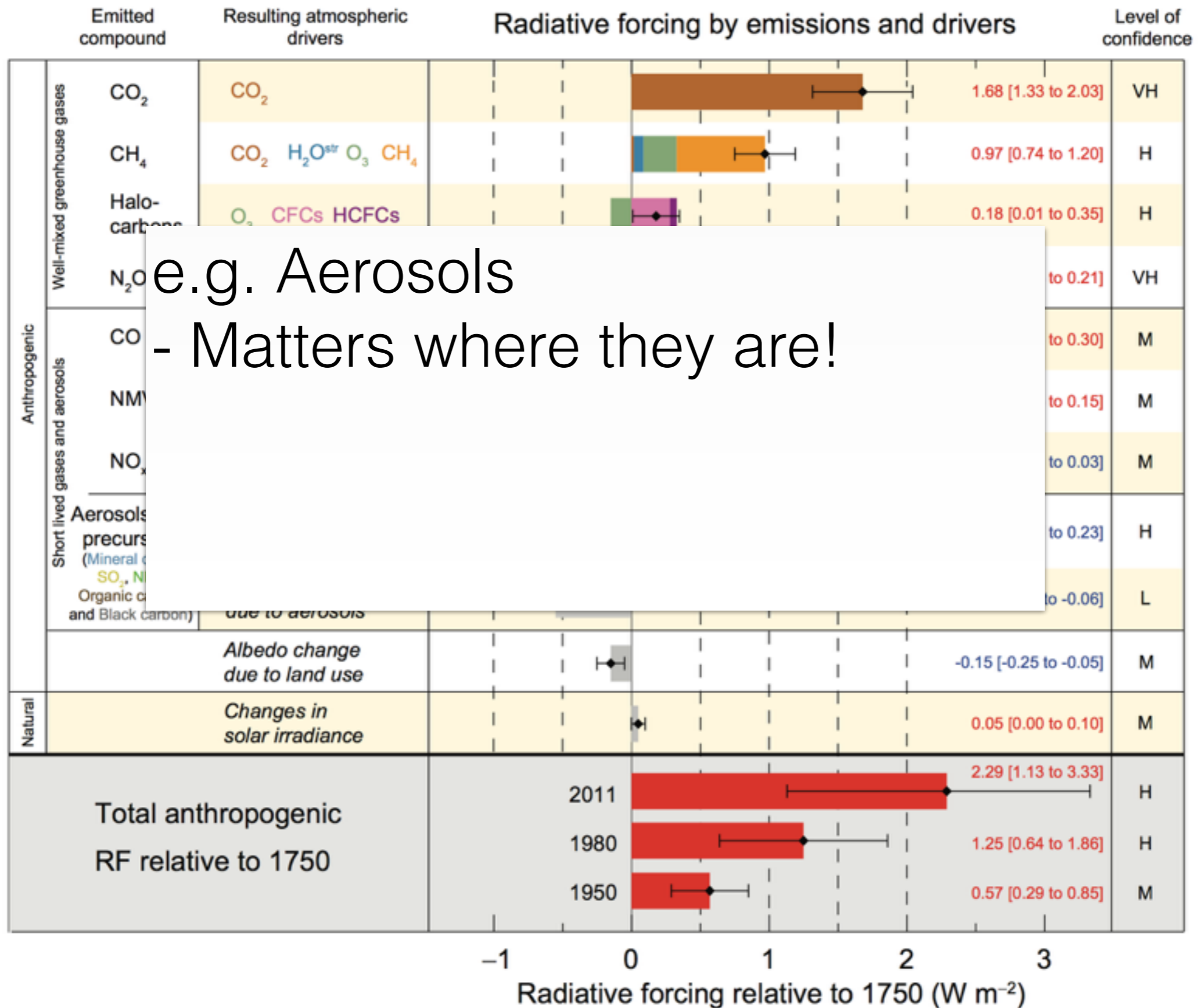
1. Some of it

2. Somewhat Short-lived

3. Reasonably Potent

4. Narrow Overlap

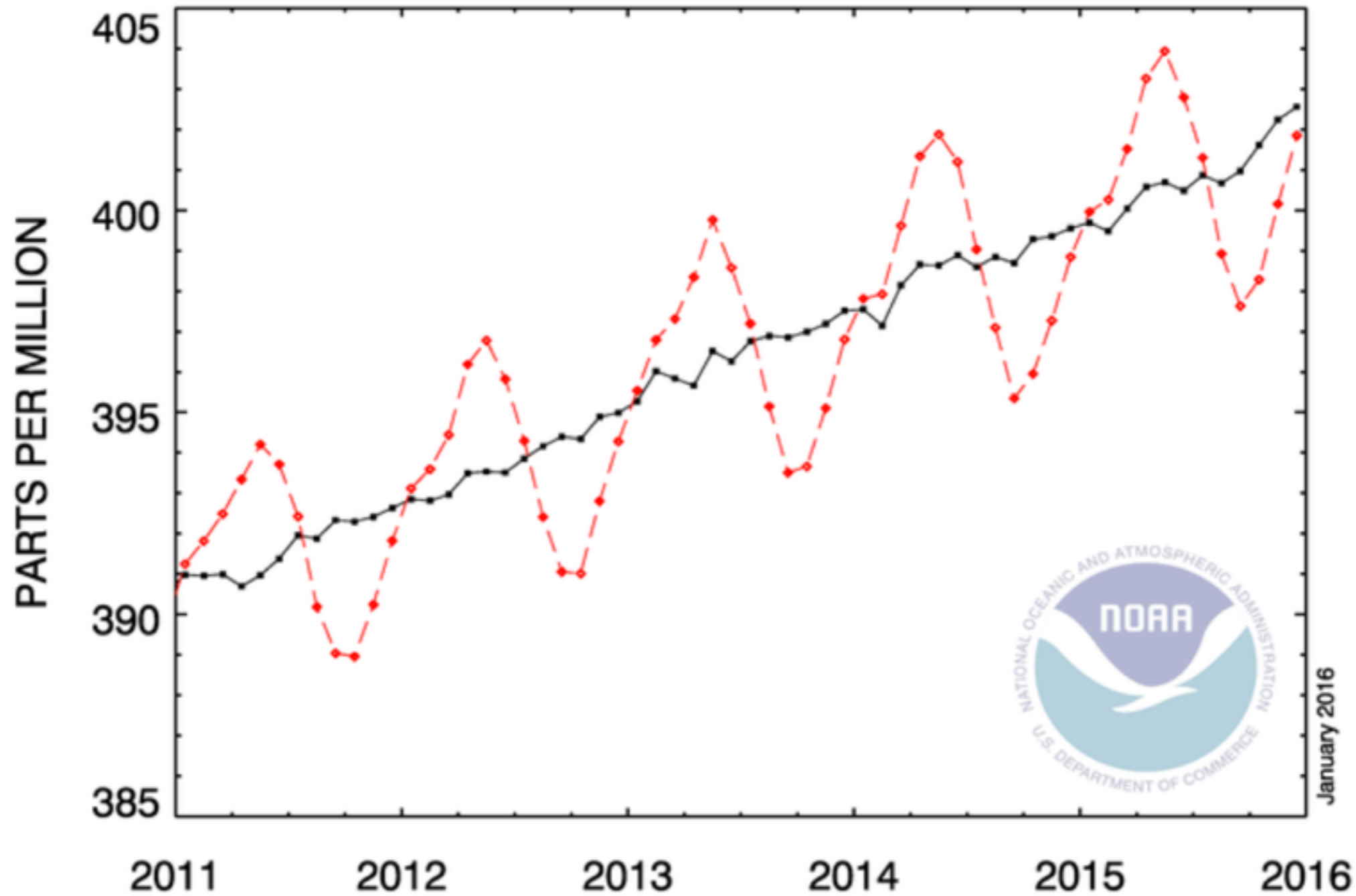
# GhG Bookkeeping



e.g. Aerosols  
- Matters where they are!

# Carbon

RECENT MONTHLY MEAN CO<sub>2</sub> AT MAUNA LOA

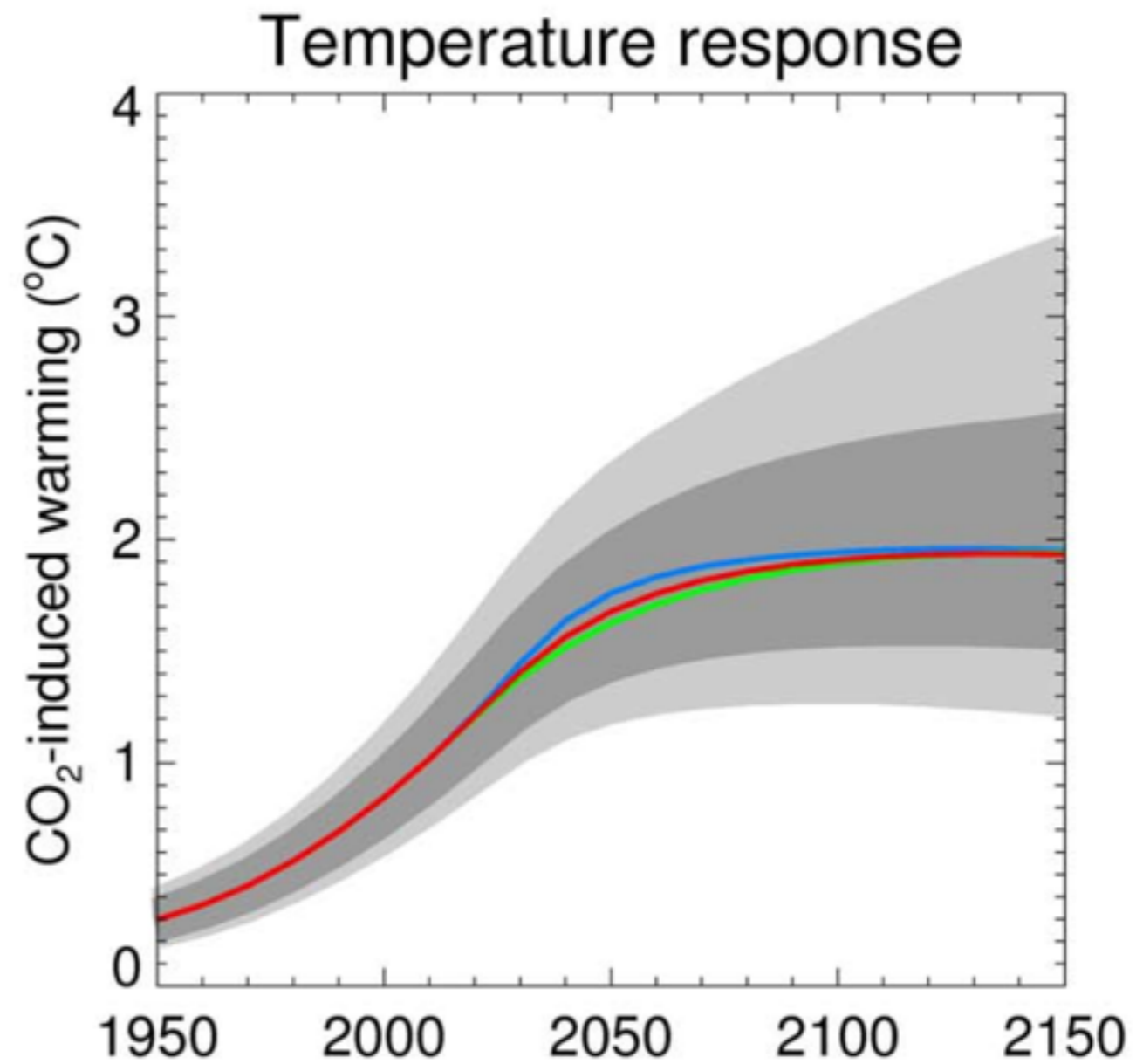
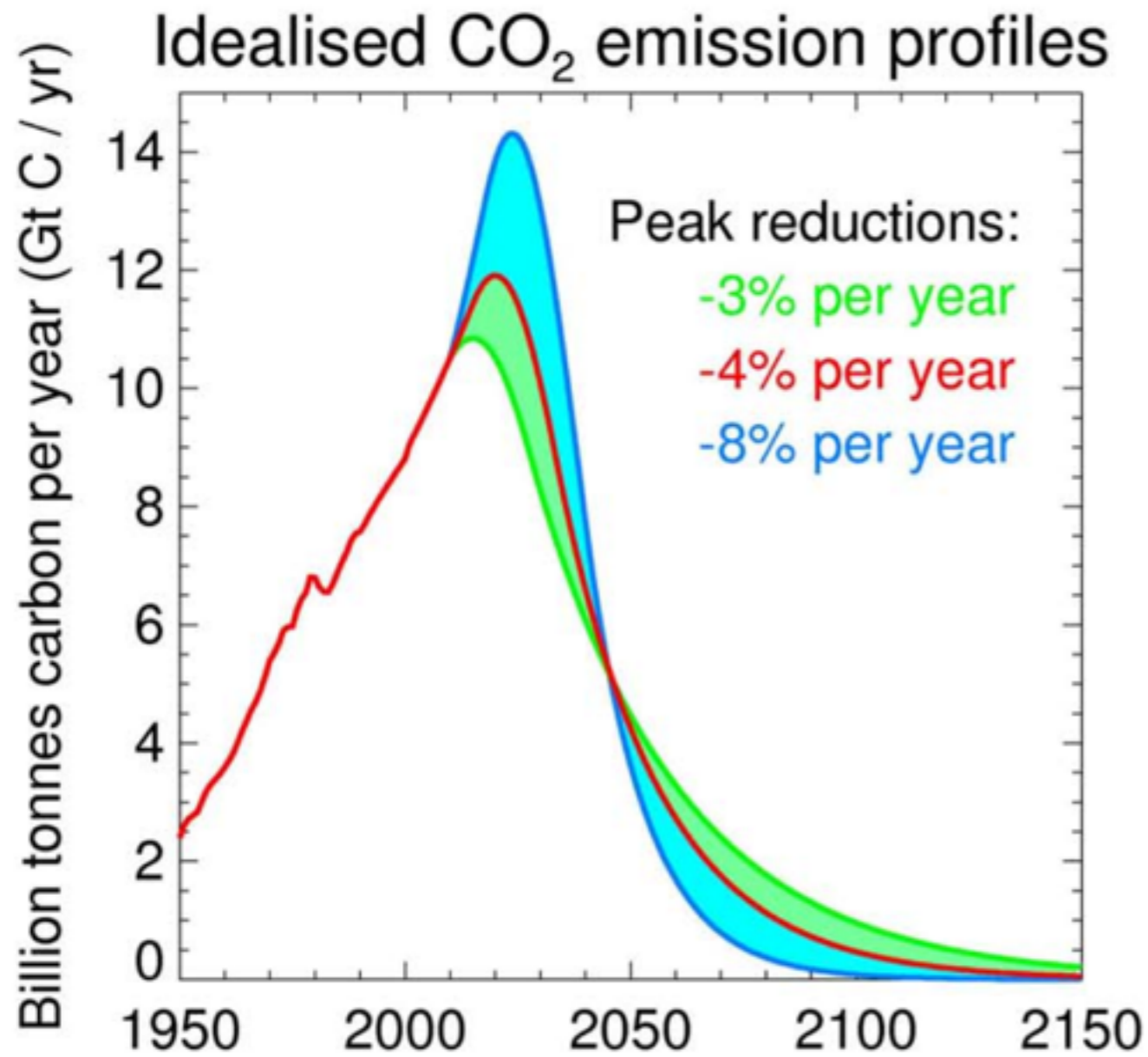


**December 2015: 401.85 ppm**





# Carbon Cycle is Slow





# Heat

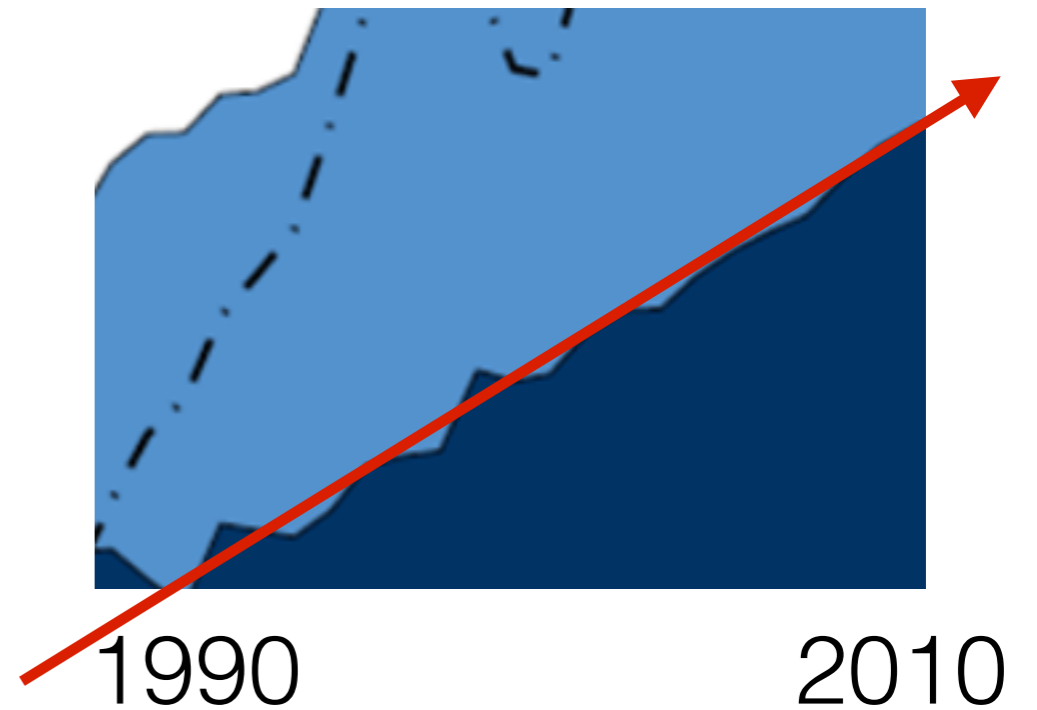
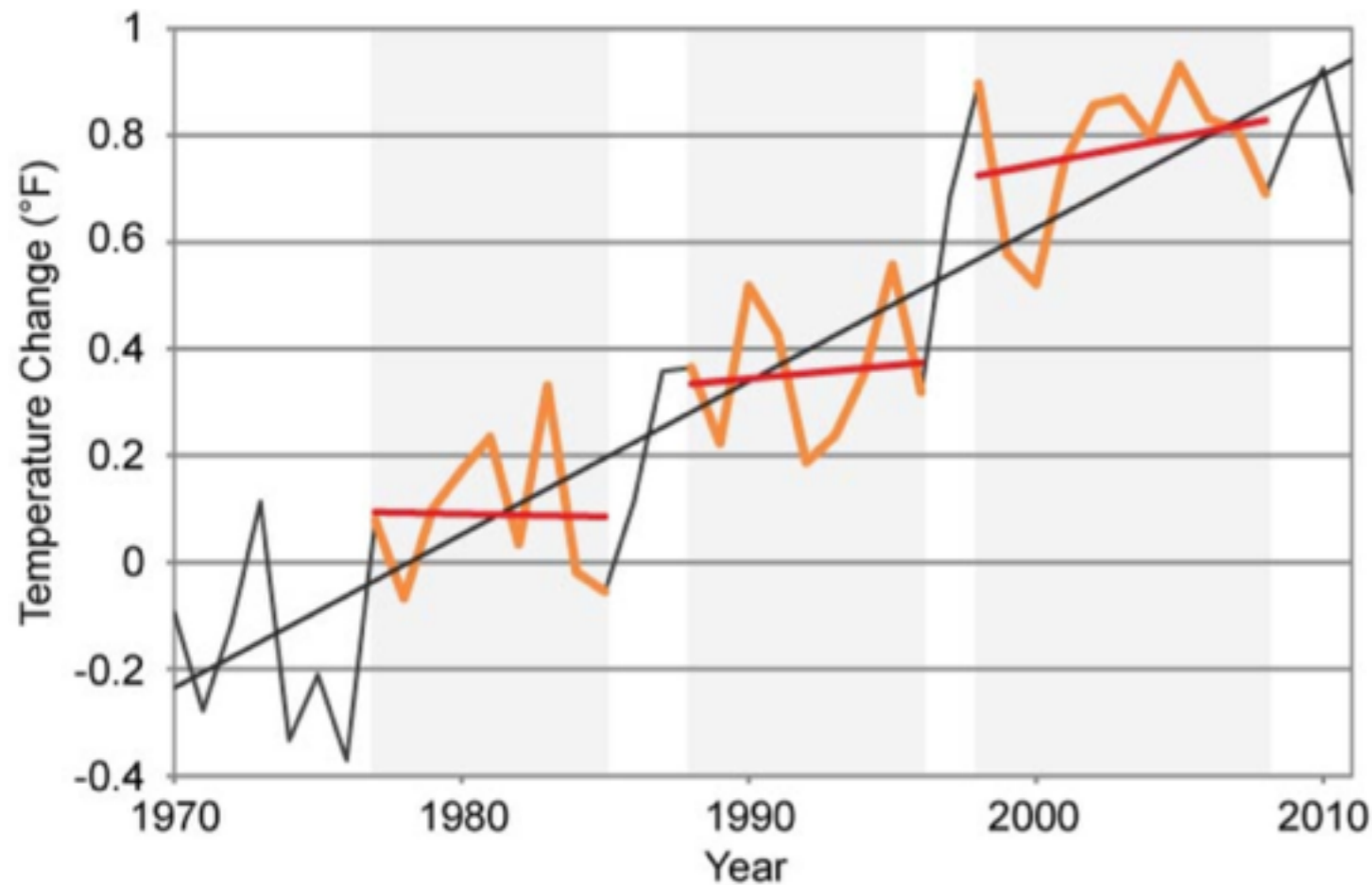




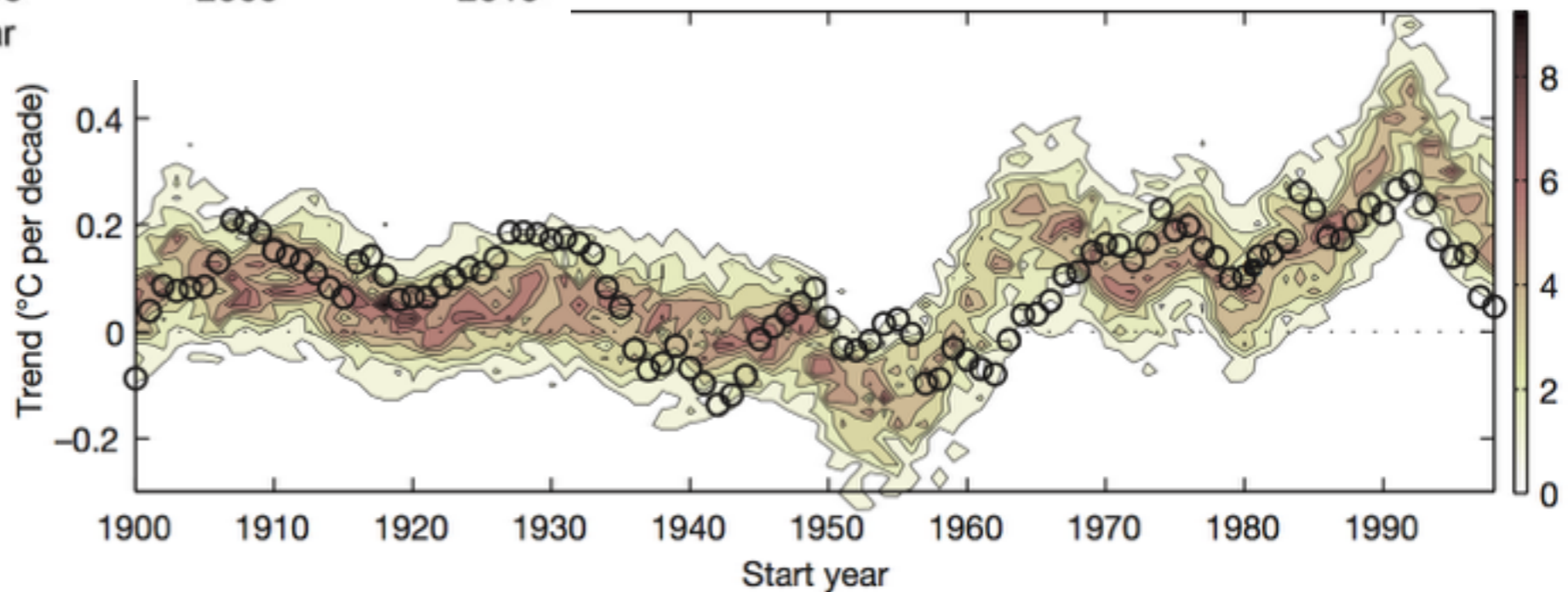


# e.g. Warming 'Hiatus'

Long-Term Warming and Short-Term Variation



(other problems too - a rant for another day)



# Putting it Together

Energy balance,  
augmented by greenhouse gases,  
heating the atmosphere,  
though the ocean is the reservoir.  
Definitely not the whole story!

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Elements:

Radiation

A handful of gases

Heat

Complexity is in their *interactions*

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Definitely not the whole story!

Elements:  
Radiation  
A handful of gases  
Heat

Stick around for the other  
talks to learn about:

Some key interactions  
The uncertainty that arises  
What we do about it

Complexity is in their *interactions*



# Resources // Questions?

