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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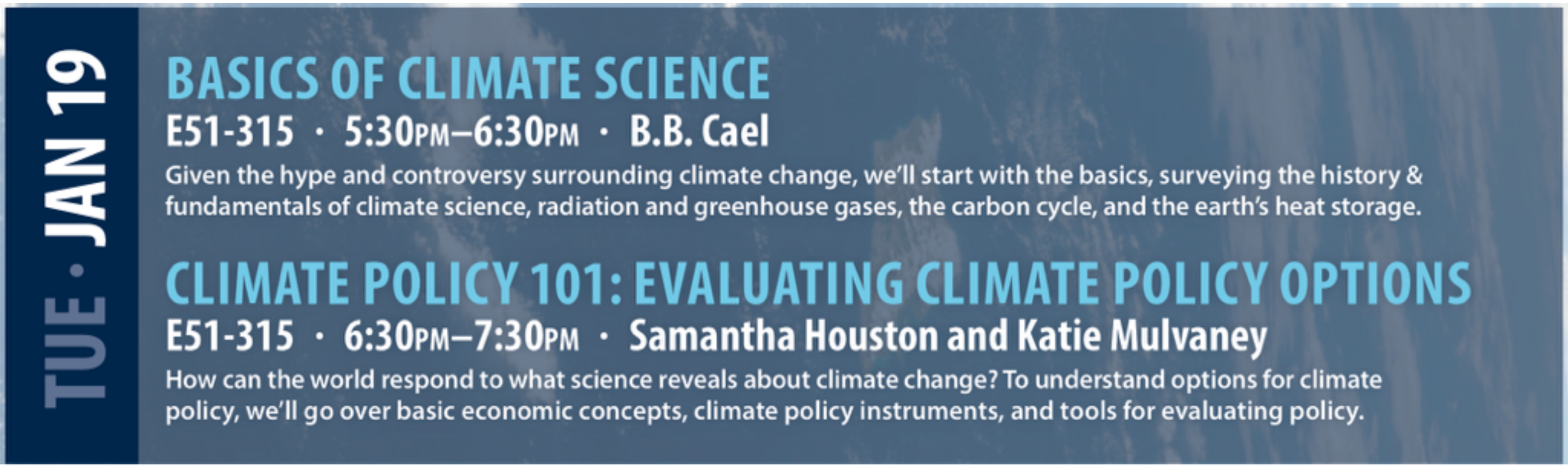

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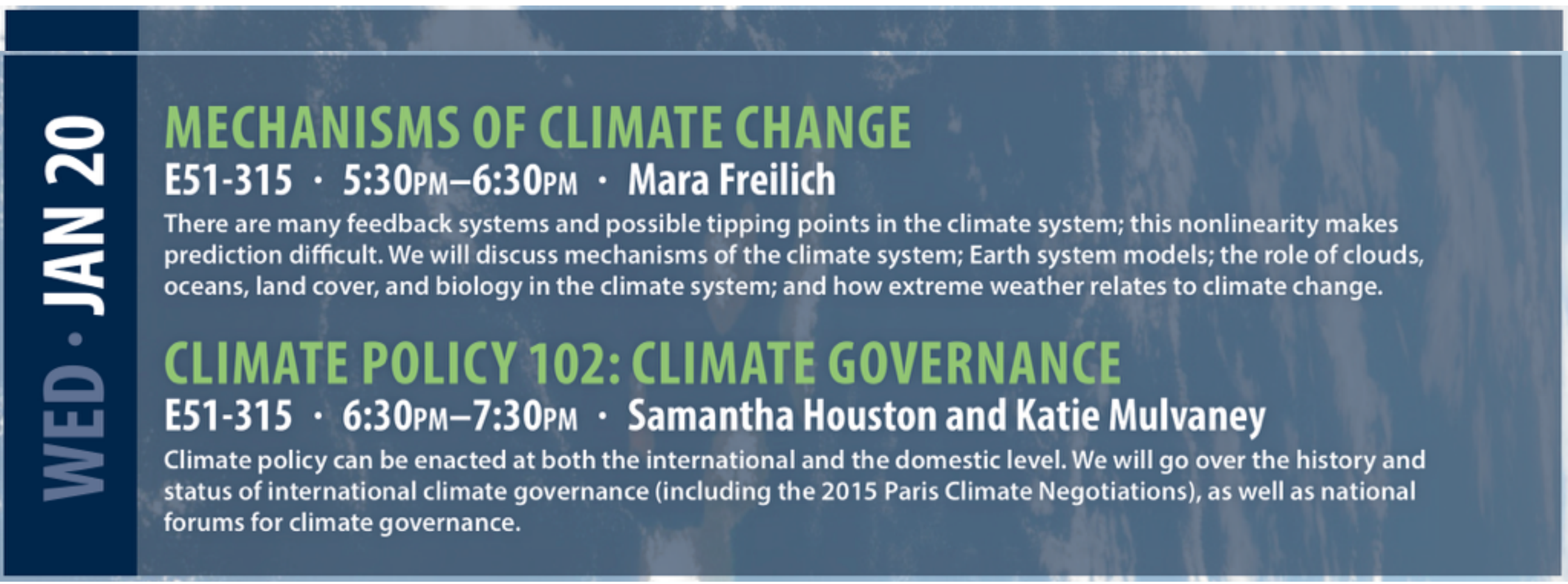

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Jan 24 - Tu BiShvat Seder for Palestine, Climate, and Racial Justice

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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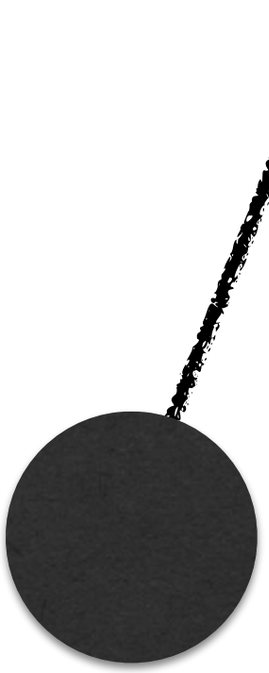

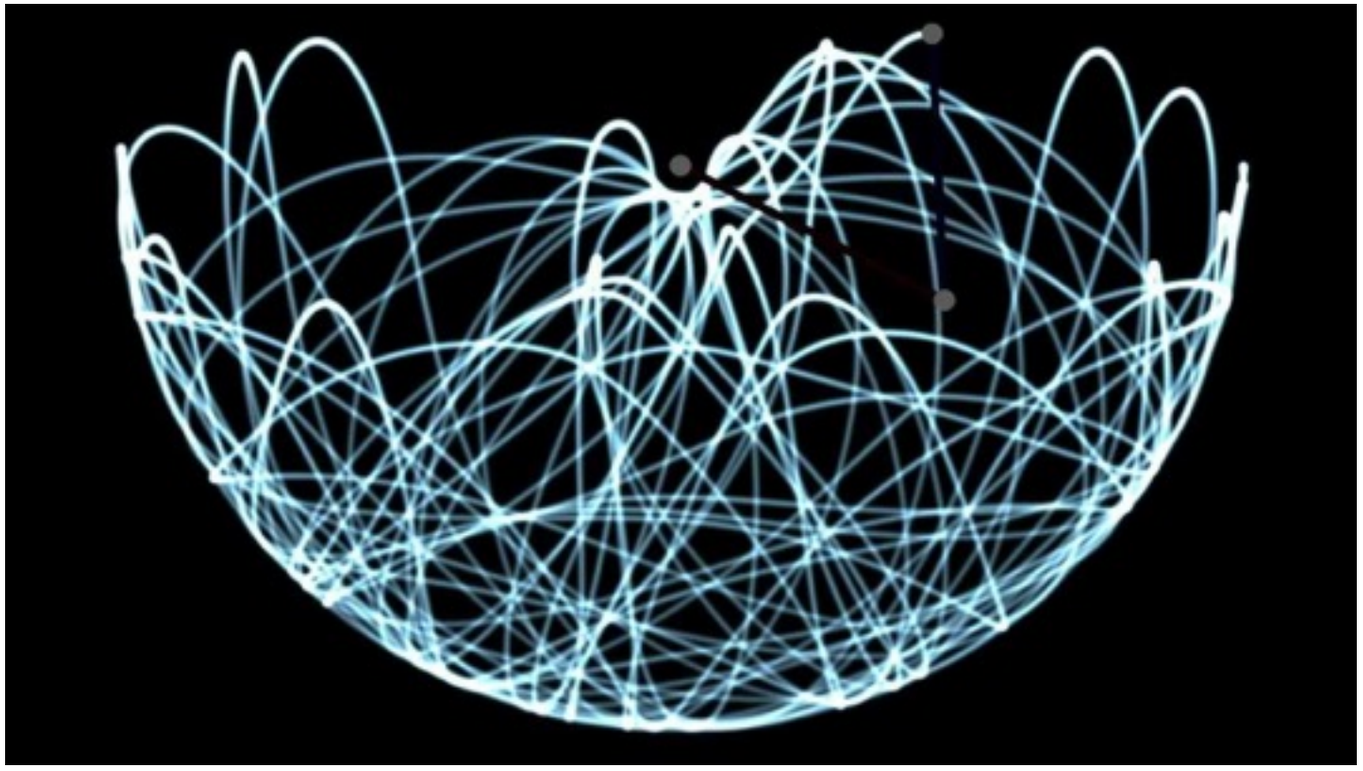

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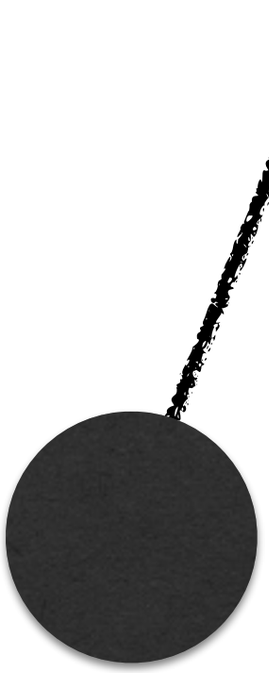
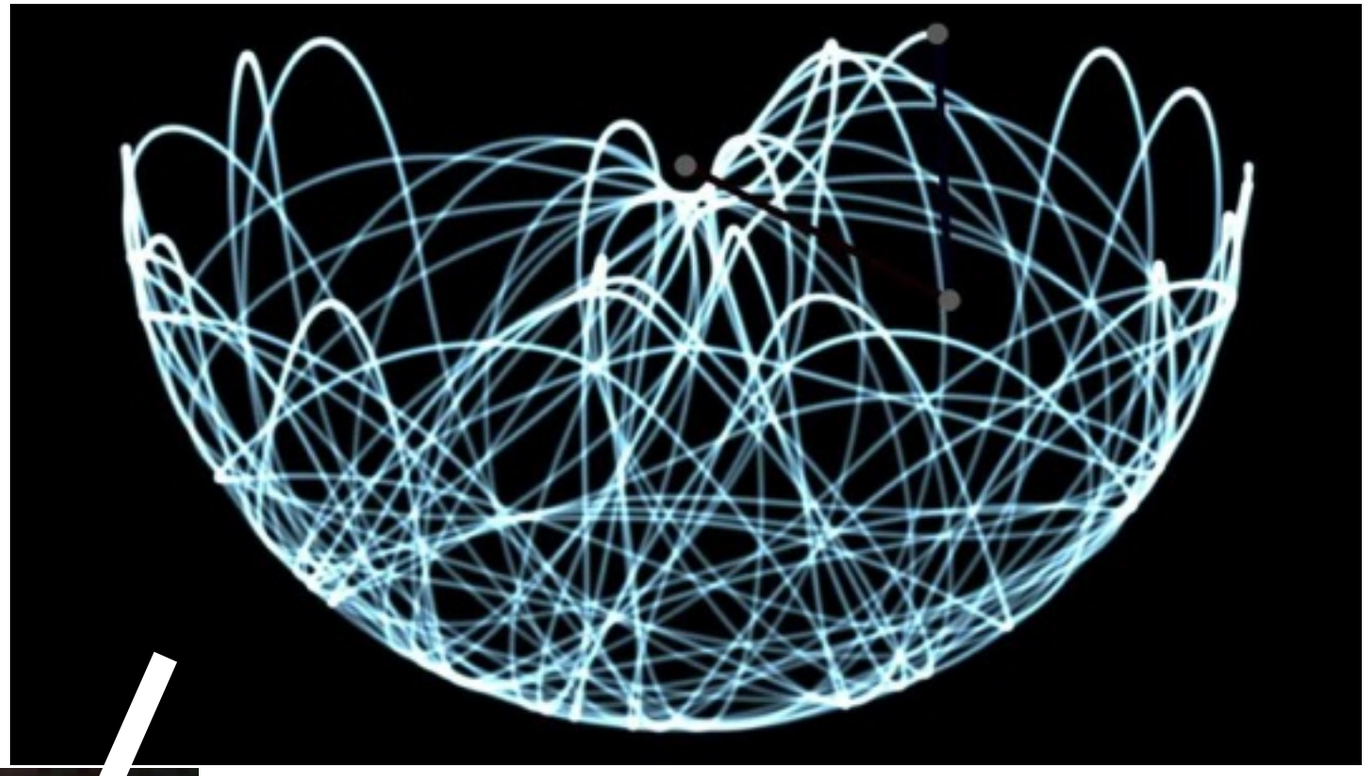
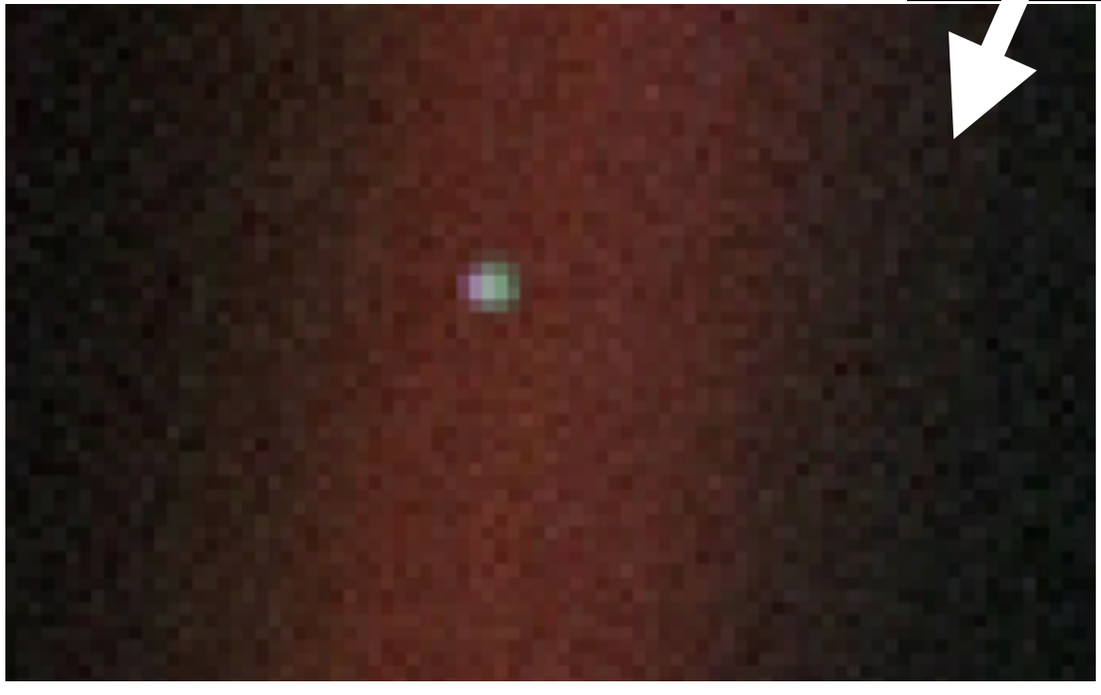






What is ‘Climate’?

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

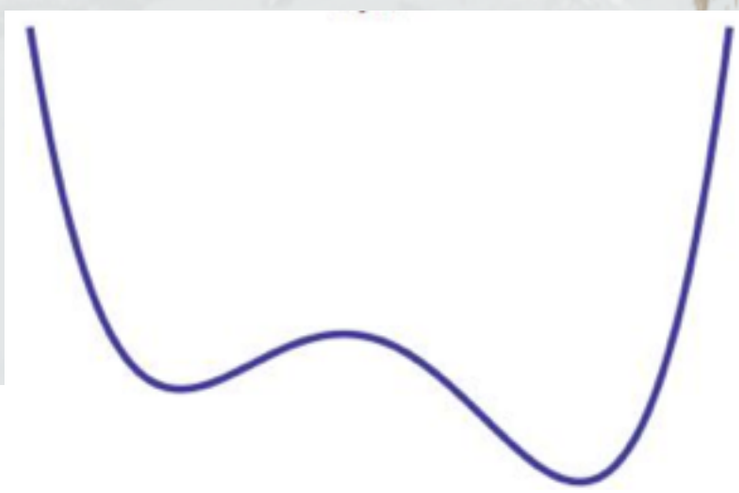
What is ‘Climate’?

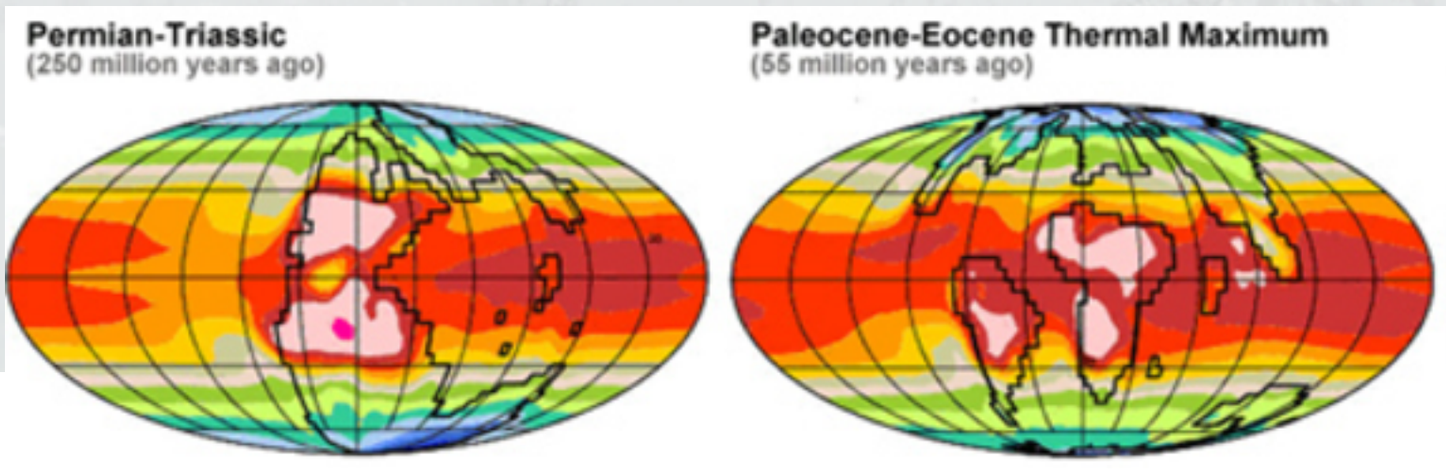
The statistics [mean & variability] of weather over decadal timescales

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?

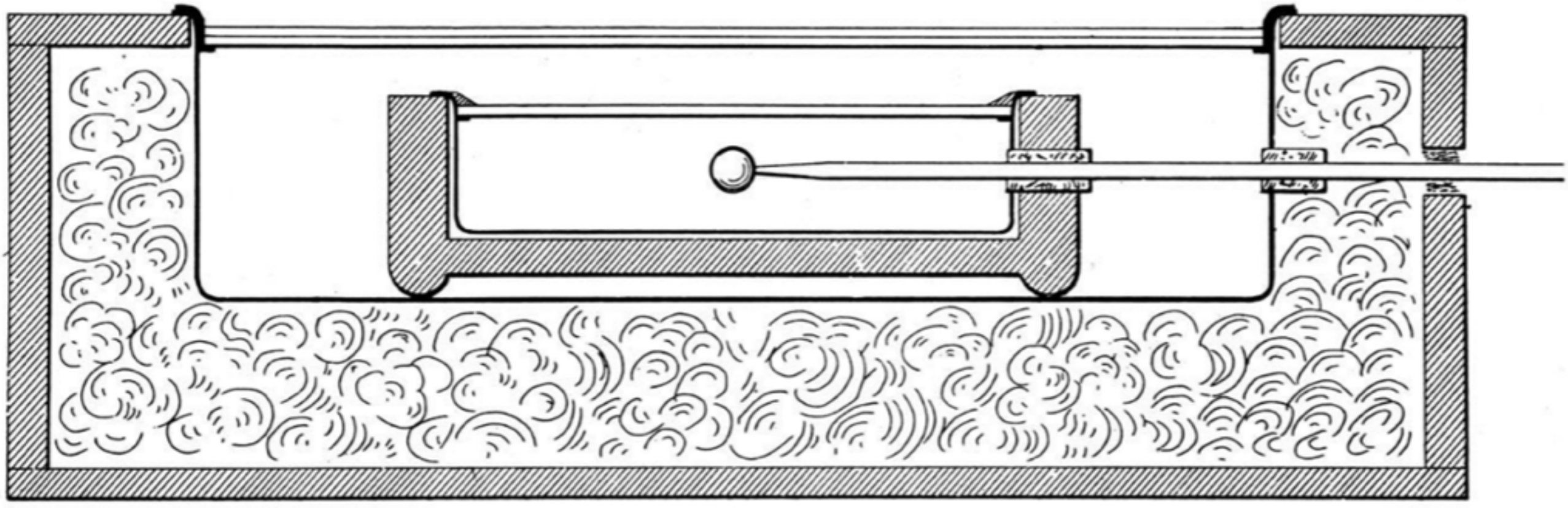




What ‘Impacts of Climate Change’ do we hear about?

A Brief History of Climate Science

- 1824: Joseph Fourier describes the greenhouse effect - ‘the temperature [of earth] can be augmented by the interposition of the atmosphere’



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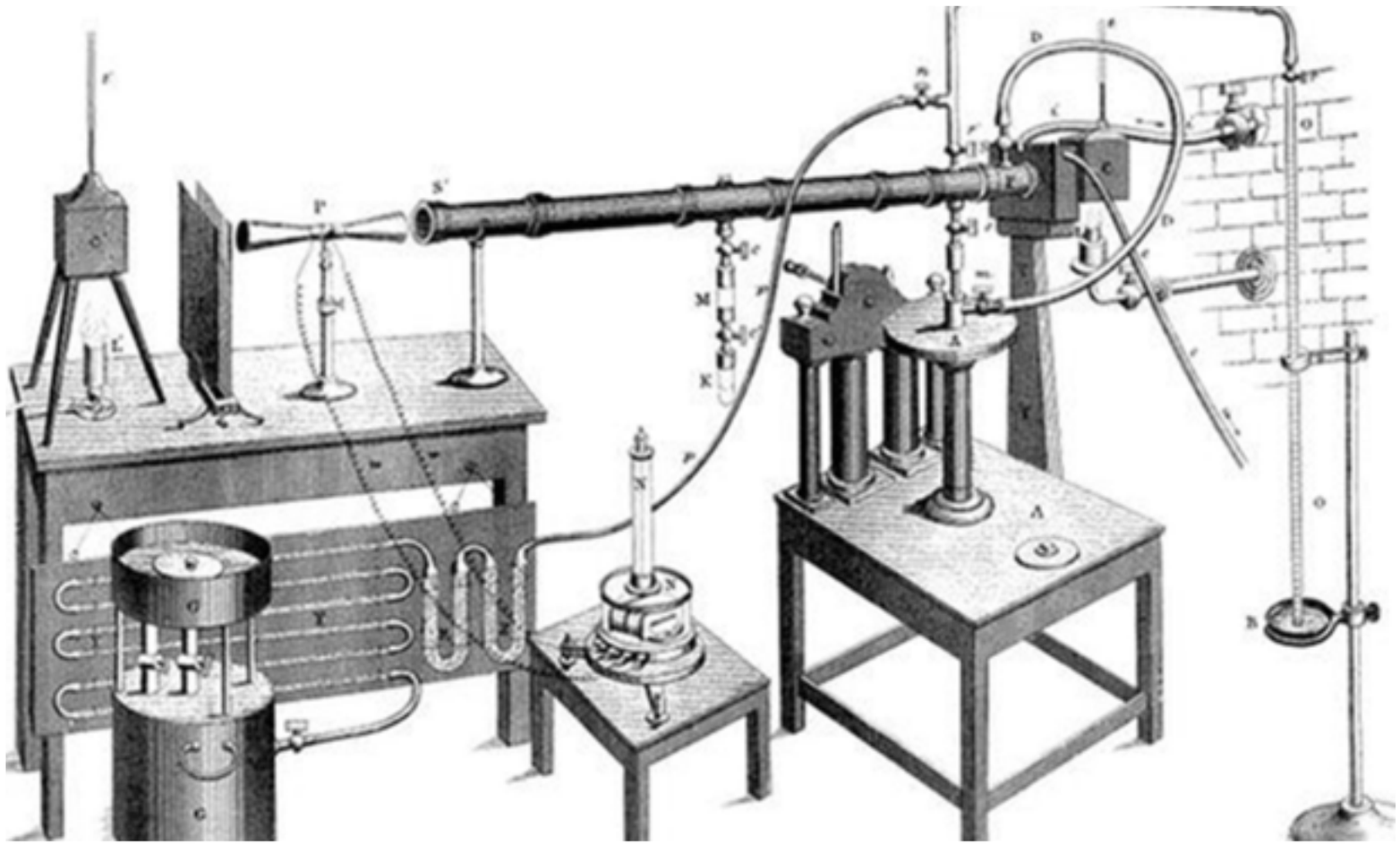

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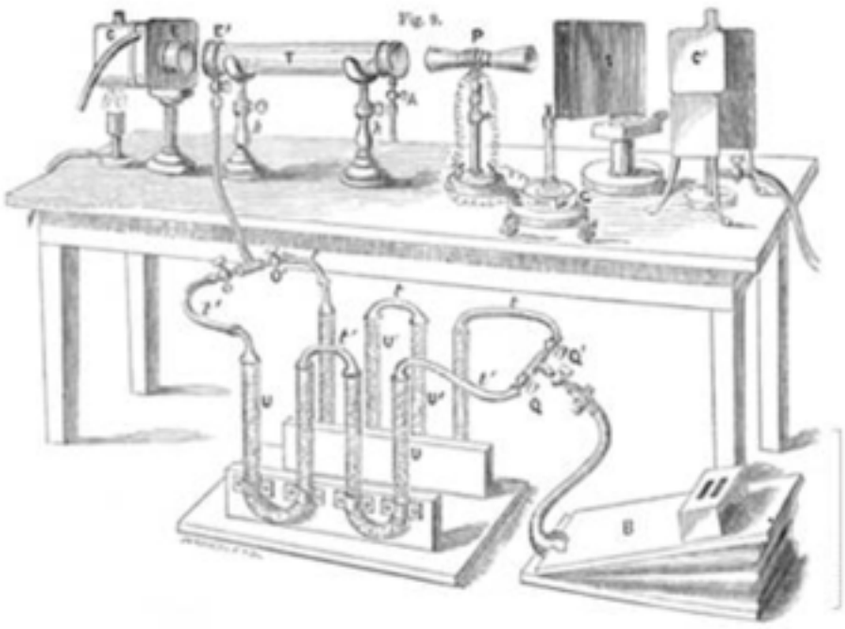

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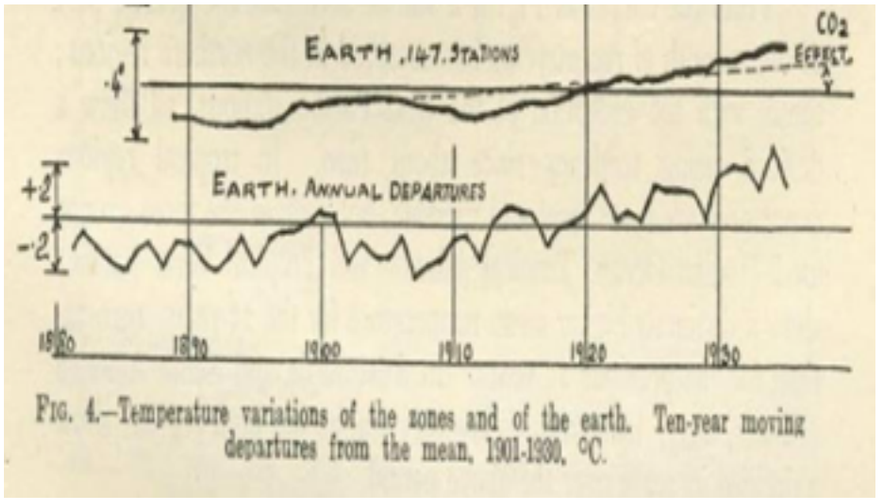

FIG. 4.—Temperature variations of the zones and of the earth. Ten-year moving departures from the mean, 1901-1930. °C.

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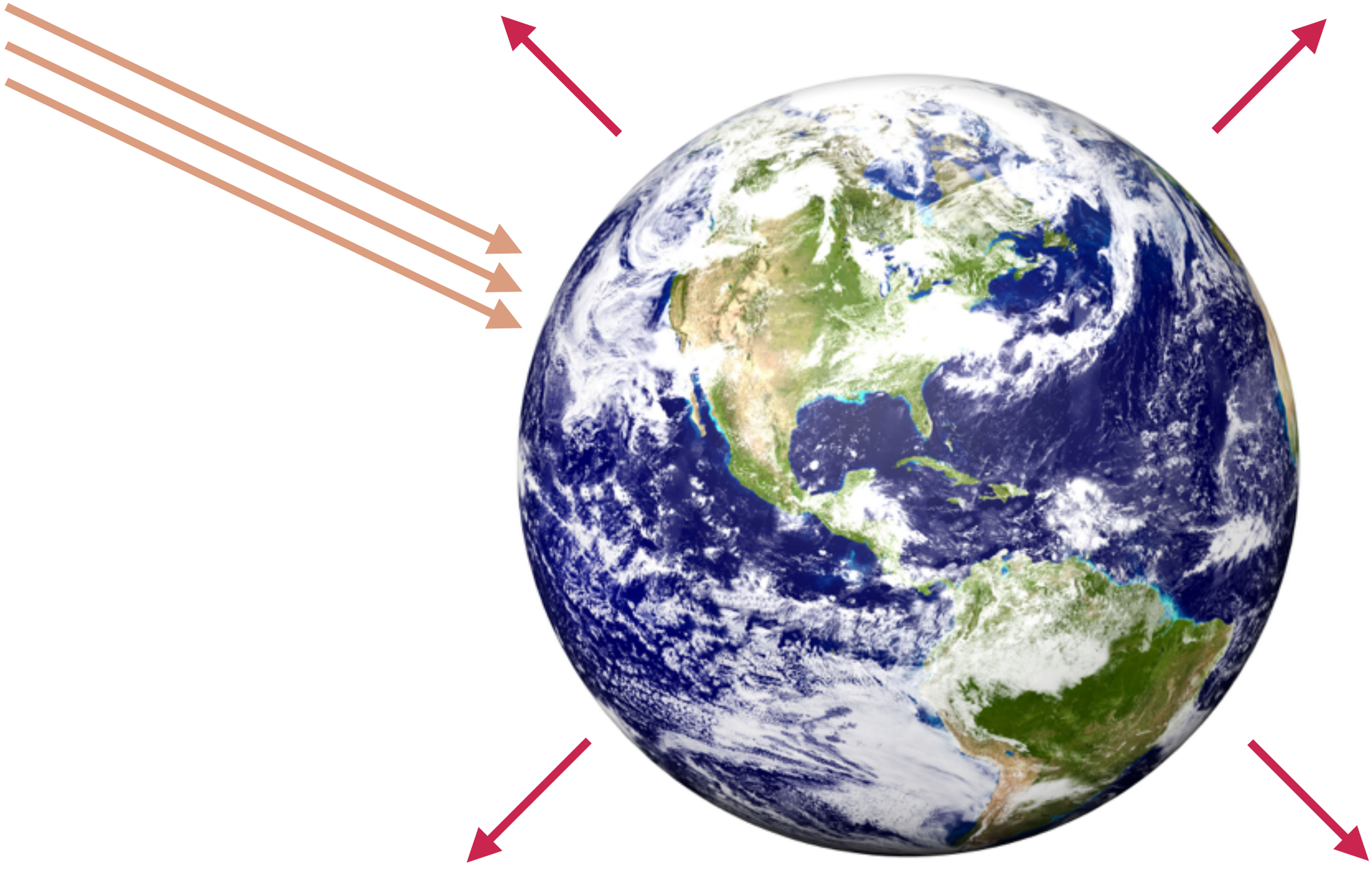
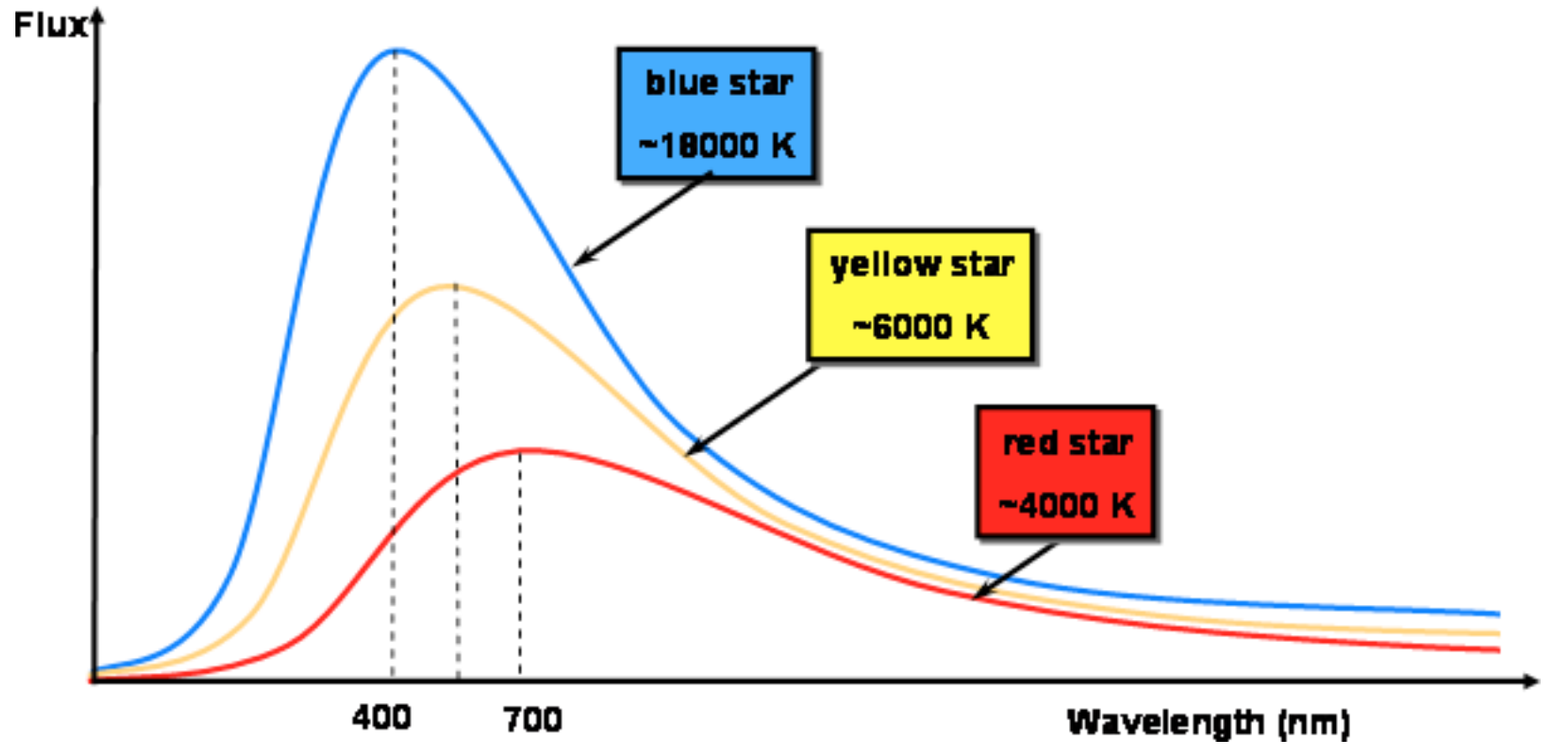
- 1989: Margaret Thatcher calls for a global treaty on climate change
- Lots more from there

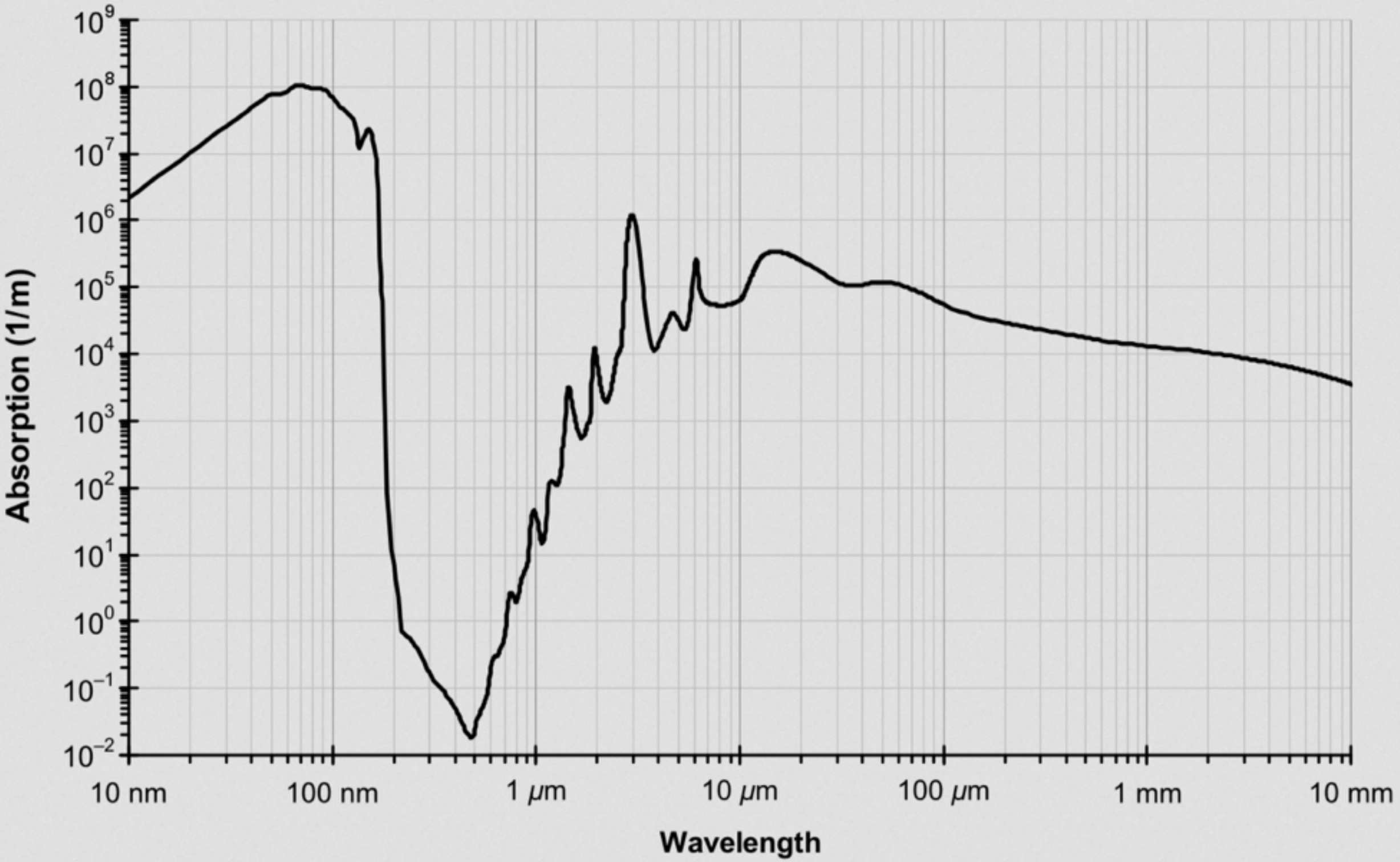
Energy Balance



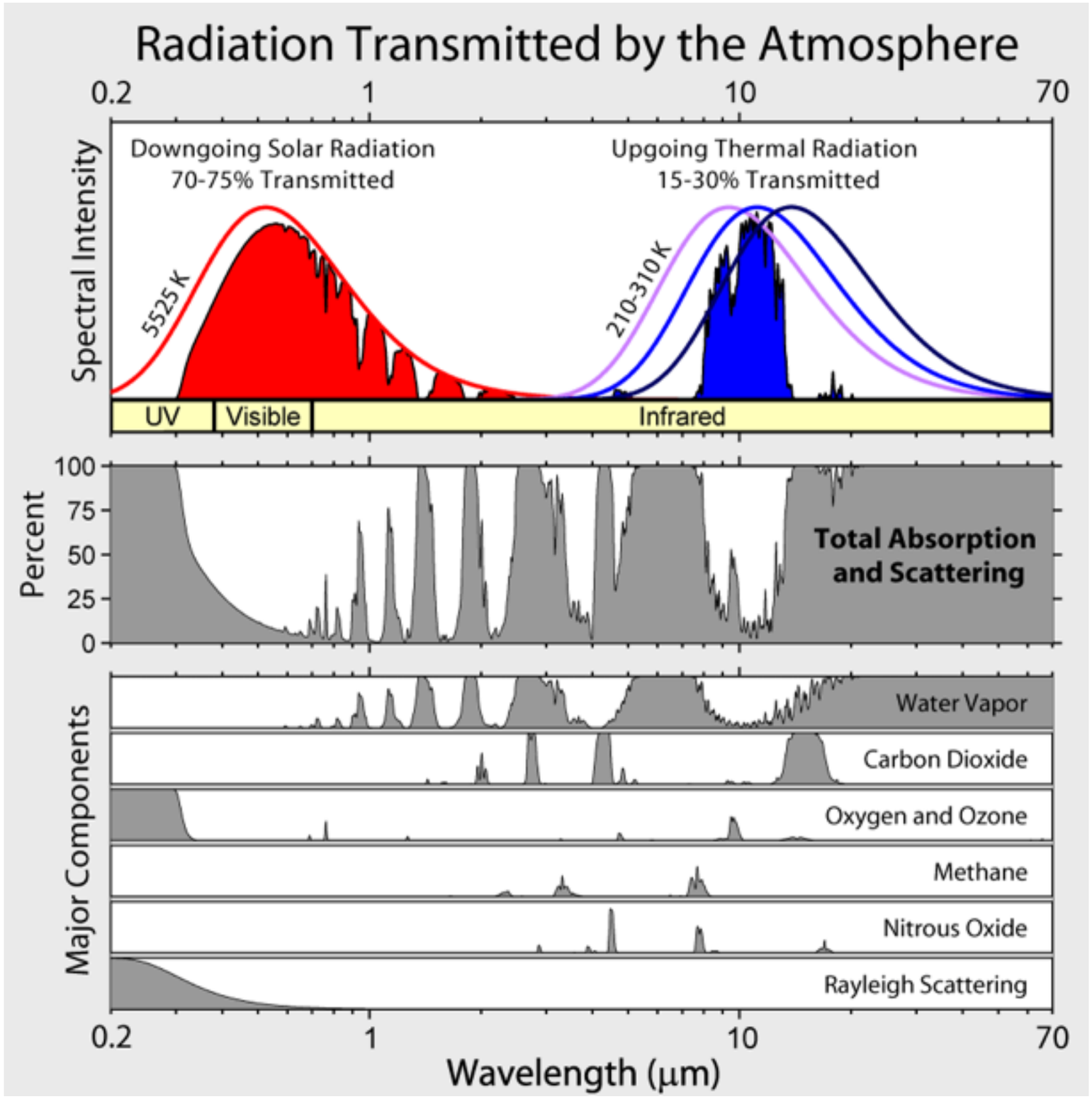
Black Body Radiation



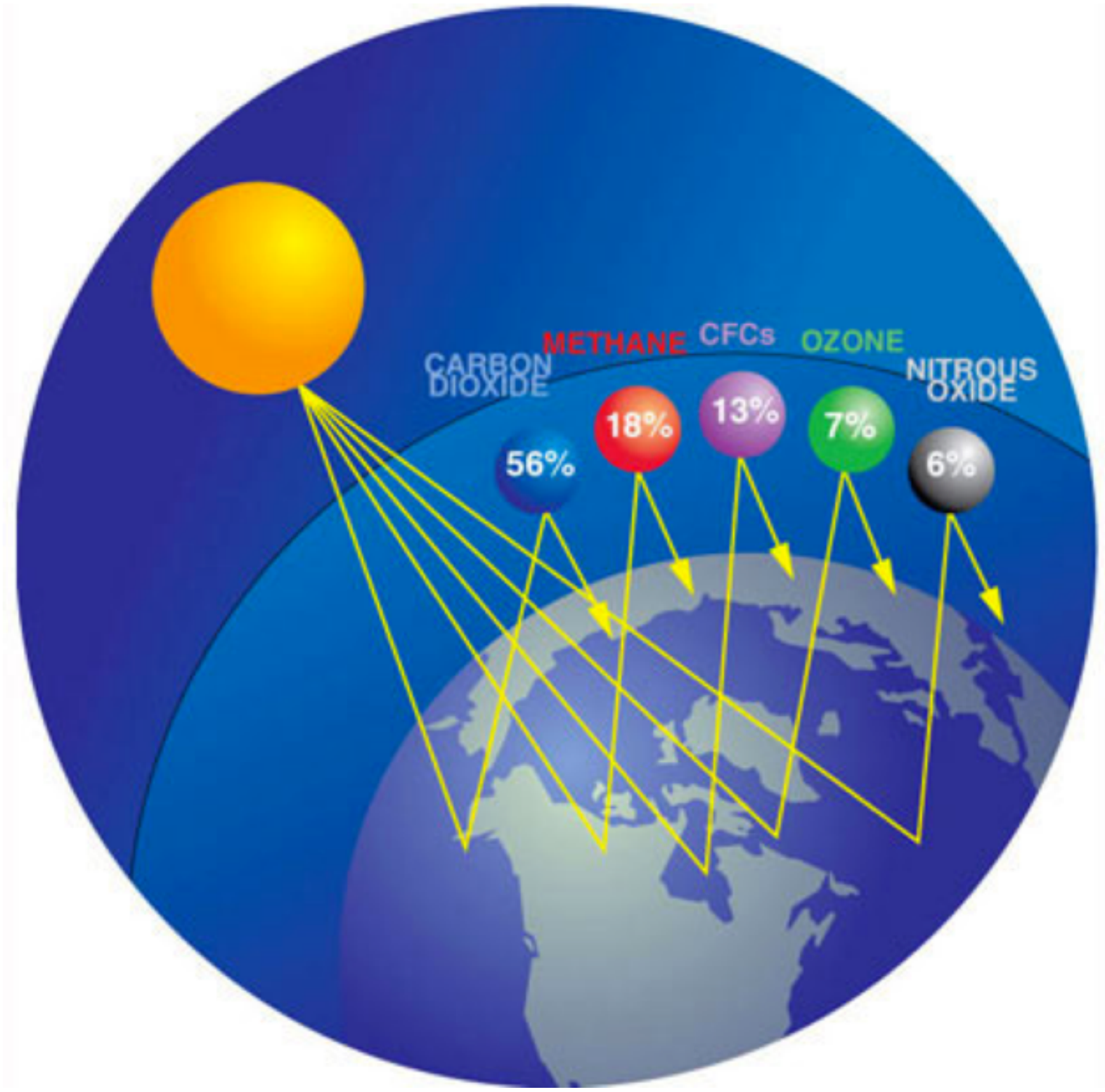
Absorption


Absorption (1/m)
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10 nm
100 nm
1 μm
10 μm
100 μm
1 mm
10 mm
Wavelength

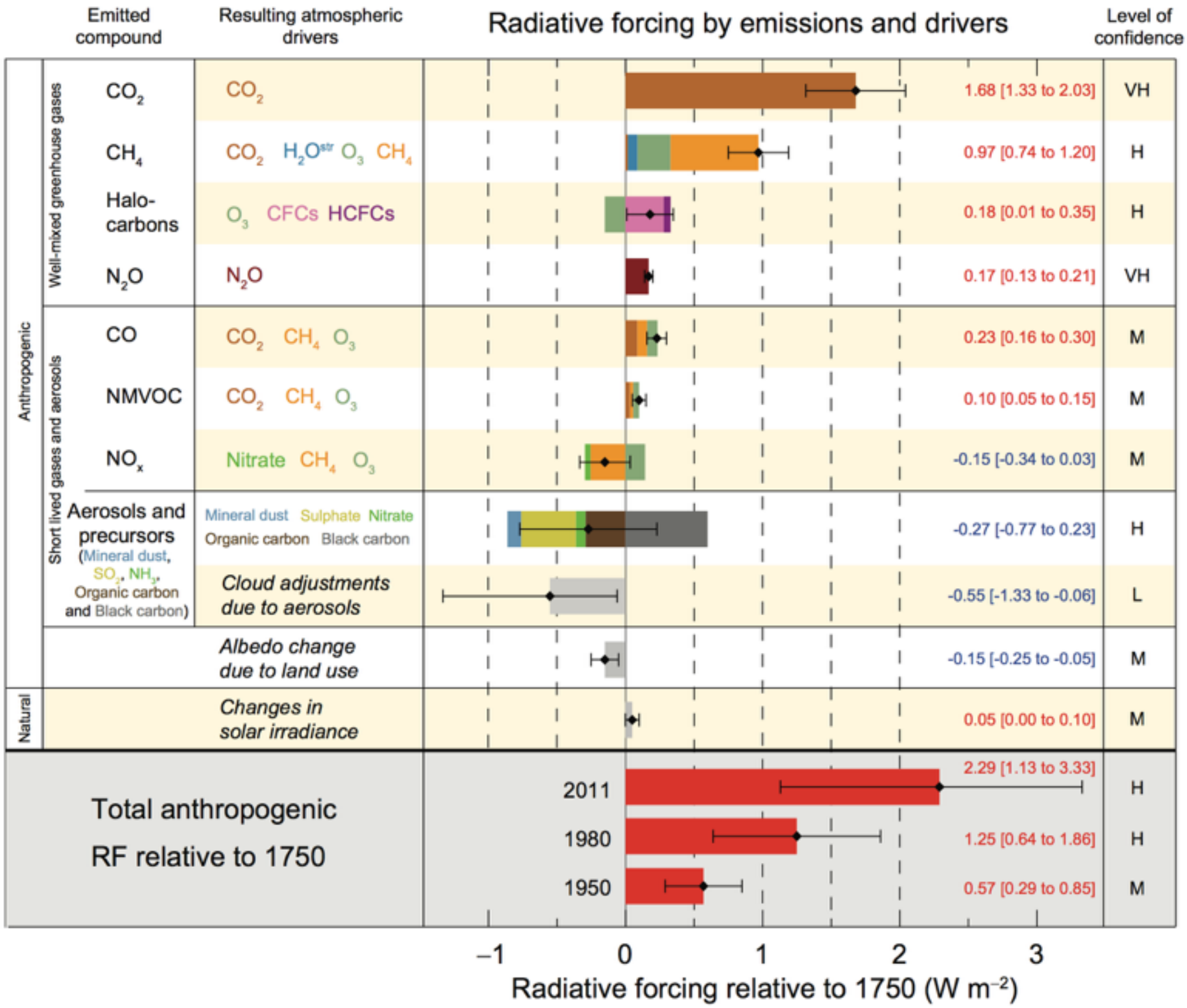
Black Body Radiation + Absorption



So a Greenhouse Gas is What?



GhG Bookkeeping



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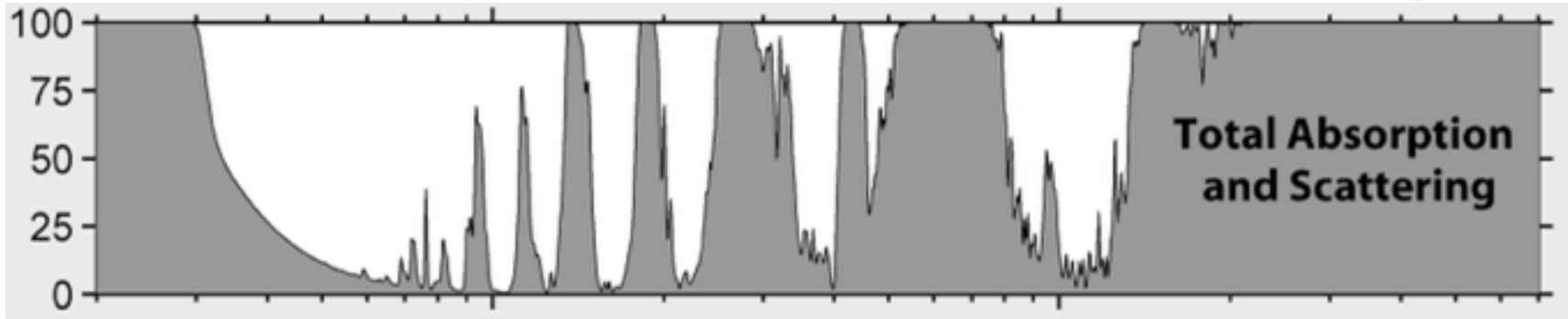
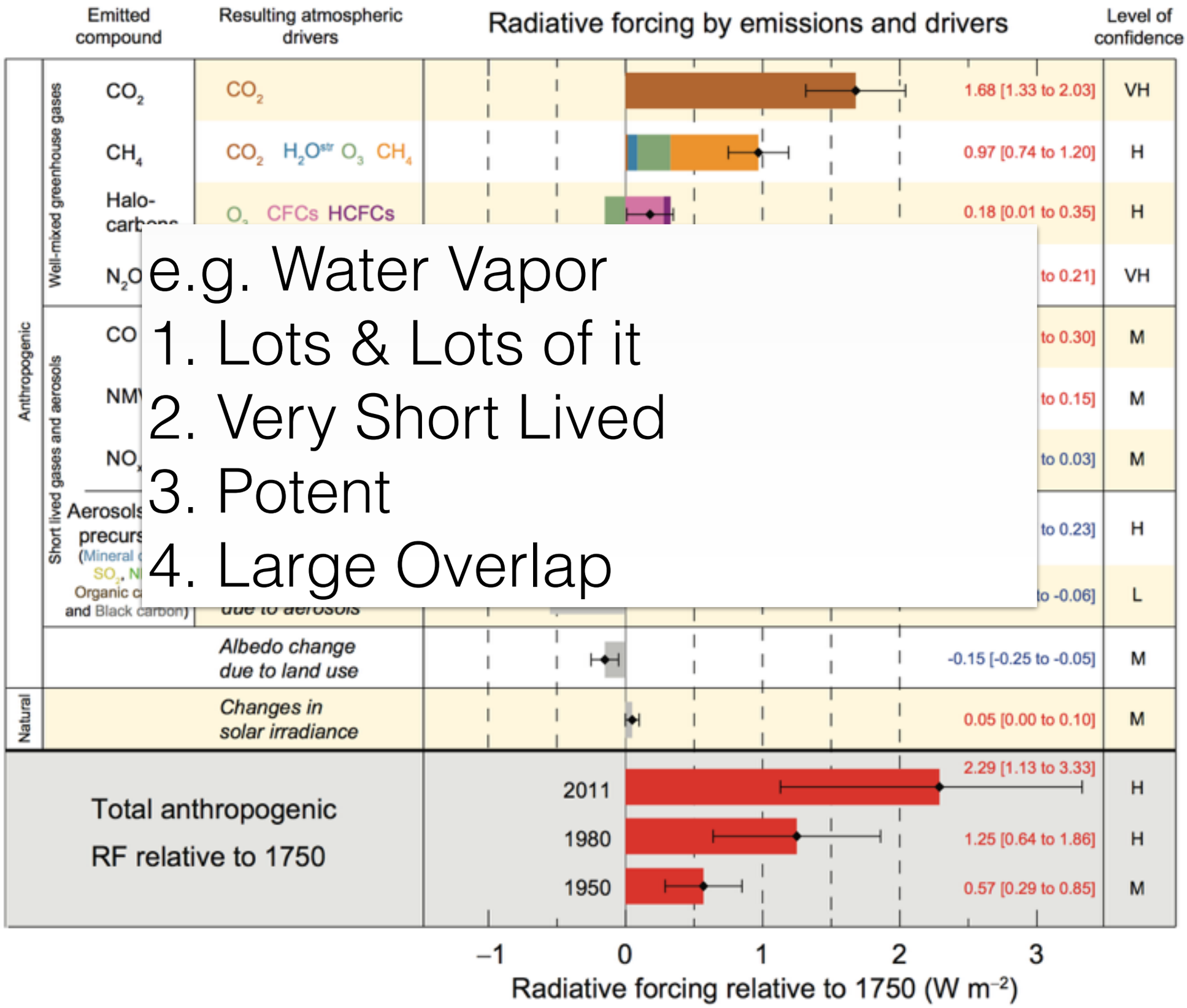


Combination of:
1.Concentration
2.Lifetime
3.Potency
4.Available photons, location…

Gas	Atmospheric Lifetime	100-year GWP[a]
Carbon dioxide (CO_2)	50-200	1
Methane (CH_4)[b]	12±3	21
Nitrous oxide (N_2O)	120	310

Concentration in 1994
358 000 ppbv
1721 ppbv
311 ppbv

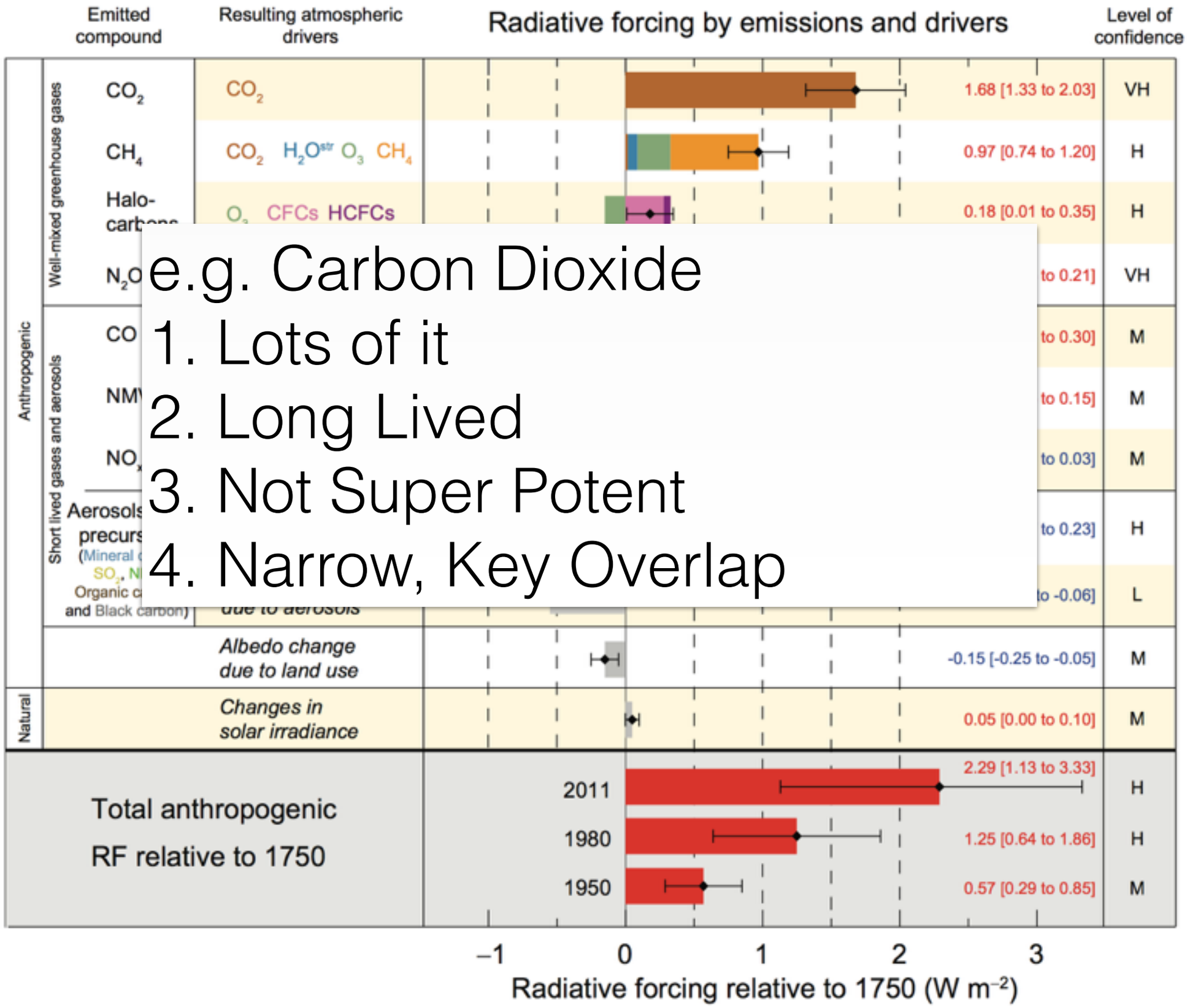
GhG Bookkeeping



e.g. Water Vapor

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

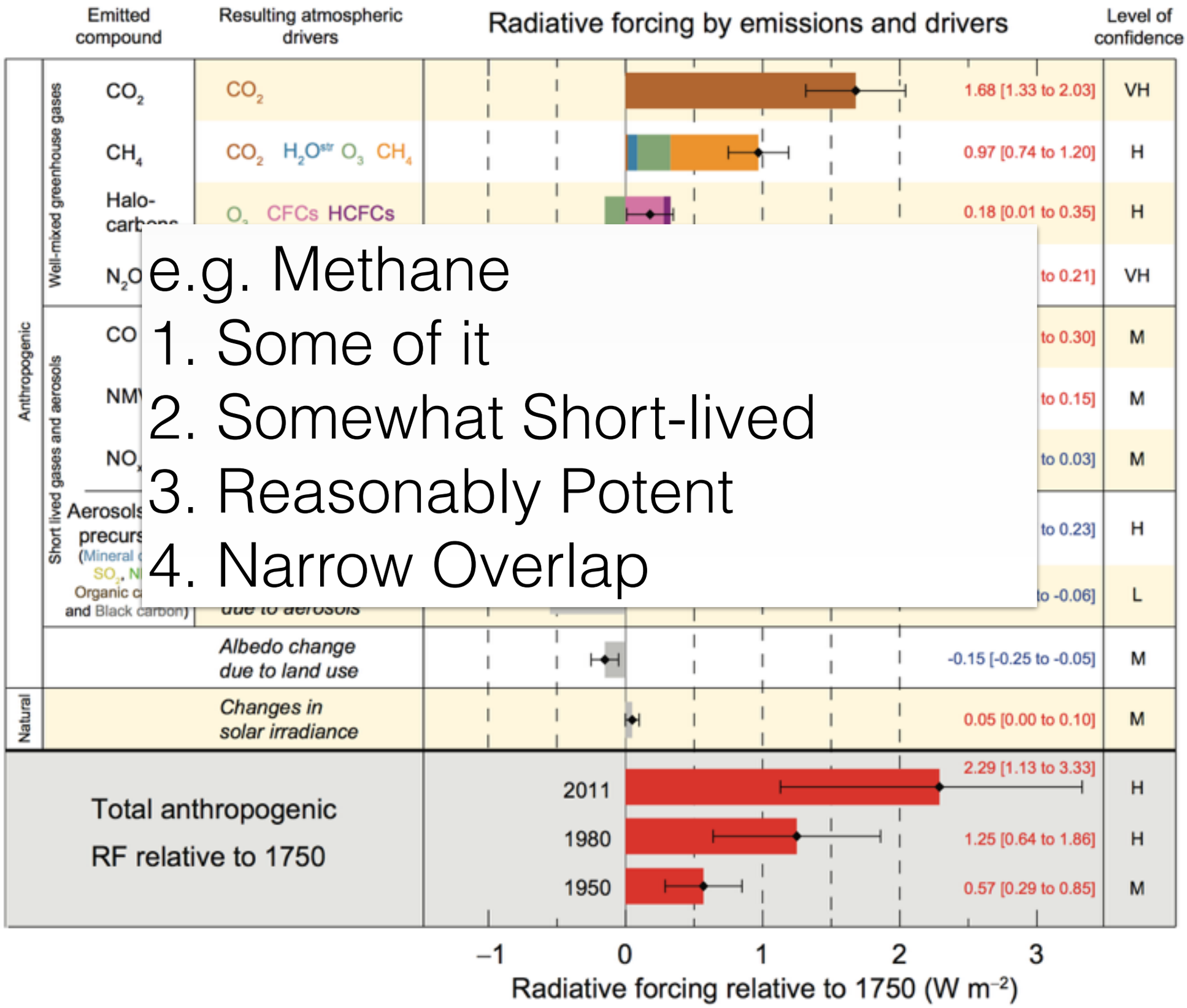
GhG Bookkeeping



e.g. Carbon Dioxide

1. Lots of it
2. Long Lived
3. Not Super Potent
4. Narrow, Key Overlap

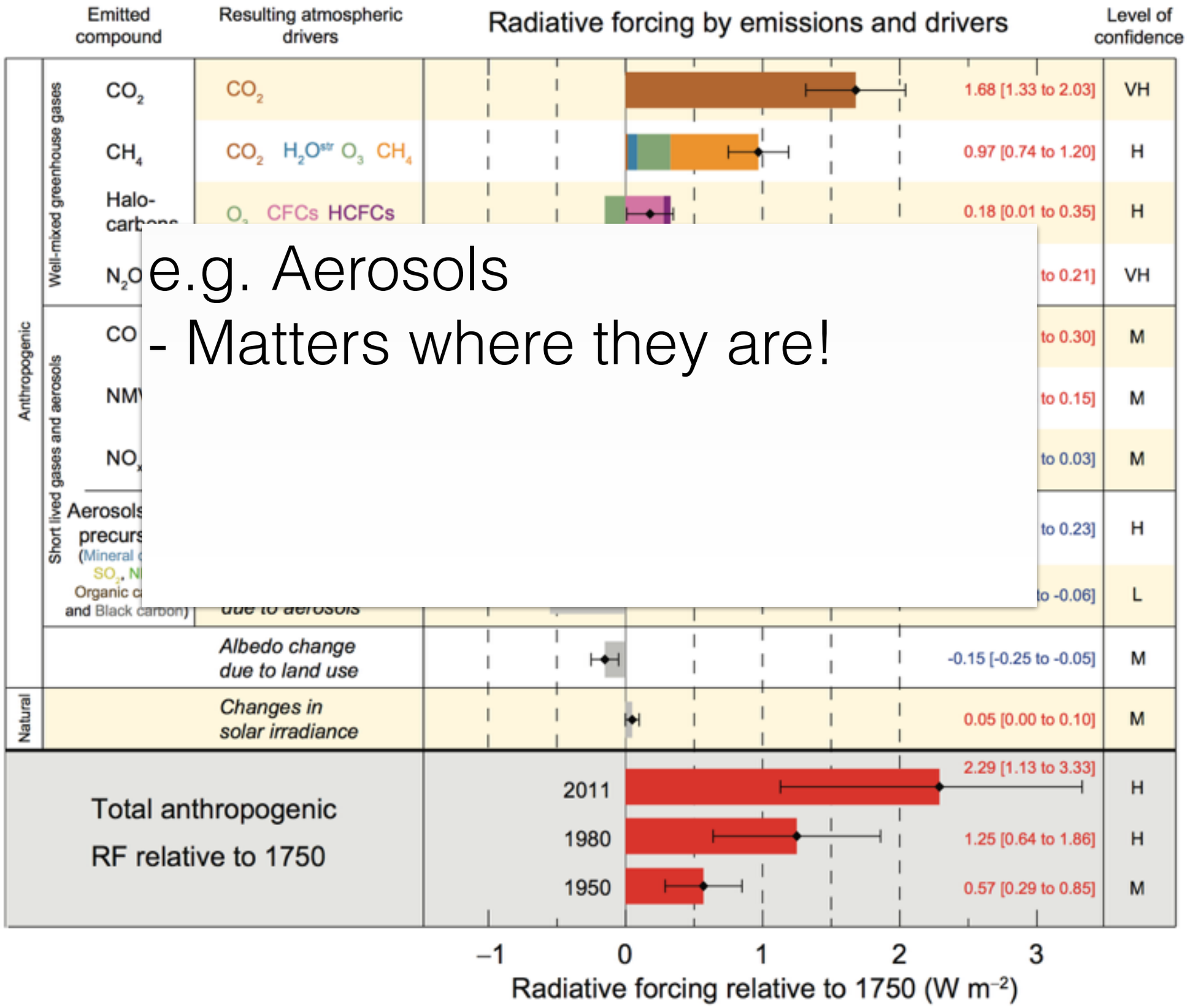
GhG Bookkeeping



e.g. Methane

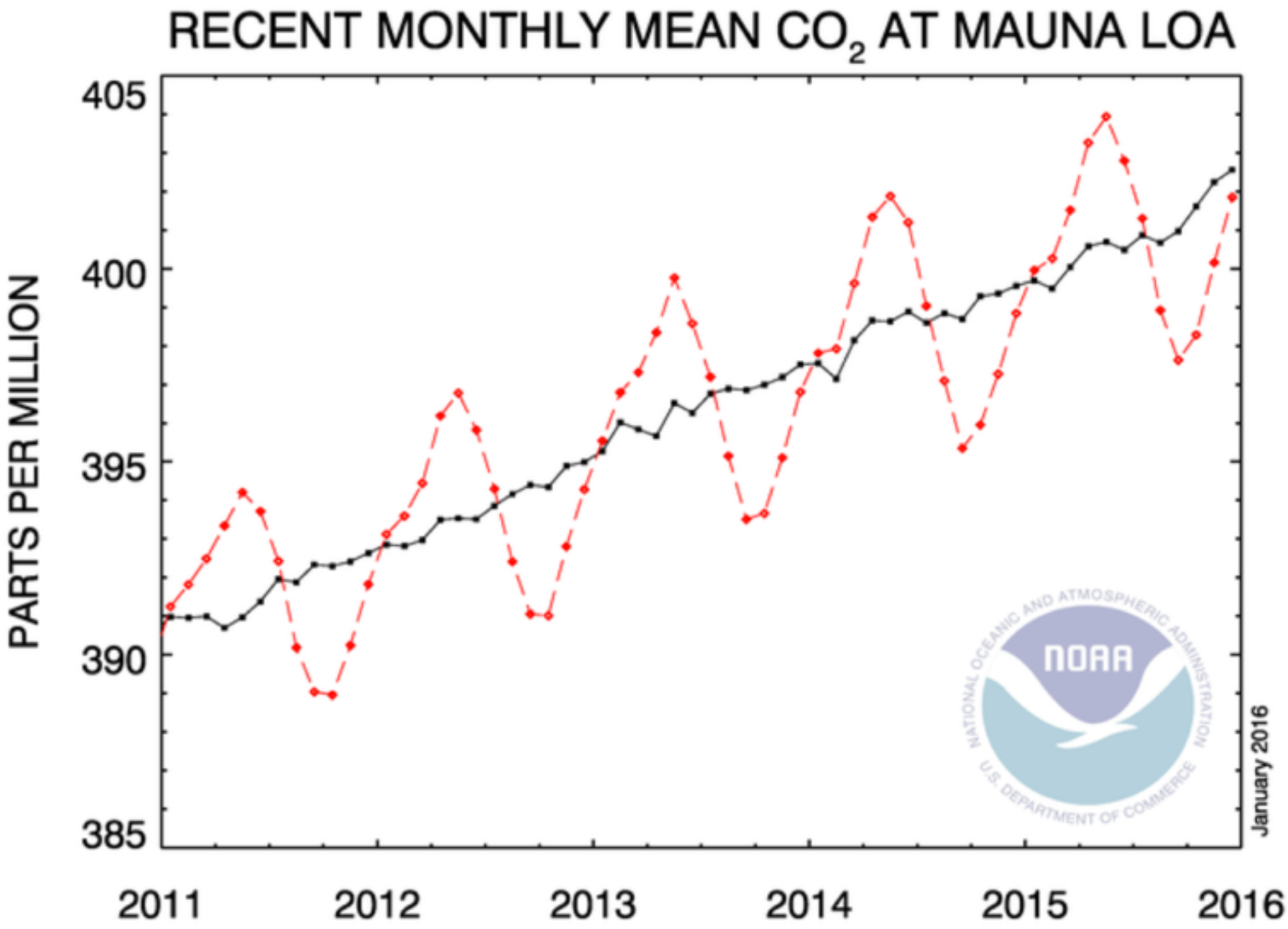
1. Some of it
2. Somewhat Short-lived
3. Reasonably Potent
4. Narrow Overlap

GhG Bookkeeping



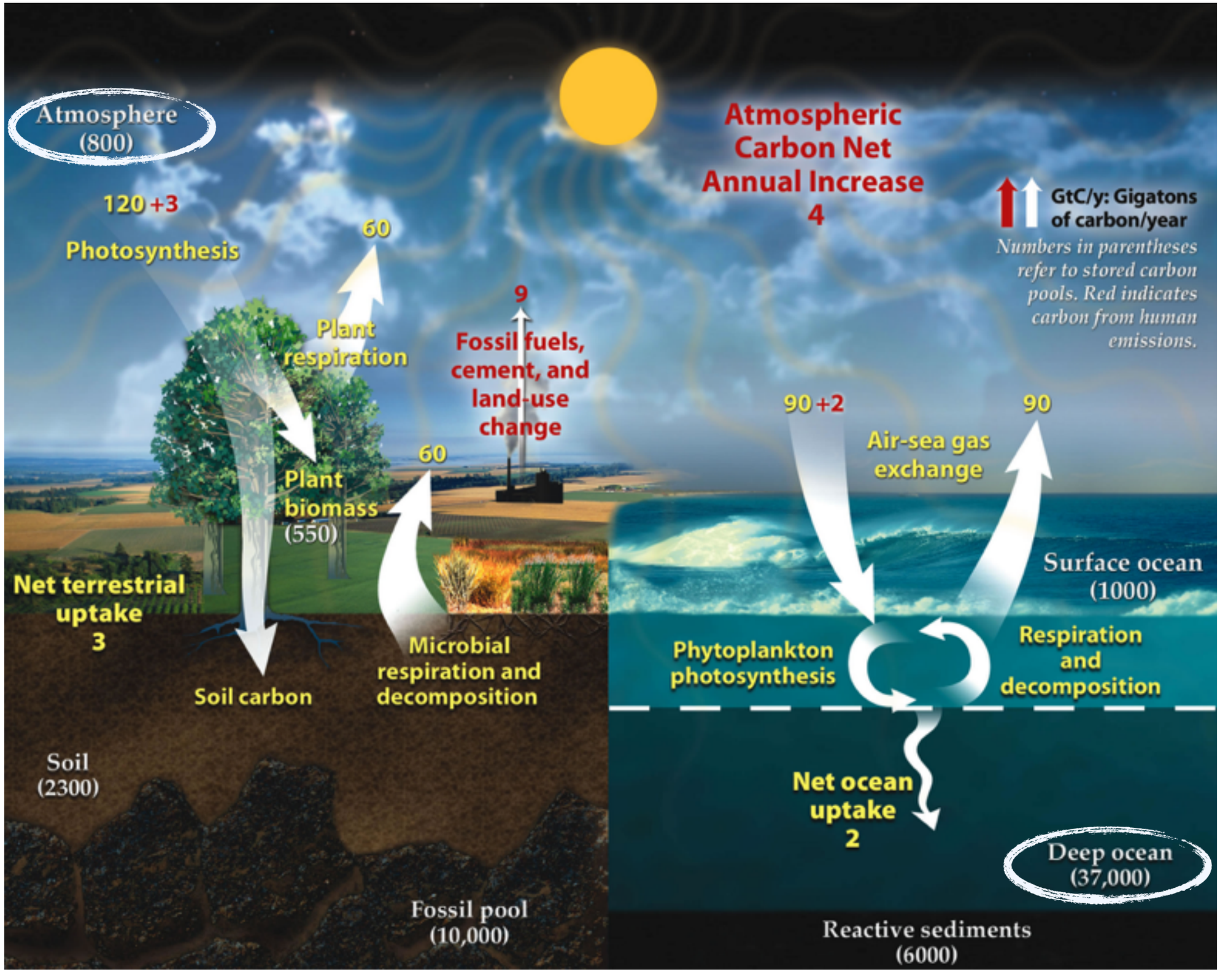
e.g. Aerosols
- Matters where they are!

Carbon

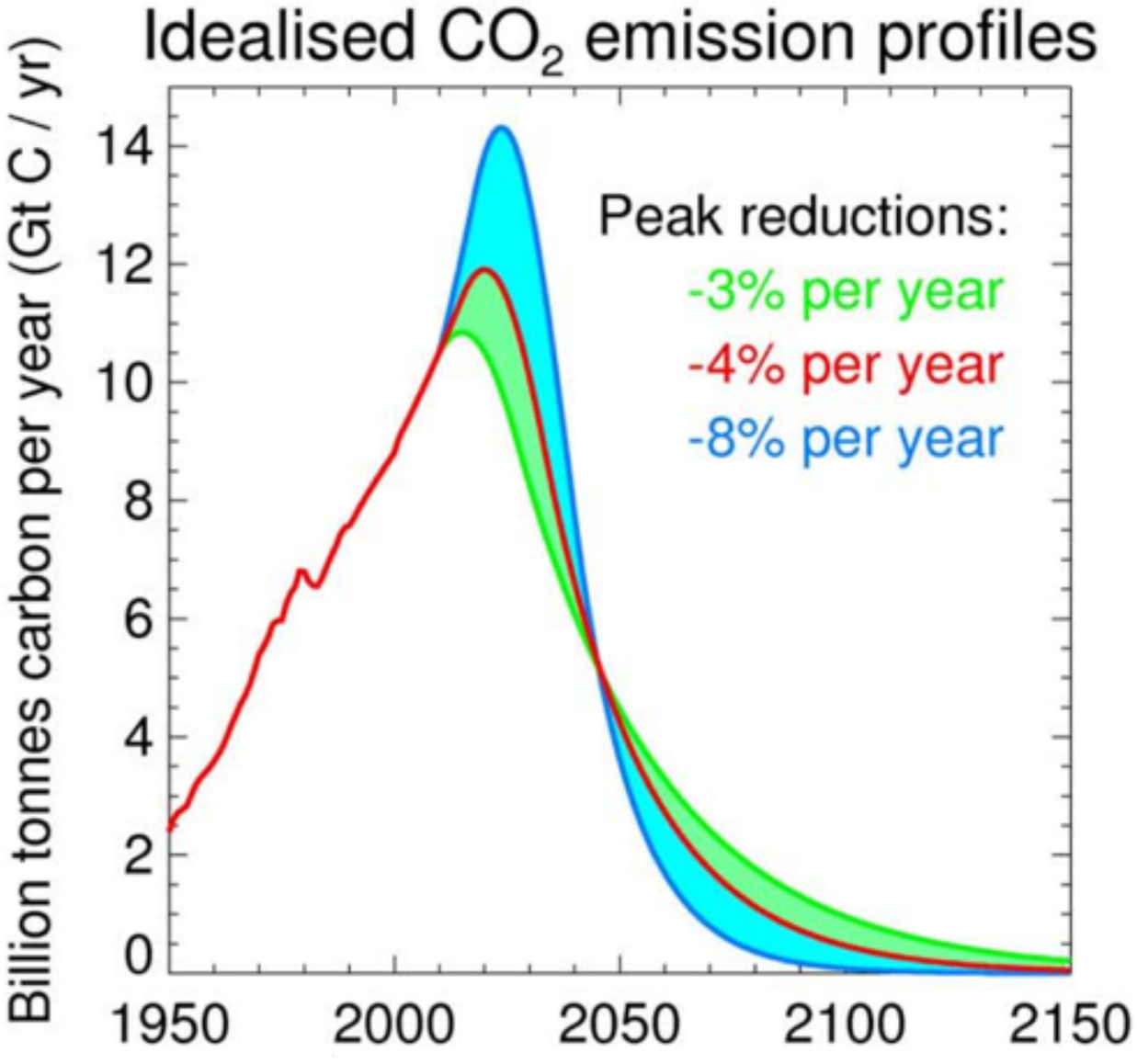


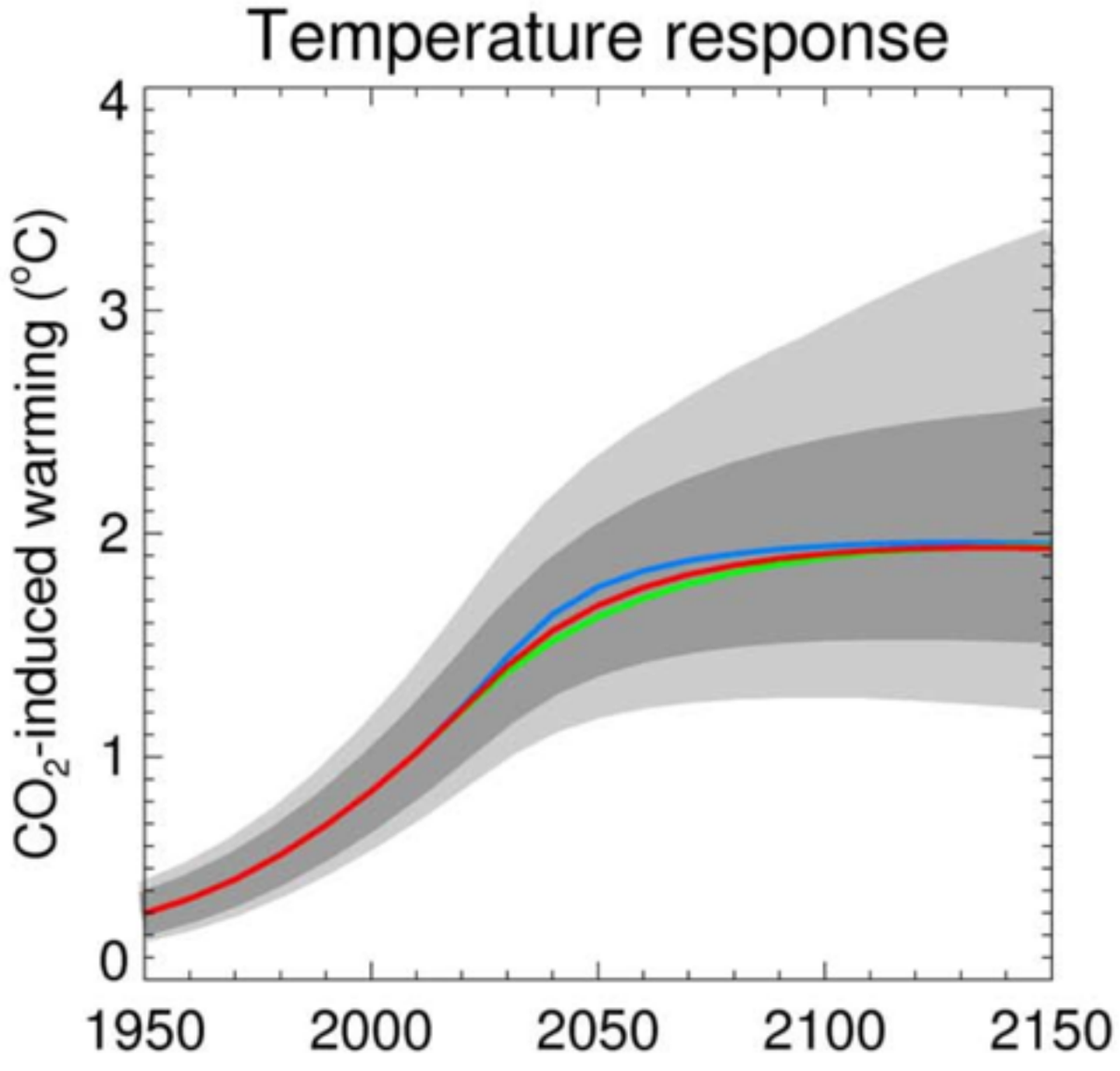
December 2015: 401.85 ppm

Carbon Cycle



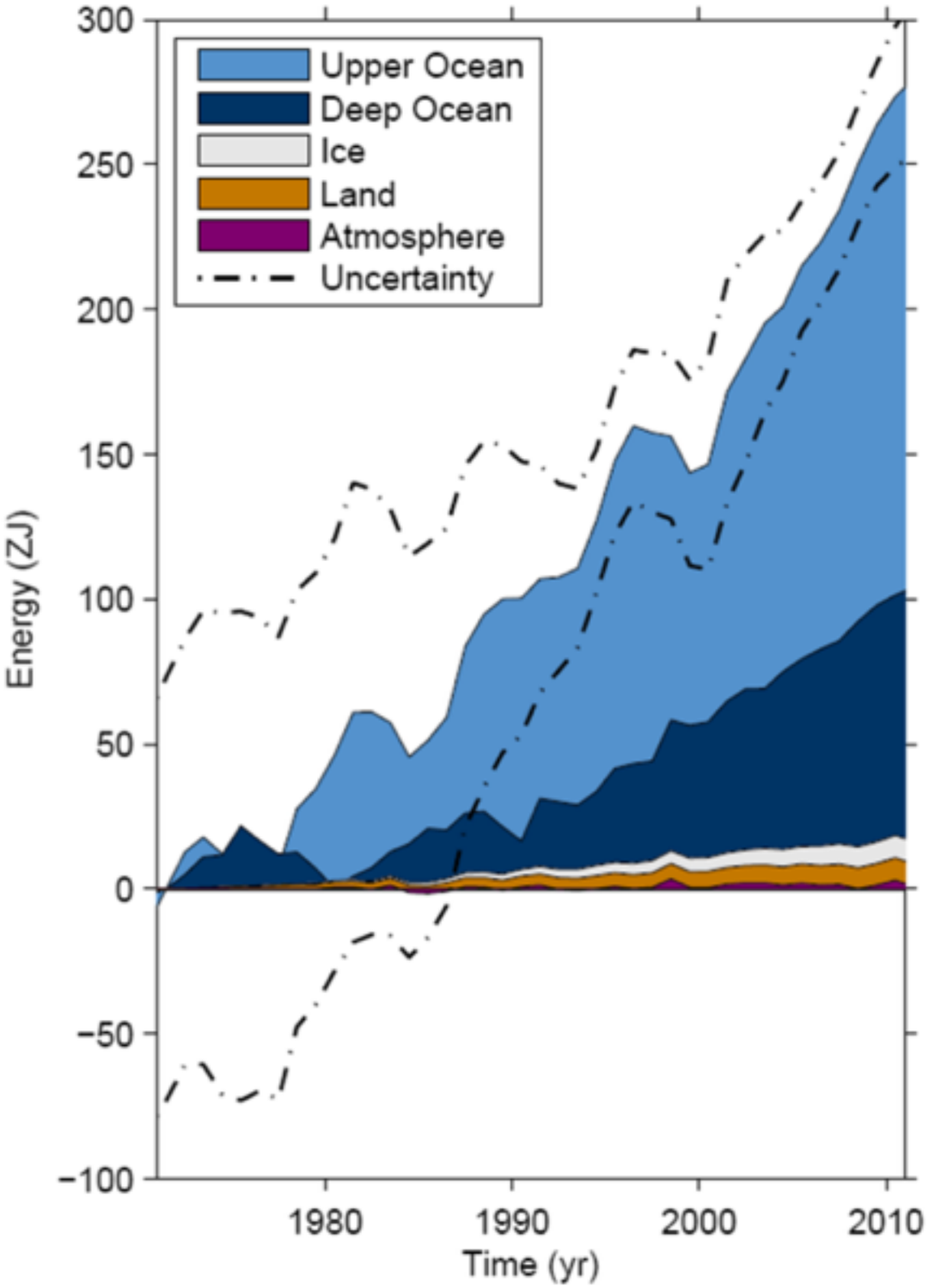
Carbon Cycle is Slow

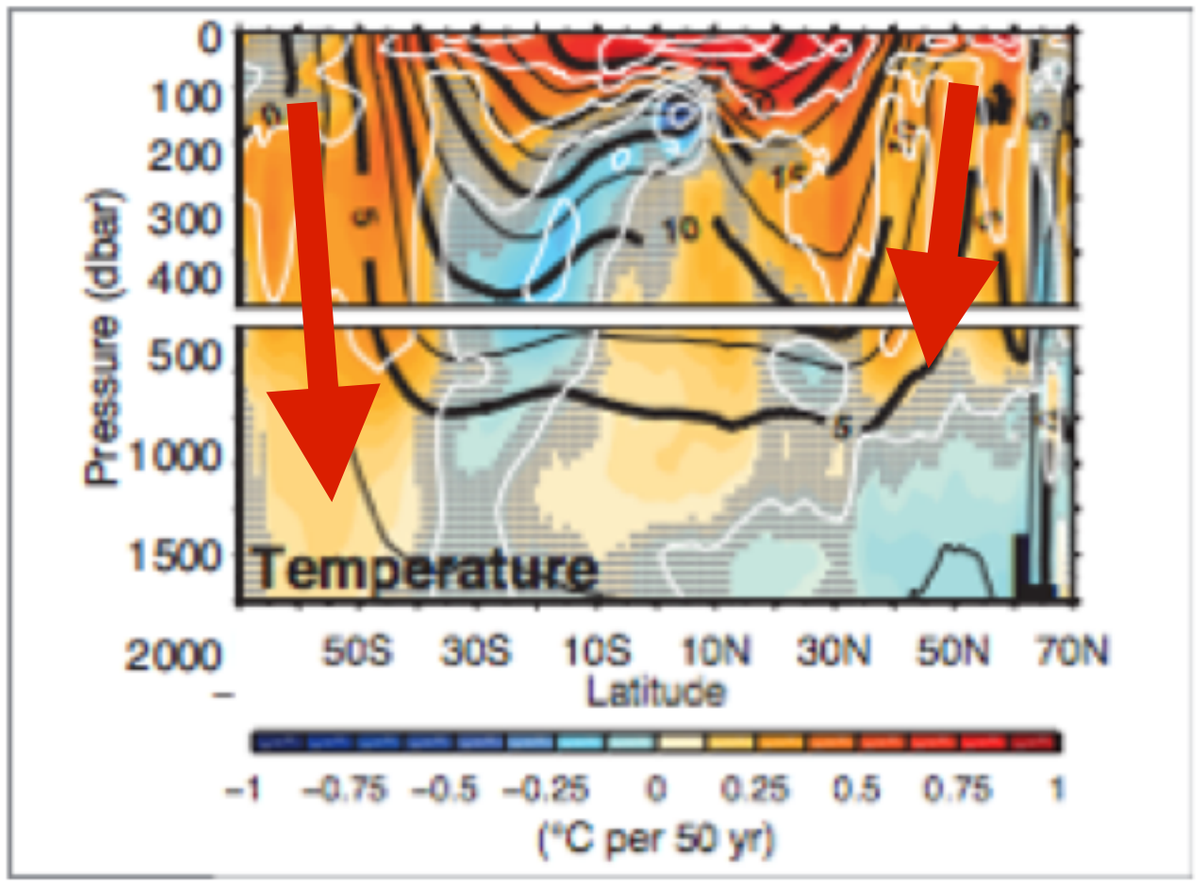




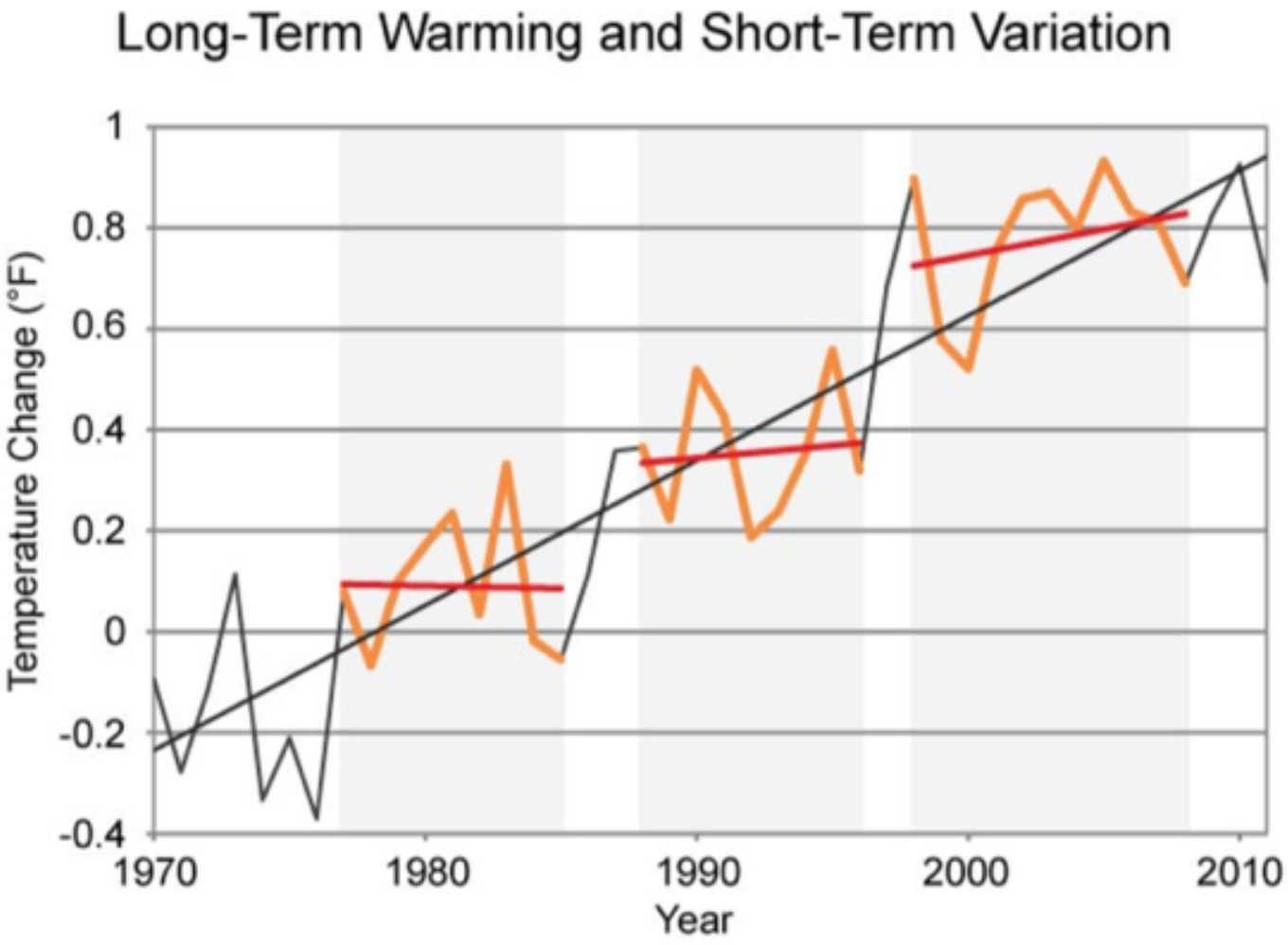
Heat

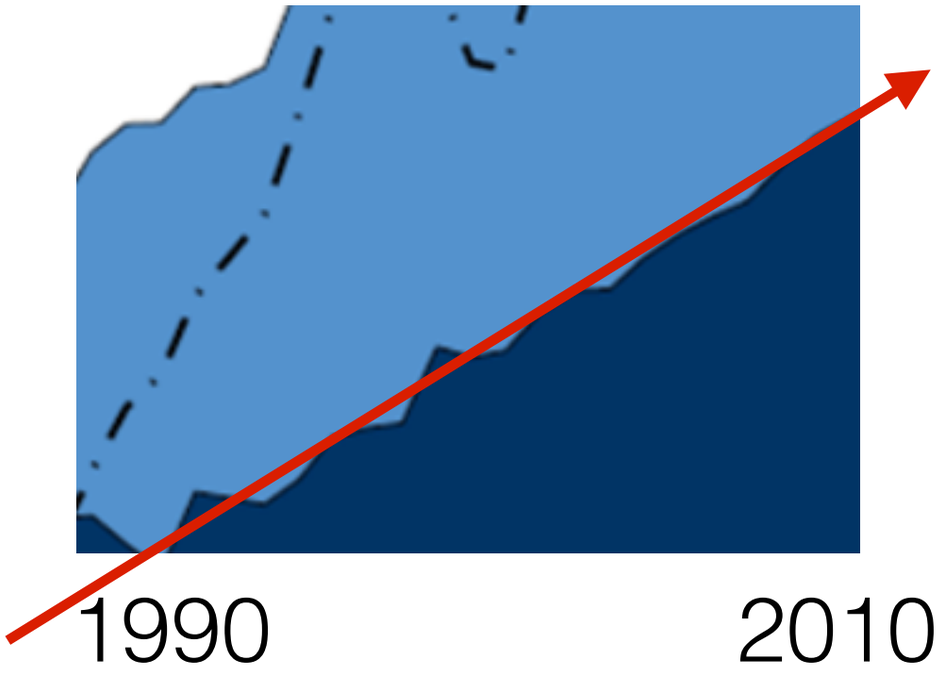
Heat Storage



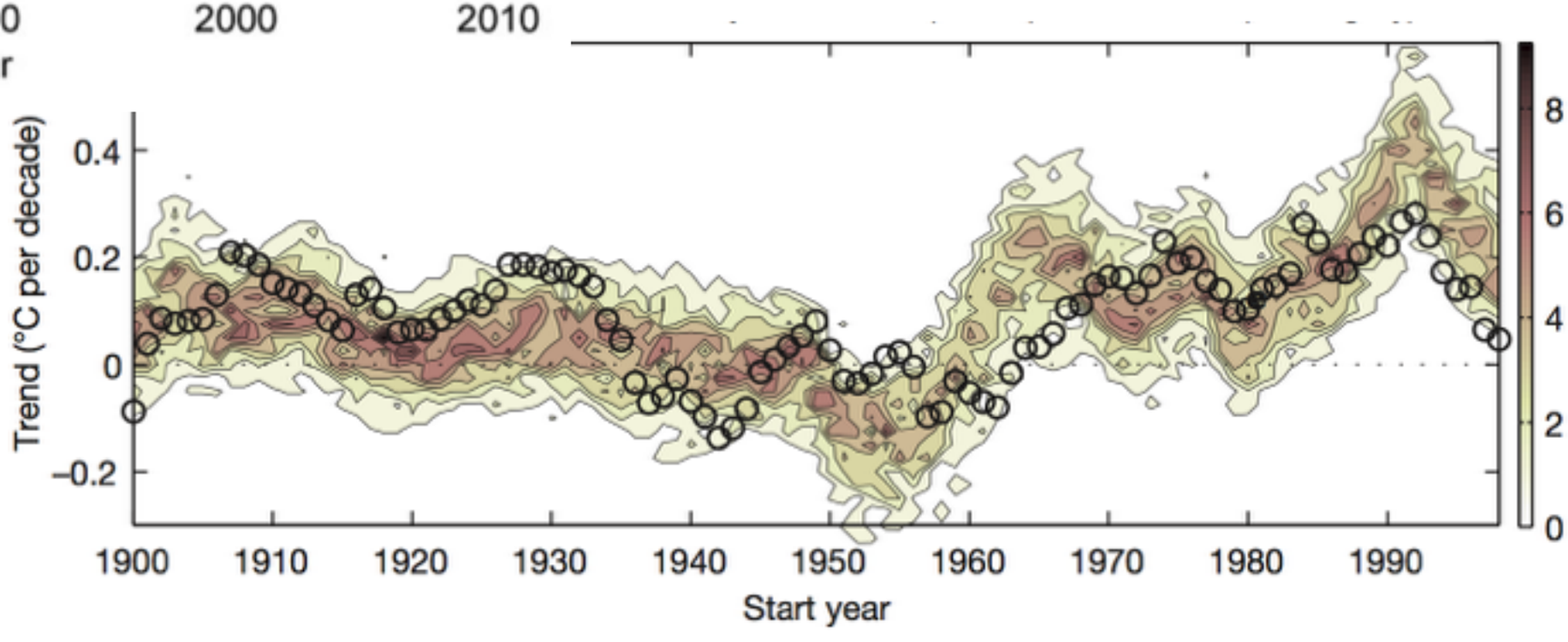


e.g. Warming ‘Hiatus’





(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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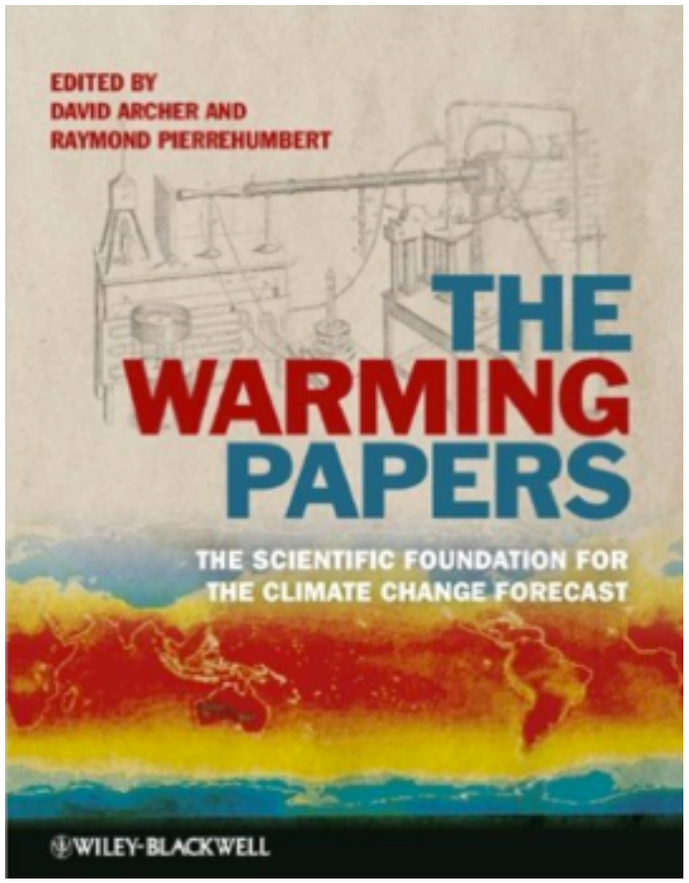
Complexity is in their *interactions*

Stick around for the other talks to learn about:

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

Resources // Questions?



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INTERGOVERNMENTAL PANEL ON climate change