# Modern Climate Change: A Symptom of a Human-Caused High-Energy Pulse

Hans-Peter Plag
Old Dominion University
Norfolk, VA, USA

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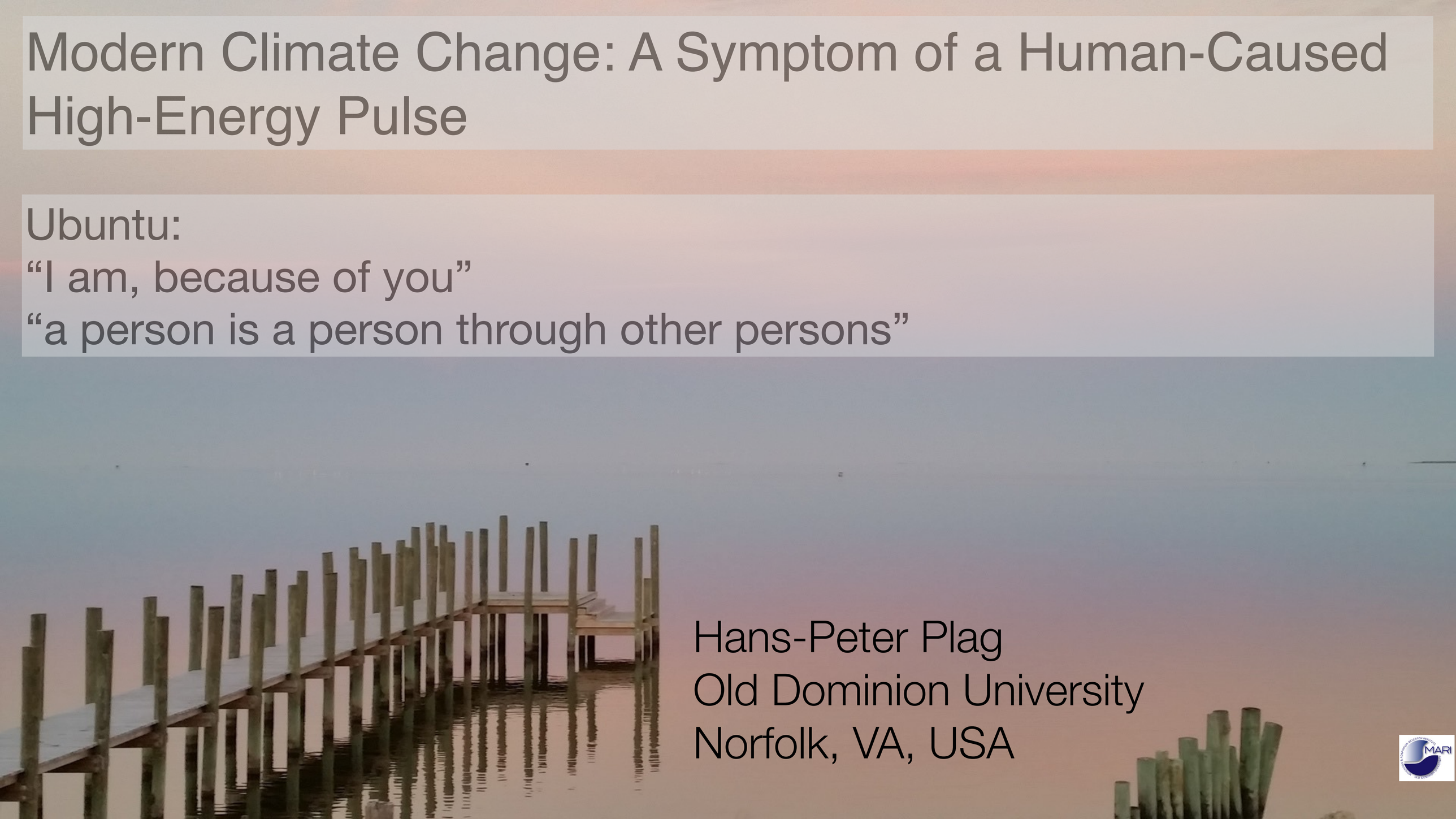
Ubuntu:
“I am, because of you”
“a person is a person through other persons”



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Our perception depends on the distance we have …

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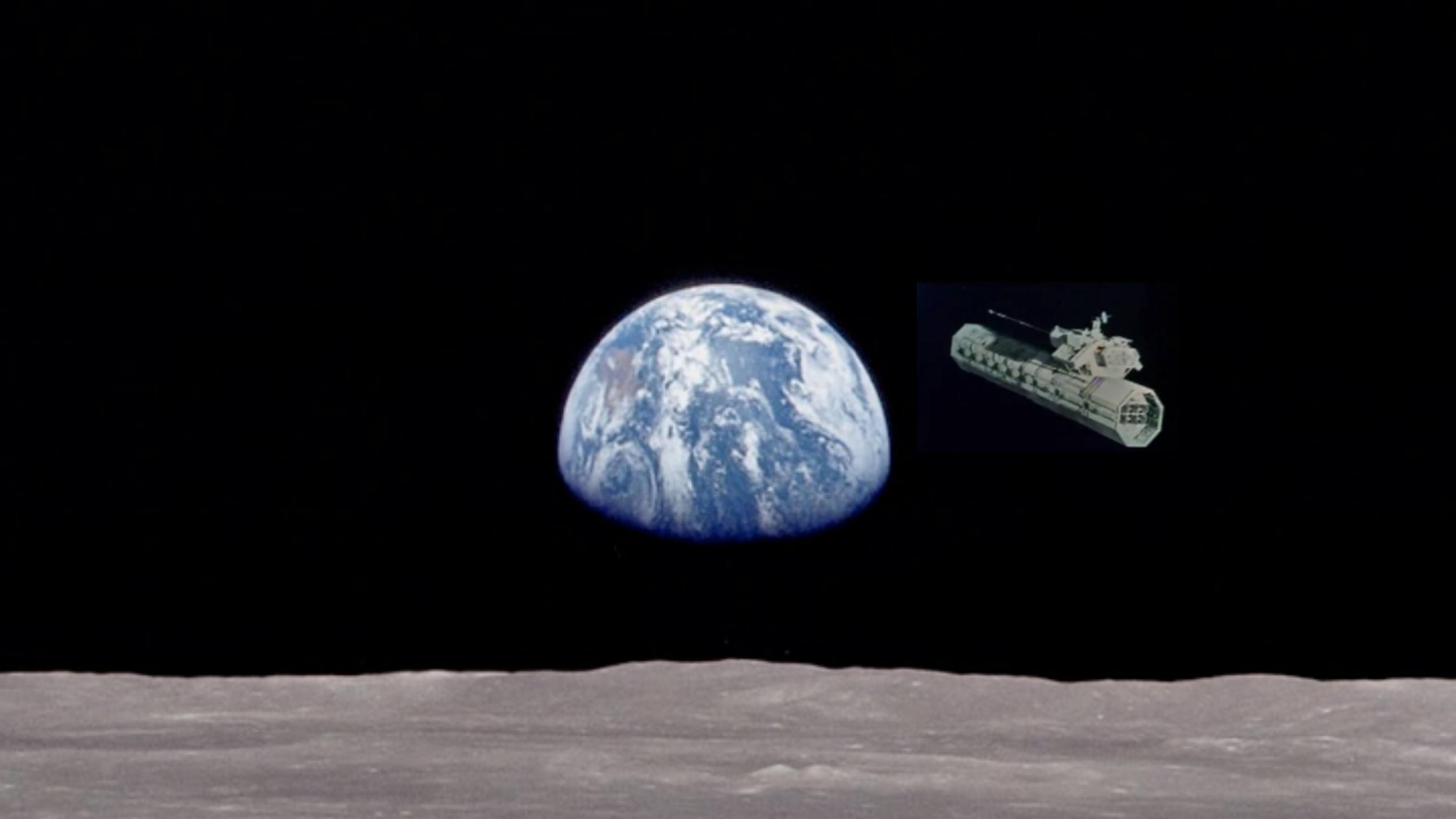

# Physiology of the Planetary Life-Support System: Homeostasis

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Global Essential Variable: Energy Imbalance: Incoming Energy minus Outgoing Energy

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(2) Where, and in what form, is the energy stored?

# Humans are aware of unusual trends



Climate change

## July on course to be hottest month ever, say climate scientists

**If global trends continue for another fortnight, it will beat previous two-year-old record**

Jonathan Watts

@jonathanwatts

Tue 16 Jul 2019 12.32 EDT



▲ Tourists leave the Acropolis on 4 July in Athens, Greece, after it closed due to high temperatures. Photograph: Miloš Bičanski/Getty Images

Record temperatures across much of the world over the past two weeks could make July the hottest month ever measured on Earth, according to climate scientists.

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Environment ▸ Climate change Wildlife Energy Pollution

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## 2020 to be one of hottest years on record, Met Office says

▲ A hydrologist checks cracks in the dried up municipal dam in the drought-stricken town of Graaff-Reinet, South Africa, in November 2019. Photograph: Mike Hutchings/Reuters

**Temperatures are expected to be more than 1.1C above pre-industrial average**

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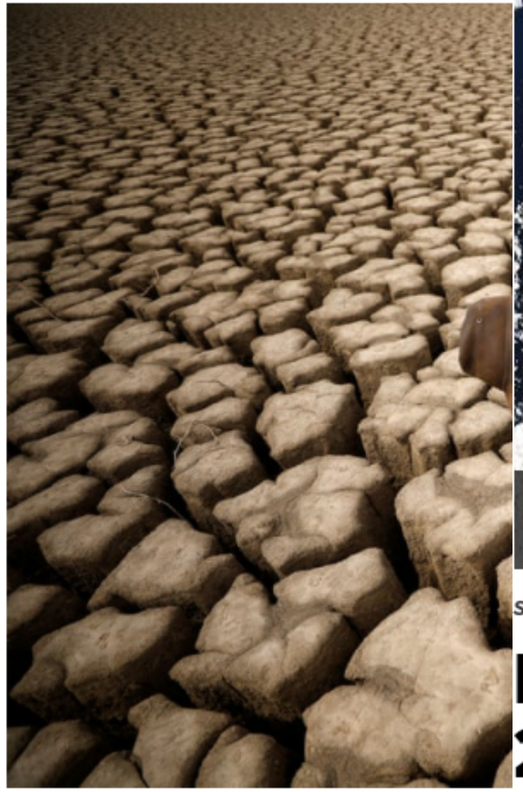

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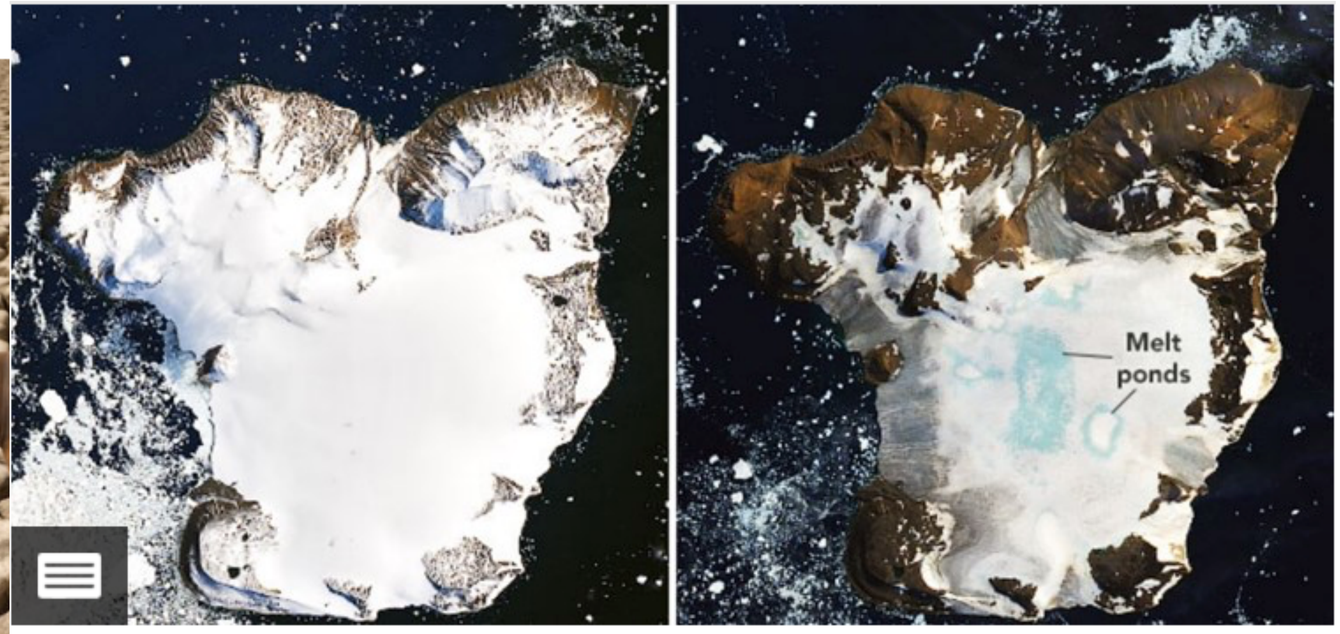


SCIENCE

## NOAA gives a 75 percent chance for 2020 to be warmest year on record

Scientists say it will almost certainly be in the top 5.

Author: Ric Kearbey
Published: 1:53 PM EDT April 29, 2020
Updated: 1:53 PM EDT April 29, 2020

# Some Humans ask Questions

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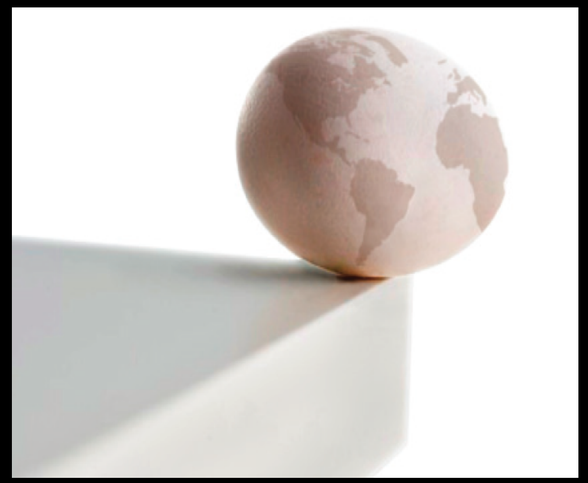
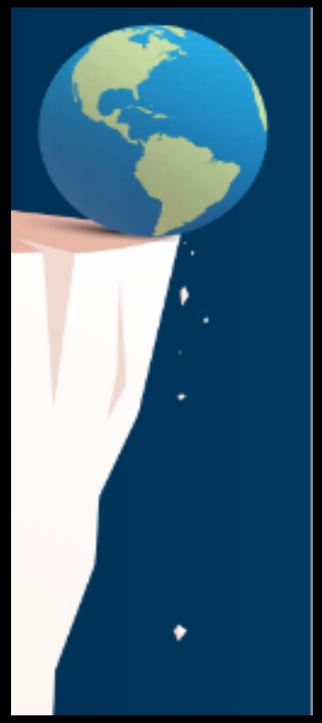
Is Earth on the edge?





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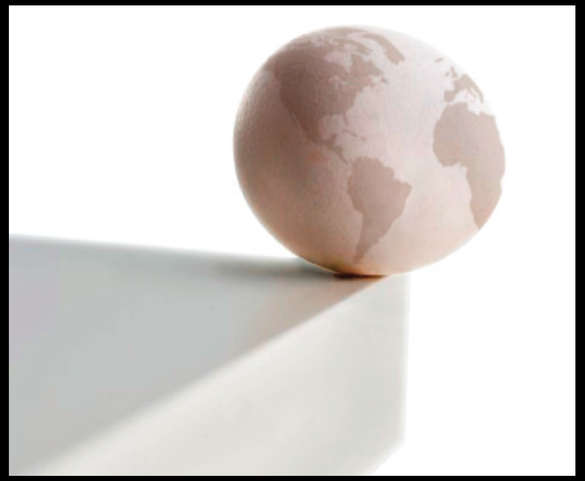

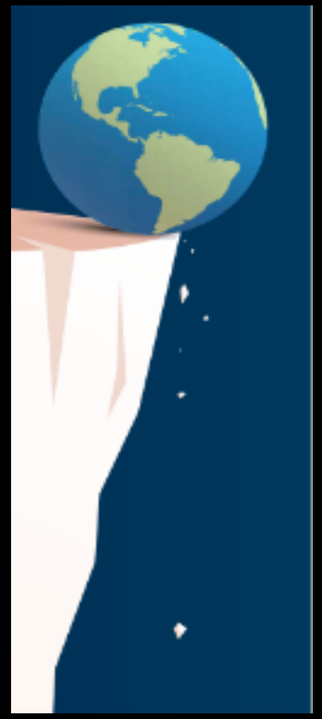

Is humanity as a global species is on the edge?

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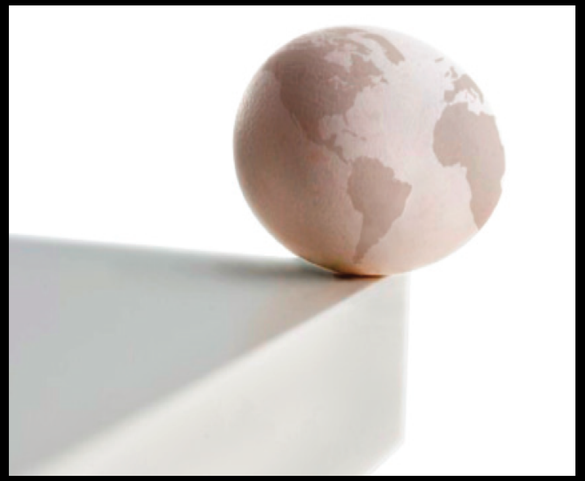

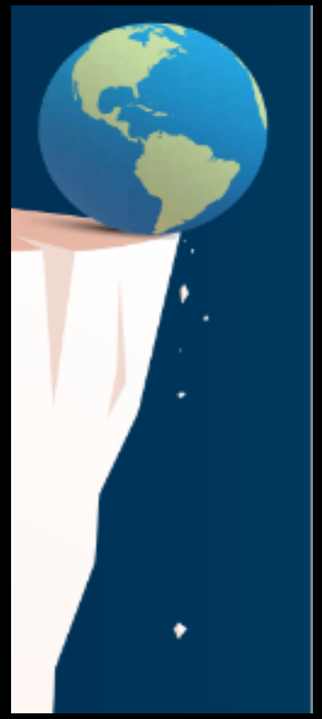

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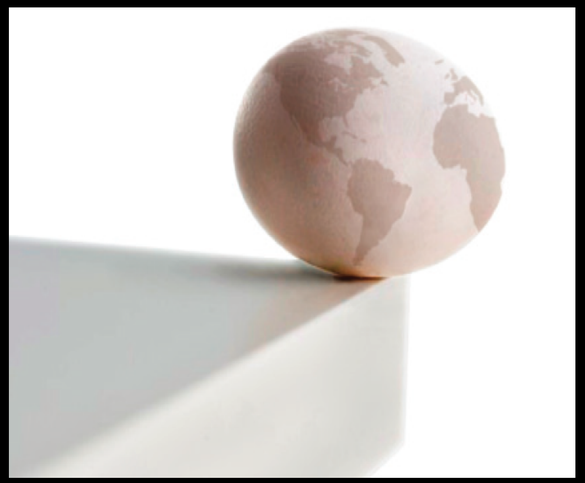
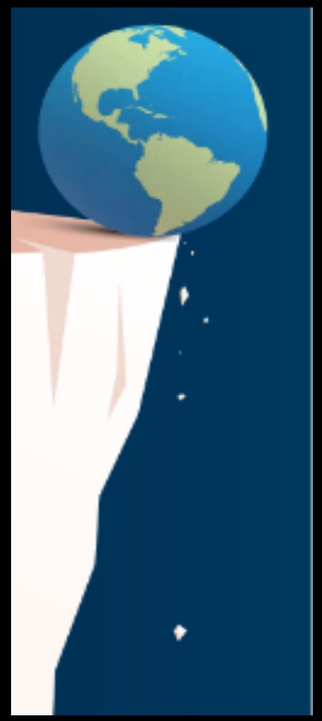
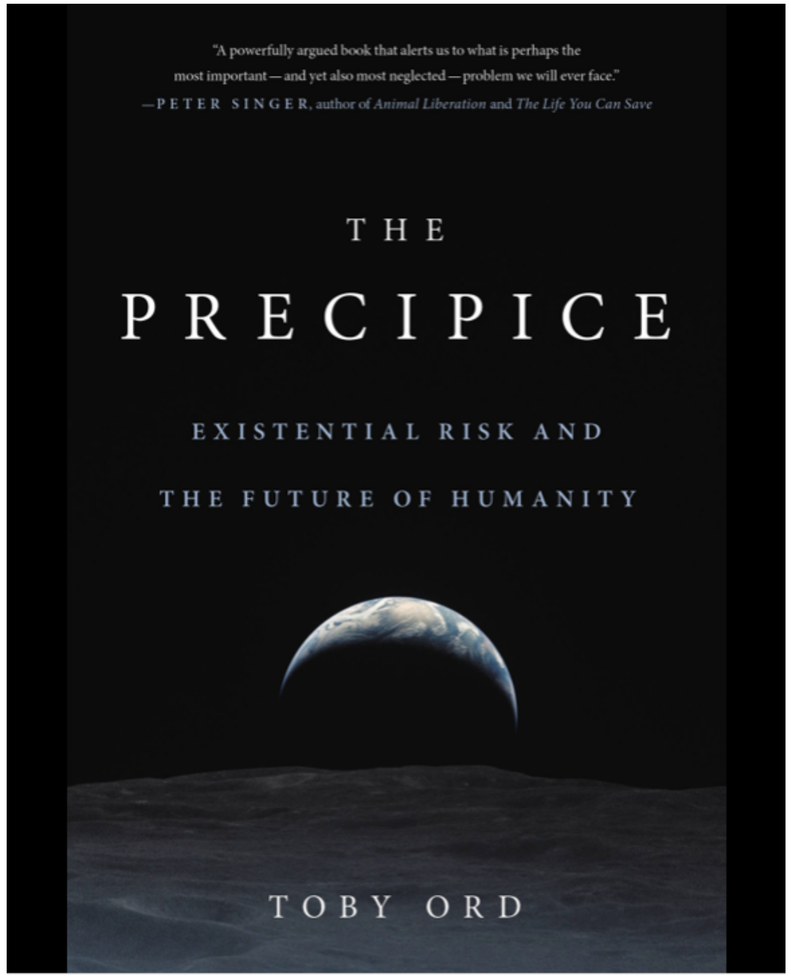


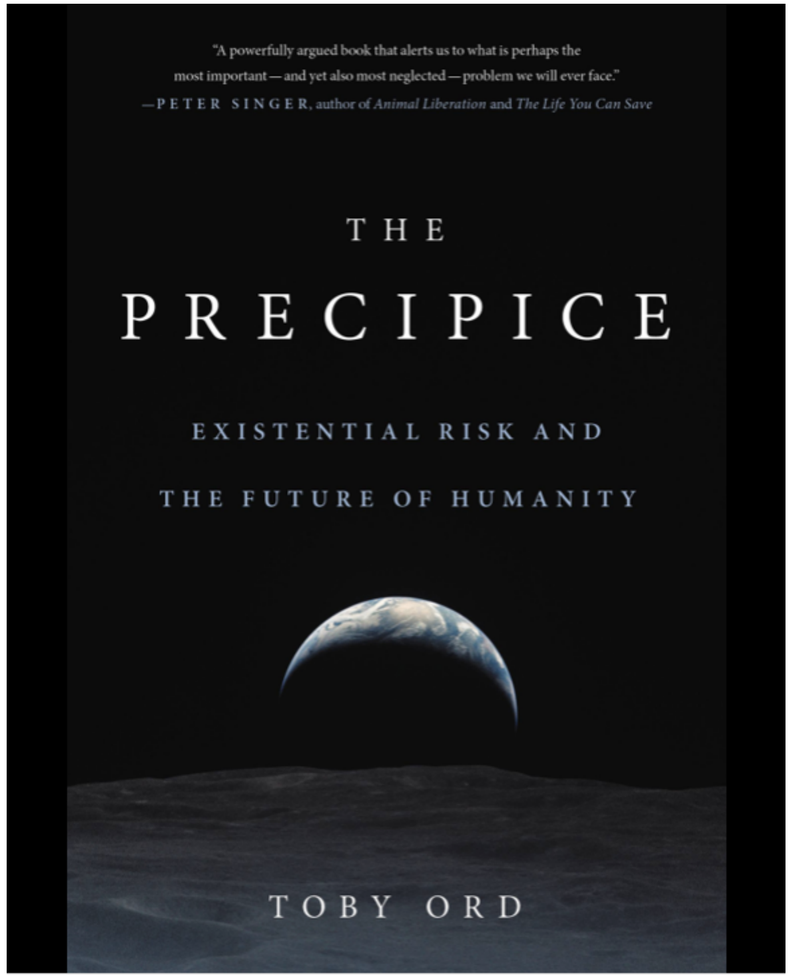


Is humanity as a global species is on the edge?

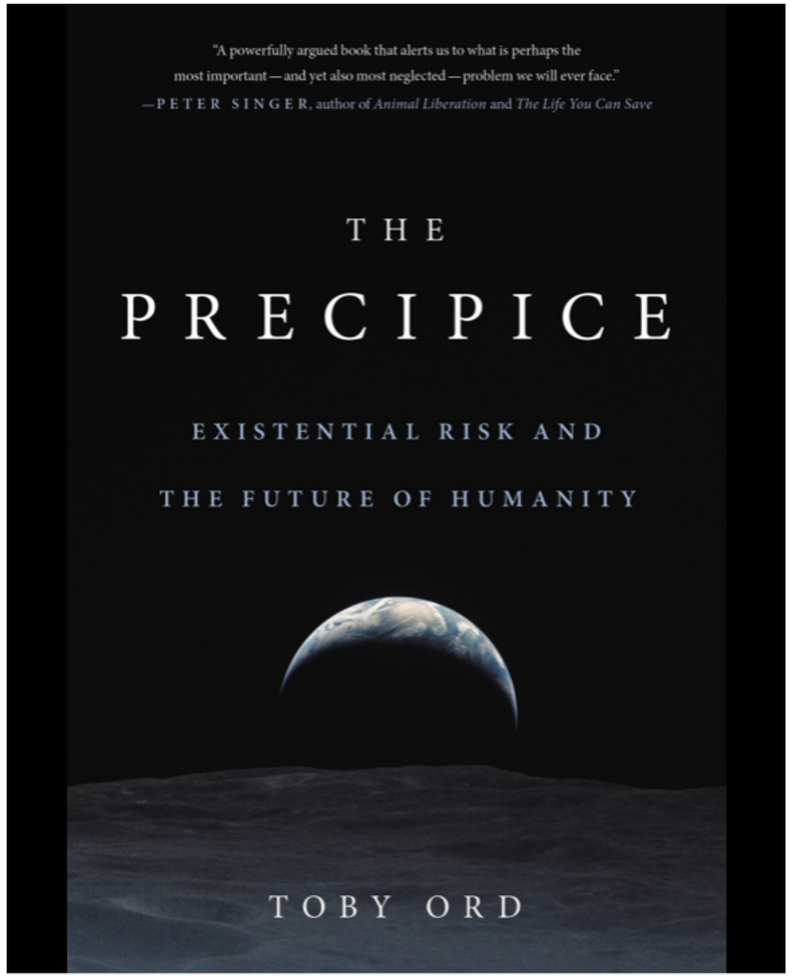
Toby Ord:
The Precipice

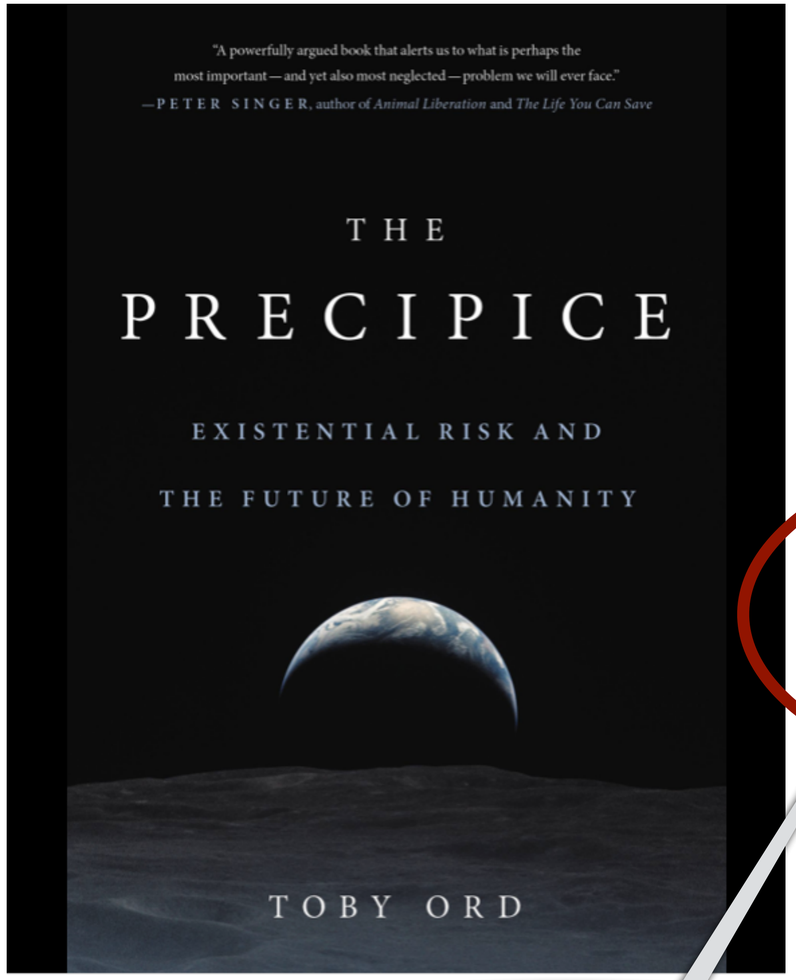



- … we stand before something extraordinarily vast and valuable—something in light of which all of history thus far will seem the merest prelude; a taste; a seed.
- Beyond these outlines, the substance of our future is mostly unknown.
- Our descendants will create it.
- If we steer humanity to a place of safety, we will have time to think. Time to ensure that our choices are wisely made …
- We rarely reflect on what that might be.
- On what we might achieve …, freed from material scarcity and internal conflict.
- Moral philosophy has been focused on the more pressing issues of treating each other decently in a world of scarce resources.
- But there may come a time, not too far away, when we … can look in earnest at where we might go from here.
- Where we might address this vast question about our ultimate values.



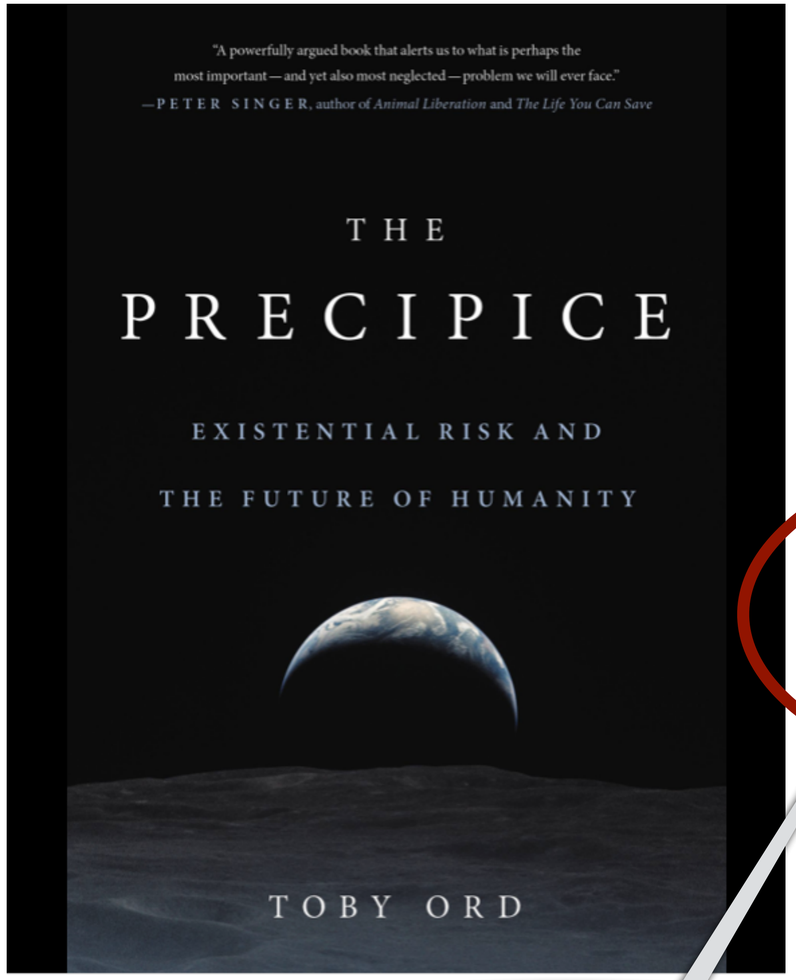

- The world is just waking up to the **importance of existential risk**.
- We have begun work on evaluating and evading the most significant threats, but have yet to scale this up in proportion to the significance of the problems.
- …, **existential risk is sorely neglected**.
- Consider the possibility of engineered pandemics, which we shall soon see to be one of the largest risks facing humanity. The international body responsible for the continued **prohibition of bioweapons** (the Biological Weapons Convention) has an **annual budget of just $1.4 million—less than the average McDonald's restaurant**.
- The entire spending on reducing existential risks from advanced artificial intelligence is in the tens of millions of dollars, compared with the billions spent on improving artificial intelligence capabilities.
- While it is difficult to precisely measure global spending on existential risk, we can state with confidence that **humanity spends more on ice cream every year than on ensuring that the technologies we develop do not destroy us**.








The human race's prospects of survival were considerably better when we were defenceless against tigers than they are today, when we have become defenceless against ourselves.
—Arnold Toynbee






GRAND STRATEGY FOR HUMANITY

1. Reaching Existential Security
2. The Long Reflection
3. Achieving Our Potential

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Contents

- The Baseline: Past Climate Changes
- The Syndrome: Modern Climate and Global Change
- The Diagnosis: A new Economy and Global Order
- The Prognosis: Leaving the “Safe Operating Space” and into the Unknown
- The Therapy: A new Ethics, Economy, and Global Governance

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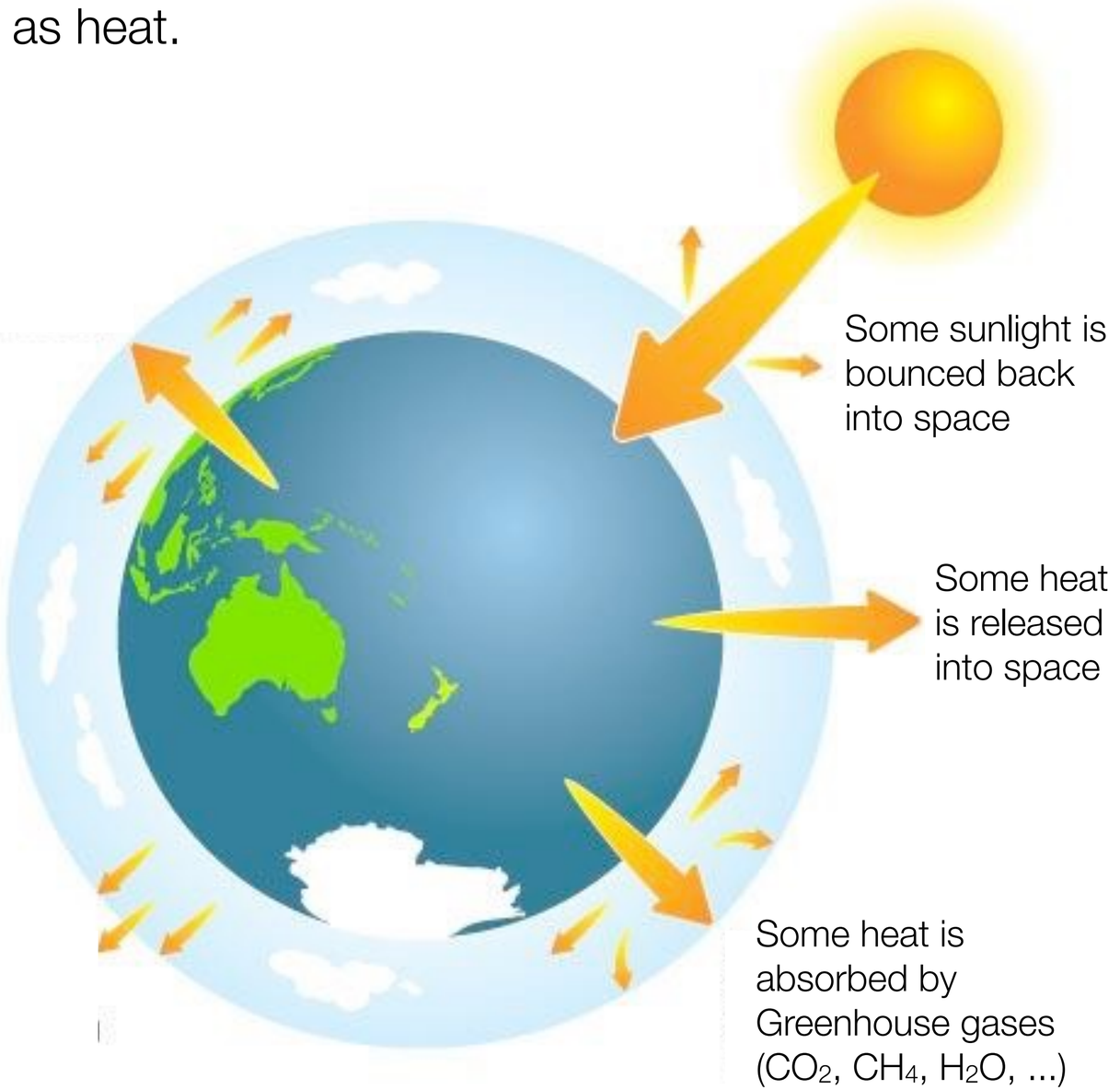

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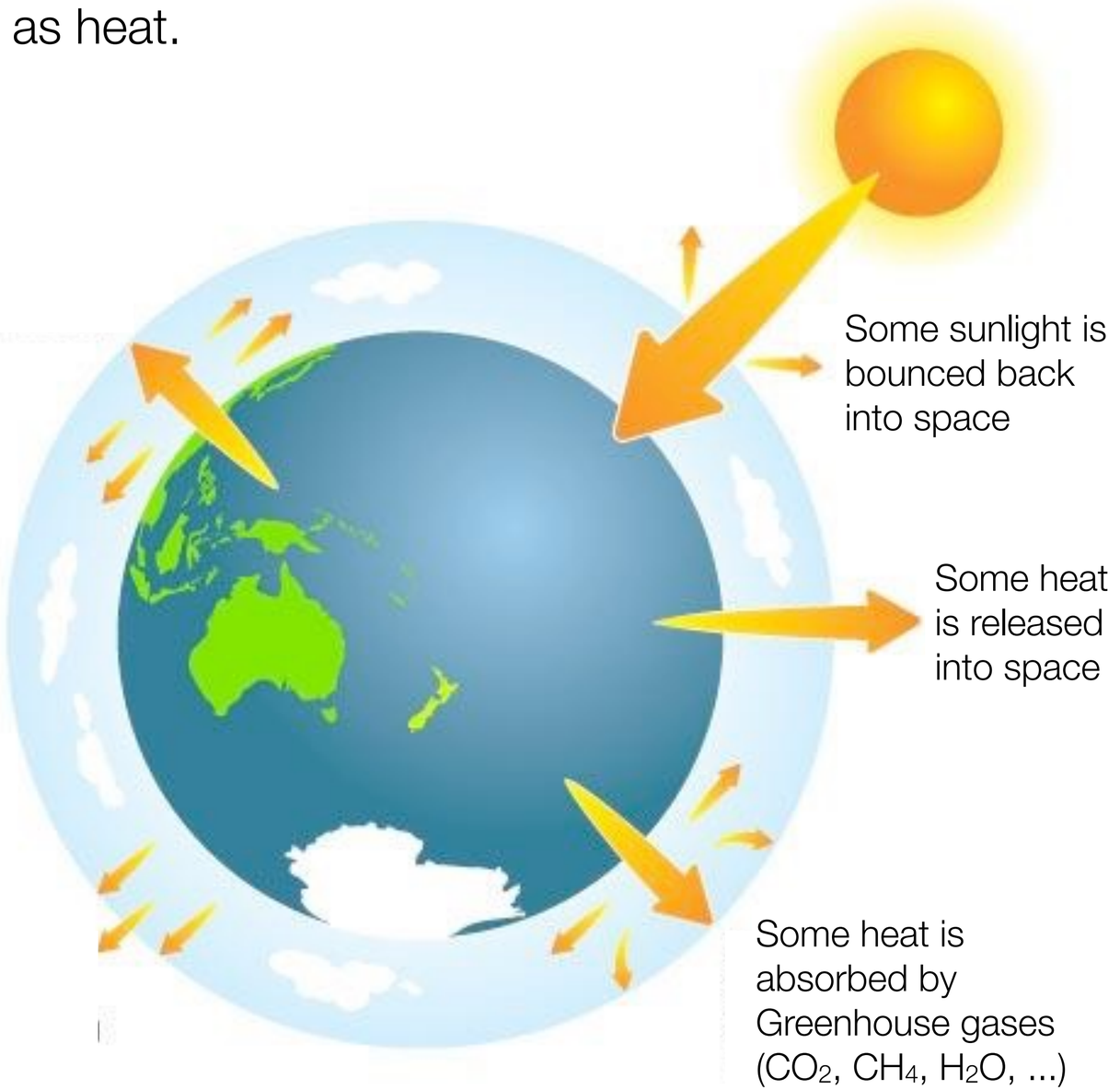

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- Reflected radiation can change (albedo)
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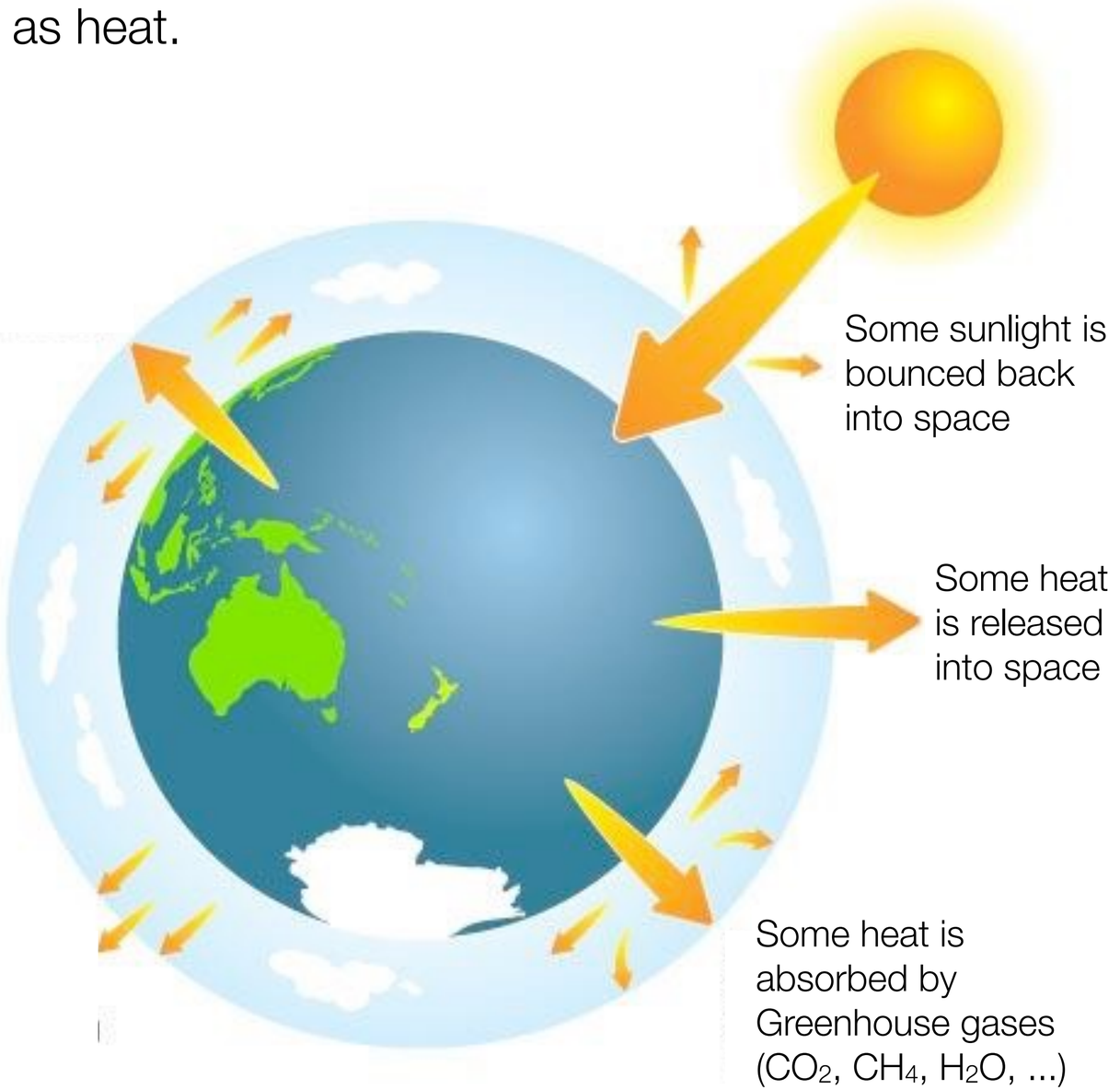

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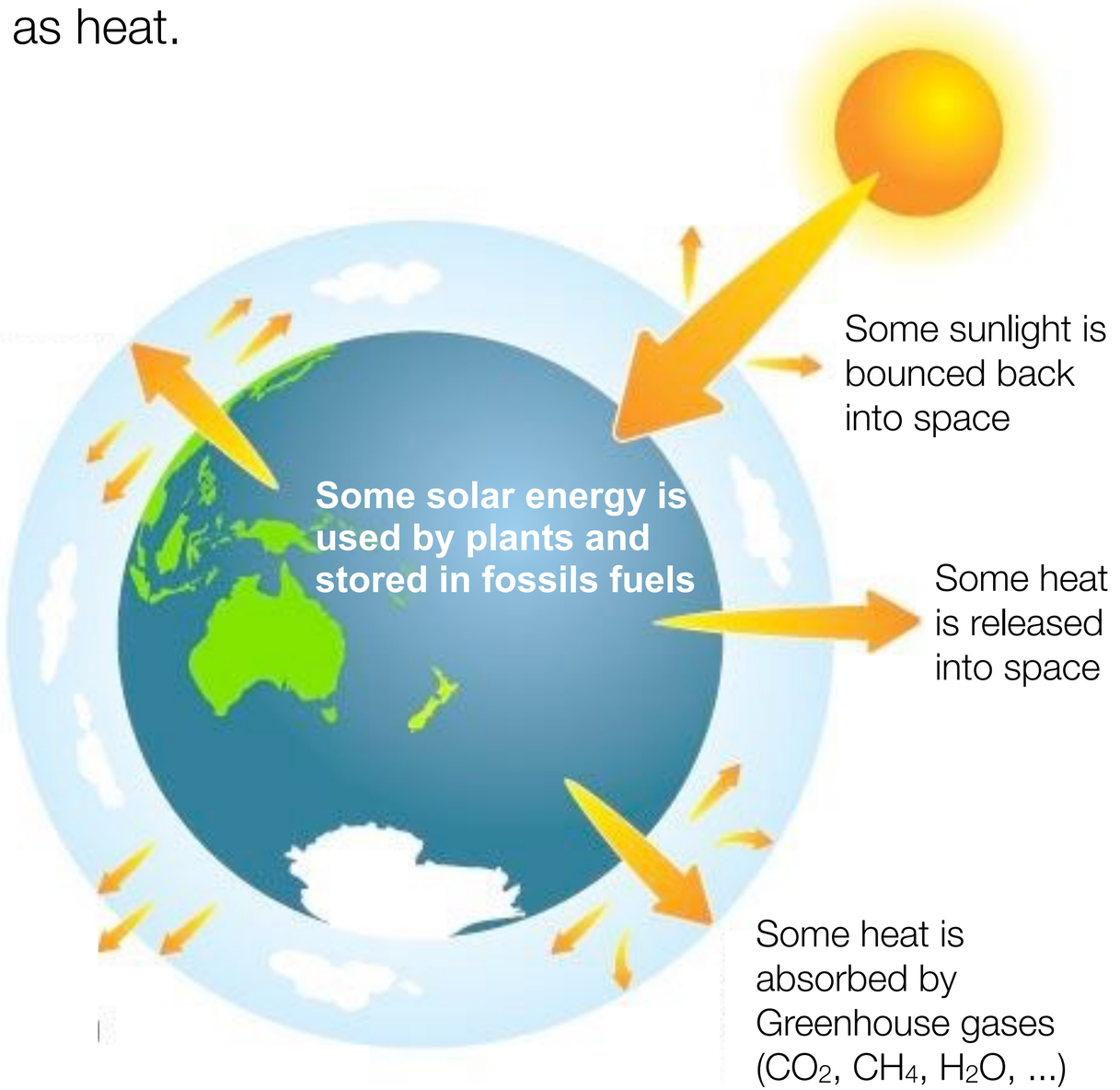

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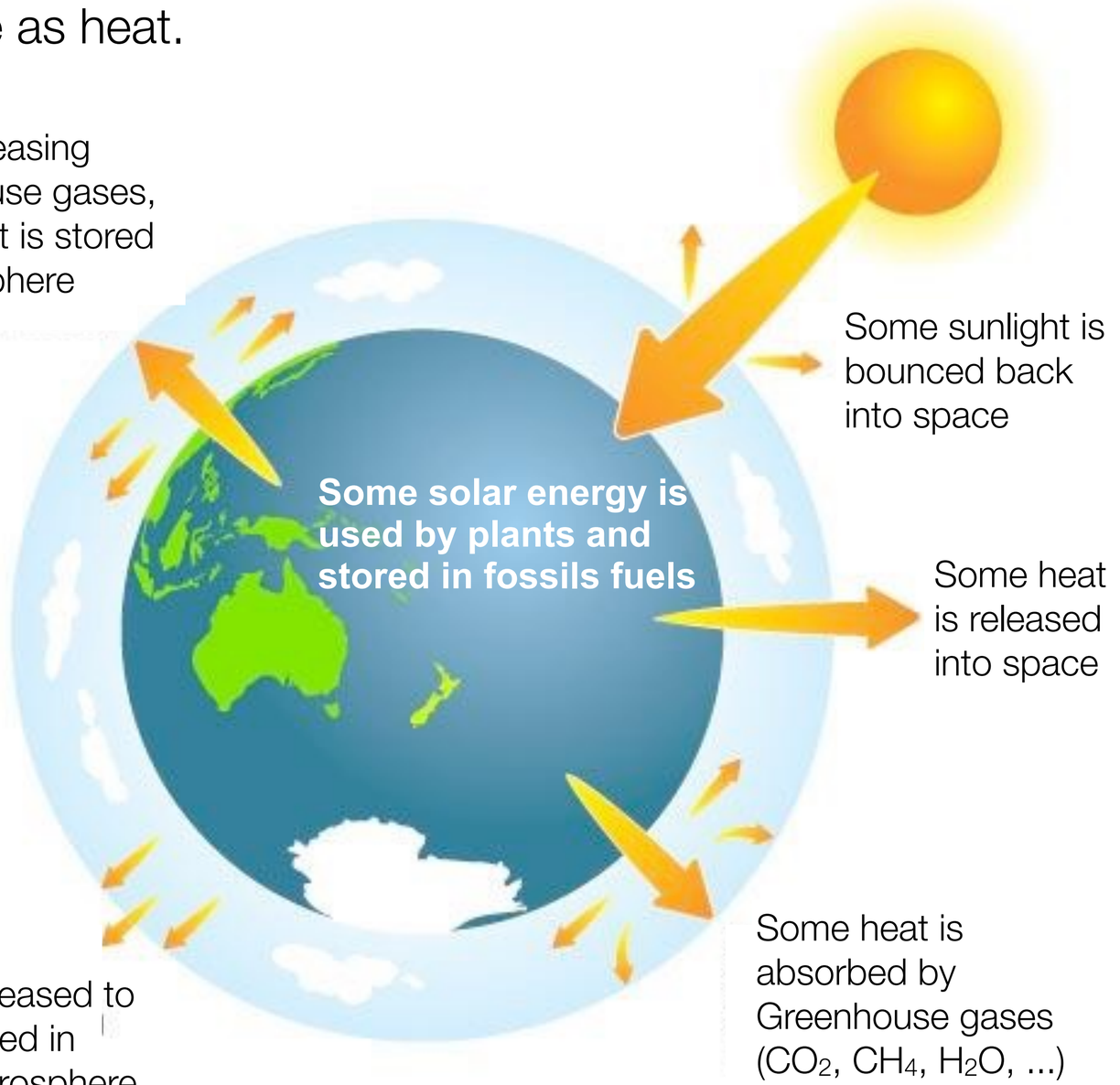

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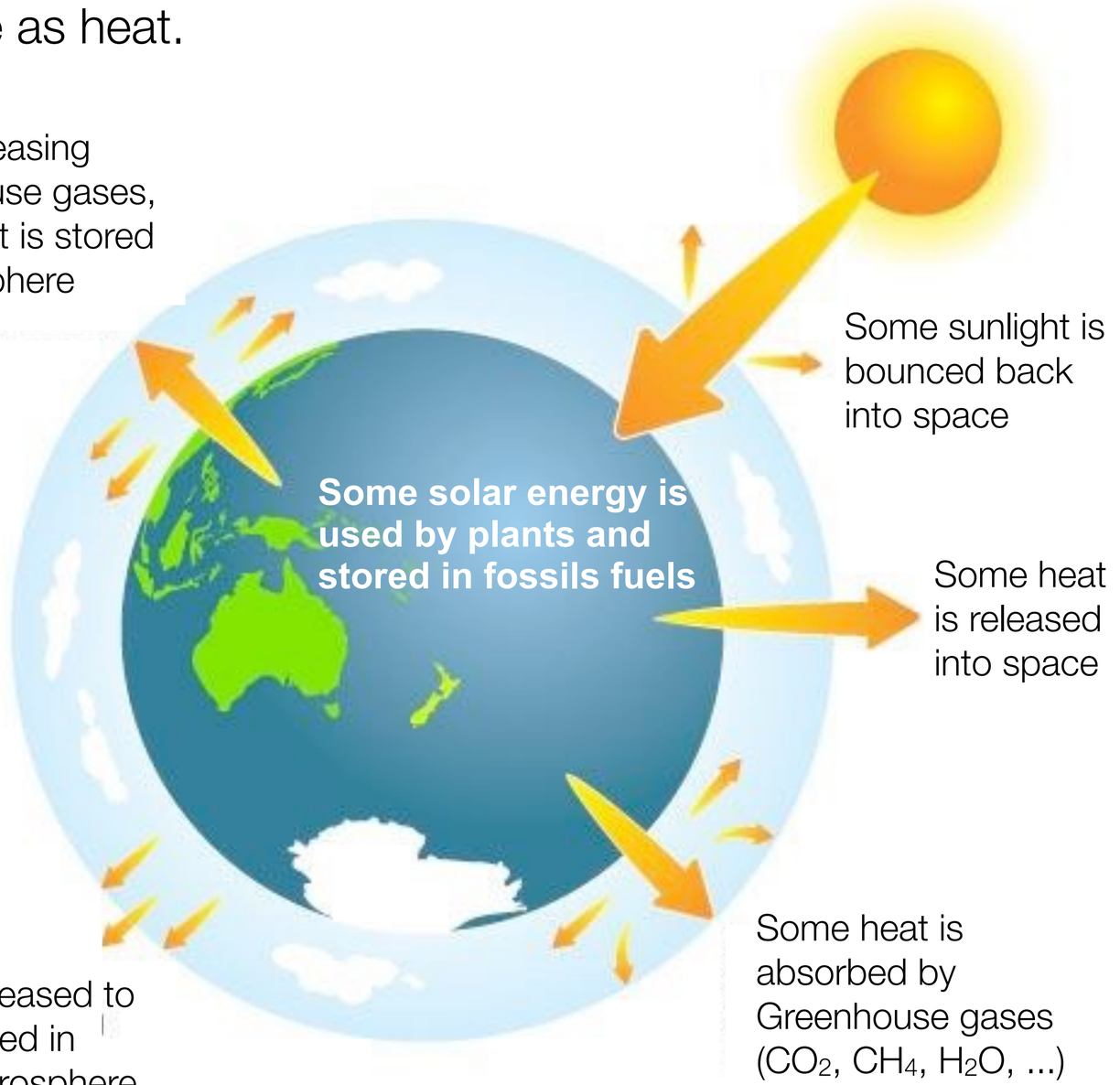

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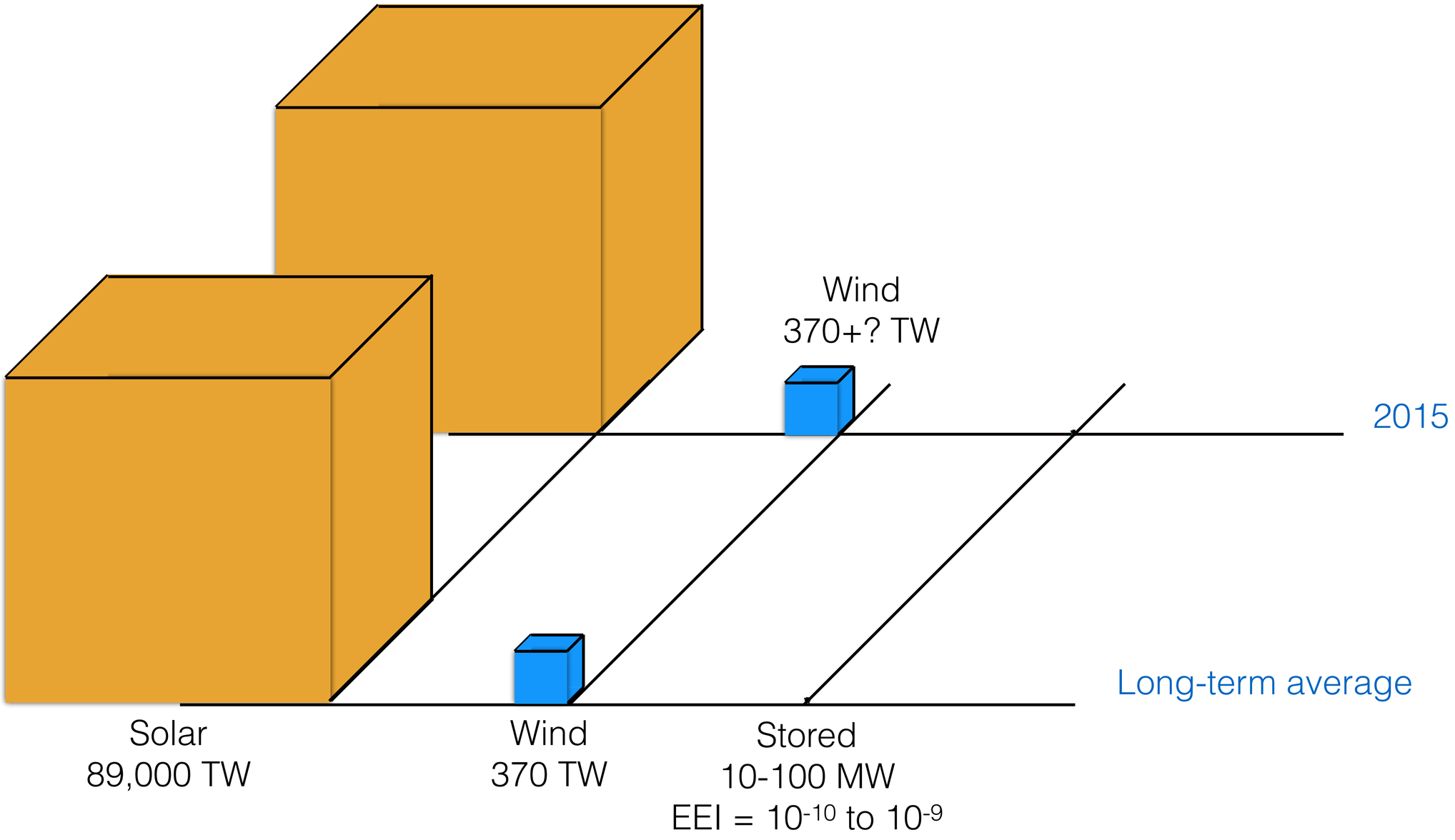

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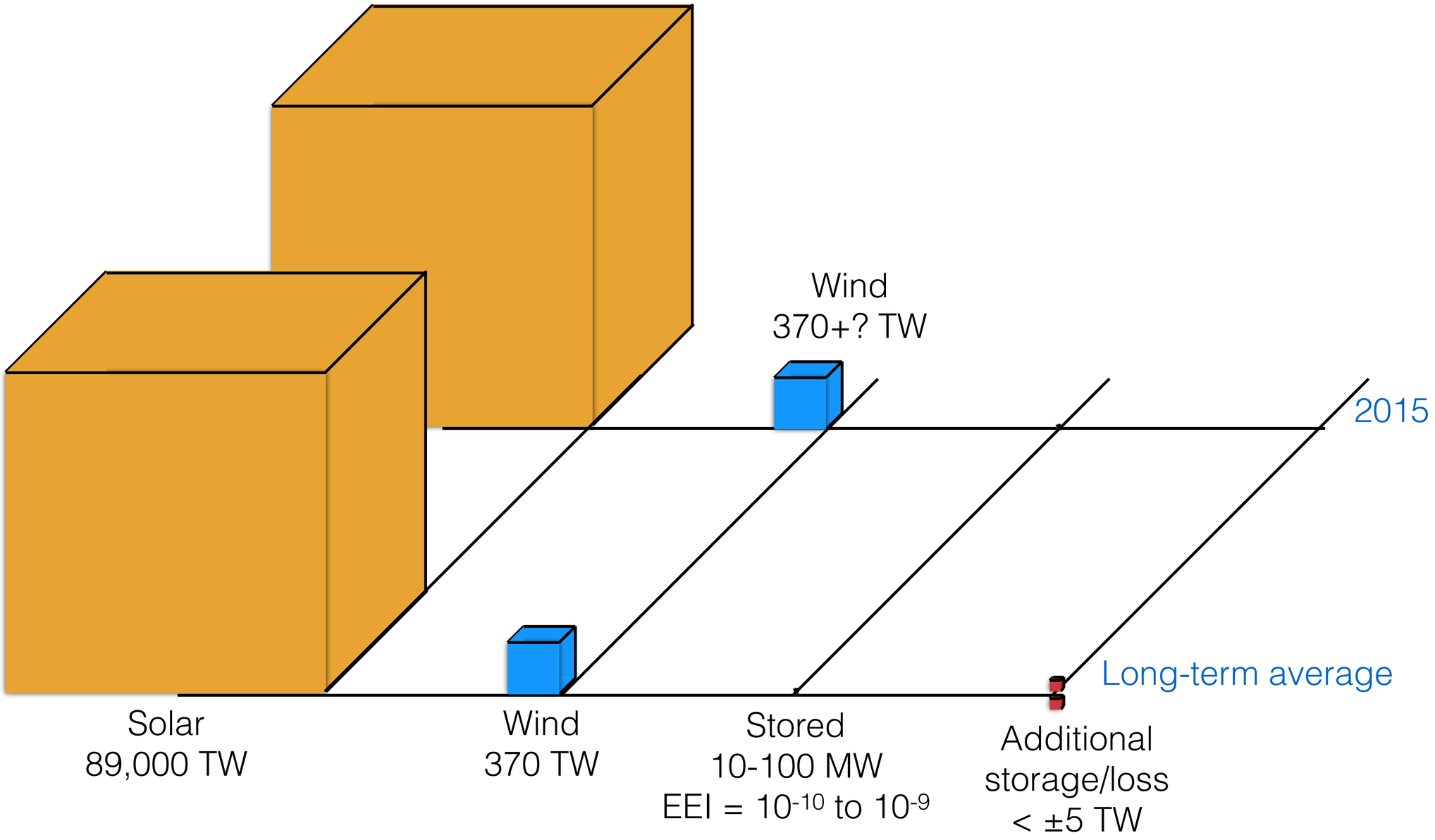

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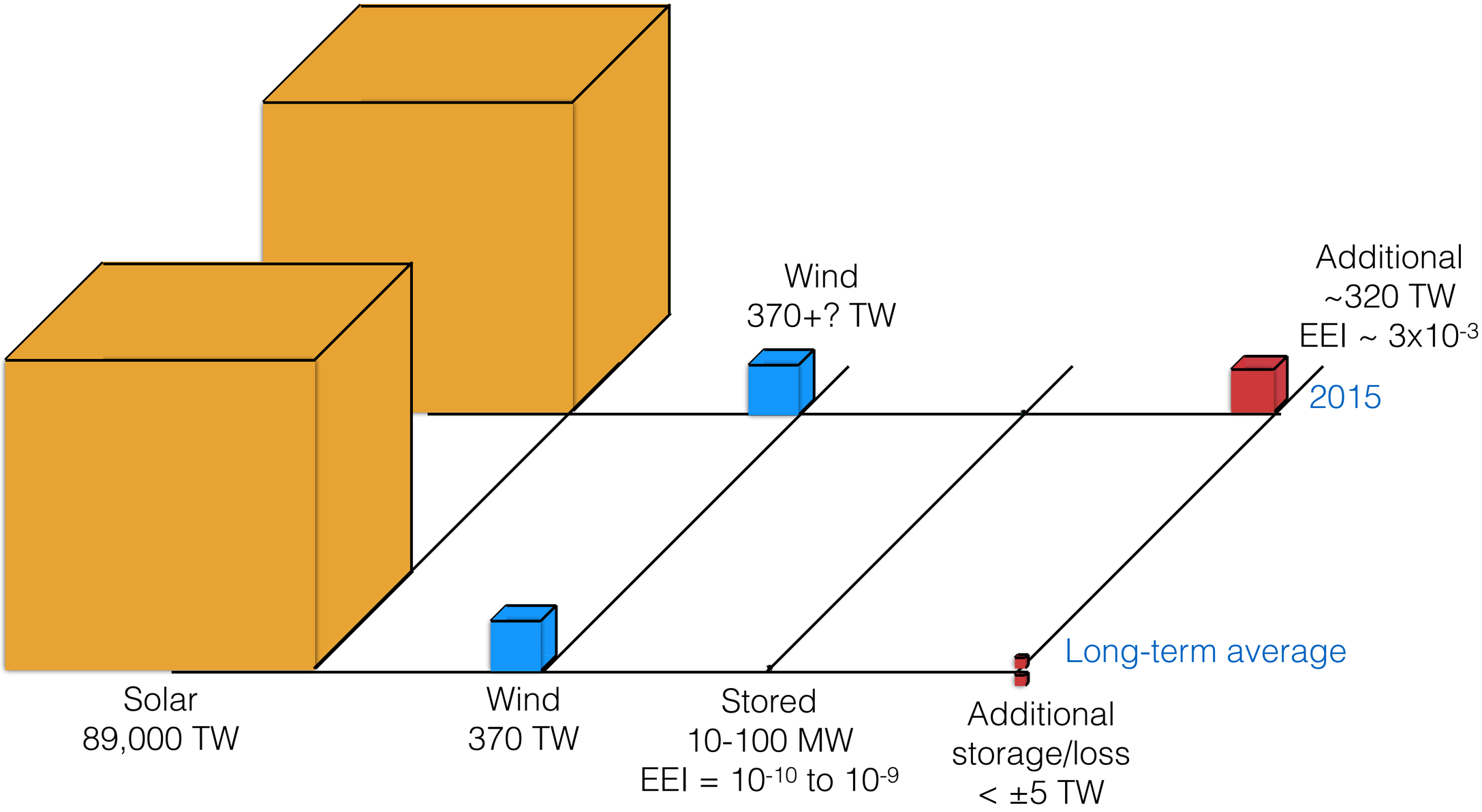

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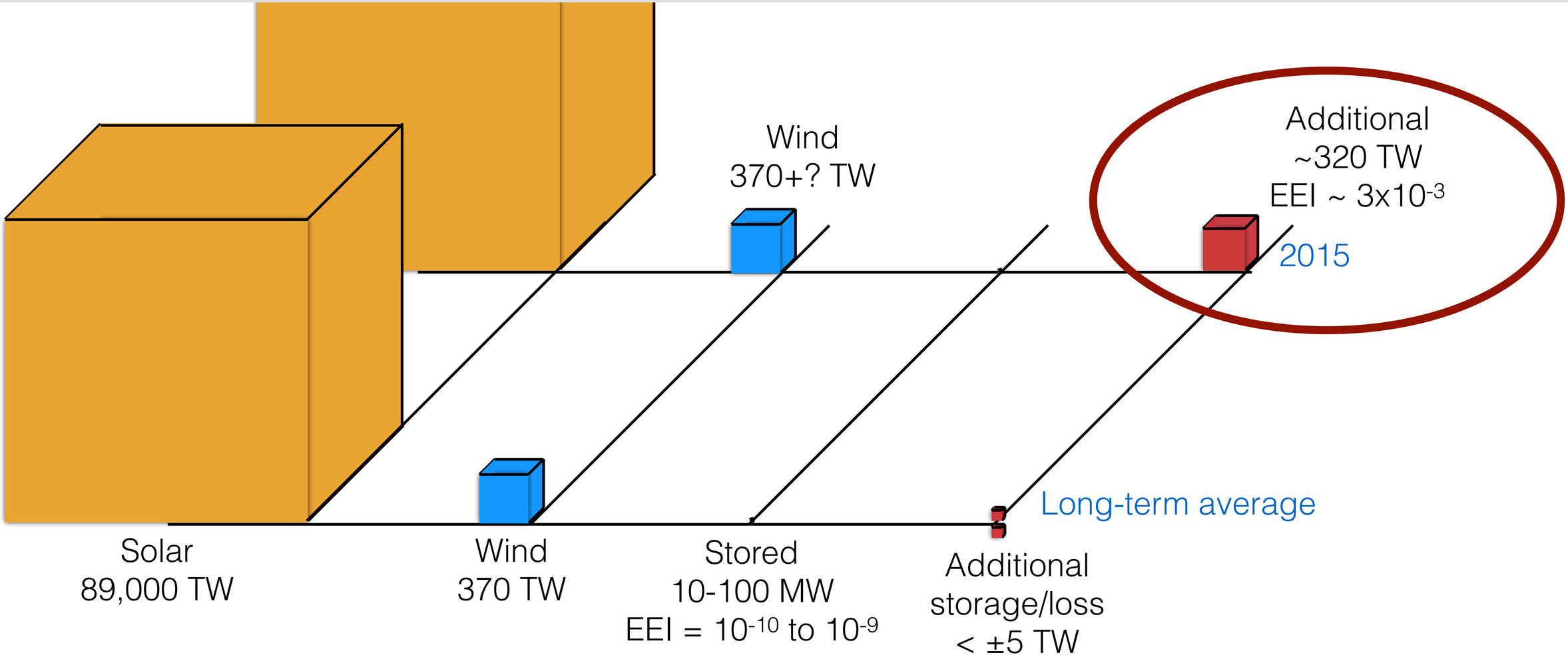
(1) Where, and in what form, is the additional energy stored?
(2) Why did the Earth's energy imbalance increased so dramatically?
(*Answer: Because atmospheric Greenhouse Gases increased and Earth's albedo changed*)



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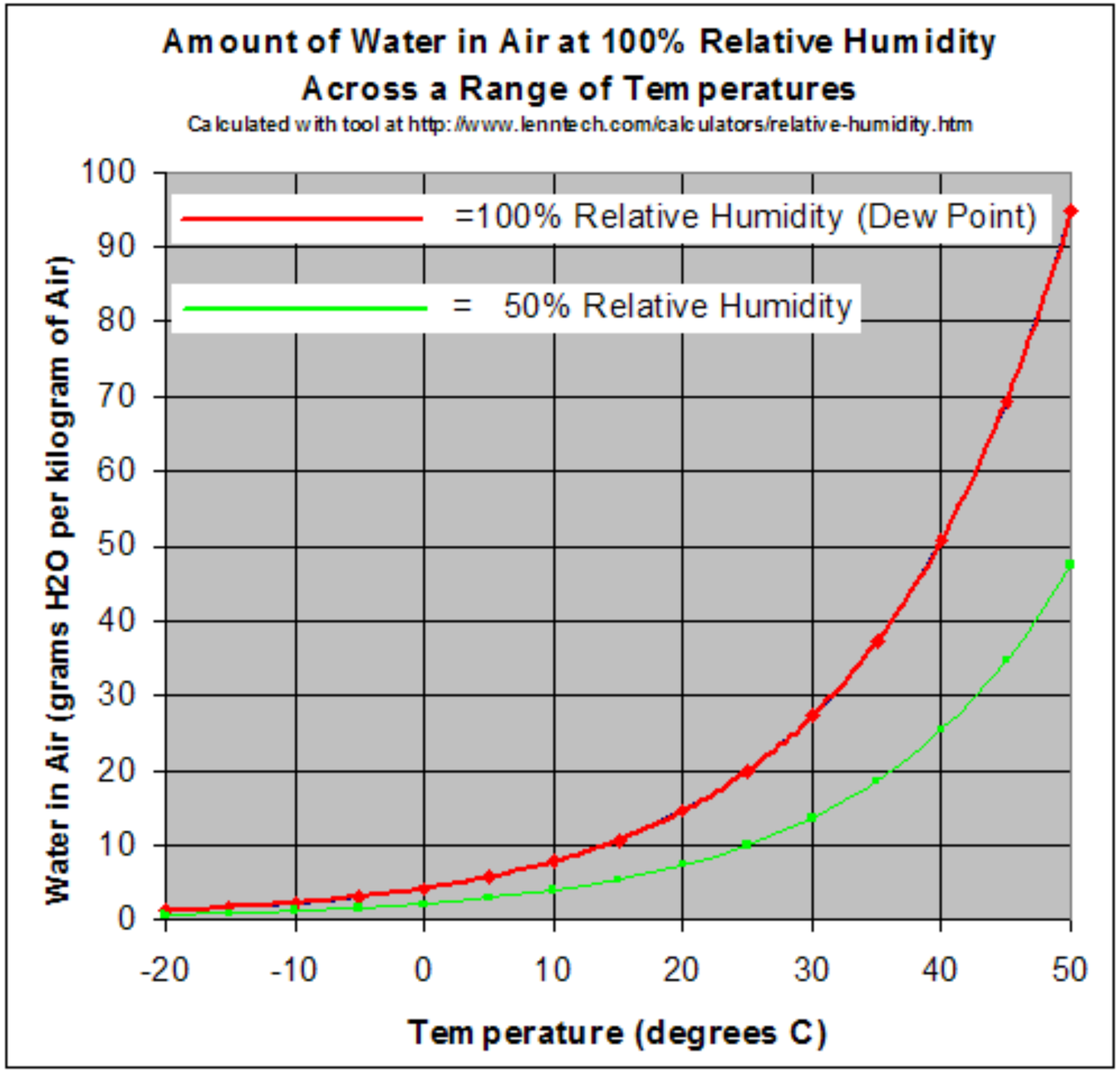

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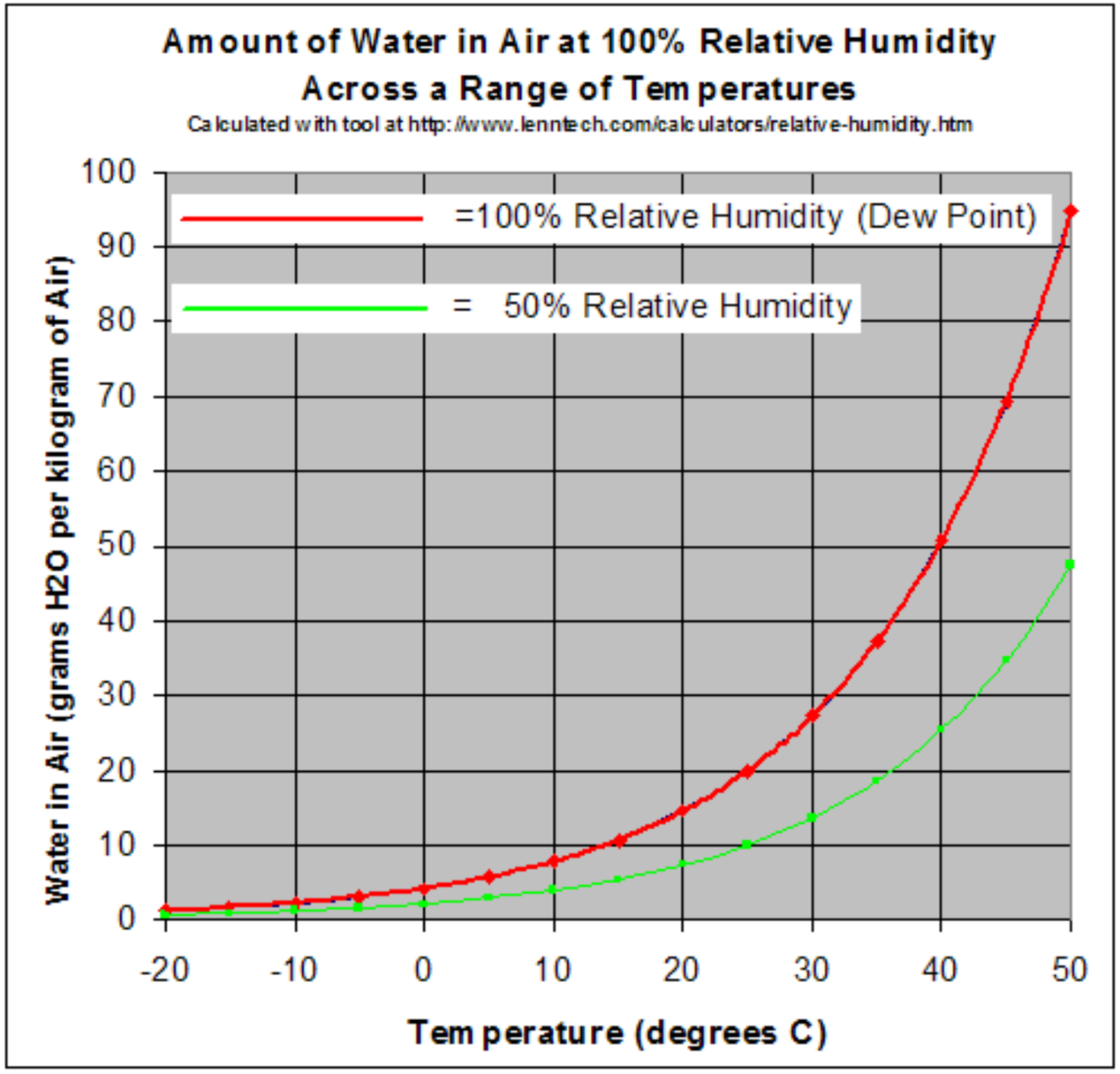


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Water: 4200 $Jkg^{-1}K^{-1}$
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Water has 4.23 times higher specific heat capacity.

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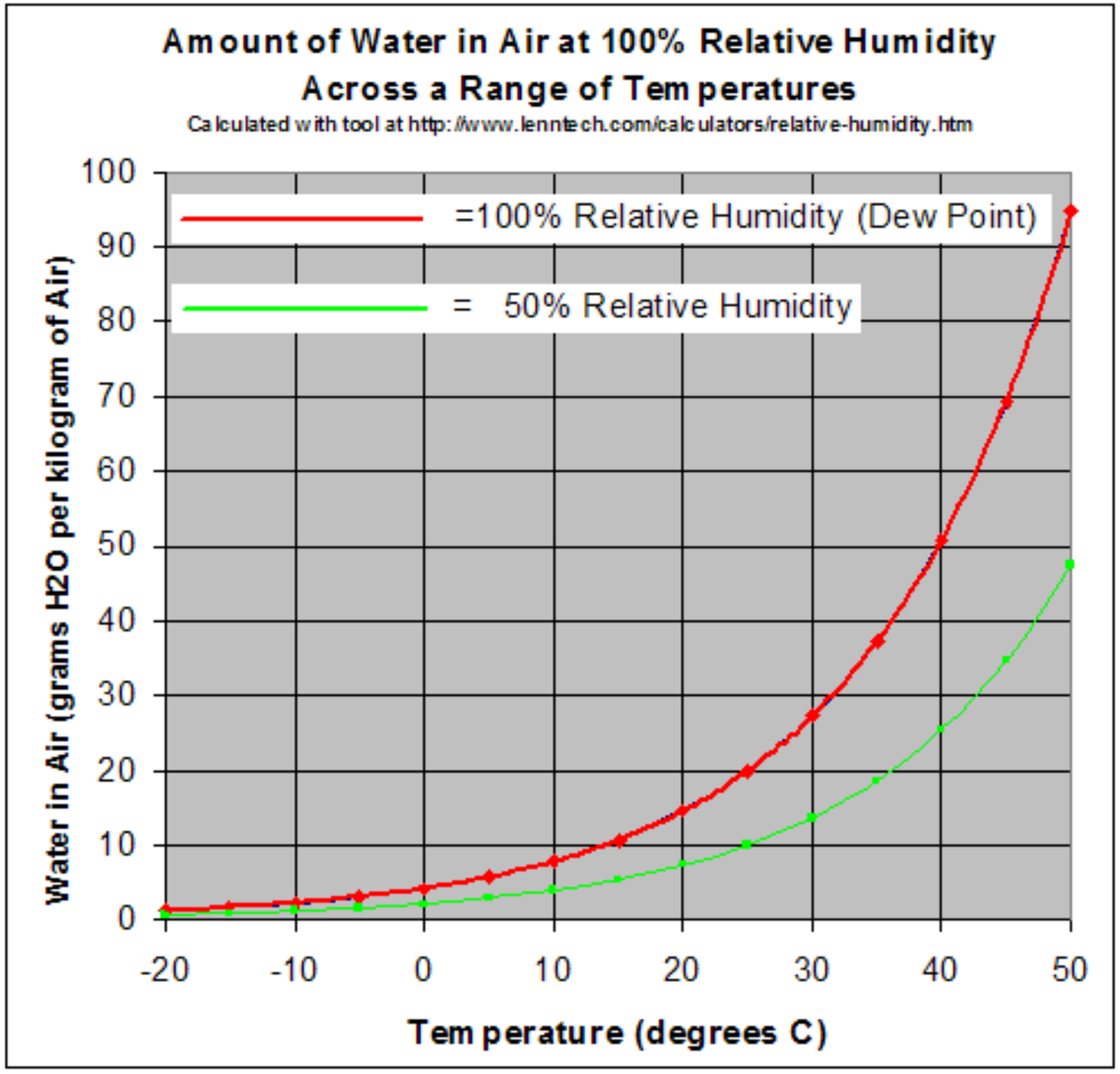


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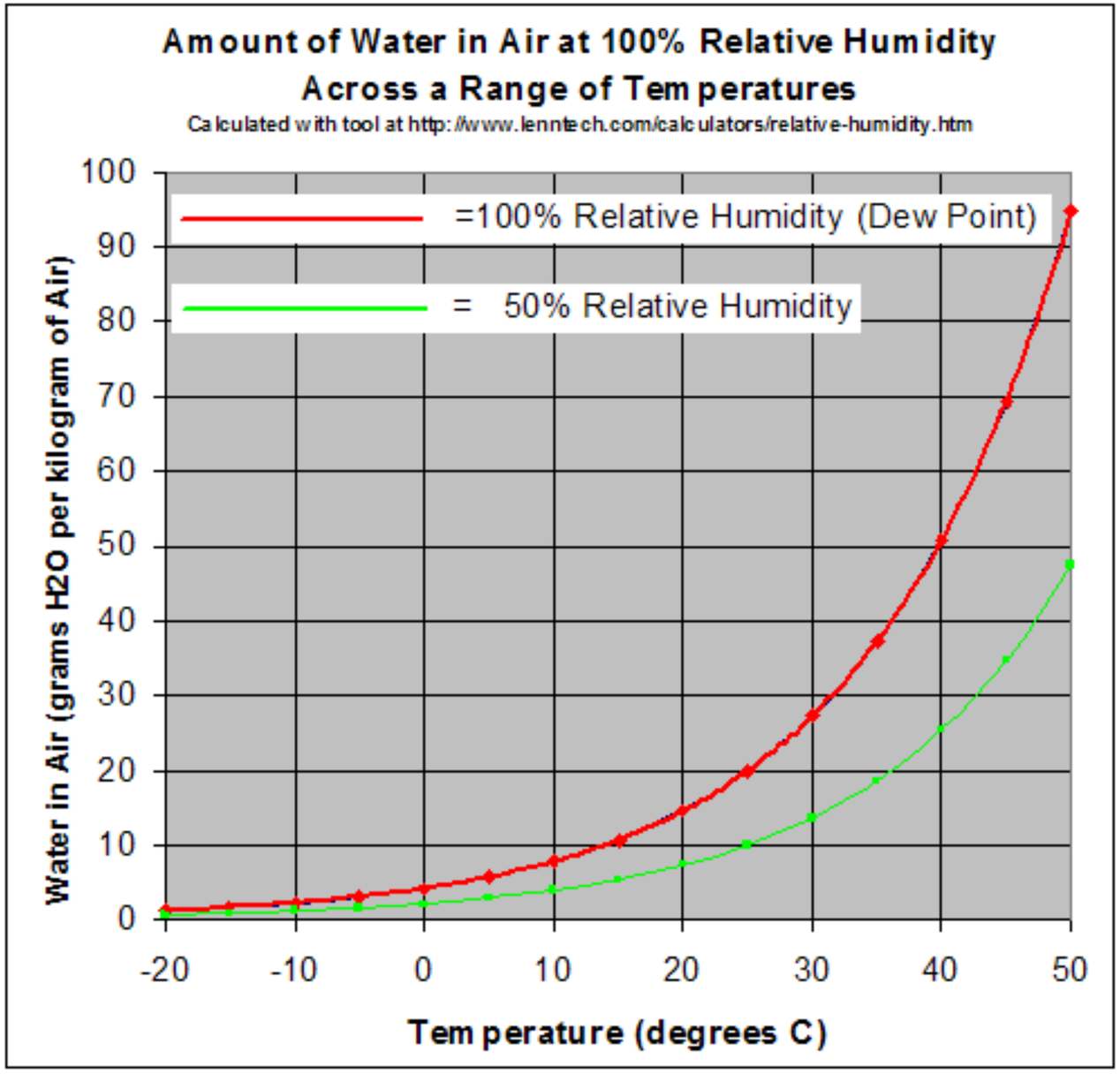


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Volumetric heat capacity:
Water compared to air:
About 3300 time higher volumetric heat capacity

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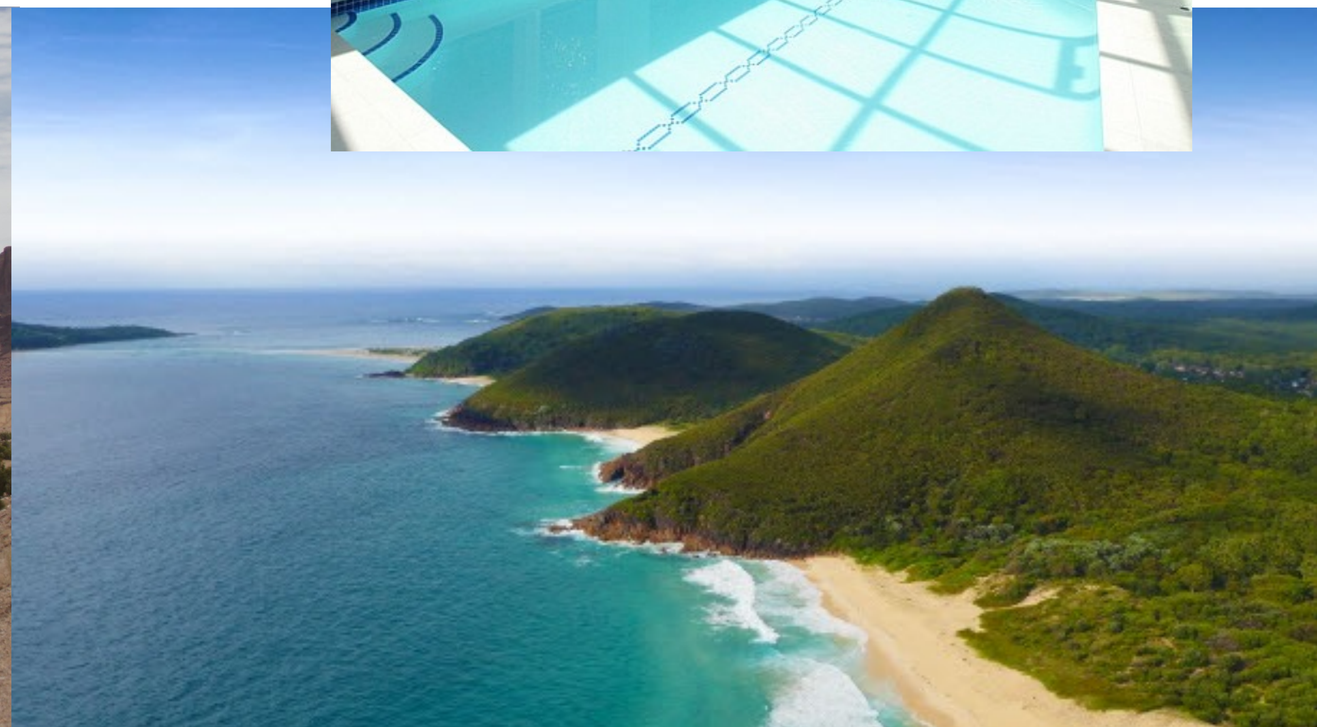
Greenhouse


Poolhouse



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Volumetric heat capacity of water compared to air:
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# Baseline for Climate Variability

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- averages
- frequency and magnitude of extremes.

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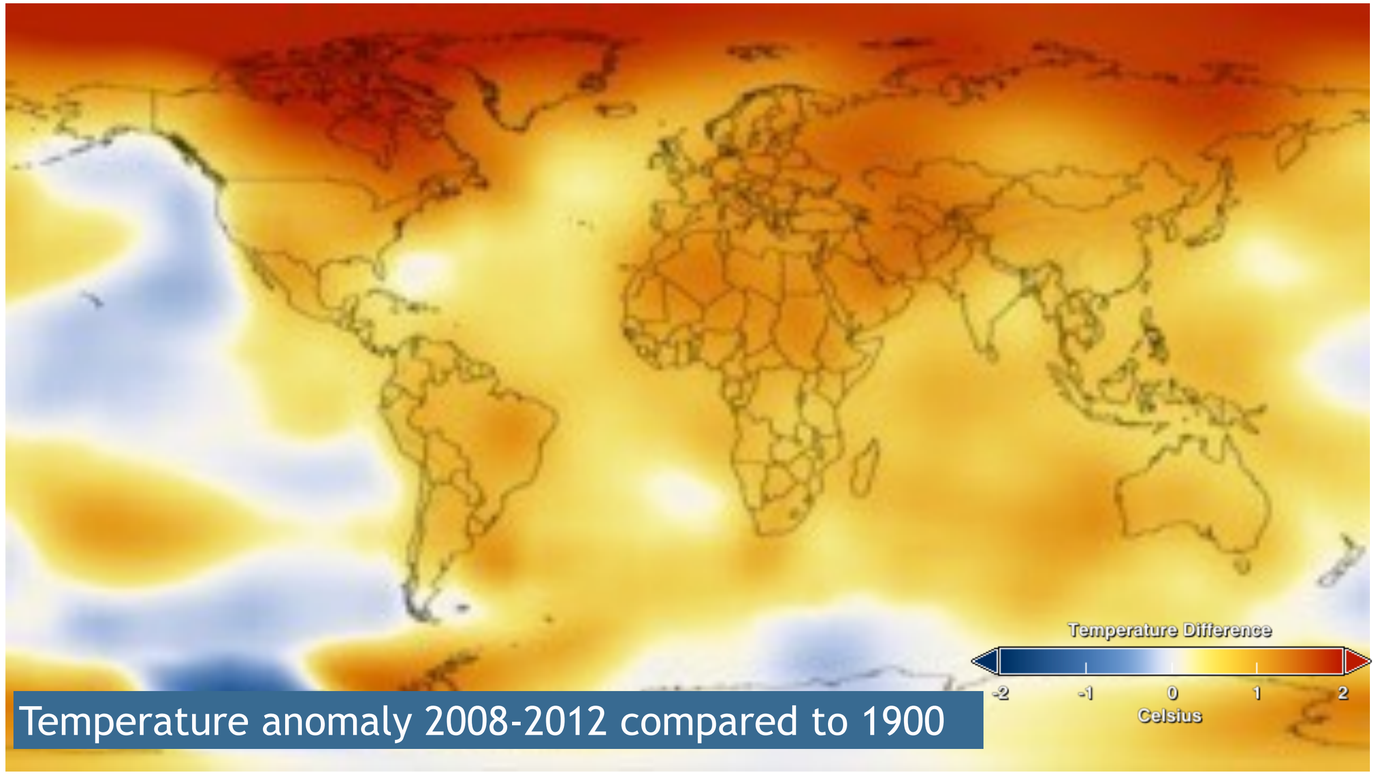
Climate can change from local to global scales.



Temperature anomaly 2008-2012 compared to 1900

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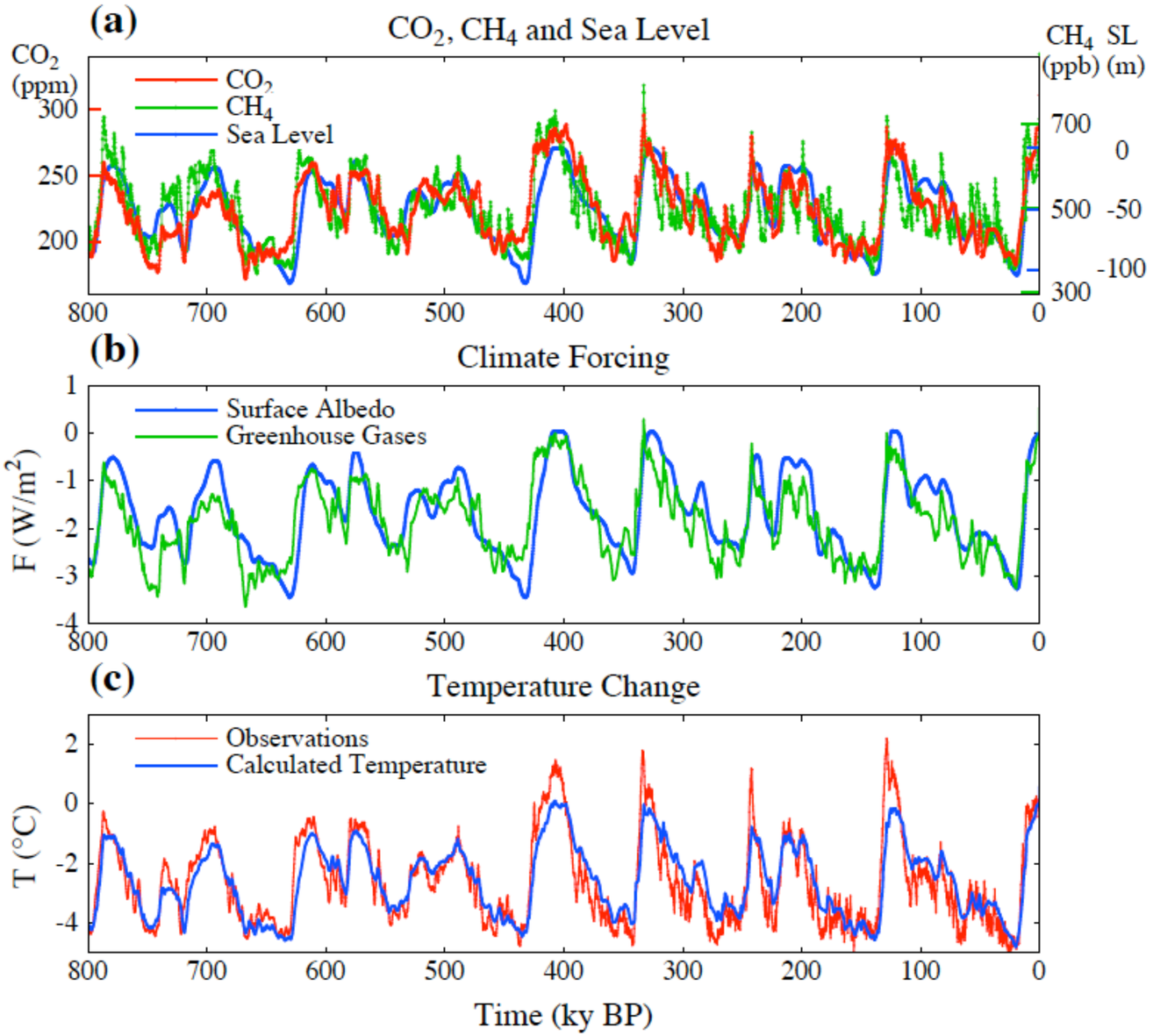
Climate can change from local to global scales.

Climate can change a lot over time.



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- retained heat (Greenhou

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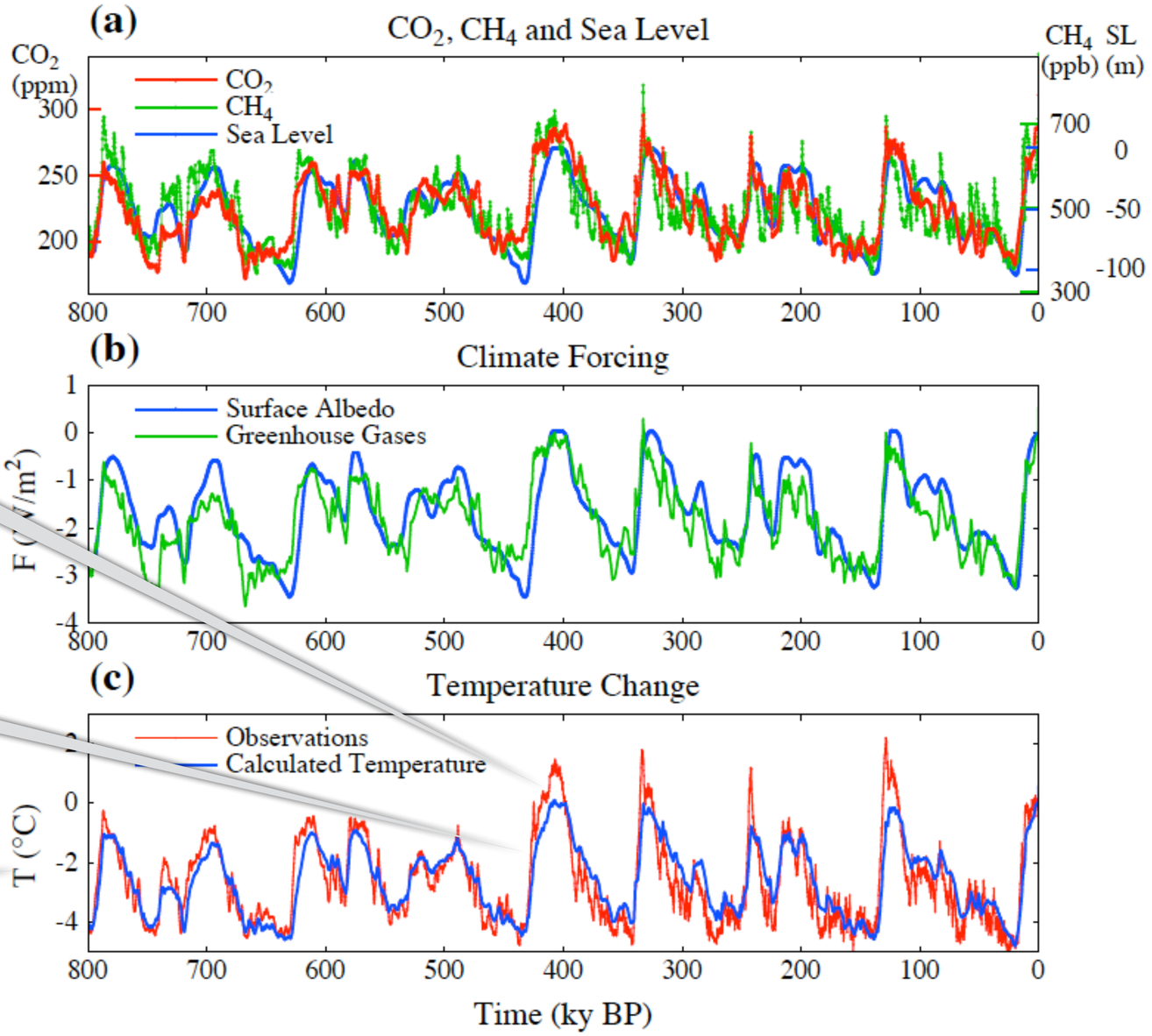
Warm period
"Inter-glacial"

Cold period
Ice age
"glacial"

Temperature difference:
4°C - 5°C



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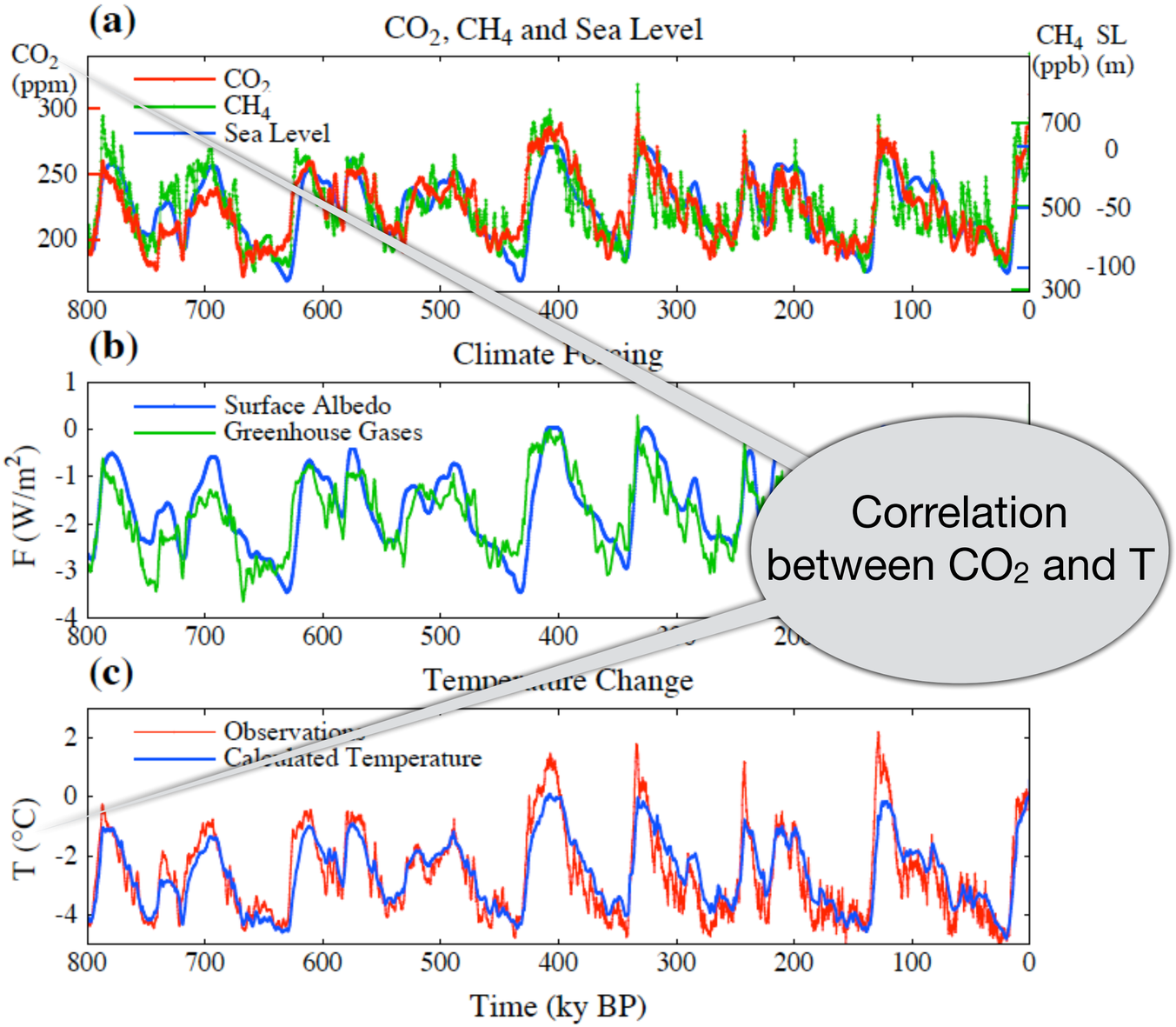

# The Baseline: Past Climate and Global Change

## Greenhouse Gases and Air Temperature

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## Greenhouse Gases and Air Temperature

EARTH OBSERVATORY
Where every day is Earth Day

Home | Image

### Svante Arrhenius (1859-1927)

Arrhenius did very little research in the fields of climatology and geophysics, and considered any work in these fields a hobby. His basic approach was to apply knowledge of basic scientific principles to make sense of existing observations, while hypothesizing a theory on the cause of the "Ice Age." Later on, his geophysical work would serve as a catalyst for the work of others.

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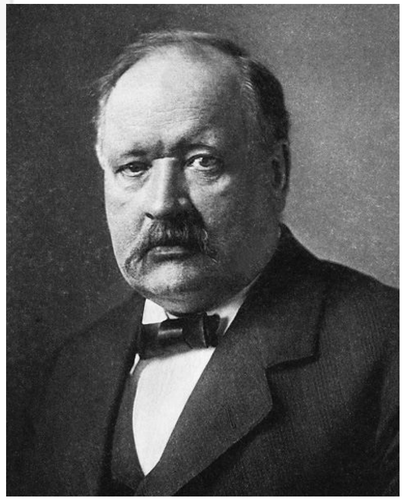

1895

In 1895, Arrhenius presented a paper to the Stockholm Physical Society titled, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground." This article described an energy budget model that considered the radiative effects of carbon dioxide (carbonic acid) and water vapor on the surface temperature of the Earth, and variations in atmospheric carbon dioxide concentrations. In order to proceed with his experiments, Arrhenius relied heavily on the experiments and observations of other scientists, including Josef Stefan, Arvid Gustaf Högbom, Samuel Langley, Leon Teisserenc de Bort, Knut Angstrom, Alexander Buchan, Luigi De Marchi, Joseph Fourier, C.S.M. Pouillet, and John Tyndall.

Arrhenius argued that variations in trace constituents—namely carbon dioxide—of the atmosphere could greatly influence the heat budget of the Earth. Using the best data available to him (and making many assumptions and estimates that were necessary), he performed a series of calculations on the temperature effects of increasing and decreasing amounts of carbon dioxide in the Earth's atmosphere. His calculations showed that the "temperature of the Arctic regions would rise about 8 degrees or 9 degrees Celsius, if the carbonic acid increased 2.5 to 3 times its present value. In order to get the temperature of the ice age between the 40th and 50th parallels, the carbonic acid in the air should sink to 0.62 to 0.55 of present value (lowering the temperature 4 degrees to 5 degrees Celsius)."

## Greenhouse Gases and Air Temperature

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**The Effect of the Combustion of Coal on the Climate — What Scientists Predict for the Future**

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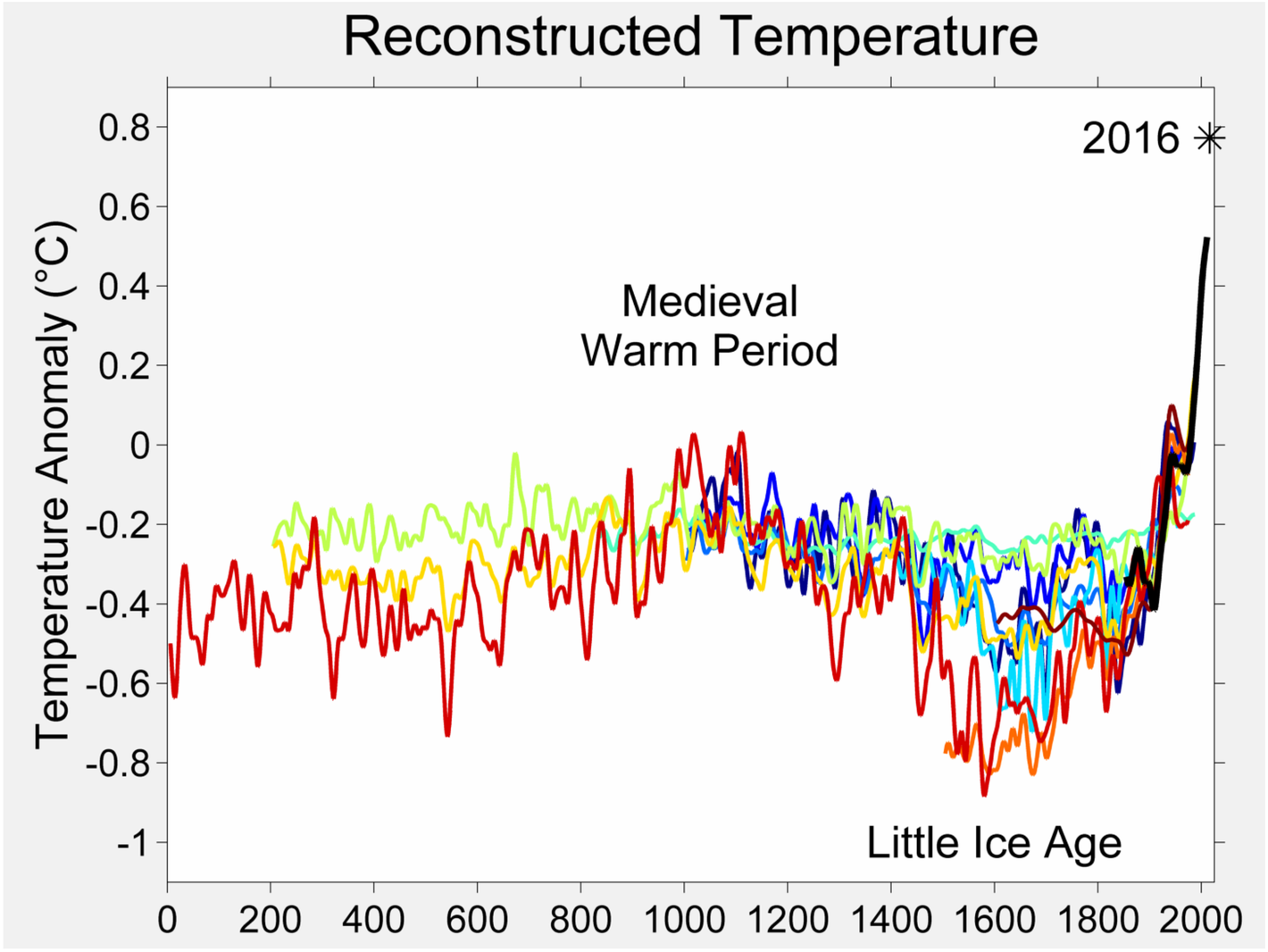

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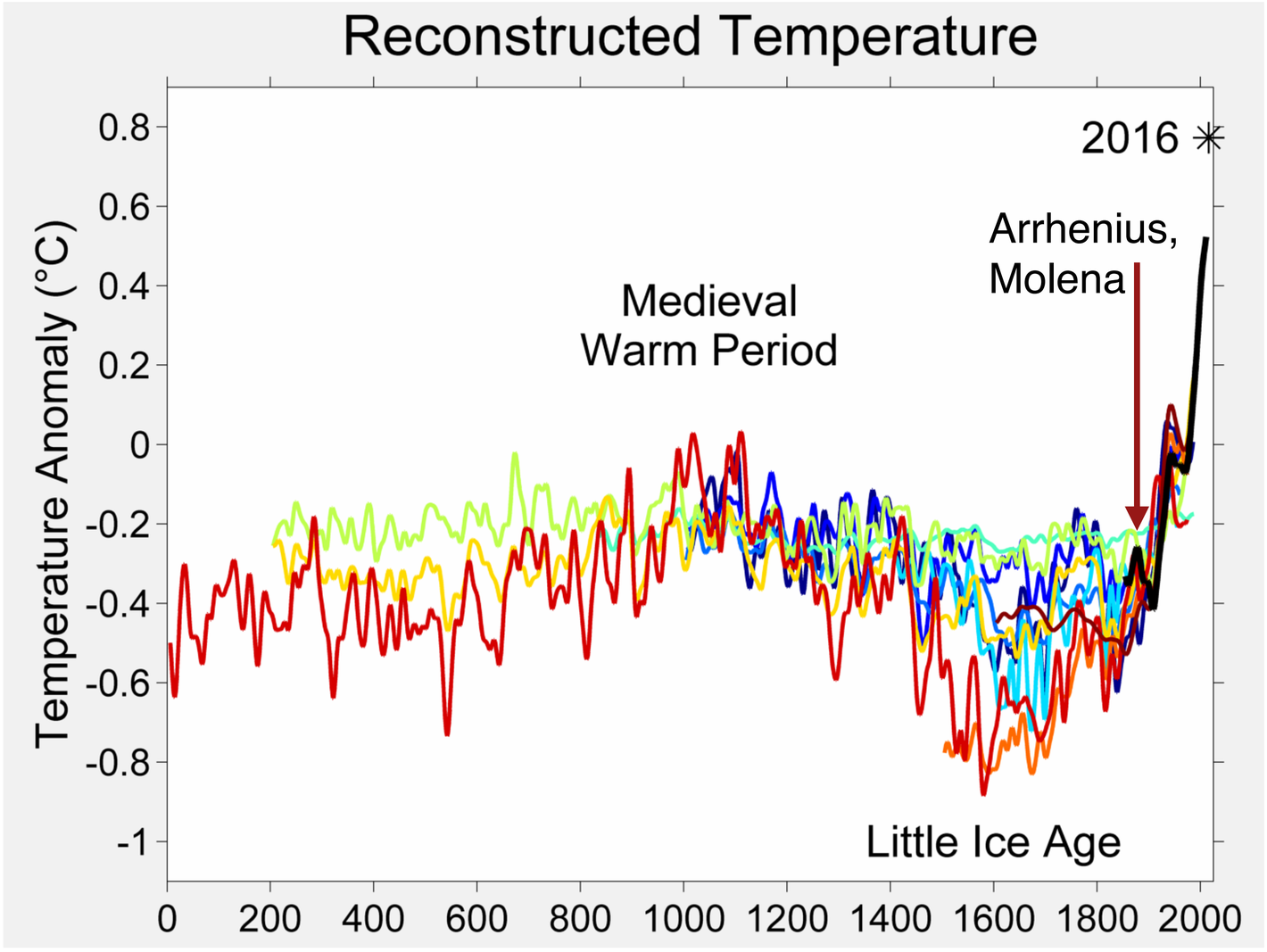

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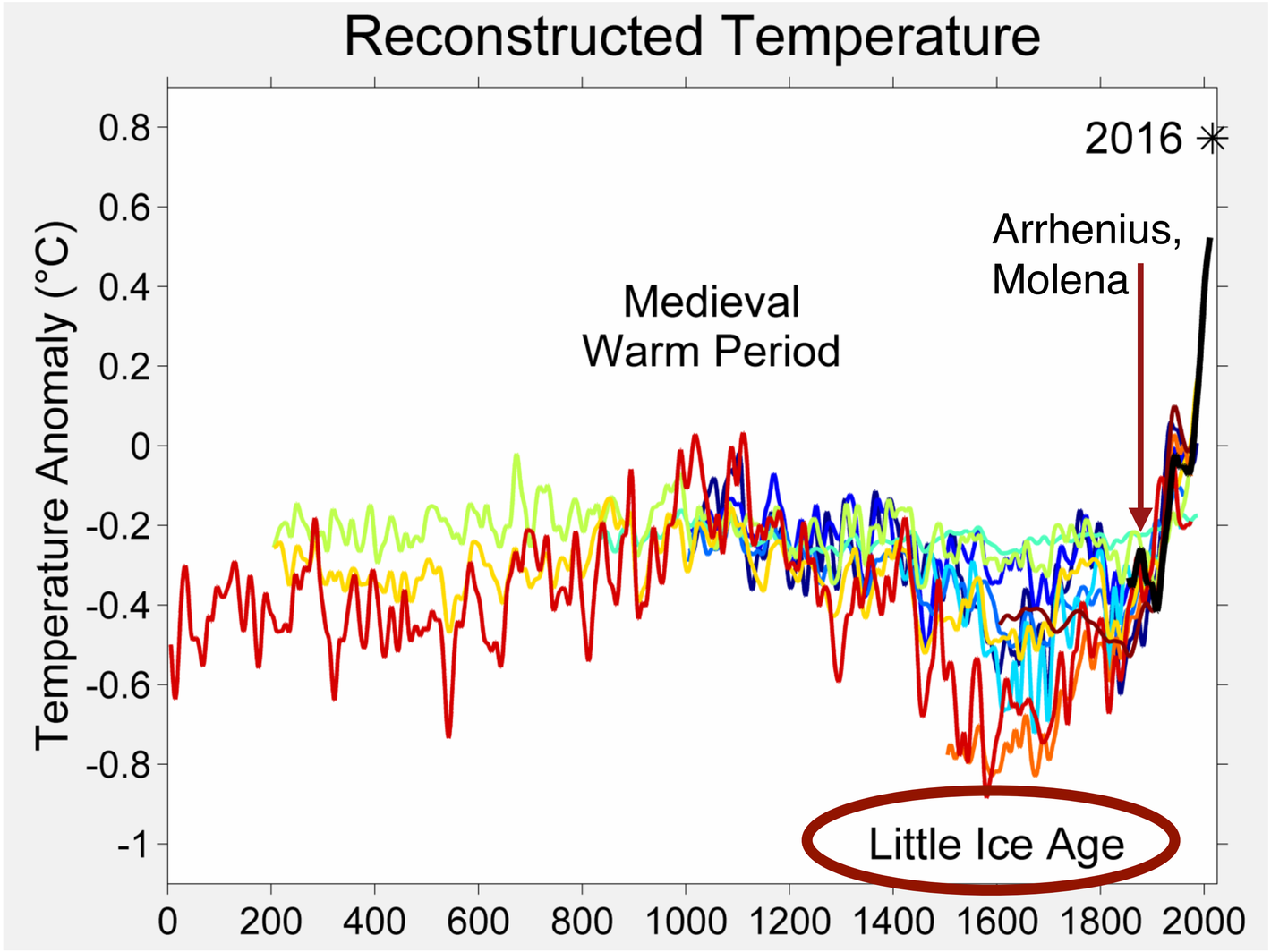

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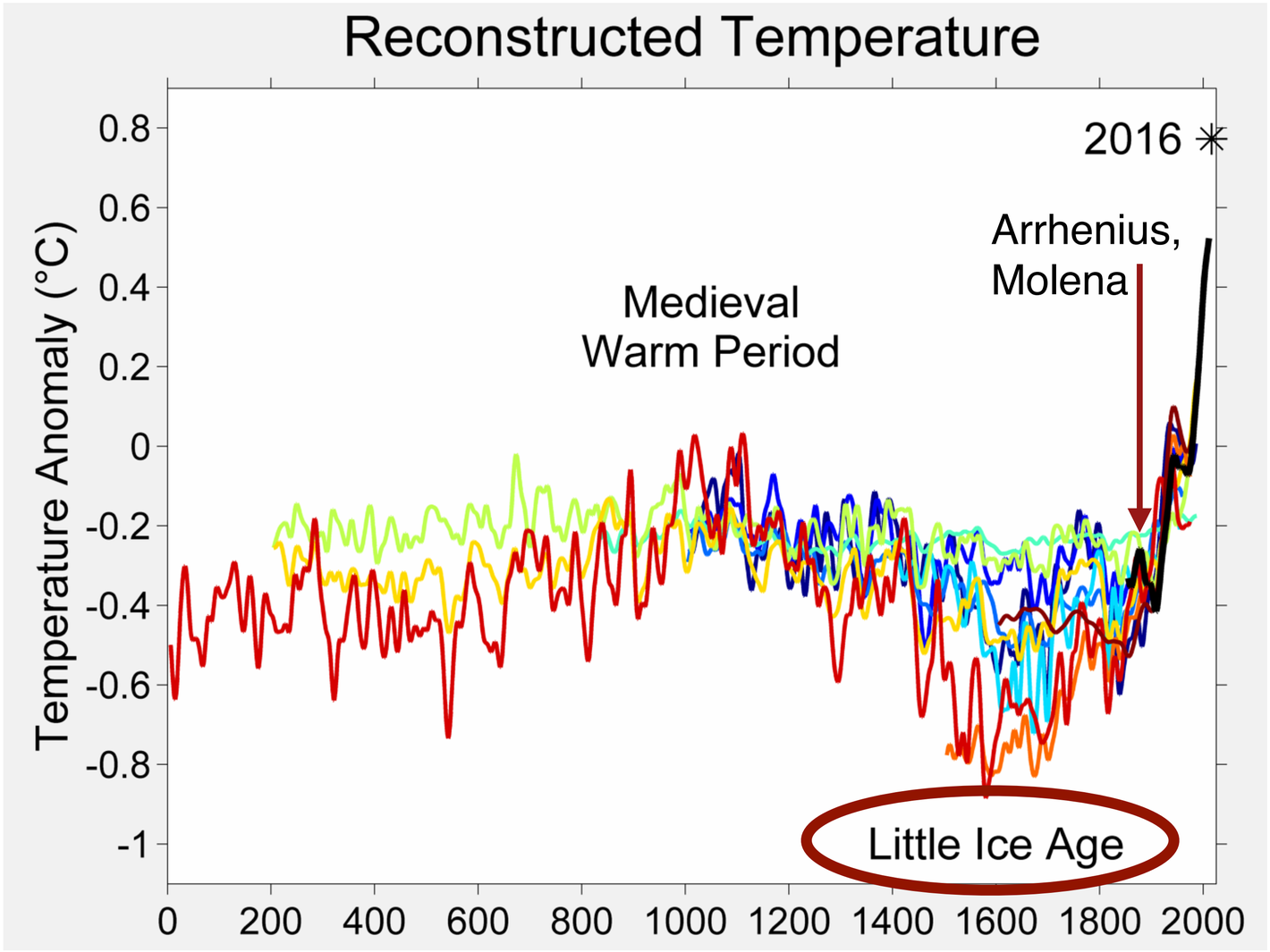


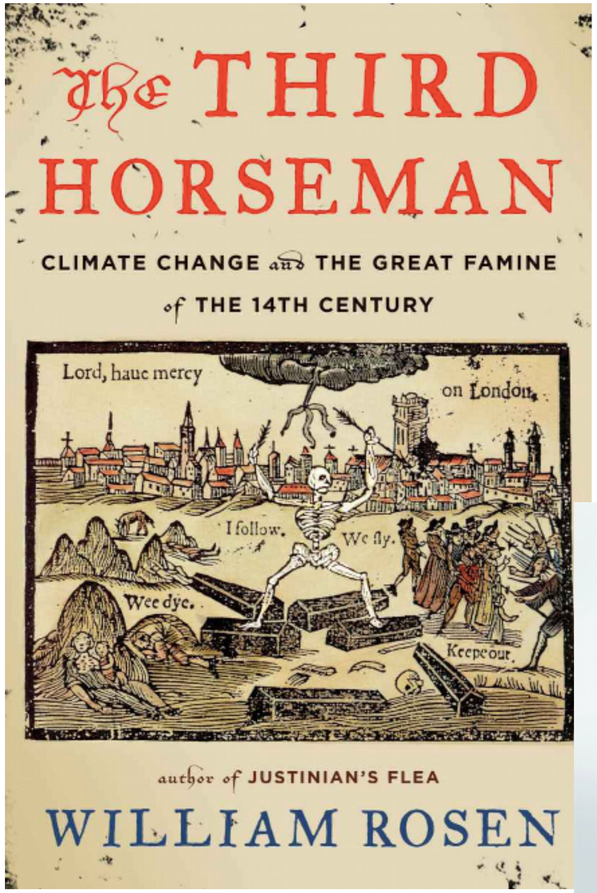


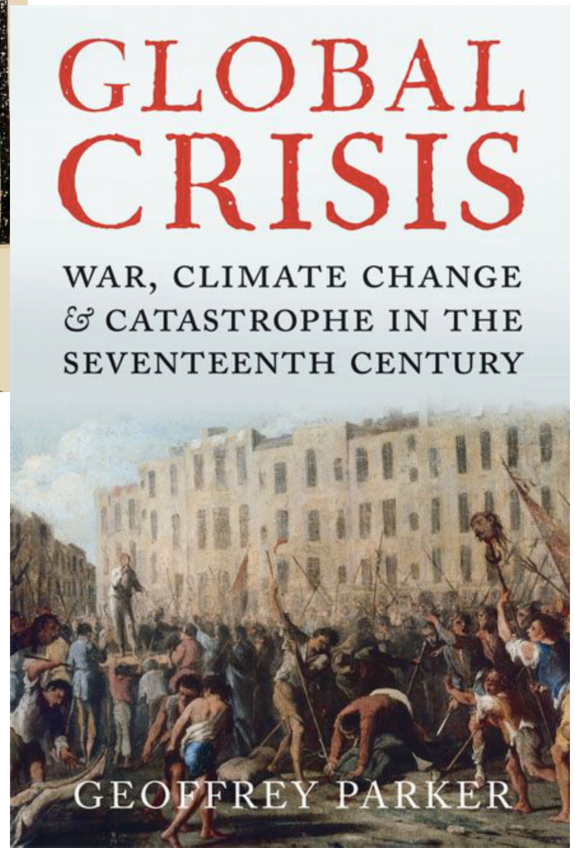

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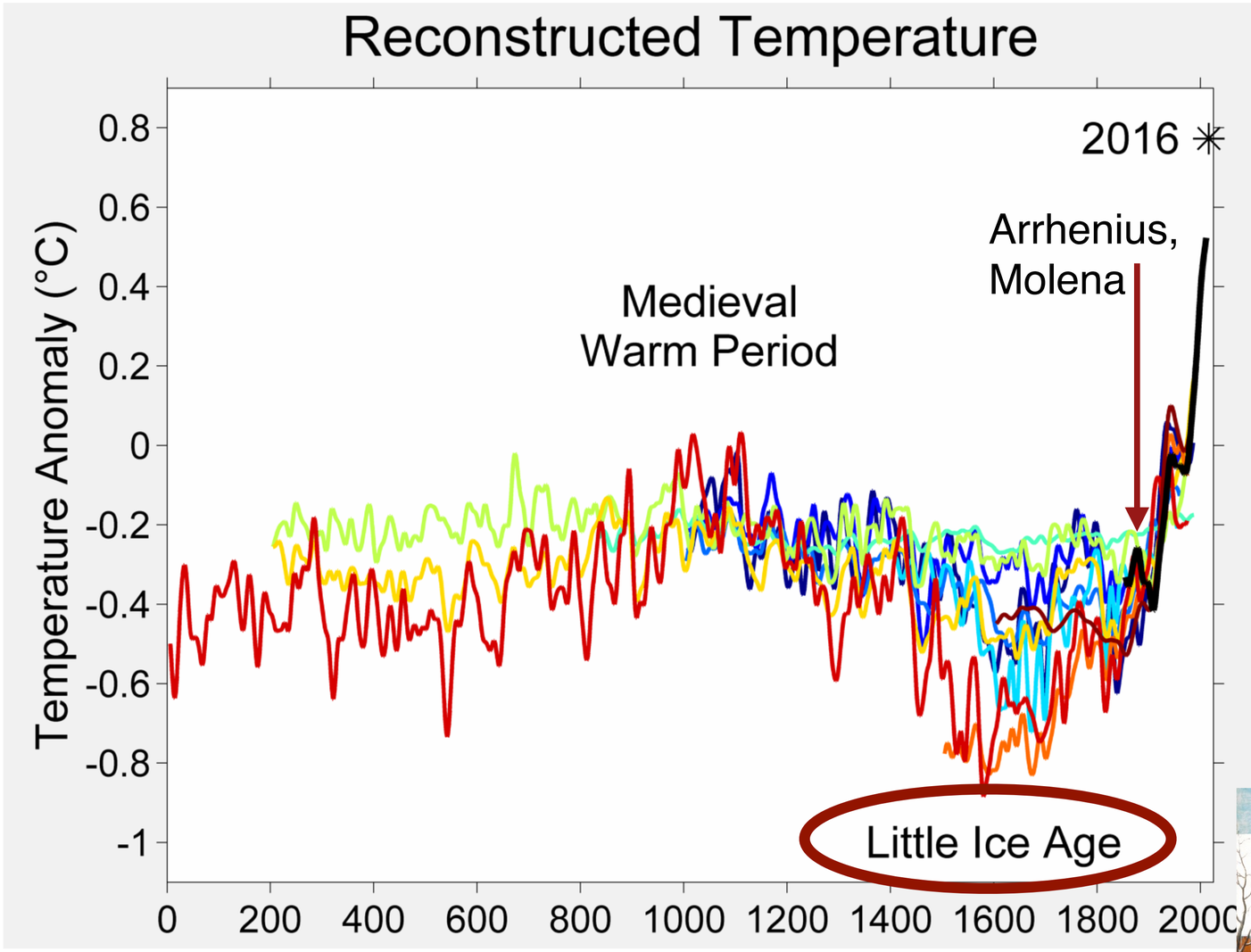


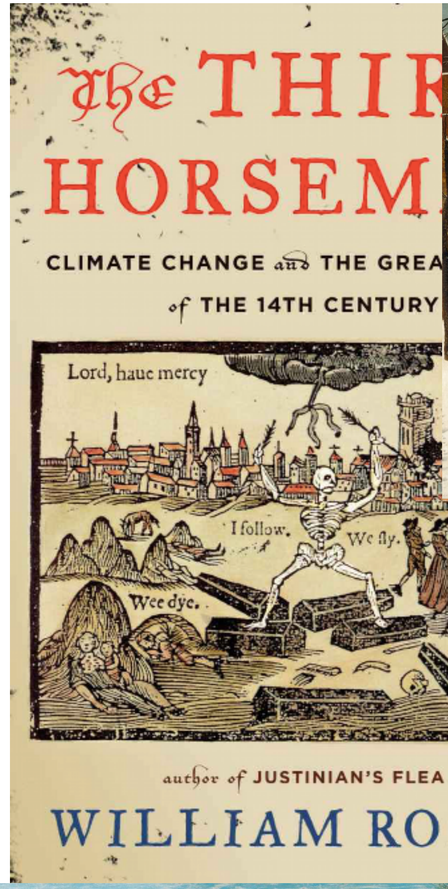


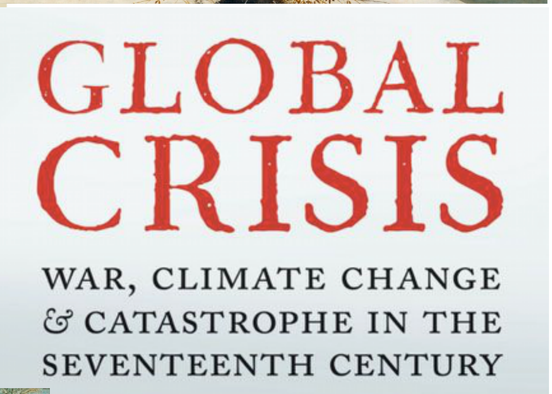


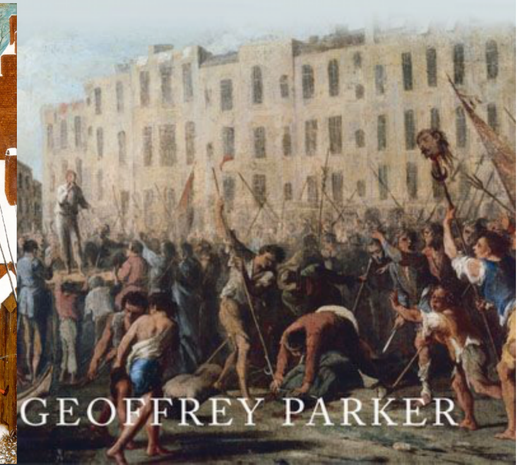

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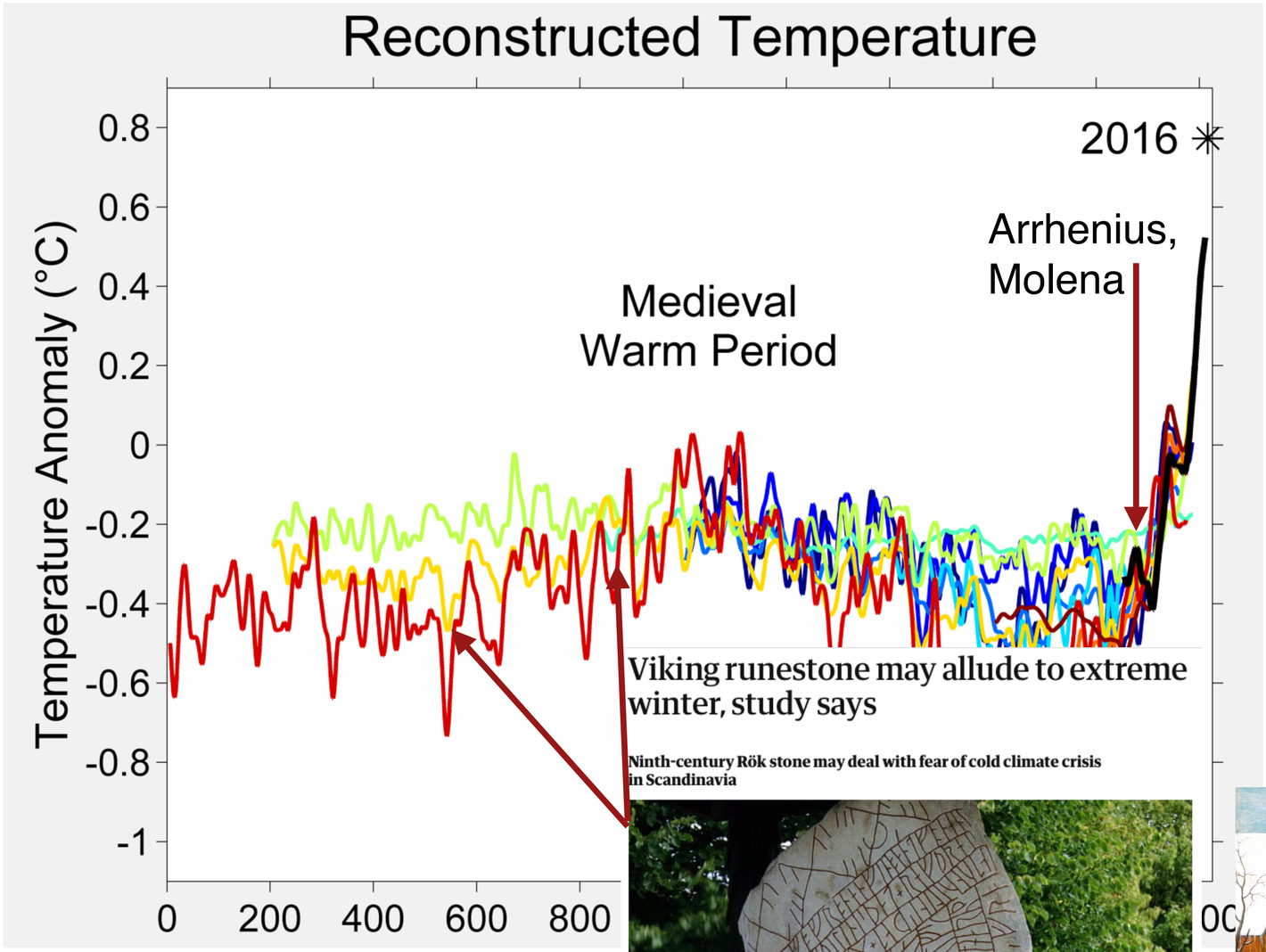
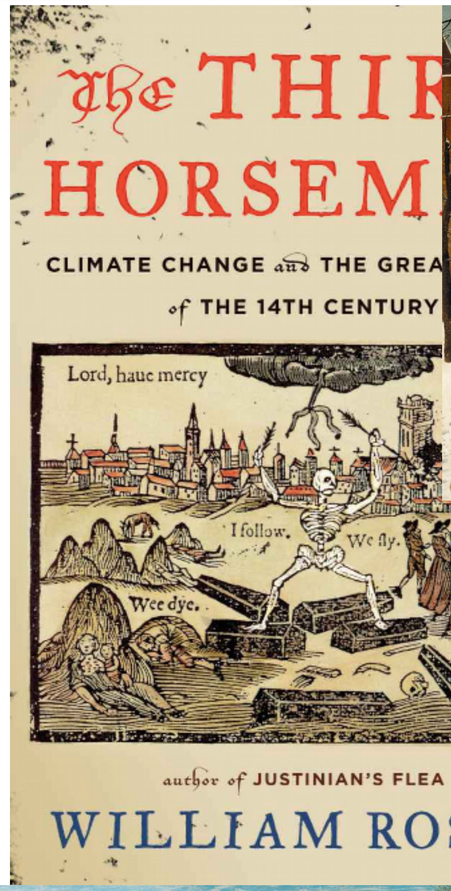



Viking runestone may allude to extreme winter, study says

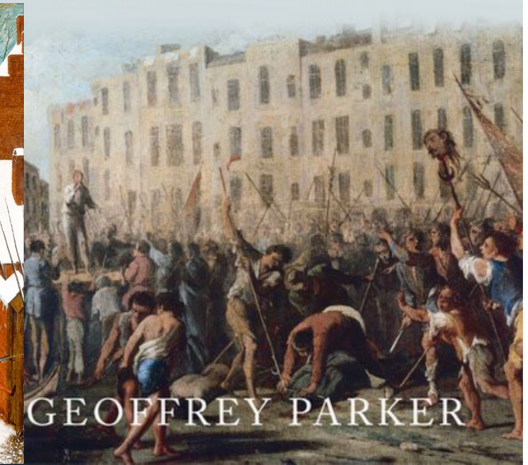
Ninth-century Rök stone may deal with fear of cold climate crisis in Scandinavia

▲ The Rök stone in Sweden bears the longest runic inscription in the world. Photograph: Alfredo Dagli Orti/Rex/Shutterstock

https://www.theguardian.com/world/2020/jan/08/viking-runestone-may-allude-to-extreme-winter-study-says







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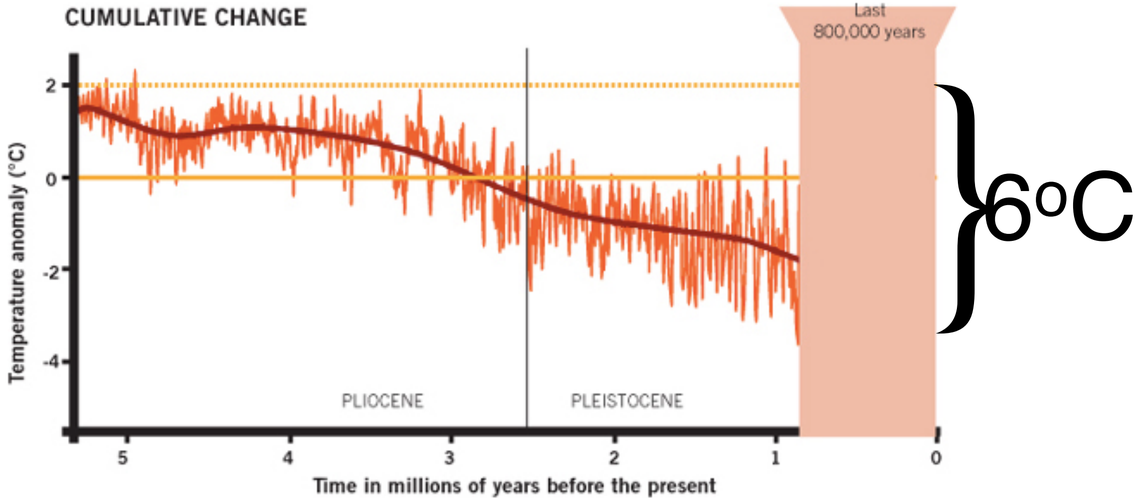


*Rockstrom and Klum, 2015*

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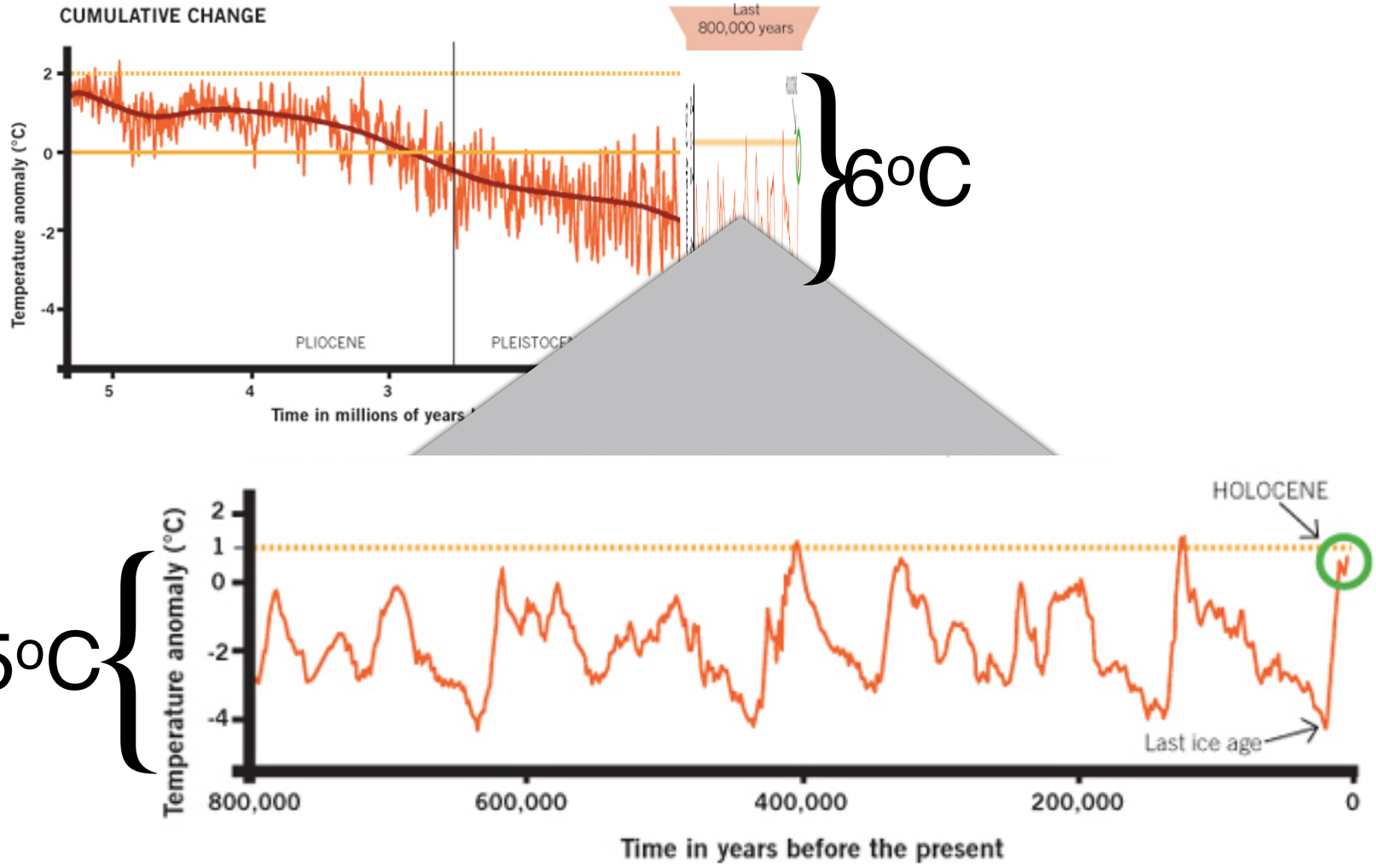


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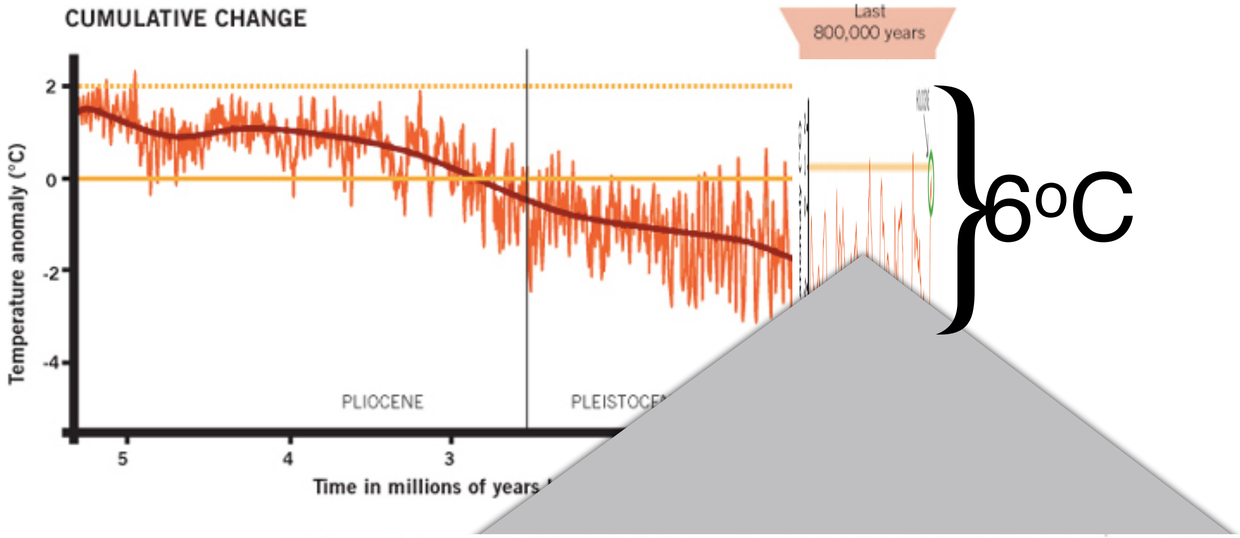


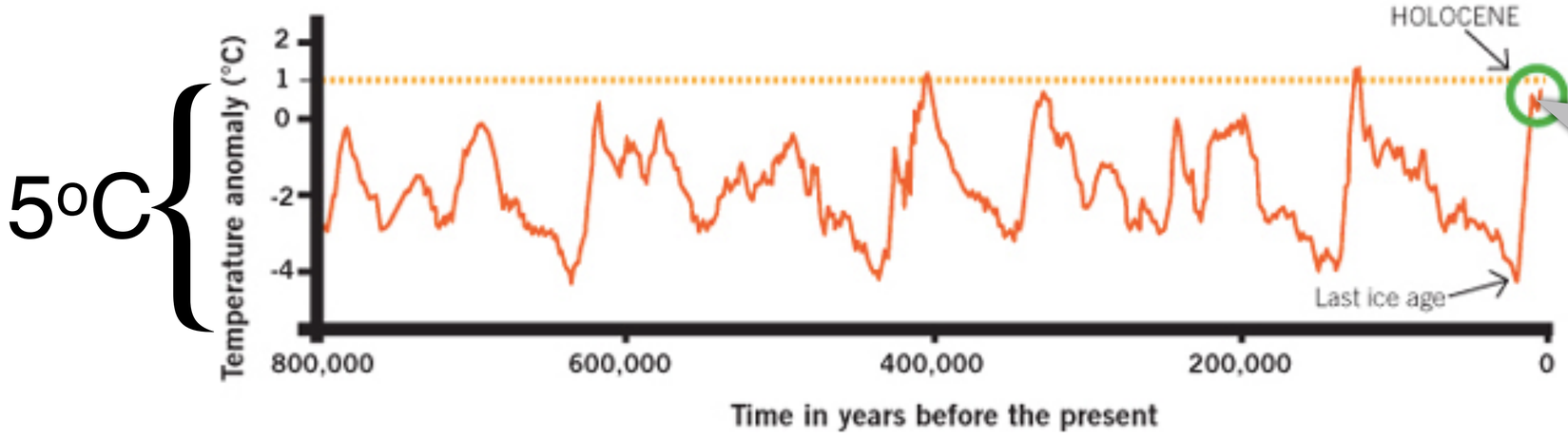


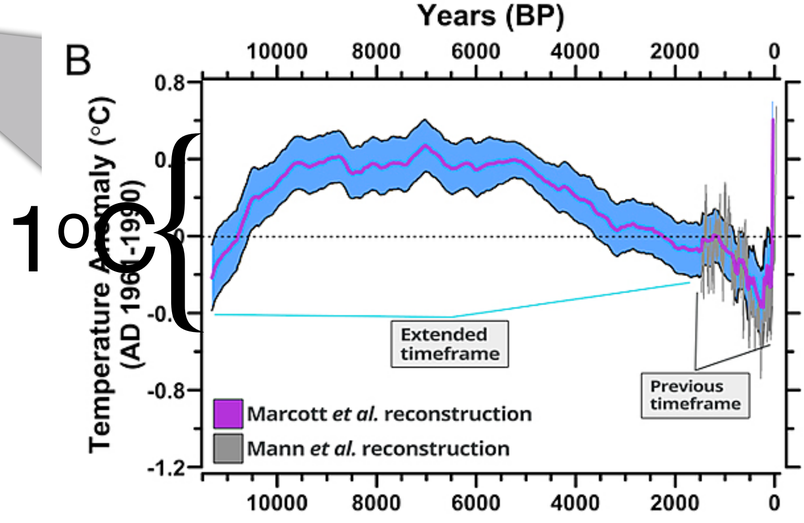


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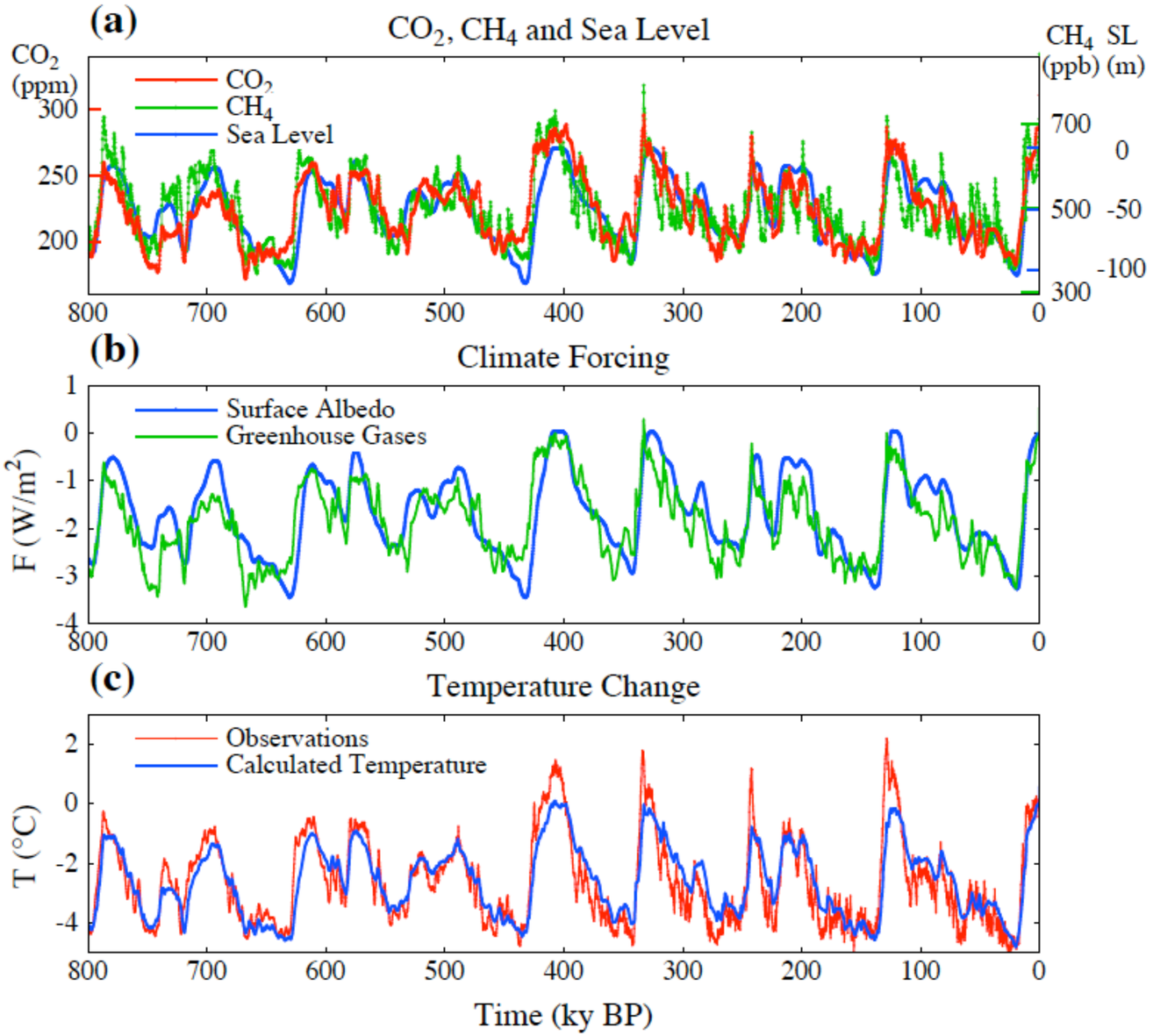

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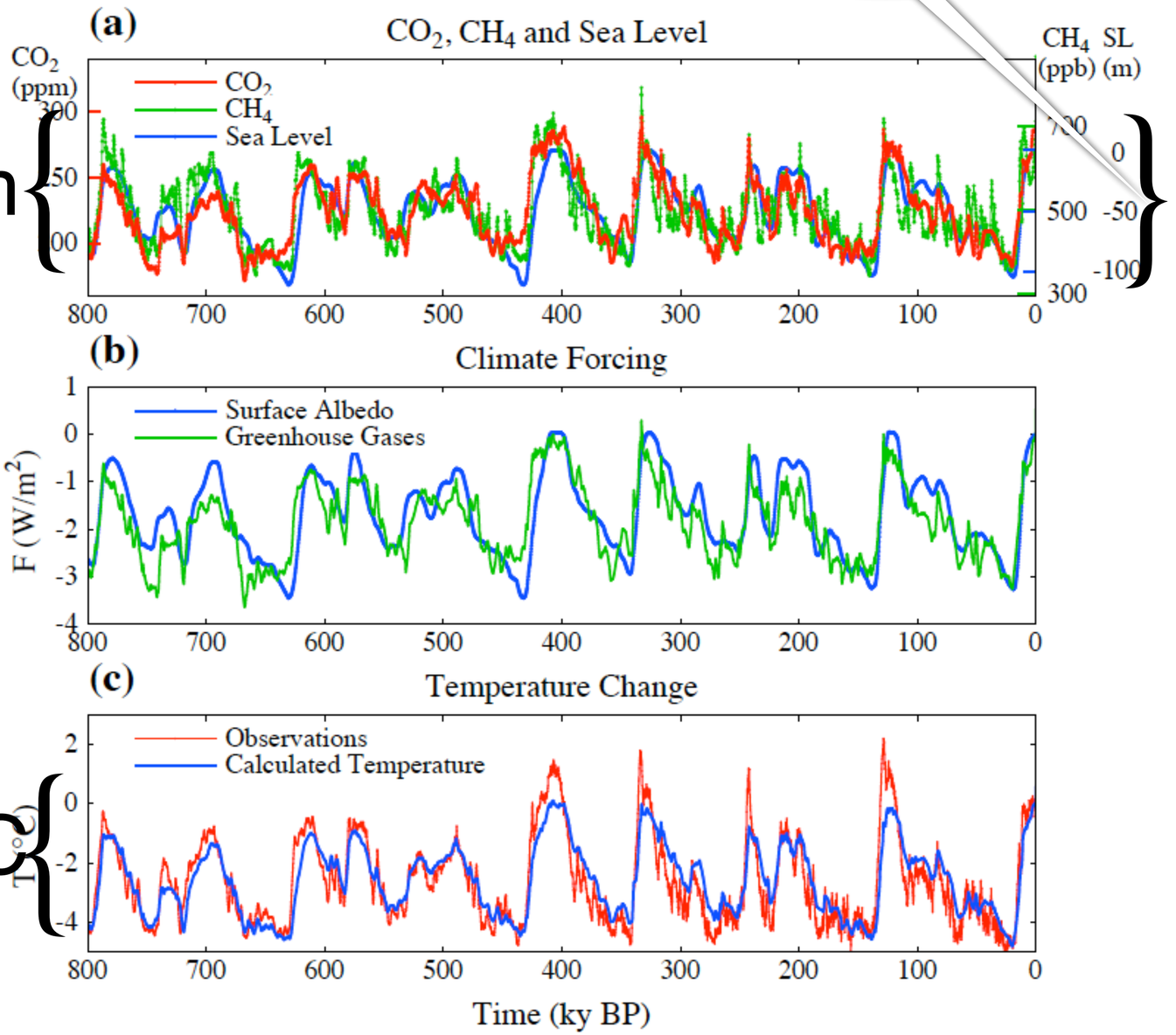
130 m

130 ppm

5°C



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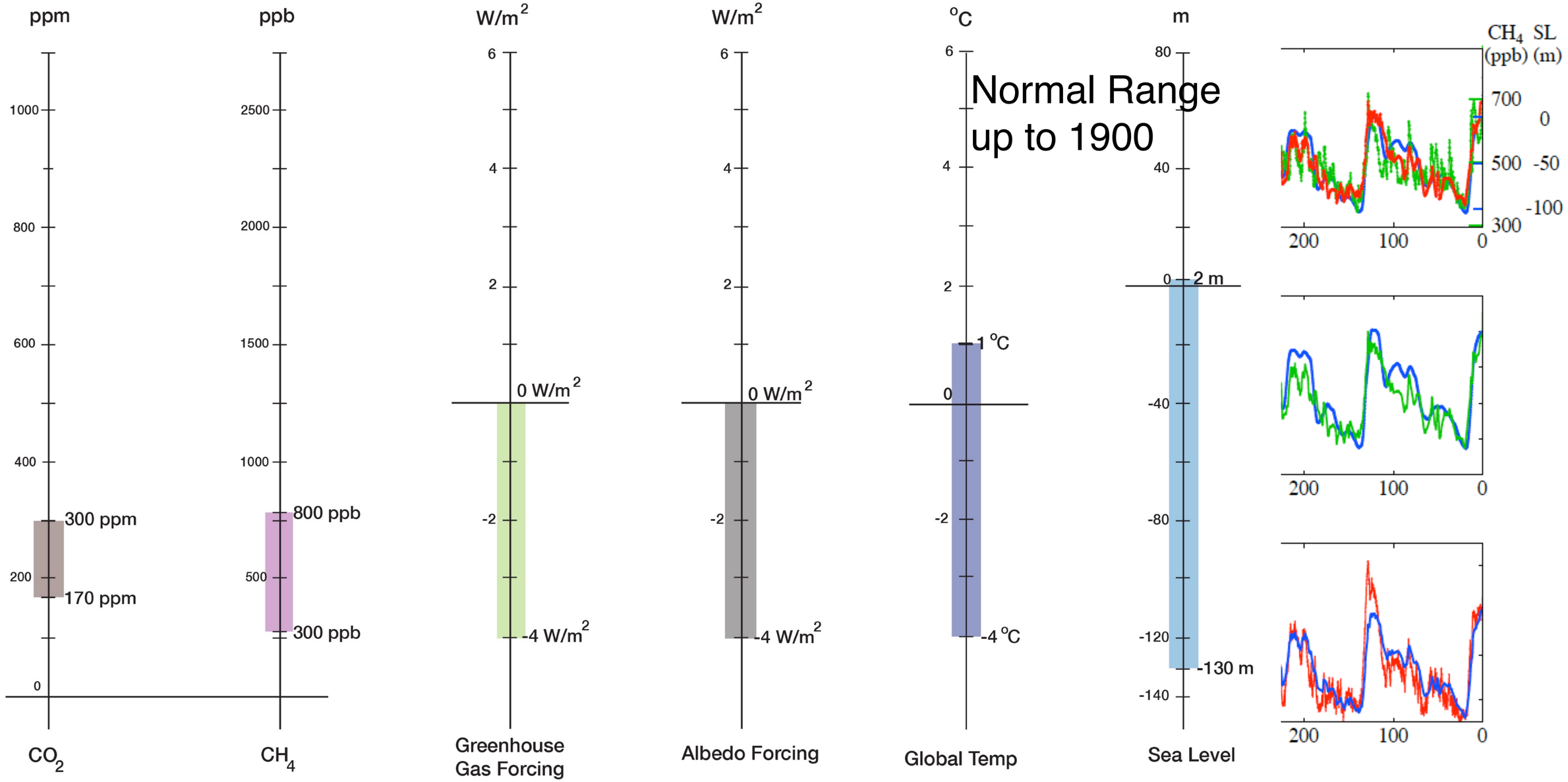

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### Long-term (centuries to millennia) correlations:

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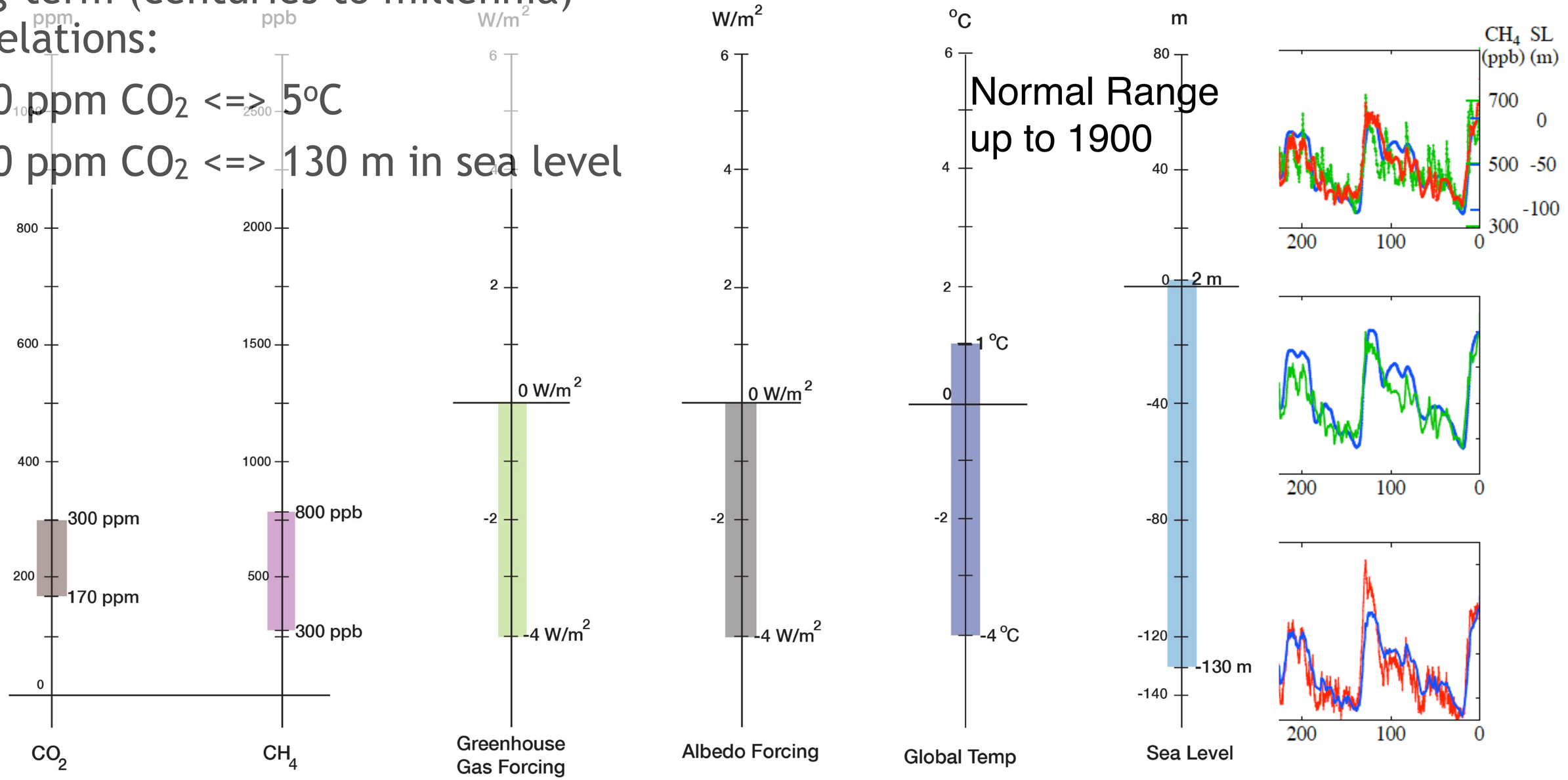

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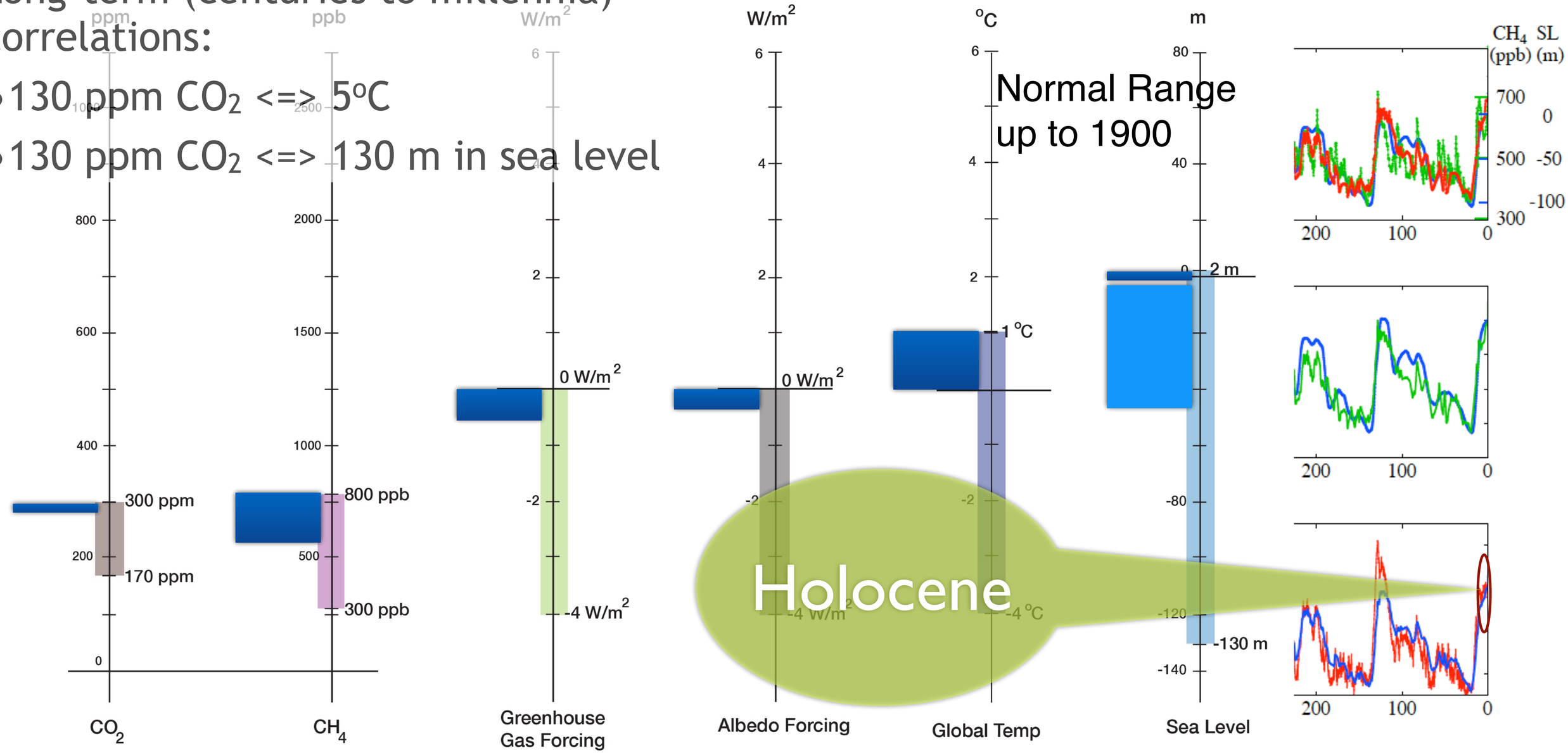

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Normalcy Bias: Climate variations are small and sea level is stable — a result of the Holocene

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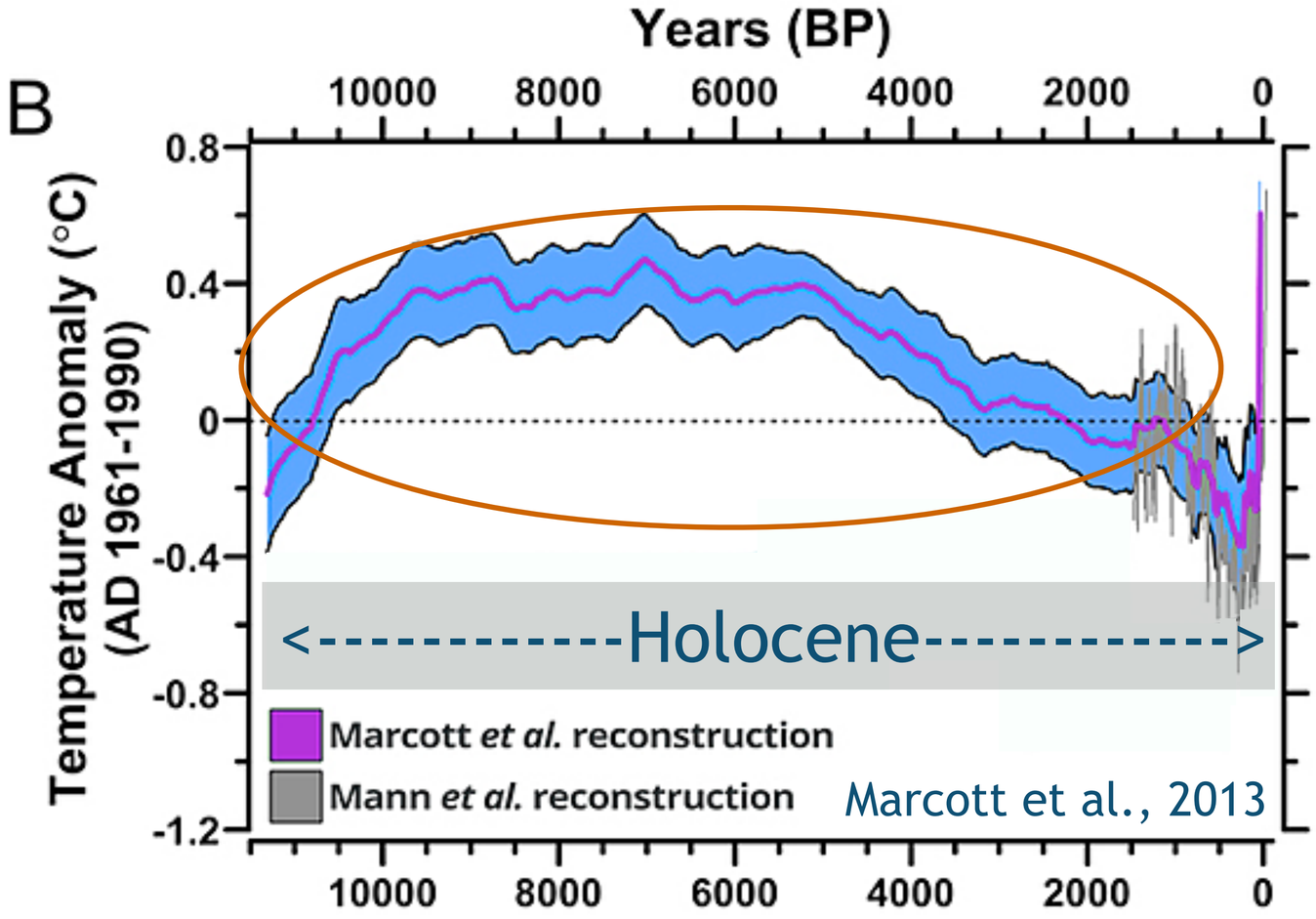


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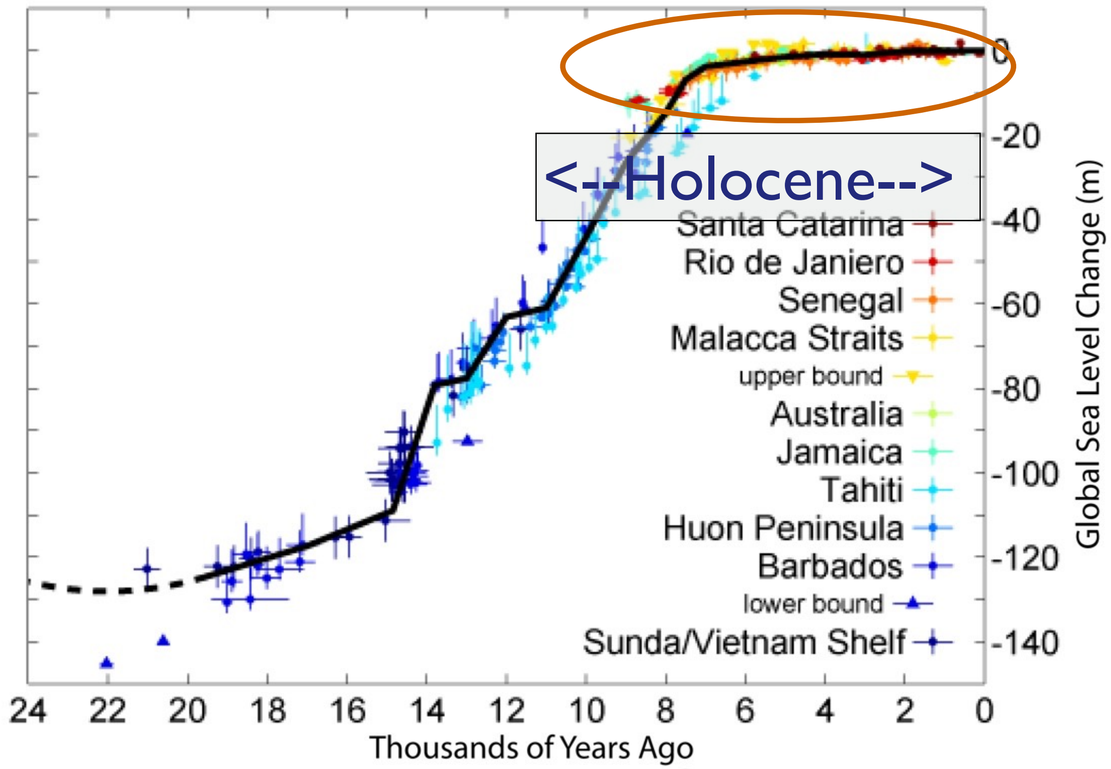

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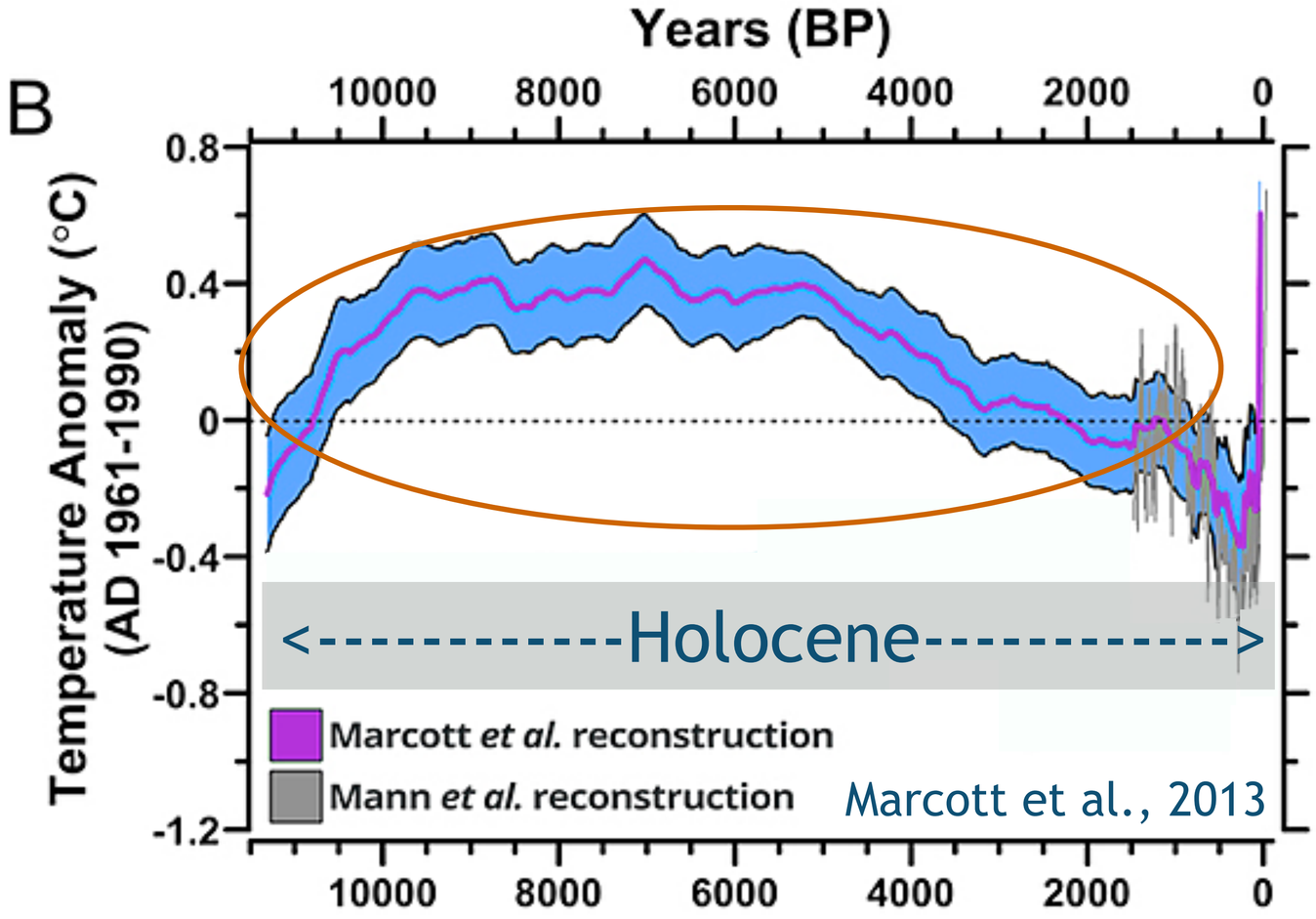


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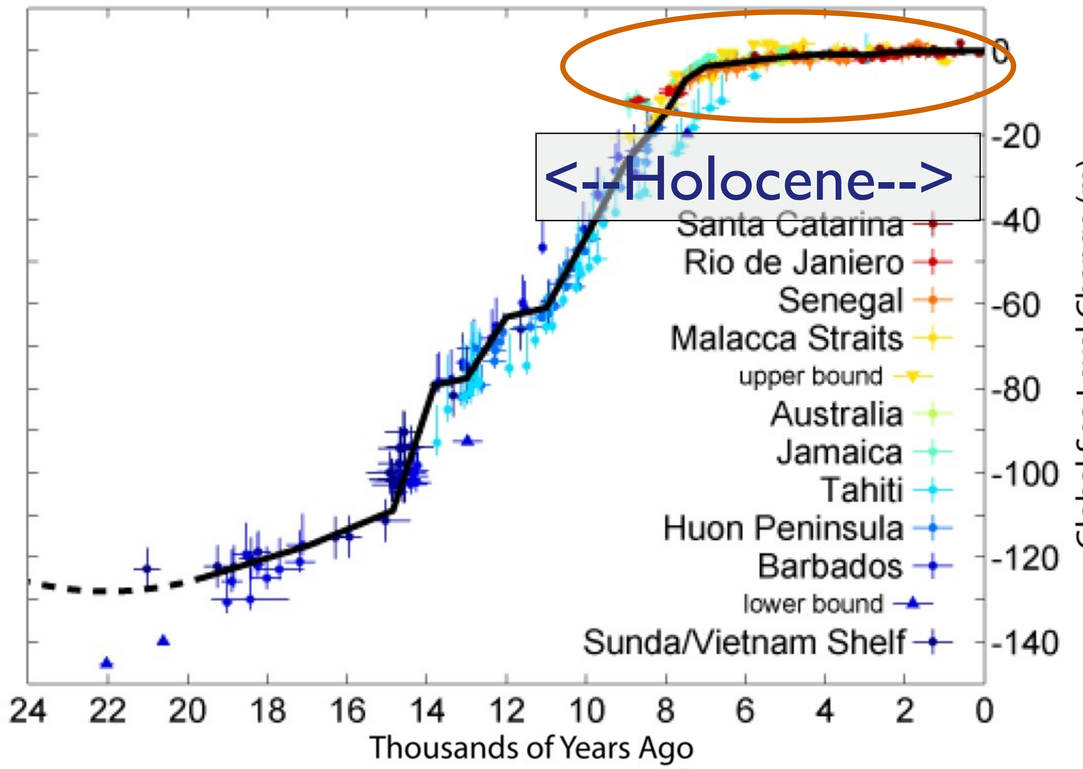


With stable climate and sea level, the Holocene was a safe operating space for humanity.

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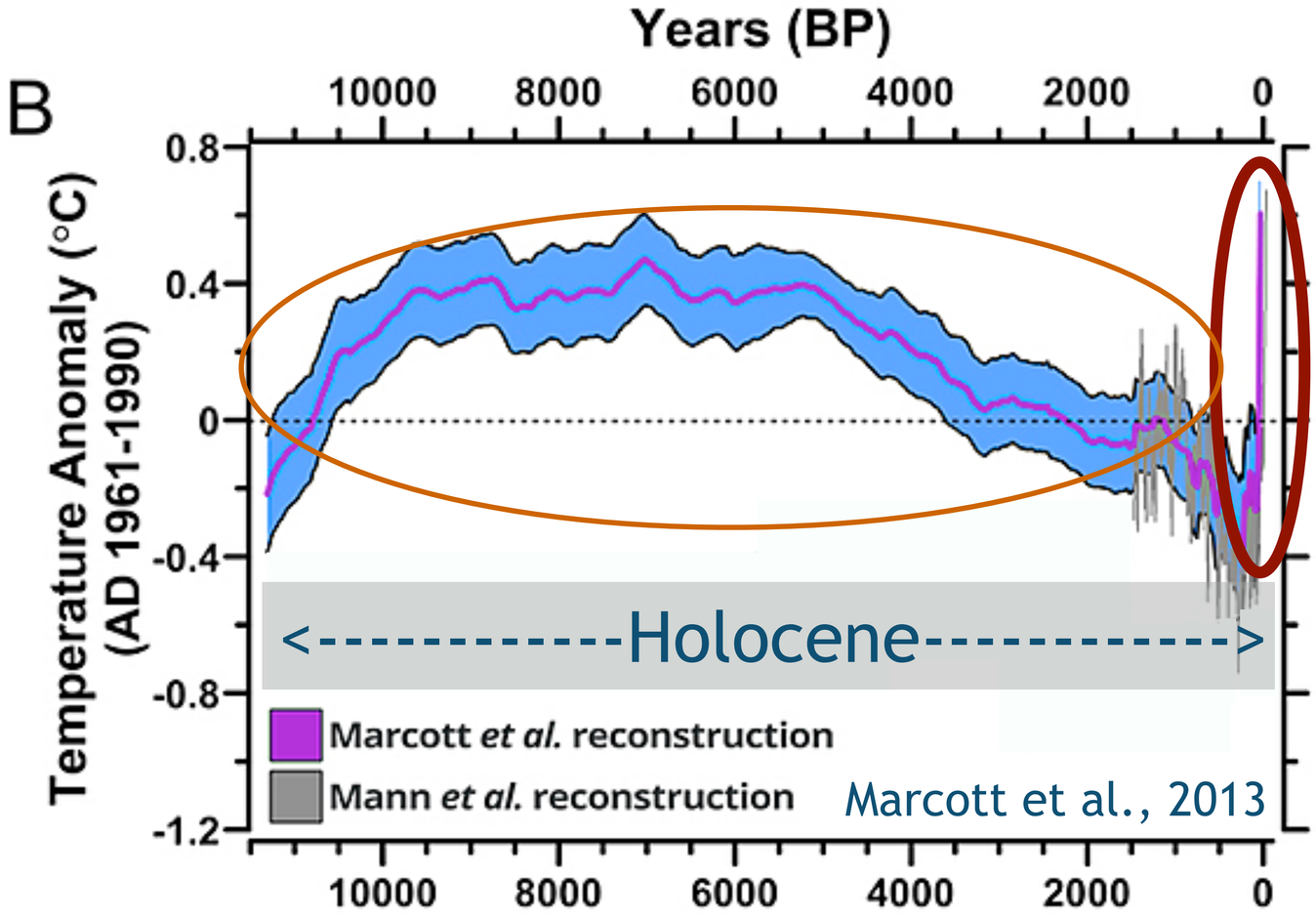


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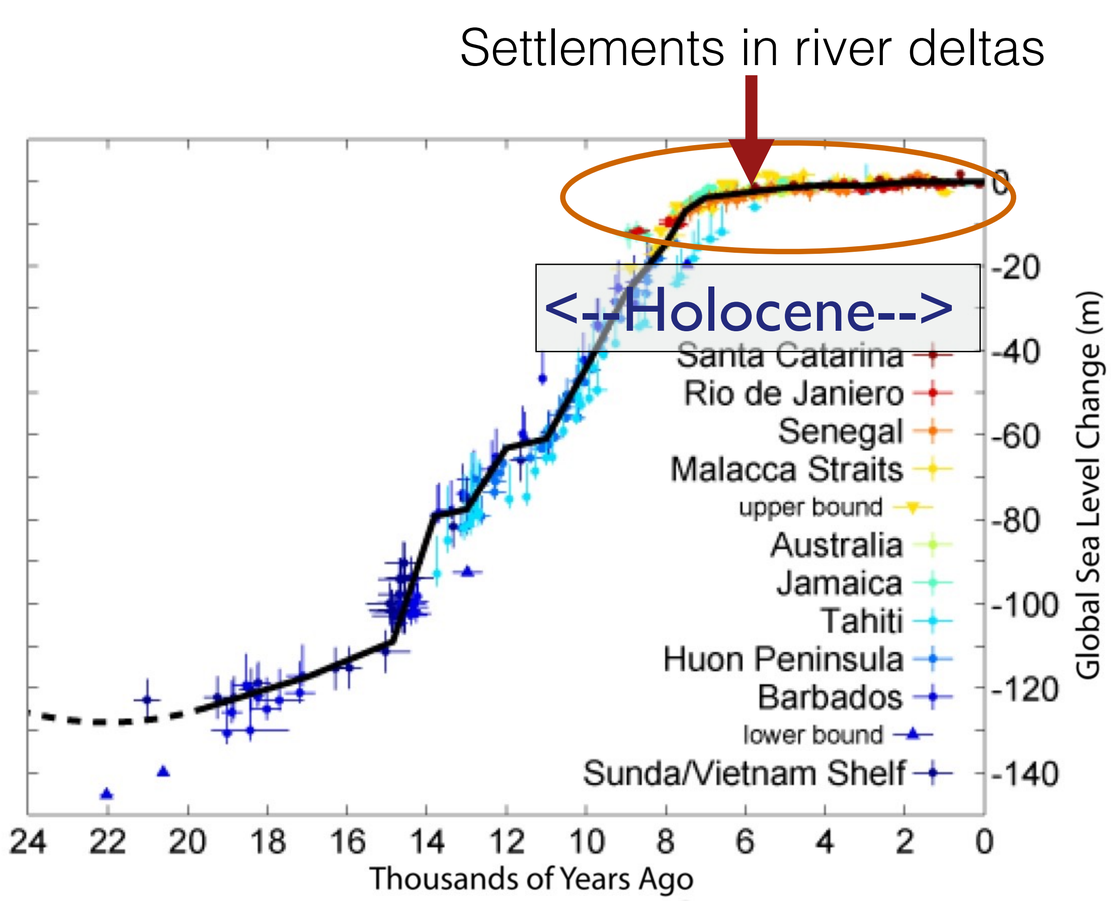


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# Key Points

Baseline

During the Holocene, climate and sea level were exceptionally stable.

The Holocene was a “safe operating space for humanity” allowing the emergence of a dominant species

# Modern Climate Change: A Symptom of a Human-Caused High-Energy Pulse

Contents



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- The Prognosis: Leaving the “Safe Operating Space” and into the Unknown
- The Therapy: A new Ethics, Economy, and Global Governance