Mitigation and Adaptation Studies

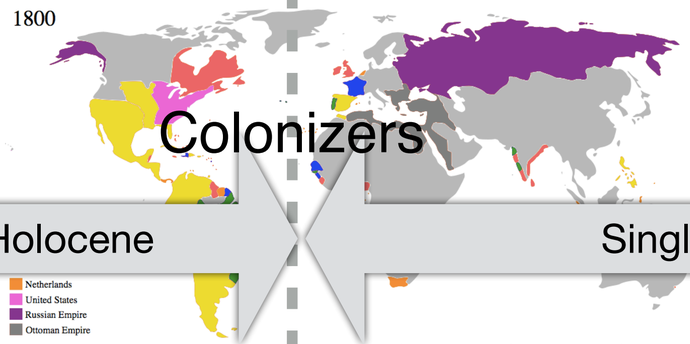
Class 2: The Syndrome of Modern Global Change: Baseline

Contents:

- Homo sapiens: An Exceptional Success Story (continued from class 1)
- Baseline

Homo sapiens: An Exceptional Success Story

Homo sapiens

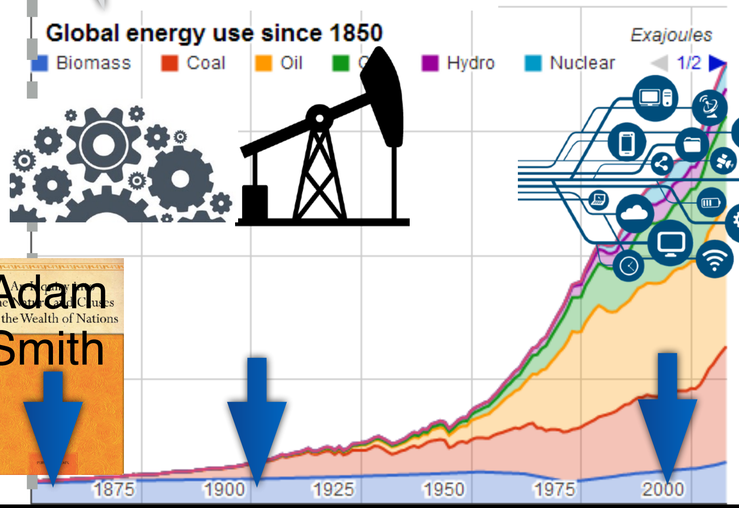


Colonizers

Holocene

Single-Species Dominance

Post-Holocene



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Population →

4 M 50 M 1.6 B 5.3 B 6.0 B 6.9 B 12 B? ?

Total energy use → <10^{-6} TW <10^{-3} TW 0.5 TW 10.0 TW 12.8 TW 16.5 TW >100.0 TW?

Homo sapiens: An Exceptional Success Story

Hom

Increasing food efficiency and reducing time needed to process food

Colonizers

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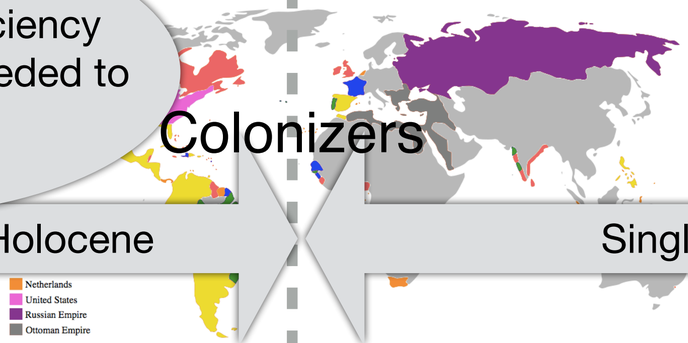

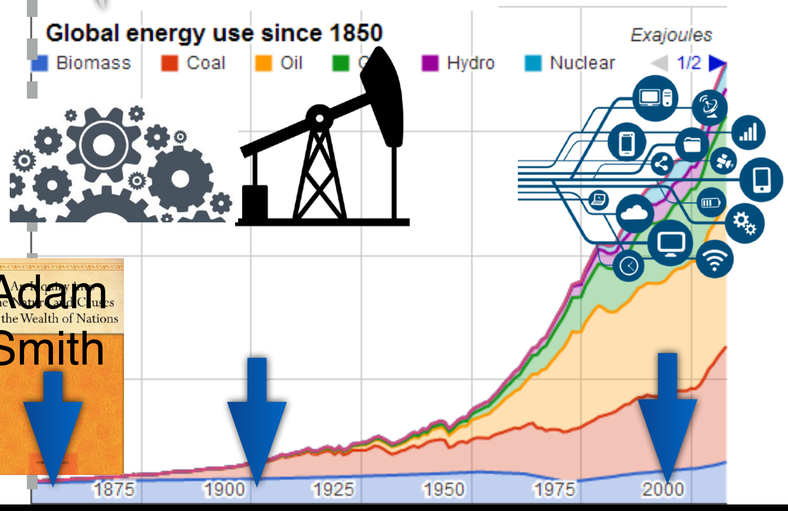

Adam Smith

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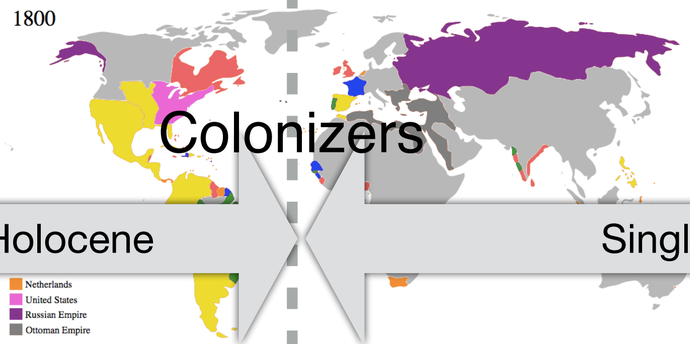

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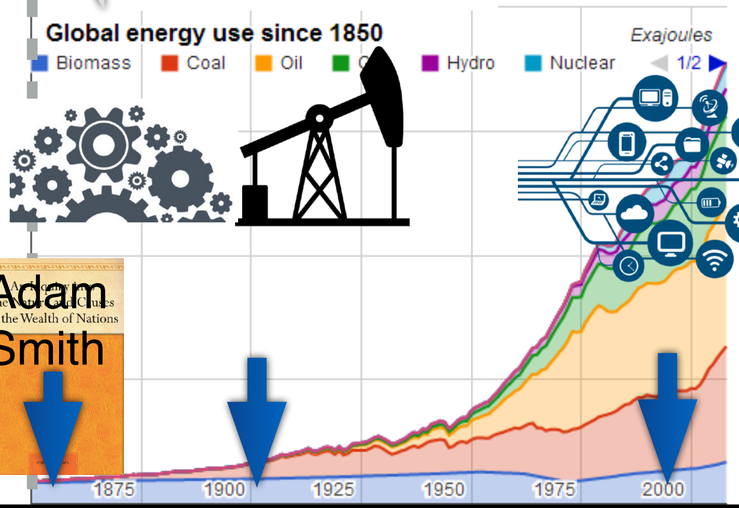

10^{4} 10^{3} Years BP 10^{2} 10^{1} 10^{0} 2000 10^{1} 10^{2} Years 10^{3}

Reducing time needed to obtain food

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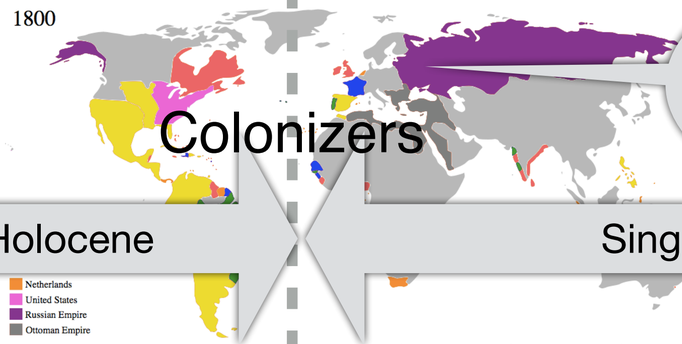
Homo sapiens: An Exceptional Success Story

Homo sapiens



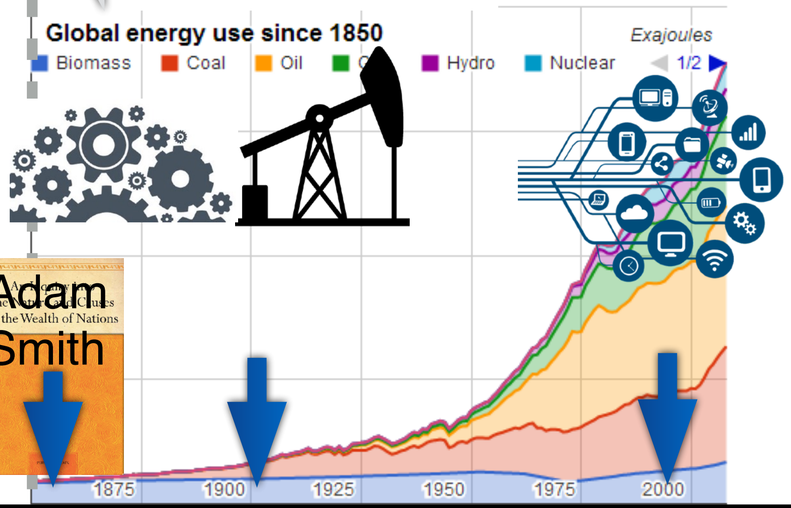
Colonizers

Increasing access to material resources

Holocene

Single-Species Dominance

Post-Holocene



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Homo sapiens: An Exceptional Success Story

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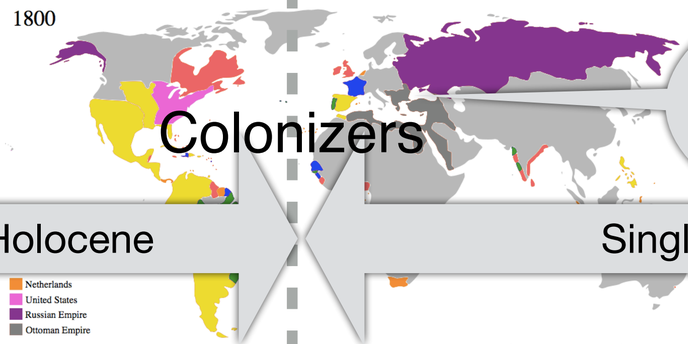


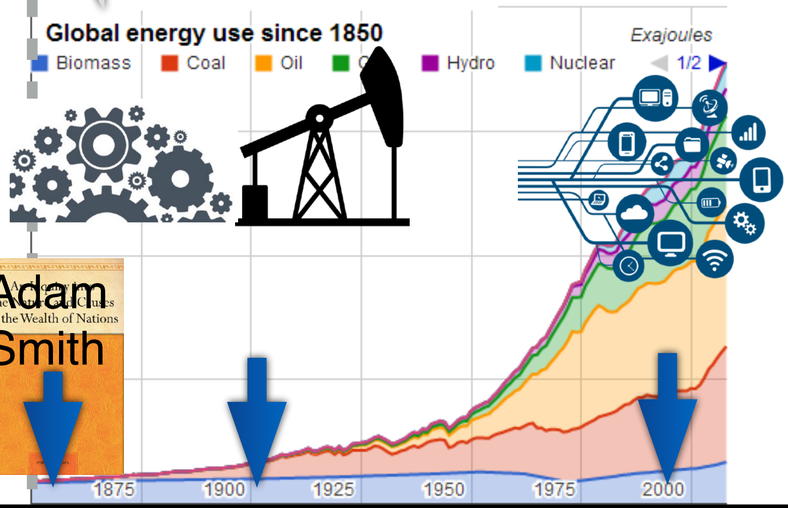
Colonizers

Mainly a light-skinned (almost white) subspecies from Europe

Holocene

Single-Species Dominance

Post-Holocene



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Homo sapiens: An Exceptional Success Story

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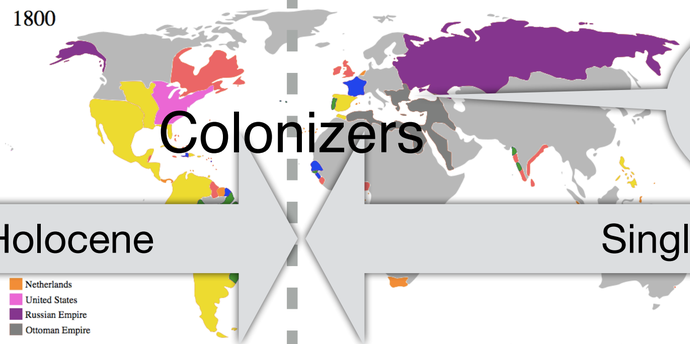

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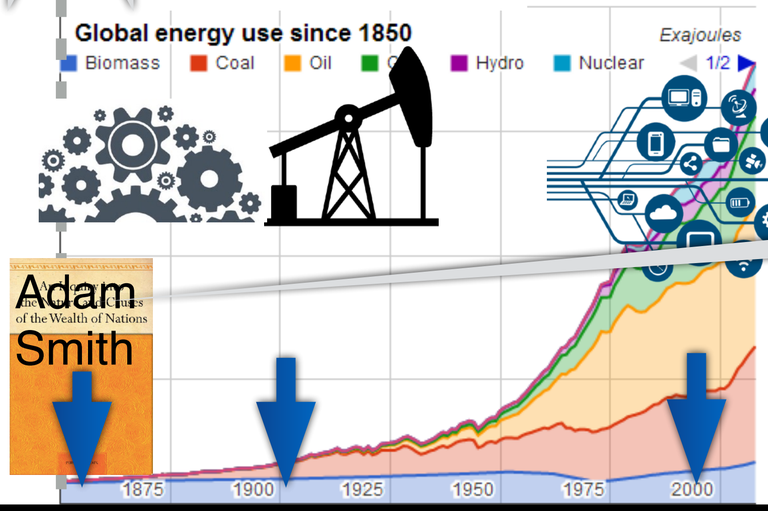

Adam Smith

Goal of economy is to create "human wealth"

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Homo sapiens: An Exceptional Success Story

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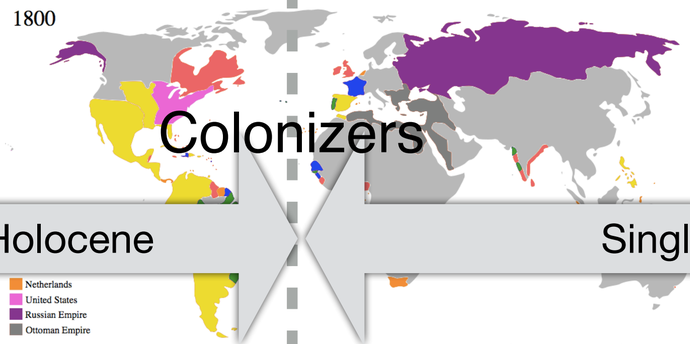

Colonizers

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Single-Species Dominance

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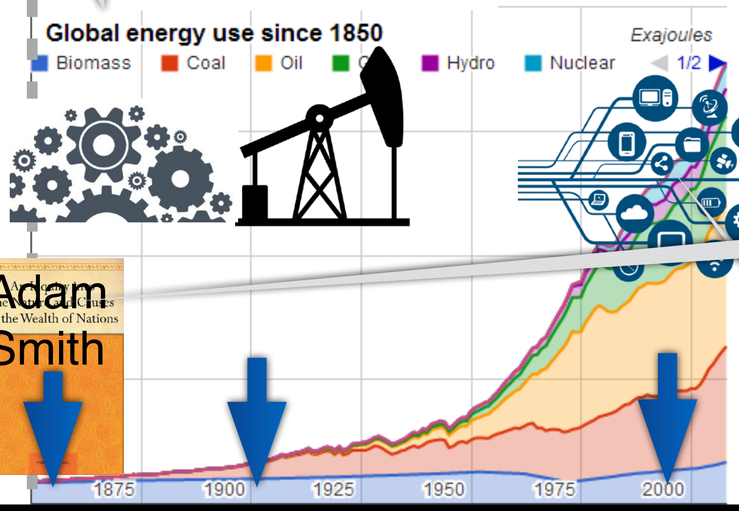

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Technology and access to fossil fuels facilitate economic growth

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Homo sapiens: An Exceptional Success Story

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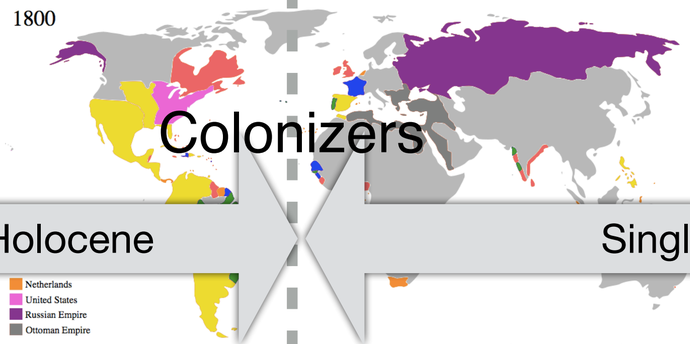


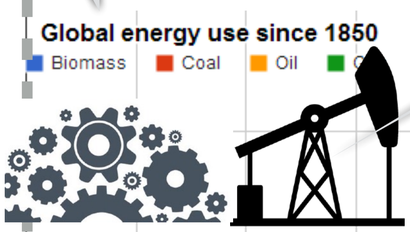
Colonizers

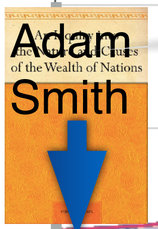
Holocene

Single-Species Dominance

Post-Holocene

Easy access to seemingly infinite energy combined with technology





Goal of economy is to create "human wealth"

10^6 10^5 10^4 10^3 10^2 10^1 10^0 10^3

Years BP

2000

Technology and access to fossil fuels facilitate economic growth

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Homo sapiens: An Exceptional Success Story

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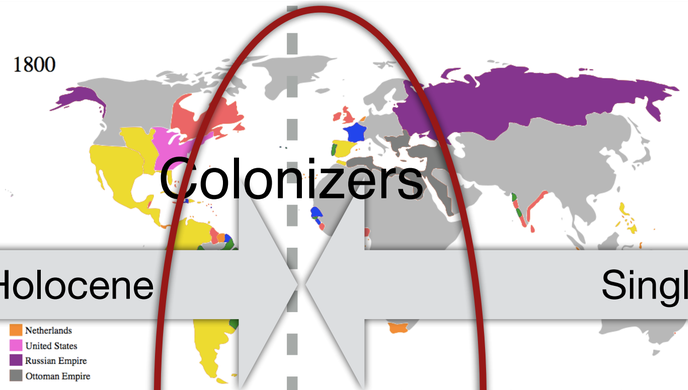

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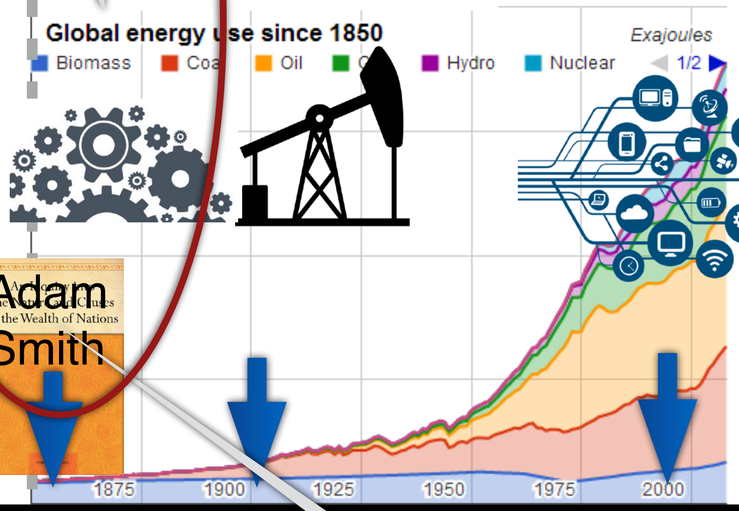

Adam Smith

10^6 10^5 10^4 10^3 10^2 10^1 10^0 10^1 10^2 10^3

Years BP

Years

Population →

4 M 50 M 1.6 B 5.[illegible] [illegible] 12 B? ?

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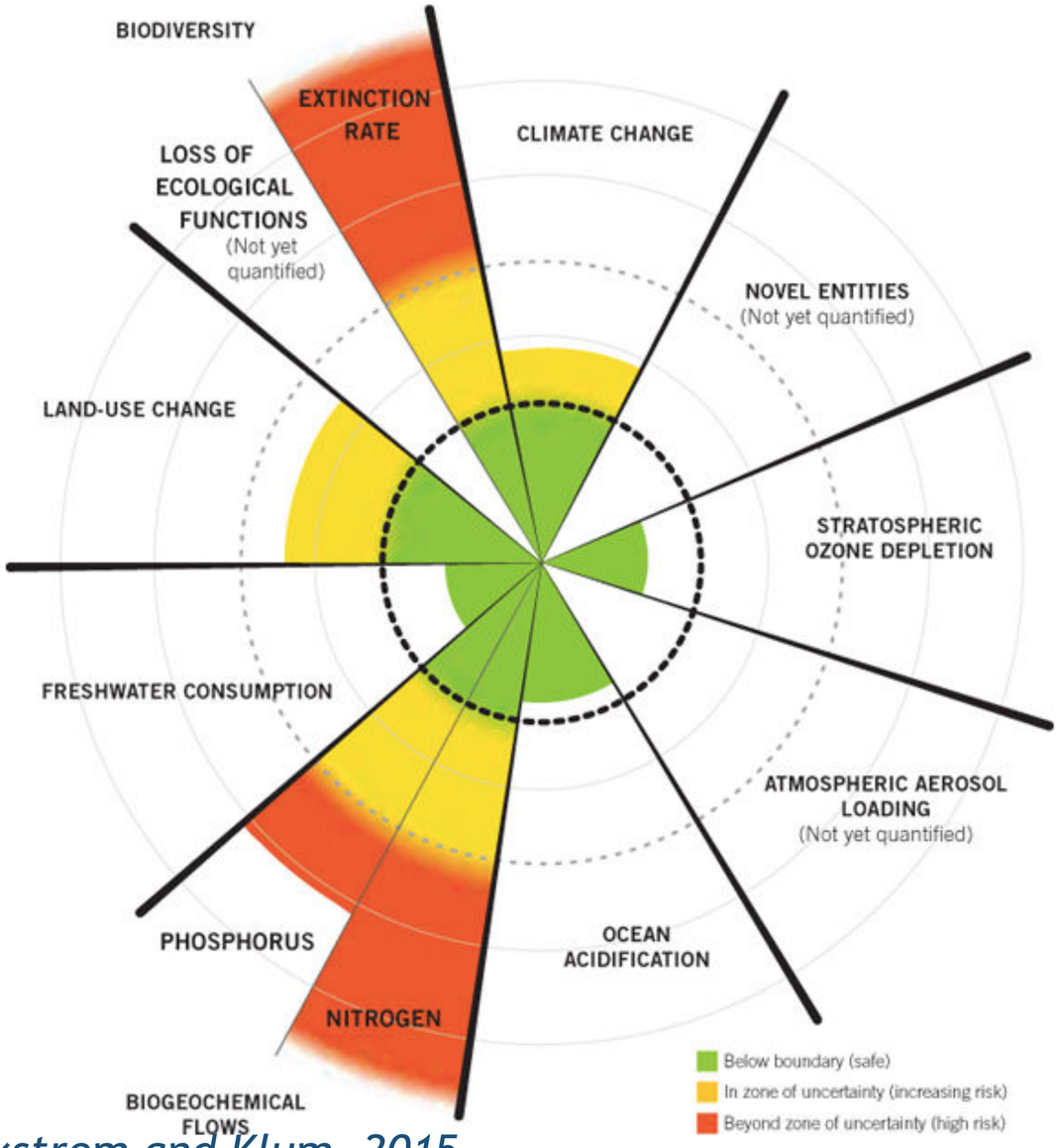
Accumulate, accumulate, …
Later:
Consume, Consume, …

Homo sapiens: An Exceptional Success Story

Impacts on the Earth's Life-Support System

Homo sapiens: An Exceptional Success Story

Impacts on the Earth's Life-Support System



Rockstrom and Klum, 2015

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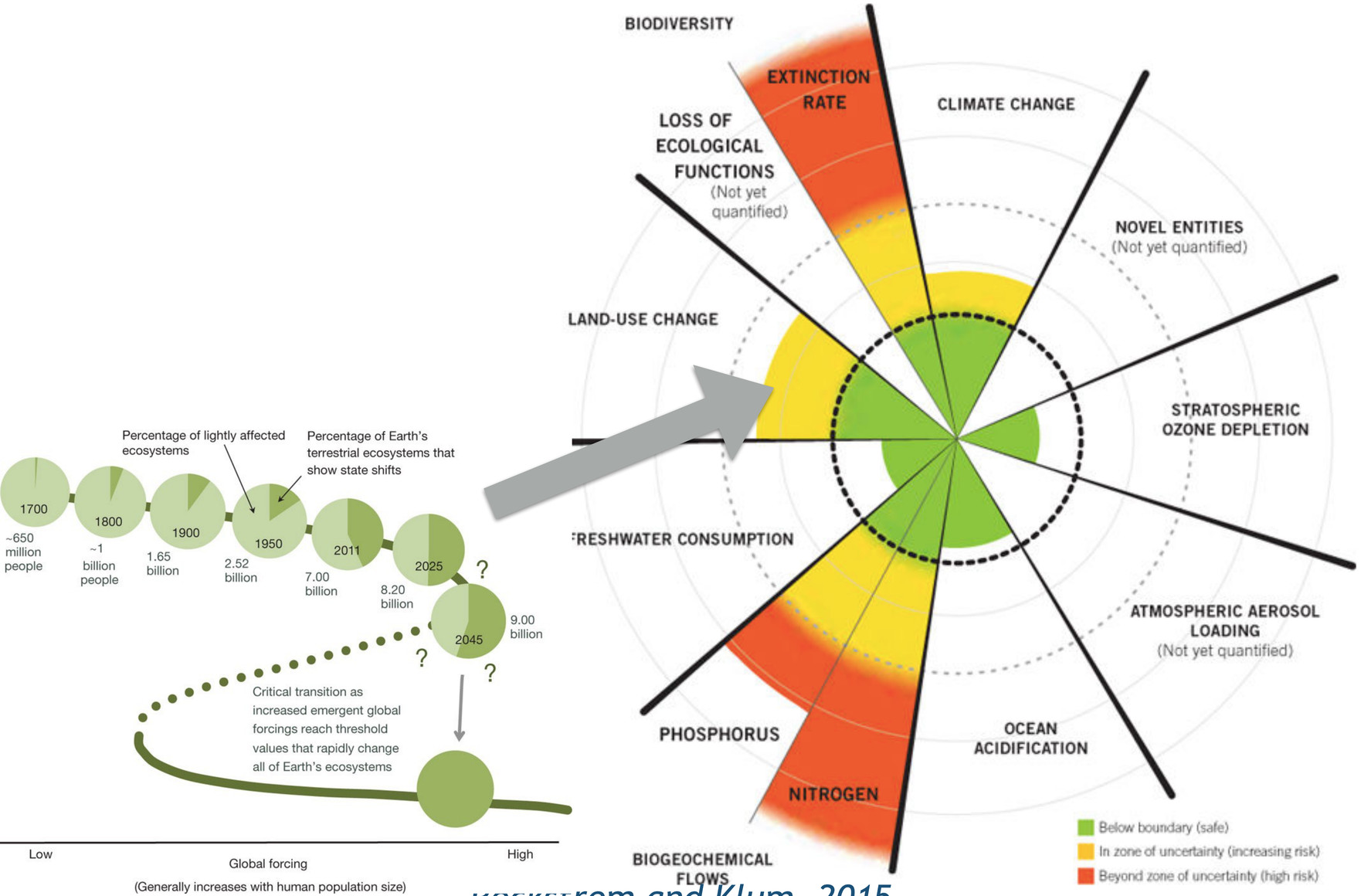

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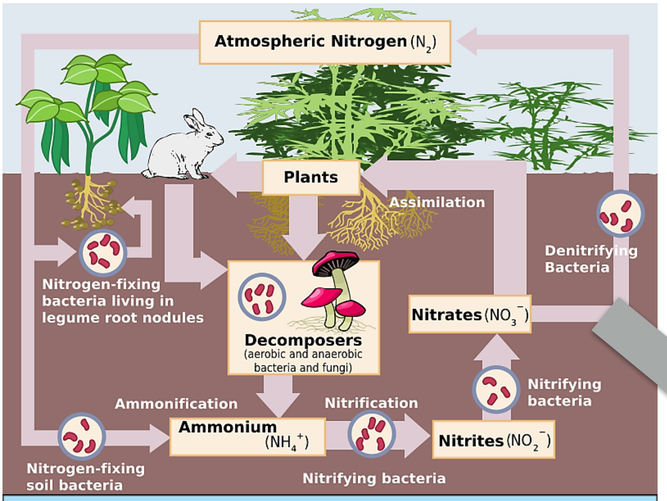

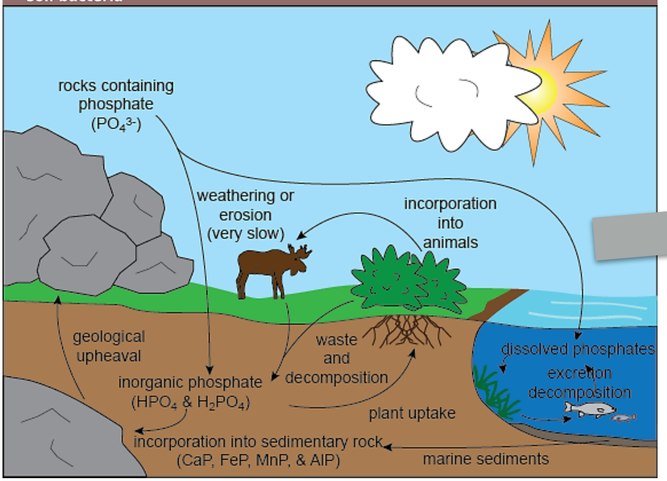

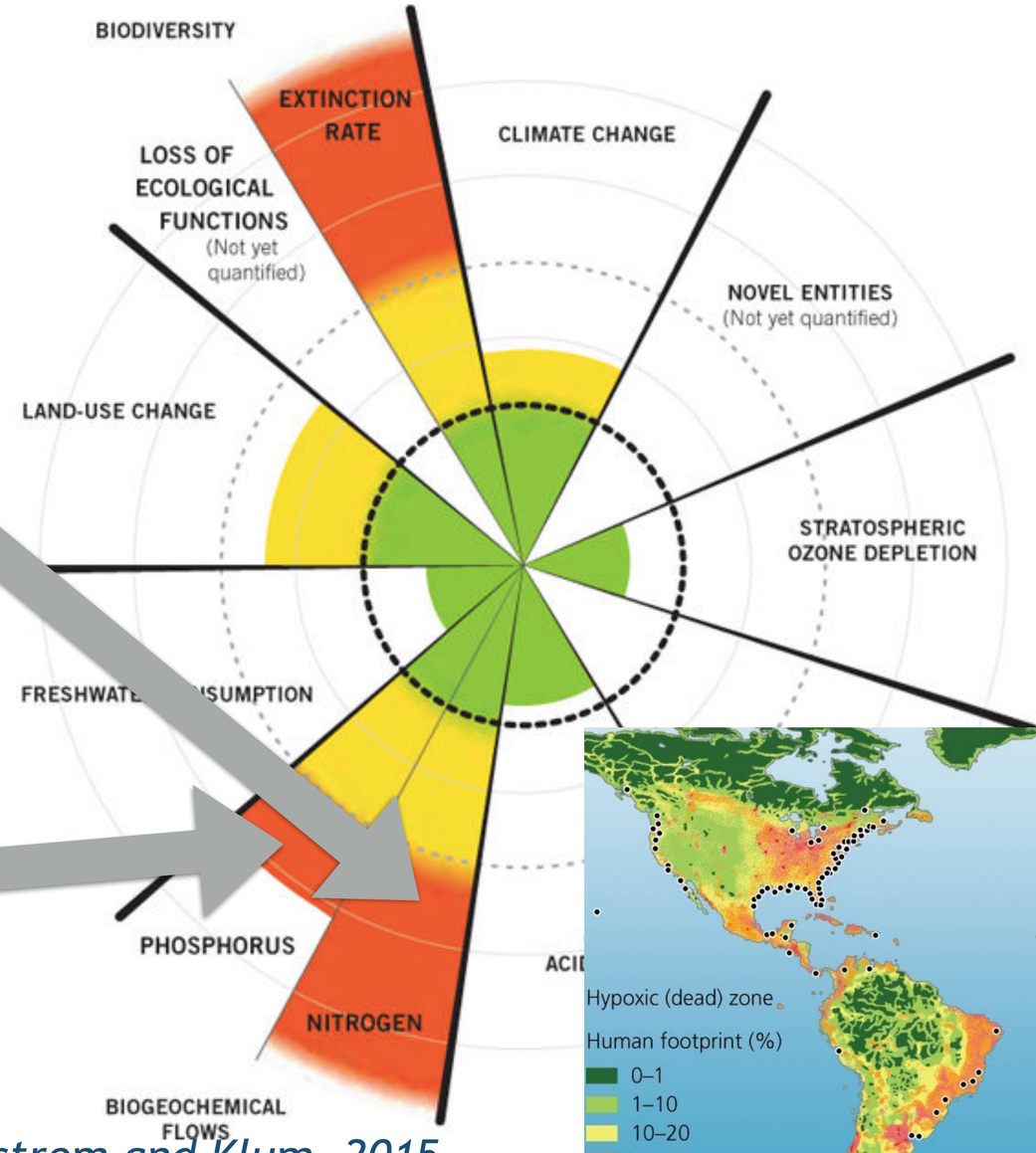

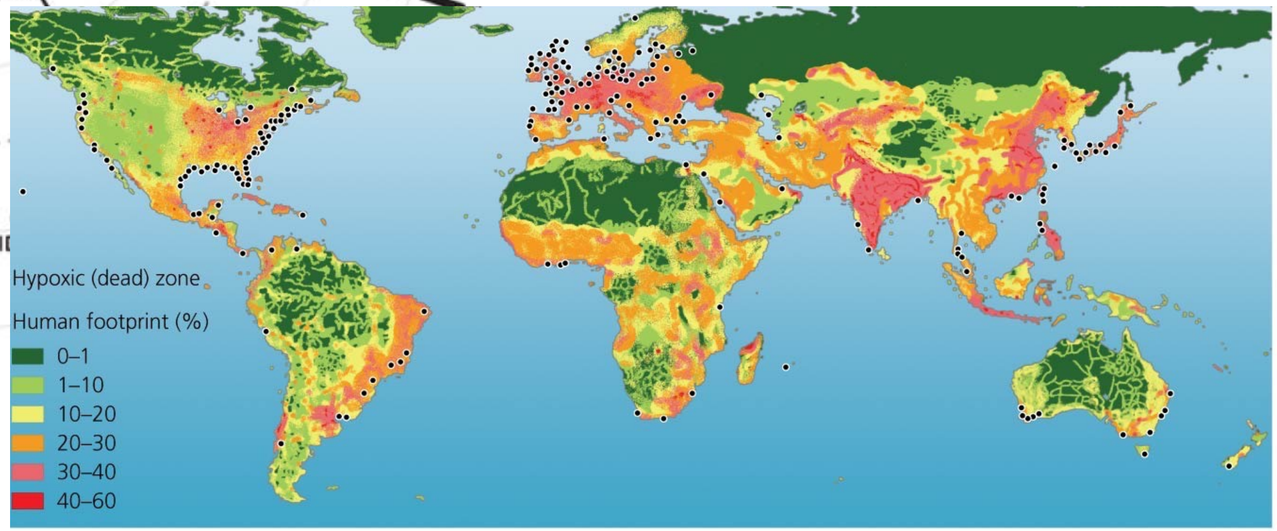

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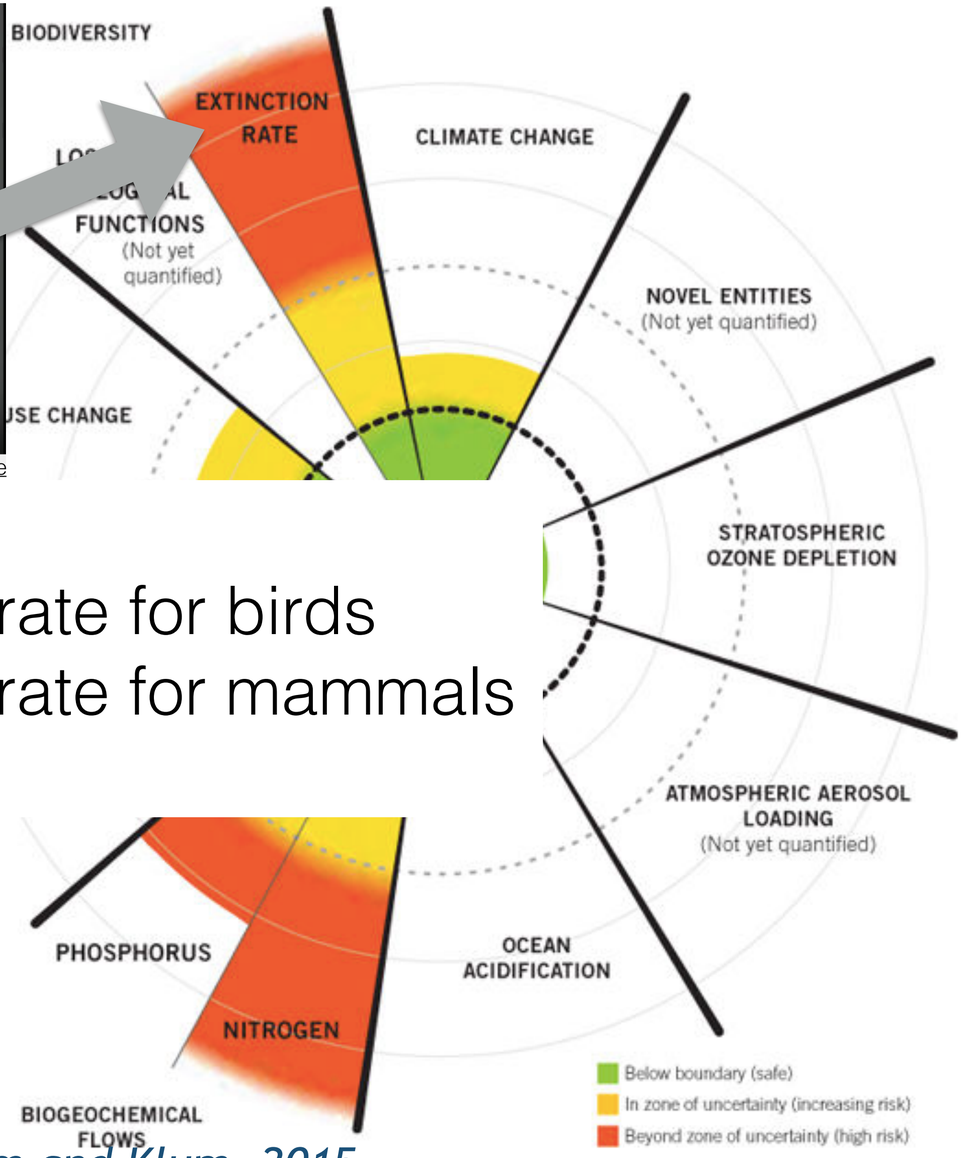
Impacts on the Earth's Life-Support System

https://www.youtube.com/watch?v=gPq9YAg9mfc&feature=youtu.be



Current extinction rates:

300 times background rate for birds

80,000 times background rate for mammals

Rockstrom and Klum, 2015

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Impacts on the Earth's Life-Support System

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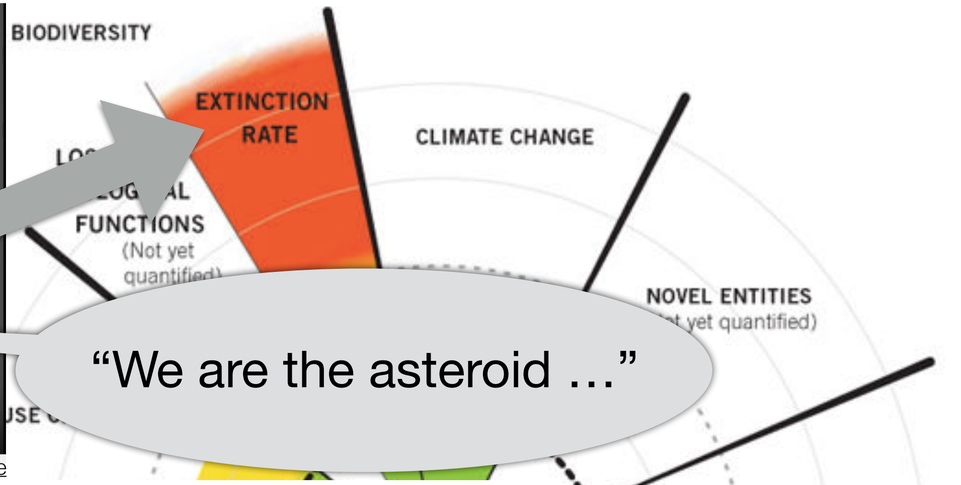

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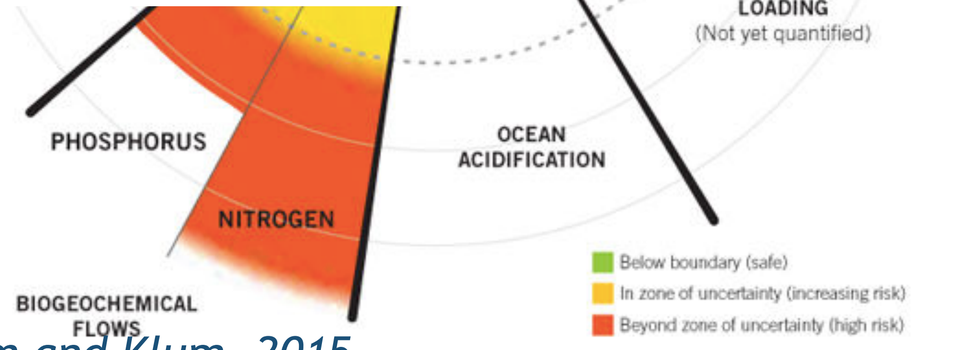

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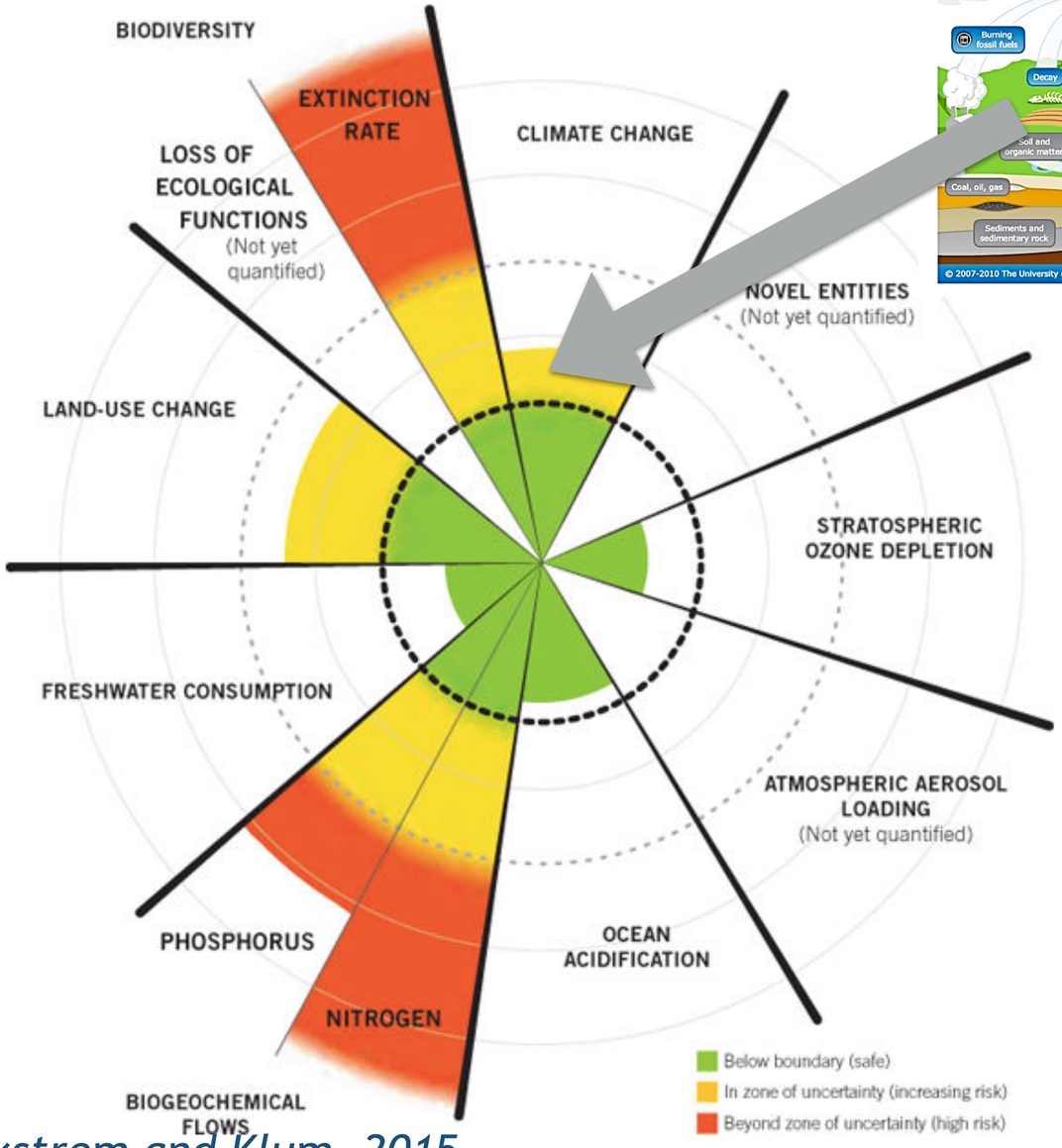

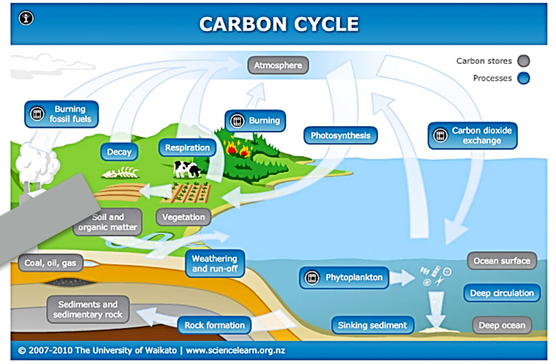

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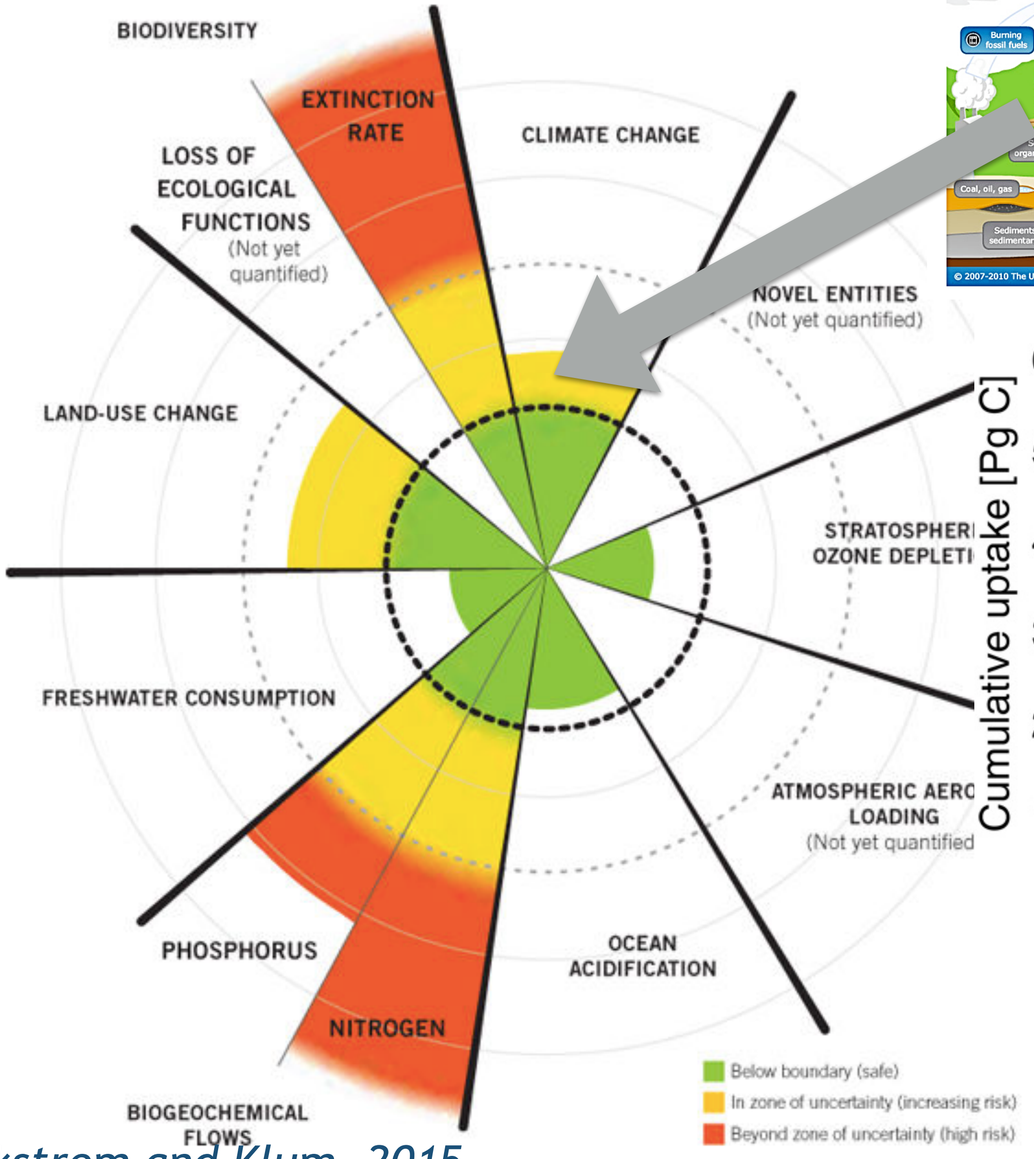
Impacts on the Earth's Life-Support System



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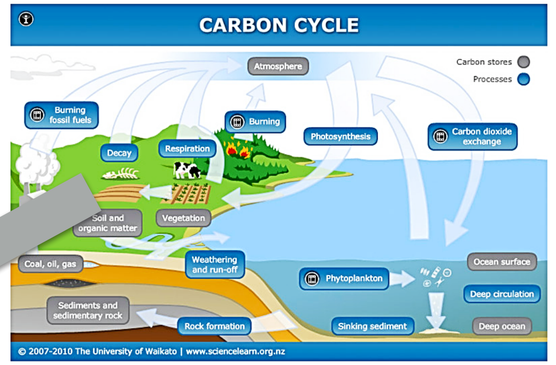

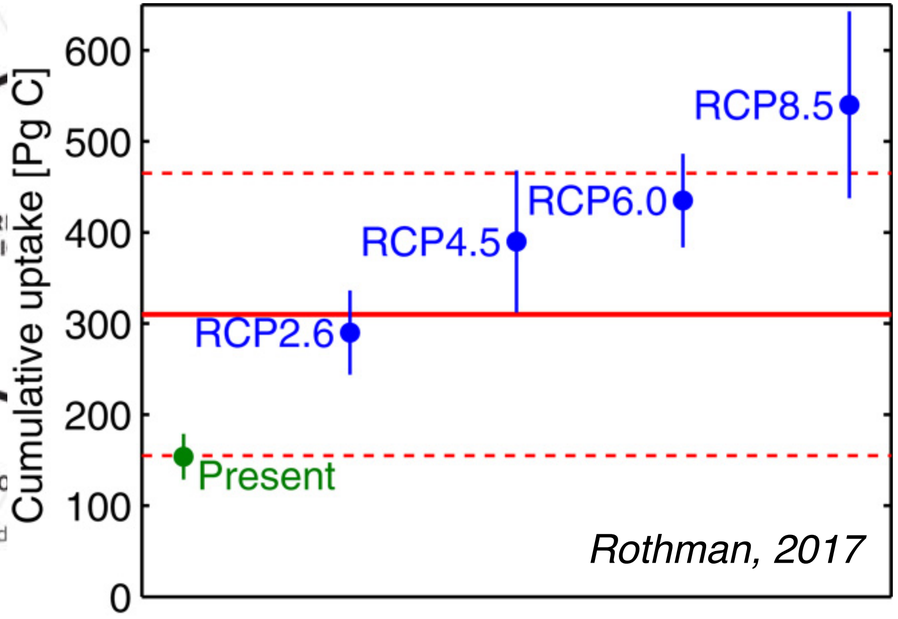

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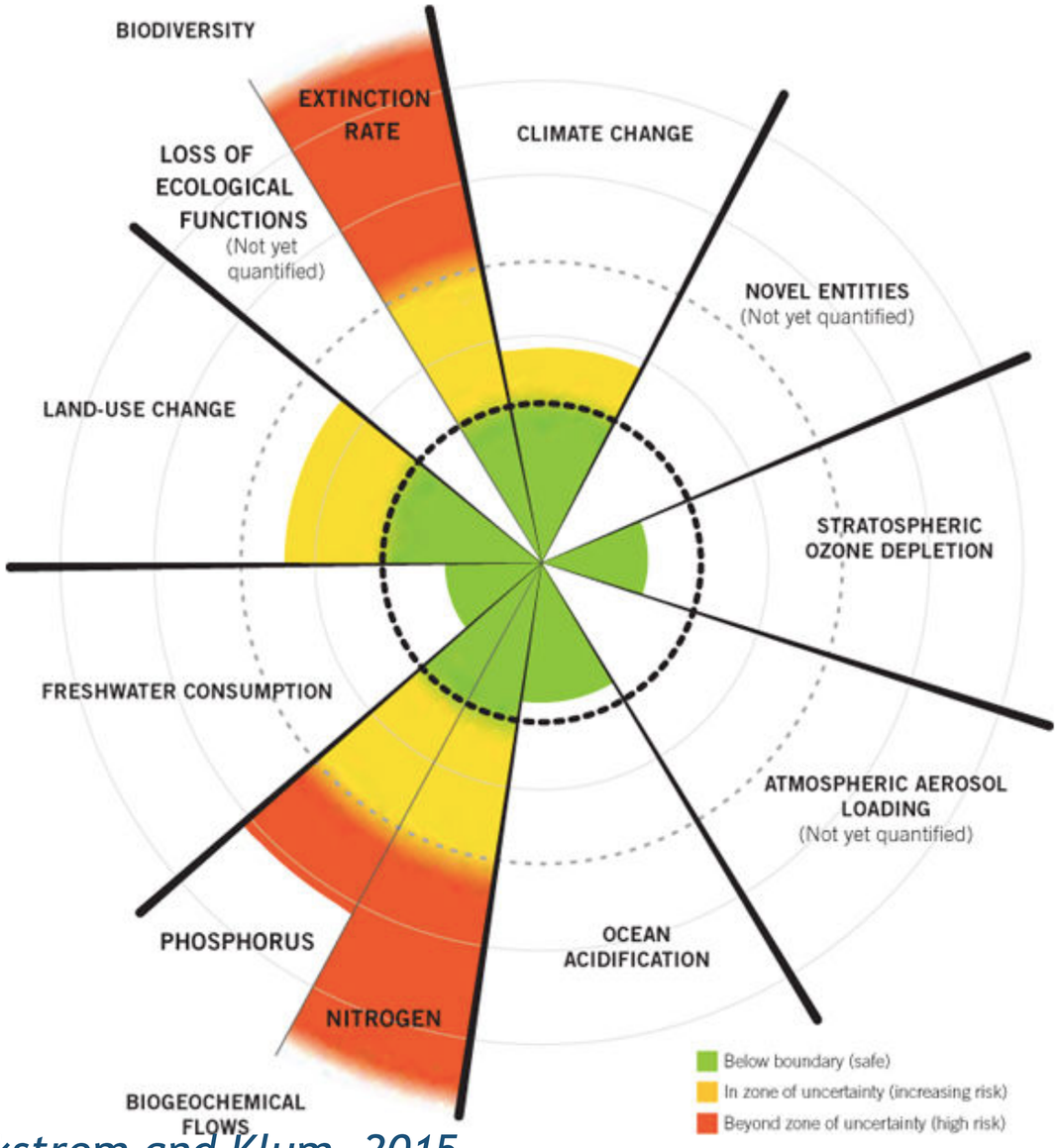
Impacts on the Earth's Life-Support System



Rockstrom and Klum, 2015

Modern climate change is a symptom, not the cause, not the "sickness."

Homo sapiens: An Exceptional Success Story

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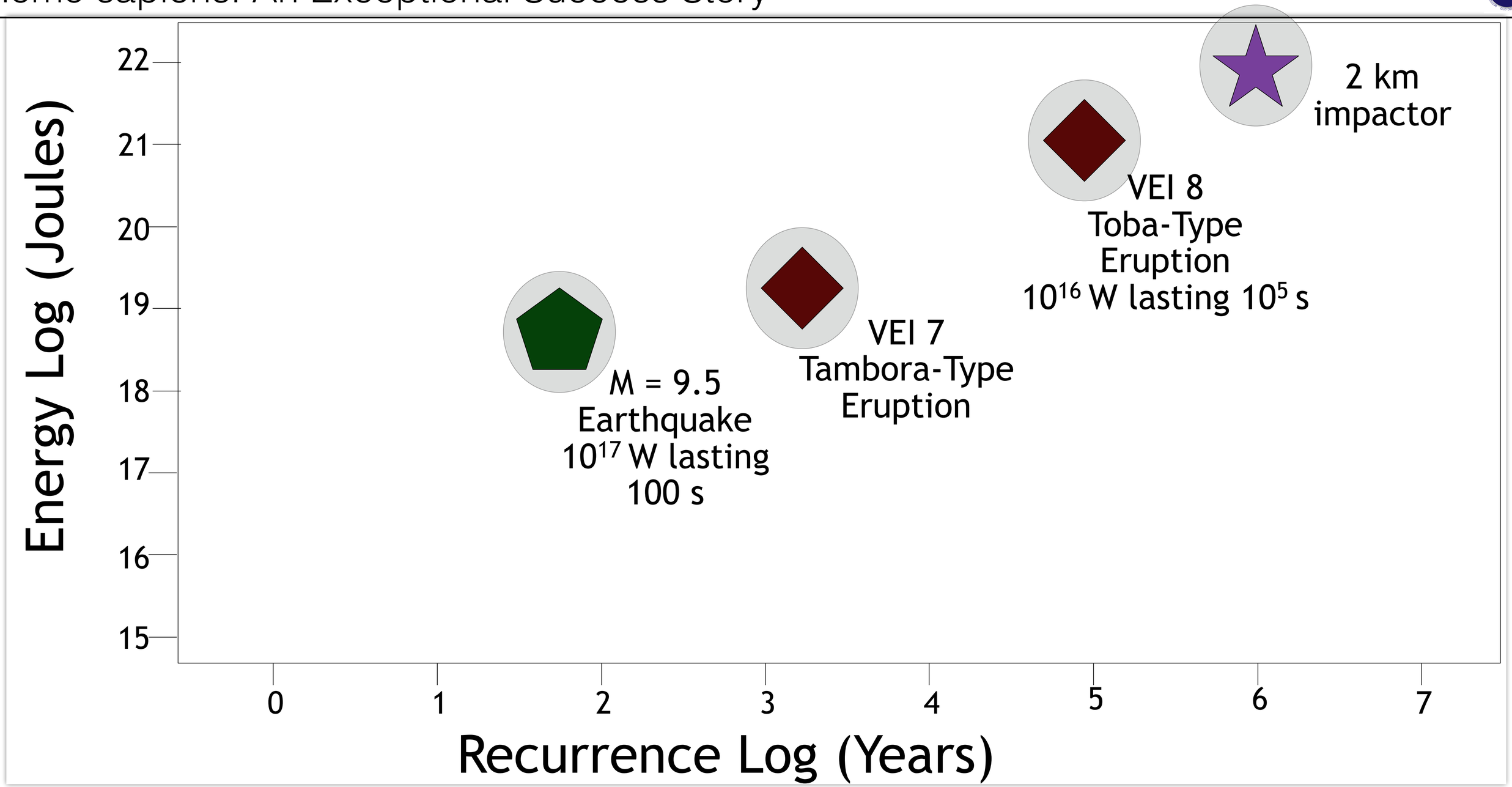

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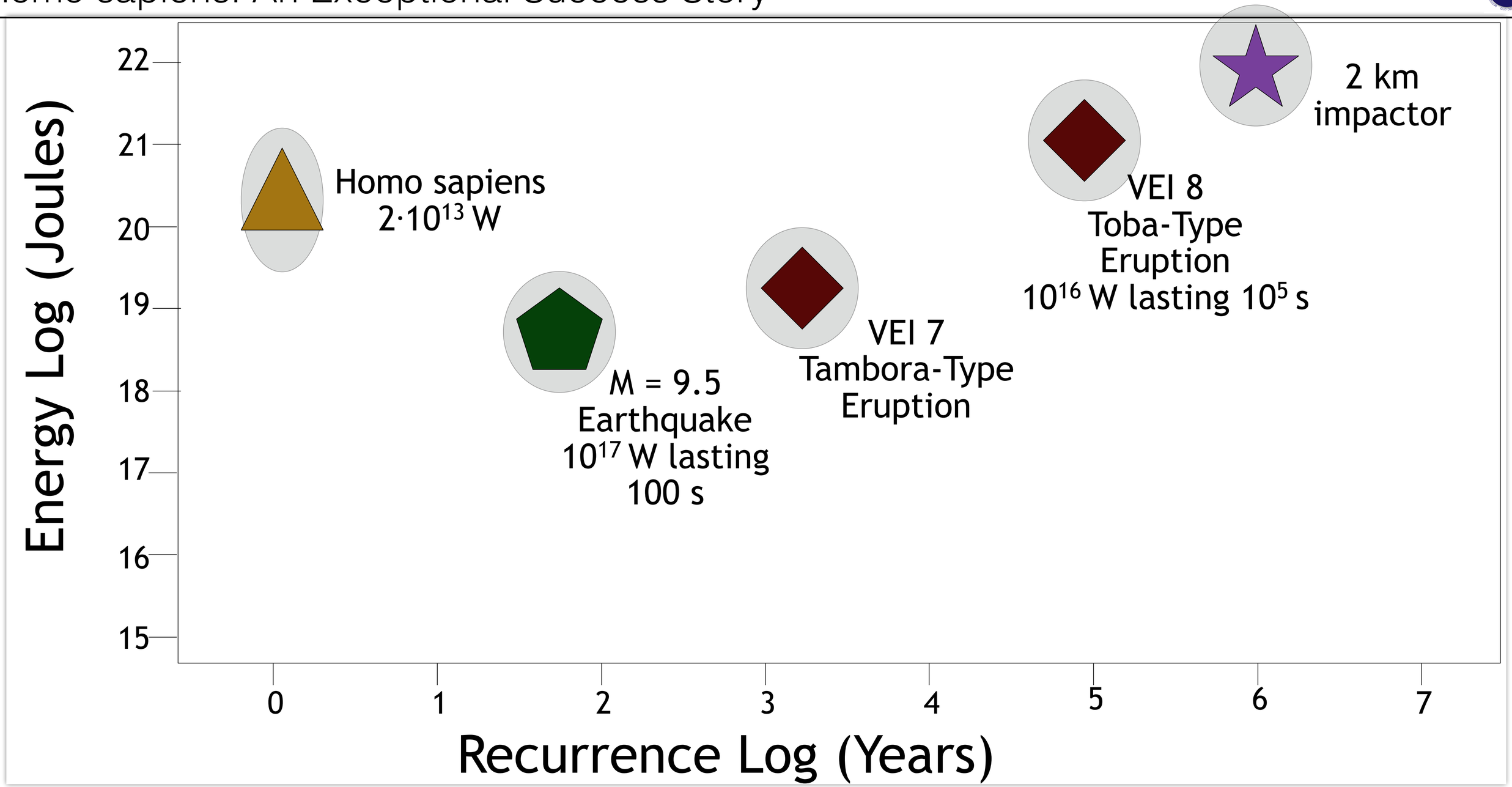

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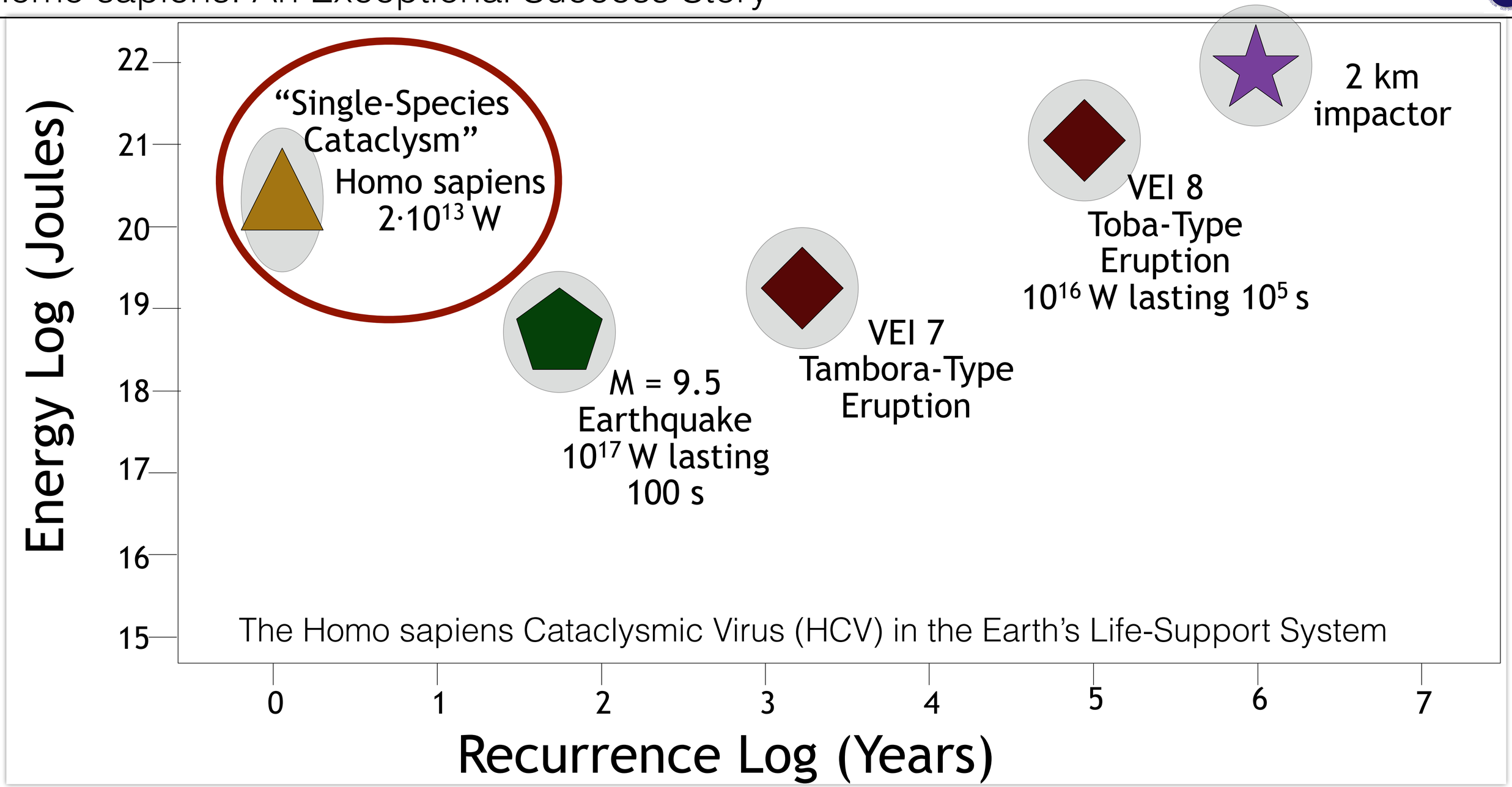
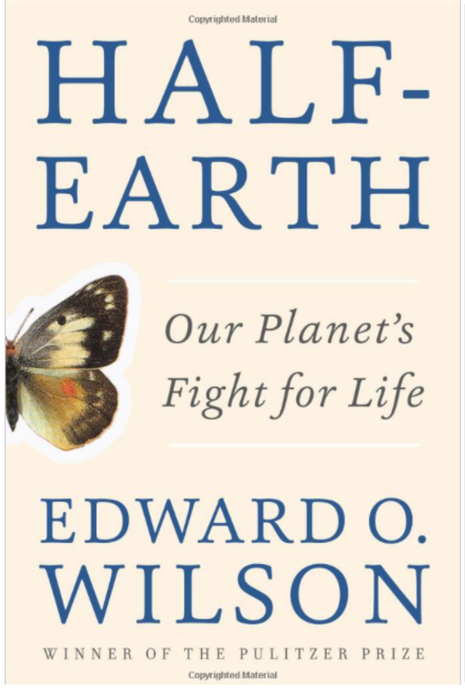


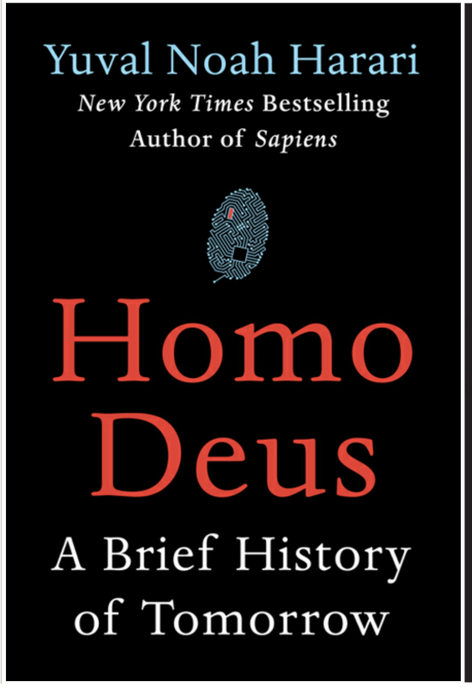

Malignant skin cancer of the planet *Plag, 2010*
Anthropogenic Cataclysmic Virus (ACV) *Plag, 2015*

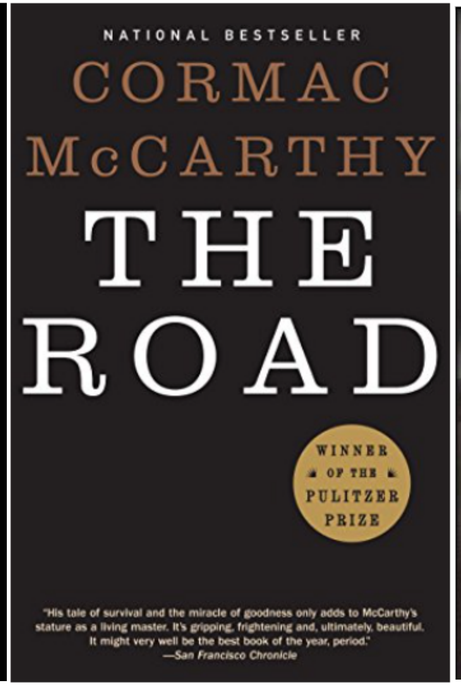

Malignant skin cancer of the planet *Plag, 2010*
Anthropogenic Cataclysmic Virus (ACV) *Plag, 2015*
Can the "virus" transform itself into the "healer"?

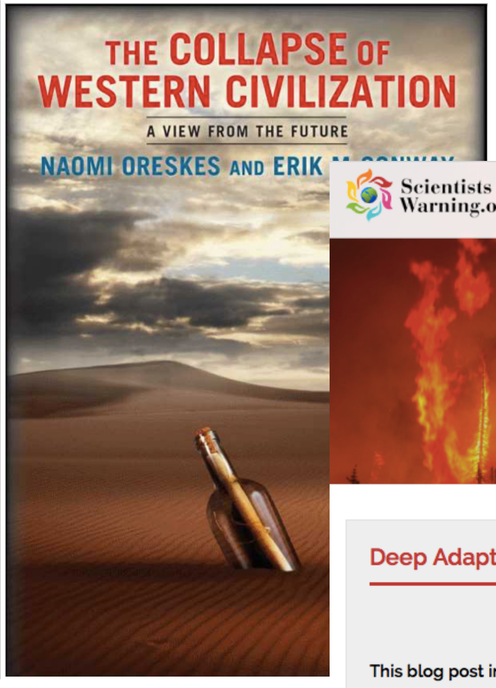
Homo sapiens and Earth

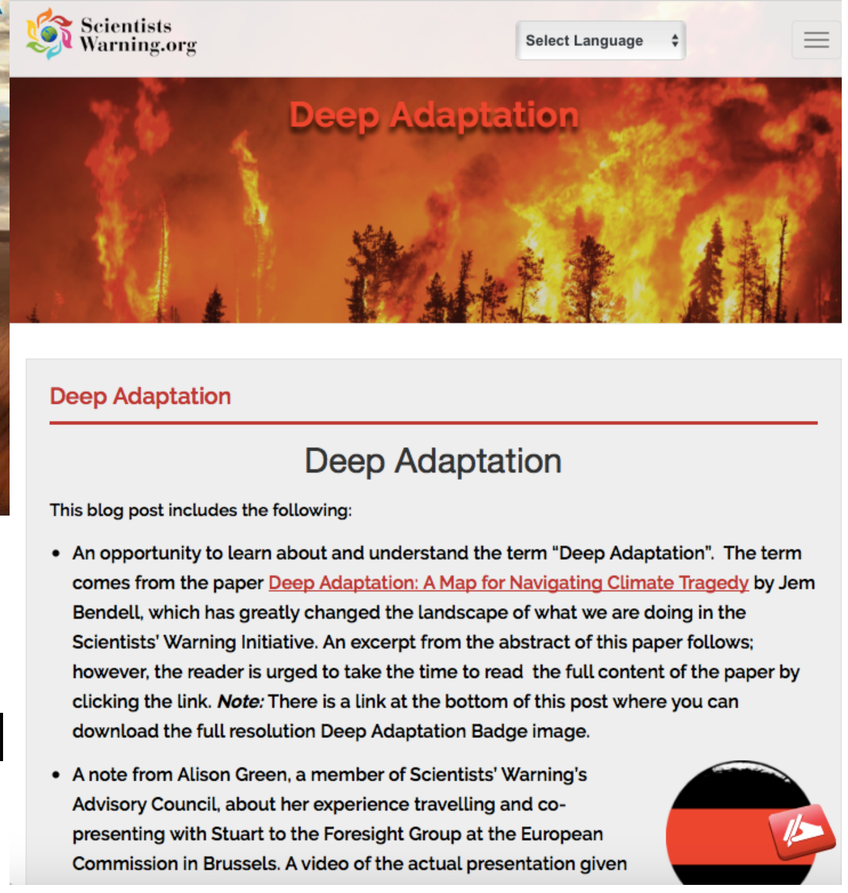
Spectrum of Possible Futures









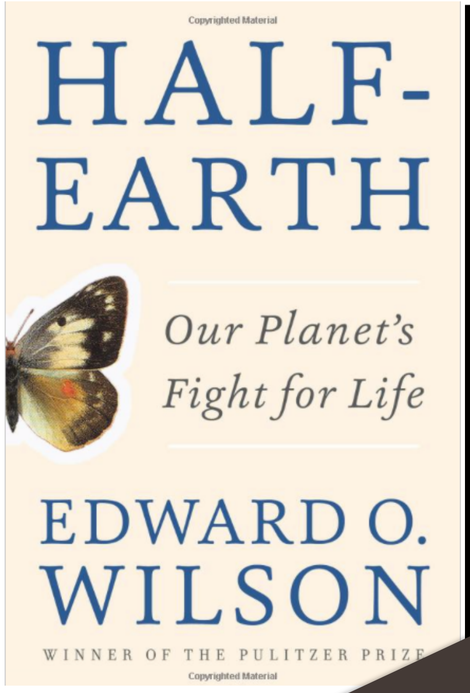


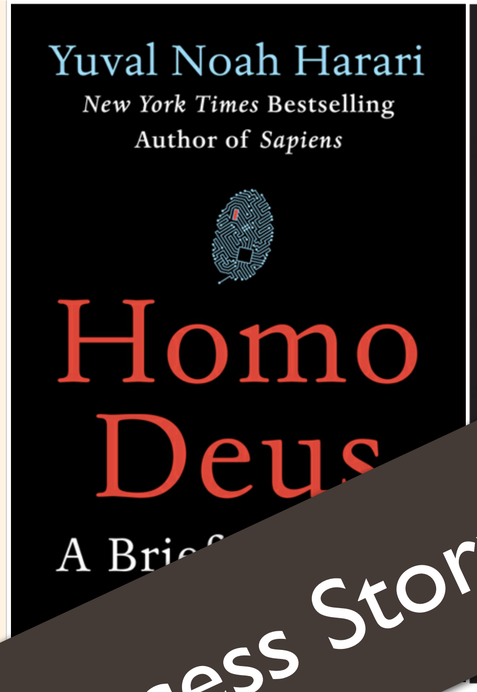
Science-based warnings to humanity

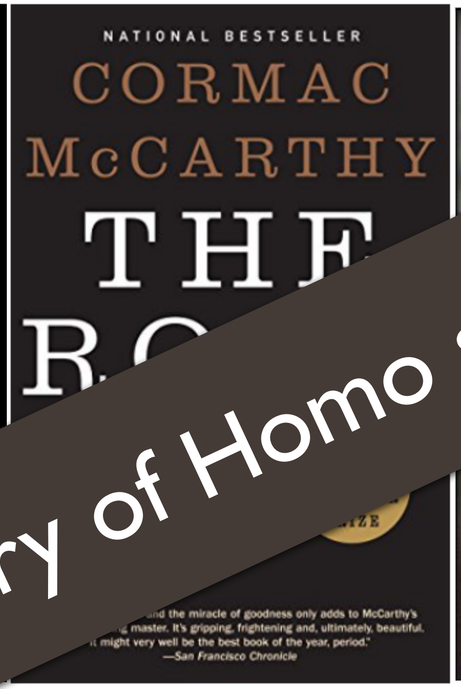
Deep Adaptation: Preparing for the time after the total social collapse - Who do we want to be then?

Homo sapiens and Earth

Spectrum of Possible Futures



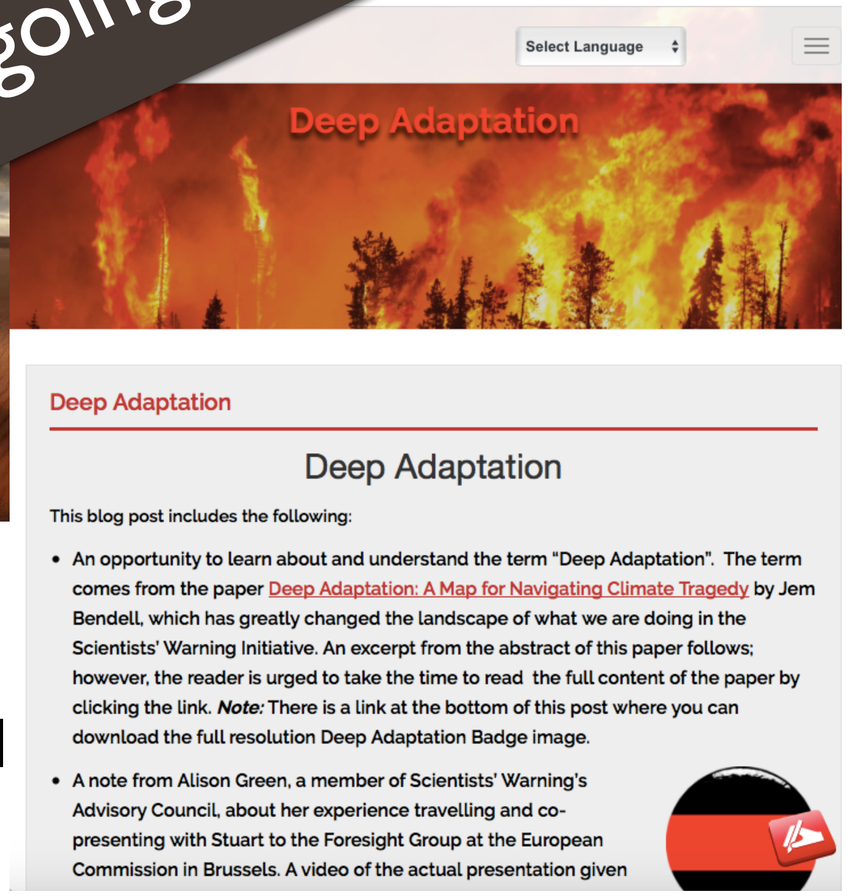




Is the Success Story of Homo sapiens going to continue?

Sci… …lings to humanity

…ptation: Preparing for the time after the total …l collapse - Who do we want to be then?



Based on Feedback: The Earth's Life-Support System and sustainability

Planetary Physiology

Flows in the Earth System also allow assessing the "Health of the Planet"

Earth: Life-Support System for many species

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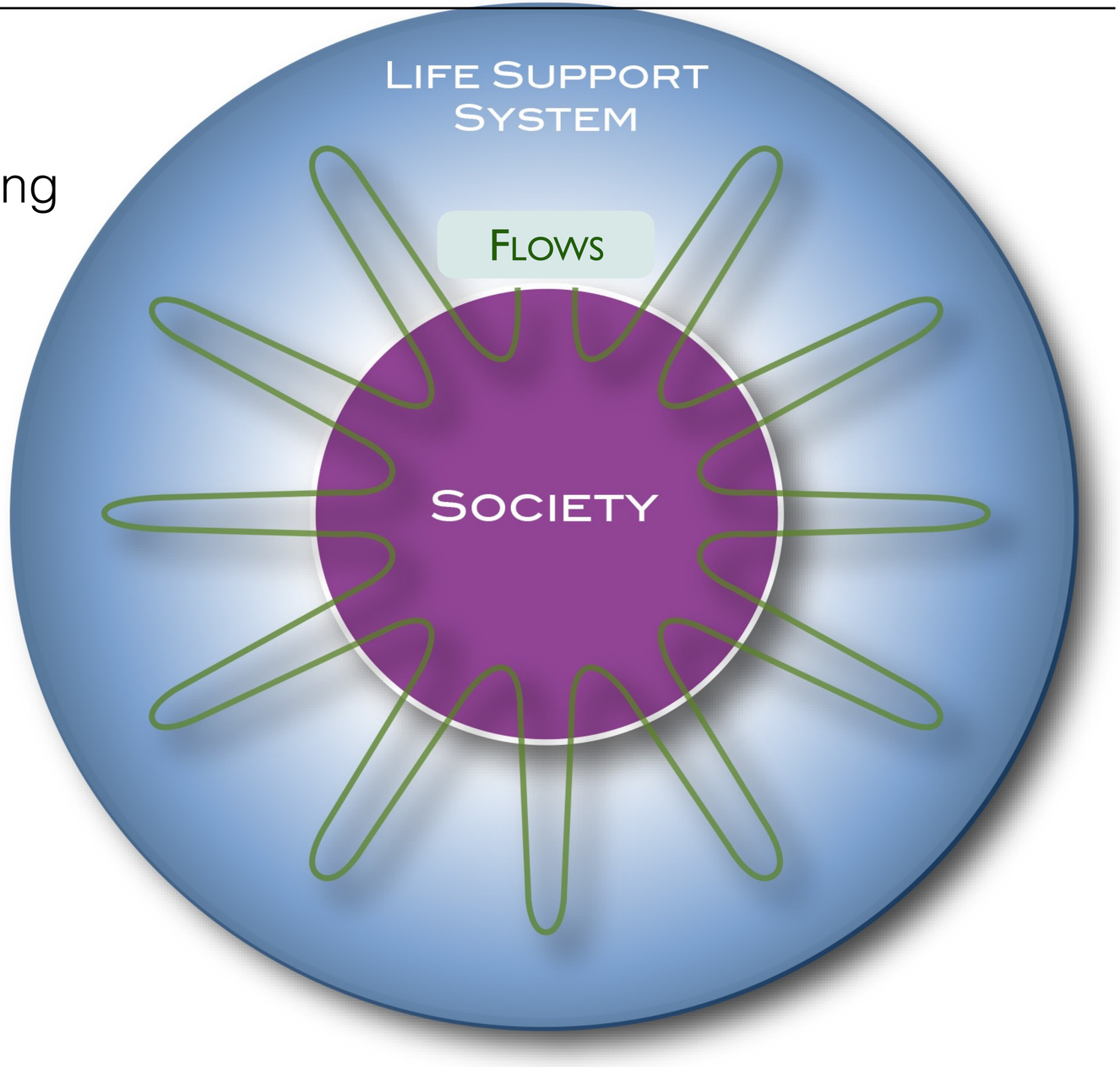

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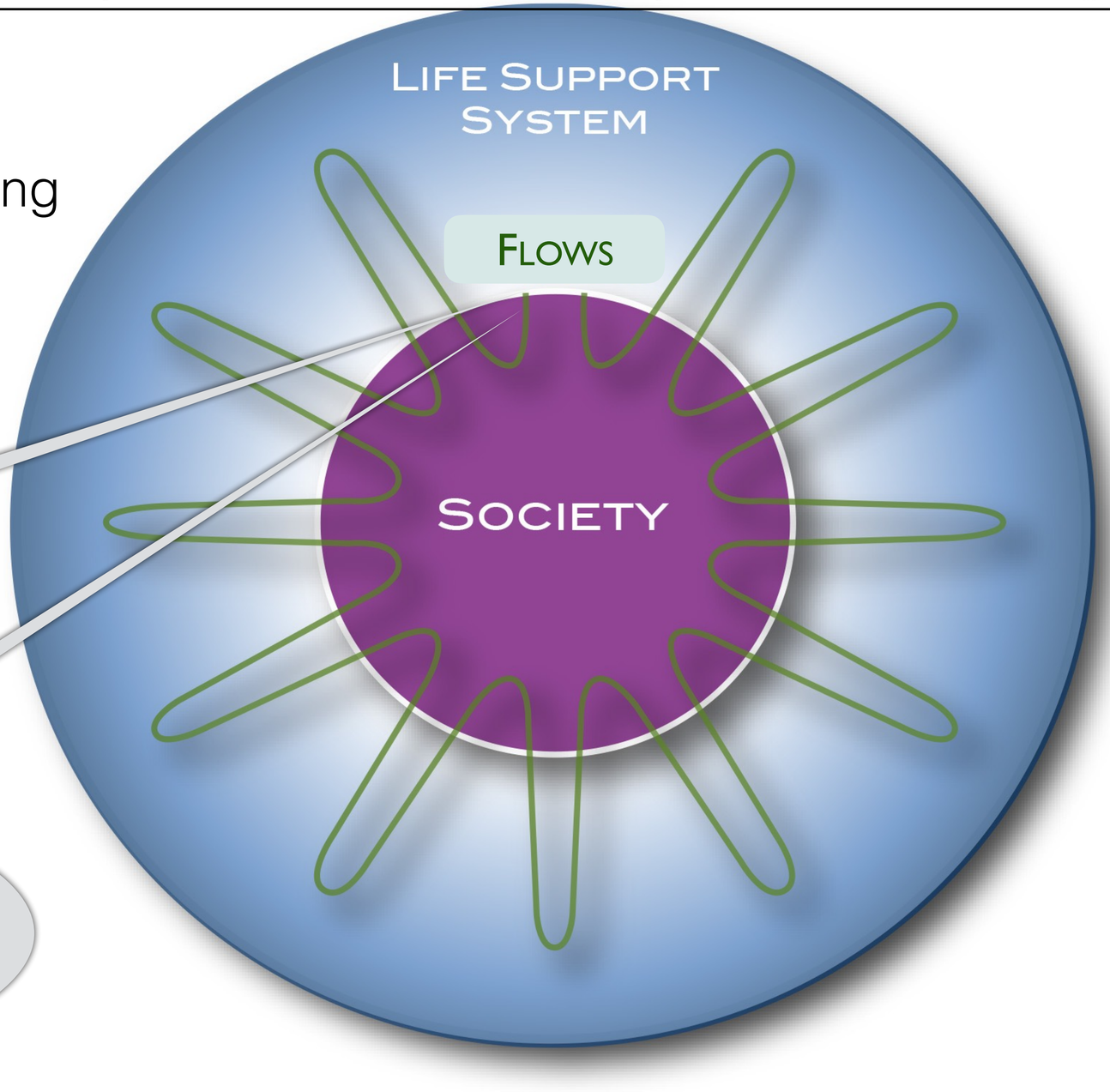
Limitations in the flows between a community and its life-support system limit the growth of the community

For Homo sapiens, the flows are regulated by ethical, social, and - recently - economic rules



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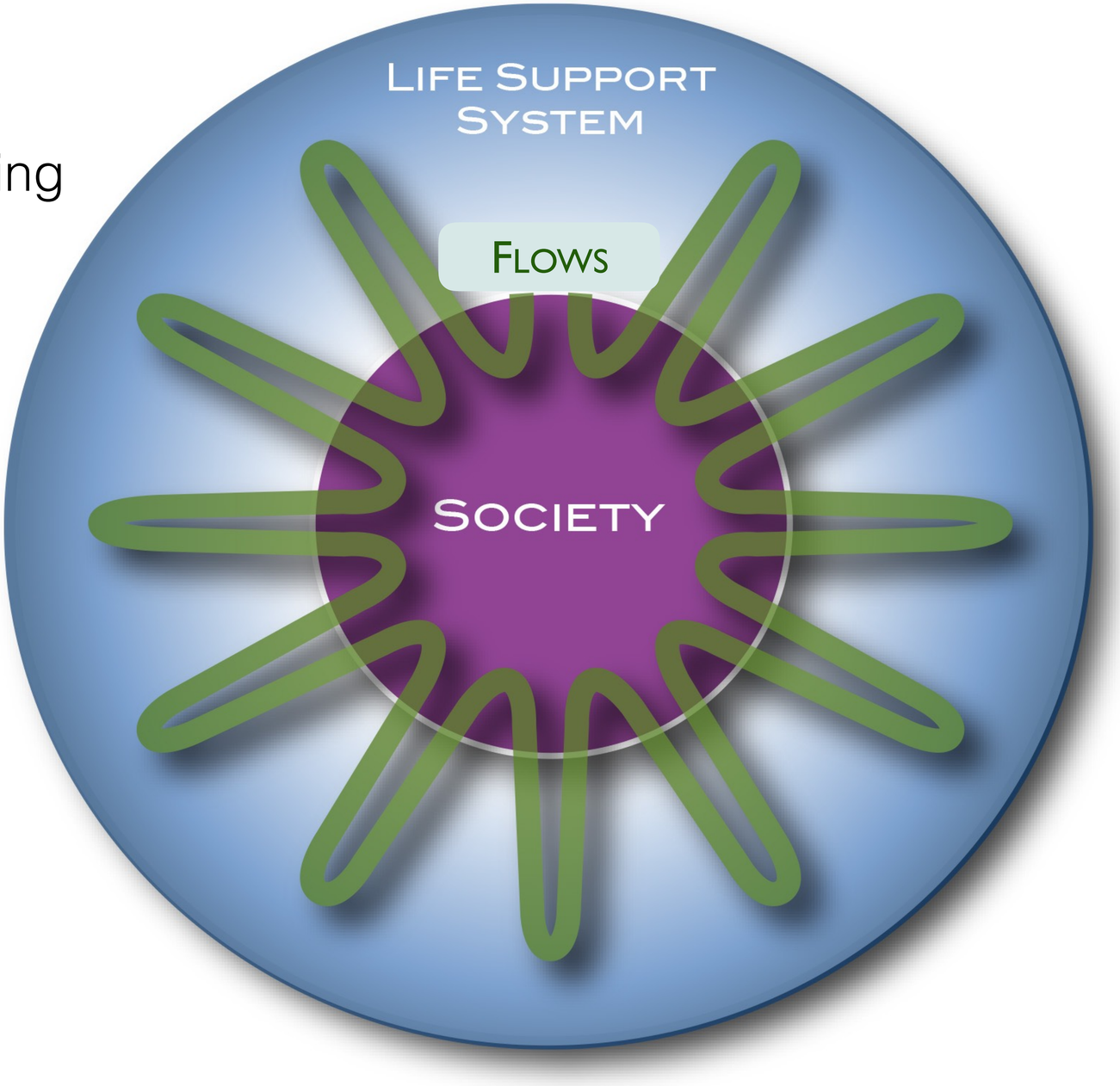

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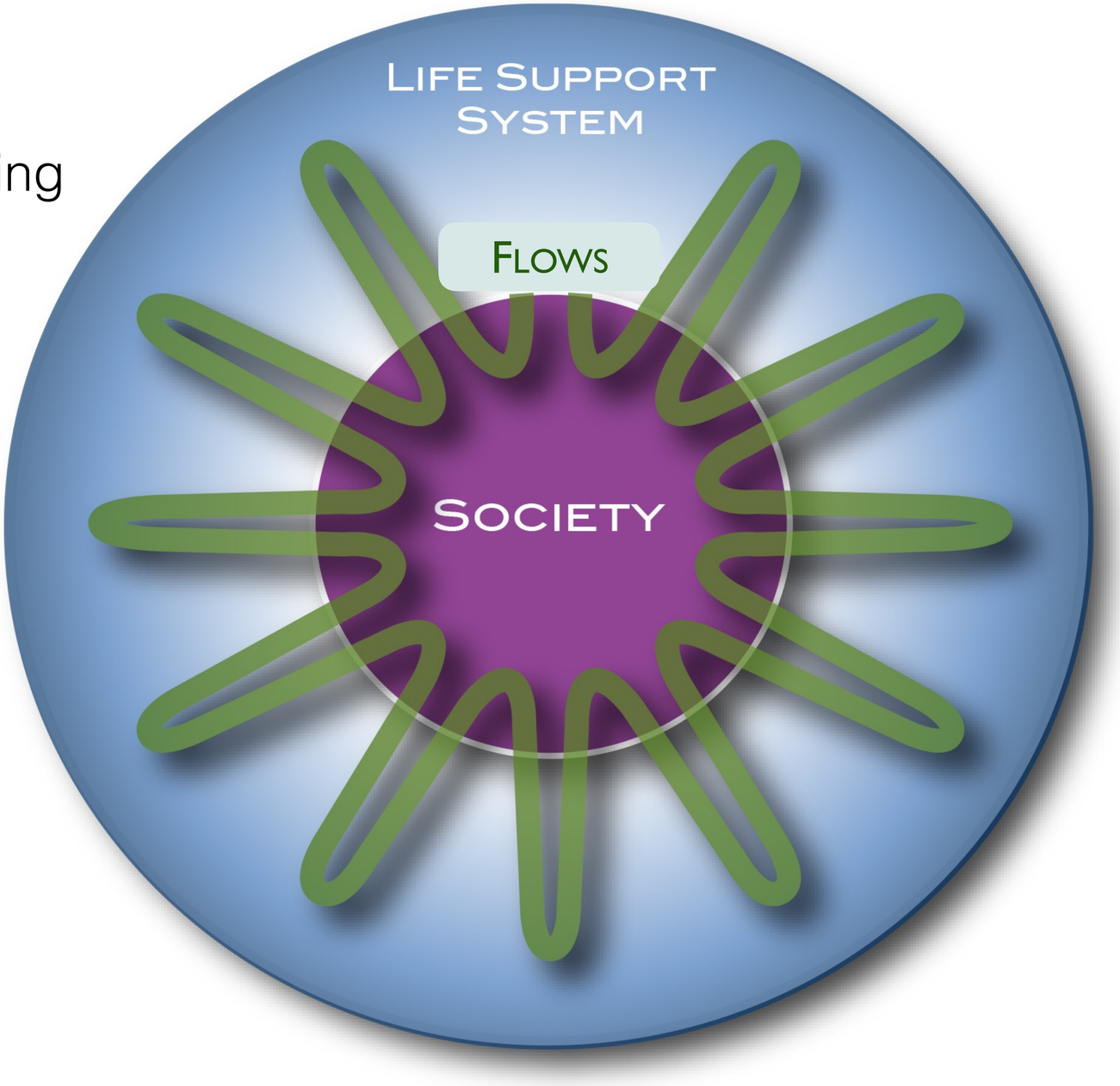

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Understanding Modern Global Change is all about Flows

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MINUTE TIMER
BARCLAY GENEVE

Based on Feedba

400 million tons (Mt)

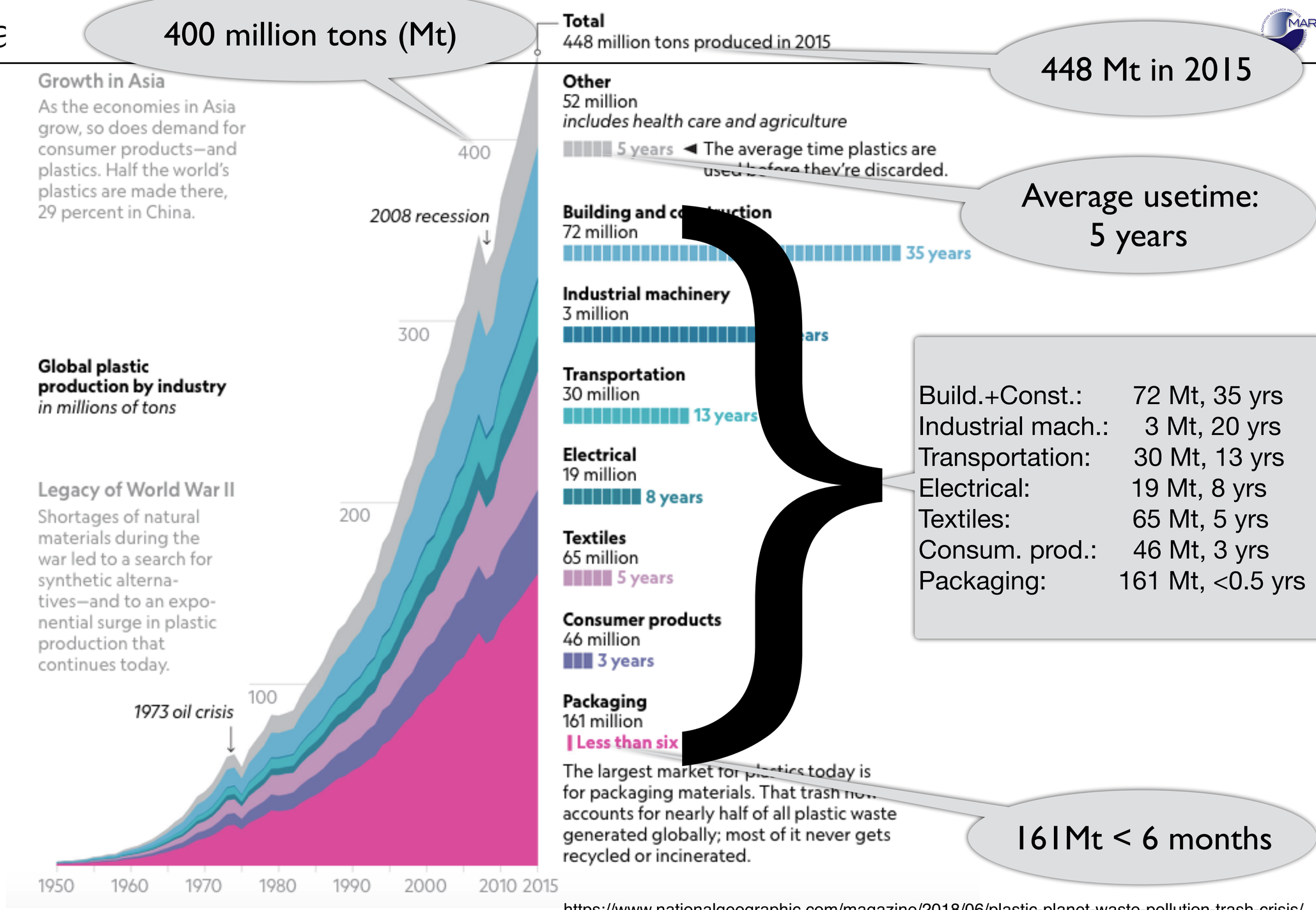
448 Mt in 2015

Average usetime:
5 years

161Mt < 6 months

A LIFETIME OF PLASTIC

The first plastics made from fossil fuels are just over a century old. They came into widespread use after World War II and are found today in everything from cars to medical devices to food packaging. Their useful lifetime varies. Once disposed of, they break down into smaller fragments that linger for centuries.



Build.+Const.:	72 Mt, 35 yrs
Industrial mach.:	3 Mt, 20 yrs
Transportation:	30 Mt, 13 yrs
Electrical:	19 Mt, 8 yrs
Textiles:	65 Mt, 5 yrs
Consum. prod.:	46 Mt, 3 yrs
Packaging:	161 Mt, <0.5 yrs

JASON TREAT AND RYAN WILLIAMS, NGM STAFF
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

https://www.nationalgeographic.com/magazine/2018/06/plastic-planet-waste-pollution-trash-crisis/

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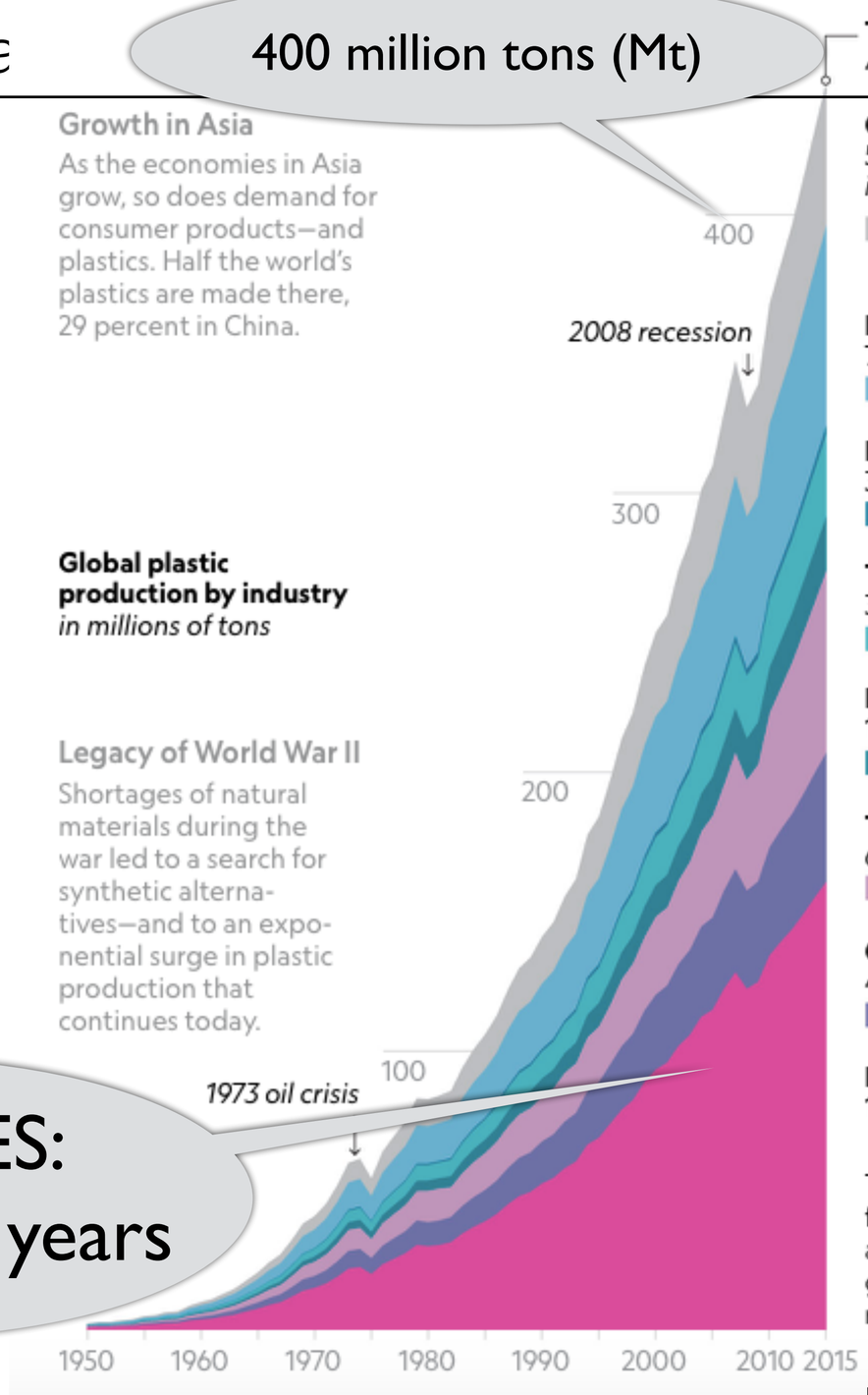

Total
448 million tons produced in 2015

Other
52 million
includes health care and agriculture
5 years ◄ The average time plastics are used before they're discarded.

Average usetime: 5 years

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35 years

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The largest market for plastics today is for packaging materials. That trash now accounts for nearly half of all plastic waste generated globally; most of it never gets recycled or incinerated.

161Mt < 6 months

LIFETIMES: 100 to 5000 years

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MINUTE TIMER
BARCLAY GENEVE

An Island Crusader Takes On The Big Brands Behind Plastic Waste

January 15, 2019 · 5:02 AM ET
Heard on Morning Edition

CHRISTOPHER JOYCE

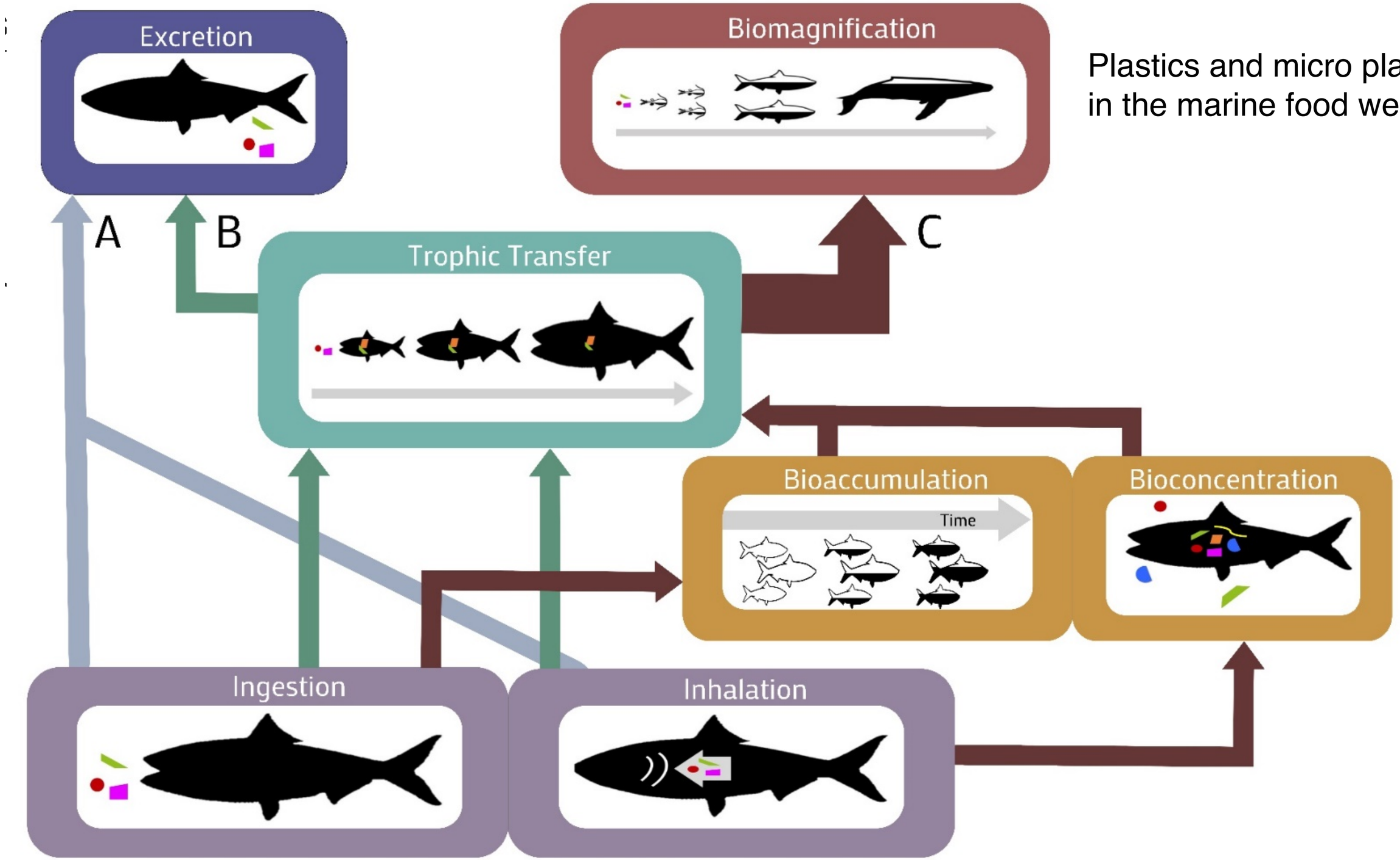
▶ LISTEN · 6:12 + QUEUE

Plastic waste washes in from Manila Bay and the ocean, covering the beach and mangrove trees of Freedom Island, a protected area in the bay.
Jes Aznar for NPR

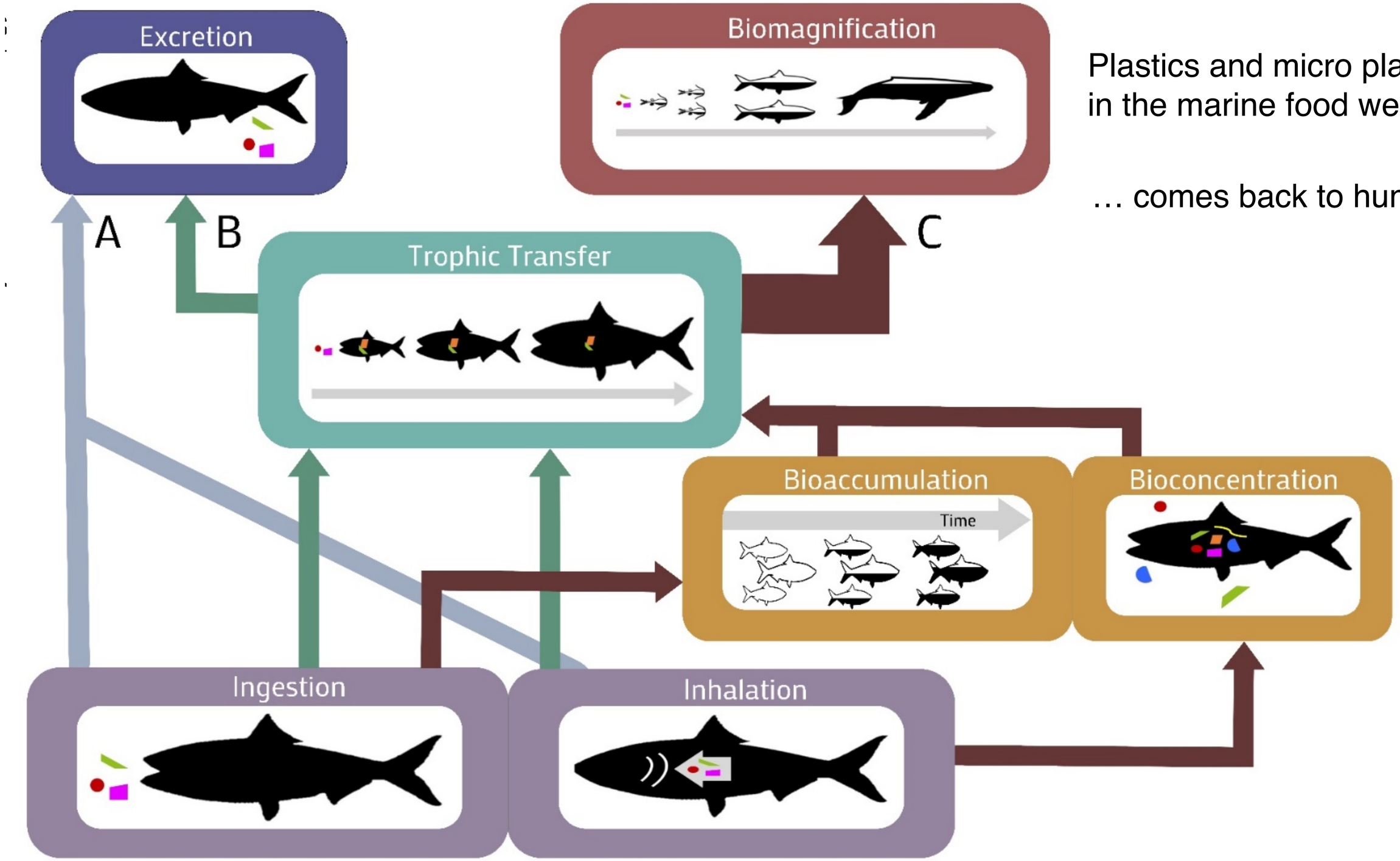
Dead whale found with 115 plastic cups, 2 flip-flops in its stomach

Detritus also included more than 1,000 other plastic pieces, including plastic bags, bottles

The Associated Press · Posted: Nov 20, 2018 9:03 AM ET | Last Updated: November 20



Plastics and micro plastics in the marine food web …



Plastics and micro plastics in the marine food web …

… comes back to humans

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Understanding Modern Global Change is all about Flows

Flows have accelerated in the last 200 years

Many new flows have been created

Many flows have been changed or interupted

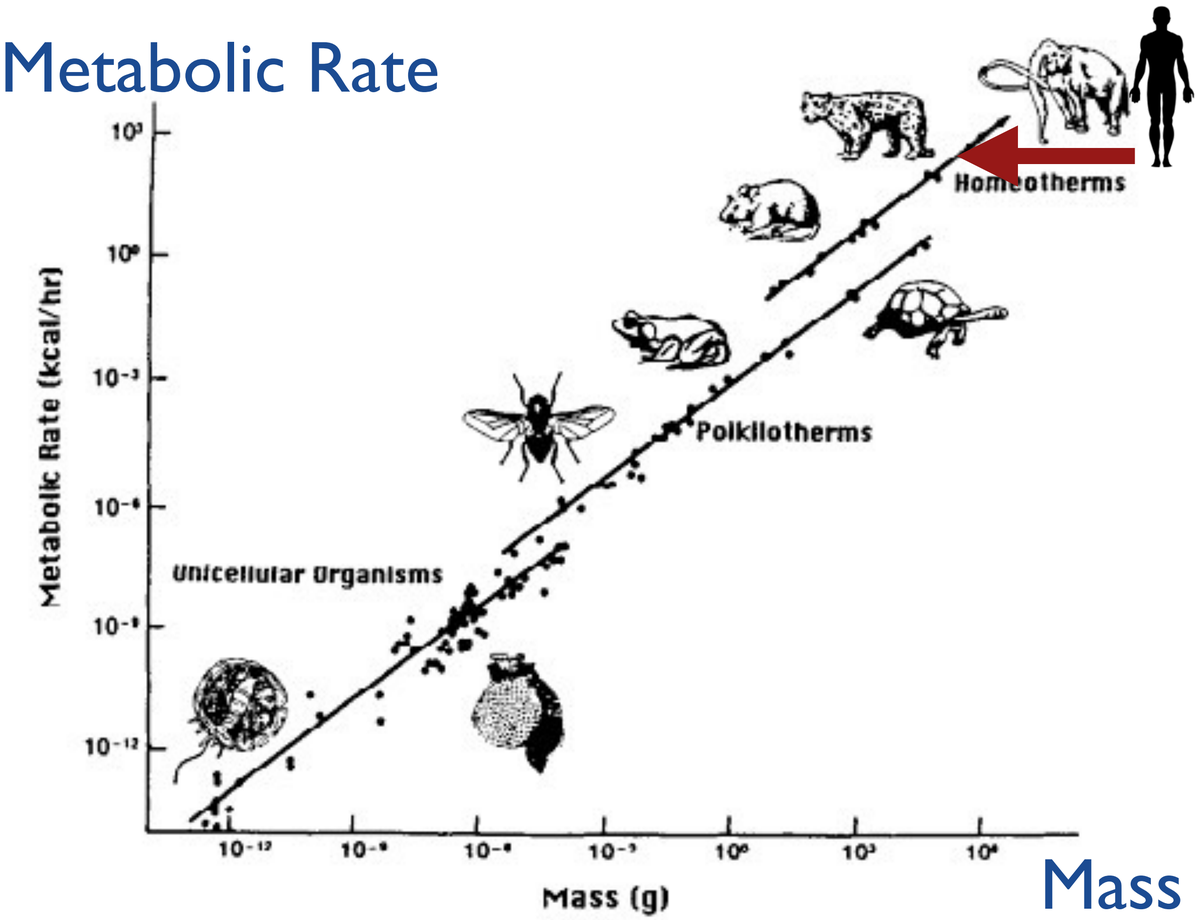
Based on Feedback: Homo sapiens: An Exceptional Success Story

Out of Scale

Scaling law for metabolic rate:
$Y = Y_0 * M^{(3/4)}$

human: Y = 50 -100 Watt

Metabolic Rate



Mass

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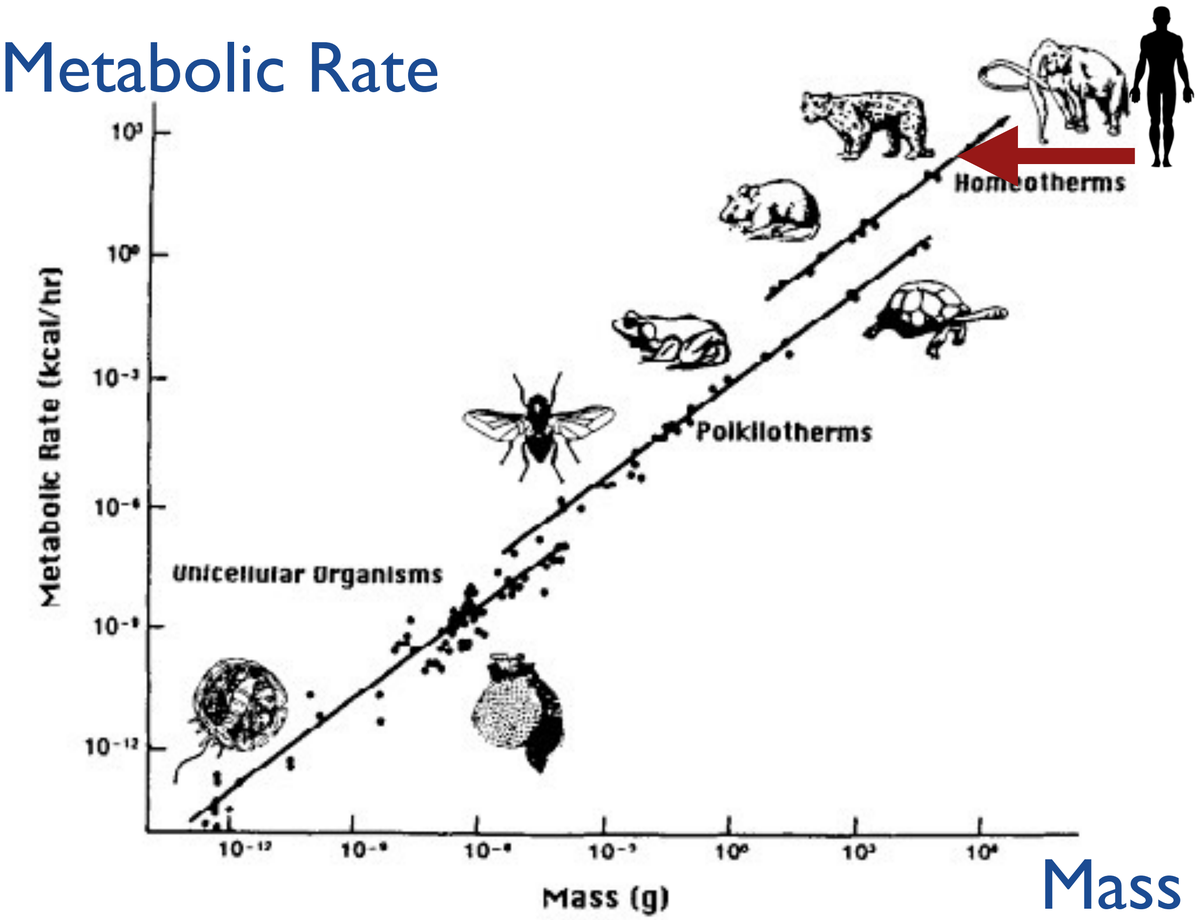

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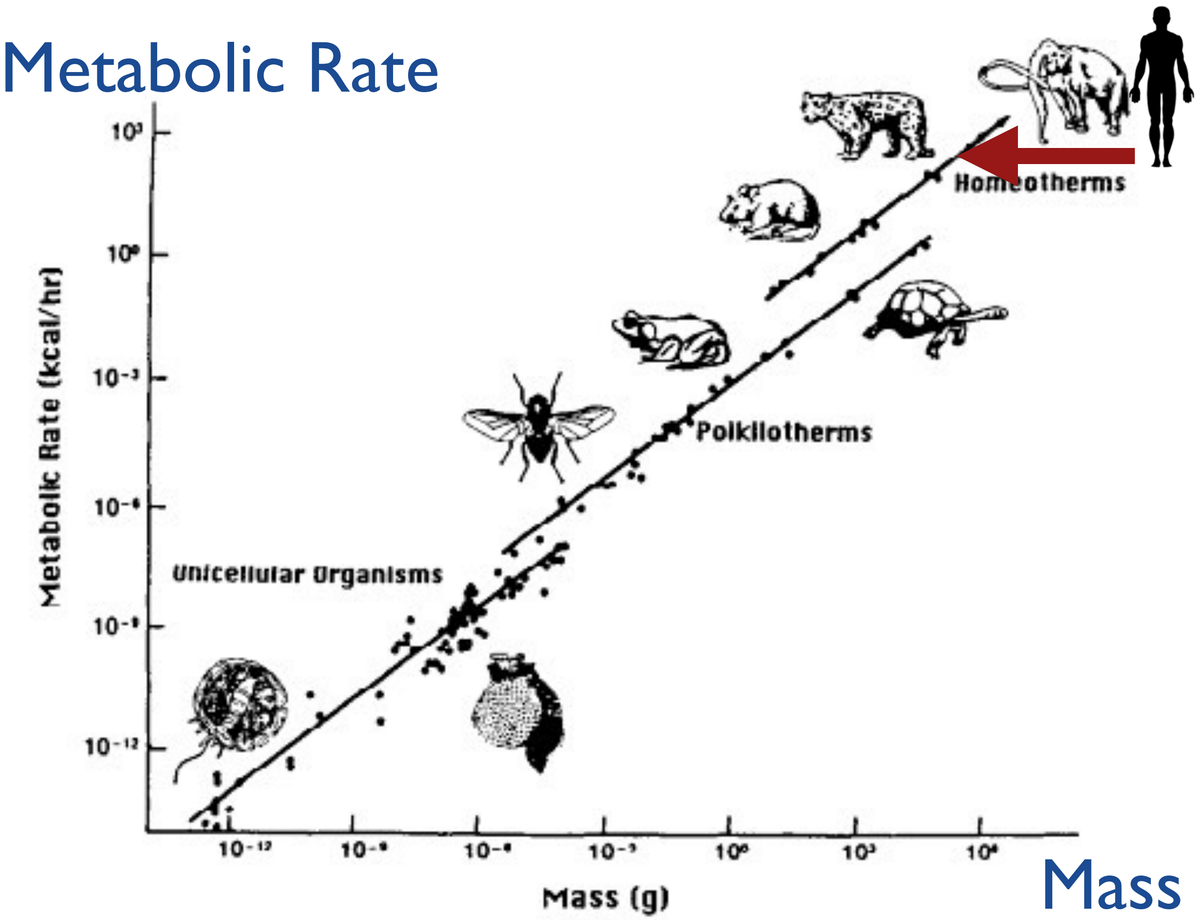

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M =	2 kg	-> Y =	5 Watt
M =	80 kg	-> Y =	80 Watt
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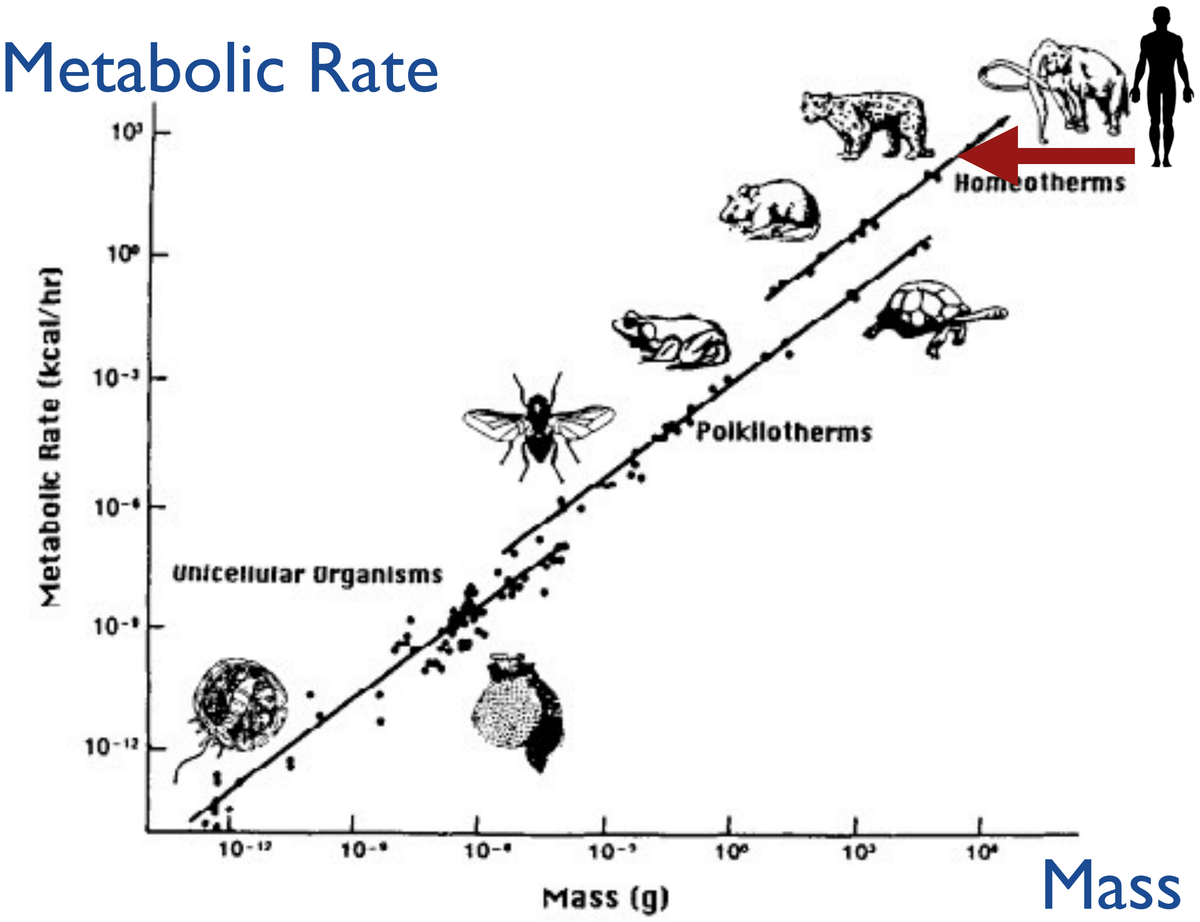

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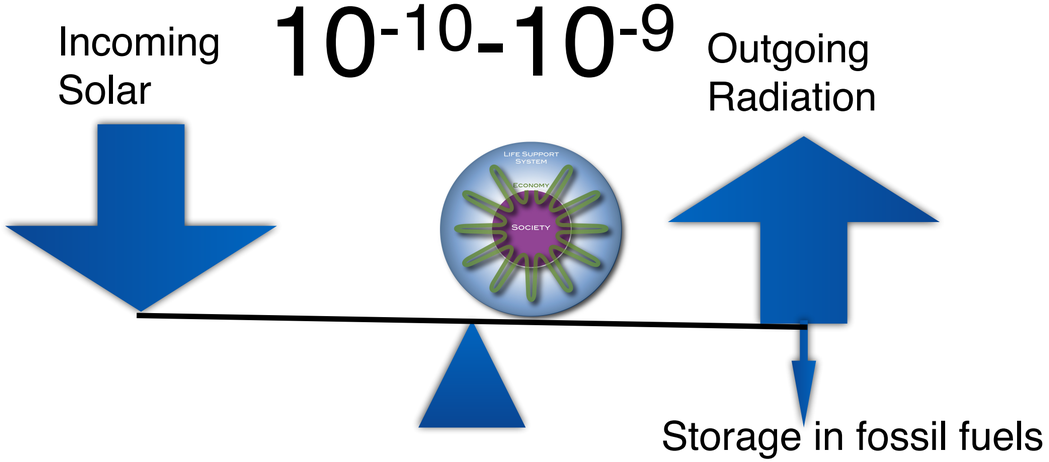
Extended metabolic rate:
$Y_E = Y + C_E$
(C_E: total energy consumption)

Energy consumption per capita:
Global Average: Y_E = 2,835 Watt
M ~ 10 metric tons

Based on Feedback: The Earth's Life-Support System and sustainability

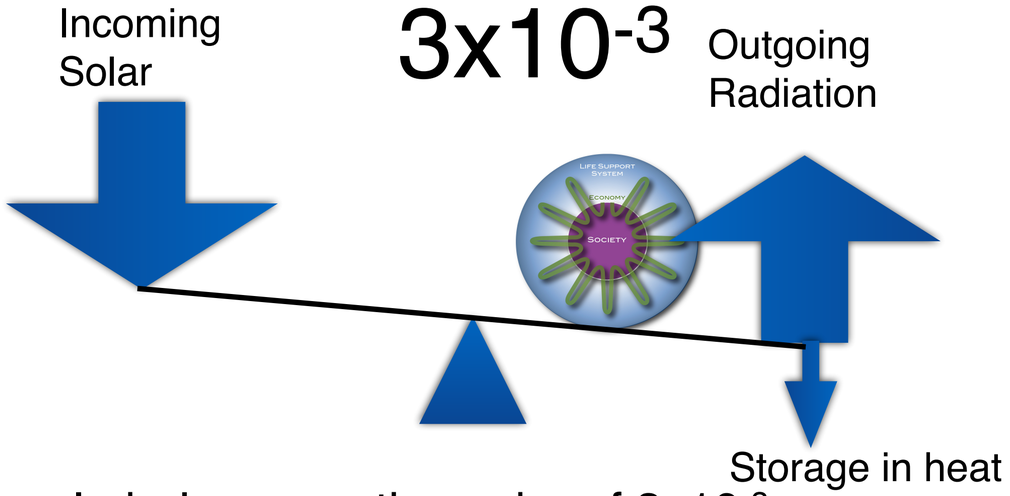
Earth's Energy Imbalance



Imbalance on the order of 10^{-10}-10^{-9}

Last 200 Million years

Total energy storage in 200 Myrs:
Order 100-1000 ZetaJoules



Imbalance on the order of $3x10^{-3}$

Last 70 years

Total energy storage per century:
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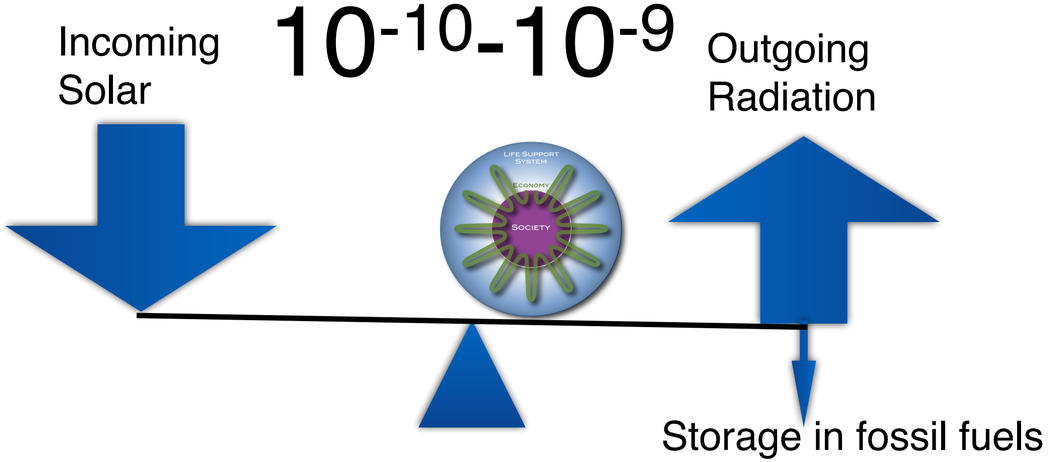

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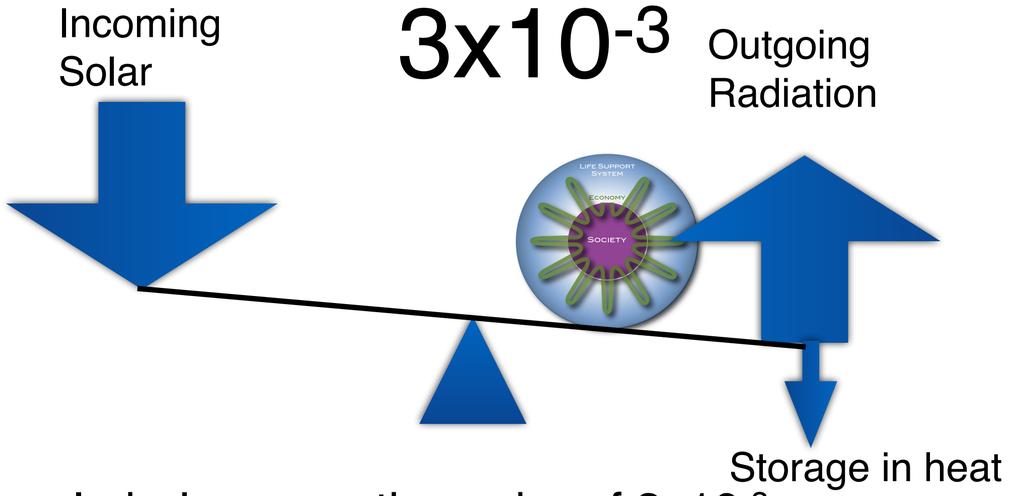

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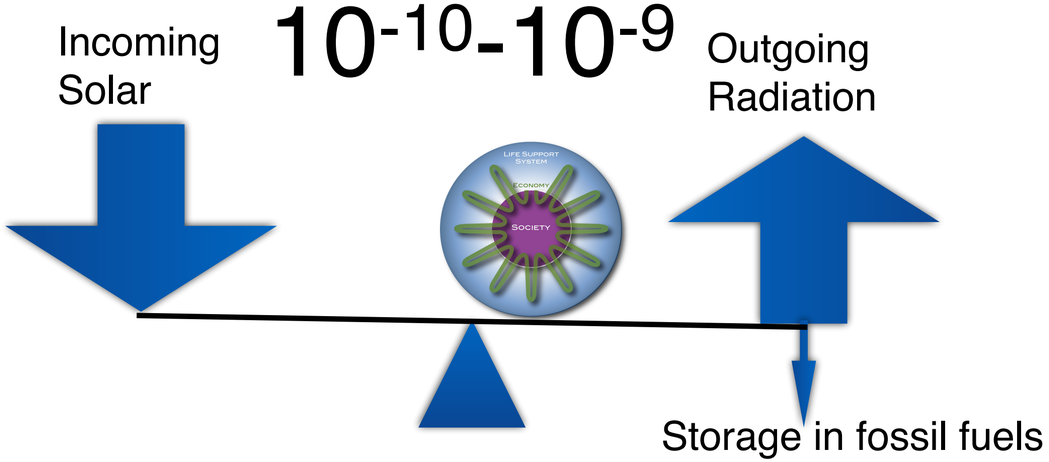

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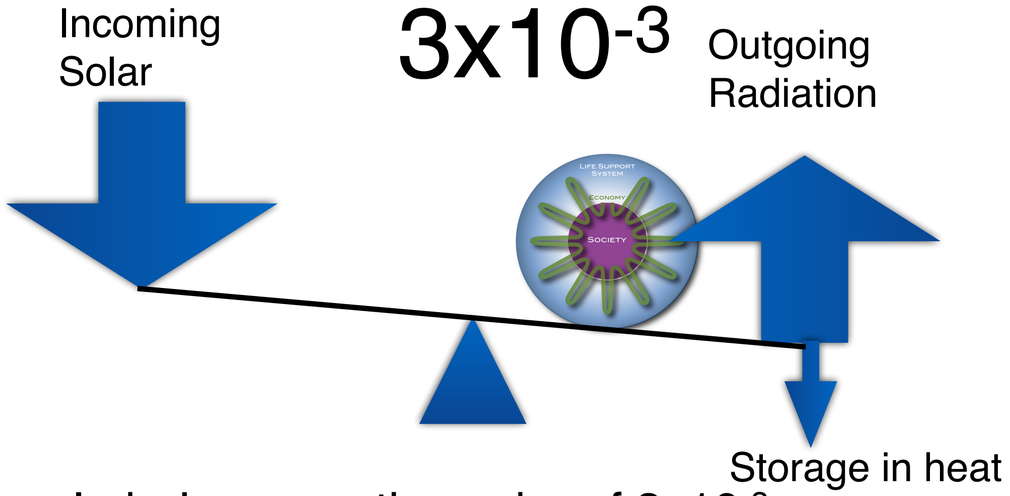

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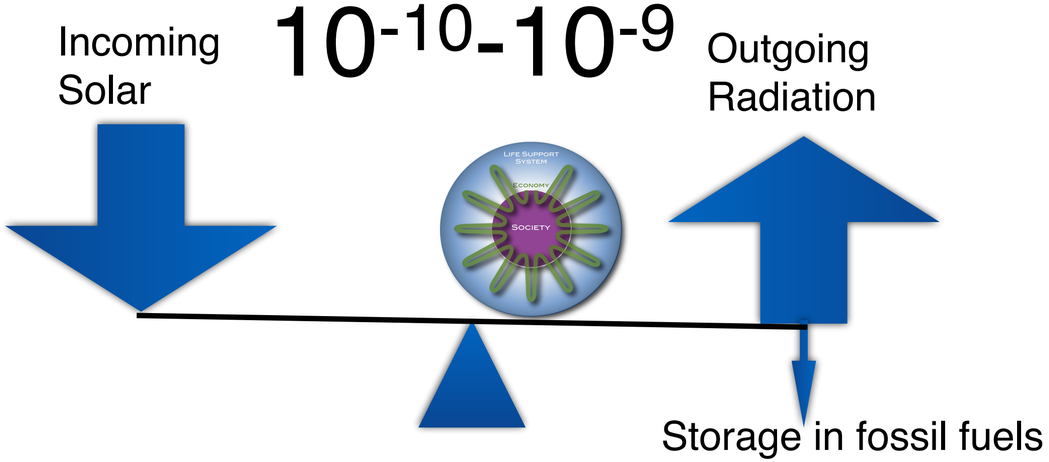

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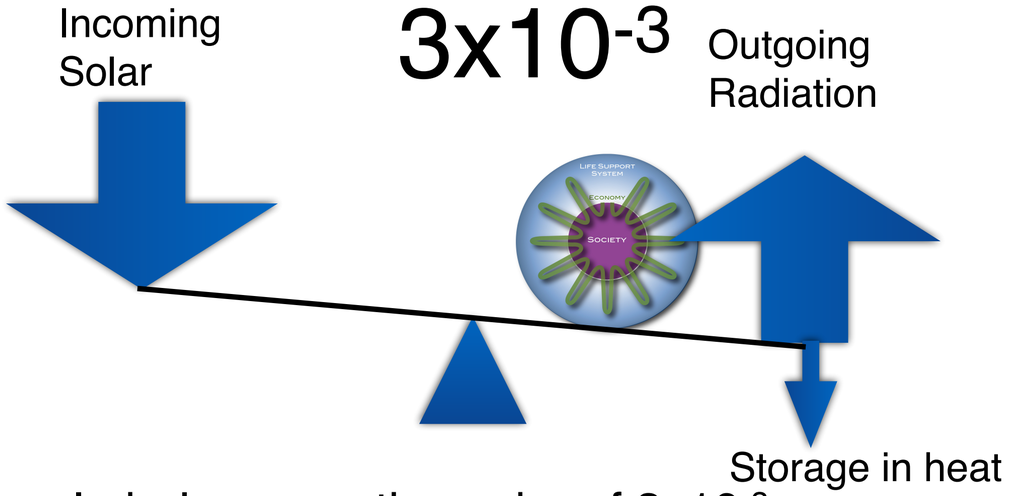

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International System of Units:
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1 Watt * 1 s = 1 Joules

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$EEI = 10^{-10} - 10^{-9}$
$I \sim 10^{5}$ TeraWatt $\sim 10^{17}$ Watt (solar irradiation)

$P = EEI * I \sim 10^{7} - 10^{8}$ Watt
(P: power of energy storage on the planet)

200 Myrs = 200,000,000 * 31,557,600 s
200 Myrs $* P$ = 6,311,520,000,000,000 * 10,000,000 Joules
= 63,115,200,000,000,000,000,000
~ 63 ZetaJules ~ 100 ZetaJules

Humanity: 20 TeraWatt,
Energy in 100 yrs:
E = 100 * 31,557,600 s * 20,000,000,000,000 Watt
= 63,115,200,000,000,000,000,000 ~ 100 ZetaJules

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Mitigation and Adaptation Studies

Class 2: The Syndrome of Modern Global Change: Baseline

Contents:

- Homo sapiens: An Exceptional Success Story (continued from class 1)
- Baseline

The Baseline: Past Climate and Global Change

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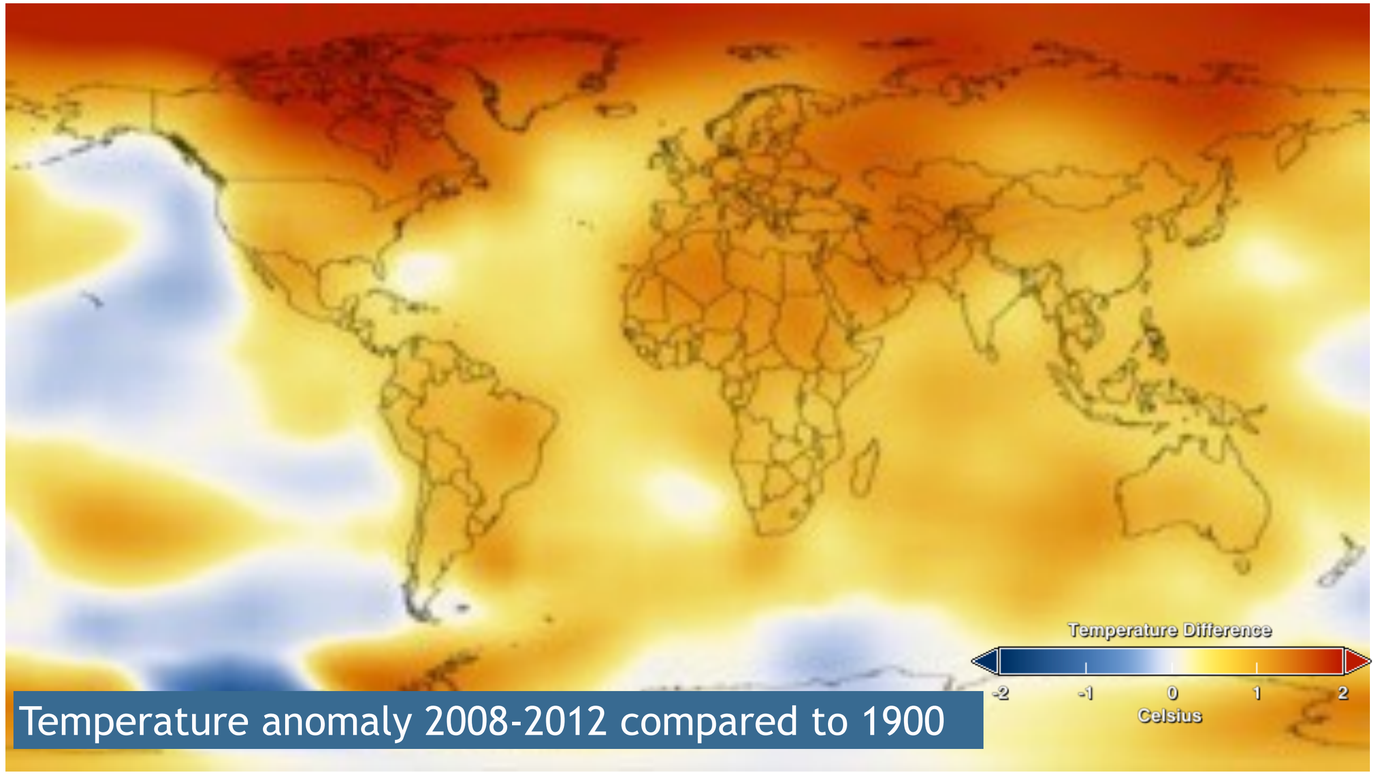

Temperature anomaly 2008-2012 compared to 1900

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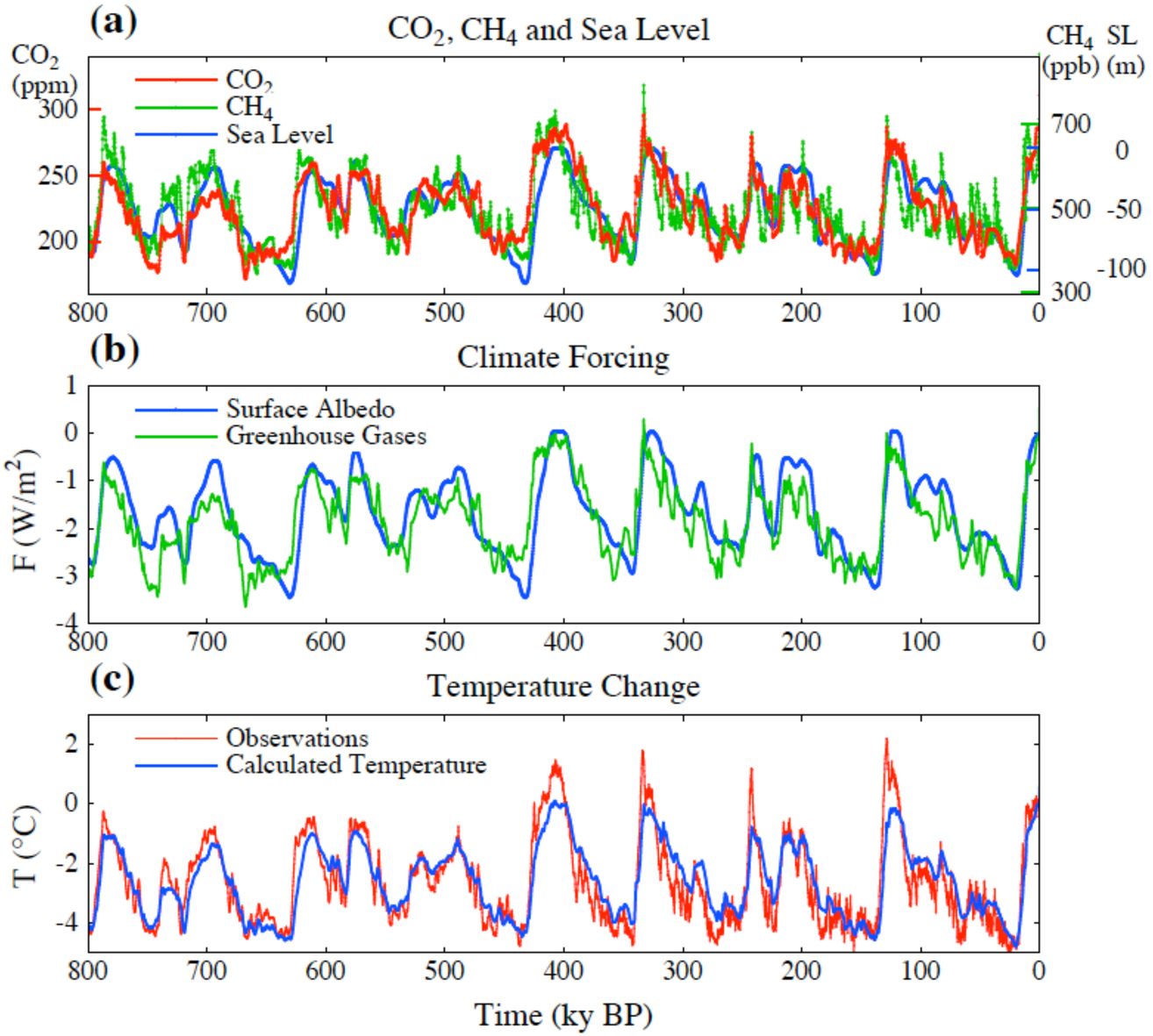
Climate can change a lot over time.



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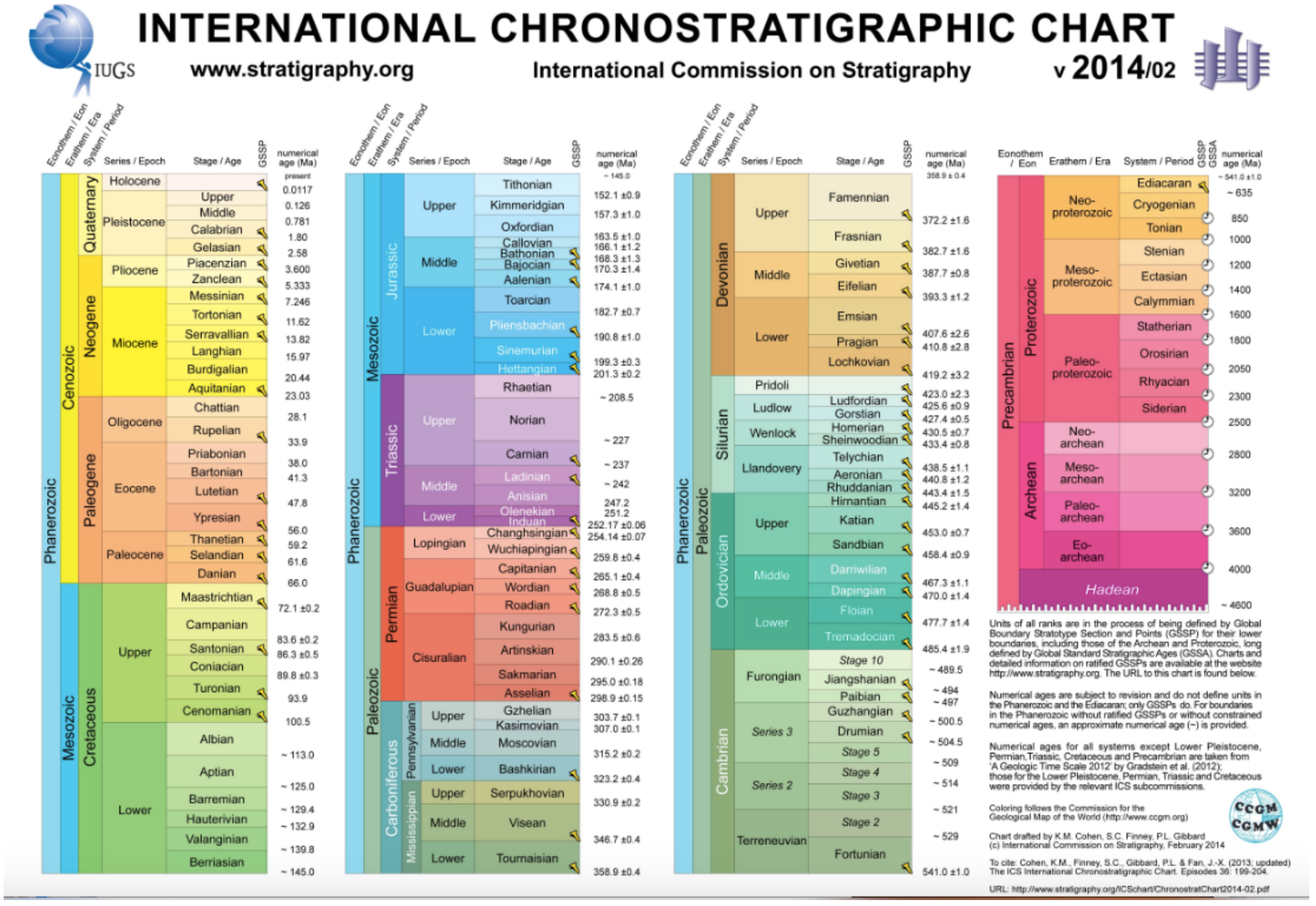

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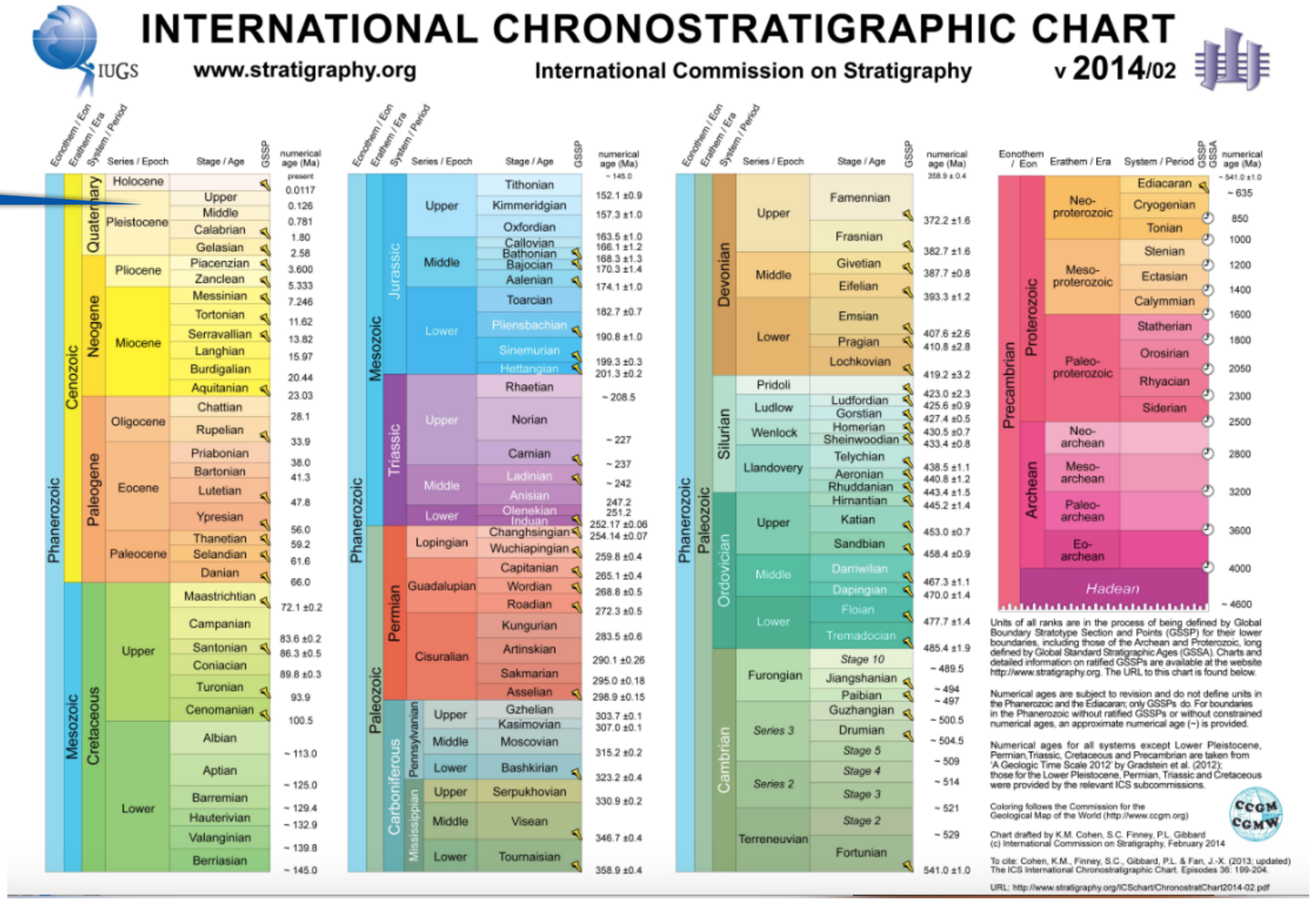
Subdivisions of the Quaternary System			
System/ Period	Series/ Epoch	Stage/ Age	Age (Ma)
Quaternary	Holocene		0.0117–0
	Pleistocene	Tarantian	0.126–0.0117
		Ionian	0.781–0.126
		Calabrian	1.80–0.781
		Gelasian	2.58–1.80
Neogene	Pliocene	Piacenzian	older



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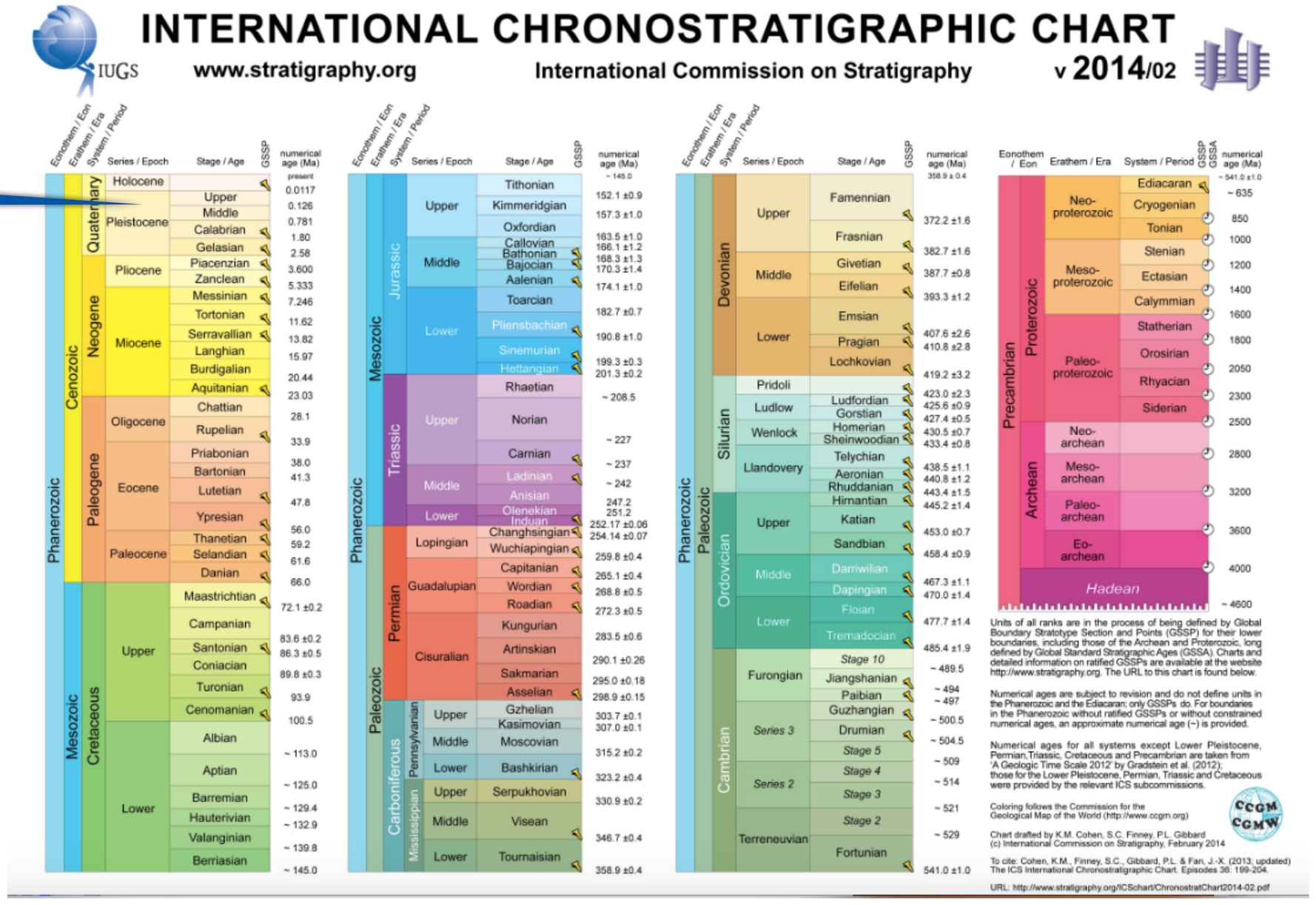

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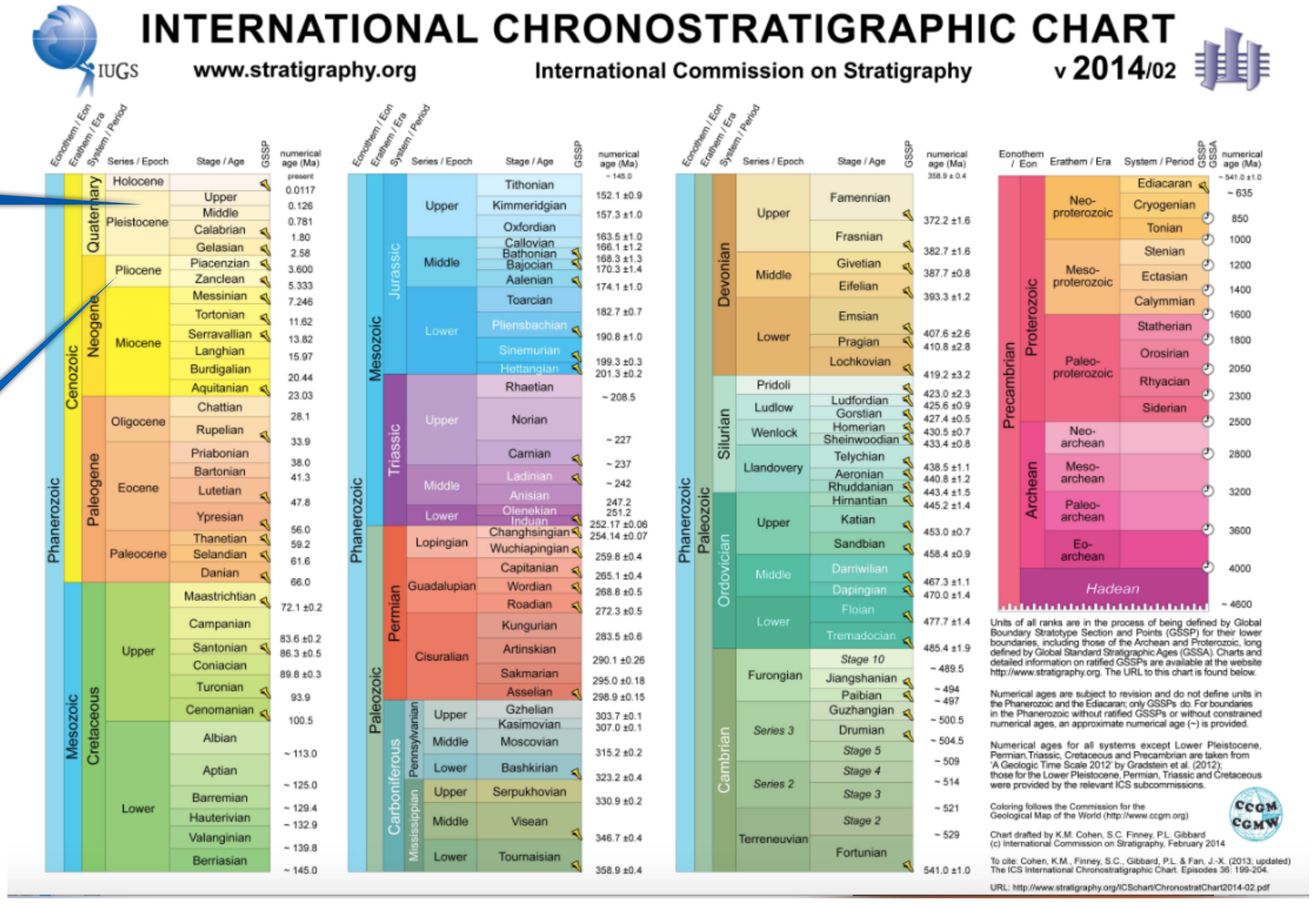
Neogene	Pliocene	Piacenzian	3.600–2.58
		Zanclean	5.333–3.600
	Miocene	Messinian	7.246–5.333
		Tortonian	11.62–7.246
		Serravallian	13.82–11.62
		Langhian	15.97–13.82
		Burdigalian	20.44–15.97
		Aquitanian	23.03–20.44
Paleogene	Oligocene	Chattian	older



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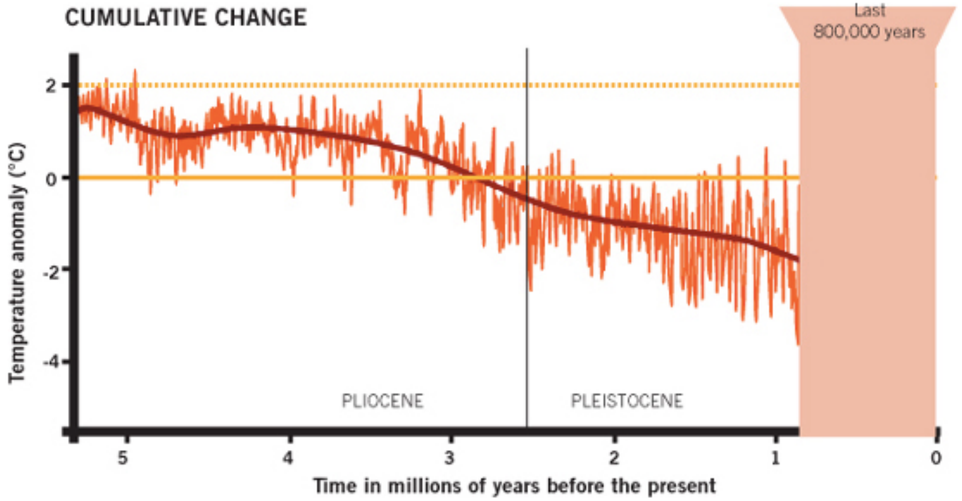

Rockstrom and Klum, 2015

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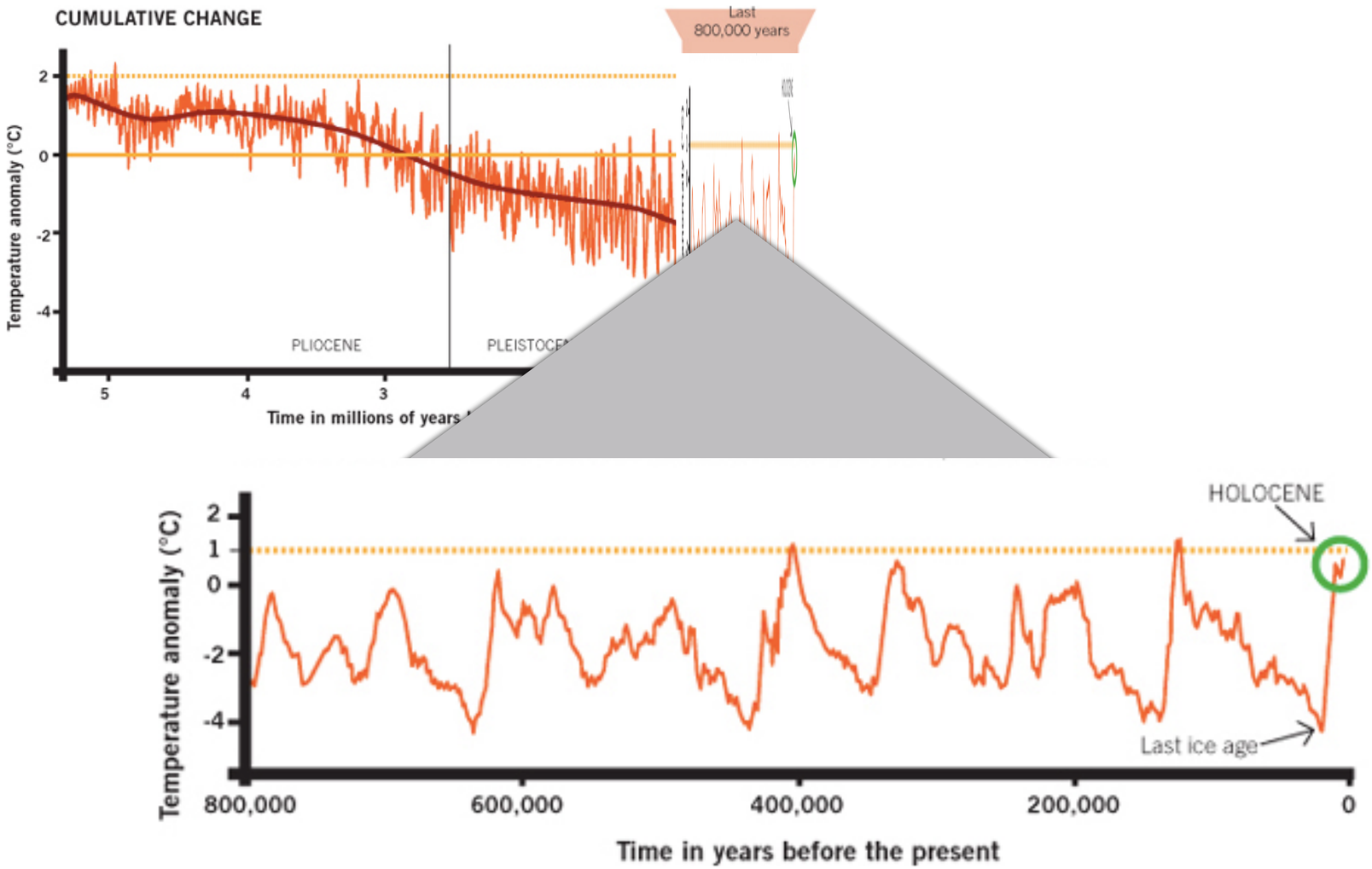

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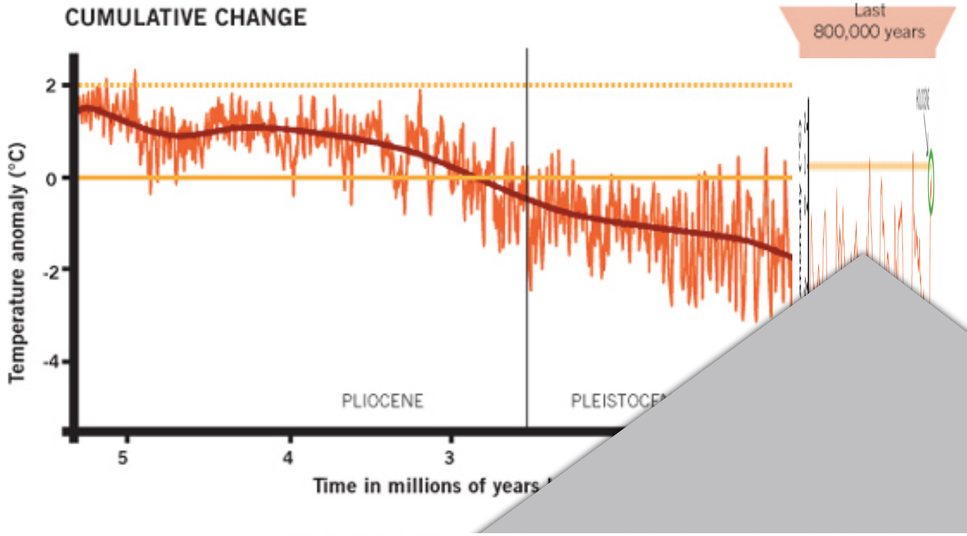

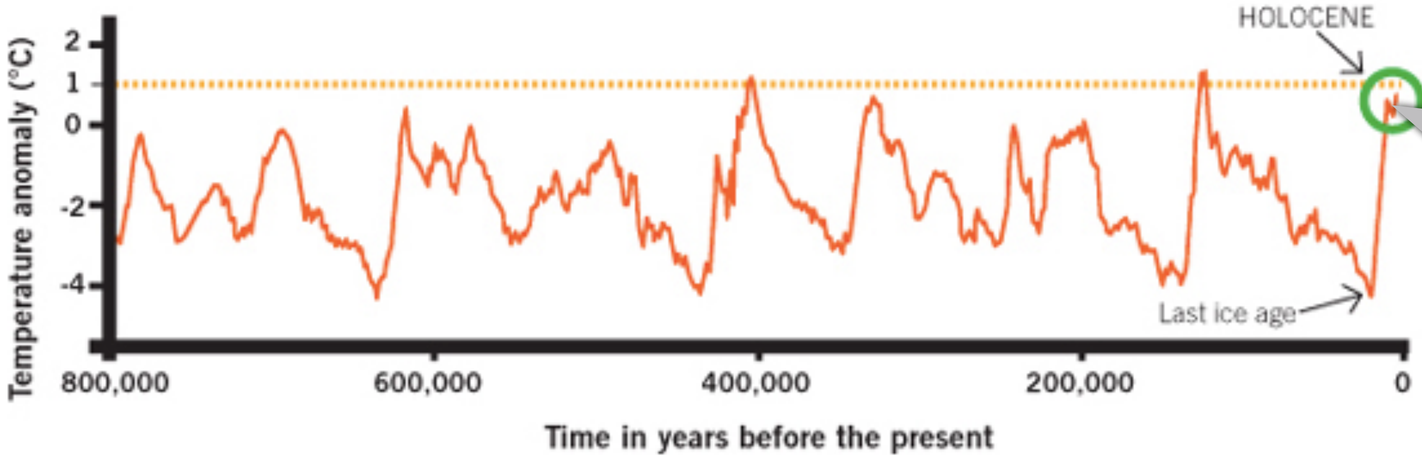

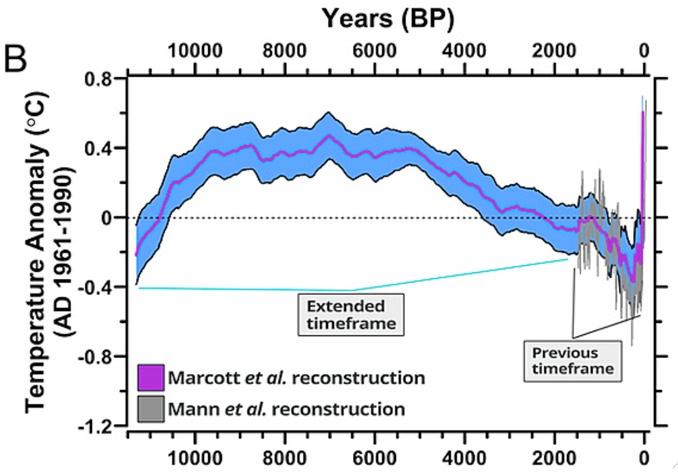

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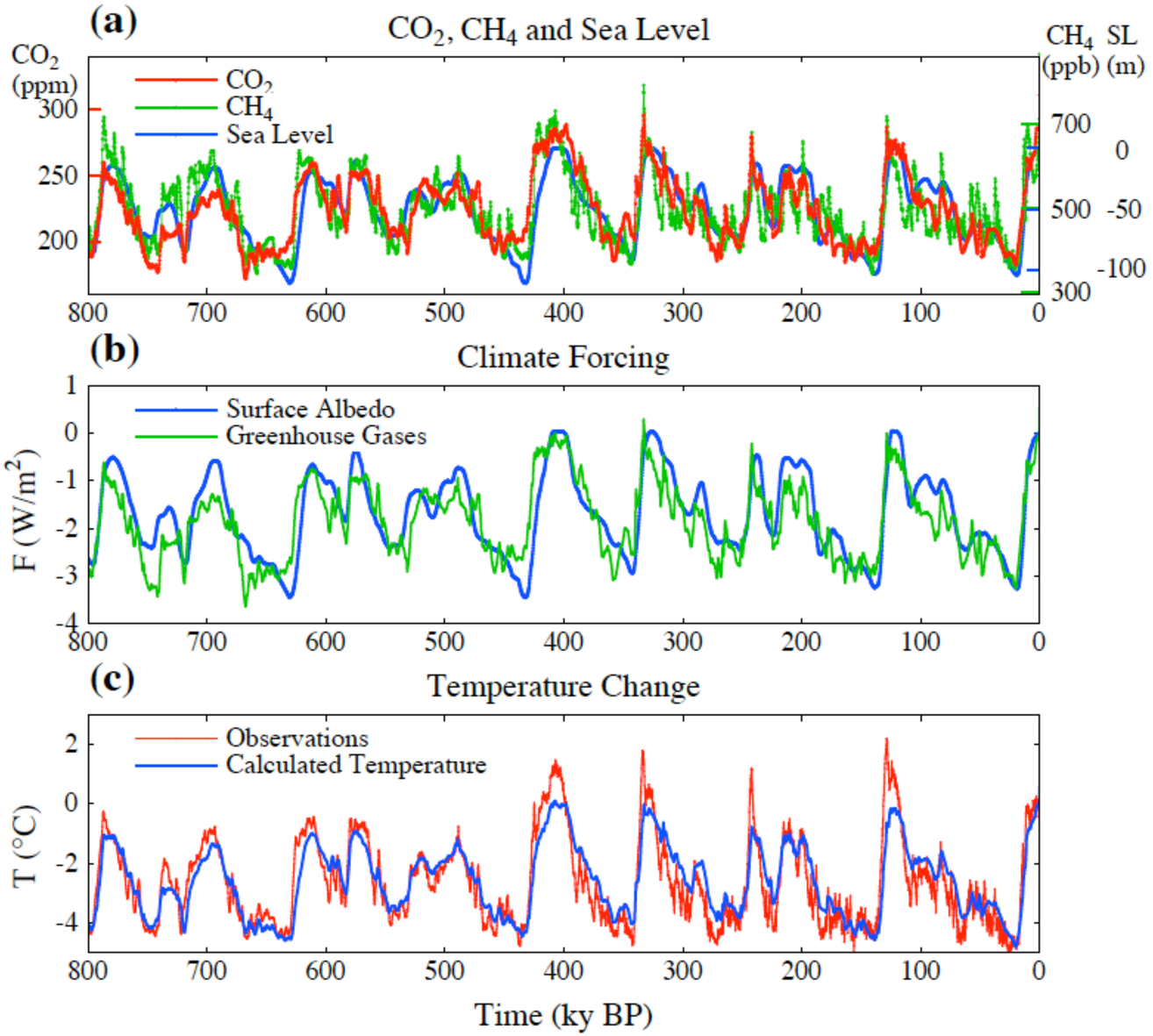
Climate can change from local to global scales.

Climate can change a lot over time.



The Baseline: Past Climate and Global Change

Climate Change is a long-term shift in the statistics of weather - averages, frequency and magnitude of extremes.

Climate is determined by:

- incoming radiation (sun)
- reflected radiation (albe
- retained heat (Greenhou

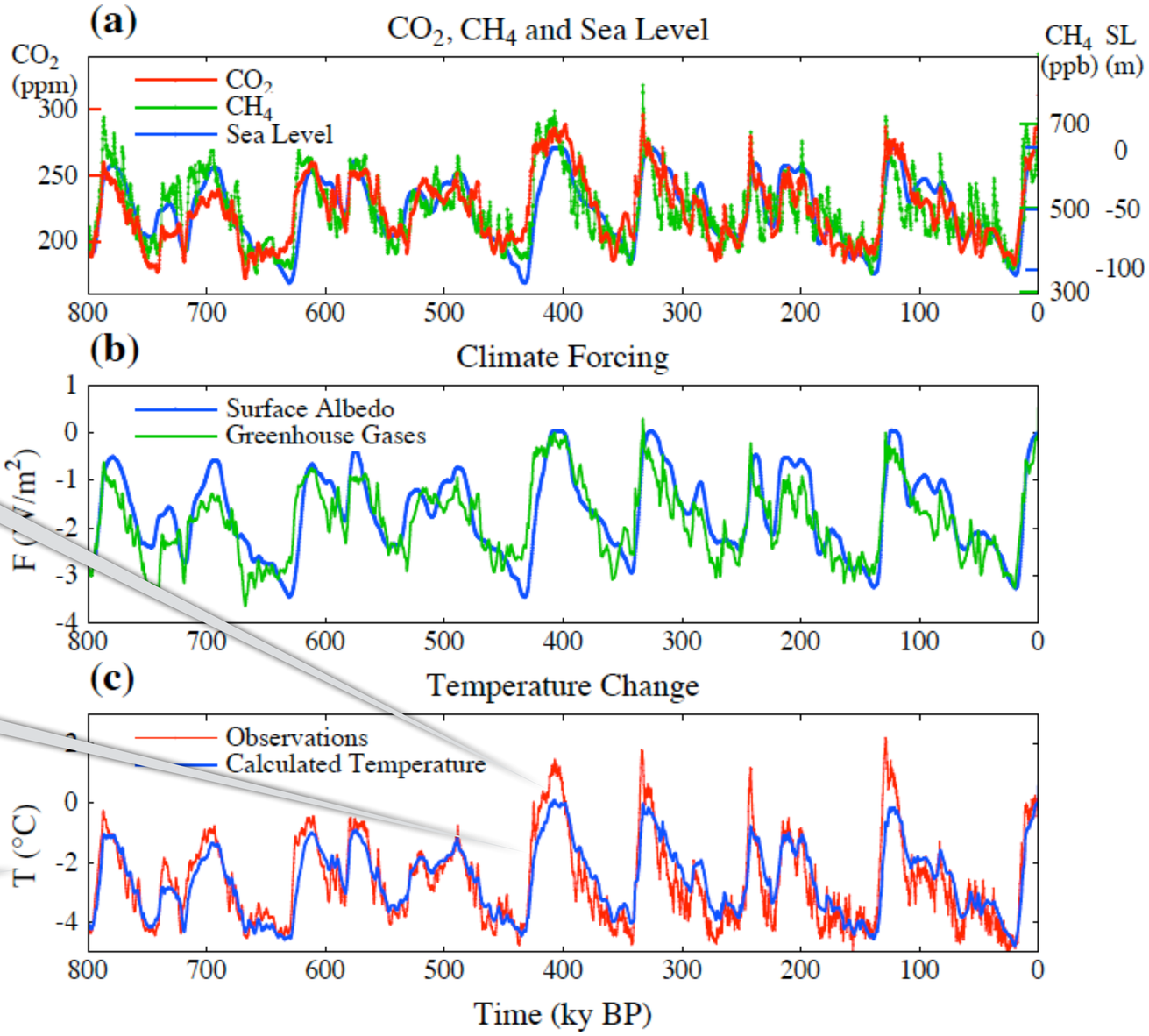
Climate can cha global scales.

Climate can change a lot over time.

Warm period
"Inter-glacial"

Cold period
Ice age
"glacial"

Temperature difference:
4°C - 5°C



The Baseline: Past Climate and Global Change

Climat… …g-term shift in the sta… …rages, fre… …f extremes.

High correlation between
- atmospheric CO2 and global mean air temperature
- sea level and mean global air temperature

Cli…

- incom… …(sun)
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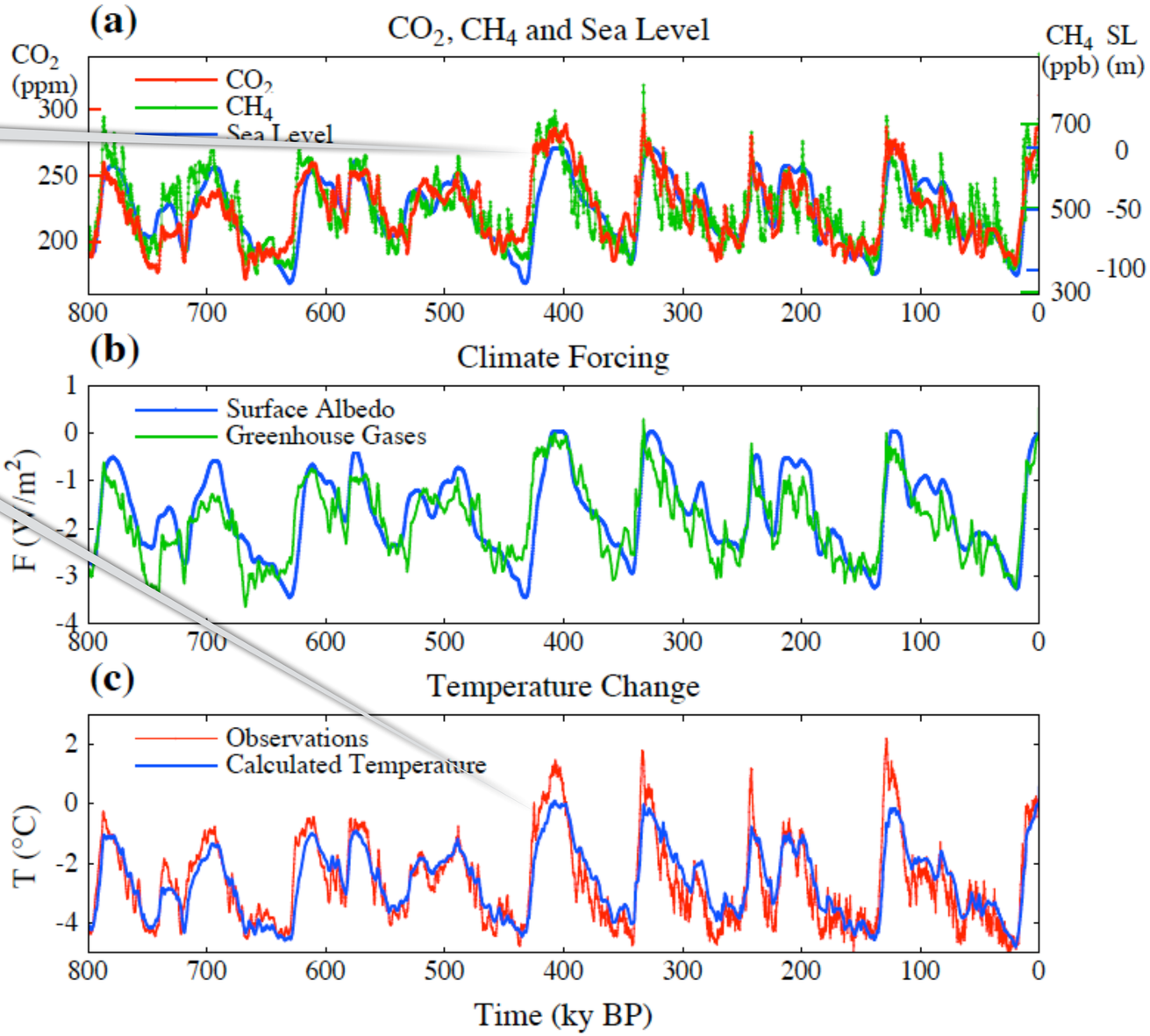

The Baseline: Past Climate and Global Change

The Baseline: Past Climate and Global Change

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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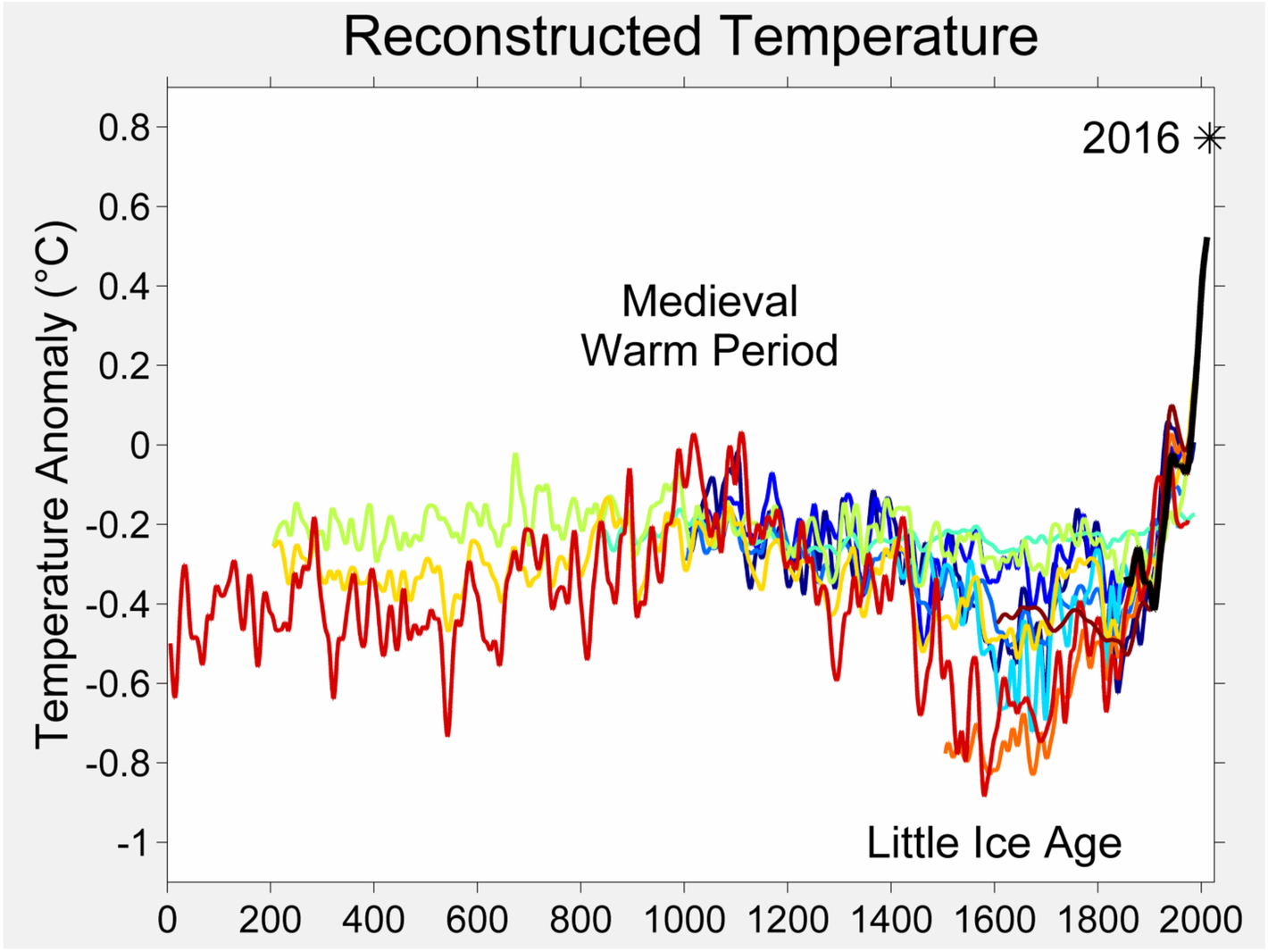
In 1895, Arrhenius presented a paper to the Stockholm Physical Society titled, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground." This article described an energy budget model that considered the radiative effects of carbon dioxide (carbonic acid) and water vapor on the 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)."

The Baseline: Past Climate and Global Change



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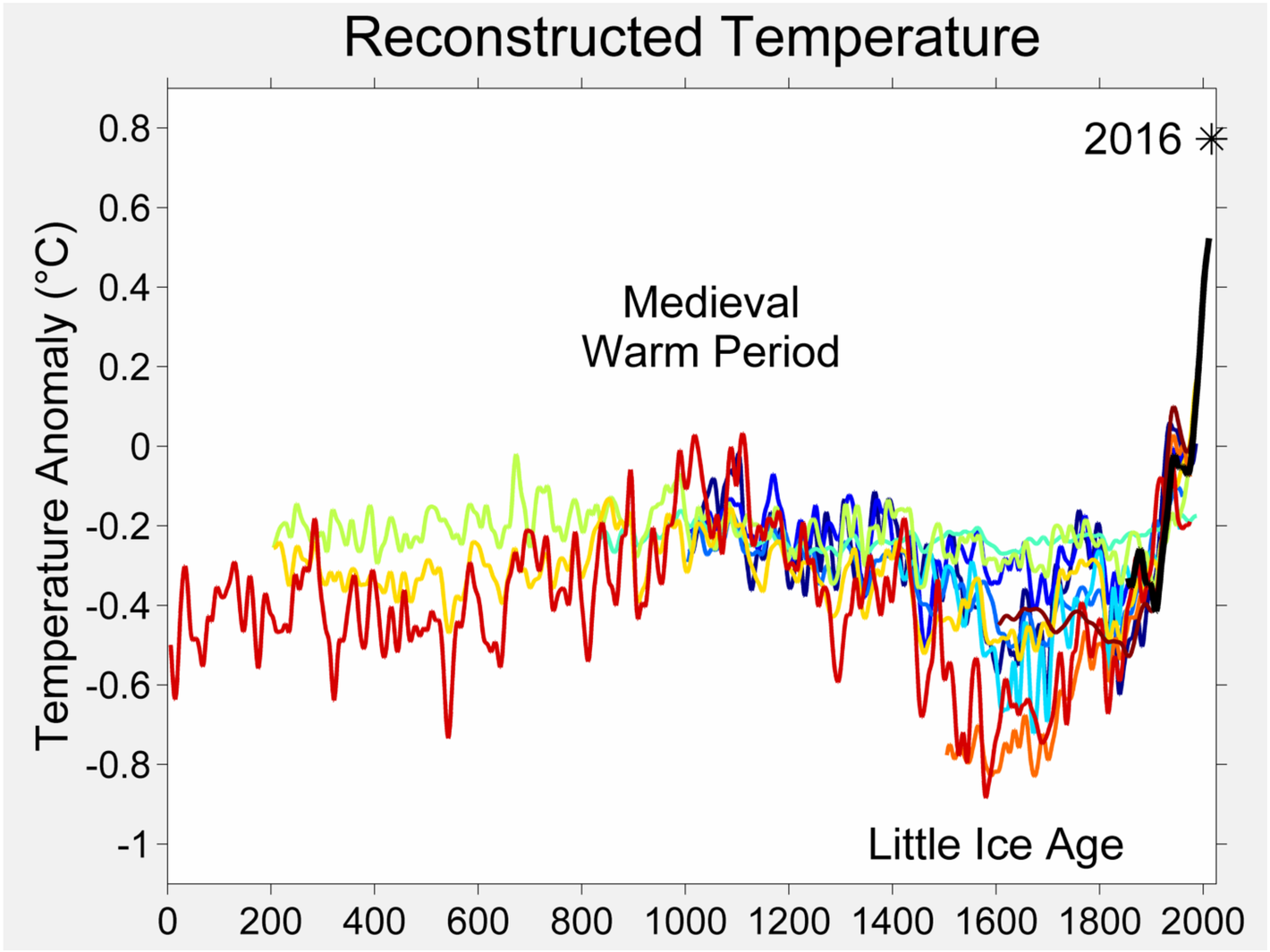

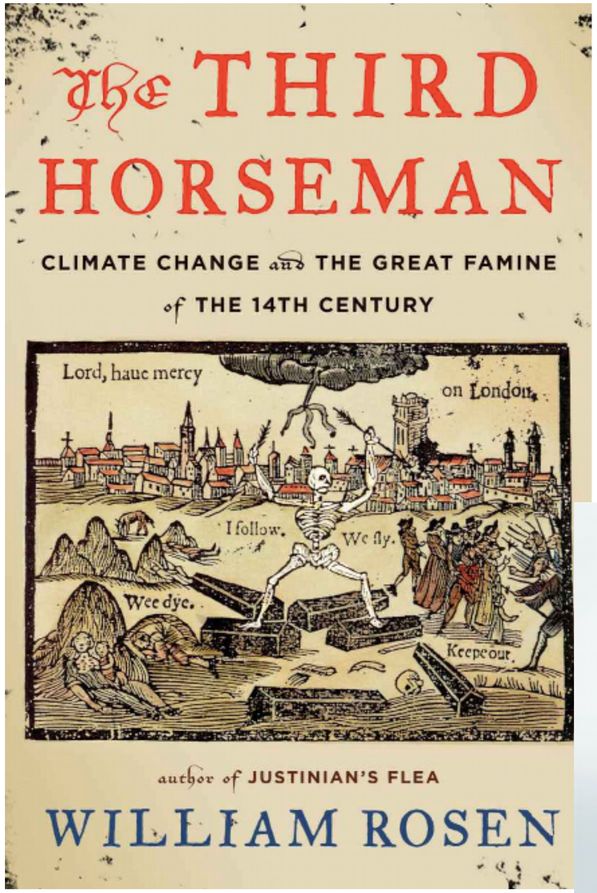

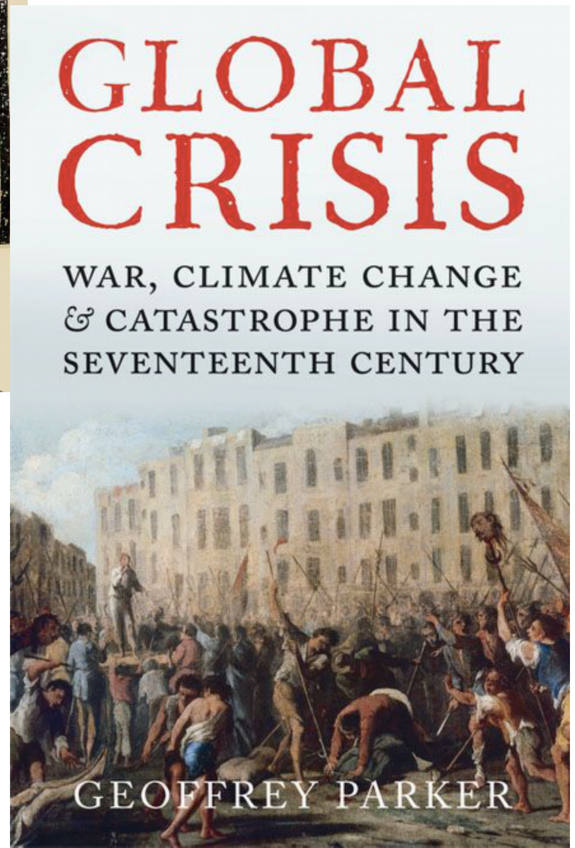

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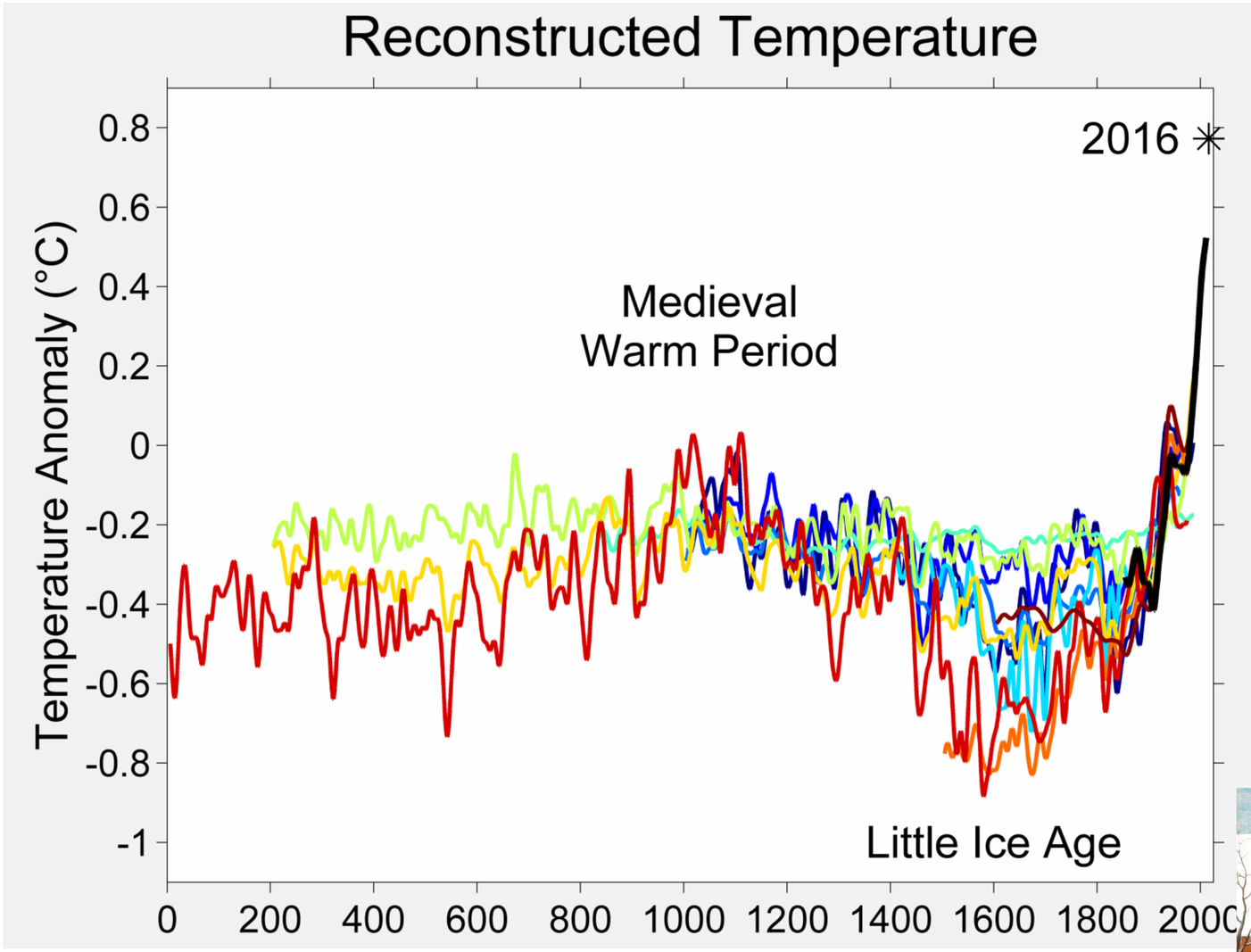

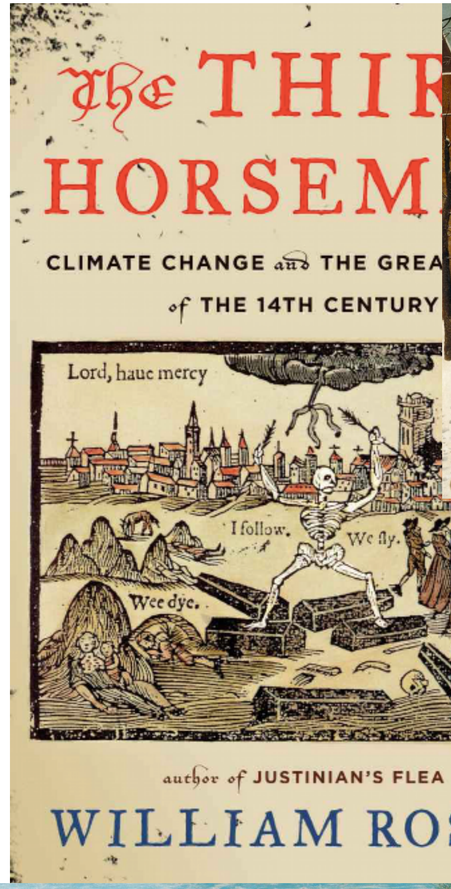

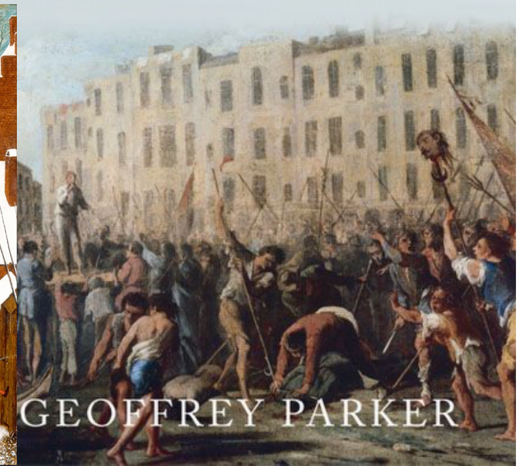

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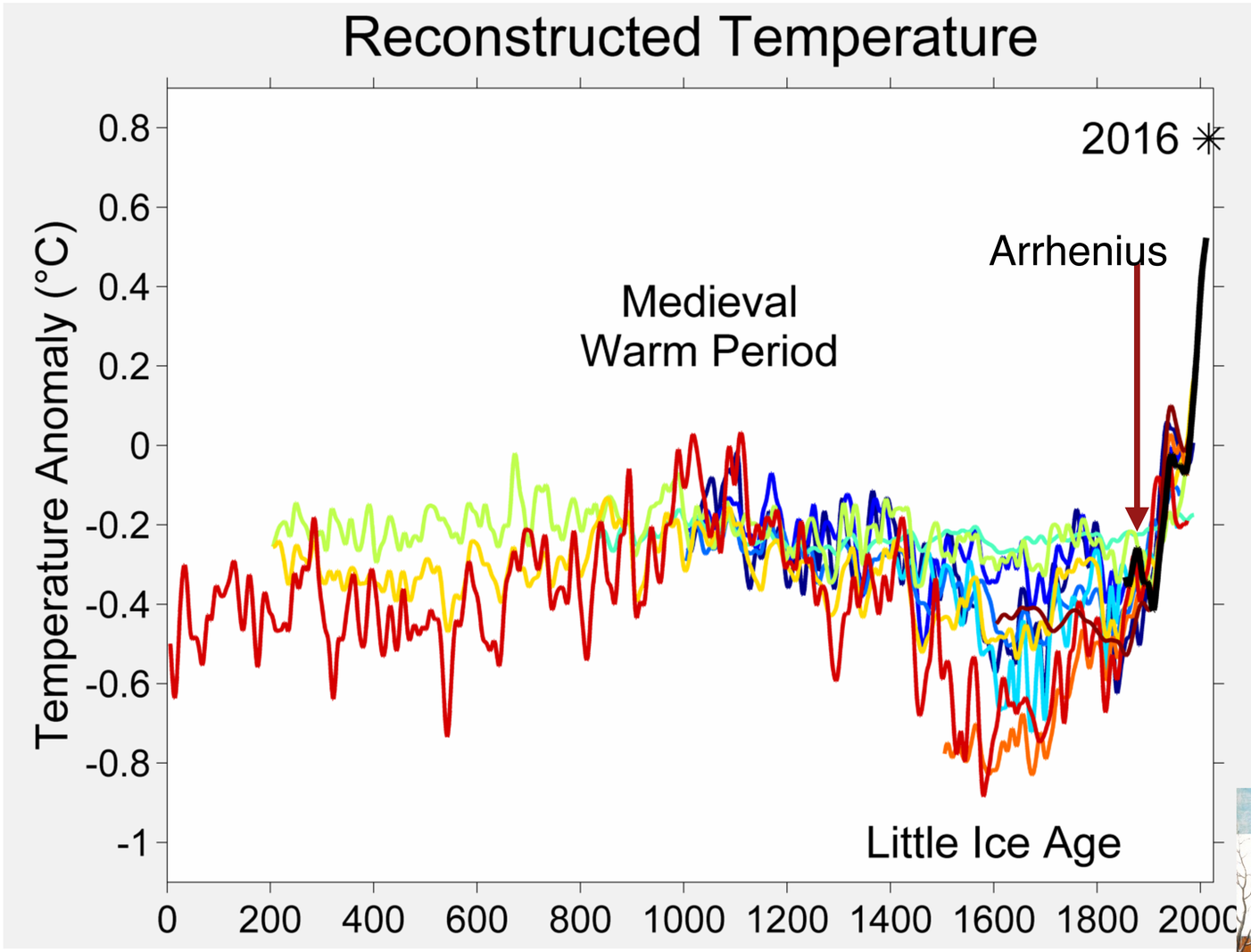

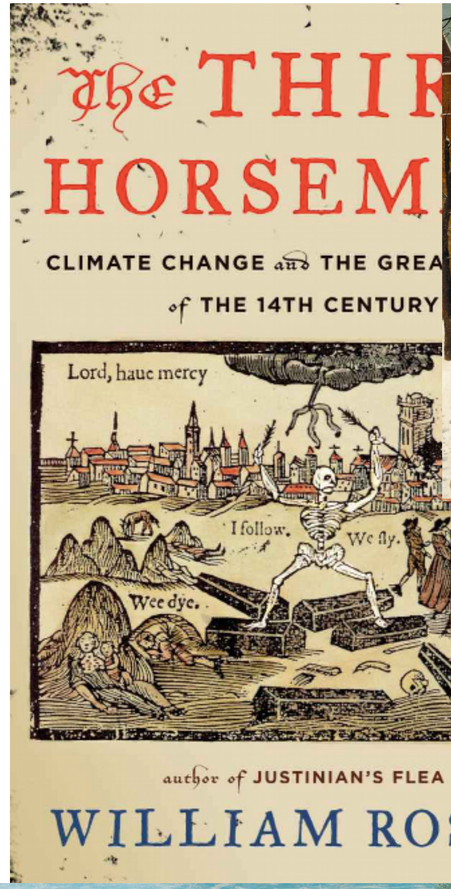

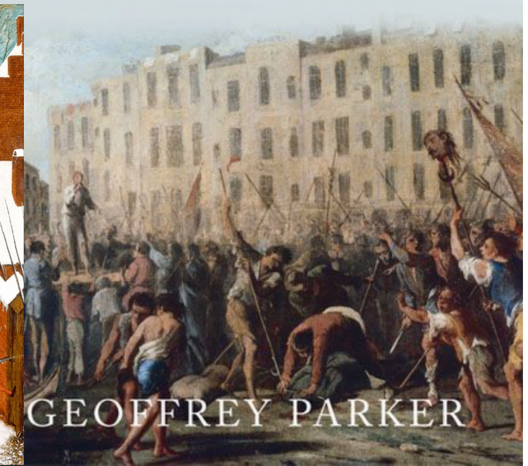

The Baseline: Past Climate and Global Change

REMARKABLE WEATHER OF 1911

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

By FRANCIS MOLENA

THE year 1911 will long be remembered for the violence of its weather. The spring opened mild and

The mean temperature of every month except November was above the average of that of the 40 years covered by

Popular Mechanics, March 1912, 393-342

"It is largely the courageous, enterprising, and ingenious American whose brains are changing the world. Yet even the dull foreigner, who burrows in the earth by the faint gleam of his miner's lamp, not only supports his family and helps to feed the consuming furnaces of modern industry, but by his toil in the dirt and darkness adds to the carbon dioxide in the earth's atmosphere so that men in generations to come shall enjoy milder breezes and live under sunnier skies."

The Baseline: Past Climate and Global Change

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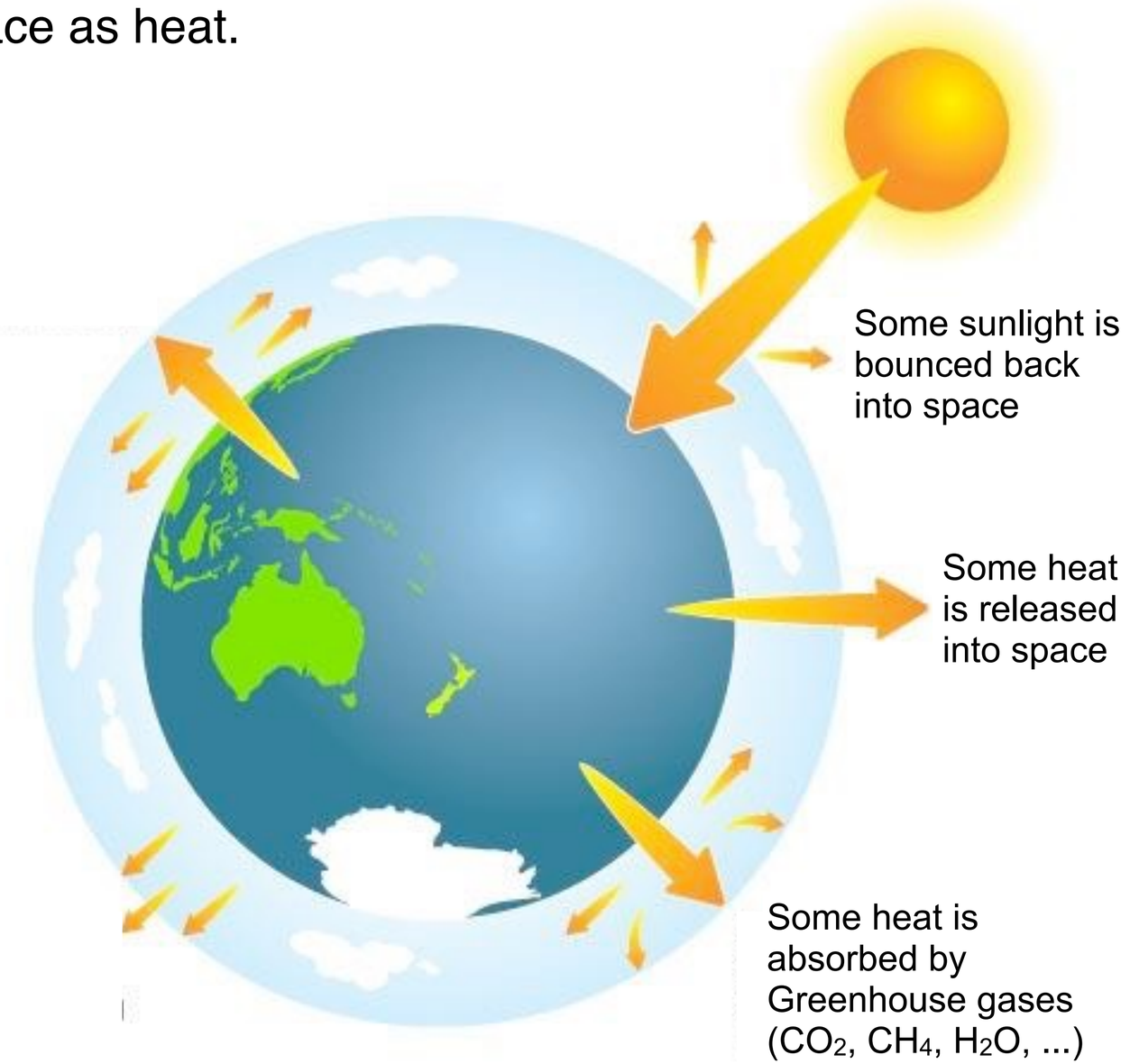

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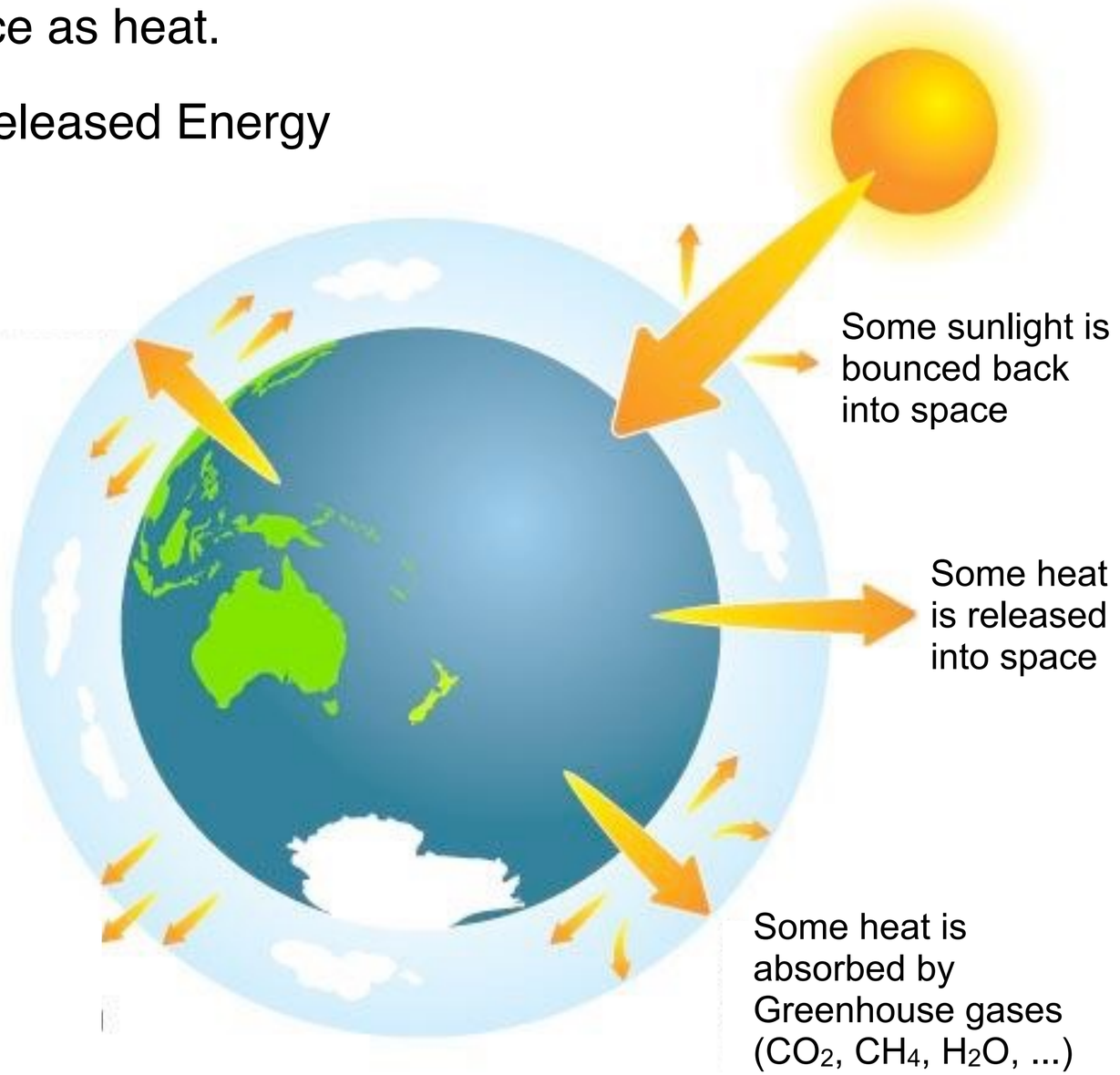
Earth’s Energy Imbalance: EI = Solar irradiance - Released Energy



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EI > 0: Global Warming
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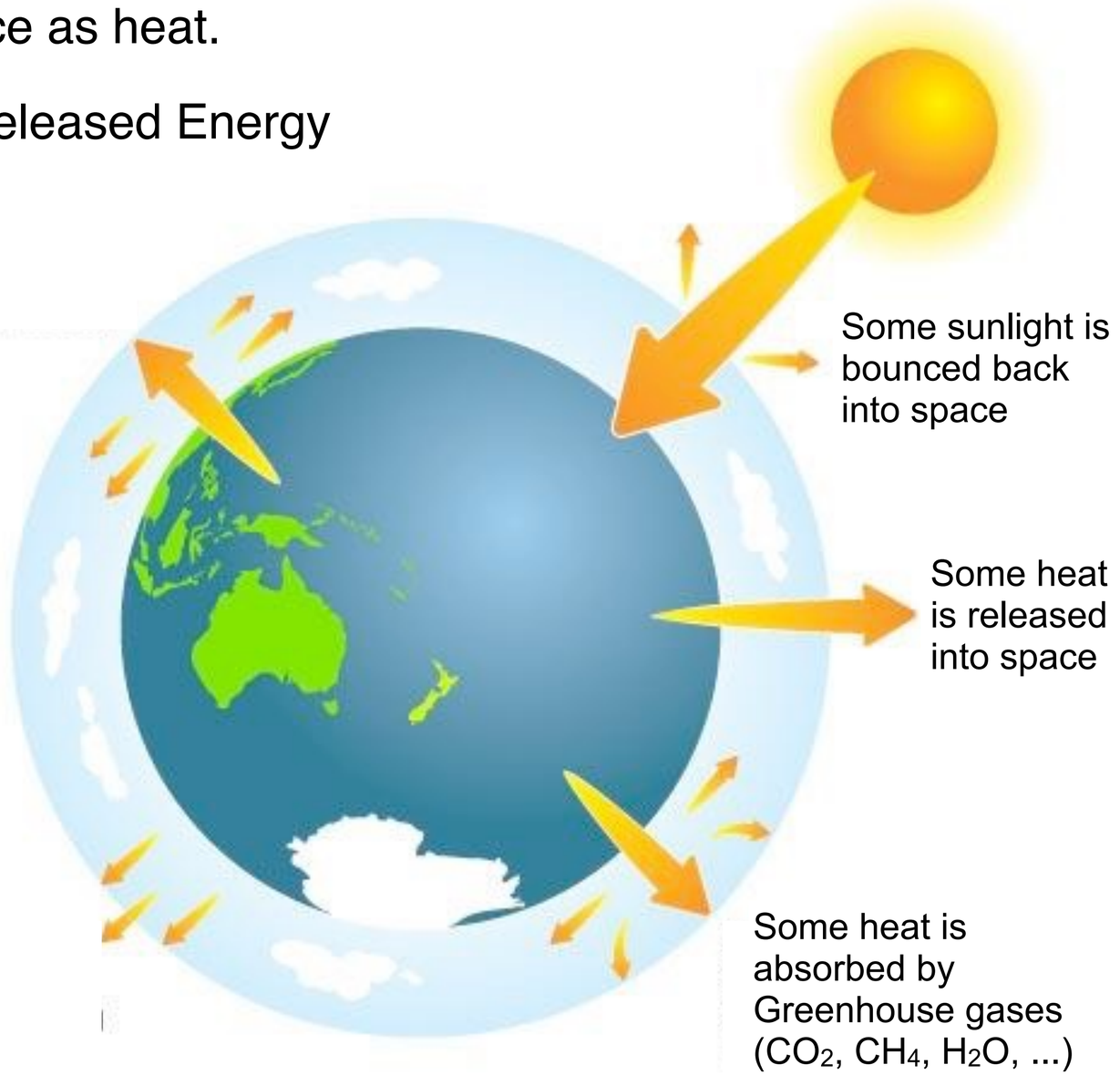

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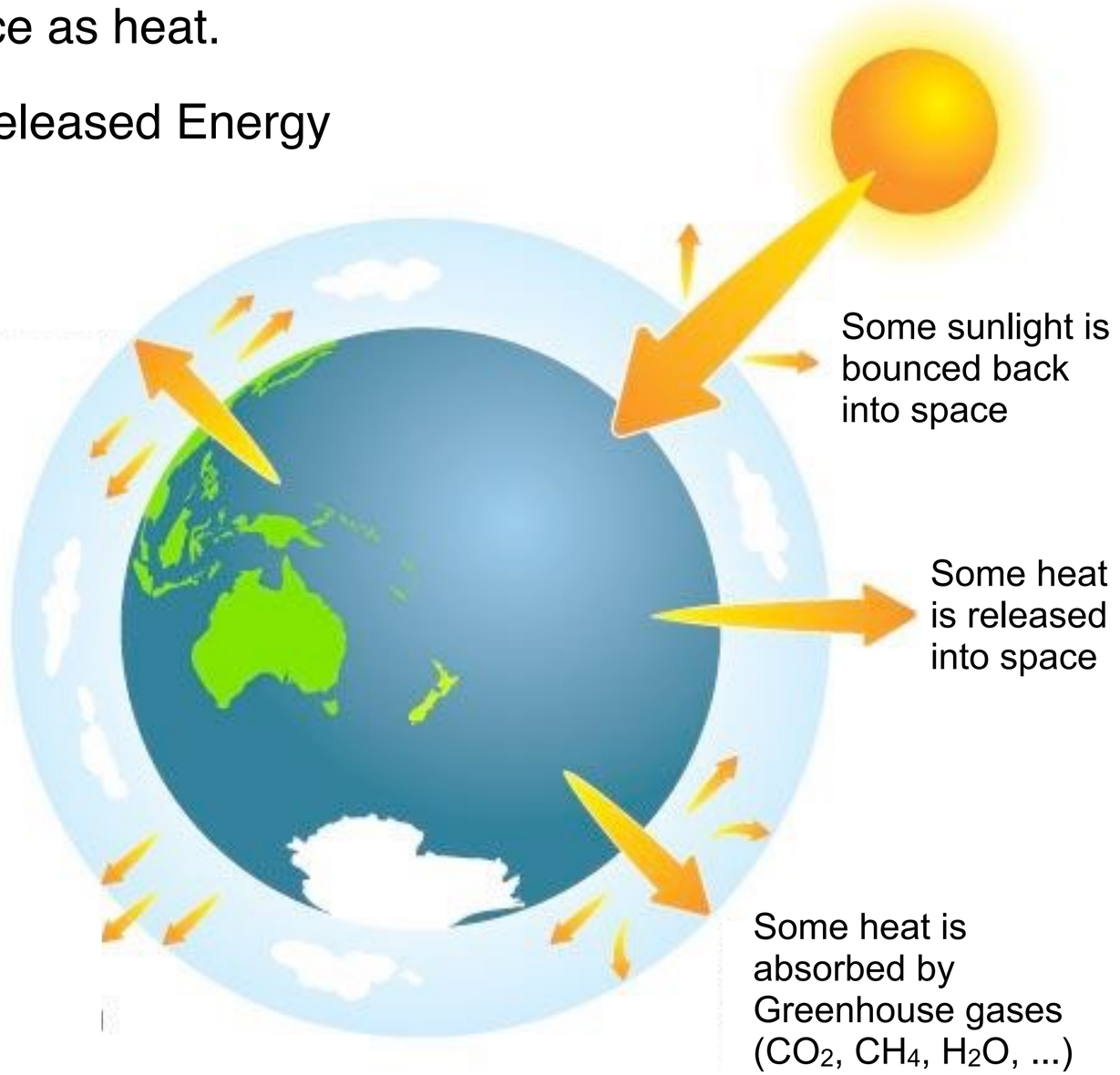
  Currently: 1366±1 W/m^2 (~240 W/m^2)
- Reflected radiation can change (albedo)
- Absorbed energy can change



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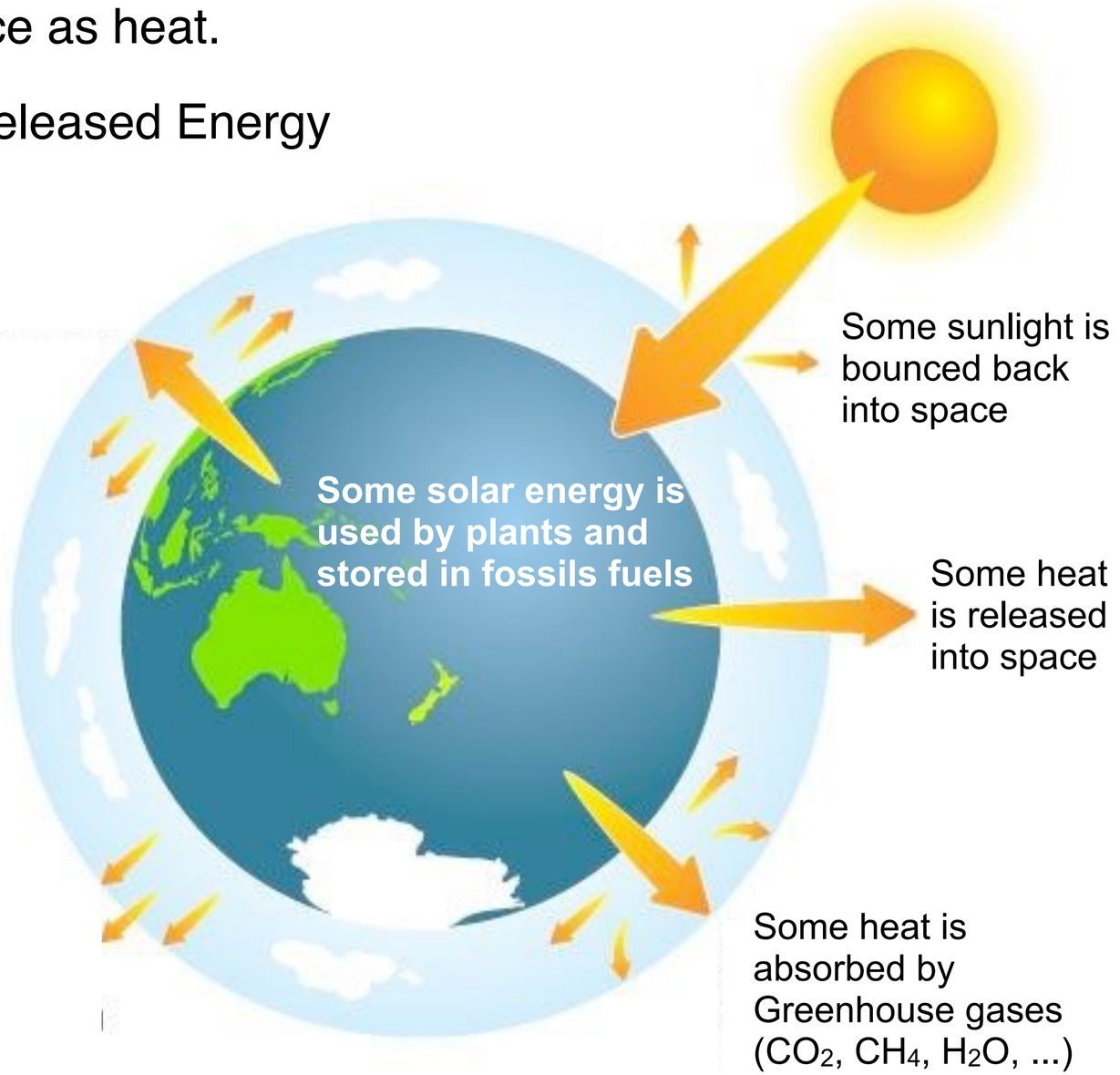

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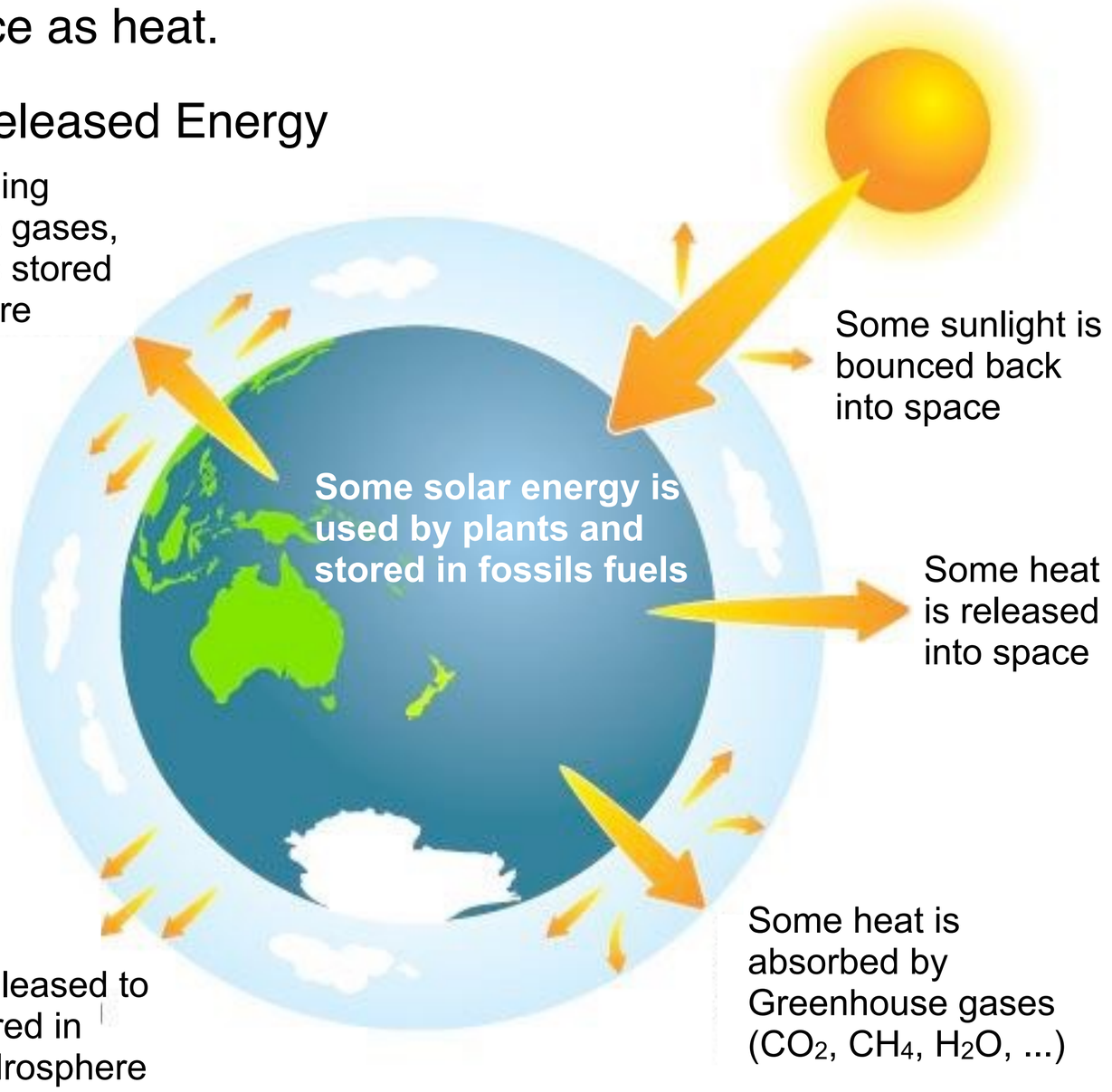

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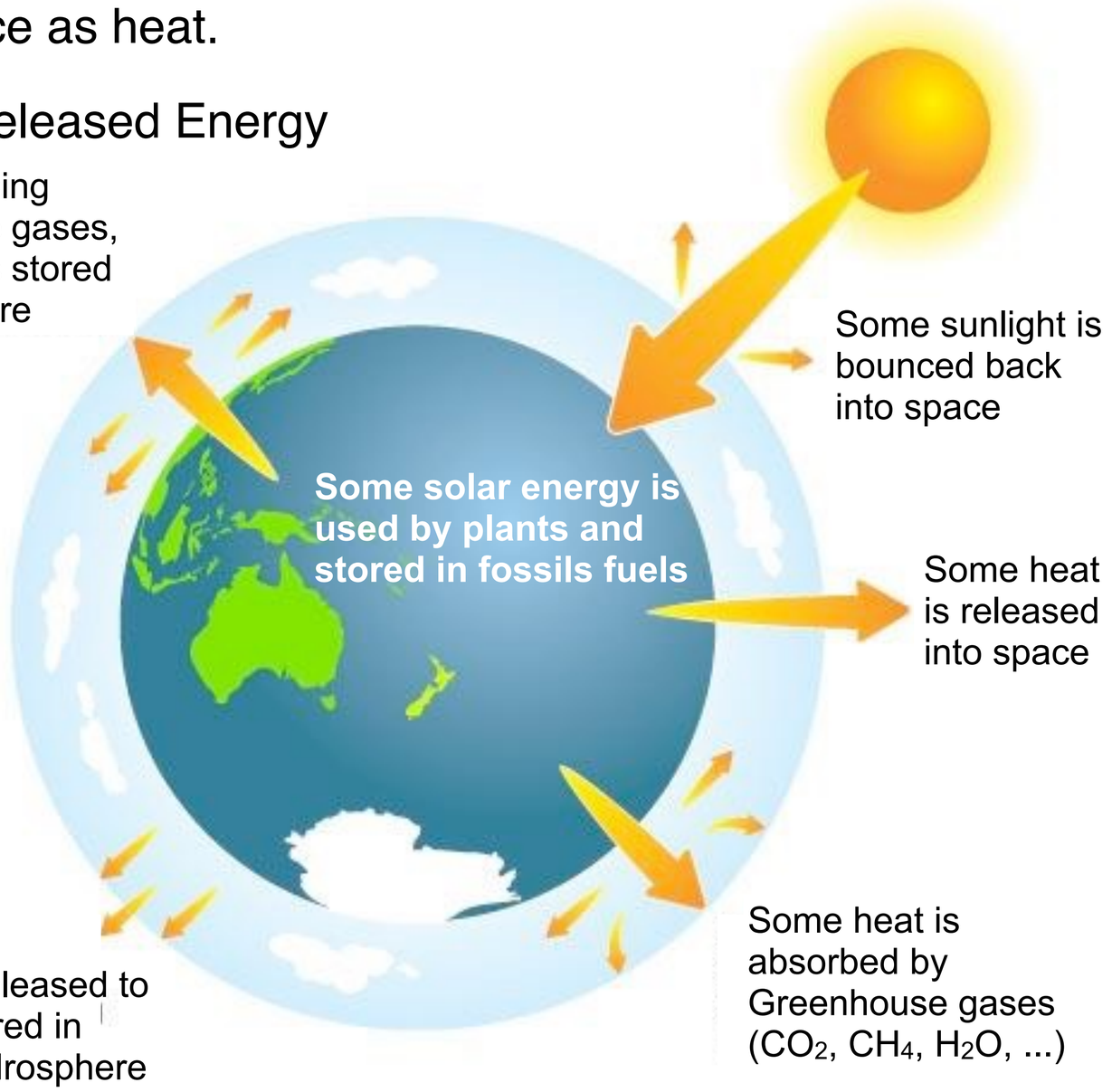
- 10,000 years EI: ±0.01 W/m^2
- Current EI: ~0.6 W/m^2



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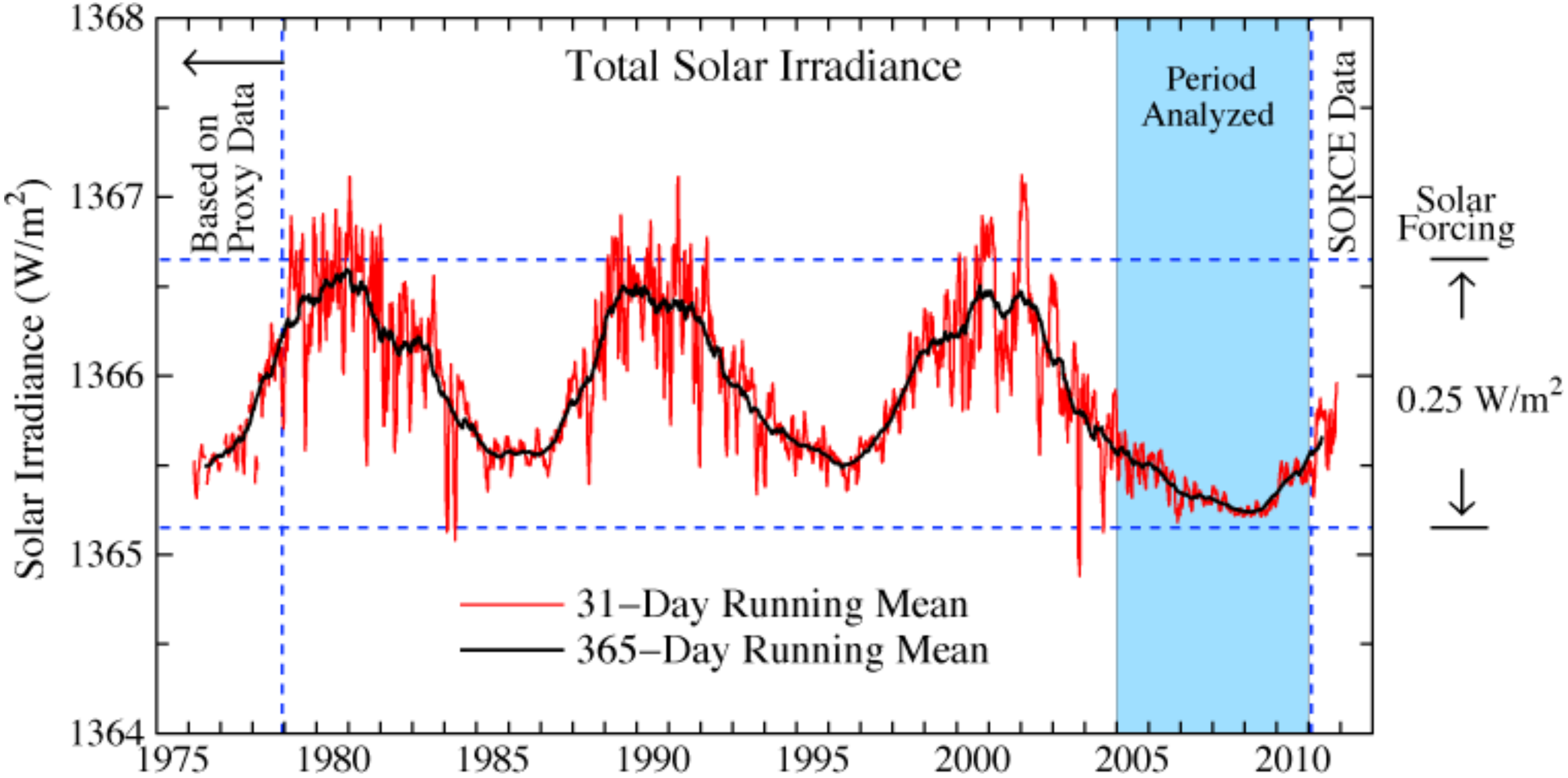

Solar irradiance in the era of accurate satellite data. Left scale is the energy passing through an area perpendicular to Sun-Earth line. Averaged over Earth's surface the absorbed solar energy is ~240 W/m², so the amplitude of solar variability is a forcing of ~0.25 W/m². (Credit: NASA/GISS)

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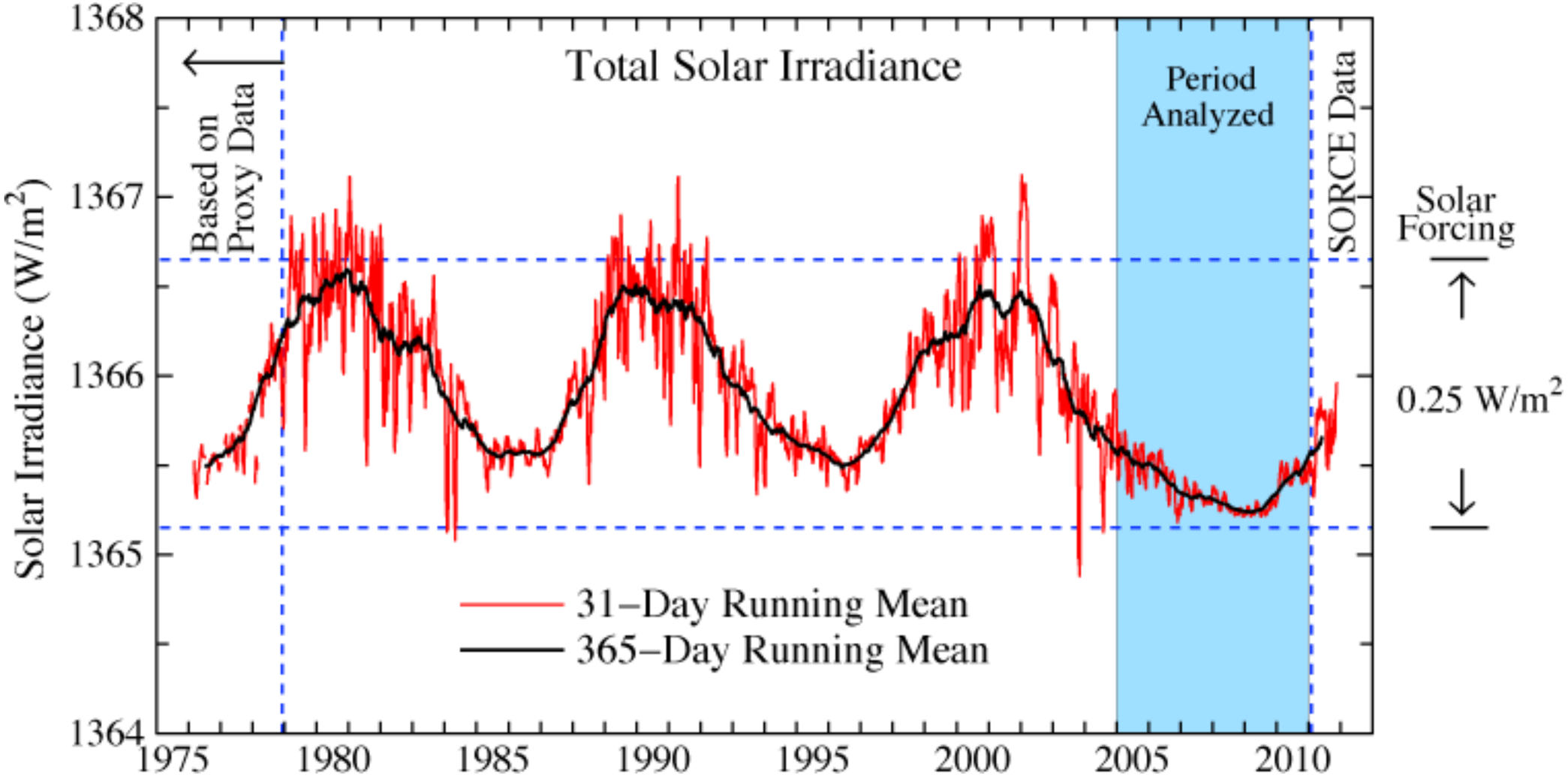

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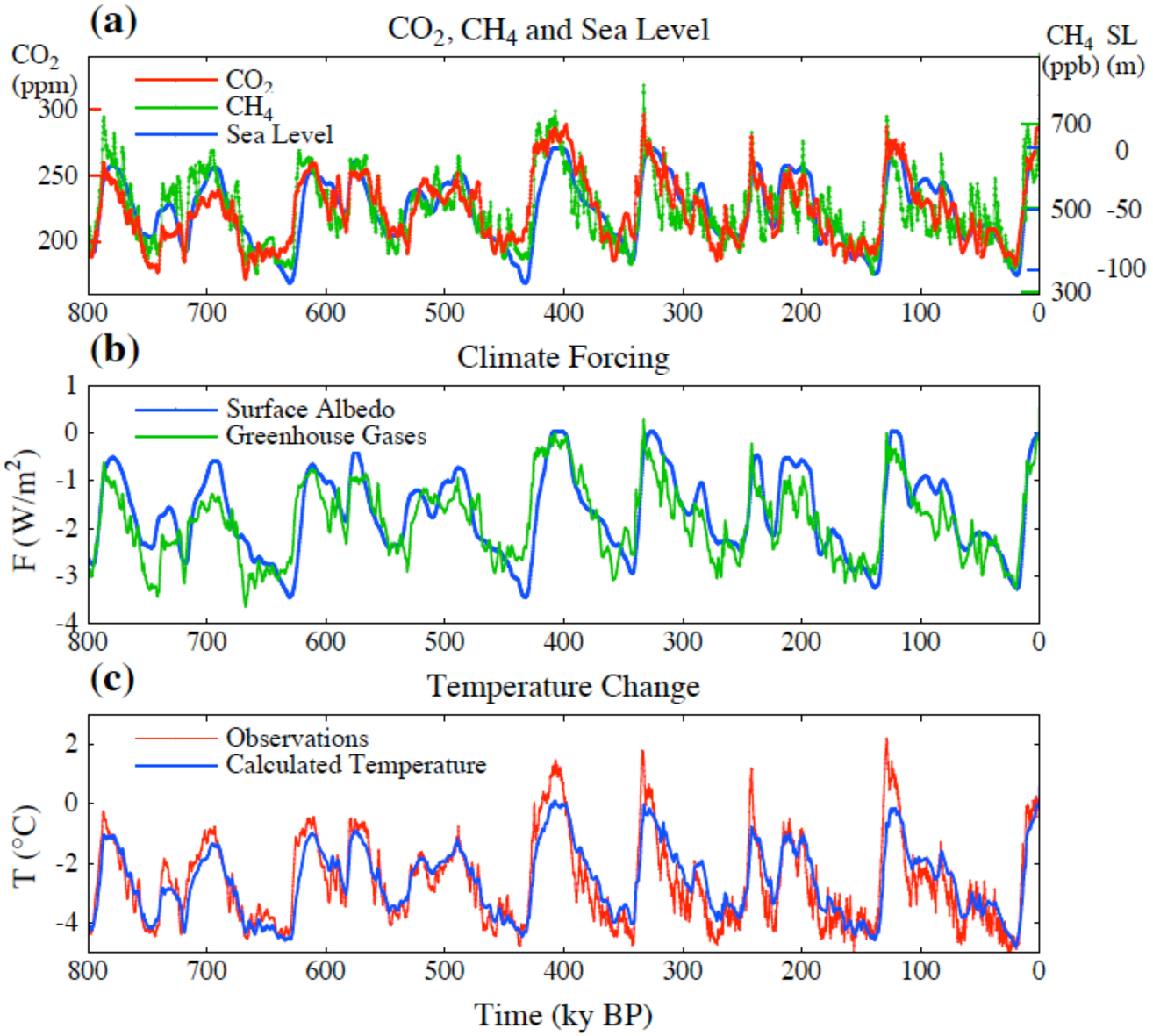


The Baseline: Past Climate and Global Change

Medical Lab Sheet

Comprehensive Metabolic Panel
Glucose (fasting): 125 mg/dL

NORMAL	PREDIABETES	MAY INDICATE DIABETES
< 100	100 to 125	> 125

YOU: 125

Vitamin D
Total vitamin D: 22 ng/mL

DEFICIENCY	INSUFFICIENCY	SUFFICIENCY
< 20	20 to 30	31 to 100

YOU: 22

Complete Blood Cell Count (CBC) Normal for all 20 values, including white blood cell count (a high count can indicate infection).

Urinalysis
Normal for all 20 values, including color, appearance, and protein.

Endocrinology Normal for TSH, which is an indicator of thyroid function, and for microalbumin and creatinine, measures of kidney function.

Chemistry Normal for iron, transferrin saturation, and ferritin. (Abnormal levels could indicate anemia, hepatitis, or other problems.)

Lipid Profile
Total cholesterol: 211 mg/dL

DESIRABLE	BORDERLINE	HIGH
< 200	200 to 240	> 240

YOU: 211

HDL ("good" cholesterol): 46 mg/dL

LOW	NORMAL
< 50	> 50

YOU: 46

LDL ("bad" cholesterol): 165 mg/dL

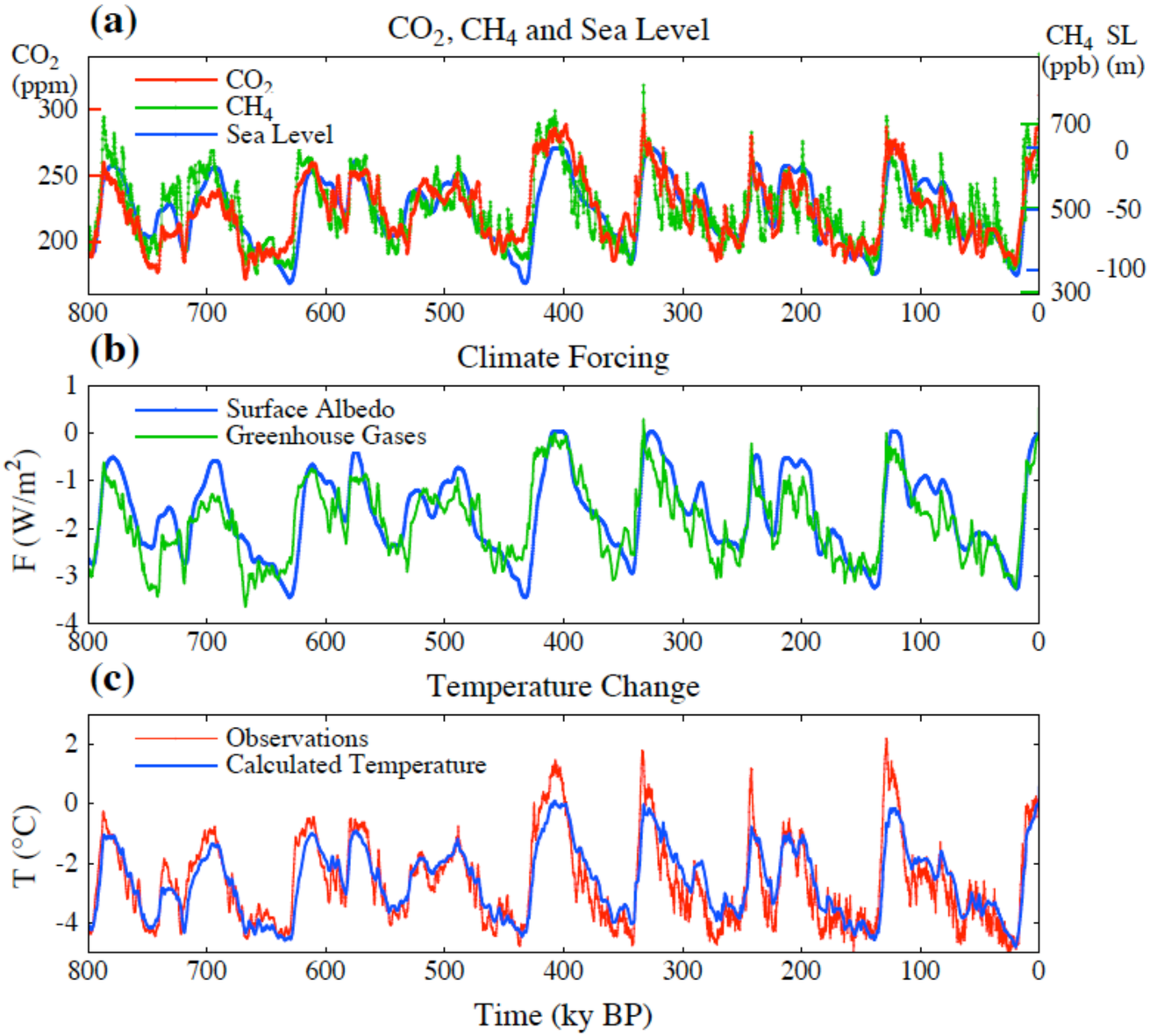
OPTIMAL	NEAR-OPTIMAL	BORDERLINE	HIGH	VERY HIGH
< 100	100 to 129	130 to 159	160 to 190	> 190

YOU: 165

Triglycerides: 160 mg/dL

OPTIMAL	BORDERLINE	HIGH	VERY HIGH
< 150	150 to 199	200 to 500	> 500

YOU: 160



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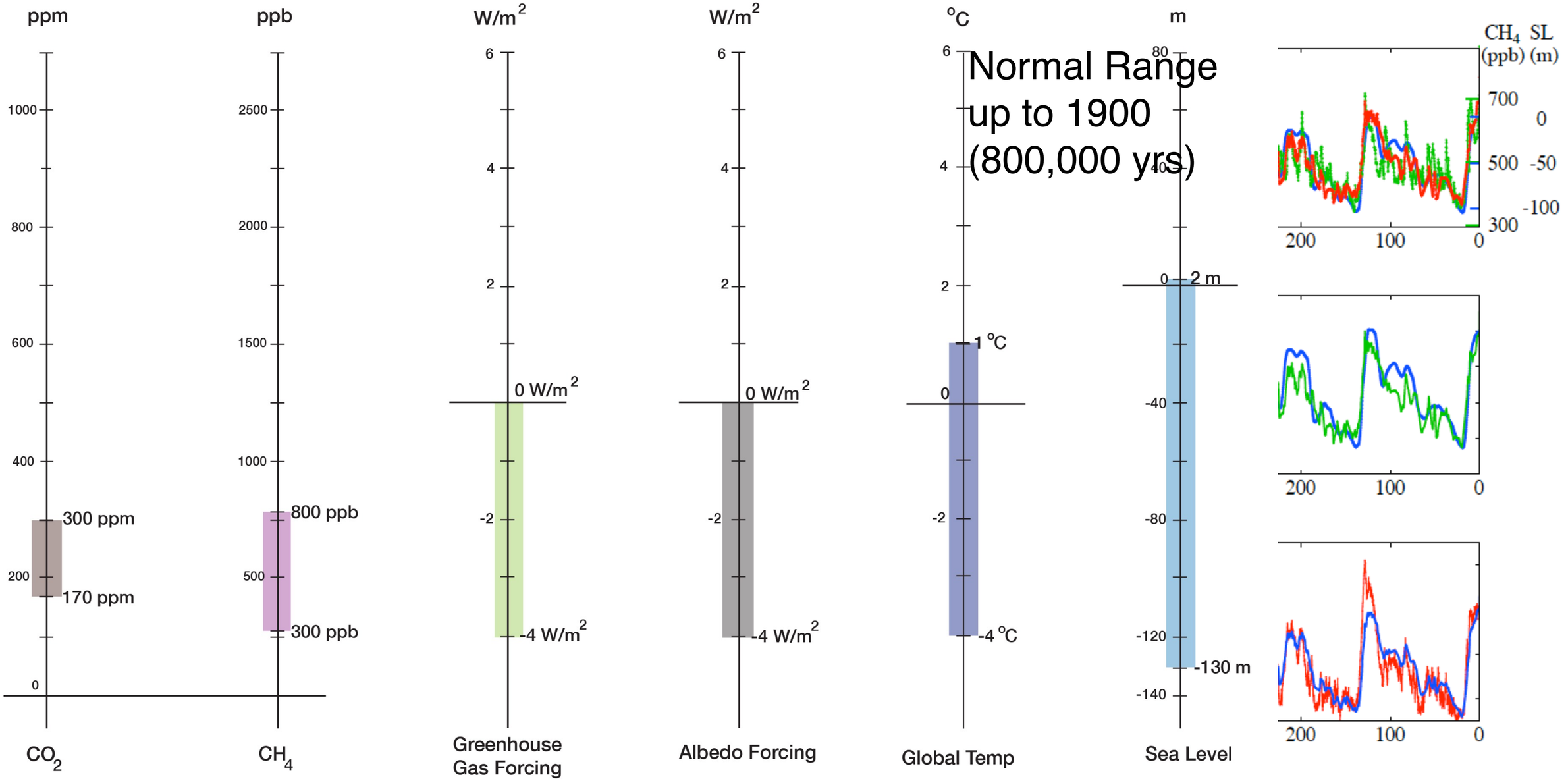
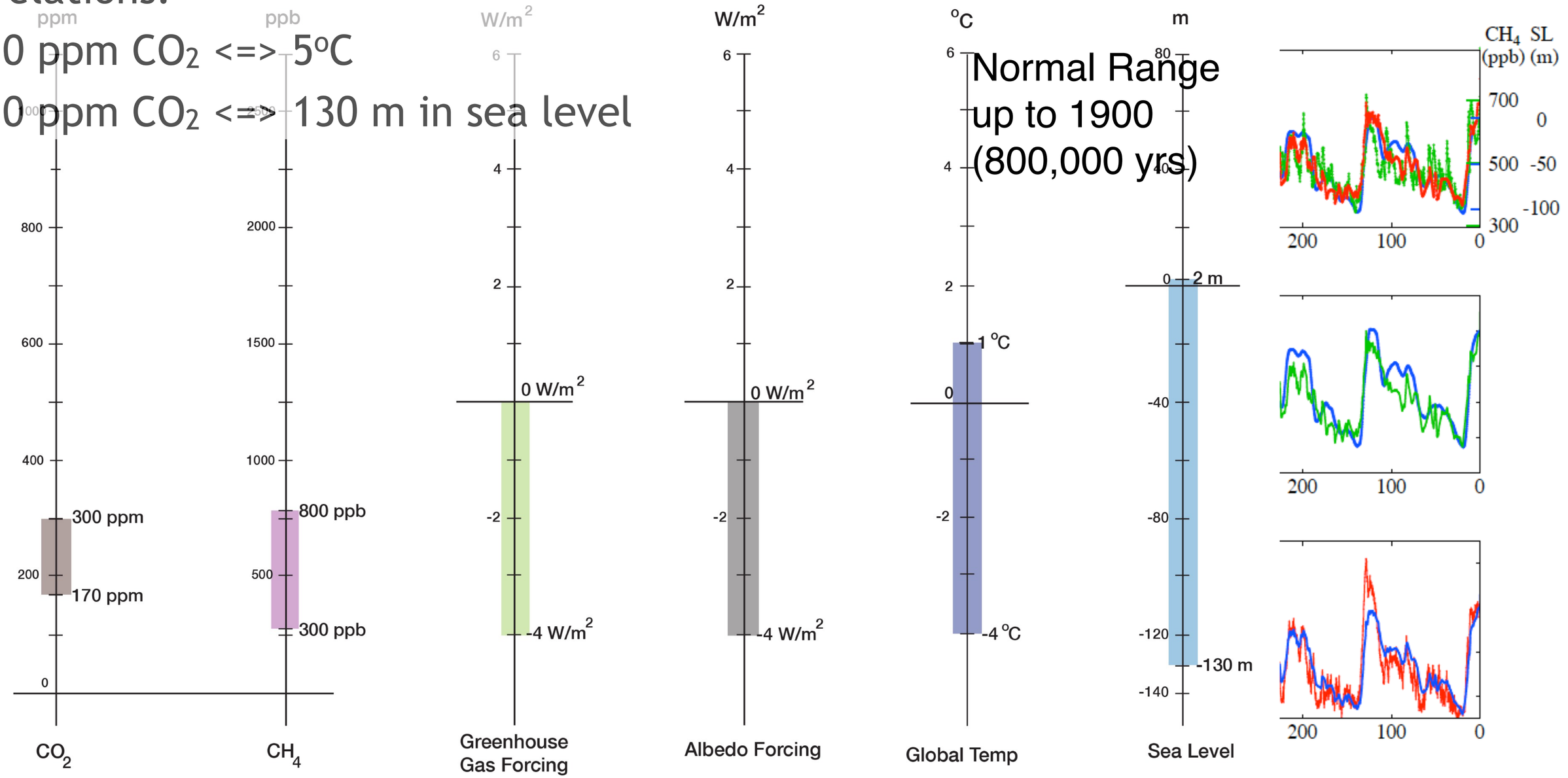


The Baseline: Past Climate and Global Change

Long-term (centuries to millennia) correlations:

- 130 ppm CO_2 <=> 5°C
- 130 ppm CO_2 <=> 130 m in sea level



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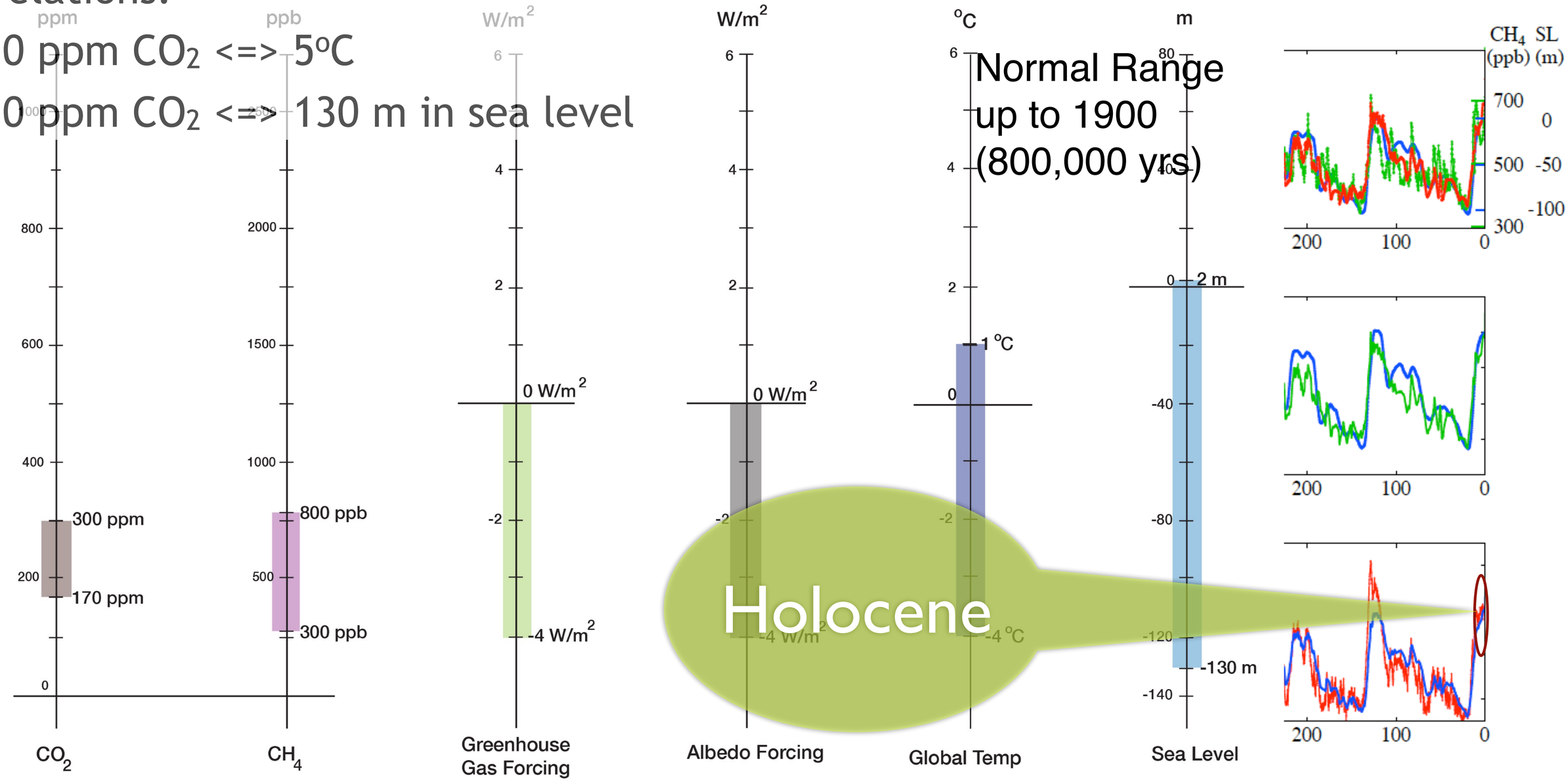

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