Understanding and Mitigating Climate Change

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Outline

- PART 1 - Overview
  - Introduction and Context
  - Consequences
  - Q&A and Discussion
- PART 2 - Science
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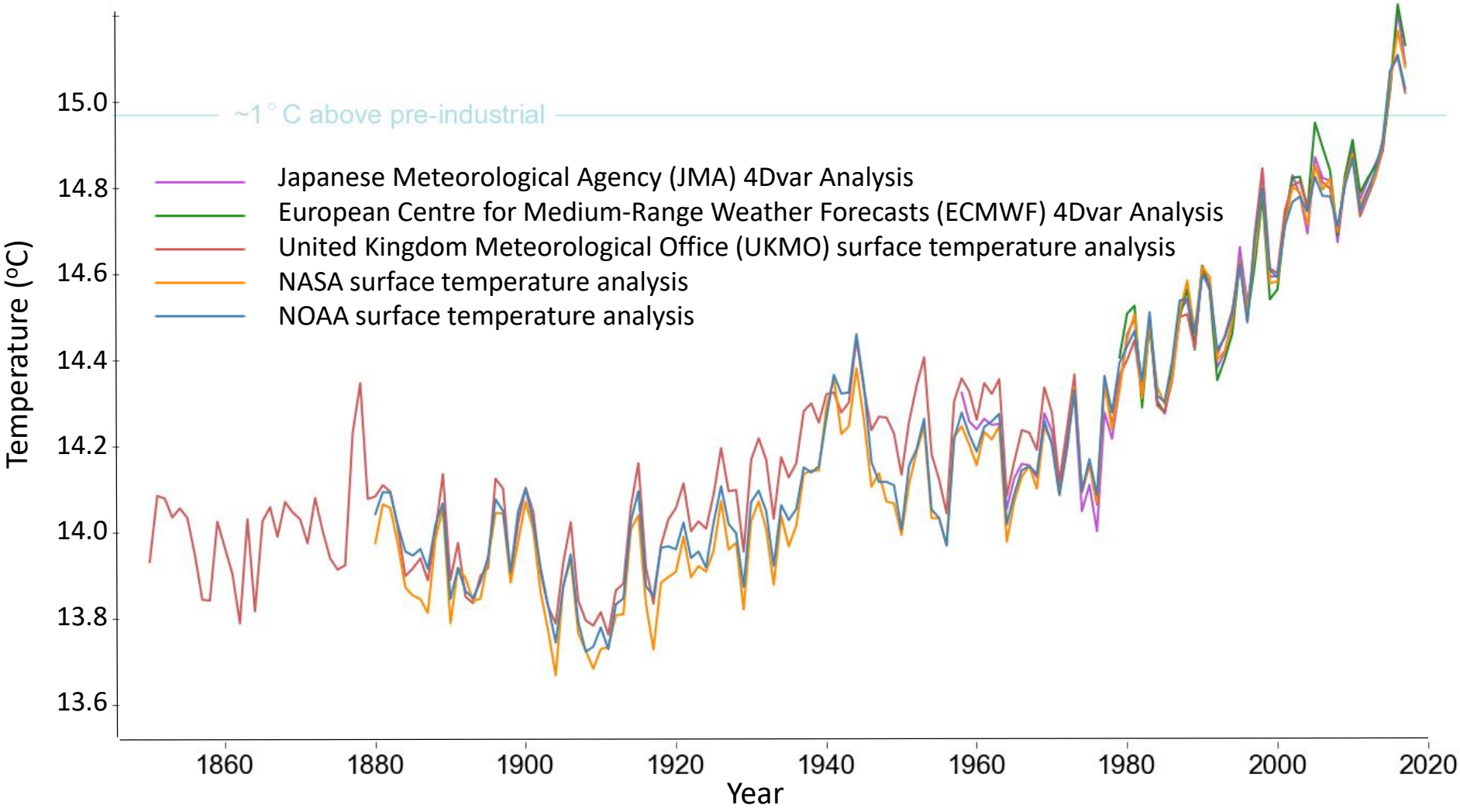
  - Feedback Effects in the Climate System
  - Stability of the Climate System and Global Warming
  - CO_2 and the Carbon Cycle
  - Q&A and Discussion
- PART 3 - Mitigation
  - Sources of CO_2 Emissions
  - International Agreements
  - Legislation
  - Solutions for Mitigating Climate Change
  - Closing Comments
  - Q&A and Discussion

PART 1
Overview

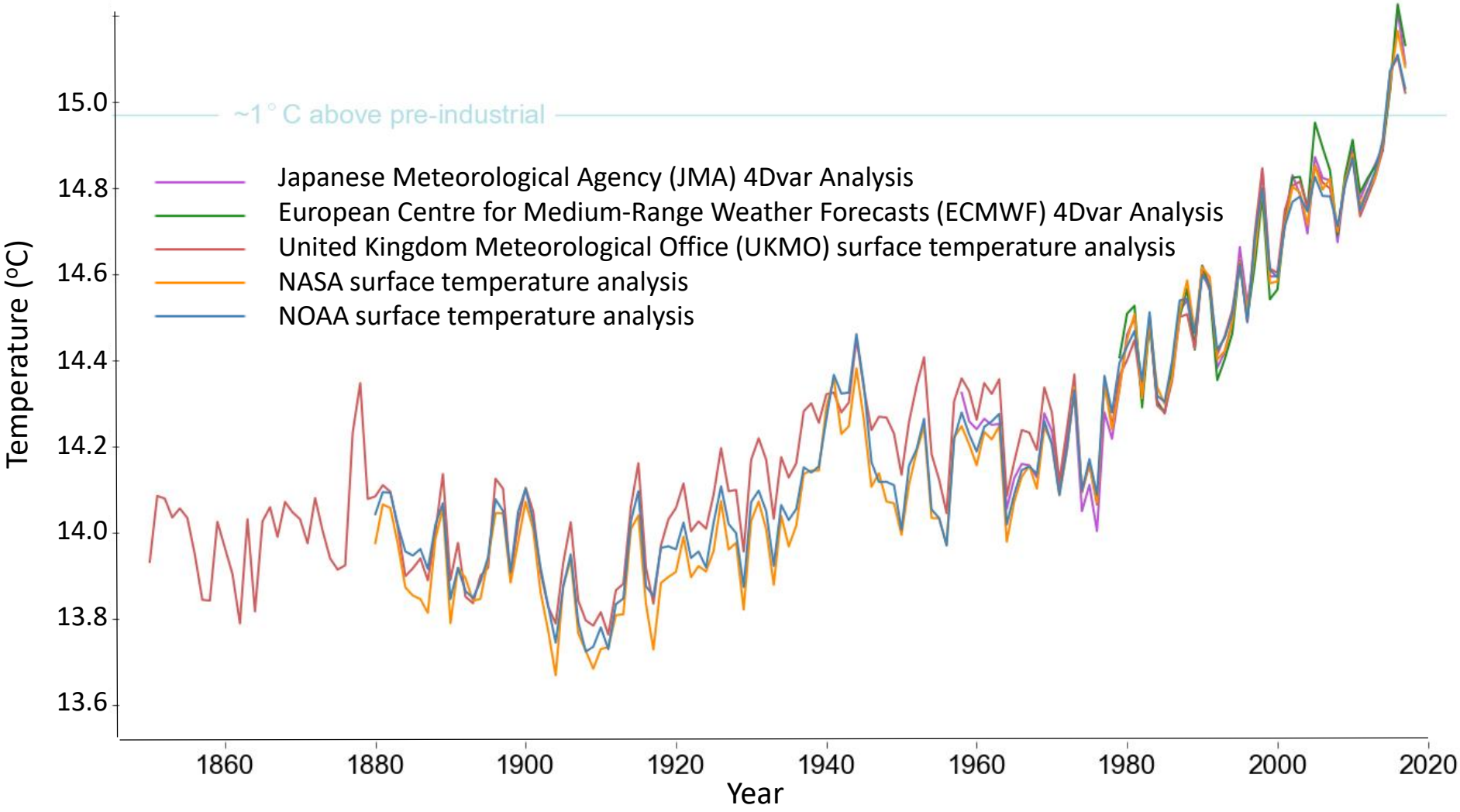
Introduction

Global Mean Surface Temperature (GMST) of the Earth by Year for 1850 to 2017



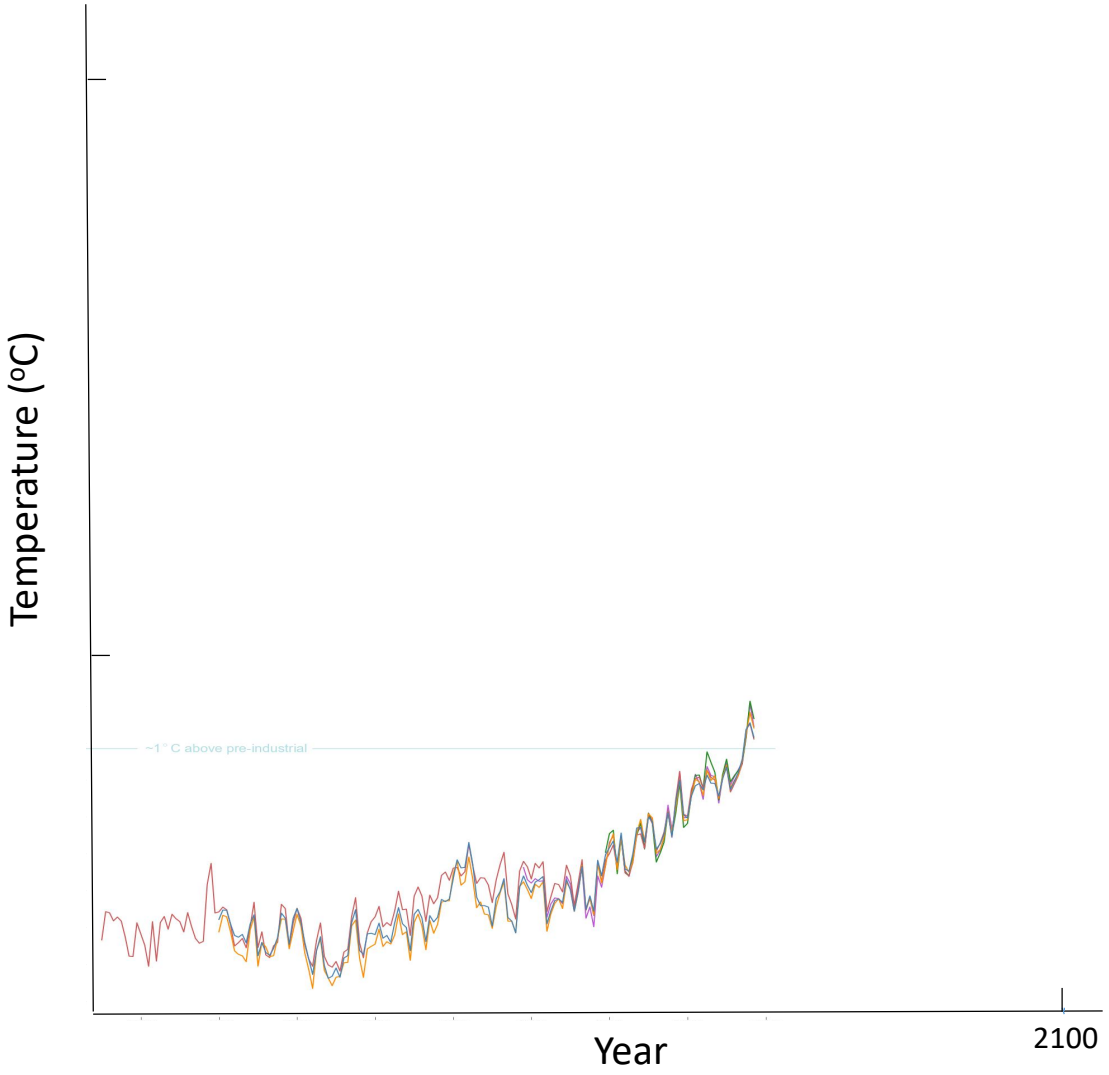
Global Mean Surface Temperature (GMST) of the Earth by year for 1850-2017 from five different analyses produced by five independent groups.

GMST is currently about 1°C above the pre-industrial level. Where will it be in 2100?



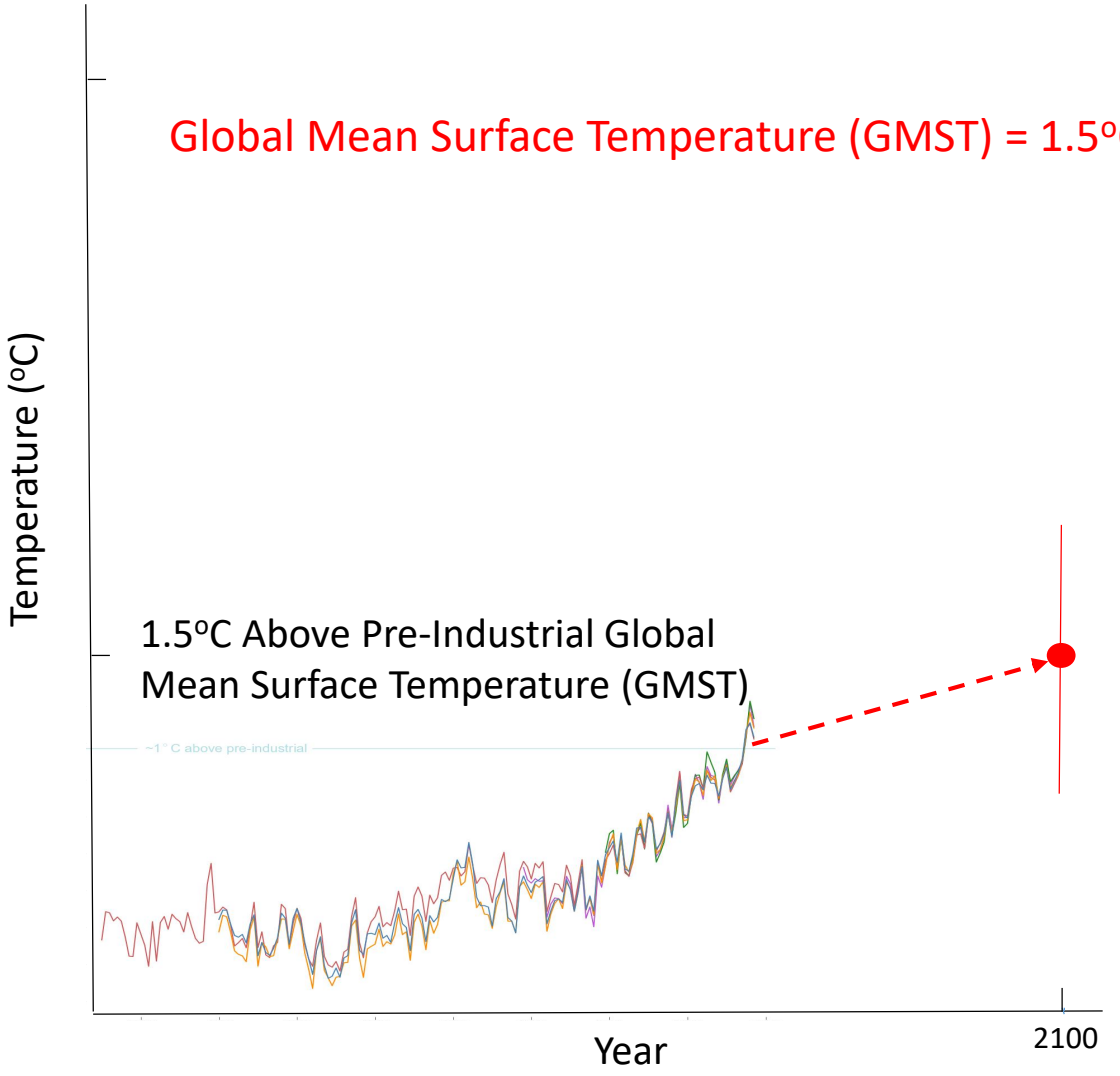
Global Mean Surface Temperature (GMST) of the Earth by year for 1850-2017 from five different analyses produced by five independent groups.

That depends on what "we" (the nations of the world) do!



Predicted GMST in Year 2100 if Follow the Recommendations of the Paris Climate Accord and Achieve Net Zero CO_2 Emissions by 2050

Global Mean Surface Temperature (GMST) = 1.5°C ± 0.7°C above pre-industrial value



The last time the Earth was this warm was about 400,000 years ago

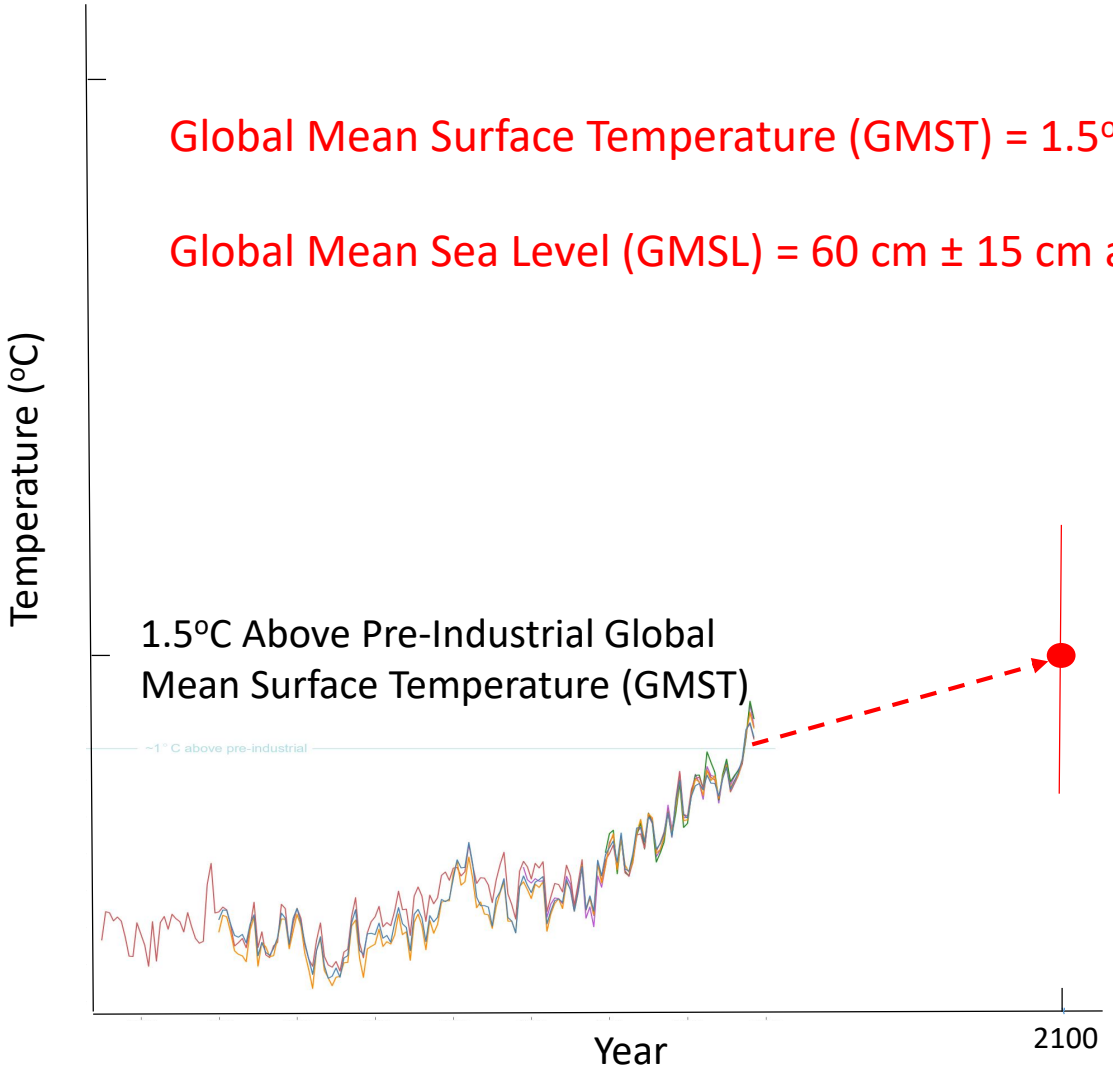
AR5 Synthesis Report: Climate Change 2014. Intergovernmental Panel on Climate Change (IPCC).

RCP 2.6

Predicted GMST in Year 2100 if Follow the Recommendations of the Paris Climate Accord and Achieve Net Zero CO_2 Emissions by 2050

Global Mean Surface Temperature (GMST) = 1.5°C ± 0.7°C above pre-industrial value

Global Mean Sea Level (GMSL) = 60 cm ± 15 cm above pre-industrial value



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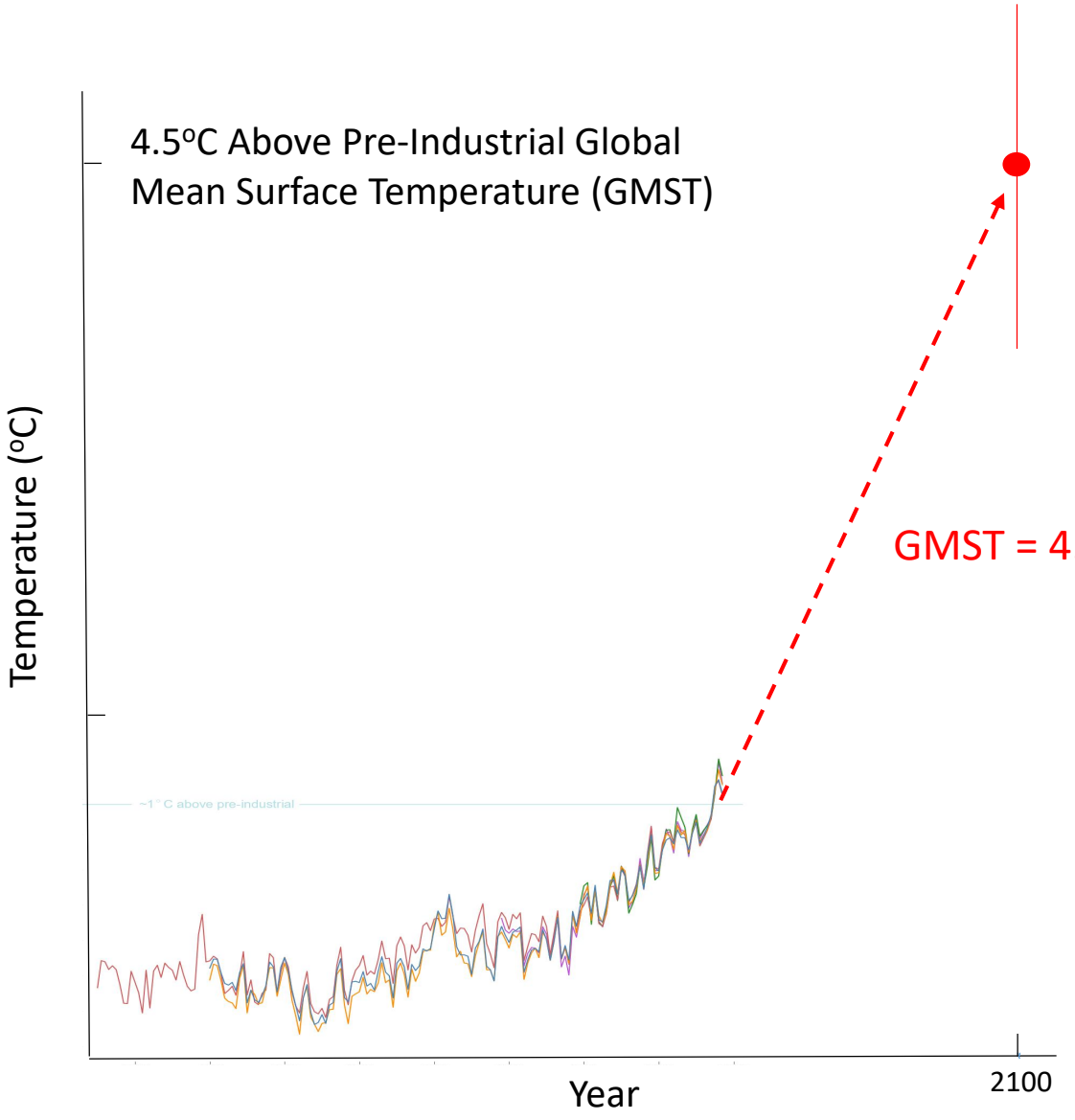

The last time the Earth was this warm was about 5,000,000 years ago

GMST = 4.5°C ± 1.0°C above pre-industrial value

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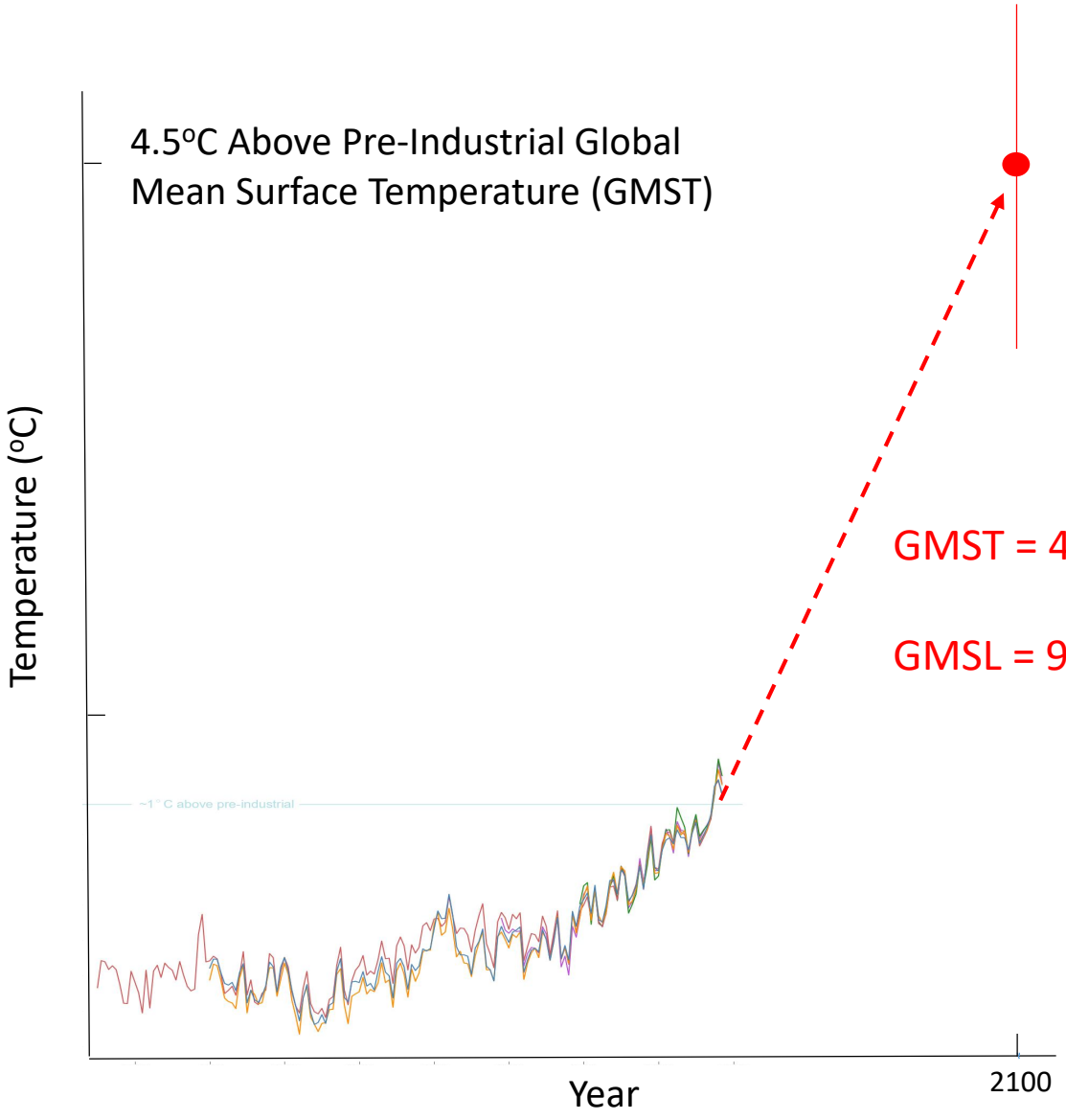
RCP 8.5

Predicted GMST in Year 2100 if Ignore Paris Climate Accord and Continue with "Business as Usual"



The last time the Earth was this warm was about 5,000,000 years ago

GMST = 4.5°C ± 1.0°C above pre-industrial value

GMSL = 90 cm ± 20 cm above pre-industrial value

AR5 Synthesis Report: Climate Change 2014. Intergovernmental Panel on Climate Change (IPCC).

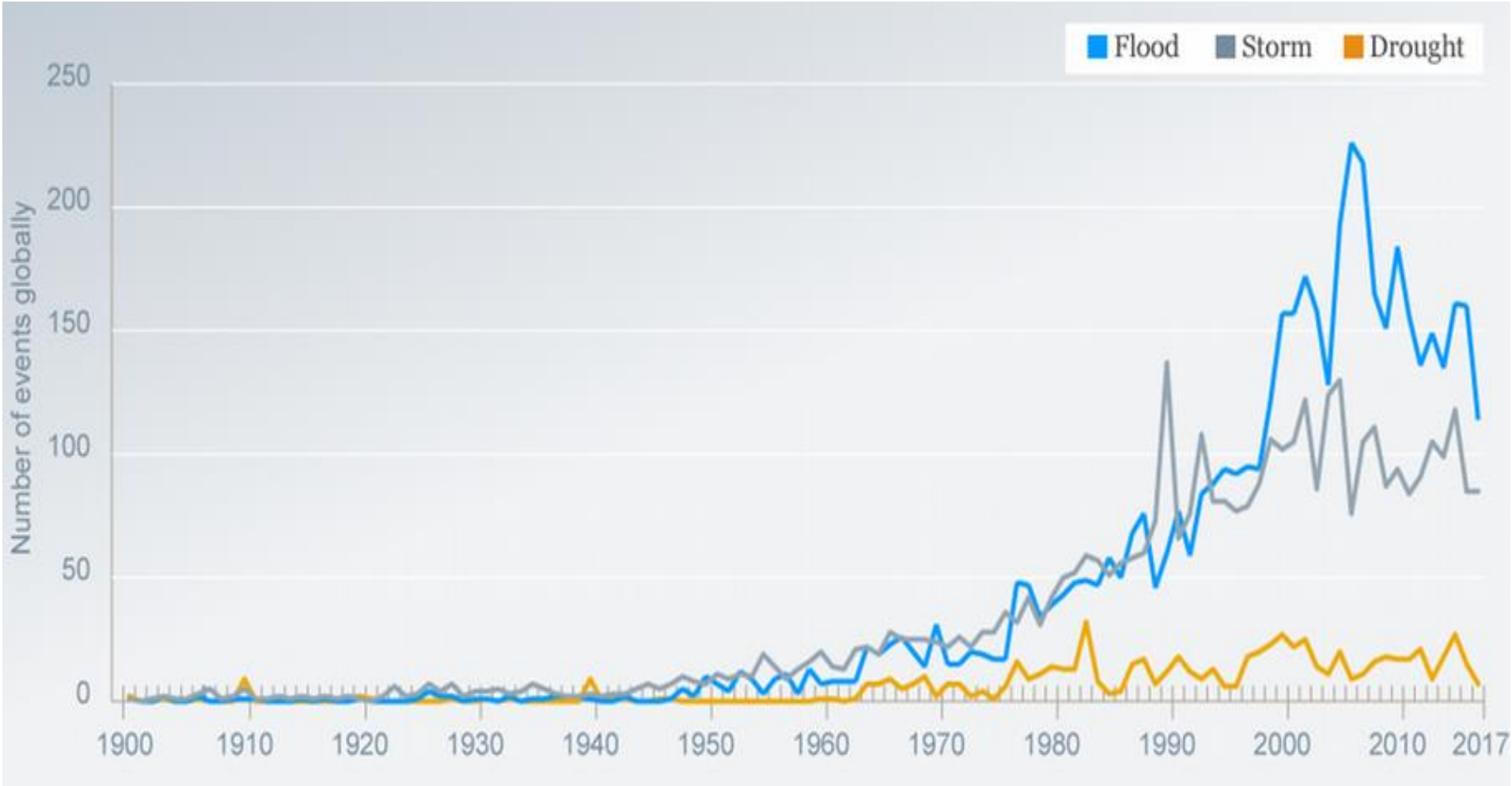
RCP 8.5

Consequences

Natural Consequences of a Warming World

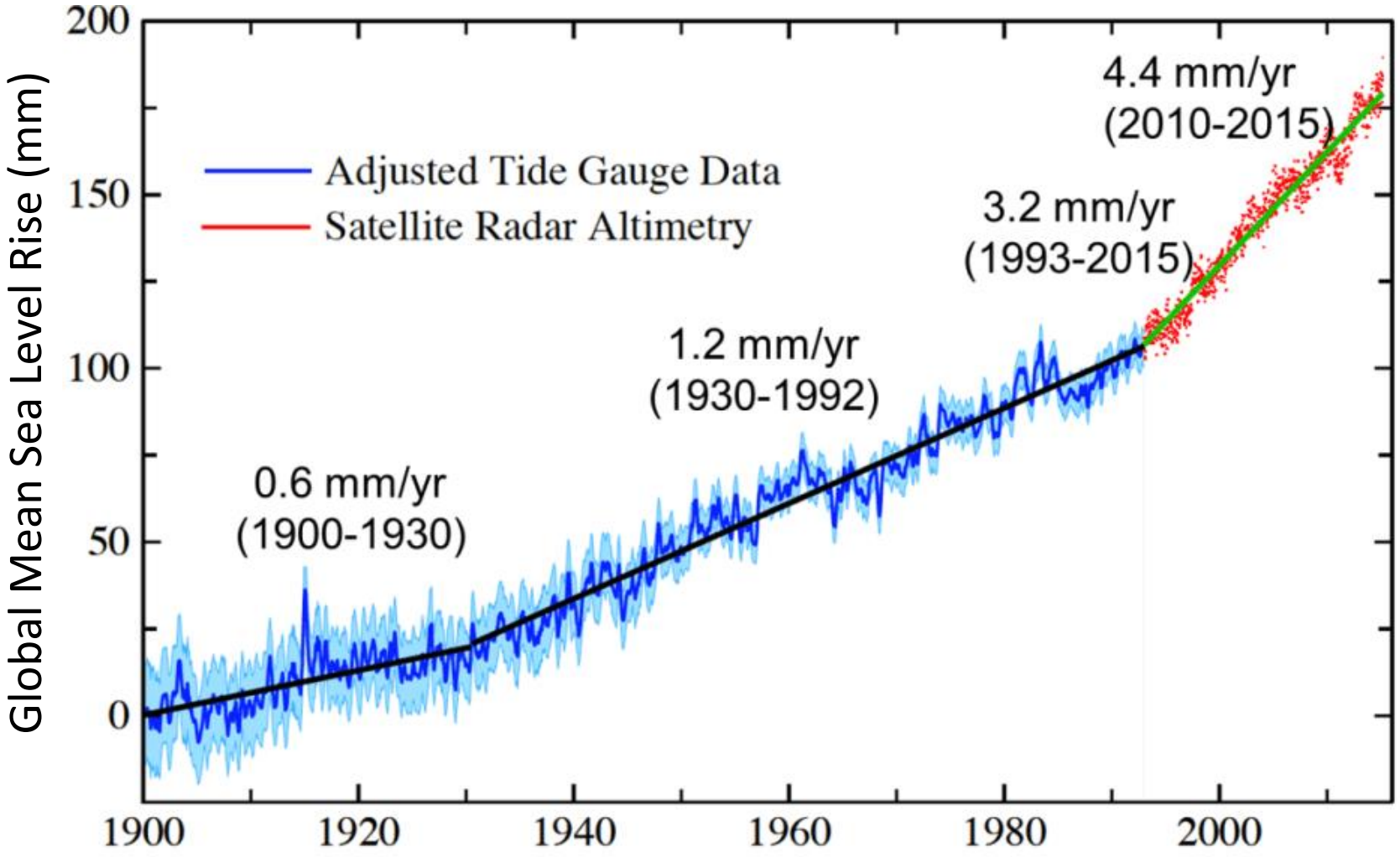
- Increasing temperature of the land, ocean and lower troposphere.
- Decreasing temperature of the upper troposphere and above.
- **Increasing frequency and intensity of severe storms.**
- Increasing Absolute Humidity (i.e., moisture) in the troposphere.
- **Increasing frequency and intensity of floods in normally wet regions.**
- Decreasing Relative Humidity in the lower troposphere over land.
- Decreasing mountain snowpacks.
- **Increasing frequency and intensity of droughts and wildfires in normally dry regions.**
- Melting of glaciers and ice sheets.
- **Rising sea levels.**
- Decreasing pH of seawater (ocean acidification).
- Decreasing oxygen levels in the ocean.
- **Increasing mortality of coral reefs (coral bleaching).**
- **Decreasing productivity of fisheries.**
- **Increasing species extinctions.**

Global Number of Extreme Weather Events by Year from 1900 to 2017



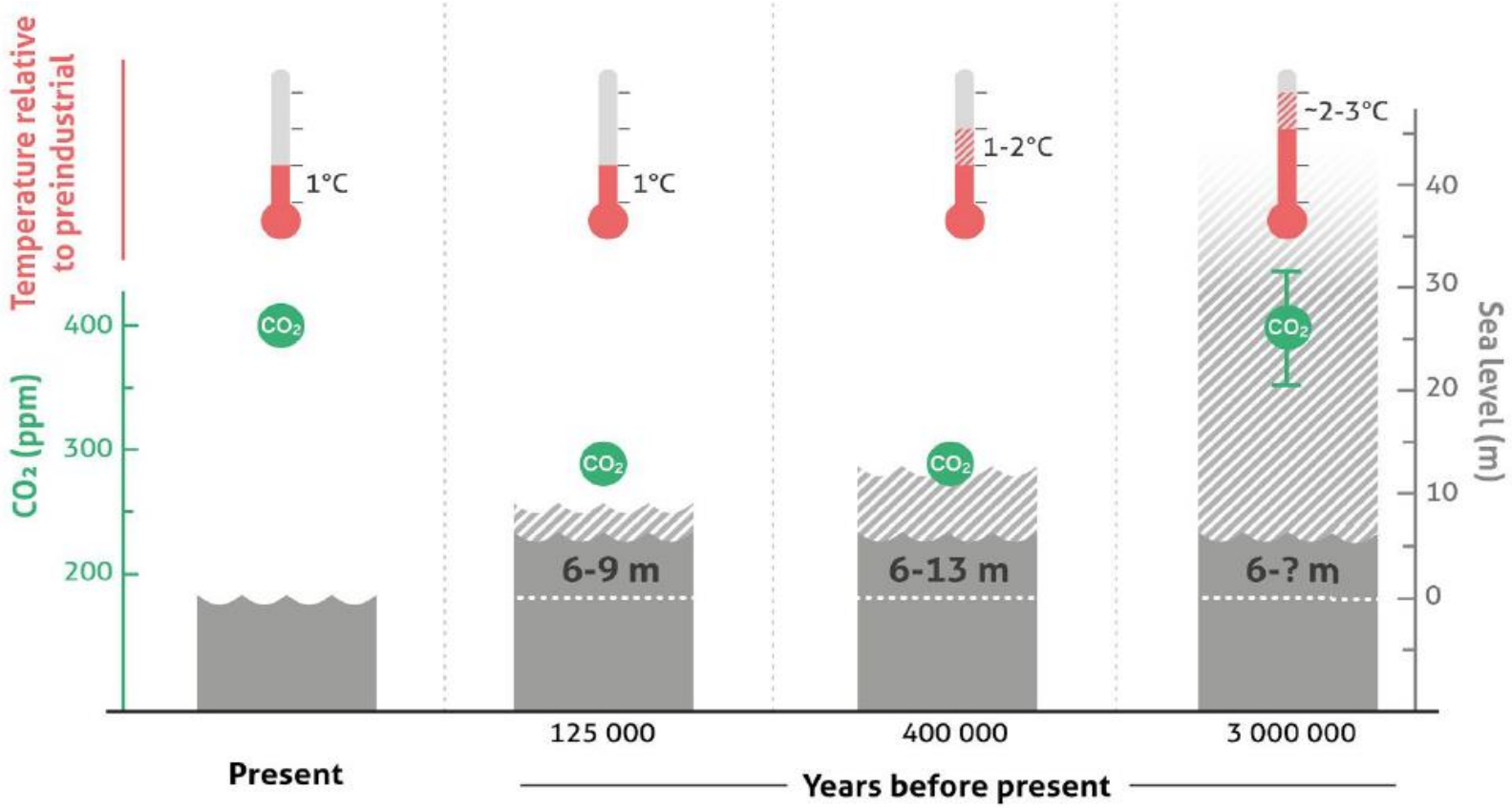
Global number of extreme weather events by year, from 1900 to 2017, as cataloged in the Emergency Events Database (EM-DAT; www.emdat.be) produced by the Centre for Research on the Epidemiology of Disasters (CRED; www.cred.be).

Global Mean Sea Level Rise from 1900 to 2015



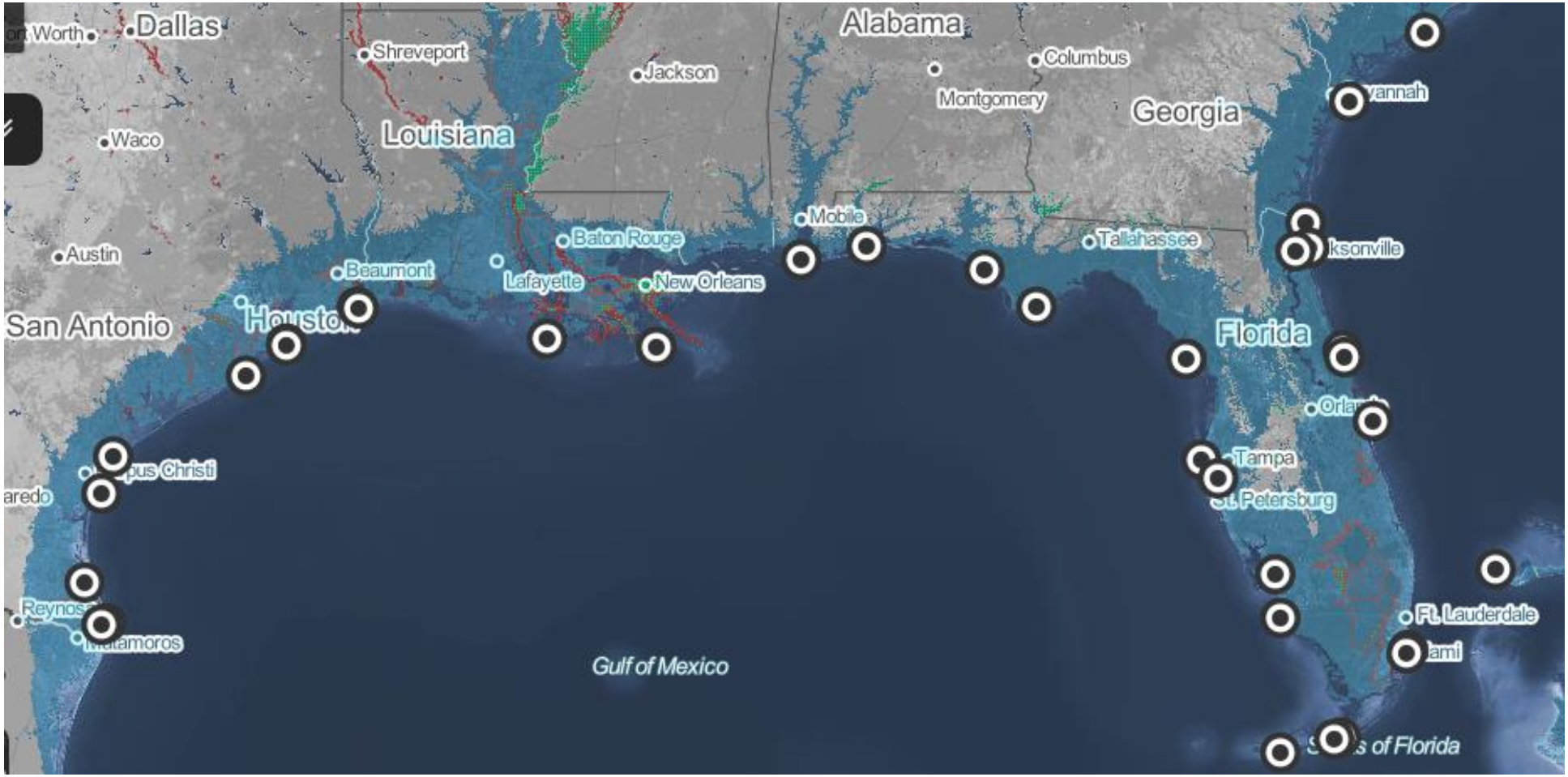
Global Mean Sea Level (GMSL) Rise in millimeters from 1900 to 2015 from tide gauge data (blue) and satellite radar altimetry data (red). After Hay *et al.* (2015).

Sea Level Rise During Past Interglacial Warm Periods



In several past interglacial warm periods between ice ages, Global Mean Surface Temperatures (GMSTs) reached levels comparable to what we are experiencing now or expect by the end of this century. The resulting Global Mean Sea Level (GMSL) rise during these periods provides guidance on **what we should expect many centuries into the future** as the oceans continue to warm and the ice continues to melt. After Dutton *et al*. 2015.

Areas Permanently Flooded by 30 m of Sea-Level Rise



surgingseas.com

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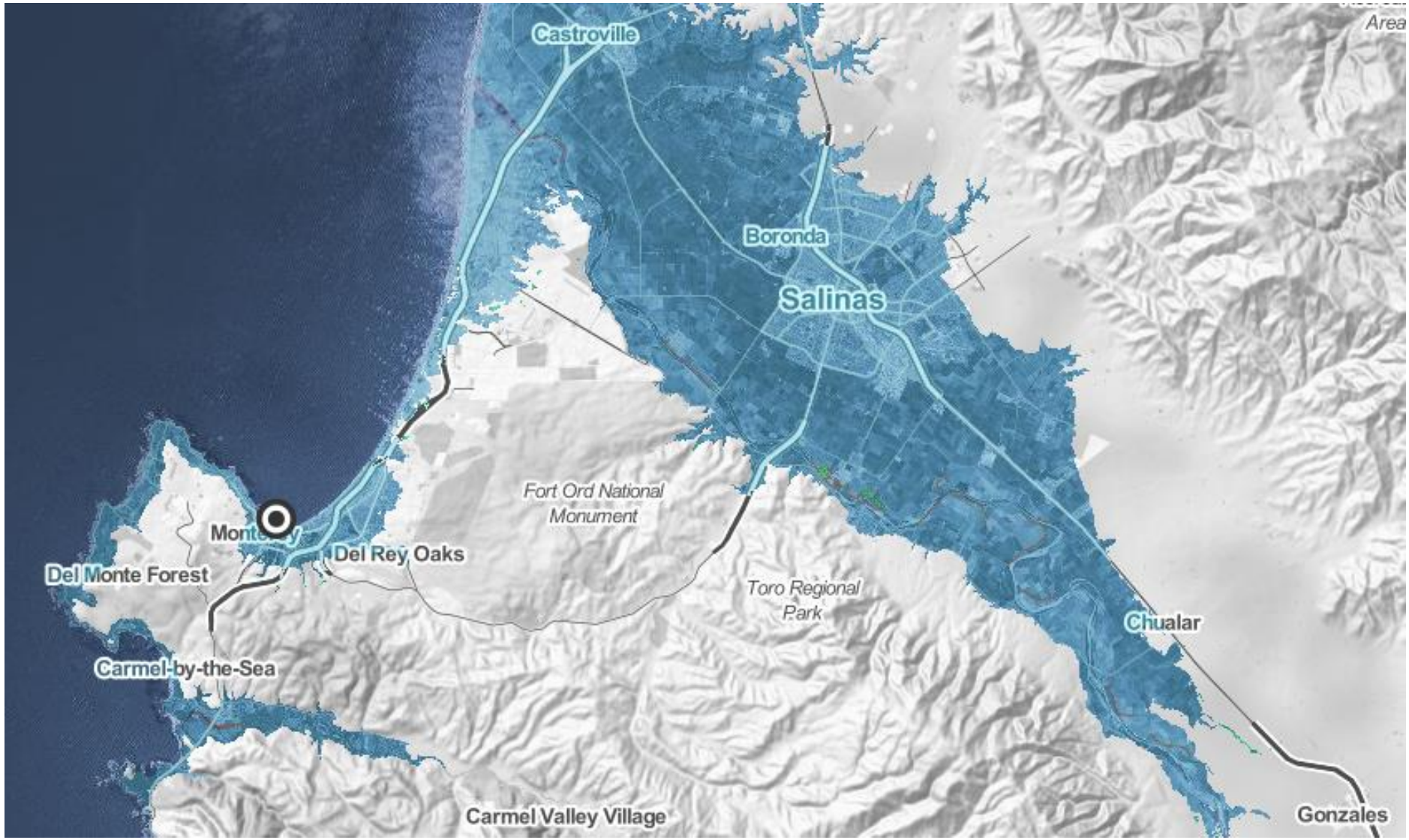


surgingseas.com

Possible Climate-Change "Tipping Points"

- As global temperatures rise, there is a real risk, however small, that one or more critical parts of the Earth's climate system will experience abrupt, unpredictable, and potentially irreversible changes (a "Tipping Point") with highly damaging impacts.
- Unfortunately, we do not know precisely how much warming is required to trigger these Tipping Points
- Some could result in strong positive feedbacks that would abruptly accelerate the rise of global temperatures and sea levels.

Human Consequences of a Warming World

- **Increasing economic costs, resulting from increasing frequency and intensity of damaging weather events, increasing prevalence of wild fires, and rising sea levels.**
- **Increasing competition among nations for water and food caused by increasing drought and decreasing agricultural and fisheries production.**
- Increasing threat of disease as tropical diseases spread into the higher latitudes.
- **Increasing displacements of people and unrest in populations susceptible to recruitment by violent extremist groups, caused by increasing drought, floods, extreme weather and sea level rise.**
- **Increasing human mortality from heat waves, other severe weather events, starvation, disease and war.**
- Risks are unevenly distributed between groups of people and between regions; risks are generally greater for disadvantaged people living in developing countries.

"It may sound frightening, but the scientific evidence is that if we have not taken dramatic action within the next decade, **we could face irreversible damage to the natural world and the collapse of our societies**."

"I believe that if we better understand the threat we face the more likely it is we can avoid such a catastrophic future."

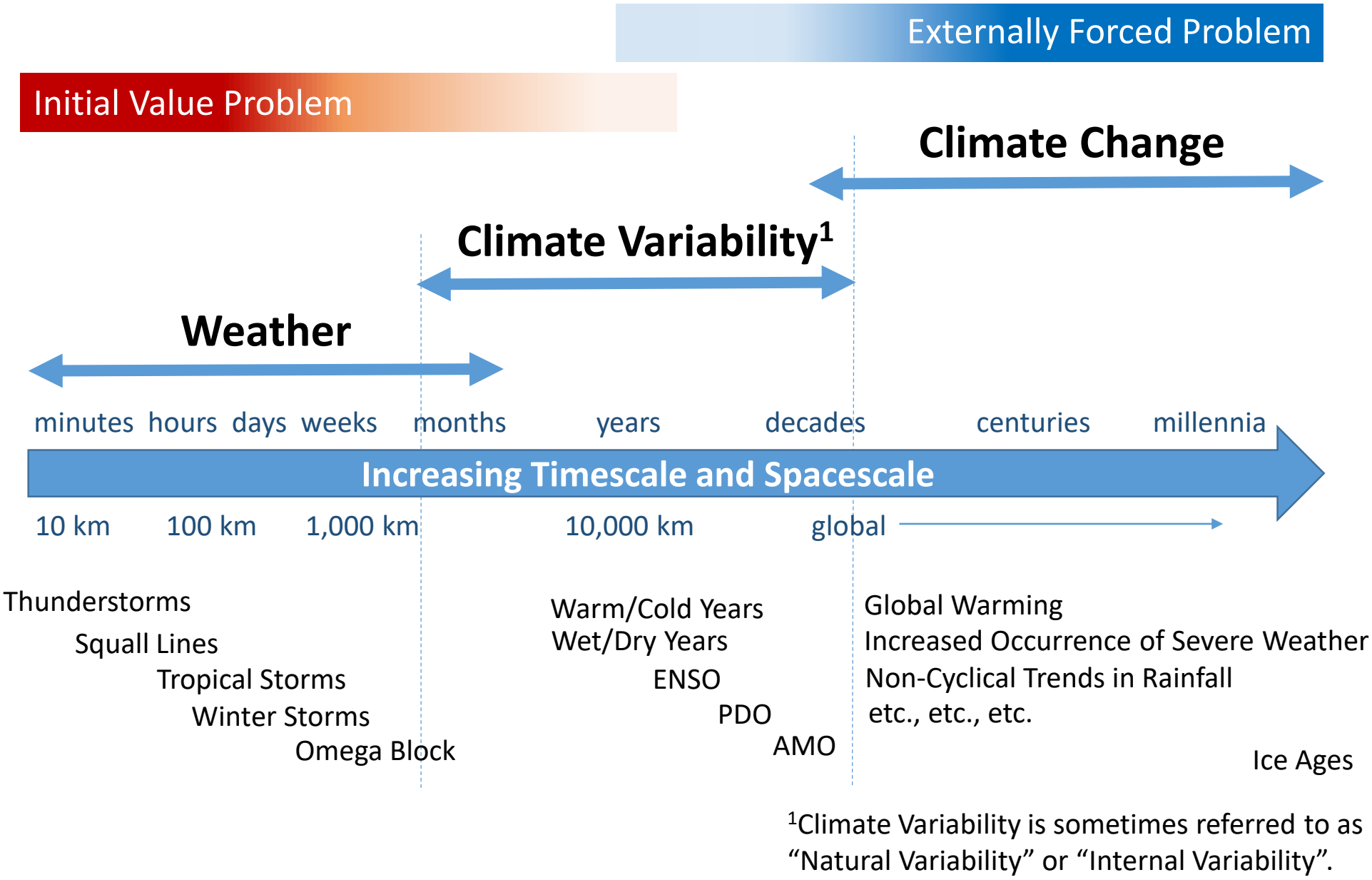
Sir David Attenborough

Q&A and Discussion

PART 2
Science

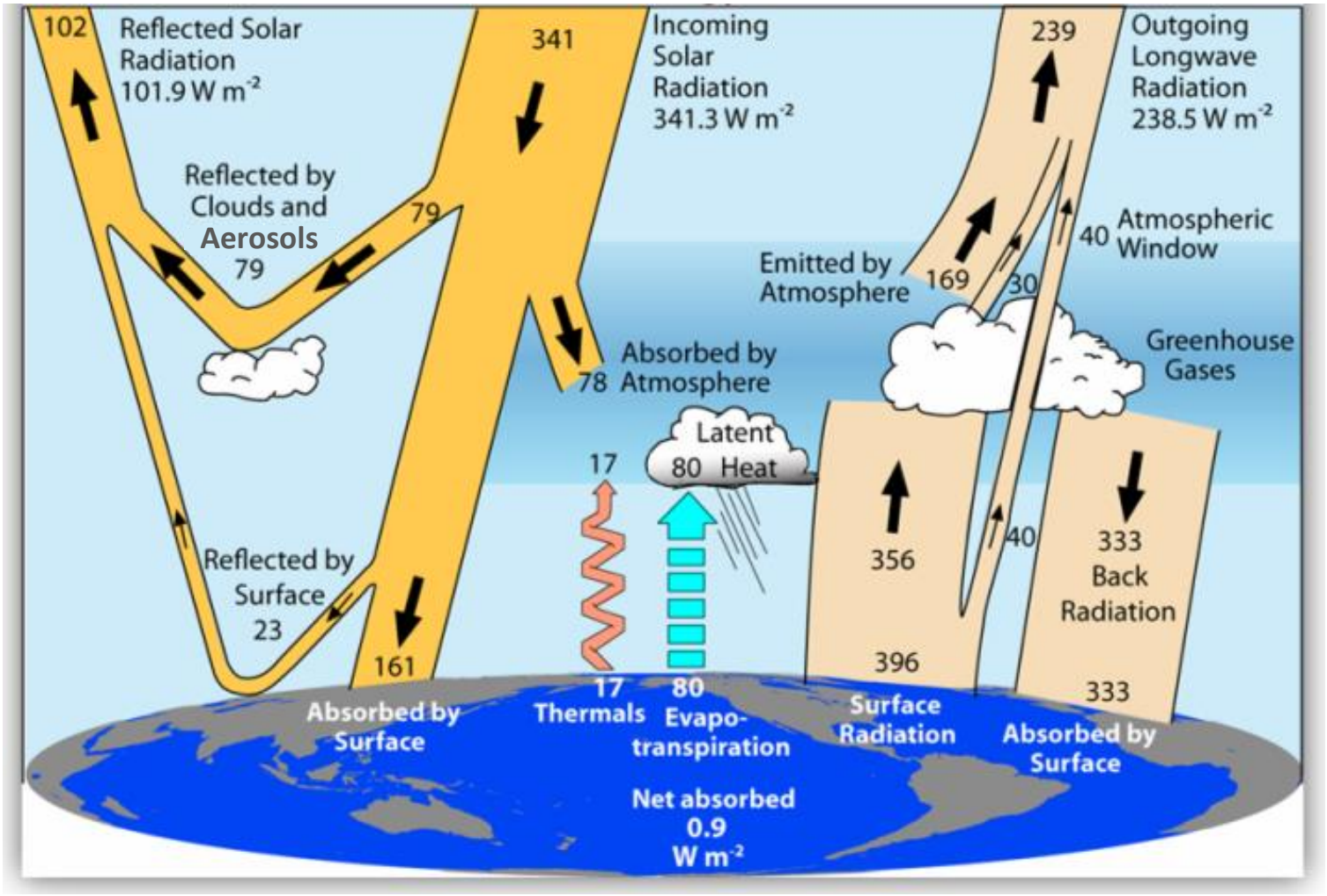
External Forcing of the Climate System

Fundamental Differences Between Weather, Climate Variability, and Climate Change



[1]Climate Variability is sometimes referred to as "Natural Variability" or "Internal Variability".

The Earth's Global Annual Mean Energy Budget



H_2O

CO_2

CH_4

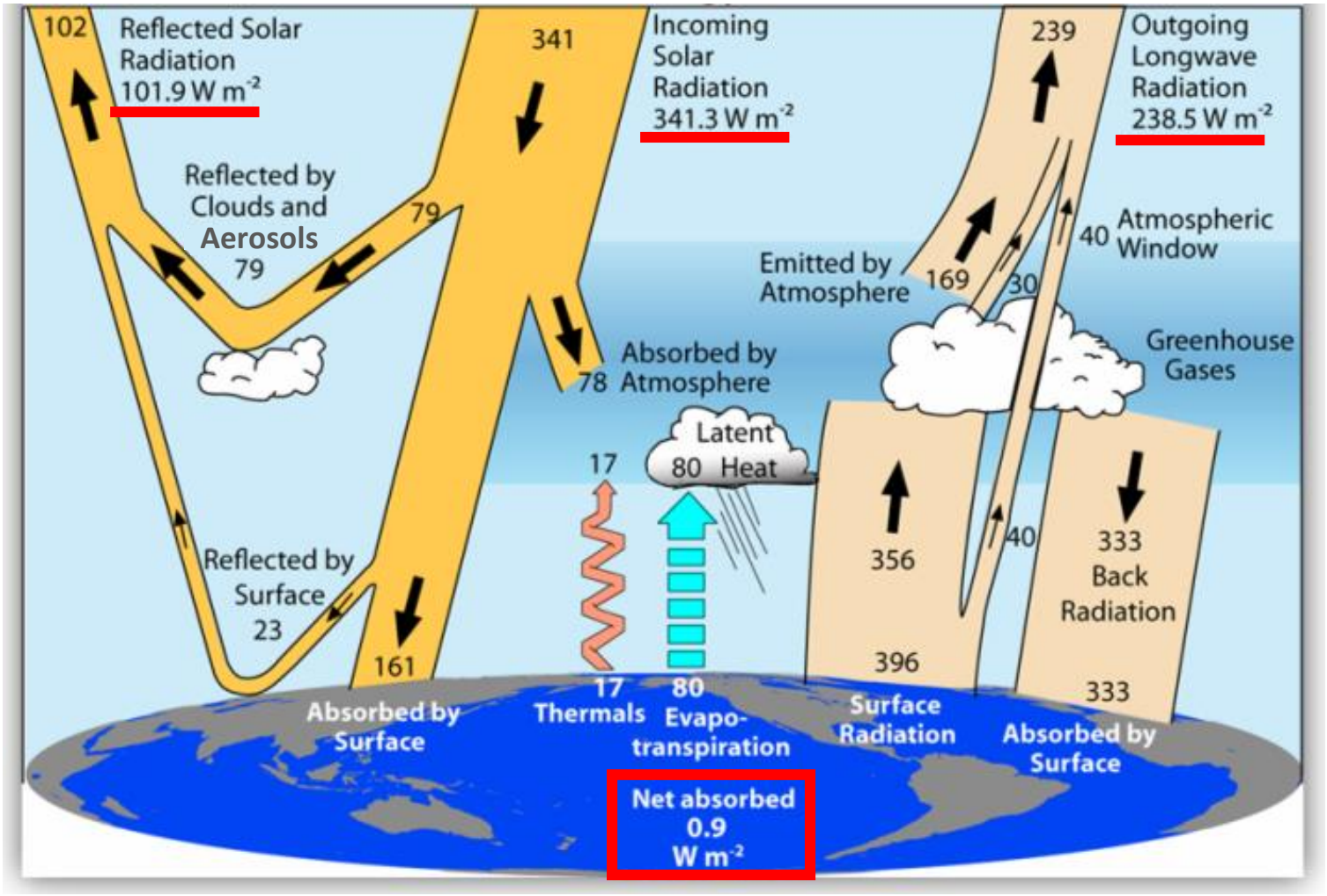
N_2O

HFCs

O_3

The earth's **Global Annual Mean Energy Budget**, averaged over the six-year period from 2000 to 2005, in Watts per square meter (W m^{-2}). After Trenberth *et al.* (2009).

The Earth's Global Annual Mean Energy Budget



H_2O

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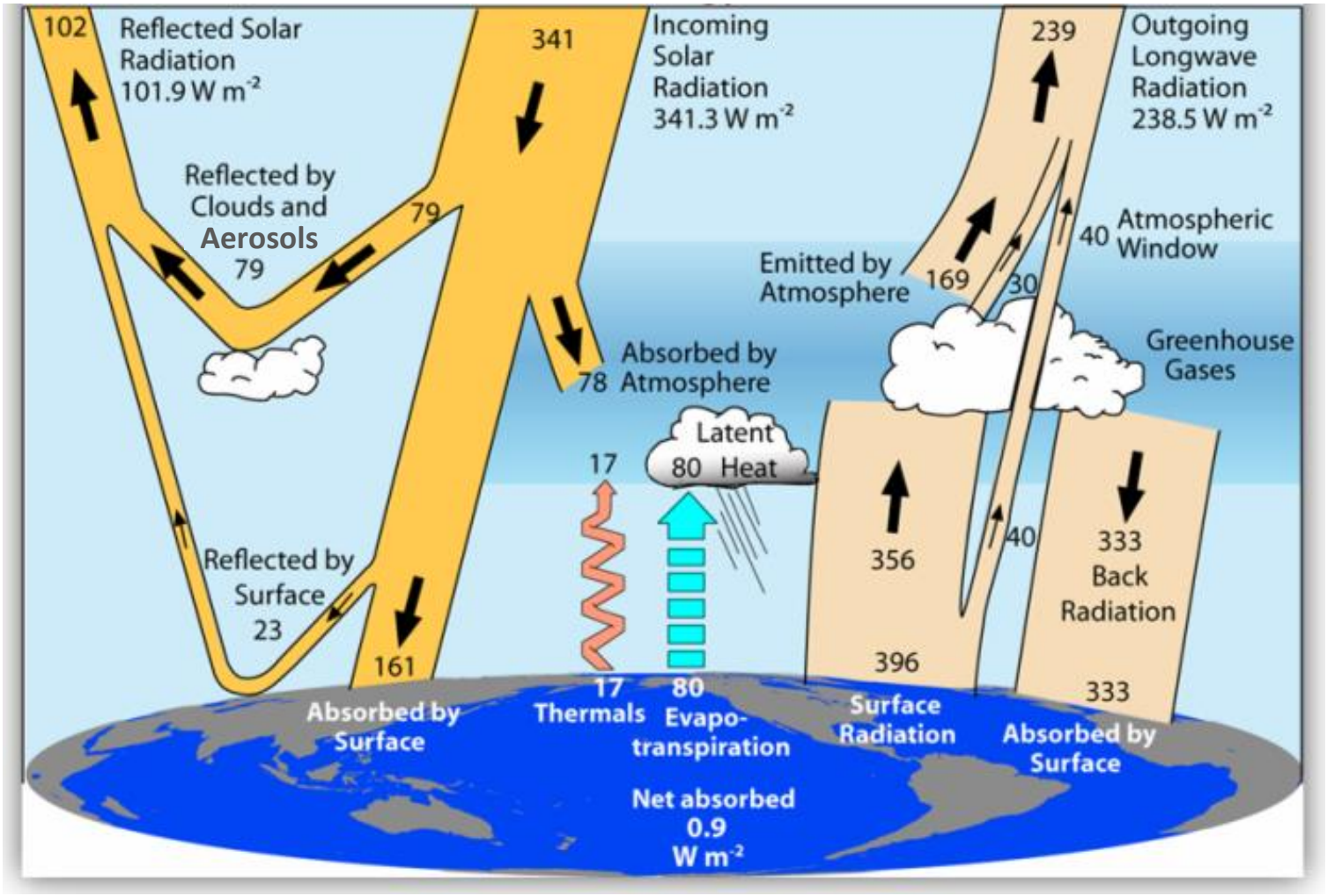
Global warming and climate change are driven by the net radiation balance at the top of the atmosphere, which is given by the Incoming Solar Radiation, minus the Reflected Solar Radiation and Outgoing Longwave (IR) Radiation. This radiation balance determines the rate at which heat is absorbed by the Earth, 0.9 W m^{-2} for the period 2000-2005 shown here.

External Forcing of the Climate System



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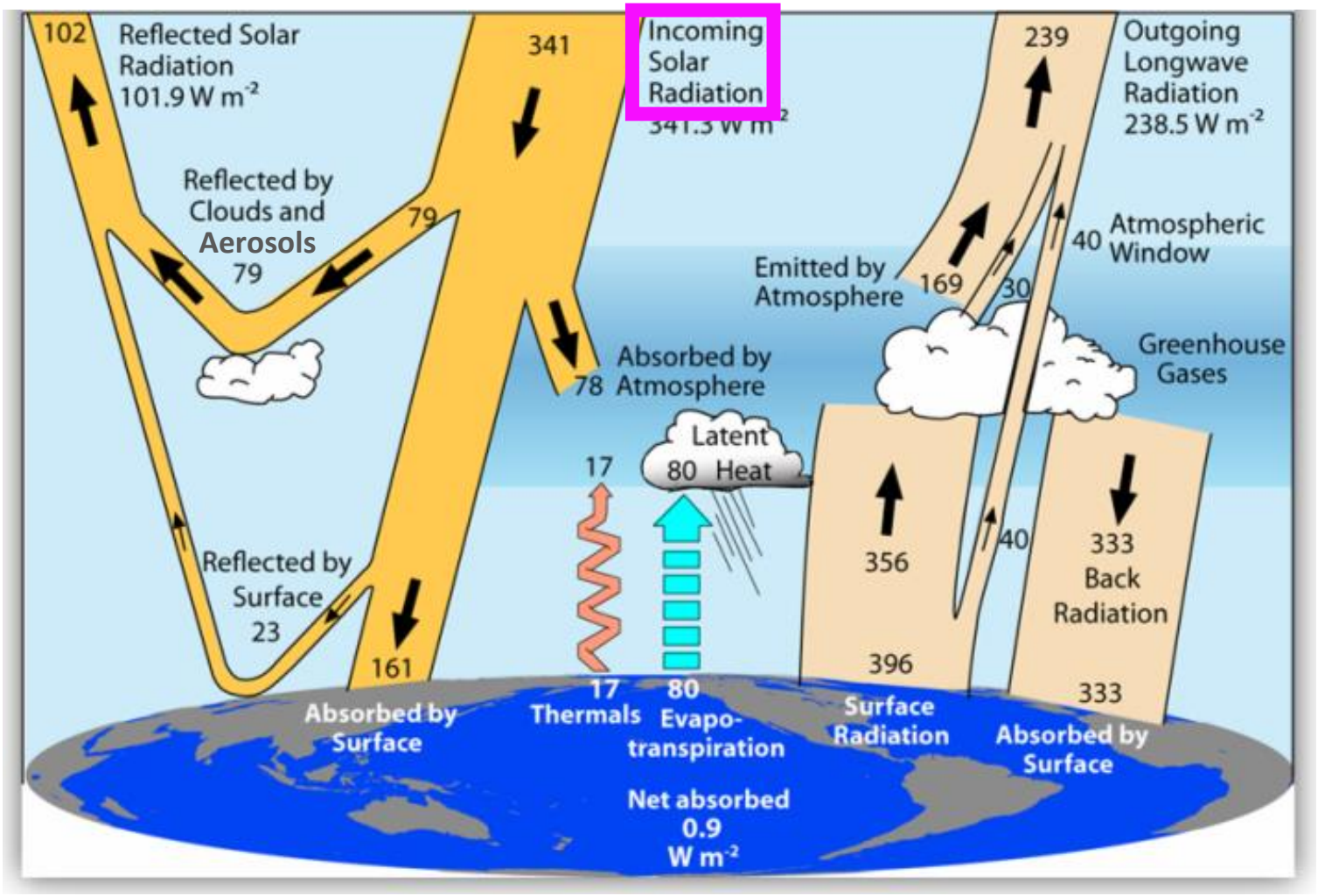
On Timescales of centuries to a few thousand years, the net radiation balance at the top of the atmosphere, and thus the Earth's Climate System, is externally forced by three factors:

External Forcing of the Climate System



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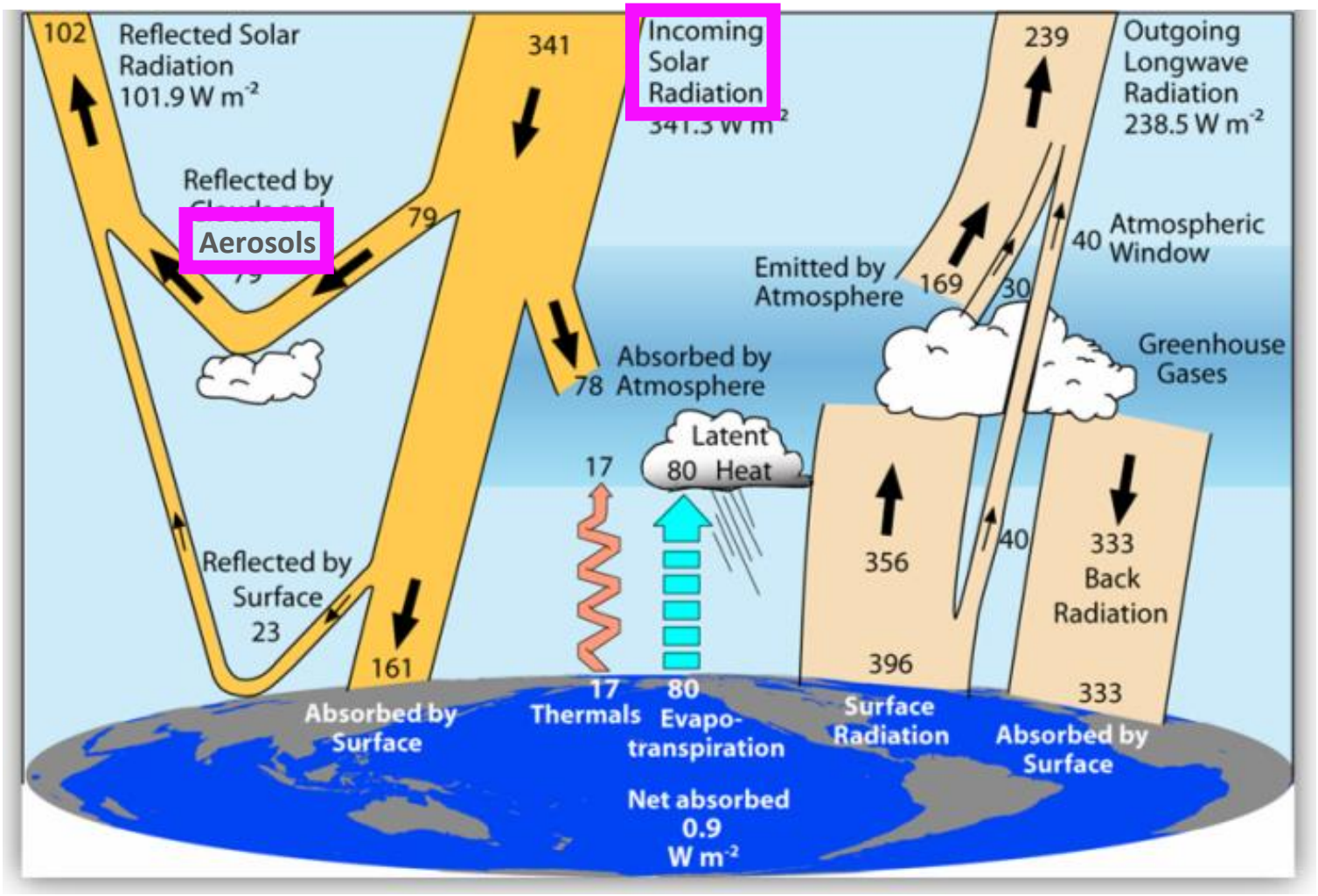
On Timescales of centuries to a few thousand years, the net radiation balance at the top of the atmosphere, and thus the Earth's Climate System, is externally forced by three factors: (1) Incoming Solar Radiation,

External Forcing of the Climate System



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On Timescales of centuries to a few thousand years, the net radiation balance at the top of the atmosphere, and thus the Earth's Climate System, is externally forced by three factors: (1) Incoming Solar Radiation, (2) Aerosols in the atmosphere, mainly ash from volcanic eruptions, and

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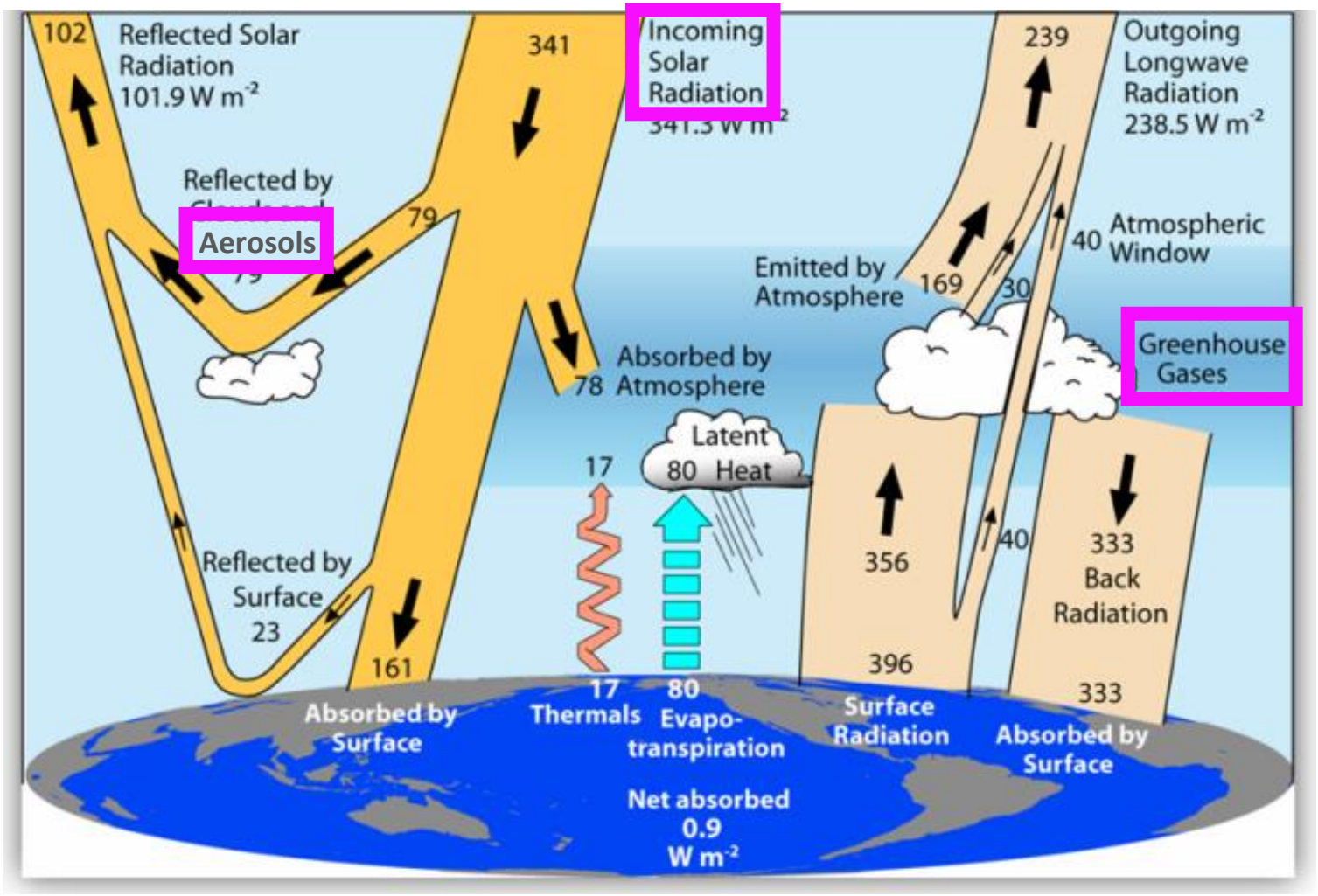

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CH_4

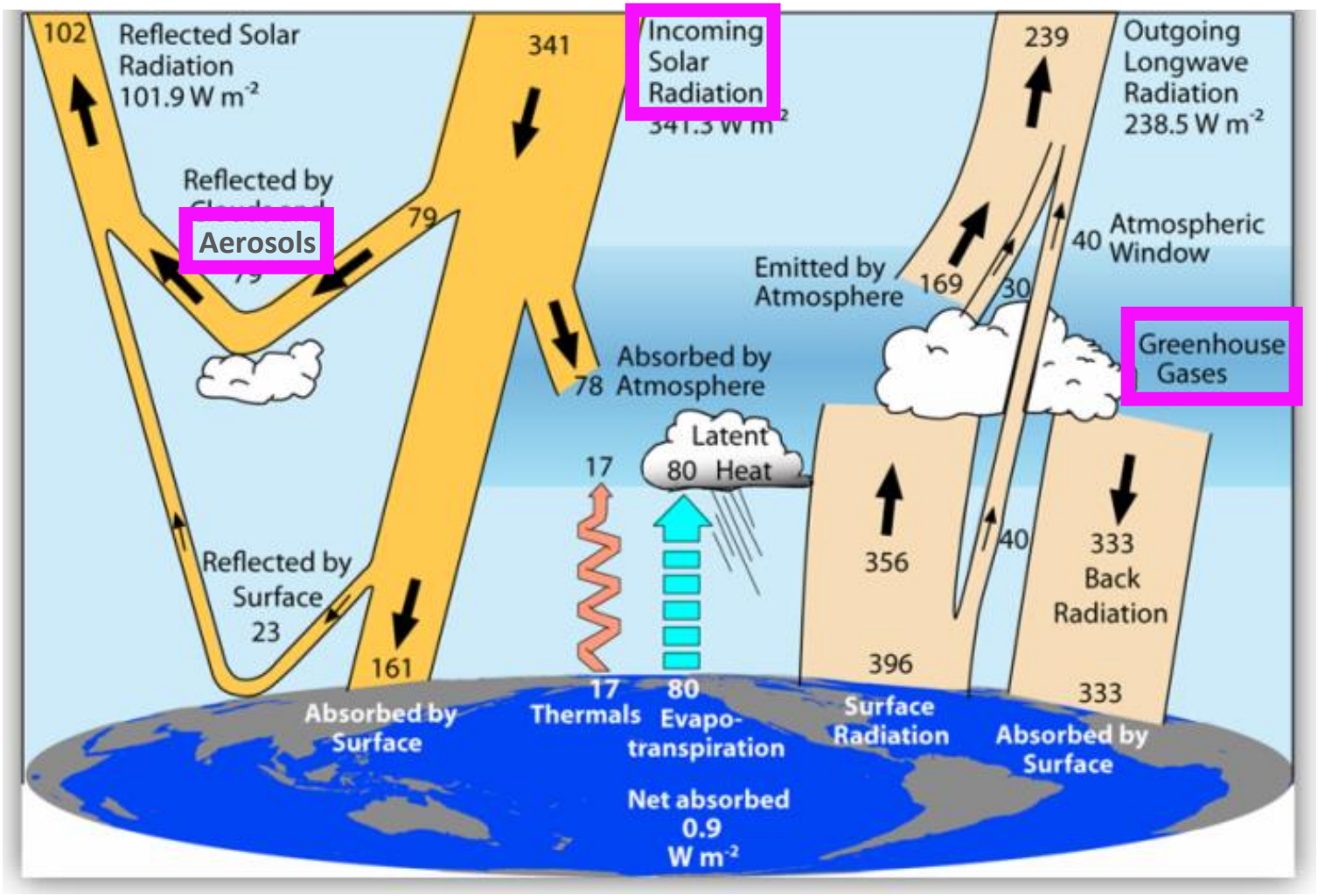
N_2O

HFCs

O_3

On Timescales of centuries to a few thousand years, the net radiation balance at the top of the atmosphere, and thus the Earth's Climate System, is externally forced by three factors: (1) Incoming Solar Radiation, (2) Aerosols in the atmosphere, mainly ash from volcanic eruptions, and (3) Greenhouse Gases in the atmosphere.

External Forcing of the Climate System



H_2O

CO_2

CH_4

N_2O

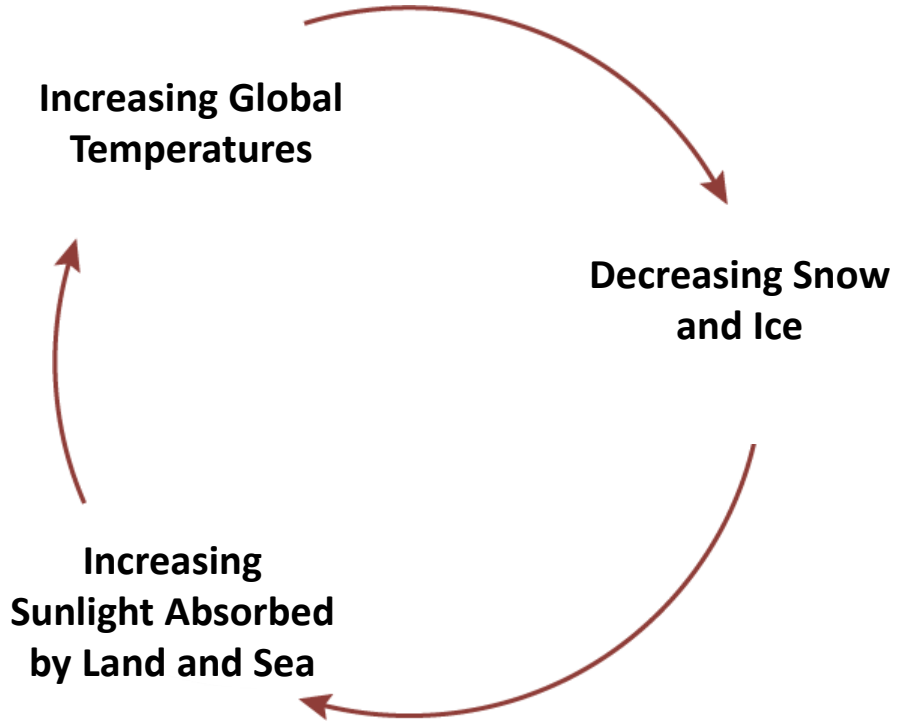
HFCs

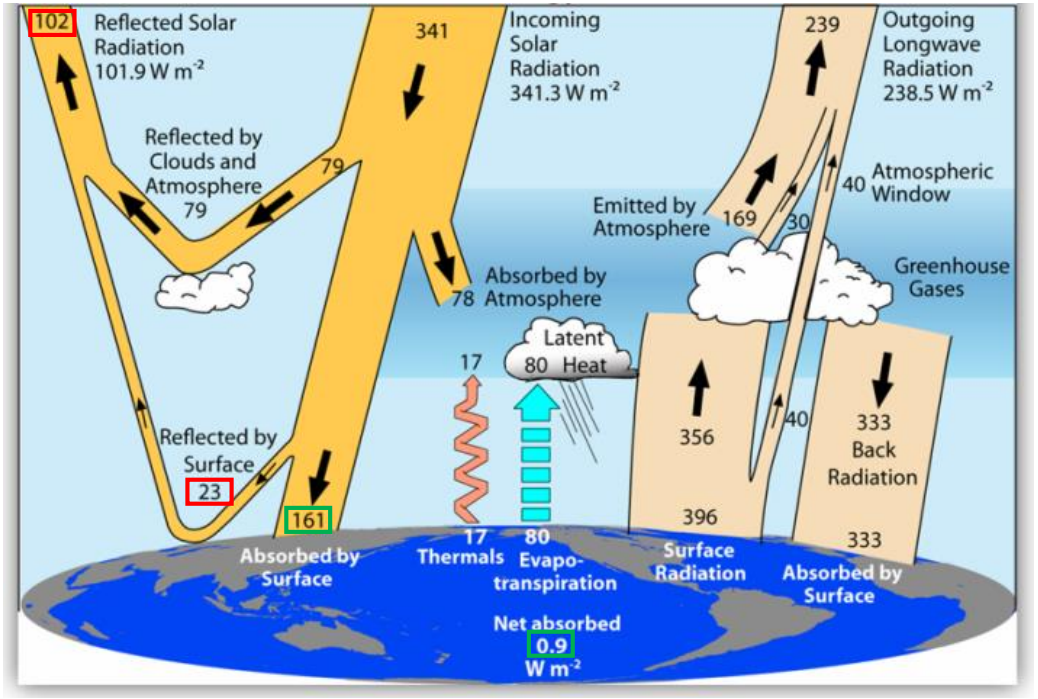
O_3

- On timescales of 100s of thousands of years, variations in the Earth's orbit come into play and drive the ice-age cycle.
- On timescales of 100s of millions of years, continental drift must be considered.
- On timescales of billions of years, catastrophic collision with a large extraterrestrial object (e.g., an asteroid or planetoid) is likely.

Feedbacks Effects in the Climate System

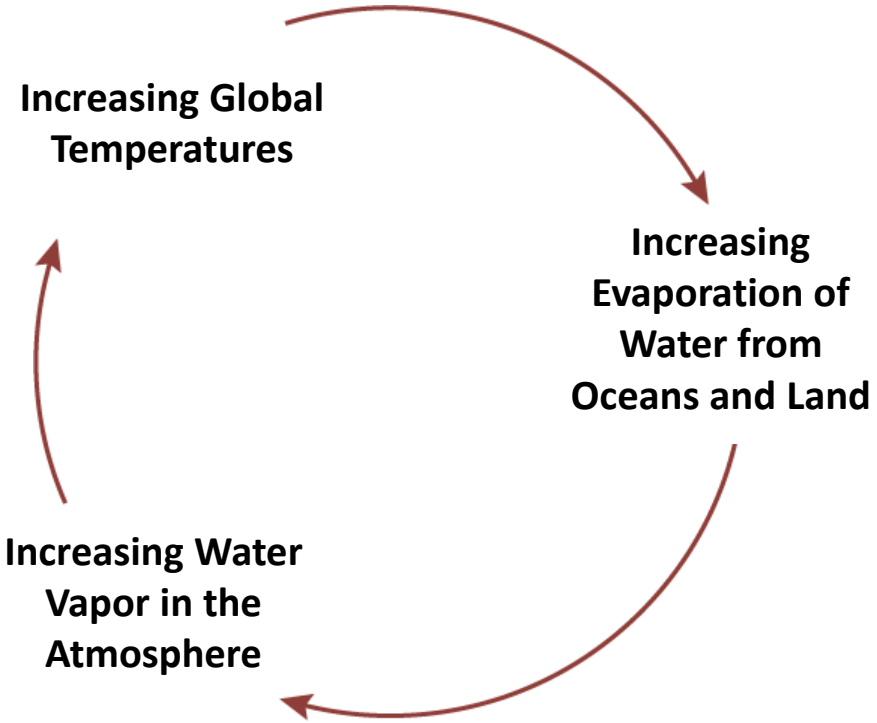
Snow/Ice Feedback

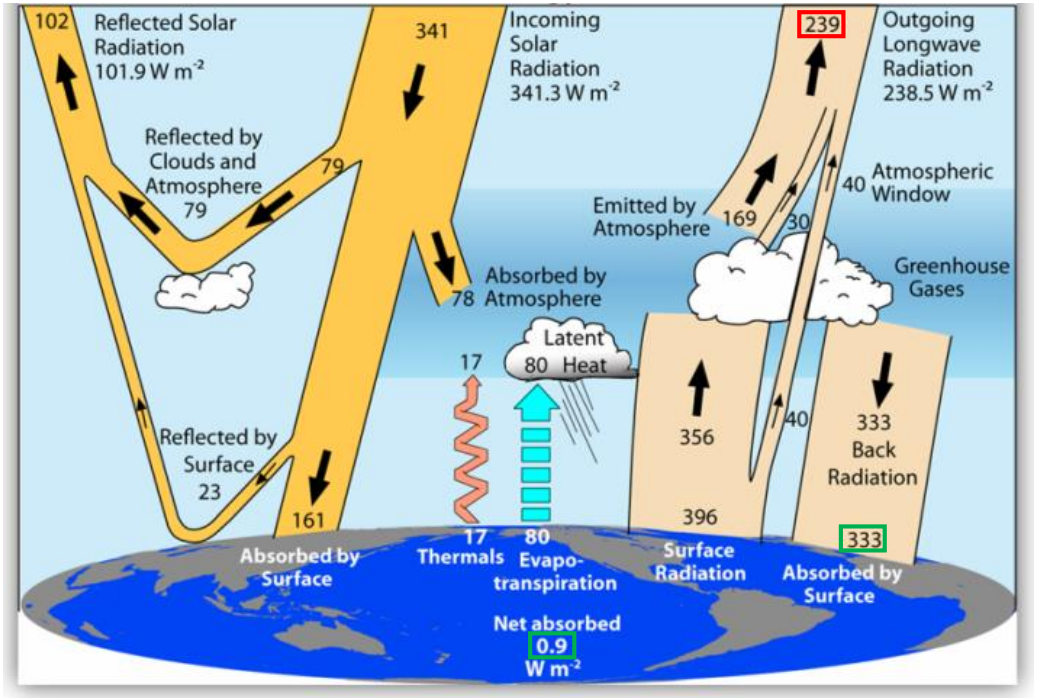




In a **warming world**, the fraction of the globe covered by snow and ice decreases from year-to-year, which results in less solar radiation reflected from the surface and more absorbed at the surface. This, in turn, increases the rate of warming, global temperatures and the rate of snow/ice melt, resulting in a **positive feedback**.

Water Vapor Feedback





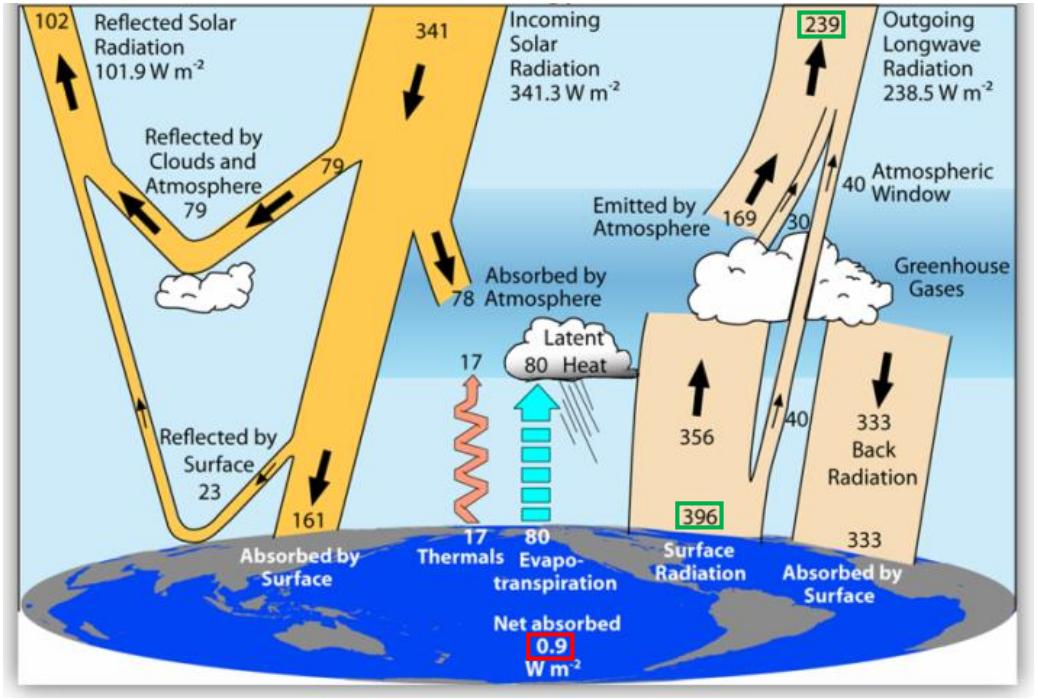
In a **warming world**, more water is evaporated from the ocean and the land each year, increasing the amount of water vapor in the atmosphere. Because water vapor is a powerful greenhouse gas, this in turn increases the rate of greenhouse warming, global temperatures and the rate of evaporation, resulting in a **positive feedback**.

Longwave Radiative Feedback

Increasing Global Surface Temperatures

Increasing Outgoing Longwave Radiation and Surface Cooling

Decreasing Global Surface Temperatures



As the surface of the Earth warms, the outgoing surface longwave radiation increases rapidly, in proportion to the fourth power of the surface temperature, in accordance with the Stefan-Boltzmann Law. This increases the rate of surface cooling and **tends to decrease global surface temperatures**, resulting in a **negative feedback**.

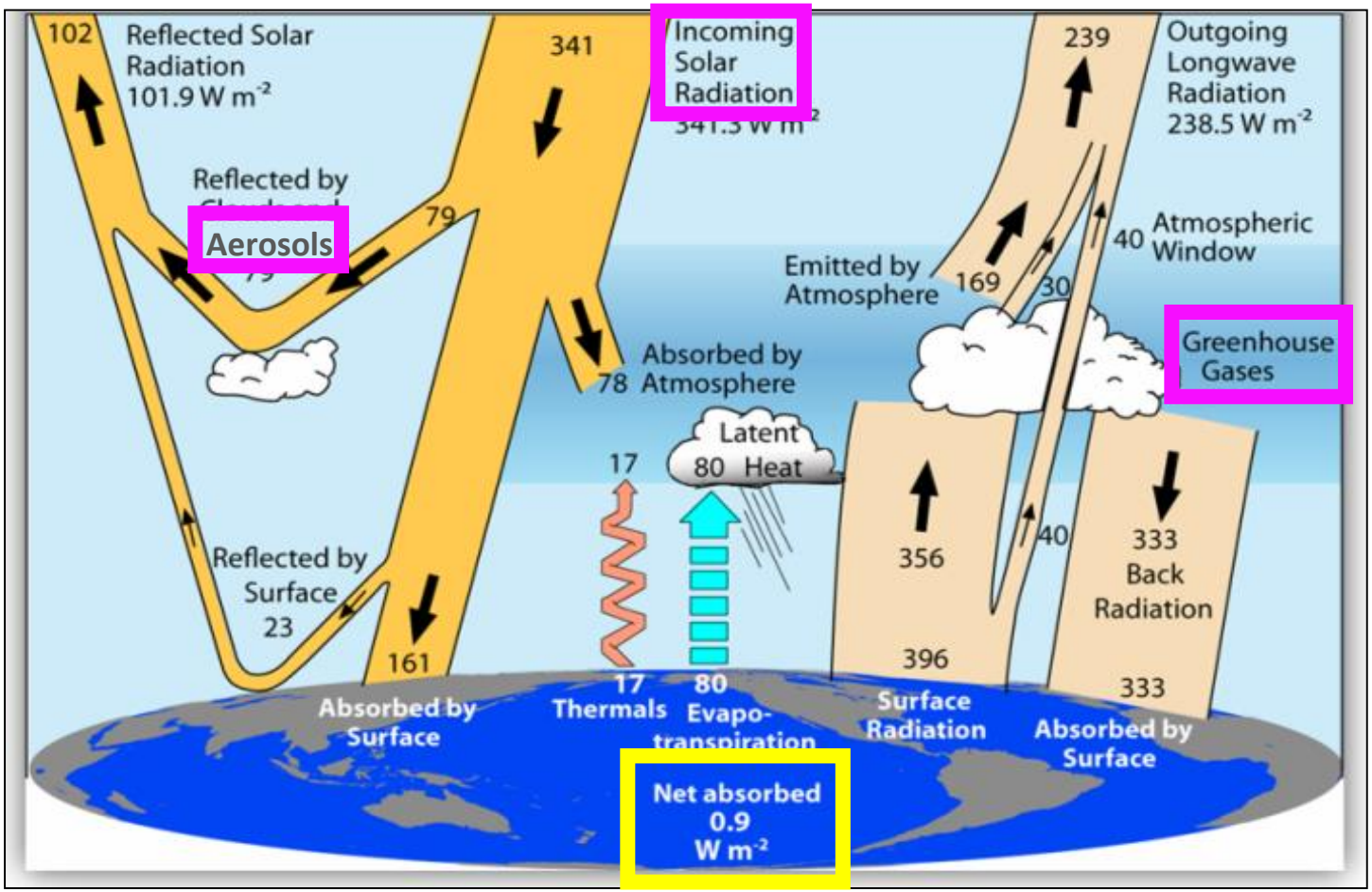
Outgoing Longwave Surface Radiation = σT^4

T is the temperature of the earth's surface in Degrees Kelvin

σ is a constant

Stability of the Climate System and Global Warming

Imbalance in the Earth's Energy Budget



H_2O

CO_2

CH_4

N_2O

HFCs

O_3

If all three of the external forcing factors (Solar Radiation, Aerosols, Greenhouse Gases) remain constant long enough (e.g., a few decades), then the Longwave Radiative Feedback would cause the incoming solar radiation and the outgoing longwave radiation to come into balance, and global warming would stop. However, mainly because of continually increasing levels of CO_2 in the atmosphere, due mainly to the burning of fossil fuels, the system is continually being nudged out-of-balance and the earth continues to warm.

How Much Heat is the Earth Absorbing as a Result of Greenhouse Warming?

From Previous Slide, the global annual mean net flow of heat energy at the surface of the earth resulting from **Anthropogenic Greenhouse Warming** (i.e., Greenhouse warming caused by humans) is **0.9 W m^{-2}**.

0.9 W m^{-2} = 0.9 Joules s^{-1} m^{-2}

Heat Absorbed by Earth Each Second = (0.9 Joules s^{-1} m^{-2})(Surface Area of the Earth)

Heat Absorbed by Earth Each Second = (0.9 Joules s^{-1} m^{-2})(5.1 x 10^{14} m^2)

Heat Absorbed by Earth Each Second = 4.6 x 10^{14} Joules s^{-1}

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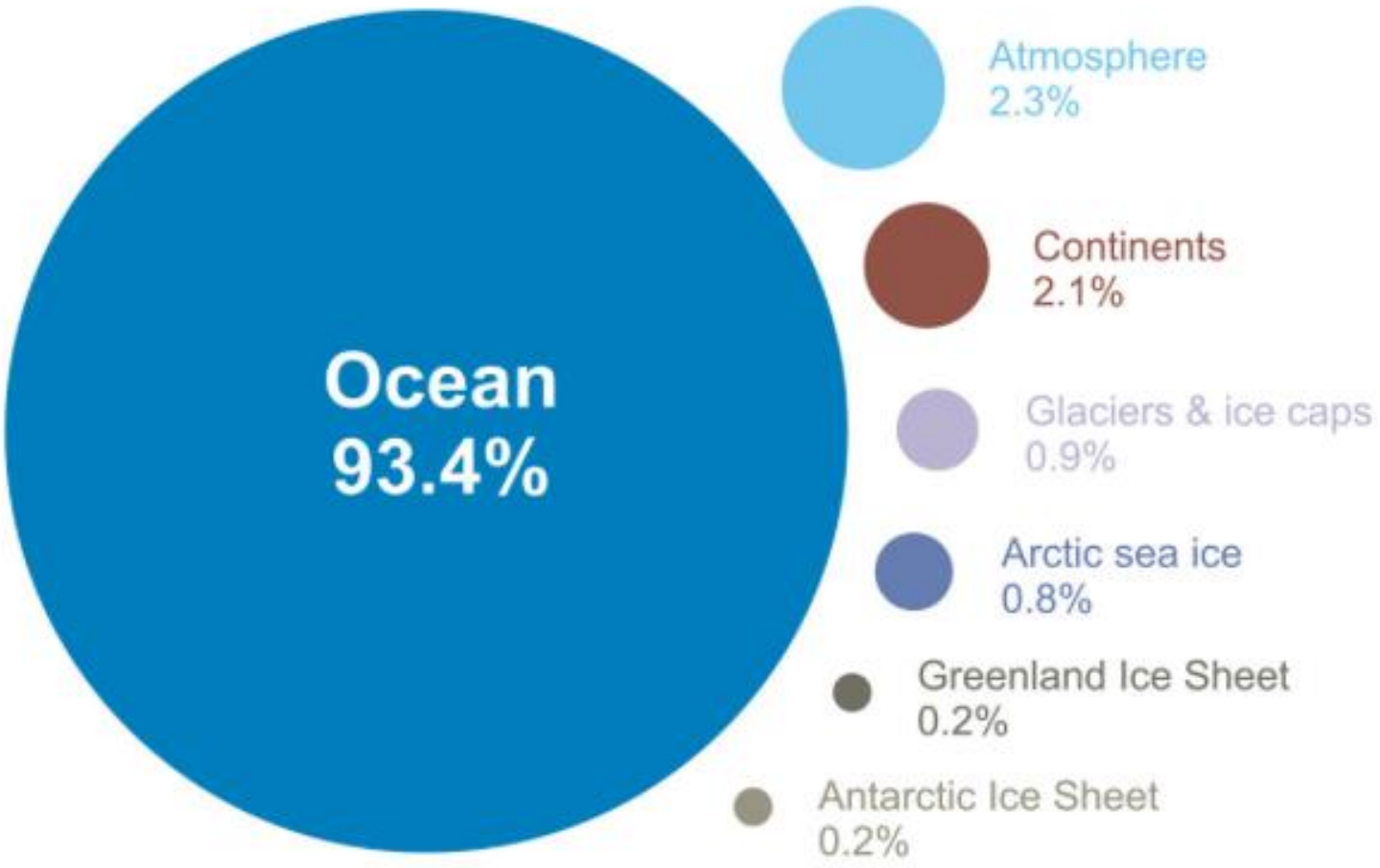
Heat Absorbed by Earth Each Second = 4.6 x 10^{14} Joules s^{-1}

The Hiroshima Atomic Bomb was a 15 Kiloton Device Which Released ~ 6.3 x 10^{13} Joules of heat

$$\text{Heat Absorbed by Earth Each Second} = \frac{4.6 \times 10^{14} \text{ Joules } s^{-1}}{6.3 \times 10^{13} \text{ Joules Bomb}^{-1}} = \textbf{~ 7 Hiroshima Bomb Equivalents } \textbf{s}^{-1}$$

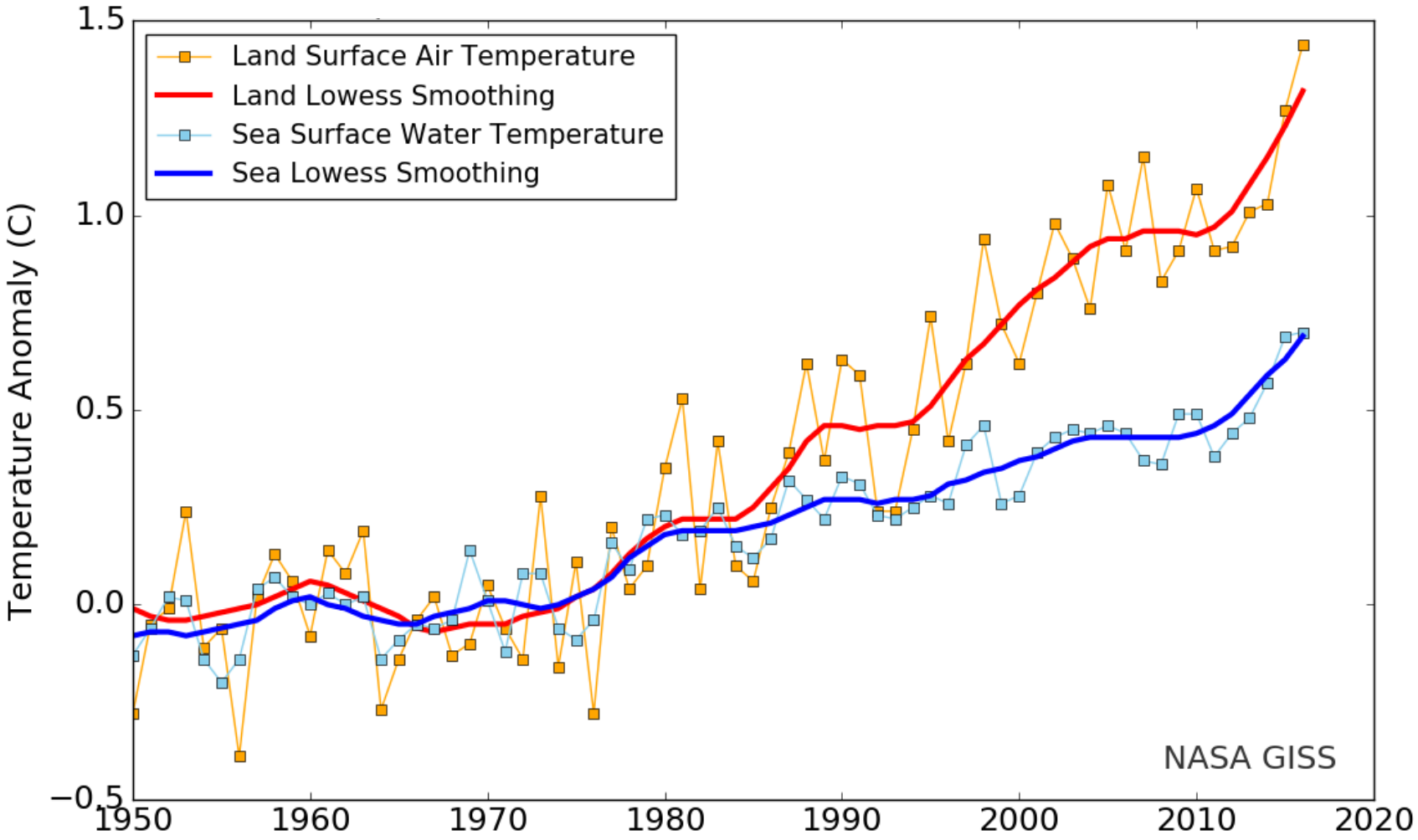
Total Heat Absorbed by Earth since 1998 **> 1 Trillion Hiroshima Bomb Equivalents**

Distribution of Heat From Greenhouse Warming



Data for 1993-2003

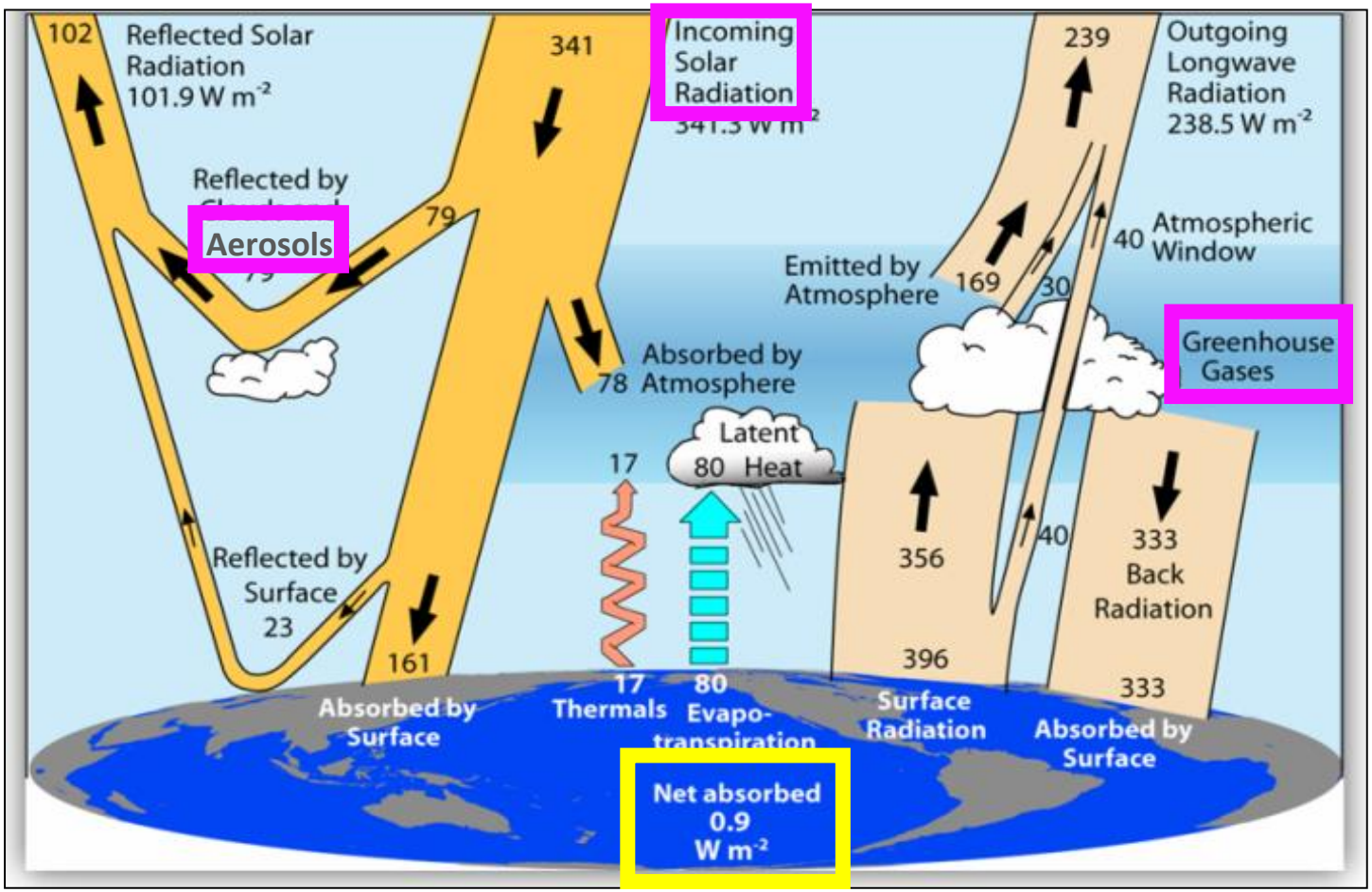
Warming of Land and Ocean 1950-2015



Annual (thin lines) and five-year-smoothed (thick lines) temperature anomalies averaged over the Earth's land area (red line) and sea surface temperature anomalies (blue line) averaged over the part of the ocean that is free of ice at all times (i.e., the open ocean).

CO_2 and the Carbon Cycle

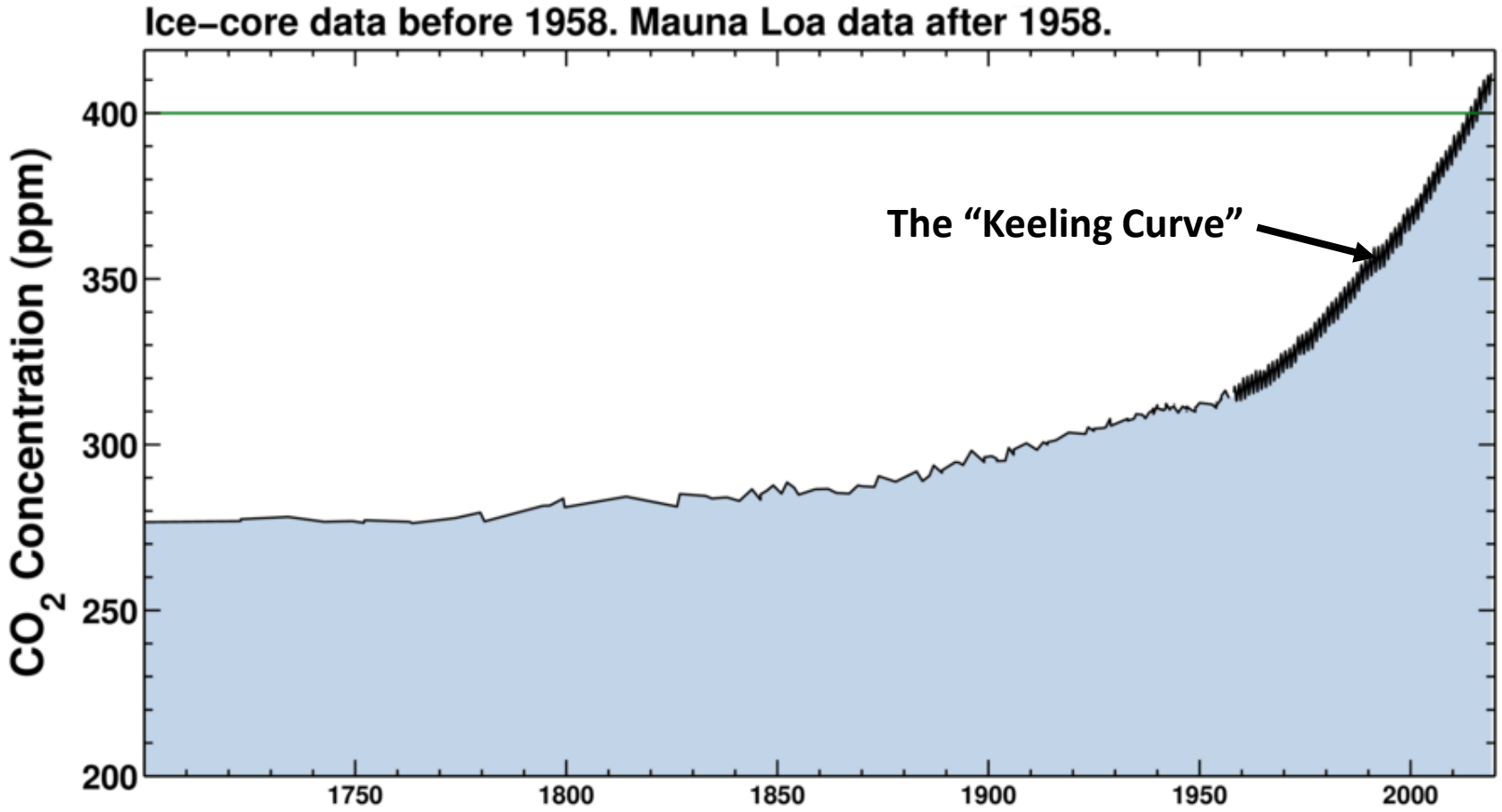
Increasing CO_2 in the Atmosphere is the Primary Driver of Global Warming and Climate Change



H_2O

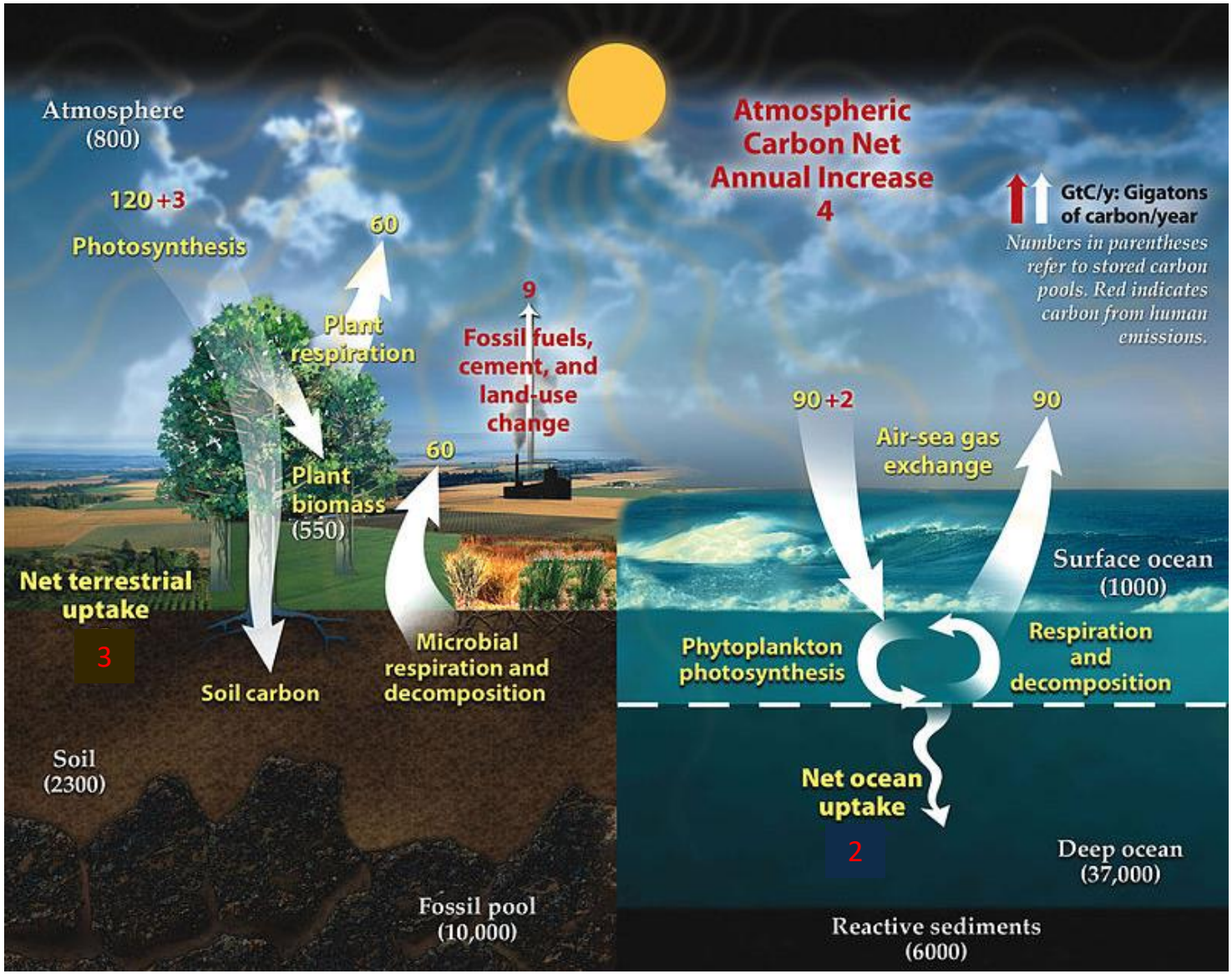
CO_2 (72%)
CH_4 (20%)
N_2O (5%)
HFCs (2%)
O_3 (1%)

CO_2 in the Atmosphere, 1700-2019



- CO_2 levels in the atmosphere are usually reported as concentrations, in parts per million (ppm). Pre-industrial levels were about 280 ppm. The current level is about 413 ppm, an increase of almost 50% over the pre-industrial level.
- The total mass of CO_2 in the atmosphere is also of interest. From 1850 to 2018, the total amount of CO_2 emitted by human activities amounted to about 2.0 trillion tons. This increased CO_2 in the atmosphere by about 1.1 trillion tons above the pre-industrial level.

The Carbon Cycle



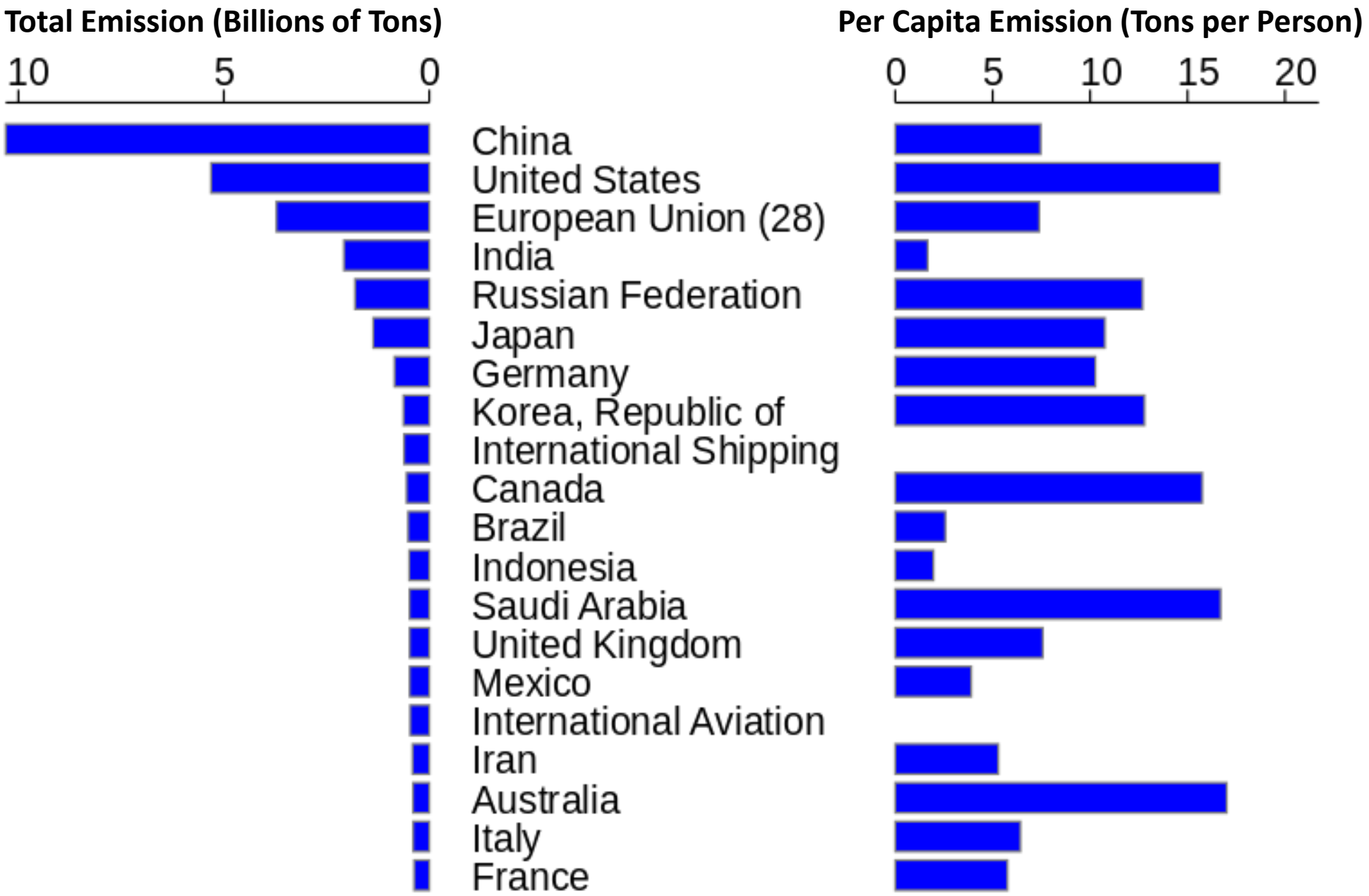
Movement of carbon between land, atmosphere, and ocean in billions of tons per year. Yellow numbers are natural fluxes, red are human contributions, white are stored carbon. Carbon emissions from volcanic and tectonic activity, which are extremely low compared to the processes depicted above, are not included.

Q&A and Discussion

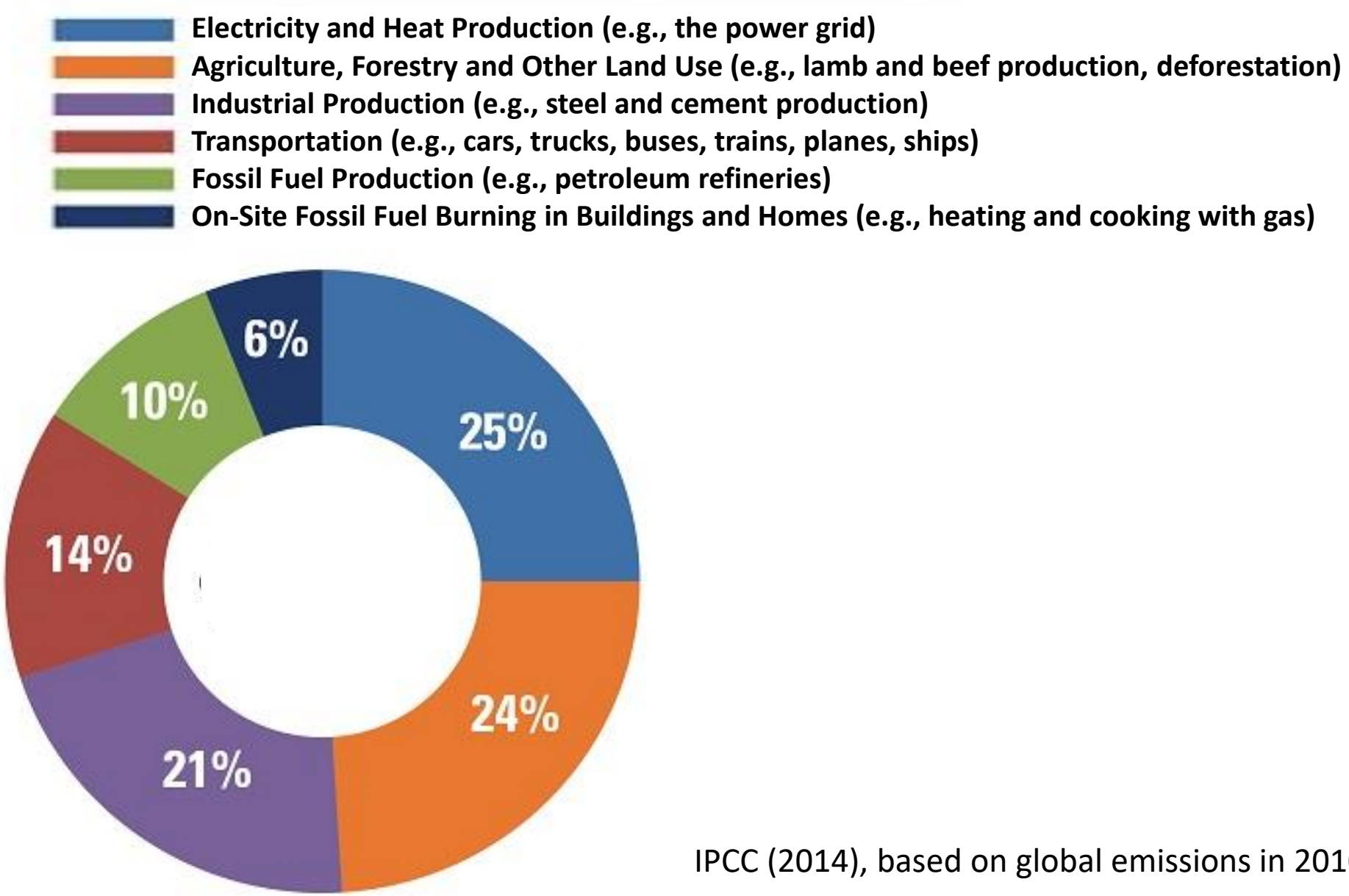
PART 3
Mitigation

Sources of CO_2 Emissions

Top 20 CO_2 Emitters for the Year 2013



Global Greenhouse Gas Emissions by Economic Sector



IPCC (2014), based on global emissions in 2010

International Agreements

UN Framework Convention on Climate Change

- The **United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty signed in Rio de Janeiro in 1992.**
- The **UNFCCC objective is to "stabilize greenhouse gas concentrations in the atmosphere** at a level that would prevent dangerous anthropogenic interference with the climate system".
- The framework sets non binding limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. Instead, **the framework outlines how specific international treaties may be negotiated to specify further action towards the objective of the UNFCCC.**
- **The UNFCCC includes 197 signatories, and enjoys broad legitimacy due to its nearly universal membership.**
- The UNFCCC parties meet in annual Conferences of the Parties (COPs) to assess progress in dealing with climate change.
- **The Kyoto Protocol and Paris Climate Accord were established under the auspices of the UNFCCC.**

Kyoto Protocol

- The **Kyoto Protocol** was **an international treaty** that extended the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and **committed countries to reduce greenhouse gas emissions.**
- **Adopted in Kyoto, Japan, in December 1997.**
- **Assigned legally binding targets for reduction of CO_2 emissions to each country.**
- **Allowed for trading of Kyoto emission reduction obligations among countries.**
- Generally placed more of a burden on developed countries with a history of significant greenhouse gas emission than on developing countries;
- **Signed by the US in 1998, during the Clinton presidency, but not ratified by the Senate.**
- **President George W. Bush opposed the Protocol and declined to pursue its ratification, making the U.S. the only signatory not to ratify it.**
- **First commitment period started in 2008 and ended in 2012.**
- **Canada withdrew from the Protocol in 2011, while Japan and Russia stated that they would not take on further Kyoto emissions reduction targets.**
- **A second commitment period was agreed on in 2012, known as the Doha Amendment to the Kyoto Protocol, in which 37 countries had binding targets for the period 2013-2020.**
- **However, the Doha Amendment never received sufficient ratifications to enter into force.**
- **In general, the Kyoto Protocol ended up a disappointing failure.**

Paris Climate Accord

Heads of delegations at the 2015 United Nations Climate Change Conference in Paris.

- The **Paris Climate Accord** is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation and finance. It is **essentially the successor to the Kyoto Protocol**.
- The Agreement was **negotiated by representatives of 196 countries and adopted by consensus on 12 December 2015.**
- **The aim is to limit the increase in global average temperature to well below 2 °C above pre-industrial levels, with a preferred goal of 1.5 °C above pre-industrial levels. This would substantially reduce the risks and effects of climate change.**
- Under the Agreement, **each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming**.
- **No mechanism forces a country to set a specific target by a specific date**, but each target should go beyond previously set targets.
- **In June 2017, President Trump announced his intention to withdraw from the agreement.**
- The earliest effective date of withdrawal for the U.S. is November 2020, but **changes in United States policy that are contrary to the Agreement have already been put in place.**

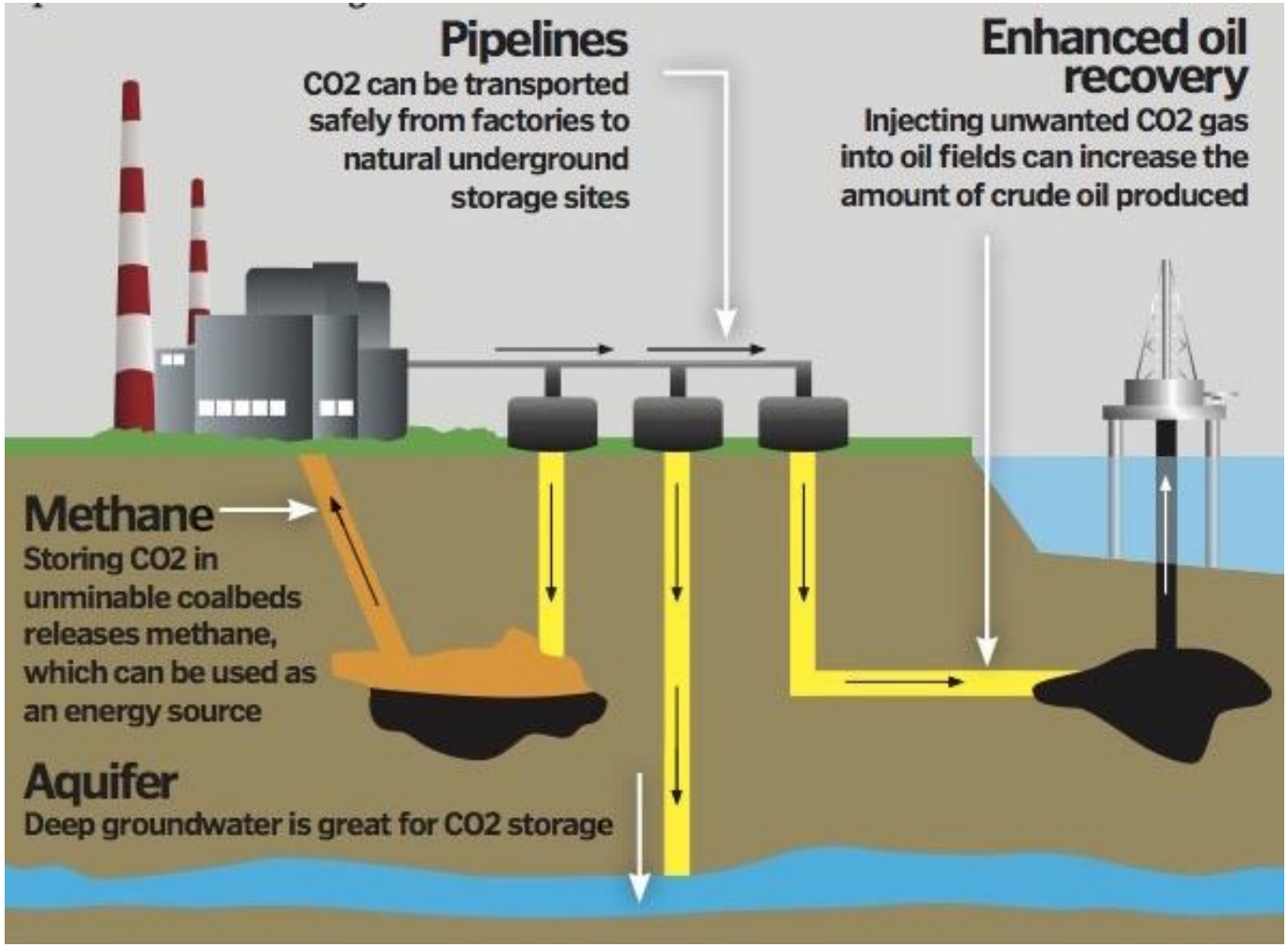
Intergovernmental Panel on Climate Change (IPCC)

- **The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.**
- The IPCC was **established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988.**
- The IPCC is an organization of 195 governments that are members of the United Nations or WMO.
- **The IPCC is divided into three Working Groups and a Task Force:**
  - Working Group I: The Physical Science Basis of Climate Change
  - Working Group II: Climate Change Impacts, Adaptation and Vulnerability
  - Working Group III: Mitigation of Climate Change
  - Task Force: Develop National Greenhouse Gas Inventories
- The IPCC **provides regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.**
- **The IPCC does not conduct its own research. Instead, it draws conclusions from the thousands of scientific papers published each year on climate change.**

Legislation

The Future Act

- Signed into law in 2018 with huge bipartisan support, the **Future Act increased the 45Q Tax Credit** value incrementally over ten years from $10 to $35 per metric ton of **$CO_2$ stored geologically** through enhanced oil recovery, and from $20 to $50 per ton of CO_2 stored in saline aquifers and other geologic formations.



- **By incentivizing the commercial deployment of carbon capture at power plants and industrial facilities around the country, the revamped 45Q Tax Credit will also spur private investment in pipeline infrastructure to meet the need to transport captured CO_2 from where it is produced to locations suitable for geologic storage.**

The Energy Innovation and Carbon Dividend Act of 2019 (EICDA)

- Sponsored by the Citizens Climate Lobby (CCL).
- Introduced into the U.S. House of Representatives as H.R. 763.
- Key Elements:
  - Carbon Fee: Puts a fee on fossil fuels which starts low, and grows over time, to incentivize consumers to move toward cleaner, cheaper options.
  - Carbon Dividend: Money collected from the carbon fee allocated in equal shares every month to the American people. About two-thirds of households will break even or receive more than they pay in higher energy prices. Government does not keep any of the money from the carbon fee.
  - Border Adjustment: To protect U.S. jobs, imported goods will be assessed a border carbon adjustment, and goods exported from the U.S. will receive a refund.
  - Will reduce America's CO_2 emissions by at least 40% in the first 12 years, with a goal of 90% reduction by 2050.
  - Will improve health and save lives by reducing air pollution.
  - Will create approximately 2.1 million new jobs over the first 10 years.
  - Targeted to take effect in 2026.

The Energy Innovation and Carbon Dividend Act of 2019 (EICDA)

- Related Developments:
  - Yale Economics Professor, Dr. William Nordhaus, won the 2018 Nobel Prize in Economics for his research related Carbon Fee and Dividend, the basis for EICDA.
  - In a 16 January 2019 statement in the Wall Street Journal, 27 former Nobel Prize winners in the Economic Sciences, 12 former Chairpersons of the President's Council of Economic Advisors, 4 former Federal Reserve Chairpersons, and 2 former Treasury Secretaries endorsed Carbon Fee and Dividend.
  - Canada began adopting their version of Carbon Fee and Dividend this year.

Carbon Pricing Bills Currently in Congress

Title	Energy Innovation & Carbon Dividend Act	Climate Action Rebate Act	Raise Wages, Cut Carbon Act	Stemming Warming & Augmenting Pay Act
House bill # Sponsors (lead + D + R)	H.R.763 Deutch + 57 + 1	H.R.4051 Panetta + 1 + 0	H.R.3966 Lipinski + 0 + 1	H.R.4058 Rooney + 1 + 0
Senate bill # Sponsors (lead + D + R)	--	S.2284 Coons + 1 + 0	--	--
Carbon Pricing Design				
Start year	2020	2020	2020	2021
Covered fuels	Coal, crude oil, natural gas, & their products	Coal, crude oil, natural gas, & their products, & solid biomass [a,b]	Coal, petroleum & its products, & natural gas	Coal, refinery products, natural gas, process GHG's, biomass & biofuels [b]
Starting price, $/mt CO_2e	$15	$15	$44 [c]	$30
Annual increase, $/mt CO_2e	+ $10 + CPI	+ $15 + CPI	+ 2.5% + CPI	+ 5% + CPI
Missed-targets increase	+ $5	+ $15	--	+ $3 @ 2 years
F-gases taxed	Yes, 10% of GWP	Yes, 20% of GWP	Yes, 10% of GWP	Uncertain [d]
CCUS[e] credits/refunds	Yes (fossil only)	Yes	Yes (fossil only)	Yes (fossil only)
Emissions (vs. 2005, net)				
Targets	– 37% /10 years -66% / 20 years – 89% [f]/30 years	– 59% /10 years -78% / 20 years – 100%[g] /30 years	None[h]	– 36% /10 years
Revenue Allocation [i]				
Treasury general fund	--	--	25%	25%
Dividends	100% (taxable) [j]	70% [k] (taxable)	--	--
Payroll tax cut	--	--	63%	52.5%
Soc Security benefits	--	--	7.5%	7.5%
LIHEAP and WAP programs	--	--	4.5% [l]	--
Low-income block grants	--	--	--	7.5%
Infrastructure	--	20% [m]	--	--
Climate adaptation	--	--	--	7.5%
Carbon sequestration	--	--	--	
Energy efficiency	--	--	--	
R&D	--	5%	--	
Transition assistance	--	5%	--	
Border Adjustment	Yes	Yes [n]	Yes	Yes
Regulatory Pause	10 years [o]	--	10 years [o]	12 years [o,p]

The Green New Deal (H. Res. 109)

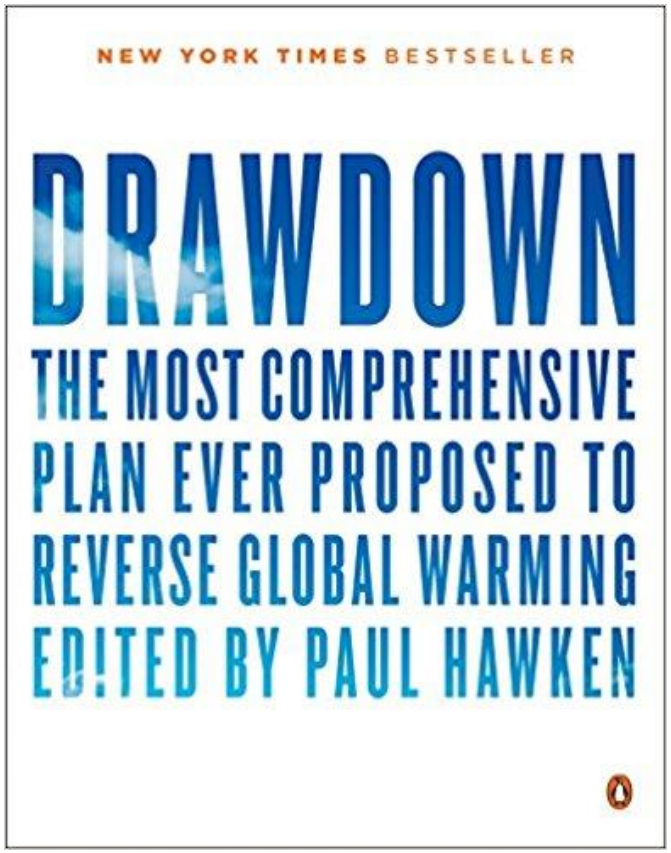
- Goals:
  - Achieving net-zero greenhouse gas emissions
  - Establishing millions of high-wage jobs and ensuring economic security for all
  - Investing in infrastructure and industry
  - Securing clean air and water, climate and community resiliency, healthy food, access to nature, and a sustainable environment
  - Promoting justice and equality

- Calls for accomplishment of these goals through a 10-year national mobilization effort for:
  - Building smart power grids (i.e., power grids that enable customers to reduce their power use during peak demand periods)
  - Upgrading all existing buildings and constructing new buildings to achieve maximum energy and water efficiency
  - Removing pollution and greenhouse gas emissions from the transportation and agricultural sectors
  - Cleaning up existing hazardous waste and abandoned sites
  - Ensuring businesspersons are free from unfair competition
  - Providing higher education, high-quality health care, and affordable, safe, and adequate housing to all

Solutions for Mitigating Climate Change

Project Drawdown (drawdown.org)

- Project Drawdown is a nonprofit organization that proposes, analyzes and ranks solutions for reducing greenhouse gases in the atmosphere, with the goal of reaching drawdown.
- Drawdown is the point in time when the concentration of greenhouse gases begins to decline on a year-to-year basis.
- The group's plan for reversing global warming is presented in the New York Times best seller, *Drawdown*, and consists of **80 Solutions** organized into **7 Sectors**.



The 7 Project Drawdown Sectors Ranked by Potential for Greenhouse Gas Reduction

Rank	Sector	Greenhouse Gas Reduction (Billions of Tons of CO_2 Eq)
1	Food	322
2	Electricity Generation	246
3	Land Use	150
4	Women and Girls	121
5	Materials	112
6	Buildings and Cities	55
7	Transportation	46

Projected Over the 30-Year Period, 2020-2050

The Top 10 of the 80 Solutions Proposed and Ranked by Project Drawdown

Rank	Solution	Sector	Greenhouse Gas Reduction (Billions of Tons of CO_2 Eq)
1	Refrigerant Management	Materials	90
2	Onshore Wind Turbines	Electricity Generation	85
3	Reduced Wood Waste	Food	71
4	Plant-Rich Diet	Food	66
5	Tropical Forests	Land Use	61
6	Educating Girls	Women and Girls	51
7	Family Planning	Women and Girls	51
8	Solar Farms	Electricity Generation	37
9	Silvopastures	Food	31
10	Rooftop Solar	Electricity Generation	25

Projected Over the 30-Year Period, 2020-2050

Overall 30-Year Impact of Following the Recommendations of Project Drawdown

- Would reduce greenhouse gases in the atmosphere over 30 years by about 1 trillion tons, which is in the ballpark of what is required to meet the Paris Climate Accord goal of holding global warming to 1.5^{o}C.
- Would cost about $30 trillion spread over 30 years, which is about 1.25% of global GDP per year.
- Would result in savings of about $74 trillion over the 30 years.

Closing Comments

Actions You Can Take as an Individual

- Learn the basics of the science behind why our planet is warming and the climate is changing.
- Do what you can to reduce your carbon footprint, while still living the life you want to live.
- Join an advocacy group, such as the Citizens Climate Lobby (CCL), and participate actively.
- Whenever you have an opportunity to interact with a leader in your community, be they political or otherwise, let them know that you want to see action taken on this issue.
- **Become a leader in your community!** And help ensure that future generations will inherit a livable world.