ACCEPT
ASEAN Climate Change and Energy Project

In-house Sharing Session 2
The Basic of Climate Change (Part 1)

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Norwegian Ministry of Foreign Affairs

Implemented by:
NUPI Norwegian Institute of International Affairs

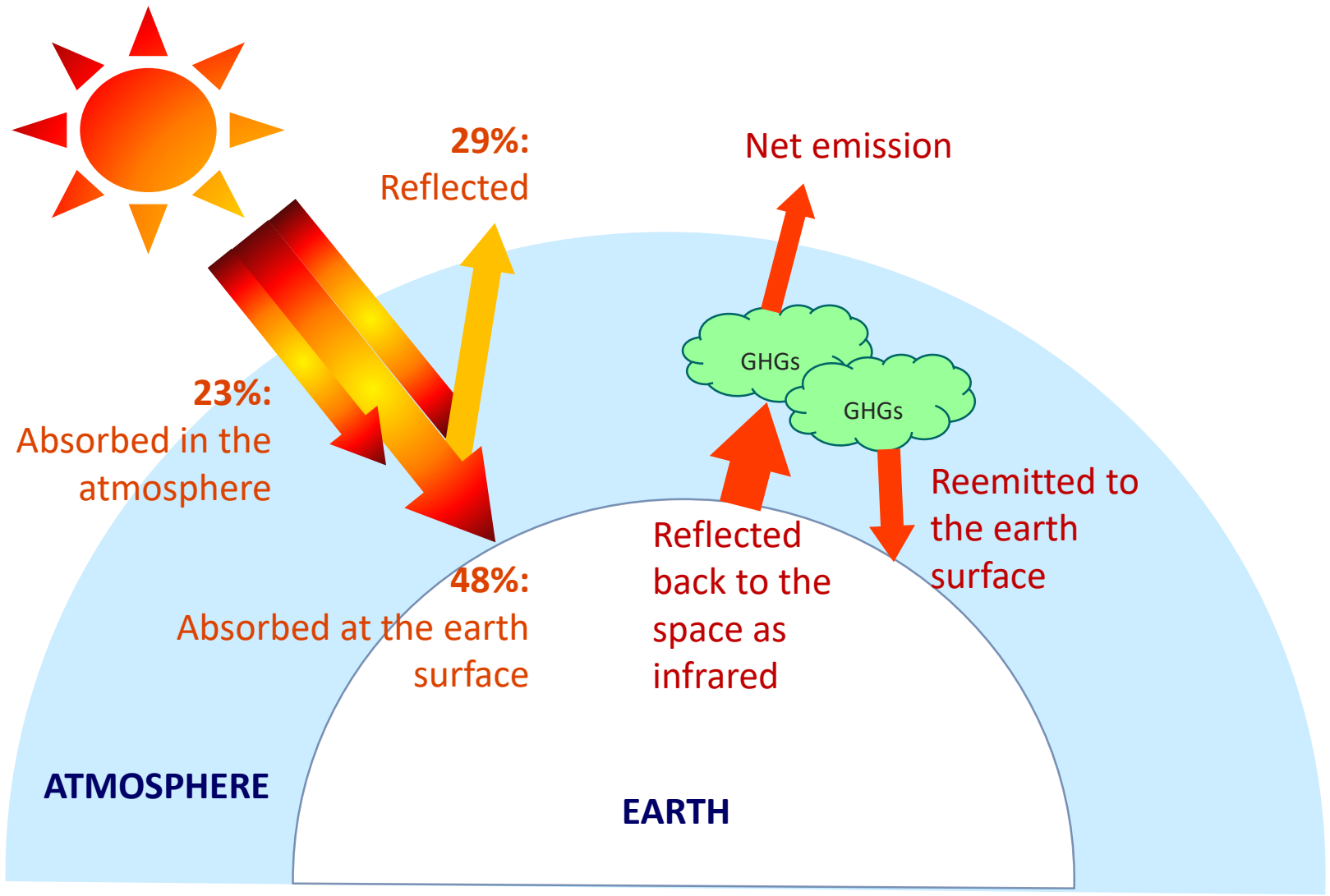
ASEAN CENTRE FOR ENERGY • ACE •

What is Global Warming?

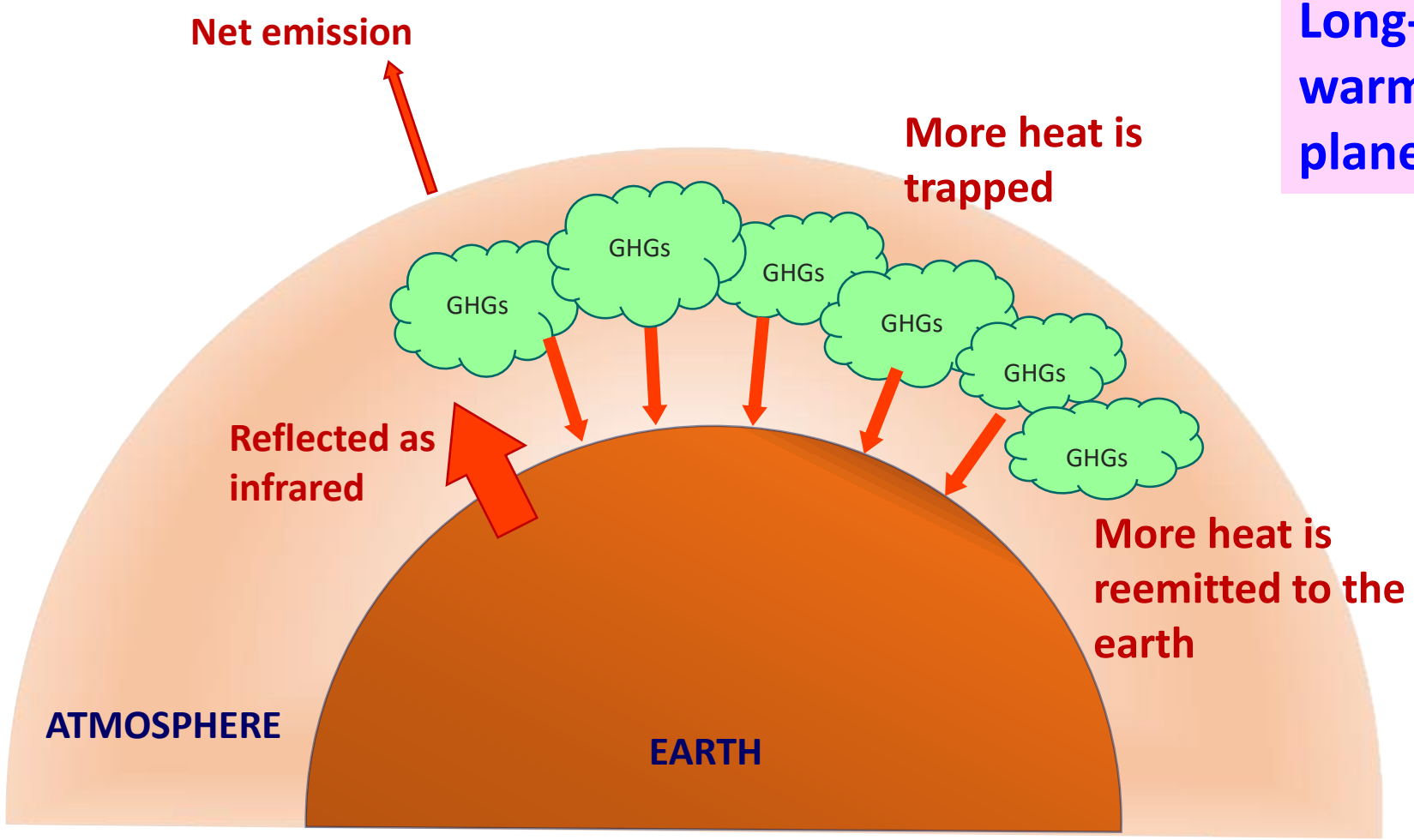
Survey:

"What's the difference between climate change and global warming?"

Greenhouse Effect – natural phenomena to keep the earth warm



Global warming – Additional GHGs (esp. CO_2) by anthropogenic activities



Long-term warming of the planet

Survey:

"Is the Sun causing global warming?"

No.

NASA: The Sun can influence Earth's climate, but it isn't responsible for the warming trend we've seen over the past few decades.

Greenhouse Gases (GHGs)

Survey: "Do you know water vapour is one of the primary greenhouse gases in the Earth's atmosphere?"

- Primary GHGs in the Earth's atmosphere:

  Water vapour (H_2O), **carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4)** and ozone (O_3)

- Other human-made greenhouse gases in the atmosphere:

  The **halocarbons** and other chlorine- and bromine-containing substances

- Other greenhouse gases (from industries):

  Sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)

Survey:
"Climate change could be caused by the human activities that produce emissions of heat-trapping greenhouse gases from fossil fuel combustion, deforestation, and land-use change.
True or false?"

Sources of Anthropogenic GHGs

Carbon dioxide (CO_2)

- Primarily through the burning of fossil fuels (oil, natural gas, and coal), solid waste, and trees and wood products
- Changes in land use: Deforestation and soil degradation add carbon dioxide to the atmosphere, while forest regrowth takes it out of the atmosphere

Methane (CH_4)

- During the production and transport of oil, natural gas and coal
- Livestock and agricultural practices
- Anaerobic decay of organic waste in municipal solid waste landfills

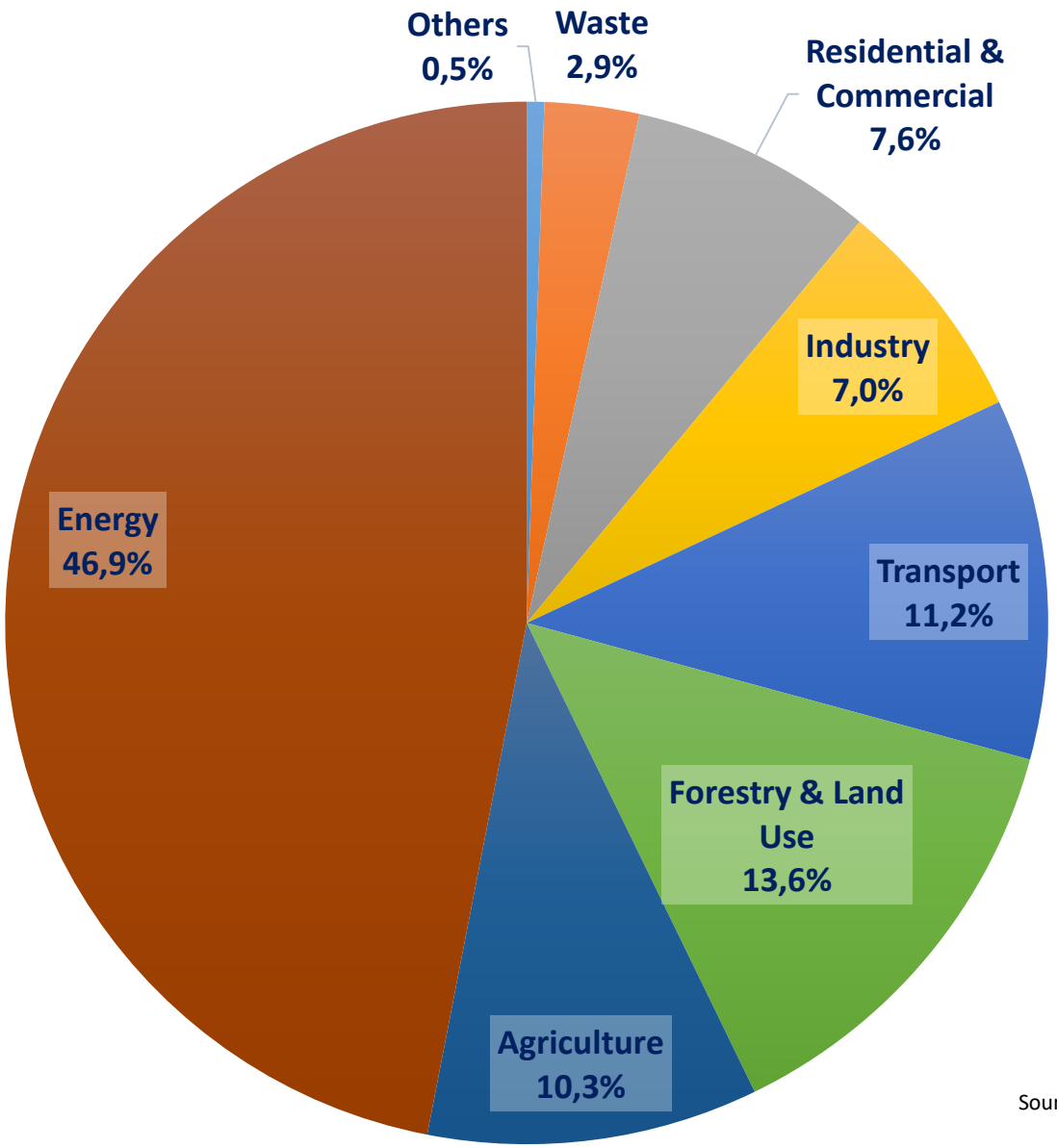
Nitrous oxide (N_2O)

- Combustion of fossil fuels and solid waste
- During agricultural and industrial activities

Fluorinated gases (do not occur naturally)

- Industrial processes; Commercial and household uses

GHG Emissions by Sector, 2010



Source: FAO, 2014

Survey:
"Do you know energy sector is the largest contributor to global greenhouse gas emissions?

Composition of the Atmosphere near Earth's surface: Permanent gases

Permanent Gases

Gas	Symbol	Percent (by Volume) Dry Air
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Neon	Ne	0.0018
Helium	He	0.0005
Hydrogen	H_2	0.0006
Xenon	X_2	0.000009

- These gases constant in time and space
- Their input is balanced by their output
- The percent if the composition always the same

Atmospheric Lifetime (years)

- From a few years to thousands of years
- All of these gases remain in the atmosphere long enough to become well mixed
- The amount that is measured in the atmosphere is roughly **the same all over the world**, regardless of the source of the emissions.

Composition of the Atmosphere near Earth's surface: Variable gases

Variable Gases

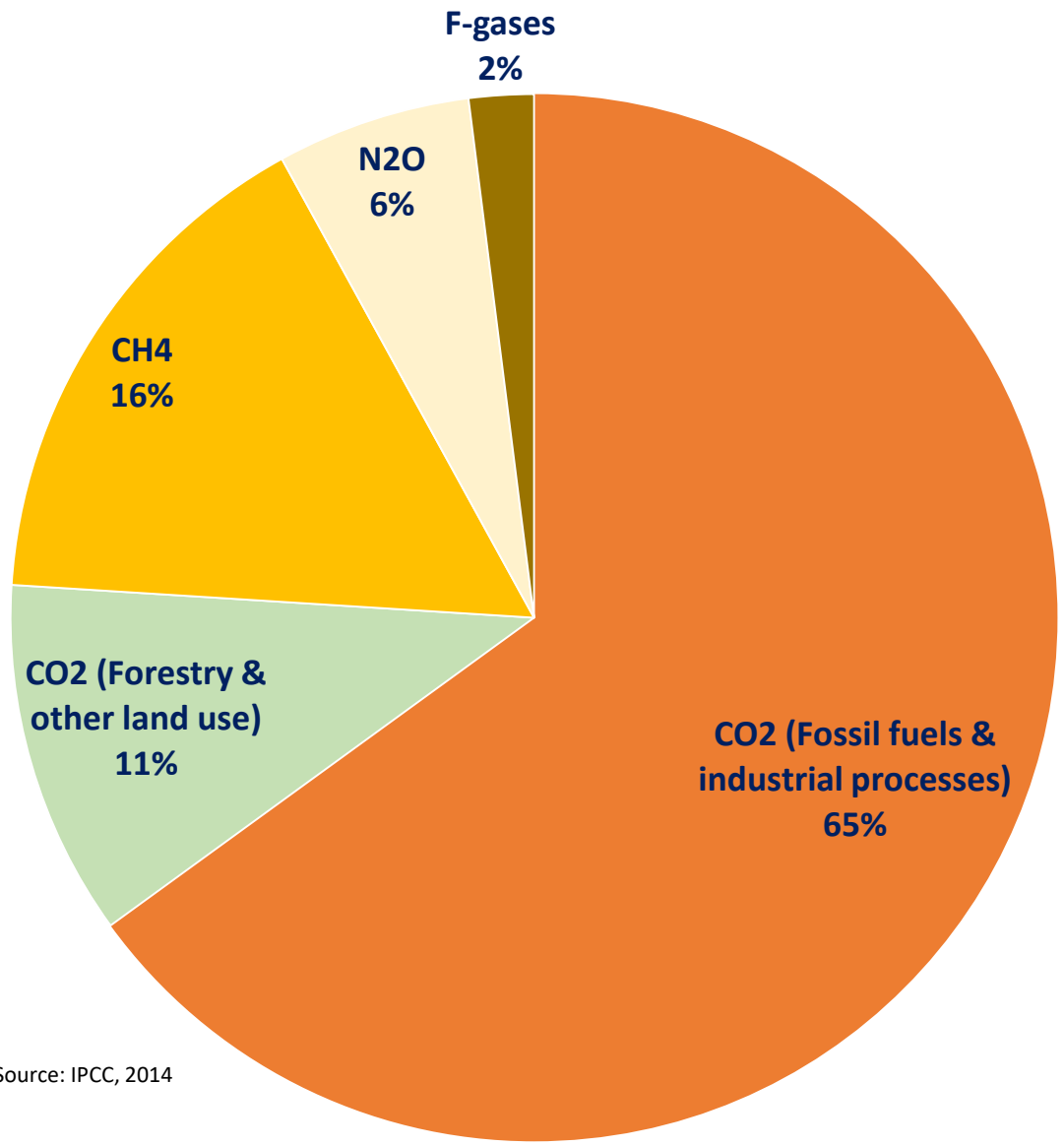
Gas (and Particles)	Symbol
Water vapor	H_2O
Carbon dioxide	CO_2
Methane	CH_4
Nitrous oxide	N_2O
Ozone	O_3
Particles (dust, soot, etc.)	
Chlorofluorocarbons	

- Input and output are not balanced
- Vary in time space
- Changing of water vapour contents: sometimes clear sky, sometimes cloudy
- How well the gas absorbs energy (preventing it from immediately escaping to space)?
- How long the gas stays in the atmosphere?

Global Warming Potential (100 year)

- a measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide
- The larger the GWP, the more warming the gas causes

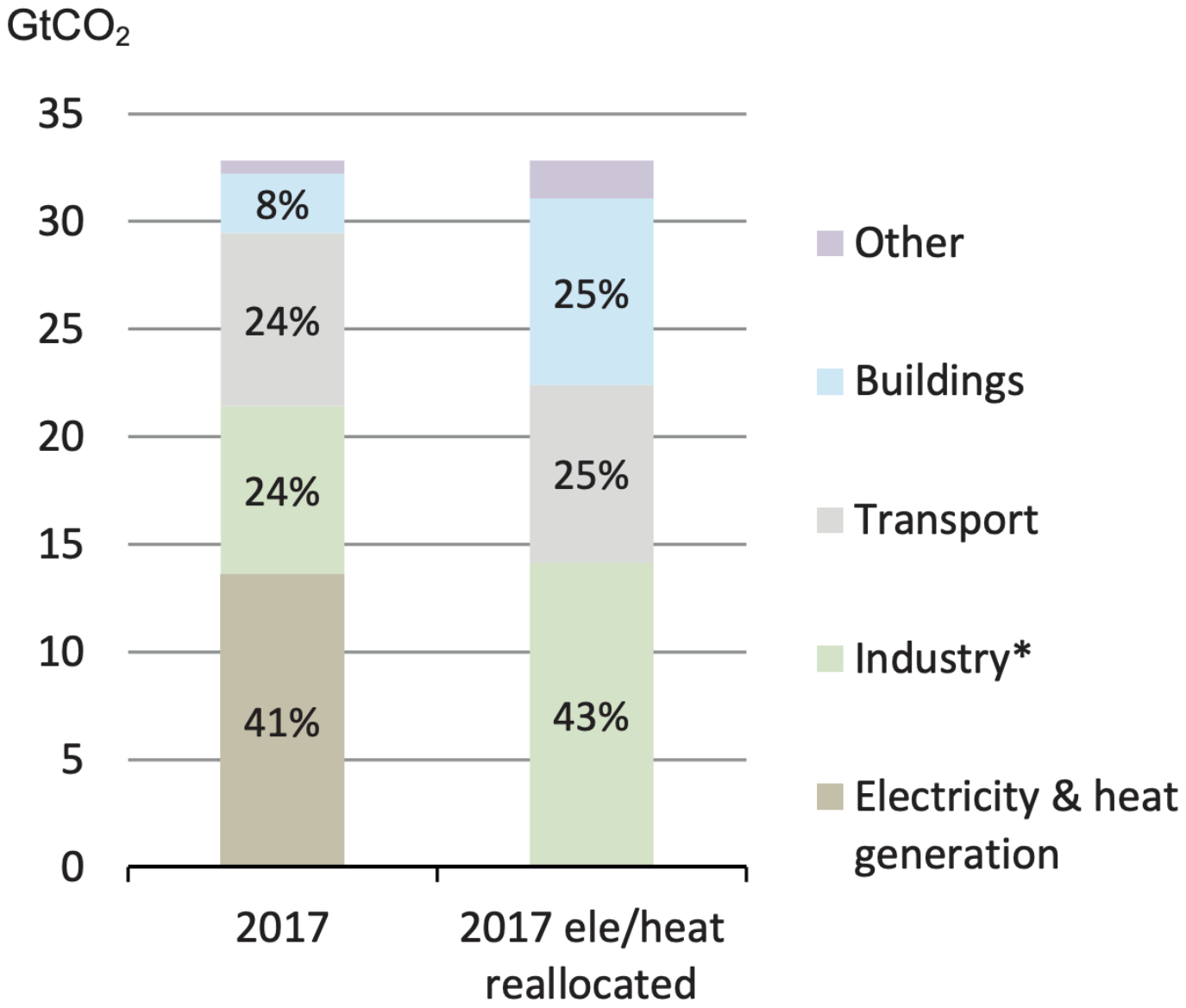
Global Anthropogenic GHG Emissions by Gas, 2010



Source: IPCC, 2014

GHGs	How well (100 GWP)	How long
CO2	1	Lifetime cannot be represented with a single value because the gas is not destroyed over time, carbon is transferred to ocean sediments (slow process): thousands of years
CH4	28–36	12.4 years
N2O	265–298	121 years

Global energy- elated CO_2 emissions by sector, 2017



Survey:
"Which sector is the largest emitter of global energy-related CO2 emissions for the past 5 years?"

Source: IEA, 2019

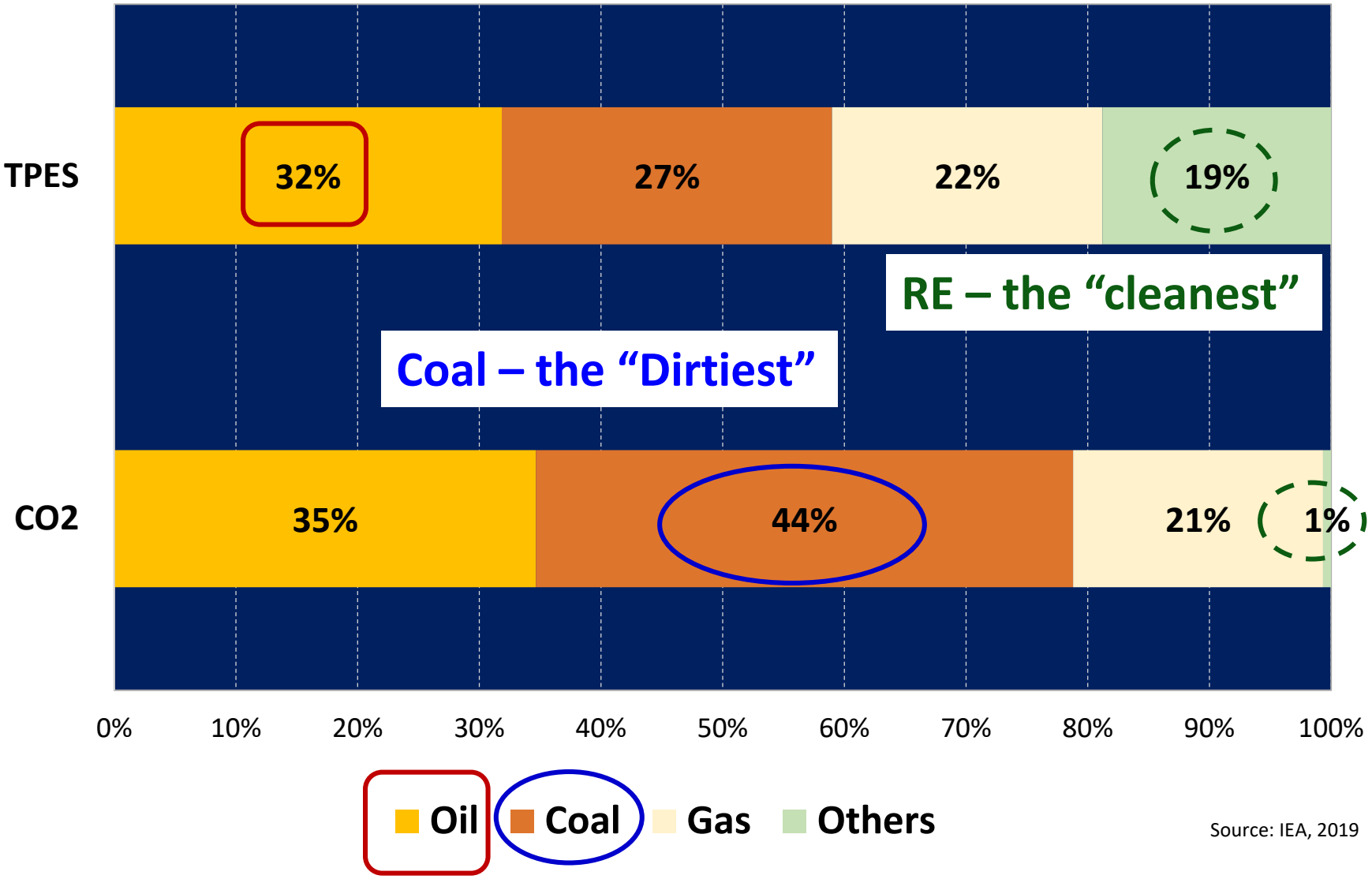
* Industry includes also energy industries own use

Survey:

"Do you know burning different types of fossil fuels emit different amounts of carbon dioxide (CO_2)?"

"Which fossil fuel emits the most carbon dioxide (CO_2) when it is burned?"

World primary energy supply and CO2 emissions: Share by fuels in 2017

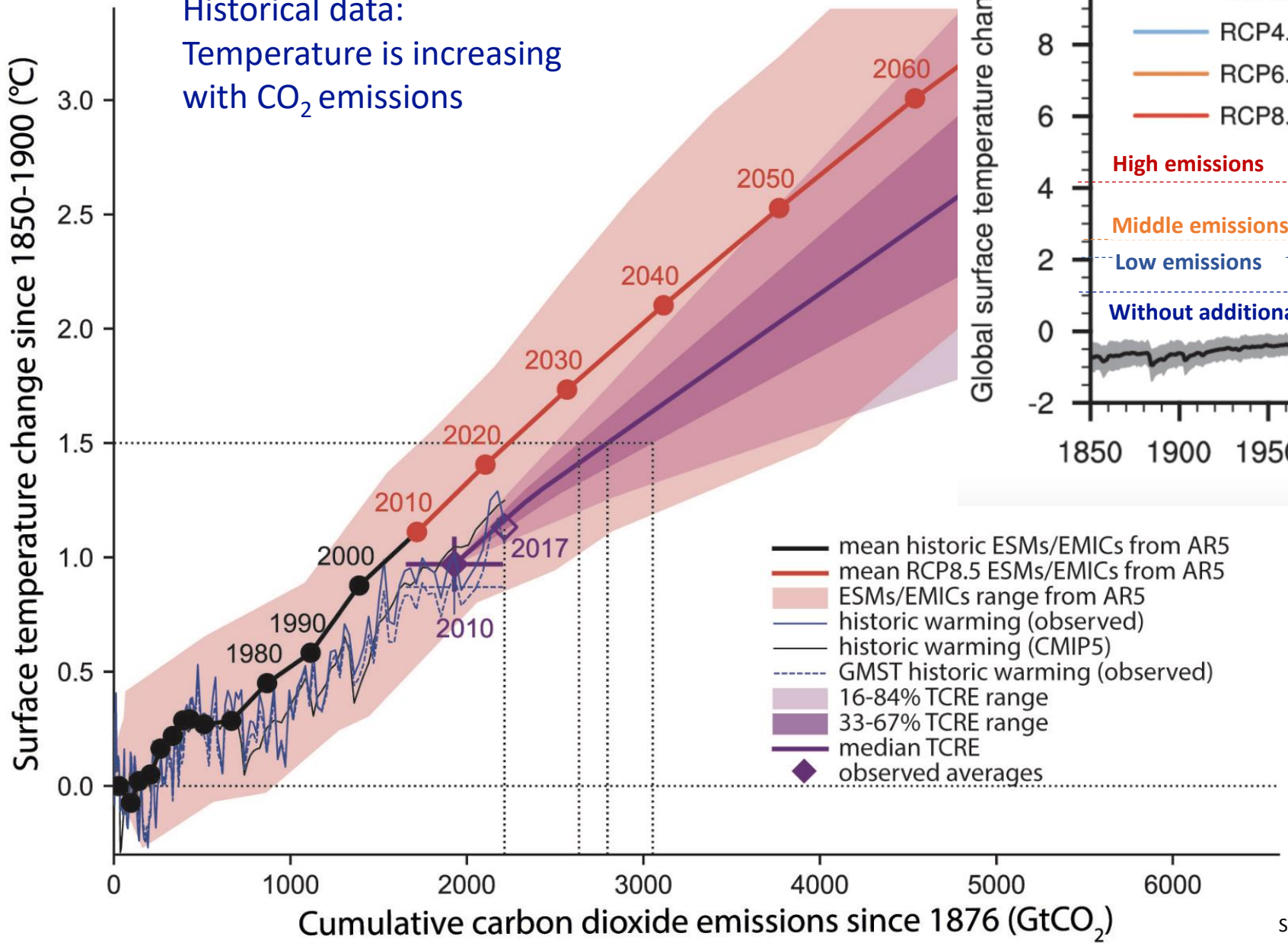


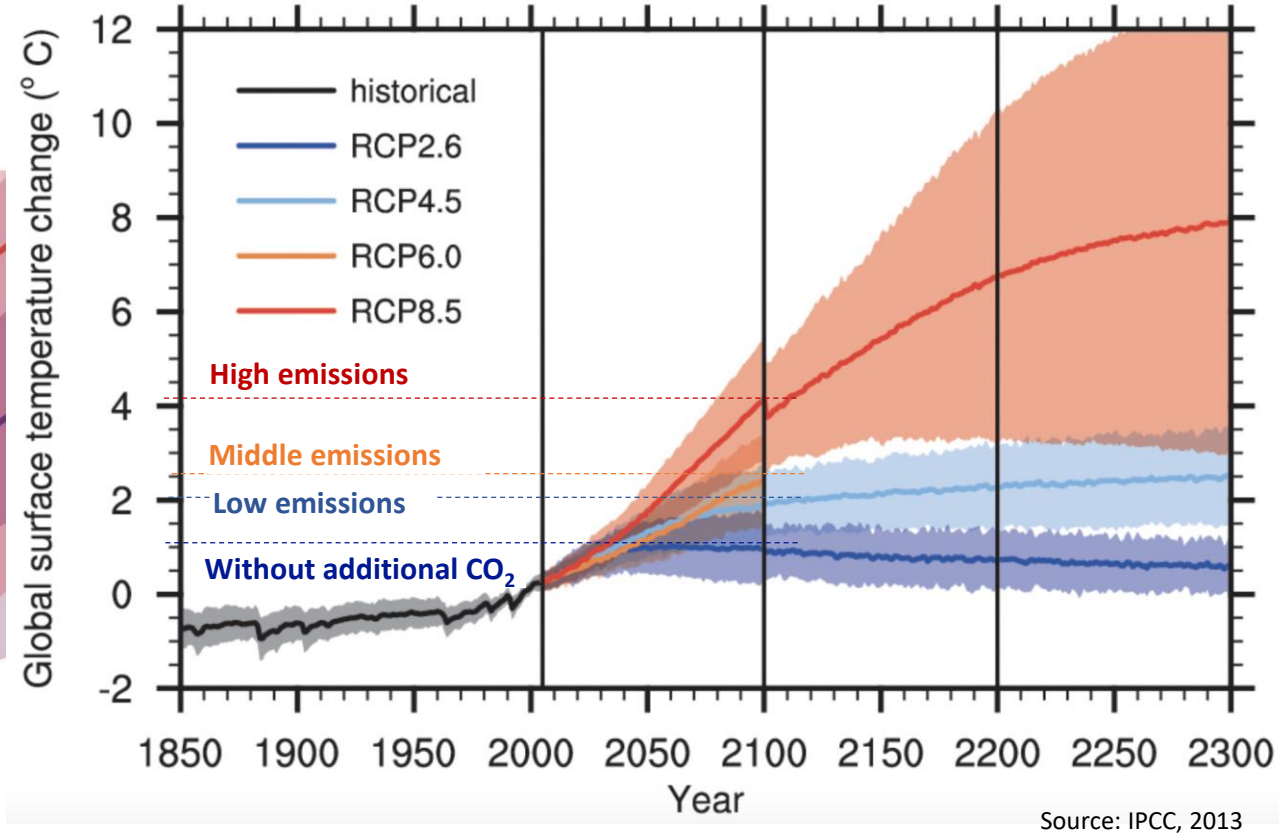
Source: IEA, 2019

Which is the **dominant** fuel in the Total Primary Energy Supply (**TPES**)?

Which is the **dominant** fuel in **CO_2** emission?

Historical data:
Temperature is increasing with CO_2 emissions





Source: IPCC, 2013

Below **2°C** by 2100:

- **Low** emission scenario

Below **1.5°C** by 2100:

- **Lower than low** emission scenario

Source: IPCC, 2018

What is Climate Change?

Survey:
"What's the difference between climate change and global warming?"

Weather Vs. Climate (NASA)

Survey: "What is the difference between weather and climate?"

- The difference between weather and climate is a measure of time.

Weather

- Conditions of the atmosphere are over a short period of time (minutes to months)
- Temperature, humidity, precipitation, cloudiness, brightness, visibility, wind, and atmospheric pressure

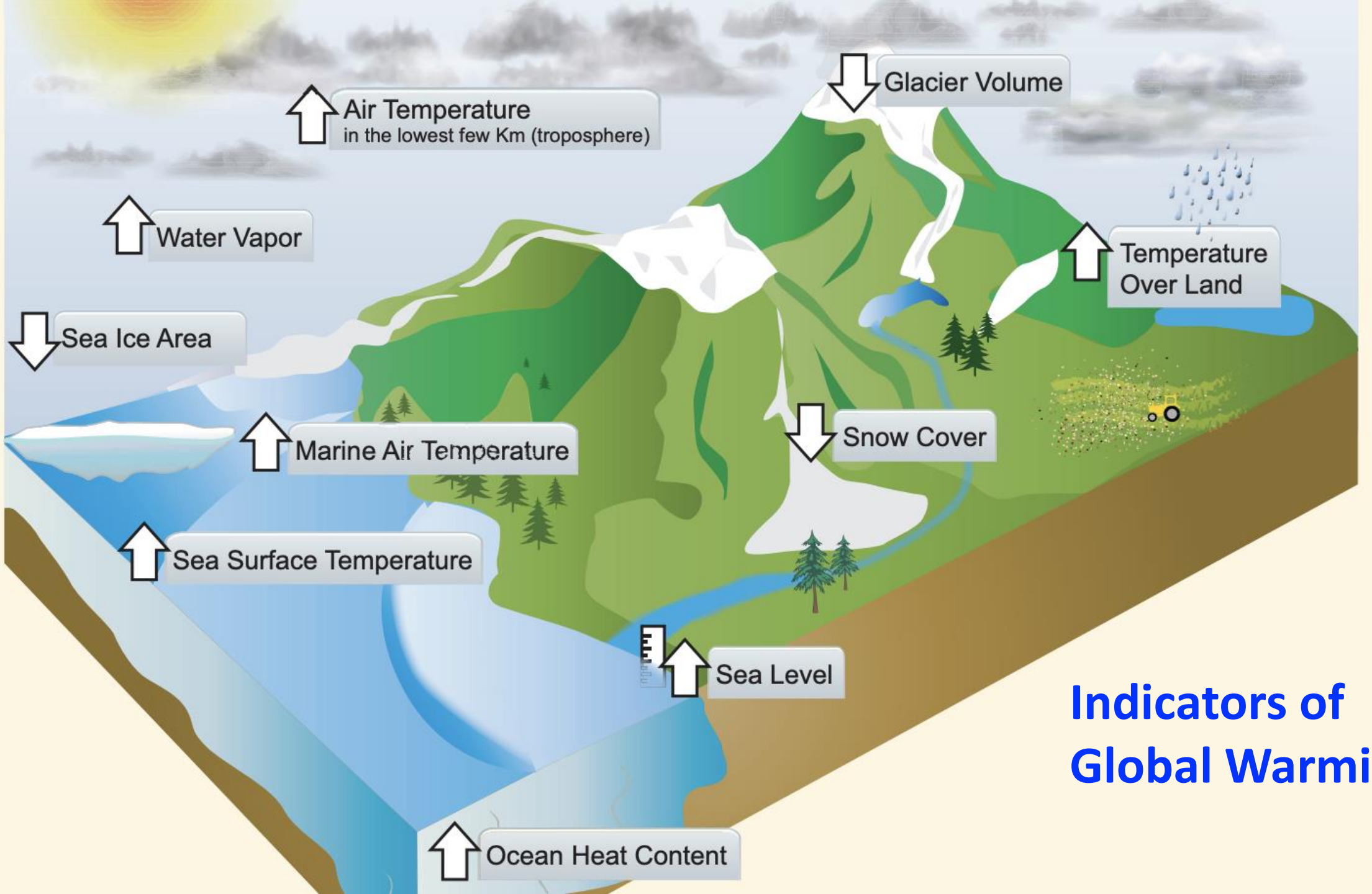
Climate

- How the atmosphere "behaves" over relatively long periods of time (months to million years)
- A statistical description of the mean and variability of weather characteristics

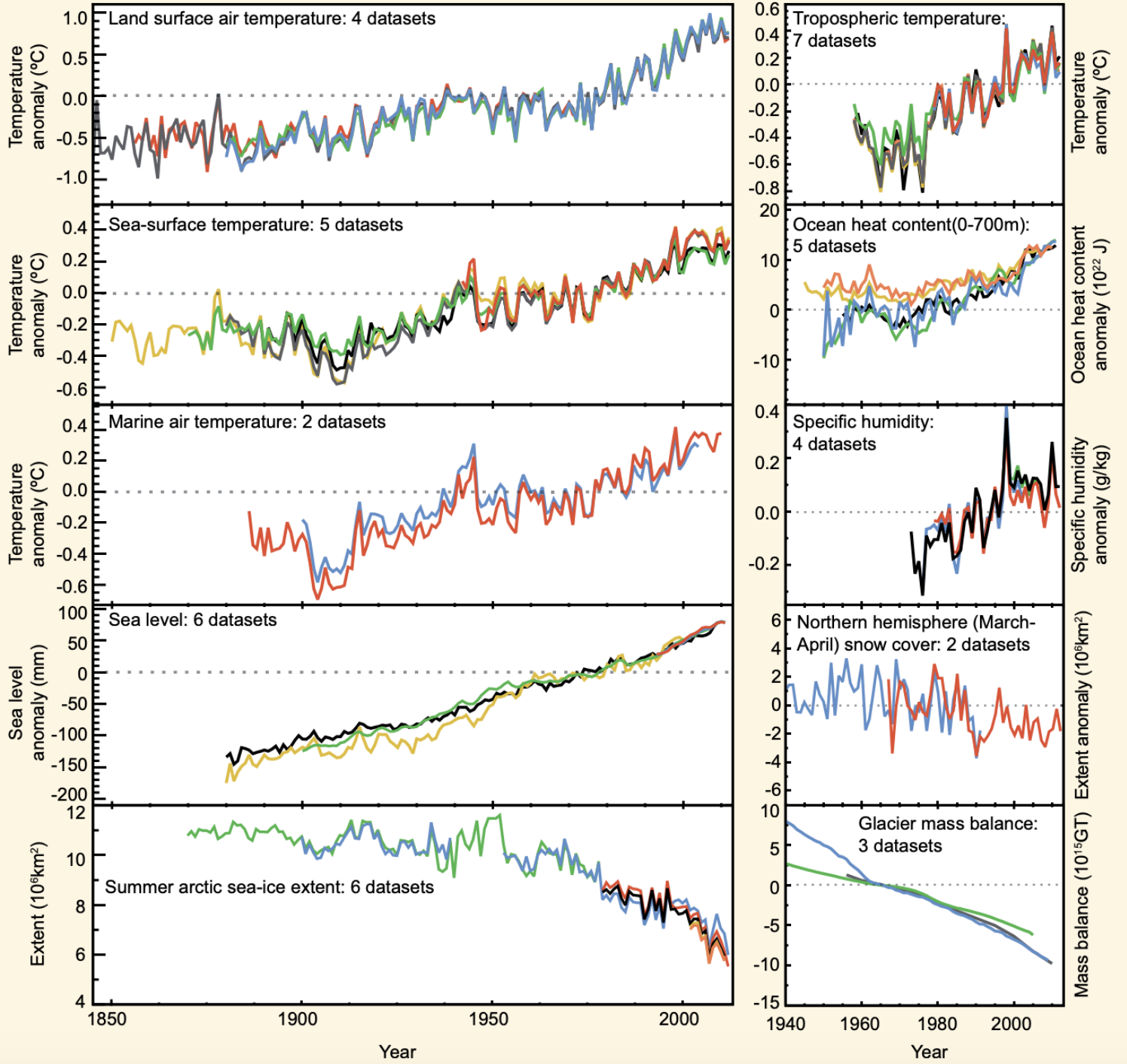
Climate Change

- A change in the state of the mean and/or variability of these elements that can be identified statistically and that persists over a longer period, typically decades or longer

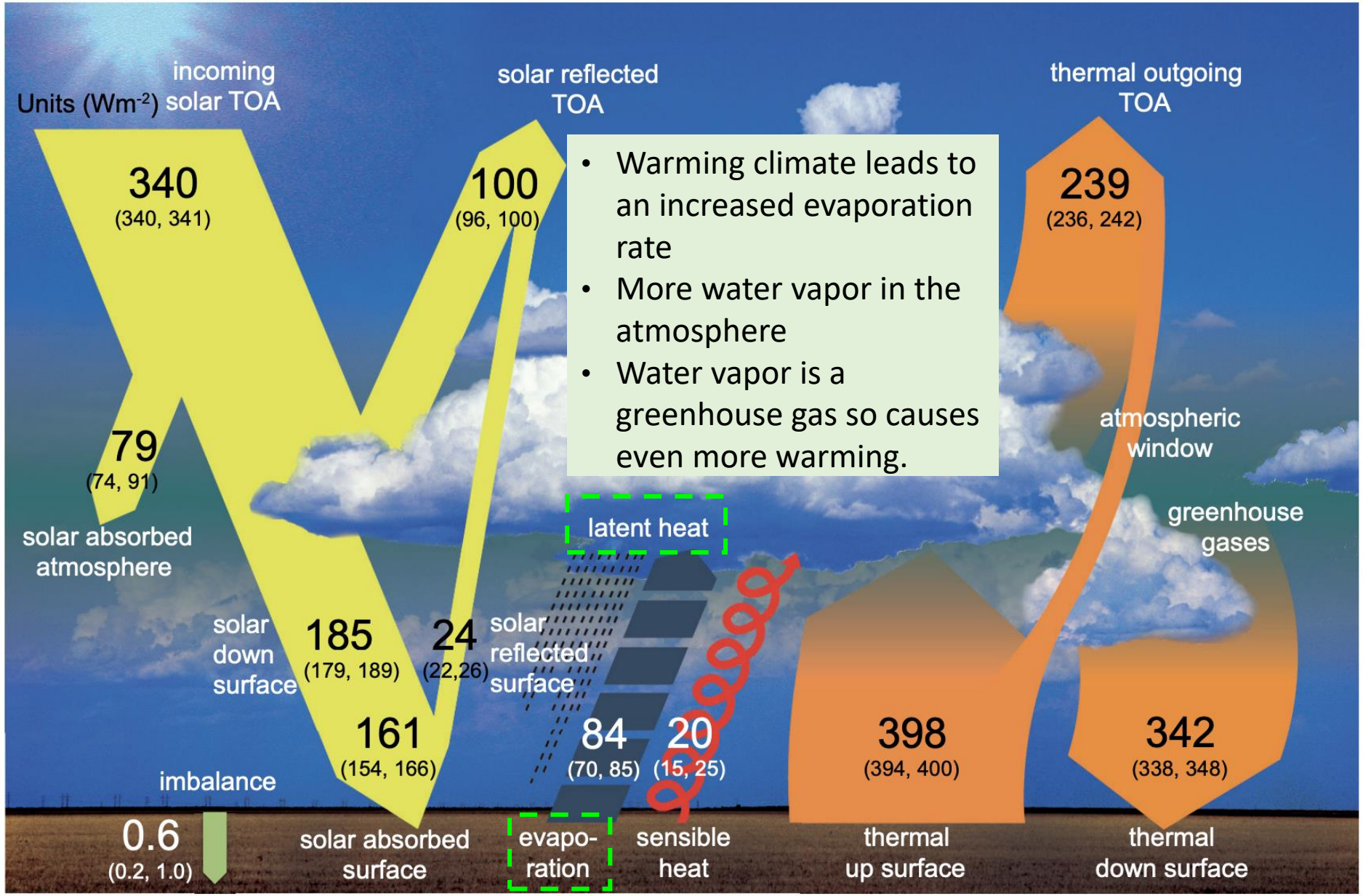
"Climate is what you expect; weather is what you get"



Indicators of Global Warming


Land surface air temperature: 4 datasets
Temperature anomaly (°C)
Sea-surface temperature: 5 datasets
Temperature anomaly (°C)
Marine air temperature: 2 datasets
Temperature anomaly (°C)
Sea level: 6 datasets
Sea level anomaly (mm)
Summer arctic sea-ice extent: 6 datasets
Extent (10⁶km²)
1850
1900
1950
2000
Year
Tropospheric temperature: 7 datasets
Temperature anomaly (°C)
Ocean heat content(0-700m): 5 datasets
Ocean heat content anomaly (10²² J)
Specific humidity: 4 datasets
Specific humidity anomaly (g/kg)
Northern hemisphere (March-April) snow cover: 2 datasets
Extent anomaly (10⁶km²)
Glacier mass balance: 3 datasets
Mass balance (10¹⁵GT)
1940
1960
1980
2000
Year

Global mean energy budget under present-day climate conditions



- Warming climate leads to an increased evaporation rate
- More water vapor in the atmosphere
- Water vapor is a greenhouse gas so causes even more warming.

The Ocean and Cryosphere

The ocean

What we know..

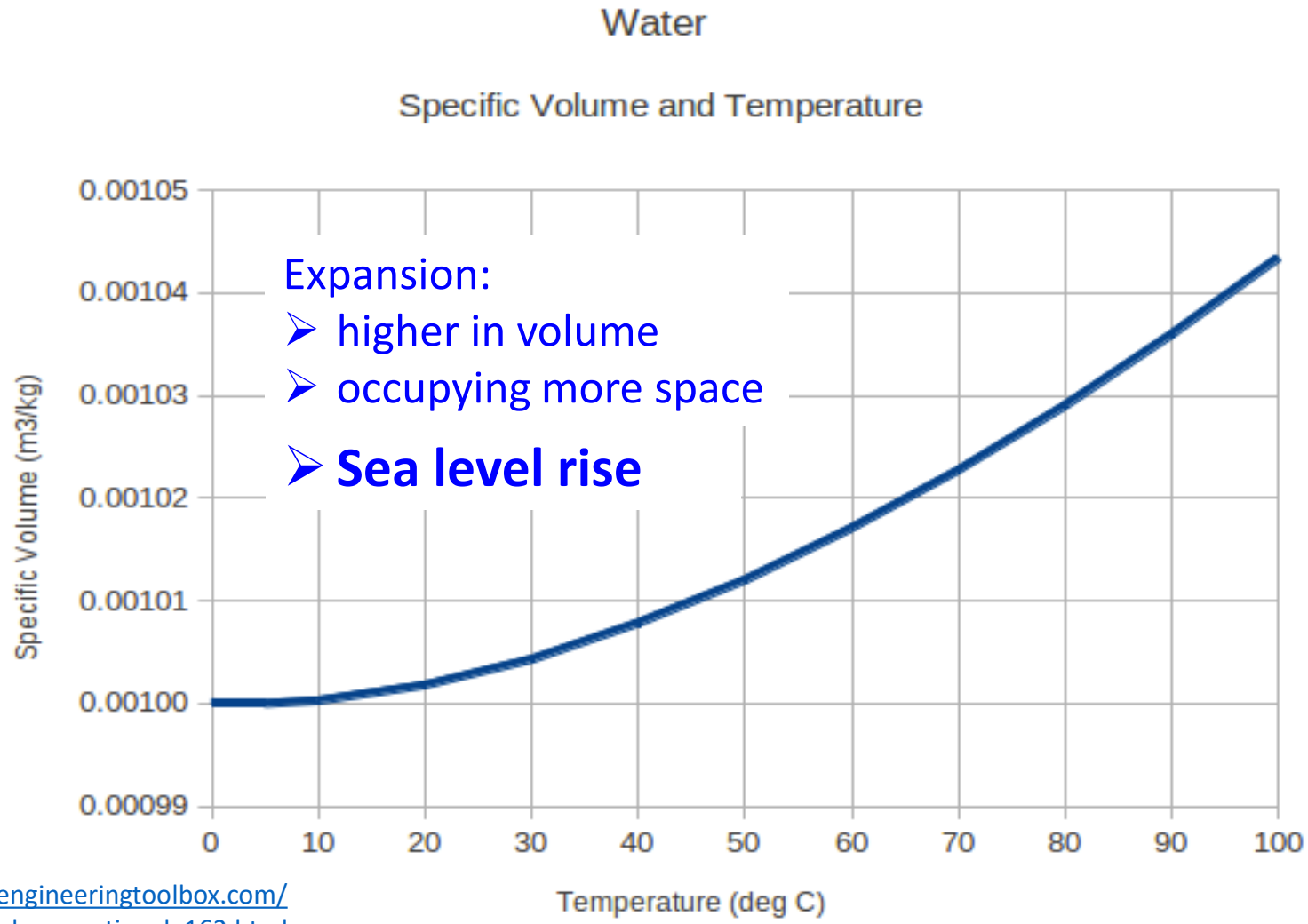
Excess heat been trapped ➔ global warming

Do you know ocean absorbs how much of heat?

About 93% of the excess heat energy stored by the Earth over the last 50 years is found in the ocean

As the ocean warms

Thermal expansion of seawater



Source:
http://www.engineeringtoolbox.com/water-thermal-properties-d_162.html

Cryosphere

- Refers to frozen components of the Earth system that are at or below the land and ocean surface
- Include snow, glaciers, ice sheets, ice shelves, icebergs, sea ice, lake ice, river ice, permafrost and seasonally frozen ground

When the earth is warmed,

- Melting of glaciers and continental ice sheets
- Transfer of water stored on land to the ocean
- **Sea level rise**

When the earth is warmed,

- Melting of sea ice
- Changing the surface albedo
- Changing the exchange rate of water vapour and CO_2 between the ocean and atmosphere
- Salt is ejected, altering the density structure and modifies the circulation of the ocean

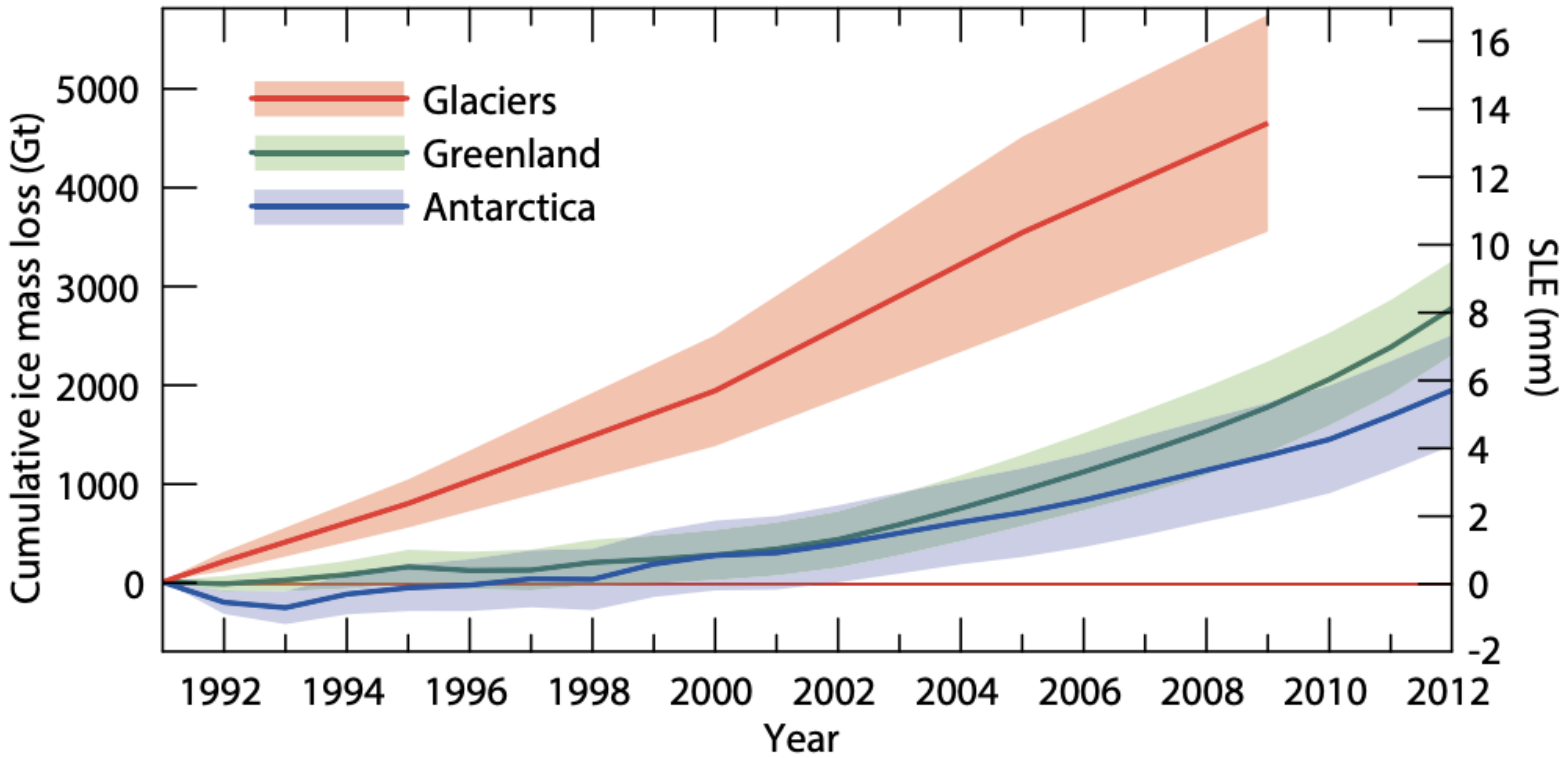
Albedo

- In the context of climate change, albedo is the fraction of solar energy that is reflected from the Earth into space
- If Earth was completely covered in ice, its albedo would be about 0.84, meaning it would reflect most (84%) of the sunlight that hit it.
- On the other hand, if Earth was covered by a dark green forest canopy, the albedo would be about 0.14 (most of the sunlight would get absorbed)
- Changes in ice cover, cloudiness, airborne pollution, or land cover (from forest to farmland, for instance) all have subtle effects on global albedo
- Using satellite measurements accumulated since the late 1970s, scientists estimate Earth's average albedo is about about 0.30

"How much extra heat are the dark waters of Arctic Ocean in summer adding to the planet? One recent study estimates that it's equivalent to adding another **25 percent** to global greenhouse emissions."

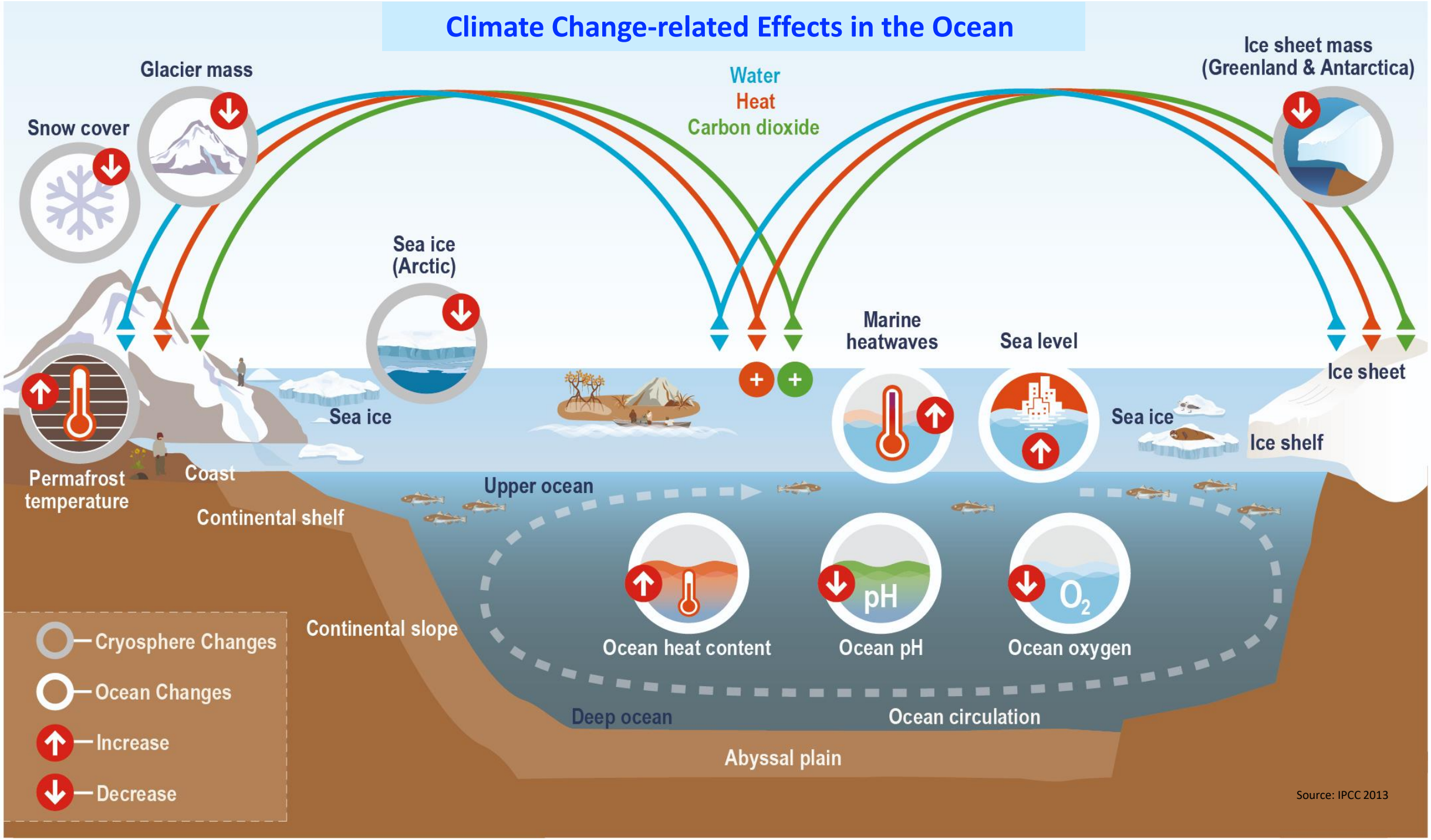
– Peter Wadhams, professor of ocean physics at Cambridge University

Contribution of Glaciers and Ice Sheets to Sea Level Change



Cumulative ice mass loss from glacier and ice sheets (in sea level equivalent) is 1.0 to 1.4 mm yr^{-1} for 1993-2009 and 1.2 to 2.2 mm yr^{-1} for 2005-2009.

Climate Change-related Effects in the Ocean



Source: IPCC 2013

Global mean air temperature

Global mean surface temperature

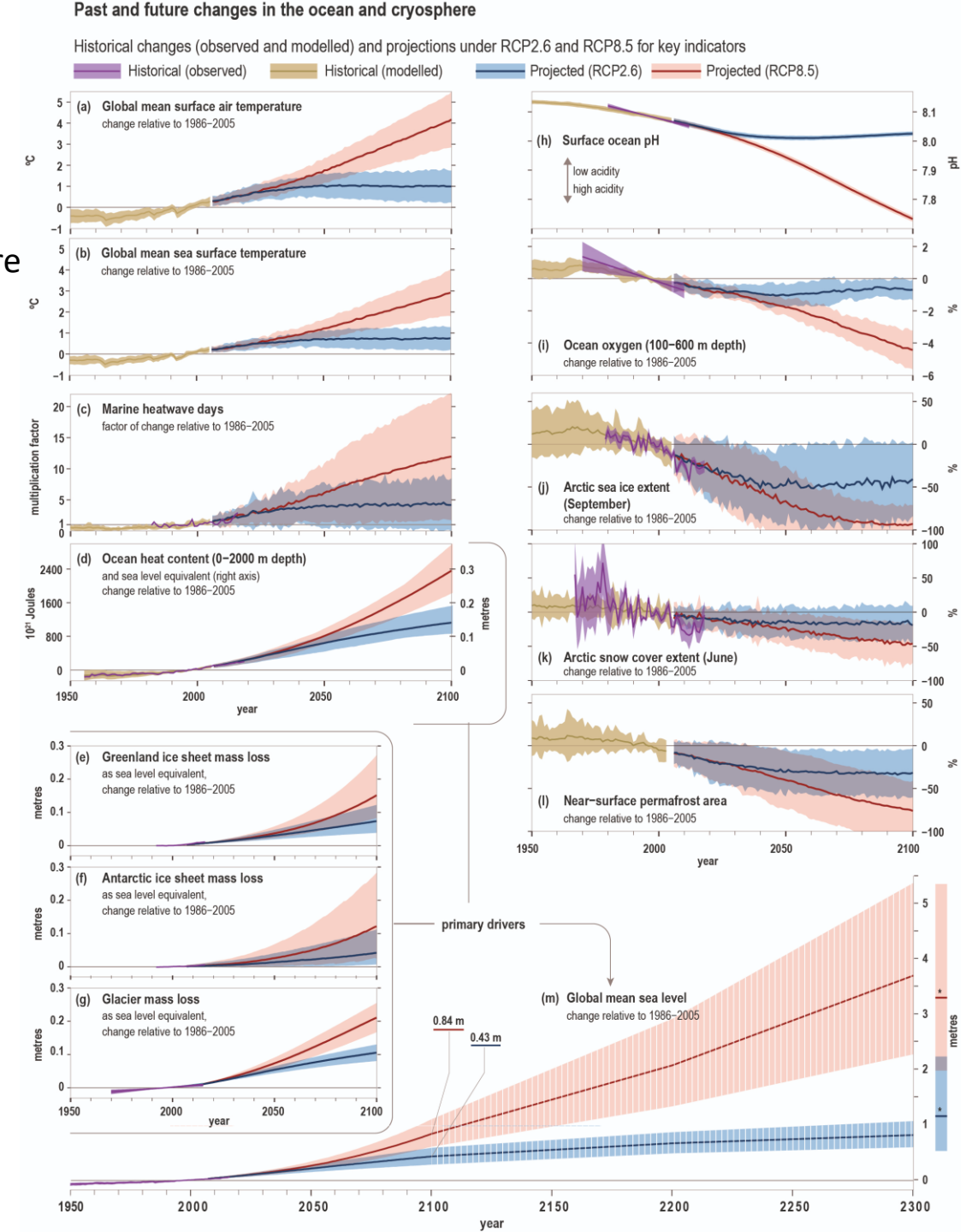
Marine heatwave days

Ocean heat content

Greenland ice sheet mass loss

Antarctic ice sheet mass loss

Glacier mass loss



Surface ocean pH

Ocean oxygen

Artic sea ice extent

Artic snow cover extent

Near-surface permafrost area

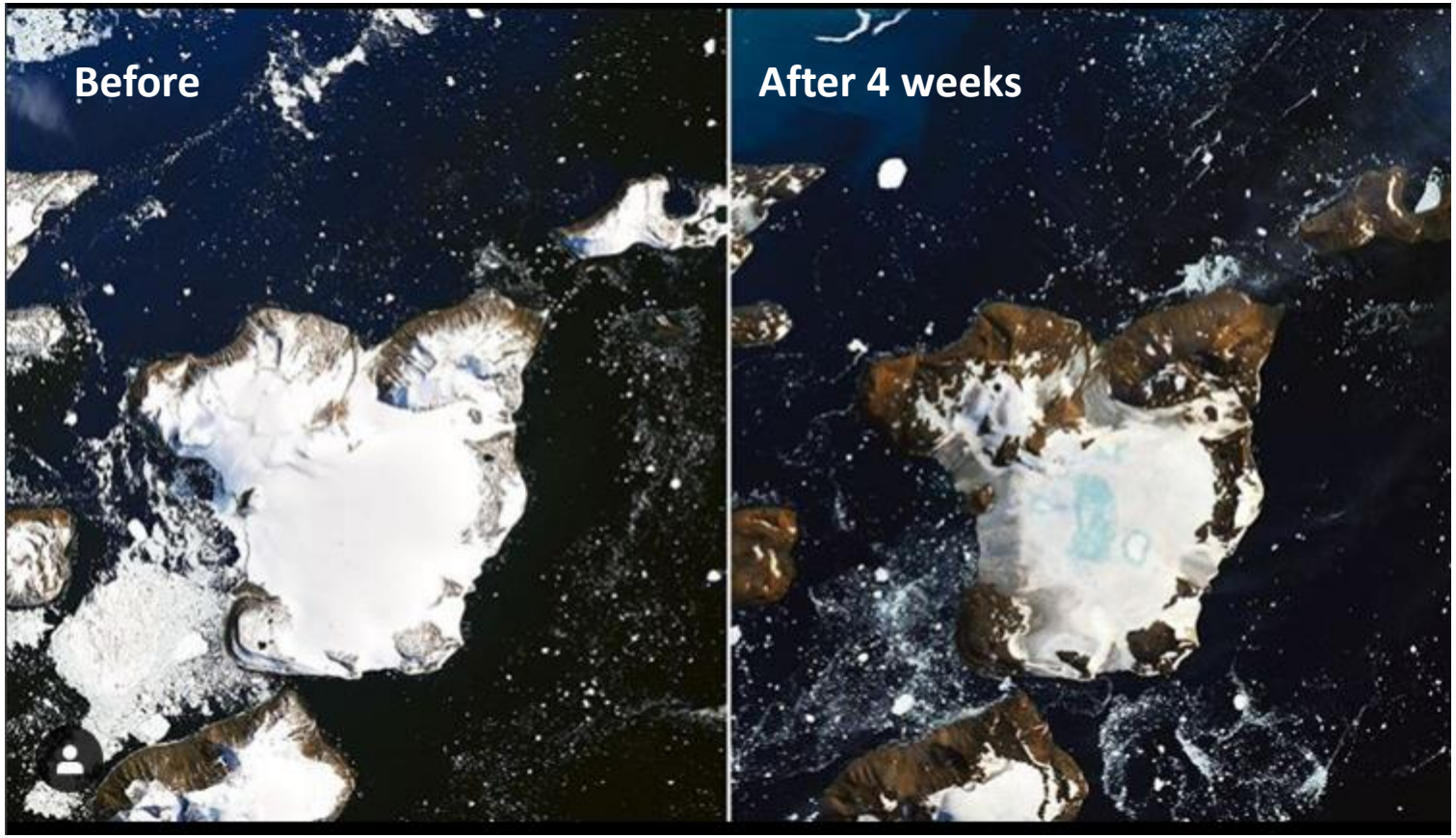
Global mean sea level

Source: IPCC 2013

How hot will it get in your lifetime?

- http://ilmasto-opas.fi/en/ilmastonmuutos/videot-ja-visualisoinnit/-/artikkeli/b4df9633-7e1f-4389-9dd0-a0539588f211/visualisoinnit.html#kuinka-lamminta

Real Evidences: Antarctica



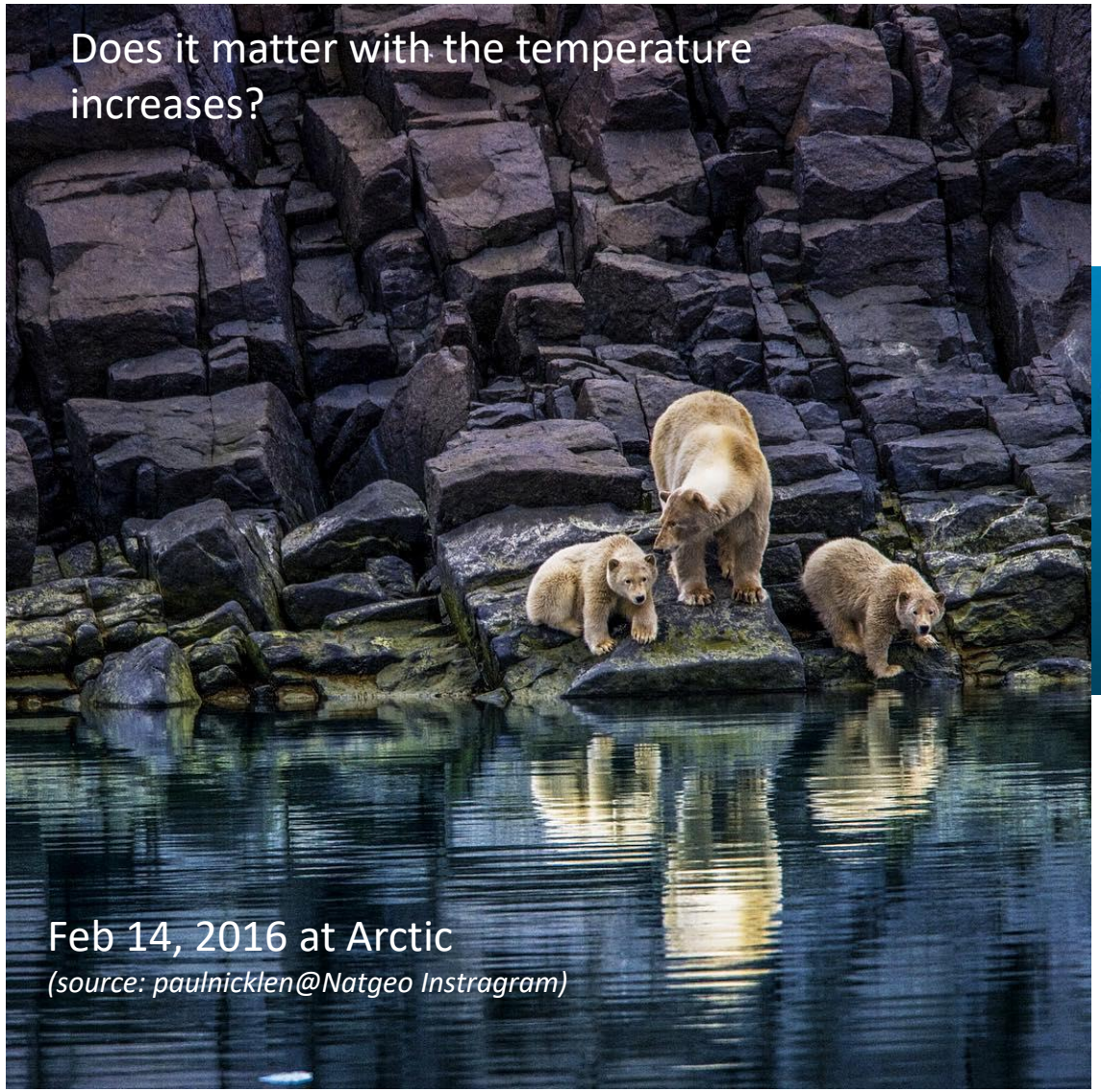
Before and after satellite images show that nearly a quarter of the snow cover on Antarctica's Eagle Island has melted after a heat wave earlier this month, an increasingly common symptom of the climate crisis. In just over a week, 4 inches of Eagle Island's snowpack melted — that's about 20% of the island's total seasonal snow accumulation, NASA's Earth Observatory said. Even during the summer, **melting like this is rare for Antarctica, one of the coldest places on Earth**.

(📷: NASA)

Real Evidences: Antarctica

Antarctica has **exceeded 20°C** for the first time, after researchers logged a temperature of 20.75°C on Seymour Island off the coast at the northernmost point of the continent.

(BBCnews)



Real Evidences: Artic

In 2018, the Arctic's oldest and thickest sea ice was observed breaking up **for the first time in recorded history**.

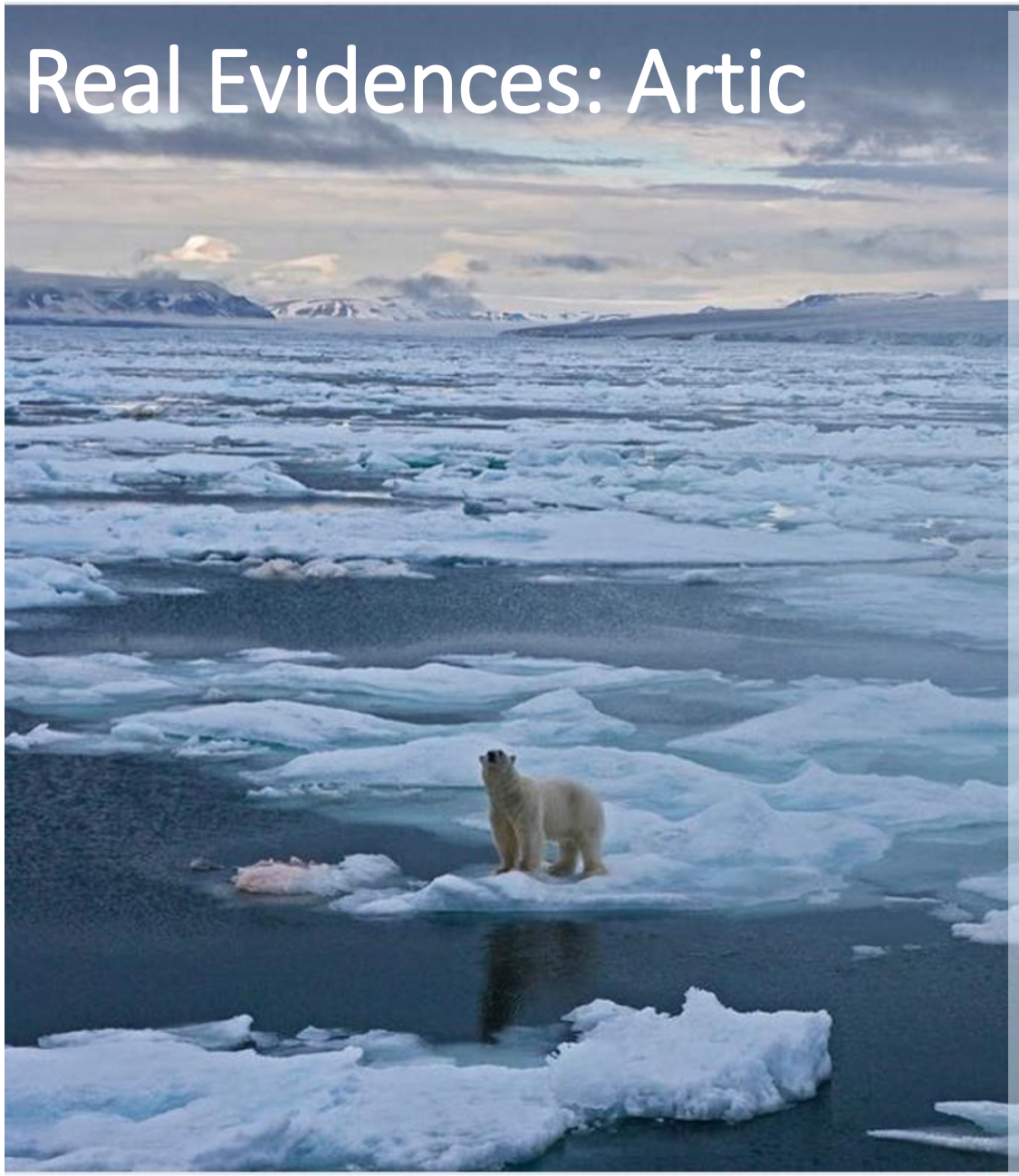
Real Evidences: Artic

Does it matter with the temperature increases?

Waterfall made by the melting glacier ice under the heat of the Arctic summer

(source: Paul Nicklen)

Real Evidences: Artic



" I am always trying to explain the difference between multiyear and annual sea ice. This mother walrus and her newborn pup are resting on a piece of multiyear ice. This is ice that lives for many years. It is much thicker and much more dense and is crucial to many species that use it as a floating home. Annual ice comes and goes with each season. So, when scientists say that the Arctic will be completely void of sea ice in the next 20 to 30 years during the summer months, that means that there will be absolutely no sea ice left anywhere in the Arctic for several months each year. What will happen to the walrus, the polar bears the bearded seals, the harp seals and the birds that all rely on some form of ice throughout the summer. " – Paul Nicklen

Sea ice as floating home

Which Mountain Is the Tallest in the World?

Studies of increased vegetation in the Arctic found that they delivered a warming effect in the surrounding landscape, with the plants absorbing more light and warming the soil.

Further Reading

Earth Energy Balance

- https://earthobservatory.nasa.gov/features/EnergyBalance
- https://www.youtube.com/watch?v=sTvqIijqvTg
- https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014GL060962
- https://climate.nasa.gov/news/673/nasa-study-earths-energy-budget-out-of-balance/
- https://earthobservatory.nasa.gov/images/84499/measuring-earths-albedo

Lifetimes & GWP

- https://www.epa.gov/climate-indicators/greenhouse-gases
- https://www.epa.gov/climateleadership/atmospheric-lifetime-and-global-warming-potential-defined
- https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

THANK YOU!

NEXT…

Basic of Climate Change Part II:

- Global warming and sea level change
- How climate risk matters in Southeast Asia: the Past and Future

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