What is Climate Change?

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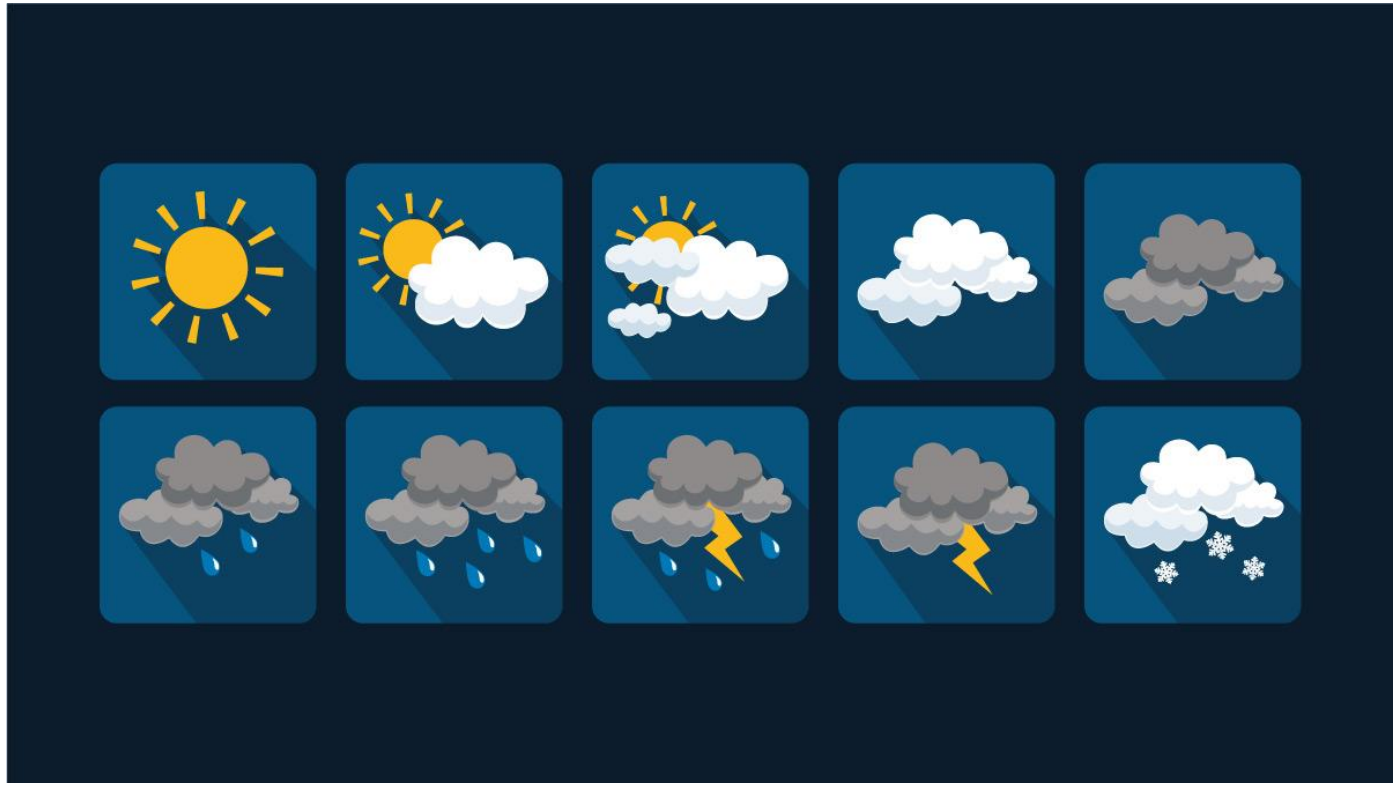
Lecture overview

- Climate
- Climate Change
- Essential Climate Variable & Climate change

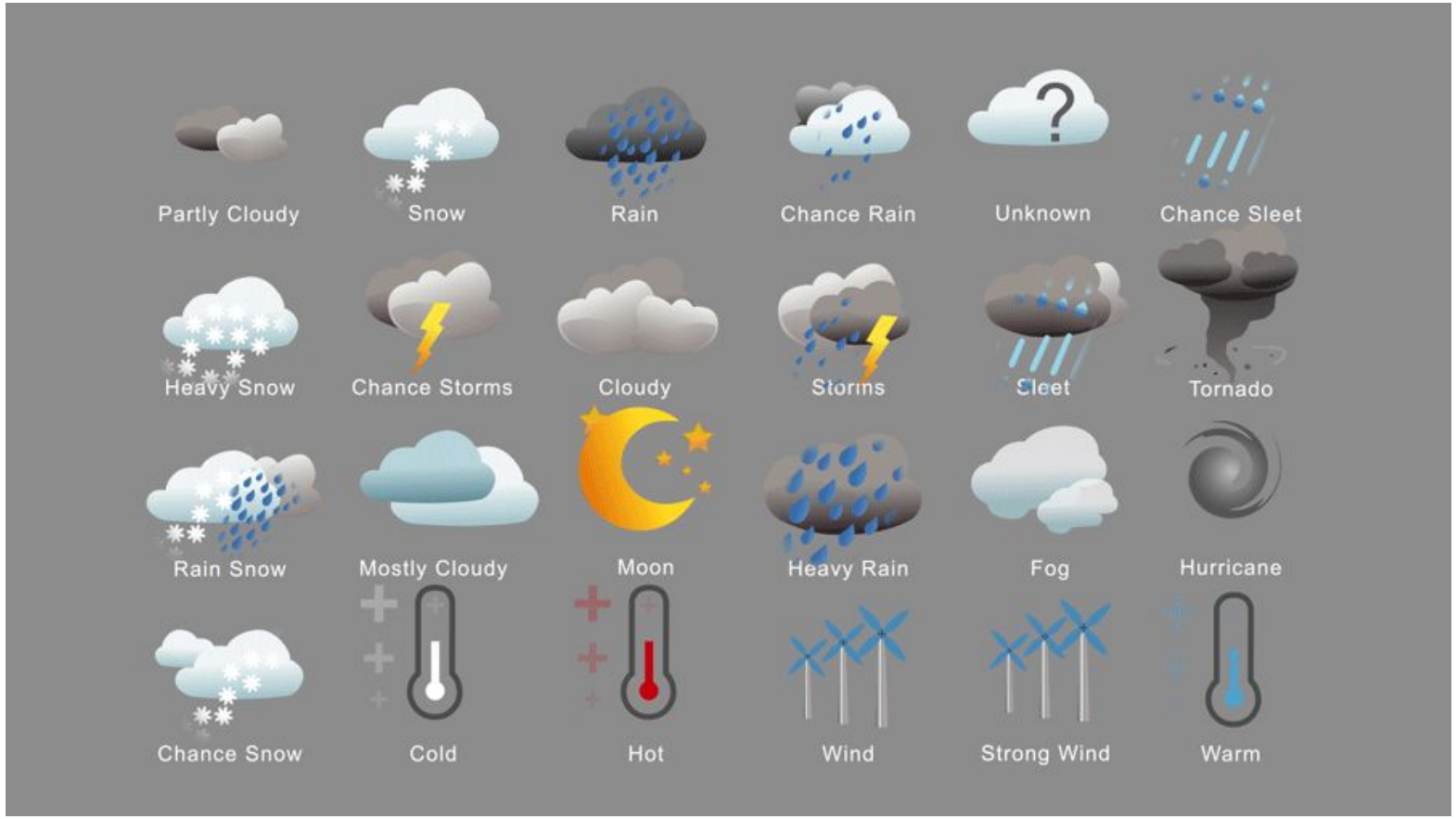
What is Climate?

Climate is defined as an area's long-term weather patterns. The simplest way to describe climate is to look at average temperature and precipitation over time.



What is Weather?

Weather is the state of the atmosphere at a particular place during a short period of time



Weather vs Climate

Weather

Can change within a few minutes or hours

Climate

Takes very long time to change!

Weather vs Climate

- Determined: Over time
- Looked at by the years
- Reported as an average
- Depends on the location on Earth
- Weather makes up climate

Measures conditions in the atmosphere

- Determined: daily
- Looked at by the minutes, hour, day, week
- Reported as a forecast
- Depends on the weather occurring mainly to the west
- Climate helps you determine the weather

Climate variables

Some meteorological variables that are commonly measured are as follows:

Temperature

Cloudiness

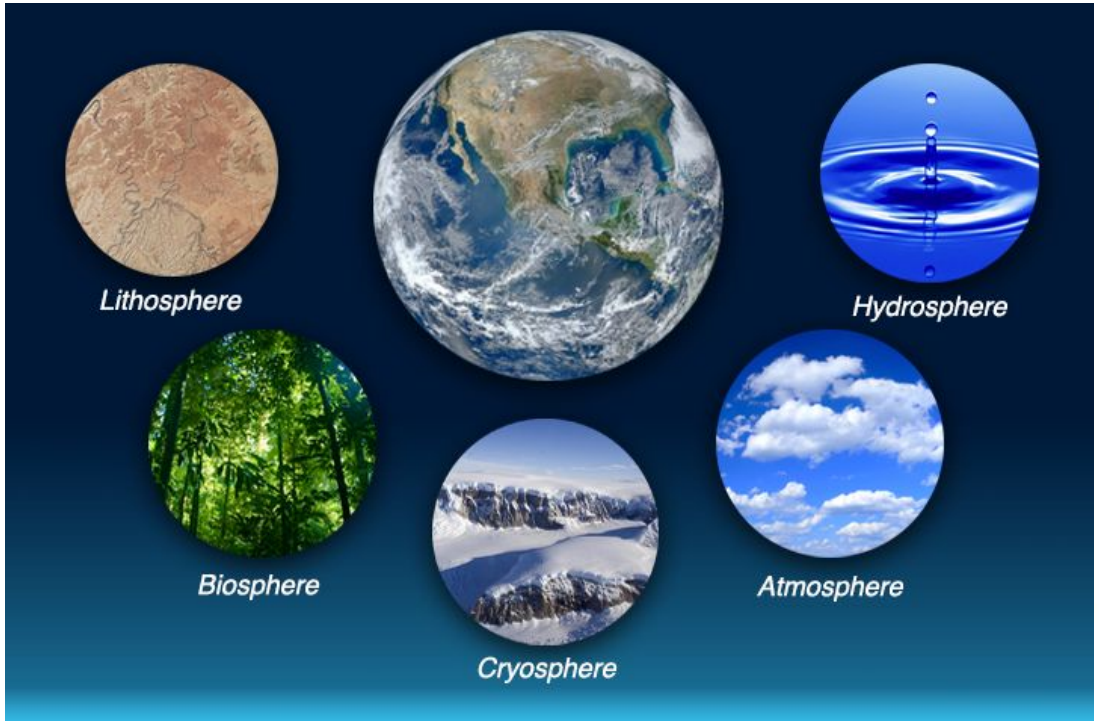
Humidity

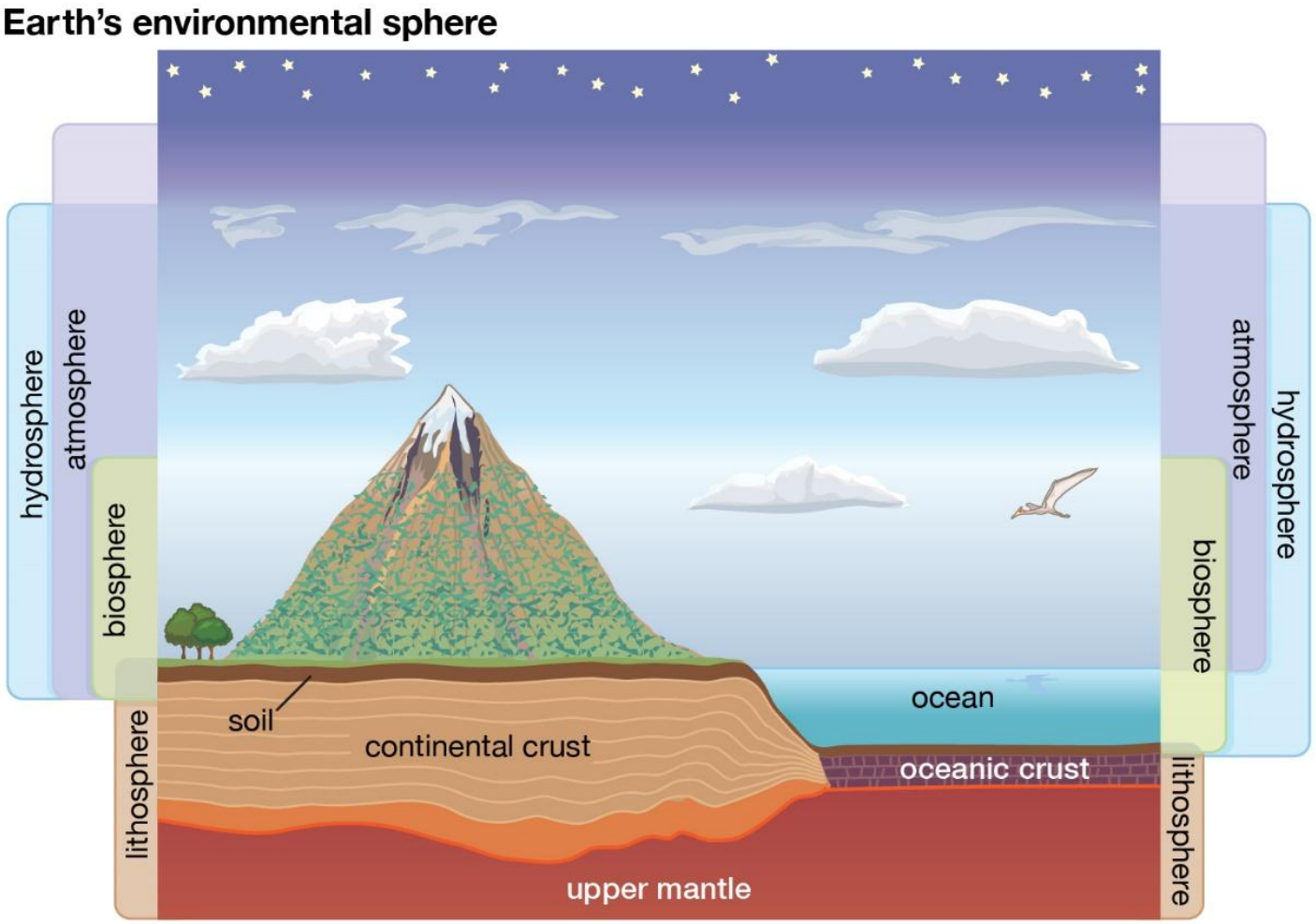
Atmospheric pressure

Precipitation

Wind

Climate System



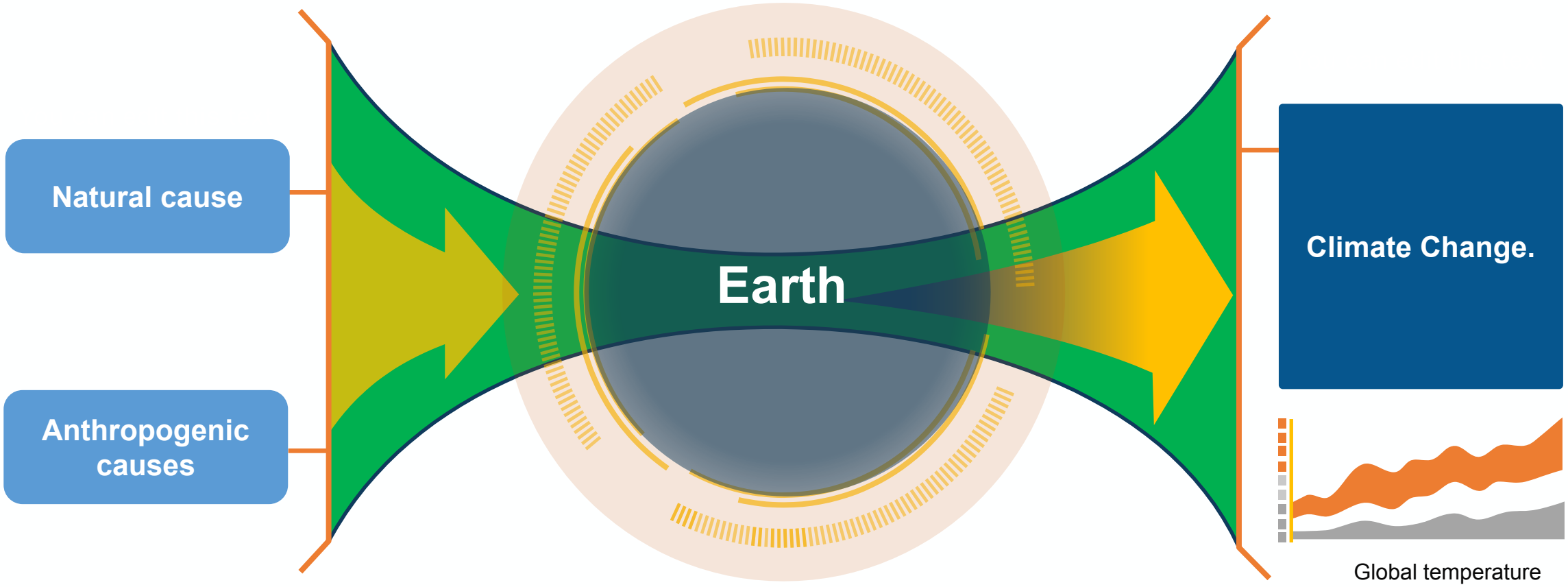


What is climate change?

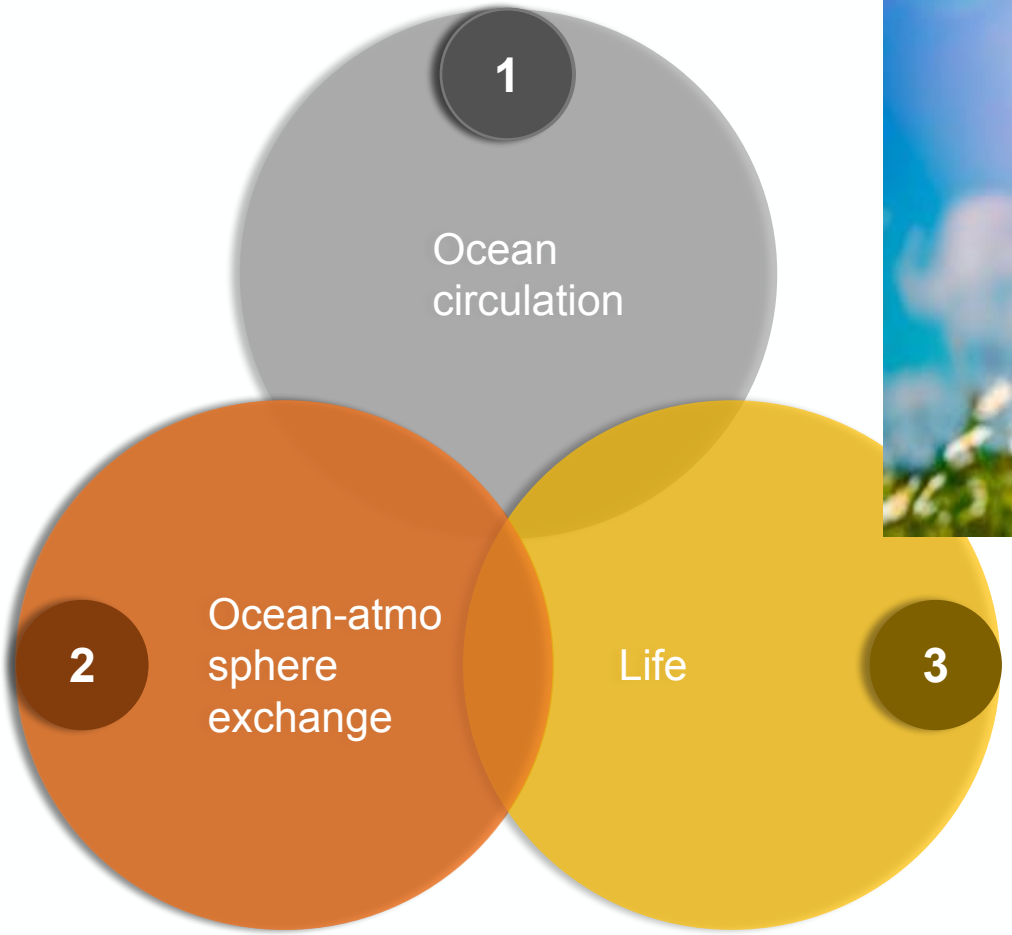
Climate change is a change in the pattern of weather, and related changes in oceans, land surfaces and ice sheets, that have come to define Earth's local, regional and global climates and occurring over time scales of decades or longer.

Human activities, especially emissions of heat-trapping greenhouse gases from fossil fuel combustion, deforestation, and land-use change, are the primary driver of the climate changes observed in the industrial era.

Climate change causes



Natural causes-Internal variability



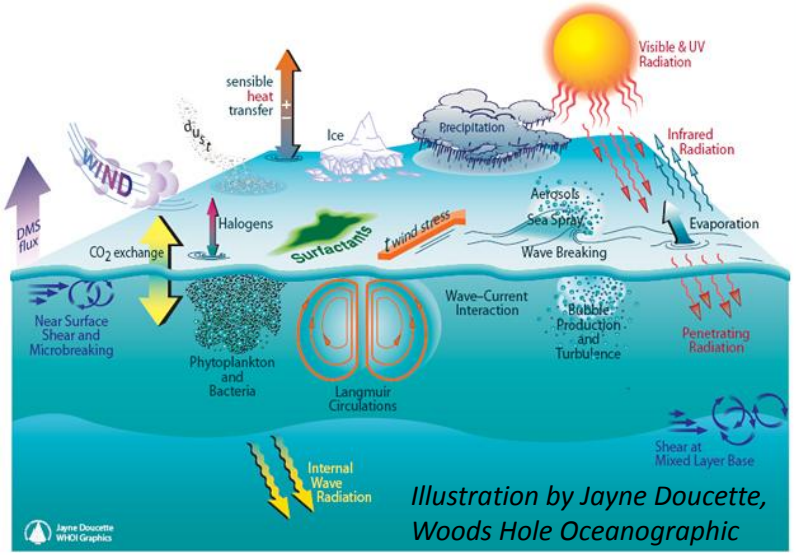
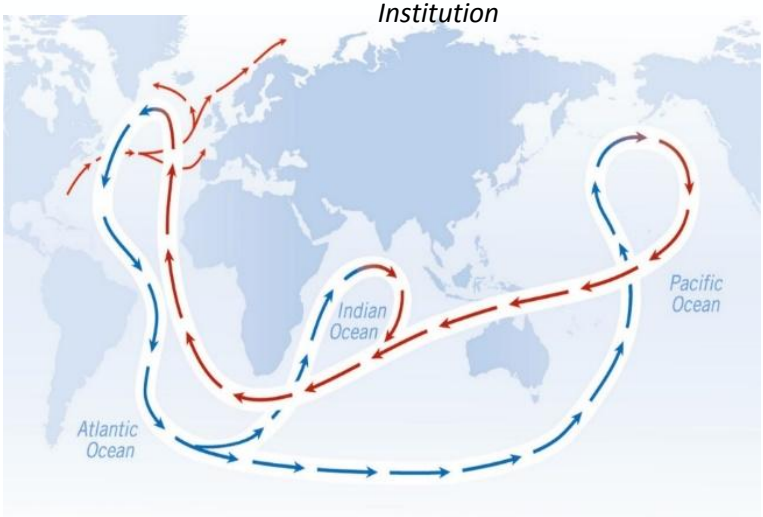
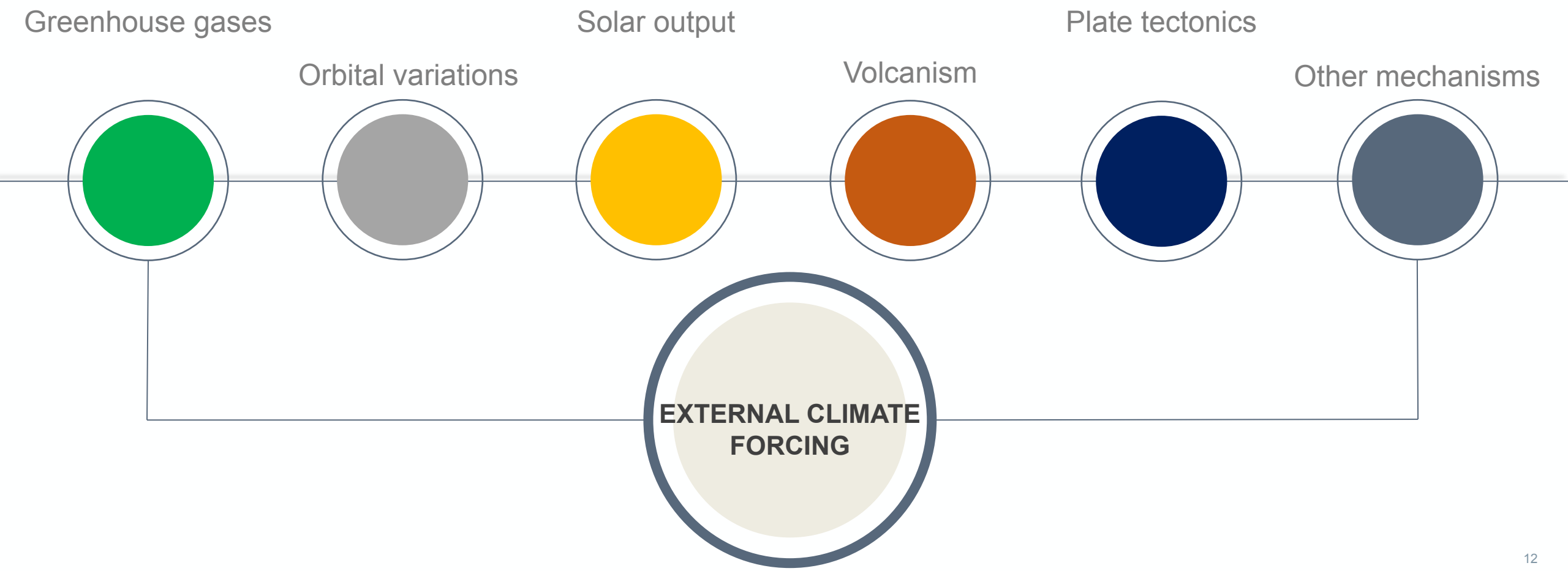


Illustration by Jayne Doucette, Woods Hole Oceanographic Institution



Natural causes-External forcing



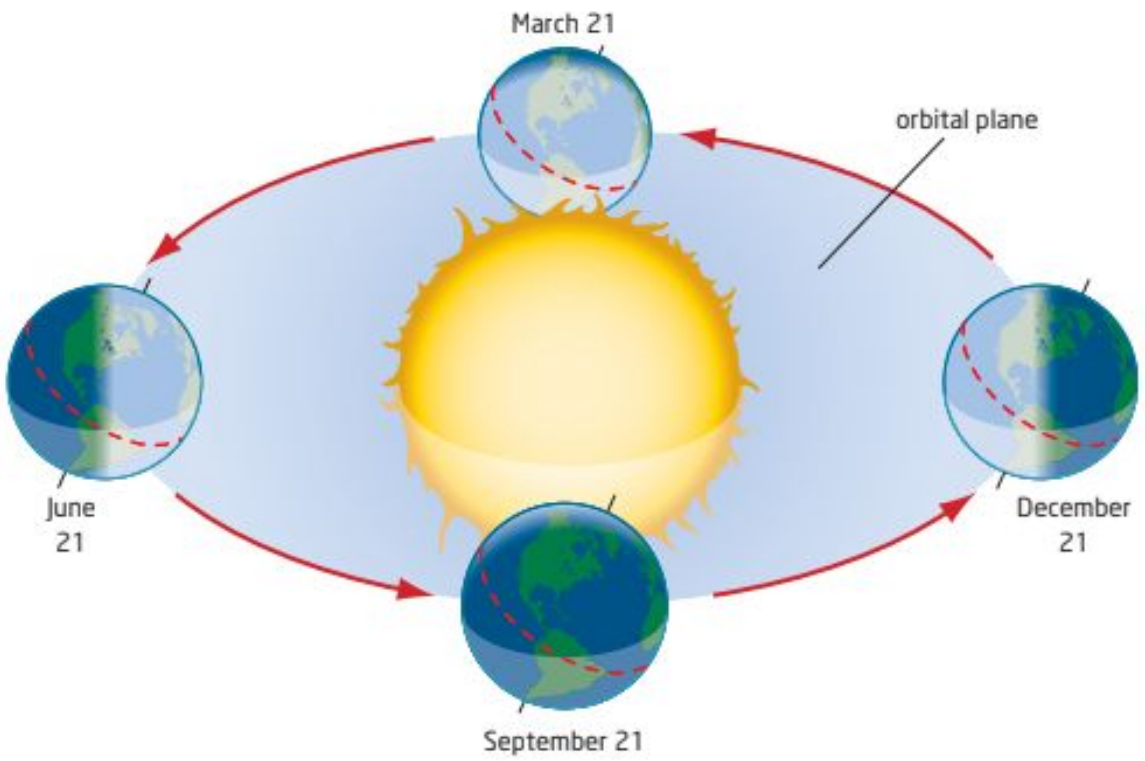
Natural causes-Orbital variation

Shifts and wobbles in the Earth's orbit can trigger changes in climate such as the beginning and end of ice ages.

More tilt = warmer summers and colder winters

Less tilt = cooler summers and milder winters

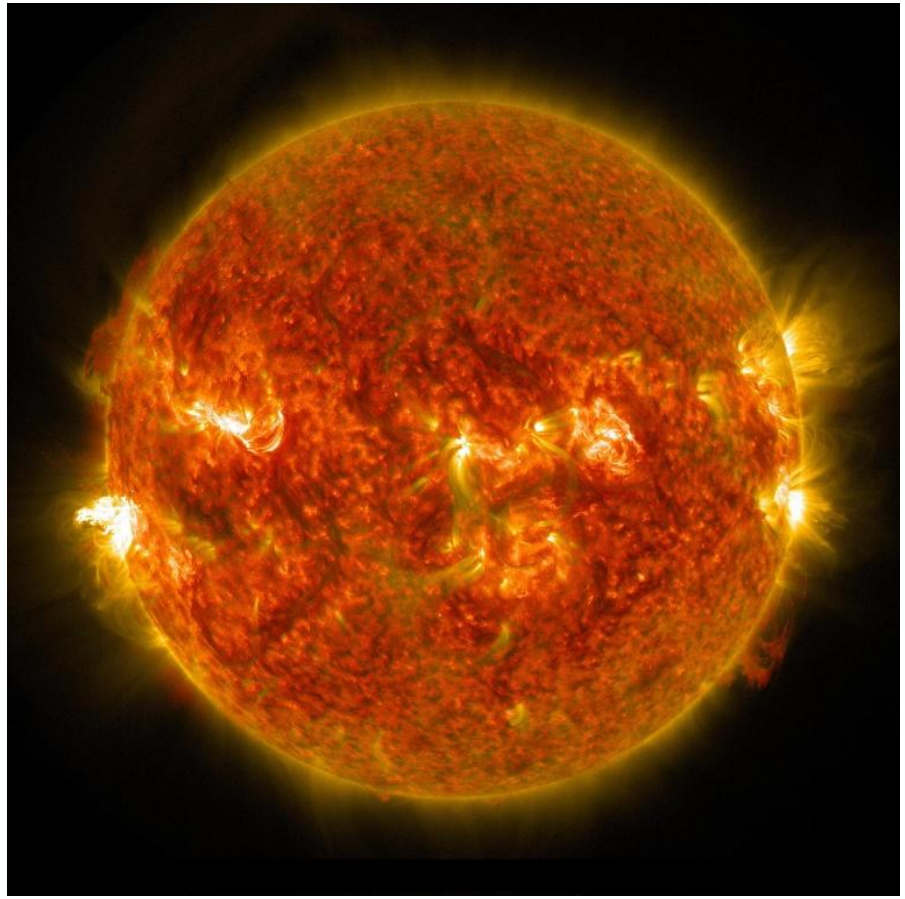
Orbital shifts are so gradual that they can only be observed over thousands of years -not decades or centuries.



Natural causes-solar output

The Sun is the source of energy for the Earth's climate system.

The Sun's energy output appears constant from an everyday point of view, small changes over an extended period of time can lead to climate changes.



Source: Swiss National Science Foundation

Natural causes-solar output

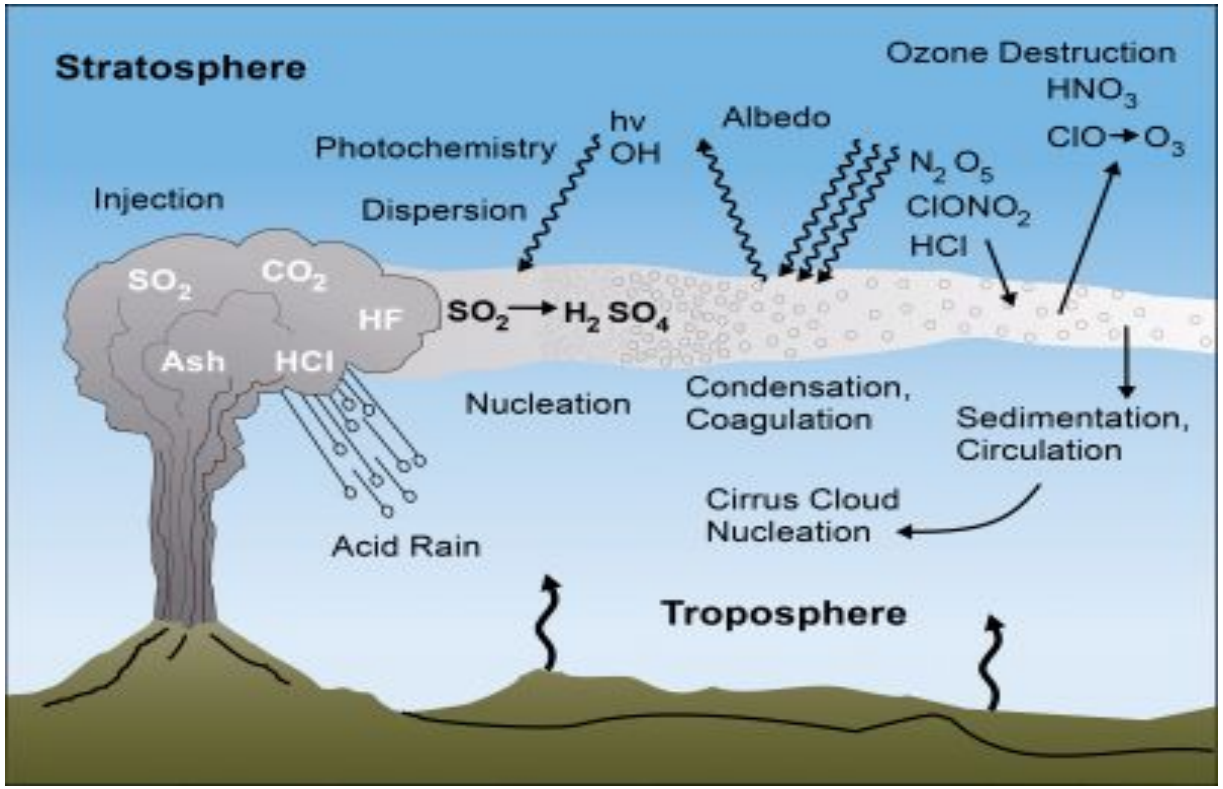
A decrease in solar activity was thought to have triggered the Little Ice Age between approximately 1650 and 1850, when Greenland was largely cut off by ice from 1410 to the 1720s and glaciers advanced in the Alps.

The Frozen Thames, by Abraham Hondius (c.1625–1691)

Pompenburg with Hofpoort in winter, by Bartholomeus Johannes van Hove (1790-1880)

Natural causes-volcanism

Volcanic eruption throws out a enormous amount of particles and other gases that effectively shield us from the Sun to lead to a period of global cooling.



Source: https://earthdata.nasa.gov/learn/sensing-our-planet/volcanoes-and-climate-change

Anthropogenic causes

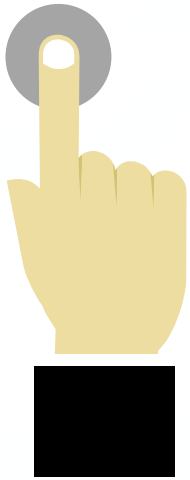
Coal mining

Deforestation

Air pollution

Greenhouse gases

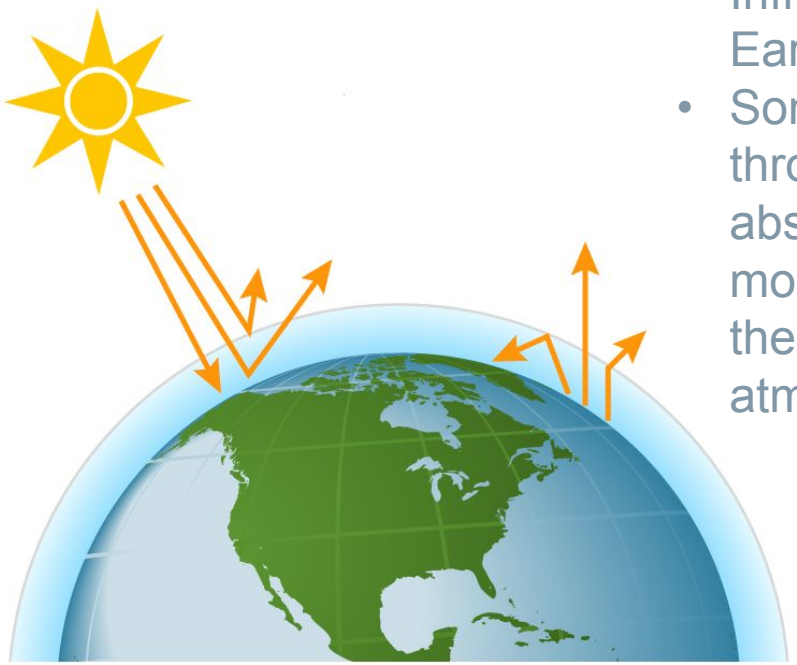
Industrial processes



Greenhouse gases

- Greenhouse gases are those that absorb and emit infrared radiation in the wavelength range emitted by Earth.

- Solar radiation passes through the clear atmosphere.
- Most radiation is absorbed by the Earth surface and warms it.
- Some solar radiation is reflected by the Earth and the atmosphere.

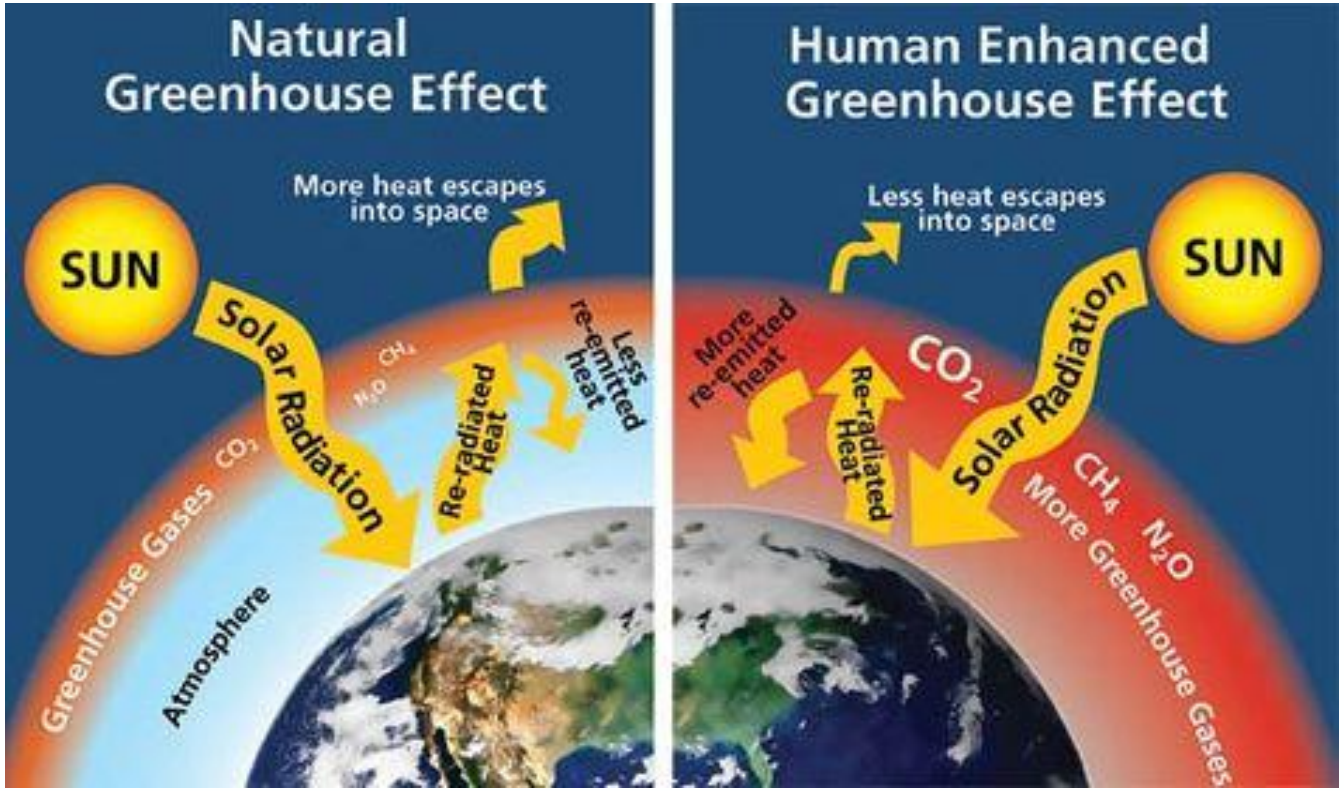


- Infrared radiation is emitted from the Earth surface.
- Some of the infrared radiation passes through the atmosphere and some absorbed and re-emitted in all molecules. The effect of this is to warm the Earth surface and the lower atmosphere.

The burning of fossil fuels like coal, oil, and gas for electricity, heat, and transportation is the primary source of human-generated emissions.

Greenhouse gases

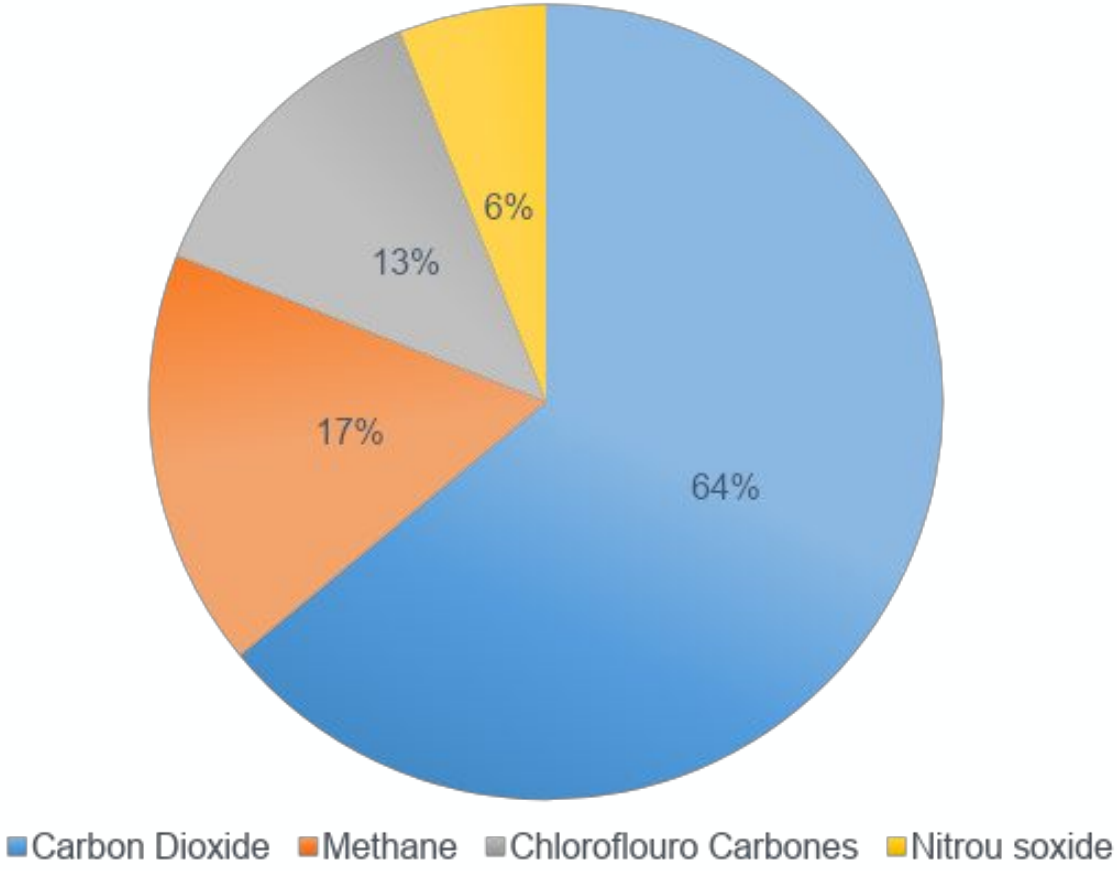
Human enhanced greenhouse gases effect



Greenhouse gases

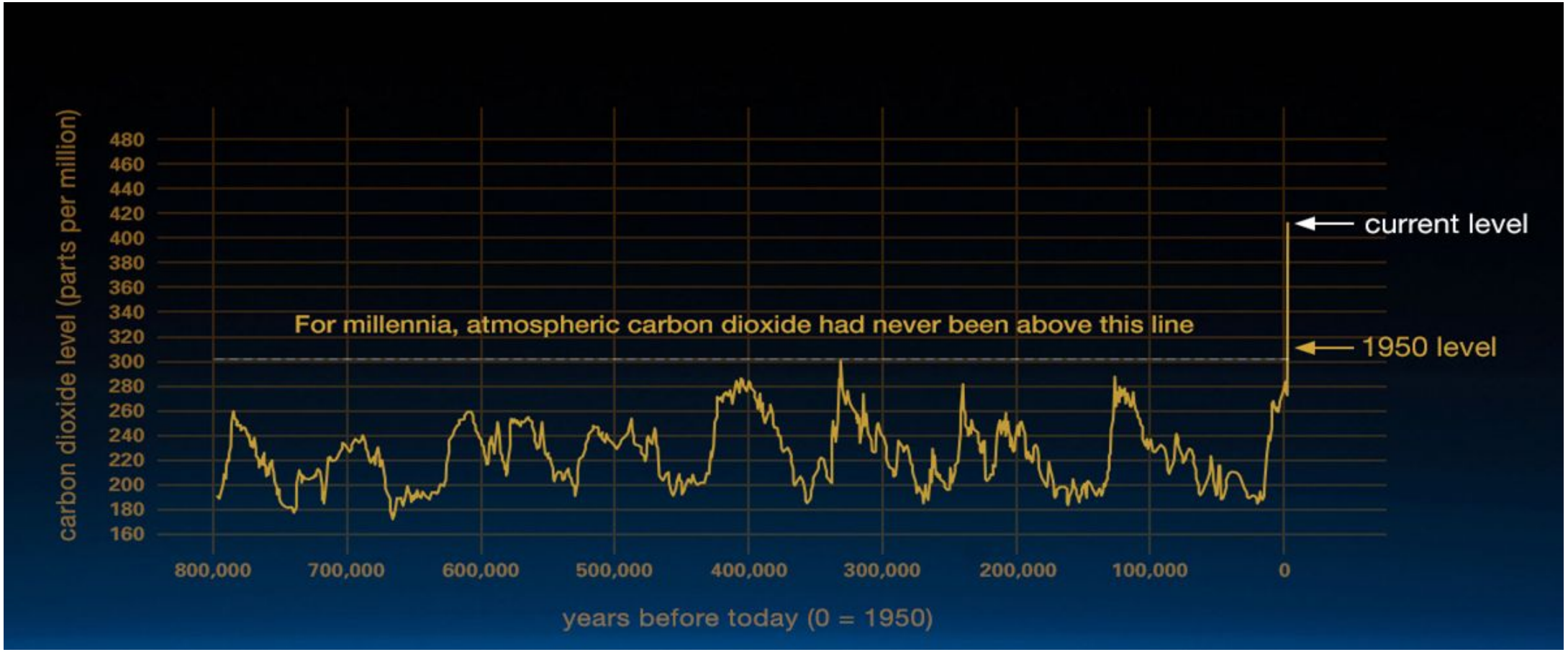
CO2 concentration in the atmosphere is currently 40% higher than it was when industrialisation began.

Other greenhouse gases are emitted in smaller quantities, but they trap heat far more effectively than CO2, and in some cases are thousands of times stronger.



Source: https://ec.europa.eu/clima/change/causes_en

Greenhouse gases- Carbon Dioxide



Sources: Credit: Luthi, D., et al.. 2008; Etheridge, D.M., et al. 2010; Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO_2 record.
https://climate.nasa.gov/evidence/

Deforestation

Deforestation is the permanent removal of trees to make room for something besides forest.

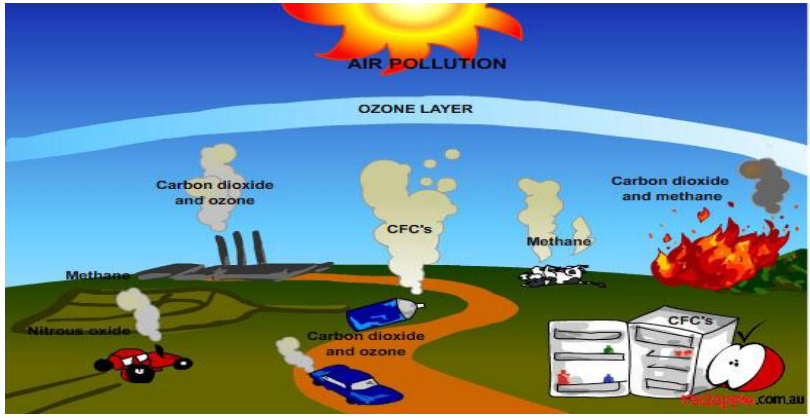
This can include clearing the land for agriculture or grazing, or using the timber for fuel, construction or manufacturing.

Air pollution

Air pollution is caused by fertiliser use, livestock production, and certain industrial processes that release fluorinated gases.

Pollutants in the air can produce serious environmental issues and contribute to climate change. The major concerns include:

- The ability of pollutants to trap too much heat in the atmosphere
- The mixture of gases with moisture in the atmosphere which produces damaging acid rain
- The increase in unnatural ozone levels
- The presence of particles in the atmosphere that block sunlight



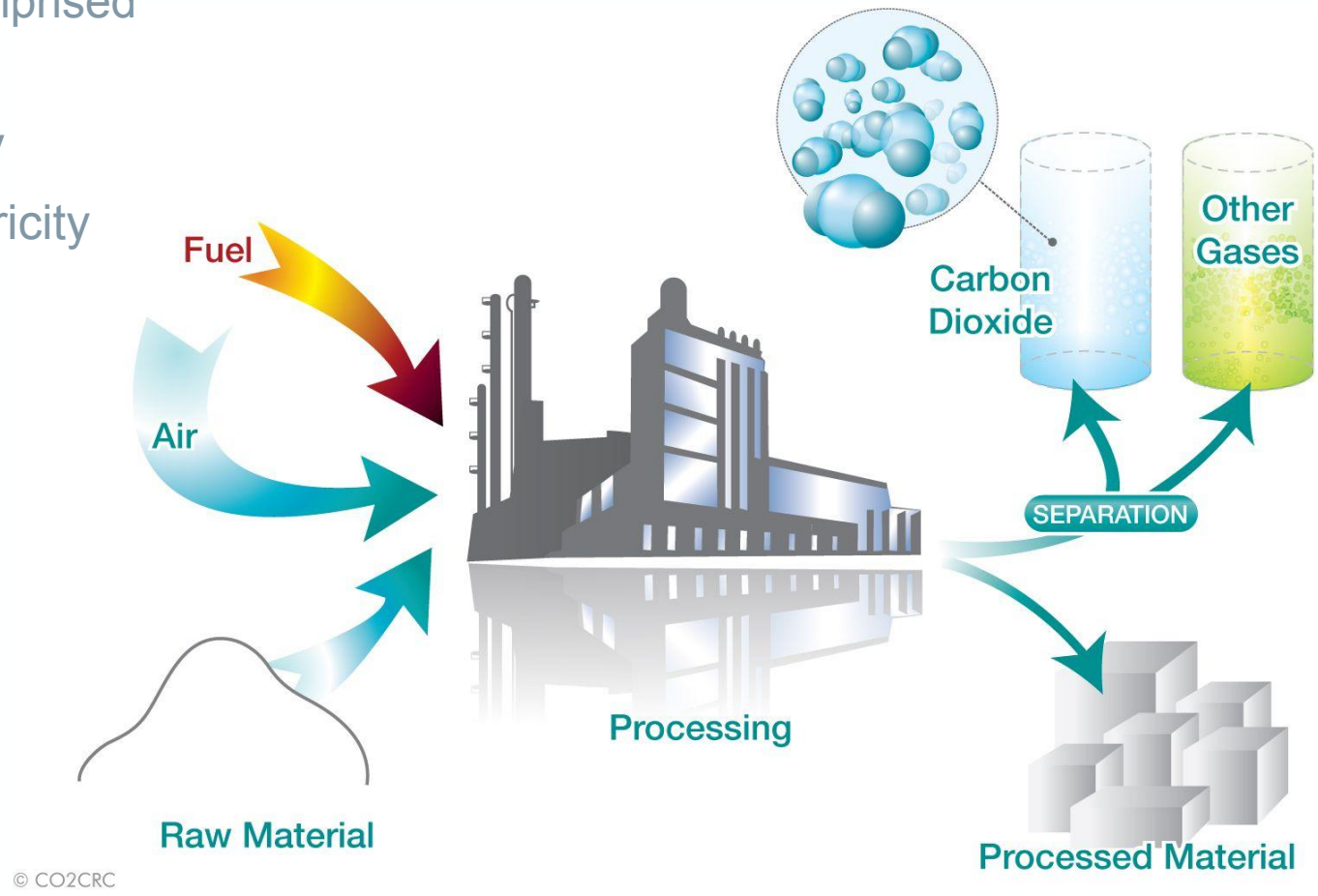
Mining

Coal mining releases methane, a potent greenhouse gas. Methane emissions from coalmines has a global warming potential 21 times greater than that of carbon dioxide over a 100-year timeline (Source IPCC).

Industrial processes

These total emissions for industrial process are comprised of: (Fischedick, Roy et al. 2014)

- Direct energy-related CO2 emissions for industry
- Indirect CO2 emissions from production of electricity and heat for industry
- Process CO2 emissions
- Non-CO2 GHG emissions
- Direct emissions for waste/wastewater



Source: CO2CRC.com

Consequences of climate change

Changes in

- Glaciers and ice sheets
- Sea level change
- Sea ice
- Heavy rainfall across the globe
- Extreme Drought
- Decline in Crop productivity
- Changes in ecosystems
- Hurricanes
- Rise in temperature
- Acidification of seawater

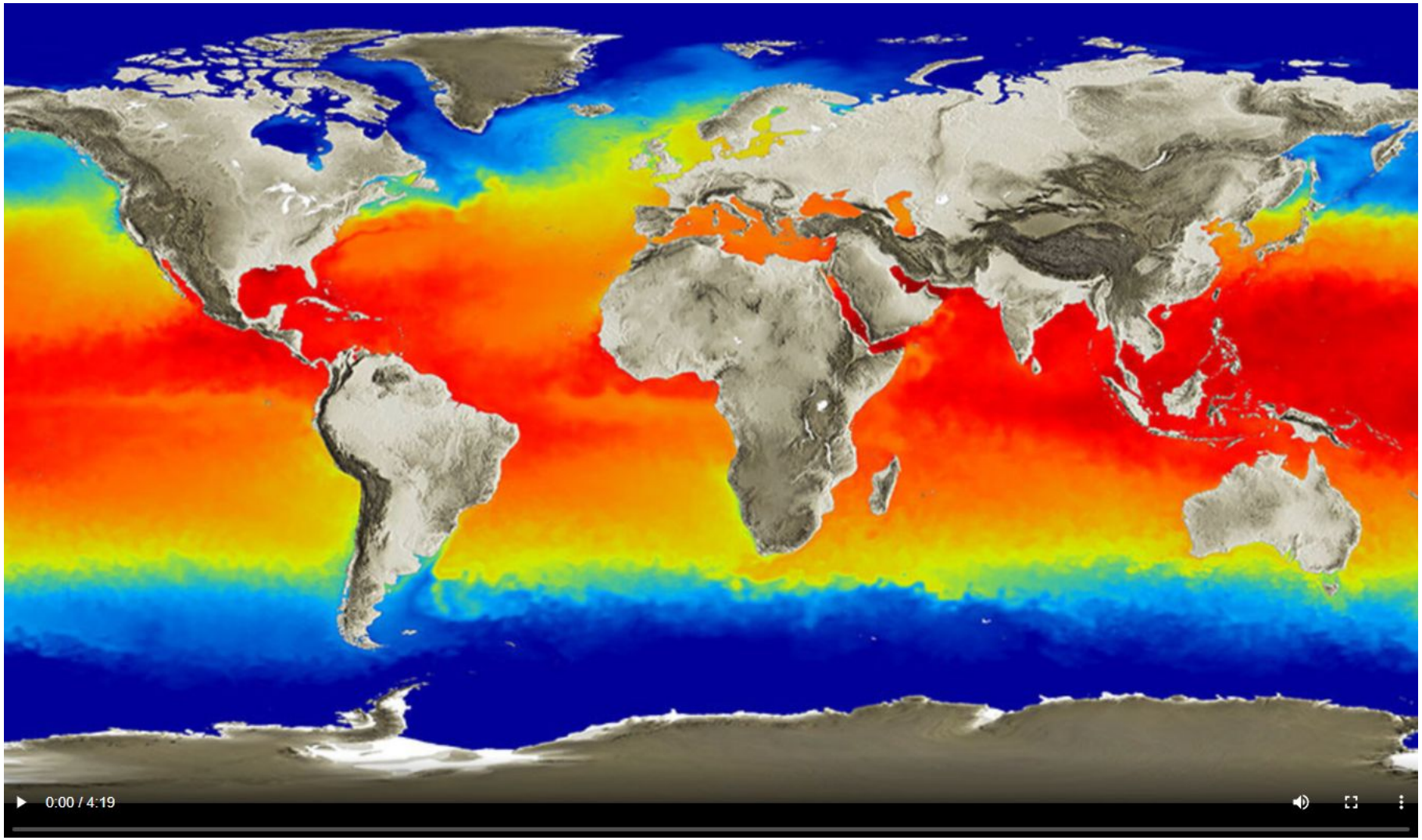
Photo credit UCSUSA

Photo credit AFP

Photo credit David Paul Morris, Bloomberg

Consequences of climate change

Source: ESA

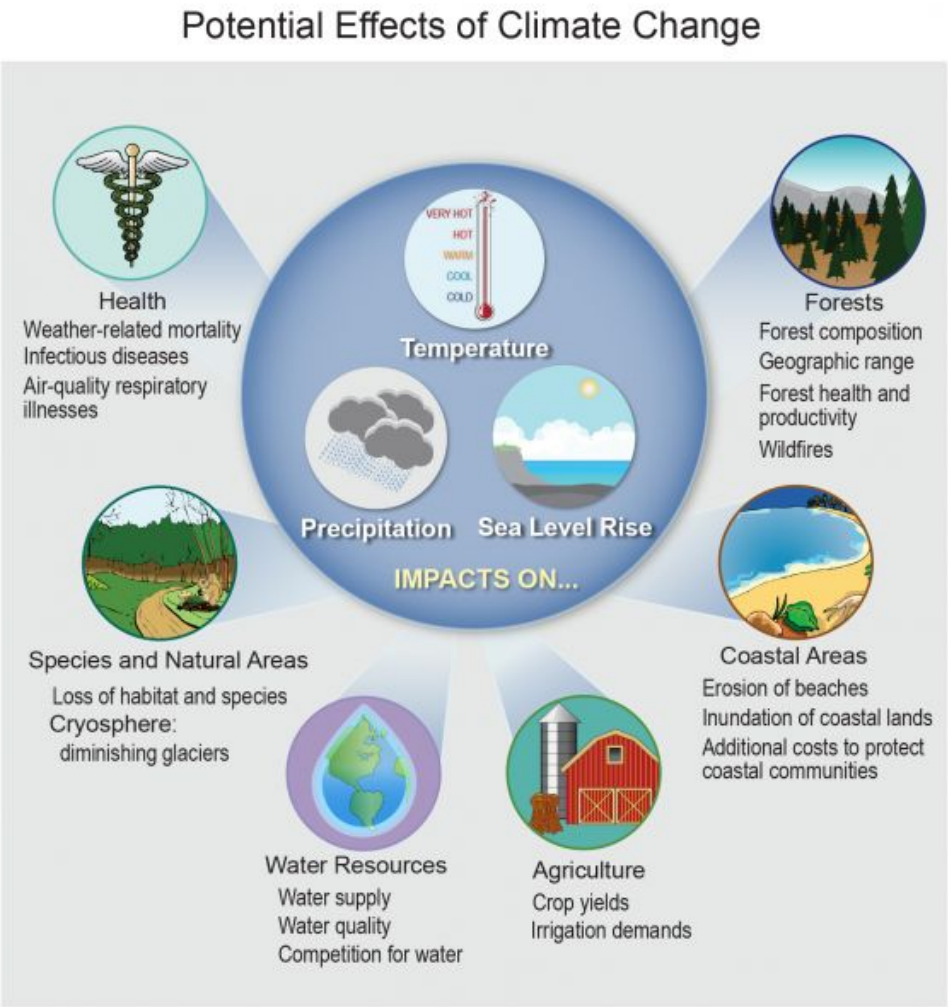


Why measuring Climate Change?

We measure climate change to understand climate, climate variability and climatic changes at the local, national, and regional, and global levels;

To understand better how climate change affects our social systems;

To better plan adaptation measures to tackle the potential or actual impacts of climate change.



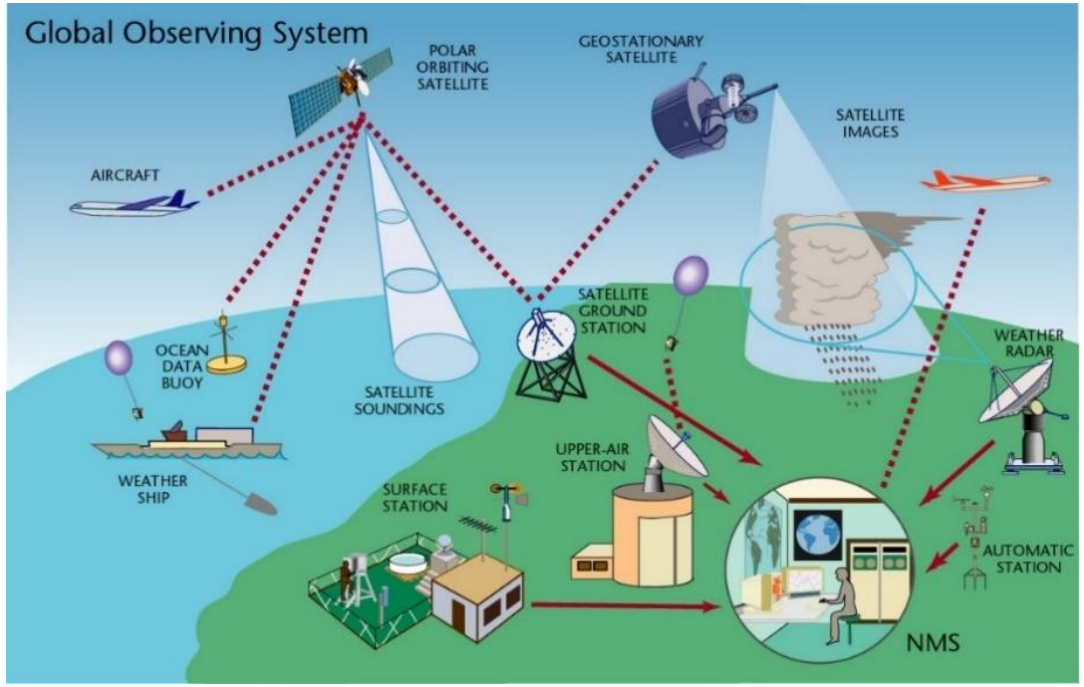
Source: U.S. Global Change Research Program

How climate change is measured over time?

Earth-orbiting satellites, remote meteorological stations, and ocean buoys are used to monitor present-day weather and climate.

Paleoclimatology data from natural sources like ice cores, tree rings, corals, and ocean and lake sediments

Scientists use this data as an input into sophisticated climate models that predict future climate trends with impressive accuracy.



Source: WMO: https://public.wmo.int/en/programmes/global-observing-system

Photo credit: Ludovic Brucker

Essential Climate Variables

Essential climate variables (ECVs) are physical, chemical, or biological variables or a group of linked variables that critically contributes to the characterisation of the Earth's climate.

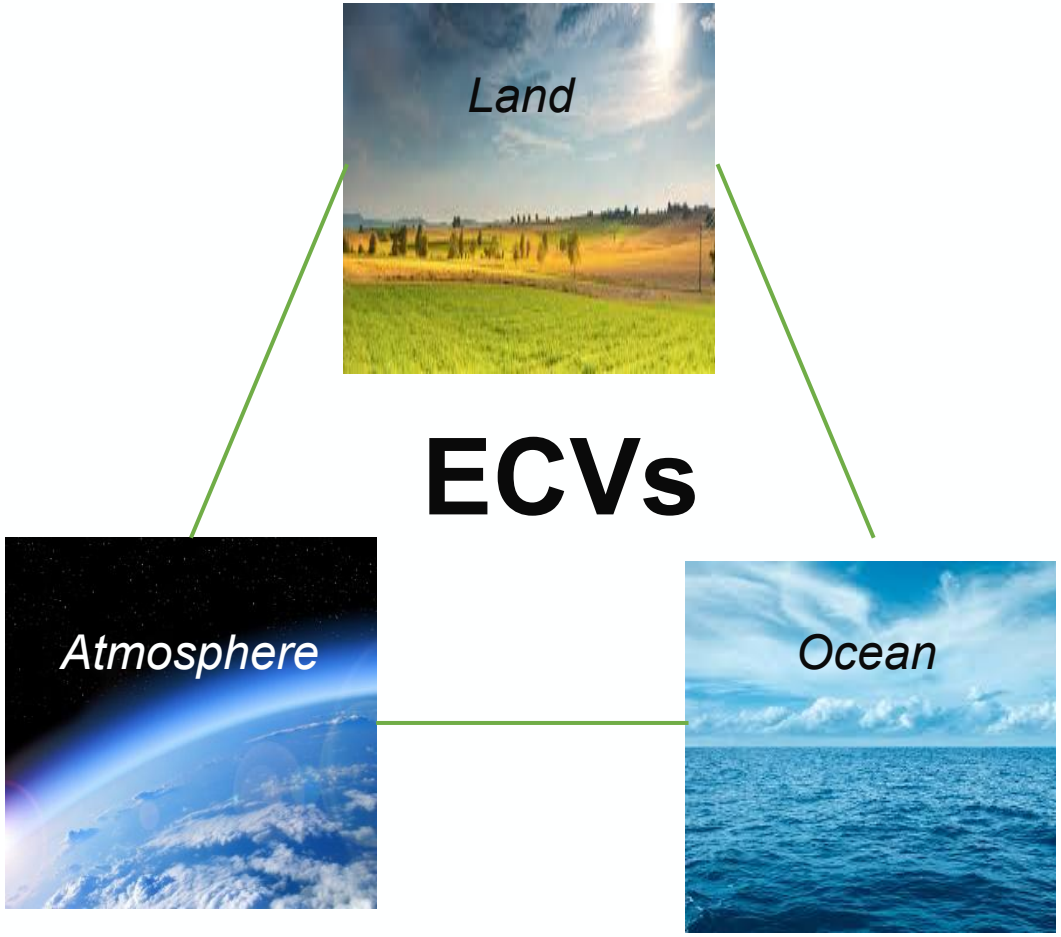
Relevance: The variable is critical for characterising the climate system and its changes.

Feasibility: Observing or deriving the variable on a global scale is technically feasible using proven, scientifically understood methods.

Cost effectiveness: Generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets.

Essential Climate Variables

ECV data records are intended to provide reliable, traceable, observation-based evidence for a range of applications, including monitoring, mitigating, adapting to, and attributing climate changes.



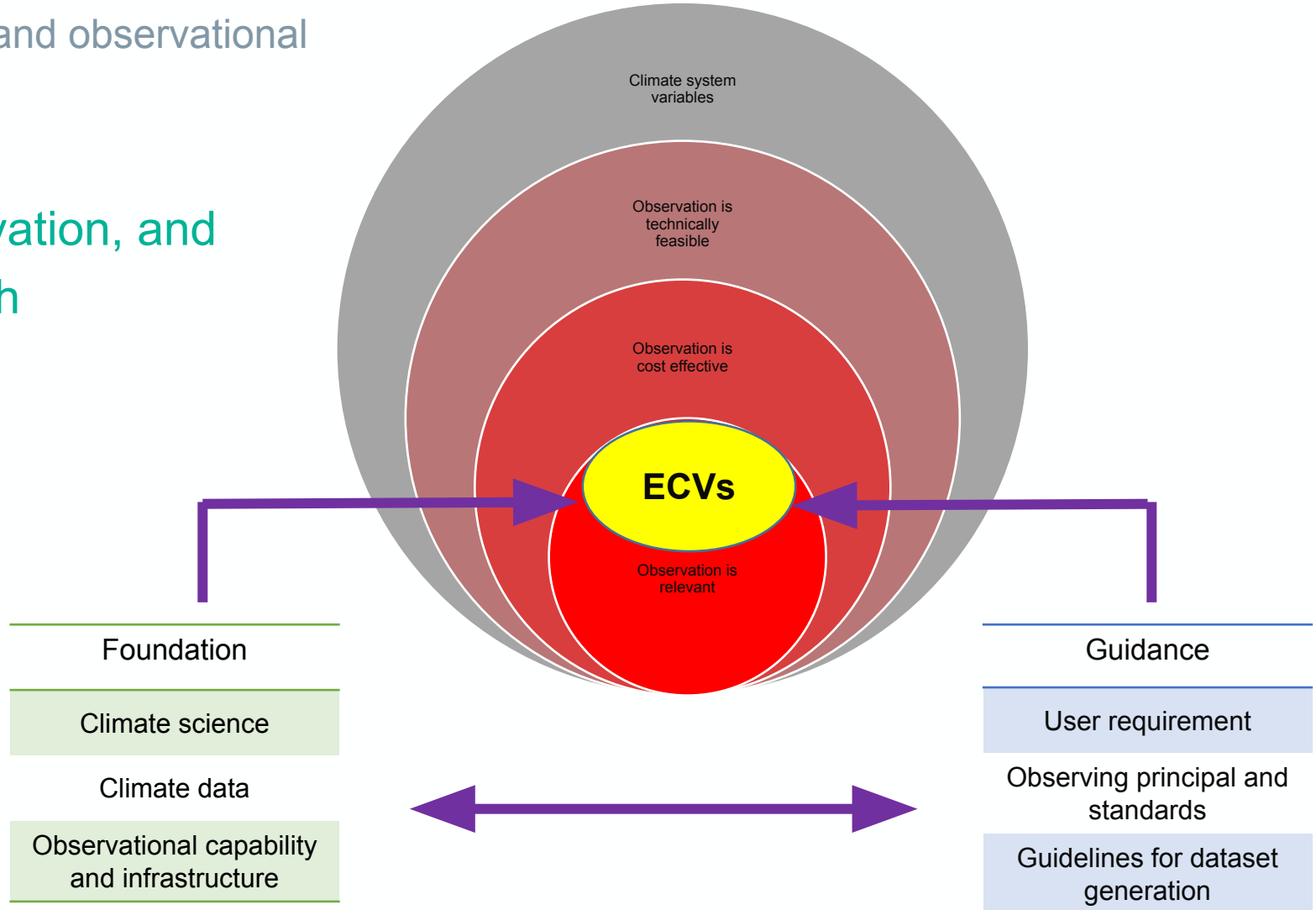
More than a list of variables

Building on existing science, data holdings and observational infrastructure.

Guidance is provided on their observation, and the generation of products from Earth observation.

They provide one basis for an organised assessment of capabilities and needs.

Organisation could be by observing a network, physical/chemical cycle or societal benefit area.



Reference: Bojinski et al., 2014

ATMOSPHERE

SURFACE

Precipitation

Pressure

Surface Radiation Budget

Surface Wind Speed and Direction

Temperature

Water Vapour

UPPER-ATMOSPHERE

Earth Radiation Budget

Lightning

Temperature

Water Vapour

Wind Speed and Direction

COMPOSITION

Aerosols Properties

Carbon Dioxide, Methane and other Greenhouse Gases

Cloud Properties

Ozone

Precursors

OCEAN

PHYSICS

Ocean Surface Heat Flux

Sea Ice

Sea Level

Sea State

Sea Surface Salinity

Sea Surface Temperature

Subsurface Currents

Subsurface Salinity

Subsurface Temperature

Surface Currents

Surface Stress

BIOGEOCHEMISTRY

Inorganic Carbon

Nitrous Oxide

Nutrients

Ocean Colour

Oxygen

Transient Tracers

BIOLOGY/ECOSYSTEMS

Marine Habitat Properties

Plankton

LAND

Above-Ground Biomass

Albedo

Anthropogenic Greenhouse Gas Fluxes

Anthropogenic Water Use

Fire

Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)

Glaciers

Groundwater

Ice Sheets and Ice Shelves

Lakes

Land Cover

Land Surface Temperature

Latent and Sensible Heat Fluxes

Leaf Area Index

Permafrost

River Discharge

Snow

Soil Carbon

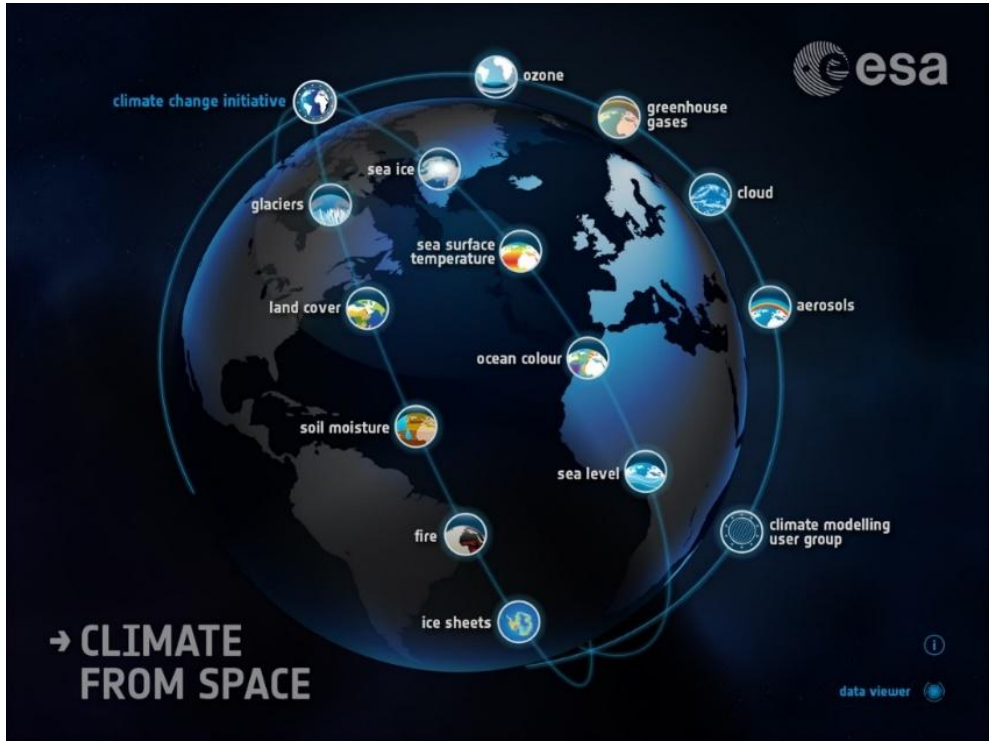
Soil Moisture

Climate Change Initiative of ESA

The European Space Agency (ESA) has launched the Climate Change Initiative (CCI) to provide satellite-based climate data records (ECVs) that meet the challenging requirements of the climate community.

The aim is to realize the full potential of the long-term Earth observation archives

Aspects of producing a satellite-based climate data records: Data acquisition, Data calibration, Algorithm development, Validation, Maintenance, Provision of the data to the climate research community



What did you learn?

- understood the difference between weather and climate
- became familiar with concepts of climate change

Read the supporting document What is Climate Change?

- became familiar with the climate change causes
- became familiar with concepts of ECVs

Read the supporting document Learn more about ECVs

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