MUNI
SCI

01 Climate system

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Content

1. What is the climate system?

- Components of the climate system
- Positive and negative climate feedback

2. Natural causes of climate change

- fluctuations in solar radiation, orbital changes
- distribution of continents and oceans, volcanic eruptions, vegetation
- atmosphere and ocean relationship
- changes in the composition of the Earth's atmosphere

Weather vs Climate

Weather

- the state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc.
- **short-term** changes in the atmosphere

Climate

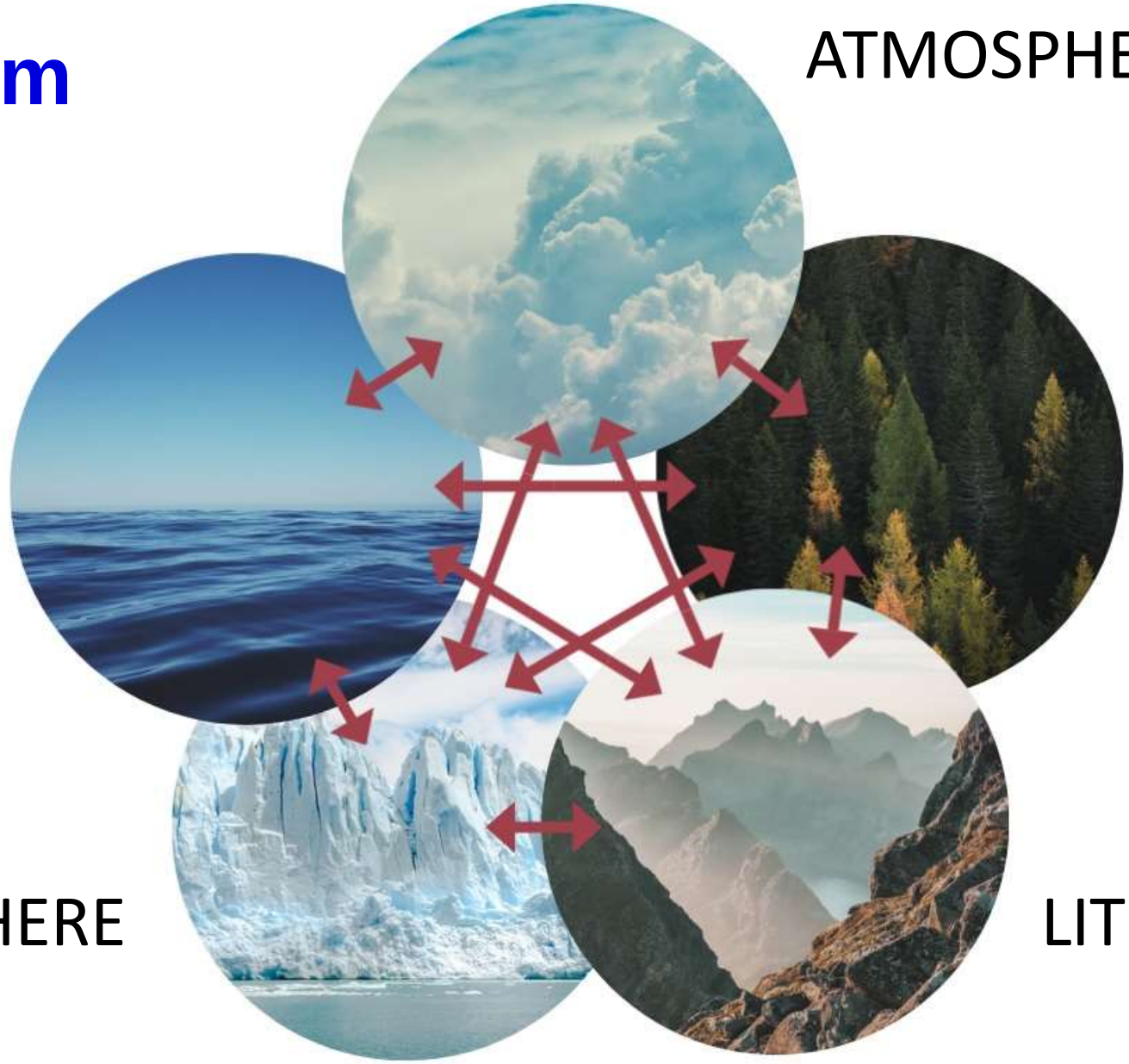
- the weather conditions prevailing in a specific area over a long period
- **long-term** characteristic weather regime (long-term average state of the atmosphere in a certain place), conditioned by the energy balance, atmospheric circulation, the character of the surface and human interventions

How does the climate change?

Climate system

ATMOSPHERE

HYDROSPHERE



BIOSPHERE

CRYOSPHERE

LITHOSPHERE

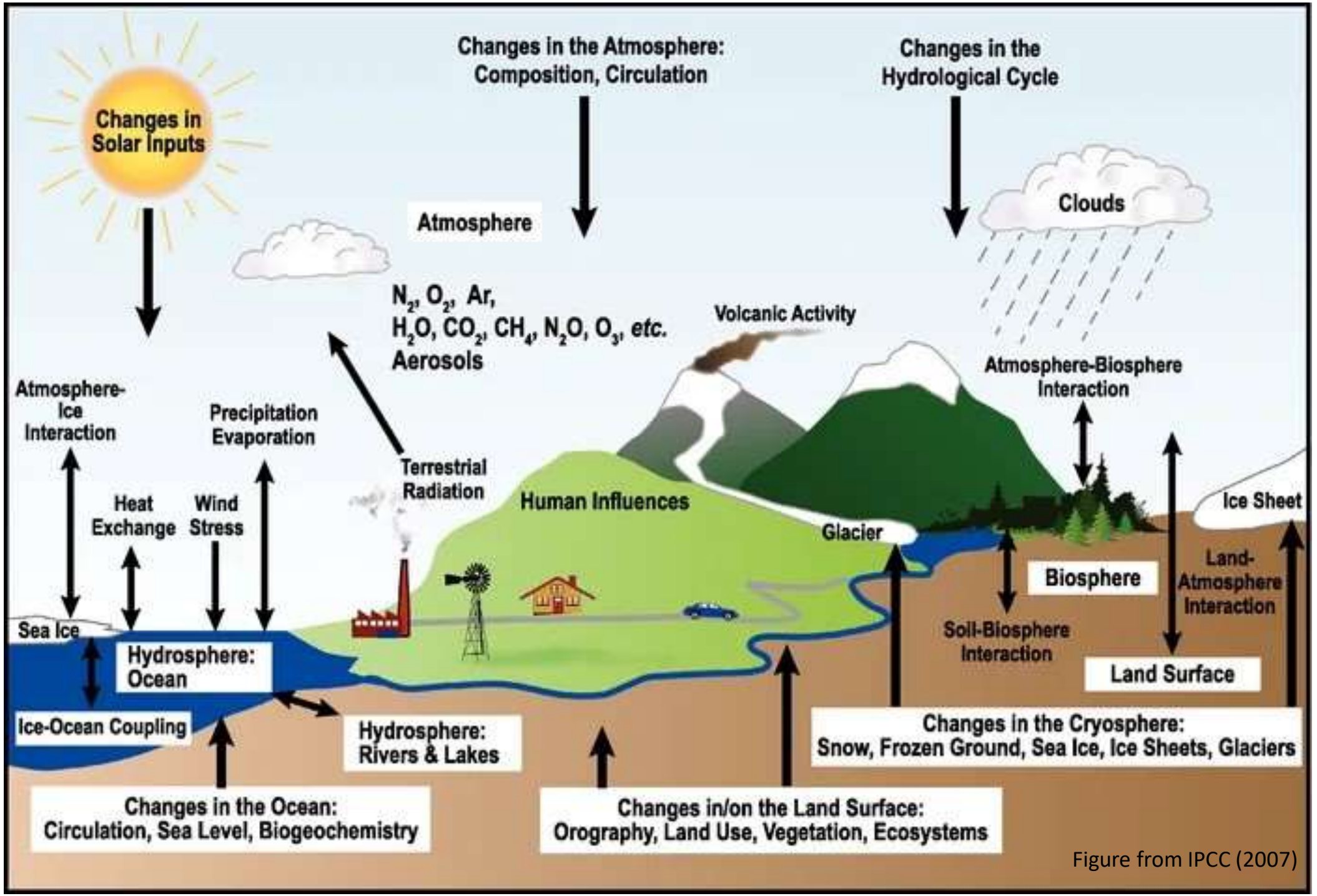


Figure from IPCC (2007)

Why is the climate changing?

Natural vs. anthropogenic causes

Climate Change – natural causes

- fluctuations in solar radiation, orbital changes
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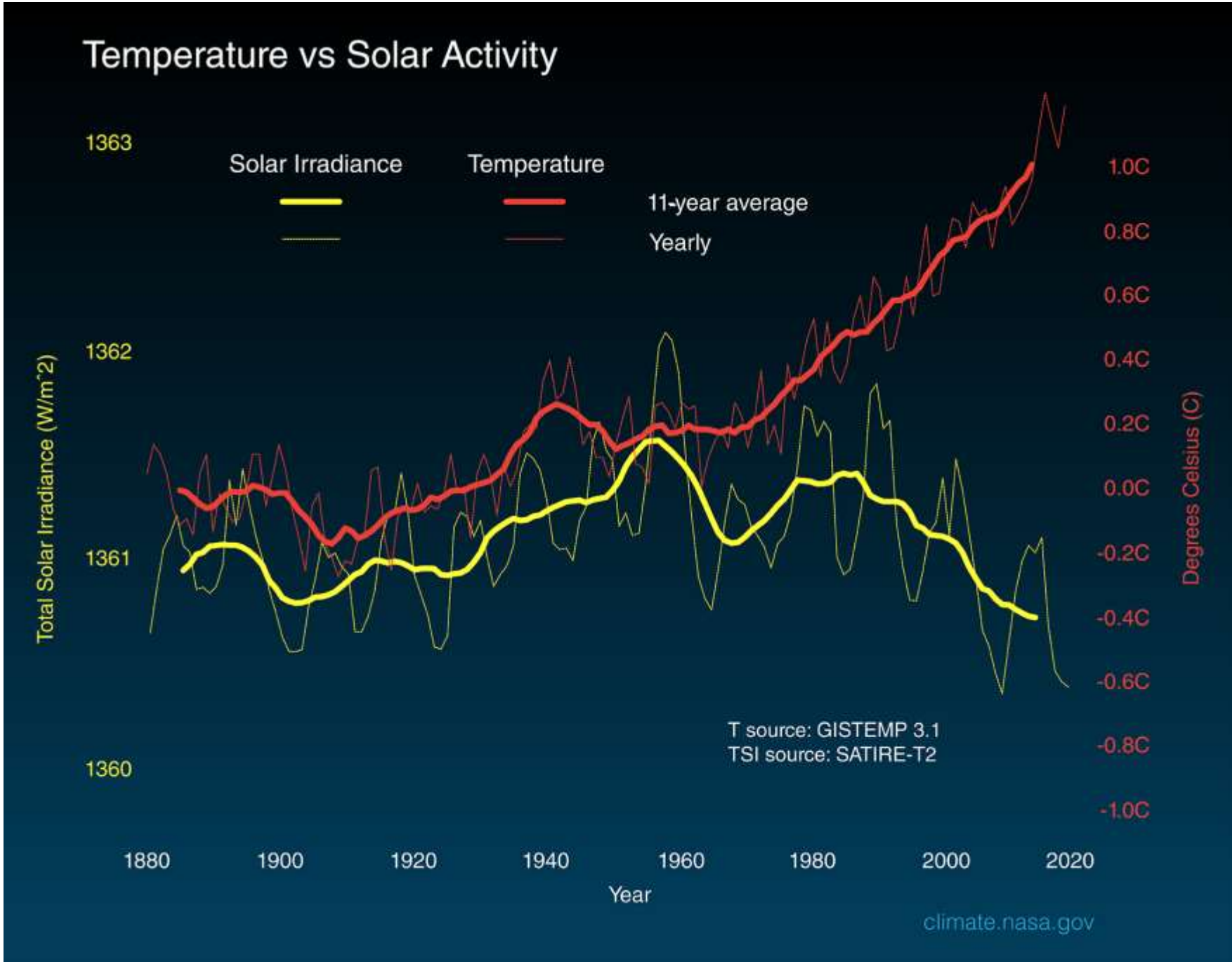
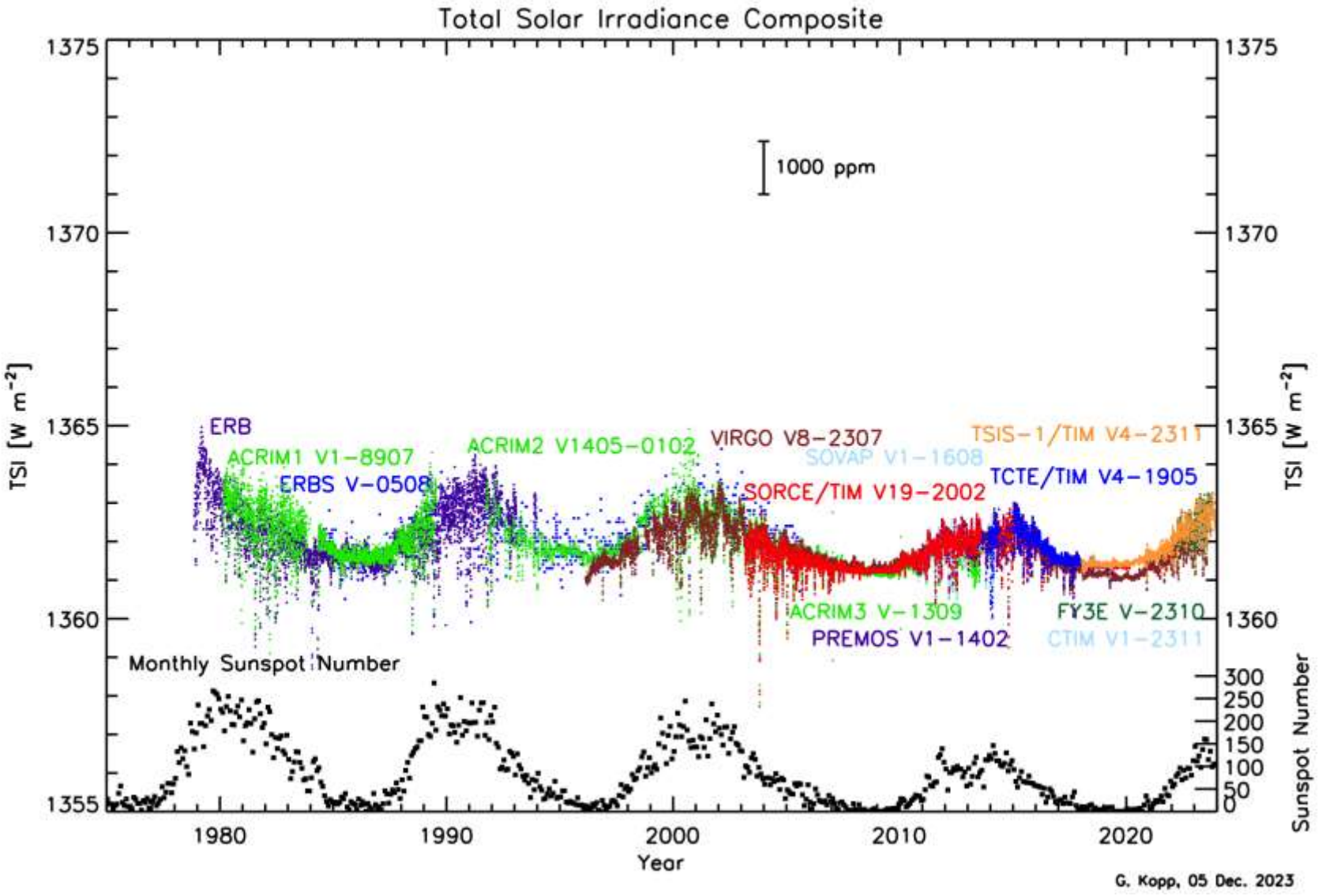
The Sun

- 73% hydrogen, 25% helium, 2% the other elements
- **thermonuclear reactions:**
  $4\ H \rightarrow 1\ He$
  + energy production

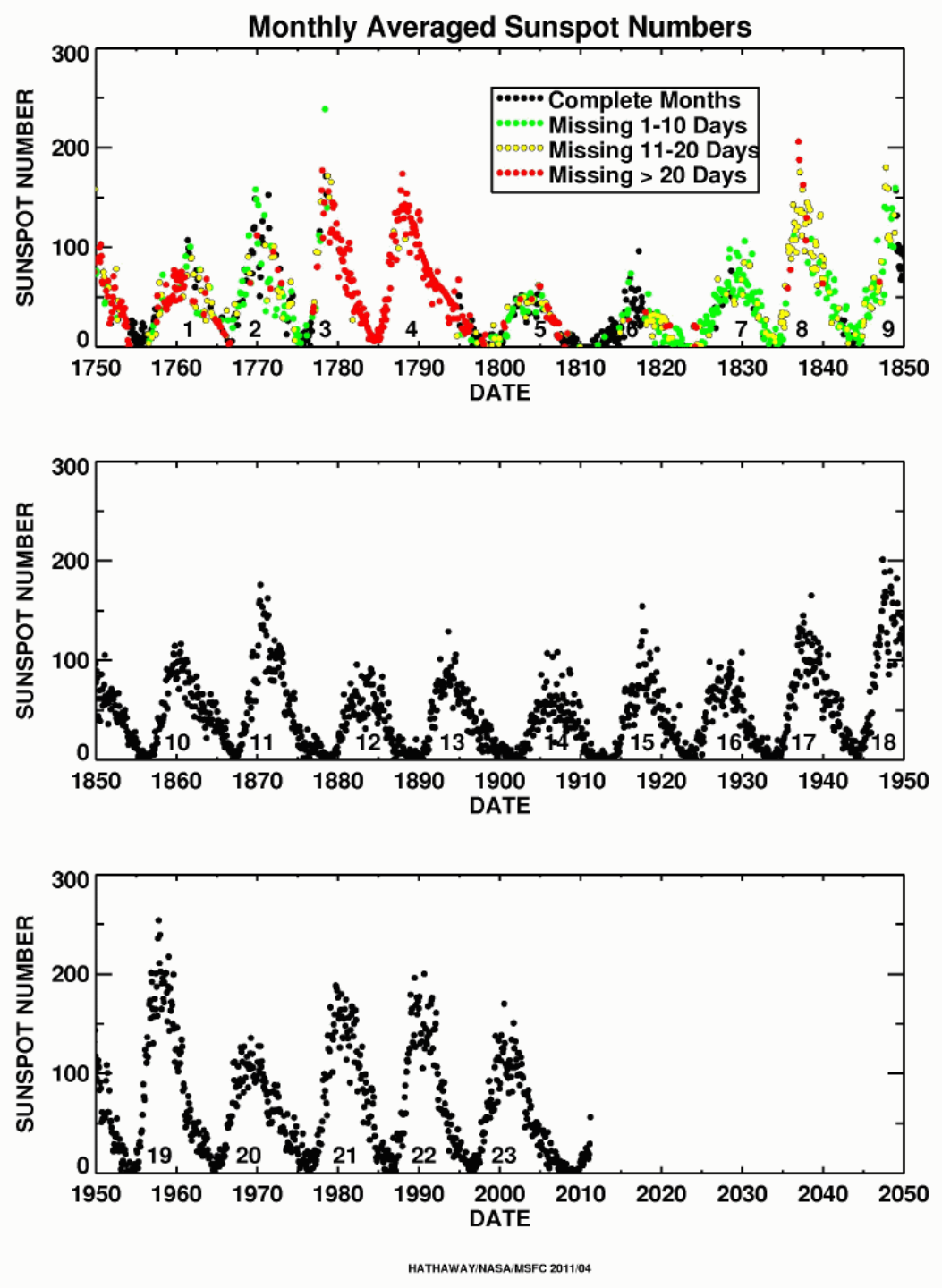


The Sun

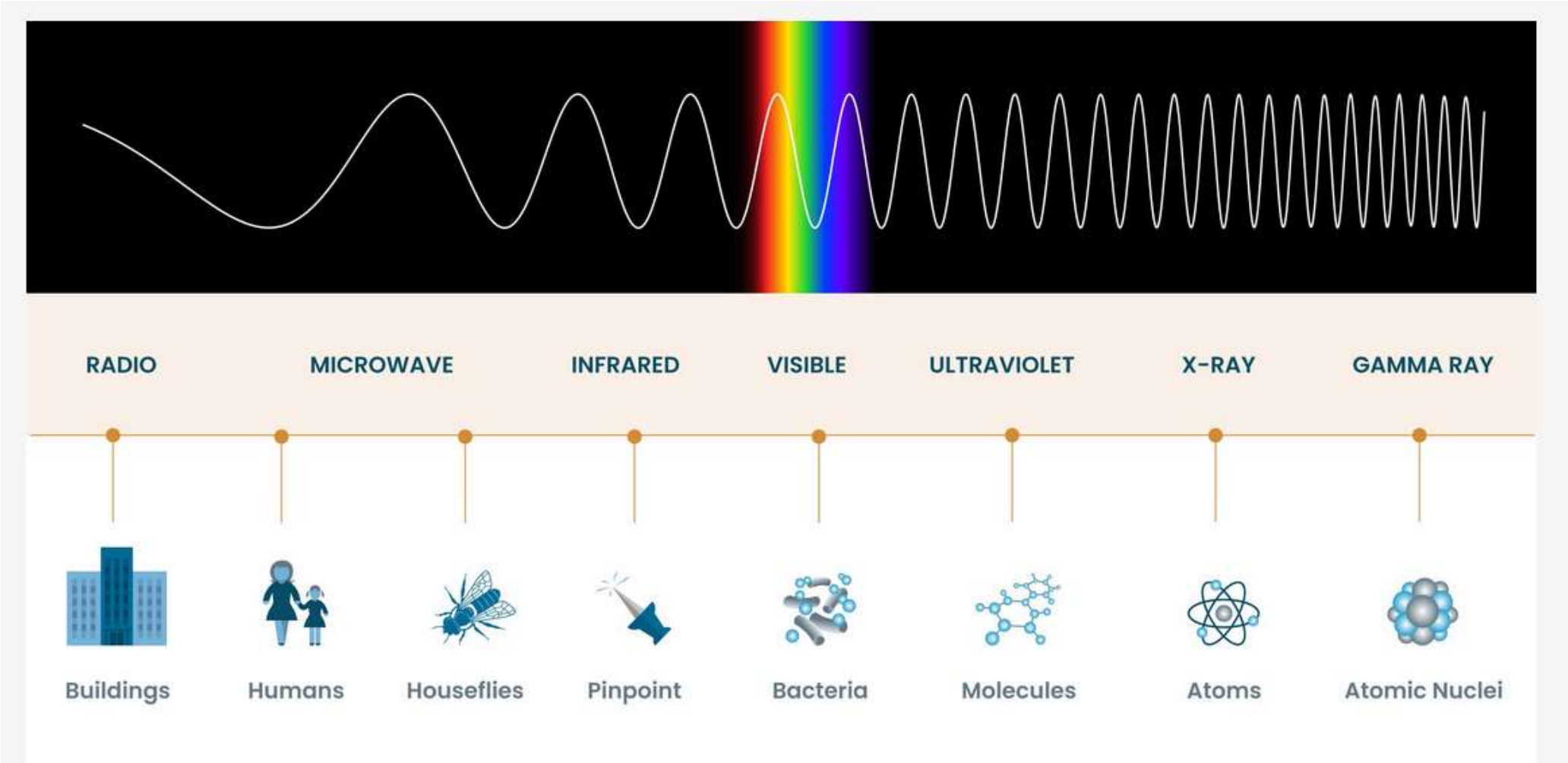
- solar activity – sunspot cycle – **Wolf number** (relative sunspot number)



Wolf number since 1750

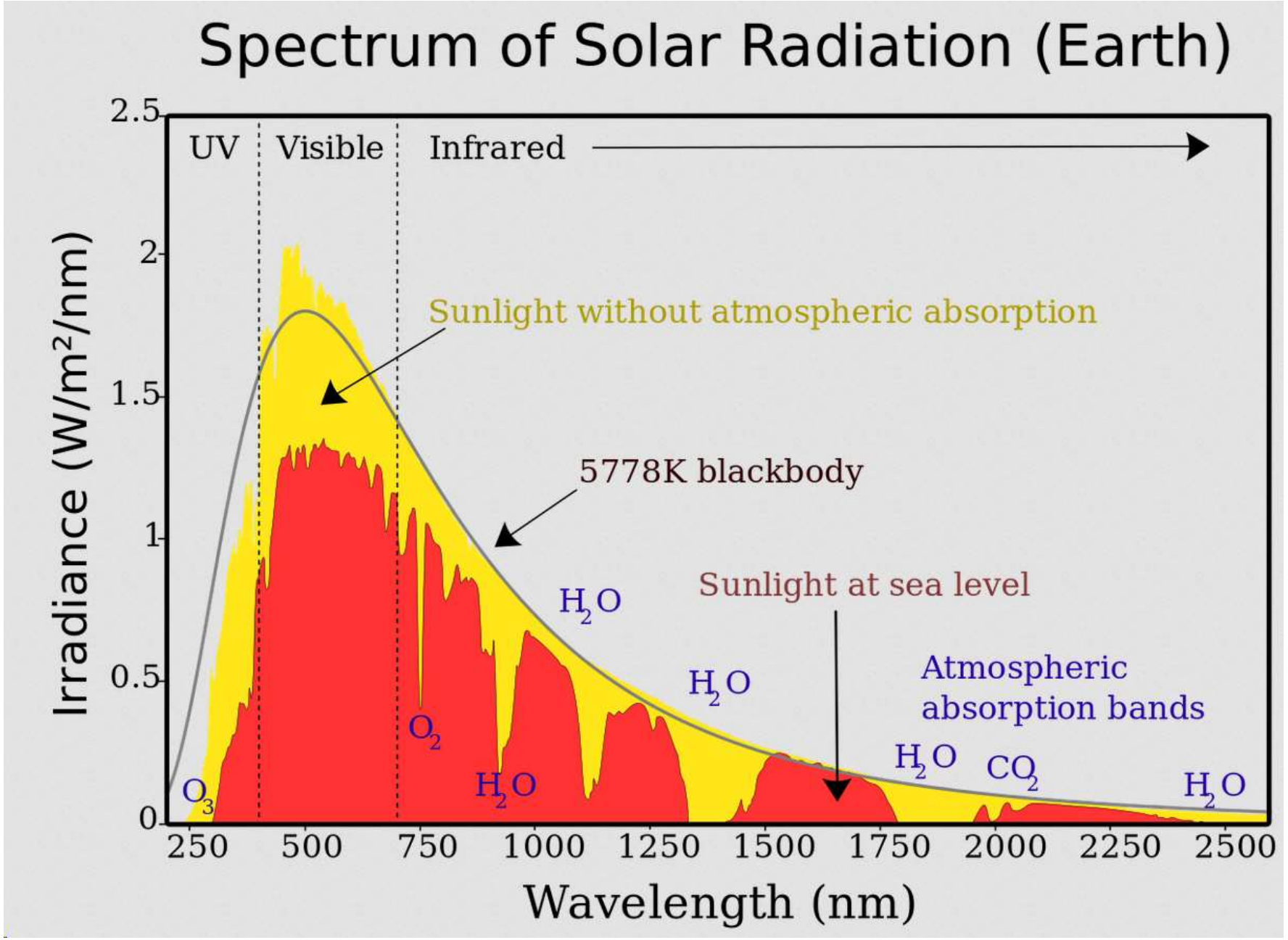


The electromagnetic spektrum

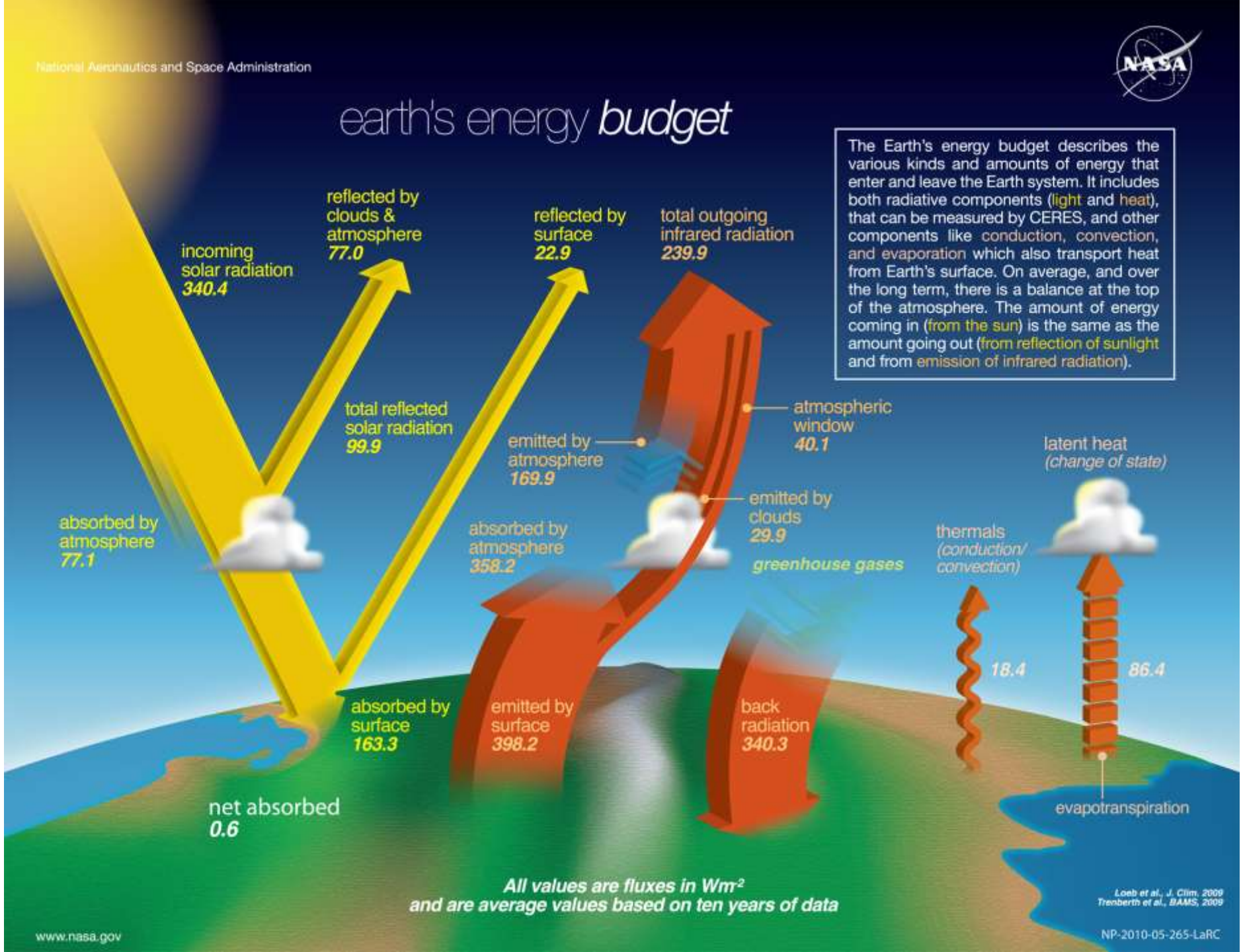


Comparison of different types of light, including wavelength size, and frequency.

https://hubblesite.org/contents/articles/the-electromagnetic-spectrum



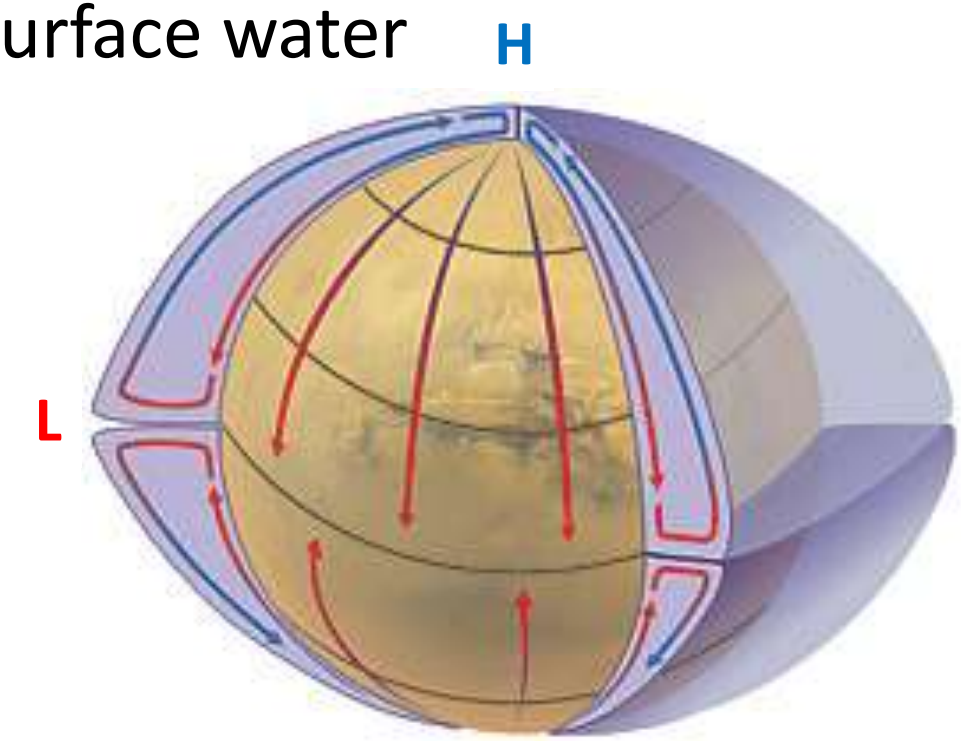
https://en.wikipedia.org/wiki/Sunlight


National Aeronautics and Space Administration
NASA
earth's energy budget
The Earth's energy budget describes the various kinds and amounts of energy that enter and leave the Earth system. It includes both radiative components (light and heat), that can be measured by CERES, and other components like conduction, convection, and evaporation which also transport heat from Earth's surface. On average, and over the long term, there is a balance at the top of the atmosphere. The amount of energy coming in (from the sun) is the same as the amount going out (from reflection of sunlight and from emission of infrared radiation).
incoming solar radiation 340.4
reflected by clouds & atmosphere 77.0
reflected by surface 22.9
total outgoing infrared radiation 239.9
total reflected solar radiation 99.9
emitted by atmosphere 169.9
atmospheric window 40.1
latent heat (change of state)
emitted by clouds 29.9
absorbed by atmosphere 77.1
absorbed by atmosphere 358.2
greenhouse gases
thermals (conduction/ convection)
18.4
86.4
absorbed by surface 163.3
emitted by surface 398.2
back radiation 340.3
net absorbed 0.6
evapotranspiration
All values are fluxes in Wm-2
and are average values based on ten years of data
Loeb et al., J. Clim. 2009
Trenberth et al., BAMS, 2009
www.nasa.gov
NP-2010-05-265-LaRC

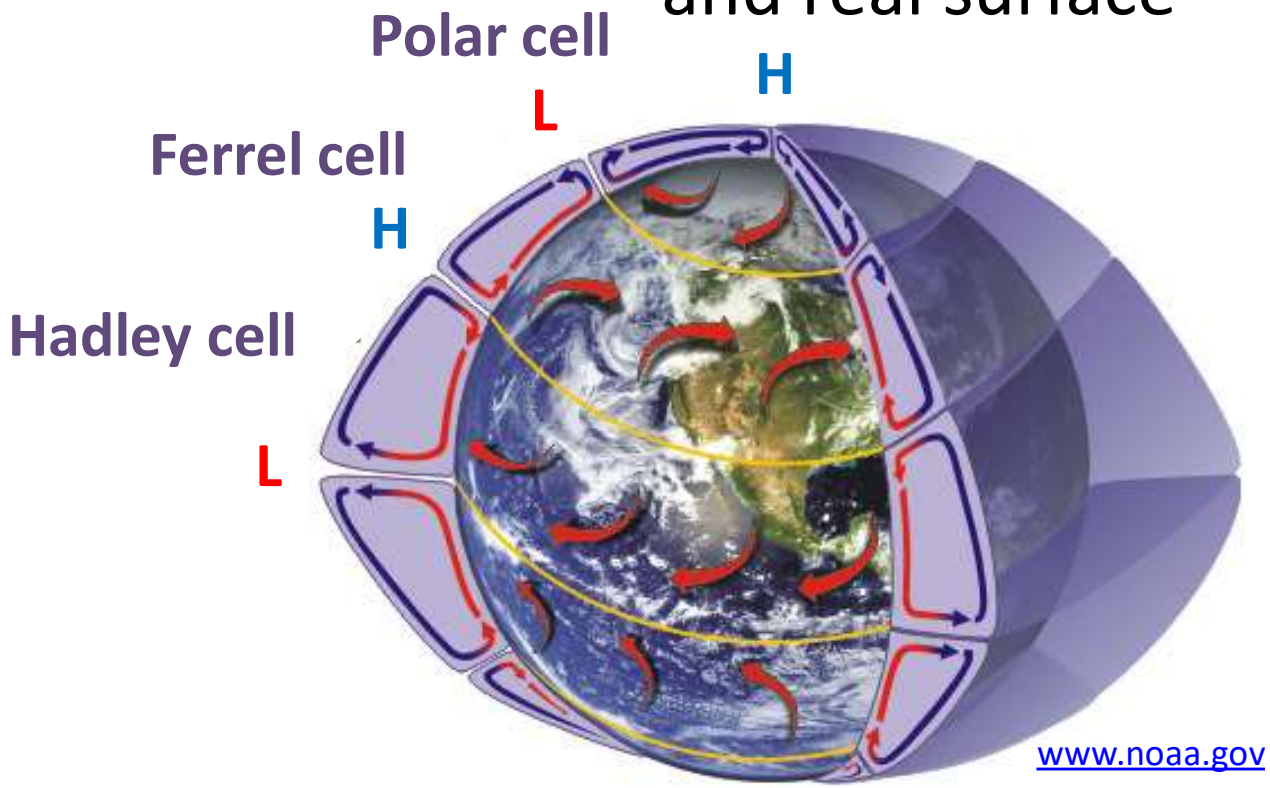
Energy distribution

Global Atmospheric Circulation

Without the Earth's rotation, tilt relative to the sun, and surface water



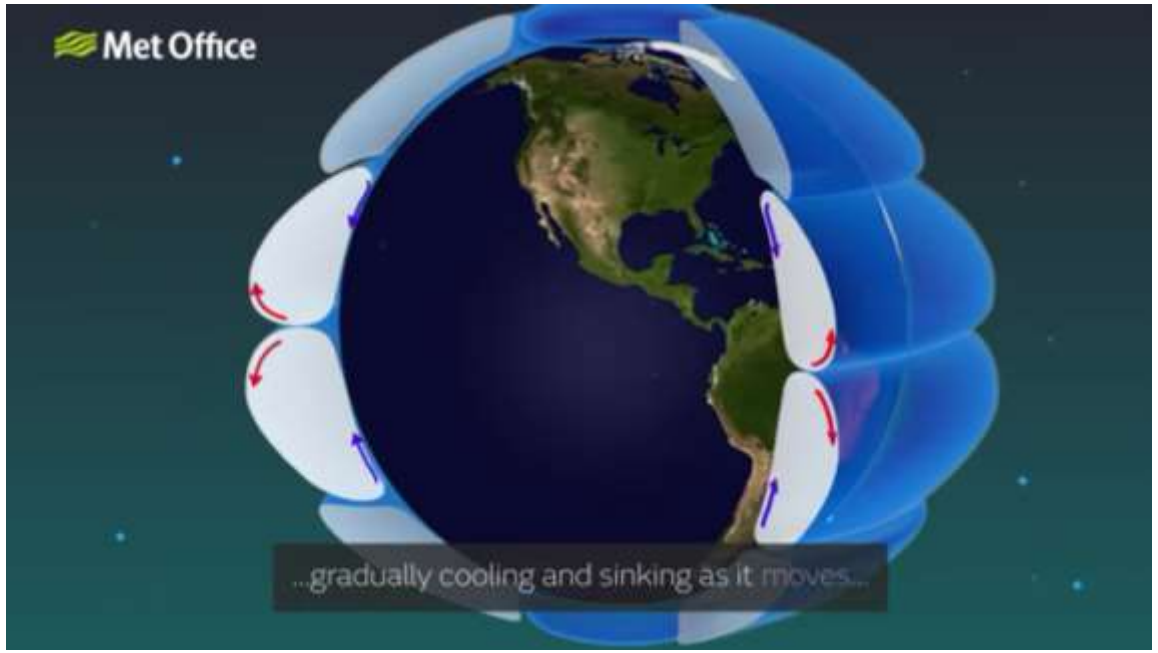
With the Earth's rotation, Earth's tilt and real surface



www.noaa.gov

Energy distribution

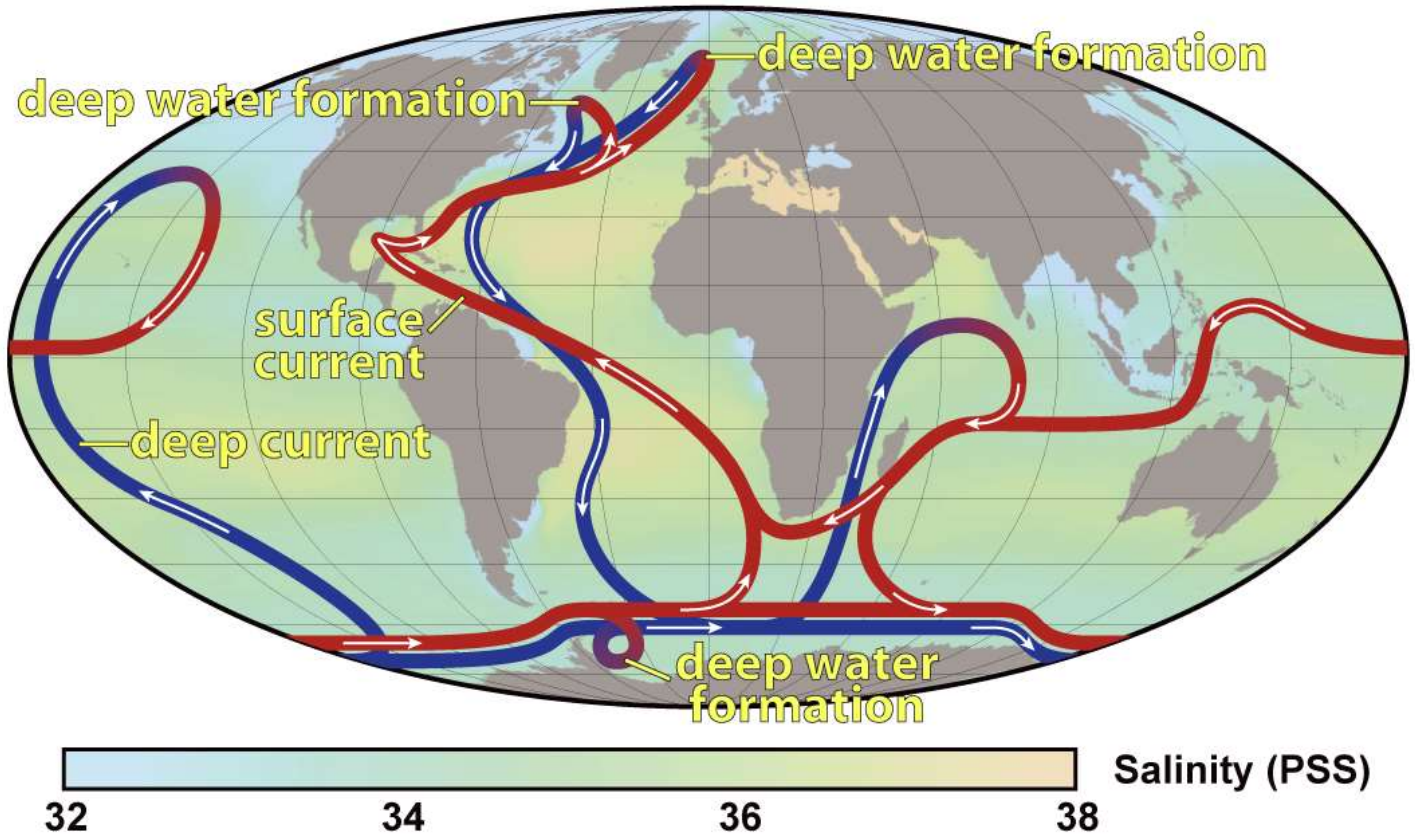
Global atmospheric circulation



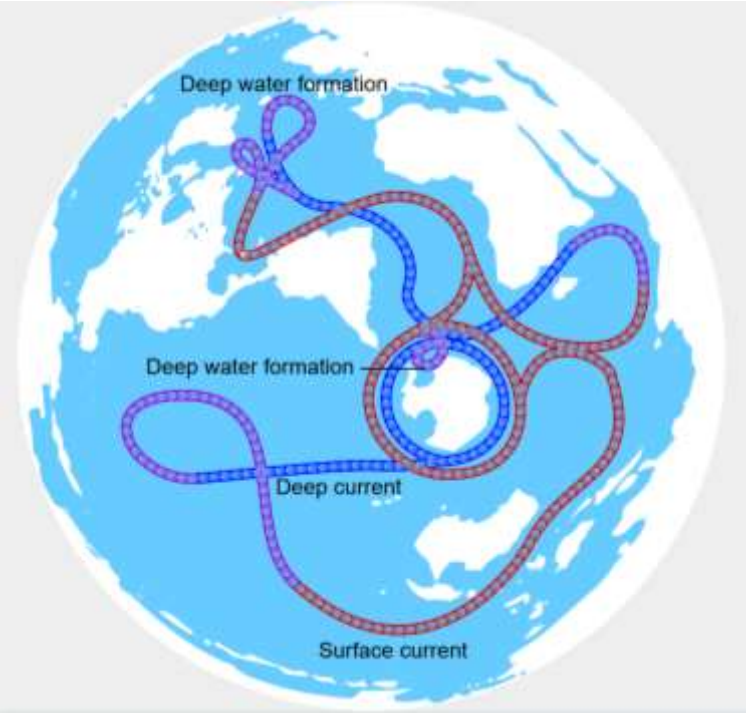
https://www.youtube.com/watch?v=xqM83_og1Fc

Energy distribution

Thermohaline Circulation



A summary of the path of the thermohaline circulation. Blue paths represent deep-water currents, while red paths represent surface currents.



Animation: https://upload.wikimedia.org/wikipedia/commons/a/ab/Thermohaline_circulation.svg

Climate Change – natural causes

- **fluctuations in solar radiation, orbital changes**
- distribution of continents and oceans, volcanic eruptions, vegetation
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The Sun – The Earth

Milankovitch Orbital Cycles

Changes in eccentricity

100.000 years cycles

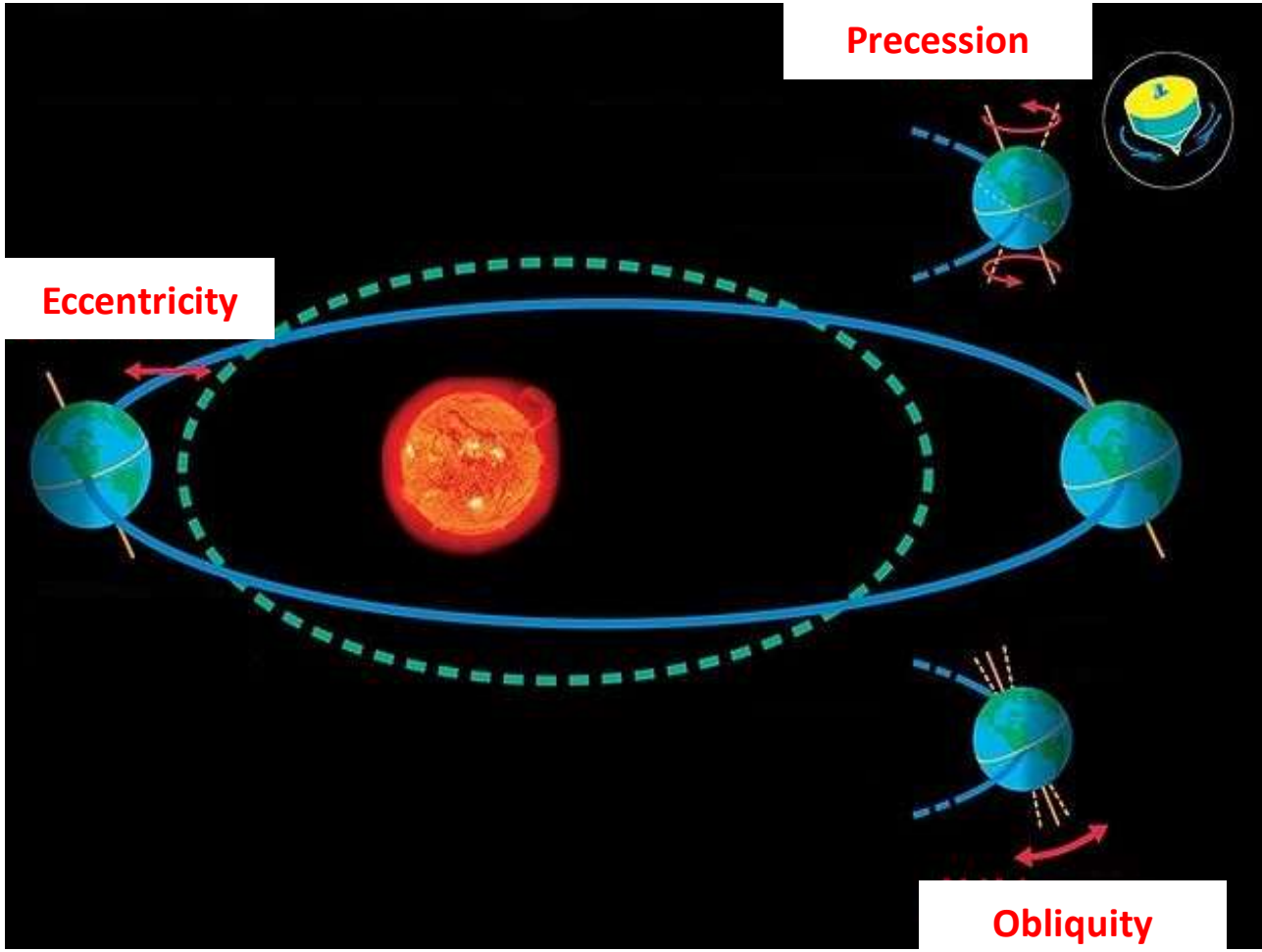
Changes in obliquity (axial tilt)

41.000 years cycles

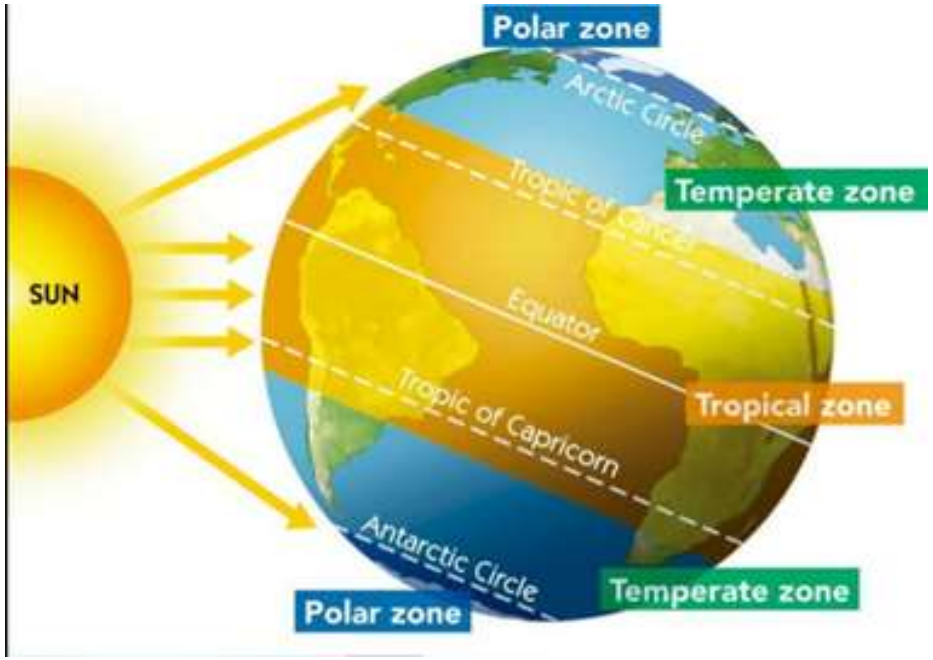
Axial precession

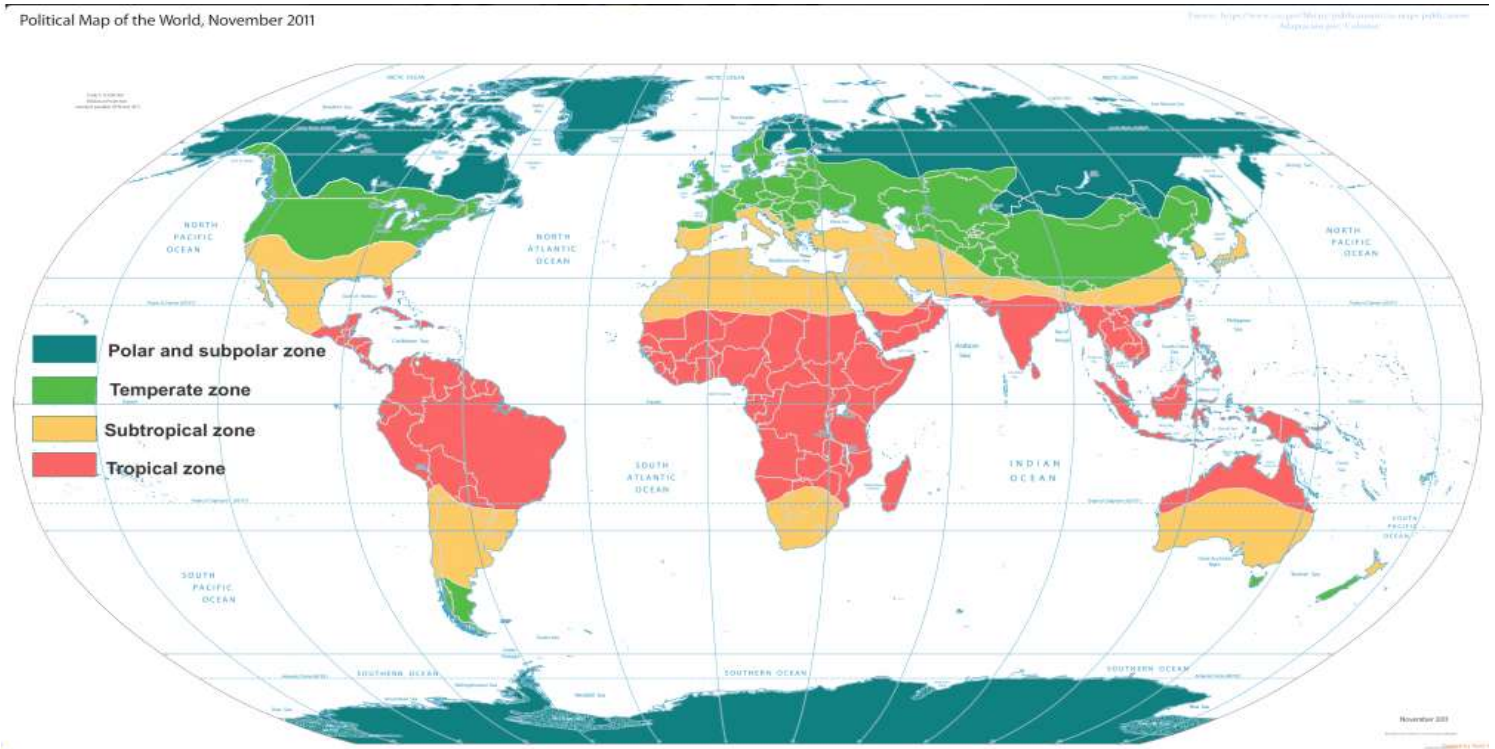
21.000 years cycles

Animations:
https://climate.nasa.gov/news/2948/milankovitch-orbital-cycles-and-their-role-in-earths-climate/



Climate Zones





https://www.youtube.com/watch?v=7yiqkOH1GTQ

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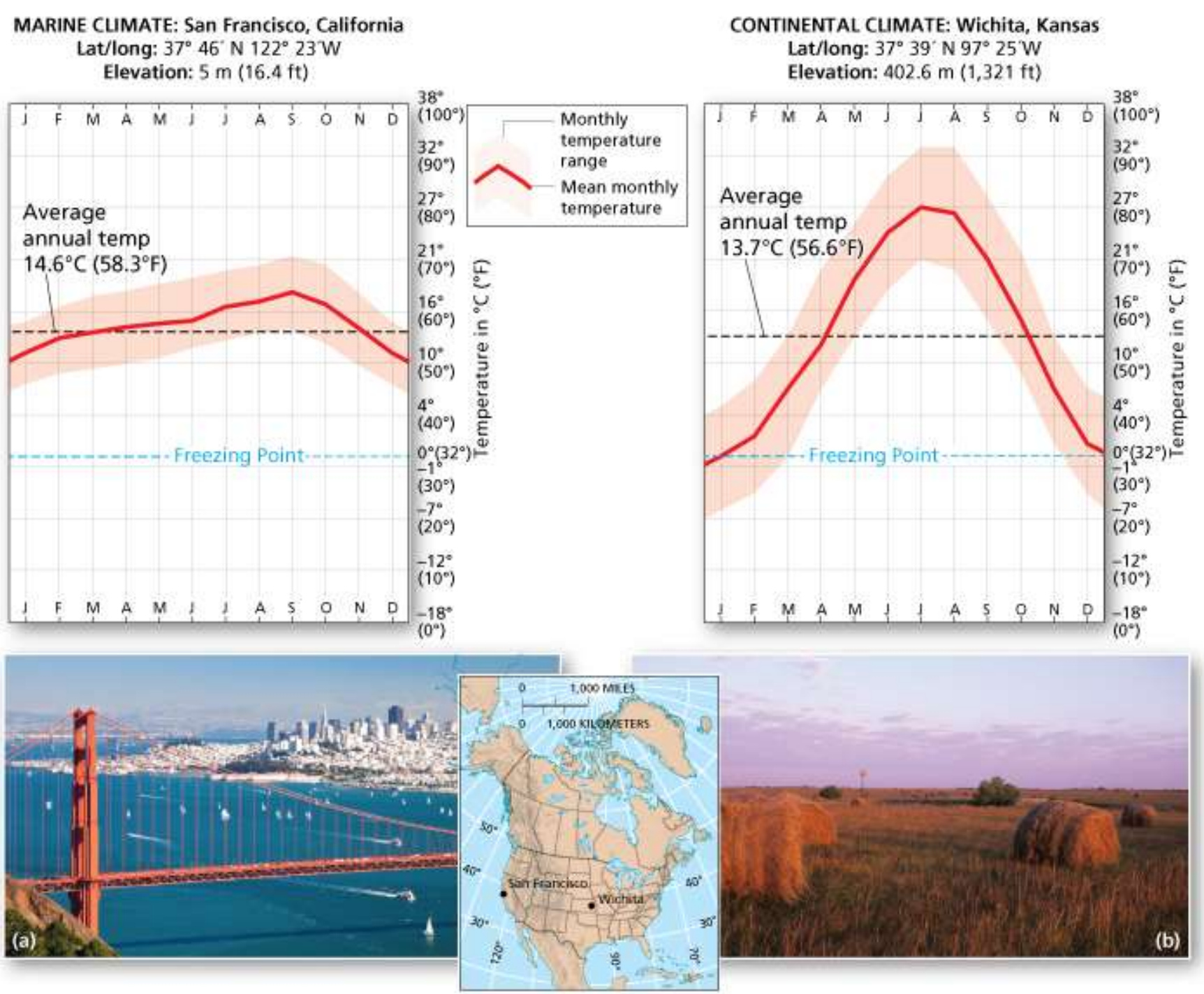
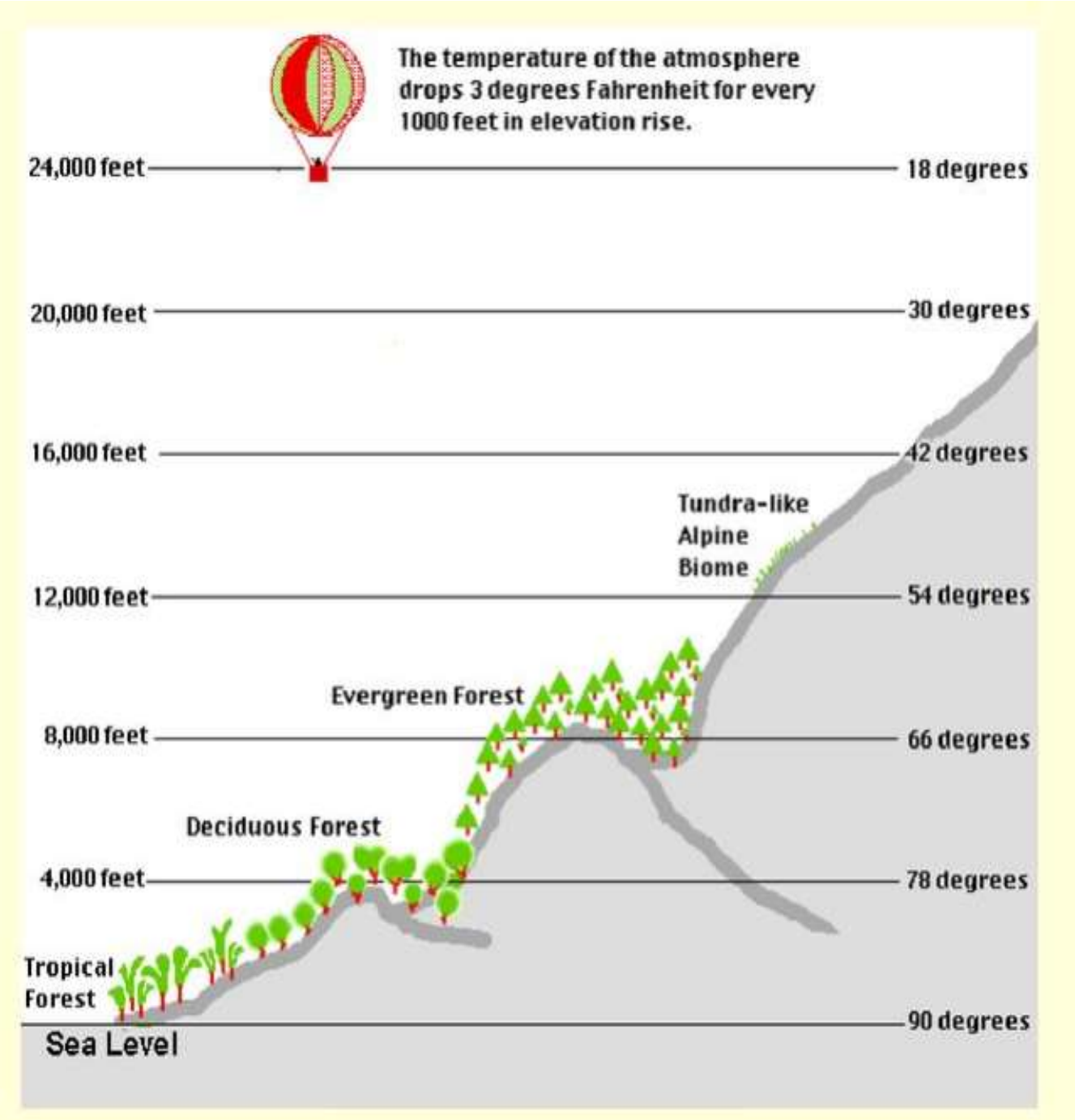
Maritime vs. continental climate



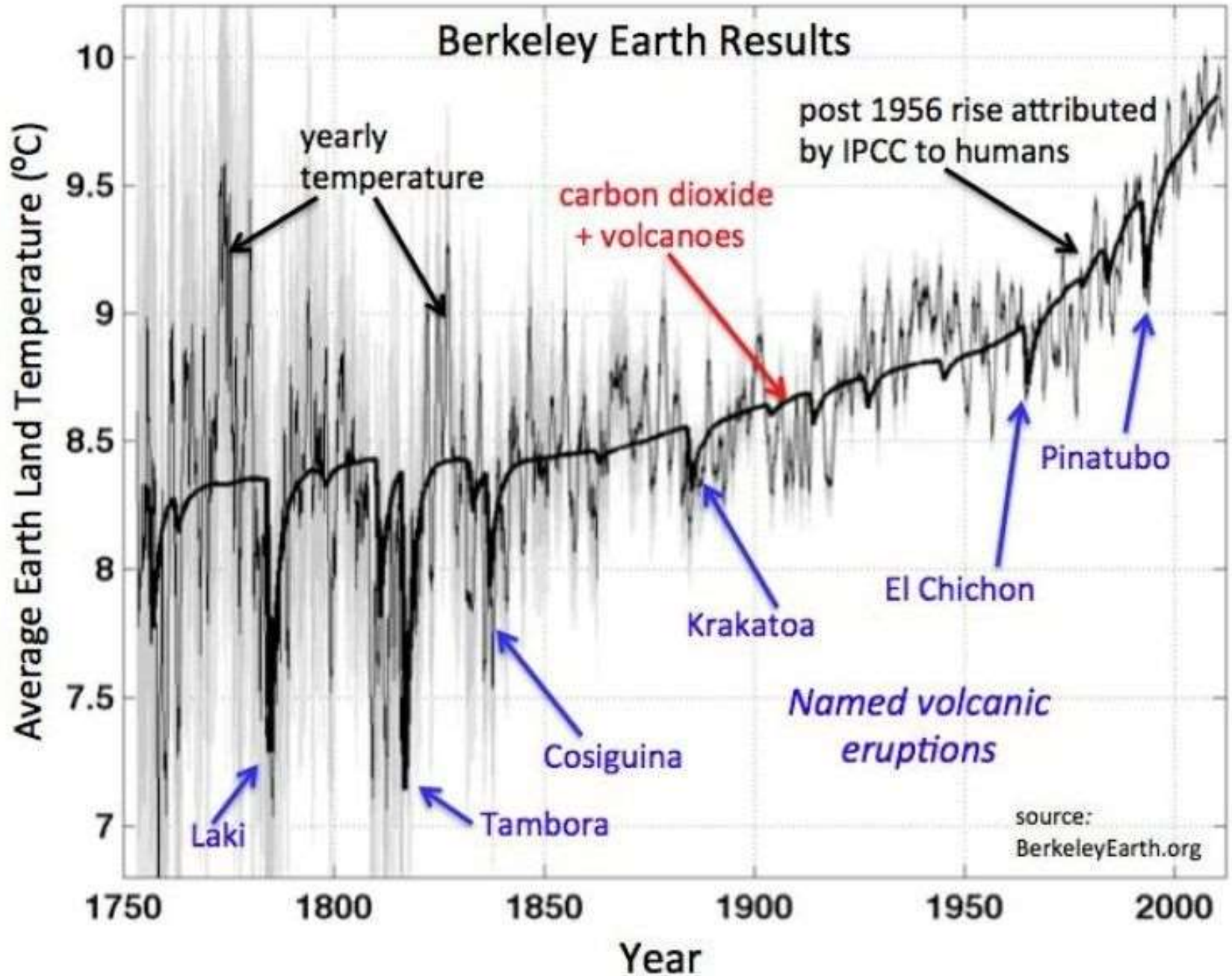
Maritime climate in northwestern and nothern Europe

Highland climate



Vegetation altitude zones

Volcanic eruptions



https://berkeleyearth.org/archive/volcanoes/

Climate Change – natural causes

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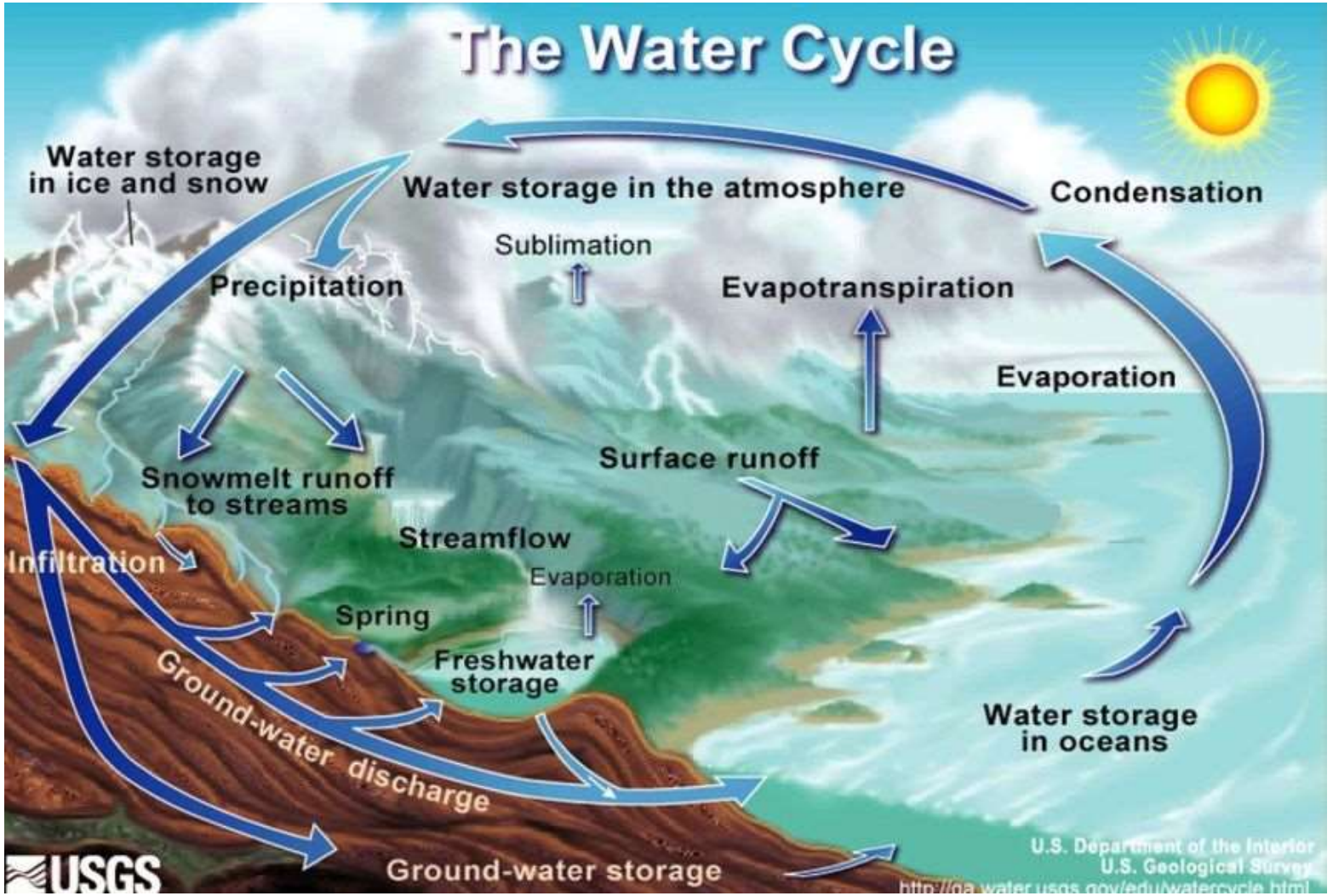
The Water Cycle



https://education.nationalgeographic.org/resource/800px-water-cycle/

The most important are:

- evaporation
- transpiration
- condensation
- precipitation
- runoff

https://www.usgs.gov/special-topic/water-science-school/science/water-cycle?qt-science_center_objects=0#qt-science_center_objects

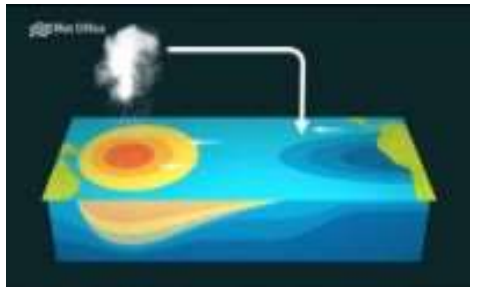
ENSO - El Niño-Southern Oscillation

SELF-STUDY

Using recommended sources, study **basic information about the phenomenon called ENSO** (where and why it occurs, processes in the ocean and the atmosphere, normal patterns, El Niño, La Niña, regional and global effects on weather/climate).

- *Hess, D. (2014): McKnight's physical geography: a landscape appreciation. 11th ed. Harlow: Pearson. Pearson new international edition. ISBN 978-1-292-02091-4,* ***143-148****.*

- *https://www.youtube.com/watch?v=WPA-KpldDVc*



Climate Change – natural causes

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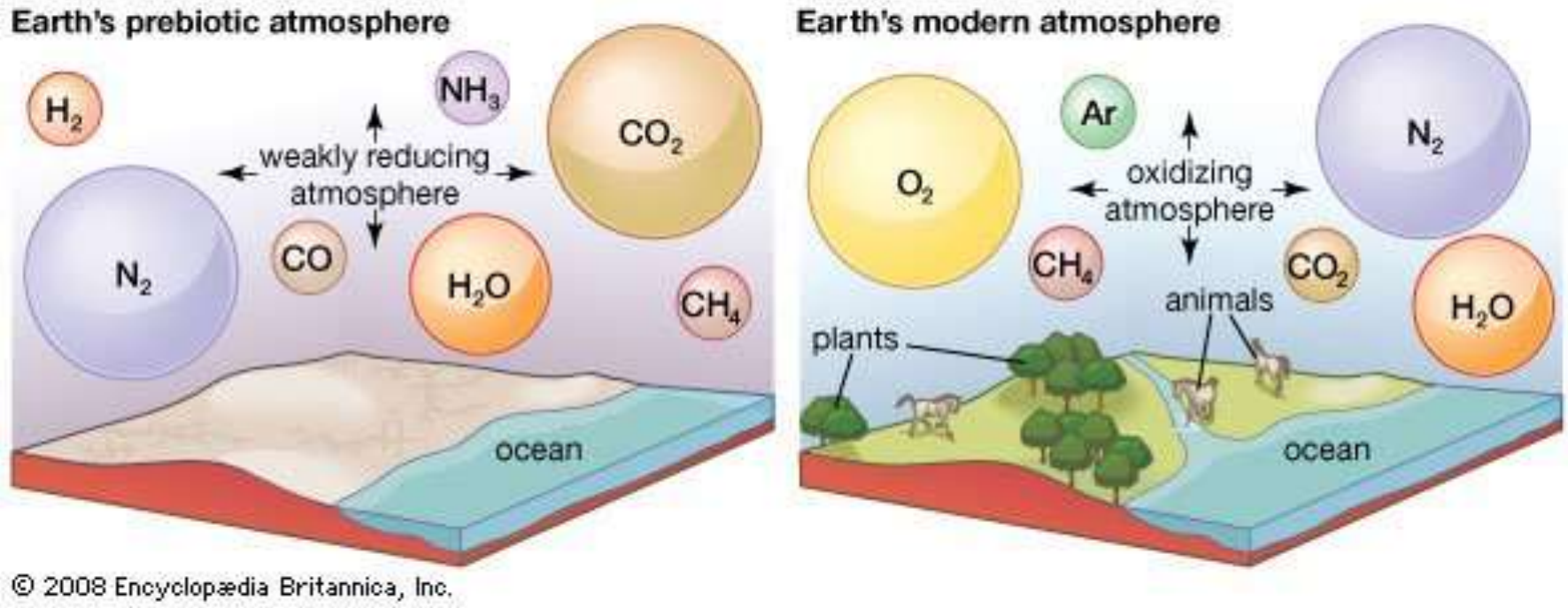
- **changes in the composition of the Earth's atmosphere**

Changes in the composition of the Earth's atmosphere

Evolution of the atmosphere



https://www.britannica.com/topic/evolution-of-the-atmosphere-1703862

https://www.youtube.com/watch?v=z1Ieb-OAoZA&list=PLW1sGr2pZxWxsgJPRPAsq4go_M4nD7Z4m

Climate feedbacks

+ Positive climate feedback = increasing effect of climatic factors

- Negative climate feedback = reducing effect of climatic factors

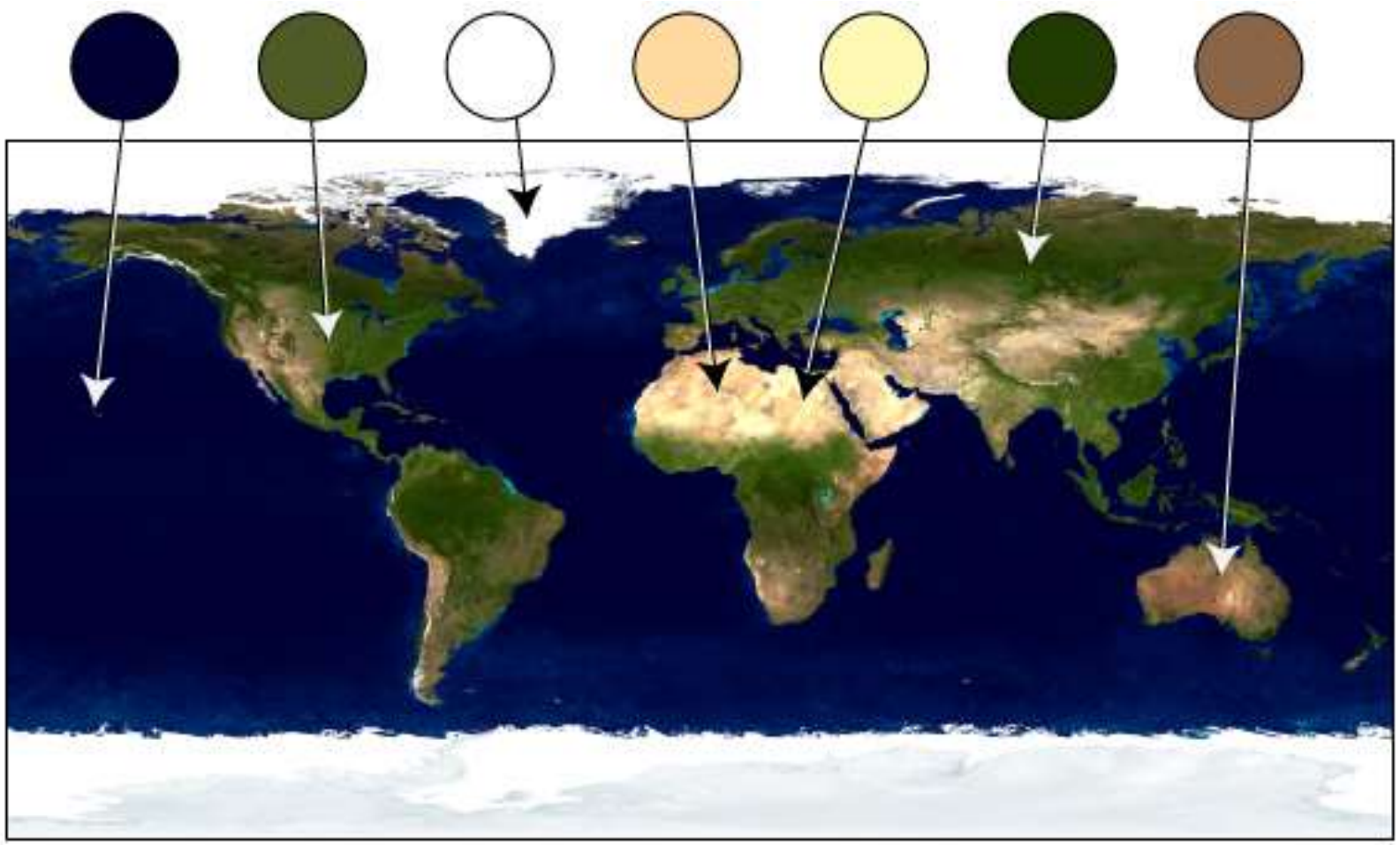
Albedo

- the amount of solar radiation reflected by a surface (% or decimal value)

A sampling of Earth's colors

Credit: UCAR SciEd with NASA image

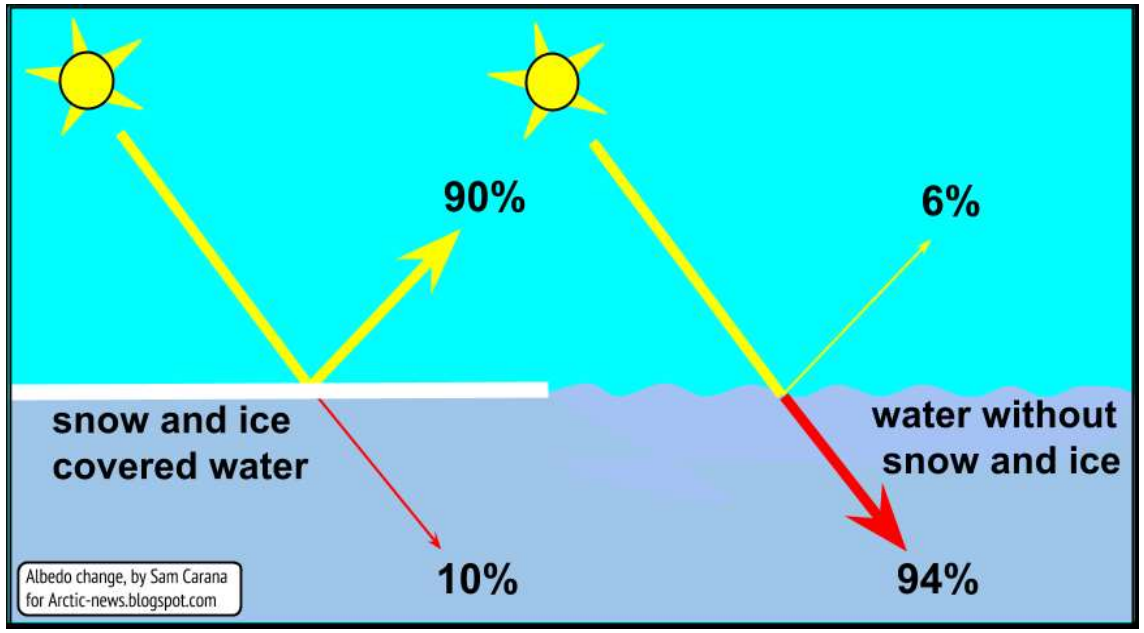
https://scied.ucar.edu



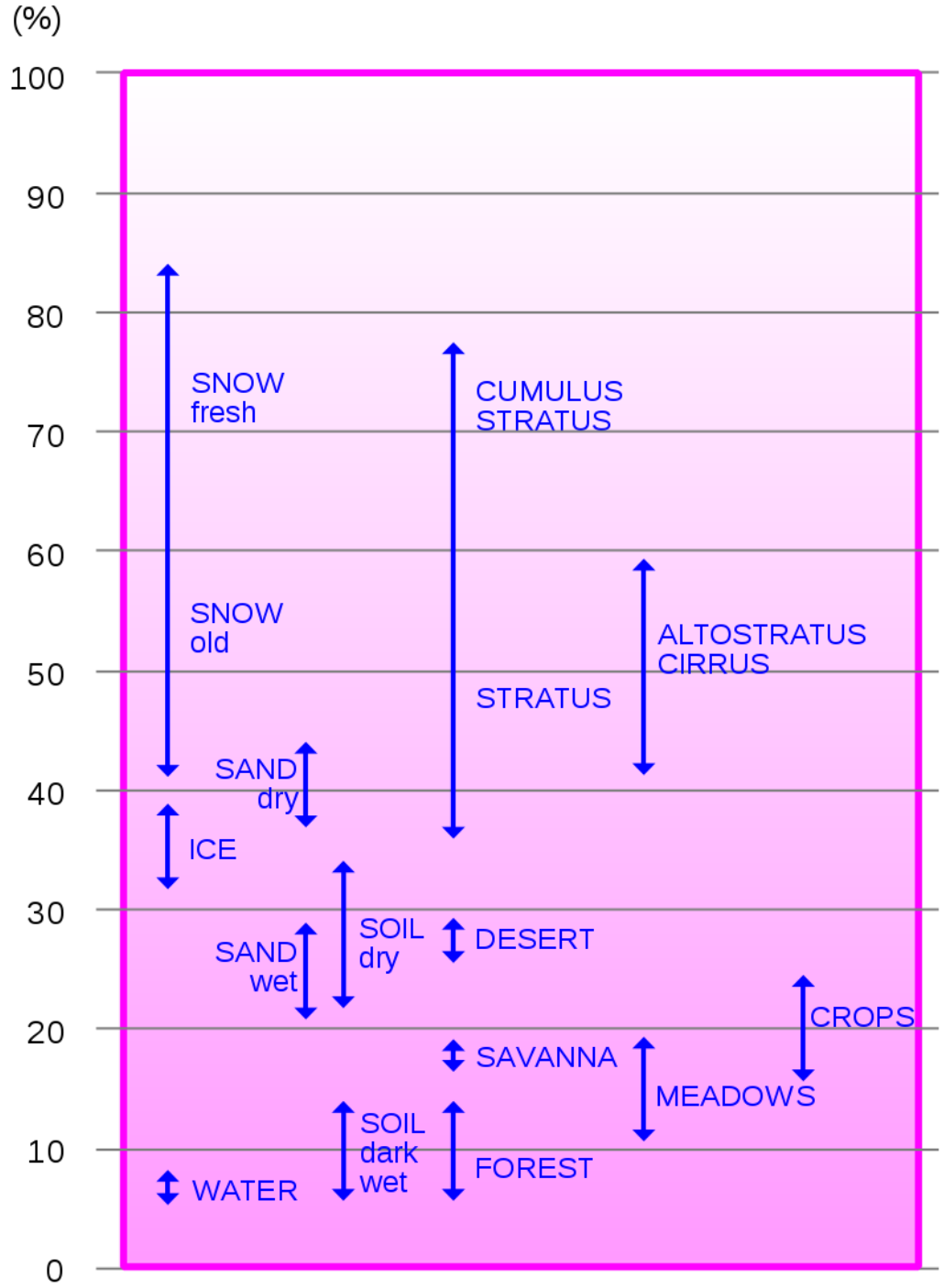
Albedo

White objects (e.g. fresh snow) – **high** albedo

Dark objects (e.g. dark soil, ocean) – **low** albedo



The percentage of reflected solar radiation relative to various surface conditions

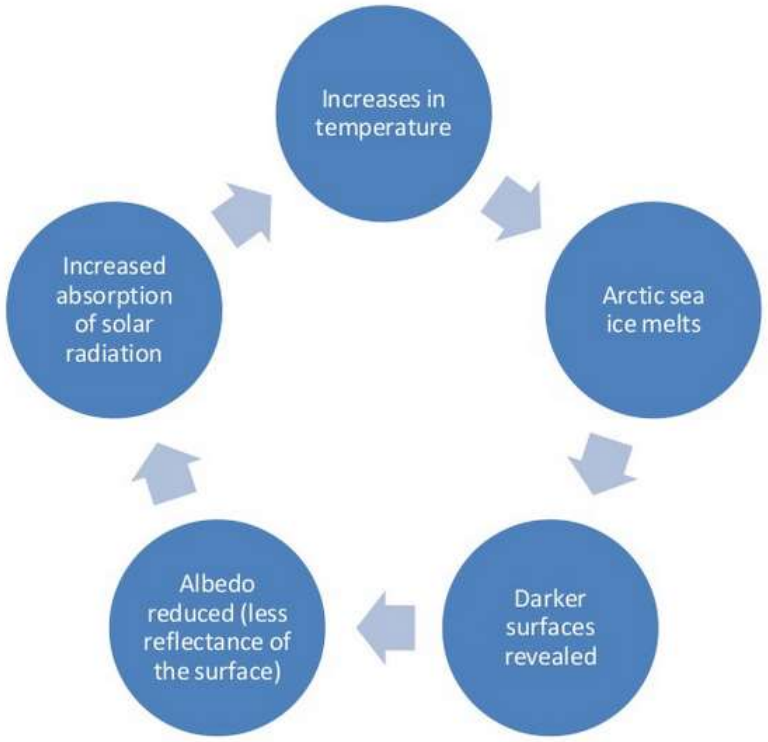


Climate feedbacks

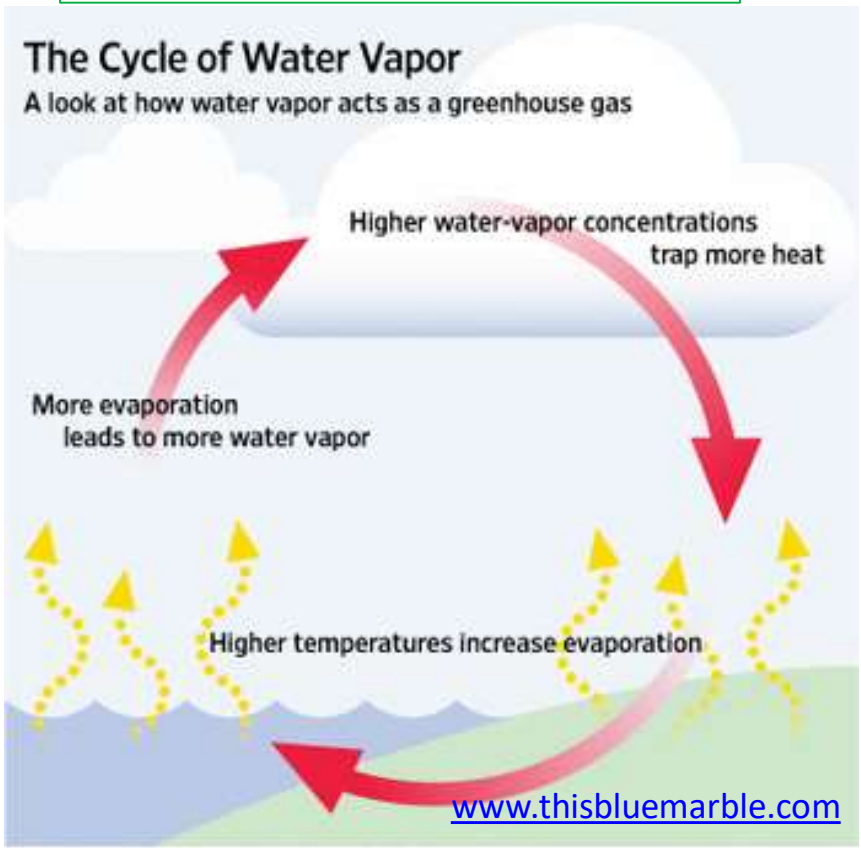
+ Positive climate feedback = increasing effect of climatic factors

- Negative climate feedback = reducing effect of climatic factors

+ Ice-Albedo Feedback

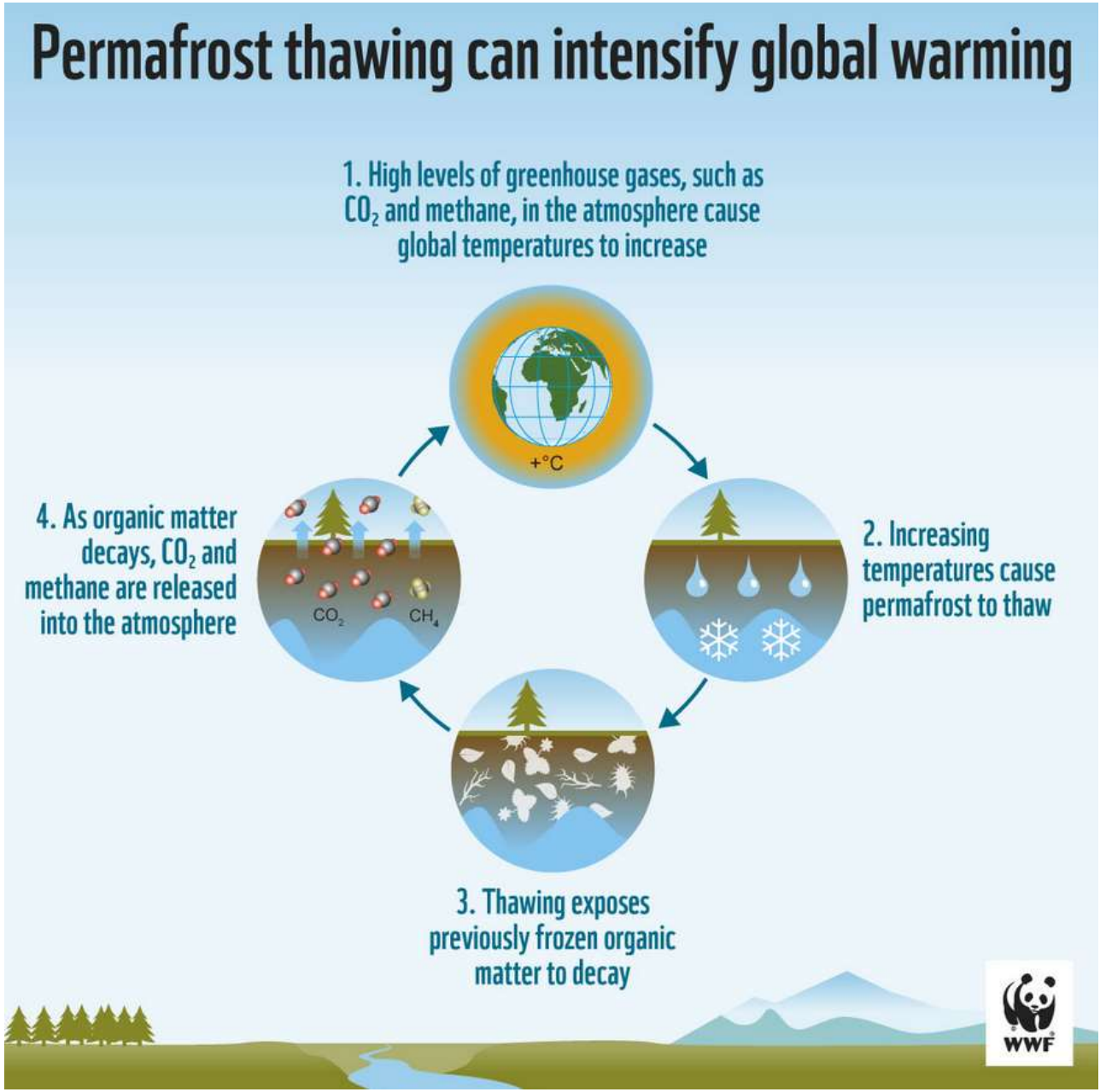


+ Water Vapour Release



Climate feedbacks

+ Carbon Release



https://www.arcticwwf.org/newsroom/features/putting-a-lid-on-methane-emissions-before-its-too-late/

Climate feedbacks

- Evaporation and Clouds

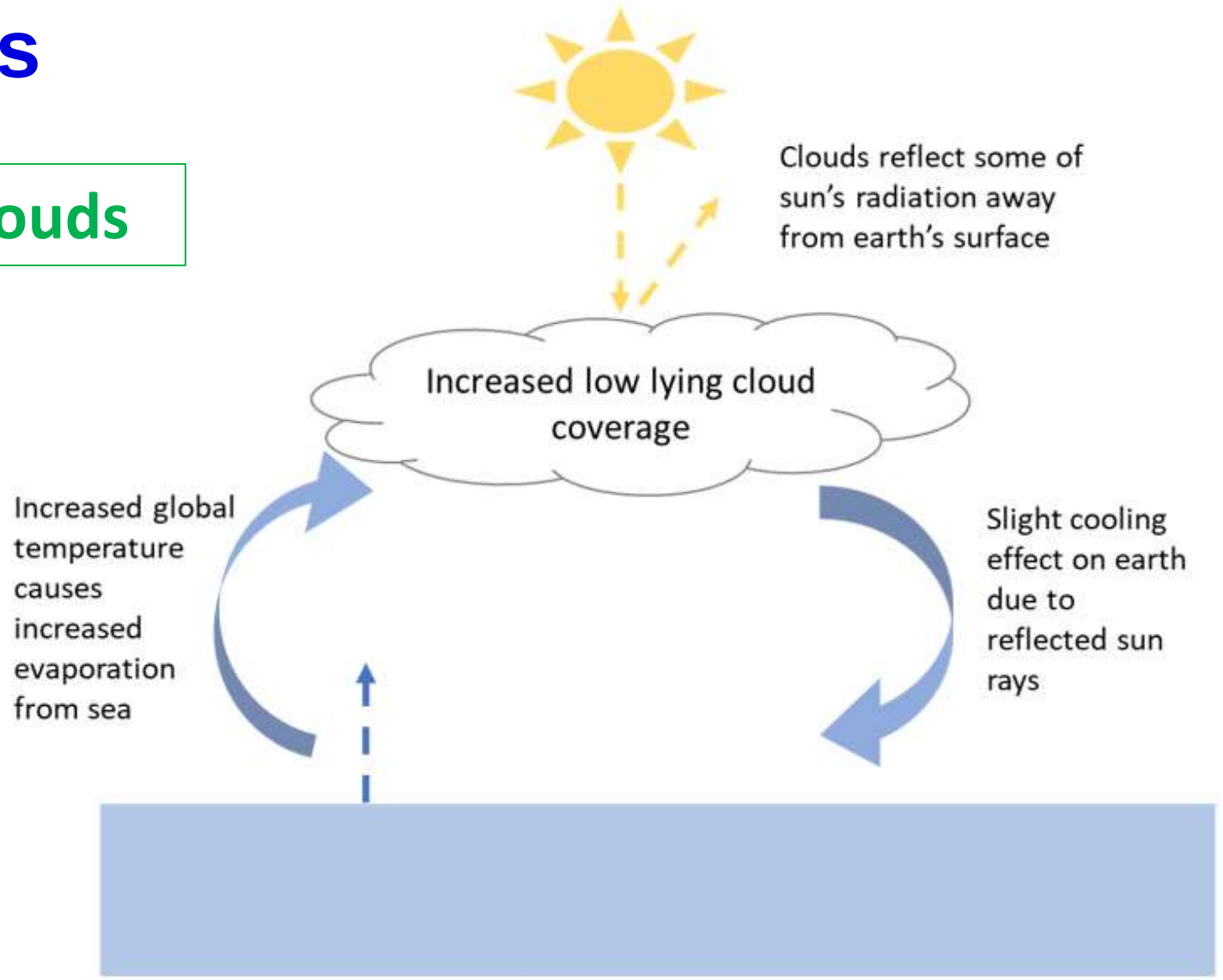


Figure 3 – *Diagram showing an example of negative feedback.*

https://actionrenewables.co.uk/news/what-are-climate-feedbacks/

Thank you for your attention

References

- Hess, D. (2014): McKnight's physical geography: a landscape appreciation. 11th ed. Harlow: Pearson. Pearson new international edition. ISBN 978-1-292-02091-4
- http://www….