Atmosphere and Climate

UCI – Environmental Science 101 July 2018

Weather vs Climate

Weather

- Short-term (minutes to months)

Example: a hot day with thunderstorms

Climate

- Average of weather over time and space, i.e., what do we expect

Example: Most summers are hot and humid in Cincinnati

Factors influencing climate

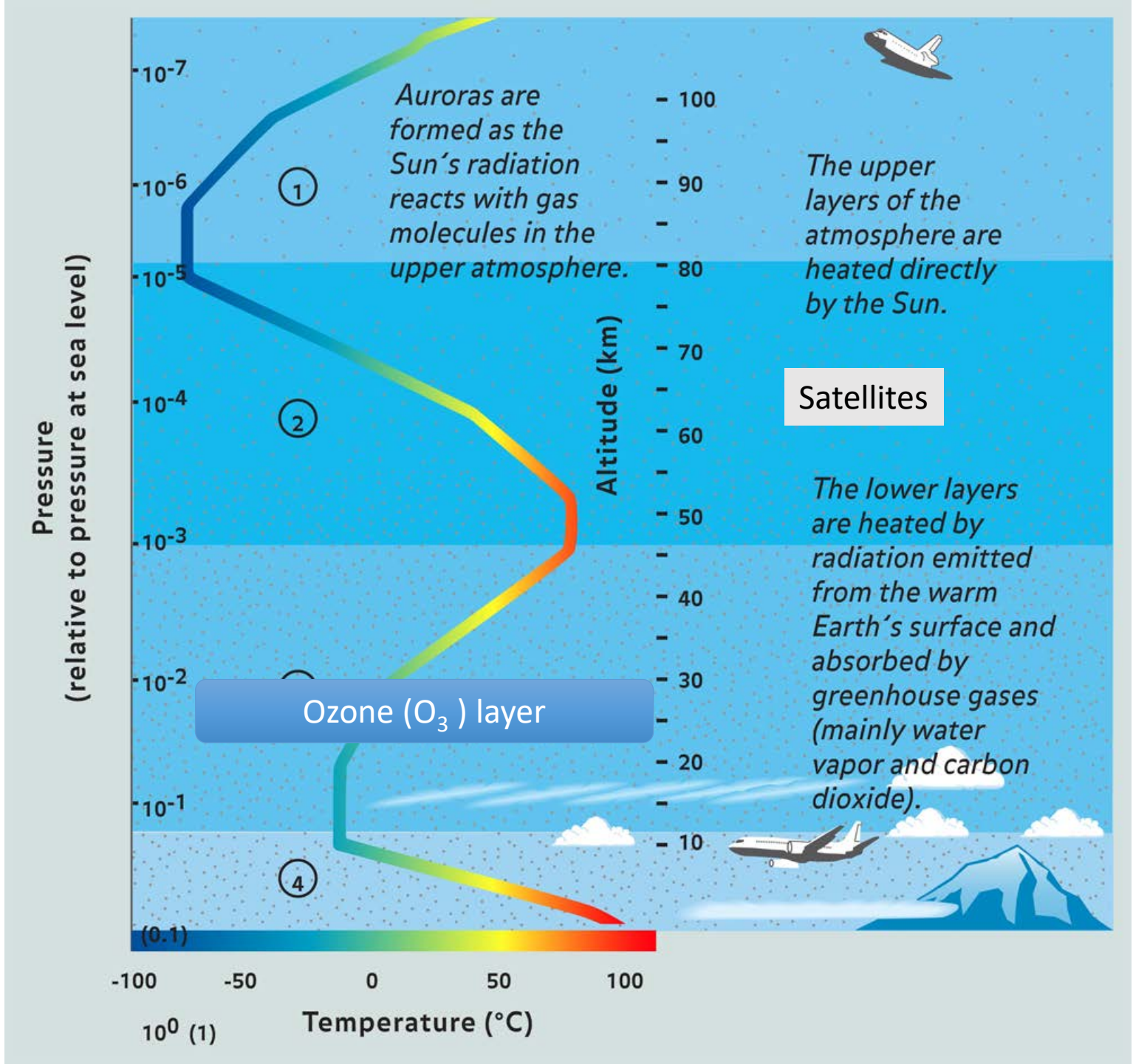
LAMECOWS

Climate

Temperature and Precipitation

Primary Driver

- solar radiation and differential heating
  - tilt of the earth relative to the sun
- convection currents
- earth's rotation and the Coriolis effect
  - ocean gyres, upwelling zones, ENSO
  - global ocean thermohaline belt……



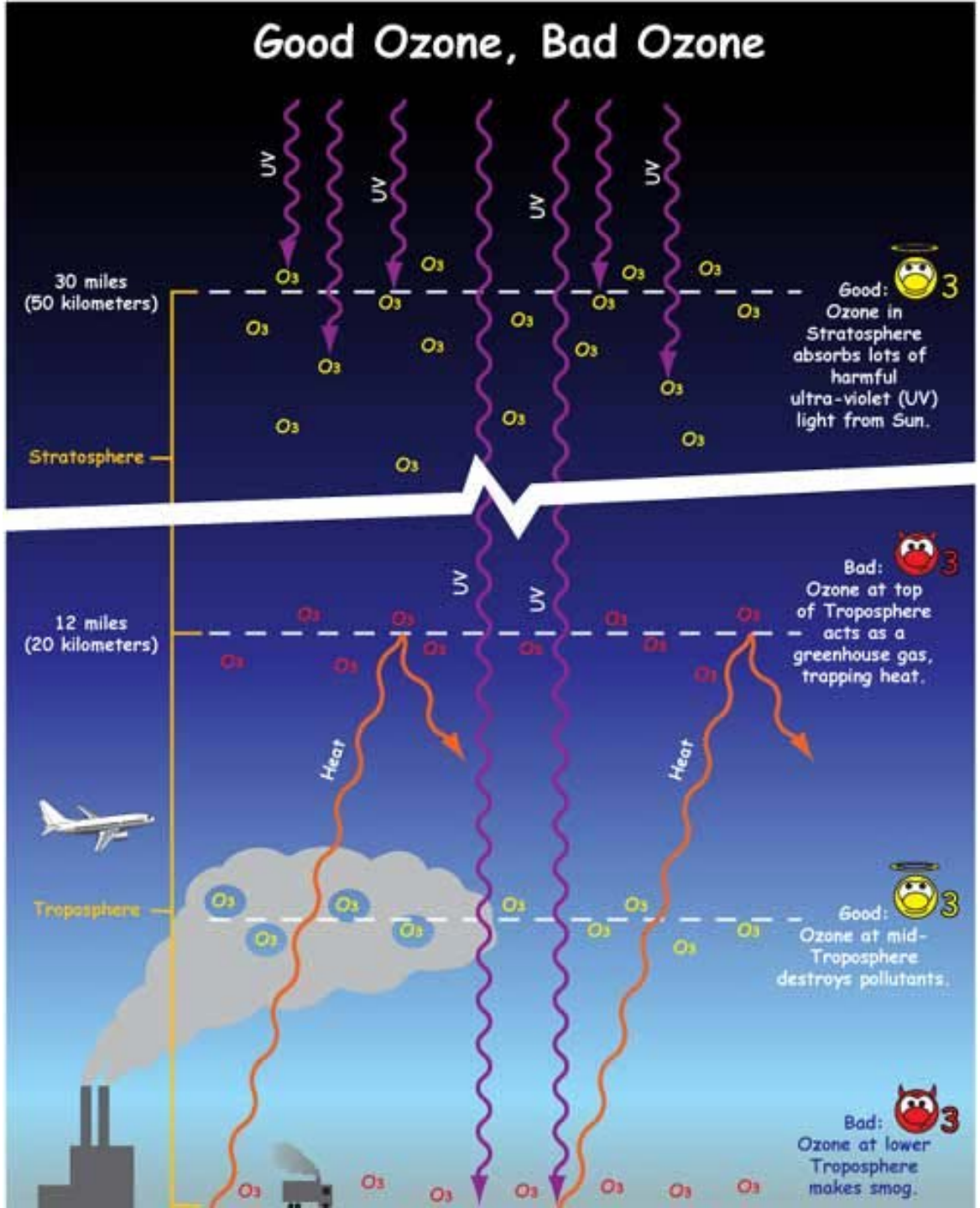
Thermosphere

Mesosphere

Stratosphere
(UV light absorbed → heat)

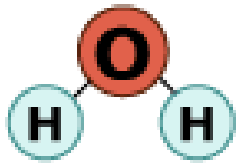
Troposphere
"The greenhouse"

Ozone

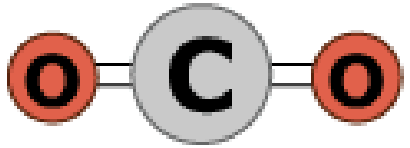

Good Ozone, Bad Ozone
UV
30 miles
(50 kilometers)
Stratosphere
Good:
Ozone in Stratosphere absorbs lots of harmful ultra-violet (UV) light from Sun.
Bad:
Ozone at top of Troposphere acts as a greenhouse gas, trapping heat.
12 miles
(20 kilometers)
Heat
Troposphere
Good:
Ozone at mid-Troposphere destroys pollutants.
Bad:
Ozone at lower Troposphere makes smog.

Greenhouse Gases

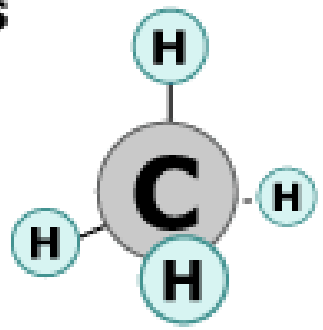
Major GHG



Water, H_2O

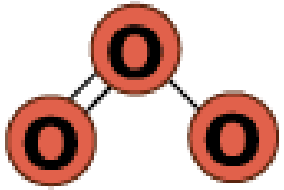


Carbon Dioxide, CO_2



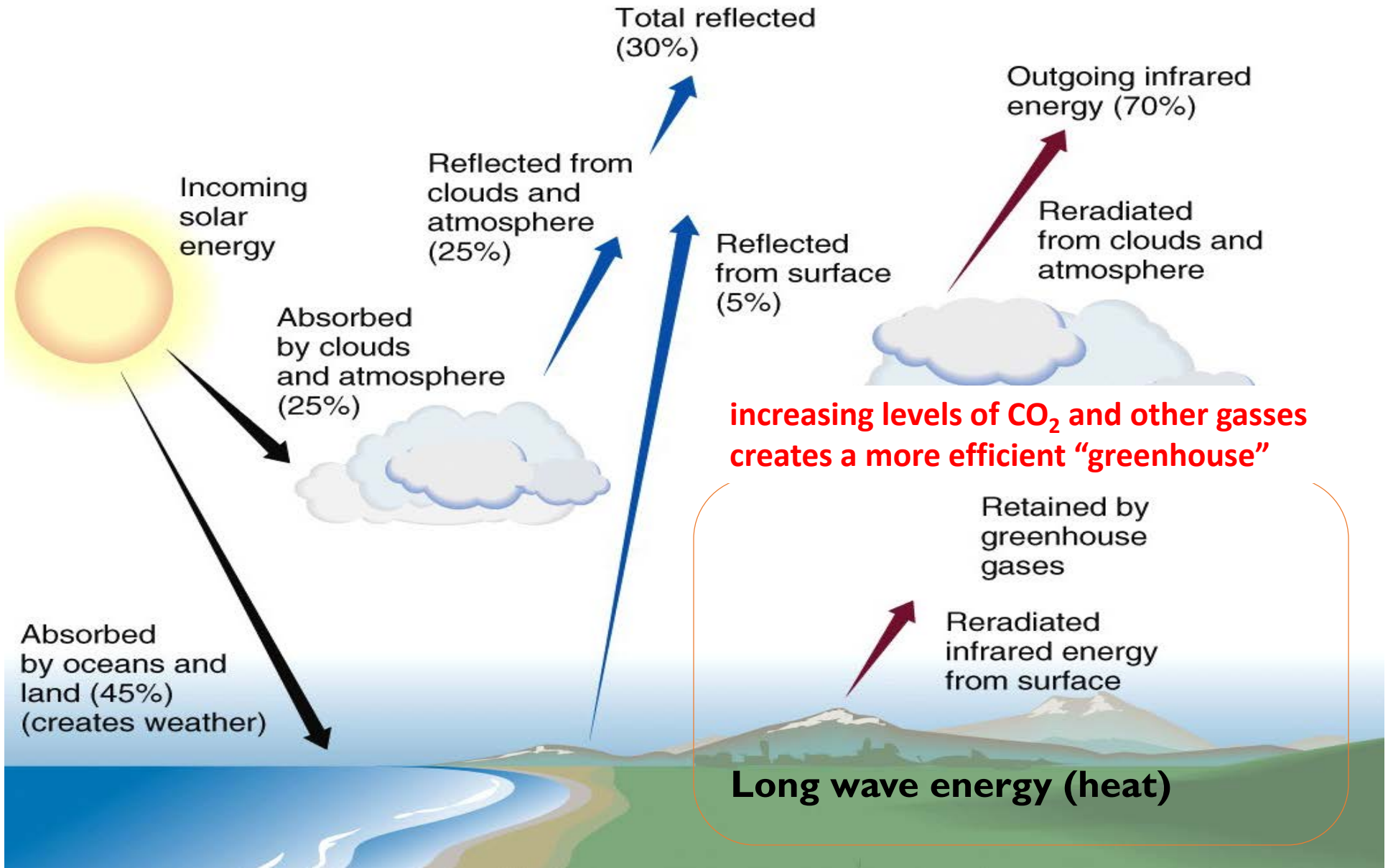
Methane, CH_4

Nitrous Oxide, N_2O



Ozone, O_3

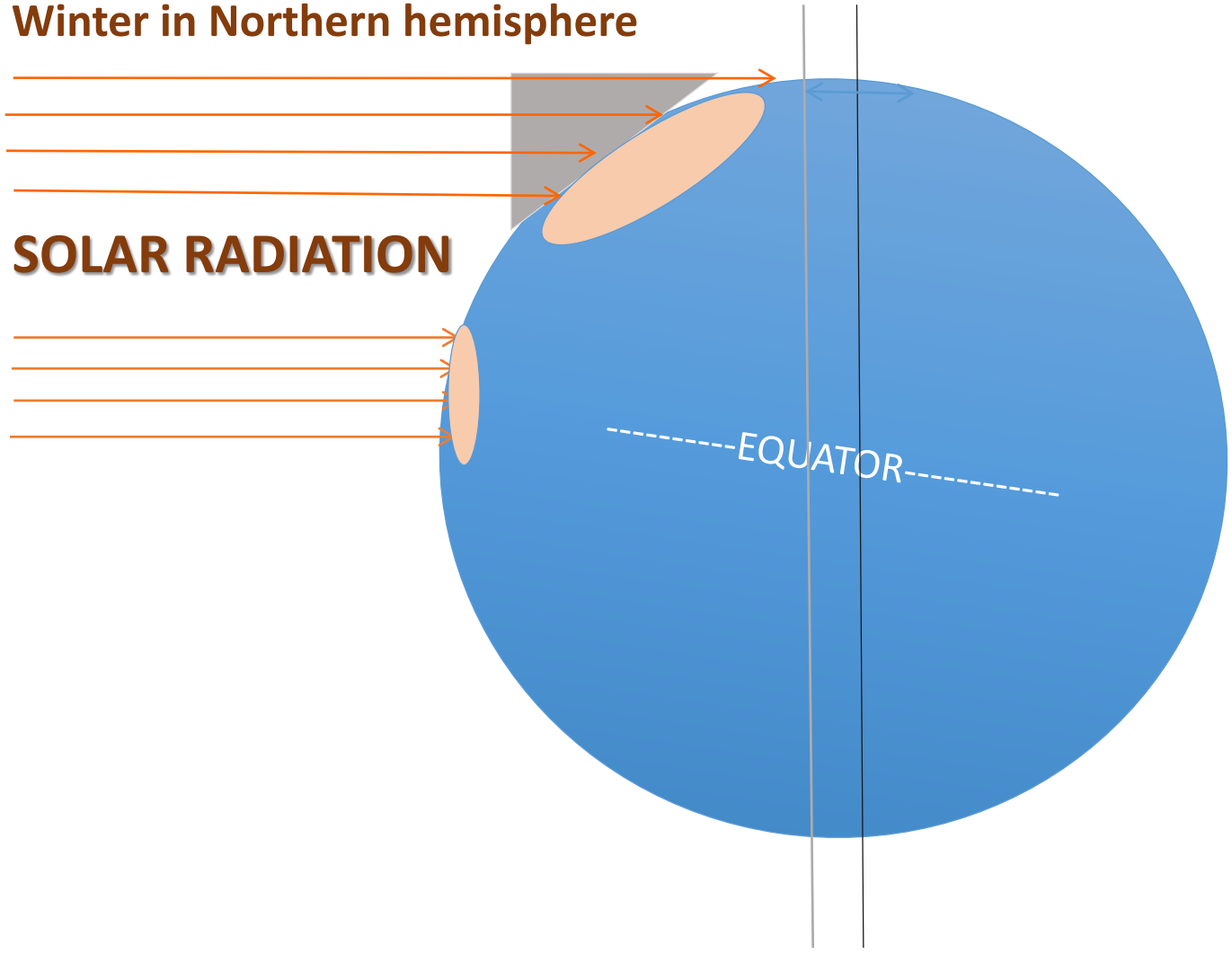
Greenhouse effect



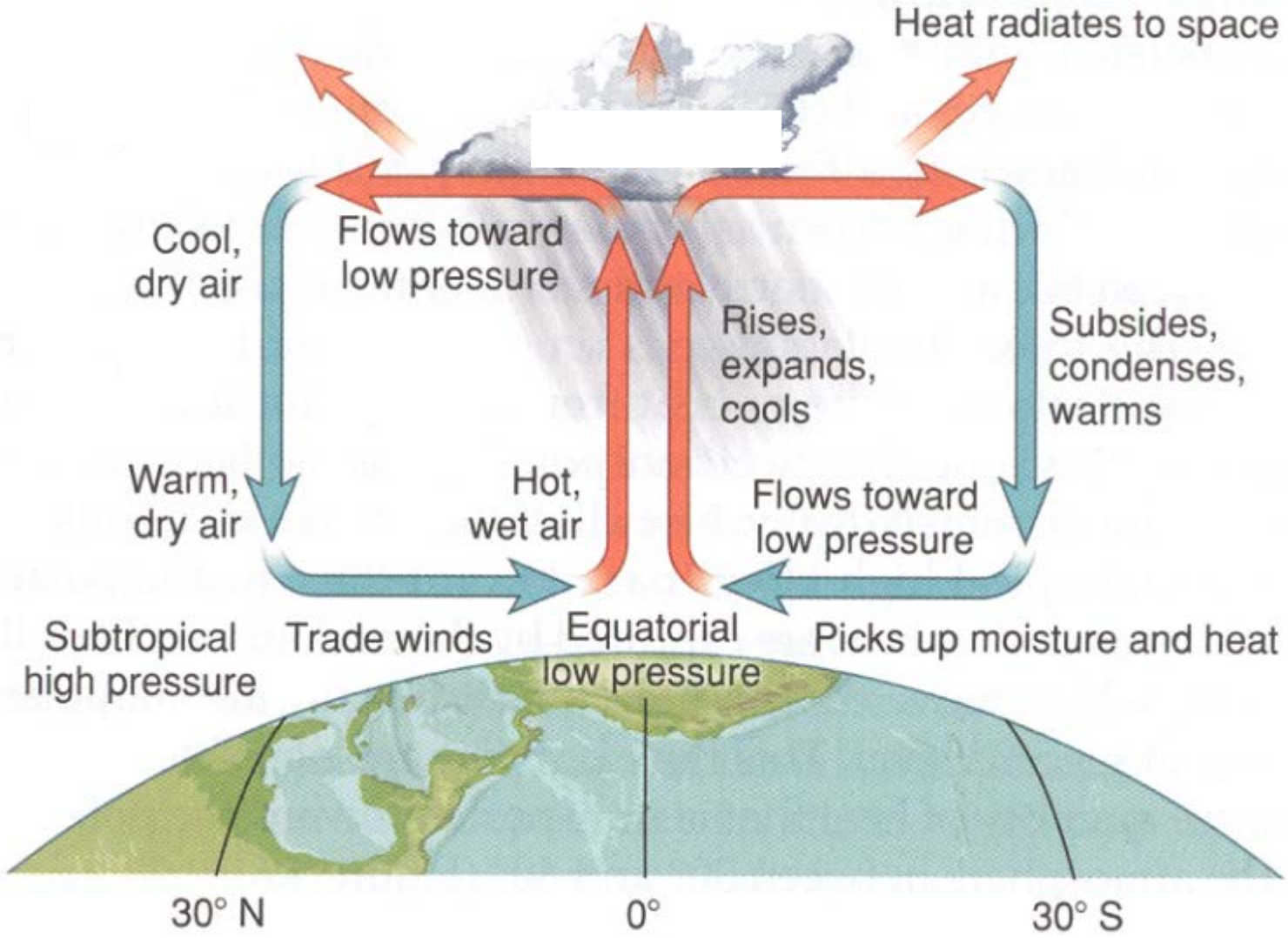
increasing levels of CO_2 and other gasses creates a more efficient "greenhouse"

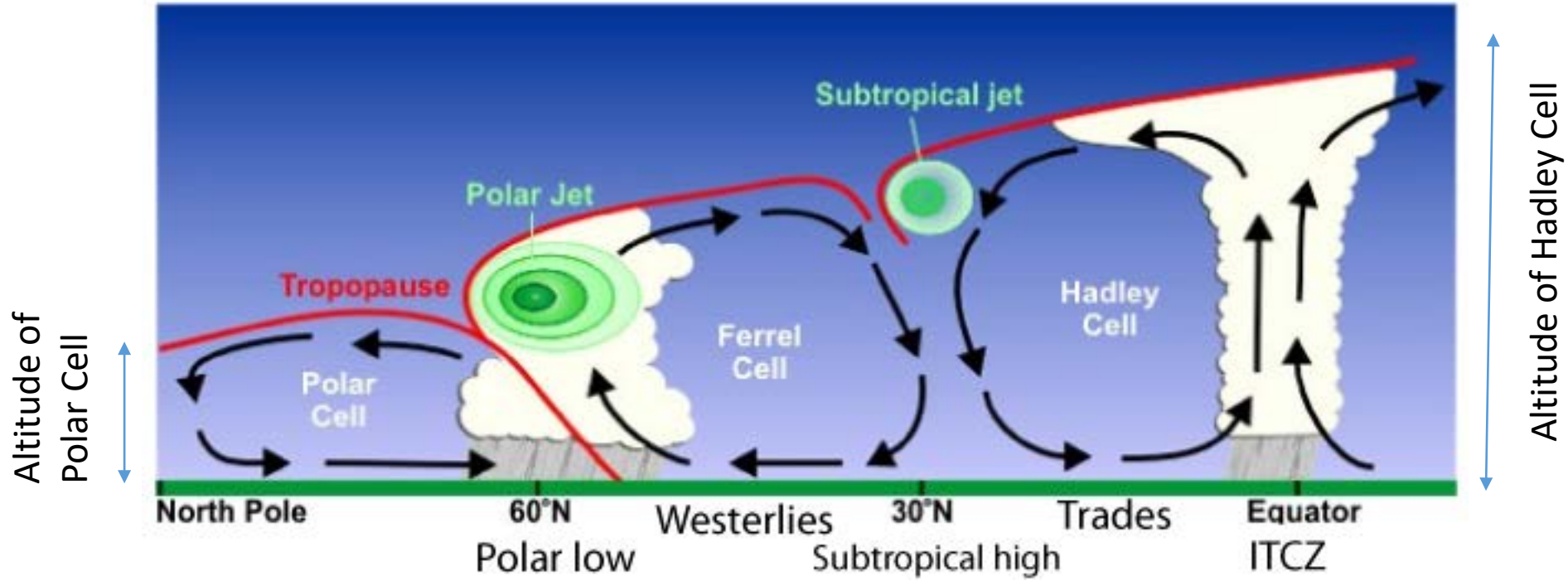
Because the axis of the earth is tilted 23.5° relative to the sun, solar radiation hits the earth most directly at the equator (±23 °N or S) and least at the poles (greater spread and thru more atmosphere).

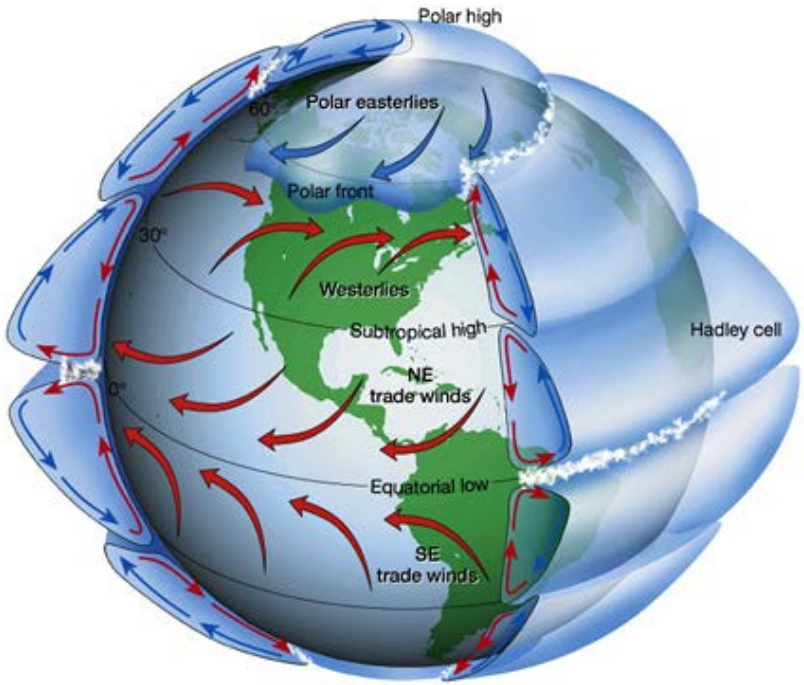
This explains the differential heating of the earth and seasonality.

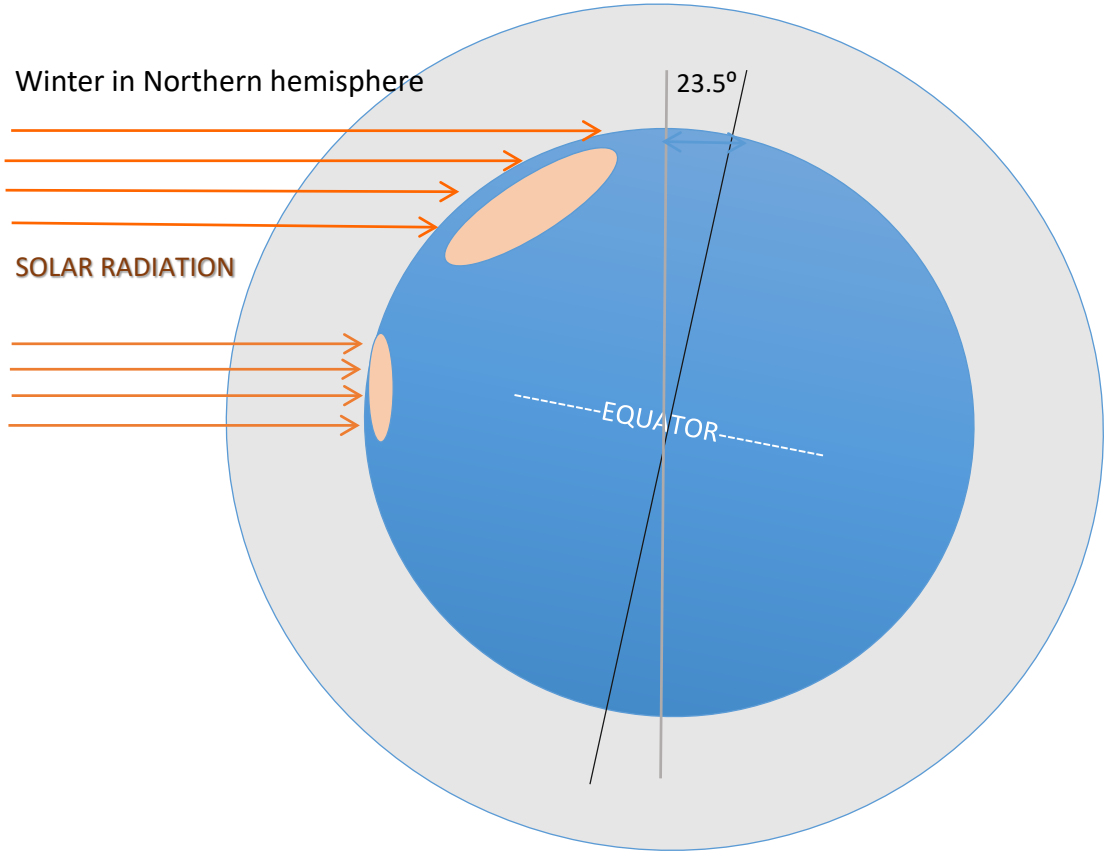


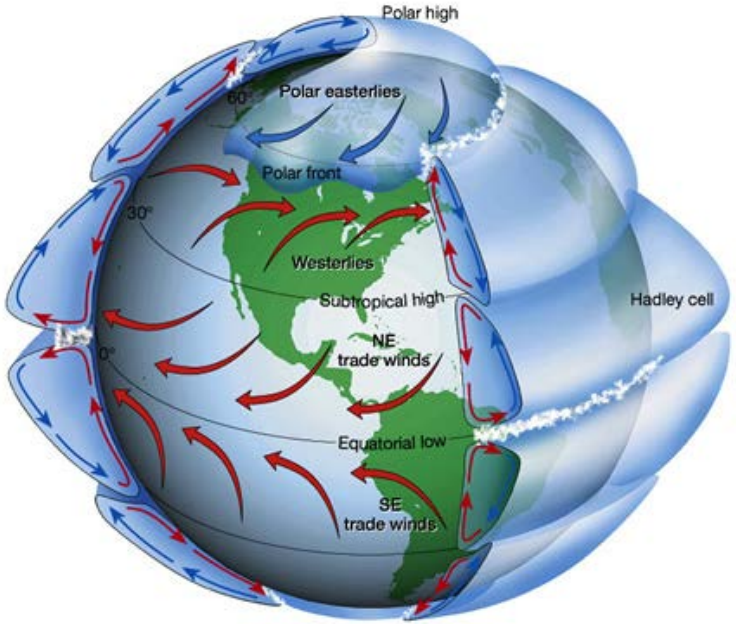
Hadley cells




Altitude of Polar Cell
Subtropical jet
Polar Jet
Tropopause
Polar Cell
Ferrel Cell
Hadley Cell
Altitude of Hadley Cell
North Pole
60°N
Westerlies
30°N
Trades
Equator
Polar low
Subtropical high
ITCZ


Polar high
60°
Polar easterlies
Polar front
30°
Westerlies
Subtropical high
Hadley cell
NE trade winds
0°
Equatorial low
SE trade winds


Winter in Northern hemisphere
23.5°
SOLAR RADIATION
EQUATOR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NE
trade winds
0°
Equatorial low
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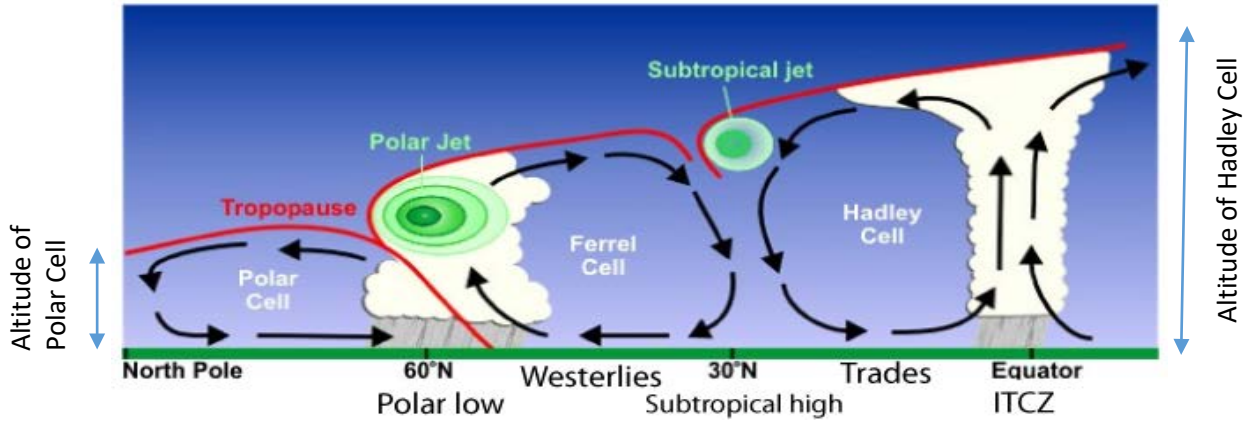
Subtropical jet
Polar Jet
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Hadley
Cell
Altitude of
Polar Cell
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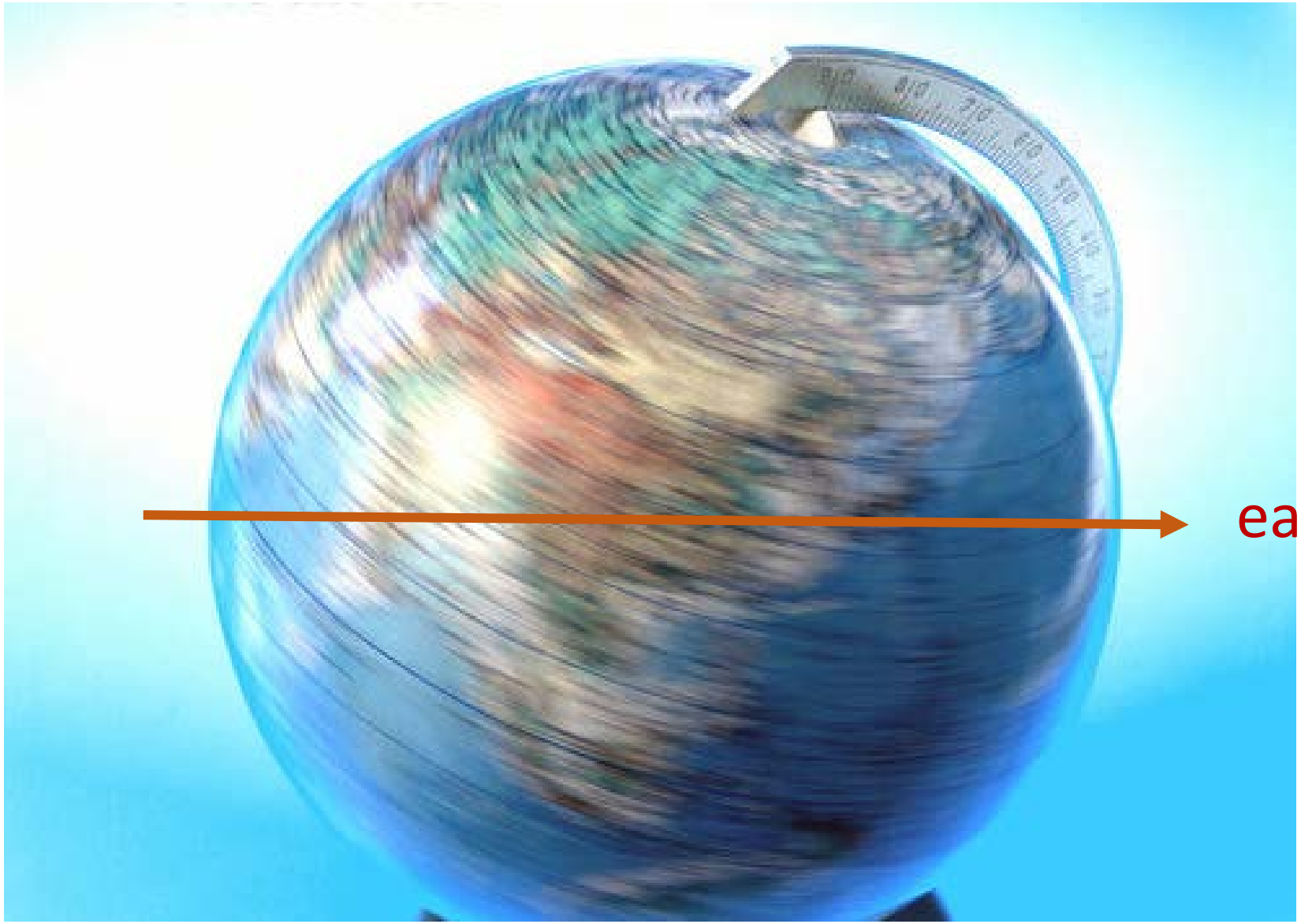
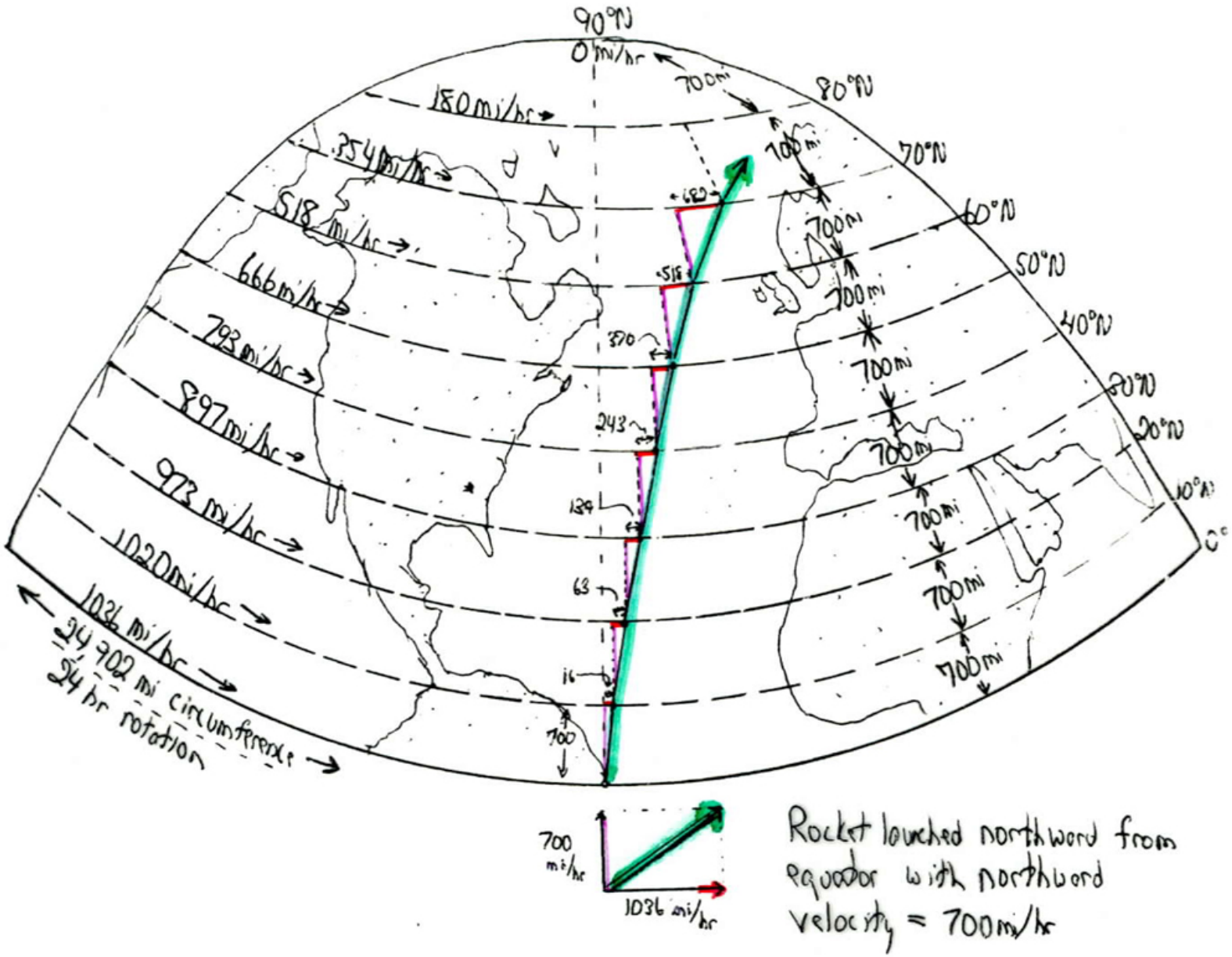
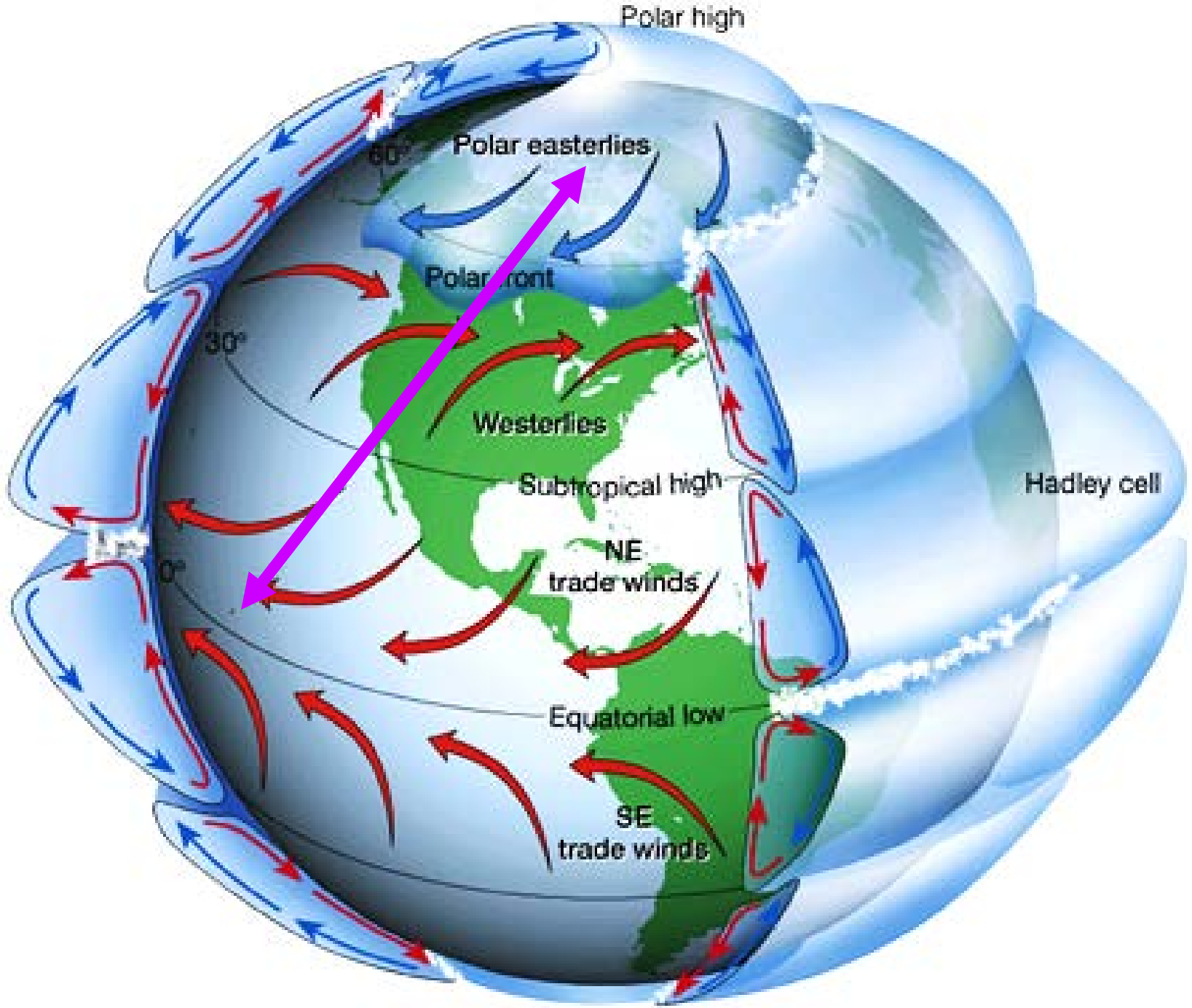
North Pole
60°N
Polar low
Westerlies
30°N
Subtropical high
Trades
Equator
ITCZ

the earth is rotating…



The Coriolis effect aka Rocket Science

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trade winds
Polar
Ferrel
Hadley

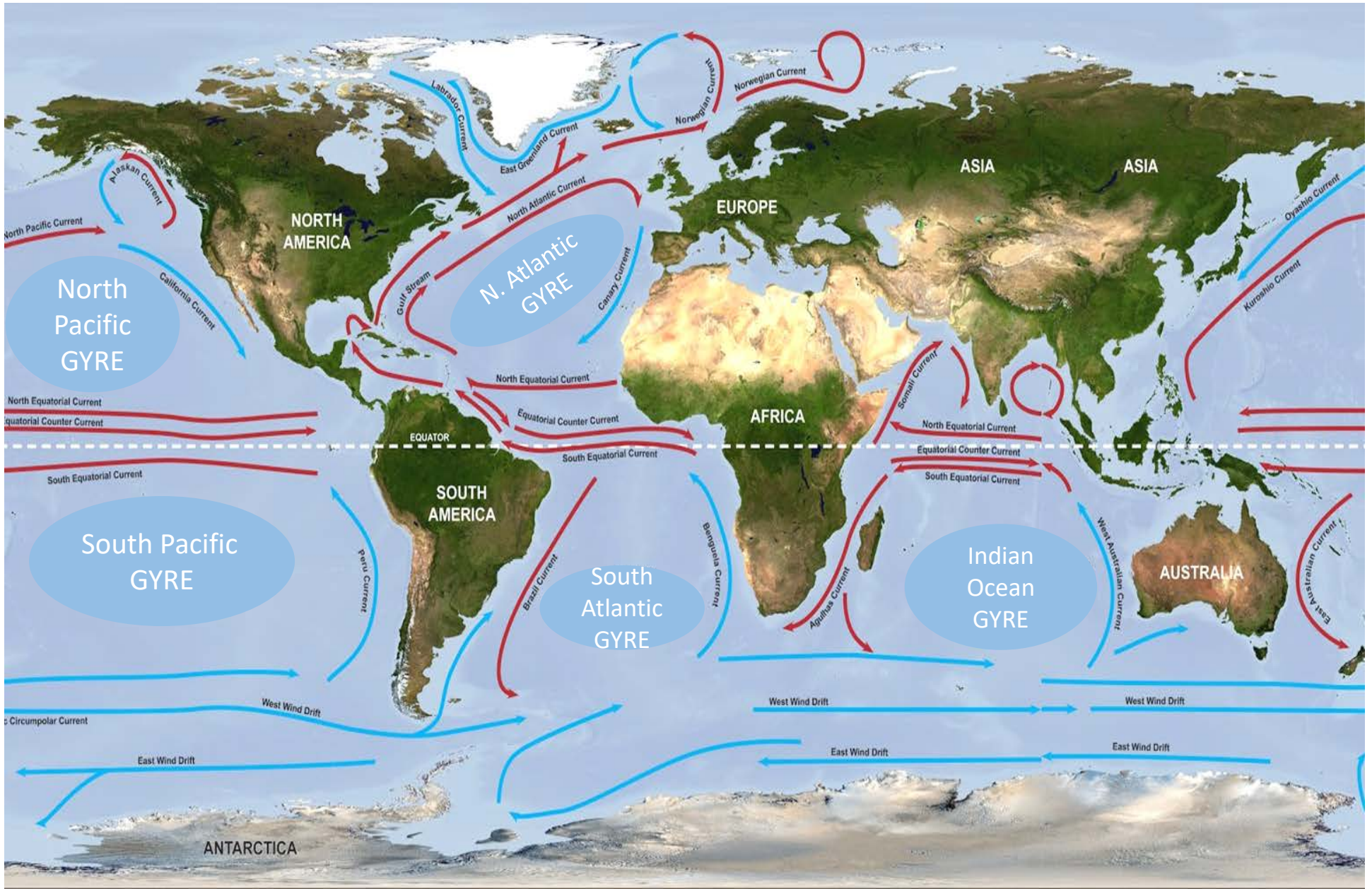

Jet streams
Occur where hot/cold air meets
http://earth.nullschool.net/

OCEAN CURRENTS

Types:

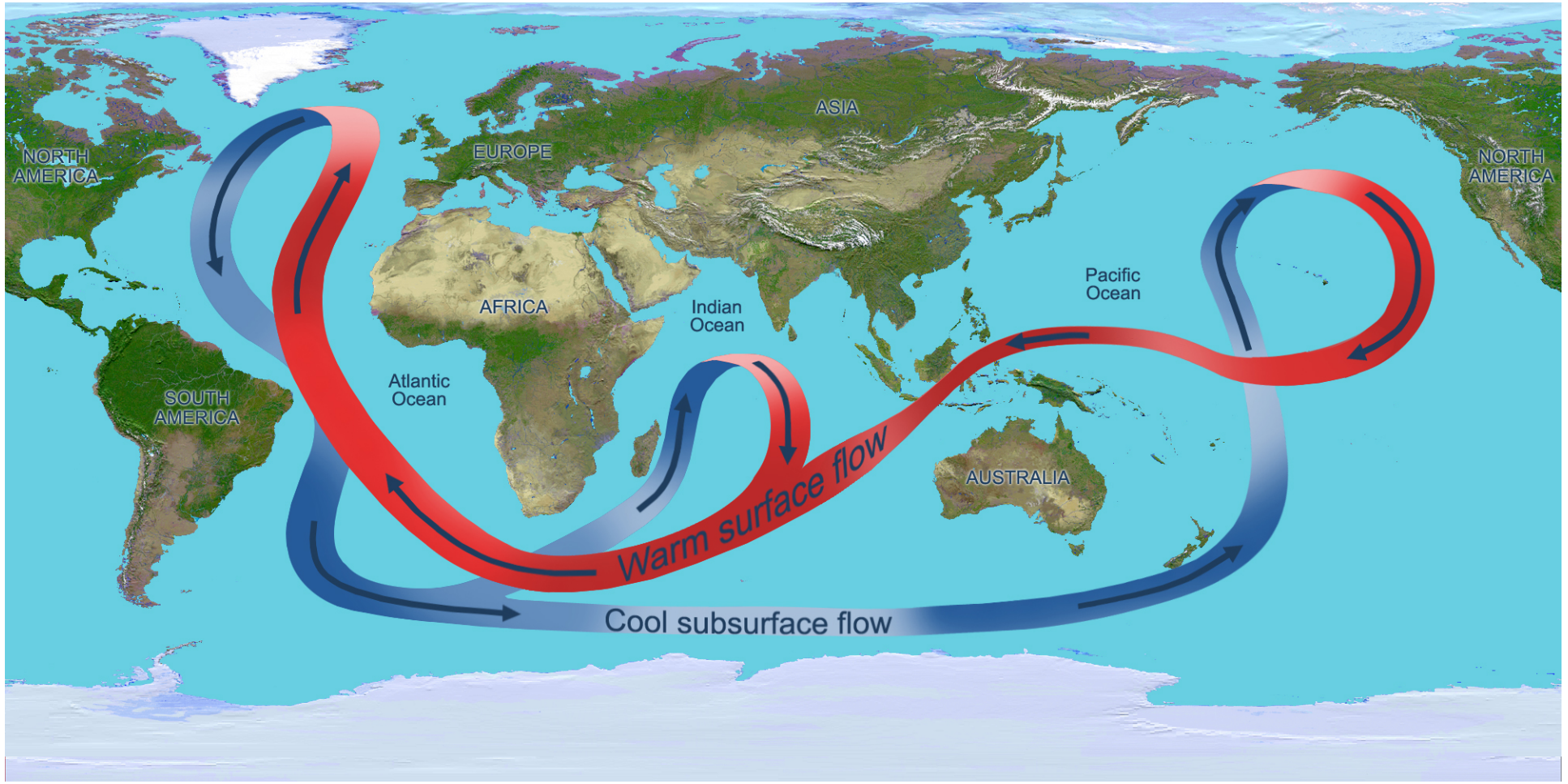
Surface and Deep

SURFACE CURRENTS



Thermohaline circulation

https://www.youtube.com/watch?v=M2Jxs7lR8ZI

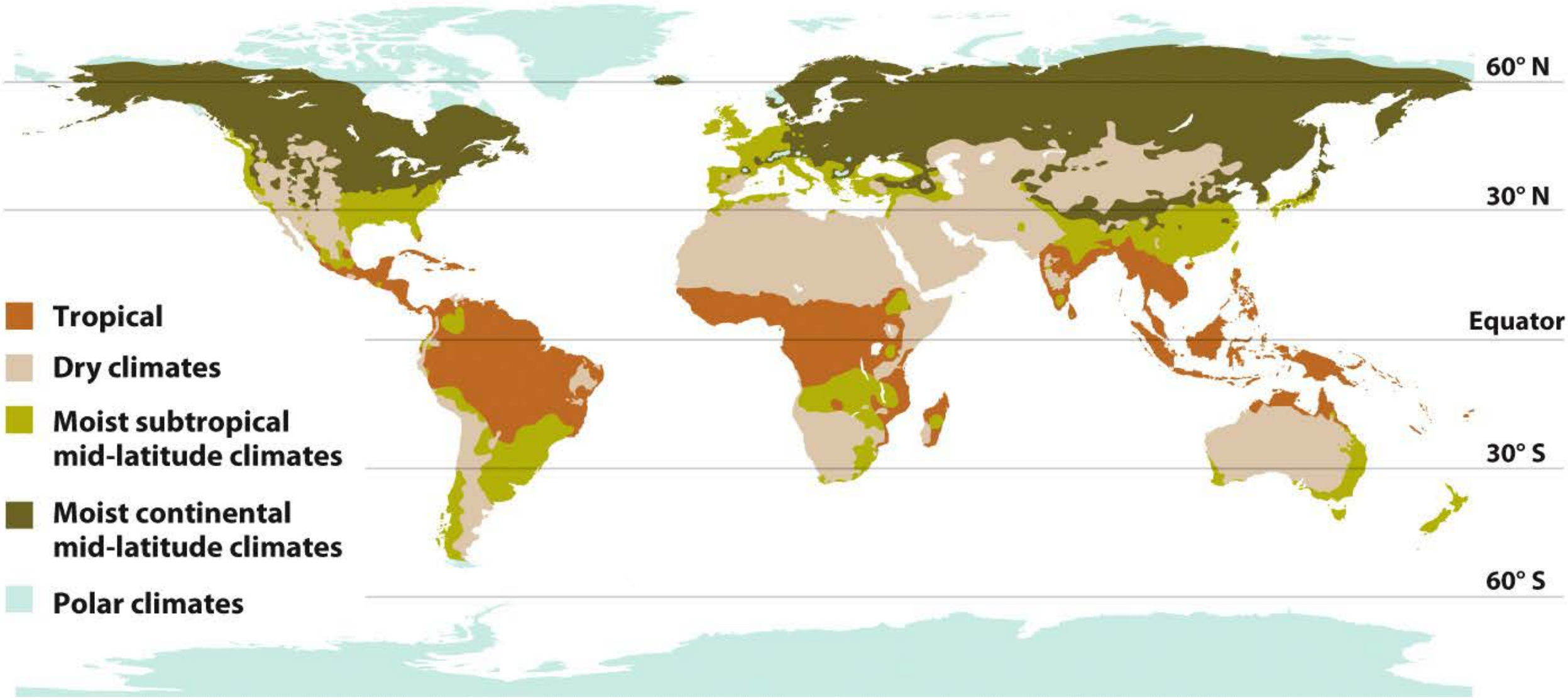


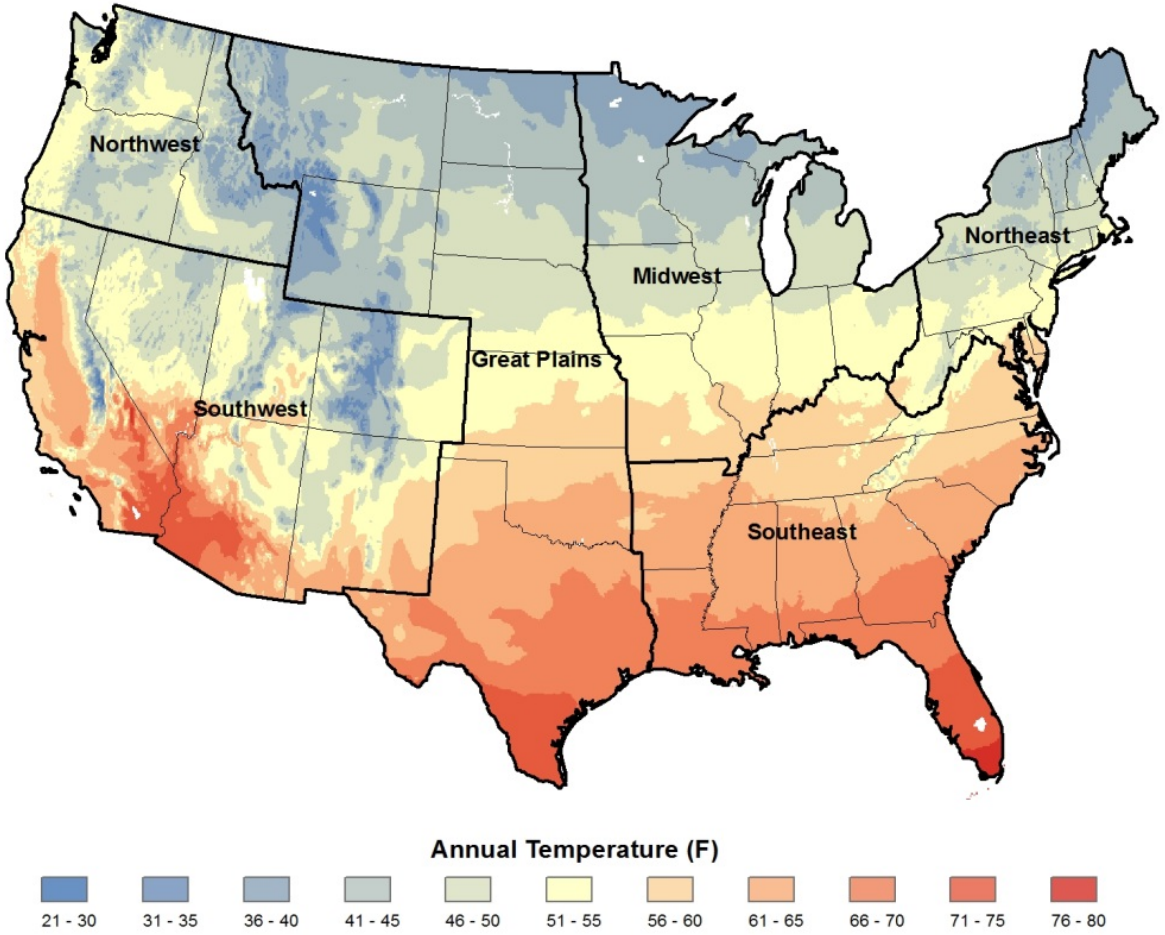
① **Warm water flows from the Gulf of Mexico to the North Atlantic, where some of it freezes and evaporates.**

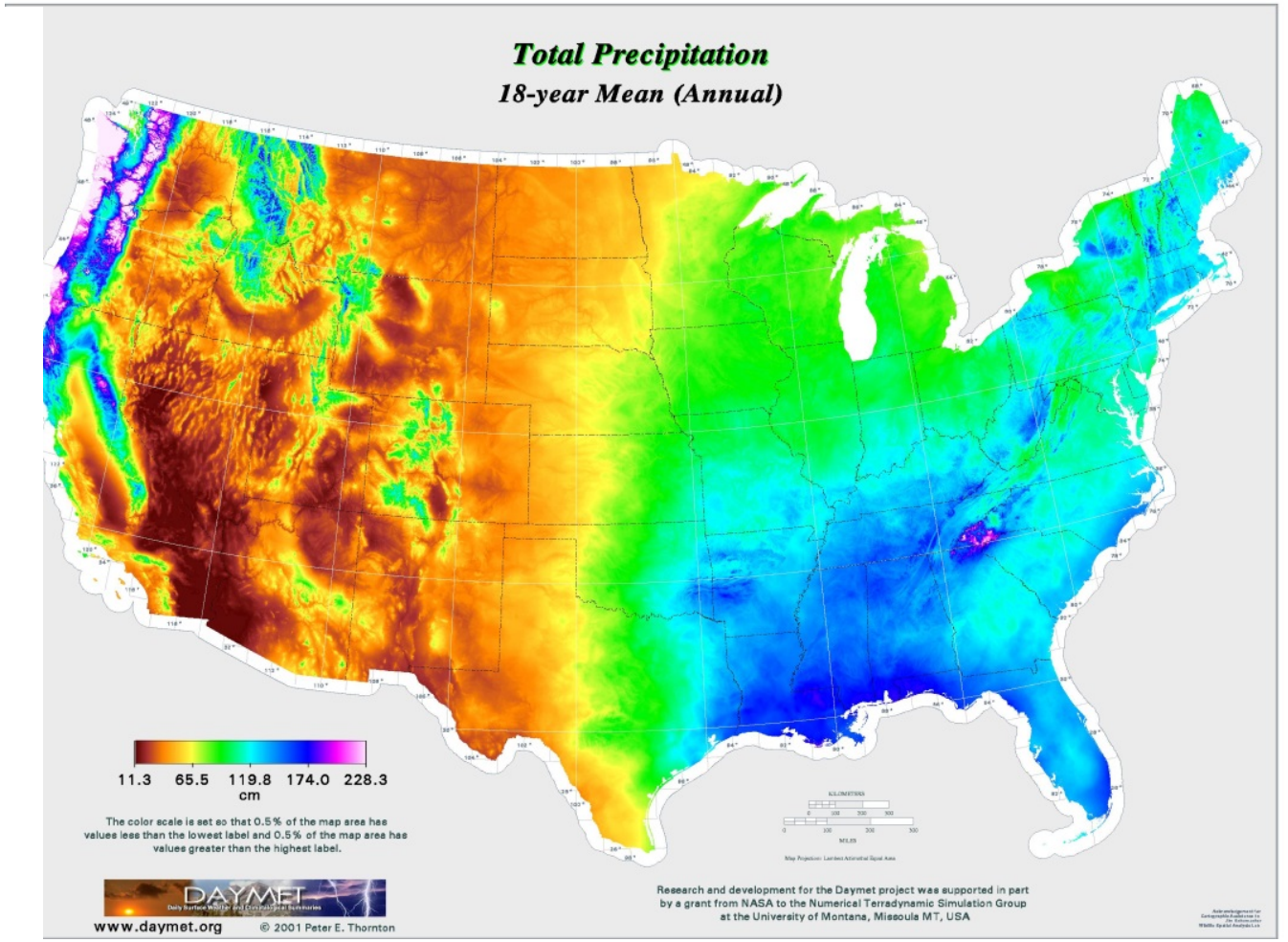
② **The remaining water, now saltier and denser, sinks to the ocean bottom.**

③ **The cold water travels along the ocean floor, connecting the world's oceans.**

④ **The cold, deep water eventually rises to the surface and circulates back to the North Atlantic.**

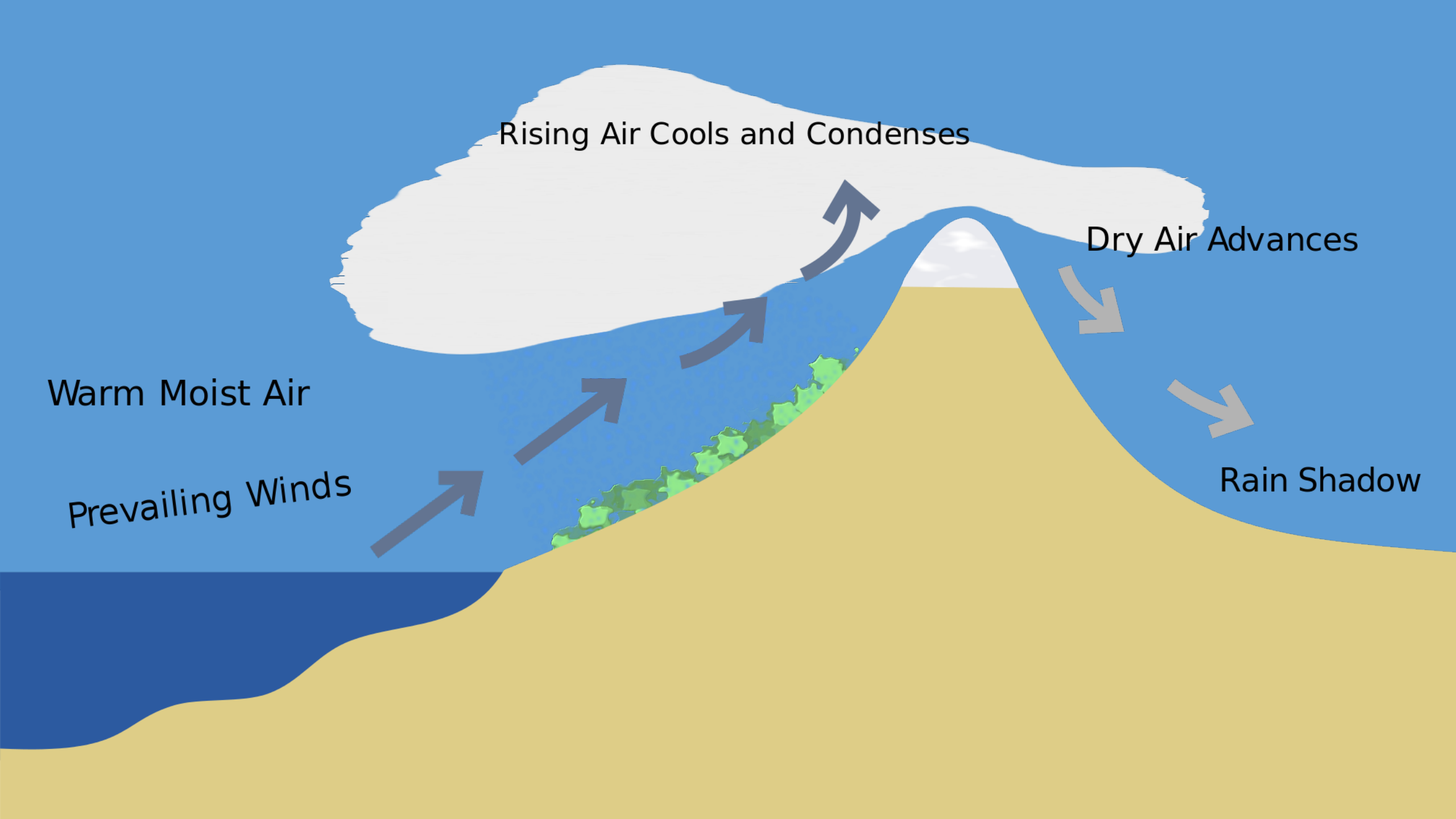

Tropical
Dry climates
Moist subtropical mid-latitude climates
Moist continental mid-latitude climates
Polar climates
60° N
30° N
Equator
30° S
60° S





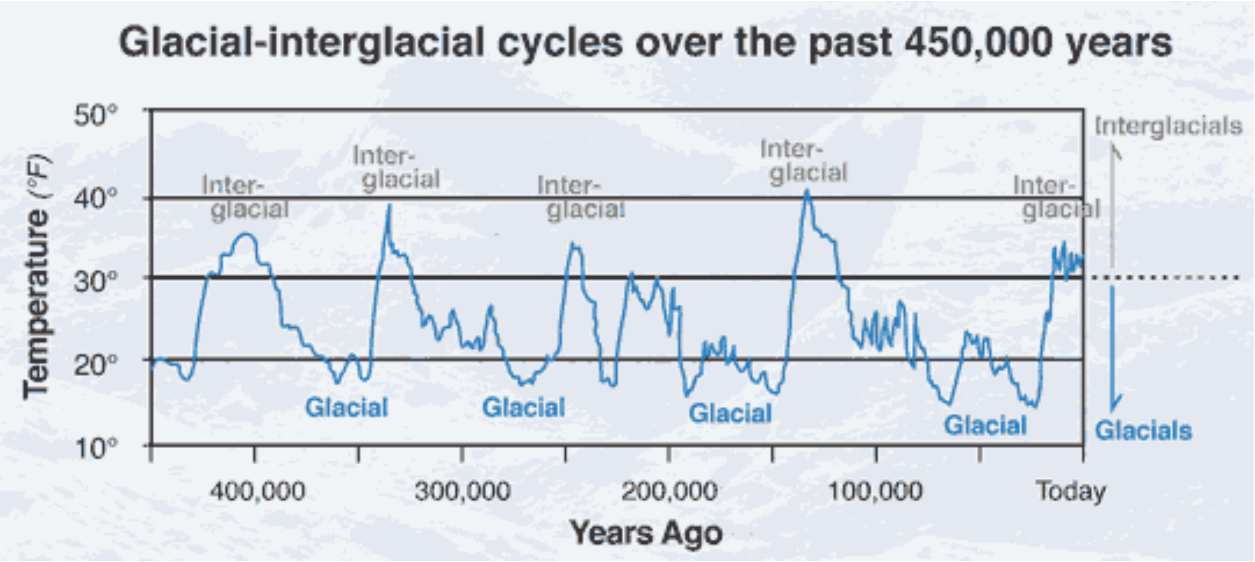
Expected

Expected?


Rising Air Cools and Condenses
Dry Air Advances
Warm Moist Air
Prevailing Winds
Rain Shadow

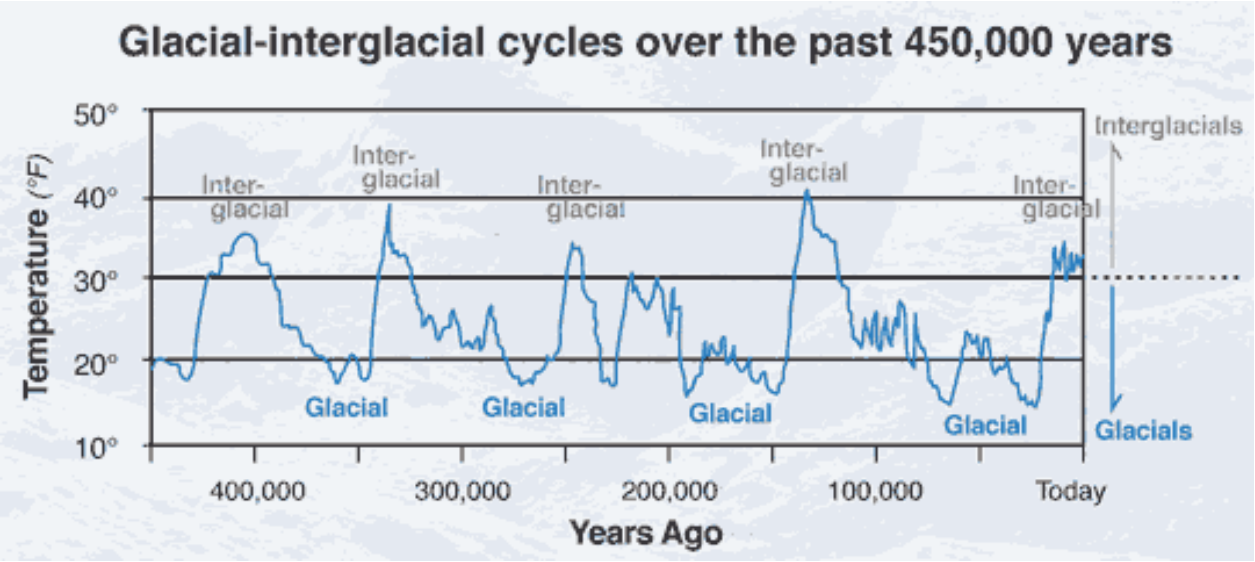
Has the climate changed?

Has the climate changed?



https://geology.utah.gov/map-pub/survey-notes/glad-you-asked/ice-ages-what-are-they-and-what-causes-them/

Has the climate changed?



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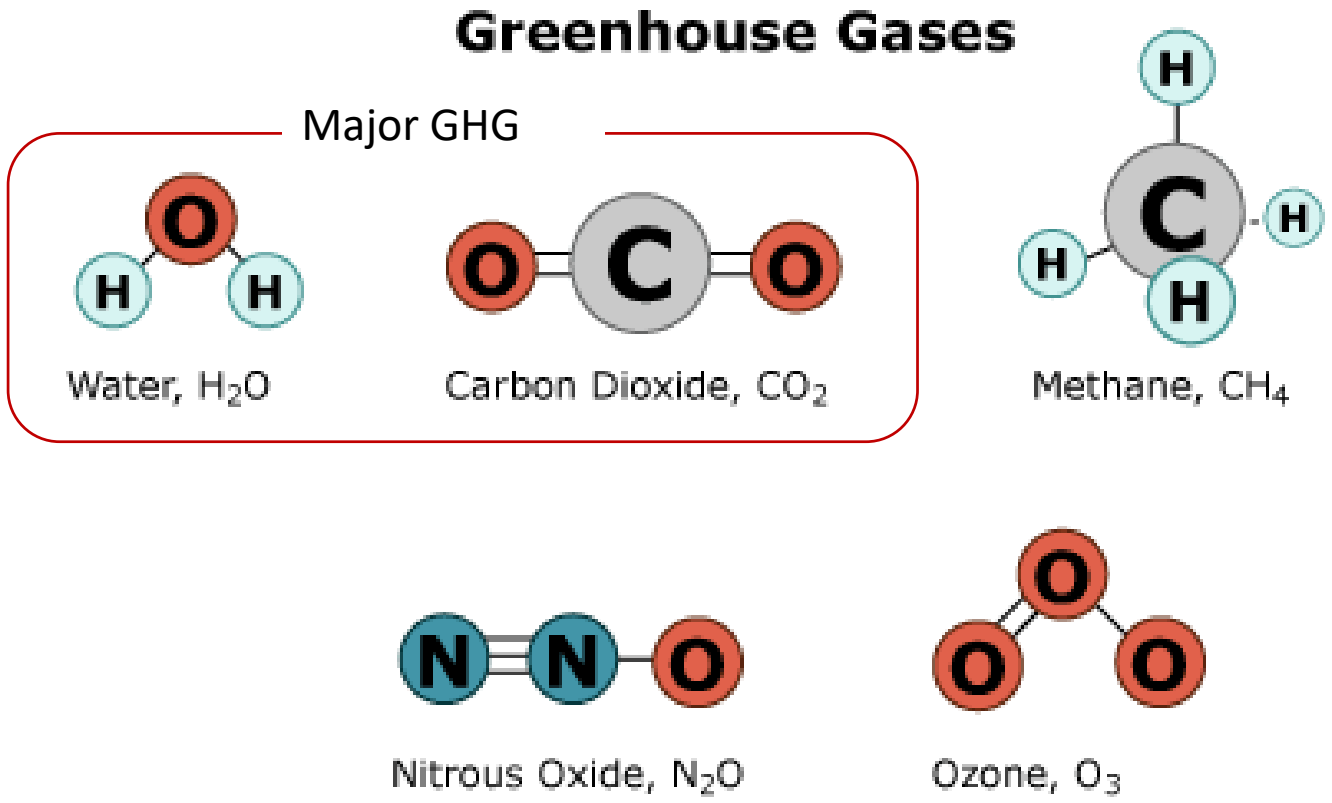
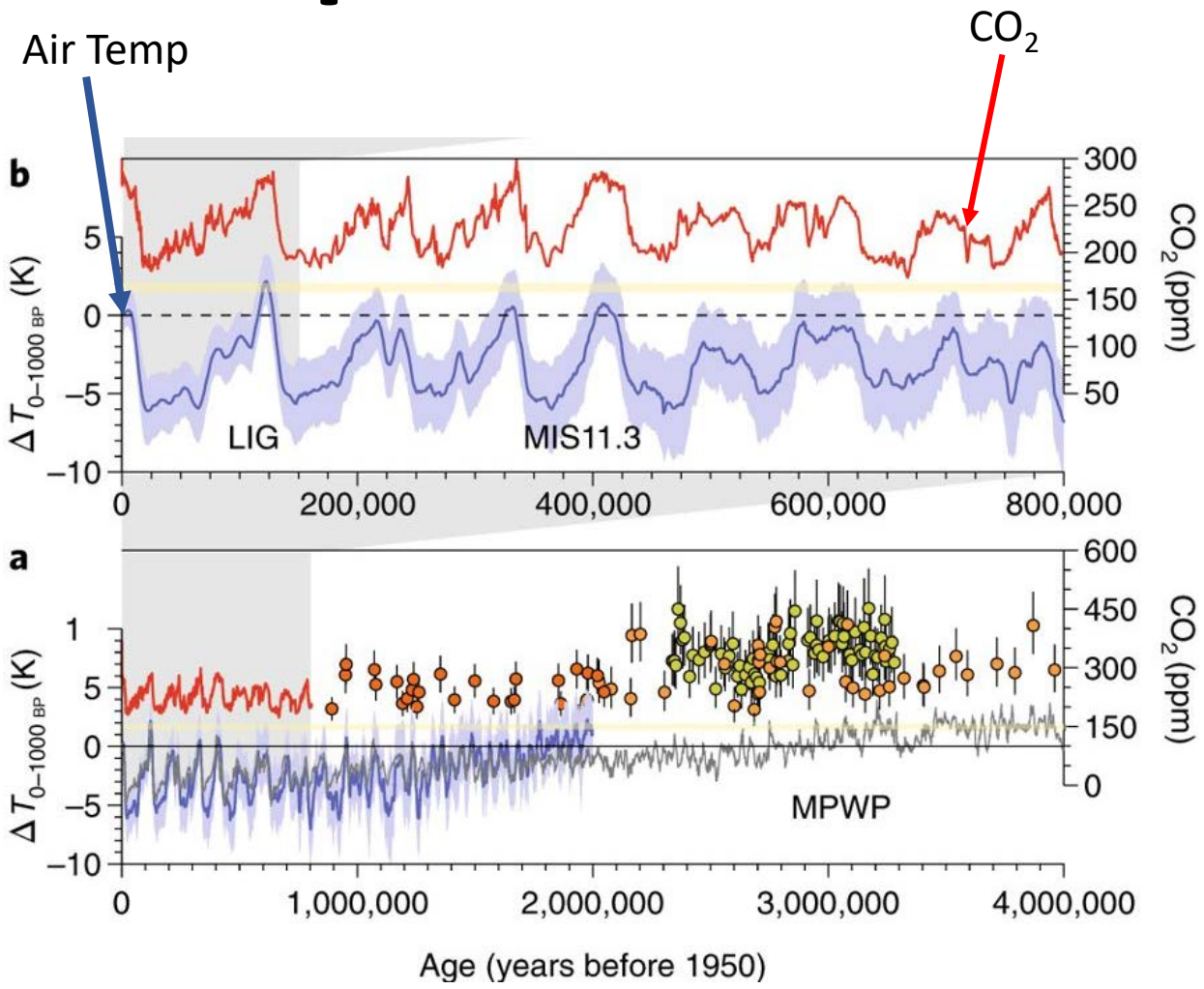
Drivers:

- Movement of continents changing ocean and air circulation patterns
- Volcanos
- Distance from the sun
- Solar output
- Atmosphere composition

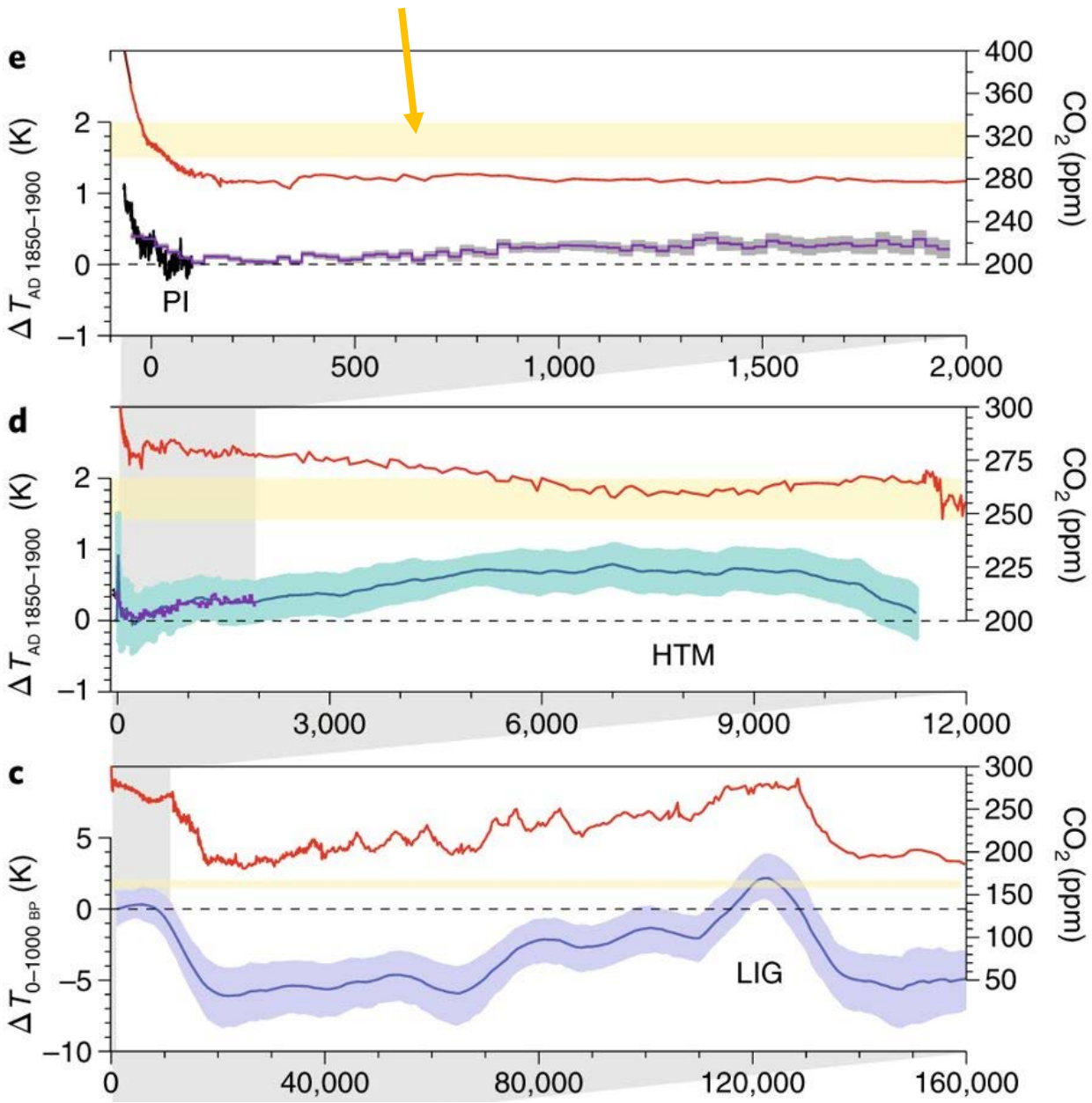
What is driving current climate change?



Temperature



Paris agreement warming target



Fischer et al 2018
https://www.nature.com/articles/s41561-018-0146-0

How has climate changed in human history?

- https://xkcd.com/1732/

Expected outcomes

Fischer et al 2018
https://www.nature.com/articles/s41561-018-0146-0

HTM: Holocene Thermal Maximum (8 kya)
LIG: Last Interglacial (120 kya)
MPWP: Mid Pliocene Warm Period (3 bya)