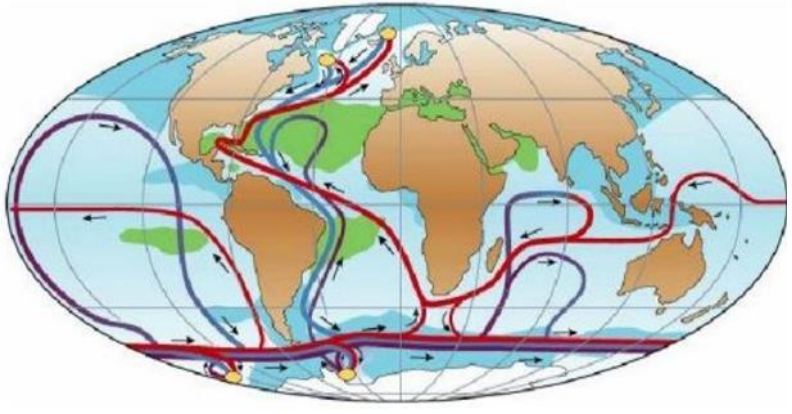
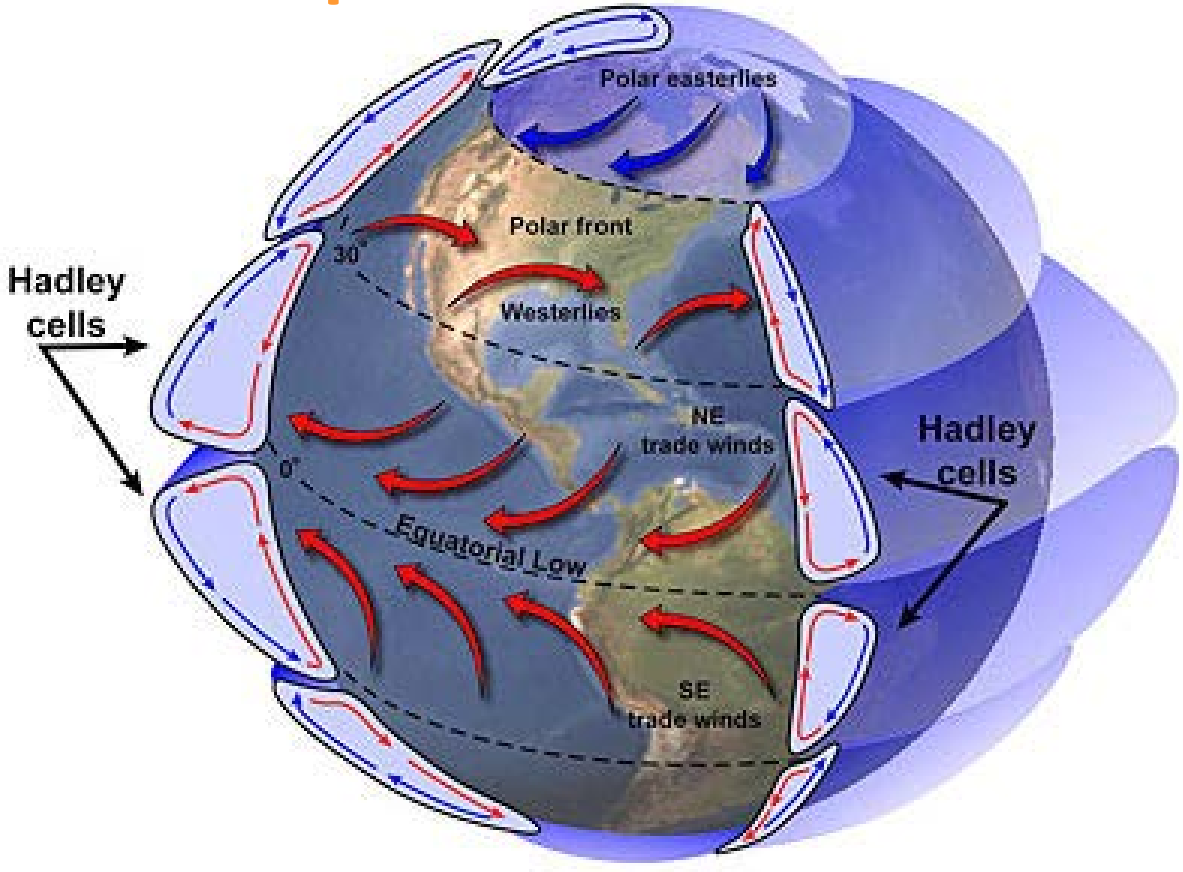
II - Climate shapes live on earth

1. Circulation cells and precipitation
2. The Ocean Land Exchange
3. Where do the Seasons come from?
4. Seasonal Land-Ocean variability
5. Wind effects on Ocean flows
6. Energy transport in the Oceans by conveyer belts



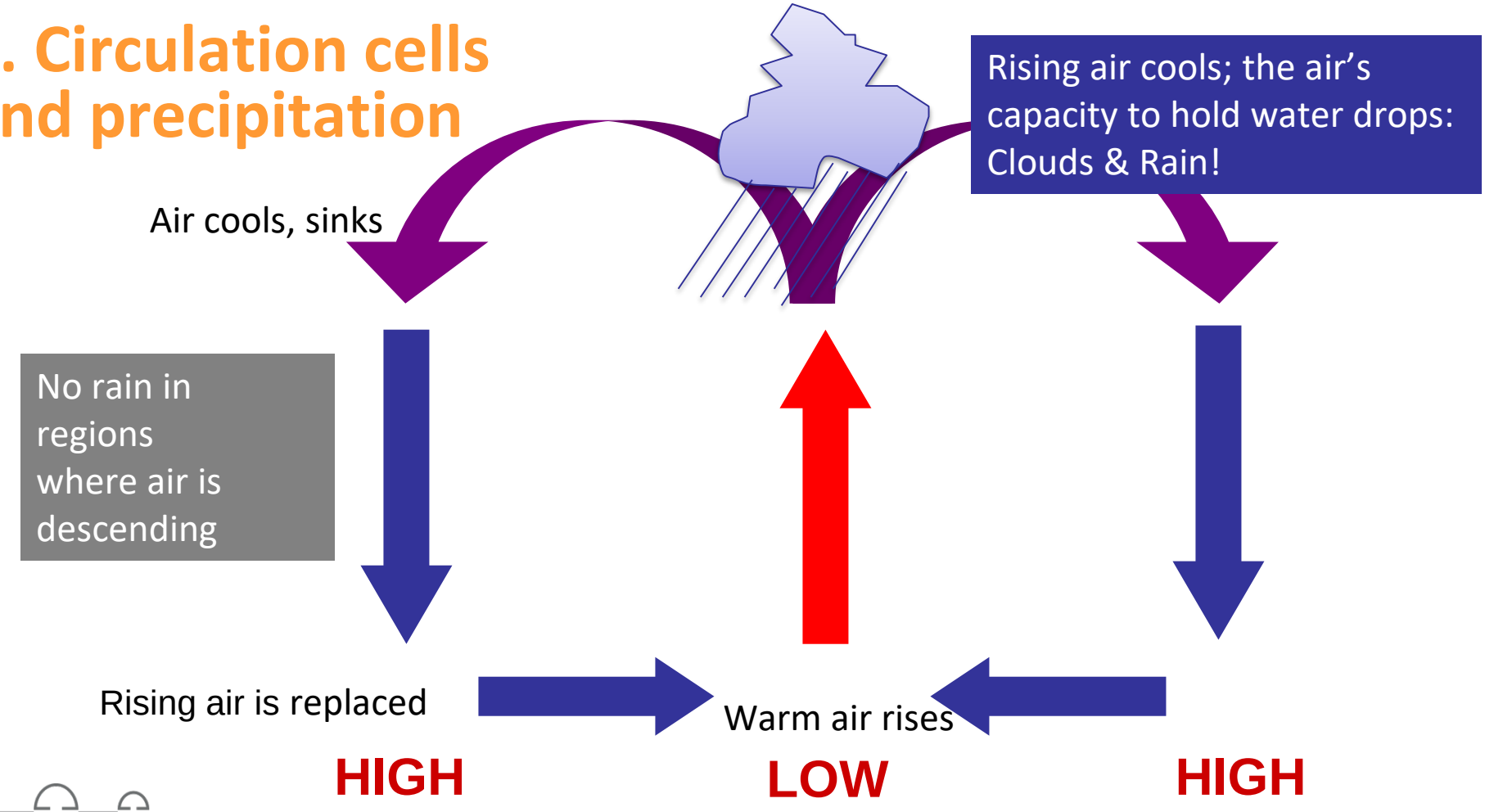
hattermann@pik-potsdam.de

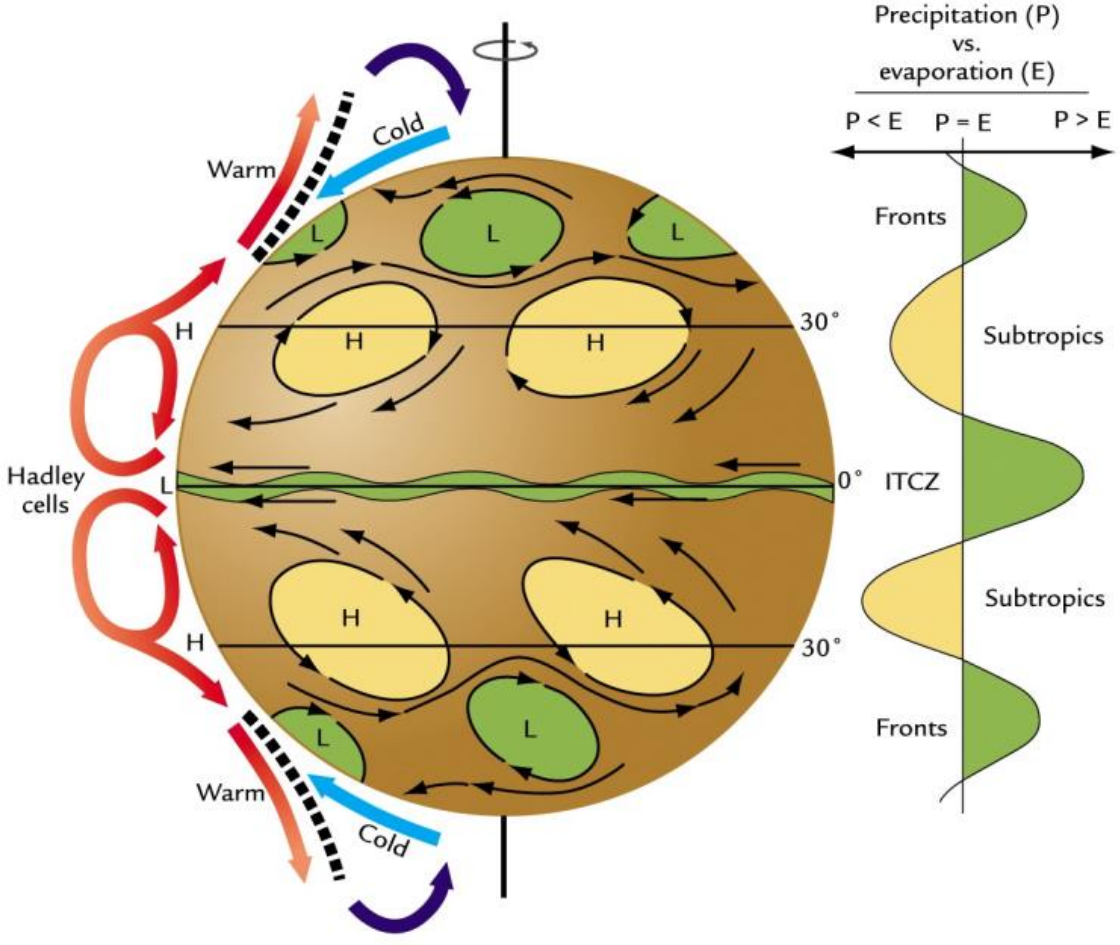
Global Atmospheric Flux and Ciculation Cells

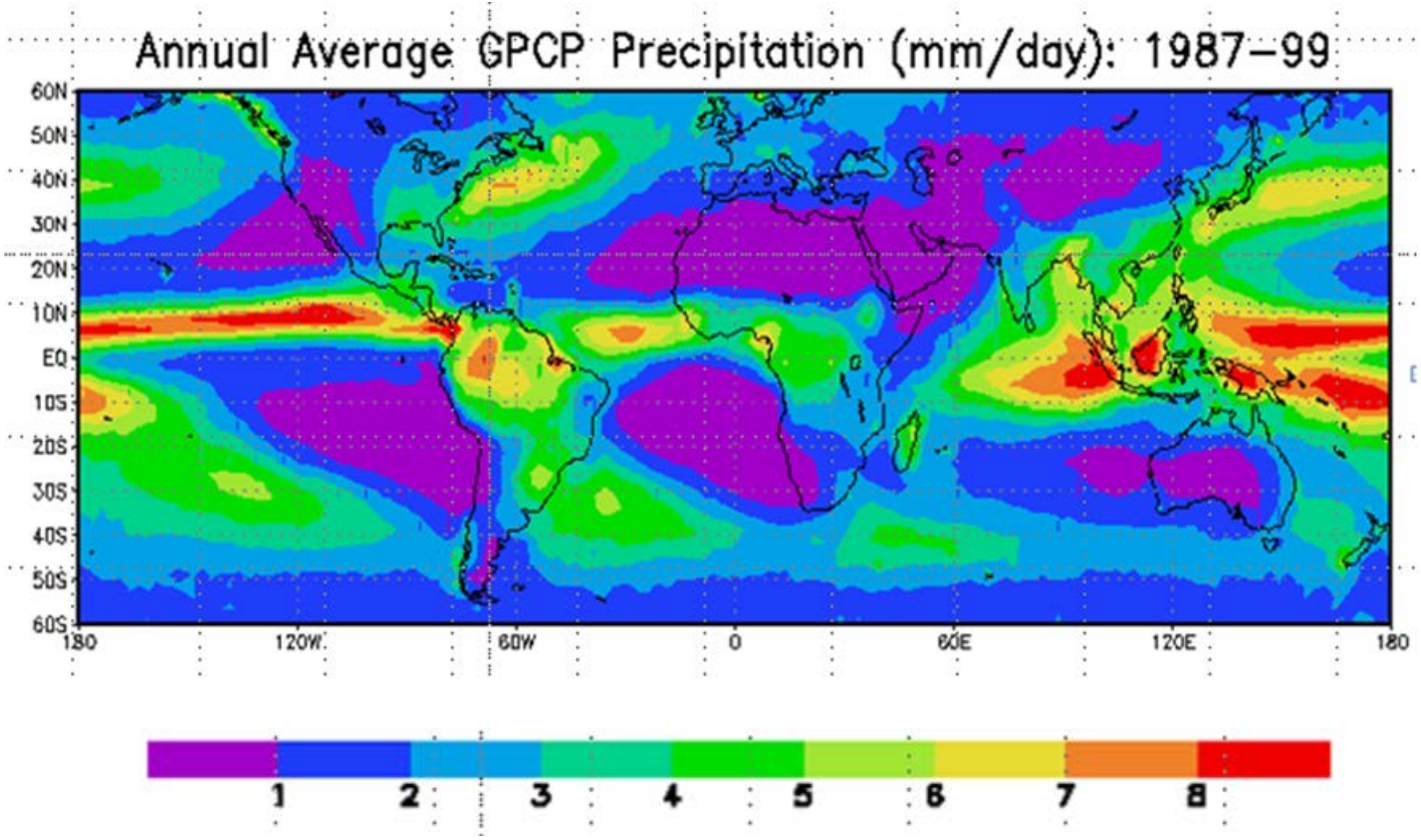


Credit: NASA

1. Circulation cells and precipitation

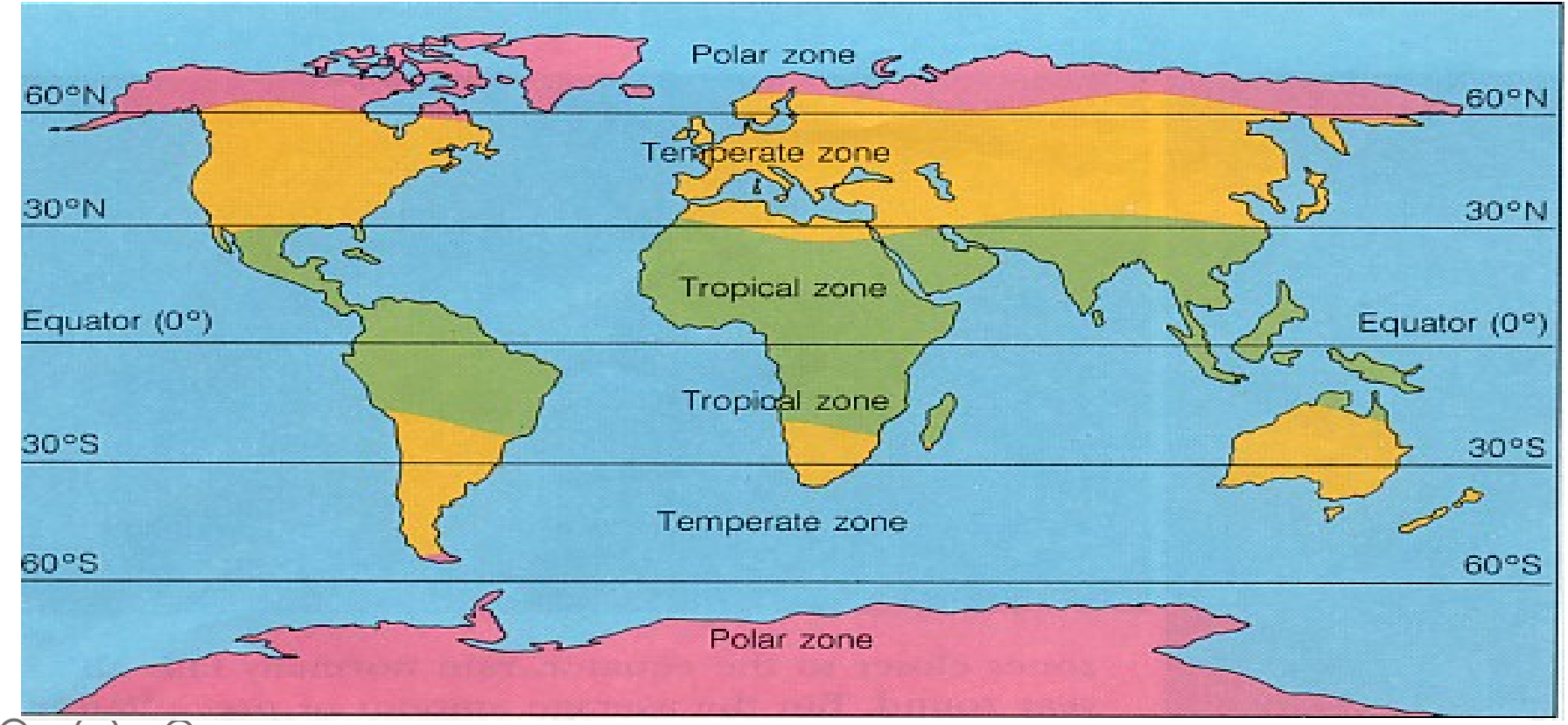



Warm
Cold
L
L
L
H
H
H
30°
Hadley cells
L
0°
ITCZ
H
H
H
30°
L
L
Warm
Cold
Precipitation (P) vs. evaporation (E)
P < E
P = E
P > E
Fronts
Subtropics
Subtropics
Fronts



http://www.nesdis.noaa.gov/EnvironmentalData.html

-> Earth's Climate Zones (rough picture)



The Ocean Land Exchange in the Climate System

Caution:

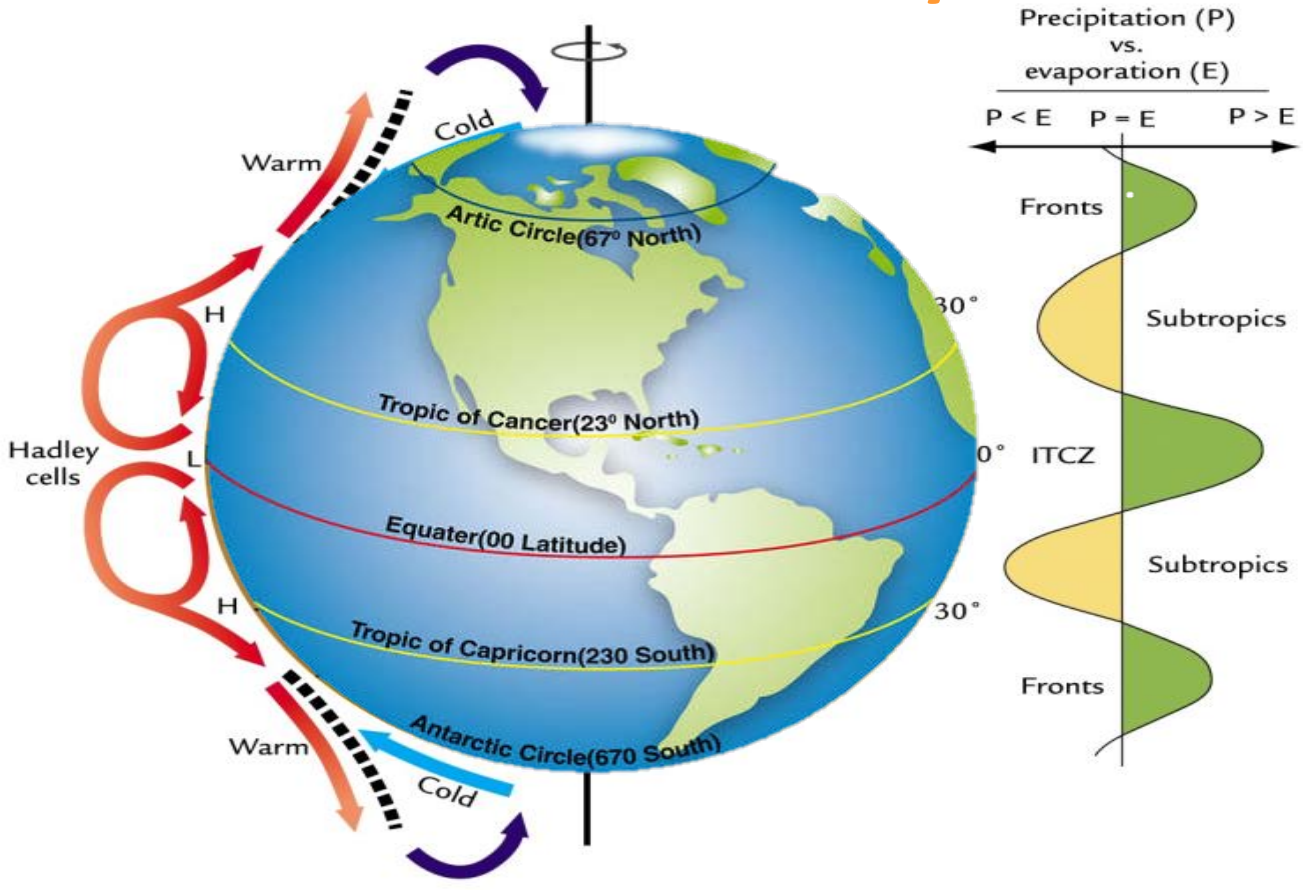
Zonal weather pattern is not completely true.

The pattern is disrupted by land-sea contrasts

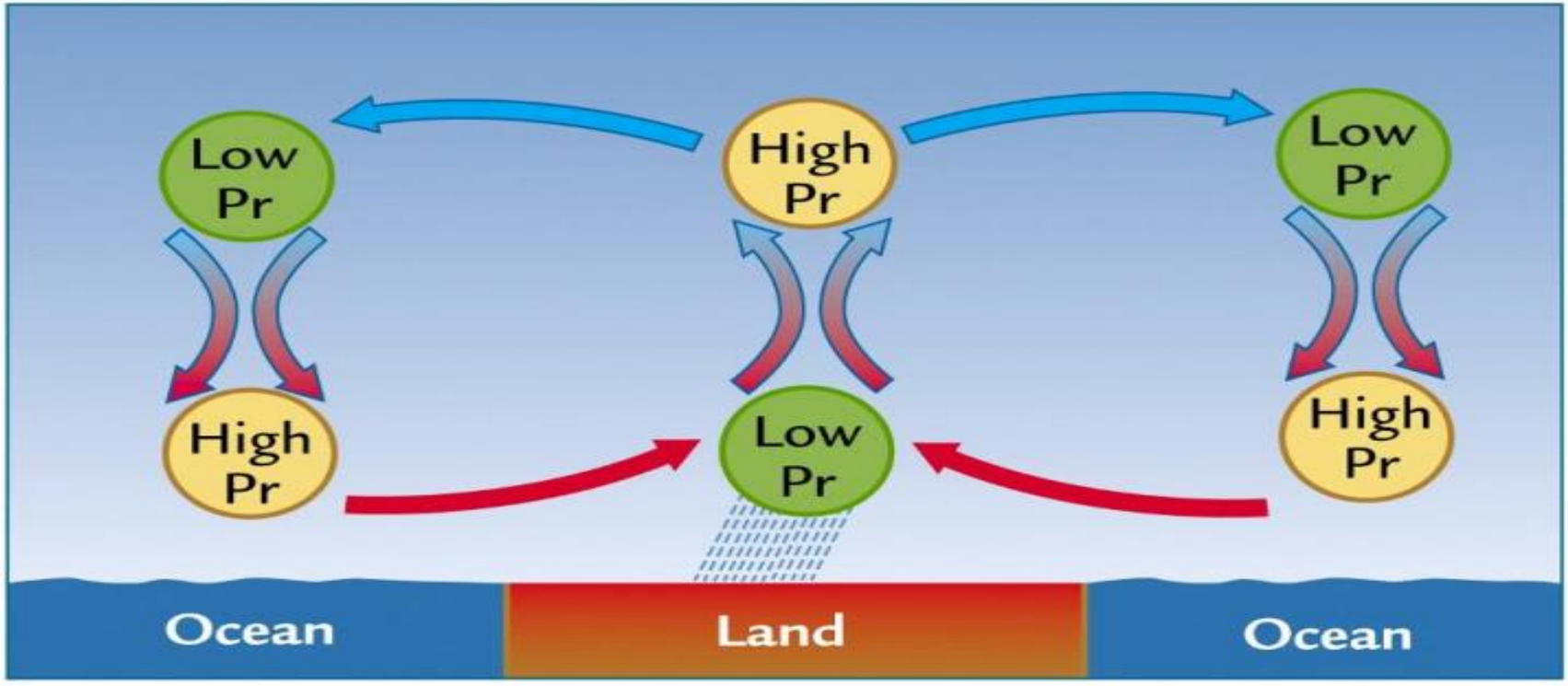
Land heats and cools rapidly

Water heats and cools slowly

2/3 of Earth‘s surface is covered by Oceans



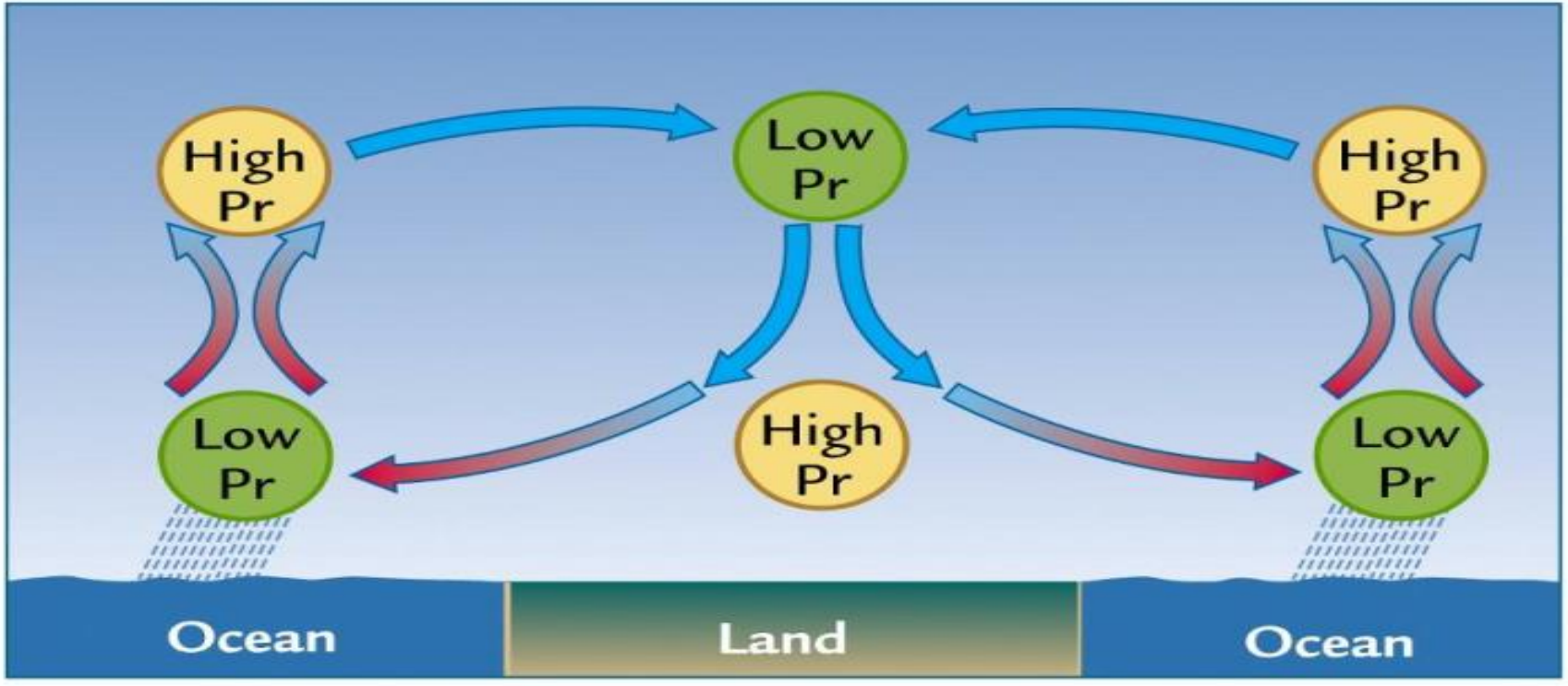
A: Seasonal Land-Ocean Variability in Summer



A

Summer

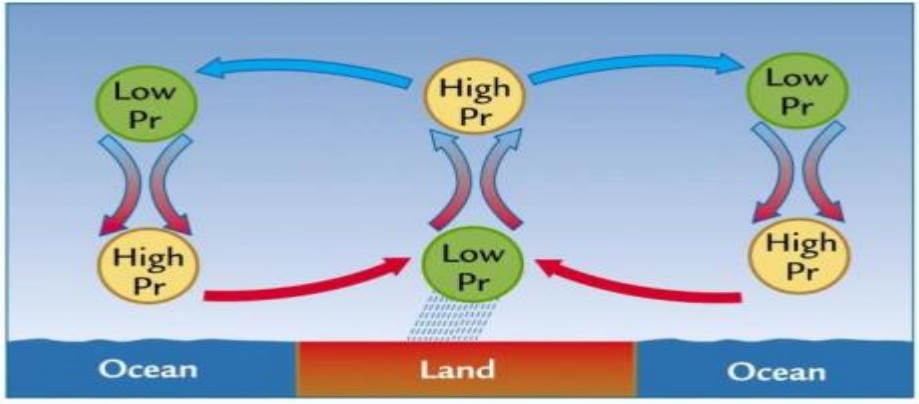
B: Seasonal Land-Ocean Variability in Winter



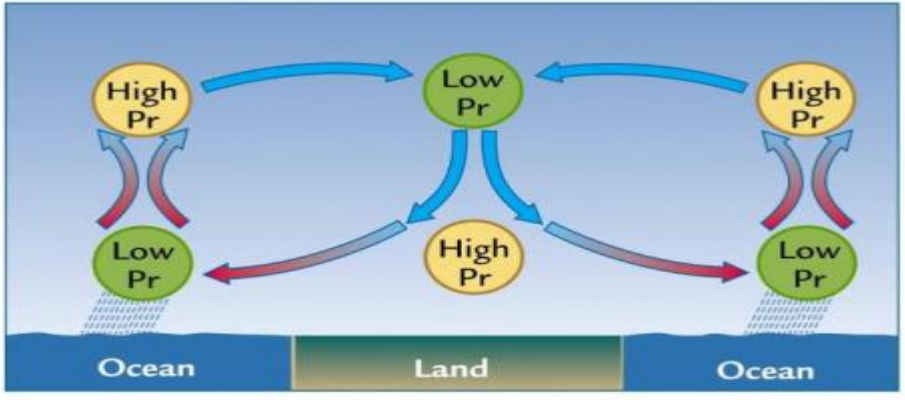
B

Winter

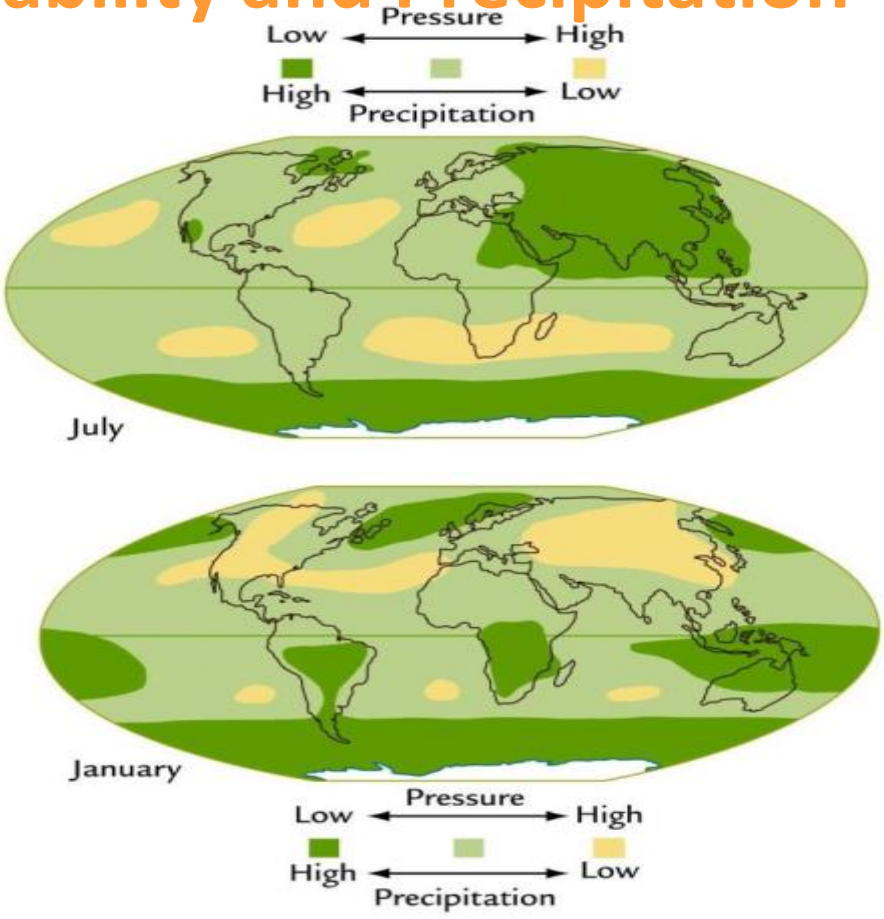
4. Seasonal Land-Ocean Variability and Precipitation



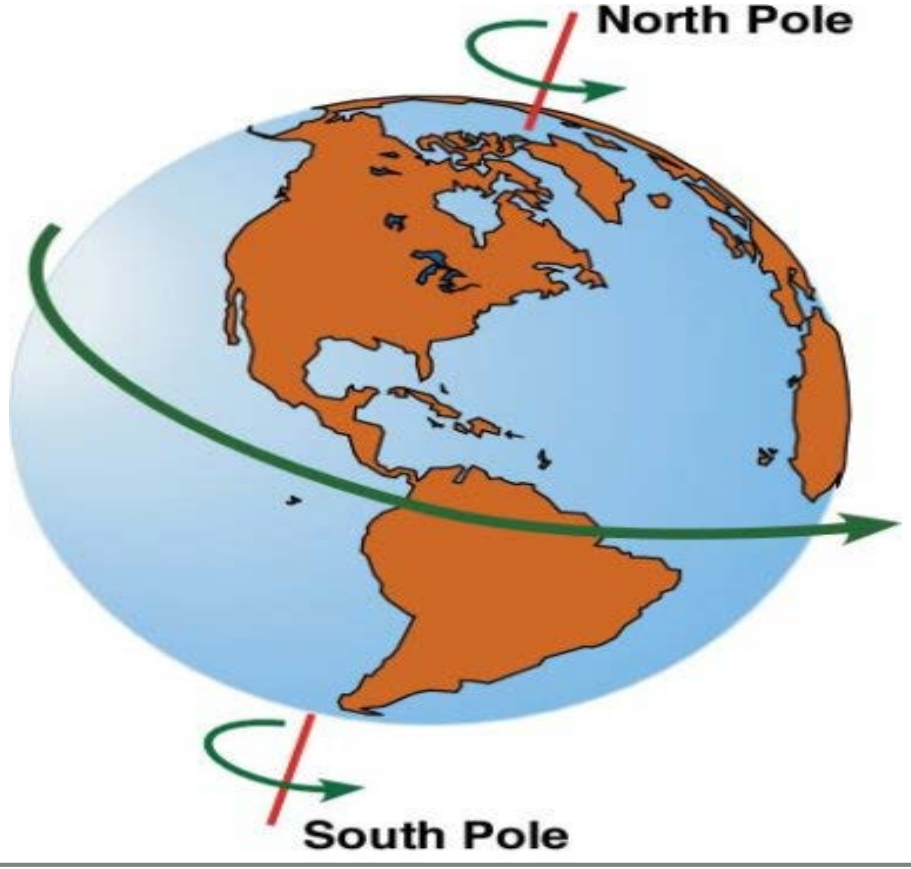
A Summer



B Winter

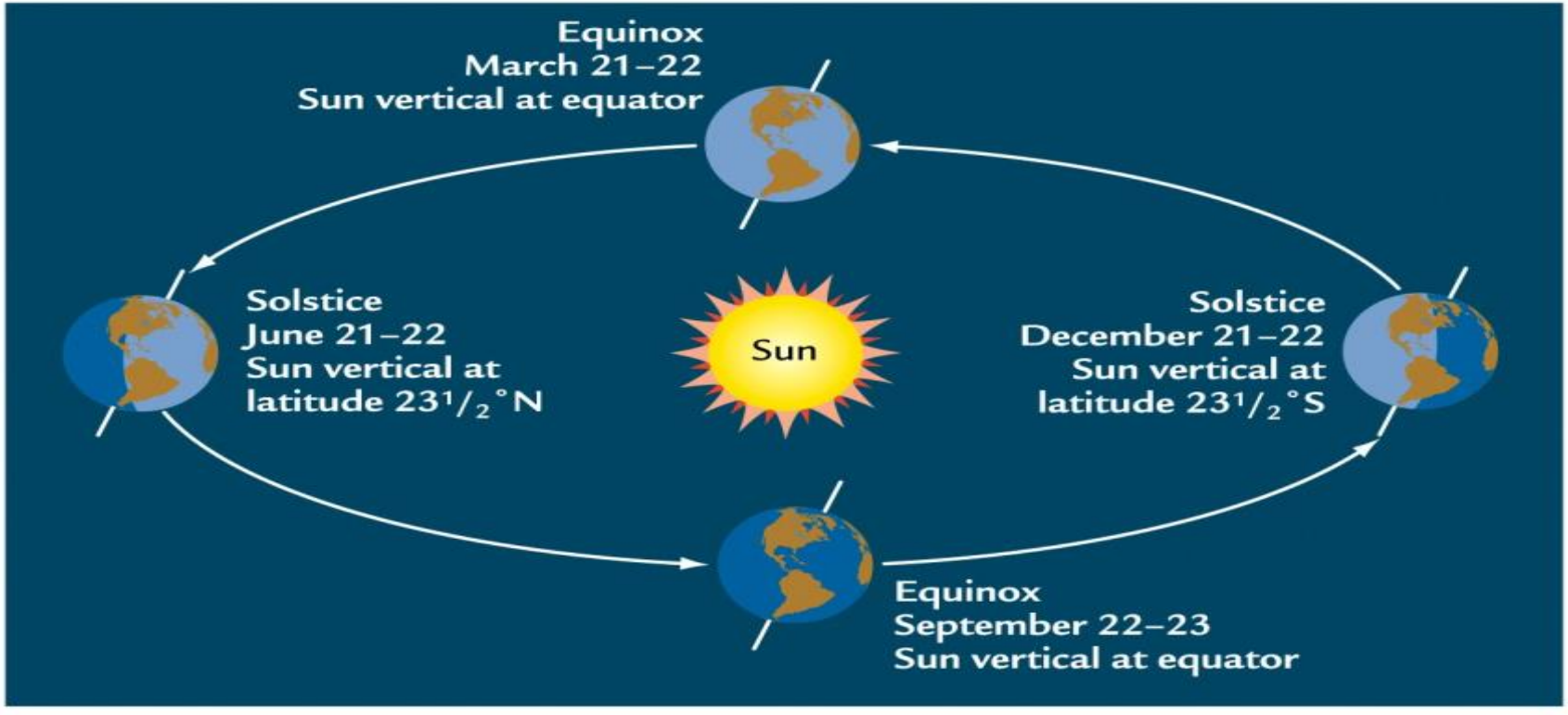


3. Where do the Seasons come from?

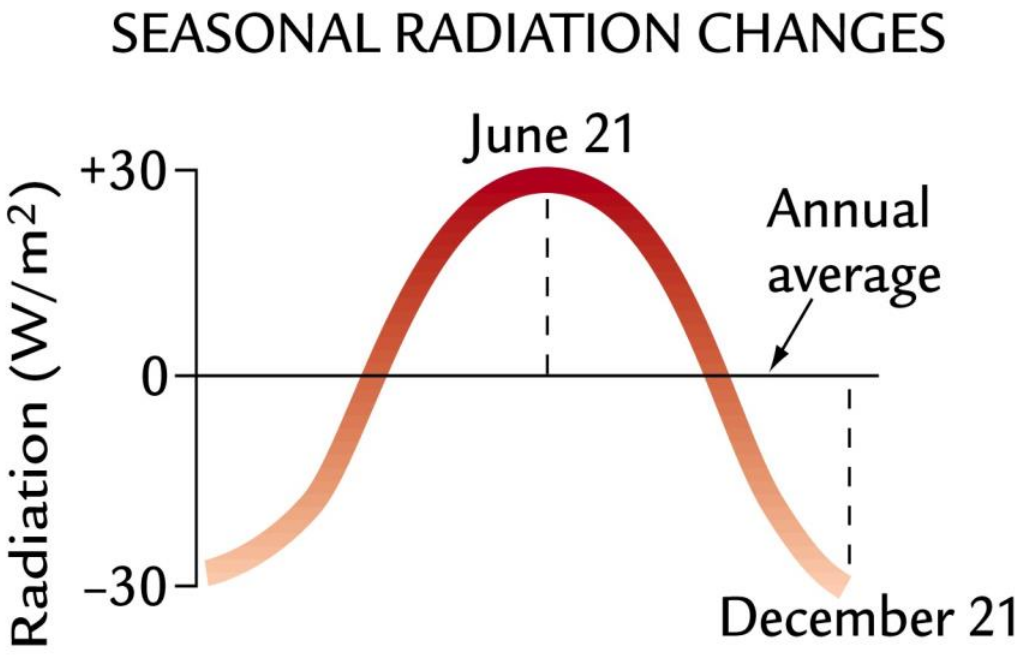


Earth's rotational plane is tilted with respect to its orbit by 23.5 °

Where do the Seasons come from?



Seasonal Radiation (Northern Hemisphere)



Top Solar Radiation in the Northern Winter

North Winter: [Dec/Jan/Feb]

Solar energy is concentrated near the equator

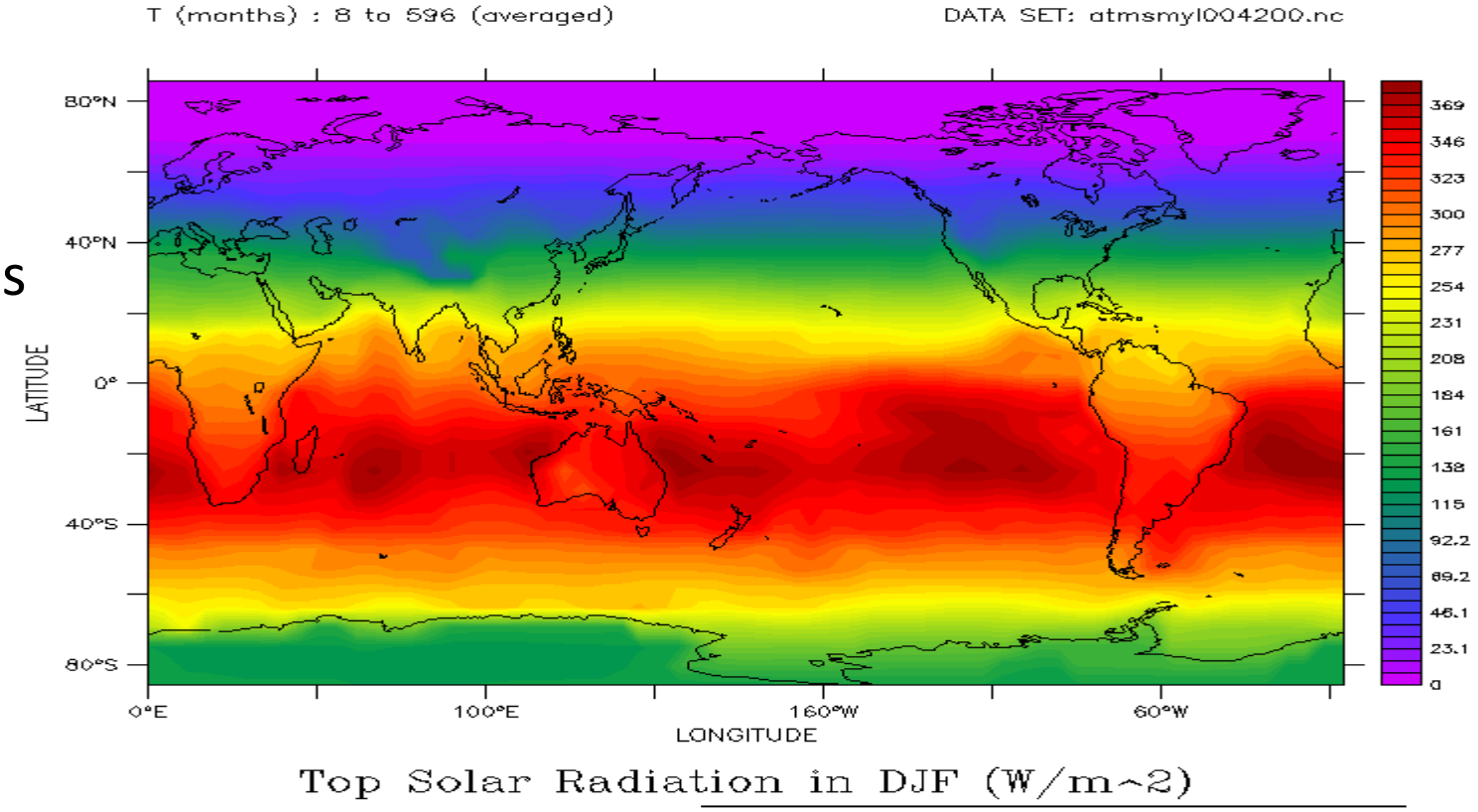
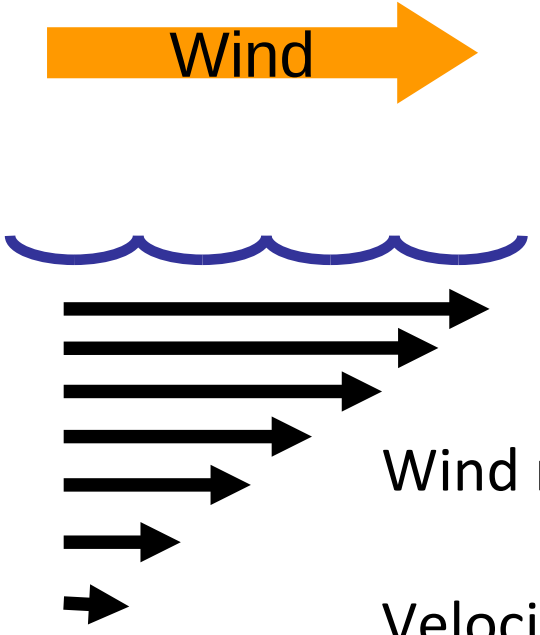


Image: Netherlands Center for Climate Research

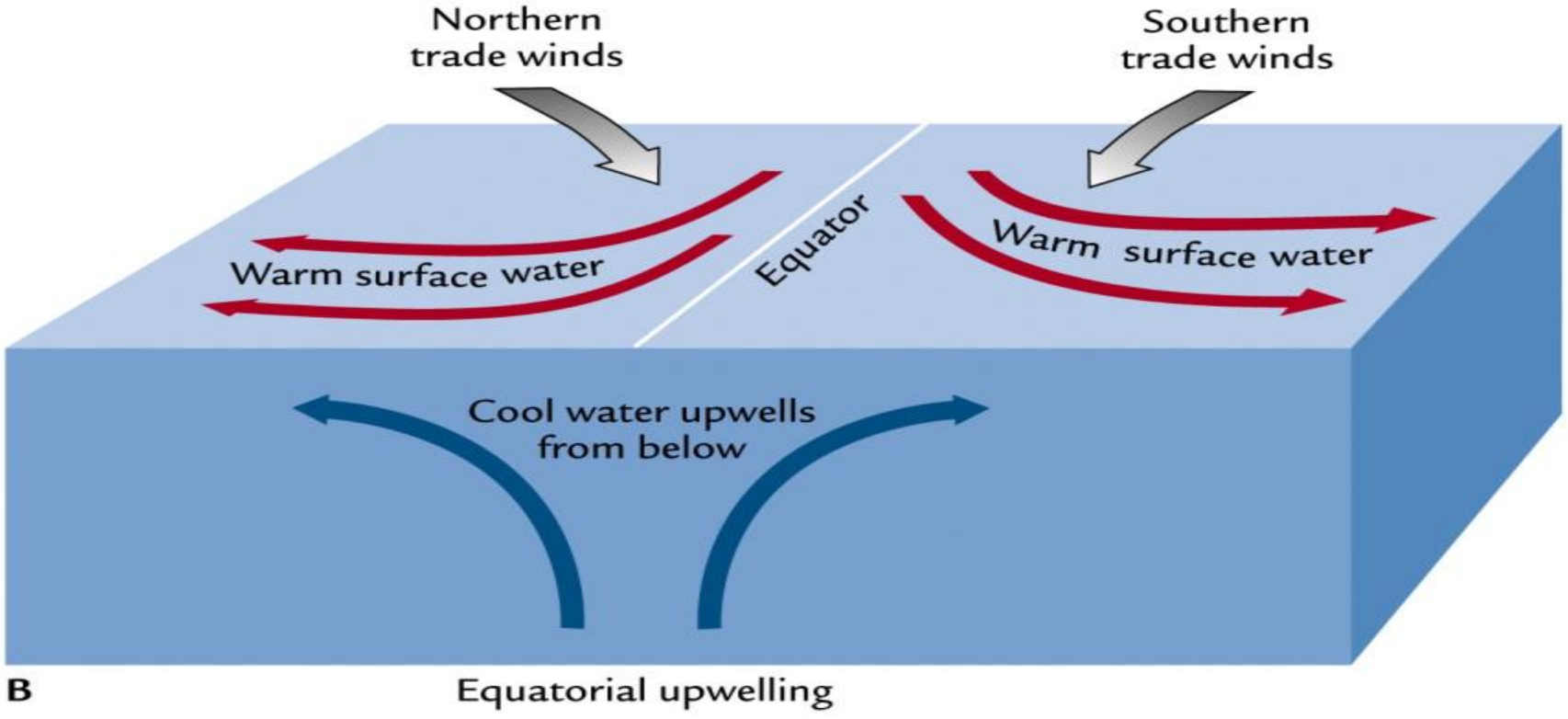
5. Wind Effects on Oceans



Wind moves surface water

Velocity of water decreases with depth

Coupling between Wind and Ocean Flow (B)

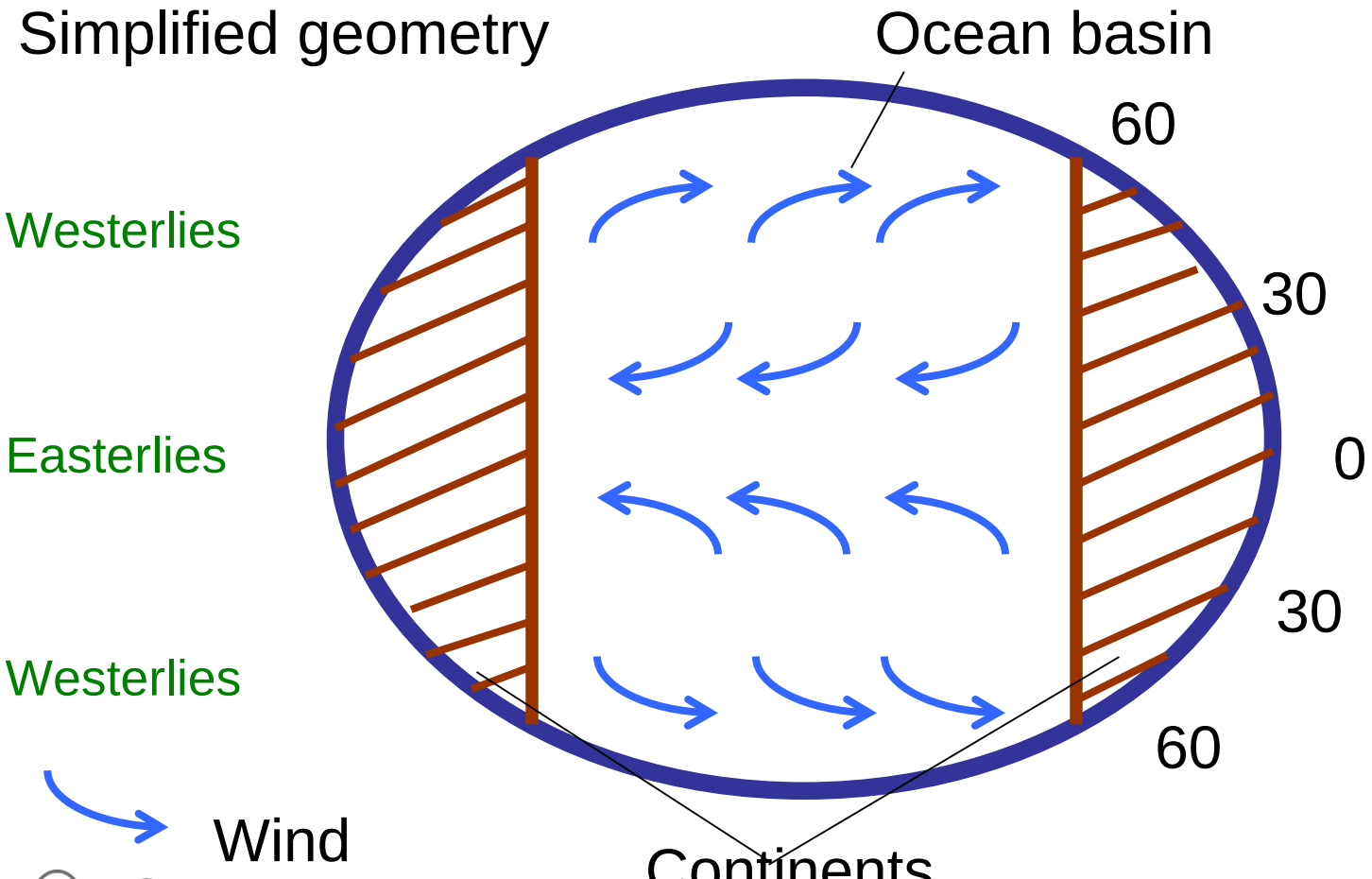


Consequences of upwelling

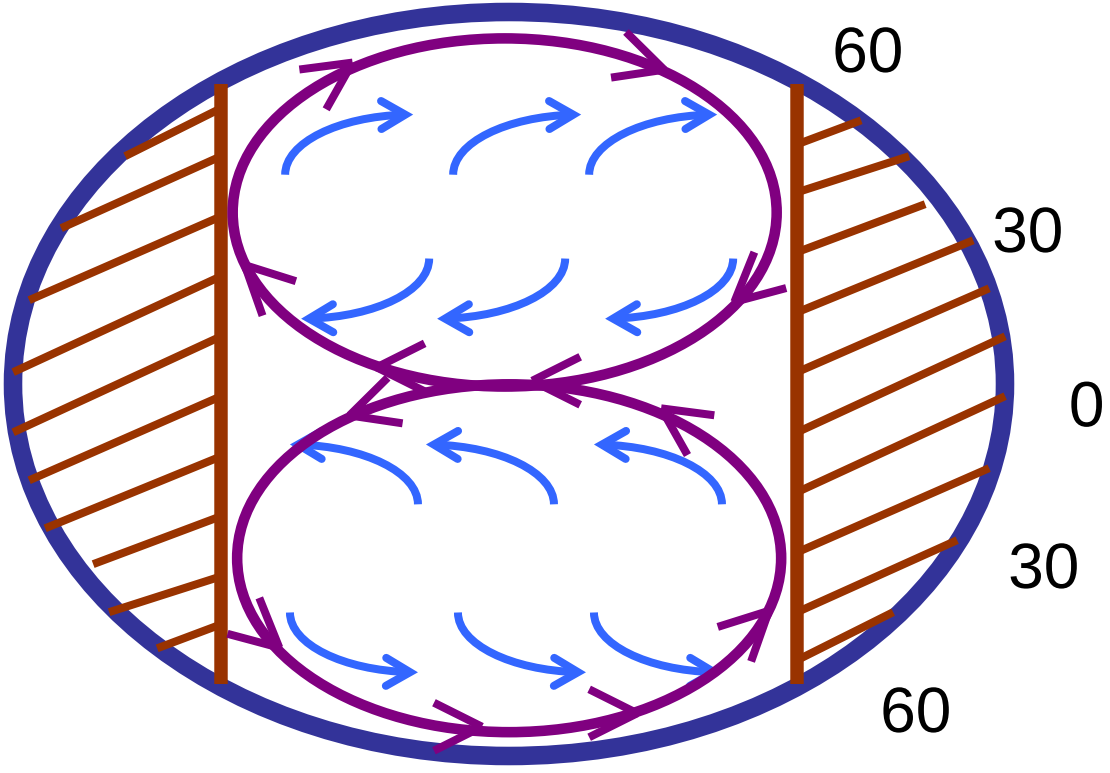
- Deep water is rich in nutrients (P, N, Fe)
- Upwelling brings nutrient-rich water to the surface ocean, fueling biological productivity (phytoplankton)
- Zooplankton eat the phytoplankton
- Fish eat both of these -> good fisheries in upwelling zones

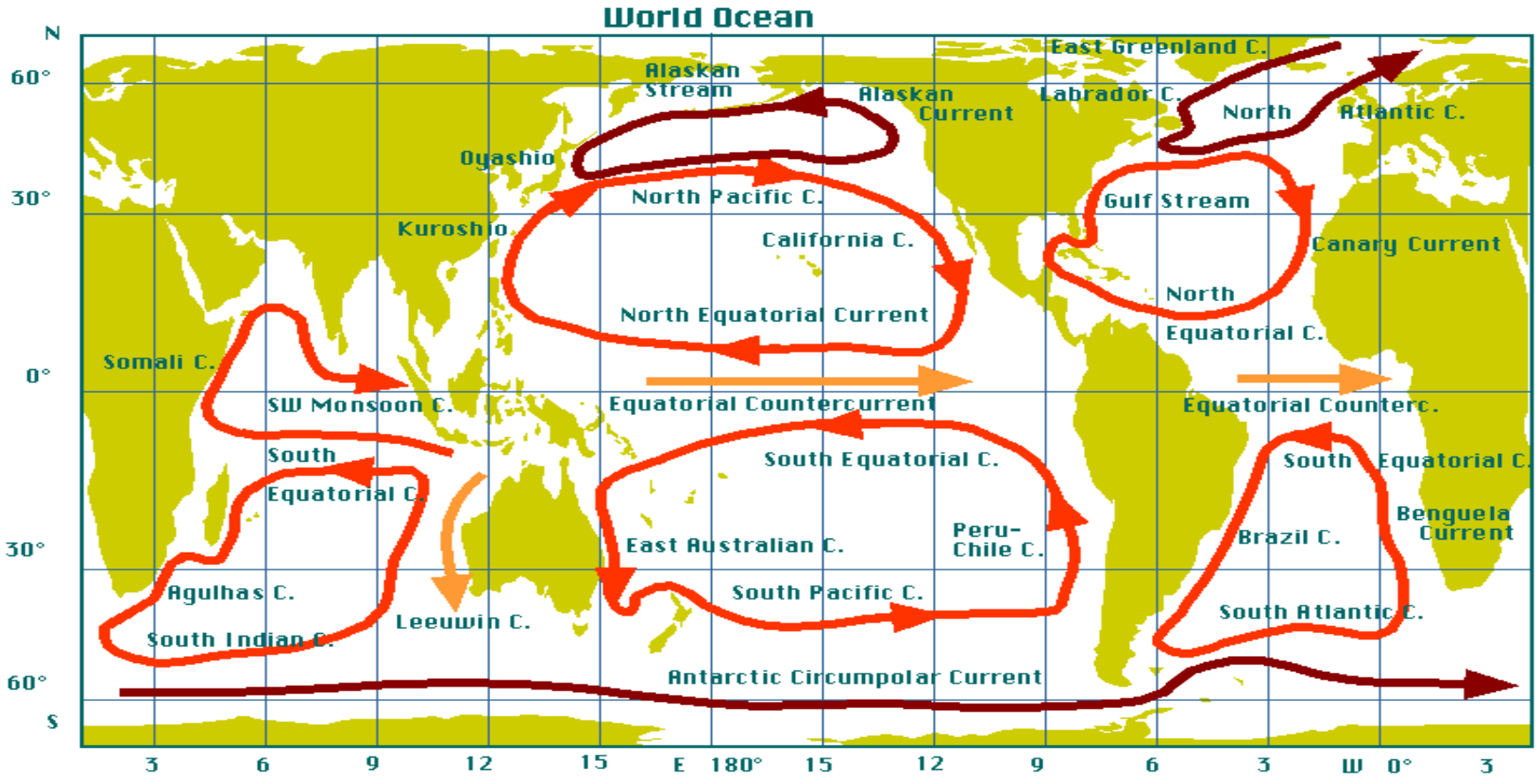
Winds also cause large gyres (circular patterns) in the surface ocean…

Simplified geometry



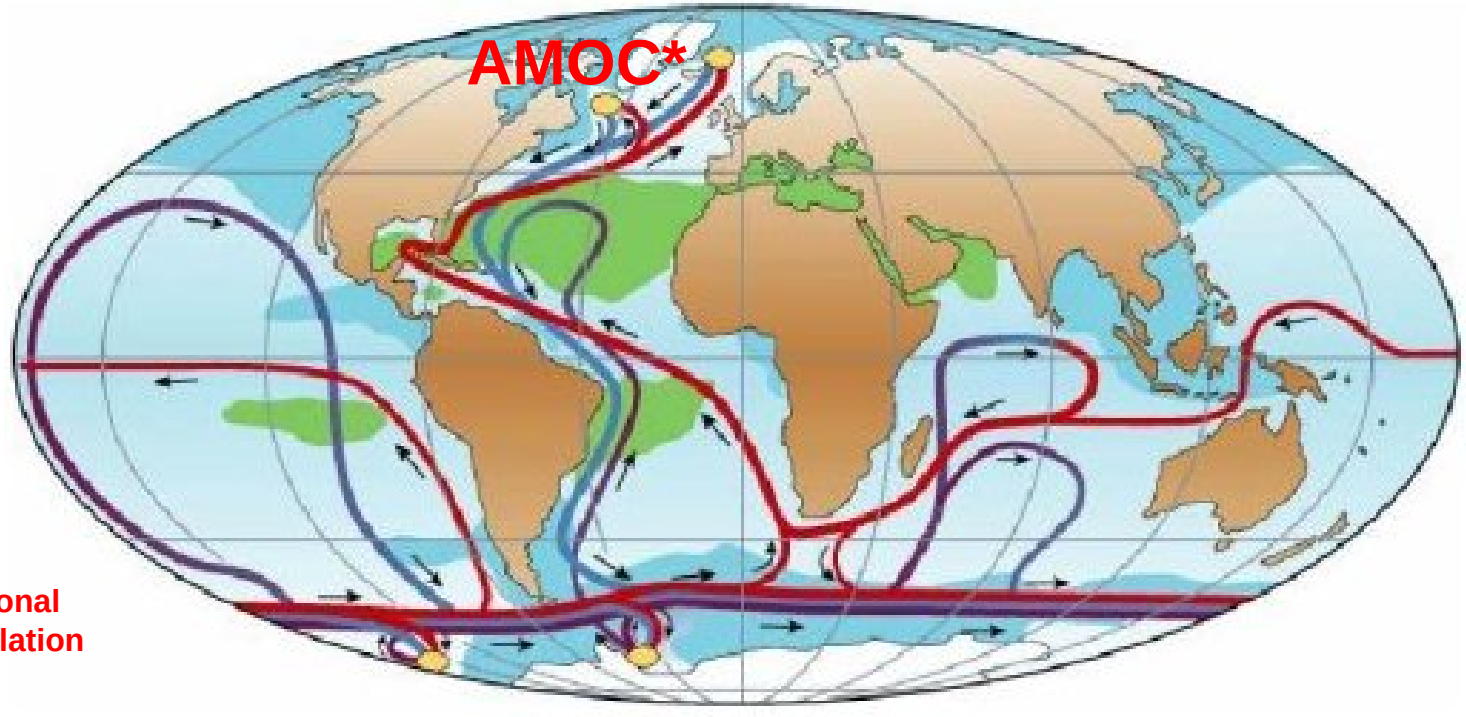
Ocean currents form large GYRES





http://www.es.flinders.edu.au/~mattom/IntroOc/notes/figures/fig2a2.html

6. Energy Transport by Conveyer Belt in the Oceans



*Atlantic meridional overturning circulation (AMOC)

(Rahmstorf, Nature 2002)

Atlantic meridional overturning circulation (AMOC)

- The Atlantic meridional overturning circulation (AMOC) is the zonally integrated component of surface and deep currents in the Atlantic Ocean.
- It is characterized by a northward flow of warm, salty water in the upper layers of the Atlantic, and a southward flow of colder, deep waters that are part of the thermohaline circulation.
- The AMOC is an important component of the Earth's climate system, and is a result of both atmospheric and thermohaline drivers.

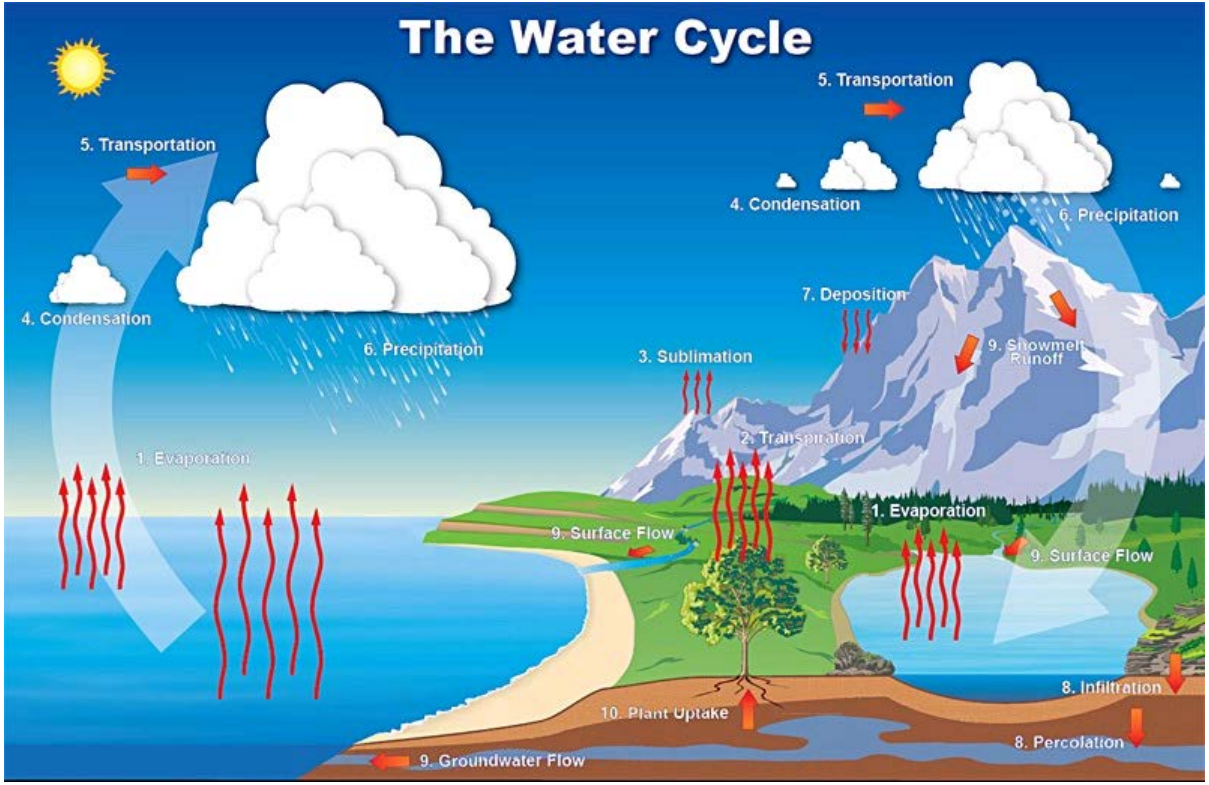
Result: Energy Transport in the Earth System

Solar energy received is greatest near the equator.

Energy is moved from the equator to the poles.

Energy is transferred by wind and ocean currents

Climate and the Water Cycle



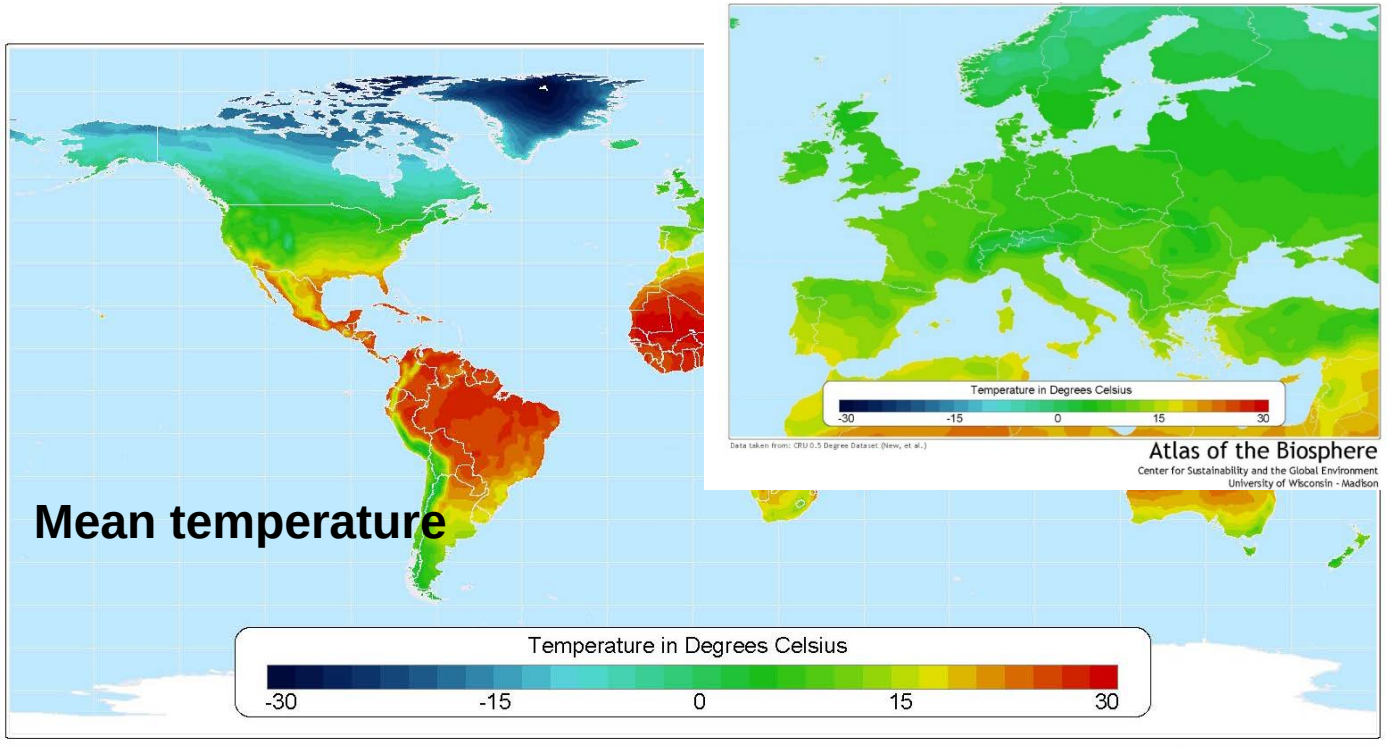
The basic water balance

=

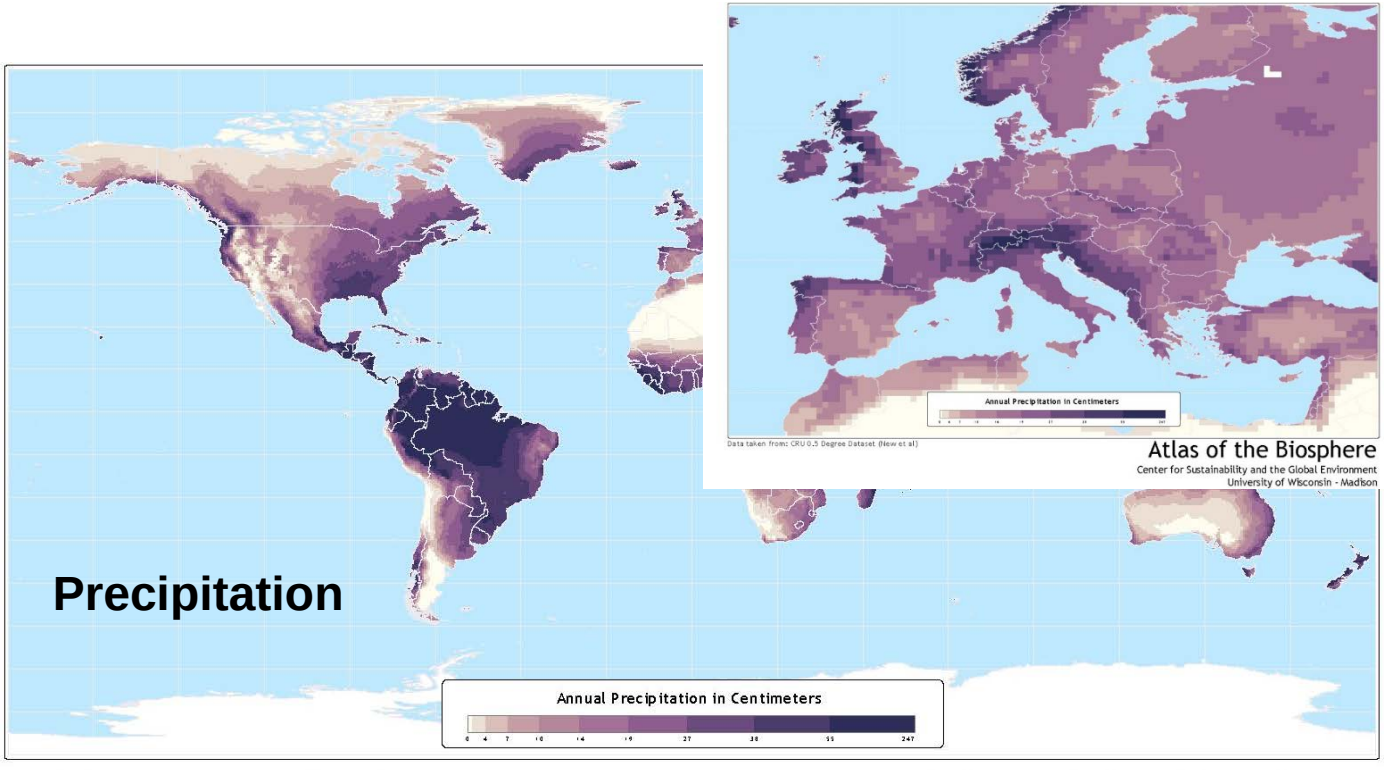
+

+

+/- Storage



Data taken from: CRU 0.5 Degree Dataset (New, et al.)



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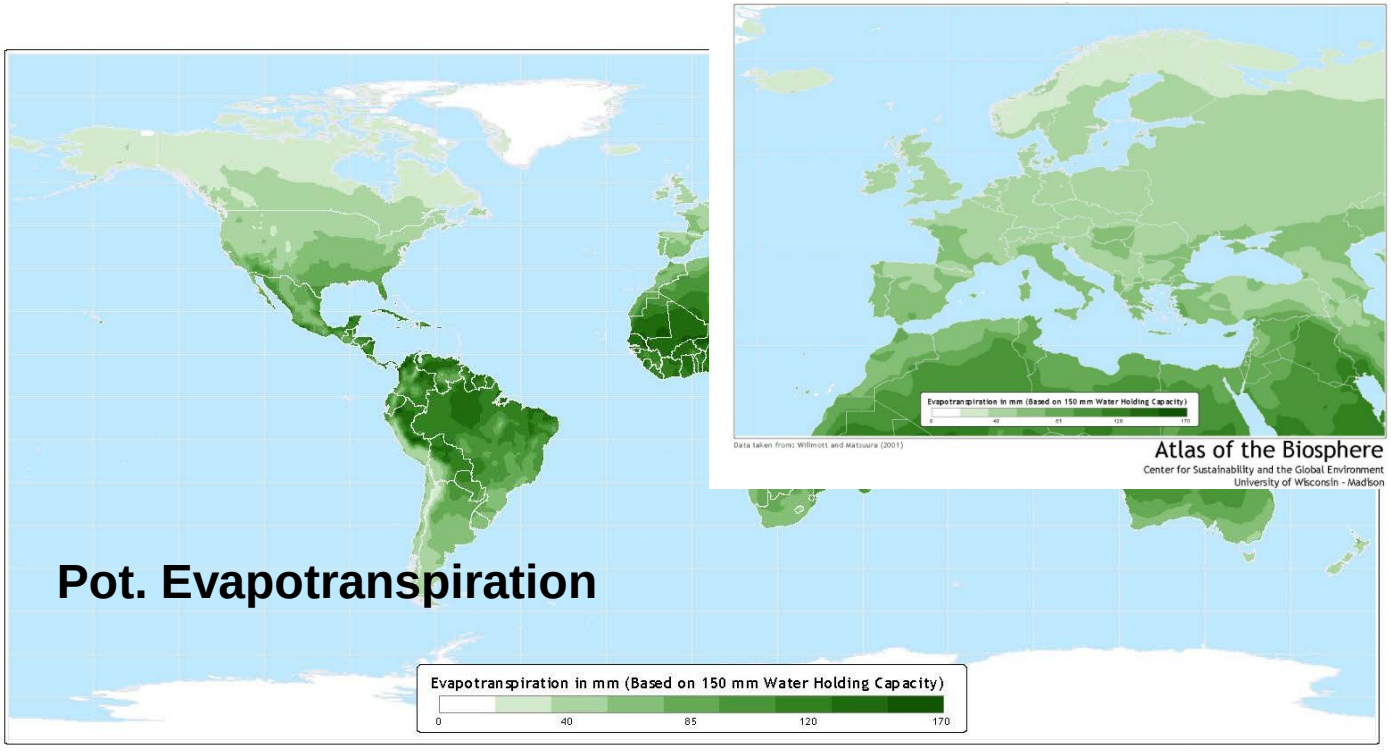
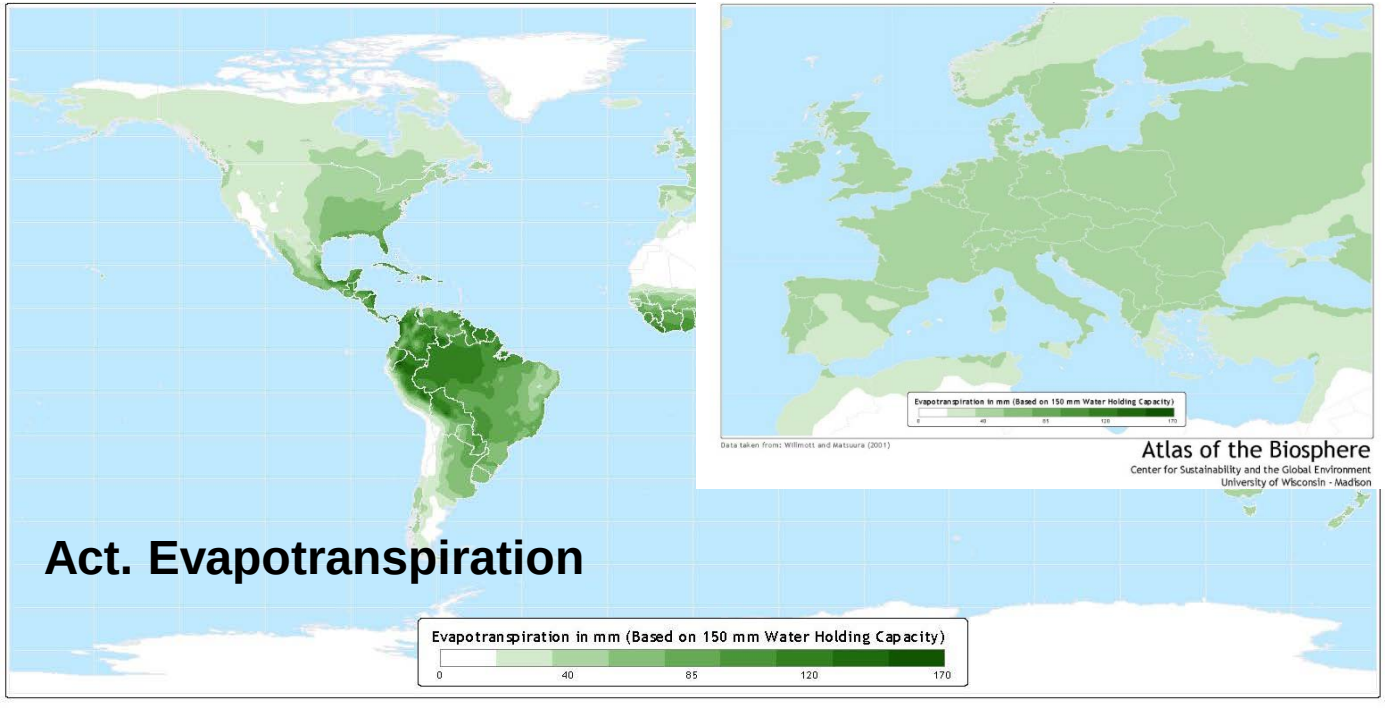


Data taken from: Willmott and Matsuura (2001)



Data taken from: Willmott and Matsuura (2001)

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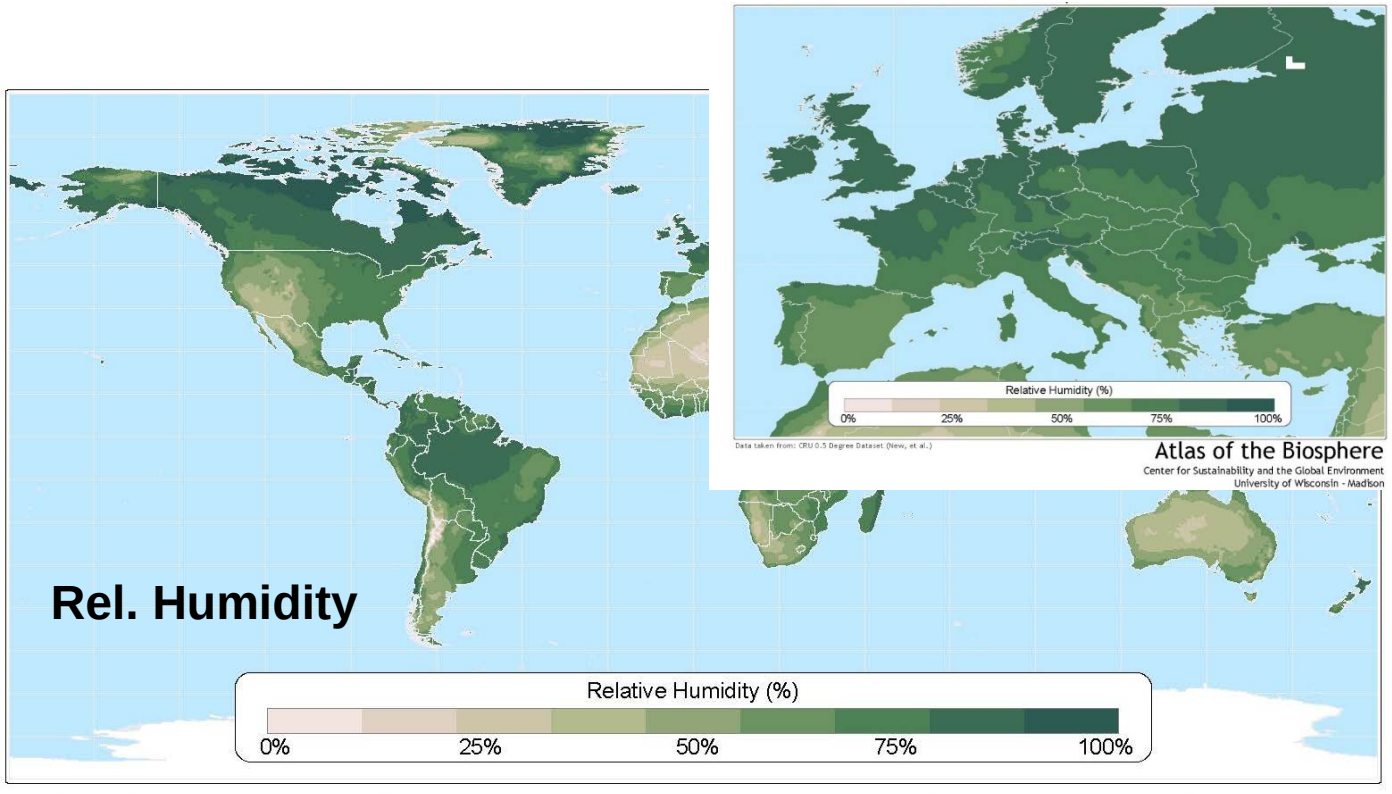
University of Wisconsin - Madison



Data taken from: CRU 0.5 Degree Dataset (New, et al.)

PIK

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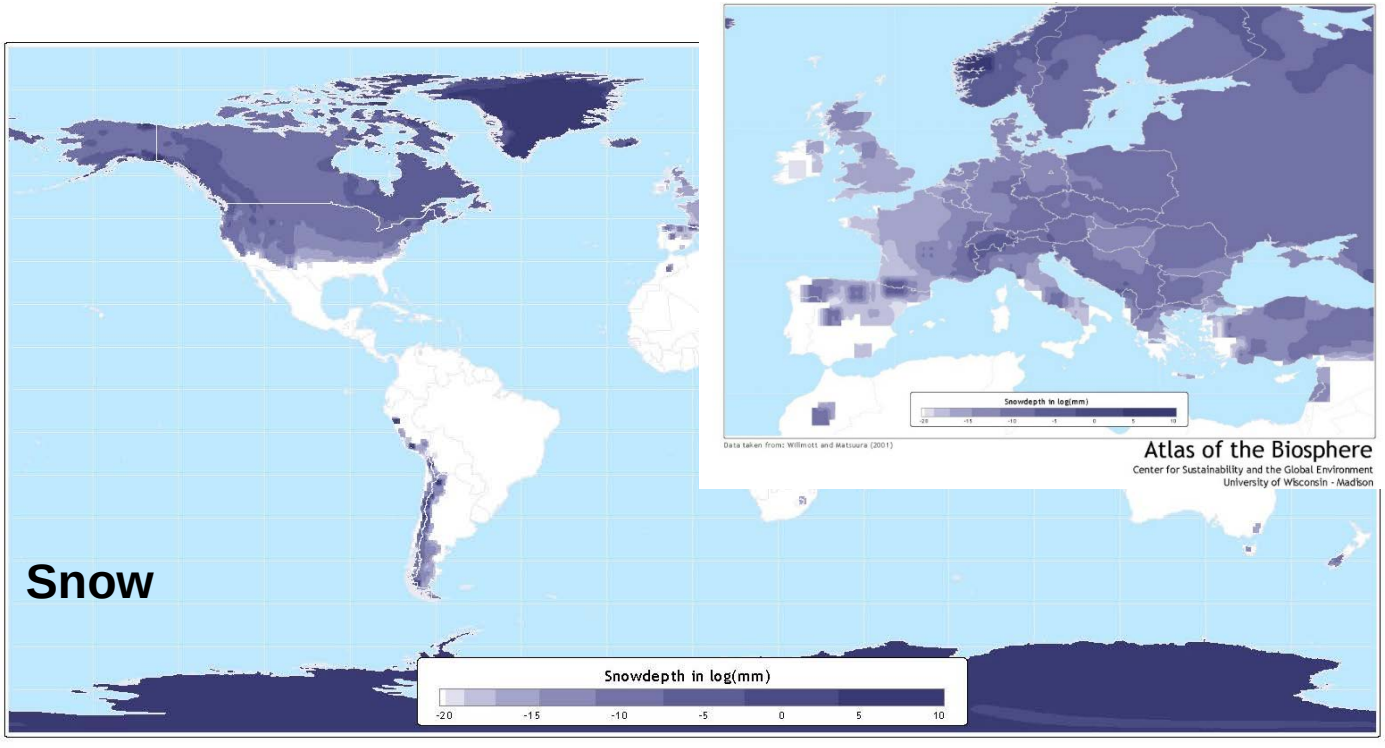

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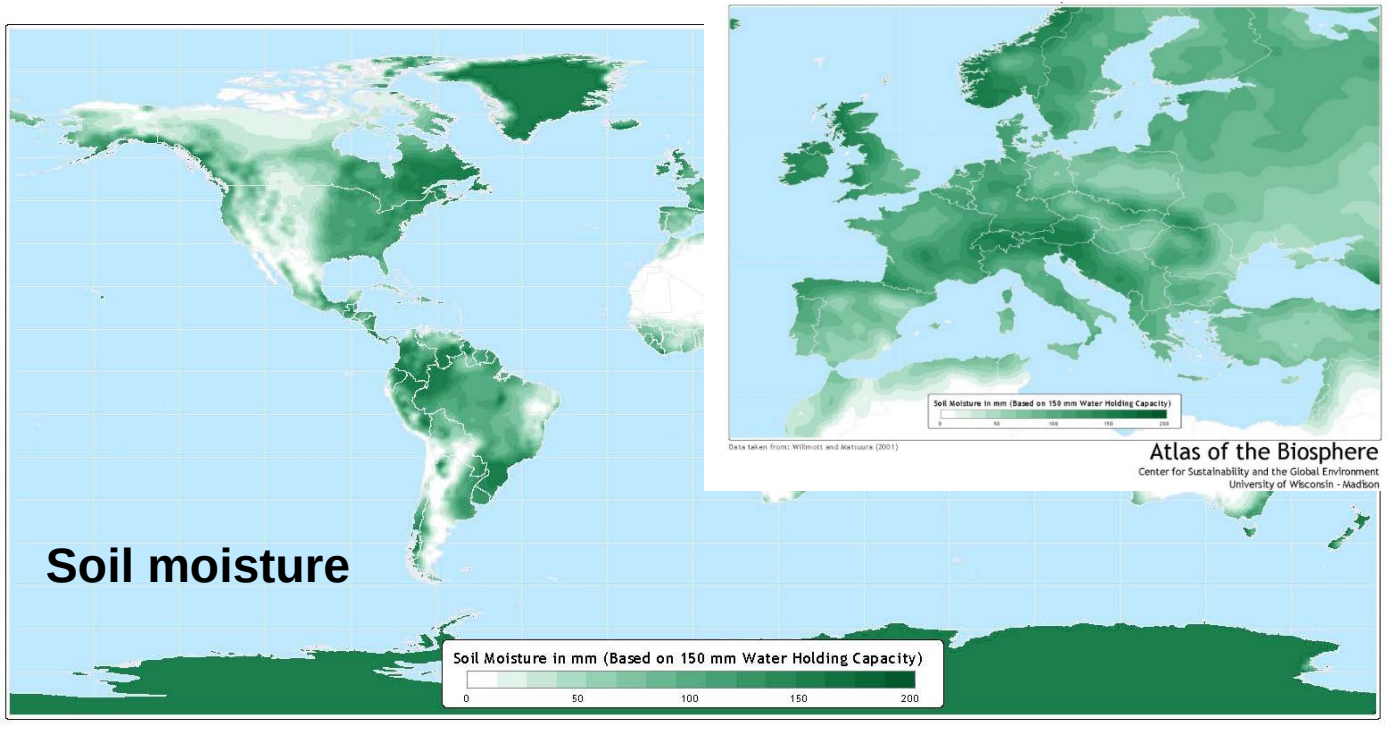

Data taken from: Willmott and Matsuura (2001)

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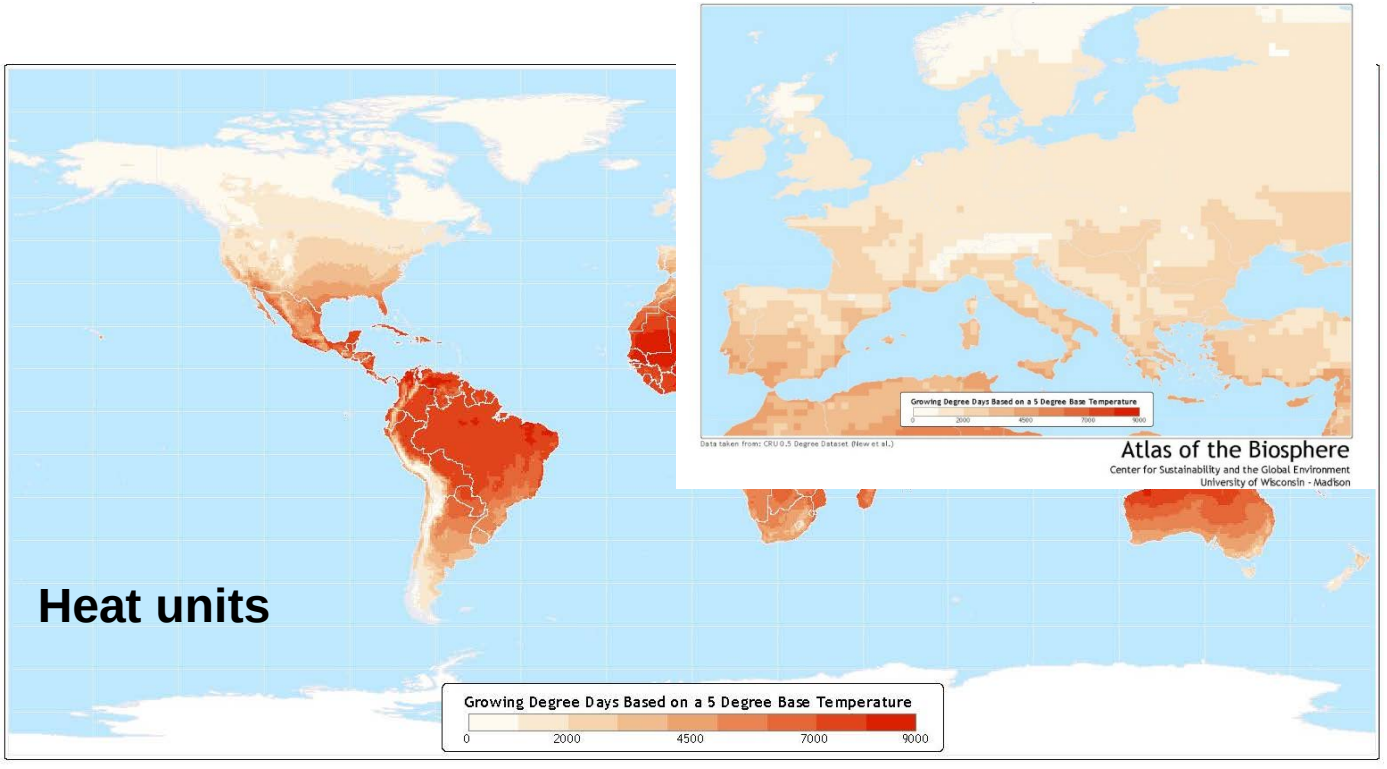

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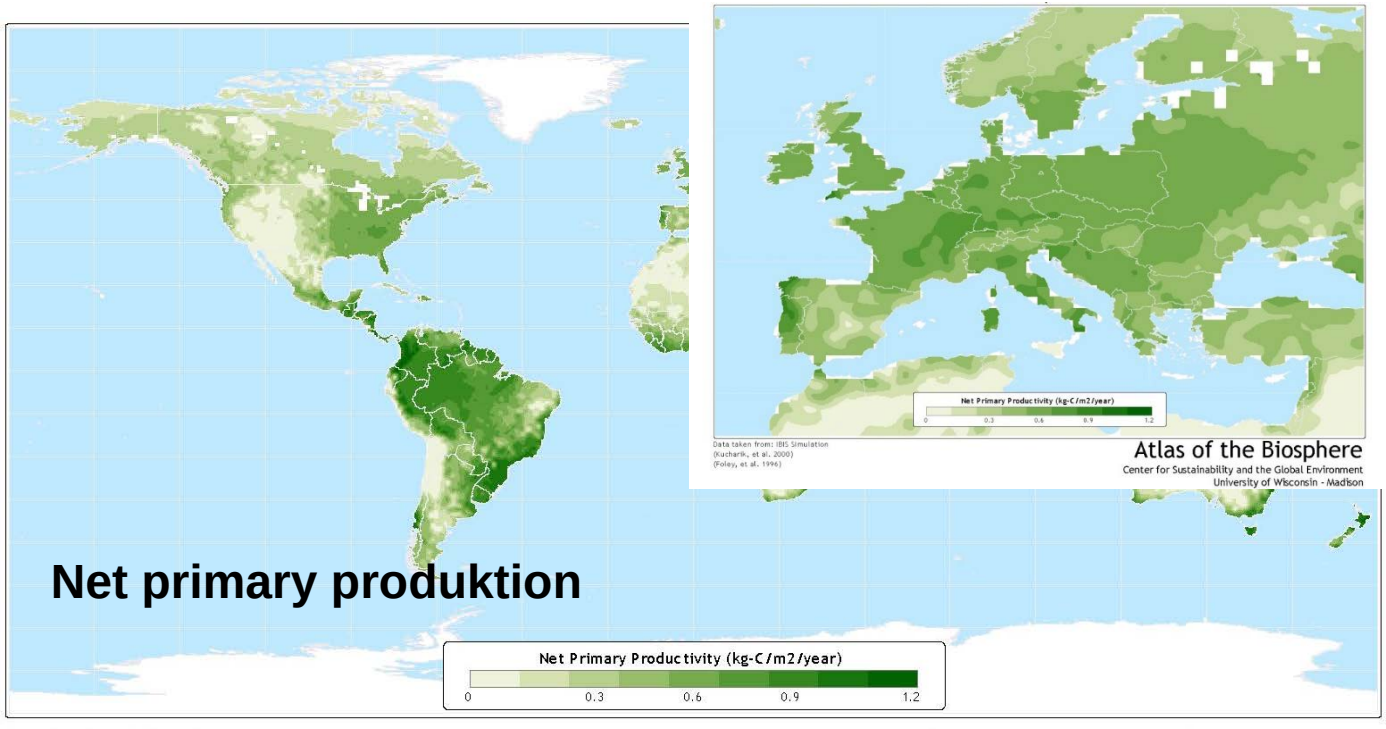

Data taken from: IBIS Simulation
(Kucharik, et al. 2000)
(Foley, et al. 1996)

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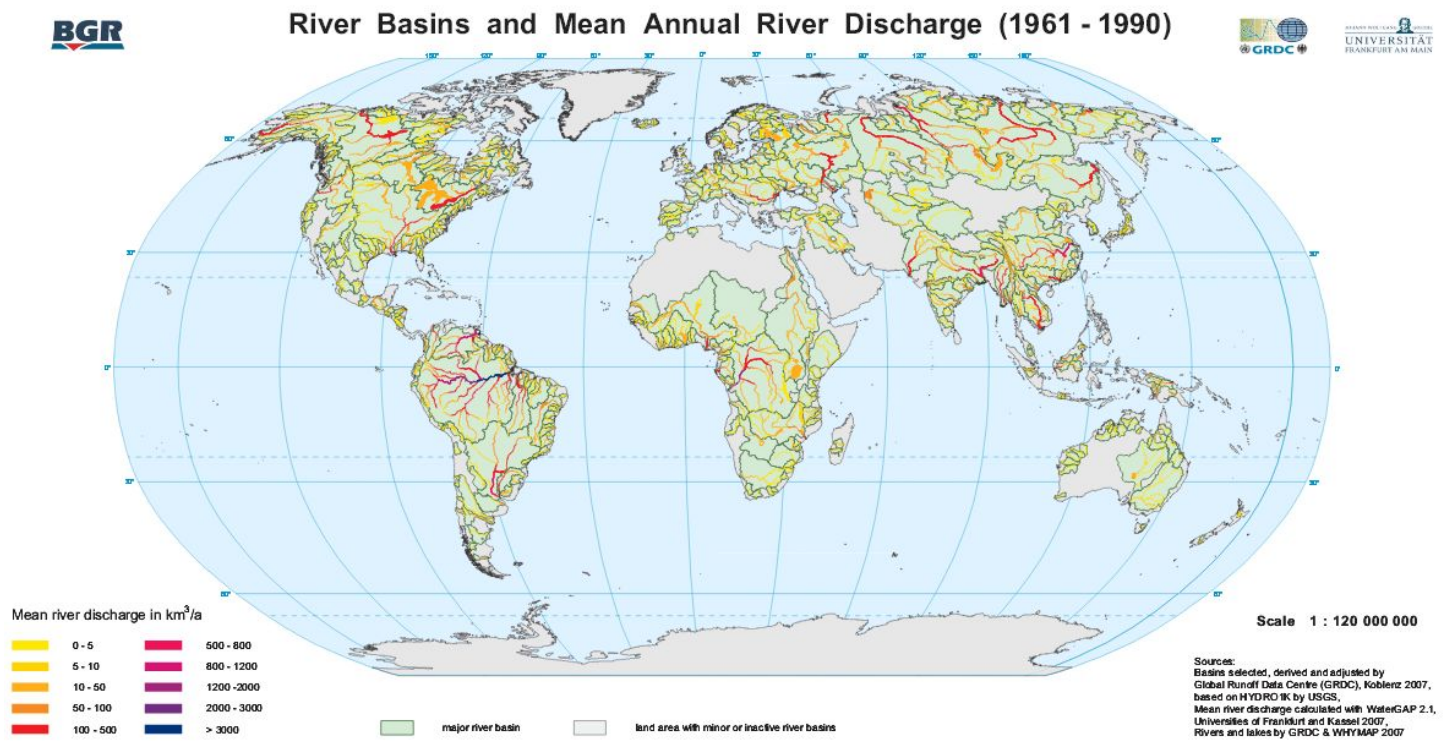
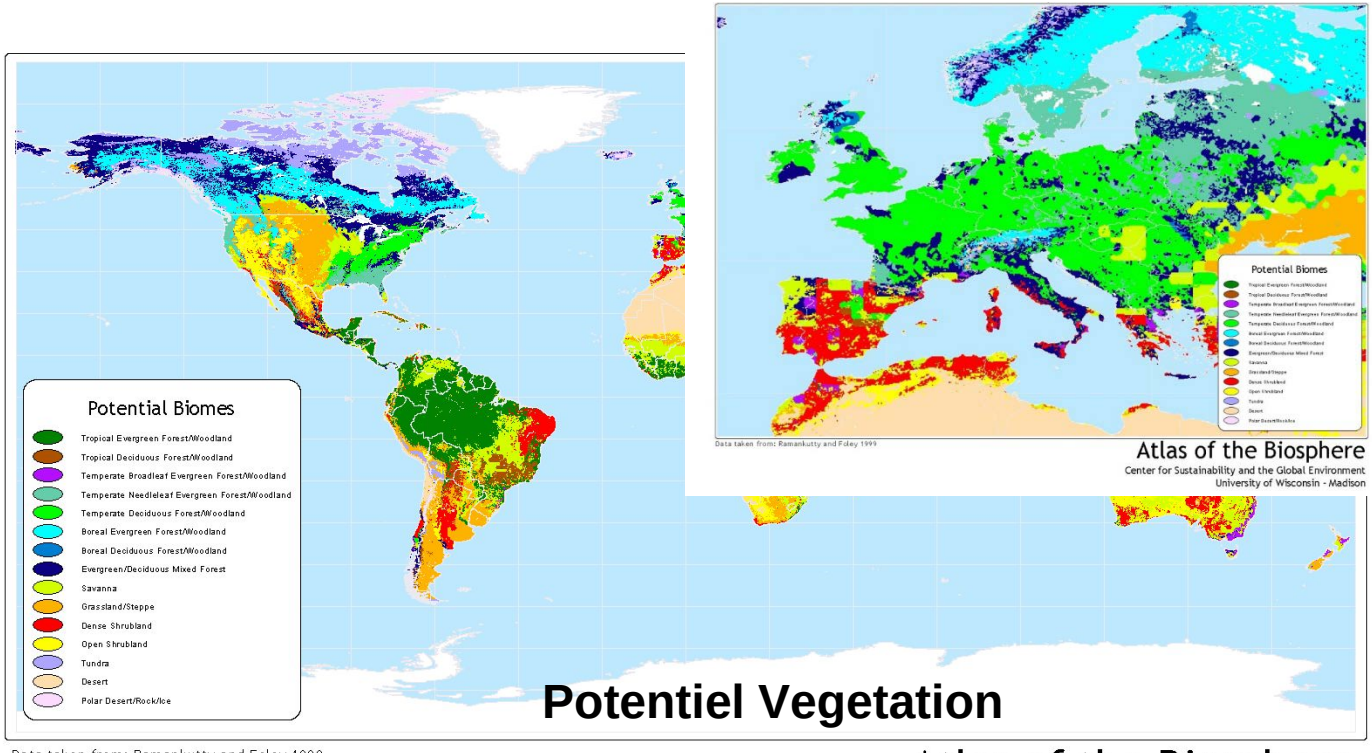

River Basins and Mean Annual River Discharge (1961 - 1990)
BGR
GRDC
UNIVERSITÄT FRANKFURT AM MAIN
Mean river discharge in km³/a
0 - 5
5 - 10
10 - 50
50 - 100
100 - 500
500 - 800
800 - 1200
1200 -2000
2000 - 3000
> 3000
major river basin
land area with minor or inactive river basins
Scale 1 : 120 000 000
Sources:
Basins selected, derived and adjusted by
Global Runoff Data Centre (GRDC), Koblenz 2007,
based on HYDRO1K by USGS,
Mean river discharge calculated with WaterGAP 2.1,
Universities of Frankfurt and Kassel 2007,
Rivers and lakes by GRDC & WHYMAP 2007

PLK



Potentiel Vegetation

Data taken from: Ramankutty and Foley 1999

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