

Friday 15 September, 2017
10:30-11:30, Class#08

- 1) Review from last few classes (Reading Chapter 2 Ruddiman)
- 3) Today's topics
 - Outgoing Longwave Radiation
 - Water transport in atmosphere
 - Global heat transport
 - Comparative Role of ocean and atmosphere

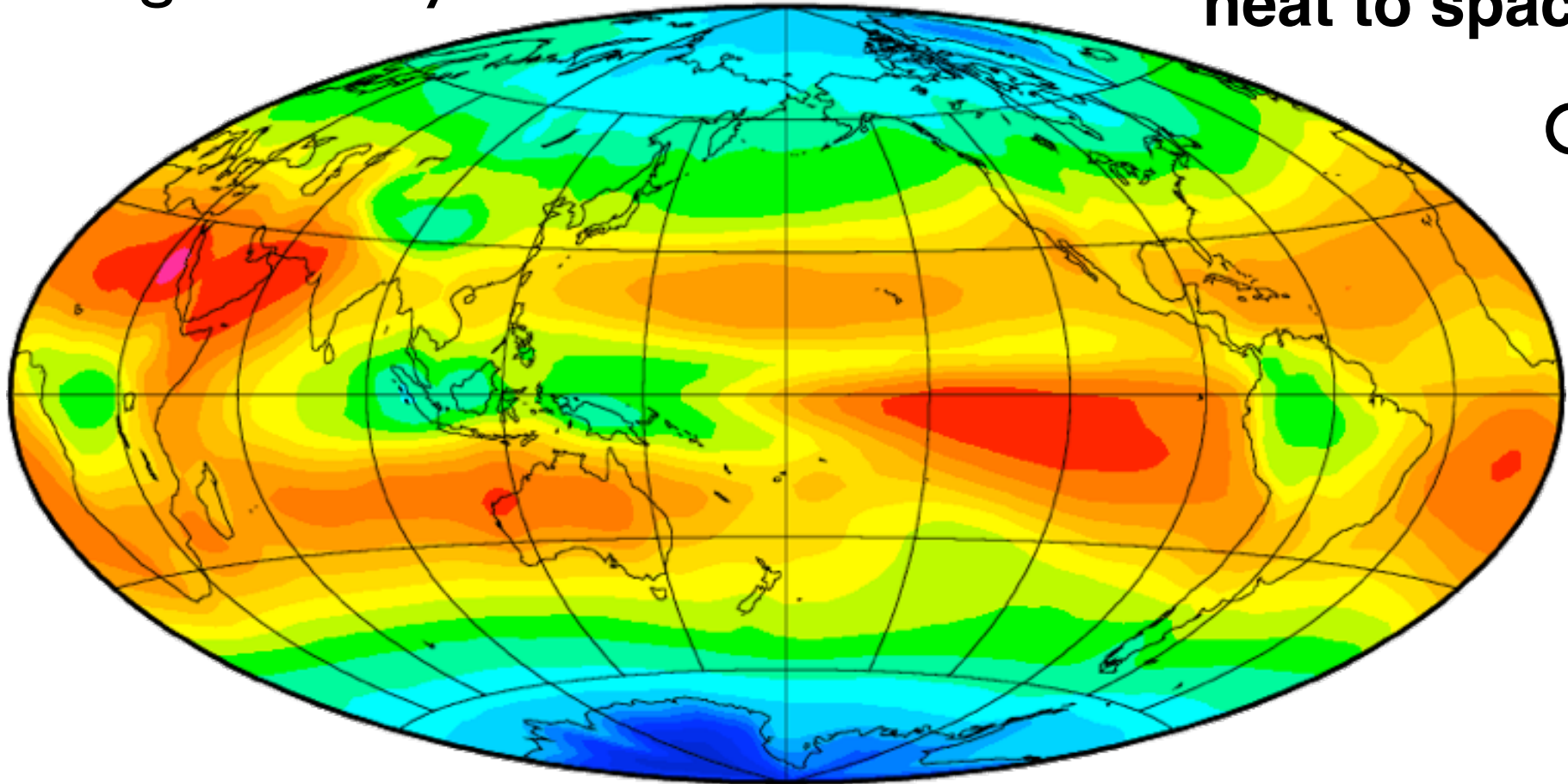
Review



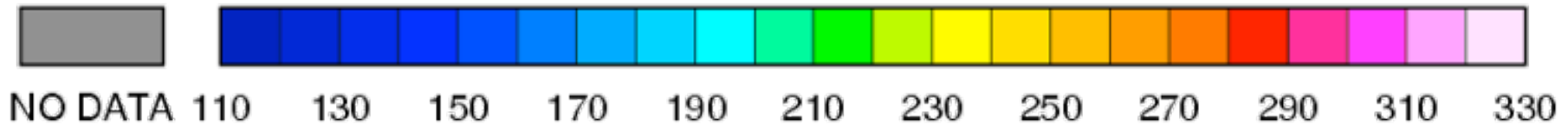
Averaged over year

Outgoing Longwave Radiation
1985-1986

**Bigger number more
heat to space**



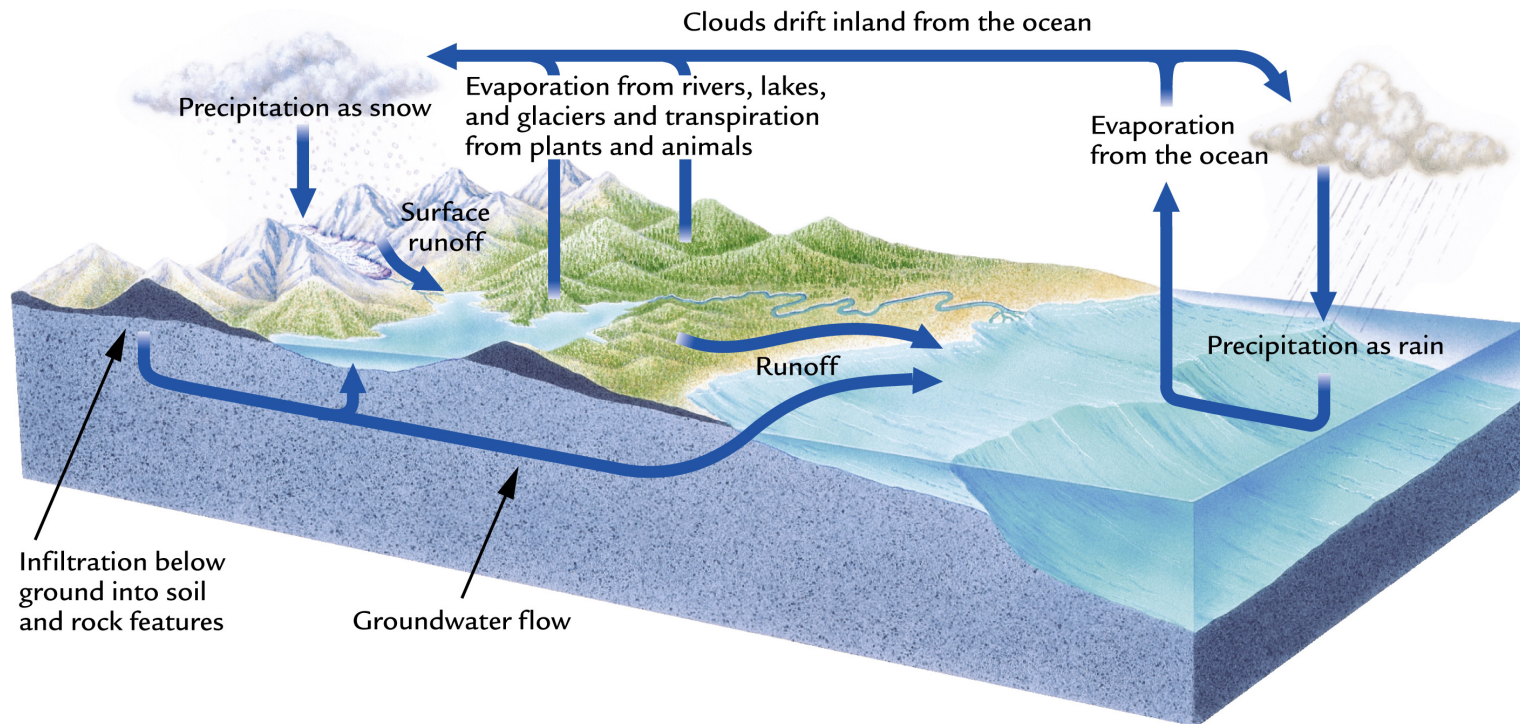
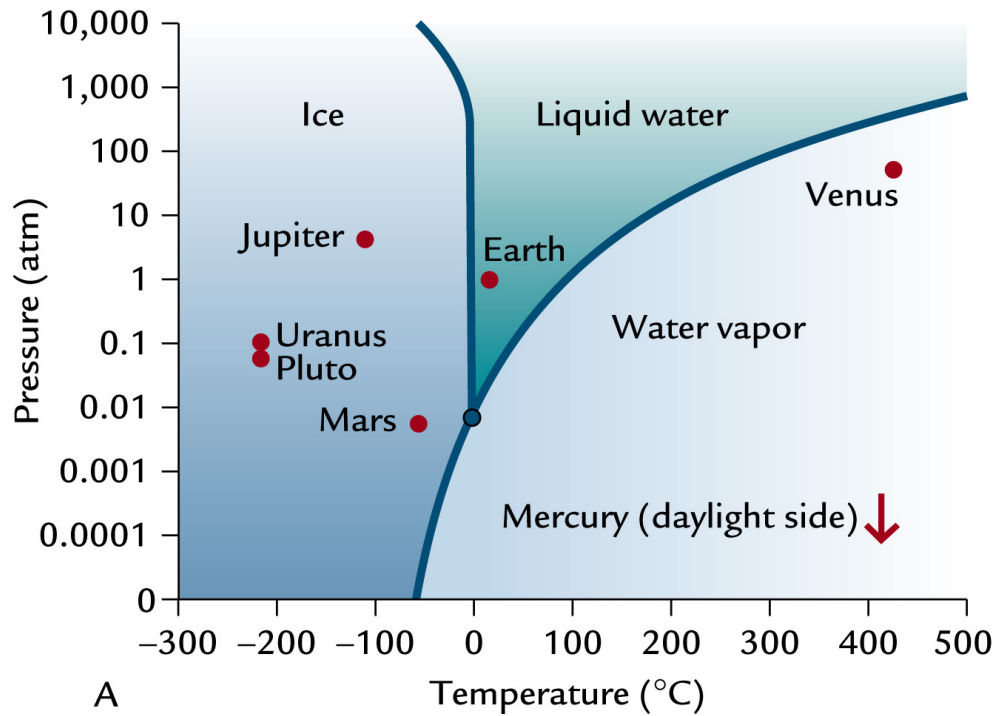
OLR



W/m^2

<http://eos.atmos.washington.edu/cgi-bin/erbe/disp.pl?olr.ann.d>

Properties of water make climate interesting!



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Global Energy Balance

Pathways of energy transfer in a global average

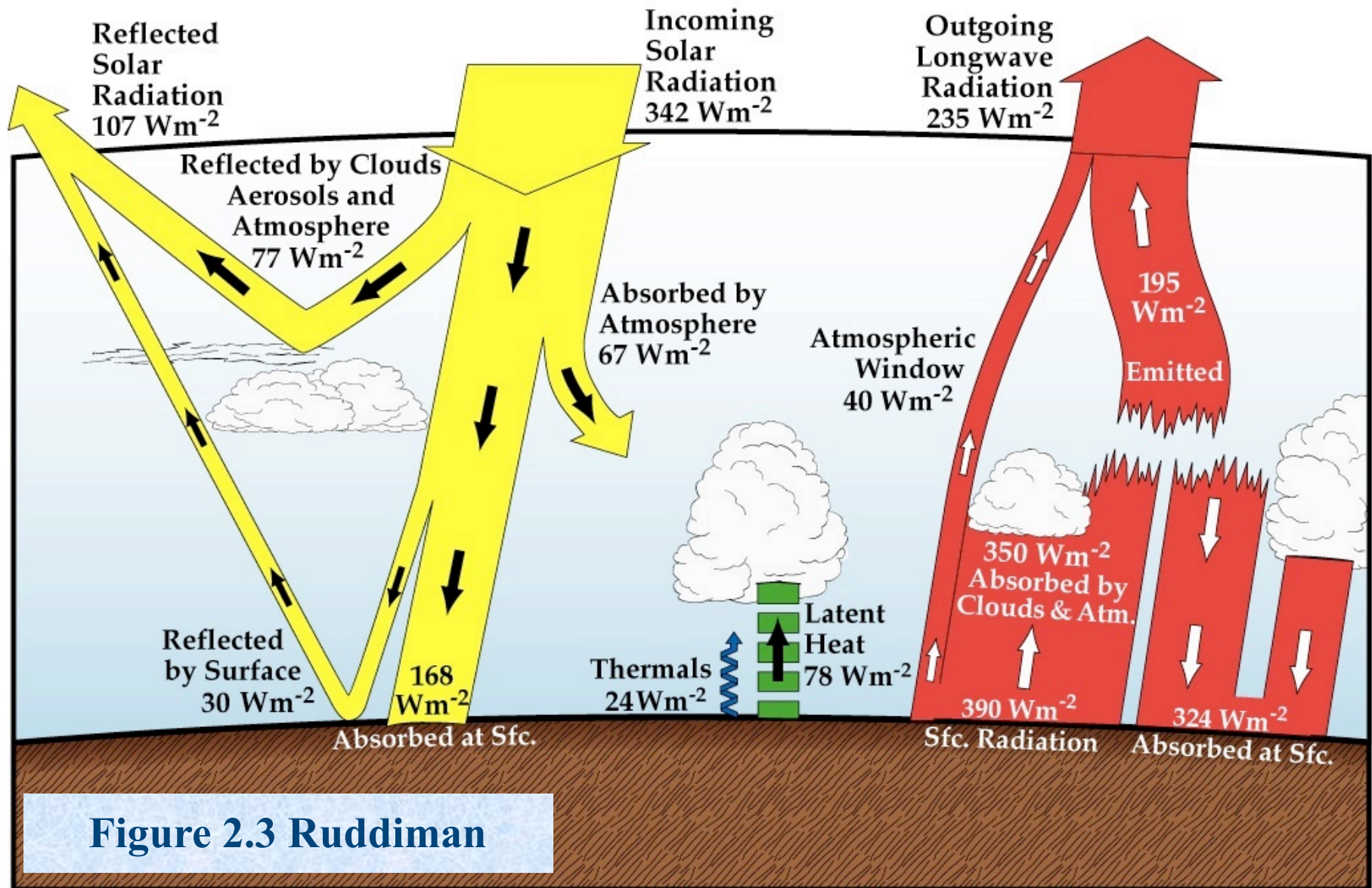
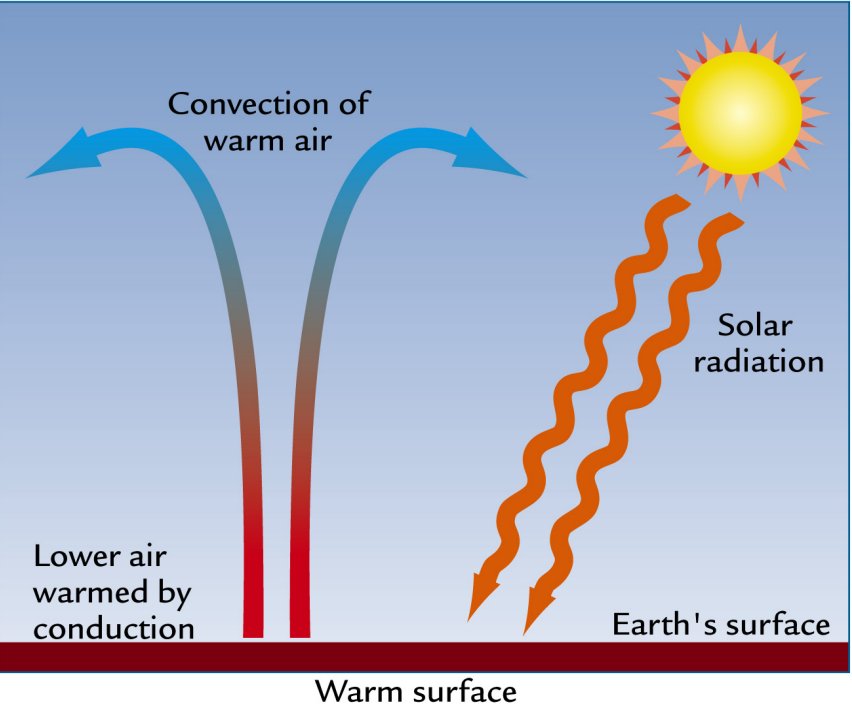
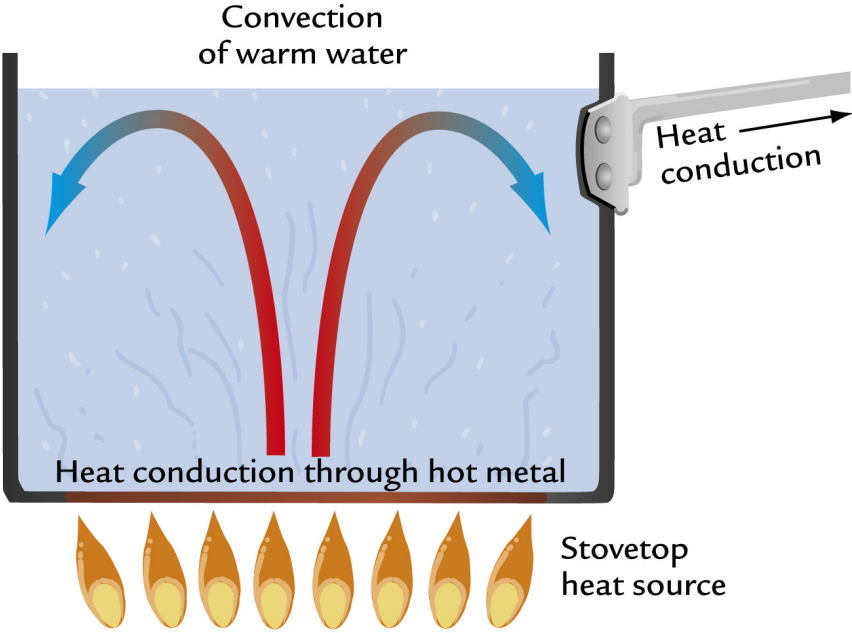


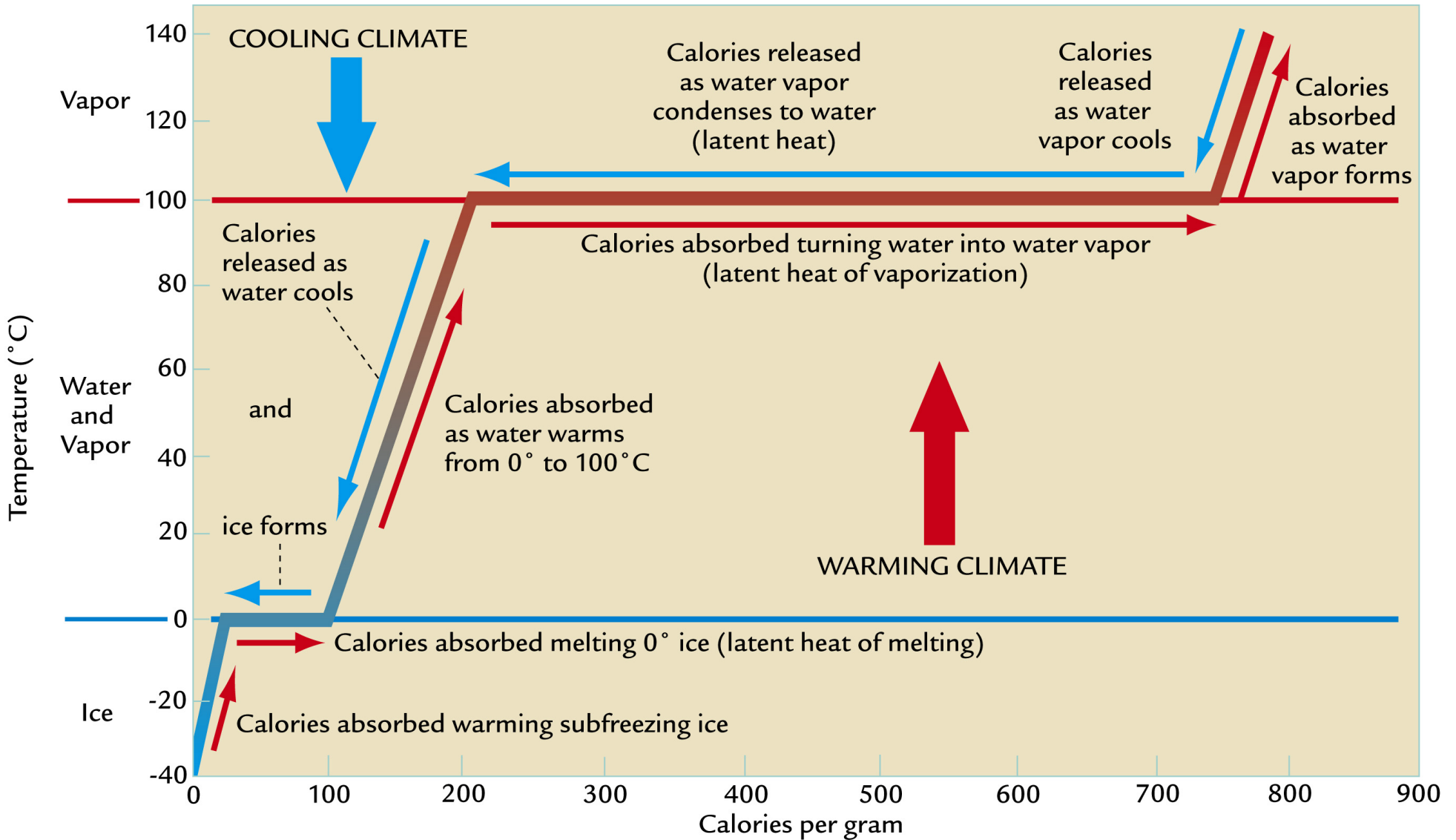
Figure 2.3 Ruddiman

Conduction (Sensible - Thermals) and Convection (Sensible and Latent)



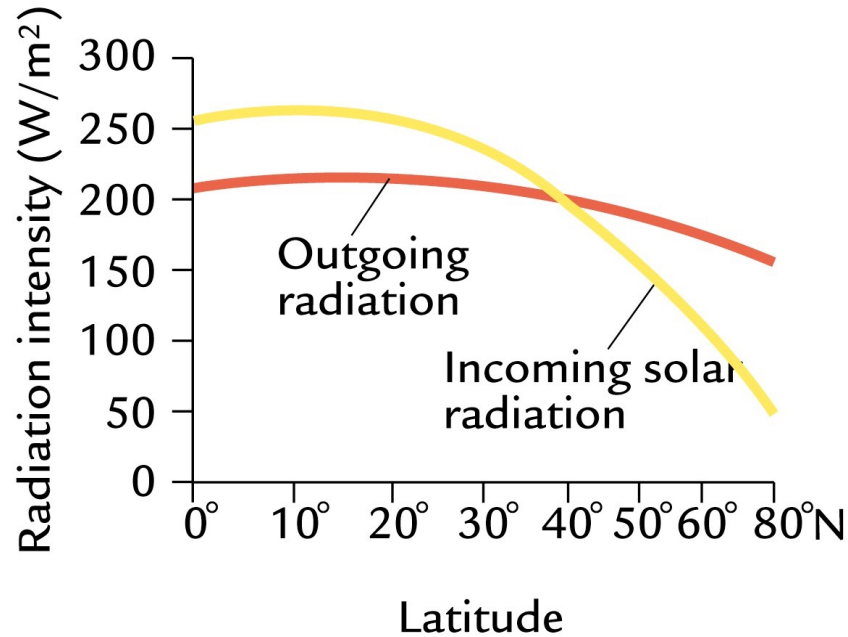
[Chap2, Ruddiman 2013]

Water helps to move Energy around

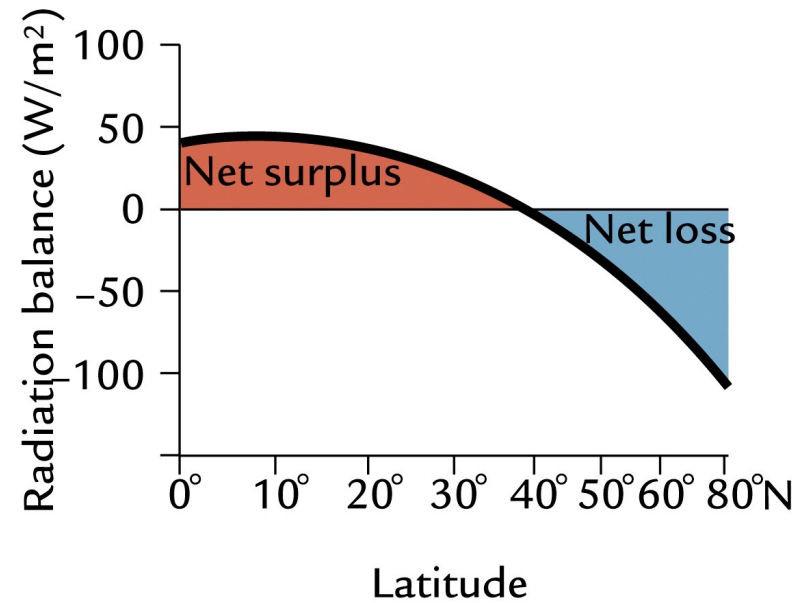


[Chap2, Ruddiman 2013]

Latitudinal Energy Balance



A

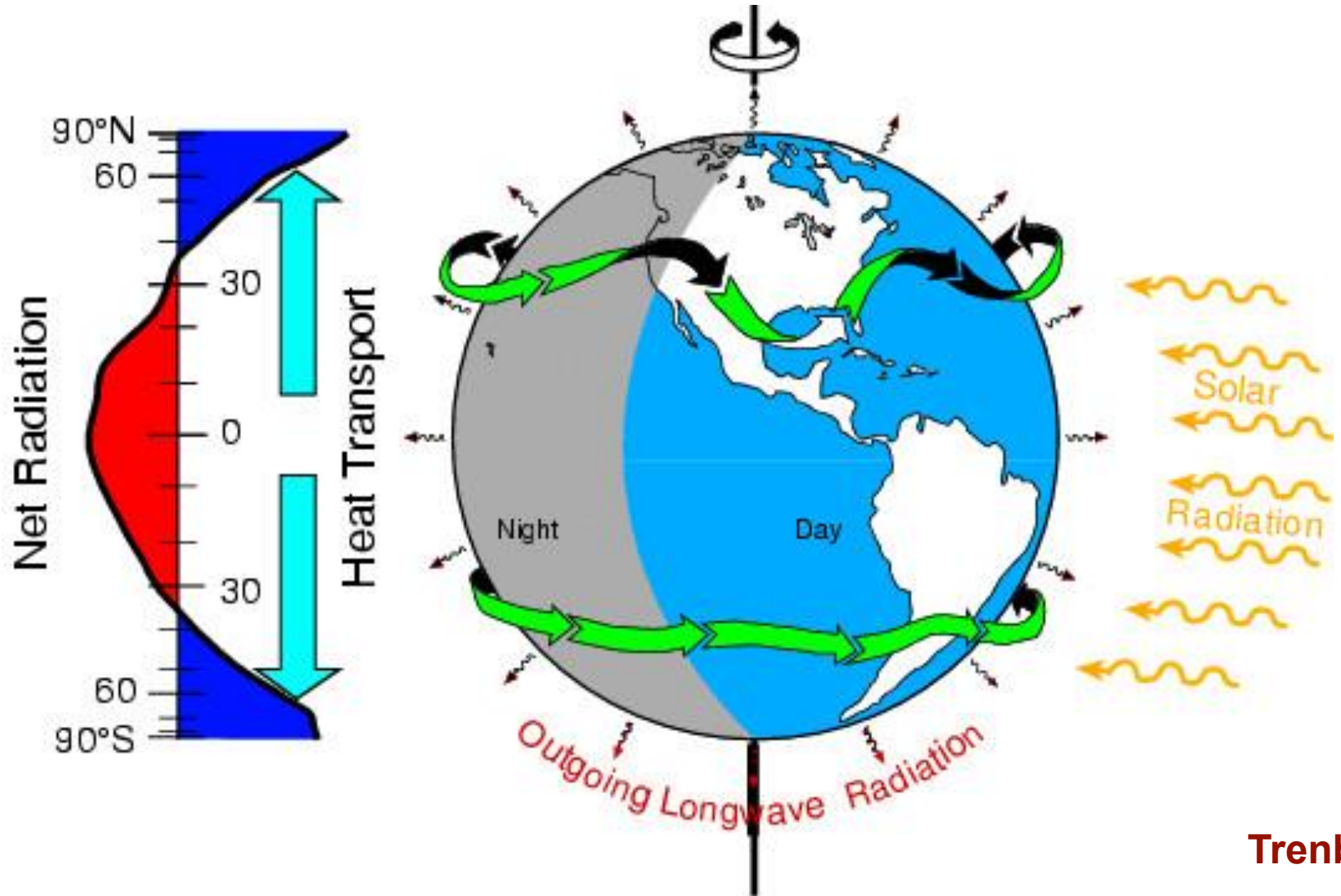


B

[Chap2, Ruddiman 2013]

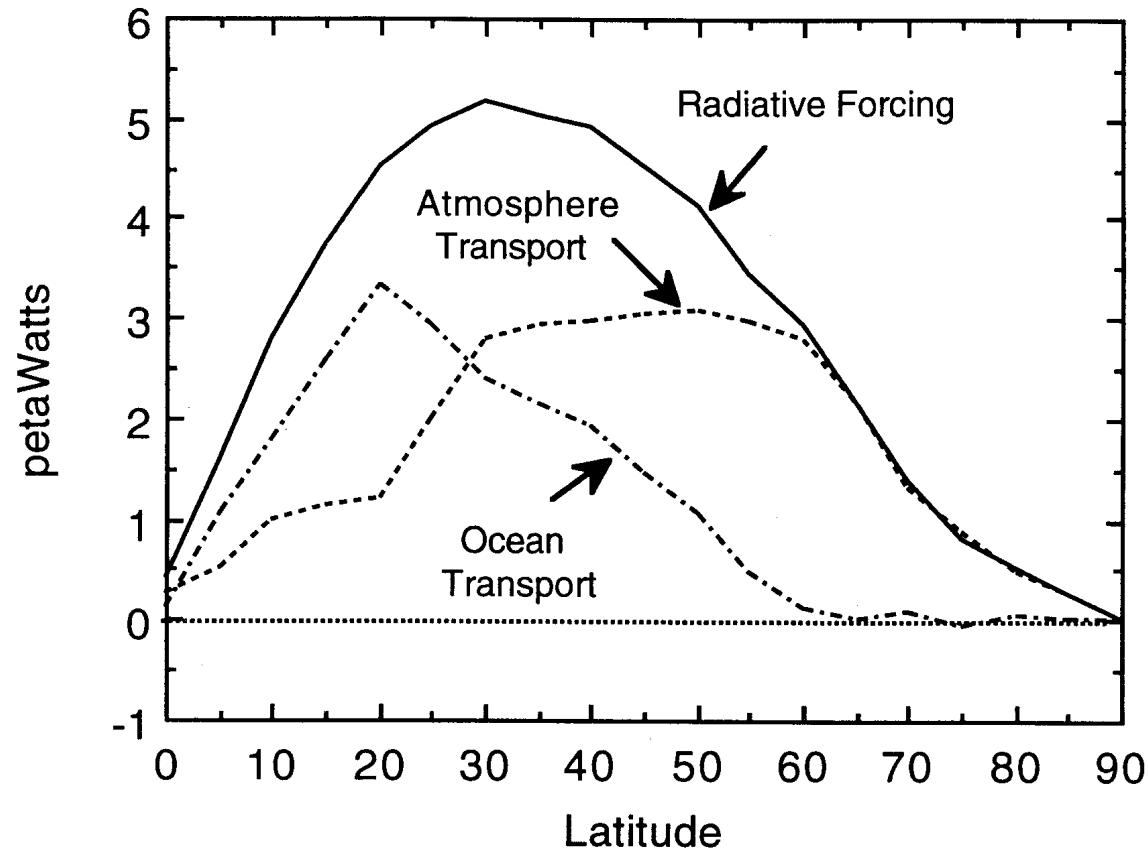
Heat must be transported poleward to balance heat imbalance

Global Heat Engine



- 1) Tropical -subtropical heat transport - Hadley Cell
- 2) Midlatitude-high latitude heat transport - storms

Energy Transport to Balance Radiation Imbalance

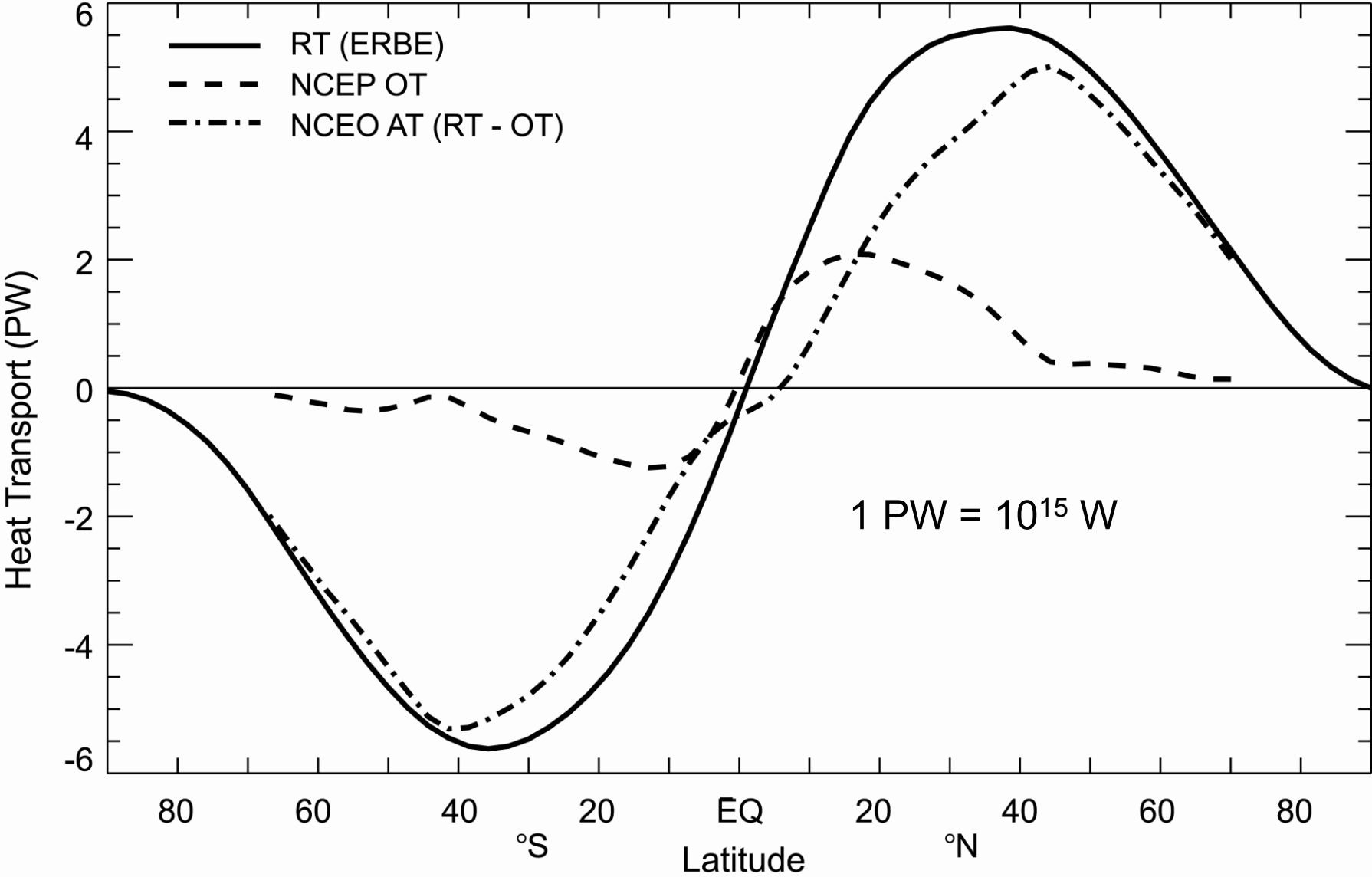


Hartmann, 1994

Fig. 2.14 Meridional transport of energy for annual-mean conditions. Net radiation and atmospheric transport are estimated from observations; ocean transport is calculated as a residual in the energy balance. [Adapted from Vonder Haar and Oort (1973). Used with permission from the American Meteorological Society.]

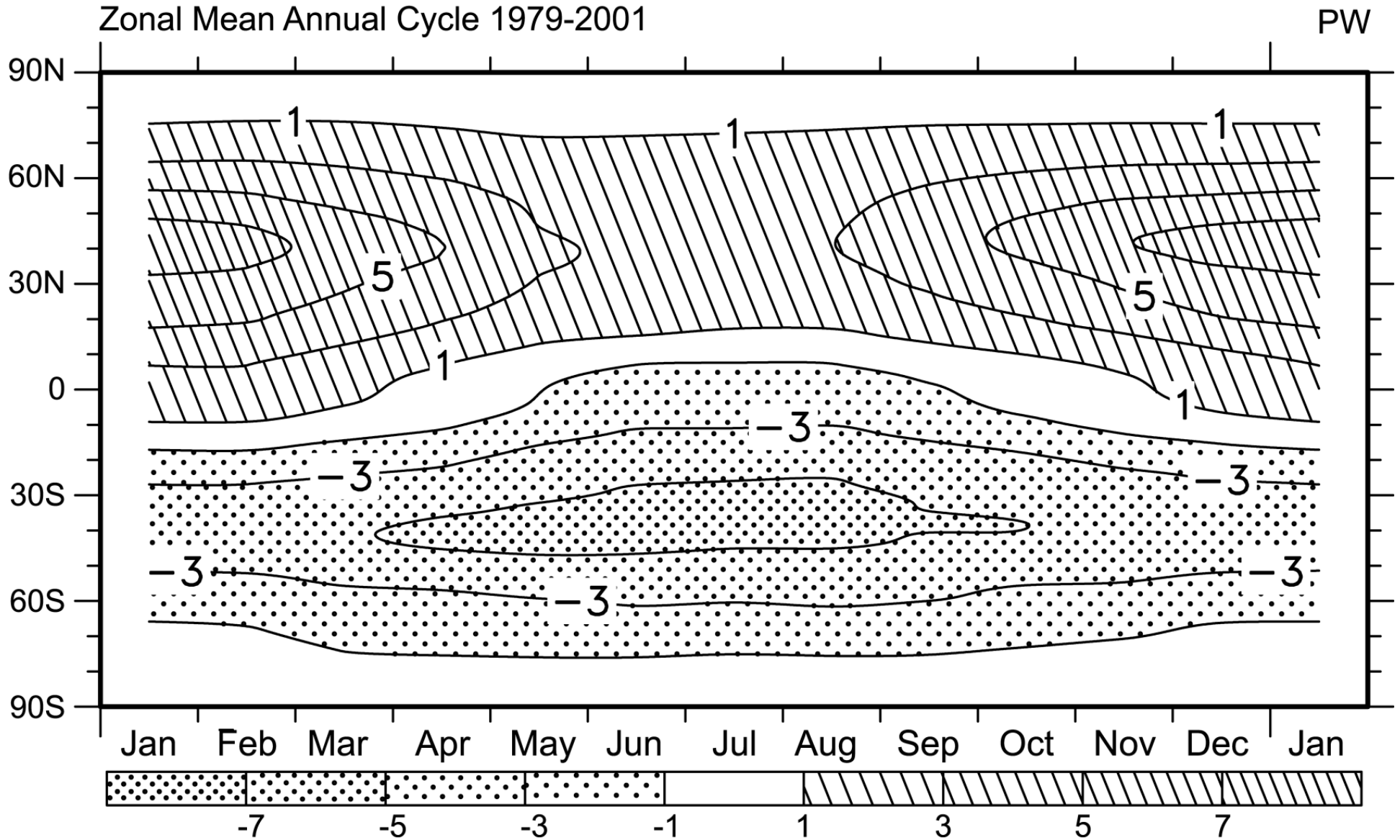
How we get this total curve and then atmospheric, then ocean as a residual. 50%/50% atmosphere/ocean, More on this later...

Energy Transport to Balance Radiation Imbalance



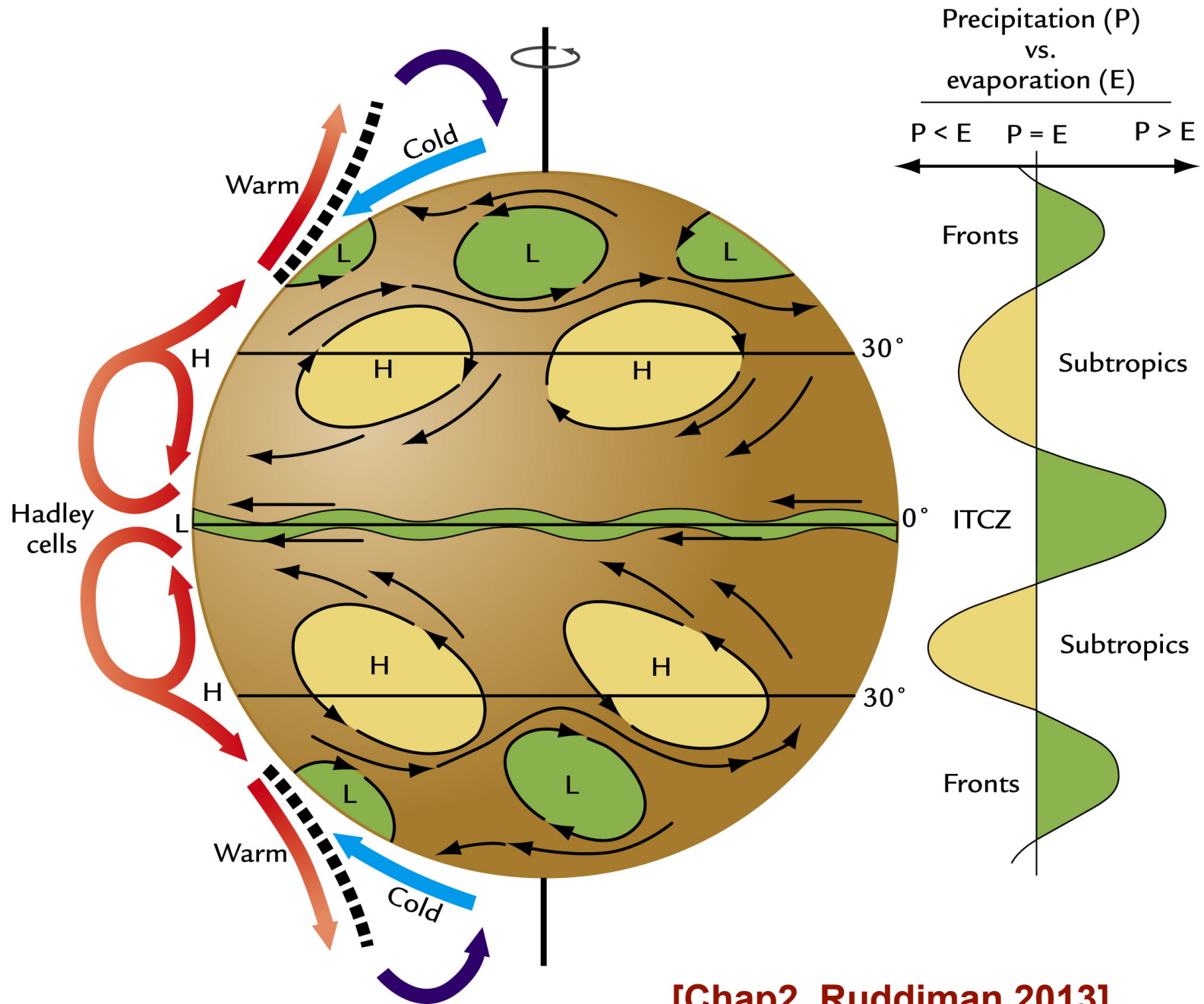
Trenberth and Caron 2001

Seasonal Cycle of Heat Transport



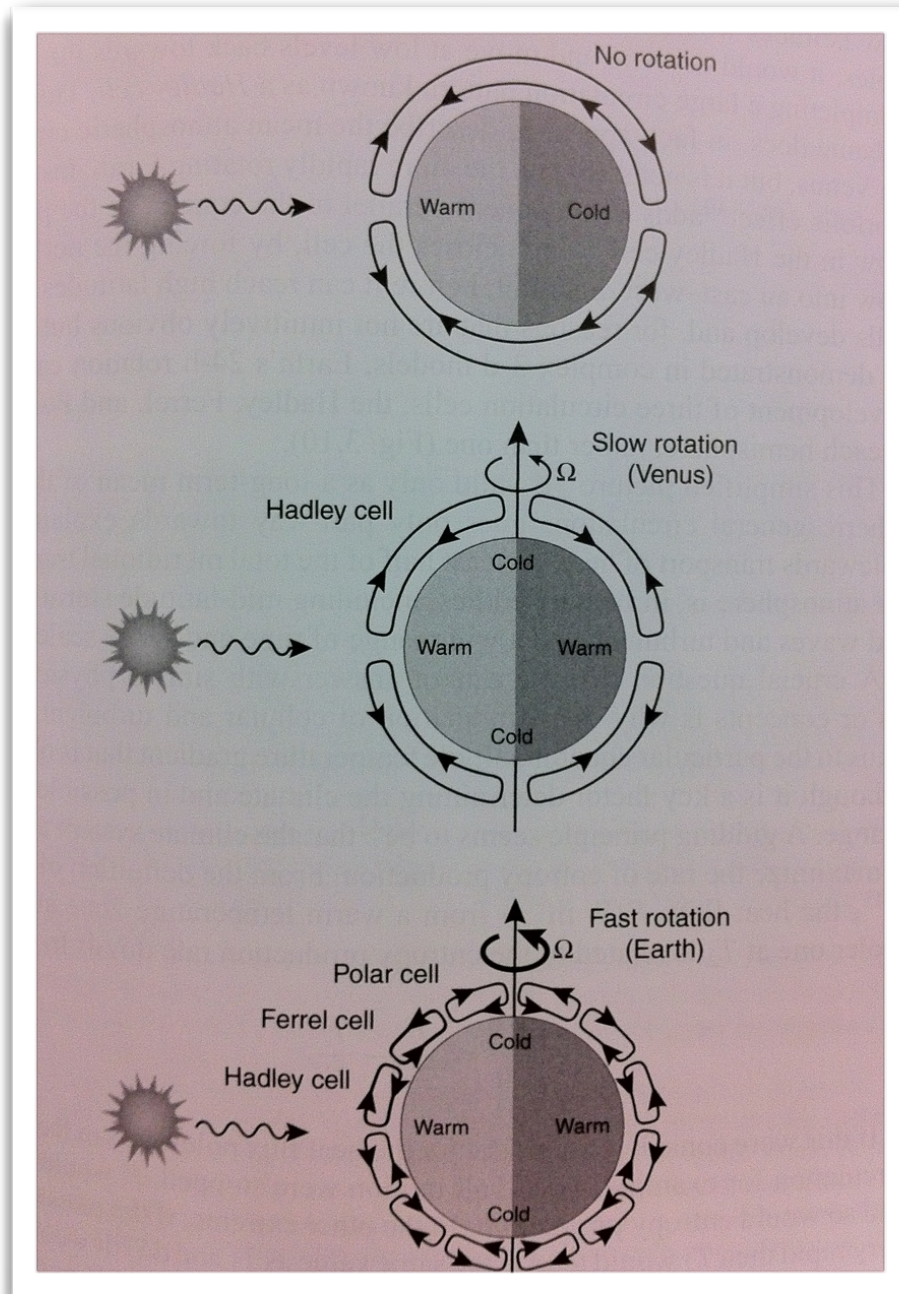
Trenberth and Stepaniak 2003

General Circulation of Atmosphere



[Chap2, Ruddiman 2013]

Rotation impacts number of meridional cells



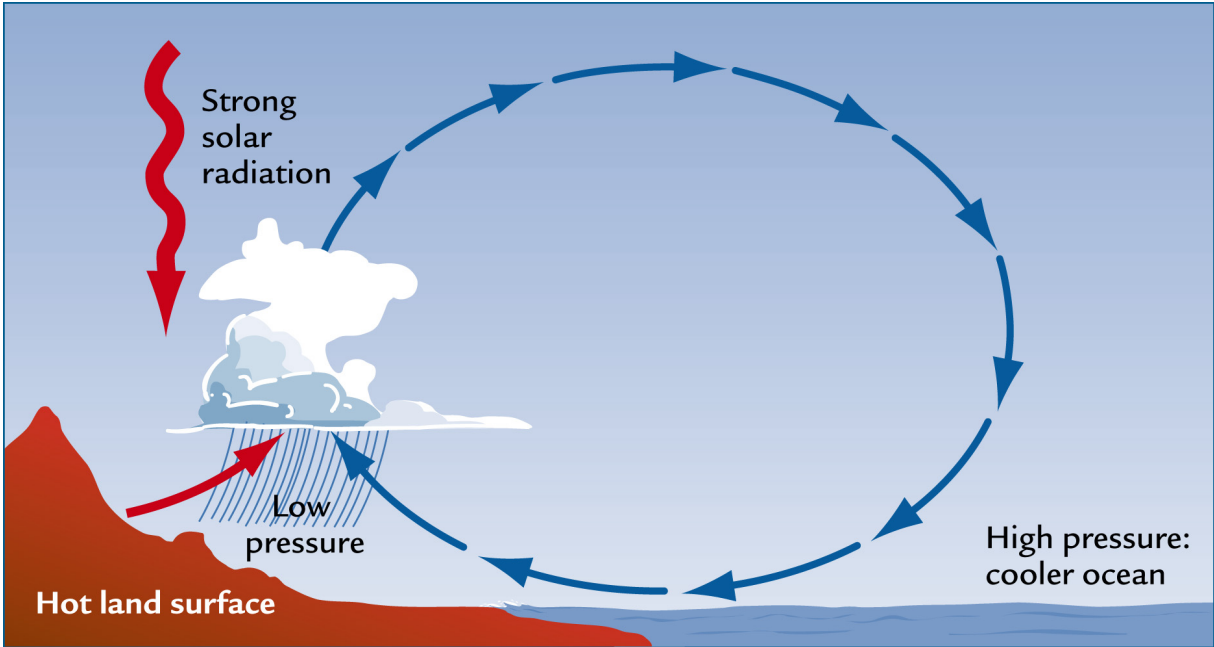
No rotation

Slow rotation

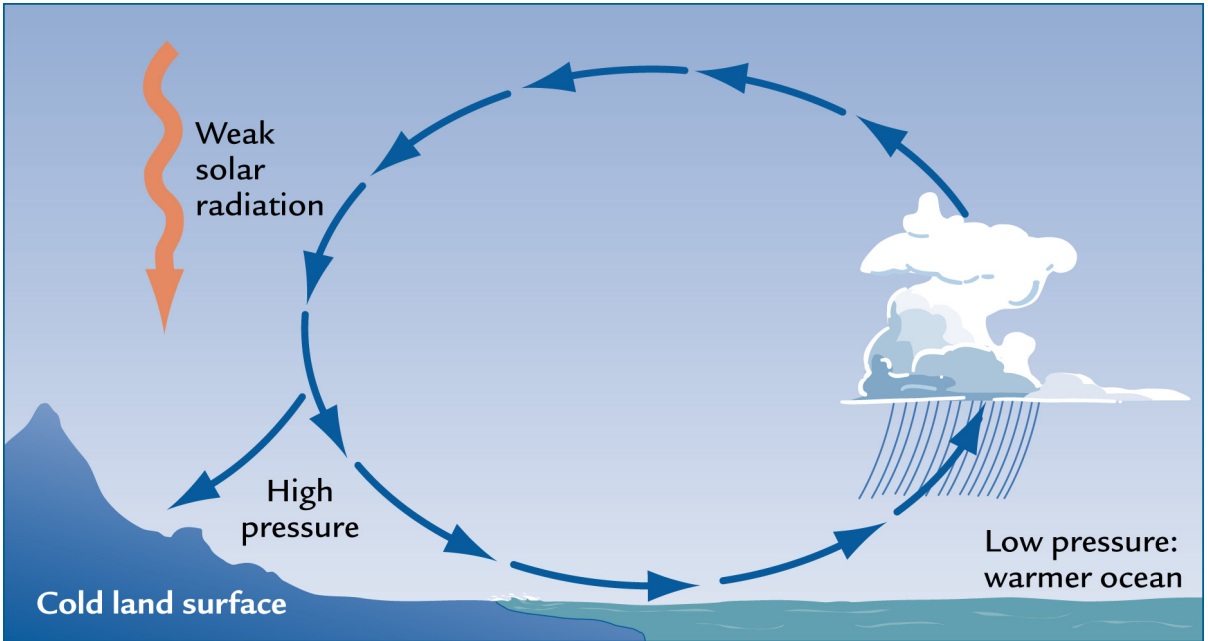
Fast Rotation

F.W. Taylor, Climate Physics

Monsoon Circulations

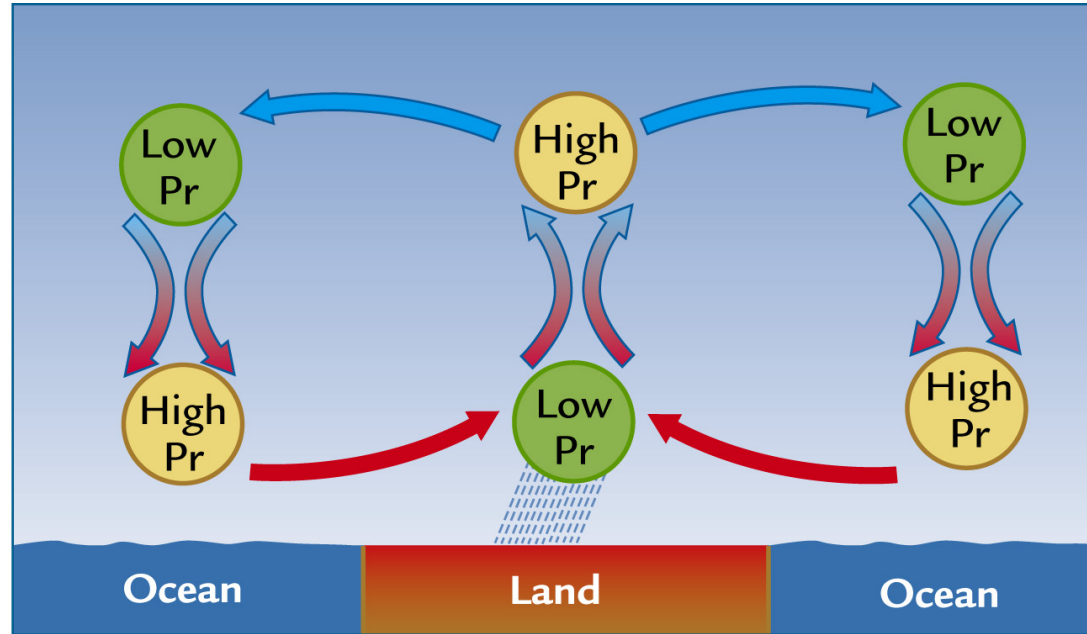


A Summer monsoon

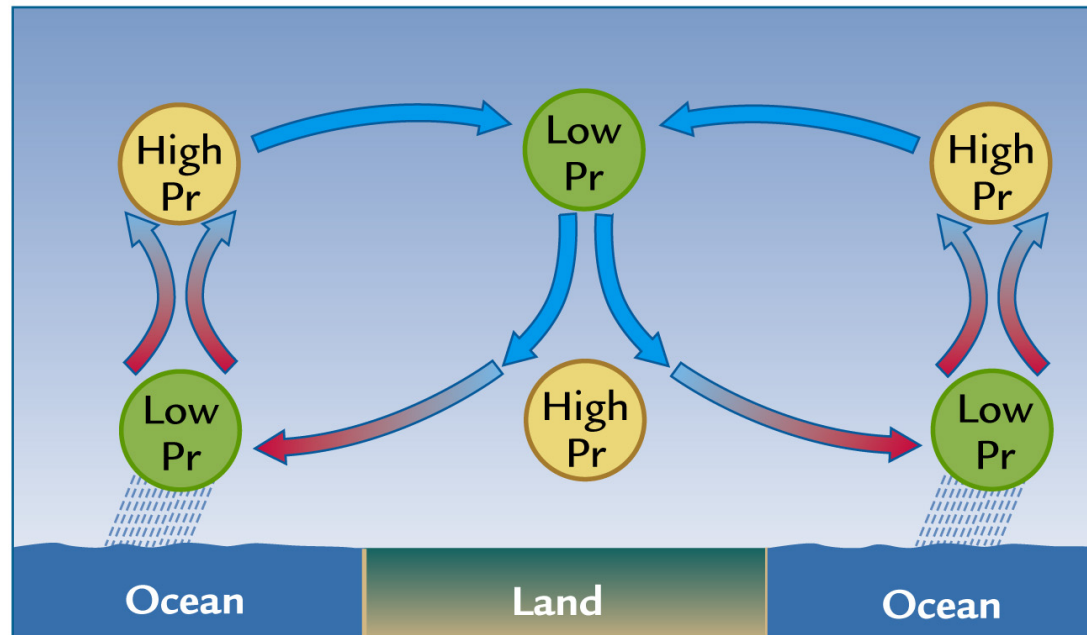


B Winter monsoon

Seasonal Circulation Patterns

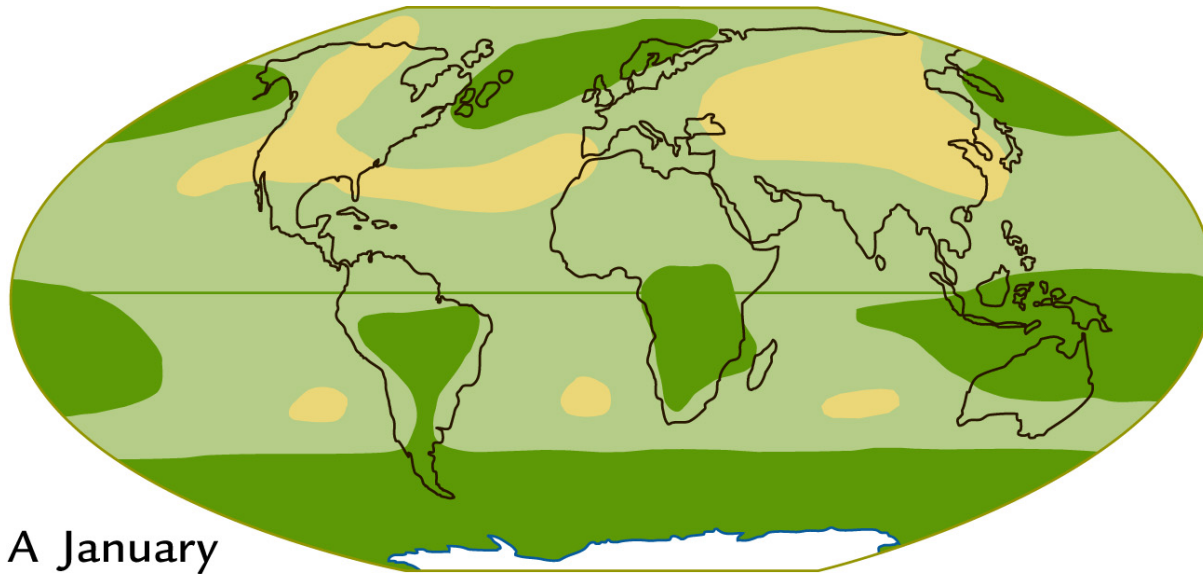


A Summer

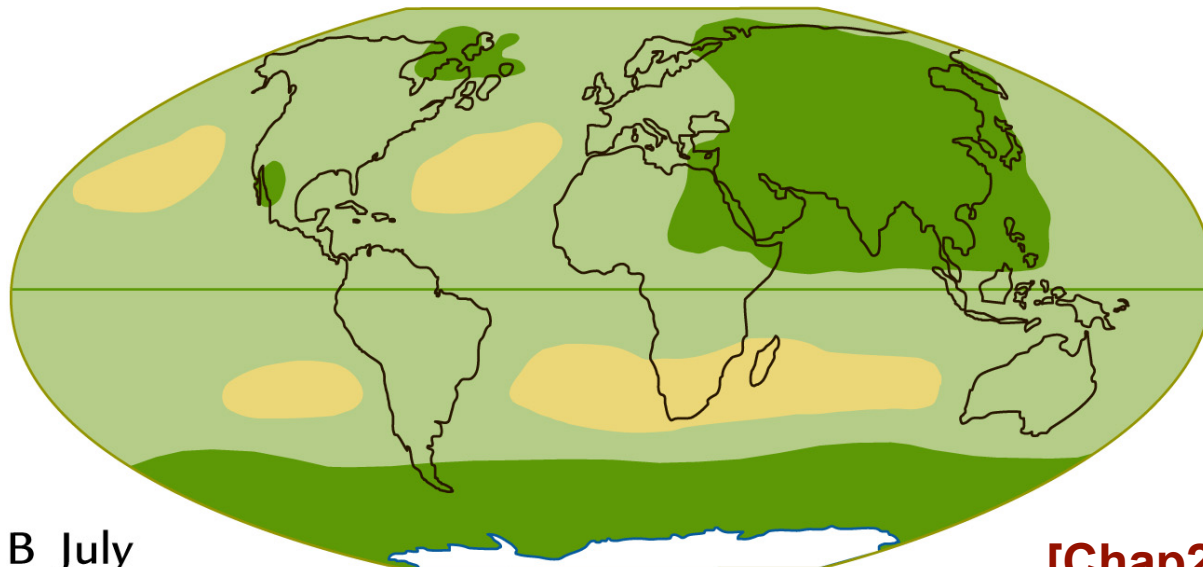
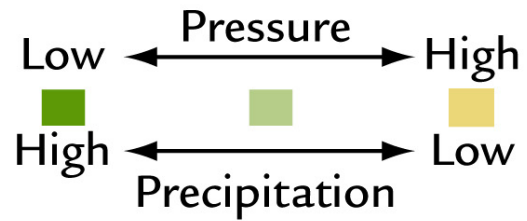


B Winter

Seasonal Pressure Patterns

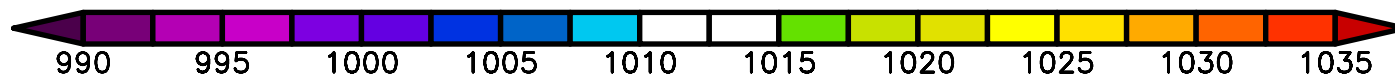
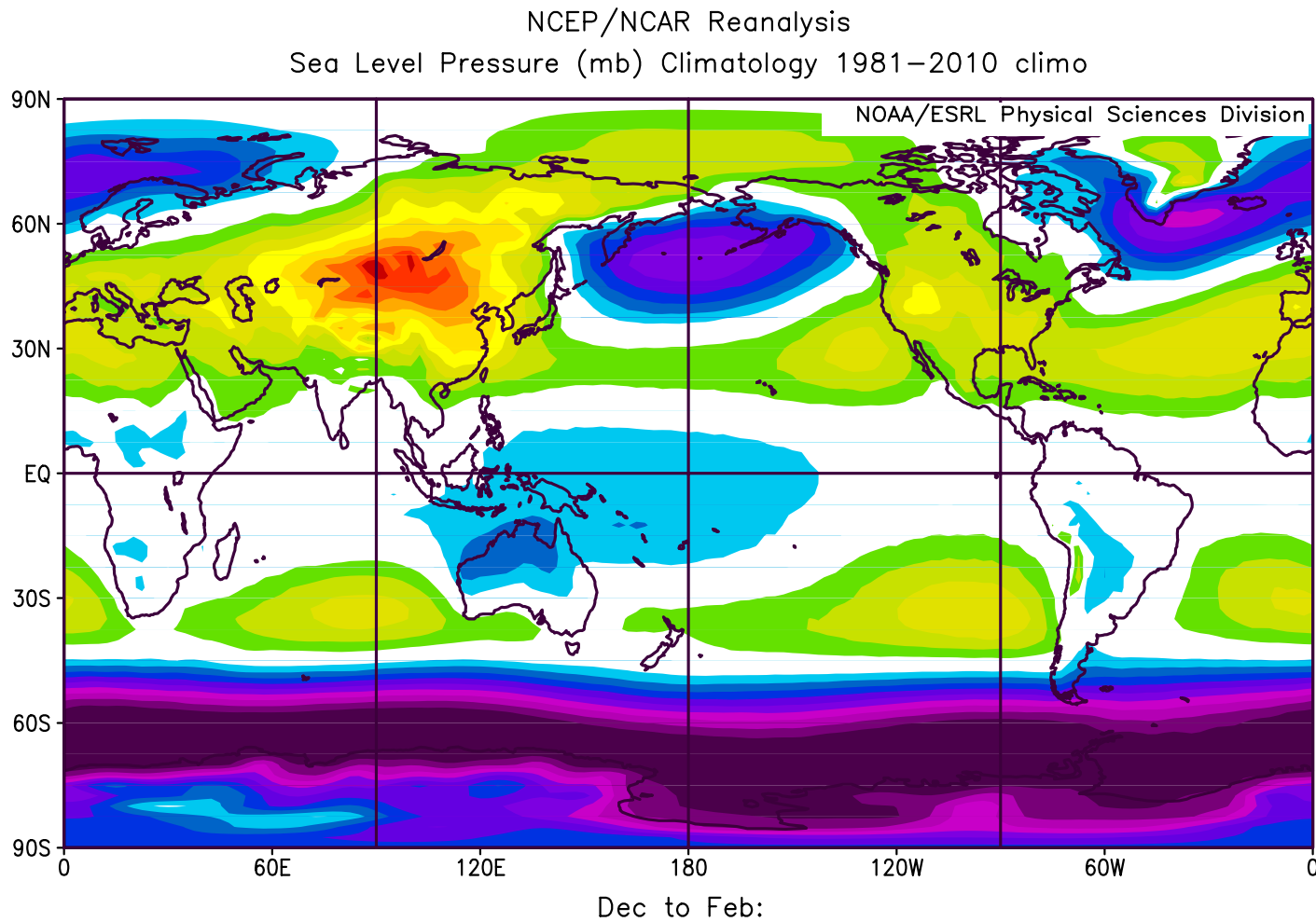


A January



B July

Seasonal Pressure Patterns with numbers: Winter



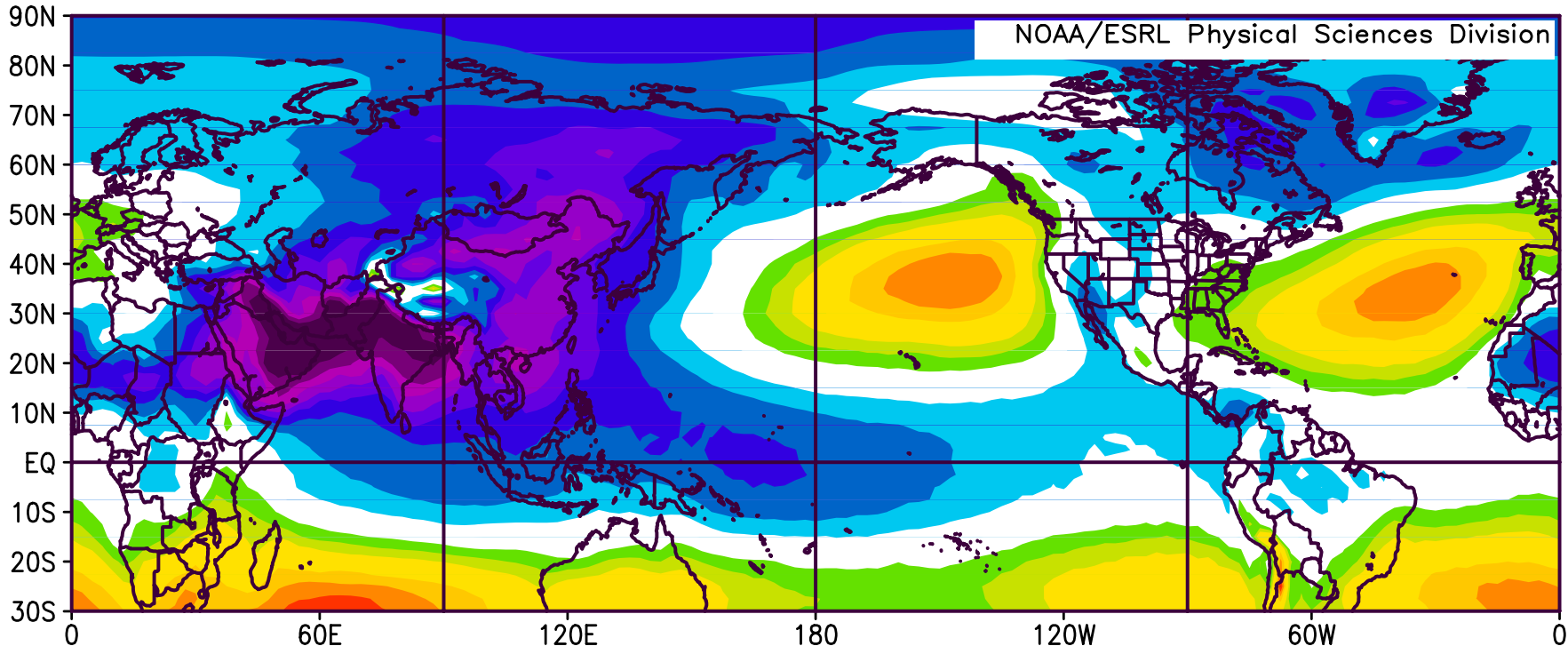
<https://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl>

units of sea level pressure: hPa or mb, hectopascals or millibars

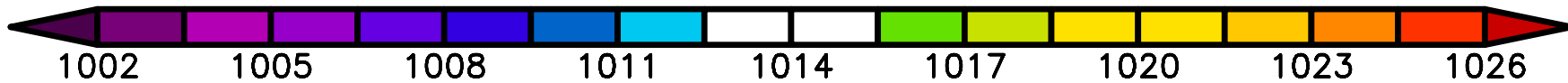
Seasonal Pressure Patterns with numbers: Summer

NCEP/NCAR Reanalysis

Sea Level Pressure (mb) Climatology 1981–2010 climo



Jun to Aug:



<https://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl>

Summary

Concepts

- **OLR, outgoing longwave radiation comes from many different levels in the atmosphere and is quite complex compared to Global Energy Balance.**
- **The water cycle is very important for moving energy around.**
- **Net excess of heat in tropics and net deficit at poles so need to transport heat to the poles.**
- **Heat transported by atmospheric storms and ocean currents**
- **Seasonal cycle of atmospheric circulation patterns (monsoon and sea level pressure)**