Global Circulations

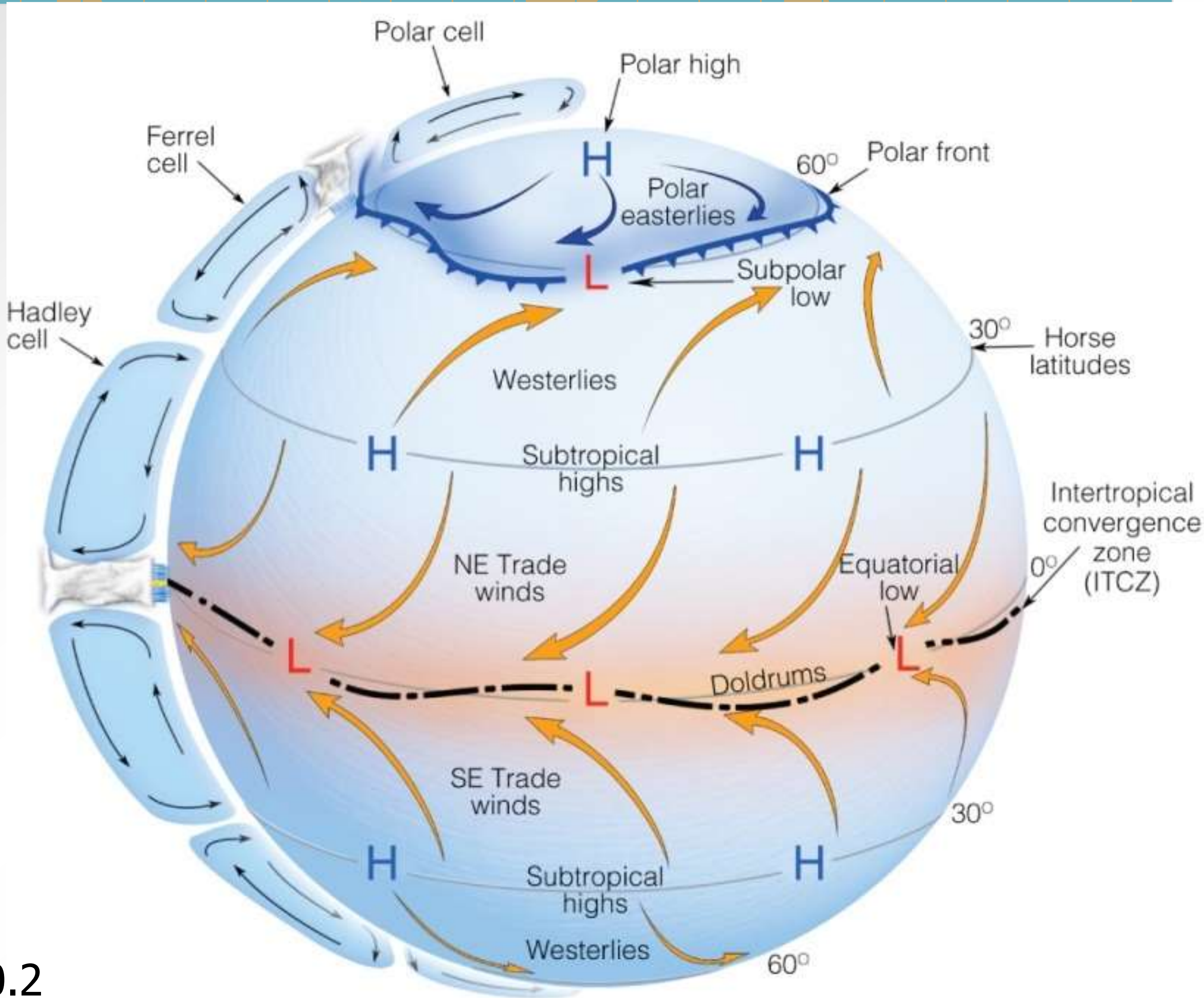
GEOG/ENST 2331 – Lecture 15

Ahrens: Chapter 10

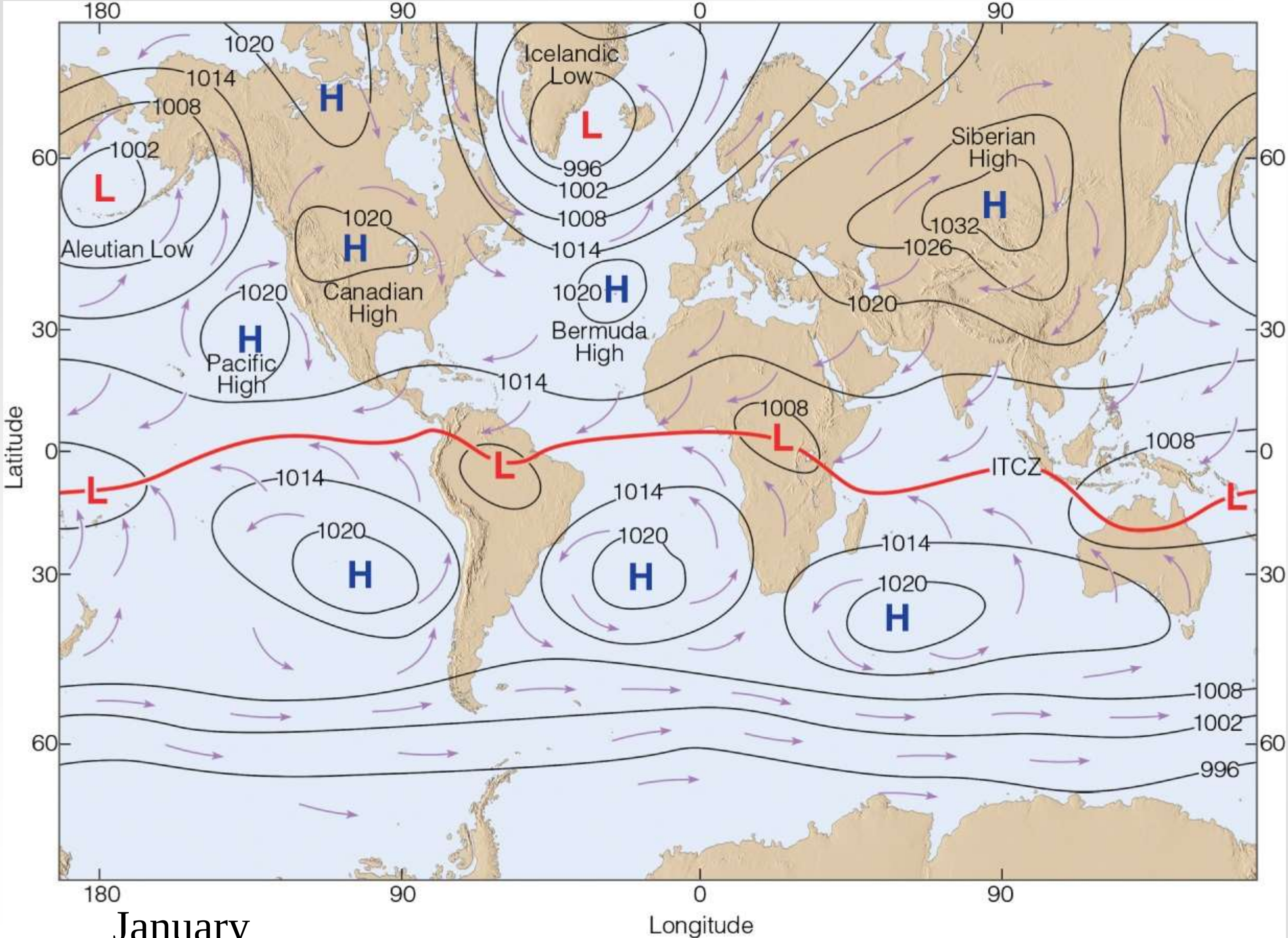
Last lecture

- Microscale (turbulence)
- Mesoscale (land/sea breeze)
- Synoptic scale (monsoon)
- Global scale (3 cell circulation)

Three Cell Model



Ahrens: Fig. 10.2



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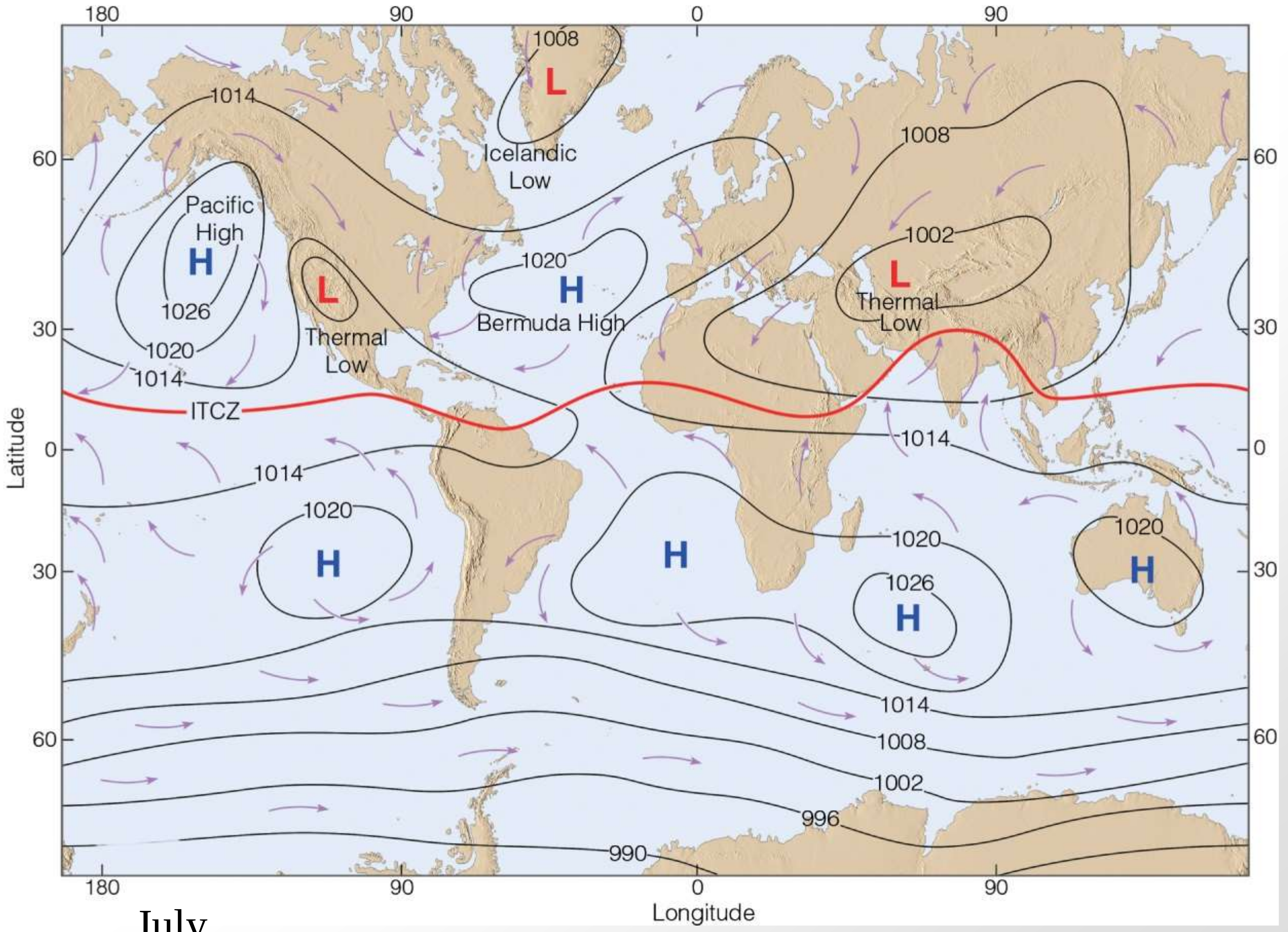
January



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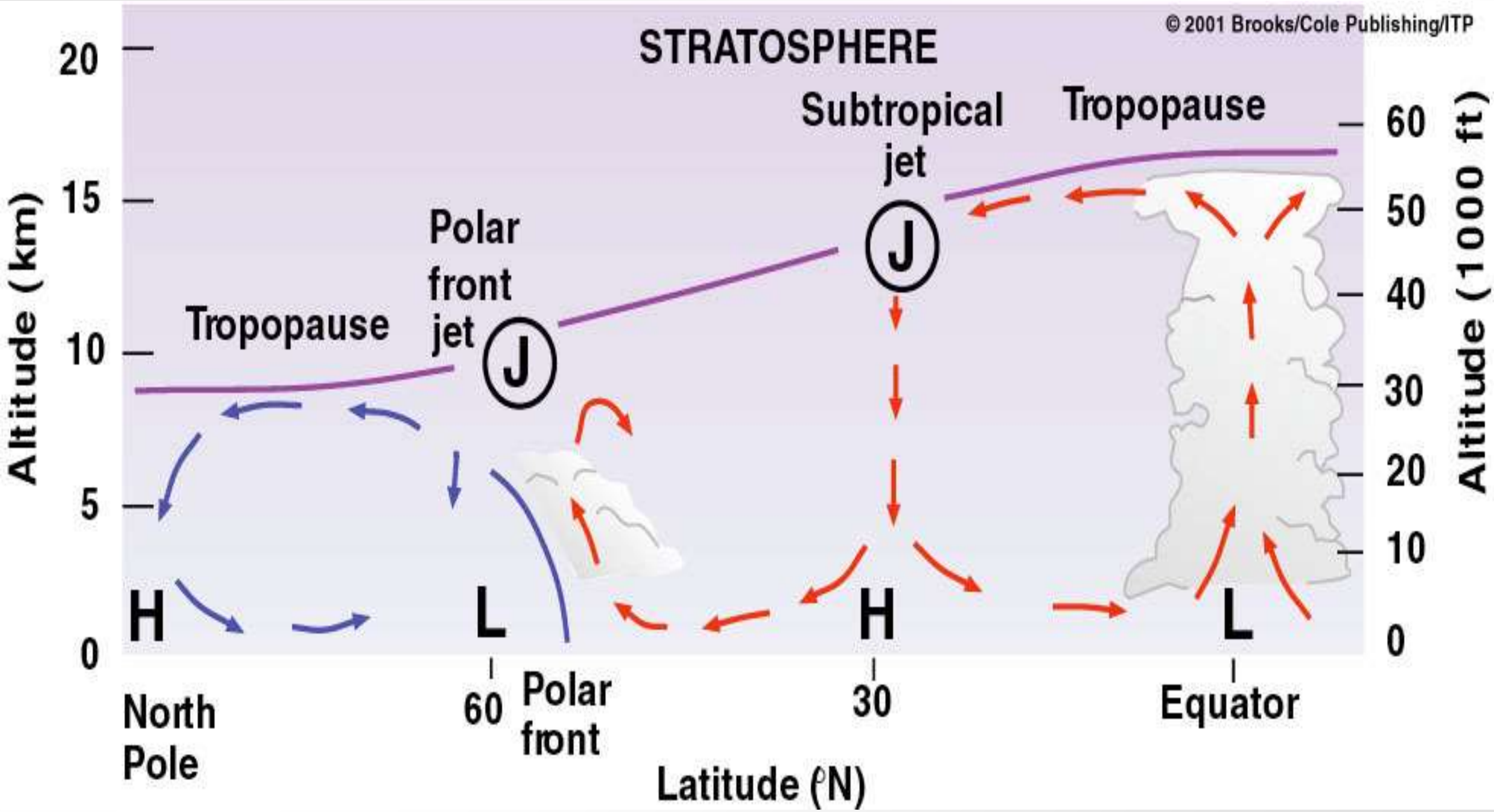
990

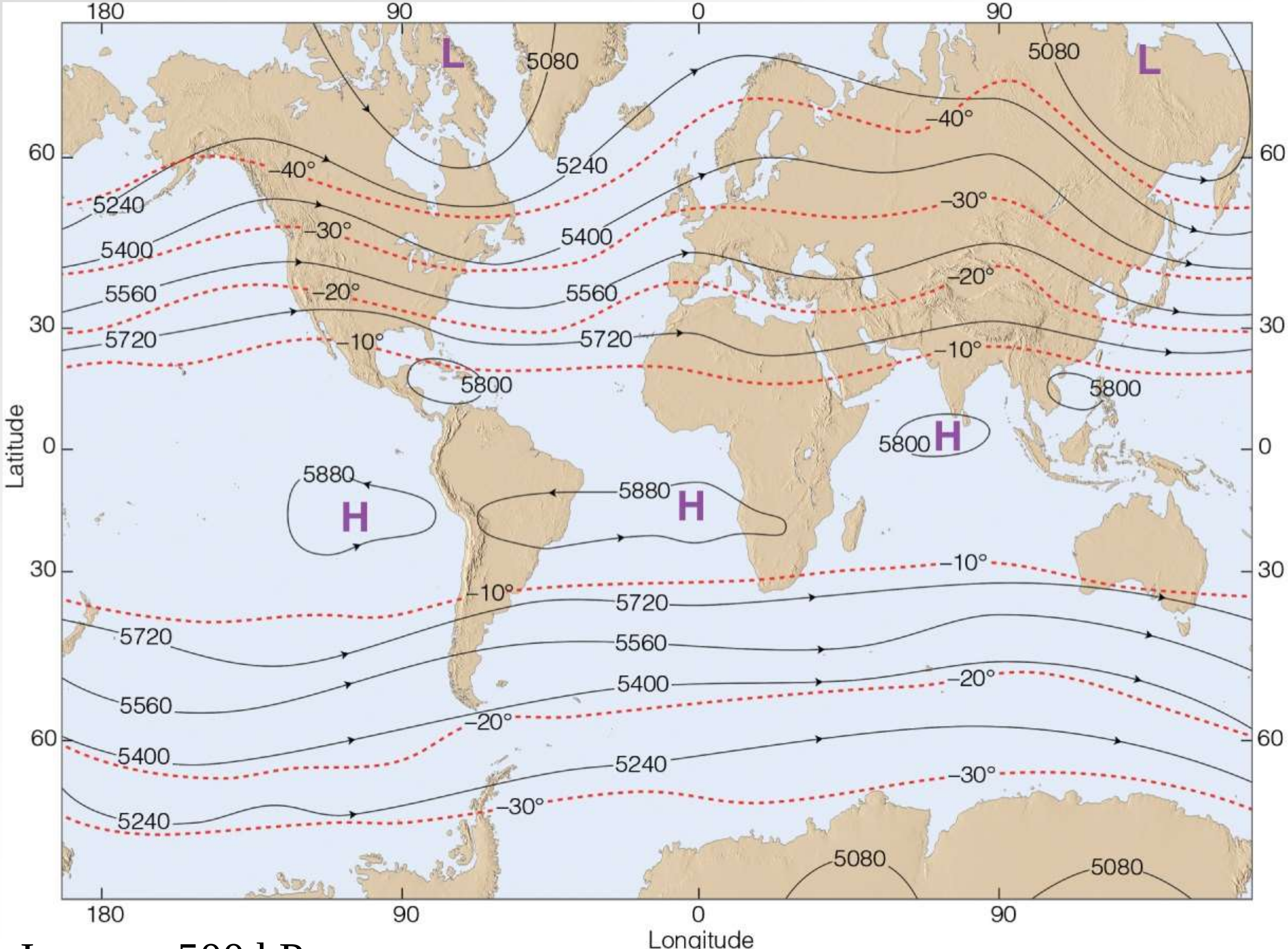
July

Upper level flow

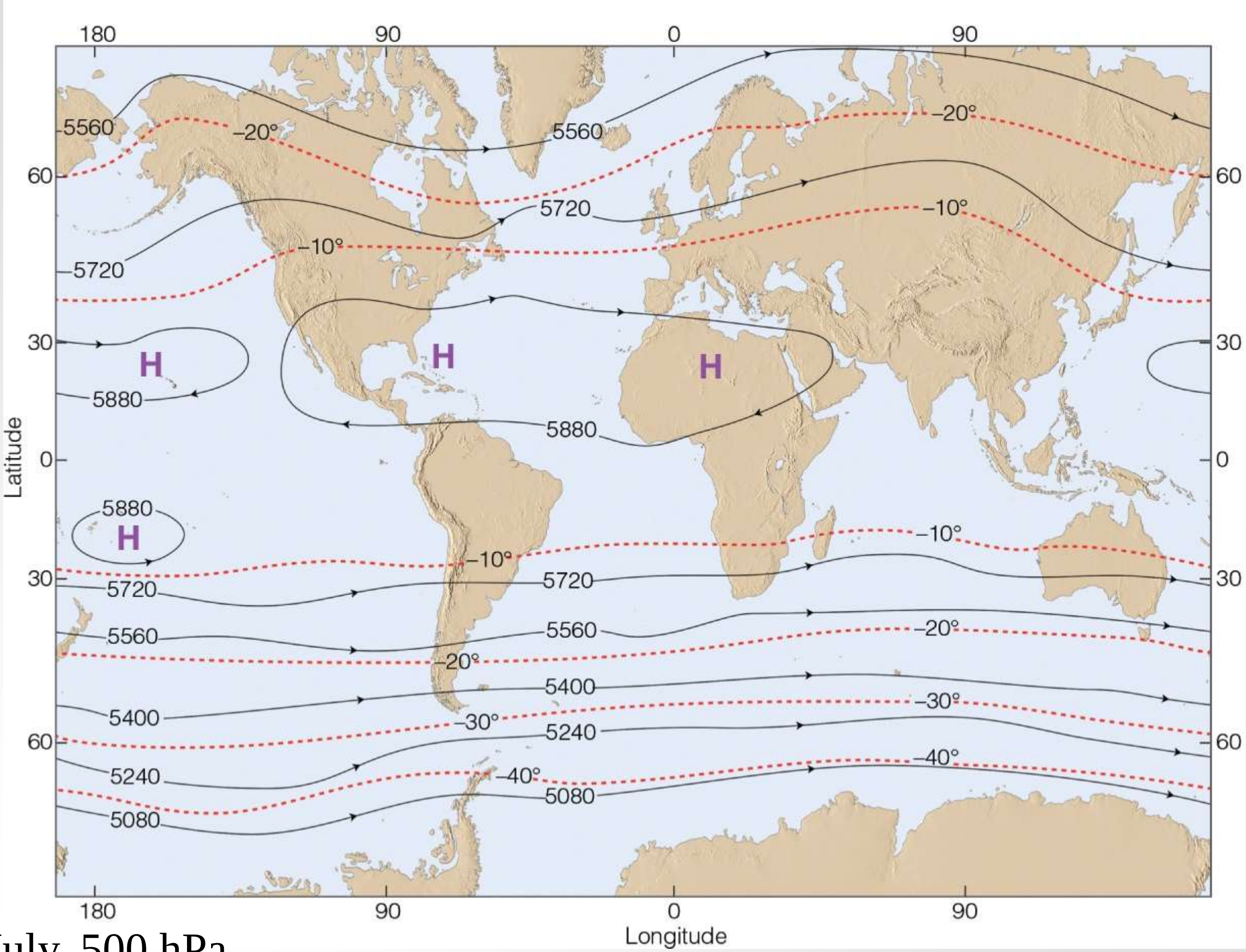
- Much less friction; winds are geostrophic
  - There is much less *meridional* heat transport
  - Strong *zonal* heat transport
- Impacts of seasons and continents
  - Circulation still shifts with the seasons
  - Land/sea contrast less evident



Ahrens: Figure 10-9



January, 500 hPa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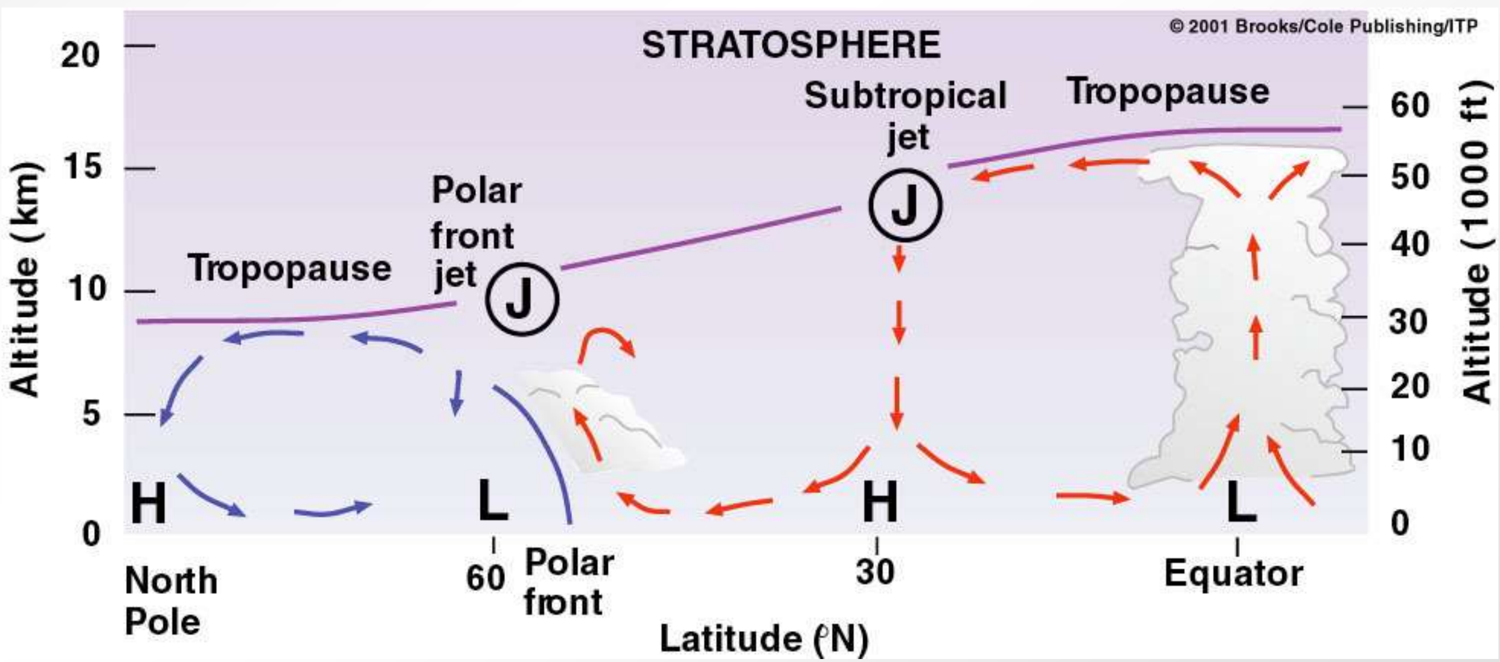
−40°
5080
5080
180
90
0
90
Longitude

July, 500 hPa

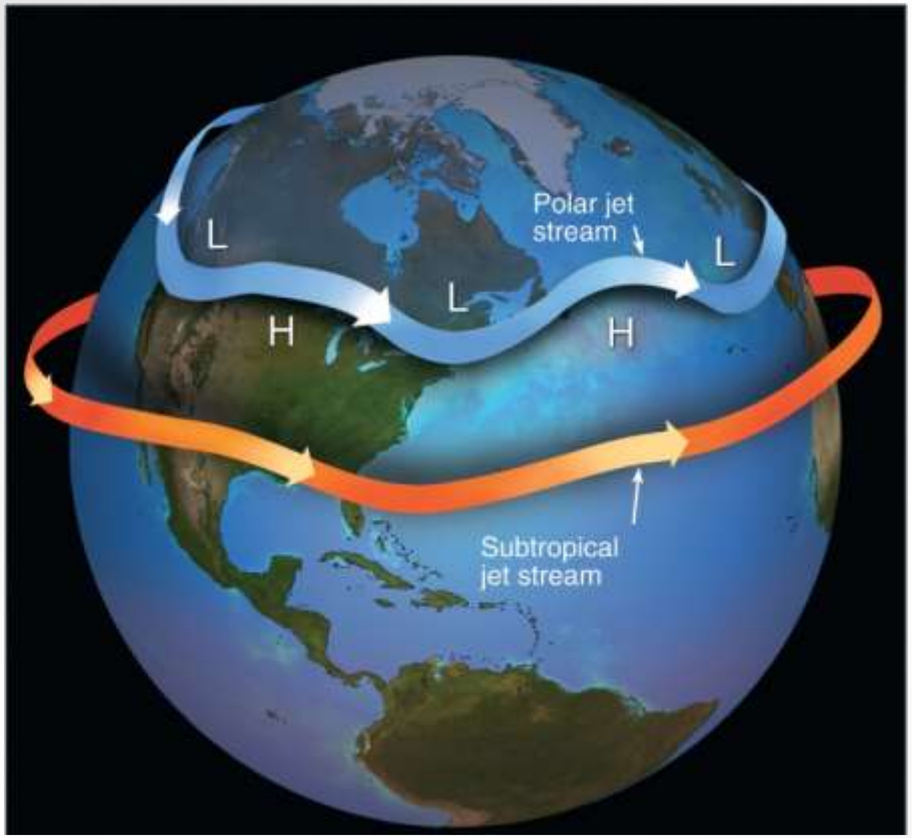
Jet Streams

Swift flowing current of air

- Thousands of km long, a few hundred km wide, a few km thick and 10-15 km above the surface.
- Speed ranges from 150 to 300 km/h.
- Jets occur at the divisions of the three cells.



Polar Jet

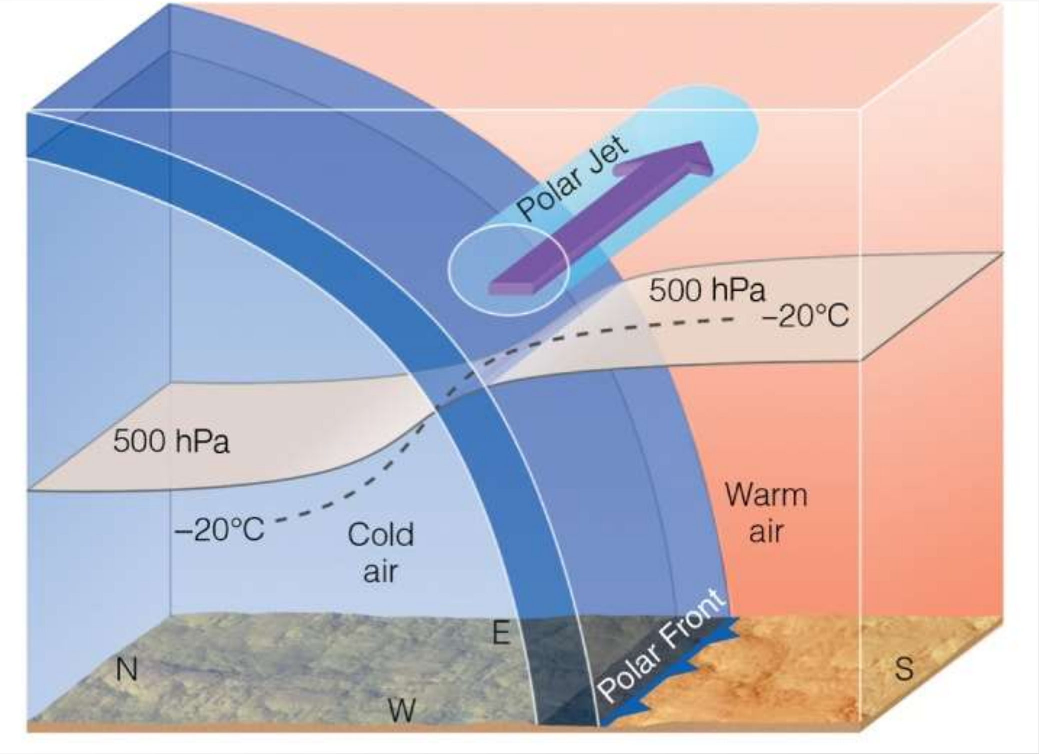


- For midlatitude regions the polar jet is more important.
- Boundary between cold and warm air.
- Surface features, such as air masses and storms, tend to follow the direction of the upper level jet stream.

Ahrens: Active Fig. 10.10

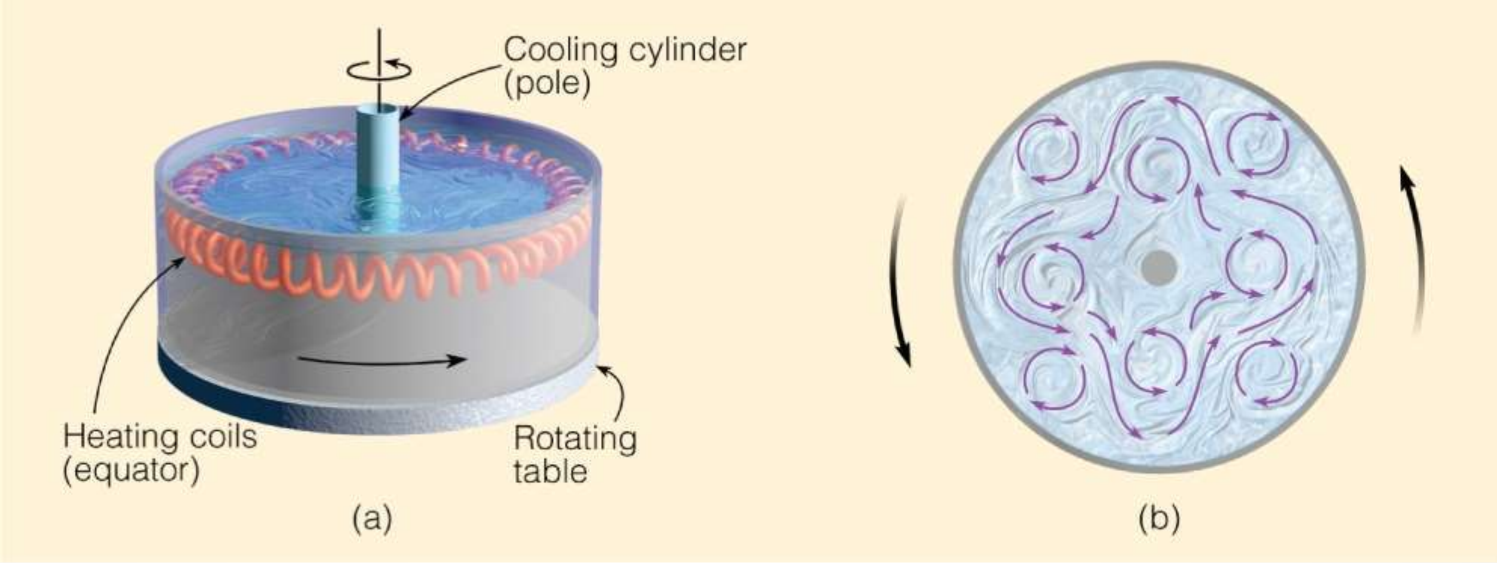
Polar Jet

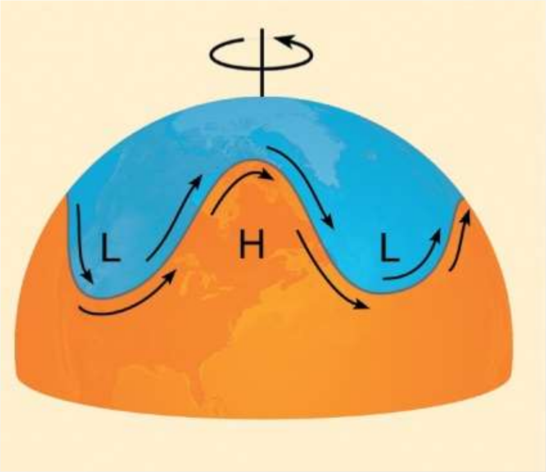
- Strong temperature gradient between Polar and Ferrel cells leads to strong horizontal pressure gradient.
- Geostrophic balance causes a strong wind parallel to isobars.



Ahrens: Fig. 10.12

The "Dishpan Experiment"





Ahrens: Figs. 1 and 2, p. 302

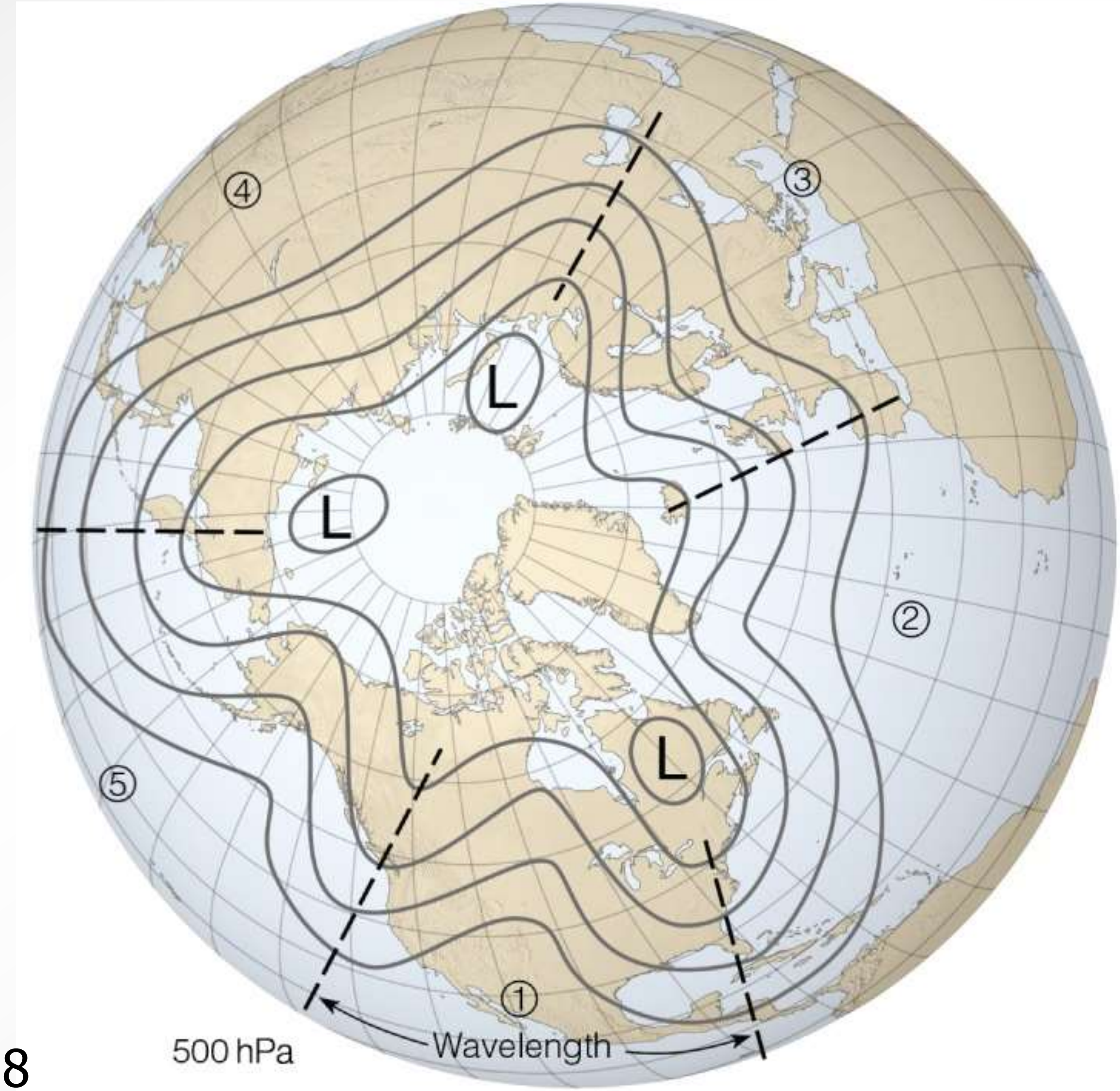
Rossby Waves

- Also known as longwaves or planetary waves

Upper air flow

- At any given time there are 3-6 Rossby waves.

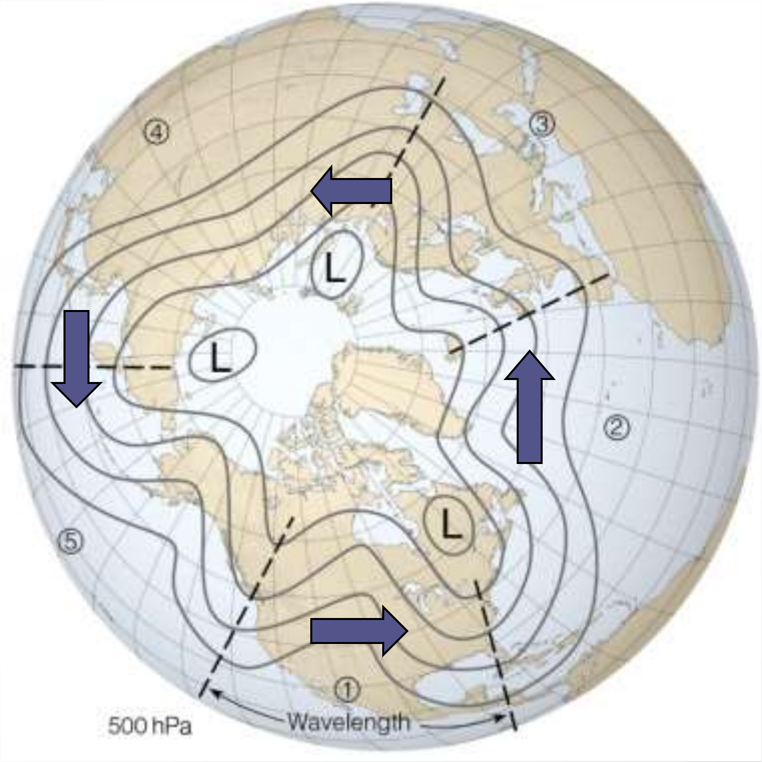
C.G. Rossby – famous meteorologist in early 20th Century.



Ahrens: Fig. 12.8

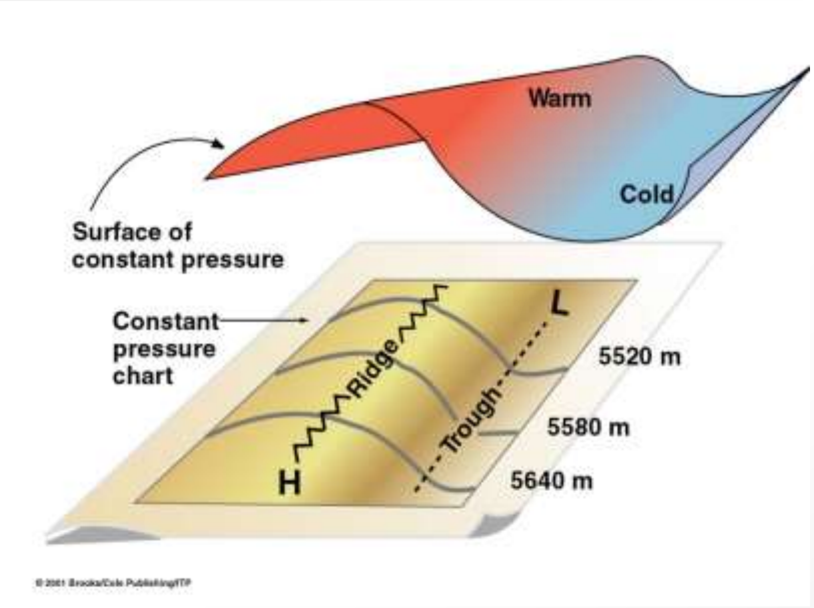
Rossby Waves

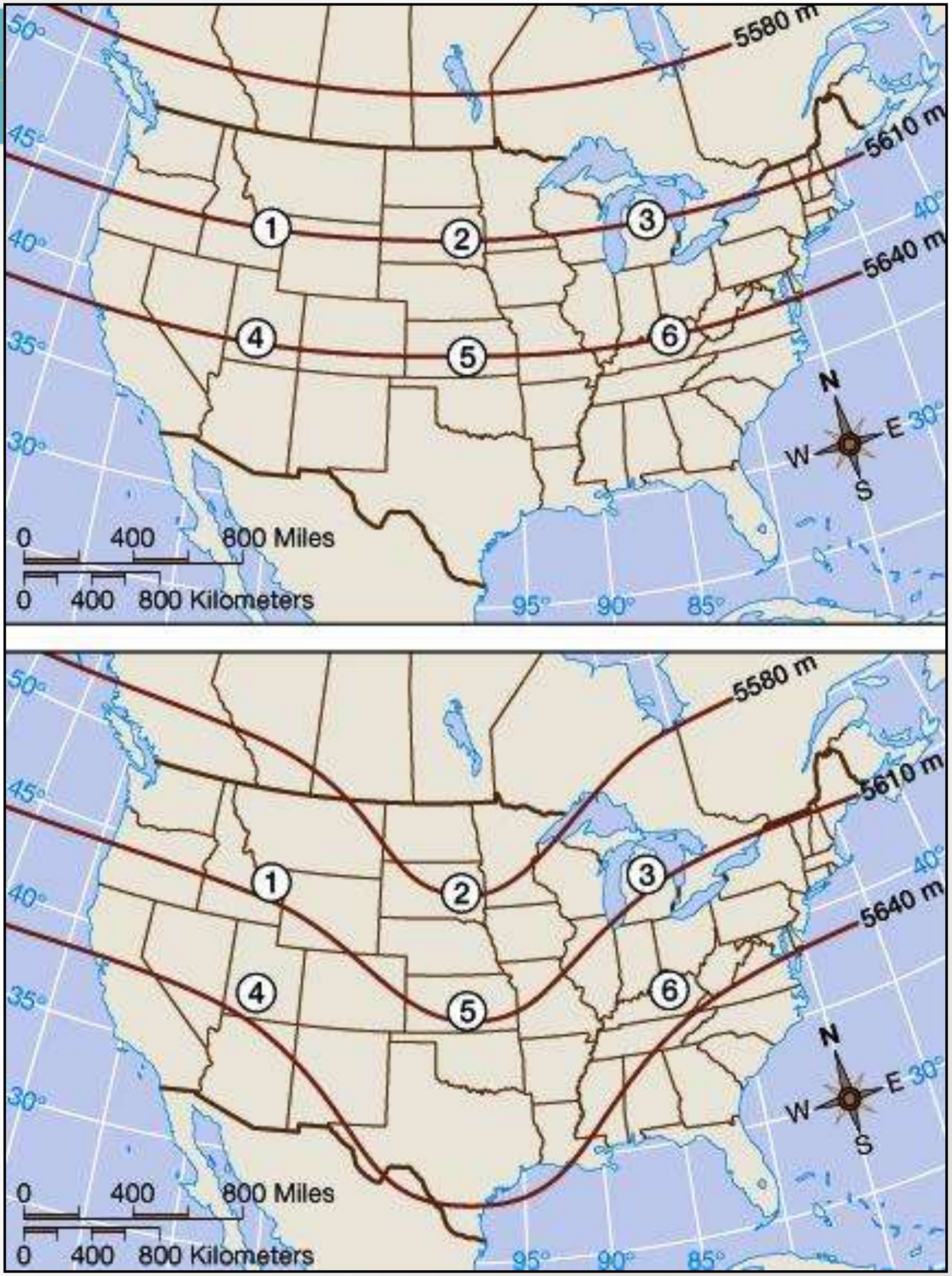
- Slow moving
  - Can be stationary for months
  - Migrate slowly west to east
  - Sometimes east to west
- Winter
  - Waves are fewer, longer, stronger



Troughs and Ridges

A&B: Figure 8-11

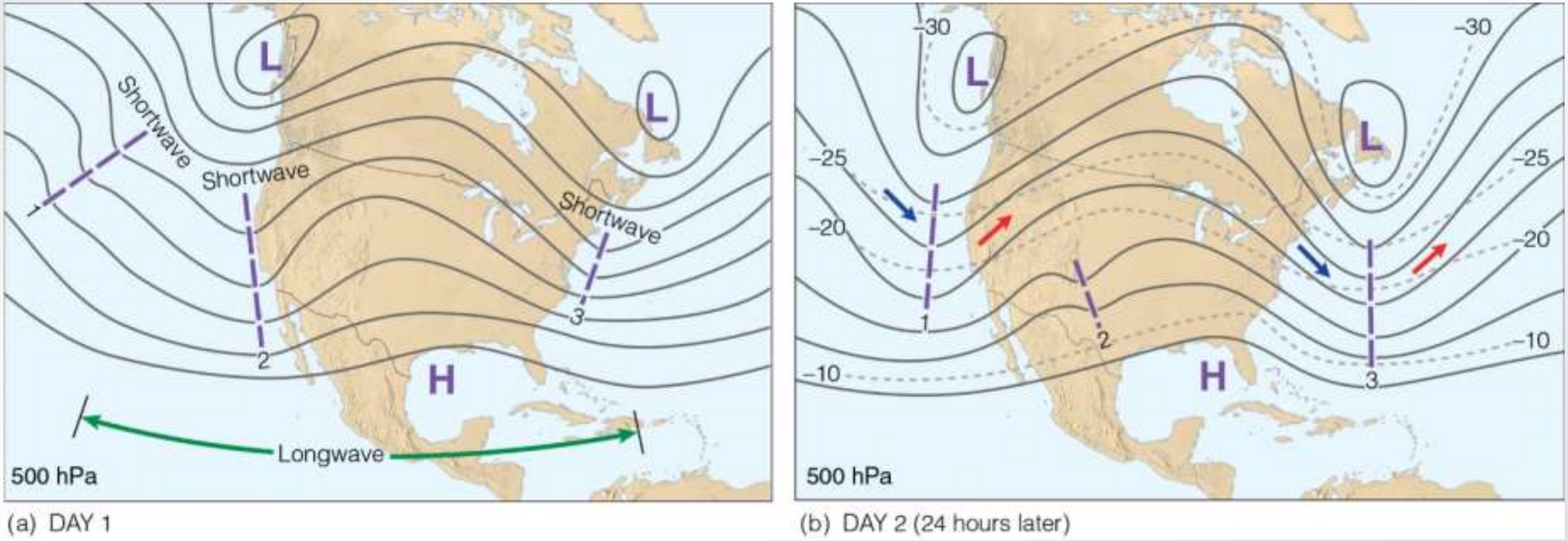




Shortwaves

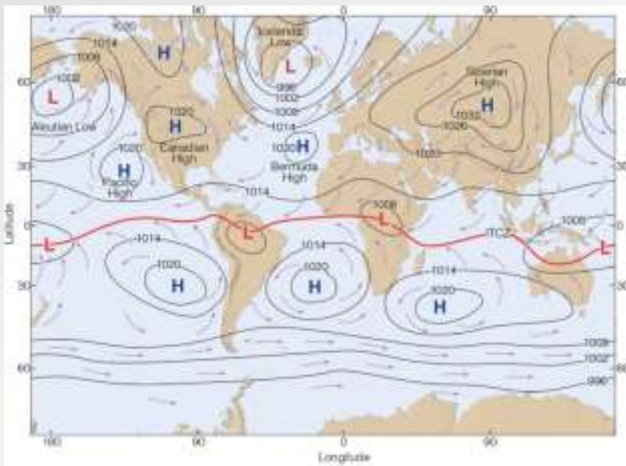
- Small disturbances or ripples embedded in Rossby waves,
- Faster-moving and travel eastward along the Rossby waves.
- Shortwaves become stronger near the troughs and weaker near the ridges of Rossby waves.

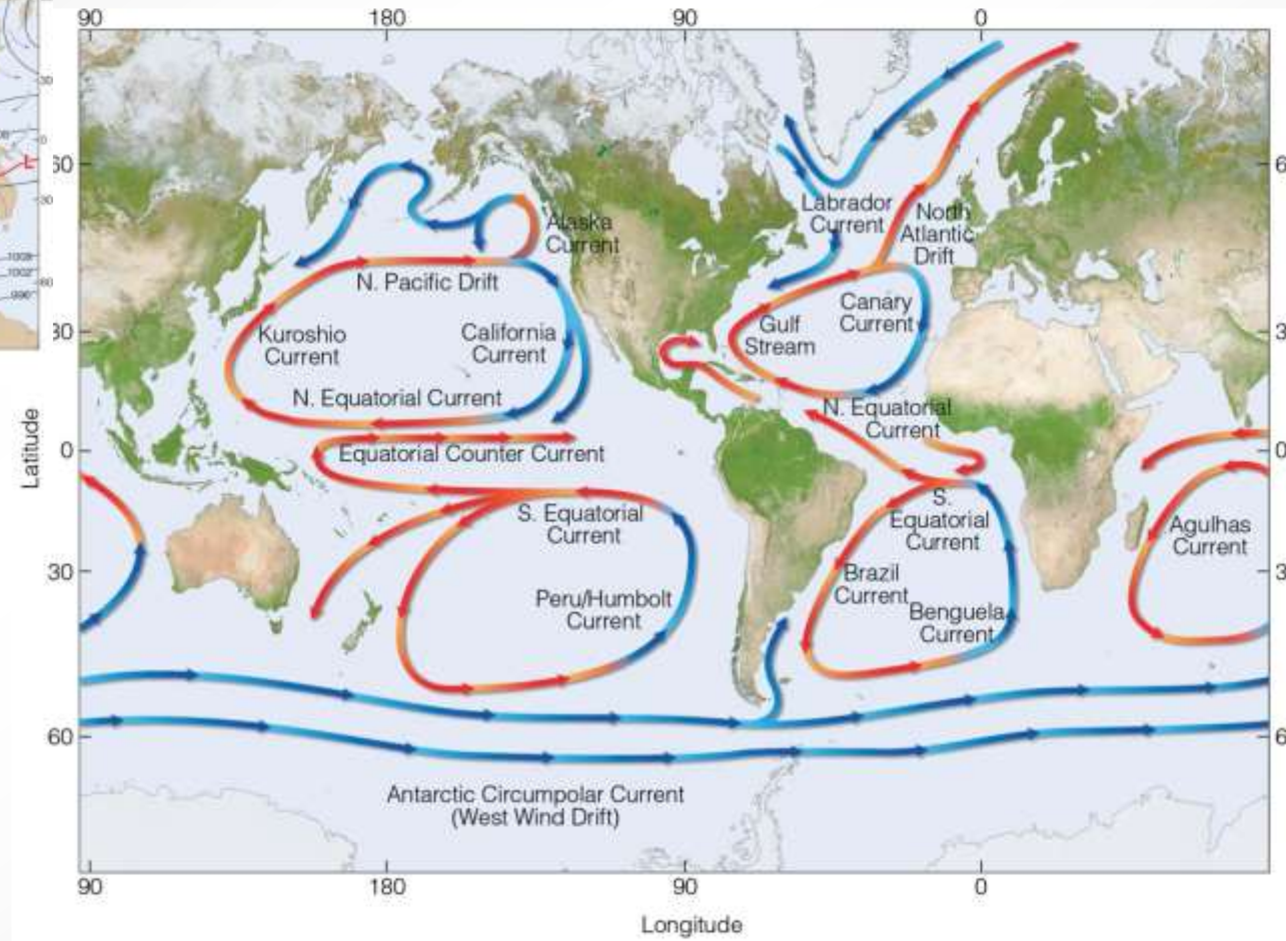
Shortwaves and Longwaves (Rossby waves)



Ahrens: Active Fig. 12.9

Global Ocean Circulation





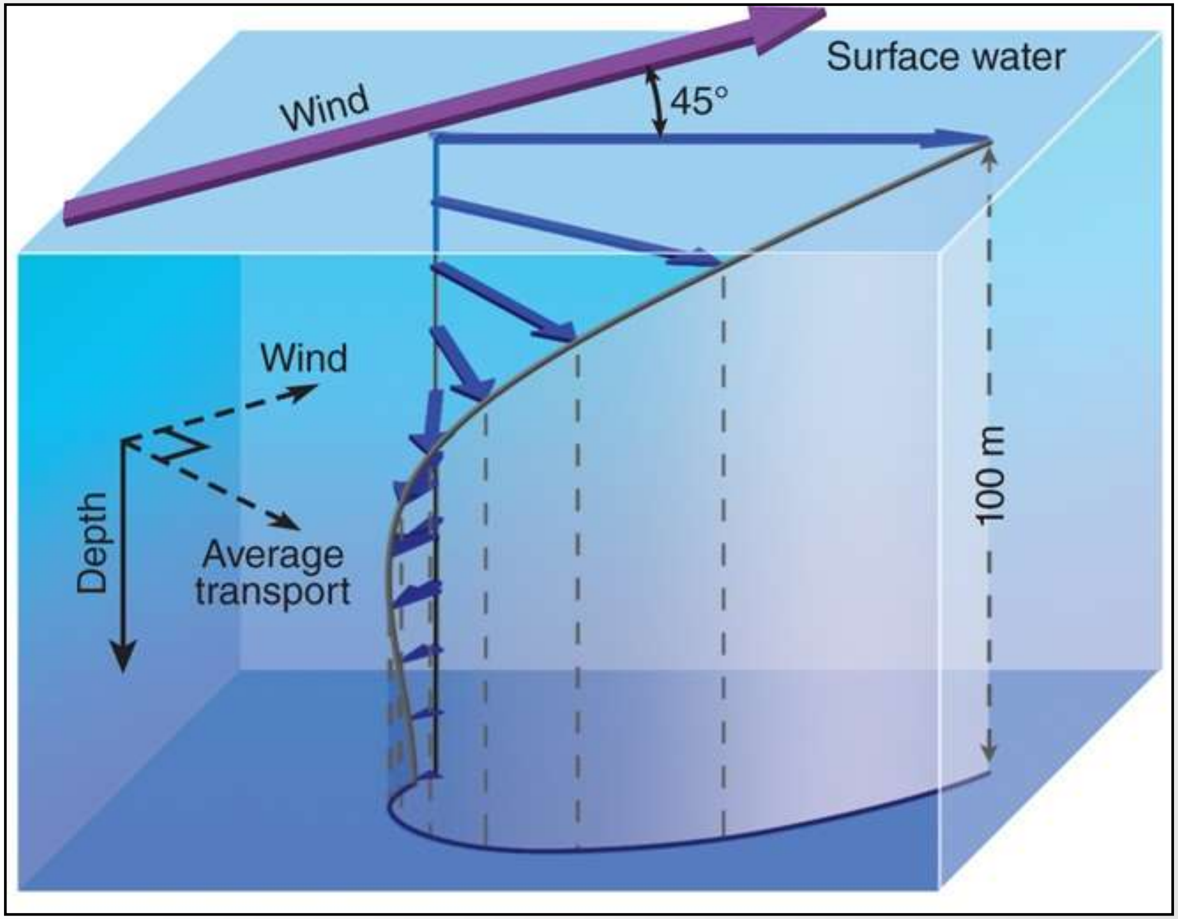
Ahrens: Fig. 10.14

Ekman Spiral

Wind drag pushes the surface waters 45° to the right (in the NH)

Deeper water is dragged along at successively greater angles

Around 100 m direction is opposite surface winds and current dies out

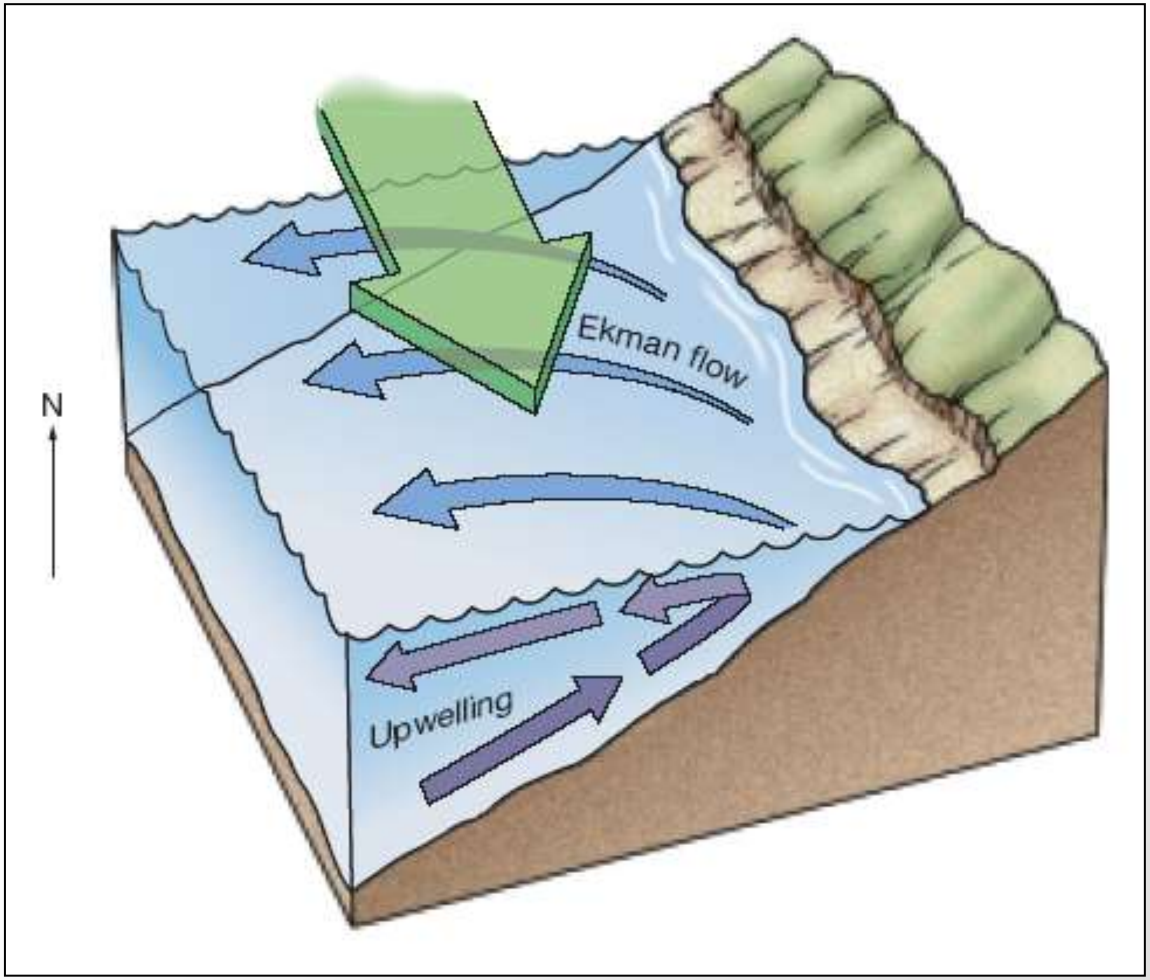


Ahrens: Fig. 10.17

Upwelling

Offshore winds, and even parallel-to-shore winds drag away the surface water and cause upwelling of **cold**, nutrient-rich water from below.

A&B: Figure 8-17

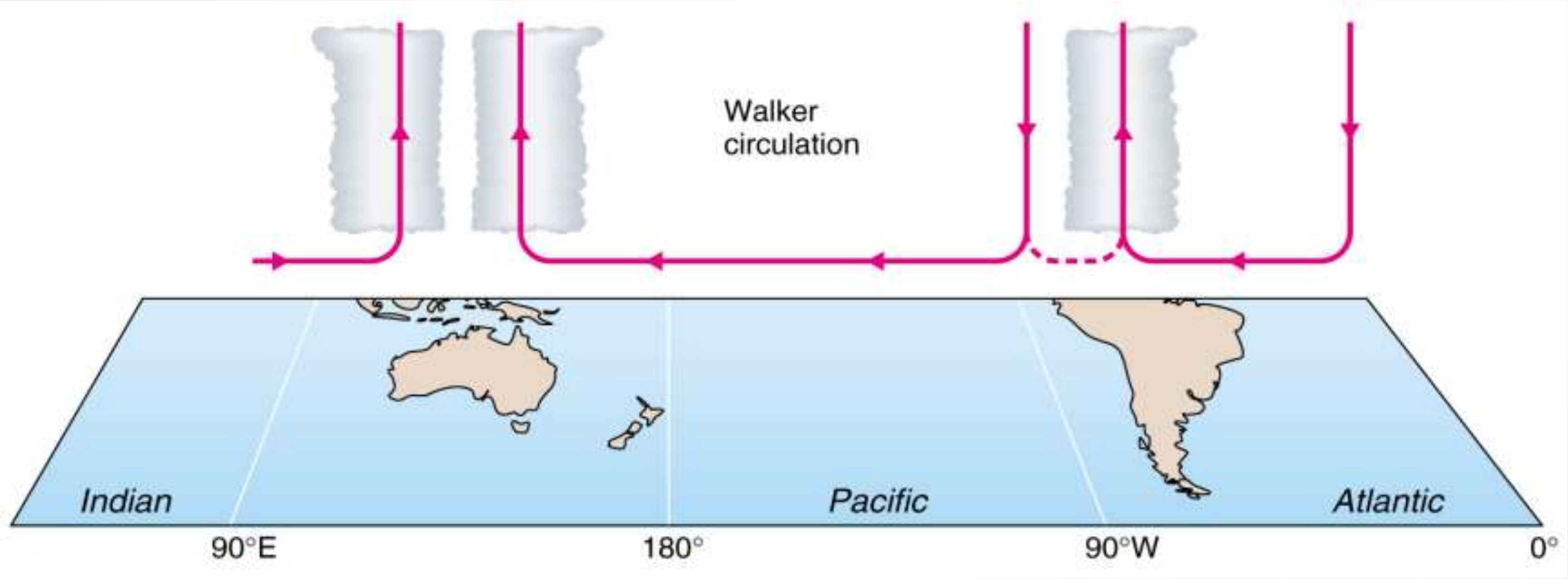


ENSO

El Niño / Southern Oscillation

- 4 to 7 year oscillation in tropical Pacific Ocean temperatures and associated changes in atmospheric circulation
- Multiple causes: linked to changes in the Asian monsoon season, long-range transport of sub-surface waves, etc.
- Irregular cycle
- Once in process weather predictions for the next season or two can be made, often with considerable accuracy.

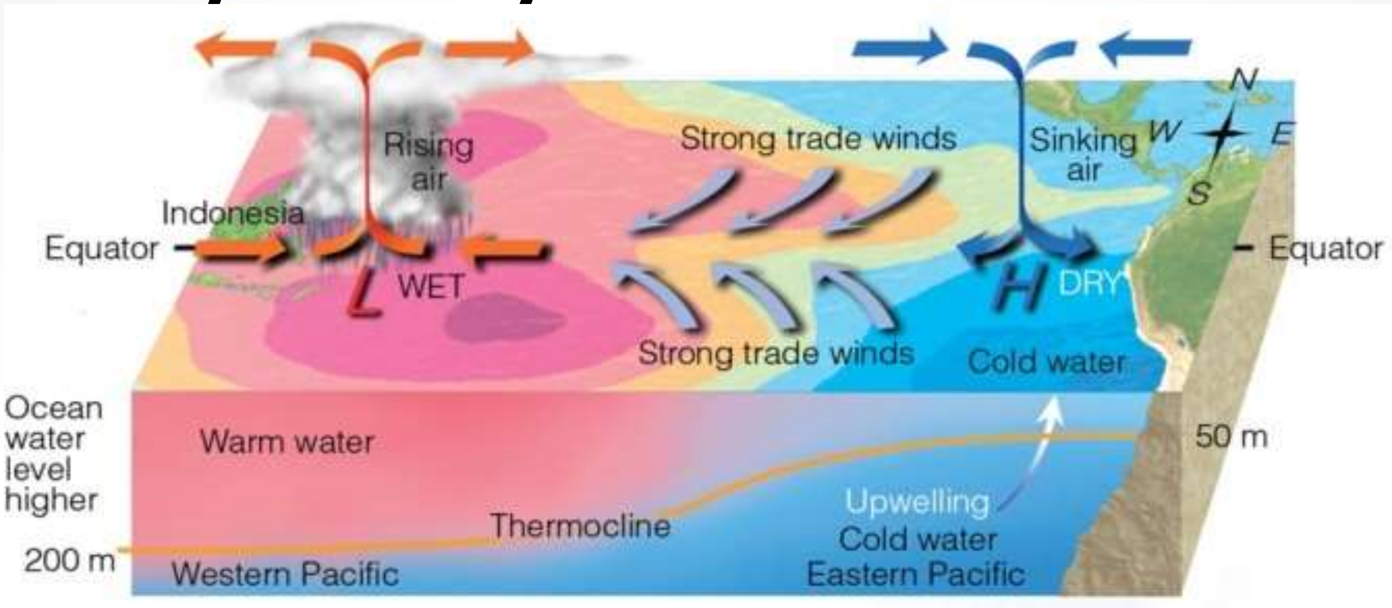
The "Normal" Walker Circulation



A&B: Figure 8-27

Walker Circulation

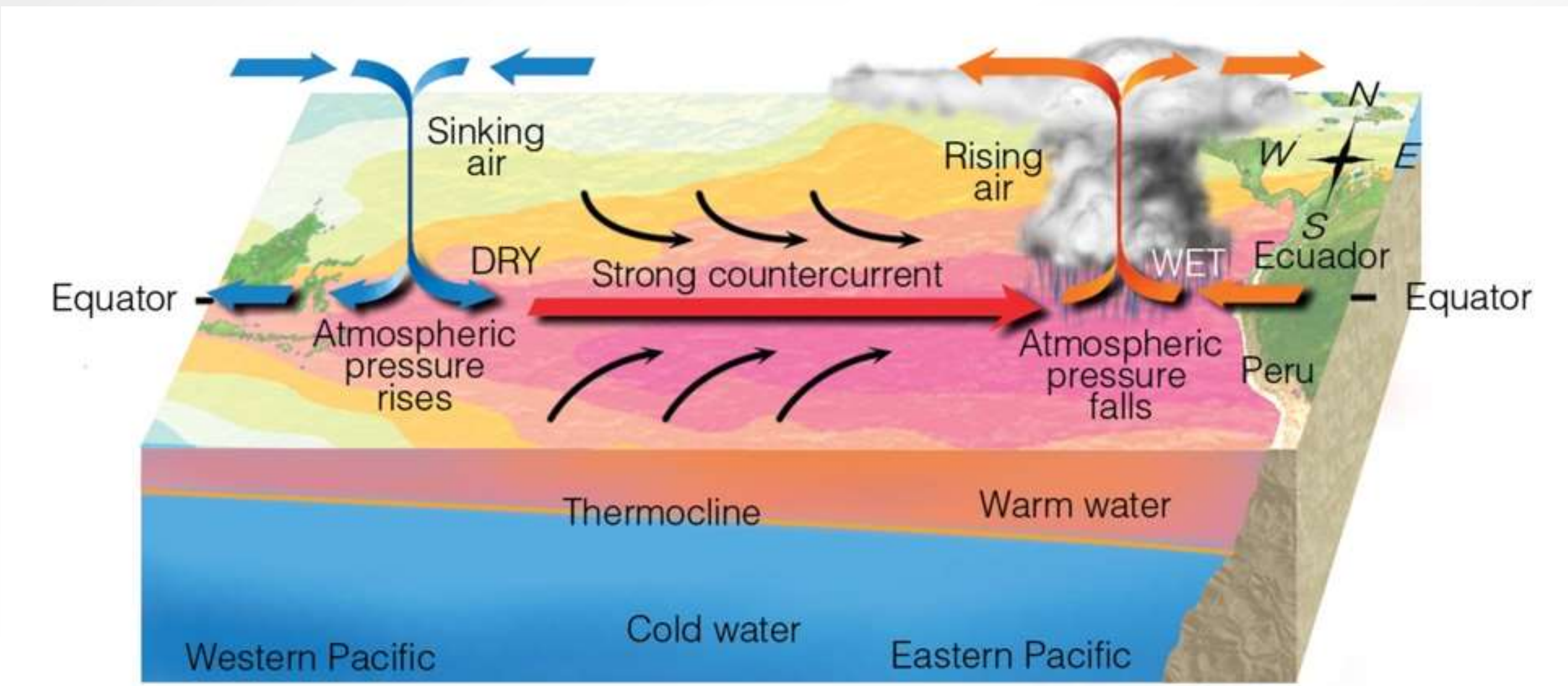
- Easterly trade winds
- Low pressure, rising air and heavy rain over western Pacific
- Winds push surface water away from South America, causing cold water to well up from below
- **Particularly intense years are called La Niña**

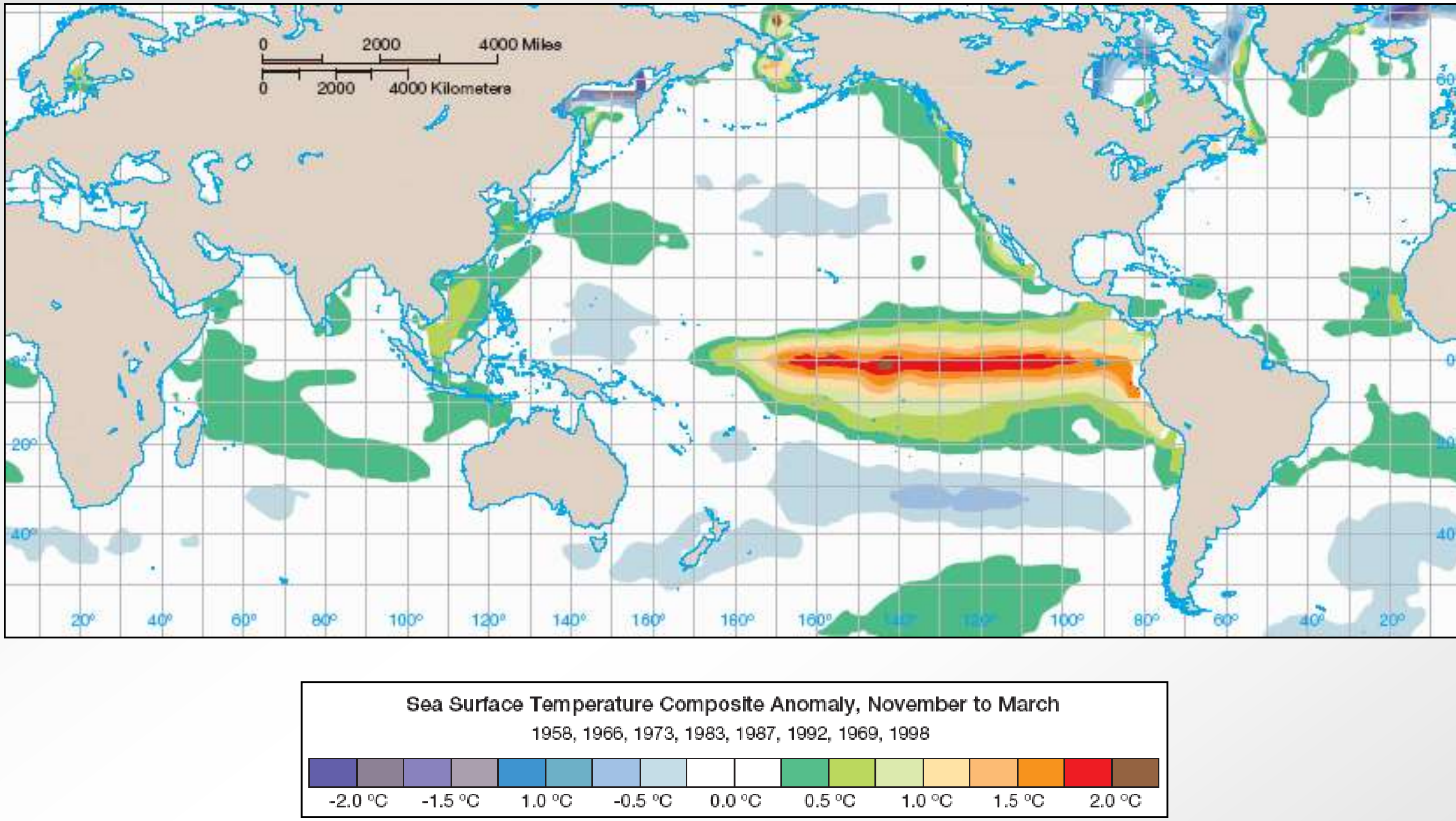


Ahrens: Fig. 10.19

El Niño

- Winds weaken or reverse
- High pressure, subsiding air, drought over western Pacific
- Upwelling in eastern Pacific stops, surface temperatures rise



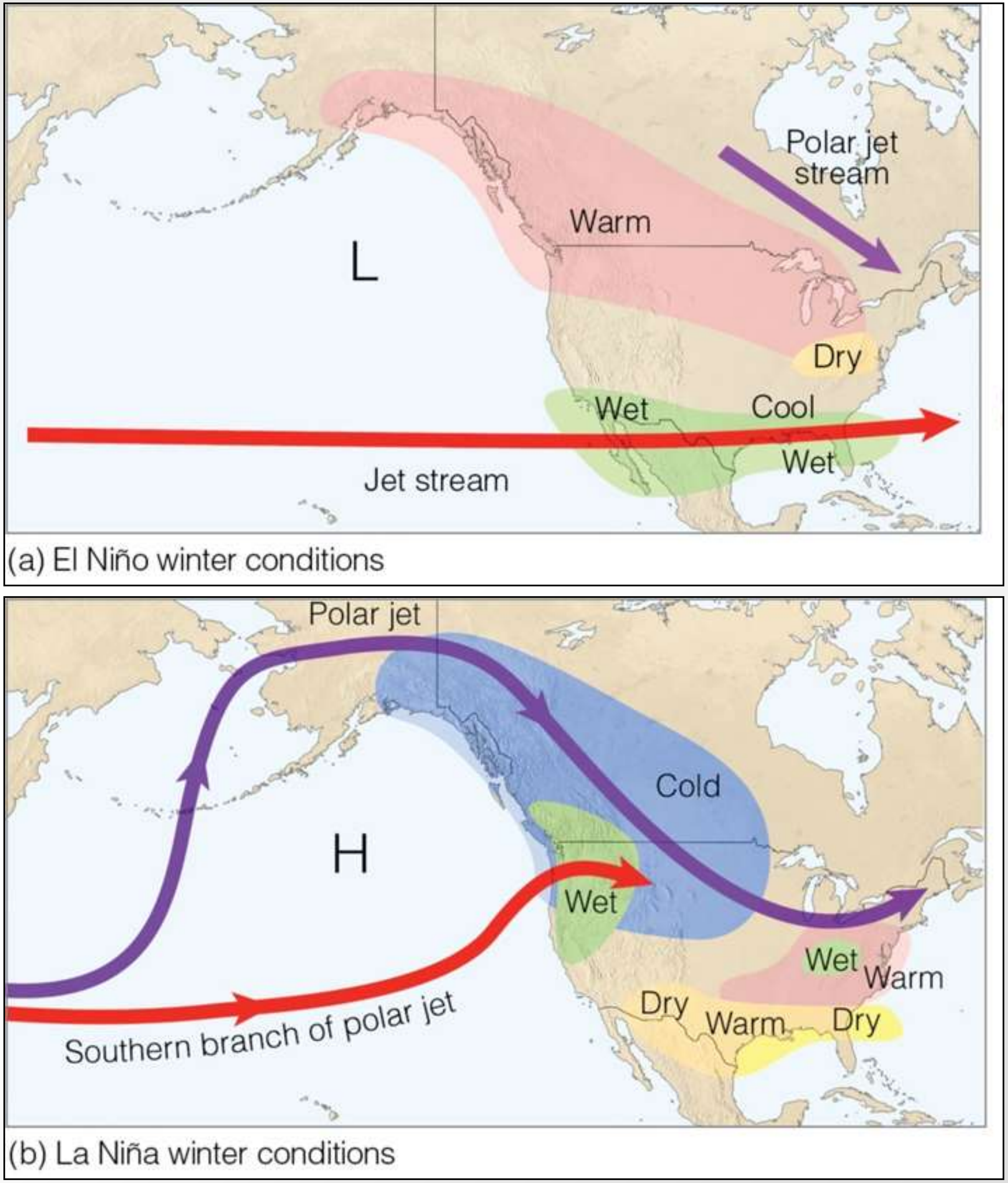


Average sea surface temperature differences from normal during the November through March period for eight El Niño episodes. A&B: Figure 8-29

Teleconnections

Relationships between climatic patterns at widely separated locations

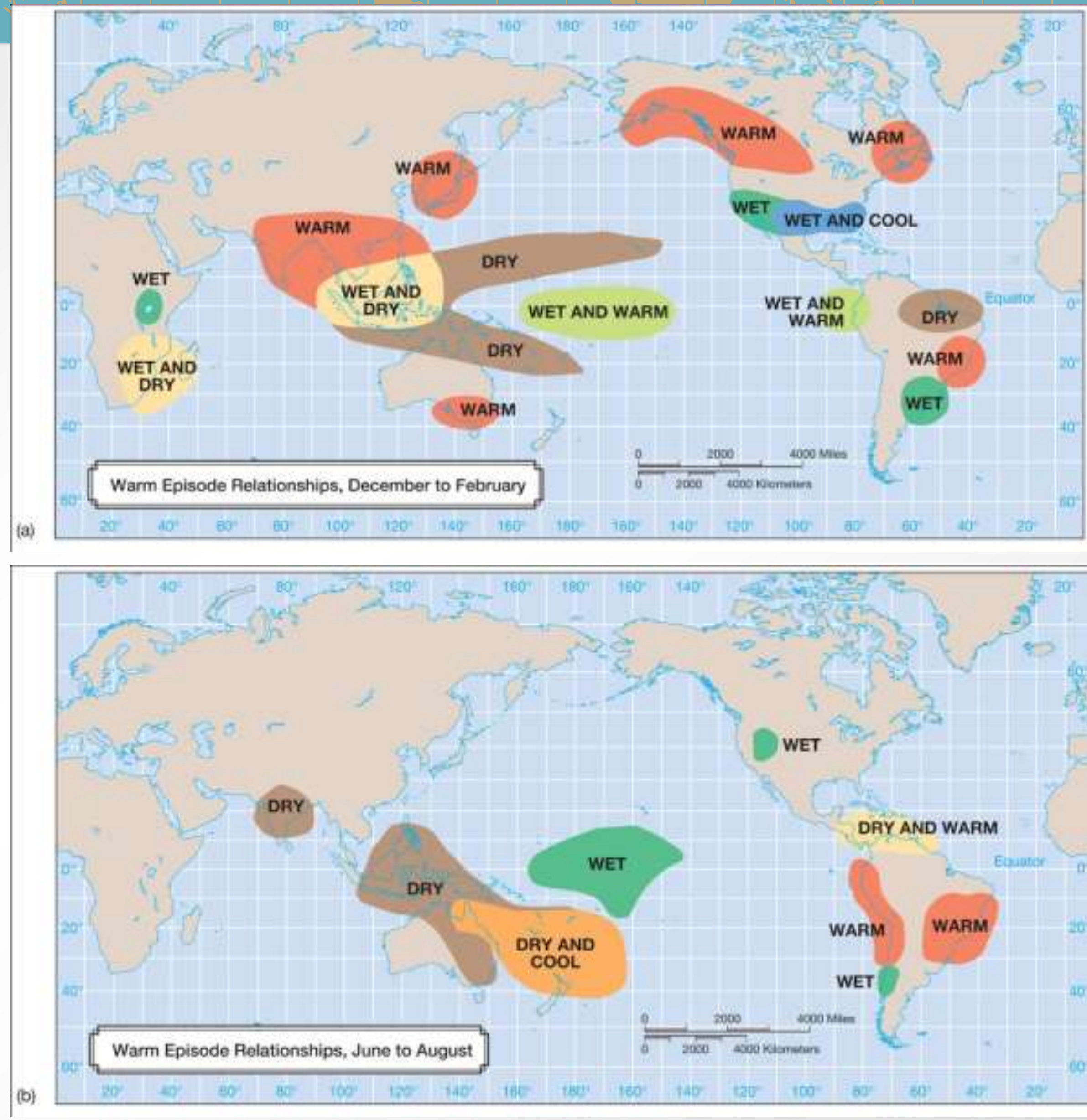
ENSO affects upper level flow and position of jet streams.



Ahrens: Fig. 10.23

Impacts of El Niño

A&B: Figure 8-35



Blocking (associated with ENSO)

Example of an omega block over western North America – Warmer and drier within the block

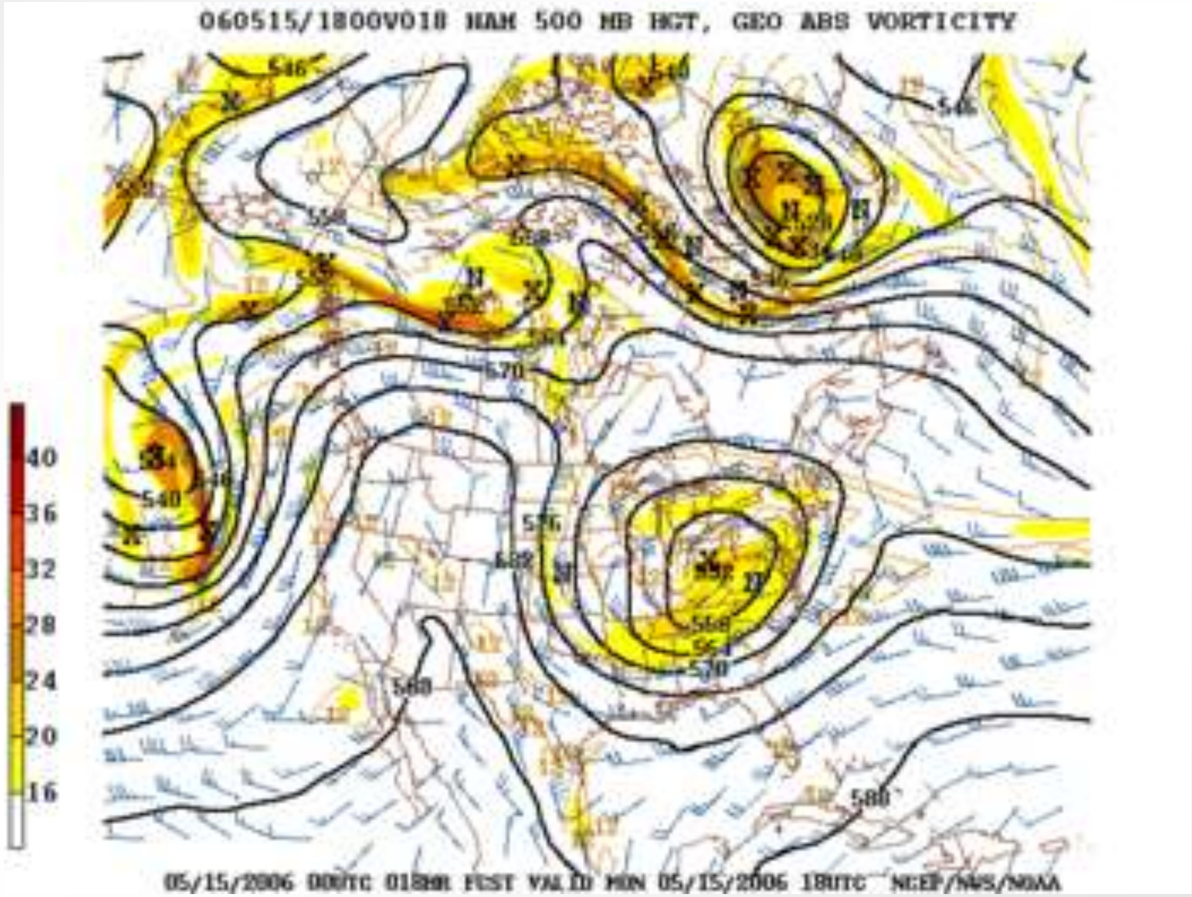
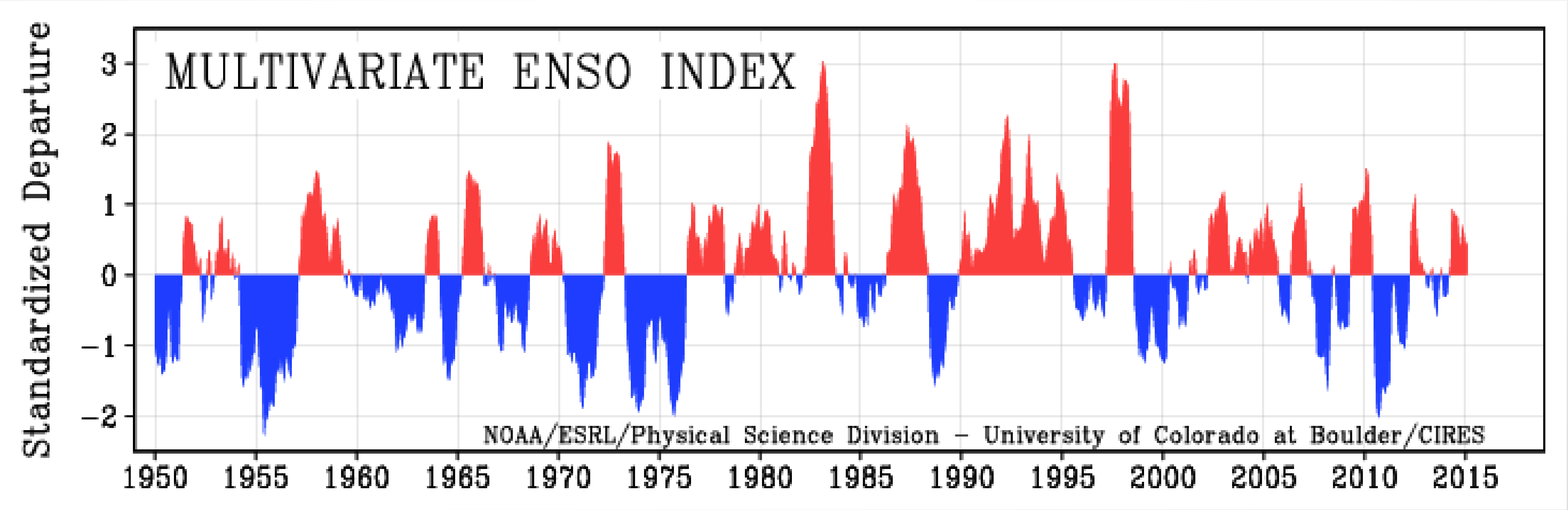


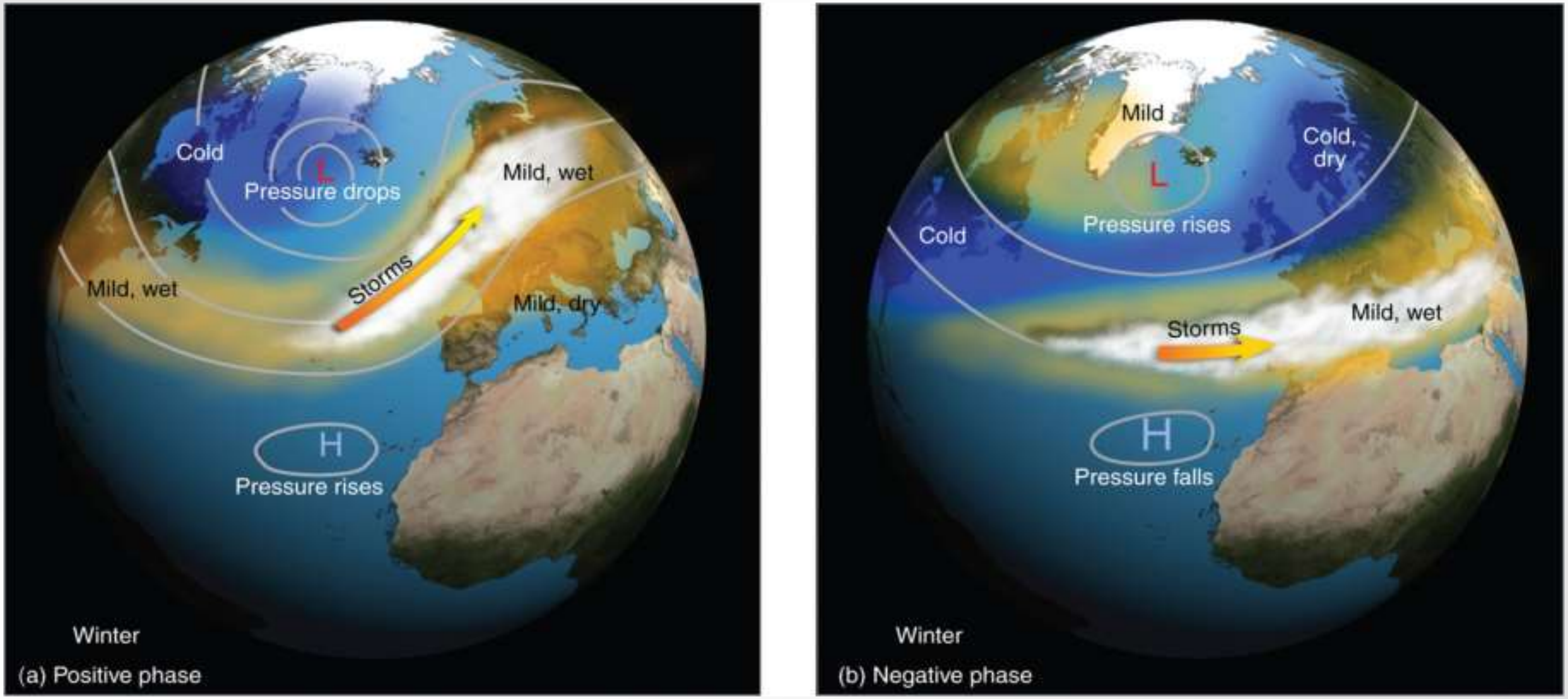
Figure May 2006

ENSO Index

- Strong positives are El Niño
- Strong negatives are La Niña



North Atlantic Oscillation (NAO)

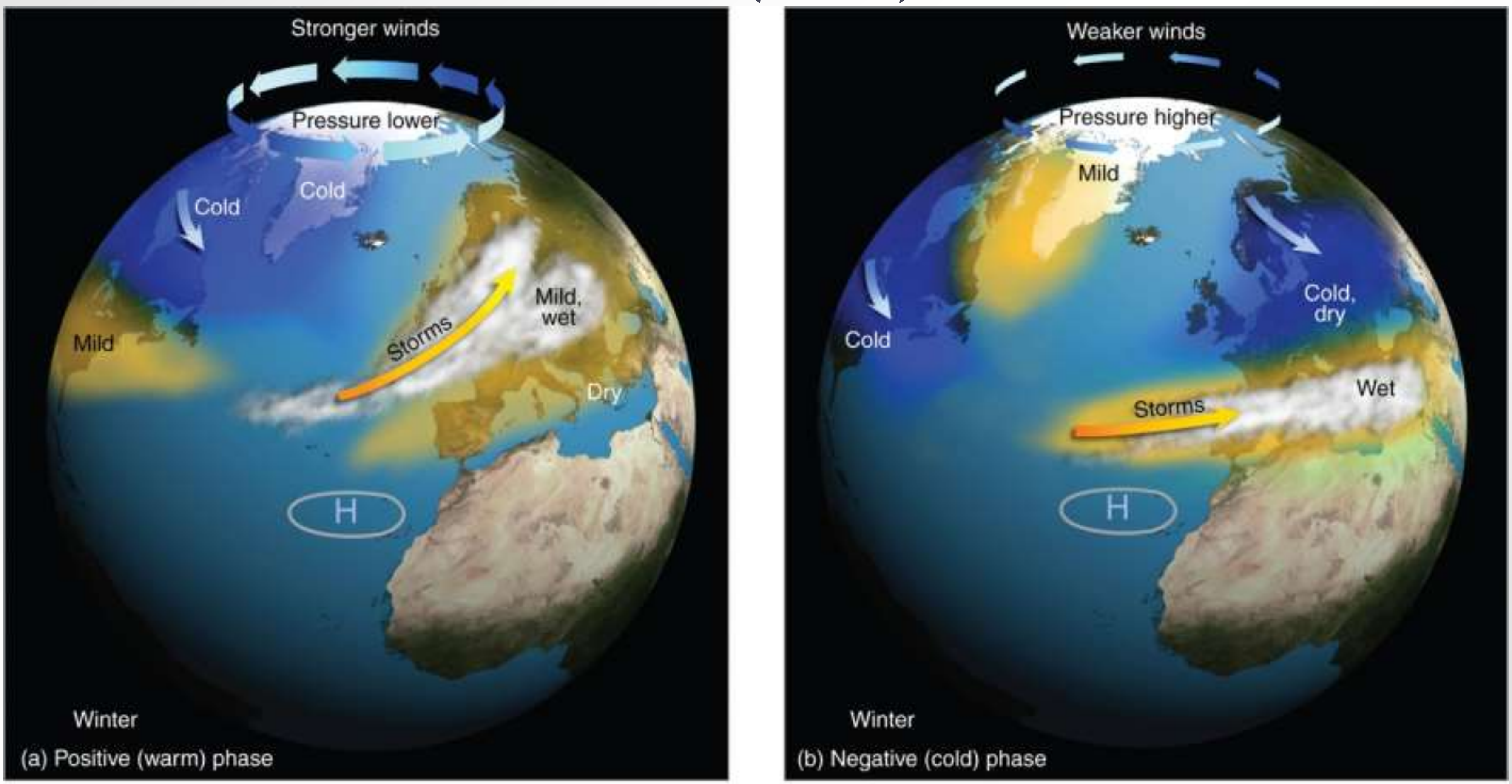


Positive

Negative

Ahrens: Fig. 10.27

Arctic Oscillation (AO)



Positive

Negative

Ahrens: Fig. 10.28

Next lecture

- Air Masses and Fronts
- Ahrens: Chapter 11