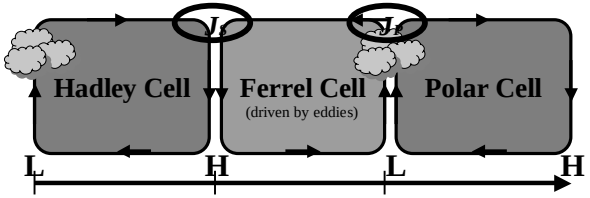
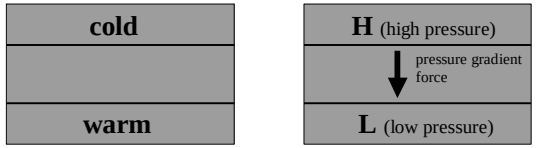
Lecture 5: Climate Tapestry



- Pressure and Wind
- Global Wind Patterns
- Effect of Earth's Rotation On Winds

Thermal Energy to Kinetic Energy



(on a horizontal surface)

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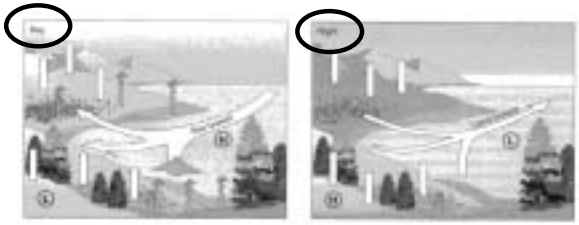
Sea/Land Breeze



- Sea/land breeze is also produced by the different heat capacity of land and ocean surface, similar to the monsoon phenomenon.
- However, sea/land breeze has much shorter timescale (day and night) and space scale (a costal phenomenon) than monsoon (a seasonal and continental-scale phenomenon).

(figure from *The Earth System*)

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Santa Ana Wind

DEFINITION

Strong warm and dry winds blow over the southern California from the Great Basin, with speeds exceed 25 knots (46 km/hr).

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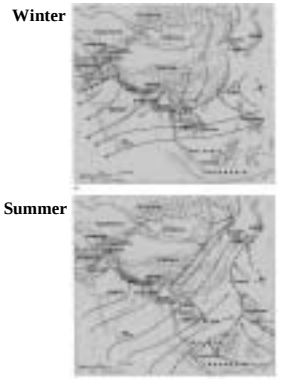
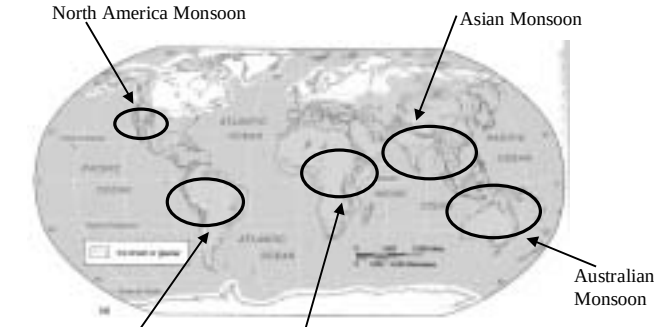
Monsoon: Another Sea/Land-Related Circulation of the Atmosphere



- Monsoon is a climate feature that is characterized by the ***seasonal reversal in surface winds***.
- The very different heat capacity of land and ocean surface is the key mechanism that produces monsoons.
- During summer seasons, land surface heats up faster than the ocean. Low pressure center is established over land while high pressure center is established over oceans. Winds blow from ocean to land and bring large amounts of water vapor to produce heavy precipitation over land: A rainy season.
- During winters, land surface cools down fast and sets up a high pressure center. Winds blow from land to ocean: a dry season.

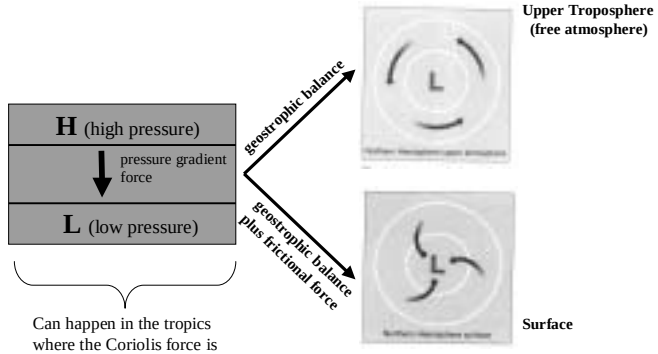
(figures from *Weather & Climate*)

How Many Monsoons Worldwide?



(figure from *Weather & Climate*)

Balance of Force in the Horizontal



Can happen in the tropics where the Coriolis force is small.

(from *Weather & Climate*)

Coriolis Force

(from *The Earth System*)

- First, Point A rotates faster than Point B ($U_A > U_B$)
- When A arrives at the latitude of B, it will have a new zonal velocity (U_{new}) faster than its original velocity U_A

→ $U_{new} > U_A > U_B$

→ A northward motion starting at A will arrive to the east of B

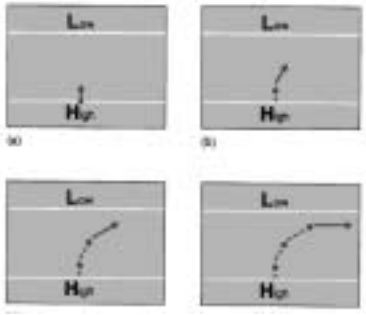
→ It looks like there is a "force" pushing the northward motion toward right

→ This apparent force is called "Coriolis force":

Coriolis Force = $f V$

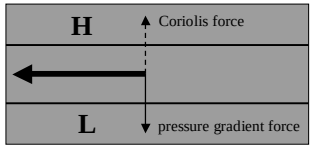
where $f = 2*\Omega*\sin(lat)$ and $\Omega=7.292 \times 10^{-5}$ rad s^{-1}

How Does Coriolis Force Affect Wind Motion?



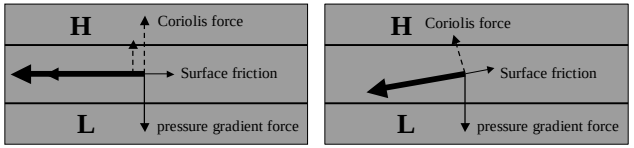
(from *Weather & Climate*)

Geostrophic Balance



- By doing scale analysis, it has been shown that large-scale and synoptic-scale weather system are in geostropic balance.
- Geostrophic winds always follow the constant pressure lines (isobar). Therefore, we can figure out flow motion by looking at the pressure distribution.

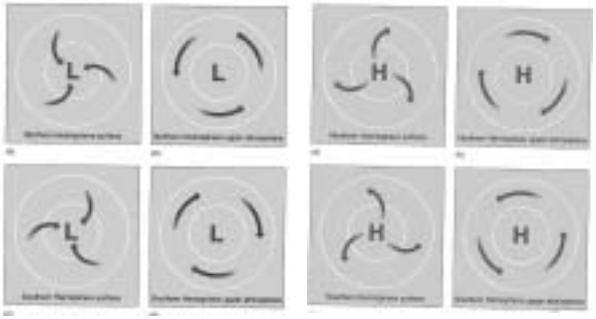
Frictional Effect on Surface Flow



- Surface friction force slows down the geostrophic flow.
- The flow turns into (out of) the low (high) press sides.
- Convergence (divergence) is produced with the flow.

Surface Geostrophic Flow

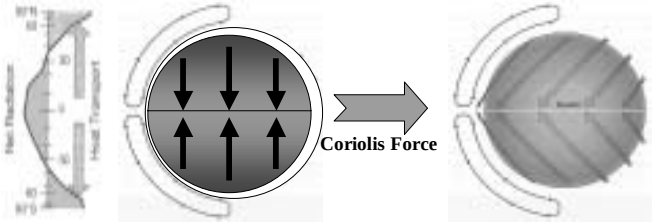
Cyclonic Flow **Anticyclonic Flow**



(figures from *Weather & Climate*)

Single-Cell Model: Explains Why There are Tropical Easterlies

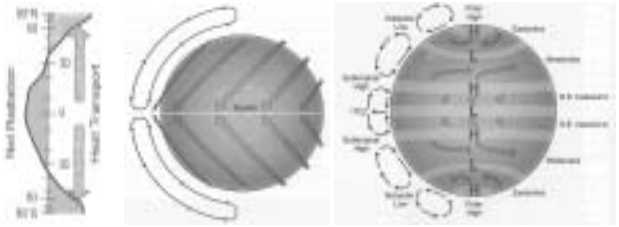
Without Earth Rotation **With Earth Rotation**



(Figures from *Understanding Weather & Climate* and *The Earth System*)

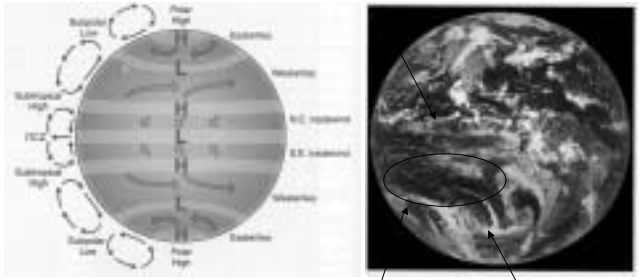
Atmospheric Circulation: Zonal-mean Views

Single-Cell Model Three-Cell Model



(Figures from *Understanding Weather & Climate* and *The Earth System*)

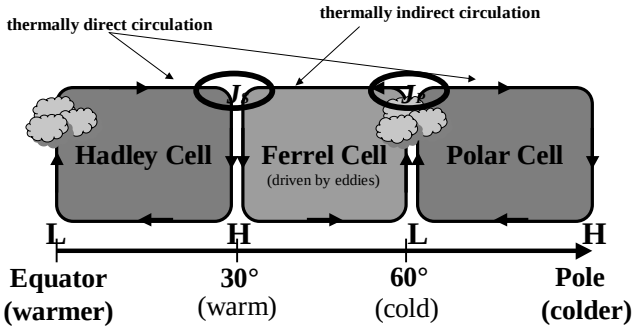
The Three Cells



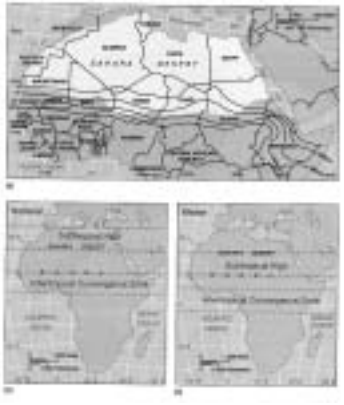
Subtropical High **midlatitude Weather system**

(Figures from *Understanding Weather & Climate* and *The Earth System*)

Properties of the Three Cells

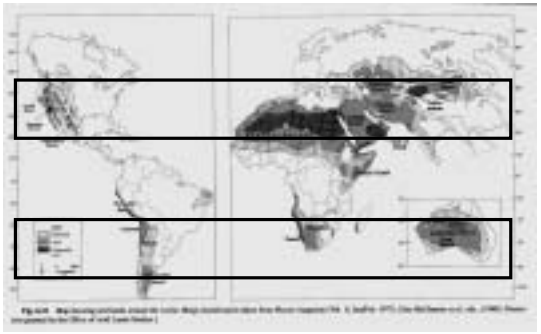


Sinking Branches and Deserts



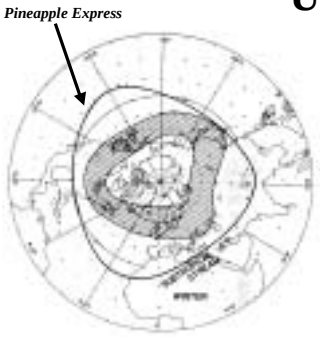
(from *Weather & Climate*)

Global Distribution of Deserts



(from *Global Physical Climatology*)

Jet Streams Near the Western US

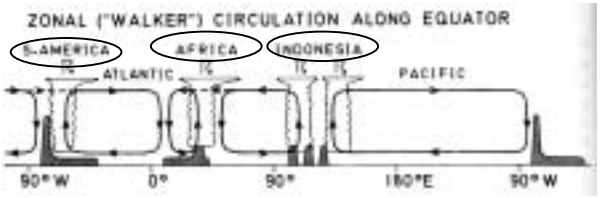


(from *Riehl (1962), Palmen and Newton (1969)*)

- Both the polar and subtropical jet streams can affect weather and climate in the western US (such as California).
- El Nino can affect western US climate by changing the locations and strengths of these two jet streams.

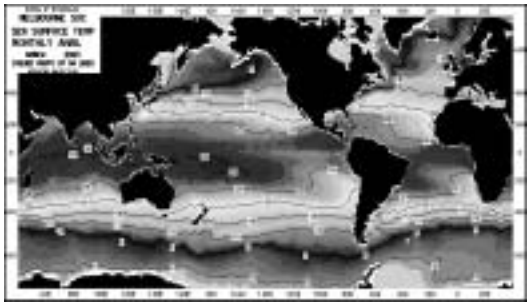
East-West Circulation

(from *Flohn (1971)*)

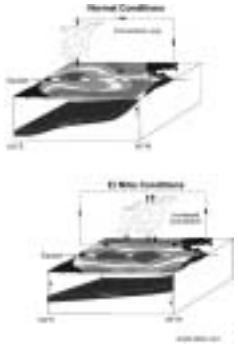


❑ The east-west circulation in the atmosphere is related to the sea/land distribution on the Earth.

Walker Circulation and Ocean Temperature



Walker Circulation and Ocean



Southern Oscillation: an atmospheric phenomenon

In 1910s, Walker found a connection between barometer readings at stations on the eastern and western sides of the Pacific (Tahiti and Darwin). He coined the term Southern Oscillation to dramatize the ups and downs in this east-west seesaw effect.

Sir Gilbert Walker