Lecture 5: Climate Tapestry

- Pressure and Wind
- Global Wind Patterns
- Effect of Earth’s Rotation on Winds

Thermal Energy to Kinetic Energy

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).

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).
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?

- North America Monsoon
- South America Monsoon
- East Africa Monsoon
- Asian Monsoon
- Australian Monsoon

(figure from *Weather & Climate*)

Balance of Force in the Horizontal

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

(figure from *Weather & Climate*)
**Coriolis Force**

- 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$^{-1}$.

(from The Earth System)

**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 geostrophic 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) pressure 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

Coriolis Force

(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**

- **Hadley Cell**: Thermally direct circulation. (warmer) Equator (H)
- **Ferrel Cell**: Driven by eddies. (warm) 30° (L)
- **Polar Cell**: Thermally indirect circulation. (cold) 60° (H) Pole (colder)

**Sinking Branches and Deserts**

- **Global Distribution of Deserts**
  - (from Global Physical Climatology)

- **Jet Streams Near the Western US**
  - Pineapple Express
  - 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.
  - (from Riehl (1962), Palmen and Newton (1969))
The east-west circulation in the atmosphere is related to the sea/land distribution on the Earth.

-from Flohn (1971)