Atmosphere-Ocean Interaction
Upcoming Schedule

- Monday, October 22: finish Chapter 10 + office hours
- Wednesday, October 24: Second midterm exam. The exam will cover Chapters 6, 7, 8, 9 and 10.
  - Closed book
    - No textbooks, calculators or cheatsheets.
  - Alternate (anti-social) seating
  - Bring a picture ID to the exam.
  - Remember to:
    - Write the 5-digit test code in lines 76-80
    - Write your name on the exam sheet and sign it
    - Turn in both the exam sheet and the answer sheet.
- Friday, October 26: begin Chapter 11.
The Single Cell Model

• This is a very simplified model based on the following three assumptions:

3. The Earth’s surface is uniformly covered with water (no differential heating of the land and the oceans).

5. The sun is always directly over the equator (no seasonal variations of the winds).

7. The Earth does not rotate.
   ♦ No Coriolis effect.
   ♦ The only active force is the pressure gradient force.
The Three Cell Model

- Keep two of the assumptions, relax the third:
  - The Earth is covered with a continuous ocean
  - The sun is always directly over the equator
  - The Earth rotates \(\rightarrow\) Coriolis force!
Observing global winds from space

Intertropical convergence zone
Winds and pressure in the real world

- Semi-permanent highs and lows: persist throughout the year, correspond to converging/diverging upper air masses.
  - Bermuda, Pacific highs; Icelandic, Aleutian lows
- Seasonal highs and lows (continents heat/cool faster)
  - Winter: Siberian high, Canadian high
  - Summer (thermal lows): Southwest US, Iran

[Images of maps showing wind patterns and pressure systems for January and July.]
Does it work?

- Yes: semi-permanent highs and lows: persist throughout the year
- No: seasonal highs and lows (continents heat/cool faster)
- No: seasonal shifts N-S (today)
- No: winds aloft in mid latitudes
Effect on the local climate

- During summer, the **Pacific high** moves north near the CA coast, and the **Bermuda high** moves closer to the SE coast.
- **CA:** dry summers
- **GA:** wet summers
Seasonal Effects on the Global Circulation.

- The three cell model neglects the Earth’s tilt.
- The tilt would cause seasonal N-S shifts.
- Bright white colors correspond to stronger winds.
- The winds are stronger in the winter.
- The wind system shifts slightly north-south during the year (think of bird migration).
The General Circulation and Precipitation Patterns

- **Converging surface flows:**
  - Low surface pressure
  - Uprising air
  - Heavy precipitation

- **Diverging surface flows:**
  - High surface pressure
  - Sinking air
  - Dry climate

- **Seasonal variations of the climate.** Example: Timbo, Guinea (Chapter 17).
Example: Tropical wet-and-dry climate (Aw)

- Timbo (Guinea)
- Wet summer season
- Dry season (Dec-Feb): hot, desert-like conditions

Grassland savanna
Winds and Pressure Systems Aloft

- The wind system aloft differs from the surface wind system. It is close to a geostrophic flow.
- There is no significant friction with the ground.
- The three cell model does not work that well in the middle latitudes.
- The winds aloft are stronger than on the ground.
- In the winter the gradients are bigger -> the winds are stronger.
Winds Aloft

- Warm air above the equator and cold air above the polar regions
- Higher pressure at the equator, lower pressure both to the north and to the south of the equator
- The pressure gradient force is towards the poles, sets the air in motion
- The Coriolis force
  - NH: to the right
  - SH: to the left
- The wind turns right in the NH and left in the SH, becomes parallel to the isobars
- Westerly winds aloft in both the NH and SH.
- Easterly winds at the surface in both the NH and SH.
Jet Streams

- Swiftly flowing air currents aloft
- Tropopause jets
  - Subtropical: 13km high, 30N
  - Polar: 10km high, 60N
  - Strong westward winds
  - Meandering pattern
- They result from strong temperature gradients at those latitudes (hence strong PG forces)
Tropopause jet streams

- Discontinuous. Position varies daily.
- May merge or split (northern and southern branches)
- Meandering pattern: may flow to the north or south
  - Important for the global heat redistribution
  - Affect local weather conditions
Atmosphere-Ocean Interaction

- The surface of the Earth impacts the air motion through the friction force.

- Newton’s III law: for every action there is a reaction. The atmosphere exerts a friction (drag) force on the surface of the Earth.

- The prevailing surface winds drive the surface currents in the oceans.

- Variations in the surface temperature of the ocean impacts the atmospheric T as well as amount of the water vapor in the atmosphere.
Major ocean currents

- **Gyres**: circular whirls of ocean currents
  - 25-40 deg angle b/n wind and current
- **Clockwise** in the North Pacific and Atlantic
- **Counterclockwise** in the South Pacific and Atlantic
Ekman Spiral

- The surface winds drive the surface currents.
- The friction force acting on the ocean surface is in the direction of the wind.
- The Coriolis force deflects the current to the right (NH).
- Each layer of water drags the water layer below, and the Coriolis force pushes the moving water below to the right.
- The direction of the ocean current changes with depth.
- The net mass transport within the first 100 m is perpendicular to the wind direction.
Upwelling of the Ocean Water

- Winds plowing along the coastal line result in a net surface current perpendicular to the wind and away from the coast.
- The warm surface water is replaced by an upwelling deep cold water.
- Water upwelling explains the low water temperatures along the California coast.
Surface Water Temperature Along California's Coast

- The low water temperatures result in low saturation vapor pressure over the ocean.
- Recall the advection fog example from Chapter 5.
- As the air moves over the land the air warms up and results in low relative humidity.
- The summer is very dry.