THE ATMOSPHERE IN MOTION

Basic Climatology
Oklahoma Climatological Survey
Factor 1: Our Energy Source

Hi, I’m the Sun! I provide 99.9999+ percent of the energy that drives the Earth’s weather and climate patterns. In other words, I pretty much make weather happen on your planet. Also, if it wasn’t for me, you wouldn’t be here!
Direct (more intense) vs. oblique (less intense) energy

Less direct energy: Colder temps!

More direct energy: Warmer temps!

Less direct energy: Colder temps!
Factor 2: Revolution & Tilt

- We’re tilted (23½ degrees) relative to the sun.
- We also revolve around the sun (once a year)
- Combined, these give us the seasons
Seasons

- Two main effects of tilt:
  - Affects the sun angle
    - Sun rises to a lower angle in the sky in winter
    - Less direct light in winter
  - Affects the time-per-day exposed to sunlight
    - Days in the winter are shorter

N.H. Summer (tilted toward)  N.H. Winter (tilted away)

Concept box: perpendicular light strikes more intensely than light from an oblique angle.
Equinoxes and Solstices for the Northern Hemisphere. The Southern Hemisphere experiences the opposite seasons.
Uneven heating should produce a global temperature pattern that looks like this... Does it?

- Yeah, pretty much.
Major Circulation Patterns

- Earth’s oceans and atmosphere move heat from the equator (and cold from the poles).

- Warm air (less dense) rises at the equator and sinks as it cools (at the poles)

- This drives our weather patterns!

- This is what our circulation patterns could look like, if …
  - the earth didn’t rotate!
Factor 3: Rotation!

- The earth spins
  - which gives us day and night.
- It also throws a curve (literally!) at our weather patterns.
- On a global scale, stuff doesn’t travel in long, straight lines.

**Concept box:** The *Coriolis Effect* deflects motion to the right in the Northern Hemisphere (to the left in the S.H.). The effect increases nearer the poles.
Major Circulation Patterns

- The earth’s rotation breaks the equator-to-pole travel into three major circulation belts in each hemisphere.
- Sinking air is dry.
- Rising moist air makes precipitation.
Major Circulation Patterns

- Generally speaking:
  - Easterly winds near the equator;
  - Westerly winds in temperate regions (most of the U.S., most of the time)
  - Easterlies again near the poles.
Variation of sunlight affects temperature (more total energy: higher temps)

- **Least variation** at the equator:
  - generally warm year round (most direct sunlight)

- **More variation** at mid-latitudes:
  - warm in the summer, cool in the winter (Oklahoma)

- **Most variation** at high-latitudes:
  - cool in the summer, cold in the winter (least direct sunlight).
The Role of Latitude

Barrow, AK (71N)

July: Two straight months of sun (still cool, though, because the sunlight is less direct). Average Temp: 40 F

January: Two straight months of darkness. Avg Temp: -14 F

Maracaibo, Venezuela (8N)

July: Avg Temp: 83 F

January: Avg Temp: 81 F
Hey, we build for this stuff!

- **Mid-Latitude Home Design**
  - Summer in OK, peak sun angle: ~78 degrees
  - Winter in OK, peak sun angle: ~31 degrees

- Overhang should be long enough for summer shade, yet short enough to allow winter sun
Factor 5: Altitude

**Generally Speaking: Higher Altitude → Cooler, drier climate**
(In climate, like in life, there are exceptions to every rule!)

Mt. Washington, NH (44°N, 6288 ft.)
annual temp: 27.2°F

Rapid City, SD (44°N, 3,202 ft.)
annual temp: 46.7°F
Lapse rate = rate of change of temperature with height

Lapse rate = \(-5.4^\circ F/1000ft\) (up to top of troposphere, around 7.5 miles)

For every 1000 feet you ascend, the temperature drops \(-5.4^\circ F\)!
Rain on one side of the mountain, dry on the other

- Air is lifted up, expands and cools, and forms clouds
- Any precipitation falls on this side of the mountain
- Air continues over mountain, but without its moisture
- As this dry air sinks, it warms because it is compressed

Altitude: Rain Shadow Effect
Factor 6: Land & Water are Different

- Land surfaces heat and cool much more quickly than water/oceans.
  - This is important because the atmosphere is mostly heated from below.

- Also, continents get in the way of oceans

- Remember our idealized “bowling ball” world?
This is January. How do the observations differ from our ideal bowling ball? Why?
Actual temps in July.

This is July. What has changed since January? Which hemisphere has more land?
Let’s Review...

- Factor 1: Our Energy Source
- Factor 2: Revolution & Tilt
- Factor 3: Rotation!
- Factor 4: Latitude
- Factor 5: Altitude
- Factor 6: Land & Water are Different
GLOBAL WEATHER PATTERNS
Jet Stream

- Relatively narrow bands of strong winds in the upper levels of the troposphere
- Generally west-to-east, but parts can be north-south
- Forms at the boundaries of circulation cells
- The Polar Jet is usually stronger because the temperature differences are greatest
**Ridges**: Warm air, usually moving from equator to pole. Associated with: tranquil weather, lighter winds, clearer skies, this is summer’s “heat dome”.

**Troughs**: Cold air, usually moving from pole to equator. Associated with: disturbed weather, stronger winds, clouds, precipitation and “weather systems”. 

Windy, cooler, cloudier, possible precip.

Calmer, warmer, sunnier, rarely precip.

Windy, cooler, cloudier, possible precip.
Global Weather Patterns

- These *ridges* and *troughs* make a pattern around the world
- Energy moves through these "waves" as they migrate around the globe
- Disruptions in one place can have impacts at far distant locations

A typical 500 mb map showing series of troughs and ridges
Teleconnections

- Connectedness of large-scale weather patterns across the world
  - If you poke one area, another area is affected as well (can be across the world, very far away)
  - Dropping a pebble in a pond—ripples created interact with waves
- For Example:
  - El Niño-Southern Oscillation (ENSO)
El Niño / La Niña

Right now, we are in an El Niño phase
Typical ENSO Winter Effects

- **El Niño:**
  - Lots of [non-Arctic] storms tracking rapidly from west-to-east across southern half of U.S.
  - Very wet across Southern states; very warm across Northern states

- **La Niña:**
  - Storm track often stays north of us
    - OK warm & dry for extended periods.
  - When it jumps south (quickly) we get weather systems, but they often lack sufficient moisture
    - We go from warm, dry and windy to cold, dry and windy
  - The storm system finally explodes with precipitation somewhere around Memphis
Other “Teleconnections” Features

- **PDO: Pacific Decadal Oscillation**
  - “Sloshing” between northern and central Pacific, typically 20-30 year period.
  - Effects similar to El Nino
  - May be a major contributor to extended drought patterns

- **NAO: North Atlantic Oscillation**
  - From Iceland to Azores: more pressure oscillations
  - Stronger impact on N. American east coast & Europe
  - “overcame” El Nino effects this past winter in eastern U.S.

- **PNA: Pacific – North American Oscillation**