Chapter 4 Weather

APES notes atmosphere, weather

see also frog book 15.1 (atmosphere) and 6.1 (biomes)

Three ways heat energy moves:

- **Radiation**: no medium needed, e.g. light
- **Conduction**: contact
- **Convection**: matter in motion

Summary:

- Solar **radiation** passes through the atmosphere
- Radiation hits the earth surface, **conducts** to air
- Hot air rises, (**convection**) cooler air comes in to take its place
- This is the basis for wind (air along the surface) and weather (condensation and precipitation)

----------n.b. (nota bene, "note well")----------

- Tilt of the earth: Basis for seasons : tilt away=winter
- equinox=equal night, solstice=extremes
- Equator is hottest, so greatest convection there, also ocean less salty there (why?)

Three global convective cells, cause winds, climates and all weather:

Hadley, Ferrel, Polar

- Ocean currents follow the winds, clockwise in N hemisphere
- Cells converge at rainy spots, diverge at deserts
- Why? Clouds lift at convection spots, cooling them = rain
- Dry air dropping from space = warm, dry air (deserts)

Layers: spheres bottom to top

- **tropo**: at the surface, where all weather happens, conduction to air from surface, convection to other layers, albedo is how much energy it reflects (albus=white)
- **strato**: higher, drier air, cooler, air travel is here, also ozone layer (stops UV)
- **meso**: middle
- **thermo**: hot, charged particles, also ionosphere, bounces radio waves
- **exo**: outer
- **magneto**; even further, deflects solar wind, protects surface (none on Mars)

Air stuff:

- compress air and it heats (bicycle pump)
- uncompress air (e.g. altitude) it cools (spray can too)
- warmer air holds more water (more energy to keep molecules in gas phase)
- cooler air holds less water
- humidity measures how much water in how much air
- **relative** humidity: compared to how much it can hold at that temp
- **absolute** humidity: total amount of water
- dew point: temp where water condenses
- rising air condenses (rain) “adiabatic cooling” rain carries the heat away
- falling air heats (e.g deserts) “adiabatic heating” absorbs energy from the surroundings
- rain shadows=dry areas after mountains
- moon shadow=a cool song by Cat Stevens
- saturated 100% RH air is fog, then rain or snow

Cells:

ITCZ: at the equator, inter-tropical-convergence-zone

Hadley cell: equator to 30°N or 30°S

Ferrel cell: 30-60°

Polar cell: 60-90°

- since earth is spinning, as air flows south, it also falls a bit west=tradewinds
- if air flows north, it also flows a bit east=westerlies (weather describes wind from source direction)
- this change of direction creates the coriolis effect
- Hurricanes are low pressure systems, rising air creates a counter-clockwise flow (L on the weather maps)
- High pressure systems create clockwise flow (H on the weather map)

Oceans:

- winds carry surface water along, so N hemisphere has clockwise currents (cool water off CA coast)
- a special current from Greenland melt flows to Hawaii, called the thermo (heat) haline (salt) current.
- ENSO is a big deal: normally winds carry water off-shore of chile, bringing up food from the deep ocean (happy fisherpeeps).
- El Niño reverses this, so sad fisherpeeps
- La nada is no flow at all

Modules 9, 10, 11 circulation

Circulation modules:

- **Module 9: Heating of the earth**
- **Module 10: Air circulation**
- **Module 11: Ocean circulation**

Module 9 heating of the earth

•**Tropo** (top) sphere-heated by contact with earth, where most weather occurs

- **Strato** (high) sphere-cooler, where commercial aircraft travel, more radiation there
- **Meso** (middle) sphere-higher, but does not contain charged particles
- **Thermo** (hot) sphere-also known as the ionosphere, charged particles from interaction with the solar wind (charged protons and others), "hot" because of these particles slowing down, but so little atmosphere it would freeze you if you were there. Three layers: D, E and F, with F being the highest, all three reflect radio waves, but only the lower ones conduct/reflect in sunlight
- **Exo** (outer) sphere-where space begins, freezing cold about one hydrogen molecule per square meter
- **Ozone**: between the troposphere and stratosphere, this absorbs UV radiation
- **Magnetosphere**: way out there, deflects solar wind, particles then spiral into the north and south poles creating the auroras.
- If no magnetosphere, we'd cook like in a microwave oven (Film: The Core), a serious issue for Mars exploration
- if no ozone layer, all plants would die, DNA would be mutated, life would cease except for deep thermal vents (possible origin of terrestrial life)
- HOT AIR RISES, COOLER AIR MOVES IN TO TAKE ITS PLACE-THIS IS THE BASIS FOR WEATHER

Globe Demo

- Seasons, tilt vs. perihelion (AUS)
- counterclockwise
- equinoxes, solstices
- hadley, ferrel polar cells
- deserts, rain forests
- tradewinds
- longitude vs latitude
- GMT-why?

Atmosphere slice: layers

Air currents: RH, AH

3 energy modes: radiation, convection, conduction

Seasons

- 4 seasons (not just an expensive hotel),
- equinox means "equal night”,
- solstices are the extremes (why sacred?)
- Earth spins counter clockwise when viewed from north pole (think: sun rises in the east)
- Latitudes are like a ladder, go horizontally (east to west), some short (near the poles), some long (equator)
- Longitudes are all long, go vertically (north to south), all the same length
- Seasons are determined by earth tilt, **not** by distance to the sun
- Although, Australia (southern hemisphere) summer happens when we are closer to sun in our elliptical orbit, so more extreme summers (tilt + proximity)
- Albedo-think of Albus (white) Dumbledore, means reflectivity. Earth is about 30%, snow is 95%

Module 10 Air currents and Water stuff

- **Relative humidity:** the amount of water in the air at a certain temperature, relative to the maximum it could hold at that temperature (RH). Look this up here: http://10.14.30.1
- You can blow on the room sensor and see this rise.
- **Absolute humidity**: true amount of water in percent water in that parcel of air (AH)

Saturation point: the max amount of water air can hold at that temp (rises with temperature, note how this compares with gases dissolved in liquids, like your dissolved oxygen (DO) lab. You may know this as fog.

You may feel more comfortable with high temp and low humidity because your body can evaporate and cool more effectively. Conversely, humid, hot weather is ugly. Cold, humid air insulates poorly, so feels chilly, so running your air conditioner when it is humid and cool may actually make you feel warmer. Why?

You can look this up, it is called the "comfort curve" or psychrometric chart:

Dew point: weather term for the temp that water will condense from air, depends on humidity (think of cool mornings, wet grass, or water vapor condensing on a cool drink)

Adiabatic cooling: think of Waimea canyon, or the mountains of the Andes, Olympics, Coastal range, Himalayas, etc. As air rises, the reduced pressure makes it cooler. Opposite of pumps, which get hot (compression). You might feel see this with aerosol spray cans (cooler when you spray something).

Questions:

1. You see a circular flow in the counter-clockwise direction in the Northern Hemisphere on windy.com. Is this low or high pressure?
2. Why is the ocean less salty near the equator?
3. As a parcel of air rises (like Waipio or the Himalayas), what happens to the absolute and relative humidity? What happens next?
4. What level of the atmosphere has most of the weather and why?

- **Adiabatic heating:** reverse of this: think of Puako or Kawaihae: as air descends, it is compressed and gets hotter.
- **Latent (hidden) heat release:** when vapor condenses from gas to liquid, it releases energy. Opposite of evaporation or boiling, which both require energy.
- **Convection:** one of three means that energy moves from place to place:
  - radiation (like light, can be reflected),
  - conduction (contact),
  - convection (movement of mass, usually air or water).
- **Hadley cells:** between 30N and 30S, convergence at the equator (hot air rises there), descends after shedding heat to space and water as it rises (rain), descending dry air forms deserts at 30N and 30S. Winds from the north to south at the surface, opposite in the stratosphere.

Check this out on windy.com:

https://www.windy.com/?20.002,-155.533,5

- **ITCZ:** intertropical convergence zone: the place near the equator where this convergence occurs, lower salinity in equatorial oceans (rains all the time, good AP question).
- Hadley Cells: Between the equator and 30N or 30S.
- **Ferrell cells:** between 30N and 60N, also on the southern hemisphere: deserts at the bottom, northward wind at the surface, opposite in space (stratosphere), which is why commercial flights usually have a headwind where they'd have a tailwind at the surface. Also why when trades are strong, mainland flights are faster/shorter.
- **Polar cells:** southward wind from 60N to 90N, creates dry desert at the north pole.

- **Coriolis effect;** spinning of earth makes air near the equator rotate faster around the axis than polar air. This difference creates hurricanes and ocean currents, therefore diagonal winds (see fig 10.6)
- **Rain shadow:** think of the coast near Mahukona or Lapakahi, between Kawaihae and Hawi: very dry as all moisture has been wrung out of the air by ascending above mount Kohala. Think also of Eastern Washington, or the Desert in Chile, where the Andes dry out the air. Many more-find some!

Mod 11 ocean currents

Check this out:

Verify on windy.com again:

https://www.windy.com/?20.002,-155.533,5

- Notice that the north pacific currents flow clockwise, south pacific counter clockwise. why?
- There are places with little forward current, so they become islands of debris, e.g. the so called "Pacific Gyre", which is about the size of Texas, and made up of floating trash.
- Gyres describe the circular flow, some refer to the islands of debris as gyres (not accurate), gyres are the circles, most equatorials move west (arrows match)
- Difference between flotsam and jetsam: one floats, the other is jettisoned from boats
- Thermohaline (thermo=heat, haline=saltwater) circulation:

This upwelling of 2000 year old water off the Kona coast is the bases for Koyo water near the airport (why is this water so precious?)

- Upwelling off the peruvian/chilean coast-Andean trench=great fishing when in normal conditions (not el niño)
- ENSO= el nino southern oscillation-a really big deal, reverses the normal ocean circulation, impacts weather around the planet

El niño and La niña (ENSO)

Note: top diagram has strong OFFSHORE wind, pulling up nutrients from below, note also that it is one big box from Peru to Indonesia, with a strong warm, dry subsidence around the coast of Peru

(good for beach folks), known as La Niña, or the little girl,

Note: lower diagram (El Niño) has main convection moving to the middle of the ocean basin, weakening the offshore wind around Peru, so sad fisher-folk. El Niño was often associated with Christmas, so the "little boy" reference.

Though ENSO is a single climate phenomenon, it has three states, or phases, it can be in. The two opposite phases, “El Niño” and “La Niña,” require certain changes in both the ocean **and** the atmosphere because ENSO is a coupled climate phenomenon. “Neutral” is in the middle of the continuum, also known as “La Nada” or “the nothing”.

1. El Niño: A warming of the ocean surface, or above-average sea surface temperatures, in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to become reduced while rainfall increases over the tropical Pacific Ocean. The low-level surface winds, which normally blow from east to west along the equator (“easterly winds”), instead weaken or, in some cases, start blowing the other direction (from west to east or “westerly winds”). This makes for sad fisher-people off the coast of Peru. Named for "the boy" or the Christmas child since it was first seen around December (winter solstice again).
2. La Niña: A cooling of the ocean surface, or below-average sea surface temperatures, in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to increase while rainfall decreases over the central tropical Pacific Ocean. The normal easterly winds along the equator become even stronger. Happy fisher-people off the coast of Peru due to nutrient upwelling from the Peruvian trench. Named after "the girl", just the opposite of "the boy".
3. Neutral: Neither El Niño or La Niña. Often tropical Pacific sea surface temperatures are generally close to average. However, there are some instances when the ocean can look like it is in an El Niño or La Niña state, but the atmosphere is not playing along (or vice versa).

Figure 11.3 below——

Top: La Nada or La Niña: happy fisher-people off the coast of Peru (nutrient upwelling)

Bottom: El Niño: sad fisher-people off the coast of Peru

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