

ATMS211 Climate and Climate Change

Mid-Term 2 Review

Note: The following is a summary of the material covered in class. Only broad concepts/themes are listed. You will need to consult your textbook, homework, and lecture notes for details.

Ocean Circulation (Ch. 5)

- surface mixed layer; wind-driven circulation; relatively short timescale
- deep ocean (thermohaline) circulation: density-driven; relatively long timescale
- bottom water formation; sea ice growth / melt; how salinity and temperature affect density
- time scales of circulations
- subtropical gyres: western versus eastern boundary currents and their effects on local climate

El Nino - Southern Oscillation (lecture slides + pp. 308-312)

- Walker circulation (how does it look as a function of height and longitude?)
- Southern Oscillation: surface pressures at Darwin and Tahiti: how are they different usually versus during El Nino?
- typical conditions in tropical Pacific versus sea surface temperature and precipitation patterns during El Nino or La Nina
- impacts on humans (worldwide)

Global Climate Models (Ch. 6)

- reasons for modeling the climate
- resolution, subgrid-scale processes, parameterizations
- chaos; ensembles of models; why do we use them?
- difficulty with clouds: they are subgrid-scale and have to be parameterized!
- what models do well / not so well / poorly

Radiocarbon Dating (lecture slides + p. 98)

- concept of half life; radioactive decay; isotopes (^{14}C , ^{12}C , ^{18}O , ^{16}O)
- assumptions made in order to perform carbon dating; how far back can you go?

Carbon Cycle (Ch. 8)

- relative sizes of reservoirs / fluxes between reservoirs; residence times
- marine biological pump: sends carbon from surface to deep ocean
- photosynthesis / respiration by land plants → seasonal cycle in atmospheric CO_2 concentration
- time scales of interaction between reservoirs; short-term versus long term carbon cycle
- carbonate-silicate cycle: chemical weathering (what type of climate favors weathering?) takes CO_2 out of atmosphere and volcanism puts it back in; long timescales (millions of years)!
- how do humans perturb this cycle?

Climate Regulation on Very Long Time Scales (Ch. 12)

- age of Earth: 4.5 billion years

- Sun burns hotter as it gets older: hydrogen converting to helium
- indicators of earth history: deep sea cores, fossil record, geological evidence of glaciations (moraines, cirques, dropstones, etc.)
- Archean: Faint early sun paradox
 - sun was dimmer; Earth should have been frozen; how to explain evidence for life (and therefore liquid water) on planet?
 - roles of CO₂ and CH₄ in maintaining “habitable” planet; role of carbonate-silicate cycle and feedback loops between temperature and CH₄
- Snowball earth (2 or 3 episodes around 800-600 million years ago)
 - role of continental geography, solar constant, ice-albedo feedback, carbonate-silicate cycle
 - What caused it to terminate? What allowed for rapid deglaciation?

Pleistocene Glaciations over Last ~700,000 years (Ch. 14)

- AKA: Glacial-Interglacial cycles or ice ages
- last glacial maximum: ~20,000 years ago
- Milankovitch cycles of eccentricity, obliquity, and precession
 - time scales, features, effect on solar radiation reaching Earth, seasonality, timing of seasons
 - what orbital characteristics favor glacial advance?
- record of ¹⁸O/¹⁶O in polar ice versus ocean sediment
 - Why do we infer what we infer from these?
 - How do they match up with the solar radiation variations?
- 100,000 year periodicity of the ice ages: need for amplifying feedbacks to accentuate the small eccentricity signal (CO₂ tracks temperature – reduced THC and enhanced biological pump draws down CO₂ as ice sheets advance?)

Holocene Climate Variability (Ch. 15)

- Younger Dryas (~10,000 years ago)
 - brief (~1000 year) return to ice age conditions after end of last ice age
 - likely scenario: THC shut down due to massive influx of fresh water into the N. Atlantic Ocean
- sun spot cycles: 22 year period; ~0.2% fluctuation on total solar energy reaching Earth
- aerosols: liquid or solid particles suspended in the atmosphere
 - Aerosol direct effect: scatter (cooling effect) and / or absorb (warming effect) sunlight
 - Aerosol indirect effect: serve as cloud condensation nuclei – tend to make clouds more reflective; generally thought of as having a net cooling effect on planet
- volcanoes: sulfuric acid aerosols in stratosphere reflect sunlight and cool planet; effects last ~2 years; tropical volcanoes have greater effect on climate than high latitude volcanoes: why?

Cretaceous – Tertiary Mass Extinction (pp. 257-263)

- 65 m.y.a. (the K-T boundary): asteroid impact off the dinosaurs and most large creatures
- massive cloud of dust and aerosol blocks out sun for several months; plants can’t photosynthesize
- evidence for asteroid: iridium layers found around the globe and big crater in Yucatan; dates match K-T boundary