Global Climate Change - Final Exam Topics Overview

Chapter 7 - Orbital Frequency Control of Solar Radiation

Earth's orbit today
- tilted axis, perihelion, aphelion

changing orbital cycles
- 41,000 yr tilt cycles
- 100,000 yr eccentricity cycles
- 23,000 yr precession of the equinoxes

changes in insolation through time (northern hemisphere summer)
- dominated by 23,000 yr precession cycles

Chapter 9 - Insolation Control of Ice Sheets

controls on ice sheets
- summer more important than winter

Milankovitch theory
- ice sheets should be controlled by 23,000 (& 41,000) yr cycles

ice sheet behavior
- equilibrium line
- ice sheet should lag insolation by ~6000 yrs

ice sheet history
- $\delta^{18}O$ in marine carbonates records glacial cycles
- 41,000 yr tilt cycles dominate the $\delta^{18}O$ signal from 2.75 m.y. to ~0.9 m.y.
- 100,000 yr eccentricity cycle dominates the $\delta^{18}O$ signal from ~0.6 m.y to present

Chapter 8 - Insolation Control of Monsoons

monsoon strength is affected by changing summer insolation

northern African monsoons followed 23,000 yr precession cycles
- evidence: Sahara lakes & Atlantic diatoms, stinky muds

Chapter 10 - Orbital Scale Changes in Carbon Dioxide and Methane

ice cores contain air bubbles which can be analyzed for CO_2 & CH_4

carbon reservoirs (shallow ocean, deep ocean, atmosphere, terrestrial biomass)

~30% of atmospheric CO_2 gone from atmosphere during glaciations

where does CO_2 go during glaciations?
- deep ocean via higher solubility of CO2 in colder water
    - carbon pumping
    - iron fertilization
    - changes in deep water currents

orbital-scale variation in methane (CH_4)
- varies primarily at the 23,000 yr precession cycles
- driven by the variation in the monsoons (expansion of wetlands)

greenhouse gases responded to changing insolation and largely acted as climate feedbacks

Chapter 12 - Last Glacial Maximum

greatest extent of northern hemisphere ice sheets was ~21,000 yrs ago
- insolation was rising, was nearly what it is today
- but more ice than today because of lag time in ice dynamics

glacial max climate - colder & drier
- extensive loess deposits
- expansion of active regions of sand dune development
- North Atlantic much colder (ice rafted debris farther south than today)
- models indicate split jet stream around Laurentide ice sheet
- glacial era lakes in S.W. North America
- displaced vegetation belts
- expanded Antarctic sea ice

how much cooler were the tropics? (important b/c tells sensitivity to greenhouse gases)
- contradictory evidence from sea surface temp studies & tropical glaciers
- perhaps middle ground is right: ~3 °C cooler

Chapter 13 - Climate During an Since the Last Deglaciation

carbon dating terminal moraines shows retreat of Laurentide ice sheet between
- 21,000 yrs (max) and 6,000 yrs (essentially gone)

changing volume of ice tracked by sea level studies (Barbados corals)

changing melt-rate seen in sea level curve & meltwater pulses in Gulf of Mexico

Younger Dryas pause in melting - temporary return to cold
- recognized in Greenland, N.Atlantic, & Europe
- not a global event
- very rapid climate change
- result of changes in N.Atlantic circulation???
- could it happen today???

Chapter 14 - Millennial Oscillations of Climate
- Dansgaard-Oeschger oscillations in Greenland $\delta^{18}O$ record
- Heinrich events (ice rafting events in N.Atlantic
- Bond (oscillations) of N.Atlantic polar foraminifera populations
- Europe: oscillationslations in soil clay & tree pollen
- Santa Barbara Basin planktic foraminifera $\delta^{18}O$, layering
- Antarctica also - but Greenland-Antarctica out of sync

climate oscillations reduced or absent during interglacial

millennial oscillations quasi-periodic (no real cyclic behavior)

possible causes?
- solar variability - not likely
- greenhouse gas forcing - unclear
- ice sheet instability
- bipolar seasaw

Chapter 15 - Humans and Preindustrial Climate

Savanna hypothesis
- bipedalism due to climate drying & shrinking of forests

Noah's flood
- Black Sea flooded from sea level rise from melting glaciers

CO_2 & CH_4 have been rising at a point in the current interglacial when they were
- falling in previous interglacials
- coincides approximately with the rise of agriculture

Chapter 16 - Climate Change During the Last 1000 years

Medieval Warm Period, Little Ice Age, modern warmth: how widespread?

evidence for Little Ice Age
- expanding snow fields in arctic Canada during Little Ice Age
- formation of sea ice around Iceland during Little Ice Age
- $\delta^{18}O$ from alpine glaciers in Peru & Tibet
- tree ring studies from around the arctic/subarctic and Mongolia
- tropical Pacific & Indian Ocean corals indicate cooler 19th century

Little Ice Age not seen
- Greenland and Antarctic ice $\delta^{18}O$
- Tasmania tree rings

proposed causes of climate change A.D. 1000 - 1850 & beyond
- orbital forcing - probably not
- bipolar seasaw - not enough data
- solar variability - no more than 10%
- explosive volcanic eruptions - part of the story
- greenhouse gas forcing - bubonic plague & Native American pandemic

Chapter 17 - Climate Changes Since the 1800s

instrumental record
- surface temperature rose ~ 0.7 °C
- deep ocean temp rose ~ 0.06 °C
- ground temperature rose

melting ice & arctic warming
- mountain glaciers melting
- arctic sea ice receding in summer
- decreasing snow cover
- Alaskan growing season increasing
- Greenland ice sheet volume decreasing near edges

rising sea level
- must first account for tectonics & isostatic rebound
- 20th century sea level rise: ~17 cm
- mostly due to thermal expansion of oceans, melting of alpine glaciers
- a little from melting in Greenland (+/- Antarctica)

Chapter 18 - Causes of Warming Over the Last 125 Years

Chapter 19 - Future Climatic Change