Notes (4/27)

• In-class reviews 4/29
• Extra Review 5/3
• All work handed back 5/4
• Comprehensive Question due 5/4
• Look at Web Page

Global Change

• Includes: ozone hole, acid rain, pollution, habitat destruction & extinction, exotic species, climate change
• We’ll focus on atmospheric CO$_2$ increase
  – Some carbon-temperature basics
  – Some SW specific ramifications
  – Vegetation migrations?
• What is known vs. what is speculation.
Carbon Cycle

- Units: Pg (Petagram, 10^{15} g)
- Major storage:
  - oceans
- Minor storage:
  - soils
- Trivial storage:
  - air, plants
- Fluxes to atmo:
  - land use and fossil fuel use
  - Out of balance.

Strom lines up dozens of data sets suspected of having a connection to climate change; all show dramatic positive correlations with industrialization and population growth. Even the anomalies point to man, Strom said, noting dips during economic downturns such as the Great Depression, when greenhouse-gas production tapered off briefly.

"Whenever you have a world recession," Strom said, "the greenhouse-gas emissions go down. They start going down first, even before you know you have a recession. When it starts going down, sell your stock."

- Fossil fuels: cars, power plants (note dips)
- Land use change: deforestation

http://www.whrc.org/carbon/index.htm
Atmospheric CO₂

- Long-term increase
- Seasonal swings
  - Why?
- How much is 350 ppm

Carbon Equation of Life

\[ \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_2\text{O} + \text{O}_2 \]

- Left to right:
  - Plants (green), aka photosynthesis
- Right to left:
  - Animals
  - All living things, aka respiration.
Direct CO₂ Fertilization

- If: plants need CO₂, and
- Given: more CO₂ is available, then
- Plants should grow better
- How can we tell?

![Graph showing growth data](image1)

Elevated CO₂ in Arid Lands

- Pour CO₂ over small plots
- FACE: Free-Air CO₂ Enrichment

![Image of CO₂ enrichment](image2)
CO₂ Effects
Deserts
• Depends on moisture
  – When wet, increased productivity
  – When dry, no effect.

CO₂ and Desert Exotics
• Exotics do better than natives with more CO₂
Greenhouse Warming: A Good Thing

• Light energy in
• Heat can’t go out
• In atmosphere:
  – Water vapor
  – CO₂
  – Other trace gases
• Without greenhouse, ±uninhabitable Earth

Greenhouse Gas Absorption

• Water vapor absorbs a lot of Earth radiation
• CO₂ absorbs additional Earth radiation
• Trace gases also absorb Earth radiation.

Global Warming?

• Instrumental record shows warming
• Ocean or land
• Now: warmest years ever: 2.2°F above avg.
• Skeptical?

2°F (1°C) Increase?

- Evaporation
  - 7% change per 1°C
  - Increased water loss from surface ecosystems
  - Increased atmospheric energy

Still Skeptical?

- Urban Heat Island Effect
  - Buildings, pavement absorb sun, emit heat

http://www.usatoday.com/weather/urbheat.htm
Warm Cities

• Is this the cause of modern warming?
• No, instrumental record is corrected.

Still Skeptical??

• Natural variability is causing temp rise
Still Skeptical??

- Natural variability is causing temp rise
  - Solar
  - Explosive volcanoes
  - Oceans

Play this video when you get a chance--


Industry Ignored Its Scientists on Climate.
Andrew Revkin, NY Times, April 23, 2009

Paleo Temperatures?

- Worldwide temperature reconstruction
- Tree rings, ice, pollen, corals

- Last 1000 years: Current warming is outside bounds of variation
Tropical storms and hurricanes are likely to become more intense, produce stronger peak winds, and increased rainfall over some areas due to warming sea surface temperatures (IPCC 2007).
How might ecosystems respond?

1000 m $\cdot 6^\circ C = 600$ m elevational shift

- Therefore, elevational displacement:
  - Up to 600 m (~1500 ft.)
- Does this ring a bell from the past?

Could lose alpine in north, subalpine in south

Forest migrations
- Out with old (Douglas-fir, ponderosa pine), in with new (Cal. White oak)
Forest migrations

• Out with old (Douglas-fir, ponderosa pine), in with new (Cal. White oak)

• Saguaro might leave Sonoran, enter Chihuahuan desert
  • Joshua Tree & creosote dominate?
So What if We Lose Ecosystems?

• Ecosystem services
  – Food, fiber, medicines, energy, etc.
  • Pollinators
    – Cycling carbon, nutrients
    – Flood control, water cleansing
    – Soil stabilization
    – Tourism (worth mega-$billions)
    – Earth’s entire genetic reservoir.

High Temperature & Water Use?
Global Warming & Precipitation

- Difficult to predict more or less precipitation on average for any region
- Warmer atmosphere:
  - Holds more moisture (energy)
- Might expect more vigorous circulation:
  - Increased frequency of El Niño events
  - More intense droughts, floods?

- Project decrease in available moisture for the Southwest
  - Decreasing evaporation
  - Even bigger decrease in precipitation
Global Change

- It is warming up: natural or anthropogenic?
- Environment appears to be changing
  - Changes are preceded, but rate is fast
- SW ecosystems likely to change
  - Some predictable ways
  - Some surprises – no paleo analog
- What to do?
  - Nations haggling Kyoto agreement now
  - Not likely to be enforceable.

Proof of global warming!!!

One More thing …

- Midlatitude glaciers in retreat
- Sea level rising 1.5mm / yr
**Will the other shoe drop?**

- Could it actually become cooler while warming?
  - Glacial snow melt puts cold freshwater in oceans
  - Ocean currents may be disrupted
  - Turning off Gulf Stream = Eurasian cooling, if not global
- Past: three abrupt cooling events during general warming since Pleistocene
- See optional reading