Welcome to Global Change!
GEOS/ECOL/GEOG/RNR/HWR

GEOS 478/578

- **Handouts:** Syllabus, initial schedule, questionnaire
- **Prerequisite:** one year of upper-level science (not NATS!) - see us if you do not have this. Comfortable with quantitative reasoning and calculations.
- Both instructors travel for research; both will be in class when they are in town
  - (get to know us all)
- Class is full… but people do drop; see us if you are interested but not yet enrolled

**Class elements**

- **Format:** lecture; 4 breakout sessions for presentation and discussion
- **Grading:**
  - Exams: 40% total (3 noncumulative)
  - Homeworks: 35% (near-weekly)
  - Participation: 5%
  - For undergraduates: Presentation (20%)
  - For graduates: Proposal (20%)
- **Resources:**
  - Website; linked thru Geoscience home page
  - Username is geos478
  - Password is global (for readings)

**Schedule**

- Website links to notes and readings for lectures and presentations
- Links to study guides and old exams will be posted later
- Dates may change by a day or two, except final which is fixed
Finally….  

- We welcome your comments about how the class is going! Please don’t hesitate to see us if you have any concerns.

What is global change?

- Climate change - ocean and atmosphere processes
- Hydrologic change
- Tectonic/geologic change
- Ecosystem change
- Land use change
- People - population, consumption, energy, land use
- Biodiversity/Extinction
- Ocean circulation (Thermohaline circulation)
- Sea level change
- Extreme events/disturbance changes
- Human impacts - health, agriculture, economic, social

Stories we’ll be following…

Atlantic hurricane season

**Stories we’ll be following…**

**El Niño to La Niña**

[Map of global temperature anomalies showing El Niño and La Niña patterns]

[Graph showing temperature variations over time]

**Stratospheric ozone hole**

[Map showing ozone levels over different regions]

http://www.theozonehole.com

**Stories we’ll be following…**

**Sea ice melting rapidly**

- Sea ice minimum usually falls in September
- 2007 set record for smallest area of sea ice observed
- Current ice declining rapidly

[Map showing sea ice extent with color coding]

http://nsidc.org/arcticseaicenews/

**Stories we’ll be following…**

**Climate policy and assessments**

[Image of IPCC report cover]

Democrats pull plug on climate bill

NAVIGATE: POLITICO | Congress | Democrats pull plug on climate bill

TAGS: Congress, Democrats, Climate Bill, Harry Reid, Barbara Boxer, Jeff Bingaman
Stories we’ll be following…

**Ecosystem developments**

Amazon drought raises research doubts

A once-in-a-century drought struck much of the Amazon rainforest in 2005, reducing rainfall by 60-75% in some areas — and giving scientists a window on to a future coloured by climate change.

The straight, forested stretch of the Amazon coast of Peru is now a parched, yellow expanse of sand and sunken trees. The drought has left the forest vulnerable to disease, and the food supply is in crisis. It has also highlighted uncertainties over the effects of climate change.

> "Amazon drought raises research doubts" news article

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Stories we’ll be following…

**Local/regional developments**

Arizona solar plant gets big boost from feds

Arizona solar plant gets big boost from feds

President Barack Obama announced Wednesday that the federal government will provide a $3.5 billion loan guarantee for a 550-megawatt solar plant in southern Arizona. The plant will be one of the largest solar projects in the country and will be the first to showcase a large-scale solar power system that can make electricity after the sun sets. The developer has struggled for two years to find a decent loan for the project.

> "Arizona solar plant gets big boost from feds" news article

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Stories we’ll be following…

**Climate change deniers?**

2500 scientists say we’ve caused global warming

I’d like a second opinion

> "2500 scientists say we’ve caused global warming" cartoon

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Stories we’ll be following…

**Current events**

A Secret Assault on Terre

The New York Times

Greenpeace is a global movement, it’s all about the environment. We're fighting for a world free of nuclear weapons and the fossil fuels that are killing us. We're working to create a future where humanity can live in harmony with nature. We're the Original Environmentalists. We're the Original Anti-war Peaceful Revolutionaries. We're the Original Peaceful Environmentalists. We're the Original Anti-war Peaceful Revolutionaries. We're the Original Peaceful Environmentalists. We're the Original Anti-war Peaceful Revolutionaries. We're the Original Peaceful Environmentalists. We're the Original Anti-war Peaceful Revolutionaries. We're the Original Peaceful Environmentalists.

> "A Secret Assault on Terre" newspaper article
A few key points for today

- The UNFCCC and the IPCC
- Observations of global warming

UN Framework Convention on Climate Change (UNFCCC)  
- global perspective

- 1992 Earth Summit (Rio de Janeiro)
- 189 countries have signed on
- Objective:
  - “Stabilization of greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system”

What is dangerous?  
(global perspective)

- Demise of W. Antarctic Ice Sheet (6m sea level rise!)
- Ice-free Arctic
- Large-scale decline of coral reef ecosystems
- Shutdown of ocean’s thermohaline circulation
- Release of methane from frozen deposits in marine sediments

From O’Neill and Oppenheimer 2002 (Science) and Pittock (2005)
### What is dangerous?
(regional/local perspective)

- Weather and climate extremes (droughts, floods, tropical storms, heat waves)
- Insufficient water supply
- Inability to grow enough food
- Loss of natural ecosystems and their goods and services
- Spread of disease
- Sea level rise
- Others… (geopolitical, social, economic…)

NY Times, 8/15/10

### What is the IPCC?

- **Intergovernmental Panel on Climate Change:** UN and World Meteorological Office  
  - 4th assessment report issued 2007 (AR4)  
- **Multipart assessment of climate change:**
  - Working Group 1 (WG1): Physical Science basis
  - Working Group 2: Impacts (incl. regional/ecological), Adaptation, Vulnerability
  - Working Group 3: Mitigation
- **Who? Scientists**
- **What? Summarizing and evaluating existing research**
- **Draws on peer-reviewed scientific literature (what is this?)**

### What is the IPCC?

- **Peer-review science:** not opinion
- **Consensus-based**
- Heavily reviewed at scientific and political levels (>30,000 comments in WG1)
- Careful treatment of uncertainties, likelihoods, types of uncertainty etc.
  - E.g. “very likely” means >90% sure
  - Likelihood vs confidence
- **Error-free?**
- IPCC is a **conservative document!**
- **Website:** [http://www.ipcc.ch/](http://www.ipcc.ch/)
  - WG1 - [http://ipcc-wg1.ucar.edu/wg1/wg1-report.html](http://ipcc-wg1.ucar.edu/wg1/wg1-report.html)

### Lessons from IPCC AR4

- Climate change is real, and we are doing it
- Consequences are emerging clearly
  - Generally not good
- Predictions are converging and agreeing
- Countries have unequal responsibilities and vulnerabilities
- Adaptation is imperative
- Mitigation is still possible and may not be as costly as once thought
Observations: Rising CO2

Data since 800,000 yrs ago from ice cores; longer less precise CO2 records from marine sediments

Consistent picture

Ten Indicators of a Warming World

Seven of these indicators would be expected to increase in a warming world and observations show that they are, in fact, increasing.
First half of 2010 broke records for global temperature (warmest Jan-July, and for many individual months)
Natural variability evident: La Niña and others

Status check: global surface temperature

Trend is accelerating over 20th century

Status check: global surface temperature trend

Reality check on global warming

- Temperature is rising
- CO2 is rising beyond recent (last 800Ky-20my) natural levels
- Increased CO2 is due to human activity (mainly fossil fuel burning)
- CO2 is a greenhouse gas that prevents energy from escaping to space
- There’s no credible alternative to explaining recent global warming
Ocean pH is declining, carbonate saturation declining, and most marine organisms don’t respond well to this.

Status check: Ocean acidification

Observations show rapid decrease
Summer ice-free conditions as early as 2030
Powerful positive feedback


Sea ice is a powerful positive feedback

- Ice is more reflective than water
- Ice melts ==> more radiation absorbed, less reflected
- More absorption means more warming
- Positive feedback on warming:
  - Initial warming ==> melting ==> more warming
- There are negative feedbacks on climate change too (and other positive ones)

Status check: Declining NH snow cover

NOAA 2009 State of the Climate
**Status check: Heat content of the ocean (700m)**

The graph shows changes in ocean heat content in joules (a measure of energy) compared to the 1958-2002 average. Different colored lines represent various studies, and the data points show fluctuations in ocean heat content over time. The graph is based on data from the NOAA 2009 State of the Climate report.

**Status check: Sea level rise**

Rates accelerating:
- 1870-1940 <1mm/yr
- 1940-1990 ~1.6mm/yr
- 1990-present ~3 mm/yr

**Observations:**
**Declining ice mass**
- Gravity measured from satellites
- Mass of polar ice is declining
- Rate is accelerating

**These indicators all increase in a warming world**

- Air temperature near surface
- Sea level
- Specific humidity
- Sea-Surface temperature
- Temperature over oceans
- Ocean heat content
- Lead surface air temperature over land

Observations from various studies:
- Gravity measured from satellites
- Mass of polar ice is declining
- Rate is accelerating

References:
- Velicogna 2009 GRL
Observations are consistent

These indicators all decrease in a warming world

Closer to home...

U.S. Drought Monitor
August 17, 2018

http://www.msnbc.msn.com/id/25834441/