Freshman Seminar on Climate Change
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Description:

The atmospheric concentration of carbon dioxide is now the highest it has been in millions of years. In a hundred years it is likely to be higher than it has been for tens of millions of years, and this raises concerns regarding a possible future climate warming. This seminar will provide the students with some background on the science of global change via a survey of the scientific debates that shape our understanding of climate change. Some of the obvious question are what will the Earth's temperature be in a 100 years? What will the sea-level be? And how bad might our best estimates be? Other questions include why are some mountain glaciers growing while others retreat? Are tropical cyclones intensifying? How warm was it in the past thousand years? And the fate of Antarctic and Greenland ice? Students will come away with a more complete understanding of the science of climate change. Course material will include readings, lectures, group discussion, and the exploration of simple mathematical models of the climate. As a prerequisite, students should have some background in high-school physics and calculus.

Materials:

Textbook: Global Physical Climatology, Dennis L. Hatmann, 1994.

Other readings will be available at http://my.harvard.edu/icb/icb.do?keyword=k28222, and these should be completed prior to attending class.

Computer: Students should have access to a computer and Matlab. Ideally, a sufficient number of laptops will be available during class meeting that some work can be accomplished there.

Week 1: Notions, swindles, and contradictions

Reading: “Climate of Man I” and "Don't Believe the Hype, Al Gore is Wrong. There's no 'consensus' on global warming", by R. Lindzen, Sunday July 2nd, Wall Street Journal.

Discussion: Group discussion regarding student’s ideas and views on climate change.

Movie: “The Great Global Warming Swindle”. How to distinguish between this range of assertions? (This arguments presented in this movie are sophisticated, but good for discussion. It is also possible to screen “An Inconvenient Truth”, or have students seen this?)

Exercise: Make a list of seeming contradictions, and the possible debates which arise within this movie and elsewhere.

Laboratory: Some concepts for representing climate phenomena using simple computer models are presented: black-body radiations, heat-capacity, equilibrium versus seasonal cycle.

Homework: A code which approaches a temperature equilibrium was discussed in class. Add a seasonal cycle to this code.

Week 2: An introduction to the climate problem

What does an observed 0.74 degree increase in “global surface temperature” mean? Could it be due to urban heat island effects? How is global surface temperature known given the changing instruments, methods, and observational coverage?

Reading: "Climate of Man II", Elizabeth Kolbert, New Yorker, 2005; IPCC 2007, chapter 3, pages 241-253; Parker (2005) on global warming is not due to urban heat islands; but then see Pielke’s blog and Pielke Matsui (2005) on how Parker didn’t get it right after all.

Laboratory: Get a very simple energy balance model to run on Matlab.

Homework: Read p18-28 of Hartmann, (sections 2.1 to 2.6). Add an atmospheric layer to the EBM.

Week 3: Mountain glaciers

Debate: Are mountain glaciers melting due to global warming?

Reading: “Kilimanjaro Glaciers: Recent areal extent from satellite data and new interpretation of observed 20th century retreat rates” by Cullen et al., 2006; "Extracting a Climate Signal from 169 Glacier Records" by Oerlemans, 2005.

Laboratory: the ice-albedo feedback ---- parameterize albedo as a function of temperature. Introduce concept of sensitivity.

Homework: How does the seasonal cycle change with the inclusion of the albedo feedback?

Week 4: Sea ice

Debate: How fast and why is the sea ice retreating?

Reading: “Is Battered Arctic Sea Ice Down For the Count?” by Kerr, 2007; “Perspectives on the Arctic’s Shrinking Sea-Ice Cover” by Serreze et al., 2007; “Natural Variability of Arctic Sea Ice Over the Holocene” by Fisher et al., 2006.

Laboratory: A simple sea ice model atop a slab ocean.

Homework: Is it harder to get sea-ice to melt or re-grow (hysteresis)?

Week 5: Greenland and Antarctica

Debate: How fast and why are the ice sheets melting?

Reading: “How Fast Are the Ice Sheets Melting?” by Cazenave, 2007; “Recent Sea-Level Contributions of the Antarctic and Greenland Ice Sheets”, Shepherd and Wingham, 2007; “Rethinking Ice Sheet Time Scales” by Truffer and Fahnestock, 2007.

Laboratory: Positive degree days, and the temperature-accumulation feedbacks.

Homework: Include a parameterization of temperature, ice-volume, and sea-level in the simple model.

Below are sketches of other possible topics

The "natural" range of Earth's temperature

Debate: How large is the natural range of Earth's temperature variability over the last millennia?

Reading: "Climate of Man III", and the following in the "Hockeystick" folder on the website: "Global-scale temperature patterns and climate forcing over the past six centuries" by Mann et al, 1998; "Hockey sticks, principal components, and spurious significance" by McIntyre and McKitrick, 2005; "Global Warming Bombshell", by Muller, 2004; and Barton's letter to Mann.

Sea-level

Reading: Past: Sea-level from corals through the last deglacation;

Future (Controversy): IPCC vs. Rahmstorf vs. Rahmstorf's rebutters.

Riddle: What would sea-level around Greenland do if/when Greenland melts?

Physics: Ocean warming. Include a two-level ocean and explore how penetration of heat into the ocean will increase its volume and slow-down surface warming.

Stratospheric Cooling

Reading:

Physics. Shortwave and longwave absorptivity and emissivity

Model: Add stratospheric layer with ozone absorption and show how temperature in that layer changes in response to changes in ozone and CO2.

Hurricanes

Reading:

Is hurricane activity increasing?

Physics: Clausius-Clapeyron

Model: add water-v**apor feedback**

Cosmic Rays and clouds

Do cosmic rays control clouds?

Model: add high and low clouds to the model

Mid-tropospheric warming

How much has the mid-troposphere warmed in the last decades? How much will it warm in the future?

Reading: Selections from the NRC report.

Ocean acidification and corals

Anthropogenic emissions of CO2 and ocean acidification.

"The dangers of ocean acidification", S. Doney, Scientific American, p58-p65, March 2006.

"Sick Seas", J. Ruttimann, Nature, August 2006.

"Anthropogenic carbon and ocean pH", Caldeira and Wickett, Nature, p365, September 2003.

"Coral reef calcification and climate change: The effect of ocean warming", McNeil et al, Geophysical Research Letters, Vol 31, 2004; and the comment by Kleypas et al. 2005 and subsequent reply.

Early anthropogenic influence

When did we first start influencing the climate and to what effect?

Global warming and Health

"Is Global Warming Harmful to Health", P. Epstein, Scientific America, April, 2004.

What to do

Can we control the climate (or at least provoke it less)?

Is it possible to reverse the warming trend?

"Defusing the Global Warming Time Bomb", J. Hansen, Scientific American, March 2004.

"Albedo enhancement by stratospheric sulfur injections: a contribution to resolve a policy dilemma?", P. Crutzen, Springer, 2006.

Predictions

Based on model calculations, reading, and educated guesses each student group will present their predictions for the state of the climate system 100 years from now. We'll award a large prize to whichever group turns out to be most correct.

The infrared iris effect

"Does the Earth have an adaptive infrared iris?", R. Lindzen et al.,
Bulletin of the American Meteorological Society, March 2001.

"No evidence for iris", D. Hartmann and M. Michelsen, American Meteorological Society, February, 2002; and the further exchange between Hartmann and Lindzen.