Global warming debates: the reading course

Spring 2016

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TF: Leah Birch

Time: Wednesday, 3-6pm.

Location: Faculty Lounge, 4th floor, Hoffman Lab.

Bibliography: Papers are posted on the course web page and linked from this document.

Web: https://canvas.harvard.edu/courses/9362

Announcements: Last updated April 16, 2016. Feel free to write, call or visit us with any questions.

Want to be an *informed* climate skeptic? Come learn from other people's mistakes...

This reading course seeks to provide an overview of the science of global change thorugh a survey of current scientific debates. Topics are specifically chosen for their relevance, interest, and open-ended nature. No *correct* answer is likely to emerge, but we hope that you will become scientifically better informed regarding relevant climate topics. An initial list of topics are provided below, but this can be revised according to current events and student interests.

Administrative

Prerequisites: This broad survey course is designed to be accessible to upper level undergraduate students who have a scientific background. APM21A and APM21B, or equivalents, or permission of instructor, are required.

Presentation: Each group of 2-3 students will be responsible for preparing and making both a preview presentation and a full presentation regarding a subset of the subjects. The preview presentation is ∼5 slides, 10 minute long, and is given the week before the subject is discussed in class. The purpose of this brief presentation is to motivate the subject, explain its importance, and especially help the other students understand the reading material by providing them some guidance and explanation about the paper(s) and the relevant background. The full presentation is ∼30 slides long and is to be used during the discussion. Please provide some background for the other students and then get to the actual scientific topics within ∼5 slides. The purpose of this presentation is to guide and excite discussion, rather than to lecture. Not actually covering all 30 slides during class time would be just fine. Presentations are to based upon the assigned reading and augmented with additional material. See further presentation guidelines here and here.

Position paper If not part of the group making a full presentation in a given week, students are asked to bring a one-page position statement (12pt single space) to class based upon the assigned reading where the first part outlines the overall issue and the second provides an initial judgement on the topic. See here and here.

Grading: Based on presentations (30%), discussion and participation (30%), and position papers (40%). If you must miss class, which obviously makes participation impossible, please obtain our permission ahead of time.

(All reading material is hosted on Dropbox)

Topics

1. **Jan 27, First meeting:** the movie "An Inconsistent Truth", please prepare by perusing "the climate of man" in 01-Background readings.

2. **Feb 03, Mountain Glaciers:** Are mountain glaciers melting? Due to global warming? First, see some beautiful pictures of glaciers "before and after" here; then note that the IPCC 4th Assessment Report stated, "Glaciers in the Himalaya are receding faster than in any other part of the world (see Table 10.9) and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate. Its total area will likely shrink from the present 500,000 to 100,000 km2 by the year 2035 (WWF, 2005)." (IPPC 2007, Working Group II: Impacts, Adaptation and Vulnerability, Chapter 10.6.2); read

Bloch et al. (2012) about the Karakoram and Himalayan glaciers and the one-age comment by Cogley (2010) on the source of misinformation in the IPCC. Optional: see Kapnick (2014) for more on the Karakoram glaciers and here for more on the IPCC process and how it failed in this particular case. readings.

3. **Feb 10, Ocean acidification:** It's an undisputed consequence of rising CO_2, but the exact effects on calcifying species and the carbon cycle is still in question, and we'll take a closer look with the following articles, posted on the website: (1) Read the RealClimate entry which sums up the chemistry nicely. (2) Lohbeck et al (2012) which suggests that organisms can evolve to adjust. readings.

4. **Feb 17, Radiative Balance** What is Earth's net radiative forcing? Read Trenberth and Fasullo (2012), who can't find the extra heat accumulating from Earth' radiative imbalance, and then Loeb et al. (2012) who argue that the heat budget balances to within uncertainty. readings.

5. **Feb 24, Cosmic Rays:** Is global warming due to a change in cosmic rays? This time we will be reading a few small bits from several papers and blogs, please follow instructions A-E carefully: (A) [An image only] Start by looking at the global-average temperature record 1-global_temperature-1850-2000.pdf; (B) [An image only] Look at the lower figure (Fig 6) on page 8 of 2-shaviv-blog-Carbon_Dioxide_or_Solar_Forcing.pdf and note the remarkable similarity of the global temperature record and this cosmic ray record. Both reach a max around 1950, a minimum in the 1970s, and then increase. A strong case that solar activity is the source of global warming? (C) [4 page reading] What is the physical mechanism that links the solar activity and the global temperature? Please read, 3-Svensmark-et-al-2009-GRL.pdf; (D) [2 pages] Next, see some other systematic errors in the brief paper, 4-Damon-Laut-2004-EOS.pdf; (E) [3 page non-technical reading] And finally, see a critical discussion of the physical mechanism linking cosmic rays and cloud condensation nuclei in 5-RealClimate-cosmic-rays-still-not-convincing.pdf. [Optional: In case you are interested, the technical references mentioned there see the "more/" folder.] readings.

6. **Mar 02, Ocean circulation failure:** Could ocean circulation change rapidly? Readings: (1.) [about 3 pages] [2.5 pages] Bryden et al., 2005 "Slowing of the Atlantic meridional overturning circulation at 25N": the actual scientific paper suggesting that the THC has already collapsed. (2.) A more recent paper showing how variable the ocean overturning circulation is. (3.) [half a page] An (unpublished) explanation of the ocean circulation "collapse" in terms of the overturning circulation seasonal cycle: readings.

7. **Mar 09, More or stronger hurricanes due to global warming:** Background: 2005 was a destructive hurricane year, global warming was blamed. The following seasons were not as dramatic. What's going on? Read at the following order: (1) Emanuel (2005) 'Increasing destructiveness of tropical cyclones over the past 30 years';

(2) Landsea et al (2006) 'Can We Detect Trends in Extreme Tropical Cyclones?'; [Optional: in the more/ directory, including the interesting resignation letter (Landsea-letter-resigning-from-IPCC.pdf).] readings.

8. **Mar 23, Hiatus:** Has global warming stopped since 2000? Please read the blog entry by Judith Curry explaining the IPCC position and arguing it's confused at best. Continue with the one page Held (2013) which summarizes the next paper, and then read Kosaka and Xie (2013) which suggest an explanation for the Hiatus (tropical Pacific). readings.

9. **Mar 30, Sea level:** From where did rapid rise in sea level during the last deglaciation originate? Read a very short introduction on uncertainty in future sea level and an event known as Meltwater Pulse 1a. Then read Clark et al. (2002) on "fingerprinting" the source of Meltwater Pulse 1a to Antarctica. If interested, skim the recent New Yorker piece on how sea level rise is affecting Southern Florida. Recent references that build on Clark et al. (2002) are in the More directory, along with the full IPCC chapter on sea level. readings.

10. **Apr 06, Antarctic ice sheet instability:** How fast could West Antarctica melt? First watch what glacier calving looks like here. Then read Pollard et al. (2015) readings. If you want more background, look at the review article by Alley et al. in the More folder, or you can watch Alley lecture on this topic here.

11. **April 13, Methane clathrates** Could significant amounts of Methane clathrates/ hydrates on the ocean floor be destabilized and released to the atmosphere due to global warming, causing a catastrophic positive feedback? See wikipedia and then the two sides of the debate. readings.

12. **April 20, Social Upheaval:** is it precipitated by climate variations? More wars in warmer climate? Our two readings this week examine the link between ENSO and civil conflicts, while examining the extent to which warm temperatures are associated with elevated levels of armed conflict in Africa. readings.

13. **April 27, How best to control emissions:** Read the Rolling Stone article by Bill McKibben (2013) and Hansen et al. (2013) for arguments that net fossil fuel extraction must be limited, and Schrag (2012) that our focus should be on spawning the innovation needed to transition away from carbon-emissions-based energy production. readings.

Other material

Radiative forcing

1. [CO_2 saturation:] Isn't the atmosphere saturated with respect to longwave trapping by CO_2 anyway? If so, additional CO_2 cannot absorb more heat and wont enhance the greenhouse effect, so nothing to worry about? This issue started with the debate between Arrhenius (calculated the expected warming due to CO_2 doubling) and Angstrom Jr (measured the radiative effect of additional CO_2 and concluded that it's negligible). Read the two RealClimate blog entries. more readings.

2. [The infrared (LW) "iris effect":] will cloud feedbacks prevent global warming? Background: The iris effect is a proposed cloud feedback that may reduce global warming. Does it work? (1) Read the short wikipedia entry; [optional, see Lindzen et al BAMS paper under the more/ directory]. (2) Lindzen and Choi (2009) try to make the case for an Iris based on present-day observations. (3-4) Trenberth et al (2010 paper and a brief RealClimate summary by the same authors) criticize them. And finally (5) Lindzen and Choi try again, addressing the criticisms they received, claiming their results are still robust. more readings.

3. [Why is the stratosphere cooling?] more readings.

4. [Climate sensitivity:] How sensitive is temperature to radiative forcing? Wikipedia gives an overview of what is meant by the term "climate sensitivity". Note the distinction between transient climate sensitivity and equilibrium climate sensitivity. Then read the 1979 National Academies report on climate sensitivity whose estimate has generally stuck (Charney et al., 1979), and then contrast this with one recent estimate that is lower (Aldrin et al. 2013). more readings.

Atmosphere

5. Heat waves: Are they due to global warming, or just a statistical fluke? Start with the NYTimes article on the Russian heat wave. Then Read Dole et al (2011) suggesting that this has nothing to do with global warming. Then Rahmstorf and Coumou (2011) claiming that this heat wave would have been very unlikely without global warming. Finally, read Otto et al (2012) which try to reconcile the two views. more readings.

6. [Mid tropospheric warming:] Is the upper troposphere warming more than the surface? Why is this expected in principle? Is the model prediction for such warming (especially in the tropics, 200-300mb) exaggerated relative to radiosonde satellite observations? Read first Douglas et al (2008) making the case that models are badly biased. Then the RealClimate entry explaining that this debate is not new and that the model-radiosonde discrepancy has already been resolved. Finally, read Santer et al (2008) trying to make the case that models are now consistent with observations (look carefully at their figure 6, are you convinced that the models are absolutely great?) more readings.

7. [Jet stream waviness and cold winters:] could global warming and the loss of summer sea ice lead to cold winters in North America via induced strong waviness of the atmospheric jet stream? read the perspective piece by Wallace et al. (2014) and make a note of the arguments that they raise against the notion of Arctic sea ice influencing mid-latitude weather. Then read Francis and Vavrus (2012) and the counter-argument by Barnes (2013). Finally, read thedot.earth entry, which includes some back and forth between the various authors. Optional: folder with articles from the popular press. more readings.

Cryosphere

8. Changes in sea ice: Does Arctic sea ice melting have anything to do with global warming, and why is Antarctic sea ice increasing? First read the short EOS overview by Overland et al (2008) and then the more detailed piece by Overland and Wang (2010). For a different view of Arctic ice loss as a positive feedback, see Screen and Simmonds (2010). Finally, Maksym et al. (2012) round out the discussion regarding Antarctic sea ice, contrasting it against its polar opposite. Also, see two nice NASA animations, and the more readings.

9. How quickly will Greenland melt, and could it contribute to significant sea level rise in the next century? Are ice streams there already accelerating? We will focus on the significant changes that have been observed in Greenland in the last ten years. The three readings (Hansen 2007; Nick 2009; Pfeffer 2008) take different positions on the question of future sea level rise primarily based on the potential for ice stream changes due to ocean and atmospheric forcing. [Optional: material on ice streams (helps to understand the Nick et al. paper) readings is given in the Joughin & Alley paper on ice streams, section on internal instabilities. For more on ice streams, the Bennett article.] more readings.

10. [Can the west Antarctica ice sheet collapse?] more readings.

Paleoclimate

11. Is the 20th century warming unusual? The "hockey stick" controversy. The IPCC report in 2001 prominently figures a reconstruction of past temperatures from Mann et al. which is often referred to as the hockey stick because it features a slow and straight decline in temperature followed by a sharp uptick in the last century. This reconstruction came under criticism for the statistical techniques which were employed. Please read: (1) RealClimate summary of the hockey stick controversy. (2) [5.5 pages] Mann et al. "Global-scale temperature patterns and climate forcing over the past six centuries". Read up to page 784, not including the section "Attribution of climate

forcings". (3) McIntyre and McKitrick, "Hockey sticks, principal components, and spurious significance". more readings.

One remarkable part of this specific debate is the involvement of the US congress. Please read under the directory Mann_vs_US_congress/: (4) Congressman Barton's letter to Mann and Mann's response. [Optional: if you'd like to learn more about the popular press response to this debate, look under popular-press/, especially at the Guardian article.] more readings.

12. Do temperature variations lead CO_2 changes during ice ages? (i) Using your own web search results, start by describing the snow accumulation process during which gas bubbles are trapped in ice cores, what is the time scale of bubble trapping in Antarctica? In Greenland? Why is there a difference? (ii) Using the above, explain what are gas ages and ice ages and what sets the difference between them. (iii) Proceed to read the assigned papers and discussing them in your report following the course guidelines: (1) RealClimate entry posted on the course web page. (2) Caillon et al. (2003). (3.) The short perspective piece by Brook (2013). (4.) Parrenin et al. (2013). Caillon (2013) argues that temperature leads CO_2 during glacial terminations (e.g., during the exit from the last glacial maximum some 20,000 years ago) and Parrenin et al. (2013) argues the opposite. Do we really know which leads and which lags? According to climate skeptics, a lead of CO_2 relative to temperature means that it is not necessarily important in this warming process. Do you agree? more readings.

13. [Anthropocene:] did early humans started altering climate through modifying atmospheric composition thousands of years ago? Did they stop an ice age from occurring? Bill Ruddiman has proposed that the human influence on climate started more than 5000 years ago, but others see climate variability prior to a couple of centuries ago as arising essentially only from natural processes. How far back does our influence reach? Readings: 1. Scientific American article by Ruddiman (2005): "How did humans first alter global climate?"; 2. Criticism: "The Holocene CO_2 Rise: Anthropogenic or Natural?", by Broecker and Stocker, 2006; 3. The reply: "On "The Holocene CO_2 Rise: Anthropogenic or Natural?", by Ruddiman 2006. [Optional: 4. Original laying out of the idea: "The anthropogenic greenhouse era began thousands of years ago", by Ruddiman 2003; 5. A third opinion, "How Long Will Our Interglacial Be?", by Crucifix and Berger, 2006; 6. A recent 2013 update by Mitchel et al, for the past ∼3000 years only, though.] more readings.

Bio feedbacks

14. [Amazon forest die-back:] A potential carbon feedback that has been heavily debated in the literature. Cox et al. is an analysis of results from a comprehensive global circulation model (GCM) which includes dynamic vegetation effects, in an effort to

simulate the response of the biosphere to climate change. Malhi et al. takes a different approach by focusing on the hydrological characteristics that contribute to the existing biome distribution. We will be engaging with two questions: 1) What is the expected response of the Amazon to climate change? 2) What will be the feedback (if any) of changes in terrestrial vegetation on the global carbon cycle (and hence, the climate)? more readings.

15. [Methane emission from plants:] Living terrestrial vegetation emits large amounts of methane into the atmosphere. This surprising recent finding may have an impact on accounting of greenhouse-gases and of sources of methane: more readings.

Broader implications

16. Food shortage? Is agricultural food production going to decrease dramatically due to global warming? Read Schlenker et al 2009 suggesting that high temperatures will decrease crop yield. Then Butler paper explaining that adaptation can make all the difference, then the comment/ reply. more readings.

But what to do?

17. How should geo-engineering be studied and employed? Discuss the concept of geo-engineering. What strategies have been proposed? How does it work? Is it feasible? Is it ethical? Discuss the pros and cons of mitigation and geo-engineering. Under which conditions would its utilization be appropriate? How would you propose to manage our risk exposure to future climate change? more readings.

More

18. Prediction and projection: Are General Circulation Models rigged? (Knutti 2007, Charney Report)

19. "An inconvenient truth" Al Gore's global warming movie.

20. Last class: Congratulations, we've reached the end. For our last meeting we'd like you to read the summary for policy makers of working group 1 of the IPCC. 18 pages of non technical reading. Please write a **3 page** (12pt, single spacing) report summarizing the IPCC recommendations, critically evaluating them based on what we covered in class. Incorporate material from all other debates in order to put the IPCC in perspective. Conclude with your own assessment of the scientific basis for present and future global warming.