# Global warming debates: the reading course

# Spring 2014

**Instructors:** Peter Huybers and Eli Tziperman

**TF:** Karen McKinnon

**Time:** Wednesday, 3-6pm.

**Location:** Shaler Room, 4th floor of the Geology Museum Building.

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

**Web:** http://isites.harvard.edu/k95676

**Announcements:** Last updated April 2, 2014. 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 or equivalent, or the permission of the instructor, is required.

**Presentation:** Groups of 2-3 student will be responsible for preparing and making a preview and full presentation regarding a subset of the topics. 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. (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.

# Lead-off topic

(All reading material is provided on the course website; see also here)

**First meeting:** the movie "great swindle of global warming", please prepare by reading "the climate of man", IPCC introduction, and Lindzen article. background basics.

1. Global warming 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. Then Guernas et al (2013) who suggest one explanation for the warming hiatus (ocean heat uptake) and then Kosaka and Xie (2013) with another explanation (tropical Pacific). Conclude with the one page summary of Held (2013). readings.

# Radiative forcing

2. 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. course website see Readings/Heat budget.

3. 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-G 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 page reading] However, is the trend seen in the above figure from Shaviv real? Read sections 1 and 2 and especially see Figs. 1 and 2 from, 4-Ahluwalia-1997-JGR.pdf; note how the two original records in Fig 1 do not show a global-warming like trend, while the combined one (Fig 2) does. (E) [2 page reading] Next, see some other systematic errors in the brief paper, 5-Damon-Laut-2004-EOS.pdf; (F) [3 page non-technical reading]. (G) And finally, see a critical discussion of the physical mechanism linking cosmic rays and cloud condensation nuclei in 6-RealClimate-cosmic-rays-still-not-convincing.pdf. [Optional: In case you are interested, the technical references mentioned there (Pierce and Adams and Erlykin et al) plus much more are posted under the "more/" folder.] readings.

# Oceans

4. 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) Representing the "acidification is a problem": Doney, et al. (2009) "Ocean Acidification: The Other $CO_2$ Problem". (3) The other side of the debate: Iglesias-Rodriguez, et al. (2008) "Phytoplankton Calcification in a High-$CO_2$ World". (4) Don't miss the technical comment after the Iglesias-Rodriguez article. readings.

# Atmosphere

5. More/ 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?'; (3) Emanuel (unpublished) Critique of "Can we Detect Tropical Cyclones?"; [Optional: look at the more/ directory for some RealClimate and popular press articles; the presenters will find there an additional interesting paper by Emanuel (2008, BAMS) that can enhance their presentation and the interesting resignation letter (Landsea-letter-resigning-from-IPCC.pdf).] readings.

6. 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. readings.

## Cryosphere

7. 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 course website under Readings/Arctic sea ice.

8. 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.] readings.

## Atmosphere, again

9. Waviness: The main question is whether Arctic climate change has an appreciable influence on mid-latitude weather? We will ask the class to 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.

## Paleoclimate

10. Do temperature variations lead CO2 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 CO2 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 oppostie. Do we really know which leads and which lags? According to climate skeptics, a lead of CO2 relative to temperature means that it is not necessarily important in this warming process. Do you agree? See the course website.

## Broader implications

11. Food shortage? Is agricultural food production going to decrease dramatically due to global warming? readings.

12. 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. course website Readings/Controlling emissions

13. 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? readings.

## Supplementary topics

14. Mountain Glaciers: Are mountain glaciers melting? Due to global warming? First, see some beautiful pictures of glaciers "before and after" by Gary Braasch (some are seen using Explorer only, it seems) here; then read the introduction to tropical glaciers from the RealClimate blog, and then the Thompson et al and Cullen et al papers. One argues that tropical glaciers melt due to global warming and the other that they are melting because the little ice age ended. readings.

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

16. Possible last class: 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.

17. Will melting permafrost increase atmospheric greenhouse gases? readings.

18. 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: readings.

19. The Clathrate gun hypothesis, could significant amounts of Methane clathrates/ hydrates on the ocean floor be destabilized and released to the atmosphere due to global warming? See RealClimate here and here.

20. 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)? readings.

21. 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. readings.

22. Why is the stratosphere cooling? readings.

23. 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 CO2 Rise: Anthropogenic or Natural?", by Broecker and Stocker, 2006; 3. The reply: "On "The Holocene CO2 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.]. readings.

24. 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). course website under Readings/Climate sensitivity

25. 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. readings.

26. Could the ocean's thermohaline circulation (THC, also referred to as the meridional overturning circulation, MOC) collapse? Perhaps it already did? This is an example of the all important "thresholds"/ "bifurcations"/ tipping points in the climate system and what they may lead to. Background: It has been suggested that the ocean circulation could change rapidly between a state where, as occurs presently, water sinks at high northern latitudes in the Atlantic to one in which this sinking is reduced or is shut-off altogether. Such a reduction in sinking might lead to cooling at high northern latitudes. There is a wide-ranging debate in the literature arguing from the perspective of models and paleoclimate observations that this might happen in the future and may have happened in the past. Lot's of maybe's and might's in this discussion...

27. Could the west Antarctica ice sheet rapidly collapse? First read Mercer (1978) for a case that West Antarctica could rapidly collapse and raise sea level by 5m, and then Vaughan (2009) for a more circumspect treatment of this possibility. Joughin and

Alley (2011) provide a good description of the instability hypothesis: course website. Also, this website gives an overview of the relevant mechanisms and links to additional resources.

28. Social Upheaval: is it precipitated by climate variations? More wars in warmer climate? Our two primary papers examine the extent to which warm temperatures are associated with elevated levels of armed conflict in Africa. The supplementary paper is more recent and takes a more general look at the potential link between El Nino and deaths to to conflict in the tropics. readings.

29. 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?) readings.