"Target CO_2" publication, "Obstruction" clarification, Paterson letter

1. "Target Atmospheric CO_2: Where Should Humanity Aim?" will appear in 3-4 days in The Open Atmospheric Sciences Journal. Thanks for suggestions, which improved the clarity.

This journal is one of the new ones with free worldwide access [we submitted the paper there after Science would not accept it because it had already been published on blogs and discussed in the media.] This experience with an Open Journal was good, so I will probably try The Open Environment Journal for a paper now in preparation. Publication would have been faster except their referee suggestions required adding a section on caveats and uncertainties, which took a long time because of other commitments. The additions (sections 4.5 and Fig. 7 in the main text and section 18 and Fig. S21 in the Supplementary Material) are useful, I believe.

Below is a draft press release that I am providing to both NASA and Columbia University, and an incomplete draft of personal "answers to frequent questions" aimed at avoiding the need to respond to the same questions multiple times. Criticisms are welcome.

2. "**Obstruction of Justice**"**.** Thanks to several people who pointed out that the correct character for comparison in "Grapes of Wrath" was Tom Joad. Responses to my "Obstruction" post show that I left a number of misimpressions.

"Gets it". My statement that neither presidential candidate "gets it", based on their enthusiasm for "clean coal" and "carbon cap and trade", generated a few angry responses. I am sorry if I left the impression that I saw no difference between candidates. One reader concluded I would vote for Ralph Nader! I am surprised, because I attached voting recommendations (based on the astute analysis of the League of Conservation Voters) including the presidential race. I believe the United States needs a third party, but the groundwork has not been laid for an effective one. Besides, there is hope that the 2008 election could bring transformational change.

I understand one being jaded, even cynical, due to failure of previous candidates (both parties) to deliver on promised transformation. But the vice presidential choices should jolt even the most jaded and somnolent into getting their fannies to the polls, if they retain any concern about life and the planet left for our children. Our best chance is to elect someone who has the capability of "getting it", if we can ever succeed in making the climate story clear enough.

My caution about what a winning candidate will actually deliver is based on experience. If my "Trip Report" (http://www.columbia.edu/~jeh1/mailings/20080804_TripReport.pdf), recounting dismal failure to help officials in various countries "get it", did not convince you, I offer another example: Australia. Response to my "Dear Prime Minister Rudd" is at (http://www.columbia.edu/~jeh1/mailings/20080401_DearPrimeMinisterRudd_reply.pdf) hardly illuminates the Australian position, but their subsequently stated goals of 450-550 ppm CO_2 does. That plan appears to have been written by the coal industry, and, if adopted globally, practically guarantees destruction of most life on the planet. I would be more critical, except that much of the problem is probably due to our failure to make the climate story clear enough. More later on this topic and the ways in which moneyed interests finagle "cap and trade" to everybody else's detriment.

PowerVote. Apologies to Andy Revkin, who responded to my "Obstruction of Justice" post thusly: "I never said you advocated 'unlawful protest' but that you endorsed 'civil

disobedience'." I should be careful in getting precise quotes. However, I do not recall endorsing civil disobedience either (yet).

My recommendation has been that young people spend maximum effort on the democratic process, affecting upcoming elections on all levels, and then, after the election, demanding that those elected deliver on their promises. I have cooperated with the (nominally non-partisan) PowerVote, Virginia Powershift, ReEnergize Iowa, 350.org, 1sky.org, etc., and have my t-shirts to prove it. Of course, there will be time to reassess later, depending on whether elected leaders show that they "get it" or, instead, return to "business-as-usual".

In this regard, I draw your attention to a note from Holly Garrett:

I am writing to let you know that we are accepting National Council Applications for SEAC (Student Environmental Action Coalition) at this time. This is a great opportunity for students and other youth to gain more skills and develop as leaders in the climate movement. *If you've met any stellar youth in your travels (especially in the UK or other countries!) please forward this to them and invite them to apply!* We're looking for dedicated and effective leaders and organizers to join the 2009 SEAC. **(obtain application from** www.seac.org**)**

Media. In "Obstruction" I forgot to raise the question about our American media. Why is it that the Kingsnorth case is on the front page and the 6 o'clock news in the UK, but the Wise County case is ignored by U.S. media? The damage in the U.S. case, both climate and mountaintop removal, exceeds that in the UK. A case with 20-year-olds standing up for their and future generations, against powerful interests, without support of Greenpeace-level organizations, would seem to warrant coverage. Is this a case of media, in a company-town, company-state, company-country situation, intentionally looking the other way? Or is it simply that these young people are not as media savvy as Greenpeace?

3. "**Dear Governor Paterson**"**.** Letter to the New York Governor is at http://www.columbia.edu/~jeh1/mailings/20081030_DearGovernorPaterson.pdf

Jim Hansen

Target Atmospheric CO_2: Where Should Humanity Aim?

Humanity must find a path to reduced atmospheric carbon dioxide, to less than the amount in the air today, if climate disasters are to be averted, according to a study to be published in Open Atmospheric Science Journal by a group of ten scientists from the United States, the United Kingdom and France[1]. They argue that such a path is feasible, but requires a prompt moratorium on new coal use that does not capture CO_2 and phase-out of existing coal emissions by 2030.

"There is a bright side to this conclusion" according to James Hansen, the lead author on the study, "by following a path that leads to a lower CO_2 amount we can alleviate a number of problems that had begun to seem inevitable, such as increased storm intensities, expanded desertification, loss of coral reefs, and loss of mountain glaciers that supply fresh water to hundreds of millions of people."

Atmospheric carbon dioxide is already 385 parts per million (ppm) and it is increasing by about 2 ppm each year as a result of the burning of fossil fuels (coal, oil, and gas), with a smaller contribution from burning of forests. The authors use evidence of how the Earth responded to past changes of CO_2 and on-going climate changes to show that atmospheric CO_2 has already entered the dangerous zone.

The authors suggest that global policies should have an initial target for atmospheric CO_2 of 350 ppm. They note that the optimum CO_2 level for maintaining a planet similar to that on which civilization developed is likely to be less than 350 ppm, but a 350 ppm target already reveals that dramatic policy changes are needed urgently. By the time such fundamental changes are achieved, knowledge will exist to help fine-tune the target CO_2.

Fig. 1a illustrates geophysical constraints that dictate essential policy actions. Coal is the largest source of atmospheric CO_2 and it is the source that would be practical to eliminate. Oil resources may be already about half depleted, depending upon the magnitude of undiscovered reserves, and it is impractical to capture CO_2 emerging from vehicle tailpipes. Coal, on the other hand, has larger reserves and the authors conclude that "the only realistic way to sharply curtail CO_2 emissions is phase out coal use except where CO_2 is captured and sequestered."

Fig. 1b shows that if coal emissions were thus phased out between 2010 and 2030, and if emissions from unconventional fossil fuels such as tar shale were minimized, atmospheric CO_2 would peak at 400-425 ppm and then slowly decline. The peak CO_2 amount would depend upon whether the smaller oil and gas reserve estimates of IPCC or the optimistic estimates of EIA are more accurate. The authors note that even if the large EIA reserve estimates are valid, peak CO_2 could be kept close to 400 ppm "if the most difficult to extract oil and gas is left in the ground via a rising price on carbon emissions that discourages remote exploration and environmental regulations that place some areas off-limits."

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[1] James Hansen[1,2], Makiko Sato[1,2], Pushker Kharecha[1,2], David Beerling[3], Robert Berner[4], Valerie Masson-Delmotte[5], Mark Pagani[4], Maureen Raymo[6], Dana L. Royer[7] and James C. Zachos[8]

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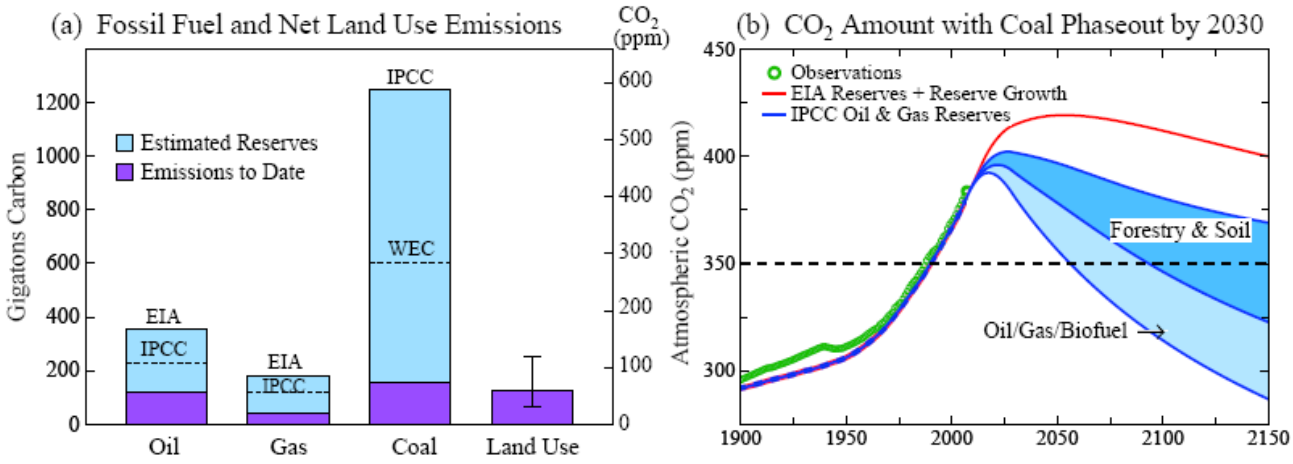

Figure 1. **(a)** Fossil fuel and net land-use CO_2 emissions (purple), and potential fossil fuel emissions (light blue). Fossil fuel reserve estimates of EIA, IPCC and WEC differ as shown. **(b)** Atmospheric CO_2 if coal emissions are phased out linearly between 2010 and 2030, calculated using a version of the Bern carbon cycle model. References [EIA (Energy Information Administration), IPCC (Intergovernmental Panel on Climate Change), and WEC (World Energy Council)] are provided in the published paper. Fig. 1 here is a combination of data from Fig. 6 and Fig. S13 in the published paper.

The authors discredit the notion of 'geo-engineering' solutions, noting that with present cost estimates the price of artificially removing 50 ppm of CO_2 from the air would be about $20 trillion. They suggest instead that "improved agricultural and forestry practices offer a more natural way to draw down CO_2." They suggest that reforestation of degraded land and improved agricultural practices that retain soil carbon could draw down atmospheric CO_2 by as much as 50 ppm. Additional significant CO_2 reduction could be achieved by using carbon-negative biofuels to replace liquid fossil fuels and phasing out emissions from natural gas-fired power plants, according to the authors. They find that a combination of these approaches could bring CO_2 back to 350 ppm well before the end of the century.

The conclusion that humanity must aim for a CO_2 amount less than the current amount is a dramatic change from most previous studies, which suggested that the dangerous level of CO_2 was likely to be 450 ppm or higher. The change is caused by realization that 'slow' feedback processes, such as ice melt and release of greenhouse gases by the soil and ocean in a warming climate, can occur on the time scale of decades and centuries. This realization stems from both improving data on the Earth's climate history and ongoing observations of change, especially in the polar regions.

The authors conclude that "humanity today, collectively, must face the uncomfortable fact that industrial civilization itself has become the principal driver of global climate." Specifically, they say that humanity "must begin now to move toward the era beyond fossil fuels", and "the most difficult task, phase-out over the next 20-25 years of coal use that does not capture CO_2, is Herculean, yet feasible when compared with the efforts that went into World War II. The stakes, for all life on the planet, surpass those of any previous crisis. The greatest danger is continued ignorance and denial, which could make tragic consequences unavoidable."

Questions and Answers (incomplete)

1. Less than 350 ppm: Are you saying that the optimum level of atmospheric CO_2, for humanity and nature, is 350 ppm?

No. In the long run, the level that we need to aim for is probably less than 350 ppm. But for the time being all that we need to know is that we must adopt policies that take the planet's atmosphere back to a CO_2 amount of 350 ppm or less. The optimum amount of atmospheric CO_2, or, better, the acceptable range, will depend upon how well we do in reducing other greenhouse gases. And it depends upon the magnitude of negative human-made climate forcings due to changes in atmospheric aerosols and surface reflectivity, which are not yet well-defined.

The important point is that we must halt and reverse the growth of CO_2, taking it back to the 350 ppm level and probably lower. That conclusion already tells us that we must fundamentally change 'business-as-usual' energy policies now. The most important implication: we must phase out coal emissions as soon as possible.

In retrospect, we should not have been surprised that the appropriate 'target CO_2' is less than 350 ppm. After all, CO_2 is the single largest climate forcing (perturbation of the planet's energy balance, which tends to alter global temperature) and humanity and natural ecosystems adapted to the climate produced by the pre-industrial ~280 ppm CO_2 amount that existed for the past 10,000 years. Civilization's infrastructure was built for the climate zones of the Holocene, and the infrastructure depends on the stable sea level of the past several thousand years.

If we were starting ab initio, with a choice of climates, would we have chosen the Holocene? That's a rhetorical question, but the Holocene is an excellent choice. It is warm enough to keep ice sheets off North America and Eurasia, but cool enough that we have mountain glaciers all around the world (as well as ice sheets on Greenland and Antarctica). Mountain glaciers are very useful, because they supply fresh water for rivers through the summer and fall, after snowmelt is long gone. An alternative would have been CO_2 of say 500 ppm, which would yield little or no ice on Earth and thus a more stable sea level, but a less diverse and interesting planet.

2. China and India: What hope is there of solving the problem with emissions from China and India increasing so rapidly?

Even though China has passed the United States in current emissions, the U.S. is responsible for more than three times the amount of fossil fuel CO_2 in the air today than any other country. Thus the United States has a responsibility to take a leadership role in finding ways to reduce emissions. Besides, early development of technology is in the best economic interest of the U.S.

China and India will surely become part of the solution, because they have more to lose from climate change than most countries. They also have more to gain from clean energies, as they presently have great pollution from use of fossil fuels. And these countries have the ability to move rapidly to new technologies, in part because they have less invested in old technologies.

I have no doubt that China and India will move smartly into the era beyond fossil fuels, once the path is better defined. The United States should be leading the way in defining a viable path.

3. Coal and R&D program for nuclear power: Why emphasize coal? Isn't coal use declining?

No. Coal is the largest source of human-made CO_2 in the air today, as much as oil and gas combined. In addition, coal use has been accelerating in the past several years, while supplies of oil are more limited. Oil emissions will inevitably decline. It does not make sense to go to extreme environments to try to squeeze every last drop of oil out of the Earth.

Coal is also the dirtiest of the fossil fuels, and is a primary cause of air pollution including particulates, mercury and radioactive materials. At present there is no such thing as "clean coal". Even if capture and sequestration of CO_2 and other pollutants becomes technically feasible (commercial scale operations of carbon capture seem to be at least a decade away) the great environmental damage associated with mountain-top removal to mine coal would remain.

In my opinion the best place for coal is to leave it in the ground. We should move on to renewable energies and improved energy efficiency. Coal supply is finite, so we must move to other fuels eventually. Why not do it sooner, rather than later, thus preserving a planet similar to the one on which civilization developed during the past several thousand years?

We should also have a strong R&D program, on an emergency basis, to evaluate the potential of next generation nuclear power, specifically breeder reactors that can burn nuclear waste, thus minimizing several problems that have been associated with nuclear power. Nuclear power may be required for base-load electrical power to allow countries such as China and India to phase out coal emissions over the next few decades. The aim should be to establish a standard safe design, one allowing modular factory construction and standard operating procedures, thus allowing rapid deployment, avoiding the long delays and price increases of the current approach.

4. Greenwash: Haven't most governments already recognized the global warming problem and begun to take actions to solve the problem?

No. Governments, utilities, and the fossil fuel industry have presented public faces acknowledging the importance of climate change and claiming that they are taking appropriate actions. Yet the facts contradict their claims. Even the apparently "greenest" countries, such as Germany and Japan, are making plans to construct new coal-fired power plants. These governments are kidding themselves and the public. Similarly, there are plans in many states within the United States for new coal-fired power plants. And several countries, including the U.S. and Japan, have plans to make submarine methane hydrates a commercially viable energy source within a decade – if left unchecked this could unlock a vast reservoir of fossil CO_2.

The best hope for leadership on this issue at the moment appears to be the United Kingdom, where the government is debating their policy regarding coal, raising the possibility of a moratorium on new coal plants. However, it would be necessary for the European Union and the Untied States to be brought on board quickly, and to move from a moratorium to phase-out of existing coal plants. The difficulty is that there are powerful coal industries in all of these countries. The governments in these countries do not seem to grasp the urgency of the situation, and they do not take a long-term view of the energy and economic situations.

5. Inter-generational inequity and injustice: when will climate change be a problem?

Some climate impacts are already becoming apparent, including an increase of extremes of the water cycle (heavier rainfall and floods, but also more intense dry periods and fires), melting of mountain glaciers with effect on fresh water supplies (once the glaciers are gone, potentially within a few decades if CO_2 growth is not halted, the rivers will tend to run dry in the summer and fall), expansion of the subtropics (affecting the Southern United States, the Mediterranean region, Australia and Africa), and shifting of climatic zones (affecting the health of some vegetation and human health through spread of disease vectors). Such climate impacts will increase over the next few decades, affecting the people who are causing emissions as well as future generations.

However, the most serious effects will be visited upon the young and the unborn, the generations that bear no responsibility for the problem. The most important effects, I believe, will be those that are irreversible for all practical purposes, specifically (1) extermination of species, and (2) ice sheet disintegration and sea level rise. If we continue business-as-usual energy policy, using more and more fossil fuels, it is likely that we will have:

(1) rapid climate change that will combine with other pressures on species to cause the rate of extinction of plants and animals to increase markedly, leading in some cases to ecosystem collapse, snowballing extinctions, and a more desolate planet for future generations.

(2) meter-scale sea level rise this century, and ice sheets in a state of disintegration that guarantees future sea level rise in the 10-meter-scale, with a continual reworking of future global coastlines out of humanity's control.

6. Protests against government inactions: what is appropriate?

Protests analogous to the ones at Kingsnorth in the United Kingdom (http://www.columbia.edu/~jeh1/mailings/20080910_Kingsnorth.pdf) and Wise County Virginia (http://www.columbia.edu/~jeh1/mailings/20081023_Obstruction.pdf) are likely to increase as young people become aware of the implications of continued coal burning. When does it become appropriate for young people to become fed up with the lack of appropriate government action?

My recommendation has been that young people spend maximum effort now on the democratic process, affecting upcoming elections on all levels, and then, after the election, demanding that those elected deliver on their promises. I have cooperated with the (nominally non-partisan) PowerVote, Virginia Powershift, ReEnergize Iowa, 350.org, 1sky.org, for example.

I have also drawn attention of youth to the Student Environmental Action Coalition (SEAC). Applications for training and participation in their programs can be found at (www.seac.org).