Young People's Burden: Requirement of Negative CO_2 Emissions

James Hansen, Makiko Sato, Pushker Kharecha, Karina von Schuckmann, David J. Beerling, Junji Cao, Shaun Marcott, Valerie Masson-Delmotte, Michael J. Prather, Eelco J. Rohling, Jeremy Shakun, Pete Smith, Andrew Lacis, Gary Russell, Reto Ruedy

18 July 2017

Above paper is published today in ***Earth System Dynamics***. There is also a video with Sophie and Jim.

Conclusions include:

1. Global warming in the past 50 years has raised global temperature (Fig. 1) well above the prior range in the Holocene (the current interglacial period, approximately the past 11,700 years) **to the level of the Eemian period** (130,000 to 115,000 years ago), **when sea level was 6-9 meters (20-30 feet) higher than today.**

2. Global warming can be held below 1.5°C (the aspirational goal of the Paris Agreement) if rapid reductions of global CO_2 emission (at least 3%/year) begin by 2021 and if there is no net growth of other climate forcings (Fig. 2). However, 1.5°C global warming exceeds estimated Eemian temperature and is not an appropriate goal.

3. The growth rate of greenhouse gas climate forcing has accelerated markedly in the past several years (Fig. 3), a conclusion starkly at odds with the common narrative that the world has recently turned the corner toward a solution of the global warming problem.

4. An appropriate goal is to return global temperature to the Holocene range within a century. Such a goal was still achievable in 2013 if rapid emission reductions had begun at that time and if there were a global program for reforestation and improved agricultural and forestry practices. Now climate restoration this century would also require substantial technological extraction of CO_2 from the air. If rapid emission reductions do not begin soon, the burden placed on young people to extract CO_2 emitted by prior generations may become implausibly difficult and costly.

Author and Sophie Kivlehan quotes

Michael Prather (re point #3 above): "What is particularly worrying about the recent uptick in greenhouse gas climate forcing, is that it is driven in part by the recent surge in methane abundance, while reduced methane is one of the requirements in most pathways to reduced greenhouse gas forcing."

Karina von Schuckmann: "The Earth is out of energy balance. Associated symptoms are contemporary sea level rise related to ice melt and warming oceans, as well as worldwide increased surface temperatures, extreme events, coastal flooding and drought. Unequivocal urgent international action is needed."

Sophie Kivlehan: I'm excited for Young People's Burden to provide support for Juliana v United States. This paper secures a strong and legitimate foundation for which young people can fight for our right to life, and a viable future. We need the adults to wake up and listen.

Jim Hansen:

(1) It is significant and gratifying that global leaders in relevant disciplines (e.g., Earth's energy balance, paleoclimate including Holocene studies, sea level, atmospheric chemistry, carbon cycle) agreed to work together on this effort, not only assuring excellence in their specialties, but also helping with the overall structure of the paper and its conclusions.

(2) The publication process, starting with a Discussion version of the paper available to the public and the research community, was very effective, and we thank the editor and reviewers for their substantial

efforts. The anonymous formal reviews were very helpful. This final version of the paper improves the clarity of the science and conclusions. New conclusions we now stress, which were only implicit in the Discussion version, include: a) Even the aspirational goal of the Paris Agreement, to keep global warming below 1.5°C, is not adequate. b) A current narrative, that humanity has turned the corner and is moving toward solving the global warming problem, is wrong. Atmospheric greenhouse gases are not only continuing to increase rapidly, their growth rate has actually accelerated rapidly in the past several years.

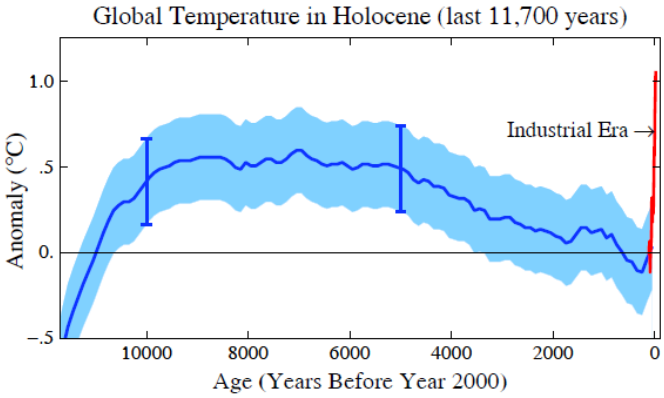

Fig. 1. Centennially smoothed Holocene temperature (Marcott et al., 2013) and ll-year running mean of modern temperature (Fig. 2 in our paper) as anomalies relative to 1880-1920.

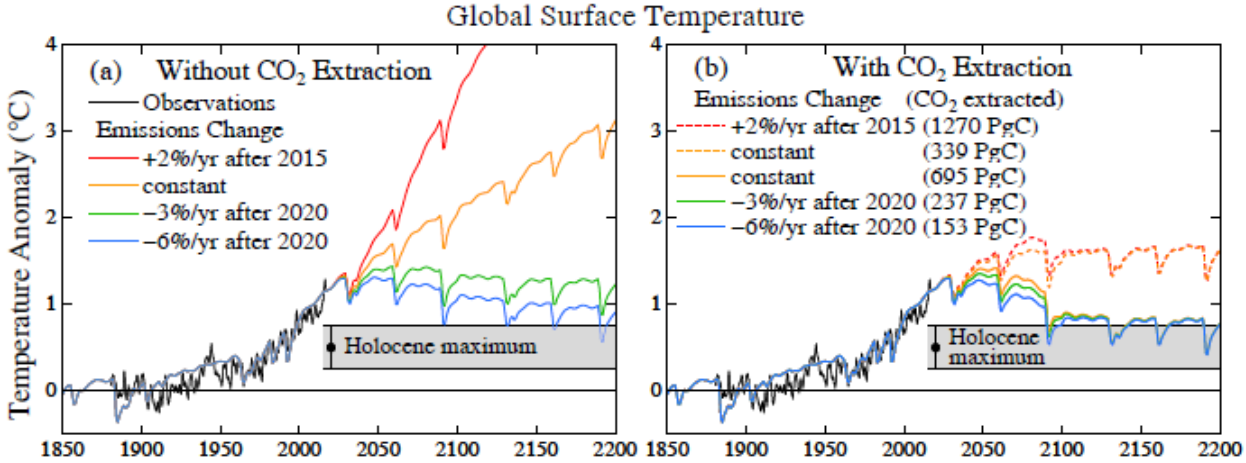

Fig. 2. Observed global temperature and simulated temperature for four alternative fossil fuel emission growth rates. Temperature zero-point is the 1880-1920 mean temperature. Gray area is the 2σ (95% confidence) range for centennially smoothed Holocene maximum.

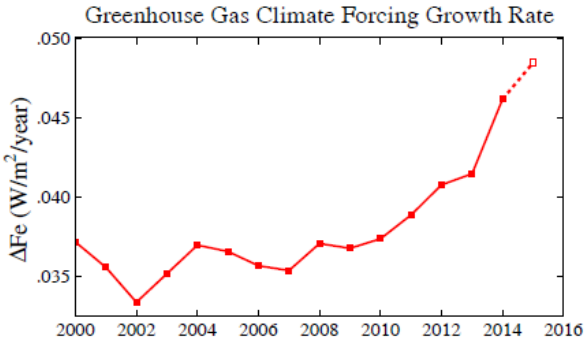

Fig. 3. Recent growth rate of total greenhouse gas climate forcing. Points are 5-year running means, except for 2015, which is a 3-year mean. See Fig. 8 in the paper for individual gases.