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Interactive comment on "Young People's Burden: Requirement of Negative CO_2 Emissions" *by* James Hansen et al.

Anonymous Referee #1

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I like this paper, and I support the authors' decision to act as advocates for strong action on slowing climate change. Mention of the lawsuit, Juliana et al. vs United States, is not critical to the scientific issues discussed, but it frames the scientific discussion. Hansen et al. first assess how much climate change is acceptable before dangerous human influence activates slow climate feed backs that will significantly raise sea level. Their choice is subjective. Based on paleoclimate evidence, they determine a target of 350 ppm for CO2 by end of the 21st century (where, depending on changes in emissions of other other non-CO2 GHGs, this target will be adjusted up or down), which restores Earth's energy balance and keeps climate in the range of the past 10,000 years. This target is stricter than other suggestions (e.g., the <1.5 C agreed on at the Paris Conference of Parties meeting), but their argument for it seems reasonable to me. They conclude that, to achieve this goal and avoid an enormous future financial burden,

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Discussion paper

emissions of CO_2 from fossil fuel combustion must be decreased by 6%/yr starting in 2021. Even at this relatively large rate of CO_2 emission reduction, additional CO_2 must be removed through changes in agriculture and forestry practices to enhance uptake by the terrestrial biosphere. Other scenarios for reducing CO_2 emissions are considered, and the costs of not acting by 2020 would be quite large. Much of the paper builds on previous work by Hansen and co-authors. Its novelty is in showing the dramatic reductions to CO_2 emissions necessary to keep climate change by 2100 within the bounds of Holocene climate. The methods used are scientifically justifiable and transparent enough that others who disagree with the paper's threshold for climate change or emission-reduction scenarios can explore other approaches. Most of the paper is well-written and clear. I recommend the paper for publication in Earth System Dynamics with minor revisions.

General comments: 1. There are many errors with the references including missing punctuation, citations from text missing in the reference list, and errors in citations. 2. Large uncertainties associated with some climate-related parameters used (e.g., climate sensitivity and current and future aerosol forcing) are not accounted for in the analysis. 3. Do the authors see a role for geoengineering in stabilizing climate within the range of the Holocene?

Specific comments: L32-33: I worry about the susceptibility of carbon stored in the terrestrial biosphere to human interference, e.g., from biomass burning. L59: I suggest making explicit here the role of non-CO_2 GHGs in the target atmospheric CO_2 abundance of 350 ppm. L173-174: It seems the 12-month running mean must end 6 months before August, 2016 (which I assume is the last month of actual T anomaly used), so the last part of the curve must be the actual T anomaly. L262-264: CO_2 released from melting permafrost ecosystems is also potentially important and would offset other practices to enhance uptake by the terrestrial biosphere. L270: How does someone reconcile the RFs in Fig. 4 with those in Table A1? Are the differences between the figure and the table for CO_2 and CH_4 attributed to the increase in RF from 1750 to 1850?

Why not make both 1750 to present? L283: RF for CO_2 here is about 10% greater than in AR5; although still potentially within IPCC's uncertainties, calling them "similar" is too vague. L415-425: Some of the discussion on atmospheric CH_4 in section 10 seems more appropriate here on observed CH_4 growth rate and reasons behind the changes. In addition to Schaefer et al. (mentioned in section 10), two new papers are appropriate. Nisbet et al. ((2016), Rising atmospheric methane: 2007–2014 growth and isotopic shift, Global Biogeochem. Cycles, 30, doi:10.1002/2016GB005406), which reaches a similar conclusion to Schaefer et al. as to the role of microbial sources in driving the increase in atmospheric CH_4 since 2007, but with more emphasis on tropical wetlands than anthropogenic agricultural sources, and Schwietzke et al. ((2016), Upward revision of global fossil fuel methane emissions based on isotopic database, Nature, vol. 538, doi:10.1038/nature19797), which suggests that emissions of CH_4 from fossil fuel sources are significantly larger than inventories indicate, but that there is no significant trend in emissions. All 3 studies (Schaefer, Nisbet, and Schwietzke) make use of isotopic constraints. L417: Turner et al. is contradicted by other studies with stronger observed constraints, so why include it? L420: The contributions of high northern latitudes to the increase since 2007 was only in 2007; various inverse model studies indicate climatological emissions (or less) in the years following 2007. L624: Section 9 is least clear and seems incomplete. While I recognize that a full economic analysis is beyond the domain of this study, selective discussion of CO_2 extraction costs without comparison with other important costs (e.g., cost of BAU, converting to renewable sources of energy, etc.) makes the section seem incomplete. Perhaps a summary of pertinent costs in a table would help. L668-676: Recent life-cycle analysis (e.g., DeCicco et al., Climatic Change (2016) 138: 667. doi:10.1007/s10584-016-1764-4) suggest that liquid biofuels result in greater GHG emissions than using petroleum. How do these results figure into this discussion? L715-719: How does this cost compare in relative terms with others? Why assume it will happen? L753-762: Comments regarding L415-425 could apply here too. L822-823: A shift from what to natural gas? L994: As mentioned earlier, values for CO_2 and CH_4 are not in agreement with what is plotted in Fig. 4.

Edits: L190: exaggerated L470: as a consequence of recent growth L504: remove extra "." L636: "." needed after "Smith et al., 2016)" L709: suggest "Now, assuming global...." L737: delete "/" L900: was in ERSST...

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