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Earth System Dynamics Discussions

Interactive comment on "The sensitivity of the energy budget and hydrological cycle to CO_2 and solar forcing" *by* N. Schaller et al.

Anonymous Referee #1

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The authors present a comprehensive and well written analysis of how the energy budget and hydrological cycle respond to contrasting radiative forcings (solar or CO2) of the same magnitude. This builds upon a body of literature, yet some novel insights and important key findings and recommendations are outlined (in particular relating to the influence on meridional temperature gradient and large-scale rainfall) and so it is my assessment that the manuscript should be published with relatively minor amendments. My main concern is that while this is exciting new science, the impact of the study may be enhanced by reducing the length and discursive nature of the text but this is a minor criticism. I outline specific points below.

1) Abstract "...mean precipitation, in simulations of transient CO2 concentration, increase..." (add in another "," after concentration). This sentence is rather long.

2) Abstract "On the other hand, lower tropospheric water vapor increases more in simulations with CO2 compared to solar forcing increase of the same magnitude." for the same radiative forcing or same temperature change? Is this due to high vs low latitude warming?

3) p.395, line 4 - many aerosols also absorb radiation

4) p.396, line 10, I suggest changing "as this is what is occurring in the real world" to "since this is more relevant for adaptation strategies."

5) p.396, line 19 "mean surface temperature neither ex-actly doubles" the temperature is not doubling - I guess you mean the temperature difference.

6) p.396-397 - I found the discussion of linear additivity to be rather verbose and difficult to penetrate and is repeated in Section 3.1. Could this be written more concisely? Also, I think the work of Good et al. (2012) Climate Dynamics ("A step-response approach..." doi 10.1007/s00382-012-1571-1) may be relevant.

7) p.398 - I find the definitions of the scenarios confusing since "74" could be confused with years which are sometimes also quoted. I suggest using S3.7, S7.2, C2X, C4X and C2X-S7.2 to signify the experiments.

8) p.399, line 21, the "rho" symbol should be defined.

9) p.401, line 13, what is the physical mechanism which explains larger than expected responses for larger forcings. One possibility is the increased LW emission level with increased CO2 levels and the reduced Plank function response at colder temperatures (e.g. Good et al. 2012).

10) p. 402, line 5-6 - I suggest "...since this is more relevant for the real world, the climate system never reaching a true equilibrium." Also, line 9 "response...does" or "responses...do"

11) p.403, line 5 - I suggest "...reduced (as occurs in warming scenarios) the...

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12) p.403, line 12 - 15-50 degrees latitude does not seem well described as mid-latitudes. It also includes the sub-tropics.

13) p.405, line 4 "is balanced" –> "is offset" (since it is too small to balance)

14) p.405, line 9 - LW is also increases due to the warming of the atmosphere. The mechanism applies to CO2 and Solar so I object to the use of the word "contrast". See also Allan (2006) JGR doi:10.1029/2006JD007304

15) p.405, line 15, could the strong negative LW cloud feedbacks also be influenced by the fast cloud adjustments to the CO2 forcings e.g. Gregory and Webb (2008)?

16) p.406, line 8, note that the increases in CO2 do not have a substantial direct effect on surface LW in the tropics due to strong water vapor absorption across the LW spectrum for high column integrated water (e.g. Allan, 2006).

17) p.406, line 11 I suggest "...causes a larger increase in water vapor and consequently larger back radiation." since it is the larger water vapor amounts that produce stronger water vapor continuum emission to the surface in the LW window region of the spectrum.

18) p.406, line 26 - this discussion is interesting but what determines the portion of available energy that goes into evaporating water, heating the surface or sensible heating? For example, if more energy is available for evaporation, this increased evaporation rate can only be sustained if the evaporated water vapor is removed from the boundary layer by convective processes, such that the atmosphere and surface energy budgets must be considered together.

19) p.407, line 23, although high cloud cover changes are small, more critical to cloud LW effects are the cloud top temperature. Zelinka and Hartmann (2010, JGR DOI: 10.1029/2010JD013817) for example show that the relatively small changes in cloud top emission temperature with warming cause positive LW cloud feedback in CMIP3 models.

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20) p.408, line 25 "by up to" –> "by as much as"

21) p.409-410 discussion is very interesting and novel I think. line 13 - does the unusual NH response in MTG link to the fast responses of land (which dominate the NH) to radiative forcings?

22) p.412 - again, does the discussion in Good et al. (2012) offer an explanation for the non-linear additivity of CO2 forcings?

23) p.412, last few lines - again, in relation to point (18) I think that the atmosphere energy budget is also integral.

24) p.412 line 29 - p413 line 2 does not seem correct. I think that a weaker circulation is necessitated by a more muted precipitation response RELATIVE to the water vapor response. Also the residence time changes are surely a diagnostic of this rather than an explanation.

Interactive comment on Earth Syst. Dynam. Discuss., 4, 393, 2013.