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Earth System Dynamics
Discussions

Interactive comment on "Climate feedbacks in the Earth system and prospects for their evaluation" *by* Christoph Heinze et al.

Anonymous Referee #2

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Review of Heinze et al

This is a very well written and useful overview of the most important climate feedback processes that govern the Earth system response to an external forcing. The concept of feedbacks and its analysis via the electric circuit analogue is well explained, and all feedbacks discussed are presented in a similar schematic, which makes the discussion about the feedback mechanism good to follow. Some generic discussions were eye-opening to me (such as the notion that the choice of a reference is not straightforward at ESM timescales, where the entire system is always in transition).

In some occassions I had the impression that forcings and feedbacks work in another direction than was suggested by the authors, and have indicated so in the list of minor comments below.

The paper is quite long, but it is very comprehensive and therefore reads as elementary textbook material for every beginning or mature ESM developer or climate system analyst. Therefore, apart from a number of minor comments, I do support publication of this manuscript in ESD.

Minor comments ==========

- p3,l23: "prognostic": it is rarely the purpose of an ESM to make a prognosis (in the sense, an expected evolution of the climate system). There is always a lot of conditionality involved, which makes the term "projection" more appropriate
- fig 1: we do miss some elements discussed later in this paper (e.g. the vegetation feedbacks on CO2 levels)
- p8,l5: "...are not included in the concept of ECS." Is this for principal or for practical reasons?
- Eq 10: it was a bit confusing to interpret E not to be a flux but a cumulative emission in mass units, maybe explain this explicitly
- p9,l10: not sure I understand what d* is
- p9,l15: what do you mean with "respective"?
- Fig 3: unclear what the black dashed arrow on the left of the figure means, it is not explained in the caption
- p12,l8: "The lower the compatible emissions, the stronger the underlying positive carbon cycle climate feedback." This is not straightforward to me. Can you explain?
- Fig 4: I suggest to make a distinction between arrows that represent a flux and arrows that point at elements in the figure

- p13,l12: "upper": do you mean the long or the short time scale here?
- p13,l19: "the feedbacks considered" in this physical subsection, is what you mean. Other feedbacks later in the manuscript do not fall in one of these categories
- p16,l25: "As the moist adiabatic lapse rate decreases with increasing surface temperature": this is also no straightforward to me. Why is this?
- p19,l2-3: I always understood that the positive feedback only occurs when cloud top is moved to a cooler layer reducing outgoing LW. When upward motion does not lead to reaching a cooler temperatures (due to warming the entire system), this positive feedback vanishes I would say. Why is it still present?
- p19, l25: "with weaker shortwave radiation": I'm missing the essential step in this sentence, which involves reducing the ability to reflect sunlight on a bright surface
- p19, l31: "increase" is not a proper, term. Probably you mean elevation, or an increase in the thickness of the layer exceeding 0oC
- p19,l34: why do we have a negative feedback here?
- fig 7/section 3.3: I would expect to also see physical feedback of evaporation increase due to higher temperature (modulated by soil moisture availability)
- p21,l13: use K or oC throughout the paper
- p25,l2: how does thinner sea ice and its reduced insulation lead to a negative feedback?
- p25,l25: the statement on effects of roughness on turbulent fluxes could deserve a reference, as this conclusion is not without controversy

- p27,l1: "thermal effects of evaporation": Normally E increases with T, but a negative feedback via available soil water applies. Vegetation feedbacks may occur in cases of episodic droughts
- p27, l29: "in" -> "on"
- p28,l6: This is the first time that bias is mentioned. Should other feedback considerations be assessed using knowledge about the impact of bias?
- p29, l23: how do wetlands modulate the amount of precipitation received?
- fig 12+13: this is quite a busy picture. I suggest to group all boxes saying "CO2 (or CH4) warming" and reroute the feedbacks loops via that single box
- fig 12: increased biomass leading to more forest fires is a negative feedback on enhanced plant growth; I don't understand this one very well
- p31, l9: "radioactively"?
- p34, l8: "physical downward transport of surface waters": do you refer to freshwater suppression of convection? A bit unclear
- p37, l14: "as a consequence": does dust production depend on global temperature? That is not stated explicitly
- p42, l32: the negative RF of stratospheric ozone is a surprise to me: I always thought ozone is an absorber in the UV spectrum and so heats up the climate system
- p45, l20: insert "and" before "which"
- p47, l3: larger what?

- p47, l34: "which happens after 120 years": please make explicit that this time you include the carbon uptake processes
- p49, l11: the time of emergence of 30-60 yrs, does that apply to temperature?
- p49, l30: delete "among"
- section 5.2.4: not entire clear how these paleo runs can add insights on feedbacks
- p53,l25: "similarities with the real world": this statement does deserve a citation
- p54, l14: "projection parameters (e.g. resolution matrices)": unclear to me

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