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Earth System Dynamics
Discussions

Interactive comment on "Radiative forcing and feedback by forests in warm climates – a sensitivity study" *by* U. Port et al.

Anonymous Referee #2

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This manuscript analyses the impact of afforestation/deforestation in two climate contexts: the pre-industrial climate and a warmer past climate, the Eocene. For each of these climates, it compares three simulations: one in which the continents are covered by forests (except for land-ice covered areas in the pre-industrial set up), one in which they are covered by low albedo deserts (bright deserts), and one in which they are covered by deserts with an albedo comparable to typical forest albedo (dark deserts). The main part of the result section compares the forest worlds to the bright desert worlds. The dark desert simulations allow for a quantification of the impact of forests on the specific aspect of hydrological properties, i.e. putting aside their impact via albedo changes. The results are mainly discussed in terms of radiative forcing and feedback parameters and temperature response. While radiative forcing changes due

to these extreme vegetation changes are comparable for the pre-industrial and Eocene climates, the temperature responses are smaller for Eocene in the case of the comparison of "forest" vs. "bright desert" worlds: forests induce a smaller warming in the Eocene case. On the other hand, when compared the "forest" world to the "dark desert" one, the forests induce a cooling which is larger in the Eocene case. The authors ascribe these different temperature responses to differences in the feedback parameters, especially in terms of albedo and clouds.

These experiments are idealised simulations in the sense that the "forest" and "desert" worlds are not realistic, they constitute a nice set of experiments to illustrate the different impacts of similar forcings for distinct climatic backgrounds. The analysis in terms of radiative forcing and feedback is pertinent and allows comparisons to other studies on these feedbacks, e.g. on response to increased greenhouse gases (GHG). In fact, it would be very interesting to push the comparison to the response to GHG further: are the feedback parameters different for these forcings (surface changes vs. GHG change?). The experiments with 2xC02 or 4xC02 should be available via CMIP5 to compare, or, if this model version is different from the CMIP5 one, comparing pairs of pre-industrial and Eocene climates, for which the main forcing is probably CO2, would be an option. I found the results generally clearly presented, albeit for a few sentences and choices for the figures which I detail in the comments below. One aspect that would be interesting to investigate is the pattern of the cloud response (Fig. 6, top) and its potential relationship to atmospheric circulation changes. From this cloud response, it seems that the Hadley cell increases more for the Eocene case than the pre-industrial one (stronger decrease of cloud cover in the sub-tropics, more extensive increase of cloud cover in the deep tropics/equatorial area), but that there is also a stronger zonal circulation change over the equatorial areas for the Eocene (as illustrated by changes in cloud cover over the East equatorial Pacific). It would be good to give more comprehensive explanations of what drives the cloud cover changes shown on Fig. 6, land surface change and/or circulation. This could also help and explain the different responses for the different background climates.

In brief, this manuscript contains results worth being published by ESD after the improvements suggested above and, in detail, below, are made.

Comments/Improvements

Abstract:

page 2578, line 2. The first sentence is strange. I would replace is with a summary of the known impact of forests on climate.

page 2578, line 19: the rationale for analysing the differences between a "forest" world and a "dark desert world", i.e. to get rid of the albedo effect, should be introduced, otherwise this sentence is misleading compared to the sentence on the "forest" vs. "bright desert" worlds on line 10.

1. Introduction:

The authors could complete their review of studies on the impact of forests/land cover with the study by Alkama et al (Climate Dynamics, 2012) who study the impact of desertification for three different climatic backgrounds.

2. Model and experiments

section 2.1: given that this manuscript investigates impacts of land surface changes, the land surface model JSBACH should be better described, in particular in terms of its set-up. I guess JSBACH is used "just" for its representation of its dynamical feedbacks in this study, and that phenology is not interactive, but it is essential to describe which processes are interactive and which are imposed.

page 2582, 2nd paragraph: is this savannah vegetation globally homogeneous? please also quantify the deep ocean temperature trends.

pages 2582 (end) and 2583, about model-data comparisons for the initial Eocene simulation (Fig 1). I think this section could be improved. In light of the text accompanying Fig 1, I think it would be appropriate to separate out the ocean and continental re-

sponses and give an idea of the deviation from the zonal mean on the figure, e.g. by representing, with a shaded area, +/- one standard deviation of the temperature from the zonal mean. Also, given that some reconstructions could be interpreted as summer temperatures rather than mean annual temperatures, it would also be worth showing the winter/annual/summer results. Nonetheless, presented as they are on Fig. 1, these results appear to compare reasonably with available reconstructions. The additional figures would be useful for illustrating the text in section 2.2.

3. Methods

page 2588: is epsilon constant throughout the simulations?

4. Results

page 2589 and fig 6. I think the figure should also show the differences in surface albedo, to allow for a better appreciation of the impact of cloud changes on planetary albedo

page 2590, 2nd and 3rd paragraphs, on ΔQSWcl. Although the terms "cloud adjustment" and "cloud masking" are well defined in these paragraphs, I don't think these names are the appropriate ones. Instead of the unclear sentence "ΔQSWcl composes of the cloud adjustment on one hand and the masking effect by clouds on the other hand", which is quite puzzling when read for the first time, one could write "ΔQSWcl describes the radiative impact of changes in cloud cover as well as an indirect impact of clouds which we define below as "masking effect"".

The relationship between cloud cover and circulation changes could be discussed e.g. at the end of the 2nd paragraph after line 15.

page 2591, comparison with the results from Caballero and Huber (2013). Can the response to GHG compared to the response to changes in land surface be compared? Your set of simulations could help and compare, as well as simulations under 2xCO2 or 4xCO2 forcings.

page 2592, about the possibility of state-dependent cloud feedback. On fig 6, it does indeed seem that the cloud cover changes are different for the Eocene and pre-industrial changes, although on the very large scale they are comparable. This could be related to atmospheric circulation changes (cf. comment above) or to Eocene vs. pre-industrial differences in land/ocean/altitude/bathymetry configurations. It would be worth including an analysis, or at least some thoughts, on this topic. Also, if low clouds are to be blamed, why not showing and commenting them?

page 2592, last lines of section 4.1, commenting Fig 9, right panel: yes, the last 250 years behave very differently from the first 150 for the Eocene case. In fact, they seem to "catch up" with the pre-industrial behaviour. It would be good to comment on this fact.

page 2593, line 10: on feedback parameters on the regional scale: please explain and possibly illustrate what is meant here.

Conclusions, last page: at this stage, commenting on the simplified set-up, it would be useful to comment on "real world" soil albedo vs. forest albedo. Which regions are "dark" vs "bright"?

Minor comments

page 2578, line 5: add an s to "type" and "climate"

page 2579, line 15: no s at the end of "warms"

page 2579, lines 23-24 "which presumably was such a warm, nearly ice-free climate" could be replaced by "which was a warm, presumably nearly ice-free climate"

page 2583, line 25: "as realistic as possible" to be replaced by "as realistically as possible"

page 2586, line 20-21: "aim at estimating" instead of "aim to estimate"

page 2587, line 1: "define" instead of "receive"

page 2587, line 13: add "The" at the beginning of the sentence

page 2587, line 15: "consist" instead of "constitute"

page 2588, line 13: "stabilises climate" to be replaced by "stabilises the climate".

page 2588, line 21: add "respectively" after "Eocene climate"

page 2590, as well as in the conclusions: "Feedbacks stabilise the early Eocene stronger than the pre-industrial climate". This sentence could be reformulated as "The feedbacks stabilising the climate are stronger for the Eocene than for the pre-industrial case".

page 2593, last lines of section 4.2: "can likely be attributed". This could be checked so that the "likely" is removed from the sentence.

page 2595, line 2-3. Do the authors mean "We assume that this simplification will only weakly affect the results of our study, at least in the qualitative sense"?

Figs 5, 7 and 11: difficult to see the hatching.

Fig 4: would benefit from a similar treatment to Fig. 9, with the first years being indicated a different color.

Interactive comment on Earth Syst. Dynam. Discuss., 6, 2577, 2015.