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Earth System Dynamics Discussions

Interactive comment on "The influence of vegetation dynamics on anthropogenic climate change" *by* U. Port et al.

Anonymous Referee #1

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General comments:

In the manuscript "The influence of vegetation dynamics on anthropogenic climate change" by Port et al. the authors used an Earth system model to investigate the effect of vegetation dynamics on carbon uptake and global climate. By separating the influence of vegetation dynamics into biogeochemical and biogeophysical effects, the authors analyzed the effect of vegetation dynamics at both the global and regional scales. This study makes a useful contribution to our understanding of the role of vegetation dynamics in the global carbon cycle and climate change. The analysis is extensive in general, but in a few places more detailed analysis and/or clarification is needed to better support the authors' argument. Sloppy writing is also observed in a few places. Furthermore, in a few places, the discussion of figures is not consis-

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tent with the figure itself (see specific comments below). The authors should address these issues before this manuscript can be considered for publication in Earth System Dynamics.

Specific comments:

The authors designed four simulation experiment (as listed in Table 2) to investigate the effect of vegetation dynamic on global climate. It looks to me that the individual and combined climate influence from biogeochemical and biogeophysical effects can be represented by analyzing the following results:

DYN – STAT (Eq. 1) the combined biogeochemical and biogeophysical effects on climate;

DYN – STAT_PS (Eq. 2) the biogeophysical effects on climate;

STAT_PS – STAT (Eq. 3) the biogeochemical effects on climate.

The authors analyzed in detail the results of (2), but not (1) and (3). Also, it would be quite interesting to investigate the linearity of climate response from biogeochemical and biogeophysical effects, i.e., to compare the climate response between (1) and the sum of (2) and (3).

Abstract:

“We assume anthropogenic CO2 emissions according to the RCP 8.5 scenario in the period from 1850 to 2120 and shut them down afterwards to evaluate the equilibrium response of the Earth System by 2300”.

I believe the response of the Earth climate system, including the response of the deep ocean and dynamic vegetation, would not reach equilibrium by 2300. For example, it will take thousands of years for the response of the full ocean to reach equilibrium.

Introduction:

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The extended tree cover leads further warming since the surface albedo is reduced.

“leads” should be “leads to”

“For the respond of the Amazonian forest”

“respond” should be “response”

“We assume a transient CO2 emission scenario according to the Representative Concentration Pathway 8.5 (RCP 8.5) until the year 2120 and set the CO2 emissions to zero afterwards”.

RCP scenario is for atmospheric CO2 concentrations. How was transient CO2 emission, as used in simulations, derived from the RCP 8.5 concentration scenario?

“Analysing the impact of vegetation dynamics on climate change on a time scale of several centuries is unique”.

Bala et al. (2006), as cited by the authors, looked at the impact of dynamic vegetation on global climate over a period of 400 years. Therefore, in this respect, this study is not unique.

Bala, G., Caldeira, K., Mirin, A., Wickett, M., Delire, C., and Phillips, T. J.: Biogeophysical effects of CO2 fertilization on global climate, Tellus B, 58, 620–627, 2006. 494

“The results are presented and discussed in tree steps”

“Tree” should be “Three”

Model setup and methods

In the simulation of STAT “The vegetation cover is held constant at the equilibrium distribution of the control simulation. However, the plant productivity and canopy conductance respond to the increased atmospheric CO2 concentrations”.

Does leaf area index respond to climate and CO2 in the STAT simulation? If so, it should be stated clearly. Note that even vegetation fractional cover does not change,

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change in leaf area index due to CO2 fertilization would feedback on climate.

“Since the climate changes due to the different plant productivity and canopy conductance are very much smaller than the changes due to the vegetation cover shifts . . . “

This statement is weak. Is there any observational and/or modeling evidence to support this argument?

“Since the vegetation cover changes are strongest at the end of the simulation . . ..”

This statement is weak too. Two questions here: first, what is the metrics used here to quantify the strength of the vegetation cover change? Second, without any quantification, how will the reader know that the vegetation cover changes are strongest at the end of simulation?

3 Results and discussion 3.1 Changes in climate and vegetation cover during the emission period (1850–2120)

In addition to precipitation change, it would be more interesting to show changes in soil moisture, which is a better indicator of water availability.

“As this decline in tree cover depends on water stress, it differs from the forest dieback found in previous studies”

I don’t understand this sentence. Is the mechanism of decline in tree cover different from previous studies or the amount of decline in tree cover different from previous studies?

“However, CO2 fertilisation becomes non-effective in regions of stronger water stress due to elevated temperatures (in parts of the Amazon region and central desert regions).”

It’s just stated above that the tree decline in Amazon is due to water stress, but here the decline is attributed to elevated temperature.

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For Sahel, “From 2090 on, precipitation declines and temperature continues to increase”.

Any possible explanation why in the model precipitation in Sahel increases until 2090 and then decrease?

3.3 Impact of dynamic vegetation on climate around 2300

3.3.1 Biogeophysical effect of vegetation dynamics on climate

“The biogeophysical effect of vegetation cover change has no significant effect on global annual mean temperature, but has an impact on regional climate change (Fig. 11).”

Please quantify the change in global-mean surface temperature. Also, Fig. 11 should be Fig. 12

“The maximum evapotranspiration increase occurs in summer (Fig. 13) as trees carry a maximum amount of leaves in this time. The resultant impact on continental temperature is evident in the annual cycle of temperature differences between the DYN and the STAT PS simulation, as the strongest cooling occurs in May and July”.

By looking at Fig. 13, temperature of DYN is larger than that of STAT_PS for the months between Jan. and Oct. I have no clue of why the author state “the strongest cooling occurs in May and July”

“Besides higher evapotranspiration, expanded boreal forests leads to a lower regional land surface albedo and thus higher net shortwave radiation in the DYN than in the STAT PS simulation. The resulting regional warming over land depends strongly on the season (Fig. 13)”.

By looking at the middle panel of Fig. 13, the albedo of DYN is larger than the albedo of STAT_PS, which is opposite to what is stated here.

“These results agree with Levis et al. (1999) who find the same counteracting effects

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of higher evapotranspiration rates and lower surface albedo due tree cover expansion in the northern high latitudes."

"due" should be "due to"

"The smaller cloud cover leads to a cooling since the loss of thermal radiation is larger and thus net long wave radiation is smaller".

Presumably, a decrease in latent heat flux as a result of smaller tree cover in DYN should decrease low cloudiness, increasing solar flux reaching the surface and thus warming the surface. But the statement here seems to suggest that the cloud feedback is dominated by changes in high cloudiness and associated longwave flux. Without showing anything associated with changes in cloud cover and shortwave and longwave flux, it's not clear what is going on in the model.

Fig. 13: What causes the decrease in temperature between October and December?

3.3.2 Biogeochemical effect of vegetation dynamics on climate

"Assuming a linear relationship between atmospheric CO2 concentration and global mean temperature, . . ."

If we think there is an approximately linear relationship between radiative forcing and global mean temperature change, and there is an approximately logarithmic relationship between radiative forcing and CO2 concentration, then there should be a logarithmic relationship between CO2 and temperature.

Also, the climate effect from biogeochemical impact of vegetation dynamics can be estimated directly from the difference between STAT_PS and STAT run. Why not show maps of temperature and precipitation change between these two runs?

Figures:

For the figures showing the model-simulated changes in terms of maps (Fig. 3, Fig., 4, Fig.6, Fig.8, Fig. 10, Fig. 11, Fig. 12, Fig. 14), the authors take the difference between

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two individual years (either the result of year 2119 minus that of year 2090 or the result of year 2299 minus that of year 2270). To reduce the signal-to-noise ratio, it would be more appropriate to take the difference in averaged simulation results between some periods. This is done in Fig. 7 where the differences in averaged 30-year results are taken (averaged results between year 2270 and 2279 minus that between year 2090 and 2119). Why not do the same thing for all other figures?

Fig. 3 and 4 can be combined together.

Fig. 8: In addition to the difference between STAT and CTL, why not show the difference in NPP between dynamic (DYN) and control (CTL) as well?

Fig. 13: The unit in evapotranspiration is given in 10ˆ7 mm day-1, but how can evapotranspiration change by the order of 10ˆ7 mm dayˆ(-1)?

Interactive comment on Earth Syst. Dynam. Discuss., 3, 485, 2012.