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Biogeosciences Discussions

Interactive comment on "A model investigation of vegetation-atmosphere interactions on a millennial timescale" *by* N. Devaraju et al.

N. Devaraju et al.

dev@caos.iisc.ernet.in

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Response to Anonymous referee #2

The manuscript by Devaraju et al. addresses an important question of possibility of multiple states in the climate-vegetation system due to interactions between climate and forest cover. The manuscript is well written; presented results are of interest for the readers of Biogeosciences. I recommend accepting this manuscript after the authors account for minor comments listed below.

We thank the reviewer for the positive remarks and recommending acceptance. The comments and suggestions helped us to improve the manuscript substantially. We have addressed all of them in the revised manuscript. The detailed point-by-point re-

sponse for the comments is given below.

(Please see the supplement for the revised manuscript and figures)

1) The IBIS model differs from most of other DGVMs as it uses two-layer scheme with the grass layer underneath the tree canopy. The JSBACH model used by Brovkin et al. (2009) uses a tiling approach; trees and grass compete for free available area. Does this difference in the land surface representation influence model results? An interesting question also is a possibility of multiple vegetation states independent of vegetation-atmosphere interactions but inherent to the vegetation model. It would be good to discuss this point in the paper.

Reply: Good suggestion. As stated in the second paragraph of section 2, "The annual carbon balance of vegetation is used to predict changes in the leaf area index and biomass for each of 12 plant functional types, which compete for light and water using different ecological strategies" Hence, the model formulation in IBIS2 and JSBACH have differences. However, the results (no multiple states) are similar. Therefore, multiple vegetation states may be independent of vegetation-atmosphere interactions but it may be inherent to vegetation models with different formulations that may not be represented in IBIS2 and JSBACH. These issues are discussed in the second paragraph of the revised version.

2) Can we infer time scale of vegetation dynamics from this study? The tree cover dynamics is not presented in the Fig. 1, and this makes it difficult to tell how quickly tree cover recovers after perturbation. A plot of dynamics of tree cover (e.g. area of tree classes lumped together) will be very helpful. A related question is on a difference in time scales of vegetation convergence between different regions. For example, where is the tree recovery slower - in tropics or in high latitudes?

Reply: Good comment. This comment helped us to find something interesting. In the revised manuscript, we have plotted the time evolution of global and regional tree cover fraction (Fig. 2). We modelled the evolution using Eqn.1 which yields two scales. We

have provided a table (Table 1) that lists the times scales of tree dynamics in the tropics, mid latitudes and high latitudes. When tree cover is allowed to recover, we see that the dynamics of tree cover converges faster in tropics ($\sim$ 4.5years). In mid latitudes, the dynamics is dominated by a 12 year fast time scale. In the high latitudes, a long time of 553 years dictates the evolution of tree cover suggesting that the long time scale in the global tree cover comes from the dynamics of boreal tree cover evolution. These are discussed in the results section now. We have also made minor modifications to the abstract and discussion to reflect this new result. To discuss the long times from high latitude vegetation dynamics, we introduce another new figure (Fig. 3) in the revised manuscript.

3) The point on the millennium timescale as a novel aspect of this study (p. 8766, l. 1-2) is not very convincing. According to the Fig. 1, the climate and carbon cycle approach new equilibrium in few hundred years. What is then a rationale for the millennium long simulation? What new could be expected, e.g., in comparison with the 500-years simulation performed by Brovkin et al. (2009)? The climate model used by Devaraju et al. does not include dynamic ocean, which long time scales could be a good reason for long-term simulations.

Reply: See the response to comment 2. As mentioned there, the millennium time scale in global vegetation dynamics results from what happens in boreal region. Even after 900 years, the tree cover fraction in boreal regions has not yet reached true equilibrium. For boreal region, the temporal evolution of annual land mean key climate and terrestrial carbon cycle variables are shown now in Figure 3. In the discussion of this figure, we suggest that the feedback between temperature (snow cover related albedo) and vegetation (tree cover extent) is primarily the cause for the longer time scales that is simulated for the high latitudes.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/8/C4568/2011/bgd-8-C4568-2011-

supplement.pdf

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