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Biogeosciences Discussions

Interactive comment on "Multiple steady-states in the terrestrial atmosphere-biosphere system: a result of a discrete vegetation classification?" *by* A. Kleidon et al.

Anonymous Referee #1

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Interactive comment on "Multiple steady-states in the terrestrial atmosphere-biosphere system: a result of a discrete vegetation classification?" by A. Kleidon et al.

The authors examine the effects of vegetation representation in climate models on the state of the climate system. They show that multiple steady states can result from a discrete vegetation classification and that differences in the simulated climates can be considerable, depending on the number of classes. The topic is certainly of relevance for the understanding of climate and its variability, in particular because multiple steady states in relation to vegetation have been less frequently addressed than those arising in relation to the ice-albedo feedback. The text is well written and the figures clear

enough even at the small scale chosen for display. However, the issue raised under (i) below should be seriously considered by the authors before the paper can go into publications. A short reply to (ii) and (iii) would also add to the quality of the paper.

Specific comments

(i) The conceptual model used to explain the emergence of steady states given a discrete representation of the vegetation is correct. However, it is misleading in the sense that multiple steady states can arise also in a continuous representation of the vegetation. Ultimately, the existence and number of steady states solely depends on the relative shape of the curves P = g(W*) and W = f(P*), in this case. Surely, for the choice in Fig. 1 one and only one steady state exists in the continuous representation, but a motivation for choosing this specific framework is missing. So the question is: Can the fact that W = f(P*) is less steep than P = g(W*) in the full phase space be justified by what presently observed in the climate system?

(ii) In the conceptual model the number of steady states is simply given by the number of classes. What about the simulations with the full model? Fig. 3 suggests that discrete representation leads to artificial model sensitivity to initial conditions when the number of classes is low, indicating the existence of multiple steady states. But there are no hints about the fact that the full model effectively reproduces the behaviour of the conceptual model. Is this so? Were the authors able to find a decreasing number of steady states with increasing number of vegetation classes?

(iii) For the understanding of the climate system and its variability, it is not only the number of steady states that is of importance, but also whether they are stable or not. This is important for addressing transitions between the steady states and eventually in relation to climate variability. Question: does the fact that a discrete representation of the vegetation may spuriously result in multiple steady states, with considerable differences in the simulated climate, also imply that in such models (rapid) transitions between steady states are possible?

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