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Biogeosciences Discussions

Interactive comment on “Future challenges of representing land-processes in studies on land-atmosphere interactions” *by* A. Arneth et al.

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General comments:

This paper provides a good review of the limitations in current models of ecosystem-atmosphere interactions. It synthetises up-to-date studies on various processes that are generally not included in simulations models, possibly leading to unrealistic simulations. It illustrates the alterations of some results when the models are improved in order to account for those additional processes.

Nevertheless two points should be revised: - The paper misses the biodiversity issue: how does functional biodiversity impact ecosystem functioning and how could it be accounted for within models? - The research area about the modelling of the interactions between socio-economics and environment, through land use change, is more advanced than what the authors write.

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Discussion Paper

Detailed comments:

Abstract:

"biological and ecological process understanding" unclear: ecology is a branch of biology "Progress has also been made regarding studies on the impacts of land use/land cover change on climate change but the absence of a mechanistically-based representation of human response-processes limits our ability to analyse how climate change or air pollution in turn might affect human land use. A more integrated perspective is necessary and should become an active area of research that bridges the socio-economic and biophysical communities". This effort is already going on. Even without a mechanistically-based representation of human response-processes, integrated environmental-economic assessments are possible by considering e.g. an optimization model, as classically done for economic studies. By simulating the differential changes in yield due to climate changes, and accounting for the associated costs, Lotze-Campen et al. (2008) constructed a land-use model that partly responds to climate change. The area of research that bridges the socio-economic and biophysical communities is, indeed, already very active. The last sentence should be adapted for taking into account those developments, which have been already discussed during the last years (e.g. Abildtrup et al., 2006, Bery et al., 2006). See also below comments on the last section.

1 Some fundamental aspects of land-atmosphere interactions research

Figure 1: very interesting figure but not so easy for immediate understanding. Some variables are not explained, e.g. ΔF2'. I do not find it a good idea to use "c" for representing the feedbacks, as "C" is used for atmospheric concentration and "ch" for heat capacity.

"(iii) the necessity to examine not only climate change but also land use and land cover change when studying land-atmosphere interactions." Here, the authors seem to under-estimate the number of studies that deal with this point (e.g. Pielke, 2005).

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2 Quantification of uncertainties and dynamic system responses

p.3550 l.20: replace “Booth et al., 2012” with “Booth et al., manuscript”, and the same in the reference list.

Figure 2 is really impressive. As the reader cannot access Booth et al., it would be useful to precise how the perturbations on the six key parameters were conducted. Probably some parameters are strongly correlated, how was this accounted for?

p.3551 l.1-5: This is definitively true. However the DGVM component of HadCM3C, like other DGVMs, runs with only a few PFTs. Various authors have discussed the importance of the biodiversity insurance hypothesis (Yachi and Loreau 1998, Balvanera et al., 2006, Gamfeldt et al., 2008, Allan et al., 2011, Isbell et al., 2011, Maestre et al., 2012): species-rich ecosystems, like the tropical forests, should be more resilient against climate change than species-poor ones. Each species might have e.g. a different temperature-optimum of photosynthesis, and for a few ones, it might well not be yet at the lower end. Therefore a model that would be able to account for such specific richness, might simulate, under climate change, a change in distribution of species that could maintain the productivity level of the forest, independently of acclimation. For progressing toward a better modelling of biosphere-atmospheric interactions, it is required to better associate community ecology and biogeochemistry (Kühn et al., 2008)

Fig.3: for an easier reading: put rather the positive side (increase of GPP with acclimation) in blue color (red being always interpreted as negative), put the neutral zone (between -5 and 5) in a light grey color. Indicate the GPP threshold chosen to eliminate low-productivity areas, like Central Australia, which is not a mineral desert. What are these white pixels in productive areas (South-eastern USA, Brazil, Central Africa, China, etc)?

p.3552 l.7: also in non-tropical regions.

p.3552 l.18: “Scheiter and Higgins, 2009” not in the reference list.

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p.3552 l.27-29: “Moreover, ecosystem responses to environmental changes might well be more resilient than expected when allowed to adjust flexibly”: very true, but again, biodiversity might be even more important for the ecosystems resilience. Species composition is said to play a role in the next section (3), so the reader is wondering why it is totally ignored here.

3 Beyond the CO2 -centric perspective: missing processes with large climate feedback potential

p.3554 l.25: “Makkonen et al., 2011” should be “Makkonen et al., 2012”. The same in the caption of Figure 4.

Fig.4: the arrows may be misleading, if they are interpreted as trajectories of model outputs.

4 Beyond climate change

p.2557 l.2: “. . .by either natural factors or humans”: it can be useful to indicate that the last model developments of some DGVMs took those two factors into account, e.g. Thonicke et al., 2010.

5 Effects of land use/land cover change on climate change – and vice versa?

p. 3561, l. 1-2: this is not correct: some global modelling studies do consider the CO2 fertilization effect, even though many questions remain. The results are often considered to be over-optimistic, especially because increased limitations in N availability are not taken into account. Therefore, several authors typically present both results (yield change under climate change with and without CO2 fertilization, e.g. Müller et al. (2010). However, it is true that most global analyses on climate change – yield interactions that account for CO2 fertilization effects are rather economic ones (Calzadilla et al. 2010) than DGVMs like. Nevertheless, a lot of regional modelling efforts of agroecosystems do include the effects of CO2 fertilization (e.g. Huang, et al., 2009)

p. 3561, l. 13-14: besides improved technology and management of crop varieties,

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specific farming systems may also compensate (even if only partly), for the climate change induced yield losses (see e.g. Altieri and Nicholls, 2008, Uphoff, 2011).

p. 3561, l. 17-24: "… even the interactions between important environmental drivers and crop yields are poorly represented in terrestrial models (Rotter et al., 2011). " This might be true; nevertheless the numerous efforts of many different groups provide diverse crop-modelling results that allow to draw some meaningful conclusions (Müller, 2011). The whole sentence is too negative and even contradicts the next one where the interest of the integrated perspective is recognised. Also there is no need of mechanistically-based representation of human processes for testing various scenarios of human behaviour under uncertainty. Such scenarios can be implemented along with several approaches (ABM, viability algorithms, etc), in order to analyse the sustainability and the chances of adaptation / mitigation of different coupled socio-economic and biophysical/biogeochemical dynamics (e.g. Huck, 2007)

p.3562 l. 3-5: + to accounting for biodiversity

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