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Biogeosciences
Discussions

Interactive comment on "The influence of land cover change in the Asian monsoon region on present-day and mid-Holocene climate" *by* A. Dallmeyer and M. Claussen

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We thank the Anonymous Referee 2 very much for his/her constructive critique and helpful suggestions.

Referee: *'The main comment I have is that it is a shame the authors chose to use prescribed SST rather than a coupled atmosphere-ocean GCM, since (as the authors themselves point out in the introduction) ocean-atmosphere feedbacks are an important part of the Asian monsoon system. For example, Abram et al (2008, Nature Geoscience 1,849-853) suggest positive feedbacks between the monsoon circulation and the Indian Ocean Dipole acting via ocean upwelling driven by changes in windstress*

over the ocean. I realise that this could introduce additional difficulties in establishing significance of the results through a possible increase in variability, but with 100 years of simulation this probably would still have been possible - but then I guess interpretation of the results might also have been harder. Nevertheless, missing out such a potentially important part of the process does have implications for how well this study captures the influence of vegetation change on climate.'

Author: We agree with the referee. Ocean-atmosphere feedbacks are indeed a very important part of the Asian monsoon system. We worked on this subject in a previous study by applying the comprehensive Earth system model ECHAM5/JSBACH-MPIOM (Dallmeyer et al., Clim. Past, 6, 195-218, 2010). We analysed the contributions of the vegetation-atmosphere interaction, the ocean-atmosphere interaction as well as their synergy to the Holocene (6000years before present to pre-industrial) climate change in the Asian monsoon region. This study confirmed the importance of ocean-atmosphere interactions in forming the Asian monsoon climate. However, our model revealed a very small synergy between the ocean-atmosphere and vegetation-atmosphere interactions. Therefore, we assume that the ocean-atmosphere interaction does not significantly affect the response of the climate to the applied land cover change, at least in our model. Including a general circulation ocean model would increase the spin-up period of our simulations by several magnitudes. The decision to prescribe sea surface temperature and sea ice is a compromise of computing power/cost spent, the horizontal resolution and complexity of the model. Furthermore, disentangling the effect of the applied vegetation change and the dynamic ocean on climate would be impossible in such a model setup (AOGCM).

In the revised manuscript, we gave information on our previous study in the introduction (see answer to the comments of referee 1) and wrote in the model and experiments section: 'With regard to the results of our previous study (cf. Dallmeyer et al., 2010), we assume a weak synergy of the vegetation-atmosphere and ocean-atmosphere interactions. To exclude a contribution of changes in ocean parameters to the simulated climate signal, we prescribe pre-industrial sea surface temperatures and sea-ice cover in all simulations. Both have been extracted from a coarse resolution experiment, performed with . . .'

Referee: *'It would be unfair at this stage to insist that the study be re-done with an AOGCM, but I think the authors should at least look into whether such a study would be likely to be an important second step or not. For example, they could analyse the effect of the vegetation change on windspeed over the ocean (and/or temperature or freshwater input via precipitation), and (through reference to the literature if possible) assess whether these vegetation-induced changes might be significant enough for the resulting feedbacks to be important. This could then point to a next stage of work.*

Author: This is, indeed, a helpful suggestion. As seen in the Fig. 3-8 of our study, the forest cover change leads to significant changes in circulation, precipitation/evaporation and temperature above some parts of the Indian Ocean. This could induce changes in the ocean dynamic and thermocline depth. However, the predominantly affected regions are the Arabian See and the Bay of Bengal and not the equatorial Indian Ocean which determines the Indian Ocean Dipole. Furthermore, the climatic signal at the sea surface is (mostly) nearly one order of magnitude smaller than the local signal on land. With regard to this fact and referring to the previous comment on a small synergy, we assume the vegetation-induced climate signal above the ocean as too weak to affect the ocean-atmosphere interaction.

Referee: *'Also, it's a little surprising that the simulations only included 2 years for spin-up. Was this long enough? How was this checked? Soil moisture can sometimes take a while (sometimes several years) to reach equilibrium after a large vegetation perturbation.'*

Author: The decision to take two years as spin-up is based on experiences. In some few regions, this might not be long enough, but even there, soil moisture is supposed to be in equilibrium after three or four years. Since we have a very long analysis period

(100 years), the results are not affected by this possible 'disequilibrium' in a few grid-boxes during the first one to two years of our analysis period.

Referee: *'It would be useful to have more information on how the vegetation model actually interacts with the atmosphere, ie: the biogeophysical parameters (eg: roughness length? albedo in snow-free conditions, and how this is modified with snow cover? Leaf area index? Parameters relating to evapotranspiration?) Currently we have no way to really see what the perturbation to the land surface properties actually was, to allow comparison with other models that may be used for similar studies.'*

We improved the model description section and wrote: 'JSBACH differentiates eight plant-functional types (PFTs). Forests can contain tropical and/or extratropical trees, which are either evergreen or deciduous. Shrubs are distinguished as raingreen shrubs or cold (deciduous) shrubs. Grass is classified as either C3 or C4 grass. For each PFT, individual physical properties such as albedo or roughness length are defined (Tab. 1) The land surface in JSBACH is tiled in mosaics, so that several PFTs can cover one grid cell. Each grid cell also contains non-vegetated area representing the fraction of seasonally bare soil and permanently bare ground (desert). JSBACH calculates dynamically the physical land surface parameters (e.g. albedo or roughness length) in each grid-cell as average of the individual properties of the PFTs and the non-vegetated area, weighted with their respective cover fraction. In the calculation of the albedo, snow-covered soils and snow-covered forest-canopies as well as the masking of snow-covered soils by forests are additionally accounted for. The soil albedo is prescribed from satellite data and does not change during the simulations. The albedo of leafs depends on the leaf area index that is calculated on the basis of temperature, soil moisture and the net primary production of the PFTs. Concerning phenology, JSBACH differentiates the four types evergreen, raingreen, summergreen and grasses. LAI can not exceed a maximum value specified for each PFT (see Tab. 1). The fluxes of energy, water and momentum between the land and the atmosphere are calculated using the averaged land surface parameter of each grid cell.

Referee: *'Overall this is potentially a very useful contribution to the literature, but I think further detail is required in order to allow the work to more easily compared with other models and for the possible importance of the omitted land-ocean feedbacks to be seen.'*

Author: We hope that the additional information given in the revised manuscript will provide a basis for the comparison of our results and future modelling studies.

Interactive comment on Biogeosciences Discuss., 8, 1693, 2011.

PFT	phenology	LAImax $[m^2/m^2]$	α_{VIS}	α_{NIR}	z_0 [m]
tropical evergreen forest	raingreen	7	0.03	0.22	2.0
tropical deciduous forest	raingreen	7	0.04	0.23	1.0
extratropical evergreen forest	evergreen	5	0.04	0.22	1.0
extratropical deciduous forest	summergreen	5	0.05	0.25	1.0
raingreen shrubs	raingreen	3	0.05	0.25	0.5
deciduous shrubs	summergreen	2	0.05	0.28	0.5
C3 grass	grass	3	0.08	0.34	0.05
C4 grass	grass	3	0.08	0.34	0.05

Tab.1: Physical properties and phenology type of each plant functional type (PFT), i.e. LAImax: maximum value of the leaf area index; $\alpha_{VIS:}$ albedo in the visible solar spectrum; α_{NIR}: albedo in the near infrared solar spectrum; z_0: roughness length of vegetation.

Fig. 1.