Clim. Past Discuss., 11, C2123–C2128, 2015
www.clim-past-discuss.net/11/C2123/2015/

Climate of the Past Discussions

Interactive comment on "The biogeophysical climatic impacts of anthropogenic land use change during the Holocene" *by* M. C. Smith et al.

Anonymous Referee #1

Received and published: 23 October 2015

General

The manuscript investigates the effect of land use changes for different periods of the Holocene using the comprehensive Earth System Model HadCM3 – The authors conclude that changes in land use had a (statistically) significant impact already in the early Holocene and local changes in land use can account for substantial regional and remote changes in temperature and precipitation including dynamical changes.

In general the manuscript is well written and understandable. It also presents some novel approaches because it uses land use changes for different time slices of the Holocene. However, results should be more critically and thoroughly evaluated related to i) previous studies and ii) possible implications of the climate model used. Therefore I suggest major revision of the manuscript before final publication. The specific

comments and suggestions for improvement are outlined below:

Specific comments:

Abstract

Maybe the authors already can add some numbers how large global and regional changes are in degrees centigrade – it's trivial to achieve a statistically significant result when the number of samples is high enough. The physical significance might however be irrelevant then.

1 Introduction

The introduction lacks a general presentation of forcings potentially influencing Holocene climate such as orbital, solar, volcanic and GHG (for an overview refer e.g. Schmidt et al. 2011) – in the present form the reader who is not too familiar with the topic might get the impression that only changes in land use were the main driver of Holocene climatic changes

2.1 Model description:

The authors state the model does not include an interactive carbon module – which effect might the change in land use have on the carbon cycle ? In their introduction they note that besides the biogeophysical effects there are also biogeochemical effects in terms of changes in CO2 that might offset parts of the albedo changes induced by land use changes.

In the last paragraph of the section authors state that changes in land use are very small and localized and therefore one needs to integrate very long times to find a small albeit statistically significant result – I find this strategy a bit unfavorable because a priori this will most likely result in a statistically significant difference independent to the physical significance of the signal (see also von Storch and Zwiers, 1999).

3 Results

CPD

11, C2123–C2128, 2015

Given the effect of changes in RF due to changes in land use, especially in the earlier periods, temperature changes seem to be quite large – According to Fig. 2, the change amounts to 2-3 K in the pre-industrial period over parts of Europe and North America. The temperature increase over these regions is approximately 1-1.5 K in the last 150 years (cf. Supplement of PAGES2k reconstructions). Given this strong impact of land use changes, the temperatures should even decrease over these regions due to the presence of the land use changes. Earlier modelling studies with constant land cover also show temperature evolutions that are comparable to proxy reconstructions using only changes in solar, volcanic and GHG concentrations – how do the authors explain such large impact of land use change?

Another important point relates to the treatment of convection, soil moisture and hence cloud cover – the drying of soils would eventually lead to less convection and less cloud cover leading to increase in shortwave radiation counteracting the increase in albedo due to land cover change. How well does HadCM3 address these processes that would be important to assess the full range and implications of land use changes, especially on the local scale ?

How do results quantitatively compare to other studies (e.g. Pongratz et al. 2010 and Betts et al. 2007, Brovkin et al. 2004) suggesting considerable less impact of changes in land use change on regional and global temperatures. Might therefore part of the results be a specific model-dependent issue ?

Please also consult the study of Boisier et al. 2012 for a more thorough discussion of potential effects of changes in other properties related to changes in land use and the dependence on specific model and model configuration. An example for a time slice, preferably the PI vs present day concerning a separation into different components (albedo, latent and turbulent heat fluxes) as carried out in the study of Boisier et al. 2012 would also help to assess the model-specific response on land use changes.

3.1.2 Remote impacts of land use

CPD

11, C2123–C2128, 2015

I wonder why the authors did not carry out in parallel a transient simulation with continuous changes in land use including changes in orbital parameters – The reason it that the equilibrium response could be different to the response one achieves when using a transient simulation – although this kind of simulation would lie outside the scope of the present manuscript at least some words addressing potential implications would be helpful to put results obtained with the multi-centennial long-time slice experiments into perspective.

3.2 Atmospheric dynamics

How can low-level surface winds advect changes into remote regions ? I would rather expect a mid-to-high altitude mechanism driving low levels wind. Also the still coarse resolution of the global climate model will not properly simulate a realistic pattern of low-level winds, especially over regions characterized by a complex land-sea mask and regions with complex topography.

3.2.2 Mean sea level pressure

I suggest to change the order of the sections starting with upper tropospheric dynamics, to mslp and eventually low-level dynamics. Changes in mslp will change the surface wind pattern In general I have some reservations with the purely thermal explanations of wind changes in the extratropics excluding dynamical reasoning for instance related to changes in baroclinicity due to changes in the overall meridional temperature gradient also affecting the upper-tropospheric circulation

3.3 Hydroclimate

Analyzing hydroclimate changes from GCM output is afflicted with high uncertainties – this should be noted somewhere because results based on only one model can lead to false or not robust conclusions given the high degree of uncertainty even the current generation of GCM/ESM shows for the hydrological cycle.

4 Temporal evolution of Holocene climate

CPD

11, C2123–C2128, 2015

Can you explain why especially the NH temperatures show such a strong temperature increase – the summer insolation decreases and winter insolation north of 30 °N has not a pronounced effect. Most reconstructions and simulations point to a decrease in NH temperatures during the Holocene (cf. also Wanner et al. 2008).

5 Discussion

In general I liked the discussion section as useful to put results into perspective – However, I don't know if it's wise to criticize studies addressing results for regional climate change based on a regional climate model, when the GCM of the present study shows potential shortcomings, i.e. the overall temperature change between MH-PI is at odds with many other studies, the biogeochemical effect and the overall coarse resolution of the HadCM3 model neglecting specific regional details.

Technical comments:

p 4603, l 12. Why is the abbreviation anthropogenic land use change "ALCC" rather than "ALUC" ?

Section 2.2.: I suggest including a table where the experimental setup is summarized with according abbreviations.

p 4612, l 24: the weblinks should be replaced by citations from the peer-reviewed literature

In Figure 2 and 3 it would be helpful to include the global average of the temperature change and also reproduce changes in the annual mean

Additional references:

PAGES 2k Consortium (2013) Continental-scale temperature variability during the last two millennia, Nature Geoscience 6, 339–346, DOI: 10.1038/NGEO1797

Boisier, J. P., de Noblet-Ducoudre, N., Pitman, A. J., Cruz, F. T., Delire, C., van den Hurk, B. J. J. M., van der Molen, M.K., MÌĹuller, C., and Voldoire, A.: Attributing the

impacts of land-cover changes in temperate regions on surface temperature and heat fluxes to specific causes: Results from the first LUCID set of simulations, J. Geophys. Res., 117, D12116,doi:10.1029/2011JD017106, 2012.

Schmidt, G. A., Jungclaus, J. H., Ammann, C. M., Bard, E., Braconnot, P. C. T. J. D. G., Crowley, T. J., ... & Vieira, L. E. A. (2011). Climate forcing reconstructions for use in PMIP simulations of the last millennium (v1. 0). Geoscientific Model Development, 4(1), pp33-45.

von Storch, H., and F.W. Zwiers, 1999: Statistical Analysis in Climate Research, Cambridge University Press, ISBN 0 521 45071 3, 494 pp.

Wanner, H., Beer, J., Bütikofer, J., Crowley, T.J., Cubasch, U., Flückiger, J., Goosse, H., Grosjean, M., Joos, F., Kaplan, J.O., Küttel, M., Müller, S.A., Prentice, I.C., Solomina, O., Stocker, T.F., Tarasov, P., Wagner, M., Widmann, M., 2008. Mid- to Late Holocene climate change: an overview. Quat. Sci. Rev. 27, 1791–1828.

Interactive comment on Clim. Past Discuss., 11, 4601, 2015.