Biogeosciences Discuss., 11, C6295–C6304, 2014
www.biogeosciences-discuss.net/11/C6295/2014/

Interactive comment on "Biogeophysical impacts of peatland forestation on regional climate changes in Finland" *by* Y. Gao et al.

Y. Gao et al.

yao.gao@fmi.fi

Received and published: 29 October 2014

General comments:

Gao and co-workers mainly analysed the climate effects of peatland afforestation as simulated by REMO. As an experimental set-up they used the land cover in 1920s and compared it against the land cover in the 2000s and compare 5 subregions with contrasting land cover changes. Although the manuscript is already in good shape, its potential impact is likely to further increase by implementing the following general suggestions:

(1) A more careful selection of the figures could reduce the length of the manuscript and better distinguish the details from the main messages. Fig 5 and Fig 6 could be display with fewer months. That would allow plotting larger subplots without loosing information. Figure 6 is barely mentioned in the manuscript, the patterns are correctly described by random. The figures add little information.

AR: Agreed. Fig. 5 in the original manuscript will be only shown with spring and summer months, and autumn and winter months will be excluded. Fig. 6 in the original manuscript will not be shown in the revised manuscript. The excluded figures will be submitted as supplements.

The information contained in fig 1 could easily be added to any of the subsequent figures (or better repeated on all subsequent maps). Fig 1 shows the altitude of the sites but nothing is done with that information.

AR: We consider Fig. 1 should be kept because it is the only figure in the manuscript that shows the entire model domain, and orography is an important factor for regional climate. However, we will revise Fig. 1 with a more proper color bar to show the orography, and we will also add the relaxation zone used in REMO simulations for this domain. (Please see the revised Fig. 1 in the end of this file).

The information in Fig 3 could be added to Table 3.

AR: Agreed. This information will be added to Table 3 in two additional columns.

In its current presentation, figure 11 does not help to convince that the model does a good job. I suggest a correlation graph between the modelled and observed temperature changes in February, March and April would better present the message.

AR: Agreed. However, we found that the spatial correlations between modeled and observed temperature changes could not help us in this problem. To address this, we investigated the temperature trends over 40 years (1959-1998) for March and April based on monthly mean daily maximum and daily minimum temperatures from E-OBS gridded observational dataset in 0.25 degree resolution. We consider that the trend of daily maximum temperature is influenced by albedo-mediated temperature changes locally for March and April, while the trend of daily minimum temperature is more related to the general climate change caused by global GHGs increases. The local effects in the trends of daily maximum temperature suggest that our modeled results show qualitatively a good correspondence to observational data. The major areas of peatland forestation, subregion1 and subregion2, are highlighted and statistically significant in the trends of maximum temperatures in both March and April but not shown in the trend of minimum temperature. The new temperatrue trend maps are in Fig.2 in the end of this file.

(2) The manuscript deals with the effect of land cover change and one of its strengths, i.e., that it has also an area of peatland restoration, is hardly used. Subregions 1 and 2 are discussed in detail much fewer attention is given to subregion5 but this could add a very interesting perspective to the discussion.

AR: We cannot really say subregion5 as a peatland restoration area because the land cover change of subregion5 is an artificial effect due to the uncertainties in FNFI maps (discussed in Section 2.2). However, we included subregion5 in the analysis because it is interesting to see the modeled climate effects of this area that with decreased forests and increased peatland. Thus, we chose subregion5 as a comparison to subregion1 and subregion2 where the land cover change actually took place, with less attention given to subregion5.

(3) There is no figure showing the relationship between land cover change and climate change. Simple correlations between all land covers in table 1 and the observed temperature and precipitation differences may result in some interesting perspective(s). The same analysis could be repeated for the drivers, i.e., change in albedo, change in ET, ...

AR: Agreed. We investigated the spatial correlations between the changes in the two surface energy balance relevant variables, surface albedo and ET, and T2m. Consequently, the changes in surface albedo and ET are correlated to the changes in the

surface parameter values which describe land cover changes. Monthly means of 15-year averaged changes of March and June are selected to represent springtime and summertime effects, respectively. The plot (Fig. 3 in the end of this file) and following descriptions about those relationships will be added in the manuscript.

“To assess the generality of the causal relationships between land cover changes and climate variables, the spatial correlations between changes in the two surface energy balance relevant variables, surface albedo and ET, and T 2m are investigated. Consequently, the spactial correlations between changes in surface albedo and ET and changes in the surface parameter values are also explored. The correlations with green vegetation ratio is not shown in Fig.3, because LAI and green vegetation ratio are both modulated with the monthly varying growth factor by the same scheme, and they are highly correlated (pearson correlation coefficient, r 2 = 0.984 for March, r 2 =0.674 for June). Monthly means of 15-year averaged changes in March and June are selected to represent springtime and summertime, respectively. The changes in T 2m are in accordance with the changes in surface albedo in March (Fig.3, a), which is almost linearly correlated with the changes in LAI (Fig.3, c) and forest ratio (Fig.3, e). The T 2m changes in June are linearly correlated with ET changes over most of the area (Fig.3, b). In general, the changes in ET are also correlated with the changes in LAI (Fig.3, d), roughness length (Fig.3, f) and forest ratio (yearly-constant, not shown), despite the influences from drought that may happen in late summer. Overall, the changes in surface albedo and ET are closely dependent on the changes in land surface parameters, which are induced by the changes in fractional coverages of land cover types in the five subregions (Table 1). The changes in T 2m are mainly modulated by the changes in albedo and ET in spring and summer, respectively. Some gridboxes located in the southeast of Finland, where mixed forest was substituted by coniferous forest mainly, show deviations in the correlations with LAI (marked by yellow circles in Fig.3, b, c, d). In this area, LAI increased with almost no change in forest ratio, which lead to relatively smaller decrease in surface albedo compared to other areas with the same magnitude of changes in LAI in March; the ET-induced cooling is outweighted by the albedo-induced warming, which causes a slight warming effect in June. In the following summer months, July and August, the ET-induced cooling effect typically gets smaller because of surface water limitation and consequent warming."

(4) At several places in the results and discussion, cloud cover and atmospheric inversions are mentioned as drivers of someof the observed changes but no evidence is provided to the reader. Is this a result from the analysis or a (logical) induction by the authors.

AR: It is a logical induction according to the results shown in Fig.8. In autumn and winter, there are varied differences of temperature but no differences in net surface solar radiation. Also there are no differences in ET, as well as in latent heat flux. Thus, the differences of long wave radiation is the only factor affecting surface energy partition.

(5) In fig 8 subplots have different units. In the text these subplots are compared as if they have the same units (p11262, 20-22). Converting the units would result in a more convincing presentation.

AR: We found by showing percentage changes for those variables are not helpful to illustrate the results. To make this part more clear, we will revise of the text as follows.

"T 2m of subregion1 shows a warming of 0.1 K to 0.2 K from February till the end of March, and an evident peak of increase from early April to early May (from DOY 95 to DOY 125), which reaches a maximum of 0.5 K in late April. T 2m of subregion2 has the same developement as subregion1 throughout the whole year, but the warming is much smaller and the biggest difference occurs in the beginning of April being only 0.12 K. This is consistent with the differences in snow depth. The snow-cover period in subregion2 is shorter along with an earlier maximum difference in snow depth. Moreover, those characteristics of the differences in snow depths are in agreement with the differences in surface albedo qualitatively because snow is the key factor that controls the surface albedo in the snow-cover period. From the beginning of May to the beginning of October, T 2m turns to show a cooling of less than 0.1 K in subregion1 and subregion2, because the cooling caused by ET exceeds the warming caused by the slightly lower albedo. The variability of the differences in net surface solar radiation in the growing season is induced by the variability of cloud cover rather than surface albedo. In November, December and January, the differences in T 2m vary in both directions. In high-latitudes, incoming solar radiation is quite small and cloud cover fraction is high in late autumn and winter. Therefore, the differences in surface albedo are not able to induce differences in net surface solar radiation in this period. Instead, the surface air temperature is sensitive to changes in the long-wave radiation balance that may lead to atmospheric air temperature inversion under a clear sky, manifesting itself as extreme cold surface air temperature. Thus, the variability of the differences in cloud cover caused by short-term variations in the climate contributes to varied differences in T 2m in this period."

Specific comments:

(1) The term 'unproductive peatland' contains some contradiction as these sites are so fertile that they are drained and used for forestry and agriculture. What is the reference for the word 'unproductive'? Euro's, water, carbon, . . .?

AR: Unproductive land in Finnish National Forest Inventory is defined as naturally treeless land or land has the potential capacity to produce a mean annual increment of less than 0.10 m 3 /ha of stem wood over bark, which can be referred to Tomppo et al. (2011). Thus, unproductive peatland means naturally treeless or sparsely treed peatland. On unproductive peatland, the growth limiting factor is not site infertility, but excess of water. Therefore, peatlands were drained to stimulate forests growth in Finland in the past. To make it more clear, the term 'unproductive peatland' will be changed to 'naturally treeless or sparsely treed peatland' in the manuscript.

(2) The objectives (top page 11253) are rather vague.

AR: Agreed. We will modify it as: The intention of this study is to understand how peatland forestation that took place in Finland influences regional climate conditions from biogeophysical aspects.

(3) Reword and add some details. Mention the effects on keeping land cover unchanged outside of Finland. This basically means that your experiment can quantify the impact of land cover change for Finnish climate but is not suitable to attribute observed changes in climate to land cover change.

AR: Agreed. We will add the discussion below about this point in the part that compares simulated results with observational data.

“However, it is difficult to compare the exact magnitudes and patterns of temperature changes because observational data contains contributions from other factors, for instance, the effects of climatic teleconnections from land cover changes in surrounding areas of Finland and short lived climate forces, such as aerosols and reactive trace gases (Pitman et al. 2009).”

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C6295/2014/bgd-11-C6295-2014-supplement.pdf

---

Interactive comment on Biogeosciences Discuss., 11, 11249, 2014.

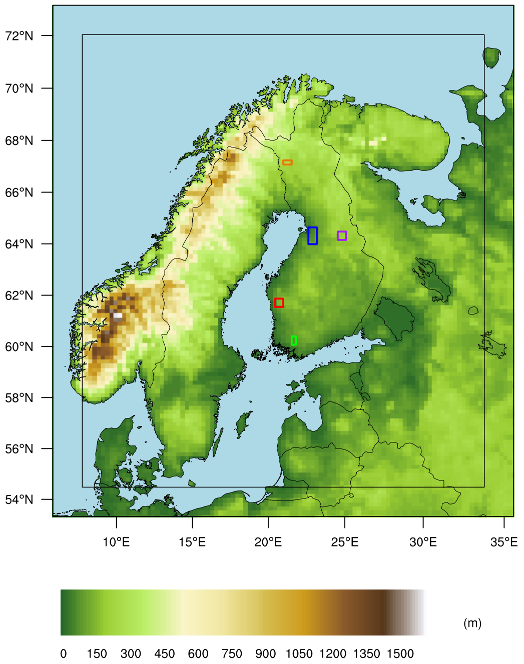

Fig. 1. Orography of the model domain, and the five selected subregions (subregion1–blue; subregion2–red; subregion3–purple; subregion4–green; subregion5-orange; relaxation zone-inner black frame).

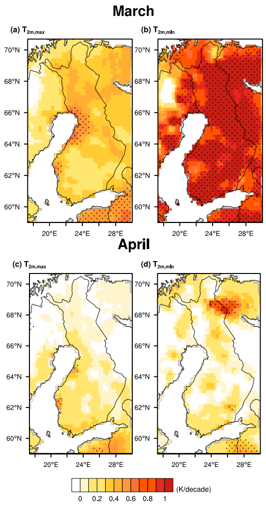

Fig. 2. Temperature trends over 40 years (1959-1998) for monthly mean daily maximum (a, c) and daily minimum temperatures (b, d) of March and April. Statistical sigificant ($p<0.1$) areas with black dots.

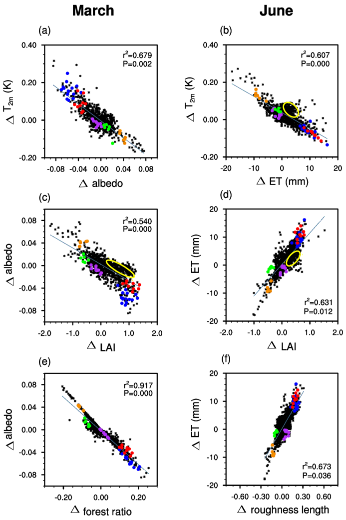

Fig. 3. Spatial correlations between changes in T 2m and changes in albedo for March (a), and between changes in T2m and changes in ET for June (b) ... (the full title is presented in the supplements)