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

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General comments:

I commend the authors for a timely study about effects of human actions on the climate system. The paper describes how the representation of vegetation in the calculation cells of the REMO model have been improved with the aid of the data of the Finnish National Forest Inventory (FNFI). This allows for estimating the effects of peatland drainage (that allows tree growth, that is, forestation) by using results of two inventories, between which a substantial change has occurred. My expertise is forest modeling, I am not able to judge the details of application of the REMO model.

The results are derived from two 18 year long simulations with REMO that use veg-

etation cover data from two FNFI measurements. The main finding is that peatland forestation results in strong spring warming that is highly heterogeneous spatially and temporally. There are also effects on albedo, precipitation and net surface radiation throughout the year.

The results compare favorably to some observations. They are presented and discussed somewhat from the point of view of their sensitivity to input data and parameter values. However, the paper would be even better if a more comprehensive sensitivity analysis had been made by additional model runs. For example:

- The paper discusses uncertainties in background albedo values (l. 527- 558)

- Local effects of peatland forestation areas on maximum net surface solar difference (l. 503-525)

- Uncertainties in translating FNFI cover information to a compatible form with REMO (l. 220-224)

Authors response (AR): Systematically changing surface parameters, such as background albedo, may help to test the robustness of simulation results. However, it requires heavy computing to do this kind of sensitivity test with a regional climate model, which makes it not really realistic. Instead, we will add figures showing correlations between changes in climate variables and changes in land surface parameters, which is helpful in understanding the effects of land surface parameters on climate changes.

- The uncertainties in background albedo values (L. 527-558) We will add the climate impacts of uncertainties in background albedo in the discussion part of the manuscript. The uncertainties of background albedo values do not influence much on the surface albedo during snow-cover period because snow cover leads to a much higher increase of surface albedo.

- The local effects of peatland forestation area on maximum difference of net surface solar radiation (L. 503-525). Our reasoning is as follows: The maximum difference in net surface solar radiation is caused by the advanced snow clearance day due to peatland forestation, when the differences of surface albedo are biggest between snow covered peatland and non-snow covered forest. This means that the maximum difference of surface albedo is mostly dependent on snow albedo. As snow albedo has a negatively linear correlation to forest ratio (Fig. 4 in the original manuscript), the maximum difference in net surface solar radiation could be roughly estimated according to the difference of forest ratio. This part will be added in discussion.

- The uncertainties in translating FNFI land cover information to a compatible form with REMO (L.220-224). We cannot use REMO with too low resolution, e.g. 100 km, for this study because it will make us lose too much information about the dynamics of the local effects of land cover changes on climate. We translated the ten FNFI land cover classes to the standard GLCCD land cover classes through comparing the definitions of land cover classes and allocating appropriate surface parameter values. We agree that it would be good to use a set of land surface parameter values produced for Finnish conditions, but it would require complete and consistent data on each parameter. Unfortunately, at this moment it is beyond our ability.

Runs with systematically changed input data/parameter values would give a better understanding of the relative importance of different factors to the results. The results of simulations are discussed in terms of peatland forestation. However, the two FNFI measurements that are 80 years apart record also many other changes of forest cover apart of peatland drainage. I would like too see a discussion what other factors (e.g. stocking) may have affected the simulations.

AR: Yes, climate effects are also shown in summertime in the southeast of Finland where mixed forest decreased and coniferous forest increased. This will be discussed with the spatial correlations required in the reply for general comment 3 from reviewer #3. Our simulations are performed with two static land cover states, and not coupled with dynamic vegetation model. So, we do not have stocking changes of the same type of forest.

The paper is well written. I have marked to the MS (Supplement) some passages that could be improved as well some other small comments.

Specific comments (in supplement: http://www.biogeosciences-discuss.net/11/C4600/2014/bgd-11-C4600-2014-supplement.pdf):

(1) Line 79-80: Is this for peatlands or in general?

AR: This refers to the averaged temperature changes over southern and northern Finland in general. This part will be modified to make it more clear to readers.

(2) Line 134 : This is unclear: do you consider the change of vegetation (e. g. forest growth) during the 18-year simulation? If this the case the growth factor should be explained in a detailed manner.

AR: The growth factor in REMO land surface scheme only describes the intra-annual cycles. Our simulations are static modeling based on two land cover maps. The definition of growth factor in the manuscript will be modified to be for clarity: the factor determines the seasonal growth characteristics of vegetation.

(3) Line 152: This is a bit unclear: later on Line 170-174 you explain that CORINE land cover map is used.

AR: GLCCD is the default land cover map to represent present land cover surface in REMO as mentioned in the manuscript. The subgrid-scale heterogeneity resolution of the improved hydrology scheme of REMO was set based on the standard land cover map (Hagemann and Gates, 2003). That work is independent to implementation of CORINE land cover map in REMO (Gao et al., 2014)

(4) Line 170: Earlier you say that there are 9.7 Mha peatlands.

AR: 9.7 million ha was the total peatland area of Finland in 1950s in Ilvessalo (1956). 22377 km 2 (7.4%) is the area of naturally treeless or sparsely treed peatland in the 10 th FNFI (2000s). They are different.

(5) Line 178-179: So you mean in this paragraph that the spatial resolution (or the units are) is the same as in CLC but contents have been taken from FNFI? Maybe this paragraph is a bit difficult to follow.

AR: FNFI maps are in 3km resolution, where as CLC map is in 1km resolution. In the earlier study (Gao et al., 2014), CLC map is used instead of the standard GLCCD map to represent present land cover conditions for our model domain. In this study, we used both historic (1st) and present (10th) FNFI maps to describe the land cover changes in Finland, for consistency in land cover classification and spatial resolution. Therefore, CLC is substituted by FNFI10 to represent present land cover situation. All the land surface parameters allocated according to land cover maps are aggregated to 18 km resolution in REMO simulation.

(6) Line 200-223: This paragraph is difficult to follow. I suggest presenting the information (percentages) as table.

AR: This part of information has been presented as table 1. An introduction sentence will be added for Table 1 in the revised manuscript.

(7) Line 223-226: I do not understand what you are trying to say here.

AR: We are trying to explain the uncertainties of land cover changes in the selected subregions. To make it more clear, we will modify the original text as follows.

" One should notice that some uncertainties may arise from sampling in the FNFI1 and FNFI10 data. This applies especially for FNFI1, where the distance between inventory lines was as high as 26 km. Therefore, subregions that are smaller than 100 km $\times$ 100 km may not be sufficient to represent the actual land cover changes spatially. However, the dynamics of the local effects of land cover changes on climate cannot be detected when averaging climate signals over large areas with diverse land cover changes. Therefore, small subregions, which cover a range of land cover change intensities, are chosen to reflect local climate impacts due to different land cover changes."

(8) Line 282-283: This relationship requires a better explanation: either from physical principles or references to work, in which it was developed.

AR: Kotlarski (2007) is given as a reference for the linear relationship in snow albedo scheme in this paragraph. We found the last sentence of this paragraph is redundant with the sentence with Kotlarski (2007) as a reference in the above. We will delete this sentence.

(9) Line 288: Why this is the reason for 6 km resolution?

AR: The resolution of subgrid-scale heterogeneity adopted for the improved soil hydrology scheme (Hagemann and Gates,2003) is set to be 10 times higher than the model resolution by using the default GLCCD. This is the context for setting the resolution of subgrid-scale heterogeneity in this study to be 3 times (18 km/3=6 km) higher than the model resolution (18 km), because the resolution of FNFI maps are 3 times lower than GLCCD.

(10) Line 298: add some words about calculation of dynamics of snow cover. It is an important model component in relation to the main result.

AR: We agree that the dynamics of snow cover is an important factor. The dynamics of snow dynamics in REMO is well described in Kotlarski (2007), therefore we will suggest that interested readers to refer to Kotlarski (2007) on the dynamics of snow cover.

(11) Line 447: Put this in caption of Fig. 10.

AR: Yes. It will be changed according to this suggestion.

(12) Line 495: Do you mean that REMO predicts winter time temperatures with bias?

AR: Yes. The cold bias over this model domain in wintertime simulated by REMO has been shown in Gao et al. (2014). The content of this paragraph will be changed according to general comment 1 from Reviewer #3.

(13) Line 503-525: You could test this by a simulation, in which you make this kind of

change for the whole subregion1 (or all regions). I do not understand why this “Only around 20% ...” constitutes an explanation for differences in max. differences – the 20% change is also in the observations. Could it be that there are factors involved in max. observed differences that your simulations do consider?

AR: Indeed, the original text could be misunderstood. About 20% of subregion1 is changed due to peatland forestation (Table 1), whereas the observational data is measured at sites with open peatland and with forests. We have clarified this paragraph as follows. “Furthermore, regional averaged difference in the simulated 11 day running mean net surface solar radiation of subregion1 (Fig. 8, d) agrees well with the observed differences in daily mean (1971-2000) net surface solar radiation (Fig.4 in Lohila et al., (2010)) between open peatland and forest sites located in southern and northern Finland. The maximum differences in the observed net surface solar radiation at nutrient-rich sites are 40-45 W/m 2 (on DOY 70) in the south, and 80-90 W/m 2 (on DOY 110) in the north of Finland. At nutrient-poor sites, the maximum differences are 30-40 W/m 2 (on DOY 80) in the south, and 60-70 W/m 2 (on DOY 115-120) in the north of Finland. The maximum difference in the simulated 11 day running mean net surface solar radiation averaged over subregion1 is 6.5 W/m 2 (on DOY 107). The timing of the maximum difference in our simulated results, for subregion1, falls within the range of that in the observed data. The much smaller magnitude of the maximum difference in the simulated results could be explained by the fact that only around 20% of the land was transformed from peatland to forests in subregion1. The maximum difference in net surface solar radiation iscaused by the advanced snow clearance day due to peatland forestation. The differences in surface albedo is biggest between snow covered peatland surface and non-snow covered forest surface, i.e. the maximum difference of surface albedo is mostly dependent on snow albedo. Snow albedo has a negative linear correlation with forest ratio (Fig. 4 in the original manuscript). Assuming that the entire land of subregion1 would have been changed from peatland to forests, the maximum difference in net surface solar radiation could be estimated to be five times larger, i.e. 32.5 W/m 2 , which is within the range of observations.”

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