Interactive Discussion on 6, C1070-C1075, 2013

Reply to anonymous Referee #1

Main suggestion 1 (referee):
please be clearer on whether this model does or does not include vegetation dynamics, in which the areal coverage of PFTs and their carbon storage pools dynamically changes. This feature seems to be included in JSBACH according to the two cited papers, but the description of the model in P3090-3091 suggests that the PFT cover is fixed. On the other hand the authors wrote "The differences in the results of the two model versions stem from the differences in the dynamics of vegetation cover and density..." in the abstract.

Reply (authorship):
As figure 1 shows, the carbon pool feature of JSBACH is not included in REMO-iMOVE. Also a dynamic vegetation module, which allows internal spatial shifts of vegetation types is not included. They can be prescribed from external land use projections. A really working dynamic vegetation scheme strongly depends on plant NPP, which in turn depends on soil water conditions. As we stated, we found the bucket soil water scheme in REMO-iMOVE not sufficient to be able to simulate the vertical profile of soil water characteristics, especially in semiarid and arid environment and under changing wet-dry cycles. Moreover, nutrient limitions (N,P) is not represented in the model so far, but they also play a major role for plant competition. Without those processes, internal vegetation shifts can not be represented.

The main difference of the model versions really stem from the differences in temporal vegetation dynamics, because the density (LAI) and areal extent (VGT) of greeness of vegetation depends now on soil and atmospheric conditions. In the former model version this was a fixed annual course. The PFT cover is fixed but can be changed by providing a PFT distribution e.g. every year.

Changes in the text:
P3090, L4: The coupled version REMO-iMOVE received all biophysical parameterizations for vegetation modeling of JSBACH, except the dynamic vegetation scheme and the carbon pool parametrization. Nevertheless land-use studies can be tackled by providing pre-compiled PFT distributions to the model every favoured time step.

P3112, L19: …and dry central European regions. For further development, the implementation of carbon pool dynamics and spatial vegetation shifts into REMO-iMOVE will first require an advanced soil water scheme with several vertical water layers, which is needed for representing root water competition. When REMO-iMOVE has received a better soil water scheme, the dynamic vegetation abilities and the carbon pool dynamics of JSBACH can be introduced to the new RCM version. The dynamic vegetation scheme of JSBACH strongly depends on plant productivity. Solely soil water limited PFTs would then be limited in growth and the PFT distribution would show realistic dynamics, in the current model these PFTs would have strong advantages over all other PFTs, therefore we did not include the dynamic vegetation in this model version.

Main suggestion 2 (referee):
please explain how the model calculates dark respiration to obtain NPP. Even through NPP is one of the key topics in this paper, the details of the respiration modeling is not given.

Reply (authorship):
The whole productivity and respiration model is based on the BETHY model – which includes all described parts (radiation interaction with the canopy, phothosynthesis, dark respiration and stomatal conductance) and was developed by Knorr, 1998. We will not include all equations in our paper, since this is already documented and published.

Changes in the text:
P3093, L3: All these parts are taken from the BETHY model (Knorr, 1998) which is a part of JSBACH. BETHY models the radiation interaction with the canopy, photosynthesis, dark respiration and stomatal conduction.

Main suggestion 3 (referee):

the discussion section needs to refer to other similar studies, realizing that the modeling system represented in this study is not quite state-of-the-art. Not only the bucketsoil water model, but also the representation of vegetation is not novel in the current context of regional climate modeling. I give some references below.

Reply (authorship):
The vegetation modeling system presented here is a state of the art approach. We coupled a 3rd generation vegetation model to a RCM. The fact, that the RCM did not comprise for a state of the art representation of the soil water dynamics does not alter the quality of the vegetation scheme nor the coupling procedure. We also would be very happy to have a multi layer soil scheme, but you cannot change all parts of a model at once. We saw that the dynamic vegetation model and the carbon pool dynamics are not working well when using REMO-iMOVE, because of the bucket soil scheme - therefore we decided to not include these features in this study.
Of course we know that our approach is not a novel in regional climate modelling, but it is a novel for the model REMO. For users of REMO it is very important to know how the model reacts and would it is doing. We show the advantages and disadvantages in the simulated climate.
Where else but in GMD could a model user read about how a model is build up and what it is doing in detail.

Main suggestion 4 (referee):

the writing in discussion section (and section 5.2.1) is not as good and careful as the other sections. The current discussion section seems more like a bullet list, summarizing each finding from the result section (partly because good discussions are already given in the respective result sections). Please go through them more thoroughly, paying attention to the use of commas, unnecessary words, and the structure of each paragraph; I believe each paragraph has to have one main point.

Changes in the text (authorship):

Discussion

The one part of REMO2009 which is changed is its surface scheme and mainly the representation of vegetation. These changes lead to the differences in the modeled climate as described in chapter 5.1.4 and chapter 5.1.5. We will discuss the main findings here.
The most distinct changes for the high northern latitudes are changes due to forest cover and the snow masking mechanism. These two effects lead to an increase in 2 m temperature in REMO- iMOVE (chapter 5.1.4). Despite the small radiative input in winter in these regions, we see a sig- nificant change in temperature, which highlights the importance of surface albedo in these regions. The fact that the cold bias in the described part of the domain is only reduced but still remains in REMO-iMOVE, even with decreased intensity, leads to the conclusion that other mechanisms apart from the surface variables contribute to the bias. Since it is not within the scope of this experiment, this feature is not further examined here. Another important effect is the intensification of warm bias in the Balkans region in late summer.
This can be clearly attributed to the changes in the vegetation cover properties, represented by LAI and VGR. The vegetation in these regions mainly consists of crop PFTs (C3 and C4). In contrast to the old model version, the newly introduced crop phenology in REMO-iMOVE is able to react dynamically to the atmospheric signal (as described in chapter 2.1.2. Hence the crops are harvested when the growing degree threshold, depending on temperature, is reached and no longer at a fixed date. This phenological scheme for crops is able to simulate the LAI in very good accordance to

observed LAI values (chapter 5.1.5) which is an improvement compared to REMO2009. The dynamic harvest of crops leads to a distinct drop in LAI and VGR mainly in August and September. This early and strong decrease of vegetation density reduces the latent heat flux and thus the near-surface evaporative cooling. This leads to distinctly increased near-surface temperatures.
Another feedback in connection to crop phenology is the decreased moisture recycling due to less near surface and atmospheric moisture availability. Less atmospheric moisture leads locally to a decrease in precipitation. The moisture recycling feedback with decreased precipitation is mostly visible in the Hungarian basin and the Balkans in July and August, when the energetic driver, the insolation, reaches its maximum values. As described in chapter 2.1.2, the parametrisation of bare soil evaporation was improved. This lead to a further increase of surface temperatures in the stated regions. This static method improves some of the shortcomings of REMO2009, but it is not able to capture realistic soil moisture dynamics like a multi layer soil water scheme. The interactive coupling of REMO with the vegetation scheme captures dynamic changes of vegetation properties like the annual cycle of LAI and photosynthetic activity due to atmospheric and soil conditions. Chapter 5.2.1 shows that REMO-iMOVE is able to reproduce the observed annual cycle of vegetation in most evaluated regions. Shortcomings still exist in some semi-arid and continental climate regions. The observed LAI values in the evaluation regions 9 and 10 do not exceed the limit of 1 (Figure 11). The simulated values show a maximum of nearly 2.5. The plant growth in these regions is mainly limited by water availability. Figure 12 shows the soil water dynamics for the evaluation regions 9 and 10. A value below 35% of the bucket fill means, that the wilting point in the soil is reached and no more water is available to plants. If the value is above 35%, water is available for plant growth. It is clearly seen, that the bucket fill never drops below 35% in region 9, even if it is located partly in semi-arid environment. In evaluation region 10, we would also expect strong plant water stress in summer due to the continental climate characteristics. But the bucket fill always exceeds 35%, meaning that water is available for plant growth. As stated earlier, the bucket soil water scheme of REMO is not able to represent horizontal soil moisture dynamics. Since that would be needed for a near realistic image of plant growth in these regions, we also can see that in the overestimated LAI value. Another factor towards an overestimation of the LAI magnitudes is the model bias in summer precipitation, which can be up to 40 to 60% in the referred regions. REMO-iMOVE now implies a new source of climate variability, since the vegetation cover dynamically adjusts to atmospheric conditions. For studies on future climate change this is vitally important, as plants are now able to adjust the growing conditions to appropriate or inappropriate climate conditions. The LAI courses in figure 11 and the NPP time series in figure 13 clearly show the influence of annual change in modeled weather characteristics on vegetation growth and productivity.
One of the most important newly introduced model feature in REMO-iMOVE is the net primary productivity of vegetation (NPP). We will discuss the stated numbers and findings of chapter 5.2.2 in more detail here. In the model, the productivity in dry regions and for certain PFTs (especially C3 and C4 grass) is mainly limited by the soil moisture availability. For C3 grass, the modeled NPP values lay in the upper range of observations nearly for all climate types. This would imply water stress free conditions in more than 200 day per year, which is unrealistic for the subtropical and temperate continental climate types. The productivity dependence on soil water in an extreme case is given in the first year of the model run, where the hydrological soil spin-up took place. Here the annual NPP rate in all arid environments (evaluation region 1 BW/BS) is very high, compared to all other years where no productivity takes place to the lack of soil water. Also in evaluation region 2 Csa (figure 13 c) the NPP rate drops to minimum values in exceptionally dry years (1999, 2000). In figure 12 we depicted the soil water courses for region 1 (BW/BS) and region 2 (Csa) for comparison. So it is clear for region 1 in the first year (spin-up), that the productivity values are high, because water is available in the soil. After the soil spin up the productivity values drop, since only in very few months in some years the soil water exceeds 35 % of the bucket fill and is available for the plants. In evaluation region 2 we can correlate the distinctive drop in NPP in the years 1999, 2000 and 2005 to the exceptionally dry state of the soil. So we can state that the overestimated grass PFT productivity is mainly due to missing horizontal soil water dynamics, which would differentiate the access of plants to water due to different rooting depths.
This is evidence for the good functionality of the productivity scheme for water dependent species.

The one part which works insufficiently in this respect is the soil hydrological scheme. It does not horizontally differentiate the access to water, so plants have direct access to water if it is present in the soil, which is a rather unrealistic assumption. A new hydrological scheme is currently under development, which is able to simulate the horizontal position of water due to the use of multiple layers. Unfortunately this scheme was not ready for use within this study.
The productivity of mediterranean shrubs and woodland is in the range of observations, which is huge. Factors like stand age or nutrition limitation are important for the growth in these climatic zones and could help to draw a more realistic picture of productivity if incorporated in the model. Nevertheless, the most important factor is the discussed insufficient soil hydrological scheme.
The productivity values of temperate zone woody PFTs range in the upper limits of observations with a tendency of overestimation. The tendency towards too high productivity is likely connected to the fact that nutrient limitation or pests are not modeled in REMO-iMOVE.
The same is true for the productivity in the boreal zone, where REMO-iMOVE overestimates the observed values clearly. The reason here may be either the unsatisfying nutrient limitation or the parameter sets in the photosynthesis scheme controlling the carboxylation and maximum electron transport rate (Bonan et al. (2011)).

Specific comments (referee)

Referee: P3088, L13-14 Based on the lack of dynamic vegetation in this model, I disagree to use the term "comprehensive vegetation representation"

Reply (authorship): ...giving rise to an interactive vegetation representation.

Referee: P3090, L4-5 "The coupled version REMO-iMOVE received the most important biophysical parameterizations for vegetation modeling of JSBACH" This (most important) is a vague statement and seems exaggerating without much context or references given.

Reply (authorship): The coupled version REMO-iMOVE received all biophysical parameterizations for vegetation modeling of JSBACH, except the dynamic vegetation scheme and the carbon pool parametrization.

Referee: P3091, L1 is "biotemperature" just a climatological annual mean temperature?

Reply (authorship): Yes – we took the same wording as in the original paper, to prevent misunderstandings

Referee: P3093, L19-20 How does the model calculate dark respiration? References for photosynthesis is given but those for respiration are not.

Reply (authorship): see reply to main suggestion 2

Referee: P3095, L14 "non-zero k and q = 0"
How can you have this condition since equation (5) is given as k = q x [NPP+] x [SLA]

Reply (authorship): As we stated in 3094 L24 this assumption is only true for the crop phenology. This is the only phenology which depends on the day before NPP rate. For the summergreen vegetation phenology the values of k and q are set, when the specific phase starts depending on soil and air temperatures – described in P3095, L19-21

Referee: P3096, L6-7, L9-10 maximum rate (eta_bare = 20%) "the resistance against bare soil evaporation will take a lower value (eta_bare = 45 %)"
I suppose "lower" in this sentence should be "higher", compared to the 20% of the soil resistance in the previous sentence.

Reply (authorship): yes of course – thanks for the comment

Referee: P3096, L22-23 "without loss of computational performance" This expression does not seem accurate. I believe there must be some increase in the computational time by coupling to JSBACH (i.e., REMO vs REMO-iMOVE).

Reply (authorship): P3096, L22-23 …without significant loss of computational performance since the model physics, where the new model constituents are based, only take minimal computation time compared to other parts of REMO.

Referee: P3097, L13 Please clarify what the surface vegetation ratio is.

Reply (authorship): P3097, L13 The surface vegetation ratio (VGR) gives the vegetated fraction of each grid cell which is covered with greened vegetation, thus this part is able to do photosynthesis. It is derived for each PFT from the specific LAI value of each PFT via Beers extinction law.

Referee: P3097 L27 "so-called perfect lateral boundary conditions" I am not familiar with this term, "perfect lateral boundary conditions". What are they?

Reply (authorship): so-called perfect lateral boundary conditions are composed by meteorological centres like ECMWF by reanalysing weather data with special models and all available measurement data. Reanalysis data are therefore the closed representation of the state of the atmosphere for a point of time in the past you can get. Reanalysis data therefore are the state of the art boundary forcing for RCMs for model validation.

Referee: P3099-3102 (section 5.1.1-5.1.3) The description in these three sections seem to be too detailed, and certainly not an "overview" as stated in the section title. Probably it is better to focus more on the two main regions (described in p3102, L27 - p3103, L7) for the readability.

Reply (authorship): This description is one of the core points for modelers and users – we want to know what has changed from the old model version to the new one. We do not want to just show where the new model version results look better – we want to show all important changes and discuss all relevant effects. So we focus on the most important regions.

Referee: P3103, L16_ The description of albedo change does not seem correct here . I believe the albedo of the snow-covered forest is higher (thus more reflection) with lower temperature and lower with higher temperature (snow melts and more tree leaves are exposed). So, "For Ts <= 10 °C the albedo is fixed to a maximum value for alpha_snow_forest." should be "For Ts <= -10 °C the albedo is fixed to a maximum value for _snowforest." (minus sign in front of 10).
Also, "For -10 °C < Ts < 0 °C the snow albedo increases linearly until the minimum value of __snowforest is reached at Ts=0â°U ¸eC." should be "For -10 °C < Ts < 0 °C the snow albedo decreases linearly…".

Reply (authorship): You are right of course:
P3103, L16-19 For Ts <= 10 °C the albedo is fixed to a maximum value for alpha_snow_forest. For -10 °C < Ts < 0 °C the snow albedo decreases linearly until the minimum value of alpha_snow_forest is reached at 0°C.

Referee: P3104, L9- In figure 10 the sensible heat looks decreased over the areas with reduced LAI and VGR, which is the opposite to the description in this sentence. Is the color scheme (sign) correct for the panels of sensible heat?

Reply (authorship): We define fluxes with a negative sign if they are directed away from the surface, so when you have a negative sign in the color scheme in figure 10 it depicts more sensible heat is

being radiated in REMO-iMOVE, thus it is getting warmer compared to REMO2009.

Referee: P3105 , L10-12 " This effect is long known (Betts et al., 1997; Avissar and Pielke, 1991), but so far not modeled in detail, using a high resolution regional climate model." The latter part of this sentence is not correct. As I suggested for discussion section, there are already several studies that include the ecophysiological aspect of the vegetation in regional climate models. Examples are:
Beltrán-Przekurat, A., C. H. Marshall, and R. a. Pielke (2008), Ensemble reforecasts of recent warm-season weather: Impacts of a dynamic vegetation parameterization, Journal of Geophysical Research, 113(D24), D24116, doi:10.1029/2007JD009480.
Winter, J. M., J. S. Pal, and E. a. B. Eltahir (2009), Coupling of Integrated Biosphere Simulator to Regional Climate Model Version 3, Journal of Climate, 22(10), 2743–2757, doi:10.1175/2008JCLI2541.1.
Steiner, A. L., J. S. Pal, S. a. Rauscher, J. L. Bell, N. S. Diffenbaugh, A. Boone, L. C. Sloan, and F. Giorgi (2009), Land surface coupling in regional climate simulations of the West African monsoon, Climate Dynamics, 33(6), 869–892, doi:10.1007/s00382-009-0543-6.
Smith, B., P. Samuelsson, A. Wramneby, and M. Rummukainen (2011), A model of the coupled dynamics of climate, vegetation and terrestrial ecosystem biogeochemistry for regional applications, Tellus A, 63(1), 87–106, doi:10.1111/j.1600-0870.2010.00477.x.
Davin, E. L., R. Stöckli, E. B. Jaeger, S. Levis, and S. I. Seneviratne (2011), COSMOCLM2: a new version of the COSMO-CLM model coupled to the Community Land Model, Climate Dynamics, 37(9-10), 1889–1907, doi:10.1007/s00382-011-1019-z.
Stéfanon, M., P. Drobinski, F. D'Andrea, and N. de Noblet-Ducoudré (2012), Effects of interactive vegetation phenology on the 2003 summer heat waves, Journal of Geophysical Research: Atmospheres, 117(D24), n/a–n/a, doi:10.1029/2012JD018187.

Reply (authorship): Yes there are models, we will state some here, since our statement leads to misunderstanding. But the most models which are there, do not couple atmospheric to vegetation processes on time-step basis –that is what we wanted to say. That concept is very new in the introduced regional model system. The other thing is, that every model has its errors, so the more models are out there, the more spread you will have in the simulations. We will rephrase the whole paragraph.

Referee: P3106, L21- p3107, L3 Why do you refer to the literature values for tropical grassland while you focus on different ecosystems? What is the main statement of this paragraph?

Reply: The paragraph is important to show the water stress dependence of grassland. Grass is always productive, if there is enough water. Since we have a bucket soil scheme in the model, grassland would be the dominating PFT in the model if we would run the vegetation dynamically.

Referee: P3108, L23-25 What is the point of this paragraph/sentence?

Reply (authorship): We want to give a valid spread of NPP values, therefore we state the belowground biomass also, which is a component of total NPP.

Referee: P3109, L1-9 Please provide the conclusion for this paragraph.
Together with the above three comments, I'd like to point out that section 5.2.1. is really hard to read, and this particular section does not provide much insights or main points. I suggest moving one paragraph in discussion section (p3110, L12-27) to the end of this section to provide a summary.

Reply (authorship):
P3109, L9-X
In this section we showed the modeled values for NPP in comparison to observed values stated in literature sources. Species like grass, which strongly are dependent on soil water show NPP values at

the upper range of observations. Mediterranean shrub and woodland also ranges in the upper band of values stated, but shows a drop in productivity in dry years as reported in the observations. NPP values for woody species of the temperate zone are in good agreement with the measurement but do not show much variability due to the fact, that nutrition limitation or productivity variations due to stand age is not modeled. Also NPP values for boreal woodland is at the upper end of observations because of the stated reasons.

Referee: P3110, L10 (also in p3106, L14) I cannot find the appendix mentioned in these sentences. Or do you mean Figure 12?

Reply (authorship):
P3110, L9-11 The LAI course in Fig. 11 and the NPP time series in Fig. 12 clearly show the influence of annual modeled weather characteristics on vegetation growth and productivity.

Referee: P3111, L10-11 Bonan et. al. (2011) is a good reference for this sentence. Bonan, G. B., P. J. Lawrence, K.W. Oleson, S. Levis, M. Jung, M. Reichstein, D. M. Lawrence, and S. C. Swenson (2011), Improving canopy processes in the Community Land Model version 4 (CLM4) using global flux fields empirically inferred from FLUXNET data, Journal of Geophysical Research, 116(G2), 1–22, doi:10.1029/2010JG001593.

Reply (authorship): Thank you very much – we will add this reference.

Referee: Table 1 What the numbers in parentheses as in "desert (7)"?

Reply (authorship):
Just an enumeration to show that we used 30 different types, since it leads to confusions we crossed it out.

Referee: Tables 4 and 5 Are these observed or simulated values? What are the two rows?

Reply (authorship): The title says: NPP range of shrubland...
So the upper row is the minimum, the lower is the maximum observed value. The two colums are the minimum and maximum values for DMC/CF. So all in all we see the spread of NPP range for shrublands (a value span of 198 to 1056 gCm^{-2} a^{-1} DM gives a range of 366 to 3771 gCm^{-2} a^{-1} FM) in the given unit to compare it to the modeled values.

Referee: Figures 4, 5, 6, 7, Please make the font size larger for the color-bar. The numbers are very hard to see. Also, can you rotate the numbers 90_ clockwise?

Reply (authorship): We don't see the point – the reader could easily zoom in in the .pdf file

Referee: Figure 11 the font sixes for the axes and tick mark labels, legend are all too small.

Reply (authorship): We don't see the point – the reader could easily zoom in in the .pdf file

Referee: Figure 12 I needed to zoom in Figure 12 by 400% using Acrobat reader, but then the legend looks blur since the resolution of the graphic is limited. It would be better to use other ways to summarize the results from all the sites, such as Taylor diagram, and show only a few examples of the time series to illustrates the key points.

Reply (authorship): we had all figures as separate diagrams, but should merge them in accordance to the editorial board of the journal – we propose to put four on one page, then it should be readable

Referee: "technical corrections"
p3095, L18, wording "The begin of the vegetative phase" should be "The beginning of the vegetative phase"

Reply (authorship): Thanks.

Referee: P3103, L26 "The snow reduction of the masking effect" This wording seems incorrect. Should be "The reduction of snow masking effect" ?

Reply (authorship):
P3103, L26 The reduction of the snow masking effect and the decrease of soil albedo cannot be the reason for the reduction of the cold bias in May, since no snow is present and the albedo is increased in REMO-iMOVE.

Referee: Figure 10, typo in the caption "vegetation ration (VGR)" should be "vegetation ratio"

Reply (authorship): Thanks.