Responses to comments of referee #1

Dear Prof. Jansson,

Thank you very much for your in-depth suggestions and constructive criticism. We appreciate the time you put into reviewing our manuscript. Below you can find a point by point reply to your comments, addressing your questions and indicating our revisions to the manuscript.

General Comments

Comment:

The paper is demonstrating how a modified version of the Orchidee-FM was developed to describe a common short rotation forest. The Orchidee model is developed for global land surface applications and the current paper deals with an updating to not only a new forest management scheme but also to a local scale of two sites in the same climate region of the world. In the objective it is clearly stated that the purpose was to modify the model to now cover a range of site conditions for SRC systems. Two modules (Allocation are changed that are related not only to parameters but also to the structure of the model. Both of those are typically very empirical in forest modelling and not always easy to describe also for more conventional forest management systems. The paper does not make any review of process oriented modelling of SRC system on a plot scale. Many such have been made for both water, carbon and nitrogen studies.

Response:

We are aware that process-based models exist that probably simulate productivity of SRC plantations very well. However, these are often heavily parameterized with site-specific information. Our aim was to develop a generalized SRC model that is capable of simulating SRC under a range of site conditions, not requiring site-specific parameterization. For this reason, we did not review the existing literature for these models. However, if the referee believes that this is a condition sine qua non, we would be willing to include one or a few paragraphs describing the process-based, plot-scale models.

Comment:

Instead it makes use of mainly eddy flux data from 2 recently established sites to support a modifications. The paper is of high interest for users and developers of the Orchidee model but the general interesting issues for how to model SRC systems is lacking.

Response:

In our revised version, we included data from several additional sites for the validation of the biomass production. Because more continuous SRC flux measurements were not available, we could only validate our modeled fluxes for one site. For the biomass production, we initially only provided predictions for 2 sites and we admit this was not enough. Therefore, we added an extra section, where we compare model predictions and site measurements[1] for a number of additional sites in a North-South gradient across Europe (FIG A).

[1] S. Njakou Djomo, A. Ac, T. Zenone, T. De Groote, S. Bergante, G. Facciotto, H. Sixto, P. Ciria Ciria, J. Weger, R. Ceulemans, Energy performances of intensive and extensive short rotation cropping systems for woody biomass production in the EU, Renewable and Sustainable Energy Reviews, Volume 41, January 2015, Pages 845-854, ISSN 1364-0321, http://dx.doi.org/10.1016/j.rser.2014.08.058.

Specific Comments

Comment:

The evaluation criteria for the acceptance of the new model is based on simple conventional statistics. Those statistics shows to my understanding only to what extent the seasonal course of the major fluxes can be described by the model. The improvement with respect to the conventional Orchidee PFT 6 is described without considering the methods for calibration. The authors need to clarify why the evaluation criteria was selected and to what extent the subjective evaluation of those conventional statics is a very well performing model and this proved to be useful tool to predict biomass productions for SRC plantations in general.

Response:

Our original aim was mainly to show how well a general model could reproduce productivity of SRC plantations and not to really to compare is with ORCHIDEE-FM. We believe that conventional statistics suffice to describe the performance of our model. The coefficient of determination (R^2) explains the variance in model performance by comparing it to the data variation. The normalized root mean square error (NRMSE) gives a measure for the accumulated model error. The Pearson correlation coefficient (PCC) shows how well the data is correlated. While R^2 and PCC give a measure for how well the trends in the data are simulated, NRMSE gives a measure for the total cumulated model error. We updated our description of the used statistics in the materials and methods section of the manuscript to include this.

Comment:

The authors are recommended to evaluate the model on NEE rather than ecosystem respiration and photosynthesis. Otherwise please justify the meaning of the separate components. . .

Response:

Figure 3 shows the cumulative, absolute comparison of NEE measured and modeled, and figure 1 shows their relative agreement. So we do evaluate NEE and the result is not very good, which is not surprising, because it is the small difference between two large (and uncertain) fluxes: GPP and R_{eco}. Since NEE is the sum of two big fluxes, one positive and one negative, small deviations in the carbon modeling are exaggerated in the NEE output. For example, a GPP of 50 gC m^{-2} y^{-1} and a R_{eco} of 40 gC m^{-2} y^{-1} results in a NEE of 10 gC m^{-2} y^{-1}, although the total amount of exchanged C is 90 gC m^{-2} y^{-1}. Moreover, we chose to evaluate the model using photosynthesis (GPP) and ecosystem respiration (R_{eco}) because they are the real (and large) physical fluxes that occur in the field, and are simulated by the model. The sum of these fluxes results in NEE. Therefore, we chose to put more emphasis on evaluating those, although we also show and discuss NEE. Moreover, for simulation of bio-energy production, GPP and R_{eco} are relevant and NEE is not. It is, however, relevant for C sequestration. We updated the manuscript section on CO_2 flux evaluation to clarify the meaning of these three fluxes.

Comment:

The more detailed evaluation of the model showed some major problems that are of higher scientific interest. 1)The Seasonal courses as presented in Fig 3. Showed interesting deviations between simulated and measured fluxes. Most obvious was with respect to Sensible heat flux.

NEE, LE and H all shows substantial differences in the seasonal patterns. Since only those represent the original measured variables it would be of high interest to know why they were not used to evaluate the quality of the model performance.
The discrepancy with respect to sensible heat flux was disregarded by the authors since they argued that it did not have any coupling to C or Water cycle in the model. This statements needs clarifications. The sensible heat flux is normally fully linked in an energy balance equations. And if considered in the model it should have some meaning for other components. I suppose the sensible heat flux should be consistent with the surface temperature of the site. This section is recommended to be excluded from the paper if it can't be justified from a reasonable interpretation. Maybe the particular boundaries to the specific sites are representing a scale for which we can't close the energy balance or something is wrong in measurements or in the model.

Response:

We prefer to leave the sensible heat flux in our manuscript for transparency. We agree that the discrepancy in sensible heat flux deserves more explanation. Therefore we extended the section on the sensible heat flux. The error is probably caused by a stable stratification that often develops in dense plantations at night. Because of this stratification the measured sensible heat flux is lower than the simulated flux. We added an insert to figure 3 in the manuscript that shows the average diurnal pattern of the sensible heat flux, which clearly shows this (FIG B). To get a better fit, we tuned the leaf albedo and added this to the list of changed parameters (table 2). This modification only caused very minor changes to the other simulations, but we updated the graphs and values. The stratification cannot be represented correctly by the calculation of surface drag, in the way it is implemented in ORCHIDEE. This problem did already exist in the model, as described by Krinner (2005)[2].

We also added a graph showing the measured and modeled soil temperature during 2011 for the POPFULL site. This is the only data we had on soil temperature. This data shows that the soil temperature was simulated very well by our model (R^2 = 0.955, NRMSE = 0.098, PCC = 0.907; FIG C.A).

We reduced figure 4 of our manuscript to only show the data for the latent heat flux and highlighted the data points corresponding to the dry spell, which shows the origin of the deviation in latent heat flux simulation (FIG D).

Comment:

2) The evaluation is fully lacking information about state variables in the soil. One such is the soil temperature and soil moisture and another is the root depth and allocation of carbon to the fine root system. This may be one of the most interesting components to be compared with an conventional forest site. I expect some comments to those soil conditions and especially with respect to the modified allocation procedure that was suggested for the orchidee-SRC model.

Response:

[2] Krinner, G., N. Viovy, N. de Noblet-Ducoudré, J. Ogée, J. Polcher, P. Friedlingstein, P. Ciais, S. Sitch, and I. C. Prentice (2005), A dynamic global vegetation model for studies of the coupled atmosphere-biosphere system, Global Biogeochem. Cycles, 19, GB1015, doi:10.1029/2003GB002199.

We added a section about soil variables. For this section we compared model simulations and site measurements of soil moisture and soil temperature of 2011 for the POPFULL site. This is the only field data we have on soil temperature and soil moisture. We described the soil temperature in the previous response paragraph.

For soil moisture, ORCHIDEE has only two soil compartments, of which one is only present after rainfall. Therefore, we plotted (FIG C.B) the modeled soil water content of the bottom compartment (dotted line) and the soil water content of both compartments (solid line) against the range of soil water content measurements up to 50 cm depth (gray area). We then compared the total simulated soil water content to the average measured soil water content, which had a reasonable fit (R^2 = 0.976, NRMSE = 0.152, PCC = 0.828). Due to the simplicity of the soil moisture simulation, the model cannot simulate the level of detail that is shown by the measurements. The model does show very clearly the decline of soil water content during the dry spell, and the replenishment of the top layer with the precipitation after the dry spell.

In ORCHIDEE, there is no rooting depth. Roots are assumed to span the full soil depth. We did not have any data on fine root allocation.

Concluding remarks

Comment:

The paper demonstrates a first approach to develop a global model to a specific forest management system. However to make the model of general interest outside the internal modeling community for the Orchidee groups it needs substantial modifications. As an internal working document the paper may be useful.

Response:

The results of our model validation are not that relevant to the modeling community, but our model modifications are. We describe process and parameter modifications to render a land surface model suitable for SRC system simulation. Our description in section 2.2 and the values in tables 1 and 2 of the manuscript are of interest to other modeling groups.
We hope that our modifications to the manuscript are satisfactory to you to consider its publication in GMD.

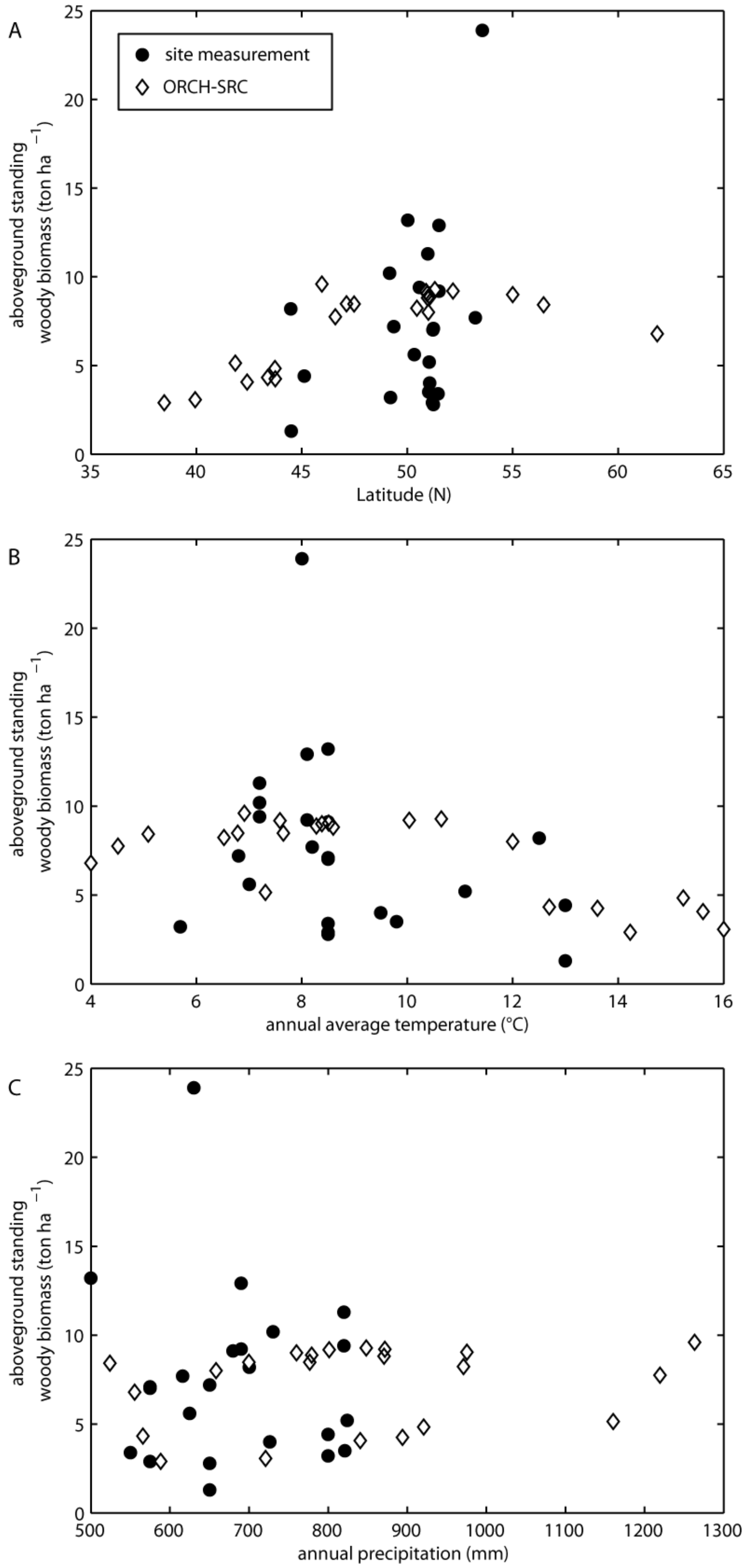

Fig. A: Comparison of aboveground standing woody biomass for ORCHIDEE-SRC simulations (open diamonds) across Europe with site measurements (black circles) across Europe. The biomass is plotted against (A) latitude, (B) annual average temperature and (C) annual precipitation.

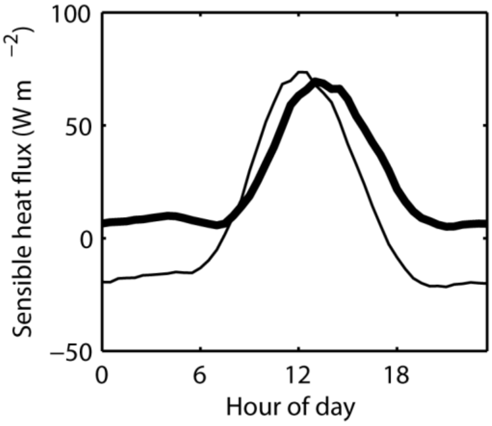

Fig. B: Insert for Figure 3, showing the average diurnal cycle of the sensible heat flux. Thin line: measurements, fat line: simulations.

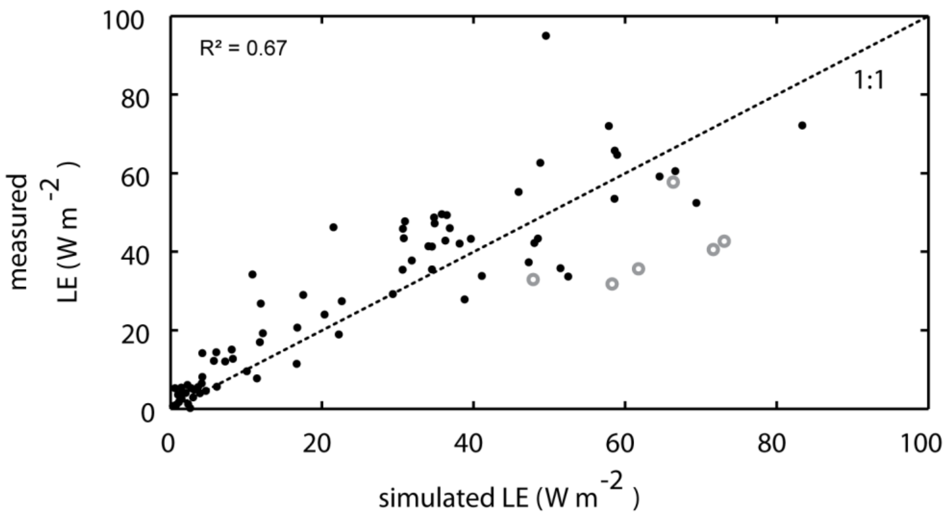

Fig. D: A 1-to-1 comparison of weekly averages of latent heat (LE)for the POPFULL site, between the model outputs and the measured values. The dotted line is the 1 : 1 line. Weeks 18-23 which represent the dry spell are highlighted as grey circles.

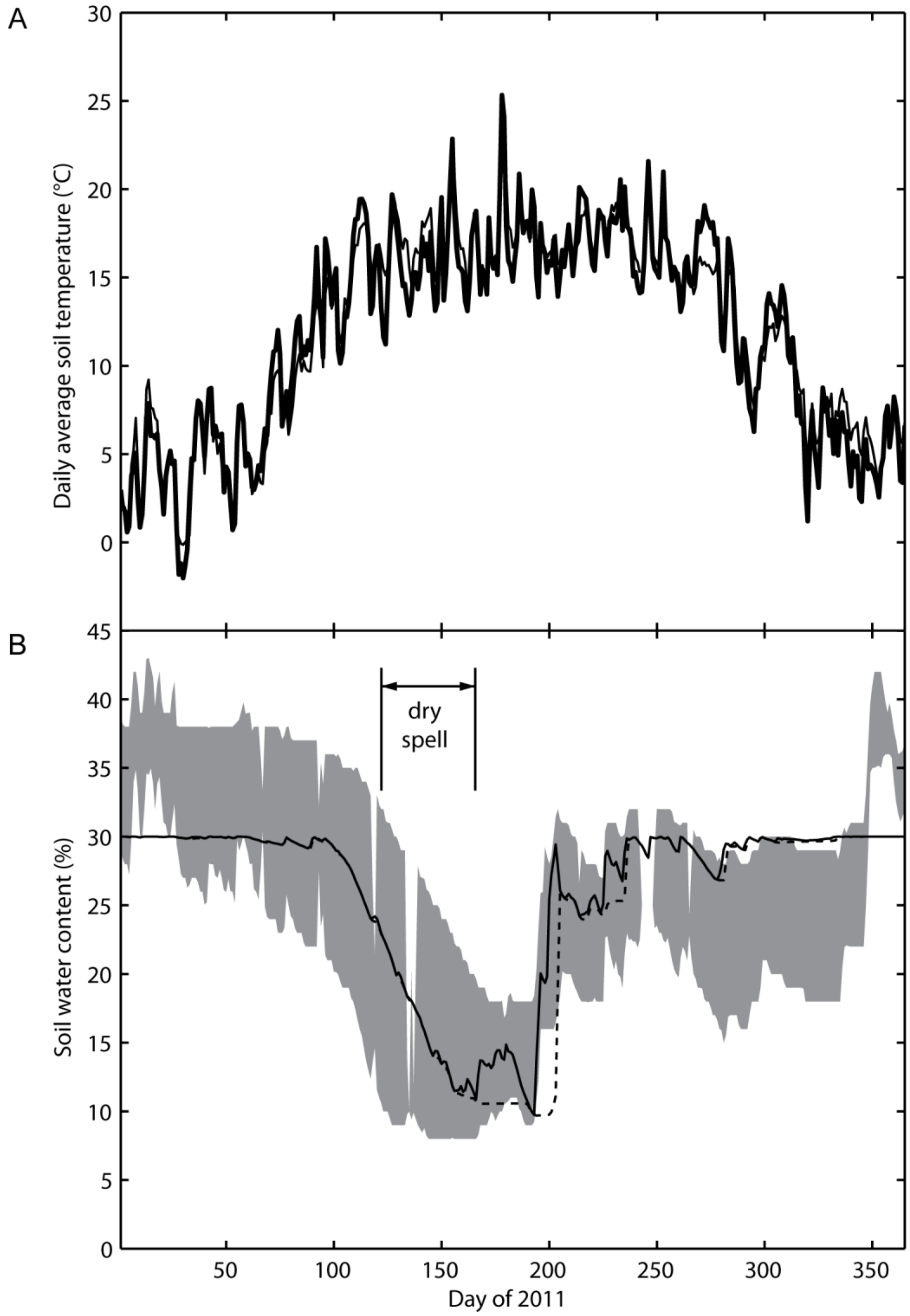

Fig. C: A comparison of modeled and measured soil state variables for 2011 at the POPFULL site. (A) shows the daily average soil temperature simulated (fat) and measured (thin). (B) shows the soil water content. The gray area represents the measured range of soil water content values for the top 50 cm of the soil. The dotted line is the soil water content of the lower water compartment of the model and the solid line is the total soil water content of the upper and lower water compartment.