**Interactive comment on "Modelling soil temperature and moisture and corresponding seasonality of photosynthesis and transpiration in a boreal spruce ecosystem" by S. H. Wu and P.-E. Jansson**

**S. H. Wu and P.-E. Jansson**

Thanks for your review and suggestions to improve the manuscript. We believe that you have raised very relevant questions and we are convinced that the paper is now substantially improved after accounting for the suggestions made. We do not want to advertise the model as our main message instead the procedure for how to calibrate and understanding the processes behind regulation of photosynthesis and transpiration is in focus.

*General comments*
*A bit more detail on the sites would be useful rather than referring to other studies. This is especially true when you describe growing season length of 160 days, but clearly this varies interannually and may be due to air or soil conditions you address.*

*AC*
*Yes the growing season as indicated from air temperature varies a lot between year but this is also because of uncertainty on how to apply the models for estimating growing season length. Statistics for the regions shows that we have general trend with an increase from 155 to 165 days for the period from 1960 to 2010 based on the statistics from SMHI. However we do not have specific valid information from the site Knottåsen since the measurements are too short at that specific site in a previous paper by Lindroth et al (2008) they noted that Knottåsen was similar as Flakaliden located more to the north. The climate conditions are also affected by relative high altitude.*

RC:
*Similarly, what is the relative cover and spatial orientation of dry, mesic, and moist conditions at your site – especially within tower footprint? Is this variability due to convergent flow? Does it add to your story if you discount it as contributing to tower response? Is it reasonable to discount these areas? What data can you show to help convince the reader that your assumptions are correct about footprint characteristics? The data that are published originates*

*AC:*
*We do not have precise data on the different distribution of the dry, mesic and moist for the continuous footprints that have been estimated for the flux measurements. The footprints show that the area is mainly dominated by dry and mesic but there is also moist areas in the nearby conditions to the mast. The footprint analysis published by Lindroth et al. 2008 shows that the majority of the fluxes are from relatively close area to the tower (around 100 m). The detailed map form Berggren et al 2004 shows*

*that also the moist plot area is close to the tower. In all directions from the tower we can assume that the footprint are a mixture of all type of moisture conditions. The transition from wet to moist is within 10 m. Our conclusions that the different flux directions could not be separated when comparing with a model assuming fixed conditions give support for the difficulties to try to account for the within footprint variability that obviously exist.*

RC
*Not clear how you deal with soil frost given the use of limited soil T data and an unclear, undefined soil water energy balance model.*

*AC*
*The uncertainties in the energy balance closure is not a problem for understanding this particular eddy flux data. However, by using our uncertainty based modeling approach we do not require any closure of the measured energy balance. Instead the model represents such a closure based on the conservation law. This means that we have an obvious good understanding of the energy balance in the model that is well described by the equations. This is also with respect to the frozen soil and snow melt conditions. When making the model calibration we are constraining our model performance on the measurements as they are and not by an assumption of consistence between the flux measurements. But of course our trust and confidence will increase when we have perfect measurements but that is never the case. Instead we believe that it is important to show what is possible based on the data that are available.*

*RC*
*The section describing performance indices seems to contain results and I wonder if it is misplaced.*
**AC**
This section describes the criteria (C1 and C2) use to constrain the model performance. No results is presented in this section. However, we do understand the reviewer point that this is part of the results since the threshold values obviously reflects the performance of the model when applied with the prior assumption of parameter ranges for the site.

RC
*Need to show that the EC data cover the range of conditions relative to the inferences drawn from model.*

*AC: The EC data obviously cover a wide range of soil conditions that may be larger or smaller than the range we have assumed in the simulated conditions. The prior assumptions with the simulated conditions was that they should be larger and then constrained by the measurements to be reduced to the actual conditions at the site.*

2

RC:

*Why add 2003 sensible heat without other energy balance terms? The ability to approximately close energy balance for a site is requisite for evaluating flux tower data.*

*AC: The basic assumption behind the uncertainty method to calibrate the model is that measurements are with errors. We can demonstrate to what extent a multi criteria will change the results in terms of obtained parameter values. We do not need a full energy balance we need to find out if the data that are available can support or contradict our understanding of how transpiration and photosynthesis are regulated according to the model. Of course also the model is wrong but our interest is in the combination*

RC:

*Specify how met data gaps were filled – were they replaced or was a regression developed?*

*AC*

*This is now done. Note that the major data was data from site and we only used non-gap filled EC data to make the calibrations. We added this but it was made in a previous study which was the reason we did not include the details.*

*RC*

*It is unclear why use dry and moist soil data if the tower is mostly dry? What about mesic site? Can you learn anything from that data?*

*AC*

*The closest plots to the EC-tower with measured soil conditions are dry and moist. This will be clarified in the revised manuscript We have made assumptions on wider range of soil conditions in the model to test to what extent that is supported by the data from the tower and soil measurements. The mesic sites are intermediate plot that is within the range. From our understanding they could not contribute with new information on how the soil temperature can explain any additional behavior in the measured fluxes*

*RC*

*Given different soil moisture regimes and veg types it would be useful to quantify the contributing area to fluxes using footprint analysis to determine if the soil-veg combinations behave differently by using periods when one or another landscape type dominates footprint.*

**AC** Yes, we had considered that too. However, are present paper does not support that the data will allow for such a detailed method. The most important problems are that the variability of soil conditions and atmospheric conditions creates an obvious uncertainty that is to be combined with the uncertainty of the model and the

measurements as such. We believe that much longer period with more measurements are needed to clarify in higher details the direct connections between different soil and plant measurements (See experience from the study by Sihong et al 2012, using 12 years of continuous data from EC measurements).

RC

*How do you evaluate spatial variability in soil physical properties in the model if you only have one observation in each dry and moist soil plots?*

*AC*

*The spatial variability in the model is understood from the continuous variability assumed in the selected parameters for the prior Monte Carlo simulations. This means that all conditions are evaluated from the very dry to moist and from warm to cold. We selected some parameters that represented the expected spatial variability of the real environment. Each single simulation is only representing one single representative homogeneous spot in the environment. That is the reason model outputs are compared with single measurements from the various spots in the environment around the flux tower. Our assumptions are that the single observations are best compared by single realization of the model. However, the ensemble of the simulations like the ensemble of the measurements represents the general behavior of the ecosystem.*

RC

*Why are soils 11.3 m and 20 layers? Doesn't this go beyond GW depth? Do these trees access GW? If so how does one partition plant water use between vadose and GW?*

*AC*

*The model represent 20 layers down to 11.3 m to make best assumption on the lower boundary conditions in this environment. The saturated ground water conditions are represented as a continuation of the unsaturated conditions. The water uptake is assumed to depend both on the dry and the wet range (see eq 16).*

*RC*

*Why is growing season defined as 5C? is this reasonable and realistic? I've seen a number of papers and presentations that suggest C uptake begins as soon as liquid water hits soil and temps are near 0C.*

*AC*

*Yes we agree with you that the 5 C is not realistic for the limit to the functionality of the plant. However, in the model the temperature sum is used to give the transfer from the winter to the growing season only as a continuous scaling. Also during the winter we have a capacity for both transpiration and photosynthesis. The threshold value vas however not selected for calibration since we instead used the temperature sum to make a scaling of the acclimation to the air temperature conditions. We used this choice mostly to make the language to corresponds with the normal literature. (see eq.*

*5) and corresponding parameters. However, we have calibrated the parameters that creates the dynamic and the level of the transition.*

*RC:*
*With only one plot each of dry and moist how do you assess spatial variability?*
**AC:**
**Note that we used also all the indivual measurements and that we hade 6 replicates of soil temperature within the plots.**

RC
*Need to separate spring vs growing season – the initiation of uptake vs seasonal uptake– the title suggests a focus on initiation but the paper blurs the two.*
**AC**
**The spring is a continuous transition from the winter dormant conditions during with a lower level of activity on both photosynthesis and transpiration. (See parameter in eq 6.**
RC
*I don't understand how total ecosystem biomass can be simulated with only a few years of data. This needs to be explained more clearly.*
*AC*
*The total ecosystem biomass simulations are established and based on the previous simulation study of Berggren et al 2008. In that study forest inventory that detailed survey of the plant biomass was made and reconstructed after the establishment of the forest in the area. Our starting conditions was based on those simulations.*

***Minor comments***
*RC*
*Page 6420 Word missing on line 12-13*
**AC**
It looks ok.
RC
*Page 6422 line 14 – here and elsewhere please be specific and say what direction and how small the change was, rather than saying only "small change".*
*AC:*
*We agree and will change the formulation. Note however that small changes were used to indicate that we could not say that the forest soil was changing. However the the data from measurements indicated a major source from the soil. The uncertainties are however big in relation to the size of the soil carbon pool*

RC
*6423 line 16-17 what is meant by high and low resolution data?*

**AC:** The major distinguish between high and low resolution data is different time

resolution. However we have changed the formulation in the new manuscript to avoid the confusion.

RC

*Page 6428 first paragraph – be consistent with plural and tense when describing climate– should be past tense and plural.*

**AC**

  Done as suggested.

RC

*Figure legends and figures in general are too small.*

**AC:**

**Adjusted the font of figures as suggested.**

*In general, sentences like "The seasonal patterns of global radiation, air temperature and precipitation during 2001–2003 are shown in Fig. 1" do not add information to the text, but rather distract the reader and ask them to look at a figure without saying why. The next sentence describes what they will see in the figure and you could add (figure reference) at the end of this sentence. This shortens the text and focuses the reader.*

**AC:**

**Yes we agree Thanks**