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Interactive Comment

Interactive comment on "Assessing seasonality of boreal coniferous forest CO₂ exchange by estimating biochemical model parameters from micrometeorological flux observations" by T. Thum et al.

T. Thum et al.

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We thank you for throughout reading of the manuscript and these comments that have greatly helped us to improve the manuscript.

Specific comments:

The aspect that our results are inline with the average behavior of the model parameters as in study of Kattge and Knorr (2007) and review by Hikosaka (2006) contrasting the earlier leaf level measurements in Finland (Aalto, 1998; Wang, 1996) is now brought up in our discussion.



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Focus: We rephrased the title to better match the content of the manuscript. It is now *Assessing seasonality of biochemical CO2 exchange model parameters from micrometeorological flux observations at boreal coniferous forest*. We did a model run to see, if seasonally varying LAI would have a large effect on our results. Parts of the manuscript were omitted. The section *Different ways to estimate Jmax* was omitted as suggested and also *Effect of climate warming and seasonality in the simulation experiments* was left out. We also shortened section 3.2.

Accuracy of formulation: We changed the standard temperature in Eq. 5 to 17 C, as was suggested. In Table 2 (former Table 1) we also give values of the parameters also at 20 C and 25 C. The parameters at the reference temperature are now denoted as Jmax,std and Vcmax,std as suggested. In Table 3 where literature values of the parameters are shown, also the corresponding temperatures are given.

In Fig. 2 instead of the daily values of the inverted parameters, the difference between late morning inversion value and the late morning fitted temperature response value is given. This difference is shown, since it was not feasible to do a fitting for as short time period as one day due to the scarcity of points. Therefore standardized value at 17 C could not be presented here as was suggested.

The Farquhar model parameters are influenced in our inversion by several factors that are difficult to exclude. We included a paragraph about this topic in the Discussion-section.

Method of flux partitioning:

1) Chamber measurements on needle respiration were done throughout spring 2002 to summer at Sodankylä. According to these measurements the respiration remains exponential to as high temperatures as 30 C, that was the uppermost measurement temperature. In 2001 the highest summer-time temperature at Sodankylä was 24 C, thus implicating that exponential temperature dependency of needle respiration is still valid in these temperatures. The temperature dependency of needle respiration did

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not change during our measurement period, therefore we expect that carbohydrates are not limiting respiration and using exponential needle respiration is justified.

2) This is certainly true, air temperature is not the best proxy to describe respiration during spring. Due to gaps in the soil temperature data in other sites than Hyytiälä we decided to use only air temperature. These results were quite good. There are some days for e.g. at Sodankylä, where doing snow melt the use of soil temperature could be better. Making the same kind of temperature response function for respiration as Markkanen et al. (2001) did for Hyytiälä is difficult for sites like Sodankylä and Norunda, where there are some very high respiration values after midsummer. However, air temperature explains often the variance in the ecosystem respiration than soil temperature and soil temperature measured at 5-10 cm depth does not represent soil respiration taking place in the most uppermost layer (Reichstein et al., 2005).

These two issues are now addressed in the Discussion section.

Interpretation of inverted values of Vcmax and Jmax:

Different processes on canopy scale

There are several factors influencing the biochemical parameters at the canopy scale that were not taken into account in the manuscript. We studied the effect of drought, seasonally varying LAI and night frosts.

We implemented drought effect into the model by using a coefficient in the stomatal conductance function, as was earlier done by Thum et al. (2007). At Sodankylä in 2001 the effect of drought was small.

To study LAI, we used needle biomass turnover rate from literature (Muukkonen, 2005) and our observations of the needle dynamics. We re-parameterized the model, but the effect on annual GPP and functioning of the model was small, as seen in Table 4. The needle biomass turnover rate at Hyytiälä is higher, but we did not perform this calculation for Hyytiälä. There are some deciduous trees at the site and they are

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difficult to quantify.

We made effort to take the night frosts into account, but this was not as straightforward. We looked, if we could make a separate fit for the inversed parameter values following night frosts (*frost* values) and the other values during spring time at Sodankylä. We used years 2001-2005. This was not successful, since all the values appeared to be in same level in the temperature response. However, there were smaller values in the *frost* points, when this was assessed via mean values. This is the same effect as seen in Fig. 2. We implemented the night frost effect in the model to see how large influence it has. Effect on the annual GPP was small.

Interpretation of the results

We agree, that in summer the correlation between temperature and Vcmax and Jmax might include in addition to temperature dependencies of the parameters also the varying photosynthetic capacity. In spring the correlation might be due to varying photosynthetic capacity changing during the dehardening process. Our fitting periods were so long that we were not able to separate changes in photosynthetic capacity and the temperature dependencies.

We investigated the temperature dependencies by looking separately at the base rate and the activation energy. When the base rate was kept fixed throughout the year and the activation energy was fitted, the activation energy of Vcmax had variability of 34

To further study the spring recovery we could use data from Sodankylä. The number of the inversed points could be increased by adding latent heat flux to the optimization process so that the afternoon points could also be used. At Sodankylä measurements of mamimum photochemical efficiency Fv/Fm by chlorophyll fluorescence measurements have been done since spring 2001. We could study how Fv/Fm and photosynthetic capacity Jmax,std and Vcmax,std behave related to each other in our long measurement series. Using this method we might be able to separate whether the connection is between Jmax,std, Vcmax,std and air temperature or if the parameters temperature

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dependencies are involved.

These points are now added to the Discussion and Conclusions.

In plots shown in Fig. 1 the fits are not anymore extrapolated to the temperature range of the plot, as suggested.

Minor comments:

-Materials and Methods section has been shortened and subtitles have been added.

-Table 1 with characterization of sites has been added.

-Table 2 has been removed.

-Fig 5-8: Only one of these figures is now shown and we give the difference between the value given by the temperature response of the parameters and the inverted value.

-Figure 9 has been removed.

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