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Comment

***Interactive comment on “Modelling basin-wide variations in Amazon forest productivity – Part 1: Model calibration, evaluation and upscaling functions for canopy photosynthesis” by L. M. Mercado et al.***

**L. M. Mercado et al.**

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Response to specific comments from Referee 1.

Thank you very much for your comments.

1. Comment

Some of the justification of this study in the introduction refers to uncertainty in the response of the Amazon rainforests to climate change (e.g. Cox et al 2000). I think it needs to be acknowledged that the main drivers of long term changes in this system are likely to be different from those that control interannual variability or season cycles.

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One must be cautious about overstating the value for long term predictions. Better understanding and modeling of the seasonal cycle does not guarantee improvement in our understanding and in predictions of long term trends.

#### Answer

The main goal of this study was to validate and evaluate a 'sun and shade' type of approach to model photosynthesis of the rainforest at different sites and seasons. In addition to the model evaluation, model parameterisation at different sites can give information on whether or not there is a need to vary photosynthetic capacity among rainforest locations. Our results show that 1) the 'sun and shade approach' can represent a realistic canopy photosynthetic response to light and diurnal cycle but also, 2) there seems to be variability of canopy photosynthetic capacity among sites. Furthermore, our study suggests the possibility of rainforest with high leaf phosphorus, having a higher canopy photosynthetic capacity ( $V_{max}$ ) which might imply a gradient of GPP across Amazonia with higher GPP where leaf P is highest.

The land surface scheme used in the Cox et al. (2000) study had a simple Beer's law and big leaf approach to scale leaf level photosynthesis to the canopy level. It has been shown that , the land surface scheme of the Cox et al. (2000) study does not validate well against observations of carbon uptake and such a land surface scheme needed improvement of their light interception and scaling up of photosynthesis from leaf to canopy level, as documented in Mercado et al. (2007). This is mainly because using Beer's law for radiation interception and the big leaf approach to scale from leaf to canopy level, most of the canopy photosynthesis is light saturated already at very low values of radiation. This model behaviour not only produces the wrong light response but also it produces a very flat diurnal cycle of photosynthesis (Figs 3ab in Mercado et al. 2007). To improve such a model, both radiation interception and scaling up of photosynthesis needs improvement. In this study we show that the 'sun and shade' approach validates well for the rainforest. Moreover, the land surface scheme used in Cox et al (2000) uses 5 plant functional types to represent land vegetation, with the

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rainforest represented with a single broad leaf type. If photosynthetic capacity across the rainforest varies, a single PFT for the whole rainforest would not be appropriate. In this study we propose that if P limits tropical forest photosynthesis across Amazonia, there might be a gradient in canopy photosynthetic capacity across the Amazon. In summary, we consider that results obtained from this study can indeed inform land surface schemes which are embedded in Global Circulation Models which aim at global and future simulations.

## 2. Comment

As often happens in this interdisciplinary field sign conventions get mixed up. Comparing equ 1 and 2 with 4 and 5, the signs are wrong in the former pair.

Answer

The referee is right. Equations 1 and 2 have been corrected so that  $GP = -NE + RE$

## 3. Comment

Page 2975, last paragraph mentions a number of criteria that were used to select measurement data. What fraction of the data were finally used at each site?

Answer

We used data only from the end of the rainy season following the criteria explained in the text.

## 4. Comment

Page 2979, last sentence says the model did well in all seasons except one. There were only 3 seasons. A more informative statement would be - well simulated in the two dry seasons but not in the wet season.

Answer

Done

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## 5. Comment

Regarding Figure 2: I would expect that when  $PAR=0$  then  $G_p$  should intersect at  $G_p=-R_c$  and  $G_p^*$  should intersect at  $G_p^*=0$ . The fact that they do not implies a positive bias in  $G_p$  and  $G_p^*$  measurements since it is impossible for photosynthesis to occur at  $PAR=0$ . Some discussion of this should be integrated into the text.

### Answer

The referee is right, i.e. when  $PAR=0$   $G_p$  should intersect at  $G_p=-R_c$  and  $G_p^*$  should intersect at  $G_p^*=0$  and this happens for both, model and measurements, but this is not shown in the plots. This is because for the purpose of model evaluation, as shown in Figure 3, we used data that was usually after 0800 or sometimes after 0900 to avoid the conditions where the storage flux was lower than an absolute value of  $10 \text{ } \mu\text{mol m}^{-2} \text{ s}^{-1}$ . In this way the model evaluation avoids the morning flush of  $\text{CO}_2$  that accumulates in the canopy during night time conditions. Therefore, the values corresponding to low  $PAR$  values are not shown in any of the plots for the aforementioned reason.

## 6. Comment

Also for this Figure the distinction between  $G_p$  (First 3 sites) and  $G_p^*$  (last 2) is not indicated the axis labels and there are no titles on the Tapajos graphs. In my pdf copy of the Figure it is impossible to distinguish the symbols representing observations and simulations but they are distinguished by line shade (grey versus black).

### Answer

Done

## 7. Comment

I think the authors should also address the apparent discrepancy between the lower  $G_p^*$  at Tapajos during the dry season and the Saleska et al 03 conclusion that  $G_p^*$  is relatively high in the dry

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Answer

Saleska et al. 2003 shows that the seasonal variation of NEE is mostly driven by the strong response of respiration to precipitation, with a weak response of GP\* as shown in figure 2b of their paper. From this figure, GP\* is slightly larger during the wet season months than during the dry season months. Eddy correlation data (only year 2002, as suggested by Saleska) used on this study is the same data used in the Saleska study. Notice in figures 2 and 3 (bottom row) of this study, that observations also show slightly lower carbon uptake during the dry season compared to the wet season. In summary there is no discrepancy between studies.

In any case, as mentioned in the response to comment 1) the main point of this study is not seasonal variations of carbon uptake in the Amazon rainforest, it is more a model calibration, validation exercise (for all seasons) where canopy photosynthetic parameters are derived for the sites studied.

#### 8. Comment

Page 2984 First paragraph: the wrong citation is used here, it should be Collatz et al 91 not 90. The correct citation is given in Table 10 but that reference is not listed in the reference section. The Collatz et al 90 citation on page 2986 is correct.

Answer

The referee is right. We have corrected the citation on the first paragraph of page 2984 and added the citation to the reference list.

#### 9. Comment

Page 2988 first paragraph and elsewhere in the paper the biases in the estimation of respiration from observations are discussed. I think the analysis recently published by van Gorsel et al 07 and 08 are relevant here as well.

Answer

**BGD**

6, S1121–S1127, 2009

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This is a very useful reference. We added the following paragraph to our discussion on ecosystem respiration

An alternative method to refine estimates of Ecosystem respiration using eddy correlation measurements (Van Gorsel et al. 2007, 2008) is yet to be tested for the Amazon rainforest sites. The method uses the maximum of the sum of the turbulent flux and storage flux of CO<sub>2</sub> in the early evening, and has been shown to be in close agreement with measurements from soil and plant respiration chambers at a moderately complex topography. Such a maximum, which is unaffected by advection (Van Gorsel et al. 2008) due to stable stratification conditions after sunset, is used to construct relationships between night time ecosystem exchange measurements and soil temperature and humidity which then can be used to predict ecosystem respiration at all times of day.'

10. Comment

Appendix A equation A6: define f

Answer

Done.

11. Comment

Discussion of stomatal conductance equation A11: 'lambda parameter".is a Lagrangian multiplier representing the marginal benefit of plant carbon gain relative to the cost of water loss. I see it as the reciprocal of that, it is the marginal water cost per carbon gain. Confusion would be less if in the definition of the term the units were expressed as mol H<sub>2</sub>O/mol CO<sub>2</sub> rather than just mol/mol.

Answer

Done as suggested

12. Comment

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Finally, it is too bad that the authors did not use the full record of multiple years at Tapajos to evaluate interannual variability. This would have provided new important information to the analysis.

### Answer

We agree with the referee, the available multiyear eddy correlation data and meteorological variables are valuable data for model evaluation that could be used in future studies. The main goal of our study was to evaluate the sun and shade model at different sites. At the time the study was initiated, only years 2001 and 2002 were available at Tapajos and as suggested by the investigators providing the Tapajos data, only data for 2002 was used for the analysis because there were issues with the 2001 data.

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