Response to the Reviewer's comments

Simulation of Surface Fluxes in Two Distinct Environments along aTopographic Gradient in a Central Amazonian Forest using the INtegrated LAND Surface Model" by Broedel et al. (2017).

NOTE:

The authors would like to thank the reviewer for their constructive comments that have shaped the discussion and focus of our revised manuscript. Detailed point-to-point answers to the reviewer comments and sections of the revised text associated with those comments are discussed below.

Reviewers' original comments are highlighted in yellow.

Text from the revised manuscript is in bold font.

Major comments

1-The objective of the study was described as (L 106-109)

"The main objective of the present work was to determine and characterize the necessary components (including soil, vegetation and hydraulic) of the Integrated Land Surface (INLAND) model to simulate the plateau and valley environments in a primary forest in the central Amazon."

The hypothesis of the study was described as (L 110-113)

"We hypothesized that the model would simulate the differences in fluxes between the plateaus and valleys because the energy exchange dynamics of these ecosystems are different due to the large diversity in their surface characteristics."

When would the model simulate the differences well? After the inclusion of "necessary components" to simulate plateau and valley environments? Are you hypothesizing that after improving soil and vegetation, the INLAND model would show improved reproduction of land surface mass and energy fluxes? This is hypothesis is not intriguing enough in my opinion as the scope is too narrow. I would strongly suggest reformulating the hypothesis and merging it with the main objective of the study to make it more interesting for the broad readership of HESS (something along this line):

"We hypothesize that to capture the variability of land surface processes at the plateaus and valleys, explicit represent of soil and vegetation parameters in numerical simulations is necessary

In response to the reviewer, the text was rephrased to:

We hypothesize that to capture the differences in land surface processes at the plateaus and valleys in a local scale, explicit representation of soil, vegetation and hydrological processes is needed. Since valley areas are dominated by shallow water tables, vertical ecosystem fluxes and horizontal hydrological fluxes are defined by this contrasting condition.

2. The authors made a commendable effort of incorporating groundwater dynamics in the model. However, the effect of representing subsurface hydrodynamics is completely ignored in the hypothesis. The conclusions section reports (L1002-1004):

"To better represent their characteristics, an adjustment of vegetation and soil parameters and the development of a lumped unconfined aquifer model was required to account for the water table dynamics in the valley area."

In response to the reviewer, we included the groundwater dynamics in the hypothesis:

We hypothesize that to capture the differences in land surface processes at the plateaus and valleys in a local scale, explicit representation of soil, vegetation and hydrological processes is needed. Since valley areas are dominated by shallow water tables, vertical ecosystem fluxes and horizontal hydrological fluxes are defined by this contrasting condition.

How does the "lumped unconfined aquifer model" improve the simulated differences in the plateaus and valleys? This point is not clear to me from the discussions presented in the results section.

In response to the reviewer, a new paragraph was added to the "*Water balance on the plateau and in the valley*" on page 20:

The lumped unconfined aquifer component was essential to represent the ET in the valley because this environment is close to saturation most part of time (Figure 5a). In Central Amazonia, it is well documented that soils are usually related to local altitude (Chauvel et al., 1987) and that forest types are defined by topography and soil which affects species composition forest dynamics, and physiological constraints (Castilho et al. 2006). In the valley areas, dominated by poorly drained hydromorphic sandy soils morphological structures, species are adapted to the conditions of episodic hypoxia as indicated by the presence of adventitious and many surface roots (Brito, 2010). Episodic hypoxic condition in these soils, and consequently to the root system, may induce a decrease in stomatal conductance and in the photosynthetic rate, limiting plant growth (Pezheshki 2001; Li et al., 2007).

3. The abstract should be re-written. Currently, this section does not reflect the objective (the central hypothesis) of the work.

In response to the reviewer, the abstract was rephrased to:

On Amazon Terra Firme forest, in a much finer (local) scale, the landscape heterogeneity resulting from topographical variability exerts significant influence in a structure and diversity patterns of vegetation, soil composition and hydrological flows, through a number of highly nonlinear processes. The main objective of the present work was to determine and characterize the necessary components (including soil, vegetation and hydraulic) of the Integrated Land Surface (INLAND) model (offline mode) to simulate two very distinct environments located in a typical Terra Firme forest in the central Amazon: plateau and valley. We hypothesize that to capture these differences in land surface processes at both areas in a local scale, explicit representation of soil, vegetation and hydrological processes is needed. Since valley areas are dominated by shallow water tables, vertical ecosystem fluxes and horizontal hydrological fluxes are defined by this contrasting condition. The results showed that after include a lumped unconfined aquifer model in the INLAND model to represent the water table dynamics in valley area and adjust the soil and vegetation parameters both area, the model was able to characterize with good accuracy the main differences that appear in the seasonal energy and carbon partitioning of plateau and valley fluxes, which are related to features of the vegetation associated with soils and topography. The simulated latent heat flux (LE) and net ecosystem exchange of carbon (NEE), for example, are higher on the plateau area while at the bottom of the valley the sensible heat flux (H) is noticeably higher than at the plateau, in agreement with observed data. Differences in simulated hydrological fluxes are also linked to the

topography, showing a higher surface runoff (R) and lower evapotranspiration (ET) in the valley area. The different behavior of the surface fluxes on both annual and diurnal time scales confirms our initial hypothesis and suggesting the importance to incorporate subgrid-scale variability by including relief attributes of topography, soil and vegetation to better representing Terra Firme forests in land surface models.

Minor comments

1-L 476-478: "The INLAND model simulated very well the difference of ET fluxes between plateau and valley …"

This is not what I see in Figure 7a. The model predicted differences in LE over plateau and valley throughout the whole year. However, the observations show differences only during dry periods (which is more intuitive). What is the reason of these discrepancies?

In response to the reviewer, the text was rephrased to:

The INLAND model is able to predict the differences in ET between the plateau and valley, specifically, higher values of ET in the plateau compared to the valley (Figure 7a). The lumped unconfined aquifer component was essential to represent the ET in the valley because this environment is close to saturation most part of time (Figure 5a). In Central Amazonia, it is well documented that soils are usually related to local altitude (Chauvel et al., 1987) and that forest types are defined by topography and soil which affects species composition forest dynamics, and physiological constraints (Castilho et al. 2006). In the valley areas, dominated by poorly drained hydromorphic sandy soils morphological structures, species are adapted to the conditions of episodic hypoxia as indicated by the presence of adventitious and many surface roots (Brito, 2010). Episodic hypoxic condition in these soils, and consequently to the root system, may induce a decrease in stomatal conductance and in the photosynthetic rate, limiting plant growth (Pezheshki 2001; Li et al., 2007). However, in terms of magnitude of ET, INLAND simulated fluxes are higher than observations. A likely explanation for these discrepancies could be related to the lack of closure of the energy balance, a well-recognized problem of the eddy covariance method (Massman et al., 2002; Aubinet et al., 2002) that has already been reported by other studies in Amazonia (Malhi et al., 2002; Von Randow et al., 2004; Rocha et al., 2004; Wilson et al., 2002). Our analyses, for example, (not shown) revealed that on average, latent and sensible heat fluxes fell 17% short of the available energy in the plateau area, while for the valley the figure was 23%, which indicates that in both areas the energy balance did not close. In addition, a recent study of Martínez-Cob and Suvocarev (2015) showed that LE obtained with the infrared gas analyzer (IRGA-LI-COR, model LI-7500), the same instrument used in this study, is not reliable during rainy periods due to failure of the instruments caused by water drops standing over the sensors heads. Therefore, potential interference of rainfall can also be responsible for underestimation of LE in the study area, in both plateau and valley.

2-L 553-554: "The surface runoff (R) simulated by INLAND on both areas was reproduced relatively well by INLAND during the period from 2002 to 2006." Model results cannot be validated without measurements from the plateau region (Figure 7b)

In response to the reviewer, the text was rephrased to:

The INLAND model predicted differences in surface runoff (R) between plateau and valley during the period from 2002 to 2006, showing larger values in the valley throughout the whole year (Figure 7b). Although the observed data are not available for each area separately, previous studies showed that surface runoff in the Asu catchment is negligible in plateau areas and that the main mechanism of runoff generation is saturation overland flow (Tomasella et al., 2008). Since the

observed surface runoff derived from stream discharge aggregates plateau and valley areas contributions, we estimated simulated R by weighting the fluxes of plateau and valley by 0.57 and 0.43 respectively. These values correspond to the fraction of each environment in the Asu catchment (Rennó et al, 2008). Although the INLAND model showed a good performance to reproduce the total R (Figure 7b), the observed values were overestimated by the model during wet season (bias= 0.4 mm day^{-1}), mainly in the first months of year when the precipitation is higher, and underestimated in the dry season (bias= -0.3 mm day^{-1}) (Table 5). In addition, during the wet season the RMSE was 0.6 mm day^{-1} and R^2 of 0.60. In the dry season, a reduction in the value of R^2 (0.53) can be observed, indicating a lower correspondence between simulated and observed R data in the valley, while RMSE also exhibited a reduction dropping to 0.3 mm day^{-1}. The simulated R represented an average value of 3.9% of total precipitation, during 2002 to 2006, in the plateau area. This value is in agreement with other studies in different regions of the Amazon (Leopoldo et al., 1995; Germer et al., 2009; Moraes et al., 2006). On the other hand, in the valley area, the R simulated by INLAND represented a higher fraction of precipitation when compared to plateau, about 25.3%. Furthermore, the INLAND model was able to predict the seasonal variability of R rates (Figure 7b): higher simulated values of R were verified during wet season (plateau = 0.4 mm day^{-1}, valley = 2.7 mm day^{-1}); while in the dry season those values dropped to 0.1 mm day^{-1} in the plateau and 0.4 mm day^{-1}) in the valley. The sensibility of INLAND model to precipitation can also be noticed during dry season: a peak of R occurred during September in both areas (valley = 0.62 mm day^{-1}; plateau =0.23 mm day^{-1}), in response to an increase precipitation (154.9 mm). The higher simulated R value in the valley area is due to the shallow water table in the prone to saturation valley areas, which are likely to produce surface runoff by saturation overland flow.

3. Figure 5b: please revise the xlabel (set, mai etc).

In response to the reviewer, the Figure 5b was revised

4. Figure 9: Missing xlabel.

In response to the reviewer, the Figure 9 was revised