Reply to Referee #1

In blue we copied the comments of the referee, in black our reply.

Major Comments

The present manuscript entitled "Contribution of understory evaporation in a tropical wet forest" to estimate the total evaporation flux and differentiate the contribution among canopy layers of a tropical wet forest in Costa Rica. The authors found distinct water fluxes through the vertical canopy gradient, along with different plants using water from different sources. The manuscript is really well written and the sampling was quite robust (sensors and plot sizes), and the data collected will serve as hydrological data that can be input into TBMs.

However, I have three major issues that I would appreciate the authors tackling/explaining before this paper is published in this present journal or elsewhere:

- There needs to be an explanation to why measurements were only done for 2 months and only in the dry season. Considering that most of the year is the wet season (ie., canopies are mostly wet), why choose only the dry season (an outlier in comparison to the rest of the year)?

Reply:

The authors do not consider the dry season as an outlier. Instead, this is important because most of the focus on evaporation studies in the tropics is on a yearly basis and do not look closer to the dry season period (Baldocchi *et al.*, 2011, Loescher *et al.,* 2005). Also, with fewer rains during the dry season it is possible to provide a clearer view of the evaporation process of the understory thanks to the larger vapor pressure deficit. Also, the water availability during the wet season does not limit the forest evaporation which depends mostly on the available energy along the canopy gradient (Hogan and Kattan, 2002, Loescher*et al.,* 2005). Contrary to the wet season, the dry season experiences a strong reduction on the precipitation rates triggering physiological responses on the trees. One of these responses is the increment of literfall (Peters, 2016; Raich, 2017), which at La Selva depends on wind and precipitation. This temporal drop of leaves during dry season allows the creation of a thinner canopy layer respect to the canopy in the wet season, which can alter the transpiration of understory species such as *Geonoma cuneate* or *Piper arieianum* which exploit the most shaded microsites at La Selva (Chazdon, 1986,1992).

Accordingly, the authors proposed to add the following text on the second paragraph of the introduction. This will underline the importance of performing detailed measurements during the dry season:

"… water (Aparecido et al., 2016). Differences in forest evaporation between wet and dry seasons depend on energy and water availability, respectively. Water availability during the wet season does not limit the forest evaporation which depends mostly on the available energy along the canopy gradient (Hogan and Kattan, 2002, Loescher *et al.,* 2005). Contrary to the wet season, the dry season experiences a strong reduction on the precipitation rates triggering physiological responses on the trees. One of these responses is the increment of literfall (Peters, 2016; Raich, 2017), which depends on precipitation and wind conditions. This temporal drop of leaves during dry season allows the creation of a thinner canopy layer respect to the canopy in the wet season, which can alter the transpiration of understory species such as *Geonoma cuneata* H. Wendl. ex Spruce or *Piper arieianum* C.DC. which exploit the most shaded microsites at La Selva (Chazdon, 1986,1992). Thus most of the total …”

- This study has a striking resemblance to Loescher et al. (2003 - "Energy dynamics and modeled evapotranspiration from a wet tropical forest in Costa Rica") paper, which also discussed canopy partitioning of water fluxes and conducted at the La Selva Research Station (like the present study). Your study is only set apart from Loescher’s due to the isotope tracing portion/water source, and that Loescher’s paper modeled ET. I suggest there being a bolder statement in the introduction stating why your study is unique and important (or adds to) in comparison to Loescher’s.

Reply:

It is true that the experimental setup is quite similar to Loescher’s paper, having some differences in terms of instrumentation along the canopy gradient. However, the main differences are:

1) Loescher’s paper is based in a plot located in a hilly section of La Selva Biological Station over andesitics lavas meanwhile this manuscript is based in a plot located in an alluvial terrace of the Puerto Viejo river. Despite both works are carried out within the same life zone (Tropical Wet Forest) according to Holdridge (1967), the specific conditions of both plots (e.g, hills vs lower terrace) may provide a different outcome.
2) It is true that the evaporation partitioning carried out by Loescher’s includes below canopy evaporation. However, there is not a clear indication at which height is this evaporation taking place. They sampled at 6 different heights beneath 30 m but did not mention at which height the “below-canopy” estimations refer to. Contrary, our manuscript states that the estimation of evaporation is performed at three specific heights (2 m, 8 m and 43 m) providing the estimations for each of them during the dry season period.
3) Loescher’s paper focused overall on the yearly evaporation given little attention to the dry season fluxes. Here, we want to fill in the gap through a detailed sampling during the dry season.

- Still related to the previous topic, your objectives should state your main questions/hypotheses much clearer. I felt like the findings were more descriptive than it was answering any question. Why not include an objectives to differentiate different plant functional groups and why their possible water source might be relevant to hydrological studies. Example: if there are more palms, and palms use more rain water; thus, if precipitation is limited in the future, would that affect palm distribution/growth/dispersal?

Reply:

The authors agreed with the reviewer's point that manuscript objectives should be better defined. However, the aim of this manuscript is to analyze the partitioning of evaporation by forest structure focusing in the differentiation of understory and overstory layers and not about the functional type of plants. The inclusion of different plant types in this manuscript was to understand better the structure of the forest and not individual roles of plant types.

Following the reviewer's recommendation, we broaden the description of the objective to be clearer about the research question. Consequently, we propose to modify the last paragraph of the introduction as follows:

"…of total evaporation (Ehleringer and Dawson, 1992). Most of the evaporation studies in the tropics focus on yearly patterns (Baldocchi et al., 2011, Calder et al., 1986, da Rocha et al., 2009, Loescher et al., 2005, Schellekens et al., 2000), the wet season (Read, 1968, Wright et al., 2017) or time windows of less than one day to study specific processes such as aerodynamic conductance (Holwerda et al., 2012). But few attempts deepening the knowledge of dry season evaporation has been found (Harper et al., 2014). Tropical forests are highly sensitive to water variability (Tan et al., 2013) and understory light availability (Brenes-Arguedas et al., 2011), which are the main factors defining the distribution of plant species. This because tree seedlings are prompted to use water dripping from the canopy by the condensation of convective fog during the dry season (Liu et al., 2010). Consequently, changes in the canopy conditions can modify the understory composition and with it the future forest evaporation. The aforementioned underlines the need to provide more information about the evaporation process during the dry season in tropical forests, as well as the role played by understory vegetation during forest evaporation. This work aims (1) to estimate the total evaporation flux during the dry season in a tropical wet forest, (2) to differentiate the contribution among canopy layers depending on their location with the canopy, (3) to define the contribution of plant transpiration to the dry season evaporation at forest level, and (4) describe the temporal dynamics of the stable isotope signatures during dry season. To study this, we made use of the energy balance to quantify the fluxes and stable water isotopes to trace the sources of water vapor."

I think this paper needs bolder statements and more impactful implications. You can see that the "conclusions" section is only a summary of the results, which in reality should be highlighting the importance of the findings being presented. In summary, it doesn't matter how well done the sampling and writing was, if the message is not clear enough (question and implications), and if there isn't a better acknowledgement and distinction of your work with other work done at La Selva.

Reply:

In the current version of the manuscript we referred to different works carried out at La Selva (e.g, Cadol *et al*. 2012, Dubayah *et al.2010*, Sánchez-Murillo 2013, Tang *et al. 2012*). It also includes the information from Loescher *et al.* (2005) that the reviewer compares to.

However, the authors agreed that the conclusions section should be reinforced and not only describe the results. Consequently, we propose to improve the conclusion section as follows:

"Forest evaporation during the monitoring period accounted for 55.9 % of the recorded precipitation. The evaporation did no experience an increment or diminution during the dry season, showing no water limitations for the evaporation process at stand level. The evaporation includes 11.7% originated from the intercepted water by plant surfaces, which modifies the isotope signature of the water before reaching the ground. The lower evaporation rates recorded (up to 2 mm d^{-1}) were linked to rainy conditions and despite this variability, the contribution of the upper and lower understory layers remains constant along the monitoring period (23.6 %). The main differences between lower and upper understory layers rely on the average contribution. The lower understory provides on average a 9.0% and the upper understory 15.0 % of the evaporation. The ample water availability did not affect the contribution of individual layers. The low variability of soil moisture during this dry season depicts a small contribution to evaporation from forest soil, a pattern that is supported by the lack of fractionated signature of stable water isotopes. The use of keeling plots to differentiate between transpiration and other sources of water vapor was affected by the highly similar signature of sources of water vapor, by the larger number of plant species and the high water concentration and variability. Evaporation processes during the dry season in Tropical wet forests are not restricted by water availability. However, understory plants and palm species can be affected during drought periods due to the reduction of superficial water availability triggered by a diminution of rains and/or changes in water dripping after fog events."

Please see my attached document for more minor comments.

Minor Comments:

Page 2, line 1: is more complex than aforementioned ecosystems. (savannas and boreal forests).

Reply:

Following the reviewer's recommendation the sentence was improved as follows:

"… However, in tropical regions the vegetation is more complex than the aforementioned ecosystems (savanna woodlands and boreal forests) and few data concerning the differentiation between understory and overstory is available."

Page 2, line 6: Aparecido et al. (2016) found similar results, even in a wetter tropical forest systems. https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.10960

Reply:

Thanks for the reference. We will include it to support this sentence.

Page 2, line 7: Not only that, but almost three times higher vapor pressure deficit that can induce transpiration as temperatures rise and moisture somewhat decreases, and soil moisture is not an issue.

Reply:

Thanks for the tip. We will include this extra information as follows:

"… radiation (Tymen et al., 2017) and almost three times higher vapor pressure deficit (Fetcher et al., 1985). These conditions can induce larger transpiration rates as consequence of the plant physiological response to rise in air temperature and vapor pressure deficit (Adelman et al., 2008; Hogg and Hurdle, 1997). "

Page 4, line 11: When and how long was the study period? It hasn't been introduced yet

Reply:

Aiming to clarify this item in the earlier in the manuscript, the following sentence will be introduced in the second paragraph of the Study Site Section:

"The monitoring period included the dry season of 2018 for 62 days between 2018-1-25 and 2018-3-26. The study was carried out at …"

Page 5, line 6: Oh, this is the sub-lot referred to in the figure. I would add a "(Figure 1)" here so it is more clear. At first, it didn't make sense to have a subplot but now I understand that that is for the hydrological measurements of the plot.

Reply:

Thanks for the recommendation; we will include it as follows:

"… them distributed within a sub plot of 200 m^2 (Figure 1) to estimate the bulk …"

Page 6, line 9: How many plants and species?

Reply:

Aiming to provide more insights about the number of species and samples, we will modify the sentence as follows:

"… for four types of plants: palms (17 samples from 5 species), trees (21 samples from 11 species), bushes (17 samples from 10 species), and lianas (12 samples from 5 species). The bark …"

Page 9, line 6: analyses or analysis?

Reply:

Thanks for the correction, it is "analysis".

Page 9, Line 6: I think data collection should come much sooner, as you already refer to "study period" before. I suggest separating data collection from analysis, and move data collection as the second methods sub-header or adding this information to the end of the first sub-header.

Reply:

Thanks for the suggestion. This will be moved to the first sub-header at the beginning of the second paragraph.

Page 9, line 7: Why not a longer period, or include wet season data? I think it would be interesting to explain that to the reader.

Reply:

As it was mentioned in the present reply in line 19, most of the evaporation studies of tropical ecosystems are focused in yearly patterns and do not deepen into the processes during the dry season.

Page 10, line 13: I suggest relocating this paragraph before the VPD paragraph, since Tair is a strong variable that drives VPD (since it is in the calculation). Also, it would be good to cite RH diurnal variability as well.

Reply:

Thanks for the advice. We will follow your recommendation of relocating the paragraph. Also, we will add the following description of the diurnal relative humidity and adding the data set in the Appendix F. The addition containing the relative humidity will be located after the VPD paragraph as follows:

"Daily variation of relative humidity along the canopy profile differs depending on the canopy height. During sunny days, the conditions at 43 m shows are the driest reaching a lower point of 45.2 % and only goes to 100 % during rainfall events. The average relative humidity at 43 m height is 80.9±14.3 %. At 8 m height the relative humidity has an average of 90.1±11.3 %with a driest point of 52.3 %. Close to the forest floor the relative humidity remains close to saturation even during sunny days. At 2 m height average is 97.2±4.8 % with a driest point of 71.0 % during the driest day."

Caption Figure 6: Why not use a nonlinear regression function?

Reply:

The linear fit showed in this figure does not correspond to the fitting of none of our samples. Instead, it is the Local Meteoric Water Line (LMWL) for La Selva Biological Station according to Sánchez-Murillo et al. (2013). The LMWL is defined as the linear relationship between δ^{18}O and δ^{2}H signatures of precipitation water in a specific geographical location (Rozanski *et al*. 2013) which became a standard procedure to describe the isotopic composition of precipitation waters. The deviations of LMWL respect to the Global Meteoric Water Line (GMWL) defined by Craig (1961) depict processes such as sub-cloud evaporation of rain, atmospheric remoistening by rainfall evaporation or conditions of snow formation as controls of the intercept and slopes of the LMWLs (Putman *et al*. 2019).

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