Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2019-213-AC4, 2019

Hydrology and Earth System Sciences Discussions
Open Access

HESSD

Interactive comment

Interactive comment on "Estimating water flux and evaporation losses using stable isotopes of soil water from irrigated agricultural crops in tropical humid regions" *by* Amani Mahindawansha et al.

Amani Mahindawansha et al.

amani.mahindawansha@umwelt.uni-giessen.de

Received and published: 27 September 2019

Dear reviewer,

We would like to thank you for the valuable feedback provided for our manuscript entitled, "Estimating water flux and evaporation losses using stable isotopes of soil water from irrigated agricultural crops in tropical humid regions". Your comments were very helpful to improve the manuscript.

Please find our point-by-point responses (starting with a '#') to the comments below.

We believe that the modifications based on the referees' comments have resulted in an

Printer-friendly version

Discussion paper

improved manuscript and hope that it is now suitable for consideration for publication as a research paper in Hydrology and Earth System Sciences. We look forward to hearing from you.

Best regards, On behalf of the authors, Amani Mahindawansha

Interactive comment on "Estimating water flux and evaporation losses using stable isotopes of soil water from irrigated agricultural crops in tropical humid regions" by Amani Mahindawansha et al. Anonymous Referee #2 Received and published: 30 July 2019 Review of Hydrology and Earth System Sciences Manuscript: hess-2019-213 Title: Estimating water flux and evaporation losses using stable isotopes of soil water from irrigated agricultural crops in tropical humid regions Authors: Amani Mahindawansha et al. This manuscript presents seasonal variations in the soil water isotopic profiles and the fraction of evaporation (FE) for different crops (wet rice, dry rice and maize) under flooded and non-flooded irrigation management practices. This topic is interesting for understanding water cycle and water conservation in agricultural fields. However, there are some issues within the manuscript that requires substantial interpretation and improvement. The following is my detailed comments.

(1) Abstract: Since only FE values were calculated and no water flux of evaporation were determined in this study, the second sentence (P.1,Lines 13-15) should be changed.

We agree with the reviewer regarding the water fluxes. In this respect, in the revised version of the manuscript, we changed the title and also the abstract accordingly following the recommendations.

Other evidences should be given to prove the occurrence of piston type matrix flow or preferential flow besides the isotopic data in the text (P.1, Lines 22-24).

The results we present here are based on isotopic profiles. From these results, we deduce the respective processes. As this text is part of the abstract, we do not see

how we should add further evidence. However, we had already included this in the discussion together with the evidence for fast mixing of irrigation water and groundwater in maize fields via cracks (Mahindawansha et al., 2018). “In maize fields at our study site, we observed that the groundwater isotopic compositions are strongly influenced by irrigation water suggesting the existence of fast flow conduits (Mahindawansha et al., 2018a). In addition, He et al. (2017) have observed leaching losses of water and nutrients in a lysimeter experiment in the same study site.” The pattern of homogeneity and variability of soil moisture can be used as an independent indicator support the interpretation. There is evidence for gravity driven, piston-type matrix flow in the literature based on soil water isotope profiles and chloride concertation (Baram et al., 2013). They also observed accumulation of salts in the deep vadose zone due to fast transport via cracks. We also point this out in the discussion section, where we underline the process understanding and how it was derived.

It is helpful to supplement important data in the abstract section to clarify the new findings of this study.

We agree with the reviewer and added the main results to the abstract.

(2) Introduction: Determination of the soil evaporation flux (E) and the fraction of E in ET (FE) have been widely studied using several methods and techniques for different irrigated crops (Liu et al., 2002; Kool et al., 2014; Sprenger et al., 2016; Zhou et al., 2016). The new scientific merits in this study are not very clearly clarified.

The merit of this study is quantifying the fraction of soil water evaporation in irrigated agricultural fields and taking into account the effect of different crop species and different irrigation and management practice at various growing stages. Additional references listed have been considered in the revised version of the introduction. To better account for previous work, we will include the following sentences: “The determination of soil evaporation and the fraction of evaporation in relation to total evapotranspiration have been widely studied using several methods for different crops. For example, Liu

et al. (2002) studied evapotranspiration from winter wheat and maize, using weighing lysimeters. Zhou et al. (2016) partitioned evaporation and transpiration fluxes for corn, soya bean, grassland and forests using flux tower measurements. Kool et al. (2014) applied different methods such as chamber, micro-lysimeter, and soil heat pulse to estimate the evaporation and used stable isotopes of water to separate evaporation from transpiration." We do not agree that the research gaps of current studies are not clearly stated. We would like to draw the attention to the end of the introduction where we already stated in first version of the manuscript: "None of the studies conducted so far have quantified the fraction of soil water evaporation in irrigated agricultural fields, while also taking into account the effect of crop species and various growing stages".

(3) Material and Methods: There are straw and non straw applications conducted for different treatments in the experiments (P.3,Lines 20-21). How does the straw application affect the seasonal variations in the FE for different irrigated crops?

We did not find a significant difference between the isotopic composition of soil water with or without straw application, and therefore pooled the results for each crop. One would have expected a stronger effect of straw application on evaporation. However, the straw was not applied as a typical mulch layer to reduce evaporation, but was partly worked into the soil to reduce crack formation. This has been mentioned in section 2.4. "The isotopic values of the two treatments (straw application and no straw as a control plot) were combined for each crop for further analysis, because there were no significant differences for stable isotopes of water between the fields with the same crop ($p>0.05$)."

Please describe in detail how to determine the time when a water shortage occurred in dry rice and maize fields (P.3,Lines 26-27).

Field workers from the IRRI were responsible for watering dry crops in case of severe soil water shortages. The decision of watering was not set by specific measurements of model application, but by expert knowledge.

The gravimetric soil water content is determined traditionally by oven-drying method. Smaller values might be resulted by using the soil water loss in cryogenic water extraction process to determine the soil water content (P.4,Lines 19-20).

We agree that the results of both methods are not directly comparable. We added a sentence to section 2.2 to address this: "The gravimetric soil water content along the soil profiles was determined based on the soil weight loss following cryogenic water extraction. Soil water content determined this way might deviate from the classical oven drying method and result in slightly lower values. However, we use the gravimetric soil water content not as an absolute value, but rather as a relative value to identify differences along the soil profile."

Root length density was analyzed as described in the P.4, Lines 21-22 in the "Material and Methods" section, but non detailed results were shown in the "3 Results" section.

We used root length density values to analyze the root growth along the season together with the plant growth. However, we decided to take this part out of the manuscript but forgot to delete it in the respective method's description. Therefore, we also removed these lines in the revised manuscript.

(4) Results: The lc-excess was developed/introduced by Landwehr and Coplen (2006) in respect to River Water Line. They used the lc-excess to determine how the isotopic values of river waters differed from their sources (i.e., precipitation). However, the authors use lc-excess to estimate the deviation in the isotopic values of the soil samples from regional precipitation. I do not find any good argument why the authors use lc-excess since there is no river water sampled during their experiments. The lc-excess is not necessarily needed in this study (P.7, Lines 9-16). Instead, the deviation of soil isotopic values from LMWL/GMWL is already indicating the evaporation process and it is more commonly used method. Lower indicates condensation process and higher indicates evaporation process.

Sprenger et al. (2017) stated that "However, we found that lc-excess was advanta-

geous over the deuterium-excess (or single isotope approaches with δ2H or δ18O) for inferring evaporation fractionation, because the lc-excess of the precipitation input is about 0‰ and with relatively little seasonal dynamics, while δ2H, δ18O, and d-excess can have an intense seasonal variability." Furthermore, Sprenger et al. (2018) stated that "The lc-excess describes the deviation of a water sample from the LMWL in the dual-isotope plot, which is used to infer soil evaporation processes due to kinetic fractionation of precipitation input" We agree with these arguments. We analyzed soil profiles from different seasons. Therefore, to avoid problems with the seasonality of δ2H and δ18O or d-excess, we used lc-excess for comparison. We also used lc-excess because Sprenger et al. (Sprenger et al., 2016, 2017, 2018), McCutcheon et al. (2017) have successfully applied it for soil water studies, previously. They specify the advantage of using lc-excess over the d-excess and further explain that water that is experiencing fractionation by evaporation has a negative lcâĂŘexcess and plots below the LMWL in a dualâĂŘisotope plot. However, we will address the point more carefully in our reviewed version.

(5) Discussion: The authors estimate the annual average reference evapotranspiration rates in dry season and wet season, respectively. Does the "evaporation of âĹij50-80%" in P.11, Line 28 mean evapotranspiration? What is the difference between evapotranspiration and evaporation in this study?

We revised the entire paper with regard to clearly referring to and differentiating between evaporation, transpiration, and evapotranspiration. Further, we rewrote this section and now use estimates based on the Craig-Gordon Model. The revised text reads: "The fraction of soil evaporation was estimated as 40 % from the beginning of the DS and decreased to 25 % towards the end, while it dropped from 80 to 60 % during the WS." With isotopes, we only estimated the unproductive losses from evaporation and different tools were used to estimate evapotranspiration. It is stated in the text as "We rigorously tested our results and checked their plausibility by reviewing regional data reported in the literature, and by using the CROPWAT modeling approach. Using the

CROPWAT model (FAO 2009) forced with meteorological data for Los Baños, Philippines, we estimated an annual average reference evapotranspiration rate of 3.65 mm d–1, with a DS average of 3.96 mm d–1 and a WS average of 3.33 mm d–1."

(6) Conclusion: Seasonal distribution of soil water content and isotopic profiles was analyzed in this study, but no fluxes of unproductive soil water losses were found. Therefore, the sentence in P.13, Lines 24-25 is required to be reorganized.

Evaporation is an unproductive water loss because apart from transpiration the rest of the water outputs from the agricultural system are considered as unproductive water losses (Bouman, 2007), and this is what we have estimated in this work.

(7) The English writing of this manuscript should be polished further. There were some grammar errors in this paper and some sentences were confusing.

As proposed, we will carry out an internal review again and work on the English language. A native proofreader had already checked the initial manuscript, and we were slightly puzzled when reading that the version submitted was still flawed. Nevertheless, we will send the paper again for proofreading.

References: [1] Liu, C.M., Zhang, X.Y., Zhang, Y.Q., 2002. Determination of daily evaporation and evapotranspiration of winter wheat and maize by large-scale weighing lysimeter and micro-lysimeter. Agr. For. Meteorol. 111, 109-120. [2] Kool, D., Agam, N., Lazarovitch, N., Heitman, J. L., Sauer, T. J., Ben-Gal, A., 2014. A review of approaches for evapotranspiration partitioning. Agric. For. Meteor. 184, 56-70. [3] Zhou, S., Yu, B.F., Zhang, Y., Huang, Y.F., Wang, G.Q., 2016. Partitioning evapotranspiration based on the concept of underlying water use efficiency. Water Resour. Res. 52, 1160-1175. [4] Sprenger, M., Leistert, H., Gimbel, K., Weiler, M., 2016. Illuminating hydrological processes at the soil-vegetation-atmosphere

References Baram, S., Ronen, Z., Kurtzman, D., Külls, C. and Dahan, O.: Desiccation-crack-induced salinization in deep clay sediment, Hydrol. Earth Syst. Sci.,

17(4), 1533–1545, doi:https://doi.org/10.5194/hess-17-1533-2013, 2013. Bouman, B. A. M.: Water Management in Irrigated Rice: Coping with Water Scarcity, Int. Rice Res. Inst., 2007. McCutcheon, R. J., McNamara, J. P., Kohn, M. J. and Evans, S. L.: An evaluation of the ecohydrological separation hypothesis in a semiarid catchment, Hydrol. Process., 31(4), 783–799, doi:10.1002/hyp.11052, 2017. Sprenger, M., Tetzlaff, D. and Soulsby, C.: Soil water stable isotopes reveal evaporation dynamics at the soil-plant-atmosphere interface of the critical zone, Hydrol. Earth Syst. Sci., 21(7), 3839–3858, doi:10.5194/hess-21-3839-2017, 2017. Sprenger, M., Tetzlaff, D., Buttle, J., Laudon, H., Leistert, H., Mitchell, C. P. J., Snelgrove, J., Weiler, M. and Soulsby, C.: Measuring and Modeling Stable Isotopes of Mobile and Bulk Soil Water, Vadose Zone J., 17(1), doi:10.2136/vzj2017.08.0149, 2018.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-213, 2019.

Printer-friendly version

Discussion paper