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Reply on RC2

Hongxiu Wang et al.

Author comment on "Technical note: Evaporating water is different from bulk soil water in δ^2H and δ^{18}O and has implications for evaporation calculation" by Hongxiu Wang et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-648-AC2, 2021

Dear Reviewer,

Thank you very much for your valuable suggestions on our manuscript entitled "Evaporating water is different from bulk soil water in d^{2}H and d^{18}O". We hope that we have the opportunity to modify our manuscript for better presentation and interpretation according to your advice. We also did some corrections based on your recommendations and the detailed response to each comment is provided below.

We are looking forward to receiving your feedback.

Sincerely,

Hongxiu Wang

Jingjing Jin

Bingcheng Si

Xiaojun Ma

Mingyi Wen

Evaporating water is different from bulk soil water in 2H and 18O

Summary:

Wang et al. sought to determine the contribution of bulk water from cryogenic extraction to evaporation water using stable isotopes of water. The team used a clever and practical method to collect evaporated water in a corn field and compared this to extracted bulk water throughout the growing season. Additionally, the authors applied a deuterium labeled irrigation to improve endmember resolution. Following the label, the evaporation and bulk water appears to decrease in 2H through time in similar overall values, whereas the 18O signature increases through time with significant differences between these two sampling domains. The authors interpret this to mean that, in this system, evaporation shows a strong preference for new water residing in large pores and that the source of evaporation differs from that of cryogenically extracted bulk water.

General Comment

I think that both the aim and the results of this study are relevant and interesting. These kinds of experiments are severely lacking in modern hydrological sciences, and are needed to force the field to think openly about flow and mixing assumptions. However, there are numerous instances where the presentation and interpretation of the results make it difficult to judge the merit of the experiment, overall. I detail these discrepancies below. I think most of the necessary analyses have been conducted but I find it hard to accept without a substantial change to the current presentation and interpretations.

Response: Thank you. We will do our best to improve the quality of our manuscript.

Specific Comments: Introduction to Evaporation Dynamics

Lines 40-51: This section is a bit unclear. How exactly are the initial evaporation phases preferentially expressing larger pores? Yes, the larger pores connecting the deeper (more positive pore water pressure) source water to the near-surface may require higher contribution from higher conductivity ("larger") pores to sustain evaporation. However, it is unclear if the source of water vapor at the evaporation front is distinctly associated with larger pores, as smaller pores are dominated by stronger capillary forces (capillary > gravity + viscous forces) that maintain the gradient that links surface evaporation to deeper layers.

I think that this section needs to be made clearer which appears to be a critical point of the manuscript. I suggest providing a more detailed link to the literature, especially as these references (e.g, Ohr and Lehman + Zhang et al) do not make such obvious pore-scale distinctions.

Response: Yes, you are right. In the stage ☐, surface smaller pores (what we called is medium pores in our manuscript) link the surface evaporation to deeper soil layers, as the large pores are invaded by air. However, in stage ☐, large pores water dominates the evaporation flux; in stage ☐, surface small pores water (defined by the residual water in soil characteristic curve) and deeper larger pores water contribute to evaporation. Moreover, as pointed out by Zhang et al. (2015) “film water cannot be easily removed unless the local capillary water is dried out and the atmospheric demand for evaporation is strong. The maximum volume of film water determines the residual water content.” And the residual water is also used as the last evaporated water in Or and Lehmann (2019). In order to be clearer, we modified our presentation for evaporation processes on P2 L43-56: “Water loss from soil progresses with air invasion into soil pores in an order from large to small (Aminzadeh and Or, 2014; Lehmann and Or, 2009; Or et al., 2013). Soil pores can be divided into large pores, medium pores, small pores. The minimum amount of small pores water is the residual water content in soil characteristic curve (Van Genuchten, 1980; Zhang et al., 2015). When larger soil pores are filled by water, water in small pores does not participate in evaporation (Or and Lehmann, 2019; Zhang et al., 2015). Therefore, soil evaporation can be divided into three stages (Hillel, 1998; Or et al, 2013). Stage □: evaporation front is in the surface soil, and water in large and medium pores participate in evaporation, but larger pores are the primary contributor. With the progressive reduction of water in larger pores, the evaporation rate decreases gradually. Stage □: evaporation front is still in the surface soil, but larger pores are filled by air, water residing in medium soil pores in the surface soil evaporates and deep larger soil pores recharge the surface medium pores by capillary pull (Or and Lehmann, 2019); the evaporation rate remains constant. Stage □: the hydraulic connectivity between surface medium pores and deep larger pores breaks, so evaporation front recedes into deep soil. Water in surface small pores and water in medium pores on the evaporation front evaporate. The evaporation rate drops to a low value."

Aminzadeh, M. and Or, D.: Energy partitioning dynamics of drying terrestrial surfaces, J. Hydrol., 519, 1257-1270, doi:10.1016/j.jhydrol.2014.08.037, 2014.

Lehmann, P. and Or, D.: Evaporation and capillary coupling across vertical textural contrasts in porous media, Phys. Rev. E, 80, 046318, doi:10.1103/PhysRevE.80.046318, 2009.

Or, D., Lehmann, P., Shahraeeni, E., and Shokri, N.: Advances in soil evaporation physics—A review, Vadose Zone J, 12, 1-16, doi:10.2136/vzj2012.0163, 2013.

Van Genuchten, M. T.: A closed□form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci Soc Am J, 44, 892-898, doi:10.2136/sssaj1980.03615995004400050002x, 1980.

Zhang, C., Li, L., and Lockington, D.: A physically based surface resistance model for evaporation from bare soils, Water Resour. Res., 51, 1084-1111, doi:10.1002/2014wr015490, 2015.

Or, D. and Lehmann, P.: Surface evaporative capacitance: How soil type and rainfall characteristics affect global□scale surface evaporation, Water Resour. Res., 55, 519-539, doi:10.1029/2018WR024050, 2019.

Hillel, D.: Environmental soil physics: Fundamentals, applications, and environmental considerations, Elsevier, 1998.

Figures and Presentation

Generally, it is difficult for the reader to interpret results from most of these figures. The labels of the figures are sporadic with non-intuitive descriptions in figure captions. Having to flip back and forth between plots and timelines to attribute dates with important time periods does not help (maybe get rid of dates, use time, and intuitive descriptors for each key time period?). Overall the quality of figures is often lacking. The exception is figure 8 which is well done. Please see my specific comments below (and attached file).

Response: Thank you for pointing out our issue on the figures. To be consistent, we changed the date to time i.e. days after precipitation/irrigation. But, for background information (Figure 4), we will keep using date.

Also regarding the fractional evaporation:

Line 325: This gets a bit confusing.

1) how are you expressing the fraction of evaporated water source from both pools if equation 10 requires input from bulk water (i.e., this should work for just BW)?

Response: The calculation of evaporative water loss is based on isotopic mass balance of bulk soil water: the change of bulk soil water isotopic composition times the soil water storage reduction is equal to evaporation vapor isotopic composition times evaporative water amount. We can use bulk soil water isotopic composition combined with Craig-Gordon model to calculate evaporation vapor isotopic composition or we can use evaporating water isotopic composition combined with Craig-Gordon model to calculate evaporation vapor isotopic composition. In order to do integration, we used bulk soil water isotopic composition to express evaporating water isotopic composition when using evaporating water isotopic composition to calculate evaporative water loss. Therefore, the evaporative water loss calculation formulas are expressed in equations 17 and 18 on P11 L259-263 : "In order to calculate evaporative water loss from EW d^{18}O, we used BW to express EW and obtained the following formulas (Eqs. 17-18) for evaporation fraction.

$$f = 1 - \left[\frac{\delta_{BW} - \delta^* + n}{\delta_I - \delta^* + n}\right]^{\frac{1}{m}}$$

, (17)

where n is an intermediate variable and can be expressed as following,

$$n = \frac{-2.13\alpha_1^*}{h - \frac{\varepsilon}{1000}}$$

, (18)"

2) why are you only comparing EW vs BW for 18O in period 2 and not 2H (or period 1)?

Response: In Period ☐, d^{2}H in BW and EW decreased with evaporation, which means that the post-evaporated bulk soil water is depleted in heavy isotope than initial bulk soil water. So, we cannot obtain evaporative water loss based on d^{2}H. The explanation was added on P17 L359-361: "However, the evaporative water loss could not be calculated from d^{2}H in BW or EW, as d^{2}H decreased with on-going evaporation (Fig. 5), which were inconsistent with the evaporation theory that soil evaporation enriches heavier water isotopes in the residual soil water." As mentioned in the former comment, the isotopic relationship between EW and BW is needed in order to use BW isotopic composition to express EW isotopic composition during the evaporative water loss calculation. However, for evaporating water, we only have 4 data points in Period ☐, so, no reliable regression should be obtained by 4 points. Unfortunately, we could not calculate evaporative water loss based on EW isotopic composition in Period ☐,. The explanation was added on P17 L361-363: "We could not calculate the evaporative water loss based on isotopic composition of EW in Period I, as we did not obtain the isotopic relationship between EW and BW.".

3) Why make all of these sporadic comparisons and list one panel as not available.

These points really detract from the meaning meant to be conveyed here.

Response: As mentioned above, the decrease of d^2H with increasing evaporation time against the evaporative theory, so we could not calculate evaporative water loss based on d^2H. The explanation was added on P17 L359-361 : "However, the evaporative water loss could not be calculated from d^2H in BW or EW, as d^2H decreased with on-going evaporation (Fig. 5), which were inconsistent with the evaporation theory that soil evaporation enriches heavier water isotopes in the residual soil water."

- **Interpretation and Explanations**

Here are some key points:

Line 361: This is quite puzzling. How could you expect a difference in detected source in 18O between evaporation and bulk water, when there is such a stronger end member separation in 2H? ~ 80 delta 2H per mil divided by instrument precision 0.2 = 400 units of detection versus almost no separation for 18O.

If this finding is indeed true, I think it is worth discussing how you would see this in one isotopic signature (2H) and not 18O. Is it possible that the instrument precision of 2H was greatly reduced after the label (e.g., drift and memory effects) whereas we see a more correct version of 18O during phase 2? Would you have any data to calculate the precision of the analysis throughout the study period to confirm?

Response: Thanks for pointing out the analysis issue. We analyzed the isotopic composition of condensation water, which was used to obtain the isotopic composition of evaporating water, as soon as we can after collecting it. We did the cryogenic extraction for bulk soil water including 0-5 cm soil and deep soil samples and subsequently analyzed the isotopic composition of bulk soil water. Therefore, our isotopic analysis started on 24-July-2016 and finished on 13-Jan.-2017. Three standard liquids LGR3C, LGR4C, and LGR5C were sequentially used to do the calibration, and three samples were analyzed following each standard. The frequent analysis of standards is to get rid of the instrument drift effect. In order to minimize the memory effect, every liquid was injected 6 times and the former 2 injections were discarded and the later 4 injections were averaged to obtain the isotopic value. Furthermore, the average d^2H and $d^{18}O$ of LGR3C, LGR4C, and LGR5C throughout our study period were -97.34±0.020 ‰, -51.51±0.045 ‰, -9.26±0.025 ‰ and -13.42±0.003 ‰, -7.88±0.006 ‰, -2.72±0.003 ‰ (MeanSE), respectively. The small standard error shows the good precision of our instrument throughout our study period. The detailed information was added on P8 L189-192 : "Three liquid standards with d^2H varies from -97.30 to -9.20 ‰ and $d^{18}O$ varies from -13.39 to -2.69 ‰ were used sequentially after each 3 samples to omit the drift effect. In order to omit the memory effect, every sample was analyzed with 6 injections and only the later 4 injections were used to obtain the isotopic value.".

However, as we went back to check our original analysis results, we found that some of our isotopic values are bigger than our standards isotopic values. In order to analyze the effect of extrapolation beyond the range of standards, we did a comparison experiment. In the experiment, 10 liquid samples with d^2H varies from 0.14 to 107 ‰ and $d^{18}O$ varies from -1.75 to 12.24 ‰ were analyzed using LGR 3C, LGR 4C, and LGR 5C as standards (same with our former analysis) and were also analyzed using LGR 5C, GBW 04401 (d^2H= -0.4 ‰, $d^{18}O$= 0.32 ‰), and LGR E1 (d^2H=107 ‰, $d^{18}O$=12.24 ‰) as standards. Using the measured isotopic value difference of the same liquid sample between using LGR 5C, GBW 04401, and LGR E1 as standards and using LGR 3C, LGR 4C, and LGR 5C as standards, we established the relationship between the measured isotopic difference with the isotope value using LGR 5C, GBW 04401, and LGR E1 as standards ($\Delta^2H = -0.0191d^2H-0.2707$, $R^2=1$; $\Delta^{18}O = -0.0526d^{18}O-0.0911$, $R^2=1$). Subsequently, we corrected our isotopic data that have d^2H larger than -9.26 ‰ and $d^{18}O$ larger than -2.72 ‰. Then, we reanalyzed our data. However, of the extrapolation beyond the standards range has negligible effect to our results. The detailed information was added on P8 L192-197 : "For the measured d^2H that is larger than -9.20 ‰ and $d^{18}O$ that is larger than -2.69 ‰, we did a further correction using the equations d^2H(post-corrected) = d^2H(measured)-0.0191 d^2H(measured)-0.2707 and $d^{18}O$(post-corrected) = $d^{18}O$(measured)-0.0526 $d^{18}O$(measured)-0.0911. The correction equations were obtained via a comparison experiment with isotopic analysis of heavy-isotope enriched water samples using the same liquid standards as we used before and using heavy-isotope enriched liquid standards."

Lines 373-375: Here is where the soil physics perspective matters. As you mention in your introduction (Lines 53-54) when tighter pores are filled with water (e.g., field capacity or wetter) the likelihood of preferential flow increases, as high porewater pressures force more water into large pores. However, under dry conditions (e.g., your irrigation event on 8/22) infiltrating water will initially fill these small pores, due to high matrix flux potential or a strong potential gradient between wetting front and dry soil. As the infiltration event proceeds, hydraulic length increases (e.g., depth of wetting front) driving down the infiltration rate (low gradient), the pore water pressures increase such that the air-entry pressure of large pores is exceeded, and then macropore or preferential flow ensues. Under the later phase gravitational forces exceed capillary "pull" into the matrix, increasing the likelihood of dual domain flow and separation between small and large pores.

The main point here is that dry conditions would likely facilitate preferential wetting of smaller pores due to strong capillary forces during initial infiltration. Thus, dry conditions could result in greater continuity between small and large pores. Having said this, preferential flow is known to happen under dry conditions too (especially in cracks) yet these conditions could really reduce the separation between the two pore domains. Note also that your introduction covers this process of preferential filling of small pores under dry conditions on Lines 52-53.

Please consider this point in your interpretation.

Response: Thank you for pointing out the controversial statement. We modified our interpretation on P2 L57-64 : "Furthermore, pre-event soil water fills the small pores. When the event water amount is small, the smaller soil pores are empty and will be filled with event water firstly (Beven and Germann, 1982; Brooks et al., 2010). But when smaller pores are filled with water or when the event water amount is large, the infiltration water goes into larger pores preferentially and bypasses the saturated smaller pores (Beven and Germann, 1982; Booltink and Bouma, 1991; Sprenger and Allen, 2020). As larger pores have larger hydraulic conductivity and flows faster, water residing in larger pores drains firstly. Conversely, water residing in small pores drains lastly (Gerke and Van Genuchten, 1993; Phillips, 2010; Van Genuchten, 1980). Therefore, smaller pores water has a longer residence time in the soil (Sprenger et al., 2019b)." and P20 L399-407 : "For large precipitation events, event water will infiltrate into the empty larger pores preferentially due to the larger hydraulic conductivity associated with larger pores, and then transfer some of the water to the surrounding empty smaller pores, bypassing pre-event water-filled small soil pores in soil matrix (Beven and Germann, 1982; Booltink and Bouma, 1991; Weiler and Naef, 2003). In our experiment, the precipitation event on 2016/7/24 was 31 mm, and the irrigation event on 2016/8/26 was 30 mm, and both are large events. Because small pores are prefilled by pre-event water, we assume that large pores will be filled by the new water; and medium pores are likely filled by the mixture of pre-event water and event water. Therefore, water in larger pores is similar to the event water and water in smaller pores is close to the pre-event water i.e. old event water (Brooks et al., 2010; Sprenger et al., 2019a)."

Beven, K. and Germann, P.: Macropores and water flow in soils, Water Resour. Res., 18, 1311-1325, doi:10.1029/WR018i005p01311, 1982.

Brooks, J. R., Barnard, H. R., Coulombe, R., and McDonnell, J. J.: Ecohydrologic separation of water between trees and streams in a Mediterranean climate, Nat. Geosci., 3, 100-104, doi:10.1038/NGEO722, 2010.

Booltink, H. W. G. and Bouma, J.: Physical and morphological characterization of bypass flow in a well□structured clay soil, Soil Sci Soc Am J, 55, 1249-1254, doi:10.2136/sssaj1991.03615995005500050009x, 1991.

Sprenger, M. and Allen, S. T.: What ecohydrologic separation is and where we can go with it, Water Resour. Res., 56, e2020WR027238, doi:10.1029/2020wr027238, 2020.

Gerke, H. H. and Van Genuchten, M. T.: A dual□porosity model for simulating the preferential movement of water and solutes in structured porous media, Water Resour. Res., 29, 305-319, doi:10.1029/92WR02339, 1993.

Phillips, F. M.: Soil-water bypass, Nat. Geosci., 3, 77-78, doi:10.1038/ngeo762, 2010.

Van Genuchten, M. T.: A closed□form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci Soc Am J, 44, 892-898, doi:10.2136/sssaj1980.03615995004400050002x, 1980.

Sprenger, M., Stumpp, C., Weiler, M., Aeschbach, W., Allen, S. T., Benettin, P., ... and McDonnell, J. J.: The demographics of water: A review of water ages in the critical zone, Rev. Geophys., 57, 800-834, doi:10.1029/2018rg000633, 2019b.

Weiler, M. and Naef, F.: An experimental tracer study of the role of macropores in infiltration in grassland soils, Hydrol Process, 17, 477-493, doi:10.1002/hyp.1136, 2003.

Sprenger, M., Llorens, P., Cayuela, C., Gallart, F., and Latron, J.: Mechanisms of consistently disconnected soil water pools over (pore) space and time, Hydrol Earth Syst Sci, 23, 1-18, doi:10.5194/hess-2019-143, 2019a.

Lines 381-382: Again, why exactly do you assume the small pores to only express old water? The average water content before irrigation was quite low (~ 0.15 in the upper 10 cm).

These 25 mm of irrigation could have filled ~7-10 cm of upper soil assuming a uniform wetting front and a conservative porosity of 0.45. Thus, the signature of infiltrating water alone could have muted the pre-event evaporation water source by >70%.

Response: Thanks again for your concern. We modified our presentations on P2 L57-64 : "Furthermore, pre-event soil water fills the small pores. When the event water amount is small, the smaller soil pores are empty and will be filled with event water firstly (Beven and Germann, 1982; Brooks et al., 2010). But when smaller pores are filled with water or when the event water amount is large, the infiltration water goes into larger pores preferentially and bypasses the saturated smaller pores (Beven and Germann, 1982; Booltink and Bouma, 1991; Sprenger and Allen, 2020). As larger pores have larger hydraulic conductivity and flows faster, water residing in larger pores drains firstly. Conversely, water residing in small pores drains lastly (Gerke and Van Genuchten, 1993; Phillips, 2010; Van Genuchten, 1980). Therefore, smaller pores water has a longer residence time in the soil (Sprenger et al., 2019b)."

Beven, K. and Germann, P.: Macropores and water flow in soils, Water Resour. Res., 18, 1311-1325, doi:10.1029/WR018i005p01311, 1982.

Brooks, J. R., Barnard, H. R., Coulombe, R., and McDonnell, J. J.: Ecohydrologic separation of water between trees and streams in a Mediterranean climate, Nat. Geosci., 3, 100-104, doi:10.1038/NGEO722, 2010.

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Phillips, F. M.: Soil-water bypass, Nat. Geosci., 3, 77-78, doi:10.1038/ngeo762, 2010.

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Sprenger, M., Stumpp, C., Weiler, M., Aeschbach, W., Allen, S. T., Benettin, P., ... and McDonnell, J. J.: The demographics of water: A review of water ages in the critical zone, Rev. Geophys., 57, 800-834, doi:10.1029/2018rg000633, 2019b.

Lines 388-393: See my comments about these stages in the introduction.

Response: Thanks. In order to be clearer, we modified our presentation in the introduction on P2 L43-56: "Water loss from soil progresses with air invasion into soil pores in an order from large to small (Aminzadeh and Or, 2014; Lehmann and Or, 2009; Or et al., 2013). Soil pores can be divided into large pores, medium pores, small pores. The minimum amount of small pores water is the residual water content in soil characteristic curve (Van Genuchten, 1980; Zhang et al., 2015). When larger soil pores are filled by water, water in small pores does not participate in evaporation (Or and Lehmann, 2019; Zhang et al., 2015). Therefore, soil evaporation can be divided into three stages (Hillel, 1998; Or et al, 2013). Stage □: evaporation front is in the surface soil, and water in large and medium pores participate in evaporation, but larger pores are the primary contributor. With the progressive reduction of water in larger pores, the evaporation rate decreases gradually. Stage □: evaporation front is still in the surface soil, but larger pores are filled by air, water residing in medium soil pores in the surface soil evaporates and deep larger soil pores recharge the surface medium pores by capillary pull (Or and Lehmann, 2019); the evaporation rate remains constant. Stage □: the hydraulic connectivity between surface medium pores and deep larger pores breaks, so evaporation front recedes into deep soil. Water in surface small pores and water in medium pores on the evaporation front evaporate. The evaporation rate drops to a low value."

Aminzadeh, M. and Or, D.: Energy partitioning dynamics of drying terrestrial surfaces, J. Hydrol., 519, 1257-1270, doi:10.1016/j.jhydrol.2014.08.037, 2014.

Lehmann, P. and Or, D.: Evaporation and capillary coupling across vertical textural contrasts in porous media, Phys. Rev. E, 80, 046318, doi:10.1103/PhysRevE.80.046318, 2009.

Or, D., Lehmann, P., Shahraeeni, E., and Shokri, N.: Advances in soil evaporation physics—A review, Vadose Zone J, 12, 1-16, doi:10.2136/vzj2012.0163, 2013.

Van Genuchten, M. T.: A closed□form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci Soc Am J, 44, 892-898, doi:10.2136/sssaj1980.03615995004400050002x, 1980.

Zhang, C., Li, L., and Lockington, D.: A physically based surface resistance model for evaporation from bare soils, Water Resour. Res., 51, 1084-1111, doi:10.1002/2014wr015490, 2015.

Or, D. and Lehmann, P.: Surface evaporative capacitance: How soil type and rainfall characteristics affect global□scale surface evaporation, Water Resour. Res., 55, 519-539, doi:10.1029/2018WR024050, 2019.

Hillel, D.: Environmental soil physics: Fundamentals, applications, and environmental considerations, Elsevier, 1998.

Lines 420-421: This is not consistent with Brooks et al. Brooks et al suggested that transpiration water and bulk soil were similar and that smaller pores with high residence time supplied this Ecohydrological flux.

Response: To the best of our knowledge, Brooks et al. (2010) suggested that large pores water will recharge streams (groundwater) and plant roots adsorb larger soil pores water, both of which making the progressively smaller soil pores contain water. In order to be clear, we added the information on P21 L452-454 : "This is consistent with the finding of Brooks et al. (2010), as progressively smaller soil pores would contain water after large pores water percolation to streams (groundwater) and plant roots uptake, and can have broad ecohydrological implications."

Brooks, J. R., Barnard, H. R., Coulombe, R., and McDonnell, J. J.: Ecohydrologic separation of water between trees and streams in a Mediterranean climate, Nat. Geosci., 3, 100-104, doi:10.1038/NGEO722, 2010.

Specific comments:

Line 10: This reads like you are referring to the pool of water as being larger. "soil water from larger pores" is more clear and direct.

Response: Done.

Line 16: maybe distinguish this as "natural precipitation.." to be clear

Response: Done

Line 26: "…evaporation losses from .." from what?

Response: In order to make the meaning clear, we modified the sentence on P1 L27-29: "We also compared soil evaporation losses derived from water isotopes of EW and BW. With a small magnitude of isotopic difference in EW and BW, the evaporation losses did not differ significantly ($p>0.05$)."

Line: 27: "implicationS" (plural)

Response: Done.

Line 28: "process" Remove or make plural.

Response: Done.

Line 36: I do not think that these two previous sentences could be considered a full paragraph.

Response: We rephrased our presentation on P2 L34-42: "Terrestrial ecosystems receive water from precipitation and subsequently release all or part of the water to the atmosphere through evapotranspiration. The evapotranspiration process consumes nearly 25 % of the incoming solar energy (Trenberth et al., 2009) and can be divided into two components: transpiration from plant leaves and evaporation from soil surface. Evaporation from soils varies from 10 to 60 % of the total precipitation (Good et al. 2015; Oki and Kanae, 2006). Precisely estimating soil evaporative water loss relative to precipitation is critical to improve our knowledge of water budget, plant water use efficiency, global ecosystem productivity, the allocation of increasingly scarce water resources, and calibrating hydrological and climate models (Kool et al., 2014; Oki and Kanae, 2006; Or et al., 2013; Or and Lehmann, 2019; Wang et al., 2014)."

Trenberth, K. E., Fasullo, J. T., and Kiehl, J. : Earth's global energy budget, Bull Am Meteorol Soc, 90, 311-324, doi:IO.II7S/2008BAMS2634.I, 2009.

Good, S. P., Noone, D., and Bowen, G.: Hydrologic connectivity constrains partitioning of global terrestrial water fluxes, Science, 349, 175-177, doi:10.1126/science.aaa5931, 2015.

Oki, T. and Kanae, S.: Global hydrological cycles and world water resources. Science, 313, 1068-107, doi:10.1126/science.1128845, 2006.

Kool, D., Agam, N., Lazarovitch, N., Heitman, J. L., Sauer, T. J., and Ben-Gal, A.: A review of approaches for evapotranspiration partitioning, Agric For Meteorol, 184, 56-70, doi:10.1016/j.agrformet.2013.09.003, 2014.

Or, D., Lehmann, P., Shahraeeni, E., and Shokri, N.: Advances in soil evaporation physics—A review, Vadose Zone J, 12, 1-16, doi:10.2136/vzj2012.0163, 2013.

Or, D. and Lehmann, P.: Surface evaporative capacitance: How soil type and rainfall characteristics affect global□scale surface evaporation, Water Resour. Res., 55, 519-539, doi:10.1029/2018WR024050, 2019.

Wang, L., Good, S. P., and Caylor, K. K.: Global synthesis of vegetation control on evapotranspiration partitioning, Geophys. Res. Lett., 41, 6753-6757, doi:10.1002/2014gl061439, 2014.

Lines 38-40: Why is this specific distinction relevant?

Response: Dividing soil pores into large, medium, and small pores helps understanding the three stages of soil evaporation processes on P2 L43-56: “Water loss from soil progresses with air invasion into soil pores in an order from large to small (Aminzadeh and Or, 2014; Lehmann and Or, 2009; Or et al., 2013). Soil pores can be divided into large pores, medium pores, small pores. The minimum amount of small pores water is the residual water content in soil characteristic curve (Van Genuchten, 1980; Zhang et al., 2015). When larger soil pores are filled by water, water in small pores does not participate in evaporation (Or and Lehmann, 2019; Zhang et al., 2015). Therefore, soil evaporation can be divided into three stages (Hillel, 1998; Or et al, 2013). Stage □: evaporation front is in the surface soil, and water in large and medium pores participate in evaporation, but larger pores are the primary contributor. With the progressive reduction of water in larger pores, the evaporation rate decreases gradually. Stage □: evaporation front is still in the surface soil, but larger pores are filled by air, water residing in medium soil pores in the surface soil evaporates and deep larger soil pores recharge the surface medium pores by capillary pull (Or and Lehmann, 2019); the evaporation rate remains constant. Stage □: the hydraulic connectivity between surface medium pores and deep larger pores breaks, so evaporation front recedes into deep soil. Water in surface small pores and water in medium pores on the evaporation front evaporate. The evaporation rate drops to a low value.”

Aminzadeh, M. and Or, D.: Energy partitioning dynamics of drying terrestrial surfaces, J. Hydrol., 519, 1257-1270, doi:10.1016/j.jhydrol.2014.08.037, 2014.

Lehmann, P. and Or, D.: Evaporation and capillary coupling across vertical textural contrasts in porous media, Phys. Rev. E, 80, 046318, doi:10.1103/PhysRevE.80.046318, 2009.

Or, D., Lehmann, P., Shahraeeni, E., and Shokri, N.: Advances in soil evaporation physics—A review, Vadose Zone J, 12, 1-16, doi:10.2136/vzj2012.0163, 2013.

Van Genuchten, M. T.: A closed□form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci Soc Am J, 44, 892-898, doi:10.2136/sssaj1980.03615995004400050002x, 1980.

Zhang, C., Li, L., and Lockington, D.: A physically based surface resistance model for evaporation from bare soils, Water Resour. Res., 51, 1084-1111, doi:10.1002/2014wr015490, 2015.

Or, D. and Lehmann, P.: Surface evaporative capacitance: How soil type and rainfall characteristics affect global□scale surface evaporation, Water Resour. Res., 55, 519-539, doi:10.1029/2018WR024050, 2019.

Lines 39-40: This sentence does not make sense as written. Also, it is not clear what you are trying to convey. Maybe you mean "minimum?"

Response: We modified the sentence on P2 L45-46: “The minimum amount of small pores water is the residual water content in soil characteristic curve (Van Genuchten, 1980; Zhang et al., 2015).”

Van Genuchten, M. T.: A closed□form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci Soc Am J, 44, 892-898, doi:10.2136/sssaj1980.03615995004400050002x, 1980.

Zhang, C., Li, L., and Lockington, D.: A physically based surface resistance model for evaporation from bare soils, Water Resour. Res., 51, 1084-1111, doi:10.1002/2014wr015490, 2015.

Line 41: See earlier comment. Rephrase to water in smaller pores (or something like this). Please revise this throughout the manuscript

Response: Done.

Line 45: Try to be clear with this term "depleted," as this is also a study of water isotopes (e.g., isotopic depletion). Maybe choose a different word (e. g., drained).

Response: Done. We modified the presentation on P2 L50-51: “With the progressive reduction of water in larger pores, the evaporation rate decreases gradually.”.

Lines 46-47: "capillary pumping" is never used in Or and Lehman (2019). This point is also unclear. Please specify.

Response: Thanks. We used “capillary pull” instead.

Line 60: use "infiltration" not "invasion"

Response: Done.

Line 71: "partitionING"

Response: Done.

Line 74: Okay, I think that the authors have used this small versus large pores enough to warrant a more specific reference. I suggest giving a more specific example of small versus large pores, especially here where vacuum pressure matters.

Response: Thanks for your concern. Commonly, we assume the cryogenic vacuum distillation with low pressure i.e. 0.2 Pa can extract all of the water in soil pores containing large and small pores, as we described on P3 L77-79 : “The isotopic composition of bulk soil water - that is extracted by cryogenic vacuum distillation, contains all pore water”. Moreover, we defined the water in small pores on P2 L45-46: “The minimum amount of small pores water is the residual water content in soil characteristic curve (Van Genuchten, 1980; Zhang et al., 2015)".

Van Genuchten, M. T.: A closed□form equation for predicting the hydraulic conductivity of unsaturated soils, Soil Sci Soc Am J, 44, 892-898, doi:10.2136/sssaj1980.03615995004400050002x, 1980.

Zhang, C., Li, L., and Lockington, D.: A physically based surface resistance model for evaporation from bare soils, Water Resour. Res., 51, 1084-1111, doi:10.1002/2014wr015490, 2015.

Lines 77-78: Good point.

Response: Thank you.

Lines 84: "improve our understanding" works better? Does not make sense as written.

Response: Done. We rephrased our description on P3 L87-88 : "This study may help to improve our understanding to the process of soil evaporation and the ecohydrological water cycle.".

Lines 133-135: Are these equations provided anywhere? Is the manuscript available for review. This seems to be an important detail.

Response: Thanks for your interest. The paper that contains the related data was submitted to Hydrological Processes and is still under review. If there is any update, we will indicate it in our manuscript.

Lines 156-158: What exactly was measured here and what was calculated? Please state explicitly here and in the Supplemental file.

Response: As mentioned on P7 L165-168 : "The air and 0-5 cm soil temperature under the newly covered plastic film during 2016/9/10 to 2016/9/28 were measured by E-type thermocouple (OMEGA, USA) with a CR1000 datalogger and 0-5 cm soil temperature in field condition during the whole field season was measured by ibutton (Maxim Integrated, DS1921G, USA) with the frequency of one hour.." So, the air and 0-5 cm soil temperature under newly covered plastic film before 2016/9/10 were calculated and others were measured. The detailed information was added on P7 L168-175 : "We estimated 0-5 cm soil temperature under the newly covered plastic film before 2016/9/10 from the temperature of 0-5 cm soil without the plastic film covering through regression. The regression was established using 0-5 cm soil temperature under the newly covered plastic film and soil temperature without plastic film covering between 2016/9/10 to 2016/9/28 using ibutton. After we obtained the 0-5 cm soil temperature under the newly covered plastic film for the whole field season, air temperature under the newly covered plastic film before 2016/9/10 was calculated from the temperature of 0-5 cm soil under the newly covered plastic film by regression between air temperature and 0-5 cm soil temperature under the newly covered plastic film.".

Lines 170-176: Looks like you have 2 paragraphs with 2 sentences and no transition? Please fix this.

Response: Done. For better flow, we moved this part to P5 L127-135 : "In order to obtain bulk soil density, field capacity, and residual water content, at the end of growing season, three 70 cm deep pits were dug, and stainless rings with the volume of 100 cm^3 (DIK-1801, Daiki Rika Kogyo Co., Ltd, Japan) were pushed into the soil at the depth of 10 cm, 20 cm, 40 cm, and 60 cm to obtain the soil samples. Subsequently, the soil samples were saturated with distilled water. The saturated soil samples were weighed and put into the high-speed centrifuge (CR21G□, HITACHI, Japan) with a serious centrifugation at the suctions of 0.01 to 7 bar. After each centrifugation, the soil samples were weighed again to obtain the soil characteristic curve. The post-centrifugation soils were oven-dried and weighed to obtain the bulk soil density. The bulk soil density was used to convert gravimetric water content, which was calculated by oven-dry method, to volumetric water content.”.

Line 175: Should use "instrument" not "machine."

Response: Done.

Lines 201-202: Is it also possible that the plastic film itself can fractionate condensed water molecules? This point might be worth clarifying/considering at this stage.

Response: In order to avoid the secondary evaporation from the plastic film, we used a piece of plastic film without hole to cover the soil surface and collected the dew in the early morning. The detailed information was presented on P4 L108-109 : “Subsequently, a piece of plastic film without hole (about 0.2 m^2, 40 cm by 50 cm) was used to cover the soil surface, with an extra 5 cm at each side.” and P4 L110-115: “After equilibrium for two days, the condensation water adhered on the underside of the plastic film was collected using an injection syringe in the early morning at about 7 a.m. to eliminate the secondary evaporation of the condensation water (Fig. 1), and transferred into a 1 mL glass vial. We assume that the condensation water is in constant equilibrium with evaporating water in soil and thus the water isotopes of evaporating water in soil can be obtained from that of condensation water on the plastic film.”.

Line 246: "mean values.." of what exactly?

Response: The information was added on P12 L269: “Further, Student’s t test (Knezevic, 2008) was used to compare two mean values of three replications.”

Knezevic, A.: Overlapping confidence intervals and statistical significance, StatNews: Cornell University Statistical Consulting Unit, 73, 2008.

Figure 4, Lines 258-259: This is very confusing . It looks like there are 4 periods. I suggest shading these these two areas with different colors or something similar.

Response: Thanks for the suggestions. Done.

Line 260: So the pink circles indicate when you compared bulk water versus evaporation water? Please clarify. Also were there no similar comparisons in Period 2?

Response: The detailed information was added on P16 L331-333 : “In Period I, we compared the mean values of EW and BW indicated by the pink circle in Fig. 4. d^2H and $d^{18}O$ of EW was significantly smaller than that in BW ($p<0.05$). Unfortunately, there was only 4 data points for EW, so we could not obtain the isotopic relationship between EW and BW." For Period II, we compared the variation of isotopic composition in EW and BW with evaporation time i.e. the slopes and intercepts. The detailed information was presented on P15 L320-330 : "The change of water isotopes in EW is very similar to that in BW. For example, in Period II, water isotopes in EW showed a similar trend as in BW: $d^{18}O$ increased with evaporation time (Fig. 5d) and the slope and intercept were significantly different from zero ($p<0.05$). And $d^{18}O$ was consistently more depleted in EW than in BW in the period with same slope but significantly smaller intercept ($p<0.01$). Also similar to that in BW, $d^{2}H$ in EW decreased with evaporation time but did not differ from that in BW ($p>0.05$, Figs. 4, 5), therefore the two lines had the similar slope and intercept (Fig. 5b). Thus, the linear relationship in $d^{18}O$ between EW and BW was given as $d^{18}O$ (EW) = $d^{18}O$ (BW)-1.99 (Fig. 5). While the slopes represent the evaporative demand of the atmosphere, regardless of the source of water, the intercept represents the initial condition of the source of water for evaporation. Therefore, the initial water source in Period II had a $d^{18}O$ value of -1.76 ‰ for BW, but of -3.75 ‰ for EW. In another words, the sources of water for BW and EW had different isotopic compositions in Period II.".

Line 263: What is the porosity?

Response: Thanks for the concern. We used high-speed centrifuge to obtain the characteristic curve and obtained field capacity and residual water content finally. The information was added on P5 L127-135 : "In order to obtain bulk soil density, field capacity, and residual water content, at the end of growing season, three 70 cm deep pits were dug, and stainless rings with the volume of 100 cm^3 (DIK-1801, Daiki Rika Kogyo Co., Ltd, Japan) were pushed into the soil at the depth of 10 cm, 20 cm, 40 cm, and 60 cm to obtain the soil samples. Subsequently, the soil samples were saturated with distilled water. The saturated soil samples were weighed and put into the high-speed centrifuge (CR21G☐, HITACHI, Japan) with a serious centrifugation at the suctions of 0.01 to 7 bar. After each centrifugation, the soil samples were weighed again to obtain the soil characteristic curve. The post-centrifugation soils were oven-dried and weighed to obtain the bulk soil density. The bulk soil density was used to convert gravimetric water content, which was calculated by oven-dry method, to volumetric water content." Therefore, the sentence was modified on P13 L285-288 : "Figure 4 shows that the soil water content in 0-5 cm reached field capacity (0.30 cm^3 cm^{-3}) with a volumetric water content of 0.300.007 cm^3 cm^{-3} right after the first large precipitation event (2016/7/24) and then decreased with evaporation time (grey bars in Fig. 4c). At the end of Period ☐, 0-5 cm soil water content was 0.050.005 cm^3 cm^{-3}, which was close to the residual water content 0.080.03 cm^3 cm^{-3}."

Line 265: Water contents can "jump"? :). please revise.

Response: Sorry, we just want to be active. But thanks. We changed it to "increased".

Line 266: Note that "Figure 4c" is not so clearly distinguished in the Figure. Would it be possible to move the letters e.g., "a)," "b)" to the left-hand side and increase the font size? Also, please refer to these sections directly in the figure captions.

Response: Thanks for the suggestion. Done.

Figure 4: Temporal variation of water stable isotopic compositions in different water bodies (dots, b, c), the dynamics of precipitation/irrigation amount (P/I, blue bars, a), and 0-5 cm soil water content (SWC, grey bars, c). Black arrows indicate deep soils sampling. The precipitation on 2016/8/26 represents irrigation. All of the values are expressed in MeanSE. Moreover, two evaporation periods are indicated by the colored

background. Period ☐ is from 2016/7/25 to 2016/8/25 (green) and Period ☐ is from 2016/8/27 to 2016/9/19 (cyan). The isotopic composition of BW and EW in Period ☐ was compared by the mean value of the measured data points indicated by the pink circle with d^{2}H -46.801.07 ‰, -57.552.60 ‰ and d^{18}O -3.220.31 ‰, -5.350.22 ‰ for BW and EW, respectively.

Line 270: remove "was"

Response: Done.

Line 277: "Therefore" ??

Response: We modified it to "Totally"

Line 278: "relatively" should be "relative"

Response: Done.

Line 282: "resulting in.." this sentence has been cut off.

Response: Thanks. We omitted the comma The detailed information was added on P14 L307-308 : "This suggests that evaporation favored lighter water isotopes of both O and H from BW resulting in greater d^{2}H and d^{18}O in BW".

Line 290: BW 18O also increased? Looks like there is a missing section??

Response: Yes, it is consistent with the last paragraph that describes BW in Period I. in order to be clearer, we jointed the two paragraphs.

Line 292: still describing period 2? Specify

Response: Yes, you are right. We added "in Period II" at the end of this sentence.

Line 306: Can you clarify why the period 1 EW and BW values are not shown together here? It looks like they would indicate a different source water for EW (minus one outlier)

Response: We added the description on P16 L331-333 : "In Period I, we compared the mean values of EW and BW indicated by the pink circle in Fig. 4. d^{2}H and d^{18}O of EW was significantly smaller than that in BW ($p<0.05$). Unfortunately, there was only 4 data points for EW, so we could not obtain the isotopic relationship between EW and BW." And on P17 L361-363 : "We could not calculate the evaporative water loss based on isotopic composition of EW in Period I, as we did not obtain the isotopic relationship between EW and BW".

Line 321: I would really suggest getting rid of the dates here and using some intuitive representation in time (e.g., before irrigation, after irrigation, early period 1 etc..) It is difficult for the reader to discern what the various times mean and their relevance is not mentioned in the Figure 6 caption.

Response: Thanks for the suggestions. Done.

Figure 6: Temporal variation of deep soil water content, d2H, d18O, and lc-excess. Upper panel represents pre-precipitation (2016/7/17, black circles) and during Period ☐ (10 DAP, 2016/8/3, blue upward-triangles; 24 DAP, 2016/8/17, red downward-triangles).

Lower panel represents pre-irrigation (2016/8/17, red downward-triangles) and during Period ☐ (6 DAI, 2016/9/1, yellow diamonds; 21 DAI, 2016/9/16, green squares). The significant difference ($p<0.05$) between pre-precipitation and 10 DAP, 10 DAP and 24 DAP, pre-irrigation and 6 DAI, and 6 DAI and 21 DAI are represented by blue, red, yellow, and green crosses, respectively.

Line 342: "preferentially evaporated" is more grammatical correct.

Response: Done.

Line 354: "...THE evaporation period..”

Response: Done.

Line 362: difference in what? Please also specify for clarity.

Response: Done. The information was added on P19 L390-392 : “No significant d^2H differences were detected between EW and BW in Period ☐ (Fig. 5). However, there was a significant $d^{18}O$ difference between EW and BW in Period ☐ and both d^2H and $d^{18}O$ in EW differed from the respective values in BW in Period I (Figs. 4, 5)”.

Line 365: "partitionING"

Response: Done.

Line 372: "...in larger pores than in small.."

Response: Done.

Line 408: difference did not make a difference?

Response: We revised the description on P21 L428-429: “ 4.3 Why the different isotopic compositions in evaporating water and bulk soil water did not make a difference in estimated evaporative water loss?”.

Please also see my specific comments in the attached pdf, if needed.

Response: Thanks.

Please also note the supplement to this comment:
https://hess.copernicus.org/preprints/hess-2020-648/hess-2020-648-AC2-supplement.pdf