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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Novel Keeling plot based methods to estimate the isotopic composition of ambient water vapor" *by* Yusen Yuan et al.

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In this manuscript, Yuan et al. proposed two new methods for estimating isotope ratio of background air vapor (delta_a) based on data collected from standard keeling-plot setups. The study is timely given that delta_a is an important variable that can yield insights into certain aspects of water cycling, but nonetheless remains underexplored as its estimation is not possible with the traditional keeling plot approach. After going through the manuscript, I feel that both of the proposed methods are interesting, theoretically well grounded and based upon realistic assumptions. Nevertheless, I have some comments that may be of help for strengthening this manuscript, as the following.

Although the theoretical framework underlying the IP method is sufficiently sound, I

feel that the authors' presentation of this method lacks clarity in several aspects. For example, one thing that I don't fully understand is why the method was named as the "intersection point" method in the first place. I understand that the proposed method was based on Yamanaka and Shimizu (2007) in which delta_a was estimated through the y (or delta_v) value of the point at which two keeling-plot lines intersect. However, it it clear from Equations 4 and 5 (L108, L109) that the method is based on a regular procedure of solving two equations for two unknowns, and that it actucally does not have much to do with calculating an intersect point (this typically would involve calculation of a x (or 1/cv) value that would render equality between two y (or delta_v) values predicted from the two different keeling plots). So maybe a different name should be used to describe this method, so to represent the underlying mathematical mechanism more accurately.

Further, the so-called IP method was developed with a vertical-profile based keeling plot as a context, but it is unclear to me what data should be used for parameterizing Cv1, Cv2, delta_v1, and delta_v2 in order for calculating delta_a from Eqn.6 (L112). For example, would the authors recommend parameterizing Cv1 using vapor concentration measured at a particular height at t1? If yes then which level of height would you prefer to use and why?

Strictly speaking, if delta_a is estimated from Eqn. 6 based on vapor concentration and isotope measurements at a particular height, then the resultant delta_a could be inevitably subject to some error the degree of which may likely depend on how much the difference (or the residual not explained by the regression equation) exists between the measured concentration value (i.e. Cv1) at this height and that predicted from the keeling plot (i.e. the regression line derived from measurements from all heights). To reduce this estimation error, I would suggest that the following calculation equations be used instead:

Ca(delta_a – delta_ET1) = k1 (Eqn.1)

Ca(delta_a – delta_ET2) = k2 (Eqn.2)

Where k1 and delta_ET1 denote values for KP1 (keeling plot at time 1) derived slope and intercept respectively, and k2 and delta_ET2 correspond to KP2 derived values.

Combining Eqns. 1 and 2 yields an equation for calculating delta_a, as:

delta_a = (k2*delta_ET1 – k1 * delta_ET2)/(k2 – k1) (Eqn. 3)

The eqn.3 shown above may be more advantageous than the originally presented Eqn. 6, due to that it is simpler in structure, and does not require isotope measurement at a particular height.

More specific comments as below:

L36: change "replying" to "relying"

L45: Maybe I missed it but I did not see anywhere in the text that evidence is presented to support the constant delta_a assumption. A possible route that I could image towards proof of this concept would be to first use Eqns. 6 or 7 to calculate delta_a at different heights using height-specific Cv and delta_v measurements. However, these calculations would have to be based on keeling plot derived delta_ET values, and thus already involve assuming that delta_a remains constant across different heights. In other words, the constant delta_a assumption is already a prerequisite for performing calculation of delta_a, and so one would easily fall into the trap of circular reasoning if the calculated delta_a values are further used as a test of the constant delta_a assumption.

L57-60: This sentence reads awkward and requires some re-writing. i.e., may be better off beginning the sentence with something like: "With the advent of laser isotope spectrometry capable of continuous and high-frequency measurements of...."

L60-61: Same as above. May be re-organized into something like: "the number of studies. . .was continuously increasing, generating new insights into processes that af-

fect dv"

L76-78: I would suggest that the authors add one or two sentences here to highlight why delta_a is important, or how and why accurate estimation of delta_a would benefit ecohydrolgocial studies.

L106: "it is changing smoothly over time" – maybe change into sth like "it remains relatively constant over a short period of time"?

L124: change "the key observation to estimate" to "provides a prerequisite for estimating"

L152: change "isotope and gas concentration analyzer" to "water vapor isotope analyzer"

L236/238: "immediate intermediate theorem" – no need to spell out the full name here, can just replace with IVT.

L276: What about arid ecosystem? Which method would you recommend for use? From what I understand, the IVT method may also be less favored, due to that it relies on more stringent criteria for data filtering (meaning higher percentage of data loss?), but I could also have missed some strengths/advantages related to this method. Further, can these two methods also be extended to time-based keeling plot cases? Maybe some additional discussion on these topics would be helpful.

L280: Your method is similar to Y & Z (2007) in that both require two keeling plot-based equations for solving for two unknowns. However, the two methods are not entirely the same, as for your method, the two unknowns to be solved are delta_a and Ca (having little to do with an intersection point), whereas for Y&Z, the two unknowns to be solved are delta_v and Cv, with the resolved delta_v considered the same as delta_a because of the meaning imbedded within an intersection point.

L287: change "is consisted of" to "consists of"

L303: See my previous comment on L45.

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