Keeling plot is a commonly used isotope-based method for partitioning evapotranspiration. The method relies on a series of simultaneous observations of concentrations and isotopic compositions of atmospheric vapor (c_v and δ_v respectively). Based on these data (or more exactly δ_v as y values and $1/c_v$ as x values), a linear regression line is built with its intercept value taken as the isotopic ratio of evapotranspiration (δ_{ET}). Once δ_{ET} is determined, the relative contribution of transpiration to total evaporation (or F_T) can then be estimated (i.e. according to Eqn. 1 as presented in the manuscript), as long as isotopic composition of each component flux (δ_E and δ_T) is known, i.e., either through measurement or modeling.

Response: We thank the reviewer for the summary of the traditional Keeling plot in solving ET partition method.

The present study proposes an alternative method for estimating F_T. The new method is still rooted in the framework of Keeling plot framework and Eqn.1, but the final equation (see Eqn. 15 in the paper) for calculating F_T does not contain δ_{ET} as an input variable, and so is different from the traditionally used Eqn. 1 in structure. The equation instead contains the keeling plot slope term k as well as the mean value of c_v and δ_v observations made in the time period over which the keeling plot is derived. The authors claim that the new method is more advantageous than the traditional method as it eliminates the need of estimating δ_{ET}, which is known to be a variable that is highly susceptible to estimation error due to some inherent features associated with the keeling method. However, after carefully examining the derivation details, I am sorry to say that the new method fails to deliver any new aspects as claimed by the authors. As a matter of fact, I feel that this new method is exactly the same as the old method, and in what follows I will outline my reasoning.

Response: We thank the reviewer for carefully examining the derivation details and confirm our final derivation results using an alternative approach. We greatly appreciate the reviewer pointing out something likely to be misunderstood of our method. We apologize that our explanation may not be clear enough in the manuscript. In our opinion, the method we proposed is a useful alternative method compared with the traditional one. Details are shown in the following text.

To begin with, I want to point out that the authors used Sine laws combined with graphical presentations of the relationships among δ_E, δ_T, δ_{ET}, δ_v and $1/c_v$ to come up with Eqn. 15 that appears novel at the first glance, yet, such use of somewhat complicated mathematical techniques seems unnecessary, as Eqn. 15 can actually be derived just by simply combining Eqn. 1 and Eqn. 2, as shown below.

We know that,

$F_T = (\delta_{ET} - \delta_E)/(\delta_T - \delta_E)$ Eqn. 1 (or Eqn. 1 in the paper)

$\delta_v = k*(1/c_v) + \delta_{ET}$ Eqn. 2 (or Eqn. 2 in the paper)

Note that Eqn. 2 can be further written into the following:

$\delta_{ET} = \delta_v - k* (1/c_v)$ Eqn. 2.1

where k is the slope of the keeling regression line of δ_v versus $1/c_v$, and δ_v and $1/c_v$ represent the mean δ_v and $1/c_v$ observations respectively.

Inserting Eqn. 2.1 into Eqn.1, and rearrange, we obtain the following:

$F_T = -k/[c_v(\delta_T - \delta_E)] + (\delta_v - \delta_E)/(\delta_T - \delta_E)$ Eqn .3

As is clear this equation is exactly the same as Eqn. 15 as presented by the authors.

Response: We thank the reviewer for carefully examining Eqn. (15) in another way. However, we still believe that our derivation based on the sine law is more general and more informative. For one thing, the direct result from sine-law-based derivation is Eqn. (14) rather than Eqn. (15):

$$F_T(\delta_x) = -\frac{1}{C_x(\delta_T - \delta_E)}k + \frac{\delta_x - \delta_E}{\delta_T - \delta_E} \quad , \qquad (14)$$

where $(1/C_x, \delta_x)$ is a random point on ordinary least squares line of $1/C_{vi}$ and δ_{vi}. Inserting point $(1/C_v, \delta_v)$ into Eqn. (14) is one of special cases. As background/ambient source point $(1/C_a, \delta_a)$ is also on Keeling line (Moreira et al., 1997), we are able to have another relationship:

$$F_T(\delta_a) = -\frac{1}{C_a(\delta_T - \delta_E)}k + \frac{\delta_a - \delta_E}{\delta_T - \delta_E} \quad , \qquad (16)$$

Although this result is not related to point $(1/C_v, \delta_v)$ in this study, we believe that a broader derivation is better than a special case.

For another, the reviewer's derivation needs to simultaneously satisfy Eqn. (1) and Eqn. (2). However, we consider that neither Eqn. (1) nor Eqn. (2) could match conceptual parameter (δ_v and C_v) with the observed individual data points (δ_{vi} and C_{vi}). Eqn. (2) in the manuscript is the Keeling plot relationship. Previously, the source of δ_v and C_v was described as atmosphere vapor (Yakir and Sternberg, 2000; Yepez et al., 2003), which has ambiguous spatial and temporal resolution. The definition of $\delta_v = \frac{1}{m}\sum_{i=1}^{m}\delta_{v_i}$ and $\frac{1}{C_v} = \frac{1}{m}\sum_{i=1}^{m}\frac{1}{C_{v_i}}$ is required for the Keeling plot equation after the sine-law-based derivation is achieved, rather than a known condition for the existing Keeling plot. We apologize that we did not distinguish the conceptual atmosphere vapor source in the Keeling plot and point $(1/C_v, \delta_v)$ in our method. In our sine-law-based derivation, point ($1/C_v$, δ_v) is not related to the Keeling plot. Although Eqn. (15) can be derived by Eqn. (1) and Eqn. (2), the parameter δ_v and C_v will be vague based on reviewer's derivation.

Although Eqn. 3 (or Eqn. 15 in the manuscript) does not contain δ_{ET}, using this so-called new equation to estimate FT actually would still require that δ_{ET} be known, because Eqn. 3 is a result of insertion of the δ_{ET} formula (i.e. Eqn 2.1) into Eqn. 1. In other words, the fact that δ_{ET} is not showing up in your final equation does not necessarily mean δ_{ET} is not needed in your calculation. As a matter of fact, there is no fundamental difference between the new and traditional methods. For example, in the traditional method, we firstly use a set of δ_v and $1/c_v$ values to estimate δ_{ET} based on the intercept of the linear regression, and then in the second step we insert the regression-derived δ_{ET} into Eqn. 1 to estimate F_T. Similarly, the execution of the Eqn. 3-based new method can also be divided into two steps: 1) estimation of δ_{ET} based on Eqn. 2.1; and 2) subsequent calculation of F_T based on the estimated δ_{ET} and Eqn. 1. The only slight difference between the two methods rests on how δ_{ET} is calculated.

Response: We thank the reviewer for the critical and constructive comments. As explained in the previous paragraph, we think sine-law-based derivation is a more general and more informative derivation. We will explain it more in the next paragraph.

The new method would require that the slope term k be calculated from the Keeling regression line, and then using k, and the mean values of $1/c_v$ and δ_v to calculate the δ_{ET} either based on Eqn. 2 or Eqn. 2.1. Apparently, such a procedure is more tedious as compared to that involved in the traditional method in which δ_{ET} is estimated as the intercept from a single step of linear regression. Yet ironically, δ_{ET} estimated this way is in theory the same as that from the traditional method, for the exact reason as stated by the authors, that is, according to Hogg et al. (2005) the point that corresponds to the mean of 1/cv and δ_v should fall exactly onto the regression line, which dictates that δ_{ET} calculated from the mean of 1/cv and δ_v together with k (the linear regression derived slope) must be the same as the intercept value. Therefore, I'm sorry to say that the authors' attempt to bypass the need for δ_{ET} parameterization was not successful, as the new method is virtually the same as the traditional one, except that it is less intuitive and more complicated to use.

Response: We thank the reviewer for the critical and constructive comments. We agree that point ($1/C_v$, δ_v) together with k will determine the intercept δ_{ET}, while our study focuses on how to bypass δ_{ET} and use the alternative ($1/C_{vi}$, δ_{vi}) and k to replace δ_{ET}. Though our final derivation looks more complicated, it quantitatively connects all the measured individual data points and F_T, and it utilizes more information of individual data points (C_{vi} and δ_{vi}) than the traditional method. In addition, the new derivation does not require any new instrument set up except the one already used for the traditional method. Our method has two advantages. First, after we use k and point ($1/C_v$, δ_v) to replace δ_{ET}, the sensitivity contributions of δ_{ET} are distributed into k, C_v and δ_v. Importantly, the uncertainty of C_{vi} and δ_{vi} is relying on the precision of the isotope analyzer, which has the potential to keep improving in the future. As a result, our method potentially reduces the uncertainty of isotope-based ET partition approach. Second, we are able to insert each individual point of ($1/C_{vi}$, δ_{vi}) into our method to obtain a high frequency F_T distribution (the output frequency of F_T could be as same as the output frequency of *in situ* isotope analyzer) when assumed that k is a constant during an observation unit (e.g., 30 min). There is no need for additional assumptions for such calculations. Based on F_T distribution during each observation unit, we are able to calculate a confidence interval of F_T based on our method rather than traditional method. To assess the variation of F_T due to the approximate calculation of Keeling plot relationship, residual sum of squares (RSS) in linear regression of the Keeling plot, was considered. By ensuring the least RSS, each individual point of ($1/C_{vi}$, δ_{vi}) will then regard as ($1/C_{vi}$, $\widehat{\delta_{v_i}}$), where $\widehat{\delta_{v_i}}$ stand for the y-axis value of ($1/C_{vi}$, $\widehat{\delta_{v_i}}$) which on the Keeling plot regression line. We defined F_{Ti} is an idealized F_T value substitute into δ_{vi} as δ_v, and $1/C_{vi}$ as $1/C_v$, which is described as following:

$$F_{T_i} = -\frac{1}{C_{v_i}(\delta_T - \delta_E)}k + \frac{\delta_{v_i} - \delta_E}{\delta_T - \delta_E} \quad , \tag{17}$$

As each individual point ($1/C_{vi}$, $\widehat{\delta_{v_i}}$) on the Keeling plot regression line must meet the relationship in Eq. (14), we have:

$$\widehat{F_{T_i}} = F_T = -\frac{1}{C_{v_i}(\delta_T - \delta_E)}k + \frac{\widehat{\delta_{v_i}} - \delta_E}{\delta_T - \delta_E} \quad , \tag{18}$$

where $\widehat{F_{T_i}}$ stands for the estimated value of F_{T_i} which is exactly equal to F_T. Then the residual error of F_{Ti} (R_i) is shown as:

$$R_i = F_{T_i} - \widehat{F_{T_i}} = (\delta_{v_i} - \delta_v)\frac{1}{\delta_T - \delta_E} = \frac{R_{\delta_{v_i}}}{\delta_T - \delta_E} \quad , \tag{19}$$

where $R_{\delta_{v_i}}$ represents the residual error of y-axis value on Keeling plots. Then we have:

$$F_{T_i} = F_T + R_i = -\frac{1}{C_v(\delta_T - \delta_E)}k + \frac{\delta_v - \delta_E}{\delta_T - \delta_E} + \frac{R_{\delta_{v_i}}}{\delta_T - \delta_E} \quad , \tag{20}$$

as R_i is derived from the least squares regression of ($1/C_{vi}$, δ_{vi}), then we have a normal distribution $R_i \sim N(0, \frac{\sum_{i=1}^{n} R_{\delta_{v_i}}{}^2}{n})$ (Hogg et al., 2005). Then we have another normal distribution $F_{T_i} \sim N(F_T, \frac{\sum_{i=1}^{n} R_{\delta_{v_i}}{}^2}{n(\delta_T - \delta_E)^2})$ based on the properties of normal distributions (for a defined function $y = ax + b$, where a and b are constant real numbers, if $x \sim N(\mu, \sigma^2)$, we have $y \sim N(a\mu + b, (a\sigma)^2)$ (Hogg et al., 2005)), which is the distribution of F_T based on the variation of C_{vi} and δ_{vi} in one observation period. As a result, 95% confidence interval of F_T should be $(F_T - \frac{3}{\delta_T - \delta_E}\sqrt{\frac{\sum_{i=1}^{n} {R_{\delta_{v_i}}}^2}{n}},\ F_T + \frac{3}{\delta_T - \delta_E}\sqrt{\frac{\sum_{i=1}^{n} {R_{\delta_{v_i}}}^2}{n}})$, which means that F_T value will be 95% possibility on this interval (3σ principle) (Hogg et al., 2005). The item $\sum_{i=1}^{n} {R_{\delta_{v_i}}}^2$ is as well as RSS in the OLS regression of the Keeling plots. The length of the confidence interval (l) is then defined as $\frac{6}{\delta_T - \delta_E}\sqrt{\frac{\text{RSS}}{n}}$ (Hogg et al., 2005). More than a specific point of F_T, the new method provided a distribution of F_T for each observation unit, which contains a 95% confidence interval. The example of confidence interval is shown in the following Figure 1.

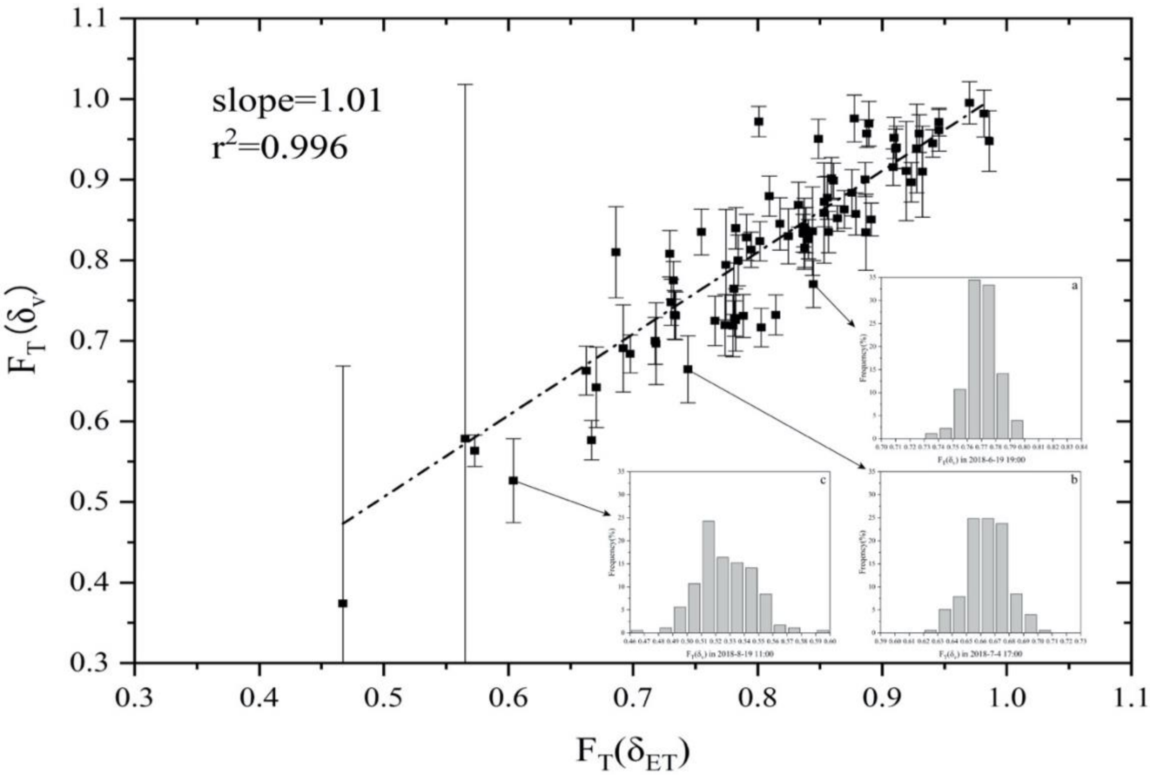

Fig. 1 Scatter plot of transpiration on evapotranspiration ratio by traditional $F_T(\delta_{ET})$ method against transpiration on evapotranspiration ratio by novel $F_T(\delta_{ET})$ method. The distributions of transpiration on evapotranspiration frequency in (a) 2018-6-19 19:00, (b) 2018-7-4 17:00, and (c) 2018-8-19 11:00 were in the bottom right corner.

Reference

Hogg, R.V., McKean, J., Craig, A.T., 2005. Introduction to mathematical statistics. Pearson Education.

Moreira, M., Sternberg, L., Martinelli, L., Victoria, R., Barbosa, E., Bonates, L., Nepstad, D., 1997. Contribution of transpiration to forest ambient vapour based on isotopic measurements. **Global Change Biology** 3, 439-450.

Yakir, D., Sternberg, L., 2000. The use of stable isotopes to study ecosystem gas exchange. **Oecologia** 123, 297-311.

Yepez, E.A., Williams, D.G., Scott, R.L., Lin, G., 2003. Partitioning overstory and understory evapotranspiration in a semiarid savanna woodland from the isotopic composition of water vapor. **Agricultural and Forest Meteorology** 119, 53-68.