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Dear Dr Blume,

I am writing on behalf of the authors of the manuscript titled “Solar forced diurnal regulation of cave drip rates via phreatophyte evapotranspiration” to thank you and the two reviewers for providing insightful and detailed comments on our manuscript. We have taken these suggestions into account in the revised manuscript and have provided a point-by-point response. We hope that our amendments and clarifications are satisfactory. Please do not hesitate to contact me if you require any more information.

Warm regards,

Katie Coleborn

Response to manuscript review

Dear Authors,
I agree with the referees that you have improved your manuscript significantly and I am positive that we will be able to publish it as soon as you made a few minor revisions as suggested by the referees and myself. Please find my suggestions below.
Best regards,
Theresa Blume

Lag time analysis: could the lag also be >24 hours? Please discuss and check.
Did you try shifting the time series for > 24 hours, i.e. several days? Are the results the same?

Lags greater than 24 hours were investigated, and in some cases the autocorrelations were slightly stronger than observed in the 0-24 hour period for example, between 11/02/2013-21/03/2013 at site G1 the strongest correlation occurred at 2.5 days (-0.86). However, this is to be expected in a time series whose fundamental frequency is 12 or 24 hrs. Where stronger autocorrelations were observed >24 hrs, they were typically harmonics of the fundamental frequency occurring at 12 hour intervals, and therefore not a new signal.

Please indicate if the correlations in table 2 are significant (by adding a star or putting them in bold letters), or if they are all significant say so in the caption. I would keep the table in its current detail and not cumulate the values to averages as suggested by Reviewer 2.

Thank you for this suggestion, we have updated the table to specify all correlations are significant.

I would call Figure 2 a table, not a figure. I am not sure if this was meant by the reviewer when asking for a sketch. I think that sketch was supposed to help explain to people who aren't experts in signal processing the steps happening when running the analysis with the toolbox. Would it be possible to provide something like that? If it is not possible to provide such a sketch, very briefly state the different steps within the SST analysis (1 or 2 sentences). If I understand correctly (I am not expert) this is a "sharpening" of a wavelet transform – so to point out the advantage over the wavelet transform it might also be helpful to put those two plots next to each other. That way people can directly see how the CWT "transforms" into the SST and how much more helpful the SST is. I agree with the reviewer that in its current state Figure 2 is basically just text and could be also moved to the text (most of it is in the text already anyway). Also, some parts of this table are not really helpful in understanding the methods (e.g. step 1 or the remark about the color scale).
Thanks for your detailed comments. As requested by reviewer #1, we have now merged Figure 2 into the methodology (excluding the unhelpful bits).

Note that synchrosqueezing was officially added to MATLAB as of release R2016a, where it was named the "wavelet synchrosqueezed transform" (WSST). We have added this to the text, and have revised our terminology and abbreviations throughout the manuscript in order to avoid confusion.

Thanks also for your suggestion of to illustrating the “sharpening” of the time-frequency content by comparing results from the new technique (the wavelet synchrosqueezed transform - WSST) with traditional wavelet analysis (continuous wavelet transform - CWT). We have made a new figure showing the time-frequency content obtained by applying both techniques side-by-side using an example. We believe this new figure is very useful and appropriately illustrates the advantages of WSST in the context of our manuscript.

The description of the different steps involved in WSST is complicated, as this is an advanced signal processing method. Now that WSST has become a recognised and readily usable technique (e.g. through MATLAB), we do not think it is necessary to elaborate on the details as we merely apply this technique to reveal phreatophyte evapotranspiration in cave drip discharge. Instead, we refer the technically minded and interested reader to the literature which contains the details.

Figure 6: remove 96pt from the legend or explain it if you find it necessary. “Daily moving average” might be more directly understood.

Thank you for this comment, we have made the changes to Fig 6.

Figure 7:add unit (years) to the last three plots. Is this supposed to be the age of the trees? Then maybe change the zero to 1 and write “age: 1 year” into the figure.
Figure 7: does it mean something different if the root is accessing the blue part of the storage or just the grey part? If yes please explain, if not it might be helpful to make this similar in the different sketches.
Figure 7: do you really mean hydraulic lift? Or just root water uptake? If you just meant root water uptake do not call it hydraulic lift – see my earlier remarks about this.
Figure 7: sometimes the blue area fills a larger fraction of the box than in other plots (c and d) – does this mean the storages are filled to a different extent? If not, please keep it consistent.
Figure 7: I would add a key word as a header to the different sketches and maybe arrows to show which ones you are supposed to compare. Otherwise you automatically start comparing a) and c) because they are right next to each other, this can cause confusion. Examples for such headers: short flow path, long flow path, large storage, small storage, low uptake, high uptake,…

Thank you for your suggestions on ways to improve Fig 7, we have taken them all into account in the revised figure.

l.525: could this also be the result of compensation as the preferred storage providing water for root uptake dries out and the tree has to shift uptake to wherever water is still available (probably at greater depth)? This would mean the roots were already present at this depth and were put to use once it became necessary. Can we really attribute this strong change between May and August solely to root growth? Assuming a linear relationship this would mean a shortening of the flow path to 1/3 of the original length so an increase in rooting depth by a factor of 3. I know this is just a very rough calculation, but please make sure if this is really the only and most probably hypothesis.

We have amended the manuscript to indicate that our explanation for why the lag time changes is speculative. We have also amended the text to include the alternative scenario suggested.

l.121: what does “well decorated” mean? Please rephrase or explain.

Well decorated means that the cave has an abundance of speleothems, we have amended the text to clarify this term.

Reviewer #1

Summary

The authors implemented many comments raised by the reviewers and the editor and improved the manuscript.

While this is good news, I still stumbled over several issues which need to be resolved before the manuscript can be accepted.

- tendency for overstatements: At various places the authors state that

L29: “This is the first observation of tree water use … “

L497: The first study that shows that tree water use affecting cave drip water …”

L 639: “This is the first volumentric observation if tree water use in cave drip water”

Given the measurements they show that there are diurnal fluctuation in cave drip rates. That this is due to tree water use is likely but not directly measured!

We thank the reviewer for raising this issue and have amended the text to better reflect the nature of our findings for example:

“L29: This is the first indirect observation of tree water use in cave drip water…”

- discussion: Figure 1 shows that the drip rates of sites G6, G8, G12 and M1 are very low compared to other sites. These low values are likely to be affected by considerable measurement uncertainty. Some of the mentioned sites even show fluctuations typical for being at the low end of sensor resolution.

Despite of this potential uncertainty, very specific results of single sites are discussed in terms of tree root dynamics (L560-564) or storage volume (L570-579). I strongly recommend to cut these paragraphs and unclear speculations. This would also help to shorten the somewhat lengthy discussion.

We have included specific examples of periods of fluctuation that relate to the different scenarios in Fig.7 at the request of the editor in a previous iteration of the manuscript. We agree with the reviewer that the measurement uncertainty could be high for sites such as M1, however, we do not think this detracts from the overall argument as we are not stating that transpiration is using X volume of cave drip water, rather we refer to the drip site flow type in general and infer the karst architecture and how this influences the drip water response to tree water use.

- conceptual diagram: I really appreciate addition of the time series sketches. Why are there no differences in a and b despite flow path length? Why is there no difference in h) and i)? Please increase font size.

We have increased the font size to highlight the differences between the sub figures.

- Figure 2 and illustration of spectral method. Both reviewers where asking for more details of the method. Now please put the text of Fig.2 into the main text, excluding some of the unimportant info, e.g. customising color scale etc. If possible give the equation for F f,t

We have now merged the text from Figure 2 into the methodology, as requested. We do not think that the reader would gain from re-stating what is involved in arriving at F(f,t) because it is complicated (not a simple equation) and has been documented in peer-reviewed literature that is properly referenced in our manuscript.

L205: why is the identification subjective? Why not use s threshold of the normalised amplitude? This would make the results more objective, especially if it is argued later on to establish a protocol for drip rate measurement and analysis.

We thank the reviewer for this comment. The frequency components can be distinguished easily from the chaos in the pseudo-colour plots. We have further explained how the criteria for strength, continuity and stability can be automated if the user chooses to do so.

- Table 2 and crosscorrelation results: I also believe that this standard analysis is valuable. Please connect these results with the SST results for the given periods, such as cycles per day and amplitude / phase. This would help to establish the SST method. Also add the minimum / maximum times info given in the text at L279 - 335 as extra column to the table.

We thank the reviewer for appreciating the value in the analysis we have included. We have included additional columns for the timing of the max and min drip rate and specified the periods with 2 cpd fluctuations.

- correlation between potential evaporation and temperature / radiation (L353, L475) is by definition because it is computed from both variables! Please cut these sentences.

Thank you for this suggestion, we have removed the sentences.

- Fig. 6 and related text L464-468: I think that the negative correlation between the 2day averaged Tair and drip rates could be coincidence and not a regular causality as it seems that this only occurred at one site in one week? To establish a better causality would need much more careful investigation and analysis. As this is not the focus of the manuscript I would recommend to cut this part.

We thank the reviewer for this comment, we believe that there is a valid causality between 2 day averaged air temperature and drip rate and have only used one example in the text for brevity and to support the link between the drip rate and tree water use.

- link between diurnal temperature range and 1cpd drip rate signal, L457-463:

Given that the first 10 days in Feb. show high temperature ranges and ET rates but no diurnal cycle in drip rates indicates that more than high transpiration rates are required, to lead to a diurnal fluctuation in drip rates. Considering a simple leaky bucket, it requires that the storage volume, inflow, root water uptake and outflow need to reach a certain state to result into a fluctuating outflow.

We agree with the reviewer that there are multiple factors influencing the occurrence of the diurnal fluctuations. In this section we highlight the influence of solar radiation and in later sections of the discussion, take into consideration the influence of other factors such as storage volume, root uptake, flow path length etc. We highlight the point that complexity of the karst architecture in determining how the diurnal fluctuations are exhibited in regards to lag time and seasonal timing. For example, “Line 641-643 We proposed that the complexity of flow pathways in the karst system accounted for the spatial and temporal variation in the daily fluctuations of drip rate.”

L90-96 This paragraph sounds like final conclusions.

We thank the reviewer for this comment. We included these details at the request of the previous reviewer who suggested emphasising the wider implications of this study in the introduction.

Table1: means of total flow volume are reported? Does this means that there are several drip counters per site which have been averaged? Or are these seasonal averages across different years? Please check this.

The mean total flow volume refers to the monthly mean at each site. We have amended the caption to reflect this.

L155: check unit of radiation

Thank you for raising this issue, we have corrected the units.

L303-308: somewhat loose paragraph

This paragraph has been reworded more concisely.

Reviewer #2

In their re-submission, Coleborn et al present a significantly improved versuion of their previously submitted manuscript. The introduction now includes some statement about the relevance of this study concerning karst modeling. A very nice sketch to elaborate the approach was added and the methodology chapter was improved. Also the discussion is more complete. A time lag analysis with temprature and drip rates was added.

Overall, I feel confident recommending the manuscript for publication now.

We thank the reviewer for their comments.

If the authors think this will help, they may replace the header "comment" with the "elaborations" in the new figure 2 (column 2).
We have included Figure 2 into the main text, as requested by reviewer #1 and the editor.

Also, in order to shorten Table 2 and still make their point, they may consider providing the mean lag time and correlation coefficients (with their standard deviations) for each location.

At the request of the editor we have preserved the format of Table 2.