Dear Editor,
Please find attached the author response to the reviewers' comments of the manuscript "Estimation of deep infiltration in unsaturated limestone environments using cave LiDAR and drip count data" by Mahmud et al. for your consideration. We believe we have addressed all questions raised by the two reviewers of the manuscript.

As requested, we have included a detailed response to reviewer's questions (below). A revised version will be provided once a decision has been made to accept the manuscript.

With kind regards,

For the authors,
Gregoire Mariethoz

Comments to the Author
Interactive comment on "Estimation of deep infiltration in unsaturated limestone environments using cave LiDAR and drip count data" by Mahmud et al.

Reviewer(s) Comments:
Anonymous Referee #1

The manuscript deals on an interesting topic like groundwater flow in the unsaturated zone of karst media considering as pilot site a cave located in SW Australia developed in aeolian calcarenites.

We appreciate the reviewer's comments.

The title is descriptive enough, although the acronym LIDAR should be clarify from the first reference since on page 8897, line 5, is noted as the name of the chamber cave and its real meaning is not explained until 8899, l.17.

Lidar is not an acronym, it is a word which combines 'light' and 'radar', and can be found in the Oxford English Dictionary (http://www.oxforddictionaries.com/definition/english/lidar). Although the word Lidar/LiDAR is thought by some to be an acronym of Light Detection And Ranging and this definition will be provided in the first reference (Page 8895, line 13).

Besides, the authors don't explain why they use this technique. This is just to check, because they have the technique, or is there any special reason?

We have used a FARO Focus3D Terrestrial LiDAR to acquire 3D geological images of the cave ceiling as it is highly capable of capturing hundreds of millions of three-dimensional points coordinates within few minutes. The reason we used LiDAR was that it allowed us to determine the precise position of each ceiling stalactite and its size and shape, which is very difficult to obtain with photographs or with any other remote sensing technique. Moreover, to locate the ground coordinates of individual drip loggers in the cave is also challenging and a high accuracy is necessary to pair each logger with a stalactite. The advent of relatively low-cost LiDAR makes this study possible.

The work is well written and structured. However it is presented like a continuation of a previous paper (Mahmud et al, inpress) that sounds partially described again in present manuscript (particularly on section 3).

We will restructure the manuscript and remove the unnecessary portion that describes the previous paper.

Besides the scope and the interest of the submitted manuscript is unclear. It sounds like the authors have installed a nice underground laboratory, they recorded a lot of data and then they try to give a meaning. This, from scientific stand point may sound potentially interesting, for a better understanding of processes in karst at small (near micro) scale, but this is not really useful in terms of infiltration assessment or unsaturated zone behaviour.

In this manuscript we demonstrate that the morphological properties of stalactites combined with drip rate monitoring is a suitable means by which to classify karst flow behaviour at a small scale. This new methodology will allow future studies to use larger spatial LiDAR data to represent the infiltration properties in unsaturated limestone formations, limited only by the size of the cave. This will be clarified as an avenue of future research in the conclusion.

In the manuscript it is indicated that this new technique can be applied to other cave sites but this sounds really difficult. Difficult to install a large number of drip water counters and difficult to apply LIDAR techniques every places everywhere.

We do not agree here with reviewer's point of view about the application of this methodology in other cave sites. Now-a-days, Zebedee, which is a hand-held LiDAR system (Bosse et al., 2012; Zlot and Bosse, 2014a, b) and drone-mounted systems (Kaul et al., 2015) are available which make LiDAR technology very useful for 3D mapping. Therefore, LiDAR can be easily acquired in most of the cave sites if there is possible human access.

Moreover, the drip loggers have been commercially available for many years (Collister and Mattey, 2008) and are relatively cheap. Therefore, we propose to relate these two emerging techniques, so that infiltration can be estimated based on LiDAR data and a minimal number of drip loggers. LiDAR could also be a useful tool in study sites which already have drip data time series (e.g. Jex et al., 2012; Markowska et al., 2015). We will identify these issues in the text to clarify the application of the process in similar cave environments.

At the end of page 8896, it is given information about how infiltration has been assessed but additional information should be done about its calculation. What method has been applied?

Additional explanation will be provided in terms of modelled evapotranspiration (ET) data which is core in determining the water budget and hence the total amount of infiltration. ET data is collected from the Australian Water Availability Project (AWAP) and referenced in the text (Raupach et al., 2009). According to Raupach et al. (2009), the ET is modelled using the mathematical equations of Priestley-Taylor.

Runoff is assumed zero but not information is given about the slope outside of the cave.

The overall land surface gradient above the cave site is calculated as ~20% using the topography map which has the cave outline properly registered on it. However, there is negligible surface runoff given the high permeability of the sand layer with hydraulic conductivity ranging from 100 to 2000 m/d (Smith et al., 2012). Over several field campaigns, runoff has never been observed at the site. This indicates maximum potential for infiltration through this karstified limestone. This information will be added in the manuscript.

What about the exokarstic features in the study area?

The overlying surface of the Tamala limestone is mantled by sands. Therefore, few karst features are seen on the ground surface except for the occasional outcrop, and the presence of these are far lower than the conventional karst landscape. The cave entrance itself is a large doline. Additionally, in chamber 2 there is evidence of solutional widening generally associated with high-flow sites. These features are documented in Treble et al. (2013) and will be summarized in the manuscript 'site description'.

Are there karst landforms (karren, doline) in the area?

There is no karren within this karst landform. There are occasional dolines e.g. the cave entrance, formed by cavern collapse, but none above the study sites. This feature will be described in the text.

Notation given to drip water points (page 8897, lines 10-15) sounds complicated and difficult to follow in the text. Probably the authors can use a more intuitive reference system considering numbers just for the point, capital letters (A-external chamber, Binner chamber) and initial letters (l-logger and m-manual). Then, notation of stalactites is noted with Arabic numbers (page 8900, lines 23-24).

In terms of the notation used for various sites, we prefer to be consistent with the very first paper published on this Golgotha cave site by Treble et al. (2013).

Figure 3 is not clear enough (too small photos, references so difficult to see) to facilitate comprehension of the text. Sites 2E and 2B are cited in the text but they can't be seen on figure 3.

We will modify Figure 3 to make references and photos clearly visible. Both the sites 2B and 2E are clearly visible in Figure 3b as we will use larger label fonts. These sites are also pictured and indicated by red arrows.

The period of record should be clarified. On page 8901 is noted from October 2012 to March 2015, but in line 19 is noted April 2012 to March 2015. However in figure 4 the records seem to start on August 2012.

The time frame of drip record should be from August 2012 to March 2015 and this typo will be corrected in all places.

On page 8901 is noted that some counters didn't work correctly sometimes and the authors obtain series gaps using statistics tools but it should be more clearly explained.

The drip time series gaps are filled with synthetic data using spline interpolation of the drip data. This will be explained in the text.

Records of figures 4a (particularly dark blue line) and 4b (most of the lines) show apparently too noise with high variation of short period phenomena which are not described in the text. How reliable are these records? A correlation (even spectral) analysis of rainfall (effective rainfall) and drip water flow would be welcome to know how rapid is the hydrodynamic response of the unsaturated zone in the cave.

Our final goal is to calculate the total amount of infiltration through the limestone formation and thus the technique necessitates summing the drip rates over the entire study duration. Therefore, the high-frequency variability within the data does not affect the calculation of cave discharge.

The observed variability is typical of that of previous studies using drip loggers. We present raw data that is not corrected for barometric pressure variations – barometric effects explain the drip variability over the time period of days to weeks, and has previously been observed in porous limestone (Genty and Deflandre, 1998). Spectral analysis would therefore reveal the barometric variations, which are not related to the hydrodynamic response.

When drip rates are of approximately the same frequency as the logging interval (15 mins), drip variability increases and are an artefact of sampling interval, and this is observed at Site 1viii and most of the slow drip sites from chamber 2. This phenomenon will be described in the manuscript.

We appreciate the idea of the reviewer to describe the hydrodynamic response of the unsaturated zone in the cave, which could be done in the future. Therefore we will introduce this discussion in the conclusion as another future possibility.

In figure 4 should be represented the rainfall (or better effective rainfall) on the right axis, for example like a histogram with values increasing from top to bottom. Present figure 4b is unclear: too many lines (particularly figure 4b) and the colour lines of the legend can be not correctly identified in the figure. Are all the records necessary or it can be selected the most representative?

Rainfall data and water budgets are shown in Figure 1 to make comparison with the drip discharge data. As already presented, we do not feel the need to add the rainfall data with Figure 4 which would make this illustration more complicated to read. To clarify Figure 4b, we will plot a few representative time series rather than all of them.

It would be better to separate present "Data analysis and interpretation" section into two different ones (on one hand Results and on the other Discussion).

We will reorganize the entire manuscript as the 2nd reviewer also suggested. Therefore the manuscript will have two separate sections on results and discussion.

Interpretation of figures 5 and 6 is not really argued in the text; it is just an assumption of figure and interpretation.

In Figure 5 and 6, we apply the methodology that was used to investigate different flow patterns classified in Mahmud et al. (2015). We try to focus on particular ceiling areas under which the loggers are placed to determine the individual contribution of these stalactites in terms of flow category. Furthermore, we illustrate how the different flow types are classified in terms of morphological analysis. To clarify the description of Figure 5 and 6, we will summarize the methodology and interpretation of results from preliminary conceptual model developed in Mahmud et al. (2015).

Besides, what is really the contribution of LIDAR tool? How these data and images contribute to a better understanding and how useful could be there in other sites? A classification of flow categories is presented in connection with Mahmud et al. (in press) without really discussion. Two major types of flows and speleothems are presented jointly with an intermediate group, controlled mainly by matrix and fracture flows. However the role of dune bedding is not considered or discussed. The bedding may contribute to lateral flow into the record sites. Thus, correlation with overburden limestones thickness above the drip sites sounds not particularly reliable and the red cylinder represented in figure 10 may be difficult to assume. Points with high correlation may receive recharge from other areas located outside of their vertical or outside of red cylinder (Fig. 10 and page 8906) and conversely spatial dependence noted on page 8904 (line 20), because of lack of correlation, may be the results of a bad drainage from an external area located above the drip water point. In karst all these aspects may be possible (and another such as it is noted at the end of page 8904).

LiDAR measurement is used to image the cave ceiling including individual stalactites. Statistical and morphological analyses of the point clouds produced by LiDAR were then used to categorize the ceiling features into different flow types. Later these flow classifications are correlated with the drip loggers' data to estimate the amount of cave discharge. Moreover, based on the LiDAR coordinates we paired the locations of individual stalactites with drip loggers on the cave floor. The possibility of using LiDAR is to upscale/extrapolate the information to the entire cave system to estimate large-scale cave discharge, based on remote sensed data and a minimal number of drip loggers. This will be clarified in the manuscript conclusion as a future research endeavour.

We thank the reviewer for pointing out the large-scale scenarios within the karst formation. We agree with the reviewer's point of view that the red column represented in Figure 10 could be moved to fit the geomorphology and could go at different angle due to the dune bedding. However, a major finding from this research is that the cave seems to have a capillary fringe effect, with very little recharge entering the cave compared to the overlying surface infiltration. So lateral flow and all the aspects the reviewer mentioned may be important, but that will likely also be affected by the capillary effect. We will discuss all these possibilities in the manuscript.

Concerning the cave discharge estimation (section 5.3), probably is better to consider the integral of the hydrograph (the whole of the volume) instead of average value of drip discharge. How is really determined the area covered by each flow category from LIDAR images? Do you mean the "catchment area" of each point?

We identify 29 individual stalactites that relate with the loggers drip data we placed in two large chambers of this cave site. We then extrapolate these loggers' data to the entirety of both chambers to predict the total infiltration within these areas. This is a fundamental outcome of this study which is made possible by the combination of drip loggers and LiDAR technology. The methodology does not include the area covered by each flow class, rather it counts the total number of stalactites that fall into various flow categories. For example, in chamber 1 we find a total of 1909 individual stalactites in the ceiling, among these 1649 are considered to have matrix flow, 17 are fracture flow, 3 fall into a combined flow category and the remaining 240 are soda-straws. We apply the average proportion of actively dripping stalactites (57%) to these values to only count the active stalactites. More clarification about this recharge quantification will be provided in the manuscript.

Moreover, there could be a possibility for further investigation with more spatially sited loggers covering greater sections of cave. This would reduce the uncertainty involved due to the limited scale of this study and would allow for accurately identifying large-scale flow variability. This is already discussed in the conclusion.

The percentage of active stalactites (71.1 %) should change along the time, so this can affect to calculations.

We agree with the reviewer that LiDAR just provides a one off snapshot and does not capture the temporal variability. However, repeat surveys based on LiDAR are feasible (Kaul et al., 2015; Zlot and Bosse, 2014a, b) and that would be a rapid and easy way of looking at changes over time. We will raise this issue in the manuscript.

How the uncertainties noted on page 8906 can affect to the calculated infiltration data (120-170%)? How are possible these infiltration values? This contrast with the averages values given in the conclusions (60-70%).

The adjacent chamber ceiling portion is dry around the sites, suggesting that infiltration is being focussed to the studied area of each chamber, which is further agreed by the conceptual model we develop (Figure 10b and c). We find that cave discharge per m^2 area is larger than the average surface infiltration (i.e. 60-70% of the rainfall) above the two wettest parts of the chambers and signify water flowing from the surrounding preferential paths to these areas. Infiltration is being focussed to the studied areas of each chamber, by approximately 120 and 170% respectively. This concentrated flow behaviour is the reason for the contrast with the average surface infiltration values given in the conclusions (60-70%). This flow characteristic could explain large-scale variabilities described by the reviewer in their earlier comments. This phenomenon will be described in detail in the modified manuscript.

What may be the storage capacity of unsaturated zone in terms of previous recharge periods?

It is indeed difficult to predict the storage capacity of the unsaturated zone in terms of previous recharge periods. However the Tamala limestone formation does have significant storage within its matrix porosity to deliver uninterrupted cave discharge during periods of water deficit. The slow dripping sites have at least a persistent base flow component, though we observe a slight reduction in drip rates for high drip sites.

How is possible this in an area where highly permeable sandy media exists (as noted in page 8896, lines 1 and 2)?

In page 8896, lines 1 and 2 we describe that the surface consists of weathered siliceous dune sands with high permeability values ranging from 100 to 2000 m/d which points towards insignificant runoff in this area. The porous sand layer is overlying the dune limestone, to variable depths, measured up to 3 m deep (Treble et al., 2013), with more than 30 m underlying dune limestone. Karst in this region is ‘syngenetic’ given that karst development was concurrent with lithification of the host rock (Grimes, 2006). This has implications for other processes that may establish vadose-zone preferential flow in these wettest areas, including preferential vertical dissolution promoted by tree roots (Jennings, 1968), or the varying permeability and/or morphology of the subsurface caprock (Treble et al., 2013).

One additional key point of the manuscript is that it considers only drip data (jointly with LIDAR data) but this only inform about hydrodynamic of the system, not about the hydrochemistry or isotopic data. So, nothing relevant about the flow path or residence time in the unsaturated zone can be inferred from the data.

In this paper we mainly focus on the infiltration flow quantification, not the characterization of flow path or residence time. Hydrochemistery or isotope data are not part of our analysis. However, at Golgotha Cave, the collection of drip logger data is ongoing, as well as analysis of tracers of water movement such as stable isotopes. These data will be the focus of future research to expand the possibility of classifying geochemical properties of drip regimes covering large-scale observation.

In present form, the manuscript is very descriptive (it shows the technique –method and the results with a qualitative interpretation). Without to quantify hydrodynamic response and lacking the hydrochemical information, it is difficult to know the functioning of unsaturated zone. Therefore, the manuscript should be improved.

In this manuscript we perform the first ever attempt at recharge estimation from cave drip data. Our recharge estimate is quantitative, based on discharge data and in line with measured infiltration from surface rainfall. Therefore in terms of the mass balance, the method seems to perform well at least in this cave site. As we already discussed in the reply to the previous comment, hydrochemical data is not the focus of this study.

Minor comments:

Site description section: it should be noted how is the topography on the study area, particularly the slope, since this affects to infiltration/runoff ratio and also if karst landscape exists in the area.

We have already discussed the ground surface gradient and landscape pattern above the cave site earlier in this response letter.

It sounds not adequate to say that study area has Mediterranean climate because after figure 2 it can be seen that rainfall occurs predominantly during the dry months in Mediterranean area

The Golgotha cave site has Mediterranean climate characterized by warm to hot, dry summers (mid-November to mid-February) and mild to cool, wet winters (mid-May to mid-August). This description is now added to the manuscript.

Page 8897, line 9: “Arabic number” instead of “numerical number”

We will change the wording “Arabic numerals” instead of “numerical number”.

Figure 9. The red colour for circles are not suitable since the cave ceiling seems also red-brown. Change the colour. Page 8903, line 10: notation letter for standard deviation and mean are unnecessary Litre, in the international metric system should be noted as “l”.

We will alter the colour in Figure 9 and the notation letter “l” instead of Litre.

Additional references

Carrasco, F.; Andreo, B.; Liñán C. and Mudry J. (2006): Contribution of stable isotopes to understanding the unsaturated zone of a carbonate aquifer (Nerja cave, south Spain). C.R. Geoscience, 338: 1203-1212. DOI: 10.1016/j.crte.2006.09.009.

Mudry, J.; Andreo, B.; Charmoille, A.; Liñán, C. y Carrasco, F. (2008): Some applications of geochemical and isotopic techniques to hydrogeology of the caves after research in two sites (Nerja Cave-S Spain, and Fourbanne system-French Jura). International Journal of Speleology, 37(1): 67-74.

Blondel, T.; Emblanch, c.; Dudal, Y.; Batiot-Guilhe, C.; Travy, Y. and Gaffet S. (2010): Transit time environmental tracing from Dissolved organic matter fluorescence properties in karst aquifers. Application to different flows of Fontaine de Vaucluse experimental basin (France). Environmental Earth Sciences. DOI: 10.1007/978-3-642-12486-0.

We will add these references in the manuscript.

Reviewer(s) Comments:
Anonymous Referee #2

In the submitted manuscript, Mahmud et al present a study that analyses and classifies the stalactites and drip rate behaviour of a karstic cave in South West Western Australia. They use a LIDAR and shape-based classification scheme from a previous study (Mahmud et al., 2015) to map the ceiling of two cave chambers. Using 34 measurement locations they record the drip rate behaviour of a large subset of the LIDAR mapped stalactites. That way they show that distinct flow behaviour can be attributed to the shape classified stalactites. Using this knowledge, the total drip inflow of the two cave chambers is assessed by attributing mean "typical" drip rates of each flow type to all stalactites of the same shape type within the two cave chambers. Knowing precipitation and actual evapotranspiration the authors show that the water infiltrating to the two cave chamber is concentrated in the vadose zone to some extent.

We thank the reviewer for these comments.

The results shown in this study are new and innovative. Therefore, this contribution can be considered valuable for the HESS audience. However, a major part of the analysis is based on a previous study (Mahmud et al, 2015), which is explained and summarized repeatedly, sometimes in a slightly confusing way. I definitely recommend summarizing this study using a preliminary conceptual model description/sketch either in the data or study site description section, and deleting all other summaries of this previous study. That way the manuscript length will shorten significantly, which will make it easier to read.

We appreciate the positive comment and the suggestion provided to restructure the format summarizing the methodology and results of preliminary conceptual model from the previous study. Therefore we will reform the sections and shorten the description from previous investigation.

Another point of criticism is the untypical structure of the manuscript. After introducing data and study sites the authors present some kind of pre-analysis and its discussion, before showing another (primary) analysis with another discussion. In all of them, references to other studies a too scarce and this particular structure may also confuse the reader. If there is no particular reason for this untypical order, please consider using the typical Introduction-Study Site- Methods –Results-Discussion-Conclusion structure.

We will reorganize the entire manuscript to follow the typical paper structure.

Some more elaborations and minor comments can be found in the attached and commented pdf. Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/12/C4162/2015/hessd-12-C4162-2015-supplement.pdf
Additional comments listed in the above mentioned pdf:

Page 8893 line 6: Monitoring or modelling?

We will change the word "constraining" with "Modelling".

Page 8893 line 8-9: Please also cite some standard literature as Ford & Williams, Goldscheider & Drew.
Ford, D. C. and Williams, P. W.: Karst Hydrogeology and Geomorphology, Wiley, Chichester., 2007.

Goldscheider, N. and Drew, D.: Methods in Karst Hydrogeology, edited by I. A. of Hydrogeologists, Taylor & Francis Group, Leiden, NL., 2007.

Both references will be added.

Page 8893 line 22: Reference?

Reference will be added.

Page 8896 line 3: Better define SWWA here again.

Will be defined.

Page 8898 line 7-8: Check language: 2 times “analyse”.

The language will be corrected.

Page 8898 line 21-22: This sentence rather belongs to the Introduction combined with a reference.

We will move this sentence to the Introduction part as a general motivation describing why karst aquifers are exceptional and should be monitored and modelled differently.

Page 8898 line 7-8: The authors should clarify that the preceding paragraph is something like a preliminary conceptual model based on previous analysis.

Will be clarified at the beginning of the paragraph.

Page 8900 line 16-26: Isn’t it enough to mention that each feature from the previous study was paired with one of the devices of this study.

The process of pairing the individual dripping stalactites with the drip logger time series is very challenging and that is why we will describe the process with a couple of compulsory sentences with less description.

Page 8900 line 16-26: Which are?

These groups will be described in the text.

Page 8902 line 5: Classifying by drip rate variability now is confusing for the reader considering the LIDAR based classification in the previous subsection. Please find a clear way of classification.

This is mostly a question of axes scales that need to be different due to the differences in the magnitude of drip values. This is the reason for different plots for chamber 2 in Figure 4(b-d). The wording will be modified in the text to clearly differentiate this illustrative grouping by drip rate variability from the LiDAR based flow classification.

Page 8902 line 8: Subsection 5.1 is results from previous analysis and should not appear in a discussion and interpretation section. This should all be done much earlier when defining the preliminary conceptual model and with thus less detail.

Subsection 5.1 will be restructured with fewer details and removed from the discussion section. We will place this section earlier in the manuscript while describing the preliminary conceptual flow model.

Page 8903 line 12: Did the authors also consider calculating CVs at individual time steps over a group of drips as in Hartmann et al. 2012?

Hartmann, A., Lange, J., Weiler, M., Arbel, Y. and Greenbaum, N.: A new approach to model the spatial and temporal variability of recharge to karst aquifers, Hydrol. Earth Syst. Sci., 16(7), 2219–2231, doi:10.5194/hess-16-2219-2012, 2012.

We do not consider the idea of CV calculation as described in Hartmann et al. (2012), as we principally focus on flow classification based on morphological analysis of cave ceiling stalactites. Moreover, we analyse the raw drip data and to perform this CV analysis we would need to integrate the data over larger time-steps and remove the barometric signal.

Page 8904 line 10: How do these findings relate to the drip classification schemes of other similar studies?
Eg in
Arbel, Y., Greenbaum, N., Lange, J. and Inbar, M.: Infiltration processes and flow rates in developed karst vadose zone using tracers in cave drips, Earth Surf. Process. Landforms, 35(14), 1682–1693, doi:10.1002/esp.2010, 2010.
or
Sheffer, N. A., Cohen, M., Morin, E., Grodek, T., Gimburg, A., Magal, E., Gvirtzman, H., Nied, M., Isele, D. and Frumkin, A.: Integrated cave drip monitoring for epikarst recharge estimation in a dry Mediterranean area, Sif Cave, Israel, Hydrol. Process., 25(18), 2837–2845, doi:10.1002/hyp.8046, 2011.

We observe rates of water movement ranging from 0.5 – 6.5 l/yr for soda-straw stalactites and up to 43 l/yr for icicle flow category in Golgotha cave; 60 – 140 l/yr for combined flow systems and 90 to 2700 l/yr for fracture flow type.

This finding is different to recent studies in Mount Carmel Cave in Israel with higher cave discharges of 320 mm/hr ≈ 2.8×10^6 l/yr (Sheffer et al., 2011) and 1.9 – 3.5×10^6 l/yr (Arbel et al., 2010) for slow drip sites. The combined and fracture flow drip rates are also significantly lower compared to Mount Carmel Cave (2.8×10^6 l/yr for the Intermediate flow to >10.5×10^6 l/yr for Quick flow (Arbel et al., 2010; Sheffer et al., 2011)).

However our drip discharge variations agree with other studies across Australian cave sites (Cuthbert et al., 2014; Markowska et al., 2015; Treble et al., 2013; Jex et al., 2012b). We will add this comparative discussion in the manuscript with additional statistics e.g. the mean drip discharges with variabilities for the classification scheme.

Page 8905 line 10: This should be mentioned in the methods section, not here. Also the description should be more precise. Was this analysis done manually or automatically? Also, the authors could consider providing a table that summarises all drips and the number of active drips for each classification group.

We will move this text to methodology section with more clarification on the process. The counting of active stalactites is performed manually from a series of digital photos covering the ceiling portion just above the drip loggers.

It is not possible to identify the water beads from LiDAR images. For this reason we cannot automatically count the active drips on large ceiling areas and we have to use photographs taken with flash that are only representative samples for each chamber, and we use an average value for each chamber individually, rather than for each flow category.

Page 8905 line 21: The mean measured discharge?

Will be rephrased with the addition of the word “mean”.

Page 8906 line 14: How do these results relate to other case studies?

Focused diffuse flow is evidenced in Golgotha cave by saturated rock viewed in vertical cross-section in the cliff face and from within the cave ceiling, by clustering of soda-straw stalactites (Treble et al., 2013). These observations will be presented in the text for justification.

We do not know any demonstration of focused flow at the scale of cave-drips in other case study that could be related to our results.

Page 8907 line 8: Figure 10 is the concluding Conceptual model of this study. Some more explanation & highlighting would certainly be justifiable

We will introduce Figure 10 as a conceptual model of Tamala limestone in Golgotha cave. In this conceptual model we show near-vertical water movement, but there could also be lateral movement along the dune bedding. The bedding shown in Figure 10, is based on the geometry that we observe in the lowest part of the cave which is the third facies. For the upper part of the cave, the depicted bedding direction/angles are indicative only because it is much harder to see in the ceilings of chamber 1 and 2, due to the weathered surfaces and the ceilings in the studied areas that are relatively featureless. We will clarify all of these points in the revised manuscript.

Page 8908 line 18: Some more elaboration on impact for karst and speleothem research communities, please.

The methodology developed in this paper allows estimating deep infiltration without measuring rainfall or ET. Usually, recharge is calculated based on rainfall and ET. Here, we estimate the amount of cave recharge, so the method could be useful to estimate ET which is difficult to measure. This will be mentioned in the manuscript.

Page 8920: Is this from the previous study? If yes, provide reference in figure caption.

We will add the reference in both Figures 5 and 6, as suggested.

Additional References:

Bosse, M., Zlot, R., and Flick, P.: Zebedee: Design of a Spring-Mounted 3-D Range Sensor with Application to Mobile Mapping, Robotics, IEEE Transactions on, 28, 1104-1119, 10.1109/TRO.2012.2200990, 2012.

Collister, C., and Mattey, D.: Controls on water drop volume at speleothem drip sites: An experimental study, J. Hydrol., 358, 259-267, http://dx.doi.org/10.1016/j.jhydrol.2008.06.008, 2008.

Cuthbert, M. O., Baker, A., Jex, C. N., Graham, P. W., Treble, P. C., Andersen, M. S., and Ian Acworth, R.: Drip water isotopes in semi-arid karst: Implications for speleothem paleoclimatology, Earth Planet. Sci. Lett., 395, 194-204, http://dx.doi.org/10.1016/j.epsl.2014.03.034, 2014.

Grimes, K. G.: Syngenetic karst in Australia: a review, Helictite, 39, 27-38, 2006.

Jennings, J.N., 1968. Syngenetic karst in Australia. In: Williams, P.W., Jennings, J.N. (Eds.), Contributions to the Study of Karst. The Australian National University, Canberra, p. 110.

Jex, C. N., Mariethoz, G., Baker, A., Graham, P., Andersen, M., Acworth, I., Edwards, N., and Azcurra, C.: Spatially dense drip hydrological monitoring and infiltration behaviour at the Wellington Caves, South East Australia, International Journal of Speleology, 41, 283–296, 2012b.