Hydrol. Earth Syst. Sci. Discuss., 11, C4786–C4794, 2014
www.hydrol-earth-syst-sci-discuss.net/11/C4786/2014/


Hydrology and Earth System Sciences
Discussions

# *Interactive comment on* "Influence of rain pulse characteristics over intrastorm throughfall hot moments" *by* J. T. Van Stan and T. E. Gay

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Received and published: 31 October 2014

We thank referee #1 for their comments on our manuscript! As we see it, the referee points out two main concerns with the manuscript in its current form: (1) imprecise language and (2) the theoretical basis of our analysis. We will correct the imprecise language in the line numbers indicated below and defend the theoretical underpinnings of the methods. Below, please find excerpts from the review and our responses in bold.

Comment: In the title and P11376L12: words enclosed in quotes means they are not being used literally and more precise wording is needed.

Response: The use of "hot" and "cold" in terms of high and low transport/biogeochemical activity, respectively, have been common terms of the field since



the early 2000's (e.g., McClain et al., 2003). These terms are further clarified as to their specific definition in this study under the methods section 2.3. (Pulse delineation and defining a throughfall "hot moment"). We will move this discussion of what "hot moment" specifically means for our study to the introduction.

Comment: temperature is not being analyzed.

Response; That is correct. Precipitation type was exclusively rainfall and, as far as the authors are aware, there is no basis in the literature for its inclusion. The authors note that referee #1 also does not provide any basis in the literature for inclusion of temperature data's influence over throughfall. As a result, we will not include temperature data in the analyses.

Comment: P11337L6-10 not all that is stored is evaporated and none that penetrates gaps also drips.

Response: The statement does not state that "all that is stored is evaporated" nor does it state that gap throughfall contributes to drip throughfall. The English conjunction "and" simply connects two phrases, meaning "in addition to", "besides", etc (according to Webster's dictionary). It does not mean that each phrase is dependent on the other in its entirety (e.g., that rainfall "is stored and evaporated" only means that each process occurs in addition to, or beside, the other. . . not that "all that is stored is evaporated"). As such, the statement was not changed.

Comment: The global range of throughfall is greater than 70-90%.

Response: We will change the wording to add the words "generally falling between 70-90%".

Comment: P11337L16 the cited papers don't all support that throughfall spatial and temporal variability control those processes, so what is the point of this sentence?

Response: This statement by referee #1 is a misrepresentation of line 16 on pg 11337, as P11337L16 does not state or even imply that these references indicate "throughfall

spatial and temporal variability control those processes". It says that throughfall has been linked to these processes by these references (which is true and not debated by referee #1). As a result, we will not change our statement.

Comment: P11338L1-12 this paragraph is convoluted and unclear.

Response: Without specifics as to what is "convoluted and unclear" about the paragraph, we are unsure what to change. We believe the paragraph clearly states that (a) much past research has examined throughfall temporal and spatial persistence, (b) a great body of literature examines meteorological and stand structure controls over throughfall, and (c) that more research is needed at the intersection of these two research veins. It then goes on to describe common throughfall enhancement mechanisms individually. Finally, we conclude with the question: how may throughfall behave at the interaction of these mechanisms? Without specific information as to what referee #1 finds "convoluted and unclear", we will not alter the paragraph.

Comment: P11338L8 what does "combi-nations of thresholds of conditions" mean?

Response: The statement is incorrectly quoted. The line actually reads "combination of thresholds in these conditions". This means combinations of meteorological variables exceeding a particular magnitude or intensity over which throughfall may be enhanced. As the statement is incorrectly quoted and we believe it to be clear in its current form, it will not be changed.

Comment: The basis of the analysis is ad hoc classification of temporal variability within storms, which was done free of basis in the meteorological literature.

Response: There is, indeed, literature basis for both classification of pulses and the application of thresholds. To begin, the literature agrees that throughfall percentage is enhanced beyond the gap fraction only after saturation of canopy surfaces (the exact saturation threshold is debated) – see the latest review on canopy water storage estimation and measurement by Friesen et al. (2015). There are also studies showing



that this canopy water storage threshold is altered by exceeding magnitudes in certain meteorological conditions – particularly for wind speeds and rainfall inclination angle (e.g., Herwitz and Slye, 1995; Van Stan et al., 2011). Discussion of these references already exist in the manuscript yet appear to have been overlooked by referee #1. As this literature basis exists, and is within the existing manuscript, we believe that we have shown our methods to not be "ad hoc" (as asserted by the reviewer). In support of our position, the authors also note that referee #1 failed to provide literature basis against the use of classifications and thresholds in biometeorological research (which is a common practice with basis in substantial literature).

Comment: Buried within the methods in section 2.3, is this statement of objectives (P11342L25): "This study seeks to iden-tify transport-driven hot moments during storm events (specifically, enhanced transla-tion of rainfall pulses into throughfall pulses by forest canopies) and characterize the combination of meteorological thresholds under which these throughfall transport hot moments occur." The justification for this concept (on the following page) comes incon-gruously from the soil biogeochemistry literature.

Response: We will move this section to the introduction as stated in response to a previous comment. We argue, however, that the justification is not unfounded (as shown in the comment preceding this one). In addition, since the statement to which referee #1 refers (P11337L16) was misrepresented by referee #1 (see previous page), we disagree that the relevance of our objective is "incongruous" with the biogeochemical literature.

Comment: Among the ad hoc decisions were: (1) eliminate about half the data because temporal patterns of throughfall were com-plex (P11342L11-16); (2) analyze medians of data and use nonparametric statistics; and (3) define "the lower threshold of any throughfall transport hot moment to be 80% of the corresponding rain pulse" (P11343L7-8) (which appears to mean the same thing as "when throughfall amounts are considered high relative to the norm (we chose > 80% of rainfall for this site)" (P11343L25-26). I think this means time periods during which throughfall rate > 0.8 *

rainfall rate, but I am not completely sure). It is possible that the primitive analysis has led to some interesting and reliable findings, but it is much more likely that it has biased results in undetectable ways.

Response: (1) Claims that substantial data were eliminated “ad hoc” because their temporal patterns “were complex” is simply untrue and unsupported by the text in the manuscript. Firstly, the pulses removed from the analysis were removed solely because the throughfall drainage phase overlapped with the proceeding pulse’s beginning, making it impossible to directly measure those pulses’ total throughfall without constructing (truly ad hoc) some indirect way of separating them. Secondly, we believe that 69 discrete and directly-quantified pulses relatively evenly spaced throughout the year provide substantial insight into throughfall dynamics at this site. (2) Using medians and nonparametric statistics is justified by the data being not normally distributed in their distribution, making these decisions not ad hoc (by its very definition). This was stated in the methods (P11343L10). (3) Referee #1 is mistaken regarding from what variable the 80% is derived. It is 80% of rainfall amount (mm) measured from an individual rain pulse – not the 5-minute rainfall intensity. The data is analyses on the “pulse” level as is clearly stated in the introduction (lines P11339L6-18), methods (lines P11342L8-16), and throughout the results/discussion – as well as indicated in Tables 1-2. It was also not ad hoc, as the reasoning behind the selection of this threshold is described in lines P11342L28-P11343L8 (to be moved to the introduction). (4) It is unclear to us, considering the above 3 response points, how the analysis is “primitive”, and how these selections have “biased results in undetectable ways”. If referee #1 could kindly provide direction as to how we may address the “undetectable” biases, we would be grateful and attempt to ameliorate them. As the comment stands, if there are no specific biases detected by the reviewer it is impossible for us to evaluate and correct them.

Comments: Unfortunately the hypotheses are not written clearly enough to be evaluated, or to determine whether the research adequately tests them.



Response: As referee #1, again, fails to provide specifics as to what aspects of our hypotheses are “unclear”, we fail to see how to improve their clarity. We opine that the following hypotheses (as detailed in lines P11339L13-18) are clear, but attempt to provide clarification as follows: “That intrastorm rain-throughfall pulses will: 1) generally cluster into beginning or internal storm pulses under more dry or wet atmospheric conditions (i.e., higher vs. lower VPD) 2) produce significantly different throughfall amounts for each pulse cluster type 3) generate hot moments in throughfall generation ($\geq$ 80% of rainfall) under consistently high wind, low vapour pressure deficit (VPD), and high rain intensity conditions across the pulse cluster types as this will minimize the epiphyte’s storage effect."

Comments: P11340L2-3 please check whether this meteorological description is correct. I do not think the Bermuda High affects winter weather at the site.

Response: Referee #1 is correct, the Bermuda High does not “drive fronts northward”. As such, this statement will be removed.

Comment: P11341L5 one km is a long distance for rainfall-throughfall data paired at 5 min inter-vals. I suspect much of the 50% of disregarded data may have been from incoher-ence between rainfall and throughfall plots? This might have systematically biased the results to only contain large-scale meteorological events.

Response: We agree that 1 km distance for rainfall-throughfall pairing is a long distance, although distances of this nature are common (e.g., most work from Levia or Inamdar at the Fair Hill CZO satellite site doing work at similar temporal scales and with more complex terrain exceed this distance: $\sim$1.5 km, see Levia et al., 2010; 2011; 2012; Siegert & Levia, 2014; Inamdar et al., 2012; 2013). We disagree, however, that this resulted in the significant removal of data as (stated earlier) data not included was done so solely on the basis of being unable to directly quantify the throughfall response to discrete rain pulses. Referee #1’s statement also indicates that they are mistaken as to how the analysis was performed – as stated earlier, the analysis was done using

individual pulses, not by comparing instantaneous 5-minute data pairs (as incorrectly asserted by the reviewer). One final point: this is the nearest clearing on this preserved barrier island landscape and, as evidenced by Figures 2 and 3, rainfall here matches throughfall very well (likely because the terrain is relatively homogenous and flat).

Comment: P11342L11-16 what is an “identifiable pulse?” The lack of clarity here makes me won-der what was different about the “identifiable” periods of throughfall as compared to those “too close together.” This is a critical step in the analysis, because it controls what data are admissible and seems likely to have biased the analysis against some important meteorological conditions. If my math is correct, it appears at least half the data were removed at this step (in terms of time). Later (P11346L6), we learn that 73% of the rain was retained in the “identifiable pulses,” which suggests that “identifiable pulse” probably means “period of high-intensity rainfall.”

Response: We will reword the term “indentifiable” to “discrete and measureable” in order to more clearly indicate that we are looking for throughfall responses that do not overlap. The remainder of this comment consists of illogical and unquantified claims that culminate in an odd assertion with seemingly no basis. Specifically: how does the fact that $\sim$70% of rainfall is retained for the analysis evidence that only “periods of high-intensity rainfall” are included? If referee #1 only looked at Table 1, they would have observed that we have a wide range of rainfall intensities for all clusters (with a median intensity that is rather low – 0.8 mm h-1). Therefore, the odd assertions of referee #1 in this comment are clearly of no sound basis.

Comment: The cluster analyses that defined pulses need more thorough description. Among the unanswered questions that bear strongly on the interpretation of the results: (1) what distance measure was employed, and were variables transformed prior to analysis? (2) what trimming rules were used–how was the number of clusters chosen? and (3) what relationship does the concept of “pulse” in this manuscript bear to any meteorological concept of pulse? There is a large literature on the parameterization of pulse models for rainfall that is not referenced in this manuscript.



Response: (1) As discussed earlier, there is substantial literature evidence of the existence of thresholds in rainfall-throughfall processes. We will repeat what was said earlier: The literature agrees that throughfall percentage is enhanced beyond the gap fraction only after saturation of canopy surfaces (the exact saturation threshold is debated) – see the latest review on canopy water storage estimation and measurement by Friesen et al. (2015). There are also studies showing that this canopy water storage threshold is altered by exceeding magnitudes in certain meteorological conditions – particularly for wind speeds and rainfall inclination angle (e.g., Herwitz and Slye, 1995; Van Stan et al., 2011). (2) As for pulse characterizations the following cluster analysis details will be added: (a) no data transformation was done prior to analysis, (b) the distance measure employed was Euclidean, and (c) the cut-off was done visually by selecting the distance measure which cut the clusters into the largest distinct groups in the dendrogram. (3) There is, of course, evidence in meteorological literature to support clustering pulse types. Meteorological inquiry is full of categorization across all scales – from air mass classifications to individual storm type classification. (4) Referee #1 suggests there is a large literature on this subject not referenced. We believed we had referenced this field appropriately. Could they please provide a few references that we have missed?

Comment: There is a lot of interesting discussion; but without clear physical basis for the analy-sis, the discussion is a series of just-so stories to explain various phenomena in the complex results.

Response: We disagree and believe we have defended the study with our responses above, our revisions, and more importantly, within the manuscript itself.

Comment: The conclusions make it sound as if the groupings of rainfall pulse characteristics and thresholds in responses emerged naturally from the data, when in reality the analysis forced these to occur: cluster analysis always finds clusters and categorizing data always forces thresholding

Response: Again, we disagree, believing that the clusters and thresholds emerged naturally from the data. We look to the reviews of other referees and editors to refute or support this opinion.

References not included in the manuscript:

Friesen et al., 2015, Evolution of forest precipitation water storage measurement methods. Hydrol. Process., In press.

Inamdar et al., 2012, Dissolved organic matter (DOM) concentration and quality in a forested mid-Atlantic watershed, USA. Biogeochem., 108: 55-76.

Inamdar et al., 2013, Temporal variation in end-member chemistry and its influence on runoff mixing patterns in a forested, Piedmont catchment, Water Resour. Res., 49: 1828-1844.

Levia et al., 2010, Temporal variability of stemflow volume in a beech-yellow poplar forest in relation to tree species and size. J. Hydrol., 380: 112-120.

Levia et al., 2011, Atmospheric deposition and corresponding variability of stemflow chemistry across temporal scales in a mid-Atlantic broadleaved deciduous forest. Atmos. Environ., 45: 3046-3054.

Levia et al., 2012, Stemflow and dissolved organic carbon cycling: temporal variability in concentration, flux, and UV-vis spectral metrics in a temperate broadleaved deciduous forest in the eastern United States. Can. J. For. Res., 42: 207-216

Siegert & Levia, 2014, Seasonal and meteorological effects on differential stemflow funneling ratios for two deciduous tree species. J. Hydrol., 519: 446-454.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 11335, 2014.