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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the Use of Measurements from a Commercial Microwave Link for Evaluation of Flash Floods in Arid Regions" *by* Adam Eshel et al.

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We would like to thank anonymous referee #2 for his review.

Comment: In general, a "smart" integration of rainfall data from different sensors, to better understand and predict flash floods should be scientifically encouraged. But, the underline assumption in these approaches is to build on the larger strength of each sensor. Knowing the large sensitivity of flash floods (and in particular desert flash floods) to rainfall spatial variability it is hard to understand why the proposed integration approach does not utilize the radar rainfall spatial distribution over the catchment and use the more accurate CML rainfall estimate to correct the mean rainfall bias? The

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main advantage of the radar rainfall is their spatial distribution and full coverage of the catchment while the main advantage of the CML rainfall is its accuracy and its mean areal nature (as opposed to point data from gauges). So, correcting the radar bias with the CML data seem as the most reasonable way to go. The authors should explain why did they choose the specific approach presented.

Response: A similar topic was raised by Francesco Marra earlier in the current discussion, hence our response may contain some overlaps. This subject was studied in the past (e.g., Cummings et al., 2009) in a relatively well gauged area. Further progress can be done in adjusting the rainfall field as well as the implementation to flood applications. In this study we chose to focus on a very specific aspect: the effect of the spatial distribution along the link on the hydrologic response. This aspect, apart from providing a better understanding of the CML "behavior" when encountering different rain patterns, can constitute an important first step of a future study which will include your suggestions in a non- well gauged, semi-arid area. We believe the fundamental understanding of the advantages, limitations and the CML rain rate-runoff response are crucial as a first step.

Comment: In addition, the scientific message of the main result of the paper, i.e., the k-CMLR relations (Figure 8), is not clear. Is the main point here the negative high correlation exists between mean areal rainfall and kurtosis for flood producing storms? or is it the envelope curve suggesting that for a given mean rain intensity (CMLR) one can identify a threshold kurtosis that supports flash flood generation? These are two different things. If the first one is the main message – this is a nice result (but must be more carefully checked and especially understand the kurtosis nature), but it is not related to flood prediction. If the second – then the high correlation is not an issue. Also, looking at figure 8 it seems that most of the circles are right to 1 mm/h (there are some points without circles with larger rain intensity but also there are quite few such points above the envelope curve), so – does the information about the kurtosis really improve prediction?

Response: Thank you for bringing up this issue. We also grappled with the envelope curve. As the data are so rare we decided that claiming such a curve would be too early, but nonetheless, a dedicated curve methodology perhaps should be reconsidered. First, we intend to claim the connection is sealed by a lower curve. As we used quite a sensitive threshold for the hydrologic response (Δ=1 m3 s-1), we consider the captured data points represent a lower bound to the "real" envelope, which we claim exists.

Specific comments:

Comment: Sources of errors in CML rainfall estimates: it would be beneficial to give the reader the sources of errors in the introduction section (1.1). Also, if possible please provide some quantitative information about the typical errors. For example, "CMLs can provide a fair ground truth for rain in populated areas, where the networks are denser." – it would be good to give the values of errors from this analysis.

Response: Sources of error can certainly be added.

Comment: P. 3 line 21-26: The authors write that "The approach is a complementary integration, using the advantages of each rain monitoring instrument to compensate the weaknesses of the other, with respect to the hydrological responses measured. . .". I tend not to agree. The weakness of the CML is that it does not cover the entire catchment and also provides too coarse resolution data; its advantage is the higher accuracy. The opposite for the radar data. How does the suggested approach use the advantages of each method to compensate the weaknesses of the other? To me it is not clear.

Response: The approach aims to enhance the contribution of the CML, is in its inner rain rate variability. You tend not to agree, but in our perception of your comment it is either that you do agree or that the complementary point of view was not well understood, and therefore needs to be amended. The claim is that the spatial resolution of the link is not sufficiently good, but at the same time constitutes a ground truth, whereas the radar is not accurate quantitatively but reveals the spatial distribution. We utilize both aforementioned strengths.

Comment: P. 4 L 10: “This implies that most of the annual rainfall is recorded by gauges located in the western part of the basin, as is the studied CML.”. But not necessarily most of the flood producing rainfall is upstream, because of the lower infiltration rates at the downstream part.

Response: This was mentioned in the description of the basin in the “Study region” chapter, but will be amended to be more specific. The nature of the rain shadow is that the majority of the storms approach from the west, and thus, all the events chosen for this analysis are such. Of course, different approaches and more CMLs from the vicinity can be used to cover a larger area, thereby leaving less blind spots. But, this additional aspect belongs to the next step of this research, which should be a Proof of Concept, including more links, spatial observations, and methods of calibration to determine how the radar can be made more trustworthy where CMLs are not present. At the moment we are in the stage of demonstrating the concept, therefore such details can not be covered as yet.

Comment: P. 4 L 27: Discharge estimation: it is not clear how from two velocity measurements one can derive the discharge of the full hydrograph for the five events. Please clarify.

Response: Water velocity measurements were possible during two flood events (a considerable achievement considering the remote location, the rare occurrence of flash floods and their limited predictability). In both cases, velocities at various depths were measured, thereby forming Figure 5, from which the the depth-velocity curve was derived.

Comment: Figure 5: seems not to be referred in the text.

Response: Thank you. Will be added in P. 4 L 28.

Comment: P. 5 L 13: how are the parameters given (a and b) different from the published parameter values for this configuration (wave length, etc.)? are you sure the only cause of these different parameter values is the use of min and max data rather than continuous data?

Response: The power law parameters are published by the ITU (ITU P.838-3). From there, the specific a and b parameters for a given configuration (i.e., the frequency and the polarization of the signal) can be taken. However, these parameters are based on the instantaneous power law (meaning - that an instantaneous rain intensity value (in mm/h) at a given time (t) will cause a path-attenuation at the same time (t) (in dB/km), which can be calculated using a and b). In our case, we merely have access to the minimum and the maximum TSL and RSL values at 15-minute intervals, from which the approximated minimum and maximum attenuation values within the 15-minute interval can be calculated. It was recently shown that the same power law-like relationship can be used to relate the averaged rain-intensity within the 15-minute interval with the maximum (or minimum) attenuation value, by taking a calibrated "a" parameter (Ostrometzky et al., 2016). The calibrated "a" parameter is indeed a function of the original published ITU "a" parameter, and thus, it remains a function of the specific signal frequency and polarization.

Comment: Kurtosis: rain rates have typically very skewed distributions. How well does the kurtosis parameter describe the heaviness of the tail for skewed distributions (as opposed to normal distributions)? Is it independent of skewness? What other parameters were proposed in the literature to describe tail thickness?

Response: Concerning symmetric distributions, the odd cumulants are zero whereas the even ones, for $k>2$, represent a change from the gauss distribution. The kurtosis is a fourth order cumulant which is highly important as it contains the information about the manner of the change. There can be additional data about the tails in cumulants of higher order but their calculation is rather cumbersome and inserts errors, and moreover, their contribution is generally negligible.

Comment: Section 5: this section is not clear - why is classification needed? Classification of what Please clarify what is the goal of the methodology described in this section and its rational.

Response: The classification relates to the description of which hydrological responses and their k-CMLR pairs are chosen eventually. The aforementioned is the goal of this technical section.

Comment: P. 7 L. 18: the velocity given is the wave celerity rather than the water velocity.

Response: Thank you for the correction.

Comment: P. 7 L. 30: why to consider discharge derivative? Please provide the rational.

Response: As hydrographs, especially in this area, are reacting with sharp increasing discharges, the discharge derivative points directly on a response to high rain intensity.

Comment: P. 8 L. 18: rain gauges are used to check the storm spottiness, but this can suffer from all the problems related to point representation of the storm that are well known. Why not use the radar data instead?

Response: Rain gauges du suffer from the above but are nonetheless acceptable for this purpose. Moreover, as we are using the radar to represent the spottiness nevertheless (in the form of kurtosis), we wanted to provide a proof to our claim by another instrument.

Comment: Figure 8 presents red and blue points indicating different wetness conditions. I would expect the author to check if these two data sets present any (statistically significant) different behavior. Such a difference is not clear from the visual inspection of the figure. What is the message in Figure 8 (see my major comment above)? The authors must better clarify it.

Response: The division to blue and red points was mainly to strengthen the claim that the envelope curve is valid only only up to a certain rain intensity value which should be close to the saturated hydraulic conductivity coefficient of the basin. It is described in detail in our opinion but can be further explained if necessary.

Comment: Discussion section: reading this section I feel it should be the continuation of the previous section showing figure 8. The text in section 7 refers mainly to the results shown in this figure. This is not a standard discussion section where more general issues are raised and the results of the present study are discussed with relation to other studies. I suggest to combine this part into Section 6.

Response: Thank you. This can be done if necessary.

References: Cummings et al., 2009 Ostrometzky et al., 2016

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