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Hydrology and Earth System Sciences
Discussions

Interactive comment on "How rainfall event characteristics affect the applicability of I_{30} as an index of intense or erosive rainfall: a brief review with proposed new rainfall index" *by* David L. Dunkerley et al.

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I thank anonymous referee #4 for taking the time to read my manuscript, and for their helpful comments. The referee makes four points, to which I have responded in order.

1. The referee argues that my manuscript does not sufficiently refer to prior publications that evaluate the use and limitations of I30. I am certainly aware of many studies that have proposed alternative indices of rainfall erosivity in relation to soil erosion, and the literature in this area is, as the referee points out, extensive. There are large

compilations of data on EI30 as an erosion index (e.g. Oliveira et al. 2012, Catena 100, 139-147, for rainfall erosivity in Brazil). A wider review of rainfall erosivity was provided by Nearing et al. (2017, Catena 157, 357-362). However, my manuscript was not intended to provide a commentary on I30 primarily in relation to soil erosion, but, as the title suggests, on the use of I30 as an index of intense or erosive rainfall. Indices of rainfall intensity are widely-used to describe or characterise rainfall in applications that are quite unrelated to soil erosion. Such applications can be found, for instance, in studies seeking to understanding flash flooding in urban environments. I think that a focus on I30 in relation to erosivity would not accord well with the orientation of my paper, which was on the extent to which I30 can be used to characterise or describe rainfall as a stand-alone index, and not the extent to which, perhaps as a component of the EI30 index, it can be used to account for soil erosion, though that is certainly one potential area of application. I certainly think that a review paper exploring the history of rainfall intensity indices would be valuable. In the meantime, I do appreciate the point made by the referee concerning the acknowledgment of prior work, and will make sure that I add some citations such as Usón and Ramos (2001, Catena 43, 293-305).

2. The referee thinks that my comments about the inapplicability of I30 to events shorter than 30 minutes duration are misplaced. I think that here the referee has in mind the estimation of I30 in short events simply by doubling the rainfall amount. Thus, the referee suggests that a rainfall depth of 7 mm recorded over 23 minutes represents an I30 value of 14 mm h-1. Though I am aware of this procedure, I cannot see any reasoned basis for it. It is evident that in the case of the rainfall referred to, the mean equivalent intensity (assuming that the rain fell at a constant rate) is $\sim$ 18.3 mm h-1. It is difficult to see how an I30 value of 14 mm h-1, supposedly an index of intense or erosive rainfall, can represent rain whose actual intensity was nearly 31% higher, at $\sim$ 18.3 mm h-1. The second example presented by the referee suggests that I30 for rain of 2 mm and 5 min duration is 4 mm h-1. I again find this difficult to accept as a meaningful index of the rainfall, since the mean equivalent intensity in that case is 24 mm h-1, which is 500% larger. The oddity of the proposed procedure is evident if

one compares a rainfall event of 10 mm in 29 minutes, for which I30 according to the procedure suggested by the referee would be 20 mm h-1, and an event of 10 mm in 31 minutes, for which (assuming constant rainfall rate) I30 would be $\sim$ 9.7 mm h-1, or less than half the I30 of the event that was just 2 minutes shorter in duration. It seems to me that if this kind of data processing protocol were to be followed, then explanatory power of the resulting indices would be very low in the case of short events, and that confusion would also arise in the interpretation of the data from those events slightly longer than 30 minutes.

3. The referee raises concerns about whether short rainfall events have any importance for landsurface processes. The referee argues that '. . . the general lack of analysis of these small events in hydrological and soil erosion studies is caused by absence of any active hydrological response in terms of runoff and/or sediment production'. The referee notes that they accept that short rainfall events delivering depths of 10 - 15 mm '..may induce runoff under some particular conditions ..'. I can certainly refer the referee to my published data on rainfall events at the arid location Fowlers Gap. There, a rainfall of 10 mm is at about the 70th percentile of rainfall event depths, and a rainfall of 15 mm exceed the 80th percentile of all event depths. For wet topical Millaa Millaa, 10 mm depth occurs at the 77th percentile of all rainfall event depths, while 15 mm represents the 82nd percentile of all rainfall event depths. Most rainfall events at both sites are therefore smaller than the depths referred to by the referee. At Fowlers Gap, 15% of all rainfall events are shorter than 30 minutes. I can also confirm that a rainfall of 10 - 15 mm in 30 minutes at Fowlers Gap would result in ecologically-important runoff at hillslope scale. Such events would also result in runoff in many urban contexts.

4. The referee criticises the lack of experimental data with which to evaluate I30 and EDf5. They note that "This reduces the present analysis to a simple climatological characterization of rainfall series and keeps the discussion on rainfall erosivity in a very speculative stage". Whilst this is undoubtedly so, it was my sole intention to present a discussion of the indices used in the characterisation of rainfall. The paper

was not intended to be seen as a paper about rainfall erosivity of soil, but about the tools or indices used to characterise rainfall in studies including those dealing with soil erosion but importantly in wider areas of application that I mention in the paper, including the analysis of rainfall thresholds for the triggering of mass movements, and in urban flash flooding (refer to the cited paper Dunkerley 2019 Earth Surface Dynamics 7, 345-360 for supporting references). A proper evaluation of I30 (and of EDf5 and other potential descriptors of intense rainfall) in many of these contexts is still lacking. I would be very interested to have suitable soil erosion data to present and analyse in the way that the referee suggests. However, I have never attempted to measure soil erosion, nor published on it, and must leave that to researchers whose experience and expertise equips them for that task. An exploration of EDf5 would in any case probably be best done within a hydrologic context such as urban drainage and flooding, since soil erosion is very probably influenced by the intensity profile during an event. This possibility was raised by Wischmeier 70 years ago. He rejected it on the basis of an argument that intensity profiles are quite variable, such that there should be no net effect on erosion rates estimated as long-term averages. Whether this is the case I suspect still awaits evaluation in sufficient environments for a general conclusion to be reached. The context of soil erosion at event scale (rather than averaged across periods of years) is further complicated because the generation of overland flow, and hence probably soil detachment and transport, is influenced greatly by antecedent soil wetness, or in other words not solely by the rainfall events themselves (and their I30 or EDf5 values) but rather also by the waiting times between rainfall events, and the event magnitudes of the sequence of antecedent rainfalls. Given these complications, it may indeed matter less which measure of rainfall event intensity is used in the context of soil erosion, than in relation to urban drainage problems and urban hydrology, or in other areas of application such as rainfall interception on vegetation, the generation of stemflow, or the propagation of fungal spores by splash resulting from the interaction of rainfall with crop canopies. I think that the further exploration of ways in which the arrival of intense rainfall may be reflected in suitable indices is needed to support research in

these diverse contexts.

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