Responses to Reviewers Comments

We thank Nadav Peleg and one anonymous reviewer for their careful review of our manuscript. We respond to their suggestions inline below. In addition, we have responded to the requests of the Executive Editor to provide the version number of our code and working links to the actual code and sample data.

Comments of Reviewer 1

Flow chart: We have provided a list of relevant distributions (now in Fig 2) and a description of both model initialization and model operation. Furthermore, the code itself is very well documented in terms of explaining precisely what the model does at teach stage. We have also added a new flow chart (new Fig 1).

Table of input parameters/distributions: These items are all well documented within our code, so we feel it is redundant to include them in the paper as well. We apologize if the reviewer did not have access to the code while creating his review.

New paragraph/other models: We have added reference to several other rainfall models and highlight the advances that STORM offers.

Re-analysis data: We have added clarification to our statement about re-analysis data products - This is especially true in regions where orography and other complicating land surface dynamics affect rainfall fields'. We feel this will address the reviewer's concerns about our previous comment on re-analysis data.

Two seasons: We take a seasonal approach to this modelling, since seasonal totals of rainfall are typically important considerations for long-term watershed planning. However, this is also required in our current approach in order to allow stochastic variations in both seasonal (or annual) totals, as well as the storm characteristics themselves. There is nothing stopping someone from further subdividing our model into 12 seasons, enabling monthly analysis of rainfall. The only inherent (and explicit) cross correlation in our model structure is the relationship between rainfall intensity and duration. We have not investigated the cross correlations structure of other model inputs.

Storm centers: No, there is only one storm center at a time in the current version of the model.

PET: PET is simulated a separate module within STORM. The reviewer is correct that it is not dependent on the rainstorm simulation. However, day and night value of PET are simulated separately, and these vary on a monthly basis (based on monthly data distributions).

500-m spacings: We removed reference to this in the general model description.

Link: We apologize that the link was not working. It is working in the updated version.

v.2017b: changed

Note: We moved the text to a more appropriate location.

Move text to methods: Done

Rainfall extremes: Our goal here is not to demonstrate that we can reproduce the spatial configuration of patterns in intensity. In fact, since intensity is a model input, we are not concerned about whether we have reproduced intensity as an output—it is a given. In fact, this is illustrated for the entire collection of gauging locations in Fig. 5. This figure shows that the model does indeed capture extreme rainfall events. We have added the length of each simulation (30 years) to Fig 9 for clarification.

Ensembles/simulations: We simulated 30 ensembles each of 30 years to evaluate STORM against observed rainfall data at WGEW. We have clarified this point in Fig 9.

Ensemble to ensemble: The reviewer has apparently misunderstood here. The simulation length and number of ensembles remains the same in all figures (30 ensembles each of 30 years). We were merely pointing out why values plot higher or lower than the 1:1 line (stochasticity).

Belongs to methodology: We disagree on this one. The data shown here are specifically from WGEW and we are demonstrating the model's skill in reproducing its rainfall characteristics.

Rainfall events: Yes, that is the 'n' referred to here. We've added clarification.

Reference: changed.

Comments of Reviewer 2

How were pdfs derived: Very good point. We have added clarification, including a reference to the automated distribution fitting tool recommended by the reviewer - For this paper, PDFs were fit manually using Matlab's Distribution Fitting Tool (distfittool), but we recommend that this be automated using a code that optimizes the fit based on maximum likelihood estimators: https://www.mathworks.com/matlabcentral/fileexchange/40167-fitmethis. Regarding which distributions are required, this information is contained in the comments of the code itself. We apologize if the link to the code was not working at the time of the review.

GEV v Other: We have added this info to the text – 'The particular distributions shown in Fig. 1 were generated by manual investigation based on best fit, but we recommend the automated approach.''

Fig 1c: We prefer 'storm center', since centroid refers to the mass of rainfall, rather than the areal center of the storm.

Stabilization: Unfortunately not. We have not investigated the processes of rainfall that lead to the particular functional form within the intensity-duration interdependence. However, we are currently working on these interdependencies using cupolas.

Fig 1f: It is not clear what the reviewer is asking for here, since there is already a legend on this figure panel. Yes, the darker of the two green curves is the 90th percentile of the relationship between intensity and duration.

Storm frequency/diurnal cycle: There is no explicit storm frequency included in the model. Instead its effect is captured by the number of storms simulated within a season, as well as by the simulated interarrival times. There is no diurnal cycle included here (apart from PET). Storms generated in our model can occur at any time with equal probability. We realize that many application might be concerned with the time of day in which the rainstorm occurred and there may be a selectivity to this, but we have not included this capability in STORM.

P7/L22: Yes, it is possible that this effect is also present in the other storm area bins. However, we believe (concurring with Syed et al) that the largest bin is the most affected and it is essentially spurious. Note: we have complete relied on the data from the Syed et al paper for this aspect of our application to Walnut Gulch.

P8/L24: Yes, wind speed and direction are likely to be relevant components of orography and we have added a statement of this in the text. We are currently working to improve characterization of orography in STORM using cupolas to capture the dependency between intensity and duration. We can also explore this for wind.

The how: changed

Spatial resolutions: changed to spatial representativeness

Radar: added mention

P2/L8: ref added

P3/L11: this was added to the sentence for clarification-- STORM performs this multi-layer parameter selection to create multiple sequences of spatially varying rainfall over a drainage basin and over a multi-decadal time series.

P3/L19: This was clarified above. The storm center is the actual middle of a circular storm area. It also has the highest intensity under our simulation method.

P3/L20: A rainstorm is characterized by a duration of non-dry days. Each one is punctuated by a randomly selected interstorm period.

P4/L5-6: Yes, this could be configured to run monthly (as 12 seasons). It would require some recoding, but it is certainly possible.

P4/L32-3: Yes, but one could certainly aggregate the native resolution of the rainfall data to a coarser resolution.

P5/L5: We think the reviewer has misunderstood here. The PTotal threshold is selected randomly and then the PTotals at every gauge are summed through the season until the median of all PTotals (at every gauge) exceeds the threshold value. We have clarified this in the manuscript.

P5/L7: Corrected

P8/L6: If the data exist, this can be done seasonally. We have clarified in the text.

P8/L19: We acknowledge that any rule-based approach like this is ripe for criticism. This is a short-term solution. We are currently working to improve the entire method for interdependency between intensity and duration.

Fig3: We looked into changing curve numbers to percentiles. However, we feel that this will create greater confusion, since we already have percentages of change to the probabilities listed on the figure. Instead, we have clarified in the caption that the curve numbers correspond to the percentiles as shown in (current) Fig 2E.

Fig 5: We have clarified this in the figure caption.

Of for: corrected

Trends in storminess: Yes, it is possible and we have added a sentence to clarify this point.

Fig 9: Yes, we acknowledge the slight overprediction in our simulated storm totals and annual precipitation totals. The figure only includes 30 ensembles of 30 years, so it is probable that with more simulations the centroid of values would shift back closer to the 1:1 line.

Fig 10: We have clarified this point in the caption. We note that the observations of declining intensity and increasing wetness at WGEW was already published elsewhere, so we have added a reference to that work.

P18/L4-13: This is a very interesting point, but beyond the scope of this paper. We should discuss collaboration on this using STORM with datasets of different temporal resolution. We have added this sentence to the manuscript: Another key area of future work would be to investigate how temporal resolution of rainfall data affects the signal of observed trends in rainfall (e.g., (Barbero et al., 2017)) and how these might yield different watershed responses.

Intensity gradient: Agreed. We have added this sentence - Finally, the density of the gauging network could have important influence on the storm intensity gradient with distance from the storm center, so the parameters of this relationship may be less certain for less dense gauge spacings.