Point-by-Point Response to Review Comments

Manuscript Title: Increased Nonstationarity of Stormflow Threshold Behaviors in a Forested Watershed Due to Abrupt Earthquake Disturbance

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Manuscript ID: hess-2022-315

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(**C** and **R** denotes Comment and Reply, respectively)

Response to Reviewer #2 (Band in University of Virginia) Comments:

C1: Zhang et al. present an interesting study of stormflow runoff threshold non-stationarity over a time-line before and following a major earthquake in the eastern periphery of the Tibetan Plateau. The earthquake resulted in a massive disturbance of the dominant forest cover due to extensive landsliding which subsequently expanded with monsoon-initiated landslide growth, then slowly began to recover with revegetation, and presumably, renewed colluvial infilling of scars.

The paper provides a good illustration of specific controls of non-stationary threshold behavior in response to geomorphic disturbance and a chronology of ecosystem recovery. This adds to our knowledge of storm event-based threshold behavior with good evidence of the watershed system dynamics and time scales of adjustment. It may be argued that this is an end-member in terms of magnitude of disturbance, but may be increasingly applicable to other cases of large, sudden land use change and slow recovery due to devastating storms, fires, or other disasters.

R1: We are very grateful for having the summary of your positive assessments of our work. Each comment has been addressed below point-by-point. We also hope that this study about the relationship between hydrological sciences and flash flood disasters could be considered for publication in the "*Hydrology and Earth System Sciences*".

C2: The documentation of the threshold stormflow behavior is interesting, but there are a set of areas in the text that are unclear. Specifically, the methods need to be clarified. Otherwise, some of the interpretation and conclusions may appear to be more qualitative and speculative, and not specifically supported by the data.

R2: Thanks for your serious comments. the methods in the revised manuscript have been clarified in the revised manuscript and the following **R3** in the revised manuscript.

C3: Figure 3 is a major result and contributes prominently to the conclusions. However, there do not appear to be sufficient observations to separate out the highest thresholds and trend with statistical significance as it appears this is determined by a single, large event. It is also not clear from the methods whether discharge was separately measured or determined for grass shrub, forest, and landslide areas. The position of the gauges suggests each drainage area is a mixture of all three land covers, and more information is required to see how each land cover contribution is deconvolved. Add more detail to this discussion. If separate measurements were not made it is not clear how these piecewise regressions were made. If this is done by modeling using curve numbers or HEC-HMS this should be clear.

R3: Thanks for your serious comments and valuable suggestions. Some results in Figure 3 indeed are important contributions to our conclusions in the revised manuscript. A sufficient amount of observed hydrological data is very significant to identify the stormflow threshold behaviors with good statistical significance. In the revised manuscript, 47 rainfall-runoff events (P>4mm) in our study area were collected and used to analyze the hydrological behaviors at watershed scales. However, in a future study, a larger amount of meteorological and hydrological data will be collected to improve the statistical significance of the data and the accuracy of data analysis.

The best option would be to simultaneously collect the event precipitation amounts (*P*), *DASI*, and discharge at a separate forest, grass-shrub, and landslide land. Actually, it is difficult to do that. In the revised manuscript, in the forest, grass-shrub, and landslide lands, *P* and *DASI* were obtained for different land use while the discharges were measured at the gauging station S6. We mainly consider the *P*+ *DASI* contributions of each land use to flow discharge in each storm event using observed field data. The potential scaled model test or runoff plots at different locations of land use could be applied in the future. Additionally, the hydrological outputs derived from the HEC-HMS model were presented by Zhang et al., (2021b). Some results were compared with our observed flood events and discussed in the revised manuscript

Reference:

Zhang, G., P. Cui, W. Jin, Z. Zhang, H. Wang, N. A. Bazai, Y. Li, D. Liu, and A. Pasuto (2021), Changes in hydrological behaviours triggered by earthquake disturbance in a mountainous watershed, Science of The Total Environment, 760, 143349.

C4: Finally Figure 3 is difficult to interpret as all data points have the same symbol and color, over all land uses. Either color code or use a different symbol so the reader can assess the degree of separation between the trends. Clarifying the statistics provided would also help. There is a composite r2 provided in table 2 for each of three distinct land uses, including two thresholds and three slopes. While the overall the correlation is significant What is the confidence in each of these parameters? Is it possible to provide SEE for each? I presume this may not be possible for the highest flow slope values if they were support by a single large storm observation.

R4: Thanks for your serious comments and valuable suggestions. Figure 3 has been modified as follows. Each color code and symbol point is presented at different locations of land uses. Each of these parameters was analyzed at the confidence level of 95%, and the Standard Error of Estimate (*SEE*) for each in multiple regressions is listed in Table 2. In the future, a larger amount of data will be collected and analyzed to better identify the threshold behaviors at hillslope and watershed scales in our experimental watershed.

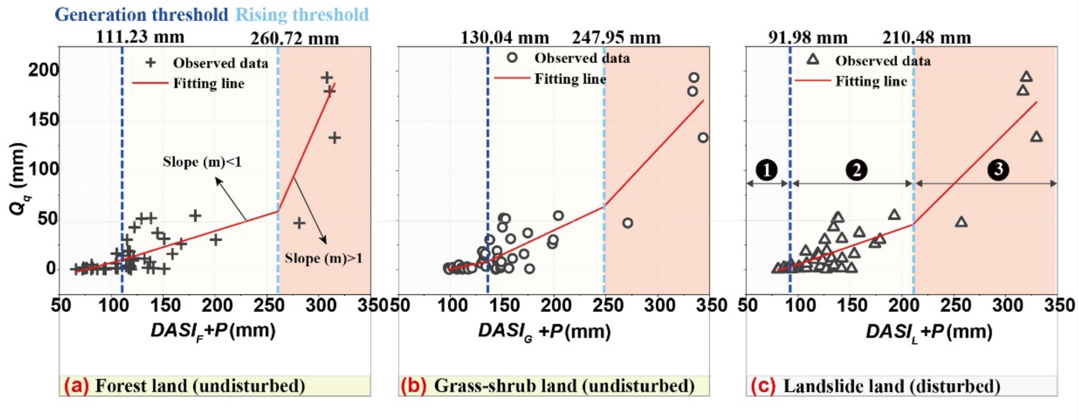

Figure 3: The piecewise regression analysis of event stormflow amount (Q_q) plotted against the sum of event precipitation amounts (*P*) and *DASI* at the forest (**a**), grass-shrub (**b**), and landslide (**c**) lands. The undisturbed forest and grass-shrub lands represent the pre-earthquake period, as reported by Zhang et al. (2021a), and the disturbed landslide land represents the post-earthquake period. Red lines indicate the liner fitting for the piecewise regression for the variable of *P+ DASI* at the confidence level of 95%.

Table 2: Comparison for parameters in assessing the three-linear threshold behaviors of *DASI+P* and Q_q relationships at the confidence level of 95%

Location	Period	Parameters						
		T_g (mm)	T_r (mm)	m_{i1}	m_{i2}	m_{i3}	r^2	*SEE*
Forest land	Pre-earthquake#	111.2	260.7	0.28	0.33	2.36	0.88**	17.17
Grass-shrub land		130.4	247.9	0.21	0.49	1.12	0.84**	15.65
Landslide land	Post-earthquake	91.98	210.48	0.24	0.36	1.04	0.87**	16.54

Note:

m_{ij} indicates the values in the slope parameter of *PRA* equations from the j_{th} phase at the *i* land (*i*=forest, grass-shrub, and landslide lands, *j*=1, 2, 3 shown in Figure 3).

\# denotes the collected data in a row, reported by Zhang et al. (2021b).

** indicates that correlation is significant at the 0.01 level (two-tailed).

SEE is the standard error of estimate in multiple regressions.

C5: The authors cite the scarcity of measurements pre-earthquake, and the logistical difficulty of accessing areas post-earthquake as limiting the information available to assess stormflow threshold behavior through this time. Some information is derived from simulation modeling, developed in a previous paper. More information on the number of actual measurements, the information provided by the HEC-HMS model, and its reliability should be provided. The authors point to a specific "tipping point," after which the stormflow thresholds begin to increase again. Are these based on land cover change derived curve numbers within the model, and are there discharge measurements sufficient to verify these changes? In figure 4b we see peak discharge for a set of events first increase and then decrease as the forest ecosystem begins to recover. How are these peak discharges adjusted for the size of the storm, or are they averaged from a larger number of events?

R5: Thanks for your serious comments and valuable suggestions. In our previous study (Zhang et al., 2021b), based on 5 min time-series data in rainfalls (9 rainfall stations) and streamflow (2018–2019), the HEC-HMS model was calibrated and validated to predict the historical (2007-2018) hydrological behaviors. The mean Nash–Sutcliffe efficiency was 0.76, showing good model performance and reliability. But some hydrological data pre- and post-earthquake are indeed scarce. This might be a limitation.

Herein, the stormflow threshold behaviors**,** including integrated watershed generation threshold ($T_{g\text{-}IWA}$) and rising threshold ($T_{r\text{-}IWA}$), were observed and calculated using equations (1) rather than the curve numbers within the model. The historical (2007-2018) flood response was predicted via the curve numbers within the model. The scarcity of runoff measurements from 2007-2018 pre- and post-earthquake might be a limitation.

The trends of values in peak discharges and flood volumes under different sizes of storm were always consistent based on our previous study from Zhang et al., 2021b). In the revised manuscript, we selected the long-term changes in a high-magnitude flood event (>10^2) to analyze and compare the changes in $T_{g\text{-}IWA}$ and $T_{r\text{-}IWA}$. It is efficient for us to compare the changes between stormflow threshold behaviors and flood response. The corresponding text has been revised as "Changes in (a) observed stormflow threshold behaviors, including the integrated watershed generation threshold ($T_{g\text{-}IWA}$) and the rising threshold ($T_{r\text{-}IWA}$), and (b) a large flood event response selected from Zhang et al. (2021a) during the periods of 2007 ~ 2018 before and after the earthquake, including peak discharge (Q_p) and flood volume (V).".

Reference:

Zhang, G., P. Cui, W. Jin, Z. Zhang, H. Wang, N. A. Bazai, Y. Li, D. Liu, and A. Pasuto (2021), Changes in hydrological behaviours triggered by earthquake disturbance in a mountainous watershed, Science of The Total Environment, 760, 143349.

C6: The analysis of threshold behavior shown in figure 5 is presented in the discussion section. I think this should be in the results section, then discussed/interpreted in the discussion section.

R6: Thanks for your suggestion. The analysis of threshold behavior shown in figure 5 mainly examines and verifies the occurrence of initial streamflow at T_g as well as of large flood response at T_r.

C7: Reword so it is clear that it was estimates there were roughly 2 x 105 landslides initiated (which is amazing)

R7: Such number of roughly 2.0×10^5 landslides following the Wenchuan earthquake was identified by Xu et al., (2014) and Fan et al. (2018). The references are as follows:

Xu, C., et al. (2013). "Three (nearly) complete inventories of landslides triggered by the May 12, 2008 Wenchuan Mw 7.9 earthquake of China and their spatial distribution statistical analysis." Landslides 11(3): 441-461.

Fan, X., et al. (2018). "What we have learned from the 2008 Wenchuan Earthquake and its aftermath: A decade of research and challenges." Engineering Geology 241: 25-32.

C8: Line 107, the term indeciduous is not clear. Remove and simply call the canopy conifer.

R8: Thanks for your comments. The term indeciduous has been removed, and revised to “*canopy conifer*”.

C9: Line 168-170, sentence may be better placed either in the introduction or discussion. It is not a specific result of the analysis done here.

R9: Thanks for your good suggestion. The sentence has been placed in the introduction.

C10: Line 261 – I presume you mean the time to peak decreased not increased following the earthquake?

R10: Thanks for your logical comments. You are right. The time to peak is decreased by 25min following the earthquake. The sentence has been revised to be “Peak discharges increased by 22.58%~367.42% and the time to peak was advanced by 25 min”.