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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Development of a Precipitation-Area Curve for Warning Criteria of Short-Duration Flash Flood" *by* Deg-Hyo Bae et al.

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We thank you for your constructive review and comments. We have attached answers and the revised manuscript. Our responses were written after this symbol (-). We believe that the manuscript is in much better form now.

Referee's comments:

Important topic of high relevance. The paper is generally of a good structure and gives good insight in what has been done in the project. But not really a new approach, already been done in similar ways in other regions. Following open issues should be addressed in the publication: The cells of convective events are much smaller than the catchments described in the paper, so in the real world only part of the catchment

will be in the focus of the precipitation event. There is little info about what type of precipitation measurement has been used, are this ground measurements or radar or some combination of it? What is the resolution of the measurement? As the convective events are difficult to measure, the uncertainty applied by this also should be discussed. In the publication a lot of abbreviations are being used, this makes it hard to read, especially as they are not commonly used abbreviations, so better replace them by the full text. As the timely distribution of a rainstorm event also has high impact on the runoff, this should be tackled as well. Some more words should be spend on how the results can be used, in what extent are the usable for warning issues and how false warnings can be handled. Who is the planned end user of the thresholds?

-We revised the paragraph and added a description of the precipitation dataset as shown below (page 3, line 20∼23). "Rainfall and soil moisture were the main datasets used to estimate Flash Flood Guidance. Rainfall data were obtained at 96 locations from the Ministry of Land, Infrastructure and Transport (MOLIT) and at 25 locations from the Korean Meteorological Administration (KMA). Rain gauges recorded data at 114 locations, and the resolution of each station was approximately 217 km2 (approximately 15*15 km)."

-We added a discussion section about the sources of uncertainty problems with this method (page 9 line 26∼page10 line 16)

"5.1 Uncertainty of flash flood forecasting method There are many flash flood forecasting methods. The methods can be divided into three categories: flow comparison methods, rainfall comparison methods, and flash flood susceptibility assessment. The proposed P-A curve is rainfall threshold that included with the rainfall comparison methods like FFG. The rainfall comparison method is a popular tool for warning about flash floods, and this method is commonly used for flash flood forecasting. However, the previous rainfall threshold method has some limitations, recent studies tried to improve warning accuracy by using distributed physical hydrological modeling (Kobold and Brilly, 2006; Reed et al., 2007; Norbiato et al., 2009). Hapuarachchi and Wang

(2008) suggested that physically based distributed hydrological models are more appropriate than data-driven models and conceptual hydrological models for flash flood forecasting. However, the most important thing of flash flood forecasting is a providing the warning information to decision makers or citizens with relatively simple, clear, and immediate. It means that not only the sophistication but also promptness with reasonable accuracy also is necessary for flash flood forecasting. In this respect, this study proposed quantitative criteria using P-A curve for flash flood warning based on FFG. The key advantage of this method is that it doesn't need any further calculation compared to the other rainfall comparison method. In other word, the proposed criteria and methodology will serve as an important tool for issuing flash flood warnings based on only rainfall information. However, this study has some assumptions and limitations. The P-A curve is based on the FFG, not real observed flash flood events because there is lack of observed flash flood events. In addition, the proposed P-A curve has some uncertainties from lots of sources such as soil moisture estimation (SURR), Threshold runoff estimation method, finding the optimal P-A curve by using ROC method, collection of actual flash flood events etc. But, these problems are not confined to this study because the phenomena triggering flash flood are very complex. Any flash flood forecast method has also large uncertainties due to input data errors, and modelling errors. Thus, it is necessary for understanding of the uncertainty from all these sources for decision making in flood warning because good uncertainty estimates of flash flood forecasts can add credibility to the forecast system."

-We changed some abbreviations to full names (TR, QFFC) .

-We added a discussion section about utilization of a P-A curve (page 10, line 18∼ page 11, line 3).

"5.2 Utilization of a P-A curve for flash flood forecasting Some flood forecasting systems have been developed and operated in some countries (Mogil et al., 1978; Sweeney, 1982; Mason, 1982; Alfieri et al., 2012). Northern America has a flash flood forecasting system using gridded flash flood guidance (GFFG). This system uses

multi-sensor precipitation estimates and forecasts based on NEXRAD (Next Generation Weather Radar), rain gauges and NWP (numerical weather prediction) model outputs. The European Flood Forecasting System (EFFS) used the LISFLOOD-FF for generating river flow and LISFLOOD-FP to model the overbank flows and inundation areas, and they use gauged rainfall, radar rainfall, and NWP model outputs (Roo et al., 2003). ALERT in Australia uses a hydrological model with real-time rainfall and water level data. They also assess the severity of flooding using simple manual guides (look-up tables). Thus, the ideal flash flood system needs to combine two approaches. It must present the criteria used to judge flash floods in an intuitive way for very short-term flash floods (less than 1 hour). It must also make predictions with sophisticated modeling using a physical distributed model for flash floods with greater than a 3-hour duration. Therefore, the FFGC (flash flood guidance criteria) are used for short-term flash floods. This study focused on using a P-A curve, and it assessed the outcome when using only gauged rainfall data. However, the quality of flash flood forecasting depends on the quality of the rainfall data. Additionally, reliable rainfall forecasts with adequate lead-time and accuracy are essential for flash flood forecasting. In general, the gauged rainfall, radar data (Sinclair and Pegram, 2005; Mazzetti and Todini, 2009), and satellite data (Soorooshian et al., 2000; Kubota et al., 2007) have been used for quantitative precipitation estimates (QPEs), and some studies have used multiple precipitation sources (Sokol, 2006; Chiang et al., 2007). Therefore, this method is necessary for assessing the applicability of using rainfall data obtained from various sources. "

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-213/nhess-2017-213-AC2-supplement.pdf

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