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Discussions
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Interactive comment on "Using rainfall thresholds and ensemble precipitation forecasts to issue and improve urban inundation alerts" *by* T.-H. Yang et al.

Anonymous Referee #1

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The proposed manuscript presents the first application and evaluation of the TAPEX NWP ensemble to extend threshold based rainfall warnings of urban floods up to 72 hours over the entirety of Taiwan. It builds on previous work which had relied upon warnings from rain gauge observations which had consequently limited the maximum warning lead time.

The proposed method uses rainfall forecasts to identify the probability of exceeding 1, 3, 6, 12 and 24 hour rainfall thresholds for lead times of 1-24, 25-48 and 49-72 hours across 352 urban areas in Taiwan. Warnings are generated based on a probability exceedance level, experiments are made with different levels and evaluated against observed warnings disseminated during seven different typhoons. The results found

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that higher threat score and probability of detection values were achieved when using lower probability thresholds, however this was at the cost of increasing the number of false alerts. In many cases the false alert ratio exceeded the success ratio meaning that the authors were unable to identify an exceedance probability level which could be used by emergency responders. The accuracy of the system was heavily driven by the accuracy of the forecasted typhoon track and showed better accuracy prior to the typhoon making landfall. The authors introduced observed rainfall data from the previous 24 hours in order that all five of the rainfall accumulation durations could be calculated during the first 24 hours of the forecast. This improved the results of all the skill scores during this period.

Overall this paper makes a good scientific contribution as it demonstrates the development of an urban flood warning system using NWP ensemble rainfall forecasts to extend the lead time. Forecasting urban flooding from intense rainfall events is of high importance but currently very few systems exist around the world. Therefore this manuscript will be of high interest to many readers who could apply the findings to help develop their equivalent warning systems. Therefore I recommend that this paper is accepted for publication after the authors have addressed the following minor corrections.

1. Provide more information about the rainfall thresholds It would be helpful for the authors to provide more information about how these rainfall thresholds are derived. A reference to Wu 2013 is provided but access to this conference proceeding does not seem possible, therefore the authors should provide more information within their manuscript. On page 5 at line 11 I do not understand the difference between the first and second level alerts, when is a second level alert created as opposed to a first level alert, does this have any impact on the evaluation presented in this manuscript?

2. Page 5 line 28 – do the 352 townships cover the entirety of Taiwan? This is a minor point but if they are only located in a certain part of the island then perhaps this could influence the evaluation scores?

3. Is there a mismatch between observed rainfall data and the TAPEX forecasts? If there is a bias in the TAPEX rainfall estimates, for example it could underestimate extreme precipitation, could this be problematic when comparing against rainfall thresholds derived from observations and when assimilating observations during day 1? If TAPEX does underestimate rainfall during a typhoon then this could mean that the threshold is not exceeded but the forecasted rain is still extreme when compared to the model climatology. On line 10 of page 9 the authors say that TAPEX rainfall forecasts were usually underestimated. In section 2.3 the authors should provide references to the verification scores of TAPEX forecasts of extreme rainfall and discuss the implications of comparing model forecasts against observed threshold values.

Does a similar issue also affect the assimilation of observation data during the first 24 hours? For example what would the affect on the results be if the authors assimilated data from the previous forecast as opposed to observation data? The authors should discuss this point either within section 2.3 or in their conclusions.

4. Are the data in figure 6 created using results with or without the data assimilation, this should be clarified in the text?

5. The explanation of the plotting of dtg in figures 6-8 needs clarification I am unclear about what is plotted at each dtg step in these figures, for example in figure 7 for cyclone Trami which made landfall on 20130821 1800 does this mean that the data plotted at 'landfall' refers to the 25-48 h data from the forecast on 20130819 1800, and the data plotted at -1 dtg refers to the 25-48 h data from the forecast on 20130819 1200 etc?

6. The proximity of a cyclone to landfall affecting the result accuracy requires further explanation On line 14 of page 9 it is suggested that when the TAPEX model is initialised with a typhoon close to or having already made landfall that this affects the track accuracy and hence the rainfall accuracy. I understand that this could be problematic for forecasts between 1-24 hours lead time but would this issue not diminish

with increasing lead time? For example the forecasts used in figure 8 (lead time 49-72 h), would these not have been initialised when the typhoons were yet to make landfall? My confusion here is linked to my confusion about the dtg in the previous point, so it would be greatly appreciated if the authors could provide clarification.

7. Provide a table of the skill scores calculated across all the typhoons This would give some useful overview statistics about the proposed system, it might also help the reader to determine how close the system is to providing a FAR<0.5 as alluded to by Coughlan de Perez et al., 2016 and at which threshold level.

The following are some minor typographical corrections:

Page 1 line 10 replace 'preceding' with 'predicting'

Page 1 line 31 replace 'European Flood Forecasting System (EFFS)' with 'European Flood Awareness System (EFAS)'

Page 3 line 6 the flash flood system in EFAS is currently the Enhanced Runoff Index based on Climatology (ERIC) see http://onlinelibrary.wiley.com/doi/10.1002/met.1469/abstract

Page 3 line 8 replace 'sources' with 'resources'

Page 4 line 8 replace 'early inundation warning system' with 'inundation early warning system'

Page 6 line 9 insert 'the' after 'The complexity of'

Page 7 equation 3 replace 'Pobability' with 'Probability'

Page 11 line 22 replace 'will appear' with 'are likely'

Figure 3 replace 'Present Time' with 'Timeline'

Table 1 caption insert 'that' so that the sentence reads 'For typhoons that did not...'

Table 5, in Matmo SR-FAR column for the 80% exceedance level did SR-FAR really

equal 1.0?

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