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Discussions

Interactive comment on "Prediction of direct runoff hydrographs utilizing stochastic network models: a case study in South Korea" *by* Y. Seo and S.-Y. Park

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The authors thank the reviewer for the valuable comments that would make the paper more comprehensive. The authors make every effort to answer the question raised by the reviewer and deliver the original idea of this research as much as possible. Please refer to the below comments raised by the reviewer and answers.

The manuscript proposes a combination of synthetic width function and rainfall-runoff model based on the width function for hydrograph estimation in ungauged basin. While the topic is interesting as appropriately underlined in the introduction, I have some

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doubts on the methodology proposed by the authors. It seems a contradiction combining the proposed methods indeed the main advantage of WFIUH models is the simplicity and the possibility to extract the information from the DEM. I agree with both reviewers and in the following I will list other comments. 1) It seems from the introduction that are not available in literature attempts to adapt the WFIUH approach to ungauged basins. Actually, I personally did an effort to reach this aim and the results are available in the two following publications: Grimaldi S, Petroselli A, Alonso G, Nardi F (2010). Flow time estimation with spatially variable hillslope velocity in ungauged basins. ADVANCES IN WATER RESOURCES, vol. 33, p. 1216-1223, ISSN: 0309-1708, doi: 10.1016/j.advwatres.2010.06.003 Grimaldi S, Petroselli A, Nardi F (2012). A parsimonious geomorphological unit hydrograph for rainfall runoff modeling in small ungauged basins. HYDROLOGICAL SCIENCES JOURNAL, vol. 57, p. 73-83, ISSN: 0262-6667, doi: 10.1080/02626667.2011.636045

Answer: We reviewed two papers that reviewer commented. The authors totally agree with the reviewer in that the efforts from previous researchers should be included in the literature review in the introduction of the manuscript. However, please understand that there are differences between the previous researches in terms of adapting WFIUH for the PUB. The most prominent difference would be flood routing. Grimaldi et al. (2010, 2012) used a modified form of WFIUH with one parameter, the hillslope velocity. The other parameter channel velocity (not celerity) is calibrated using the catchment travel time. Therefore, there is no consideration of diffusion effect in channel routing. Please note that Da Ros and Borga (1997), Franchini and O'Connell (1996), Naden (1992) and originally van de Nes (1973) started from the basic solution of the advection-diffusion equation of flow perturbation, which has a Gaussian-form solution with two parameters, celerity and diffusion coefficient for flood wave propagation. Especially, Da Ros and Borga (1997) discussed the effect of the diffusion coefficient, which is also noted by Rodriguez-Iturbe and Rinaldo (1997). Also, both Da Ros and Borga (1997) Franchini and O'Connell (1996) discussed that the order of those two parameters can be physically determined.

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2) From these latter papers it is clear that I do not see any added value in using a stochastic approach to simulate synthetic drainage networks since the DEM is full of information useful for appropriately estimating the WFIUH.

Answer: The authors absolutely agree with that the most similar form of the width function to real network can be obtained from the DEM. However, our attempt in this paper is focusing on, first, showing that the actual width function can be mimicked using stochastic network models, which has never been pursued before. The reviewer may ask why at this stage. There are two reasons in this attempt. First is that when the authors looked at the effect of rainstorm movement on resulting runoff hydrograph, most of previous researches were focusing on a specific catchment of their own. There was no general description on the effect of storm movement. Therefore, the authors introduced network configuration and seek to figure out what would be the moving effect under different network configuration. The results were interesting in that an 'efficient' network (less sinuous network) is more sensitive to moving storms than a 'less efficient' network (more sinuous network). The peak flow increase is more than two or three times bigger compared to efficient networks. Please refer to Seo and Schmidt (2012, 2013) in this point. The Gibbsian model and the parameter, beta was used to categorize drainage networks in terms of investigating moving storm effects.

The idea was constrained in urban catchments (Seo and Schmidt, 2012, 2013, 2014a, 2014b) and extended in this study for natural watersheds. Okay. Let us say that the actual width function can be mimicked using stochastic network models. Then, the effect of moving storm is also can be evaluated based on the results from previous studies (Seo and Schmidt, 2012, 2013, 2014b). The historic record flood in Iowa in 2008 shows the importance of moving storm effects (Krajewski and Mantilla, 2010). It would be important to estimate accurate flow under moving storms. Combined with the WFIUH approach, the stochastic network model can be used not just produce hydrographs in an ungagged basin, but also evaluate the sensitivity of the basin to spatial and temporal variation of rainfall, especially, moving storms. It seems like that

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the author's basic idea and intend were not properly stated in the paper, which will be reflected in the revised manuscript.

On the other hand, most of the knowledge about PUB has been well developed within a catchment. DEM could work for the sophisticated analysis and prediction. One of fundamental purposes of PUB, however, is synthesis across places by Darwinian approach (reductionist approach or top-down approach) for generalization (Blöschl et al., 2013). Our methodology matches the concept of PUB for better understanding hydrological responses in terms of a catchment property. By characterizing catchments with the physical property of the catchment scale (beta (sinuosity)) that does not need parameterization we can overcome the fragmentation from Newtonian approach and constrain complexity from other various properties. This study leads to generalizing catchment hydrologic responses over places in future study for catchments in mid-west, and beta could be one of bridges for runoff prediction in ungauged basins. The authors would say the contribution of this study can be found in that point.

3) The proposed case study seems not appropriated. Indeed, in my opinion, the application of WFIUH should be limited to small watershed and surely not to a basin of thousands of Km2. Moreover the case study does not include any DEM analysis or preprocessing and the watershed is resampled (I am not sure to have well understood) in a raster of 24*28 cells...that means that the lattice resolution is around of 3Km*3km. This is not reasonable for WFIUH approach (the hillslope component would be included in the channel component).

Answer: First, the authors agree with reviewer that a proper scale for a certain model exist and it should be suggested. However, in terms of the application of the WFIUH, please note that Naden (1992) applied the WFIUH to River Thames at Cookham with a catchment area of 7000 km2. Of course, Naden (1992) applied a hillslope response function, which was user-defined. In terms of the DEM analysis, we manually reconstructed the river network of the test watershed.

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The authors agree with the reviewer that the impact of grid sizes is important when applying the WFIUH. The sensitivity analysis of grid size was performed by Da Ros and Borga (1997), which showed that 10% increase in peak flows with 1200% increase in threshold grid area. They showed that the WFIUH is able to reduce the effect of threshold area selection. The authors would say quantifying the contribution of channel and hillslope contribution and their relation with grid sizes is another interesting topic that should be fully addressed in the future when applying the WFIUH.

4)Figure 4 is particularly representative of my concerns. Why should we simulate that drainage networks? the DEM could tell us which the most similar to the real one.

Answer: The basic idea is that with the concept of network configuration, the impact of rainstorm movement on the resulting runoff hydrographs and peak flows can be generalized and assessed and the stochastic network model was utilized in the same line. The other reason is that the network configuration can be one of important factor characterizing a watershed and need an analysis based on the concept of regionalization, which will contribute to the PUB. Please refer to the answers for this comment 2) in terms of moving storm effect and contribution to the PUB.

5)In general the proposed application does not include enough information, for instance, it is not clear how the rainfall data are managed.

Answer: The soil and land use of the watershed were attached. The spatial rainfall distribution was not considered in this study. Instead, Thiessen polygon was used to obtain average rainfall over the watershed. Rainfall gages to build the Thiessen polygon were also attached. The details of the application will be included in the revised manuscript. Please understand that this study focused on the possibility of combining stochastic model and the WFIUH in terms of potential contribution to the PUB in their simplest forms.

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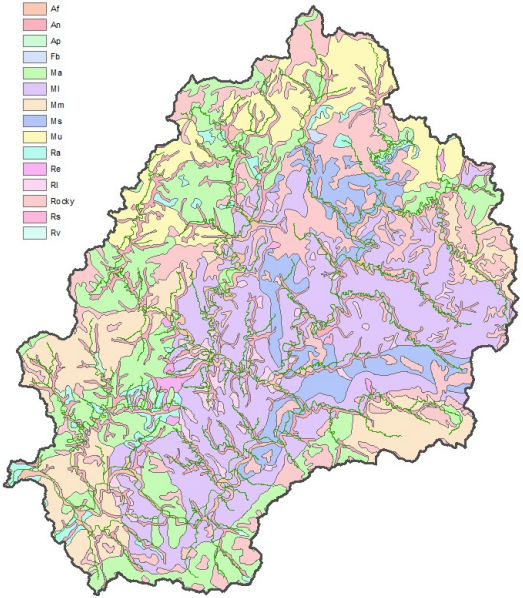

Fig. 1.

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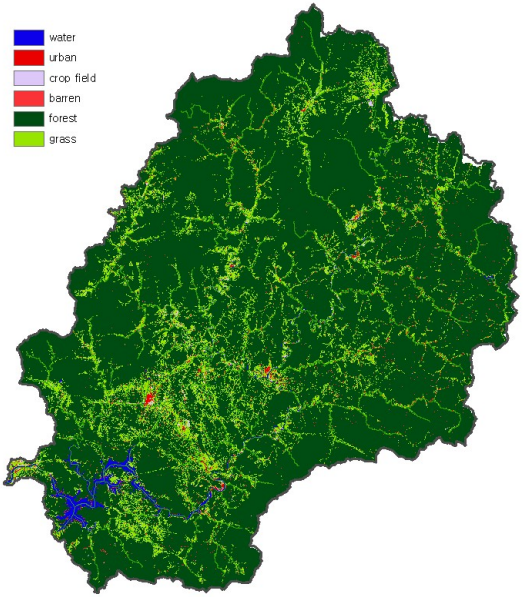

Fig. 2.

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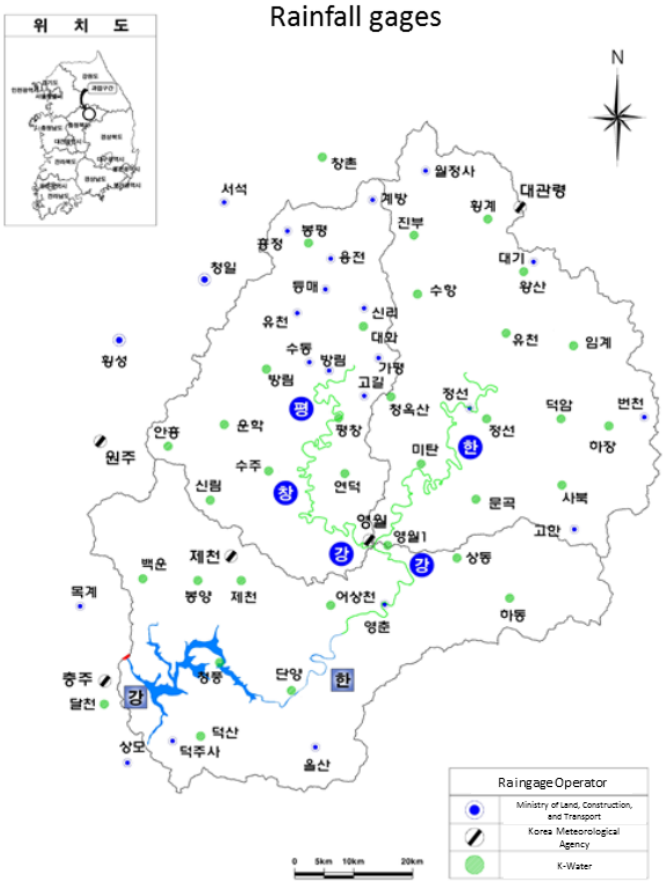

Fig. 3.

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