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Hydrology and Earth System Sciences
Discussions
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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 paper aims to reproduce the actual channel network using a stochastic Gibbsian model, then to calculate a unit hydrograph width function which can be used in modelling runoff on ungauged basins. An application case is shown on three rainfall/runoff events on one Korean catchment. My main comments concern: - The originality of the approach: the paper doesn't state clearly the limitations of the existing approaches and the added-value obtained with the method proposed herein. It is not clear why to model the channel network structure and not to use the channel network extracted from DEMs. The objectives and the methodology must be stated clearly.

Answer: The authors agree with the reviewer in that the limitation of the existing methodologies and the added knowledge obtained with the suggested approach were not properly and clearly stated in the paper. We would say that the main advantage of the suggested approach in this paper is to propose a way to deal with uncertainties especially regarding information about drainage network by combining stochastic network model. And also, direct connection of stochastic network model with hydrologic modeling has never been pursued before for this purpose. Actually, it started with analyzing urban drainage networks in old Southwestern Chicago area where the information about drainage network is sometimes missing and not fully identified (Cantone and Schmidt, 2011; Seo and Schmidt, 2014). The effort started with applying GIUH to urban drainage networks (Cantone, 2010; Cantone and Schmidt, 2011). Seo and Schmidt (2014) showed the applicability of the modeling approached especially with Gibbs' model in urban catchments. This paper extended the idea and applied it to a natural watershed in South Korea. DEM is more accessible now, so we fully agree with the reviewer in that point. But, as stated earlier, the aim of this paper is not on the most prevailing approaches but on showing a way to deal with network uncertainties by alternative approaches and also showing that the suggested approach is applicable to natural watersheds and potentially helpful to the PUB. The authors will include the purpose and scope of the paper as well as the limitation of the proposed approach in the manuscript as the reviewer suggested.

- The paper doesn't present the hydrological rainfall/runoff model used, neither the hydrological processes modelled. How Figures 3 and 7 were produced, what parts of rainfall contribute to runoff, and what is the spatial distribution of rainfall, soil, landuse and runoff?

Answer: The hydrological process modeled in this paper is direct surface runoff and the methodology (runoff-rainfall model) is described in the manuscript (please see page 11254, line 16-page 11255, line 24). The model transforms the width function to runoff hydrographs based on the solution of the 1D advection-diffusion equation for flow per-

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turbation. It was originally proposed by Van de Nes (1973). Naden (1992) applied it to a watershed in UK. The advantage of the model especially compared to GIUH is well described by Franchini and O'Connell (1996) and Da Ros and Borga (1997). The runoff hydrograph was calculated only at the outlet of the watershed. 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.

- The application case is limited to only one catchment where rainfall/runoff are measured, and it is not clear how the methodology can be applied on ungauged basins in various hydro-climatic conditions. How to regionalize the model parameters: beta, celerity, diffusivity and others?

Answer: We would like to say that the reviewer's comment is important in the PUB because a methodology should be tested under various hydro-climatic condition to evaluate the suggested approach. But, again, this study is an initial attempt to extend the basic idea of combining stochastic network model with a hydrologic model based on the width function to a natural watershed. Therefore, tests under various condition can be addressed in the future study. Due to the nature of stochastic models, one hundred realization of networks for each beta were computed in this paper. This paper also provide analysis on moving storms. The results showed that the stochastic network models (Gibbs' model) is able to reproduces the hydrologic runoff of the original river network even for moving storms. In addition, the study on the regional distribution of beta is undergoing for 71 watersheds in Midwestern regions of USA by the authors and will be presented soon hopefully. The celerity and diffusion coefficients are functions of channel geometry, especially channel slope (please see page 11256, line 21-page 11257, line 6).

- A comparison between the new approach and existing approaches must be undertaken in order to show the novelty and the utility of the methodology.

Answer: As mentioned earlier, this study is an initial attempt to extend the basic idea of combining stochastic network model with a hydrologic model based on the width function to a natural watershed. Direct connection of stochastic network model with hydrologic modeling has never been pursued before for the purpose of dealing with drainage network uncertainty. In terms of the rainfall runoff model performances, the results from a HEC-1 model composed of 35 subcatchments were compared with the results from the WFIUH as shown in Figure 3. The subcatchments were attached and the information of the HEC-1 model will be included more in detail in the manuscript.

Other comments: - Page 11256, lines 1-10: Please give the characteristics of the rainfall/runoff events: spatial distribution of rainfall, rainfall intensities, runoff coefficients, etc. Why not to use a large number of rainfall/runoff events and not to apply on various catchments?

Answer: As mentioned earlier, the spatial rainfall distribution was not considered in this study. Instead, Thiessen polygon was used to obtain average rainfall over the watershed. The map showing rainfall gages considered in this study is attached for a reference. The catchment average rainfall intensity is shown in Figure 3. Again, please be understood that this study is an initial attempt to extend the basic idea of combining stochastic network model with a hydrologic model based on the width function to a natural watershed. Therefore, a number of tests under various condition for various catchments can be addressed in the future study.

- Page 11257, lines 1-5: How were chosen the values of the celerity and the diffusion coefficient?

Answer: The celerity and diffusion coefficients are functions of channel geometry, especially channel slope, the details are described in the manuscript (please see page 11256, line 21-page 11257, line 6). The channel cross section is assumed to be a wide rectangular channel. An averaged channel bottom slope (2.65×10-4 m/m) and initial depth of 2.25 m were used to obtain the celerity and diffusion coefficient. These values fall within the range suggested by Franchini and O'Connell (1996).

- Page 11257, lines 10-18: A numerical criteria must be given for comparing observed and calculated hydrographs in order to justify the conclusion that "the WFIUH successfully reproduces the runoff hydrographs."

Answer: This paper repeatedly used the Nash-Sutcliffe Efficiency (NSE) to evaluate how close the stochastic network models mimic the response of the original (Please see Figure 8 and Figure 11; page 11260, line 23-25). As the reviewer commented, NSE was also calculated for the results of Figure 3. For the August 1999 storm, the NSE was 0.81 and 0.91 for WFIUH and HEC-1, respectively. For the September 199 storm, the NSE was 0.58 and 0.72 for WFIUH and HEC-1, respectively. Lastly, for the 2004 storm, NSE was 0.51 and 0.73 for WFIUH and HEC-1, respectively. Considering the HEC-1 model is composed of 35 subcatchments and calibrated based on observation, the uncalibrated WFIUH shows a good performance compared with HEC-1. Combined with Gibbs' model, the NSE is increased up to 0.85, 0.71, and 0.64 for three storm events as shown in Figure 8.

- Page 11257, line 21: "shows a realization".

Answer: Corrected.

- Page 11257, line 19: What geometric criteria were used to compare the channel network sinuosity?

Answer: Troutman and Karlinger (1992) defined the measure of sinuosity (H) as the difference between sum of the shortest distances from all points and sum of distances from all points that follow along the path of a network. Therefore, H = 0 for Scheidegger model and greater than zero for others. Seo and Schmidt (2013) defined a normalized sinuosity (H') by dividing H by the sinuosity of the Scheidegger model. As the reviewer mentioned, we included the normalized sinuosity (H') as a measure of sinuosity of the uniform model. The normalized sinuosity of the uniform model of the test watershed is

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0.67.

- Page 11257, lines 19-24: Do references concern Figure 4 and not 3?

Answer: Yes. Lines from 19 to 24 describes the realization of stochastic models including Scheidegger, Gibbs', and Uniform model as shown in Figure 4.

- Page 11257, lines 1-5 and Figure 5: Why only the bifurcation ratio Rb is discussed? How about the other ratios of Horton-Strahler laws (Ra and Rl) and other geomorphometric descriptors?

Answer: Additional analysis for Horton's area and length ratio was included as the reviewer suggested. During the calculation of Ra and Rl, we noticed some mistakes in calculation and, hence, the bifurcation ratio was re-evaluated and newly obtained. We thank the reviewer for that. The results are attached.

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C4942/2014/hessd-11-C4942-2014-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 11247, 2014.

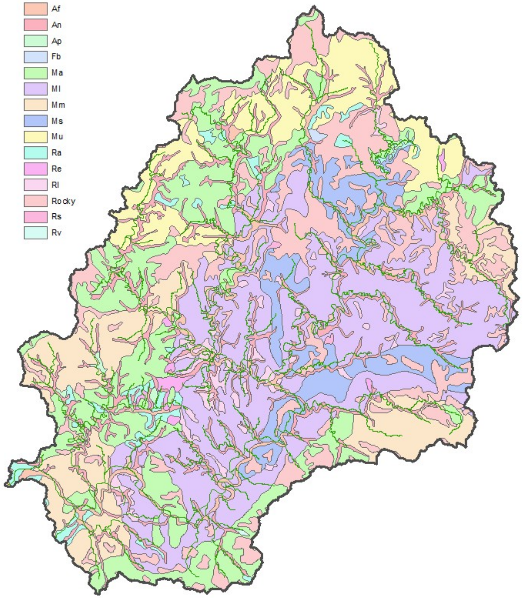

Fig. 1.

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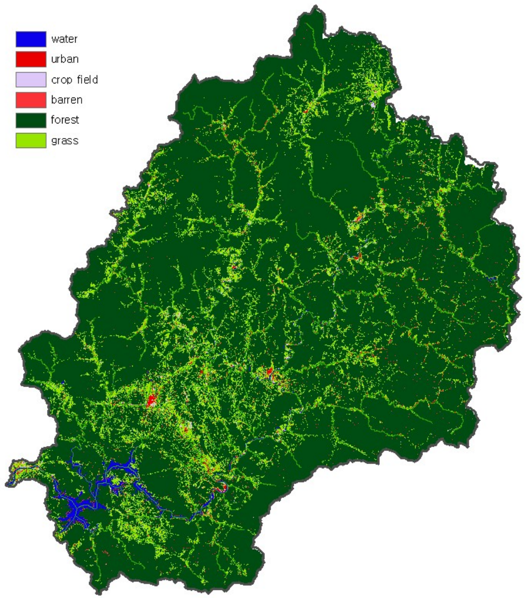

Fig. 2.

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Fig. 3.

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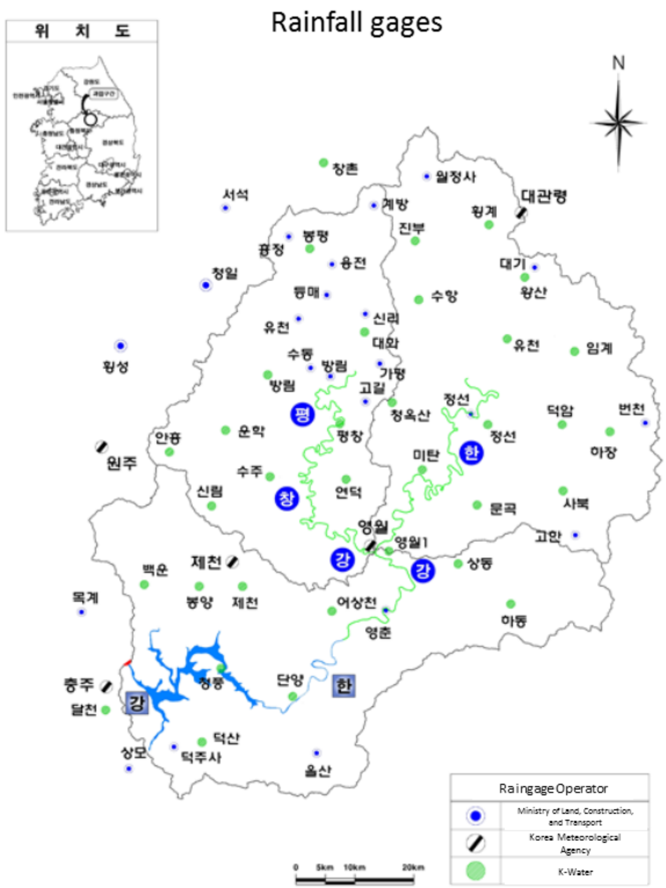

Fig. 4.

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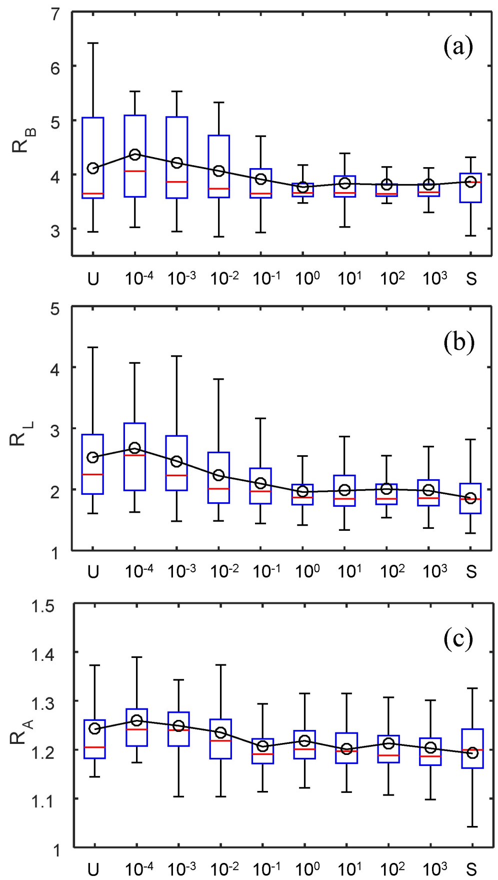

Fig. 5.