Geoscientific Model Development Discussions

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Reply on RC1

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Community comment on "An Improved Algorithm for Simulating Surface Flow Dynamics based on the Flow-Path Network Model" by Qianjiao Wu et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-92-CC1, 2022

Thanks for all of the comments and suggestions for our submission GMD-2022-92. We have carefully examined the comment in the interactive discussion of its preprint, and revised the manuscript accordingly. Detailed correction is listed below point by point.

General comments:
This manuscript describes a new algorithm for surface flow dynamics simulation, which is an improvement to the existing TIN-based method by Chen et al. (2014). Both of them divide a raster DEM into TIN, generate flow path network (FPN) over the TIN, and track the flow along the FPN. The main difference to the TIN-based method, if I understand the text correctly, is that the algorithm proposed in this study adopts an improved Manning equation to calculate the flow velocity, as well as the parallel computing to improve the efficiency. The new Manning equation takes into account slope length factor, topographic wetness index and flow path curvature, while a new method is introduced for topographic wetness index calculation with the TFN network. Although it is odd to introduce new parameters into the Manning equation, the results show the behavior to be effective. Overall, I find this may be a useful paper, and it may propose an effective improvement to the classical Manning equation.
Response: Thanks for the comments.

However, I think this manuscript is not reader-friendly especially for people who know less about this field. Firstly, the section Methodology lacks some important figures for illustration. For example, are the triangular facets of FPN (e.g., L136) and TFN (e.g., 169) the same? Secondly, some abbreviations and letters appear in multiple equations and have different definition. For example, S denotes slope in Eq. 1&6, and denotes specific catchment area in Eq. 4. Thirdly, the flow path is simulated over triangular facets (Section 2.1), and the parameters are calculated for DEM grids (Section 2.2), so how to combine the triangular facets and grids when simulating the surface flow dynamics?
Response: Thanks for the comments. 1) The triangular facets of FPN (e.g., L136) and TFN (e.g., 169) is not the same. We have added the related figure (P8, Line 184). 2) The letters of all of the equations have been rearranges and corrected in the revised manuscript. 3) The flow path is simulated over triangular facets (Section 2.1), and the parameters are calculated for DEM grids (Section 2.2). When simulating the surface flow dynamics, we assigned the value of parameters at its corresponding position to the flow source points to combine the triangular facets and grids.

I have major issue with the improved Manning equation. The authors explain that the *slope length factor, topographic wetness index and flow path curvature should be normalized for Eq. 6, but I find no information about the method for normalization. Does this step rely on any parameter in the DEM? If so, a point may be assigned with different flow velocities when different basins or sub-basins containing this point are adopted. In addition, the results show that the improved Manning equation combining four parameters outperforms the classical Manning equation only considering the slope. More assessments may be valuable to show whether all the four parameters are acting, or a better result may happen when only two or three important parameters are adopted.*

Response: Thanks for the comments. In order to avoid large fluctuation of flow velocity before simulating the surface flow dynamics, we tried to normalize the three parameters and the normalization algorithm has been added in the revised manuscript (P10, L218-221). And this step not rely on any parameter in the DEM. We first tried to combine three parameters with the classical Manning equation and found that the behavior is effective. We are trying to value whether all the four parameters are acting or a better result may happen when only two or three important parameters are adopted.

Finally, the authors may add more descriptions about their methods and assessments such as whether they consider the baseflow like Chen et al. (2014) when assessing the algorithms. More discussions are need to explain why they ignored some conditions, such as the infiltration and water depth (Nilsson et al., 2022).

Response: Thanks for the comments. Daily observed daily flow discharge at the outlet of the BBW in 2001 are measured data provided by the BBW Watershed Monitoring Station. The observed daily flow discharge is combined surface runoff discharge with the baseflow discharge. The improved algorithm also only simulated the surface runoff discharge which is added to the baseflow discharge for getting the daily flow discharge. The baseflow discharge is calculated using the method proposed by Zhang et al. (2012). For the comparison, the same procedure was used for the SWAT simulates the daily flow discharge. Thus, we no need to consider the other conditions. We have supplemented it in the revised manuscript (P13, L289-294).

SPECIFIC COMMENTS:

(1) *P2 L41&54 The statements here are contradictory that "regular-grid DEMs can better describe continuous terrain surfaces" in L41 and TIN is "better expression of complex and changeable surface" in L54.*

Response: Thanks for the comments. The regular-grid DEMs can better describe the continuity of topography. TIN can better express the complexity and fluctuation of the terrain surface. We have corrected it in the revised manuscript.

(2) *P3 L67-78 The authors described that the method of Shen et al. (1995) can "simulate runoff and surface flow discharge at any position and time" in L67-68. However, they stated that the introduced methods including Shen et al. (1995) "can only simulate the surface flow dynamics of a limited number of points" (L75-76), and it is difficult to simulate "at any location" (L78). The statements above are contradictory.*

Response: Thanks for the comments. Shen et al. (1995) explored the water balance equation and Muskingum method to simulate runoff and surface flow discharge at any grid cell and time. The algorithm simulated the surface flow discharge based on the grid cell acquired by splitting the watershed and simulated the runoff of all of the grid cell. We have corrected it in the revised manuscript (P3, L66-68).

(3) *P5 L118-137 The authors may want to add a figure to Section 2.1 to show the processes of FPN generation clearly.*

Response: Thanks for the comments. The processes of FPN generation have been illustrated in Figure 1. The specific tracking algorithm have been described in detail by Chen et al. (2014) and we have referenced the paper in Section 2.1.

(4) *P6 L147 The definitions of letters in Eq. (1) were not introduced.*

Response: Thanks for the comments. We have added the definitions of letters in Eq. (1) in the revised manuscript (P6, L146-147).

(5) *P7 L173 The reference of TFN by Zhou et al. (2011) seems to be missed. The authors may explain why they accepted the method of Zhou et al. (2011) for the flow accumulation but used a new method rather than the one of Zhou et al. (2011) for aspect. Can it improve the accuracy?*
Response: Thanks for the comments. Consider the constant slopes and aspects of the triangular facets, we tried to obtain the slope and aspect from the TFN constructed from the no-depression DEM by the TFN algorithm (Zhou et al., 2011). The accuracy of the surface flow dynamics demonstrates that the behavior is not bad. We hope to get the required parameter from the vector TFN or FPN for the further integration.

(6) *P7 L183 "n denotes the nth triangular facet"? The "n" may be the number of the triangular facets treating the cell as the vertex. In addition, it is different for the readers to understand the triangular facet mode of TFN because there is no figure and the triangular facets decided by FPN in Figure 2 may mistake them.*
Response: Thanks for the comments. The "n" denotes the number of the triangular facets treating the cell as the vertex and we have corrected it in the revised manuscript (P7, L182-182). In addition, we added a figure to understand the triangular facet mode of TFN in the revised manuscript (P8, L179-180).

(7) *P7 L186-188 For Eq. (4), A should denote the number of flow lines passing the cell over the TFN (Zhou et al., 2011).*
Response: Thanks for the comments. We have corrected it in the revised manuscript (P7, L185-186).

(8) *P8 L194 tanβ denotes the slope (m/m).*
Response: Thanks for the comments. We have corrected it in the revised manuscript (P8, L193).

(9) *P8 L204 How did the authors normalize the slope length factor, topographic wetness index, and flow path curvature?*
Response: Thanks for the comments. The min-max normalization method was utilized to normalize the three parameters in this study. We have supplemented it in the revised manuscript and added the related reference in the paper (P8, L203-204).

(10) *P8 L214 The analytic hierarchy process (AHP) may be effective according to the results. But authors may explain more about why they decided the relative importance between the parameters like Matrix 1. A reference is required because the method of AHP is existing.*
Response: Thanks for the comments. We tried to give the relative importance between the parameters like Matrix 1 and the matrix is deemed to pass the consistency test. So, we used the elements of the eigenvector corresponding to the maximum eigenvalue of the Matrix 1 as the weights. We had added the reference about the method of AHP in the revised manuscript (P8, L205).

(11) *P11 L262 The resolution of original DEM was 5 m. Why only the resolutions ranging from 10 m to 30 m were adopted for subsequent analysis?*
Response: Thanks for the comments. We retrieved the critical points from the 5 m DEM with different thresholds of 0.5, 1.0, 1.5, 2.0 and 2.5 m to construct the TIN with different scales. The flow source points were obtained from the DEM with the resolution of 10, 15, 20, 25 and 30 m which are resampled from the 5 m DEM. Then the TIN was combined with the flow source points to generate the FPN for the surface flow dynamics simulation. The resolutions of flow source points ranging from 10 m to 30 m were adopted for subsequent analysis.

(12) *P12 L276-283 This paragraph should be improved because multiple thresholds with different uses are confusing. Is the filter threshold used to avoid narrow facets as described in L127-128? Are the same values of drainage network threshold (2000 m2) and the filter threshold (8 m) adopted by the DEMs with coarser resolutions (i.e., 10-30 m) used below? If so, the distance between two points over a10-m resolution DEM is always longer than 8 m, is this threshold necessary?*
Response: Thanks for the comments. We retrieved the critical points from the 5 m DEM with different thresholds and not retrieved the critical points from DEM with different resolutions. Because the RMSE of drainage-constrained TIN slightly increases when the threshold of extracting the drainage networks is greater than 2000 m2 and the threshold of 8 m was used to filter the critical points because the greater threshold value basically keeps the RMSE of drainage-constrained TIN unchanged. Thus, in order to reduce the narrow facets, we selected the threshold of 2000 m2 to extract the drainage networks and the threshold of 8 m to filter the retrieved critical points with different thresholds of 0.5, 1.0, 1.5, 2.0 and 2.5 m.

(13) *P12 L282 A table can be added to list the numbers of critical points and facets over DEMs with different resolutions.*
Response: Thanks for the comments. We list the numbers of critical points and triangular facets with different thresholds in Table 8. Here, we only illustrated the numbers of critical points and triangular facets with the threshold of 0.5 m and so we not list a table.

(14) *P12 L285-288 There are six resolutions but five flow line numbers. So is the resolution of 5 m ignored?*
Response: Thanks for the comments. The 5 m DEM is not ignored. The flow source points were obtained from the DEM with the resolution of 10, 15, 20, 25 and 30 m which are resampled from the 5 m DEM. The drainage-constrained TINs were constructed by the critical points extracted from the 5 m DEM.

(15) *P13 L293 Which step requires the threshold to cut the flow line?*
Response: Thanks for the comments. The FPN_C algorithm was described in the paper "Wu, Q., Chen, Y., Zhou, H., Chen, S. and Wang, H.: A new algorithm for calculating the flow path curvature (C) from the square-grid digital elevation model (DEM), ISPRS Int. J. Geo-Inf., 9(9), 32–34". The cubic B-spine interpolation algorithm was used to smooth flow line over the flow path network in the FPN_C algorithm. To reduce the likelihood of overfitting, the flow line was cut up by a threshold.

(16) *P14 L298 Table 3 contains land use data, climate data, and soil data, but the caption only mentions the land use data, while only the land use data was used in this study.*
Response: Thanks for the comments. We have replaced the caption of Table 3 as Summary of input data used for the simulations in the BBW region. The Manning's roughness coefficient is determined according to the land-use types of the BBW region in Table 3 and the values proposed by Thompson (1999). Other data were used for the baseflow discharge simulation.

(17) *P17 L322 Why was only the resolution of 30 m adopted for comparison between SWAT and the improved algorithm?*
Response: Thanks for the comments. We only have 30 m resolution of data required by the SWAT model currently and only compared their results under the resolution of 30 m. But we will compare their accuracy under other resolutions in the further research.

(18) *P19 L348 The terms "scale" and "resolution" seem to be mixed up in this manuscript.*
Response: Thanks for the comments. We have corrected all of the confusing uses in the revised manuscript.

TECHNICAL CORRECTIONS

(1) *P2 L50 The full name of the abbreviation "BGIS" should be "Basin Geomorphic Information System" rather than "Geomorphic Information System". And the reference "Tachikawa (1994)" may be false because this reviewer found the article published in 1992 and another journal according to the DOI.*
Response: Thanks for the comments. We have corrected it in the revised manuscript. (P2, L49)

(2) *P3 L68-69 The full name of the abbreviation "SCS" and "HRU" were missed.*
Response: Thanks for the comments. We have added their full name in the revised manuscript. (P3, L67-68)

(3) *P21 L374 There are two lines labeled as scale = 5 m.*
Response: Thanks for the comments. The three labels have been corrected in the revised manuscript. (P21, L369)

References
(1) *Chen, Y., Zhou, Q., Li, S., Meng, F., Bi, X., Wilson, J. P., Xing, Z., Qi, J., Li, Q. and Zhang, C.: The simulation of surface flow dynamics using a flow-path network model, Int. J. Geogr. Inf. Sci., 28(11), 2242-2260, https://doi.org/10.1080/13658816.2014.917312, 2014.*
Response: Thanks for the comments. We have corrected it in the revised manuscript. (P26, L504-506)

(2) *Nilsson, H., Pilesjö, P., Hasan, A., & Persson, A. (2021). Dynamic spatio-temporal flow modeling with raster DEMs. Transactions in GIS, 26, 1572-1588. https://doi.org/10.1111/tgis.1287*
Response: Thanks for the comments. We have added it in the revised manuscript. (P27, L537-538)

(3) *Shen, X., Wang, L. and Xie, S.: A dynamic precipitation-runoff model for a watershed based on grid data, Acta Geographica Sinica, 50(3), 264-271, https://doi.org/10.11821/xb199503009, 1995.*
Response: Thanks for the comments. We have corrected it in the revised manuscript. (P27, L547-548)

(4) *Tachikawa, Y., Shiiba, M. and Takasao, T.: Development of a basin geomorphic information system using a TIN-DEM data structure, Water Resour. Bull. Am. Water Resour. Assoc., 30(1), 9-17, https://doi.org/10.2208/prohe.36.677, 1994.*
Response: Thanks for the comments. We have corrected it in the revised manuscript. (P28, L557-558)

(5) *Zhou, Q., P. Pilesjö, and Y. Chen (2011), Estimating surface flow paths on a digital elevation model using a triangular facet network, Water Resour. Res., 47, W07522, doi:10.1029/2010WR009961.*
Response: Thanks for the comments. We have corrected it in the revised manuscript. (P28, L588-589)