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Hydrology and Earth System Sciences Discussions

Interactive comment on "Which type of slope gradient should be used to determine flow-partition proportion in multiple-flow-direction algorithms – tangent or sine?" *by* L.-J. Zhan et al.

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The authors thank the Dr. Paolo Tarolli for the constructive comments and criticism which are helpful for improving the final version of this paper. Below we try to answer the issues raised by the referee.

Comment 1: Goal of the work. I have some difficulties to understand the goal of this work. Is for a better interpretation of surface flow? Subsurface flow? Flow in rivers? The main differences among all flow direction algorithms are related to the hillslopes, while in well-defined channels, narrow valleys, the performances tend to be similar.

Why introducing equation (2) and (3)?

Response: The goal of this short note is to argue that the flow-partition function (Eq. 1 in the original manuscript) used in MFD algorithms should be designed based on a clear hydrological theory and revisit the flow-partition function from the perspective of hydrological theory. The deduction performed based on hydrological theory gets a flow-partition function with the similar form as Eq. (1) but conceptually related to sin(b), instead of tan(b) as used currently.

The idea shown in Eq. 2 in the original manuscript is consistent with that of the MFD algorithms, which any downslope neighboring cell will receive the outflow from the central cell. Therefore, we used Eq. 2 to model the water outflow from a central cell to its i-th downslope neighboring cell on the gridded DEM.

As a complex issue, the movement of water on the landscape is primarily driven by gravity and to some degree modified by the properties of the material it flows through or over (Gruber and Peckham, 2009). The effect of gravity can be estimated with DEM while the surface properties and conditions are cumbersome to be described and treated quantitatively (Wilson, 2012). For simplifying this issue, we used Manning's equation (Eq. 3 in the original manuscript) to describe the flow rate from a given cell distributed to neighbouring downslope cells on surface.

Comment 2: Why consider the only multiple flow algorithm? Why not compare these analyses with other algorithms such as Dinf and D8 (or D8-LTD). Dinf at my eyes, in hillslope environment, perform better than multiple flow, since it is not so dispersive, just a compromise between D8 and Multiple Flow.

Response: The applicable conditions (e.g., terrain condition of study area, grid size of DEM, and the practical purpose) of different flow direction algorithms are different (Tarboton, 1997, Gruber and Peckham, 2009; Qin et al., 2011). MFD algorithms with flow-partition function as Eq. 1 in the original manuscript have also been widely used to calculate the hydrologic land-surface parameters for quantifying water flow and related surface processes (Gruber and Peckham, 2009; Wilson, 2012). In this study we focus on questioning the use of tan(b) in the general flow-partition function (Eq. 1 in the original manuscript) applied to MFD algorithm from the perspective of hydrological theory. Therefore, the comparison between the interest MFD algorithms and other flow direction algorithms (such as D-inf and D8) are not included in this short note.

Comment 3: Analysis of the results. This section is really poor and unsuitable. First of all, the authors, as they rightly reported in the last sentence of the discussion, have to test their results on real and also synthetic landscapes. This is the way that all the authors of flow direction algorithms followed. Fig. 1 and 2 are not enough, and the differences showed in Fig. 2 are nothing without real data, comparison with other algorithms, and statistics. Also an analysis on secondary topographic attributes (such wetness index) should be addressed in order to test any differences in using sin or tan.

Response: In this short note we focus on questioning the use of tan(b) in the general flow-partition function (Eq. 1 in the original manuscript) applied to MFD algorithm from the perspective of hydrological theory, rather than the design of a new MFD algorithm. In the original manuscript, Section 3 gave an example shown in Fig. 2 to show that the use of sin(b) instead of tan(b) in the flow-partition function will affect the SCA results of MFD algorithms. If the opinion in this manuscript are accepted, the follow-up work on how to design a new MFD algorithm with a specific flow-partition function based on sin(b) will be needed. It will also need additional work to evaluate the new-designed algorithm on real and also synthetic landscapes, as the way followed by all works of designing flow direction algorithm. We believe those are beyond this short note.

Because the analysis of the results in current manuscript has shown that the use of sin(b) instead of tan(b) in the flow-partition function will make a difference in the SCA results of MFD algorithms, the secondary topographic attributes (such as topographic wetness index) will also get difference in the use of sin(b) instead of tan(b), according to the definition of those SCA-based topographic attributes. We will revised the manuscript to state this point.

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