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Hydrology and Earth System Sciences Discussions

Interactive comment on "Gradually-varied open-channel flow profiles normalized by critical depth and analytically solved by using Gaussian hypergeometric functions" *by* C. D. Jan and C. L. Chen

C. D. Jan and C. L. Chen

cdjan@mail.ncku.edu.tw

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Reviewer comment 1: Notations: The authors have used the notation h for depth of flow, whereas the standard notation for flow depth is y. Thus, the notations h, hc and hn should be changed to y, yc and yn respectively. Response to Comment 1: It might be a misunderstanding that y is the standard notation for flow depth. In fact, the symbols h, d and y are all common symbols used to represent the flow depth in the fields of hydrology and hydraulics. For example, in the famous text book of open-channel hydraulics by Chow (1959), he used d to represent the flow depth and y to represent the stage of water surface respect to the bottom of the channel, as shown in Pages 39 and 219, Figs. 3-1 and 9-1 in the book. The relationship between y and d could be written as d = ycos(slope angle). For mild slope of channel with small slope angle, cos(slope angle)approximatelly equals 1 and y approximatelly equals d, and under this assumption, Chow (1959) used y to replace d, but this does not mean y is the standard notation for flow depth. In general, y is the standard notation for the vertical coordinate. However, if the journal HESS treats y as a standard notation for flow depth, we will agree to change the notation h to y.

Reviewer comment 2: All the analysis is based on approximations involving hydraulic exponents M and N, which is a crude approximation that does not hold good for practical sections like trapezium and circle. Furthermore, computation of flow profiles using hypergeometric function requires more programming effort and execution time. On the other hand, without any assumption of hydraulic exponents the flow profiles can be easily computed using a fourth order Runge-Kutta method. This will require much less programming effort and computer time. Thus, the authors' work is merely an academic exercise having no utility. Response to Comment 2: (1) Yes, the traditional analysis on the gradually varied flow (GVF) profile by using the integration method involves the assumptions of the hydraulic exponents M and N. There are some exist methods to find suitable values for flow in channels with different cross section shapes, as shown in the Chapters 4 and 6 of the Chow's book (1959). The analytical solution of GVF profile by using the integration method and the Gaussian hypergeometric function (GHF) has the advantage of providing independent solutions of previous computation steps, and the total length of the water surface profile can be evaluated with a single computation. (2) It is not true that the computation of flow profiles using Gaussian hypergeomic function requires more programming effort and execution time as mentioned by the reviewer. Actually, the computation of Gaussian hypergeomic function is well ready in commercial software, such as MATLAB and Mathematica. No more programming effort and execution time are needed by using the Gaussian hypergeomic function.

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(3) Solving the GVF profile by using a fourth order Runge-Kutta method belongs the field of numerical method. The result from the numerical method cannot provide total length of the water surface profile with a single computation. Of course numerical solutions have their own values for practical problems, but it does not mean we should deny the value of analytical solution. Even though having some kinds of limitations, analytical solutions have their own values, especially in academic interests. (4) This paper presents novel concepts and tools to analytically solve the GVF profiles in sustaining and non-sustaining channels. This paper has laid the foundation to compute at one sweep the critical-depth(hc)-based GVF profiles in a series of sustaining and adverse channels, which have horizontal slopes sandwiched in between them. To obtain the GHF-based solutions from the hc-based GVF equation is our first step for developing a viable method to compute the hc-based GVF profiles subject to a variety of the boundary conditions imposed in such a series of interconnected sustaining and adverse channels. Working toward that goal, we have come up with two significant results produced from this study: Firstly, we have obtained the GHF-based solutions from the hc-based GVF equation, which proves to be applicable for computing the GVF profiles in both sustaining and adverse channels. Secondly, we have analytically proved that the GHF-based M and A profiles, if normalized by hc rather than by hn, can asymptotically reduce to the hc-based dimensionless H profiles as hc/hn $\rightarrow$ 0. Both significant results thus constitute the principal conclusions drawn from this study.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 11791, 2012.