Uniform flow formulas for irregular sections in straight channels

Reply to review of P. Rameshwaran

The authors would like first to thank the reviewer for his valuable job.

Question 1): *The title - Uniform flow formulas for irregular sections - suggests that the new methods are applicable to all planform rivers (i.e. straight, meander and skewed simple or compound rivers) but the sections up to 4 are only deals with straight simple (K4 case?) or compound channels (other cases). Are these methods applicable to all planform rivers?*

Reply: The reviewer is right. In the paper we didn't investigated the effect of meandering. We referred only to straight channels, even if formulas for straight channels are usually extended also to meandering channels. We changed the title in "Uniform flow formulas for irregular sections in straight channels".

Question 2): *The SKM or similar methods can be numerically solved (see our paper with Ramesh waran & Shiono 2007) i.e. for irregular sections. You only need to discretized into linear elements for analytical solution only (lines 101 to 102).*

Reply: In the introduction we meant to say that analytical or approximated solutions require to neglect secondary flows. Of course, it is possible to carry on numerical integration along the lateral (y) direction of the vertically integrated Reynolds equation, like it is done with the SKM or similar methods. This doesn't avoid the need of using empirical parameters, required to compute the eddy viscosity. In the revised paper we corrected the text to and we added the missing reference.

Question 3): *In SKM papers, the friction factor is defined as f=8gRS/U^2 but some other papers including Huthoff et al. 2008, it is defined as f=gRS/U^2. The authors need to state their friction factor equation.*

Reply: Our friction coefficient is the same one used by Huthoff in his traditional approach ($f=gn^2/R^{1/3}$). In the paper the value of f shown in equation (7) was divided by the gravity acceleration, which was taken into account in the first term on the right side of equation (5). To avoid any ambiguity, we changed in the revised paper Eqs. (5) and (7) according to the previous definition of f.

Question 4): *Looking at 13 km Alzette study reach in Figure 4, It got variety of planform (straight, bend/curve, meander etc). In such cases, the energy losses not only form bed roughness elements* *but also from secondary flows due to planform and expansions and contractions in meandering. Are these methods applicable to the Alzette study reach? The authors need to clarify this.*

Reply: The Manning coefficient has, in the context of the indirect method for discharge estimation, the meaning of a calibration parameter, that we use to match the water levels measured in the downstream section with the level computed by the 1D hydraulic model.

It is well known from the parameter estimation theory (*Aster et al., 2012*) that in any numerical model the uncertainty of the estimated parameters, obtained by matching the computed and the measured model output, grows very quickly with the parameter number. This implies the need of minimizing the number of parameters, also by neglecting the effect of irregularities and heterogeneities. Of course, it would be very easy to fit very well the measured and the computed water level hydrographs (that are the output of the hydraulic model) also by differentiating the Manning coefficient along the reach or along the section, but the corresponding parameter error would become very large even with a small error in the topography or in the measured water levels. These errors strongly affect the discharge computed by the hydraulic model. Moreover, if the computed Manning coefficients or the parameters of other formulas were used for prediction purpose (which is a major benefit of the indirect measurement approach) the predicted discharges would be affected by an even stronger error. All this implies, of course, that test n.2 can be thought as the validation of the proposed formulas for their use in the specific method for the discharge estimation.

On the other hand, as explained in the paper, it is very difficult to carry on field tests for the validation of these formulas, because roughness coefficients are unknown and the results of all formulas can be scaled according to the selected Manning coefficient or to other parameters. The indirect method provides a unique possibility of carrying on a simultaneous estimation of both the Manning coefficient and the discharge hydrograph.

In the revised paper we expanded the introduction to the indirect discharge measurement method, by adding:

" It is well-known in the parameter estimation theory (Aster et al., 2012) that the uncertainty of the estimated parameters (in our case the roughness coefficient) grows quickly with the number of parameters, even if the matching between the measured and the estimated model variables (in our case the water stages in the downstream section) improves. The use of only one single parameter over all the computational domain is motivated by the need of getting a robust estimation of the Manning's coefficient and of the corresponding discharge hydrograph."

Question 5): *Line 400, the length of the reach is about four times the top width of the section. Line 450, in the inlet section a constant velocity, normal to the section, is applied, and the pressure is left unknown. Is the length (i.e. using constant velocity inlet) enough for flow to develop within 3D model? The authors need to provide evidence.*

Reply: To address the reviewer concern, we carried out new computations to check the sensitivity of the estimated discharge with respect to the length of the prismatic reach. An extension of about 10% has been applied, increasing the size of the computational domain from about 20×10^6 to about 21×10^6 elements. The computed dimensionless sensitivity has been equal to:

$$S = \frac{L}{Q}\frac{\Delta Q}{\Delta L} = 0.002,$$

which we believe indicates a robust estimation, also because a small change in the results can be motivated also by the grid change. We added in the revised paper:

"Stability of the results has been checked against the variation of the length of the simulated channel. The dimensionless sensitivity of the discharge with respect to the channel length is equal to 0.2%".

Question 6): *Lines 460 to 462: CFX allows the use, inside the boundary layer, of a velocity logarithmic law, according to an equivalent granular size. What is the logarithmic d_{50} relationship used in CFX?*

Reply: The logarithmic wall law implemented in ANSYS CFX solver is the modified version of the Launder and Spalding (1974) log-law equation (Shen and Diplas, 2010; Ansys CFX-solver theory guide, Rel.14.0, 2006):

$$\frac{u}{u^*} = \frac{1}{k}\ln\left(\frac{c_\mu^{\frac{1}{4}} y k^{\frac{1}{2}}}{\nu}\right) - \frac{1}{k} ln\left(1 + \frac{0.15 d_{50} c_\mu^{\frac{1}{4}} k^{\frac{1}{2}}}{\nu}\right) + C$$

where:

$c_\mu = 0.09$ is an empirical coefficient;

k= local turbulent kinetic energy;

ν= kinematic viscosity of the fluid;

d_{50}=average granular size;

C=log-layer constant dependent on wall roughness.

where the applied value d_{50} = 0.73 m has been selected according to its relationship with the *n* Manning coefficient, given by Eq. (27) (Yen, 1994).

Question 7): *What is the d_{50} value used? Is the logarithmic relationship and first (i.e. boundary mesh size) valid (see papers Nicholas, 2005; Lane et al., 2004; Carney et al., 2006, Rameshwaran et al. 2011)?*

Reply: Given that the logarithmic law is no longer valid for a distance from the boundary wall (*y*):

$y \leq 0.1\ d_{50}$

as reported inside "lecture notes on turbulence " (B. Mutlu Sumer, 2013), the authors decided to locate the first point of the mesh above the river bed at a distance *y* equal to 0.1 d_{50}=0.07m.