

## General comments

The Authors proposed analytical/numerical solutions for different rheological models and proposed the Sobol's global sensitivity analysis to evaluate the influence on the simulations of the parameters involved in the investigated models. Their approach can be very helpful to guide the calibration of these numerical models that in the majority of the cases lead to a trial-and-error approach. To improve the paper quality, I would suggest small changes in the paper organization. For example, I'd suggest moving the description of the Sobol analysis in a small, dedicated Section before the models description. Now, the latter is described in the Section of the O'Brien and Julien's model. Furthermore, it would be amazing if the authors would apply O'Brien and Julien's model to simulate the case of Valle Camonica. In this way, coupling the analytical solutions and the Sobol analysis the authors would emphasize their work. Differently, using the 1D case, they should investigate some other parameters with a greater variance than the used one. Generally, I think that Section 4 (Application and discussion) should be strengthened.

## Specific comments

Line 31 - 33. Moreover, ...has been accomplished. Please, consider deleting or rewriting this sentence. It's not very clear.

Line 43. ...we show that two parameters of the widely used FLO-2D. Can you briefly introduce these two parameters?

Line 50. Maybe it should be better to call the flow velocity 'depth-averaged flow velocity'

Line 61. Probably, the Voellmy's rheology was applied to debris flows before the paper you mentioned (Kelfoun et al., 2011, <https://doi.org/10.1029/2010JB007622>). Please, check if other authors have already used this approach to model debris flows.

Line 65 – 75. Please, declare  $\theta$  and  $\Phi$  in Eq. 4 and 5.

Line 98. Why did you say that the Manning's coefficient can be easily identified? How do you calculate it?

Line 139. Could you insert the Sobol equation?

Line 147 – 148. ...obtained considering typical values from the literature. For researchers working on this topic your  $C_v$  and  $\gamma_s$  are reasonable but probably it would be better to motivate their ranges choice.

Line 295. Please, indicate the DEM resolution

Line 295. So, you calculated  $\mu$  using the slope of the depositional area. However,  $\mu$  changes during the flow motion. Probably, the procedure more reasonable should be using your analytical solutions to restrict the variability range of  $\mu$ . Starting from this range, a trial-and-error procedure should be performed to demonstrate that the selected  $\mu$  (0.249) results in the best match between simulated and real data.

Line 330. 30 s or 18 s?

## Technical corrections

Line 76 – 78. Please check the English of the sentence 'The solution for.. when  $B = 0$ .

Line 167. Zegers et al. (2020), ~~that~~ which