Response to the comments of reviewers for nhess-2020-289

Answers to Technical items for which revision is required --- '*Numerical investigation on the kinetic characteristics of the Yigong landslide in Tibet, China*'

The authors are grateful for the reviewers' comments and suggestions. The manuscript has been revised and each point of the reviewers' comments has been incorporated and addressed. Your comments have greatly improved the quality of this manuscript and we hope the revised manuscript will be of suitable standard to be accepted for publication in your journal.

Reviewer #2:

This paper analyzed the run-out process of an interesting catastrophic rockslide occurred in Tibet, China through field investigation and numerical simulation. The 2D and 3D SPH models were adopted to simulate the dynamic process of this landslide, and the Bingham model was used to describe the rheology. Then the simulated velocity and depositional characteristics were compared with field observations and measured data, and generally good results were obtained. This paper is well-written. The structure is clear, and the conclusions are reliable. The topic of this paper, which is pretty important for the mitigation of huge landslide induced disaster chain (landslide-landslide surge waves-landslide dam lake-dam break-flood chain), is definitely of interest to the readership of this Journal. Therefore, the reviewer suggests a minor revision before acceptance.

The following comments are for the authors' reference.

1. Line 14, how do you consider the effect of collision in the SPH model? Collision may contribute to the disintegration of the rock mass, and in addition, the plastic deformation caused by collision may also dissipate part of the energy. Are your models capable of depicting these effects?

Answer: Thank you for this comment. In the presented SPH model, the disintegration of the rock mass caused by the collision effect cannot be considered. We add some explanation in the manuscript as follows:

"*On the other hand, high-speed sliding may lead to the disintegration of the rock mass and influence the propagation behaviour. However, this phenomenon cannot be considered in the presented SPH model.*" (Lines 340-341)

2. There are some minor grammatical mistakes in the manuscript. Please check them carefully. For instance, in Line 27, "feathers" should be "features"? and in Line 35, "in predominantly" should be "predominantly in". In Line 250, "the results is shown" should be "the results are

shown".

Answer: We are sorry for the grammatical mistakes. The manuscript has been checked carefully and the mistakes have been corrected.

3. Line 90-95, how do you know the volume and velocities of the landslide?

Answer: The volume of the Yigong landslide mass is about 3.0×10^8 m^3, which is cited from Shang et al. (2003). Li et al. (2020) simulated the velocity process using the Massflow software, and showed that the maximum velocity during the landslide propagation is larger than 100 m/s. According to Xu et al. (2012), the run-out time of the landslide is around 3 min, the total run-out distance is about 8,000 m. Therefore, the average sliding velocity is about 40 m/s. We add the references in the manuscript.

"*About 3.0×10^8 m^3 rock and soil slid down along the gully for about 3 min (Shang et al. 2003; Xu et al. 2012).*" (Line 92)

"*According to eyewitness' account, the total sliding time of the Yigong landslide was about 3 min. The runout distance was about 8,000 m. Therefore, the average sliding velocity of the landslide was estimated to be about 40 m/s. According to the dynamic analyse results (Zhang, 2013; Li et al., 2020), the maximum velocity during the landslide propagation was more than 100 m/s. Therefore, the velocity time history predicted by the SPH model in this work fits the literature data well and is reasonable and reliable.*" (Lines 328-332)

Li, J., Chen, N.S., Zhao Y.D., Liu, M., Wang W.Y.: A catastrophic landslide triggered debris flow in China's Yigong: factors, dynamic processes, and tendency, Earth Sciences Research Journal, 24, 71-82, doi: 10.15446/esrj.v24n1.78094, 2020.

Shang, Y.J., Yang, Z.F., Li, L.H., Liu, D., Liao, Q.L., Wang, Y.C.: A super-large landslide in Tibet in 2000: background, occurrence, disaster, and origin, Geomorphology 54, 225–243, doi: 10.1016/S0169-555X(02)00358-6, 2003b.

Xu, Q., Shang, Y., van Asch, T., Wang, S., Zhang, Z., Dong, X.: Observations from the large, rapid Yigong rock slide—debris avalanche, southeast Tibet, Canadian Geotechnical Journal, 49,589–606, doi: 10.1139/T2012-021, 2012.

Zhang, Y.J.: Study on dynamic characteristics of typic rock avalanche on canyon area, Ph.D. thesis, School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University, 28 pp., 2013.

4. Line 100, "estimated original slope surface", but how to estimate?

Answer: Thank you for this comment. The original slope surface is cited from Yin (2000). We add the reference in the manuscript.

"*Figure 6 shows the path profile of this landslide. In this figure, the original slope surface (blue dashed line) and the present slope surface (green solid line) are from Yin (2000).*" (Lines 100-101)

Yin, Y.P.: Characteristics of Bomi-Yigong huge high-speed landslide in Tibet and the research on disaster prevention, Hydrogeology and Engineering Geology, 4, 8–11, 2000. (in Chinese with English abstract)

5. Line 155, are you sure the fluid is incompressible? The continuity equation is compressible, because density changes with time. And Eq. 3 is the state equation showing the relationship between density and pressure. So, the fluid should be (at least) weak compressible.

Answer: We agree with the reviewer's comment. In the presented model, the landslide mass is assumed as a kind of weakly compressible fluid. We correct the expression in the manuscript:
"*In this study, the flow-like landslide is assumed as a kind of weakly compressible viscous fluid.*" (Line 156)

6. Eq.3, please specify the way how you determine the parameters in this equation. And also, please specify the values of these parameters in the 2D and 3D simulations.

Answer: Thank you for this comment. In Eq.3, ρ is the density calculated by the continuity equation (Eq.1). ρ_0 is the reference density which can be measured through laboratory tests. c_s is the sound speed at the reference density, which can be set equal to ten times the maximum velocity (Zheng and Chen, 2019). γ is a parameter which can be set to 7.0 for a good simulation of weak compressible (Zhang et al., 2020). We specify the way to determine the parameters and their values used in this paper as follows:
"*where ρ is the density calculated by the continuity equation. ρ_0 is the reference density which can be measured through laboratory tests. c_s is the sound speed at the reference density, which can be set equal to ten times the maximum velocity (Zheng and Chen, 2019). γ is the exponent of the equation of state, and is usually set to 7.0 for a good simulation of weakly compressible (Zhang et al., 2020).*" (Lines 164-167)
"*According to Li et al. (2020), the average density of the Yigong landslide mass was about 2,000 kg/m^3. The strength characteristics of the landslide mass were studied through a series of high-speed ring shear tests and rotary shear tests in the previous researches (Hu et al., 2015; Wang et al., 2017). According to the test results, the values of the c and φ of the landslide mass can be approximately set to be 10 kPa and 20°, respectively. The sound speed cs is set to be 10v_{max} (v_{max} is the maximum sliding velocity of the landslide mass). The parameter γ in the equation of state is set to be 7.0 for a good simulation of weakly compressible.*" (Lines 224-230)

Zheng, B., Chen, Z.: A multiphase smoothed particle hydrodynamics model with lower numerical diffusion, Journal of Computational Physics 382: 177–201, doi.org/10.1016/j.jcp.2019.01.012. 2019.
Zhang, W.J., Ji, J., Gao, Y.F.: SPH-based analysis of the post-failure flow behavior for soft and hard interbedded earth slope. Engineering Geology, 267, 105446, doi.org/10.1016/j.enggeo.2019.105446, 2020.
Li, J., Chen, N., Zhao, Y., Liu, M., Wang, W.: A catastrophic landslide triggered debris flow in China's Yigong: factors, dynamic processes, and tendency. Earth Sciences Research Journal, 24(1), 71–82, doi: 10.15446/esrj.v24n1.78094, 2020.

7. Line 195, how do the number of particles influence the simulation results?

Answer: Thank you for this comment. According to Mao and Liu (2018), the simulation accuracy of the SPH model can be enhanced by decreasing the particle size and increasing the particle number. However, computational efficiency decreases sharply with the particle number increment (Liu and

Liu, 2003). Therefore, in the presented work, we used the appropriate number of SPH particles to achieve an appropriate balance between the computational efficiency and accuracy. We add some explanations in the manuscript as follows:

"*The number of SPH particles used in the numerical model can influence the computational efficiency and accuracy simultaneously (Liu and Liu, 2003; Mao and Liu, 2018). Therefore, to reach an appropriate balance between the computational efficiency and accuracy, 7,662 blue particles are used to represent the landslide mass and 5,906 grey image particles are used to simulate the sliding surface. The diameter of those particles is 8 m.*" (Lines 219-223)

"Mao ZR, Liu GR. A smoothed particle hydrodynamics model for electrostatic transport of charged lunar dust on the moon surface. Computational Particle Mechanics, 2018, 5(4): 539-551.

Liu GR, Liu MB. Smoothed Particle Hydrodynamics: a Mesh-free Particle Method. World Scientific Press, Singapore, 2003."