

Deriving debris flow dynamics from horizontal impact force measurements

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Basal Normal Force



Generalized Pareto Distribution

McCoy et al., 2013

Horizontal Impact Force

- Does horizontal impact force also follow Generalized Pareto Distribution?
- Are there any differences between debris flow surges and water-rich intersurge in terms of force distribution?
- Can we derive debris flow dynamics from horizontal impact force?

Study site

- Jiangjia Ravine
- 48.6 km²;
- 10-20 debris flow events per year (max 28);
- 400 to 1000 mm rainfall per year between May and October
- 270 m long on a 3.4° slope



Monitoring and experiment setting



Debris flow event on August 25, 2004

- Rainfall began at 11:24:00 local time
- Debris flow started at 12:40:00 local time
- 49 debris flow periods
- 42 debris flow surges
- 38 impact force measurements recorded



Debris flow surges on August 25, 2004





Concentration

Concentration

Impact force time series

- 19th Debris flow Sugre
- Empirical Mode
 Decomposition (EMD)
- Short-term Fourier transform (STFT)
- Moving-window median filter
- Large grain impact



Impact force time series

- 24th Debris flow Sugre;
- Multiple surges with different magnitudes



Normalized Impact Force Distribution



Normalized Impact Force Distribution



GA: Gamma distribution;GP: Generalized Pareto distribution;NA: Nakagami distribution;NO: Nomal distribution;LL: Log-logistic distribution

$$RSS = \sum_{i=1}^{N} (y(Fn(i)) - f(Fn(i)))^{2}$$

Normalized Impact Force Distribution





Power spectral density (PSD)



 $PSD(f) = \frac{1}{N} \sum_{n=0}^{N} STFT(n, f),$

Physical Model



Farin et al., 2019

$$PSD(f,t) = \int_D \int_y \int_z R_{impact} |2\pi f F_{x1}|^2 dz dy dD$$

$$R_{impact} = \frac{U\phi p(D)}{D^2}$$

$$F_{x1} \approx I_{x1} = (1 + e_b) m u_{impact} \sin \alpha = (1 + e_b) m U$$

Sediment flux over three sensors







Conclusion

- Debris flows at Jiangjia Ravine are quasi-static and viscous flows with high solid-fluid interactions;
- Probability density functions of horizontal impact force are consistent with a log-logistic distribution;
- Surges and intersurge flow have similar impact force distribution, but surge usually has a heavy tail;
- Discharge estimated from impact force model is comparable to other field estimations.