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Using Smoothed Particle Hydrodynamics to investigate the effect of complex slide rheology on landslide generated waves.

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Numerical modelling of submarine slide dynamics is important owing to a lack of direct observations or measurements. Slide rheology affects the initial acceleration and velocity of the slide, which are both important factors in wave generation and the resultant tsunami hazard. A simple, widely-used rheological model of a deformable slide is a Newtonian fluid. However, detailed slide observations suggest that more complex rheological models, including a finite yield strength and shear thinning, are required to faithfully describe the acceleration and deceleration of the slide.

Here we use a Smoothed Particle Hydrodynamics (SPH) code to investigate the effect of submarine slide rheology on slide dynamics and wave generation. We consider three rheologies: a Newtonian rheology; a Bingham rheology, which adds a yield stress to the Newtonian formulation; and a Herschel-Bulkley rheology, which includes a yield strength and a non-Newtonian viscous term. SPH is Lagrangian and mesh free which enables it to efficiently track large deformations and therefore the motion of a submarine slide. Implementation of each rheological model was verified by comparison with analytical solutions for laminar flow on an inclined plane.

We examine the sensitivity of slide acceleration, maximum speed and wave characteristics to the type of rheological model and its coefficients, such as the yield strength and strain rate exponent. We also demonstrate convergence tests and analysis of the performance of the rheological formulations in SPH in terms of accuracy vs computational cost. Our results show that slides with a Newtonian fluid rheology accelerate faster than slides which incorporate a yield strength. The waves generated by Newtonian slides are higher in amplitude but shorter in wavelength than those generated by slides with complex rheologies. In 3D simulations the Newtonian slides show greater lateral spreading than those with yield strengths, which affects the characteristics of the wave generated and its propagation. Waves generated by a Newtonian slide show a more consistent amplitude in all directions, whereas those generated by slides with complex rheologies are more directionally focused.

Our results will help to quantify how critical landslide rheology is to tsunami hazard assessment. Additionally, an understanding of how slides with yield stresses decelerate and halt in comparison to their Newtonian counterparts, will be useful for placing offshore infrastructure and determining how best to defend it against submarine slides.