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Landslide Force History inversion: Measuring the dynamics of catastrophic landslides using seismology and satellite remote-sensing

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Empirical constraints on the dynamics of very large landslides are hard to obtain. In principle, such constraints are to be found in the long-period seismic waves radiated by a landslide mass sliding down and variably loading the substrate beneath. Here we present inversions of long-period seismograms for the time-varying forces driving catastrophic landslides at a number of locations around the world. Once calibrated using remote-sensing imagery and differential topographic data (where possible), these "Landslide Force History" (LFH) inversions indicate masses of 10^{10}–10^{12} kg (with volumes of around 5×10^{6}–5×10^{8} m^3) underwent maximum accelerations in the range 1–3 m s^{-2}. Integration of the inverted acceleration histories indicates the mean landslide masses reached speeds of 25–75 m s^{-1}; integration again yields the 3D relative trajectories of motion of the landslide centers of mass, indicating travel distances of 800 m to 6000 m in 50–160 s. Estimated rates of change of potential and kinetic energy suggest that apparent basal friction increases during slip, with effective friction coefficients approaching around 0.3–0.6 prior to arrest. These inversion results indicate that fundamental properties of catastrophic landsliding can be estimated through remote observation, and that global assessment of major landslides is feasible, at least in principle, in near-realtime.