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Taking the Pulse of Global Landslide Occurrence 2010-2018

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We take the pulse of global landslide occurrence in a 9-year snapshot from 2010 to 2018 and attempt to answer the questions i) what can we learn from the available record of significant and/or damaging landslides and related processes?, ii) what are the implications for landslide hazard assessment?, and iii) what are the implications for landslide risk? Our analysis has utilised four data sources; i) internet sources on landslide occurrence, ii) Google Earth, iii) digital topographic data, and iv) remote sensing (including satellite data and optical imagery). Our global study indicates that heavy rainfall is the most common local and regional trigger for small magnitude landslides (these may be associated with El Niño events, monsoons, or tropical cyclones) (e.g., Brazil, 2011; Myanmar, 2015; Colombia, 2017; Japan, 2018) and that landslides are signature geomorphic processes in extreme rainfall environments. Landslide-triggering rainfall thresholds may differ from region to region suggesting a region-specific intensity threshold conditioned by landscape and environment. Earthquakes (>M6.0) triggered significant landslides during the period (e.g., China 2014; Nepal, 2015; New Zealand, 2016; Papua New Guinea, 2018; Indonesia, 2018) generating major regional landslide events as well as large-scale individual landslides. In terms of regional materials and environment, many landslides occurred in residual soils in tropical regions (e.g., Mexico, 2013; Guatemala, 2015; Colombia, 2017) and fine-grained Quaternary sediments (including loess) in sediment storage landscapes (e.g., Canada, 2010; USA, 2014; Afghanistan, 2014; Kyrgyzstan, 2018); large rock avalanches occurred in global glacial environments (e.g., Canada, 2010; USA, 2016) where the impacts of climate-change related glacier ice loss are dramatic. A number of landslides also occurred in coastal slopes (e.g., United Kingdom, 2017; Greenland, 2017); where these are of large magnitude and exhibit catastrophic behaviour they may cause significant tsunamis (e.g., USA, 2015). Where potential landslides in coastal slopes have been detected, the sites are subject to state-of-the-art monitoring utilising advanced technologies (e.g., Norway 2010-2018). Elsewhere major individual catastrophic landslides occurred as the terminal phase of a deforming rock slope (e.g., China, 2017). Mining activity has led to the failure of tailings dams (e.g., Canada, 2014; Brazil, 2015), rock waste dumps (e.g., China, 2013), and open pit slopes at mine sites (USA, 2013); other human activity has also led to catastrophic landslides in artificial slopes (e.g., China, 2015). Importantly, many landslides create secondary hazards in complex process chains (e.g., China, 2010); these include landslide damming of rivers (e.g., Pakistan, 2010; Nepal, 2014; China 2014), landslide tsunamis and other displaced water effects, and outburst floods/debris floods from the failure of natural and artificial debris dams. Long process chains have resulted in distal damage (e.g., Switzerland, 2017) and are a critical challenge for hazard assessment. Satellite and remote sensing technologies have produced a revolution in landslide detection and monitoring methodologies; retroactive and proactive mitigation are also very well developed as a response to landslide hazard. Finally, we examine the implications of the 9-year landslide record for the magnitude and frequency relations of landslides, and assess the fatal casualty response to global landslide occurrence.