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New direct measurements explain when and why turbidity current systems are active

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Seafloor sediment flows called turbidity currents are the primary agent for sediment, nutrient and organic carbon transport to the deep-sea and pose a serious hazard to globally important seafloor cables and pipelines. Understanding the timing and triggers of these flows is therefore important for the reconstruction of past climates, extending hazard catalogues, and to design resilient infrastructure that support our daily lives. It was generally thought that major external triggers are required to trigger turbidity currents; however, it is challenging (often impossible) to date the deposits that these flows leave behind with sufficient precision to link them to a trigger. Therefore, it is unclear as to whether only major external events (earthquakes, river floods, storms etc.) trigger flows, and how flow triggering varies between different types of system. Here we analyse new direct measurements, using novel technology, that identify triggering mechanisms with unusual precision. We show that three disparate system-types (fjord-head delta-, large river- and oceanographically-fed) show a common behaviour, despite major differences in scale, location and sediment input. Turbidity currents are active only when a sediment supply threshold is exceeded (over time windows of weeks to months), but effectively 'switched off' for other periods. Once beyond that threshold, even relatively minor perturbations can trigger a flow. We then discuss how much larger (>1000 km3) submarine landslides offshore from glaciated margins, that generate large volume turbidity currents, are switched on for much longer periods (1000s of years), following periods of rapid accumulation of glacier-derived sediment. We explain this switch on by a combination of heightened sediment delivery, which either triggers flows by direct river influence, or primes slopes to failure by setting up excess pore pressures in the subsurface. Pore pressures dissipate orders-of-magnitude more quickly in sandy systems (hours to weeks), than in clay-dominated systems (such as the glacially-influenced slopes), which may take 100s-1000s of years. Thus, the permeability of the slope sediments is the key control on how long a system may remain 'switched on'. During system 'switch off', major events such as earthquakes, floods or large storms may be ineffective in triggering flows; hence the system response to external triggers is non-stationary over time. Our findings indicate that caution should be applied when attempting to use turbidite deposits to extend historical catalogues over timescales where sediment supply fluctuates. While it is unlikely that the timing of a turbidity current can be precisely predicted by hazard assessments, the common trend that we observe across four system types worldwide, indicates that we can forecast temporal windows in which they are more likely.