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Coseismic-initiated calving at a freshwater-terminating glacier: Tasman Glacier, New Zealand

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Glacier retreat resulting from iceberg calving represents one of the major controls on ice loss from water-terminating glaciers (ice sheets, tidewater and freshwater glaciers) globally. However, the impact that calving has on the transfer of mass between the cryosphere and hydrosphere is still heavily debated, and the physical mechanisms behind calving remain poorly understood. Hitherto, the initiation of calving events has largely been attributed to underlying glaciological mechanisms (including fracturing of ice due to high longitudinal stress gradients) and changes in the proglacial water-body characteristics. We present evidence for a large-magnitude calving event following high magnitude (>Mw 6) earthquakes as a potentially important triggering mechanism of calving in tectonically-active areas. We describe the response of Tasman Glacier, New Zealand, a freshwater-terminating glacier undergoing accelerated calving retreat, to the Mw 6.3, 5.7 and 4.5 Christchurch 22 February 2011 earthquakes and the subsequent calving event. Time-series analysis of timed video and photographic records of the glacier terminus immediately pre-, co- and post- the 22 February earthquakes demonstrates that the large calving event on the 22 February 2011 occurred in direct response to a resonance effect caused by shear (S-) waves oscillating the terminus at the ice-water interface. We suggest that, in this instance, the magnitude of calving was amplified because Tasman Glacier had reached a critical threshold for buoyancy-induced calving in relation to perturbations in lake level. Prior to this event, small- to intermediate magnitude calving, leading to terminus retreat, had been dominated by thermo-erosional notching at the waterline, destabilising the subaerial ice cliff. Indeed, recent (post-2006) large calving events have primarily been driven by torque-induced, buoyancy-driven calving. Hence, in tectonically-active areas, coseismic-initiated calving can have an episodic, but strong control on retreat, potentially destabilising a glacier system and leading to accelerated recession, accentuating climate-forced mass balance changes.