Links between the human dimension and long term tectonics: Mw 7.8 Kaikoura Earthquake, South Island New Zealand, 14th November 2016

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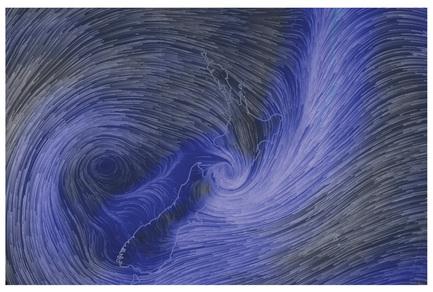
Introduction:

Long-term tectonics shape the landscape we live on. Collision over tens of millions of years has produced the Himalayan mountain chain, the Tibetan Plateau and the atmospheric disturbance that produces the Asian monsoon. But it is the dynamic, short-term manifestations of tectonics and plate boundaries and their aftermath that most dramatically impact people's lives. The shaking of a large main shock, while overwhelming, is over within minutes. In contrast, the consequences of the shaking on the landscape can last for years to decades. In particular, in mountainous environments, a sedimentary hazard cascade (SHC) can dominate a region for years to decades following a large earthquake. The 1999 Chi-Chi earthquake in Taiwan, the 2008 Wenchuan earthquake in China and most recently the 2016 Kaikioura earthquake in New Zealand provide the opportunity to quantify and model some of these impacts. In particular, improved knowledge of spatial and temporal variations in rock erodibility help us to understand the physical connections between tectonic structure and the Earth surface, both in the short and in the long term. Quantifying rock damage (erodibility) as a result of tectonic processes is an important step in exploring the link between the processes that occur on the timescales of the human dimension and long term tectonics.

Landslides:

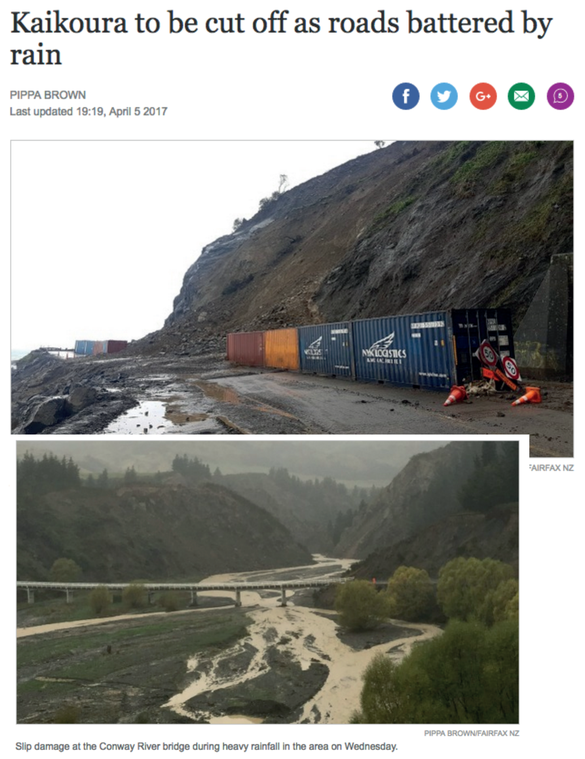
Nearly 5,000 landslides have been mapped as resulting from the M7.8 Kaikoura earthquake from North Canterbury through to Marlborough (GeoNet). As well as blocking the main roads and rail north and south of Kaikoura, and many smaller roads, landslides have caused widespread damage to farm fences, tracks and water supplies which will take years to repair. No one was killed by landslides, but some properties are still evacuated in but some properties are still evacuated in Goose Bay and Kaikoura because of the landslide or rockfall risk.
The landslides occurred in two distinct rock types – relatively young soft sandstones and mudstones, and older hard sandstones and mudstones (greywacke) – which behave quite differently. Understanding the landslides distribution and behaviour with aid recovery over the medium to long term. The huge amount of landslide material coming down rivers over the coming decades will affect bridges and flood protection and may alter river courses. Increased turbidity of streams and rivers will also have an effect on freshwater and marine ecology.

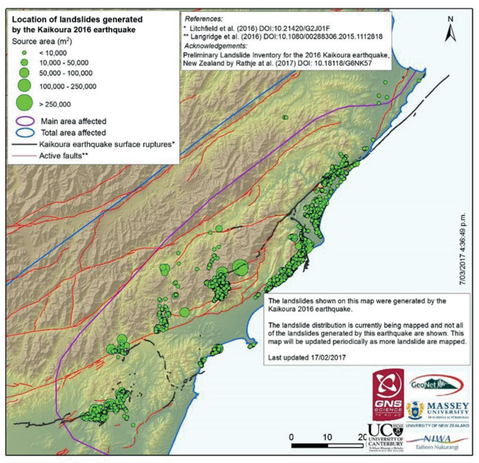


Ex-tropical cyclone Cook 13th April 2017

5 months post earthquake:

Coming into winter roads into Kaikoura are either still closed or partially open. Two large rainfall events within a week of each other in April, ex-cyclones Debbie and Cook, have remobilised landslide material causing road closures and isolation for Kaikoura.

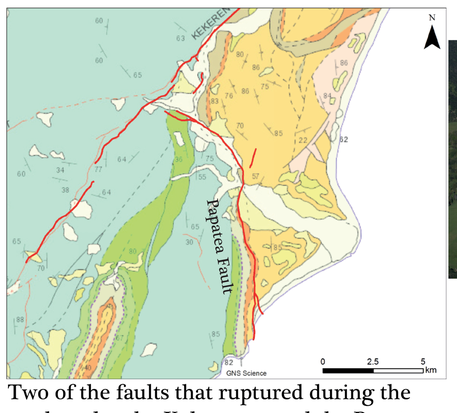





MARCUS GIBBS
State Highway 1 south of Kaikoura, between Peketa and Goose Bay, was closed for eight days while work was carried out stabilising major slips.

Landslides and faults:

A number of the large landslides that resulted from the Kaikoura Earthquake occurred along or adjacent to faults.



Two of the faults that ruptured during the earthquake; the Kekerengu and the Papatea faults.

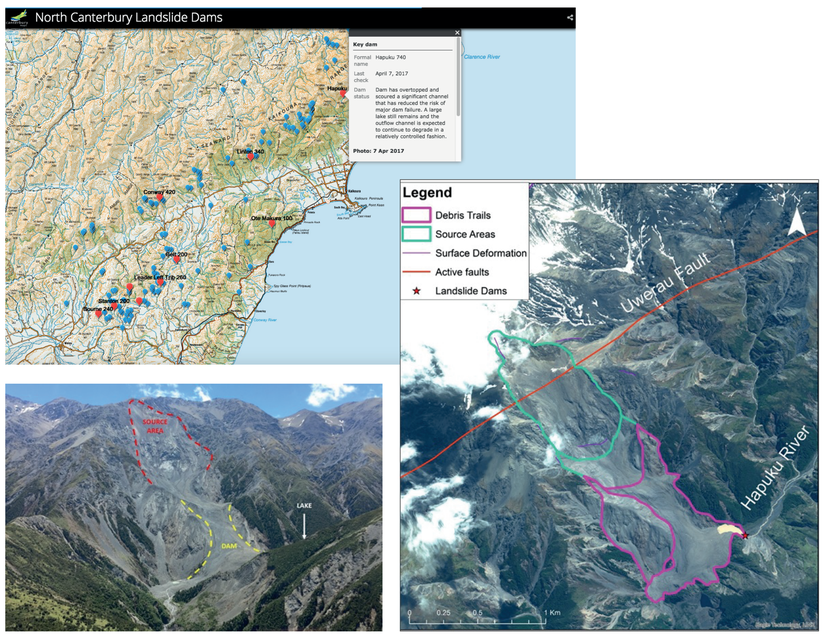
Several large landslides occurred along the Papatea Fault, which juxtaposes Cretaceous and Miocene rocks.

Landslides along the Hope Fault triggered by the Kaikoura Earthquake. Although the Hope Fault was notable during the earthquake for being a major fault that didn't rupture, in fact the rupture jumped across it, rock weakened by previous fault ruptures made it susceptible to landsliding.

Landslide Dams:

The GeoNet landslide team is working with Environment Canterbury, Hurunui, Kaikoura and Marlborough district councils, and NZTA to assess and manage the risk from landslide dams to downstream communities and infrastructure. Monitoring is focussed on six dams that remain high risk – the Waima (Ure), Hapuku, Linton, Ote Makura, Conway and Stanton river dams. Other dams are also being monitored, but they are of lower risk.

The priorities for landslide dam monitoring change with the landscape; future heavy rain, aftershocks or a dam breach change the risk and will likely see some landslide dams upgraded or downgraded for monitoring.



Work planned following the Kaikoura Earthquake:

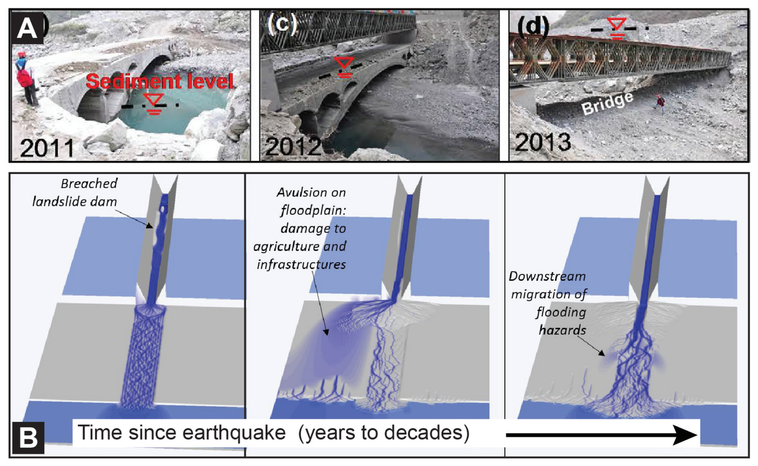
Documentation of the trajectory of landslide disturbance in representative river catchments impacted by the Kaikoura Earthquake

Quantifying rates of sediment transfer from hillslopes to channels using in-situ monitoring and repeat LiDAR surveys.

Determination of the grainsize earthquake induced coarse-grained sediment and how that influences the fluvial network and consequences for river morphology change and capacity for flood conveyance.

Use of observations to validate numerical models of channel hydraulics and morphodynamics with the ultimate aim of being able to forecast downstream consequences of sediment transfer.

3D models linking rock strength parameters, including those related to tectonic history, to landslide distributions in mountainous areas



(A) an example of the dramatic impacts of the post-seismic river aggregation on infrastructure following the 2008 Mw 7.9 Wenchuan earthquake, China (Zhang et al. 2016). (B) EROS model demonstrating the potential for modelling the catchment scale flooding responses to earthquake induced landslides and landslide dams (Davy et al. 2009)

Acknowledgements:

The science response to the Kaikoura Earthquake involved researchers from GNS Science, GeoNET, NIWA, the Universities of Canterbury, Otago, Auckland and many overseas institutions. In particular, conversations with the Earthquake Geology and Landsliding teams at GNS Science are noted. Dimitri Lague and Thomas Croissant, University of Rennes contributed EROS model results.

References cited:

Davy, P.; Lague, D. 2009. Fluvial erosion/transport equation of landscape evolution models revisited. Journal of Geophysical Research: Earth Surface, 114(F3): doi: 10.1029/2008JF001146.

Zhang, S.; Zhang, L.; Lacasse, S.; Nadim, F. 2016. Evolution of Mass Movements near Epicentre of Wenchuan Earthquake, the First Eight Years. Scientific Reports, 6: doi: 10.1038/srep36154.