# Multi-hazards quantitative assessment - an empirical graphical methodology

Alexandre Dunant[1], Tim Davies[1], Mark Bebbington[2]
[1] Department of Geological Sciences, University of Canterbury; [2] Institute of Fundamental Sciences , Massey University

Scan me

RESILIENCE TO NATURE'S CHALLENGES | Kia manawaroa – Ngā Ākina o Te Ao Tūroa | National SCIENCE Challenges

# WHAT?

*Time to read?* *yes* →

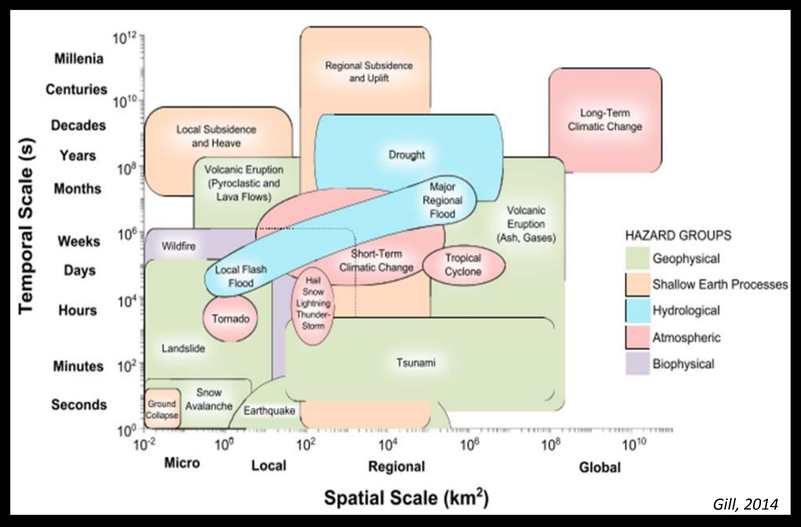
*no* ↓

**Abstract**: The impact of natural disasters has been increasing in the recent years. Despite developing international interest in multi-hazard events, few studies quantify the dynamic interaction that characterise these phenomena. It is argued that without taking into account the dynamic complexity of natural catastrophes, impact assessment will underestimate risk, leading to increased vulnerability and distorted emergency management priorities. The work presented herein demonstrates how we can use graphs and networks to assess the complex impact of multi-hazard scenarios. First, the combination of maximal hazard footprints and exposed nodes (e.g. infrastructure) is used to create the hazard network. Iterative simulation of the subnetwork defined by actual hazard magnitudes is then exploited to provide an estimate of the overall compounded impact from a sequence of hazards.

In order to illustrate this novel method, the Kaikoura earthquake event that occurred in 2016 is used as a calibrating event to validate the method and further study the cascading events that might threaten other parts of New Zealand. The cascading hazards include numerous landslides events. The results of the impact model on the road system will then be compared with the recorded level of service following the 2016 events. This technique is intended to inform the basis of challenging scenarios for preparing communities and emergency services.

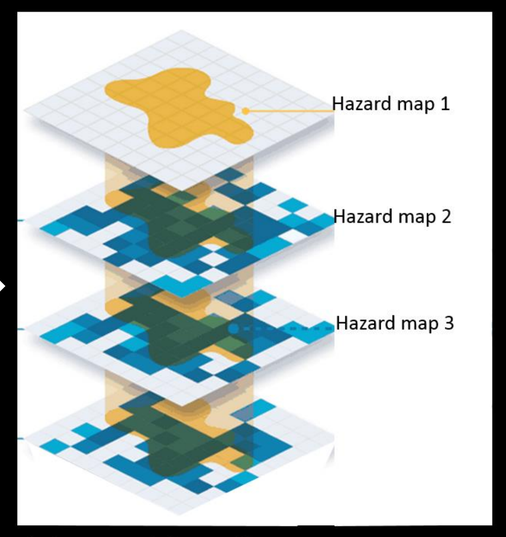
## Multi-hazard is a very real …


## … and complex problem …




*Gill, 2014*

## … to be addressed

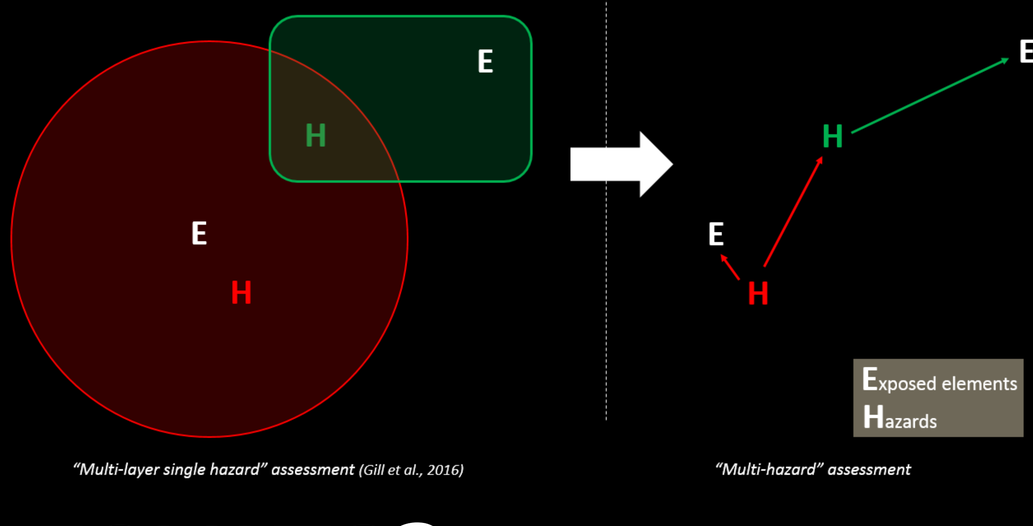



*"Multi-layer single hazard" assessment (Gill et al., 2016)*

# HOW?

## NETWORK FRAMEWORK

*Hazard footprints* → *Hazard network*

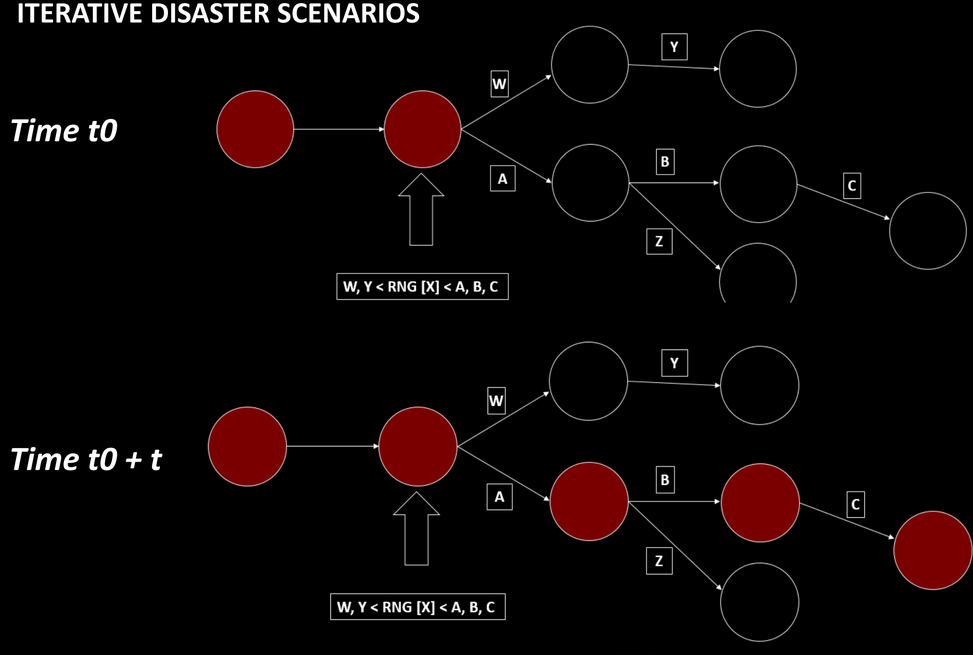



*"Multi-layer single hazard" assessment (Gill et al., 2016)*

**E**xposed elements
**H**azards

*"Multi-hazard" assessment*

## ITERATIVE DISASTER SCENARIOS

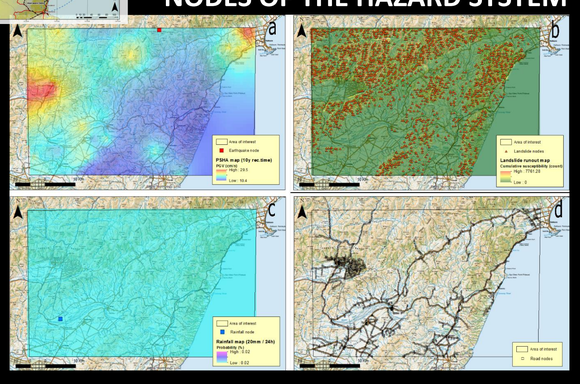



Schematic of the network propagation protocol. If the RNG (Random number generated) is below the expected recurrence frequency on a specific edge then the cascade continues.

# RESULTS?

## KAIKOURA CASE STUDY

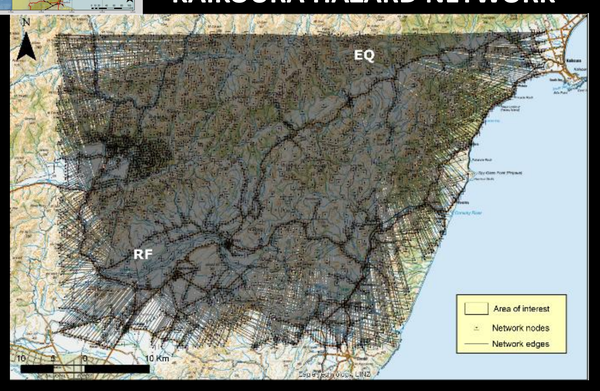
## NODES OF THE HAZARD SYSTEM




(a) The red square node represents the nominal (random) "earthquake source" and the background is displaying a 10-year recurrence time PGV (Peak Ground Velocity) map (Tarbali and Bradley 2014). The location of the node is not depicting a specific epicentre and is used to conceptualize the regional effect of "earthquakes".
(b) The red triangular nodes represents the potential "landslides" and the background displays the cumulative runout susceptibility modelled using Flow-R (Horton et al. 2013). The location of the node represents the centroid point of catchment of order 1 in the study area. In this case, and contrary to the earthquake node, the aim of the landslide node locations is to delineate a coherent geographical area to be affected by either earthquakes (co-seismic landslides) or rainfall (rainfall-induced landslides). Using a random "conceptual" location (as for the earthquake node) would cause an erroneous triggering effect as the landslide nodes are linked to the earthquake and rainfall effects by the local PGV & the rainfall intensity values respectively.
(c) The blue square node represents the "rainfall" source and the background displays the probability of a rainfall of intensity of 20mm/24h. As for the earthquake node, the rainfall node is set as a concept for "rainfall" at a random location (the current location is actually in the vicinity of the station from where the probability has been calculated - but didn't have to be for the purpose of the exercise).
(d) The black square represents the roads. The road node locations are set by creating a node every 500m along the road line.



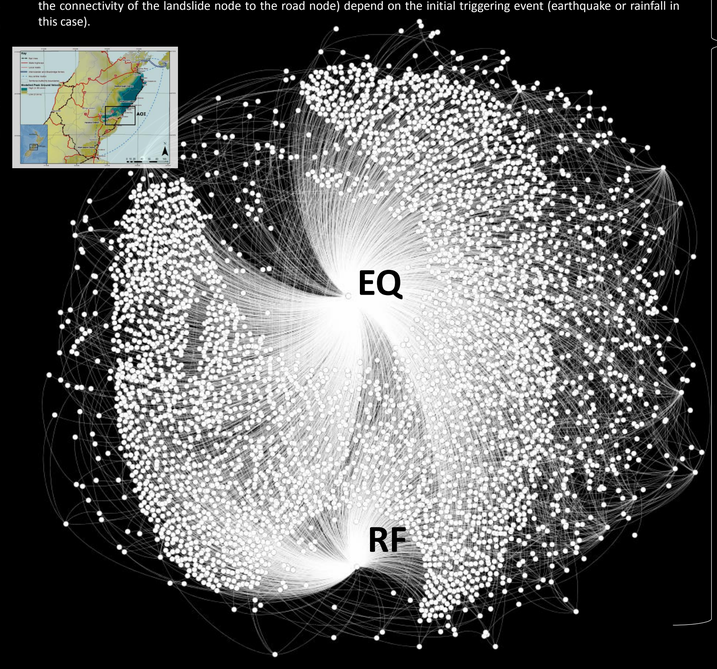
## KAIKOURA HAZARD NETWORK



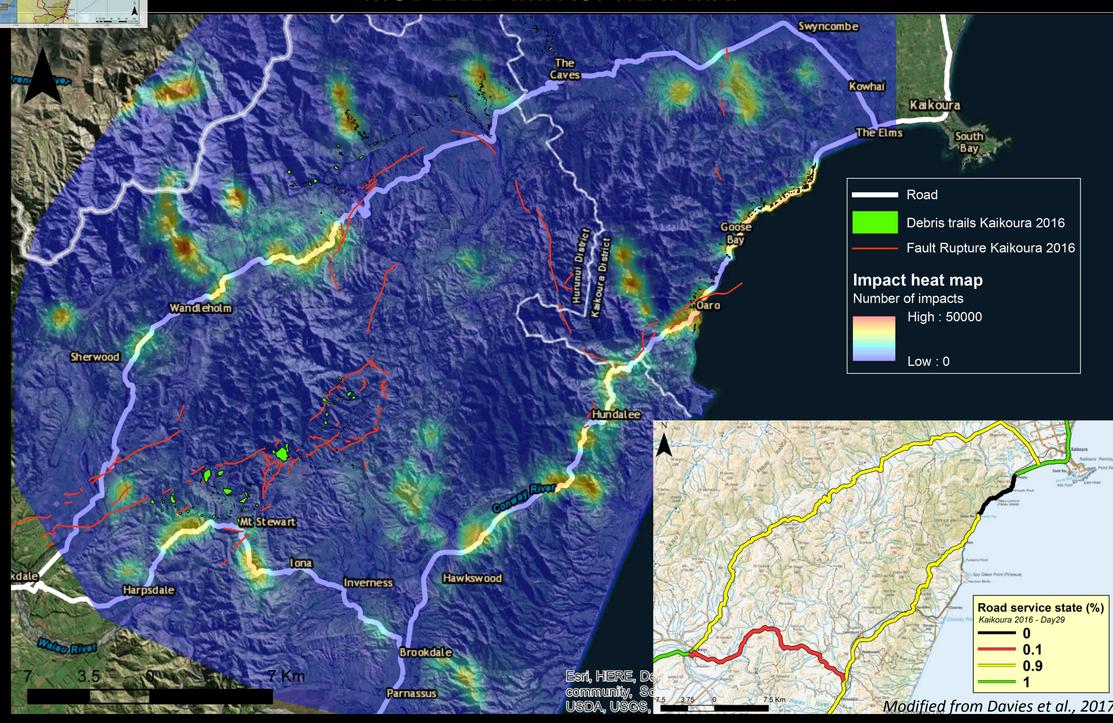

## HAZARD MATRIX INTERACTION

| SOURCE \ TARGET | LANDSLIDE | ROAD |
|---|---|---|
| Rainfall | *a* 2% of 20mm/24h | *b* |
| Earthquake | *c* | *d* |
| Landslide | *e* | *f* |

(a) Rainfall and landslide are connected by the probability of a threshold intensity of 20mm/24h.
(b) (e) The cross represents non-connectivity. In particular, landslides are not considered to trigger other landslides and rainfalls are not considered to have a direct impact on the road.
(c) (d) Earthquakes are considered to trigger a landslide node if the PGV threshold value is reached. In the same way, earthquakes can impact the road if a threshold value of PGV is reached.
(f) Landslide and road nodes are connected by the two runout susceptibility models. The runout models selected (thus the connectivity of the landslide node to the road node) depend on the initial triggering event (earthquake or rainfall in this case).

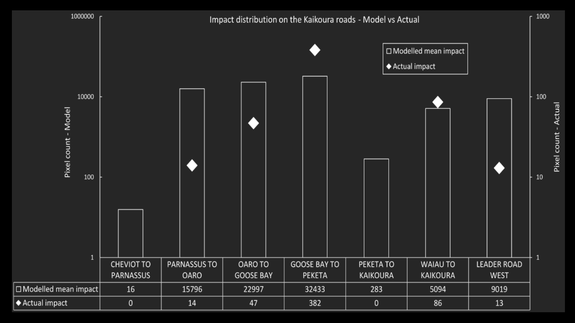



## MODELLED IMPACT HEAT MAP




*Modified from Davies et al., 2017*

## VALIDATION (WORK IN PROGRESS)




| | CHEVIOT TO PARNASSUS | PARNASSUS TO OARO | OARO TO GOOSE BAY | GOOSE BAY TO PEKETA | PEKETA TO KAIKOURA | WAIAU TO KAIKOURA | LEADER ROAD WEST |
|---|---|---|---|---|---|---|---|
| Modelled mean impact | 16 | 15796 | 22997 | 32433 | 283 | 5094 | 9019 |
| Actual impact | 0 | 14 | 47 | 382 | 0 | 86 | 13 |