The new QuakeAUS: impact of revised GA earthquake magnitudes on hazards and losses

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Geoscience Australia (GA) is updating the seismic hazard model for Australia through the National Seismic Hazard Assessment (NSHA18) project (Allen et al., 2017). The update includes the corrections of measurements of local magnitude, M_L and the conversion of the M_L values to moment magnitude, M_W. Moment magnitude is the preferred magnitude type for probabilistic seismic hazard analyses, and all modern ground motion prediction equations use this magnitude type. This is because M_L is a purely empirical estimate of earthquake size whereas M_W is a theoretically-based measure of earthquake size, derived from the seismic moment, M_0 of the earthquake which is given by:

$$M_0 = u \, A \, D$$

where A is the rupture area of the fault, D is the average displacement on the fault and u is the shear modulus of rock. The seismic moment quantifies the size of each of the pair of opposing force couples that constitute the force representation of the shear dislocation on the fault plane. For comparison with the more familiar magnitude scale, M_W is calibrated to M_0 using the following equation:

$$M_W = 2/3 \log_{10} M_0 - 10.7$$

Prior to the early 1990s, most Australian seismic observatories relied on the Richter (1935) local magnitude (M_L) formula developed for southern California. At regional distances (where many earthquakes are recorded), the Richter scale tends to overestimate M_L relative to modern Australian magnitude formulae. Because of the likely overestimation of local magnitudes for Australian earthquakes recorded at regional distances, there is a need to account for pre-1990 magnitude estimates due to the use of inappropriate Californian magnitude formulae. A process was employed that systematically corrected local magnitudes using the difference between the original (inappropriate) magnitude formula (e.g., Richter, 1935) and the Australian-specific correction curves (e.g., Michael-Leiba and Malafant, 1992) at a distance determined by the nearest recording station likely to have recorded a specific earthquake.

The relationship between M_L and M_W developed for the NSHA18 demonstrates that M_W is approximately 0.3 magnitude units lower than M_L for moderate-to-large earthquakes ($4.0<M_W<6.0$). Together, the M_L corrections and the subsequent conversions to M_W more than halve the number (and consequently the annual rate) of earthquakes exceeding magnitude 4.5 and 5.0, as shown in Figure 1. This has downstream effects on hazard calculations when forecasting the rate of rare large earthquakes using Gutenberg-Richter magnitude-frequency distributions in PSHA. A secondary effect of the M_L to M_W magnitude conversion is that it tends to increase the number of small and moderate-sized earthquakes relative to large earthquakes. This increases the Gutenberg–Richter b-value, which in turn further decreases the relative annual rates of larger potentially damaging earthquakes (Allen et al., 2017).

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RISK FRONTIERS' SEMINAR

This year's seminar will be held at the Museum of Sydney on

Wednesday 31st October, 2018

from 2.00pm until 4.30pm followed by light refreshments in the foyer.

Please make a note in your diary.

OCTOBER 2018

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Preliminary seismic hazard calculations by Allen et al. (2017b) using the new earthquake source catalogue are compared with the existing PGA hazard map for B_e site conditions for a return period of 500 years in Figure 2. We have updated the earthquake source model to incorporate the new GA catalogue into QuakeAUS , and obtained a new hazard map for Australia similar to that in Figure 2.

Preliminary loss estimates using the new version of QuakeAUS show large scale reductions. Losses in a national residential portfolio for 200 year ARP and for AAL are 30% and 35% of their former values respectively. The changes are not regionally uniform, with the largest reductions occurring in Perth and the lowest reductions occurring in Darwin. Among the five perils that are modelled on Risk Frontiers' Multiperil Workbench (earthquake, fire, flood, hail and tropical cyclone), earthquake previously had the largest 200 year ARP loss but now lies below tropical cyclone in a near tie with flood and hail, and its AAL has dropped from second last to last, below hail.

We expect to release QuakeAUS 6.0, including these changes, early in the third quarter of 2018.

References

Allen, T., J. Griffin, M. Leonard, D. Clark and H. Ghasemi (2017). An updated National Seismic Hazard Assessment for Australia: Are we designing for the right earthquakes? Proceedings of the Annual Conference of the Australian Earthquake Engineering Society in Canberra, November 24-26, 2017.

Michael-Leiba, M., and Malafant, K. (1992). A new local magnitude scale for southeastern Australia, BMR J. Aust. Geol. Geophys. Vol 13, No 3, pp 201-205.
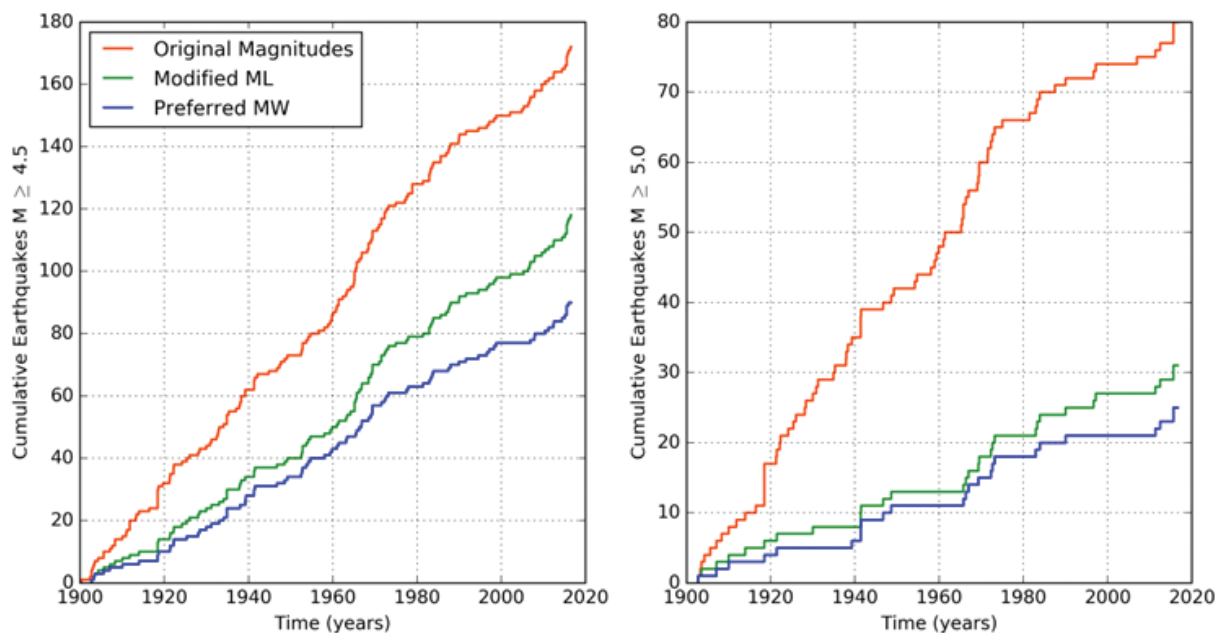
Figure 1. Cumulative number of earthquakes with magnitudes equal to or exceeding 4.5 (left) and 5.0 (right) for earthquakes in eastern Australia (east of 135°E longitude) from 1900 to 2010. The different curves show different stages of the NSHA18 catalogue preparation: original catalogue magnitudes, modified magnitudes (only local magnitude modified), and preferred Mw (for all earthquakes). Source: Modified from Allen et al., (2017).
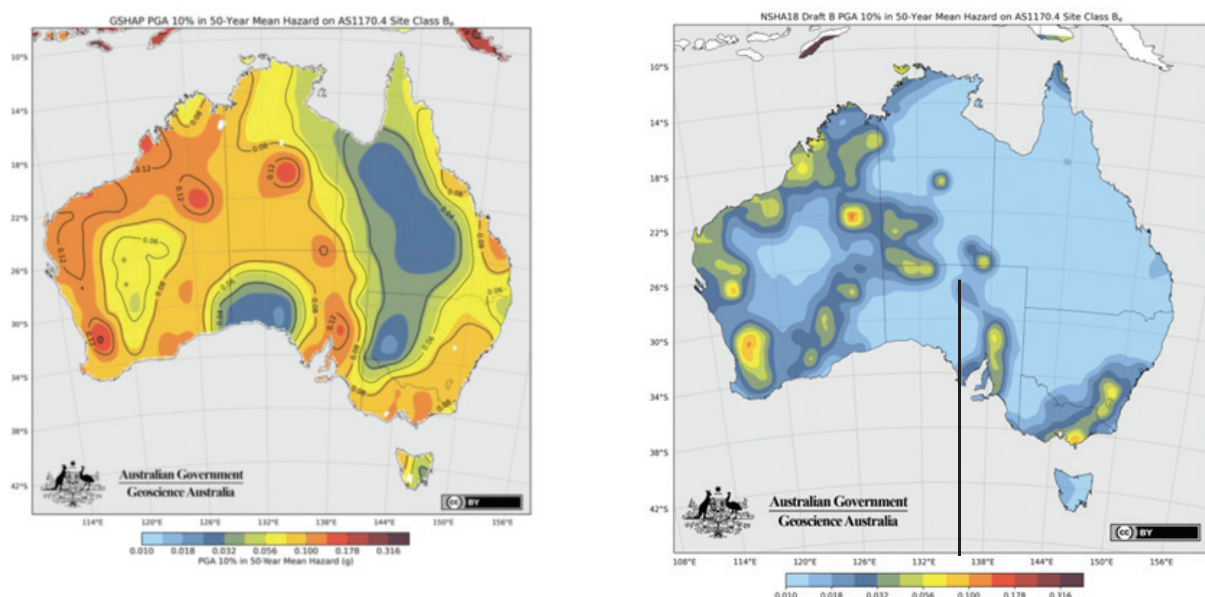
Figure 2. Existing (left) and draft (right) PGA maps for site class Be for a return period of 500 years. Source: Modified from Allen et al. (2017).

Tathra 2018 Bushfires

James O'Brien, Mingzhu Wang, Jacob Evans

The 2017/18 bushfire season across southeastern Australia during this hot summer season burned through 237,869 hectares from 11,182 fires prompting seven Emergency Warnings, 25 Watch and Act alerts and 16 Total Fire Ban days[1]. Despite the high number of fires, the losses were limited, until the Tathra fires with two homes lost in Comboyne. True to its mission of better understanding natural disasters, Risk Frontiers produced in-depth intelligence from aerial photography, field survey and GIS analytics. In what follows we report the results of these exercises.

Observations from the field

The early December 2017 heatwave (December was the 5th hottest on record) set the conditions for the bushfires in New South Wales on 18 March 2018. The high temperatures combined with high winds established the conditions under which an electrical fault apparently triggered the fire. The bushfires in Tathra destroyed around 65 homes, damaged 48 homes, destroyed 35 caravans and cabins and burned 1250 hectares of bushland, in additional to the emotional trauma experienced by survivors. Fortunately there were no casualties.

Risk Frontiers scientists (James, Mingzhu and Jacob) arrived in Tathra on April 10th, a little over three weeks following the peak of the bushfire damage, due to the high proportion (around 50%) of properties which contained asbestos. Our objective was to investigate the most affected areas in Tathra.

New above-ground electricity infrastructure in the region was a clear sign of the work undertaken to repair the obliterated power network and an indication of the extensive damage to infrastructure that left Tathra without power and water for a number of days following the fire.

We were able to quickly cover the whole town in less than a day on foot with the exception of some isolated areas in Reedy Swamp where the fire started and a small number of houses are located. This survey was useful to qualitatively gauge the assumptions used in our bushfire loss model, FireAUS. Our observations can be summarised as follows:

Zero-One (binary) damage ratios: We saw very few cases of partial damage to structures. It appears that once fire hits a structure during a bushfire it will almost certainly be completely destroyed. That's not to say that the adjacent structures at the same address will always burn; we observed several cases of sheds that were burnt while the main house was unscathed and vice versa. The partial damage we did observe was charring to the sides of properties, where it appeared an active effort had been made to save the property.

Statistical dependence of bushfire risk on distance to bush: As described above, there is no clear pattern in the spatial distribution of damage when observed at close-range. However, the statistics of bushfire damage based on aggregated data from a broad area do show the importance of distance of a property to the nearby bush (see Figure 2). Whether a property is burnt in a bushfire seems determined by random chance and this chance is conditioned by the distance to the bushland. In FireAUS, we assume that any two addresses equidistant from the bush have equal probabilities of burning.

Independence of risk from building types: We observed damage to different construction types: unreinforced masonry, wood, fibro, mobile homes and even stone. There were destroyed brick houses away from the bush and spared wood and fibro houses close to the bush and vice-versa. The damage for this locality appears independent of building types even when globally influenced by proximity to bushland. If there are other risk factors that could explain the building damage, they are not visible in a short inspection and would require a full forensic investigation of each damaged building. The prevailing view was that newer homes generally seemed to perform better than older homes – and in one case a home built within the last 5 years sustained minimal bushfire damage (timber steps were destroyed) although that property was also actively defended by neighbours.

Mapping damage
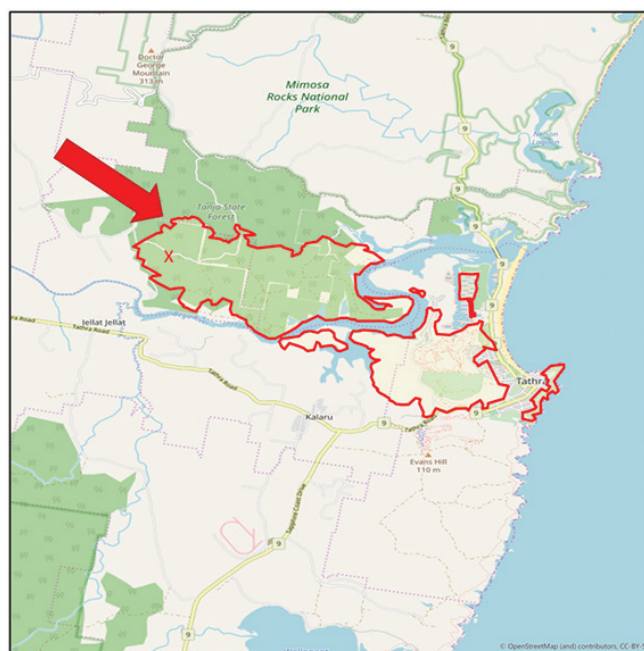
Figure 1 - Vicinity of Tathra / Reedy Swamp bushfire with prevailing wind direction on the day indicated by arrow and X indicating approximate ignition point.

As the events in Tathra unfolded, Risk Frontiers started the data gathering process to provide a view of this event. Our damage analysis is based on post-fire ground surveys and RFS burned area data captured from live data feeds on Sunday. We also acquired 25 km^2 of pre-fire satellite imagery (WorldView-2, 2m resolution) for vegetation analysis and utilized Pitney Bowes Geovision for building location and bushland / tree data.

Figure 2 provides a complete map of damaged properties (house icons) overlain with bushland boundaries (green shading) derived from GeoVision data. It is clear that a number of these properties are surrounded by bushland and are therefore deemed to be at a distance of zero metres from the urban and bushland interface. Properties not within the bushland areas are assigned the linear distance in metres to the nearest pre-fire bushland area greater than 0.5 sq km in area, not necessarily the bushland that burned. Further analysis could be undertaken to classify the burned vegetation - however, in the Tathra region, the majority of

[1]https://www.rfs.nsw.gov.au/news-and-media/ministerial-media-releases/minister-urges-public-to-remain-prepared-with-ongoing-dry-conditions

bushland burned around properties and it is difficult to recover the clear timeline of local ignition.

There are eyewitness reports of ember attack and the pattern of damage around the different locations has destroyed houses at some distance from the bushland interface with adjacent properties destroyed by either further ember attack or contagion from the neighbouring property.
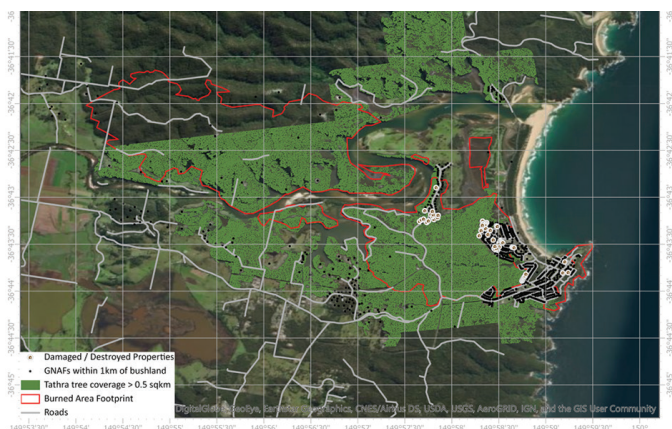

Figure 2 - Location of destroyed homes and adjacent bushland in Tathra classified from pre-fire imagery and GeoVision (Minimum area threshold for contiguous vegetation: 500 m²)

Individual data

While Figure 2 demonstrates the spatial distribution of destroyed homes graphically, it is useful to quantify the loss as a function of distance to adjacent bushland. The data presented are in cumulative form so as to be consistent with other Risk Frontiers reports and other research. Figure 3 shows the percentile of destroyed buildings in relation to nearby bushland from recent major bushfires in Australia:

• January 2003 Canberra bushfires (damaged suburbs include Duffy)
• February 2009 "Black Saturday" bushfires in Victoria (damaged suburbs include Marysville and Kinglake)
• February 2011 Perth bushfires (damaged suburbs include Roleystone)
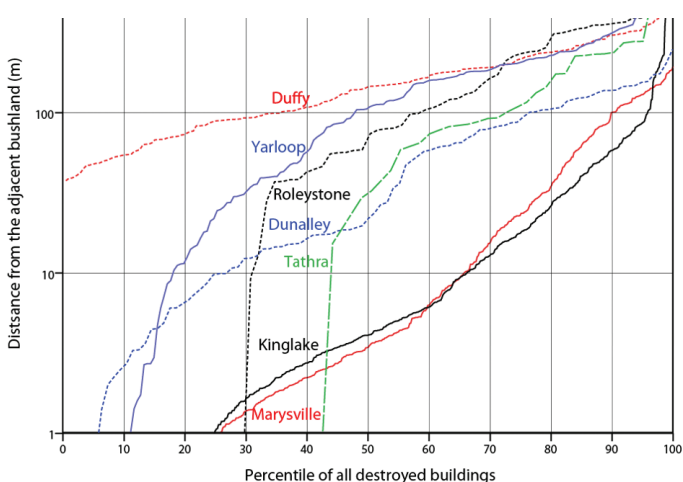
Figure 3: Cumulative distribution of buildings destroyed in major bushfires in Australia in relation to distance from nearby bushland. For reference, approximately 25% of homes destroyed in Marysville and Kinglake were within 1m of bushland while 31% of buildings destroyed in Roleystone (Perth) were within 1m of bushland. A little over 40% of homes in Tathra destroyed were within 1m of bushland.

• January 2013 Tasmania bushfires (damaged suburbs include Dunalley)
• January 2016 Yarloop, WA bushfire

Some new statistics and evidence that emerged from the bushfire damage in Tathra are as follows:

- 42% of destroyed homes were within 0m of classified bushland boundaries.
- 50% of surveyed destroyed homes were within 30m of the bushland interface and 72.6% of surveyed homes destroyed were within 100m of the bushland interface. These results closely match the findings previously presented in the "Bushfire Penetration into Urban Areas in Australia" report prepared for the 2009 Victorian Bushfires Royal Commission by Risk Frontiers.
- No homes were destroyed further than 630m from bushland.

Figure 4 - A view of a destroyed property from Riverview Crescent, Tathra looking west in the direction of the fire's ignition point across the Bega River. Note the burned vegetation in the distance and the lower green belt on the river's edge demonstrating ember attack across the river.

Figure 5 - Map and aerial imagery showing property losses in the vicinity of Oceanview Drive, Tathra (1) in top left corner. Note the proximity to bushland immediately behind those properties and the distance to those lost in the lower right corner at Francis Hollis (2) and Bay View Drive (3), suggesting ember attack. House icons again denote destroyed properties. Wind direction was from top left to bottom right of image, red line and shading showing burnt boundary.