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Damage surveys following the Hobsonville Tornado in Auckland and Tropical Cyclone Evan in Samoa.

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Abstract

NIWA and GNS are Crown Research Institutes in New Zealand with interests in Natural Hazards research. Recently they have partnered to develop the RiskScape multi-hazard impact and risk assessment tool for application in New Zealand and potentially the Pacific Islands. However, for only a few previous damaging wind storm previous events has field data for wind damage to buildings in New Zealand been gathered and none has been collected for wind events in the Pacific Islands. Here we describe results from two recent damage surveys following the Hobsonville Tornado in Auckland and Tropical Cyclone Evan in Samoa and how these results have been applied to improving RiskScape fragility and casualty functions.

Introduction

NIWA and GNS are Crown Research Institutes in New Zealand that conduct research into Natural Hazards such as earthquakes, volcanic eruptions, Tsunami, floods, wind storms, and land-slides. Recently they have partnered to develop the RiskScape multi-hazard impact and risk assessment tool for application in New Zealand and potentially the Pacific Islands. However, for only four previous damaging wind storm events (the Taranaki Tornado outbreak of 2007 (Reese et al 2008), the Greymouth downslope easterly storm of 2008 (Turner et al., 2011), TC Yasi (Wehner and Ginger, 2011) in 2011 - in conjunction with Geoscience Australia - and the South Taranaki Bight storm of March 2012) has field data for wind damage to buildings in New Zealand been gathered and none has been collected for wind events in the Pacific Islands. Here we describe results from two recent damage surveys following the Hobsonville Tornado in Auckland and Tropical Cyclone Evan in Samoa and how these results have been applied to improving RiskScape fragility and casualty functions.

Hobsonville Tornado

Meteorological data and modelling

While the Hobsonville tornado of December 6, 2012 was typical of many New Zealand tornadoes in terms of its physical characteristics, it was unique in two aspects (i) the severity of the human casualties it inflicted, and (ii) it passed within a few hundred metres of a MetService weather station with 1-minute observations. About 12:20 pm NZDT (see Figure 1) severe straight line winds likely associated with a rear flank downdraft (see figure 2 - note the pressure surge at 12:21 pm during the passage of the meso-cyclone [figure 4]) and an EF1 tornado struck parts of the Whenuapai and Hobsonville suburbs of Auckland causing the deaths of 3 workers at a school construction site, injuring 7 people and causing about 10 million damage to property and contents. The 3 workers were killed when strong winds blew large concrete slab wall onto the cab of a truck they were sheltering in at the time. The injuries were caused by strikes from flying debris and people being blown through glass doors. Water ingress due to torrential rain following (see Figure 3) wind/debris damage to tile roofs was responsible for much of the damage bill.

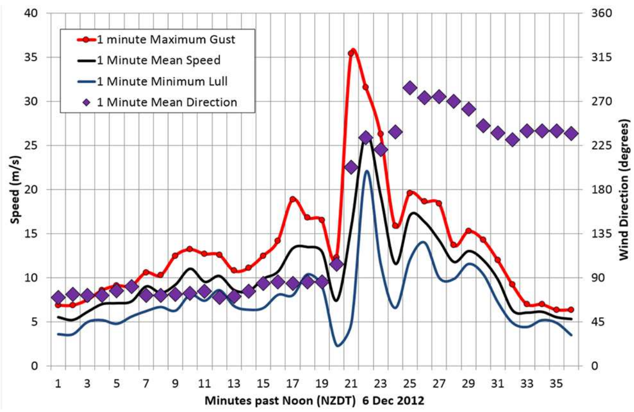

Figure 1. Time series of 1-minute maximum 3-sec gust, mean speed, and 3-sec lull and mean wind direction between 12:01 and 12:36 pm NZDT December 6, 2012 for Whenuapai AWS (Note: NIWA Climate Database Agent Number 23976; anemometer location 36°47′12.03′ S, 174°37′53.68′ E; station elevation 23 m.)

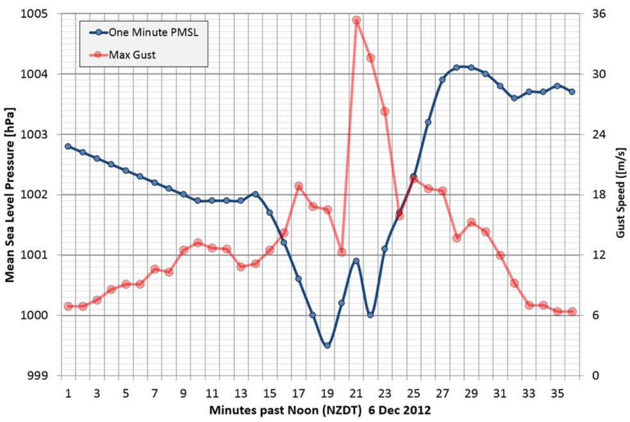

Figure 2. Time series of 1-minute mean-sea level pressure between 12:01 and 12:36 pm NZDT December 6, 2012 for Whenuapai AWS. The maximum gust series is also displayed for ease of comparison with other figures.

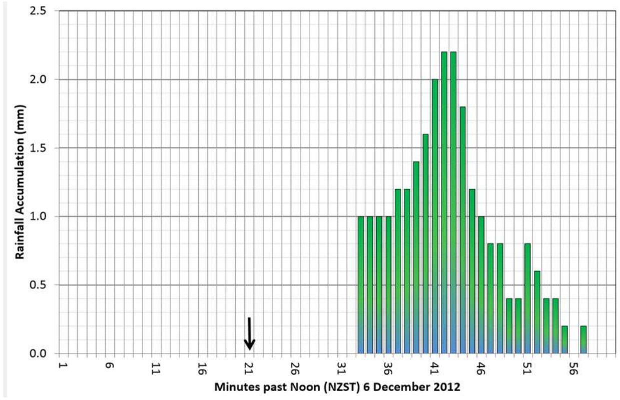

Figure 3. Time series of 1-minute rainfall between 12:01 and 1:00 pm NZDT December 6, 2012 for Whenuapai AWS. The arrow indicates the time of peak maximum gust.

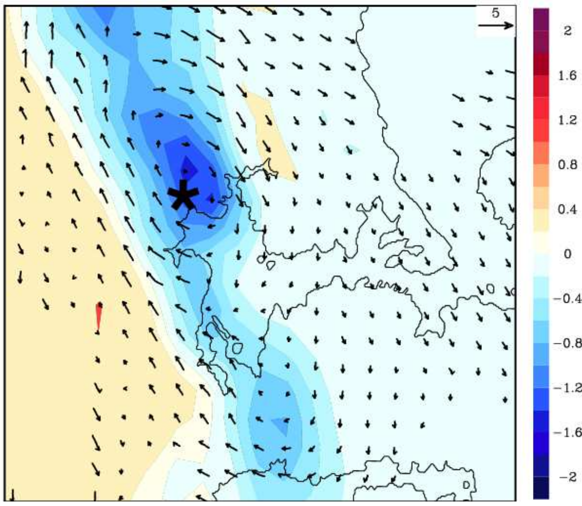

Figure 4. Wind vectors (m/s) at 600 m agl relative to storm motion (12 m/s from NW) and relative vorticity (s^{-1}) for 12:30 pm NZDT Dec 6, 2012 as forecast (Initial time 06:00 NZDT Dec 6, 2012) by NZCSM model. Hobsonville's location is marked by the black asterisk.

Damage Survey

Six hours after the tornado hit, NIWA's professional photographer was able to gain access to the area and took many photos before clean-up commenced, and 45 hours (on Dec 8) afterwards 3 NIWA staff and a mechanical engineer from Univ. of Auckland undertook a more detailed damage assessment of the worst affected properties and unaffected surrounding properties.

In total, 143 properties were surveyed of which 112 were in either damage state 2 or 3 (See Figure 10). The main area of damage occurred in a NZDF housing estate with many buildings of the same age (1960's) and construction (weatherboard single story, with either tile or sheet metal roofs) Photos of properties and observations/estimates of the following building attributes were recorded; gps coordinates (NZTM), address, use, number of storey's, wall cladding, roof cladding, pitch and geometry, percentage of wall openings occupied by openings, age, eave width, skylights (no.), damage to walls, roofs, upwind exposure, openings, debris impact, and water damage. A follow-up postal survey on content losses, displacement and business disruption is underway. Overall, the damage and wind-speeds were assessed as being much less severe than for Oakura, Taranaki 2007 which was EF2.

Estimates of the tornado strength based on the Enhanced Fujita scale were made and mapped (see Figure 5) and along with the wind observations a probable track of the tornado overlain were use to create a gridded wind-field (Δx=20 m), and applied to an Auckland City asset database within RiskScape to estimate probable losses and casualties. This calibration exercise revealed that when using the existing damage curve the estimated damage was much lighter than observed. So a new damage curve for weatherboard, post 1960 houses has been developed based on the data collected (see Figure 6). Similarly losses seem much less than provisional insurance estimates ($300,000 as opposed to $10 million). Part of this is likely due to the high proportion of water damage, and to issues in how NZDF assets are represented in the database, but most of the discrepancy can be attributed to an overly-conservative damage state curve. Previous curves have been developed from damage by straight line winds and this highlights the need to have separate damage curves for tornadoes. It was also noted that separate casualty functions also need to be developed and applied due to the fact that there is little warning for tornadoes (in NZ) and these cause most wind related fatalities whereas for extreme gales where there is more warning fewer people are outside (the fatalities here and in Albany in 2011 were all at construction sites).

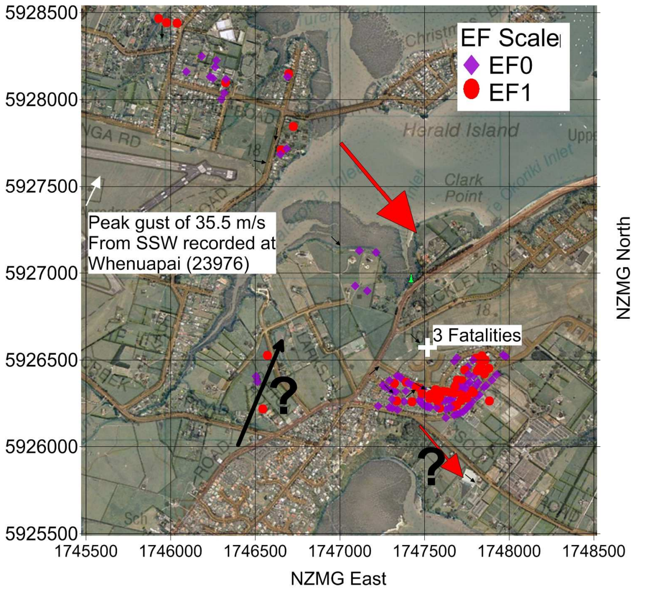

Figure 5. Plot showing location of surveyed properties in Whenuapai (NW section) and Hobsonville (SE section) which suffered varying degrees of damage and associated EF scale rating. The location of the school construction site where the 3 fatalities occurred is marked by the white cross. The red arrows show the general direction of movement of the storm.

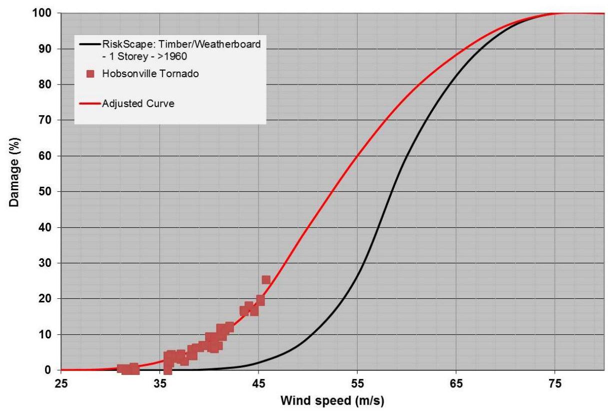

Figure 6. Wind damage curves for post 1960 timber weatherboard 1-story houses as used in RiskScape (Black line) and as derived for the Hobsonville Tornado (Red curve).

Tropical Cyclone Evan

Meteorology

Tropical Cyclone Evan (track shown in Figure 7) developed from a tropical disturbance that first formed about 600 km west of Samoa on December 9 with Category 1 (Australian Tropical Cyclone Intensity scale) winds first estimated at 1800 UTC 11 December, 2012 (0800 LST 12 December, 2012) when the storm was 400 km west of Apia. TC Evan rapidly moved eastward at 22 km/hr and strengthened to 65 knots (TC 3) by 1800 UTC on the 12th, it continued to strengthen to 80 knots but its eastward movement slowed and it turned sharply to the NW at 0000 UTC on the 13th after it had passed the eastern end of Upolo. Here central pressures were estimated to be about 963 Hpa and deepening. Evan strengthened further as it moved NW and became Category 4 by 1200 UTC on the 13th when the centre was about 20 km NE of Apia. Peak gusts of up to 113 knots were reported around then. While TC Evan did not make landfall as it passed Samoa, significant wind damage occurred in the areas of Tafitoala and Si'umu villages on south coast during the afternoon of the 13th (around the time TC Evan made it's sharp North-west turn), with the most extreme damage (see Figure 8) caused by tornadoes (eyewitness reports) during a period of a two-three hours of very heavy rain, low visibility and very strong winds off the sea. Damage further east along the coast and also at higher altitudes away from the coast was not as severe and less widespread. TC Evan also caused a major and damaging flood of the Vaisigano River in Apia. Only minor storm surge was reported and this did little damage.

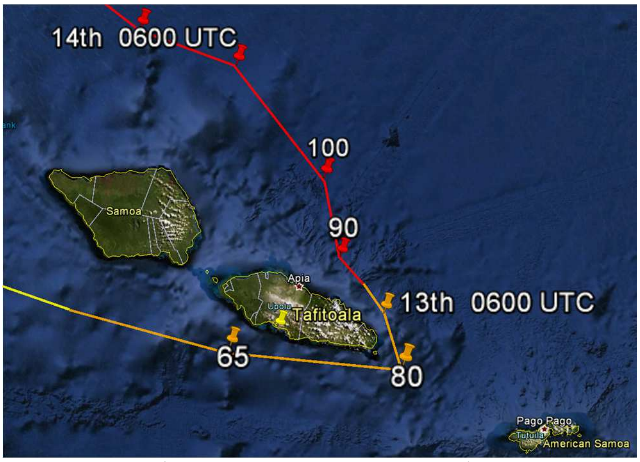

Figure 7: Track of TC Evan centre in the vicinity of Samoa on Google Earth map for 13th and 14th December 2012. The coloured pins mark positions 6 hours apart, the orange colours highlight parts of the track in which TC Evan was TC 3, and Red when it was TC 4. Estimates of peak sustained speeds (in knots) at position of pins are also shown. The position of Tafitoala is shown, Si'umu is about 4km east along the coast. These villages are where wind damage was most severe on Upolo and where the wind-damage survey efforts were concentrated.

Damage Survey

One of the motivations for the survey was that it represented a chance to compare the impact of a different hazard (wind) on similar housing stock to that which was surveyed following the Sep 2009 South Pacific Tsunami (Reese, 2011). Our wind damage survey was conducted on the 7th and 8th of February (8 weeks after the cyclone), but although some clean-up and repairs had been undertaken there was plenty of damage to inspect, and we were able to interview nearly all the property inhabitants, or their neighbours or relatives to gain an accurate idea of damage, content losses and roof/building type (when missing).

In all 109 properties were surveyed along the south coast and similar attributes as to Hobsonville were recorded on survey forms, but with the important addition of a "Fale" style building (see Figure 9), along with estimates of the building condition.

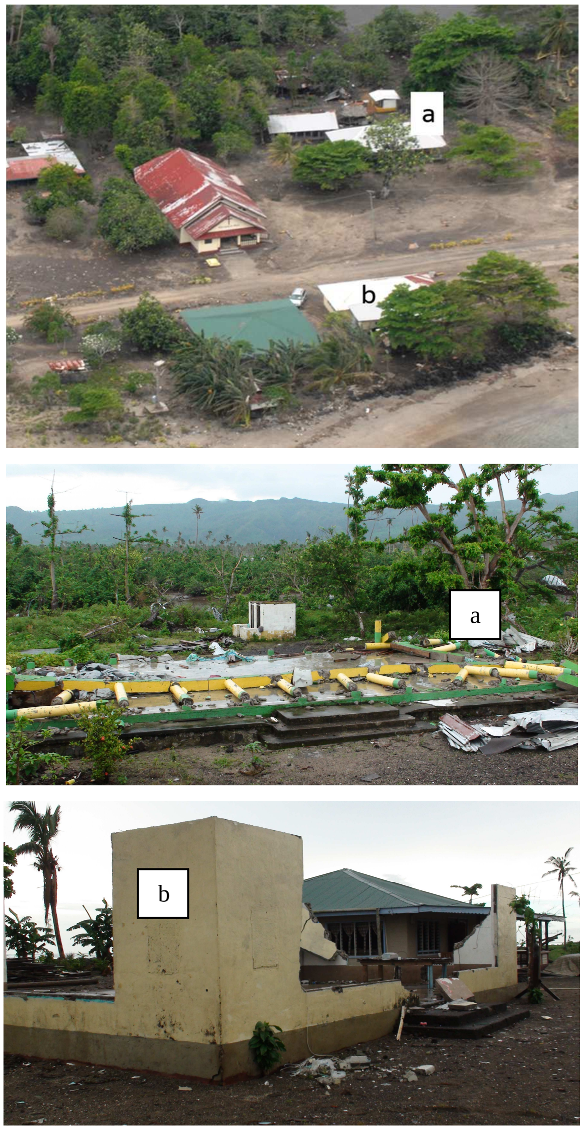

Figure 8. Photos of part of Tafitoala village that suffered wind-damage in TC Evan. The upper photo is from an aerial reconnaissance mission taken after the September 2009 Tsunami. The bottom panels show extreme damage to buildings after TC Evan. The middle panel is of the fale (sheet metal roof, reinforced concrete pillars on slab - damage state 5) at position "a" in the upper photo, the bottom photo is of the church meeting house (sheet metal roof, concrete cladding large openings on slab – damage state 5) at position "b". Note, the undamaged dwelling (minor roof damage only) adjacent which was occupied during the cyclone.

Figure 9. Typical Samoan Residential Fale, These buildings are a single storey open air with timber (or reinforced concrete) pylons connecting the roof structure with concrete slab or timber (piles) floor. Other typical features include a sheet metal or thatched roof.

Building condition was felt to a better indicator than age, because buildings more than 10 years old were considered "old" by locals and recently constructed houses using "recycled" material were considered "new"! Many of the finer-scale damage estimations done after Hobsonville or Yasi were not attempted due to the arduous heat and humidity experienced.

About 50% of buildings had damage states 4 or 5, i.e. irreparable or totally destroyed, and 75% had content losses exceeding 50%, (see Figure 10). Like Hobsonville much of the contents damage was due to water damage. Generally, "new" well built houses had little roof or structural damage but these still tended to experience water-ingress and this resulted in some loss of contents, mostly rated at <10%, but occasionally 10-50%.

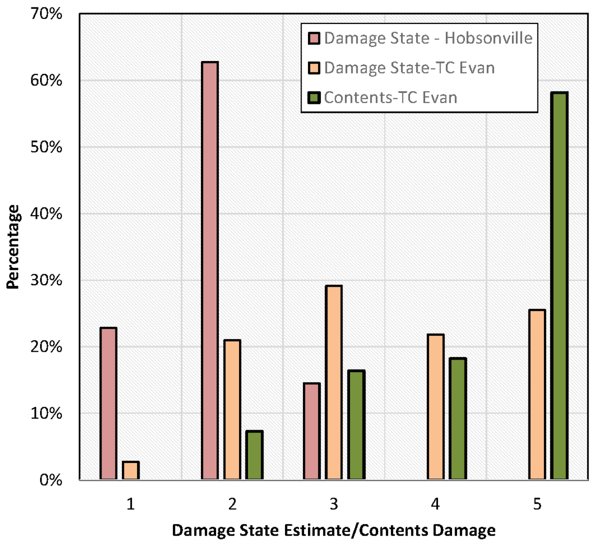

Figure 10. Distribution of Damage State and Content loss estimates due to wind (and water ingress) for the 110 damaged properties surveyed in Tafitoala, Si'umu, and Mulivai, and for the 143 properties surveyed in Hobsonville (Damage state only shown). Damage state categories are; 1=Light non-structural, 2=Minor non-structural, 3=Moderate-structural repairable, 4=Severe/structural irreparable, 5=Collapse. Content damage classes are; 2= <10%, 3=10-50%, 4=50-80%, 5= >80%.

Conclusions

The Hobsonville, Auckland tornado and Tropical Cyclone Evan which hit Samoa in December 2012 provided two severe wind events for which damage surveys were carried out and reported upon here. In all 112 wind-damaged properties were surveyed in Hobsonville, while 109 wind-damage properties were surveyed in Samoa. In Hobsonville, damage (especially structural) to buildings was relatively light, but costs were high due to a large amount of water ingress due to heavy rain following damage to roofs (often with only a few tiles missing). In Samoa, damage to buildings and fales was more severe and some isolated extreme damage due to tornadoes embedded within convective bands was observed. However, here too there was much damage that was also attributed to water ingress, and for well-built houses which had little roof or structural damage this was the main cause of loss. While the logistics of these surveys can be difficult, they are still very much needed to fill in data gaps and are useful in calibrating damage curves within existing hazard impact assessment tools such as RiskScape. Analysis of the results from both surveys is ongoing.

Acknowledgments

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References

Reese, S., B. Bradley, J. Bind, G. Smart, W. Power, and J. Sturman, 2011: Empirical building fragilities from observed damage in the 2009 South Pacific Tsunami. Earth Science Reviews, Special Issue, 107,156-173.

Reese, S., R. Turner, M. Revell, S. Reid, S. Schroeder, SR Uma, S. Thurston, 2008: Riskscape: Post-tornado survey – Taranaki events of July 4th and 5th, 2007. Joint Technical report of NIWA/GNS/BRANZ.

Reese, S., B. Bradley, J. Bind, G. Smart, W. Power, and J. Sturman, 2011: Empirical building fragilities from observed damage in the 2009 South Pacific Tsunami. Earth Science Reviews, Special Issue, 107,156-173.

Wehner, M., and J. Ginger, 2011. Survey methodology; are we capturing the right. Presentation at Geoscience Australia wind-vulnerability workshop. Townsville, Qld.

Turner, R., M. Revell, S. Reese, S. Moore, S. Reid, 2011: Some recent extreme wind events in New Zealand, Winds and Structures (An International Journal), Vol 15, No 2, 163-176.