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USING REALISTIC DISASTER SCENARIO ANALYSIS TO UNDERSTAND NATURAL HAZARD IMPACTS AND EMERGENCY MANAGEMENTS REQUIREMENTS

Annual project report 2015-2016

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Cover: To help agencies prepare for future disasters, research is modelling the potential impact of disasters that are beyond our experience, such as a major earthquake affecting a capital city.

Photo: John McCombe New Zealnd Fire Service

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EXECUTIVE SUMMARY

The study of historical occurrences of natural disasters only provides a very limited view of the full range of risk Australia is exposed to. Catastrophe models have been designed as a tool to extrapolate beyond past experience and as such can help risk practitioners prepare for the types of events yet to be seen.

In this project we propose to apply the same techniques at the core of catastrophe models to design realistic disaster scenarios. The focus is not only on the hazard magnitude to be expected from the rare extreme events simulated but also on the likely impact in terms of building damage, infrastructure disruption and injuries / loss of human lives. To provide a global picture of natural disaster risk in Australia a range of perils and locations are selected through the 3 years of the project. To date the scenarios delivered cover Tropical Cyclones, Earthquake and Heatwave perils while the regions around Adelaide, Melbourne and Southeast Queensland have been at the center of our analysis. In the last year of the project our focus will shift towards flooding events triggered by Tropical Cyclones in Queensland and East Coast Lows in New South Wales.

It is our hope that emergency services can leverage the type of information generated from such scenarios to assess their capabilities to cope with the response and recovery task. Several examples of utilisation to date are listed in this report along with promising leads for the coming year.

END USER STATEMENT

Corey Shackleton, *Community Resilience, NSW Rural Fire Service*

The project has seen good progress over the period with scenarios for tropical cyclones, earthquakes and heat waves in the regions around Adelaide, Melbourne and Southeast Queensland.

While end user buy-in and commitment to scenarios in the 3rd year has been limited, through discussions at the recent Research Advisory Forum, interest and potential benefits seem positive for the proposed future work on heat waves. Further discussions are required with health agencies to determine the value of this work.

During the project to date, NSW SES and Vic SES both appear to have seen benefits in the scenarios work in their jurisdictions.

The project will continue to deliver scenarios in the final (3rd) year which will be closely developed with targeted agencies. Final year options for the project are being investigated and include:

1. East Coast Low event in NSW; and
2. Multi-hazard (wind/rain/storm surge) TC in Queensland.

While results have been delivered as part of this project, the investment in any further work in this area and the broader utilisation of the project requires careful consideration by BNHCRC and partner agencies.

INTRODUCTION

Government agencies, including those responsible for emergency management, response and policymaking, need to prepare for natural disasters and other emergencies before they happen. Given the rare occurrence of such events past historical experience does not provide a fully comprehensible picture of the range of impacts to be expected. In many instances, emergency responders or government planners have to deal with unforeseen consequences of disasters; one such example is the extensive damage to infrastructure in Christchurch following the Darfield earthquake in October 2010.

Realistic disaster scenarios can be used to facilitate emergency management, response planning and policymaking. They allow end-users to visualise the impacts of plausible events before they happen. For the purpose of this project, we define 'disaster scenarios' as a collection of maps, data and descriptive information of human and material losses due to a natural hazard event.

We qualify these scenarios as 'realistic' for two reasons: first, we will develop scenarios for events that haven't occurred but have a high likelihood of occurring and causing extensive damage, and we will model as many details as possible from these events.

The main tool used to accomplish this is the catastrophe loss model, or CAT-model for short. CAT-models provide a mathematical representation of natural disaster events, and are usually developed from statistical analysis of past event data, guided by engineering, technical knowledge and expert judgement. CAT-models usually consist of three parts: a hazard module, which expresses the probability and intensity of natural processes leading to damage; a vulnerability module, which calculates the amount of human or material loss due to a natural hazard process; and an exposure module, which provides the location and quantity of assets at risk. As an example, an earthquake loss model hazard module provides the likelihood of a given level of ground-motion at an arbitrary location due to an earthquake; the vulnerability model provides an estimate of damage and casualty from a given level of ground-motion; and the exposure module provides the number and quality of assets (building type, number of people, etc.) at a given location.

In Year 1 of the project two scenarios were developed following these methods. First, a magnitude 6 earthquake event was modelled near Adelaide along with projected damage to the built environment, casualties, and disruption of essential infrastructure. In parallel a second scenario simulated a category 4 tropical cyclone impacting South East Queensland and resulting in major structural damage to buildings in the region.

The two scenarios under development in Year 2 of the project include a heatwave event in South East Australia and a series of Earthquakes in Melbourne. After an overview of the methods at the core of the project, the report will discuss utilisation to date and identified potential for future user engagement.

PROJECT BACKGROUND

The aim of the project is to develop a series of realistic disaster scenarios, according to the definition given above. The research effort is focused on studying Australian-specific vulnerability and hazard information, to be used in the development of the scenarios. These scenarios have two main objectives in terms of utilisation: (1) explore likely impacts from extreme disasters so that risks and capability gaps can be better understood and (2) improve risk communication tools.

SCENARIO BUILDING METHODOLOGY

Scenario selection

As mentioned in the introduction, Year 1 of the project delivered scenarios for an Adelaide Earthquake (EQ) and a Queensland Tropical Cyclone (TC). In year 2, and after initial interest from end users, our efforts have focused on developing modelling capabilities for a new peril: heatwave (HW). The region under study is South East Australia and the impact of the modelled events is measured in terms of heat related human fatalities. To complement this deliverable a series of three EQ events impacting the Melbourne region are implemented as a second Year 2 scenario. For year 3, and after consultation with end users, the following scenarios are currently being envisaged: (1) A East Coast Low event impacting New South Wales with important storm surges, wind damage, flash flooding and coastal erosion; and (2) a multi-hazard (wind/rain/storm surge) TC in Queensland.

Hazard modelling

For some of the scenarios analysed researchers have been able to leverage Risk Frontiers' suite of CAT-models (e.g. EQ, TC) while for other perils the hazard generators needed to be developed in the context of the project. This includes the Year 2 heatwave scenario and the East Coast Low event planned for year 3. In all cases the end product from the hazard generation modules consist of a series of maps characterising the hazard risk magnitude (i.e. the event risk footprint).

Vulnerability modelling

To model hazard consequences a link between hazard magnitude and likely impact is needed. These vulnerability functions are typically computed from historical experience of the impact to be expected at various hazard thresholds. In some cases, such as building damage from TC or EQ, engineering based models can be used; in others a pure data driven method is preferred. To project a likely number of human fatalities from a given heatwave intensity we selected the data driven approach (see following section).

Exposure modelling

Having built a framework to assess potential hazard risk along with the likely impact to be expected from several hazard thresholds, the final stage of the

scenario building process is to match the exposure at risk with the hazard footprint. In the context of this project exposure can refer to the building stock, networks of critical infrastructure as well as the location of the population most at risk.

Scenario analysis

It is the combination of the hazard, vulnerability and exposure modules that allows the design of realistic natural disaster scenarios. Typical modelled outcomes consist of a projected number of building damaged (along with induced economic loss), disruption to key infrastructures and likely number of injuries and deaths. From these it is expected that agencies responsible for key response and recovery tasks can assess their capability to cope with the projected stress on emergency services and aftermath of the events.

WHAT THE PROJECT HAS BEEN UP TO

RESEARCH

The main focus of the research in Year 2 has been the development of a framework to assess heatwave risk. Unlike most other natural disasters, heatwaves are still lacking a clear definition and a well-accepted schema to communicate risk levels. Using a new metric recently introduced by the Bureau of Meteorology (the Excess Heat Factor, or EHF, Nairn and Fawcett, 2013) and a database of historical heat related deaths in Australia (Coates et al. 2014), Risk Frontiers' researchers have developed a classification that can help communicate about heat related fatality risk.

Category	Accumulated EHF	Peak EHF
CAT0	> 0	> 0
CAT1	> 30	> 15
CAT2	> 80	> 30
CAT3	> 150	> 50
CAT4	> 300	> 70

HEAT RELATED FATALITY RISK CLASSIFICATION SYSYEM BASED ON THRESHOLDS OF EXCESS HEAT FACTOR (EHF).

Additionally, and from analysis of past historical records of heat related fatalities in the area under study, a vulnerability function was designed to project the likely death rate from a population exposed to each of these categories. 1.6 deaths are for instance expected for every 100 000 people exposed to a category 4 heatwave in the region.

Along with a newly developed heatwave footprint generation module this allowed us to produce a series of 3 heatwave events impacting Southeast Australia with an estimate of likely fatalities in each case.

UTILISATION AND COMMUNICATION

Utilisation to date

- The Department of Planning, Transport and Infrastructure in South Australia used the Year 1 Adelaide EQ scenario for a cost benefit analysis of retrofitting properties.
- The Year 1 Queensland TC scenario was utilised by AFAC / AGD to exercise catastrophic disaster planning at commissioner level.
- A workshop was held about the Adelaide EQ scenario for a number of SA government representatives and agencies.

- Workshop held for the Council of Chief Operating Officers (CCOSC) detailing the SE Qld Tropical Cyclone scenario.
- 3 articles promoting the work in Magazines (Asia Pacific Fire Magazine in Fire Australia)

Upcoming engagement opportunities

- Workshop on heatwave risk planned with emergency management services in Victoria (August 16).
- Multi-agency exercise on an earthquake scenario held by the SA SES (15 October 2016)
- Year 2 EQ scenario to be used for Melbourne Earthquake exercise

Presentations

- 1 presentation for the AFAC 2015 (EQ scenario) and 2 presentations for the AFAC 2016 (TC and HW scenarios)
- Presentation to Business Continuity Institute Sydney (2015)
- Invited presentation to Victorian Emergency Services sponsored by EMV (April 2016)
- 1 presentation at the 5th Australian & New Zealand Disaster & Emergency Management (2016)
- Presentation to the national Business Continuity Institute Forum (2016)
- Talk at the BCMIE (Business Continuity Management Information Exchange) and AIES (Australian Institute of Emergency Services SA Division) combined dinner forum in Adelaide. (7 June 2016)

Other:

2 post-disaster damage surveys were completed by researchers from the CRC and Cyclone Testing Station after the November 15 super cell thunderstorm in Brisbane and TC Marcia in north Queensland.

PUBLICATIONS LIST

Gissing, A., McAneney, J. (2016) Planning for catastrophic disasters. Asia Pacific Fire Magazine No 57

Koschatzky,V (2016) What if a large earthquake hit? Asia Pacific Fire Magazine No 56

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Krupar R. and M. Mason (2016) "Quantifying and communicating the uncertainty in tropical cyclone rainfall and wind risk using numerical weather prediction ensemble track forecasts." Oral presentation at the 5th Australian and New Zealand Disaster and Emergency Management, 30 May 2016.

Krupar R. and M. Mason (2016) "Forecasting the impact of tropical cyclones using global numerical weather prediction ensemble forecasts: A Tropical Cyclone Marcia (2015) wind and rainfall case study." AFAC16 conference in Brisbane, extended abstract and oral presentation as part of the Research Forum. August 2016.

Loridan, T. (2016) "The Excess Heat Factor as a metric for heat related fatalities: defining heatwave risk categories". AFAC16 conference in Brisbane, extended abstract and oral presentation as part of the Research Forum. August 2016.

CURRENT TEAM MEMBERS

During the past year Dr Felipe Dimer de Oliveira, previous project leader, has resigned from Risk Frontiers and consequently left the project. Currently, this project is being staffed by:

- Dr Thomas Loridan, Risk Frontiers, project leader
- Dr Matthew Mason, UQ, project leader

Over the past year, the following staff were involved in the scenario development:

- Dr Valentina Koschatzky, Risk Frontiers, researcher: with a background on aerospace engineering, Valentina has been responsible for developing Risk Frontiers earthquake loss models
- Dr Rich Krupar, UQ, Postdoctoral researcher: Rich is in charge of the TC scenario development for Year 3 and his research to date has focused on rainfall and storm surge modelling.
- Emma Phillips, Risk Frontiers, PhD student: Emma is using network and graph theory to assess critical infrastructure disruption.

Recently a new PhD student, Thomas Kloetzke (funded by BNHCRC top-up scholarship) has begun modelling tropical cyclones using high-resolution Weather Research Forecasting (WRF) and is exploring ways to include this modelling platform into the current scenario project.

The following staff members will also contribute to the project in Year 3:

- Dr Thomas Mortlock, Macquarie University / Risk Frontiers, Postdoctoral researcher: Thomas has a background in oceanography and coastal erosion modelling and will take the lead for the Year 3 East Coast Low scenario.

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Nairn, J., Fawcett, R., 2013. Defining heatwaves: heatwaves defined as a heat impact event servicing all community and business sectors in Australia. CAWCR Technical report No 060. The Centre for Australian Weather and Climate Research A partnership between the Bureau of Meteorology and CSIRO.