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

Annual project report 2016-17

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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 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 rare extreme events 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 have been selected through the 3 years of the project. The scenarios cover Tropical Cyclones, Earthquake, Heatwaves and flooding induced by East Coast Lows while the regions around Adelaide, Melbourne, Northern New South Wales and Southeast Queensland are at the center of our analysis.

To facilitate communication of our key results a web content has been drafted to provide a description of each catastrophic event studied. The web content is hosted by the Australian Institue for Disaster Resilience (AIDR) knowledge Hub and targets a broader audience than the technical reports delivered as part of the project's milestones.

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. The web content also offers a source of information for a wider audience and plays a role in educating the general public on the potential threat posed by Australian natural disasters.

END USER STATEMENT (S)

David Mazzaferri, Livingtstone Shire Council, Queensland

I read with interest the fine work conducted by the research team in the Tropical Cyclone Marcia Scenario and the implications of this event if it occurred. This scenario is being investigated to use as an exercise in the new year the implication of the findings in the scenario will be great test in capability of our Local Disaster Management Group and Coordination Centre. I complement the great work done

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 visualize 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 have developed scenarios for events that haven't occurred but have a high likelihood of occurring and causing extensive damage, and we model as many details as possible from these events.

Over the three years of the project a total of six scenarios were developed. 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 (Year 1) a second scenario simulated a category 4 tropical cyclone impacting South East Queensland and resulting in major structural damage to buildings in the region. In the second year of the project the modelling effort focused on generating heatwave events in South East Australia and a series of Earthquakes in Melbourne. Finally the third year involved the simulation of a fully coupled multi-peril (wind, flood and storm surge) TC scenario in North Queensland as well as a East Coast Low induced flooding event in northern New South Wales.

PROJECT BACKGROUND

Realistic disaster scenarios try to illustrate the risk associated with extreme natural disasters. They typically correspond to events that have not occurred yet but are considered physically possible given our understanding of the key processes driving risk.

The main tool used to accomplish scenario generation 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.

This chain of modelling assumptions forms the basis of all scenario presented in this project and will take different forms depending on the risk being studied.

RESEARCH APPROACH

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 utilization: (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 were developed: (1) A East Coast Low event impacting New South Wales with important storm surges, flash flooding and coastal erosion; and (2) a multi-hazard (wind/rain/storm surge) TC in Queensland.

Hazard modelling

Researchers have been able to leverage Risk Frontiers' suite of CAT-models (e.g. EQ, TC). In all cases the end product from the hazard generation modules consist of a series of maps characterizing 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.

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.

KEY MILESTONES

DELIVERY OF 6 CATASTROPHE SCENARIOS COVERING 4 DISTINCT NATURAL DISASTERS

Earthquake events in Melbourne and Adelaide (2 scenarios)

Tropical cylone in Queensland (2 scenarios)

East Coast Low and associated floods in New South Wales

Heatwave event and associated human fatalities in Adelaide and Melbourne

WEB PORTAL TO SUMMARIZE SCENARIO RESULTS

Web content hosted by Australian Institue for Disaster Resilience (AIDR) and their Knowledge Hub

UTILISATION OUTPUTS

ACHIEVEMENTS

Media: The Year 2 heatwave work attracted some media interest at the start of the 2016/2017 summer, including:

- ABC AM radio, December 1, 2016: 'Experts warn against underestimating heatwave threat'. http://www.abc.net.au/news/2016-12-01/experts-warn-against-underestimating-heatwave-threat/8081264
- ABC news 24 live interview, December 1 2016: 'Experts warn against underestimating heatwave threat'. https://pagedata.info/data/542e8e5
- Sydney Morning Herald, December 2, 2016, Peter Hannam: "Everyone is under great threat: call for cyclone-like categories for heatwaves". http://www.smh.com.au/environment/everyone-is-under-great-threat-call-for-cyclonelike-categories-for-heatwaves-20161201-gt2bkh.html
- SBS World News, December 2 2016
- Week end sunrise live interview, December 3 2016

Local Government: Livingstone Shire have indicated that they are keen to utilize the Tropical Cyclone Sceanrio in an exercise

State Goverenment: VICSES have indicated that they are keen to utilize the Melbourne Earthquake scenario in an exercise.

WHERE TO FROM HERE

Although the six scenarios studied over this project provide a good overview of Australia's most threatening natural disasters the list is clearly not exhaustive. The catalogue of scenario would benefit from inclusion of, for instance, other perils such as severe convective storms and hail epsiodes, or strong low pressure systems generating waves and surge hazard in the south West of the country.

The other dimension worth intergrating in the current framework would be the impact of cascading events. As illustratd by the 2009 Black Saturday bushfires and the deadly heatwaves occurring during the same period in Victoria, the combination of several disasters over the same period will have catastrophic impacts on the ability of emergency and recovery services to cope with the threat. Other examples of such cascading event potential include Tropical cyclones making multiple landfalls or a series of flooding events occurring over a short window of time leaving the ground completely saturated.

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

Koschatzky, V & Dimer de Oliveira, F & Somerville, P (2016) What if a large earthquake hit Adelaide? Fire Australia Magazine Summer 2015

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.

Krupar III, R. J. and M. S. Mason (2017): A multi-hazard tropical cyclone disaster impact scenario model for Queensland. 13th Americas Conference on Wind Engineering, Gainesville, FL 21 – 24 May 2017.

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.

Loridan, T., Coates, L., Argüeso, D., Perkins-Kirkpatrick, S.E. and J. McAneney (2016). The Excess Heat Factor as a metric for heat-related fatalities: defining heatwave risk categories, Australian Journal of Emergency Management, vol 31, no. 4.

Loridan, T. (2016). A heatwave classification for heat related fatality risk. Asia Pacific Fire, October 2016.

Mortlock, T., Roche, K, O'Brien, J, Wang, M. (2016), Visualising the potential cost to communities and infrastructure arising from seawater inundation. Proceedings of the 2016 Coast to Coast Conference, Melbourne, Australia, August 2016.

TEAM MEMBERS

At the end of the first year Dr Felipe Dimer de Oliveira, initial project leader, has resigned from Risk Frontiers and consequently left the project. In year 2 and 3 the project was being staffed by:

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

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

In Year 3 a new PhD student, Thomas Kloetzke (funded by BNHCRC top-up scholarship) has contributed to the modelling of tropical cyclones using high-resolution Weather Research Forecasting (WRF).