Wind risk map of the Australia region: Early results

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1 INTRODUCTION

Climate change is expected to increase severe wind hazard in many regions of the Australian continent with consequences for exposed infrastructure and human populations. The objective of this paper is to provide an initial nationally consistent assessment of wind risk under current climate, utilizing the Australian/New Zealand wind loading standard [1] as a measure of the hazard. This work is part of the National Wind Risk Assessment (NWRA), which has been commissioned by the Australian Federal Government (Department of Climate Change and Energy Efficiency) to highlight regions of the Australian continent where there is high wind risk to residential structures under current climate, and where, if hazard increases under climate change, there will be a greater need for adaptation. This assessment is being undertaken by separately considering wind hazard, infrastructure exposure and the wind vulnerability of infrastructure (residential buildings only). The NWRA aims to initially provide a benchmark measure of wind risk nationally (current climate), underpinned by the National Exposure Information System (NEXIS) developed by Geoscience Australia and the wind loading standard [1]. The outputs of the NWRA will be crucial to informing climate change adaptation options regarding severe winds which should be of significant concern to decision-makers in planning, construction, emergency services, and the insurance industry, as well as the community as a whole.

The methodology developed at Geoscience Australia to analyse the direct impact of severe wind on Australian communities involves the parallel development of the understanding of wind hazard, residential building exposure and the wind vulnerability of residential structures. Here we provide a preliminary indication of the current climate wind risk expressed as annualized loss.

2 WIND HAZARD

While there is significant uncertainty on how the likelihood and intensity of extreme winds will be influenced by climate change, the understanding of current regional wind hazard for the Australian region is also in need of improvement. Australian wind hazard is based on the statistical analysis of extreme wind observations and subjective engineering judgment. Observations include peak 3-second wind gusts captured at a small number of meteorological measurement stations, mainly located at significant city and regional airports. These provide a poor spatial representation of wind hazard.

2.1 Regional Wind Hazard

Within the NWRA, we intend to replace the wind loading standard as the source of wind hazard by taking advantage of wind hazard assessments using simulated data being developed at Geoscience Australia utilizing separate techniques for the three main wind hazards: tropical cyclones; thunderstorms; and synoptic winds. Regional wind hazard can be considered as the broad-scale low spatial resolution wind hazard, which is derived using modeling techniques with a spatial resolution of a few to tens of kilometers. The component wind hazard associated with each weather system (cyclonic, thunderstorm and synoptic) are combined for each return period (RP) considered, to determine the regional wind hazard. This part of the NWRA is reported elsewhere at this workshop [2], and will be further refined before being utilised for the current climate wind risk assessment.

2.2 Local Wind Hazard

The magnitude of severe wind varies considerably between building structures and locations due to differences in terrain, height of the structure, the influence of the surrounding structures and topographic features. Regional hazard assessments do not accurately depict the localised terrain and topography, and therefore the estimates need to be further refined to derive the local wind hazard. For this study, spatial algorithms were developed from the wind multiplier formulae detailed in [1, 3], to estimate the influence of terrain and topography as explained in [4]. These algorithms quantify local wind conditions at each location. Over city and major town urban regions the wind multipliers were evaluated at high spatial resolution by applying satellite remote sensing techniques, GIS software and elevation datasets in conjunction with the formula. The influence of all multipliers was aggregated to about 1400 statistical local areas (SLA's) using a cumulative probability approach developed utilising the results from all major cities and some towns. This part of the NWRA is reported elsewhere at this workshop [5].

3 EXPOSURE

Fundamental to any risk assessment is an understanding of exposure. Building type, construction (roof and wall) type, building age, number of storeys, business type and replacement value and the spatial location of buildings are critical parameters for understanding the potential impact on Australian communities from various hazards. The National EXposure Information System (NEXIS) [6] provides a nationally consistent exposure catalogue at the building level for both the present time and also into the future, by considering population projections and their effect on residential buildings. NEXIS therefore enables the assessment of future losses associated with climate change induced severe wind hazard as well as increased population. The NEXIS residential exposure catalogue is used to determine the location and value of residential buildings "exposed" to the severe wind hazard, and was provided aggregated to SLA level. The value of the housing is related in general terms to the house size. All values in NEXIS are *replacement costs* in 2009 Australian dollars.

4 WIND VULNERABILITY

Vulnerability is the third leg of the paradigm that underpins the impact and risk analysis. This relates the capacity of buildings, infrastructure and people to withstand hazards. For the NWRA where only direct impact to residential buildings is considered, the wind vulnerability relates the 10-metre height 3-second gust wind speed to the damage level (% replacement value) for a population of residential structures with identical attributes (e.g. brick veneer walls and tiled roof, constructed post-1980).

Prior to this study, there was a paucity of Australian wind vulnerability models for residential buildings. Relationships derived from insurance data by Dr. George Walker of Aon Re for North Queensland structures were in use [7]. Walker's pre-1980 curve represents the vulnerability of North Queensland residential structures before the lessons of cyclones Althea (1971) and Tracy (1974) influenced construction practice. His post-1980 curve shows a significantly reduced vulnerability due to changes to the Queensland Building Act. While the curve development process was not a full engineering analysis these curves were considered the best vulnerability relationships available at the time, and have been used by other researchers [8]. Walker's pre-1980 vulnerability curve has been utilised for the residential building populations of Perth, Brisbane and the Gold Coast [9]. Some limited justification for this assignment was derived from a post tornado damage assessment [10] which showed a correspondence between contemporary brick veneer damage losses and Walker's pre-1980 curve. The NWRA is developing wind vulnerability models which are not utilized here. This initial assessment utilises Walker's curves [7] and a range of developmental curves for Region A structures [11].

5 IMPACT/LOSS AND RISK CALCULATIONS

The general methodology applied by Geoscience Australia to risk and impact analyses is a paradigm of Hazard ➔Exposure ➔Vulnerability ➔Impact. Each element of this paradigm is required to ensure comprehensive and integrated assessment within a consistent framework. The approach starts with the assessment of severe wind return-period hazard as detailed. For each return-period hazard level, the potential for residential building damage is linked to the hazard through the vulnerability relationship for the structure type under consideration.

Only the direct damage to residential structures is being considered. Damage is calculated through the interaction of wind speed, building exposure and vulnerability. The value of the loss was calculated as the full cost of repair or replacement ("new for old"). This is significantly greater than the insured value where payout is often on a "like for like" basis. The method being used to calculate the costs of damage assesses the return period of exceedance loss levels (50 to 5000 years) at the SLA level across the continent. Losses are then regressed to obtain a Probable Maximum Loss (PML) curve[1] for each SLA and region. The losses represented by the curve range from frequent minor losses through to those associated with catastrophic events having disastrous effects on each SLA region. Annualised loss, which is evaluated by integrating the area under the PML curve, represents the average annual cost to the region due to exposure to the hazard viewed through a very wide window of time (time window of 2000 years was adopted).

Figure 1 shows the expected loss (% of replacement cost) for the 500 year return period hazard (i.e. BCA design event; residential housing) for the 1388 SLA's over the Australian continent. The tropical coast displays the highest loss, due mainly to the high hazard values, however for locations on the east coast the percentage of older structures is also a significant factor (i.e. older established towns). Figure 2 displays the corresponding annualized loss (% of replacement cost)

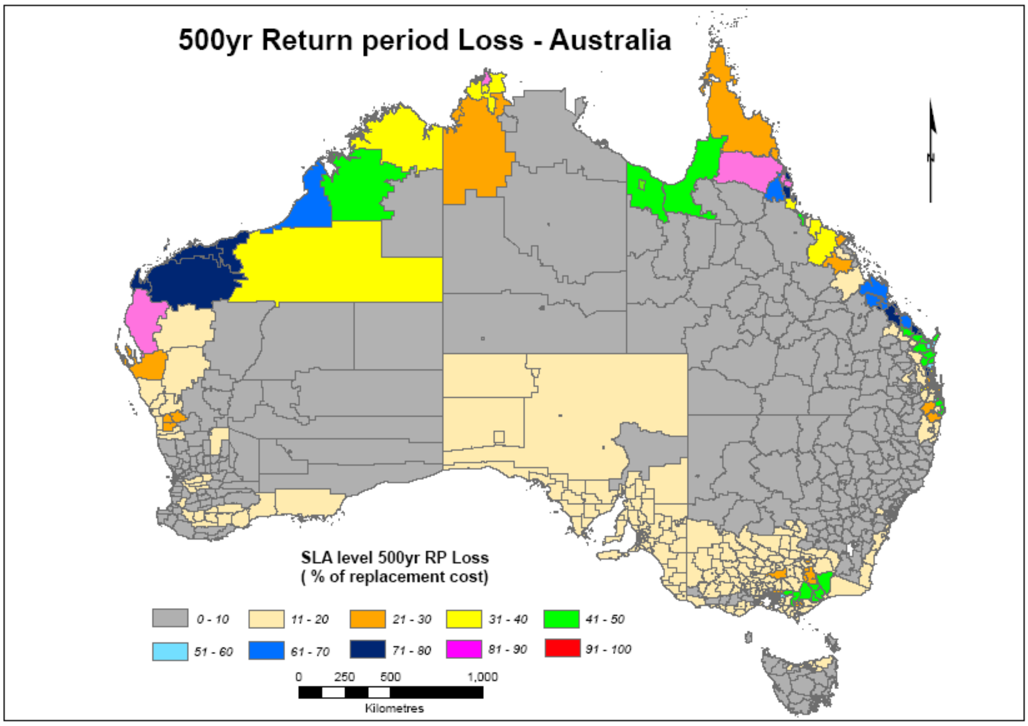

Figure 1. 500 Year return period loss (% of replacement cost) for residential housing in 1388 statistical local area regions (SLA's) for the Australian continent.

[1] The Probable Maximum Loss (PML) curve relates damage of a population of similar structures to the likelihood (return-period) for the hazard.

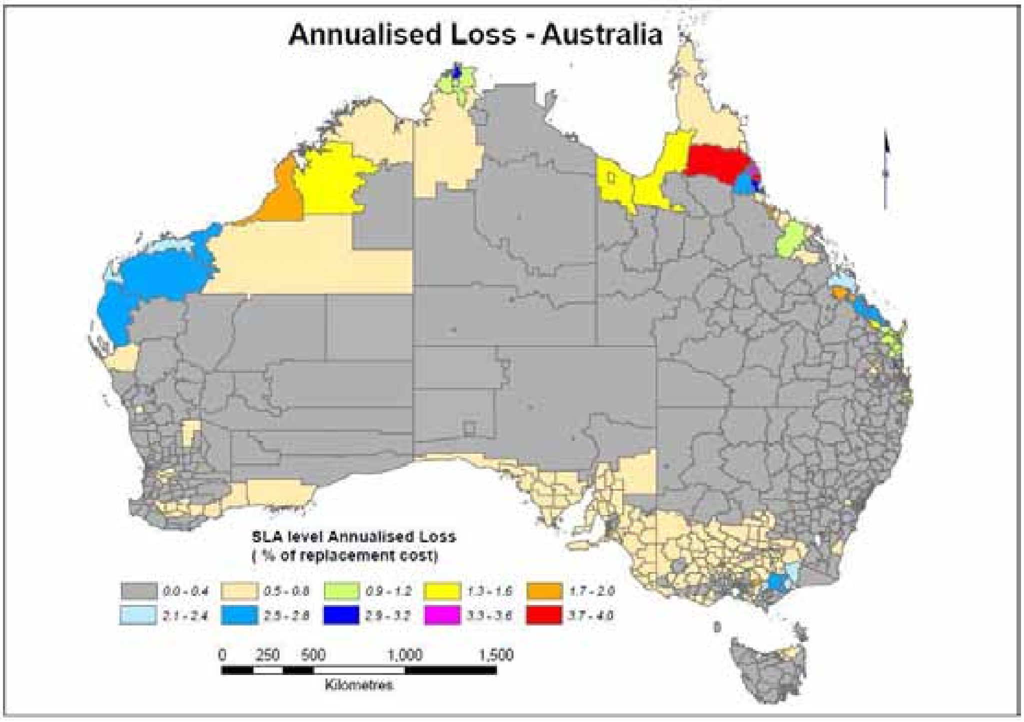

Figure 2. Annualised loss (% of replacement cost) for residential housing in 1388 statistical local area regions (SLA's) for the Australian continent.

6 CONCLUSION

Climate change is expected to increase severe wind hazard in many regions of the Australian continent with consequences for exposed infrastructure and human populations. The aim of the paper is to provide an overview of the risk that peak wind gusts pose to a number of Australian communities (residential buildings) under current climate, utilising the regional hazard as given in [1] as a proxy for the actual current climate hazard. It provides a "first-pass" assessment of the national scale peak wind gust risk for Australia, representing the first iteration of what will be a continuously improving product.

7 REFERENCES

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