NATURAL DISASTER LOSSES AND CLIMATE CHANGE: AN AUSTRALIAN PERSPECTIVE

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Summary

Ninety-five percent of building losses in Australia over the last century are due to natural hazards of a meteorological nature – tropical cyclones, floods, thunderstorms (especially hailstorms) and bushfires. This study reviews a recent analysis of insured property losses due to natural hazards over the last four decades that found no obvious remaining trend after these losses had been indexed correctly for changes in population, wealth and inflation. In other words, no signal remains that could be ascribed to other factors including anthropogenic climate change. Such trends are also noticeably absent from changes in a frequency-severity potential destructiveness index developed for land-crossing tropical cyclones on the east coast of Australia. This is also the case for the probability of national losses from bushfire, which has remained remarkably stable over the last century. We can say little about flood, which although important, is not uniformly insured in Australia. We conclude that to date, societal changes – wealth and population - are the principal reasons for increasing inflation-adjusted costs of natural disasters in this country.

We can cite few examples of legislative changes that might encourage communities to adapt more aggressively to anticipated changes in global climate. We suspect that this is in part due to the very large uncertainty associated with climate change predictions at a local level. Nonetheless, improved building codes introduced after the destruction of Darwin in 1974 by Tropical Cyclone Tracy show what can be done where there is a demonstrated need. We also argue that in addition to more scientific studies on improving climate predictions under different emission scenarios, more quantitative effort be invested in detailing the vulnerability of communities to climate change. The recent study by Chen and McAneney (2006) looking at fine resolution estimates of the global coastal population as a function of distance from the shoreline and elevation above sea level is one example of this type of work.

Background

Meteorological hazards dominate losses in Australia's short-recorded history of natural disasters. In terms of the total number of buildings destroyed (insured and uninsured) between 1900 and 2003, tropical cyclones have been most destructive, accounting for almost one third of losses with floods and bushfires each contributing about another 20%, as do thunderstorms if hail, gust and tornado are combined. Earthquake only accounts for 7%, a proportion that is heavily dependent upon a single event - the 1989 Newcastle earthquake[1] (Figure 1). This breakdown of cumulative losses by hazard suggests that Australia should be more sensitive than many other jurisdictions to changes in global climate, but by itself tells us nothing about how things are changing over time. The bulk of this paper will address this question.

We begin with an examination of a recent indexation of the Australian Insurance Disaster Response Organisation's (IDRO) database of insured losses since 1967. Our interest is to see whether any observable signal remains after we have adjusted original losses for changes in inflation, population and wealth, in much the same way as has already been done for the US hurricane record (Pielke and Landsea 1998). The effort has been to estimate event losses in today's dollars; in short, what this event would cost the insurance industry if it were to reoccur today. Any residual trend might

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[1] For long return period events such as damaging earthquakes, the historical record in Australia is an inadequate sample on which to judge the future.

then be ascribed to other factors including anthropogenic climate change.

In attempting to probe more deeply, we then look at two particular hazards: tropical cyclones and bushfires. We will have less to say about flood, which despite being important in an Australian context (Blong, 2004) has not been universally insured.

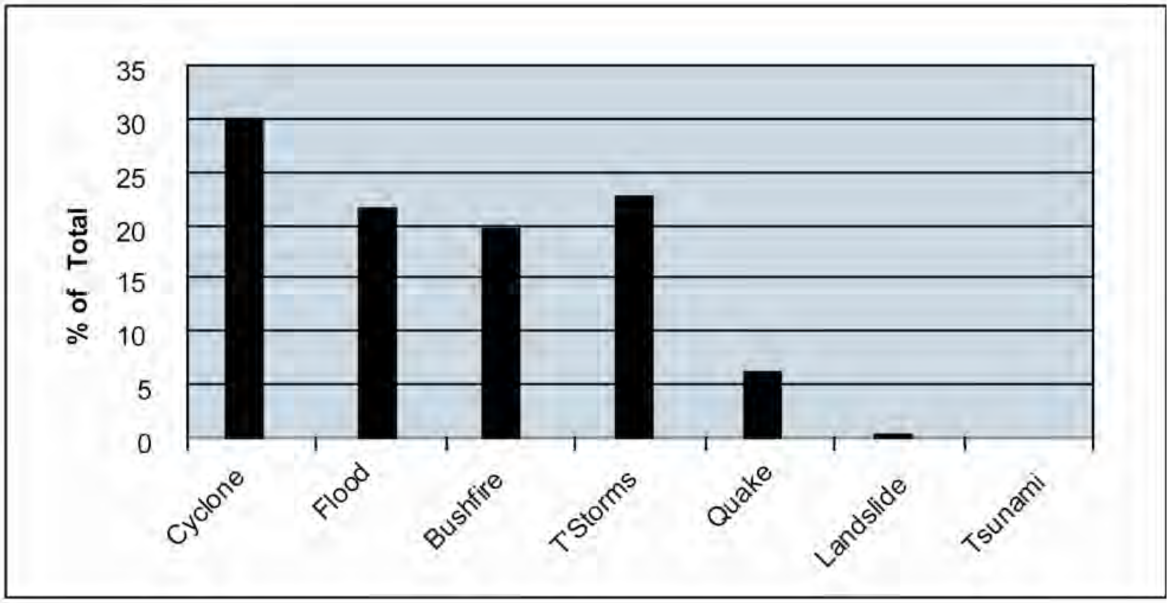

Figure 1: Percentage of the accumulated building damage between 1900 and 2003 attributed to different perils. T'storms refers to the combined losses from thunderstorms – hail, gust and tornadoes. Damaged buildings (including commercial premises) have been normalized to *residential house equivalents* destroyed using relative floor areas and building costs, where one *house equivalent* could equal two homes each 50% destroyed or 10 homes each of which experienced damage amounting to 10% of their replacement value. During bushfires, as compared with some other perils such as hailstorms, say, homes are more often than not completely destroyed (Source: *PerilAUS* database, Risk Frontiers.)

Insured losses – what would they cost today?

Crompton (2005) has previously explored a number of different indexation methodologies and applied them to the IDRO Natural Disaster Event List. The Disaster List is a record of natural hazard events in Australia that have caused significant insured losses. The list begins in 1967 and contains details of each event including date; areas affected; total insured (industry) cost in "original" dollars; and total industry loss in "equivalent current" dollars. Although the threshold loss for inclusion in the database has been varied over time, most refer to events with insured losses in excess of $A10 million.

Each of the indexation methodologies developed by Crompton (2005) incorporated a range of surrogate factors to account for changes in population, inflation, and wealth across regions. The preferred approach (Appendix A) possesses important attributes of simplicity; easy accessibility of the underpinning information; and, by adjusting only for changes in building value, is *independent* of land value. This methodology and that of Pielke and Landsea (1998) produce very comparable adjustments. Since damage to dwellings often makes up a major component of most catastrophe losses, our approach assures reasonable alignment to total insured losses.

Figures 2a and b below present the results of this analysis[2] with the five non-weather-related events in the Disaster List – four earthquakes and one tsunami – excluded. Annual losses have been calculated for years ending 30 June to take account of the southern hemisphere seasonality of the main meteorological hazards. Indexed tropical cyclone losses in

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[2] The 1974 Brisbane flooding due to Tropical Cyclone Wanda has been classified as a flood rather than a cyclone.

Figure 2b have been reduced by 50% in a notional effort to account for improved building standards in tropical cyclone-prone areas introduced after Tropical Cyclone Althea devastated Townsville in 1971 and Tropical Cyclone Tracy destroyed Darwin in 1974. In fact, the actual reduction will be unique for each tropical cyclone path. Using Tropical Cyclone Tracy as an example, our research suggests that the current loss for the event would reduce by approximately 65% if Tracy were to reoccur today and all buildings affected were constructed as per the new building code (i.e. post-1980 construction).

When correctly indexed, the time series of insured losses exhibit no obvious trend (increase or decrease) over the last four decades. Figure 2b reveals that the increasing trend in unadjusted losses (Figure 2a) is largely attributable to changes in the number and value of dwellings.

Figures 3a and b show the breakdown by frequency and contribution to insured losses by hazard type. Hailstorms have the highest average loss per year followed by tropical cyclones and flood. The breakdown in insured losses by peril over this shorter time period is somewhat different to that of the total number of buildings lost over the last century as displayed in Figure 1.

Frequency & severity of tropical cyclones that made landfall on the Australian east coast

We now consider the time series of tropical cyclones that have crossed the east coast of mainland Australia during the last 45 years. Only events having a central pressure less than or equal to 995hPa were included. The analysis begins from the 1961 season and ends at the current 2005 season.

Cyclone activity in the South-Western Pacific region is strongly related to the El Niño - Southern Oscillation (ENSO). Cooler ocean temperatures exist in the Western Pacific and Coral Sea during El Niño episodes and ocean temperatures near the Queensland coast are typically above average during La Niña phases. Consequently, cyclone activity tends to shift further away from the east coast of Queensland and further north resulting in fewer than normal landfalling tropical cyclones during the El Niño phase than during the La Niña phase.

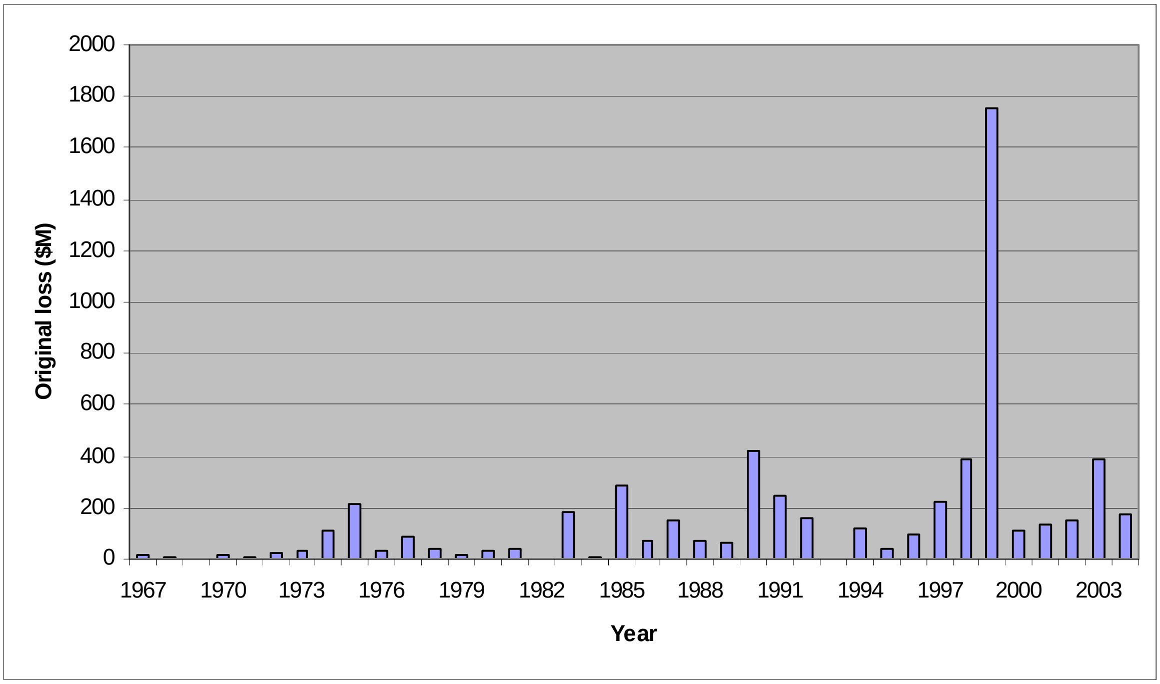

Figure 2a: Original annual aggregate insured losses ($M) for weather-related events in the IDRO database for 12-month periods ending 30 June.

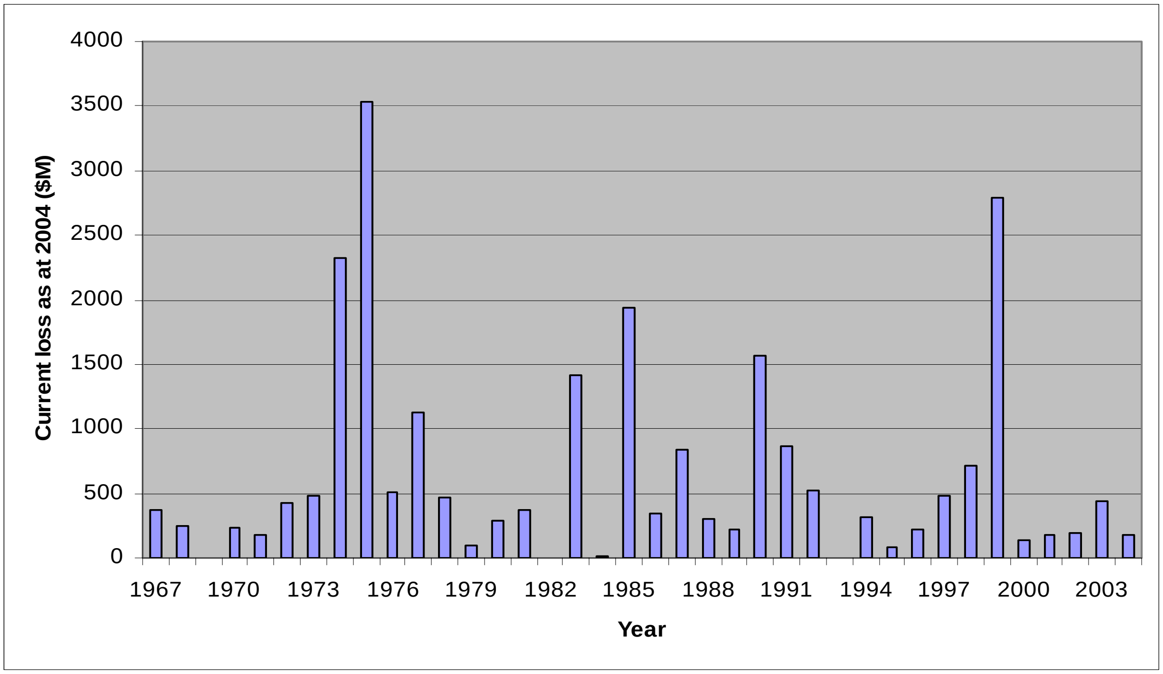

Figure 2b: As for (a) above but losses have been indexed to 2004 dollars. Tropical cyclone losses have been reduced by 50% in a notional attempt to account for post–1980 improvements in building codes in tropical cyclone-prone areas.

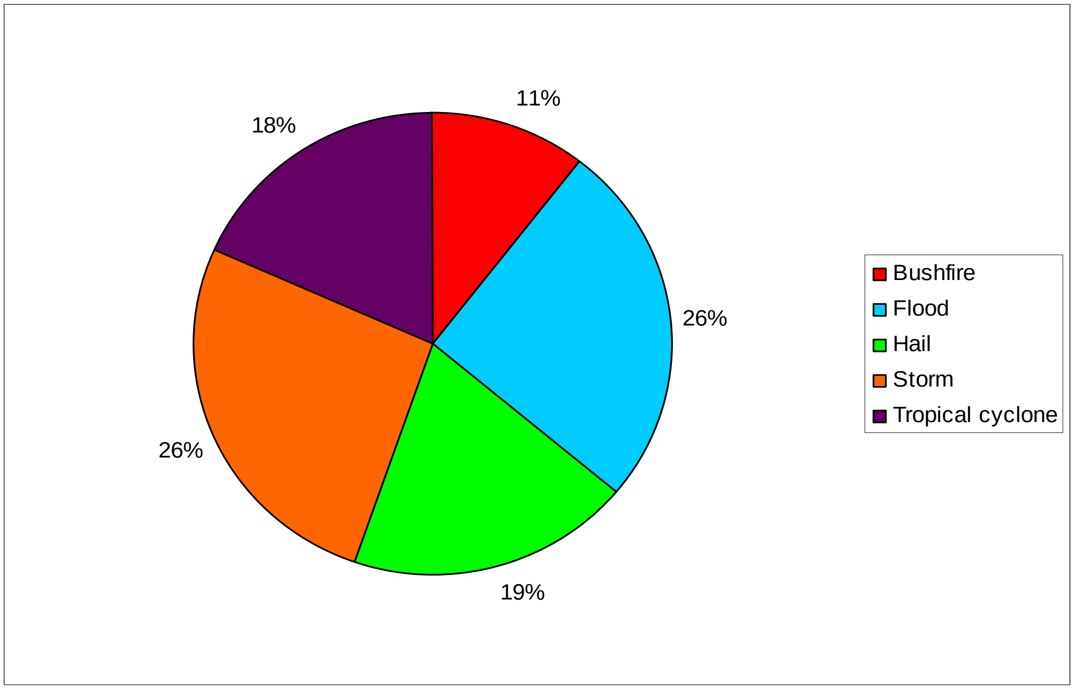

Figure 3a: Percentage of the number of weather-related events classified by hazard type in the IDRO database. Here event losses from hailstorms have been separated from other forms of severe weather – tornados and high winds.

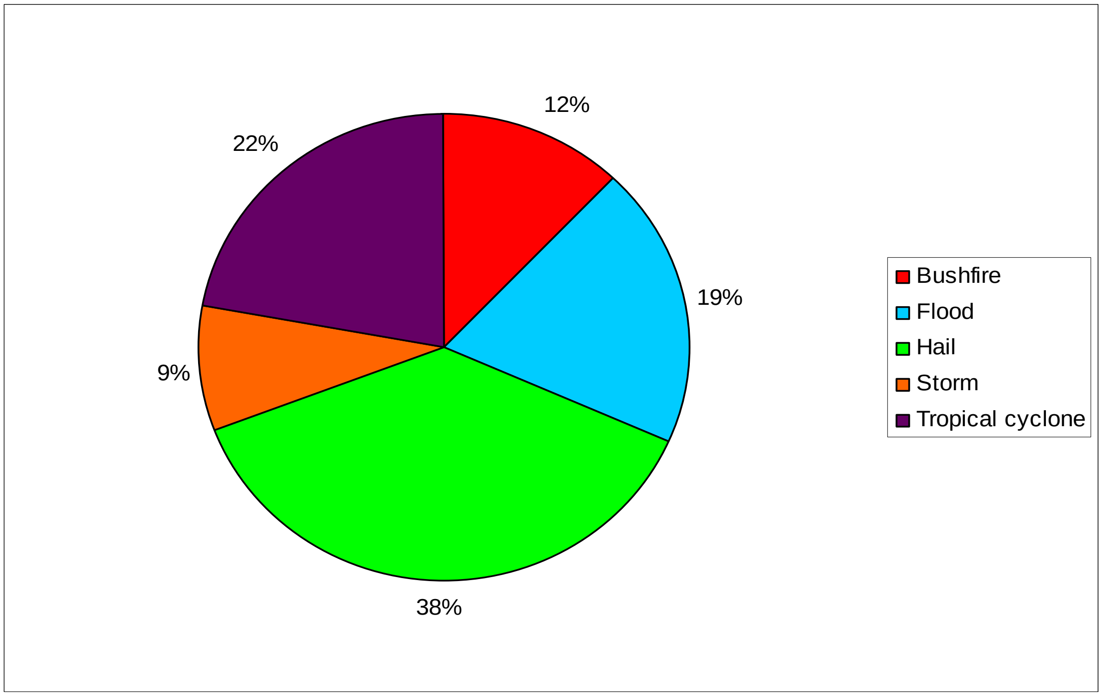

Figure 3b: Percentage of the total current loss as at 2004 ($M) of weather-related events classified by hazard type. Tropical cyclone losses have been reduced by 50% in a notional attempt to account for post–1980 improvements in building codes in tropical cyclone-prone areas.

Figure 4 shows successive five-season period frequencies of tropical cyclones that have crossed the east coast. Within each of the five-season periods there are different numbers of El Niño, La Niña, and neutral events. With the exception of 1971-75, there have been between two and four tropical cyclones for each period. It comes as no surprise that La Niña episodes dominated during this period.

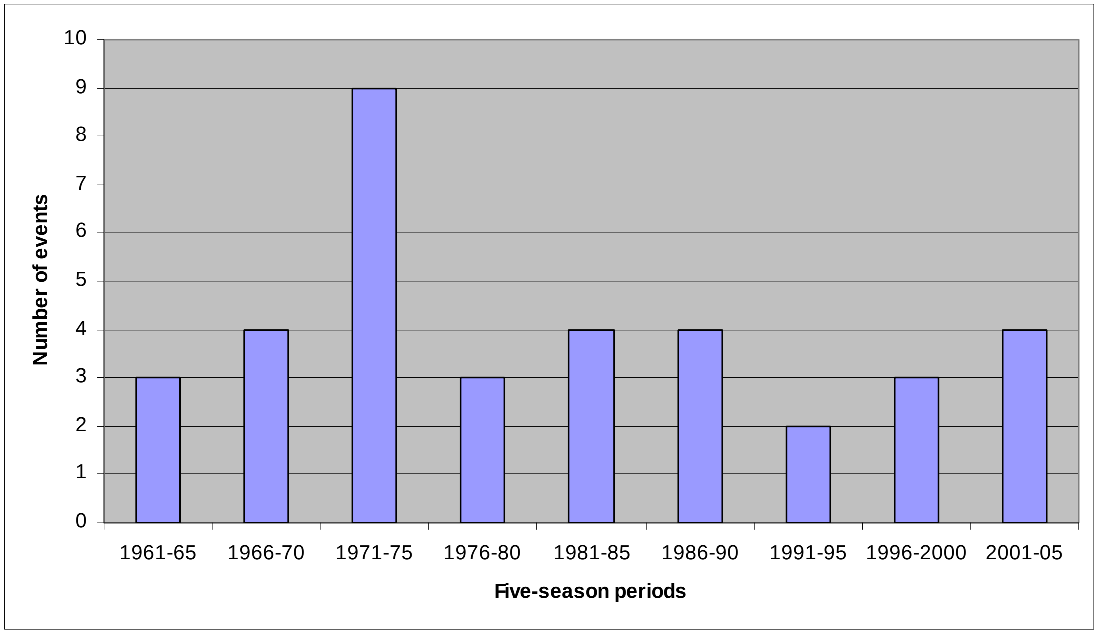

Figure 4: Number of tropical cyclones to cross the east coast during five-year periods.

Figure 4 only tells part of the story. Of more interest is the combination of frequency and intensity. According to Gray (2003), when normalised for coastal population, inflation, and wealth per capita, tropical cyclone-spawned damage in the US rises by a factor of four for each successive increase in Saffir-Simpson intensity category. Thus a landfalling

Category-3 hurricane typically causes about four times the normalised damage of a Category-2 hurricane and so forth. Assuming that this same ratio between cyclone categories holds true for Australian conditions, Figure 5 takes this weighting into account. In calculating these figures, Category-5 and -4 events have each been assigned an equal weighting of 1/4; Category-3 a weighting of 1/16; Category-2 a value of 1/64 and Category-1 events 1/256. These are then summed for each 5-year period to obtain a relative potential destructiveness index.

By concentrating on the damage potential of the hazard alone, Figure 5 assumes a uniform portfolio of assets at risk. It also allows for Australia's low population density and the large physical distances between population centres on the exposed east coast. Actual damage arising from individual tropical cyclones will vary widely as a result of differences in population, terrain, topography, proportions of construction conforming to improved (wind loading) building codes, wealth per capita, direction and forward speed, storm surge, and rainfall.

Again we see no obvious change (increase or decrease) in the potential destructiveness over the time periods represented in Figure 5. Figures 4 and 5 focus on the east coast because this is where most of the insured exposure is located; however, very similar results hold for the western and north coasts of Australia or for the entire coastline. Nonetheless we do acknowledge that the small number of cyclones per five–year time interval makes it difficult to draw very robust conclusions.

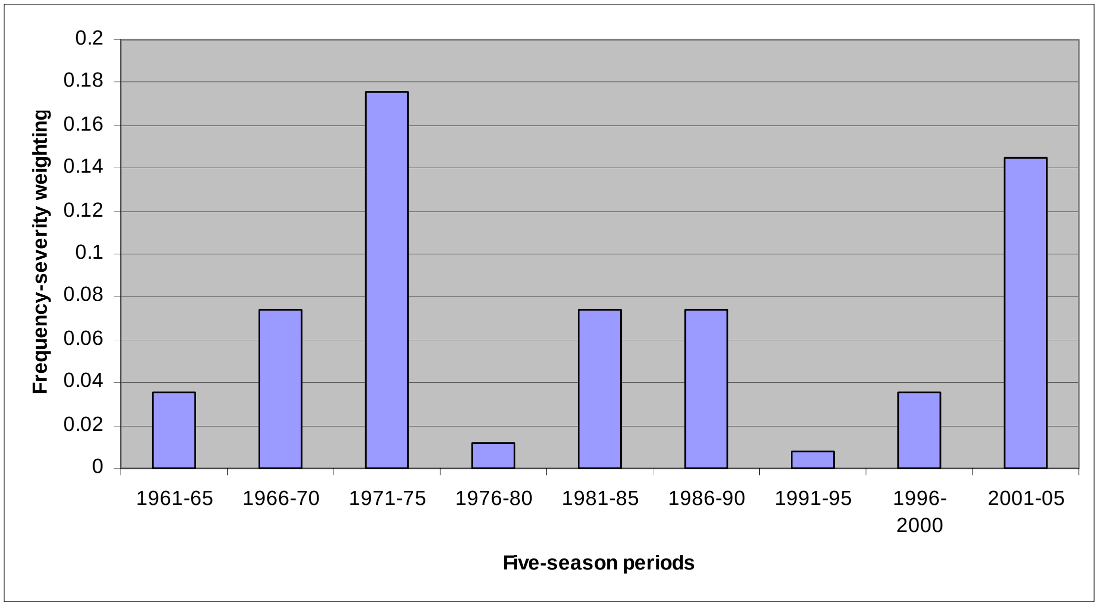

Figure 5: Combined frequency-severity of tropical cyclones that have crossed the east coast of Australia during five-year periods.

Annual probability of bushfire losses

Many papers on bushfire risk in Australia have concluded that the bushfire hazard will increase under high carbon dioxide emission scenarios (e.g. Pitman et al., 2006 and papers cited therein). With this in mind, it is interesting to look at the statistics of event losses over the last century. Table 1, drawn from Risk Frontiers *PerilAUS* database of building losses, lists two relevant statistics and illustrates how these change when calculated between a given start year and 2003. The first row indicates that at least some home destruction can be expected in approximately 60% of years, a statistic that has remained remarkably constant despite large increases in population, improvements in fire fighting technology and better understanding of bushfire physics. The corollary is that in 40% of years, bushfires cause no home losses. On reflection, this stability is perhaps not too surprising given that the propensity for fires to escalate once started is largely a function of the surface water budget, ambient temperatures, windspeed, and fuel load. Of these variables, only the latter is subject to human intervention through controlled burnoff practices. Moreover, once a fire exceeds a certain scale, there is very little that can be done to stop it until it runs out of fuel.

The second row of Table 1 lists the average annual frequency of having more than 25 homes destroyed within a single week, in other words, the annual probability of having a significant event loss as opposed to a large annual loss. This statistic has similarly remained remarkably constant at around 40%. At current average asset values (AU$375,000 for average home and contents), an event loss of 25 homes would come close to AU$10 million, the lower limit for consideration in the IDRO database. The 7-day time window has some relevance for reinsurance contracts but is introduced here merely to confirm that the stability of the annual probability of any loss mentioned already also holds true for larger events.

Although we concede that bushfire losses are the result of a complicated mix of social and climatic phenomena, the inference is again clear. We have little signal that can be unequivocally assigned to a human-induced changing climate. To argue that global increases in temperature and an increasingly lengthy urban-forest interface (Chen and McAneney 2005) have been exactly compensated by improved fire management techniques would stretch credulity.

Table 1: Statistics of bushfire loss probabilities (Source: *PerilAUS*, Risk Frontiers) calculated between the start year and 2003. The top row lists the frequency of any (non-zero) loss, while the second includes only those that resulted in more than 25 homes destroyed within a single week. Data in the first column (1900) has been adjusted to account for missing data (McAneney 2005).

Start Year	1900	1926	1939	1967	1983	1990
Annual probability of a loss	57%	54%	49%	59%	62%	64%
Annual Probability of a major event	40%	43%	41%	38%	38%	36%

Implications for research and policy

The evidence reviewed above suggests that, in Australia, population, inflation and wealth are the predominant reasons for increased insurance losses to this point. The role of monotonic changes in the magnitude of natural disaster losses attributable to anthropogenic climate change or otherwise, appears minor and is not detectable at this time.

Given the above conclusion, it seems reasonable that research on climate change science should go hand in hand in a holistic manner with disaster management and mitigation research. As in other parts of the world, there is not a strong formal connection between researchers in the two communities in Australia. An important area of common interest between the disciplines should be quantifying and reducing vulnerability to coastal inundation, storms, bushfires and floods.

An encouraging example of what is possible is work undertaken at Risk Frontiers on identifying Australian addresses vulnerable to a wide range of ocean-related natural catastrophes such as storm surge, tsunami and significant sea-level rise under global warming (Chen and McAneney, 2006). Using the most recent, fine resolution global databases, this work quantifies the number of addresses in Australia located within 3 kilometres of the coast and having an elevation less than 6 metres above mean sea level. This paper also provides a way of providing plausible lower bound global estimates on the numbers of people at risk in coastal areas.

When it comes to developing and implementing climate change adaptation policy to, for example, reduce vulnerability in a particular locality or constituency, there is a disconnect. On the one hand, confidence in global climate models is highest for global average temperature and perhaps rainfall and sea-level rise. Policy implications have naturally centred on reducing global emissions at a global level, e.g. Kyoto protocol. Meanwhile, disaster management and mitigation requires projections at a local level and for small-scale event-based phenomena such as floods, hailstorms and tropical cyclones. Global climate models cannot currently provide these projections with any skill.

There are very few examples of policies or legislation in Australia developed to help communities adapt to possible future climate change. An often-cited reason is the lack of reliable information at the local scale noted above. Given the truth of the oft quoted "all politics is local" attributed to Tip O'Neil, the Speaker of the House of Representatives in the US, it is difficult to see significant changes occurring in the near future in this country.

One positive Australian adaptation example to which we can point is the improved wind loading code introduced in the 1980's as part of a *National Building Code of Australia*. These codes have been mentioned already and were introduced and enforced for all new housing construction following the destruction of Darwin by Tropical Cyclone Tracy in 1974. As a result, dramatic reductions in tropical cyclone-induced losses were observed following Tropical Cyclones Winifred (1986) and Aivu (1989) (Walker, 1999) and more recently, Larry (2006) (Guy Carpenter, 2006). While these improvements were introduced in response to existing natural variability in the occurrence of natural hazards, they provide a perfect example of steps that should be taken to start to adapt to any future impacts of climate change.

It is not unknown for insurance companies to adjust their risk profile in response to perceived changes in climate variability or extreme events. After Samoa suffered three major tropical cyclones within four years in the late 1980s and 1990s, the country's only insurer refused to renew insurance policies for tropical cyclone damage and clients could only get new policies at a higher premium and with a structural engineer's certificate. Similarly Fiji was hit by a succession of tropical cyclones in the mid 1980s. Half the insurance companies operating in the country withdrew and those that remained raised premiums and insisted on engineering reports for commercial buildings (Leigh *et al.* 1998). More recently Allstate in the US has been reported as stopping offering polices in coastal parts of New York City and Nassau, Suffolk and Westchester counties where the risk of hurricanes is perceived to be too high (as reported in the New York Times, 11 March 2006).

The 12-month cycle of insurance and reinsurance means that such reactive responses by the industry can take effect very quickly. They can also have important social and economic consequences. On a positive note, the withholding of insurance or inclusion of conditions relating to building construction can prompt policy and legislative changes that reduce overall vulnerability to current natural hazards regimes and to the anticipated impacts of climate change. In other words, they promote adaptation.

Clearly, scientific research that will improve the reliability of global climate projections under different emission scenarios and improve confidence in their representation of smaller scale phenomena and extreme events is important. Similarly important are strategies that address the root cause of the changing risk and increasing uncertainty: greenhouse gas emissions. However, in the context of this paper, policies and research directed at helping societies adapt to the effects of current and future climate change and variability through quantifying and reducing physical and social vulnerability to extreme events is the critical issue. Researchers and practitioners in fields such as disaster risk reduction, disaster studies, natural hazards research and insurance and reinsurance already have the relevant tools, knowledge and experience to make an important contribution; indeed they deal with extreme events, variability and uncertainty on a regular basis. Improved understanding and ability to cope with current climate variability and weather extremes is a fundamental step towards adapting to potential future climate variability and weather extremes.

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Appendix A

Indexation Methodology

$$CL_{04} = L_a \times N_{a,b} \times D_{a,s}$$

CL_{04} - event loss converted to 2004 value (current loss);

a - year the event occurred;

L_a - event loss in year ‘a’ (original loss);

b - Urban Centre / Locality (UC/L) impacted by the event. The UC/L Structure groups Census Collection Districts (CCDs) together to form defined areas according to population size criteria (http://www.abs.gov.au);

$N_{a,b}$ - dwelling number factor, determined by the ratio of the number of dwellings as at 2004 in the UC/L originally impacted by the event to the number in year ‘a’. This information is derived from the 1966 and 2001 Census of Population and Housing;

s - State/Territory that contains the UC/L impacted by the event;

$D_{a,s}$ - dwelling value factor, determined by the ratio of the State/Territory average *nominal* value of new dwellings in 2004 to that of year ‘a’. The dwelling value factor is calculated for the State/Territory that contains the UC/L impacted by the event. State/Territory average *nominal* values of new dwelling units are calculated by dividing the value of building work completed within a year by the number of completions within the same year. The relevant values are taken from the ABS *Building Activity* reports (http://www.abs.gov.au).

Note that the increase in average dwelling value is in part due to increasing average dwelling size and marked improvements in the quality of the housing stock (http://www.abs.gov.au).

While it has been shown the most important factors have been quantified and combined in the above indexation methodology, it is important to recognise factors not accounted for in the adjustment process. These include but aren’t necessarily limited to the following:

- changes in insurance penetration;
- changes in the quality of insurance issued over time i.e. companies ceasing to offer policies in high risk areas;
- changes in the impact of post-event inflation (demand surge);
- possibility of no change in population or exposure for particular events even though it is automatically assumed in the adjustment - imagine a hailstorm whose footprint extended across an already densely populated area where there have been no material changes in population or dwelling numbers since the time of the event;
- the impact of loss mitigation measures, e.g. improved bushfire prevention and fighting measures or new levees constructed near or around rivers in the case of flood;
- possibility that some recent events in the Disaster List not registering a loss had the same event occurred years ago, i.e. demographic changes mean that it’s now possible for an event to register a loss in an area where there may not have been any people living in the past. This is particularly a problem for hazards such as hailstorms where there is no record of the event unless it impacted a populated area;
- frequency and magnitude of some of the hazards in the Disaster List are affected by meteorological and atmospheric cycles.

Note that not all of these adjustments increase the original loss.

When applied to the Disaster List, the preferred approach and that of Pielke and Landsea (1998) produce comparable current loss values. This is no coincidence, as dwelling assets comprise the main driver of the Australian wealth factor (63% for the 12-month period ending in June 2004) while the preferred methodology uses dwelling number and dwelling value factors directly. A disadvantage of the Australian wealth factor is that the dwelling assets also include land value. Moreover, an indexation methodology based on dwellings rather than population has advantages in that the housing stock increased at almost double the rate of population during the period 1911 to 1996. The outcome has been a marked decline in the average number of occupants of each dwelling in Australia from around 4.5 in 1911 to around 2.5 by 1996 (http://www.abs.gov.au).