Senate Standing Committee on Environment and Communications
Inquiry into Recent Trends in and Preparedness for Extreme Events

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Summary of comments

1. The Intergovernmental Panel on Climate Change's 2012 Special Report "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" provides the most up-to-date and comprehensive assessment of recent trends and projected changes in extreme weather events, and on adapting to these changes.
2. The conclusions of the IPCC report regarding observed and projected changes in extremes are more nuanced than is often recognised. For some extremes there is considerable confidence that extreme events are becoming more frequent or intense. But for other extremes the evidence is either absent or, as yet, not strong.
3. Improved weather forecasts provide perhaps the simplest, cheapest, and best-targeted adaptation to offset the deleterious effects of weather extremes now and in a changing climate. This will be the case even for those extremes for which our confidence in projected change is low.

Background

1. I am an Australian Research Council Professorial Fellow at Monash University.
2. My research, over forty years as a climate scientist, has focussed on monitoring, understanding, and predicting variations and changes in weather and climate extremes (eg., Nicholls 1979, 1984, 1985, 1995, 2004, 2012; Karl et al., 1999; Nicholls and Alexander, 2007), and their human and ecological impacts (eg., Nicholls 1986; Nicholls et al., 2006; Nicholls and Lucas, 2007; Nicholls et al., 2008).
3. I was one of two Coordinating Lead Authors of the chapter on observed and projected changes in weather and climate extremes in the recent Intergovernmental Panel on Climate Change (IPCC) assessment of weather and climate extremes.
4. I comment below on the Terms of Reference related to recent and projected trends in extreme weather events, and on the preparedness of key sectors and emergency management for extreme weather events.

Comments related to specific Terms of Reference of the Inquiry.

Term of Reference (a) recent trends on the frequency of extreme weather events, including but not limited to drought, bushfires, heatwaves, floods and storm surges;

Chapter 3 ("Changes in Climate Extremes and their Impacts on the Natural Physical Environment", Seneviratne et al., 2012) in the IPCC Special Report "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (Field et al., 2012) is the most recent, and most comprehensive, effort to collate and assess scientific understanding about changes in weather and climate extremes. Amongst the Chapter's conclusions are the following regarding recent trends of extreme weather events:

> "**There is evidence from observations gathered since 1950 of change in some extremes.** It is *very likely* that there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights, at the global scale, that is, for most land areas with sufficient data. It is *likely* that these changes have also occurred at the continental scale in North America, Europe, and Australia. There is *medium confidence* of a warming trend in daily temperature extremes in much of Asia. *Confidence* in observed trends in daily temperature extremes in Africa and South America generally varies from *low* to *medium* depending on the region. Globally, in many (but not all) regions with sufficient data there is *medium confidence* that the length or number of warm

> spells or heat waves has increased since the middle of the 20th century. It is *likely* that there have been statistically significant increases in the number of heavy precipitation events (e.g., 95th percentile) in more regions than there have been statistically significant decreases, but there are strong regional and subregional variations in the trends. There is *low confidence* that any observed long-term (i.e., 40 years or more) increases in tropical cyclone activity are robust, after accounting for past changes in observing capabilities. It is *likely* that there has been a poleward shift in the main Northern and Southern Hemisphere extratropical storm tracks. There is *low confidence* in observed trends in small-scale phenomena such as tornadoes and hail because of data inhomogeneities and inadequacies in monitoring systems. There is *medium confidence* that since the 1950s some regions of the world have experienced a trend to more intense and longer droughts, in particular in southern Europe and West Africa, but in some regions droughts have become less frequent, less intense, or shorter, for example, in central North America and northwestern Australia. There is limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at regional scales because the available instrumental records of floods at gauge stations are limited in space and time, and because of confounding effects of changes in land use and engineering. Furthermore, there is low agreement in this evidence, and thus overall *low confidence* at the global scale regarding even the sign of these changes. It is *likely* that there has been an increase in extreme coastal high water related to increases in mean sea level in the late 20th century."

It should be noted that the terms used in the above quotes to describe the uncertainty estimates related to these various trends (indicated in italics in the above excerpt) have very specific meanings in the IPCC, and care should be taken in their interpretation. In particular it should be noted that:

> "'*Low confidence*' in observed or projected changes in a specific extreme neither implies nor excludes the possibility of changes in this extreme." (Seneviratne et al., 2012).

The Chapter also considered the evidence for anthropogenic influences on such trends in extremes and concluded:

> **"There is evidence that some extremes have changed as a result of anthropogenic influences, including increases in atmospheric concentrations of greenhouse gases.** It is *likely* that anthropogenic influences have led to warming of extreme daily minimum and maximum temperatures at the global scale. There is *medium confidence* that anthropogenic influences have contributed to intensification of extreme precipitation at the global scale. It is *likely* that there has been an anthropogenic influence on increasing extreme coastal high water due to an increase in mean sea level. The uncertainties in the historical tropical cyclone records, the incomplete understanding of the physical mechanisms linking tropical cyclone metrics to climate change, and the degree of tropical cyclone variability provide only *low confidence* for the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences. Attribution of single extreme events to anthropogenic climate change is challenging."

The above quotes indicate that the situation regarding observed changes in climate and weather extremes, and the attribution of these changes to human actions, is more nuanced than is often assumed. Some extremes have been increasing in frequency or intensity, but for some others the evidence of change is either absent or not strong, as yet. As a result of this, the Chapter concludes that it is difficult to determine if the weather is becoming more extreme in general:

> "While there is evidence that increases in greenhouse gases have *likely* caused changes in some types of extremes, there is no simple answer to the question of whether the climate, in general, has become more or less extreme. Both the terms 'more extreme' and 'less extreme' can be defined in different ways, resulting in different characterizations of observed changes in extremes. Additionally, from a physical climate science perspective it is difficult to devise a comprehensive metric that encompasses all aspects of extreme behavior in the climate."

Term of Reference (b) based on global warming scenarios outlined by the Intergovernmental Panel on Climate Change and the Commonwealth Scientific and Industrial Research Organisation of 1 to 5 degrees by 2070:

(i) projections on the frequency of extreme weather events, including but not limited to drought, bushfires, heatwaves, floods and storm surges,

Regarding projections of changes in extreme events through the 21st century, the IPCC extremes report concluded (Seneviratne et al., 2012):

> "**Models project substantial warming in temperature extremes by the end of the 21st century.** It is *virtually certain* that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur through the 21st century at the global scale. It is *very likely* that the length, frequency, and/or intensity of warm spells or heat waves will increase over most land areas. For the Special Report on Emissions Scenarios (SRES) A2 and A1B emission scenarios, a 1-in-20 year annual hottest day is *likely* to become a 1-in-2 year annual extreme by the end of the 21st century in most regions, except in the high latitudes of the Northern Hemisphere where it is *likely* to become a 1-in-5 year annual extreme. In terms of absolute values, 20-year extreme annual daily maximum temperature (i.e., return value) will *likely* increase by about 1 to 3°C by mid-21st century and by about 2 to 5°C by the late 21st century, depending on the region and emissions scenario (considering the B1, A1B, and A2 scenarios). Regional changes in temperature extremes will often differ from the mean global temperature change.
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> **It is *likely* that the frequency of heavy precipitation or the proportion of total rainfall from heavy rainfalls will increase in the 21st century over many areas of the globe.** This is particularly the case in the high latitudes and tropical regions, and in winter in the northern mid-latitudes. Heavy rainfalls associated with tropical cyclones are *likely* to increase with continued warming induced by enhanced greenhouse gas concentrations. There is *medium confidence* that, in some regions, increases in heavy precipitation will occur despite projected decreases in total precipitation. For a range of emission scenarios (SRES A2, A1B, and B1), a 1-in-20 year annual maximum 24-hour precipitation rate is *likely* to become a 1-in-5 to 1-in-15 year event by the end of the 21st century in many regions, and in most regions the higher emissions scenarios (A1B and A2) lead to a greater projected decrease in return period. Nevertheless, increases or statistically non-significant changes in return periods are projected in some regions.
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> **There is generally *low confidence* in projections of changes in extreme winds because of the relatively few studies of projected extreme winds, and shortcomings in the simulation of these events.** An exception is mean tropical cyclone maximum wind speed, which is *likely* to increase, although increases may not occur in all ocean basins. It is *likely* that the global frequency of tropical cyclones will either decrease or remain essentially unchanged. There is *low confidence* in projections of small-scale phenomena such as tornadoes because

competing physical processes may affect future trends and because climate models do not simulate such phenomena. There is *medium confidence* that there will be a reduction in the number of mid-latitude cyclones averaged over each hemisphere due to future anthropogenic climate change. There is *low confidence* in the detailed geographical projections of mid-latitude cyclone activity. There is *medium confidence* in a projected poleward shift of mid-latitude storm tracks due to future anthropogenic forcings.

It is *very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future. There is *high confidence* that locations currently experiencing adverse impacts such as coastal erosion and inundation will continue to do so in the future due to increasing sea levels, all other contributing factors being equal.

Projected precipitation and temperature changes imply possible changes in floods, although overall there is *low confidence* in projections of changes in fluvial floods. *Confidence* is *low* due to limited evidence and because the causes of regional changes are complex, although there are exceptions to this statement. There is *medium confidence* (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in local flooding, in some catchments or regions. Earlier spring peak flows in snowmelt and glacier-fed rivers are *very likely*.

There is *medium confidence* that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration. This applies to regions including southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil, and southern Africa. Definitional issues, lack of observational data, and the inability of models to include all the factors that influence droughts preclude stronger *confidence* than *medium* in the projections. Elsewhere there is overall *low confidence* because of inconsistent projections of drought changes (dependent both on model and dryness index)."

As noted in the comments related to observed changes in extreme events, it should be recognised that the terms used in the above quotes to describe the uncertainty estimates related to these various trends (indicated in italics in the above excerpt) have very specific meanings in the IPCC, and care should be taken in their interpretation. In particular it should be noted that:

"'*Low confidence*' in observed or projected changes in a specific extreme neither implies nor excludes the possibility of changes in this extreme." (Seneviratne et al., 2012).

So, "low confidence" in projections of a specific extreme, such as flooding, does not mean that the authors conclude that there will not be any change in the specific extreme, but that the uncertainties are too great to make useful projections, at this time, regarding such changes. It should be noted, however, that for some extremes, such as hot days and extreme sea levels, projections of increasing frequency and intensity of extremes can be made, even now, with considerable confidence.

The different levels of confidence in projected changes in extremes, and our inability to determine whether or not the climate is becoming more extreme in general, means that an approach to adapting to possible changes in extremes that does not rely on high confidence in projected changes is required. This issue is discussed in response to the following Term of Reference.

Term of Reference (c) an assessment of the preparedness of key sectors for extreme weather events, including major infrastructure (electricity, water, transport, telecommunications), health, construction and property, and agriculture and forestry; Term of Reference (d) an assessment of the preparedness and the adequacy of resources in the emergency services sector to prevent and respond to extreme weather events;

Accurate weather forecasts provide a means for mitigating the deleterious effects of climate and weather extremes now, and also provide an approach to offset any exacerbation of such extremes by anthropogenic climate change, without requiring highly confident projections of changes in extremes:

> "Improving weather forecasts, and ensuring more extensive use of the forecasts in decision-making is the simplest, cheapest, best-targeted adaptation to offset the detrimental consequences of climate change. And if by some miracle the climate does not change, then all we have done is save lives and reduce the current costs of disasters – not such a bad thing." (Nicholls, 2011).

Nevertheless, and despite the improved accuracy of forecasts of weather extremes such as heat waves, heavy rains, and tropical cyclones in recent years (Nicholls, 2001), some sectors of the economy at risk from extreme weather events, including the management of some major infrastructure, do not adequately include weather forecasts into their management.

> "In some cases this is because of a false perception that weather forecasts are not sufficiently accurate to use in disaster risk management. While this was a reasonable assumption in the past, rapid developments in weather forecasting, based on greatly improved prediction models and monitoring, mean that it is time for decision-makers to rethink whether or not modern weather forecasts should be integrated into their risk management. This will save lives and reduce damage now. But it will also help us cope with any worsening of extreme weather, as the climate changes." (Nicholls, 2011).

One sector where efforts have been made to incorporate improved weather forecasting into emergency alerts and management is the health services sector where, in most cities across the world, efforts have been made to develop and implement heat wave alerts systems, to reduce the increased mortality and morbidity that accompanies such extreme weather. One example of the effects of heat waves is that the heat wave related mortality in southeast Australia on the weekend heat wave prior to the devastating bushfires of Black Saturday in 2009 was more than double the mortality caused by the bushfires. Mortality may even have been higher during that heat wave except that the Victorian Government had just introduced a heat wave alert system based on the documented relationship between threshold temperatures and increased mortality in Melbourne (Nicholls et al., 2008). The Victorian heat wave alert system, and the underlying science, continues to be improved (http://health.vic.gov.au/environment/heatwave/index.htm), as is the case in other cities across Australia and the world.

Similar systems, for heat waves but also for other weather extremes, could be applied in other sectors of the economy, including the management of major infrastructure, and would be a useful "hedge" against the possibility that extreme weather may be exacerbated by anthropogenic factors in the future (Nicholls, 2012). While such systems could not provide a complete answer to the possible deleterious impacts of climate change, they would provide a useful adjunct to efforts to mitigate greenhouse gas emissions and especially against the global warming to which we are already committed from historical emissions. Improved weather forecasts and their improved application also provide a means to reduce the deleterious impacts of weather and climate extremes now, as well as into the future.

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