CLIMATE COUNCIL

# HURRICANE BRIEFING

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## Background

Already, this Atlantic hurricane season has seen devastation with Hurricane Harvey bringing extremely intense and prolonged rainfall and flooding to Texas and Louisiana. Analysis by MetStat (2017) reveals that over a 5-day period the storm delivered 1-in-25,000 year rainfall to a widespread area. Less than a week after this storm, which resulted in more than 70 deaths and left tens of thousands homeless, Hurricane Irma left a trail of destruction and devastation across the Caribbean and Florida. This hurricane was one of the most powerful hurricanes on record, with the highest recorded wind speed reaching almost 300 km per hour. At least 50 people have been killed by Irma, and the damage bill of both Hurricanes Irma and Harvey is expected to be approximately $200 billion.

The series of hurricanes in the Atlantic has prompted many people to ask the Climate Council about the influence of climate change on hurricanes (referred to as “tropical cyclones” in Australia). This briefing paper helps explain the science behind the link between climate change and hurricanes, and provides information on Australian tropical cyclone activity and impacts.

## The Influence of Climate Change on Hurricanes

**Climate change, driven by the burning of coal, oil and gas, is influencing all extreme weather events** – including hurricanes (referred to as “Tropical Cyclones” in Australia) – because they are now occurring in a more energetic climate system with a hotter, moister atmosphere (Trenberth 2012). Consistent with this basic physical understanding, a statistically significant increase in intense hurricane activity has been observed in the North Atlantic region since the 1970s (Kossin et al. 2007; IPCC 2013). Hurricane behaviour is likely to be affected by climate change in two main ways:

1. The increasing temperature of the surface ocean affects the intensity of cyclones (along with changes in upper atmosphere conditions), both in terms of maximum wind speeds and in the intensity of rainfall that occurs in association with the cyclone. This is because the storms draw energy from the surface waters of the ocean, and as more heat (energy) is stored in these upper waters, the cyclones have a larger source of energy on which to draw (Emanuel 2000; Wing et al. 2007).
2. The formation of hurricanes most readily occurs when there are very warm conditions at the ocean surface and when the vertical temperature gradient through the atmosphere is strong. As the climate continues to warm, the difference between the temperature near the surface of the Earth and the temperature higher up in the atmosphere, is likely to decrease as the atmosphere continues to warm. As this vertical gradient weakens, it is likely that fewer hurricanes will form (DeMaria et al. 2001; IPCC 2012).

In summary, it is likely that **fewer hurricanes will form as the climate warms, but a higher fraction of those that do will be intense, more damaging hurricanes**.

## Further information on climate change and storms


## Coastal flooding: the most direct link to climate change

The most direct influence of climate change on the impacts of hurricanes is via **coastal flooding**. Typically the damage from hurricanes comes from:

1. Excessively high winds that directly damage built infrastructure and the natural environment; and
2. Coastal flooding caused by a storm surge, and the heavy rainfall that often accompanies the storm.

## What is a storm surge?

A storm surge is **a rise above normal sea level resulting from strong onshore winds and/or reduced atmospheric pressure**. Storm surges, which accompany hurricanes, can cause extensive flooding of coastal areas. The area of sea water flooding may extend along the coast for hundreds of kilometres, with water pushing several kilometres inland if the land is low-lying. The worst impacts of a storm surge occur when it coincides with a particularly high tide (Figure 1).

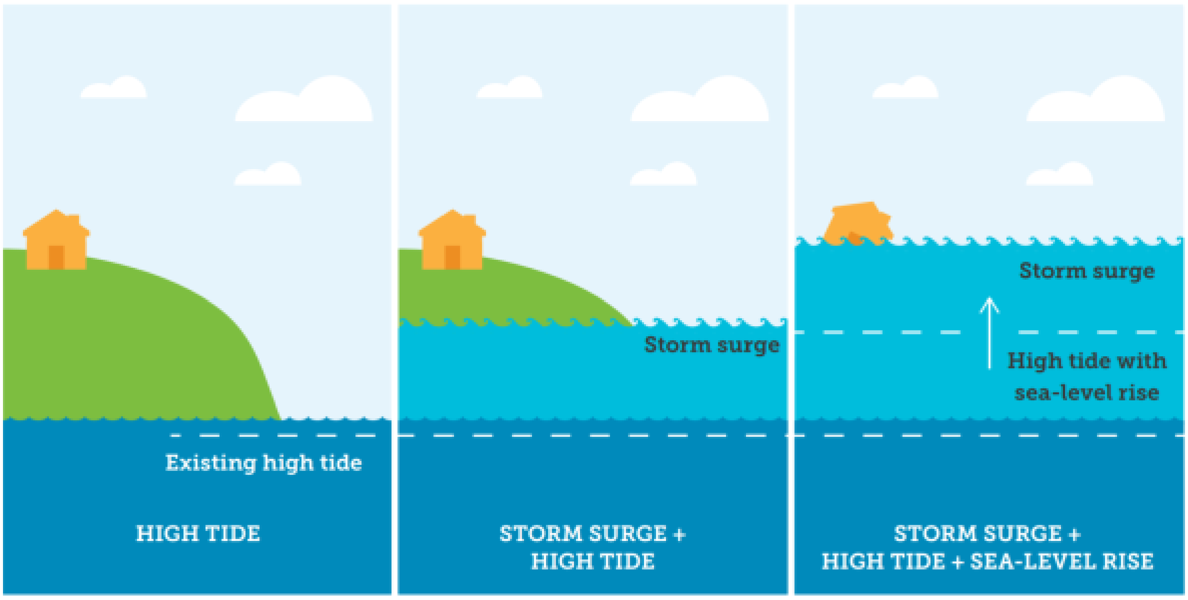


**Figure 1:** Climate change increases the base sea-level and thus exacerbates the effects of a storm surge on coastal flooding (Climate Council 2016).

## How are storm surges affected by sea-level rise?

The rise of sea levels globally because of climate change – due to warming oceans and melting ice sheets – means that **storm surges are now riding on higher sea levels than they were earlier.** This is increasing the extent and severity of flooding damage from cyclones and other weather systems than can drive storm surges.

## Why is heavy rainfall becoming more intense?

As greenhouse gases increase in the atmosphere, the **climate system is warming because these gases are trapping more heat**. Global average surface temperature has already risen to more than 1°C above pre-industrial levels, and this means that the atmosphere is storing more heat than before. The oceans are also warming, especially at the surface, and this is driving higher evaporation rates that, in turn, increase the amount of water vapour in the atmosphere (Figure 2). **A warmer atmosphere can hold more water vapour, leading to more intense rainfall.** The 1°C temperature rise that has already occurred and increasing evaporation have led to an increase of about 7% in the amount of water vapour in the atmosphere (Hartmann et al. 2013). Because of the increasing heat and additional water vapour in the atmosphere, the climate system of today is significantly more energetic than it was 60-70 years ago. Hurricanes and other extreme weather events are occurring in this more super-charged atmosphere.

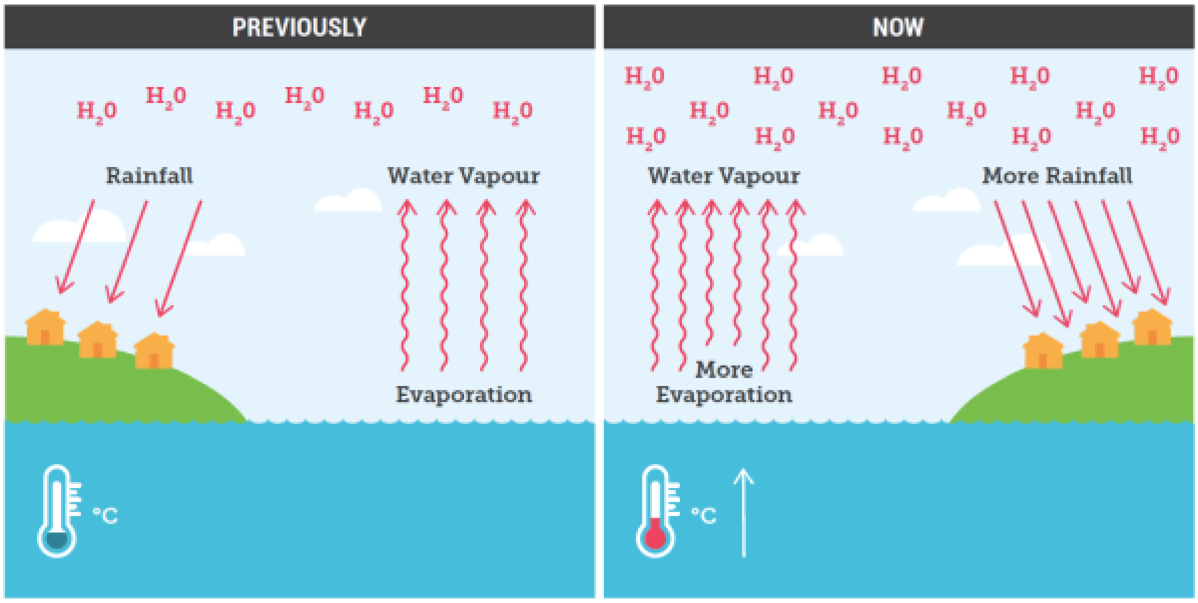


**Figure 2**: The influence of climate change on the water cycle (Climate Council 2016). Left: The pre-climate change water cycle. Right: The water cycle operating under higher surface and ocean air temperatures, leading to more water vapour ($H_2O$) in the atmosphere, and in turn, more rainfall.

## Tropical Cyclones in Australia

## Trends

For most regions around the world, trends in hurricane frequency and intensity are difficult to discern because of the lack of long-term, consistent observational data. This is the case in Australia, where for the 1981 to 2007 period, no significant trends in the number of cyclones or their intensity were found (Kuleshov et al. 2010), although a comparison between tropical cyclone numbers in 1981-82 to 2012-13 shows a decreasing trend (Dowdy 2014).

## Future predictions

An **increase is likely in the proportion of the most intense tropical cyclones**, those with stronger winds and heavier rainfall such as Yasi, while the total number of tropical cyclones will likely decrease. A greater proportion of Tropical Cyclones may reach further south along Australia's east and west coastlines (CSIRO and BoM 2015).

## Costs

### Health Impacts

Storms such as tropical cyclones can cause damage to property, infrastructure and claim human lives. While storms can cause immense physical damage, they can also cause mental distress. Studies have shown that in the aftermath of severe storms, survivors demonstrated a 25% increase in the onset of depression after the storm event. Emotional stress can undermine the resilience of individuals and communities, placing further physical, emotional and financial burdens onto recovery efforts (Martin 2015).

### Environmental Impacts

Natural ecosystems can suffer serious impacts from the high winds of tropical cyclones. For example, coral in the Great Barrier Reef suffered extensive physical damage to the coral in 2011 when tropical cyclone Yasi passed over large areas of the reef. Coral damage was reported across an area of approximately 89,000 $km^2$ of the Great Barrier Reef Marine Park. In total 15% of the park sustained some damage and 6% was severely damaged (GBRMPA 2011). The ecological impact of this severe tropical cyclone is likely to be evident for several decades (GBRMPA 2011).

### Economic Impacts

The damages in Australia from major flooding, tropical cyclones and severe storms for the 1967-1999 period were estimated to be $28.6 billion, based on 2008 residential pricing (DCC 2009). Australia has experienced a stormy last five years, with some of the nation's most damaging storm events occurring within this period. For example, Tropical Cyclone Yasi was one of the most powerful cyclones to have affected Queensland since records began, and was one of Australia's costliest natural disasters. The tropical cyclone first hit the North Queensland coast on 2 February 2011, creating widespread damage and contributing to flooding across Queensland. The costs to the agricultural and tourism industries alone were estimated at $1.6 billion and $600 million respectively (QRA and World Bank 2011).

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