



TROPICAL CYCLONES AND CLIMATE CHANGE: FACTSHEET



TROPICAL CYCLONES AND CLIMATE CHANGE: FACT SHEET

KEY POINTS

- Climate change is increasing the destructive power of tropical cyclones.
 - All weather events today, including tropical cyclones, are occurring in an atmosphere that is warmer, wetter, and more energetic than in the past.
 - It is likely that maximum windspeeds and the amount of rainfall associated with tropical cyclones is increasing.
 - Climate change may also be affecting many other aspects of tropical cyclone formation and behaviour, including the speed at which they intensify, the speed at which a system moves (known as translation speed), and how much strength is retained after reaching land – all factors that can render them more dangerous.
 - In addition, rising sea levels mean that the storm surges that accompany tropical cyclones are even more damaging.
- While climate change may mean fewer tropical cyclones overall, those that do form can become more intense and costly. In other words, we are likely to see more of the really strong and destructive tropical cyclones.
- Australia typically sees fewer tropical cyclones during an El Niño event than during a La Niña event. However, every year brings the risk of one or more powerful, destructive cyclones crossing our coast, so we always need to be prepared!

BACKGROUND

Tropical cyclones, known as hurricanes in the North Atlantic and Northeast Pacific, typhoons in the Northwest Pacific, and simply as tropical cyclones in the South Pacific and Indian Oceans, are among the most destructive of extreme weather events.

Many Pacific Island Countries, including Fiji, Vanuatu, Solomon Islands and Tonga, lie within the South Pacific cyclone basin. In recent years, a run of extraordinarily damaging cyclones in the Pacific has taken a heavy toll on local economies. In Australia, Cyclone Yasi in 2011 and Cyclone Debbie in 2017 remain two of our most costly disasters.

This fact sheet goes through some of the science of how climate change is influencing tropical cyclones.

THE INFLUENCE OF CLIMATE CHANGE ON TROPICAL CYCLONES

Climate change is affecting the conditions under which tropical cyclones form and develop. Today research links climate change to many different aspects of tropical cyclone formation and behaviour including how often they form, maximum windspeed, amount of rainfall, the speed at which a system intensifies, the speed at which a system moves (known as translation speed), how much strength is retained after reaching land, the duration of tropical cyclone seasons, and the geographic range of tropical cyclones.

While there may be differences in the state of knowledge about these various trends and their links to climate change, there is little doubt that overall, climate change is increasing the destructive power of tropical cyclones. This is especially true when considering other impacts of climate change that, while not directly affecting tropical cyclone behaviour, are nonetheless increasing the dangers. For example, tropical cyclones are now riding upon higher sea levels, meaning that storm surges – often the deadliest aspect of a cyclone – are higher and penetrate further inland than they would otherwise. Climate change is also damaging many natural coastal defences, including coral reefs and mangroves, leaving communities and infrastructure more exposed.

Frequency, windspeed and rainfall

Tropical cyclones form most readily when there is a very warm ocean surface and a strong temperature gradient through the atmosphere – i.e. a big difference in the temperature of the air at the surface and the air higher up. A warming climate means that the temperature gradient is likely to decrease, so the conditions under which tropical cyclones form may occur less often. This means that the overall number of tropical cyclones that form will likely decrease. In Australia, there has already been a decrease in the number of tropical cyclones observed (CSIRO and BoM 2022). However, rising ocean surface temperatures and a warmer, wetter atmosphere provide a larger source of energy for tropical cyclones to draw on once they are formed. It is thus likely that tropical cyclones will become more intense with climate change in terms of maximum wind speed and the amount of rainfall they produce (IPCC 2012, 2023). Looking at two of 2017's most destructive hurricanes – Irma and Maria – the amount of rainfall was likely six percent and nine percent higher, respectively, compared to a world without climate change (Patricola and Wehner 2019).

In summary, there are likely to be fewer tropical cyclones overall but a higher fraction of those that do form will likely be more intense and destructive.

Until recently, with the exception of the North Atlantic basin where records show a clear increase in the intensity of hurricanes over recent decades,¹ there has not been enough historical data of sufficient quality to discern clear

¹ Since 1980, the number of North Atlantic hurricanes with winds stronger than 200km/h have doubled, and those with winds stronger than 250km/h have tripled (Rahmstorf et al. 2018).

real-world trends in tropical cyclone activity. However, in 2020 an analysis of nearly 40 years of satellite imagery concluded that maximum wind speeds are getting stronger for tropical cyclones in almost every region where they form, affirming what models had long predicted (Kossin et al. 2020).

Rapid intensification

As well as reaching higher intensity, it is also possible that a warming climate is enabling tropical cyclones to strengthen more quickly (Bhatia et al. 2019). "Rapid intensification" is a term used to describe the dramatic strengthening of tropical cyclones over a short period of time. The US National Hurricane Center defines this as an increase in wind strength of at least 35mph (56kmh) within 24hrs. In the 2020 North Atlantic hurricane season, a record-equalling ten storms exhibited rapid intensification. Two of 2020's record number of North Atlantic hurricanes, Eta and Iota, strengthened by 80mph (129kmh) in 24hrs, an intensification rate observed only eight times before and never so late in the season. In the early 1980s, the chance of a hurricane rapidly intensifying were 1-in-100. Those odds have now shortened by at least a factor of five (Bhatia et al. 2018). Rapid intensification can lead to disastrous outcomes, as it can be difficult to predict, so that coastal communities may not be given adequate warning to prepare for an intense tropical cyclone (Bhatia et al. 2019).

Retaining strength after landfall

It is also possible that tropical cyclones are staying stronger for longer after making landfall. A tropical cyclone, which derives its strength from warm ocean surfaces, begins to lose strength on reaching land. However, climate change may cause tropical cyclones to weaken more slowly when making landfall than in a world without climate change, thus wreaking more destruction and reaching communities further inland (Li and Chakraborty 2020). Recalling the aforementioned trend of rapid intensification, it appears that on a warming planet, tropical cyclones are both powering up more quickly and winding down more gradually.

Slower moving

Lastly, there is evidence that tropical cyclones are moving more slowly. i.e. the rate at which a system tracks across the ocean and land (translation speed), as opposed to its maximum wind speed. On average, it appears that translation speed decreased by ten percent between 1949 and 2016 (Kossin 2018). This may be the result of a slowdown in atmospheric circulation (Zhang et al. 2020). Slow-moving cyclones, such as Hurricane Maria in 2017, can be hugely destructive, dumping immense amounts of rain over a small area, while also sustaining damaging windspeeds for a longer period (Resnick 2017).

Coastal flooding

In addition to the above factors, the most direct influence of climate change on the impacts of tropical cyclones is via coastal flooding. In addition to damage from high winds, damage from tropical cyclones comes from

flooding caused by a storm surge, and the heavy rainfall that accompanies tropical cyclones.

A storm surge is a rise above normal sea level resulting from strong onshore winds and/or reduced atmospheric pressure. Storm surges, which accompany tropical cyclones, 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).

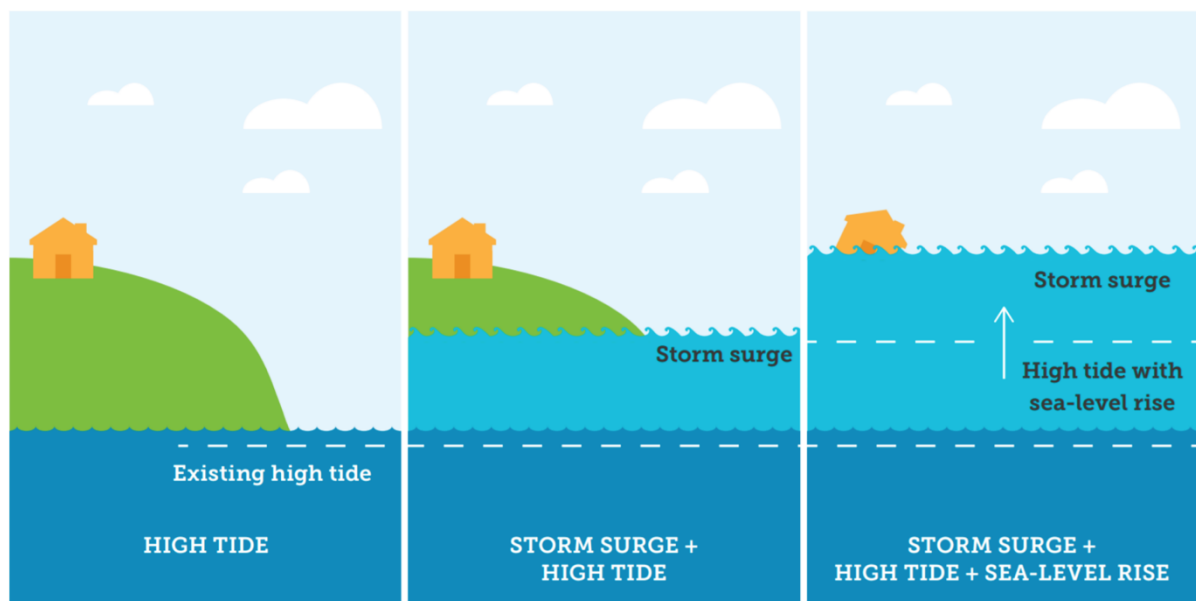


Figure 1: Climate change increases the base sea-level and thus exacerbates the effects of a storm surge on coastal flooding (Climate Commission 2013).

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, increasing the extent and severity of flooding damage from tropical cyclones and other weather systems that can drive storm surges.

COUNTING THE COST

Destructive storms fuelled by climate change have huge environmental, social and economic 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: Coral Reefs

The Great Barrier Reef is already under immense threat from climate change, devastated by three mass bleaching events in the space of five years.

Tropical cyclones bring both risks and benefits for coral reefs. Winds, cloud and rain associated with tropical cyclones can cool sea surface temperatures. For example, the southern section of the Great Barrier Reef was spared from mass bleaching in 2016 because of late summer cooling of ocean temperatures from ex-Tropical Cyclones Winston and Tatiana (GBRMPA 2016). Whereas, on the downside, climate change could result in more intense tropical cyclones hitting the Australian coast, which will in turn increase the risk of physical damage to reefs.

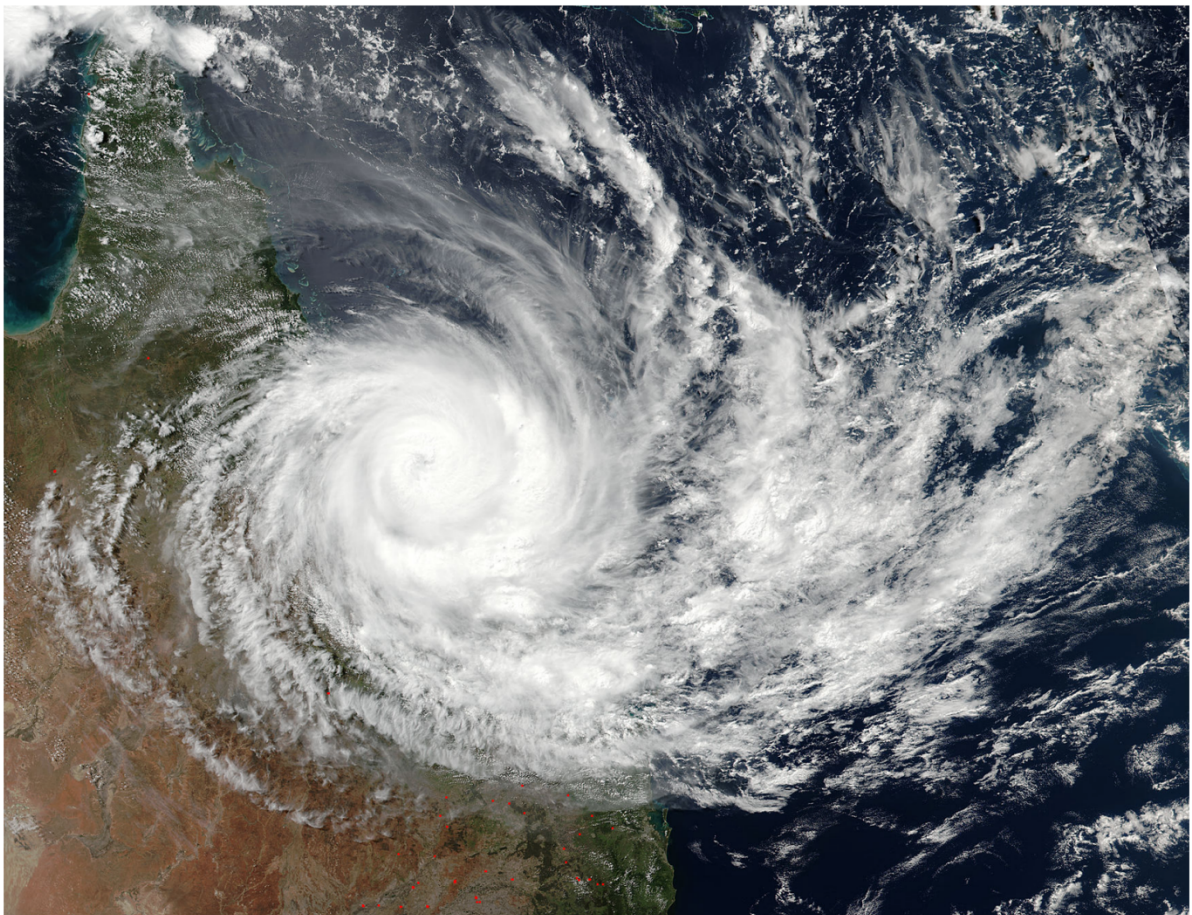


Figure 2: Tropical Cyclone Debbie in 2017 making landfall over the north Queensland coast. Climate change could result in more intense cyclones which can cause physical damage to reefs.

In 2016, Tropical Cyclone Yasi passed over large areas of the Great Barrier Reef. Coral damage was reported across an area of approximately 89,000 km² 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.

Economic impacts

In 2015, category five Tropical Cyclone Pam, then the strongest South Pacific cyclone on record², caused damage equivalent to 64 percent of Vanuatu's GDP. A year later, Tropical Cyclone Winston, an even stronger cyclone, brought devastation to Fiji, with damages amounting to 31 percent of GDP. In 2018, Tropical Cyclone Gita hit Tonga, causing losses equivalent to 38 percent of GDP. In 2020, Tropical Cyclone Harold – the second strongest cyclone to hit Vanuatu after Cyclone Pam – severely affected Vanuatu, Solomon Islands, Fiji and Tonga, compounding the economic impact of COVID-19 (Taylor, 2020).

The cost of extreme weather disasters in Australia has more than doubled since the 1970s (Climate Council 2021). Cyclone Yasi caused huge economic impacts. It was one of the most powerful tropical cyclones to have affected Queensland since records began, and was one of Australia's costliest natural disasters. Tropical Cyclone Yasi first hit the North Queensland coast on 2 February 2011, creating widespread damage and contributing to flooding across Queensland. The tropical cyclone brought extreme winds of up to 285 km/h, heavy rain of up to 200-300 mm in 24 hours and storm surges, including a 5 m tidal surge at Cardwell. The costs to the agricultural and tourism industries were estimated at \$1.6 billion and \$600 million respectively (QRA and World Bank 2011). Modelling by Insurance Australia Group and the National Centre for Atmospheric Research has shown that the chance of a strong cyclone hitting Brisbane or another major population centre is now higher, as tropical cyclones are moving further south (Thompson 2020).

² Measured in terms of peak 10-minute sustained windspeed.
Based on data from EM-DAT: The international disasters database | <https://www.emdat.be/>

CYCLONES IN AUSTRALIA: GENERAL PROJECTIONS FOR THE FUTURE

Australia is projected to experience fewer tropical cyclones, but a greater proportion will be of high intensity and destructive potential (CSIRO and BoM 2022). A greater proportion of tropical cyclones may reach further south along Australia's east and west coastlines (CSIRO and BoM 2015).

References

Bhatia, K., Vecchi, G., Murakami, H., Underwood, S., Kossin, J. (2018) Projected Response of Tropical Cyclone Intensity and Intensification in a Global Climate Model. *Journal of Climate* 31 (20).

<https://doi.org/10.1175/JCLI-D-17-0898.1>

Bhatia, K. T., Vecchi, G. A., Knuston, T. R., Murakami, H., Kossin, J., Dixon, K. W., Whitlock, C. E. (2019) Recent increases in tropical cyclone intensification rates. *Nature Communications* 10.

<https://doi.org/10.1038/s41467-019-08471-z>

Callaghan, J. and Power, S.B. (2011) Variability and decline in the number of severe tropical cyclones making land-fall over eastern Australia since the late nineteenth century. *Climate Dynamics* 37.

<https://doi.org/10.1007/s00382-010-0883-2>

Climate Commission (2013) The Critical Decade: Extreme Weather

<https://www.climatecouncil.org.au/extreme-weather-report>

CSIRO and BoM (2015) Climate Change in Australia – Technical Report.

<https://www.climatechangeinaustralia.gov.au/en/publications-library/technical-report/>

CSIRO and BoM (2022) State of the Climate 2022. <http://www.bom.gov.au/state-of-the-climate/>

GBRMPA (Great Barrier Reef Marine Park Authority) (2011) Impacts of tropical cyclone Yasi on the Great Barrier Reef: a report on the findings of a rapid ecological impact assessment.

http://www.gbrmpa.gov.au/__data/assets/pdf_file/0008/8783/GBRMPA_ImpactsTC_Yasi_on_GBRSept2011.pdf

GBRMPA (Great Barrier Reef Marine Park Authority) (2016) Interim Report: 2016 Coral Bleaching Event on the Great Barrier Reef.

<https://elibrary.gbrmpa.gov.au/jspui/handle/11017/3044>

Intergovernmental Panel on Climate Change (IPCC) (2012) *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*.

https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf

Intergovernmental Panel on Climate change (IPCC) (2023) AR6 Synthesis Report: Climate Change 2023. <https://www.ipcc.ch/report/sixth-assessment-report-cycle/>

Kossin, J.P. (2018) A global slowdown of tropical-cyclone translation speed. *Nature* 558.

<https://doi.org/10.1038/s41586-018-0158-3>

Kossin, J. P., Knapp, K. R., Olander, T. L., Velden, S. (2020) Global increase in major tropical cyclone exceedance probability over the past four decades. *Proceedings of the National Academy of Sciences* 117 (22). <https://doi.org/10.1073/pnas.1920849117>

Kuleshov, Qi, L., Fawcett, R., Jones, D. (2008) On tropical cyclone activity in the Southern Hemisphere: Trends and the ENSO connection. *Geophysical Research Letters* 35 (14). <https://doi.org/10.1029/2007GL032983>

Li, L. and Chakraborty, P. (2020) Slower decay of landfalling hurricanes in a warming world. *Nature* 587. <https://doi.org/10.1038/s41586-020-2867-7>

Martin, U. (2015) Health after disaster: A perspective of psychological/health reactions to disaster. *Cogent Psychology* 2 (1) <https://doi.org/10.1080/23311908.2015.1053741>

Patricola, C. M. and Wehner, M. (2018) Anthropogenic influences on major tropical cyclone events. *Nature* 563. <https://www.nature.com/articles/s41586-018-0673-2>

QRA (Queensland Reconstruction Authority) and World Bank (2011) Queensland recovery and reconstruction in the aftermath of the 2010/2011 flood events and cyclone Yasi. <http://qldreconstruction.org.au/u/lib/cms2/world-bank-report-1.pdf>

Resnick, B. (2020) Why Hurricane Maria is such a nightmare for Puerto Rico. *Vox*, 22 September 2017. <https://www.vox.com/science-and-health/2017/9/21/16345176/hurricane-maria-2017-puerto-rico-san-juan-meteorology-wind-rain-power>

Steffen, W. and Bradshaw, S. (2021) Hitting Home: The compounding costs of climate inaction. Climate Council. <https://www.climatecouncil.org.au/resources/hitting-home-compounding-costs-climate-inaction/>

Taylor, Dame Meg (2020) Christiana Figueres Oration at the 7th Australian Emissions Reduction Summit. 3 December 2020. <https://www.forumsec.org/2020/12/03/if-there-is-any-chance-left-to-save-ourselves-from-this-climate-crisis-we-are-going-to-have-to-act-now-dame-meg-to-aust-emission-reduction-summit/>

Thompson, G. (2020) Severe cyclones are spreading further south and it could mean tens of billions in damages. *ABC*, 6 March 2020. <https://www.abc.net.au/news/2020-03-06/cyclones-spreading-south-could-cause-tens-of-billions-in-damage/12020218>

Zhang, G., Murakami, H., Knutson, T. R., Mizuta, R., Yoshida, K. (2020) Tropical cyclone motion in a changing climate. *Science Advances* 6. <https://doi.org/10.1126/sciadv.aaz7610>

Image Credit: Figure 2. "NASA Sees Tropical Cyclone Debbie Make Landfall in Queensland", licensed under CC BY 2.0.


Thank you for supporting the Climate Council.


The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

CLIMATECOUNCIL

 facebook.com/climatecouncil

 twitter.com/climatecouncil

 info@climatecouncil.org.au

 climatecouncil.org.au

The Climate Council is a not-for-profit organisation and does not receive any money from the Federal Government. We rely upon donations from the public. We really appreciate your contributions.

DONATE

climatecouncil.org.au/donate