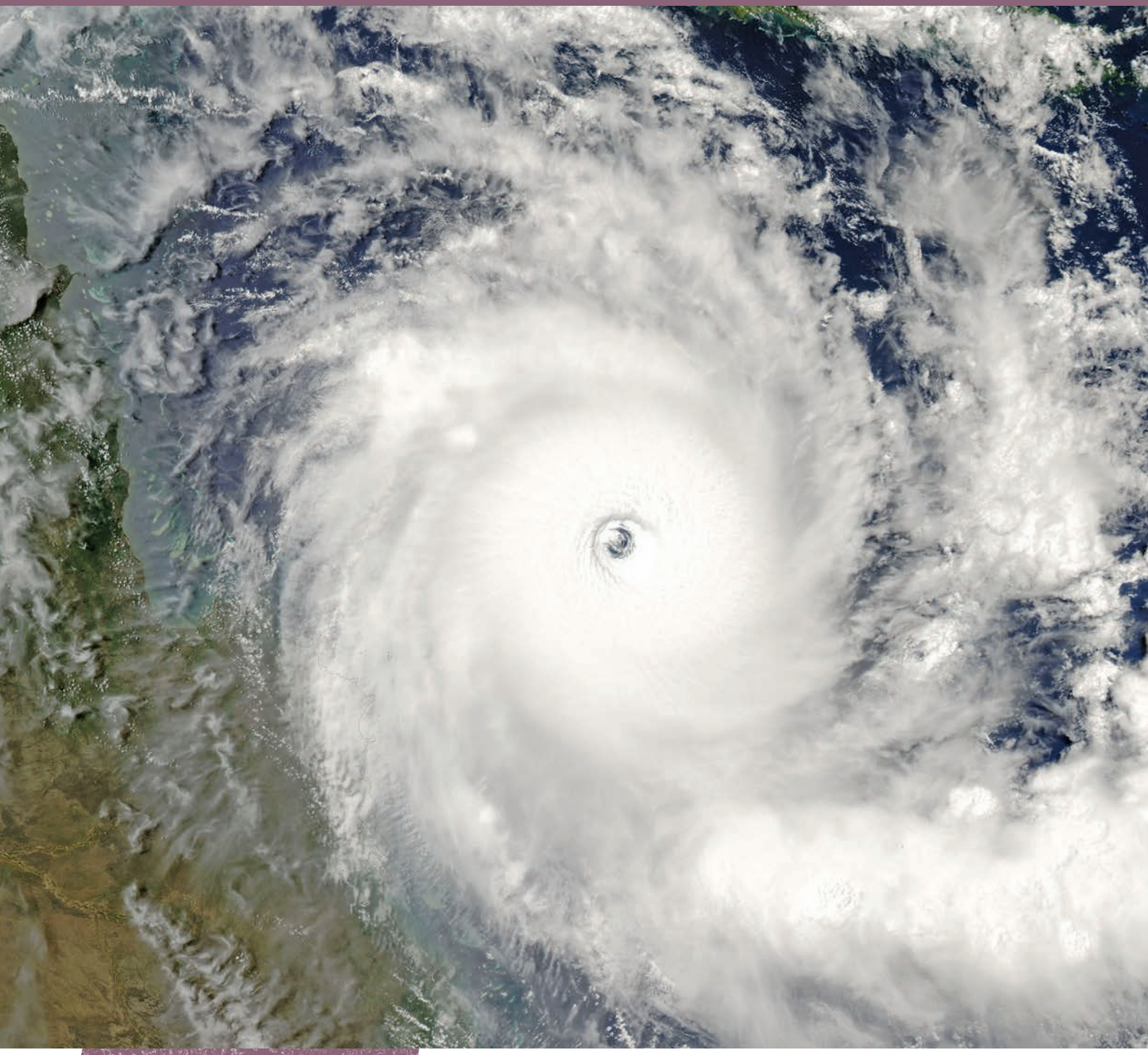
Earth Systems and Climate Change Hub

National Environmental Science Programme

Tropical cyclones and climate change in Australia



Severe Tropical Cyclone Ingrid, 8 March 2005 (Image: Jeff Schmaltz, NASA)

> The total number of tropical cyclones observed in the Australian region has decreased significantly in recent decades.

> Climate models project a future decrease in the total number of tropical cyclones, but an increase in the proportion of high intensity storms (stronger winds and greater rainfall).

> Coastal impacts from tropical cyclones are likely to worsen due to rising sea levels and increases in tropical cyclone-related extreme rain and wind events.

Tropical cyclones are known as hurricanes in the United States, Mexico, Central America and the Caribbean, and typhoons in Southeast Asia and Japan.

Tropical cyclones are intense weather systems that occur in tropical regions of the world, including around northern Australia. They can produce extreme winds, waves and rainfall, and can cause coastal hazards such as storm surges, flooding and coastal erosion. Tropical cyclones are among the costliest natural disasters to regularly impact Australia. For instance, insured losses in Queensland exceeded $1 billion for Cyclone Yasi in 2011 and for Cyclone Debbie in 2017, making them the two most expensive cyclones in the state's history.

The costs associated with extreme weather hazards and disasters, including those caused by tropical cyclones, are likely to change in the future due to increasing greenhouse gas emissions. Understanding extreme weather hazards and how they respond to a changing climate is valuable for increasing Australia's preparedness and resilience to such events.

Researchers in the Earth Systems and Climate Change Hub are developing improved resources on tropical cyclones and how they may change in the future to help us plan for and deal with climate change with greater confidence.

Tropical cyclones in the Australian region

In Australia, tropical cyclones occur most frequently in the Gulf of Carpentaria, the Coral Sea and off the northwest coast, so they have the potential to impact many parts of northern Australia.

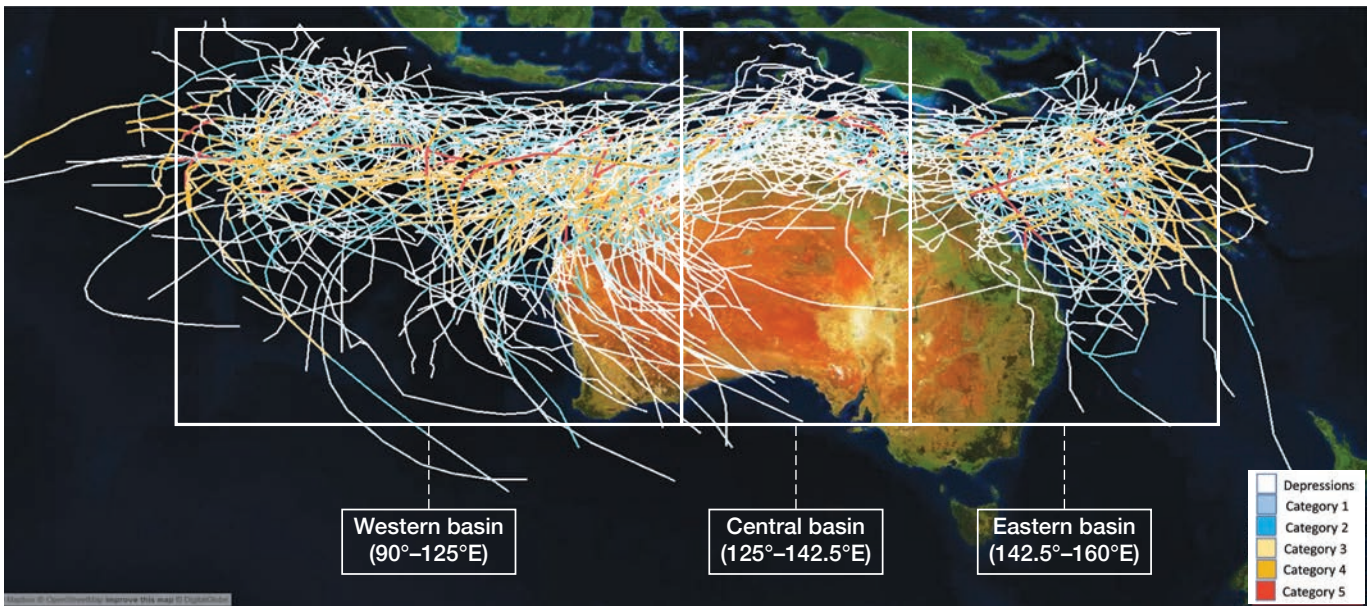
They can develop in close proximity to coastal communities and intensify rapidly, making accurate forecasts particularly vital for emergency planning and preparation activities aimed at safeguarding our communities, infrastructure and ecosystems.

The tracks that tropical cyclones take in the Australian region are generally more erratic than in other parts of the world, which poses an additional challenge for forecasters.

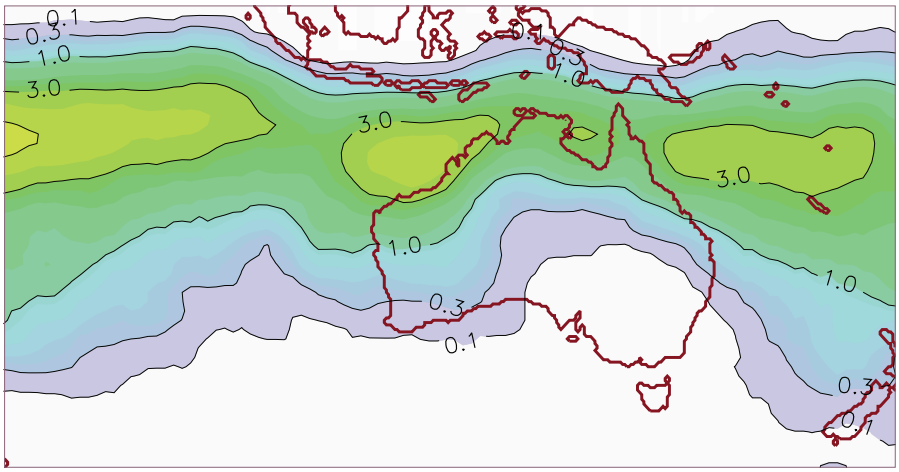
On average, about 11 tropical cyclones form or move into the Australian region each year[1], with about four of these systems crossing the Australian coast. The area between the Pilbara coast in Western Australia and Cape York Peninsula in Queensland experiences the most cyclones in a typical season. However, tropical cyclone frequency in the Australian region varies considerably from year to year due to the influence of naturally-occurring climate drivers. For example, fewer cyclones generally occur during El Niño years than in La Niña years.

The overall number of tropical cyclones recorded in the Australian region has decreased significantly in recent decades. The physical mechanisms behind this decrease are currently unknown, but are likely to be due to a combination of both natural variability and the changing climate.

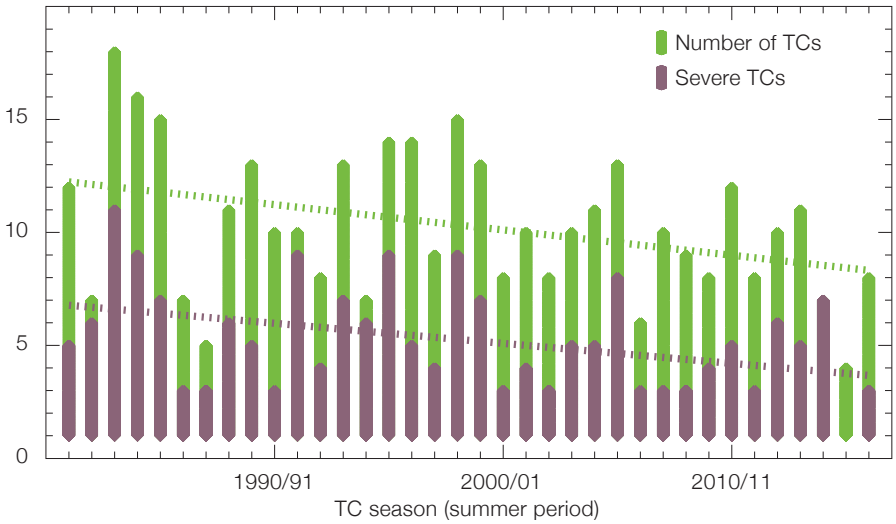
1 Long-term average 10.6 based on 36 cyclone seasons from 1981/82 to 2016/17.



ABOVE: **Tropical cyclone tracks in the Australian region (90°E – 160°E) and its three basins during the period from 1981/82 to 2016/17.** Colours show intensity for Category 1 (light blue) – Category 5 (red). Higher categories (orange to red tracks) correspond to stronger winds near the cyclone centre. Tropical cyclone tracks are sourced from the Bureau of Meteorology database.



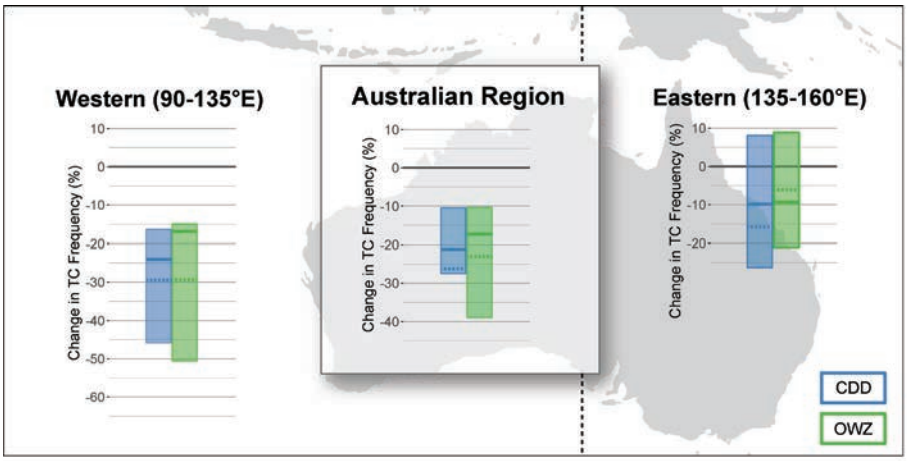
LEFT: **Average number of tropical cyclones per decade.** Tropical cyclone tracks are sourced from the Bureau of Meteorology, as well as neighbouring government agencies, from 1981/82 to 2016/17.



ABOVE: **Downward trend in tropical cyclone numbers in Australia over past decades.** Number of tropical cyclones (TCs) (green: Category 1–2) and severe TCs (purple: Category 3–5) from 1981/1982 to 2016/2017.

Future Australian tropical cyclone activity under a changing climate

Climate models indicate that tropical cyclone numbers in the Australian region are likely to decrease this century due to increased human-caused emissions of greenhouse gases. Although there is reasonable confidence in the direction of change (i.e. fewer), the exact magnitude of the decrease is more challenging to predict given the large spread in projected changes between different models. However, different modelling methods generally agree that cyclones forming in the western Australian region are likely to decrease more than in the eastern Australian region, where both increases and decreases are projected, depending on the climate model.



LEFT: **Projected changes in tropical cyclone frequency from 1970–2000 to 2070–2100 based on two ensembles of models.** The bars show the middle 50% of projected changes in future tropical cyclone frequency based on two different modelling methods of identifying tropical cyclones in global climate models under a high emissions scenario for greenhouse gases. The two methods are the CSIRO Direct Detection (CDD) method in blue and the Okubo-Weis-Zeta (OWZ) method in green (applied to the RCP8.5 emissions scenario for the CMIP5 set of global climate models). The solid (dashed) horizontal lines in each bar show median (mean) values of the projected frequency changes.

There is likely to be a greater proportion of severe or intense tropical cyclones in the future climate due to the increasing energy available to power cyclones. Rainfall produced by tropical cyclones is also expected to increase, particularly the intensity of extreme rainfall events which could increase by about 10% or more per degree of global warming (noting that about one degree of warming has already occurred). This is because a warmer atmosphere can hold more moisture, as well as increase the energy available for cyclones.

Sea levels will continue to rise throughout Australia, increasing storm surge risk. When the increased sea levels are combined with projected increases in extreme rainfall intensity, it is likely that flooding will increase in frequency and magnitude in the future for many coastal and estuarine regions throughout Australia, including for extreme weather events such as tropical cyclones.

There is some potential that tropical cyclones may also reach further south under a warmer climate, associated with warmer oceans and changing large-scale wind patterns. However, there is relatively low confidence in regional aspects of these projections due to challenges associated with modelling tropical cyclones, including their frequency, intensity, formation and tracks.

Tools, data and further information

- Tropical cyclone data portal – provides a range of information on cyclone climatology including projections, impacts and landfall details: **https://shiny.csiro.au/Tropical-Cyclone-Projections-Portal/**
- Review paper on tropical cyclones in the Australian region: **https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.602**
- Historical data and climatology information: **http://www.bom.gov.au/climate/maps/averages/tropical-cyclones/**
- Information on tropical cyclone intensity: **www.bom.gov.au/cyclone/about/intensity.shtml**
- Extreme weather research under Project 2.8 of the Earth Systems and Climate Change Hub – includes links to a variety of research publications on this topic: **http://nespclimate.com.au/extreme-weather-projections/**
- Bell SS, Chand SS, Tory KJ, Dowdy AJ, Turville C, Ye H. 2018. Projections of southern hemisphere tropical cyclone track density using CMIP5 models, *Climate Dynamics*, doi:10.1007/s00382-018-4497-4
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- Lavender SL, Dowdy AJ. 2016. Tropical cyclone track direction climatology and its intraseasonal variability in the Australian region, *Journal of Geophysical Research – Atmospheres*, doi:10.1002/2016JD025562
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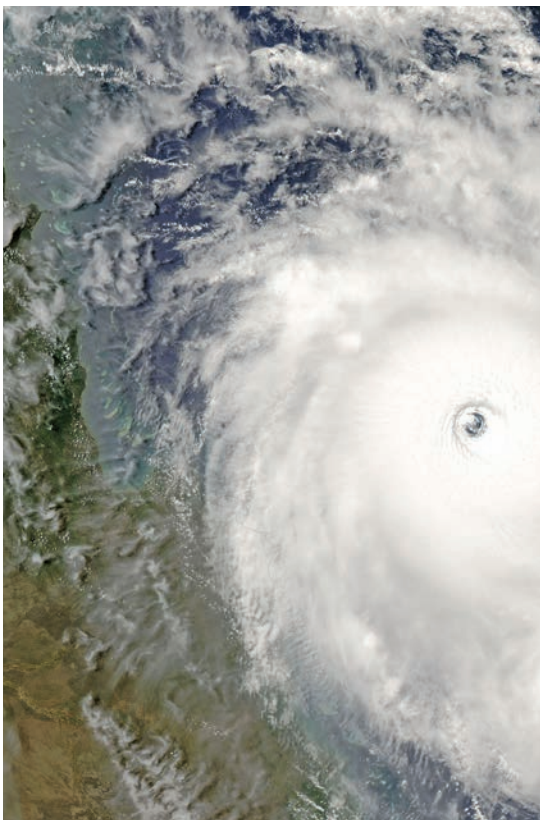

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The Earth Systems and Climate Change Hub is funded by the Australian Government's National Environmental Science Program.