



Earth Systems and
Climate Change
Hub

National Environmental Science Programme

Intense east coast lows and climate change in eastern Australia



East coast lows cause coastal hazards on the east coast of Australia.
Image: iStock.com/lovleah

> Intense east coast lows are likely to occur less frequently in the future, particularly during the cooler months of the year, but those that do occur could be more hazardous.

> Human-caused climate change will likely increase the intensity of rainfall extremes caused by intense east coast lows.

> Coastal flooding and erosion resulting from intense east coast lows will be exacerbated by rising sea levels.

East coast lows (ECLs) are low-pressure systems that occur around south-eastern Australia. ECLs can cause heavy rainfall, strong winds, large waves, widespread flooding and coastal erosion on the east coast of Australia between southern Queensland and Tasmania. Intense ECLs have at least one major hazard associated with their occurrence, such as extreme winds, waves, rain or flooding. More intense events can lead to injury, loss of life, infrastructure damage and large insurance losses.

Future changes to east coast lows and their impacts

Impacts associated with extreme weather hazards and disasters, including those caused by intense ECLs, are likely to change in the future due to increasing greenhouse gas emissions.

Understanding extreme weather hazards and how they may change as the climate continues to warm is critical for increasing Australia's preparedness and resilience.

Climate change projections show that fewer ECLs are likely to occur in a warmer world, especially during cooler months. Projections also indicate there will be fewer of the more intense ECLs that cause the largest impacts. However, this does not mean that there will be less damage from these intense events. Future rainfall from ECLs is likely to increase in intensity, particularly in the more extreme events. Sea level rise means

that coastal flooding and erosion events will become more frequent and damaging when ECLs occur.

Researchers in the Earth Systems and Climate Change Hub have significantly improved Australia's

scientific knowledge of intense ECLs and how they may change in the future. The Hub has provided tailored data, information products and expert advice to help Australia better plan for and deal with climate change.



The *Pasha Bulker* ran aground near Newcastle during an intense east coast low in 2007. Image courtesy of the Ross and Pat Craig Collection, University of Newcastle, Australia

Rainfall from intense east coast lows in a warmer world

In a warmer world, the atmosphere can hold more moisture. The maximum amount of moisture in the air increases by about 7 per cent for every degree Celsius of additional warming.

This means that during very intense rainfall events (such as those associated with intense ECLs), the maximum rate of rainfall is expected

to be higher in a warmer world, increasing the chance of storms with very heavy rainfall. This is the case for relatively short-duration (e.g. hourly to daily) extreme rainfall events that currently occur on average about once every few years. Increases in rainfall intensity may be particularly pronounced in ECLs closer to the coast due to changes in ocean

currents and increased sea surface temperatures. These projected changes in extreme rainfall from intense ECLs have implications for flood risk factors in the future, including for highly populated locations like cities.

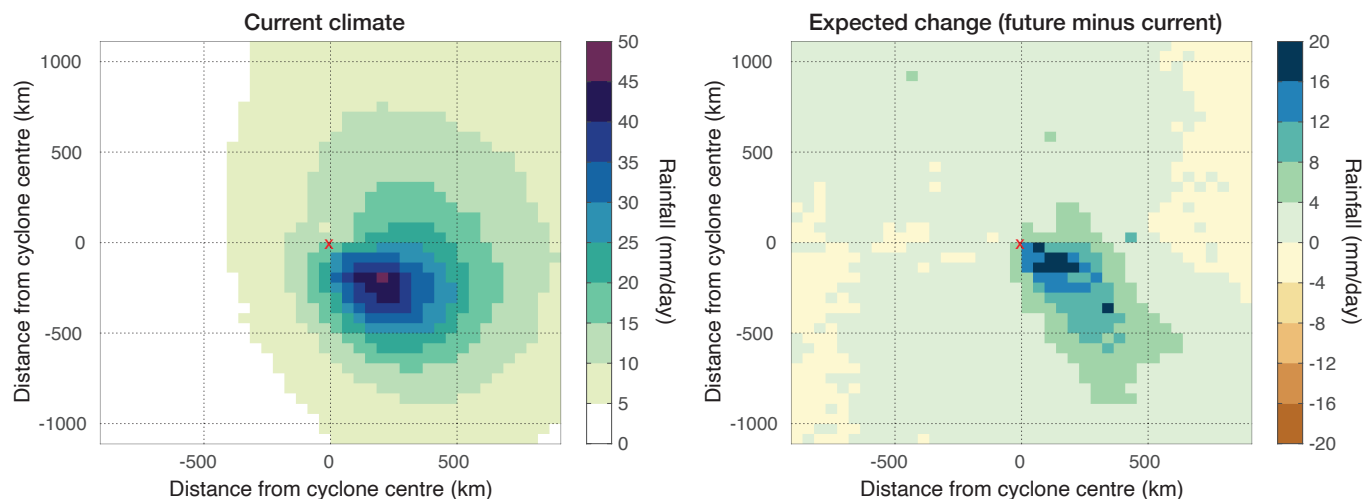


Figure 1: East coast low rainfall is likely to increase under a warmer climate. Average east coast low rainfall in the current climate is shown in the left panel. The change in rainfall for the future climate for a high emissions scenario (RCP8.5) is shown in the right panel (based on the results for the period 2060-2079 minus 1990-2009). For further details see Cavicchia et al. (2020).

>>> CASE STUDY

Changing flavours of east coast lows

There are a variety of different forms, or ‘flavours’, that east coast lows can take. Some look like the lows that move through the storm tracks to the south of Australia and some are decaying tropical cyclones, while others are ‘hybrid’ systems that combine substantial characteristics of both. Additionally, ECLs can also be ‘shallow’ lows that are only seen on surface weather maps, while

others are ‘deep’ lows which can reach five or more kilometres above the surface. ESCC Hub researchers have worked to better understand how all these different flavours of ECLs influence our weather, now and into the future.

Hub research has shown that hybrid lows tend to have stronger surface winds and are likely to decline in frequency into the future, especially during the cooler months. Deep cyclones tend to last longer and produce stronger winds and heavier rainfall. These ECLs are also likely to decline in frequency into the future. However, this doesn’t necessarily indicate a decrease in heavy rain events, since a warming world means the ECLs that do occur are likely to produce more rain, particularly for the more intense and shorter duration rainfall events. These results help to better understand how more complex future changes in ECL characteristics could translate into impacts on communities, infrastructure and ecosystems.

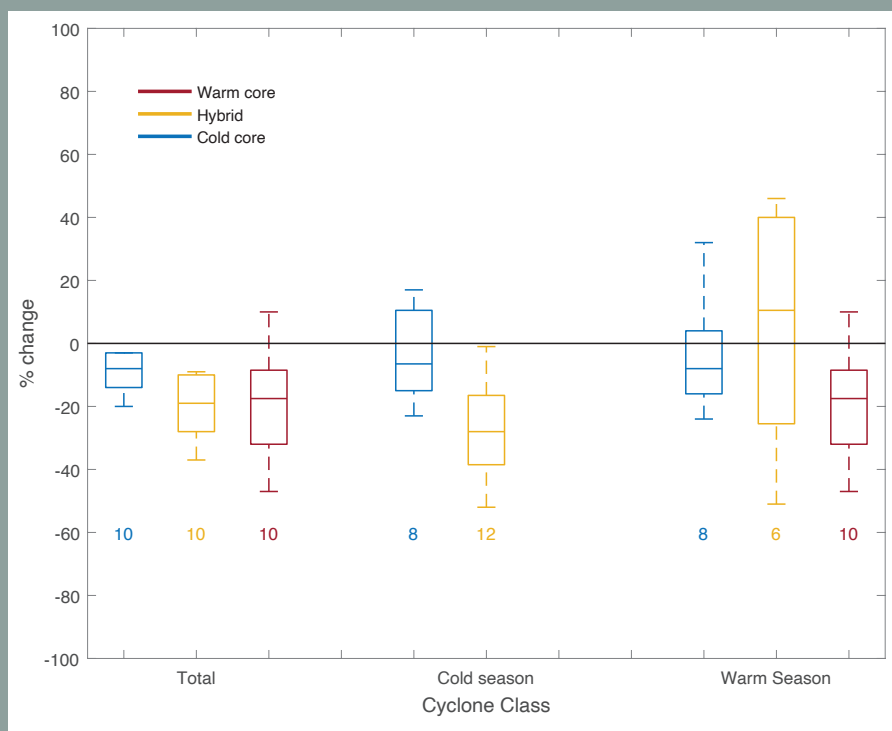


Figure 2: Projected declines in the future frequency of different types of ECLs under a high emissions scenario (RCP8.5) for the period 2060-2079–1990-2009. This is shown for ECLs that have more tropical characteristics (‘warm core’), those that are more like lows in the storm tracks south of Australia (‘cold core’) as well as those that have combined substantial characteristics of both (‘hybrid’). For further details see Cavicchia et al. (2020).

Sea level rise and east coast lows in a warmer world

Global average sea level has risen by about 22 cm since 1880 and is currently increasing at a rate of about 3 mm per year.

Rising sea levels have consequences for a variety of hazards along the Australian coast, including coastal erosion, storm surge and coastal inundation. For example, coastal

inundation in Sydney is now occurring nine times more frequently than if global sea level rise had not occurred. Estimates suggest that the rate of future sea level rise in the Sydney area will increase at a similar rate to the projected average global sea level rise (0.61 to 1.10 m by 2100 under a high emissions scenario).

Record sea levels associated with ECLs experienced in the past (for example, the 1974 *Sydney* storm in Newcastle) are projected to occur more than 200 times per year by 2100 under a high emissions pathway. In the future, the record high sea levels we have historically experienced will be a very common event, with ECLs further exacerbating those sea levels and flood impacts to levels far outside the range of anything experienced to date.

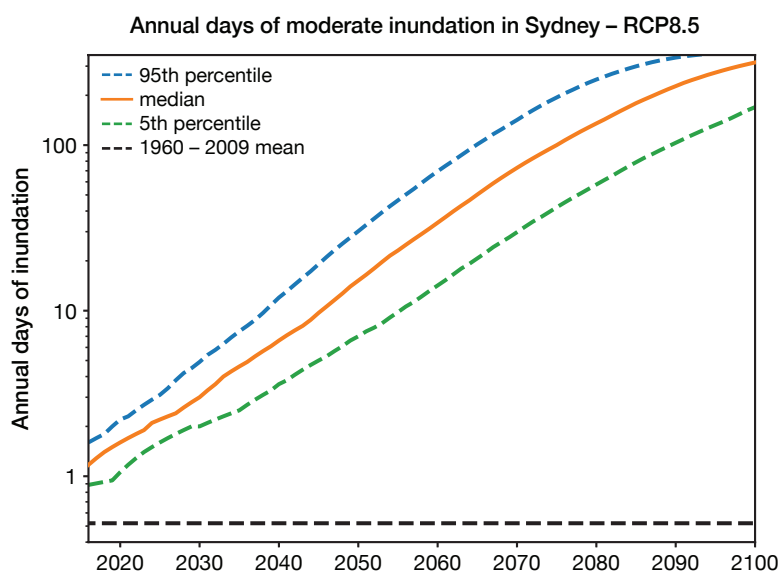


Figure 3: The number of days with inundation in Sydney will increase in the future, exacerbated by the effect of intense ECLs. Number of days per year of moderate inundation in Sydney for a high emissions pathway this century (RCP8.5, noting that low emissions pathways still have increases in sea level but with lower rates of increase). The orange solid line indicates the central estimate, while dashed blue and green lines indicate the likely range based on an ensemble of model projections. The dashed black line shows the historical mean for the period 1960 to 2009. Adapted from Hague et al. (2019).

>>> CASE STUDY

What would the NSW April 2015 east coast low look like in a warmer world?

The NSW April 2015 ECL produced a large amount of rainfall and a significant flooding event in Sydney and adjacent coastal regions, along with very strong winds and large waves. This ECL caused loss of life and substantial damage to highly populated areas of the central New South Wales coastline, including the Sydney Metropolitan, Central Coast and Hunter regions.

Considering a scenario based on 2.5 degrees Celsius of additional global warming above the 2015 climate (which could potentially occur later this century under a high greenhouse gas emissions pathway), a future version of this storm might have 15-20 per cent more rainfall over a 24-hour period. Larger increases in hourly rainfall extremes may also be possible (around 25 per cent more intense). These percentage changes are central estimates for that future scenario, noting that higher or lower values are

plausible. Projected changes such as these have substantial implications for flood risk management.

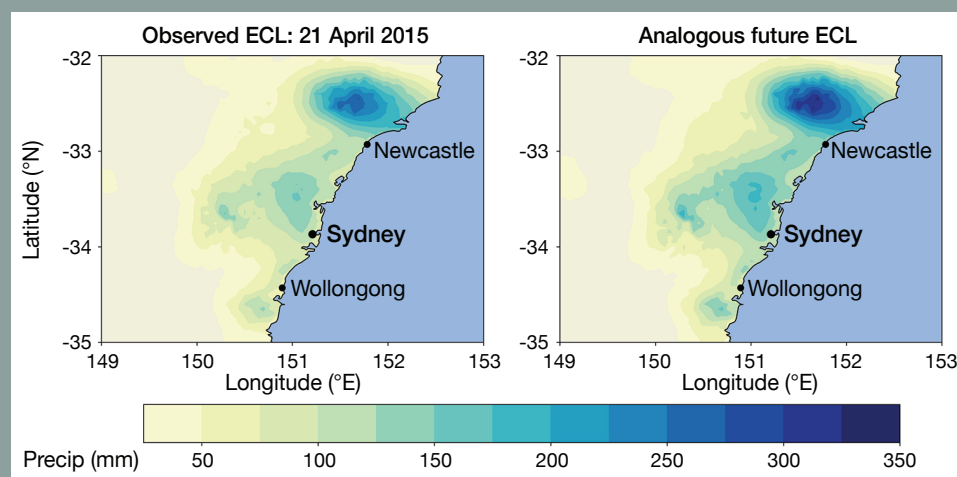


Figure 4: Future hazard scenario: in a future warmer climate an event like the 2015 NSW ECL is likely to have even more extreme rainfall, with implications for flood risk management. FAR LEFT: observed rainfall from the April 2015 ECL (for the 24 hours ending 9 am April 21). RIGHT: the rainfall amount projected for a future version of this ECL (based on a scenario with 2.5 degrees Celsius of global warming above the climate of 2015).



East coast lows will exacerbate sea levels resulting in coastal inundation.
Image: iStock.com/RugliG

Coastal erosion and east coast lows in a warmer world

A gradual but substantial increase in coastal erosion is expected this century due to increasing sea levels.

This is likely to cause coastlines to move inland, particularly for locations with sandy soil rather than rocky headlands.

Intense ECLs can cause severe erosion due to strong onshore winds and large wave heights. However, the influence of ECLs on erosion varies significantly between different locations and depends on many factors. As a result, precise estimates of future

coastal erosion are difficult to produce for specific locations. For example, the severity of the impacts from the June 2016 ECL storm in NSW (which caused significant coastal erosion on Sydney's northern beaches) was due in large part to the unusual direction of the incoming waves.

Coastal erosion can also be reversed in some cases if changes in wind patterns and currents enable more sand to be deposited. Variations in river flows, either due to rainfall change or changes in catchment

management, can also change sediment supply to the coast which can lead to variations in the rate of erosion for nearby coastlines. Whether a coastline will erode also depends on the makeup of the coast. For instance, granite cliffs are less erodible than sandy coastlines. However, for coastal areas of Australia affected by ECLs, future changes in coastal erosion are likely to be dominated by sea level rise rather than by changes in the wind, storm, ocean current and wave climate.



Intense east coast lows may increase coastal erosion.
Image: iStock.com/MyfanwyJaneWebb



Climate change science to inform policies and decisions

Climate change science information is critical to help deal with current and future impacts of extreme weather hazards, including those caused by intense ECLs.

Intense east coast lows may lead to more extreme rainfall, increasing the risk of floods. Image: iStock.com/Jaykayl

The Earth Systems and Climate Change Hub has produced data, information and provided advice on current trends and future changes to weather hazards relevant to Australian decision makers and managers. For example, information and advice on water availability related to future intense ECLs was provided to water resource managers in NSW. As intense ECLs often result in extreme rainfall, they can be important contributors to regional water availability. Changes in their future occurrence can impact the state's future water security. Updated weather hazards information and data, including on ECLs, have also been included in scenario analysis and the development of [science guidelines](#) for assessing physical climate risks to support reporting under the recommendations of the Task Force on Climate Related Financial Disclosures in Australia.

The Hub has focused on making climate change information more user-friendly so it can more easily be applied to emergency management, risk assessment, scenario analysis and adaptation activities.

>>> FURTHER INFORMATION

- Pepler A.P and Dowdy A.J. 2021. Intense east coast lows and associated rainfall in eastern Australia. *Journal of Southern Hemisphere and Earth Systems Science*. Just accepted abstract available at www.publish.csiro.au/ES/justaccepted/ES20013
- Cavicchia L, Pepler A, Dowdy A, Evans J and Walsh K. 2020. Future changes in the occurrence of hybrid cyclones: the added value of cyclone classification for the east Australian low pressure systems. *Geophysical Research Letters*, 47 (6). <https://doi.org/10.1029/2019GL085751>
- Hague B.S, McGregor S, Murphy B.F, Reef R, and Jones D.A. 2020. Sea-level rise driving increasingly predictable coastal inundation in Sydney, Australia. *Earth's Future*, 8 (9). <https://doi.org/10.1029/2020EF001607>
- Pepler A and Dowdy A. 2020. A three-dimensional perspective on extratropical cyclone impacts. *Journal of Climate*, 33 (13). <https://doi.org/10.1175/JCLI-D-19-0445.1>
- Dowdy A.J, Pepler A, Di Luca A, Cavicchia L, Mills G, Evans J.P, Louis S, McInnes, K.L and Walsh, K. 2019. Review of Australian east coast low pressure systems and associated extremes. *Climate Dynamics*, 53. <https://link.springer.com/article/10.1007/s00382-019-04836-8> Download the full paper from [ResearchGate](#)
- McInnes K.L., Church J, Monselesan D, Hunter J.R, O'Grady J.G, Haigh I.D, and Zhang X. 2015. Information for Australian impact and adaptation planning in response to sea-level rise. *Australian Meteorological and Oceanographic Journal*, 65. <http://www.bom.gov.au/jshess/docs/2015/mcinnnes.pdf>
- Additional details on hazardous weather phenomena in Australia's changing climate are available from the ESCC Hub website: <http://nеспclimate.com.au/extreme-weather-hazards-in-a-changing-climate-project-5-5/>

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