Earth Systems and Climate Change Hub

National Environmental Science Programme

East coast lows and climate change in Australia

East coast low coastal impacts June 2016, Collaroy Beach, Sydney
(Image: C.Drummond, NSW Water Research Laboratory)

> Intense east coast lows can cause extreme wind, ocean waves, rainfall and flooding which can have severe impacts on coastal communities, businesses and ecosystems.

> There is no clear trend in the number of east coast lows which have been observed over the past decades.

> Climate model projections show that fewer east coast lows are likely to occur in the future due to increasing greenhouse gas emissions.

East coast lows (ECLs) are low-pressure systems near south-eastern Australia that can be caused by both mid-latitude and tropical influences over a range of levels in the atmosphere. Intense ECLs can be defined as having at least one major hazard associated with their occurrence, including extreme winds, waves, rain or flooding.

East coast low (ECLs) are also sometimes called Australian east coast cyclones or maritime lows. They can cause a range of hazards including damaging winds, prolonged heavy rainfall and very rough seas. The more intense events can lead to impacts such as injury, loss of life, infrastructure damage and large insurance losses. However, ECLs can also have beneficial impacts including heavy rainfall that can contribute significantly to catchment inflows important for water supply and ecosystems, as well as heavy snowfall in some cases.

An example of a recent intense ECL occurred in June 2016 around the northern beaches of Sydney. This event resulted in over 300 mm of rainfall between 4–6 June at Robertson (Illawarra, NSW) together with severe flooding and coastal erosion. This resulted in substantial damage to private property, public infrastructure and local ecosystems.

The costs associated with extreme weather hazards and disasters, including those caused by 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 valuable for increasing Australia's preparedness and resilience.

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

East coast lows in the current climate

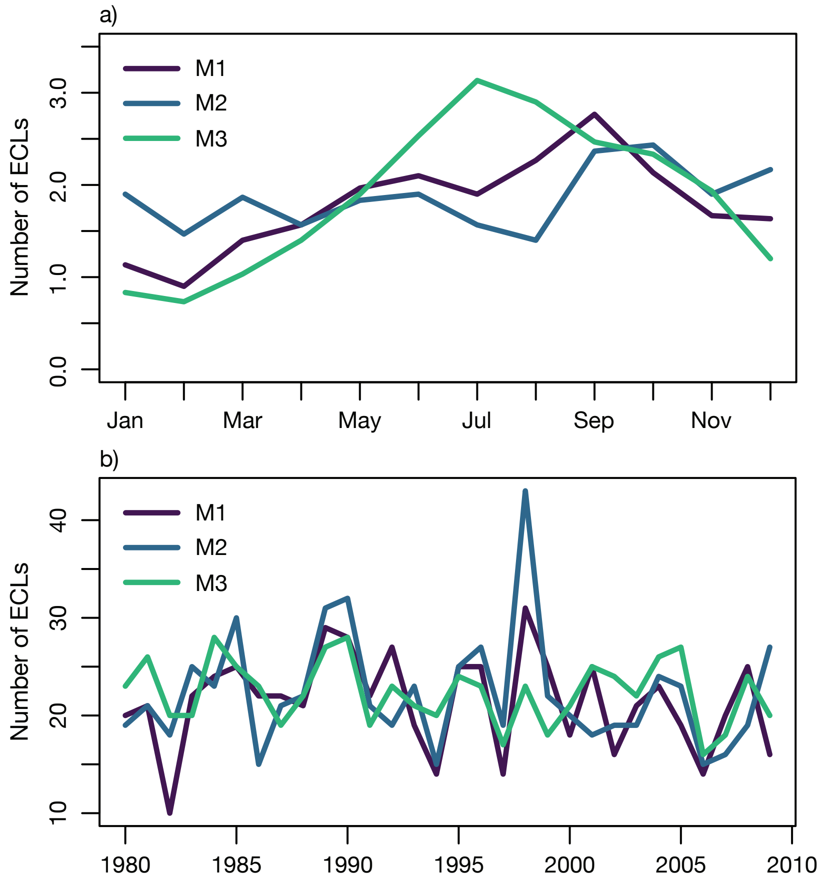
ECLs have been observed to occur on average about 22 times per year, for 36 days per year (as some events last longer than a day).

Of the 22 ECLs observed per year, on average 2–3 cause extreme daily rainfall above 100 mm, 7–8 cause widespread daily rain above 25 mm, and one will intensify rapidly. There is large variability from year to year in the number of ECLs that occur, with observations in recent decades showing no clear trend in ECL numbers.

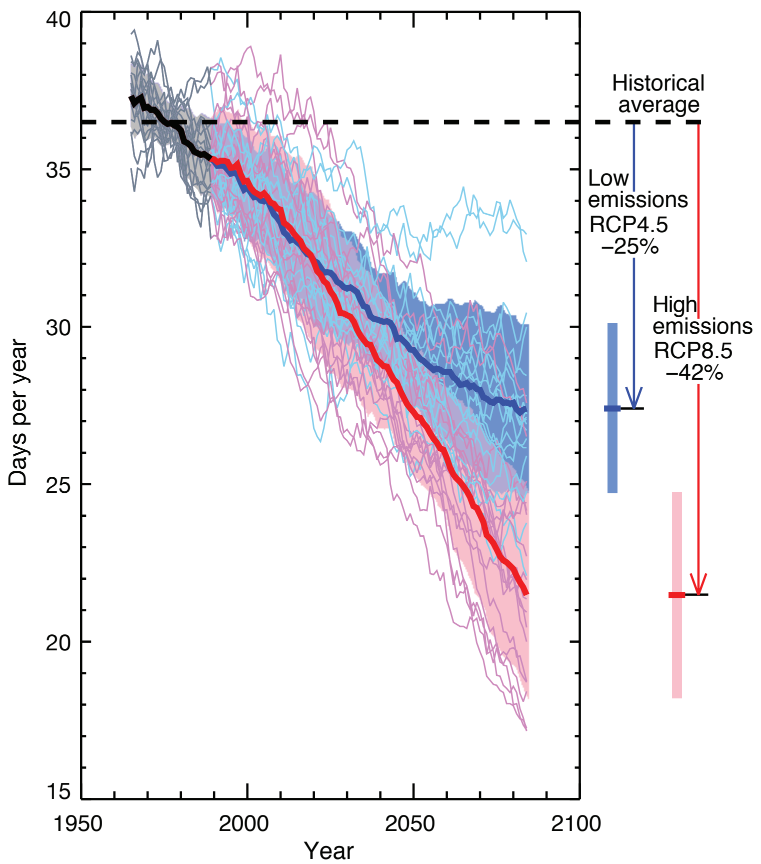
ECLs have distinct characteristics compared to low-pressure systems in other regions, such as tropical cyclones. Unlike tropical cyclones, the number of ECLs that occur is not significantly influenced by the El Niño-Southern Oscillation. Intense ECLs can occur at any time of the year but are most common during the cooler months (in contrast to tropical cyclones). In addition, sea surface temperatures have a relatively weak influence on ECL activity whereas they play a much larger role in the formation of tropical cyclones.

Compared to low-pressure systems in other regions of Australia the formation of ECLs often involves a substantial combination of both mid-latitude and tropical influences.

ECLs often have strong winds and rotation over a range of different vertical levels through the atmosphere, particularly for the more extreme events during winter. ECLs can occur near coastal communities with the potential to intensify rapidly and cause relatively small-scale (e.g. ranging in size from a few to several hundred kilometres) weather extremes. Thunderstorms and cold fronts can also interact with ECLs, exacerbating the weather extremes.



ABOVE: **Number of ECLs on average for each month of the year and for individual years.** This is shown based on three different ECL detection methods (labelled as M1, M2 and M3) using historical data from 1980 to 2009.



Future east coast low activity under a changing climate

Climate projections based on modelling indicate that fewer ECLs are expected to occur in the future, particularly during the cooler months of the year. The projections show larger reductions for higher greenhouse gas emissions scenarios. These reductions in ECL numbers are due to changes in conditions at higher levels in the atmosphere associated with ECL development.

LEFT: **Downward trend in the projected number of days with east coast lows.** The annual number of days with ECLs is indicated based on 18 global climate models for a moderate emission scenario (blue) and a high emission scenario (red). The historical period (black) is also shown, with a 30-year moving average applied to all data shown here.

Although fewer ECLs are projected to occur in the future under a changing climate, other important changes in our climate will affect the impacts of future ECLs on eastern Australia. For example, rising sea levels are likely to increase the impacts of large waves on coastal regions, and extreme rainfall is predicted to increase in intensity resulting in increased risk factors for flooding in some cases. In addition, changes in storm characteristics under climate change can potentially have significant influences on various coastal processes, such as changes in the intensity, frequency and duration of extreme wind and wave events caused by ECLs. Changes in wave direction can also influence processes such as coastal sediment transport and beach shape, which can have impacts on coastal infrastructure and ecosystems as well as our leisure activities.

There are still considerable uncertainties in our understanding of how some ECL characteristics may change in the future, including in the intensity of associated hazards such as extreme wind and changes in wave direction. Potential future changes such as an expansion of the tropics due to climate change could also influence the mechanisms which drive the formation of ECLs resulting in potential changes in ECL frequency and/or intensity.

The influence of climate change on future ECLs and associated extremes	
ECL occurrence	Fewer ECLs are likely due to increasing greenhouse gas emissions, particularly during the cooler months of the year.
ECL-related rainfall and flooding	Fewer events, particularly during winter, but with increased rainfall intensity in some cases, corresponding to increased flood risk factors.
ECL-related waves	Fewer large wave events are likely in the future, particularly during winter. Trends are less clear for the intensity of extreme wave events (given uncertainties in future ECL wind speeds) and for wave direction.
ECL-related coastal hazards	Sea levels will continue to rise, thereby increasing risks from ECLs associated with storm surge, coastal flooding and erosion.
ECL intensity and duration	Changes in the intensity and duration of ECLs, and associated extreme wind events, are not clear based on current knowledge.

Bottom image: C.Drummond, NSW Water Research Laboratory

Tools, data and further information

- Review article on ECLs – provides a summary of a wide range of information sources: **https://link.springer.com/article/10.1007/s00382-019-04836-8**
- Historical database of ECL occurrence based on sea-level pressure charts, as well as rain, wind and wave data associated with ECL events: **http://www.bom.gov.au/climate/escci/matches.shtml**
- Information on future projections of ECLs for New South Wales: **https://climatechange.environment.nsw.gov.au/Impacts-of-climate-change/East-Coast-Lows/Future-East-Coast-Lows**
- Historical climatology information on ECLs and influences on their formation: **http://nespclimate.com.au/wp-content/uploads/2019/04/cavicchia_etal_jcli_2019.pdf**
- Extreme weather research under Project 2.8 of the Earth Systems and Climate Change Hub – including links to a variety of research publications on this topic: **http://nespclimate.com.au/extreme-weather-projections/**
- Cavicchia L, Dowdy A, Walsh K. 2018. Energetics and dynamics of subtropical Australian east coast cyclones: Two contrasting cases, *Monthly Weather Review*, doi:10.1175/MWR-D-17-0316.1
- Pepler AS, Di Luca D, Evans J. 2017. Independently assessing the representation of midlatitude cyclones in high-resolution reanalyses using satellite observed winds, *International Journal of Climatology*, doi:10.1002/joc.5245

For more information, please contact: Dr Andrew Dowdy
andrew.dowdy@bom.gov.au
www.nespclimate.com.au

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