ANNEX 14

EXPERT OPINION OF DR ANDREW WATKINS ON FLOODING IN BRISBANE AND THE KIMBERLEY REGION

Expert opinion on the 2022-2023 Brisbane and Kimberley flood events and their relationship to anthropogenic climate change.

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Dr Watkins was a Lead Author of the Australian Government's first National Climate Risk Assessment, integrating climate hazards with exposure and vulnerability across eight key systems of importance to Australia, and informing the National Adaptation Plan. He previously served as Head of Climate Prediction at the Bureau of Meteorology, leading early warning systems for climate extremes, including El Niño, drought, fire, and flood events. His leadership and stakeholder engagement during the Black Summer bushfires were recognised with the award of a Bureau Australia Day Medallion. His work spans climate hazard characterisation, climate forecasting, and risk communication, with strong translation into policy and practice. He was awarded the W.J. Gibbs Medal by the Australian Meteorological and Oceanographic Society for excellence in climate science and communication, and has contributed internationally through the United Nations World Meteorological Organization expert groups. His work includes co-authorship of global State of the Climate reports and leadership of climate risk and early warning system initiatives in the Asia-Pacific region.

Expert Opinion

1. The Intergovernmental Panel for Climate Change most recent report states “It is unequivocal that human influence has warmed the atmosphere, ocean and land”[1].

2. Heavy and record rainfall and flooding in Brisbane in 2022 and in the Kimberley in 2022/23 were associated with intense low pressure systems. Both weather systems were fuelled by near record ocean temperatures (due to climate change), were made more likely and more impactful due to a rare triple year La Niña (which are now more frequent due to climate change), with greater moisture available to fall as rain (as the atmosphere carries significantly more moisture due to climate change).

3. Using a causal networks approach[2], it is virtually impossible / exceptionally unlikely[3] for these events to have occurred as observed with no climate change influence, and hence without the increase in regional and global atmospheric and oceanic heat from the extraction and burning of fossil fuels in Australia and internationally.

4. Anthropogenic climate change will continue to impact these same regions throughout the remainder of this century and beyond[4]. While the types of weather systems that caused the flooding in Brisbane and the Kimberley are likely to decrease in number, those that do occur are equally likely to increase in intensity, with greater wind speeds, storm surges, sub-daily and daily rainfall totals, and associated riverine, flash, coastal and estuarine flooding. Brisbane may experience more impacts from tropical cyclones in the future.

5. Future projections of flooding in both regions show that while there is limited clarity on the increase or decrease in the frequency of flood events, when floods do occur, they are likely to be associated with heavier sub-daily and multi-day rainfall and hence result in higher peak flood levels. The floods should not be viewed in isolation. Compounding, cascading and concurrent climate change–related events will have far greater effect in Australia than individual events in isolation[5].

6. Ultimately communities at risk will need to move from flood prone zones as costs of protection, recovery and insurance become prohibitive. This has social, financial, culture and emotional impacts on communities, families and people. Every oil, gas and coal project is directly increasing this risk[6].

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[1] Intergovernmental Panel on Climate Change, Assessment Report Six, Summary for Policy Makers, 2022 https://www.ipcc.ch/report/ar6/wg1/resources/spm-headline-statements/
[2] Processes and principles for producing credible climate change attribution messages: lessons from Australia and New Zealand https://iopscience.iop.org/article/10.1088/2752-5295/ad53f5
[3] Definition of ‘exceptionally unlikely’ P.4 IPCC AR6 Summary for Policy Makers https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf
[4] DCCEEW National Climate Risk Assessment, Sept 2025 https://www.dcceew.gov.au/climate-change/policy/adaptation/ncra
[5] National Climate Risk Assessment, Future Climate and Hazards Report, https://www.acs.gov.au/documents/fadb05a9fa254835b840db73383910d7/about
[6] Quantifying the regional to global climate impacts of individual fossil fuel projects to inform decision-making https://www.nature.com/articles/s44168-025-00296-5

Background

7. Stable concentrations of greenhouse gases play a critical role in a livable climate[7]. Earth without greenhouse gases would have an average temperature of around -19°C. With preindustrial levels of greenhouse gases (280ppm), the global average atmospheric temperature was around +14°C.

8. In the past century, the burning of coal, oil and gas has increased greenhouse gases in the atmosphere by over 50% of its preindustrial levels, reaching a concentration in excess of 420 parts per million, a level not experienced any time in the past 3 million years, and hence by no previous humans[8].

9. This rapid shift has in turn altered the fine energy balance between the Earth and space. In 2025, the difference between energy entering the atmosphere from the sun, and energy being reflected or radiated back out to space, was the largest in the satellite record.

10. However only around 1% of the excess energy being captured is warming the atmosphere. Around 3% goes into melting ice and glaciers, 5% goes into warming the land surface itself, while 91% goes into the oceans, where much remains hidden well below the surface[9].

11. The last 11 years have been the warmest 11 years on record for the globe[10]. The scale of recent changes across the climate system as a whole are unprecedented over many centuries to many thousands of years[11].

Can we attribute individual weather events to climate change?

12. Climate attribution science has progressed markedly in the past decade, with most events of national or global significance being studied to determine if climate change altered their likelihood or magnitude. In all 85% of the 967 known attribution studies found an event or trend to have been influenced by human-caused climate change, while only 8% (mostly cold extremes) found no direct evidence of human influence[12].

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[7] IPCC AR4 Historical Overview of Climate Science
https://www.ipcc.ch/site/assets/uploads/2018/03/ar4-wg1-chapter1.pdf
[8] Toward a Cenozoic history of atmospheric CO2
https://www.science.org/doi/10.1126/science.adi5177
[9] IPCC AR6 Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity
https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-7/
[10] World Meteorological Organization, State of the Global Climate in 2025
https://wmo.int/publication-series/state-of-global-climate/state-of-global-climate-2025
[11] IPCC AR6 Summary for Policymakers Headline Statements
https://www.ipcc.ch/report/ar6/wg1/resources/spm-headline-statements/
[12] Mapped: How climate change affects extreme weather around the world
https://interactive.carbonbrief.org/attribution-studies/index.html

13. However in many cases, the authors note that their estimates are likely an underestimate of the role of excess greenhouse gases and the burning of fossil fuels. The primary reason for this underestimate is that the land, ice, ocean and atmospheric system is now fundamentally changed from what it was prior to large scale human caused emissions of greenhouse gases. As no aspect of these systems remains as they were in preindustrial times, all weather and climate events have been altered in some way.

14. It is also now possible to quantify the regional to global climate impacts of individual fossil fuel projects[13].

Background to events:

15. Flooding in and around Brisbane in 2022 was the result of a series of Tasman Sea low pressure systems (East Coast Lows) stalled by a blocking high over New Zealand. This resulted in intense and sustained rainfall upon already saturated soils, which produced major flooding across south-eastern Queensland and eastern New South Wales between 22 February and 9 March 2022[14].

16. More than 50 sites recorded over a metre (1000 mm) of rainfall in the week ending 1 March, with rainfall totals generally 2.5 to 5 times their monthly average. Widespread major flooding[15] occurred in Brisbane and Ipswich along the Brisbane River and many smaller creeks and rivers. River levels along the lower Brisbane River, Bremer River and Lockyer Creek peaked below the floods of January 2011 and January 1974. Flooding produced an estimated AUD$7.7 billion of infrastructure damage and economic loss in Queensland alone[16].

17. The February - March 2022 rainfall and flooding in eastern Australia has been described in the prestigious science journal Nature as ‘The impossible flood’, redefining extreme floods in Australia[17].

18. In the Kimberley, ex-Tropical Cyclone *Ellie* moved into the region on 29 December 2022 and interacted with a strong monsoon flow, producing multiple

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[13] Quantifying the regional to global climate impacts of individual fossil fuel projects to inform decision-making https://www.nature.com/articles/s44168-025-00296-5
[14] Special Climate Statement No. 76, BoM Extreme rainfall and flooding in south-eastern Queensland and eastern New South Wales https://www.bom.gov.au/climate/current/statements/scs76.pdf
[15] Major flooding is defined by the Bureau of Meteorology as flood levels that will result in extensive inundation, supply routes closed, areas isolated and evacuations may be required https://www.bom.gov.au/water/awid/id-316.shtml
[16]The social, financial and economic costs of the 2022 South East Queensland Rainfall and Flooding Event https://www.qra.qld.gov.au/sites/default/files/2022-07/dae_report_-_south_east_queensland_rainfall_and_flooding_event_-_8_june_2022.pdf
[17] How February 2022 redefines extreme floods in Australia, Nature, 2025 https://www.nature.com/articles/s43247-025-02307-z

days of heavy rainfall and flooding[18]. The Fitzroy River reached 14.23 metres, more than a metre higher than the previous record, isolating the town of Fitzroy Crossing and multiple communities in the surrounding areas. Damage of the Great Northern Highway bridge cut the main Perth to Darwin supply route. Over 600 residents were evacuated during the flooding with at least 40 homes and businesses destroyed with many more damaged.

19. Some locations in the Kimberley had rainfall which exceeded 0.5% to 0.05% Annual Exceedance Probability (AEP) over 24–72 hour time periods. This means the chance of such heavy rainfall occurring naturally during any year was between 1 in 200 and 1 in 2000.

Question 1: Can you please explain the factors that contributed to the flooding that occurred in Brisbane (2022) and Kimberley (2022/2023) and whether and how they are connected to climate change or made more likely by climate change? In answering this question, please also outline the attribution studies, peer-reviewed literature and any projections that you have utilised to reach your answer.

20. Both the Brisbane and Kimberley floods set records, or near records, for rainfall intensity or flooding, despite initially appearing to be systems that would have not necessarily produced record setting rainfall in the past. There were clearly a number of contributing natural and anthropogenic climate factors to the weather patterns (ie East coast lows in the case of Brisbane, and Tropical cyclone/low in the case of Kimberley floods) which increased the impacts of the events.

21. Recent research[19] has suggested that a tailored causal network approach, which notes both anthropogenic climate change and natural climate variability influences on preconditions and proximate causes of a hazardous weather or climate event, can demonstrate the influence of climate change on any event. Our answer to Question 1 will follow that approach.

Global and regional warming of the oceans and atmosphere

22. Globally, 2022 was the globe's 5th or 6th warmest year on record at that time (since exceeded by 2023, 2024 [hottest year on record], and 2025), 1.15C above the preindustrial (1850-1900) mean temperature[20]. It was the 46th consecutive

[18] BoM special report on Tropical Cyclone Ellie: https://www.bom.gov.au/cyclone/history/pdf/Ellie_2022_report.pdf
[19] Processes and principles for producing credible climate change attribution messages: lessons from Australia and New Zealand https://iopscience.iop.org/article/10.1088/2752-5295/ad53f5
[20] U.N World Meteorological Organization State of the Climate in 2022 report: https://library.wmo.int/records/item/66214-state-of-the-global-climate-2022

year with global temperatures above the 20th century average[21]. The global ocean surface temperature was 6th warmest on record[22].

23. Global greenhouse gas concentrations, global sea level and global ocean heat content reached record highs in 2022, but have all been exceeded since. These are all directly linked, as around 91% of the excess heat generated by human caused climate change is absorbed by the oceans.

24. For Australia, it was the 22nd warmest year since records began in 1900 (123 years), +0.5C above normal.[23]

25. In 2022, the Tasman Sea was 2nd warmest on record in 2022 (by 2025, 3rd warmest), Coral Sea warmest on record (by 2025, second warmest), and Northern Tropical waters 2nd warmest (by 2025, 4th warmest) on record[24].

26. The World Meteorological Organization's latest decadal outlook report[25] (May 2026) notes that "It is very likely (91% chance) that global mean near-surface temperature will exceed 1.5°C above the 1850-1900 average levels for at least one year between 2026 and 2030. It is also likely (75% chance) that the 2026-2030 five-year mean will exceed 1.5°C above the 1850-1900 average"

27. *The long term warming trend of the global and regional sea surface temperatures, directly attributable to anthropogenic climate change, means there was additional fuel (both heat and moisture) for the weather systems associated with the two flood events in question[26], as well as contributing to poleward shifts in tropical weather patterns which would have altered the location of formation and system tracks[27].*

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[21] U.S National Oceanographic and Atmospheric Administration State of the Climate in 2022 report https://www.ncei.noaa.gov/news/global-climate-202212
[22] Berkeley Earth Global Temperature Report for 2022: https://berkeleyearth.org/global-temperature-report-for-2022/
[23] Bureau of Meteorology State of the Climate 2022 report: https://www.bom.gov.au/climate/current/annual/aus/2022/
[24] Bureau of Meteorology Australian climate variability and chance - timeseries graphs, sighted 25 May 2026: https://www.bom.gov.au/cgi-bin/climate/change/timeseries.cgi?graph=sst&area=trop&season=0112&ave_yr=0&ave_period=6190
[25] World Meteorological Organization Global Annual to Decadal Climate Update 2026-2035 https://library.wmo.int/viewer/69882/download?file=WMO-GADCU-2026-2035_en.pdf&type=pdf&navigator=1
[26] Effects of high local sea surface temperature on the extreme rainfall over the eastern coast of Australia in February 2022 https://link.springer.com/article/10.1007/s00704-026-06246-3
[27] The expanding tropics: a critical assessment of the observational and modeling studies. https://wires.onlinelibrary.wiley.com/doi/epdf/10.1002/wcc.251

Changing La Niña patterns

28. The El Niño - Southern Oscillation (ENSO) climate phenomenon in the tropical Pacific Ocean describes the periodic cycle between El Niño and La Niña events in tropical ocean surface temperatures that drive regional shifts in weather patterns that have a global impact[28].

29. La Niña events are associated with wetter than average years across Australia, with an earlier onset of the northern monsoon and, particularly in double year events, an increased risk of flooding[29]. The increase in flood risk from multi year La Niña events is due to the saturation of soils by above average rainfall in the first year, meaning rainfall in the subsequent years cannot be soaked up but instead floods across the landscape.

30. Historically, La Niña drives *cooler* than average global and Australian temperatures. In 2002, both Global and Australian temperatures were significantly *warmer* than average, almost solely due to the extraction and burning of coal, oil and gas, and the resultant additional greenhouse gas warming.

31. The 2022 La Niña was the third consecutive La Niña year, and only the 3rd reliably recorded triple year event, following 1998-2001 and 1973-1976. Recent research[30] has suggested that multi-year ENSO events occur more frequently now than in pre-industrial times, largely due to anthropogenic warming of the top layers of the ocean.

32. Observations also show a trend towards a more La Niña-like pattern or warming in the Pacific since at least the early 1980s[31] when satellite monitoring made observing ENSO patterns plausible, while strong El Niño and La Niña events have occurred more frequently than average since 1960 compared with the first half of the 20th century[32].

33. As there is strong link between Australian rainfall extremes / flooding and La Niña, the observed trend towards more frequent multi-year events, as well as a trend towards a more La Niña-like background state, means antecedent

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[28] World Meteorological Organization El Niño / La Niña Phenomena https://wmo.int/topics/el-Niño-la-Niña-phenomena

[29] Bureau of Meteorology “what is La Niña and how does it impact Australia”: https://www.bom.gov.au/climate/updates/articles/a020.shtml

[30] Increased frequency of multi-year El Niño–Southern Oscillation events across the Holocene https://www.nature.com/articles/s41561-025-01670-y

[31] On the future zonal contrasts of equatorial Pacific climate: Perspectives from Observations, Simulations, and Theories https://www.nature.com/articles/s41612-022-00301-2

[32] Anthropogenic impacts on 20th century ENSO variability https://www.nature.com/articles/s43017-023-00427-8

conditions for 2022-23 Australian flood events were elevated by both natural variability and anthropogenic climate change.

Increases in atmospheric moisture

34. The Clausius-Clapeyron relation is a standard equation in chemical thermodynamics that describes the relationship between temperature and water vapour. It has been known to science since the 1830's[33].

35. It shows that a warmer atmosphere can hold more water vapour than a cooler atmosphere. The equation shows that for each degree Celsius of global warming, the atmosphere can hold an additional 7% more moisture[34].

36. Observations of water vapour show that it has been increasing by at least 1% per decade since the late 1970s, with likely greater increases above the surface[35]. Recent research shows that extreme rainfall intensity is increasing with temperature at rates exceeding those expected from Clausius-Clapeyron alone[36]. This has been observed in Australia (see following section).

37. For rain to fall, there needs to be moisture in the atmosphere and a trigger (such as a weather event that can release water). The increased - and increasing - moisture in the atmosphere means an increased likelihood of heavier rainfall events than in the past in any comparable rainfall-favourable situation.

38. An increase in evaporated moisture carries additional energy into the atmosphere, called latent heat, which can provide more energy[37] for some processes that generate extreme rainfall events, such as thunderstorms, cyclones and east coast lows, which further increases the likelihood of heavy rainfall.

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[33] What a 190-year-old equation says about rainstorms in a changing climate https://www.pnas.org/doi/10.1073/pnas.2304077120

[34] Conceptual Framework for Changes of Extremes of the Hydrological Cycle with Climate Change https://link.springer.com/article/10.1023/A:1005488920935

[35]Global Changes in Water Vapor 1979–2020 https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2022JD036728

[36] Super-Clausius–Clapeyron scaling of extreme precipitation explained by shift from stratiform to convective rain type https://www.nature.com/articles/s41561-025-01686-4

[37] The latent heating feedback effect on storm tracks in current and future climates https://www.nature.com/articles/s41612-026-01421-9

39. Seven of the 10 wettest northern Australia wet seasons have occurred since 1998, including during the recent La Niña periods 1998–2001, 2010–2011, and 2022–2023[38].

40. The increase in atmospheric moisture globally and over Australia, as a direct result of anthropogenic warming, means more moisture is available to fall as rain during extreme weather events such as occurred in Brisbane in 2022 and the Kimberley in 2022/2023.

Increases in extreme rainfall events

41. Observations show that there has been an increase in the intensity of sub-daily heavy rainfall events in Australia, particularly over the summer months[39].

42. The intensity of short-duration (hourly) extreme rainfall events has increased by 8-10% per degree Celsius over Australia, with values in some tropical areas reaching 14%. When only the most extreme events were studied for Brisbane and Sydney, an 18% per degree increase was found for 1 in 100 (1% Annual Exceedance Probability) events.

43. Short-duration (sub-daily) extreme rainfall events are of increasing intensity due to climate change, and are often associated with flash flooding and hence increased risk to communities.

East coast lows

44. East coast lows (ECLs), such as the event associated with the Brisbane floods of 2022, are intense low pressure systems near eastern Australia that can be caused by both mid-latitude and tropical influences over a range of height / pressure levels in the atmosphere[40].

45. Long term trends (1959-2023) shows that there is a statistically significant decrease in these intense low pressure systems for the November to April period (ie period during which the Brisbane floods occurred), but a small increase in the number of heavy rain days on the eastern seaboard associated with these lows [41]. While limited observed data makes quantitative assessment of historical ECL rainfall intensity changes difficult, modelling does show that climate change is likely to result in fewer but more intense ECLs.

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[38] Section “Heavy Rainfall, climate change and flood risk” in: https://www.csiro.au/en/research/environmental-impacts/climate-change/State-of-the-Climate/Australias-Changing-Climate
[39] Trends in Annual Maximum Sub-Daily to Daily Precipitation Over Australia https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2025JD044650
[40] Geosciences Australia, East Coast Low risks https://www.ga.gov.au/bigobj/GA4206.pdf
[41] Recent trends in extratropical lows and their rainfall over Australia: https://doi.org/10.1071/ES24002

46. A recent study has demonstrated that the well above average sea surface temperatures (+2℃) in the vicinity of the ECL associated with the February-March 2022 floods in eastern Australia can explain an increase in the intensity and southwards shift in position of the ECL associated with extreme flooding[42].

47. *While there is evidence that East Coast Lows have been decreasing in numbers, they are likely to be increasing in intensity, with higher associated rainfall rates, due to anthropogenic warming of both the atmosphere and oceans.*

Tropical Cyclones

48. Tropical cyclones, such as ex-Tropical Cyclone *Ellie* which impacted the Kimberley in 2022-2023, are intense, low-pressure systems that form over warm tropical oceans and generate galeforce or stronger winds, heavy rainfall and coastal storm surges. Australia currently experiences around 10-11 tropical cyclones per year[43], of which around 4 make landfall. Typically more tropical cyclones occur in La Niña years, and fewer in El Niño years.

49. The total number of tropical cyclones in the Australian region per year has decreased significantly in recent decades[44] with at least a 10% decline in the frequency of tropical cyclones over the past 40 years[45].

50. However, since 1979 there has been an increase in the proportion of high intensity tropical cyclones both in Australia and around the world, meaning that the tropical cyclones that do occur are generally more intense, with higher wind speeds, larger storm surges, greater coastal erosion, more heavy rainfall and increased coastal, estuarine and riverine flooding, than occurred in the past[46].

51. Rainfall associated with tropical cyclones has increased, globally, by around 1.3% per year, associated with greater evaporation in the outer bands of tropical cyclones due to warming trends in ocean and air temperatures[47] [48].

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[42] Effects of high local sea surface temperature on the extreme rainfall over the eastern coast of Australia in February 2022 https://link.springer.com/article/10.1007/s00704-026-06246-3
[43] BoM Tropical Cyclone Climatology https://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/climatology/
[44] National Environmental Science Program, Tropical Cyclones and Climate change https://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_Tropical_Cyclones_FINAL_Nov11_2019_WEB.pdf
[45] Future Climate and Hazards Report, National Climate Risk Assessment, September 2025 https://www.acs.gov.au/documents/fadb05a9fa254835b840db73383910d7/about
[46] https://www.acs.gov.au/pages/hazards-cyclones
[47] Global increase in the rain rate of tropical cyclones prior to landfall, Nature 2026 https://www.nature.com/articles/s41467-021-25685-2
[48] Global increase in tropical cyclone rain rate, Nature 2021 https://www.nature.com/articles/s41467-021-25685-2

52. *The proportion of intense tropical cyclones has increased in the Australian region, with greater tropical cyclone-associated rainfall globally, linked to the anthropogenic warming of the oceans and atmosphere, as well as some component of natural climate variability associated with climate drivers such as El Niño and La Niña.*

Question 2: Based on the current state of knowledge and best available science, please explain the extent to which climate change could contribute to future floods in these regions in Australia.

53. The National Climate Risk Assessment was released by the Commonwealth Government[49] in September 2025[50]. It outlines the best current understanding of Australia's future weather and climate hazards, and the risks to all sectors of Australia's economic, built, social and environmental areas of importance[51].

54. In relation to the causes and drivers of future flooding in the Brisbane and the Kimberley regions, it notes in part (*direct quotes in italics*):

55. *Australia's climate has warmed and will continue to warm into the future (very high confidence). Average daily temperatures are projected to increase across the country, with the greatest increases over inland areas.*

56. *The frequency and duration of marine heatwaves are projected to increase (high confidence). At +3.0°C of global warming, the Tasman Sea will approach a permanent marine heatwave state, and the Great Barrier Reef and Ningaloo Reef will experience annual conditions for extreme bleaching (high confidence).*

57. *Extratropical storms (including east coast lows) are projected to become less frequent (medium confidence) but may have greater impacts when they do occur (medium confidence). Changes in rainfall intensity as well as higher sea levels mean a higher chance of coastal flooding from future extratropical storms.*

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[49] Minister Bowen media release for release of the National Climate Risk Assessment https://minister.dcceew.gov.au/bowen/media-releases/cascadThe frequency of tropical cyclones is likely to decrease (medium confidence), but the proportion of category 4 and 5 events may increase (low/medium confidence). Little change or a small southward shift in tropical cyclone tracks is possible (low confidence).
ing-compounding-and-concurrent-national-climate-risk-assessment-shows-why-climate-action-so-important

[50] National Climate Risk Assessment DCCEEW
https://www.dcceew.gov.au/climate-change/policy/adaptation/ncra

[51] National Climate Risk Assessment ACS
https://www.acs.gov.au/pages/national-climate-risk-assessment

58. *The frequency of tropical cyclones is likely to decrease (medium confidence), but the proportion of category 4 and 5 events may increase (low/medium confidence). Little change or a small southward shift in tropical cyclone tracks is possible (low confidence).*

59. *It is likely that the El Niño – Southern Oscillation will continue to change this century, with high variability (low to medium confidence) and more frequent swings from strong El Niño to strong La Niña. There is some evidence that consecutive La Niña events may occur frequently over the 21st century*[52]

60. Recent literature highlights that future ENSO events are likely to be more intense more often[53], as well as driving even warmer ocean surface temperature extremes[54].

61. *The projected changes in annual maximum one-day runoff vary across regions and time, with some climate models showing increases across the country and others showing decreases. As a result of this large range in model outcomes, changes in future riverine and flash flooding have low confidence*

62. *When floods do occur, they may have higher water levels due to higher rainfall totals (low confidence). In parts of the east coast and tropics, an increase in annual high (90th percentile) runoff is projected, with a corresponding increase in flood risk (low to medium confidence).*

63. The National Climate Risk Assessment directly compared the case of flooding in the Brisbane region, including south eastern Queensland and north eastern New South Wales, in 2022 with a similar event modelled at +3 degrees Celsius of global warming[55] (shown in **Appendix A**). The Assessment found that the +3C event far exceeded the event in 2022 with:

64. *Extreme rainfall significantly more widespread than March 2022*
65. *7-day rain totals >1600 mm*
66. *Daily totals of up to 900 mm*
67. *Likely to have more flooding over a larger area than 2022*
68. *Area impacted extending from Bundaberg to Port Macquarie*
69. *Major flood warnings for multiple rivers from the Clarence to the Burrum*

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[52] Increased occurrences of consecutive La Niña events under global warming https://www.nature.com/articles/s41586-023-06236-9
[53] Increase in ENSO Frequency and Intensity Under 20th and 21st Century Warming: Insights From CMIP6 Large Ensembles https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2025GL116541
[54] Stronger ENSO-induced global SST variability in a warming climate https://www.nature.com/articles/s41467-026-70140-9
[55] Page 51,Comparing the past and future: a mid-century flood, Australia's Future Climate and Hazards report https://www.acs.gov.au/documents/fadb05a9fa254835b840db73383910d7

70. The Assessment notes that some southwards shift in tropical cyclones is possible, meaning potentially increasing numbers of events like *Severe Tropical Cyclone Alfred* which crossed the coastline near Brisbane in 2025[56], and an unnamed tropical cyclone which struck the Gold Coast in 1954[57].

71. Overall, climate scientists expect that the intensity of extreme rainfall events will increase[58]. Compound events (where floods are followed or preceded by other extreme hazards) will make future risks and future impacts from flooding far greater[59].

72. The National Climate Risk Assessment Communities Technical Report[60] notes that coastal communities, which includes Brisbane, are highly vulnerable to future changes in riverine, flash and coastal flooding, while regional and remote communities, such as those in the Kimberley, face greater risks from compound events involving successive hazardous climate and weather events.

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[56] Severe Tropical Cyclone Alfred (22U) https://www.bom.gov.au/cyclone/history/Alfred2025.shtml
[57] Queensland, February 1954
Cyclone - The Great Gold coast cyclone
https://knowledge.aidr.org.au/resources/cyclone-the-great-gold-coast-cyclone-queensland/
[58] Will extreme rainfall events become more intense in the future
https://nesp2climate.com.au/wp-content/uploads/2024/08/Fact-Sheet_Extreme-Rainfall.pdf
[59] Compound natural disasters in Australia: a historical analysis
https://doi.org/10.1080/17477891.2021.1932405

[60] National Climate Risk Assessment Communities Technical Report 2025
https://www.acs.gov.au/documents/8c8d736ff83643d79c5b2070645ba8dd/about

Appendix A

Australia's National Climate Risk Assessment rainfall and flood comparison of the February-March 2022 rainfall event and a similar event at a global temperature 3°C above pre industrial.

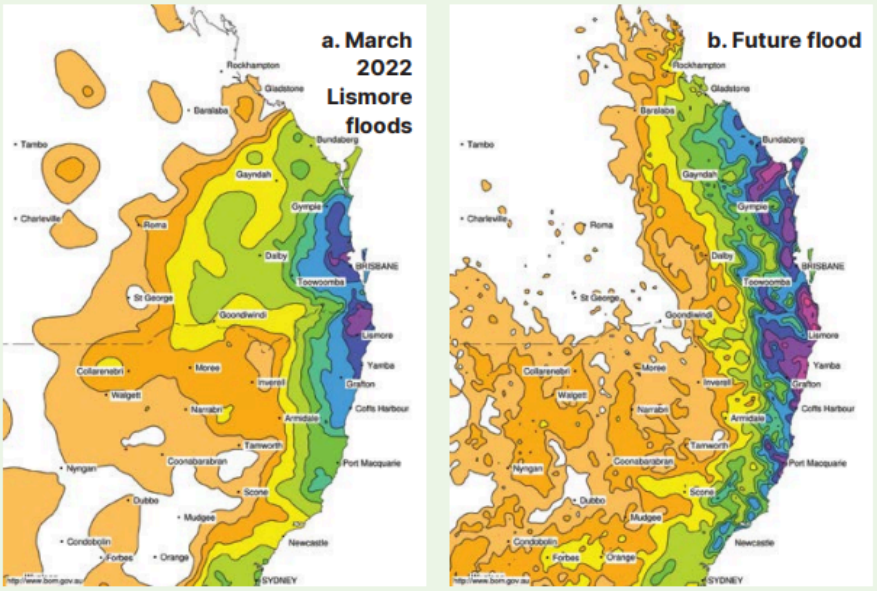
Comparing the past and future: a mid-century flood

Climate models can show us what a future flood event might look like. This future scenario is not a forecast, but it can help us to anticipate and plan for possible future events by comparing them with past events.

Under this scenario, a February flood event occurs when global temperatures have reached around 3.0°C warmer than normal. The scenario shows extreme rainfall with daily totals of up to 900 mm and 7-day totals greater than 1600 mm. Flooding extends over large areas from Bundaberg to Port Macquarie, and major flood warnings are in place for multiple rivers from the Clarence to the Burrum (Figure 22).

This future scenario can be compared with the Lismore floods of March 2022. During that event, floodwaters peaked at 14.4 m, more than 2 m above the previous records set in 1954 and 1974.

In comparison, the future flood event could impact a much larger area than in March 2022, have more widespread extreme rainfall and have a more substantial impact on the social, economic, built and natural environments.



- Extreme rainfall significantly more widespread than March 2022
- 7-day rain totals >1600 mm
- Daily totals of up to 900 mm
- Likely to have more flooding over a larger area than 2022
- Area impacted extending from Bundaberg to Port Macquarie
- Major flood warnings for multiple rivers from the Clarence to the Burrum

Figure 22: Map and impacts of a future flooding scenario at 3.0°C of global warming (b), compared with the March 2022 Lismore floods (a).