

Possibility & Effects of Tropical Cyclones In Wind Regions A & B

Dr Bruce Buckley

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Brought to you by the Climate and Sustainability Practice Committee



Acknowledgement of country

The indigenous custodians have cared for this Country — its lands, waters, skies and living things — for more than 65,000 years, making theirs one of the world's oldest continuously surviving cultures.

This culture understood that the decisions made by one generation echoed for many future generations.

This is a perspective relevant to today's conversation about climate, buildings, and the communities we ultimately serve in our professional roles as actuaries.



Important notice for all participants

This meeting is being conducted in accordance with Institute's Code of Conduct and attended by members in their professional capacity.

It is acknowledged that professional members in their employed capacity, may be active market participants in their respective industries who may compete with each other as defined by competition law.

Participants are, therefore, reminded that in accordance with their competition law compliance obligations they should not:

- discuss any matter that may be perceived as being cooperation by competitors in a market to influence that market;
- discuss any matters that could be regarded as fixing, maintaining or controlling prices, allocation of customers or territories, coordinating bids and/or restricting output or acquisitions in any circumstances;
- share commercially sensitive information relating to their employer;
or
- share information for an anti-competitive purpose.



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Q&A



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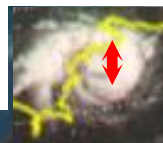
Tropical Cyclone over time

Dr Bruce Buckley

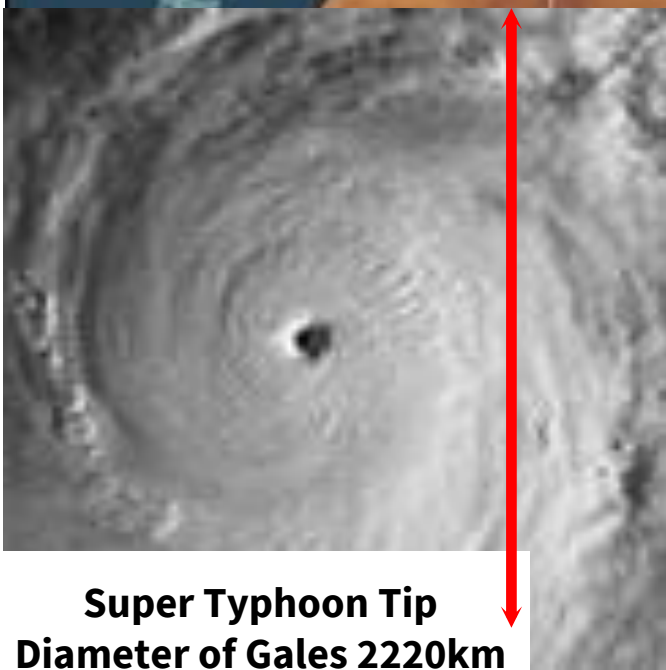
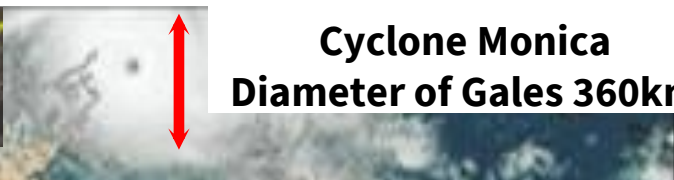
Tropical Cyclones vary significantly from one event to another

TCs physical size, structure & intensity vary significantly. Australian TC Scale differs from US Saffir-Simpson Scale
Risk models vastly simplify TC structures & do not capture consequences of sequential impacts, climate change

Cyclone Tracy
Diameter of Gales 100km



Cyclone Monica
Diameter of Gales 360km



Super Typhoon Tip
Diameter of Gales 2220km

Tropical cyclone categories

Category	Wind Speed Range (km/h)	Wind Description
1	90–124 km/h	Damaging winds
2	125–164 km/h	Destructive winds
3	165–224 km/h	Very destructive winds
4	225–279 km/h	Very destructive winds
5	>280 km/h	Very destructive winds

US SS: Tropical Storm 119-153km/h = US SS: Cat 1 154-177km/h = US SS: Cat 2 >177km/h = US SS: Cat 3-5

Know your weather. Know your risk. Australia => 3 second gusts, US SS => 1 minute average speeds

bom.gov.au

Tropical Cyclones: Extreme damage - recent TCs missed large centres

Cat 1* TC Alfred (SE Qld), March 2025

- 133,000 claims
- ~\$1.5 billion insured cost
- \$1.2 billion Federal Government cost
- ~500,000 people without power for up to a week

**Alfred was Cat 1 inside Moreton Bay, but below TC intensity for the coastal crossing of the eye
ICA Natural Disasters Data February 2026*

Cat 3 TC Seroja (Kalbarri), April 2021

- 10,066 claims
- \$431 million insured cost (\$2022)
- 32,000 customers lost power

Recent cyclones have generally impacted Regions C & D with higher wind loading codes

Cat 4 TC Debbie (Qld), March 2017

- Wind / rain damage Hamilton Island, Proserpine, Bowen. Rain, flood damage SE Qld
- 77,000 claims
- \$2.35 billion insured losses (\$2022)

Cat 4 TC Tracy (Darwin), December 1974 (before TC wind loading code)

- 71 Deaths
- 80% of all Darwin buildings destroyed, all damaged
- Total loss of all services for weeks (power, communications, water & sanitation)
- \$7.4 billion insured cost (\$2022)

Cat 2 TC Alby (SW WA, incl Perth), April 1978

- 5 Deaths
- Most devastating storm on record for SW WA, including bushfire, wind & storm surge
- Gust to 150km/h at Albany
- \$522 million insured losses (\$2022)

TC Debbie 28 March 2017

Category 4 TC impact at Airlie Beach / Hamilton Island (Qld)– Wind loading code Region C on the coast, B inland. Large-sized TC, Cat 2 within 12 hours of coastal crossing. Slow moving after landfall, increasing flooding.

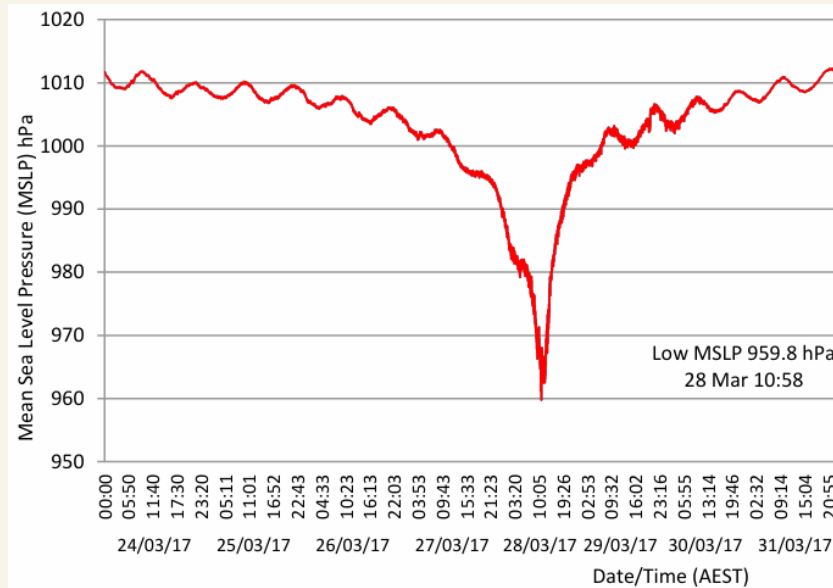
Central pressure 957 hPa over Whitsundays, peak strength of the cyclone. Strongest observed TC impact in the satellite era for the Whitsunday region. Houses damaged at Bowen, Proserpine, Airlie Beach, Collinsville, also SE Qld.

Crossed coast near Airlie Beach, estimated sustained winds of 150 km/h, gusts near 263 km/h (a Qld record), then recurved inland and passed over SE Qld.

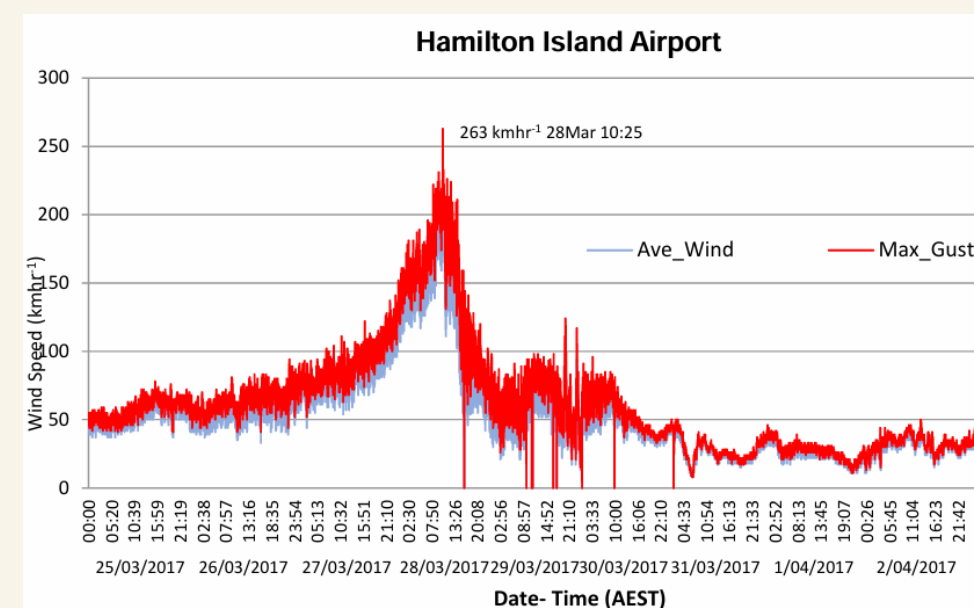
Multiday rainfall totals ~1000mm. Major flooding across SE Qld.



Track & Intensity of Debbie



Air pressure graph, Hamilton Is.



Wind speed & gusts Hamilton Is.

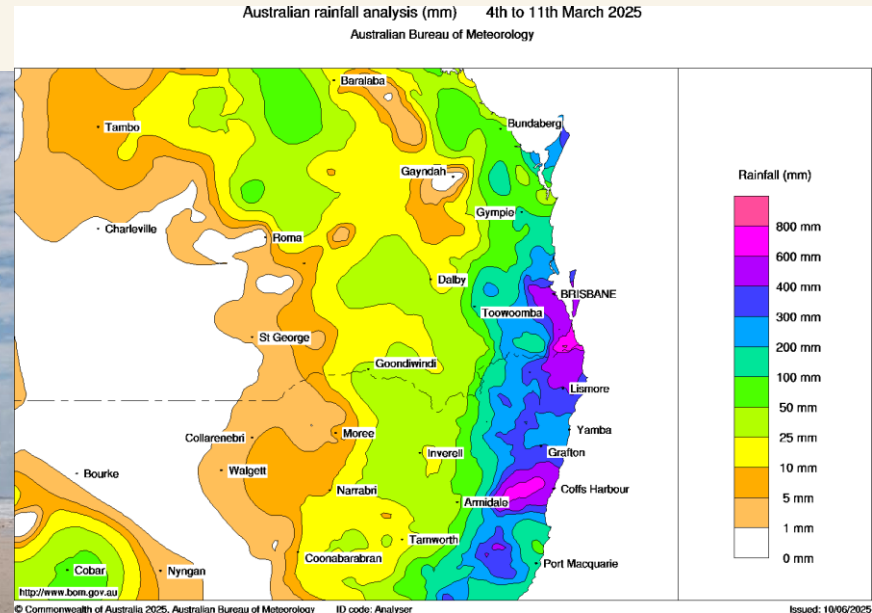
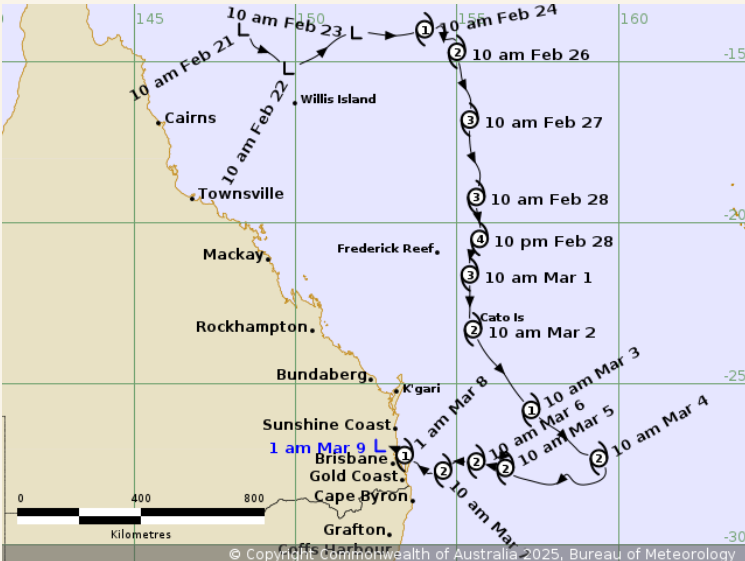
TC Alfred March 2025 Most impactful since TC Wanda (Cat 2 – Maryborough 1974)

Category 0-1 TC impact across Greater Brisbane, Gold Coast & Northern Rivers of NSW – Wind loading code Region B1.

Large circulation, slow moving at time of coastal impact. ~ 500,000 people without power for up to a week.

Strongest gusts: 120km/h Cape Byron (Cat 2), Cape Moreton 109 km/h, Gold Coast Seaway 107km/h & Redcliffe 104 km/h (Cat 1).

Most damage from wind / rain effects. Lower Springbrook received 1148mm & Dorrigo 917mm from this event. Several rivers reached major flood levels, but major centres escaped significant inundation.



Track & Intensity of Alfred

Erosion of Main Beach, Gold Coast

Weekly Rainfall totals to 11 March 2025

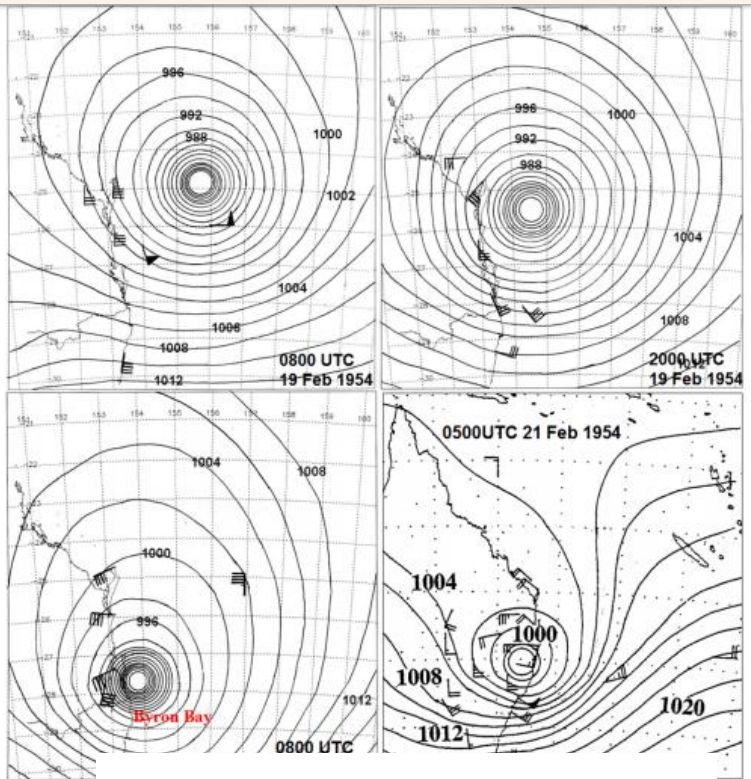
1954 Gold Coast Tropical Cyclone

Category 3 TC impact at Southport (Qld)- Wind loading code Region B1.

Central pressure 962 hPa at time of coastal impact, lowest pressures recorded in Coolangatta but the eye passed over MacIntosh Island, Southport. (Best track data is incorrect).

Major damage across the region. Waves flooded road at Kirra. Houses flooded to roof top at MacIntosh Island (Southport) with record floods Tweed Heads, Murwillumbah, Lismore, Casino.

Fast moving - 40 km/h.



MSLP Analyses GC Cyclone
By Jeff Callaghan



Courier Mail Front Page
22 Feb 1954



MacIntosh Is 1950 & 2015



TC Seroja April 2021

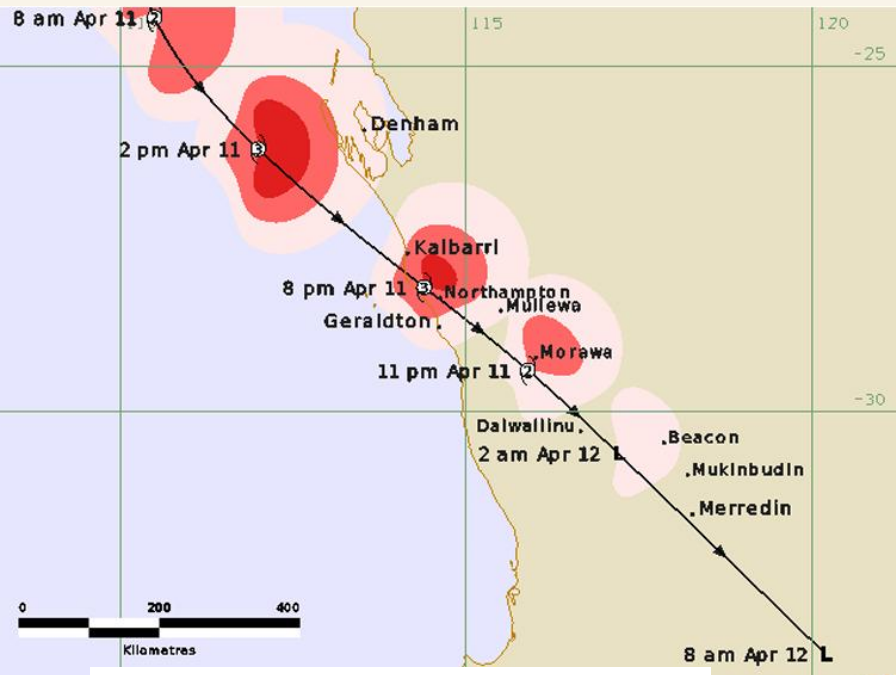
Category 3 TC impact at Kalbarri – Port Gregory (WA) – Wind loading code Region B. Asymmetric, fast moving mid-sized TC.

Category 3 TC at time of coastal impact. Strongest observed TC impact in the satellite era (1977 onward) for west coast Region B.

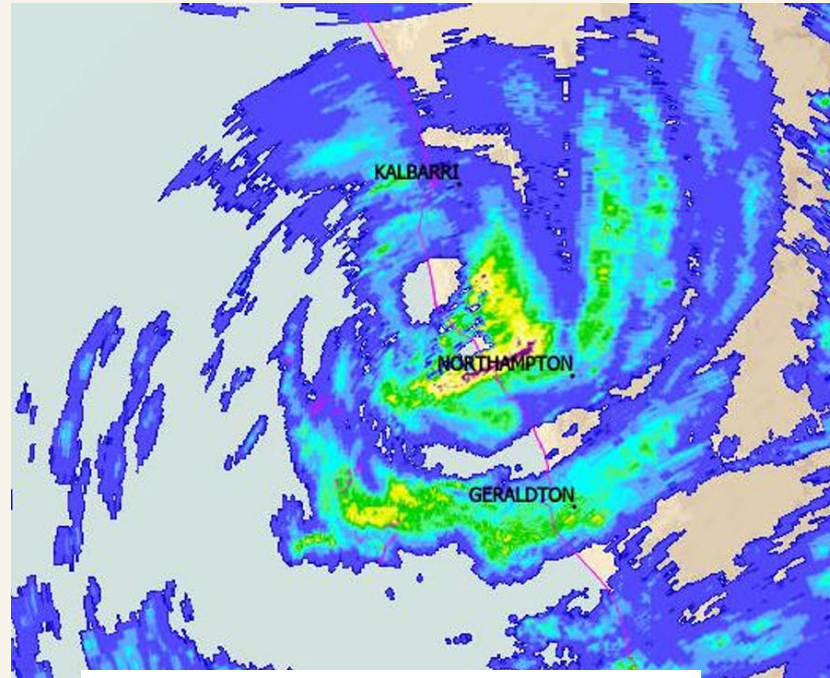
Kalbarri 3 second wind gust (Meanarra Tower) of 170km/h. Doppler radar estimate for sustained winds on coast near Kalbarri ~200km/h.

Damaging wind gusts right across WA Wheatbelt with significant damage to many towns. Jetty collapse at Carnarvon.

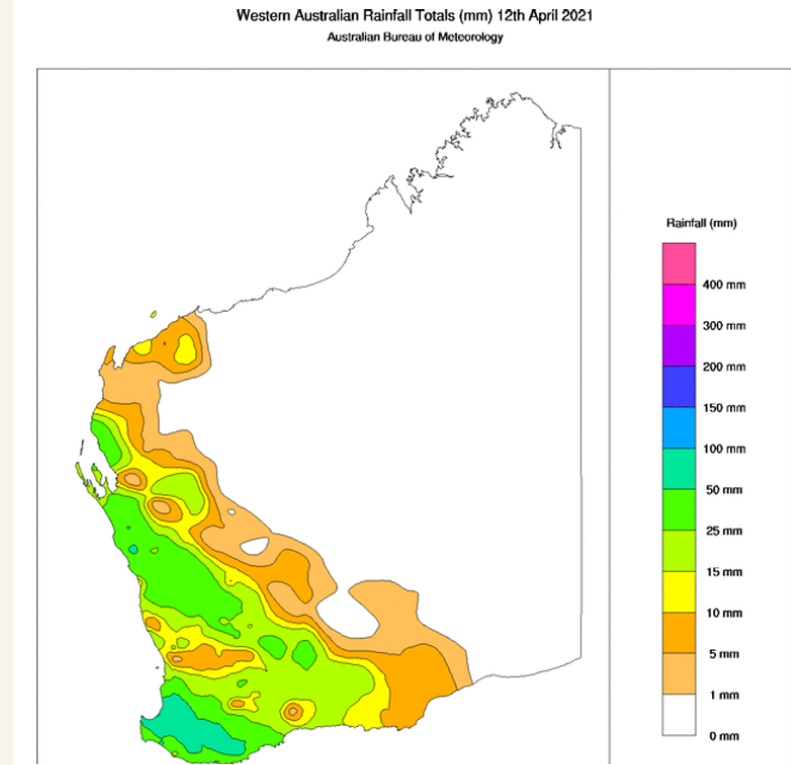
Fast moving (50-65 km/h) – so marked asymmetry with strongest winds from the N through SE of the cyclone centre.



Track & Intensity of Seroja



Radar reflectivity at time of coastal crossing



24hr Rainfall totals 12 April 2021

TC Alby April 1978

Category 4 TC offshore (930hPa), Cat 2 impact SW WA, including Perth – Wind loading Region A. Extra-tropical structure.

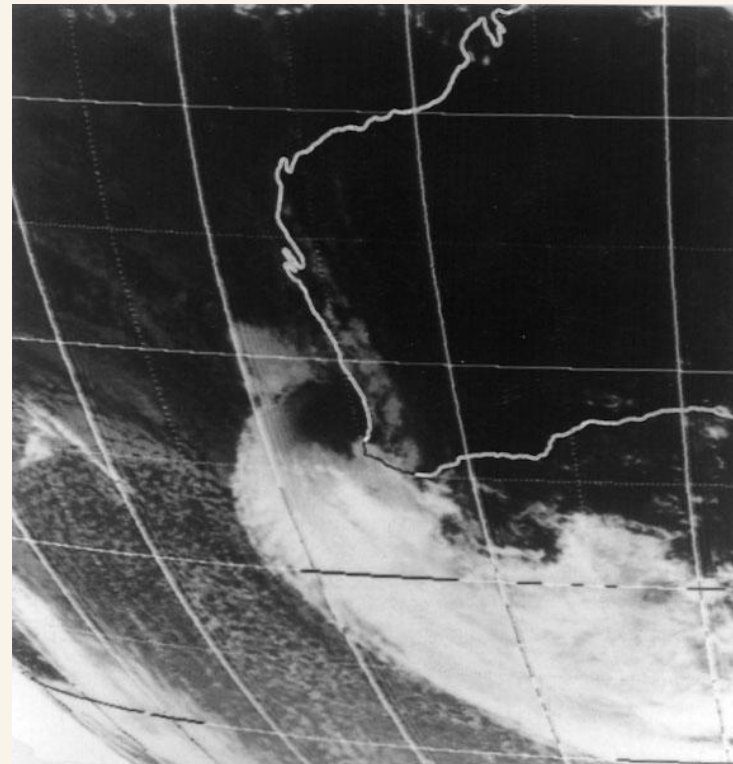
Most destructive TC on record for WA. Gale force winds observed up to 450km from the eye over land. Albany gust 150km/h, Fremantle 143 km/h, Perth city 122km/h. Over 360 significant bushfires affected 43 shires with stock losses over 10,000 head of sheep, cattle and horses.

Alby did not cross the coast (100km off Cape Leeuwin) but produced a storm surge of 1.3m near Busselton. Storm surge inundated properties at Busselton, Bunbury and flooded front lawns in Rockingham.

Fast moving - 60 km/h past Perth, 90km/h past Cape Leeuwin.



Track & Intensity of Alby



GMS1 IR Satellite Image By NASA - NASA, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=14173616>



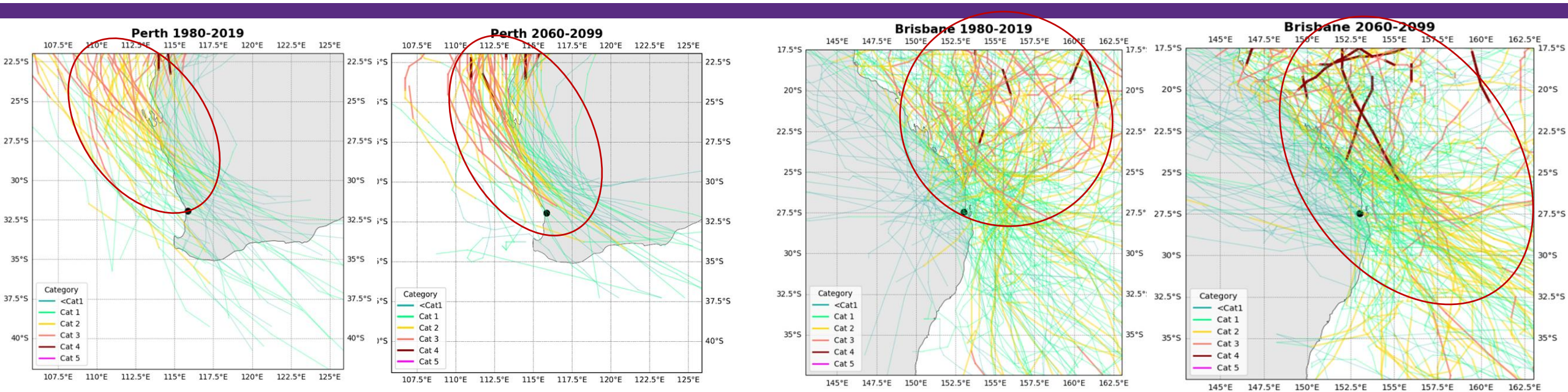
Bushfires (Top) & Floreat Beach erosion
Source: The West Australian

Potential Tropical Cyclone Climate Change Risks: Regions A & B

Historical Cat 3+ impacts south of 25°S are very rare. TC Seroja (2021) & the 1954 Gold Coast TCs are 2 cases.

All Cat 1+ CESM-HR (25km resolution) climate model predictions for TCs passing within 250km of Perth & Brisbane show marked variability over several decades. High Cat TCs still infrequent but with several Cat 3+ impacts south of 25°S in future decades. This implies risks of severe tropical cyclone impacts in Regions A & B rise significantly over the coming decades.

Source: IAG / NCAR research. Note these intensities are at 25km resolution - actual TC intensities can be 1 category more intense.



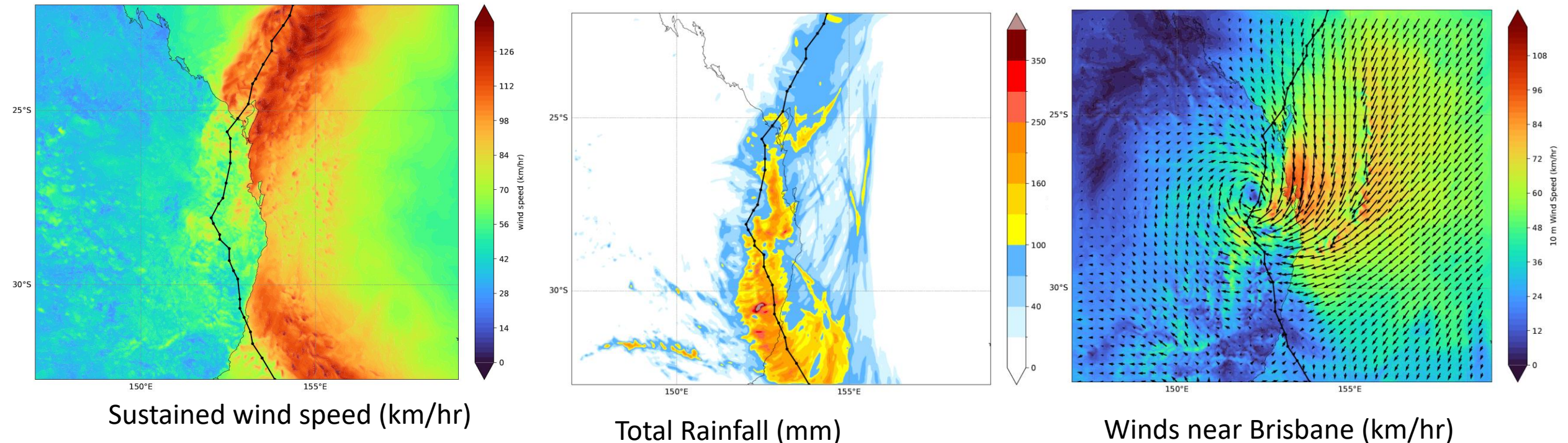
Detailed Future Climate Tropical Cyclone for SE Queensland

The results of a future climate tropical cyclone (~2074) from CESM-HR downscaled to 3km resolution (Model date: 3 Feb 2074).

The simulation shows the TC track with wind speed (left), total rainfall (centre) and wind vectors near Brisbane (right) as this TC crosses SE Queensland.

Peak sustained overland wind speeds in Wind Region B1 ~ 130km/h, gust ~190km/hr (Mid Category 3), highest accumulated rainfall 450mm

Source: IAG / NCAR research.





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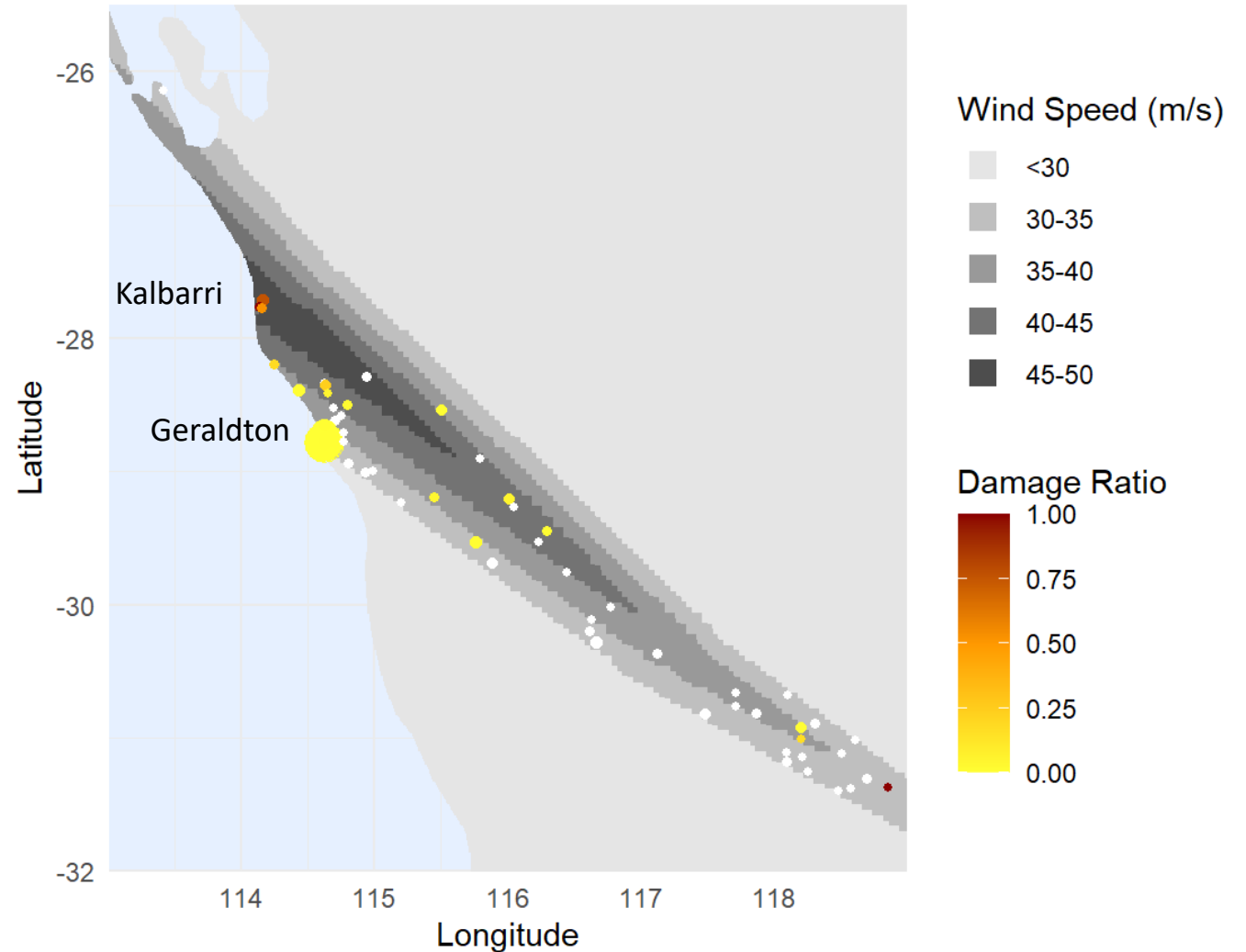
Tropical Cyclone Seroja Claims Analysis

Zachary Seggar

Damage Ratios Relative to Wind Speeds

- Very high damage ratios concentrated in the Kalbarri area.
- Isolated pockets of much higher damage ratios further inland that are in wind region A.
- Very low damage ratios in Geraldton highlighting the importance of not relying on a single event-level damage ratio to represent an event.
- Damage ratios should be examined by wind band, especially where exposure is uneven.

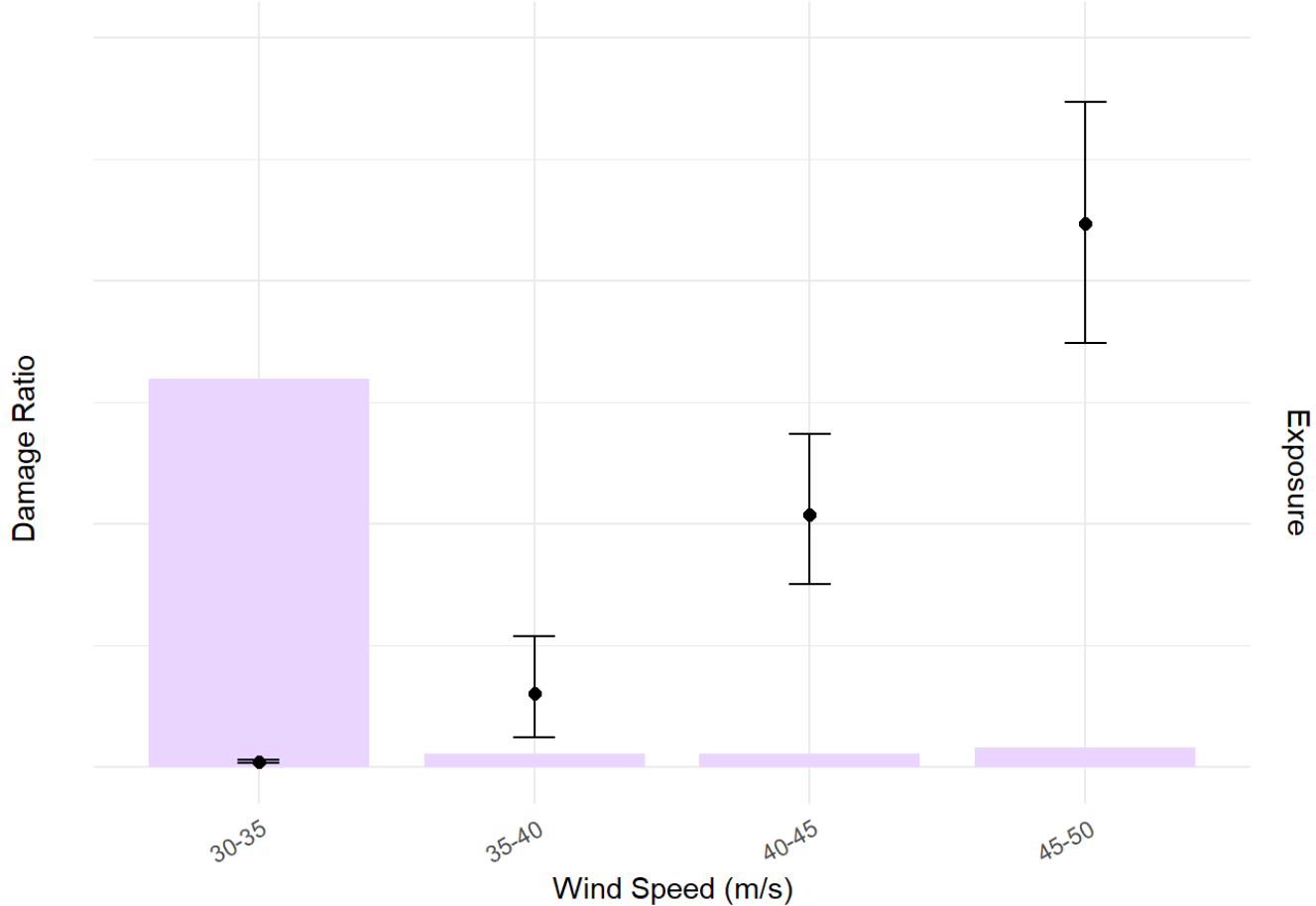
Seroja Windfield and Damage



Seroja Damage and Exposure – By Wind Band

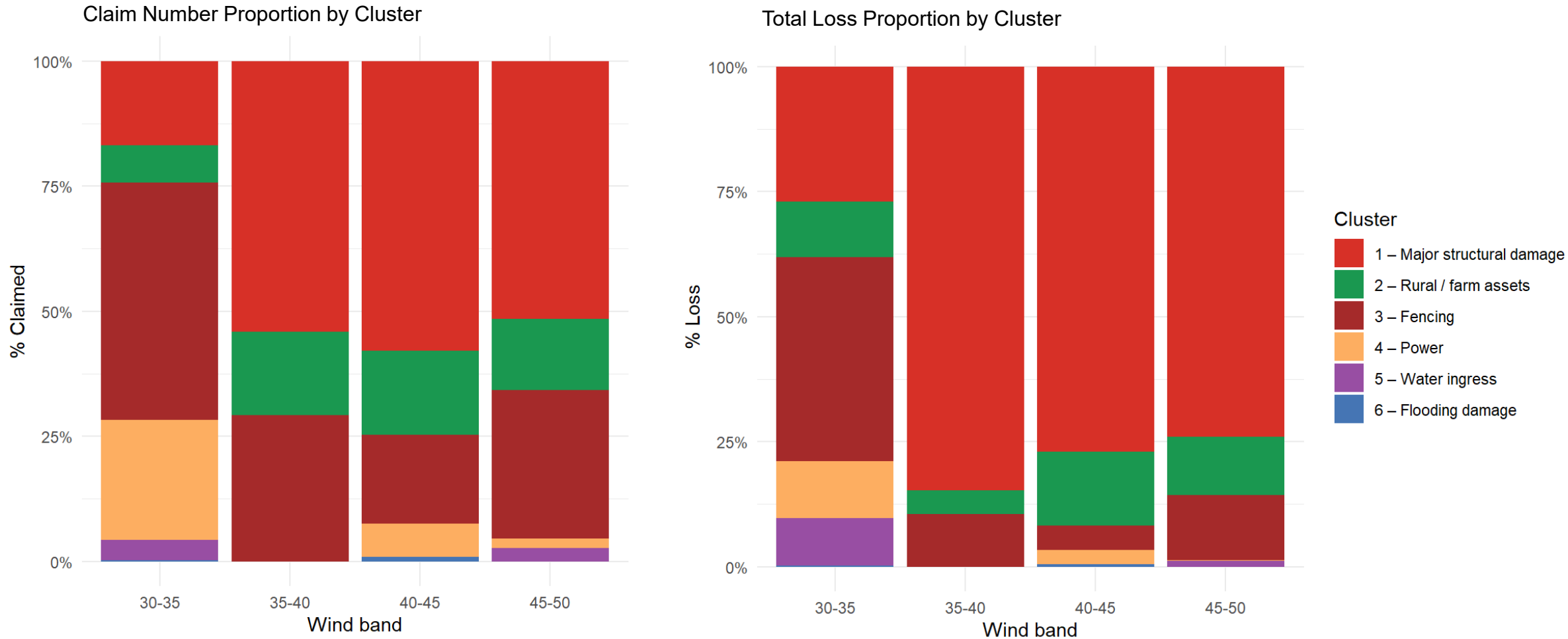
- Largest exposure sits within the 30–35 m/s wind band representing the Geraldton area.
- Corresponding damage ratio in Geraldton is well below 1%.
- Damage ratios increase sharply at higher wind speeds.
- The second highest exposure is in the 45-50 m/s wind band which represents the Kalbarri region.
- Damage ratios in Kalbarri exceed 20% highlighting likely widespread structural damage.

Seroja Damage Ratio with Bootstrap 95% CI



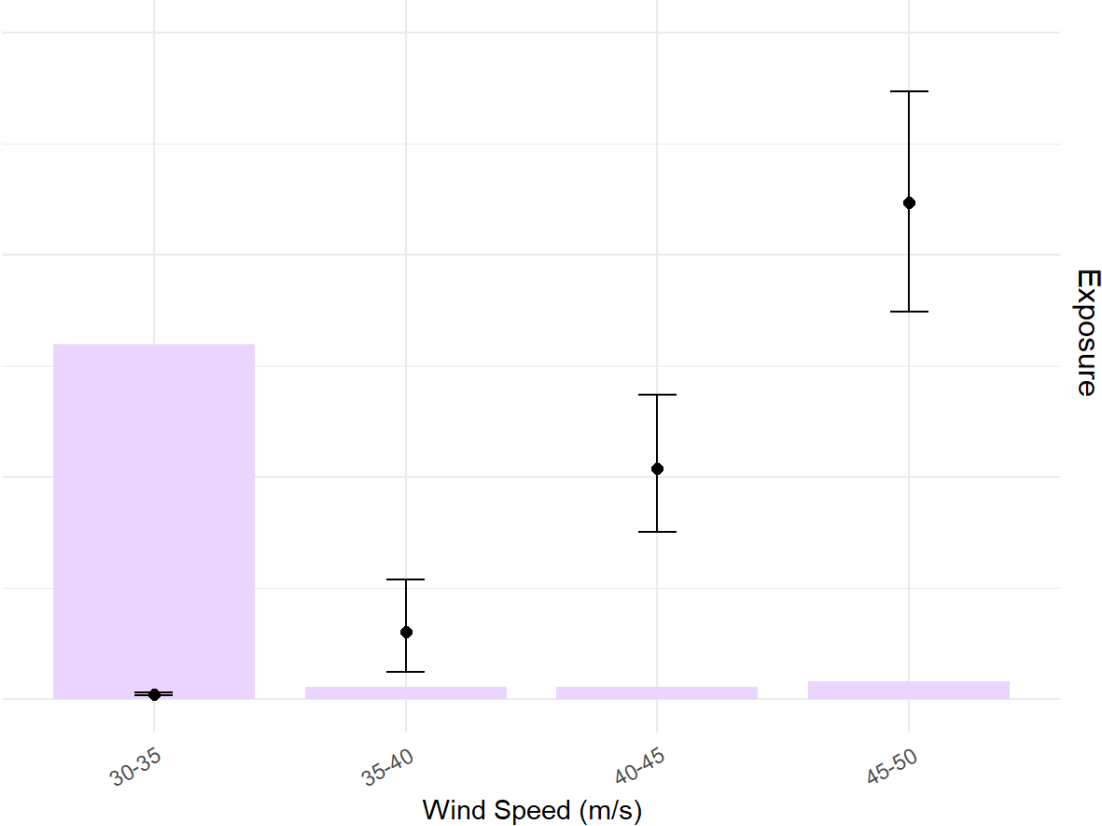
m/s	30-35	35-40	40-45	45-50
km/h	108-126	126-144	144-162	162-180
Category	1	2	2	3

Seroja – Type of Damage by Claim Number and Total Loss

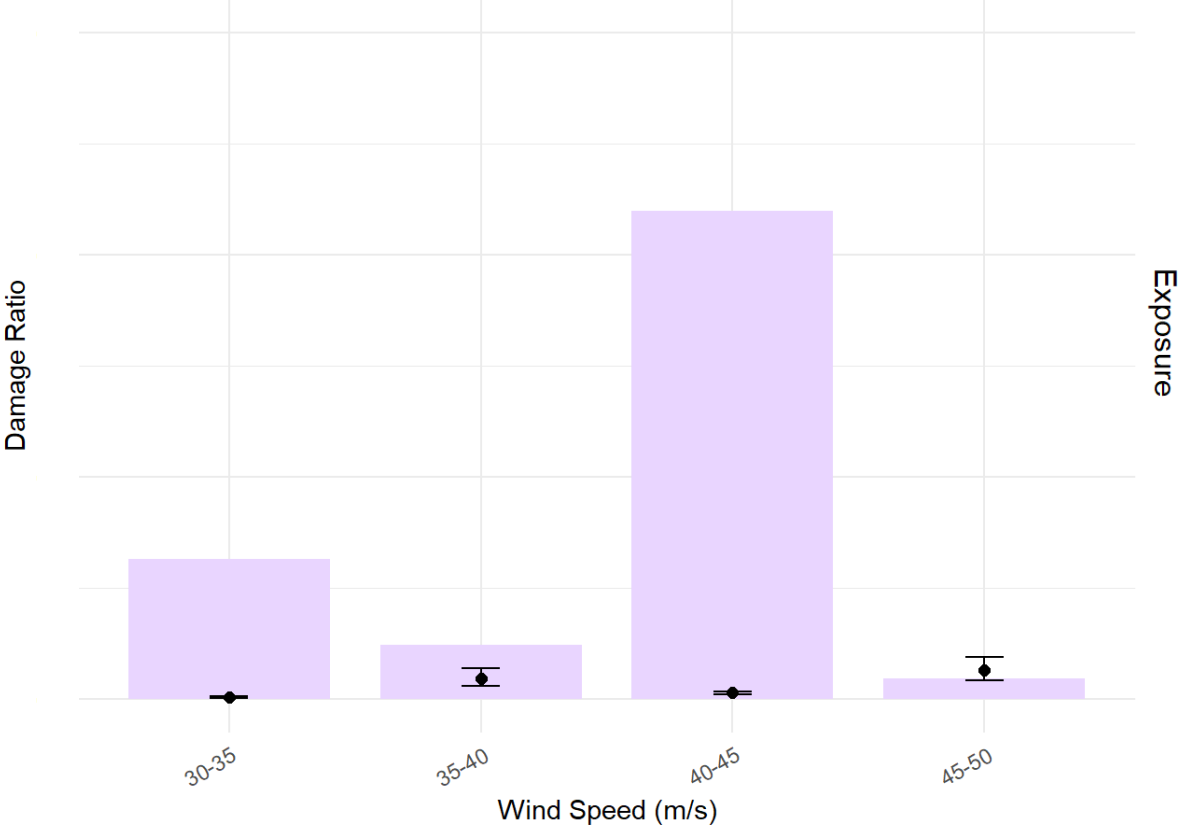


Seroja vs Debbie – Damage Ratio by Wind Band

Seroja Damage Ratio with Bootstrap 95% CI

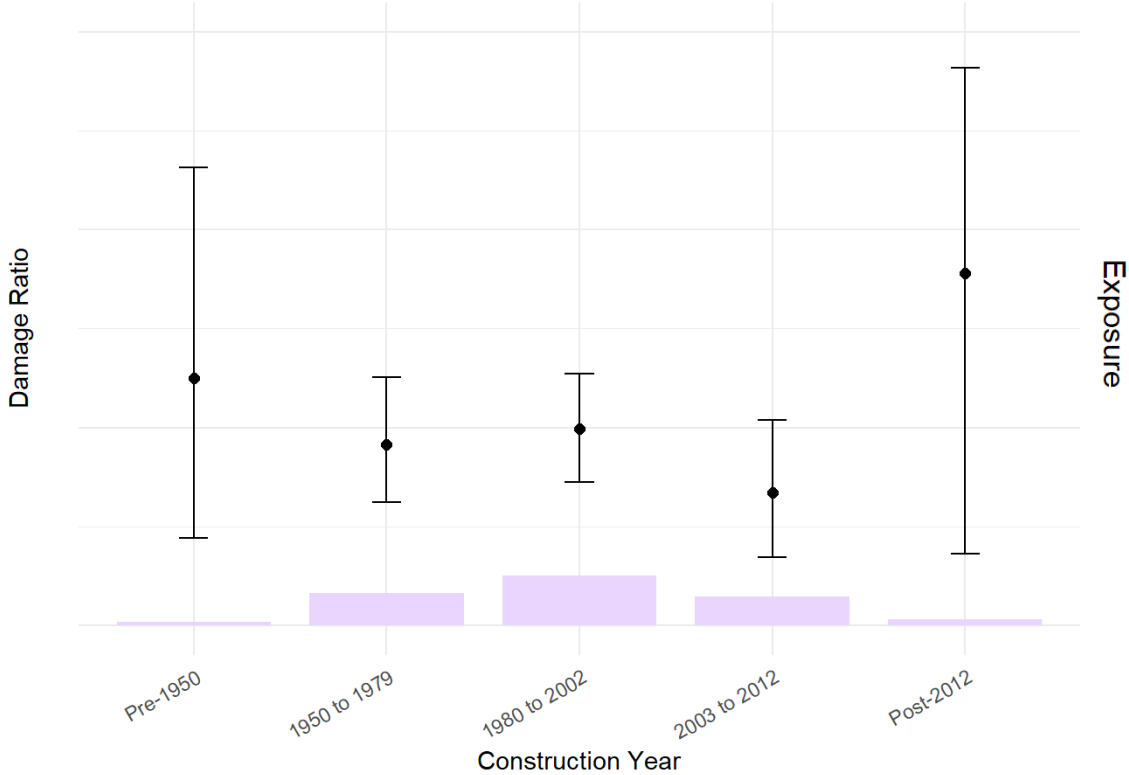


Debbie Damage Ratio with Bootstrap 95% CI

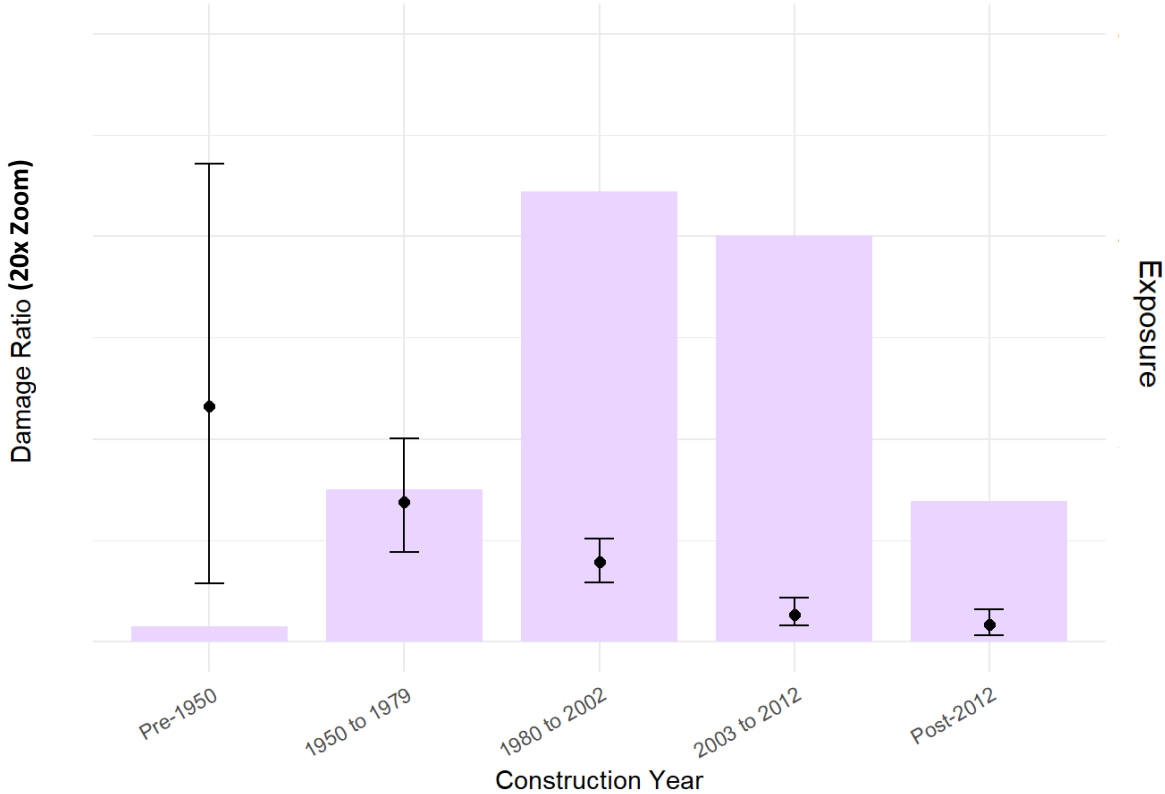


Seroja Vs Debbie – Damage Ratio By Year Built for Wind gusts between 40-50m/s

Seroja Damage Ratio with Bootstrap 95% CI



Debbie Damage Ratio with Bootstrap 95% CI



Beyond Building Code

- Large differences between Proserpine/Airlie Beach and Kalbarri that are not fully explained by differences in the building code.
- Kalbarri characteristics:
 - Wide spacing between houses
 - Little vegetation shielding.
 - Sits in valley open to onshore flow.
- Proserpine/Airlie Beach
 - Irregular coastline
 - Bays and headlands provide protection with immediate terrain rise behind the foreshore.
 - Proserpine is in a valley.
- Another cyclone impact in the region
- Local Attitudes
- Rainfall
- Construction Types





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Institute.**

Tropical Cyclone Seroja, ex-Tropical Cyclone Alfred and the future

Dr Geoff Boughton

Possibility and effects of tropical cyclones in regions A and B



TC Seroja, ex TC Alfred and the future



We acknowledge the original custodians of the land throughout Australia



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Effects of recent tropical cyclones in region B

- TC Seroja – what it did and why
- TC Alfred – what it did and why
- TC Alfred – what it could have done if the forecast event had arrived
- What we can learn from these two events to reduce the impact of future cyclones in region B

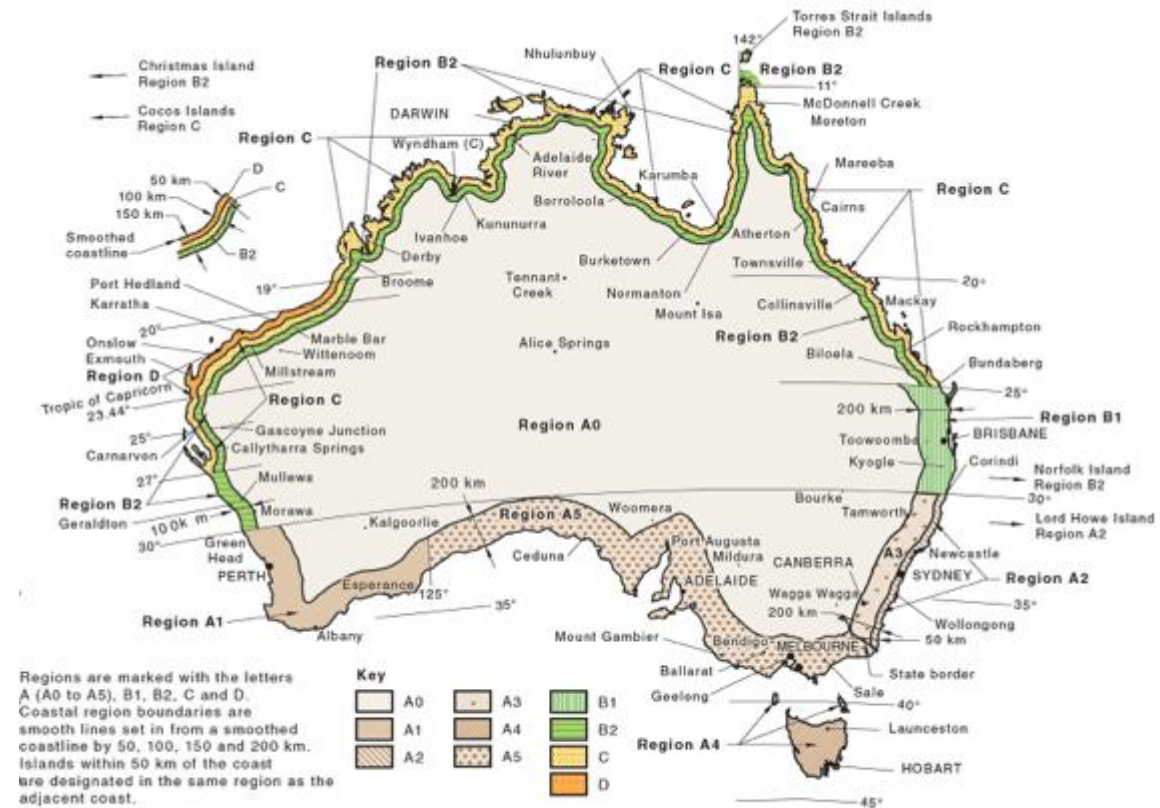
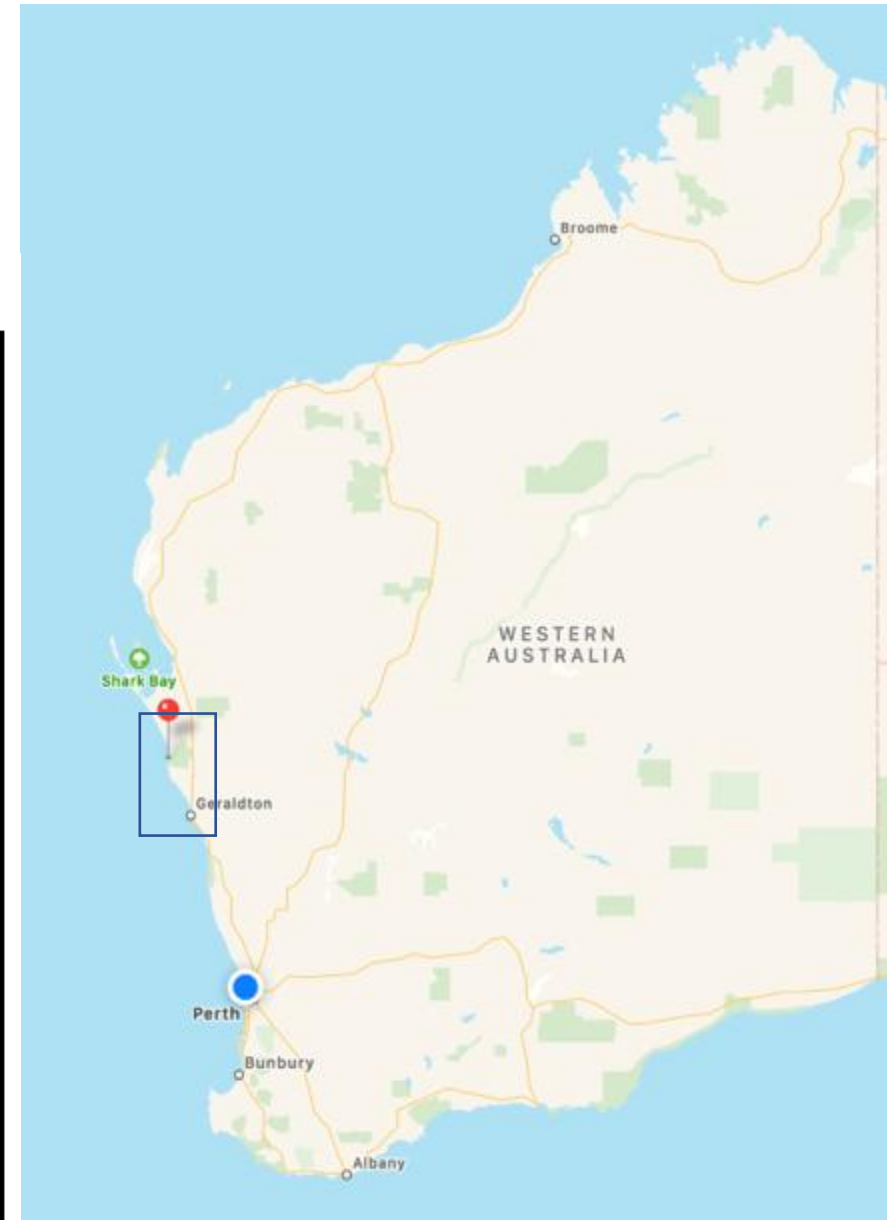
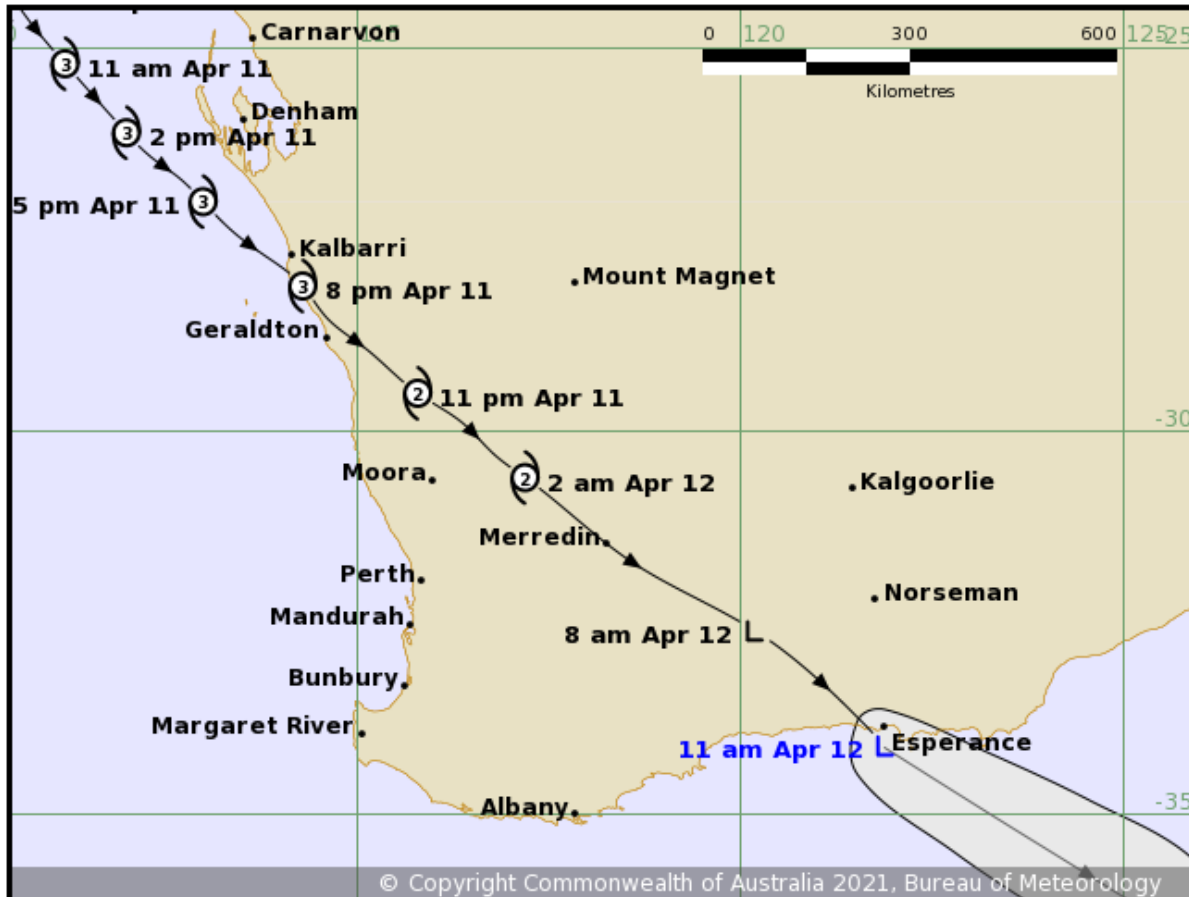


Figure 3.1(A) — Wind regions — Australia



TC Seroja track and affected area

Issued at 11:33 am AWST Monday 12 April 2021. Refer to Tropical Cyclone Advice Number 29.



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Total roof loss and wall damage

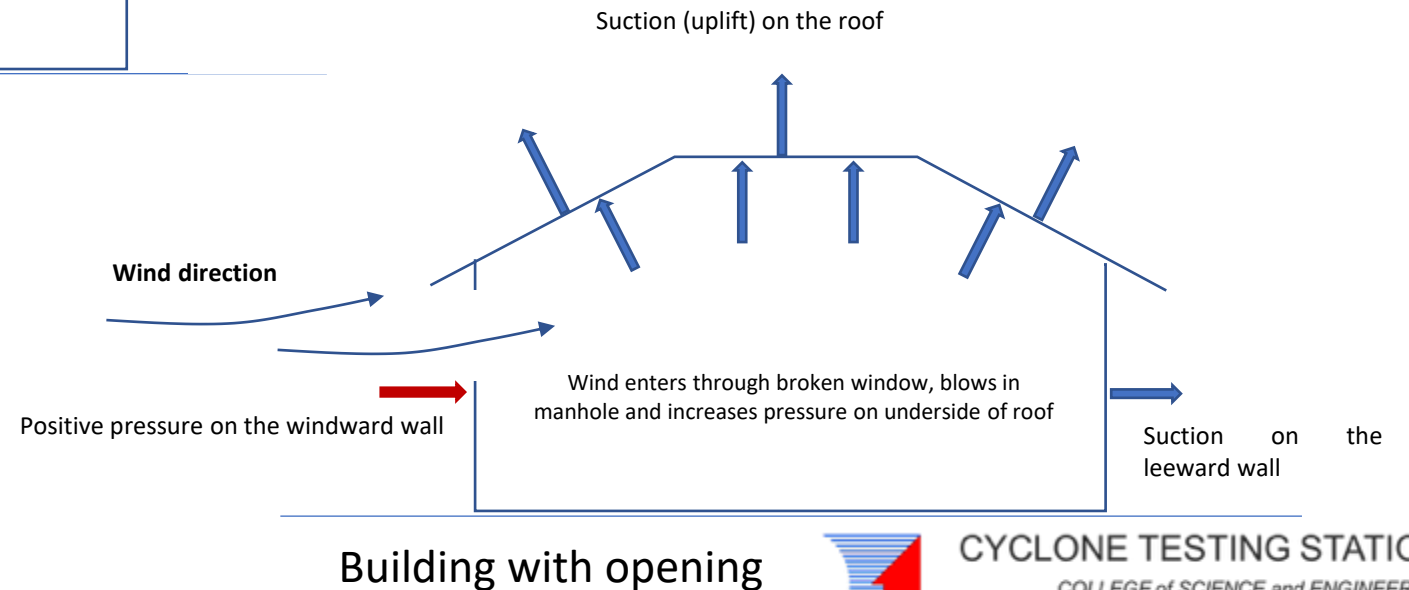
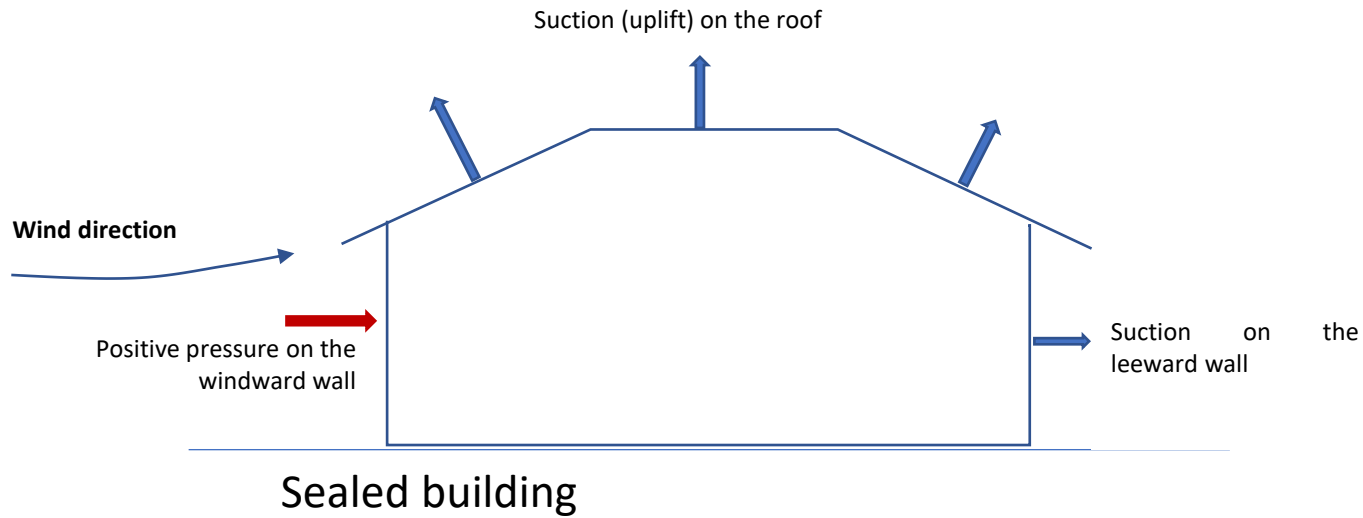


~ 80% design wind speed



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Internal pressure





~ 80% design wind speed



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~ 80% design wind speed



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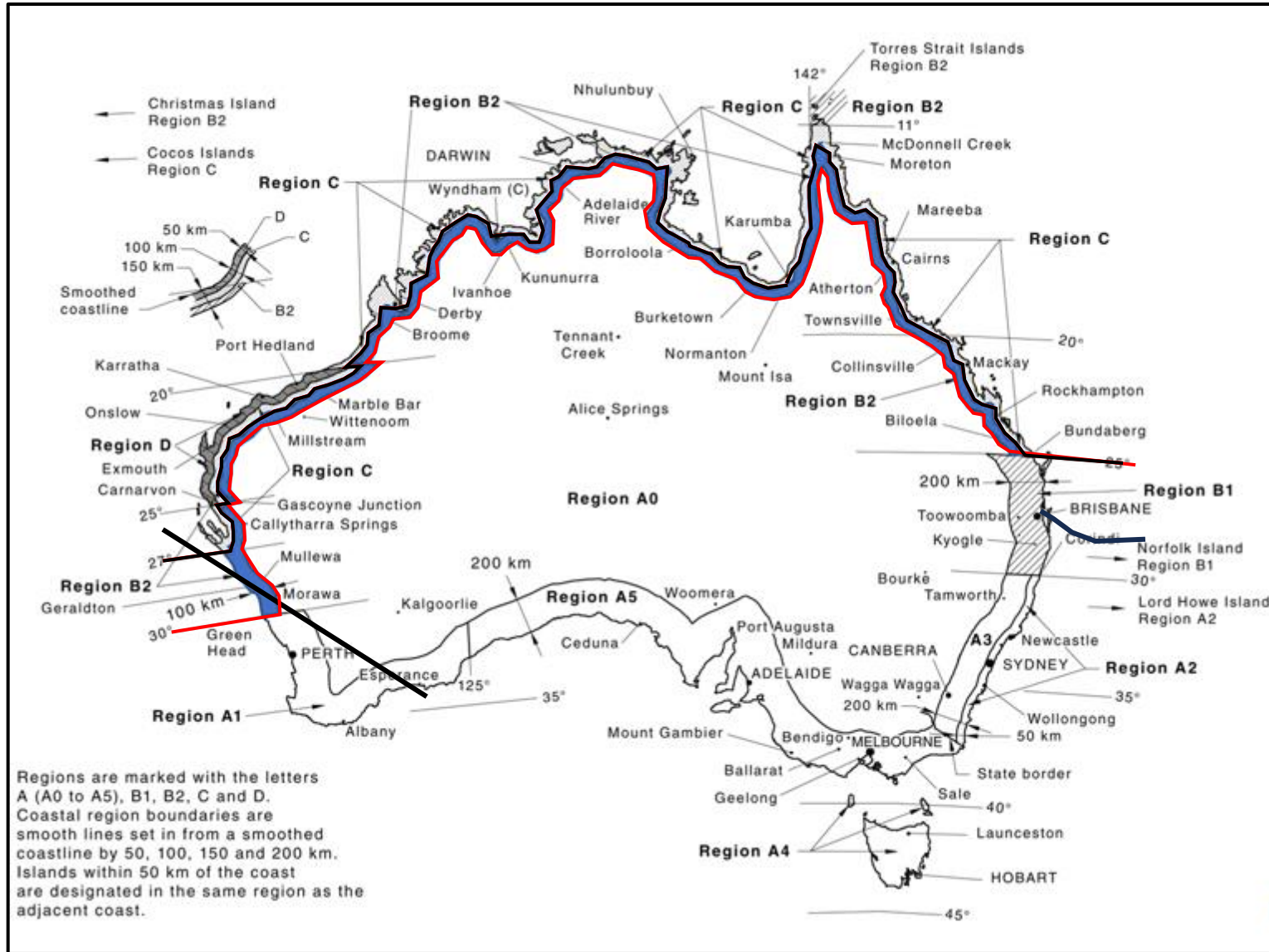
Cyclone regions

Up to 2024 regions C and D

- design C, D for internal pressure

Since 2024 regions B2, C, D

- design B2, C, D for internal pressure



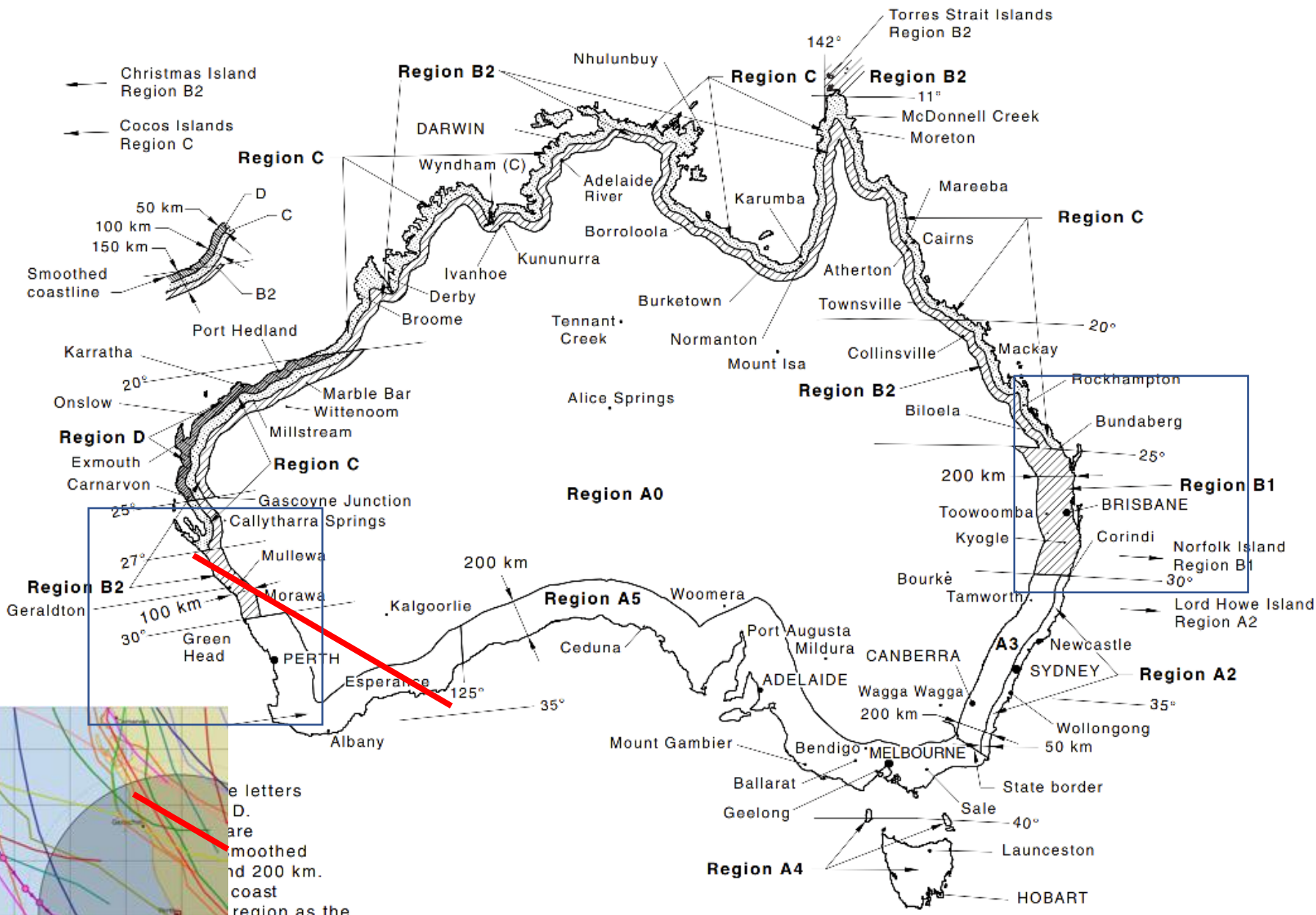
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Wind-borne debris







Christmas Island
Region B2

Cocos Islands
Region C

50 km
100 km
150 km

Smoothed coastline

D
C
B2

Region C

Region B2

Region C

Region B2

Region C

Region D

Region C

Region A0

Region B2

Region B1

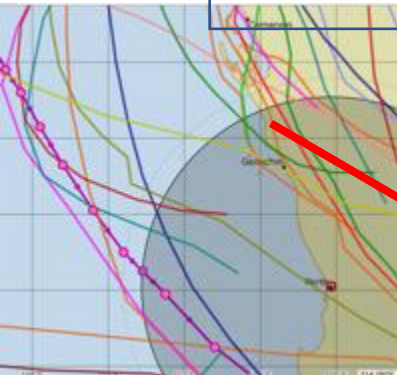
Region B2

Region A5

A3

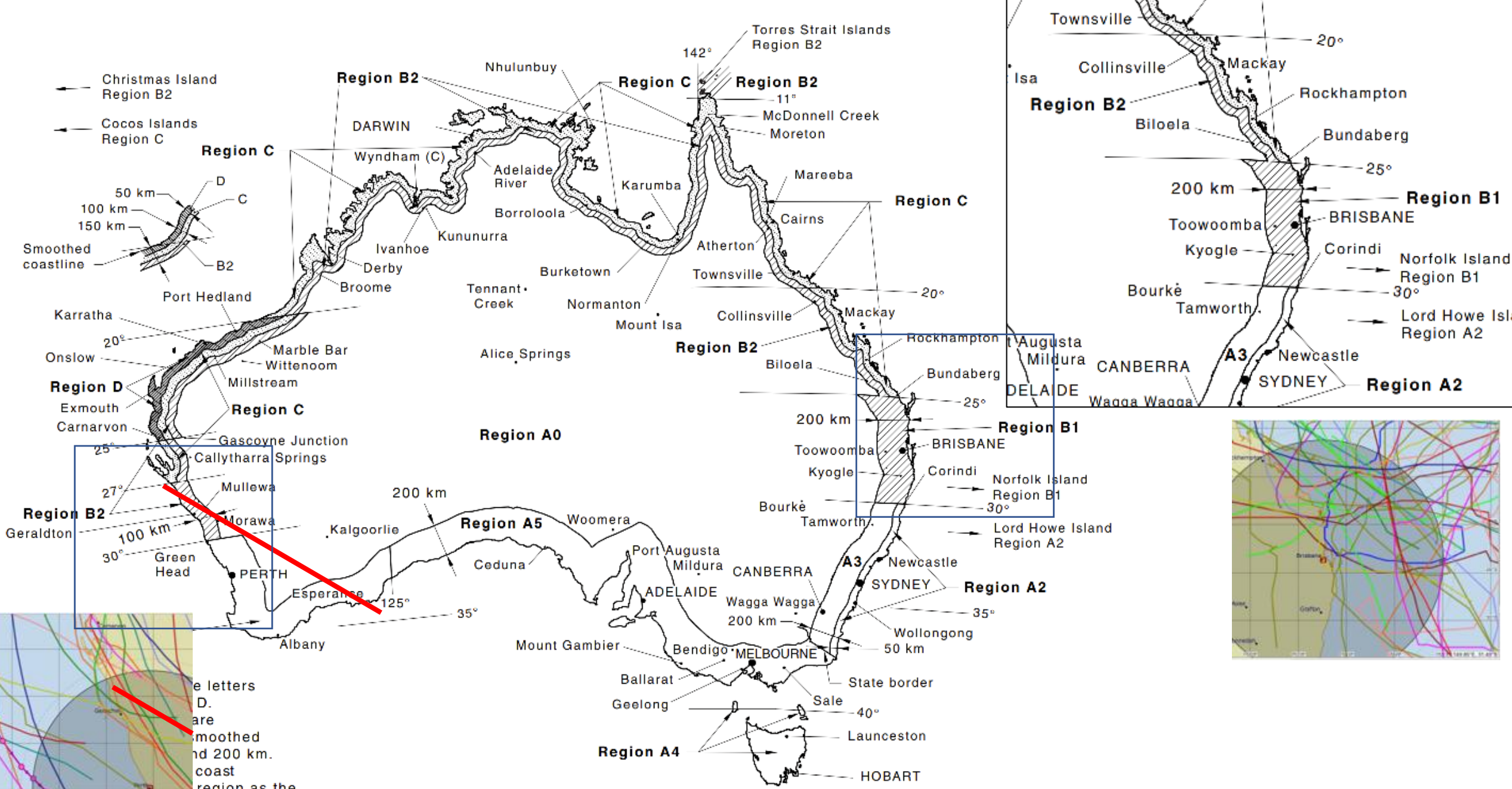
Region A2

Region A4



The letters
D.
are
smoothed
and 200 km.
coast
region as the



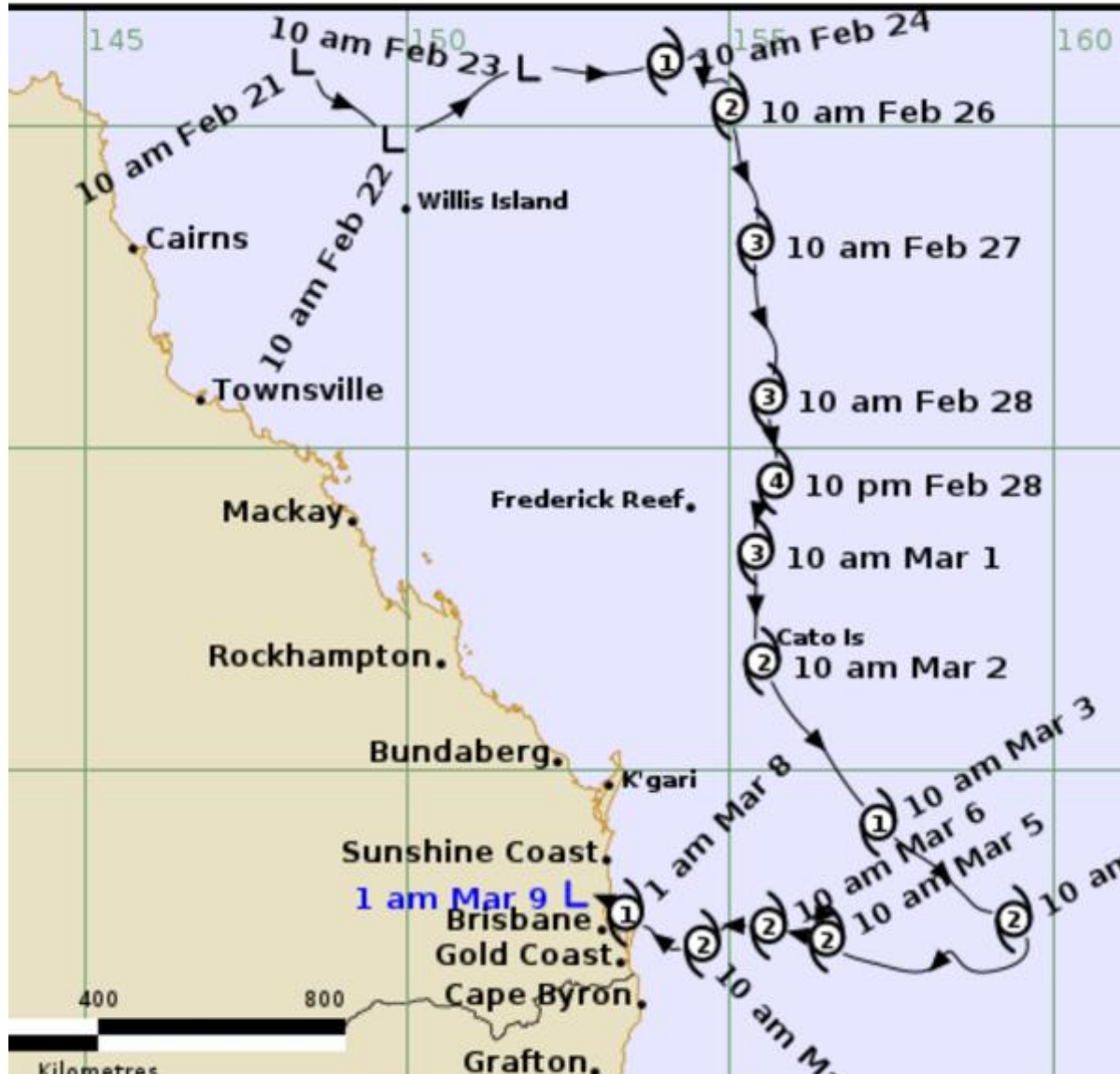


The letters D, are smoothed and 200 km. coast region as the



TC Alfred

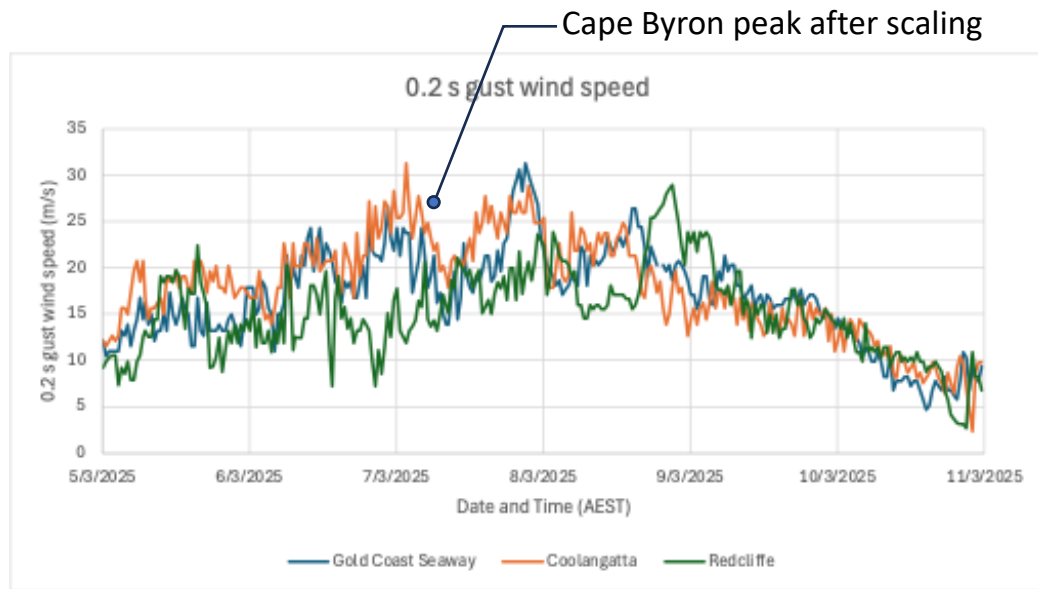
am AEST Sunday 9 March 2025. No Tropical Cyclone Advice is current for this s



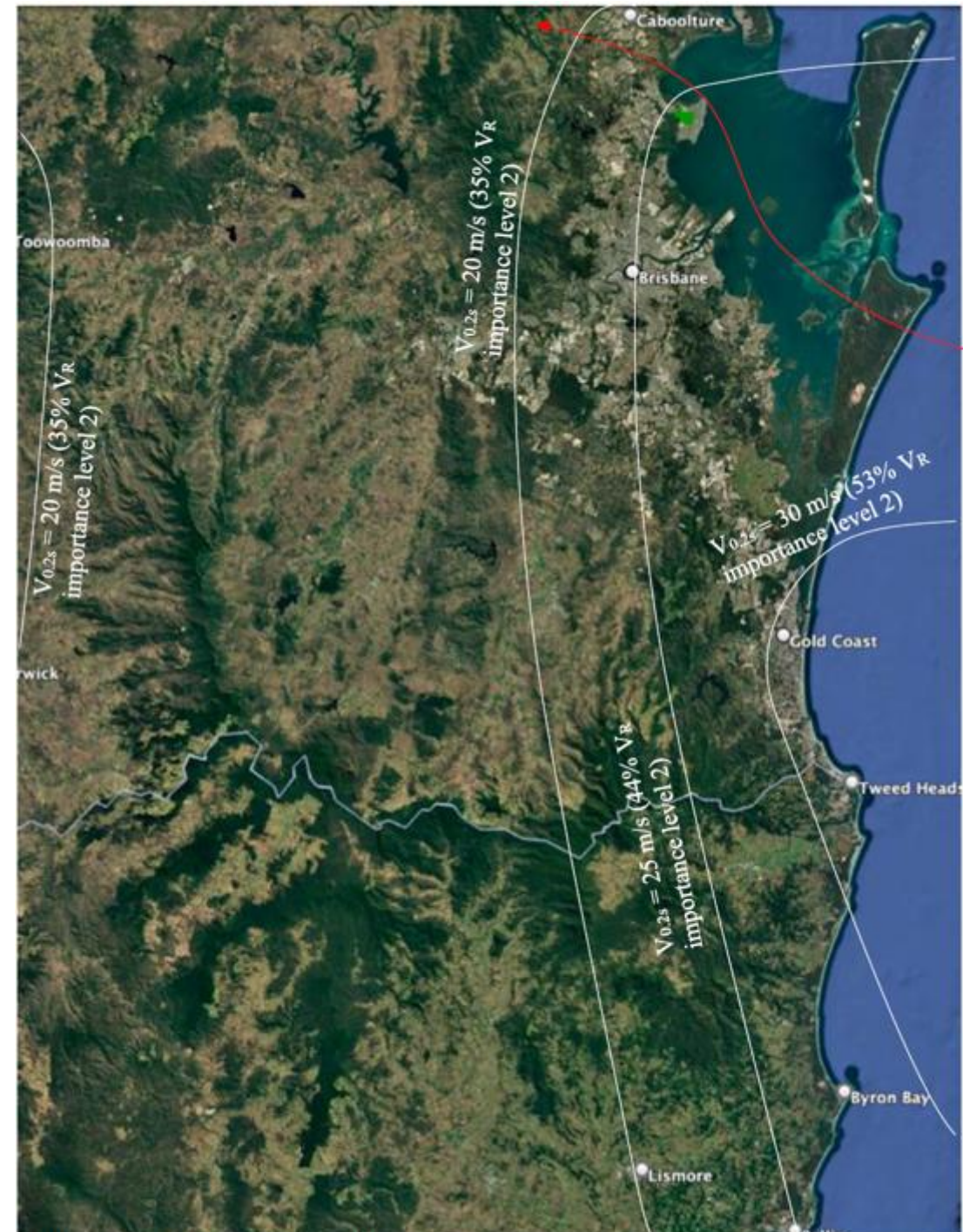
- Very wide
- Slow moving
- Lots of rain
- Stalled as a Cat 1 near Moreton Bay
- Crossed coast as an ex-TC



TC Alfred Wind speeds



Max gusts approx. 32 m/s
equivalent to 10 m on flat open land
Days of driving wind and rain

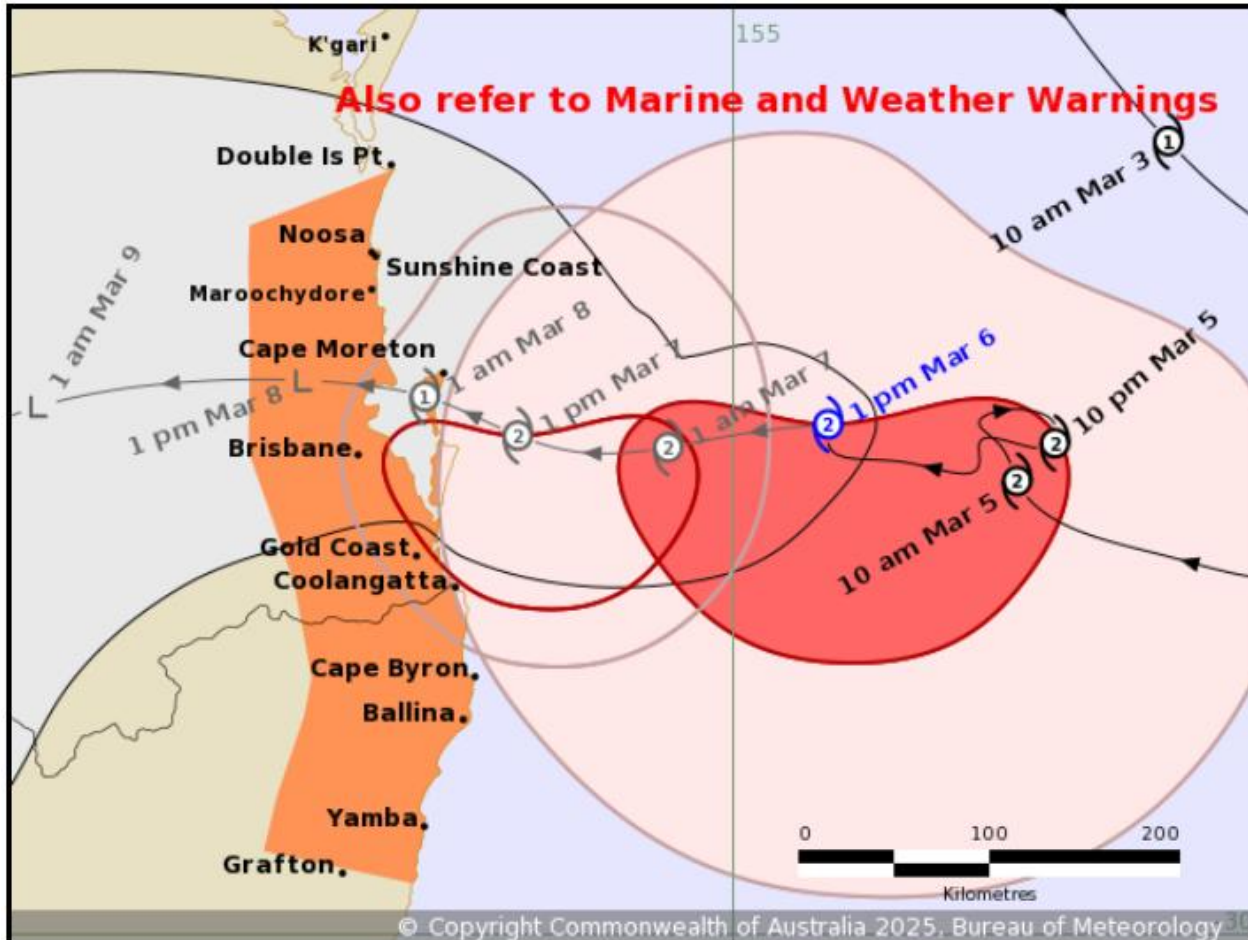


TC Alfred forecast – 155 km/h gusts

TROPICAL CYCLONE FORECAST TRACK MAP

Tropical Cyclone Alfred 22U

Issued at 1:33 pm AEST Thursday 6 March 2025. Refer to Tropical Cyclone Advice Number 21.



During its journey West
Winds forecast at landfall (Gold
Coast/Brisbane): 140 to 155 km/h

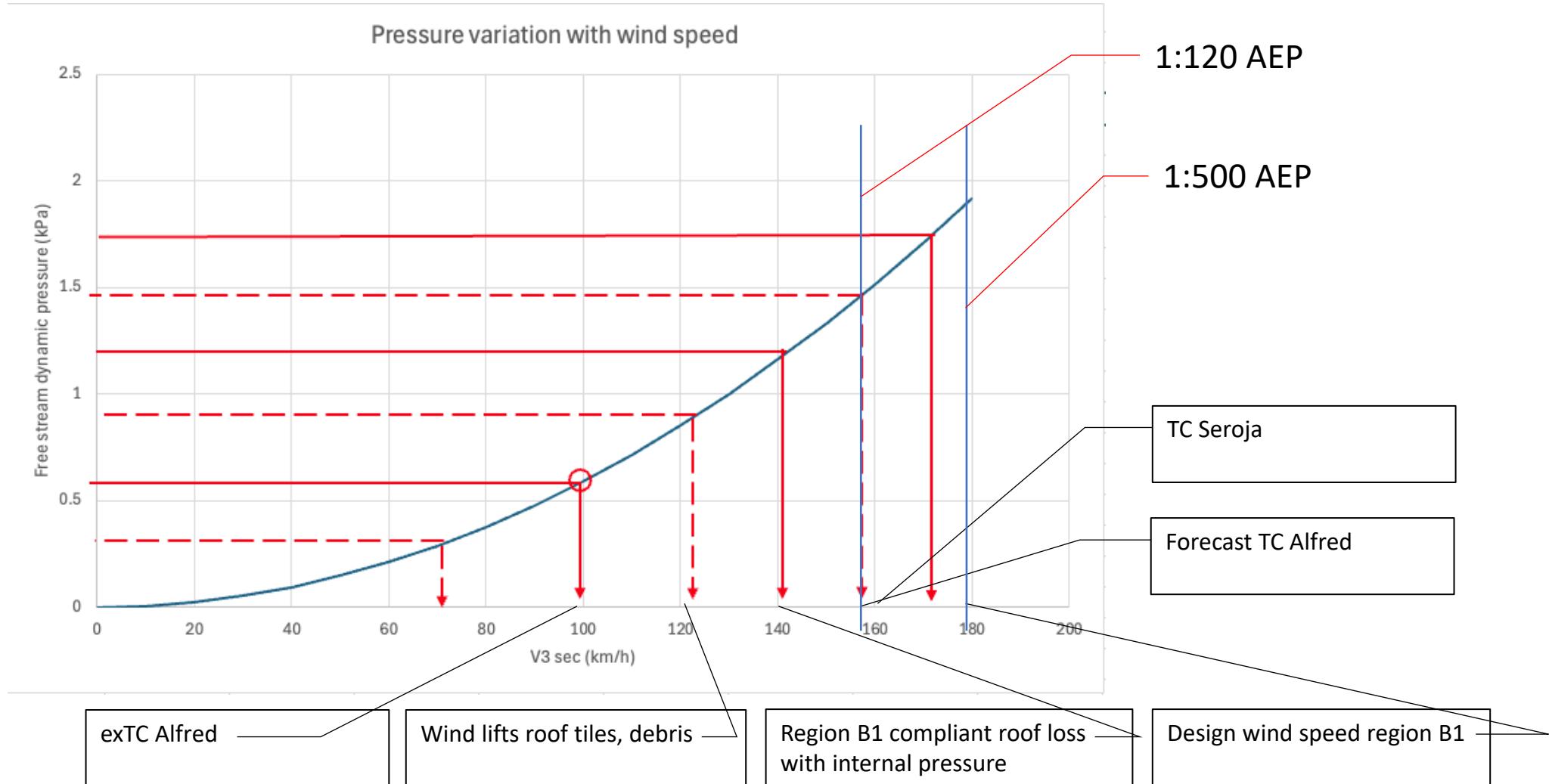


After forecast TC Alfred?

- Consequences of 155 km/h winds
 - Similar to TC Seroja
 - > 200,000 homes with roof damage
 - > 1.4 times annual housing starts
 - > 500,000 people homeless
-
- Need to learn from near misses



Thresholds of damage



New region B2?

Potential for changing 50 km strip of SEQ and NE NSW from B1 to B2

Design for internal pressure

Incremental housing cost ~1%

Minimise consequences of future medium probability events (1/120)

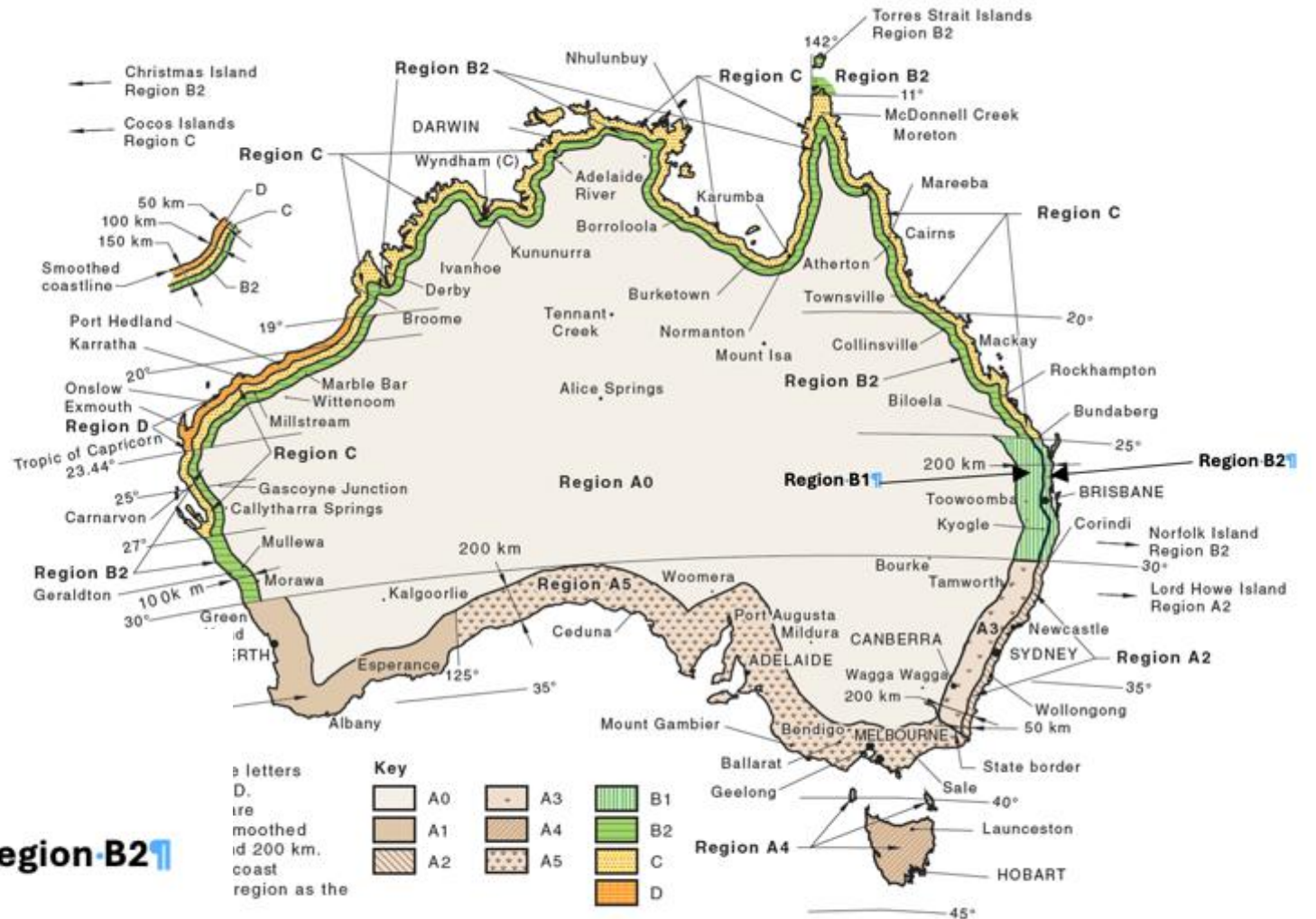


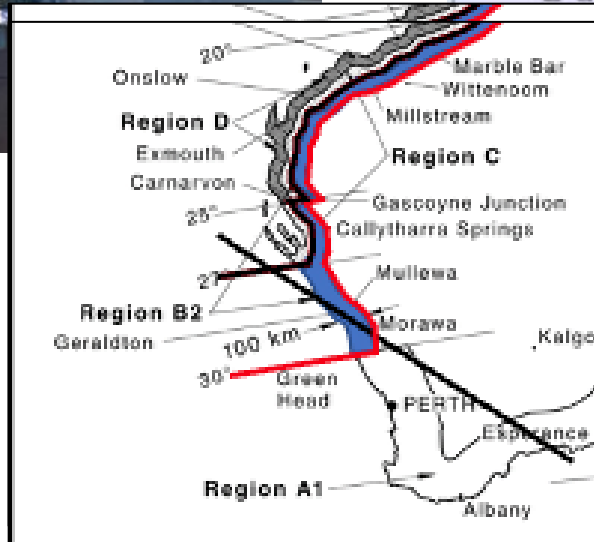
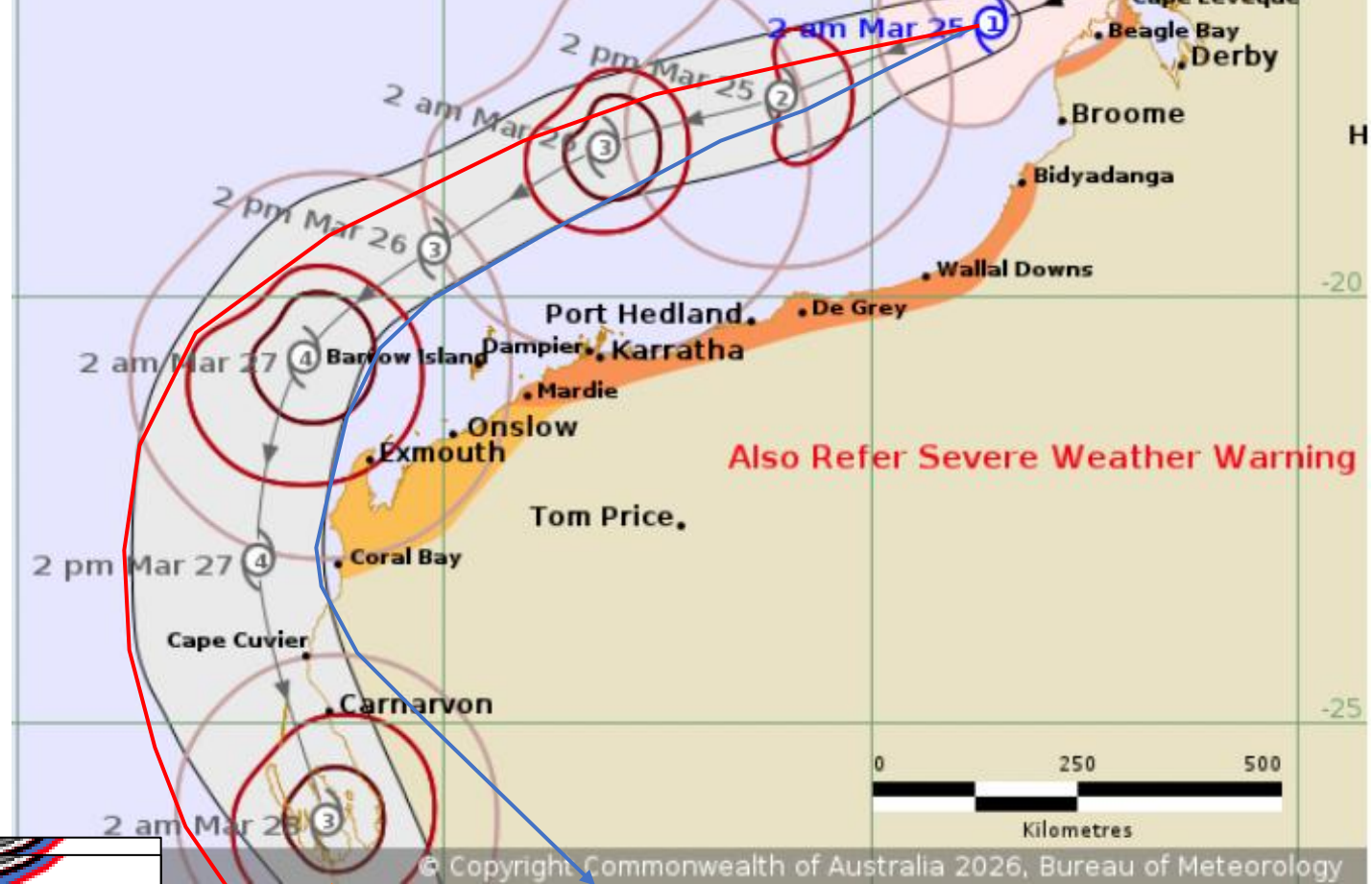
Figure 3.1(A) — Wind regions — Australia



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TC Narelle?



Kalbarri
Geraldton
Perth



Q&A



Join at slido.com
#1481821



Question time





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Thank you

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