bushfire&natural HAZARDSCRC

IMPROVED MODELING OF STORM SURGES AND WAVES ALONG THE AUSTRALIAN COAST

AFAC 2015, Adelaide

Yasha Hetzel, C. Pattiaratchi, I. Janekovic

School of Civil, Environmental and Mining Engineering/ UWA Oceans Institute
The University of Western Australia, WA

Australian Government
Department of Industry and Science
Business Cooperative Research Centres Programme

THE UNIVERSITY OF WESTERN AUSTRALIA

FIRE AND FLOOD

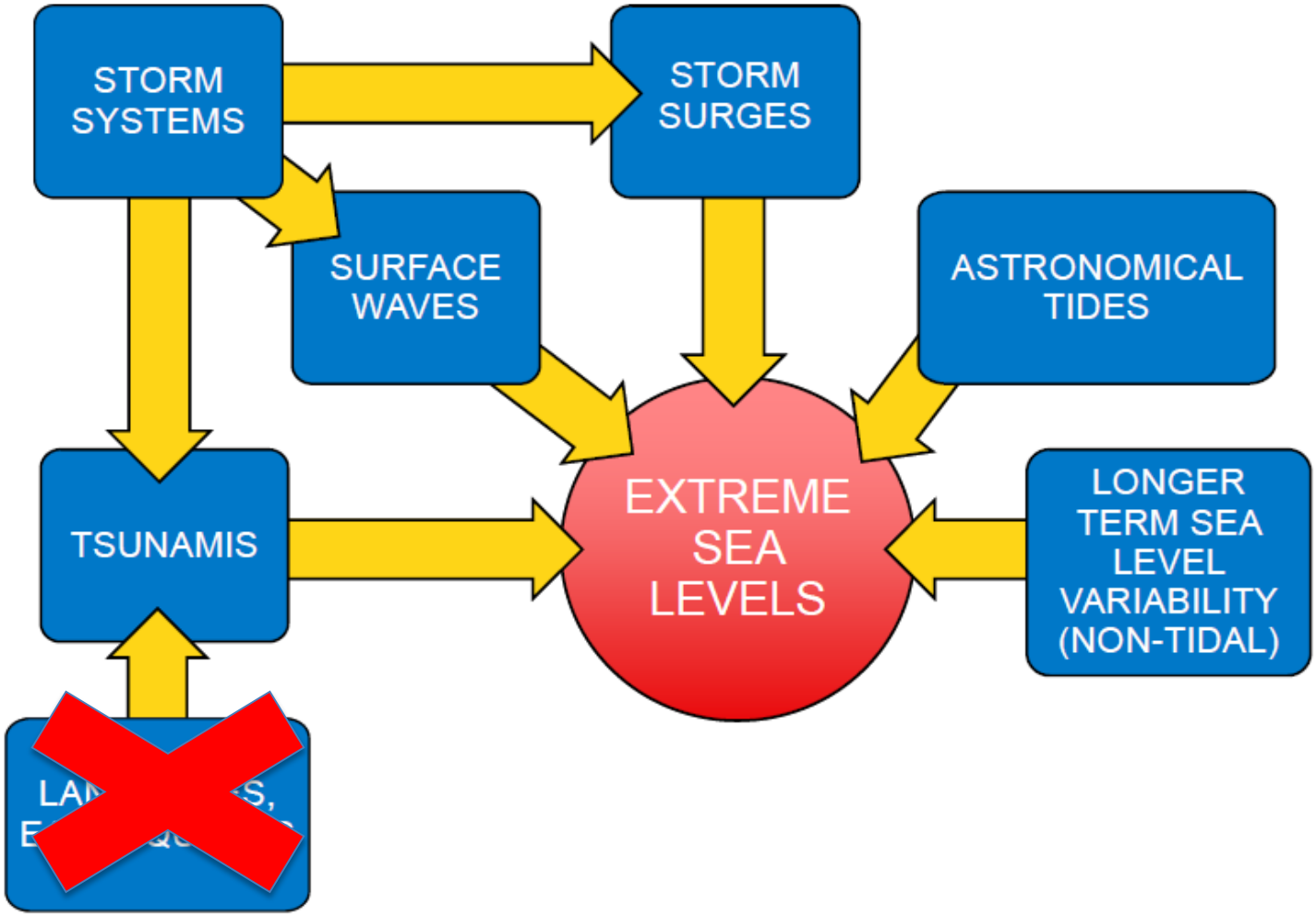
EXTREME WEATHER EVENTS

Many processes and scales, modeling challenges

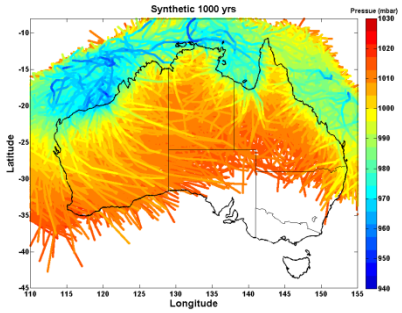
AIM = IMPROVED PREDICTIONS OF EXTREME SEA LEVELS

- Planning
- Public warnings
- Disaster response
- Harbour operations

EXTREME SEA LEVELS

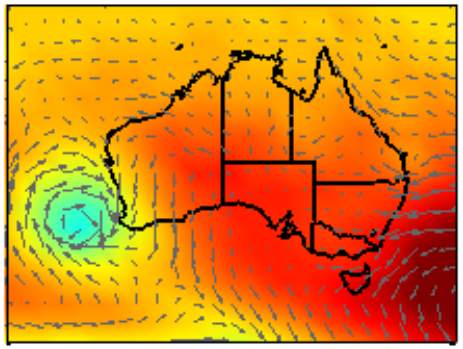


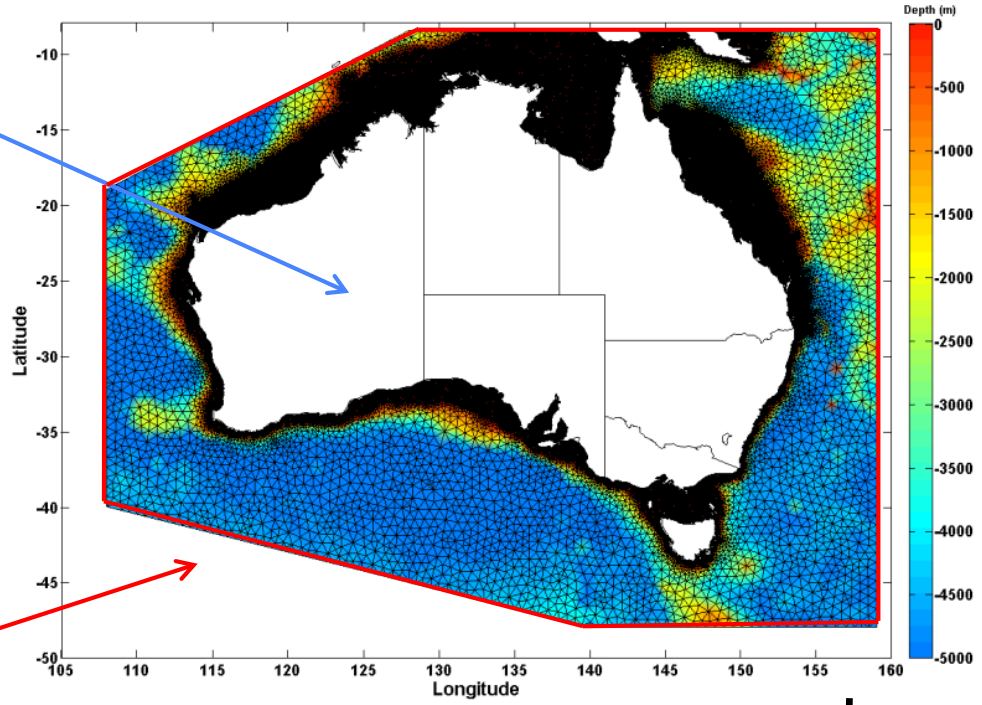
SEA LEVEL HINDCASTS



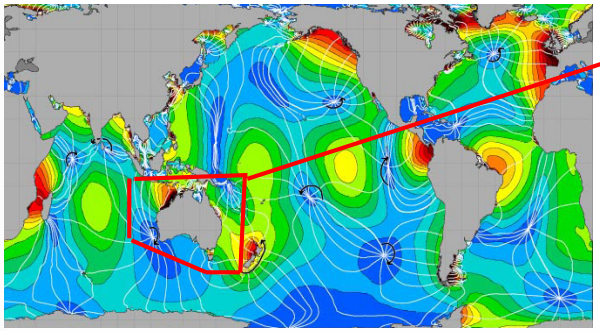
Tropical Cyclones

NCEP: 1949-2014





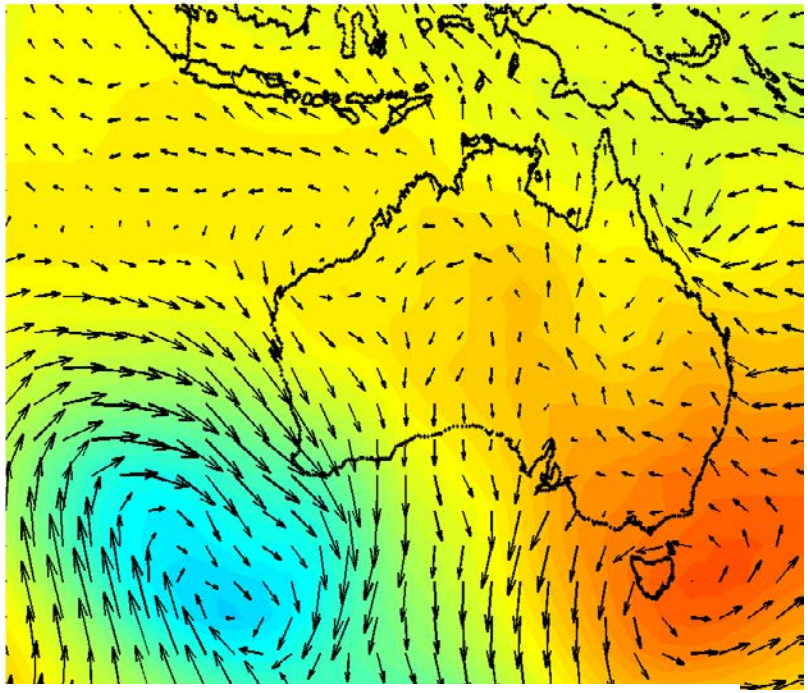
Global tidal model



Total Sea level (~60 year time series)

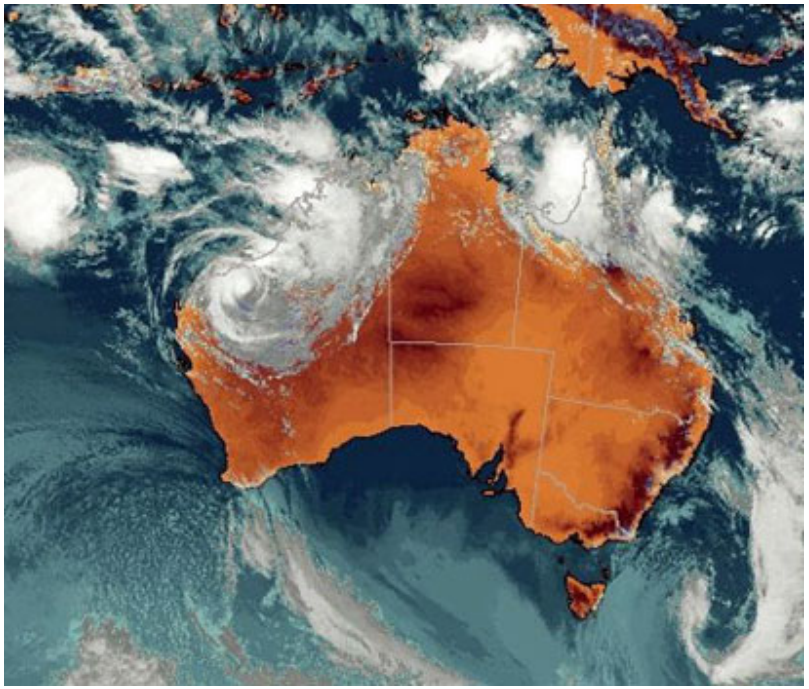
EXTREME EVENTS – STORM SURGE

Extra-tropical



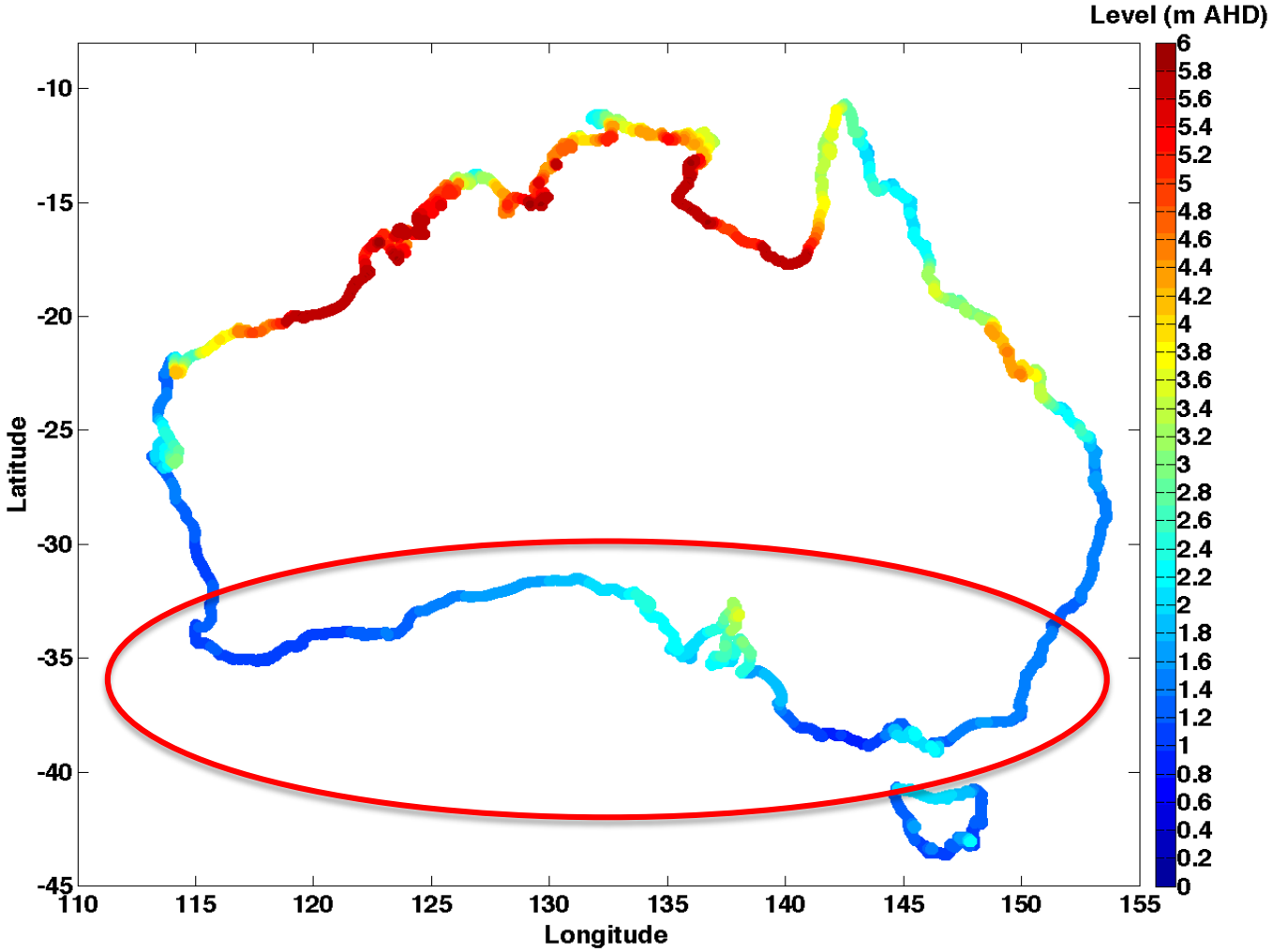
1,000 ± 500 km
Surge - 2-5 days
Several hundred km
Sprawling geometry
Apr-Aug

Tropical (cyclones)



500 ± 200 km
Surge - up to half a day
Usually < 200 km
Compact and nearly symmetrical
Nov-Apr

1:1000 ARI: TOTAL WATER LEVEL (TROPICAL + EXTRATROPICAL)

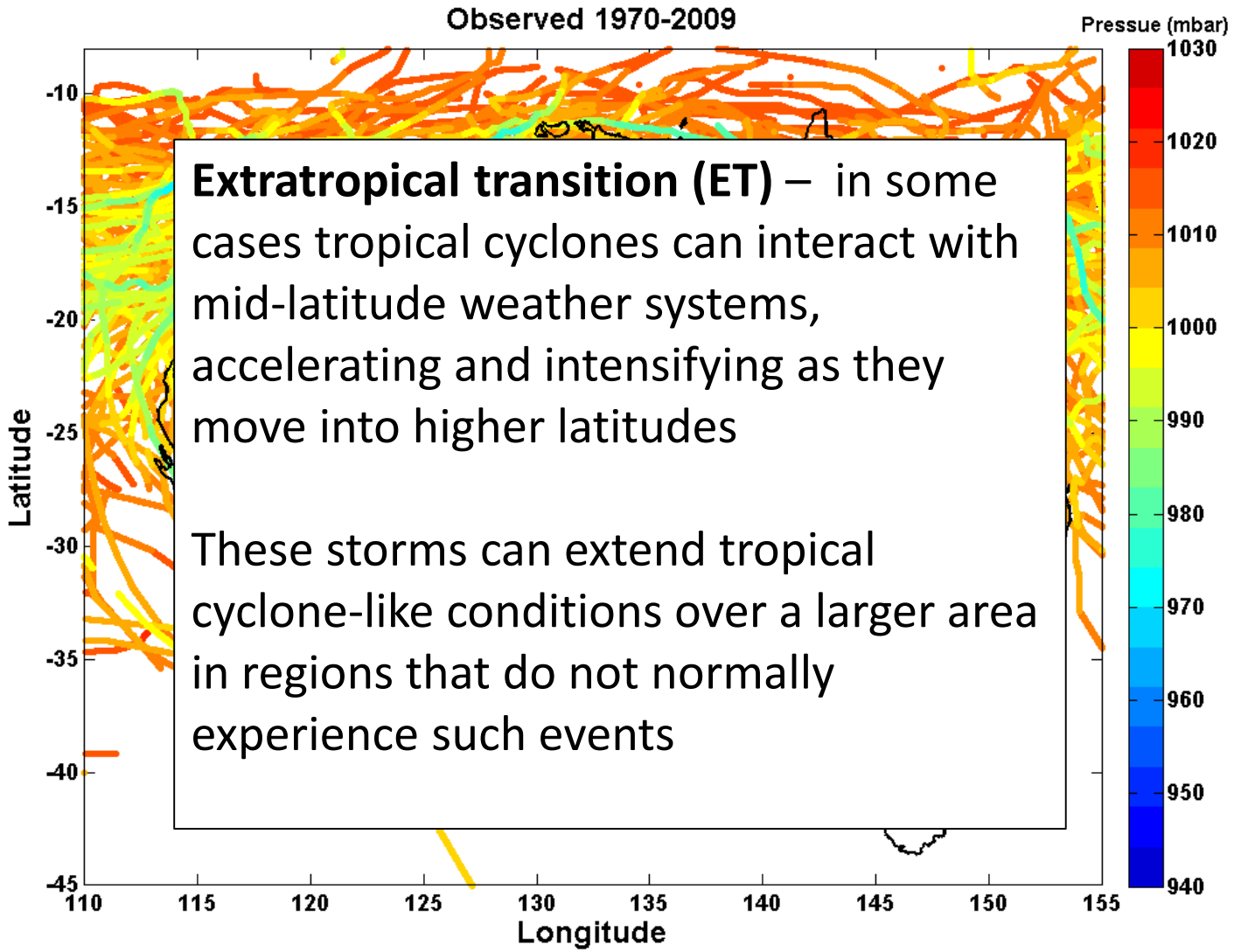


IMPROVED EXTREME SEA LEVEL PREDICTIONS ARISING FROM:

1. Tropical to extratropical storm transition
2. Surface wave effects
3. Continental Shelf Waves
4. Meteorological tsunamis



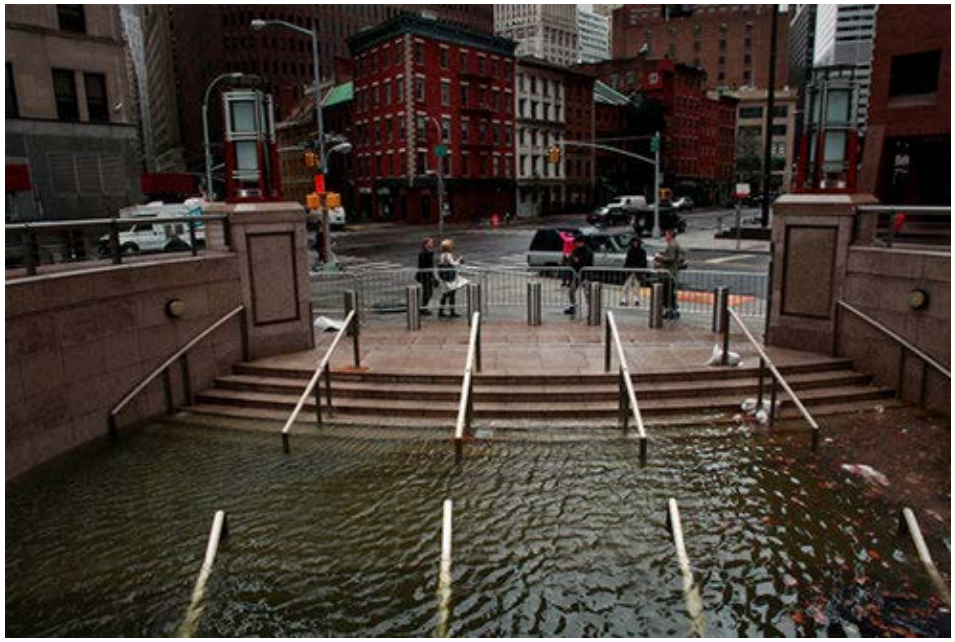
TROPICAL TO EXTRATROPICAL CYCLONE TRANSITION



Extratropical transition (ET) – in some cases tropical cyclones can interact with mid-latitude weather systems, accelerating and intensifying as they move into higher latitudes

These storms can extend tropical cyclone-like conditions over a larger area in regions that do not normally experience such events

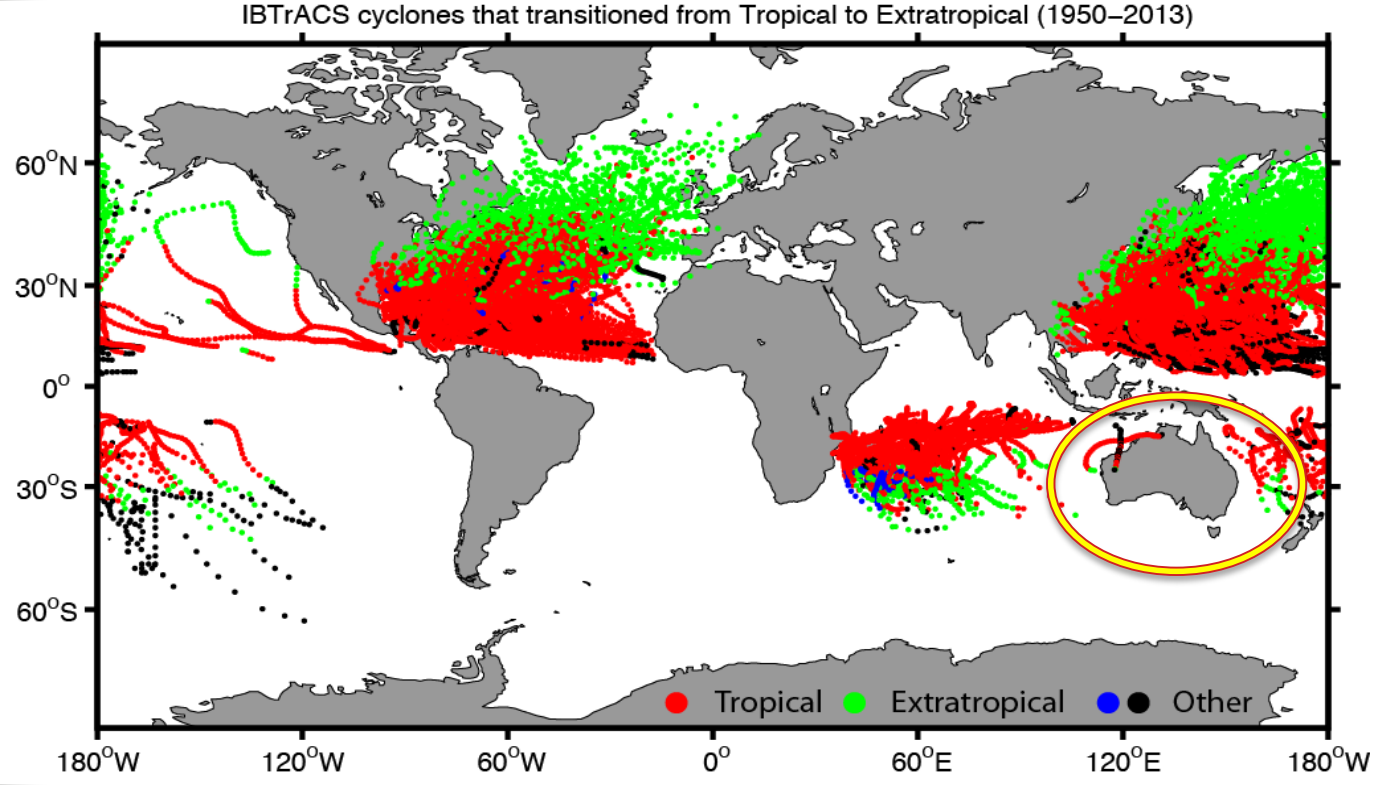
HURRICANE SANDY



New York City, October 2012

$65 billion in damage in the US

EXTRATROPICAL TRANSITION GLOBALLY



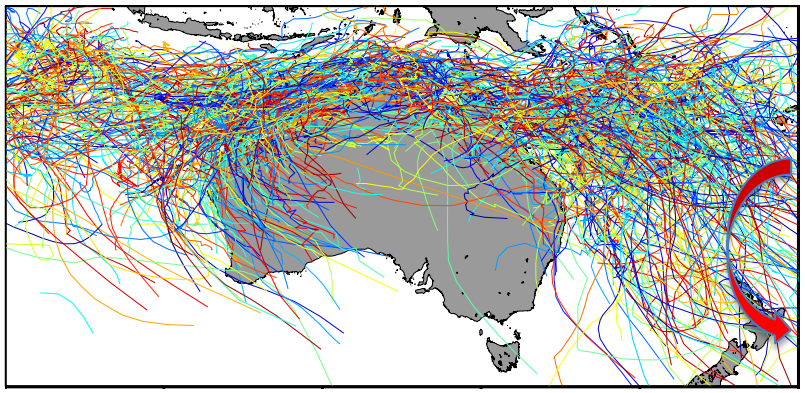
Storms in global database that transitioned from tropical to extra-tropical

The lack of activity around Australia illustrates the lack of information about ET rather than occurrence

ET occurs closer to the equator around Australia than in any other ocean basin

AUSTRALIAN TROPICAL CYCLONE TRACKS

All TC tracks 1950-2013

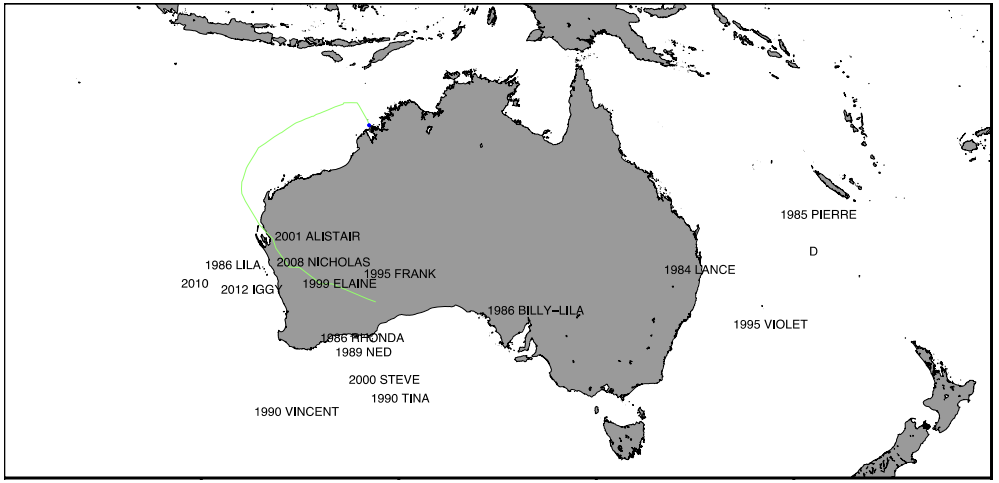


Storms recorded to have undergone ET

Mavis 1971 (nw WA)
Vida 1975 (sw WA; not well documented)
Alby 1978 (sw WA)
Hazel 1979 (Shark Bay)
Idylle 1979 (sw WA)
Herbie 1988 (Shark Bay)
Ned 1989 (sw WA)

TC curvature toward east somewhat lessens risk to east coast of Australia

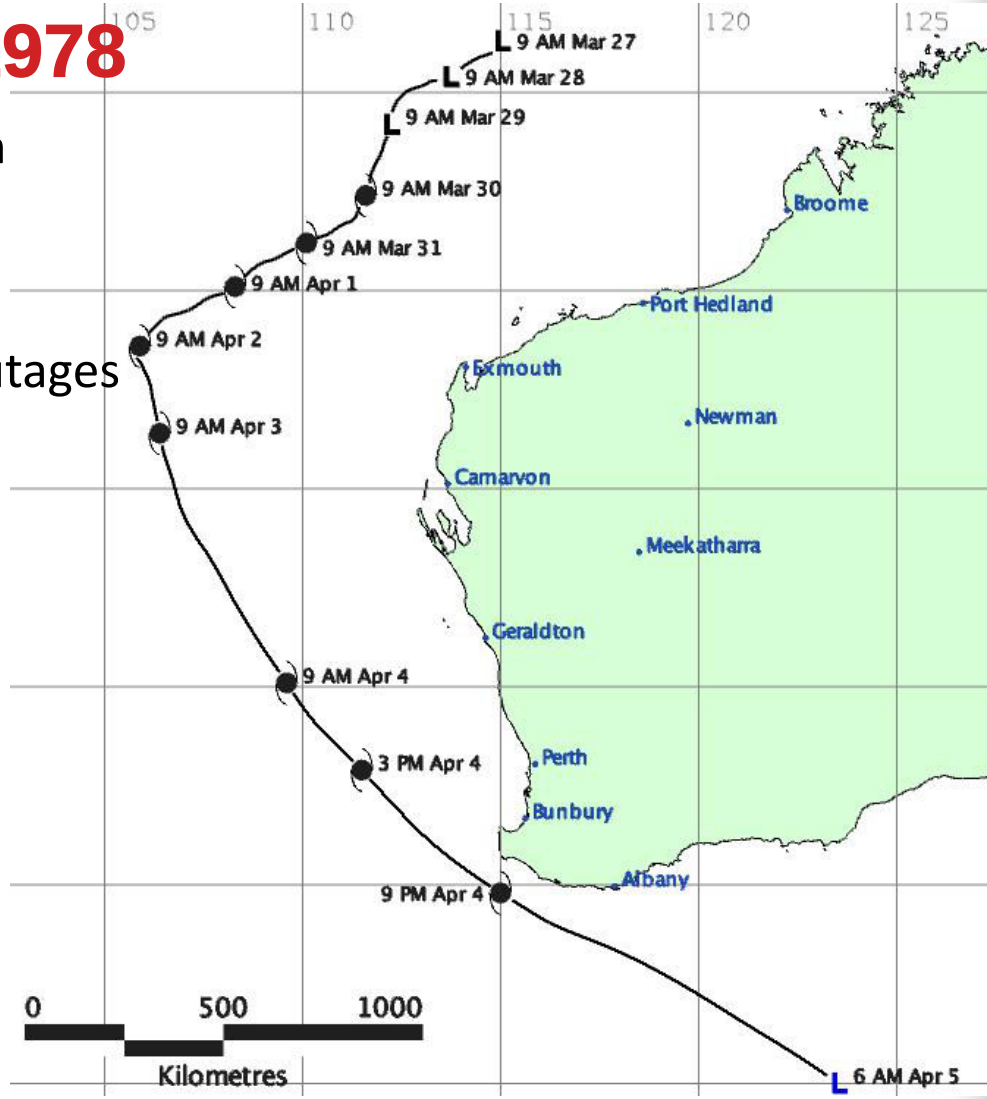
Cyclones passing south of 24 deg and within 100 km of coast: potential for ET to cause damage



CYCLONE ALBY APRIL 1978

- Worst extratropical transition event in Australia
- 5 lives lost
- Extreme winds, dust storms, power outages
- Flooding, erosion, fire
- $50 million in damage
- Loss of 1000's of sheep and cattle

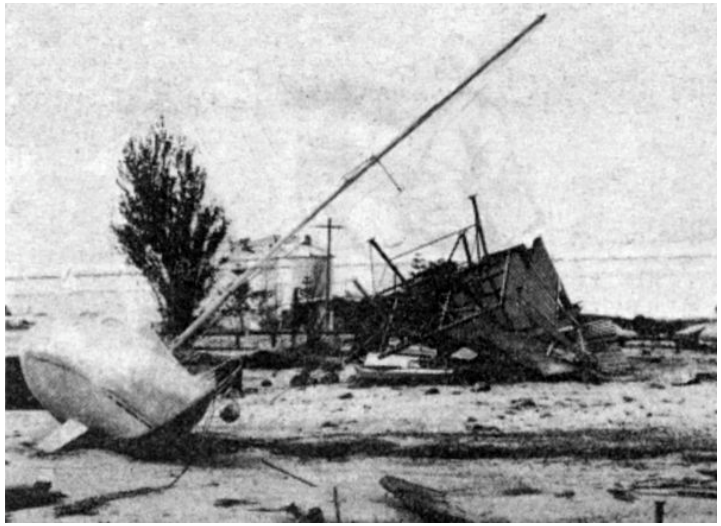
Source: Bunbury public library



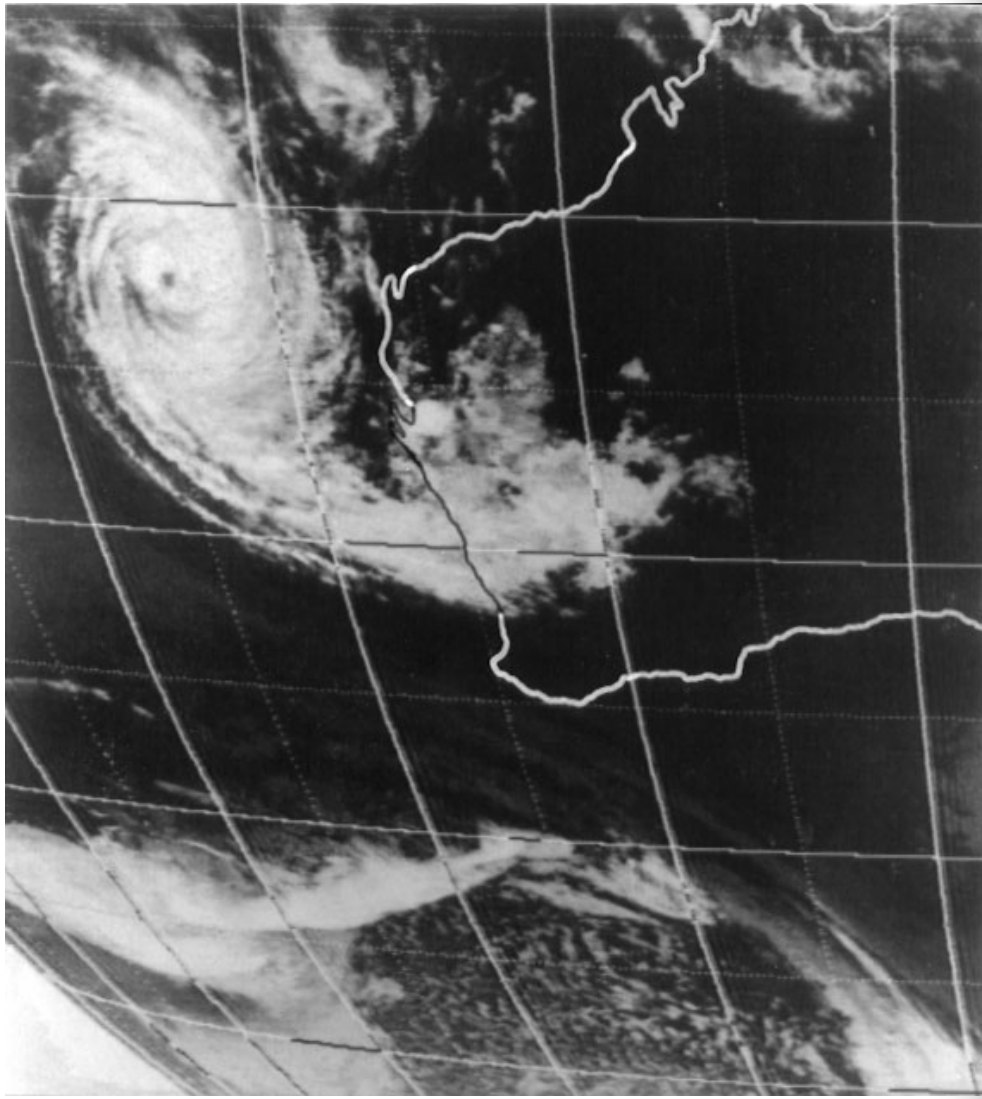
Source: BOM

CYCLONE ALBY

Category 4 cyclone that interacted with an approaching cold front with devastating results



Source: Bunbury public library

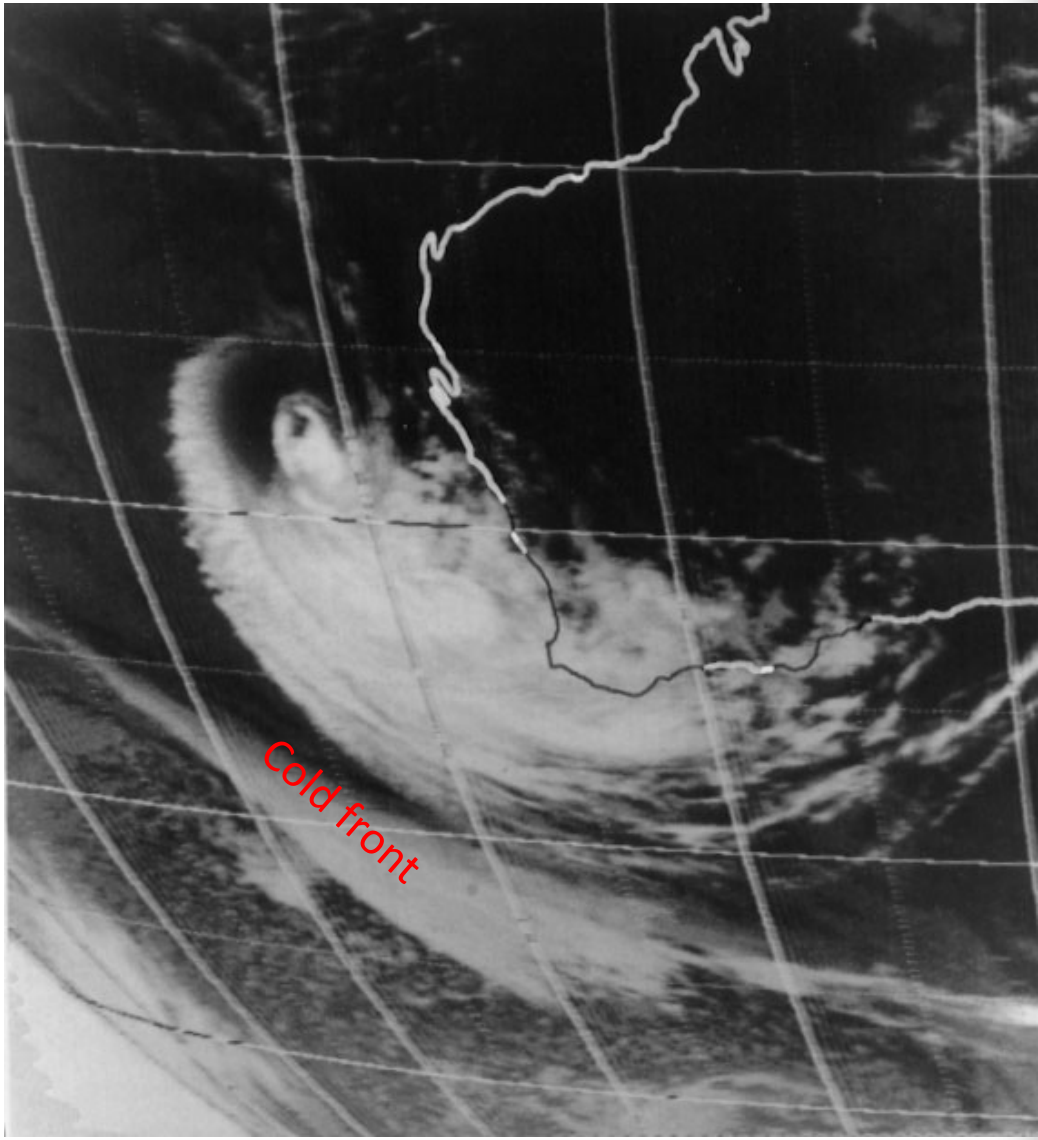


Source: BOM

CYCLONE ALBY

Weather forecasters were caught off guard as Alby unpredictably interacted with a cold front and underwent Extratropical transition (ET)

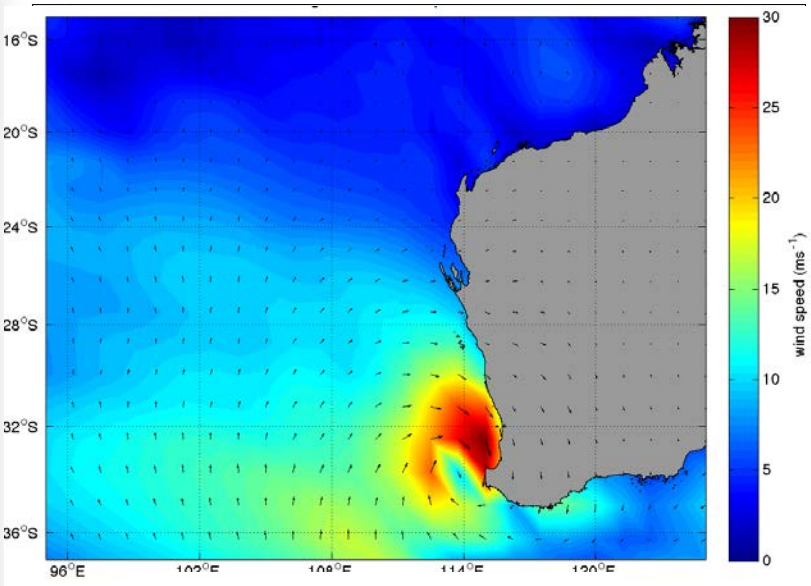
These transitioning storms can extend tropical cyclone-like conditions over a larger area in regions that do not normally experience such events



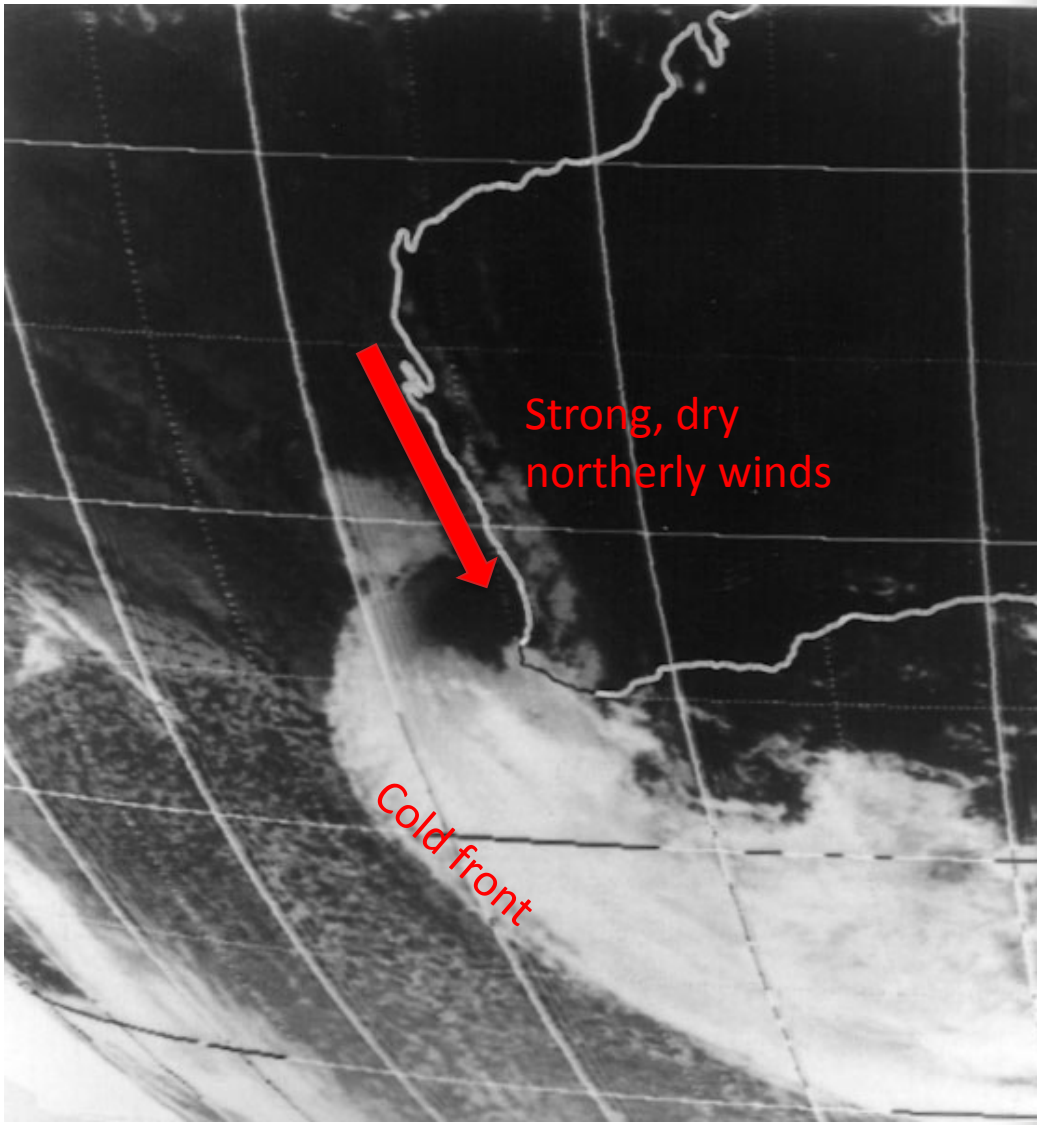
The start of Alby's extratropical transition

CYCLONE ALBY 1978

- **Alby** accelerated to 80 km/hr as it passed the SW of the state.
- Recorded wind gusts of 150 km/hr were recorded with little or no rain along the coast

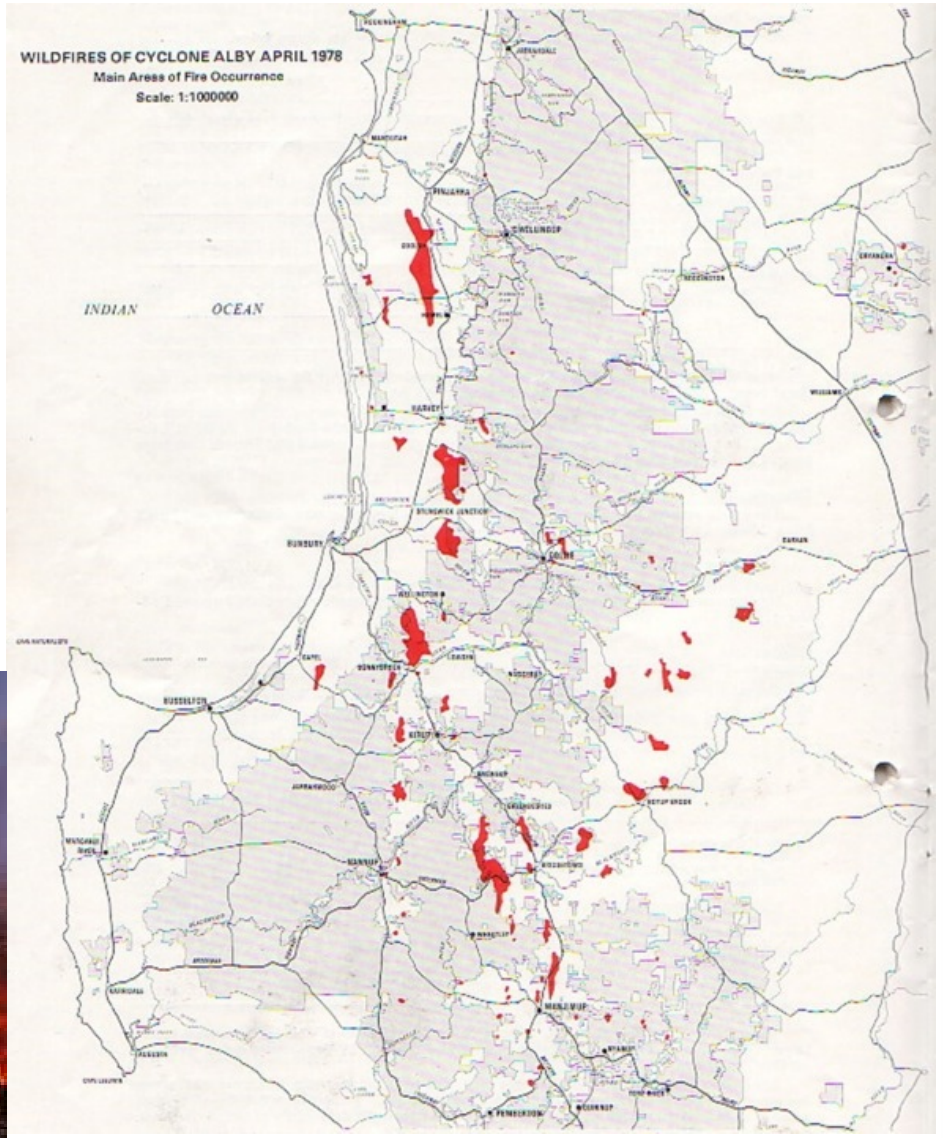


JRA55 reanalysis winds

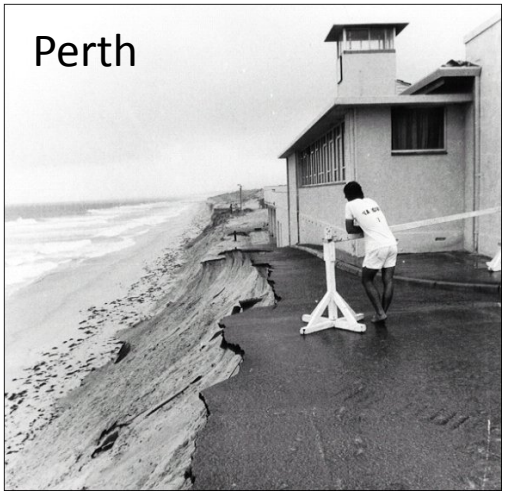


CYCLONE ALBY

>90 bushfires fanned by intense dry northerly winds burned an estimated 114,000 ha of forest and farmland



CYCLONE ALBY – FLOODING & EROSION



Source: BOM

Source: Bunbury public library

Bunbury

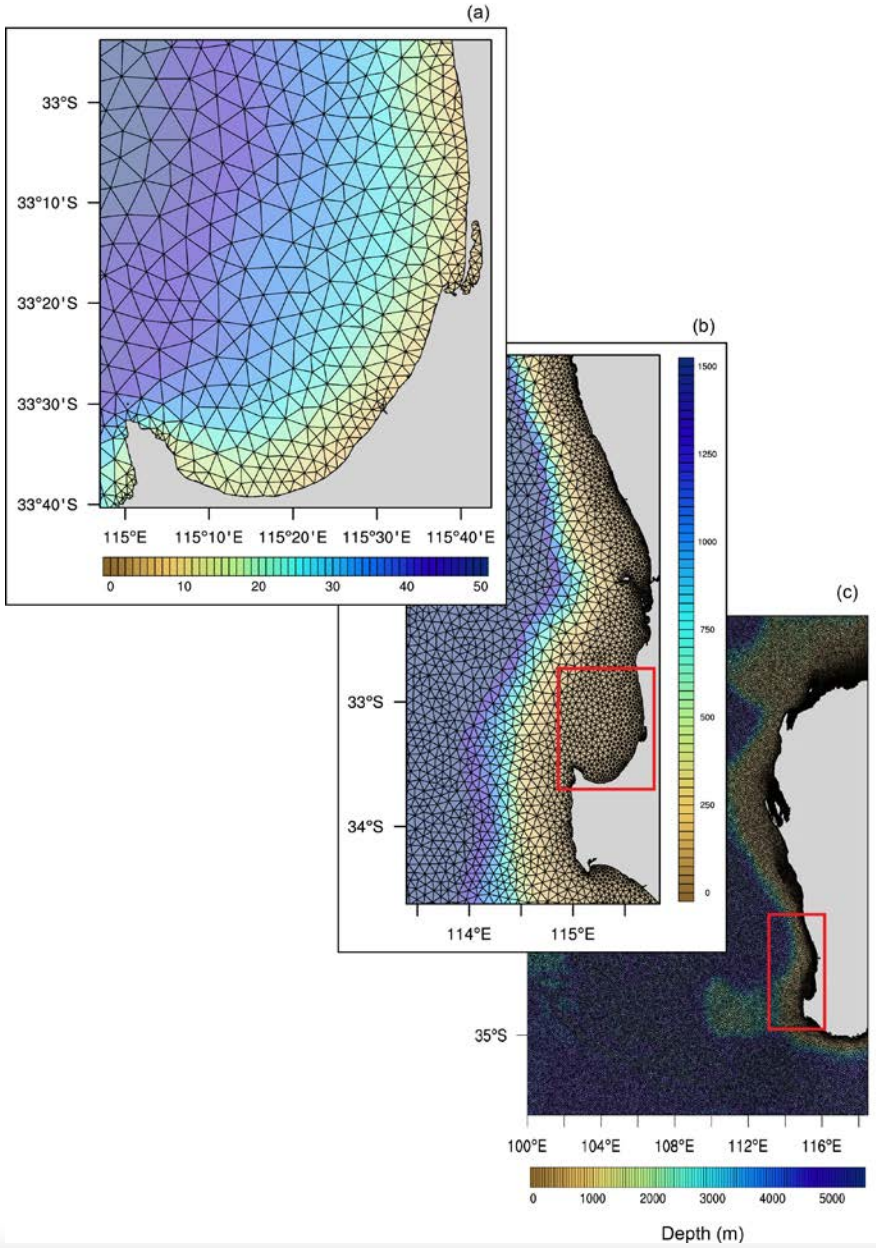
STORM SURGE MODEL

A hydrodynamic modeling system has been set up to simulate storm surges around Australia

The unstructured mesh grid allows for **high resolution** ~ 100 m at the coast

The SCHISM **hydrodynamic model** is 2-way coupled with the advanced **Wind Wave III model**, allowing for investigation of wave effects

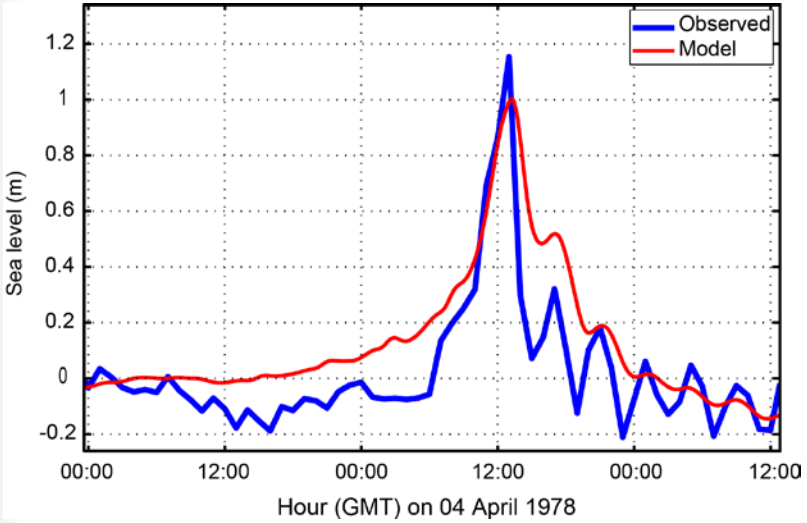
Realistic wind, pressure, and tides from global models force the surge-wave model

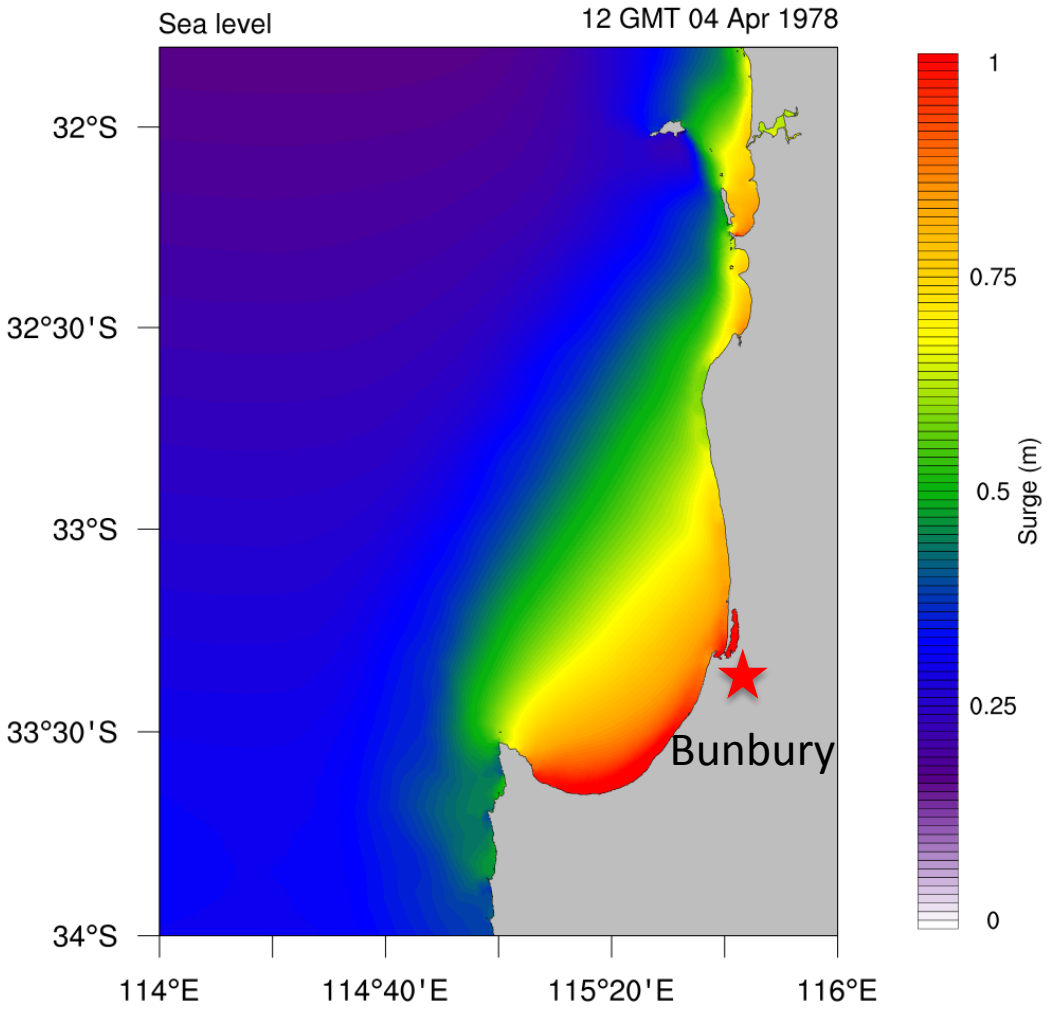


STORM SURGE MODEL – ALBY RESULTS

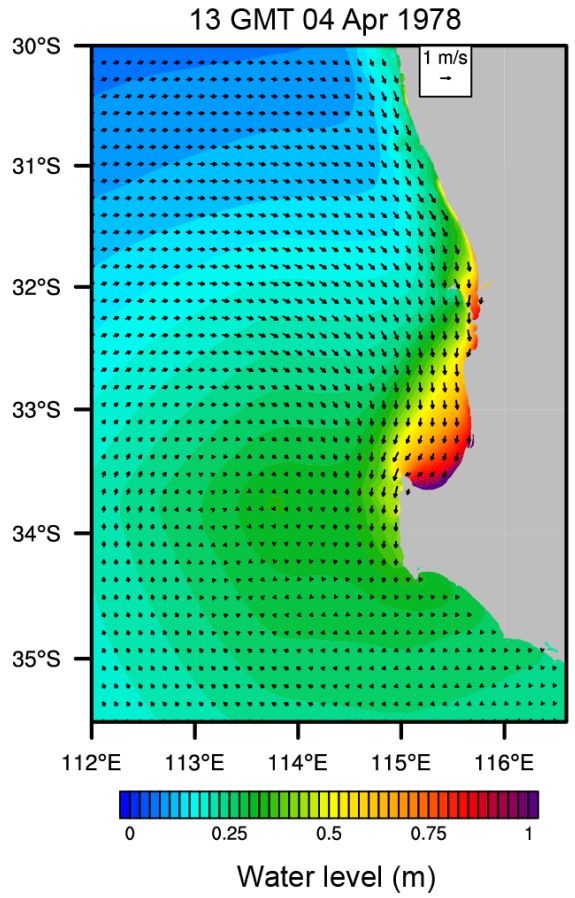
Storm surges >1m matched well with observations

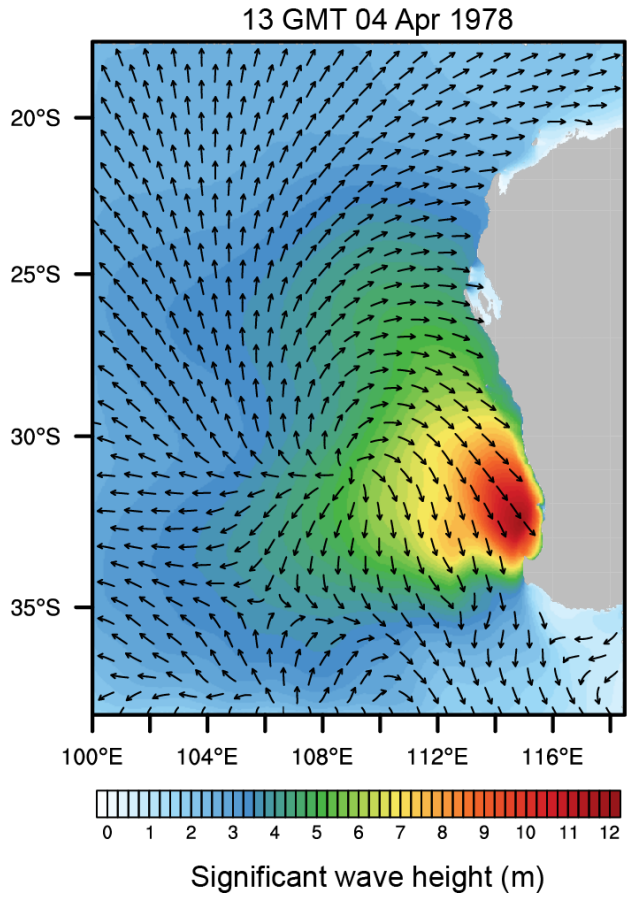
Most damage occurred in Bunbury and Busselton where a shallow bay fronted by low-lying coast was exposed to the high winds and waves





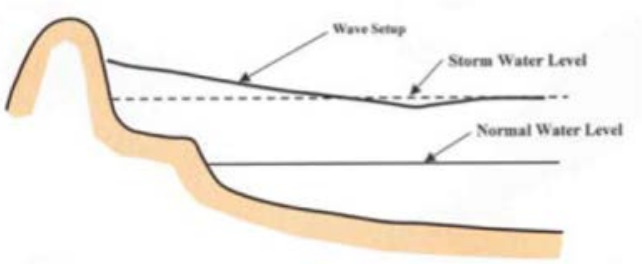
INCLUDING THE EFFECTS OF WAVES





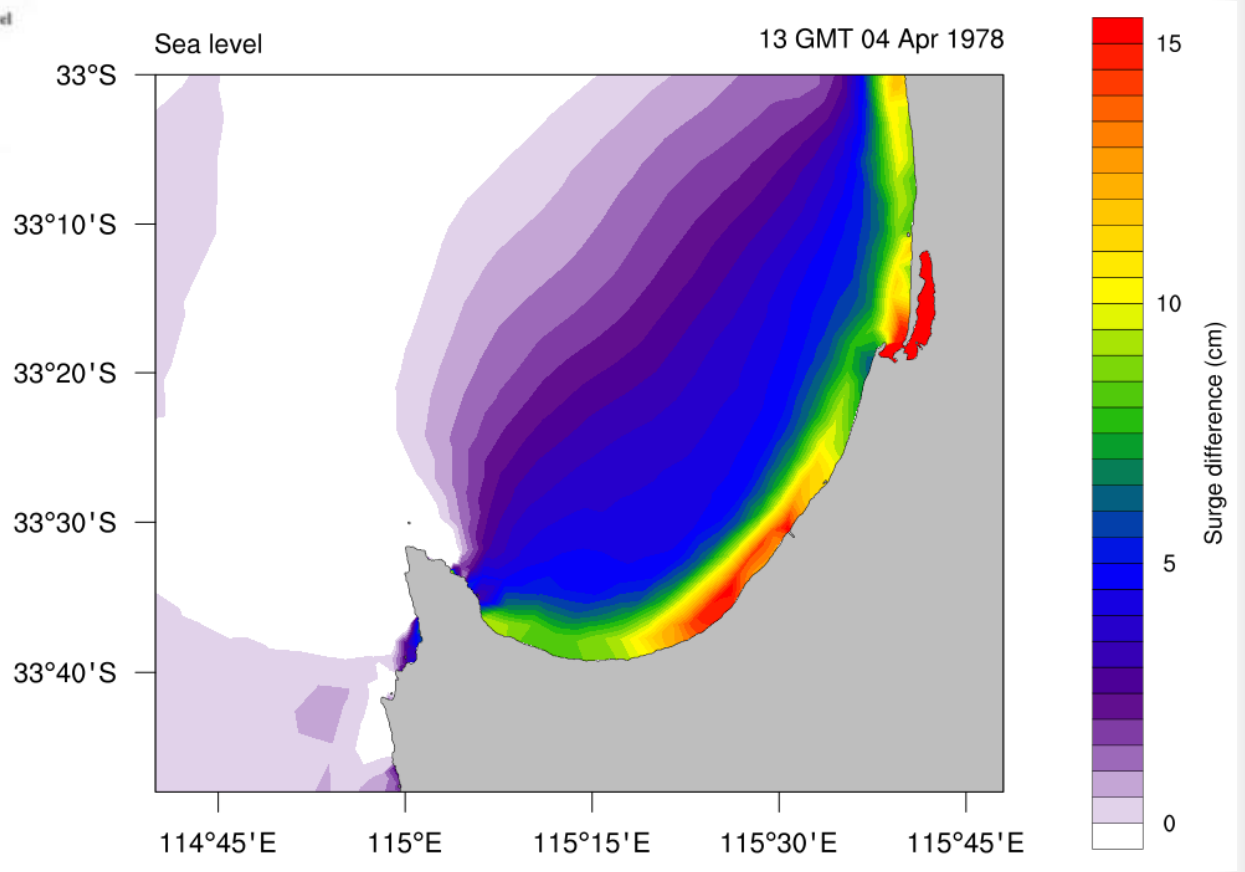
Wave heights of >10m were observed offshore and simulated by the model

WAVE EFFECTS

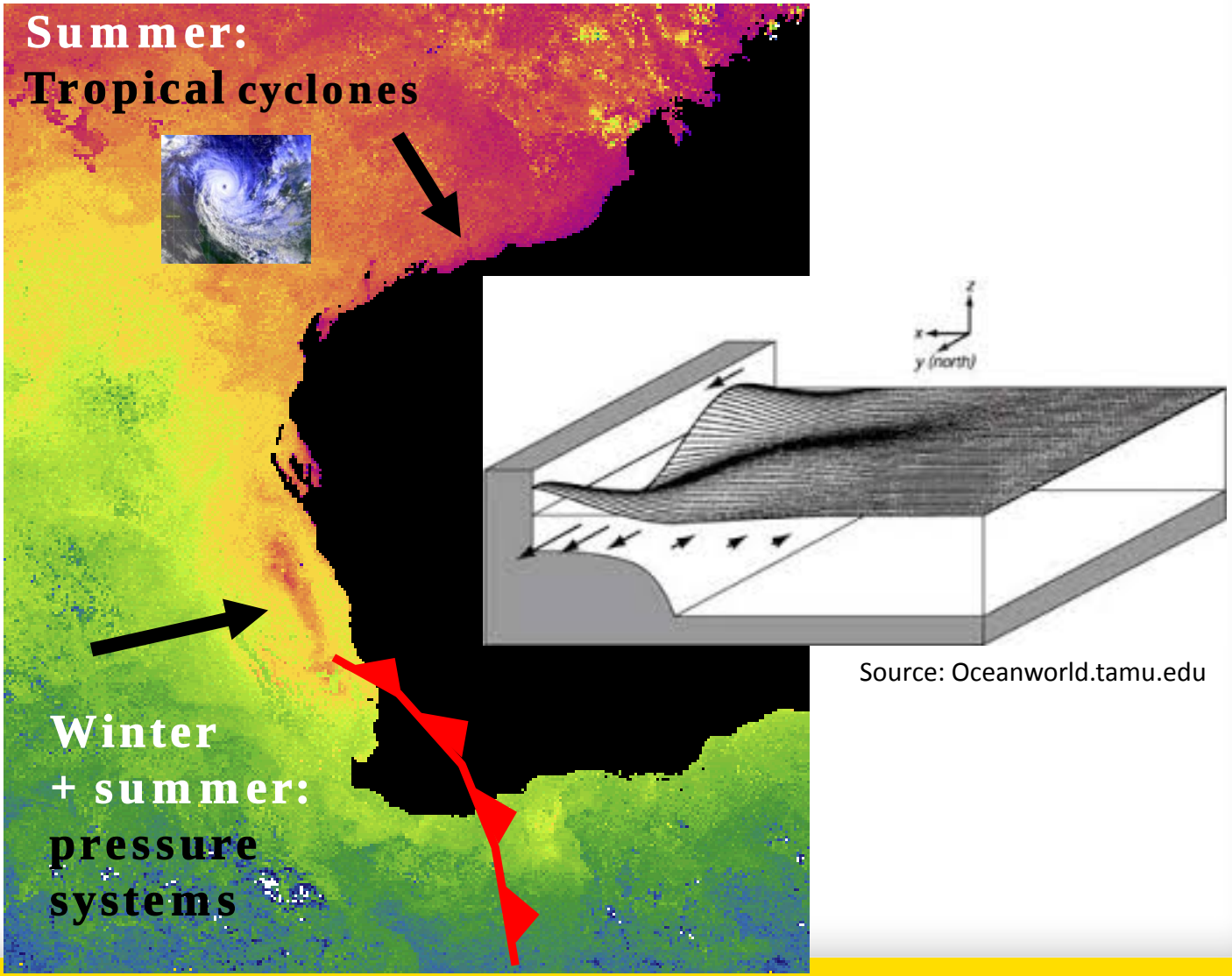


Increase in water level near the coast due to the presence of waves

~10-50% difference in surge height when waves included in simulation

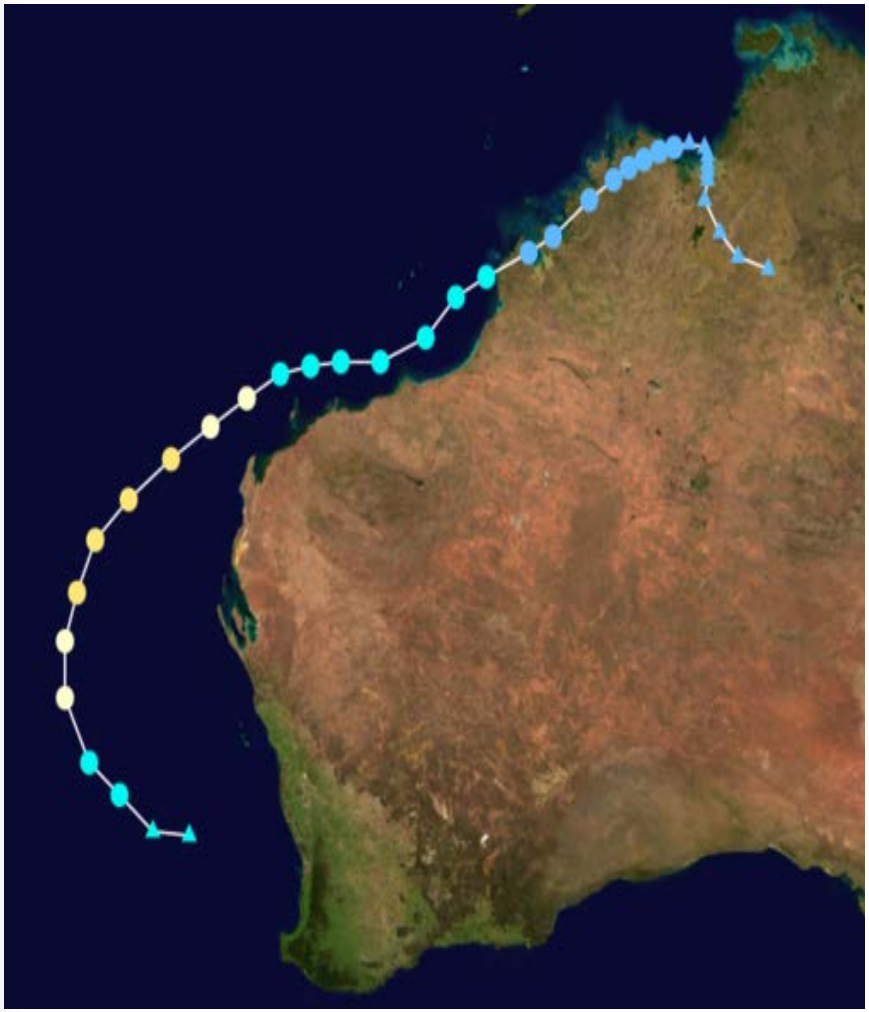


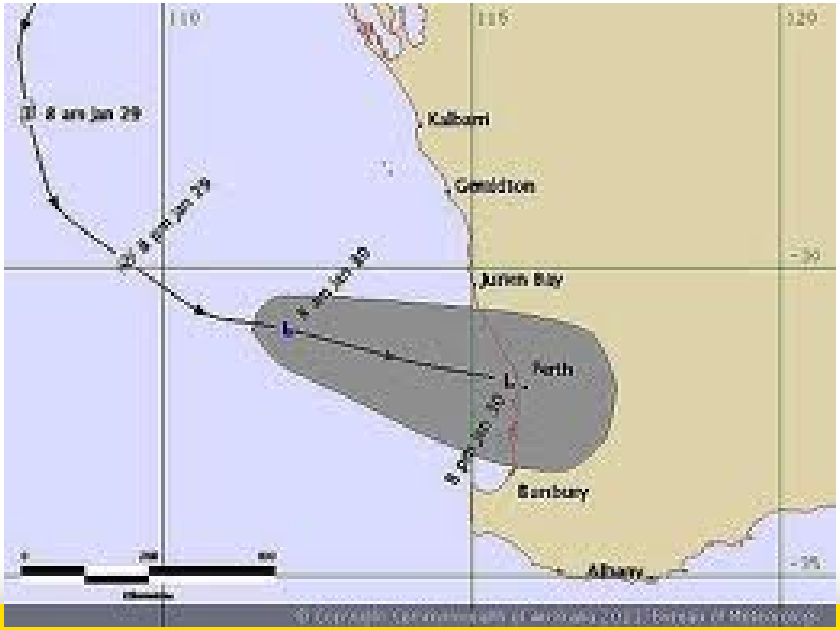
CONTINENTAL SHELF WAVES



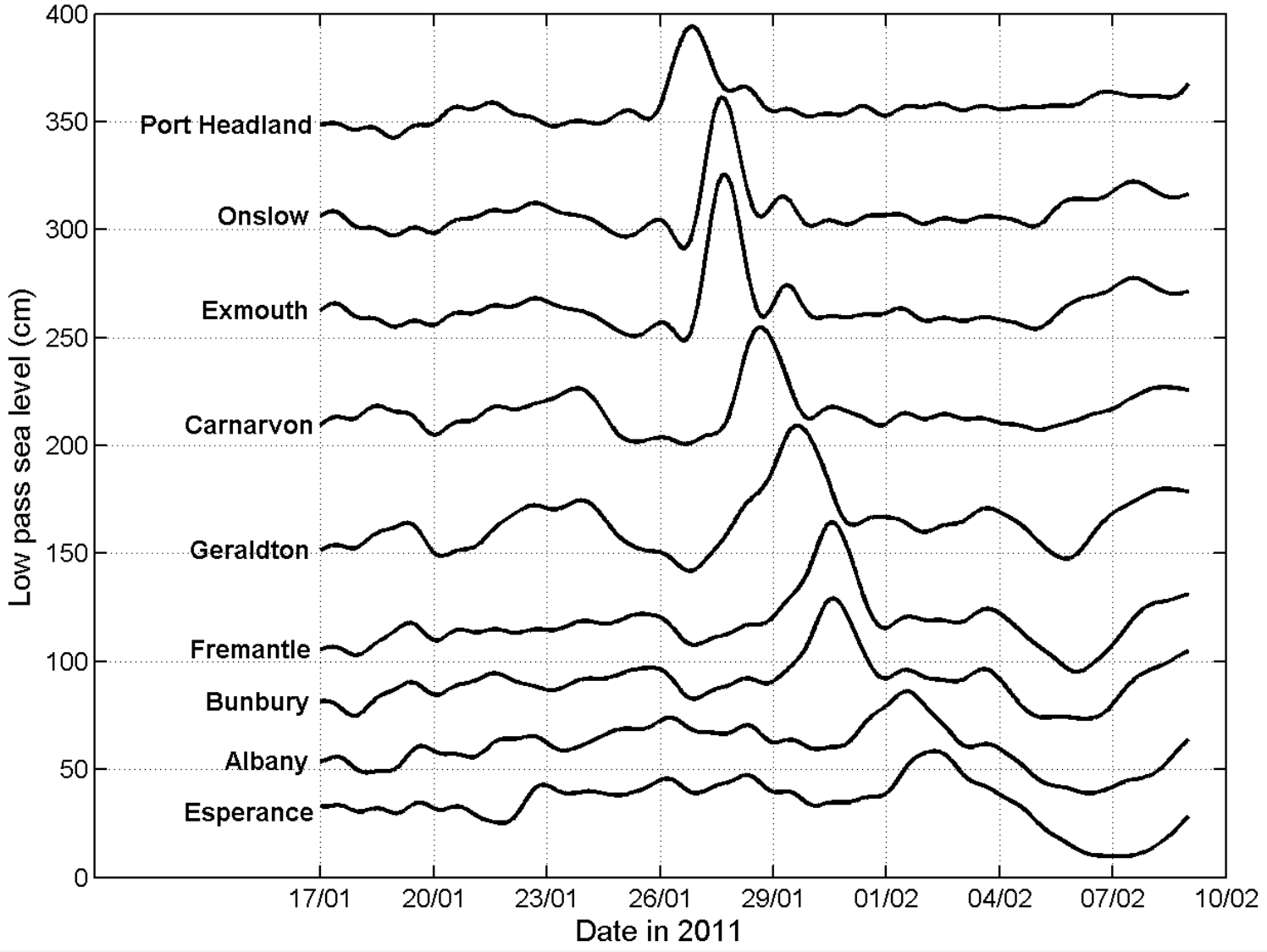
Source: Oceanworld.tamu.edu

TC BIANCA: 30 JANUARY 2011

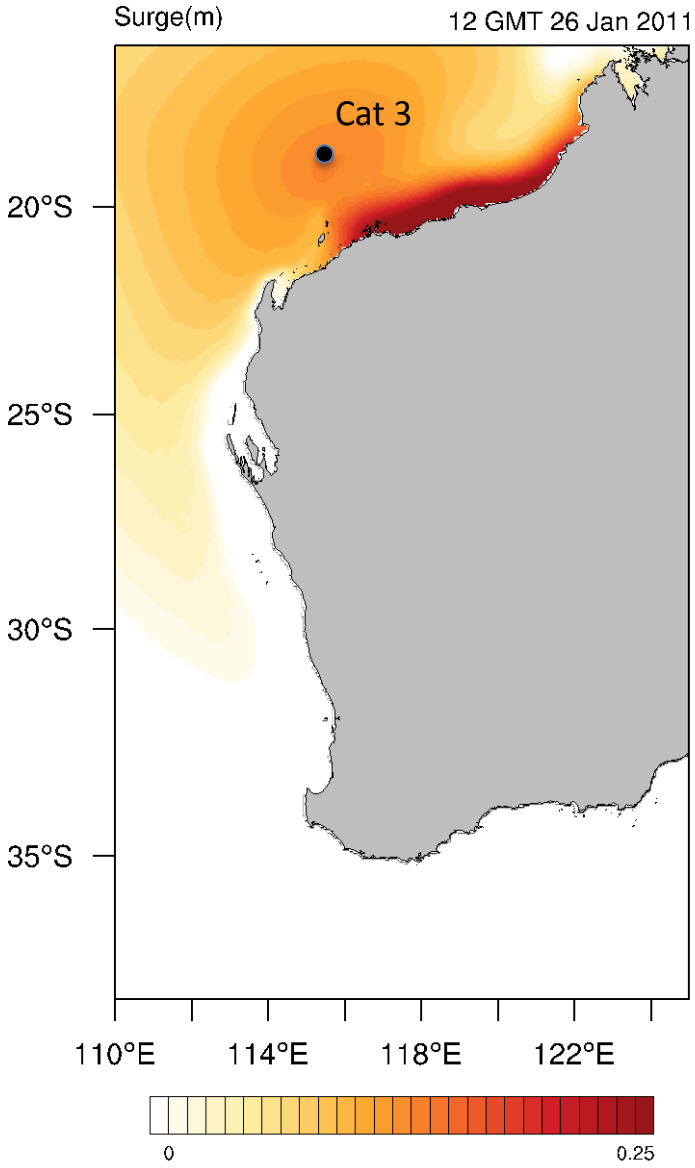




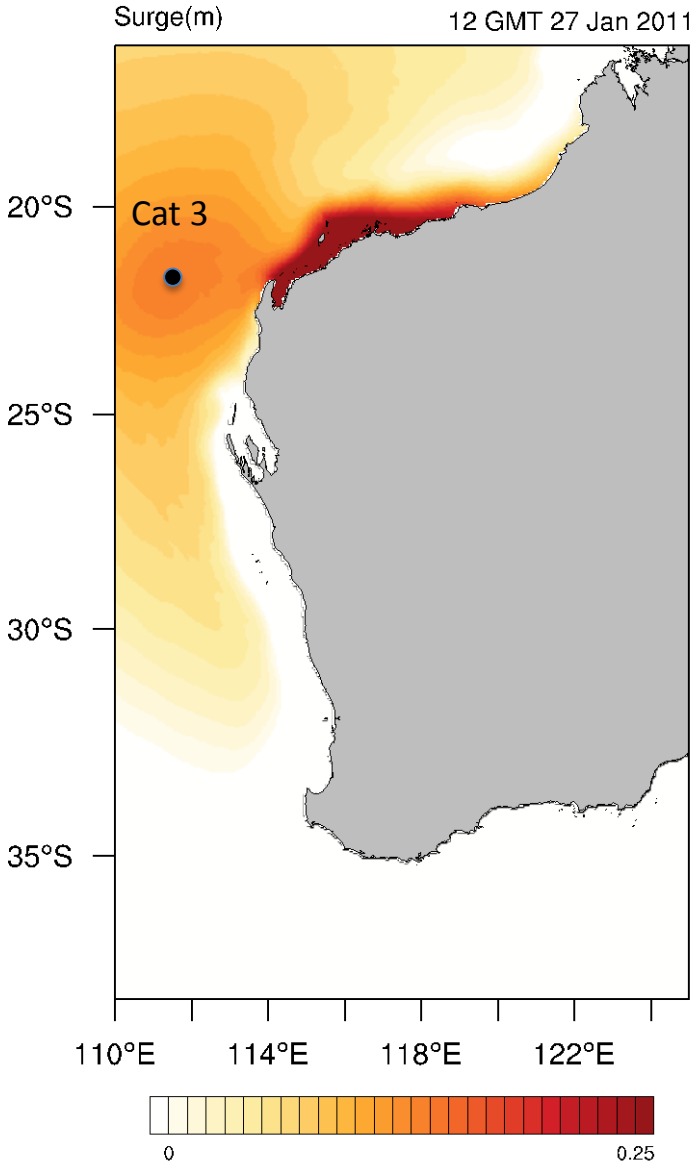
CONTINENTAL SHELF WAVES (TC BIANCA)



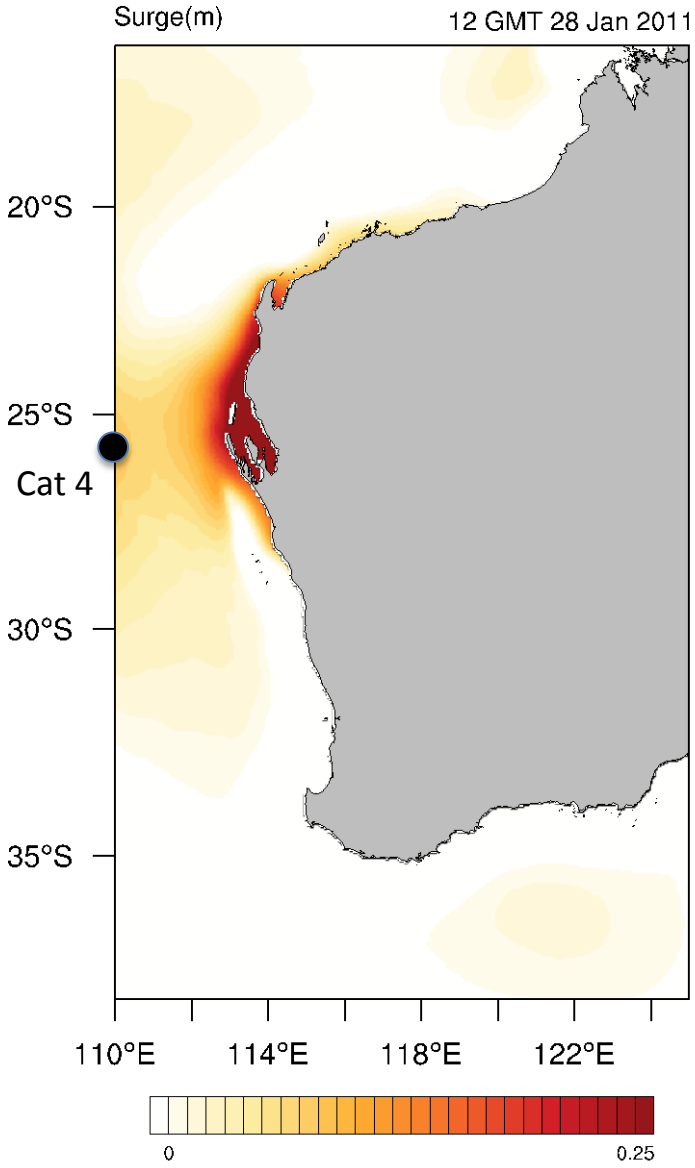
Model simulation of TC Bianca Continental Shelf Wave



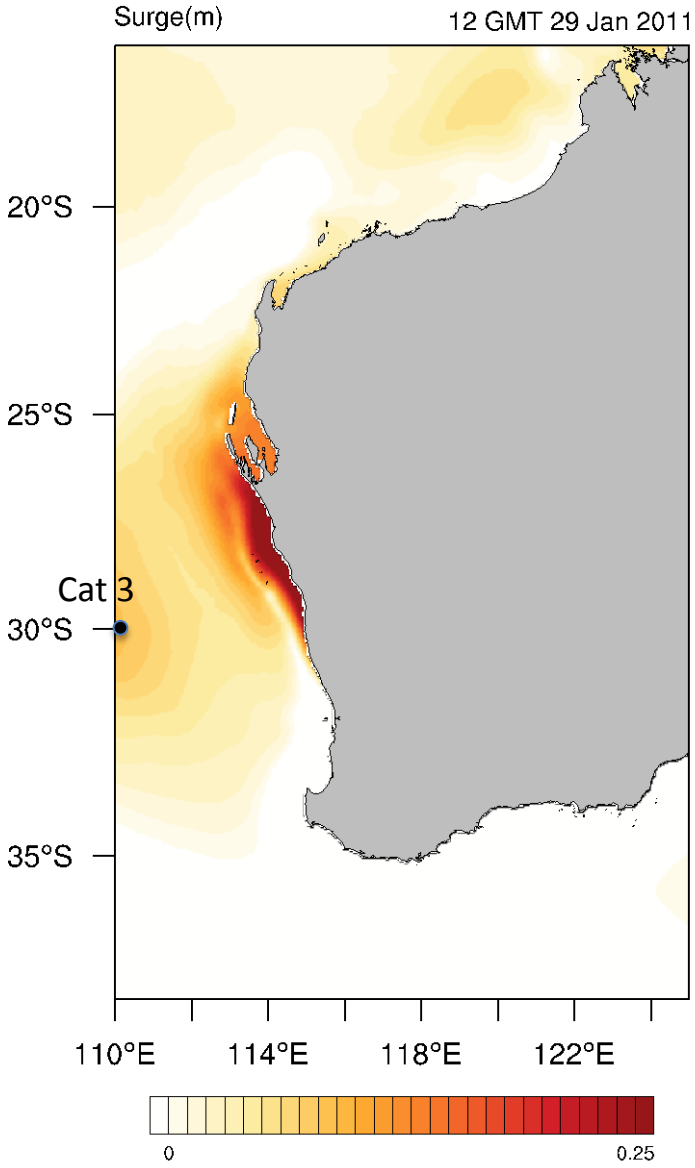
Model simulation of TC Bianca Continental Shelf Wave



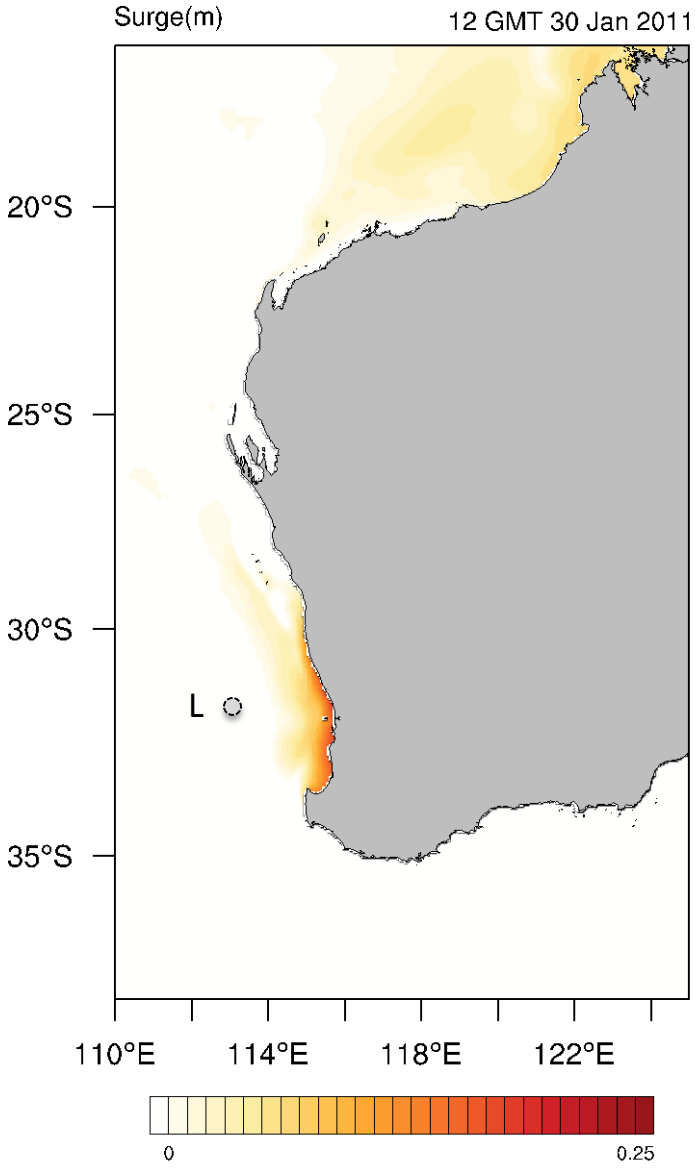
Model simulation of TC Bianca Continental Shelf Wave



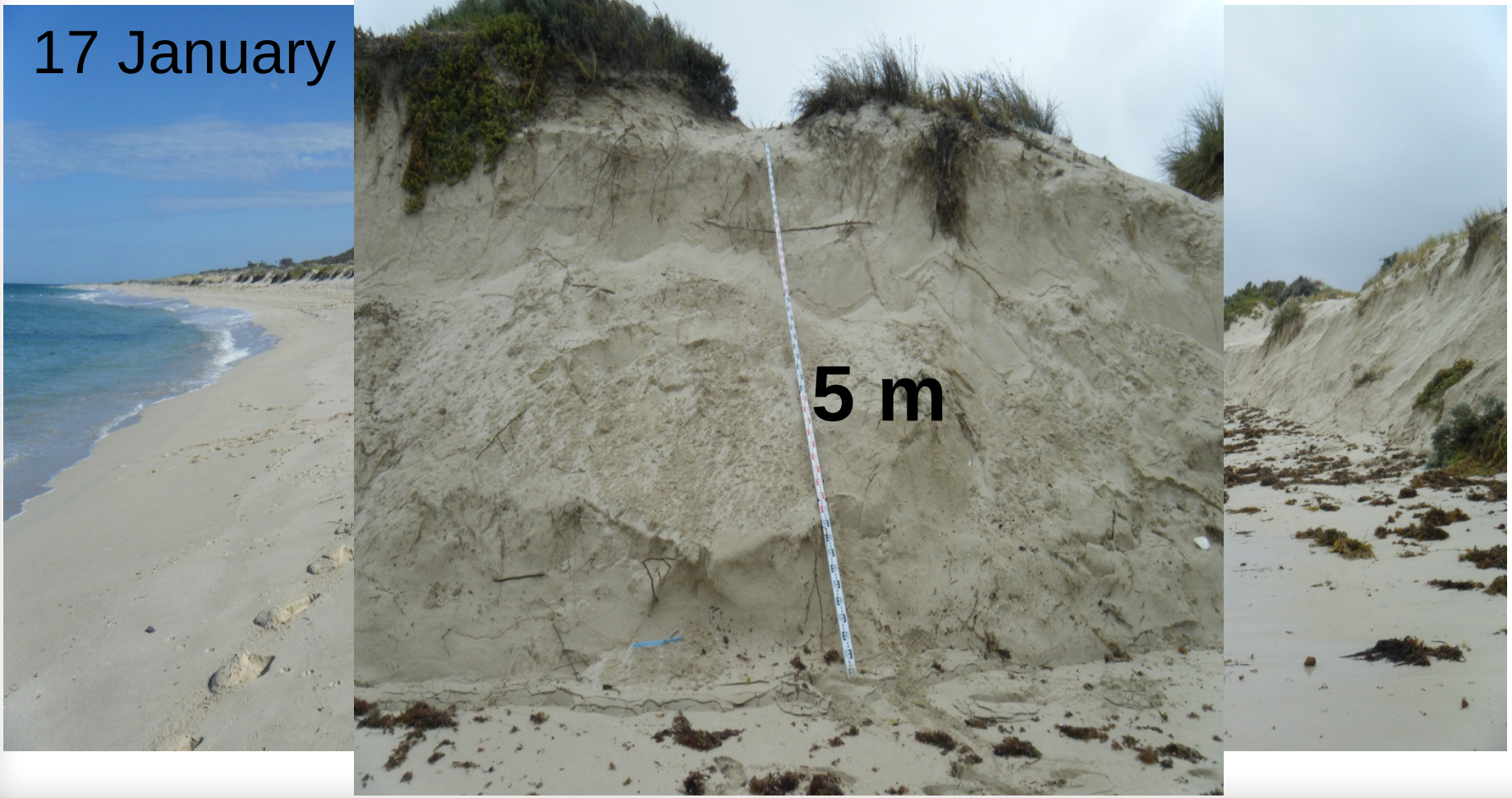
Model simulation of TC Bianca Continental Shelf Wave



Model simulation of TC Bianca Continental Shelf Wave

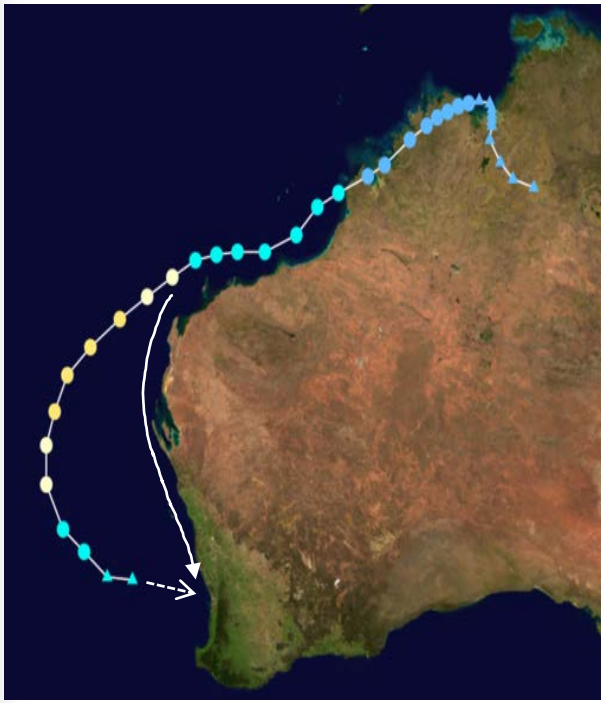


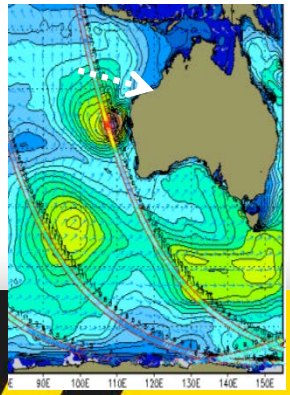
TC BIANCA IMPACTS @ YANCHEP BEACH



TC BIANCA IMPACTS @ PERTH CBD?

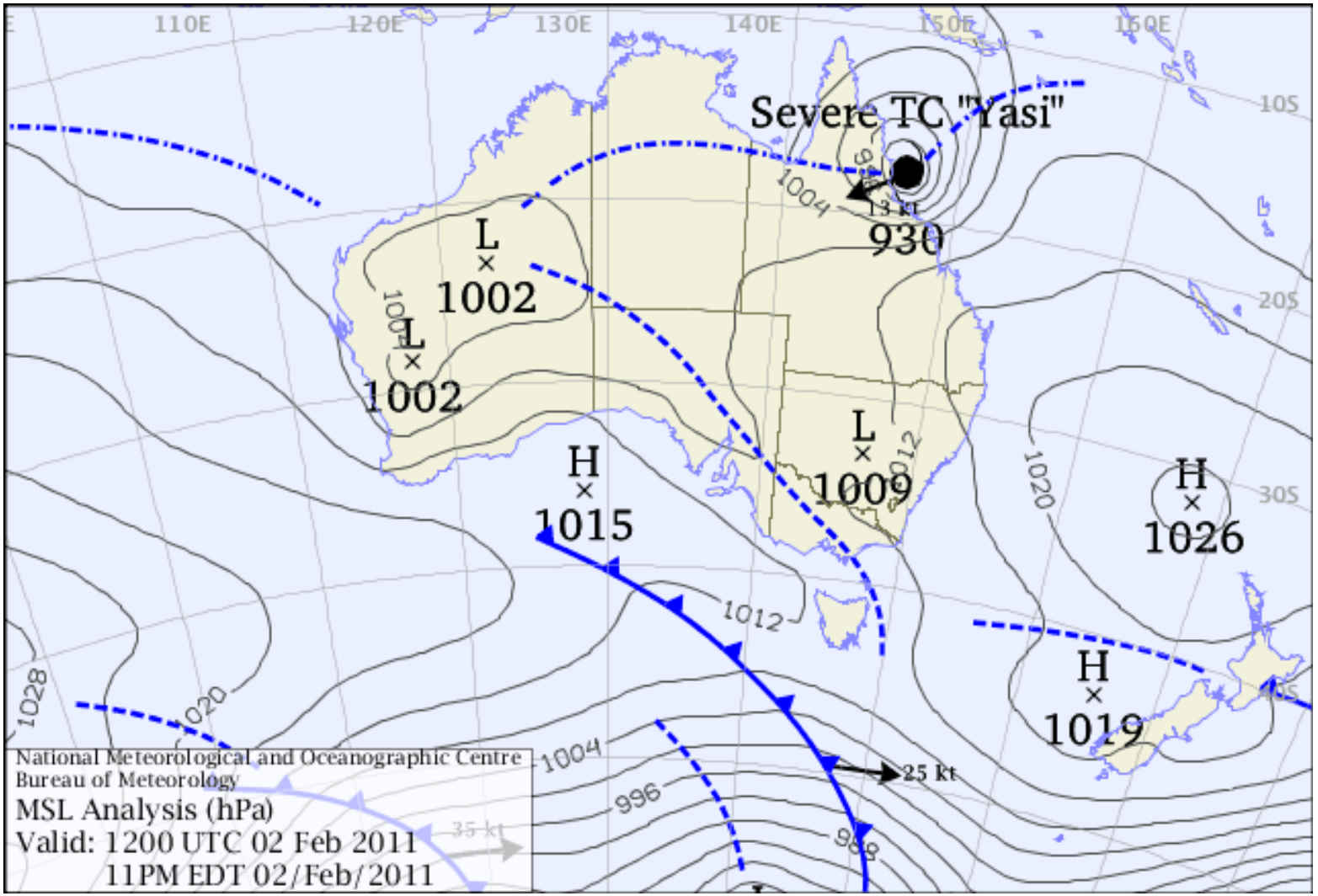
TROPICAL CYCLONE BIANCA: JAN 30-31 2011





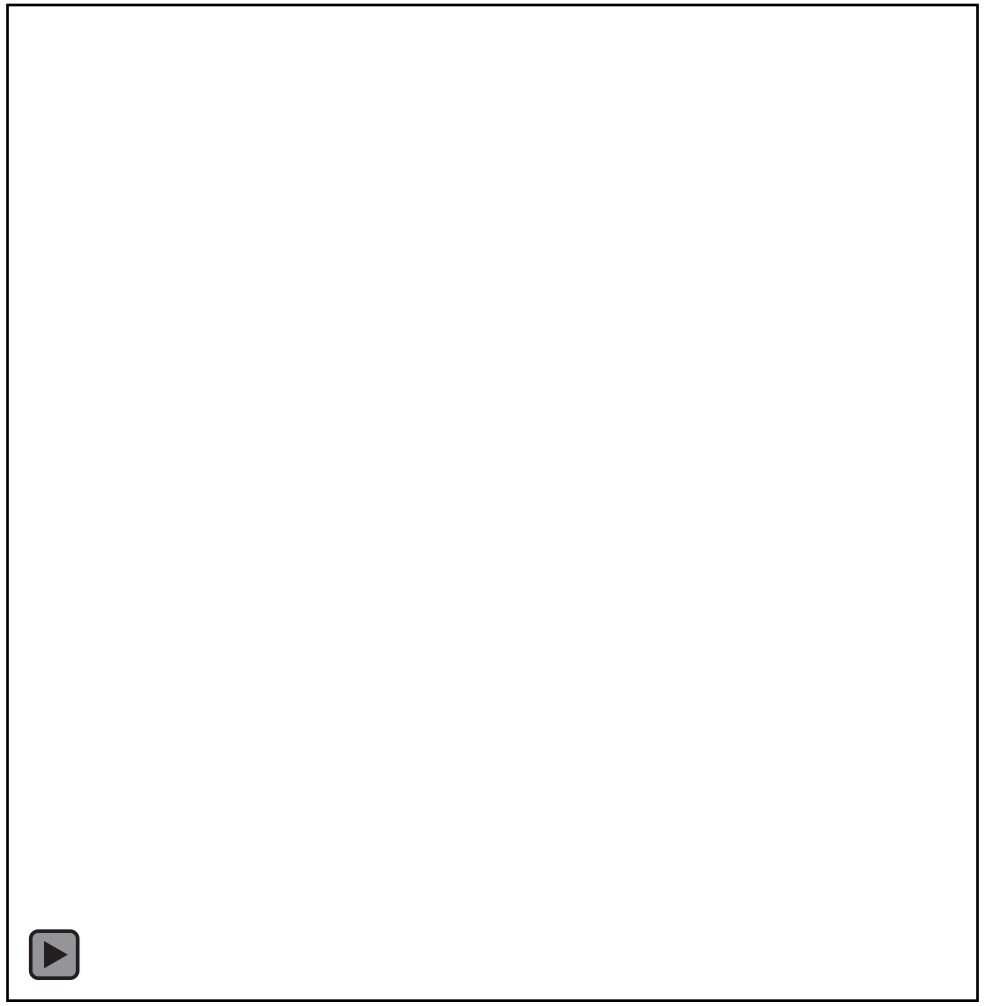
Flooding around the Swan river typically commences at about 1.6m CD, with flooding of the Kwinana Freeway at Como around 1.8 m CD. The underground railway can flood at ~2.4 m CD.

SIMULATING MULTIPLE STORM SURGES AROUND AUSTRALIA



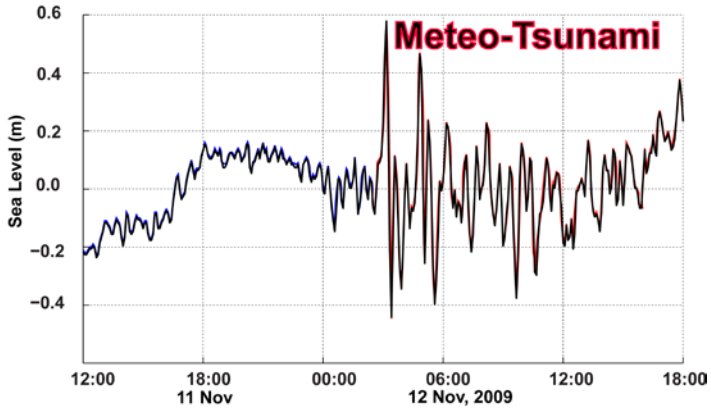
SIMULATING MULTIPLE STORM SURGES AROUND AUSTRALIA

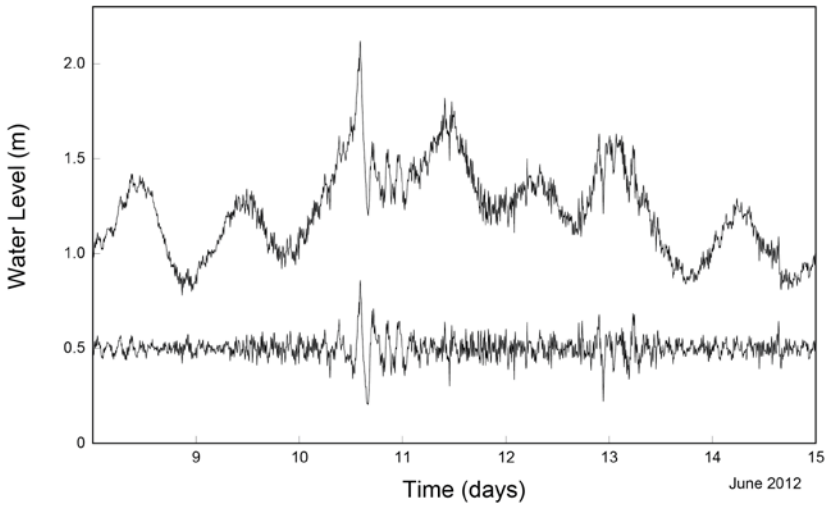
1. TC Bianca
2. TC Anthony
3. TC Yasi
4. Cold fronts (SA & Tas)

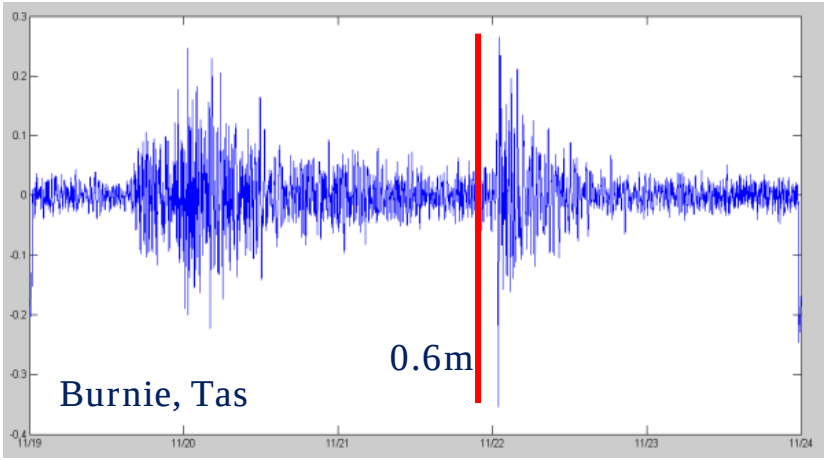


METEOTSUNAMIS

Large amplitude short period sea level oscillations forced by meteorological disturbances

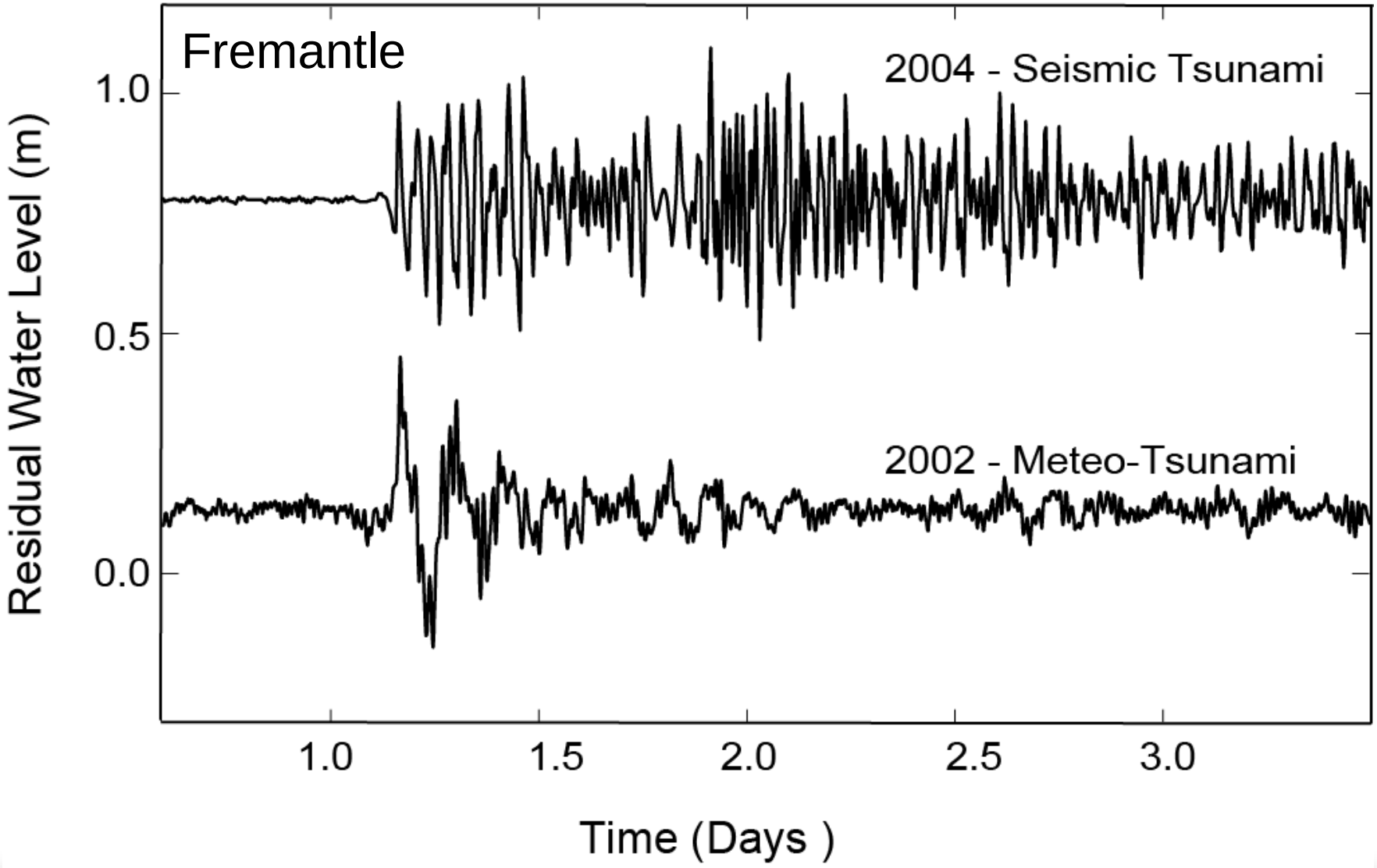




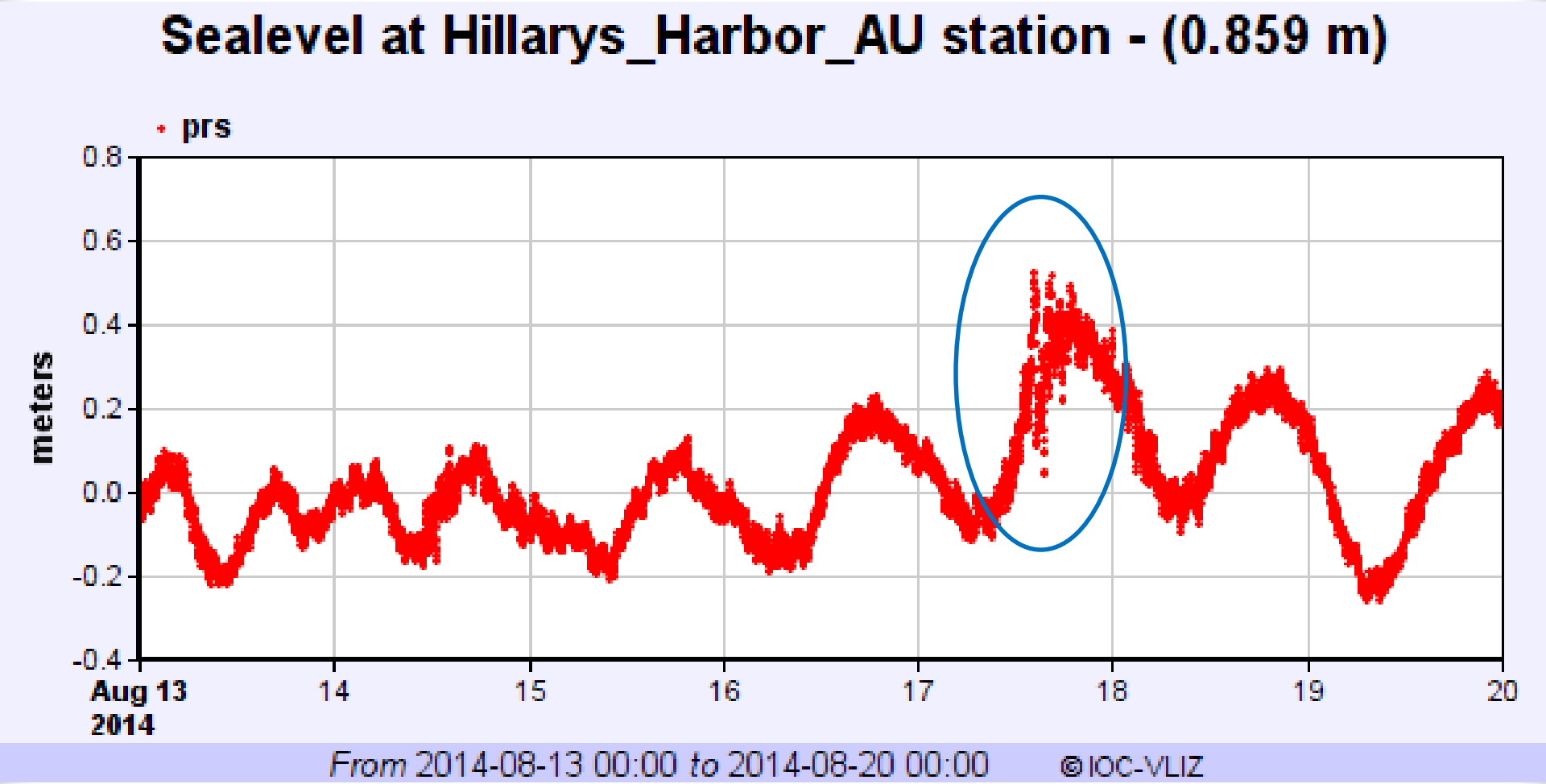


Highest water level recorded in 115 years

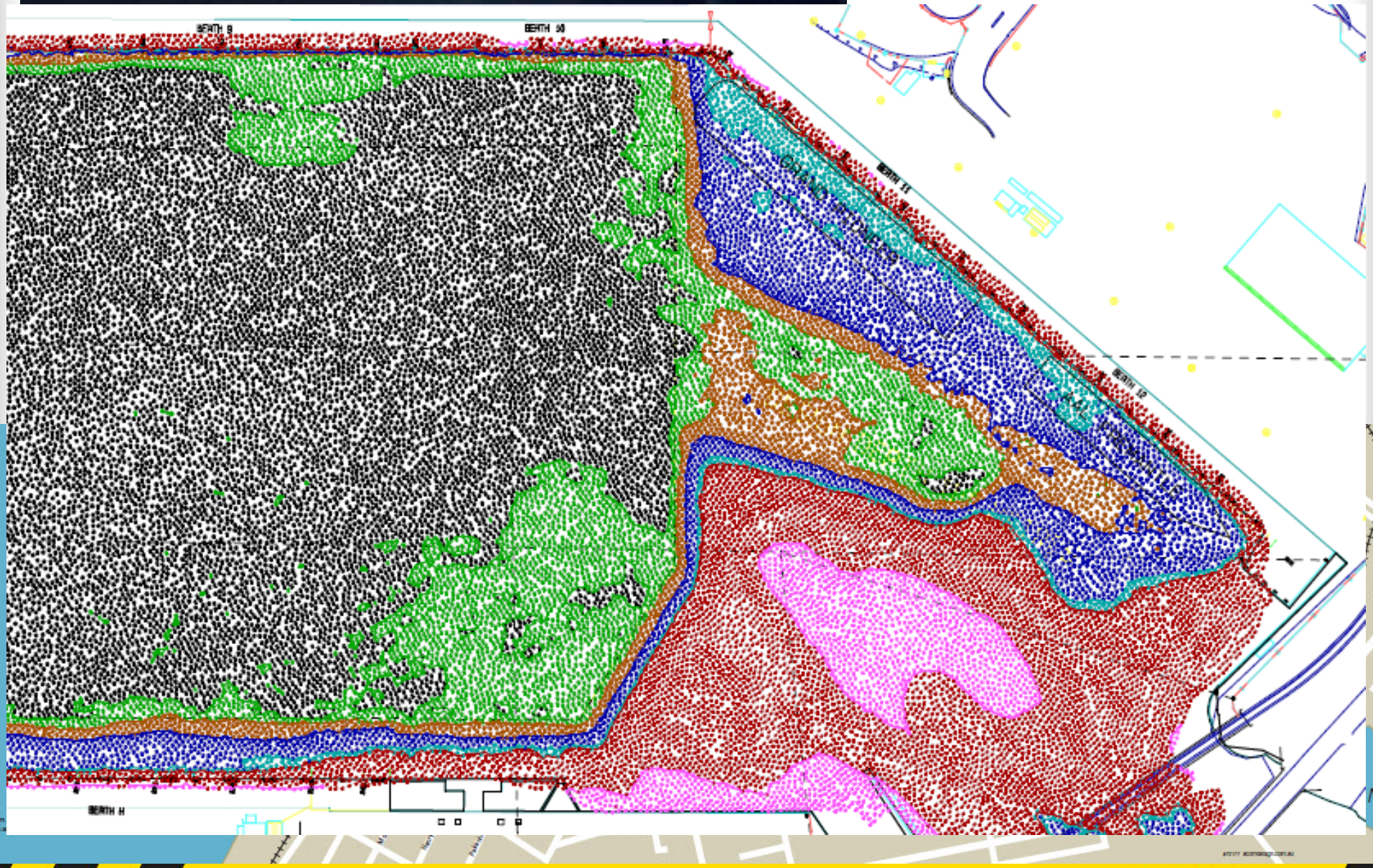
SEISMIC AND METEOROLOGICAL TSUNAMIS



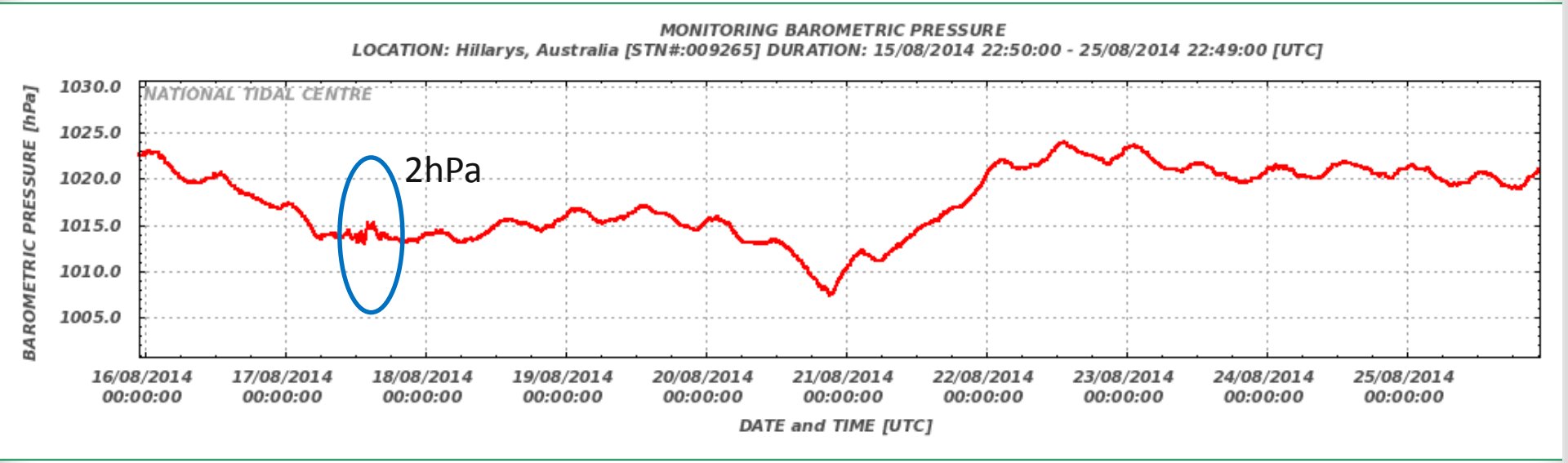
EVENT OF 17 AUGUST



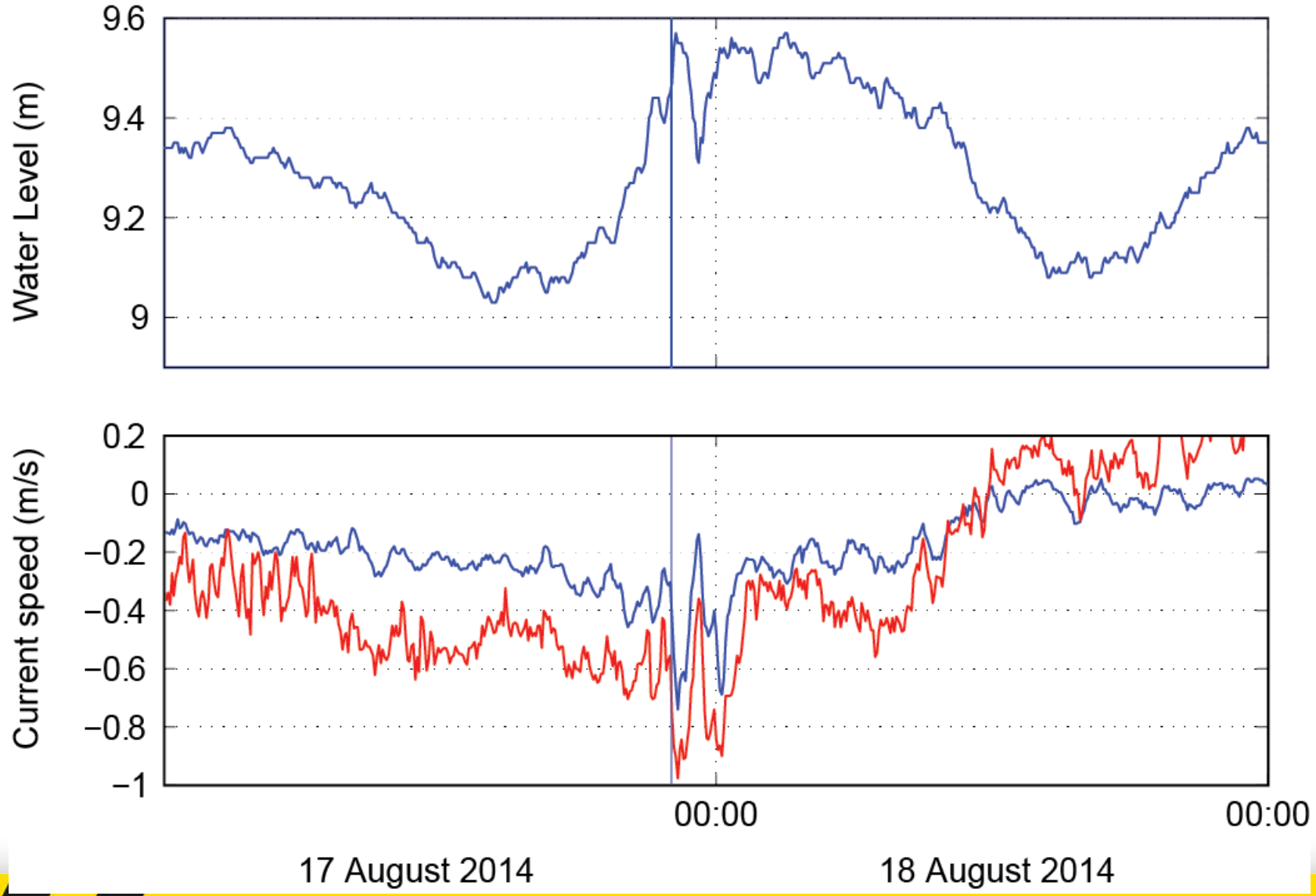
EVENT OF 17 AUGUST – SHIP ACCIDENT



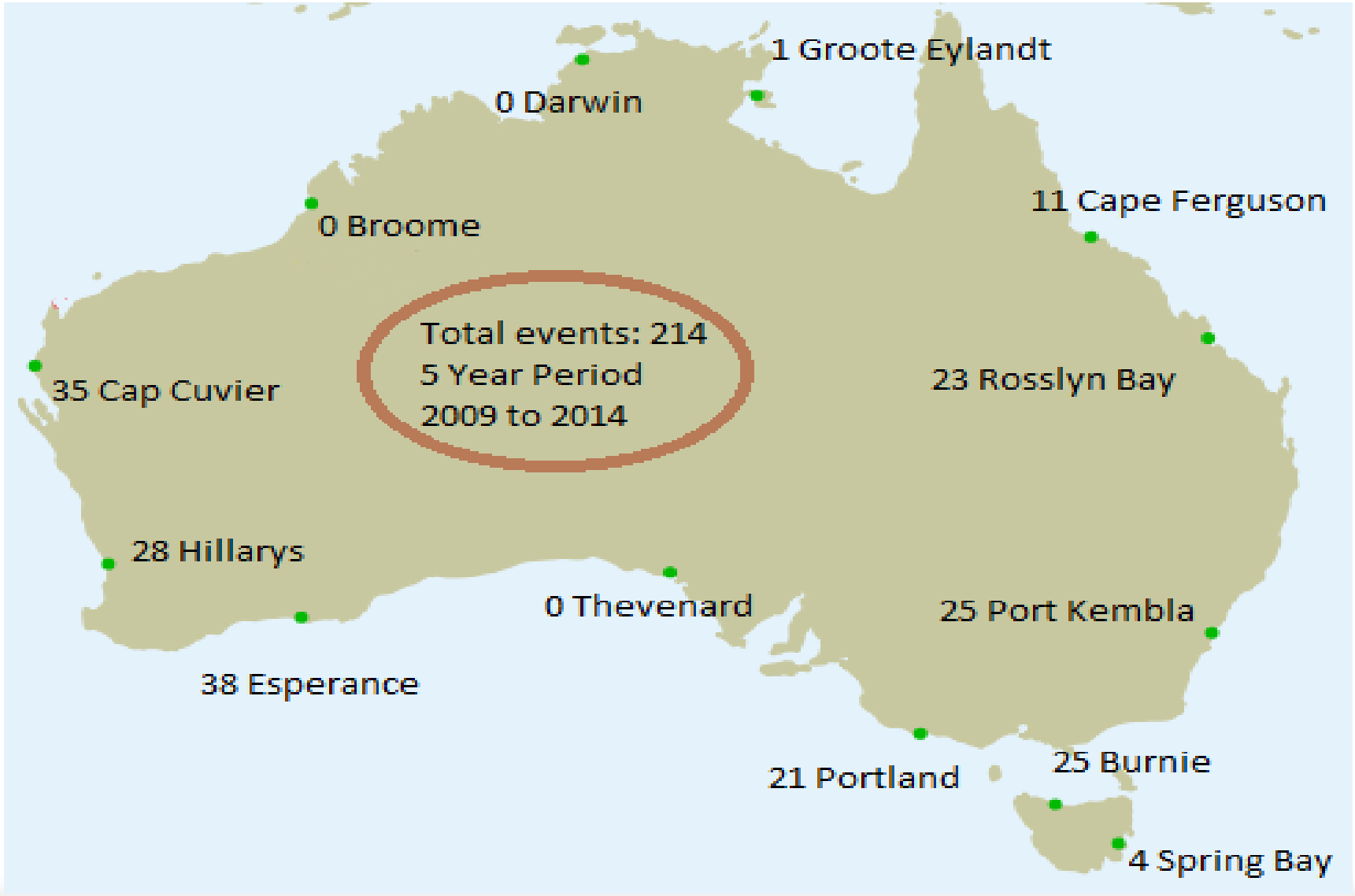
EVENT OF 17 AUGUST: AIR PRESSURE



EVENT OF 17 AUGUST: CURRENTS &WL (AWAC)



OTHER EVENTS AROUND AUSTRALIA




Extreme sea level
DANGER TODAY
LOW
MODERATE
HIGH
VERY HIGH
EXTREME
ocean
surfing

Thank you!