Tropical Cyclone Oswald – Coastal Monitoring

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Introduction

The Coastal Impacts Unit of the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) is responsible for measuring waves and storm tide levels along the Queensland coastline. This information is used for weather forecasting, and for monitoring and assessing storm erosion and peak storm surges. This paper summarises the coastal data collected during the passage of Ex-Tropical Cyclone Oswald through Queensland in January 2013, as presented in DSITIA (2013).

Background

The Bureau of Meteorology began tracking a low pressure weather system in the Gulf of Carpentaria on 17 January 2013. The system intensified and developed into a category 1 tropical cyclone and was officially named Tropical Cyclone Oswald on Monday 21 January 2013. TC Oswald then crossed Cape York Peninsula on 22 January and deteriorated into a low pressure system before tracking south inland of the coastline. The remnants of Ex-Tropical Cyclone Oswald remained significant as it moved down the coast due to the high rainfall, cyclonic winds, large waves and extreme sea levels it produced, impacting virtually the entire QLD coastline. The south east corner was particularly affected by flooding events when the system stalled over the region. For the Coastal Impacts Unit the event was especially interesting because it was one of the few occasions when a single weather system was seen to impact every monitoring site along the coast.

Methods

DSITIA operates a network of 14 wave monitoring sites along the Queensland coastline. Wave data from the network is collected by DSITIA to monitor wave conditions for coastal management and engineering; and for boating and shipping safety. Wave data is also routinely provided to the Bureau of Meteorology to assist in weather forecasting and severe weather warnings. Significant wave height (Hsig), maximum wave height (Hmax), peak energy direction, wave period information and other details are all determined from wave records spanning approximately 30 minutes each.

DSITIA also operates a network of 25 storm tide gauges located in shallow water, waterways and harbours along the Queensland coastline. The storm tide network allows real-time access to sea level data during severe weather events to monitor the impacts of coastal flooding from storm surges. The sea level data includes three components that impact on flood and coastal inundation levels; the tide, wave setup and storm surge. Of particular interest is the measurement of tidal residual, which is the difference between observed sea level and predicted astronomical tide. All storm tide stations, with the exception of Cooktown are additionally fitted with barometers. The information collected during storm events is used to monitor the severity of the event, and to help improve forecasts and modelling of future events.

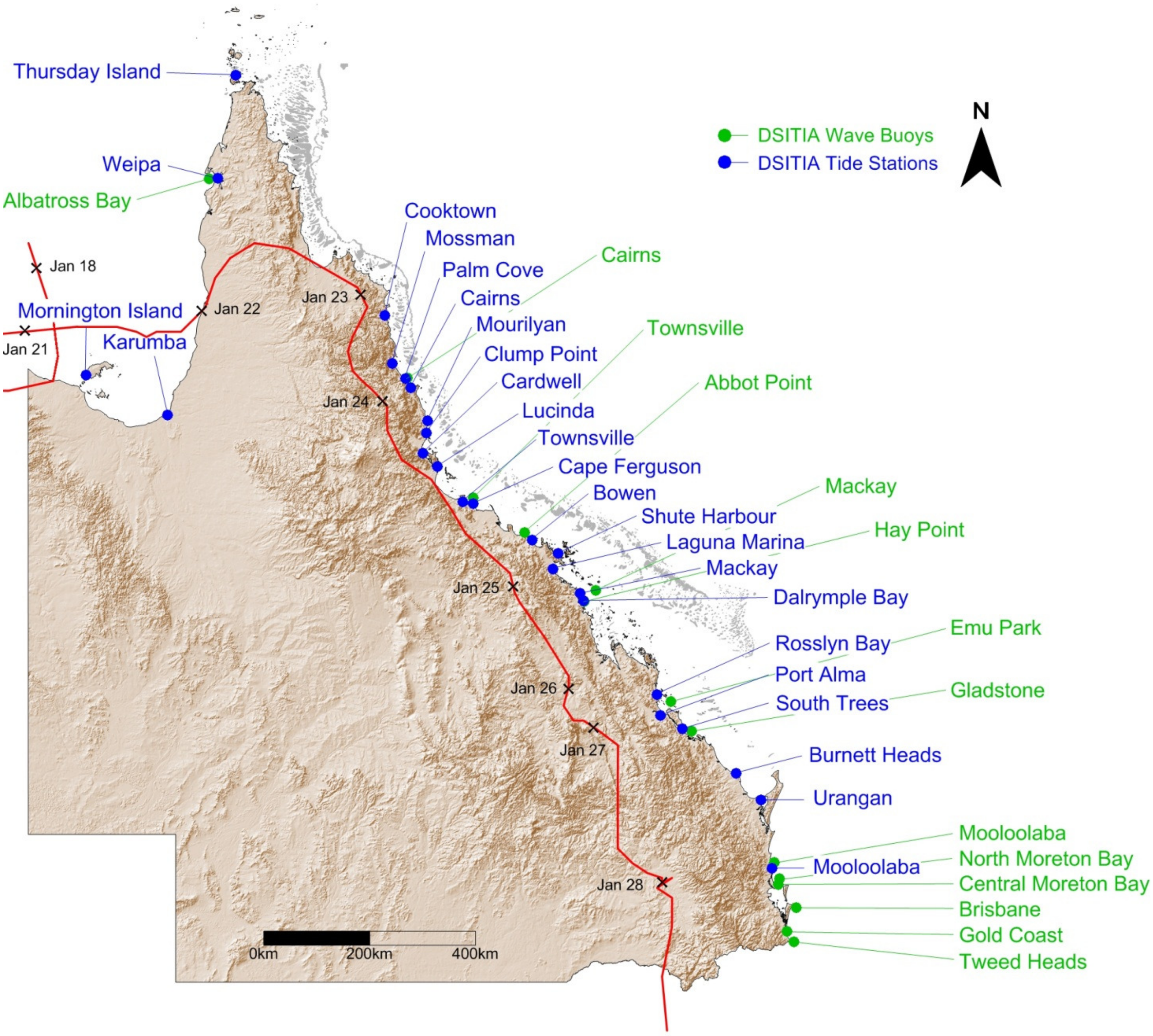

Figure 1 - DSITIA Wave and Tide site locations and the Ex-TC Oswald track

Results

Ex-Tropical Cyclone Oswald generated a number of record top 10 highest waves along the Queensland coast, including some sites with more than 30 years of data. The largest Hsig observed during the passing of Ex-Tropical Cyclone Oswald was 7.11m measured by the Brisbane buoy, located 10 km off-shore from point lookout, in a water depth of 70m. The peak Hsig was recorded at 7:30am on 28 January and ranked third in the record of 37 years in length. The maximum wave height measured during this period was 12.11m at Brisbane. By comparison the largest wave ever recorded by the Coastal Impacts Unit was the result of an east coast low in 2006 which produced a Hmax of 16.80m at the same location.

Table 1 - Peak significant and max wave heights (30+ years of data in bold)

Site (start year)	Peak Hsig (m)	Time / Date	Event Ranking	Peak Hmax (m)	Time / Date	Event ranking
Albatross Bay (2008)	4.06	1:00pm 22nd	1	6.69	1:00pm 22nd	1
Cairns (1975)	**2.32**	**11:30pm 23rd**	**4**	**4.68**	**11:00pm 23rd**	**2**
Townsville (1975)	**2.75**	**6:30am 24th**	**9**	**5.41**	**7:30am 24th**	**4**
Abbot Point (2012)	2.99	4:00pm 24th	1	5.48	6:30pm 24th	1
Mackay (1975)	**3.06**	**9:30am 23rd**	**37**	**5.57**	**9:00am 23rd**	**55**
Hay Point (1977)*	**2.38**	**11:00pm 24th**	**11**	**4.30**	**8:30pm 24th**	**23**
Emu Park (1996)	3.90	11:00am 25th	1	7.39	10:30am 25th	2
Gladstone (2009)	3.15	2:00am 25th	2	5.77	2:00pm 25th	2
Mooloolaba (2000)	5.59	5:30am 28th	2	10.50	5:00am 28th	2
Central Moreton (2011)	2.27	7:30am 28th	1	4.39	9:30am 27th	1
North Moreton (2010)	5.88	10:00pm 27th	1	10.32	11:30pm 27th	1
Brisbane (1976)	**7.11**	**7:30am 28th**	**3**	**12.11**	**7:30am 28th**	**6**
Gold Coast (1987)	6.27	10:30am 28th	2	10.49	9:30am 28th	6
Tweed Heads (1995)	6.71	8:30am 28th	2	11.83	9:00am 28th	2

The majority of tide gauge sites observed sea levels within 0.50m of reaching Highest Astronomical Tide (HAT). With the exception of Karumba, all the maxima were within 35 minutes of the predicted high tide. At Karumba the maximum level was reached 5 hours after the high tide. From the 25 monitoring sites there were 3 sites with levels greater than HAT. The most extreme was recorded at Weipa where the peak level of 3.89m was 0.51m higher than HAT. The lowest barometric pressure recorded by the gauges was 988.8hPa at Clump Point.

In order to best illustrate the influence of the event down the coast, Figure 2 shows the wave activity recorded over all sites, Figure 3 shows the tidal residuals between Townsville and Mooloolaba, and Figure 4 shows the barometric pressure recorded between Thursday Island and Townsville. The sites are ordered from north to south so that the movement of the storm position over time can be easily identified. The time where the storm was closest to the recording site is also shown as a black line, and labelled accordingly underneath the site name.

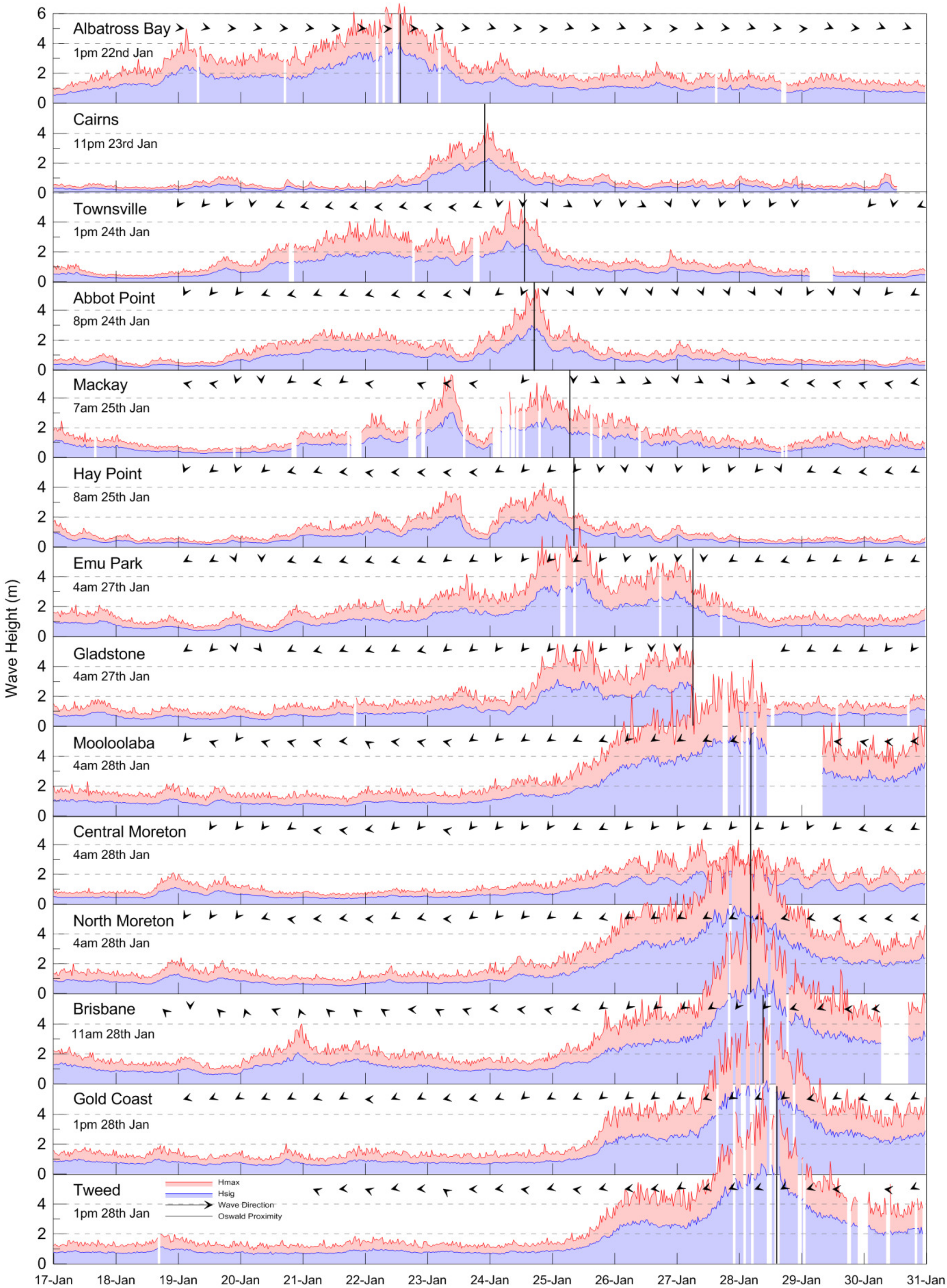

Figure 2 - Wave heights and peak wave directions

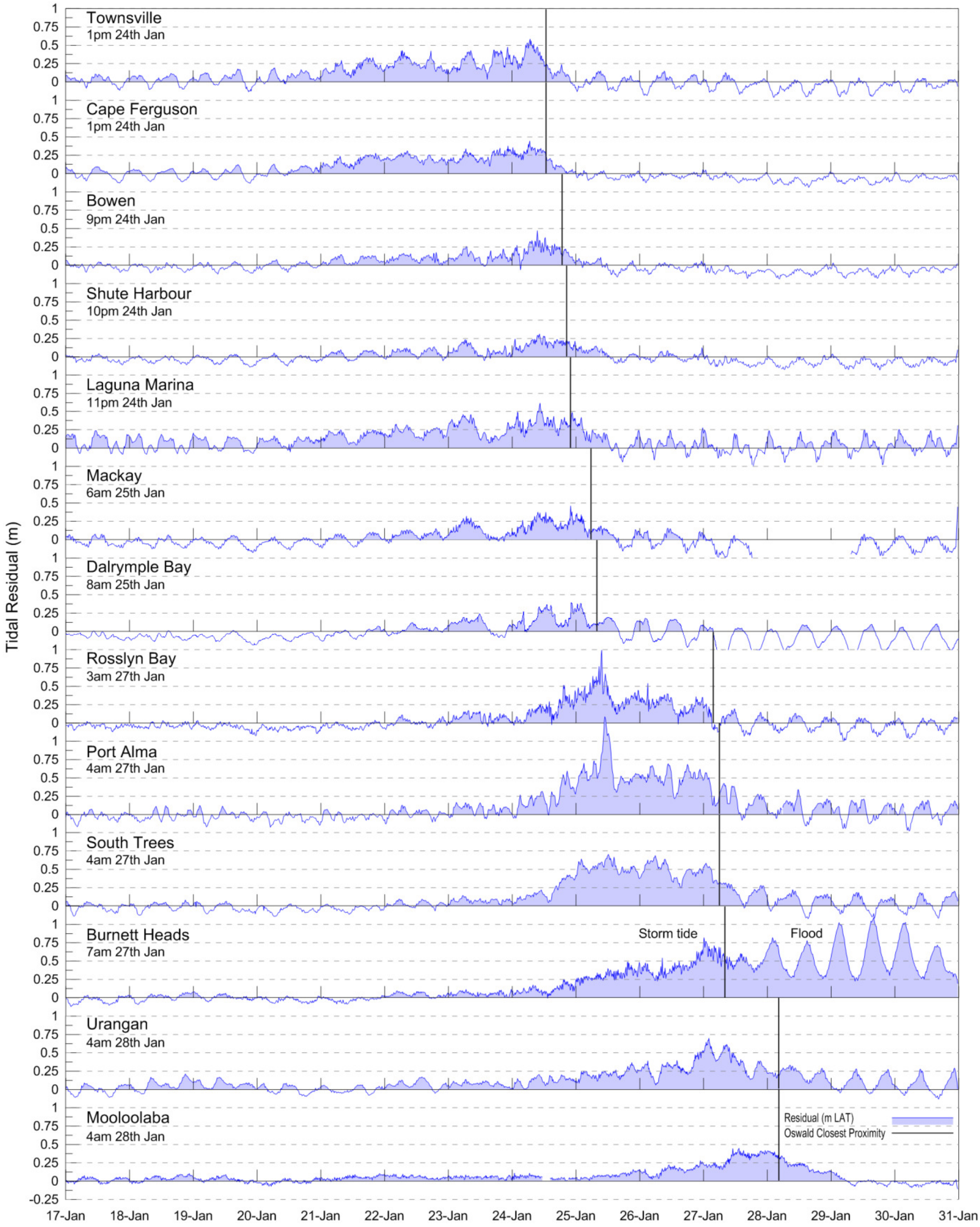

Figure 3 - Tidal residuals (Townsville - Mooloolaba)

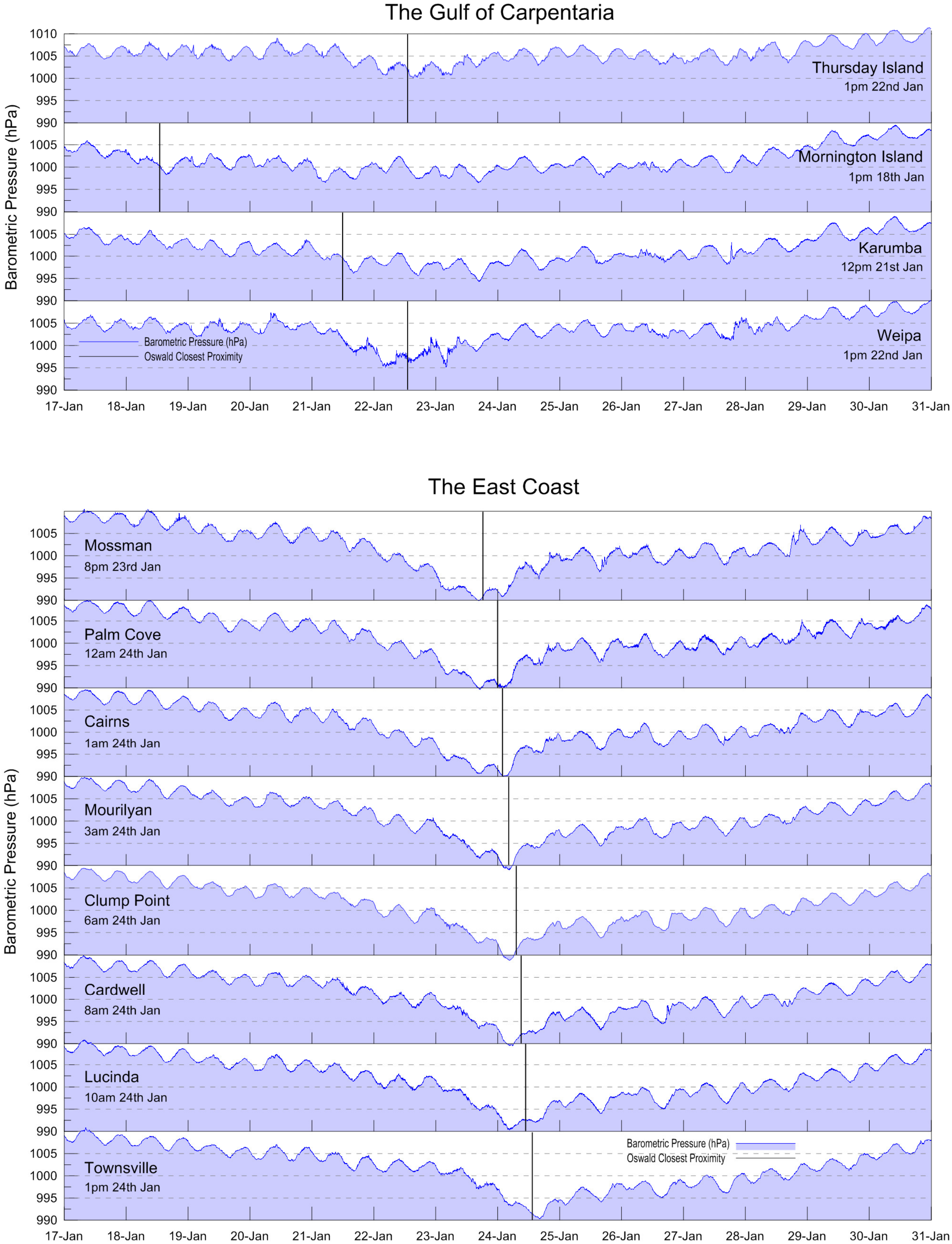

Figure 4 - Barometric pressure (Thursday Island - Townsville)

Discussion

Immediately distinguishable from the recorded data is the progression of the weather system down the coast over roughly a 6 day period. Nearly all sites show a clear correlation between the time when the system was closest, and the peak recorded values.

The impact on south east Queensland is clear, with more dramatic differences between the observed conditions before and during the event. Wave conditions were more severe in this region compared to regions further north, likely due to a combination of the influence of the Great Barrier Reef limiting wave growth and the travel speed of the system. The tidal residuals at Burnett Heads (located near the mouth of the Burnett River at Bundaberg) indicate the point where the storm tide coincided with floodwater from the river systems, transforming the storm tide gauge into a flood gauge while the region was inundated for several days.

Gaps in the data can be observed, either sporadic or spanning several hours, serving as an additional indicator of the extreme nature of the event being monitored. These gaps tend to occur during the peaks, and can either be attributed to exceeded instrument limitations, or issues with maintaining real-time data transmission during increasingly inclement weather. The larger gaps often correspond to power failure on the land, disabling the gauges or wave data receiver stations.

All DSITIA storm tide monitoring sites showed noticeable tidal residuals when the storm was nearby. While only 3 sites exceeded HAT, and only by small amounts, the recorded tidal residuals show that although Ex-TC Oswald was travelling inland as a low pressure system, it still had considerable impact on the Queensland coastline.

Take Home Messages

The data collected during Ex-TC Oswald is interesting to analyse due to the widespread impact throughout Queensland. It is especially interesting to observe that the storm caused the most disruption when it was in the south east corner, despite having weakened into an Ex-Tropical Cyclone several days earlier. Clear time-correlation was found between the peaks from all three measured phenomenon (wave heights, tidal residuals, minimum barometric pressure) with respect to each other as well as the storm position tracking provided by BoM.

This event highlights the value and importance of maintaining the DSITIA wave and tide monitoring networks. The ongoing collection and publication of actual extreme event conditions is significantly beneficial to emergency managers and the scientific community working to improve Queensland's resilience to extreme events.

Acknowledgments

1. Cyclone Oswald tracking data and imagery courtesy of Bureau of Meteorology (www.bom.gov.au)
2. Queensland mapping data provided by Maritime Safety Queensland (www.msq.qld.gov.au)
3. Queensland topography data from Geoscience Australia (www.ga.gov.au)
4. Great Barrier Reef data courtesy of the Great Barrier Reef Marine Park Authority (www.gbrmpa.gov.au)

References

Queensland Government, DSITIA (2013). *Tropical Cyclone Oswald – Coastal Monitoring Data Report*. Coastal Impacts Unit. Publishing pending.