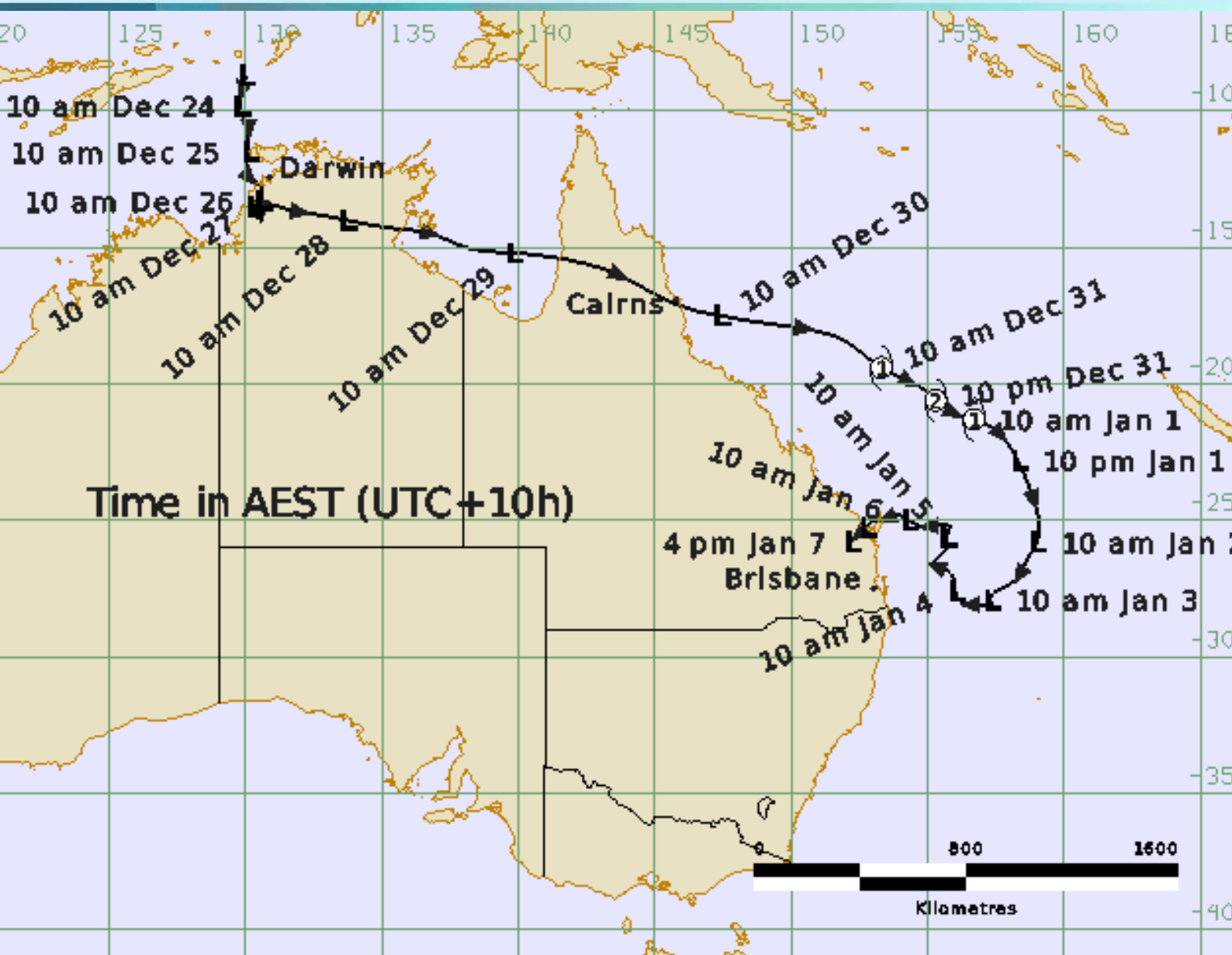




# Tropical Cyclone Seth

22 December 2021 – 07 January 2022

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14 February 2022



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# 1 Summary

Tropical Cyclone *Seth* was a tropical cyclone for a little over 24 hours in the Coral Sea but its entire track lasted 15 days. The most significant impacts were severe flooding in southeast Queensland and hazardous surf along the southern Queensland and northern New South Wales coast. The low was responsible for onset of the monsoon over Darwin and the Top End.

The system originated north of the Northern Territory in the eastern Timor Sea on 23 December and moved south, passing just to the west of the Tiwi Islands on Christmas Day before crossing the coast near Dundee Beach southwest of Darwin early on 26 December. The low was slow moving before tracking east over land into the Gulf of Carpentaria on 28 December then over Cape York Peninsula on 29 December and into the Coral Sea on 30 December.

Tropical cyclone intensity is estimated on the morning of 31 December, peaking at category 2 intensity later that day based on observations at Frederick Reef where wind gusts peaked at 82 knots (kn) (152 kilometres per hour (km/h)) at 1308 Universal Time Coordinated (UTC) 31 January (1908 Australian Eastern Standard Time (AEST) 31 January (AEST=UTC+10 hours)). Gale-force winds were recorded at Marion Reef, Frederick Reef and Cato Island, while storm-force winds were recorded at Frederick Reef.

On 2 January, *Seth* was reclassified as a sub-tropical system but still produced gales until later on 3 January. A strong circulation continued on following days as it moved slowly to the northwest then west crossing the southern Queensland coast on 7 January near Hervey Bay. The system then weakened overland but not before producing extreme rainfall in the area.

The most significant hazards during this event were:

Heavy rainfall and associated flooding in southeastern Queensland as the low moved over land. Intense flooding occurred on the Mary River. Daily falls exceeded 400 millimetres (mm) to 9am AEST on 8 January, including at Marodian 674 mm, Mt Kanigan 650 mm, Miva 572 mm and Glenwood 523 mm.

Hazardous surf and coastal inundation on southern Queensland and northern New South Wales coast on 2-5 January.

FIGURE 1 a. Best track of Tropical Cyclone *Seth* 24 December 2021 – 6 January 2022 (times in AEST, UTC+10).

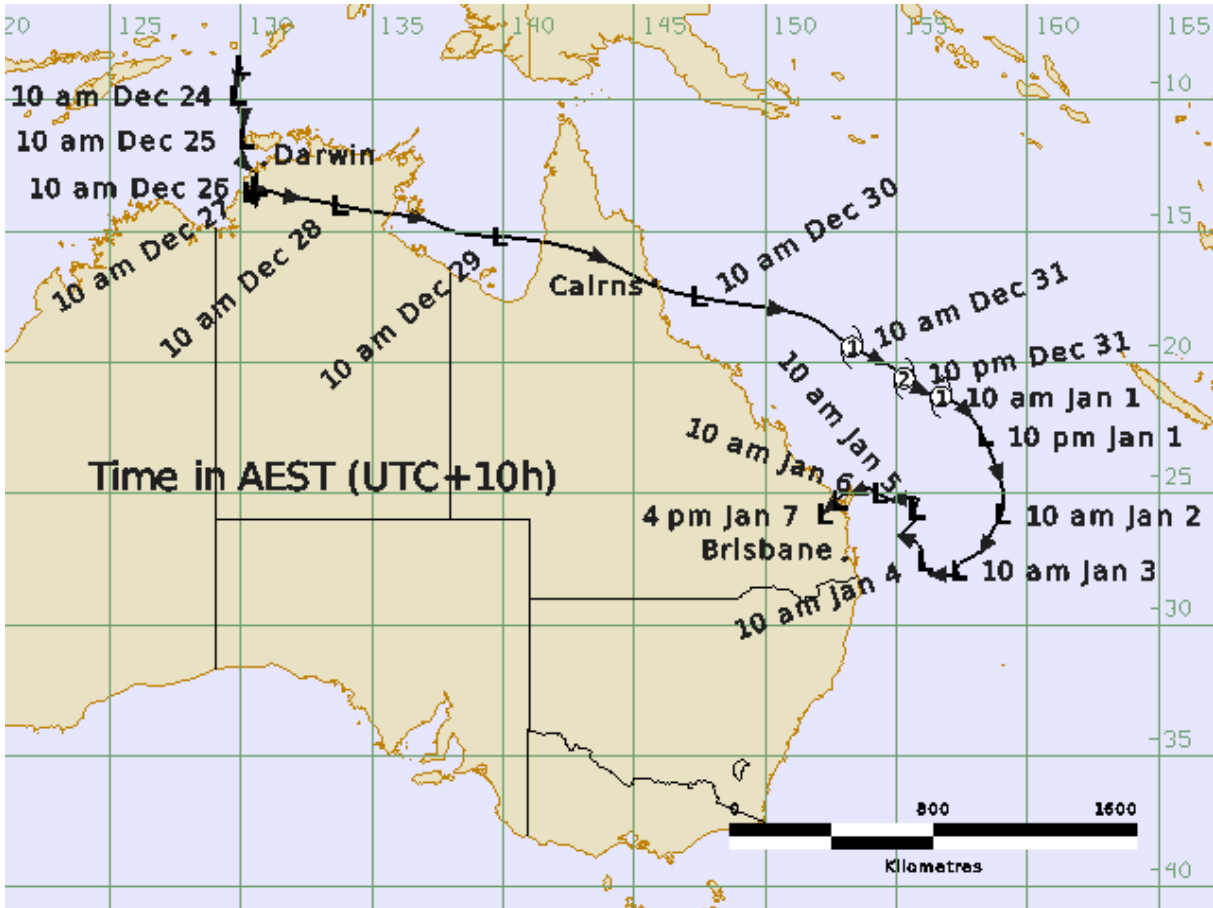
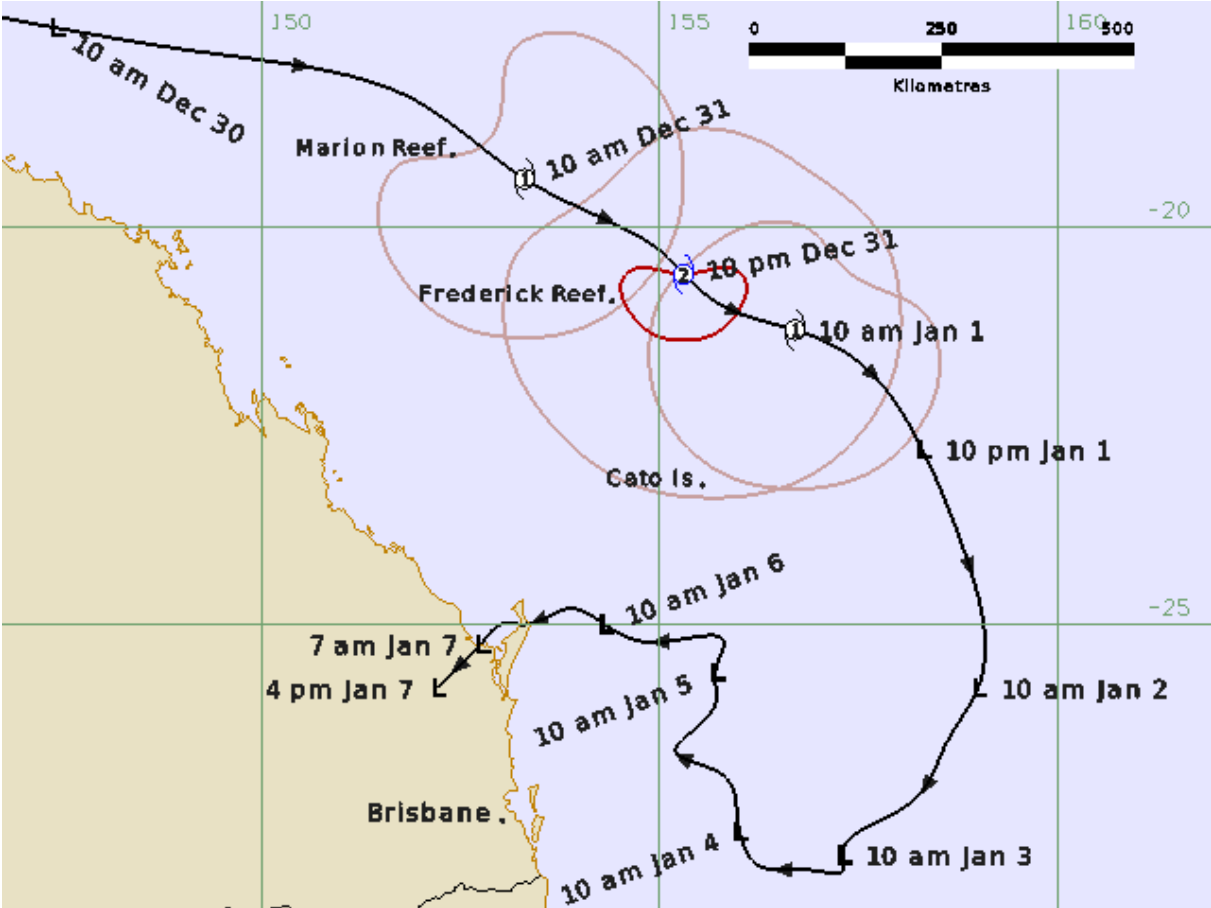


FIGURE 1 b. Best track of Tropical Cyclone *Seth* in Coral Sea 30 December 2021 – 6 January 2022 (times in AEST, UTC+10).



## 2 Meteorological Description

### 2.1 Intensity analysis

A low formed in the monsoon trough on 23 December north of the Northern Territory coast in the eastern Timor Sea region. Deep convection increased sufficiently near the centre to indicate initial Dvorak T=1 early on 24 December. Despite being in an environment conducive for development and model guidance which indicated intensification, the circulation only developed slightly until it made landfall near Darwin early on 26 December.

The system weakened somewhat over land and became elongated as it progressed into the Gulf of Carpentaria and across the Cape York Peninsula. Once over the warm Coral Sea on 30 December, development was encouraged by a near gale-force monsoonal flow to the north and strong southeasterlies between the circulation and land despite strong wind shear. Gales were briefly observed at Holmes Reef in the monsoon flow. However deep convection did not become organised and Dvorak satellite estimates were around 1.5. Advanced Scatterometer (ASCAT) passes (ASCAT-B at 1116 UTC and ASCAT-C at 1208 UTC 30 December) continued to show an elongated centre with near gales north and south.

Deep convection developed closer to the centre overnight despite persistent northwesterly wind shear. Tropical cyclone intensity was estimated at 0000 UTC 31 December based on an improved satellite signature (refer Figure 2) and by observations of gales at Marion Reef to the northwest and Frederick Reef to the southeast. A Hai Yang 2C (HY-2C) scatterometer pass at 0307 UTC 31 December also showed gales, albeit not encircling the centre.

For the analysis of peak intensity there were several inputs. Dvorak analyses through 0000, 0600, 1200 and 1800 UTC indicated a Current Intensity (CI) of 3.0, corresponding to winds of 35-45 kn. However, Frederick Reef registered storm-force winds (winds above 48 kn (89 km/h)) for a period around 0900 UTC 31 December peaking at 57 kn (106 km/h) at 0915 UTC 31 December. Figure 3 shows the microwave images (37 and 89 GHz) with the location of Frederick Reef overlaid, just outside the region of deepest convection. Around this time Frederick Reef recorded a minimum pressure of 988.8 hectoPascals (hPa), when the centre was 90 km away. Based on these observations, the central pressure was estimated at 982 hPa, a notable decrease from the 0000 UTC estimate of 992 hPa based on Marion Reef observations. A central pressure of 982 hPa corresponds to a maximum wind of 53 kn in this situation using the standard wind pressure relationship. Soil Moisture Ocean Salinity Radiometer (SMOS) at 0717 UTC showed a small area above 50 kn while an ASCAT-C wind analysis at 1145 UTC shows a small region of 50 kn as shown in Figure 4. although 1051 UTC (ASCAT-B). Combining the above information, the peak intensity is estimated at 55 kn (102 km/h), albeit in a small region, at 1200 UTC 31 December.

However, weakening was immediate with a subsequent dramatic loss of deep convection caused by dry air and northwesterly wind shear. Maximum winds were maintained higher than Dvorak estimates and influenced by observations (gales at Cato Island until 1200 UTC 1 January) and scatterometry passes. Gales are estimated to be restricted to southern quadrants only by 0600 UTC 1 January and hence below tropical cyclone intensity. This was based on HY2B (0212 UTC), AMSR2 (0313 UTC) and model analyses, and subsequent partial passes of ASCAT (1125 UTC) and HY2B at 1901 UTC 1 January.



By early on 2 January, the system was reclassified as a sub-tropical system. The low-level circulation was broad and elongated with convection still confined south of the centre. However, the area of gales extended more than half-way around the centre as depicted on a HY2C pass at 0212 UTC 2 January and HY2B at 0750 UTC (refer Figure 5) which was also consistent with model analyses. Winds eased below gale-force later on 2 January as shown on HY2C at 1529 UTC, 2 January (refer Figure 5).

Figure 6 plots the various intensity estimates. The peak best track estimates are above both subjective Dvorak and objective estimates noting that objective estimates only started during 31 December.

## 2.2 Structure

In the initial stages the circulation remained reasonable shallow. Once in the Coral Sea both the strong monsoonal flow northeast of the centre and southeasterly flow south of the centre led to a strong asymmetric wind field. Gales were estimated to extend beyond 120 nautical miles (nm) (220 km) but restricted in the northwest quadrant as confirmed by observations at Marion Reef on 31 December. The strongest winds were located south of the centre as demonstrated by Frederick Reef observations and supported by scatterometry mentioned earlier and shown in Figure 4, and also model wind fields. The radius to maximum winds was estimated at 40 nm (75 km) from scatterometry and radiometry wind analyses.

On 1 January the system became strongly influenced by the mid-latitude upper level low and began exhibiting sub-tropical characteristics. The area of gales to the north reduced with the loss of deep convection and separation to the monsoon flow. By 0600 UTC 1 January, gales were estimated less than halfway around the centre, but on 2 January gales again extended further around the centre as shown by scatterometry HY2C at 0212UTC, HY2B at 0750 UTC and partial ASCAT at 1151 UTC 2 January. However, by 1800 UTC 2 January winds eased below gale-force. Figure 5 shows HY2 images at 0750 UTC with gales in all quadrants and then at 1529 UTC with no gales.

## 2.3 Motion

In the early stages off northern Australia, the circulation moved south, then was slow moving overland. An increase in monsoonal flow steered the low to the east southeast from 27 December, moving over the Gulf of Carpentaria and then Cape York Peninsula reaching the Coral Sea on 30 December. The influence of a mid-latitude upper low steered the system more to the south later on 1 January then southwest on 2 January. Steering influences became weak and the sub-tropical low then meandered first to the west then north then again to the west crossing the southern Queensland coast early on 7 January.

FIGURE 2. Visible image at 0000 UTC 31 January, at the time tropical cyclone intensity is estimated.

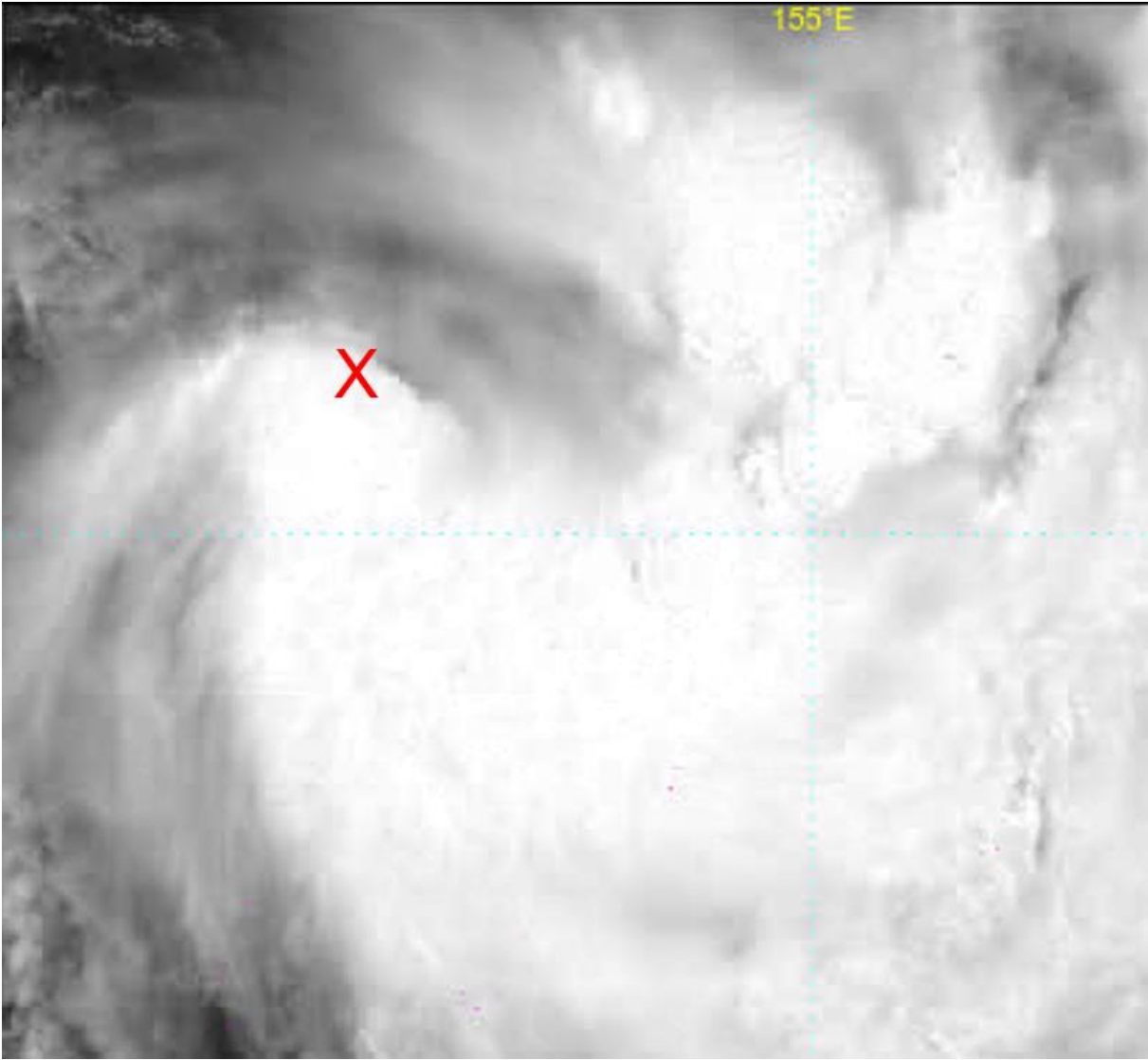


FIGURE 3. GMI Microwave at 0910 UTC 31 January, near peak intensity and Frederick Reef, indicated with 'o' reports winds to 57 kn.

Images courtesy NRL: <https://www.nrlmry.navy.mil/TC.html>

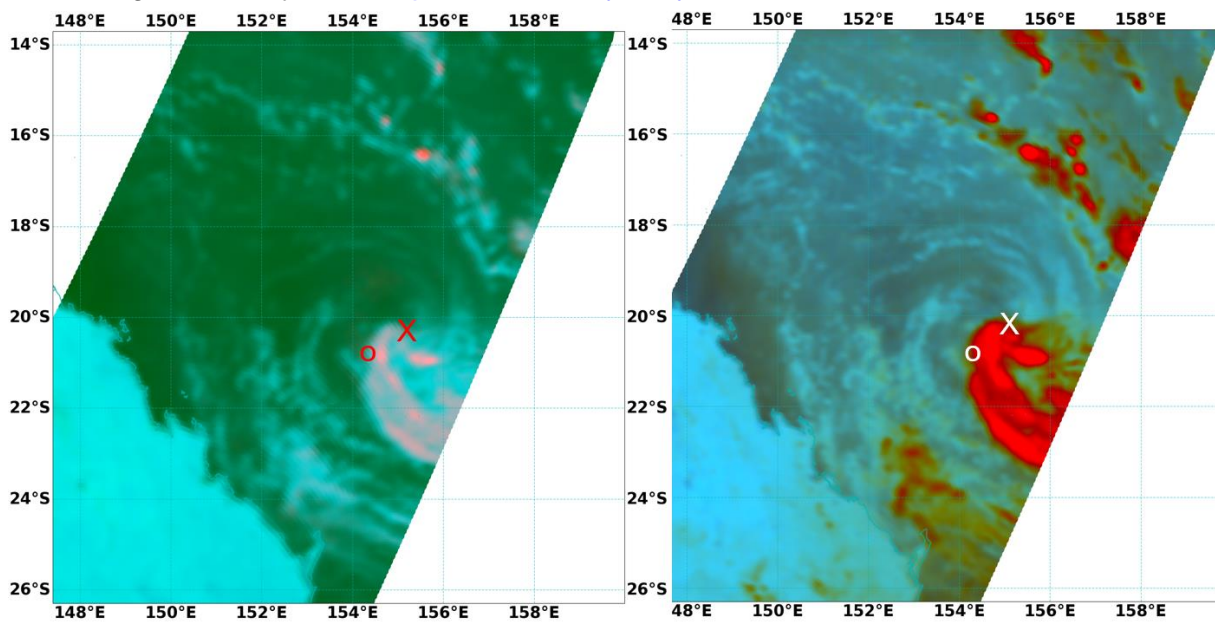


FIGURE 4. Wind speed distribution from left, SMOS radiometer at 0717 UTC 31 December and right, ASCAT-C at 1157 UTC. The centre is indicated by 'x' and Frederick Reef location by 'o'.

Images courtesy NRL: <https://www.nrlmry.navy.mil/TC.html>

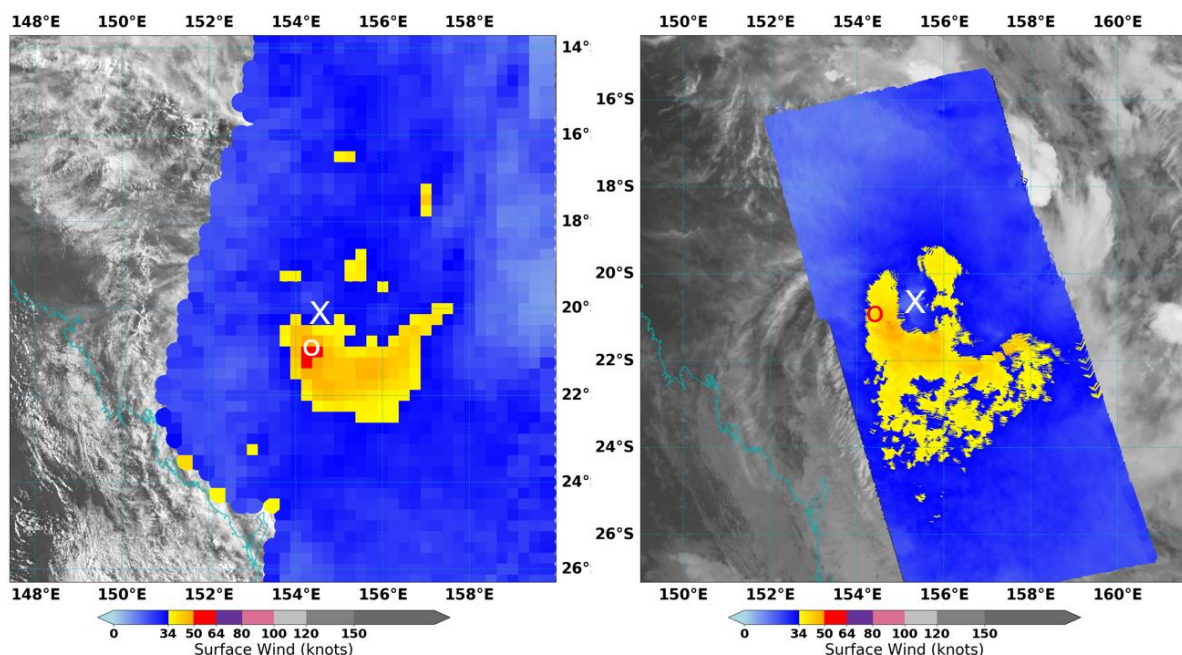


FIGURE 5. Winds from left, HY2B at 0750UTC and right, HY2C at 1529 UTC, 2 January. Images courtesy NRL: <https://www.nrlmry.navy.mil/TC.html>. Data copyright EUMETSAT.

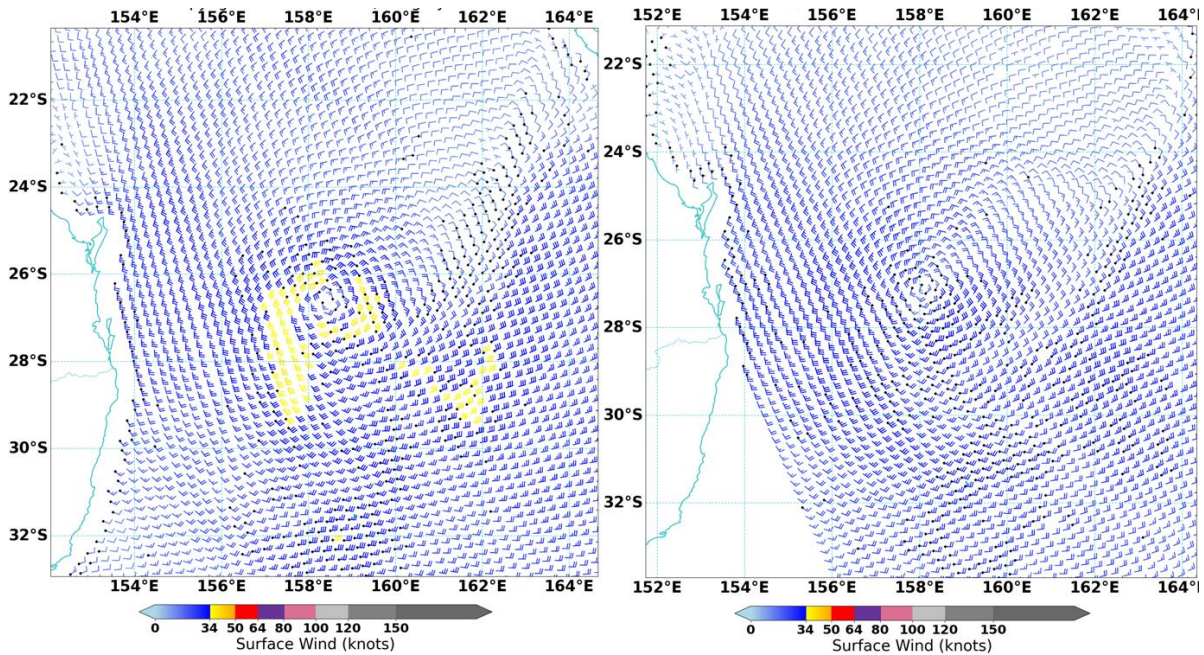
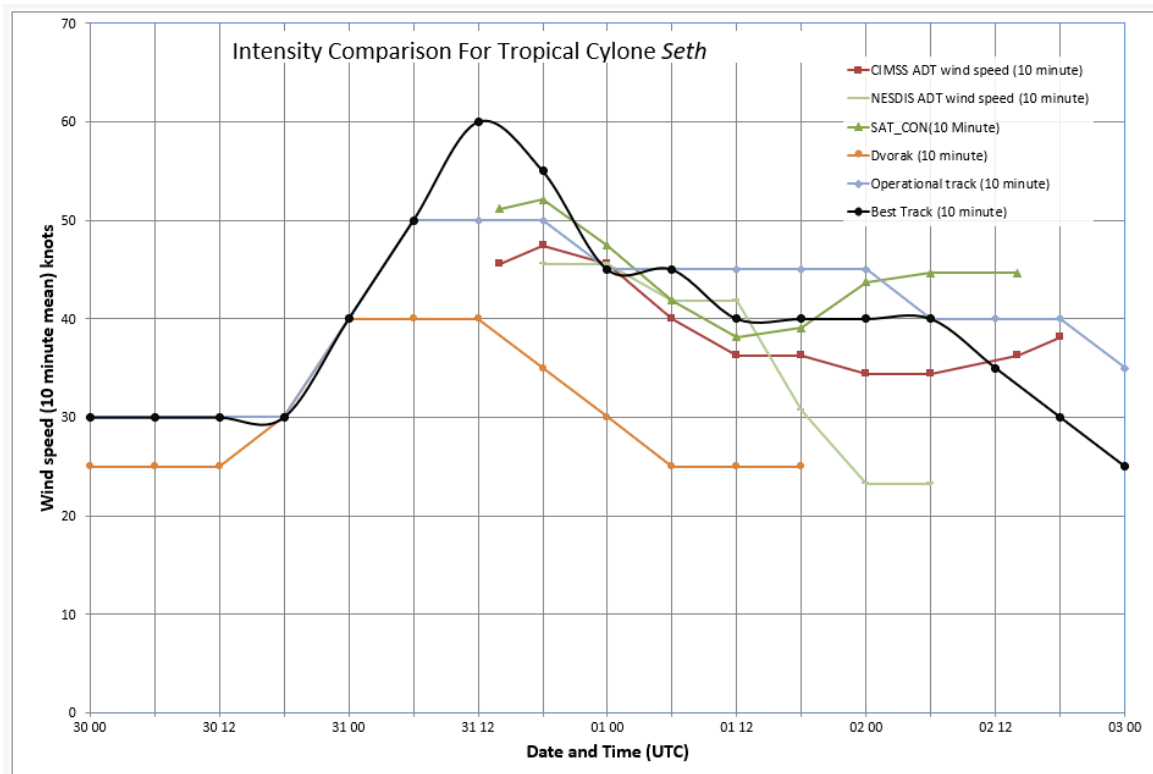


FIGURE 6. Plot of objective and subjective intensity estimates for *Seth*.



## 3 Impact

There were three separate impacts (in chronological order):

### 3.1 Heavy rain across Northern Territory and northern Queensland, 23-30 December.

The main impacts were disruptions to transportation. There were multiple road closures over the Top End and a peak at major flood level in the Waterhouse River at Beswick.

### 3.2 Large waves and coastal erosion southern Queensland and northern New South Wales 2-5 January.

The large waves and strong onshore winds combined with high astronomical tides to cause tides exceeding the highest astronomical tide (HAT) levels. Significant wave heights exceeding 4 metres (m) were recorded at Brisbane and Tweed offshore buoys on 3 January.

Hazardous surf conditions led to the closure of many beaches along the New South Wales and southeast Queensland coast and during the same period two drownings were reported in the media.

### 3.3 Heavy rainfall and associated flooding occurred across parts of the Wide Bay Burnett region in Southeast Queensland on 7-8 January as the low moved over land.

Major flooding in the Mary and Burnett Rivers and minor to moderate flooding in the Burrum-Cherwell and Upper Brisbane Rivers. There was also significant flash flooding in many local creeks. Numerous swift water rescues were carried out overnight Friday 8 January into Saturday 9 January, with one confirmed fatality (Kanigan area) and one person missing. A second fatality was confirmed on Tuesday 11 January (Tiaro area) and one person remains missing at the time of writing this report. Initial assessments suggested 30 homes and 50 businesses were damaged by floodwaters in Maryborough.

Refer also to the following section on Observations for rainfall totals.

## 4 Observations

### 4.1 Wind

Frederick Reef refer Figure 7.

Gales\* for 17 hours between 2339 UTC 30 December to 1651 UTC 31 December.

Storm force winds: 0852-0933 UTC 31 December.

Maximum 10-minute mean wind 57 kn (106 km/h) at 0915 UTC 31 December.

Maximum 3-second wind gust 82 kn (152 km/h) at 0908 UTC 31 December.

Marion Reef

Gales for 3.5 hours from 2334 UTC 30 January to 0304 UTC 31 January.

Maximum 10-minute wind 42 kn (78 km/h) at 0001 UTC 31 January.

Maximum 3-second wind gust: 60 kn (111 km/h) at 0017 UTC 31 January.

Cato Island refer Figure 8.

Gales from 07UTC 31 Dec to 1200UTC 1 January (periodic gales 02-07UTC 31 Dec.).

Maximum 10-minute mean wind: 43 kn (80 km/h) at 1133 UTC 31 December. Maximum 3-second wind gust: 53 kn (98 km/h) at 0239 UTC 1 January.

\*Note: gales: 10-minute mean winds of 34-47 kn (63-88 km/h); storm-force winds: 10-minute mean winds of 48-63 kn (89-117 km/h).

### 4.2 Lowest Mean Seal Level (MSL) Pressure

Marion Reef 993.4 hPa at 2029 UTC 30 January

Frederick Reef 988.8 hPa at 1909 UTC 31 December.

### 4.3 Rainfall

Northern Territory: Heavy rain fell associated with the early stages of the low from 23-27 December. Figure 6 shows the weekly rainfall to 30 December highlighting rainfall exceeding 300 mm over the Top End and Qld Gulf of Carpentaria coast.

Notable daily falls to 9am CST included:

- 25 December: Point Stuart 175 mm, Gunn Point 147 mm;
- 26 December: Milingimbi 235 mm, Maningrida 211 mm, Dum-In-Mirrie 181 mm;
- 27 December: Berrimah 201, Darwin Hospital 181 mm;
- 28 December: Maud Creek 174 mm, Nitmiluk Rangers 144 mm;
- 29 December: Thorak Cemetery 242 mm, East Arm 150 mm.

North Queensland: Heavy rain accompanied the passage of the low over Cape York Peninsula. Notable daily falls to 9 am AEST included:

28 December: 198.4 mm at Dunbar Station

29 December: 235.2 mm at Kowanyama and 191 mm at Dunbar Station.

30 December: 213 mm at Riverview, 152 mm Port Douglas.

Southeast Queensland: Intense rainfall and associated flooding occurred in the Wide Bay region following landfall of the low. Widespread rainfall totals of 150-230 mm were recorded across the Mary River as well as parts of the Burnett River (Barambah Creek and downstream of Paradise Dam). In the hills to the north-west of Gympie, 400-674mm was recorded to 9am Saturday 8 January by Bureau of Meteorology rain gauges. In these areas, the intensity and 24-hour totals exceeded records set in January 2013 (ex-Tropical Cyclone Oswald). There were some anecdotal reports of falls exceeding 800 mm.

Highest official reports to 9am 8 January:

Marodian 674 mm; Mt Kanigan 650 mm; Miva 572 mm and Glenwood 523 mm.

Figure 10 shows the daily radar accumulation to 9am AEST 8 January indicating the distribution of the heaviest rainfall.

#### 4.4 High waves and storm tide

The prolonged strong southeasterly wind flow over a large area south of the system produced high swell waves that caused hazardous surf conditions on the southeastern Queensland and northern New South Wales coastline. Both Brisbane and Tweed wave rider buoys recorded significant wave heights exceeding 4m on 4 January, with associated wave periods exceeding 10 seconds (s) as shown in Figure 11.

Onshore winds and high waves combined with very high astronomical tides to cause some coastal inundation and beach erosion.

FIGURE 7. Wind and pressure observations at Frederick Reef, 31 December - 1 January. Times in AEST (UTC+10h).

Note: winds corrected to 10m height using 0.87 reduction factor. Gusts as measured at 30m.

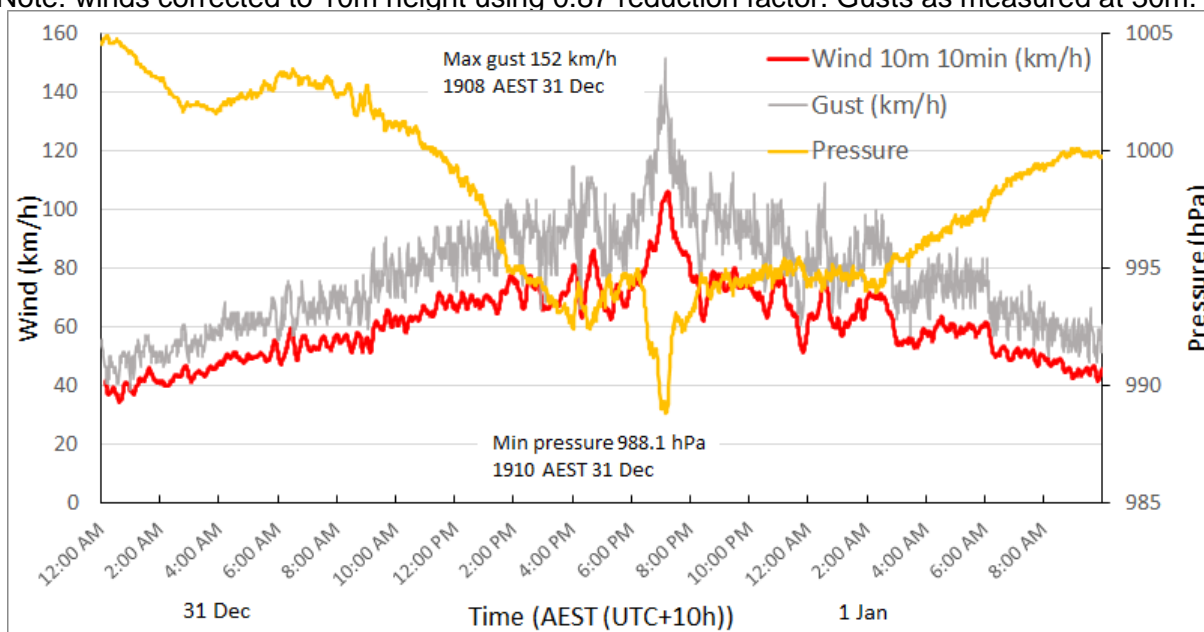


FIGURE 8. Wind and pressure observations at Cato Island, 31 December - 2 January. Times in AEST (UTC+10h).

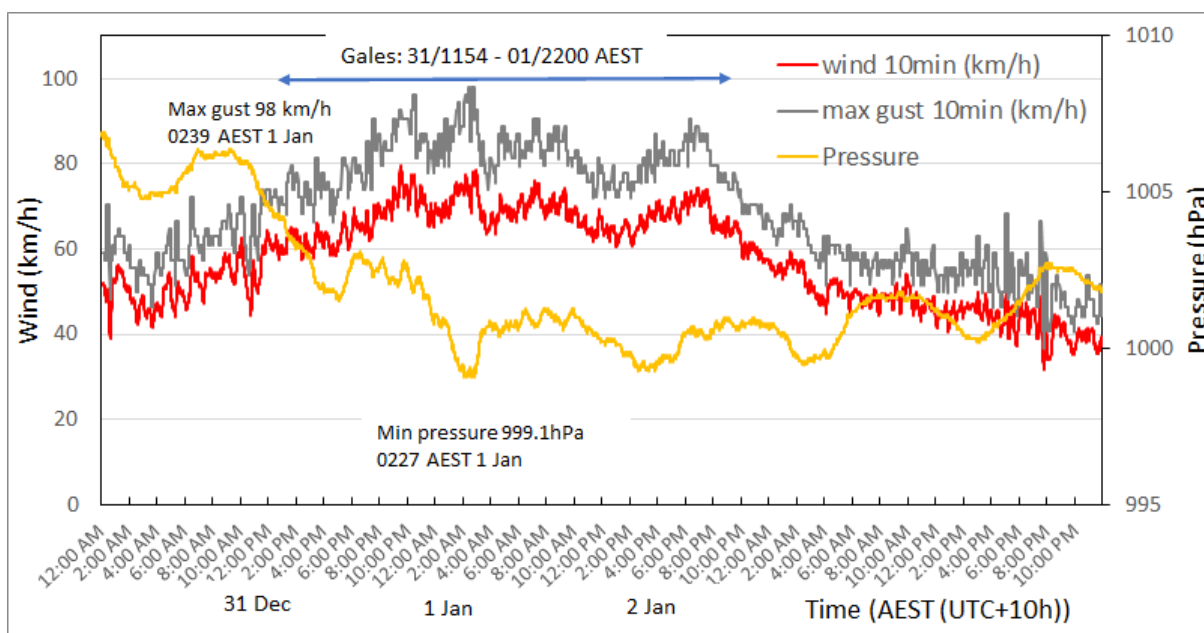




FIGURE 9. Distribution of rainfall totals for the week ending 30 December.

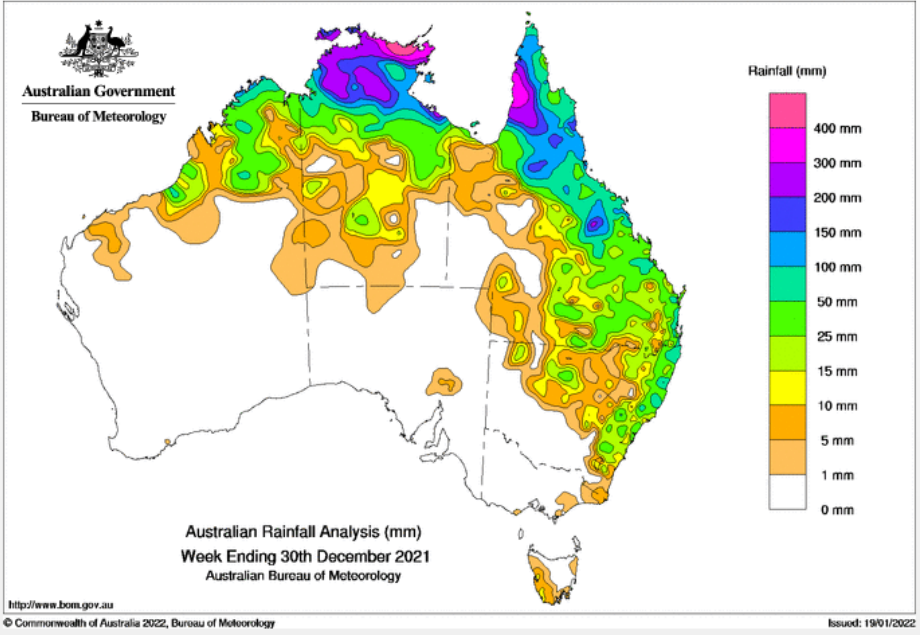


FIGURE 10. Daily radar (Kanigan) accumulation to 9am AEST 8 Jan. showing the distribution of heavy rain in the Wide Bay region.

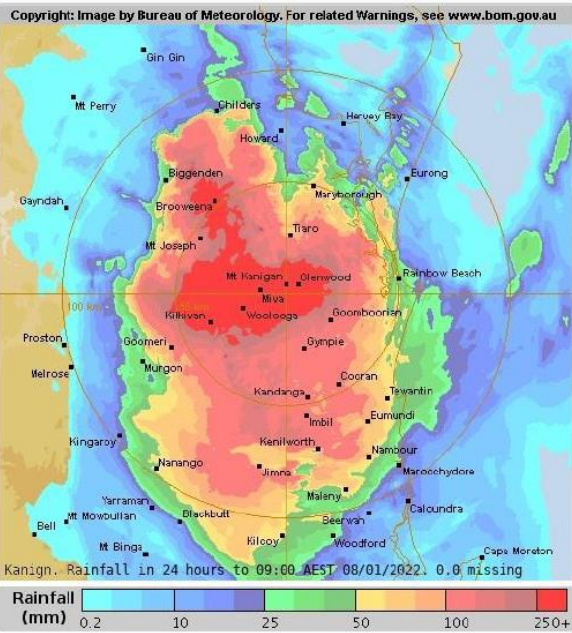
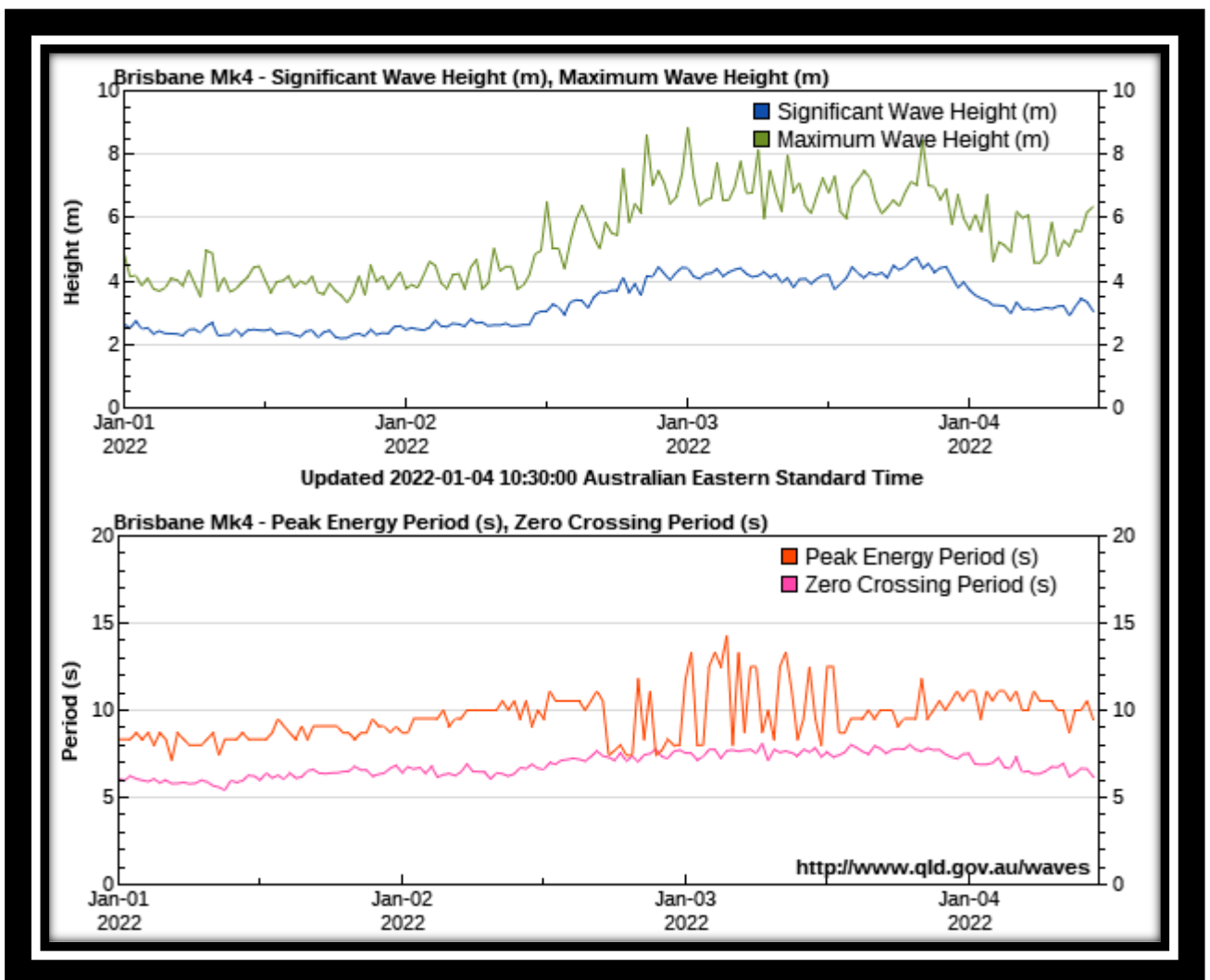


FIGURE 11. Wave height and period for Brisbane wave rider buoy at Brisbane, 1-4 January 2022. Image source: [www.qld.gov.au/waves](http://www.qld.gov.au/waves)



**TABLE 1. Best track summary for Tropical Cyclone *Seth* 30 December 2021 to 2 January 2022.**

Refer to the Australian Tropical Cyclone database for complete listing of parameters and track from 23 December to 7 January. Note: UTC is AEST - 10 hours.

\*not at tropical cyclone intensity. \*\*sub-tropical from 00 UTC 2 January.

Year	Month	Day	Hour UTC	Pos. Lat. S	Pos. Long. E	Pos. Acc. nm	Max Wind 10min kn	Max gust kn	Cent. Press. hPa	Rad. of gales (NE/SE/SW/NW)	Rad. of storm (NE/SE/SW/NW)	RMW n mi
2021	12	30	00	17.5	147.5	50	30	45	997	-	-	-
2021	12	30	06	17.8	149.2	30	30	45	996	-	-	-
2021	12	30	12	17.9	150.6	40	30	45	994	-	-	-
2021	12	30	18	18.4	151.8	30	30	45	994	-	-	-
2021	12	31	00	19.4	153.3	20	40	55	992	120/120/120/40	-	30
2021	12	31	06	20.0	154.5	20	50	70	986	120/180/120/60	0/0/50/0	40
2021	12	31	12	20.6	155.3	20	55	75	982	120/180/150/60	0/0/50/0	40
2021	12	31	18	21.0	155.3	30	45	65	986	90/180/150/60	-	40
2022	01	01	00	21.3	155.8	30	45	65	988	60/150/150/60	-	40
2022	01	01	06	21.7	156.7	30	45*	65	988	0/150/150/0	-	40
2022	01	01	12	22.8	158.3	30	40*	55	990	0/150/160/0	-	50
2022	01	01	18	24.0	158.8	30	40*	55	990	0/180/160/0	-	50
2022	01	02	00	25.8	159.0	20	40**	55	990	50/180/120/80	-	50
2022	01	02	06	26.5	158.6	15	40**	55	988	50/180/120/80	-	50
2022	01	02	12	27.1	158.3	15	35**	50	990	0/150/170/110	-	50
2022	01	02	18	27.5	157.7	15	30**	45	990	-	-	-

## 5 Forecast Performance

Official tropical cyclone forecasts were issued from 24-26 December and from 31 December to 3 January. A tropical cyclone watch was first issued at 09:30 CST 24 December from Point Stuart in Northern Territory west to Kalumburu in Western Australia including Darwin. Advices were cancelled at 2130 CST 25 December when there was high confidence that the low was not going to develop into a tropical cyclone at that stage. Ocean wind warnings for a tropical cyclone were issued in the Coral Sea from 31 December to 2 January. Although there were no tropical cyclone advices issued for the Australian east coast, severe weather warnings were issued for hazardous surf and high tides.

The accuracy figures for Tropical Cyclone *Seth* below and in Figure 12 show that the forecast position performed better than the five-year average at all time steps. The intensity forecasts had higher errors than the five-year average for the first 48 hours, in part based on overestimating the intensity during the early stages of development. These were based on official forecast tracks issued from 0000 UTC 24 December to 1200 UTC 25 December then from 0600 UTC 31 December to 0600 UTC 2 January 2022.

	00	06	12	18	24	36	48	72	96	120
<b>Position Absolute error (km)</b>	23	41	51	65	71	86	100	92	129	229
<b>Intensity Absolute error (kn)</b>	2.5	3.7	5.3	6.6	8.1	11.3	11.6	9.9	8.3	5.7
<b>Sample Size</b>	16	16	16	16	16	16	16	16	16	16

FIGURE 12 a. Position accuracy figures for Tropical Cyclone *Seth*.

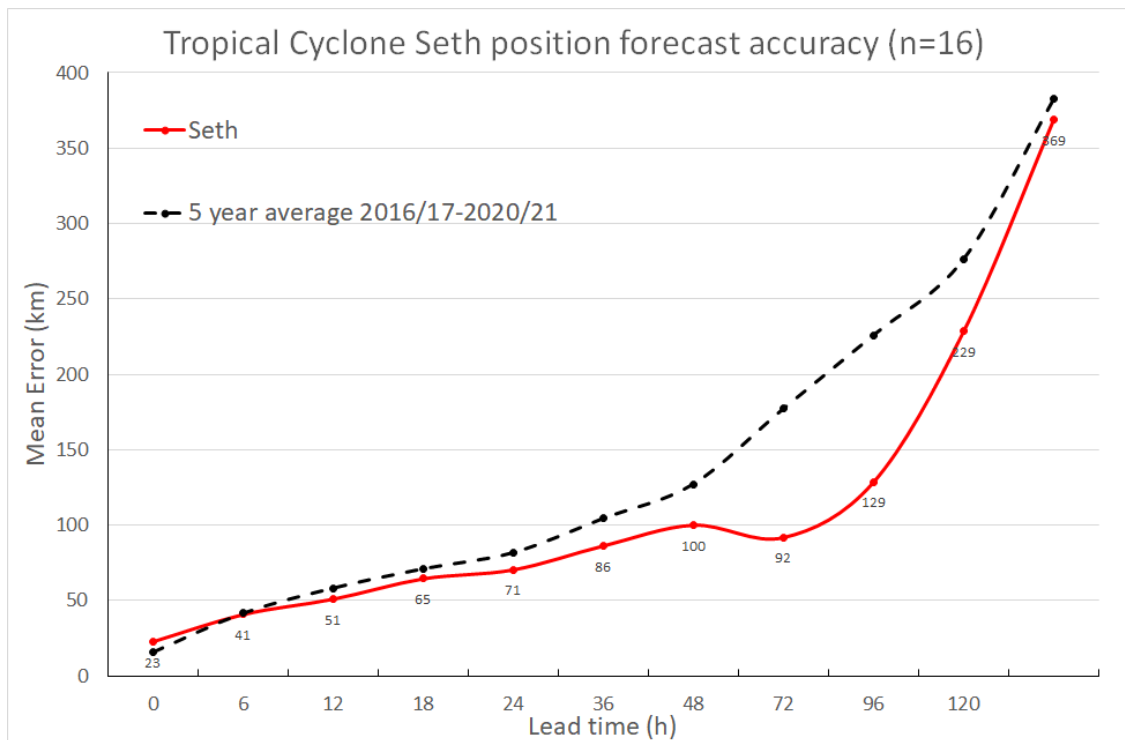


FIGURE 12 b. Intensity accuracy figures for Tropical Cyclone *Seth*.

