Australian Government
Bureau of Meteorology

# Severe Tropical Cyclone *Damien*

## 3 – 10 February 2020

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# 1 Summary

A tropical low formed over land in the Kimberley, about 190 kilometres (km) southeast of Kununurra on 3 February 2020. The low tracked west and moved offshore, near the Dampier Peninsula, north of Broome during 5 February. Once over water it gradually intensified and reached tropical cyclone strength at 0300 Universal Time Coordinated (UTC) (11 am Australian Western Standard Time AWST, AWST=UTC+8 hours) 6 February. The environment became more favourable as *Damien* moved west southwest and it went through a period of rapid intensification during 6 February and increased from a category 1 to a category 3 system in under twenty-four hours. *Damien* turned south towards the Pilbara coast on 7 January and made landfall as a category 3 severe tropical cyclone around 0730 UTC (3:30pm AWST) 8 February at a peak intensity of 85 knots (kn) (157 kilometres per hour (km/h)). The severe cyclone crossed the coast over the Karratha-Dampier region, with the eye moving directly over the town of Karratha. Karratha Airport recorded the highest wind gust of 105 kn (194 km/h) at 0631 UTC 8 February. The system continued to move inland weakening on 9 February and the remnant tropical low tracked southeast over the inland Pilbara, eastern Gascoyne and northern Goldfields.

The Bureau of Meteorology's Dampier radar sustained significant damage during the passage of *Damien*. Extensive vegetation damage was reported and there was some damage to property and infrastructure, including Karratha Airport.

Heavy rainfall caused flooding initially through the Kimberley when the system was a tropical low, then through the Pilbara and eastern Gascoyne. Widespread totals of 100 to 200mm and isolated falls up to 235mm were recorded near the Pilbara coast. *Damien* delivered rainfall and river flows to Pastoral areas that had been drier than average for at least two years and filled many dams and water resources including the Harding Dam, the main water supply for the Karratha/Dampier area.

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FIGURE 1. Best track of Severe Tropical Cyclone *Damien* 3 – 10 February 2020 (times in AWST, UTC+8).

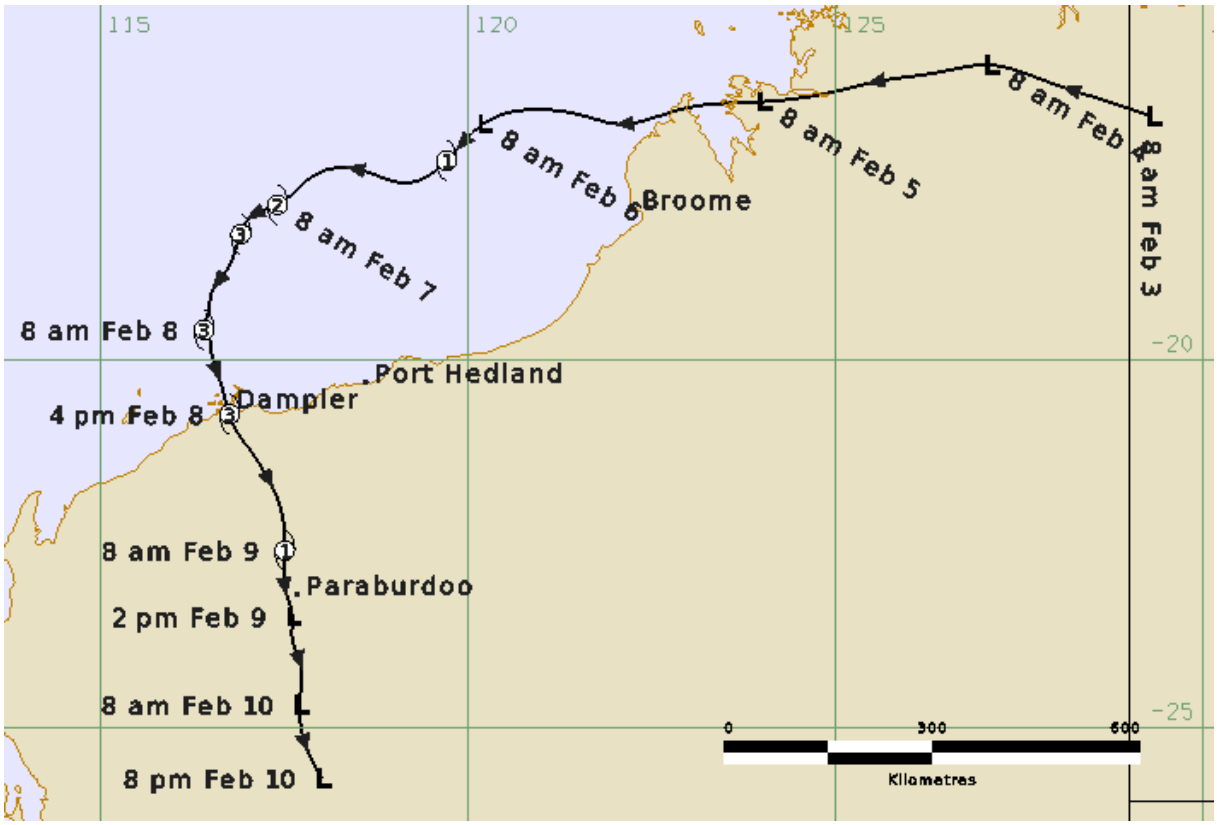
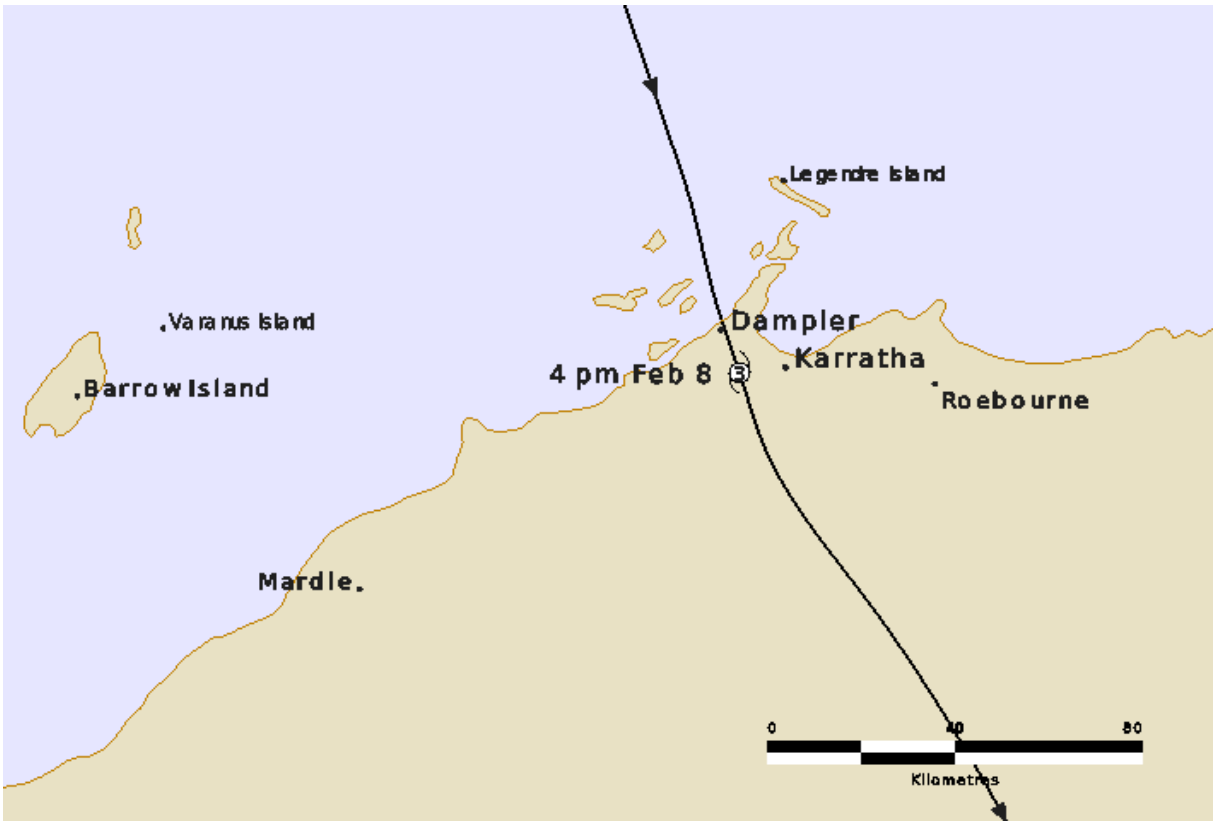


FIGURE 2. Enlargement of best track of Severe Tropical Cyclone *Damien* showing observation sites near the location of the coastal crossing (times in AWST, UTC+8).



# 2 Meteorological Description

## 2.1 Intensity analysis

A low formed over the Kimberley on 3 February and moved offshore early on 5 February. Once offshore a Data T number (DT) of 2.0 was assigned at 1200 UTC 5 February. The low began to develop in a favourable environment. A DT of 3.0 was reached by 0300 UTC 6 February and an intensity of 35 kn was obtained. Damien then underwent a period of very rapid intensification. A Scatterometer Satellite (SCATSAT) pass at 1230 UTC 6 February (refer Figure 3) showed 35 - 40 kn winds in most quadrants. A plot of subjective and objective intensity estimates is shown in Figure 4. Objective intensity estimates from the Satellite Consensus (SATCON) and Advanced Dvorak Technique (ADT) were higher than the best track intensity estimates in the period leading up to this time as intensity estimates were biased towards the surface observations from Rowley Shoals Automatic Weather Station (AWS). An Advanced Microwave Sounding Radar (AMSR2) pass at 1720 UTC 6 February showed the increased curved banding in the deep convection with a microwave eye becoming apparent (refer Figure 5) and intensity was increased to 50 kn (93 km/h). Microwave imagery continued to show improved curved banding so intensity was further increased to 65 kn (111 km/h) by 0000 UTC 7 February. No Dvorak constraints were broken in the DT numbers through this time as subjective Dvorak had only increased from 2.5 at 0000 UTC 6 February to 4.0 at 0000 UTC 7 February. The intensity estimates were biased more towards objective estimates with SATCON and ADT at near 70 kn by 0000 UTC 7 February.

Subsequent microwave imagery showed a relaxation in the curved banding and *Damien* appeared to have a temporary slow down in the rate of intensification between 0000 UTC and 1200 UTC on 7 February. Imagery early on 7 February showed the eye wall and curved banding had reduced on the eastern side. During the day convection began to increase and an 1804 UTC AMSR2 image showed *Damien* had deep convection encircling the centre once again (refer Figure 6) with a decreased radius to maximum wind and intensity was increased to 75 kn (139 km/h).

Intensity estimates continued to increase and *Damien* reached a peak 10-minute mean wind intensity of 85 kn (157 km/h) by 0300 UTC 8 February. This intensity was maintained as *Damien* crossed the Western Australian coast near the community of Karratha at around 0730 UTC 8 February (refer Figure 7). Objective intensity estimates climbed higher as *Damien* approached the coast but a network of surface observations influenced the final peak intensity.

*Damien* moved inland and weakened quickly as it tracked south, decreasing to below tropical cyclone strength by 0600 UTC 9 February.

## 2.2 Structure

*Damien* initially had a small radius to gales of around 40-50 nautical miles (nm) (74-93 km), as the cyclone intensified this gradually expanded to a more typical 80-90 nm (148-

167 km). From 0000 UTC 8 February the radii were determined by a dense network of surface observations. As *Damien* reached peak intensity the cyclone was symmetric with a complete eye wall structure.

The radius to maximum wind was initially 25 nm (45 km) but decreased down to 10 nm (18 km) by 1200 UTC 7 February as *Damien* reached hurricane intensity. As *Damien* approached land the RMW increased from 10 nm to 20 nm (18 to 37 km) as the inner eye wall temporarily weakened. The RMW contracted slightly to 15 nm (28 km) as *Damien* crossed the coast and then expanded out to 30 nm (55 km) as it weakened below tropical cyclone strength.

## 2.3 Motion

Initially the mid-level ridge located to the south of *Damien* was the main steering influence and the tropical cyclone moved in a westerly direction. By 7 February a mid-level trough had amplified to the west of *Damien* which eroded the influence of the ridge. At this point *Damien* turned towards the southwest. The trough continued to be the main influence over *Damien*'s motion and from 8 February *Damien* moved south and then south southeast as it crossed the Australian coast and weakened.

# 3 Impact

*Damien* had a large impact on the Northwest Shelf oil and gas industry and on the communities of the Dampier-Karratha region as it crossed the coast. Significant damage to property and public infrastructure including the Karratha Airport was reported with an estimated cost of $6 million dollars to repair. Extensive damage to vegetation was also reported. The bureau of Meteorology's Dampier radar sustained significant damage during the passage of the cyclone rendering it unserviceable and in need of replacement (refer Figure 8).

A storm surge accompanied the passage of Damien as it crossed the Pilbara coast. King Bay recorded a peak residual (actual tide subtract predicted tide) of 1.82 m at 0826 UTC 8 February. Refer Figure 7 for a plot of the King Bay tide and residual. The passage of Damien at around 0800 UTC did not coincide with the predicted high tide at 0245 UTC which mitigated the effects of the surge.

Heavy rainfall which caused flooding fell in the Kimberley in the early stages of *Damien*'s development and through the Pilbara as it crossed the coast.

Notable rainfall totals in the 48 hours to 9 am AWST 9 February included Karratha Airport 235.2 millimetres (mm) and Roebourne Airport 234.8 mm. Ginginjibby recorded 153.2mm in the 72 hours to 9am AWST 11 February.

The West, North and Eastern Kimberley, Ashburton, Pilbara Coastal Streams, Fortescue, Gascoyne, Murchison, De Grey and Salt Lake Rivers District catchments were all affected by rainfall from *Damien*.

*Damien* delivered rainfall and river flows to Pastoral areas that had been drier than average for at least two years and filled many dams and water resources including the Harding Dam, the main water supply for the Karratha/ Dampier areas.

The passage of the tropical low across the top end of Australia produced very heavy rainfall, refer Figure 8 for a weekly rainfall map.

# 4 Observations

## 4.1 Wind

Karratha AWS recorded gales between 2241-2304 UTC, 2309 UTC 7 February, 2316 UTC 7 February – 0117 UTC 8 February, 0247-0712 UTC, 0853-1450 UTC 8 February. Storm force winds were recorded between 0358 – 0705 UTC and 0903 – 1450 UTC 8 February. Hurricane force winds were recorded between 0554-0656 UTC and 0910-1103 UTC 8 February. The peak 10-minute mean wind recorded was 78 kn (145.42 km/h) at 0636 UTC 8 February. The maximum 3-second wind gust recorded was 105 kn (194.4 km/h) at 0631 UTC 8 February. Refer to Figure 9 for a plot of wind and MSLP.

Legendre Island AWS recorded gales between 0312-2012 UTC 8 February. Storm force winds were recorded between 0952-0957 UTC, 1009-1540 UTC and 1643-1651 UTC 8 February. The peak 10-minute mean wind recorded was 62 kn (115 km/h) at 1316-1320 UTC and 1322-1324 UTC 8 February. The maximum 3-second wind gust recorded was 77.4 kn (143 km/h) at 1250 UTC 8 February.

Roebourne AWS recorded gales between 0326 – 1539 UTC 8 February. Storm force winds were recorded between 0531 – 1307, 1330-1331 UTC 8 February. Hurricane force winds were recorded at 1120 UTC 8 February. The peak 10-minute mean wind recorded was 64 kn (118.5 km/h) at 1120 UTC 8 February. The maximum 3-second wind gust recorded was 87.1 kn (161.3 km/h) at 1120 UTC 8 February.

Mardie AWS recorded gales between 0720 – 0800 and 0815 - 1053 UTC 8 February. The peak 10-minute mean wind recorded was 37 kn (68.5 km/h) at 0910 - 0916 UTC 8 February. The maximum 3-second wind gust recorded was 48.6 kn (90 km/h) at 0907 UTC 8 February.

## 4.2 Pressure

Karratha AWS recorded a minimum pressure of 956.7 hectopascals (hPa) at 0821 and 0822 UTC 8 February.

Legendre Island AWS recorded a minimum pressure of 955.5 hPa at 1347 UTC 8 February.

Roebourne AWS recorded a minimum pressure of 979.7 hPa at numerous times between 0900 -1000 UTC 8 February.

Mardie AWS recorded a minimum pressure of 992.7 hPa at 0836 UTC 8 February.

## 4.3 Rainfall

The highest recorded rainfall totals in the 48-hour to 9 am AWST 9 February were:

- Karratha Airport 235.2 mm

- Roebourne Airport 234.8 mm

Ginginjibby recorded 153.2mm in the 72 hours to 9am AWST 11 February.

## 4.4 Storm Surge

King Bay recorded a total storm tide of 4.26 m at 0246 UTC 8 February and a peak storm surge of 1.82 m at 0826 UTC 8 February.

# 5 Forecast Performance

The accuracy figures for Severe Tropical Cyclone *Damien* show that the forecast performance was exceptional compared to the 5-year mean. The 72-hour track accuracy was 50 km, well below the 5-year average of 187 km. Model guidance was extremely consistent indicating as far ahead as 5 days that the initial westwards movement of Damien would abruptly change to a southwards track which would result in a Pilbara coast impact.

The accuracy statistics obtained by comparing the forecast positions against the best track positions for *Damien* are

| | **00** | **06** | **12** | **18** | **24** | **36** | **48** | **72** | **96** | **120** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Absolute error (km)** | 19 | 29 | 38 | 44 | 46 | 47 | 50 | 50 | 84 | 80 |
| **RMS Error (km)** | 25 | 32 | 41 | 47 | 50 | 52 | 59 | 58 | 91 | 80 |
| **Sample Size** | 18 | 18 | 18 | 18 | 18 | 17 | 15 | 11 | 7 | 3 |

Figure 10 is a plot of the accuracy figures for *Damien* compared to the five-year mean.

## TABLE 1. Best track summary for Severe Tropical Cyclone *Damien*

Refer to the Australian Tropical Cyclone database for complete listing of parameters. WST is UTC + 8 hours.

| Year | Month | Day | Hour UTC | Pos. Lat S | Pos. Long. E | Pos. Acc. nm | Max Wind 10 min kn | Max gust kn | Cent. Press. hPa | Rad. of gales (NE/SE/ SW/NW) | Rad. of storm (NE/SE/ SW/NW) | RMW n mi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 02 | 03 | 00 | 16.7 | 129.3 | 60 | 15 | 35 | 1005 | | | |
| 2020 | 02 | 03 | 06 | 16.6 | 129.0 | 40 | 15 | 35 | 1002 | | | |
| 2020 | 02 | 03 | 12 | 16.5 | 128.7 | 40 | 15 | 35 | 1004 | | | |
| 2020 | 02 | 03 | 18 | 16.2 | 127.8 | 40 | 15 | 35 | 1002 | | | |
| 2020 | 02 | 04 | 00 | 16.0 | 127.1 | 40 | 15 | 35 | 1004 | | | |
| 2020 | 02 | 04 | 06 | 16.1 | 126.4 | 40 | 15 | 35 | 1000 | | | |
| 2020 | 02 | 04 | 12 | 16.2 | 125.7 | 40 | 15 | 35 | 1001 | | | |
| 2020 | 02 | 04 | 18 | 16.4 | 124.8 | 60 | 20 | 45 | 1000 | | | |
| 2020 | 02 | 05 | 00 | 16.5 | 124.0 | 40 | 20 | 45 | 1000 | | | |
| 2020 | 02 | 05 | 06 | 16.6 | 122.9 | 20 | 20 | 45 | 999 | | | |
| 2020 | 02 | 05 | 12 | 16.8 | 122.0 | 30 | 25 | 45 | 998 | | | |
| 2020 | 02 | 05 | 18 | 16.7 | 121.6 | 30 | 30 | 45 | 996 | | | |
| 2020 | 02 | 06 | 00 | 16.8 | 120.2 | 30 | 30 | 45 | 995 | | | |
| 2020 | 02 | 06 | 06 | 17.3 | 119.7 | 30 | 35 | 50 | 992 | 40/50/40 | | 25 |
| 2020 | 02 | 06 | 09 | 17.6 | 119.2 | 20 | 40 | 55 | 990 | 40/50/40 | | 25 |
| 2020 | 02 | 06 | 12 | 17.4 | 118.4 | 30 | 40 | 55 | 990 | 40/50/40/ 30 | | 20 |

| Year | Month | Day | Hour UTC | Pos. Lat S | Pos. Long. E | Pos. Acc. nm | Max Wind 10 min kn | Max gust kn | Cent. Press. hPa | Rad. of gales (NE/SE/ SW/NW) | Rad. of storm (NE/SE/ SW/NW) | RMW n mi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 02 | 06 | 18 | 17.5 | 117.9 | 30 | 50 | 70 | 985 | 40/50/55/ 45 | 30 | 15 |
| 2020 | 02 | 07 | 00 | 17.9 | 117.4 | 30 | 65 | 90 | 976 | 50/70/70/ 60 | 30 | 15 |
| 2020 | 02 | 07 | 06 | 18.1 | 117.0 | 20 | 65 | 90 | 971 | 50/70/70/ 60 | 30 | 15 |
| 2020 | 02 | 07 | 09 | 18.3 | 116.9 | 10 | 65 | 90 | 971 | 50/70/70/ 60 | 30 | 10 |
| 2020 | 02 | 07 | 12 | 18.6 | 116.8 | 10 | 75 | 105 | 965 | 70/80/80/ 60 | 40/40/30/ 30 | 10 |
| 2020 | 02 | 07 | 15 | 18.8 | 116.7 | 10 | 75 | 105 | 963 | 70/80/80/ 60 | 40/40/30/ 30 | 10 |
| 2020 | 02 | 07 | 18 | 19.1 | 116.5 | 10 | 75 | 105 | 963 | 60/80/80/ 60 | 40/40/30/ 30 | 10 |
| 2020 | 02 | 08 | 21 | 19.4 | 116.45 | 10 | 80 | 110 | 958 | 80/80/80/ 60 | 50/50/40/ 40 | 20 |
| 2020 | 02 | 08 | 00 | 19.6 | 116.4 | 8 | 80 | 110 | 958 | 80/80/80/ 70 | 50/50/40/ 40 | 20 |
| 2020 | 02 | 08 | 01 | 19.7 | 116.5 | 8 | 80 | 120 | 958 | 80/90/80/ 70 | 50/50/40/ 40 | 20 |
| 2020 | 02 | 08 | 02 | 19.8 | 116.5 | 8 | 80 | 120 | 958 | 80/90/90/ 70 | 60/50/40/ 45 | 15 |
| 2020 | 02 | 08 | 03 | 19.9 | 116.5 | 5 | 85 | 120 | 955 | 90/80/90/ 70 | 60/50/40/ 45 | 15 |
| 2020 | 02 | 08 | 04 | 20.1 | 116.5 | 5 | 85 | 120 | 955 | 90/90/90/ 70 | 60/50/40/ 45 | 15 |

| Year | Month | Day | Hour UTC | Pos. Lat S | Pos. Long. E | Pos. Acc. nm | Max Wind 10 min kn | Max gust kn | Cent. Press. hPa | Rad. of gales (NE/SE/ SW/NW) | Rad. of storm (NE/SE/ SW/NW) | RMW n mi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 02 | 08 | 05 | 20.2 | 116.65 | 5 | 85 | 120 | 955 | 90/90/90/ 70 | 60/50/40/ 40 | 15 |
| 2020 | 02 | 08 | 06 | 20.4 | 116.6 | 5 | 85 | 120 | 955 | 90/70/80/ 70 | 60/45/35/ 40 | 15 |
| 2020 | 02 | 08 | 07 | 20.6 | 116.7 | 5 | 85 | 120 | 955 | 90/70/80/ 70 | 60/45/35/ 40 | 15 |
| 2020 | 02 | 08 | 08 | 20.7 | 116.7 | 5 | 85 | 120 | 955 | 90/60/70/ 70 | 60/40/35/ 40 | 15 |
| 2020 | 02 | 08 | 09 | 20.9 | 116.8 | 8 | 80 | 110 | 955 | 90/60/70/ 70 | 55/40/35/ 40 | 15 |
| 2020 | 02 | 08 | 12 | 21.2 | 117.0 | 10 | 70 | 100 | 967 | 80/60/50/ 70 | 40/35/35/ 40 | 15 |
| 2020 | 02 | 08 | 15 | 21.5 | 117.2 | 15 | 60 | 85 | 972 | 70/50/40/ 70 | 30/25/25/ 30 | 15 |
| 2020 | 02 | 08 | 18 | 21.9 | 117.4 | 20 | 50 | 75 | 978 | 60/40/40/ 40 | 30/20/0/0 | 20 |
| 2020 | 02 | 09 | 00 | 22.6 | 117.5 | 20 | 35 | 50 | 986 | 30/30/40/ 0 | | 30 |
| 2020 | 02 | 09 | 03 | 23.1 | 117.5 | 15 | 35 | 50 | 989 | 0/0/40/0 | | 30 |
| 2020 | 02 | 09 | 06 | 23.5 | 117.6 | 20 | 30 | 45 | 992 | | | |
| 2020 | 02 | 09 | 12 | 23.8 | 117.6 | 30 | 30 | 45 | 992 | | | |
| 2020 | 02 | 09 | 18 | 24.1 | 117.7 | 30 | 30 | 45 | 992 | | | |
| 2020 | 02 | 10 | 00 | 24.7 | 117.7 | 30 | 25 | 40 | 996 | | | |
| 2020 | 02 | 10 | 06 | 25.3 | 117.8 | 30 | 25 | 35 | 996 | | | |

| Year | Month | Day | Hour UTC | Pos. Lat S | Pos. Long. E | Pos. Acc. nm | Max Wind 10 min kn | Max gust kn | Cent. Press. hPa | Rad. of gales (NE/SE/ SW/NW) | Rad. of storm (NE/SE/ SW/NW) | RMW n mi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2020 | 02 | 10 | 12 | 25.7 | 118.0 | 45 | 25 | 35 | 998 | | | |

FIGURE 3. SCATSAT pass at 1230 UTC 6 February during the early stages of *Damien*'s development.

Image courtesy of https://www.nrlmry.navy.mil/TC.html

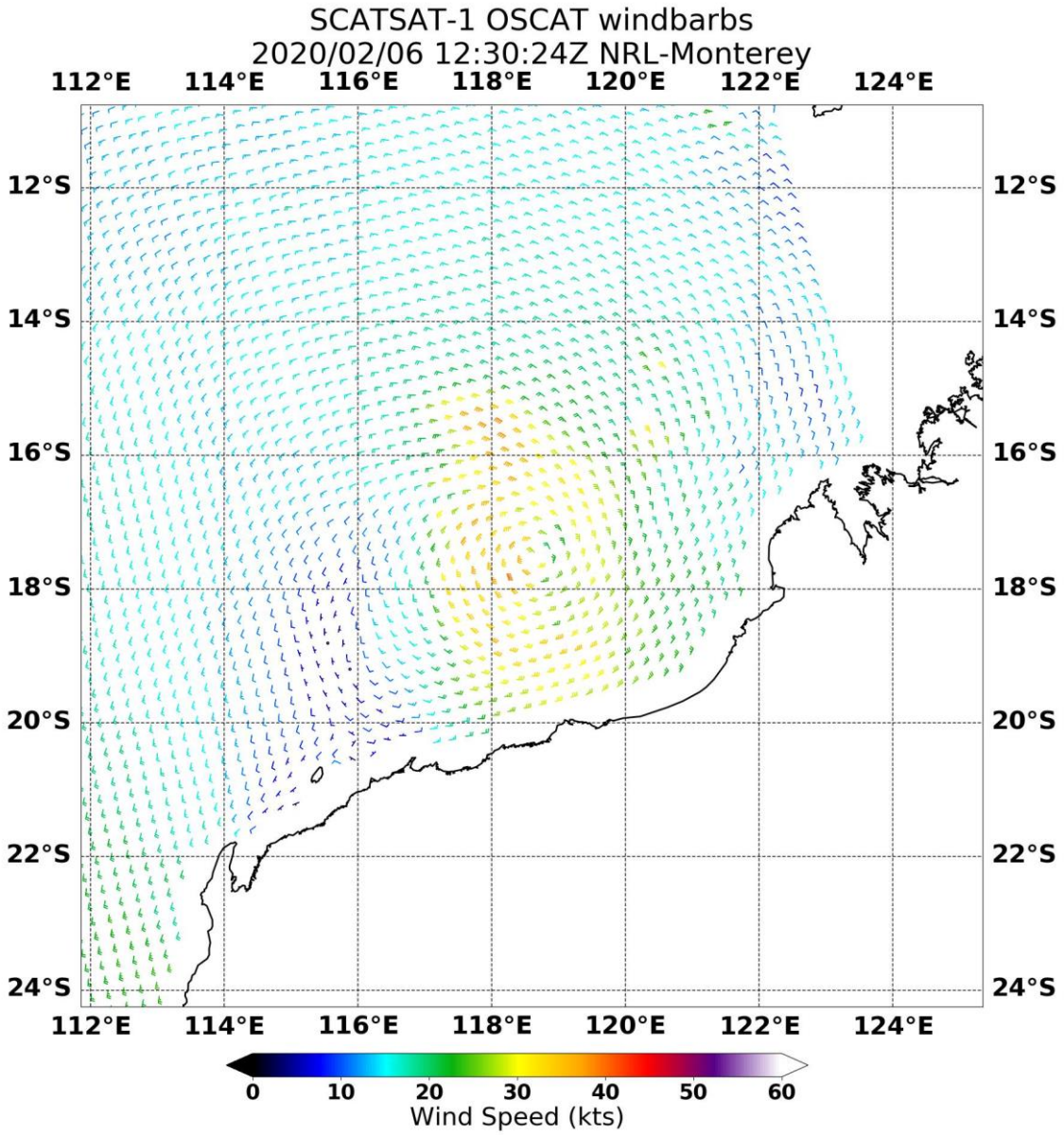


FIGURE 4. Plot of objective and subjective intensity estimates for *Damien*.

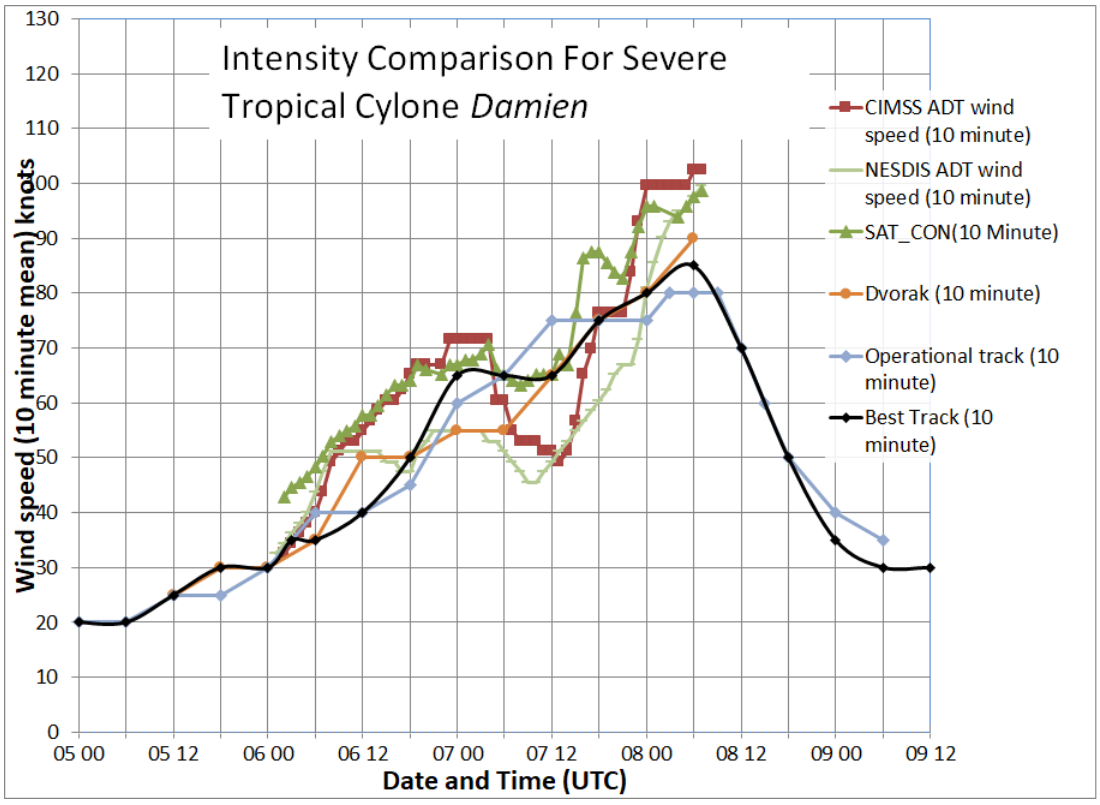


FIGURE 5. AMSR2 image at 1720 UTC 6 February as *Damien* intensified.

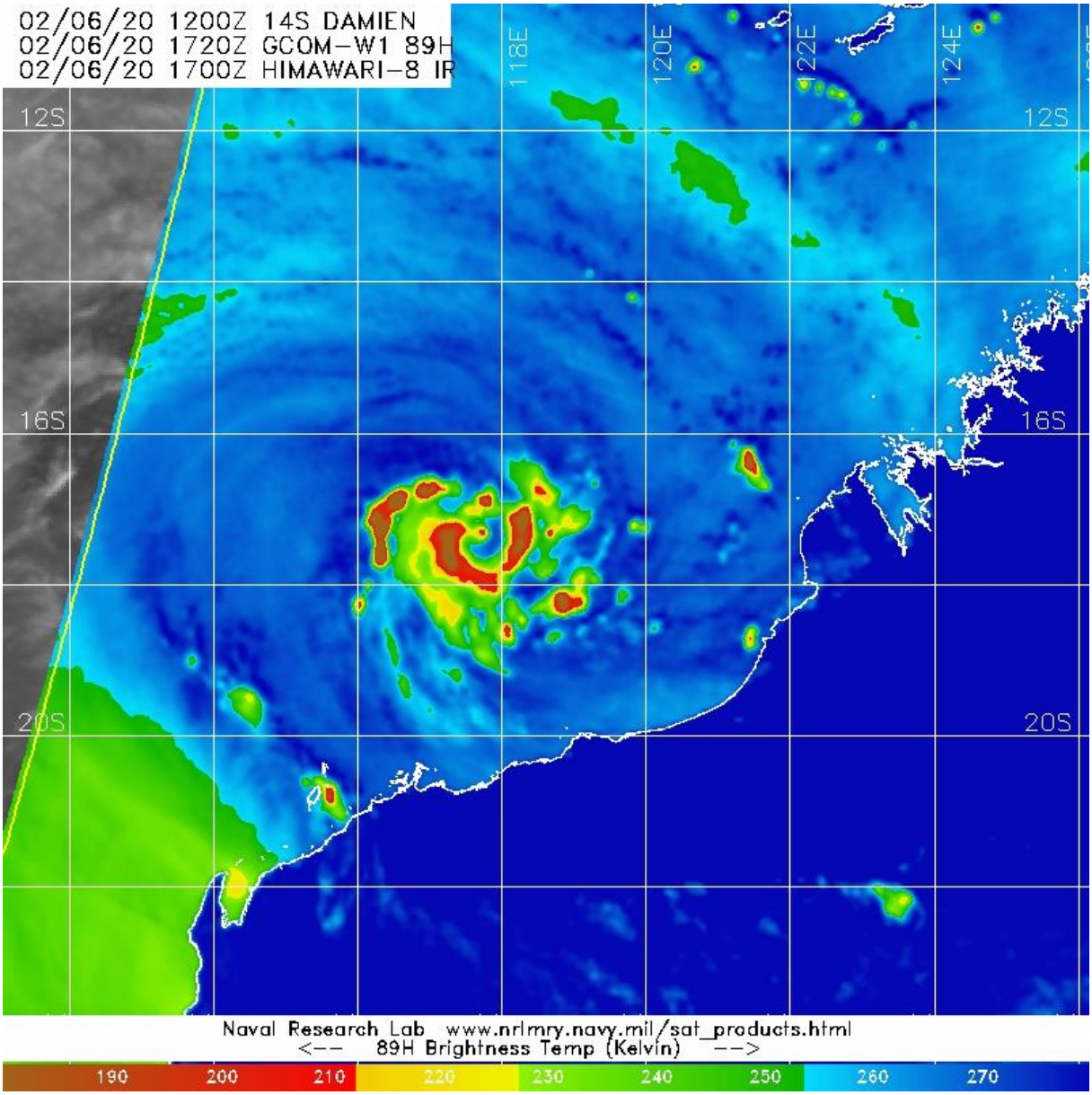


FIGURE 6. 1804 UTC 7 February AMSR2 image.

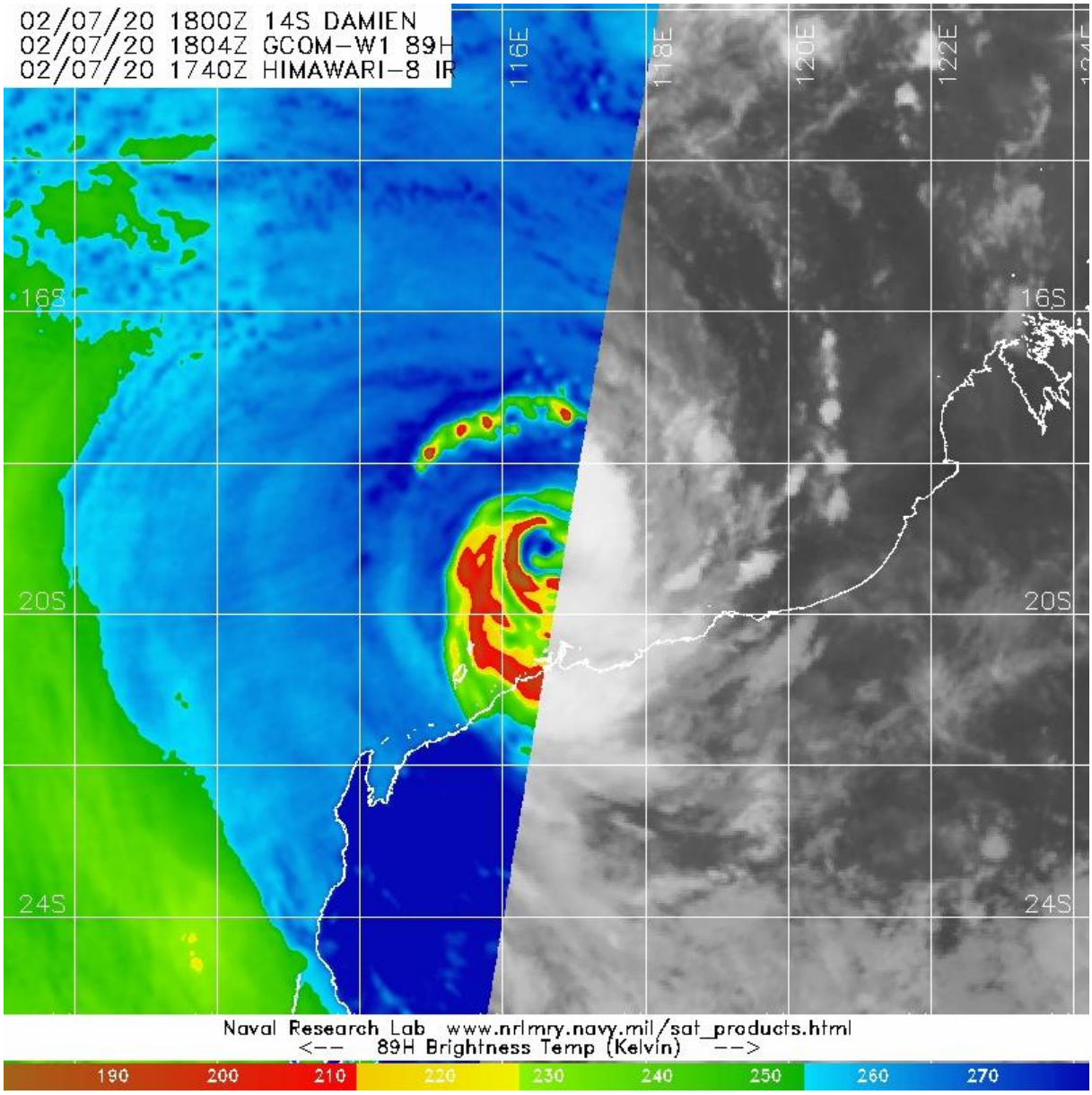


FIGURE 7. 0615 UTC 8 February AMSR2 image as *Damien* crossed the Western Australian coast at peak intensity.

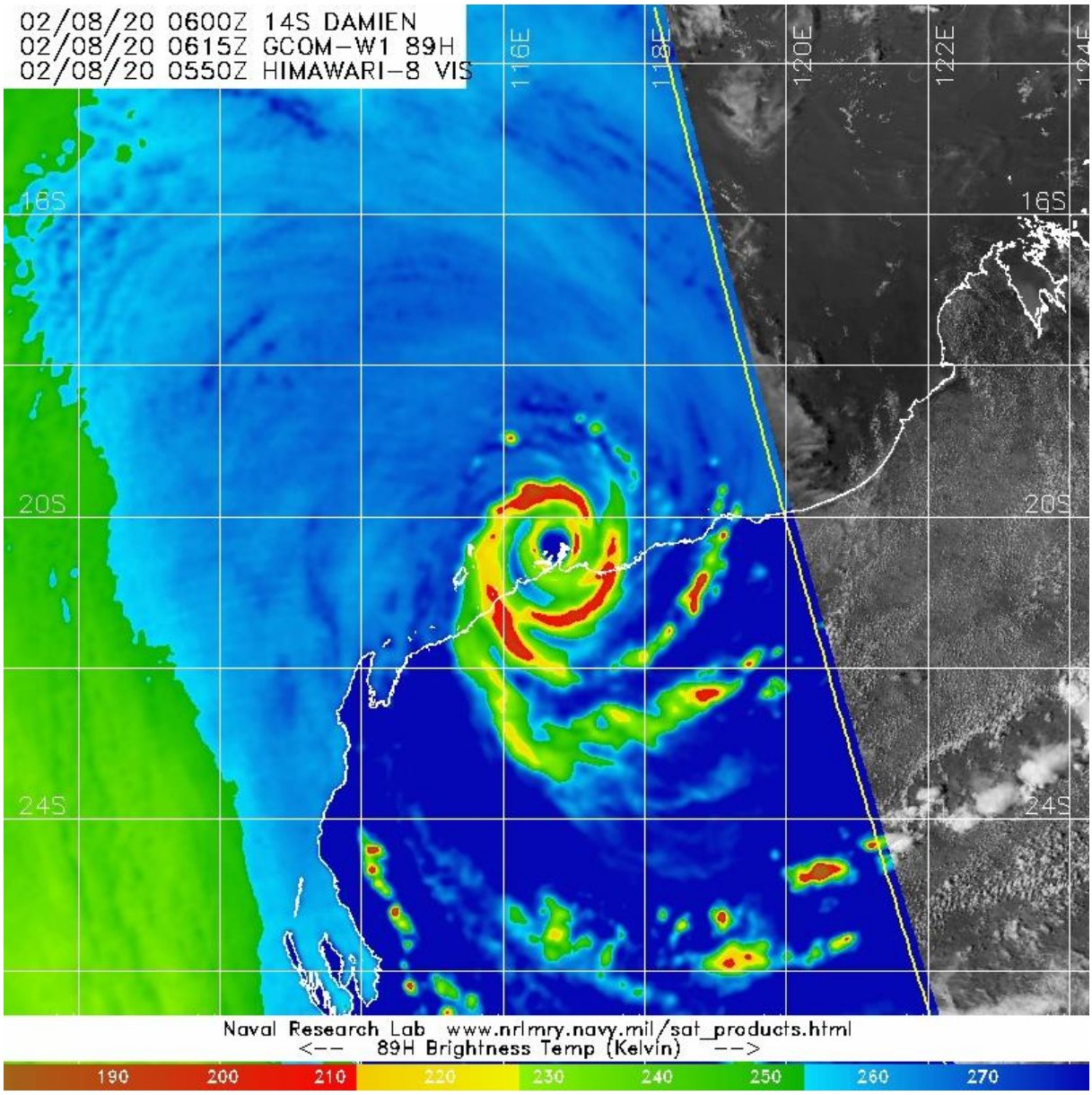


FIGURE 8. Dampier Radar before and after the passage of Severe Tropical cyclone *Damien*.

FIGURE 7 Plot of the King Bay tide recorded on 8 February.

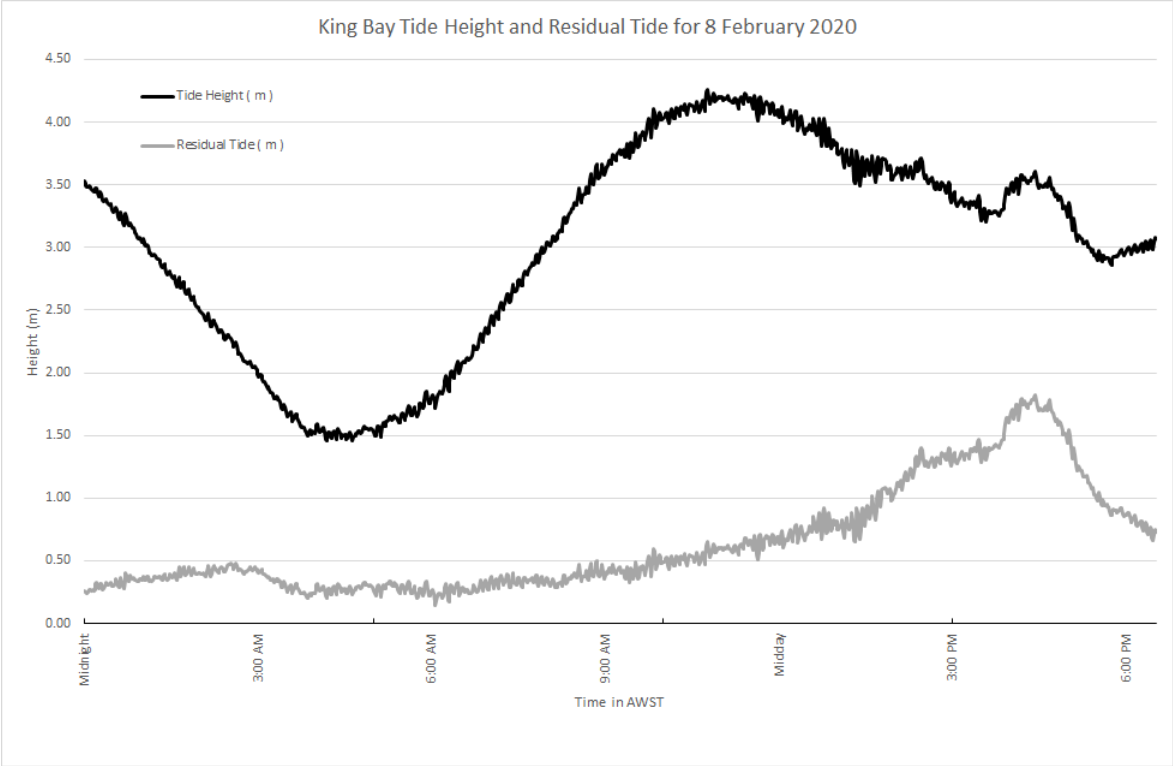


FIGURE 8. Graph of the weekly rainfall for Western Australia for the seven days ending 11 January 2020.

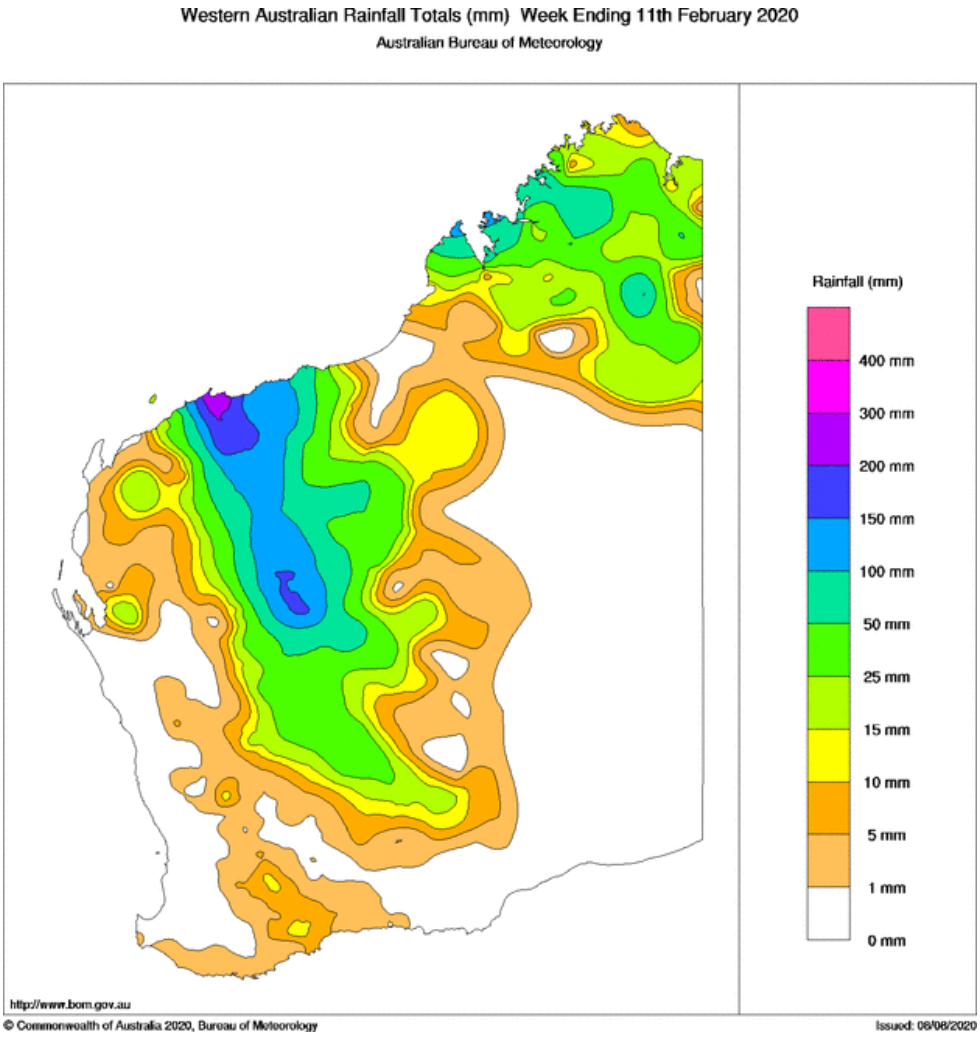


FIGURE 9 Plot of wind and pressure observations recorded by Karratha AWS.

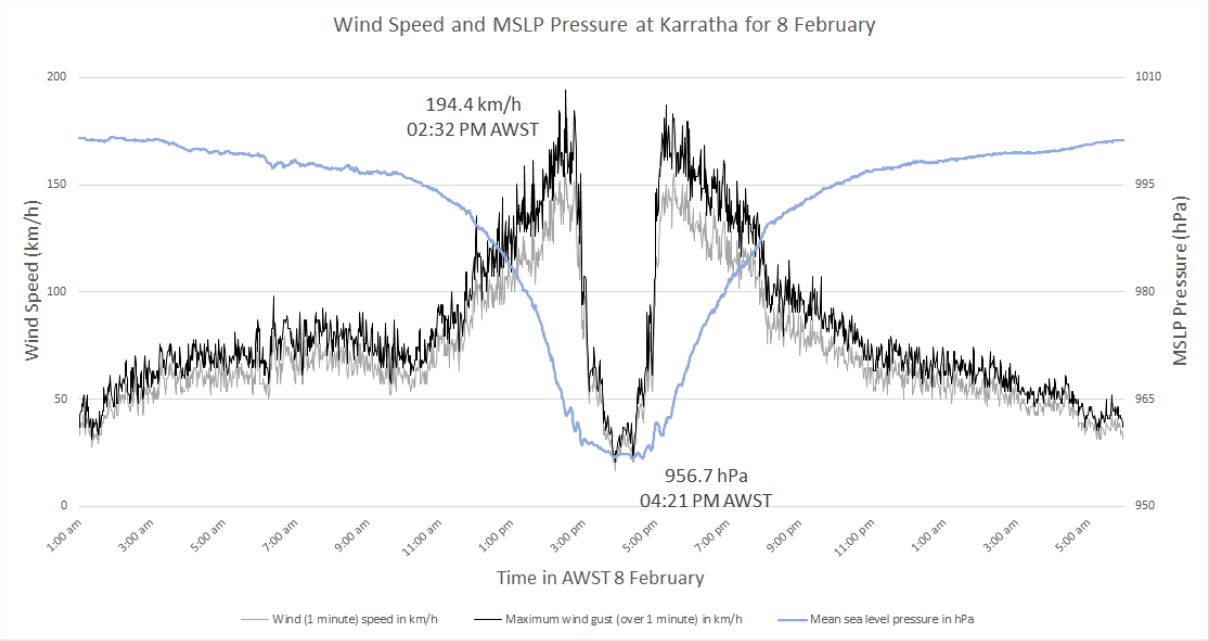


FIGURE 10. Accuracy figures for Severe Tropical Cyclone *Damien.*