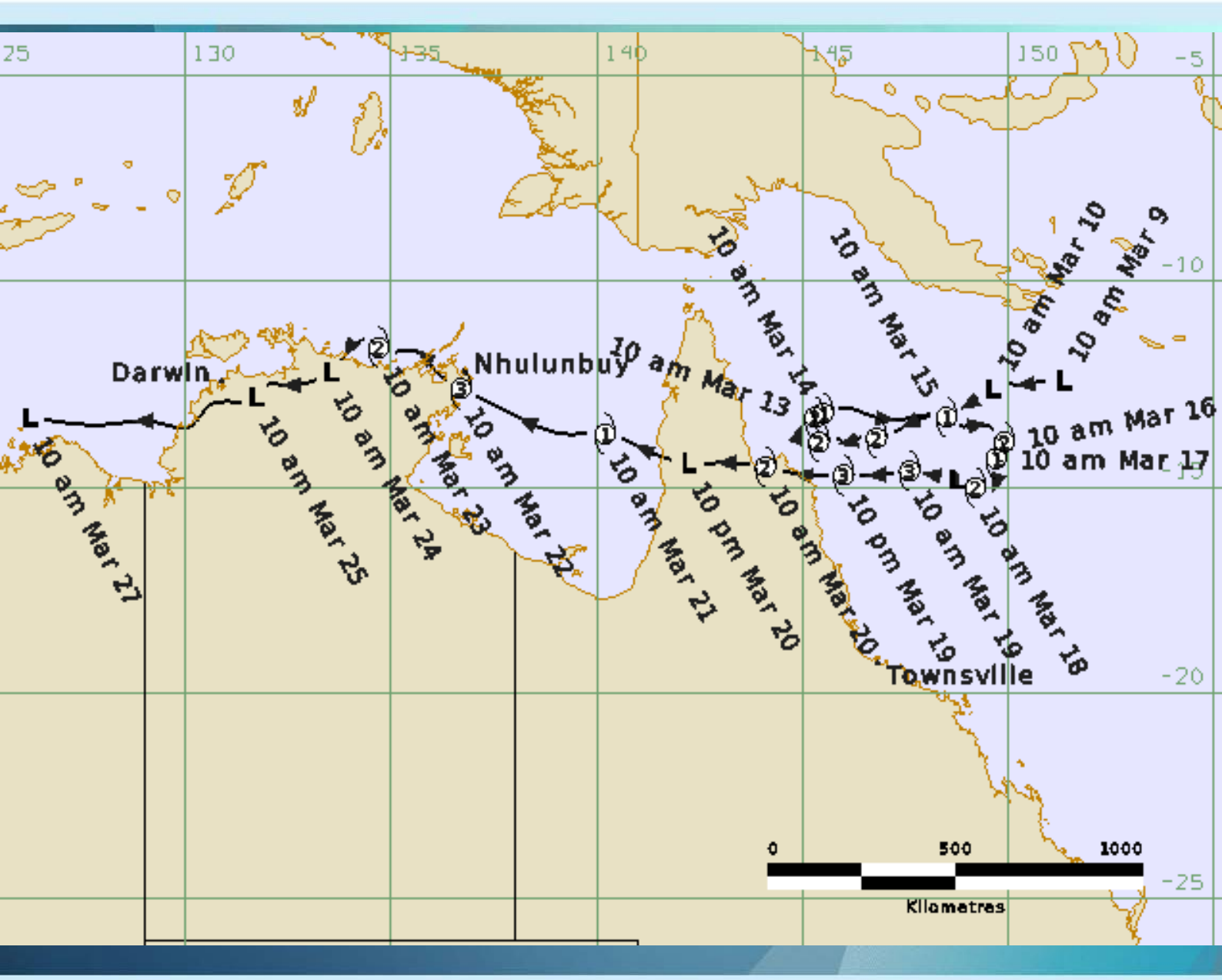
Australian Government
Bureau of Meteorology

Severe Tropical Cyclone Nathan

9 – 27 March 2015

Tony Wedd, Lauren Pattie, Joe Courtney, Matthew Boterhoven, Severe Weather Environmental Prediction Services 31 August 2022



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1. Summary

Severe Tropical Cyclone Nathan was a long-lasting tropical cyclone that made multiple landfalls as it moved, from the Coral Sea to the far north Queensland coast, then across the Gulf of Carpentaria and over the Top End of the Northern Territory coast.

After forming into a tropical cyclone on 10 March, Nathan quickly reached category two intensity but remained at that intensity as it moved slowly to the west over the following days. Nathan came within 60 km of the far north Queensland coast during 13 March causing a brief period of gales to a remote part of the coast north of Cooktown. Nathan then tracked away to the east and weakened slipping below cyclone intensity briefly on 14 March, before redeveloping to category 2 intensity once more on 15 March. Nathan once more weakened below cyclone intensity on 17 March as it slowed and drifted southwards. However, from late on 17 March to 18 March Nathan underwent a period of rapid intensification reaching category three intensity as it recommenced a track to the west. Nathan made landfall in a sparsely populated area of the coast north of Cooktown in the early hours of 20 March as a category three cyclone. It then quickly weakened as it moved overland.

Nathan redeveloped again on 21 March in the Gulf of Carpentaria, reaching category 3 intensity as it crossed the Northern Territory coast south of Nhulunbuy on the morning of 22 March. Nathan's northwesterly track meant it moved over water later that day and resulted in the system maintaining category two intensity during 23 March. It then weakening slightly, crossing the NT coast as a category one intensity system on the morning of 24 March west of Maningrida.

Initially Nathan was an averaged sized tropical cyclone having gales extending 80-90 nm (150-165 km) to the north, associated with monsoonal forcing. However, from its period of rapid intensification on 18 March, Nathan became a very small circulation, having gales extend only about 30-60 nm (55-110 km) from the centre. This small size was maintained during its time over the Gulf of Carpentaria and as it affected the Northern Territory coast.

The small scale of the system and its track over generally remote parts of the coastlines, both in Queensland and Northern Territory, meant that wind impacts were minor. Some minor damage occurred at Cooktown as Nathan crossed the far north Queensland coast.

Fortunately, the destructive core of the cyclone skirted around the north coast communities of Nhulunbuy, Galiwink'u, Ramingining and Milingimbi, which were affected by Severe Tropical Cyclone Lam in February. Residents of Galiwink'u on Elcho Island who were temporarily housed in a tented camp after Lam destroyed their houses were placed in secure accommodation during Nathan's passage. Several hundred residents of the community of Warruwi on Goulburn Island were evacuated by air to Darwin for the second time this season in anticipation of a direct hit from Nathan.

The cyclone and its remnant tropical depression brought heavy rainfall and flooding to many parts of the Northern Territory's Top End. The highest 24-hour rainfall totals included 208 mm at Alcan Mine on the Gove Peninsula, 261 mm at Fanny Creek and 215 mm at Dorisvale in the Katherine River catchment, and 208 mm at Snowdrop Creek in the Waterhouse River catchment.

Figure 1. Best track of Severe Tropical Cyclone Nathan 9 – 24 March 2015 (times in AEST, UTC+10).

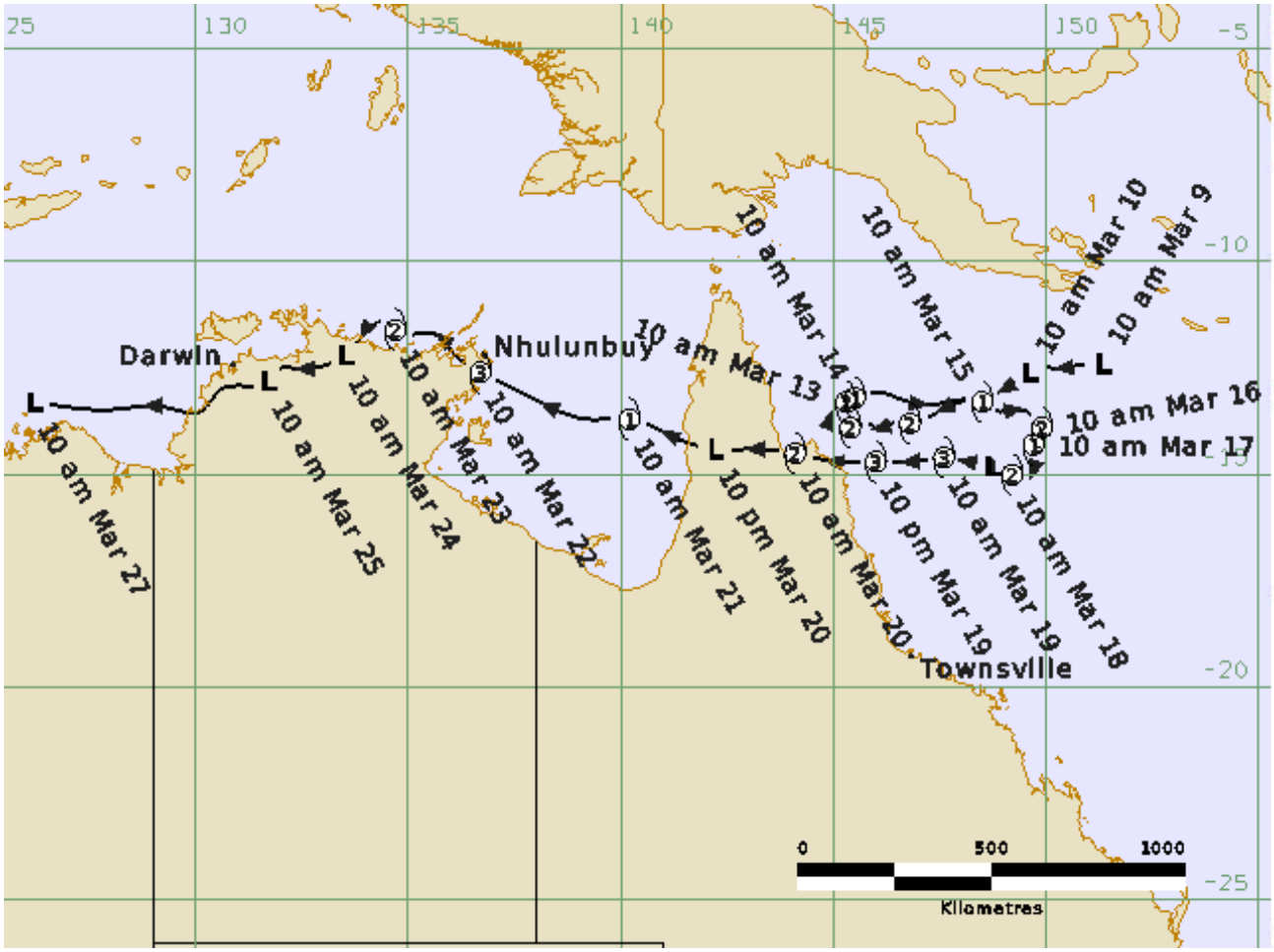


Figure 2 . Detailed best track of Severe Tropical Cyclone Nathan in the Coral Sea and far north Queensland, 17 – 20 March 2015 (times in UTC; AEST-10).

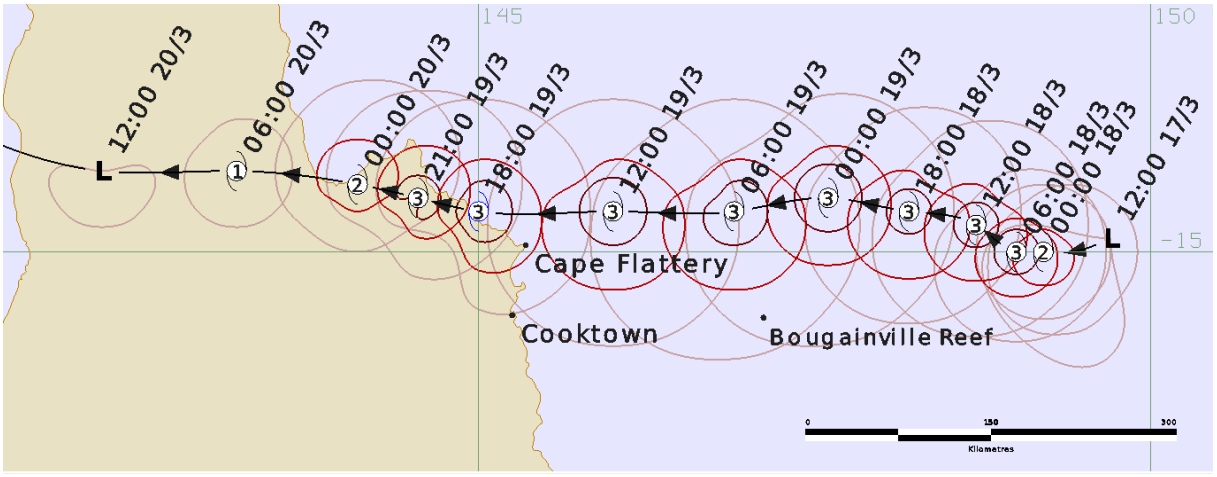
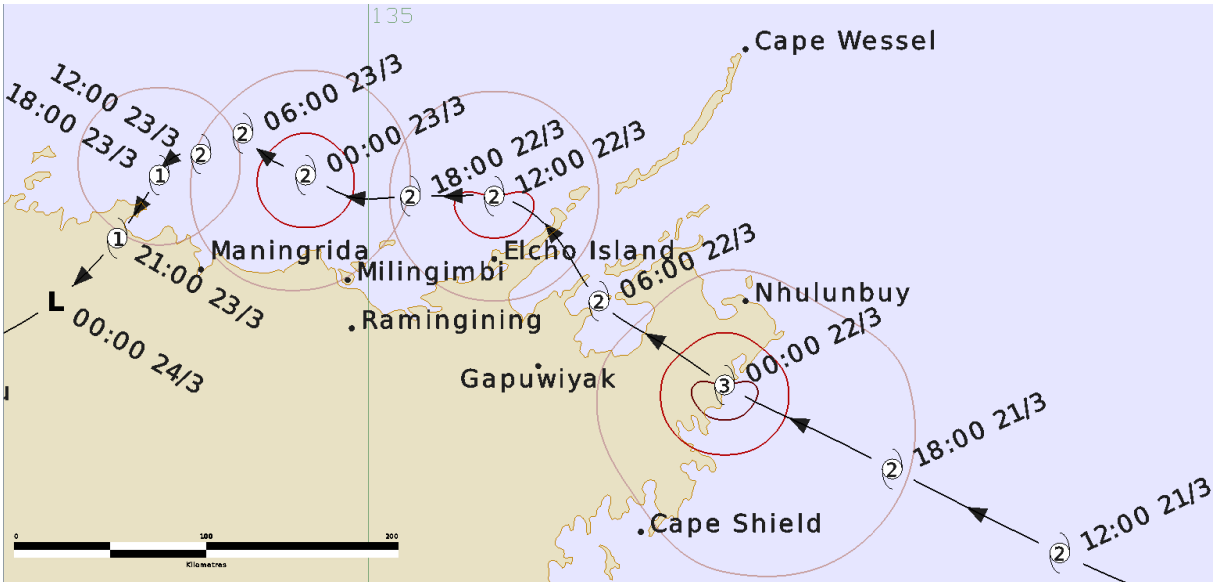


Figure 3. Detailed best track of Severe Tropical Cyclone Nathan over Northern Territory, 21 – 24 March 2015 (times in UTC; ACST-9.5).



2. Meteorological Description

2.1 Intensity analysis

Figure 1 shows the track of Nathan, while Figures 2 and 3 are more detailed tracks near the Queensland and Northern Territory coasts respectively. Figure 4 is a plot of objective and subjective intensity estimates during the lifetime of Nathan. A low formed in the monsoon trough in the Coral Sea on 9 March, associated with both a strong MJO and Equatorial Rossby wave. Deep convection increased near the centre and gales are likely to have developed initially on the northern side on 10 March. Tropical cyclone intensity is estimated for the first time at 12 UTC on 10 March, as deep convection became more organised about the centre as shown in the AMSR2 89 GHz microwave image at 1521 UTC 10 March in Figure 5. An ASCAT-A scatterometry image at 1120 UTC 10 March in Figure 6 also confirms that gales were evident around the centre. Nathan quickly reached category 2 intensity by 00 UTC 11 March and remained at a similar intensity for several days whilst tracking slowly just off the north Queensland coast.

Intensification was constrained by ongoing easterly vertical wind shear. The ASCAT-A at 2325 UTC 12 March indicated the strongest winds northeast of the centre but weakening occurred thereafter. During 13 March, convection near the centre eased, and eroded north and east of the centre. By 12 UTC 14 March, Nathan weakened below tropical cyclone intensity, confirmed by ASCAT showing gales only to the north of the centre.

Overnight on 14 March and during 15 March, deep convection increased north of the centre, coincident with a decrease in wind shear and Nathan resumed developing. ASCAT-B at 1210 UTC 15 March indicated 50 kn (93 km/h) to the northeast of the centre, confirming Nathan was at category two intensity. An increase in the east to northeasterly wind shear during 16 March corresponded with deep convection eroding to be only evident southwest of the centre. Nevertheless, gales remained around the centre, only contracting to the southwest quadrant at 12 UTC 17 March.

However, overnight on 17 March, the wind shear eased and deep convection redeveloped near the centre heralding a period of rapid intensification to the point a small eye emerged on visible and infra-red by 06UTC 18 March as shown in Figure 7. Nathan then remained at category 3 intensity through to landfall just after 18 UTC 19 March. Figure 8 shows the ASCAT-B distribution of winds at 1226 UTC and Figure 9 shows the SSMIS 91 GHz microwave image 16 1808 UTC near landfall.

The peak intensity was estimated at 80 kn (150 km/h) near landfall, and was generally consistent with SATCON objective guidance, but slightly lower than the operational estimate of 90 kn (167 km/h), shown in the event intensity comparison in Figure 4. Cape Flattery recorded maximum winds of 65 kn (120 km/h) and peak gusts to 90 kn (165 km/h) at 1620 UTC as Nathan passed 15 nm (28 km) to the north (see Figure 18). Although the highest winds are likely to have occurred south of the centre, the radius of maximum winds was estimated at just 10 nm (18 km), so just to the north of the Cape Flattery. Figure 10 shows the centre clearly evident near the coast on the Cairns radar at 18 UTC 19 March.

The cyclone weakened below tropical cyclone intensity as it moved over Cape York Peninsula late on 20 March. The circulation emerged into the Gulf of Carpentaria on 21 March and quickly redeveloped. Deep convection consolidated about the centre during the

day and Nathan reached category 2 intensity that night. Intensification was supported by a reduction in the easterly wind shear.

The SSMIS 91 GHz microwave images in Figure 11 shows the development of a small well-developed eye as Nathan approached the Northern Territory coast. This development was apparent on the Gove radar as shown in Figure 12 as Nathan crossed the coast. An eye was only apparent on conventional infra-red images in the few hours prior to landfall. Landfall intensity was estimated at 70 kn (130 km/h, category 3), consistent with Dvorak CI of 4.5 but higher than objective methods. Objective intensity estimates did not detect an eye pattern and hence estimates are likely too low. Gove Airport recorded a brief period of gales as Nathan made landfall. Although Gove was only 40 km from the centre it remained outside the highest winds.

Satellite and radar signatures subsequently showed weakening of the circulation, likely because of land influences. However, late on 22 March, Nathan reached open waters and an eye redeveloped on microwave and on radar. The intensity was estimated to peak at 60 kn (110 km/h, category 2) at this time. The SSMIS 91 GHz microwave images in Figure 13 shows the distinct small eye at 1909 UTC 22 March followed by weakening in deep convection to be confined south of the centre at 1108 UTC 23 March.

Nathan finally crossed the Northern Territory coast at category 1 intensity on 24 March on a remote area of the coast west of Maningrida. Shortly thereafter Nathan weakened below cyclone intensity and tracked to the west southwest overland. The circulation emerged over waters in the Joseph Bonaparte Gulf on 25 March but failed to redevelop.

Figure 4. Plot of objective and subjective intensity estimates for Nathan.

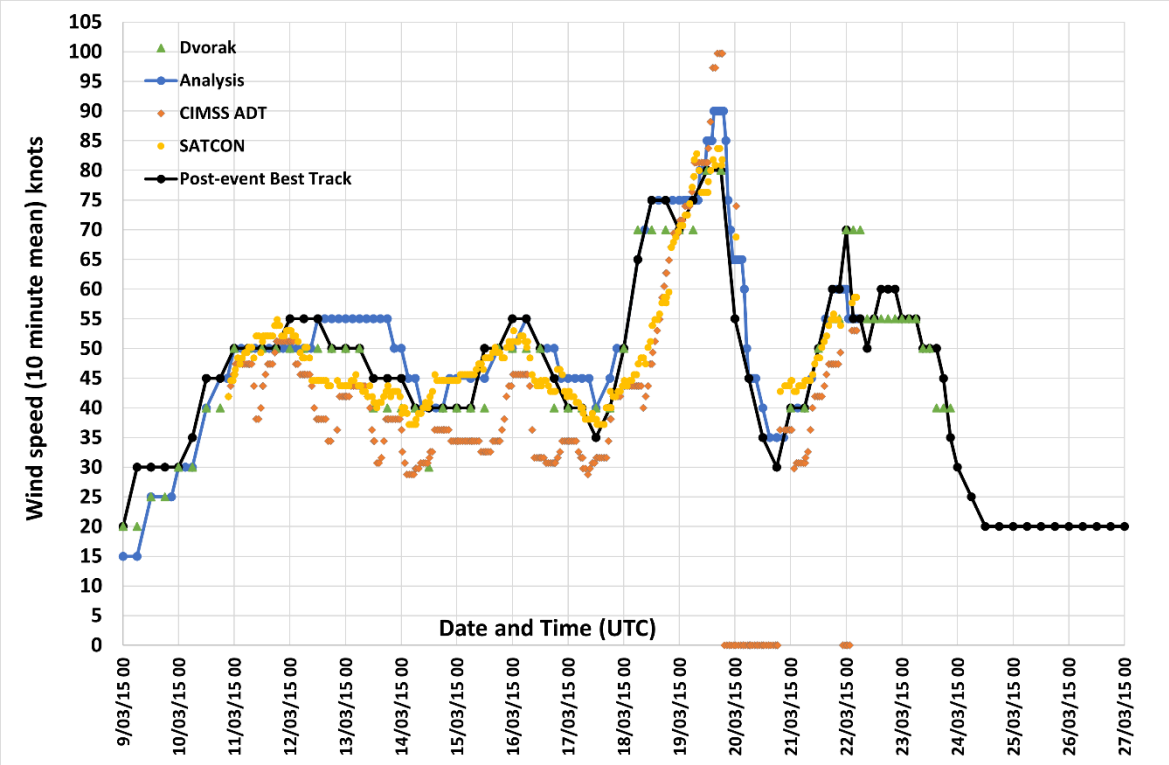


Figure 5. AMSR2 89 GHz microwave image at 1521 UTC 10 March, after Nathan first attained tropical cyclone intensity.

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

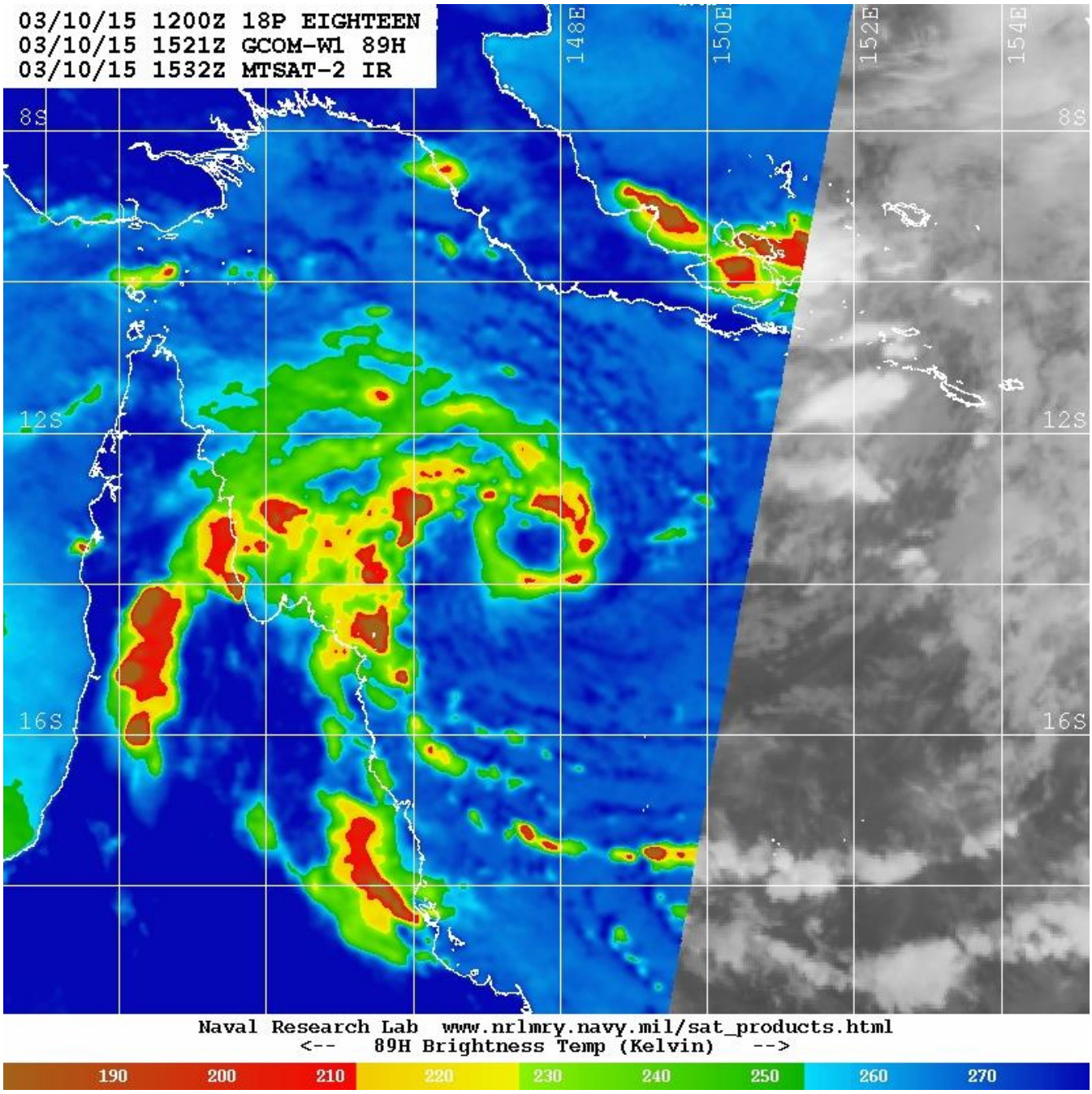


Figure 6. ASCAT-A scatterometery image at 1120 UTC 10 January, near the time tropical cyclone intensity is estimated.

Image courtesy of NOAA: https://manati.star.nesdis.noaa.gov/datasets/ASCATData.php

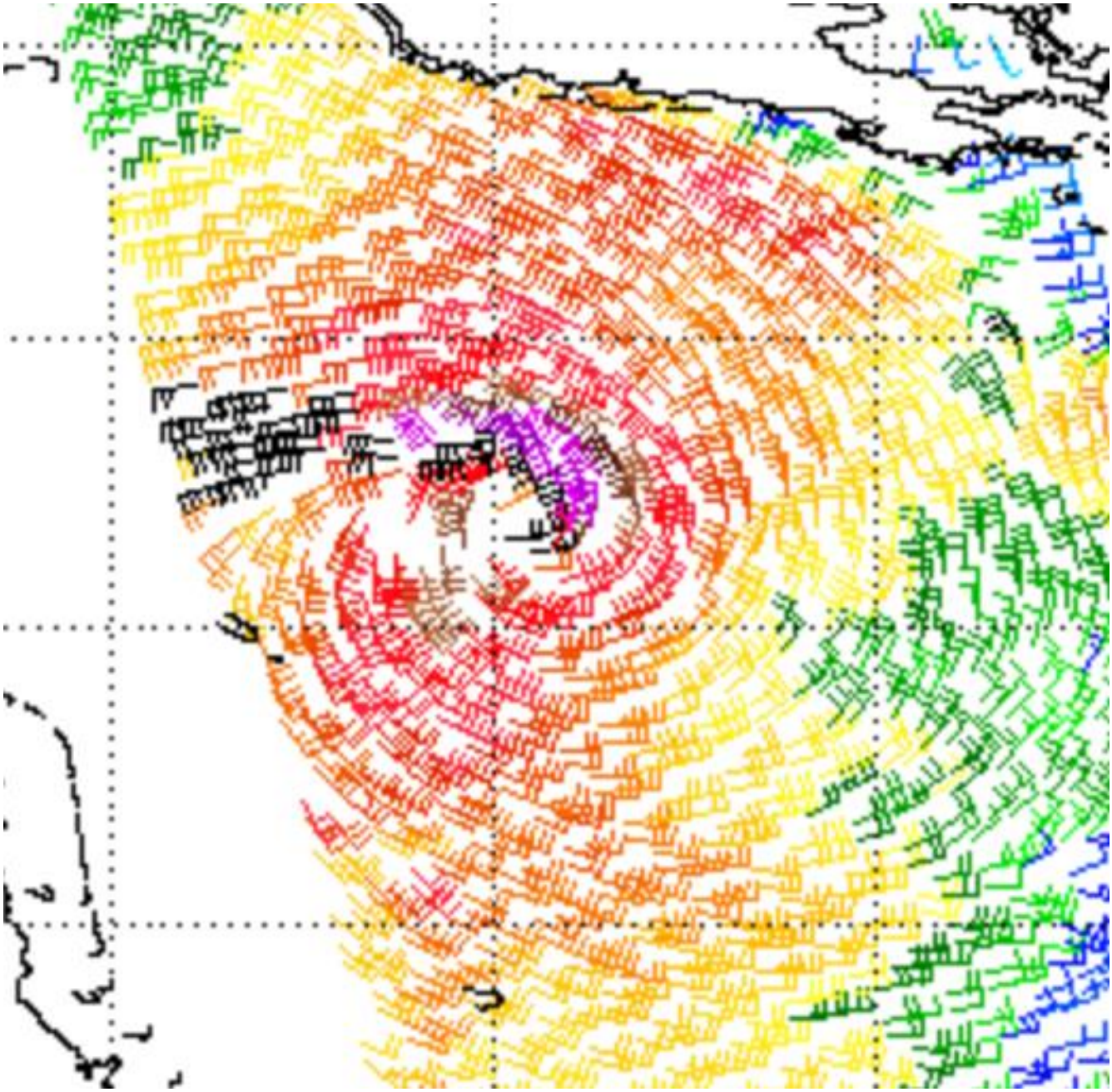


Figure 7. 24-hour comparison of visible images at 06 UTC 17 March (left) and at 06UTC 18 March. The change from the centre being removed from deep convection to a small eye was an indicator of rapid intensification.

The 'x' marks the centre location.Image courtesy of NRL:https://www.nrlmry.navy.mil/TC.html

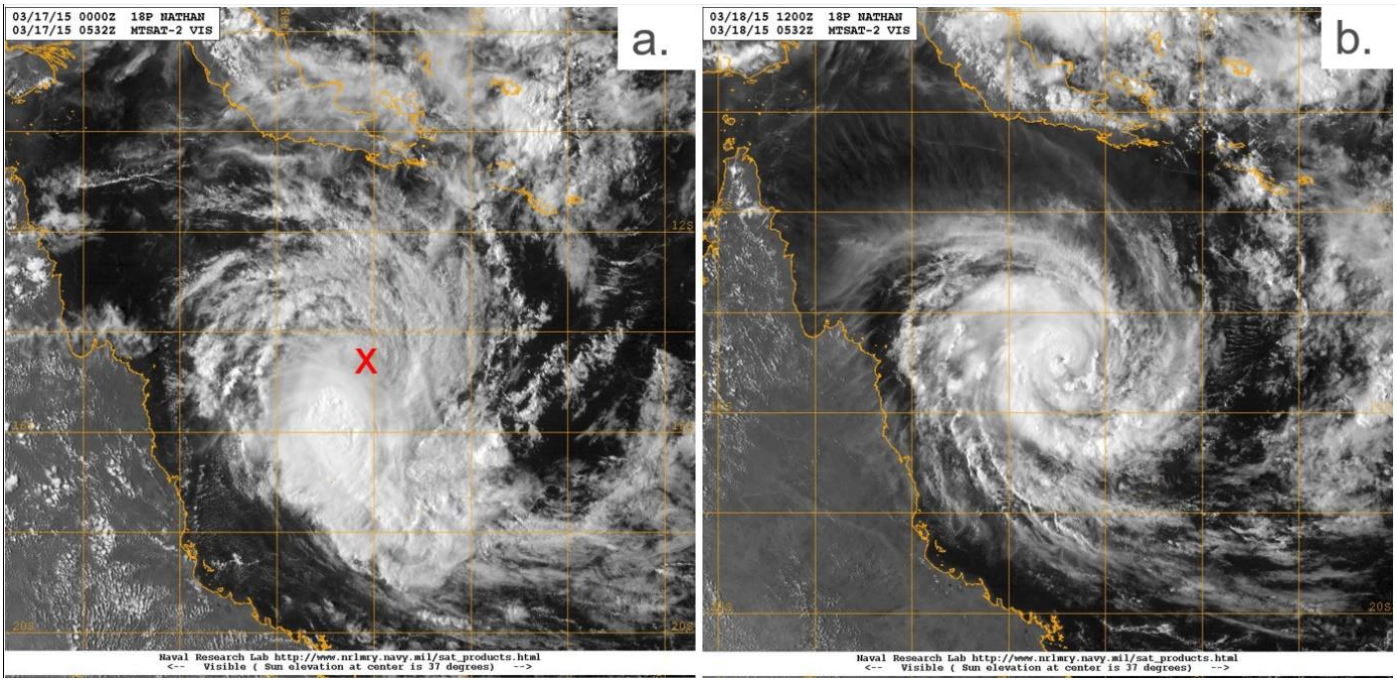


Figure 8. ASCAT-B wind analysis at 1226 UTC 19 March ahead of landfall. The grid is 2 x 2 degrees (120 nm or 222 km).

Image courtesy of NOAA: https://manati.star.nesdis.noaa.gov/datasets/ASCATBData.php

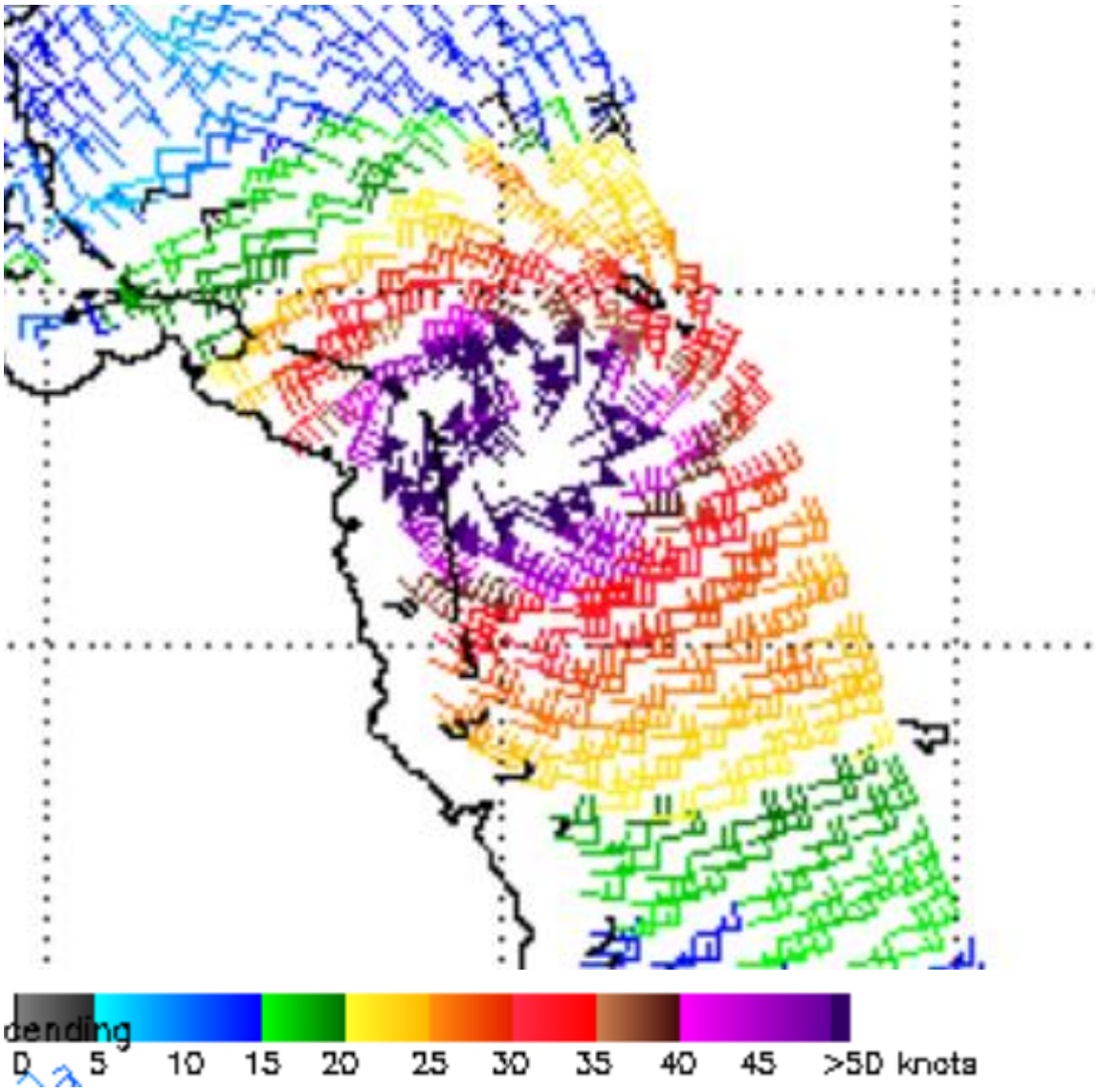


Figure 9. SSMIS 91 GHz microwave at 1808 UTC 19 March showing Nathan near peak intensity as it nears the coast.

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

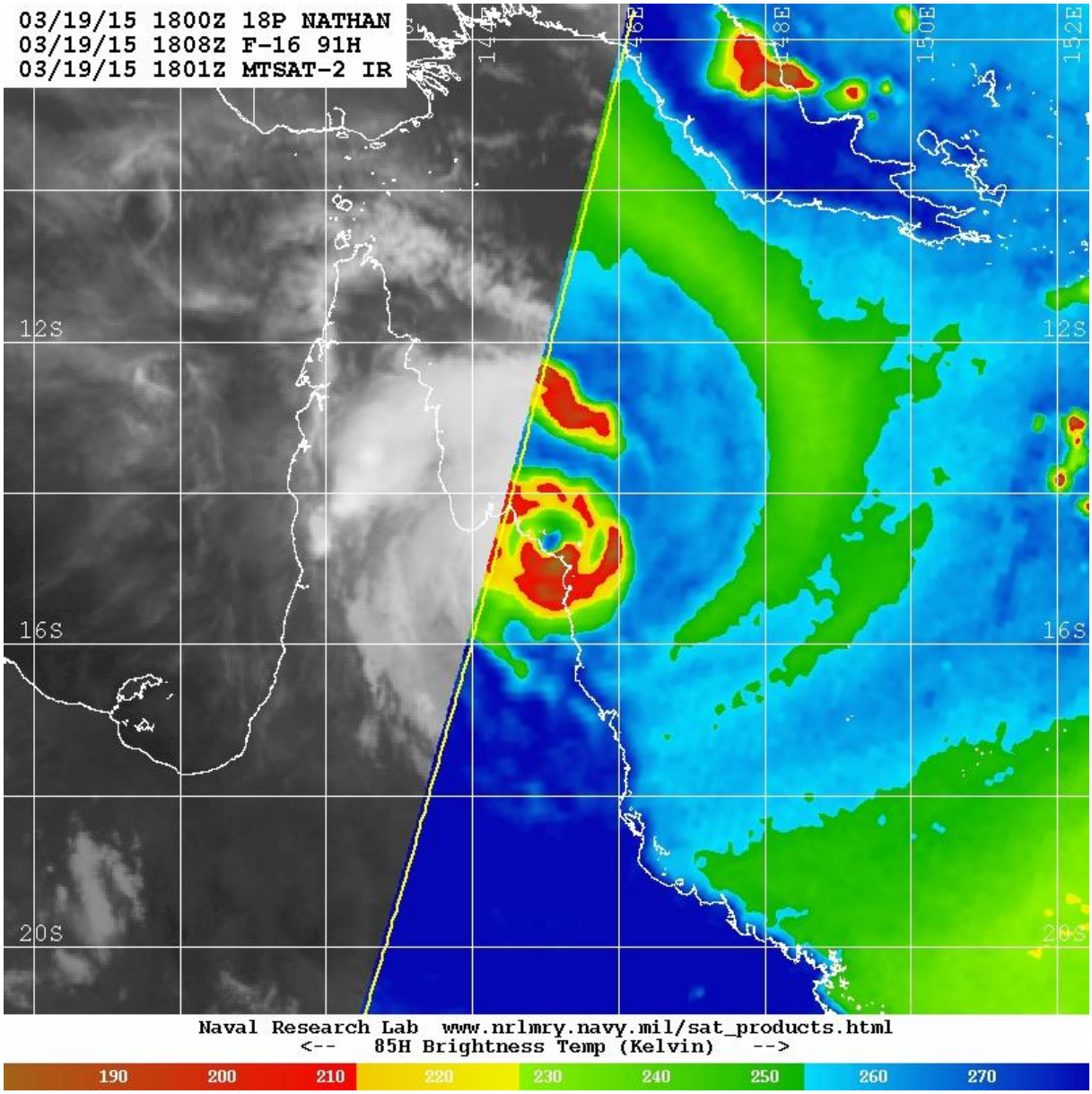


Figure 10. Cairns weather radar at 1800 UTC 19 March showing Nathan crossing the coast near Cape Flattery. Range rings are every 50 km.

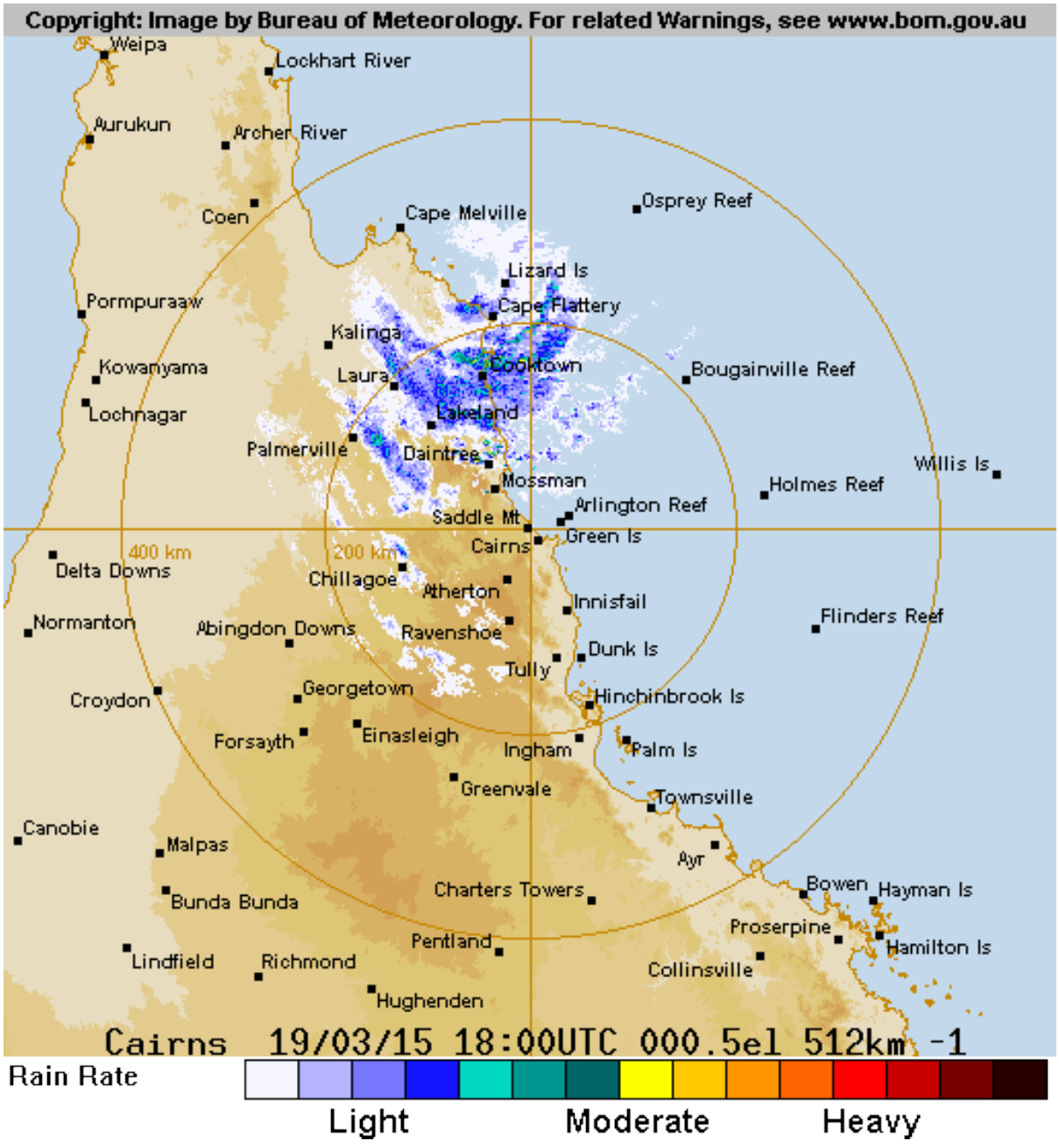


Figure 11. SSMIS 91 GHz microwave images on 21 March at 0856 UTC (left) and at 2242 UTC (right), showing the development of an eye as Nathan nears the Northern Territory coast.

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

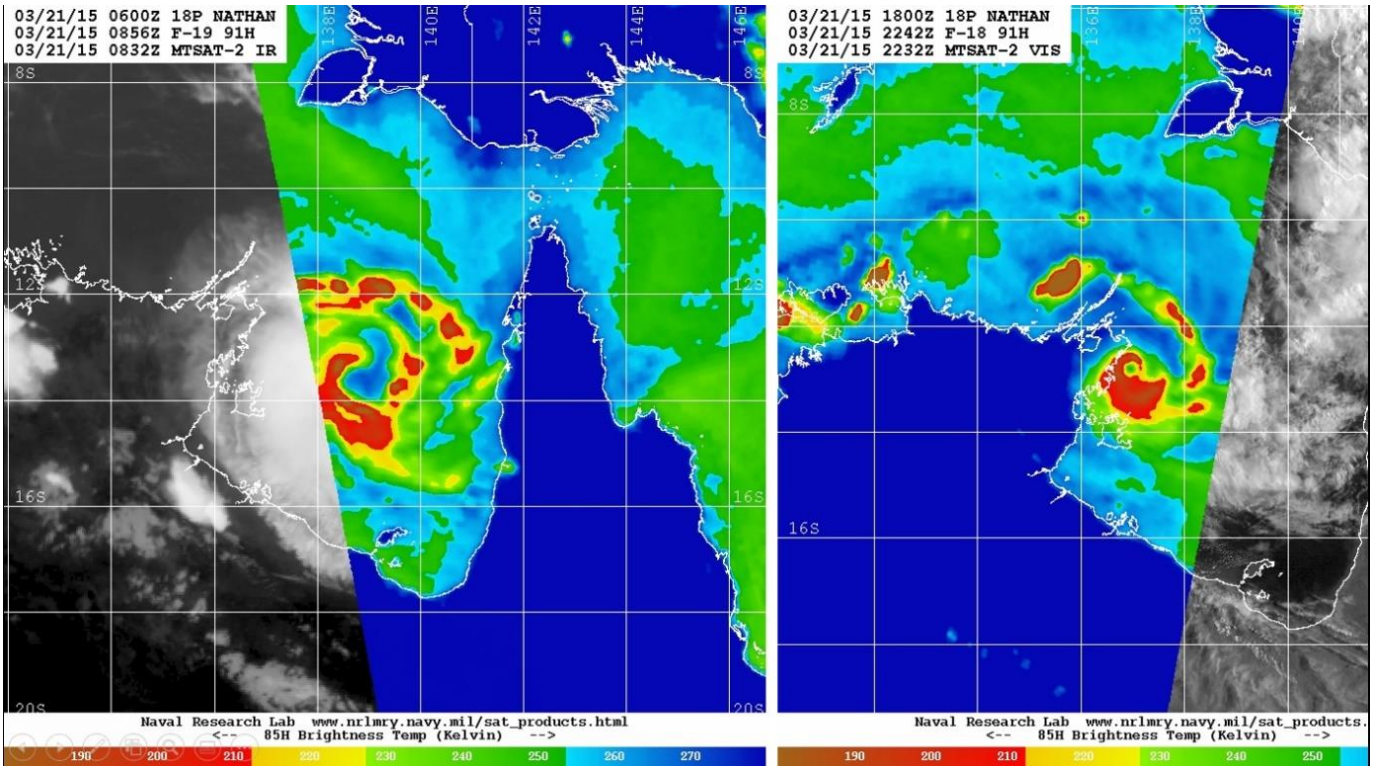


Figure 12. Gove weather radar at 0000 UTC 22 March showing Nathan crossing the coast. Range rings are every 50km.

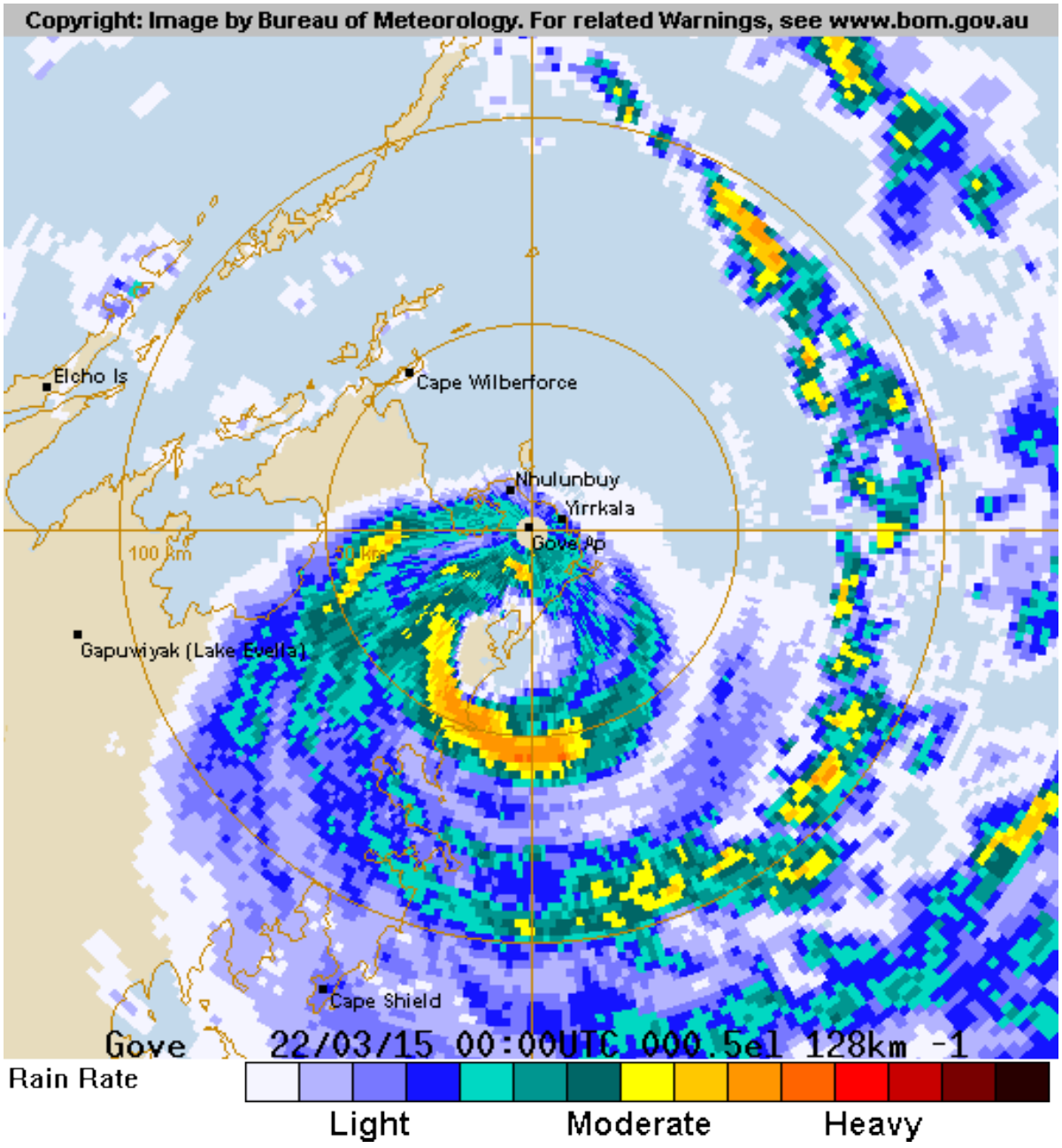


Figure 13. SSMIS 91 GHz microwave images showing the weakening prior to final landfall on 24 March; at 1909 UTC 22 March (left) and at 1108 UTC 23 March (right).

The 'x' marks the centre location. Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html.

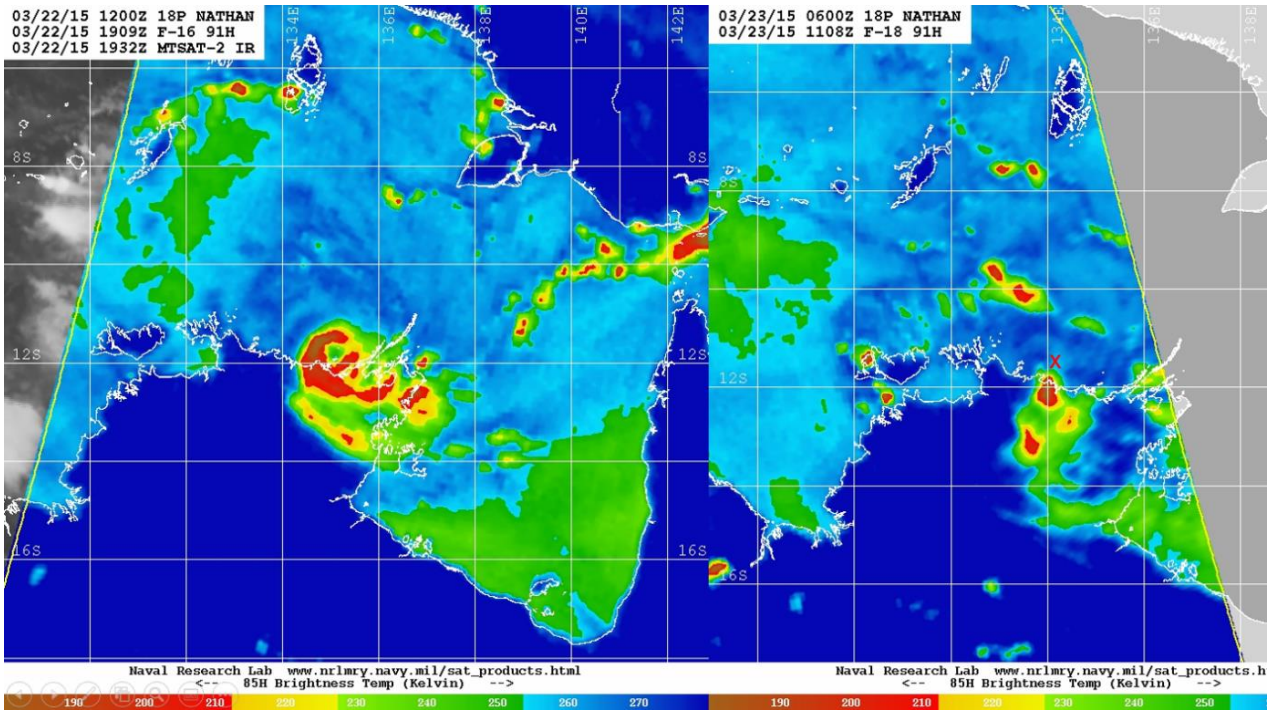
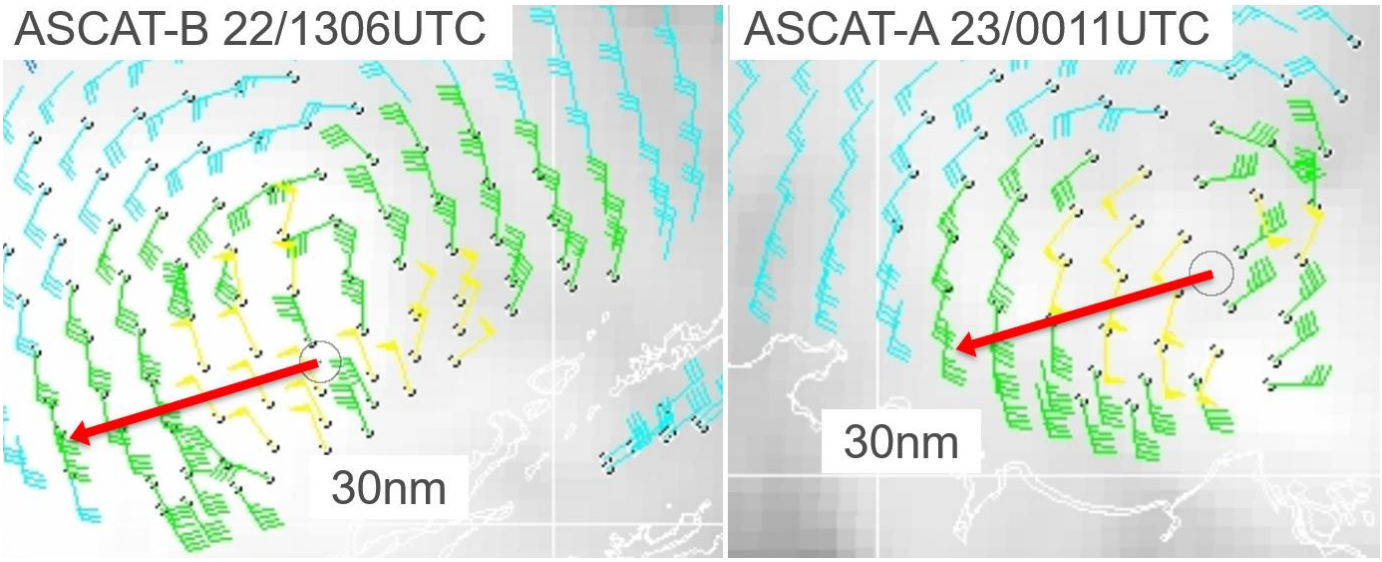


Figure 14. Winds from left, ASCAT-B at 1306 UTC 22 March and right, ASCAT-A at 0011 UTC 23 March.

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



2.2 Structure

Figure 15 shows the wind radii (gale, storm, hurricane-force) by quadrant during the event.

10-20 March Coral Sea

A strong monsoon resulted in gales being highest in northern quadrants from 10-15 March as shown in Figure 5. The gale radius averaged 70 to 100 nm (130-185) to the north and 40 to 70 nm (75-130 km) to the south. The radius of maximum winds ranged from 20 to 40 nm (35-75 km during this period.

During 15 March gales extended to 90 nm southwest of the centre assisted by synoptic southeasterly enhancement.

During the rapid intensification period from late on 17 to 18 March, the extent of gales reduced significantly to just 30 to 40 nm (55-75 km). Satellite imagery showed a very small eye emerging on 18 March and the radius of maximum winds reduced to 5-8 nm (9-15 km).

Late on 18 March gales extended to about 50-60 nm (95-110 km) in southern and northwest quadrants as Nathan tracked steadily to the west. Bougainville Reef, south of the track, reported periods of gales between 20 UTC 18 March to 12 UTC 19 March.

Cape Flattery recorded gales between 1220 UTC and 1810 UTC 19 March, and storm-force winds between 1350 UTC and 1650 UTC 19 March (refer Figure 18). Cape Flattery recorded maximum 10-minute winds of 65 kn (120 km/h) and maximum 3-second wind gust 90 kn (167 km/h) at 1620 UTC, as Nathan passed 15 nm to the north. Wind observations showed an abrupt reduction from about 16 UTC as Nathan passed to the north. This is partially explained by topography disrupting the wind flow.

Land influences reduced the extent of gales as Nathan neared the coast and tracked across Cape York Peninsula.

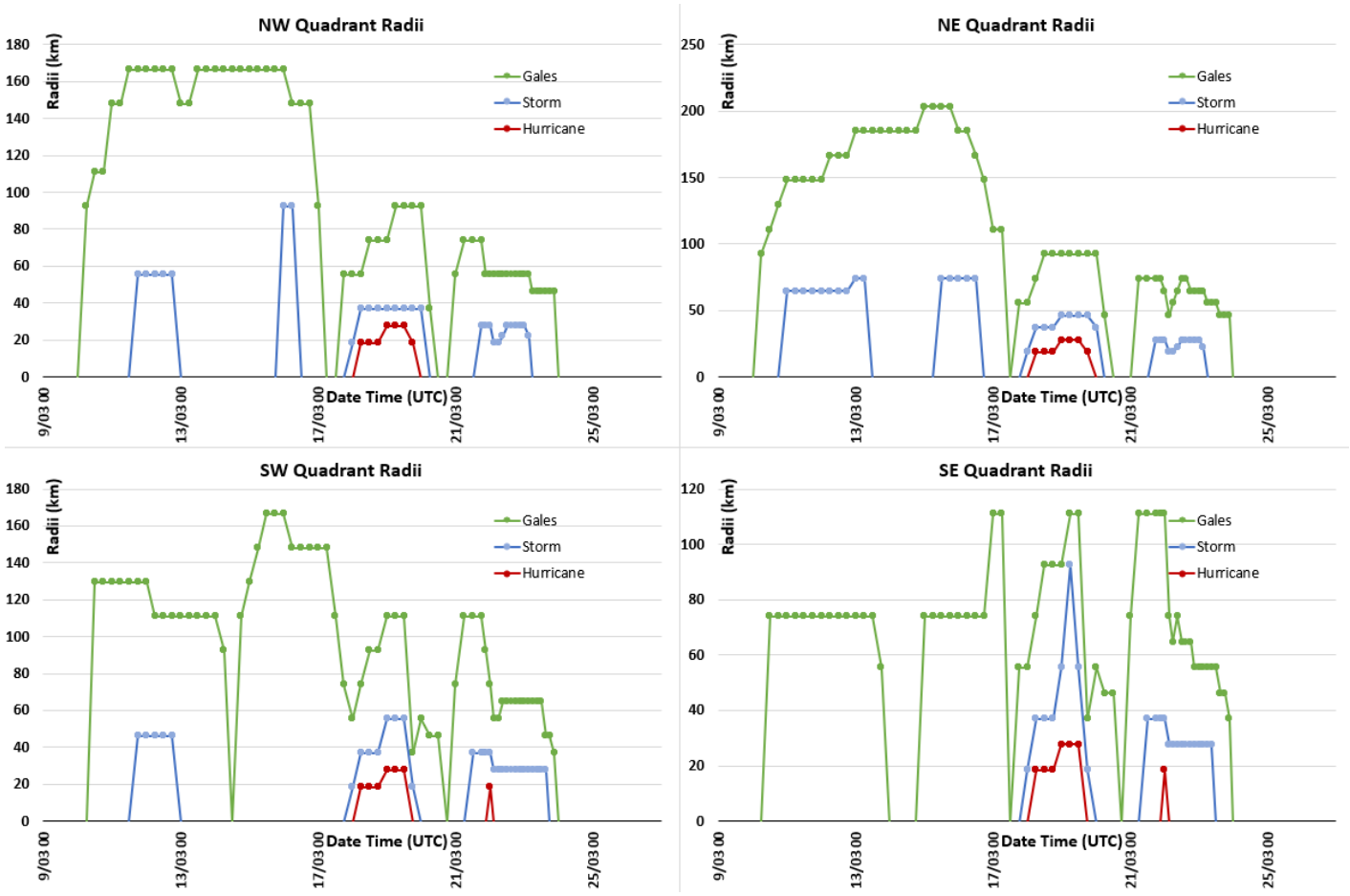
21-24 March Gulf of Carpentaria and Northern Territory

In the Gulf of Carpentaria, the steady west northwest motion (~20 km/h) contributed to an asymmetry in the extent of gales, to 60 nm in the south but just 30-40 nm in northern quadrants. Towards landfall, estimates of gale extent were based upon ASCAT images near 0000 UTC 22 March, supported by observations at Gove where a brief period of gales was observed. The microwave images in Figure 11, supported by the radar sequence identify a contraction of the RMW to just 8 nm (15 km) at landfall. Hurricane-force winds are only estimated to occur south of the centre in an isolated part of the coast.

Observations from Gove, Ngayawili (near Galiwink'u on Elcho Island), Milingimbi and Maningrida, along with ASCAT imagery such as in Figure 14 suggested the gale radius was no more than 35 nm (65 km) as it tracked along the north coast from 22 March through until landfall on 24 March.

The maximum winds are likely to have continued south of the centre close to the coast on 23 March through until landfall early on 24 March. The radius of maximum winds is estimated at just 10-12 nm (20 km) during this time.

Figure 15. Wind radii analysis (gale, storm, hurricane-force) by quadrant during Nathan.



2.3 Motion

Initially a weak ridge to the south was the dominant steering influence allowing a westerly track towards the north Queensland coast. On 12 March, this ridge weakened as a mid-latitude trough moved into the Tasman Sea and the cyclone was slow moving over the following days and was pushed back out to sea on 14 March. On 17 March, a mid-level ridge centred over central Australia extended into the Coral Sea to the south of the cyclone causing Nathan to resume a westerly track. This pattern was maintained over following days as Nathan moved over Cape York Peninsula.

As Nathan emerged over the Gulf of Carpentaria, the mid-level ridge strengthened over Western Australia to the southwest. Nathan was then steered on a steady west to northwest track. Nathan crossed the northeast Arnhem Land coast, just south of Nhulunbuy on 22 March, but reached open waters again later that night.

Nathan then tracked in a general westerly direction just off the Northern Territory coast on 23 March until it turned southwest early on 24 March, crossing the coast. The weakened circulation then moved overland, emerging over the Joseph Bonaparte Gulf early on 26 March and tracking to the west.

3. Impact

3.1 North Queensland, 12, 20-21 March.

Lizard Island experienced damaging wind gusts on 12 March as Nathan came close to the coast but there was little impact on the mainland. As Nathan made landfall on 20 March some wind damage occurred in Cooktown, but fortunately the zone of maximum winds occurred on a remote part of the coastline to the north. The photos in Figure 16 are an indication of the impact on Lizard Island.

3.2 Northern Territory 22-25 March

Nathan crossed the Northern Territory coast as a category 3 system, with wind gusts estimated to be to 155 km/h near the centre. However, the town of Nhulunbuy remained outside of the zone of destructive winds and experienced around 3 hours of sustained gales on Sunday morning. The highest gust recorded at Gove Airport was 98 km/h at UTC (09:34 ACST) 22 March.

Nathan maintained category 2 intensity as it emerged from the Gove Peninsula near Arnhem Bay and passed over Elcho Island around 1900 ACST 22 March. Nathan continued westwards over the southern Arafura Sea just north of the Top End coast during 23 March, before weakening rapidly as it turned southwest that evening. Nathan made its third and final landfall at category 1 intensity in a remote area between Maningrida and Goulburn Island around 0630 ACST 24 March. Nathan then weakened below tropical cyclone intensity by 1400 ACST 24 March as it tracked further inland close to the towns of Gunbalunya and Jabiru.

Fortunately, the destructive core of the cyclone skirted around the north coast communities of Galiwink'u, Ramingining and Milingimbi, which were damaged by Severe Tropical Cyclone Lam in February. Residents of Galiwink'u on Elcho Island who were temporarily housed in a tented camp after Lam destroyed their houses were placed in secure accommodation during Nathan's passage. The strongest gust recorded at Ngayawili AWS near Galiwink'u was 107 km/h at 1900 ACST 22 March and 3 hours of gale-force winds were observed during the cyclone's passage. Several hundred residents of the community of Warruwi on Goulburn Island were evacuated by air to Darwin for the second time this season in anticipation of a direct hit from Nathan. The strongest gust recorded at Warruwi on Goulburn Island was 69 km/h at around 2200 ACST 23 March.

The cyclone and its remnant tropical depression brought heavy rainfall and flooding to many parts of the Northern Territory's Top End. The highest 24-hour rainfall totals included 208 mm at Alcan Mine on the Gove Peninsula, 261 mm at Fanny Creek and 215 mm at Dorisvale in the Katherine River catchment and 208 mm at Snowdrop Creek in the Waterhouse River catchment.

Figure 16. Building damage on Lizard Island. Photo supplied via Queensland Fire and Emergency Services (QFES).

Figure 17. Aftermath of Nathan on Lizard Island. Photo supplied via Queensland Fire and Emergency Services (QFES).

4. Observations

4.1 Wind

Bougainville Reef (observed mean winds at 17 m height adjusted to 10 m)

Gales at times between 2033 UTC 18 March to 1136 UTC 19 March.

Maximum 10-minute mean wind 48 kn (90 km/h) at 0709 UTC 19 March.

Maximum 10-minute mean wind 51 kn (95 km/h) at 0709 UTC 19 March.

Maximum 3-second wind gust 65 kn (120 km/h) at 0601 UTC 19 March.

Cape Flattery refer Figure 18.

Gales at times between 1220 UTC to 1810 UTC 19 March.

Storm-force winds at times between 1350 UTC to 1650 UTC 19 March.

Maximum 10-minute mean wind 65 kn (120 km/h) at 1620 UTC 19 March.

Maximum 3-second wind gust 90 kn (167 km/h) at 1620 UTC 19 March.

Gove.

Gales for two hours between 2351 UTC 21 March to 0151 UTC 22 March.

Maximum 10-minute mean wind 40 kn (74 km/h) at 0041 UTC 22 March.

Maximum 3-second wind gust 53 kn (98 km/h) at 0004 UTC 22 March.

Ngayawili (near Galiwink'u on Elcho Island)

Gales for just over four hours between 0624-1038 UTC (1554 and 2008 ACST) 22 March.

Maximum 10-minute mean wind 43 kn (80 km/h) at 0915 UTC (1815 ACST) 22 March.

Maximum 3-second wind gust 60 kn (111 km/h) at 0912 UTC (1839 ACST) 22 March.

Milingimbi

Brief marginal gales between 20-21 UTC 22 March.

Maximum 10-minute mean wind 34 kn (63 km/h) at 2024 UTC 22 March.

Maximum 3-second wind gust 56 kn (104 km/h) at 2016 UTC 22 March.

*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

Cape Flattery

988.5 hPa at 1610 UTC 19 March (centre passed approximately 28 km to the north).

Gove

994.8 hPa at 0032 UTC 22 March (centre passed approximately 40 km to the south).

Ngayawili (near Galiwink'u on Elcho Island)

993.5 hPa at 0827 UTC 22 March (centre passed approximately 32 km to the north).

Milingimbi

999.5 hPa at 1927 UTC 22 March (centre passed approximately 40 km to the north).

4.3 Rainfall

Queensland:

Figure 19 and 20 shows the weekly rainfall ending 14 March and 21 March, respectively. Ongoing strong onshore flow as Nathan lingered off the coast from 11-14 March caused rainfall totals exceeding 200 mm near the North Tropical Queensland coast, north of Townsville.

Daily rainfall totals exceeded 100 mm on 20-21 March near the track of Nathan as it moved over the Cape York Peninsula.

Northern Territory:

The cyclone and its remnant tropical depression brought heavy rainfall and flooding to many parts of the Northern Territory's Top End. The highest 24-hour rainfall totals included:

208 mm at Alcan Mine on the Gove Peninsula,

261 mm at Fanny Creek and 215 mm at Dorisvale in the Katherine River catchment and

208 mm at Snowdrop Creek in the Waterhouse River catchment.

Figure 21 shows the weekly rainfall accumulation to 9 am March 28, indicating the distribution of the heaviest rainfall.

4.4 High waves and storm tide

Cooktown recorded a storm surge of 0.8 m as Nathan made landfall to the north. Fortunately, landfall occurred at close to low tide minimising the storm tide and impact to the coast. Source: www.qld.gov.au/tides.

There were no observations of the storm surge on the Northern Territory coast on 22 March

Figure 18. Wind and pressure observations at Cape Flattery, 19-20 March. Times in AEST (UTC+10h).

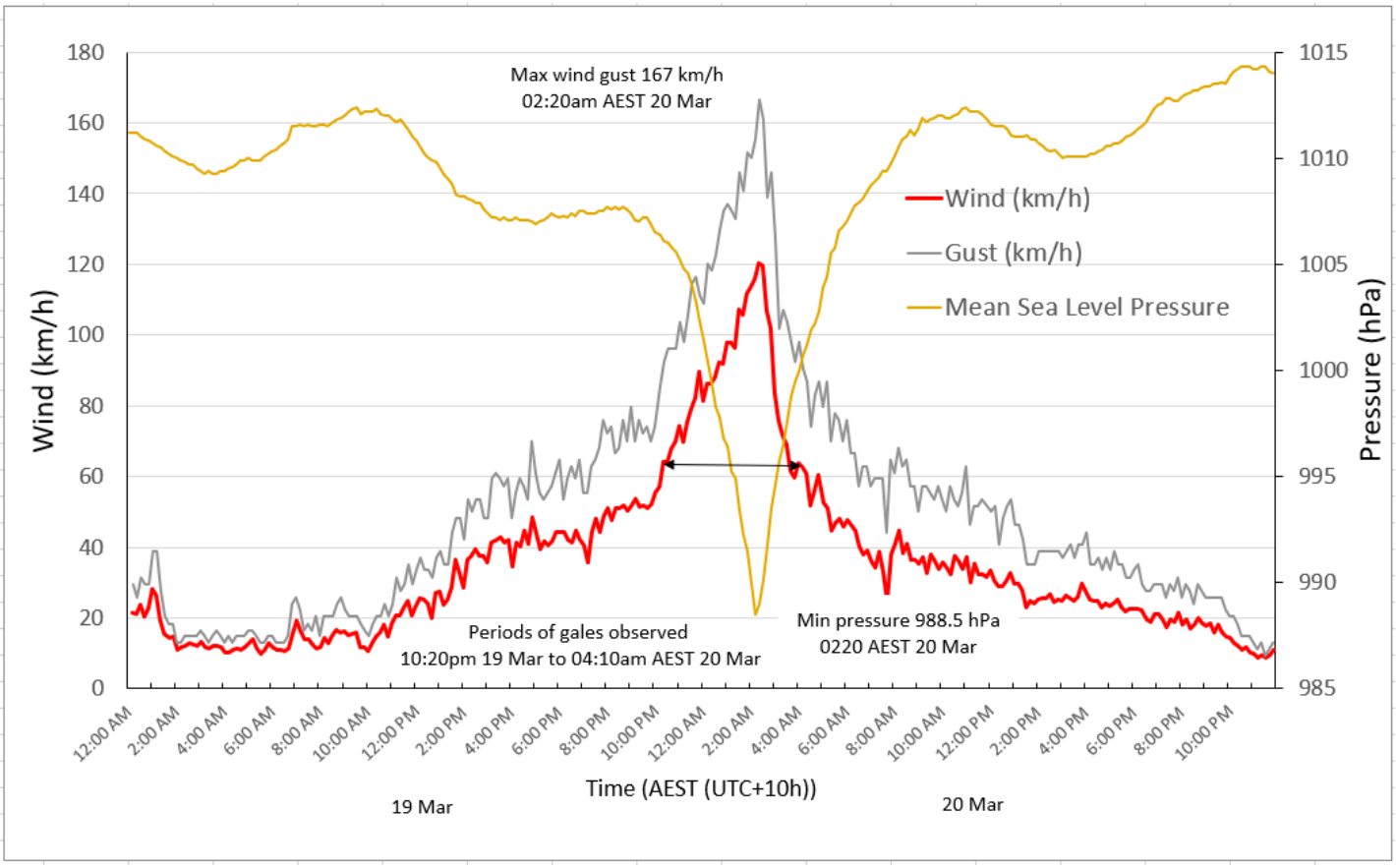


Figure 19. Distribution of rainfall totals over Queensland for the week ending 14 March.

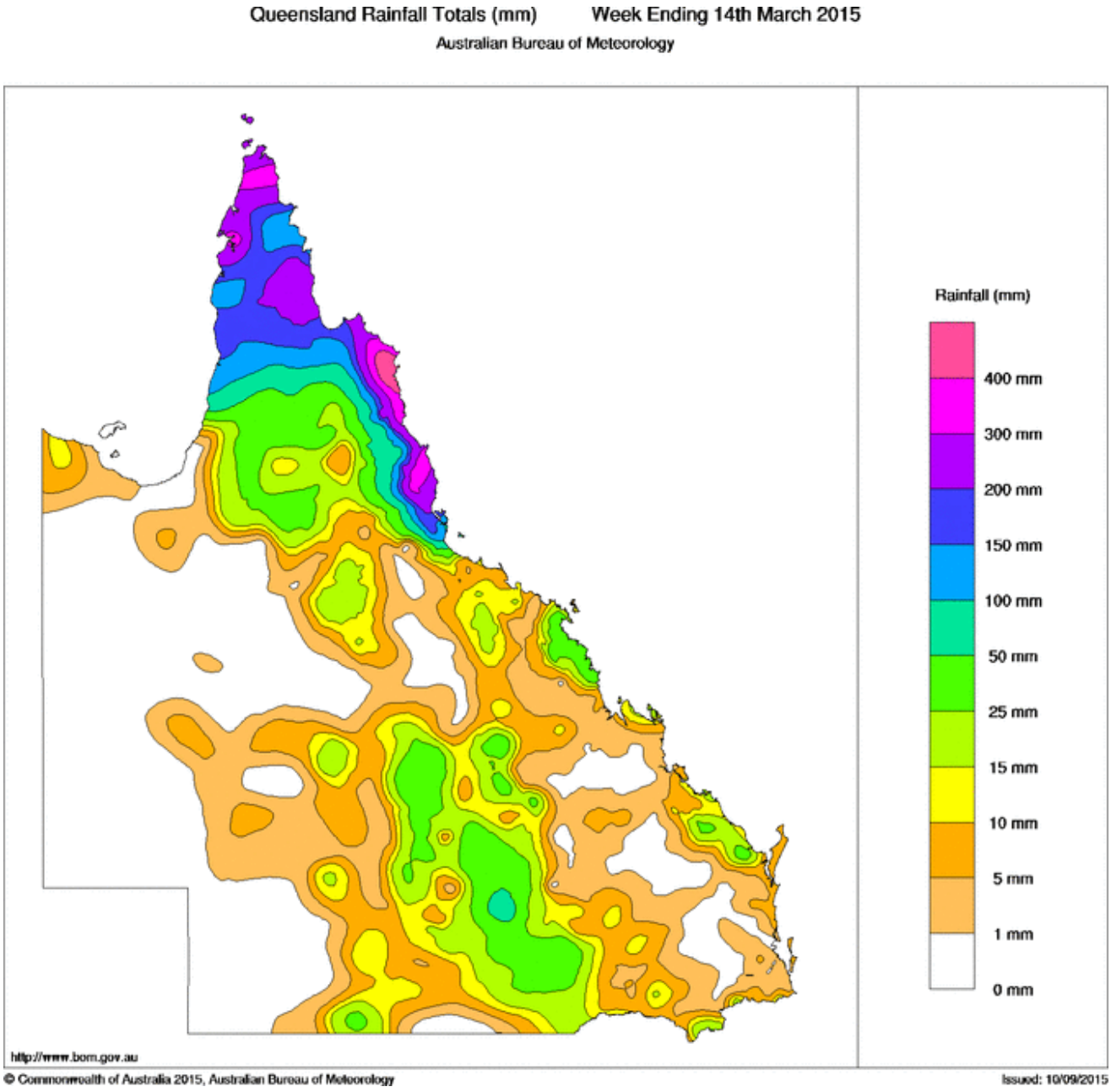


Figure 20. Distribution of rainfall totals over Queensland for the week ending 21 March.

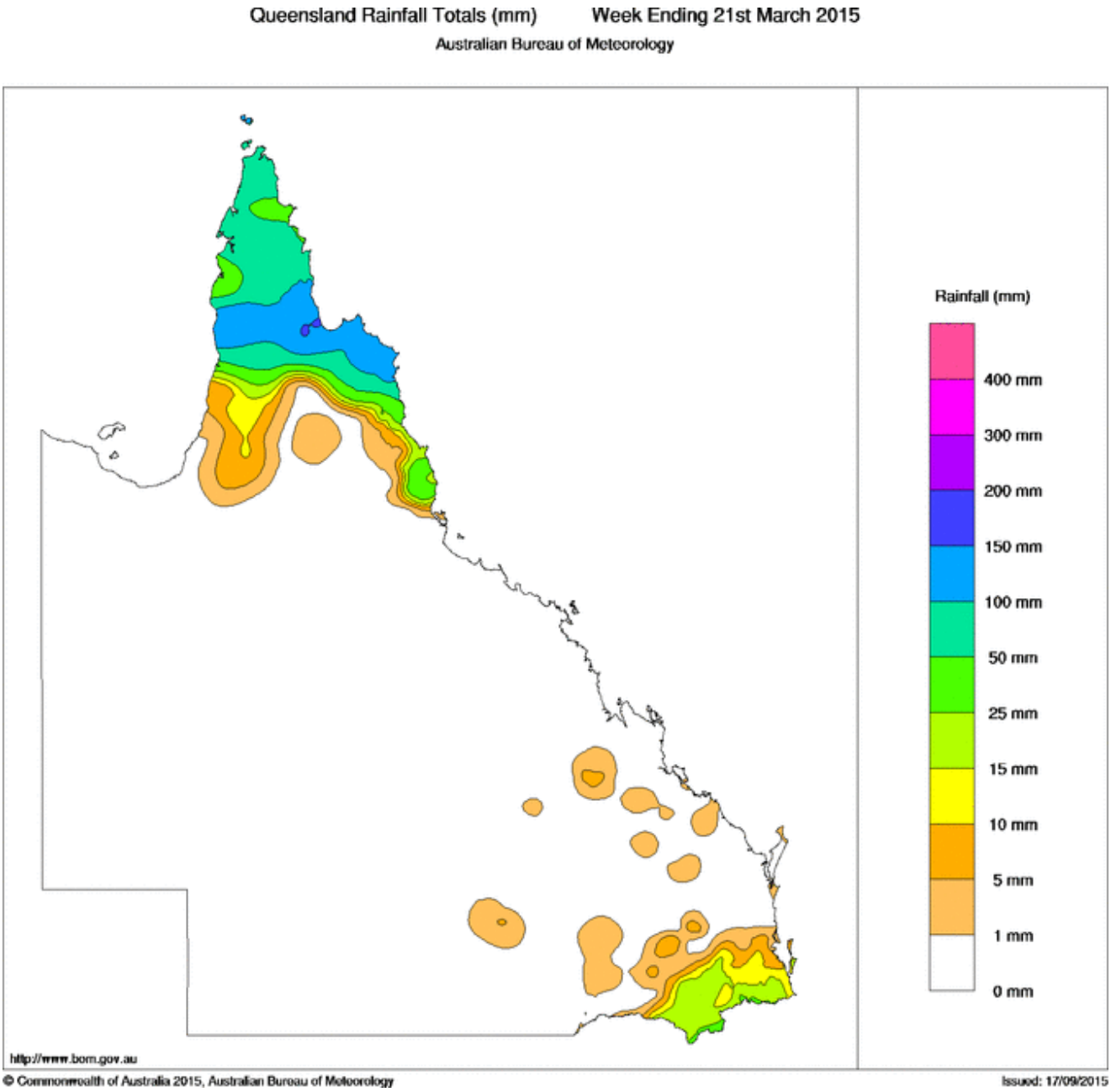


Figure 21. Distribution of rainfall totals over the Northern Territory for the week ending 28 March.

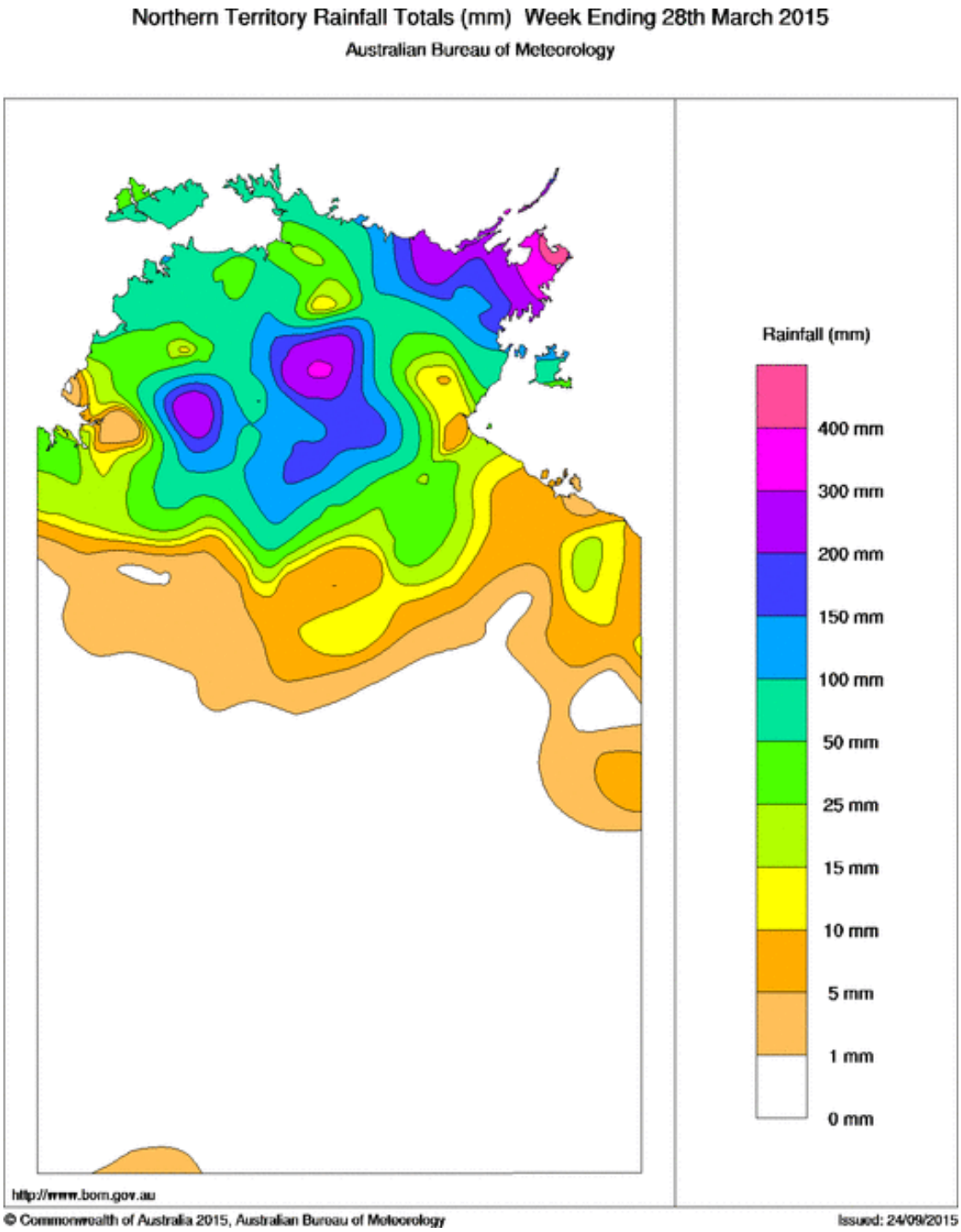


TABLE 1. Best track summary for Severe Tropical Cyclone Nathan 9 – 23 March 2015.

Refer to the Australian Tropical Cyclone database for complete listing of parameters and track from 9 to 24 March. Note: UTC is AEST - 10 hours.

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 nm
2015	3	9	0000	12.4	151.3	30	20	35	1000	0/0/0/0	0/0/0/0	-
2015	3	9	0600	12.4	150.9	50	30	35	998	0/0/0/0	0/0/0/0	-
2015	3	9	1200	12.5	150.4	45	30	40	998	0/0/0/0	0/0/0/0	-
2015	3	9	1800	12.5	149.9	40	30	45	998	0/0/0/0	0/0/0/0	-
2015	3	10	0000	12.6	149.6	40	30	45	998	0/0/0/0	0/0/0/0	-
2015	3	10	0600	13.0	149.0	30	35*	50	996	50/0/0/50	0/0/0/0	-
2015	3	10	1200	13.2	148.3	20	45	55	993	60/40/70/60	0/0/0/0	25
2015	3	10	1800	13.5	147.5	20	45	65	991	70/40/70/60	0/0/0/0	25
2015	3	11	0000	13.8	146.8	20	50	70	990	80/40/70/80	35/0/0/0	25
2015	3	11	0600	13.8	146.4	25	50	70	986	80/40/70/80	35/0/0/0	20
2015	3	11	1200	13.9	146.0	25	50	70	986	80/40/70/90	35/0/0/0	20
2015	3	11	1800	13.8	145.8	20	50	70	986	80/40/70/90	35/0/25/30	30
2015	3	12	0000	13.9	145.4	20	55	70	985	80/40/70/90	35/0/25/30	25
2015	3	12	0600	13.9	145.1	20	55	70	982	90/40/60/90	35/0/25/30	20
2015	3	12	1200	13.8	144.9	15	55	80	980	90/40/60/90	35/0/25/30	20
2015	3	12	1800	13.5	145.1	20	50	75	980	90/40/60/90	35/0/25/30	20
2015	3	13	0000	13.3	145.3	20	50	75	980	100/40/60/80	40/0/0/0	25
2015	3	13	0600	13.3	145.2	20	50	75	980	100/40/60/80	40/0/0/0	30
2015	3	13	1200	13.2	145.0	25	45	75	985	100/40/60/90	0/0/0/0	25
2015	3	13	1800	13.1	145.0	25	45	75	987	100/30/60/90	0/0/0/0	25
2015	3	14	0000	13.2	145.5	20	45	70	992	100/0/60/90	0/0/0/0	25
2015	3	14	0600	13.1	145.8	25	40	65	993	100/0/50/90	0/0/0/0	25
2015	3	14	1200	13.3	146.8	25	40*	55	995	100/0/0/90	0/0/0/0	40
2015	3	14	1800	13.3	147.7	25	40	55	993	100/0/60/90	0/0/0/0	40
2015	3	15	0000	13.3	148.5	25	40	55	993	110/40/70/90	0/0/0/0	20
2015	3	15	0600	13.5	148.8	20	45	55	989	110/40/80/90	0/0/0/0	20
2015	3	15	1200	13.5	149.5	15	50	70	987	110/40/90/90	40/0/0/0	30
2015	3	15	1800	13.8	149.8	20	50	70	988	110/40/90/90	40/0/0/0	30
2015	3	16	0000	13.9	149.9	20	55	75	986	100/40/90/90	40/0/0/50	30
2015	3	16	0600	14.1	150.0	15	55	75	984	100/40/80/80	40/0/0/50	30
2015	3	16	1200	14.1	149.7	15	50	70	989	90/40/80/80	40/0/0/0	30
2015	3	16	1800	14.2	149.8	20	45	65	990	80/40/80/80	0/0/0/0	30
2015	3	17	0000	14.3	149.7	15	40	55	992	60/60/80/50	0/0/0/0	30
2015	3	17	0600	14.7	149.7	20	40	55	993	60/60/80/0	0/0/0/0	30
2015	3	17	1200	14.9	149.7	20	35*	50	995	0/0/60/0	0/0/0/0	30
2015	3	17	1800	15.0	149.4	20	40	55	993	30/30/40/30	0/0/0/0	20
2015	3	18	0000	15.0	149.2	10	50	70	988	30/30/30/30	10/15/15/10	8
2015	3	18	0600	15.0	149.0	10	65	90	977	40/40/40/30	15/20/20/15	5
2015	3	18	1200	14.8	148.7	10	75	105	971	50/50/50/40	15/25/25/20	5

2015	3	18	1800	14.7	148.2	10	75	105	972	50/50/50/40	15/30/30/20	5
2015	3	19	0000	14.6	147.6	15	70	100	975	50/60/70/40	25/30/30/20	10
2015	3	19	0600	14.7	146.9	8	75	105	973	50/60/70/50	25/35/35/20	10
2015	3	19	1200	14.7	146.0	8	80	110	969	50/60/60/50	25/35/35/20	12
2015	3	19	1800	14.7	145.0	8	80	110	969	50/50/20/50	25/30/15/20	10
2015	3	19	2100	14.6	144.6	8	65	90	972	50/40/25/45	25/20/12/20	10
2015	3	20	0000	14.5	144.1	8	55	75	980	50/30/30/40	20/12/12/20	12
2015	3	20	0600	14.4	143.2	15	45	65	985	25/25/25/20	0/0/0/0	15
2015	3	20	1200	14.4	142.2	15	35	50	988	0/25/25/0	0/0/0/0	15
2015	3	20	1800	14.1	141.2	20	30	45	992	0/0/0/0	0/0/0/0	20
2015	3	21	0000	13.7	140.2	20	40	55	990	0/40/40/30	0/0/0/0	25
2015	3	21	0600	13.7	139.2	20	40	55	990	40/60/60/40	0/0/0/0	25
2015	3	21	1200	13.4	138.3	20	50	70	988	40/60/60/40	0/20/20/0	15
2015	3	21	1800	13.0	137.5	10	60	85	986	40/60/60/40	15/20/20/15	12
2015	3	21	2100	12.8	137.1	10	60	85	986	40/60/50/30	15/20/20/15	10
2015	3	22	0000	12.6	136.7	10	70	100	979	35/60/40/30	15/20/20/15	8
2015	3	22	0300	12.4	136.4	10	55	75	988	25/40/30/30	10/15/15/10	8
2015	3	22	0600	12.2	136.1	10	55	75	988	30/35/30/30	10/15/15/10	8
2015	3	22	0900	11.9	135.9	10	50	70	988	35/40/35/30	12/15/15/12	8
2015	3	22	1200	11.7	135.6	10	55	75	986	40/35/35/30	15/15/15/15	8
2015	3	22	1500	11.7	135.4	10	60	85	984	40/35/35/30	15/15/15/15	8
2015	3	22	1800	11.7	135.2	10	60	85	984	35/35/35/30	15/15/15/15	10
2015	3	22	2100	11.7	134.9	10	60	85	984	35/30/35/30	15/15/15/15	12
2015	3	23	0000	11.6	134.7	10	55	75	986	35/30/35/30	15/15/15/15	12
2015	3	23	0300	11.5	134.5	10	55	85	986	35/30/35/30	12/15/15/12	10
2015	3	23	0600	11.4	134.4	15	55	75	986	30/30/35/25	0/15/15/0	10
2015	3	23	0900	11.4	134.3	15	50	70	988	30/30/35/25	0/15/15/0	10
2015	3	23	1200	11.5	134.2	15	50	70	990	30/30/35/25	0/0/15/0	10
2015	3	23	1500	11.5	134.1	15	50	70	992	25/25/25/25	0/0/15/0	10
2015	3	23	1800	11.6	134.0	15	45	65	994	25/25/25/25	0/0/0/0	10
2015	3	23	2100	11.9	133.8	20	35	55	996	25/20/20/25	0/0/0/0	12
2015	3	24	0000	12.2	133.5	20	30	45	1000	0/0/0/0	0/0/0/0	-
2015	3	24	0600	12.5	132.8	20	25	45	1002	0/0/0/0	0/0/0/0	-
2015	3	24	1200	12.5	132.3	20	20	45	1004	0/0/0/0	0/0/0/0	-
2015	3	24	1800	12.5	132.0	20	20	45	1004	0/0/0/0	0/0/0/0	-
2015	3	25	0000	12.8	131.7	20	20	45	1006	0/0/0/0	0/0/0/0	-
2015	3	25	0600	13.0	130.6	20	20	45	1006	0/0/0/0	0/0/0/0	-
2015	3	25	1200	13.5	130.1	20	20	45	1008	0/0/0/0	0/0/0/0	-
2015	3	25	1800	13.5	129.6	20	20	45	1008	0/0/0/0	0/0/0/0	-
2015	3	26	0000	13.4	129.2	20	20	45	1008	0/0/0/0	0/0/0/0	-
2015	3	26	0600	13.4	128.7	20	20	45	1008	0/0/0/0	0/0/0/0	-
2015	3	26	1200	13.5	128.0	20	20	45	1008	0/0/0/0	0/0/0/0	-
2015	3	26	1800	13.4	126.9	20	20	45	1008	0/0/0/0	0/0/0/0	-
2015	3	27	0000	13.3	126.2	20	20	45	1008	0/0/0/0	0/0/0/0	-

5. Forecast Performance

Official tropical cyclone forecasts were issued from 10-24 March. A tropical cyclone watch was first issued just before noon 10 March from Coen to Cape Tribulation Point in far north Queensland. There were a total of 118 tropical cyclone advices issued during the event.

The accuracy figures for Nathan in the table below and in Figure 22 show that the forecast position performed better than the five-year average at all time steps, other than at 120 hours. Conversely the intensity forecasts had higher errors than the five-year average other than at 96 to 120 hours as shown in Figure 23. This was due to several influences, the initial overestimation of intensity until it rapidly developed; timing differences of landfall that resulted in rapid weakening, and difficulties in the positioning relative to land as Nathan tracked near the coast. This is partially based on overestimating the intensity during the early stages of development. These were based on official forecast tracks issued from 0000 UTC 10 March to 0000 UTC 24 March.

	0	6	12	18	24	36	48	72	96	120
Position Absolute error (km)	13	31	42	54	61	87	119	206	348	515
Intensity Absolute error (kn)	2.9	6.9	10.2	13.0	14.4	16.8	17.6	17.4	16.9	16.5
Sample Size	57	57	57	57	57	57	56	56	51	46

Figure 22. Position accuracy figures for Severe Tropical Cyclone Nathan.

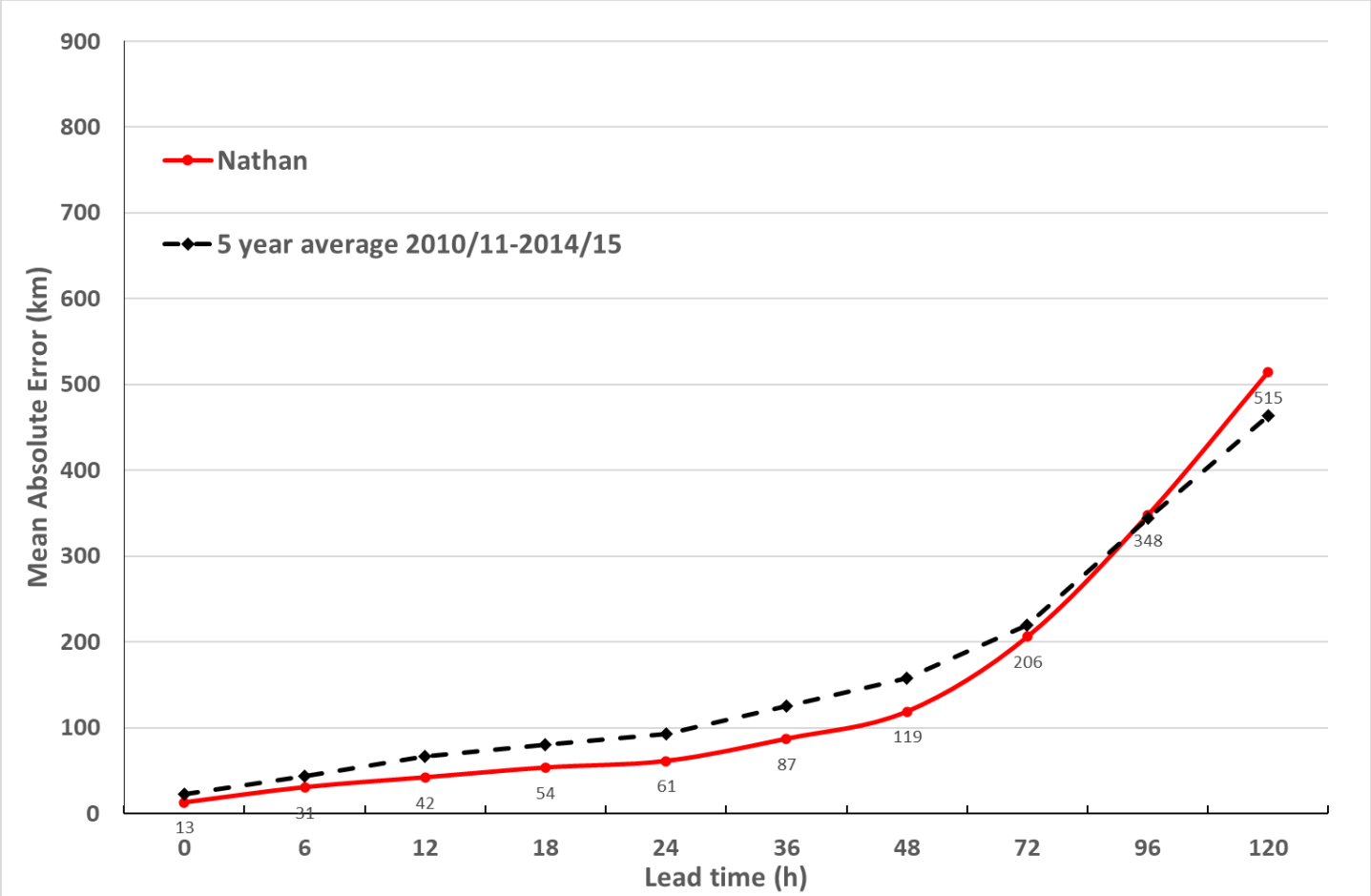
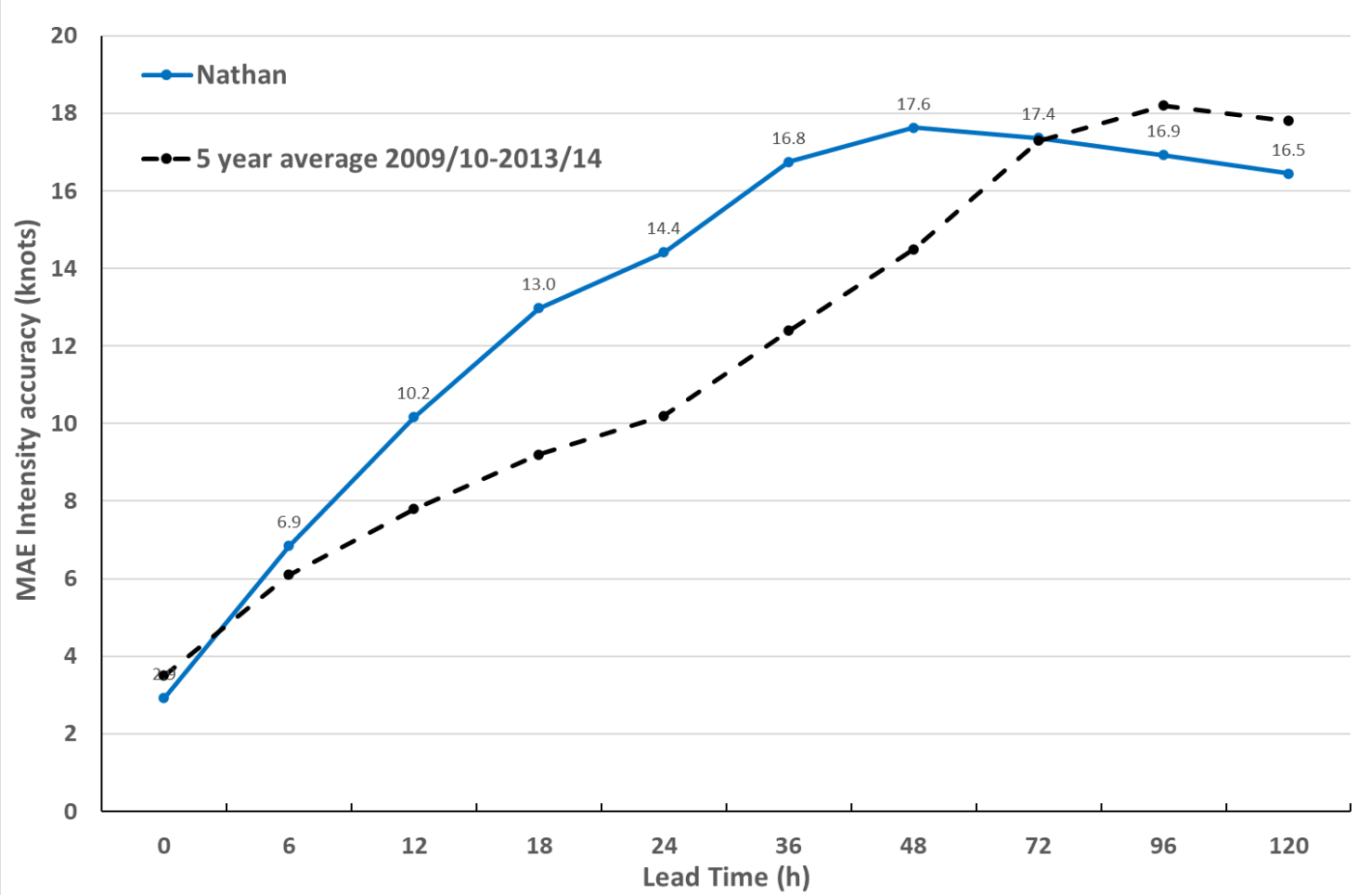


Figure 23. Intensity accuracy figures for Severe Tropical Cyclone Nathan.



6. Appendix: List of abbreviations

ADT	Advanced Dvorak Technique	km/h	kilometres per hour
ACST	Australian Central Standard Time	kn	knot
AEST	Australian Eastern Standard Time	LLCC	low level cloud centre
AMSR2	Advanced Microwave Scanning Radiometer	MET	Model Expected T-number
ASCAT	Advanced Scatterometer	METOP	Meteorological Operational Satellite
ATMS	Advanced Technology Microwave Sounder	MJO	Madden-Julian Oscillation
AWS	automatic weather station	mm	millimetres
AWST	Australian Western Standard Time	MSLP	mean sea level pressure
C	Celsius	nm	nautical mile
CI	Current intensity	NOAA	National Oceanic and Atmospheric Administration
CIMSS	Cooperative Institute for Meteorological Satellite Studies (USA)	NRL	Navy Research Lab (USA)
CIRA	Cooperative Institute for Research in the Atmosphere (USA)	PAT	Pattern T-number
EIR	Enhanced InfraRed	RH	relative humidity
ERC	eyewall replacement cycle	RMW	radius of maximum winds
FNMOC	Fleet Numerical Meteorology and Oceanography Centre (USA)	RSMC	Regional Specialised Meteorological Centre
FT	Final T-number	SAR	Synthetic Aperture Radar
GCOM	Global Change Observation Mission	SATCON	satellite Consensus
GHz	Gigahertz	SMAP	Soil Moisture Active Passive
GMI	Global Precipitation Measurement Microwave Imager	SMOS	Soil Moisture and Ocean Salinity
h	hour	SSMIS	Special Sensor Microwave Imager/Sounder
hPa	hectopascal	TC	Tropical Cyclone
HSCAT	Hai Yang 2 Scatterometer (HY-2B, HY-2C)	TCWC	Tropical Cyclone Warning Centre
km	kilometres	UTC	Universal Time Co-ordinated