

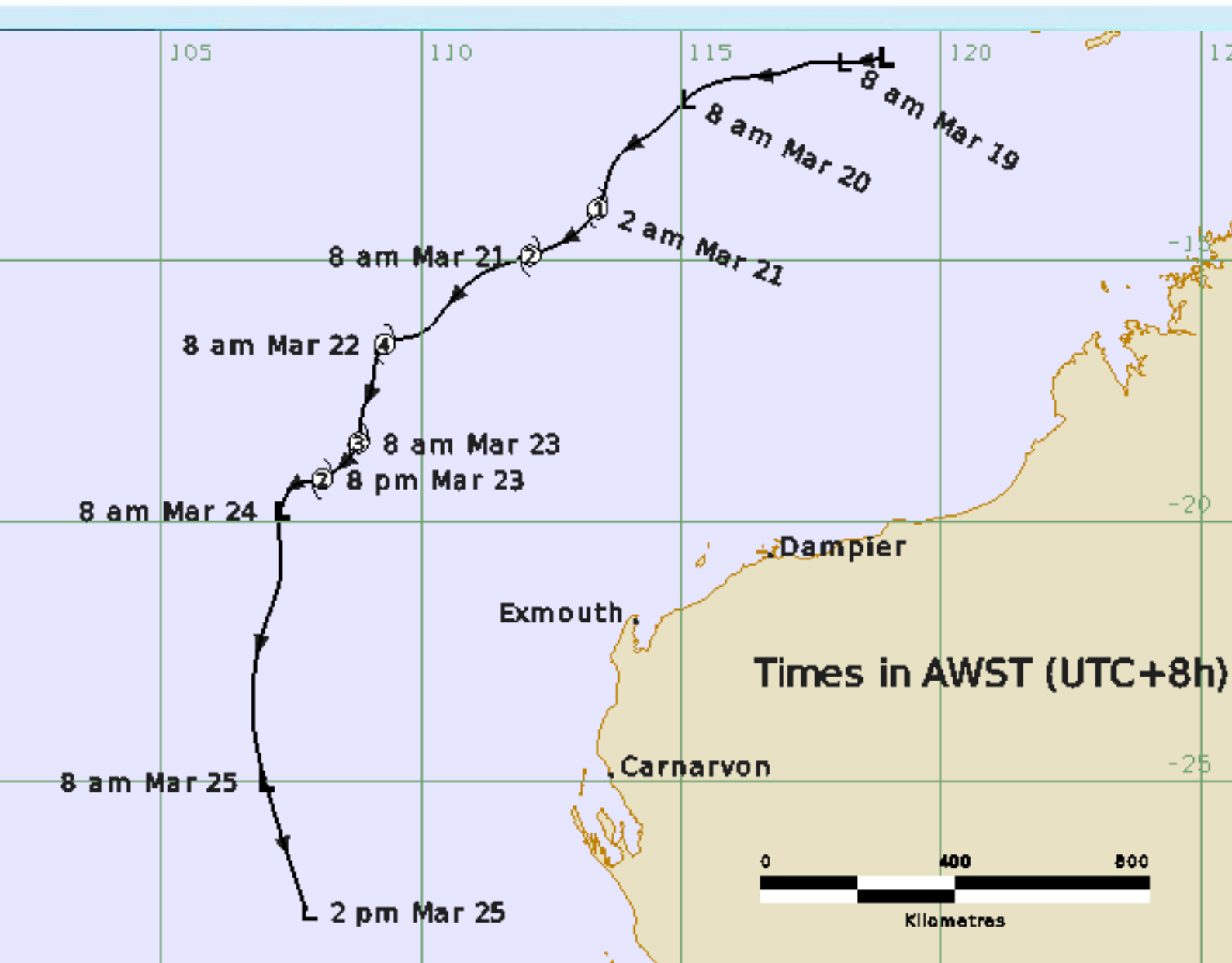


Australian Government
Bureau of Meteorology

Severe Tropical Cyclone *Charlotte*

19 – 25 March 2022

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June 2022



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1 Summary

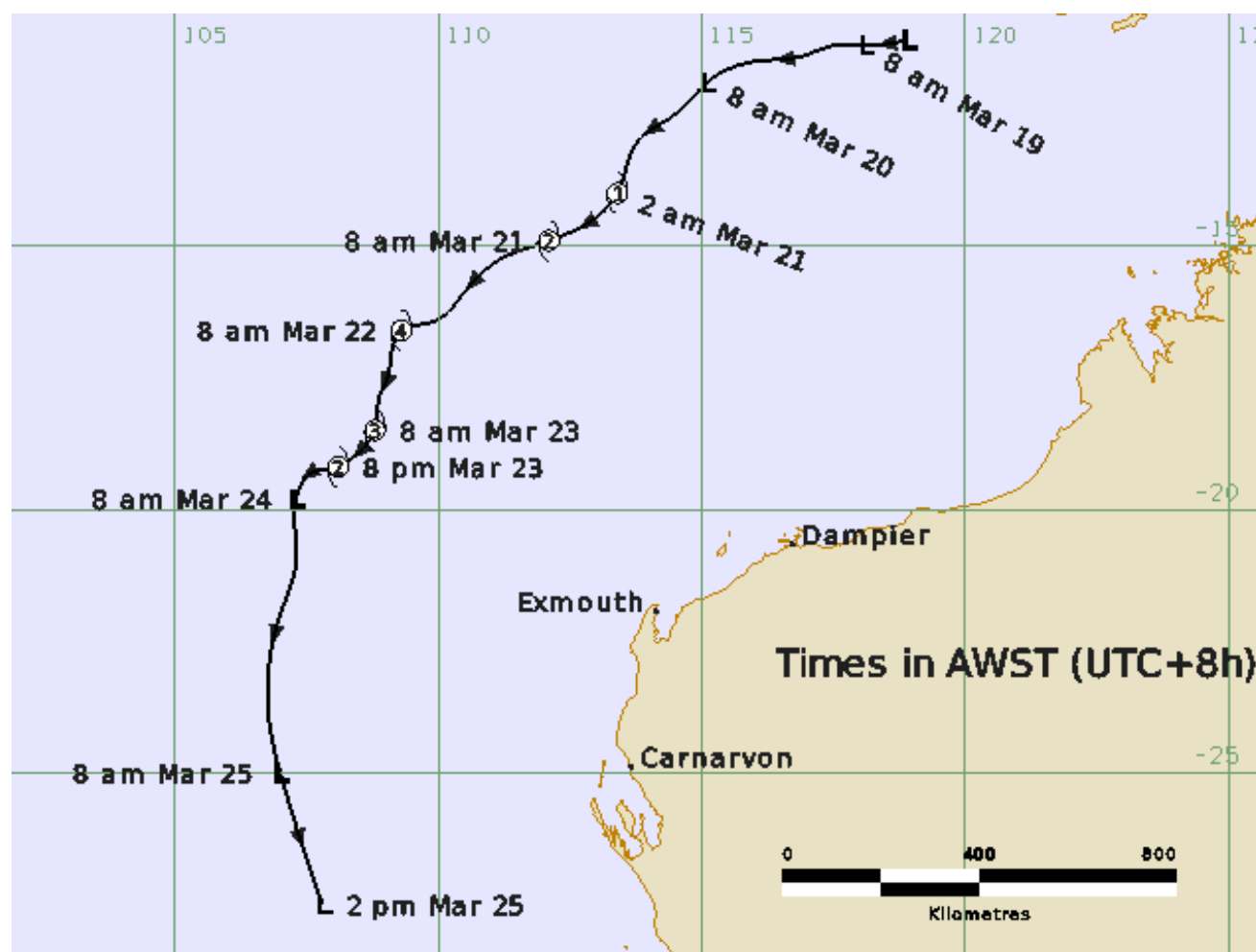
A tropical low formed over the northern Timor Sea on the 16 March and tracked westwards. During the 19 March the low started intensifying while moving southwest over open waters in between Indonesia and Western Australia. The system was named tropical cyclone *Charlotte* during Monday morning 21 March. The next 24 hours was quite significant where *Charlotte* rapidly intensified from a category 1 to a category 4 cyclone on 22 March. *Charlotte* maintained this intensity for at least 12 hours as it tracked south-westwards under the influence of a subtropical ridge.

The cyclone began weakening during 23 March due to drier air intrusion and increasing north-westerly wind shear. The system was downgraded to a tropical low at 1800 UTC 24 March as it moved south over cooler waters off Western Australia.

There was no direct impact from Severe Tropical Cyclone *Charlotte* to the Australian mainland or island communities. Earlier in its life cycle, it caused heavy rain over the Timor-Leste but there were no reports of any damages.

Severe Tropical Cyclone *Charlotte* was the eighth tropical cyclone in the Australian region for the 2021/22 season.

FIGURE 1. Best track of Severe Tropical Cyclone *Charlotte* 19 - 25 March 2022 (times in AWST, UTC+8h).



2 Meteorological Description

2.1 Intensity analysis

A tropical low began in the Timor Sea on 16 March and tracked westwards across Timor-Leste into the Indian Ocean, south of Bali. Persistent convection began consolidating near the low centre and the system was given an initial Dvorak T-no. 1.0 at 0000 Coordinated Universal Time (UTC, UTC=Australian Western Time (AWST) - 8 hours) UTC 19 March.

The low continued to track over open waters between Indonesia and Western Australia during 19 March and showing signs of organised convection. The Dvorak analysis was estimated to be T2.0 at 1800 UTC 19 March with an intensity of 30 kn (56 km/h). The Soil Moisture and Ocean Salinity (SMOS) pass at 2222 UTC 19 March indicated possible gales developing in the eastern quadrant.

The convective banding structure 0.4 Log 10 spiral at 0000 UTC 20 March, giving a Dvorak intensity of T2.5. The high resolution Advanced Scatterometer ASCAT METOP-C pass at 0203 UTC 20 March had 30 kn (56 km/h) in the southeast quadrant.

The low continued to develop under favourable upper pattern with low wind shear and sea surface temperatures around 30-degrees Celsius (C). The Cooperative Institute for Meteorological Satellite Studies (CIMSS) shear was estimating 10-15 kn (18 – 28 km/h) north-easterly. The Hai Yang-2B Advanced Scatterometer (HSCAT) sensor at 1030 UTC 20 March indicated 30 kn (56 km/h) covering more than half-way around the centre with gales in the southeast quadrant. The ASCAT METOP-B at 1343 UTC 20 March indicated the system had gales in the southern semicircle with a maximum of 45 kn (83 km/h) within 40 nm (74 km) of the centre.

Charlotte reached tropical cyclone intensity at 1800 UTC 20 March. The National Oceanic and Atmospheric Administration (NOAA-20) Advanced Technology Microwave Sounder (ATMS) and Global Change Observation Mission-W1 (GCOM-W1) Advanced Microwave Scanning Radiometer 2 (AMSR2) passes at 1733 UTC 20 March showed strong banding with deep convection on the southern side. The gale radius was estimated to be around 60 nm (111 km) wrapping more than half-way around the centre. The Dvorak estimate with a Log10 spiral wrapped 0.6 degree giving a CI=3.0. The system was named *Charlotte* with maximum winds of 45 kn (83 km/h) within 25 nm (46 km) of the centre at 1800 UTC 19 20 March.

The SMAP (Figure 2) pass at 2214 UTC 20 March showed gales wrapping more than half-way around the centre with a maximum of 50 kn (92 km/h) near centre. F17 SSMI 89 GHz pass at 2248 UTC 20 March (Figure 3) showed deep convection surrounding the middle level circulation.

Charlotte rapidly developed into a category 2 system by 0000 UTC 21 March with the Dvorak intensity estimated at CI=3.5 increasing to CI=4.0 at 1200 UTC 21 March. *Charlotte* developed a tight strong core that was evident on the Global Precipitation Measurement (GPM) Microwave Imager (GMI) 89 Ghz sensor at 1250 UTC 21 March (Figure 4).

The GCOM AMSR2 pass at 1820 UTC 21 March showed storm force winds in all quadrants and with maximum wind exceeding 64 kn (118 km/h) in southern quadrant. This was confirmed

by the SMOS microwave pass at 2244 UTC 21 March (Figure 5). The Dvorak intensity estimate using embedded centre pattern was FT4.5.

The system developed a clear eye measuring 6 nm (11 km) in diameter around 2100 UTC 21 March. Figure 6 shows the evolution of the eye in a series of Himawari-8 images between 1800 UTC 21 March and 0230 UTC 22 March. The SMOS microwave pass at 2244 UTC 21 March indicated hurricane force winds surrounding the eye. The Dvorak data-T intensity using enhanced IR imagery was estimated to be consistently at 6.0 between 2100 – 2300 UTC.

Charlotte maintained its peak intensity of 90 kn (167 km/h) between 0000 UTC and 1200 UTC 22 March. The enhanced IR imagery showed a pulsating Dvorak light grey eye temperature throughout the day. The AMSR2 microwave pass at 0632 UTC 22 March showed strong circular core of deep convection surrounding the eye. The wind estimates were above 64 kn (118 km/h).

The 1102 UTC 22 March Soil Moisture Active Passive (SMAP) radiometer pass showed *Charlotte* maintaining peak intensity of above 80 kn (148 km/h) within 15 nm (28 km) of centre. The cloud structures at 1200 UTC 22 March indicated the first signs of a weakening for *Charlotte*. The Dvorak Final-T intensity was estimated at T=5.0, holding the CI at 5.5.

Charlotte continued to weaken from 1200 UTC 22 March as it moved over cooler waters below 27C and into a region of moderate north to north-easterly vertical wind shear. There was a notable increase in lightning strikes near the centre, alluding to the intrusion of dry air.

The increasing shear led to the low-level circulation centre (LLCC) becoming exposed on 23 March. The Special Sensor Microwave Imager (SSMIS) sensor microwave imagery at 1058 UTC 23 March showed the LLCC to be located within 50 nm (93 km) of the deep convection. The ASCAT MetOp-B pass at 1420 UTC 23 March indicated the system was weakening rapidly with absence of storm force winds.

Charlotte was downgraded to a low at 1800 UTC 23 March. The SMAP radiometer pass at 2229 UTC 23 March and SMOS pass at 2305 UTC 23 March, indicating the system no longer contained gales in any of the quadrants.

Figure 8 plot shows the subjective and objective intensity estimates for Severe Tropical Cyclone *Charlotte*. The objective estimates Satellite Consensus (SATCON) and CIMSS Advanced Dvorak Technique (ADT) was not available until 23 March.

2.2 Structure

The gale radius for *Charlotte* ranged between 60 – 90 nm (111 - 167 km) in the northern semicircle to 90 - 110 nm (167 - 203 km) in the south. This asymmetry in the gales were maintained throughout *Charlotte*'s lifetime.

The hurricane force winds were estimated between 10-18 nm (18 - 33 km) during its peak intensity, while the storm force winds ranged between 30 nm and 60 nm (55 - 111 km).

2.3 Motion

Charlotte moved under the influence of a mid-level high for most of its life. The steering influence initially pushed a developing system in a westerly direction and later towards the southwest in the Indian Ocean.

During its peak intensity, the steering influence became southwards oriented because of a stationary upper trough to the southwest. This caused the system to be subjected to increasing shear, hence its rapidly weakening trend between 22-23 March.

As a sheared system, the low then moved southwards once again under the influence of the subtropical ridge, until it weakened below tropical cyclone intensity on 25 March.

3 Impact

Severe Tropical Cyclone *Charlotte* was an oceanic system, remaining well away from Australian mainland and island communities, hence no impact was recorded.

4 Observations

No significant observations of wind, pressure, rainfall or storm surge was recorded for the event over the Australian mainland or over island communities.

5 Forecast Performance

Official tropical cyclone forecasts were issued from 20-24 March. Ocean wind warnings for a tropical cyclone in the Indian Ocean commenced at 0632 UTC 20 March and continued until 0107 UTC 24 March. The tropical cyclone information bulletin commenced 0048 UTC 21 March and was cancelled at 0138 UTC 24 March when there was confidence that the system had weakened below tropical cyclone intensity. The system continued to produce gales, in one or two quadrants, once again from 1200 UTC 25 March but it was no longer categorised as a tropical system by this time. There were no tropical cyclone advices issued for the Australian mainland or Islands.

The accuracy figures for Severe Tropical Cyclone *Charlotte* below and in Figure 9. The intensity forecast errors were consistently increasing from 2.5 kn (5 km/h) at 00 hours to 18.9 kn (35 km/h) at 48 hours. The intensity errors were a consequence of the forecasts being biased to the model guidance not being able to capture the depth of a rapidly developing and weakening system. The forecast intensity errors were better than the five-year average between the 72-96 hour forecast range.

The track position errors were slightly above the five-average in the first 36 hours of the forecast, however the position errors increased significantly between the 48-96 hour forecast range. The large positional errors in the 48-96 hours forecast range were due to the subtle steering influences on the 23-24 March where the system steering influence shifted from the subtropical ridge to the effect of the north-westerly flow ahead of an upper trough.

The accuracy statistics obtained by comparing the forecast positions and the intensities against the best track for *Charlotte* are

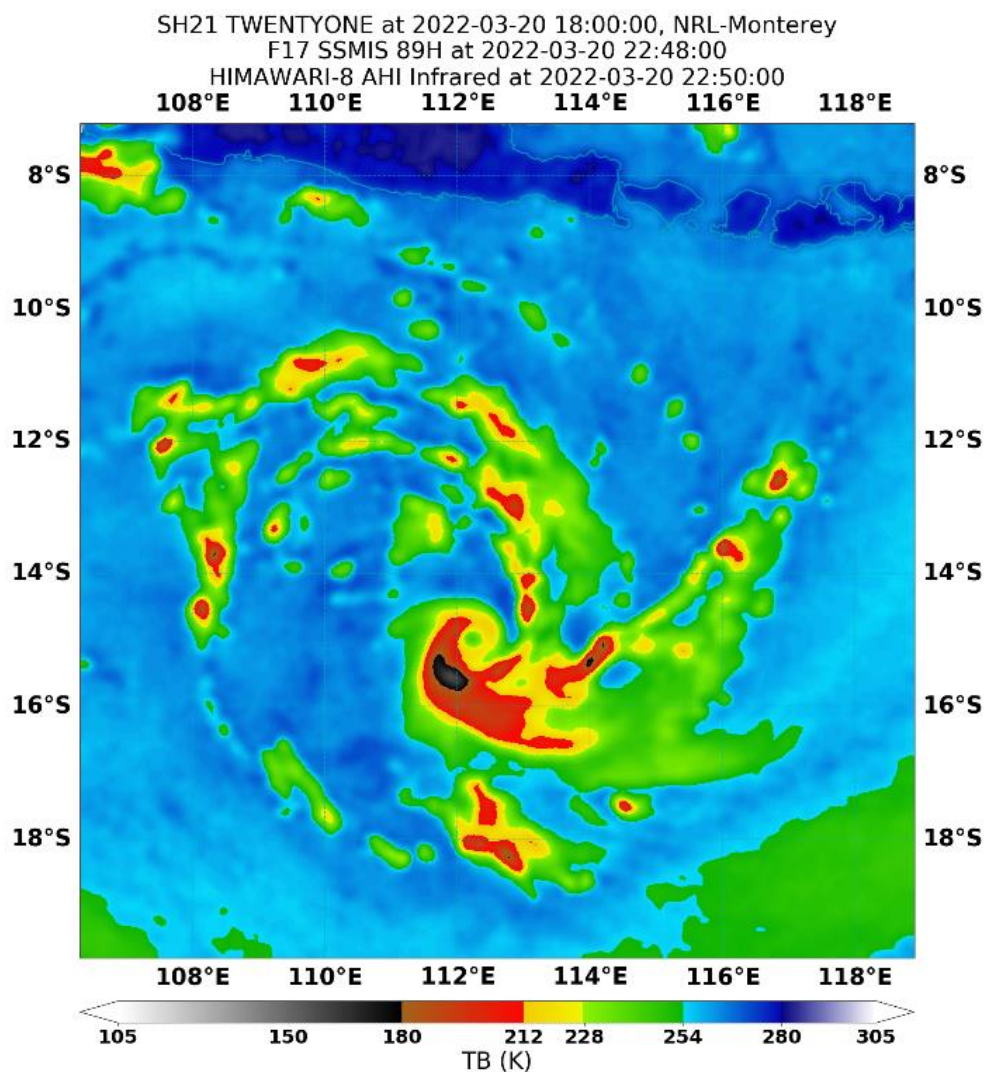
	00	06	12	18	24	36	48	72	96	120
Position Absolute error (km)	38	55	68	79	90	120	157	276	385	-
Intensity Absolute Error (kn)	2.5	5.9	9.1	11.9	13.8	19.3	18.9	9.4	5.0	-
Sample Size	16	16	16	16	16	15	13	9	5	-

TABLE 1. Best track summary for Severe Tropical Cyclone *Charlotte*

Refer to the Australian Tropical Cyclone database for complete listing of parameters. Note: AWST is UTC - 8 hours. * not at tropical cyclone intensity.

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
2022	3	18	1800	11.1	118.9	45	20	45	1008	0/0/0/0	0/0/0/0	-
2022	3	19	0000	11.2	118.1	35	20	45	1007	0/0/0/0	0/0/0/0	-
2022	3	19	0600	11.2	117.5	30	25	45	1002	0/0/0/0	0/0/0/0	-
2022	3	19	1200	11.4	116.9	25	25	45	1003	0/0/0/0	0/0/0/0	-
2022	3	19	1800	11.5	116.0	35	30	45	1001	0/0/0/0	0/0/0/0	-
2022	3	20	0000	11.9	115.1	30	35*	50	1001	0/60/0/0	0/0/0/0	-
2022	3	20	0600	12.5	114.5	25	35*	50	1000	0/60/0/0	0/0/0/0	-
2022	3	20	1200	13.0	113.8	25	40*	55	997	0/60/60/0	0/0/0/0	-
2022	3	20	1800	14.0	113.4	20	45	65	995	60/60/60/0	0/0/0/0	25
2022	3	21	0000	14.9	112.1	20	50	70	992	70/80/80/0	0/40/40/0	20
2022	3	21	0600	15.3	111.1	10	50	70	991	50/100/90/30	0/50/50/0	15
2022	3	21	1200	16.0	110.4	15	55	75	988	50/100/90/30	20/50/50/25	15
2022	3	21	1800	16.4	110.0	15	65	90	979	70/110/90/60	30/50/50/30	10
2022	3	21	2100	16.5	109.6	8	90	125	957	70/110/90/60	30/50/50/30	8
2022	3	22	0000	16.6	109.3	10	90	125	957	70/110/90/60	30/50/50/30	8
2022	3	22	0600	17.1	109.1	10	90	125	957	60/100/90/60	30/40/40/30	8
2022	3	22	1200	17.6	109.0	10	90	125	956	60/100/90/60	30/40/40/30	8
2022	3	22	1800	17.8	108.9	20	80	110	965	60/100/90/60	30/30/30/30	8
2022	3	23	0000	18.5	108.8	15	70	100	973	60/100/90/60	20/30/30/20	8
2022	3	23	0600	19.0	108.4	30	65	90	977	60/100/90/50	20/30/30/20	8
2022	3	23	1200	19.2	108.1	30	55	75	983	60/100/90/50	20/30/30/20	15
2022	3	23	1800	19.3	107.6	20	30	45	1001	0/0/0/0	0/0/0/0	-
2022	3	24	0000	19.8	107.3	25	30	45	1001	0/0/0/0	0/0/0/0	-
2022	3	24	0600	21.0	107.3	20	30	45	1002	0/0/0/0	0/0/0/0	-
2022	3	24	1200	22.0	107.0	35	30	45	1002	0/0/0/0	0/0/0/0	-
2022	3	24	1800	24.1	106.8	30	30	45	1002	0/0/0/0	0/0/0/0	-
2022	3	25	0000	25.0	107.0	25	30	45	1002	0/0/0/0	0/0/0/0	-
2022	3	25	0600	27.5	107.8	25	30	45	1002	0/0/0/0	0/0/0/0	-

FIGURE 2. F17 SSMIS 89 GHz microwave pass at 2248 UTC 20 March showing deep convection wrapping around the centre, 4 hours after it was



named Tropical Cyclone *Charlotte*

FIGURE 3. SMAP pass at 2214 UTC 20 March showing 50 knots in the southeast quadrant, 4 hours after *Charlotte* was named

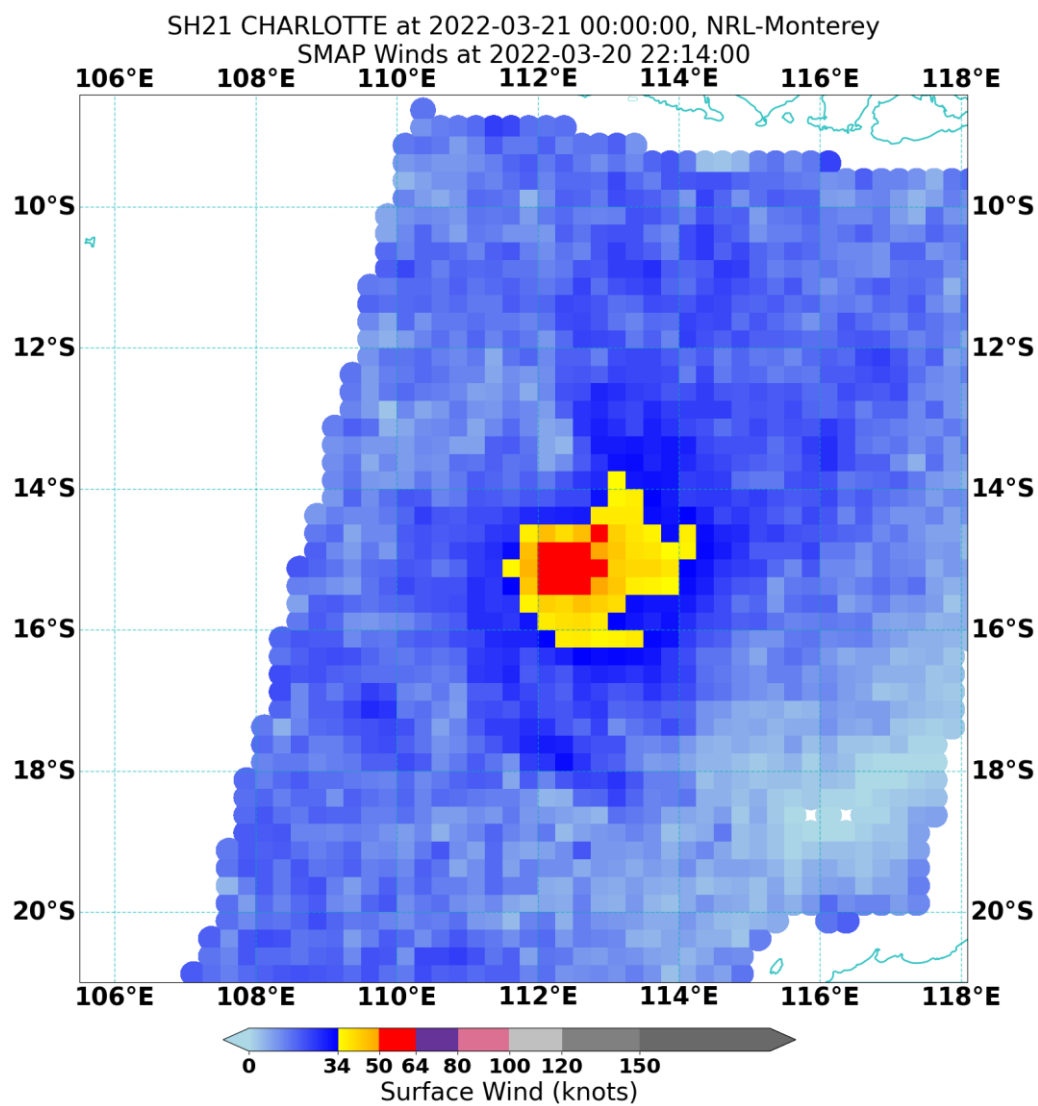


FIGURE 4. GMI 89 GHz microwave pass at 1250 UTC 22 March Severe Tropical Cyclone *Charlotte*. Dvorak intensity estimated at T4.0.

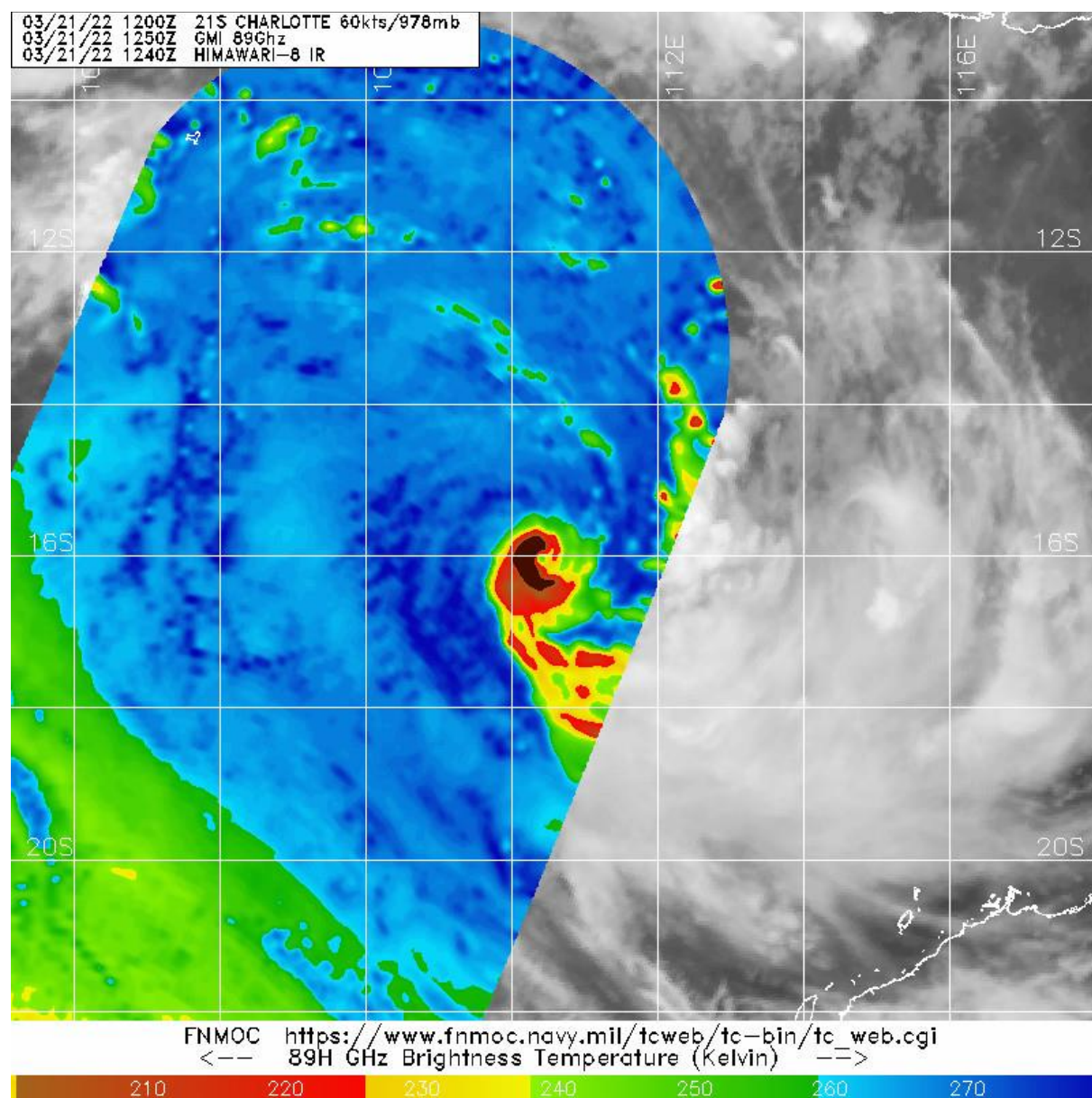


FIGURE 5. SMOS pass at 2244 UTC 21 March indicating winds greater than 64 knots around the centre. The centre is marked with an x.

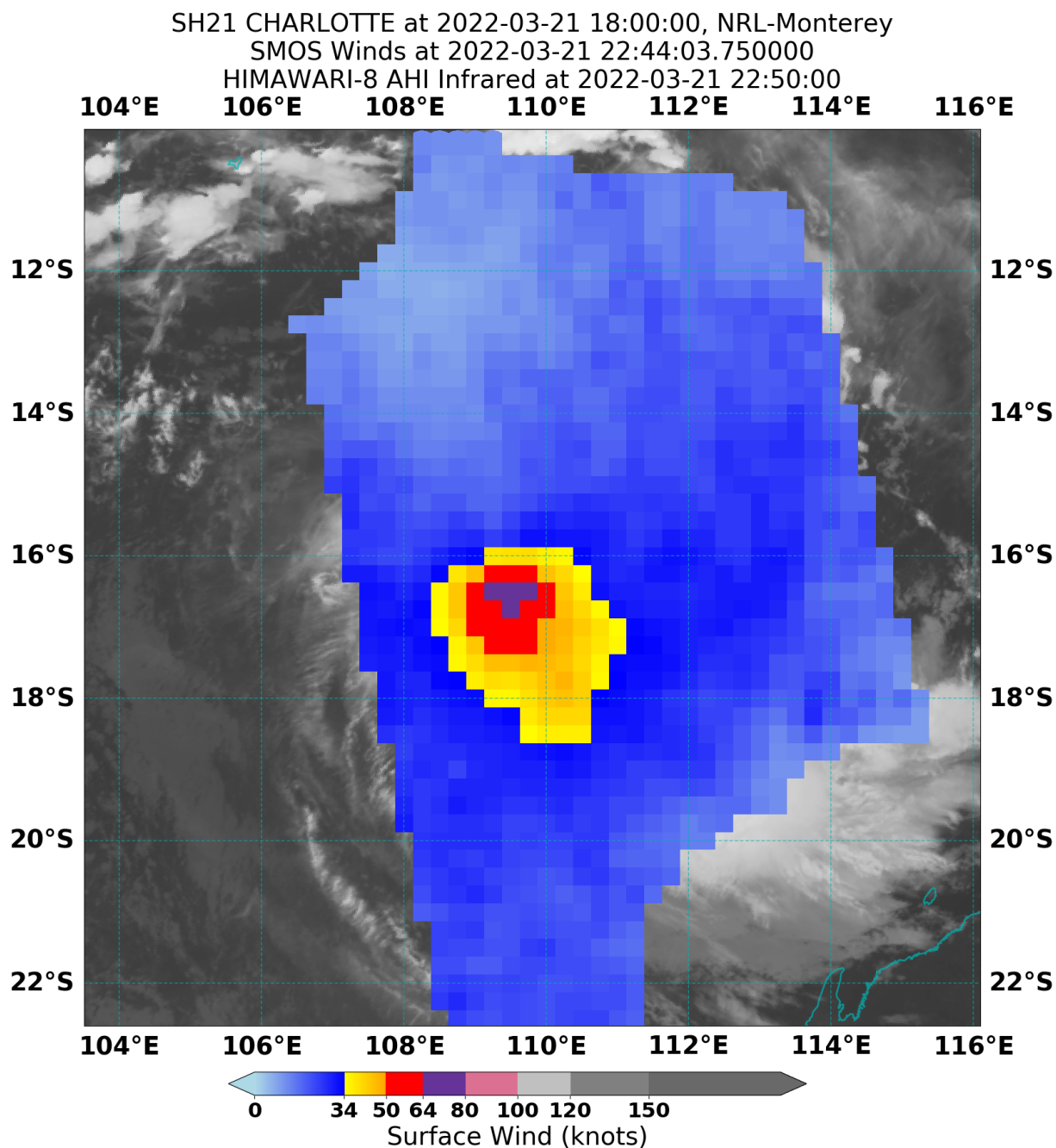


FIGURE 6. Himawari satellite images between 1800 UTC 21 March and 0230 UTC 22 March during the time of *Charlotte's* peak intensity

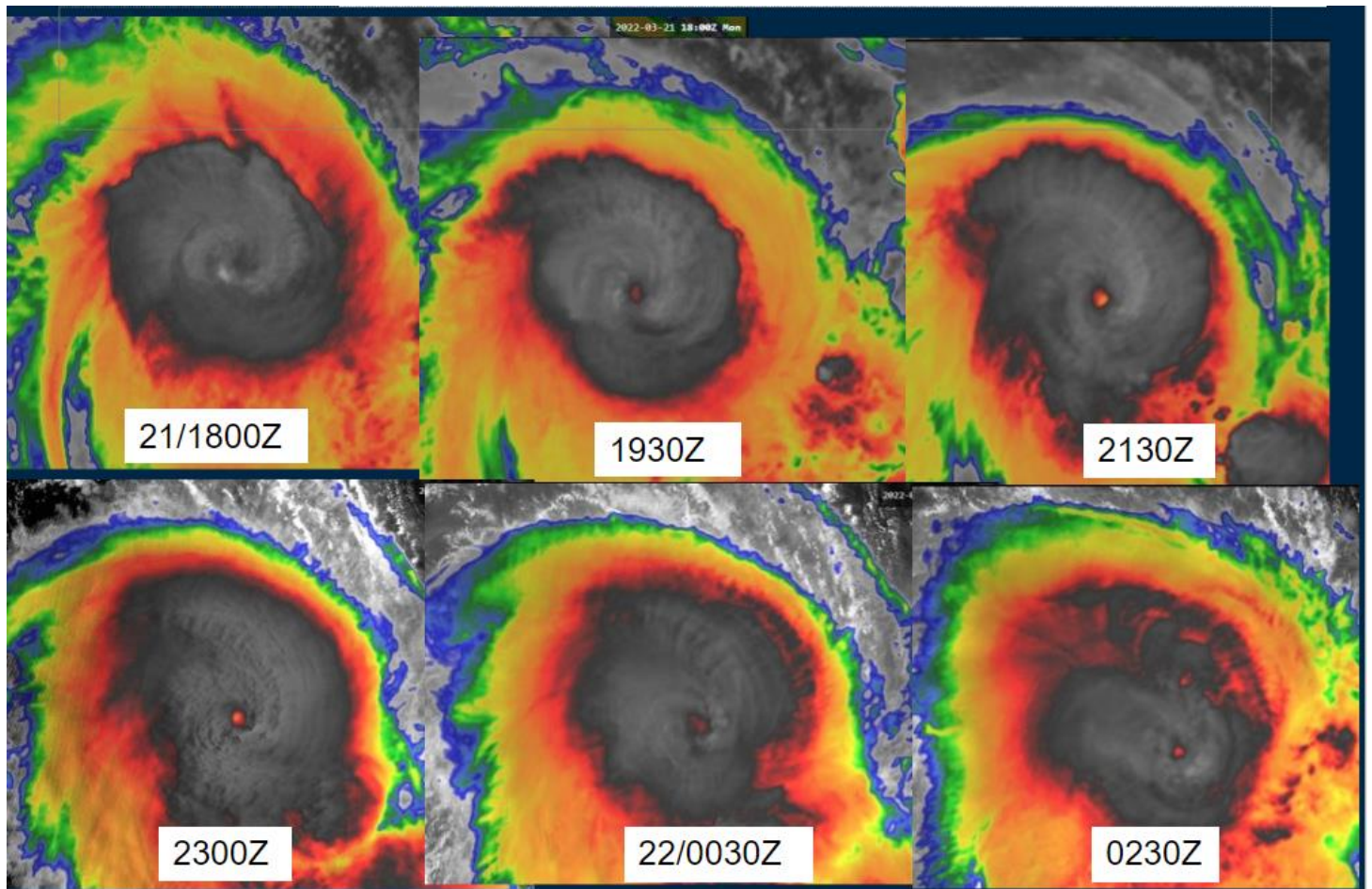


FIGURE 7. SMAP pass at 1102 UTC 21 March indicating Severe Tropical Cyclone *Charlotte* nearing peak intensity.

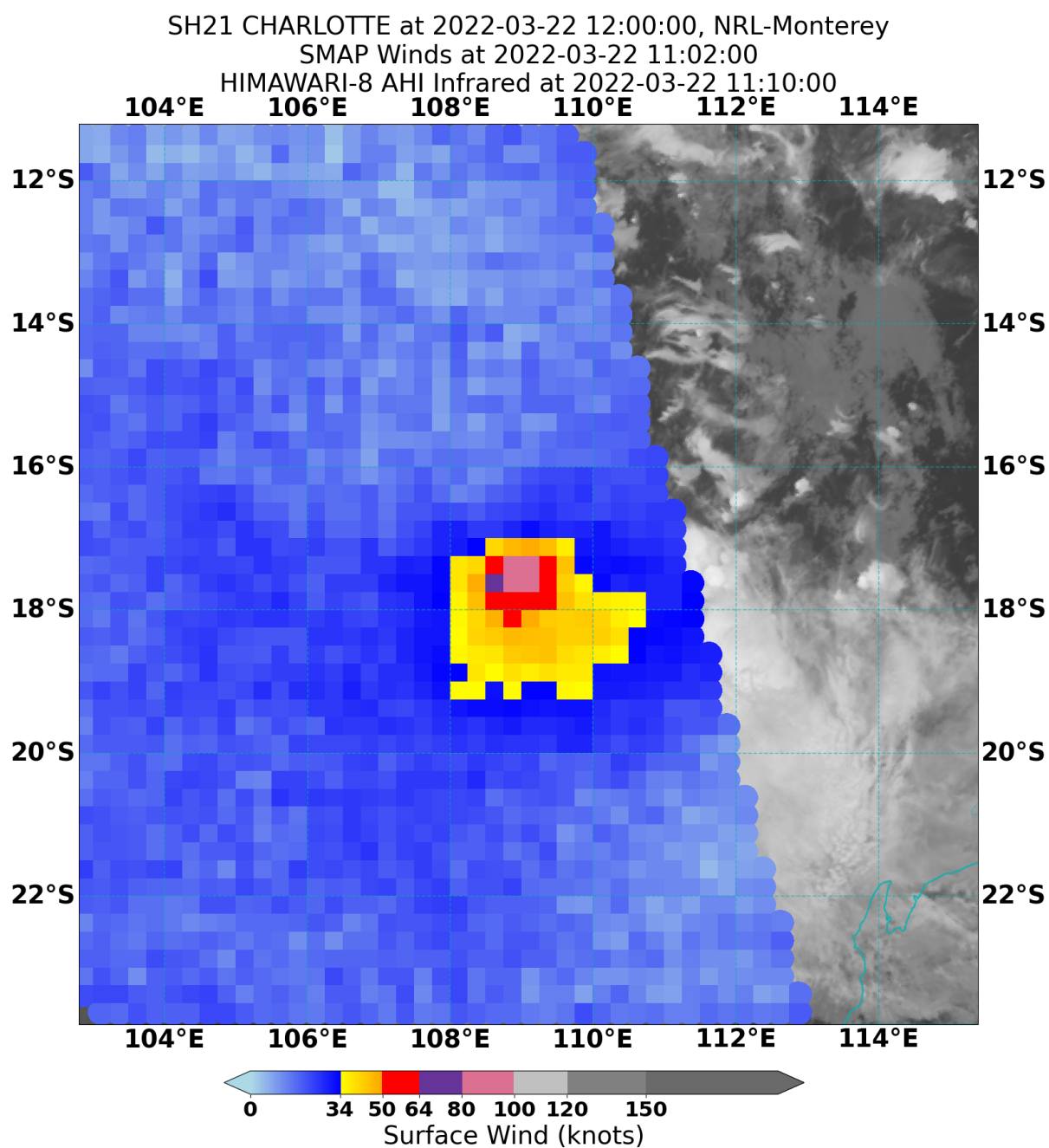


FIGURE 8. Plot of objective and subjective intensity estimates for Severe Tropical Cyclone *Charlotte*.

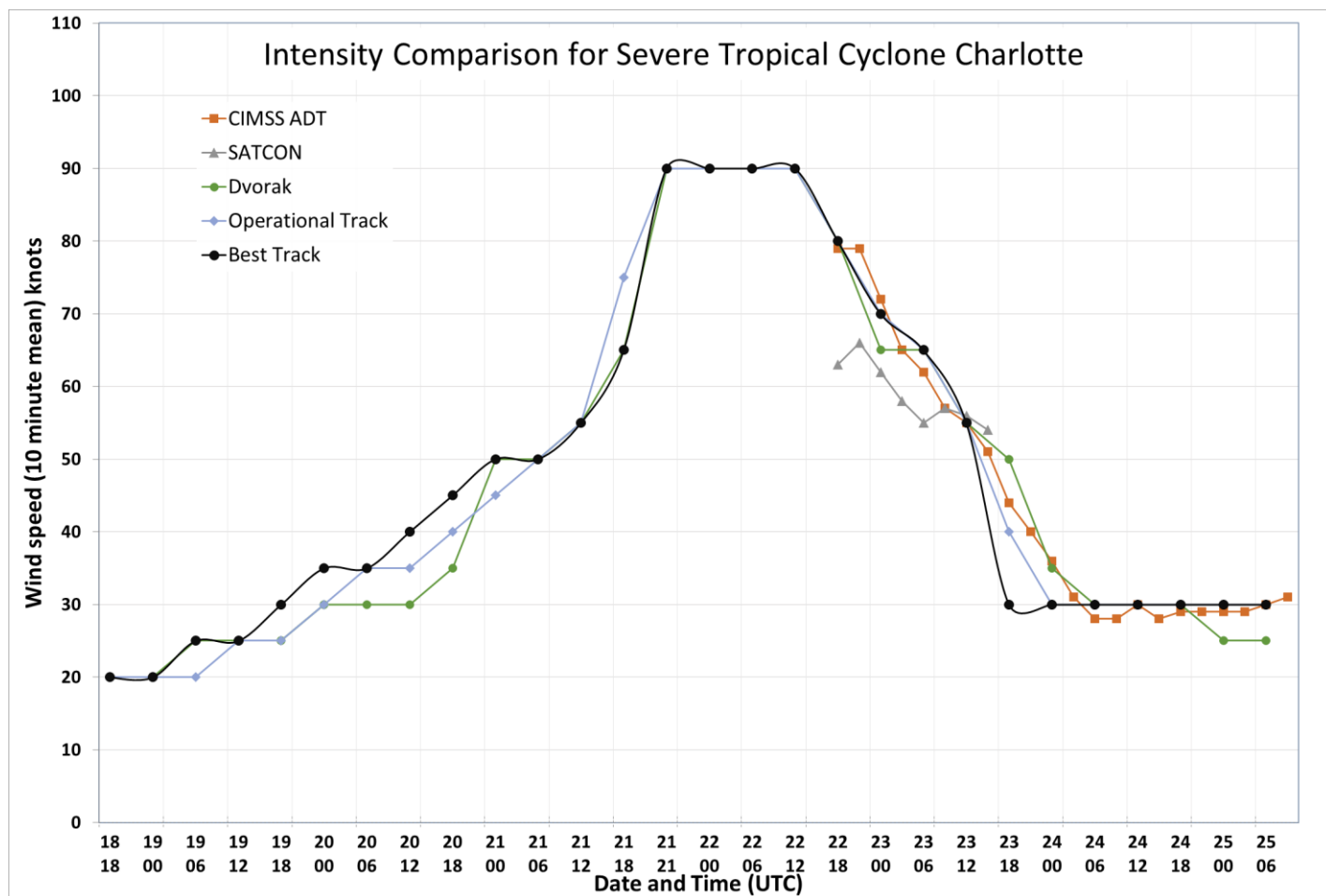


FIGURE 9 a. Position accuracy figures for Severe Tropical Cyclone *Charlotte*

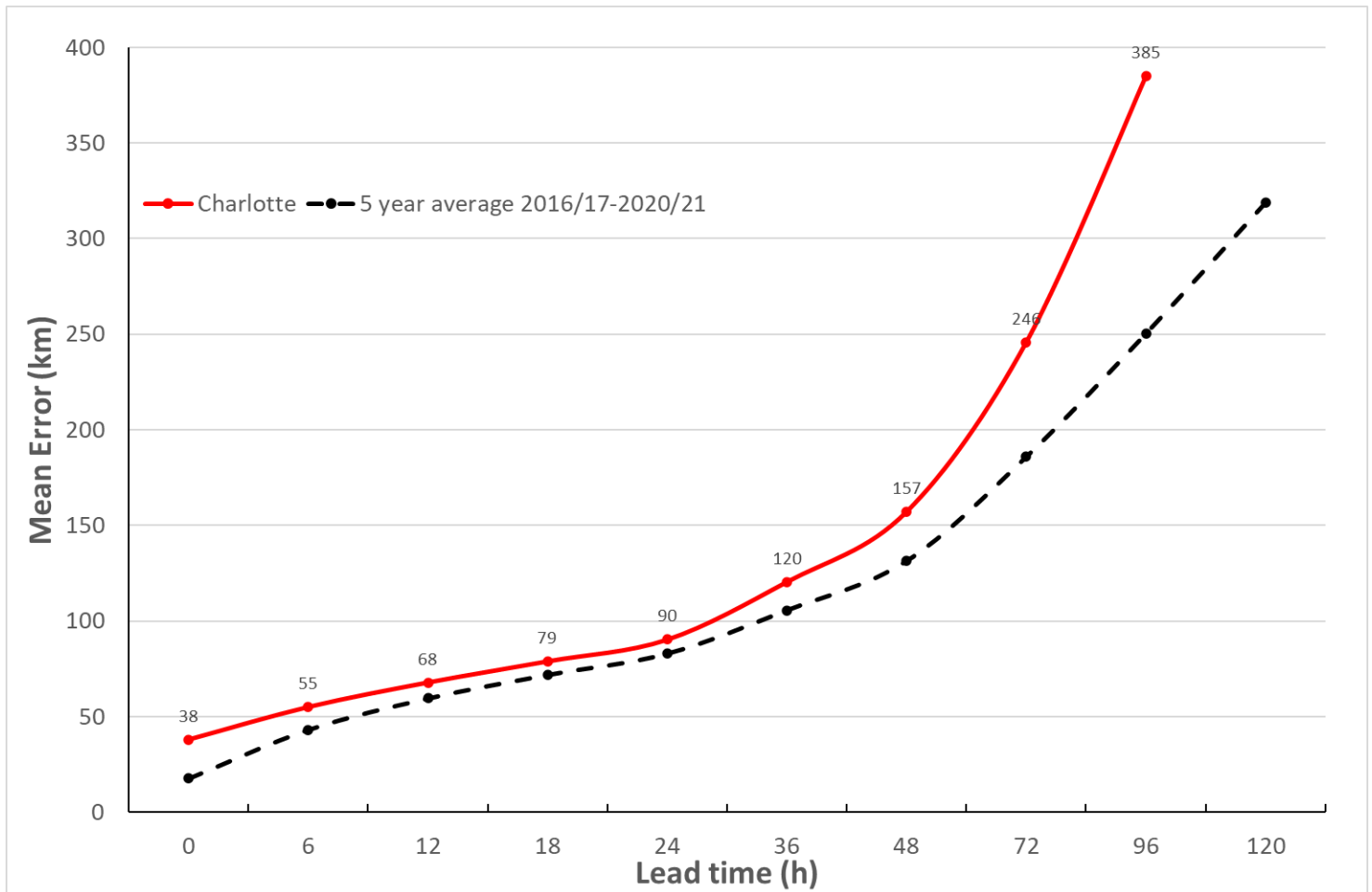


FIGURE 9 b. Intensity accuracy figures for Severe Tropical Cyclone *Charlotte*

