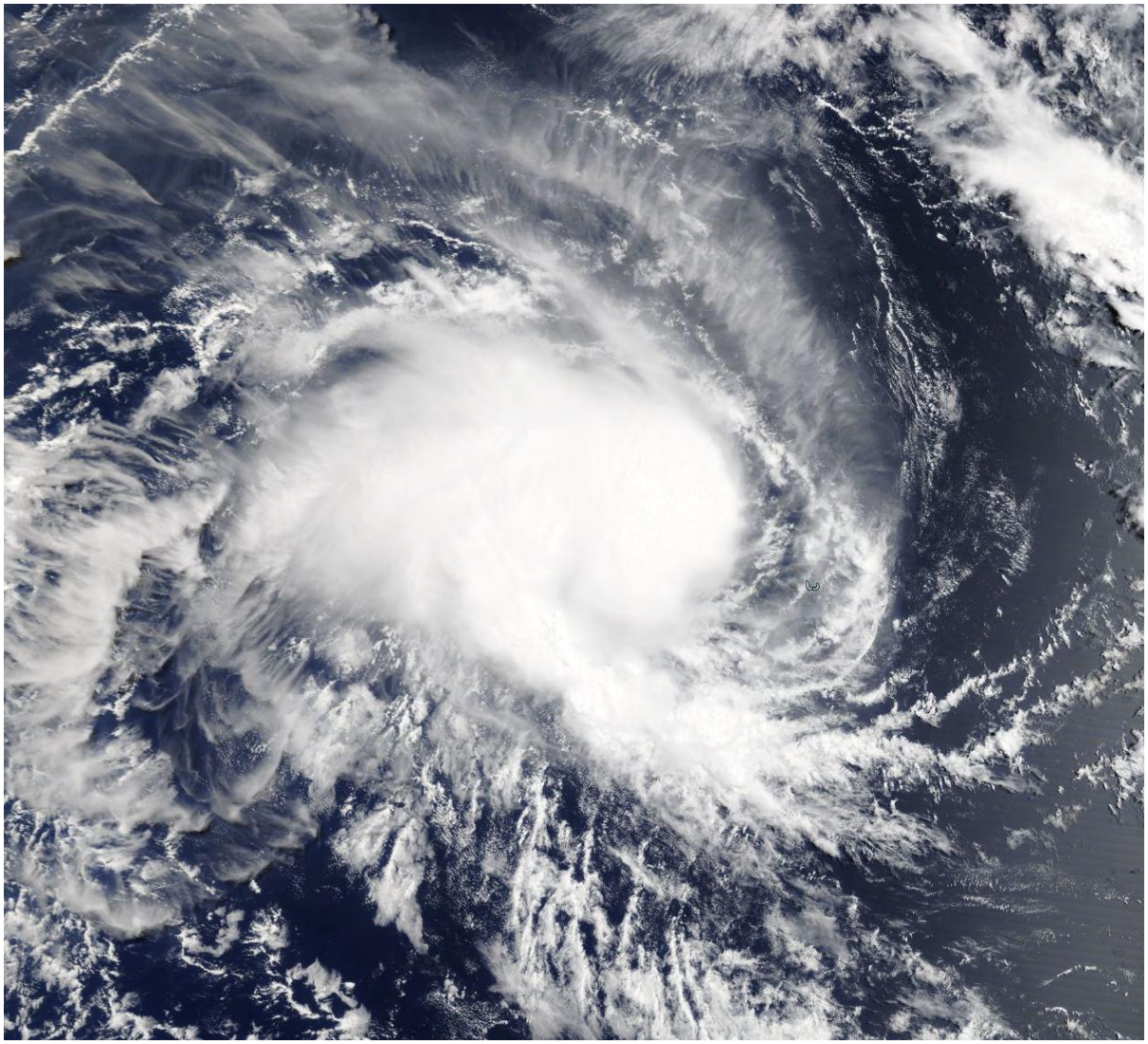
The Bureau of Meteorology

Severe Tropical Cyclone Savannah

8 March 2019 – 18 March 2019

Craig Earl-Spurr, Tropical Cyclone Environmental Prediction Services



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Cover image: Severe Tropical Cyclone Savannah passing near Cocos (Keeling) Islands. Source NASA Worldview

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1. Summary

A tropical low formed on 8 March within the monsoon trough to the north of Western Australia. For the next five days the low moved generally westward but failed to develop significantly due to the sustained influence of easterly vertical wind shear. The low then turned sharply towards the southwest on 13 March as a mid-latitude trough approached. As it moved southwest the low strengthened and Tropical Cyclone Advices were issued for the Cocos (Keeling) Islands commencing at 0648 UTC 13 March (1318 CCT 13 March, CCT = UTC +6.5). Following further intensification, the low became Tropical Cyclone Savannah during the afternoon of 14 March when it was about 130 kilometres north-northwest of the Cocos (Keeling) Islands.

Strong to gale force winds were experienced on the islands as Savannah passed to the west with a peak gust of 43 kn (80 km/h) recorded at 2135 UTC 13 March. Vegetation damage and minor property damage were reported.

Tropical Cyclone Advices were cancelled at 0647 UTC 14 March when Savannah was 140 kilometres to the west of the Cocos (Keeling) Islands. As it continued moving southwest, Savannah intensified into a category 2 system early on the 15th of March and then into a category 3 severe tropical cyclone early on the 16th of March whilst maintaining a general southwest track.

On the 16th and 17th of March, Savannah tracked more towards the west southwest and developed further into a category 4 severe tropical cyclone during the 17th of March. It reached a peak intensity at 0600 UTC 17 March with 10-minute mean winds of 95 kn (175 km/h). Savannah then weakened back into a category 3 severe tropical cyclone shortly prior to crossing into La Reunion's area of responsibility (west of 90E) early on the 18th of March. Refer to Figure 1 for Savannah's track and Table 1 for tabulated parameter estimates.

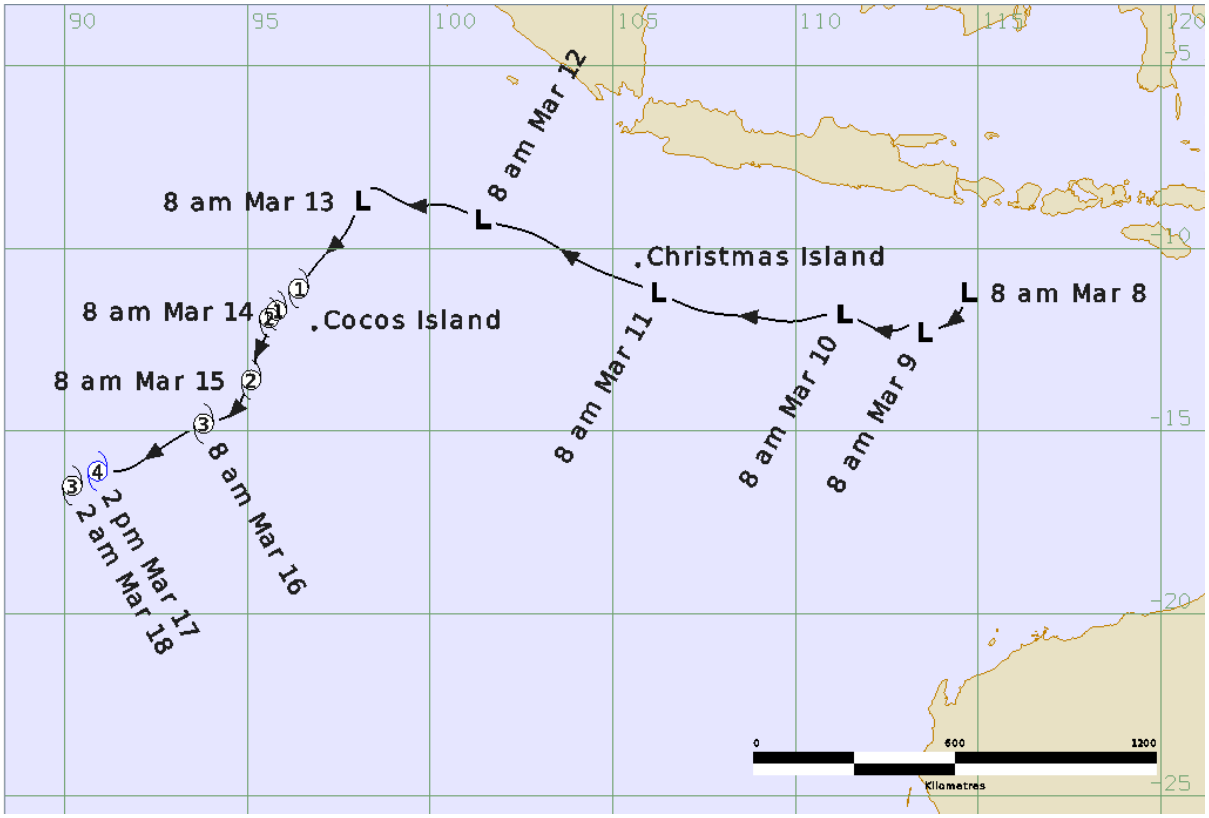

Figure 1 Best Track of Severe Tropical Cyclone Savannah (times in AWST, UTC +8).

Table 1 Best track summary for Severe Tropical Cyclone Savannah 8-18 March 2019

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
2019	3	8	0000	11.2	114.7	30	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	8	0600	12.0	114.3	30	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	8	1200	12.2	113.9	60	25	45	1007	0/0/0/0	0/0/0/0	-
2019	3	8	1800	12.3	113.7	30	30	45	1004	0/0/0/0	0/0/0/0	-
2019	3	9	0000	12.3	113.5	30	30	45	1004	0/0/0/0	0/0/0/0	-
2019	3	9	0600	12.1	113.3	15	25	45	1006	0/0/0/0	0/0/0/0	-
2019	3	9	1200	12.2	112.9	45	25	45	1007	0/0/0/0	0/0/0/0	-
2019	3	9	1800	12.2	112.2	30	20	45	1010	0/0/0/0	0/0/0/0	-
2019	3	10	0000	11.8	111.3	15	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	10	0600	12.0	110.0	30	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	10	1200	11.9	109.0	60	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	10	1800	11.7	107.4	45	25	45	1009	0/0/0/0	0/0/0/0	-
2019	3	11	0000	11.2	106.2	30	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	11	0600	10.8	105.1	45	20	45	1010	0/0/0/0	0/0/0/0	-
2019	3	11	1200	10.3	104.0	45	20	45	1010	0/0/0/0	0/0/0/0	-
2019	3	11	1800	9.6	102.8	60	20	45	1011	0/0/0/0	0/0/0/0	-
2019	3	12	0000	9.2	101.4	45	20	45	1011	0/0/0/0	0/0/0/0	-
2019	3	12	0600	8.8	100.3	45	20	45	1010	0/0/0/0	0/0/0/0	-
2019	3	12	1200	8.8	99.4	60	20	45	1010	0/0/0/0	0/0/0/0	-
2019	3	12	1800	8.4	98.3	45	25	45	1008	0/0/0/0	0/0/0/0	-
2019	3	13	0000	8.7	98.1	30	30	45	1004	0/0/0/0	0/0/0/0	-
2019	3	13	0600	9.7	97.6	15	30	45	1006	0/0/0/0	0/0/0/0	-
2019	3	13	1200	10.2	97.1	45	30	45	1005	0/0/0/0	0/0/0/0	-
2019	3	13	1800	11.1	96.4	45	40	55	1001	0/45/60/45	0/0/0/0	15
2019	3	14	0000	11.7	95.8	30	45	65	997	0/45/60/45	0/0/0/0	15
2019	3	14	0600	11.9	95.6	45	50	70	991	0/45/60/45	0/0/30/0	15
2019	3	14	1200	12.4	95.5	45	50	70	992	45/45/60/45	0/30/30/0	15
2019	3	14	1800	12.8	95.3	45	55	75	987	45/45/60/45	0/30/30/0	10
2019	3	15	0000	13.6	95.1	30	55	75	988	45/45/60/45	20/30/30/20	10
2019	3	15	0600	14.0	94.9	20	65	90	980	45/60/60/45	20/30/30/20	10
2019	3	15	1200	14.4	94.7	20	65	90	980	45/60/60/45	20/30/30/20	10
2019	3	15	1800	14.7	94.2	30	65	90	980	45/60/60/45	20/30/30/20	10
2019	3	16	0000	14.8	93.8	15	70	100	976	45/60/60/45	20/30/30/20	10
2019	3	16	0600	15.0	93.4	15	70	100	976	45/60/60/45	20/30/30/20	10
2019	3	16	1200	15.3	92.9	15	80	110	968	45/60/60/45	20/30/30/20	10
2019	3	16	1800	15.7	92.3	15	85	120	964	45/60/60/45	20/30/30/20	10
2019	3	17	0000	16.1	91.4	15	90	125	960	45/60/60/45	20/30/30/20	10
2019	3	17	0600	16.1	90.9	10	95	135	953	60/60/75/45	20/30/30/20	10
2019	3	17	1200	16.3	90.6	30	90	125	957	60/60/75/45	20/30/30/20	10
2019	3	17	1800	16.5	90.2	30	80	110	967	45/75/75/45	20/30/30/20	10

Refer to the Australian Tropical Cyclone database for complete listing of parameters. UTC=WST-8h.

2. Meteorological description

2.1. Intensity analysis

A moderately strong pulse of the Madden-Julian Oscillation moved through the Indian Ocean in early March before quickly weakening as it reached Australian longitudes. An area of enhanced convection became evident on satellite imagery but was clearly under the influence of moderate to strong vertical wind shear with deep convection displaced to the west of the low-level centre. During 11 and 12 March the low-level circulation became completely void of deep convection at times. During 13 March the vertical wind shear eased as a mid-level trough approached from the southwest. Deep convection became better aligned with the low-level centre (refer Figure 2) as the system strengthened and it reached tropical cyclone intensity early on the morning of 14 March.

Savannah continued strengthening as deep convection began to completely obscure the low-level circulation and the system reached category 2 intensity at 0600 UTC 14 March. As Savannah continued strengthening it became a category 3 severe tropical cyclone at 0600 UTC 15 March and an eye became visible on microwave imagery (refer Figure 3).

Over the following 24 hours, Savannah maintained a relatively steady intensity before strengthening further during the evening of 16 March as a pinhole eye became evident and persisted into 17 March (refer Figure 4). At 0000 UTC 17 March Savannah reached category 4 strength, peaking at an intensity of 95 kn (175 km/h) at 0600 UTC 17 March. Beyond this time the eye was no longer evident, and Savannah weakened marginally, back to a category 3 tropical cyclone at 1800 UTC 17 March shortly before moving out of the Australian region.

Objective intensity guidance generally performed well providing relatively consistent and realistic estimates (refer Figure 5).

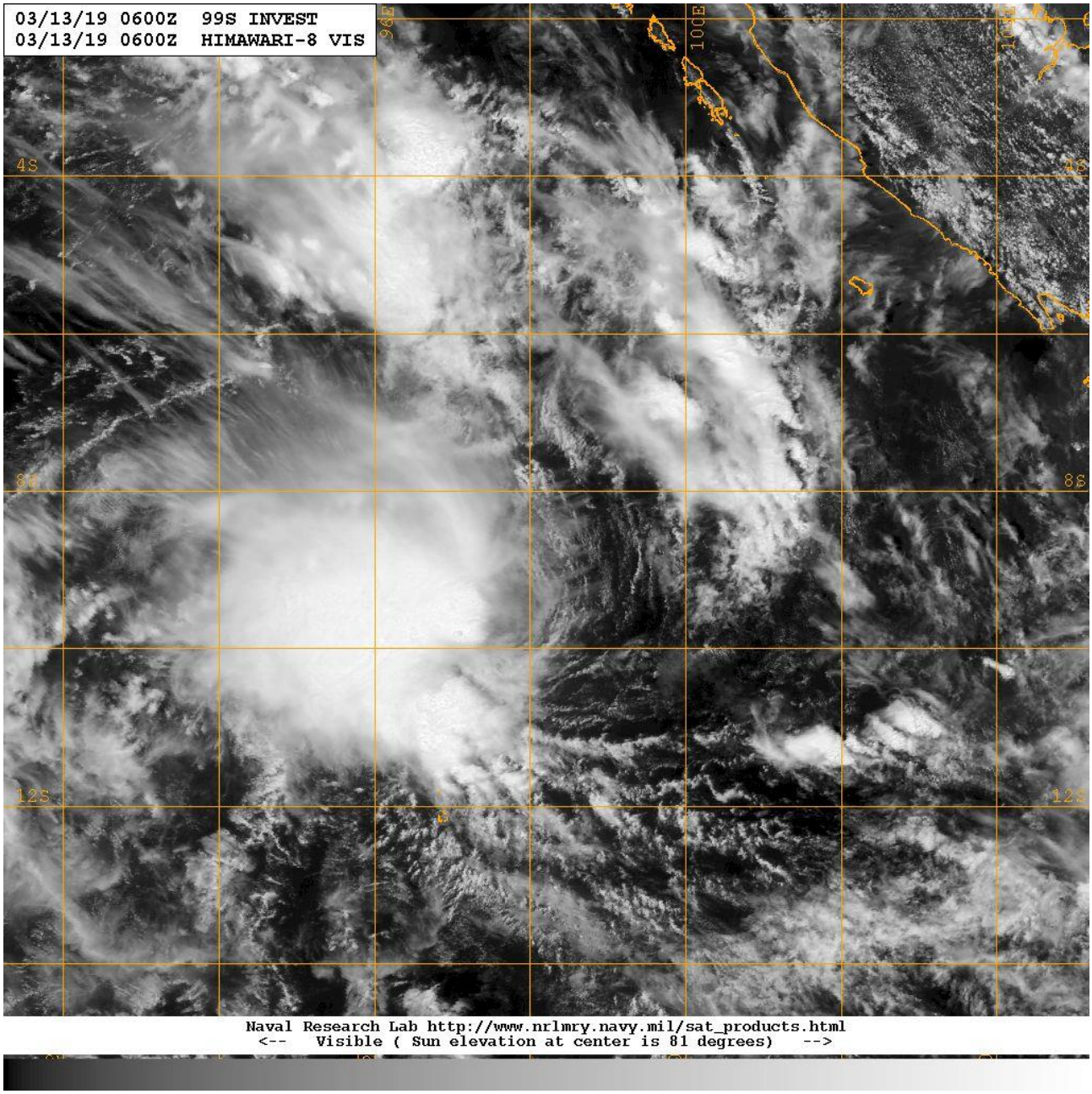

Figure 2 Himawari-8 visible channel satellite image at 0600 UTC 13 March, showing deep convection to the west of, and partially covering, the low-level circulation. Images courtesy JMA and NRL: https://www.nrlmry.navy.mil/TC.html

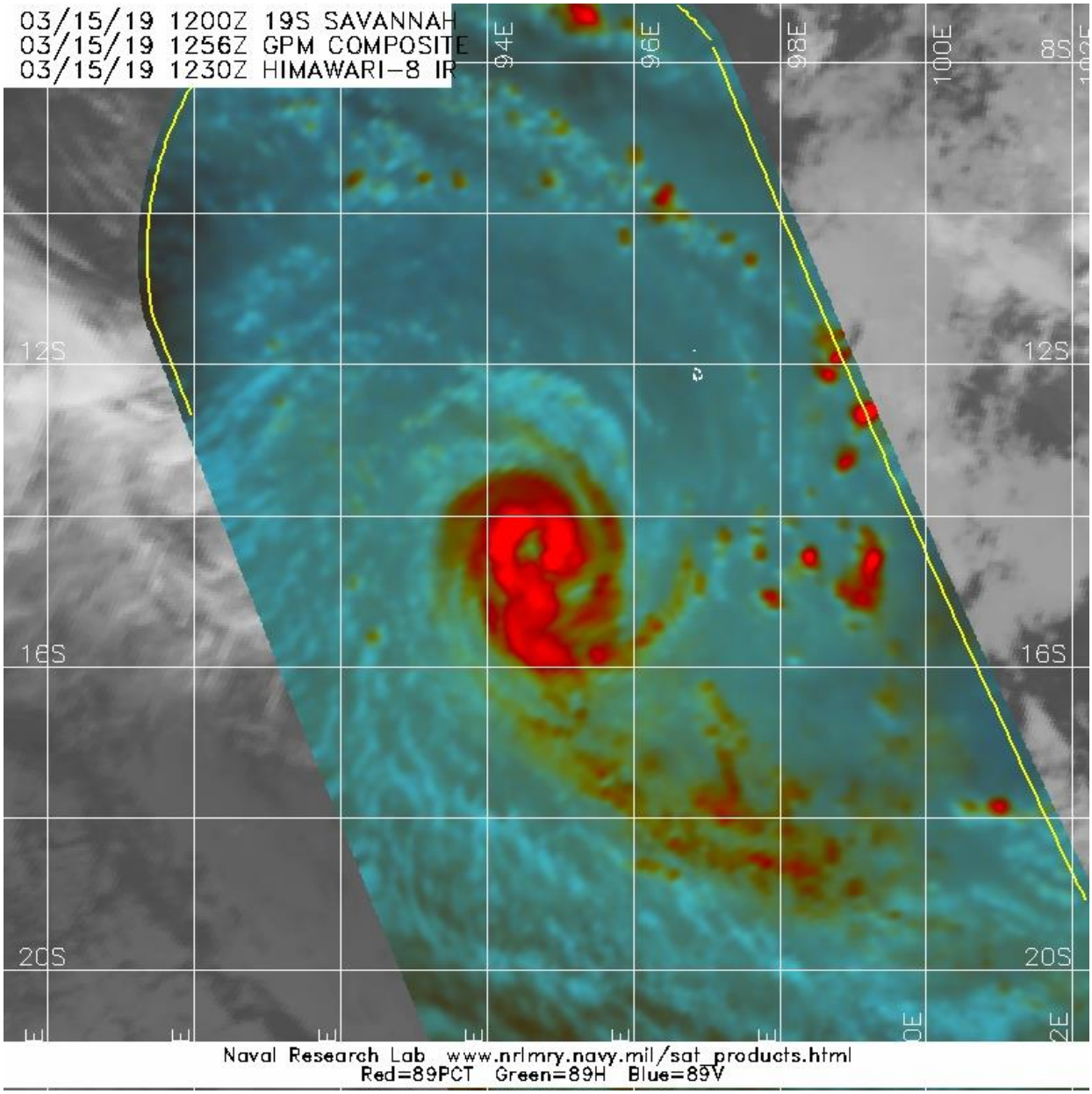

Figure 3 Global Precipitation Measurement Microwave Imager (GMI) colour composite 89 GHz microwave pass at 1256 UTC 15 March showing an eye. Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

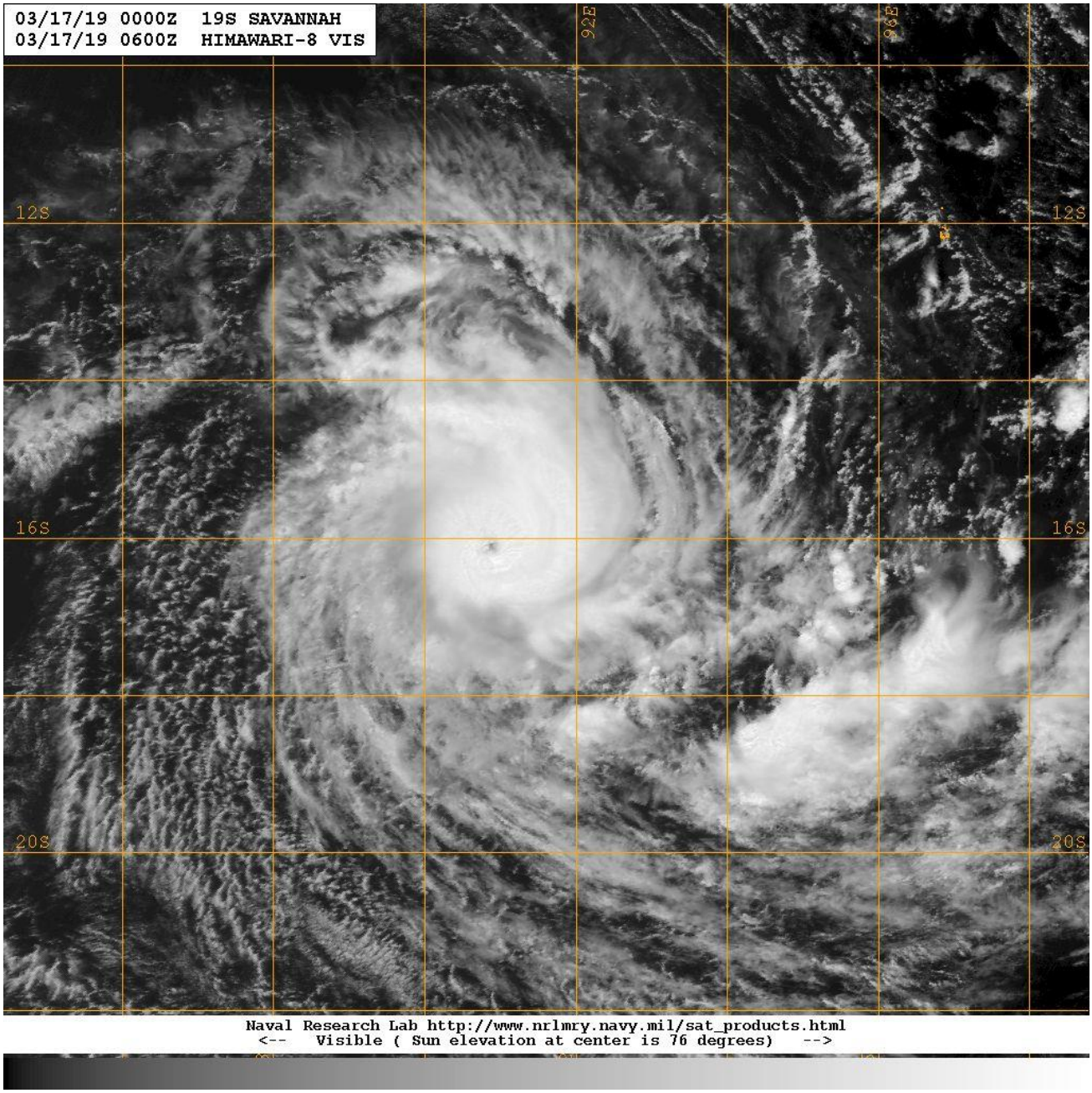

Figure 4 Himawari-8 visible channel satellite image at 0600 UTC 17 March, showing a pinhole eye. Images courtesy JMA and NRL: https://www.nrlmry.navy.mil/TC.html.

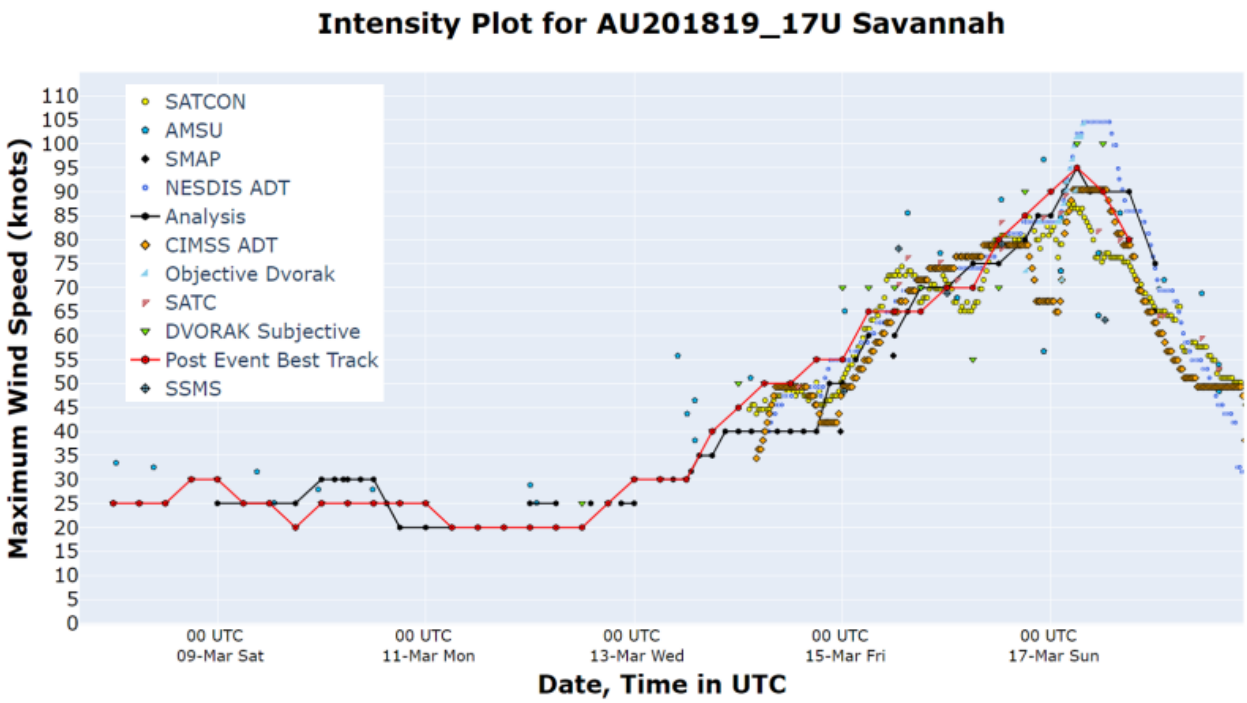

Figure 5 Intensity plot of objective and subjective guidance. SATCON, CIMSS ADT, NEDIS ADT, AMSU, SATC, CIMSS ADT, and Objective Dvorak have been adjusted from 1-minute to 10-minute mean winds.

2.2. Structure

Throughout its lifetime Savannah had a radius to gales smaller than the climatological average. Initially this was 45 nm (75 km), extending to 60 nm (110 km) in the southwest quadrant. It then increased to 60 nm (110 km) in the southeast quadrant on 15 March and to 75 nm (140 km) through the southern semicircle from 17 March. The radius of maximum winds was initially 15 nm (30 km) but decreased to 10 nm (20 km) as Savannah strengthened into a category 2 tropical cyclone.

Radius to storm force winds was 20 to 30 nm (35 to 55 km) and radius to hurricane force winds was 15 nm (30 km), both also below the climatological average.

2.3. Motion

In the days prior to reaching tropical cyclone strength, Savannah was steered west to northwest, passing close to Christmas Island, under the influence of a mid-level ridge to the south. A mid-latitude trough passing to the south on 13 and 14 March caused Savannah to take an abrupt turn towards the south-southwest and past the Cocos (Keeling) Islands. This track then returned to a more westward track from 16 March after the trough had passed and a new, albeit weaker mid-level ridge became the dominant steering influence.

3. Impact

Strong to gale force winds were experienced on the Cocos (Keeling) Islands early on the morning of 14 March as Savannah passed to the west. Vegetation damage and minor property damage were reported.

4. Observations

Gale force winds were recorded at Cocos Island Airport AWS for a brief period between 1928 – 1935 UTC 13 March. The peak 10-minute mean wind recorded was 35 kn (65 km/h) at 1934 UTC 13 March. The peak 3-second wind gust recorded was 43 kn (80 km/h) at 2135 UTC 13 March.

A minimum Mean Sea Level Pressure of 1003.9 hPa was recorded at Cocos Island Airport AWS at 2114 UTC 13 March.

5. Forecast Performance

Tropical Cyclone Watches, for gales expected within 48 hours but not within 24 hours, were not issued for this event. Rather, the first Tropical Cyclone Advice was issued as a Warning for the Cocos (Keeling) Islands at 0648 UTC 13 March with the expectation of gales impacting the islands within 24 hours. The lack of a Watch was due to the initial expectation that the tropical low wouldn't strengthen into a tropical cyclone as it passed near the islands.

Gale force winds first developed at the Cocos Island Airport Automatic Weather Station at 1928 UTC 13 March, little more than 12 hours after the first Warning.

Tropical Cyclone Advices were cancelled at 0647 UTC 14 March when Savannah was 140 km to the west of the Cocos (Keeling) Islands.

Table 2 contains a summary of forecast errors compared to the 5-year average. The position and intensity errors can also be seen in Figure 6 and Figure 7 respectively. The number of samples drops off in the longer term due to a relatively short period of official forecasts being issued prior to Savannah moving out of the region. The number of samples drops below 10 at 72 hours and below 6 thereafter. For this reason statistics have not been included beyond 72 hours.

Forecast track position errors for Savannah were very similar to the 5-year average. Intensity errors were similar to the 5-year average for the first 36 hours of forecasts but then increased significantly beyond that. This is mostly due to early official forecasts failing to capture the peak intensity of Savannah but also coincides with a smaller dataset to verify against due to Savannah moving out of the region.

Table 2 Forecast position and intensity errors for Severe Tropical Cyclone Savannah compared to the 5-year average.

	0	6	12	18	24	36	48	72
Position Mean Absolute Error (km)	26	42	59	71	81	100	127	216
5 year average 2014/15-2018/19	18	44	59	74	85	111	135	187
Intensity Mean Absolute Error (kn)	4.7	6.4	7.9	8.8	9.3	14.2	18.6	30.0
5 year average 2014/15-2018/19	3.5	6.1	7.8	9.2	10.2	12.4	14.5	17.3
Sample Size	18	18	17	16	15	13	11	7

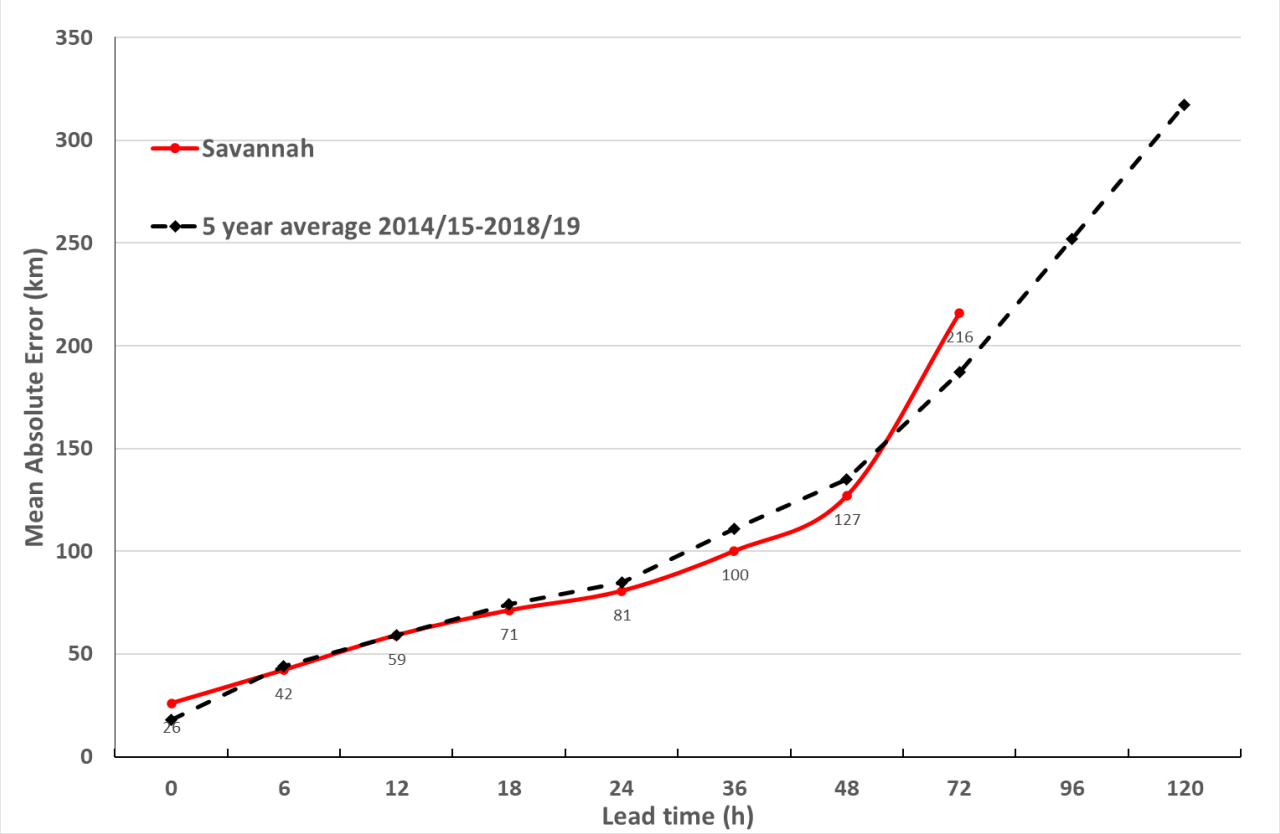

Figure 6 Forecast position errors for Severe Tropical Cyclone Savannah compared to the 5-year average.

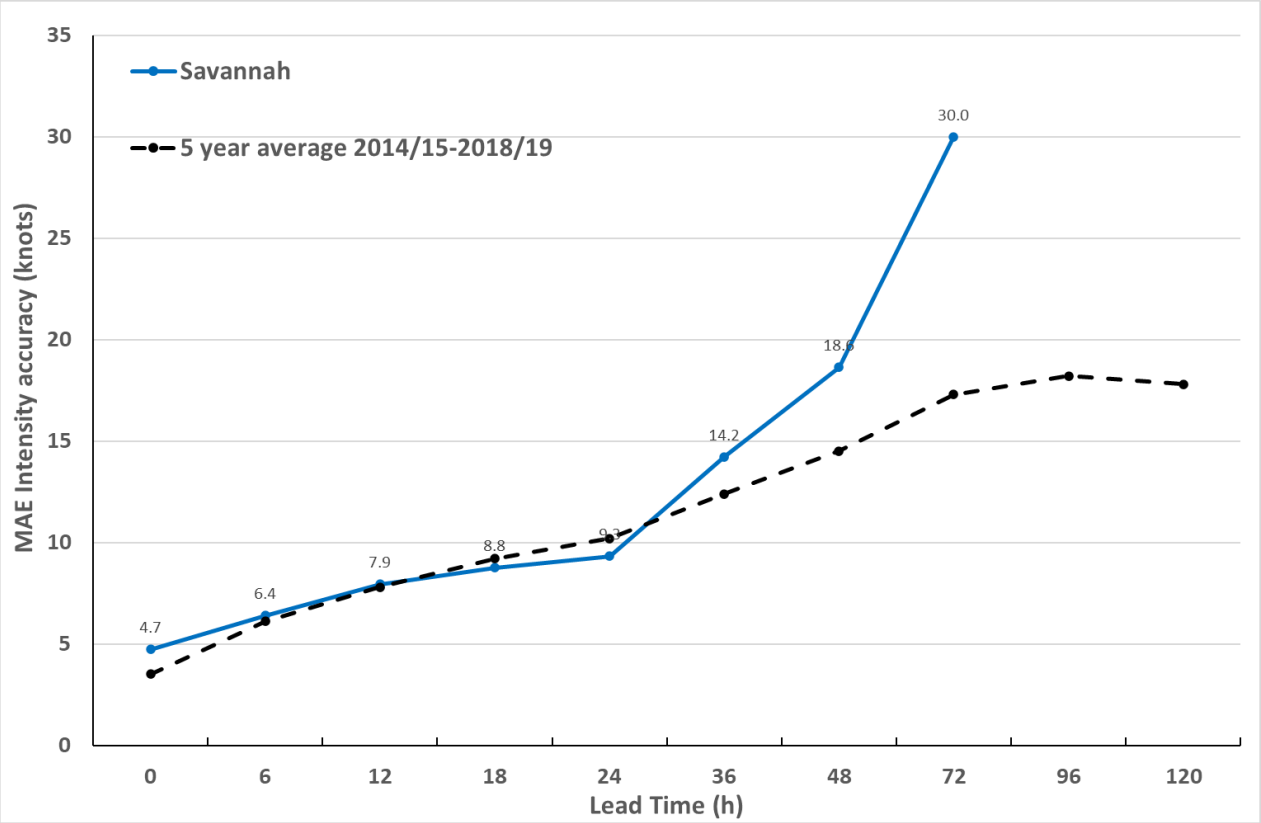

Figure 7 Forecast intensity errors for Severe Tropical Cyclone Savannah compared to the 5-year average.

6. Appendix: List of abbreviations

Abbreviation	Term
ADT	Advanced Dvorak Technique
ACST	Australian Central Standard Time
AEST	Australian Eastern Standard Time
AMSR2	Advanced Microwave Scanning Radiometer
AMSU	Advanced Microwave Sounding Unit
ASCAT	Advanced Scatterometer
ATMS	Advanced Technology Microwave Sounder
AWS	Automatic weather station
AWST	Australian Western Standard Time
°C	Celsius
CCT	Cocos Islands Time
CI	Current intensity
CIMSS	Cooperative Institute for Meteorological Satellite Studies (USA)
CIRA	Cooperative Institute for Research in the Atmosphere (USA)
EIR	Enhanced InfraRed
ERC	eyewall replacement cycle
FNMOC	Fleet Numerical Meteorology and Oceanography Centre (USA)
FT	Final T-number
GCOM	Global Change Observation Mission
GHz	Gigahertz
GMI	Global Precipitation Measurement Microwave Imager
h	hour
hPa	hectopascal
HSCAT	Hai Yang 2 Scatterometer (HY-2B, HY-2C)
km	kilometres
km/h	kilometres per hour
kn	knot

LLCC	LLCC
MET	Model Expected T-number
METOP	Meteorological Operational Satellite
MJO	Madden-Julian Oscillation
mm	millimetres
MSLP	mean sea level pressure
NESDIS	National Environmental Satellite, Data, and Information Service
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NRL	Navy Research Lab (USA)
PAT	Pattern T-number
RH	relative humidity
RMW	radius of maximum winds
RSMC	Regional Specialised Meteorological Centre
SAR	Synthetic Aperture Radar
SATCON	Satellite Consensus
SMAP	Soil Moisture Active Passive
SMOS	Soil Moisture and Ocean Salinity
SSMIS	Special Sensor Microwave Imager/Sounder
TC	Tropical Cyclone
TCWC	Tropical Cyclone Warning Centre
UTC	Universal Time Co-ordinated