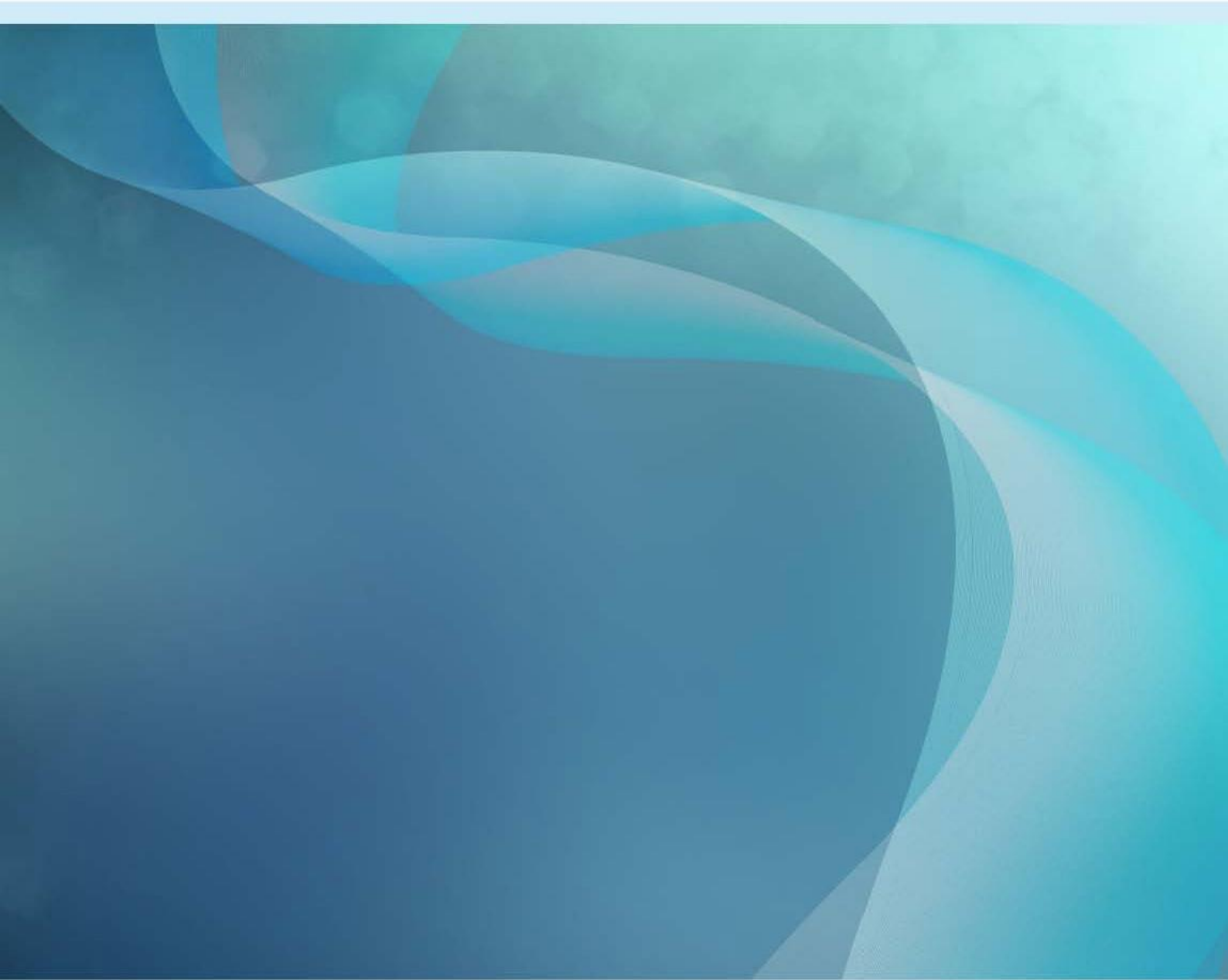




Australian Government
Bureau of Meteorology

Severe Tropical Cyclone *Kate*

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May 2015



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Table of Contents

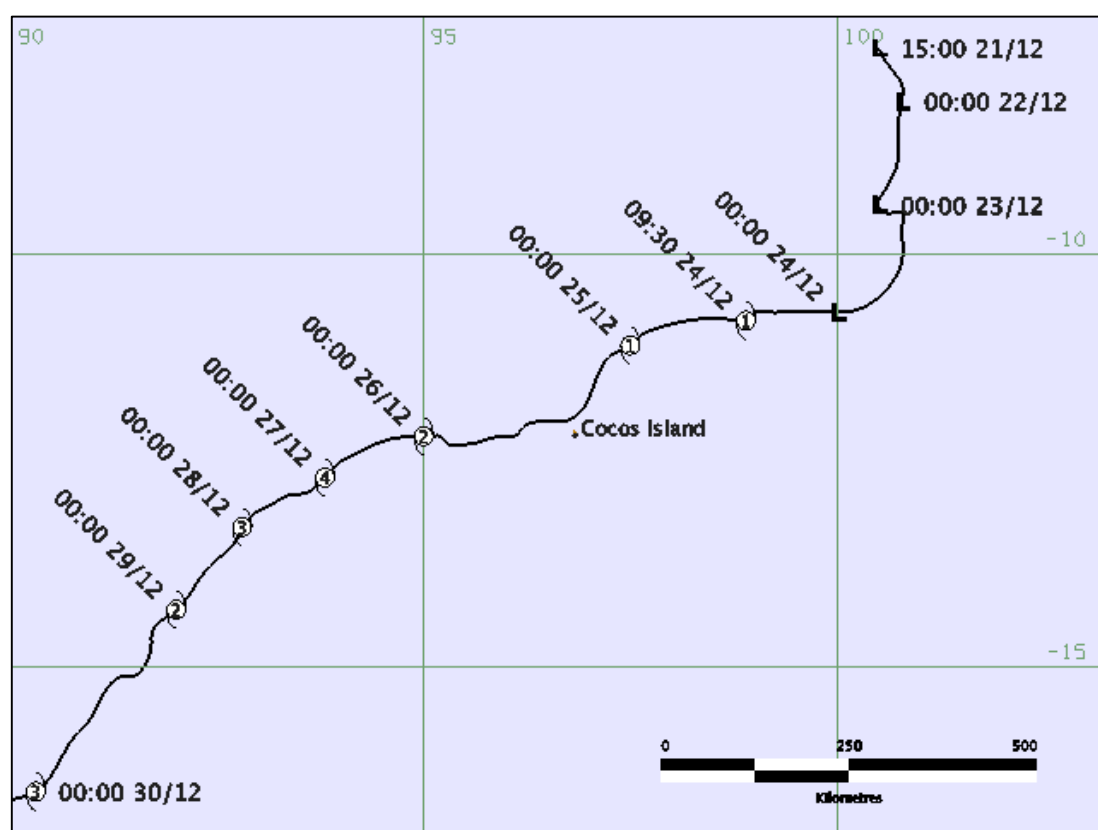
1	Summary	1
	Figure 1. Best track of STC <i>Kate</i> 21- 30 December 2014 (times in UTC, WST is +8, +6.5 hours to obtain Cocos Keeling Island local time).	2
2	Meteorological description	3
2.1	Intensity analysis.....	3
2.2	Structure	4
2.3	Motion	4
3	Impact.....	5
4	Observations	6
4.1	Wind.....	6
4.2	Rainfall.....	6
5	Forecast Performance	7
	TABLE 1. Best track summary for Severe Tropical Cyclone <i>Kate</i>	8
	FIGURE 2. Comparison of objective and subjective intensity analysis techniques for <i>Kate</i>	10
	FIGURE 3. 89 GHz AMSR2 microwave image 0551 UTC 25 December 2014 of <i>Kate</i> near the Cocos Keeling Islands.....	11
	FIGURE 4. 91 GHz TC SSMIS microwave image 2347 UTC 26 December 2014 near peak intensity.	12
	Figure 5. Accuracy statistics for <i>Kate</i>	13

1 Summary

A tropical low pressure system developed to the southwest of Sumatra during 21 December. The low initially moved towards the south and then towards the west-southwest. The low reached tropical cyclone strength at 0930 UTC (1730 WST = UTC+8 hours) 24 December when it was 275 kilometres (km) northeast of the Cocos Keeling Islands. *Kate* tracked towards the west-southwest and passed close to the Cocos Keeling Islands on 25 December. Gales were recorded on the islands with a maximum gust of 55 knots (kn) (102 kilometres per hour (km/h)) at 0708 UTC 25 December. This was also accompanied by 107.6 millimetres (mm) of rain in a 24 hour period to 9 am WST 25 December. Flooding was reported from Home and West Islands. A number of trees were damaged and there was some property damage.

As Severe Tropical Cyclone *Kate* continued to move in a southwest direction it intensified further due to favourable conditions. *Kate* reached a peak intensity of around 80 kn (148 km/h) at 0000 UTC 27 December. Around 1200 UTC on 27 December wind shear increased and the cyclone began to weaken. Wind shear decreased during 28 December and 29 December which allowed *Kate* to re-intensify. *Kate* crossed 90°E at 0000 UTC 30 December with an intensity of 80 kn (148 km/h). The system continued to intensify in La Reunion's area of responsibility (AOR).

Figure 1. Best track of STC *Kate* 21- 30 December 2014 (times in UTC, WST is +8, +6.5 hours to obtain Cocos Keeling Island local time).



2 Meteorological description

2.1 Intensity analysis

A low pressure system formed in an active monsoon trough late on 21 December. An ASCAT (Advanced SCATterometer) pass at 1518 UTC 21 December showed a 15 kn (28 km/h) circulation around 7.5°S 100.5°E however satellite imagery at this time showed little or no deep convection or curved banding. Convection improved and a Dvorak T-number (DT) of 1.0 (T1.0) was assigned at 0600 UTC 22 December. The low moved in a southerly direction and slowly developed before turning to the southwest on 24 December.

Kate reached cyclone strength at 1000 UTC 24 December with a persistent T3.0 achieved. The cyclone continued to only slowly intensify. CIMSS (Cooperative Institute for Meteorological Satellite Studies) wind analyses showed shear had increased to about 20 kn (37 km/h) from the east northeast during 25 December. On the afternoon of 25 December *Kate* passed close to the Cocos Keeling Islands with a maximum 3-second wind gust of 55 kn (102 km/hr) recorded at 0708 UTC 25 December. Satellite imagery (refer Figure 3) through this period showed that *Kate* had lost the initial curved band pattern and had become a sheared system with convection confined to the southwest quadrant with low level cloud lines visible in the northeast quadrant.

Later on the 25 December the wind shear decreased slightly and *Kate* began to intensify. Microwave imagery from 1830 UTC 25 December showed the formation of an eye. *Kate* continued to develop during 26 December with an eye becoming apparent in infra-red (IR) imagery around 1000 UTC 26 December. *Kate* reached a 10-minute mean wind peak intensity of 90 kn (167 km/h) at 1800 UTC 26 December (refer Figure 4). During this period CIMSS ADT (Advanced Dvorak Technique) increased steadily, however the scene type applied fluctuated between an eye and other scene types. This resulted in ADT estimates being lower than subjective Dvorak estimates which consistently used an eye pattern from 1000 UTC 26 December to 1000 UTC 27 December. The best track intensity was biased towards subjective Dvorak through this period. AMSU (Advanced Microwave Sounding Unit) and SATCON (Satellite Consensus) estimates were in general agreement (refer Figure. 2) though at times the intensity may have been underestimated due to the small size of the tropical cyclone.

Later on 27 December wind shear analyses showed an increase to 20-30 kn (37 – 55 km/h) of east-northeast shear and *Kate* began to weaken. Satellite and microwave imagery from around 0900 UTC 27 December showed the eye structure had eroded and convection was confined to western quadrants. Wind shear remained in the 10-20 kn (19 – 37 km/h) range from the east-northeast and *Kate*'s structure fluctuated with an eye appearing and disappearing in microwave imagery. The intensity slowly weakened to 60 kn (111 km/h) by 0000 UTC 29 December. From 0000 UTC 29 December wind shear dropped to 5-10 kn (10 – 19 km/h) and the tropical cyclone began to re-intensify. By 1100 UTC an eye had redeveloped in both microwave and IR imagery. *Kate* crossed 90°E into La Reunion's AOR around 0000 UTC 30 December with a 10-minute mean wind of 80 kn (148 km/h).

2.2 Structure

Kate was generally a small system. Initially the tropical cyclone was asymmetric with a gale radius of around 40 nm (74 km) in all quadrants with the exception of the northeast which had no gales. Gradually the gale radius expanded to 60 nm (111 km) in the western quadrants while the *cyclone* was under shear. *Kate* passed close to the Cocos Keeling Islands. Wind observations recorded on the islands indicated a small gale radius of 30 nm (55 km) in the eastern quadrants and satellite imagery clearly showed an asymmetric tropical cyclone with convection only in the southwest quadrant. As *Kate* intensified the gale radius expanded to around 90 nm (167 km) in the southern quadrants and 60 nm (111 km) in the northern quadrants. *Kate* became symmetric for a short period on the 28 December but for most of its life gales generally extended further in the southeast quadrant.

The eye radius was small at 7-10 nm (13-19 km) most of the time an eye was present. It expanded to 15 nm (28 km) at 0000 UTC 28 December as *Kate* went through a weakening phase.

2.3 Motion

Initially the tropical cyclone was steered slowly in a southerly direction by the northwest monsoon flow to the north. By 24 December a mid-level ridge was located to the east and south and as a result *Kate* began to move in a southwest direction. During 27 and 28 December the mid-level ridge was eroded and the westerly steering flow became balanced by the easterly influence of the monsoon to the north. *Kate*'s motion slowed to around 3 kn (5 km/h) to the southwest during this period. During 29 December *Kate*'s motion continued to the southwest but the speed increased to around 7 kn (13 km/h) before the tropical cyclone crossed 90°E into the La Reunion AOR.

3 Impact

The passage of *Kate* close to the Cocos Keeling Islands on 25 December produced strong winds and heavy rainfall. Flooding was reported from Home and West Islands. A number of trees were damaged and there was some property damage.

4 Observations

4.1 Wind

The Cocos Keeling Islands recorded gale force winds (winds equal to or greater than 34 kn or 63 km/h) between 0342 and 0616 UTC and between 0646 and 0728 UTC 25 December. A maximum wind gust of 55 knots (102 kilometres per hour) was recorded at 0708 UTC 25 December.

4.2 Rainfall

The Cocos Island tipping bucket rain gauge (TBRG) recorded 107.6 mm to 9 am WST 25 December and a further 35.6 mm to 9 am WST 26 December. The manual rain gauge at the Cocos Keeling Islands airport was read at 9 am WST 26 December and recorded a two day total of 149 mm.

5 Forecast Performance

The first tropical cyclone watch for a developing tropical low was issued on 23 December for the Cocos Keeling Islands. The first warning was declared early on 24 December. All warnings were cancelled at 1300 UTC 25 December as *Kate* moved away from the islands.

The accuracy statistics obtained by comparing the forecast positions against the best track positions for Severe TC *Kate* are

	0	06	12	18	24	36	48	72	96	120	144	168
Absolute error (km)	28	48	64	71	73	102	122	139	168	234	273	457
RMS error (km)	34	54	70	78	80	107	132	175	210	274	305	546

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

Refer to the Australian Tropical Cyclone database for complete listing of parameters. WST is UTC + 8 hours, CCT is UTC + 6.5 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 nm
2014	12	21	1500	7.5	100.5	60	15	45	1007			
2014	12	21	1800	7.7	100.6	60	15	45	1007			
2014	12	22	0000	8.1	100.8	45	20	45	1007			
2014	12	22	0600	8.6	100.7	45	20	45	1007			
2014	12	22	1200	9.0	100.7	45	20	45	1007			
2014	12	22	1800	9.2	100.6	45	25	45	1004			
2014	12	23	0000	9.4	100.5	60	25	45	1004			
2014	12	23	0600	9.5	100.6	60	25	45	1004			
2014	12	23	1200	9.5	100.8	60	30	45	1002			
2014	12	23	1800	9.9	100.8	60	30	45	1002			
2014	12	24	0000	10.7	100.0	45	30	45	1004			
2014	12	24	0600	10.7	99.3	45	30	45	1001			
2014	12	24	1000	10.8	98.9	45	35	50	998	0/40/40/40		30
2014	12	24	1200	10.8	98.8	45	35	50	998	0/40/40/40		30
2014	12	24	1800	10.9	97.8	45	40	55	996	30/40/60/40		30
2014	12	25	0000	11.1	97.5	30	40	55	992	30/40/60/60		30
2014	12	25	0600	12.0	96.8	20	45	65	988	30/30/60/60		20
2014	12	25	1200	12.2	96.0	15	50	70	985	60/90/90/60	20	20
2014	12	25	1800	12.3	95.5	30	55	75	983	60/90/90/60	20	10
2014	12	26	0000	12.2	95.0	25	55	75	983	60/90/	20	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 nm
										90/60		
2014	12	26	0600	12.3	94.4	20	60	85	980	60/90/90/60	20	10
2014	12	26	1200	12.4	94.2	20	80	110	964	60/90/90/60	40	10
2014	12	26	1800	12.5	94.0	20	90	125	955	60/90/90/60	40	15
2014	12	27	0000	12.7	93.8	10	90	125	955	60/90/90/60	40	15
2014	12	27	0600	12.9	93.5	10	90	125	955	60/90/90/60	40	10
2014	12	27	1200	13.0	93.2	20	90	125	955	60/90/90/60	30	15
2014	12	27	1800	13.1	93.0	20	85	120	960	60/60/80/60	30	20
2014	12	28	0000	13.3	92.8	20	80	110	965	80	40	10
2014	12	28	0600	13.5	92.7	20	70	100	973	60	40	10
2014	12	28	1200	13.6	92.6	20	65	90	976	80/80/80/50	60/60/60/30	10
2014	12	28	1800	13.9	92.3	20	60	85	982	80/80/80/50	60/60/60/30	15
2014	12	29	0000	14.3	92.0	20	60	85	982	80/100/80/80	60	15
2014	12	29	0600	14.6	91.7	20	60	85	980	80/100/80/80	60	15
2014	12	29	1200	15.1	91.5	15	65	90	976	50/100/50/50	40/80/40/40	15
2014	12	29	1800	15.7	90.9	10	70	100	973	60	40	10
2014	12	30	0000	16.5	90.3	10	80	110	967	40/80/60/40	30	10

FIGURE 2. Comparison of objective and subjective intensity analysis techniques for *Kate*.

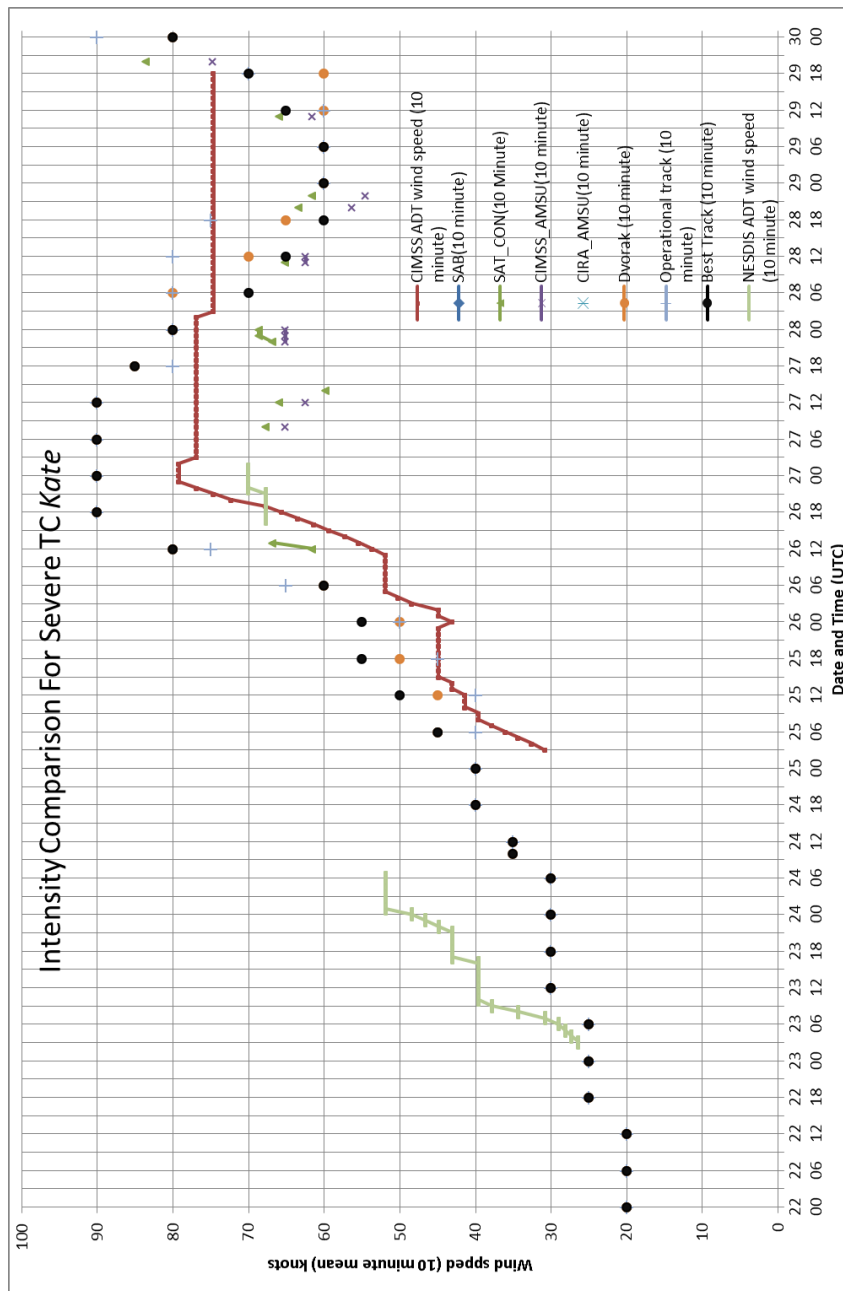


FIGURE 3. 89 GHz AMSR2 microwave image 0551 UTC 25 December 2014 of *Kate* near the Cocos Keeling Islands.

(image courtesy of NOAA NRL: <http://www.nrlmry.navy.mil/>)

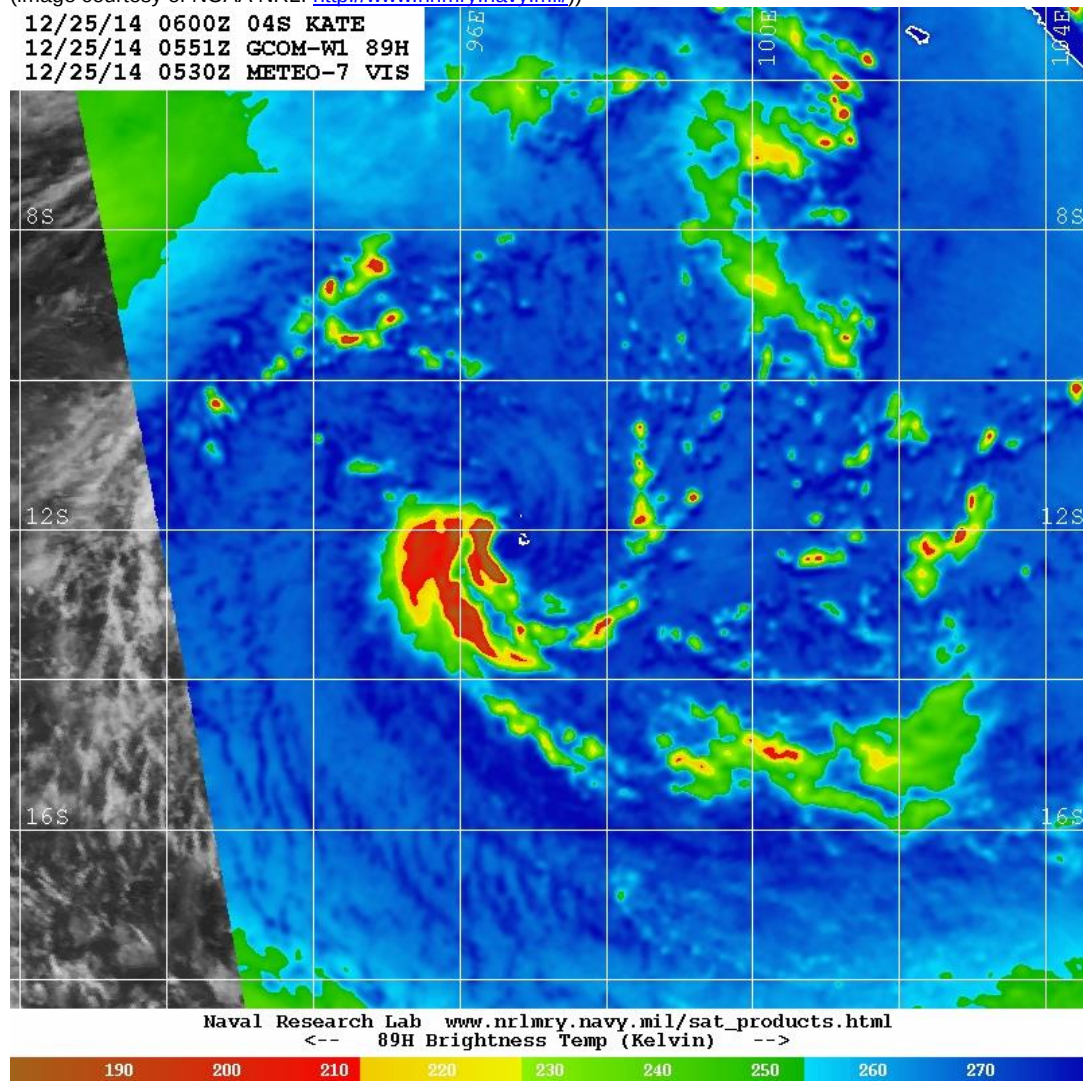


FIGURE 4. 91 GHz TC SSMIS microwave image 2347 UTC 26 December 2014 near peak intensity.

(image courtesy of NOAA NRL: <http://www.nrlmry.navy.mil/>)

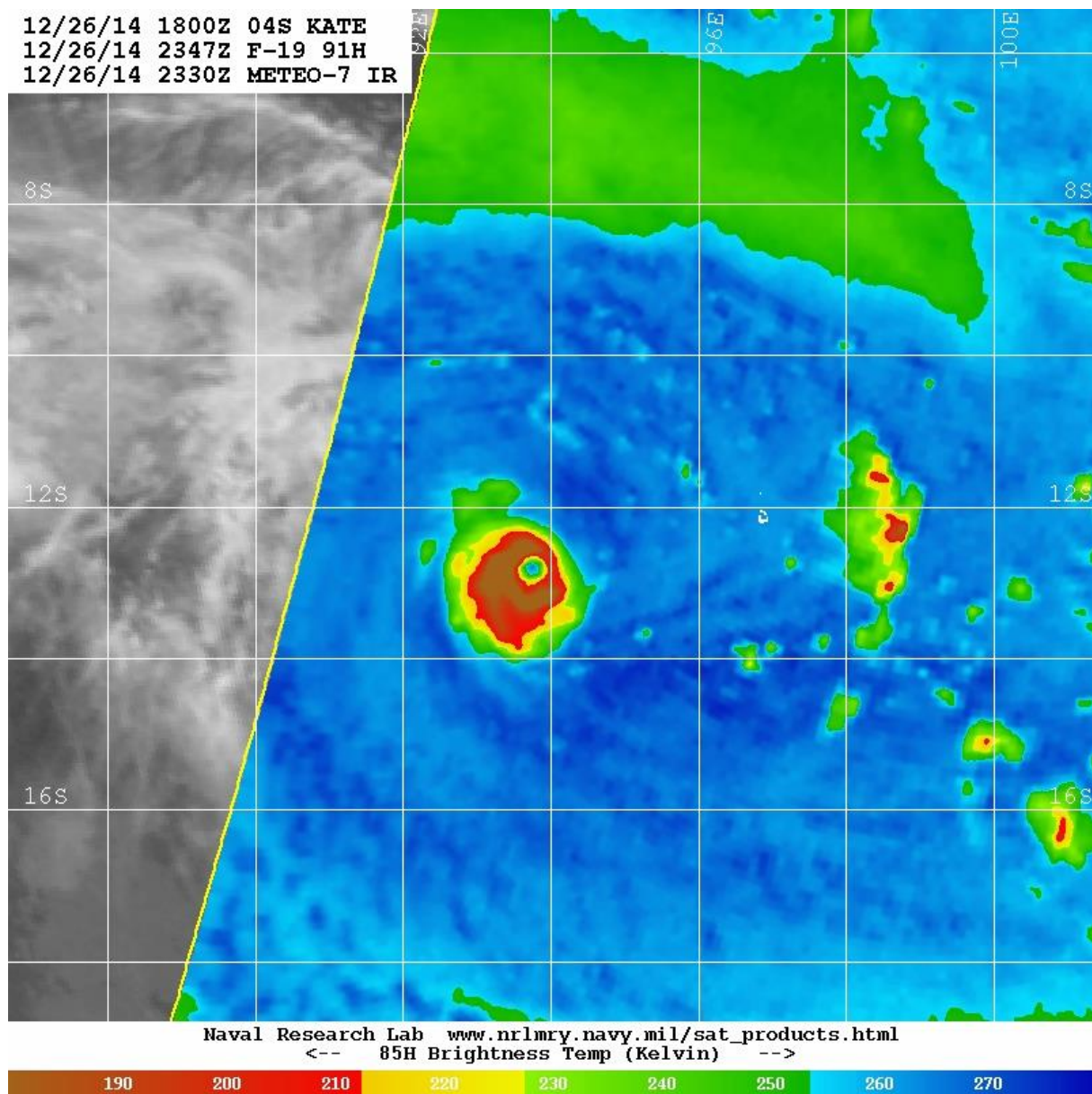


Figure 5. Accuracy statistics for *Kate*

