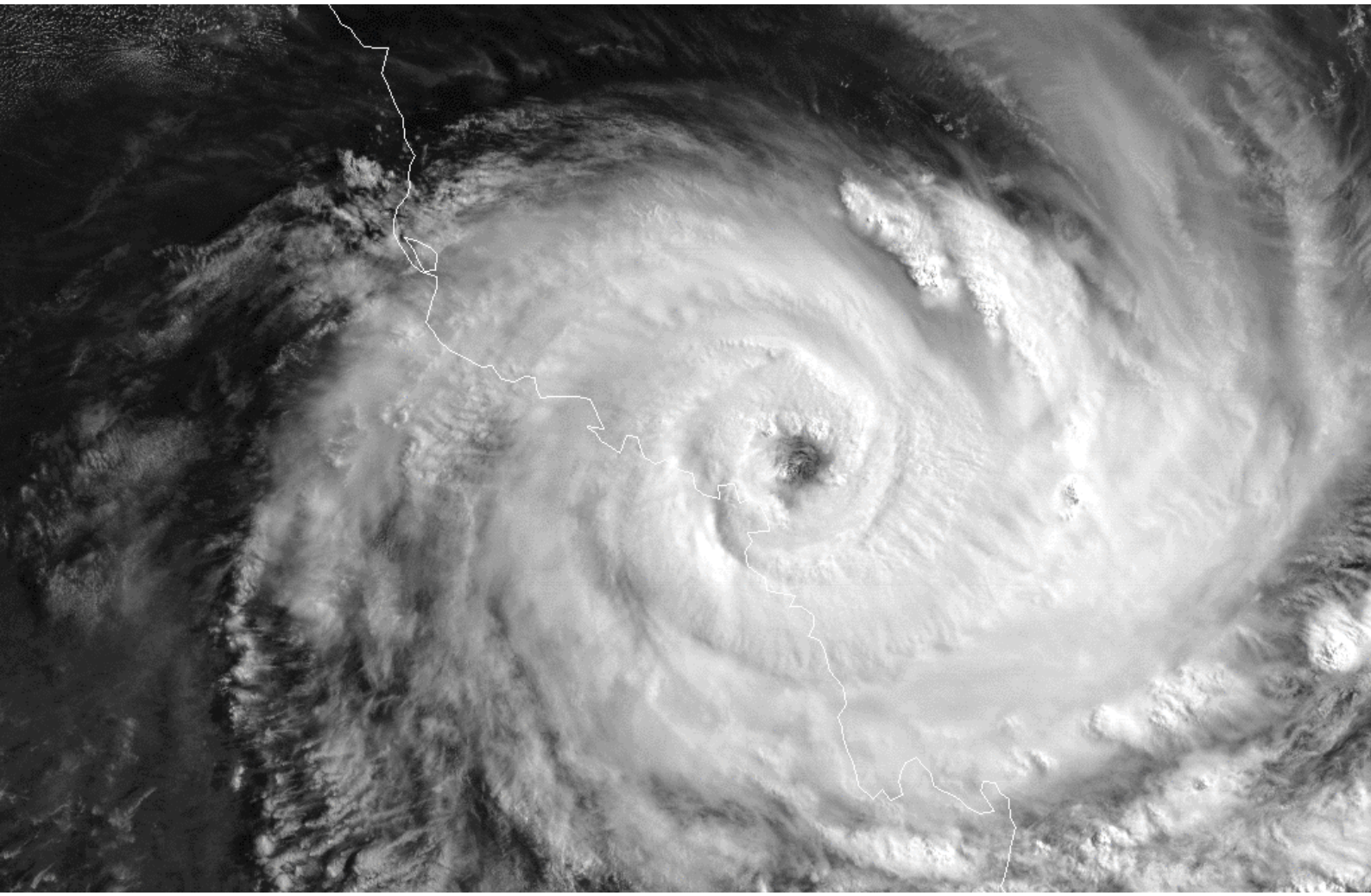
2017

Force Thirteen Cyclone Reports

Cyclone Debbie (201711)



Cyclone Debbie was the first major cyclone to impact Australia since Cyclone Marcia of 2015, and was the second major cyclone of 2017 worldwide.

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Cover photo: Himawari-8 image of Cyclone Debbie on March 27th at 23:10 UTC.

FORCE THIRTEEN

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1.1. Synoptic History

On March 21st, a new circulation appeared near the Louisiade Archipelago, Papua New Guinea. The system initially tracked southwards, and developed significantly over the next three days, particularly with its areal influence. By March 24th, the system's influence had extended to around 1150 miles from northwest to southeast, though land areas were not yet affected.

Late on March 24th, the system acquired tropical storm force winds, and was named Debbie. From the beginning, Debbie's thunderstorm activity on the eastern side was very expansive, and the storm hosted a pronounced inflow plume to the north. This contributed to the first significant weather from the storm which occurred over the Cape York Peninsula early on March 25th, producing significant rainfall.

Later on March 25th, Debbie's preliminary band reached the coast of Australia and extended from Bowen in the north to Fraser Island in the south. By this time, a rift began to appear within Debbie, which until now had been producing energetic spells of convective activity near the center. This northwest-southeast rift may have been caused by dry air intrusion, and halted any further development until early on March 26th when new convection wrapped around the center of the cyclone.

The southeastern element of the convection drifted off to the east and lost prominence in favour of Debbie's new bands, and signs of an eye were beginning to appear but no meaningful gains were made until late on March 26th, when an apparent ragged eye had collapsed and a possible eyewall replacement cycle took place. This had been completed within a few hours and a new, more well defined albeit still fairly ragged eye appeared within Debbie.

By the early hours of March 27th, Debbie's significant bands were beginning to impact areas west of the storm, in Bowen and Townsville in particular. Debbie's eye, at times, began to look particularly impressive, and for a short period on March 27th reached an eye temperature of around 0 degrees Celsius, coupled with cloud tops of less than -70 Celsius inclusive. This would typically correlate to a mid-range Category 4 cyclone on the Saffir-Simpson Hurricane Wind Scale, though its appearance was so fleeting that such an intensity designation would seem unreasonable within the wider context.

For a time, Debbie began to display annular characteristics, but this never truly occurred as the western half of the storm began to distort due to land interaction, and subsequently the western and southwestern eyewall became disrupted as Debbie closed in on the final 100 miles until landfall.

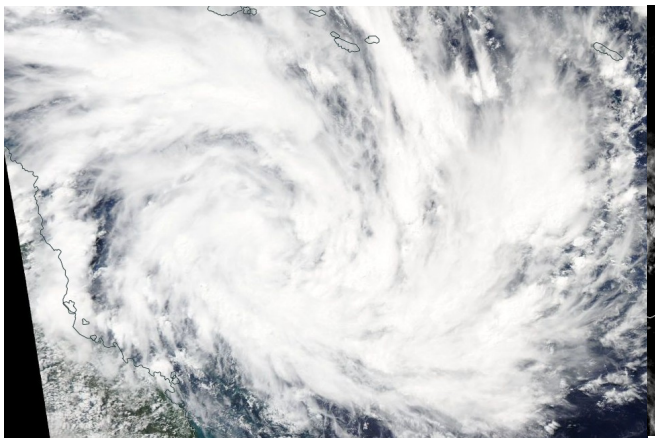
Late on March 27th, Debbie briefly turned towards the west and completed a tight clockwise loop over the course of a one hour period, before turning back towards the west-southwest, making landfall at around 00:00 UTC on March 28th over Hayman island, and again at around 01:45 UTC three miles northwest of Airlie Beach. Both of these landfalls occurred with winds of at least 120mph, corresponding to a Category 3 storm on the Saffir Simpson Hurricane Scale, and a Category 4 storm on the Australian Cyclone Scale.

Debbie's eye collapsed within two hours of landfall, and convection began to transfer from the center of the storm to its still prominent northern band, which flared up immensely for an 8 hour period on March 28th, and again for around 12 hours on March 29th, offshore. These flare-ups, whilst not near the center of Debbie, produced gusty winds and heavy rainfall over the landfall area and further south and west.

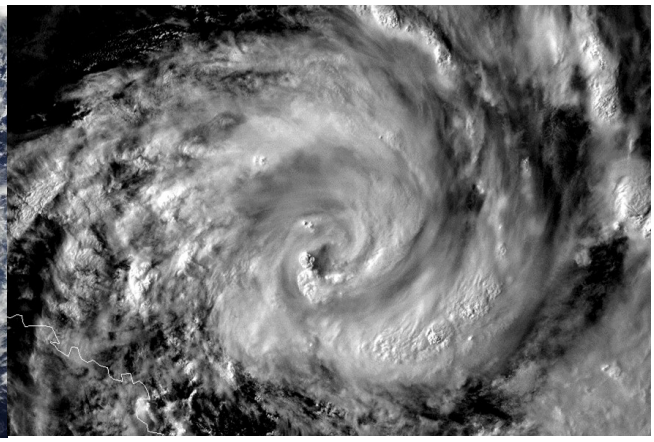
Debbie turned south late on March 28th, and then towards the southeast early on March 29th, maintaining tropical storm intensity until later on that day, when ground observations no longer held evidence that Debbie was a tropical storm. Force Thirteen at this point downgraded it to a depression, and then a remnant low by 00:00 UTC on March 30th.

On the afternoon of March 30th, the remnants of Debbie emerged offshore near southern Queensland, still moving towards the southeast or east-southeast, and turned further towards the east by this time. The system intensified once again, and gale force winds encompassed a large area around the storm over the following days until the storm lost its circulation and dissipated on April 2nd.

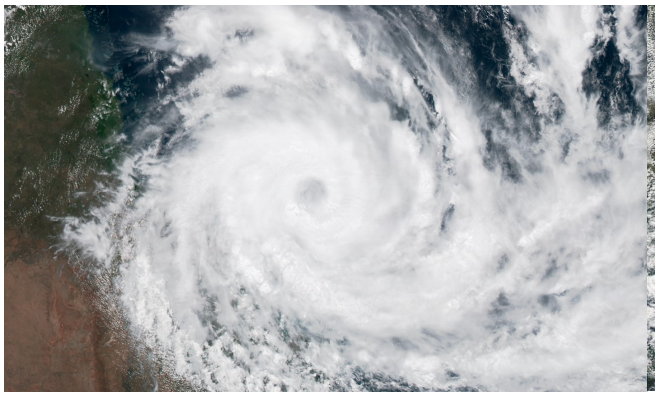
1.1. Synoptic History



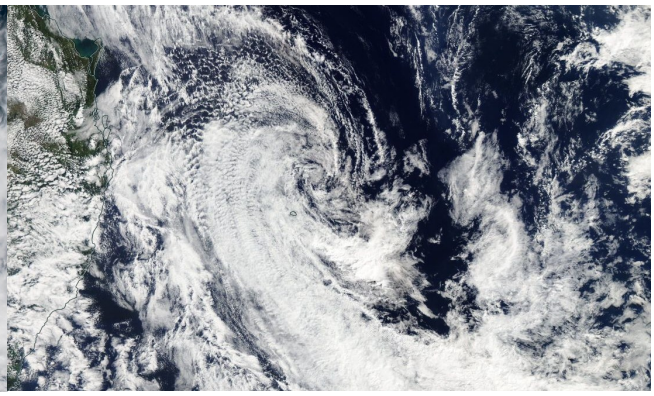
March 24th



March 26th

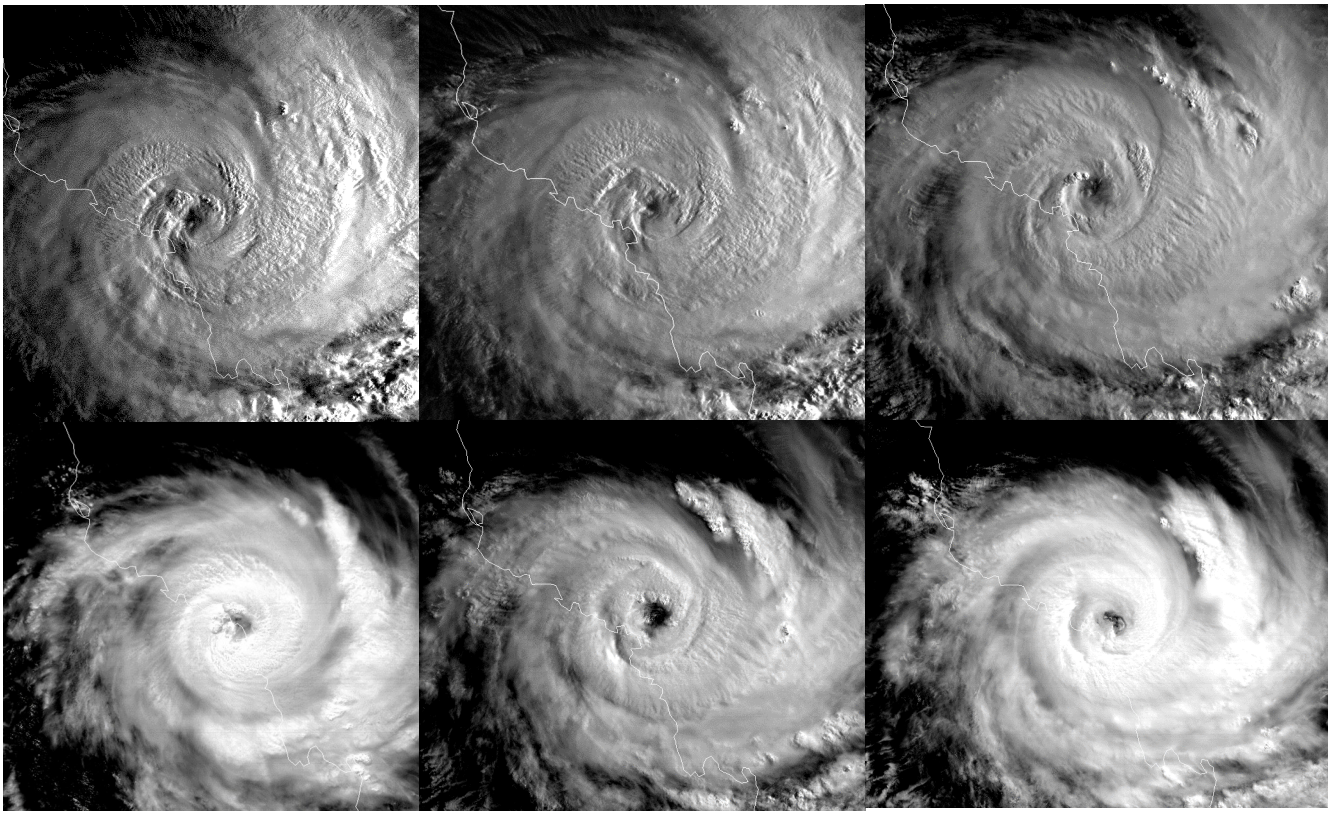


March 27th



April 2nd

Landfall Progression



1.2. Best Track

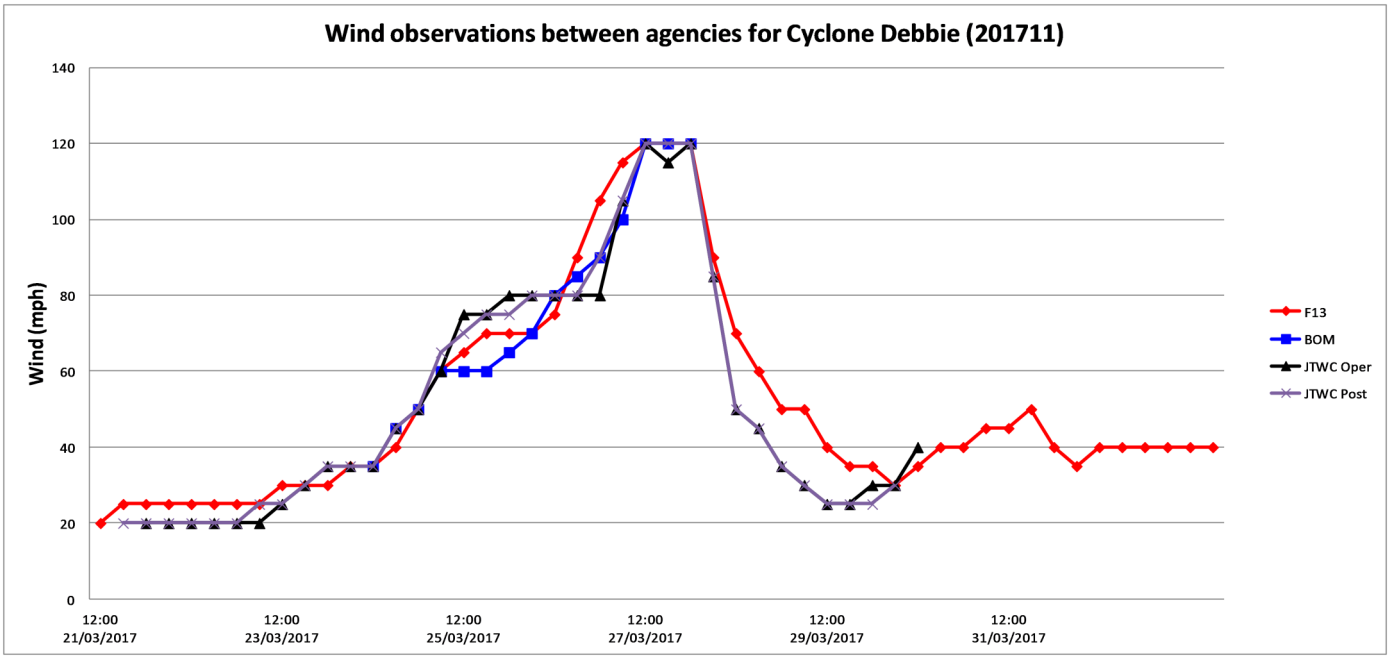
Below is the best track analysis from Force Thirteen, using Force Thirteen's SATOPS—a tool which uses infrared satellite imagery and cloud temperatures to estimate a storm's wind speed and air pressure. SATOPS does not take precedence over surface observations.

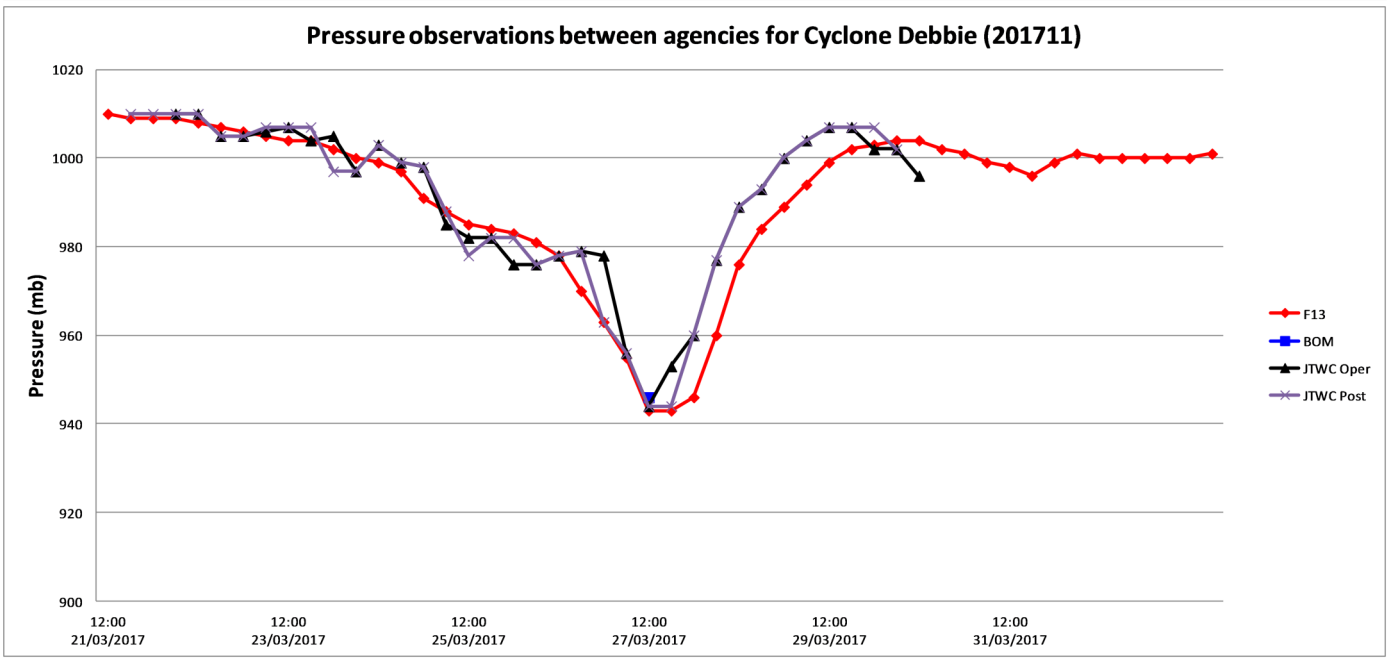
Date (dd/mm/yyyy)	Time	Latitude	Longitude	Wind	Press	Stage
21/03/2017	12:00			20	1010	Tropical Disturbance
21/03/2017	18:00			25	1009	Tropical Disturbance
22/03/2017	00:00	-11.7	151.8	25	1009	Tropical Disturbance
22/03/2017	06:00	-12	151.7	25	1009	Tropical Disturbance
22/03/2017	12:00	-12.1	151.9	25	1008	Tropical Disturbance
22/03/2017	18:00	-12.5	152.5	25	1007	Tropical Disturbance
23/03/2017	00:00	-12.7	153.1	25	1006	Tropical Disturbance
23/03/2017	06:00	-13.6	152.9	25	1005	Tropical Disturbance
23/03/2017	12:00	-14.5	152.6	30	1004	Tropical Disturbance
23/03/2017	18:00	-15.7	152	30	1004	Tropical Disturbance
24/03/2017	00:00	-16	151.7	30	1002	Tropical Disturbance
24/03/2017	06:00	-16.2	151.6	35	1000	Tropical Depression
24/03/2017	12:00	-16.8	151.8	35	999	Tropical Depression
24/03/2017	18:00	-17.4	152.3	40	997	Tropical Storm
25/03/2017	00:00	-17.6	152.4	50	991	Tropical Storm
25/03/2017	06:00	-17.7	152.2	60	988	Tropical Storm
25/03/2017	12:00	-17.8	152.2	65	985	Tropical Storm
25/03/2017	18:00	-17.9	152	70	984	Tropical Storm
26/03/2017	00:00	-18.2	151.8	70	983	Tropical Storm
26/03/2017	06:00	-18.4	151.2	70	981	Tropical Storm
26/03/2017	12:00	-18.9	151.1	75	978	Category 1
26/03/2017	18:00	-19.1	151	90	970	Category 1
27/03/2017	00:00	-19.4	150.3	105	963	Category 2
27/03/2017	06:00	-19.5	150.2	115	955	Category 3
27/03/2017	12:00	-19.7	149.8	120	943	Category 3
27/03/2017	18:00	-19.9	149.2	120	943	Category 3
28/03/2017	00:00	-20.1	148.8	120	946	Category 3
28/03/2017	06:00	-20.3	148.5	90	960	Category 1
28/03/2017	12:00	-20.7	147.8	70	976	Tropical Storm
28/03/2017	18:00	-21.3	147.2	60	984	Tropical Storm
29/03/2017	00:00	-21.7	147	50	989	Tropical Storm
29/03/2017	06:00	-22.2	146.8	50	994	Tropical Storm
29/03/2017	12:00	-23.3	146.9	40	999	Tropical Storm
29/03/2017	18:00	-23.9	147.1	35	1002	Tropical Depression
30/03/2017	00:00	-24	147.1	35	1003	Remnant Low
30/03/2017	06:00	-24.4	148.1	30	1004	Remnant Low
30/03/2017	12:00	-25.6	149.9	35	1004	Remnant Low
30/03/2017	18:00	-27	152	40	1002	Remnant Low
31/03/2017	00:00	-27.5	152.7	40	1001	Remnant Low
31/03/2017	06:00	-28.8	156.2	45	999	Remnant Low
31/03/2017	12:00	-29.4	157.2	45	998	Remnant Low
31/03/2017	18:00	-29.1	159	50	996	Remnant Low
01/04/2017	00:00	-29.2	159.1	40	999	Remnant Low
01/04/2017	06:00	-29.1	159.4	35	1001	Remnant Low
01/04/2017	12:00	-29	159.8	40	1000	Remnant Low
01/04/2017	18:00	-29	160	40	1000	Remnant Low
02/04/2017	00:00	-28.9	160.1	40	1000	Remnant Low
02/04/2017	06:00	-29.1	160.4	40	1000	Remnant Low
02/04/2017	12:00	-29	160.5	40	1000	Remnant Low
02/04/2017	18:00	-28.4	160.9	40	1001	Remnant Low

1.3. Track Chart

1.4. Comparison with other agencies

Debbie was monitored by the Regional Specialized Meteorological Centre at the Australian Bureau of Meteorology (BOM), and by the U.S. Joint Typhoon Warning Center (JTWC). Below shows comparisons between all three agencies, along with the JTWC's operational vs. post-analysed intensities.
Data from the BOM is incomplete at the time of publication.





2. Effects on Land

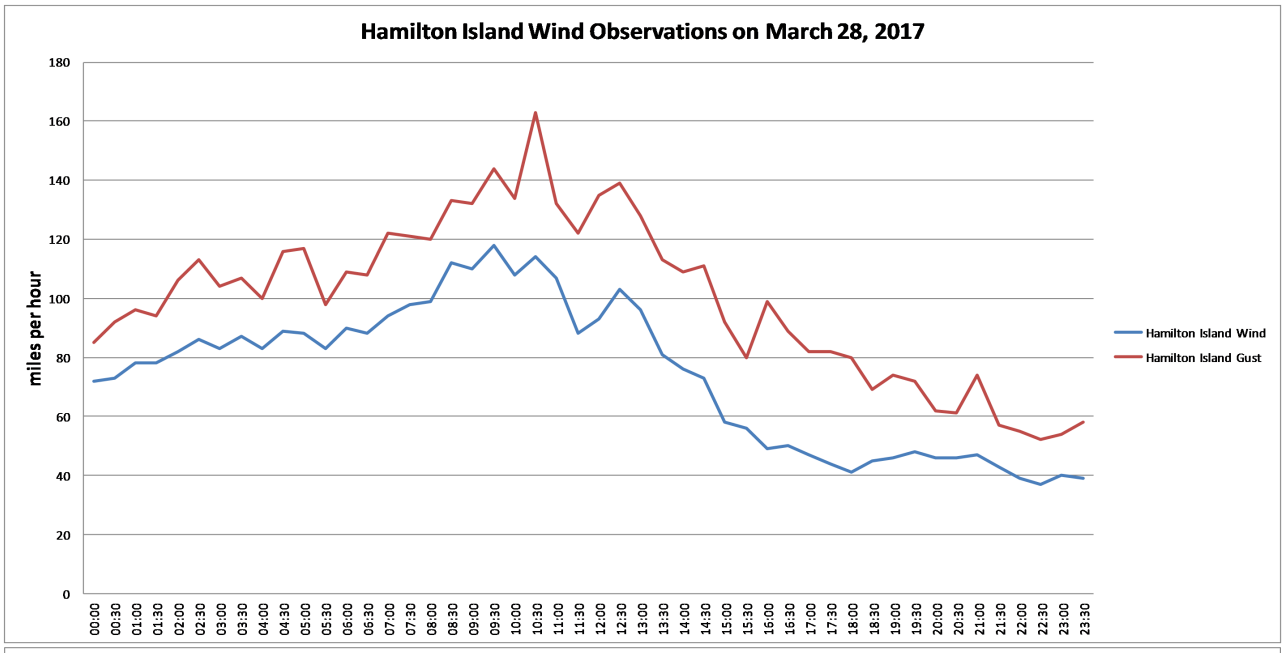
Cyclone Debbie produced rainfall totals of over 250mm (10 inches) in some parts of Queensland, leading to flooding not seen since the remnants of Cyclone Oswald impacted the area in 2013. Additionally, winds of near 120mph were recorded on Hamilton Island, gusting to 160mph. Before Debbie landed, an indirect fatality was attributed to the storm in a vehicle accident in Proserpine, a town which would go on to record the second lowest pressure from the storm. One other fatality is thought to have occurred in Queensland.

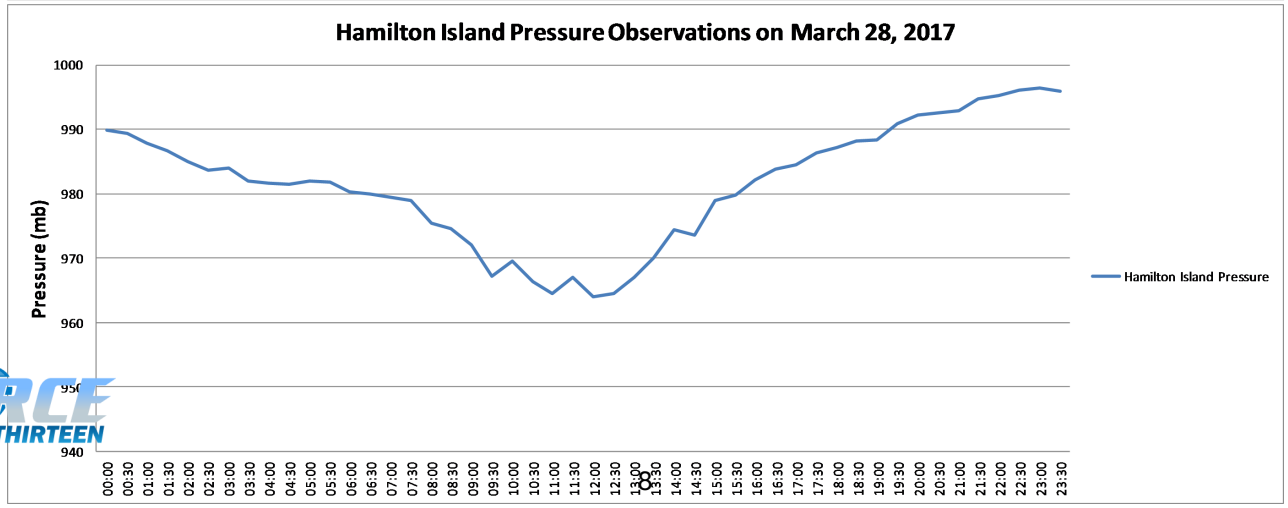
Throughout Queensland, hundreds of schools were closed and thousands along the coastal area from Bowen to Mackay were advised to evacuate. Power outages impacted on tens of thousands of customers, and the storm downed many trees and deroofed numerous houses near the coast. Damages are expected to rise above A$250 million.

Flooding plagued parts of New South Wales from the remnants of Debbie, where three fatalities are known to have occurred due to flooding.

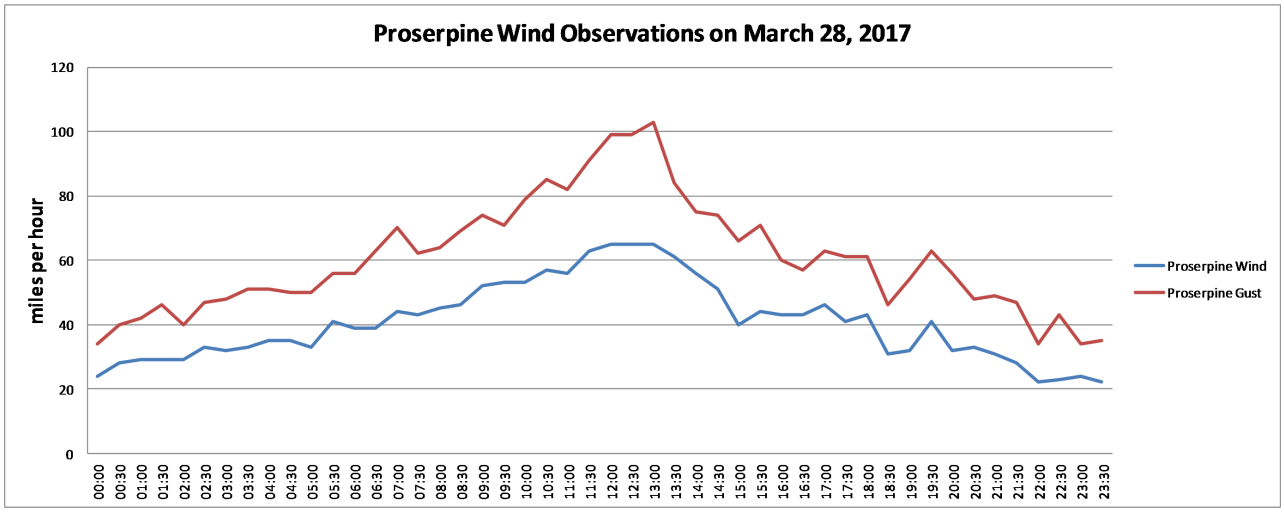
On Hamilton Island, tropical storm force winds were first recorded on March 26th at 10:41pm local time. These winds increased to hurricane force on March 28th at 1:00am, and reached their peak of 118mph sustained at 9:30am on March 28th, remaining above 100mph for several hours around this time.

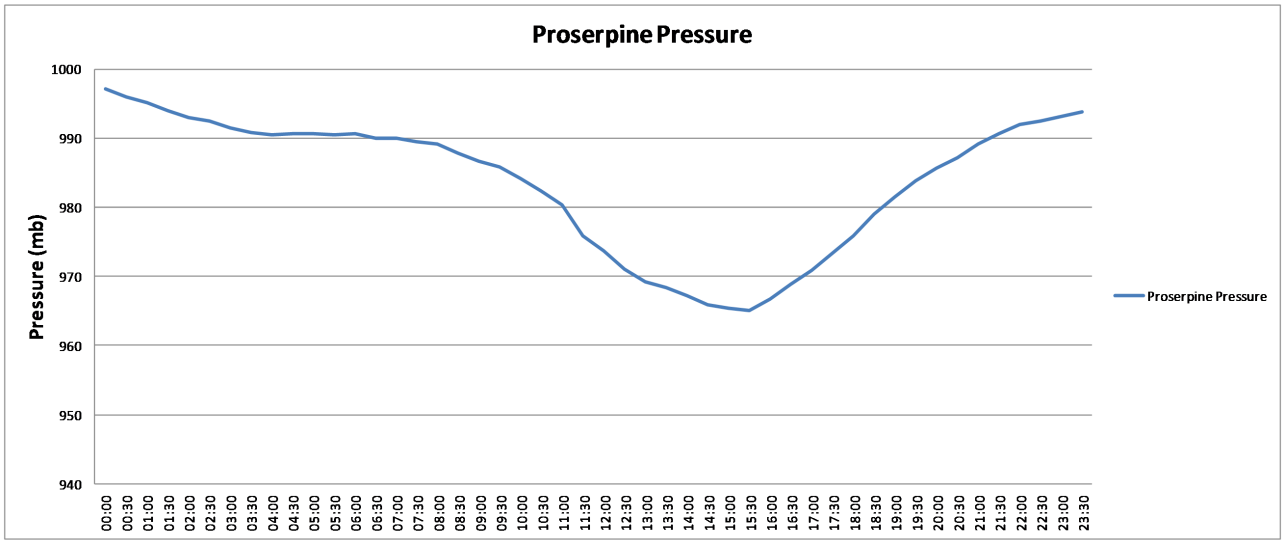
In Proserpine, winds peaked at 72mph on March 28th at 12:42pm
At Bowen Airport, winds peaked at 61mph on March 28th at 1:00pm and 1:30pm
In Mackay, winds peaked at 40mph on March 28th at 2:00am
At Hay Point, winds peaked at 50mph on March 29th at 1:00am





2. Effects on Land





Rainfall totals (satellite derived):

Coen	300mm	St Lawrence	200mm
Cooktown	120mm	Moranbah	40mm
Wujal Wujal	20mm	Clermont	60mm
Cape Tribulation	10mm	Emerald	30mm
Cairns	5mm	Yeppoon	110mm
Innisfail	5mm	Rockhampton	180mm
Ingham	5mm	Gladstone	80mm
Townsville	5mm	Biloela	60mm
Ayr	20mm	Banana	60mm
Bowen	130mm	Moura	40mm
Proserpine	180mm	Rolleston	40mm
Airlie Beach	100mm	Springsure	60mm
Hayman Island	50mm	Alpha	70mm
Hook Island	40mm	Injune	50mm
Whitsunday Island	35mm	Mitchell	70mm
Haselwood Island	35mm	Roma	40mm
Workington Island	30mm	Miles	80mm
Edward Island	30mm	Chinchilla	70mm
Bloomsbury	160mm	Theodore	80mm
Mackay	250mm	Monto	40mm
Sarina	230mm	Gin Gin	60mm
Koumala	210mm	Bundaberg	30mm
Carmila	210mm	Childers	40mm
		Maryborough	20mm

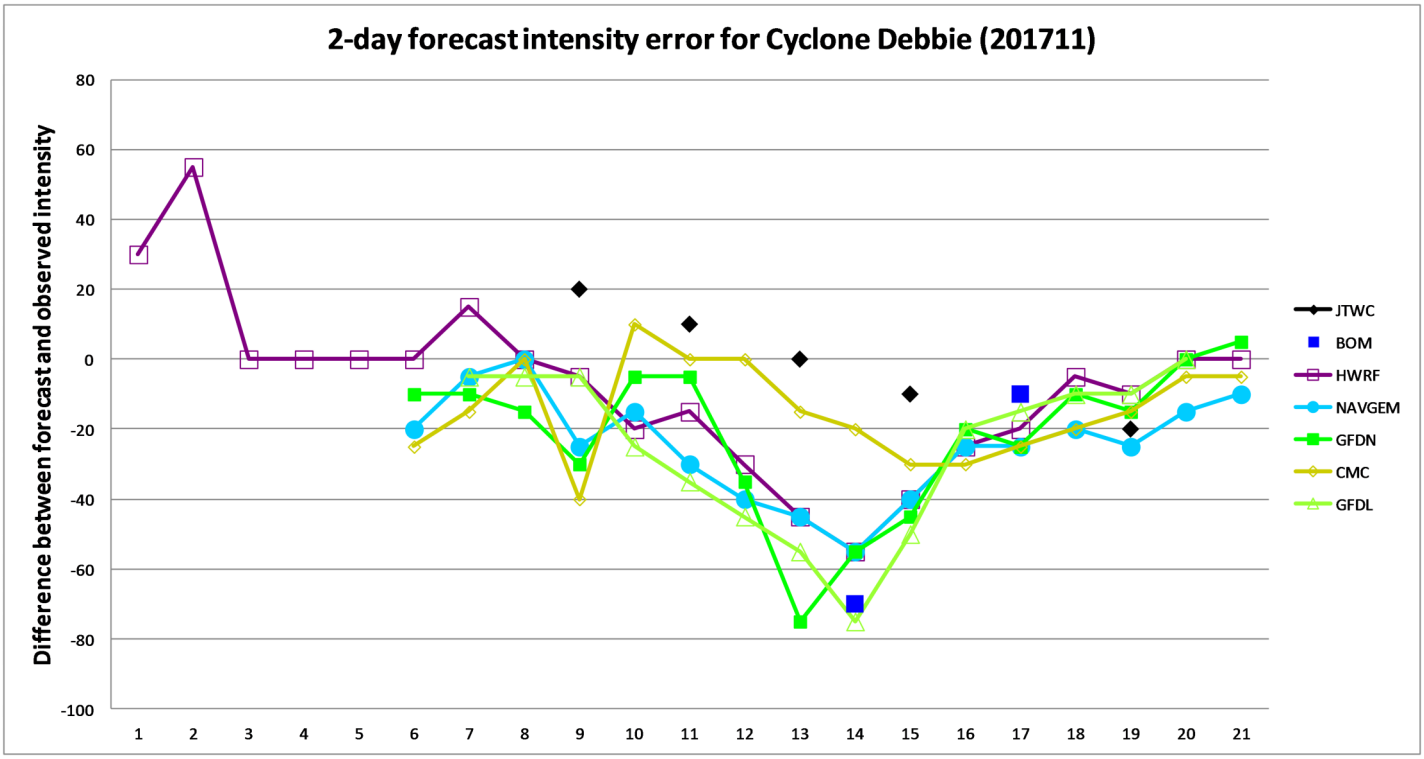
2. Effects on Land

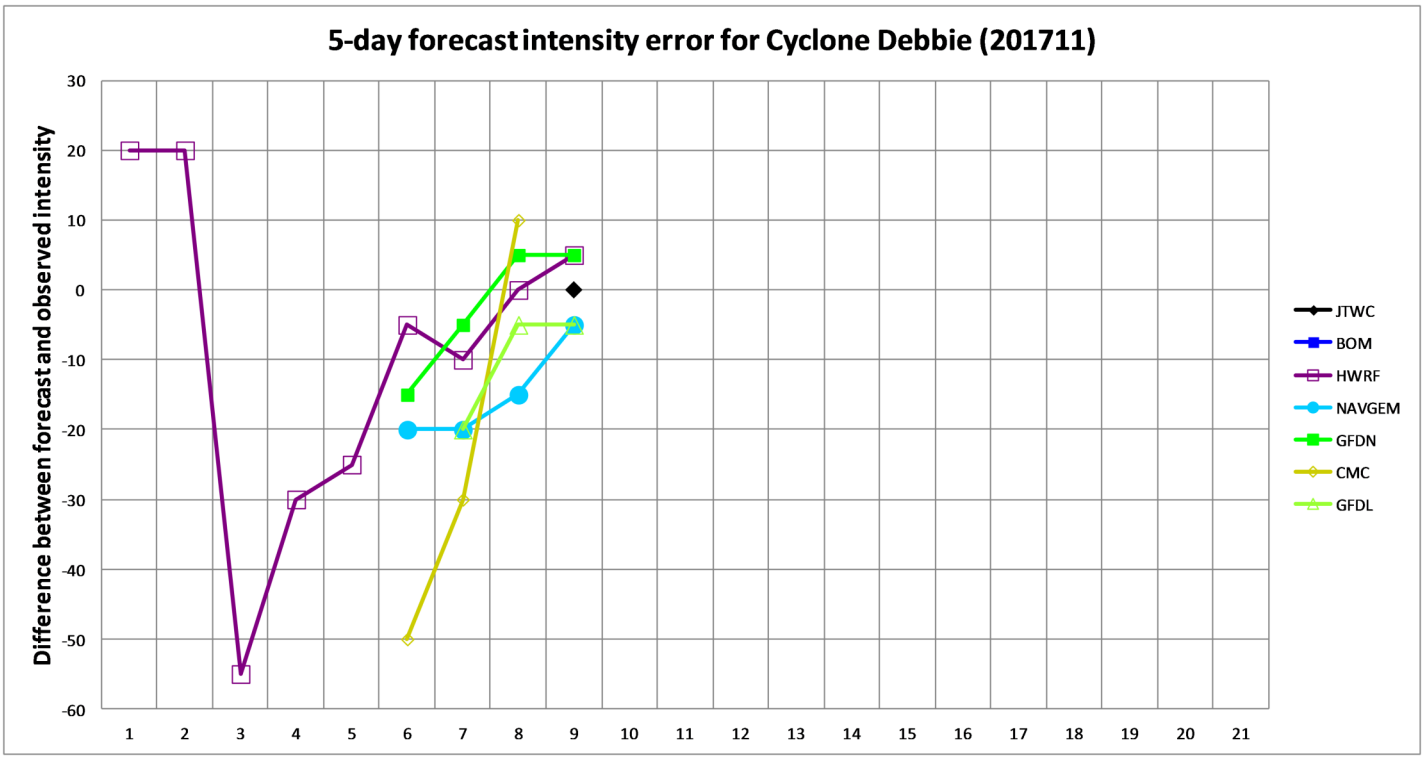
Rainfall totals (satellite derived):

Biggenden	40mm
Gayndah	50mm
Mundubbera	50mm
Eidsvold	40mm
Gympie	40mm
Kilkivan	20mm
Goomeri	30mm
Murgon	30mm
Wondai	40mm
Kingaroy	40mm
Nanango	60mm
Yarraman	80mm
Cooroy	30mm
Sunshine Coast	30mm
Caboolture	60mm
Kilcoy	50mm
Toogoolawah	50mm
Crows Nest	60mm
Dalby	30mm
Toowoomba	70mm
Gatton	30mm
Kallangur	70mm
Brisbane	110mm
Ipswich	100mm
Forest Lake	120mm
Gold Coast	30mm
Boonah	130mm
Aratula	150mm
Warwick	120mm
Killarney	140mm
Stanthorpe	120mm
Inglewood	30mm
Goondiwindi	20mm
Wallangarra	100mm
Tenterfield	90mm
Drake	110mm
Kyogle	120mm
Casino	130mm
Maclean	80mm
Grafton	80mm
Deepwater	40mm
Emmaville	30mm
Glen Innes	20mm
Ashford	20mm
Corindi Beach	50mm
Coffs Harbour	50mm
Urunga	30mm
Macksville	30mm
Dorrigo	30mm
Armidale	20mm
Uralla	20mm
Barraba	10mm
Manilla	30mm
Attunga	20mm
Carroll	40mm
Gunnedah	30mm
Tamworth	10mm
Walcha	40mm
Frederickton	20mm
Gloucester	40mm
Newcastle	10mm
Greta	30mm
Mount Thorley	40mm
Broke	70mm
Jerrys Plains	70mm
Denman	110mm
Wollombi	80mm
Sydney	10mm
St Marys	50mm
Katoomba	40mm
Blackheath	60mm
Lithgow	70mm
Bathurst	20mm
Wellington	60mm
Dubbo	50mm
Parkes	60mm
Condobolin	120mm

3. Forecasting Critique

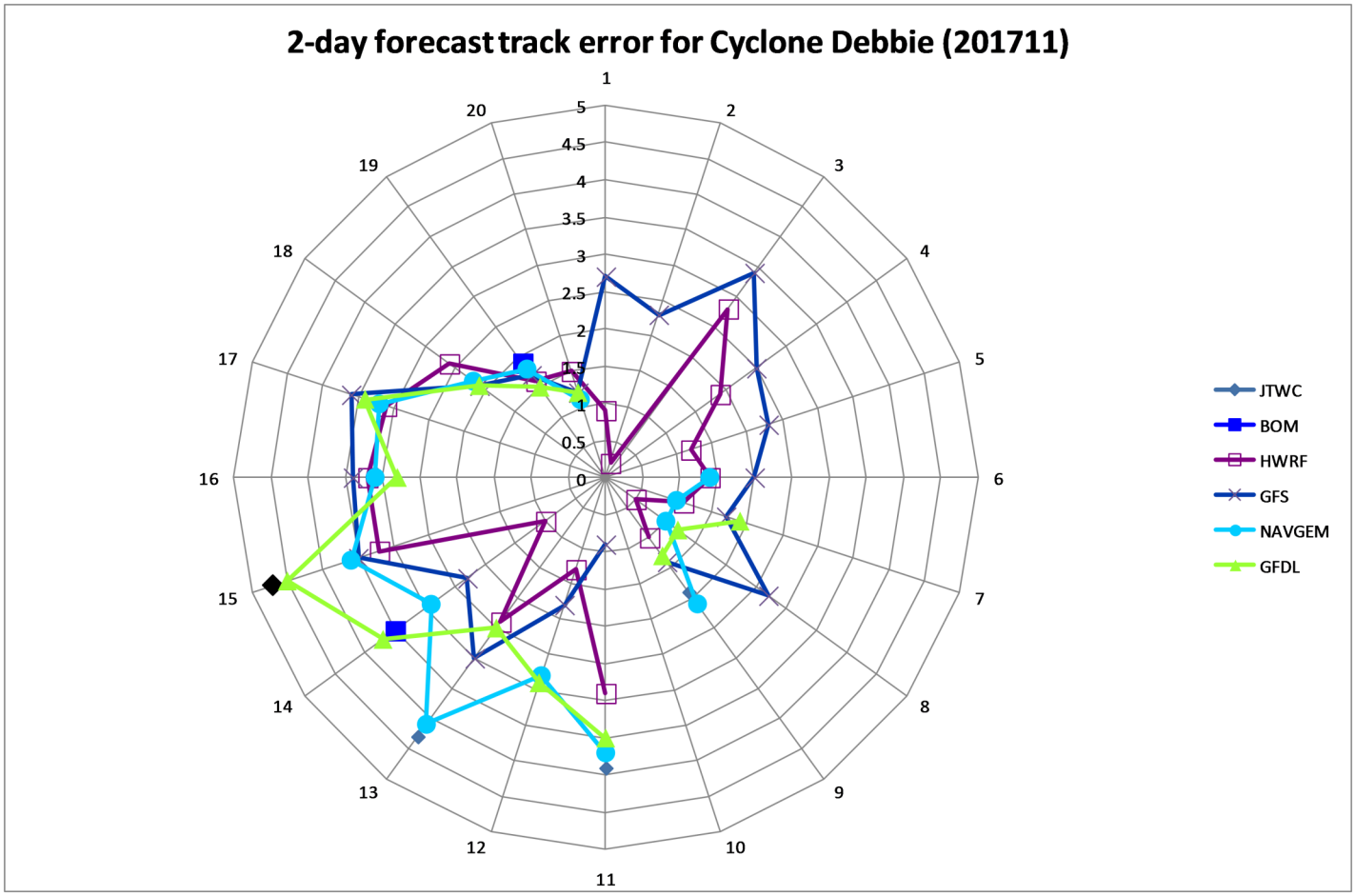
The next two pages show the track and intensity forecast error from the computer models, the BOM and the JTWC during Cyclone Debbie.
The intensity error charts show how many miles per hour the model predictions were from the observed intensity two and five days later. A value of 0 denotes a perfectly accurate prediction. Negative values correspond to predictions lower than the observation, and positive values show predictions higher than the observation.

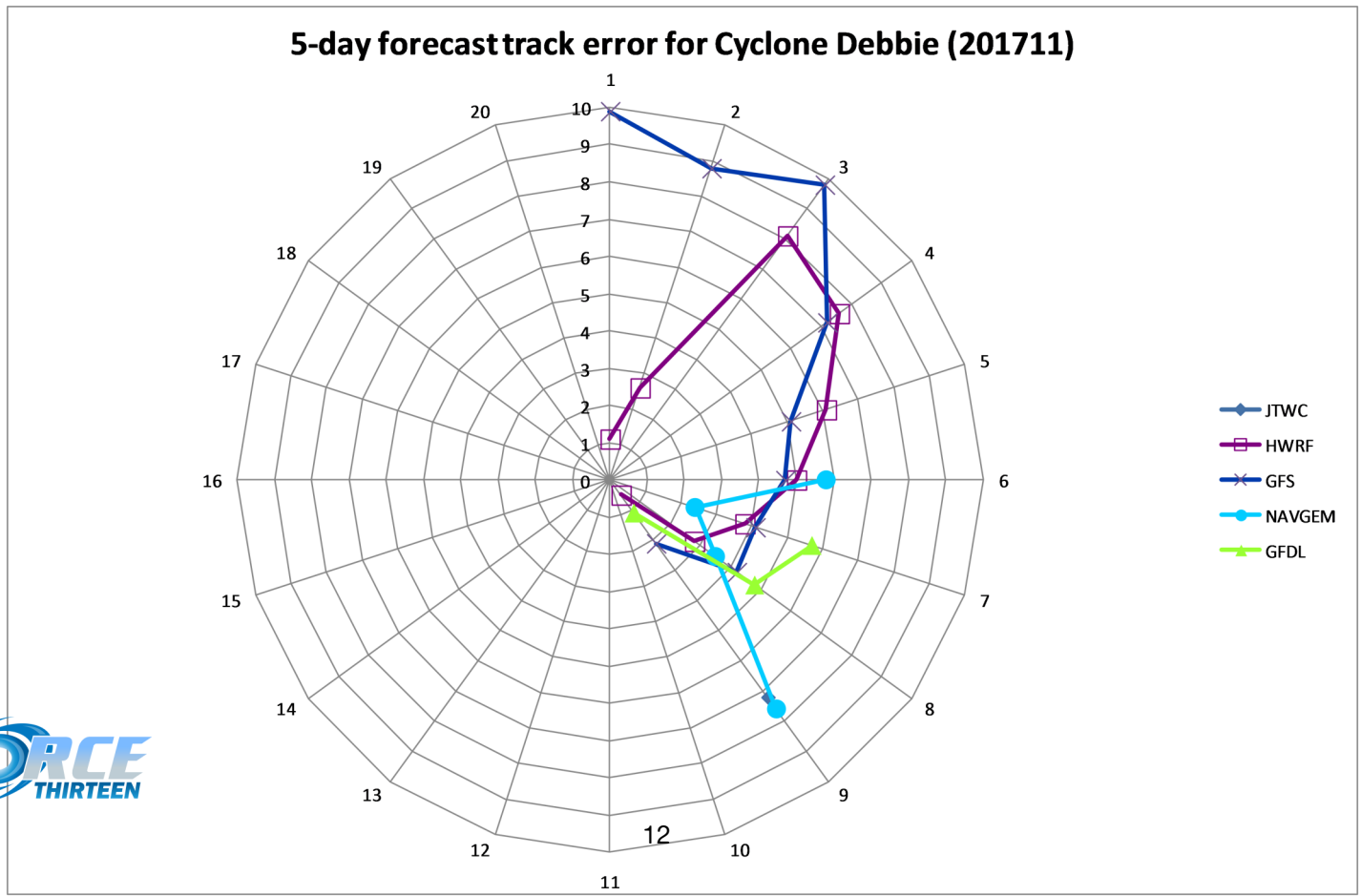




3. Forecasting Critique

The track error graphics show how far away from a perfectly accurate positional prediction the computer models, the BOM, and the JTWC predicted two and five days before the fact. Values are expressed in angular degrees, and a value closer to 0 (the center of the graphic) indicates a more accurate prediction.





3. Forecasting Critique

Data from the charts are published below.

2-day forecast intensity error								
Run	JTWC	BOM	HWRF	GFS	NAVGEM	GFDN	CMC	GFDL
2017032218			30					
2017032300			55					
2017032306			0					
2017032312			0					
2017032318			0					
2017032400			0		20	10	25	
2017032406			15		5	10	15	5
2017032412			0		0	15	0	5
2017032418	20		5		25	30	40	5
2017032500			20		15	5	10	25
2017032506	10		15		30	5	0	35
2017032512			30		40	35	0	45
2017032518	0		45		45	75	15	55
2017032600		70	55		55	55	20	75
2017032606	10		40		40	45	30	50
2017032612			25		25	20	30	20
2017032618	25		20		25	25	25	15
2017032700			5		20	10	20	10
2017032706	20	10	10		25	15	15	10
2017032712			0		15	0	5	0
2017032718			0		10	5	5	

5-day forecast intensity error								
Run	JTWC	BOM	HWRF	GFS	NAVGEM	GFDN	CMC	GFDL
2017032218			20					
2017032300			20					
2017032306			55					
2017032312			30					
2017032318			25					
2017032400			5		20	15	50	
2017032406			10		20	5	30	20
2017032412			0		15	5	10	5
2017032418	0		5		5	5		5

Model	**Average**	**Predictions**
JTWC	12.1	7
BOM	40	2
HWRF	18	30
GFS	0	0
NAVGEM	22.8	20
GFDN	19.5	20
CMC	18.2	19
GFDL	22.6	17

Therefore, the best agency for intensity predictions was the JTWC, and the best model was the HWRF.

3. Forecasting Critique

Data from the charts are published below.

2-day forecast track error								
Run	JTWC	BOM	HWRF	GFS	NAVGEM	GFDN	CMC	GFDL
2017032218			0.9	2.7				
2017032300			0.2	2.3				
2017032306			2.8	3.4				
2017032312			1.9	2.5				
2017032318			1.2	2.3				
2017032400			1.4	2	1.4			
2017032406			1.1	1.7	1			1.9
2017032412			0.5	2.7	1			1.2
2017032418	1.9		1	1.4	2.1			1.3
2017032500								
2017032506	3.9		2.9	0.9	3.7			3.5
2017032512			1.3	1.8	2.8			2.9
2017032518	4.3		2.4	3	4.1			2.5
2017032600		3.5	1	2.3	2.9			3.7
2017032606	4.7		3.2	3.5	3.6			4.5
2017032612			3.2	3.4	3.1			2.8
2017032618			3.1	3.6	3.2			3.4
2017032700			2.6	2.1	2.2			2.1
2017032706		1.9	1.6	1.7	1.8			1.5
2017032712			1.5	1.2	1.1			1.2

5-day forecast track error								
Run	JTWC	BOM	HWRF	GFS	NAVGEM	GFDN	CMC	GFDL
2017032218			1.1	9.9				
2017032300			2.6	8.8				
2017032306			8.1	9.8				
2017032312			7.6	7.2				
2017032318			6.1	5.1				
2017032400			5	4.7	5.8			
2017032406			3.8	4.1	2.4			5.7
2017032412			2.8	4.2	3.5			4.8
2017032418	7.2		0.5	2.1	7.6			1.1

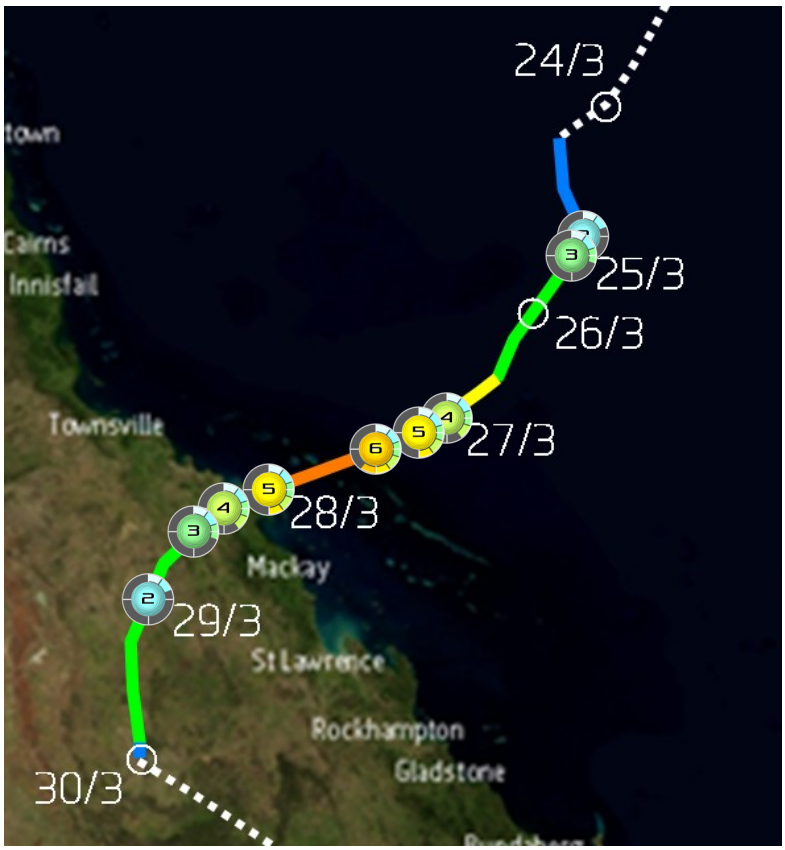
Model	**Average**	**Predictions**
JTWC	4.4	5
BOM	2.7	2
HWRF	2.6	28
GFS	3.6	28
NAVGEM	3.0	18
GFDL	2.8	16

Therefore, the best agency for track predictions was the BOM, and the best model was the HWRF.

4. Cyclone Destruction Potential Scale

The Cyclone Destruction Potential Scale (CDPS) is a new way of measuring cyclone impacts in a more meaningful way. For the past 45 years, storms worldwide have been measured using the Saffir-Simpson Hurricane Wind Scale, split into five categories. However, this scale measures wind alone, and does not correlate well with actual impacts on land, measured by monetary damage.
The CDPS measures other factors, such as storm size and forward speed as well as intensity to create a ten tiered scale that encompasses tropical storms as well as hurricanes.

Stage 1—Small or weak storms that are unlikely to cause a significant impact.
Stage 2—Generally disorganised storms that can cause significant damage.
Stage 3—Further organised systems that are likely to cause significant damage.
Stage 4—Somewhat powerful storms that are likely to cause extensive damage.
Stage 5—Powerful storms that are likely to cause devastating damages.
Stage 6—Very powerful storms that are likely to cause catastrophic damage.
Stage 7—Extremely powerful storms that are likely to cause catastrophic damage.
Stage 8—Super storms that are likely to cause incredible damage.
Stage 9—Super storms that may cause total damage.
Stage 10—Super storms that are likely to cause total damage.



Cyclone Debbie was the ninth storm to be observed by Force Thirteen using the CDPS—a method which was adopted in January 2017.

Debbie reached Stage 6 on the CDPS scale, the second highest seen this year after Cyclone Enawo.

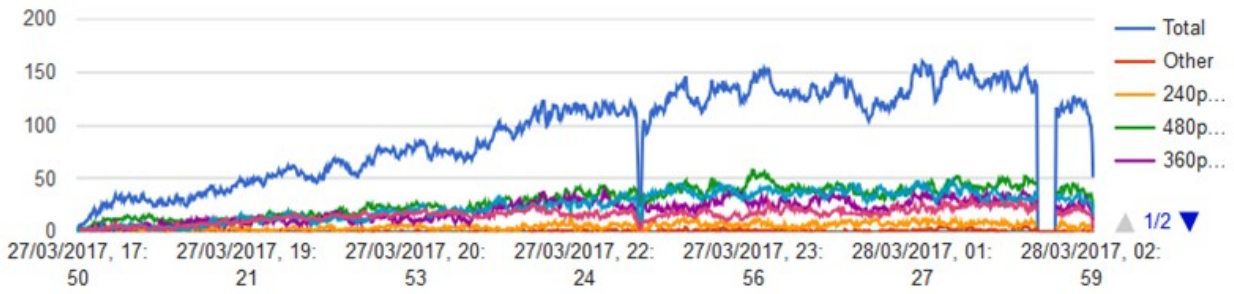
The Cyclone Destruction Potential Scale was created by Devon Williams in 2016. More information can be found at: https://drive.google.com/file/d/0B7pEWk6yHKggSE1STHg2UFJmbHM/view

5. Force Thirteen's Coverage on Debbie

Force Thirteen issued twelve updates and a further nine hours of live coverage on Cyclone Debbie. Four of the updates on the main channel were issued by Force Thirteen Australia. Force Thirteen Australia also issued fifteen updates on the system before and after naming.

The videos received a 95% approval rating overall.

One particular video during Force Thirteen's coverage of Debbie was a recording aboard the International Space Station. This video was picked up by the Sydney Morning Herald, ABC, MSN, Russia Today, CNN, Buzzfeed, Mashable, and The Guardian, and for a time became the number 1 top trending video on YouTube Australia. The video has also been used on dozens of other Australian national and local news websites. The video quickly became the most viewed and most liked video ever on the Force Thirteen channel, amassing over 330,000 viewings by April 3rd.



Additionally, Force Thirteen's live stream was viewed by over 8,000 during the impending landfall of Debbie, as the graphic shows above. Viewing gradually picked up throughout the stream as day broke over Australia.

Overall, the channel reached 413,147 viewers during the life of Debbie, broken down geographically:

Australia	306,308
United States	22,181
New Zealand	17,825
United Kingdom	6,824
Canada	4,627
Germany	3,342
India	3,900
Philippines	2,954
South Africa	2,719
Mexico	2,392
Others	40,075

The channel also received donations during the event and the live stream, which was greatly appreciated. Force Thirteen runs without external funding, and all donations received are invested directly into project resources to enhance the coverage from all facets of the project.

Comments, suggestions and inquiries should be directed to force-13@hotmail.co.uk, or any of Force Thirteen's online platforms.