Australian Government
Bureau of Meteorology

Tropical Cyclone *Inigo*

30 March – 8 April 2003

Perth Tropical Cyclone Warning Centre
Bureau of Meteorology

A. Summary

Inigo was a small cyclone that developed into one of the strongest cyclones ever monitored by satellite in the WA region having estimated sustained winds of 130 knots at peak intensity at 1400 WST (0600 UTC) 4 April about 830 km north-northwest of Karratha. However, the system weakened rapidly due to wind shear as it approached the coast and caused no known damage on the mainland.

During its development phase, however, the low crossed over parts of eastern Indonesia producing heavy rain that caused landslides and flooding. At least 50 people were killed. Many thousands of homes were destroyed or severely damaged and damage to infrastructure and crops was estimated to approach A$10 million. Thousands of hectares of rice fields and plantations, several hundred houses, churches, schools, three bridges, dozens of cars and motor bikes were damaged or swept away. Flood waters in some areas were up to 5 metres deep.

Two Indonesian fishing vessels, with about five to eight crew each, were reported missing several days after *Inigo* passed over their position near 12°S. Although no further information is available, presumably both vessels went down as *Inigo* was nearing its peak intensity at their location.

B. Meteorological Description

Intensity Analysis
A westward-moving convective disturbance near PNG in the monsoon trough on 26 March formed into a broad low pressure area over Irian Jaya the following day, north of the upper ridge in an area of easterly shear. On 28 March, an increase in convection over the northern Arafura Sea was associated with a developing middle-level circulation. This feature showed improved organization early the next day as a low-level easterly wind surge interacted with the system.

During 29 and 30 March, the low-mid level circulation was identifiable up to 500 hPa as it moved west at around 13 km/h across the Banda Sea, north of

Timor. During this period, cloud system organization appeared to be limited by easterly shear and Quikscat passes indicated that light easterly flow persisted at the surface. On 31 March, the disturbance turned towards the southwest and moved over the eastern end of the island of Flores. Strong upper divergence enhanced convection near the system centre, causing heavy rainfall in Flores and Timor, but the development of a strong low-level circulation appeared to be impeded by interaction with the islands.

Early on 1 April, the low moved into the Savu Sea and commenced a period of rapid intensification as north-easterly shear decreased slightly. A Central Dense Overcast (CDO) pattern developed overnight, and curved bands on the western side of the system wound tightly into the system centre. Cyclone intensity is estimated at 1400 WST (0600 UTC) 1 April when visible imagery showed a ragged eye feature about 1 degree diameter. An eye feature was more evident in the 1452 WST (0652 UTC) TRMM microwave image, with an inner diameter of about 20 nm, and the western eye wall located over the island of Sumba. Notably, at 850 hPa, the 0800 WST (0000 UTC) 1 April wind analysis showed only 15 knot winds just over 1 degree from the Low Level Circulation Centre (LLCC) (at Waingapu, Sumba), emphasizing the small scale of the system. The subsequent (0943 UTC) Quickscat image showed an area of gale-force winds to the south even though the centre was over Sumba Island.

The cyclone's development was arrested as it passed over Sumba, an island about 75 km wide having a mountain range to 550 km. However, once clear of the island it recommenced rapid intensification from 1800 UTC. Operationally the cyclone was not named *Inigo* until 0800 WST (0000 UTC) 2 April. Low wind shear and strong upper divergence to the south persisted on the following days allowing *Inigo* to rapidly develop reaching category 5 intensity and Dvorak CI of 7.0 on 4 April (see Fig. 2).

Inigo reached peak intensity at about 1400 WST (0600 UTC) 4 April when the mean 10 minute winds were estimated at 130 knots. At 1400 WST (0600 UTC) 4 April the visible image (see Fig. 3) showed a well defined eye about 30 km in diameter within a smooth CDO with an embedded distance of one degree. The Dvorak enhanced infra-red image indicated a DT of 7.0 based on a surrounding temperature of CMG equivalent to an Eno. of 6.0 plus an eye adjustment factor of 1.0 (eye temperature of WMG surrounded by CMG). Using the standard Atkinson and Holliday pressure-wind relationship and an environmental pressure of 1008-1009 hPa this suggests a central pressure of about 900 hPa. Other more recent studies investigating the influence of TC size may suggest that the central pressure was higher than 900 hPa given *Inigo*'s small size.

Later on 4 April and the following day, *Inigo* began to weaken and with the approach of a strong upper level trough from the west, upper level winds gradually increased. This process was particularly evident on 6-7 April as *Inigo* re-curved to the south-southeast towards the Pilbara coastline. *Inigo* crossed the coast at approximately 1300 WST (0500 UTC) near Mardie station. At this time the system is estimated to have weakened below tropical

cyclone intensity although surface winds at Mardie, Karratha, Varanus Island and Barrow Island were near gale-force.

Motion
A mid to upper level ridge over northern Australia steered the developing low moved in a steady west to southwest direction. The course changed slightly to the southwest as *Inigo* moved west of 120°E. By 4-5 April the ridge was eroded to the south and an approaching mid-level trough caused *Inigo* to abruptly re-curve towards the south-southeast on 6 April. As steering winds increased *Inigo* rapidly sheared. The low level centre gradually accelerated but only reached a speed of 20 km/h as it crossed the coast.

C. Impact

During the development phase of *Inigo*, the low crossed over parts of eastern Indonesia producing heavy rain that caused landslides and flooding. At least 50 people were killed: 31 in the Ende district on Flores Island, 10 in the east Flores district and 9 in the Sikka district on Besar Island. Many thousands of homes were destroyed or severely damaged and damage to infrastructure and crops was estimated to approach A$10 million. 24-hour rainfall totals on 2 April on the island of Flores were 223 mm at Larantuka and 164 mm at Maumere. Mudslides 'wiped out' Ndona town. Thousands of hectares of rice fields and plantations, several hundred houses, churches, schools, three bridges, dozens of cars and motor bikes were damaged or swept away. The towns of Ende and Larantuka were flooded, schools and government offices shut, water and power supplies cut off and thousands of people evacuated. Flood waters in some areas were up to 5 metres deep. Seven villages were also flooded by the Oessao River in east Kupang district, West Timor, displacing residents and contaminating water supplies. (source http://www.relief.int, Jakarta Post).

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The intensity of *Inigo* had created tremendous media and public interest in the days prior to coastal crossing. Although forecasts consistently emphasized significant weakening to a probable Category one to two coastal impact, Pilbara coastal communities were prepared for the possibilities of a Category 3 (severe) impact. Pastoralists anticipating heavy rainfall after a poor 'wet season' were disappointed when *Inigo* collapsed at landfall. However, a severe thunderstorm developed as *Inigo* passed near to Mardie station. Although no damage was reported, 148.8 mm of rain fell in just two hours and 101.8 mm in one hour (total rainfall was 173.6 mm). The radar sequence shows the storm had characteristics of being severe and occurred in an environment of high low-level shear and abundant low cloud moisture. There were some industrial losses due to shutdowns and reduced operations as *Inigo* approached the Pilbara coast.

D. Observations

Wind/Pressure
Surface observations are only available as *Inigo* neared the WA coastline. The lowest recorded pressure of 997.7 hPa was measured at Mardie as *Inigo* crossed the coast.

Rainfall
Mardie Station recorded 173.6 mm in the 24 hour period to 9am on 9 April, with 148.8 mm of this total falling in just 2 hours.

E. Forecast Performance

Although the rate of development and weakening was underestimated, in general forecast performance was good. Forecast tracks, based upon a consensus of a range of models proved consistent. The models also identified the re-curvature of *Inigo*. Models also were generally consistent as *Inigo* tracked toward the coast.

The first watch was issued at 1600 WST on 5 April for areas between Coral Bay and Port Hedland. The first warning was issued at 1545 WST on 6 April for areas between Onslow and Wallal. Overall, the community were relieved that *Inigo* weakened rapidly as it approached the coast although pastoralists were disappointed at the lack of rain.

Table 1. Best track summary for *Inigo,* 31 March – 8 April 2003.
Note: Add 8 hours to convert to WST. Refer to best track database for complete track details.

Year	Month	Day	Hour (UTC)	Position Latitude S	Position Longitude E	Max wind 10min knots	Central Pressure hPa	Rad. of Gales nm
2003	03	31	0000	7.7	124.0	20	1006	
2003	03	31	0600	8.3	123.0	20	1004	
2003	03	31	1200	8.6	122.3	20	1004	
2003	03	31	1800	8.8	121.9	20	1002	
2003	04	1	0000	9.1	121.5	25	1000	
2003	04	1	0600	9.6	121.0	35	994	30
2003	04	1	1200	10.0	120.3	35	995	60
2003	04	1	1800	10.3	119.8	40	992	60
2003	04	2	0000	10.7	119.5	45	990	105
2003	04	2	0600	11.1	119.0	55	985	105
2003	04	2	1200	11.3	118.6	60	975	105
2003	04	2	1800	11.4	118.4	65	965	105
2003	04	3	0000	11.8	118.0	75	960	105
2003	04	3	0600	11.9	117.5	85	950	105
2003	04	3	1200	12.1	117.0	100	935	120
2003	04	3	1800	12.4	116.4	105	920	150
2003	04	4	0000	12.6	115.8	120	910	150
2003	04	4	0600	13.1	115.2	130	900	150
2003	04	4	1200	13.6	114.5	130	900	150
2003	04	4	1800	14.0	114.0	125	905	150
2003	04	5	0000	14.3	113.6	120	910	150
2003	04	5	0600	14.4	113.2	115	915	150
2003	04	5	1200	14.6	113.0	105	925	120
2003	04	5	1800	14.8	112.9	95	935	120
2003	04	6	0000	15.0	112.8	90	945	105
2003	04	6	0600	15.3	112.7	85	950	105
2003	04	6	1200	15.6	112.9	80	955	105
2003	04	6	1800	16.0	113.2	75	960	105
2003	04	7	0000	16.6	113.5	70	970	105
2003	04	7	0600	17.5	113.9	60	980	105
2003	04	7	1200	18.3	114.4	50	988	80
2003	04	7	1800	19.1	114.9	40	992	40
2003	04	7	2100	19.5	115.1	35	992	40
2003	04	8	0000	20.0	115.3	35	995	30
2003	04	8	0300	20.6	115.6	35	997	
2003	04	8	0600	21.1	116.0	35	997	
2003	04	8	0900	21.5	116.5	25	1000	

Figure 1. Track of Tropical Cyclone *Inigo* 31 March – 8 April 2003.
All times in WST.

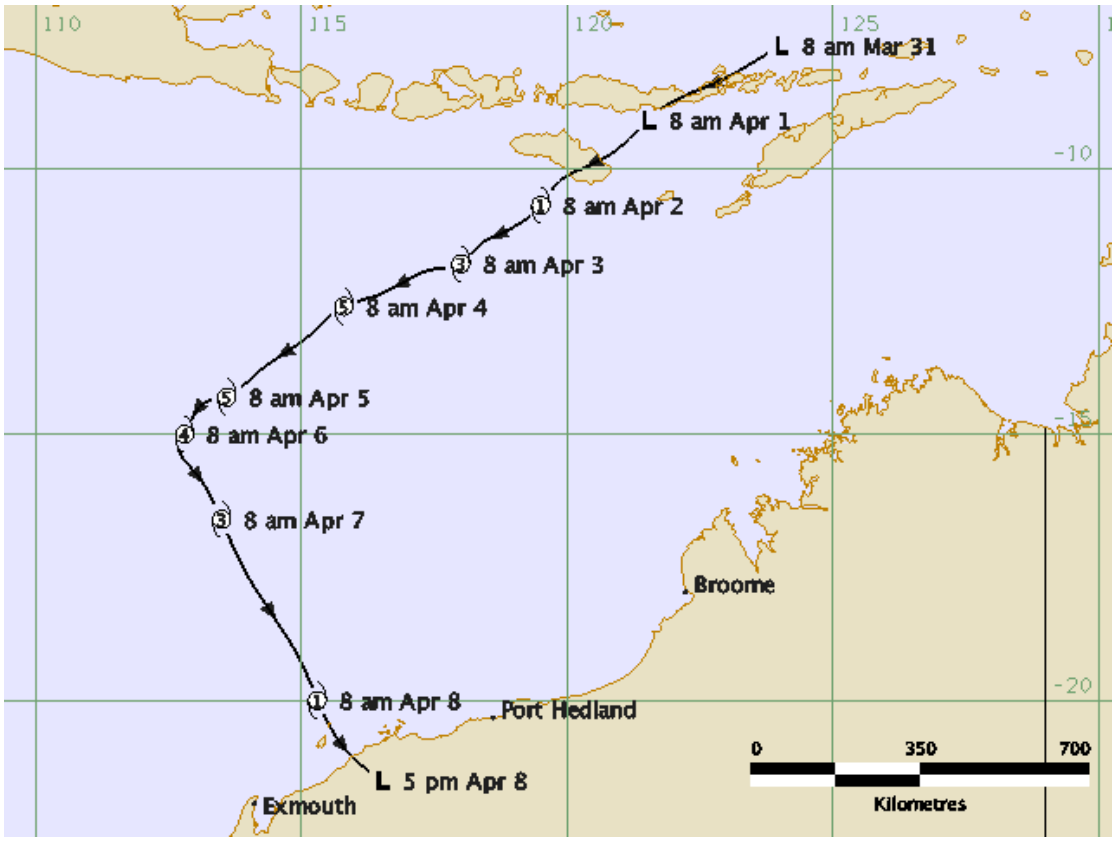

Figure 2.TRMM 85GHz Microwave image of Tropical Cyclone *Inigo*, 1629 UTC 3 April 2003.
(image courtesy of US NRL: http://www.nrlmry.navy.mil/)

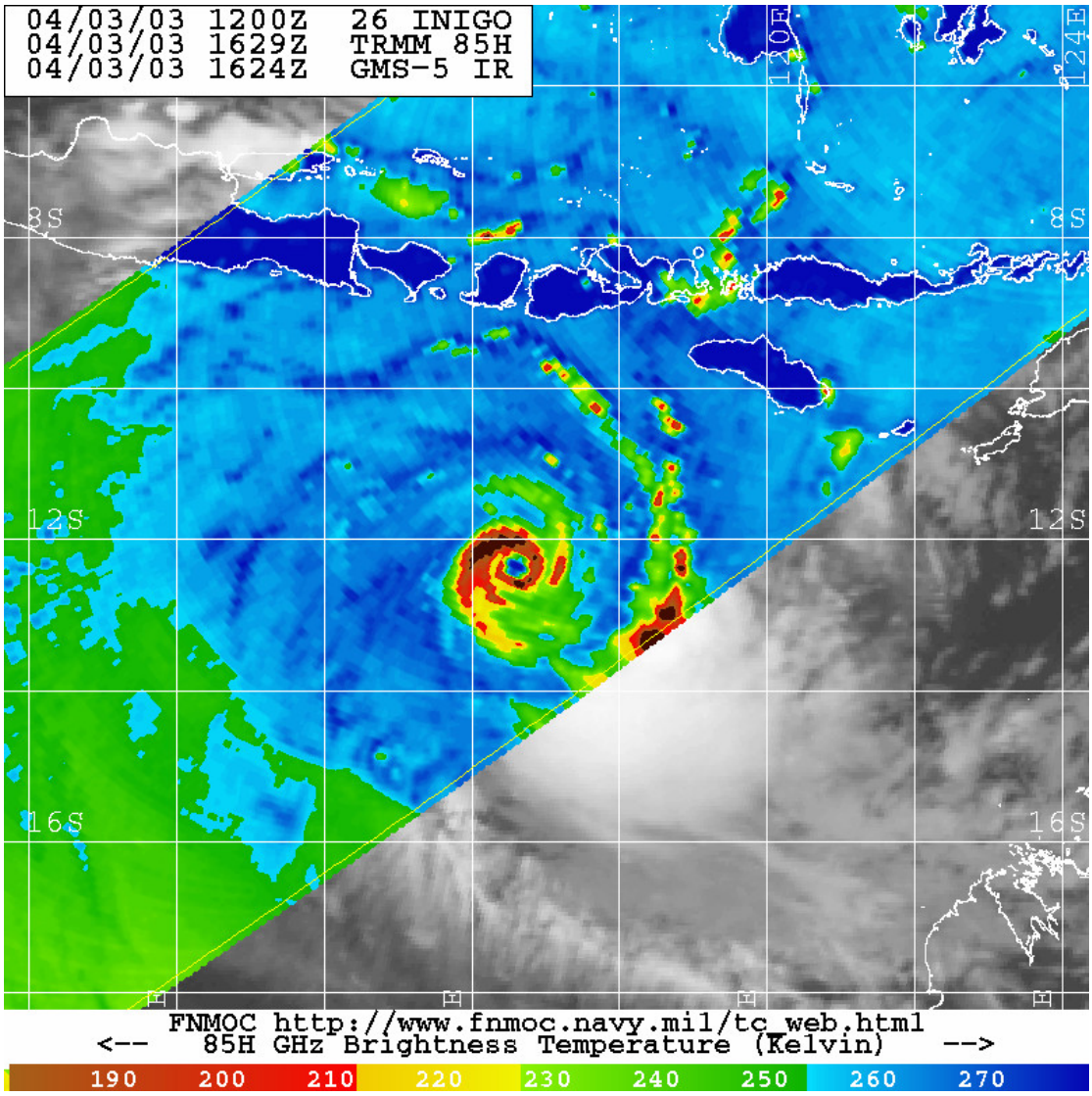

Figure 3.Visible image of Tropical Cyclone *Inigo*, near maximum intensity 0530 UTC 4 April 2003.
(image courtesy of US NRL: http://www.nrlmry.navy.mil/)