The Bureau of Meteorology

Tropical Cyclone Ellie

21 December 2022 – 8 January 2023

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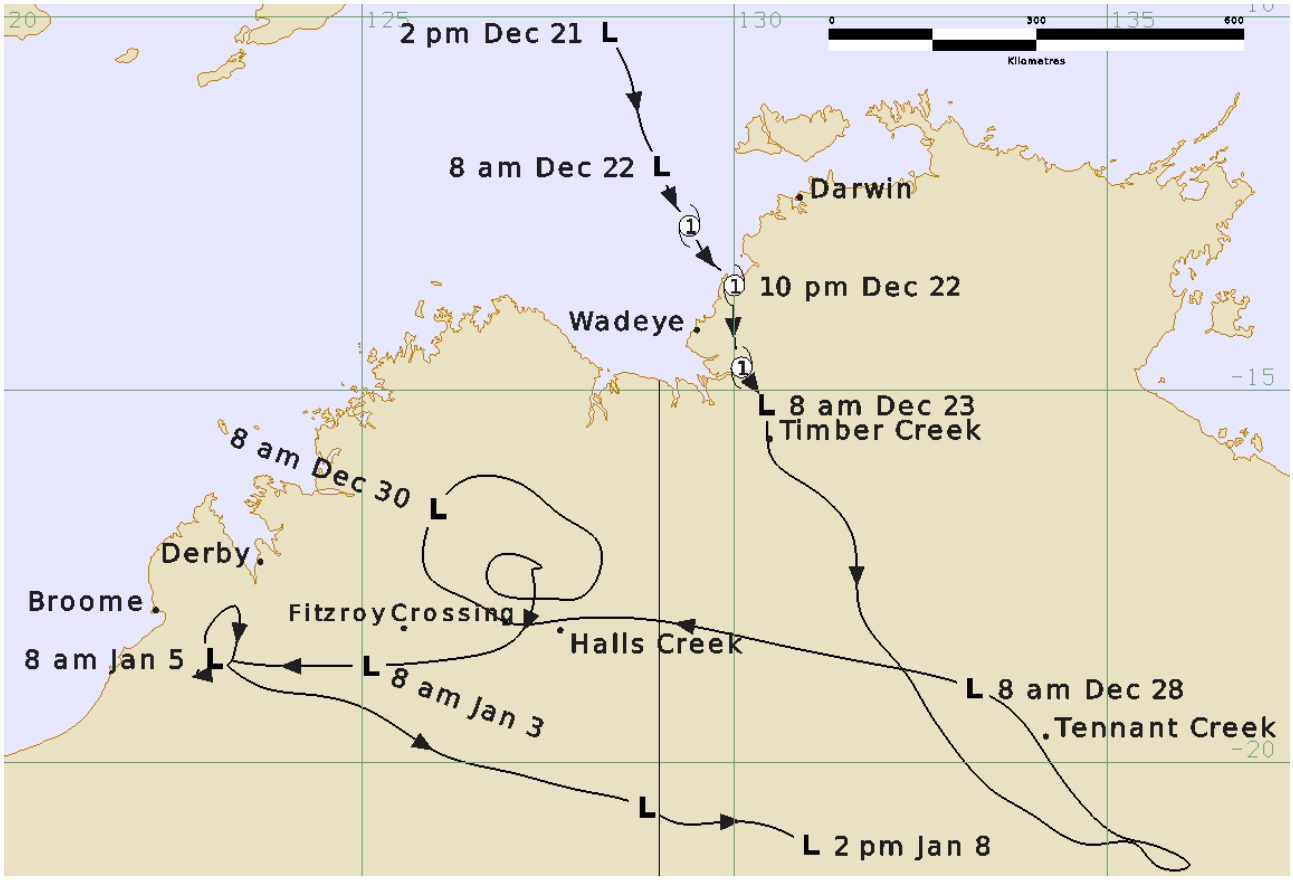

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Cover image: Track of Tropical Cyclone Ellie

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1. Summary

Although Ellie's time as a tropical cyclone near the Northern Territory coast was short lived, as a tropical low it spent two weeks over the Northern Territory and the Kimberley region of Western Australia where it was responsible for enormous rainfall and flooding impacts.

A tropical low formed within the monsoon trough to the northwest of Darwin in the Timor Sea on 21 December and intensified quickly as it moved south. The low reached tropical cyclone intensity on the evening of 22 December with a peak 10-minute mean wind intensity of 40 knots (kn) (75 kilometres per hour (km/h)). Tropical Cyclone Ellie crossed the Northern Territory coast just south of the Daly River mouth at 1400 Universal Time Co-ordinated (UTC) (2330 Australian Central Standard Time (ACST)). Ellie continued moving inland and weakened below tropical cyclone intensity during the morning of 23 December. Refer to the tracks in Figure 1 (entire track) and Figure 2 (track 21–23 December). See Table 1 for tabulated parameter estimates for the period 21–23 December.

As a tropical low, Ellie continued moving southeast across central parts of the Northern Territory where heavy rainfall led to flooding in many communities, most notably Timber Creek, and cut major roads. From 27 December it was steered to the northwest and moved into the Kimberley on 29 December. The low became slow moving over the inland Kimberley and aided by a strong monsoon flow to the north, produced multiple days of heavy rainfall. The Fitzroy River reached its highest levels on record, peaking at 15.81 metres (m) at Fitzroy Crossing on the afternoon of 4 January, isolating the town and many other nearby communities. Over 200 people were evacuated from various communities throughout the Fitzroy Valley. The Great Northern Highway bridge at Fitzroy Crossing sustained significant damage beyond repair. The bridge is usually relied on as the only all-weather road connection between the west and east Kimberley. Road transport to Fitzroy Crossing had to be rerouted while a barge and low-level floodway solutions were implemented. Main Roads WA anticipate that it will take one to two years to replace the bridge.

On 3 January the low moved further west towards Broome and became slow moving for several days. Although it remained over land, the system strengthened causing gales over west Kimberley waters on 4 January. A peak wind gust of 53 kn (98 km/h) was recorded at the Broome National Tidal Centre (NTC) automatic weather station (AWS) at 2055 UTC 4 January (0455 Australian Western Standard Time (AWST) 5 January). Heavy rainfall continued to be associated with the system and Broome also became cut-off by road due to flooding across the Roebuck Plains. The system began moving southeast once more on 6 January, eventually dissipating over the southwest of the Northern Territory on 8 January.

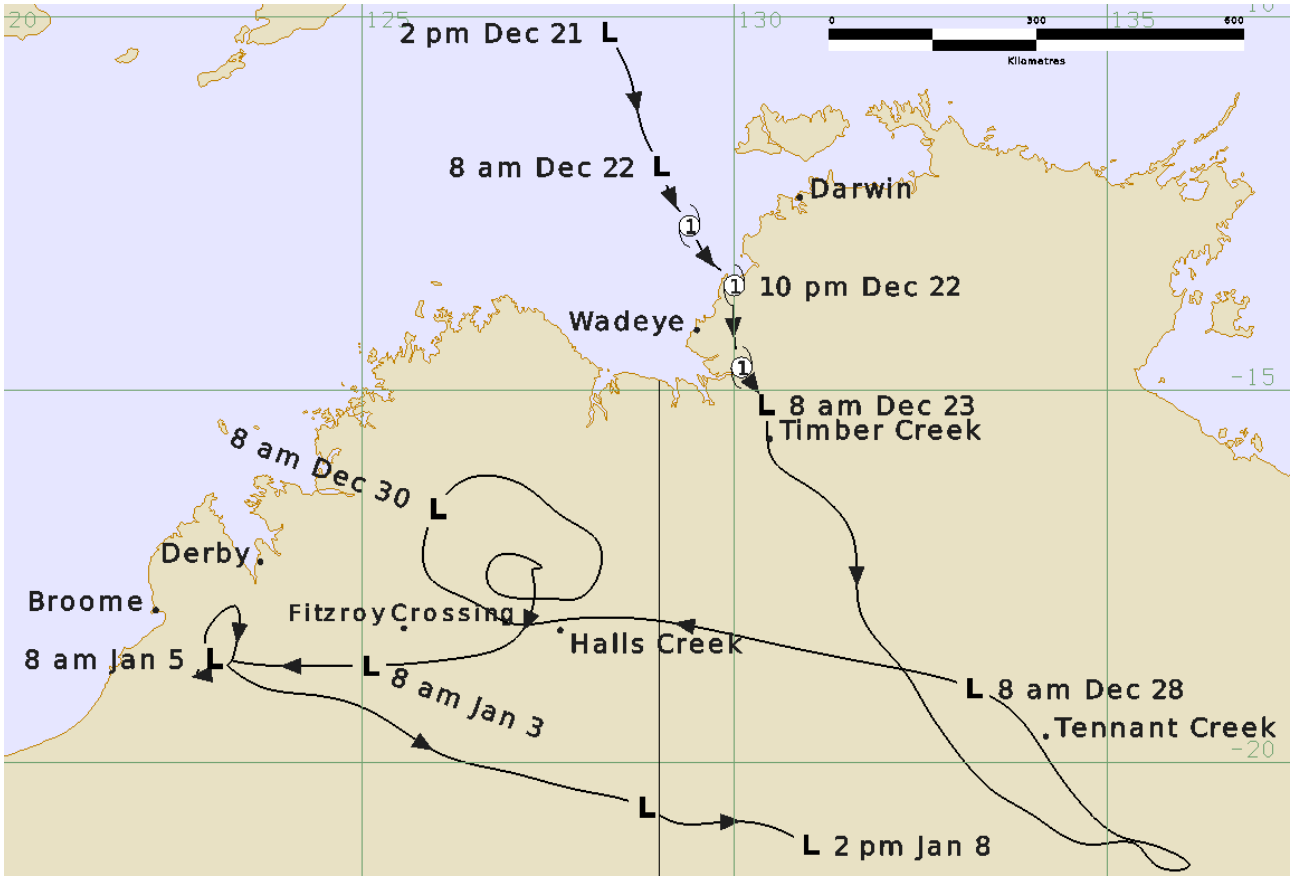

Figure 1. Best Track of Tropical Cyclone Ellie (times in AWST, UTC +8).

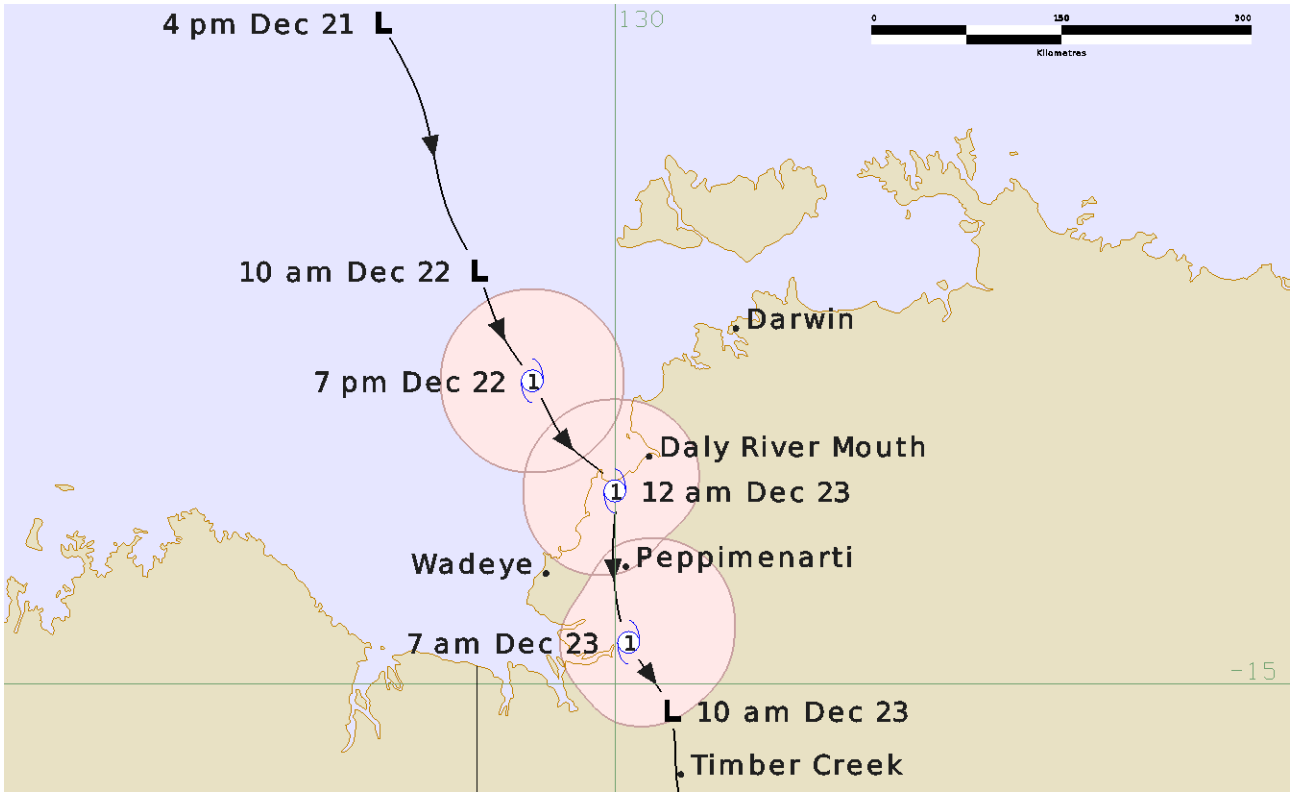

Figure 2. Best Track of Tropical Cyclone Ellie as it crossed the Northern Territory coast (times in ACST, UTC +9.5). The area of gale-force winds are shown in pink.

Table 1. Best track summary for Severe Tropical Cyclone Ellie 21-23 December 2021

Refer to the Australian Tropical Cyclone database for complete listing of parameters to 8 January 2023. UTC=ACST-9.5h or WST-8h.

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	12	21	0600	10.2	128.3	45	20	45	1000	0/0/0/0	0/0/0/0	-
2022	12	21	1200	10.8	128.6	30	25	45	1000	0/0/0/0	0/0/0/0	-
2022	12	21	1800	11.6	128.8	30	25	45	998	0/0/0/0	0/0/0/0	-
2022	12	22	0000	12.0	129.0	30	25	45	998	0/0/0/0	0/0/0/0	-
2022	12	22	0600	12.5	129.2	20	30	45	996	0/0/0/0	0/0/0/0	-
2022	12	22	0900	12.8	129.4	15	40	55	995	40/40/40/40	0/0/0/0	15
2022	12	22	1200	13.3	129.7	10	40	55	990	40/40/40/40	0/0/0/0	15
2022	12	22	1400	13.6	130.0	10	40	55	990	40/30/40/40	0/0/0/0	10
2022	12	22	1500	13.8	130.0	10	40	55	991	40/30/30/40	0/0/0/0	15
2022	12	22	1800	14.3	130.0	15	40	55	992	40/35/30/30	0/0/0/0	15
2022	12	22	2100	14.7	130.1	15	40	55	992	50/40/30/30	0/0/0/0	15
2022	12	23	0000	15.2	130.4	15	30	45	996	0/0/0/0	0/0/0/0	-
2022	12	23	0600	15.9	130.5	20	20	45	998	0/0/0/0	0/0/0/0	-

2. Meteorological description

2.1. Intensity analysis

The Madden-Julian Oscillation strengthened over Australian longitudes during mid to late December and this coincided with an active monsoon burst across the north of Australia. An area of enhanced convection became evident on satellite imagery during 20 December. During 21 December some rotation in the convection could be seen and a Dvorak T number 1.0 was assigned at 0600 UTC 21 December. Weak convective spiral bands began to form; however, by 1200 UTC only a small area of convective cloud remained; which exhibited a sharp temperature gradient on the eastern boundary. By 1500 UTC 21 December the convective cloud had begun to take on a curved band appearance with more deep convection forming nearby.

By 0000 UTC 22 December visible (VIS) imagery revealed several convective spiral bands around a low-level centre. The bands continued to improve and wrap more closely around the centre of a very small system. By 0600 UTC the three-hour average DT had increased to be close to 3.0 however the FT number was constrained to 2.5 at this time. As the low tracked towards the Northern Territory coast the FT reached 3.0 by 0900 UTC 22 December and microwave imagery showed strong curvature in the deep convection (refer 89GHz SSMIS image at 1007 UTC in Figure 3). The Berrimah radar located at Darwin was used to track Ellie and it showed the tropical cyclone improved in structure as it approached the coast. An Hai Yang 2B (HY 2B) scatterometer pass at 0924 UTC (refer Figure 4) showed gales in at least the western quadrants of the system and the tropical low was deemed to have reached tropical cyclone intensity at this time. The low tracked steadily towards the coast and crossed just to the south of the Daly River mouth as a Category 1 tropical cyclone at 1400 UTC 22 December with a peak 10-minute mean wind intensity of 40 kn (75 km/h). Ellie weakened once over land and was estimated to be below tropical cyclone intensity at 0000 UTC 23 December.

Ellie remained a well-developed low over land for many days as it tracked first to the southeast and then back to the west. The circulation was invigorated by the inflow of warm moist monsoonal flow as it tracked west across the Kimberley. The low was located near Broome by 3 January and periods of gales were recorded at the Broome NTC AWS during 3 and 4 January (UTC) and a maximum wind gust of 48 kn (89 km/h). The SSMIS microwave pass at 1940 UTC 4 January in Figure 5 shows strong curvature in the convective band over water at the time Broome was recording gales. By 6 January the low tracked east away from the coast and began to weaken, dissipating over land on 8 January.

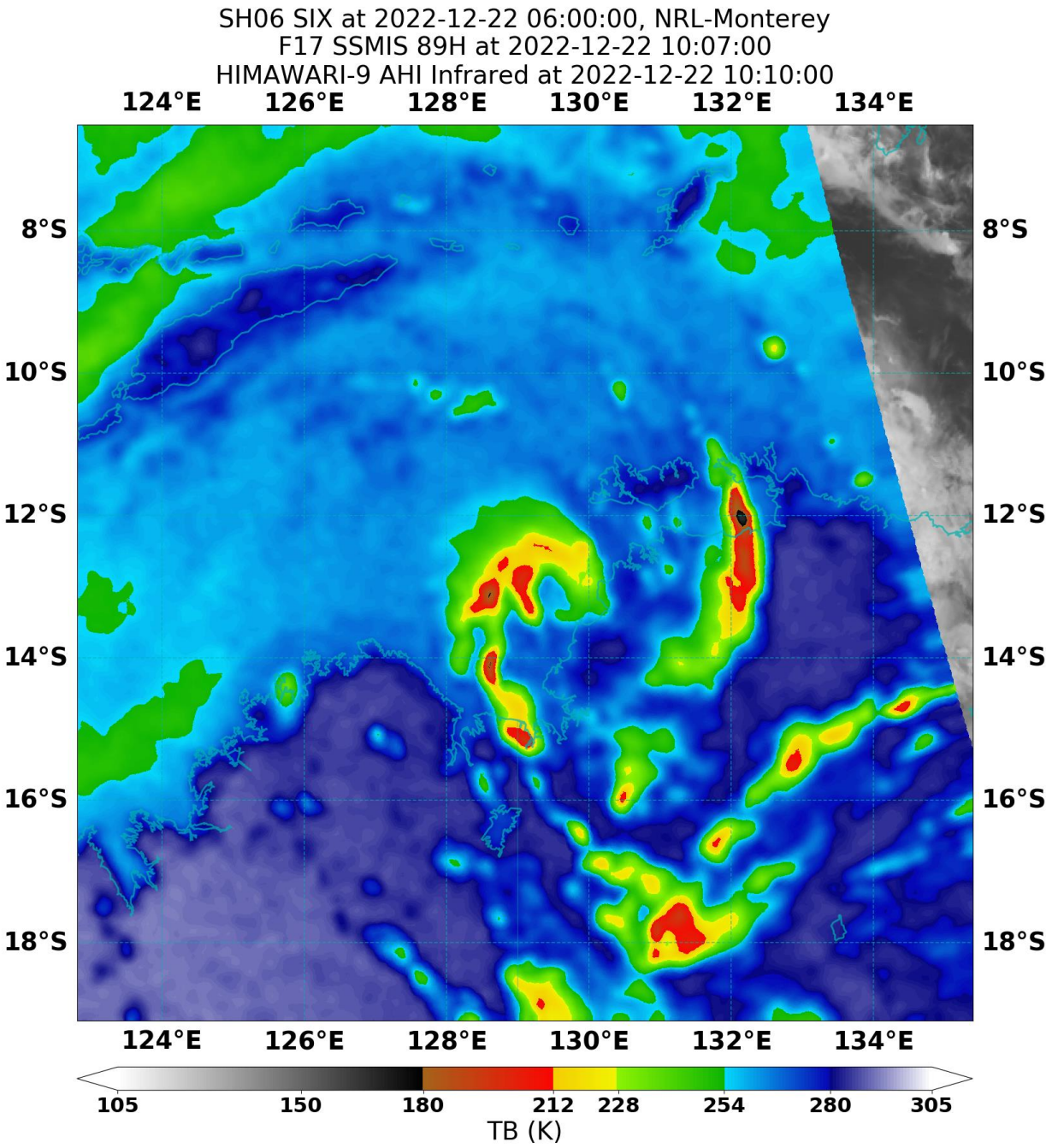

Figure 3. Special Sensor Microwave Image Sounder (SSMIS) 89 GHz microwave image at 1007 UTC 22 December, a few hours before landfall. Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

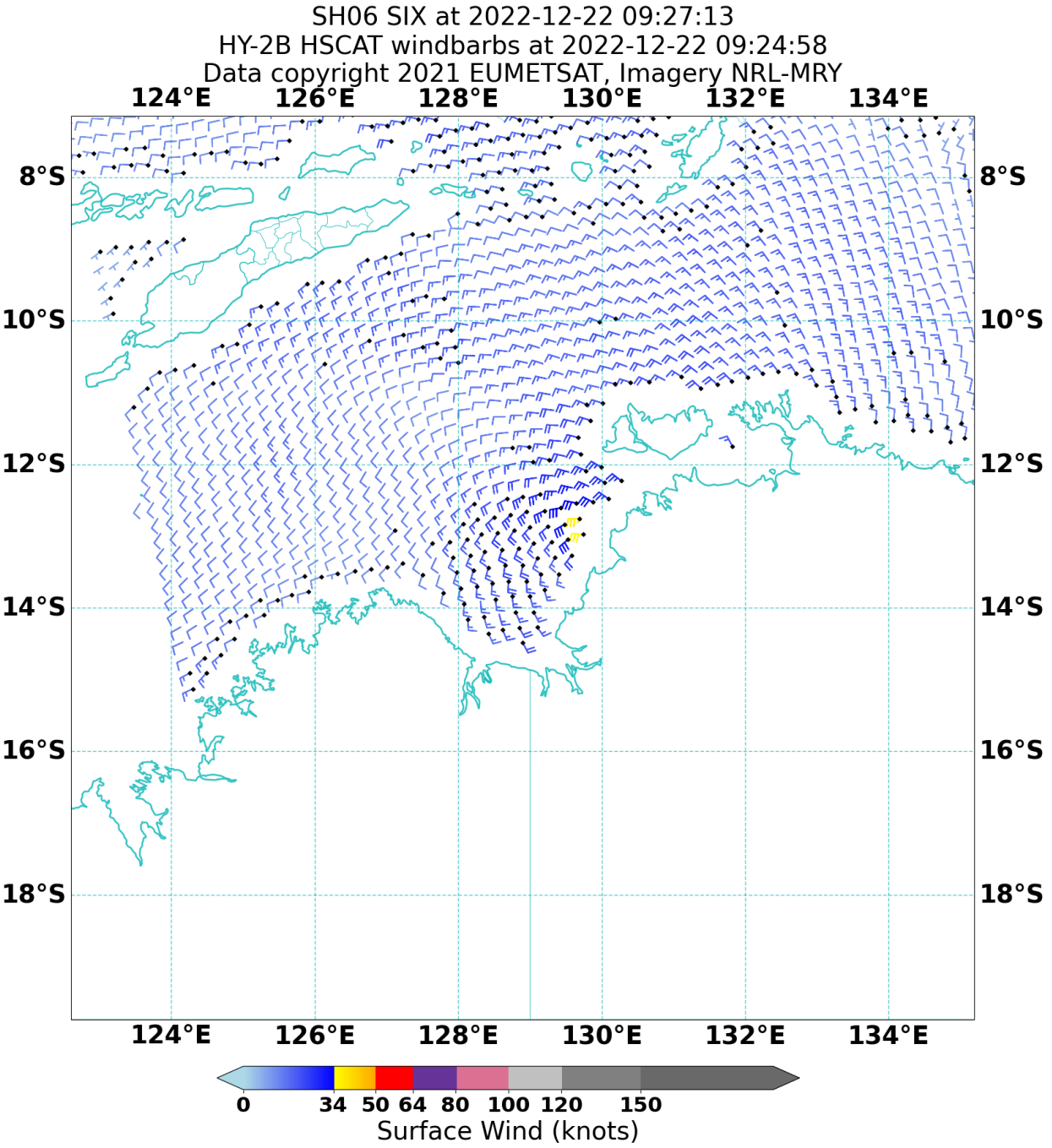

Figure 4. Hai Yang (HY-2B) scatterometer pass at 0924 UTC 22 December showing gales in at least the western quadrants. Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

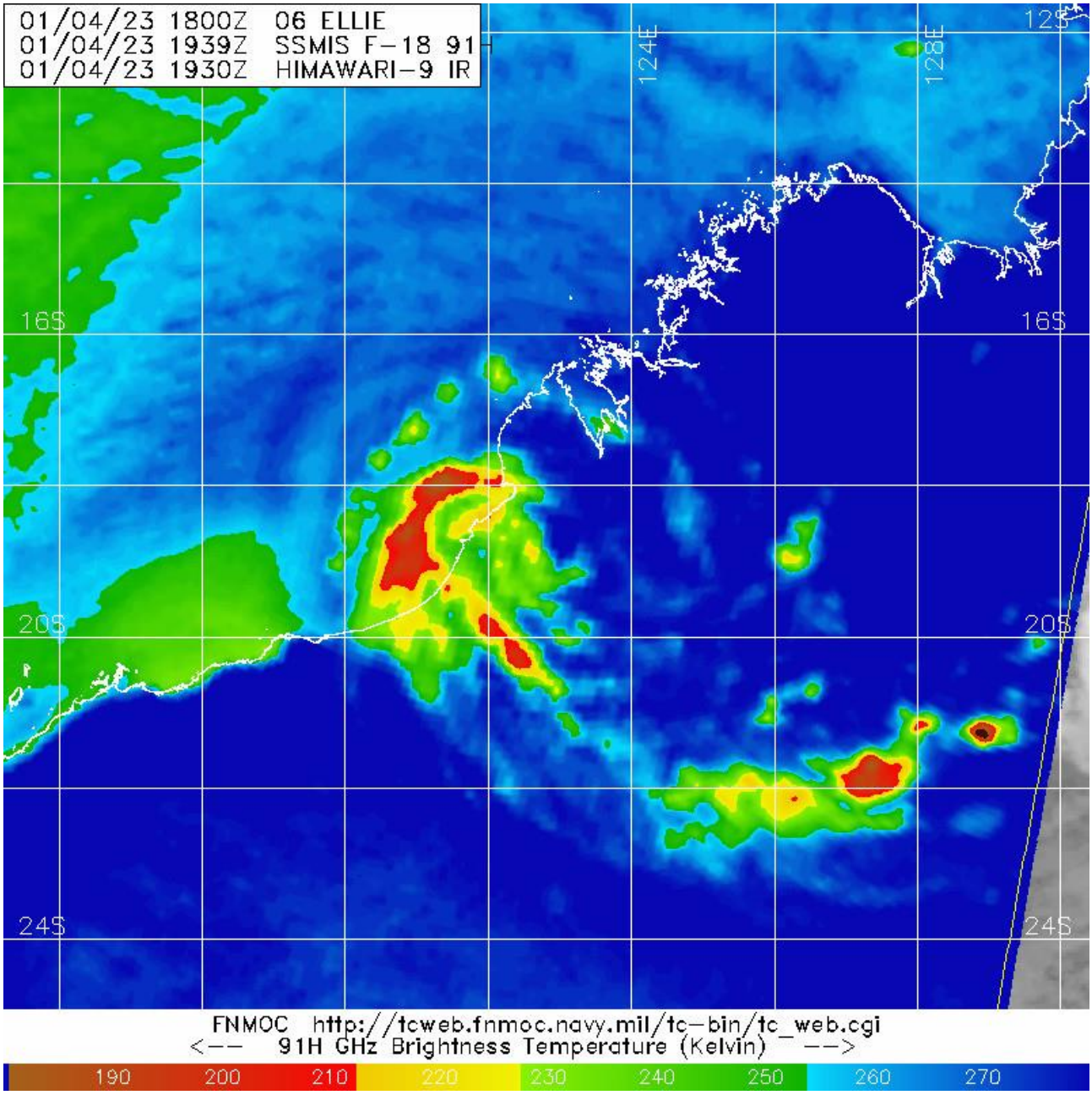

Figure 5. SSMIS 89GHz microwave image at 1940 UTC 4 January as Broome recorded a period of gale force winds. Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

2.2. Structure

Ellie was a very small tropical cyclone with a radius to gales that ranged from 30 to 50 nautical miles (nm) (55 to 75 km) as it formed and crossed the Northern Territory coast. The radius to maximum winds (RMW) was 15 nm (28 km).

The radius to gales was larger during the period 3 and 4 January while the low was inland from Broome. The southwest quadrant was steady at 80 nm (150 km) but the northwest quadrant ranged from 90 to 120 nm (165 to 220 km).

2.3. Motion

During formation the steering flow for Ellie was dominated by a ridge to the east and the well-developed monsoon to the north. The ridge to the east led to strong northerly steering winds on the eastern side of the system, that combined with the vigorous monsoon flow, pushed Ellie towards the south southeast until 27 December. Once Ellie crossed the coast and weakened, steering would have been influenced by the lower levels of the atmosphere rather than the mid to upper levels. Steering influences were then weak, with a monsoon trough across northern Australia and a moderate high-pressure system located in the Great Australian Bight. Under this regime the low moved very slowly west across the Kimberley until 5 January. As the high in the Bight retreated eastwards ahead of a trough over Western Australia, Ellie also began to move slowly eastwards, until it dissipated well inland on 8 January.

3. Impact

3.1 Wind

Wind impacts were minimal, given that Tropical Cyclone Ellie was a small system that crossed the coast at a remote location southwest of Daly River Mouth. Gales were not recorded at any location, although strong winds were described at Peppimenarti in media reports as the system passed close by overnight on 22-23 December. Trees were felled and tents were flattened, adding to accommodation shortages in the community (https://www.abc.net.au/news/2022-12-24/cyclone-ellie-displaces-homeless-residents/101806274 accessed 19 Feb 2023).

As ex-Tropical Cyclone Ellie approached the west Kimberley coast on 4 January, gales were recorded at Broome Jetty and were likely to have also occurred along the west coast of the Dampier Peninsula. Aside from significant disruptions to road transport, there was no damage reported.

3.2 Heavy rain and flooding

The most significant impacts were associated with heavy rain and flooding across the Northern Territory and the Kimberley region in Western Australia.

Roads were extensively affected, either by being made impassable or being damaged. Affected communities included:

- Peppimenarti experienced local flooding.
- One Mile and Myatt communities – flooding on 23 December with evacuation of outlying communities to Timber Creek. A car near Timber creek was washed off the road with the motorist requiring recue and dozens of individuals displaced. The Victoria Highway (part of national Highway 1) was damaged cutting NT off from WA around 25 December.
- Heavy rain in central NT caused closure of the Stuart and Barkley highway cutting the Northern Territory 'Top End' off from the remainder of the country.

Photo: 1. The Stuart Highway flooded between Tennant Creek and Alice Springs in late December. Source: Facebook: Steve Edgington MLA.

- As Ex TC Ellie shifted into the Kimberley region exceptionally heavy rain commenced with some locations exceeding 0.5% to 0.05% AEP over 24–72 hour time periods. The rainfall resulting in the largest flooding in modern recorded history in Martuwarra (the Fitzroy River).
- Communities impacted in early January included Kupungarri near Mount Barnett, Muludja, Darlngunaya, Bungardi, Burawa, Junjuwa, Mindi Rardi, Kurnangk and Parukupan around Fitzroy Crossing.
- The Fitzroy River flood exceeded all previous records by over a metre at both Fitzroy Crossing and Willare and by smaller margins at Dimond Gorge, Noonkanbah, Fitzroy Barrage and Looma.
- Over 600 residents were evacuated with at least 40 homes and businesses destroyed with many more damaged.
- During the recovery effort over 300 Australian Defence Personnel assisted with recovery and evacuation efforts using multiple fixed and rotary wing assets to such an extent that a mobile air traffic control centre was deployed to manage over 200 air movements a day from Fitzroy Crossing.
- Property inundation occurred downstream of Fitzroy Crossing at Yungngora (near Noonkanbah) and Camballin.
- Extensive road and infrastructure occurred throughout the Fitzroy region, including destruction of the Fitzroy River bridge which handles Great Northern Highway traffic, sewer and electricity line destruction and millions of dollars of bitumen and road damage, particularly at Willare.

Photo: 2. The Great Northern Highway flooded and destroyed west of Willare. Source: Facebook: Kimberley Police.

Photo: 3. The Great Northern Highway at Fitzroy Crossing Bridge. Source: Facebook

- Heavy rain associated with ex-TC Ellie caused significant flooding on the Great Northern Highway south of Broome around Roebuck Plains closing the road for a number of days, however only minor damage was reported.

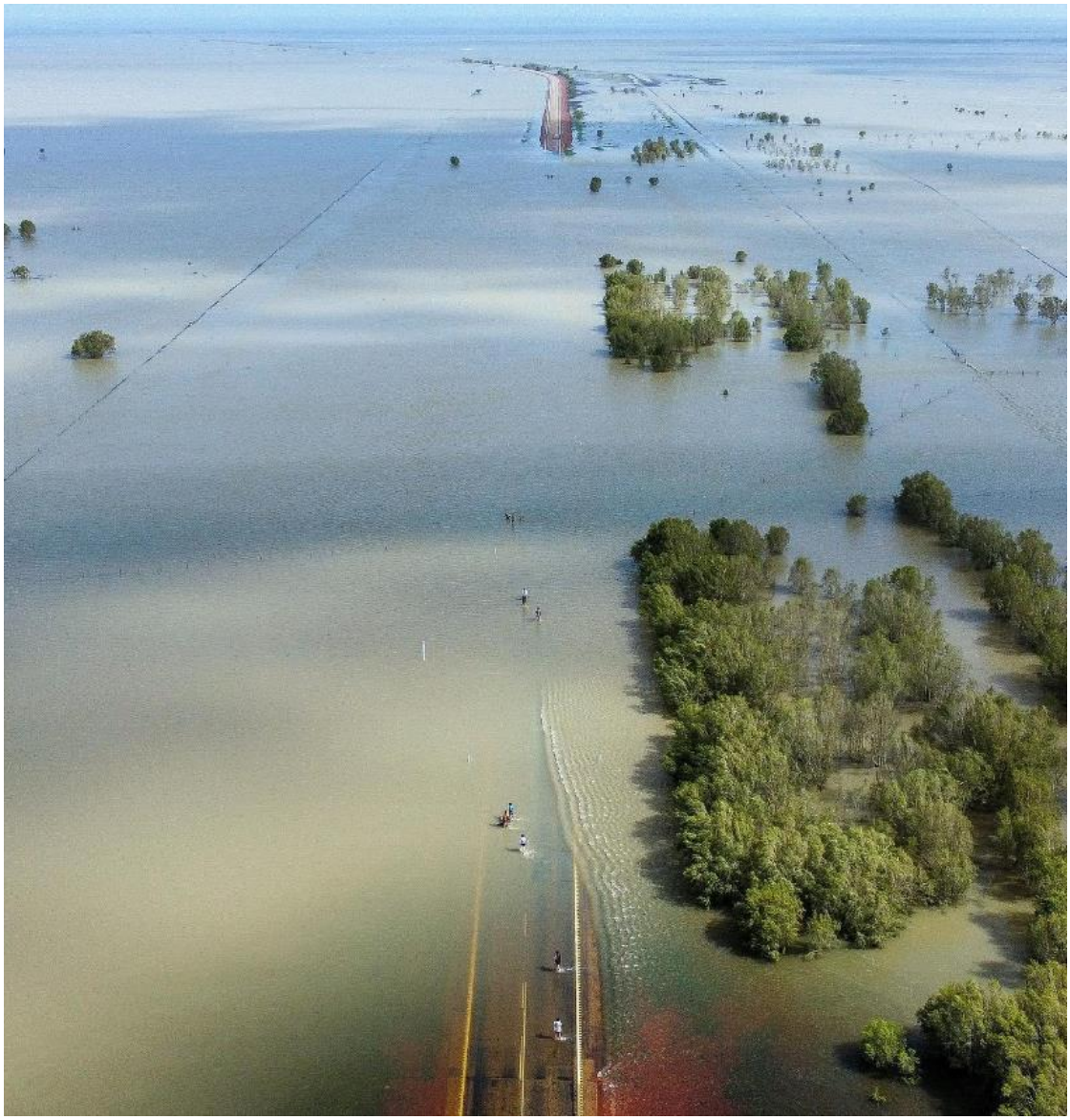

Photo: 4. Roebuck Plains flooding. Source: Facebook: Lap Around Aus.

4. Observations

4.1. Winds

There were no observations available in the zone of impact during Ellie's phase as a tropical cyclone.

Gale force winds were recorded at Broome NTC AWS for periods between 1813 – 2129 UTC 3 January and 1457 – 2255 UTC 4 January. The peak 10-minute mean wind recorded was 38 kn (70 km/h) at 1953 UTC 3 January. The peak 3-second wind gust recorded was 52.7 kn (98 km/h) at 2055 UTC 5 January. The AWS anemometer height is at a non-standard height of 18.97 m and observations have been adjusted to be the equivalent of the Bureau of Meteorology standard height of 10 m.

4.2. Pressure

Fitzroy Crossing recorded a minimum mean sea level (MSL) pressure of 991.8 hectoPascals (hPa) at 1624 UTC 2 January.

Broome Airport recorded a minimum MSL pressure of 989.5 hPa at 1922 UTC 3 January.

Broome NTC recorded a minimum MSL pressure of 988.5 hPa at 1915 UTC 3 January.

4.3. Rainfall

Heavy rainfall was recorded along the track of Ellie as it moved over the Northern Territory and Western Australia. Figures 6a, 6b and 6c show the weekly rainfall distribution during a. 19-26 December 2022; b. 26 December 2022 – 2 January 2023; and c. 2-9 January 2023 respectively.

Notable Observations

Highest Daily Northern Territory rainfall totals to 9 am local time

- 241.5 mm at Timber Creek Victoria Highway 24 Dec.
- 208.0 mm at Bradshaw Range Control 24 Dec.
- 193.2 mm at Townsend Creek 24 Dec.
- 184.6 mm Victoria River Downs 24 Dec.

Highest Daily Western Australia rainfall total to 9 am local time

- 355.6 mm Dimond Gorge 2 January

Highest Weekly rainfall totals

- 830.2 mm Dimond Gorge to 3 Jan.
- 701.8 mm Napier Downs to 4 Jan.
- 570.8 mm Broome Airport to 6 Jan.

4.4. River height

Fitzroy River at Fitzroy Crossing peaked at 15.81 m on 4 Jan. (previous record 13.96 m, major flood level 12.5 m)

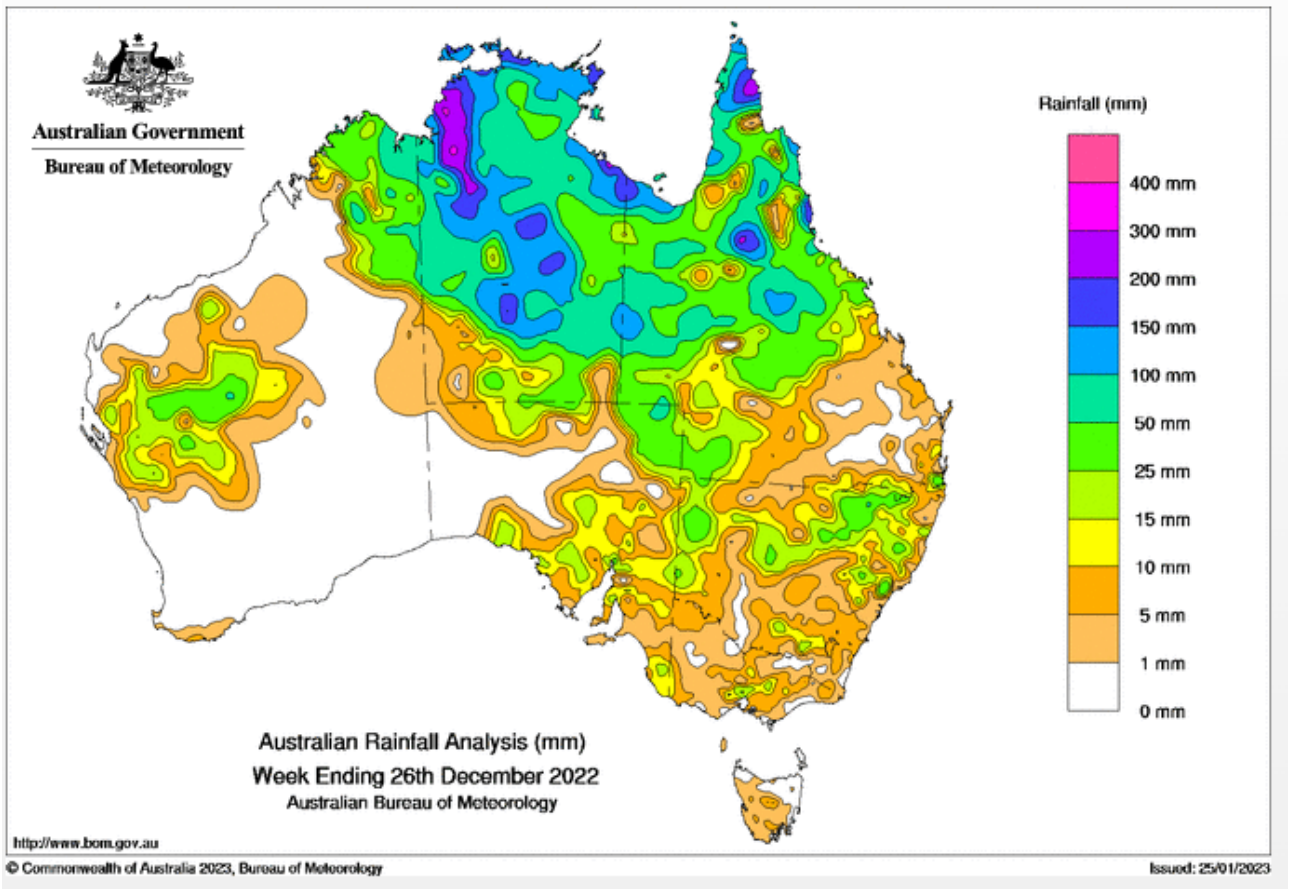

Figure 6a. Weekly rainfall distribution: 19-26 December 2022. Image: http://www.bom.gov.au/climate/maps/rainfall/?variable=rainfall&map=totals&period=week&region=nat&year=2022&month=12&day=26

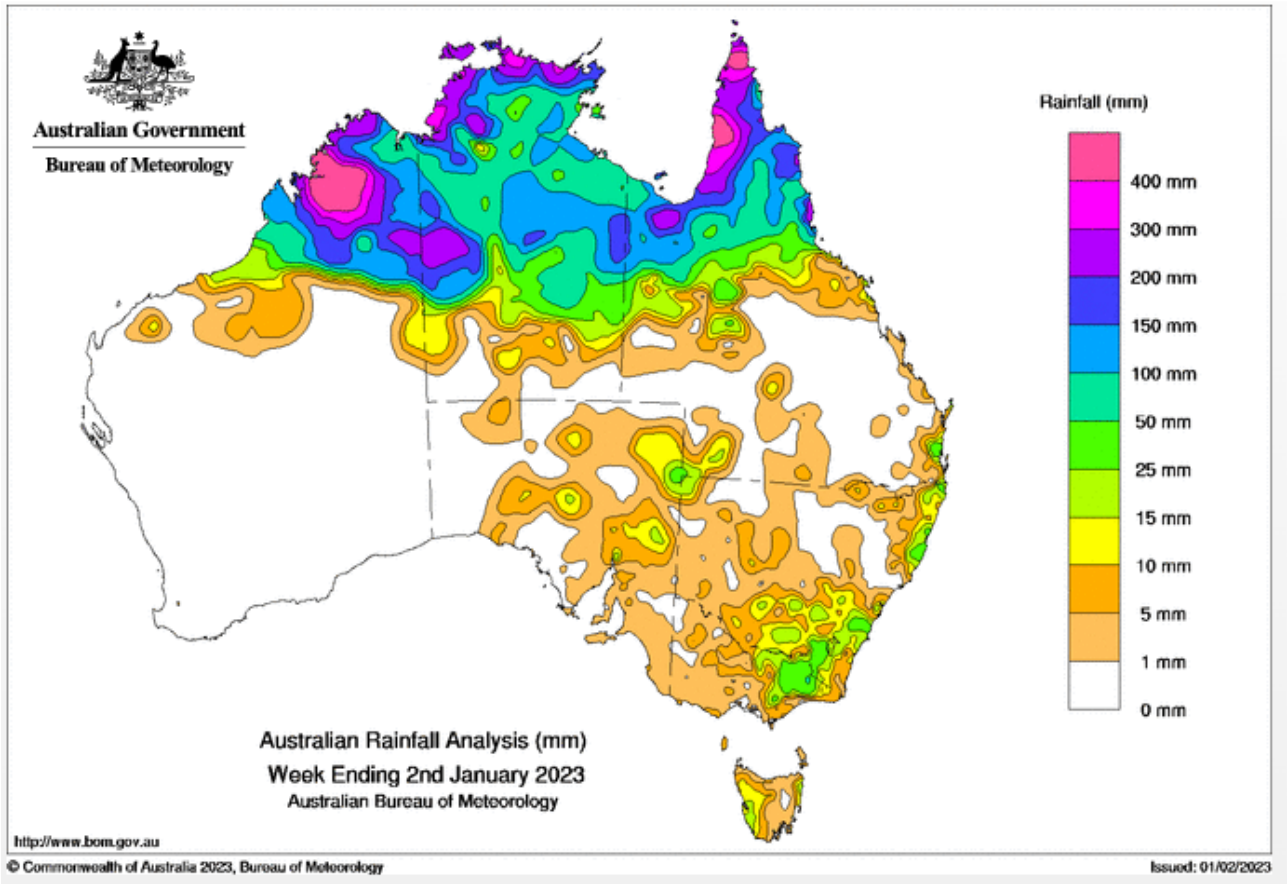

Figure 6b. Weekly rainfall distribution: 26 December 2022 – 2 January 2023. Image: http://www.bom.gov.au/climate/maps/rainfall/?variable=rainfall&map=totals&period=week&region=nat&year=2023&month=01&day=02

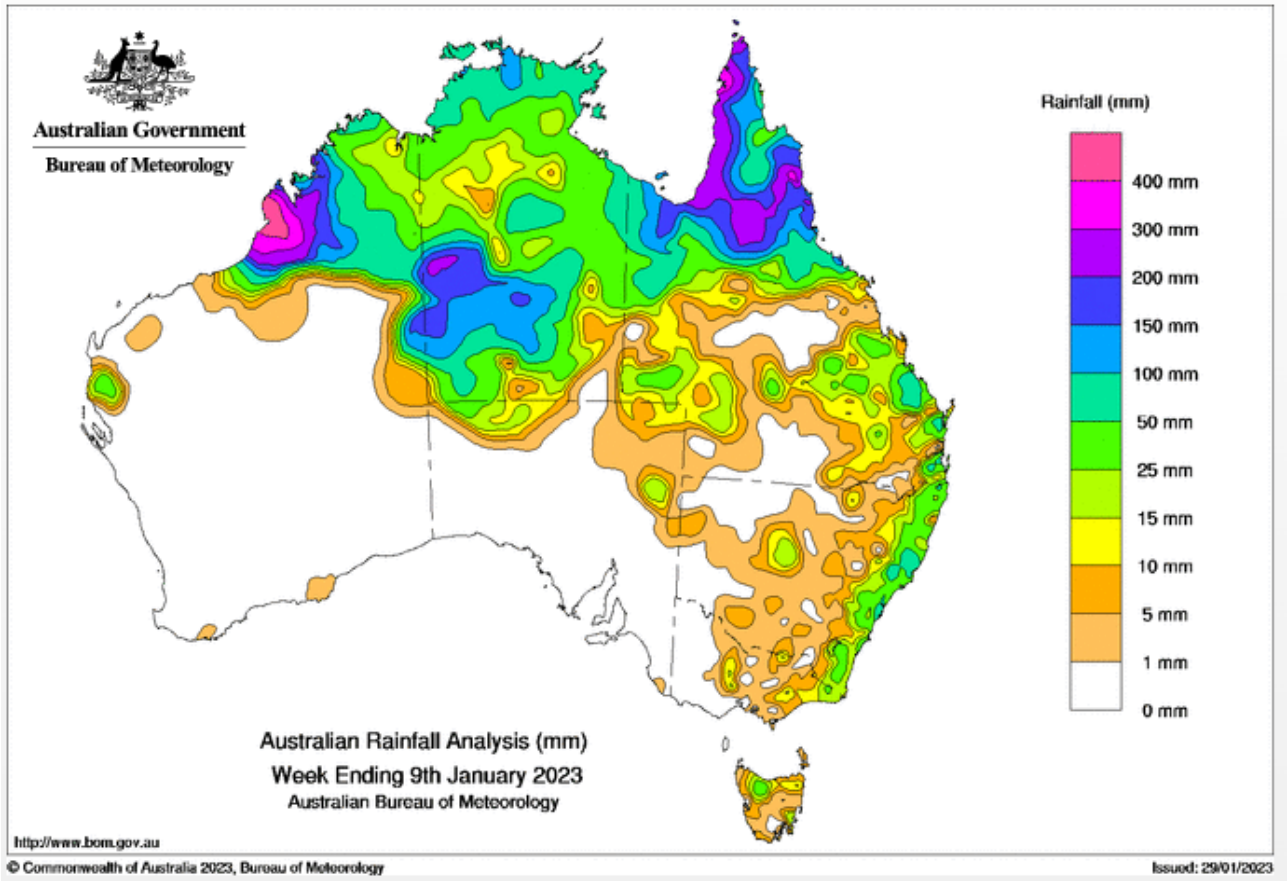

Figure 6c. Weekly rainfall distribution: c. 2-9 January 2023. Image: http://www.bom.gov.au/climate/maps/rainfall/?variable=rainfall&map=totals&period=week&region=nat&year=2023&month=01&day=09

5. Forecast performance

Overall models failed to indicate the formation of Ellie and Tropical Cyclone Outlooks in the days preceding the event only indicated a low risk of a tropical cyclone developing.

Official tropical cyclone warnings were issued from 0300 UTC 22 December until 0100 UTC 23 February when Ellie weakened below tropical cyclone intensity over land. Severe weather warnings were then issued for the Northern Territory and subsequently for Western Australia.

As the low moved west across the Kimberley there was the possibility of Ellie redeveloping into a tropical cyclone if it moved off the coast. As the probability of this scenario was assessed as being low, no tropical cyclone advices were issued.

In general, severe weather warnings accurately portrayed the rainfall distribution as the circulation moved over the Northern Territory and Western Australia. However, on a few days there were localised heavier falls than expected that contributed to the extreme flood impact across parts of the Kimberley.

There are insufficient data points to present accuracy statistics for the track and intensity for this event.

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
ASCAT	Advanced Scatterometer
ATMS	Advanced Technology Microwave Sounder
AWS	automatic weather station
AWST	Australian Western Standard Time
C	Celsius
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
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