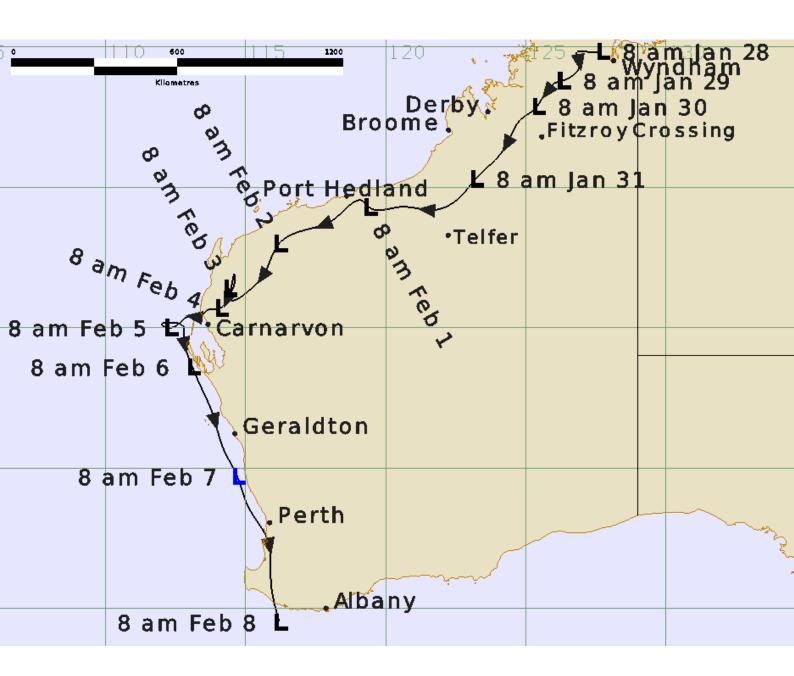


Tropical Low 12U

28 January - 8 February 2021

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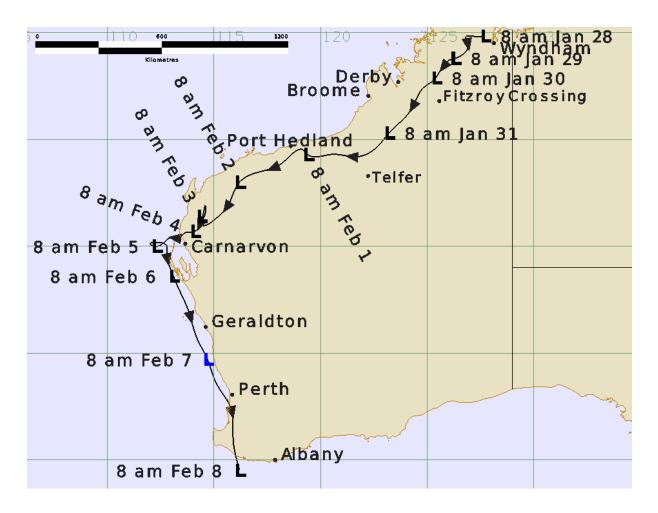
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1 Summary

Tropical low 12U developed over the far north Kimberley and traversed much of Western Australia before moving into the Bight and becoming merged with a mid-latitude system. The low did not develop into a tropical cyclone however gales were present in the southwestern quadrant as it moved south, just offshore from the west coast.

The low produced extended periods of heavy rainfall as it moved over the Kimberley, Pilbara and Gascoyne and caused flooding of roads and rivers across those districts. The Gascoyne River reached moderate flooding level and the main highway north sustained significant damage. As the low moved over the southwest corner on 7 and 8 February heavy rainfall was recorded in many agricultural districts. The rainfall also assisted in extinguishing a severe wildfire that had been raging to the northeast of Perth for many days and that had been responsible for the loss of many homes.

FIGURE 1. Best track of Tropical Low 12U, 28 January – 8 February 2021 (times in AWST, UTC+8).



2 Meteorological Description

2.1 Intensity analysis

The passage of the Madden-Julian Oscillation across northern Australia combined with equatorial Rossby wave activity led to an active monsoon burst in late January. There was a significant increase in convection over the north of Western Australia and a surface low located to the northwest of Wyndham became evident on 28 January. The low tracked slowly southwest over land with the circulation clearly visible on the Wyndham radar. Satellite imagery showed a well-developed circulation with some curved banding in the deep convection. Surface observations indicated the low had an initial intensity of 15 knots (kn).

During 30 January the low continued to track slowly southwest over the inland Kimberley and then took a westward turn during 31 January. Surface observations indicated the low may have intensified and the 10-minute mean wind was increased to 30 kn near the centre early on 1 February. As 12U moved west over the inland Pilbara, the speed of motion increased markedly. Satellite imagery showed awell developed low-level circulation despite having little deep convection associated with it, refer Figure 2 for a visible (VIS) image at 0200 Universal Time Co-ordinated (UTC) (1000 Australian Western Standard Time (AWST)) 1 February 9; AWST=UTC+8 hours). The low was visible on Port Hedland radar which confirmed that 12U was a very small, circularand fast moving circulation.

On 3 February the fast westwards motion ceased abruptly and 12U meandered around the same location in the northern Gascoyne region for about twenty-four hours. During 4 February the low once again began a westwards movement and moved offshore north of Carnarvon, reaching open water for the first time. Conditions were not favourable for development with relatively cool sea surface temperatures of less than 27° Celsius and an environment of increasing vertical wind shear.

As the low moved slowly southward synoptically driven gales developed in the southwest quadrant as a result of the increasing pressure gradient between 12U and the high-pressure system located to the southwest, refer to Figure 3, a 1328 UTC Ocean Scatterometer (OSCAT) pass on 5 February. Satellite imagery still showed an exposed low-level centre off the coast of Western Australia however a large swathe of deep convection was now present in the southern quadrants. This area of deep convection that developed in the strongly baroclinic zone south of 12U produced heavy rainfall over southern parts of Western Australia during 6 and 7 February.

Subsequent scatterometery passes showed gales continued in the southwest quadrant as the low tracked south and into the Southern Ocean where it became part of a mid-latitude frontal system during 8 February, refer Figure 4.

2.2 Structure

Despite being over land while 12U was located in the tropics it had a well-developed circulation with some convective spiral bands. As 12U moved further south it became an exposed low-level circulation with little convection. Once the low reached open ocean where development may have been expected to occur the broader environmental conditions were

not favourable. During the period 12U was over the ocean it was an asymmetric system with synoptically driven gales confined to the southwest quadrant. The radius to maximum wind (RMW) was large at 100 nautical miles (nm) with a gale radius of 220 nm. As 12U moved south, the RMW contracted to 40 nm and the gale radius to 180 nm.

2.3 Motion

The low was steered southwest by the low to mid-level anticyclone over Australia. As the ridge strengthened to the south over Western Australia 12U moved in a more westerly direction. By 3 February the high had weakened and 12U drifted in a weak steering regime until 5 February. An approaching mid-level trough became the main steering influence and 12U moved southwards down the coast of west Australia and into the Southern Ocean by 8 February.

FIGURE 2. Visible image at 0200 UTC 1 February showing a weak low with an exposed low-level centre.

Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

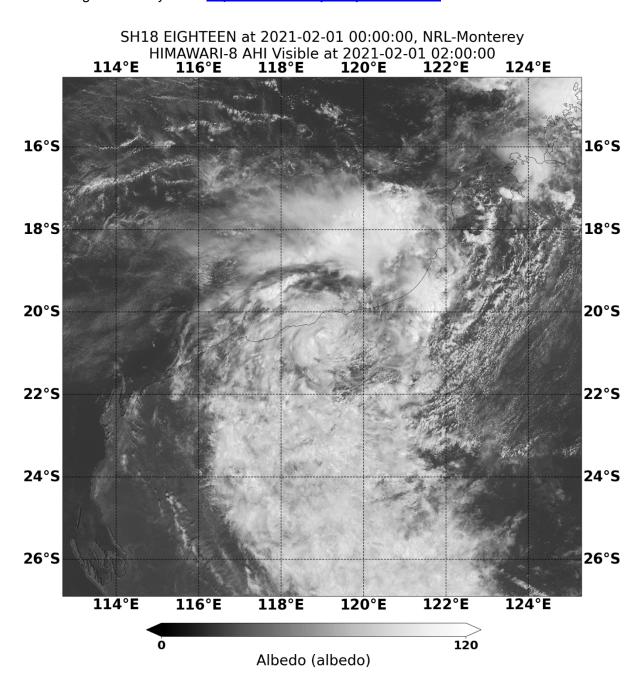


FIGURE 3. OSCAT pass at 1328 UTC 5 February showing gales present in the southwest quadrant.

Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

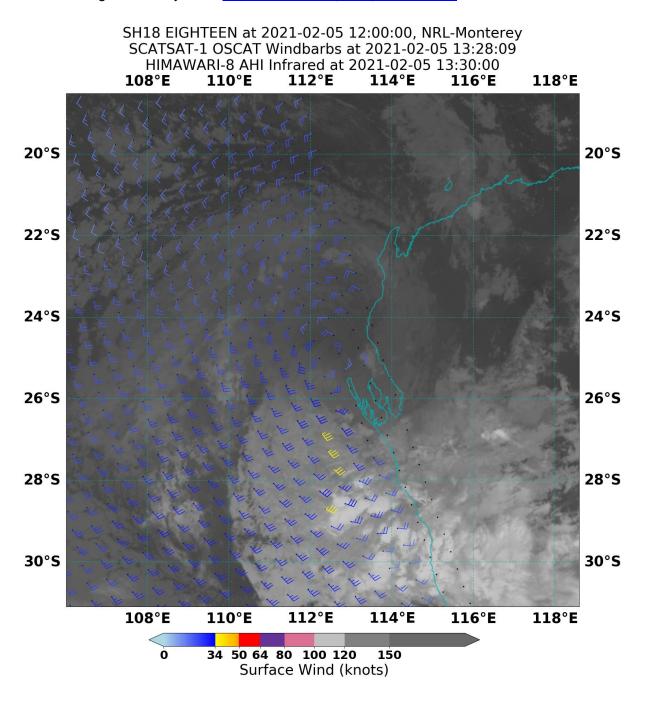
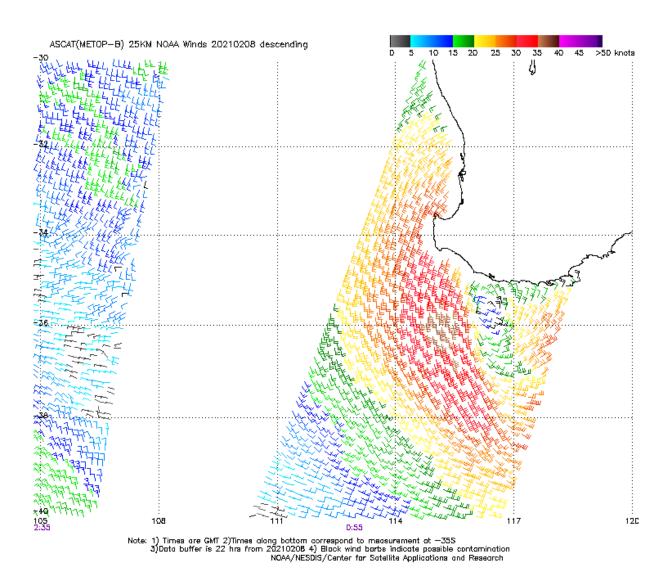


FIGURE 4. An Advanced Scatterometer (ASCAT) pass at 0055 UTC 8 February as the low moves into the Southern Ocean.

Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html



3 Impact

The low produced extended periods of heavy rainfall as it moved over the Kimberley and Pilbara, flooding of roads and rives was reported however little impact was recorded. Refer Figure 5 for a map of heavy rainfall in the Kimberley for the week ending 2 February.

As the low tracked over the Gascoyne it became slow moving. There were many highest daily rainfall records broken on 4 and 5 February. The Gascoyne River reached moderate flooding level and the main highway north sustained significant damage. About 40 stranded travellers were rescued by emergency services. Residents in areas outside the levee in the town of Carnarvon were evacuated and many suburbs experienced loss of power due to rising floodwaters. Refer Figure 6 for a map of heavy rainfall in the Gascoyne for the week ending 9 February.

As the low moved over the southwest corner on 7 and 8 February heavy rainfall was recorded in many agricultural districts. The rainfall also assisted in extinguishing a severe wildfire that had been raging to the northeast of Perth for many days and that had been responsible for the loss of many homes.

FIGURE 5 Rainfall totals for the week ending 2 February 2021.

Western Australian Rainfall Totals (mm) Week Ending 2nd February 2021 Australian Bureau of Meteorology

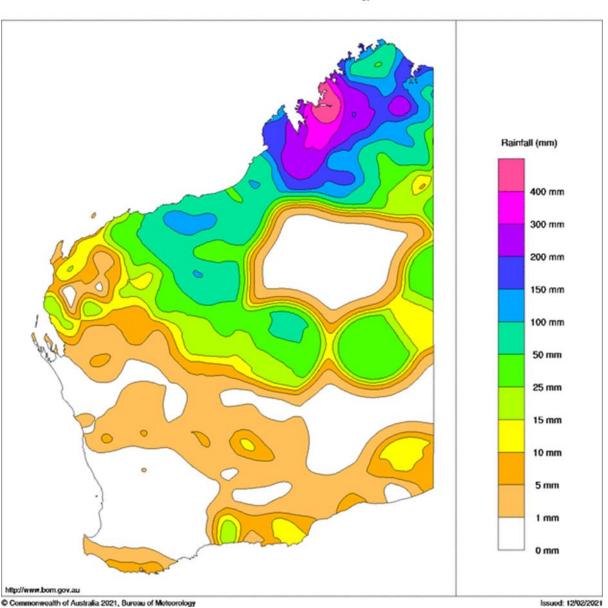
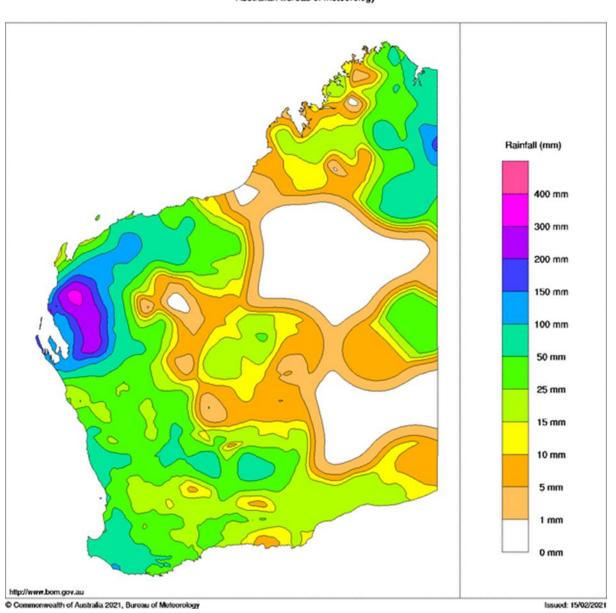


FIGURE 6 Rainfall totals for the week ending 9 February 2021.

Western Australian Rainfall Totals (mm) Week Ending 9th February 2021 Australian Bureau of Meteorology



4 Observations

4.1 Rainfall

Record highest daily rainfall for February were recorded at many locations including:

To 9am AWST 4 February

Hill Springs 153.0 mm Byro 139.4mm Carey Downs 121.0mm Gascoyne Junction 101.2mm

To 9am AWST 5 February

Carnarvon Airport 137.2mm Shark Bay Airport 96.6mm Steep Point 88.0mm Tamla 83.0mm

To 9am AWST 7 February

Jurien Bay 98.0mm Nambung Station 90.5mm

To 9am AWST 8 February

Karridale 88.8mm Kirup 80.2mm Pemberton 73.0mm

Notable rainfall totals during the event:

In the 72 hours to 9am 31 January:

Myroodah 409.8mm Debesa 334mm Liveringa Station 309.8mm Mount Hart Station 306.6mm

In the 24 hours to 9am 1 February:

Derby Main Roads 123.4mm Troughton Island 95.8mm Ripon Hills Road 94.6mm

In the 24 hours to 9am 2 February:

59 Mile Peg 109.4mm Indee 101.8mm Black Hills 89mm

In the 24 hours to 9am 3 February:

Connanarrina 112.6mm Emu Creek 108.8mm Hill Springs 100mm

In the 24 hours to 9am 4 February:

Hill Springs 153mm

Carey Downs 121mm

Gascoyne Junction 110.2mm

In the 24 hours to 9am 5 February:

Shark Bay Airport 96.6mm

Wahroonga 84mm

Denham 77.2mm

Steep Point 70.6mm

In the 24 hours to 9am 6 February:

Steep Point 88mm

Tamala 83mm

In the 24 hours to 9am 7 February:

Jurien Bay 98mm

Nambung Station 90.5mm

Lancelin East 85mm

Hill River Springs 80.4mm

Moora 74.6mm

Warradarge 62.8mm

Jurien Bay 61.6mm

In the 24 hours to 9am 8 February:

Karridale (DPRID) 88.8mm

Windy Harbour 66.8mm

Collie 62.7mm

Greenbushes 61.4mm

Brennans Ford 56.8mm

Rocky Gully South 56.6 mm

4.2 Riverine Flooding

The long track meant that 12U impacted several catchments across the Kimberley, Pilbara and Gascoyne Districts.

4.2.1 Kimberley

Fitzroy River Catchment:

Fitzroy River at Fitzroy Crossing reached multiple peaks above minor flood level.

10.86m on 1 February

10.84m on 12 February

Fitzroy River at Noonkanbah reached multiple peaks above minor flood level.

10.35m on 4 February

9.90m on 14 February

4.2.2 Pilbara

De Grey River Catchment:

Oakover River at Ripon Hills Road reached multiple peaks above minor flood level.

3.98m on 2 February

2.85m on 7 February

Nullagine River at Nullagine reached multiple peaks above minor flood level.

2.05m on 1 February

1.22m on 6 February

Lyndon-Minilya Rivers:

Minilya River at Minilya Bridge maintained around moderate flood level for multiple days.

Floated around 4m on 4 – 6 February.

4.2.3 Gascoyne

Gascoyne River Catchment:

Gascoyne River at Jimba peaked at moderate flood level.

7.01m on 5 February

Gascoyne River at Fishy Pool peaked above minor flood level.

8.45m on 5 February

Gascoyne River at Nine Mile Bridge peaked above moderate flood level.

7.03m on 6 February

5 Forecast Performance

Official tropical cyclone forecasts were issued from 29 January to 2 February. A tropical cyclone Watch was first declared at 9am AWST 29 January between Cape Leveque and Pardoo. From 30 January the area was gradually extended westward to include major centres such as Port Hedland and Karratha. From 1 February the Watch area was extended from Exmouth southwards to Minilya and then to Carnarvon to account for the westward moving track. On 2 February the TC Advice was cancelled as the low was no longer expected to develop into a tropical cyclone.

The accuracy figures for Tropical Low 12U and in Figure 7 a show that the forecast position performed slightly worse than the five-year average at lead times up to 96 hours. The intensity forecasts (refer Figure 7b) had lower errors than the five-year average for the first 24 hours but were significantly larger at longer leas times. This was due to 12U never attaining the forecast tropical cyclone intensity. These were based on official forecast tracks issued from 0000 UTC 29 January to 0000 UTC 2 February.

Model guidance could be described as poor during the event. From as early as 29 January model guidance indicated that 12U would move offshore of the south Kimberley coast and track over water. The European Centre for Medium Range Weather Forecasting (ECMWF) model performed better in the early stages and indicated that 12U would likely remain over land until about 1 February but then it would move west northwest and offshore of the Pilbara coast, intensifying over the ocean. Refer Figure 8 which is a four-panel image of model output for 1200 UTC 1 February. Around the 1 February models began to indicate that 12U would likely remain over land for longer and move offshore near Carnarvon, the eventual outcome.

Intensity guidance varied and was largely dependent on when individual models moved 12U over open water. Some models such as the Australian Community Climate and Earth-System Simulator (ACCESS-G) indicated 12U could rapidly develop into a severe tropical cyclone. Most models persisted with a scenario where 12U moved offshore and intensified into a tropical cyclone until about 2 February. This led to the poorer intensity accuracy figures in the longer term.

	00	06	12	18	24	36	48	72	96	120	144	168
Position Absolute error (km)	31	47	66	84	100	139	177	225	239	257	286	330
Intensity Absolute error (kn)	2	3	4	5	6	11	18	29	29	23	14	8
Sample Size	17	17	17	17	17	17	17	17	17	17	16	12

FIGURE 7 a. Position accuracy figures for Tropical Low 12U.

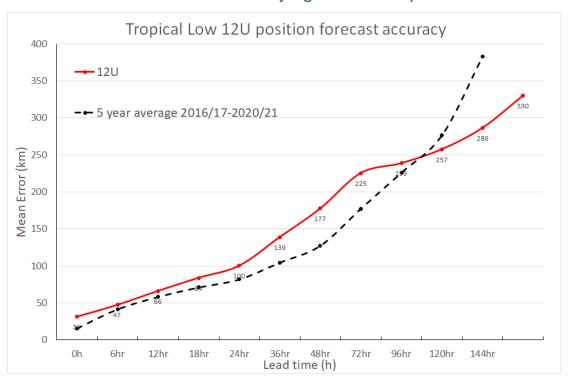


FIGURE 7 b. Intensity accuracy figures for Tropical Low 12U.

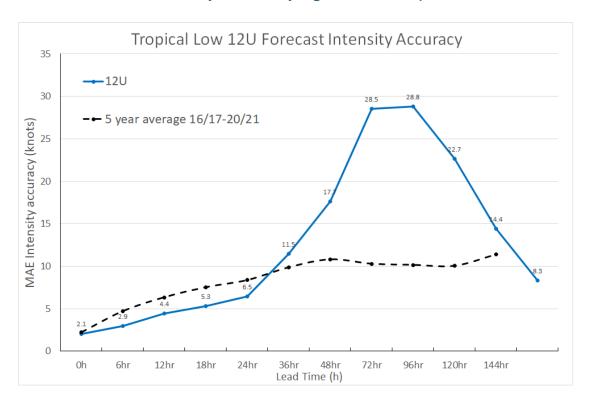


FIGURE 8 Model output for 1200 UTC 1 February with a model run base time of 0000 UTC 29 February.

Top left ECMWF, top right Global Forecast System (US), bottom left ACCESS-G, bottom right Unified Model (UK).

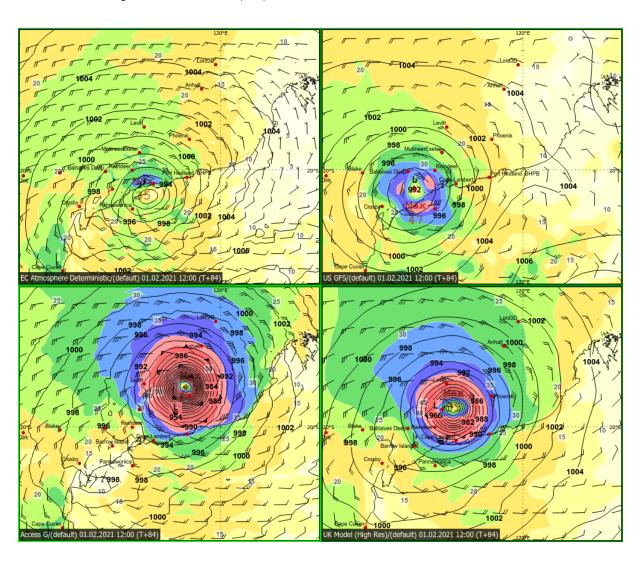


TABLE 1. Best track summary for Tropical Low 12U 28 January to 8 February 2021.

Refer to the Australian Tropical Cyclone database for complete listing of parameters and track Note: UTC is AWST - 8 hours.

Year	Mon th	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 n mi
2021	01	28	00	15.1	127.7	30	15	45	998			
2021	01	28	06	15.1	127.2	30	15	45	998			
2021	01	28	12	15.2	126.8	30	15	45	996			
2021	01	28	18	15.5	126.9	30	15	45	996			
2021	01	29	00	16.2	126.3	30	15	45	996			
2021	01	29	06	16.3	126.0	30	15	45	996			
2021	01	29	12	16.6	125.8	30	15	45	996			
2021	01	29	18	16.8	125.6	30	15	45	996			
2021	01	30	00	17.1	125.4	30	20	45	994			
2021	01	30	06	17.6	124.8	30	20	45	994			
2021	01	30	12	18.2	124.4	30	20	45	994			
2021	01	30	18	18.8	124.1	30	20	45	994			
2021	01	31	00	19.7	123.2	30	20	45	996			
2021	01	31	06	20.3	122.7	30	20	45	996			
2021	01	31	12	20.8	121.8	30	20	45	994			
2021	01	31	18	20.7	120.5	20	30	45	994			
2021	02	01	00	20.7	119.4	10	30	45	992			

Year	Mon th	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 n mi
2021	02	01	06	20.5	119.2	5	30	45	992			
2021	02	01	12	21.1	118.2	5	30	45	992			
2021	02	01	18	21.5	117.2	5	30	45	992			
2021	02	02	00	22.0	116.2	10	30	45	992			
2021	02	02	06	22.8	115.8	20	30	45	992			
2021	02	02	12	23.7	115.1	10	30	45	992			
2021	02	02	18	23.9	114.4	10	30	45	992			
2021	02	03	00	23.6	114.4	10	30	45	992			
2021	02	03	06	23.8	114.4	10	30	45	992			
2021	02	03	12	23.7	114.5	10	30	45	992			
2021	02	03	18	23.1	114.6	20	30	45	992			
2021	02	04	00	24.3	114.1	10	30	45	990			
2021	02	04	06	24.4	113.6	10	30	45	990			
2021	02	04	12	24.6	113.4	15	30	45	992			
2021	02	04	18	24.6	113.0	15	30	45	992			
2021	02	05	00	25.0	112.3	10	30	45	994			
2021	02	05	06	24.9	112.0	10	30	45	994			
2021	02	05	12	25.0	112.8	15	35	50	992	0/0/220/0		100
2021	02	05	18	25.1	112.8	15	35	50	992	0/0/220/0		100
2021	02	06	00	26.4	113.1	10	35	50	992	0/0/220/0		40

Year	Mon th	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 n mi
2021	02	06	06	27.1	113.4	10	35	50	992	0/0/220/0		40
2021	02	06	12	28.0	113.8	20	35	50	992	0/0/180/0		40
2021	02	06	18	29.3	114.2	10	35	50	992	0/0/180/0		70
2021	02	07	00	30.3	114.7	15	35	50	992	0/0/180/0		70
2021	02	07	06	31.4	115.1	15	35	50	990	0/0/180/0		70
2021	02	07	12	32.6	115.8	20	35	45	992	0/0/120/0		70
2021	02	07	18	34.0	115.9	20	35	45	994	0/0/180/0		70
2021	02	08	00	35.5	116.2	20	35	45	994	0/0/120/0		60