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DEPARTMENT OF SCIENCE AND TECHNOLOGY
Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)
Weather Division

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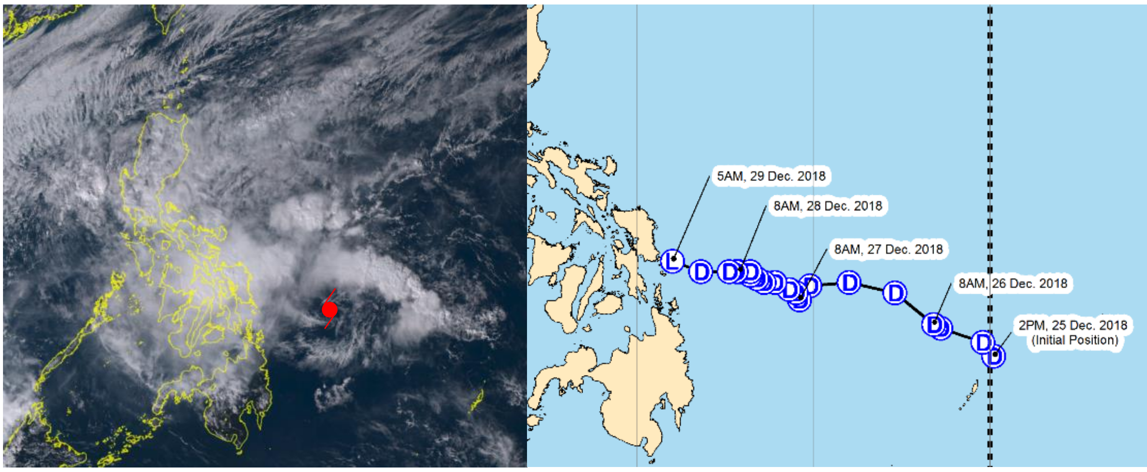
TROPICAL CYCLONE REPORT

Tropical Depression USMAN and the Heavy Rainfall Event of 28-29 December 2018

Tropical Depression USMAN is the 21st and last Philippine tropical cyclone for the 2018 season and only tropical cyclone within the Philippine Area of Responsibility (PAR) for the month of December 2018. As a tropical depression during its entire lifespan, USMAN did not bear any international name from the Regional Specialized Meteorological Center (RSMC) in Tokyo. Although relatively weak by meteorological standards, this tropical depression was one of the key weather systems that caused the **Heavy Rainfall Event of 28-29 December 2018** over large portions of Southern Luzon and Eastern Visayas that resulted in hundreds of casualties and millions of pesos in damages to personal and public property.

Meteorological History

USMAN developed from a tropical disturbance embedded within a near-equatorial buffer zone (Conover and Sadler 1960; Ramage 1995) situated over the western portion of the Caroline Islands. This disturbance was first noted on the surface weather chart in the afternoon of 23 December 2018. PAGASA first noted the disturbance as a tropical depression at 2:00 PM of 25 December with maximum winds of 45 km/h and central pressure of 1002 hPa as the system approached Palau. USMAN entered the PAR at 3:00 PM of the same day.



(a) (b)

Fig. 1. (a) Himawari-8 RGB composite image at 2:00 PM on 28 December and (b) DOST-PAGASA warning best track of Tropical Depression USMAN. The low level circulation center of USMAN in (a) is marked by a cyclone symbol.

The movement of USMAN was rather erratic over shorter time periods (i.e. 3- or 6-hour movement). High vertical wind shear and cold, dry air advection associated with the cold surge of the Northeast Monsoon over the Philippine Sea prevented the depression from further organizing, as suggested by the lack of sustained convective activity near the center of USMAN. This lack of sufficient organization prevented the depression from having a single low-level circulation center that persists for more than 48 hours, resulting in short-term erratic movement (i.e. looping motion, sudden relocation of center) in the warning best track (Fig. 1.b). This erratic behavior was more evident during the period of 27-28 December. However, on longer time periods, the general heading of USMAN was fairly consistent – west-northwestward towards Eastern Visayas.

The unfavorable environmental conditions induced by the cold surge prevented USMAN from significantly intensifying. Throughout its lifespan, the depression reached a peak maximum wind speed of 55 km/h near the center and lowest estimated central pressure of 1000 hPa. This peak intensity was reached at 8:00 AM on 26 December and was maintained until 5:00 PM of 28 December.

At 5:00 AM of 29 December, with persistent unfavorable environment and proximity to rugged landmass of Eastern Visayas, USMAN weakened into an area of low pressure. This remnant low made landfall in the vicinity of Borongan, Eastern Samar at 6:00 AM of the same day.

The Heavy Rainfall Event of 28-29 December 2018

Despite being a weak tropical cyclone, the passage of Tropical Depression USMAN and its remnant low resulted in widespread heavy rains over Bicol Region, Eastern Visayas and portions of MIMAROPA and CALABARZON. From 28 to 29 December 2018, prolonged and excessive rainfall over these areas resulted in multiple landslides and flooding incidents that claimed the lives of more than 150 people and caused extensive damages to agriculture and infrastructure.

Based on manned and unmanned rain gauge observations during the event (Fig. 2), Bicol Region, Samar Island (particularly over Northern and Eastern Samar), Quezon, Oriental Mindoro, Romblon, Marinduque, and portions of northern Panay island received 2-day rainfall of at least 100 mm over the two-day period of the event. Bicol Region, Northern Samar and the southern portion of Quezon receiving the brunt of heavy rains, with 2-day rainfall accumulations of 250 mm or greater. In particular, all of the 11 operational rain gauges in Bicol Region reported 2-day rainfall of at least 250 mm.

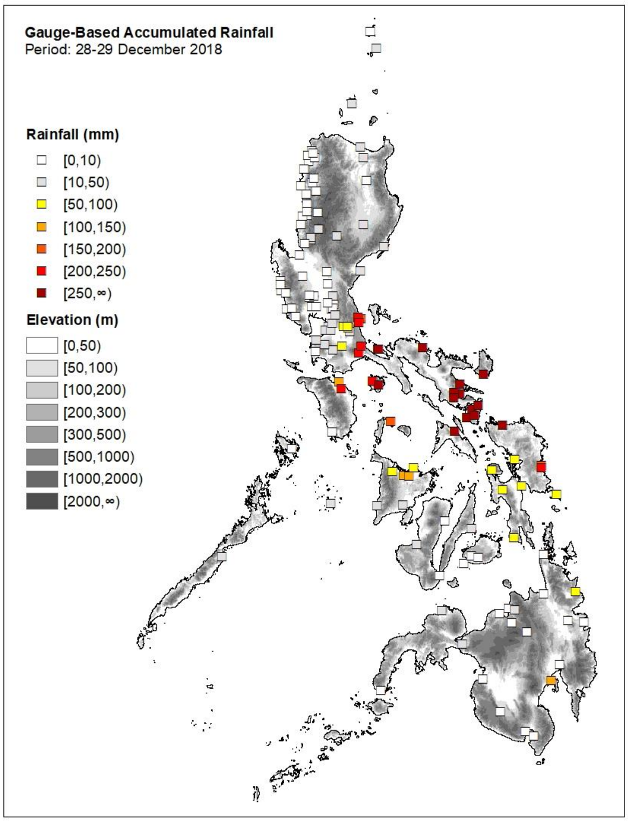


Fig. 2. Gauge-based rainfall observation during the Heavy Rainfall Event of 28-29 December 2018. Data from both synoptic station reports and automatic rain gauge measurements of DOST-PAGASA.

Of the 139 stations with reliable observation data during the event, the highest 2-day rainfall was 573.2 mm which was recorded in Daet, Camarines Sur. Meanwhile, the highest 24-hour accumulated rainfall was recorded in Catarman, Northern Samar on 28 December, reaching 438.0 mm. The ten highest 2-day rainfall observations from the 139 operational stations during the Heavy Rainfall Event is presented in Table 1.

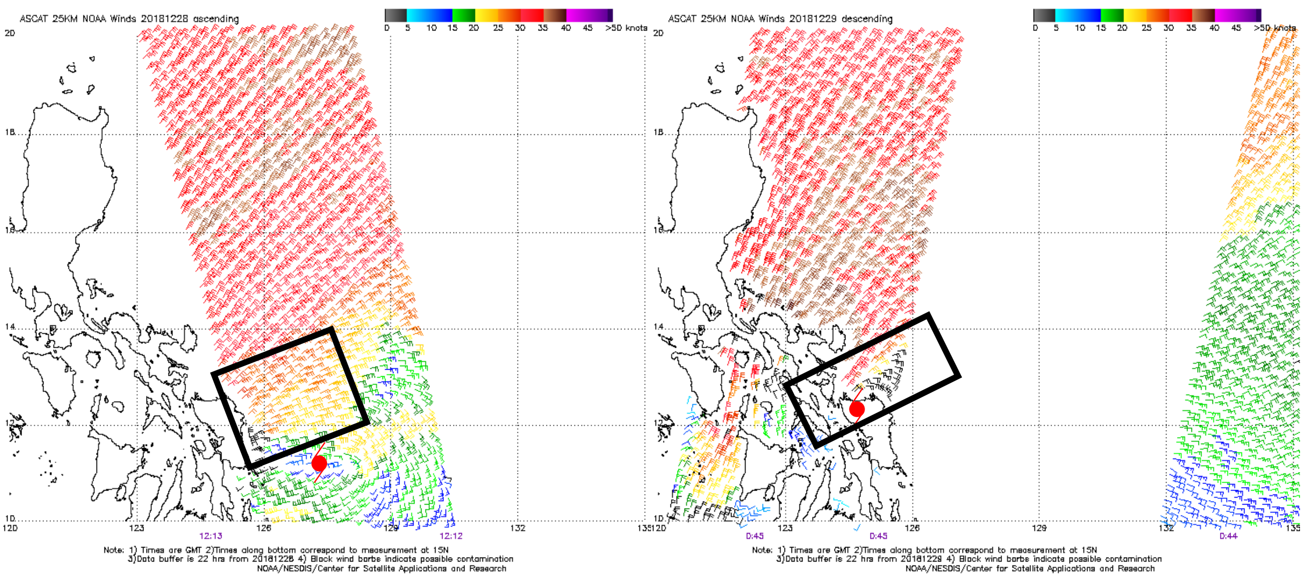
Table 1. Highest rainfall observations during the Heavy Rainfall Event of 28-29 December.

Station Category	Location	Accumulated Rainfall (mm)	Percentage of Normal Rainfall	Normal Rainfall: December (mm)
Synoptic Station	Daet, Camarines Norte	573.2	97.4%	588.4
Synoptic Station	Legazpi City, Albay	460.1	88.4%	520.2
Synoptic Station	Catarman, Northern Samar	446.8	-	-
Synoptic Station	Alabat, Quezon	430.7	67.7%	636.6
Automatic Rain Gauge	Tabaco City, Albay	429.0	-	-
Automatic Rain Gauge	Bulan, Sorsogon	395.0	-	-
Synoptic Station	Virac, Catanduanes	384.1	85.0%	451.8
Synoptic Station	Juban, Sorsogon	368.2	-	-
Automatic Rain Gauge	Guinobatan, Albay	337.0	-	-
Automatic Rain Gauge	Irosin, Sorsogon	333.0	-	-

Note: Juban Synoptic Station has no normal rainfall because the station has been in operation for less than 30 years. Meanwhile, all automated rain gauges have no normal values.

Why the Event happened?

The Heavy Rainfall Event of 28-29 December 2018 was driven by **widespread convective activity** brought about by the **interaction between the wind flows of the cold surge and the cyclonic circulation of the tropical depression.** Previous observational studies (i.e. Chen et al. 2012; Ogino et al. 2018; Yokoi and Matsumoto 2008) suggest that in the presence of a westward-propagating cyclonic circulation (either a low pressure area or a tropical cyclone) during a cold surge event (i.e a cyclone-cold surge coupling), a convergence zone is generated by the northeasterly surge flow and the easterly flow at the northern edge of the cyclonic disturbance. The wind convergence due to the coupling of the cold surge and the tropical depression was evident in surface wind fields derived from ASCAT passes on 28 and 29 December (Fig. 3). While the cold and dry air advection during cold surges suppresses convective instability, this suppression is compensated by the aforementioned convergence, as well as the eddy heat and moisture transport from the surface of the Philippine Sea. Such conditions result in enhanced convection and precipitation (Ogino et al. 2018).

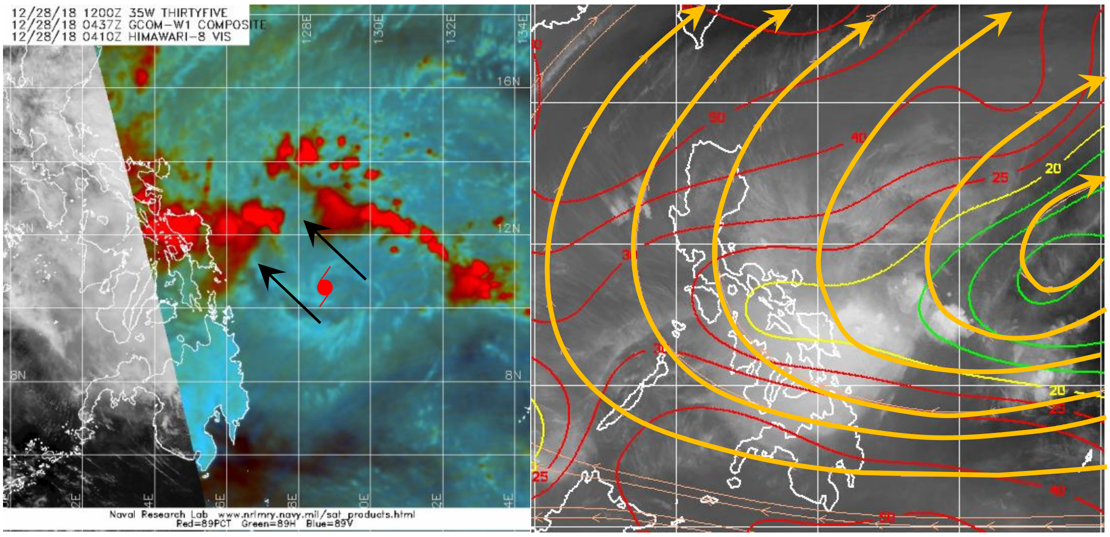


(a) (b)

Fig. 3. METOP-A ASCAT surface wind fields at (a) 8:12-8:13 PM on 28 December and at (b) 8:45 AM on 29 December. The areas of convergence in both fields are identified using black boxes, while the low-level circulation center of USMAN is marked by a cyclone symbol.

Aside from influencing the intensity and movement of USMAN, the prevailing vertical wind shear on 28 and 29 December also influenced the timing and extent of areas where high rainfall accumulations were observed.

Satellite-derived vertical wind shear data shows that moderate (30-35 km/h) southeasterly shear displaced much of the deep convection associated with USMAN and the convergence zone to the northwest of the low-level circulation center. In Fig. 4., the prevailing southeasterly shear over the tropical depression on 28 December displaced the deep convection to the northwest towards Samar Island, bringing heavy rainfall over the island (i.e. 438.0 mm in 24 h over Catarman, Northern Samar) and leaving the low-level circulation center exposed. This feature is normally observed on weaker tropical cyclones in high vertical shear environment (i.e. during cold surges).



(a) (b)

Fig. 4. (a) GCOM-W1 89GHz composite microwave image at 12:37 PM of 28 December and (b) satellite-derived vertical wind shear magnitude and direction at 11:00 AM of the same day. For (a), the location of low-level circulation center of USMAN is marked by a cyclone symbol, while the direction of displacement of the convection is indicated by the black arrows. The red and blue-green cloud signatures indicate deep convective and low-level clouds, respectively. For (b), the direction of wind shear is emphasized from the original image using orange streamlines.

Antecedent Rainfall

In the week preceding the Event, rainfall accumulations in excess of 100 mm were already observed by multiple gauge stations over the eastern section of Luzon and Visayas, especially over Bicol Region mainland, Samar island, Aurora, Quezon and Rizal (Fig. 5a). These were roughly the same areas affected by the Event. Of the 139 operational stations used in this report, the highest 1-week rainfall observed was 336.5 mm over General Nakar, Quezon. The rest of the 10 stations with the highest antecedent rainfall are presented in Table 2.

Table 2. Stations with the highest rainfall observation during the week before the Heavy Rainfall Event and the corresponding daily rainfall over these stations for 22 and 23 December.

Station Category	Location	Accumulated Rainfall (mm)		
		21-27 December	22 December	23 December
Automatic Rain Gauge	General Nakar, Quezon	336.5	54.0	194.5
Synoptic Station	Daet, Camarines Norte	287.3	52.0	212.5
Synoptic Station	Juban, Sorsogn	277.0	160.4	100.6
Automatic Rain Gauge	Sampaloc, Quezon	253.0	79.5	77.0
Automatic Rain Gauge	Real, Quezon	222.5	34.0	124.5
Synoptic Station	Infanta, Quezon	220.8	30.4	133.1
Automatic Rain Gauge	Tabaco City, Albay	214.5	24.0	154.0
Synoptic Station	Casiguran, Aurora	214.1	39.0	109.5
Synoptic Station	Aparri, Cagayan	193.4	0.0	5.0
Automatic Rain Gauge	Gubat, Sorsogon	191.5	129.5	53.0

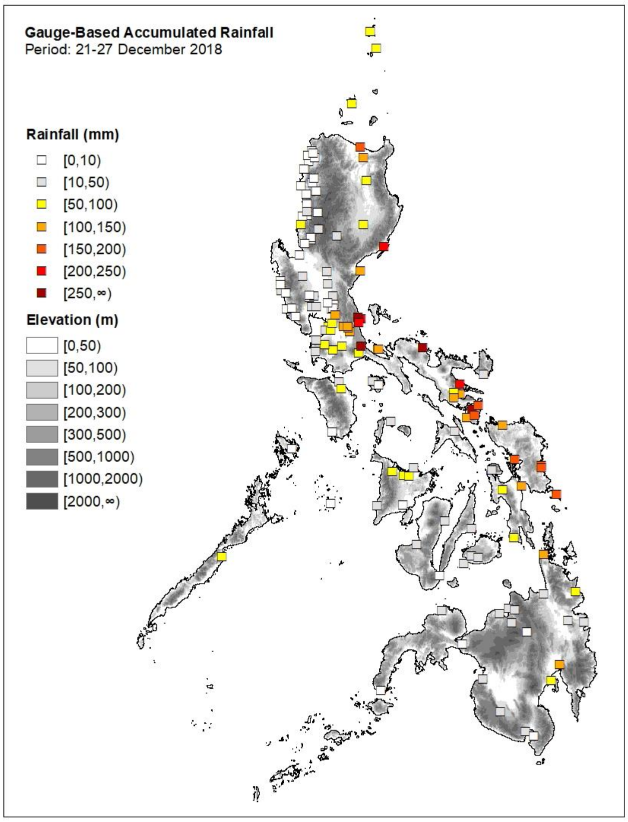
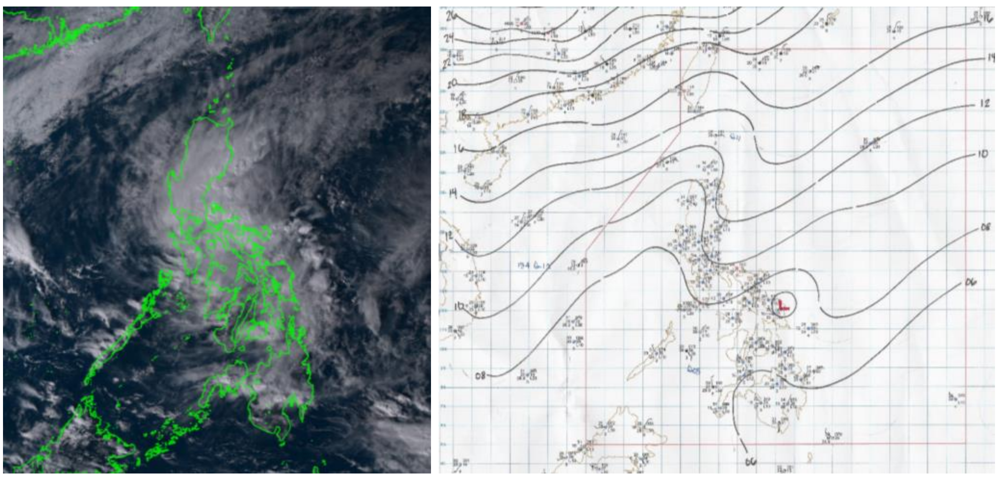


Fig. 5. Gauge-based rainfall observation during the period of 21-27 December 2018. Data from both synoptic station reports and automatic rain gauge measurements of DOST-PAGASA.

In the areas that received accumulated rainfall of at least 100 mm during the week before the Event, most were recorded from 22 to 23 December. For the 10 stations listed in Table 2, except for Aparri, Cagayan, between 61.9 and 95.3% of the 1-week antecedent rainfall was observed within the said 2-day period. The heavy rainfall observed during this period was due to the passage of a westward-moving shallow low pressure area in the Central Philippines and its subsequent interaction with an ongoing cold surge (via the same mechanism discussed in this report).



(a) (b)

Fig 6. (a) RGB composite image and (b) surface weather chart at 2:00 PM on 23 December 2018 showing the sh allow low pressure area and an ongoing cold surge.

Other Significant Meteorological Observations

Table 3 presents the extremes of wind and pressure observations from selected PAGASA synoptic stations that conducted hourly observations during the passage of USMAN. The data from the manned stations indicate that the lowest mean sea level pressure (MSLP) was observed in Borongan City, Eastern Samar and in Tacloban City, Leyte, with both stations reaching 1000.1 hPa at 3:00 PM and 4:00 PM of 28 December, respectively. At nearly the same time, all other stations in Eastern Visayas, as well as two (2) stations in Bicol Region (Juban, Sorsogon and Legazpi City, Albay) reached their lowest MSLP throughout the passage. During this period, the center of USMAN was still roughly 300 km east of Eastern Samar. Having the lowest MSLP recorded before the center of USMAN made its closest approach over these stations supports the warning period analysis that USMAN had weakened before it made landfall over Eastern Samar in the early hours of 29 December.

Table 2. Extremes of wind and pressure observations from selected synoptic stations for the period of 27-29 December 2018.

Station Name	Lowest MSLP		Peak Gust		
	Date and Time	Value (hPa)	Date and Time	Dir.	Value (km/h)
Borongan City, Eastern Samar	2018.12.28, 3:00 PM	1000.1	2018.12.28, 3:05 PM	NE	47
Tacloban City, Leyte	2018.12.28, 4:00 PM	1000.1	2018.12.28, 7:10 PM	W	22
Catbalogan City, Samar *	2018.12.28, 2:00 PM	1002.3	-	-	-
Guiuan, Eastern Samar	2018.12.28, 3:00 PM	1002.7	2018.12.28, 2:35 PM	ENE	58
Catarman, Northern Samar *	2018.12.28, 3:00 PM	1002.7	-	-	58
Juban, Sorsogon	2018.12.28, 3:00 PM	1002.8	2018.12.29, 10:40 AM	NNE	43
Maasin City, Southern Leyte	2018.12.28, 3:00 PM	1002.8	2018.12.28, 11:27 AM	NNW	36
Legazpi City, Albay *	2018.12.28, 2:00 PM	1003.4	-	-	43
Masbate City, Masbate	2018.12.28, 3:00 PM	1003.6	2018.12.28, 3:54 PM	NNW	36
Roxas City, Capiz	2018.12.29, 3:00 AM	1004.4	2018.12.28, 7:35 AM	N	43
Romblon, Romblon	2018.12.29, 3:00 AM	1004.8	2018.12.28, 1:20 AM	N	65

* Extremes of wind and pressure observations were obtained directly from reported hourly observations due to the lack from tropical cyclone passage reports from these stations.

Meanwhile, the highest near-surface wind speed was recorded in Romblon (Romblon), reaching 65 km/h at 1:20 AM on 29 December, followed by Guiuan and Catarman with 58 km/h peak gust. Similar to extremes of MSLP, the peak gusts were also observed well before the closest approach of USMAN over these stations. Higher wind gusts were also reported in other stations north of the areas directly affected by USMAN, especially over the eastern section of Northern and Central Luzon (Table 3). For instance, within the 24-hour period before landfall, a peak gust of 79 km/h was reported by PAGASA Basco Station in its 2:00 PM, 28 December and 2:00 AM, 29 December synoptic reports. This was the highest peak gust recorded by the PAGASA synoptic station network during the entire duration of USMAN. The higher gust observations over the eastern section of Northern and Central Luzon were attributed to the prevailing cold surge over Luzon and the surrounding waters at the time of the passage.

Table 3. Reported gusts (km/h) from three-hourly synoptic observation reports from selected PAGASA stations on the eastern section of Northern and Central Luzon from 11:00 AM on 28 December to 2:00 AM on 29 December

Station Name	Peak gust (km/h) in the synoptic report				
	12/28 2:00 PM	5:00 PM	8:00 PM	11:00 PM	12/29 2:00 AM
Itbayat, Batanes	47	43	50	58	54
Basco, Batanes	79	47	54	58	79
Aparri, Cagayan	43	43	50	43	43
Casiguran Aurora	36	43	43	43	47

Notes: Peak gust in a particular observation report is the highest gust observed within the 3-hour period before the report time.

Warning Information

The precursory low pressure area of USMAN was first mentioned in a Weather Advisory dated 24 December, when it was predicted that its trough will bring inclement weather over portions of Mindanao. In another Weather Advisory issued the following day, 25 December, PAGASA indicated that the precursory low might enter the PAR and develop into a tropical depression within 24 to 36 hours.

PAGASA issued its first Severe Weather Bulletin (SWB) for USMAN at 5:00 PM on 25 December after the precursory low developed into a tropical depression and entered the PAR. A total of 20 SWBs were issued to the public, disaster managers and other end-users throughout the monitoring and warning period. The final SWB was issued at 8:00 AM on 29 December, when USMAN weakened into a low pressure area shortly before landfall over Eastern Samar. However, due to the threat of heavy rainfall from its remnant low, several Weather Advisories were still issued at 11:00 AM on 29 and 30 December.

Tropical Cyclone Warning Signal (TCWS) #1 was the highest warning signal raised by PAGASA over any locality in the country during the passage of USMAN. A total of 26 areas covering the entire Bicol Region and most of Visayas and MIMAROPA were placed under TCWS #1, with the first warning signal issued at 11:00 PM on 26 December. All warning signals were lifted by PAGASA at 8:00 AM on 29 December when USMAN weakened into a low pressure area.

Supplementary to the issuance of Severe Weather Bulletins by the Weather Division, local Heavy Rainfall Warnings and Thunderstorm Advisories were also issued by the agency through the Southern Luzon and Visayas Regional Services Divisions (SLPRSD and VPRSD, respectively). In additional, flood bulletins for telemetered river basins and general flood advisories for non-telemetered basins were also issued by the Flood Forecasting and Warning Centers and the Main Operations Center-Hydrometeorology Division, respectively, to various affected regions.

Preliminary Damage Statistics

As of 20 January 2019, a total of 238,127 families or 1,015,978 persons from the regions of CALABARZON, MIMAROPA, Bicol and Eastern Visayas were affected by USMAN. A total of 156 dead, 26 missing and 105 injured persons were reported in these areas by local disaster managers. In addition, these regions also suffered from damages to agriculture and infrastructure worth Php 5,411,793,138.68 (National Disaster Risk Reduction and Management Council 2019). Because of the significant impact of USMAN to various local government units, four (4) provinces (Camarines Norte, Camarines Sur, Albay, and Sorsogon) in Bicol Region, as well as one (1) city and seven (7) municipalities in Oriental Mindoro, were placed under a state of calamity.

Decommissioning

With total damages due to USMAN exceeding Php 1 billion, DOST-PAGASA will be decommissioning the name “USMAN” in the list of Philippine tropical cyclone names alongside “OMPONG” and “ROSITA”. The replacement names for these three (3) will be implemented in 2022.

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- For Figs. 1a and 6a, the National Institute of Information and Communications Technology (NICT) and DOST-Advanced Science and Technology Institute (ASTI)
- For Fig. 3, the Center for Satellite Application and Research (STAR) of NOAA/NESDIS
- For Fig. 4a, the United State Naval Research Laboratory (NRL) – Monterey
- For Fig. 4b, the Cooperative Institute for Meteorological Satellite Studies (CIMSS) of the University of Wisconsin at Madison.

Notes:

(1) All dates and times presented in this report are in Philippine Standard Time or PhST (UTC+8).
(2) Damage statistics are based on the most recent NDRRMC Situational Report at the time of writing. For more updated information, please contact the Operations Center (OpCen), NDDRMC.

Disclaimer

This report presents a summary of pertinent information obtained during the **operational warning period.** As such, the information presented herein are not final and are subject to change when additional data becomes available.