EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

12 September 2018,12:30 UTC

Tropical Cyclones MANGKHUT and BARIJAT

Guam, Northern Mariana Islands, Philippines, China, Vietnam

MANGKHUT: GDACS Tropical Cyclone Red Alert
BARIJAT: GDACS Tropical Cyclone Green Alert

7 September 2018 - ongoing

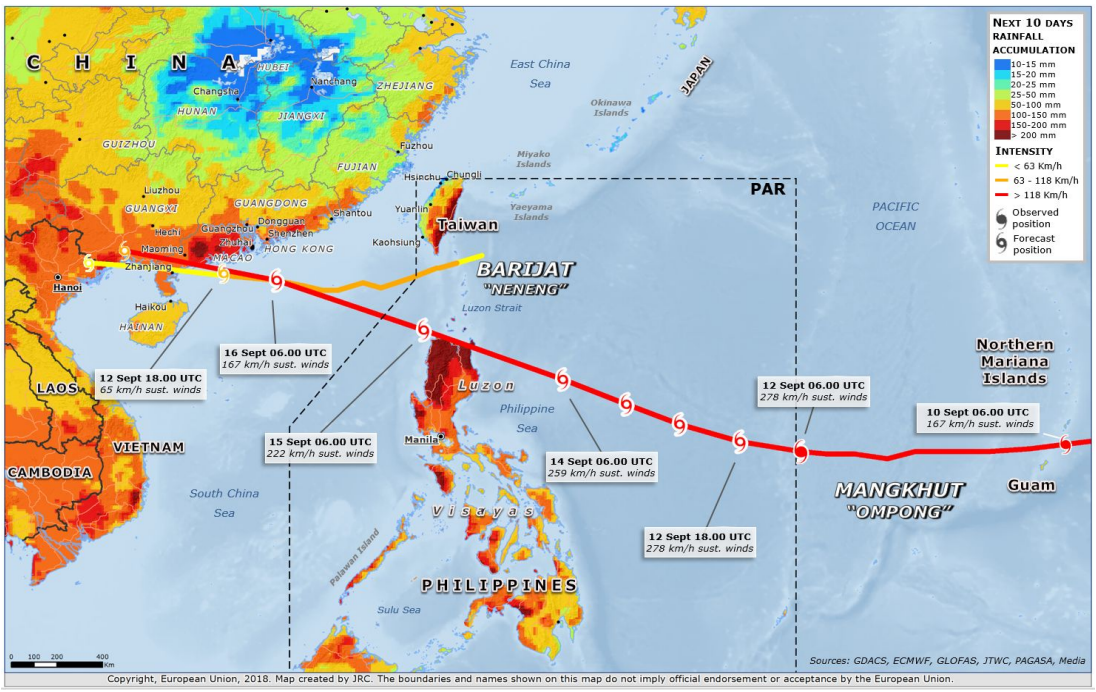


***Figure 1** - TC MANGKHUT and BARIJAT in Guam, Northern Mariana Islands, Philippines, China (as of 12 Sep 2018, 06:00 UTC)*

1 Executive Summary

- Tropical Cyclone **MANGKHUT** (OMPONG in the Philippines) passed over Rota island (Northern Mariana Islands) in the morning (UTC) of 10 September, as an intense Typhoon. During its passage, strong winds (max. sustained winds **170-180 km/h**), heavy rainfall (over **200 mm**) and storm surge (about **0.5 m**) affected the Northern Mariana Islands, especially the southern Islands of Rota, Tinian and Saipan, as well as Guam, causing power outages and, according to media,

some local flooding. Afterwards it continued moving west-northwest over the Philippine Sea, strengthening and entering the Philippine Area of Responsibility (PAR) on 12 September morning (UTC).

- MANGKHUT is forecast to reach the coast of north-eastern Philippines (Cagayan province, Babuyan islands) on 14 September, as a very intense Typhoon (winds up to **260 km/h**, rainfall greater than **500 mm,** storm surge about 1 m), and the coast of south-western Guangdong (China), west of Hong Kong and Macau, on 16 September, still as a Typhoon. However the **uncertainty** of the forecast track/intensity is still **very high**.
- It should be noted that the heavy rainfall could affect several areas of northern Philippines, already affected just few days ago by the Tropical Cyclone BARIJAT (NENENG in the Philippines), that is currently moving west over the South China Sea and is forecast to reach the area of Zhanjiang on 12 September evening (UTC) and the coast of northern Vietnam on 13 September, as a Tropical Depression. Heavy rain, winds and storm surge could affect these areas during its passage. The same areas will be affected again on 16-17 September by the passage of MANGKHUT.
- The Joint Research Centre (JRC) is following the event through the information automatically collected and analysed in the Global Disasters Alerts and Coordination System (GDACS). GDACS issued a **RED** alert for TC MANGKHUT in Guam and Northern Mariana Islands on 7 September for the possible impact in the Philippines. TC BARIJAT is currently classified as **GREEN** alert in the same system.
- The Copernicus Emergency Response Mapping service was activated by ERCC on request of the US FEMA on 10 September for Guam and The Northern Mariana Islands.
- The Philippines National Disaster Risk Reduction and Management Operation Center (NDRRMOC) raised his alert level to **RED** at 8:00AM of 11th September local time. Preparedness measures have been identified.

2 Situation Overview

2.1 Meteorological Situation

Tropical Cyclone MANGKHUT

- **PAST**: Tropical Cyclone MANGKHUT formed over the north-west Pacific Ocean on 7 September and started moving west, strengthening. It passed over Rota island (Northern Mariana Islands) with maximum sustained winds of 170-180 km/h. Strong winds, heavy rains and storm surge affected the Northern Mariana Islands, especially the southern Islands of Rota, Tinian and Saipan, as well as Guam (see impact in Section 2.2). After having passed these islands, it continued moved west-northwest over the Philippine Sea, strengthening further.
- **CURRENT**: On 12 September at 06:00 UTC, its centre was located approx. 1,400 km south-east of Cagayan (northern Luzon island, Philippines) and it had max. sustained winds of 278 km/h (equivalent to a Category 5 in the SSHS, see Annex 2). It is currently entering the Philippine Area of Responsibility (PAR), but it will enter within the next 12 h and will be locally named OMPONG.
- **FORECAST** (as of 12 September, 06:00 UTC TC data): it could reach the coast of north-eastern Cagayan Province, including the Babuyan islands (northern Luzon, Philippines) on 14 September afternoon (UTC), as a very intense Typhoon with max. sustained winds up to 250 km/h, and the south-western coastal areas of Guangdong and Hong Kong / Macau on 16 September, still as a

Typhoon with max. sustained winds up to 140-170 km/h. However the **uncertainty** of the forecast track/intensity is still **very high**.

- **HAZARDS:** Very strong winds, heavy rains and storm surge could especially affect northern Philippines, especially **Cagayan province,** including **Babuyan**, and the Batanes on 14-15 September, as well as Hong Kong, Macau and the south-western coastal areas of the province of Guangdong (China) on 16-17 September.
- **UNCERTAINTY**: TC MANGKHUT is forecast to reach the northern areas of the Luzon (Philippines) on 14 September, passing over north-eastern Cagayan and the islands of Babuyan. There is still some uncertainty on the area of the landfall, some models provide different track (more to the south) with a possible landfall over northern Isabela province. The maximum sustained wind speed during the expected landfall has a large variability and it is between 175-260 km/h (95-140 knots).

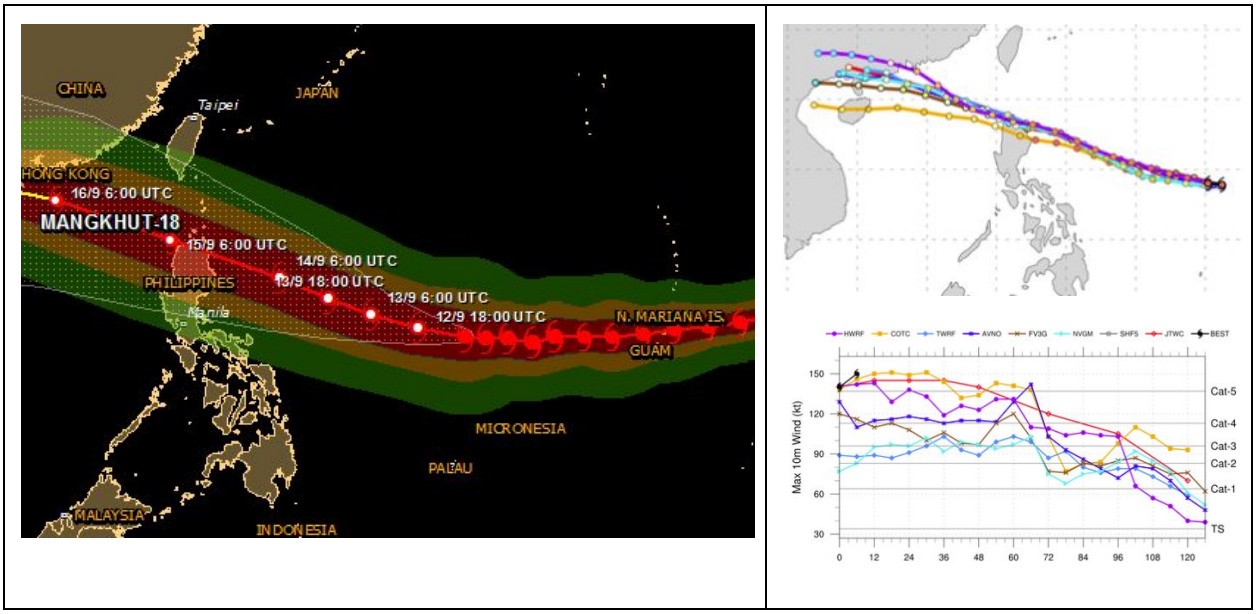


***Figure 2** - TC MANGKHUT uncertainty track/intensity (as of 12 Sep, 06:00 UTC). Sources: GDACS (LEFT), NOAA-HWRF (RIGHT)*

Tropical Cyclone BARIJAT

- **PAST**: Tropical Cyclone BARIJAT formed on 9 September over the Luzon strait and started moving west over the South China Sea slighting strengthening.
- **CURRENT**: On 12 September at 00.00 UTC its centre was located approx. 170 km south of Hong Kong (China) and approx. 400 km east of Zhanjiang city (Leizhou Peninsula, southern Guangdong Province, China), with maximum sustained wind speed of 74 km/h (Tropical Storm).
- **FORECAST** (as of 12 September, 06:00 UTC TC data): It is forecast to reach the area of Zhanjiang (south-western Guangdong, China) on 12 September evening (UTC), as a Tropical Storm, and the coast of northern Vietnam on 13 September, as a Tropical Depression.

- **HAZARDS:** Heavy rain, strong winds and storm surge could affect south-western Guangdong Province and Hainan Island (China) over 12-13 September as well as northern Vietnam over 13-15 September.

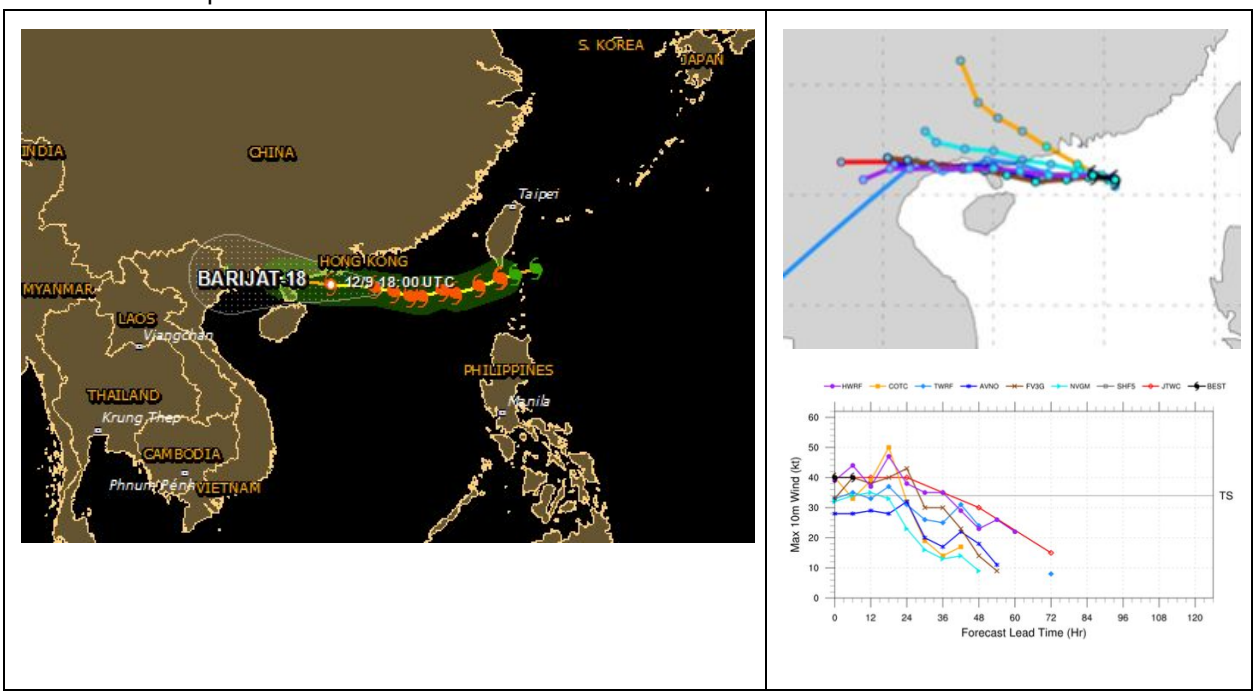


***Figure 3** - TC BARIJAT uncertainty track/intensity (as of 12 Sep, 06:00 UTC). Sources: GDACS (LEFT), NOAA-HWRF (RIGHT)*

Warnings in effect

As of 12 September, 06:00 UTC, there are the following warnings in effect:

PHILIPPINES (source: PAGASA)

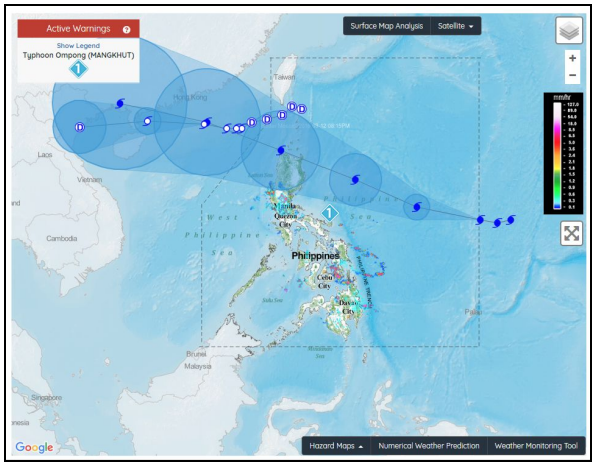


***Figure 4** - Latest Active Warnings page taken from PAGASA: http://bagong.pagasa.dost.gov.ph*

TC MANGKHUT has just entered the Philippine Area of Responsibility (PAR). A Tropical Cyclone Warning Signal (TCWS) #1 is in effect for Catanduanes (Luzon) and according to PAGASA, a TCWS #1 may be also raised in the provinces of Cagayan, Isabela, Aurora, Camarines Norte and Camarines Sur (northern Luzon) tomorrow morning (13 Sep, local time).

Hong Kong (source: Hong Kong Observatory)

- MANGKHUT: no Tropical Cyclone Warning Signal
- BARIJAT: The Tropical Cyclone Warning Signal - Strong Wind Signal, No. 3[1] is in force.

2.2 Humanitarian impact

Up to now no relevant humanitarian impact has been caused by the events. As of 12 September at 12:00 UTC, several power outages were reported on Guam Island (see Figure 5a and 5b). No flooded areas have been detected by the Copernicus EMS trough radar images (see session 4.1), although some flooded area were reported by media (see figure 6).

The Philippines National Disaster Risk Reduction and Management Operation Center (NDRRMOC) raised his alert level to RED at 8:00AM local time of 11th September. Preparedness measures have been identified[2].

The population of the provinces/regions potentially affected of the countries potentially most affected by winds larger than 118 km/h (Category 1 or higher strength, see SSHS), (according to the last forecast available (GDACS), is shown in the table below. The area already affected of Guam and Northern Mariana Islands are also included.

Affected provinces

Region Province	Country	Population
Guam	Guam	140000 people
Northern Mariana Is.	Northern Mariana Islands	60000 people
Cagayan Valley	Philippines	2.3 million people
Cordillera Administrative Region	Philippines	1.1 million people
Ilocos	Philippines	3.5 million people
Guangdong	China	69.6 million people
Hong Kong	China	5.8 million people
Macau	China	380000 people
Guangxi	China	46.8 million people
Quang Ninh	Viet Nam	910000 people

***Table 1** - Population of the potentially affected provinces (source:GDACS, 12 Sep, 6:00 UTC)*

[1] Strong Wind Signal, No. 3 (see: http://www.hko.gov.hk/textonly/warning/ea.htm)
[2] https://www.dswd.gov.ph/dswd-readies-for-the-looming-super-typhoon/

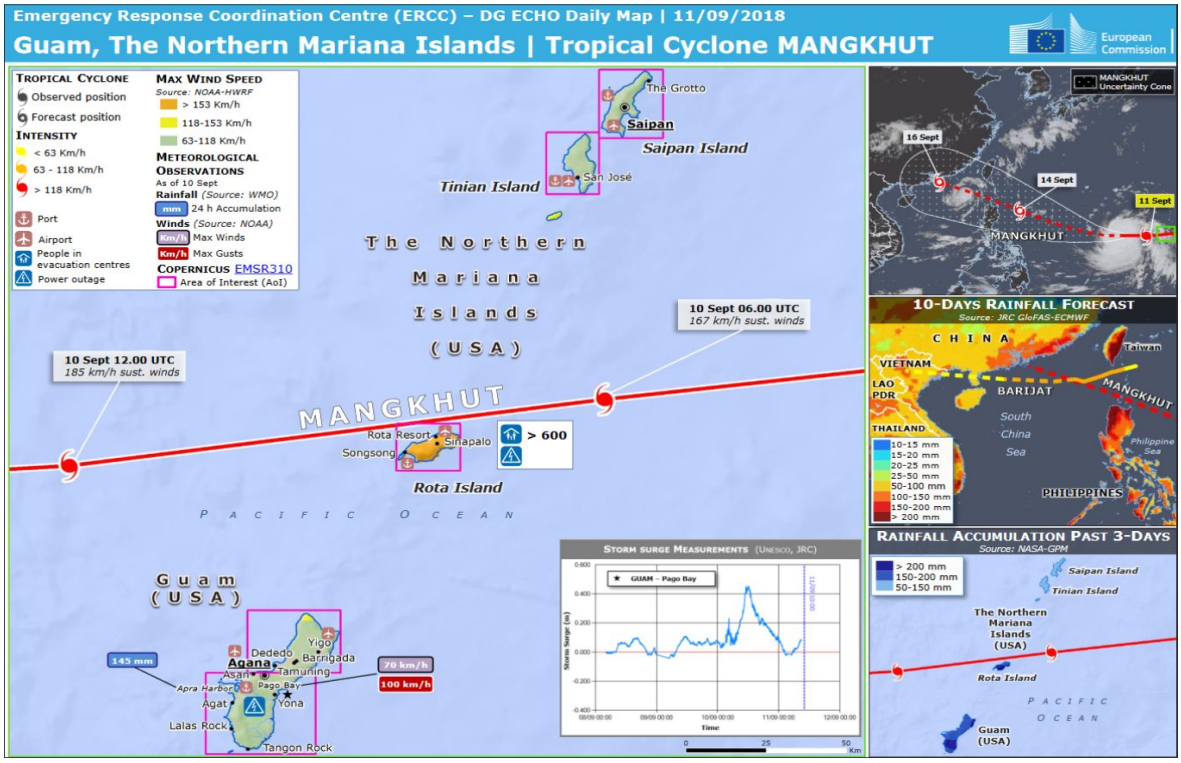


Figure 5a *- ECHO Daily map of 10th September 2018 - Impact of TC MANGKHUT on Guam and The North Mariana Islands.*

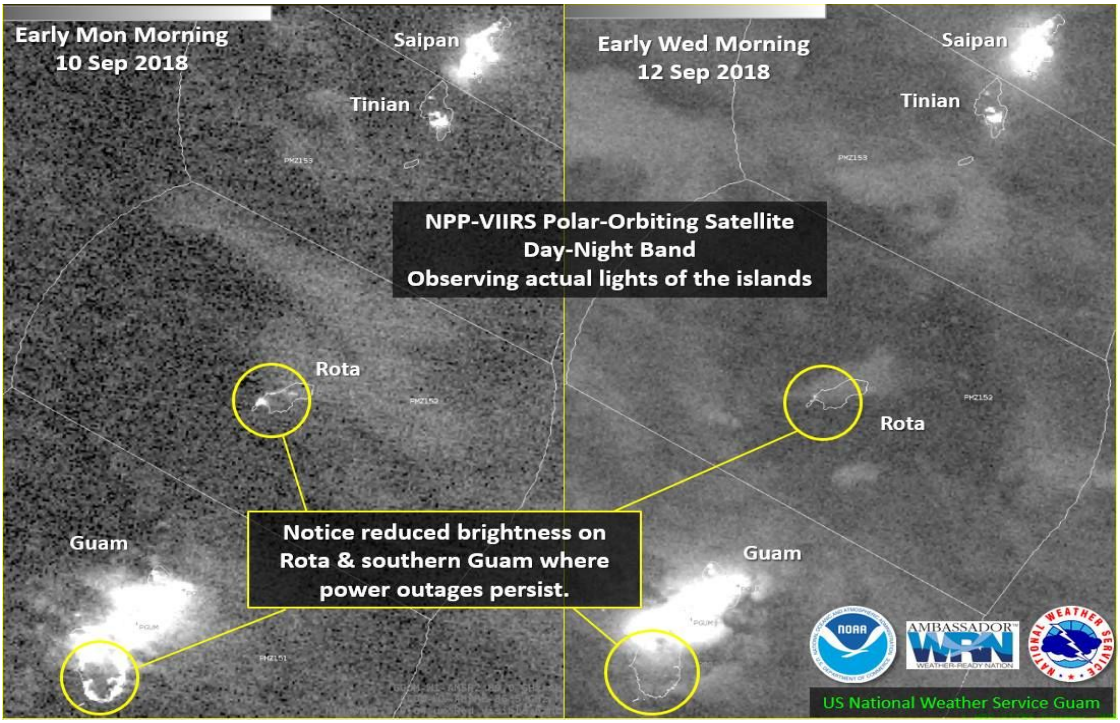


Figure 5b *- NPP-VIIRS Polar Orbiting Satellite, indicating the lack of lights in the Rota and Guam islands on 12 Sept 2018 (Source: NOAA).*

***Figure 6** - Flooded areas reported by media (credit: Rick Cruz/PDN)*[3]

3 JRC contributions

In the period after the end of ARISTOTLE services and the beginning of the new 24h service that is being prepared, JRC supplies ERCC with a similar service during working hours.

The JRC provides updated information on TC MANGKHUT since 7th September for the ECHO Daily Flash reports, available at http://erccportal.jrc.ec.europa.eu/ECHO-Flash.

GDACS System

JRC is responsible for the operation of GDACS (www.gdacs.org) that plays a major role in alerting the international community to humanitarian emergencies during natural disasters. The alerts of GDACS (Green, Orange, Red) are based on the severity of the event, the population involved and the vulnerability of the countries (see Annex). GDACS also sends e-mail and SMS alerts to subscribed recipients.

The JRC is closely following this event because of the strength of this Tropical Cyclone and the vulnerability of the country. The present report was done at the request of the ERCC.

[3] https://eu.guampdn.com/story/news/2018/09/11/homes-roads-power-system-damaged-mangkhut/1261431002/

Event alert

GDACS has issued the first **ORANGE** Alert for this event in Guam on 7th September 00:00 UTC (the Orange was imposed as the landfall in Guam was more than 3 days after), reclassified as **RED** alert with the following bulletin of 12:00 UTC. Then the alert changed from Orange to Red and Green, depending on the variation of the forecasted intensity and track. Until 10th September the alert level remained **ORANGE** for Guam and Mariana Islands but starting from the 18:00 UTC forecast of the same day, the track started to include northern Philippines and it remained RED since then.
According to the latest bulletin (12 Sep, 06:00 UTC), the GDACS alert level is now **RED** (for high winds) for this event in Guam, Northern Mariana Islands, Philippines, China with nearly 43 million people in Category 1 or higher. strength winds (> 120 km/h). The possible impact due to winds, rainfall and storm surge are shown below, while the automatic GDACS report for TC **MANGKHUT** can be found at this address:
http://www.gdacs.org/report.aspx?name=MANGKHUT-18 .

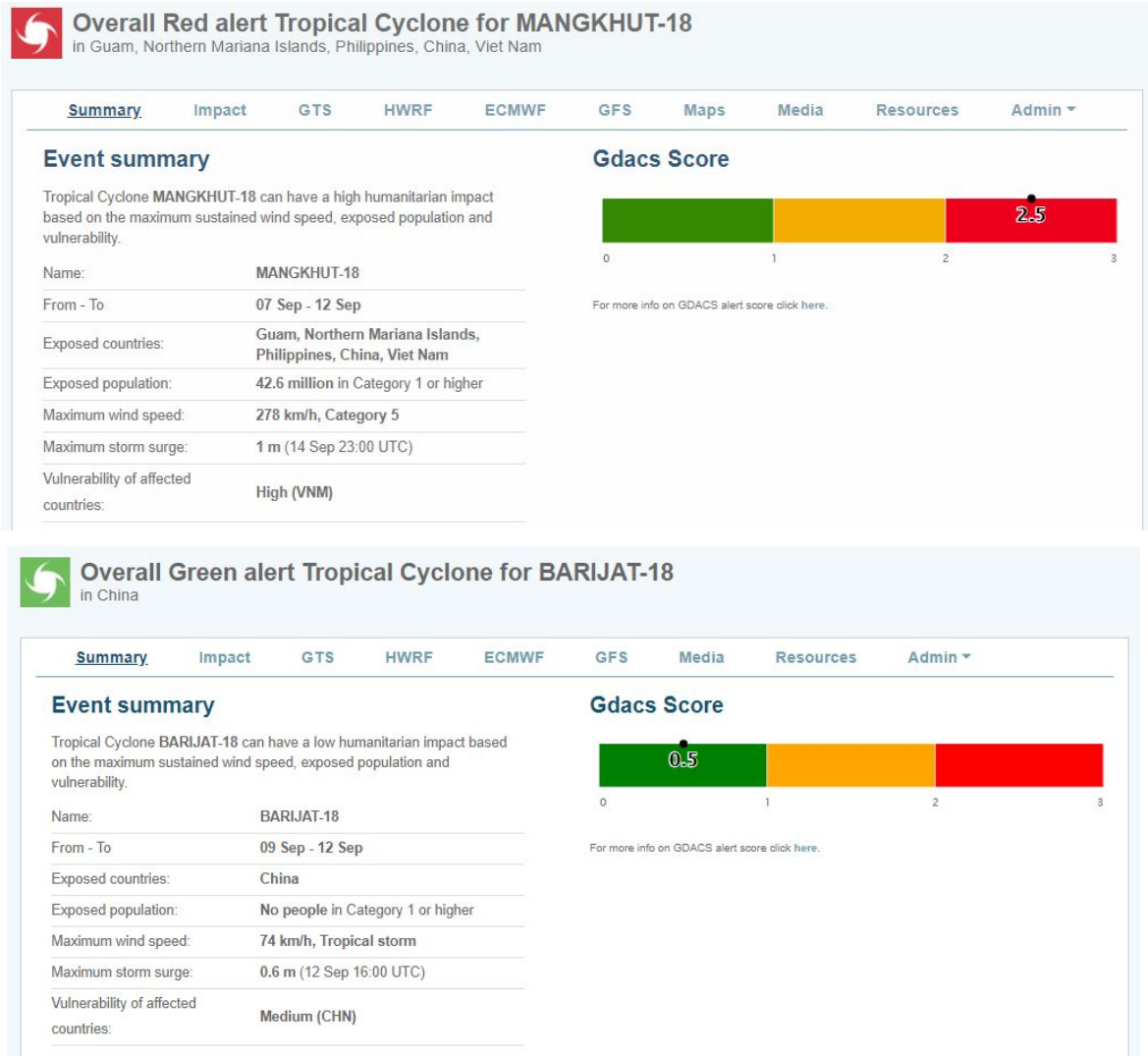


***Figure 7** - Automatic GDACS impact estimation (as of 12 Sep 2018, 06:00 UTC).*
MANGKHUT (Top), BARIJAT (Bottom),

The GDACS response for the other Tropical Cyclone BARIJAT is GREEN for the possible impact in northern Vietnam. It is mentioned here because during its path it may have caused heavy rain in northern Philippines that will be reached by Typhoon MANGKHUT with greater vulnerability and could produce heavy rain also in southern China and northern Vietnam.

Bulletin Timeline

Advisory	Alert color	Date (UTC)	Category	Wind speed	Population in Tropical Storm	Population in Cat.1 or higher	Location (lat, lon)
1		07 Sep 2018 00:00	Tropical depression	**37 km/h** (23 mph)	no people	no people	12.3, 168
2		07 Sep 2018 06:00	Tropical depression	**46 km/h** (29 mph)	no people	no people	12.4, 166.7
3		07 Sep 2018 12:00	Tropical depression	**56 km/h** (34 mph)	no people	no people	12.8, 165.5
4		07 Sep 2018 18:00	Tropical storm	**65 km/h** (40 mph)	no people	no people	13, 163.9
5		08 Sep 2018 00:00	Tropical storm	**65 km/h** (40 mph)	no people	no people	13.6, 162.3
6		08 Sep 2018 06:00	Tropical storm	**74 km/h** (46 mph)	no people	no people	14.3, 160.8
7		08 Sep 2018 12:00	Tropical storm	**83 km/h** (52 mph)	no people	no people	14.8, 159.1
8		08 Sep 2018 18:00	Tropical storm	**102 km/h** (63 mph)	no people	no people	14.9, 157
9		09 Sep 2018 00:00	Category 1	**120 km/h** (75 mph)	no people	no people	15.1, 154.9
10		09 Sep 2018 06:00	Category 1	**130 km/h** (80 mph)	no people	no people	15.3, 152.9
11		09 Sep 2018 12:00	Category 1	**139 km/h** (86 mph)	no people	no people	15.1, 150.9
12		09 Sep 2018 18:00	Category 1	**148 km/h** (92 mph)	49000 people	no people	14.7, 149.1
13		10 Sep 2018 00:00	Category 1	**148 km/h** (92 mph)	210000 people	5300 people	14.5, 147.4
14		10 Sep 2018 06:00	Category 2	**167 km/h** (103 mph)	210000 people	130000 people	14.3, 145.7
15		10 Sep 2018 12:00	Category 3	**185 km/h** (115 mph)	210000 people	no people	14.1, 144.2
16		10 Sep 2018 18:00	Category 3	**204 km/h** (126 mph)	160000 people	no people	14, 142.6
17		11 Sep 2018 00:00	Category 4	**222 km/h** (138 mph)	no people	no people	14, 141.2
18		11 Sep 2018 06:00	Category 4	**250 km/h** (155 mph)	no people	no people	14, 139.7
19		11 Sep 2018 12:00	Category 5	**259 km/h** (161 mph)	no people	no people	13.7, 138.6
20		11 Sep 2018 18:00	Category 5	**259 km/h** (161 mph)	no people	no people	13.9, 137.3
21		12 Sep 2018 00:00	Category 5	**259 km/h** (161 mph)	no people	no people	13.9, 136.2
22		12 Sep 2018 06:00	Category 5	**278 km/h** (172 mph)	no people	no people	14, 135.2
22		12 Sep 2018 18:00	Category 5	**278 km/h** (172 mph)	no people	no people	14.4, 132.8
22		13 Sep 2018 06:00	Category 5	**269 km/h** (166 mph)	no people	no people	15.1, 130.4
22		13 Sep 2018 18:00	Category 5	**269 km/h** (166 mph)	7.8 million people	no people	15.9, 128.3
22		14 Sep 2018 06:00	Category 5	**259 km/h** (161 mph)	58.7 million people	5.1 million people	16.9, 125.8
22		15 Sep 2018 06:00	Category 4	**222 km/h** (138 mph)	163.2 million people	3.3 million people	18.9, 120.3
22		16 Sep 2018 06:00	Category 2	**167 km/h** (103 mph)	167.7 million people	37.3 million people	20.9, 114.5
22		17 Sep 2018 06:00	Tropical storm	**93 km/h** (57 mph)	no people	no people	22.1, 108.5

Actual track of the current bulletin
The alert for forecast greater than 3 days is limited to Orange level.

***Figure 8** - GDACS Alert for Tropical Cyclone MANGKHUT - Event Timeline, population affected, max. sustained winds (the Category is based on the Saffir-Simpson Hurricane Scale, see Annex), as of 12 Sep 2018, 06:00 UTC.*

Impact estimation

The TCs have three dangerous effects (strong winds, heavy rains and storm surge). The possible impact of Typhoon MANGKHUT over the next few days in the potentially affect countries (**Philippines**, China) is shown below, while the impact of MANGKHUT in Guam and Northern Mariana Islands has been already included in the Section 2.2.

Note: This Section is focused only on MANGKHUT, since it is the most significant event, however it should be noted that TC BARIJAT has already affected the northern Philippines and southern Taiwan with heavy rains, and could also affect southern China (Guangdong, Hainan) and northern Vietnam with heavy rain, this could worsen the situation during the passage of MANGKHUT.

Wind

- **PHILIPPINES:** The center of MANGKHUT is expected to pass over Cagayan province (including Babuyan islands) northern Philippines, on 14-15 September, as a very intense Typhoon with max. sustained winds of over 270 km/h (equivalent to a Category 5 in the SSHS, see Annex). Very strong winds (up to 270 km/h, with higher gusts) could affect Cagayan Province, including Babuyan islands. Strong winds (>118 km/h) could also affect the Batanes islands, as well as the other provinces of northern Luzon (Philippines).

  Potentially most affected areas: **Cagayan Province (including Babuyan islands), Batanes, Apayao, Ilocos Norte**

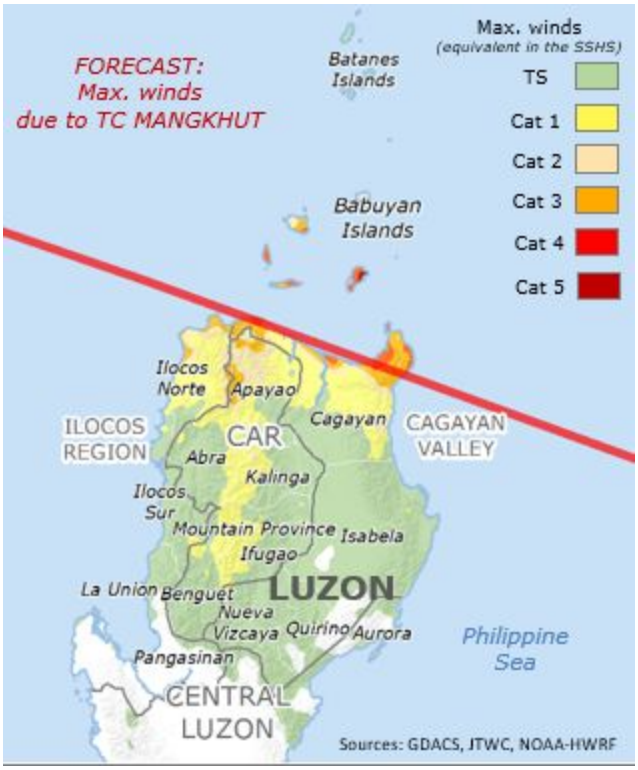


***Figure 9** - FORECAST: max. winds in the northern Philippines (GDACS, NOAA-HWRF)*

- **CHINA (Taiwan):** the center of MANGKHUT is forecast to pass approx. 300 km south of southern Taiwan. Tropical Storm force winds (63-118 km/h) could affect southern Taiwan during its passage.

  Potentially most affected areas: **Pingtung, Taitung, Kaohsiung** (southern Taiwan).

- **CHINA (Guangdong Province, Hong Kong and Macau)**: MANGKHUT is expected to reach the coastal areas of Guangdong, west of Hong Kong and Macau on 16 September, still as a Typhoon with max. sustained winds of over 140-160 km/h (equivalent to a Category 1-2 in the SSHS, see Annex). Strong winds (up to 170 km/h, with higher gusts) could also affect these areas on 16 September. Tropical Storm winds could also affected the other areas of Guangdong, Hainan and Guangxi province (China), as well as northern Vietnam

  Potentially most affected areas: south-western **Guangdong**, **Hong Kong** and **Macau**.

  NOTE: South-western Guangdong and Hainan (China) and northern Vietnam will be affected by strong winds also on 12-15 September, due to the passage of BARIJAT.

Rainfall

- **PHILIPPINES:** TC MANGKHUT is expected to produce very heavy rains (locally total acc. > 500 mm) over several areas of northern Luzon, in particular in the mountain areas and along the coast of Cagayan (see Figure 10). This amount of rainfall could cause landslides and flash floods. These areas have been already recently affected by heavy rains (>200 mm/72h, in the Batanes), caused by the passage of BARIJAT.
  It could also enhance the “Habagat” (south-west monsoon), causing occasional rainfall over Palawan, Mindoro and Western Visayas.

  Potentially most affected areas: **Cagayan Province, including Babuyan islands, Batanes Isabela, Aurora, Apayao, Ilocos Norte, Ilocos Sur, Abra, Benguet, Mountain Province, Kalinga.**

  The total rainfall accumulation forecast for the next 5 days (NOAA-HWRF, 12 Sep, 00:00 UTC) and the last 3 days total rainfall accumulation (NASA GPM) are shown in Fig. 10 whereas the climatological information (WMO) is contained in Table below.

Climatological Information Mean Total Precipitation *(World Bank)*	**Sep**
Santa Ana (Cagayan)	274.15 mm
Tuguegarao (Cagayan)	249.4 mm
Baguio (Benguet)	416.52 mm

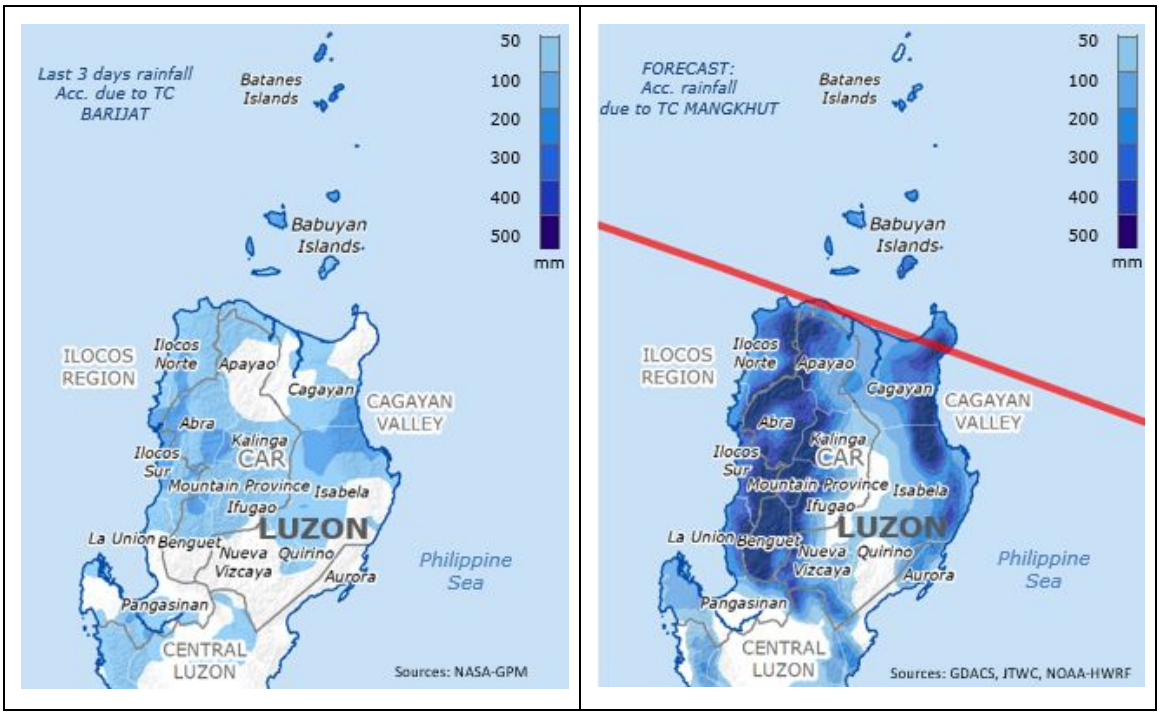


Figure 10 *- Total rainfall amounts accumulated during the last 3 days based on NASA GPM (left panel) and total rainfall forecast for the next 5 days based on NOAA-HWRF (right panel)*

- **CHINA (Taiwan):** according to the last forecast, it is forecast to produce heavy rainfall (**over 500 mm**) over southern and eastern Taiwan, especially on the mountain areas, with the risk of floods and flash floods. The southern areas of Taiwan have been already recently affected by rains (200 mm/72h), caused by the passage of BARIJAT.

  Potentially most affected areas: **Pingtung, Taitung** (southern-easter Taiwan)

Climatological Information Mean Total Precipitation *(World Bank)*	**Sep**
Pingtung City	240 mm
Taitung City	270 mm

- **CHINA (Guangdong Province, Hong Kong and Macau)**: There is still a large uncertainty on the possible forecast, however based on the last data available, heavy rain could affect these areas on 15-17 September (locally over 200 mm), with the risk of floods and flash floods. These areas will be affected by heavy rains, during the passage of BARIJAT on 12-13 September.

Climatological Information Mean Total Precipitation (WMO)	**Sep**
Haikou (Hainan island)	251.0 mm
Hong Kong	327.6 mm
Macau	194.1 mm

Storm Surge

According to the latest JRC HyFlux2 storm surge calculation (using as input the data of the bulletin of 12 Sep 2018 06:00 UTC), the areas potentially most affected are is northern Philippines with a maximum of:

- 1.0 m in Sorongan, on 14 Sep 23:00 (UTC)

The storm surge estimated in Guam, occurred on 10 Sept, was not very high, with maximum height of 0.5 m in Rota island. The estimation is confirmed by the available measurements in Guam that shows a maximum storm surge lower than 0.5 m (Fig. 11).

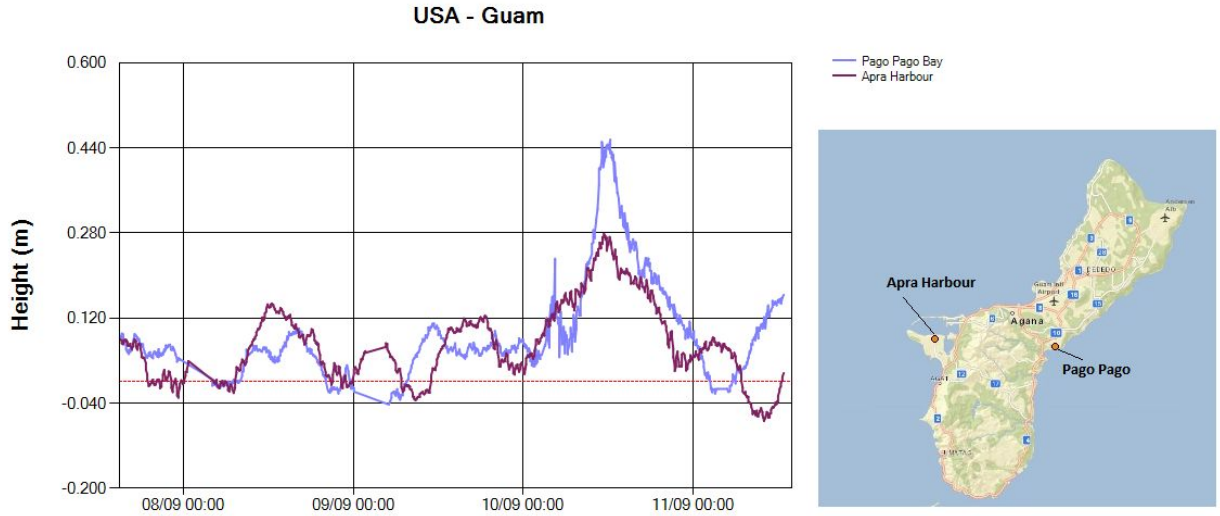


Figure 11 *- Storm surge estimated from measured sea level in Guam: Pago Pago bay (blue curve), Apra Harbour (dark red)*

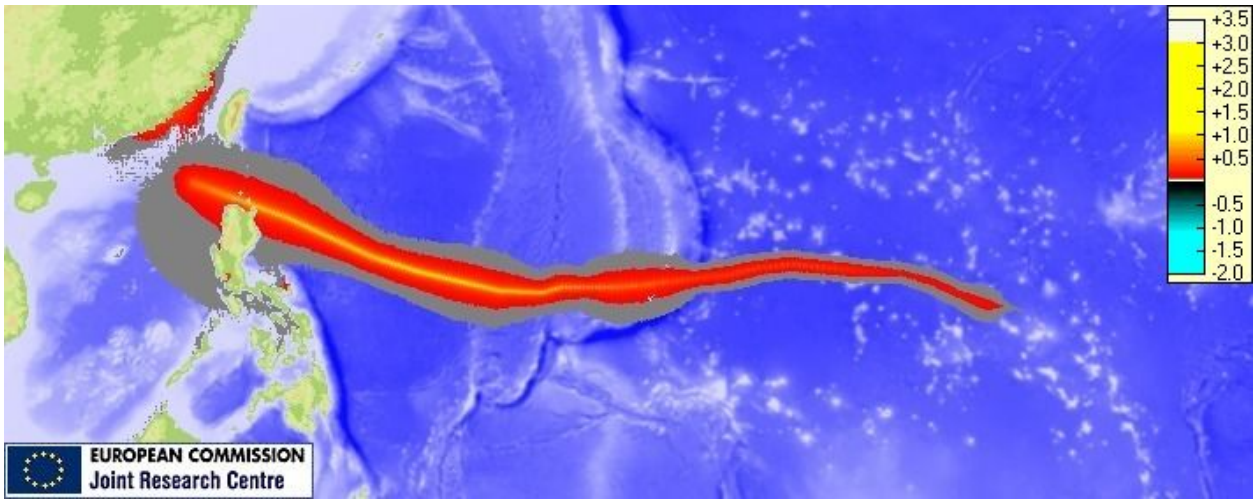


Figure 12 *- Storm surge over the track of MANGKHUT*

The list of locations for storm surge is shown below (Fig. 13).

Date	Name	Country	Alert	Storm surge height (m)
14 Sep 2018 23:00:00	Sorongan	Philippines		1.0m
14 Sep 2018 21:00:00	Cadagatan	Philippines		1.0m
15 Sep 2018 00:00:00	Banoa	Philippines		1.0m
15 Sep 2018 00:00:00	Visita	Philippines		1.0m
15 Sep 2018 00:00:00	Poso	Philippines		0.9m
14 Sep 2018 20:00:00	Bawa	Philippines		0.9m
14 Sep 2018 20:00:00	Cabiraoan	Philippines		0.9m
14 Sep 2018 20:00:00	Casambalangan	Philippines		0.9m
14 Sep 2018 22:00:00	Minabul	Philippines		0.8m
15 Sep 2018 18:00:00	Gongkou	China		0.8m
15 Sep 2018 18:00:00	Huanggang	China		0.8m
15 Sep 2018 18:00:00	Shantou	China		0.8m
15 Sep 2018 18:00:00	Dahao	China		0.8m
15 Sep 2018 18:00:00	Aotou	China		0.8m
15 Sep 2018 18:00:00	Siwei	China		0.8m

Figure 13 *- Reference locations for storm surge calculations.*

The detailed impact for Storm Surge in the North Philippines is shown in the Figure 14. The maximum storm surge is estimated in Sorongan island, in the Babuyan Archipelag.

The storm surge estimated for the Barijat TC is rather low; the maximum value is estimated in China:

- 0.8 m in Na-hsieh, on 13 Sep 4:00 (UTC)

These values could still change due to the track/intensity uncertainty and do not include the possible effects on China because storm surge is calculated only for 3 days forecast.

Note: *JRC storm surge calculations don't include wave, tide and river effects. It is important to note that in the area of a delta river, the storm surge may be higher. The torrential rains that may affect the mountains areas during the passage of a Tropical Cyclone may increase the river flow and its outflow could be blocked by the incoming storm surge. This could create floods in the surrounding areas of the cities close to a delta river.*

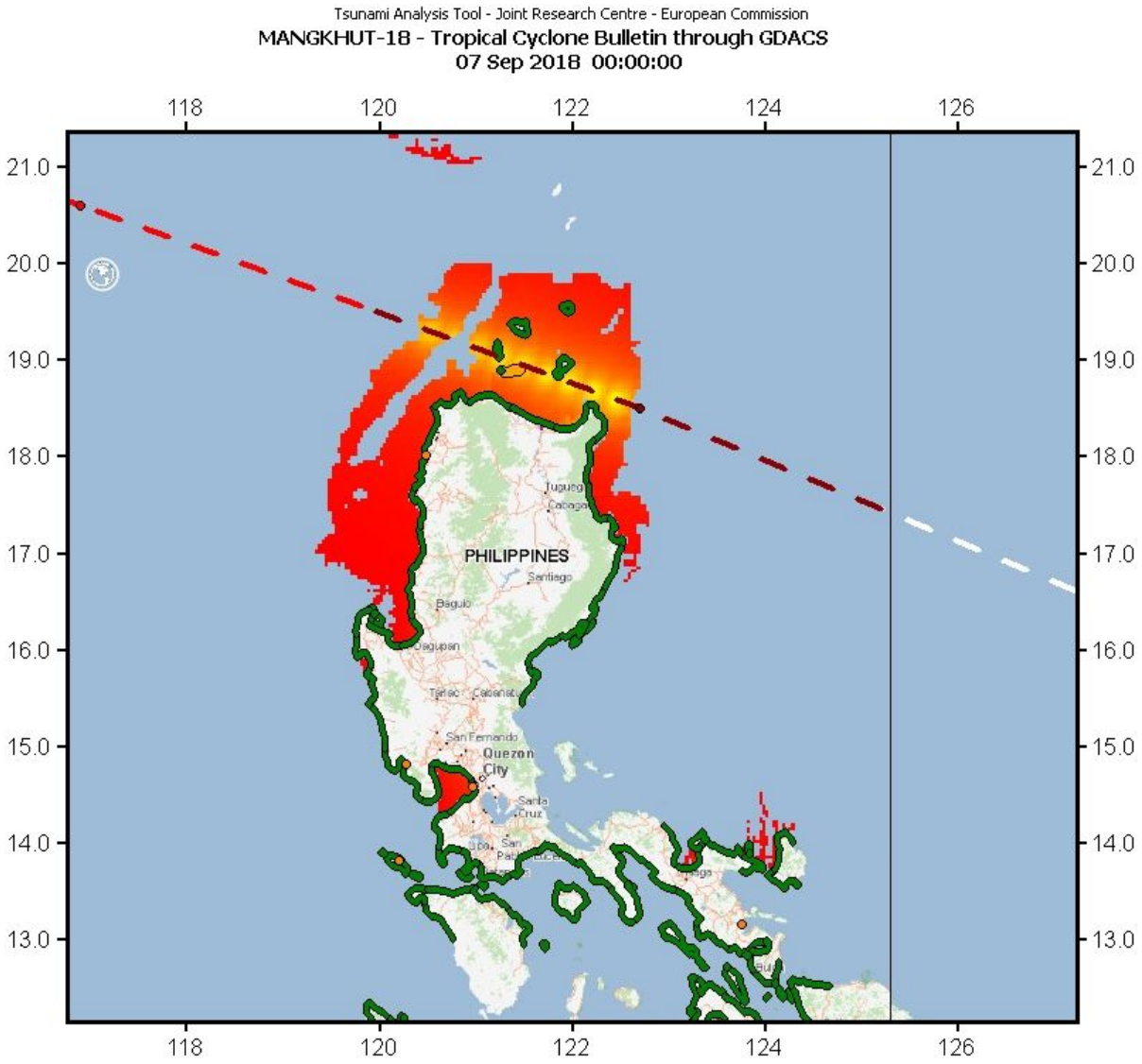


Figure 14 *- Storm surge impact in the North Philippines (Hyflux2, GDACS model): Green color for coastal impact (<1m), Orange color (1-3 m) - This calculation is based on bulletin 20 (11 Sep 2018 18:00)*

According to NOAA buoy measurements, the off-shore wave height measured by a buoy north of Guam, was about 11 m (37 feet).

GLOFAS System

The Global Flood Awareness System (GloFAS), jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF), is independent of administrative and political boundaries. It couples state-of-the art weather forecasts with a hydrological model and with its continental scale set-up it provides downstream countries with information on upstream river conditions as well as continental and global overviews. GloFAS is part of the Copernicus Emergency Management Service.

According to the latest forecast from 12 September 2018 GloFAS predicts a low probability of river floods with a magnitude higher than 5 year return periods for the northern part of the Luzon island affecting the river basins Cagayan, Abra and Agno (see Figure 15). River discharges will start increasing from 14 September onwards with peak discharges predicted around 16/17 September.

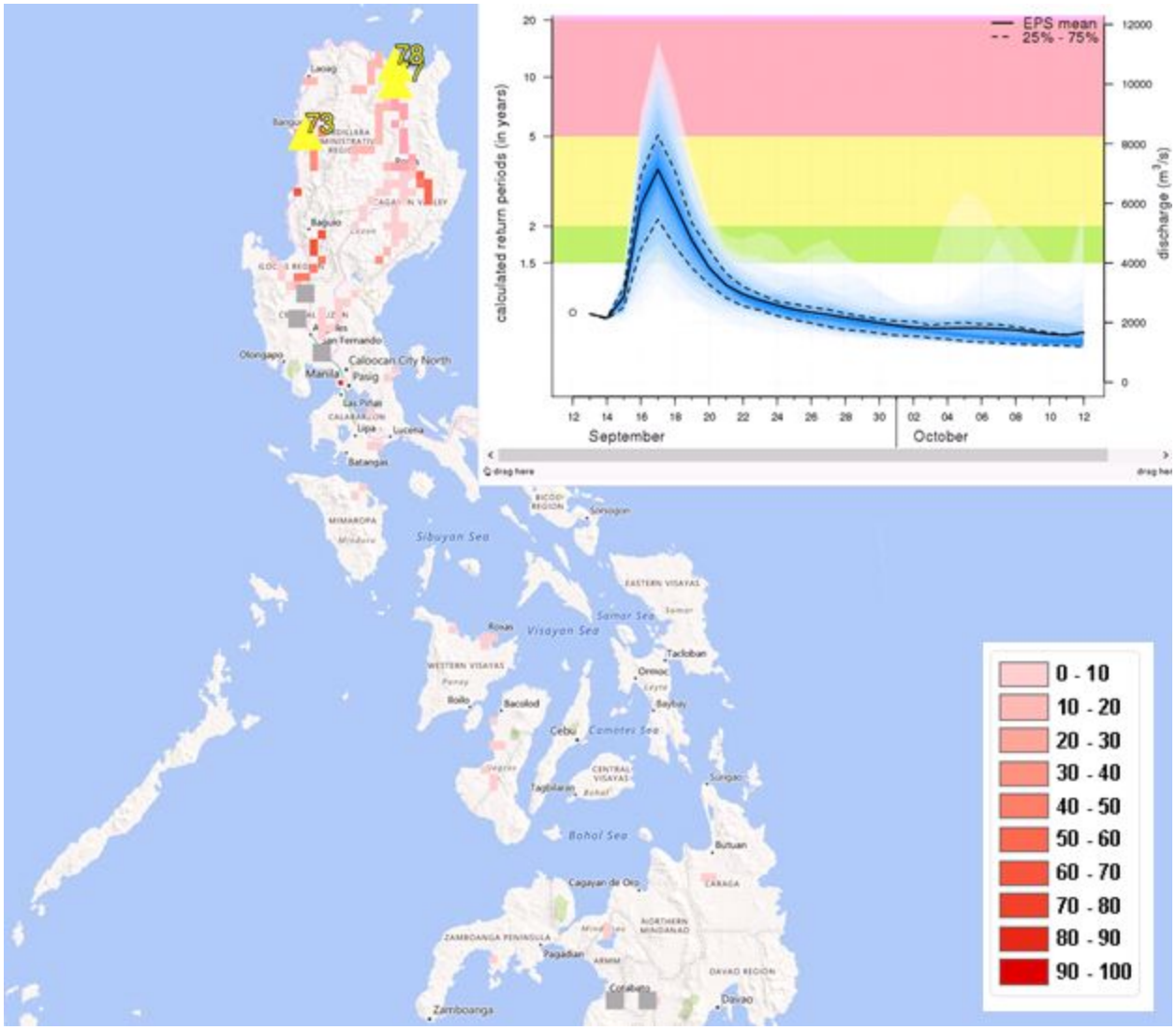


Figure 15 - *GloFAS forecast from 12-09-2018 for the Philippines. Red shaded pixels denote the probability [%] to exceed a 5 year return period flood. The hydrographs depicts the predicted river discharge at the outflow of the Cagayan river (northernmost point).*

4 Other information

4.1 Copernicus EMS activation

The Copernicus Emergency Management Service (EMSR310) was activated by the EU Delegation in Washington on behalf of the US Federal Emergency Management Agency (FEMA) on 10 September at 2.56 UTC for Guam and The Northern Mariana Islands. The areas of interest cover the entire area of the islands of Guam, Rota, Aguijan, Tinian and Saipan. The first assessment from 5m resolution radar data acquired on 11 September at 07:57 UTC **did not show any flooded areas**. For the time being no further assessments are foreseen.

Fig. 15 shows the activation extent map for this activation (location of areas of interest and products).

More information on the activation is available at
http://emergency.copernicus.eu/mapping/list-of-components/EMSR310

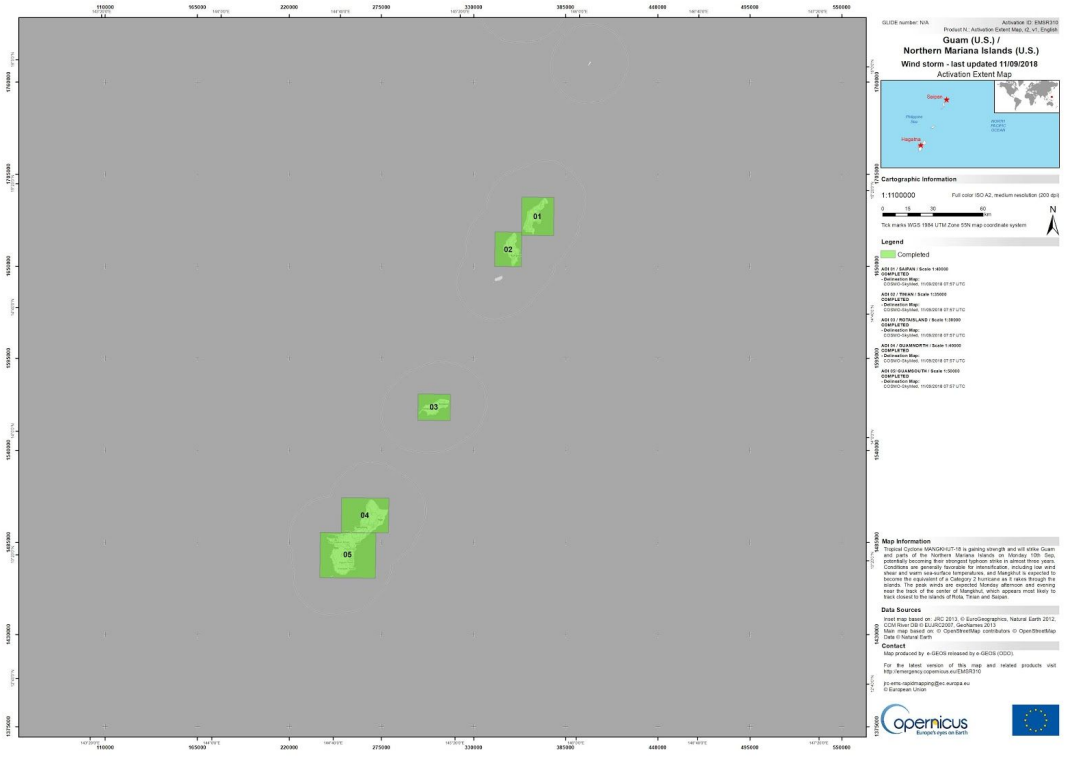


Figure 15 *- Activation Extent Map of the Copernicus EMS activation for TC Mangkhut (EMSR310)*

4.2 Virtual OSOCC Activation

None.

4.3 International Charter activation

The US authorities were initially planning to activate the Charter but didn't proceed given the first knowledge on impact.

5 Expected Updates

The report will be updated if relevant changes will be identified.

6 References and contact points within JRC

Contact points within JRC: Disaster Risk Management Unit
- Alessandro Annunziato, alessandro.annunziato@ec.europa.eu (GDACS)
- Pamela Probst, pamela.probst@ec.europa.eu (GDACS Meteorologist)
- Chiara Proietti, chiara.proietti@ec.europa.eu (Humanitarian response)
- Thomas Petroliagkis, thomas.petroliagkis@ec.europa.eu (GDACS Meteorologist)
- Annett Wania, annett.wania@ec.europa.eu (Copernicus EMS activation)

- Ian Clark, ian.clark@ec.europa.eu
- Tom De Groeve, tom.de-groeve@ec.europa.eu

For updated information on the disaster, please consult the following web sites:

- GDACS: http://www.gdacs.org
- ERCC portal: http://erccportal.jrc.ec.europa.eu/
- Copernicus EMS: http://emergency.copernicus.eu/mapping/list-of-components/EMSR310
- National Meteorological service:
    - Guam: http://www.prh.noaa.gov/guam/
    - Northern Mariana Islands: https://www.weather.gov/prh/aboutGUM
    - Philippines: http://bagong.pagasa.dost.gov.ph/
    - Taiwan: https://www.jma.go.jp/jma/indexe.html
    - China: http://www.cma.gov.cn
    - Hong Kong: https://www.hko.gov.hk/contente.htm
    - Vietnam: http://www.nchmf.gov.vn
    - Japan: https://www.jma.go.jp/jma/indexe.html
- WMO Severe weather Information Centre: http://severe.worldweather.org/
- Regional Specialized Meteorological Centres (RSMCs) and Tropical Cyclone Warning Centres (TCWCs):
    - RSMC Tokyo-Typhoon Center / Japan Meteorological Agency: http://www.jma.go.jp/en/typh/
- NOAA-HWRF (Hurricane Weather Research and Forecasting system): http://www.emc.ncep.noaa.gov/gc_wmb/vxt/HWRF/index.php

- JRC Emergency Report
    - 2018 - NW Pacific Typhoons: Past events, current situation and seasonal forecast http://portal.gdacs.org/GDACSDocuments/015-NW%20Pacific%20Typhoons_update.pdf

Annex 1 - Detailed Map on the Tropical Cyclone

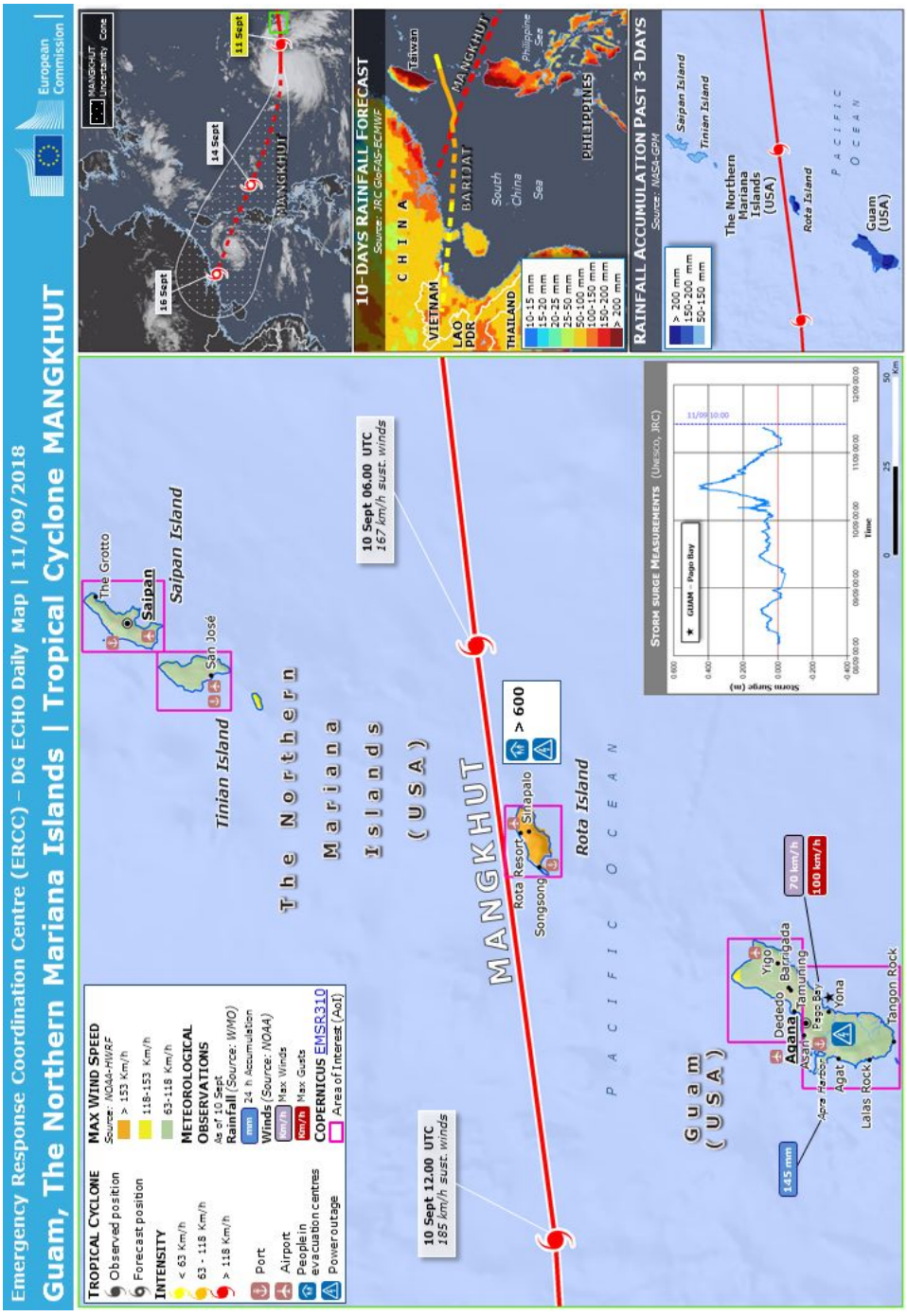


Figure A1.1. *- TC MANGKHUT in Guam and the Northern Mariana Islands (ECHO Daily Map of 11 Sep 2018)*

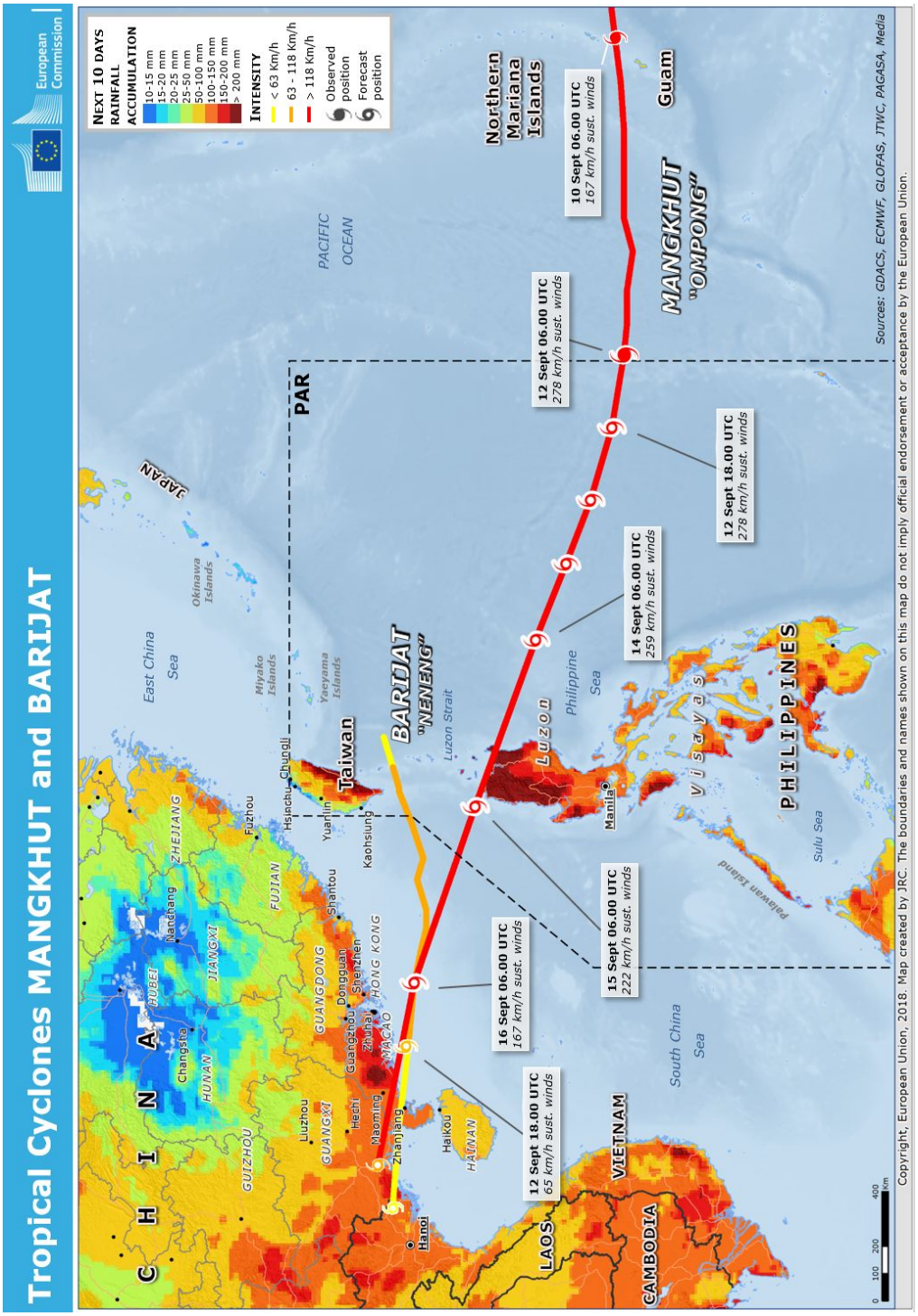


Figure A1.2 *- TC MANGKHUT and BARIJAT in Guam, Northern Mariana Islands, Philippines, China (as of 12 Sep 2018, 06:00 UTC)*

Figure A1.3. *- TC MANGKHUT in the Philippines, track and provinces potentially affected.*

Annex 2 - GDACS Alerts

JRC is responsible for the operation of GDACS (Global Disaster Alerting Coordination System), that plays a major role in alerting the international community to humanitarian emergencies during natural disasters. The alerts of GDACS (Green, Orange, Red) are elaborated based on the severity of the event, the population involved and the vulnerability of the countries. GDACS also sends e-mail and SMS alerts to subscribed recipients. A detailed description of GDACS can be found in the GDACS Guidelines available at:
http://www.gdacs.org/Documents/GDACS%20Guidelines%202014_-_FINAL.PDF

GDACS ALERTS		
	**GREEN ALERT**	Moderate event, International Assistance not likely
	**ORANGE ALERT**	Potential local disasters, International Assistance might be required
	**RED ALERT**	Potentially severe disasters, International Assistance is expected to be required

Tropical Cyclones (TCs) are among the most dangerous natural disasters, causing every year extensive damage and deaths in several countries around the world. They have three destructive effects (strong wind, heavy rain and storm surge). GDACS includes the analysis of all TCs occurring worldwide.

TC information:
JRC set up an automatic routine that includes the TC bulletins produced by the National Oceanic and Atmospheric Administration (NOAA) and the Joint Typhoon Warning Center (JTWC) into a single database, covering all TC basins. This information is used in GDACS for the wind impact, and as input for the JRC storm surge system. JRC has recently developed new tools for the analysis of the TC impacts and included new sources (NOAA Hurricane Weather Research and Forecast - HWRF and Global Forecasting System - GFS, global high resolution model of the European Centre for Medium Weather Forecast -ECMWF).
→ NW Pacific: JTWC data

Wind
The GDACS alert levels for the TCs are based on the risk formula that includes:

- TC wind speed[4] (hazard)
- Population affected
- Vulnerability of the affected country

The equivalent Category based on the Saffir-Simpson Hurricane Wind Scale (SSHS), 1-min sustained winds, is also indicated in GDACS (see next page).
The overall alert for a Tropical Cyclone comes from **wind effects.**

[4] GDACS, JTWC, NOAA wind information based on 1-min sustained winds; other centers: 10-min average (see: https://www.wmo.int/pages/prog/www/tcp/documents/WMO_TD_1555_en.pdf)

Recently, in order to avoid too much false alerts or flip-flop effects due to the too early forecast and change of track direction or intensity, the alert level for forecast data with more than 3 days lead time is limited to Orange Alert, even if Red Alert is estimated.

Storm Surge

Storm surge is an abnormal rise of water above the predicted astronomical tides, generated by strong winds and by a drop in the atmospheric pressure. It was implemented in the HyFlux2 code, routinely used in GDACS to model inundation due to tsunami run-up.

The GDACS alert levels are based on the maximum storm surge height:

- Green: < 1.0 m;
- Orange: 1.0m - 3.0 m;
- Red: > 3.0 m.

It should be noted that the estimation of the sea level is strongly dependent on the initial data (wind velocity and direction). The sea level change according to each bulletin that was available.

TC Classification used in GDACS

The equivalent Category based on the Saffir-Simpson Hurricane Wind Scale (SSHS) is also indicated in GDACS. The SSHS is the official scale used by NOAA-NHC for the North Atlantic TC basin and is a scale from 1 to 5, based on the hurricane's 1-min sustained wind speed and it estimates the potential property damage (see Table A2.1). Note: for the NW Pacific basin, the JMA uses the following classes: Tropical Depression, Tropical Storm, Severe Tropical Storm, Typhoon, based on 10-min average winds.

Saffir-Simpson Hurricane Wind Scale (SSHS), source NOAA-NHC		
Hurricane CATEGORY	**1-min sustained winds (km/h)**	**Types of Damage Due to Hurricane Winds**
Cat. 1	119 - 153	Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
Cat. 2	154 - 177	Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks
Cat. 3 *Major Hurricane*	178 - 208	Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes
Cat. 4 *Major Hurricane*	209 - 251	Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
Cat. 5 *Major Hurricane*	≥ 252	A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months

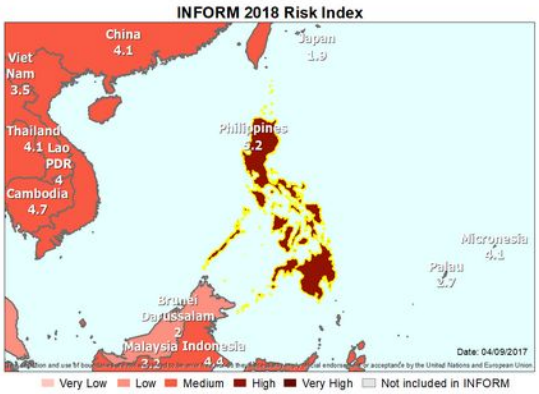
Table A2.1 -*TC Classification (Saffir-Simpson Hurricane Wind Scale), used in GDACS. (see NOAA-NHC: http://www.nhc.noaa.gov/aboutsshws.php)*

Annex 3 - INFORM

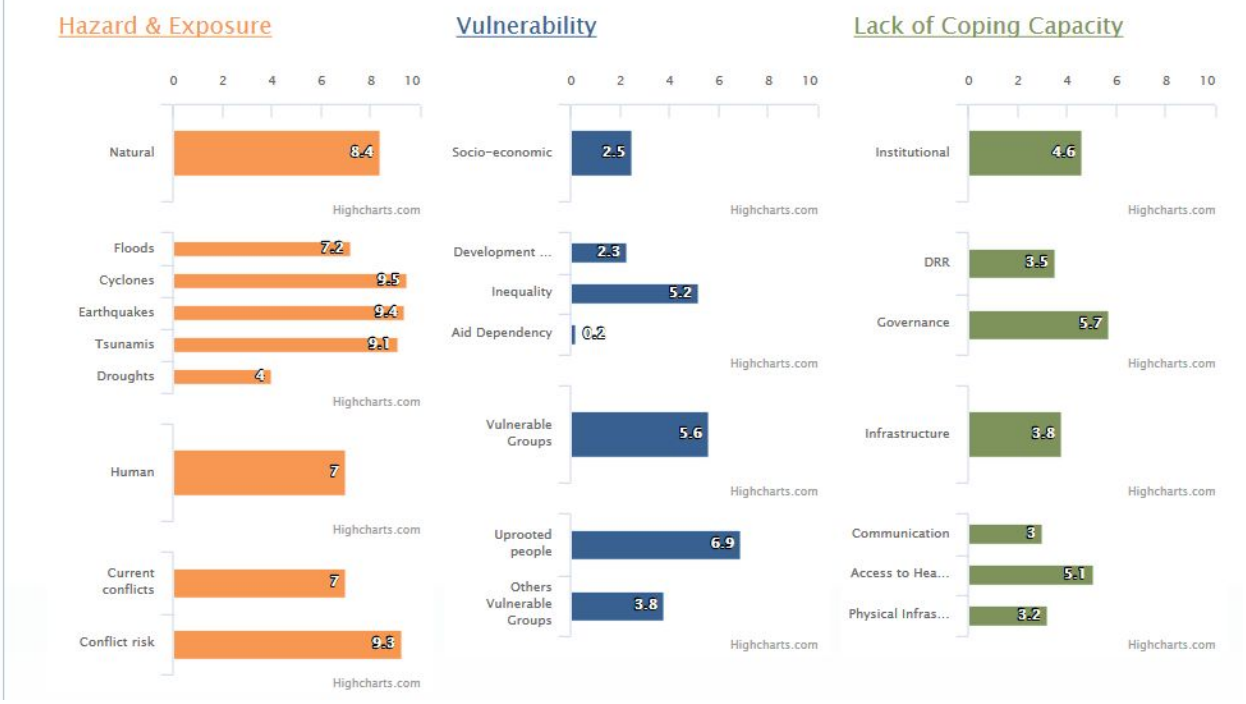
PHILIPPINES

South-Eastern Asia
Lower middle income

	Value	Rank	Trend
INFORM Risk	5.2	39	—
Hazard & Exposure	7.8	10	—
Vulnerability	4.2	69	—
Lack of Coping Capacity	4.2	108	—



RISK DIMENSIONS AND COMPONENTS

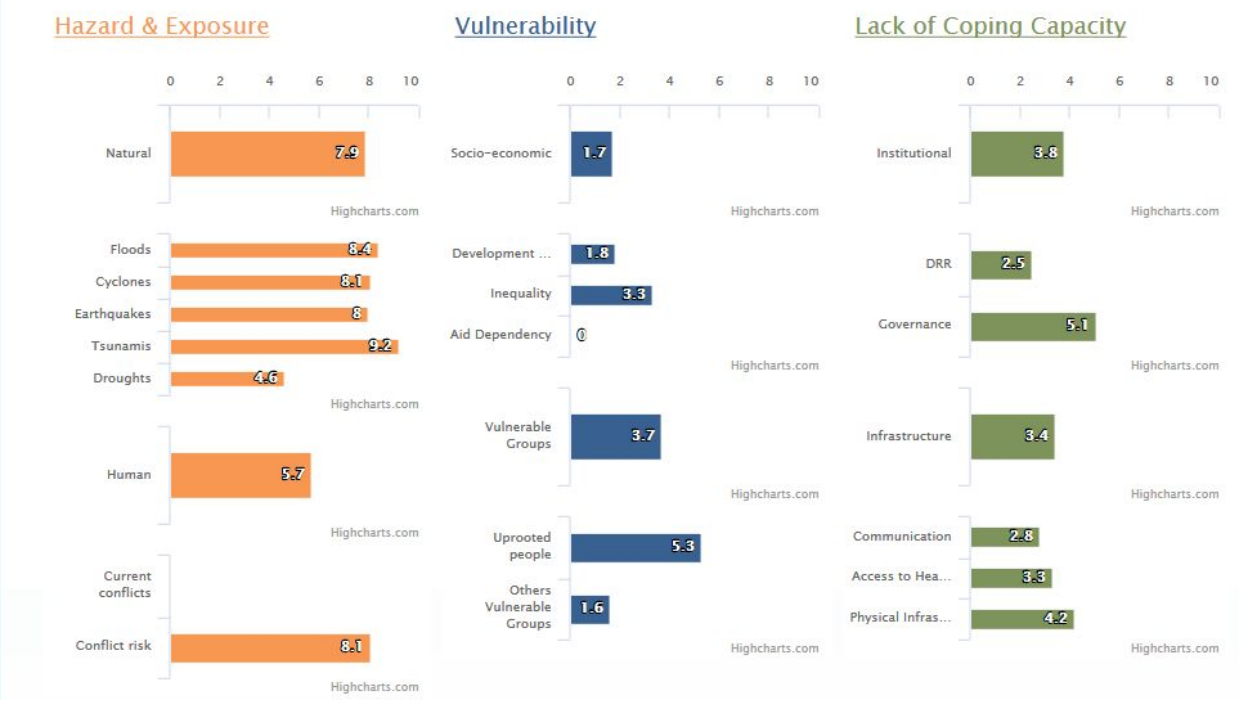


CHINA

Eastern Asia
Upper middle income

	Value	Rank	Trend
INFORM Risk	4.1	77	—
Hazard & Exposure	6.9	21	—
Vulnerability	2.8	110	—
Lack of Coping Capacity	3.6	131	—

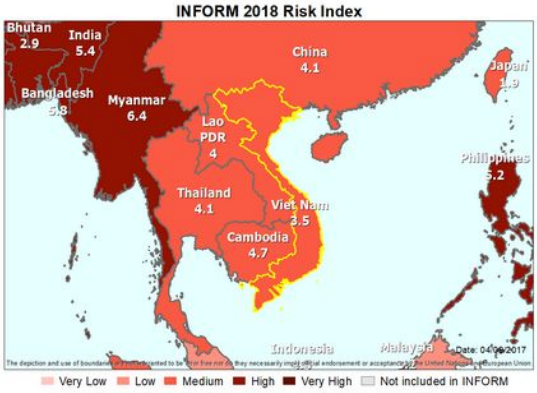
RISK DIMENSIONS AND COMPONENTS



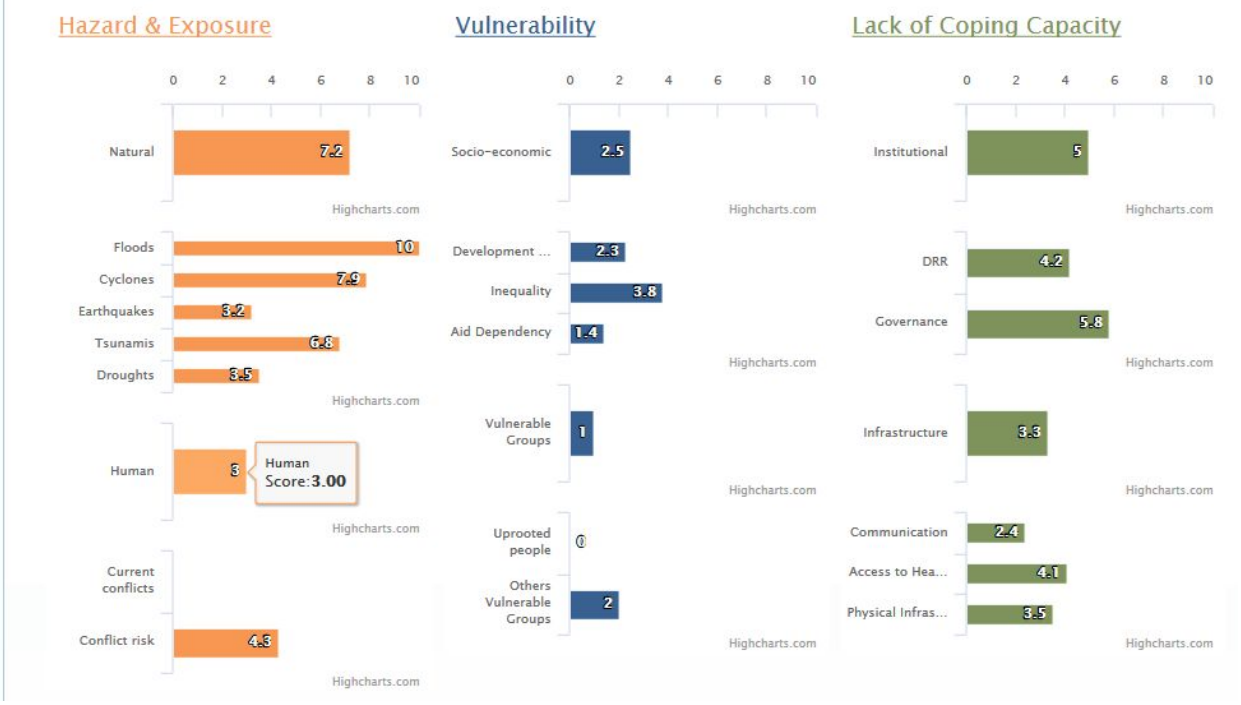
VIET NAM

South-Eastern Asia
Lower middle income

	Value	Rank	Trend
INFORM Risk	3.5	99	—
Hazard & Exposure	5.5	41	—
Vulnerability	1.8	143	—
Lack of Coping Capacity	4.2	106	—



RISK DIMENSIONS AND COMPONENTS



Annex 4 - Historical TCs in the area

The Tropical Cyclone (TC) basin of the NW Pacific is the most active in terms of number of events (about 30% of global TCs develop in this area). On average, 26 Tropical Storms or higher strength, with at least 16 becoming Typhoons, occur every year in this basin. The TCs can form throughout the whole year, though most of them typically develop during the period between May/June and November, with the climatological peak of activity in August.

The JRC detailed analysis on the most significant TCs in the whole NW Pacific basin can be found on the JRC Emergency Report available on GDACS at:
http://portal.gdacs.org/GDACSDocuments/015-NW%20Pacific%20Typhoons_update.pdf

The most significant TCs the affected Guam, southern areas of the Northern Mariana islands over the last years are shown Annex 4.1., while the ones of the northern Philippines in Annex 4.2 and the ones of China, Hong Kong Macau in Annex 4.3.

Annex 4.1. Guam, southern areas of the Northern Mariana islands

- **May 2015, DOLPHIN,** from 9 May to 19 May, with max. sustained wind of 175-204 km/h (GDACS). It killed 1 person and nearly 1,000 homeless.
- **Aug 2015, SOUDELOR** (Philippines name Hanna), from 30 July to 08 Aug, with max. sustained wind of 160-170 km/h (GDACS).
- **Oct 2014, VONGFONG,** from 3 Oct to 14 Oct, with max. sustained wind of 167 km/h (GDACS).
- **Aug 2004, CHABA,** from 18 Aug to 5 Sep, with max. sustained wind of 270-290 km/h (JTWC). It killed 1 person.
- **Dec 2002, PONGSONA,** from 2 Dec to 12 Dec, with max. sustained wind of 240 km/h (JTWC). It killed 1 person.
- **June 2002, CHATAAN,** from 27 June to 13 July, with max. sustained wind of 240 km/h (JTWC).

Annex 4.2. Northern Philippines

- **Oct 2016, HAIMA** (locally named LAWIN), from 14 Oct to 26 Oct, made landfall in Cagayan with max. sustained wind of 200-220 km/h (GDACS). It killed 19 people and nearly 270,000 houses were destroyed, mostly in Cagayan and Isabela provinces.
- **Oct 2016, SARIKA** (locally named KAREN)**,** from 12 Oct to 19 Oct, made landfall in Aurora province on 15 October 2016, with max. sustained winds of 200 km/h, affecting more than 150 000 people and damaging more than 7 800 houses, mostly in Aurora province.

- **Sep 2016, MERANTI** (locally named FERDIE), from 8 Sept to 17 Sept, passed close to the Batanes islands on 13 September as a very intense Typhoon (with max. sustained winds of 296 km/h, GDACS), causing over 16 600 people evacuated and more than 1 300 houses damaged in Batanes.

- **Sep 2014, KALMAEGI** (locally named LUIS), from 11 Sep to 18 Sep, made landfall in Cagayan (Luzon) on 14 Sep, with max. sustained winds up to 130 km/h. It killed 24 people.

- **Oct 2011, NALGAE,** made landfall in the province of Isabela (Luzon) on 1 October, with max. sustained winds up to 240 km/h. It killed 17 people and destroyed more than 5 500 houses.

- **Sep 2011, NESAT,** made landfall over Luzon on 28 Sep, less than one week before NALGAE, as an intense Typhoon with max. sustained winds up to 200 km/h. It killed 85 people and destroyed nearly 7 500 houses,

Annex 4.3. CHINA (Guangdong Province), Hong Kong, and Macau

- **2017 - HATO**, made landfall along the coast of Guangdong province (China), west of Macau and Hong Kong, on 23 Aug 2017, with max. sustained winds up to 150-160 km/h (GDACS). It killed 12 people and more than 26000 people were displaced.

- **2015 - MUJIGAE** (Philippines name KABAYAN): from 1 Oct to 5 Oct, with max. sustained winds up to 170-210 km/h (GDACS).

- **2013 - USAGI**, from 16 Sep to 24 Sep, made landfall along the coast of Guangdong province (China), near Shanwei (east of Hong Kong) on 22 Sep, with max. sustained winds up to 250 km/h (GDACS).

- **2012 - VICENTE**, made landfall along the coast of Guangdong province (China), west of Macau and Hong Kong, on 23 July, with max. sustained winds up to 210 km/h (GDACS). It killed 2 people in the Philippines and 11 people in Vietnam.

Annex 5 - Weather forecasts for Specific Locations (Ensemble Meteograms)

5.1 - Product Description

Ensemble Meteograms contain information coming from both the deterministic singe model high-resolution (HRES) operational forecast and the Ensemble Prediction System (EPS) comprising 50 ensemble (ENS) members plus one (control forecast).

The horizontal resolution of the HRES is ~8 km whereas the resolution of ensemble members (and the control) is ~16 km. HRES is denoted by blue, whereas the control forecast (of the ensemble) is denoted by red colour.

The values of the ensemble are contained in a box plot type of diagram that graphically depicts groups of numerical data through their quartiles while maximum and minimum values are highlighted by whiskers.

The first panel of meteogram contains the total (low - medium & high) cloudiness in octas. The second panel refers to the total (convective and large-scale) precipitation utilising values estimated over 6-hour intervals. The third panel refers to the instantaneous (averaged over 10 minutes) wind speed values. The fourth panel refers to the temperature at 2 meters height.

All Meteograms are based on the latest run of ECMWF HRES and EPS initiated from Wednesday 12 September 00 UTC (Analysis).

Points of References

- Batanes Islands - Philippines (Annex 5.2)

- Babuyan Islands - Philippines (Annex 5.3)

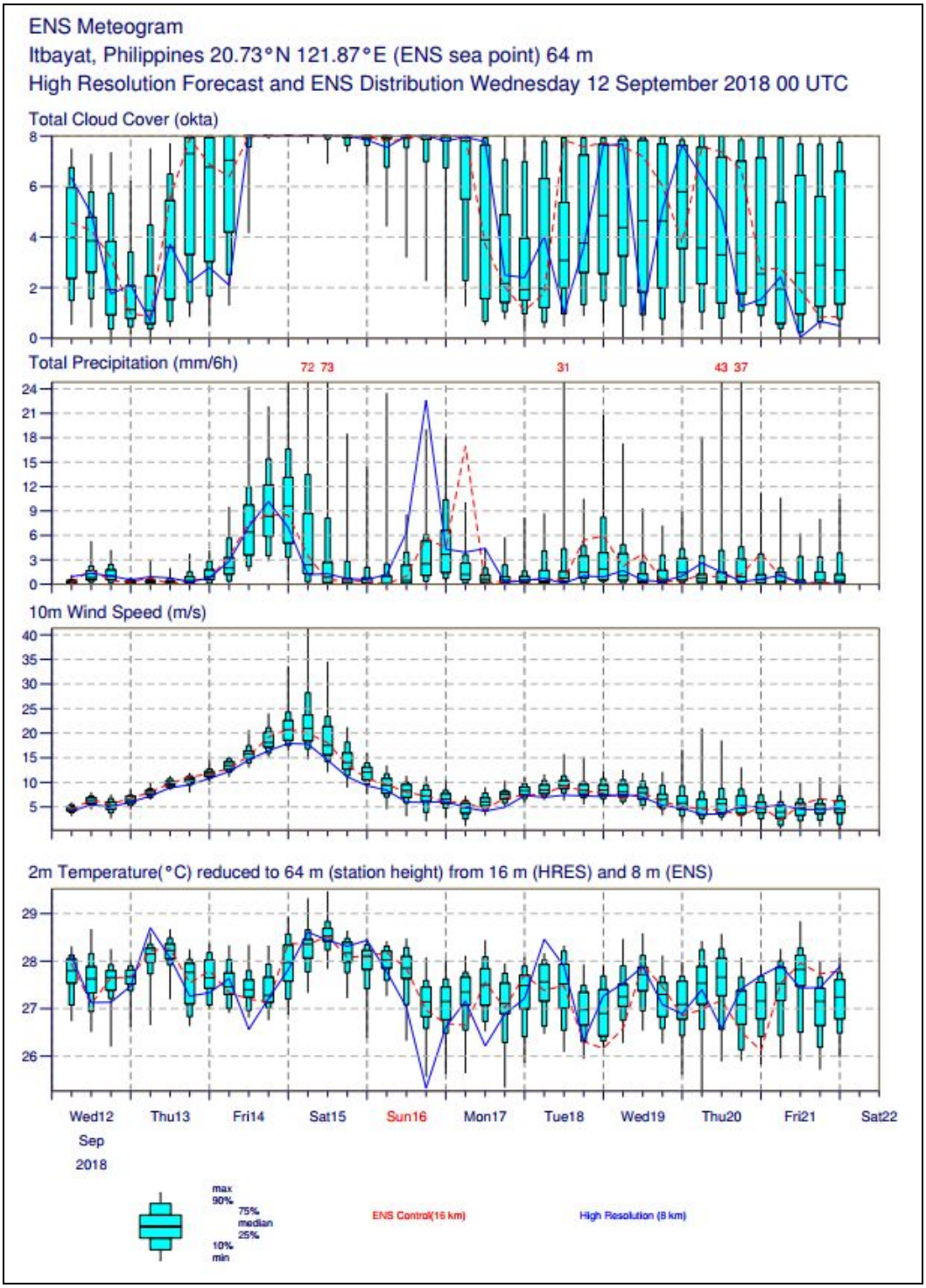
- Tuguegarao - Philippines (Annex 5.4)

- Baguio - Philippines (Annex 5.5)

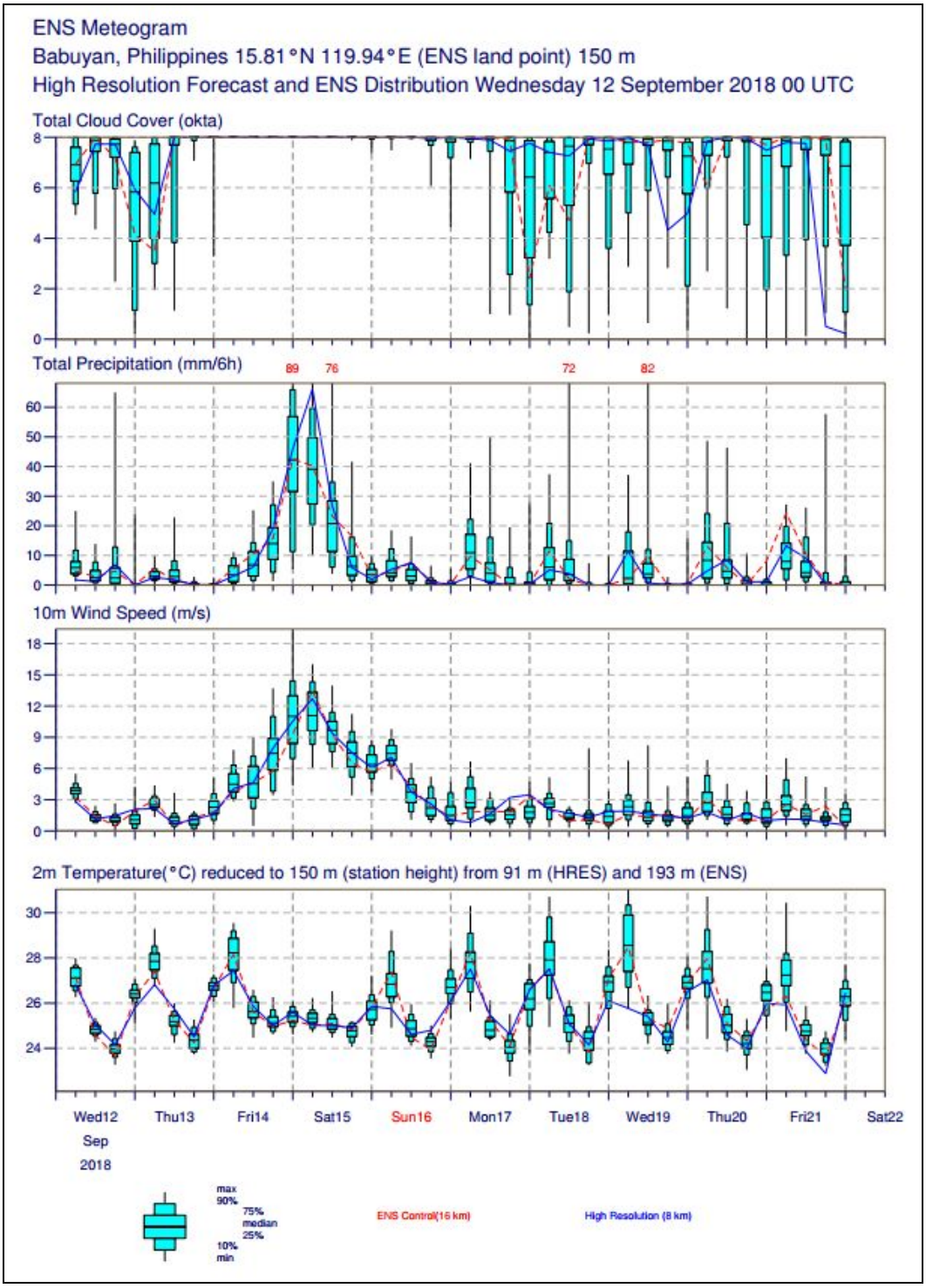
- Baggao - Philippines (Annex 5.6)

- Hong Kong - China (Annex 5.7)

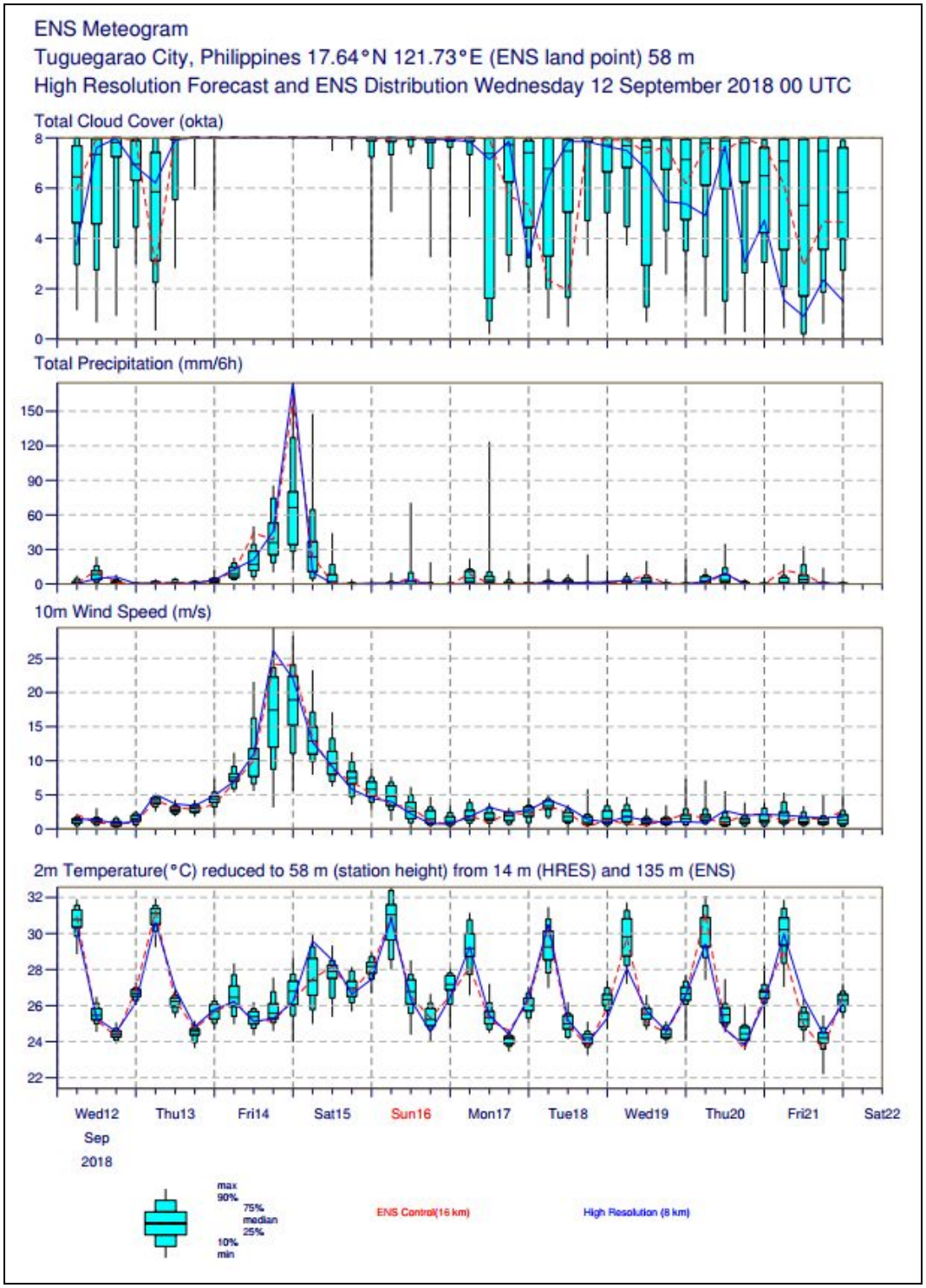
5.2 - Meteogram for the greater area of Itbayat - Batanes Islands (Philippines)



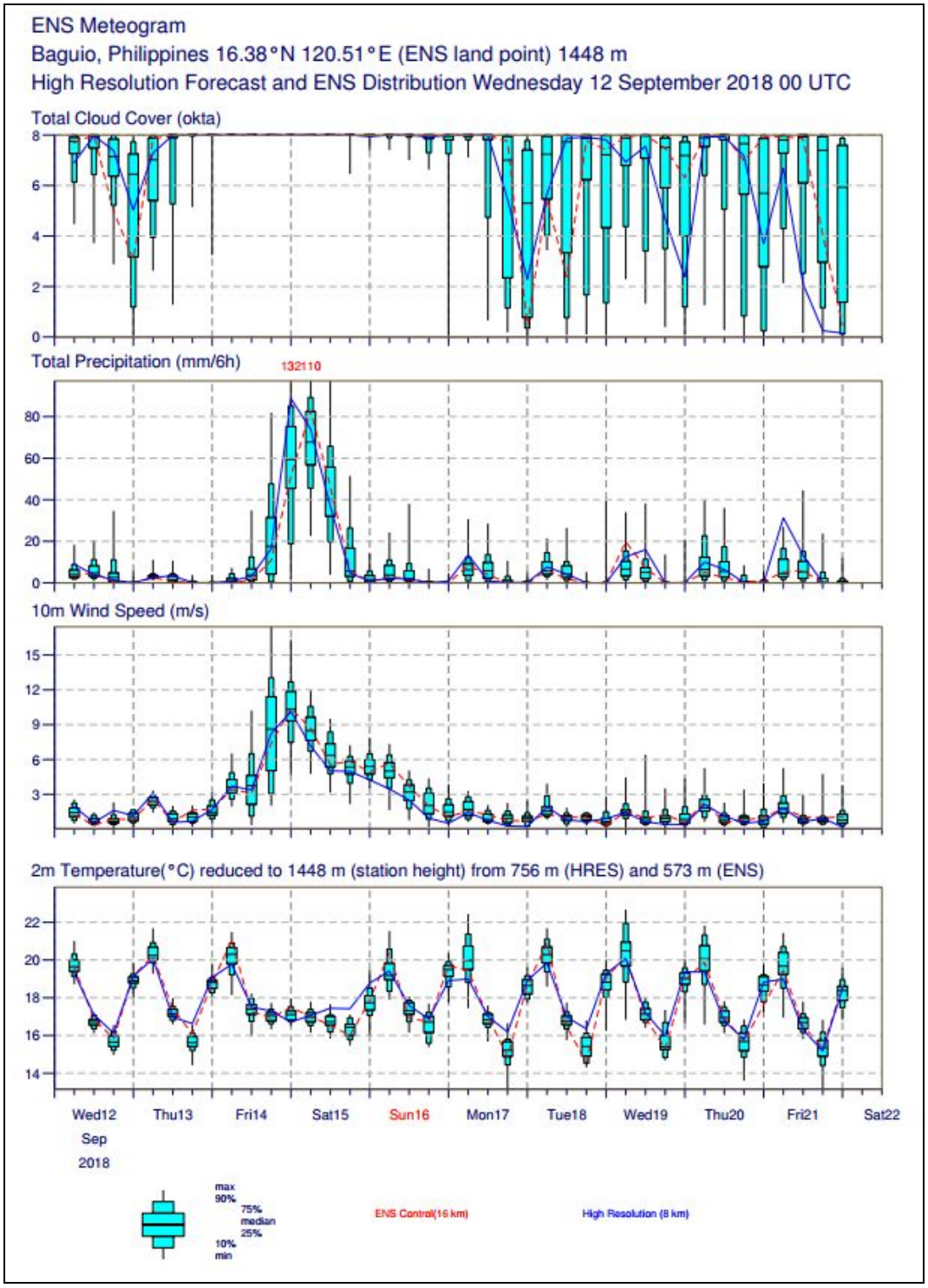
5.3 - Meteogram for the greater area of Babuyan Islands (Philippines)



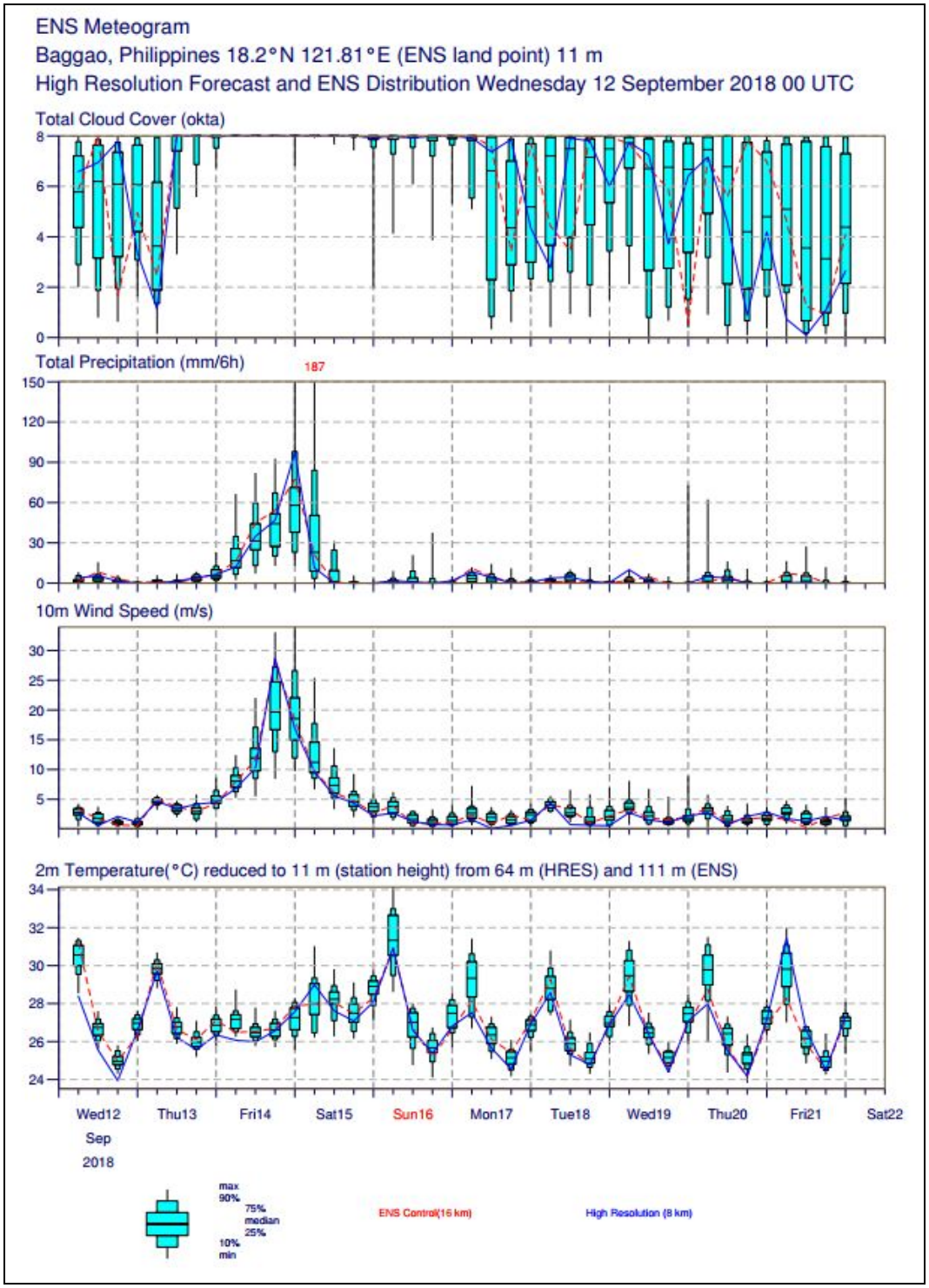
5.4 - Meteogram for the greater area of Tuguegarao (Philippines)



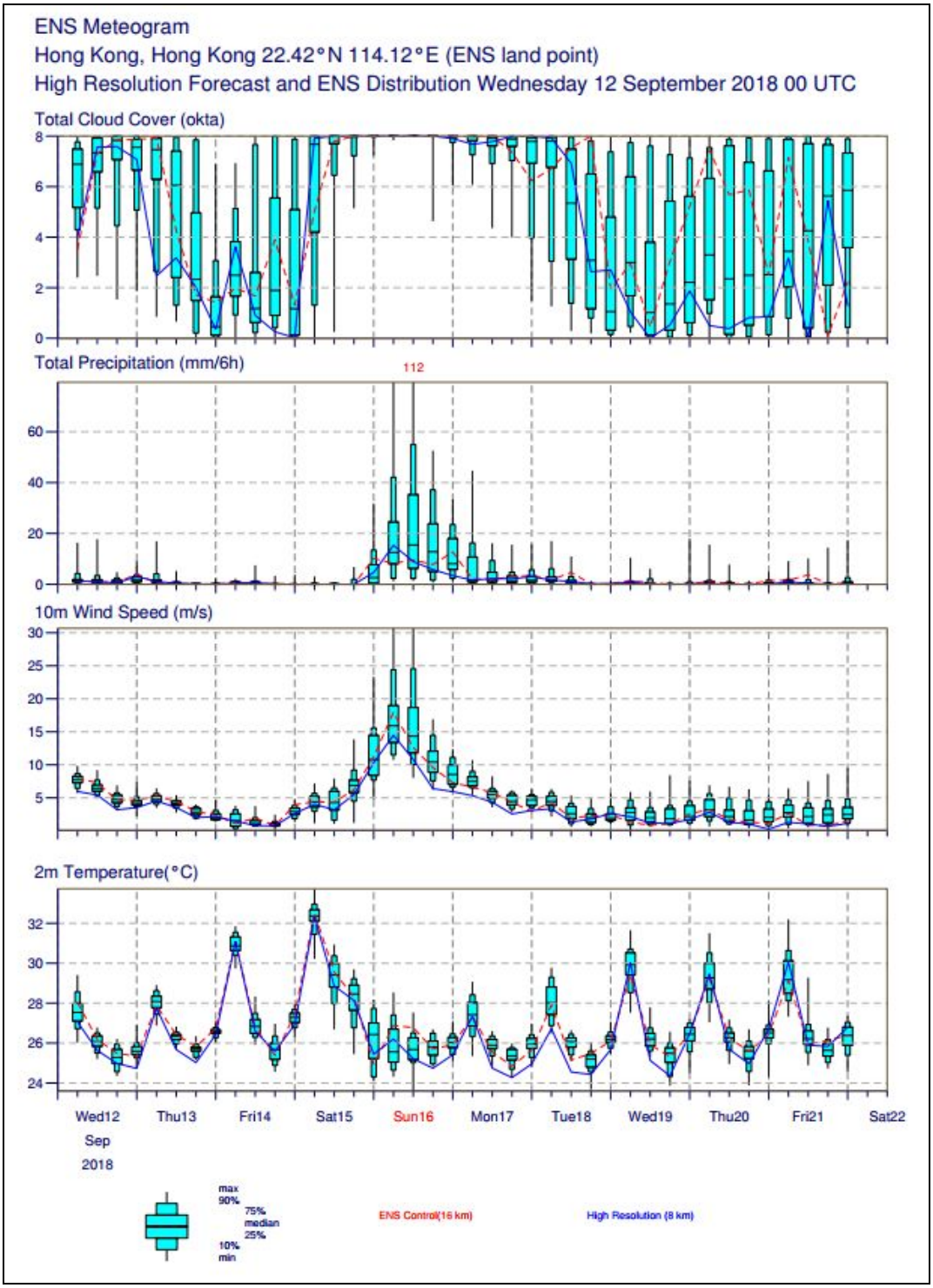
5.5 - Meteogram for the greater area of Baguio (Philippines)



5.6 - Meteogram for the greater area of Baggao (Philippines)



5.7 - Meteogram for the greater area of Hong Kong (China)



Annex 6 - Tropical Cyclone Strike Probability for TC MANGKHUT and BARIJAT (based on ECMWF HRES & Ensemble Prediction System)

6.1 - Product Description

These charts show the evolution of the position and intensity of tropical cyclones (TCs) in the ECMWF (European Centre for Medium-Range Weather Forecasts) high-resolution (HRES) and ensemble forecasts (comprising 50 plus one control equal probable members) based on the Ensemble Prediction System (EPS). They provide a measure of the uncertainty in the latest ECMWF forecast based on 12 Sep 2018 00 UTC. These products are generated for all TCs that have been officially observed at the initial time of the forecast. The main characteristics of Strike Probabilities are shown below (Fig. A6.1).

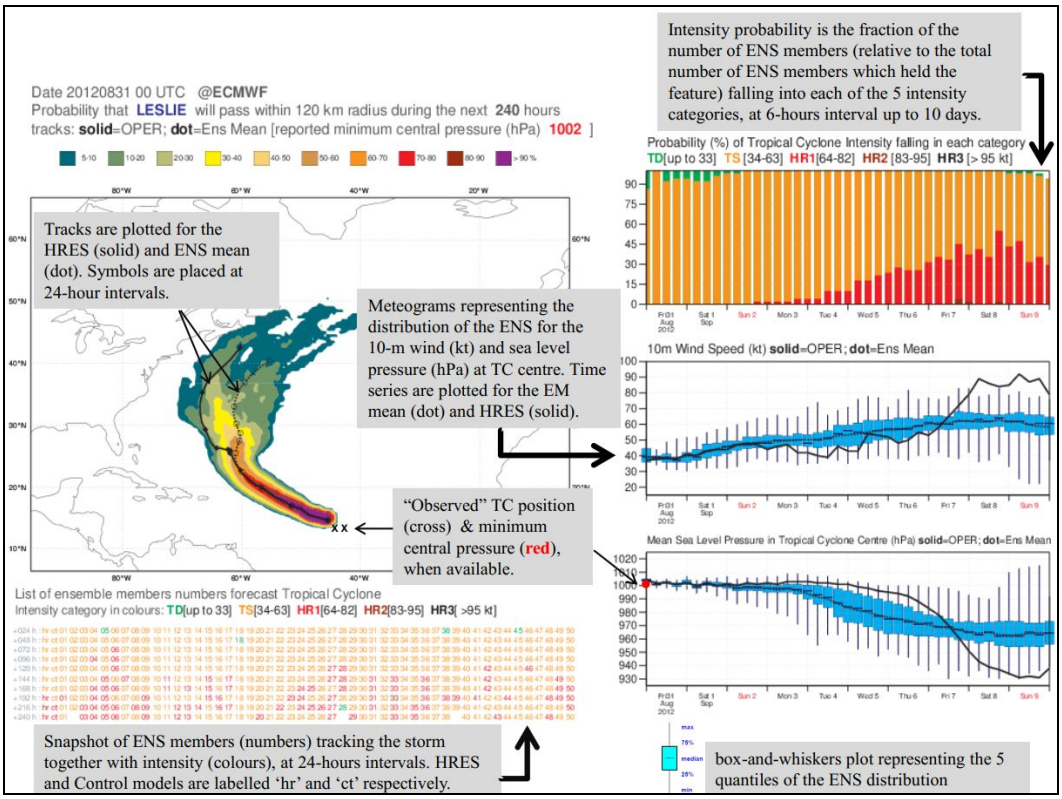
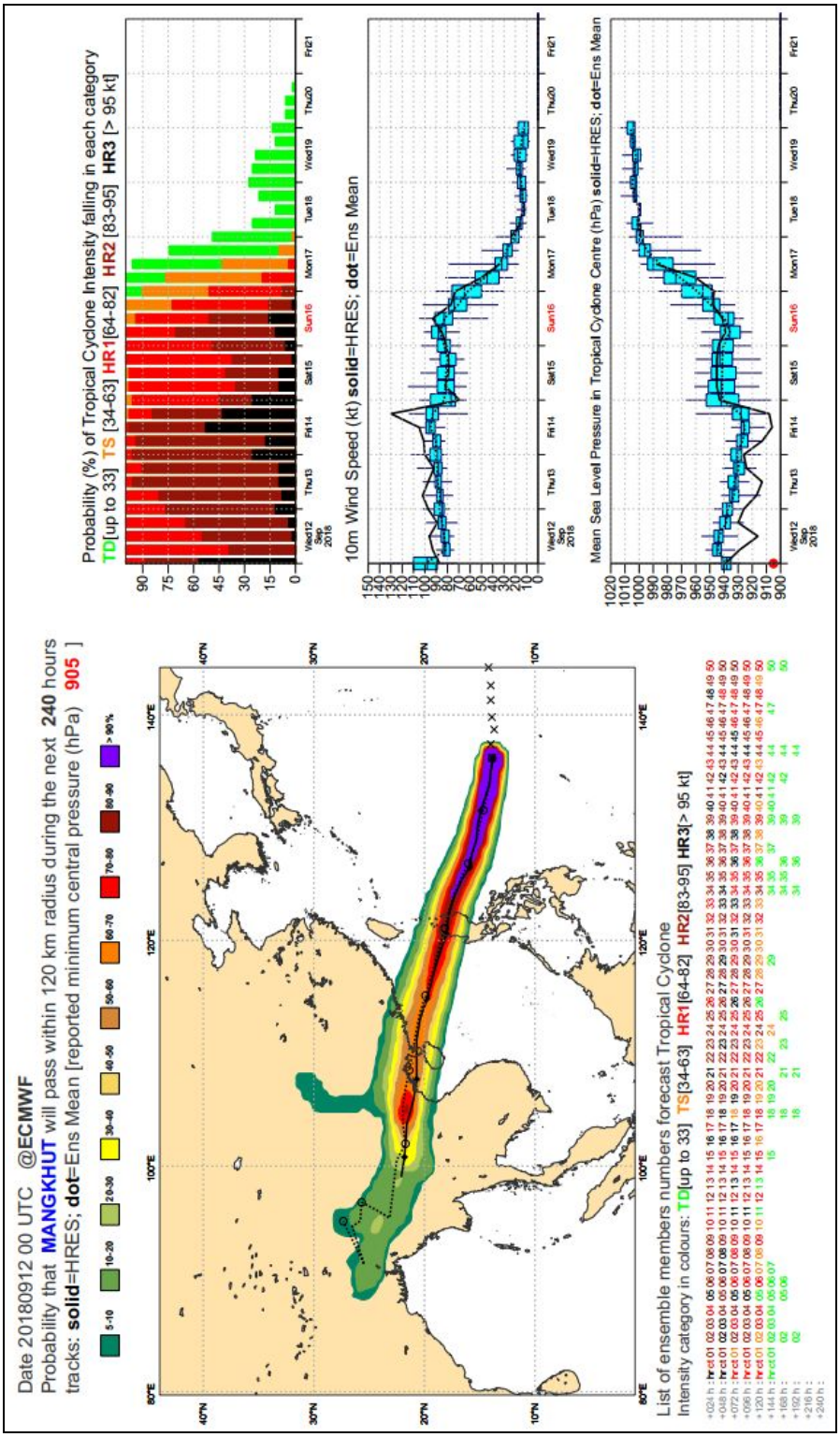


Figure A6.1 *- Main characteristics of Strike Probabilities (Map).*

For a quick-look graphical guide to interpreting these products see https://www.ecmwf.int/sites/default/files/tracks_example.pdf. A detailed explanation about the ECMWF Tropical Products and the tracking algorithm can be found at https://www.ecmwf.int/sites/default/files/TC_ShowGuide.pdf.

Current Annex 6 contains Strike Probabilities for TC MANGKHUT (6.2) and TC BARIJAT (6.3).

6.2 - Strike Probabilities for TC MANGKHUT



6.3 - Strike Probabilities for TC BARIJAT