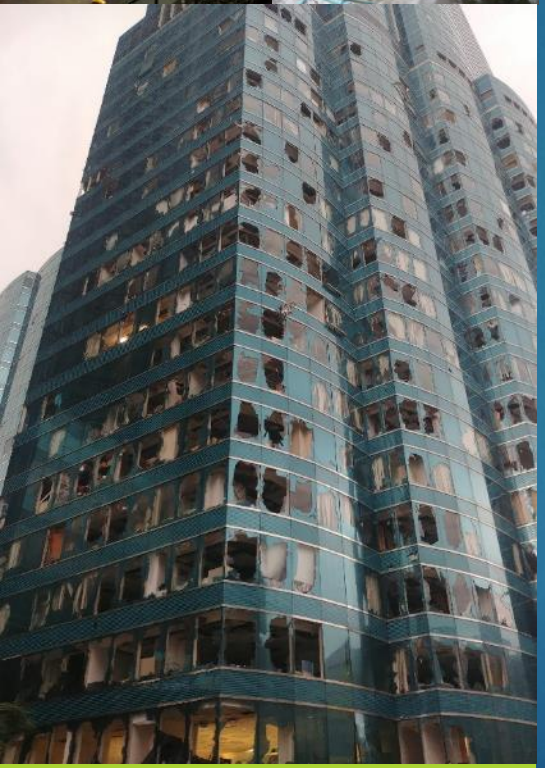

Photo Credit: Mo Wong, HC Chan & Alex Ng

Development of Impact-based Forecast Services at the Hong Kong Observatory

2nd KMA/WMO Workshop on Impact-based Forecasts in Asia, Seoul, Korea, 19–21 November 2018

YEUNG, Hon-yin

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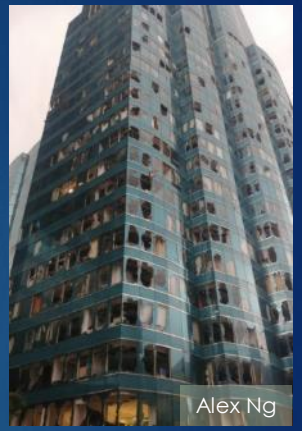
Super Typhoon **Mangkhut**

An illuminating case for Multi-Hazard Impact-Based Forecasting, Alerting & Warning

Impacts to HK - Actual Severity

- Mangkhut was the sixteenth tropical cyclone necessitated the issuance of the No.10 Hurricane Signal (the highest typhoon signal) in Hong Kong since World War II, lasting for 10 hours on 16 September 2018, packing extreme high winds and record-breaking storm surge.
- Extensive damages: serious flooding in many coastal and low-lying areas, substantial damages of coastal structures and buildings, over 60,000 reports of fallen trees, numerous reports of smashed windows or glass curtain walls, and interruptions of power supply to over 40,000 households and fresh water affected over some places. Hundreds of vessels stranded, sunk or seriously damaged. Traffic and transportation services were also seriously affected ...
- While over 450 people were injured during the stormy weather, there was luckily no fatality on that day



Reference:
HKO Blog - A Wake up Call from Mangkhut
http://www.weather.gov.hk/blog/en/archives/00000216.htm

(Photo courtesy of Alex Ng, MCW, H C Chan, Christina, Kevin Wong & Mo Wong)

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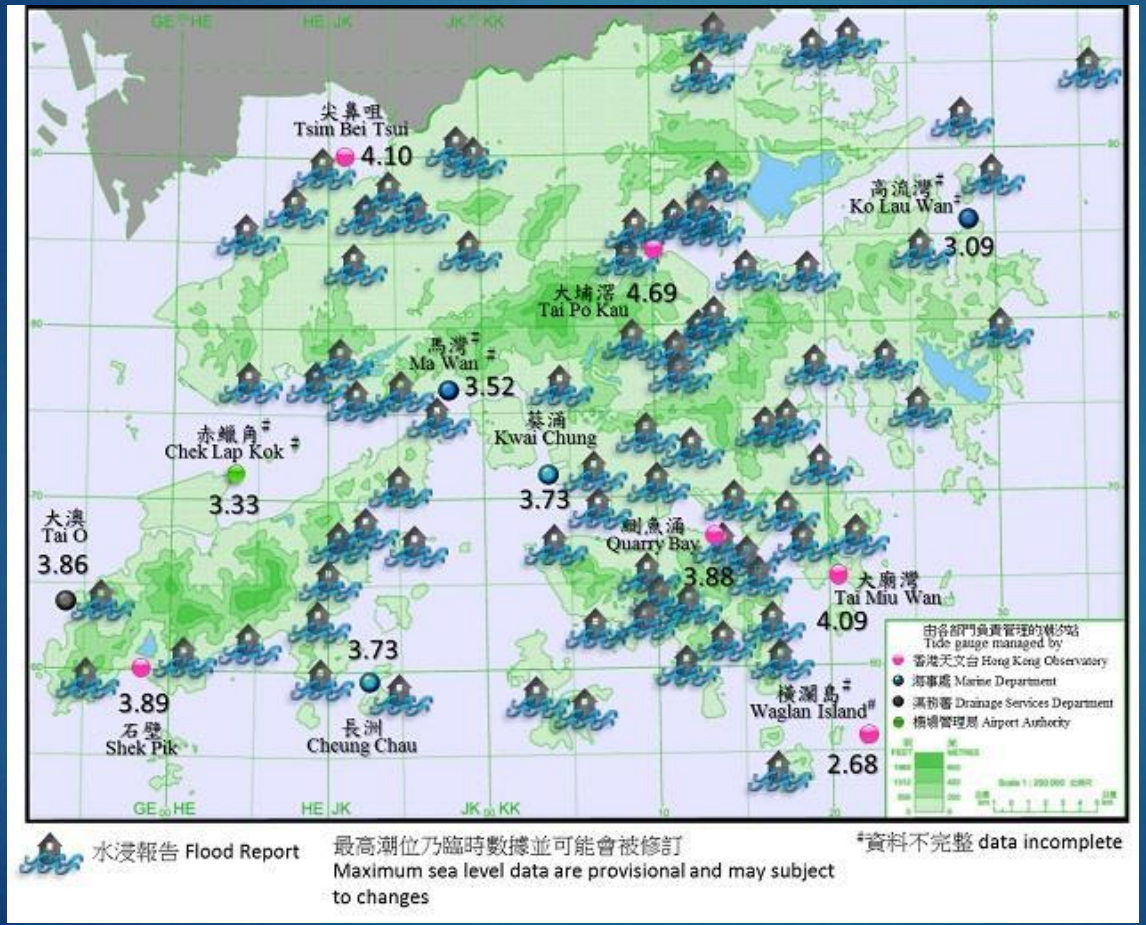
Interruption of Power & Water Supply

Based on news and social media

The incident reports are not exhaustive

Maximum Sea Level & Flood reports



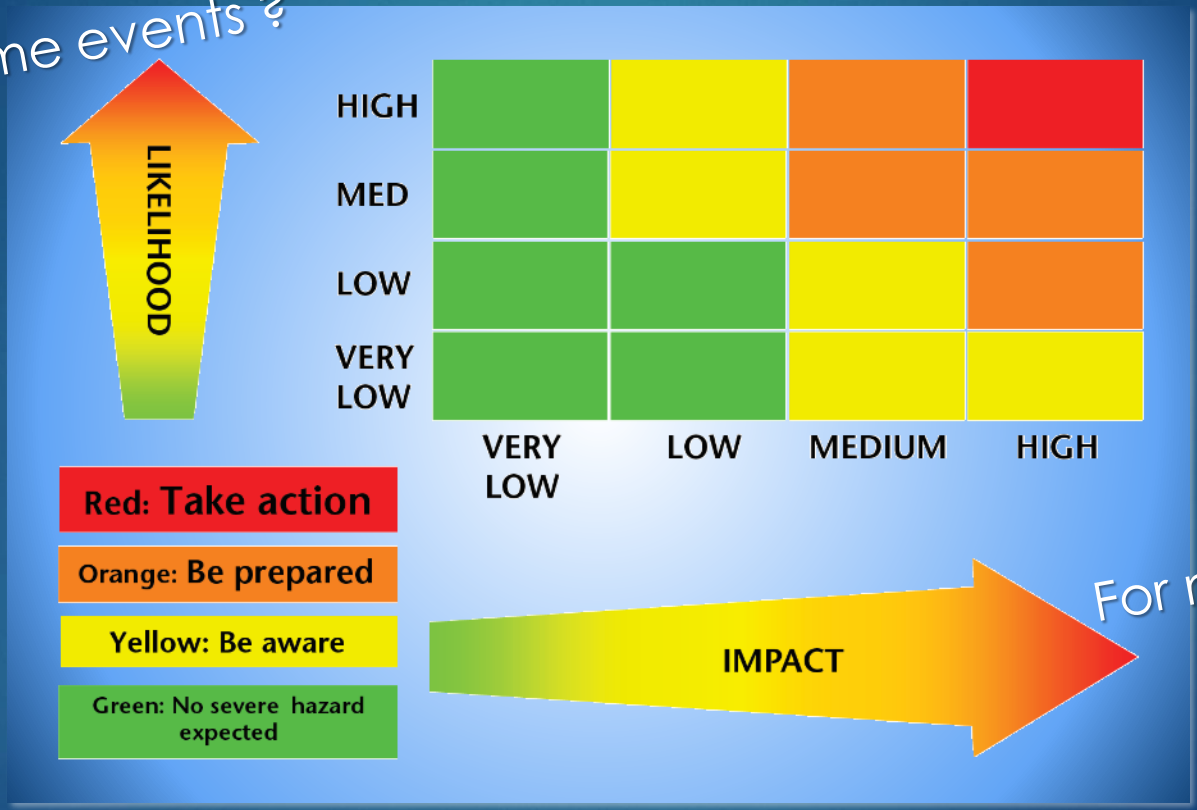
In unit of metres above Chart Datum

Based on reports from government departments, news and social media on 16 September 2018

The flood reports are not exhaustive

The Risk Matrix

For extreme events ?



For multi hazards ?

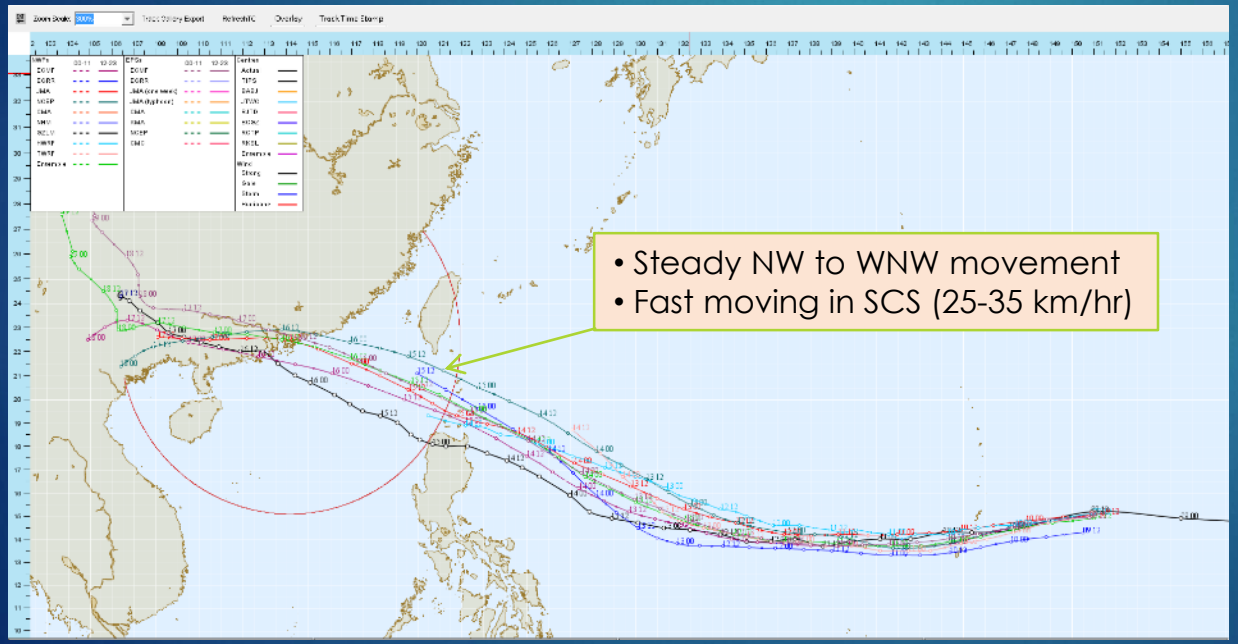
Source: UKMO / WMO

Multi Hazards from Super T. Mangkhut

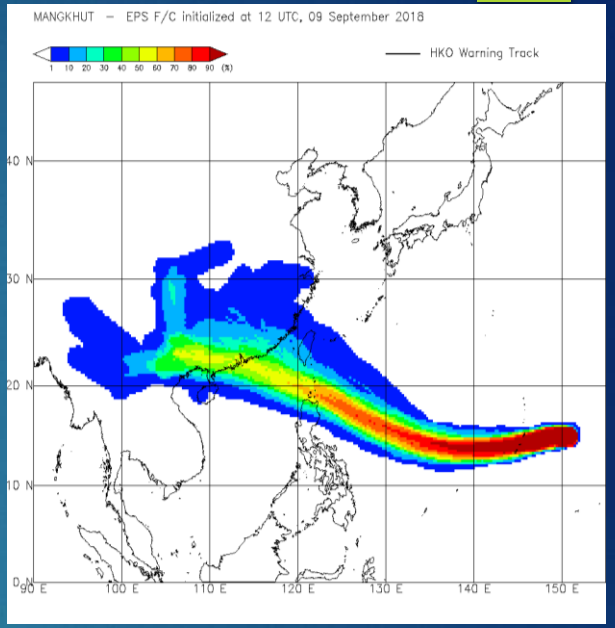
- Forecasting considerations –
  - Track proximity, above-typhoon intensity, large wind structure, storm surge, heavy rainfall, etc.
  - All subject to high uncertainty with naturally low likelihood for extreme weather
  - Risks of wind damage, coastal flooding, flash floods, landslide, etc.
- Warning and communications strategies –
  - Early alert, repetitive reminders, one authoritative voice
  - Traditional X social media
- How could the risk matrix be applied?

Likelihood – Track

- Good consensus among deterministic models (EC, EGRR, JMA, NCEP) and EPSs on the track of Mangkhut 6 days ahead.
- Forecaster was confident in forecasting **gale force** winds for 16 Sep in the 9-Day Weather Forecast issued on 10 Sep morning.



TC Strike Probability Map
(on 12UTC, 9 Sept 2018)



9-Day Weather Forecast
Issued at 11:46 HKT on 10/9/2018

16/9 (Sunday)
Wind: West to northwest force 6 to 7, south to southeast force 8 later.
Weather: Cloudy to overcast. Heavy rain with squalls and thunderstorms.

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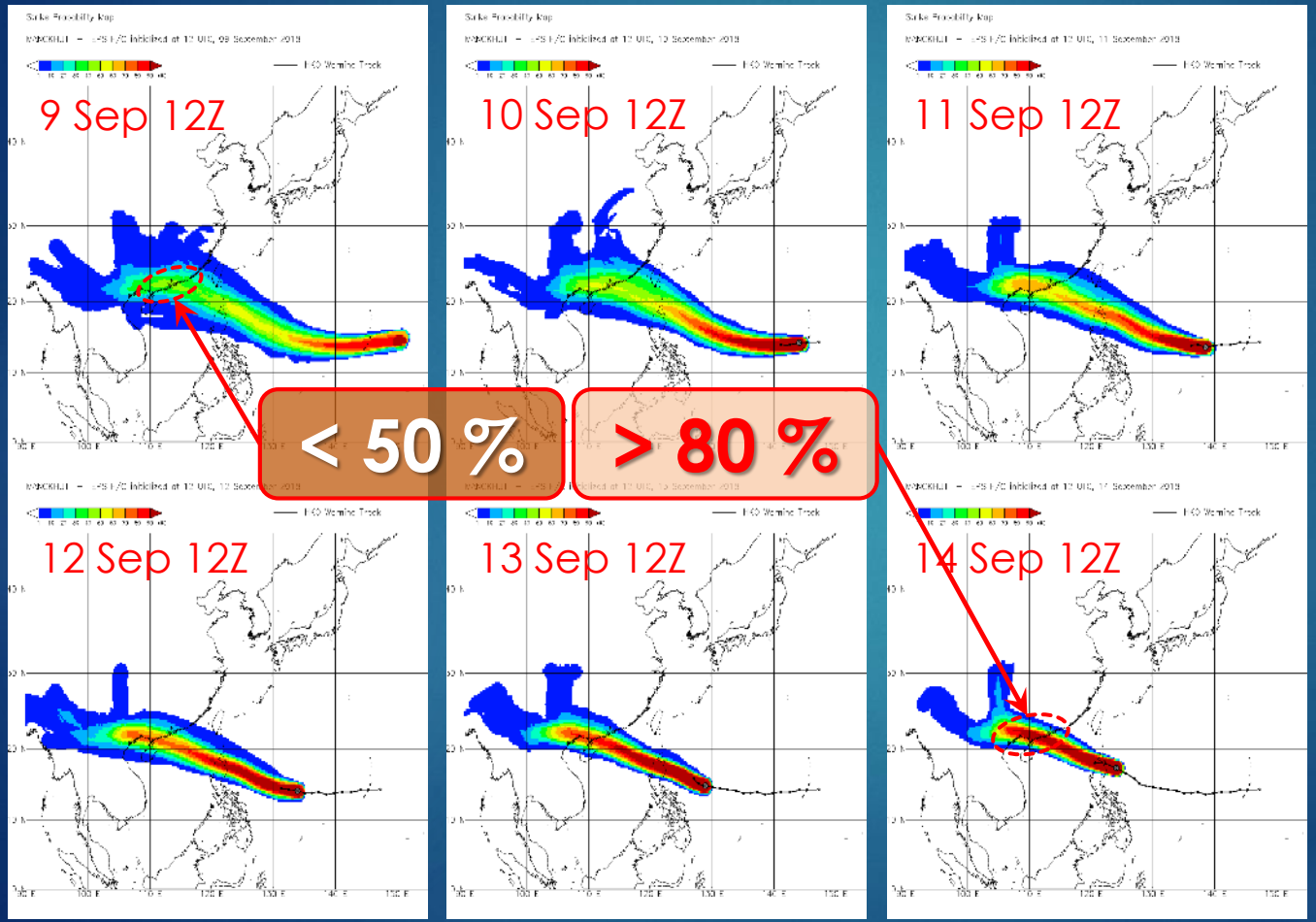
Likelihood – Track (cont'd)

Cautious! Model-predicted TC landfalling point flip-flopping day by day
Likelihood monotonically increasing for landfalling over western coast of Guangdong



TC Strike Probability Maps

Grand Ensemble of EC, UKMO, NCEP

1. Earlier model runs suggested Mangkhut would move across Luzon Strait and then head **towards Pearl River Estuary**. *(i.e. direct hit to HK with stronger intensity)*

2. Later, models suggested more landmass interaction over Luzon and **landfall over western part of Guangdong**.
   (i.e. weaker intensity over South China Sea and further away from Hong Kong)

3. Finally, most of the models changed the story again and suggested a landfall location **to the west of Pearl River Estuary**.

4. Forecasters should be cautious and NOT following the detailed track changes too closely

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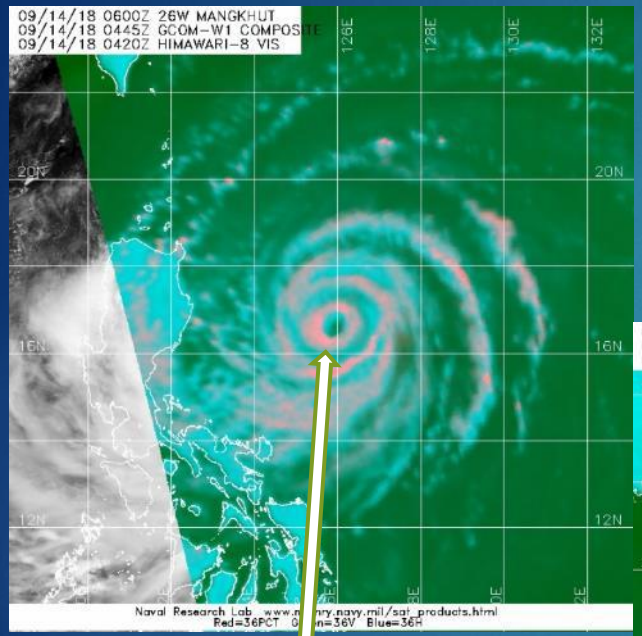
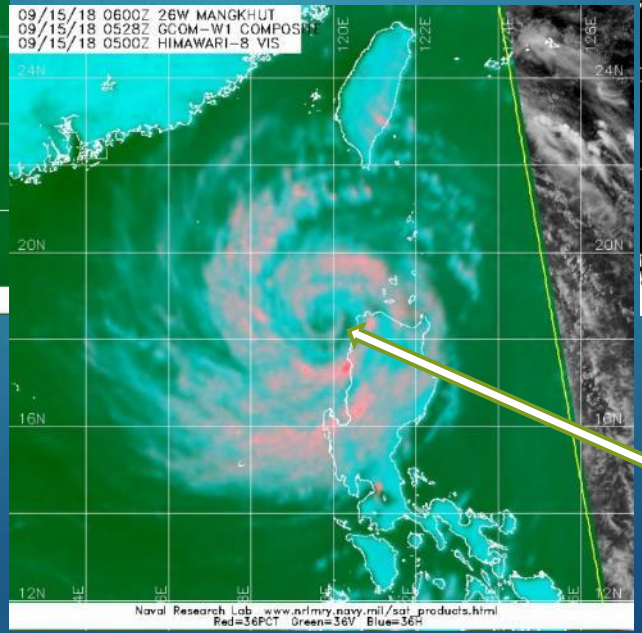
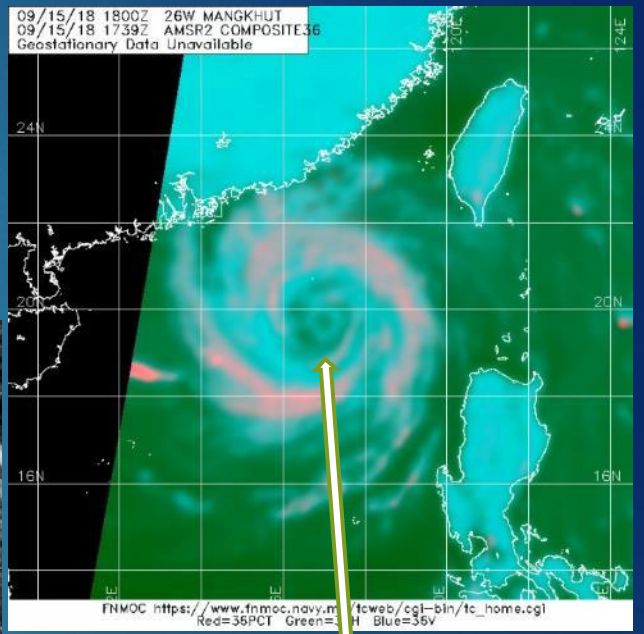
Likelihood – Intensity (Eyewall)



Strong inner eyewall

Microwave imageries showed the eyewall structure changed after interacting with the land mass of northern Luzon





Inner eyewall rebuilt over the SCS, albeit much weaker

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Likelihood – Intensity (Subjective)

Warning Intensity given by some major centres (14 – 16 Sept 2018)

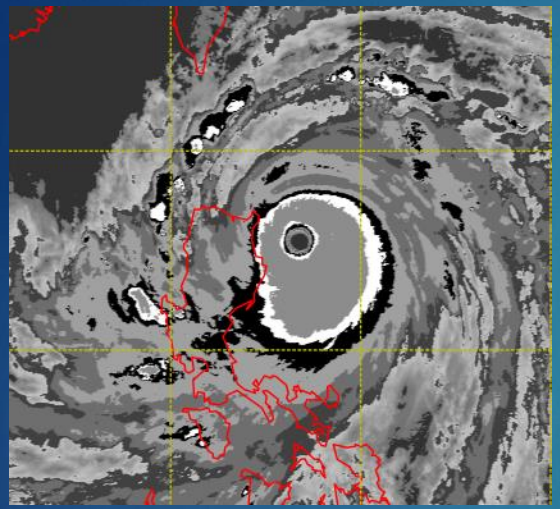
Large differences in intensity assessment **before making landfall over Luzon** and **near Pearl River Estuary**. Likely causes include :

- Method/Look up table in Dvorak analysis
- Uncertainty in Dvorak analysis (especially for storms with unusual structure)
- Availability and use of in-situ surface and radar observations

Time	HKO (10-min mean)	CMA (2-min mean)	JMA (10-min mean)	JTWC (1-min mean)
12Z 14 Sep	130	126	110	145
18Z	135	126	110	145
00Z 15 Sep	120	101	90	115
06Z	105	93	90	105
12Z	105	93	85	105
18Z	105	97	80	--
00Z 16 Sep	95	97	75	90
06Z	95	93	75	80

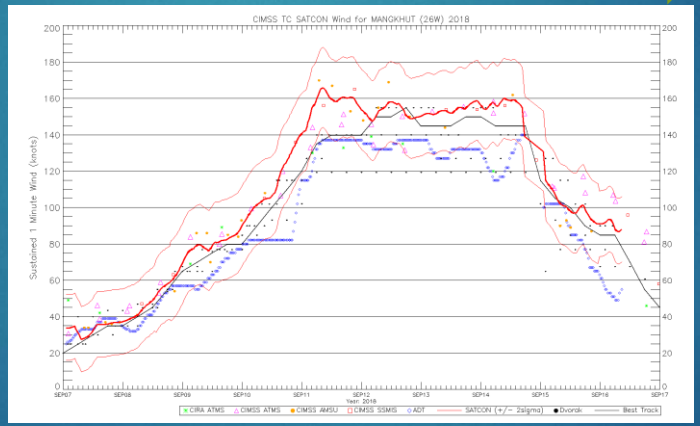
Likelihood – Intensity (Satellite)

Satellite pattern and Dvorak analysis suggested the intensity of Mangkhut weakened considerably after entering SCS

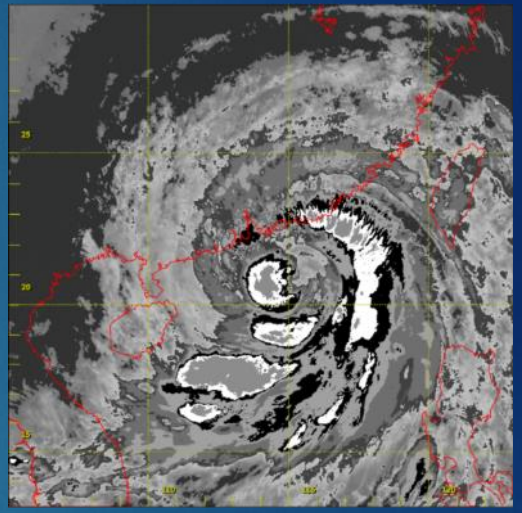


Strongest pattern at 14 Sep 1420Z
DT = 7.5, corresponding to about
144 kt

Weakened

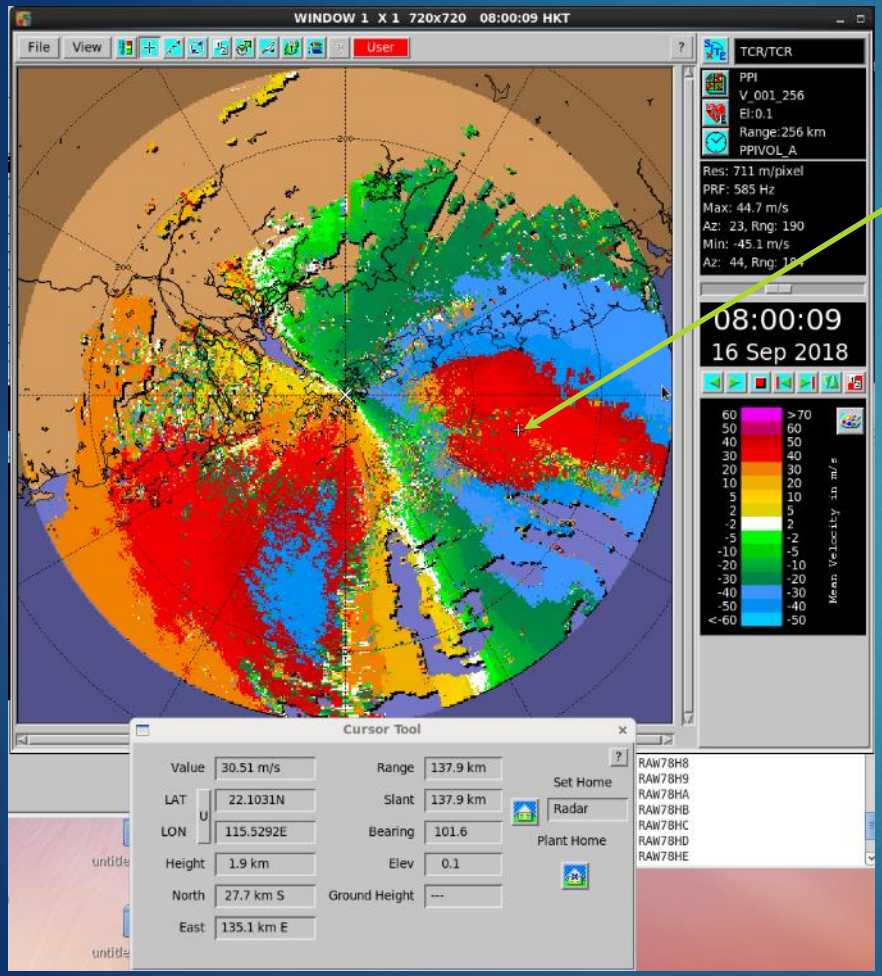


SATCON analysis of intensity change



Weaker pattern at 15 Sep 2350Z
DT = 4.5, MET = 4.5 to 5.0, PT = 4.5 to 5.0,
Corresponding to about
80-85 kt

Likelihood – Intensity (Radar)



TCR PPI 0.1 degree Doppler radial Velocity
= 45.1 + (45.1 – 30.5) = 59.7 m/s [at ~1.9 km level]

Assuming a reduction factor of 0.7*
= 59.7*0.7 = ~42 m/s
≈ **82 kt** [~ surface]

Hurricane force winds (at least 80-85 kt) are confidently "nowcast" using Doppler winds and surface observations

*O Lee, 2010 : 利用雷達多普勒風估算熱帶氣旋的地面風力分佈, HKO Reprint No. 865 (in Chinese only)

Likelihood – Intensity (Surface Obs)

Actual wind speed observations for offshore islands and exposed site along the shore of Hong Kong

Max 10-min wind speed **more than 90 kt** generally recorded at different station levels:

Station name (anemometer height)	Max 10-min mean wind	Max Gust
Waglan Island (83 m)	49.9 m/s (180 km/hr)	60.9 m/s (220 km/hr)
Cheung Chau (99 m)	47.9 m/s (173 km/hr)	59.2 m/s (212 km/hr)
Clear Water Bay (75 m)	52.8 m/s (191 km/hr)#	65.2 m/s (234 km/hr) #

Provisional data, subject to further verification
damaged shortly after reaching highest value, maximum value may be higher

Likelihood – Intensity (Station → 10-m Level)

Estimated 10 m wind using log wind profile with different roughness length (z0) :

Station name (anemometer height)	Max 10-min mean wind	Estimated Equivalent 10-m wind	
		z0 = 0.0002	z0 = 0.005
Waglan Island (83 m)	49.9 m/s	41.7 m/s	39.0 m/s
Cheung Chau (99 m)	47.9 m/s	39.5 m/s	36.8 m/s
Clear Water Bay (75 m)	52.8 m/s	44.5 m/s	41.7 m/s

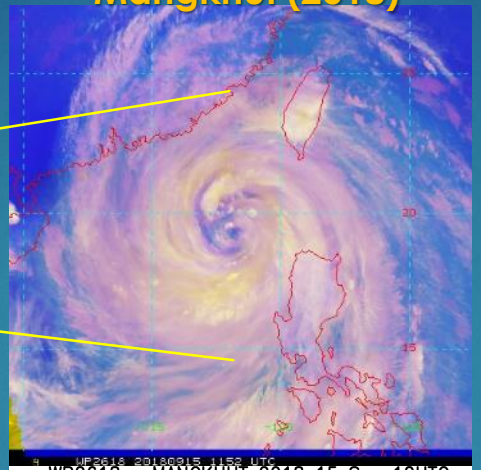
For offshore island and near shore stations facing open sea, the lower roughness value may be more representative. This suggest a 10-m wind speed of **at least 80-85 kt** (40-45 m/s) is of high confident. This also generally aligns with the Doppler wind from radar observations.

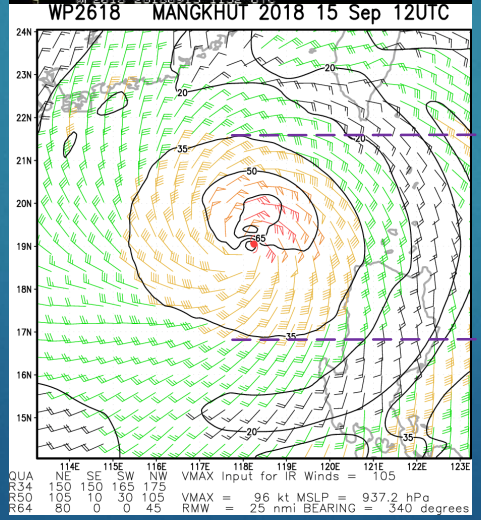
As estimated maximum intensity of TC over open sea is usually higher than that of ground observations (e.g. 5-10 kts), therefore, it is reasonable to estimate the maximum wind speed of Mangkhut to be in the range of 85 to 95 kt when it was over the open sea near Pearl River Estuary

Likelihood – Structure (Cloud bands)

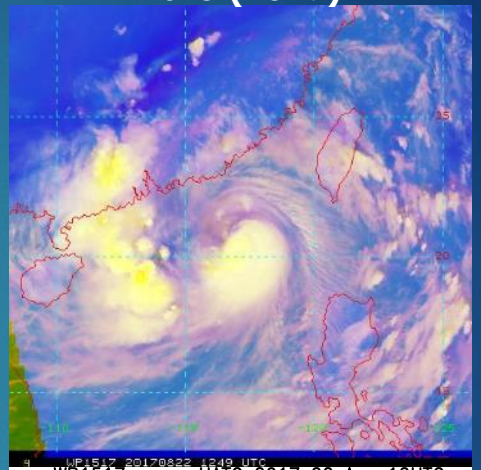
Mangkhut has an extensive circulation which is significantly larger than that of Hato in 2017

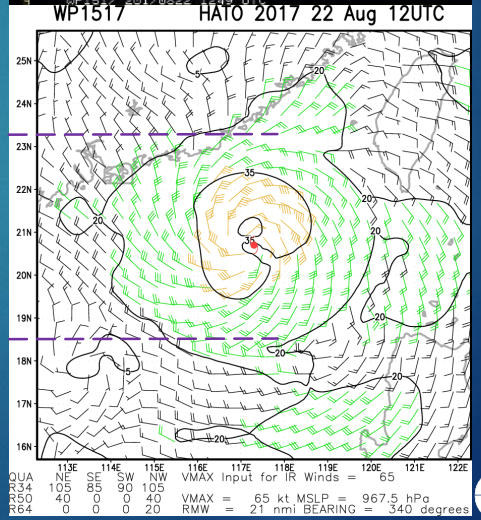
Mangkhut (2018)





Hato (2017)





(Image source : NOAA, RAMMB, http://rammb.cira.colostate.edu/products/tc_realtime/index.asp)

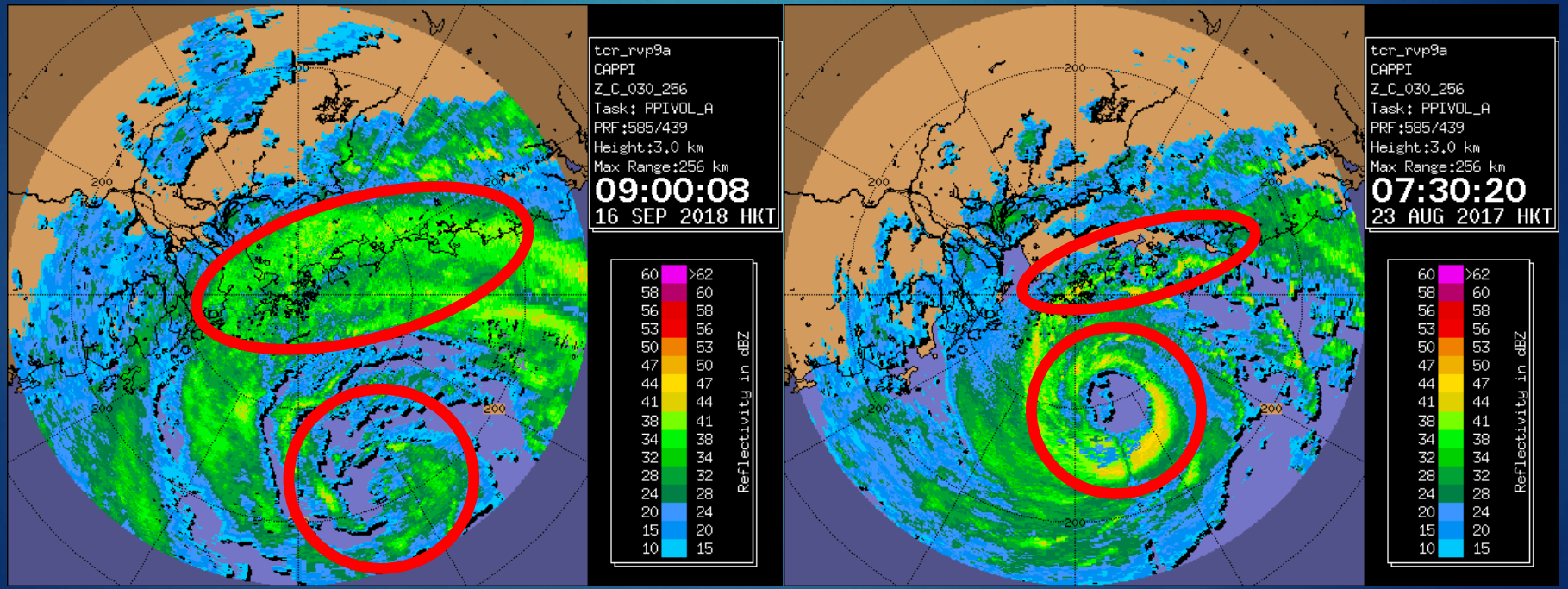
Likelihood – Structure (Rainbands)

Mangkhut
16 Sept 2018

Loose convections near the eyewall
Intense & broad outer spiral bands

Hato
23 Aug 2017

Solid convections completing the eyewall
Intense but narrow outer spiral bands



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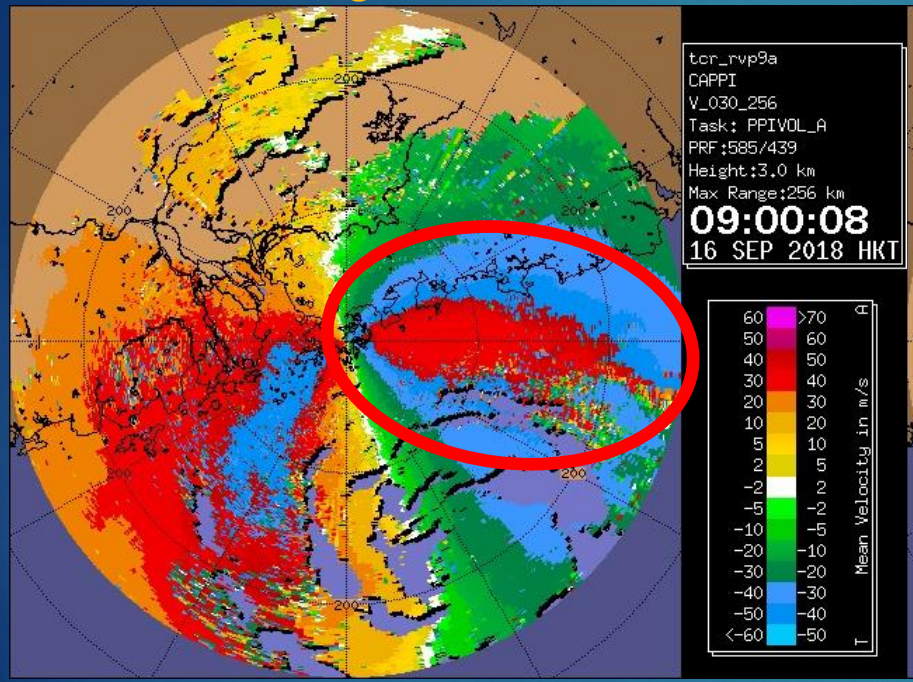
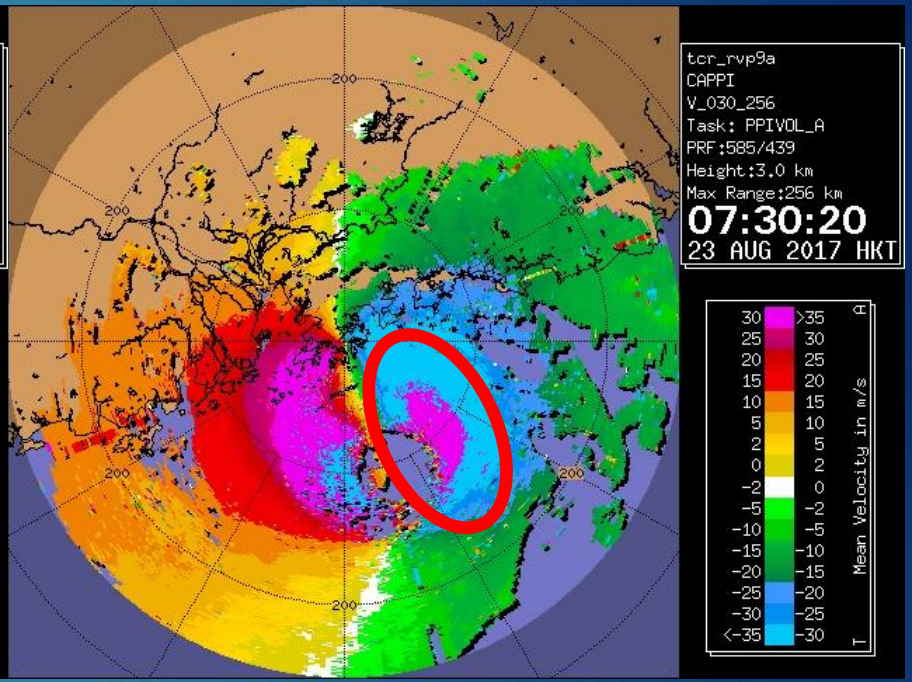
Likelihood – Structure (Doppler Winds)

Mangkhut 2018



Stronger radial winds over the spiral band to the north of the eyewall
(note: blue→red indicating folding)

Hato 2017



Stronger radial winds close to the centre of Hato

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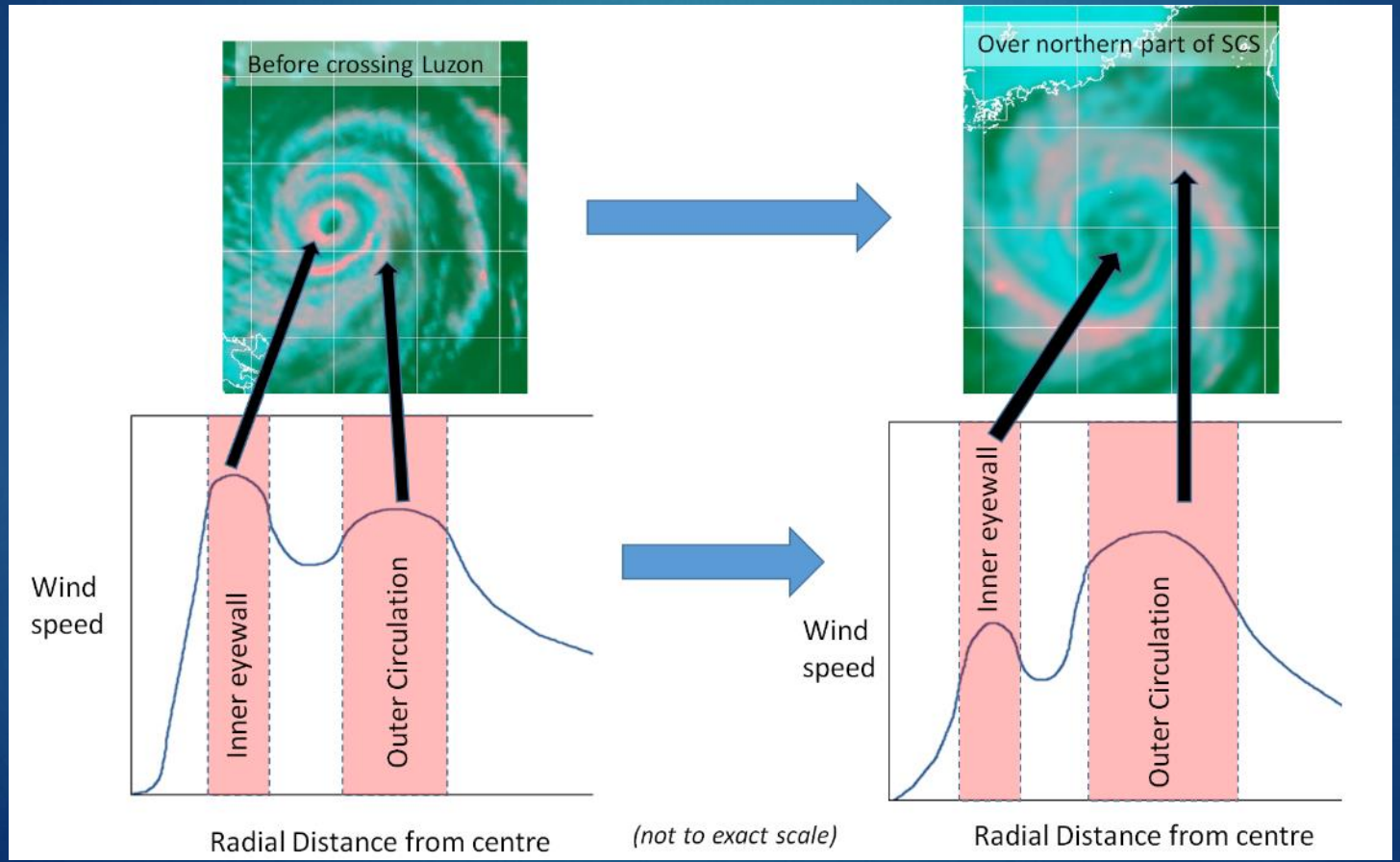
Likelihood – Structure (Evolution)

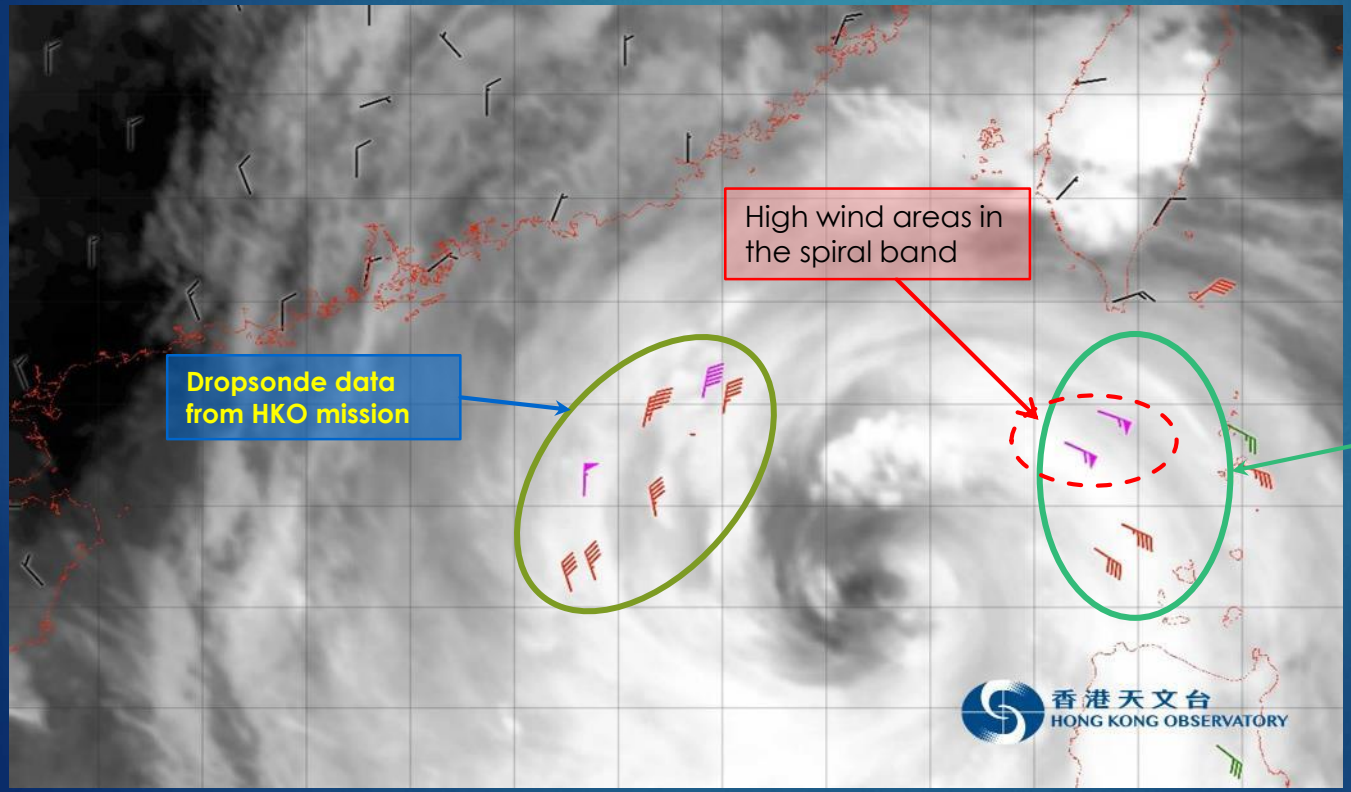
Schematics indicating the likely structural change of Mangkhut crossing Luzon :

Before **After**



Likelihood – Extreme Winds (Dropsonde)

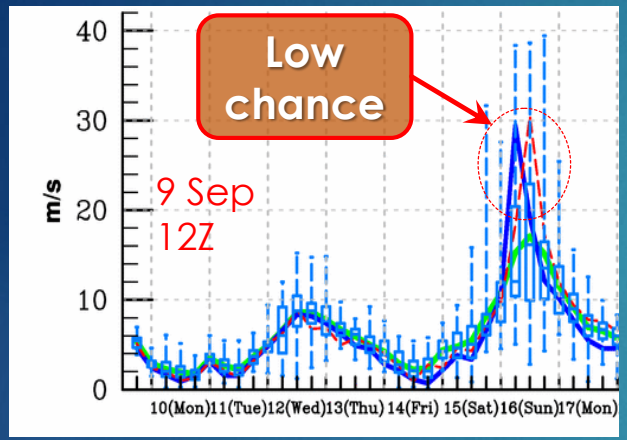
Wind data from dropsonde surveillance flights during Mangkhut

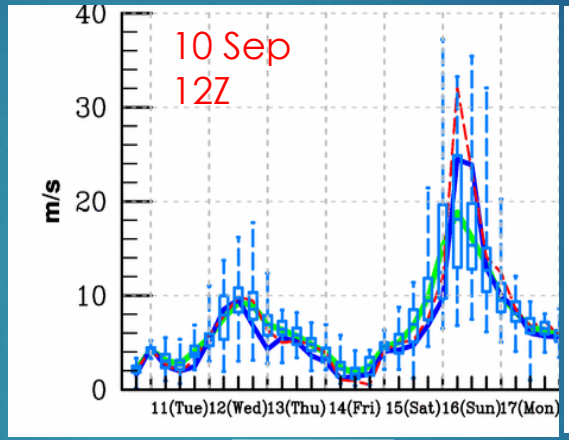


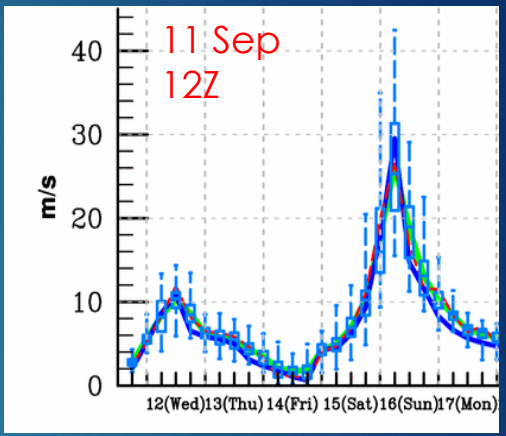
In liaison with RSMC Tokyo, HKO dropsonde bulletins in BUFR format are disseminated through GTS on a near real-time basis.

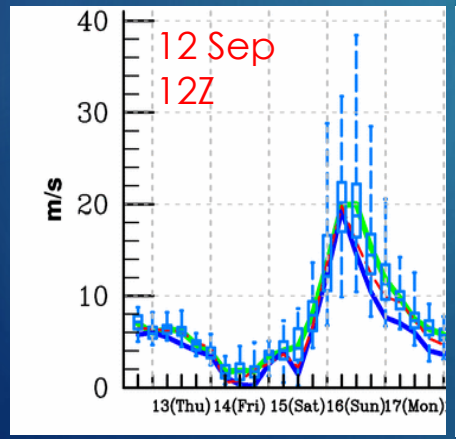
Likelihood – Extreme Winds (ECMWF EPS)

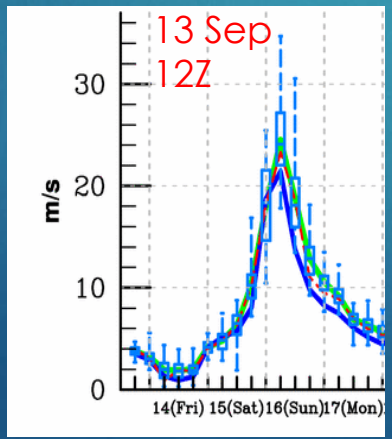
ECMWF EPS forecasts for Hong Kong signaling violent winds (~ 20-30 m/s)
Evolving from small likelihood → almost certainty over time

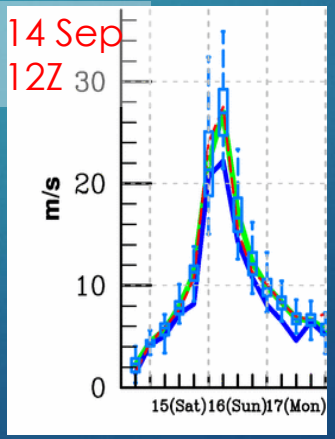


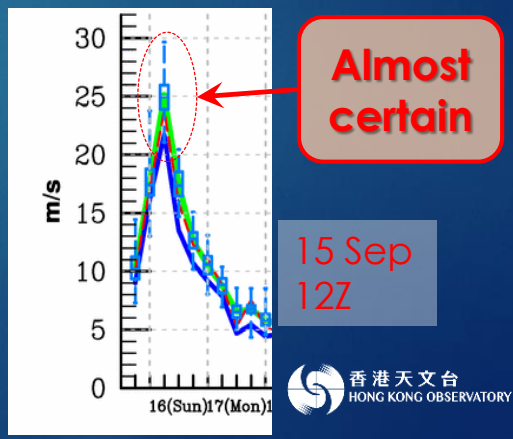












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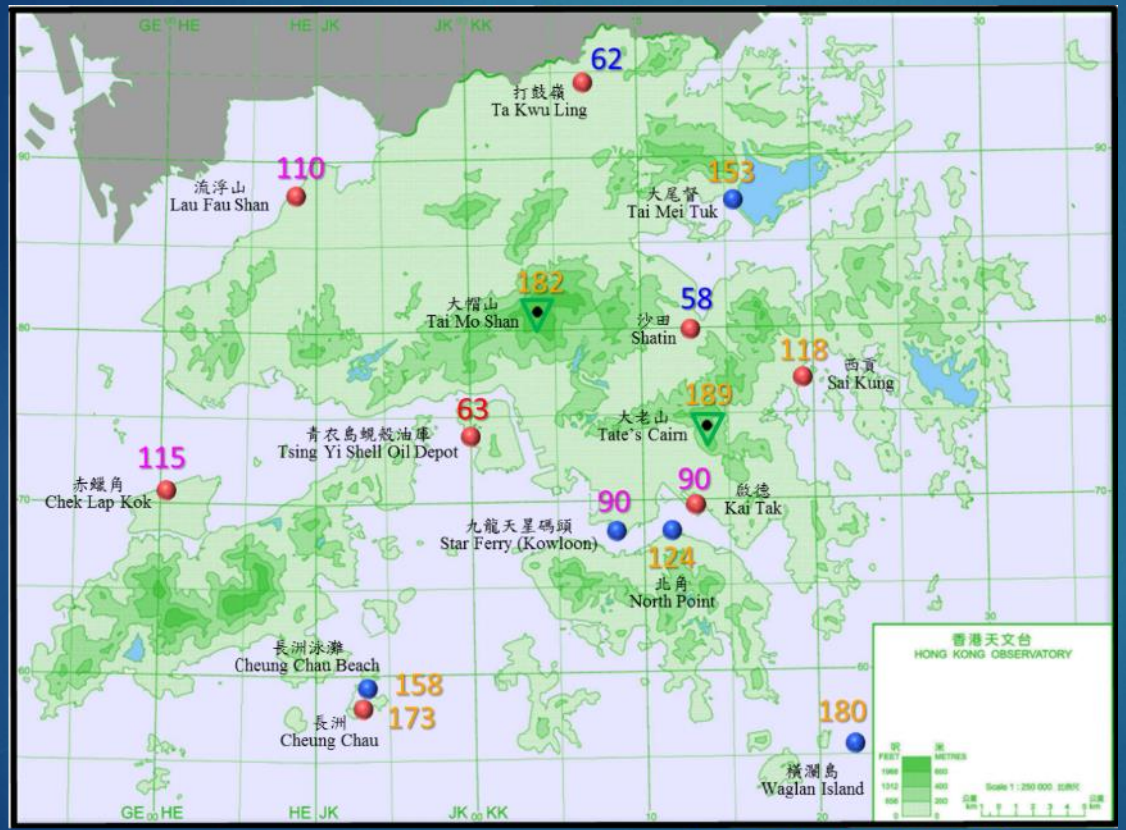
Likelihood – Extreme Winds (Actual)

Actual : Storm to hurricane force winds generally over Hong Kong during the day.



Maximum 10-min mean wind speed recorded over Hong Kong

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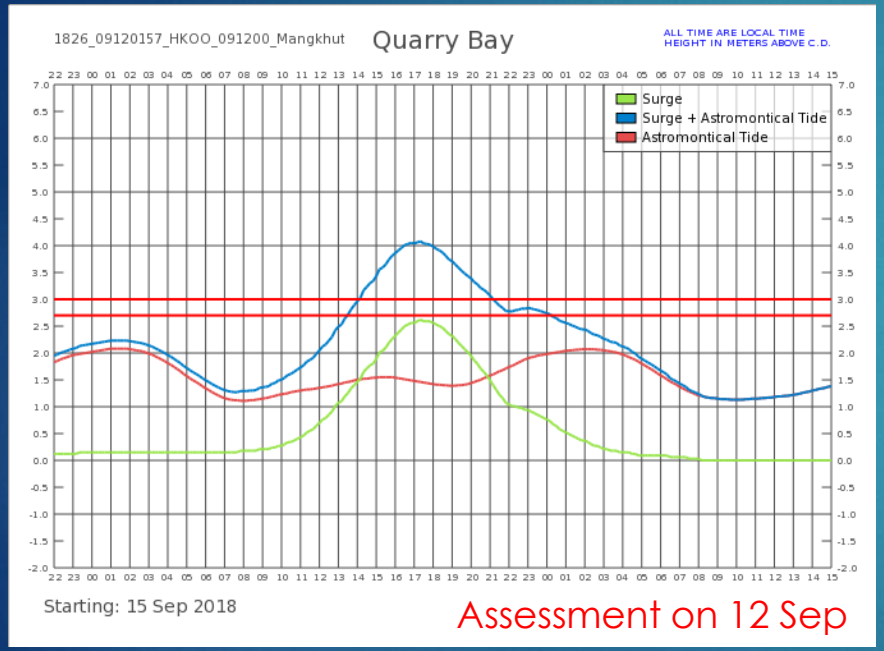
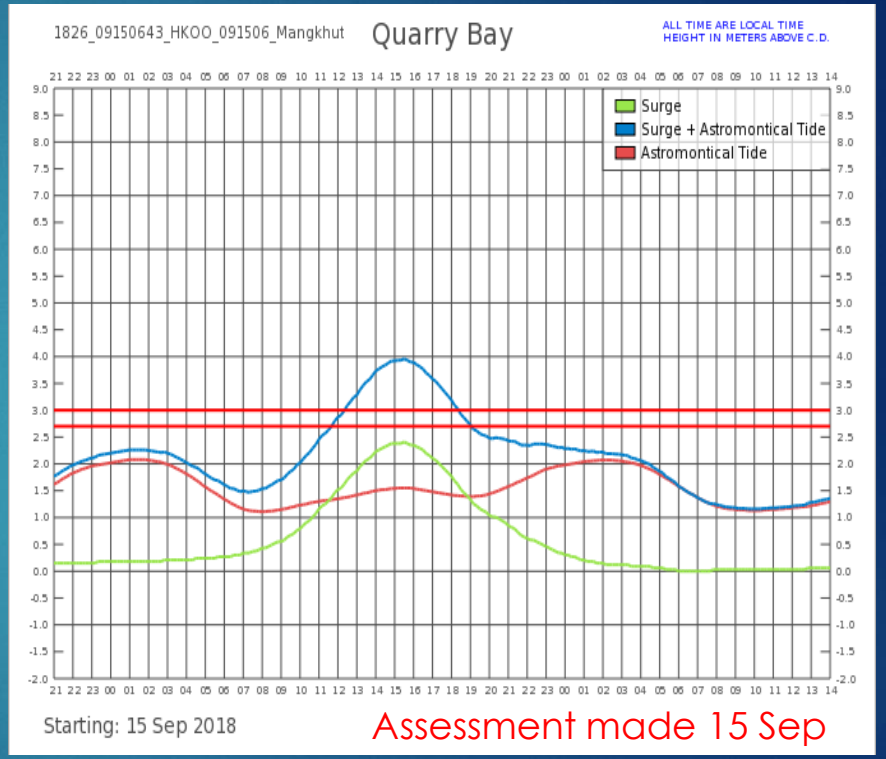
Likelihood – Storm Surge

Storm surge model (SLOSH) consistently predicted severe storm surge for 16 Sep



Assessment on 12 Sep



Assessment made 15 Sep

As recorded at Quarry Bay in Victoria Harbour of Hong Kong on 16 Sep 2018 :
actual maximum sea level was **3.88 m** (above chart datum)
with maximum storm surge of **2.35 m** (new record!)
(*Figures are provisional only and subject to further verification*)

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Likelihood – Extreme Rainfall (Analogue)

Daily Rainfall Forecast 14/00 UTC F/C

HKT	Analogue TC RF		ECMWF	JMA
	analogue	1/2(anl+max anl)		
20180914	0.1*	0.3*	0.2*	2.0*
20180915	0.0*	0.0*	143.6	0.5
20180916	-	-	211.4	74.4
20180917	-	-	84.5*	40.1*

Daily Rainfall Forecast 14/12 UTC F/C

HKT	Analogue TC RF		ECMWF	JMA
	analogue	1/2(anl+max anl)		
20180914	1.8*	9.0*	0.1*	0.9*
20180915	8.3	52.6	2.1	0.5
20180916	22.4*	39.5*	102.6	86.0
20180917	-	-	24.6	39.5
20180918	-	-	4.0*	11.1*

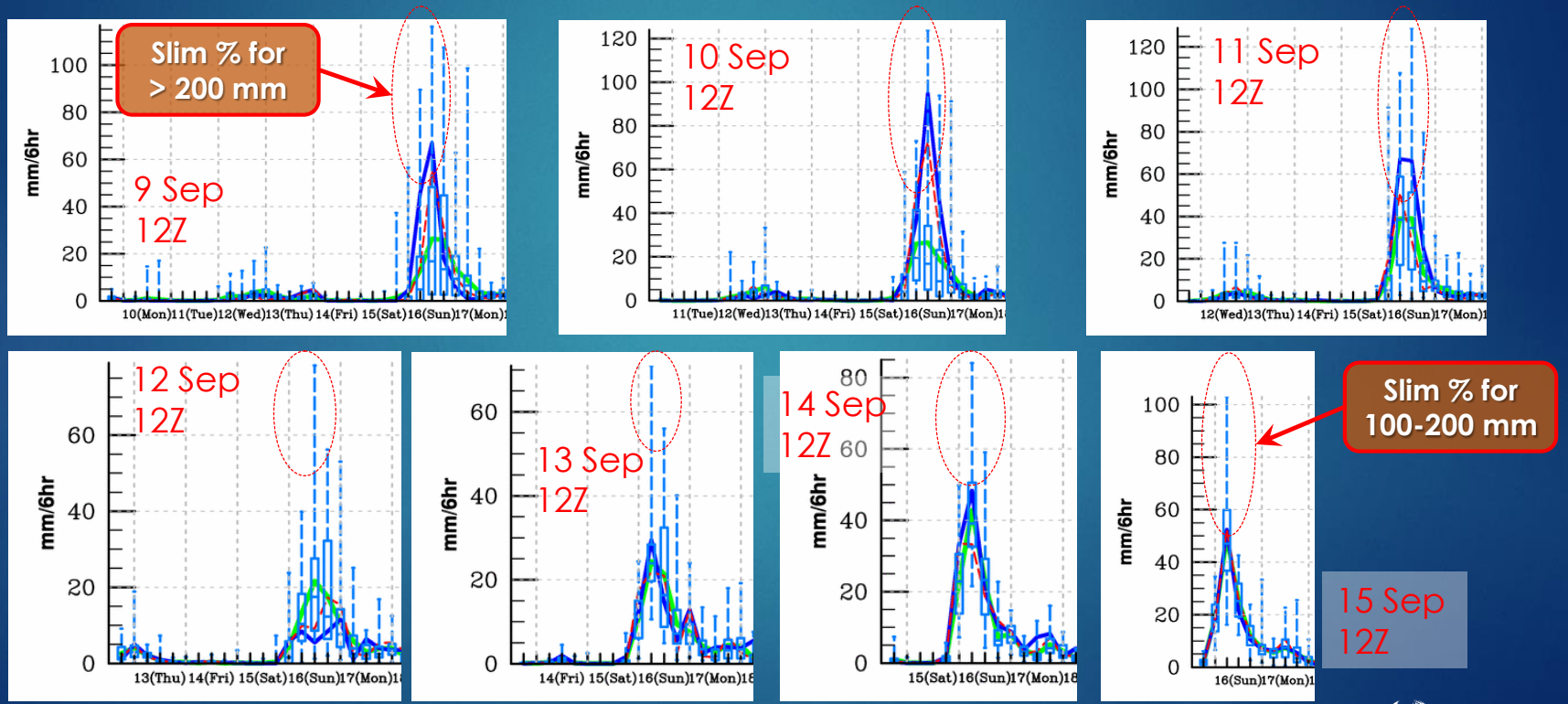
Daily Rainfall Forecast 15/00 UTC F/C

HKT	Analogue TC RF		ECMWF	JMA
	analogue	1/2(anl+max anl)		
20180915	0.8*	88.0*	1.0*	0.0*
20180916	46.9	154.9	134.1	94.0
20180917	0.0*	43.7*	25.0	43.3
20180918	-	-	5.7*	22.5*

Objective "Analogue TC Rainfall" forecasts and NWP models (ECMWF and JMA) one to two days ahead generally indicated heavy rain of order 100-200 mm possible on 16 Sep 2018

Likelihood – Extreme Rainfall (ECMWF EPS)

ECMWF EPS forecasts for Hong Kong signaling heavy rain on 16 Sep 2018
Extreme rainfall (say >200 mm) possible but likelihood remained slim throughout



Beyond Likelihood – Extreme Rainfall Signals by EFI/SOT

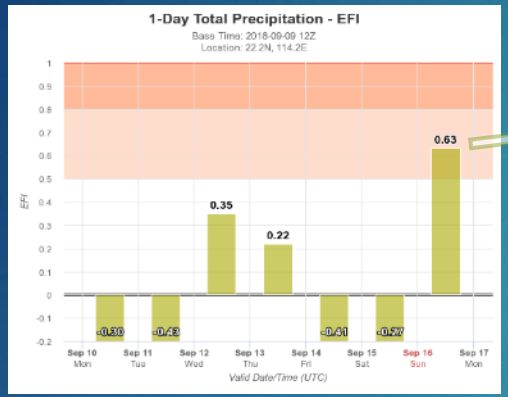
Base time

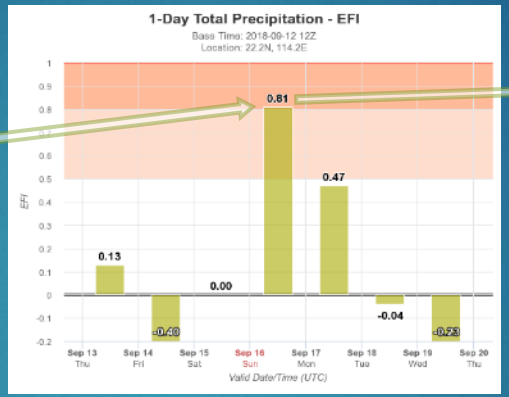
09 Sept, 12UTC

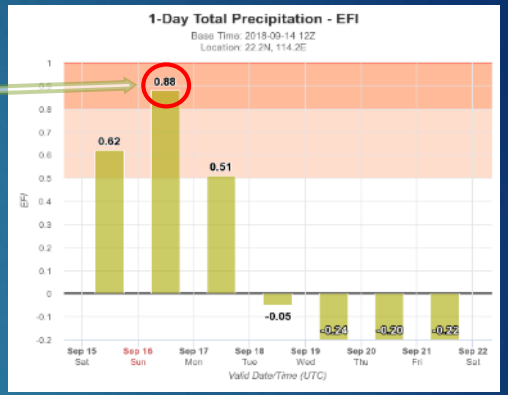
12 Sept, 12UTC

14 Sept, 12UTC

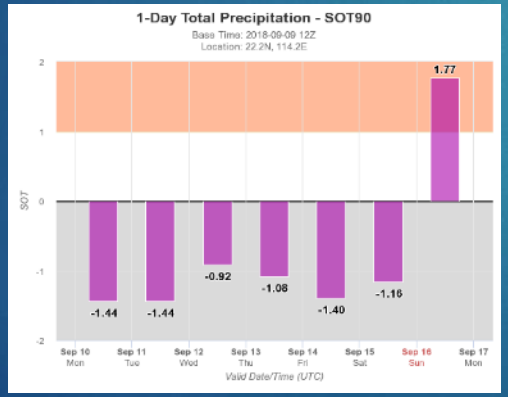
EFI

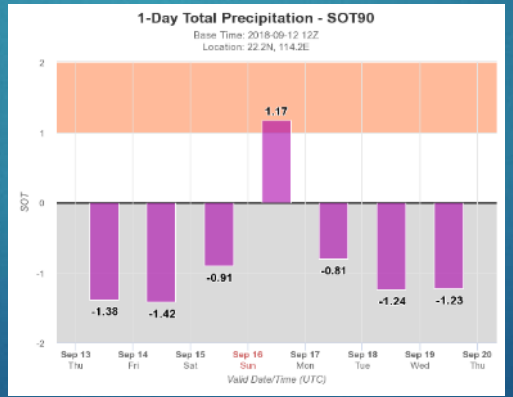


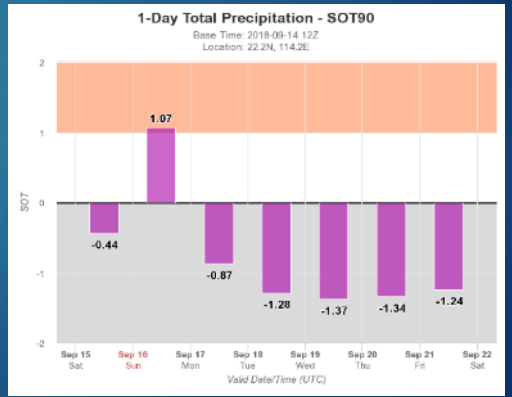




SOT







EFI and SOT are powerful tools for identifying potentially extreme weather compared to climatology for a given location and time of year. A high EFI value indicates that an extreme event is more likely than usual but the values do not represent probabilities of that event.
(Ref : https://confluence.ecmwf.int/display/FUG/Extreme+Forecast+Index+-+EFI)

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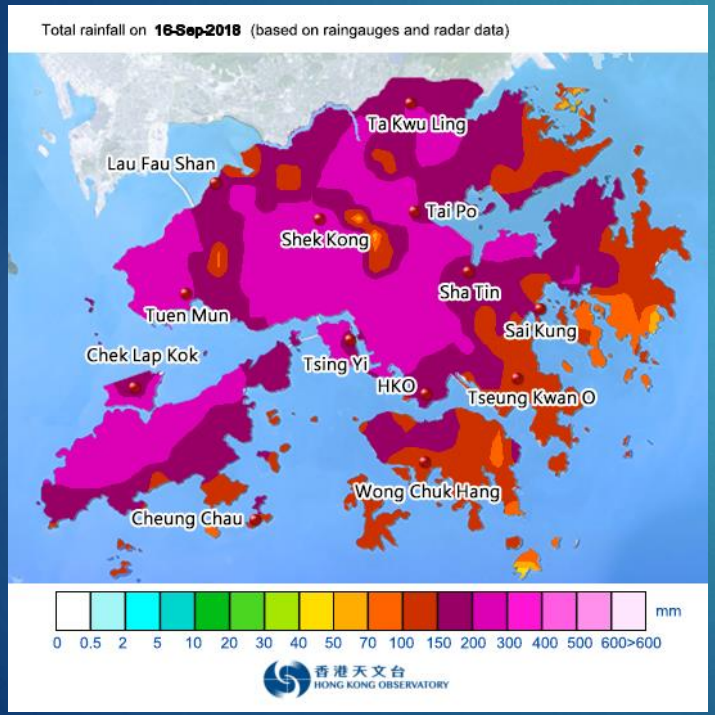
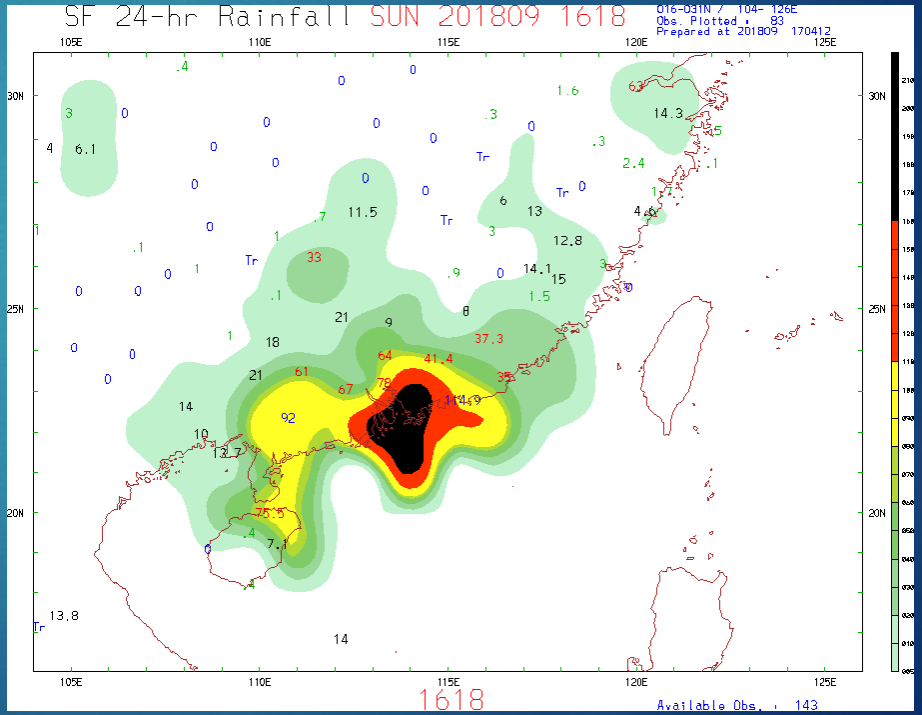
Actual Rainfall on 16 Sep (Observation Analyses)

Rainfall generally well above 100 mm, with many places exceeded 200 mm
Daily rainfall registered at HKO HQs 167.5 mm





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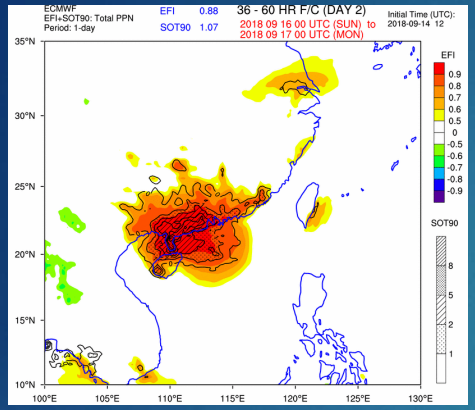
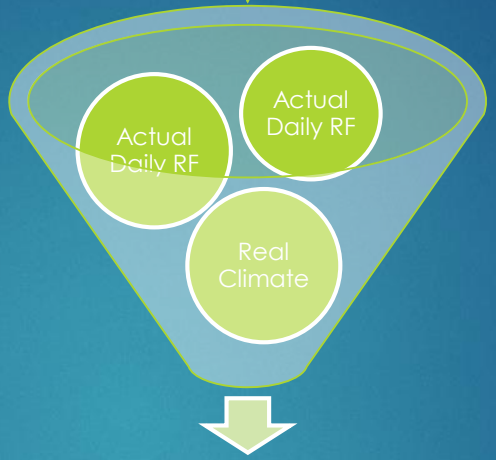
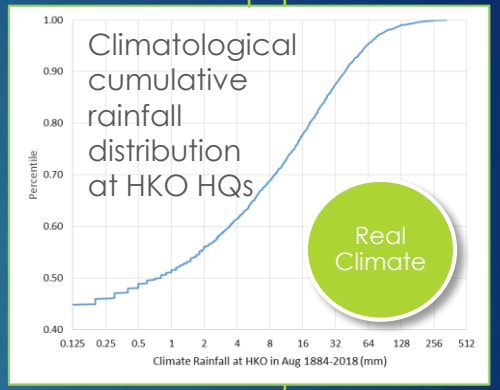
Beyond Likelihood – New Method based on OEFI & CEFI

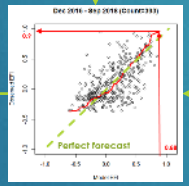






EFI

Observed EFI (OEFI)

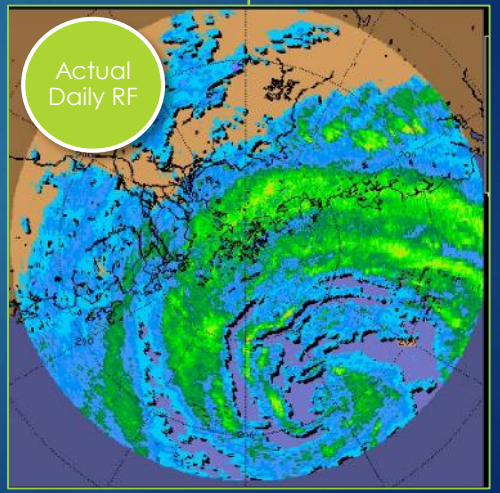


Calibrated EFI (**CEFI**)

EFI equivalent %-tile

Real Climate^{-1}

Forecast daily rainfall



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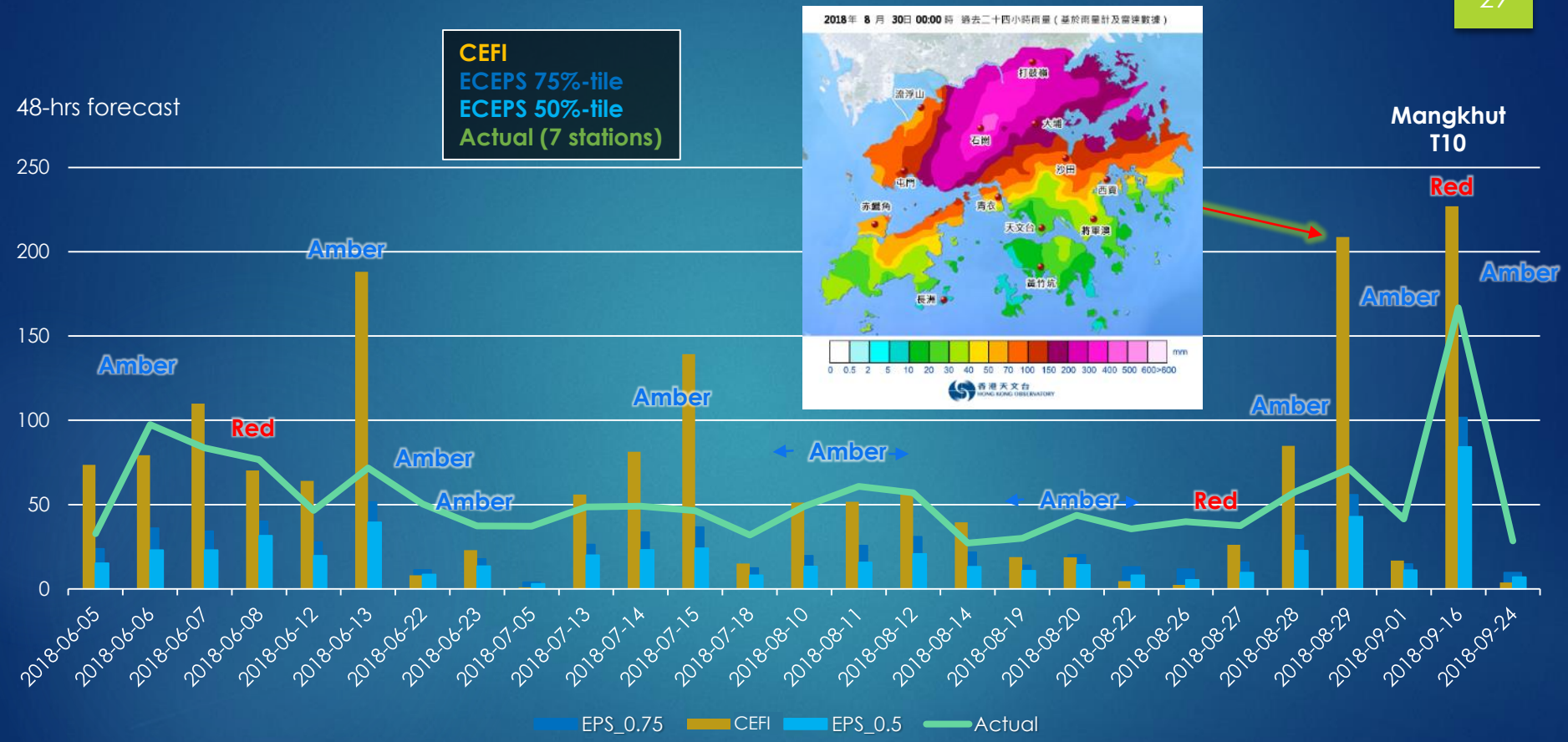
Performance Check – Extreme Rainfall Forecast based on CEFI



Cases in 2018 with 7 Selected stations' averaged daily rainfall >= 25mm

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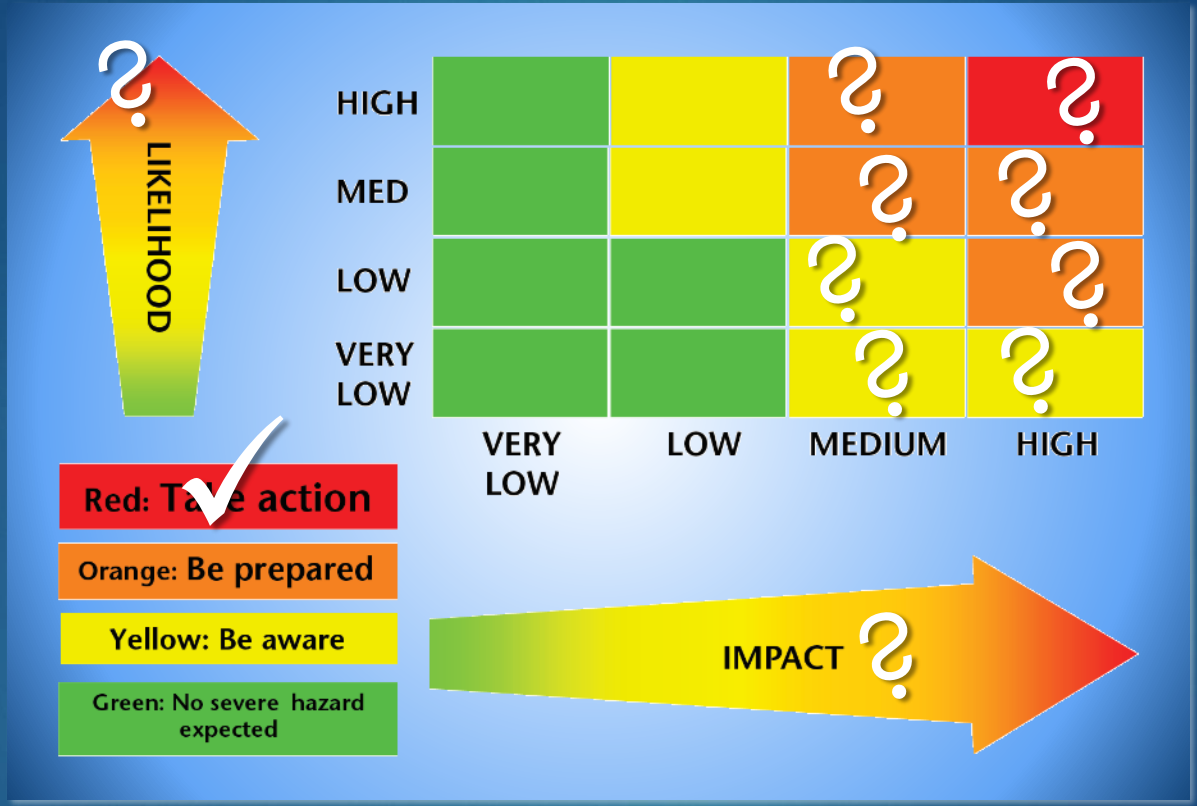
Overall Risk Assessment



Challenges:

(1) How to define impact severity for multi-hazard risk?

(2) Naturally small likelihood for extreme impacts. How to "calibrate"?

Actions Taken – **Early Alert**

Four days ahead and well before the issuance of the actual Tropical Cyclone Warnings, a "Special Weather Tips" was issued on 12 Sep 2018, alerting the public of the threats, including potential storm surge, posing to Hong Kong by Mangkhut:

Super Typhoon Mangkhut now over the western North Pacific will enter the South China Sea this Saturday and move quickly towards the coast of Guangdong. As Mangkhut has a large circulation with intense winds, it will pose considerable threat to the coast of Guangdong. Although there are still uncertainties in its track, Mangkhut is expected to bring adverse weather to Hong Kong on Sunday with frequent squalls and heavy rain according to the present forecast track. Seas will be very rough with swells. Together with the storm surge, low-lying areas may have flooding or backflow of seawater.

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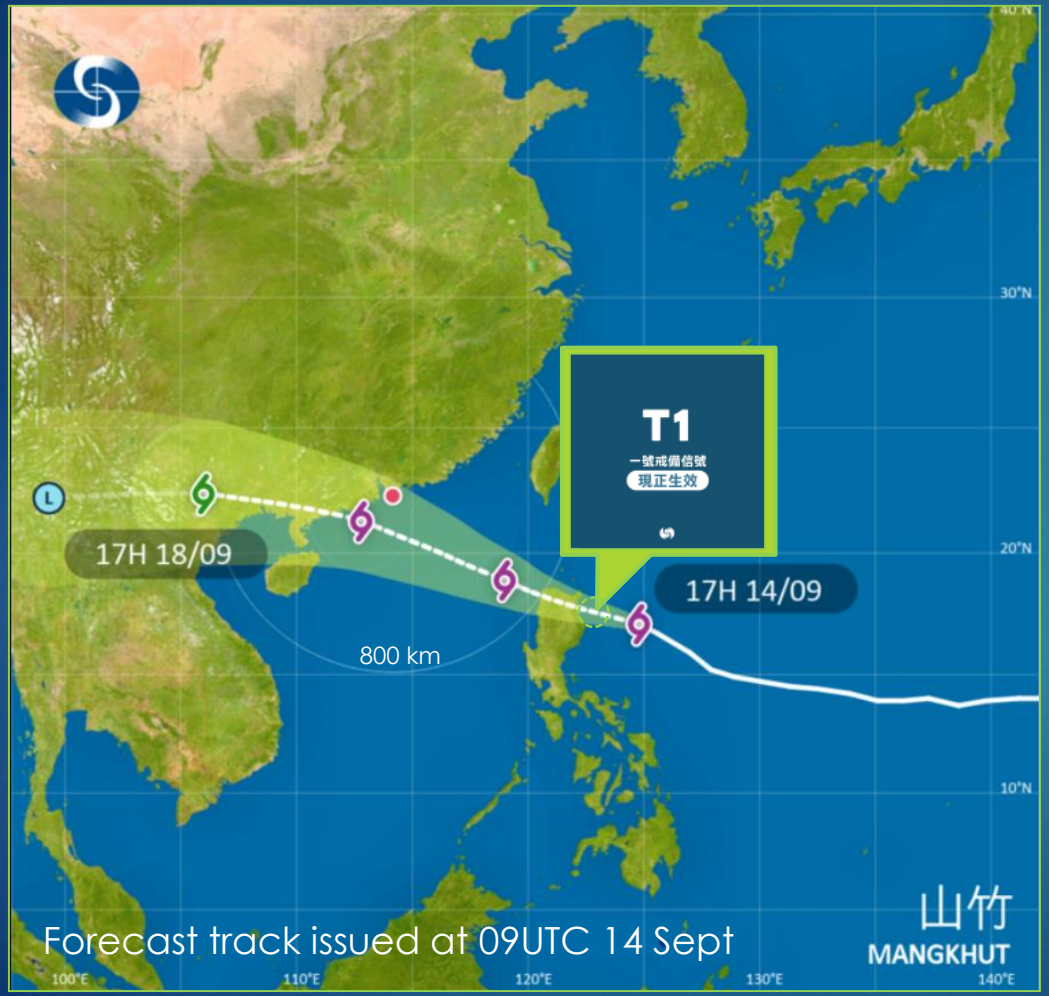
Actions Taken – **Early Warning**



As Mangkhut is a fast moving storm with a large circulation, the Standby Signal No.1 (T1) was issued at 22:20 pm on 14 Sept 2018 when Mangkhut was still about 1110 km from Hong Kong (the default practice is 800 km)

Actions Taken – **Impact Communications**

Multi-Channel Warning Dissemination
+ Comprehensive Communication Strategies + Use of Social Media

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Remarks

A wake up call by nature

- Mangkhut is the most destructive typhoons striking Hong Kong in the past three decades

Forecasting challenges

- Deadly characteristics – intense, extensive circulation, fast moving
- Track - landfalling to the east or west of Hong Kong and how close to Hong Kong
- Intensity assessment – significant differences in intensity assessment among warning centers may confuse the general public and weaken the authoritativeness of the meteorological services, especially for the areas directly affected by the storm
- Structure - unusual wind structure with intense spiral rainbands outside eyewall
- Storm Surge & extreme rainfall – estimating maximum water level and risk of inundation heavily depends on the track, structure and intensity assessment at the time
- Likelihoods for different weather elements vary widely and chance of extreme events (e.g. rainfall) are naturally slim
- Impact severity, especially for multi-hazards, difficult to be quantified by a single index

Remarks (cont'd)

Warning strategies

- Early alerts/warnings due to extensive circulation and fast moving storm
- Emphasizing considerable threat to Hong Kong in advance, in particular adverse weather, storm surge and high winds

Communication strategies

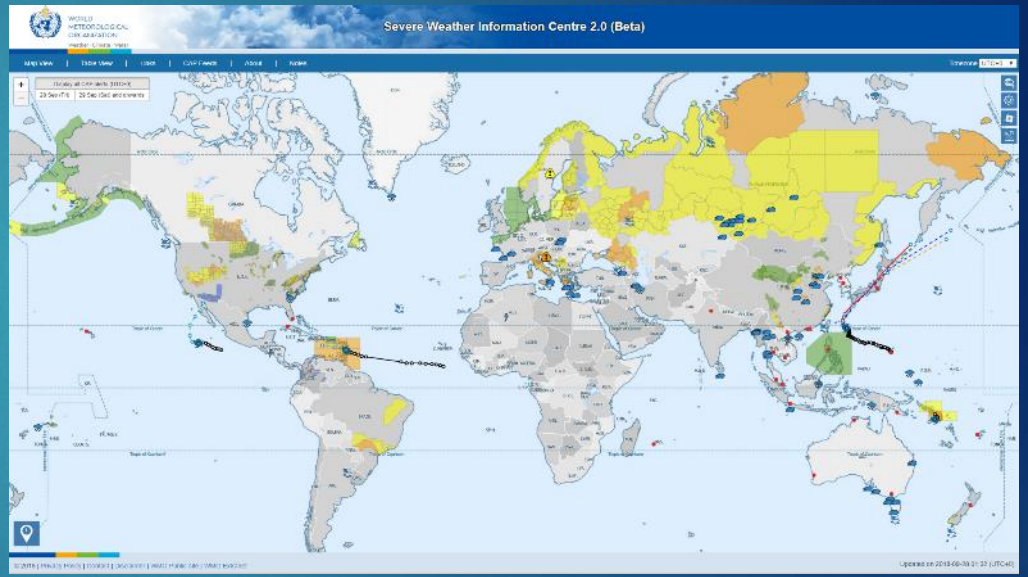
- Early alert to and liaison with government departments (e.g. inter-departmental coordination meeting & joint press conference)
- Formulating media and social media communication plan days ahead to effectively provoke public awareness of potential hazards and inform precautionary measures
- Regular and timely update of alerts and weather situations (e.g. wind, rainfall, storm surge) to the public during the passage of the storm

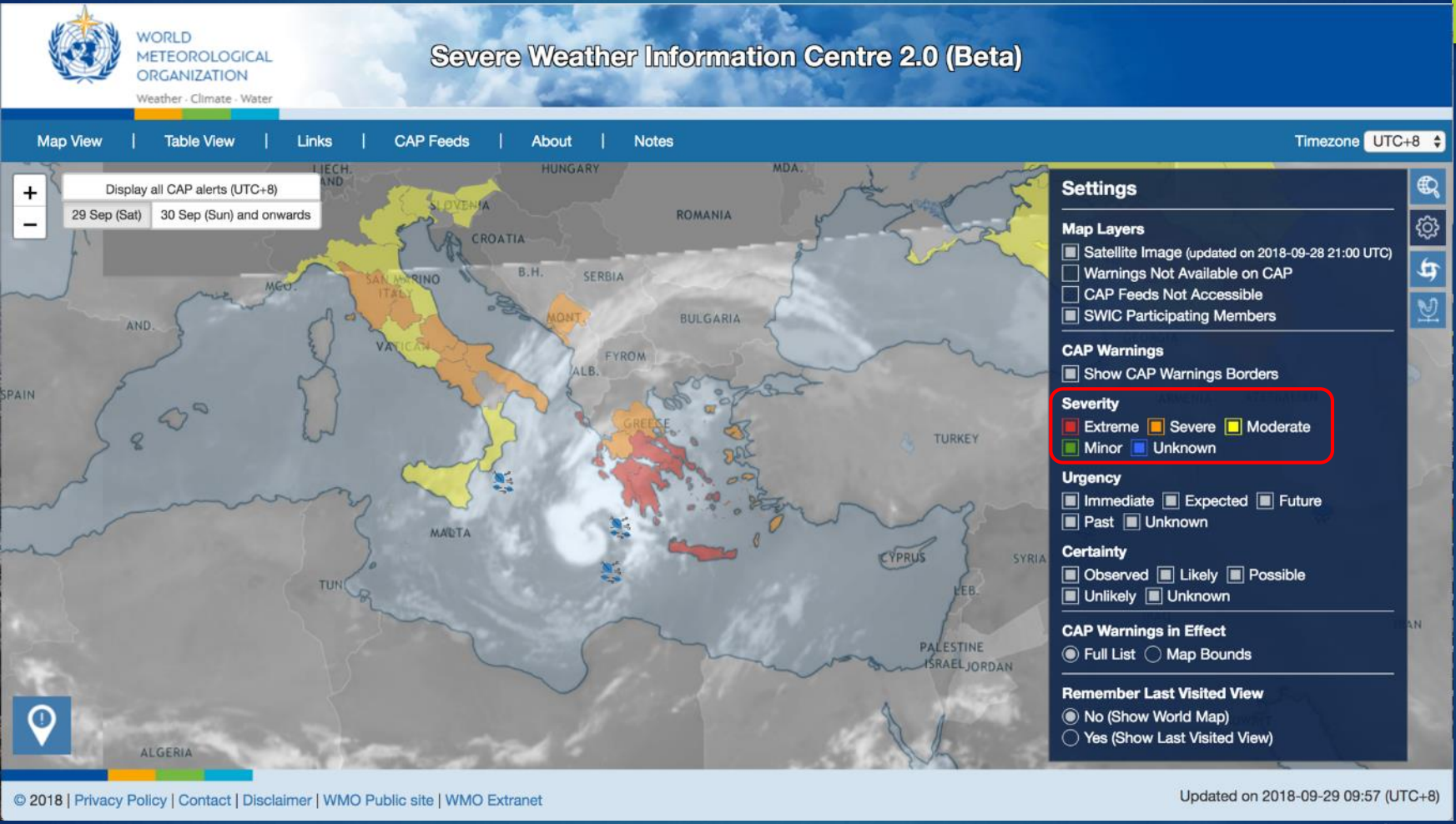
Other IBF Services

~ International / WMO ~

WMO Severe Weather Information Centre

- Revamped and launched on 2 October 2018 as SWIC 2.0 Beta for aggregating authoritative warning signals related to high-impact weather, water and climate events
- Developed and maintained by HKO
- As an initial core components of the WMO Global Multi-hazard Alert System (GMAS)
- Providing a web-based GIS user interface to GMAS users





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Adoption of ISO 22324 Standard for colour-coded alerts

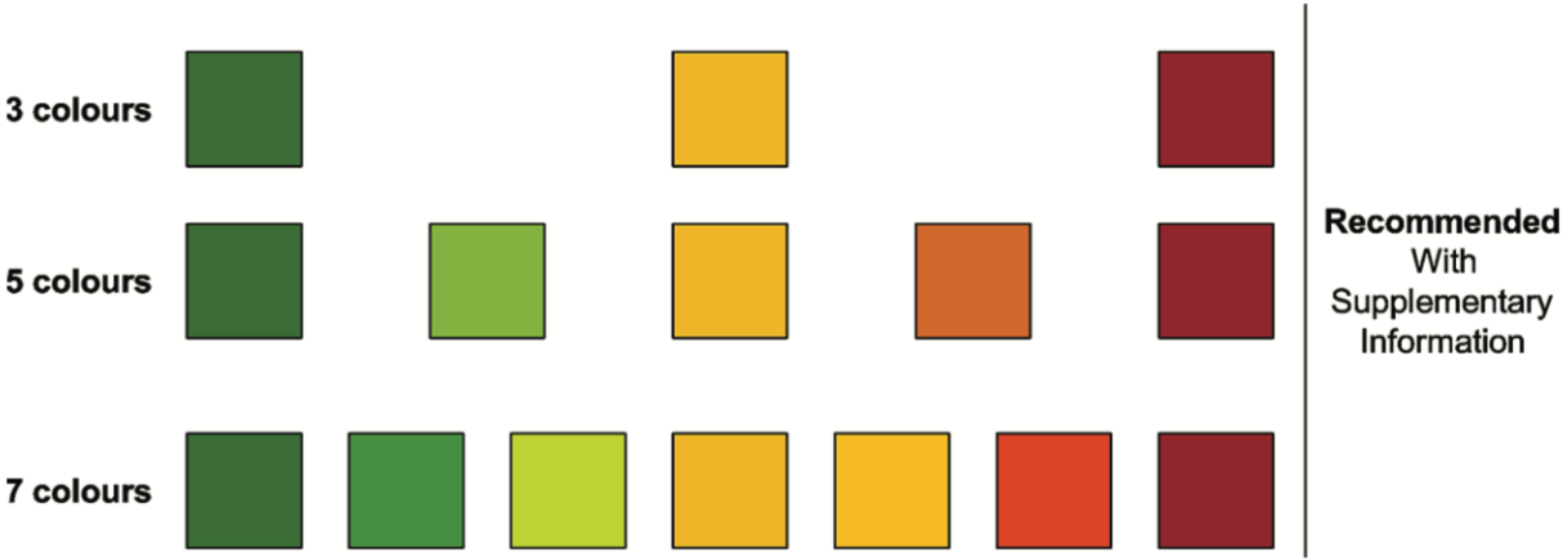


Figure 1 — Guideline for use of basic colours

Tropical Storm Warning issued September 28 at 4:20PM EDT by NWS NWS National Hurricane Center

for United States of America

Issued time: 2018-09-28 16:20:00 (UTC-04)

Event: Tropical Storm Warning

Effective time: 2018-09-29 17:00:00 (UTC-04)

Expire time: 2018-09-29 04:30:00 (UTC-04)

Download

Urgency: Expected

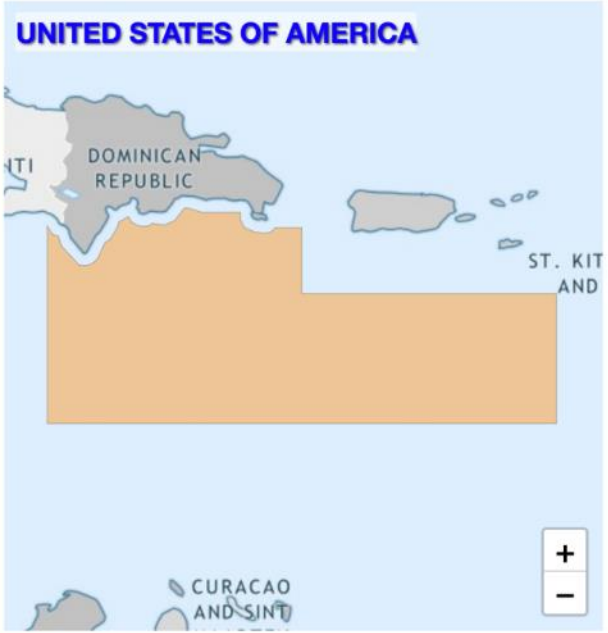
Severity: Severe

Certainty: Likely

National Weather Service

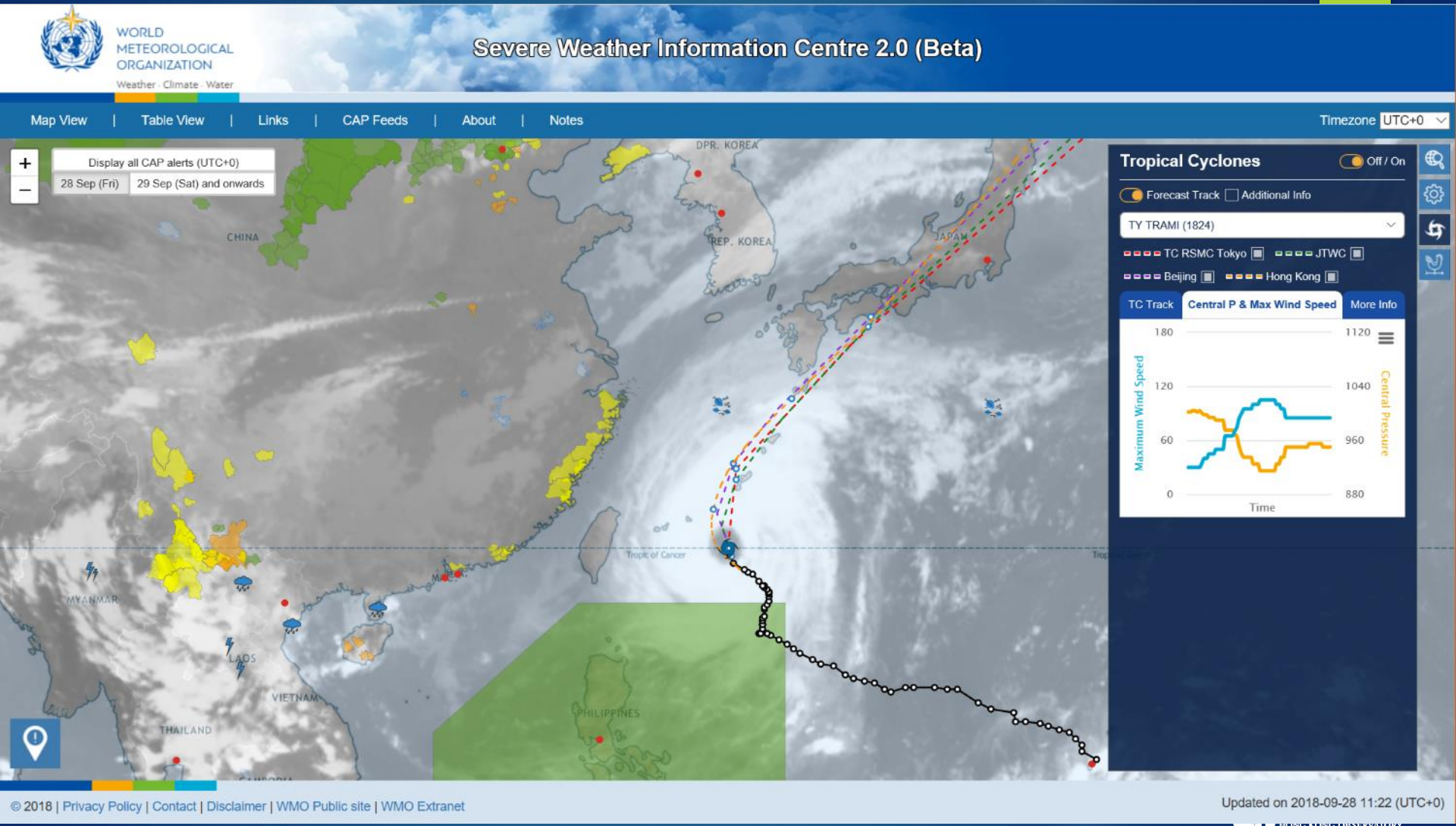
Description

Offshore Waters Forecast for the Tropical N Atlantic from 07N to 22N between 55W and 64W, the SW N Atlantic S of 31N W of 65W including Bahamas, and the Caribbean Sea. Seas given as significant wave height, which is the average height of the highest 1/3 of the waves. Individual waves may be more than twice the significant wave height. ...TROPICAL STORM WARNING... .TONIGHT...TROPICAL STORM CONDITIONS POSSIBLE. NE to E winds 30 to 35 kt, diminishing to 20 to 25 kt late. Seas 7 to 10 ft in NE to E swell. .SAT...E winds 20 to 25 kt. Seas 6 to 9 ft in NE



Affected area

Caribbean N of 15N between 64W and 72W


WORLD METEOROLOGICAL ORGANIZATION
Weather · Climate · Water
Severe Weather Information Centre 2.0 (Beta)
Map View | Table View | Links | CAP Feeds | About | Notes
Timezone UTC+0
Display all CAP alerts (UTC+0)
28 Sep (Fri)
29 Sep (Sat) and onwards
DPR. KOREA
REP. KOREA
JAPAN
CHINA
MYANMAR
LAOS
VIETNAM
THAILAND
PHILIPPINES
Tropic of Cancer
Tropical Cyclones
Off / On
Forecast Track
Additional Info
TY TRAMI (1824)
TC RSMC Tokyo
JTWC
Beijing
Hong Kong
TC Track
Central P & Max Wind Speed
More Info
Maximum Wind Speed
Central Pressure
Time
180
120
60
0
1120
1040
960
880
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Updated on 2018-09-28 11:22 (UTC+0)
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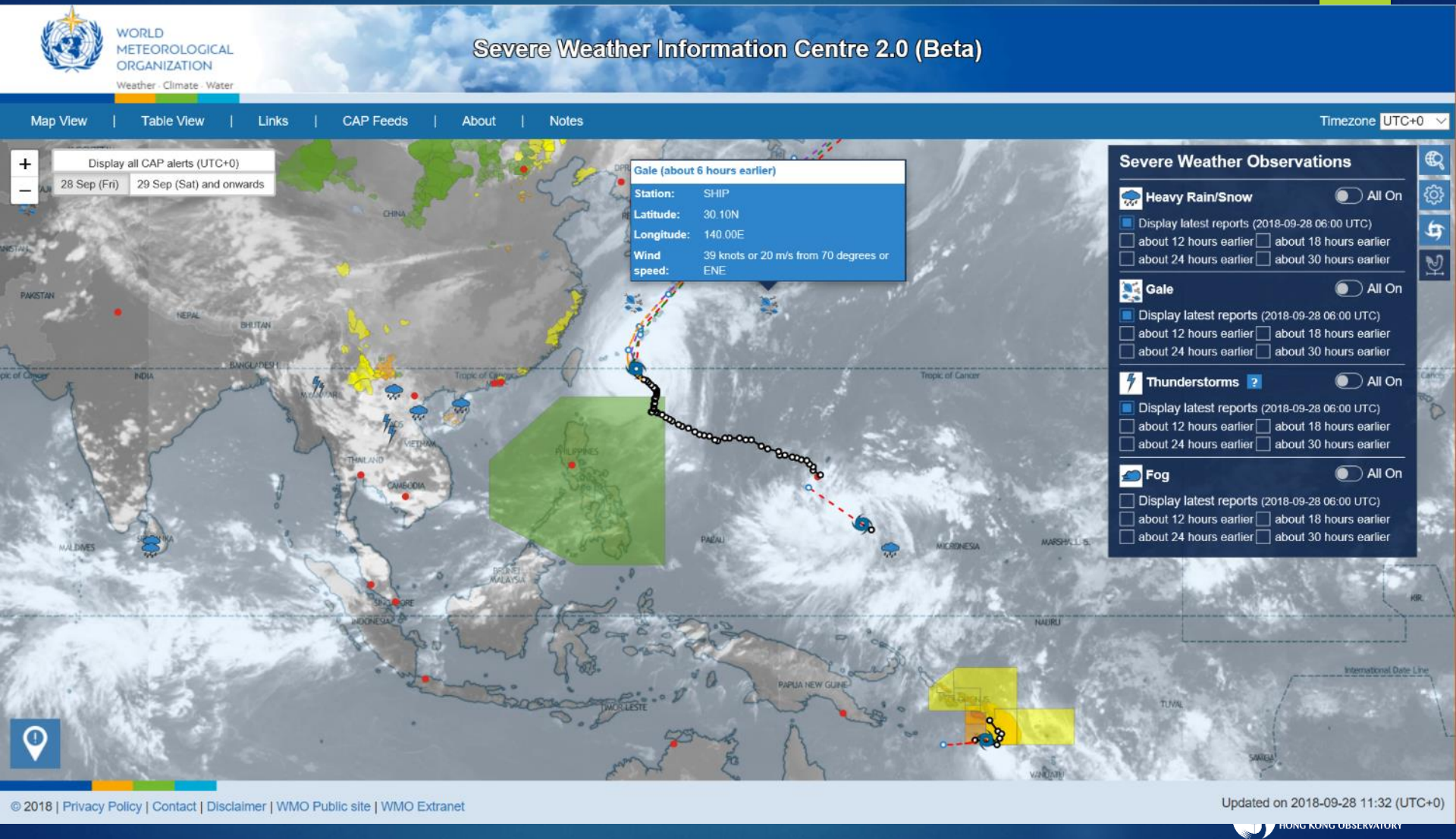

Updated on 2018-09-28 11:32 (UTC+0)

CAP Feeds

ISSUING ORGANISATION	LANGUAGE	RSS/ATOM FEED OF CAP ALERTS	FEED STATUS
Anguilla: Disaster Management Anguilla	en	https://axa-primary.capews.com/capews/public/atom?type=cap	Actual
Antigua and Barbuda: Meteorological Services	en	http://alert.metoffice.gov.ag/capfeed.php	Actual
Argentina: Servicio Meteorologico Nacional	es	http://www3.smn.gob.ar/feeds/CAP/avisocortoplazo/rss_acpCAP.xml	Actual
Austria: Zentralanstalt für Meteorologie und Geodynamik	de, en	http://meteoalarm.eu/ATOM/AT.xml	Actual
Barbados: Department of Emergency Management	en, fr, es	https://brb-secondary.capews.com/capews/public/atom?type=cap	Actual
Belgium: Royal Meteorological Institute	nl, fr, en	http://meteoalarm.eu/ATOM/BE.xml	Actual
Bosnia and Herzegovina: Federalni hidrometeorološki zavod BiH	bs	http://meteoalarm.eu/ATOM/BA.xml	Actual
Brazil: Instituto Nacional de Meteorologia - INMET	pt	http://alert-as.inmet.gov.br/cap_12/rss/alert-as.rss	Actual
Bulgaria: НАЦИОНАЛЕН ИНСТИТУТ ПО МЕТЕОРОЛОГИЯ И ХИДРОЛОГИЯ - ФИЛИАЛ ПЛОВДИВ	bg	http://meteoalarm.eu/ATOM/BG.xml	Actual

Specialized IBF Services
~ UN & Humanitarian Activities ~

Support Humanitarian Planning & Response

- Provide products and services to United Nations (UN) and humanitarian agencies to improve contingency planning through establishing a WMO Coordination Mechanism (WCM)
- Establish a WMO Situation Room (WSR) to facilitate and coordinate WMO response to major disasters
- GMAS as a supporting platform
- **HKO committed to assist in developing WCM/WSR/GMAS**

UN and other humanitarian agencies

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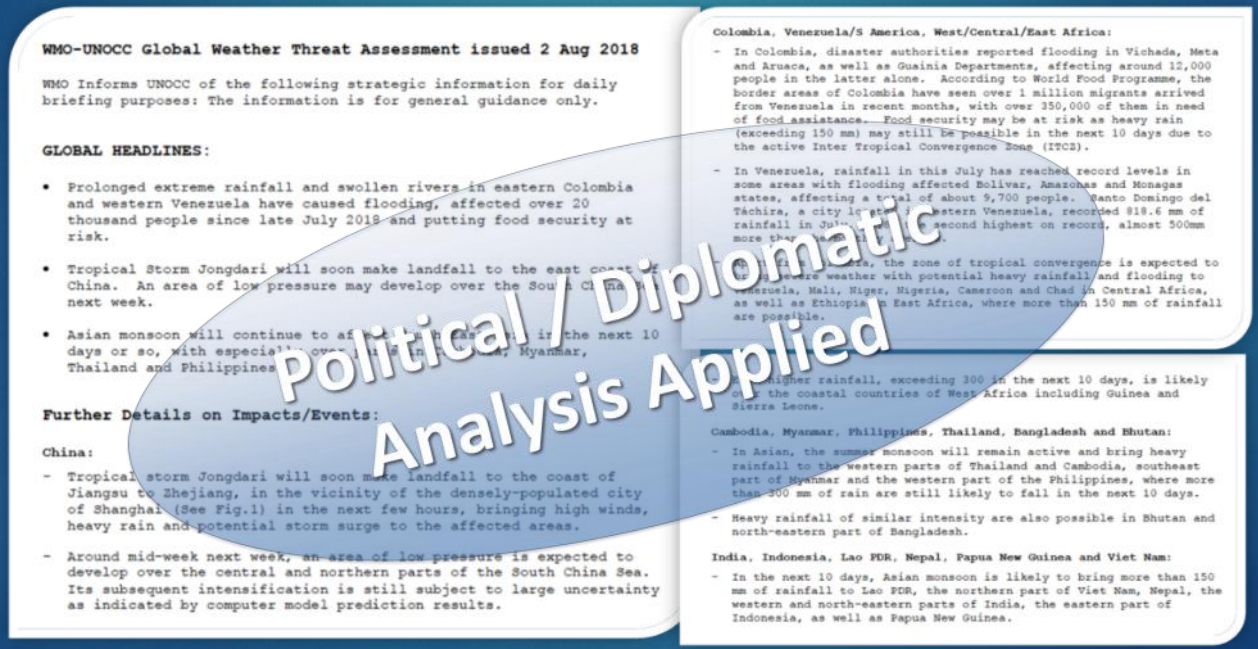
Trial Support for UNOCC

- UNOCC – United Nations Operations & Crisis Centre
  - Concerns for the impacts of major natural disasters, such as tropical cyclones, regional flooding due to monsoon, etc.



WMO-UNOCC Global Weather Threat Assessment issued 2 Aug 2018

WMO Informs UNOCC of the following strategic information for daily briefing purposes: The information is for general guidance only.

GLOBAL HEADLINES:

- Prolonged extreme rainfall and swollen rivers in eastern Colombia and western Venezuela have caused flooding, affected over 20 thousand people since late July 2018 and putting food security at risk.
- Tropical Storm Jongdari will soon make landfall to the east coast of China. An area of low pressure may develop over the South China Sea next week.
- Asian monsoon will continue to affect [illegible] in the next 10 days or so, with especially [illegible], Myanmar, Thailand and Philippines.

Further Details on Impacts/Events:

China:

- Tropical storm Jongdari will soon make landfall to the coast of Jiangsu to Zhejiang, in the vicinity of the densely-populated city of Shanghai (See Fig.1) in the next few hours, bringing high winds, heavy rain and potential storm surge to the affected areas.
- Around mid-week next week, an area of low pressure is expected to develop over the central and northern parts of the South China Sea. Its subsequent intensification is still subject to large uncertainty as indicated by computer model prediction results.

Colombia, Venezuela/S America, West/Central/East Africa:

- In Colombia, disaster authorities reported flooding in Vichada, Meta and Aruaca, as well as Guainia Departments, affecting around 12,000 people in the latter alone. According to World Food Programme, the border areas of Colombia have seen over 1 million migrants arrived from Venezuela in recent months, with over 350,000 of them in need of food assistance. Food security may be at risk as heavy rain (exceeding 150 mm) may still be possible in the next 10 days due to the active Inter Tropical Convergence Zone (ITCZ).
- In Venezuela, rainfall in this July has reached record levels in some areas with flooding affected Bolivar, Amazonas and Monagas states, affecting a total of about 9,700 people. Santo Domingo del Táchira, a city located in western Venezuela, recorded 818.6 mm of rainfall in July, the second highest on record, almost 500mm more than [illegible].

[illegible], the zone of tropical convergence is expected to [illegible] severe weather with potential heavy rainfall and flooding to Venezuela, Mali, Niger, Nigeria, Cameroon and Chad in Central Africa, as well as Ethiopia in East Africa, where more than 150 mm of rainfall are possible.

[illegible] higher rainfall, exceeding 300 in the next 10 days, is likely over the coastal countries of West Africa including Guinea and Sierra Leone.

Cambodia, Myanmar, Philippines, Thailand, Bangladesh and Bhutan:

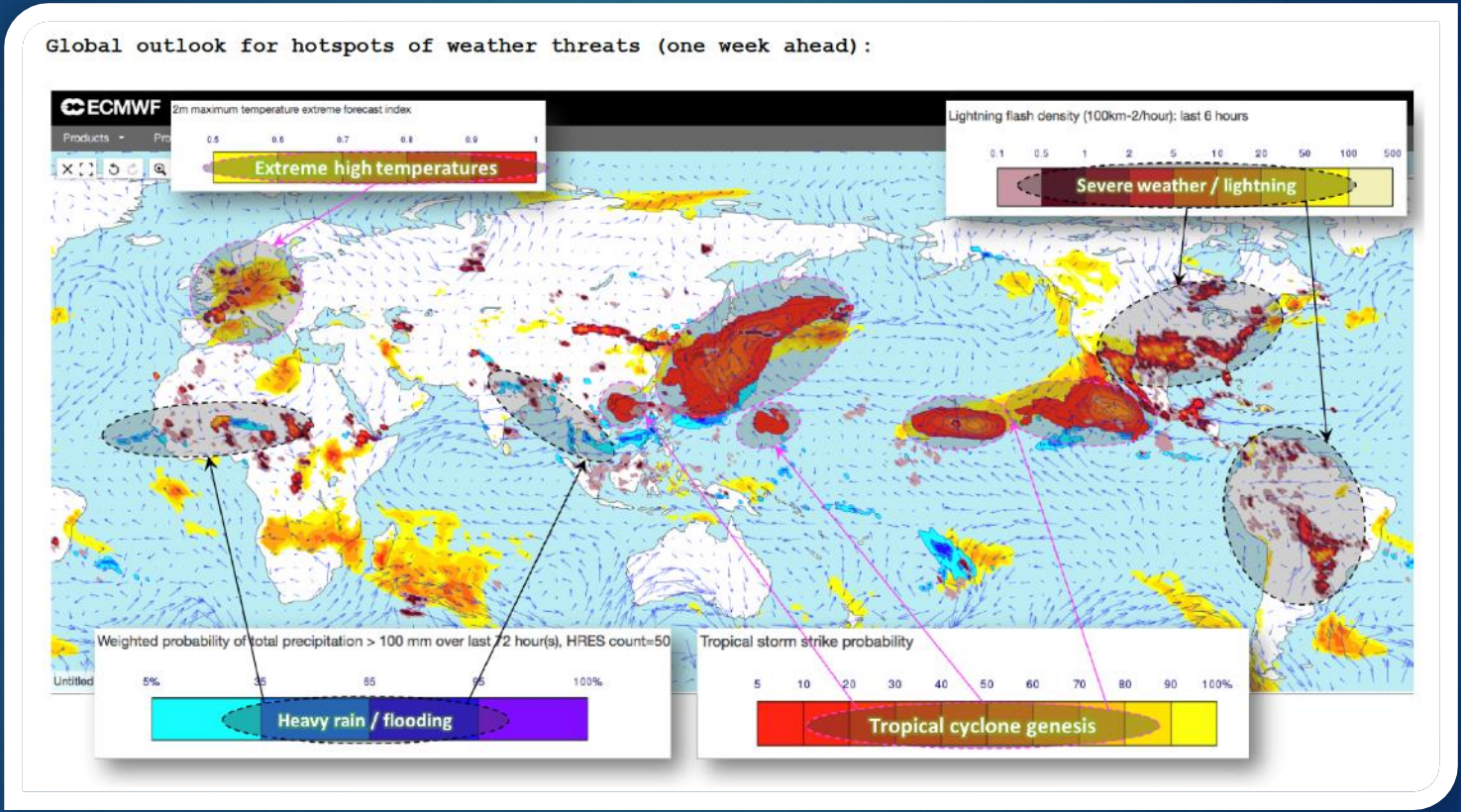
- In Asian, the summer monsoon will remain active and bring heavy rainfall to the western parts of Thailand and Cambodia, southeast part of Myanmar and the western part of the Philippines, where more than 300 mm of rain are still likely to fall in the next 10 days.
- Heavy rainfall of similar intensity are also possible in Bhutan and north-eastern part of Bangladesh.

India, Indonesia, Lao PDR, Nepal, Papua New Guinea and Viet Nam:

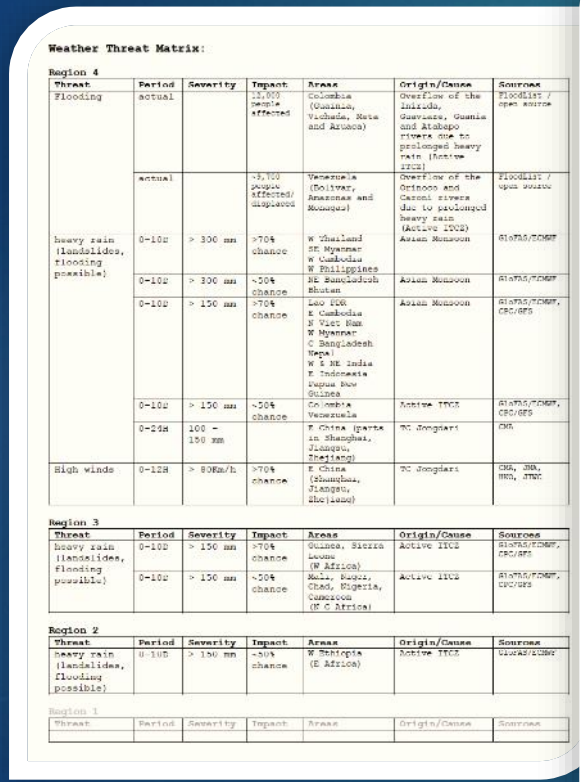
- In the next 10 days, Asian monsoon is likely to bring more than 150 mm of rainfall to Lao PDR, the northern part of Viet Nam, Nepal, the western and north-eastern parts of India, the eastern part of Indonesia, as well as Papua New Guinea.

Daily Support Product : *Global Weather Threat Assessment report*

Trial Product for Early Alerts of UNOCC:
Global Outlook for hotspots of weather threats



Key Step in Information collection :
Weather Threat Matrix



Weather Threat Matrix:

Region 4

Threat	Period	Severity	Impact	Areas	Origin/Cause	Sources
Flooding	actual		12,000 people affected	Colombia (Guainia, Vichada, Meta and Aruaca)	Overflow of the Inirida, Guaviare, Guania and Atabapo rivers due to prolonged heavy rain (Active ITCZ)	FloodList / open source
	actual		~9,700 people affected/ displaced	Venezuela (Bolivar, Amazonas and Monagas)	Overflow of the Orinoco and Caroni rivers due to prolonged heavy rain (Active ITCZ)	FloodList / open source
heavy rain (landslides, flooding possible)	0-10D	> 300 mm	>70% chance	W Thailand SE Myanmar W Cambodia W Philippines	Asian Monsoon	GloFAS/ECMWF
	0-10D	> 300 mm	~50% chance	NE Bangladesh Bhutan	Asian Monsoon	GloFAS/ECMWF
	0-10D	> 150 mm	>70% chance	Lao PDR E Cambodia N Viet Nam W Myanmar C Bangladesh Nepal W & NE India E Indonesia Papua New Guinea	Asian Monsoon	GloFAS/ECMWF, CPC/GFS
	0-10D	> 150 mm	~50% chance	Colombia Venezuela	Active ITCZ	GloFAS/ECMWF, CPC/GFS
	0-24H	100 - 150 mm		E China (parts in Shanghai, Jiangsu, Zhejiang)	TC Jongdari	CMA
High winds	0-12H	> 80Km/h	>70% chance	E China (Shanghai, Jiangsu, Zhejiang)	TC Jongdari	CMA, JMA, HKO, JTWC

Region 3

Threat	Period	Severity	Impact	Areas	Origin/Cause	Sources
heavy rain (landslides, flooding possible)	0-10D	> 150 mm	>70% chance	Guinea, Sierra Leone (W Africa)	Active ITCZ	GloFAS/ECMWF, CPC/GFS
	0-10D	> 150 mm	~50% chance	Mali, Niger, Chad, Nigeria, Cameroon (N C Africa)	Active ITCZ	GloFAS/ECMWF, CPC/GFS

Region 2

Threat	Period	Severity	Impact	Areas	Origin/Cause	Sources
heavy rain (landslides, flooding possible)	0-10D	> 150 mm	~50% chance	W Ethiopia (E Africa)	Active ITCZ	GloFAS/ECMWF

Region 1

Threat	Period	Severity	Impact	Areas	Origin/Cause	Sources

Region 4

Threat	Period	Severity	Impact	Areas	Origin/Cause	Sources
Flooding	actual		12,000 people affected	Colombia (Guainia, Vichada, Meta and Aruaca)	Overflow of the Inirida, Guaviare, Guania and Atabapo rivers due to prolonged heavy rain (Active ITCZ)	FloodList / open source
	actual		~9,700 people affected/ displaced	Venezuela (Bolivar, Amazonas and Monagas)	Overflow of the Orinoco and Caroni rivers due to prolonged heavy rain (Active ITCZ)	FloodList / open source
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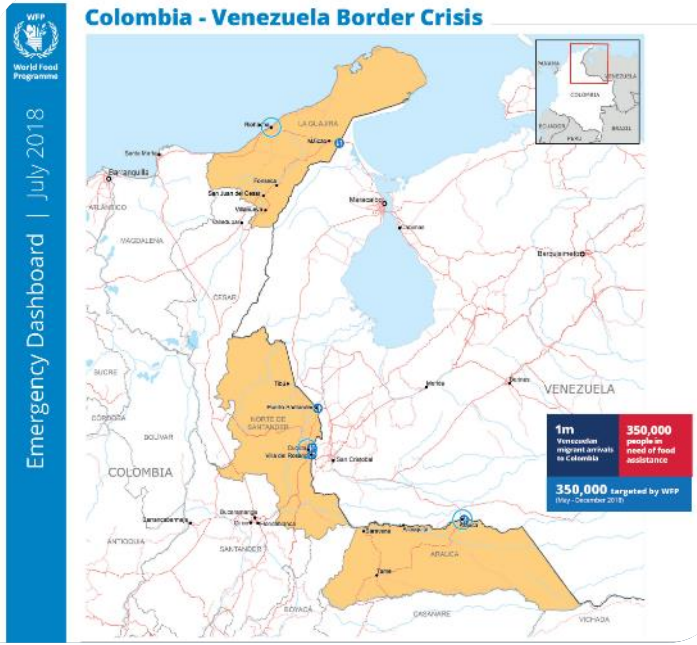
	0-24H	100 - 150 mm		E China (parts in Shanghai, Jiangsu, Zhejiang)	TC Jongdari	CMA
High winds	0-12H	> 80Km/h	>70% chance	E China (Shanghai, Jiangsu, Zhejiang)	TC Jongdari	CMA, JMA, HKO, JTWC

Validated Case : ***serious flooding in S. America***

Around 2,700 people have been affected in the state of **Amazonas** by the flooding of **the River** , which also connects with Colombia, before the **rains** that are registered in south **Venezuela** , said on Tuesday, July 31 to **EFE** the director **Civil Protection** of that entity, Si Rodríguez.



Victims of winter in the Eastern Plains - Other Cities - Colombia - ELTIEMPO.COM

the capital there was an emergency on June 22, which left about 3,000 people affected by the overflow of the Arauca River, which is already being overcome.

Emergency in Guasinia
Photos: Courtesy

'Water has already taken us out of the house'

Sandra García, 38, and Indira Carvajalino, 50, are two mothers of the Guasinia family who, in the middle of the water, who already has them above the knee, and the scarcity of food, try to survive in the Guasinia with their families

Sandra, who arrived in Guasinia from Cumaribo, Vichada, 12 years ago, had to leave her house in the settlement of Platanillal, near Inírida. There she lived with her two children, aged 9 and 16, and her husband, and her sister, also with two children (6 and 13 years old) and husband. A month ago the water rose 70 centimeters and did not go down again.

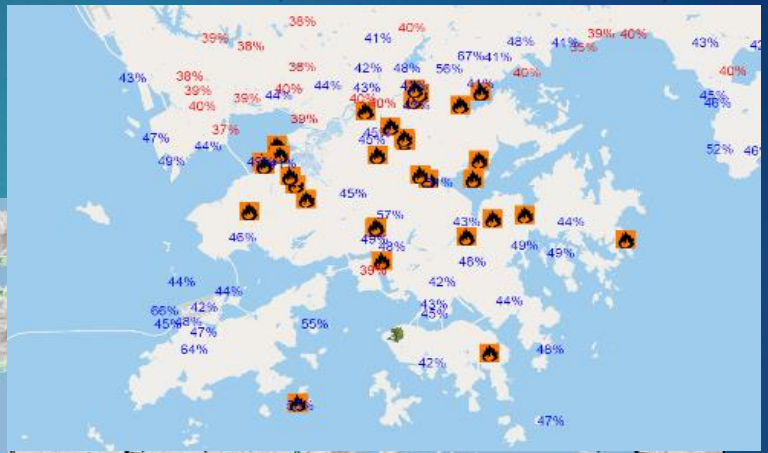
“The water took us out of the house. Some neighbors let me get close. I am living in an altico, right there in Platanillal”

Upcoming IBF Services

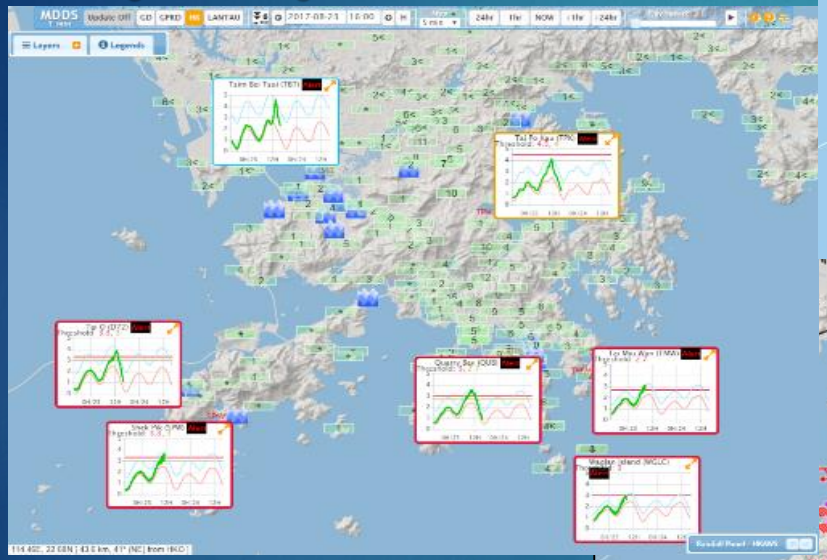
~ BD / AI / Crowdsourcing ~

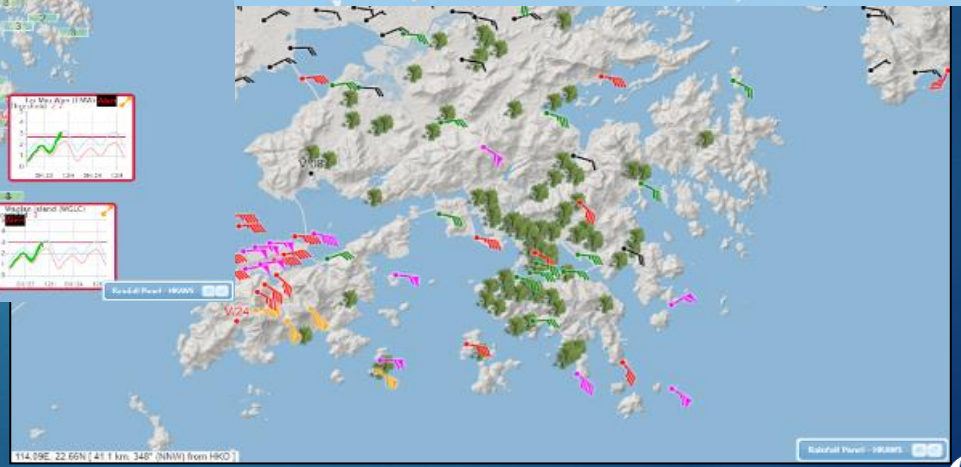
Weather Impact Analysis by AI

Hill fires - dry weather vs human activity



Flooding - storm surge vs rainfall





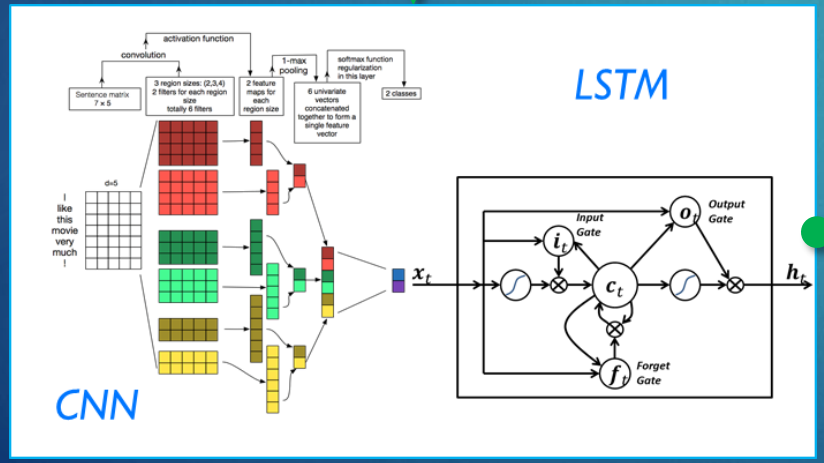
Tree damage – highly dependent on typhoon winds directions

Collecting Traffic Impacts by Deep Learning

- **Input: *online traffic news***

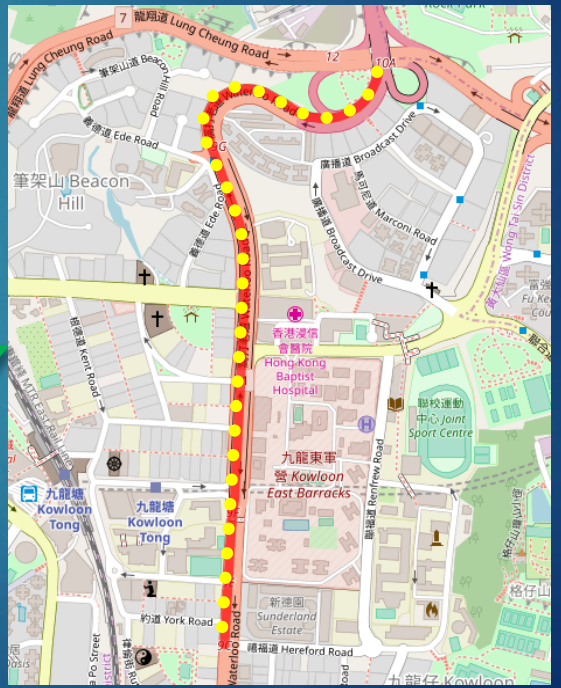
「窩打老道往沙田方向，近映月臺一段擠塞，龍尾：羅福道」

(Heavy traffic on Waterloo Road heading to Sha Tin near Moonbeam Terrace)



Deep-learning Neural Networks

- **Output: *traffic status on GIS***



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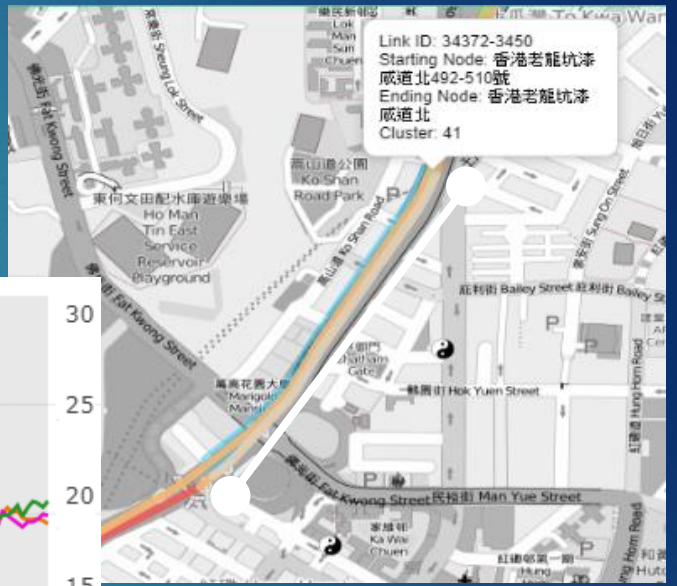
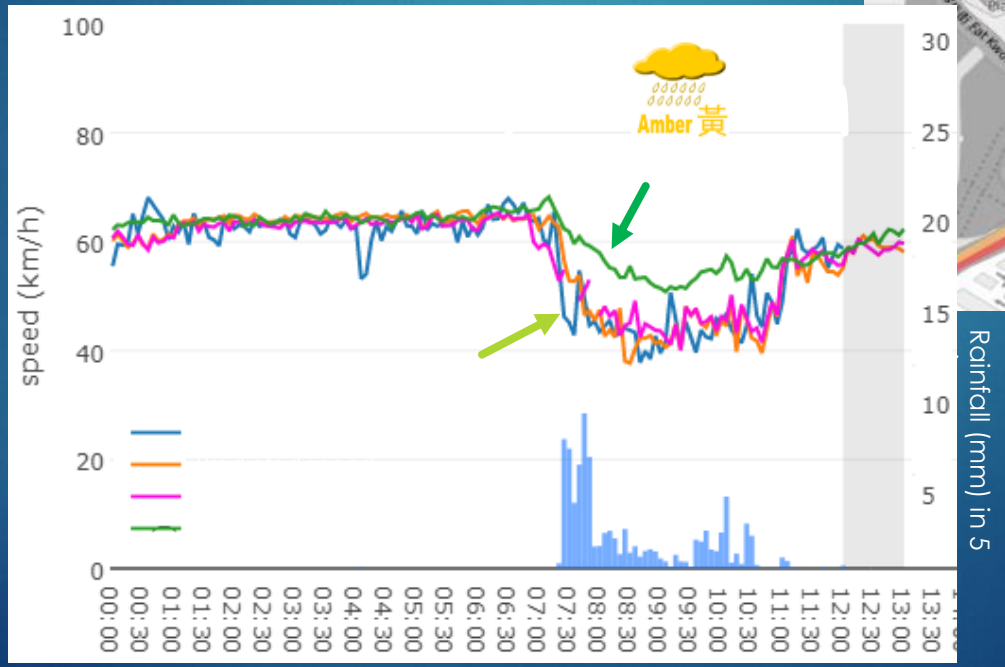
Predicting Wx Impact on Road Traffic

- Learn the correlation between rainfall amount and traffic speed
- Aim at predicting impact on road traffic due to rain



Chatham Road North
Wed. 13 April, 2016



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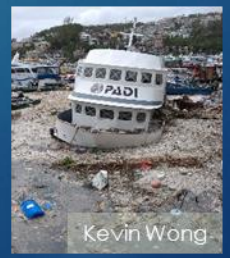
Crowd-Sourcing for Wx and Impacts



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Ways Forwards

- Collecting impact data by crowd-sourcing
  - exploring social media and big data
  - grabbing timely impact information
  - establishing common operational picture
- Building impact database
  - to provide a firm basis for developing impact-based forecast services
- Better capturing of extreme events by network of high-density IoT sensors
- Develop extreme forecast products
- Smart Airport project
- Support WMO's initiatives of IBF / WCM / WSR / GMAS

Thank you