MEMBER REPORT
Hong Kong, China

ESCAP/WMO Typhoon Committee
15th Integrated Workshop
1-2 December 2020

I. Overview of tropical cyclones which have affected/impacted Member's area since the last Committee Session

1. Meteorological Assessment (highlighting forecasting issues/impacts)

Five tropical cyclones affected Hong Kong, China from 1 January to 31 October 2020 (tracks as shown in Figure 1): Tropical Storm Nuri (2002) in June, Tropical Strom Sinlaku (2003) and Typhoon Higos (2007) in August, Tropical Storm Nangka (2016) and Typhoon Saudel (2017) in October.

The position errors of forecasts issued by the Hong Kong Observatory (HKO) for these five tropical cyclones are summarized in Table 1. The performance of tropical cyclone forecasts was generally satisfactory with the average errors within the "potential track area" (the probable area of tropical cyclone location with a probability above 70%).

In Hong Kong, Higos necessitated the issuance of the Increasing Gale or Storm Signal, No. 9, the first time since Super Typhoon Mangkhut (1822) hitting Hong Kong in 2018. Nangka necessitated the issuance of No.8 Gale or Storm Signal, while Nuri, Sinlaku and Saudel necessitated the issuance of No. 3 Strong Wind Signal.

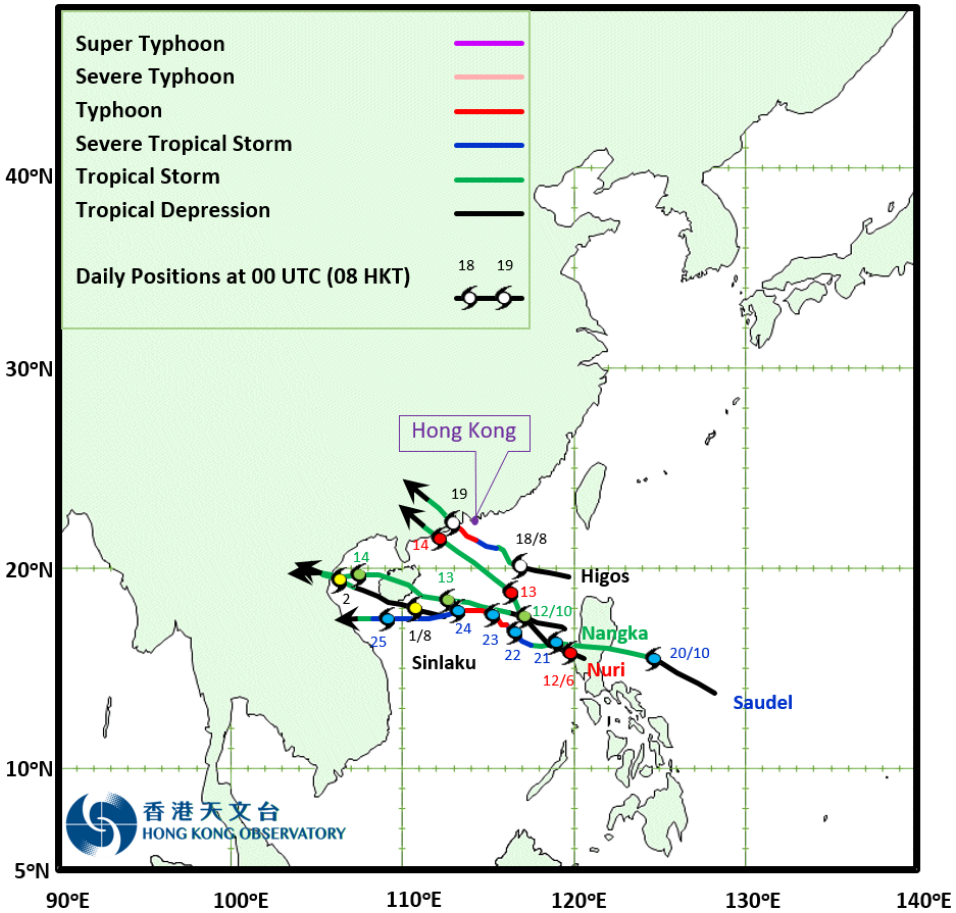

Figure 1 – Tracks of tropical cyclones that affected Hong Kong, China from 1 January to 31 October 2020.

	Position forecast error (km) (No. of cases)				
	24-hr	48-hr	72-hr	96-hr	120-hr
Nuri (2002)	23 (3)	72 (1)			
Sinlaku (2003)	71 (2)				
Higos (2007)	124 (2)				
Nangka (2016)	54 (5)	125 (3)	195 (1)		
Saudel (2017)	54 (11)	78 (9)	81 (7)	144 (5)	210 (3)

Table 1 Performance summary of track forecasts issued by HKO at 00 UTC and 12 UTC as verified against HKO's warning positions for the five tropical cyclones that affected Hong Kong, China from 1 January to 31 October 2020.

2. Hydrological Assessment (highlighting water-related issues/impact)

In terms of rainfall, Higos was the wettest tropical cyclone affecting Hong Kong by far in 2020. It brought more than 150 millimetres of rainfall to Hong Kong. About 70 millimetres of rainfall was generally recorded over Hong Kong during the passage of Sinlaku. The rainfall associated with Nuri, Nangka and Saudel was less than 30 millimetres.

3. Socio-Economic Assessment (highlighting socio-economic and DRR issues/impacts)

During the passage of Nuri, a person was tragically drowned in the rough seas while surfing in Lantau Island. A catamaran was overturned under rough sea conditions. 13 people on board fell into sea and were later rescued. One of them was injured.

During the passage of Sinlaku, incidents of blowing down objects were reported in many places. In Tsim Sha Tsui, two people were injured by a fallen tree while hoarding boards toppled by strong winds also caused one person injured and two vehicles damaged. A canopy in Kwun Tong and scaffolding in Tseung Kwan O collapsed under high winds. In Pok Fu Lam, some plastic fences were blown away and wounded a passer-by.

At least 7 people were injured in Hong Kong during the passage of Higos. There were more than 800 reports of fallen trees and 2 reports of flooding. Two campers were stranded in Tap Mun and had to be rescued by police officers. Private cars were damaged by a fallen tree in Shek Mun. Windows were broken in an apartment building in Tseung Kwan O. There were backflow of sea water in Tai O and reports of minor flooding in some areas. 14 flights were diverted from landing at the Hong Kong International Airport.

At least 3 people were injured in Hong Kong during the passage of Nangka. There were about 250 reports of fallen trees. Private cars were damaged by fallen trees in Sham Shui Po, Tsuen Wan and Yuen Long.

Saudel did not cause any significant damage in Hong Kong.

4. Regional Cooperation Assessment (highlighting regional cooperation success and challenges

The 52nd Session of the Typhoon Committee was originally scheduled to be held in Hong Kong in February 2020. In view of the development of the COVID-19 pandemic, the Committee decided to conduct the 52nd Session by means of two video conferences after consulted the Typhoon Committee Members. The HKO hosted the two video conferences on 6 March and 10 June 2020 respectively. This was the first time in the history of the Typhoon Committee to conduct its annual session via video conferences.

Over 120 meteorological, hydrological and disaster risk reduction experts in the Asia Pacific region from 12 out of the 14 Typhoon Committee Members joined these two video conferences. Dr. Cheng Cho-ming, the Director of the HKO, was elected as the Chairperson of the 52nd Session of the Typhoon Committee and presided at these two video conferences. The session reviewed achievements in the past session and discussed various Members' activities and operational and research collaborations in the Typhoon Committee region.

Figure 2 - Members participated in the first video conference for the 52nd Session of the Typhoon Committee held on 6 March 2020

II. Summary of Progress in Priorities supporting Key Result Areas

1. Collaborative tropical cyclone observations in EXOTICCA

2. Deployment of drifting buoys in the South China Sea and western North Pacific for tropical cyclone monitoring

3. New gauging stations in coastal areas of Hong Kong

4. Installation of anemometers on board of vessels travelling over local waters

5. Continuous development of the website of the Severe Weather Information Centre (SWIC 2.0) for Disaster Risk Reduction

6. New forecast products on the "Earth Weather" visualizing high-impact weather associated with tropical cyclones

7. Enhancement of tropical cyclone track probability forecast to cover wider geographical area

8. Advances in HKO's nowcasting support and research activities

9. Application of SWIRLS in just-in-time drainage inspection and clearance

10. Use of Chatbot for delivery of tropical cyclone information

11. Guidance on rapid intensification of tropical cyclones

12. PRobabilistic Inundation Map Evaluation System (PRIMES)

13. Mesoscale, high-resolution and probabilistic regional prediction systems for tropical cyclones

14. A new web-based Tropical Cyclone Information Processing System (TIPS)

15. Enhancing public awareness on typhoon hazards

1. Collaborative TC observations in EXOTICCA

Main text:

Under the Experiment on Typhoon Intensity Change in Coastal Area (EXOTICCA) project, the Shanghai Typhoon Institute (STI) of the China Meteorological Administration (CMA) and the Hong Kong Observatory (HKO) have been collaborating to conduct field campaign experiments on the tropical cyclones (TCs) over the South China Sea (SCS) since 2014. Intensive observations collected from new types of instruments provide indispensable data for better understanding of intensity and structures of TCs. During each TC season, HKO conducts air-reconnaissance and dropsonde observation missions within the Hong Kong Flight Information Region. The collected data are utilized to analyse intensity and structure of TCs (Figure 3) in near real-time basis for supporting forecast and warning operations in HKO; and the data have been shared with other Members to support related operational or research development activities.

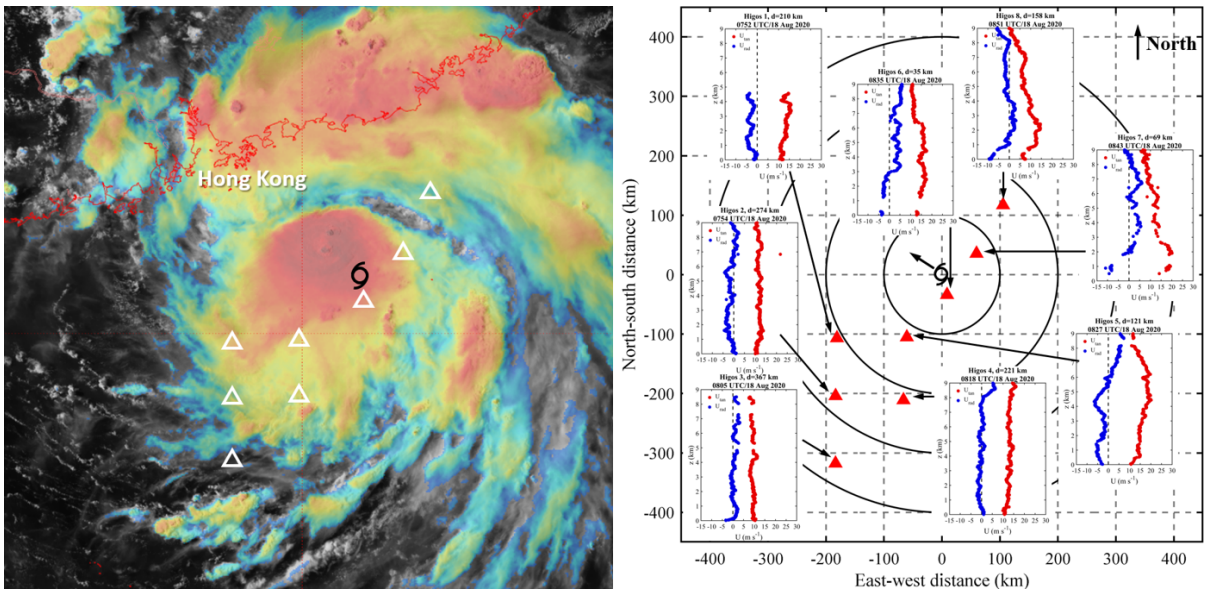

Figure 3 - Wind profiles (radial and tangential components in blue and red respectively) over tropical cyclone Higos collected from the aircraft dropsonde measurement system of HKO (locations of dropsonde marked in triangles) on 18 August 2020 during passage of Typhoon Higos.

On 12-14 October 2020, a multi-platform field campaign experiment for tropical cyclone Nangka was conducted by STI, Hainan Meteorological Bureau and their collaborating institutes. Advanced observation instruments including unmanned aerial vehicles (UAVs) (Figures 4 and 5), aircrafts, rocket dropsonde, small unmanned marine vessel, and wind lidar were deployed to collect meteorological elements such as profiles of wind, temperature, pressure, and humidity with very high temporal resolution for Nangka. Combining with rapid-scan data of CMA's FY4A satellite, it was the first-ever field campaign conducted in South China Sea that various types of observing platforms for TC reconnaissance and conducting measurements from ocean surface to atmosphere were utilized in a seamless integrated approach.

Figure 4 - Left: UAV (model TW328) measurement system developed by Sichuan Tengdun Technology and STI. Right: Flight track and wind observations collected by TW328.

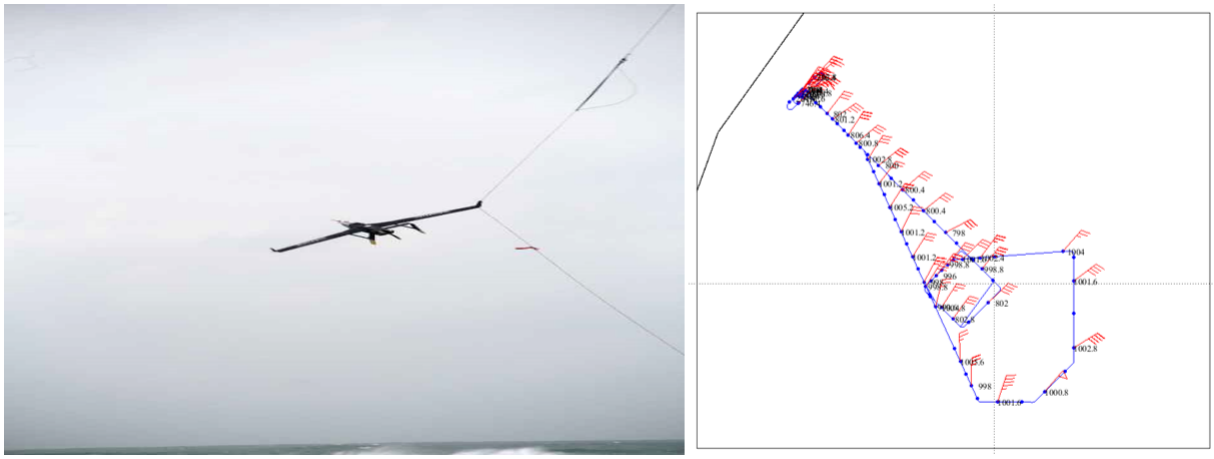
Figure 5 - Left: UAV (model HY30A) measurement system developed by Nanjing University of Aeronautics and Astronautics and STI. Right: Flight track and wind observations collected by HY30A.

Identified opportunities/challenges, if any, for further development or collaboration:

Collaborative field campaign experiments will be continued under EXOTICCA. The observation data will be utilized for the assessment of TC intensity and structure. They will also be shared with the Members for supporting research or demonstration projects to enhance analysis and forecast of TCs. They should benefit in the understanding of TC intensity and structure and improvement in NWP model forecast of high-impact weather such as heavy rain and high winds due to TCs for disasters risk reduction.

Priority Areas Addressed:

Integrated

- Enhance collaborative activities with other regional/international frameworks/organizations.

Meteorology

- Enhance the capacity to monitor and forecast typhoon activities particularly in intensity and structure change.

- Develop and enhance typhoon analysis and forecast technique from short- to long-term.
- Improve forecast of high-impact weather such as heavy rain and high winds associated with landfalling TCs for disasters risk reduction.
- Enhance, in cooperation with TRCG, training activities in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

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2. Deployment of drifting buoys in the South China Sea and western North Pacific for tropical cyclone monitoring

Main text:

HKO continued to deploy drifting buoys in 2020 to monitor tropical cyclone activities in the region. The deployment was arranged under the Barometer Upgrade Scheme of the Global Drifter Programme (GDP) of WMO-IOC Data Buoy Cooperation Panel (DBCP). Three drifting buoys were deployed in the South China Sea, and another two in the western North Pacific in July 2020 with the assistance of the Hong Kong voluntary observing ships (VOS) (Figure 6). Hourly observations of sea level pressure and sea surface temperature were collected and transmitted to HKO via satellites for onward dissemination on the GTS.

Based on past experience, operation of the drifters lasted one to two months only before they ran ashore or lost communication for various reasons. By the end of September 2020, only one drifter survived over the sea east of the Luzon Strait. Despite this, some of the buoys did capture valuable information during their lifetime from active tropical cyclones that formed and affected the region (Figures 7 and 8). In particular, Buoy "AMOHK21" (WMO ID: 5301656) off the South China coast came across Tropical Depression Sinlaku (2003) in early August and Typhoon Higos (2007) about two weeks later (Figure 9). Buoy "AMOHK24" (WMO ID: 5301659) to the east of Luzon also captured the low pressures associated with Super Typhoon Maysak (2009) in late August (Figure 10).

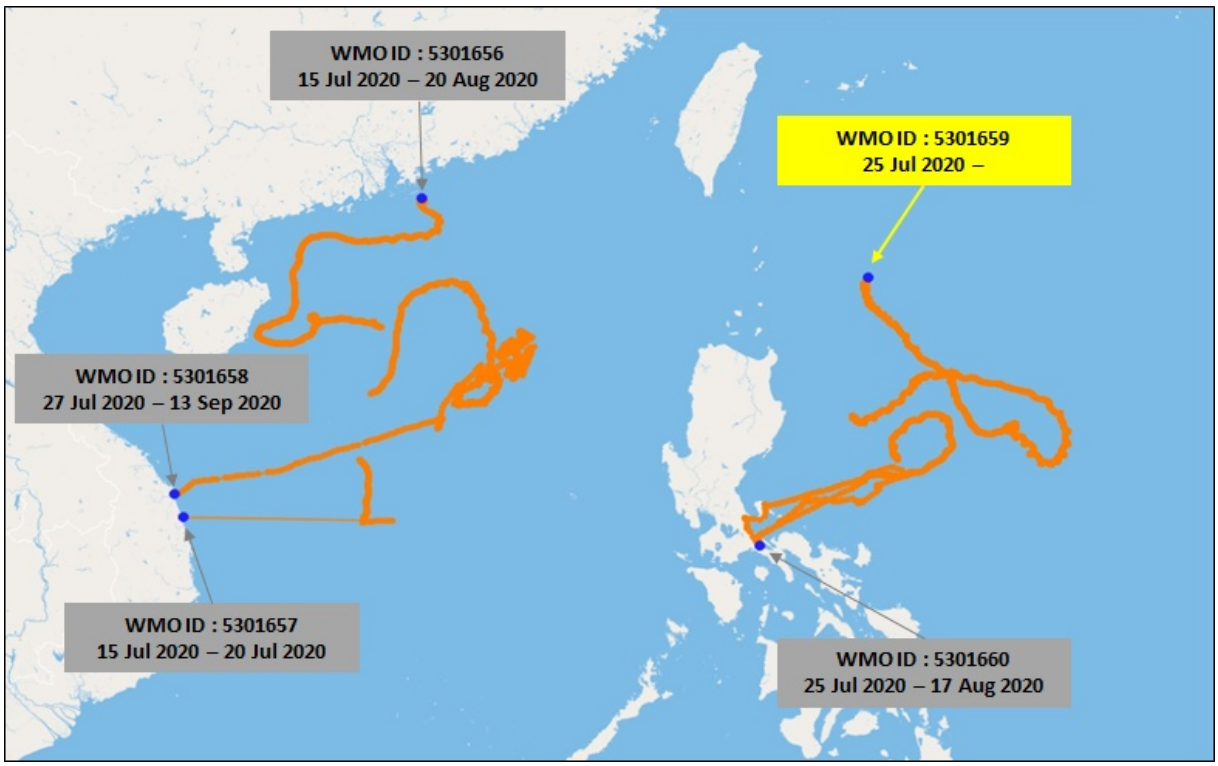

Figure 6 – Track of the five drifting buoys deployed over the region. The blue dots denote their latest reported position

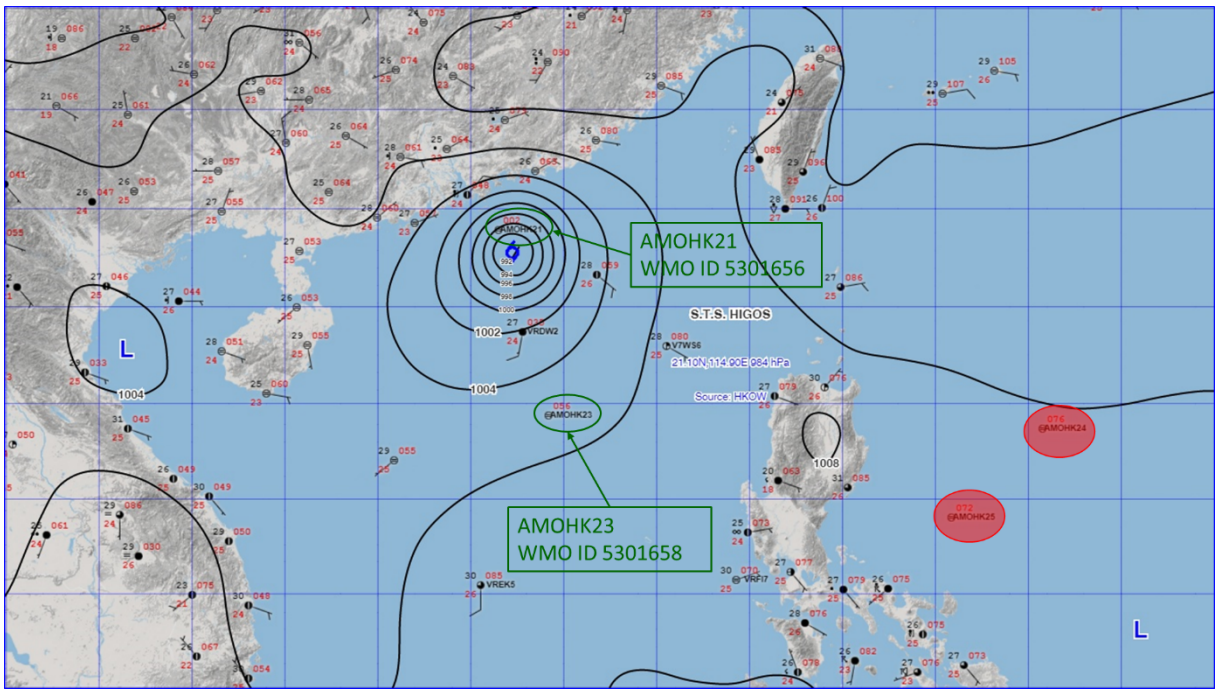

Figure 7 – Higos (2007) captured by Buoys "AMOHK21" and "AMOHK23" over the South China Sea at 12 UTC on 18 August 2020. The red-filled ellipses show the location of the other two drifters in operation.

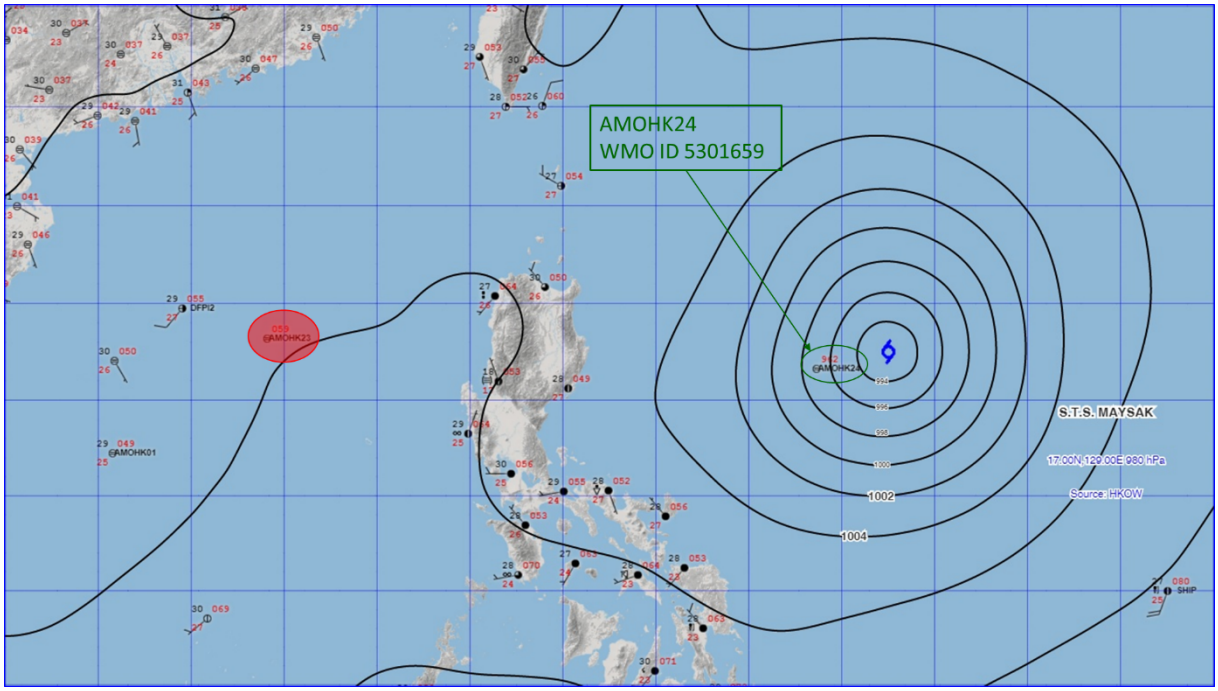

Figure 8 – Maysak (2007) captured by Buoys "AMOHK24" over the western North Pacific at 12 UTC on 29 August 2020. The red-filled ellipse shows the location of another drifter in operation over the South China Sea.

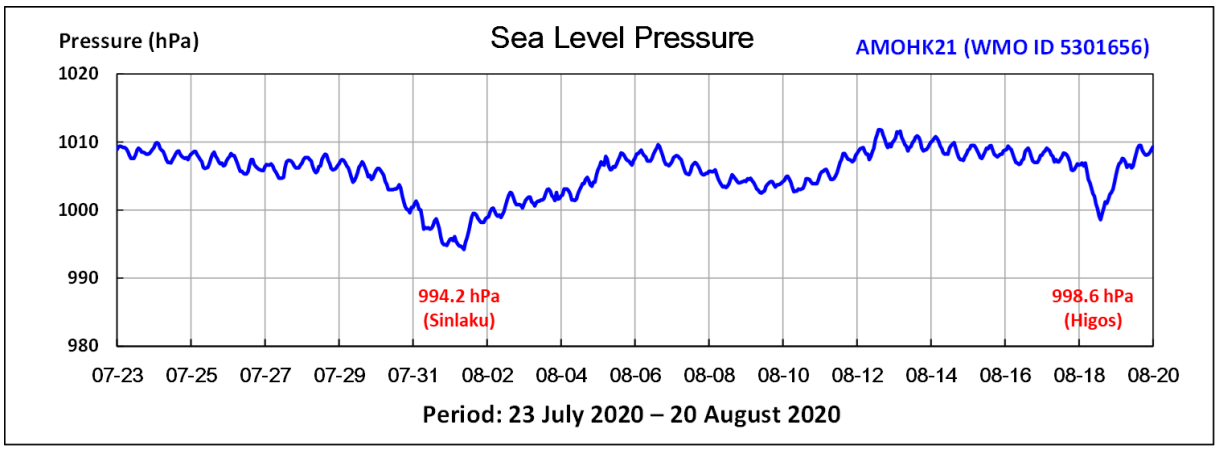

Figure 9 – Time series of pressure measurements by "AMOHK21" capturing the low pressures within the circulation of Sinlaku (2003) and Higos (2007)

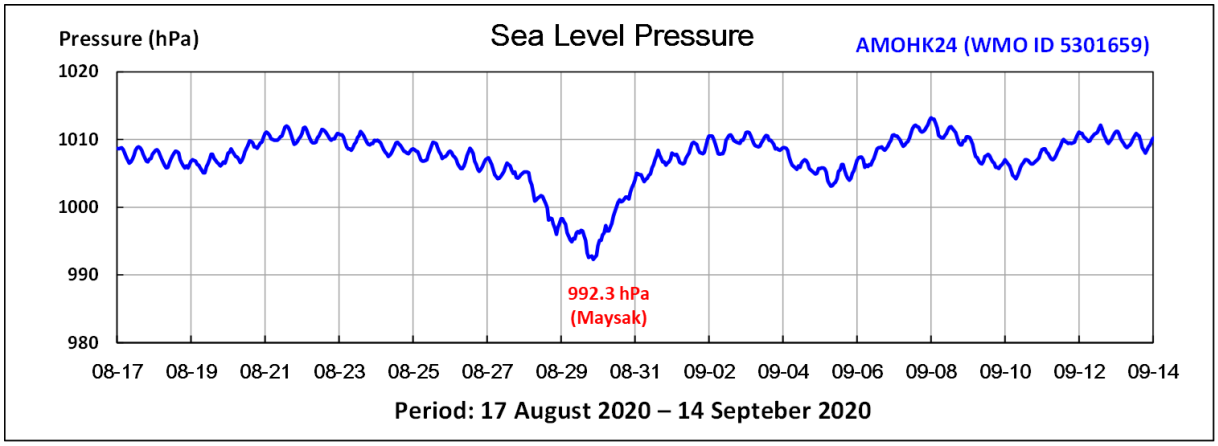

Figure 10 – Time series of pressure measurements by "AMOHK24" capturing the low pressures within the circulation of Maysak (2009)

Identified opportunities/challenges, if any, for further development or collaboration:

HKO will continue the deployment of drifting buoys in the South China Sea and western North Pacific in 2021, and will also arrange to install an automatic weather system onboard a voluntary observing ship to further enhance the marine meteorological observation.

Priority Areas Addressed:

Meteorology

- Enhance the capacity to monitor and forecast typhoon activities, particularly in genesis, intensity and structure change.
- Promote communication among typhoon operational forecast and research communities in Typhoon Committee region.

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3. New Gauging Stations in Coastal Areas of Hong Kong

Main text:

Based on situation during the passage of severe/super typhoon in recent years, HKO, in collaboration with Drainage Services Department (DSD), jointly spent efforts to install new gauging stations in coastal areas of Hong Kong to reduce the hazards brought by storm surge and overtopping wave.

Some coastal areas in Hong Kong are vulnerable to seawater flooding caused by extreme storm surges and/or huge overtopping waves. To tackle this challenge, DSD has installed new gauging stations for 18 locations in coastal areas, for example Heng Fa Chuen, Lei Yue Mun and Tai O. The new gauging stations comprise water level sensors, staff gauge and camera for real-time flood monitoring especially during adverse weather conditions. These measures allow online monitoring at designated locations so as to facilitate resources deployment in case the flood water at a particular location reaching the trigger level. It also enables early deployment of DSD's emergency teams to the flooding locations for carrying out flood alleviation work and provides supplementary information for HKO's daily operation and long-term tidal monitoring.

Taking the example of Tropical Cyclone Higos (2020), with the new gauging stations at Heng Fa Chuen, Tai O and Lei Yue Mun, more real time water level and site images were collected during the passage of Higos. With these real-time hydrometric data, the duty officers in Emergency Control Centre of DSD could quickly analyze the flooding situation and coordinate emergency services to minimize flooding impacts.

Identified opportunities/challenges, if any, for further development or collaboration:

To minimise the impact of tropical cyclones, it is important for various government departments to join hands to gear up capacity building in preparation, emergency response and recovery in addition to public education.

Priority Areas Addressed:

Integrated

- Enhance activities to develop impact-based forecasts and risk-based warning.

Hydrology

- Improve typhoon-related flood (including river flood, urban flood, flash flood and storm surge, etc. the same below) monitoring data collection, quality control, transmission and processing.

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4. Installation of anemometers on board of vessels travelling over local waters

Main text:

In order to enhance the capability of monitoring local winds during tropical cyclone situations, HKO started to install anemometers on board of vessels travelling over local waters since late 2018. So far two pilot boats and a small ferry were equipped with ultrasonic anemometers, providing real-time wind data to HKO Headquarters via 4G mobile network. For vessels of which the mounting mast may block the exposure, a dual-sensor set up will allow the choice of using data from the sensor which is more freely exposed. See Figure 11 which shows dual anemometers installed on board of a pilot boat.

Figure 11 – Dual ultrasonic anemometers were installed on board of a pilot boat travelling over local waters in Hong Kong.

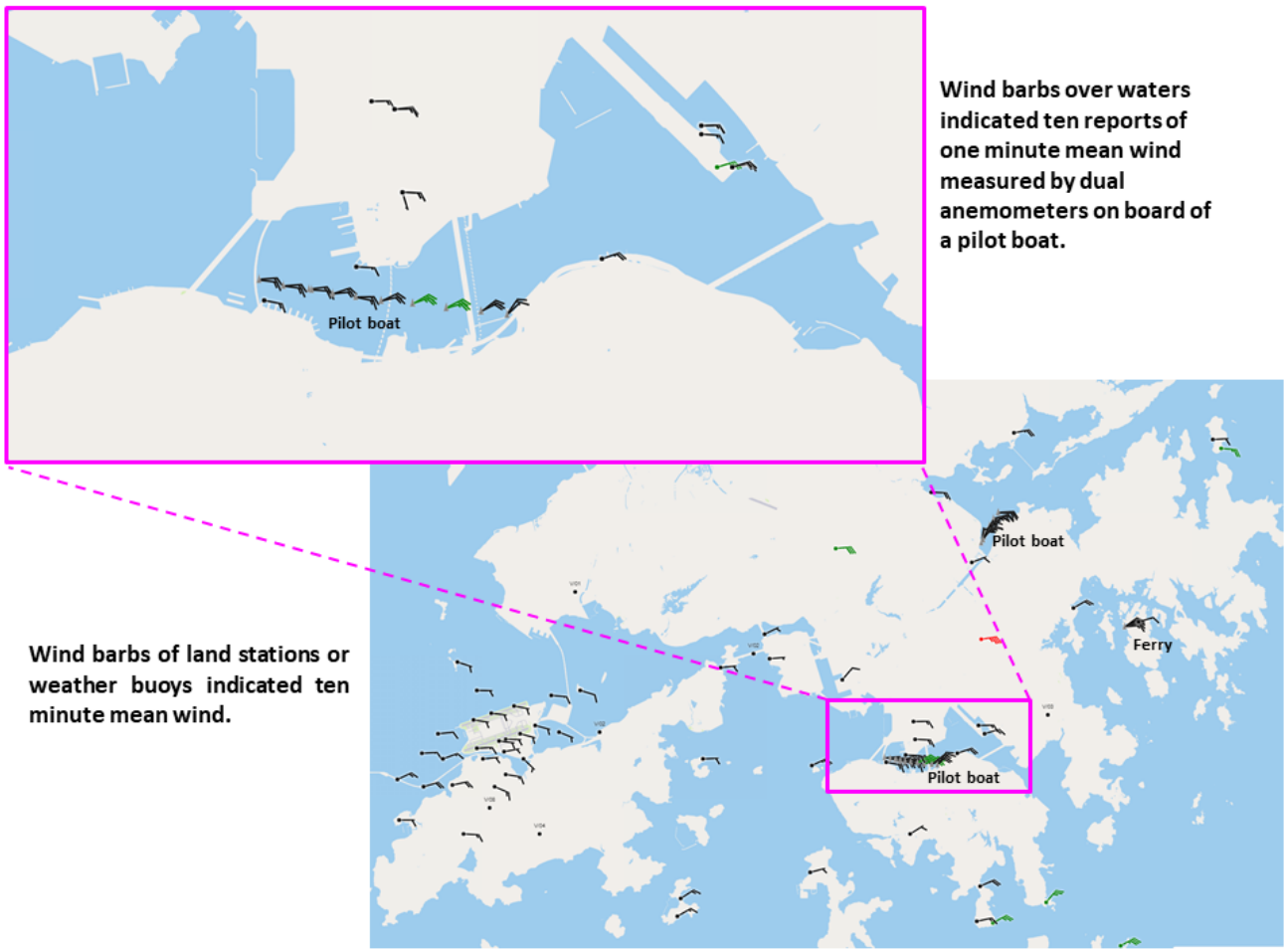

Figure 12 – Display of wind barbs showing (i) one minute mean winds measured by anemometer on board of vessels (longer averaging period is not used as the positions of vessel could be very different over a longer time); and (ii) ten minute mean winds measured by anemometer at land stations or weather buoys at round 16:30 local time on 18 August 2020, when Tropical Storm Higos was about 240 kilometres to the southeast of Hong Kong

Identified opportunities/challenges, if any, for further development or collaboration:

HKO plans to install anemometers on board of more vessels. In fact, an anemometer was installed on board of a vessel which travelled outside local waters to the South China Sea. However, real-time wind data could not be guaranteed owing to the lack of reliable communication link. In this regard, HKO is exploring the use of satellite communication system for real-time wind data transmission on board of vessels travelling over the South China Sea.

Priority Areas Addressed:

Meteorology

- Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.

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5. Continuous development of the website of the Severe Weather Information Centre (SWIC 2.0) for Disaster Risk Reduction

Main text:

In response to the WMO's initiative of the implementation of Global Multi-hazard Alert System (GMAS) framework as stipulated in Resolution 13 (Cg-18) to enhance disaster risk reduction in the global scale, HKO enhanced the WMO website of SWIC using technology of Geographical Information System (GIS) and adopting the latest WMO map. As in Sep 2020, 78 official data feeds of warnings and alerts from WMO Members in the format of Common Alerting Protocol (CAP) were incorporated into the SWIC 2.0 website, an increase of more than 20% from 2019. In addition, it also displays the tropical cyclone advisories and warnings from Regional Specialized Meteorological Centres, Tropical Cyclone Warning Centres, and National Meteorological Centres in the Typhoon Committee region in both map view and table view.

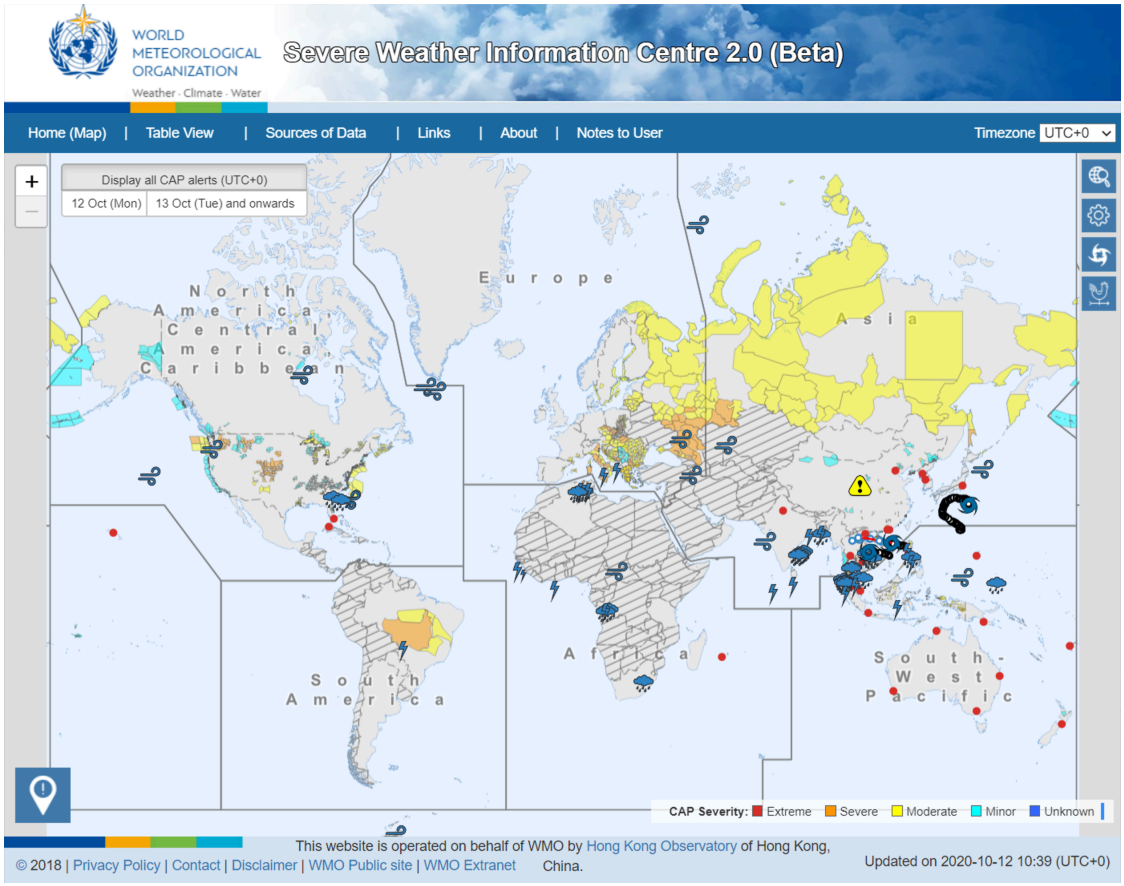

Figure 13 – SWIC 2.0 website

Identified opportunities/challenges, if any, for further development or collaboration:

1. Tropical cyclone advisories and warnings should be made available in machine readable format, e.g. XML, JSON, etc., to facilitate the use of official forecast and warnings by websites and online media.
2. The use of CAP format in dissemination of weather warnings and alerts from WMO Members should be further promoted.

Priority Areas Addressed:

Integrated

- Enhance activities to develop impact-based forecasts and risk-based warning.
- Enhance collaborative activities with other regional/international frameworks/organizations, including Typhoon Committee and Panel on Tropical Cyclone cooperation mechanism.

Meteorology

- Promote communication among typhoon operational forecast and research communities in Typhoon Committee region.
- Enhance RSMC capacity to provide regional guidance including storm surge, responding to Member's needs.

Hydrology

- Enhance capacity in flood risk (hazard, inundation) information, mapping and its application.

DRR

- Promote international cooperation of DRR implementation project.

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6. New forecast products on the "Earth Weather" visualizing high-impact weather associated with tropical cyclones

Main text:

Since the launch of "Earth Weather" webpage in 2019, a number of new forecast products were added to the webpage. New products related to high-impact weather associated with tropical cyclones include forecasts of wind gusts based on model outputs of ECMWF and prediction of waves, swell and peak wave periods based on HKO's wave model driven by wind forecasts of ECMWF. When tropical cyclone forecast track has been issued by HKO, the above products based on selected ECMWF EPS member most aligned with HKO's tropical cyclone forecast track instead of deterministic forecasts would be displayed on the webpage.

Furthermore, browsing experience was improved in a new version of the website rolled out in June 2020 with adoption of WebGL for graphic rendering and more advanced data processing techniques to reduce the volume of data to be downloaded by users.

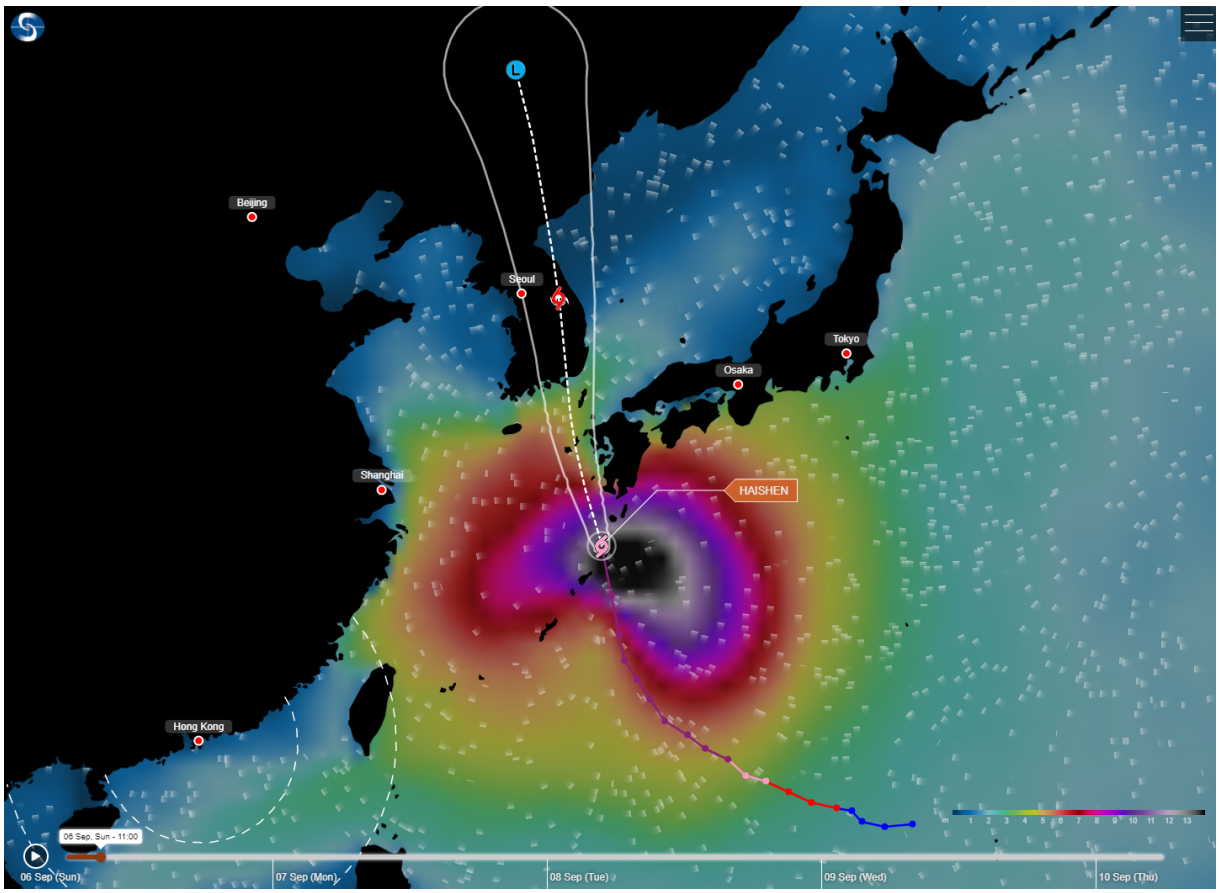

Figure 14 – Sample screenshot of "Earth Weather" webpage showing forecasts of significant wave height and direction with overlay of the forecast track of Tropical Cyclone Haishen on top.

Identified opportunities/challenges, if any, for further development or collaboration:

The content of the webpage would be further enriched, such as automatic city forecasts, for users to appreciate the changes in weather at major tourist destinations.

Priority Areas Addressed:

Meteorology

- Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.
- Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

Hydrology

- Enhance capacity in advanced technology (including satellite data, GIS, RS, QPE/QPF, ensemble, parallel computing) utilization in typhoon-related flood forecasting and early warning, and hydrological modelling.

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7. Enhancement of service on tropical cyclone track probability forecast to cover wider geographical area

Main text:

HKO launched the "Tropical Cyclone Track Probability Forecast" product in August 2017 to show the probability of tropical cyclone (TC) movement in the next nine days within HKO's area of responsibility (7-36°N, 100-140°E). In July 2020, this product has been enhanced to cover all named tropical cyclones in the western North Pacific up to 180°E. This enables members of the public to appraise the trend of TC movement and be better prepared.

The "Tropical Cyclone Track Probability Forecast" utilizes prognostic information extracted from several Ensemble Prediction Systems (EPSs) of global NWP models. The probability information in color represents the chance of the tropical cyclone coming within 120 kilometers of that location on the map in the coming nine days.

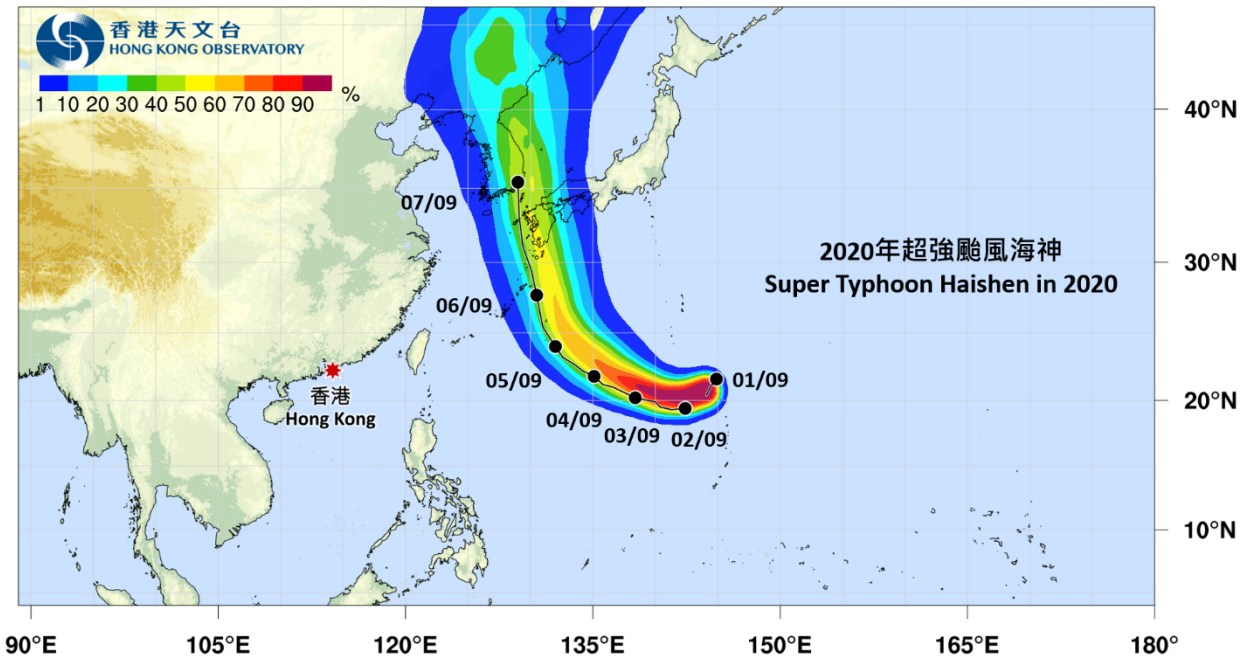

Figure 15 – Track probability forecast for Super Typhoon Haishen on 1 September 2020 with actual positions and tracks plotted in black dots and line.

Identified opportunities/challenges, if any, for further development or collaboration:

Regional collaboration on the development of probabilistic forecasts for tropical cyclone intensity and structure as well as the post-processing techniques of EPSs and NWP models will be explored.

Priority Areas Addressed:

Integrated

- Enhance activities to develop impact-based forecasts and risk-based warning.

Meteorology

- Develop and enhance TC analysis and forecast technique from short- to medium-range.

- Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

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8. Advances in HKO's Nowcasting Support and Research Activities

Main text:

Following WMO's designation of HKO as the Regional Specialized Meteorological Centre (RSMC) for Nowcasting in June 2018, a dedicated website has since been operating to provide real-time rainfall nowcast and significant convection products to NMHSs (https://rsmc.hko.gov.hk/) (Figure 16). Enhancements of nowcast products in the web portal are in the pipeline.

Com-SWIRLS has been progressively upgraded and close collaborations with NHMSs in southeast Asia are underway to enhance the nowcast techniques. Data exchange with the Viet Nam Meteorological and Hydrological Administration (VNMHA) and the Thai Meteorological Department (TMD) have been established. Quantitative Precipitation Forecasts (QPF) for the two countries has been developed with satisfactory performance. Several verification metrics such as fractions skill score (FSS) suggested that the performance of QPF is effective for different rainfall thresholds in the next couple of hours. Further tuning in QPF and enhancement of the tracking algorithm are underway to enhance the skill of rainfall nowcast over the regional domain for future deployment of nowcast product on RSMC website.

Figure 16 – Website of RSMC Hong Kong for Nowcasting

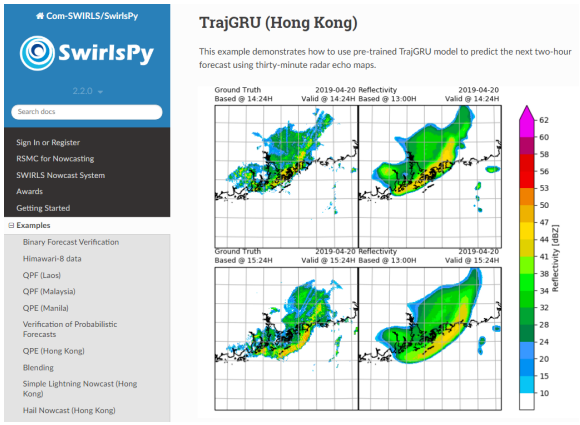

Figure 17 – Example of radar reflectivity nowcast using TrajGRU.

Additionally, the new version of Com-SWIRLS features a novel deep learning rainfall nowcast model known as TrajGRU (trajectory gated recurrent unit) that was jointly developed by HKO and the Hong Kong University of Science and Technology, and a training dataset named as HKO-7 to perform radar nowcasting (Figure 17). Other new features have been included in the software package such as blending of different sources of data such as satellite derived radar reflectivity and a GPU version of QPF. More details can be found in the website: https://com-swirls.org/.

Furthermore, a research project titled "Integrated Precipitation Estimator using Radar and Satellite (IPERS)" was conducted under Typhoon Committee Research Fellowship 2019.

Identified opportunities/challenges, if any, for further development or collaboration:

The RSMC for Nowcasting website provides real-time nowcast products for NMHSs. Support to interested NMHSs in implementing Com-SWIRLS will continue for capacity development on nowcasting techniques in the NMHSs of southeast Asia. It is envisaged that the newly established collaborative development platform of Com-SWIRLS will facilitate knowledge

exchange and nowcast techniques development more effectively. Training on nowcasting techniques and Com-SWIRLS will be organized through training attachments of other NMHSs. Further development on the predictability of the intensification and dissipation of rainstorms using deep learning method and to enhance quantitative precipitation estimation (QPE) and rainfall nowcast due to tropical cyclones and other significant convective weather processes will be pursued.

Priority Areas Addressed:

Integrated

- Enhance activities to develop impact-based forecasts and risk-based warning.
- Enhance collaborative activities with other regional / international frameworks/organizations, including Typhoon Committee and Panel on Tropical Cyclone cooperation mechanism.

Meteorology

- Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.
- Enhance, in cooperation with TRCG, training activities in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

Hydrology

- Enhance capacity in impact-based and community-based operational flood forecasting and early warning, including methodology research, hydrological modelling, and operation system development.
- Enhance capacity in advanced technology (including satellite data, GIS, RS, QPE/QPF, ensemble, parallel computing) utilization in typhoon-related flood forecasting and early warning, and hydrological modelling.

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9. Application of SWIRLS in Just-in-time Drainage Inspection & Clearance

Main text:

With the aid of tailor-made products from HKO's SWIRLS rainfall now-casting system, Drainage Services Department (DSD) introduced the "just-in-time clearance" arrangement in rainy season 2020 in order to reduce the flood risks during rainstorms by prompt drainage inspection and clearance.

Before the onset of a rainstorm, DSD staff will be deployed to inspect about 200 locations which are susceptible to blockage by litter, fallen leaves or the like, and will immediately arrange for clearance works if necessary. Furthermore, they will inspect and clear all main drains and rivers immediately after a rainstorm or when a typhoon signal is about to be lowered to prepare for the challenges of further rainstorms.

Over 200 flooding cases between 2017 and 2019 have been analysed, and it is found that over 60 per cent of them were due to blocked drains by litter, fallen leaves or other washouts carried by surface runoff. The "just-in-time clearance" arrangement is definitely an appropriate solution.

Identified opportunities/challenges, if any, for further development or collaboration:

HKO will continue to provide real-time nowcast products and other relevant support to DSD for implementing the "just-in-time clearance" initiative. It is envisaged that the newly established collaborative development in further reducing the flood risk will facilitate impact-based forecast and risk-based warning effectively. Further enhancement of SWIRLS would be pursued to support drainage inspection and clearance in order to further reduce the flood risk, particularly during tropical cyclone situations.

Priority Areas Addressed:

Integrated

- Enhance activities to develop impact-based forecasts and risk-based warning.

Hydrology

- Enhance capacity in impact-based and community-based operational flood forecasting and early warning, including methodology research, hydrological modelling, and operation system development.

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10. Use of Chatbot for Delivery of Tropical Cyclone Information

Main text:

To enable users to gain access to weather information including tropical cyclone warnings and related information quickly and easily, HKO launched a pilot Chatbot service, branded as HKO's mascot Dr. Tin, on its mobile app and Facebook page.

The Chatbot adopts artificial intelligence technology to understand user's questions in its natural language processing module and then responds by way text-based dialogues in English and local languages. It supports enquiries on local weather conditions, forecast, warnings, tides, local standard time, as well as weather forecast, sunrise and sunset times of major cities worldwide. In particular, users may acquire the tropical cyclone forecast track, local tropical cyclone signals, latest storm news, as well as precautions to take through the chatbot directly.

The pilot Chatbot service enables interaction with users in direct and natural ways without additional manpower. Owing to overwhelming response, it is planned to integrate the Chatbot service on HKO's website to provide additional channel for access of the service.

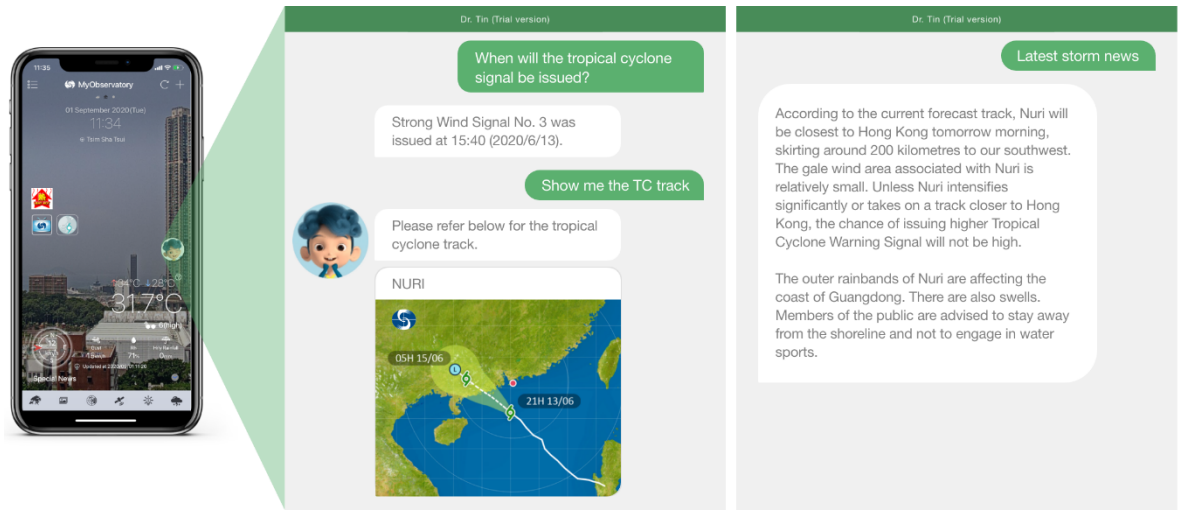

Figure 18 – Sample screen of HKO's Chatbot responding to questions about tropical cyclone

Identified opportunities/challenges, if any, for further development or collaboration:

The Chatbot will also be enhanced to answer more questions of users' concerns especially during hazard situations like tropical cyclone through the study of the record of dialogue to understand areas of improvement of the chatbot.

Priority Areas Addressed:

DRR

- Enhance Members' disaster reduction techniques and management strategies.

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11. Guidance on rapid intensification of tropical cyclone

Main text:

In recent years, a tropical cyclone rapid intensification (RI) forecast guidance, namely "TINT-RI", has been put into operational trial by HKO to assist forecasters in assessing chance of RI of tropical cyclones over the western North Pacific and the South China Sea. Several predictors including the Tropical Cyclone Heat Potential (TCHP) of the National Oceanic and Atmospheric Administration (NOAA), sea surface temperature (SST) and SST-anomaly (SSTA) as well as upper level divergence, relative humidity and vertical wind shear from the ECMWF deterministic model forecasts are utilized to predict the probability of RI within the next 12, 24, 36 and 48 hours. The probability is classified into 3 categories (very likely, likely and nil) for forecasters' reference. TINT-RI successfully indicated possibilities of RI in several TC cases in 2020 such as Higo (Figure 19), Maysak and Haishen.

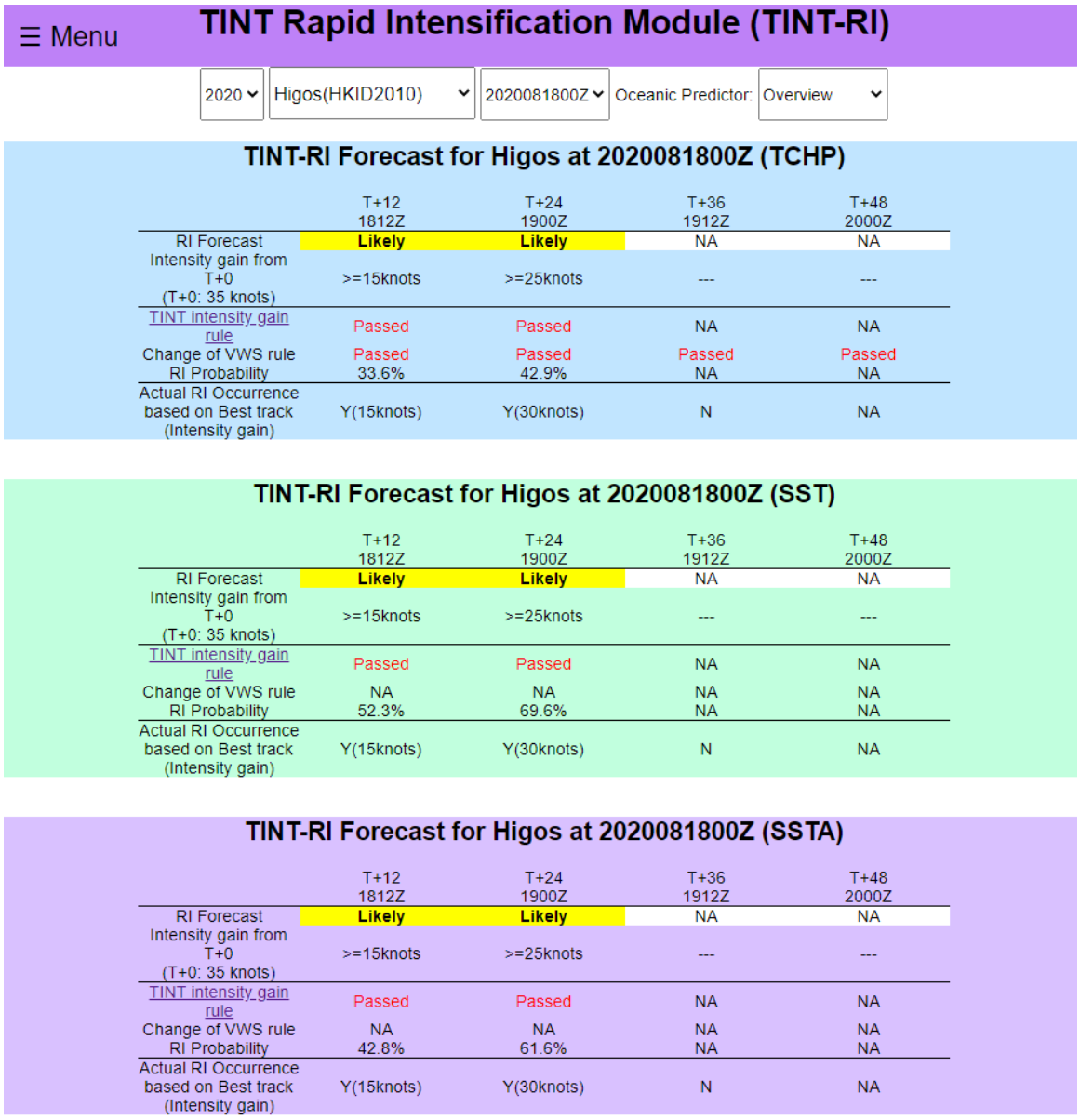

Figure 19 – Rapid intensification forecasts for tropical cyclone Higos at 00Z on 18 August 2020.

Identified opportunities/challenges, if any, for further development or collaboration:

Research studies on tropical cyclone intensity forecast using output from ECMWF Ensemble Prediction System (EPS) with gradient boosting algorithm to extract features from the EPS to enhance forecast performance and extend the forecast range are underway. Other machine learning techniques to enhance precipitation forecast due to landfall TCs are also being pursued.

Priority Areas Addressed:

Meteorology

- Develop and enhance TC analysis and forecast technique from short- to medium-range.
- Enhance and provide tropical cyclone intensity guidance based on NWP models, EPSs, AI/machine learning techniques, together with inputs from observation data or analysis products such as TCHP and SST.

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12. PRobabilistic Inundation Map Evaluation System (PRIMES)

Main text:

A new PRobabilistic Inundation Map Evaluation System (PRIMES) for storm surge prediction was developed and implemented for operational trial in HKO during the tropical cyclone season of 2020. Based on the historical error of the cross track, along track and central pressure of the deterministic tropical cyclone warning tracks issued by HKO, the system generates for each run over 300 hypothetical tropical tracks and the associated storm surge forecasts with the operational storm surge model SLOSH (Figure 20). The probabilities of possible storm surge scenarios for Hong Kong are then computed, along with various inundation risk assessment products including ensemble time-series plot of the predicted sea levels, probability map and exceedance map of the peak sea level, as well as the forecast inundation maps for different regions in the territory.

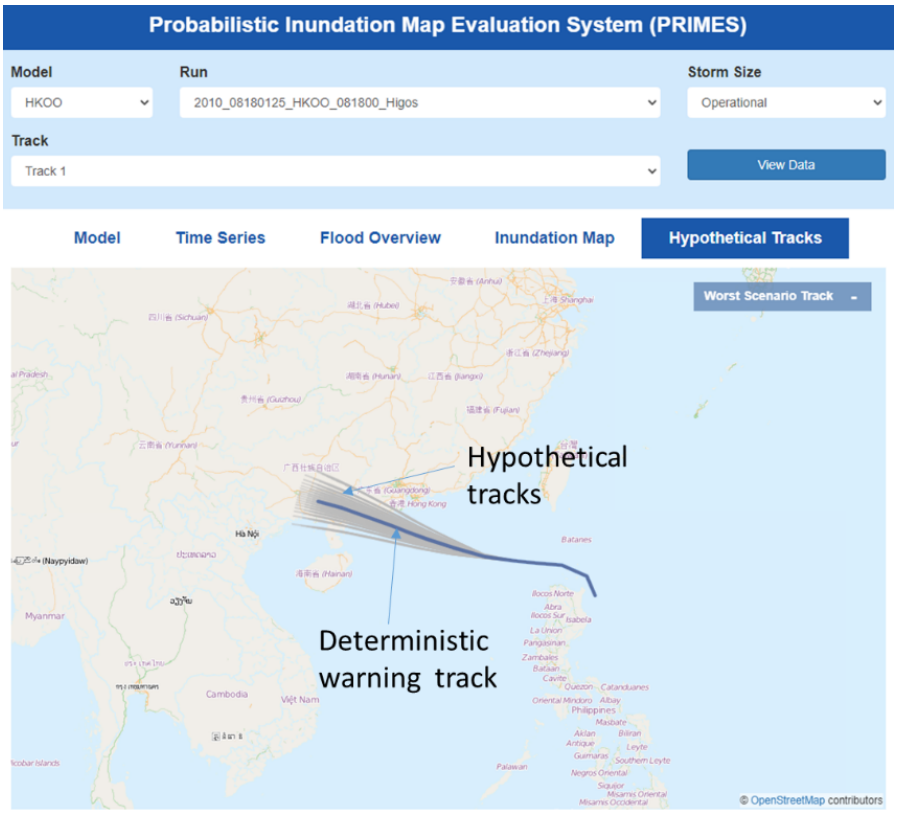

Figure 20 – Hypothetical tropical cyclone tracks generated on PRIMES

The usefulness of PRIMES was amply demonstrated during the passage of Typhoon Higos (2007) on 19 August 2020. Figures 21 and 22 showed the probability map of peak sea level over 3 metres (above Chart Datum) from PRIMES based on the 00Z and 12Z warning tracks of 18 August 2020 respectively. The highest sea levels observed on 19 August 2020 as shown in Figure 23 indicated that the results output from PRIMES were generally in good agreement with the actual outcome. The information provided by PRIMES proved to be useful and timely for assisting the HKO forecasters in assessing the risk of storm surge inundation in Hong Kong.

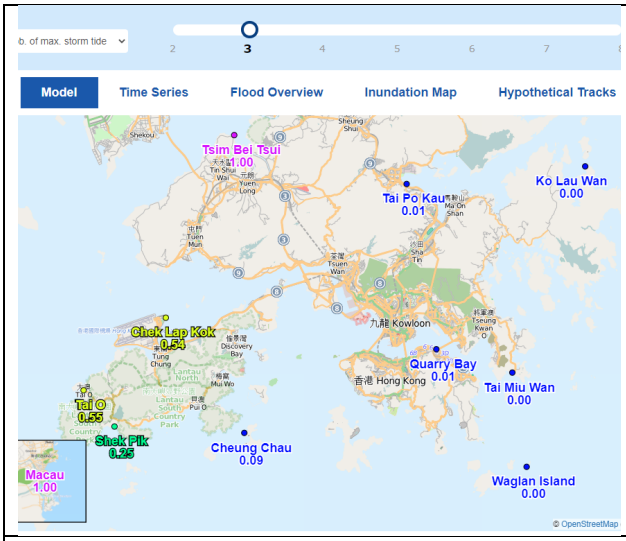

Figure 21 : Probability map of peak sea level reaching 3 metres based on warning track of 00Z, 18 Aug 2020

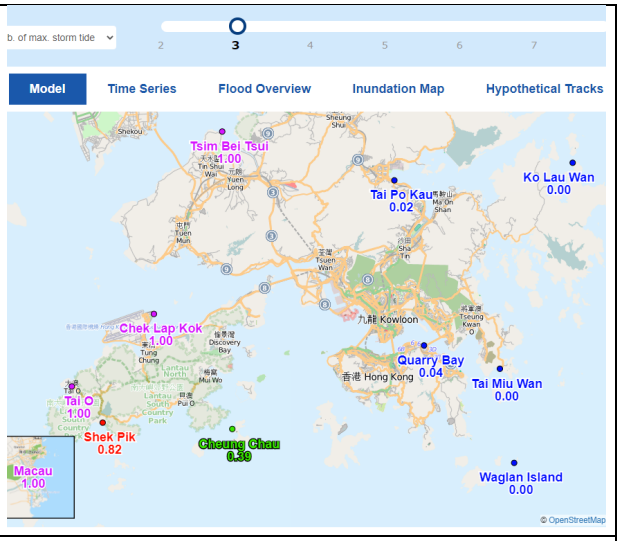

Figure 22 : Same as Figure 21, but for 12Z, 18 Aug 2020

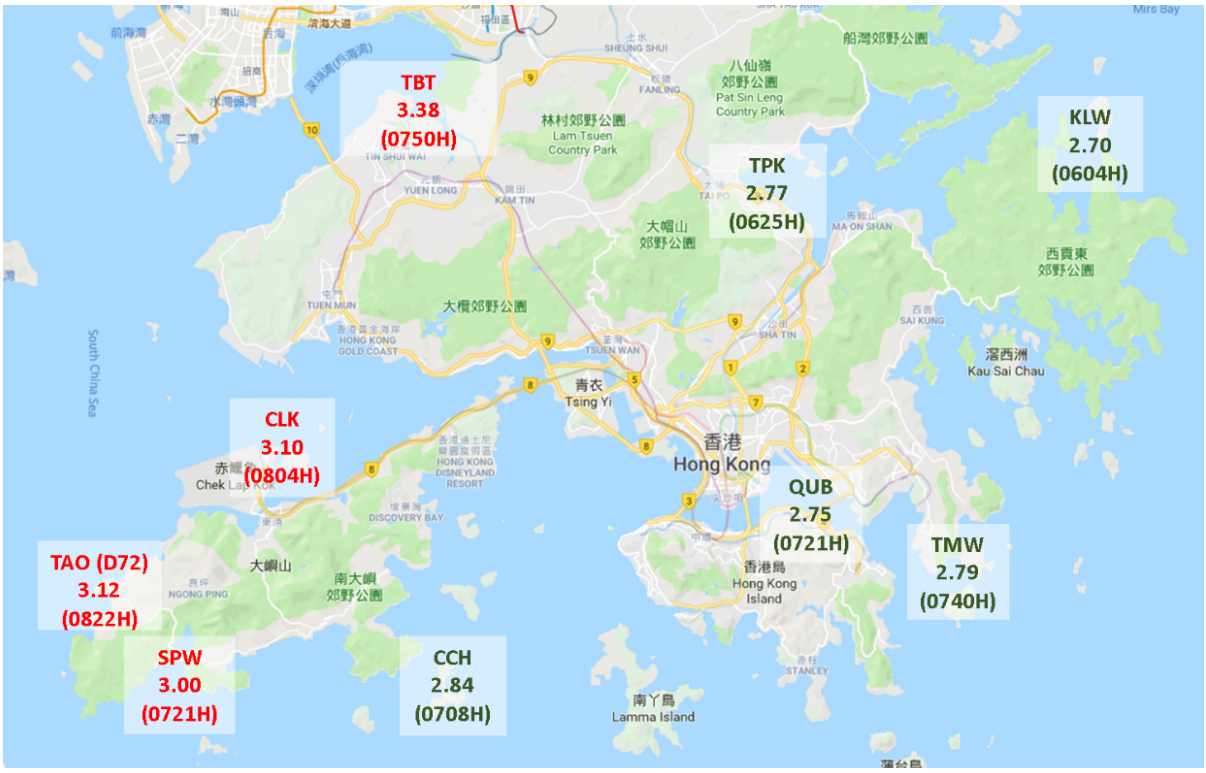

Figure 23 – Peak sea levels observed during the passage of Typhoon Higos

Identified opportunities/challenges, if any, for further development or collaboration:

HKO plans to further enhance the PRIMES by ingesting the EPS forecast tracks to incorporate flow-dependent uncertainty estimates in the prediction.

Priority Areas Addressed:

Integrated

- Enhance activities to develop impact-based forecasts and risk-based warning.

Meteorology

- Develop and enhance typhoon analysis and forecast technique from short- to long-term.
- Strengthen the cooperation with WGH and WGDRR to develop impact-based forecast and risk-based warning.

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13. Mesoscale, high-resolution and probabilistic regional prediction systems for tropical cyclones

Main text:

HKO operates a mesoscale numerical weather prediction suite, the Atmospheric Integrated Rapid-cycle (AIR) forecast system based on the Non-hydrostatic Model to provide forecasts over East Asia and the western North Pacific at 10-km resolution up to 72 hours ahead (Meso-NHM), as well as over southern China and the northern part of the South China Sea at 2-km resolution up to 15 hours ahead (RAPIDS-NHM). In addition, the 200-m resolution Aviation Model (AVM) provides hourly-updated urban-scale forecasts over Hong Kong as well as aviation-specific products for the Hong Kong International Airport (HKIA).

In support of regional prediction of aviation-impact weather under the Asian Aviation Meteorological Centre (AAMC) initiative, the AAMC-WRF, an extended-domain prediction system covering (20^0S – 60^0N, 45^0E – 160^0E) continues to provide forecast guidance in a real-time manner. Furthermore, a 10-km, 20-member experimental Mesoscale EPS (MEPS) supports probabilistic assessment of high-impact weather (Figure 24).

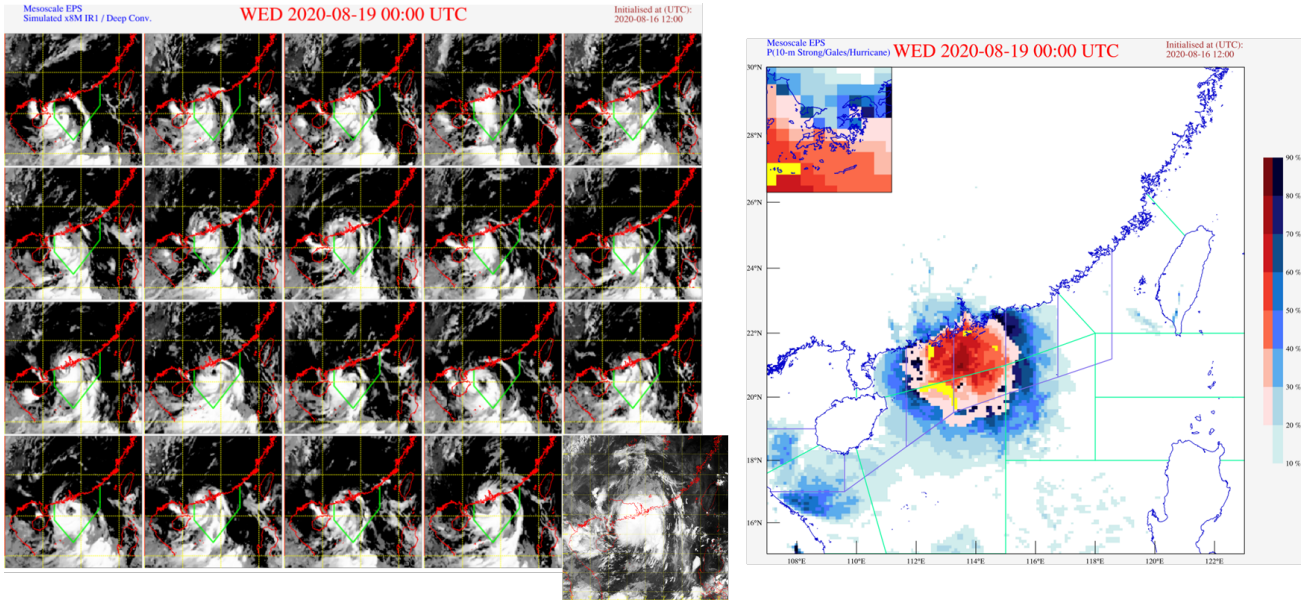

Figure 24 – Stamp map (left) of simulated satellite imagery by the MEPS of HKO during the passage of Higos (actual satellite observations shown in lower right) in the morning of 19 August 2020. The corresponding wind product by the MEPS (right) indicated a high chance of gales (red pixels), and also the possibility of hurricane-force winds (yellow pixels) to the southwest of Hong Kong.

Identified opportunities/challenges, if any, for further development or collaboration:

Research and development of advanced assimilation techniques, including ensemble-based methods for regional radar composites and new-generation satellite observations, would continue. Moreover, regional exchange of model output products would be explored with a view to fostering closer collaboration.

Priority Areas Addressed:

Integrated
- Enhance activities to develop impact-based forecasts and risk-based warning.

Meteorology
- Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.
- Develop and enhance typhoon analysis and forecast technique from short- to long-term.
- Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

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14. A new web-based Tropical Cyclone Information Processing System (TIPS)

Main text:

In 2001, HKO developed a prototype TIPS (standalone application) to automate the plotting of satellite/radar fixes, observed and predicted tropical cyclone positions and tracks, as well as to calculate ensemble forecast tracks, etc. With continuous improvement over the years, TIPS has become an indispensable decision support tool for tropical cyclone forecast and warning operations at HKO.

A new, web-based version of TIPS has been under active development at HKO with a view to handling an ever-increasing amount of observation and forecast information while improving performance and efficiency. The first phase of the new TIPS was rolled out in the typhoon season of 2020, it allows users to overlay real-time observations, including wind observations, satellite imageries etc., together with latest and past tropical cyclone forecast tracks from NWP models and warning centres. Tracks of more NWP models, e.g. from KMA and DWD have also been made available for forecasters' reference. Furthermore, the new TIPS also offers greater flexibility for forecasters to create NWP model ensemble tracks, such as the incorporation of NWP model tracks for different model initial time.

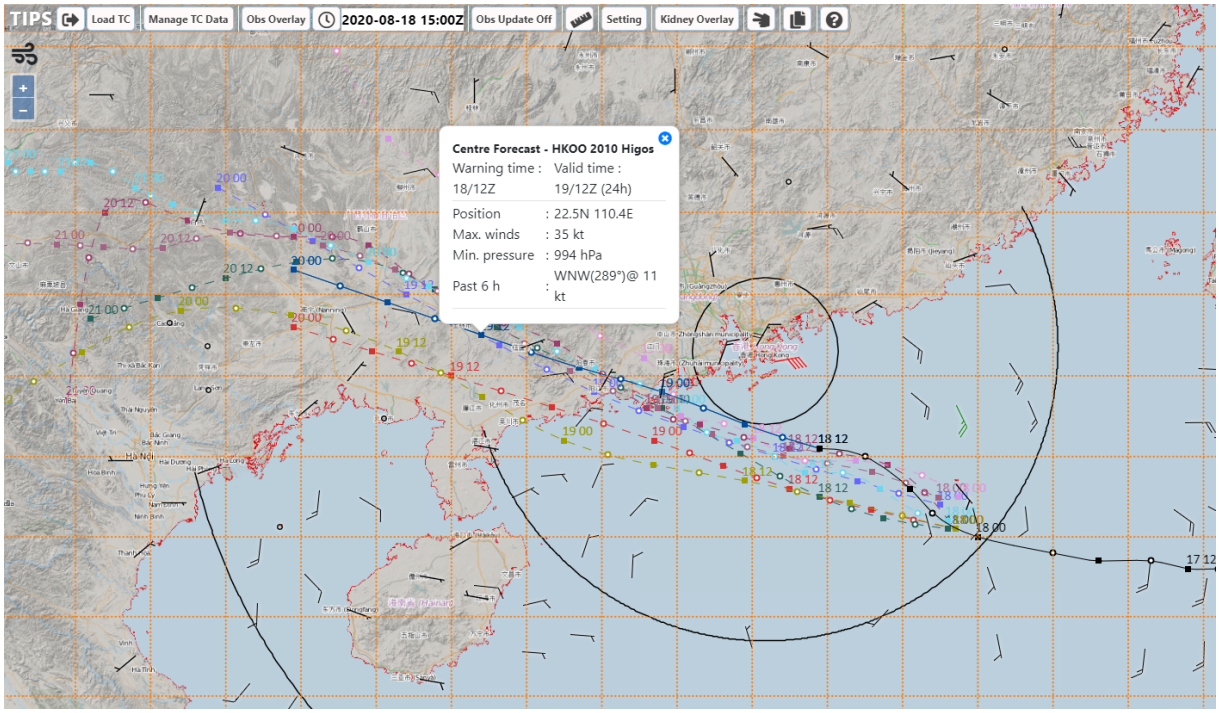

Figure 25 – Sample screenshot of new web-based version of TIPS showing wind observations during the passage of Tropical Cyclone Higos with overlay of the forecast tracks from various NWP models and warning centres.

Identified opportunities/challenges, if any, for further development or collaboration:

More display and analysis functionalities for the new TIPS will be developed to support tropical cyclone forecast and warning operations.

Priority Areas Addressed:

Meteorology

- Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.
- Develop and enhance typhoon analysis and forecast technique from short- to long-term.
- Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.

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15. Enhancing public awareness on typhoon hazards

Main text:

HKO has always been committed to utilise various channels to enhance public communication and raise public awareness on typhoon hazards. Its official Facebook (FB) page and Instagram (IG) platforms, launched in March 2018, continued to gain popularity with over 226,000 followers on FB and over 34,000 followers on IG. A new set of TV and radio Announcements in the Public Interest (API) on storm surge threats was launched in November 2019, which adopted a combination of cartoon animation and live action in its production (Figure 26). In 2020, HKO also produced other educational videos on typhoon-related topics, as well as the hazards and precautions (Figure 27). The videos were broadcasted on local TV stations as well as HKO's social media platforms.

Moreover, HKO has been participating as a collaborating partner in the COPE project, an international collaborative effort involving the Hong Kong Jockey Club Disaster Preparedness and Response Institute, the United Nations Office for Disaster Risk Reduction and the World Meteorological Organization, in the production of the COPE Disaster Book Series to increase disaster resilience of children. In 2020, two children's books respectively on "Cyclones" and "Storm Surge" have been published. The "Storm Surge" book is also based on the story of Super Typhoon Mangkhut striking Hong Kong in 2018.

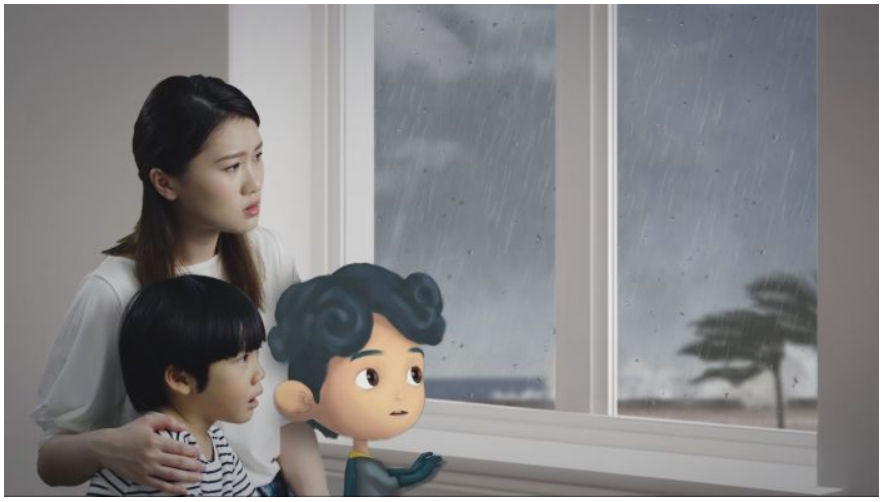

Figure 26 – TV Announcement in the Public Interest (API) on storm surge threats.

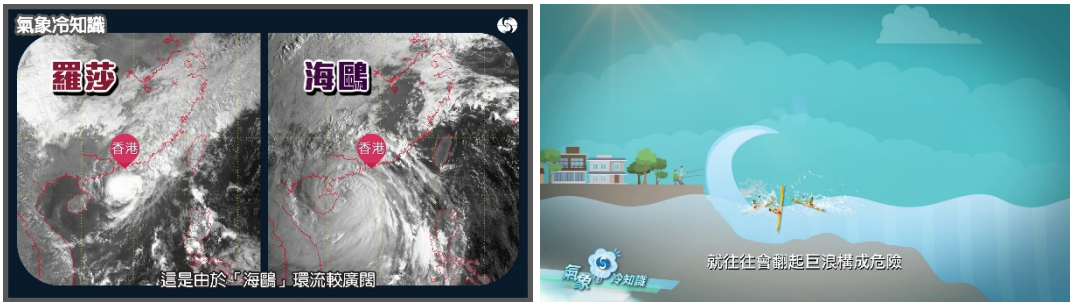

Figure 27 – Educational videos on typhoon-related topics, including the hazards and precautions

Figure 28 - The COPE book on "Storm Surge" is based on the story of Super Typhoon Mangkhut striking Hong Kong in 2018.

Identified opportunities/challenges, if any, for further development or collaboration:

HKO will continue to produce videos and social media posts to remind public on typhoon-related hazards. Collaboration opportunity with local institutes/organisations in developing new initiatives to enhance public awareness on typhoon-related hazards will also further be explored.

Priority Areas Addressed:

DRR

- Share experience/know-how of DRR activities including legal and policy framework, community-based DRR activities, methodology to collect disaster-related information.
- Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.

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Appendix I - Priority Areas of Working Groups

WG	Priorities
Integrated	1. Enhance activities to develop impact-based forecasts and risk-based warning.
	2. Strengthen cross-cutting activities among working groups in the Committee.
	3. Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism.
Met	4. Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.
	5. Develop and enhance typhoon analysis and forecast technique from short- to long-term.
	6. Enhance and provide typhoon forecast guidance based on NWP including ensembles and weather radar related products, such as QPE/QPF.
	7. Promote communication among typhoon operational forecast and research communities in Typhoon Committee region.
	8. Strengthen the cooperation with WGH and WGDRR to develop impact-based forecast and risk-based warning.
	9. Enhance, in cooperation with TRCG, training activities in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.
	10. Enhance RSMC capacity to provide regional guidance including storm surge, responding to Member's needs.
Hydrology	11. Improve typhoon-related flood (including river flood, urban flood, mountainous flood, flash flood and storm surge, etc. the same below) monitoring data collection, quality control, transmission and processing.
	12. Enhance capacity in typhoon-related flood risk management (including dam operation), integrated water resources management and flood-water utilization.
	13. Enhance capacity in impact-based and community-based operational flood forecasting and early warning, including methodology research, hydrological modelling, and operation system development.
	14. Enhance capacity in flood risk (hazard, inundation) information, mapping and its application.
	15. Enhance capacity in assessment and dealing with the impacts of climate change, urbanization and other human activities on typhoon-related flood disaster vulnerability and water resources availability.
	16. Enhance capacity in advanced technology (including satellite data, GIS, RS, QPE/QPF, ensemble, parallel computing) utilization in

	typhoon-related flood forecasting and early warning, and hydrological modelling.
DRR	17. Provide reliable statistics of mortality and direct disaster economic loss caused by typhoon-related disasters for monitoring the targets of the Typhoon Committee.
	18. Enhance Members' disaster reduction techniques and management strategies.
	19. Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.
	20. Promote international cooperation of DRR implementation project.
	21. Share experience/know-how of DRR activities including legal and policy framework, community-based DRR activities, methodology to collect disaster-related information.