MEMBER REPORT [Republic of Korea]

ESCAP/WMO Typhoon Committee
15th Integrated Workshop
Video Conference, Vietnam
1 – 2 December 2020

CONTENTS

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

1. Meteorological Assessment (highlighting forecasting issues/impacts)

Twenty two typhoons have occurred by November 26, 2020 in the western North Pacific basin. The number of typhoons in 2020 was below normal compared to the 30-year (1981−2010) average number of occurrences (25.6). Four out of twenty two typhoons, including JANGMI (2005), BAVI (2008), MAYSAK (2009), HAISHEN (2010), have influenced the Korean Peninsula from August to September; JANGMI (2005), MAYSAK (2009), and HAISHEN (2010) made landfall on the Korean Peninsula. The tracks of the typhoons affecting the Peninsula are presented in Fig. I-1.

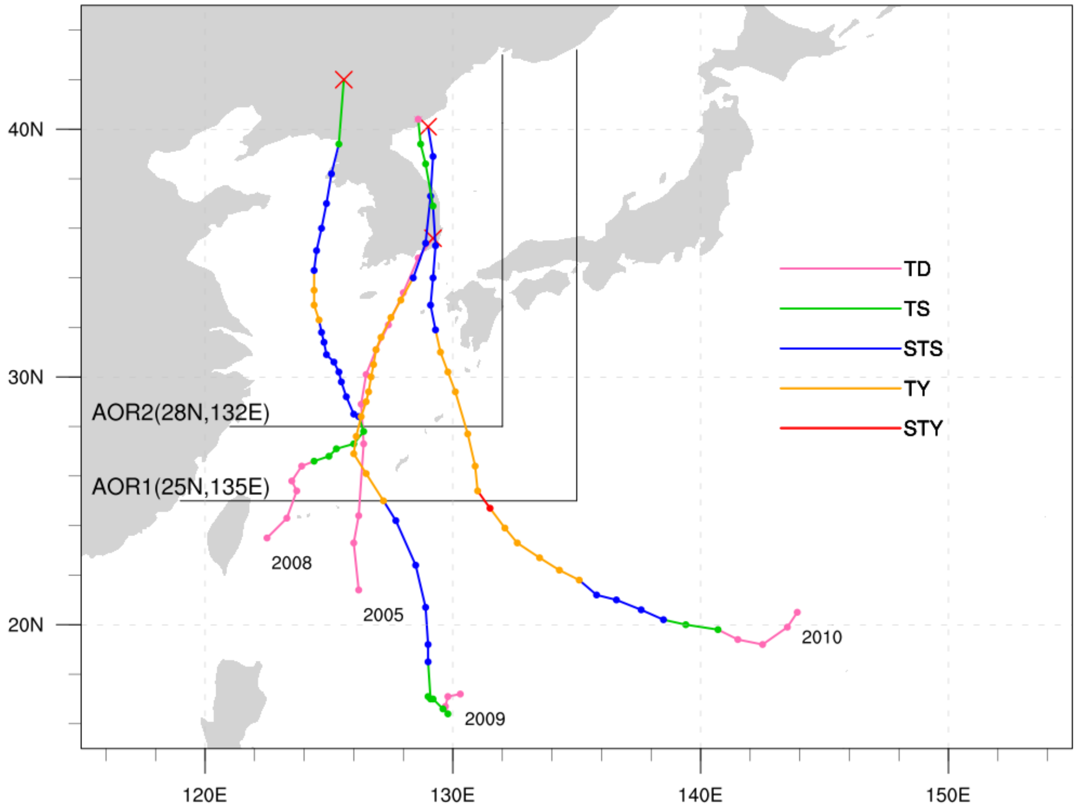


Fig. I-1. TC tracks that affected the Korean Peninsula in 2020

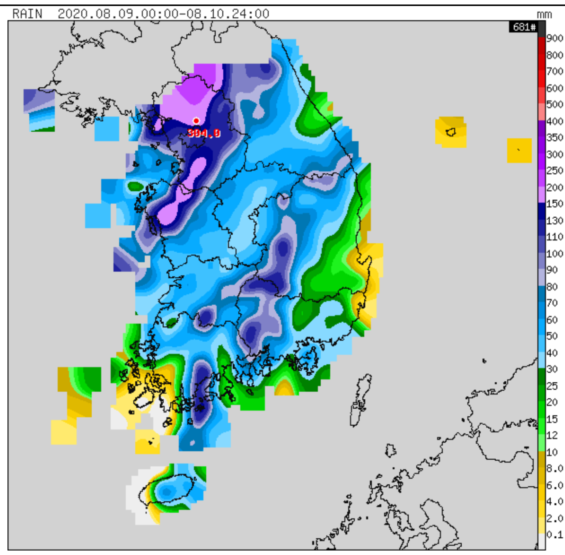
JANGMI (2005) made landfall south of Geojedo in the southeastern part of Tongyeong on August 10. It then downgraded into a tropical depression in the west-northwest part of Ulsan on the same day. It moved to the northeast and passed through the Korean Peninsula. During the passage, heavy rainfall of 304 mm was recorded in the northern part of Korea. Peak gusts exceeded 28 m/s in the northeastern part of Korea.

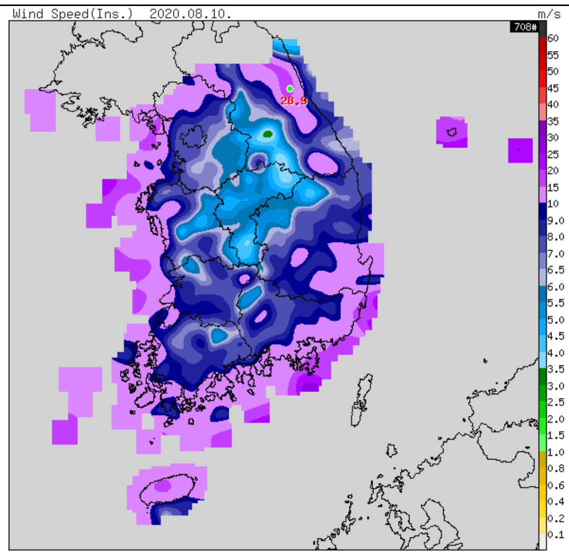
BAVI (2008) occurred at sea approximately 200 km in the southeastern part of Taipei, Taiwan on August 22, 2020. After passing through the West Sea of Korea, it landed on Ungjin in Hwanghaedo, North Korea on August 27. It was weakened as a tropical depression on land approximately 180 km into the eastern part of Shenyang, China on the same day, bringing a significant amount of rainfall with strong winds. From August 26 to 27, accumulated precipitation of more than 472 mm was recorded around Halla Mountain on Jeju Island. A peak gust of 66 m/s was observed in Jeolla Province. In addition, high waves of more than 8 m were observed in the West Sea of Korea.

MAYSAK (2009) made landfall on the southwestern coast of Busan on September 3, 2020. Passing through the east sea of Jeju, it moved northeastward; Korea experienced high winds and heavy rainfall from September 2 to 3. During that period, an accumulated precipitation of more than 1037 mm was recorded at Seogwipo on Jeju Island. A peak gust of 46 m/s was recorded in Gyeongsang Province. In addition, high waves of more than 8 m and less than 12 m were observed in the southern sea and east sea of Korea.

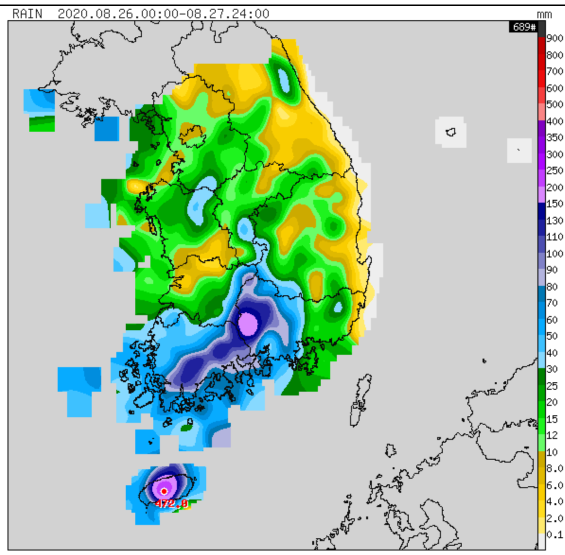
HAISHEN (2010) made landfall on the southern coast of Ulsan on September 7, 2020. From October 1 to 2, an accumulated precipitation of more than 547 mm was recorded on Halla Mountain on Jeju Island. A peak gust of 42 m/s was observed in Gyeongsang Province.

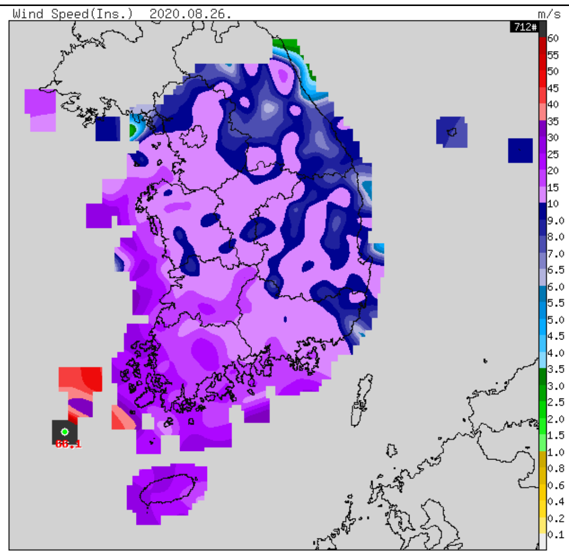
No. 5. JANGMI (August 10−11)



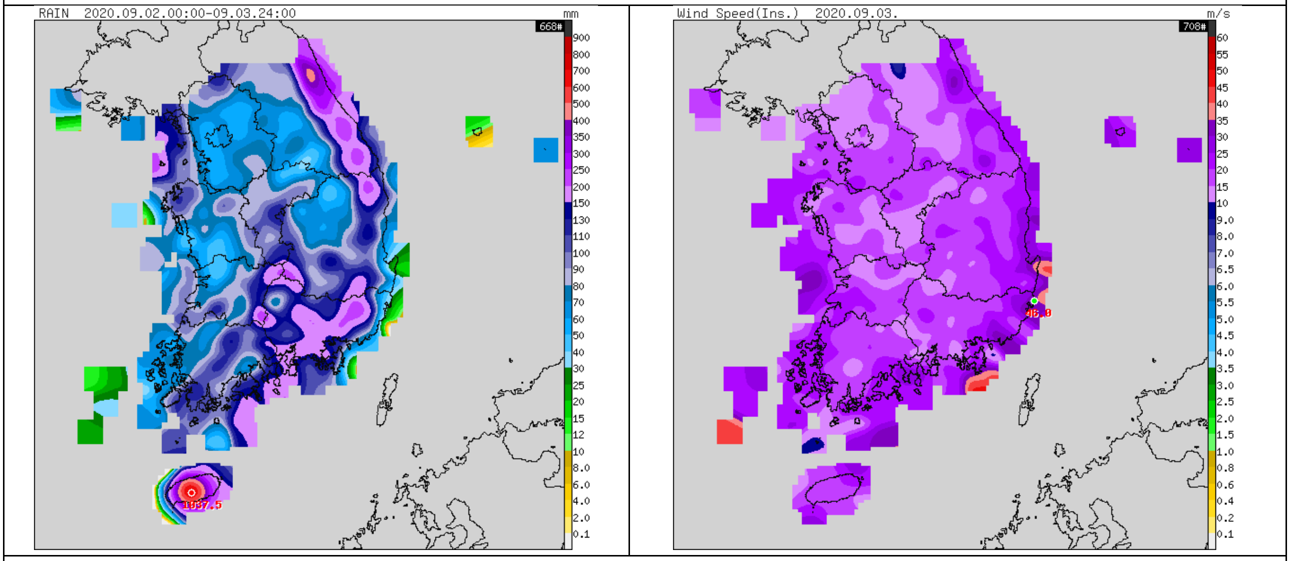


No. 8. BAVI (August 26−27)





No. 9. MAYSAK (September 2−3)



No.10. HAISHEN (September 6−7)

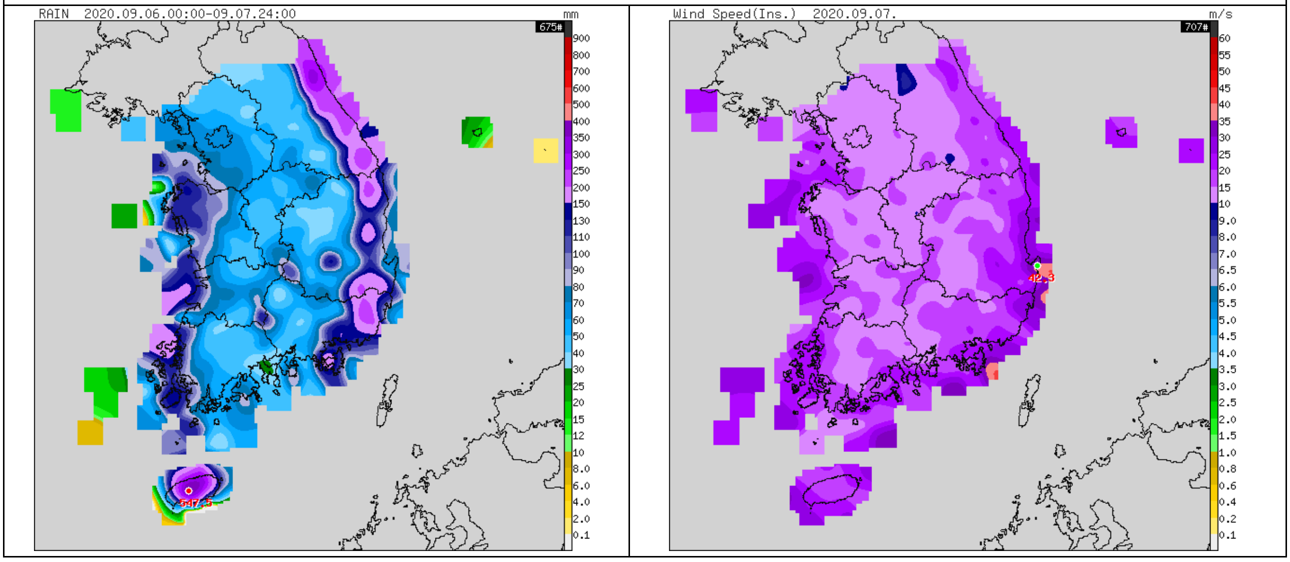


Fig. I-2. Distribution of accumulated rainfall (left) and gust (right) during the passage of seven typhoons affecting the Korean Peninsula.

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

Typhoon No.5 JANGMI was a tropical storm with a central pressure of 1,000 hPa, a maximum wind speed of 18 m/s, and strong with radius of 460 km at 3 o'clock on August 9, and occurred in the sea around 600 km southwest of Okinawa, Japan. According to the KMA, it landed in Geoje-si, Gyeongsangnam-do, Korea around 14:50 on August 10. It was interpreted that it was transformed into extratropical cyclone with a central atmospheric pressure of 998 hPa on land around 17:00 on August 10, about 10 km northwest of Ulsan Metropolitan City. Fortunately, there was no major damage inland due to its weak power.

Typhoon No.8 BAVI occurred near about 200 km southeast of Taipei, Taiwan. It reached its maximum peak at 9 o'clock on August 26, about 210 km southwest of Seogwipo, Jeju Island, Korea. Due to Typhoon BAVI, the instantaneous maximum wind speed of 47.4 m/s was recorded at 20:29 on

August 26 in Heuksan-do, Sinan-gun, Jeollanam-do, Korea. Typhoon BAVI inflicted large and small accidents such as traffic control in some areas in the southwest Korea peninsula; however, contrary to the original expectations, it passed without relatively large damage to Seoul and other metropolitan areas.

Typhoon No.9 MAYSAK occurred at 15:00 on August 28 in the sea, about 1,040 km northeast of Manila, Philippines. It landed on the southwest coast of Busan Metropolitan City at 2:20 on September 3 according to the KMA. After landing on the Korean peninsula, it has progressed rapidly northeast. Due to Typhoon MAYSAK, the instantaneous maximum wind speed of 49.2 m/s was recorded in Gosan-ri, Hangyeong-myeon, Jeju-si, Jeju-do, on September 2.

Typhoon No.10 HAISHEN occurred on September 1 in the sea, about 780 km north of Guam. It landed on the southern coast of Ulsan Metropolitan City at 9 o'clock on September 7. After landing on the Korean peninsula, it went north at a rapid pace.

Especially, Typhoon MAYSAK and HAISHEN caused severe damages to Korea with heavy wind and flooding, respectively. No.9 MAYSAK caused severe damage with both heavy rainfall and wind. It sprinkled more than 1,000 mm of rainfall in the mountainous areas of Jeju Island and drove a strong wind, which is the 7th place in history with a speed of 49.2 m/s. In particular, it penetrated Busan city (a large city following Seoul in Korea) and the Gyeongbuk area (southeast region of Korea), and the amount of direct/indirect damage caused by it was tentatively counted to more than 100 billion KRW (appx. 8.5 million USD). In the Gyeongbuk area, the estimation in the marine and fisheries sector was 46 billion KRW and eight (8) ports suffered damage worth 7 billion KRW. In addition, there were two (2) missing and five (5) injured by No.10 HAISHEN. More than 956 people were evacuated nationwide and about 5,000 households suffered from power outages, and more than 300 flight schedules were cancelled.

In 2020, the Flood Control Offices of ROK issued the total of seventy-eight (78) flood watches and thirty-one (31) flood warnings nationwide from July to September and most of them were due to four typhoons that densely occurred in August:

- Twenty-one (21) watches and seven (7) warnings by the Han River Flood Control Office;
- Twenty-five (25) watches and five (5) warnings by the Nakdong River Flood Control Office;
- Thirteen (13) watches and five (5) warnings by the Geum River Flood Control Office;
- Nineteen (19) watches and fourteen (14) warnings by the Yeongsan River Flood Control Office

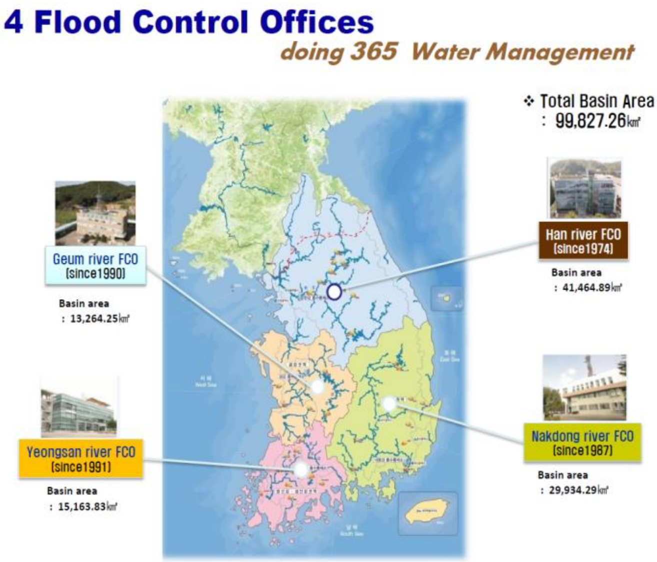


Fig. I-3. Locations of 4 Flood Control Offices (FCOs) of Ministry of Environment, ROK

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

In 2020, there were a lot of damages due to the record breaking longest rainy season (Changma in Koran) for 54 days ever. At least 30 people had been dead already before first impact typhoon (JANGMI) came. Most of damages have been caused by landslide due to the weakening foundation. Total 4 typhoons affected the ROK from January to October this year (Table 1). Among them, Typhoon MAYSAK and HAISHEN caused casualties and economic damages the most.

Table 1. List of typhoons which have affected the Republic of Korea in 2020

No.	Typhoon Name	Duration
2005	JANGMI	August 10 ~ 11
2008	BAVI	August 26 ~ 27
2009	MAYSAK	September 2 ~ 3.
2010	HAISHEN	September 6 ~ 7.

(By the courtesy of KMA web site, www.weather.go.kr)

JANGMI (2005) was formed south-southwest of Okinawa Island on August 9th. It went north quickly and hit Geoje in the Republic of Korea with a central pressure of 998 hPa at 14:50 pm, August 10th. About 2 hours later, Typhoon JANGMI changed into extratropical cyclone.
Although dissipated early, it made disaster management officials nervous because there had been a huge damage by landslide just a few days ago. Therefore, the Minister of the Ministry of the Interior and Safety (MOIS) held an emergency meeting with local government on August 9th as typhoon JANGMI could lead a more serious damages during monsoon season. Damages caused by typhoon JANGMI were relatively minor but, the terribly long monsoon caused the most. From August 1st to 10th 31 people were dead, 11 were missing and 8 were injured. Additionally, 20,826 facilities (public 8,470 and private 12,356) such as roads, bridges and rivers were affected during the same period.
(The above information is based on reports and press releases published by the MOIS)

BAVI (2008) was approaching to Jeju Island where a high seas watch was issued on August 24th. The MOIS raised the alert level from Attention to Caution and deployed site-situation-manager to 17 cities on 25th of August in respond to typhoon coming (Fig. 1.). Also, local governments are ordered to thoroughly prepare in advance. A force of the typhoon has died down quickly but it affected Jeju Island the most. The accumulated precipitation in Jeju was 460.5 mm. As a result, there was no casualty but one household (five people) was evacuated, 550 facilities were damaged and 10,450 households were suffered from blackout.

	
Checking the crane (Incheon)	Checking COVID-19 screening center (Paju)
	
Checking construction site (Sejong)	Checking the restoration of river bank (Jeonbuk)
	
Pre-evacuation near seaside (Jeonbuk)	Checking the washed highway (Jeonnam)

(By the courtesy of MOIS Official Press Release on August 26th)

Fig. I-4. Major activities pictures of site-situation-managers to prepare for Typhoon BAVI
(The above information is based on reports and press releases published by the MOIS)

MAYSAK (2009), formed near the Philippines as a midget typhoon, became a huge typhoon when it passed through the southeast side of the Republic of Korea on September 2nd. The accumulated precipitation was 1,045 mm and the maximum instantaneous wind speed was 49.2 m/s in Jeju Island. MOIS raised the alert level from Attention to Caution on 1st and raised again to Serious on 2nd. The

President issued special instruction in order to control a danger zone, to evacuate all personnel and to prevent accidents by strong wind. Typhoon MAYSAK caused more damages by strong wind than by heavy rain. 1 person was dead, 3 were injured and 42 households were evacuated. 1,579 facilities (public 825 and private 754) were damaged and the temporary power cuts affected 294,169 households. To make it worse, damages by this typhoon became more serious due to the following typhoon (The above information is based on reports and press releases published by the MOIS).

HAISHEN (2010) hits the ROK in a row after Typhoon BAVI and MAYSAK hit. It started from near Guam on 1st of September and slowly approached to the ROK through Japan. MOIS dispatched site-situation-manager to 17 cities of concern for typhoon damages on 5th of September. It was reported that the central minimum pressure of typhoon was 955 hPa and the intensity was very strong when it's near Ulsan in the Republic of Korea. The condition has worsened due to continuous damages from typhoons. 2 people were missing and 5 were injured. The Minister of the MOIS designated 5 cities and 19 towns such as Goseong and Gyeongju as a special disaster area which are affected the most (Fig. 2.). About 550 million USD were funded to these areas for the relief expenditure and the additional benefits for victims such as providing living support and reducing electric charges (Table 2).

(By the courtesy of MOIS Official Press Release on September 29)

Fig. I-5. Major damage pictures of a special disaster area by Typhoon MAYSAK and HAISHEN

Name of province	Damage costs of facilities (million USD)		Recovery costs (million USD)
	Private	Public	
Gyeongbuk	6.93	82.47	184.25
Gangwon	3.48	62.95	168.57
Jeju	1.96	3.90	22.35
Gyeongnam	1.95	16.46	44.76
Busan	1.67	6.14	12.99
etc.	5.18	7.11	115.29
Total	21.17	179.03	548.21

(By the courtesy of MOIS Official Press Release on September 29)

(The above information is based on reports and press releases published by the MOIS)

II. Summary of Progress in Priorities supporting Key Result Areas

1. Web-based Portal to Provide Products of Seasonal Typhoon Activity Outlook for TC Members (POP1)

Main text:

The KMA has issued a seasonal outlook for typhoons occurring in the western North Pacific basin on its website (http://gtaps.kma.go.kr/TSP/index.php) since 2014. The information about the number of typhoons and track pattern is provided based on the results of three types of models: multi-regression models, global dynamical models, and hybrid models of statistical and dynamical methods (Fig. II-1). In 2020, the KMA provided TC Members with a seasonal outlook for western North Pacific typhoon-activities on its website. Seasonal outlooks for summer and fall were issued in late May and late August, respectively. In the summer seasonal outlook (June to August), 7 to 15 typhoons were forecast. In the fall seasonal outlook (September to November), 11 to 13 typhoons were forecast.

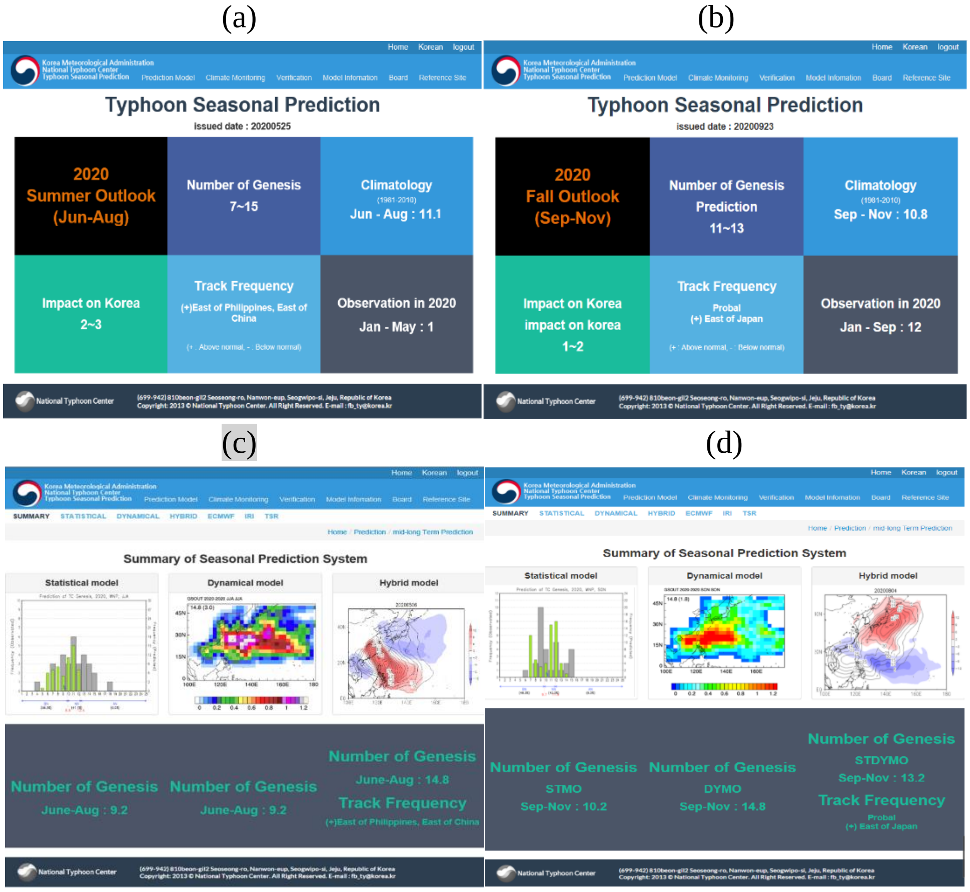


Fig. II-1. Sample pages of the website for KMA's seasonal typhoon activity outlook: (a) summer, (c) model prediction result during June to August, (b) fall, (d) model prediction results during September to November.

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2. New Classification of Typhoon Intensity

Main text:

The KMA changed its typhoon intensity classification in 2020. The existing classification used three categories based on typhoons' sustained wind speed: medium, strong, and very strong since 2019. However, the rate of occurrence of very strong typhoons in the last 30 y (1989–2019) is approximately 30%, even when the frequency of typhoons with very strong winds is more than 50% among typhoons affecting the Korean Peninsula.

In this regard, the KMA has introduced the new category "super strong" to the typhoon intensity scale since May 2020 to effectively prevent the impact of super-strong typhoons related to global warming. The new intensity classification is as follows:

Table II-1. Typhoon intensity classification of KMA

Scale	Maximum sustained wind speed
Medium	More than 25 m/s (48 knots) − less than 33 m/s (64 knots)
Strong	More than 33 m/s (64 knots) − less than 44 m/s (85 knots)
Very strong	More than 44 m/s (85 knots) – less than 54 m/s (104 knots)
Super strong	More than 54 m/s (104 knots)

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3. Service of Five-Day Tropical Depression (TD) Forecast

Main text:

The KMA issued five-day tropical depression (TD) forecasts from May 2020 to provide better information earlier to the public and strengthen communication with the media. When the TD is expected to upgrade into a typhoon within 24 h (called 'fTD'), the KMA analyzed and released information for five days.

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4. Operational Service of GEO-KOMPSAT-2A

Main text:

The KMA began operating GEO-KOMPSAT-2A (GK2A) at 00UTC on July 25, 2019, after the successful launch on December 4, 2018. The KMA operates three different observation areas with a 10-min schedule. The GK2A's AMI (Advanced Meteorological Imager) observes the Full Disk (FD) once, Extended Local Area (ELA) five times, and Local Area (LA) five times every 10 min. In particular, the LA mode can be used for rapid scan target area observation, such as tropical cyclones, covering a 1000 km × 1000 km area every 2 min with flexibility for location changes. The KMA utilized this special target observation to monitor three typhoons and one tropical depression (8^{th} BAVI, 9^{th} MAYSAK, 10^{th} HAISHEN, and 13^{th} TD) in 2020. The official request for the target area observation is available via a designated web page (http://datasvc.nmsc.kma.go.kr/datasvc/html/special/specialReqMain.do) to support national and international services over the Asian Pacific region (RA II and RA V).

Level 1B data of GK2A were released through the National Meteorological Satellite Center (NMSC) website and through direct broadcasts since July 25, 2019. The KMA broadcasts meteorological observations from all 16 bands with full resolution using Ultra High-Rate Information Transmission (UHRIT) and maintains High-Rate Information Transmission (HRIT) broadcasts corresponding to COMS 5 channels. Low-Rate Information Transmission (LRIT) broadcasts will be replaced by meteorological services for shipboard small antennas. The KMA also disseminates GK-2A level 1B data via landlines. The full disk data from 16 bands, approximately 2.25 GB in volume, are provided by FTP in real-time. Considering the network bandwidth limitation, FTP is issued one account per country. Currently, 14 countries are registered, namely Australia, Bangladesh, Germany, Hong Kong, India, Indonesia, Japan, Malaysia, Nepal, Russia, Singapore, Taiwan, Vietnam, and the USA. GK-2A level 1B and level 2 products in netCDF format are available on the NMSC website (http://nmsc.kma.go.kr/enhome/html/main/main.do) and DCPC-NMSC (http://dcpc.nmsc.kma.go.kr). The data requested by users can be downloaded in non-real-time. User registration is required to access this service.

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5. Developing Typhoon Analysis Technique based on Weather Radar Network

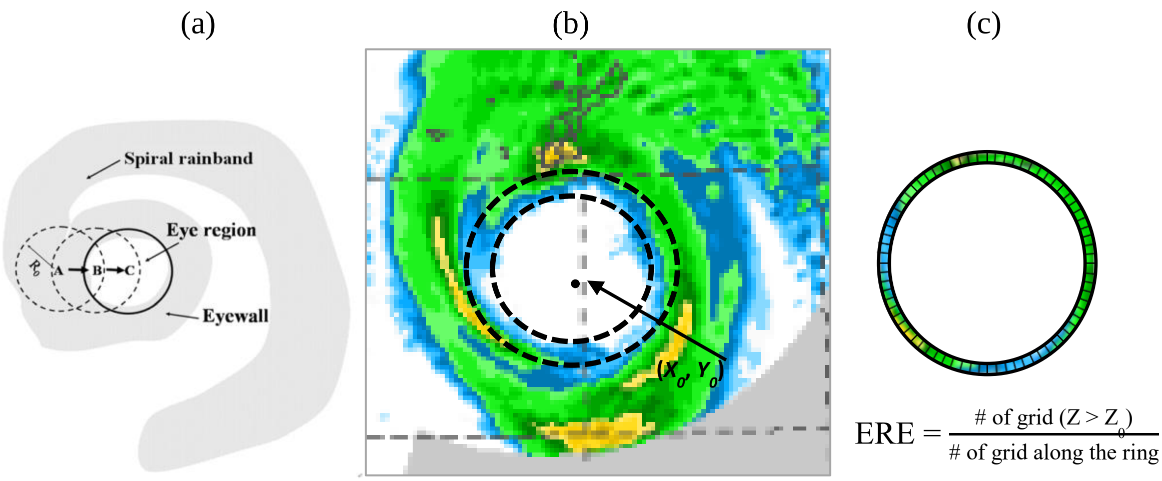
Main text:

The Weather Radar Center (WRC) of KMA provided Typhoon (TY) analysis information, such as the positions (latitude, longitude) of the typhoon, moving speed and direction, wind speed, strong wind potential area, and heavy rainfall area, using a nationwide composite of radar rainfall, three-dimensional Doppler wind fields, and a radar rainfall mosaic from neighboring countries in Eastern Asia.

To support more effective analysis than in previous years, WRC has improved the functions of the typhoon analysis tool in the Radar Data Analysis System. We have also organized the radar task force team consisting of experts (e.g., weather radar and satellites) with many years of experience in typhoon analysis and radar image interpretation this year. The team supported the position of TY and relevant information of the weather forecaster using a combination of radar rainfall composite and radial velocity from individual radar data every three hours when TY moved into the Typhoon-Watching area and every hour within the Typhoon-Alert Area.

Additionally, to automatically provide more accurate and objective TY center position and its intensity information than human analysis, the KMA has developed a separate TY tracking technique by introducing a modified algorithm based on the spatial structure of reflectivity surrounding the TY eye using the radar rainfall composite, which was originally proposed by Chang et al. (2009). The capability of the reflectivity-based algorithm is expanded to apply to a composite image of Eastern Asia and a nationwide radar rainfall composite over the Korean Peninsula.

To compensate for the weakness of the reflectivity-based algorithm for weak TY eyes by the penetration of dry air, a new tracking technique has been developed based on the horizontal vorticity derived from three-dimensional Doppler wind fields with high spatiotemporal resolution (e.g., 1 km and 10 min).



$$\mathrm{ERE} = \frac{\text{\# of grid } (Z > Z_0)}{\text{\# of grid along the ring}}$$

Fig. II-2. Concept diagram for automatic tracking algorithm based on the morphology of reflectivity and vorticity around TY eye: (a) tracking concept of TY position, (b) determination of TY position, and (c) calculation of the effective radius of an eye (ERE) (Chang et al., 2009).

(a) (b)

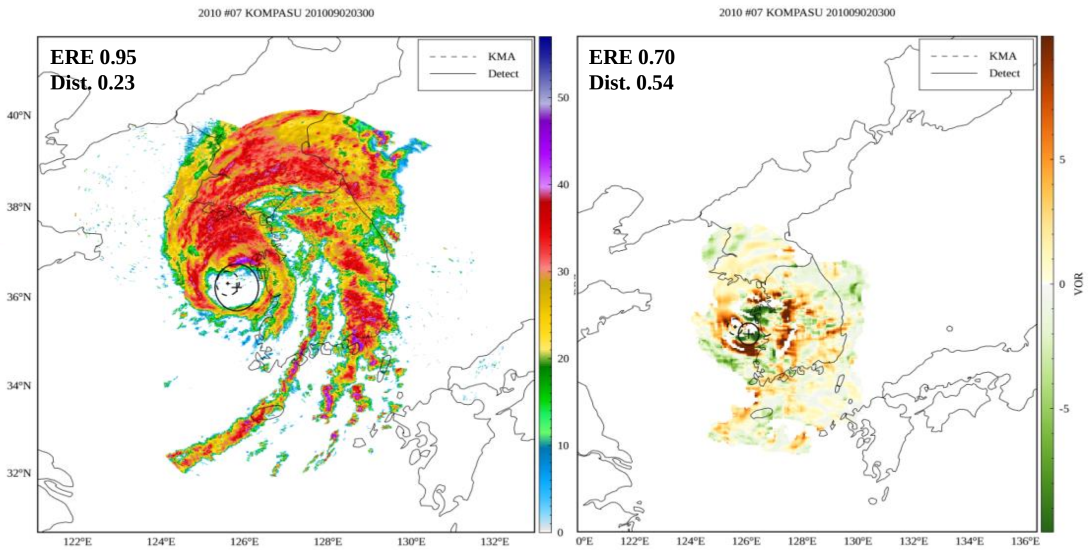


Fig. II-3. Example of the identified typhoon centroid by automatic tracking algorithm based on (a) radar reflectivity composite and (b) horizontal vorticity.

Regarding TY tracking accuracy, we expect that the new tracking algorithms using the reflectivity and vorticity structure along the typhoon spiral will guarantee the objectiveness of the TY position, unlike human analysis based on an expert system.

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

Real-time implementation of automatic typhoon tracking algorithm, its validation, and improvement (for any typhoon cases in summer 2021).

Priority Areas Addressed:

The real-time correction of the projected path of a typhoon by comparisons with radar-based typhoon center and the estimation of typhoon-induced high-risk areas (including a potential area of strong wind, heavy rainfall, and flooding).

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6. Preliminary Observation of Typhoon using NIMS/KMA Atmospheric Research Aircraft (NARA)

Main text:

The National Institute of Meteorological Sciences (NIMS)/KMA, has operated the KMA/NIMS Atmospheric Research Aircraft (NARA) since December 2017. The NARA has been used to preliminarily observe typhoon landings in Korea 1 to 2 days in advance. For three typhoons (8^{th} Francisco, 9^{th} Lekima, and 13^{th} Lingling) in 2019, dropsonde observations from the NARA provided the atmospheric structure from approximately 6,096m to the sea-surface layer. Concurrently, sea surface wind speed was also estimated by the Stepped Frequency Microwave Radiometer (SFMR).

For the 13^{th} typhoon Lingling on September 6, 2019, when the typhoon was located on the south-southwest sea 430 km from Jeju Island in Korea, Fig. II-16 illustrates observations from the SFMR (left), ground-based radar (center), and dropsondes (right), respectively. The observed sea surface wind speed prevailed over 10–14 m/s and dropsonde observations could describe the vertical wind shear difference from ① to ④, as well as the change of horizontal wind direction from north-northeast via northeast to east close to the typhoon. Estimated precipitable water of 45–46 mm was similarly found at ①–③ relatively close to precipitation band while 42.7 mm were found at ④.

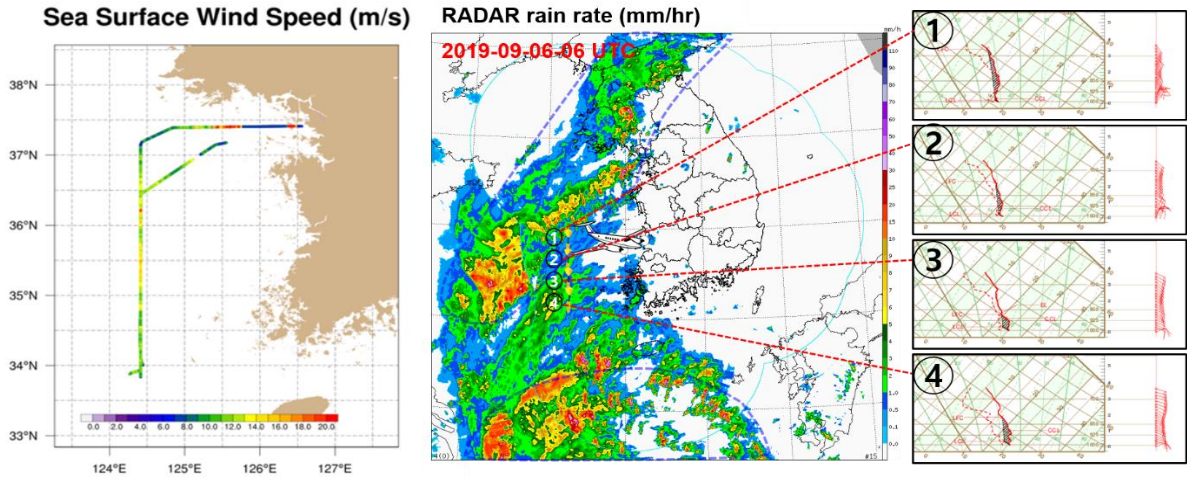

Fig. II-4. Observations from the NARA and ground-based radar on September 6, 2019. Sea-surface wind speed from the SFMR is shown along the route of the NARA (left). Rain rate distribution from the ground-based radar is described and black circles from ① to ④ indicate the observation point with dropsonde (center). Skew-T Log P diagrams corresponding to each dropsonde observation are also depicted (right).

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7. Total Water Level Prediction for Typhoon-related Disaster Reduction

Main text:

The KMA developed an ocean/port prediction system that calculates marine weather forecasts, such as waves, storm surges, and total water level (TWL) in consideration of the typhoon track and intensity issued by KMA typhoon forecasters. For this purpose, Holland's model was used using the central pressure, maximum wind speed, and maximum wind speed radius. The coastal storm surge and wave models were set up for five Regional Offices of Meteorology with a 500-m spatial resolution.

Coastal flooding caused by typhoons is one of the greatest threats to life and property along the coastline. TWL prediction can produce effective coastal hazard forecasts. The predicted sea level is used to determine whether coastal flooding occurs in coastal areas. TWL predictions are computed as a combination of tide, storm surge, wave run up, and wave setup information. The KMA has developed TWL predictions for 110 stations, including flood-vulnerable areas and sea-level measuring stations, to provide guidance on potential coastal flooding related to typhoons.

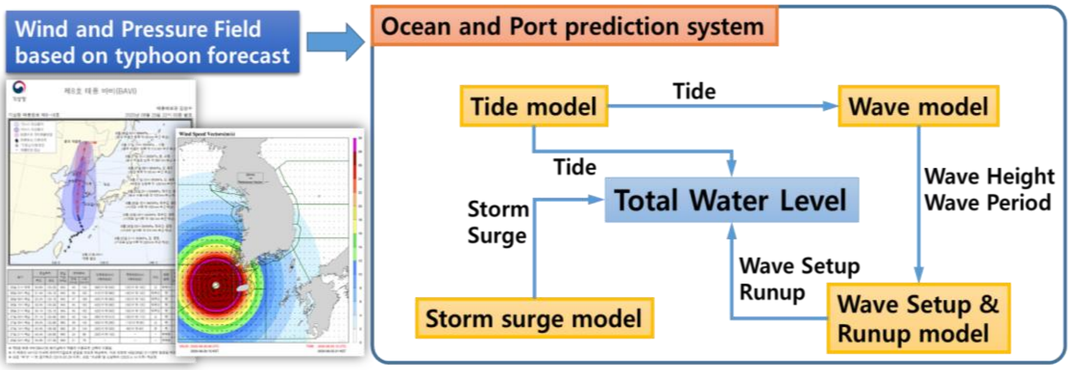

Fig. II-5. Flowchart of TWL prediction based on typhoon forecast

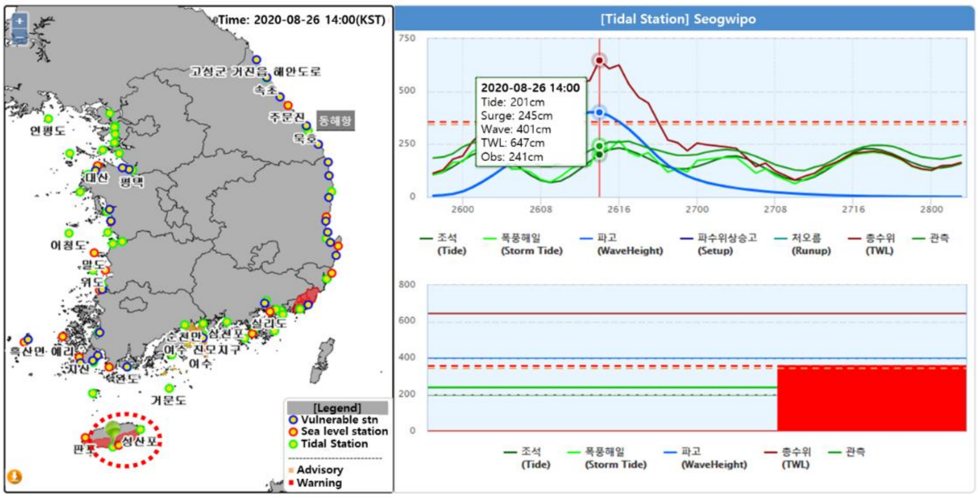

Fig. II-6. Time series of TWL at the Seogwipo station for the case of TY0808 BAVI (August 26, 2020).

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8. Special Exhibition ‘Confession of the One-eyed Wind’

Main text:

KMA held a special exhibition highlighting a typhoon, titled ‘Confession of the One-eyed Wind.’ Typhoons have been a major part of Jeju culture, in humanities and natural sciences. The special exhibition was held from May 12 to July 5 at the Jeju National Museum of Korea, Jeju Korea, co-hosted by the Jeju Regional Office of Meteorology and Jeju National Museum of Korea, and sponsored by the National Typhoon Center/KMA.

► Contents: Many kinds of materials in the field of humanities, equipment, and instruments for weather observation, as well as historical records of typhoons and the traditional lifestyle showing how the residents of Jeju have coped with gales and typhoons. It also features works by many contemporary artists inspired by wind and typhoons.

Fig. II-7. Special Exhibition ‘Confession of the One-eyed Wind’ in 2020

An art brochure on the ‘Confession of the One-eyed Wind’ was published by the KMA and Jeju National Museum of Korea. It contained various information about the special exhibition, historical records, and scientific stories on typhoons that had not been shown in the exhibition. It consisted of three chapters and 48 exhibits, including historic typhoon data indicating how they have caused considerable damage to Korea that show how the Jeju people have survived through severe gales and typhoons. In addition, ten articles written by historians and professors help understand the science and folklore of typhoons.

This is the first book that combines natural sciences such as geology and meteorology focused on typhoons. It also has a humanity theme that includes history, folklore, and art. Although typhoons cause tremendous damage, they present an opportunity to reflect on how to preserve our environment and how to hand it over to the next generation.

The Exhibition, ‘Confession of the One-eyed Wind’ is available on VR and YouTube.

► YouTube: https://www.youtube.com/watch?v=CUXDx9QQI24

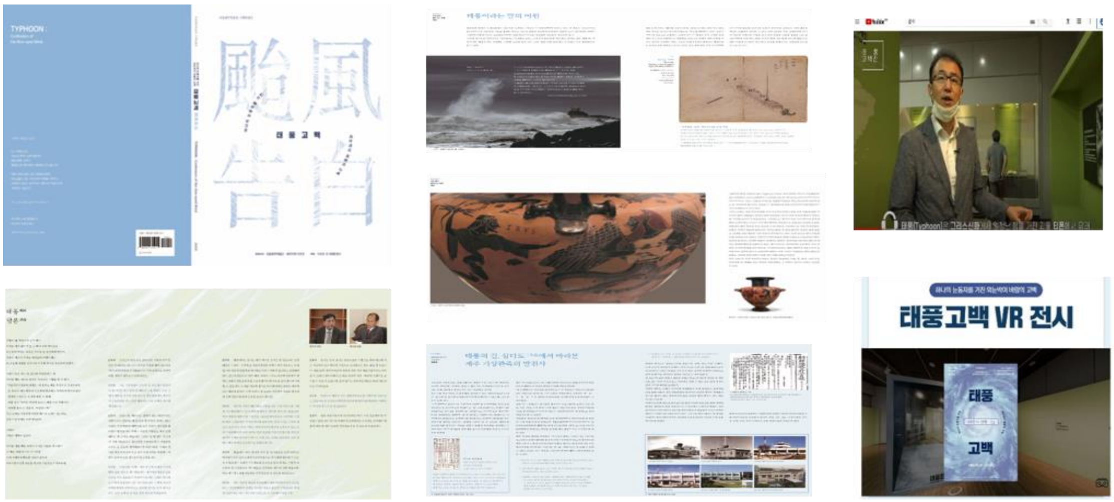

Fig. II-8. Art brochure for the exhibition, ‘Confession of the One-eyed Wind’

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9. Research Project on Establishment of Hydrological Data Quality Control in TC Members

Main text:

In order to improve the accuracy and reliability of flood forecasting, quality control of hydrological data is one of the key factors. The Republic of Korea has developed and operated the system for national hydrological data quality control for major river watersheds nationwide, thereby improving the accuracy and efficiency of flood forecasting. In addition, the Han River Flood Control Office (HRFCO) of the Ministry of Environment has published the annual hydrologic data report using the national hydrological data quality control system and supplied the qualified hydrologic data to the public via the webpage.

The project for improvement of hydrological data quality control in TC members started in 2018 and will be conducted by 2022 for 5 years. The objective of this project is to diagnose the current state of the target country (Lao P.D.R, Malaysia, Philippines, Republic of Korea, and Thailand), to provide the direction and guidelines for a hydrological data quality control, and to develop the hydrological data quality control system in TC members. It is expected, eventually, that TC member countries will be able to improve flood forecasting performance by using highly qualified hydrological data.

The preliminary studies on the hydrological data quality management for target countries in TC region conducted in 2018. In addition, the 1st and 2nd expert missions (field surveys) for target countries in order to determine the current status were successfully completed in 2019 thanks to close cooperation with TC members. Initially it was planned to hold the expert mission wrap-up meeting in Korea this year to summarize the outcomes of expert missions and finalize the technical report with consent by TC members. However, as a face-to-face meeting has been impossible due to the unexpected prolonged COVID19 outbreak, it is inevitably decided to have an online pre-meeting of wrap-up on November 27. If the current plan will be able to be followed, the face-to-face warp-up meeting of expert mission will be held in Korea next year.

Except for this, this year the basic direction for the quality control of hydrological data in TC members and standard method for correcting outliers and missing data was already established. In principle, the RDS (reciprocal distance squared) method is used to correct outlier data for rainfall, and a relational formula between upstream and downstream is applied to correct outlier data for water level. In addition, a method of manual correction based on the accumulated experiences and insights of practitioners is also suggested as a complementary method for improving data quality.

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

It is necessary to manage unexpected changes in external environment such as COVID19. Fortunately, the first and second field surveys were carried out successfully in 2019, and the inspection of the target basins and acquisition of basic data for the project were completed. However, there were some restrictions on face-to-face project discussions with working-level members of TC. Nevertheless, this situation was secured through online meetings.

Through the project, it is expected that capacity building for hydrological data quality control of TC members will be improved and high quality hydrological data can be published to public person and used for flood forecasting system

Priority Areas Addressed:

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

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10. Task Improvement to Empower Capability in National Flood Forecasting

Main text:

In the Republic of Korea this year, in order to make the flood management network even denser, the number of flood warning points was expanded to 65, and flood information points were expanded to 409 (which was 90 more than before). Through this, monitoring of areas with high inundation risk among the living spaces close to the public, such as water front parks and parking lots, was strengthened.

To respond to local flash floods preemptively, the nationwide hydrological observation period was reduced from 10 minutes to 1 minute and these are provided to disaster-related agencies.

In addition, as the necessity for improving forecast accuracy through comprehensive management and analysis of seven (7) rainfall radar observation data across the country was emphasized, the national plan to establish the National Integrated Center for Rainfall radars (tentative) was announced.

In addition, the Ministry of Environment sought a plan to strengthen cooperation among related agencies for hydro-meteorological forecasting, which are the Flood Control Office (FCO) of Ministry of Environment, the KMA and the K-water to increase the ability to respond to climate crises at the national level. This is a policy decision that reflects the concern considering increase in uncertainty in hydro-meteorological forecast due to climate change.

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

It is possible to present a guideline for establishing a flood management decision-making system in TC members by providing an example of close cooperation between related agencies to improve more effective flood management to reduce flood damage caused by typhoons.

Priority Areas Addressed:

Enhance capacity to manage typhoon-related flood risk

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11. Enhancement of Flood Forecasting Reliability with Advanced Technologies

Main text:

The Ministry of Environment announced that it is promoting “Scientific Flood Management” by applying advanced technologies as a measure to fundamentally reduce repeated flood damage caused by torrential heavy rainfall in July and August in Korea annually.

The Ministry of Environment is planning to introduce a flood forecasting system using artificial intelligence (AI) by 2025. Current manpower-centered flood forecasting required many years of experience and it is difficult to derive results in a short period of time, but AI techniques (such as machine learning and deep learning etc.) are expected to be able to derive results in a short period of time if the stability of input variables is secured. The sensors to collect flood information will be installed in 100 local rivers nationwide that are vulnerable to flooding, and a flood forecasting platform will be built by 2025, using the AI based on the data and information collected from each sensor.

In addition, the rainfall radars are going to be used to catch flash floods caused by surprise heavy rainfall. Since the existing methods of flood forecasting centered on the water level of rivers has limitations in prediction flash floods, particularly, in urban areas, forecasting information will be provided to the public 1-hour before the occurrence of flash floods in the minimum administrative district unit using a rainfall radar. The rainfall radar intensively observes low-altitude rainfall events closest to the surface. As rainfall conditions occurring within a short time can be observed in detail with high accuracy, it is reasonable for using them in flood forecasting for large-size river or flash flood.

A satellite that monitors water resources and water disasters will be developed by 2025 as planning to respond to extreme floods. The main purpose of operating this satellite is to provide extensive monitoring specialized in the water resources, including spatial flood forecasting. This year, preliminary researches such as the development of ground model for verifying an image radar and demonstration of related algorithms (verification and utilization) are going to be carried out.

If the satellite will be successfully launched and operated in 2025, ultimately, i) more accurate information will be able to be acquired in a timely manner when a disaster occurs in Northeast Asia, ii) a spatial flood forecasting system will be established, iii) the signs of disaster occurrence (flood, drought, maritime disaster, etc.) will be monitored to ensure the safety of the public against disasters, and iv) it is expected to be possible to accumulate information on the nationwide of country.

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

In order to improve flood management in TC member countries, not only traditional flood forecasting based on experiences and intuition by practitioners, but also scientific flood forecasting plan based on more advanced technology will be possible. Also TC members can use the practical methodology for flash flood forecasting using radar rainfall data

Priority Areas Addressed:

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 modeling

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12. Flood Risk Map of Korea

Main text:

The establishment of flood risk map of Korea was determined in 1999 as a part of the preliminary research planning working group for the non-structural flood control measures. In 2001, a basic survey of flood risk mapping was conducted.

The flood risk map for national rivers completed in 2016 and the works for provincial rivers are ongoing. The flood risk maps will be completed for all rivers in Korea by 2021 according to a master plan.

From 2021, the flood risk map, which has been viewed in 2D paper drawings, will be built as a System based on GIS so that it can be easily provided online.

The flood risk map plays an important role in visually identifying areas where inundation damage can occur by notifying the expected spatial range and depth of flooding. This is expected to be used a very useful tool when making decisions to respond for flood-related disasters. In addition, this map will be used as basic data for establishing a national comprehensive plan of natural disaster mitigation, an emergency response plan, and a windstorm insurance management map.

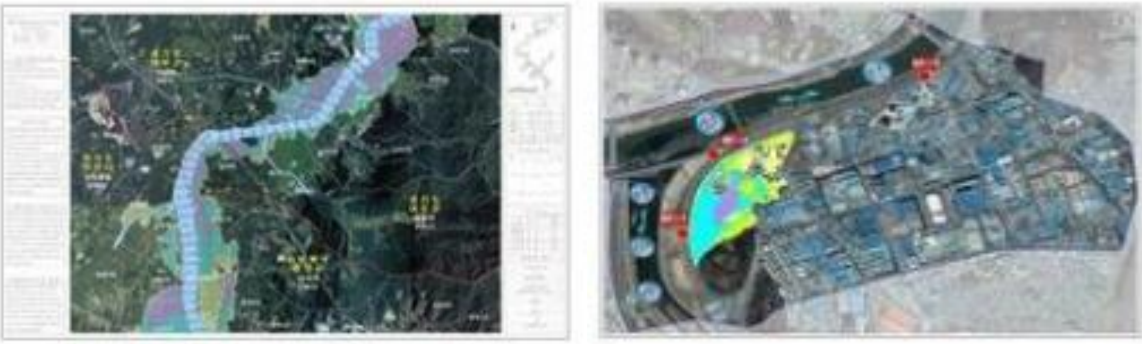

Fig. II-9. Flood Risk Map of Korea based on GIS

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

It is determined that Korea's flood risk mapping know-hows and an information providing system for decision-makers and general public can be used to prevent flood disasters in the TC member countries.

Priority Areas Addressed:

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

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13. Capacity Building / Knowledge sharing in DRR

Main text:

In the 14th Integrated Workshop, the WGDRR proposed conducting the Expert Mission with a new name, "Capacity Building / Knowledge Sharing among Typhoon Committee Members," as one of the Cross-cutting Projects.

The objective of the Capacity Building / Knowledge Sharing is to share information and experiences including policies, technologies, and researches results related to DRR among the Members and to cooperate among WGM, WGH, WGDRR, and TRCG to derive maximum result efficiently and effectively.

The program had been expected to be held in Palau, August 2020. However, due to COVID-19 NDMI suggested the publication of reports not holding a face to face program and the TC WGDRR agreed with it. The reports include the global disaster reduction project of NDMI implemented in Philippines from 2013 to 2015, and in Vietnam and Lao PDR from 2016 to 2019.

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

After publishing NDMI's reports, TC WGDRR is planning to distribute them to TC members including WGM, WGH, and TRCG. In addition, the TC WGDRR will discuss about carrying forward a program in 2021 as the capacity building / knowledge sharing in DRR.

Priority Areas Addressed:

Sharing and exchanging knowledge and experiences about technical areas such as disaster prevention, early warning systems, emergency operations and so forth among TC member countries in order to improve the capacities on disaster risk reduction.

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14. Maintenance on the ARWS and FFAS installed in the Philippines from 2013 to 2015

Main text:

At the 44th Session of Typhoon Committee in 2012, Philippines had requested NDMI to conduct a field investigation due to the huge damages by the typhoon Washi. After several meetings with Philippines, NDMI implemented an ODA project to strengthen the countries' capability of flash flood preparedness in 2013.

The process of ODA project, which is carried by NDMI installing Flood Alert System and Automatic Rainfall Warning System (ARWS*), consists of three steps:

1) Conducting Field Survey
2) Installation and Inspection
   * Warning Post (WP), Rainfall Gauge (RG), Water Level Gauge (WG)
3) Operating Educational Program

In 2013, 2014 and 2015 NDMI had implemented the ODA project including the field survey, the installation and inspection, and the operating educational program. As a result, NDMI installed 4 RGs, 3 WGs. 5 WPs in Cagayan de Oro, Mindanao Island in Philippines.

In 2020, NDMI planned to conduct maintenance on the ARWS and FFAS installed in the Philippines from 2013 to 2015. NDMI started conducting an operational status survey on system virtually such as abnormal facilities and the detailed equipment needed for maintenance. However, NDMI had to delay the field survey scheduled in April, 2020 due to the outbreak. NDMI is trying to find a way to operate an educational program virtually and is expected to finish the whole project by April, 2021.

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

Next year, NDMI will initiate the project on installing ARWS and FFAS in Lao PDR. In addition, NDMI is planning to expand the ODA project on Fiji and the Philippines for 2022.

Priority Areas Addressed:

Strengthen the capability of flood preparedness in Philippines.

Make a strong partnership and collaboration between Republic of Korea and the target countries of the ODA project.

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15. The Video Meeting of Typhoon Committee Working Group on Disaster Risk Reduction

Main text:

The Video Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (TC WGDRR) was held virtually in November 20th and led by NDMI, Republic of Korea. Around 20 representatives from TC member countries participated in the meeting and discussed the review of activities & budget in 2020 and Annual Operations Plans (AOPs) & budget for 2021. As a discussion result, WGDRR decided 2021 AOPs & Budget as same as 2020 AOPs & Budget.

Table II-2. Annual Operations Plans (AOPs) with budget in 2020

No.	Items	Budget (USD)	No.	Items	Budget (USD)
1	Capacity Building / Knowledge Sharing in DRR	10,000	2	Setting up Early Warning and Alert System	-
3	TC WGDRR Annual Meeting	-	4	Benefit Evaluation of Typhoon DRR	6,000
5	Sharing Information related to DRR	-	6	Making Educational Video	2,000
7	Seminar for TC Crowd-sourcing high density non-conventional weather data	12,000	Total Budget (USD)		30,000

During the meeting, each AOP coordinator explained the progress of AOP. STI reported “Benefit Evaluation of Typhoon Disaster Prevention” and STI will continue this project. HKO also presented the progress of AOP which is “Making Educational Video”.

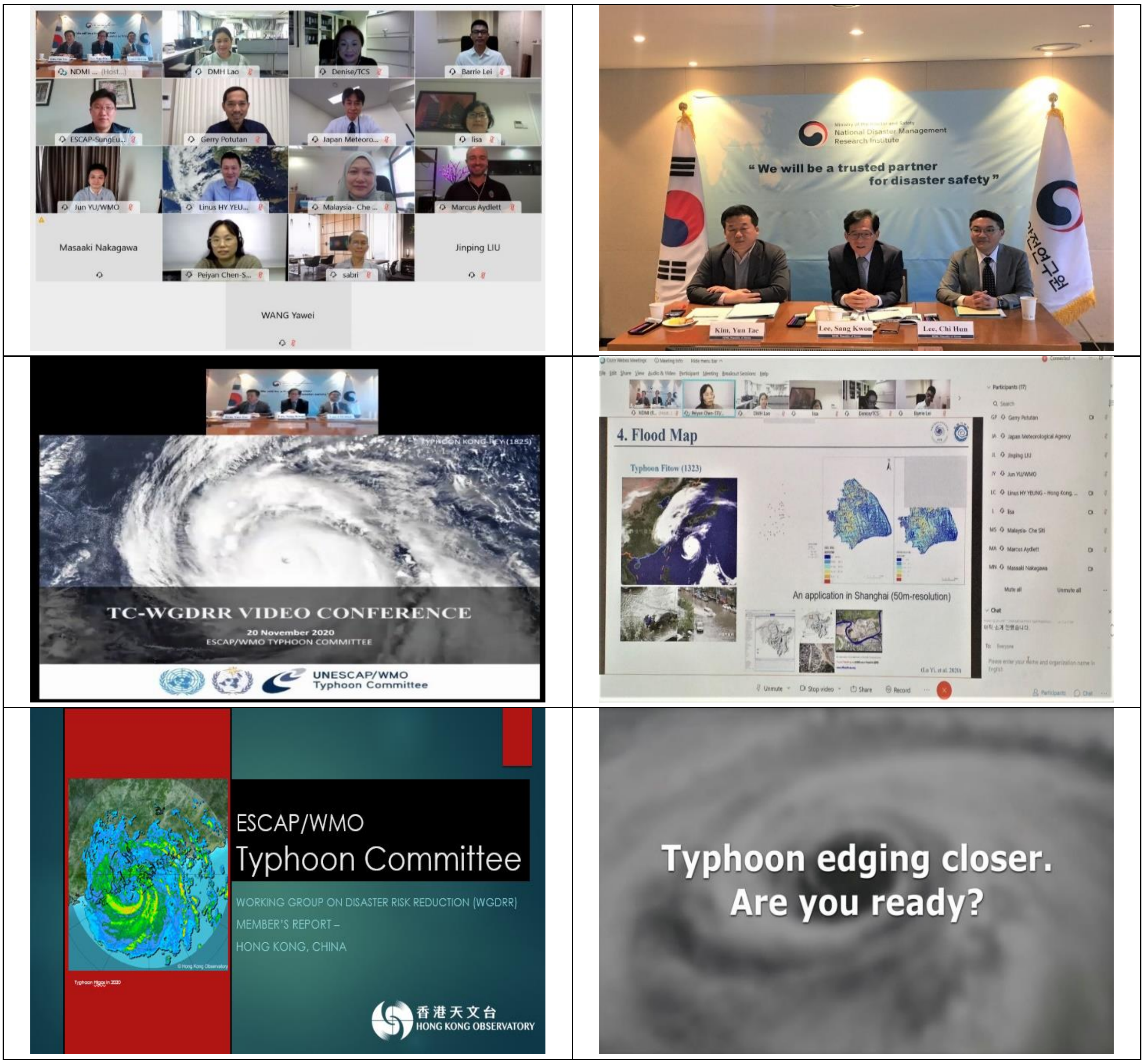

Fig. II-10. Photos of the Video Meeting of TC WGDRR

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

By holding the video meeting, NDMI could review WGDRR's achievements in 2020 and build strategic plans for 2021. Also, NDMI tried to establish a strong cooperative tie among the TC member countries as well.

Priority Areas Addressed:

Develop and enhance partnership among TC members and promote opportunity to share the information and experience on disaster risk reduction.

Strengthen the target “F” of Sendai Framework, which is “substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this Framework by 2030.”

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16. Sharing Information Related to DRR

Main text:

As one of the AOPs of TC WGDRR, NDMI has been trying to share information related to disaster risk reduction at the ESCAP/WMO Typhoon Committee website. At the website, there is a Typhoon Committee (TC) Forum Session, which consists of two parts:

1. Shanghai Typhoon Institute Typhoon BBS : A discussion platform for typhoons, moderated by Shanghai Typhoon Institute (STI) and Typhoon Committee Secretariat (TCS)
2. Typhoon Committee Forum: A discussion platform among the working groups of TC
   * Three Working Groups: Working Group on Meteorology (WGM), Working Group on Hydrology (WGH), Working Group on Disaster Risk Reduction (WGDRR)

NDMI has been responsible for the WGDRR session to share information related to DRR.
The Topics in the session are:

1. ENFORCEMENT DECREE OF THE FRAMEWORK ACT ON THE MANAGEMENT OF DISASTER AND SAFETY
2. Framework act on the management of disaster and safety in the Republic of Korea
3. Thailand's Act 2007 and National Plan 2015

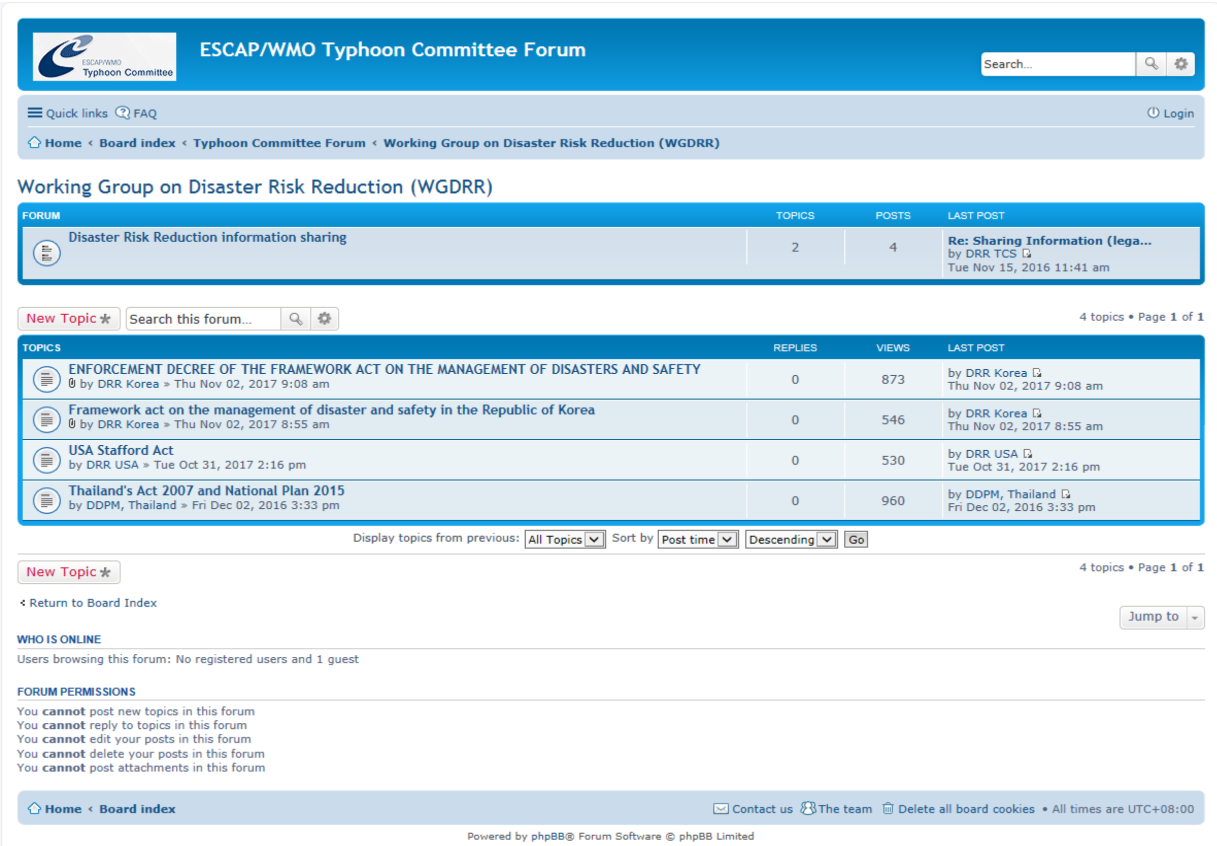

Fig. II-11. TC WGDRR Forum Website (http://www.typhooncommittee.org/forum/viewforum.php?f=12)

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

Sharing information related to DRR through the TC forum website a good framework to promote knowledge sharing among TC member countries. Also, it could be a good opportunity to share information regarding disaster risk management to the public. Therefore, NDMI will keep promoting the use of the website so that all information about the related knowledge and experience from the TC members could be a good chance to draw continuous attention of the public in the field of disaster risk reduction.

Priority Areas Addressed:

Share knowledge related to DRR among the TC member countries, and strengthen the capacity to make a strong partnership with not only the TC members but also international organizations.

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