MEMBER
REPORT
[Republic of Korea]

ESCAP/WMO Typhoon Committee
16th Integrated Workshop
(Video Conference)
2 – 3 December 2021

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 typhoons have occurred until November 25, 2021 in the western North Pacific basin. The number of typhoons in 2021 was below normal compared to the 30-year (1991−2020) average number of occurrences (25.1). Three out of twenty typhoons, including LUPIT (2109), OMAIS (2112), CHANTHU (2114), have influenced the Korean Peninsula from August to September; OMAIS (2112) made landfall on the Korean Peninsula. The tracks of the typhoons affecting the Peninsula are presented in Fig. I-1.

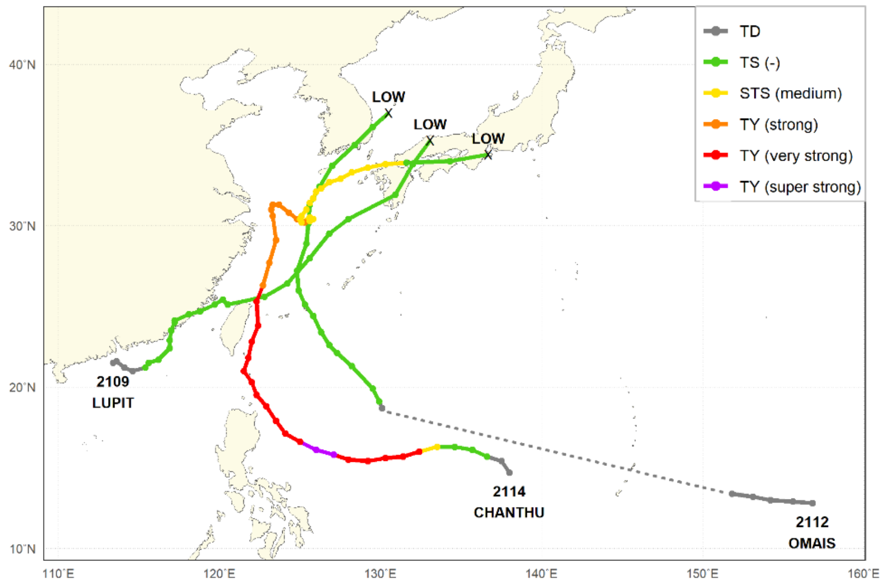


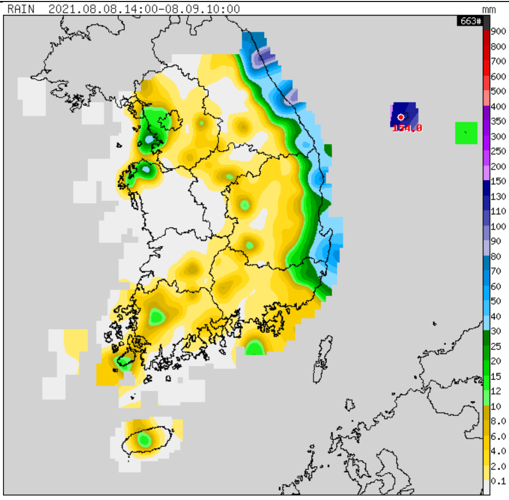
Figure I-1 TC tracks that affected the Korean Peninsula in 2021

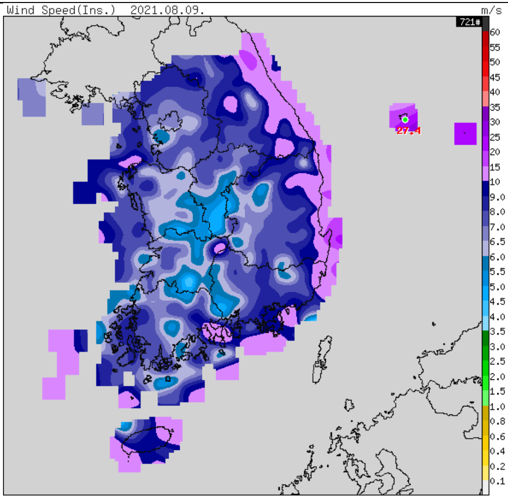
LUPIT (2109) developed to a tropical storm near the sea in Hong Kong on August 4 and landed in the southern part of China, but soon moved into the sea. Then, LUPIT (2109) moved northeast and landed near the Kagoshima, Japan. From 8 to 9 August, accumulated precipitation of more than 150 mm was recorded and a peak gust of 27.4 m/s was observed at Ulleungdo.

OMAIS (2112) made landfall near Goseong, Gyeongsangnam-do province at 15 UTC on 23 August. It passed through the southeastern part of the Korean Peninsula and moved into the East Sea. During the passage, heavy rainfall of 188 mm was recorded and a peak gust of 33 m/s was observed in the southern part of Korea.

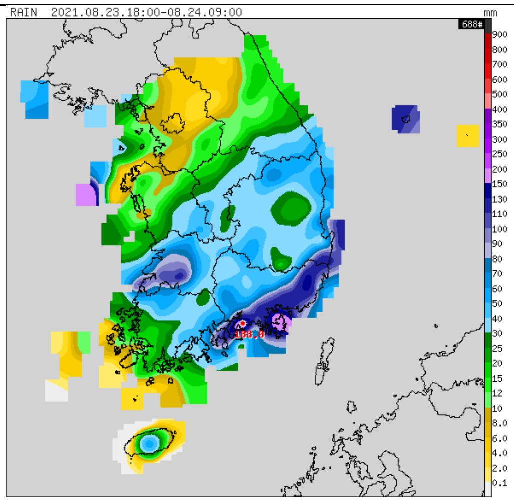
CHANTHU (2114) maintained the intensity of a tropical storm for more than 10 days. CHANTHU (2114) developed to a tropical storm in the western sea of Guam on 7 September, passed the eastern sea of Taiwan, and moved to the East China Sea on 13 September. Afterwards, however, it almost stayed and moved along the unusual track in the sea area until 15 September. Then it began to move northeast, passing the sea area south of Jeju, and it landed in Japan on 17 September. From 15 to 17 September, accumulated precipitation of more than 544 mm was recorded on Mt. Halla on Jeju Island. A peak gust exceeding 30 m/s was observed in Jeju.

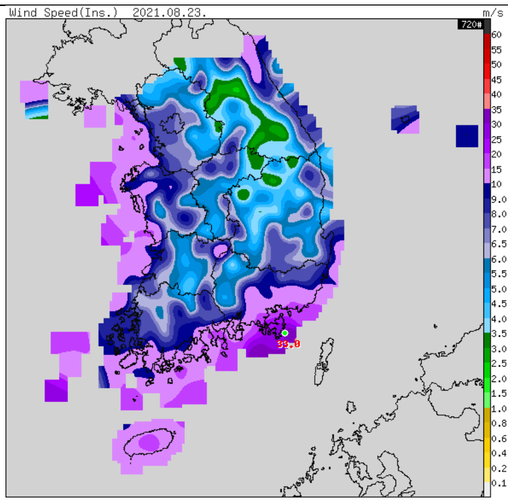
No. 9. LUPIT (August 8-9)



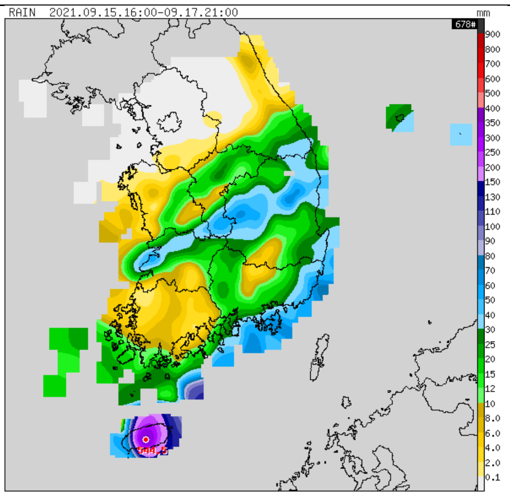


No. 12. OMAIS (August 23−24)





No. 14. CHANTHU (September 15-17)



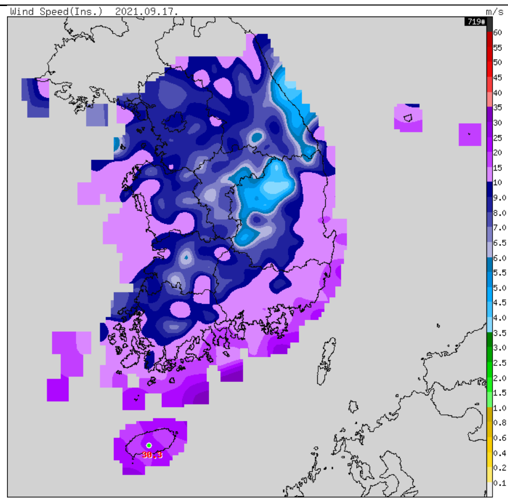


Figure I-2 Distribution of accumulated rainfall (left) and gust (right) during the passage of three typhoons affecting the Korean Peninsula.

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

Out of twenty typhoons occurred (as of October 2021), there were three typhoons directly and indirectly affected Korea from August to September, but only one, Typhoon No.12 OMAIS of them landed inland of Korea in August. Especially, Typhoon OMAIS landed on the southeastern coast of Korea at dawn on August 24th and poured a lot of rainfall as it passed through the southern region toward the east sea. The maximum accumulated precipitation for two days after OMAIS landed was 227.5 mm in Pohang City, the southeast region of Korea. Since the typhoon's landing and movement route was in the coastal region on the right side of peninsula, there was some damage to the ports and a few of local landslides occurs. The government estimated the cost of recovery for damage caused by OMAIS in nine cities and provinces of Korea at 104.9 billion KRW. In Busan, up to 70 mm of rainfall per hour fell, causing damage such as flooding of houses and vehicles. Road control was in many places. In addition, Typhoon CHANTHU moved to Japan on September 17th, passing through Jeju Island, located in the southern part of Korean Peninsula, very closely. Although it was small in size, it sprayed a lot of rainfall at around 50 mm per hour on Jeju Island while maintaining medium strength. As a result, more than 1,100 mm of heavy rain fell on Mt. Halla, located in the center of the Island, for six days. Due to Typhoon CHANTHU, a special announcement for typhoon warning was issued at the Jeju Int'l Airport and dozens of flight schedule were cancelled. However, fortunately there was no major economic loss or casualties.

In addition, the rainy season in Korea, a little later than usual, started in early July. Within five days of the start, more than 600 mm of accumulated precipitation occurred in Jeolla-do and Gyeongsan-do, the southern region of Korea. In particular, in Jeollanam-do, three people were killed and more than 500 houses were inundated due to flooding. The water level of the Yeongsan River rose by 30 cm per hour as rainwater from the streams merged into the Yeongsan River due to heavy rain. In the southern coastal area, the records of daily and hourly precipitation in July were newly updated. The submerged rice paddies in Jeollanam-do reached over 21,000 ha, and road loss and flood damage occurred in various places due to landslides.

In 2021, four Flood Control Offices of the Ministry of Environment, ROK issued only five flood watches nationwide between July and August. Although there was some of inland damage caused by typhoons and flooding this year, but fortunately, there were no severe flooding event and large-scale typhoon damage in South Korea, so the number of official issues for flood watch and warning decreased compare to the previous years.

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

There were three typhoons that have affected the Republic of Korea in 2021 (*Table 1*). Although the frequency of heavy rainfall and typhoon advisory has increased compared to those in the past 5 years (2016 ~ 2020), the damage of human and property has significantly decreased (death 18.1%, property 15.8%). There was 1 person injured from typhoon OMAIS. In addition, 3 people were dead and 1 person was injured due to the heavy rainfall from July 5th to 8th.

Table I-1 List of typhoons which have affected the Republic of Korea in 2021

No.	Typhoon Name	Period
2109	LUPIT	2021.08.04. ~ 2021.08.09.
2112	OMAIS	2021.08.20. ~ 2021.08.24.
2114	CHANTHU	2021.09.07. ~ 2021.09.18.

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

Typhoon 'LUPIT' (2109) was formed with a tropical typhoon in the southeast of Hongkong, China. It developed as moving northeast slowly. It landed in Guangdong, China with a central pressure of 985 hPa and a maximum wind speed of 21 m/s on August 5th. After landing in China, it passed through Taiwan and landed in Kagoshima, Japan with a central pressure of 985 hPa and a maximum wind speed of 21 m/s at 21:00 on August 8th. On August 9th, it was transformed into an extratropical cyclone in Osaka, Japan. LUPIT approached the east coast near South Korea. Typhoon LUPIT had affected the east side of South Korea from 8th to 9th of August. It recorded a lot of rain on the east coast and damaged to private facilities estimated at 680,000 USD for 2 days (Aug. 8th ~ 9th).

Typhoon 'OMAIS' (2112) affected South Korea from 23rd to 24th of August. It passed Jeju Island and landed Gyeongsangnam-do which is the southern part of Korean peninsula. Especially heavy rainfall, concentrated in the Pohang, Gyeongsangbuk-do, resulted in maximum 227.5mm of precipitation for 2 days. In result, total 463 blocks were inundated and one person got injured. The damage was concentrated in rivers and streams (277 cases, 57% of the public facility damages) because of the heavy rainfall exceeding the river design standards. Typhoon 'OMAIS' caused damage to properties estimated at 18 million USD (*Table 2*). Including damage costs by heavy rainfall from Jul 5th to 8th, total damage costs are 53 million USD which is 4.9% in comparison with the last year and 15.8% in comparison with the last 5 years.

Inundation of market

Inundation of market

The washed road

The washed levee

(By the courtesy of MOIS official document on October)

Figure I-3 Major pictures of damage by typhoon OMAIS in Pohang, Gyeongsangbuk-do

Table I-2 Property recovery costs by heavy rainfall and typhoon in the Republic of Korea in 2021

Categories	Total (million)	Recovery by Central Government		Recovery by Local Government
		Heavy rainfall (Jul 5~8)	Typhoon OMAIS	
Total	53	30	18	5
Public facility	43	24	15	4
Private facility	10	6	3	1

(By the courtesy of MOIS official document on October)

Typhoon ‘CHANTHU’ (2114) had affected the Republic of Korea from Sep. 13th to 17th. It moved to the southeast from Shanghai, China, stayed in the southern part of Jeju island in South Korea with a central pressure of 955 hPa and weakened to be an extratropical typhoon in Japan. Precipitation of up to 1,276 mm was recorded for 5 days (Sep. 9th ~13th) in Jeju. There were no casualties but it caused damage to property estimated at 80,000 USD.

II. Summary of Progress in Priorities supporting Key Result Areas

1. Improve the Algorithm of Typhoons Summer Prediction (POP1)

Main text:

The KMA has shared typhoon seasonal prediction results with member countries through its website until 2020. But since 2021, the information started to be provided to member countries via e-mail. The information about the number of typhoons and their track patterns is provided based on the results of three types of models: multi-regression model, global dynamical model, and two hybrid models of statistical and dynamical methods.

In early June 2021, the KMA provided member countries with summer predictions for western North Pacific typhoon-activities via e-mail. The summer seasonal outlook (June to August) predicted 9 to 14 typhoons, which is similar to the actual number of typhoons, 10. The track density was predicted to be higher in the southern sea of Japan and eastern sea of China through the eastern sea of Taiwan.

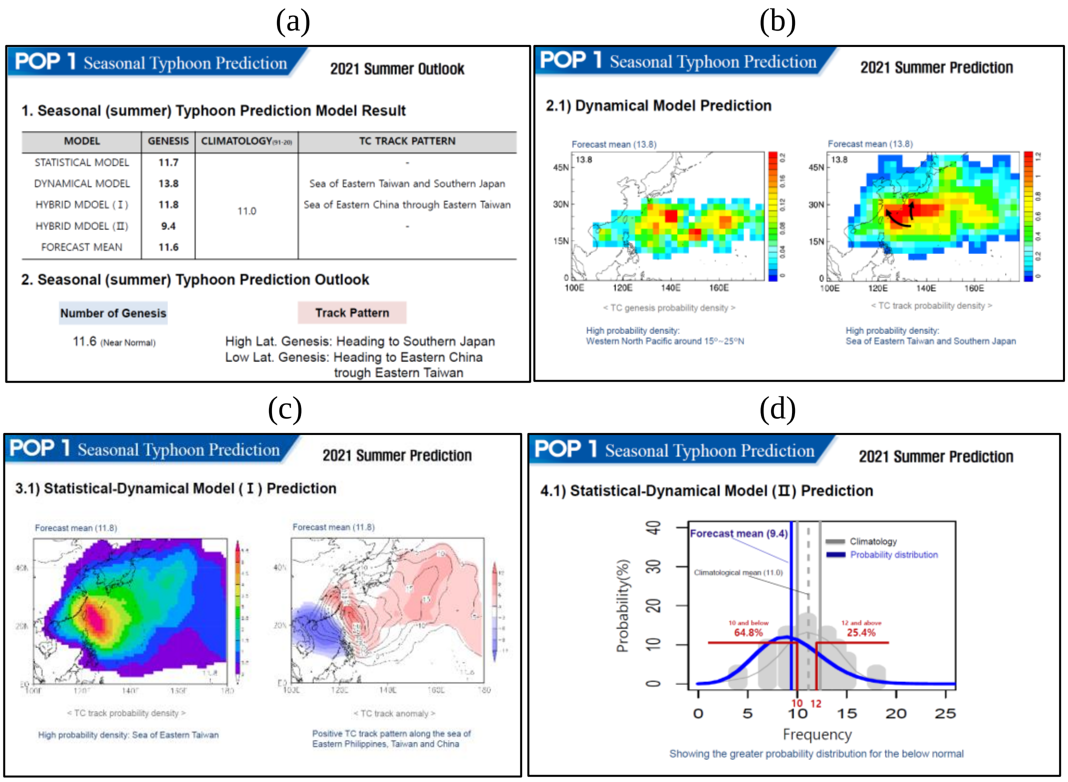


Figure II-1 Sample of KMA's typhoon summer activity outlook: (a) summer prediction results with (b) dynamical model, (c) statistical-dynamical model (I), and (d) statistical-dynamical model (II)

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

An algorithm of statistical-based typhoon season prediction using climate factors is under development. The new statistical model will be used for forecasting from the summer of 2022.

Priority Areas Addressed:

<u>Meteorology</u>

- Develop and enhance typhoon analysis and forecast techniques from short- to long-term.

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2. Extended Tropical Depression (TD) Forecast

Main text:

In 2020, the KMA started to issue five-day forecasts of tropical depressions (TDs) that are expected to develop into tropical cyclones (TCs) within the next 24 hours, rather than waiting for the TC stage to be reached before issuing forecasts. This enabled us to provide early warnings to the public and strengthen communications with the media. Since this year's typhoon season (starting from mid-May 2021), the TD stage information included strong wind areas. The full forecast information now includes tracks, intensities, areas where winds are expected to exceed 15 m/s and 25 m/s, and areas that the TC center will pass through with an estimated probability of 70%.

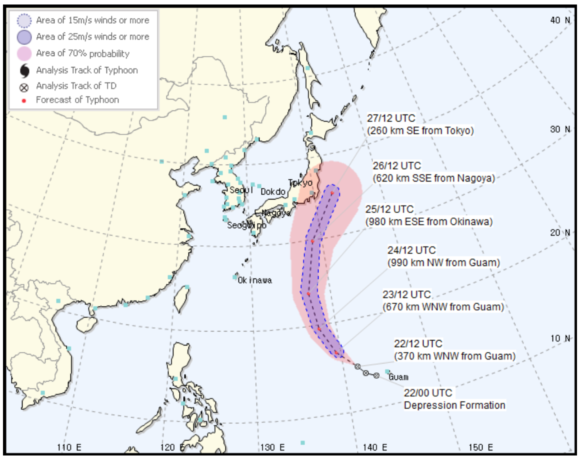

Figure II-2 KMA Tropical Depression (TD) forecast issued at 12 UTC on 22 June, 2021

Identified opportunities/challenges, if any, for further development or collaboration:
The typhoon forecast service will be improved continuously.

Priority Areas Addressed:
<u>Meteorology</u>
- Enhance the capacity to monitor and forecast typhoon activities particularly in terms of genesis, intensity and structure change.
- Develop and enhance typhoon analysis and forecast techniques from short- to long-term.

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3. Rapid Scan Service of GEO-KOMPSAT-2A

Main text:

The KMA began to operate GEO-KOMPSAT-2A (GK2A) at 00 UTC on 25 July 2019, after its successful launch on 4 December 2018. The KMA operates three different observation areas with 10-minute schedule. The GK2A's AMI (Advanced Meteorological Imager) observes the full disk (FD) image once, extended local area (ELA) five times, and local area (LA) five times within every 10 minutes. In particular, the LA mode can be used for target area observation using rapid scan such as for tropical cyclone, covering a 1,000 km x 1,000 km area every 2 minutes with flexibility for location changes. The KMA utilized this special target observation to monitor typhoons and tropical depression since 2019.

Table II-1 GK2A Rapid Scan for Typhoons, 2019-2021

Year	Total	Typhoon or Tropical Depression Names
2019	5	5th DANAS, 9th LEKIMA, 13th LINGLING, 17th TAPAH, 18th MITAG
2020	4	13th Tropical Depression, 8th BAVI, 9th MAYSAK, 10th HAISHEN
2021	2	6th IN-FA, 14th CHANTHU

The official request for target area observation is available on the 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). This will provide significant improvements in the real-time monitoring of tropical cyclones.

GK2A level-1B and level-2 products in netCDF format are available on the website of the National Meteorological Satellite Center (NMSC) (http://nmsc.kma.go.kr/enhome/html/main/main.do) and at the DCPC-NMSC (http://dcpc.nmsc.kma.go.kr). The data requested by users can be downloaded in non-real time. User registration is needed to access this service.

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

The use of GK2A rapid scan service should be encouraged to member states.

Priority Areas Addressed:

Meteorology

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

DRR

- Promote international cooperation in DRR projects.

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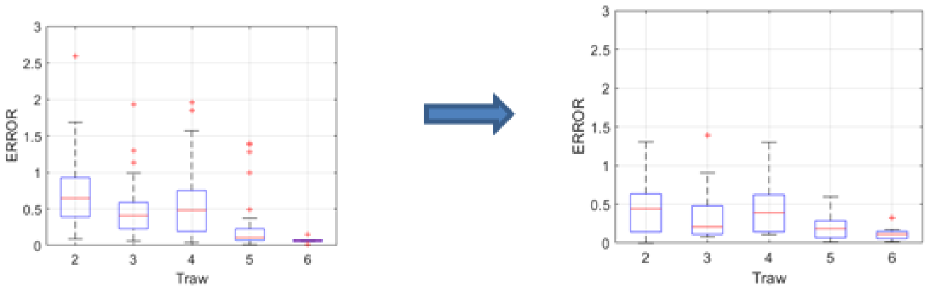
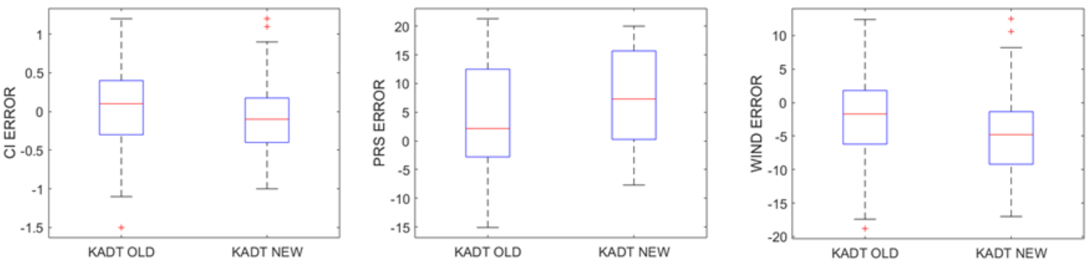
4. GEO-KOMPSAT-2A Utilization for Tropical Cyclone (PP2)

Main text:

The National Meteorological Satellite Center (NMSC) of the KMA has developed various typhoon analysis techniques to provide better information on tropical cyclones based on satellite observations, especially when TCs are approaching to the Korean Peninsula. We still use the Dvorak technique to provide TC center position and intensity information for both the subjective Dvorak technique (SDT) and the advanced Dvorak technique (ADT) analysis. However, the KMA has developed a Korean advanced Dvorak technique (K-ADT) by introducing the modified algorithm of TC center location, the ensemble TC intensity number algorithm, and the new wind speed/pressure conversion algorithm. Unlike the current ADT using the combination of spiral centering (SC) and ring fitting (RF) methods, when T# is greater or equal to 2.5, K-ADT has been using a new pattern-based TC centering algorithm by applying COMBO (SC+RF) method for eye TCs and SC method for non-eye TCs even if they are weak. Only if the TC center determined by SC algorithm is out of the normal forecast error range (1.5° within 24 hours), the storm forecast center position (FCST) is used in K-ADT. To reduce the uncertainty in TC intensity caused by the errors in the TC center, K-ADT calculated the ensemble CI number from the distance-weighted averaged CI value using nine different TC center locations. K-ADT also implemented the relationship equation between CI-maximum wind speed and CI-minimum pressure using best-track data and CI by the KMA, which is based on the methodology outlined in Knaff and Zehr (2007) and Courtney and Knaff (2009), to consider different stages, positions and moving speed of TCs and environmental background. However, from the center location validation study for 2019-2020 typhoon cases, we found K-ADT used 34% of FCST, 29% of SC, 31% of COMBO, and 6% of extra. We are adjusting the algorithm to reduce the difference of center locations between Best Track and K-ADT. The KMA will keep up our efforts to improve the accuracy of K-ADT.



(a) K-ADT Center location error (left: before, right: current)



(b) K-ADT Intencity error comparison(L: CI, M: Pressure, R: Max Wind)

Figure II-3 GK2A K-ADT Updates

Starting this year, the KMA is providing wind gust radii for the size of typhoon. The NMSC developed application techniques to improve lower level wind analysis using GK2A with other satellite data. Lower level ocean winds around tropical cyclones are based on near real-time multiplatform satellite measurements, such as cloud top temperature (CTT), atmospheric motion vectors (AMVs) of visible, infrared and water vapor bands on GK2A, microwave sounder (AMSU-A), and scatterometer (ASCAT).

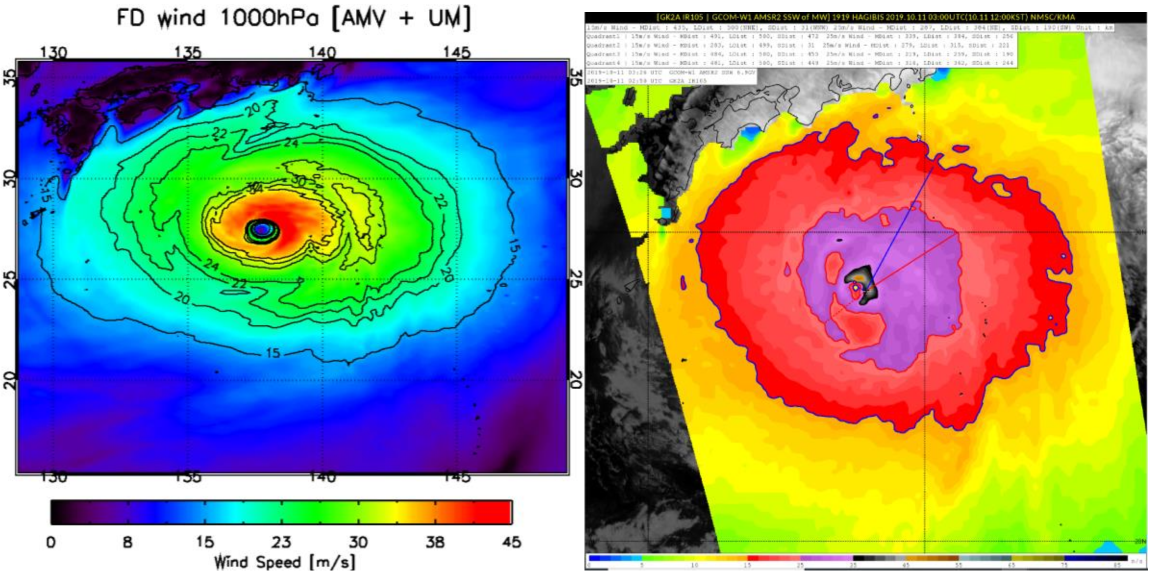


Figure II-4 GK2A Lower level wind example (2019 19th HAGIBIS)

The KMA is also developing severe warning percentile analysis for rain and wind using GK2A information. A database of 41 years (1980-2020) of historical tropical cyclones, which impacted on either precipitation or wind across the Korean Peninsula, was created. Around 28°N latitude, 90 percentile is about 4.3 mm/hr for precipitation and 33 m/s for wind speed using averaged values within 200-km radius from the center of the storm. We calculate percentile using GK2A precipitation (FD, 2km, 6.2, 7.3, 8.5, 11.2, 12.2 μm) and surface wind (FD, NWP, 3-h, 10km, grid) to provide severe warnings for dominant rain or winds.

Identified opportunities/challenges, if any, for further development or collaboration:
Lack of chance to introduce GK2A TC-related products to member states due to the COVID-19.

Priority Areas Addressed:
Meteorology
- Enhance the capacity to monitor and forecast typhoon activities particularly in terms of genesis, intensity and structure change.

DRR.
- Promote international cooperation in DRR projects.

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5. Developing Typhoon Analysis Technique based on Weather Radar Network

Main text:

The Weather Radar Center (WRC) of the KMA provided typhoon (TY) analysis information, which offers the center position (latitude, longitude), moving direction and speed of typhoons, wind speed, strong wind potential area, and heavy rainfall area, using a nationwide composite of three-dimensional radar reflectivity and doppler wind fields.

Recently, the application of artificial intelligence (AI) techniques to typhoon analysis has been on the rise. The KMA also developed a technology to analyze the center of typhoons using one of the AI techniques. The WRC produces rainfall images for the entire area of the Korean Peninsula every 5 minutes by using high resolution radar data. Radar images generated at fast time intervals are related to moving echoes, and these moving echoes are also related to the wind of typhoons. The technique that produces vectors from a sequence of image is an optical flow (OF) technique. From this OF technique, the KMA developed a technique called ACTION— automatic center detection of typhoons using image processing based on operational radar network.

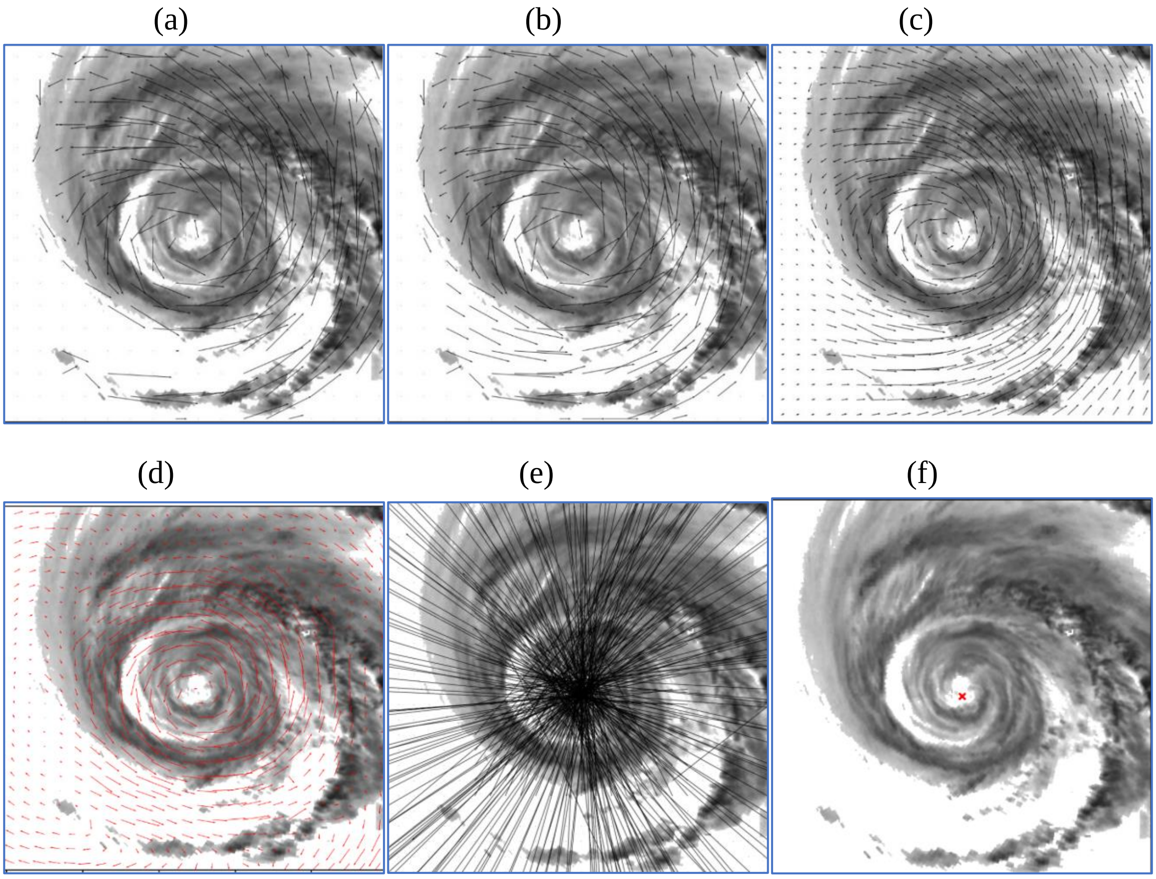

Figure II-5 Concept flow for determining the center of a typhoon based on the optical flow technique: (a) producing basic vector using frame dense optical flow, (b) producing vectors in the echo-empty area by interpolation and removing single component vectors, (c) producing dense vector field by extrapolation based on radial basis function, and (d) removing mean field vector, (e) producing the normal component of the vectors, and (f) determining the center of the typhoon.

By adding the vectors from interpolation and extrapolation in the echo-empty area, the computable vectors for determining the center of typhoons are incremented. The basic concept of ACTION is to detect the maximum rotational center by deriving motion vectors from the instantaneous change of the before and after radar images. To overcome the weakness that the movement of a typhoon itself is included in the vector, the process of removing the typhoon's own movement is added by adapting a moving window technique. This process repeats automatically every 5 minutes, and the center of a typhoon is provided.

(a) (b)

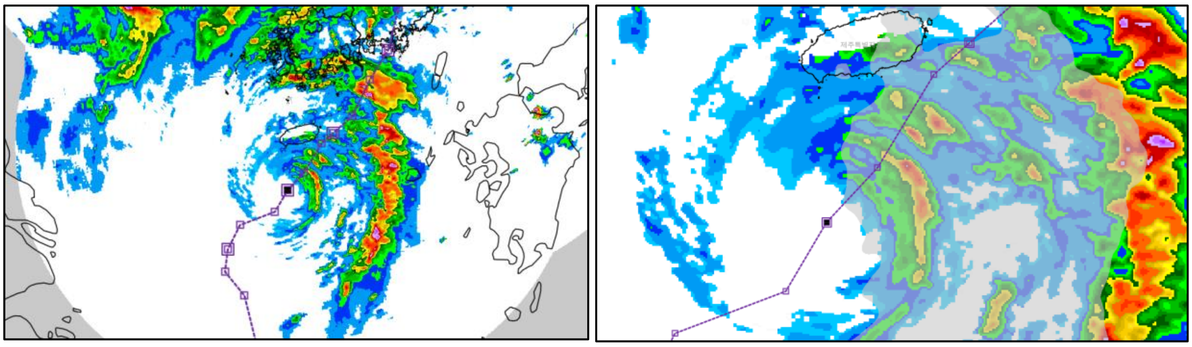

Figure II-6 Example of determining the typhoon center by ACTION: (a) Typhoon OMAIS was tracked by ACTION algorithm (filled black box indicates 23 August 2021 09UTC) (b) shaded area with gray color indicates strong wind potential area.

Regarding the TY tracking accuracy, this new tracking algorithm, ACTION, will guarantee the objectivity of the TY location, unlike human analysis based on an expert system.

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

Real-time implementation, validation and improvement of the automatic typhoon tracking algorithm (for any typhoon cases in summer 2022).

Priority Areas Addressed:

<u>Meteorology</u>

- Enhance the capacity to monitor and forecast typhoon activities particularly in terms of genesis, intensity and structure change.
- Develop and enhance typhoon analysis and forecast techniques from short- to long-term.

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6. Analysis Typhoon Intensity Using Floating Buoy Observation

Main text:

The KMA observed typhoons with a floating buoy near the Ieodo Ocean Research Station in south of Jeju Island, during the typhoon season in 2021.

OMAIS (2112) was developed on August 20 in the southeastern ocean of Okinawa, and after passing Jeju Island it landed near the coast of Goseong, Gyeongsang-do province around midnight on August 23. As the typhoon passed through the sea near the floating buoy, the buoy was continuously used to analyze the typhoon intensity and size.

(a) (b) (c)

Figure II-7 Observation with a floating buoy (a), drop the floating buoy from the Gisang 1 vessel (b) and intensity analysis of OMAIS (2112) using the buoy data (c).

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

To support real-time typhoon intensity analysis, the KMA plans to expand floating buoy observation.

Priority Areas Addressed:

<u>Meteorology</u>

- Enhance the capacity to monitor and forecast typhoon activities particularly in terms of genesis, intensity and structure change.
- Develop and enhance typhoon analysis and forecast techniques from short- to long-term.

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

Main text:

The Republic of Korea started to establish a system for hydrological data quality control in 2007, and has been effectively monitoring and managing the quality of hydrological data for major river basins nationwide. In order to improve the accuracy and reliability of flood forecasting, quality control of hydrological data is one of the key factors. 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. At this moment, even the public can easily obtain quality-controlled hydrological data online.

The project for improvement of hydrological data quality control in TC members is a five-year project that started in 2018 and is expected to complete next year, 2022. The goal of the project is to the improvement of flood prediction and forecasting performance in TC members through securing quality control of hydrological data. The detailed objectives are to diagnose the current state in the target member countries (Lao P.D.R, Malaysia, Philippines, Republic of Korea, and Thailand), to provide the direction and guidelines for hydrological data quality control, and to develop the hydrological data quality control system in TC members.

Sequentially, the baseline survey and studies on the hydrological data quality management for target countries in TC region was completed in 2018. The first and second expert missions (field surveys) for target countries in order to determine the status and analyze the needs of each member were successfully conducted in 2019. Initially it was planned to hold the expert mission wrap-up meeting in Korea in 2020 to emphasize the outcomes of expert missions and finalize the technical report with consent by TC members; however, as a face-to-face meeting was not be possible due to the unexpected prolonged COVID19. There was inevitably an online pre-meeting of wrap-up on November 27 and the final wrap-up meeting is planned to be held in November this year.

As of this year, the standard value setting for each item of quality control and measures to compensate for outliers/missing values have been confirmed. The computing module of the system has also started and is technically progressing in smooth way. Fortunately, thanks to the completion of two expert mission before the outbreak of COVID and the continuous work cooperation in the project implementation with member countries thought online meetings and virtual communications, according to the initial project plan, it seems reasonable to provide the stand-alone PC version of the basic-level hydrological data quality control system for member countries next year. In addition to the system, guidelines for quality management of hydrological data and a technical report are in progress and will be finalized in the future after reviewing among member countries.

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 and virtual communications.

Through the project, it is expected that capacity building for hydrological data quality control of TC members will be improved and qualified hydrological data can be accessible by the public.

Priority Areas Addressed:

Integrated

- N/A

Meteorology

- Develop and enhance typhoon analysis and forecast technique from short- to long-term

DRR

- Enhance Members' disaster reduction techniques and management strategies

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8. Task Improvement to Ensure Capability in National Flood Forecasting and Management

Main text:

In terms of strengthening preemptive capacity to respond to flood in South Korea, in November 2020, the Ministry of Environment participated in the Pan-Government Task Force to prepare an innovative comprehensive plan for responding to floods and relevant disasters. As part of that, this year, the Ministry of Environment has increased the spatial points for flood warnings and provision of information, so that more residents can quickly recognize flood information in nearby rivers and evacuate prior to the designated period for responding to natural disasters. Accordingly, the number of flood warning points for national and local rivers has been increased to 69 before the flood season (June 21 to September 20 every year), and it is planned to increase to 75 by the end of this year.

The flood information points, which provide the risk of vulnerable points to flooding such as parks and parking lots in rivers by real-time observation along with flood warning points, were operated at 534 points, an increase of 125 compared to the previous year (409 locations). Flood information is provided in four stages (attention – watch– warning – serious).

In addition, this year, the government made efforts to strengthen communication and cooperation with local governments and residents in establishing government-led flood management policies and strategies such as the releases of multi-purpose dams. In May, the Ministry of Environment held meetings of ‘Multilateral Communication for Flood Management with Dams’ at each of 20 multi-purpose dam sites across the country, in which local government authorities and residents participated in order to establish a cooperative system for flood management among major stakeholders in practical level. A representative requests from local residents was to write the SMS text, sent when the dam discharge is released, in an easier-to-understand way. Through this, it was expected that the residents in the downstream area of the dam could respond and evacuate more effectively in an event of flooding.

At last, by 2025, it is planned the installation of x-band small rainfall radar for local flash flood prediction in major downtown area will be expanded from the current 2 units to a maximum 9 units, so that specialized manpower and equipment for advanced flood forecasting will be secured. The observatory network with the x-band small rainfall radar can observe rainfall in an urban area with a radius of 40 km in high resolution. When the construction of the observatory network is completed, the accuracy of flood forecasting in each area will be improved, enabling preemptive responses to local flash floods. The Ministry of Environment plans further to improve the flood forecasting ability by organically managing the observation information produced from the network of the x-band small rainfall radar and the existing large radar. The Koran government is promoting various policies to prepare for the increasing risk of flooding due to climate change. The key to policy establishment is that it is important rapidly to recognize key information such as rainfall in advance in order to respond to localized torrential rains that occur frequently due to climate change.

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

In Korea, the number of forecast points (sites) is continuously increasing to improve the accuracy and timeliness of flood forecasting. In addition, by applying the latest technology such as rainfall radar to flood management, the Korean government is making active efforts to effectively respond to flash floods, which have recently increased in frequency and severity not only in Korea but also in many of member countries. It is expected that the results of these strategies to flood forecast and management will provide good lessons for developing flood prediction and flood management response strategies in member countries as well.

Priority Areas Addressed:

<u>Integrated</u>

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

<u>Meteorology</u>

- 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

<u>DRR</u>

- Enhance Members’ disaster reduction techniques and management strategies
- Share experience/know-how of DRR activities including legal and policy framework, community based DRR activities, methodology to collect disaster-related information

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9. Enhancement of Flood Information Services for the Public

Main text:

The Ministry of Environment provides the ‘Flood Alarm’ app service for flood forecast-related special warnings and information. This can be seen as a Korean policy case reflecting the principle that it is important not only to the government but also to the people themselves, to quickly recognize the flood-related risk information around them in order to respond to localized torrential heavy rainfall, which are frequently increasing recently due to climate change, etc. For special warnings and information related to flood forecasting, the public can check the flood situation across the country with their smartphone using the ‘Flood Alert’ app, and they can also receive flood information from nearby rivers.

The ‘Flood Alarm’ app was first launched in 2015 and has been continuously updated up to the presented by expanding the detailed information list, increasing the information provision site, enhancing user convenience, and improving technical errors. Through this, it has been developed to provide more accurate and useful flood-related information in a timely manner. Using the app, the public can find the volume of precipitation in each region and the water level of each river, dam, and weir in real time. In addition, if the areas or rivers with frequently visited parking lots, campgrounds, etc. is registered by a user; a real-time flood risk information through smartphone notifications can be received.

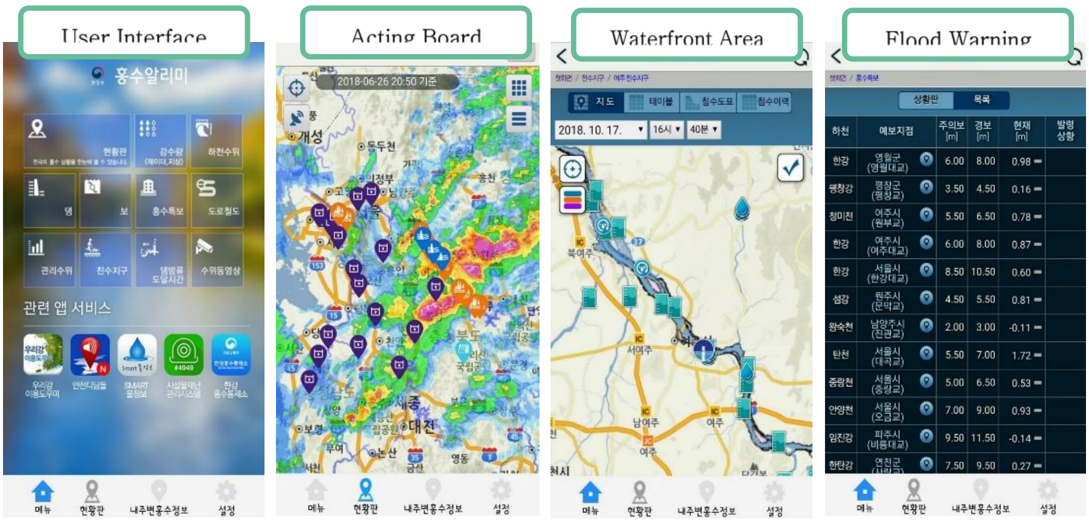

Figure II-8 ‘Flood Alarm’ application of Ministry of Environment, ROK

In addition, the establishment of flood risk map of Korea, marked the inundation risk areas by flood around rivers across the country, 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 Ministry of Environment has published an online version of the Flood Risk Map on the Flood Risk Map Information System (www.floodmap.go.kr) since March of this year so that anyone can easily find it. In the past, flood risk maps were prepared and distributed by the Flood Control Office of the ME to support the efficient disaster prevention work of local governments. However, as the flood risk map in released online this time, it is expected that the map will be used more effectively for the general public to quickly identify flood risk areas and evacuate from them.

The flood risk map, released online this year, provides detailed inundation prediction information for 2,982 km of national rivers and 18,795 km of local rivers in the major river basins in South Korea. The public can find the range of flood risk and estimated depth of flooding through reaching the name of river in the online portal system. The range of risk and inundation depth indicated on the map are from the results of hypothetical analysis that the extreme conditions of levee collapse and overflow occur based on the relevant flood scenario, and have nothing to do with the safety of the actual hydraulic facilities in a river.

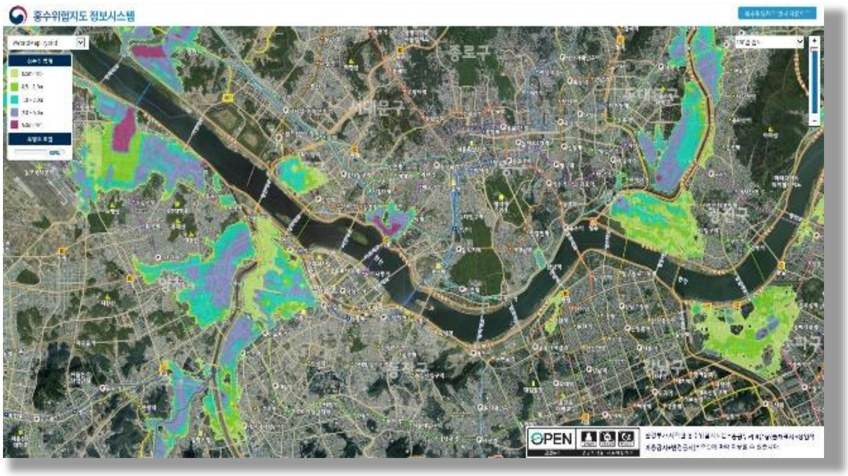

Figure II-9 Online-version of Flood Risk Map by Ministry of Environment, ROK

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

In order to prepare effective countermeasures against natural disasters such as typhoons and floods, accurate and appropriate information and data management is necessary. In particular, in today's complex and organic conditions of individual life forms and social environments, individual access to information should be secured. In the past, disaster management authorities such as the government or local governments unilaterally provided disaster information and response measurements in a top-down format. However, it is more important at this moment to have a system that allows individuals to independently check disaster information, make a choice, and then actively respond in the event of a disaster.

It is considered that the flood information app and online flood risk map will be good reference cases for member countries for the establishment of disaster information management strategies to reduce the socioeconomic and loss of life caused by typhoons and floods.

Priority Areas Addressed:

Integrated

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

Meteorology

- Strengthen the cooperation with WGH and WGDRR to develop impact-based forecast and risk-based warning

DRR

- Enhance Members' disaster reduction techniques and management strategies
- Share experience/know-how of DRR activities including legal and policy framework, community based DRR activities, methodology to collect disaster-related information

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10. 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 research 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 2021. However, due to the outbreak of COVID-19 around the World NDMI decided to postpone the seminar to next year 2022.

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

- NDMI would need to consider another way to achieve 'Capacity Building / Knowledge sharing in DRR' such as holding virtual meeting or publishment to share information and experiences on DRR

Priority Areas Addressed:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee.
- Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism

Meteorology

- Promote communication among typhoon operational forecast and research communities in Typhoon Committee region

DRR

- Share experience/know-how of DRR activities including legal and policy framework, community-based DRR activities, methodology to collect disaster-related information
- Promote international cooperation of DRR implementation project

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11. Setting up Early Warning and Alert System

Main text:

Since 2013, NDMI has been implementing Global DRR project to strengthen the countries' capability of flash flood preparedness. NDMI conducted the project with the Philippines from 2013 to 2015 and with Lao PDR and Vietnam from 2016 to 2019. In 2020, NDMI planned to implement the project with Lao PDR as requested.

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

- Conducting Field Survey
- Installation and Inspection

  * Warning Post (WP), Rainfall Gauge (RG), Water Level Gauge (WG)
- Operating Educational Program

NDMI had decided to install ARWS in Houaphanh and Xaisomboun Province through discussion with the Department of Meteorology and Hydrology (DMH). NDMI conducted field survey for positioning ARWS and river surveying. Through the meeting with DMH and the local government of Houaphanh and Xaisomboun province, NDMI chose five places for WP, RG and WG in Sam Neua, Houaphanh and one place in Thathom, Xaisomboun. NDMI were expected to install ARWS on November 2021 however, due to the outbreak in Lao PDR, NDMI had to delay the installment until April, 2022.

Figure II-10 Pictures of Conducting Field Survey in Houaphanh, Lao PDR


Figure II-11 Pictures of Conducting Field Survey in Xaisomboun, Lao PDR

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

- Next year, NDMI will initiate the DRR project on installing ARWS and FFAS in the Philippine. In addition, NDMI is planning to expand the project to Fiji for 2023.

Priority Areas Addressed:

<u>Integrated</u>

- Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism

<u>Meteorology</u>

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

Hydrology

- 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

DRR

- Enhance members' disaster reduction techniques and management strategies
- Promote international cooperation of DRR implementation project

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12. The 16th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (VC)

Main text:

The 16th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (TC WGDRR) led by NDMI was held virtually on 5th of November. Including WMO, ESCAP, TCS, ADRC, and TC members, total 23 were participated in the meeting. The meeting featured the review of activities & budget in 2021 and discussed Annual Operations Plans (AOPs) & budget for 2022. As a discussion result, WGDRR decided tentative 2022 AOPs & Budget.

Table II-2 Annual Operations Plans (AOPs) with budget in 2022.

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	-	**Total Budget (USD)**		18,000

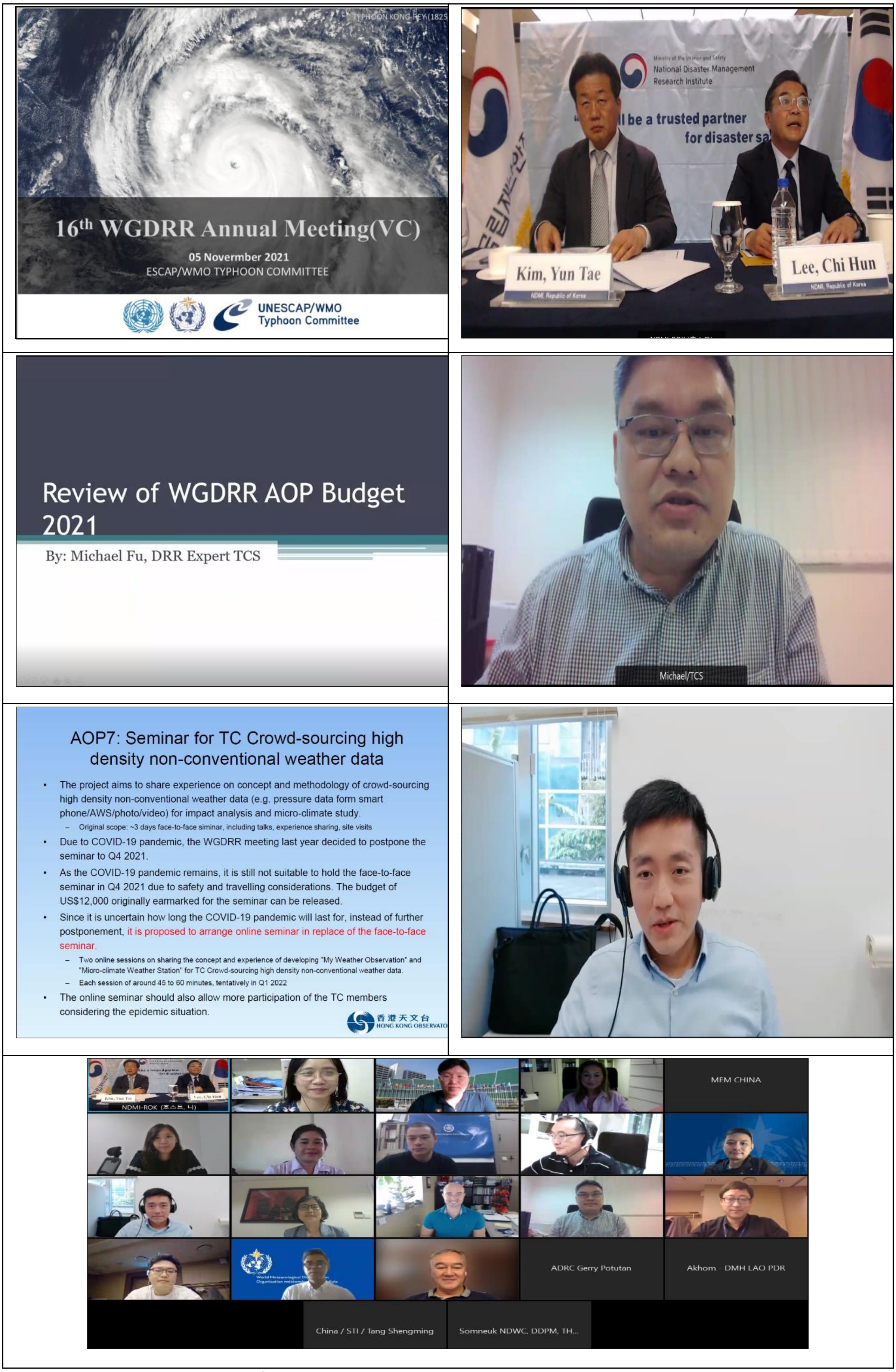

Figure II-12 Pictures of the 16th Annual Meeting of TC WGDRR (VC)

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

By 16th TC WGDRR Annual Meeting, WGDRR could review WGDRR's achievements in 2021 and build strategic plans for 2022. It was a great chance to find ways for advancement of WGDRR as well as for contribution to strengthen the capability of disaster risk reduction on the member countries.

Priority Areas Addressed:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee
- Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism

DRR

- Promote international cooperation of DRR implementation project
- Share experience/know-how of DRR activities including legal and policy frame work, community-based DRR activities, methodology to collect disaster-related information

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13. Sharing Information Related to DRR

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:

- Shanghai Typhoon Institute Typhoon BBS: A discussion platform for typhoons, moderated by S hanghai Typhoon Institute (STI) and Typhoon Committee Secretariat (TCS)
- 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:

- ENFORCEMENT DECREE OF THE FRAMEWORK ACT ON THE MANAGEMENT OF D ISASTER AND SAFETY
- Framework act on the management of disaster and safety in the Republic of Korea
- Thailand's Act 2007 and National Plan 2015

Figure II-13 *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 could be a good example 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:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee
- Enhance collaborative activities with other regional/international frameworks/organizations, including TC and PTC cooperation mechanism

DRR

- Promote international cooperation of DRR implementation project

- Share experience/know-how of DRR activities including legal and policy frame work, community-based DRR activities, methodology to collect disaster-related information

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