MEMBER REPORT [Republic of Korea]

ESCAP/WMO Typhoon Committee
19th Integrated Workshop
Shanghai, China
19 - 22 November 2024

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)
2. Hydrological Assessment (highlighting water-related issues/impact)
3. Socio-Economic Assessment (highlighting socio-economic and DRR issues/impacts)
4. Regional Cooperation (highlighting regional cooperation and related activities)

II. Summary of Progress in Priorities supporting Key Result Areas

[WGM]

1. Improvement of the Algorithm for Summer Typhoon Prediction (POP1)
2. Deployment of Drifting Buoys for Typhoon Forecasts and Analysis (AOP12)
3. Development of AI-Based TC Automatic Analysis System
4. Experimental Service for Commentary on Typhoon Forecasts
5. GEO-KOMPSAT-2A Utilization for Tropical Cyclones (AOP10)

[WGH]

6. Improvement of Hydrological Data Quality Control System in TC Members
7. Enhancing Flood Forecasts and Providing Customized Flood Information
8. Flood Warning Alarm through Navigation Service

[WGDRR]

9. Capacity Building / Knowledge sharing in DRR
10. Setting up Early Warning and Alert System
11. The 19th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction
12. Sharing Information Related to DRR

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 as of November 5, 2024 in the Western North Pacific basin. The number of typhoons in 2024 was near normal compared to the 30-year (1991-2020) average number of occurrences (25.1). Eight typhoons formed between June and August, which is below the average of 11. However, in September, eight typhoons developed, exceeding the normal rate of 5.1. Two typhoons, JONGDARI (2409) and SHANSHAN (2410), influenced the Korean Peninsula. The tracks of Typhoon JONGDARI and SHANSHAN are presented in Fig. I-2.

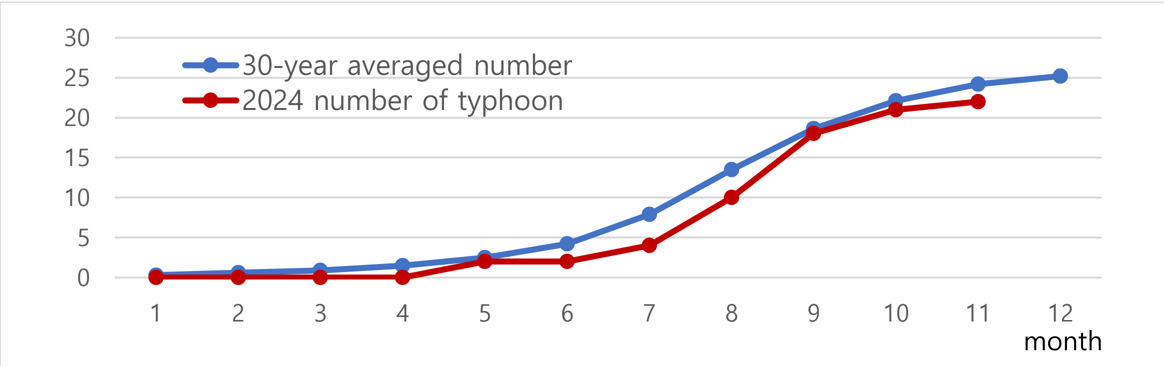


Figure I-1 Comparison of monthly accumulated typhoon occurrences in 2024.

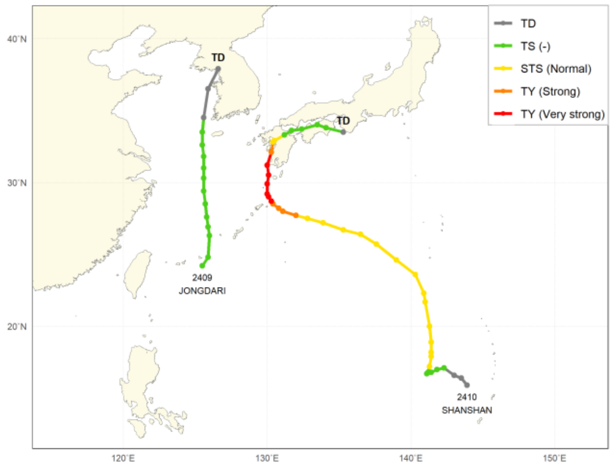


Figure I-2 TC tracks that affected the Korean Peninsula in 2024.

JONGDARI (2409) developed as TS (tropical storm) at 18 UTC on August 18, near the ocean south of Okinawa and moved north-ward. It then entered the Emergency Zone of the Korea Meteorological Administration (KMA) (north of 28N, west of 132E), but its intensification was limited due to interference from the strong Tibetan High centered over Jeju Island. As it passed Jeju, its minimum central pressure was 1000 hPa, and maximum sustained winds were 18 m/s. As JONGDARI entered the West Sea, there were no observations of wind speeds over 17 m/s near the center of the storm. It weakened to a TD (tropical depression) at 12 UTC on August 20 near Heuksando, near the southern west coast. The TD then moved northward over the west coast, bringing precipitation to the Korean Peninsula. On August 20, accumulated precipitation of 169 mm was recorded and a peak gust of 29.9 m/s was observed on Mt. Halla on Jeju Island. Since 2024, KMA has issued a special explanatory typhoon information as a test run, specifically for impactful typhoons. This information is only available in Korean and is released once daily. It contains the current analysis information of a typhoon, the status of the environment, and an explanation of potential further changes. The explanatory information for JONGDARI was issued twice at 06 UTC on August 19 and 20.

SHANSHAN (2410) developed as a fTD (forecast tropical depression) at 00 UTC on August 21, and it was upgraded to a TS at 18 UTC the same day, near Guam. SHANSHAN passed through a region of warm pool and weak vertical wind shear, allowing it to reach a central minimum pressure of 935 hPa. It moved very slowly at a speed of 10 m/s due to the weak steering flow. Although it moved slowly, there was not much weakening of intensity from the sea surface cooling associated with upwelling. SHANSHAN moved westward more than initially expected and then turned northeast. It made landfall in Kyushu, Japan, and weakened as it moved inland. The southeast sea of Korea was included in the typhoon's strong wind area, resulting in precipitation impacts on the eastern side of the Korean Peninsula. From 28 to 29 August, accumulated precipitation of 168 mm was recorded at east coast region of the Korean Peninsula, and a peak gust of 26.9 m/s was observed on Maemuldo in south-eastern part of the Korean Peninsula.

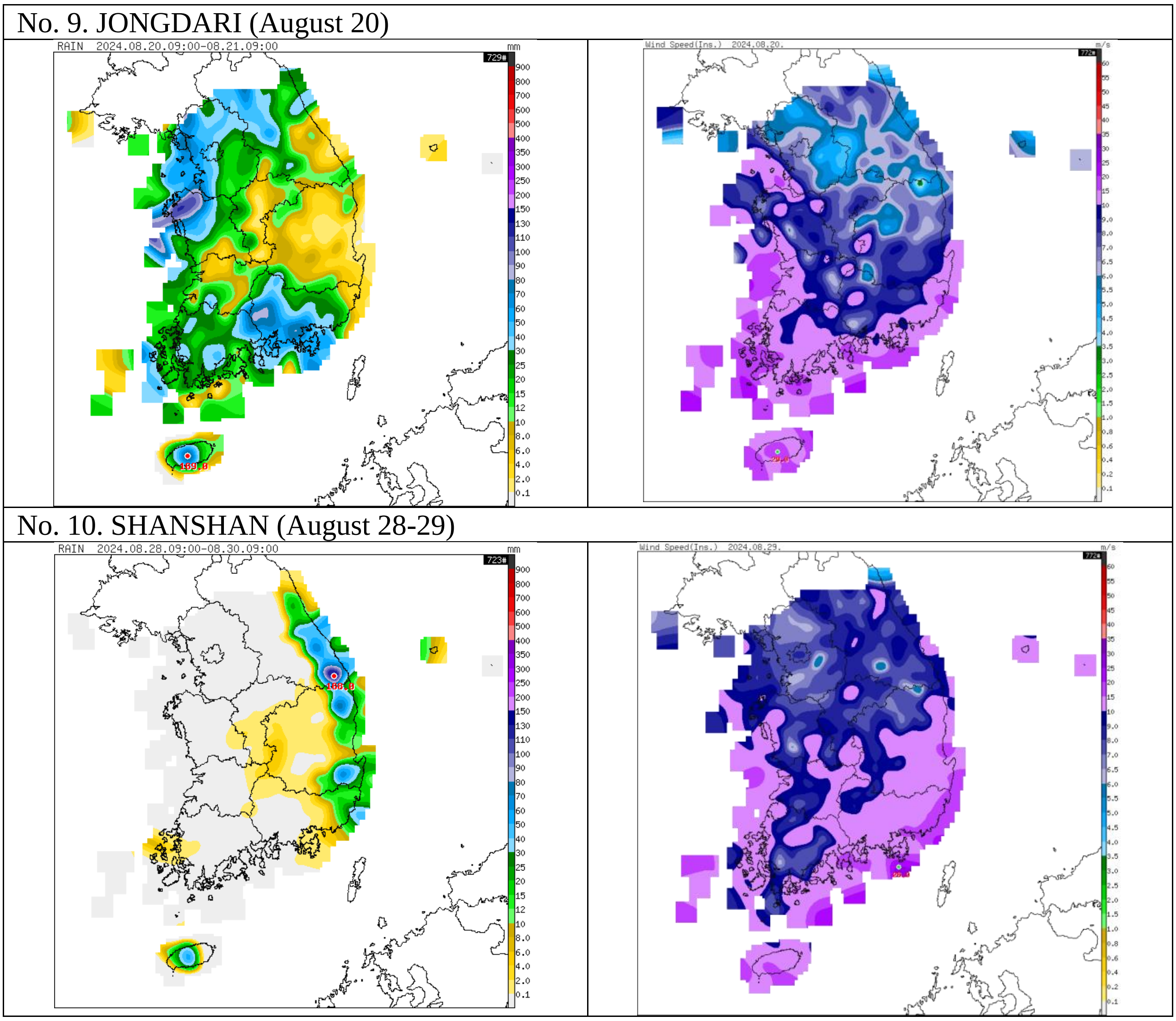


Figure I-3 Distribution of accumulated rainfall (left) and gust (right) during the passage of two typhoons affecting the Korean Peninsula in 2024.

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

Of 19 typhoons were monitored in this year (as of 23 September 2024), TWO typhoons have indirectly affected the Republic of Korean (hereafter, ROK). The Typhoon No. 9 JONGDARI moved northward and came very close to the ROK on 21 August and its path of occurrence is illustrated in Figure I-4. In addition, the typhoon No. 10 SHANSHAN had indirect impacts especially to southern parts of the ROK.

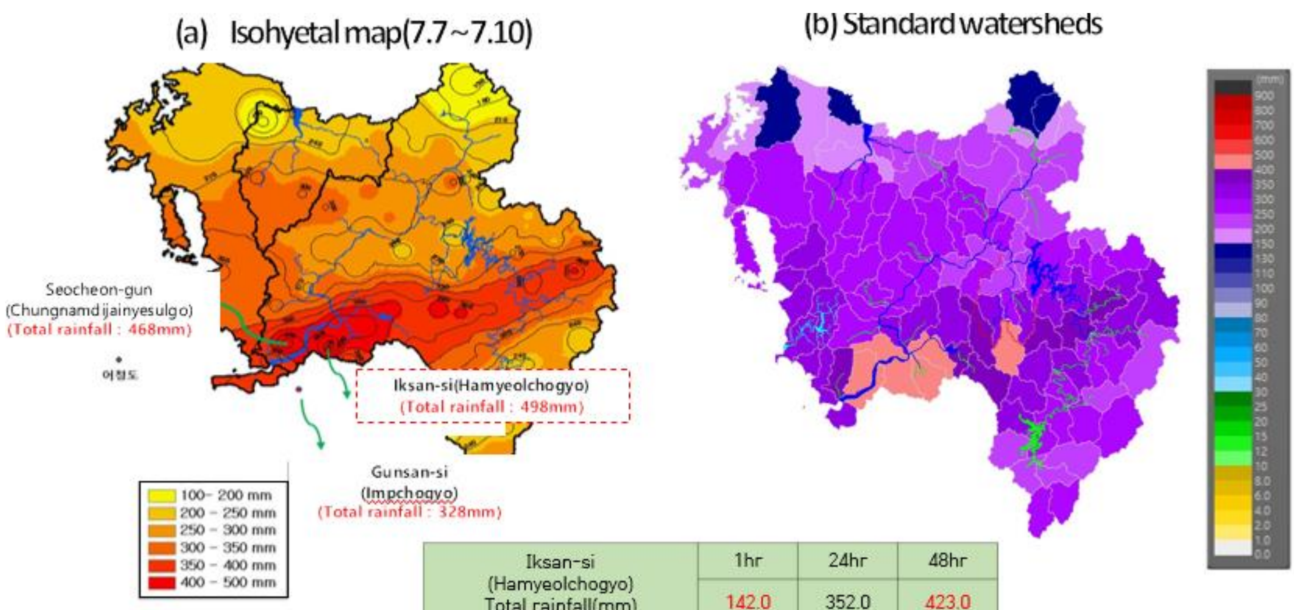
Figure I-4 Path of occurrence for Typhoon No. 9 JONGDARI

The typhoon JONGDARI was the first typhoon which affected ROK in 2024 and has caused 1 casualty and a victim was hurt. However, overall damages were general minimal. Typhoon JONGDARI was recognized as a very rare type of typhoon as it struck lightning with a very strong intensity, which is very rare in the ROK. In particular, as many as 1,300 lightning strikes were observed overnight near the Jeollanam Province.

Even though the certain regions were affected by two typhoons in August, the typhoons changed their expected paths and avoided to landing on the ROK without significant flooding damages caused from typhoons. Since the year of 1951 in the ROK, there were only two years, 1988 and 2009, when were no typhoon landing. As of mid of October, it is highly possible that there would be no typhoon landing in the ROK in 2024. This is analyzed as the result of two large high-pressure systems pushing back the typhoons, which caused the record-breaking heat wave and tropical night nation until early of October in the ROK. As two high pressures took hold, they influenced the path of typhoons moving toward the ROK.

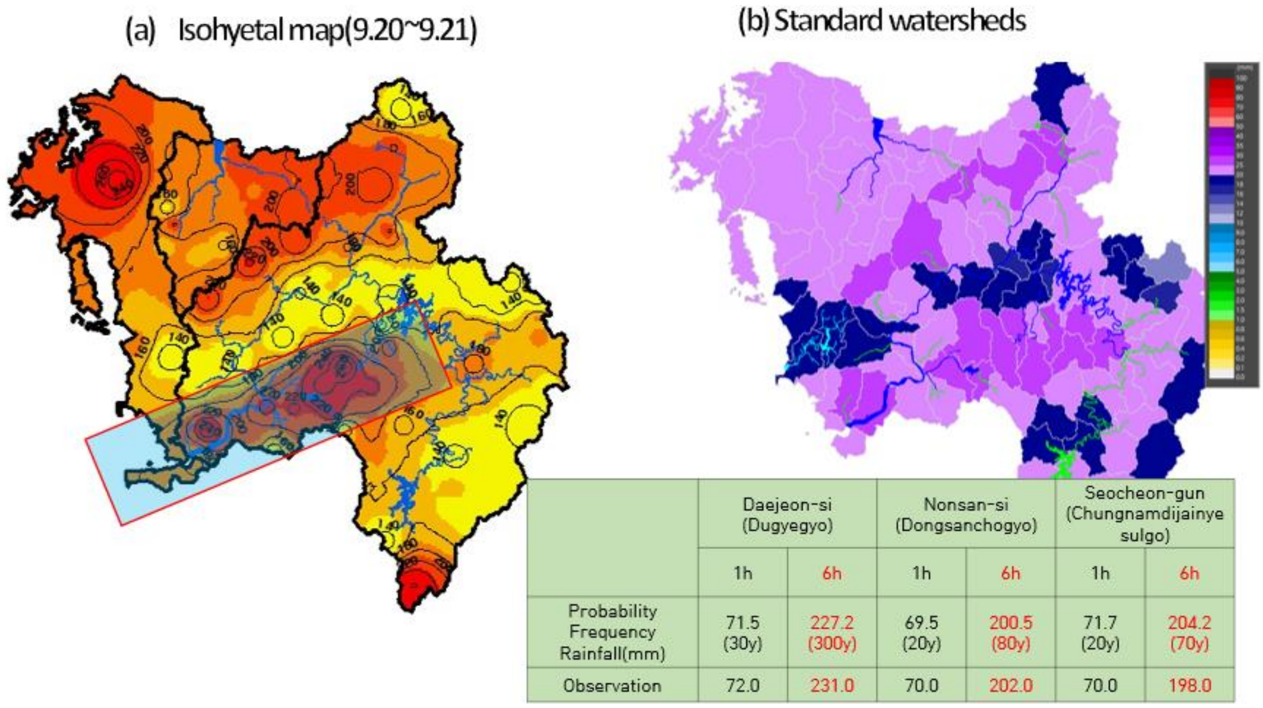
The flood forecasting sites have increased from existing 75 to 223 sites in 2024. The Flood Control Offices of ROK, located across the country, issued the total of 134 flood watches and 38 flood warnings nationwide between July to September in 2024. Considering there were 71 and 22 cases respectively compared to the similar period last year, the number of issued watches and warnings has increased this year. Rather than being caused by a flood from typhoons, this is analyzed to be due to heavy torrential rainfall in the Jeollabuk Province (located in the southwest), the Chungcheong Province (located in the central area), and the Gyeongsang Province (located in the southeast) in mid-July. It is also caused by the expansion of increasing flood warning sites from national rivers to local rivers.

Geum River Basin received unprecedented rainfall amount during the summer season in 2024. About 400~500 mm of areal rainfall has been observed in the Geum River Basin within 4 days from July 7 to 10, which corresponded to frequency of about 500-years for rainfall durations of 1 to 24 hours. The areal rainfall isohyetal map in the overall river basin and respective standard watersheds in the Geum River Basin are presented in Figure I-5. 41 flood bulletins have been issued just within 24 hours in July 10, indicating that this extreme storm has generated significant amount of runoff and causing the water levels to rise abruptly for rivers located in Geum River Basin. Geum River Basin was also attacked by another extreme storm from Sep 20 to 21, where it received about 230 mm of areal rainfall that corresponded to frequency of about 70 to 300-years for 6-hours rainfall duration. The areal rainfall isohyetal map in the overall river basin and respective standard watersheds in the Geum River Basin during the extreme storm in Sept are presented in Figure Figure I-6. 22 flood bulletins have been issued intensively within 24 hours in Sep 21.



Iksan-si (Hamyeolchogyo) Total rainfall(mm)		1hr	24hr	48hr
		142.0	352.0	423.0
Probability Frequency Rainfall (mm)	200 year	94.7	314.0	362.0
	500 year	103.5	364.0	410.0

Figure I-5 Areal rainfall isohyetal map in the overall river basin and respective standard watersheds in the Geum River Basin during the extreme storm in July 2024



	Daejeon-si (Dugyegyo)		Nonsan-si (Dongsanchogyo)		Seocheon-gun (Chungnamdijainyesulgo)	
	1h	6h	1h	6h	1h	6h
Probability Frequency Rainfall(mm)	71.5 (30y)	227.2 (300y)	69.5 (20y)	200.5 (80y)	71.7 (20y)	204.2 (70y)
Observation	72.0	231.0	70.0	202.0	70.0	198.0

Figure I-6 The areal rainfall isohyetal map in the overall river basin and respective standard watersheds in the Geum River Basin during the extreme storm in September 2024

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

There were a total two typhoons that affected the Republic of Korea this year (Table I-1). Among them – SHANSHAN and JONGDARI, the JONGDARI has caused economic losses.

Table I-1 List of typhoons that affected the Republic of Korea in 2024

No.	Typhoon Name	Duration
2409	JONGDARI	19 ~ 20 August, 2024
2410	SHANSHAN	22 ~ 31 August, 2024

While typhoon JONGDARI has been affecting the Republic of Korea, the heavy rain warning has been issued for the metropolitan area, inland areas of Gangwon, mountainous regions, and the Chungnam region, with strong showers of 30 to 50 mm per hour accompanied by gusty winds and thunder. Fortunately, no casualties were reported, though there were incidents of vehicle flooding in Ulsan and store flooding in Chungnam. Several facilities, including national parks, roads, and rivers, were temporarily closed. In Gyeongju, six residents evacuated due to landslide concerns but safely returned home. The Central Disaster and Safety Countermeasures Headquarters initiated emergency operations and convened meetings to manage the situation. Various ministries, such as the Ministry of Land, Infrastructure and Transport (MOLIT) and the Ministry of Environment (MOE), maintained emergency shifts to ensure safety. Firefighters were pre-deployed, and the Coast Guard directed fishing vessels to safe waters. Preventive measures, including mooring vessels and securing outdoor billboards, were implemented.

A heavy rain has affected in South Korea from September 19 to 20. All heavy rain warnings were lifted by 21:30 on September 21, although light rain persisted in southern regions and Jeju. Jeju recorded 764.5mm of rainfall, and Changwon saw 519.2mm, with some areas experiencing intense downpours exceeding 100mm per hour. No casualties occurred, but flooding affected 170 houses and 26 stores. Agricultural damage was significant, with 4,116 hectares of farmland impacted. Many facilities, including 641 sections of national parks, 155 riverside parking areas, and 55 ferry routes, were temporarily closed. More than 1,500 people evacuated, and 455 households remained unable to return home. Emergency shelters and relief supplies were provided, including food, blankets, and personal care kits. Government agencies operated under emergency protocols, managing safety measures such as flood control and dam releases. Central and local disaster management agencies held meetings to assess risks and coordinate evacuations

II. Summary of Progress in Priorities supporting Key Result Areas

1. Improvement of the Algorithm for Summer Typhoon Prediction (POP1)

Main text:

The National Typhoon Center of the Korea Meteorological Administration (NTC/KMA) has been continuously improving seasonal prediction techniques since 2021 to enhance the accuracy of typhoon summer outlooks and improve responses to typhoon damage in the WNP region in advance. With four improved types of seasonal prediction models, NTC produced a prediction for the summer season (June to August) in 2024 and shared the results with member countries via email in early June. With oceanic and atmospheric environmental indicators, four types of models were used for the 2024 summer typhoon forecast as follows:

- (New) Statistical Model: Predictable TC Frequency
- Dynamic Model based on GloSea6: Predictable TC frequency and track density
- Statistical-Dynamic Hybrid I based on CFS: Predictable TC frequency and track density
- Statistical-Dynamic Hybrid II based on GloSea6: Predictable TC frequency and track density

A new statistical model, developed in 2022, uses a variety of climate index predictors such as PMM, TSA, IOD, and Sea Ice. For the summer season (June to August) in 2024, it predicted a TC frequency of 6.1 in the west domain of 140E, while showing a prediction of 0 in the east domain of 140E. Therefore, its results showed a below-normal prediction.

The Glosea6-based dynamic model predicted high activity in northeast sea area of the Philippines and south of Japan. Tracks from the northeast sea of the Philippines to the South China Sea, or from Guam to the southeast sea area of Japan, were expected to have a TC frequency of 7.6.

In 2024, the regression equation for the CFS-based hybrid model was updated by extending the statistical analysis period of CFS data and typhoon tracks from 1982-2015 to 1982-2022. New predictors and regression equations were developed to improve seasonal prediction accuracy. The model predicted an increase in track density from the northeast sea of the Philippines to the South China Sea, with a TC frequency of 9.3 during the summer season.

In the GloSea6-based hybrid II model case, only historical observations of GMSST and SOI were previously used to construct a regression equation for predicting typhoon activity during summer. In 2024, the model was improved by adding GloSea6 hindcast values to better reflect climate characteristics. The model predicted an increase in track density from near the Philippines to the South China Sea, with a TC frequency of 6.2 for June to August 2024.

With the weakening of El Niño, which peaked in winter 2023, many seasonal prediction models predicted a transition to neutral conditions in summer 2024, eventually leading to La Niña conditions. Compared to historical observations, typhoon activity during early summer was generally reduced, similar to the decaying years of El Niño. Most models predicted below-normal typhoon activity for the summer of 2024. During the period from June to August 2024, eight typhoons were observed, which is below the 30-year average of 11.

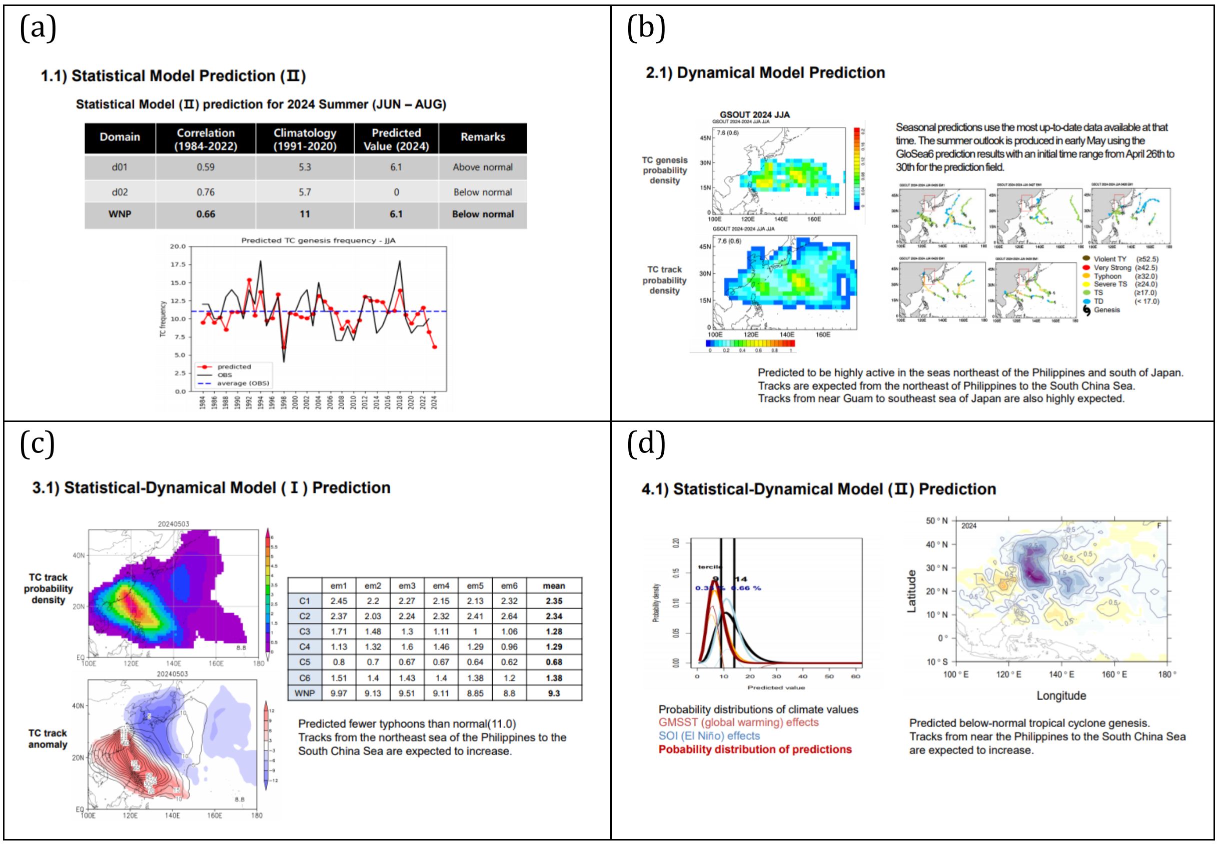


Figure II-1 Examples of KMA's typhoon summer activity outlook for 2024: Summer prediction results with (a) (new) statistical model, (b) dynamical model, (c) statistical-dynamical model and (d) statistical-dynamical model (II).

Identified opportunities/challenges, if any, for further development or collaboration:
It is planned that techniques for probability-based seasonal predictions of typhoons will be developed. The summer 2025 outlook, based on the improved models, will be shared with members in early June 2025.

Priority Areas Addressed:
<u>Meteorology</u>
- Develop and enhance typhoon analysis and forecast techniques from nowcast to medium-range, and seasonal to long-range prediction.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:
Member: Republic of Korea
Name of contact for this item: Ms Seonghee Won
Telephone: +82-64-909-3960
Email: shwon11@korea.kr

2. Deployment of Drifting Buoys for Typhoon Forecasts and Analysis (AOP12)

Main text:

Since 2022, NTC/KMA has deployed drifting buoys in the WNP to address the lack of observations in the ocean, focusing on analyzing the development of typhoon intensity every summer. In 2024, following the action of AOP12 by the Working Group on Meteorology, NTC/KMA deployed 7 drifting buoys and shared real-time observational data with member countries through the GTS. To reduce the potential for pressure observation errors caused by external impacts on the sensors, which occurred during previous experiments, the buoys were replaced with ball-shaped drifting buoys in 2024 to enhance observational performance. In collaboration with Jeju University, the Korea Institute of Ocean Science and Technology (KIOST), and National Taiwan University, it was possible to use research vessels to drop the buoys in the far ocean. In collaboration with National Taiwan Normal University (NTNU), 3 buoys were deployed between August 16 and 18. With the use of KIOST's research vessel, one buoy was deployed in the southern region of the EEZ on August 18, and 3 additional buoys were deployed in the eastern sea area of the Philippines between August 21 and 25.

A webpage has been operated for sharing observation data (http://hms.otronix.com:60481/), accessible through login. Observed pressure and temperature, recorded every 30 minutes, are displayed on the website in a table and also as a time series when each value is clicked. The expected operating period of each buoy is about 3 months. As Typhoon JONGDARI (2409), BEBINCA (2413), PULASAN(2414) and KONG-REY(2421) approached the observation site of a buoy, SST and pressure near the typhoon were observed.

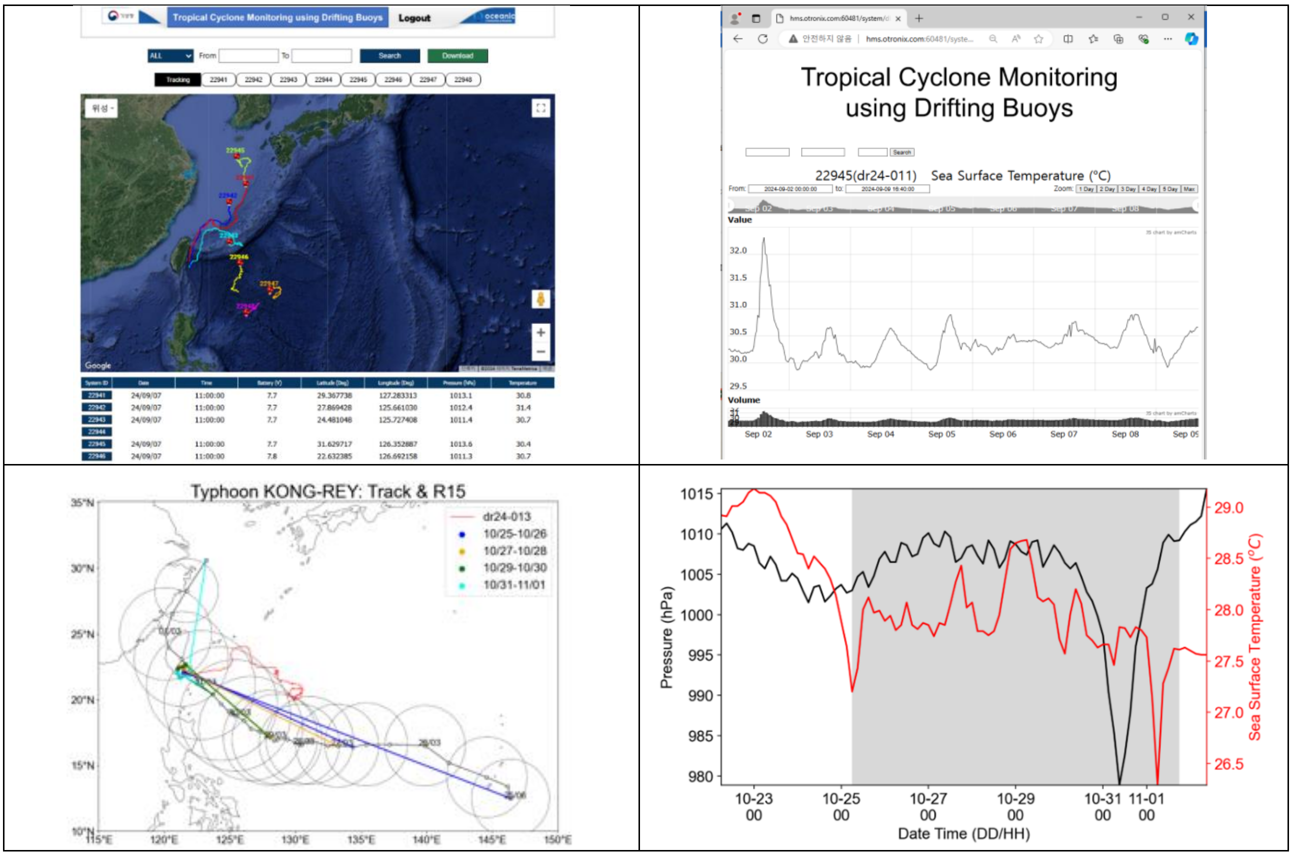


Figure II-2 Example of analysis results for a typhoon using drifting buoys.

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

In 2025, drifting buoys are planned to be deployed in the WNP and will share real-time data with member countries through the GTS or a webpage.

Priority Areas Addressed:
Meteorology

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

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:
Member: Republic of Korea
Name of contact for this item: Ms Seonghee Won
Telephone: +82-64-909-3960
Email: shwon11@korea.kr

3. Development of AI-Based TC Automatic Analysis System

Main text:

NTC/KMA has developed an AI model for automatic TC analysis since 2022 with the aim of providing TC forecasters with guidelines for real-time TC analysis. The automatic TC analysis system is composed of three parts: TC center, intensity, and size. The automatic TC center and intensity analysis models have been developed based on two machine learning methods: CNN and ConvLSTM. The former model uses 5 different satellite images with a combination of single and brightness temperature differences, while the latter model uses 3 different satellite images as input. Therefore, the automatic TC center and intensity models produce a total of ten and six analysis results, respectively. Through seven years (2016-2022) of cross-validation, the automatic TC size analysis model has been developed based on a CNN-based pix2pix GAN. The model produces a total of 35 results for the distribution of TC winds and calculates the radius of 34 kt and 50 kt winds in four directions: northeast, northwest, southeast, and southwest. This system gives analysis results of each TC center, intensity, and size every hour when TCs exist over the Western North Pacific region, and outputs are displayed in the AI-based TC analysis system. KMA is preparing for the test operation of the integrated automatic TC analysis system for center, intensity, and size next year, and plan to continue efforts to improve the system.

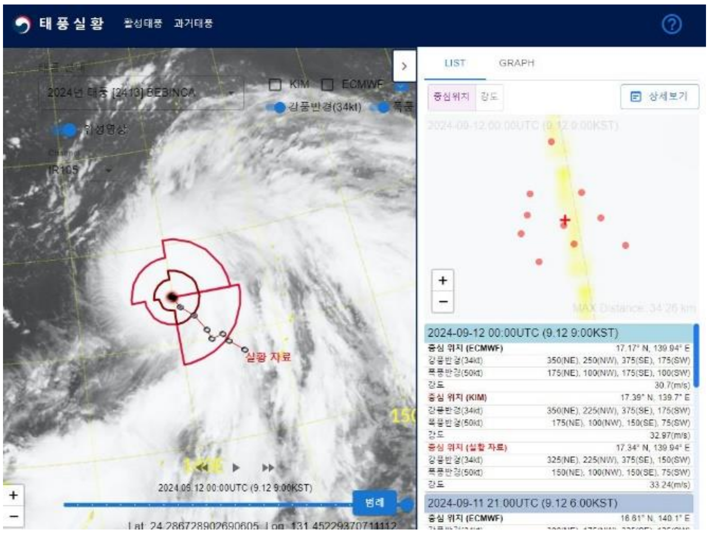


Figure II-3 Examples of the AI-based TC analysis (center, intensity, and size) system at NTC/KMA

Identified opportunities/challenges, if any, for further development or collaboration:
The integrated automatic TC analysis system, combining the center analysis, intensity, and size models, is set to operate internally in real time for automated typhoon analysis in 2025.

Priority Areas Addressed:
Meteorology
- Develop and enhance typhoon analysis and forecasting techniques from short- to long-term.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:
Member: Republic of Korea
Name of contact for this item: Ms Seonghee Won
Telephone: +82-64-909-3960
Email: shwon11@korea.kr

4. Experimental Service for Commentary on Typhoon Forecasts

Main text:
In 2024, KMA conducted an experimental service providing commentary on typhoon forecasts as a test run, specifically for typhoons with expected impacts. This commentary is available only in Korean and is released once daily. It contains the current analysis of a typhoon, the status of the environment, and an explanation of potential fluctuations in the forecast. The explanatory information for JONGDARI was issued at 06 UTC on August 19. JONGDARI was moving northward in the ocean area near Okinawa and was expected to enter KMA's emergency zone (28°N, 134°E) within 12 hours. There were favorable conditions due to high SST, but intensification was limited by weak

upper-level divergence caused by the influence of a strong high. It was expected to be downgraded to a TD after entering the West Sea. The information included a forecast for the TD's movement from the West Sea to land after the downgrade, as well as a description of its potential fluctuations depending on STR. This information is intended to help local governments and the media in understanding the status of a typhoon and the potential variations in emergency situations.

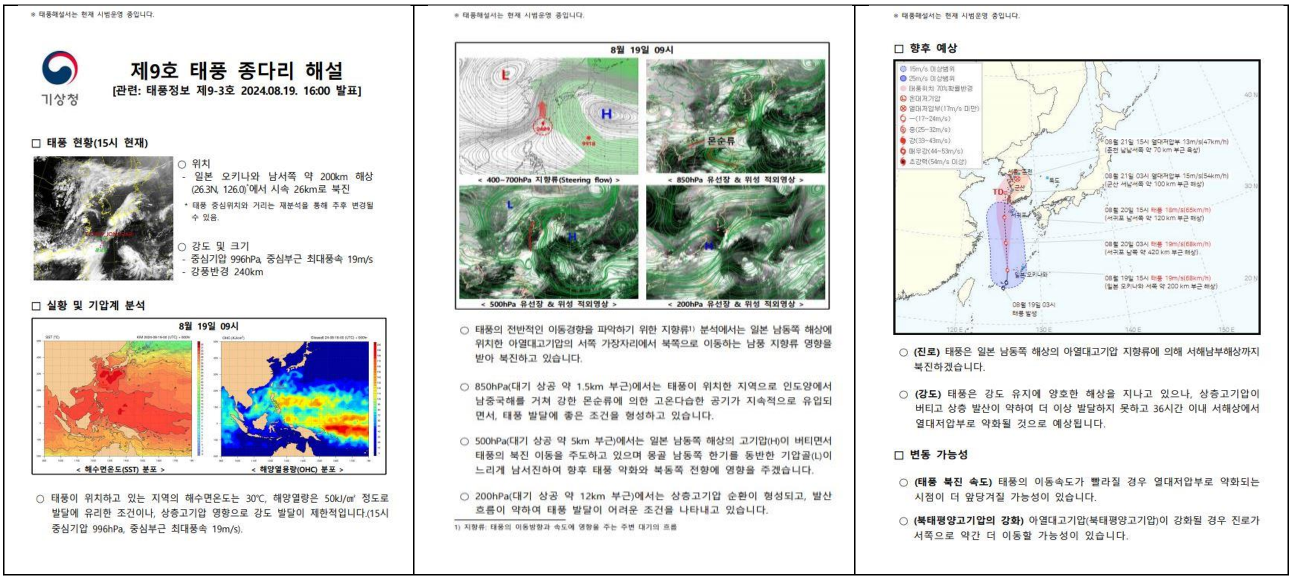


Figure II-4 Example of typhoon forecast commentary

Identified opportunities/challenges, if any, for further development or collaboration:
When direct impacts from typhoons are expected, commentary information on typhoon forecast will be provided.

Priority Areas Addressed:
<u>Meteorology</u>
- Develop and enhance typhoon analysis and forecasting techniques from short- to long-term.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:

Member: Republic of Korea
Name of contact for this item: Ms Seonghee Won
Telephone: +82-64-909-3960
Email: shwon11@korea.kr

5. GEO-KOMPSAT-2A Utilization for Tropical Cyclones (AOP10)

Main text:

GEO-KOMPSAT-2A (GK2A) was launched on December 5, 2018, as a successor to the COMS satellite. It is equipped with a next-generation, 16-channel advanced meteorological imager capable of generating full-disc images every 10 minutes.

To enhance national and international meteorological services in the Asia-Pacific region (RA-II and RA-V), the National Meteorological Satellite Center of the Korea Meteorological Administration (NMSC/KMA) offers a rapid scan service, accessible via the designated webpage (http://datasvc.nmsc.kma.go.kr/datasvc/html/special/specialReqMain.do). This service significantly improves real-time monitoring of tropical cyclones. In 2024, a rapid scan was conducted for Typhoon KRATHON (2418). Additionally, Open API and download services are available on the same website.

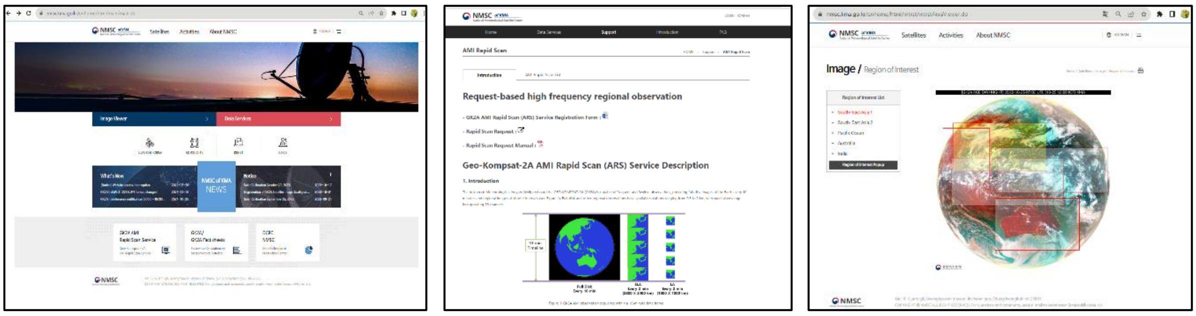


Figure II-5 NMSC's English home page (left), AMI Rapid Scan page where users can request rapid scans (center), and Region of Interest page for international users (right).

NMSC/KMA analyzes basic tropical cyclone (TC) characteristics at intervals of 3 to 6 hours using Dvorak techniques based on GK2A measurements. When a TC is expected to impact the Korean Peninsula or is currently affecting the region, KMA conducts analyses every hour. Key TC characteristics include the cyclone's center, intensity, radii of strong wind areas, and movement information.

NMSC/KMA is also developing Atmospheric Motion Vectors (AMVs) utilizing the Optical Flow (OF) method. AMVs are valuable satellite-based products for monitoring cloud movement caused by various atmospheric phenomena. NMSC/KMA is currently producing rapid scan AMVs, which offer enhanced spatiotemporal resolution compared to standard AMVs, by leveraging rapid scan data from GK2A. To address the scarcity of low-level cloud vectors in AMVs, the number of vectors is increased using the OF method. The wind direction derived from the OF method exhibits quality comparable to that obtained from AMVs, and the high-density vector output is beneficial for analyzing the rotation of a typhoon's eye. This approach is expected to greatly enhance real-time analysis capabilities due to rapid scan imagery and fast computation speeds.

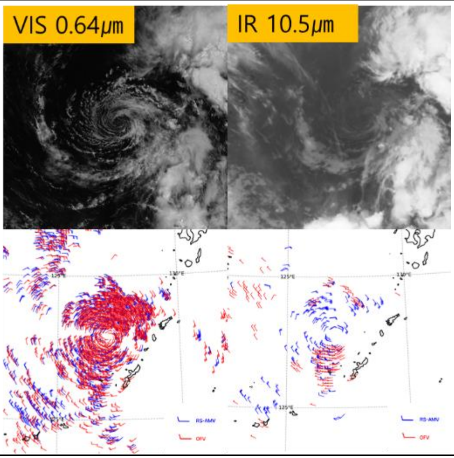
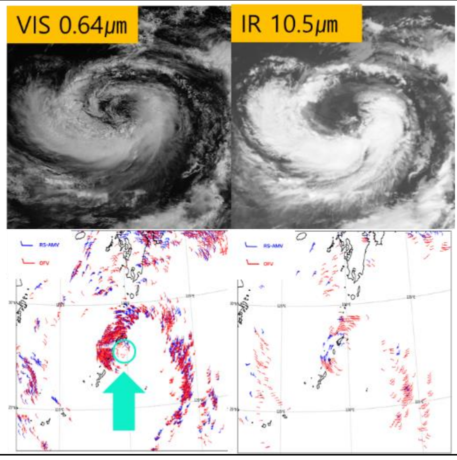
AERE (2204)	KHANUN (2306)
	

Figure II-6 The red (blue) color vectors represent the results of the Optical Flow (OF) and Atmospheric Motion Vector (AMV) methods, respectively. Two typhoon cases have been selected to evaluate the performance of both methods: the left panel displays Typhoon AERE (2204), while the right panel presents KHANUN (2306). Vectors were generated using channel images at Visible 0.64 μm and IR 10.5 μm.

Furthermore, NMSC/KMA supports typhoon forecasting using various GK2A products. Key factors influencing typhoon development include Sea Surface Temperature (SST) and Ocean Heat Content (OHC). GK2A SST, with a resolution of 2 km, is produced every 10 minutes, along with a 1-day composite field. GK2A SST achieves an accuracy with a root mean square error (RMSE) of 0.7 K compared to OSTIA. The GK2A OHC, with a resolution of 25 km, demonstrates accuracy within 12 KJ/cm².

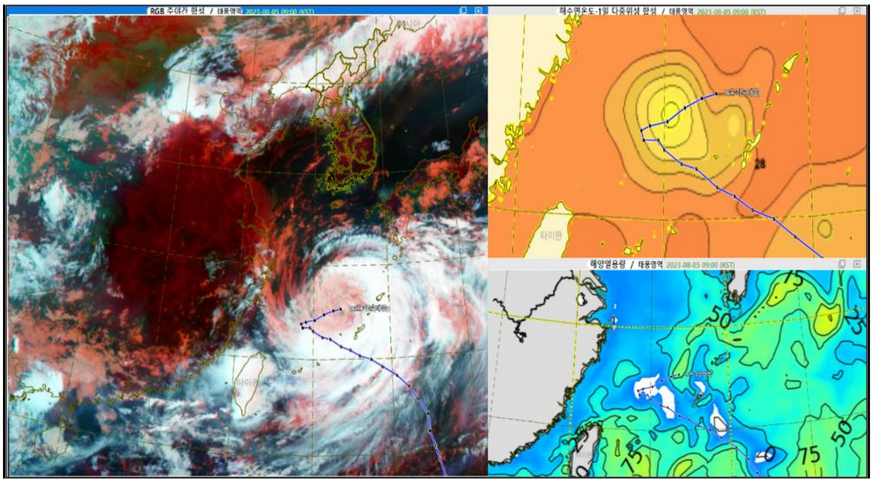


Figure II-7 The development or weakening of KHANUN (2306) has been analyzed using sea surface temperature (SST, upper right) and ocean heat content (OHC, lower right). KHANUN (2306) was projected to traverse an area where the SST was approximately 23°C and the OHC was less than 50 KJ/cm². These conditions indicate a sufficient environment for the typhoon to weaken significantly.

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

- NMSC hopes that many users will take advantage of GK2A's rapid scan service. In addition, we plan to distribute data in various ways and develop a new GK2A viewer to enable users to conveniently utilize GK2A data.

Priority Areas Addressed:

<u>Meteorology</u>

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

DRR

- Promote international cooperation for DRR implementation projects.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	**Please ✓ the related pillar(s)**
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:

Member: Republic of Korea
Name of contact for this item: Geun-Hyeok RYU
Telephone: +82-70-7850-5824
Email: geunhyeokryu@korea.kr

6. Improvement of Hydrological Data Quality Control System in TC Members

Main text:

The project for improvement of hydrological data quality control in TC members has been a long term project of multiple phases that has been firstly initiated since 2004 and now it comes to 5th phase. This 5th phase project is a five-year project as well that has been started since 2022 where the main objective of this 5th phase project is to further enhance and upgrade the flood forecasting and information system in the target TC members countries (Lao P.D.R, Malaysia, Philippines, and Thailand).

Several milestones were achieved in the projects of previous phase. For instances, the baseline survey and studies on the existing hydrological data quality control management in the TC members countries have been completed in 2018. Apart from that, field surveys were also been conducted in 2019 to identify the problems encountered in respective TC member country. Finally, a customized hydrological data quality management system that meets the needs of the target TC member's countries was successfully established in 2022 credited to the cooperation given by the TC members countries and the endless efforts contributed by the research and system developing teams.

The current stage involves the application of Artificial Intelligence (AI) for hydrological data quality control management. This AI module is currently being developed and it will be integrated into the existing PC version of hydrological data quality control management system that has been established in last year. The AI module will be consisting of two main pillars where one describes the anomaly detection in hydrological data time series and the other one describes the correction of the abnormal data using AI.

It has been identified that both supervised and unsupervised AI algorithms would be utilized to detect the abnormal data in the selected hydrological data time series. The supervised AI algorithm selected for anomaly detection was *XGBoost*, which is an extension of gradient boosting and it locates the anomalies by treating one class as anomalies and the other as normal data. Similar to other supervised AI algorithms, *XGBoost* requires a series of labeled data for model training for enabling the trained model to learn how to distinguish the abnormal data from the normal ones.

Inversely, an unsupervised AI algorithm requires no labeled data for model training. It isolates the abnormal data from the normal data based on the statistical parameters such as desired contamination level or percentile specified by the user. Isolation Forest (IF) has been adopted as the unsupervised AI algorithm for anomaly detection in the module. IF is an ensemble method that isolates anomalies by constructing random forests and isolating data points that require fewer splits in the tree to be isolated. It is simple yet effective approach for detecting anomalies. The AI module established for hydrological data quality control management system is illustrated in Figure II-8. The correction of abnormal data using AI will also be developed in the upcoming stage where a series of appropriate algorithms have been undergoing trials and validations currently.

Apart from that, AI will also be applied for flood forecasting in member's countries. The research team is currently working on predicting the extreme floods by adopting a deep learning algorithm known as Long-Short Term Memory (LSTM). It is believed that the member's countries would be benefited from integrating the AI in flood forecasting so that a reliable prediction could be made within a limited time. The AI module for flood forecasting is expected to be completed in the upcoming year.

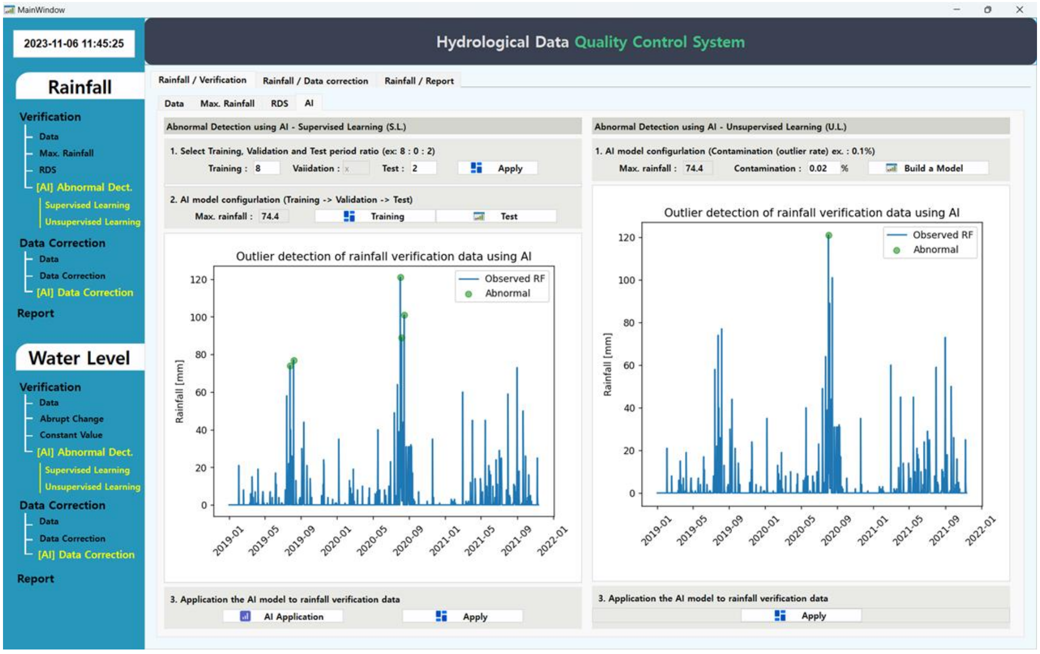


Figure II-8 AI module for hydrological data quality control management system

Identified opportunities/challenges, if any, for further development or collaboration:
There were some restrictions on using the collected hydrological data from the member's countries due to insufficient amount used for AI model training and testing. It is a rule of thumb that a reliable AI model can only be achieved by providing as much data as possible for model training and testing. This issue have been solved as the local authority in respective member's countries has promised to provide sufficient amount of hydrological data for development of the AI model.

Priority Areas Addressed:

Integrated
1. Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.

Meteorology
8. Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

DRR
N/A

Contact Information:
Member: Republic of Korea
Name of contact for this item: Chung-Soo KIM
Telephone: +82-31-910-0274
Email: alska710@kict.re.kr

7. Enhancing Flood Forecasts and Providing Customized Flood Information

Main text:

The Ministry of Environment of ROK has been planning on enhancing and improving the flood forecast by integrating artificial intelligence (AI) in real time flood forecasting since years ago. AI-based flood forecasting strategies and technologies from a mid to long-term perspective have been introduced in order to promptly, timely and thoroughly conduct flood forecasts up to tributaries and streams across the country. By learning the relationship between rainfall and water level during floods occurred in the past through AI, it is expected to be able to quickly predict the water level based on the hydrological and meteorological data without conducting hydrological and hydraulic simulations which are time consuming.

In year 2024, the AI based flood forecasting sites have been expanding from 75 to 223 (almost 3 times increase) whereby each location is integrated with Long Short-Term Memory (LSTM) deep learning algorithm for flood monitoring and forecasting in interval of 10 minutes. By expanding the flood warning issue locations, the government is hoping that the reliability of flood forecasting can be further improved. Likewise, it is also hopeful that the flood alert issue and disseminating system can be further automated and simplified. Figure II-9 shows the demonstration of applying LSTM deep learning algorithm for flood forecasting.

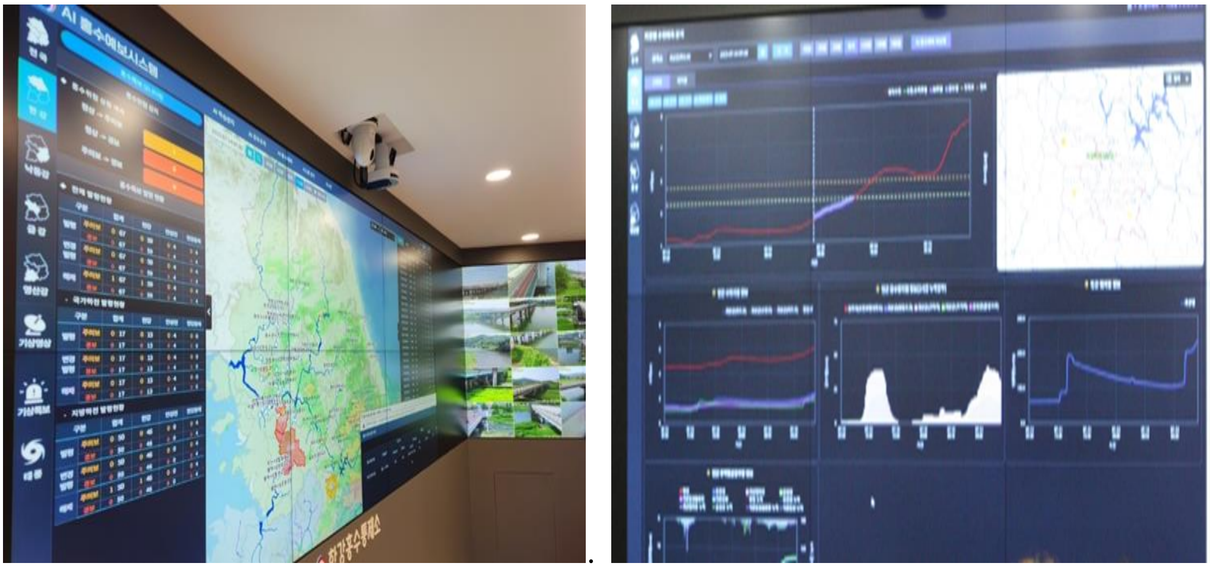


Figure II-9 Demonstration of applying LSTM deep learning for flood forecasting.

Recently, due to abnormal weather caused by climate change, heavy or extreme storms that are difficult to predict are occurring frequently, and the importance of advance preparation for floods is increasing. Accordingly, the Ministry of Environment has proposed the flood mitigating measures by closely cooperating with related organizations and authorities to ensure that flood response measures are actually operational in the field even during the occurrence of extreme event.

With that, the Ministry of Environment launched the 5 major initiatives, which will be implemented for flood mitigation especially during summer season in 2024 for establishing a flood safety system that is based on science and operates smoothly in the field by securing the public safety as the top priority. These 5 major initiatives are:

1) Flood Forecast using AI
2) Providing the Flood Information that the Public can feel
3) Early/Advance Preparation in Flood Vulnerable Areas
4) Securing additional Water Storage Capacity during Extreme Storms
5) Strengthen the Response Capabilities in Field

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

In recent years, the importance of responding to urban flooding is growing in many member countries of TC. The importance of flood countermeasures in urban areas considering the characteristics of flooded areas (drainage system, impervious area, and population density etc.) is being emphasized due to the expansion of flood management from river flood control in the past to urban flood. In this respect, it is expected that the establishment of Korea's strategy for urban flooding and its performance can be a reference for urban flood management in TC Members.

Priority Areas Addressed:

<u>Integrated</u>
1. Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.

<u>Meteorology</u>
N/A

<u>DRR</u>
16. Enhance Members' disaster risk reduction techniques and management strategies.

Contact Information:
Member: Republic of Korea
Name of contact for this item: YoHan CHO
Telephone: +82-2-590-9985
Email: airmass@korea.kr

8. Flood Warning Alarm through Navigation Service

Main text:

Due to various complex causes such as an increase in unexpected flooding and an increase in vehicle moving on road facilities even during flood season, there were incidents in the past that the drivers were unaware of flood occurrences while they were driving and they still drove to the flood affected areas, causing them trapped in the floods and suffered from monetary losses.

In order to prevent the recurrence of damages in the public's lives due to flooding of roads and underpasses during the annual summer flood season, the Ministry of Environment signed an MOU with the Ministry of Science and ICT and private navigation companies and launched a real-time flood risk alarm service. Starting from July 2024, the drivers can receive the real time flood warnings through 6 major navigation service providers in ROK (Kakao Navigation, Naver Map, TMap, Altan, INAVI, and Hyundai/Kia Car Navigation) where the potential or actual flood affected areas will be indicated in the map and through voice alarm as well. This enables the drives to avoid the flood affected areas even when they are driving.

This service has been provided in accordance to the 5 major initiatives proposed by the government for flood mitigation where it can be classified under the second major initiative, which is providing the flood information that the public can feel. Before this service is introduced, even if you received a flood warning text message, you could not properly check where was the origin of the flood warning issue spot while driving. Starting this year, for the first time, when a vehicle driver enters the vicinity of a flood warning issue spot or dam discharge point, voice alarm will be provided through the navigation system, allowing drivers to be more careful when driving in dangerous areas such as low-lying areas.

This service is possible in 223 flood hotspots over the ROK where the flood warning alarm will be indicated automatically in the map and through voice alarm simultaneously when a driver is approaching the affected area (radius of 1.5 km and above for flood warning and radius of 1 km for dam release). Flood warning/flood warning notification text messages utilize individual mobile phone location information (GPS) to provide information on whether a driver is currently located in an area at risk of flooding and a map of nearby areas at risk of flooding, allowing a driver to quickly escape from the risk area.

Providing flood warning alarm through navigation service is a good example of using digital technology to protect the people's safety and solve social problems based on public-private cooperation. The government also promised that will continue to actively discover ways and continue to work with the private sector to provide digital technology that can be felt by the public in the future. The Ministry of Environment is playing the vital role in this service through providing the real time flood warning and dam release data to the navigation service providers. Figure II-10 illustrates the screenshots of flood warning alarm in navigation service.

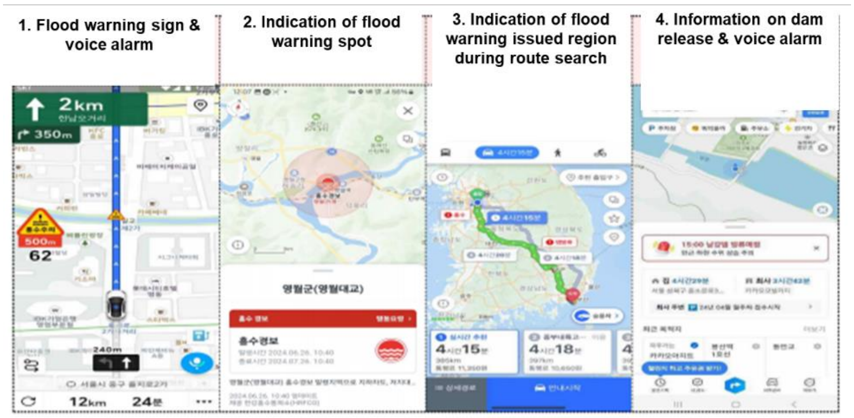


Figure II-10 Screenshots of flood warning alarm in navigation Service (Examples in TMap, Naver Map, Kakao Navigation)

Identified opportunities/challenges, if any, for further development or collaboration:
This initiative provides immediate flood information to the driver while he/she is driving, allowing he/she to avoid dangerous areas resulted from floods or river inundation. This portrays a good example of using digital technology that the member's countries may learn to protect the people's safety and solve social problems that can be felt by the public.

Priority Areas Addressed:

<u>Integrated</u>
N/A

<u>Meteorology</u>
8. Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

<u>DRR</u>
16. Enhance Members' disaster risk reduction techniques and management strategies.

Contact Information:
Member: Republic of Korea
Name of contact for this item: YoHan CHO
Telephone: +82-2-590-9980
Email: airmass@korea.kr

9. Capacity Building / Knowledge sharing in DRR

Main text:

NDMI hosted the Capacity Building / Knowledge Sharing in DRR program jointly with WGH from 24 to 26 September at ICHARM, JMA, and Tohoku University. The objective of the Capacity Building / Knowledge Sharing is to strengthen not only a host country's disaster management capability, but also participants' as well by sharing information and experiences including policies, technologies, and researches results related to DRR among the Members.

NDMI dispatched 6 experts and experts from various field attended the program including TCS, NDMI, VDDMA, and SPU. 5 experts from NDMI, Mr. Michael Fu, and Mr. Nguyen Thanh TUNG made technical presentations on disaster management and the detailed subject is as follows.

- Living in the "New Normal" Extreme Weather- Setting the Agenda for Disaster Preparedness (Mr. Michael Fu)
- Status of Dyke System and Flood Responses in Dyked Rivers (Mr. Nguyen Thanh TUNG)
- Urban Inundation Prediction Technology using Deep learning and Sensor (Dr. Jaewoong Cho)
- Understanding and Assessment of Emerging Risk on Disaster in Korea (Dr. Kyoungjun Kim)
- Understanding of Disaster Scientific Investigation and Activities (Dr. Seungyong Choi)
- Present and Future Challenges of Early Warning System (Dr. Chihun Lee)
- NDMI overview and its main works(Ms. Eunji Seo)

Also experts from ICHARM, NIED, JMA, and Tohoku university made presentation and made the workshop more practical and informative.

Figure II-10 Capacity Building and Knowledge Sharing in DRR program at ICHARM in 2024

Figure II-11 Capacity Building and Knowledge Sharing in DRR program at JMA in 2024

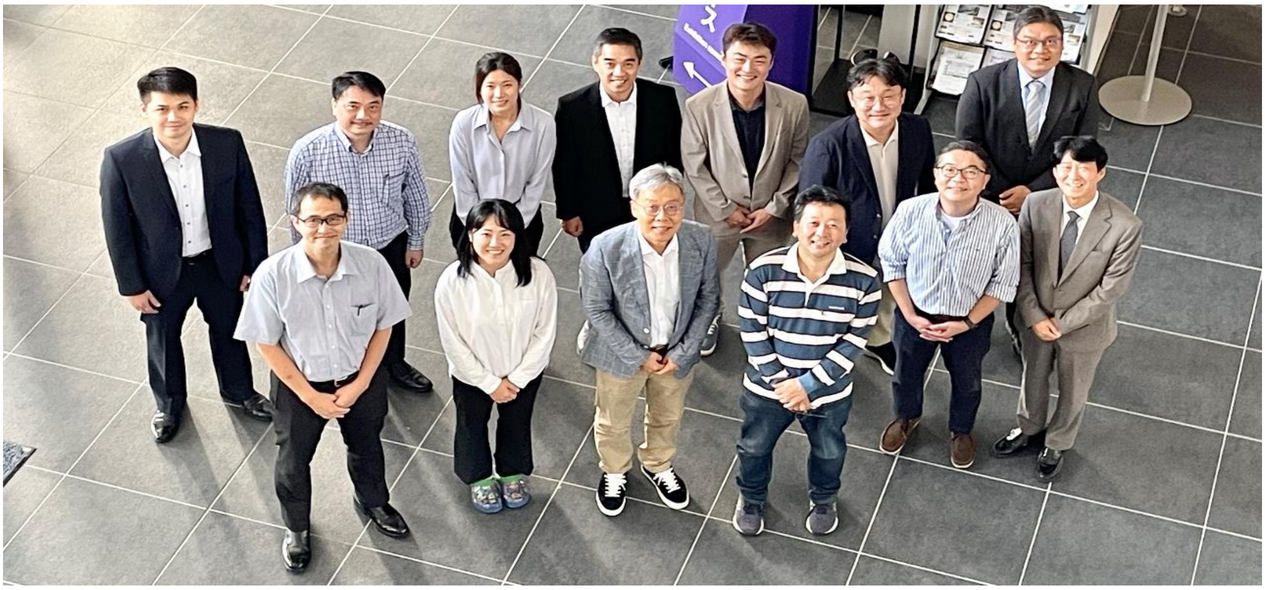


Figure II-12 Capacity Building and Knowledge Sharing in DRR program at JMA in 2024

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

- NDMI is planning to hold a knowledge sharing program in conjunction with PRIMO 2025 to be held in Hawaii from 17 to 20 March, 2025.

Priority Areas Addressed:

Integrated

- Strengthen cross-cutting activities among working groups in the Committee.
- Enhance collaborative activities with other regional/international frameworks/organizations,i ncluding technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

Meteorology

- Promote communication among typhoon operational forecast and research communities inT yphoon Committee region.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:

Member: Republic of Korea
Name of contact for this item: Lee, Chihun
Telephone: +82-52-928-8085
Email: chihun@korea.kr

10. 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. As a request from Philippines, NDMI has started the project for the Philippines again from 2022. As a result of feasibility study, NDMI has chosen to install ARWS in Olongapo and La paz city with discussion with the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). The whole process of DRR project, which is carried by NDMI installing Flood Alert System and Automatic Rainfall Warning System (ARWS*), consists of three steps:

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

NDMI conducted a field survey to choose sites for constructing WP, RG, and WG. Through the meeting with PAGASA and the local government of Olongapo and La paz city, NDMI chose three areas for WP, three areas for RG, and three areas for WG in Olongapo and La paz city (Figure II-14). In addition, NDMI is planning to conduct the training and educational program in October for local officials and the residents in the Philippines.

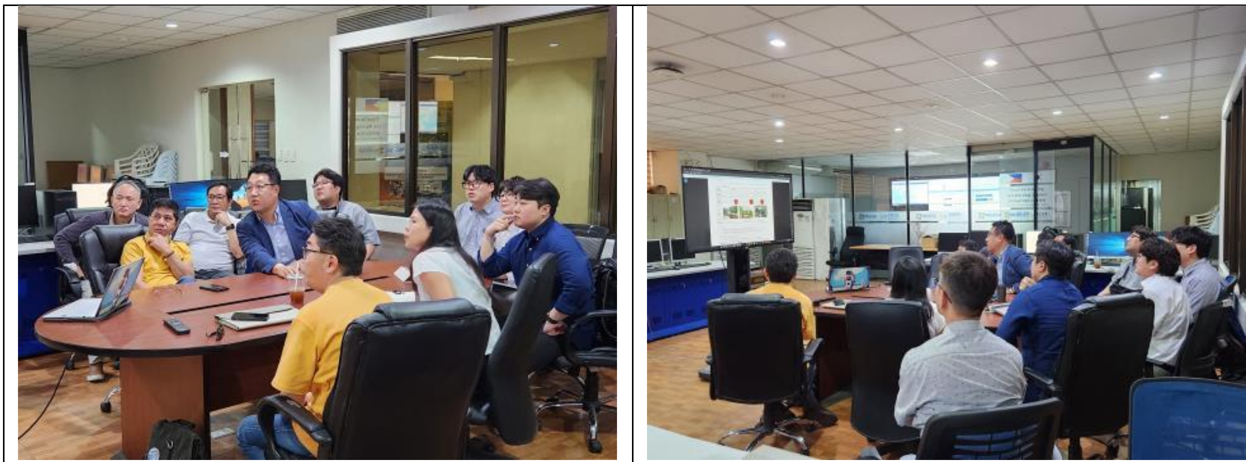


Figure II-13 Pictures of having meeting with PAGASA

Figure II-14 Pictures of Conducting Field Survey in the Philippines

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

- NDMI will conduct a self-assessment on the project in 2023~2024 for the Philippines

Priority Areas Addressed:

Integrated
- Enhance collaborative activities with other regional/international frameworks/organizations,including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

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

Hydrology
- Improve typhoon-related flood (including riverine flood, flash flood, urban flood, and coastal flood) monitoring, data collection and archiving, quality control, transmission, processing, and sharing framework.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	**Please ✓the related pillar(s)**
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	✓
Preparedness and response capabilities	✓

Contact Information:
Member: Republic of Korea
Name of contact for this item: Lee, Chihun
Telephone: +82-52-928-8085
Email: chihun@korea.kr

11. The 19th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction

Main text:

The 19th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (TC WGDRR) was held in Seoul, Republic of Korea from 25 to 28 June 2024. Around 40 representatives from international organizations and TC members participated the meeting. The meeting featured an international cooperation for reducing disaster risk around the world and AOPs of WGDRR. The topic for the annual meeting was "Towards EW4All: Bridging Gaps for Effective Disaster Risk Reduction". In the meeting, TC members shared disaster management policies, information, and current status of technology development related to EW4All. The WGDRR members reviewed 2024 Annual Operation Plans (AOPs) and discussed a tentative AOP with budget in 2025. In addition, Advisory Working Group meeting has been jointly held with WGDRR annual meeting.

Table II -1 Tentative Annual Operations Plans (AOPs) with budget in 2025

No.	Items	Budget (USD)	No.	Items	Budget (USD)
1	Capacity Building / Knowledge Sharing in DRR	12,500	**2**	Setting up Early Warning and Alert System	-
3	TC WGDRR Annual Meeting	3,000	**4**	Benefit Evaluation of Typhoon DRR	6,000
5	Sharing Information related to DRR	-	**6**	Making Educational Video	3,000
Total Budget (USD)					**24,500**

Figure II-15 Pictures of the 19th Annual Meeting of TC WGDRR

Priority Areas Addressed:

Integrated

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

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:

Member: Republic of Korea
Name of contact for this item: Lee, Chihun
Telephone: +82-52-928-8085
Email: chihun@korea.kr

12. 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:

- Shanghai Typhoon Institute Typhoon BBS: A discussion platform for typhoons, moderate d by Shanghai 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 DISASTER AND SAFETY
- Framework act on the management of disaster and safety in the Republic of Korea
- Thailand's Act 2007 and National Plan 2015

In order to share the status of damages from typhoon, WGDRR members will share informa tion using Glide(https:glidenumber.net).

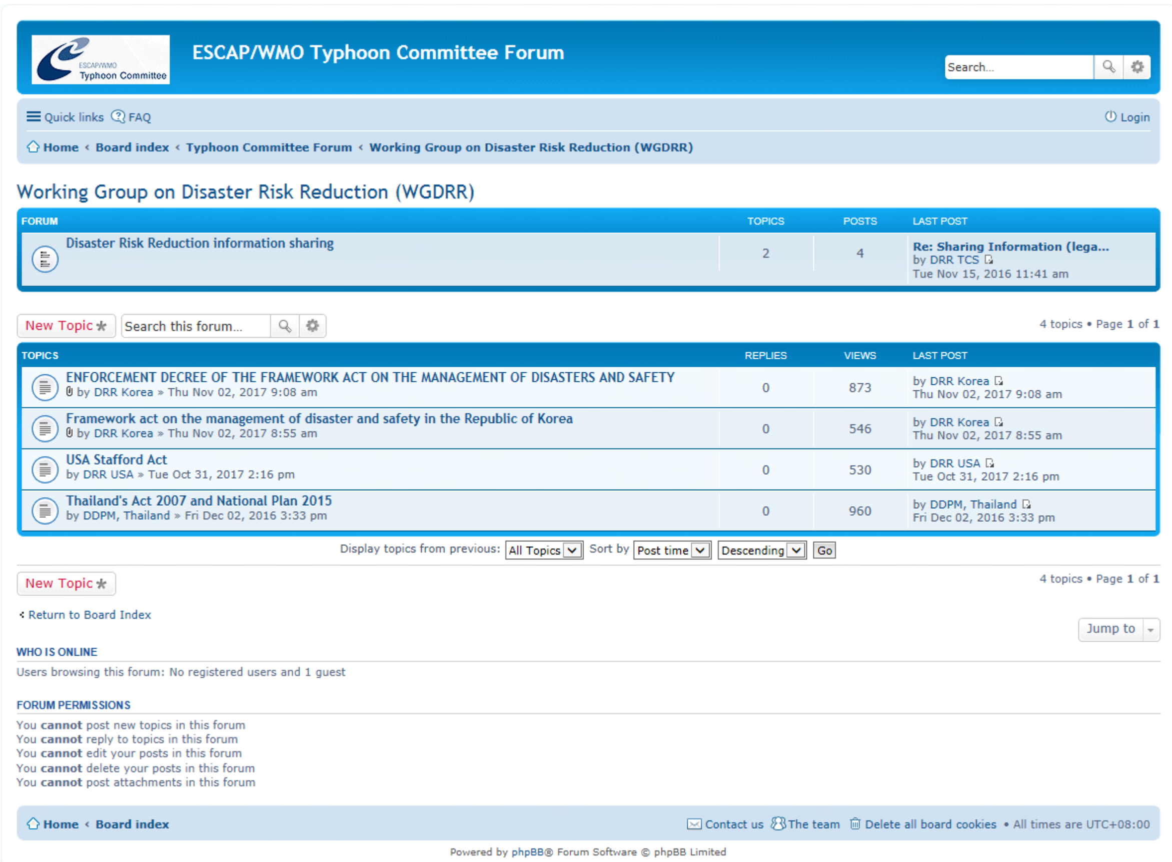


Figure II-16 TC WGDRR Forum Website (http://www.typhooncommittee.org/forum/viewforum.php?f=12)

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

- Active participation from members for sharing information is needed.

Priority Areas Addressed:
Integrated

- Enhance collaborative activities with other regional/international frameworks/organizations,including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	**Please ✓the related pillar(s)**
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	✓
Preparedness and response capabilities	

Contact Information:
Member: Republic of Korea
Name of contact for this item: Lee, Chihun
Telephone: +82-52-928-8085
Email: chihun@korea.kr