# MEMBER REPORT [Republic of Korea]

**ESCAP/WMO Typhoon Committee**
**20th Integrated Workshop**
**Macao, China**
**2 - 5 December 2025**

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# 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-six typhoons have occurred as of November 21, 2025 in the Western North Pacific basin. The number of typhoons in 2025 was near normal compared to the 30-year (1991-2020) average number of occurrences (25.1). No typhoons were observed until May. In July, a total of seven typhoons developed, exceeding the 30-year climatological average of 3.7. Throughout the season, no typhoons made landfall on or directly affected the Korean Peninsula, marking the first such occurrence since 2009.

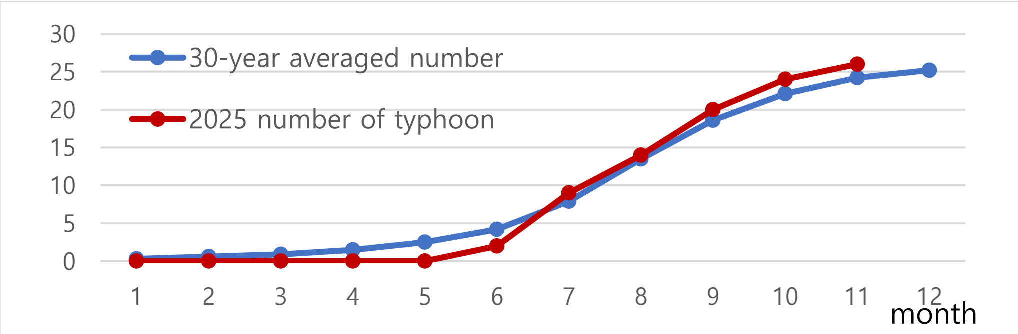


Figure I-1. Comparison of monthly accumulated typhoon occurrences in 2025

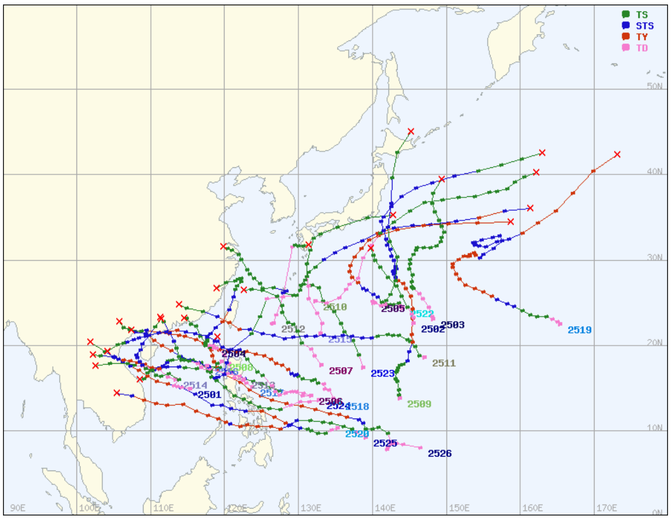


Figure I-2. TC tracks in the Western North Pacific in 2025

In 2025, although the overall typhoon activity in the Western North Pacific basin was near normal, large-scale circulation patterns around East Asia played a crucial role in steering typhoons away from the Korean Peninsula. From early summer, anomalously warm sea surface temperatures (SSTs) further strengthened the Western North Pacific Subtropical High (WNPSH). During summer, enhanced convection over the western Pacific induced a pronounced anticyclonic circulation around Korea and Japan, forming a typical Pacific–Japan (P–J) pattern. In addition, from June to early July, intensified Indian monsoon convection contributed to the establishment of a stationary Circumglobal Teleconnection (CGT) pattern across the mid-latitudes. As a result, a persistent high-pressure system over Korea effectively blocked the northward movement of typhoons throughout the summer season. Meanwhile, due to the anticyclonic circulation over the Korean Peninsula, easterlies were present to the south of Korea, while the monsoon westerlies blew across areas south of 30°N. As a result, convection was active around 25°N, leading to tropical cyclone (TC) genesis at relatively higher latitudes during this summer. However, the expansion of the WNPSH and the eastward extension of the Tibetan High suppressed the intensification of TCs and also blocked their northward movement toward the Korean Peninsula, resulting in no typhoons moving northward to Korea this year.

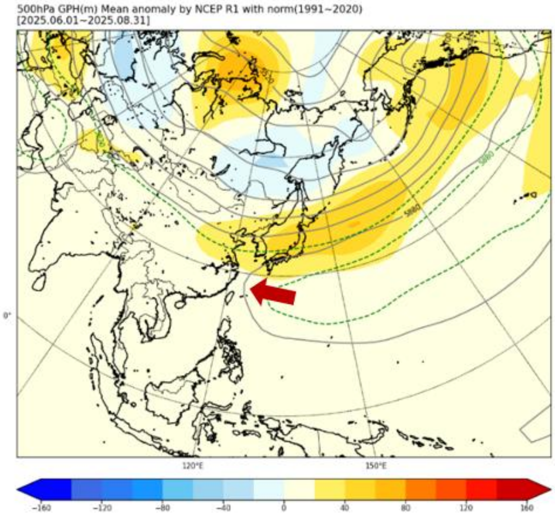


Figure I-3. Anomaly field of 500-hPa geopotential height (GPH) during June–August 2025

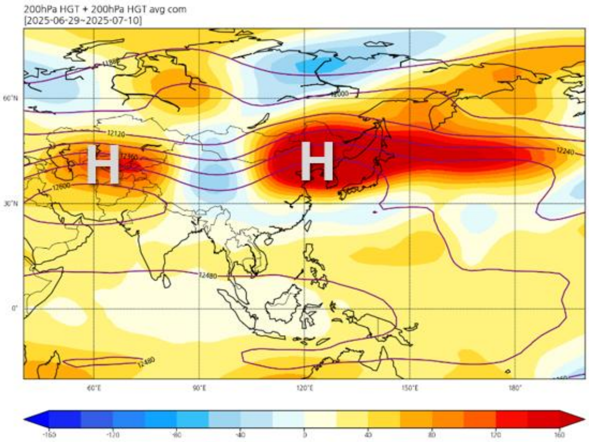


Figure I-4. Anomaly field of 200-hPa geopotential height (GPH) during June–early July 2025

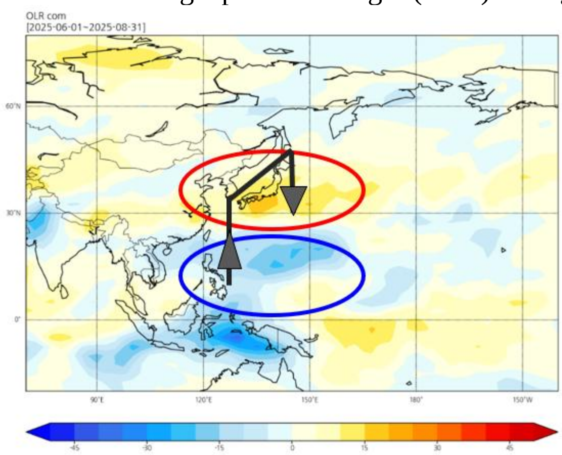


Figure I-5. Anomaly field of outgoing longwave radiation (OLR) during June–August 2025

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

In 2025, Republic of Korea (ROK) did not directly suffer from typhoon attacks. As of 21st October, there were total about 23 typhoons occurrences in this year and none of them had landed at Korea Peninsular. Table I-1 summarized the list of typhoon occurred in year 2025.

Table I-1: List of Typhoon occurred in 2025

| Typhoon ID | Typhoon Name | Start | End |
|---|---|---|---|
| 202523 | NAKRI | 2025.10.8 15:00 | 2025.10.15 03:00 |
| 202522 | HALONG | 2025.10.5 03:00 | 2025.10.10 15:00 |
| 202521 | MATMO | 2025.10.2 09:00 | 2025.10.6 21:00 |
| 202520 | BUALOI | 2025.9.24 03:00 | 2025.9.29 21:00 |
| 202519 | NEOGURI | 2025.9.18 21:00 | 2025.9.29 09:00 |
| 202518 | RAGASA | 2025.9.18 21:00 | 2025.9.25 15:00 |
| 202517 | MITAG | 2025.9.18 15:00 | 2025.9.20 00:00 |
| 202516 | TAPAH | 2025.9.6 21:00 | 2025.9.8 21:00 |
| 202515 | PEIPAH | 2025.9.4 03:00 | 2025.9.5 21:00 |
| 202514 | NONGFA | 2025.8.30 09:00 | 2025.8.31 03:00 |
| 202513 | KAJIKI | 2025.8.23 09:00 | 2025.8.26 15:00 |
| 202512 | LINGLING | 2025.8.21 09:00 | 2025.8.22 03:00 |
| 202511 | PODUL | 2025.8.8 03:00 | 2025.8.14 15:00 |
| 202510 | BAILU | 2025.8.3 09:00 | 2025.8.6 09:00 |
| 202509 | KROSA | 2025.7.24 12:00 | 2025.8.4 09:00 |
| 202508 | CO-MAY | 2025.7.23 21:00 | 2025.7.31 09:00 |
| 202507 | FRANCISCO | 2025.7.23 09:00 | 2025.7.25 15:00 |
| 202506 | WIPHA | 2025.7.18 03:00 | 2025.7.23 03:00 |
| 202505 | NARI | 2025.7.13 03:00 | 2025.7.15 09:00 |
| 202504 | DANAS | 2025.7.5 03:00 | 2025.7.9 09:00 |
| 202503 | MUN | 2025.7.3 03:00 | 2025.7.8 09:00 |
| 202502 | SEPAT | 2025.6.23 09:00 | 2025.6.25 03:00 |
| 202501 | WUTIP | 2025.6.11 09:00 | 2025.6.15 03:00 |

However, ROK did suffer from severe flood damages due to heavy concentrated rainfall occurred at southern and western parts of Korea Peninsular during the summer season. Heavy rainfall fell across various parts of the country from 10th to 20th July due to the influence of the active monsoon front. The cumulative 5-day rainfall amount in heavy downpours areas (such as Sancheong, Hapcheon, Hadong, Changnyeong, and Haman which located at Gyeongnam province) occupied about 63% of annual rainfall amount where the average annual rainfall amount was about 1266 mm. In other words, a total of about 720 mm of rainfall amount has been recorded within 5 days and this unprecedented concentrated heavy rainfall has resulted in severe flood damages in the affected areas. The landslides triggered by heavy rainfall that occurred at a village in Sancheong County on 19th July caused 4 casualties, 2 residents in missing, and 2 residents in cardiac arrest.

Figure I-6. The inundated village in Yesan-gun (Seosan, Chungnam) [left]; The overflowing Taehwa river at Sancheong, Gyeongnam [right]

In 2025, the Flood Control Offices at ROK issued a total of 126 flood watches and 43 flood warnings nationwide between June to early September. Flood occurrences in 2025 were mainly due to concentrated heavy rainfall of unprecedented magnitude and intensity that exceeded the design capacity of river embankments and sewer drainage systems. It can be observed from Figure I-7. that the monthly rainfall distribution for Korea Peninsular in July 2025 has been concentrating at southern regions and western coast.

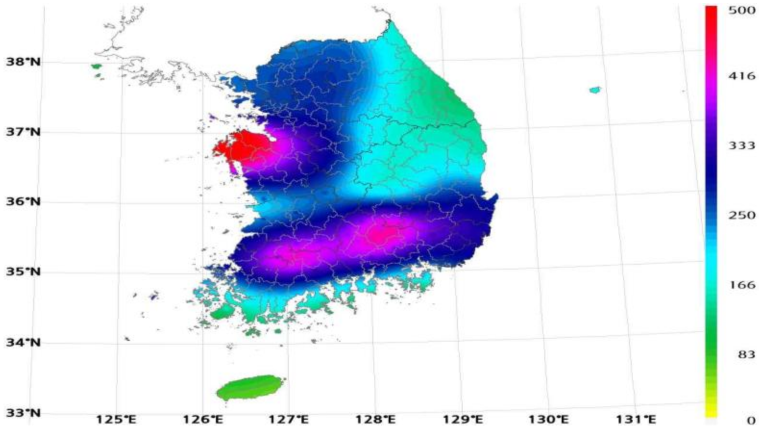


Figure I-7. Monthly rainfall distribution map for Korea Peninsular in July 2025

In order to mitigate and address flooding issues efficiently, The Ministry of Environment of ROK exploits AI, digital twin models, and smart CCTV to enhance flood risk detection, improve AI-based flood and urban inundation forecasts, and expanding the pilot operations of urban inundation forecasts. The early flood warning issue locations have been expanding from 75 to 223 (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. Apart from that, “The Dam-River Digital Twin Water Management Platform” has been established to recreate real dam and river hydrological information in a 3D virtual space using various sensors and data. The application of this platform has also been extended to all local governments where they can now access a wide range of hydrological information for all 3,816 river sections nationwide (including areas without water level stations), such as water level forecasts, CCTV footage of national rivers, flood hazard maps and vulnerable area information, downstream impacts of dam discharges, and alerts on access risks near rivers during floods.

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

The 2025 tropical cyclone season brought no direct typhoon impacts to Republic of Korea, resulting in zero economic or social losses caused by tropical cyclones.
Although the Republic of Korea avoided direct tropical cyclone impacts this season, the South Korea experienced significant weather instability in 2025. This instability required a proactive national disaster response due to localized heavy rainfall events and drought conditions in other areas.

## Heavy Rainfall (16 -20 July, 2025)

Severe heavy rainfall affected central and southern regions of the Republic of Korea from July 16 to 20, 2025, causing substantial localized damage and widespread casualties. The scale of the resulting damage necessitated an immediate and coordinated government response, leading to the prompt raising of the severe level.
During the period from July 16 to 20, cumulative rainfall totals exceeded 550mm in multiple areas, with the hardest-hit regions primarily located in Gyeongnam and Jeonnam.

Table I-2. Total Accumulated Precipitation (16 – 20 July*)*

| Area | Gyeongnam | | | | | Jeonnam | |
|---|---|---|---|---|---|---|---|
| | Sancheong | Hapcheon | Hadong | Changnyeong | Haman | Gwangyang | Damyang |
| Precipitation (mm) | 793.5 | 699.0 | 621.5 | 600.0 | 584.5 | 617.5 | 552.5 |

The Central Disaster and Safety Countermeasures Headquarters raised the emergency level to Severe (Level 3), and was further characterized by the following critical actions:

- Crisis Alert Escalation: Activation of national resources and government-wide coordination
- Comprehensive Damage Reporting: Real-time status collection of human casualties and facility damages
- Proactive Evacuation Management: Managed temporary evacuation of residents
- Major Infrastructure Suspension: Rail and Road transportation control
- Proactive Facility Closures: Closure of High-risk sites
- Emergency Shelter Provided: Immediate temporary shelter was secured for 2,444 persons

Despite these extensive and early response efforts, the unprecedented severity of the rainfall has led to significant impacts on human casualties and facility damages, as detailed below:

- Human Casualties: 28 persons (17 deceased, 11 missing)
  - Gyeongnam (Sancheong 10), Gyeonggi (Gapyeong, Osan 3), Chungcheong (Seosan, Dangjin 3), Jeonnam (Gwangju 1)
- Facility Damage: A total of 4,237 damage cases (1,999 public facilities, 2,238 private facilities)
- Road inundation(778), soil loss(197), collapse of river facilities(403), building inundation (1,857)
- Evacuation: 13,492 persons were temporarily evacuated across 15 provinces/cities

## Extreme Drought in Gangneung (30 Aug. -22 Sep., 2025)

The Gangwon-Gangneung region faced a severe water scarcity episode during this period, prompting a formal 'Disaster State' declaration on August 30. This episode was deemed the second most severe since 1917, underscoring the historical urgency of the situation. Despite severely depleted water reserves, a swift and comprehensive multi-agency response—including emergency water supply and strict water conservation measures—stabilized the situation. The 'Disaster State' was officially concluded on September 22, 2025, following subsequent rainfall and successful operational water management efforts.

The Ministry of Interior and Sagety(MOIS) initiated a unified, multi-sector response to address the critical water shortage:

- High-Level Inter-Agency Coordination: Multiple high-level countermeasure meetings were held to coordinate efforts (President: 30 Aug., Prime Minister: 5 Sep., Minister: 27 Aug)
- Disaster Declaration: 'Drought Disaster State' formally declared on August 30
- On-Site Support: A Whole-of-Government on-site support team was operated (1 Sep.).
- Financial Support: Special grant (KRW 1.5 billion) was provided for drought relief (12 Sep.).
- Defense Ministry Support: Mobilized water transport vehicles (327 units)
- Fire Agency Support: Utilized high-volume mobile pumping systems (12 Sep.)

The Gangneung-si initiated an immediate and comprehensive response on August 29, activating its Local Emergency Coordination Center (ECC) and Disaster Countermeasures Headquarters. The core strategy centered on stringent Water Conservation Measures to reduce consumption. Mandatory restrictions were imposed, including the closure of all public sports facilities and a mandatory 75% valve reduction on water meters. The Gangneung-si also distributed bottle water to support citizens. These aggressive measures successfully maintained essential supply until supply normalization began on September 19, when restrictions were removed for apartments and accommodation facilities.

While the final monetary damage assessment remains incomplete, the drought caused significant widespread disruption across the region:

- Critical Water Reserve Depletion: Obong Resrvoir(Primary Water Source) dropped to critical historical lows (approx.15% in late August), threatening essential living and industrial water supply.
- Mandatory Lifestyle Disruption: 75% valve reduction on residential water meters and the closure of all public sports facilities
- Economic Sector Impact: Water supply was restricted to 113 apartments and 10 accommodation facilities, resulting in negative economic effects on the local tourism sector.

# II. Summary of Progress in Priorities supporting Key Result Areas

## 1. Prediction of Summer Typhoon Outlook (POP1)

**Main text:**

The National Typhoon Center (NTC) of the Korea Meteorological Administration (KMA) has been continuously advancing its seasonal prediction techniques since 2021 to enhance the accuracy of typhoon outlooks and improve preparedness against potential typhoon impacts in the Western North Pacific (WNP) region. In 2025, KMA utilized four improved seasonal prediction models to produce the summer (June–August) typhoon outlook and shared the results with Member Countries via email in early June.

The statistical model, which uses climate indices such as the Pacific Meridional Mode (PMM), Tropical South Atlantic (TSA), Indian Ocean Dipole (IOD), and Sea Ice as predictors, predicted 6.4 TCs in the western domain (west of 140°E) and 4.6 TCs in the eastern domain (east of 140°E), resulting in a total of 11 TCs expected in the WNP during summer 2025. The GloSea6-based dynamical model projected high activity in the northeastern sea area of the Philippines and south of Japan, with dominant tracks extending either from the northeastern Philippines to the South China Sea or from Guam to the southeastern sea area of Japan. It predicted a TC frequency of 7.4 for the season. The CFS-based hybrid model indicated an increase in track density from the eastern sea area of the Philippines to the South China Sea, forecasting a TC frequency of 12.2 during the summer period. The GloSea6-based Hybrid II model, constructed through regression equations linking TC frequency to historical observations of GMSST and SOI predicted from GloSea6, suggested a decrease in track density near the Korean Peninsula, with a TC frequency of 5.9 for June–August 2025. During the observation period (June–August 2025), fourteen typhoons were recorded, which is near the 30-year climatological average of 11. Verification results of TC frequency prediction revealed that the statistical model exhibited the smallest errors and the highest correlation with observations. The dynamical model tended to overestimate TC frequency and showed a low correlation. The CFS-based hybrid model captured the general trend reasonably well but was less accurate than the statistical model. Meanwhile, the Hybrid II model, which used GMSST and SOI as predictors, showed the poorest performance, failing to reproduce the observed trend in TC frequency.

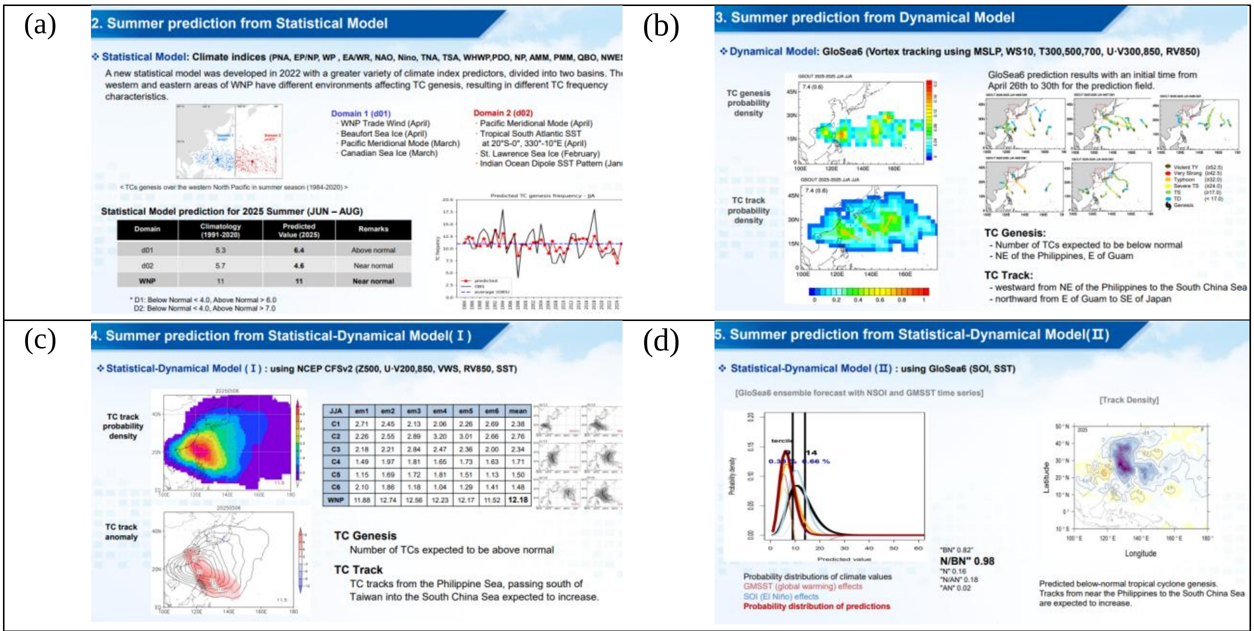


Figure II-1. Examples of KMA's typhoon summer activity outlook for 2025: Summer prediction results with (a) statistical model, (b) dynamical model, (c) statistical-dynamical model, and (d) statistical-dynamical model (II)

**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 2026 outlook, based on the improved models, will be shared with Members in late May 2026.

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

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

| Key Pillars of EW4All | |
|---|---|
| Disaster risk knowledge and management | |
| Detection, observation, monitoring, analysis, and forecasting | ✓ |
| Warning dissemination and communication | |
| Preparedness and response capabilities | |

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

**Main text:**
Since 2022, NTC/KMA has been deploying drifting buoys in the WNP to address the lack of in-situ ocean observations in typhoon genesis and intensification regions, particularly during the summer typhoon season.

In 2025, as part of the Working Group on Meteorology AOP12 project, KMA deployed 13 drifting buoys in the WNP in collaboration with Jeju University, the Korea Institute of Ocean Science and Technology (KIOST), and National Taiwan Normal University. In addition, five additional buoys were provided by KIOST, further expanding the observational coverage. Among these, three buoys were equipped with wind sensors, enabling the collection of near-surface wind speed and direction data alongside oceanic variables. The deployed buoys operated autonomously, recording sea surface temperature and pressure every 30-minutes, and transmitting the data to a central collection server. These observations were shared in near real-time through the Global Telecommunication System (GTS) and a dedicated web-based data-sharing portal. A data access platform has been established at http://hms.otronix.com:60481/, which is accessible upon login. On this platform, observed SST and pressure data are displayed both in tabular format and as time-series plots. Users can click on individual data entries to visualize temporal trends for each buoy.

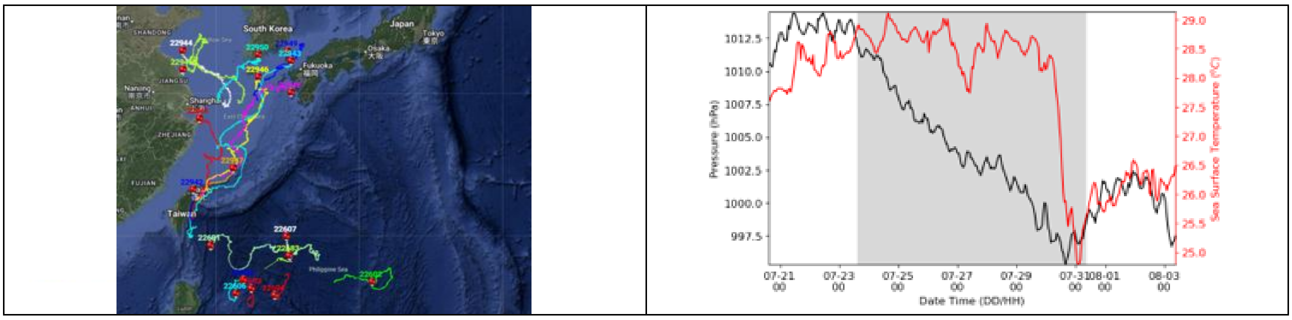

Figure II-2. Example of analysis results for a typhoon using drifting buoys

**Identified opportunities/challenges, if any, for further development or collaboration:**
In 2026, 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. KMA will continue its efforts to secure observational data from low-latitude ocean regions and will actively promote joint observation initiatives in collaboration with other countries and institutions.

**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 | |
|---|---|
| Disaster risk knowledge and management | |
| Detection, observation, monitoring, analysis, and forecasting | ✓ |
| Warning dissemination and communication | |
| Preparedness and response capabilities | |

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## 3. AI-based Developments for Typhoon Forecasting

**Main text:**
NTC/KMA has been actively integrating AI technologies into typhoon forecasting and real-time monitoring. As of 2024, the National Institute of Meteorological Sciences of the Korea Meteorological Administration (NIMS/KMA) is operating three AI weather prediction models: FourCastNet2, Pangu-Weather, and GraphCast. Each model is initialized with three different numerical weather prediction (NWP) model datasets—KIM, UM, and IFS—resulting in a total nine AI forecast configurations. The GFDL vortex tracker has been applied to extract track and intensity forecasts from the AI-model outputs. The resulting guidance products, including typhoon tracks, intensity, and wind radii, are delivered to operational typhoon forecasting system, supporting forecasters with additional data-driven insights. Performance evaluations conducted on typhoon cases in 2024 showed that the AI-based models outperformed traditional NWP models in track prediction, demonstrating promising potential for operational use. However, for intensity forecasting, the AI

models consistently underestimated storm strength, indicating a need for further improvement in model training and structure.

In parallel, NTC/KMA has been developing an AI-based real-time TC analysis system since 2022 to support the operational monitoring of TCs. The system consists of three core modules: TC center, intensity, and size (wind radii) estimation. Each module utilizes advanced learning methods such as CNN and ConvLSTM, and uses GK2A geostationary satellite imagery as input data. The training dataset includes both single-channel brightness and brightness-temperature difference features, enabling the model to capture complex structural characteristics of typhoons. Verification results from the 2024 typhoon season indicated that the TC center estimation module performs well for strong typhoons, providing high positional accuracy. However, larger errors were observed for weaker systems, likely due to their disorganized cloud structures, which make it more difficult for automated TC center algorithms to detect the center accurately. Further enhancements are currently under review to improve performance for these weak systems. The intensity estimation module tended to overestimate the intensity of weak typhoons while underestimating the strength of stronger typhoons. For typhoon size estimation, the system generally underestimated wind radii.

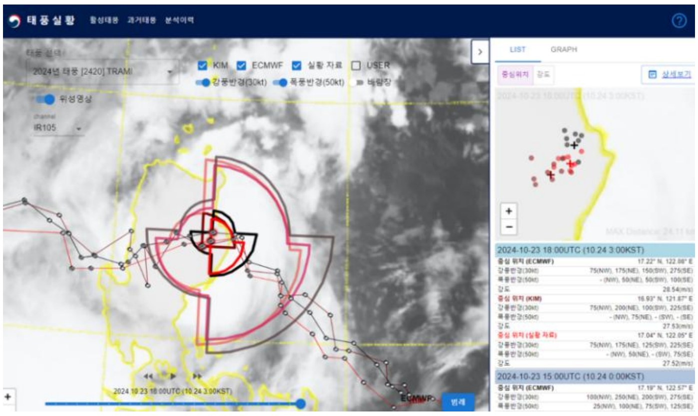

Figure II-3. Examples of the AI-based TC analysis (center, intensity, and size) system at NTC/KMA

**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.

**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** | |
|---|---|
| **Disaster risk knowledge and management** | |
| **Detection, observation, monitoring, analysis, and forecasting** | ✓ |
| **Warning dissemination and communication** | |
| **Preparedness and response capabilities** | |

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## 4. Improvement of Typhoon Intensity Classification at KMA

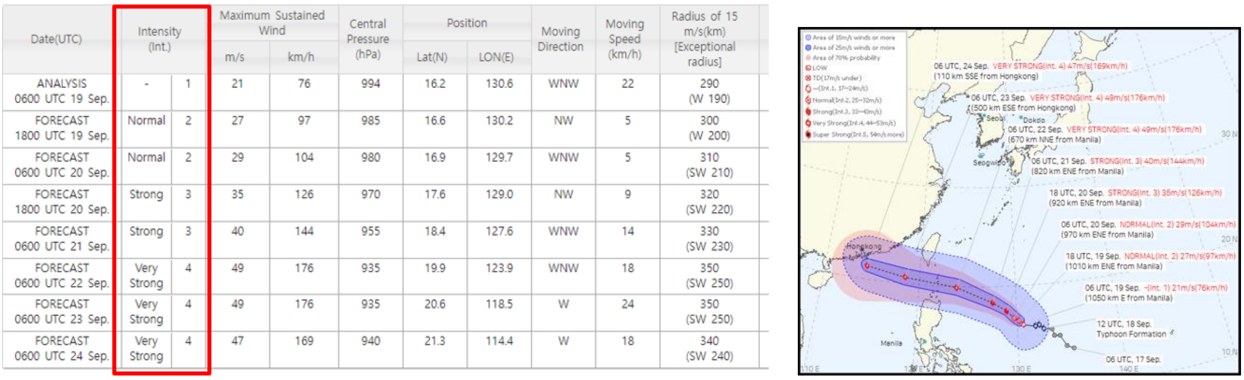
**Main text:**

Since 2025, KMA has revised its operational intensity classification for tropical cyclones and has provided it in parallel with the existing system in typhoon forecast information. Previously, descriptive intensity terms were assigned based on the sustained maximum wind speed at the typhoon center, with categorical labels used to convey intensity information. Under the new system, five numerical categories are introduced. Intensity 1 corresponds to 17–24 m/s, Intensity 2 to 25–32 m/s, and the categories increase sequentially up to Intensity 5 for winds exceeding 54 m/s.

This revision enhances clarity and consistency across forecast products and helps improve public understanding. The improvement of the typhoon intensity classification was carried out at the request of the Government of the Republic of Korea and was developed through consultations with domestic experts and feedback from the general public. Beginning in 2026, the parallel provision of both systems will be discontinued, and only the new numerical intensity classification will be applied in typhoon forecast information.

Table II-1. New TC Intensity Classification at KMA

| Wind Speed (m/s) | Old Classification | New Classification |
|---|---|---|
| 17–24 | - | Intensity 1 |
| 25–32 | Medium | Intensity 2 |
| 33–43 | Strong | Intensity 3 |
| 44–53 | Very Strong | Intensity 4 |
| ≥54 | Super Strong | Intensity 5 |



| Date(UTC) | Intensity (Int.) | | Maximum Sustained Wind | | Central Pressure (hPa) | Position | | Moving Direction | Moving Speed (km/h) | Radius of 15 m/s(km) [Exceptional radius] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | m/s | km/h | | Lat(N) | LON(E) | | | |
| ANALYSIS 0600 UTC 19 Sep. | - | 1 | 21 | 76 | 994 | 16.2 | 130.6 | WNW | 22 | 290 (W 190) |
| FORECAST 1800 UTC 19 Sep. | Normal | 2 | 27 | 97 | 985 | 16.6 | 130.2 | NW | 5 | 300 (W 200) |
| FORECAST 0600 UTC 20 Sep. | Normal | 2 | 29 | 104 | 980 | 16.9 | 129.7 | WNW | 5 | 310 (SW 210) |
| FORECAST 1800 UTC 20 Sep. | Strong | 3 | 35 | 126 | 970 | 17.6 | 129.0 | NW | 9 | 320 (SW 220) |
| FORECAST 0600 UTC 21 Sep. | Strong | 3 | 40 | 144 | 955 | 18.4 | 127.6 | WNW | 14 | 330 (SW 230) |
| FORECAST 0600 UTC 22 Sep. | Very Strong | 4 | 49 | 176 | 935 | 19.9 | 123.9 | WNW | 18 | 350 (SW 250) |
| FORECAST 0600 UTC 23 Sep. | Very Strong | 4 | 49 | 176 | 935 | 20.6 | 118.5 | W | 24 | 350 (SW 250) |
| FORECAST 0600 UTC 24 Sep. | Very Strong | 4 | 47 | 169 | 940 | 21.3 | 114.4 | W | 18 | 340 (SW 240) |

Figure II-4. Examples of typhoon information with the new intensity classification

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

From 2026, a new typhoon intensity classification will be officially adopted and provided in KMA's typhoon information.

**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** | |
|---|---|
| **Disaster risk knowledge and management** | |
| **Detection, observation, monitoring, analysis, and forecasting** | ✓ |
| **Warning dissemination and communication** | ✓ |
| **Preparedness and response capabilities** | |

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

**Main text:**

The National Meteorological Satellite Center of the Korea Meteorological Administration (NMSC/KMA) has operated the GEO-KOMPSAT-2A (GK2A) since December 2019. GK2A has a 16-channel Advanced Meteorological Imager capable of generating full-disc images every 10 minutes. Below is a summary of NMSC/KMA activities in the tropical cyclones (TC) field in 2025.

1) Satellite Data Service

To enhance national and international meteorological services in the Asia-Pacific region (RA-II and RA-V), 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 2025, a rapid scan was conducted for Typhoon WUTIP (2501). Additionally, Open API and download services are available on the same website (Figure II-5).

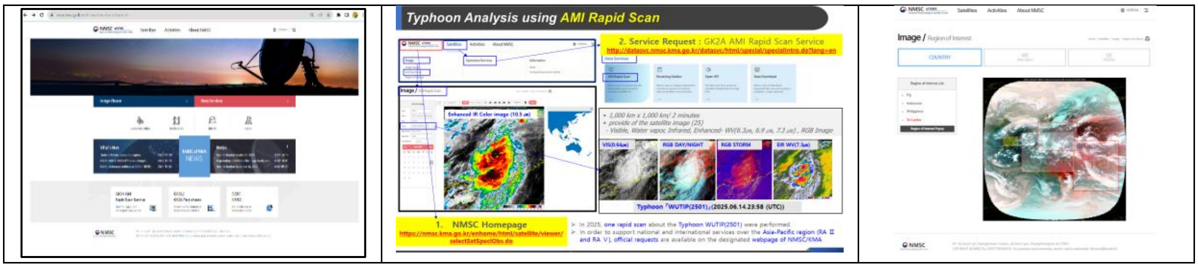


Figure II-5. NMSC's English homepage (left), the AMI Rapid Scan page where users can request a quick scan (center), and the Region of Interest page for international users (right)

2) TC Applications

i) Dvorak Techniques

NMSC/KMA analyzes basic tropical cyclone (TC) characteristics at intervals of 3 to 6 hours using Subjective Dvorak Techniques (SDT) 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 information includes the tropical cyclone's center, intensity, radii of strong wind areas, and movement direction and speed.

ii) SST and OHC

NMSC/KMA produces sea surface temperature (SST) and ocean heat content (OHC) based on GK2A, which are key factors influencing typhoon development. GK2A SST is 2 km resolution and is generated every 10 minutes, with daily composite data also provided. GK2A SST has an accuracy of 0.7 K with a root mean square error (RMSE) compared to the Operational Sea Surface Temperature and Ice Analysis (OSTIA). GK2A OHC has an accuracy of within 11.4 KJ/cm$^2$ with 25 km resolution.

iii) Sea Wind

NMSC/KMA uses sea surface wind (SSW) and 15 m/s wind radius from five active scatterometer sensors, including ASCAT, OSCAT, and HSCAT, and two passive sensors, including AMSR-2 and GMI. We produce 10 m wind data and 15 m/s strong wind radius from numerical weather prediction

(NWP) models (KIM and ECMWF). By synthesizing the 10-meter wind data from these numerical models and satellite SSW data, the 15 m/s wind radius can be estimated using numerical model data where satellite observations are missing. Additionally, by utilizing SSW data, it is possible to determine whether the 10-meter wind data produced by the numerical models are over- or underestimated (Figure II-6).

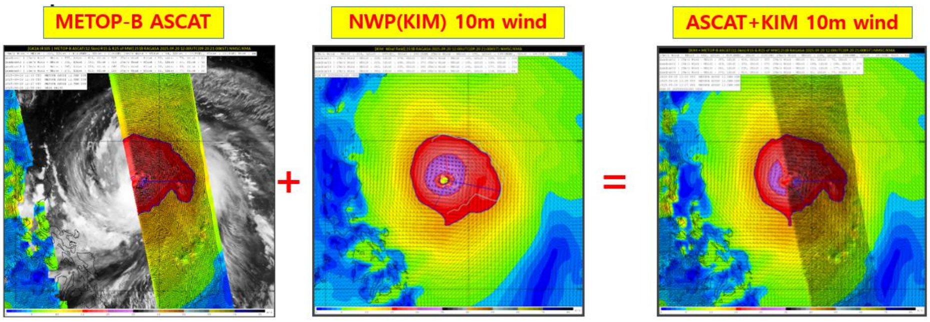


Figure II-6. Wind radius of Typhoon LAGASA (2518) from METOP-B ASCAT (Active Satellite Sensor, left), numerical weather prediction model KIM (center), and satellite and numerical model composite (right)

iv) Water Vapor

By analyzing dry areas using water vapor images, we can analyze the development, weakening, and movement of a typhoon. When a dry area strongly flows into the northern or western regions of a typhoon, the downdraft is strengthened with dry areas in water vapor images. Consequently, the upper atmosphere north of the typhoon becomes drier, causing the typhoon to weaken significantly or even turn northeast. To understand the dry area near the center of Typhoon LINGLING (2512), we analyzed the relative humidity (RH) of AMI/GK2A and MHS/MetOp-C. The vertical profiles of RH of GK2A and NWP reveal that dry areas with RH below 50% are distributed in the layer below 600hPa. This indicates that Typhoon LINGLING rapidly weakened as the upper atmosphere's dry area descended toward the typhoon (Figure II-7).

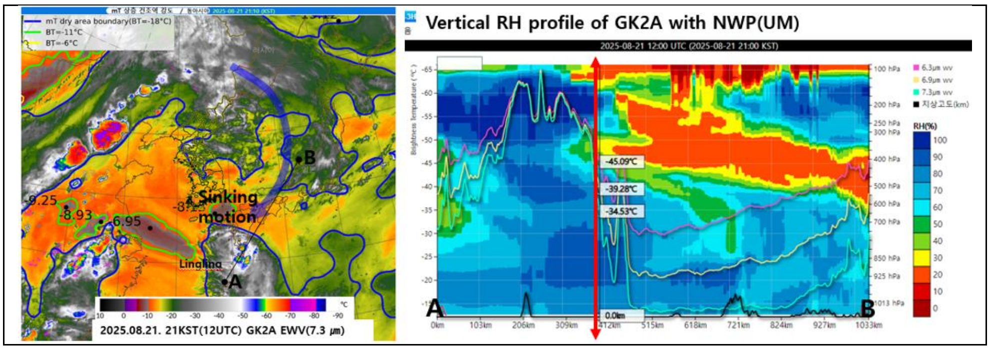


Figure II-7. Water vapor (EWV) (7.3㎛) images (left) and vertical cross-sections of RH of GK2A+NWP (right) of Typhoon LINGLING (2512)

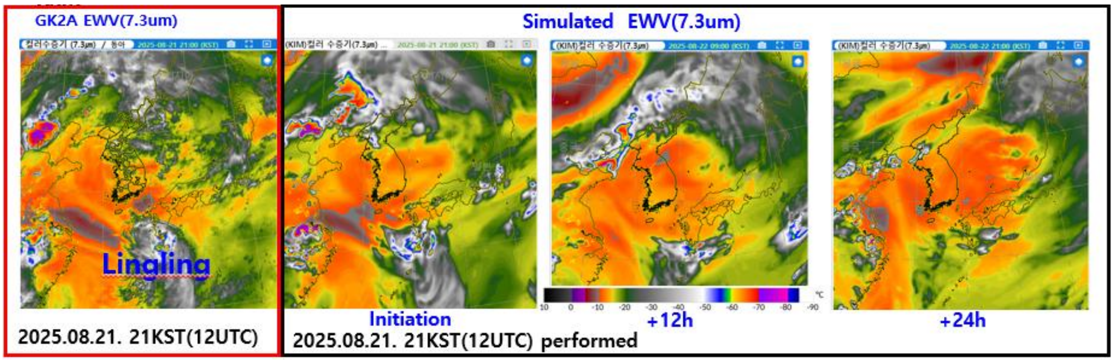


Figure II-8. Analysis of the weakening of Typhoon LINGLING (2512) using water vapor radiation simulated prediction images

NMSC/KMA is producing simulated water vapor images using numerical models. By comparing simulated water vapor images with real time water vapor images, the numerical models can be evaluated and the development or weakening of typhoons can be predicted. To predict typhoon development or weakening, we are generating simulated prediction images for +3, +6, +9, +12, …. and +144 hours (Figure II-8).

3) Training and Education

KMA is conducting training on typhoon analysis and satellite data utilization using GK2A data, through Official Development Assistance (ODA) and Korea International Cooperation Agency (KOICA) projects to support meteorological technology for ASEAN countries in 2025. Four training courses, including those on building a typhoon monitoring system and a disaster response early warning system, were provided to 50 forecasters from 13 countries. Participating countries included Laos, Mongolia, Vietnam, Indonesia, the Philippines, Kenya, Liberia, Bangladesh, Colombia, Peru, and Fiji (Figure II-9).

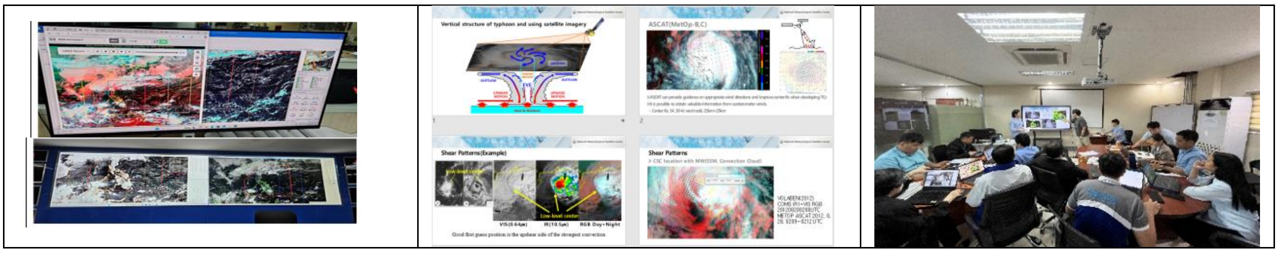

Figure II-9. Integrated Typhoon Monitoring and Forecasting Platform System in the Philippines (left), training materials (center), and training course (right)

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

- NMSC/KMA will distribute GK2A-related products through multiple channels and develop a new data viewer to utilize GK2A data, such as rapid scan images.

**Priority Areas Addressed:**

Meteorology

- 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 | |
|---|---|
| **Disaster risk knowledge and management** | |
| **Detection, observation, monitoring, analysis, and forecasting** | ✓ |
| **Warning dissemination and communication** | |
| **Preparedness and response capabilities** | |

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## 6. Continuous Development of Hydrological Data Quality Control System and Flood Forecasting System for TC Member Countries using Artificial Intelligence (AI) Technique

**Main Text:**

Two computer programs have been developed under the Annual Operational Plans (AOP) 2 and 3, where Artificial Intelligence (AI) techniques have been applied for hydrological data management and flood forecasting. The program developed under AOP 2 is titled “*Hydrological Data Quality Control System using AI*,” while the one under AOP 3 is “*Flood Forecasting using AI*.” The Hydrological Data Quality Control System was designed to detect and correct outliers in hydrological datasets (rainfall and water level) using AI-based approaches. Machine learning algorithms, *Isolation Forest* (unsupervised) and *XGBoost* (supervised) were adopted for outlier detection, while a Long Short-Term Memory (LSTM) Auto-encoder deep learning model was employed for correcting the detected outliers in the subsequent stage. This system provides significant benefits to the target Typhoon Committee (TC) member countries by facilitating a shift from traditional, manual, and human-dependent processes toward AI-enabled, data-driven hydrological data management.

In addition, a Flood Forecasting System based on LSTM deep learning has also been developed. This AI-based flood forecasting system is user-friendly and can be easily operated by users with minimal background in AI or hydrology. The system includes a Bayesian Optimization module that automatically determines the optimal hyper-parameters for the LSTM model, thereby improving model performance and efficiency. Through this system, users can forecast future water level or streamflow at monitoring stations by analyzing the embedded relationships between historical input and output data using the trained LSTM model. The system promotes the application of Fourth Industrial Revolution (4IR) technologies among the target TC member countries, contributing to enhanced flood forecasting accuracy and improved preparedness for flood-related disasters. Both systems are currently in their final development stages, and their distribution and implementation in the target member countries are expected in the upcoming year.

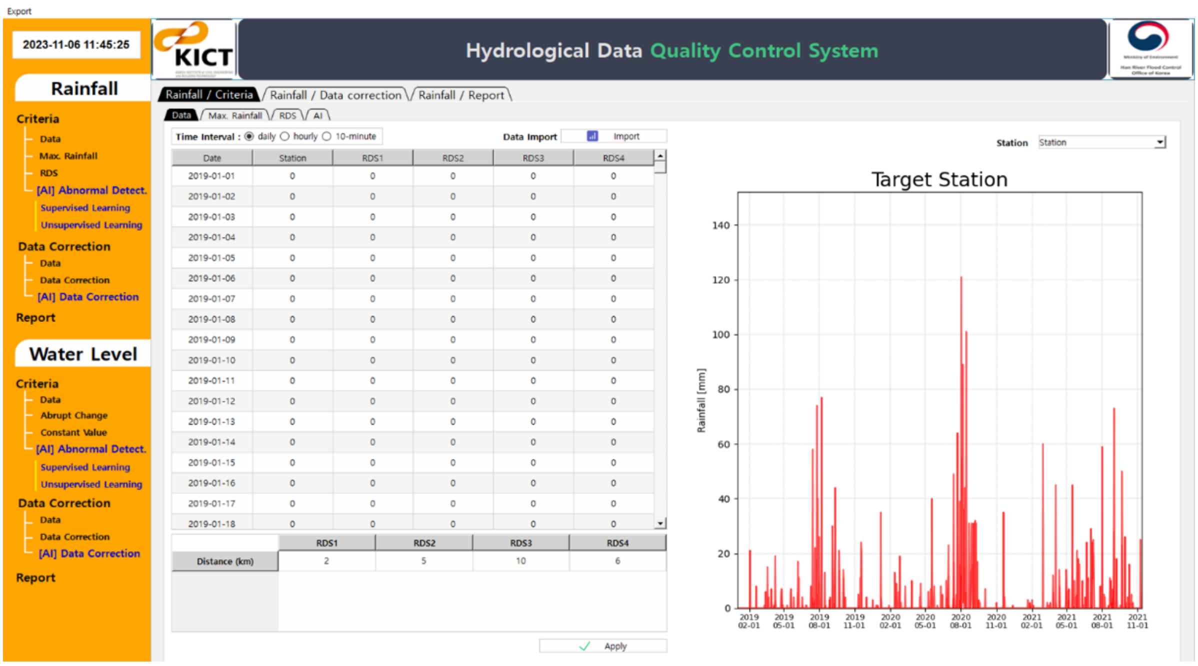

Figure II-10. Example of user interface for Hydrological Data Quality Control System using AI

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

1. Training session and user manuals should be provided to the users or practitioners in the target TC member countries in order to assist them in effectively mastering the developed systems for application in real world.
2. Regular maintenance and system upgrades should be carried out based on feedback received from users to continuously enhance the effectiveness, reliability, and usefulness of the developed systems.

**Priority Areas Addressed:**

<u>Hydrology</u>

- 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.

- Strengthen capacity in effective flood forecasting and impact-based early warning, including hazard mapping and anticipated risk based on methodological and hydrological modelling, and operation system development.

- Increase capacity in utilization of advanced science and technology for typhoon-related flood forecasting, early warning, and management.

**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** | ✓ |

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## 7. Rapid Flood Risk Detection through Cutting Edge Science and Technology

**Main Text:**
The Ministry of Environment of Republic of Korea has been using AI, digital twin models, and smart CCTV to enhance flood risk detection as well as improving AI-based flood and urban inundation forecasts. Apart from that, it is also planning to expand the pilot operations of urban inundation forecasts to enable more urbanized areas are equipped and closely monitored by flood forecasting system, so that appropriate actions could be taken before the occurrences of flood disaster.

In 2024, the number of early flood-warning locations expanded from 75 to 223, representing a threefold increase. Each location is equipped with a Long Short-Term Memory (LSTM) deep learning algorithm that provides flood monitoring and 10-minute interval forecasts. In 2025, pilot operations for urban inundation forecasting will expand from the current four regions to six, covering Seoul (Dorimcheon), Gwangju (Hwangyongcheon), Pohang (Naengcheon), Changwon (Changwoncheon), Jeongju (Musimcheon), and Busan (Oncheoncheon)

Figure II-11. Demonstration of applying LSTM deep learning for flood forecasting in Han River Flood Control Office (HRFCO)

In addition, Digital Twin (DT) technology has been deployed across all local governments to enhance water resources management and flood forecasting capabilities. The *Dam–River Digital Twin Water Management Platform* is an intelligent system that accurately reconstructs real-time dam and river hydrological conditions within a 3D virtual environment using integrated sensor networks and multi-source data. By simulating and predicting hydrological processes, the platform supports early forecasting and preparedness for water-related hazards, including floods and droughts. It enables pre-event scenario simulations, such as assessing downstream impacts of dam releases or identifying areas at risk of inundation due to rising river levels during extreme rainfall events—thereby facilitating more scientific and proactive decision-making. Through this platform, local governments can access comprehensive information for all 3,816 river sections nationwide (including ungauged reaches), such as water level forecasts, CCTV imagery of national rivers, flood hazard maps and vulnerability information, projected downstream impacts of dam discharges, and alerts on access risks near rivers during flood conditions.

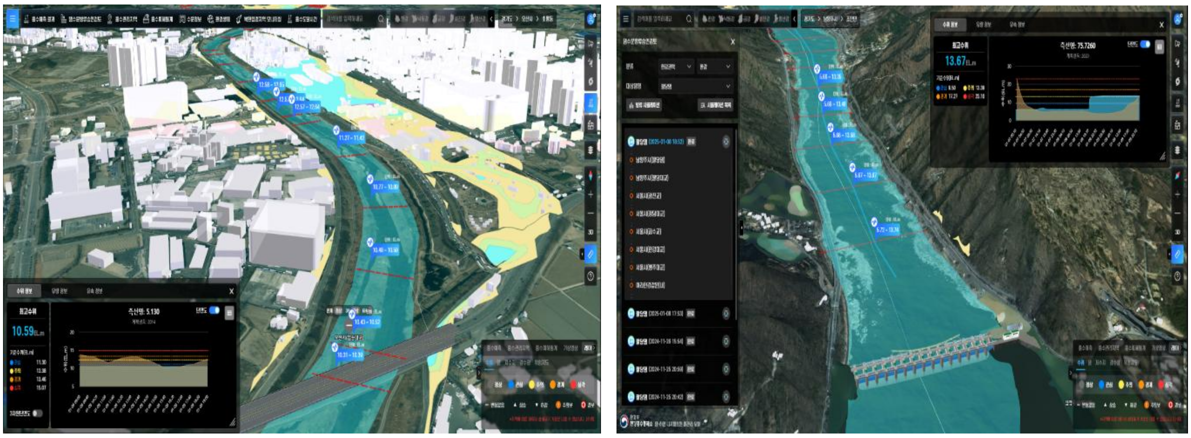

Figure II-12. Water level forecasting for entire river sections and visualization of river hazard situations in DT platform [left]; Assessment of downstream river impacts during dam discharge [right]

**Priority Areas Addressed:**

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.

- Enhance capacity in typhoon-related flood risk management (including land-use management, dam operation, etc.) and integrated water resources management and flood-water utilization.

**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** | |

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## 8. Capacity Building / Knowledge sharing in DRR

**Main text:**

NDMI participated in the 「World Bosai Forum 2025」, hosted a session titled "*From Data to Action: Monitoring Systems and Early Warnings for DRR*" held from March 8 to 10 at Sendai International Center in Japan. 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 5 experts and experts from various field attended the program including NDMI and VDDMA. 1 expert served as the session moderator and 3 experts from NDMI and Mr. Nguyen Thanh TUNG from VDDMA made technical presentations on disaster management and the detailed subject is as follows.

- UNESCAP/WMO Typhoon Committee Working Group on Disaster Risk Reduction (WGDRR) Activity (Dr. Choi Woo Jung)
- International Cooperation on Disaster Risk Reduction – Flood Ealry Warning System - (Dr. Kim Jinyoung)
- Landslide Early Warning System: Challenges Amid Climate Change in Korea (Dr. Suk Jaeuk)
- Typhoon Yagi (2024) in Vietnam: Damages, Response Efforts, Post-Disaster Recovery and Lessons (Mr. Nguyen Thanh TUNG)

Also experts from IRIDeS, Keio university, Harvard university, and Tohoku university made presentation and made the workshop more practical and informative.


Figure II-13. Capacity Building and Knowledge Sharing in DRR program at World Bosai Forum in 2025

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

- NDMI is planning to hold a knowledge sharing program with WGH in Vietnam in 2026.

**Priority Areas Addressed:**

<u>Integrated</u>

- Strengthen cross-cutting activities among working groups in the Committee.

<u>Meteorology</u>

- Promote communication among typhoon operational forecast and research communities in Typhoon 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** | |

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## 9. 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 self-assessment and inspected operation and management status of the Early Warning and Alert System from 30 June to 7 July, in Danao and Olongapo, Philippines. Following the system's establishment, real-time water level monitoring became possible, which confirmed the capacity for immediate early response. Furthermore, through the meeting with PAGASA and the local government of Olongapo and Danao cities, NDMI identified the necessity of implementing supplementary measures for strengthening local technicians' capabilities and improving the technical transfer system.

Figure II-14. Pictures of having meeting with CDRRMO and PAGASA

Figure II-15. Pictures of Conducting a Self-Assessment in the Philippines

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

- NDMI will implement the project at Cebu cities in the Philippines from 2026 to 2030.

**Priority Areas Addressed:**

<u>Meteorology</u>

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

<u>Hydrology</u>

- 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** | ✓ |

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## 10. The 20th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction

**Main text:**
The 20th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (TC WGDRR) was held in Seoul, Republic of Korea from 27 to 30 May 2025. Around 50 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 “Shifting paradigms in disaster Risk Reduction: Strategies for Climate Change Risks”. In the meeting, TC members shared disaster management policies, information, and current status of technology development related to disaster risk reduction. The WGDRR members reviewed 2025 Annual Operation Plans (AOPs) and discussed a tentative AOP with budget in 2026. In addition, Advisory Working Group meeting has been jointly held with WGDRR annual meeting face to face.

Table II-2. Tentative Annual Operations Plans (AOPs) with budget in 2026

| No. | Items | Budget (USD) | No. | Items | Budget (USD) |
|---|---|---|---|---|---|
| 1 | Capacity Building / Knowledge Sharing in DRR | 11,000 | 2 | Setting up Early Warning and Alert System | - |
| 3 | TC WGDRR Annual Meeting | 6,000 | 4 | Benefit Evaluation of Typhoon DRR | 6,000 |
| 5 | Sharing Information related to DRR | - | 6 | Making Educational Video | 3,000 |
| 7 | Making Typhoon(Yagi) video | 2,700 | 8 | Cloud-Based Early Warning System Development | 2,000 |
| **Total Budget (USD)** | | | | | **30,700** |


Figure II-16. Pictures of the 20th Annual Meeting of TC WGDRR

**Priority Areas Addressed:**
<u>Integrated</u>

- Strengthen cross-cutting activities among working groups in the Committee.

**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** | |

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# 11. 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, moderated 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 information using Glide(https:glidenumber.net).

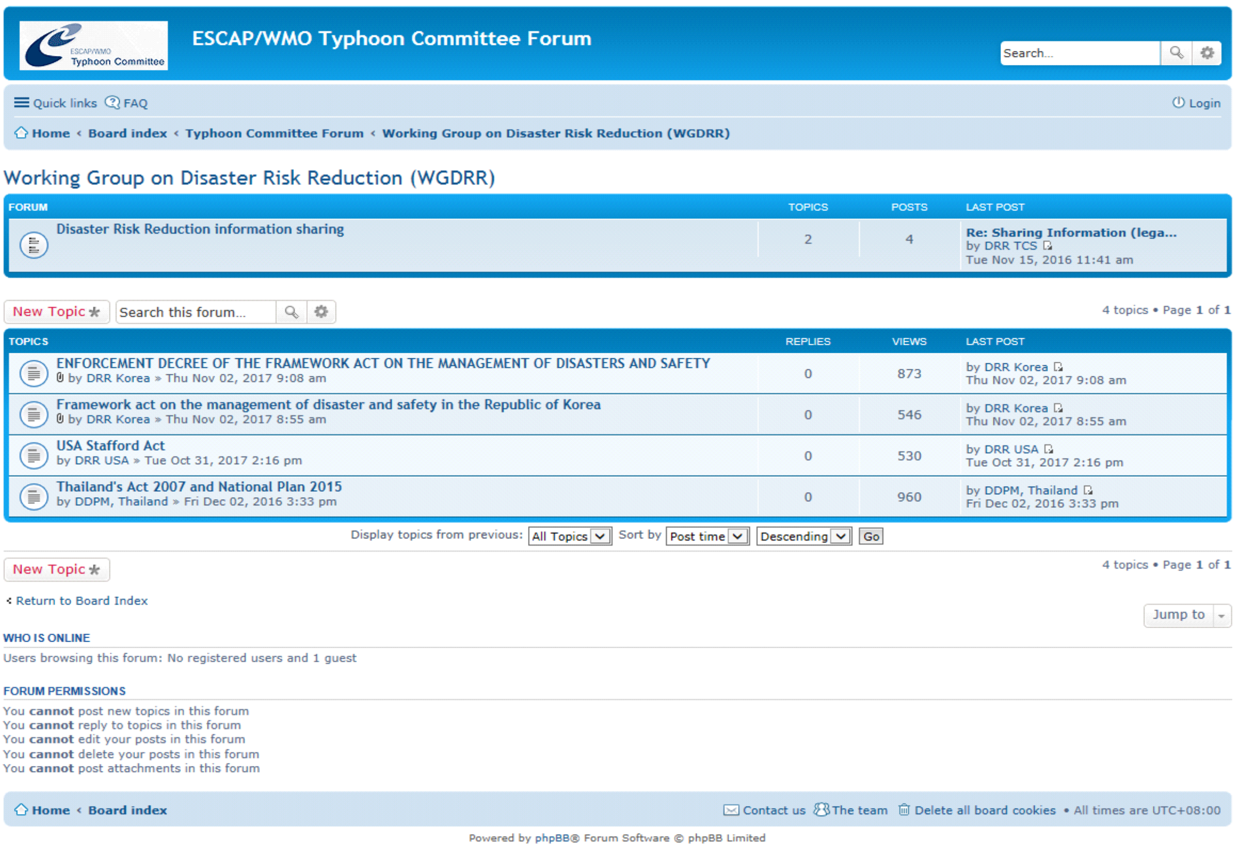


Figure II-17. TC WGDRR Forum Website (http://www.typhooncommittee.org/forum/viewforum.php?f=12)

**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** | |

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