

**MEMBER
REPORT
[Republic of Korea]**

**ESCAP/WMO Typhoon Committee
18th Integrated Workshop
ESCAP - UN Conference Center, Bangkok, Thailand
28 November – 1 December 2023**

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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)

Sixteen typhoons occurred until November 17, 2023 in the Western North Pacific basin. The number of typhoons in 2023 was below normal compared to the 30-year (1991–2020) average number of occurrences (25.1). Only two typhoons developed in September, which was significantly less than normal (5.1). One typhoon, KHANUN (2306), influenced the Korean Peninsula and made landfall. The track of Typhoon KHANUN is presented in Fig. I-2.

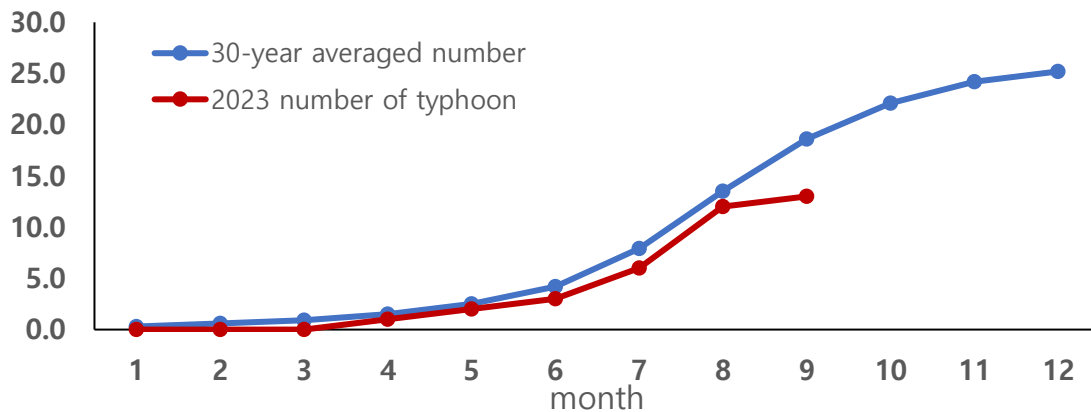


Figure I-1 Comparison of accumulated typhoon occurrences by month in 2023.

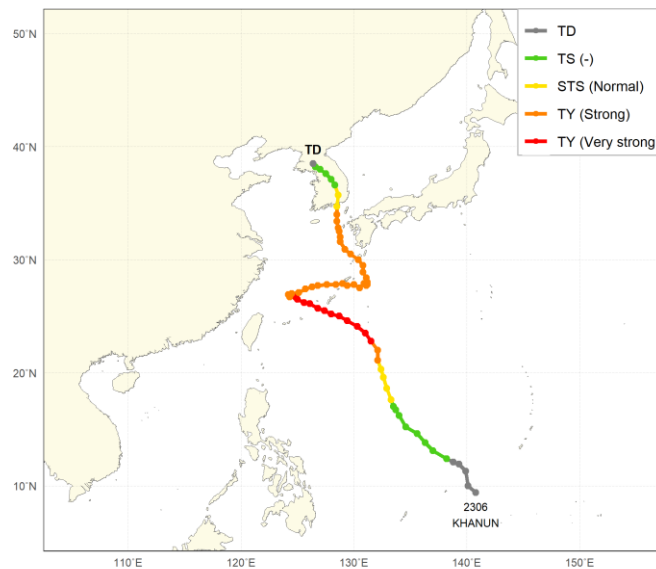


Figure I-2 TC track that affected the Korean Peninsula in 2023.

Typhoon KHANUN (2306) remained active for more than 16 days, undergoing rapid intensification (RI) and showing two unusual track transitions that led to significant forecast errors. Typhoon KHANUN developed into an fTD on July 26 and was upgraded to a TS at 18 UTC on July 27 near Guam while moving northwest towards the East China Sea. In the early stages of KHANUN's development, it was expected to make landfall near Shanghai, China, due to the steering flow generated by the subtropical ridge. However, as the Equatorial Ridge (ER)

strengthened, KHANUN moved from the East China Sea to the southern sea area of Kyushu, Japan. During this period, KHANUN was expected to make landfall in the southern part of Kyushu based on most NWP's results. However, with the strengthening of the subtropical ridge, the typhoon turned northward again on August 8. It passed through the sea area west of Kyushu, Japan, and made landfall on the southern part of the Korean Peninsula at 00 UTC on August 10. The typhoon crossed the Korean Peninsula on a northward track, causing heavy rainfall and strong wind damage. From August 9 to 10, an accumulation of over 200 mm of precipitation was recorded in the southeastern Korean Peninsula. A peak gust of 34.9 m/s was observed at Gadeokdo, located in the southern part of the Korean Peninsula.

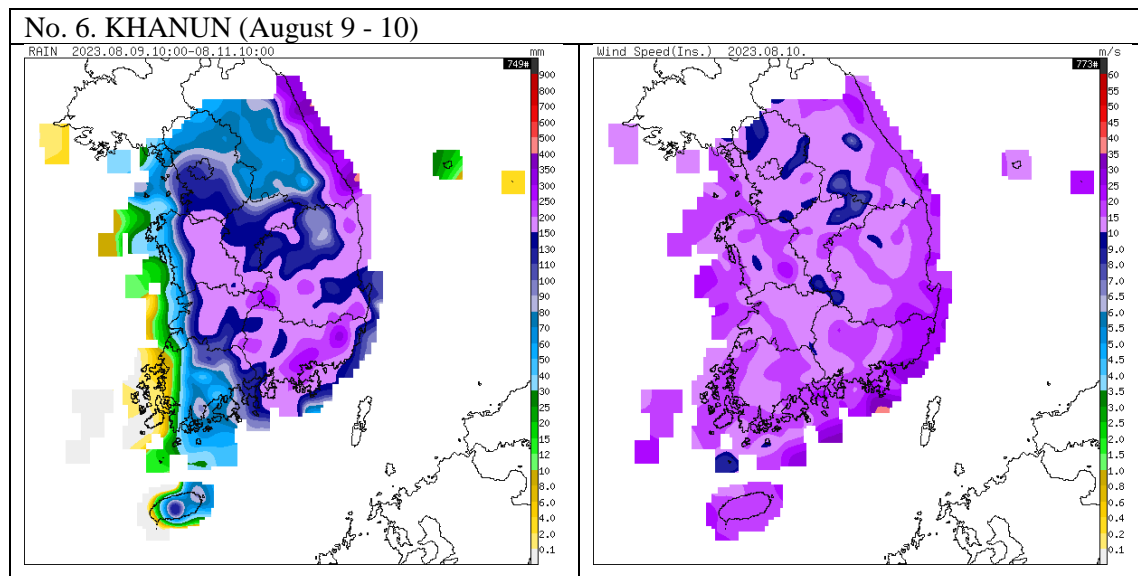


Figure I-3 Distribution of accumulated rainfall (left) and gust (right) during the passage of Typhoon KHANUN (2306).

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

Of 12 typhoons were monitored this year (as of 1 September 2023), the ONLY typhoon that landed on the Korean Peninsula and had a direct impact was Typhoon No.6 KHANUN. After KHANUN, 6 Typhoons occurred in August alone, accounting for 50% of the total number of typhoons this year, but there was no direct or indirect impact.

As Typhoon KHANUN passed through South Korea on August 10th, accumulated rainfall exceeded 100 mm in most areas of the country. As it was the first typhoon to cross the Korean Peninsula from north to south since 1951, there was great concern about damage depending on the predicted timing of its landing.

In particular, along KHANUN's northward path after landing, the eastern region recorded the heaviest rainfall in August since observations began in 1968. Nationwide, 361 cases of facility damage were recorded, and 2 casualties occurred. More than 15,000 people were temporarily evacuated.

Typhoon KHANUN swept the entire Korean Peninsula, but analysis suggests that the damage to life and property was not as great as initially feared. This is believed to be the result of prior preparations such as evacuating residents in vulnerable areas, refraining from going out, and controlling traffic.

In 2023, the Flood Control Offices of ROK issued the total of 71 flood watches and 22 flood warnings nationwide between June to September. Considering there were 28 and 8 cases respectively compared to the similar period last year, the number of issued watches and warnings have increased this year.

Rather than being caused by a flood from typhoons, this is analyzed to be due to heavy torrential rainfall in the southwest and the central area in mid-July

Rainfall in summer in Korea have been characterized by continuous raining around June and July caused from the seasonal rain front, but recently, there has been a change due to the unstable atmosphere. Starting in 2021, rainfall pattern in Korea has been noticeably different from the past and seems more closely tropical heavy rainfall.

In particular, this year, in mid-July, as record-breaking heavy rainfall occurred in the central region of South Korea and the river embankment collapsed, 17 vehicles passing through an underpass near a river were submerged in water, resulting in the death of 14 people on the spot.

At this time, the cumulative number of deaths reached 41 due to localized heavy rainfall for about a week nationwide, and there were 740 reports of facility damage (slope loss, road damage, building collapse, river bank loss, etc.). 1,976 people from 6,532 households were temporarily evacuated.

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

From January to October 2023, total one typhoon has affected the Republic of Korea out of 16 typhoons which have been formed near Korean peninsula. Typhoon KHANUN started from Okinawa, Japan made landfall near Geoje on 10th August. There was no life damage by Typhoon KHANUN but it caused facilities damages; inundated/swept roads(70) and houses(30), soil loss(6), bridge sinking(2) and etc. Property damage by Typhoon KHANUN is around 56 billion won(around 43 million USD)(Table I-1).

Province	Damage (million)	Recovery Cost(million)			
		Total	Private facility	Compensation	Public facility
Total	42.5	84.3	8.8	4.4	71.1
Daegu	8.0	13.7	0.9	0.8	12.0
Gyeongbuk	12.8	22.9	3.1	0.3	19.5
Gangwon	12.1	30.7	2.5	2.1	26.1
Etc.	9.6	17.0	2.3	1.2	13.5

Table I-1. Damage and Recovery cost by Typhoon KHANUN

Ministry of Interior and Safety (MOIS) supported temporary houses for the victims of typhoon KHANUN and flood. Total 73 houses were provided; 50 temporary houses and 23 rental houses (Figure I-4).



Figure I-4. Temporary houses for the victims of typhoon KHANUN and flood

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 developed a statistical model with the purpose of improving the accuracy of seasonally predicting the genesis of tropical cyclones (TCs) in the WNP. This model aims to predict the frequency of TCs occurring over the WNP during the summer season (June-July-August). The model used for prediction is the ordinary least square regression model, which includes predictors such as WNP trade wind (April), Pacific Meridional Mode (March), Canadian Sea Ice (March), St. Lawrence Sea Ice (March), and others. This model is used to estimate the frequency of TCs in the WNP. During the summer season in 2023, it was predicted that 5.5 typhoons would develop west of 140°E (Domain1), and 3.0 typhoons would develop east of 140°E (Domain2). As observed, 5 typhoons occurred in Domain1, mainly in June and July, while 5 typhoons occurred in Domain2 in August. The dynamical model, based on the KMA Global Seasonal Forecasting System (GloSea6), predicted a typhoon frequency of 8.8 for the WNP during the summer season of 2023, with a high track density expected in the southern sea area of Japan. This projection was due to the anticipated southeastward shift of the subtropical high. However, during this summer, the subtropical high extended more northwestward than the climate average. As a result, there was increased typhoon activity in the region east of the Philippines. NTC/KMA shared the results of the summer prediction with members of the Typhoon Committee via email.

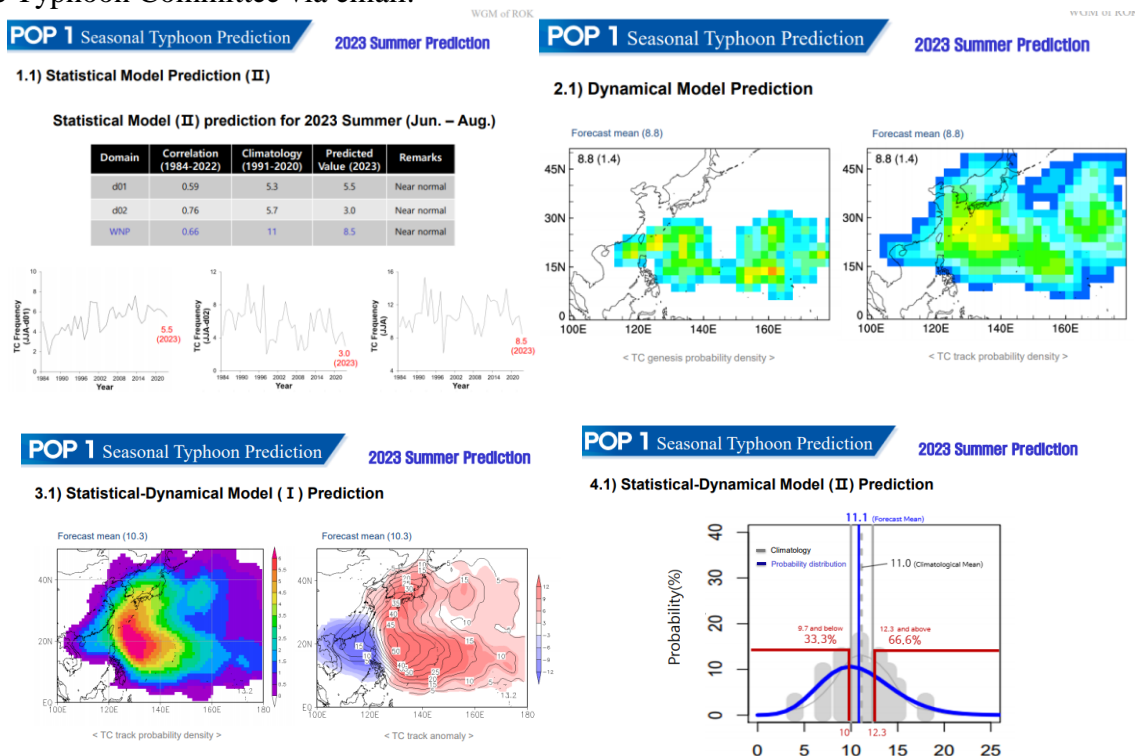


Figure II-1 Seasonal prediction results of the frequency of TCs during the summer season in 2023.

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

Improvements to Hybrid1 using CFS and Hybrid2 using Glosea6 will enhance the forecast accuracy for summer 2024. The summer 2024 outlook, based on the improved models, will be shared with members in late May 2024.

Priority Areas Addressed:

Meteorology

- Develop and enhance typhoon analysis and forecast 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	

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2. Deployment of Drifting Buoys for Typhoon Forecasts and Analysis

Main text:

In 2022, NTC/KMA deployed 7 drifting buoys in the WNP to fill the lack of typhoon observations in the ocean, focusing on analyzing the development of typhoon intensity. These buoys measured SST, pressure, and wave height every 20 minutes. During the approach of Typhoon NANMADOL, a pressure value of 983 hPa was recorded at one station. In 2023, NTC/KMA deployed 12 buoys and shared real-time observational data with member countries through the GTS. A dedicated webpage has been created for sharing observations (<http://hms.otronix.com:60481/>), accessible through login. The webpage displays SST and pressure values for each station in tabular format. As Typhoon KHANUN approached the observation site of a buoy deployed south of the west coast, SST and pressure near the typhoon were observed. Despite the distance from the center being around 300 km, the data was used to confirm the typhoon's strong wind radius and high SST environment. Similarly, as Typhoon KOINU approached the buoy stations deployed in the eastern Philippines, observations were conducted on SST and pressure along the typhoon’s track. As the typhoon approached the area where the buoys were located, the data from these buoys were used to analyze the typhoon's intensity and wind radius. Through buoy observations, forecasters realized that Typhoon KOINU was a compact typhoon, small in size but strong in intensity.

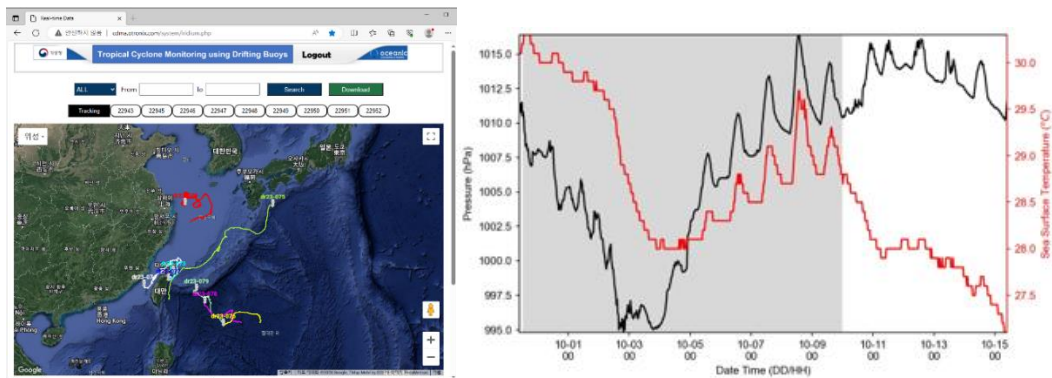


Figure II-2 Example of analysis results for a typhoon using drifting buoys.

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

In 2024, NTC/KMA will continue to deploy more than 5 drifting buoys in the WNP and share real-time data with member countries.

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	

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3. Development of AI Models for TC Analysis

Main text:

NTC/KMA has developed AI models for automatic TC analysis since 2022, providing forecasters with guidelines for real-time TC analysis. In 2023, the AI model for center location analysis was tested and validated for 2022 TC cases. The center location analysis system consists of 10 AI models, which are based on convolutional methods and 5 combinations of satellite imagery (single channel: 0.64 μ m, 10.4 μ m, BTD: 10.4-3.9 μ m, 10.4-8.6 μ m, 8.6-11.2 μ m). Table 1 represents the configuration of this system. The distance errors for different TC intensities range from 3.7 km (nighttime, ST) to 49.3 km (nighttime, TD), which are lower than the uncertainties among the best tracks from KMA, JMA, and JTWC (Table 2). Though the performance is less skillful for weak systems such as TD and TS, averaging the 10 locations allows for a possible center to be guessed. At the same time, the variability of the 10 results can serve as an index to see the uncertainty of cases. In comparisons with real-time analysis, cases with large uncertainty show big differences among KMA, JMA and JTWC as well. The center analysis system was implemented for real-time use, beginning operation in the summer of 2023, and it automatically analyzes TC center every hour.

Table II-1 Configuration of the center location analysis model.

	Models (10)	Satellite image	Period
Training	2 ML (CNN, ConvLSTM) X 5 channel combination	Himawari-8	2016 – 2021
Inference		GK2A	2022

Table II-2 Distance errors of the AI system (unit: km).

	TD	TS	TY	ST
Distance error (day/night)	36.9/49.3	34/32.8	12.4/13.7	11/3.7
Best-track uncertainty	49	39	15	11

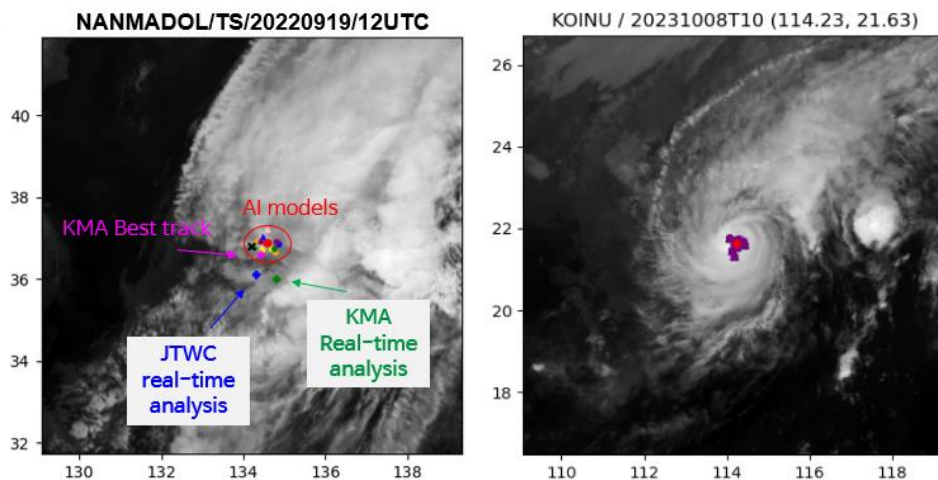


Figure II-3 Examples of TC center location analysis of the AI models (a) with analysis and best track, and (b) operational image provided in real-time.

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

AI analysis technology for typhoon size and intensity, as well as the analysis of typhoon centers, is currently under development. The results of this development are expected to be shared with member countries in 2024.

Priority Areas Addressed:

Meteorology

- Develop and enhance typhoon analysis and forecast 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	

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4. 2023 TRCG Research Fellowship Scheme by KMA

Main text:

NTC/KMA offered the Typhoon Research Fellowship Program of the Typhoon Committee Training and Research Coordination Group (TRCG). The program was joined by two participants from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and the Thai Meteorological Department (TMD) from June 12 to 23, 2023. During the program, the participants studied the rapid intensification mechanism and binary TC interaction at NTC for two weeks. Using NTC's TOS system, they analyzed typhoon intensity with GK2A images and investigated the influences of environmental fields using variables predicted by the Korean Integrated Model (KIM). In addition, the participants shared the results of their research on the development process and environmental factors of Typhoon RAI (2122) and CHANTHU (2114) with NTC forecasters.



Figure II-4 Typhoon Committee TRCG Research Fellowship at NTC/KMA in 2023

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

KMA will continue to offer research fellowships in 2024. Information on the number of available positions and the duration of these fellowships will be announced in March 2024.

Priority Areas Addressed:

Integrated

- Strengthen the cooperation between TRCG, WGM, WGH, and WGD RR to develop impact-based forecasts, decision support, and risk-based warnings.

Meteorology

- Promote communication among typhoon operational forecast and research communities in the Typhoon Committee region.
- Enhance training activities with TRCG, WGH, and WGD RR in accordance with Typhoon Committee's forecast competency, knowledge sharing, and the exchange of the latest developments and new techniques.

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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5. The 13th Korea-China Joint Workshop on Tropical Cyclones

Main text:

NTC/KMA hosted the 13th Korea-China Workshop on Tropical Cyclones from May 22 to 26, 2023, in Jeju, Republic of Korea. This workshop is one of the cooperative activities agreed upon in the cooperation between KMA and the China Meteorological Administration (CMA) in the field of meteorology. NTC/KMA and the Shanghai Typhoon Institute (STI) of CMA have been co-hosting this joint workshop annually since 2008. The workshop was resumed after a four-year hiatus since 2019.

This event was attended by five experts from STI and the Shanghai Marine Meteorological Centre, along with two experts from the National Meteorological Satellite Center (NMSC) and the National Institute of Meteorological Sciences (NIMS), and one expert from the APEC Climate Center (APCC). During the workshop, the participants shared the latest research achievements in various fields, such as observation, climate, satellite analysis technology, AI-based analysis technology, and numerical models.

STI/CMA and NTC/KMA also had a bilateral meeting during the workshop. STI introduced visiting scientists related to AP-TCRC and visiting editors related to TCRR, suggesting joint research between NTC and STI in the future. NTC inquired about the feasibility of sharing observation data on the Shanghai coast of China, as well as the possibility of sharing HSCAT wind products (from HY-2B/C/D) for typhoon analysis. In addition, five delegates from CMA visited the NMSC located in Jincheon for a technical tour. Through this workshop, the two organizations discussed ways to further cooperate.



Figure II-5 Group photo from the 13th Korea-China Joint Workshop on Tropical Cyclones.

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

The 14th workshop will be held in China in May 2024, hosted by STI.

Priority Areas Addressed:Integrated

- Strengthen the cooperation between TRCG, WGM, WGH, and WGD RR to develop impact-based forecasts, decision support, and risk-based warnings.

Meteorology

- Promote communication among typhoon operational forecast and research communities in the 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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6. GEO-KOMPSAT-2A Utilization for Tropical Cyclones (AOP10)

Main text:

GEO-KOMPSAT-2A (GK2A) was launched on December 5, 2018, as a follow-on satellite to COMS. GK2A features a 16-channel next-generation advanced meteorological imager and generates a full-disc image every 10 minutes.

In order to support national and international services over the Asia-Pacific region (RA-II and RA-V), official requests for this rapid scan service are available on the designated webpage of the National Meteorological Satellite Center (NMSC) (<http://datasvc.nmsc.kma.go.kr/datasvc/html/special/specialReqMain.do>). The service will provide significant improvements in real-time monitoring of tropical cyclones. The rapid scan covers a 1,000 km x 1,000 km area every 2 minutes with flexibility for location changes. In 2023, 7 domestic requests about the Typhoon LAN (2307) and HAIKUI (2311), and an international request about DOKSURI (2305) from Hongkong, were completed. Additionally, Open API service and download services have been provided through the same website.

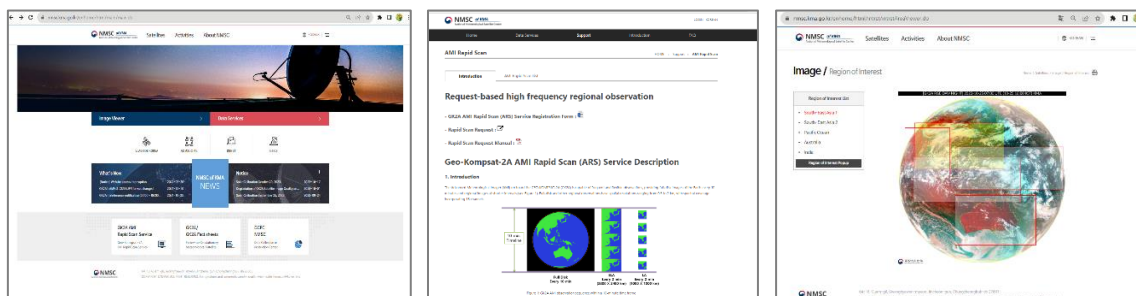


Figure II-6 NMSC’s English home page (left), AMI Rapid Scan page where users can request rapid scans (center), and Region of Interest page for international users (right).

NMSC also provides customized GK2A image services to RA-II and RA-V members. In the case of Indonesia, the service is planned to be changed to the requested Mercator projection starting November 2023 (<http://nmsc.kma.go.kr/enhome/html/intrst/intrstAreaViewr.do>).

In 2024, NSMC plans to develop and distribute packaged S/W operating on macOS, Windows 10, and Linux. The free S/W enables users to download GK2A data for areas of interest to their local PC in real-time, allowing them to store and analyze the data. Moreover, NMSC has joined NOAA’s NODD (NOAA Open Data Dissemination) service. As a result, members will be able to access GK2A data through NOAA’s NODD (<https://www.noaa.gov/information-technology/open-data-dissemination>) in the U.S. starting in December 2023.

NMCS provides basic TC information based on the Dvorak techniques every 3 hours, especially every 1 hour for typhoons affecting the Korean Peninsula. This information includes TC center, intensity, wind radii, and moving information using GK2A. GK2A offers various level-2 meteorological products, such as sea surface temperature, GK2A winds blending with sea surface wind (11 levels from 1000 hPa to 100 hPa), wind field data combining numerical weather prediction models and atmospheric motion vector, and ocean heat content (OHC) for TC analysis. Those satellite products greatly help us understand more details of typhoon structure, contributing to the decision-making of TC analysts.

NMSC has developed an artificial intelligence (AI) model that simulates visible images at night in East Asia since March 2021. This year, the center has modified its AI model to adjust “the typhoon area” since May 2023. Twenty-four-hour day/night RGB images have been used to monitor high-impact weather during the night since March 2021. Additionally, for objective typhoon analysis, NMSC and NTC/KMA have developed a typhoon center and intensity estimation model using artificial intelligence techniques. The AI-based products have been applied for typhoon analysis during test operations, and improvements are planned in 2024.

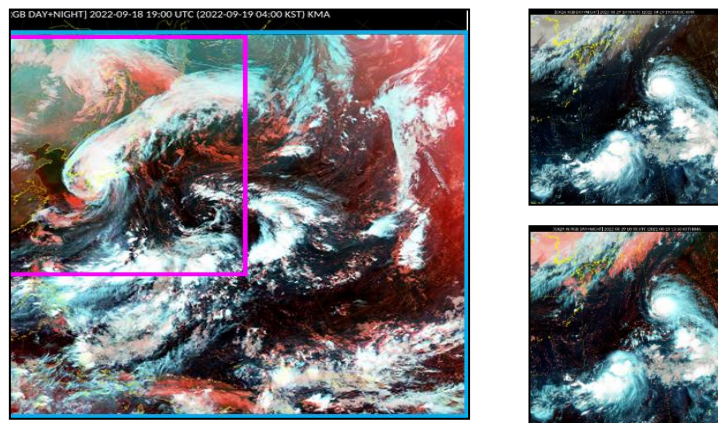


Figure II-7 An AI-based day/night RGB imagery for the East Asian area indicated by a pink box and the typhoon area indicated by a blue box (left), a conventional day/night image (upper right), and a new AI-based day/night RGB image (lower right).

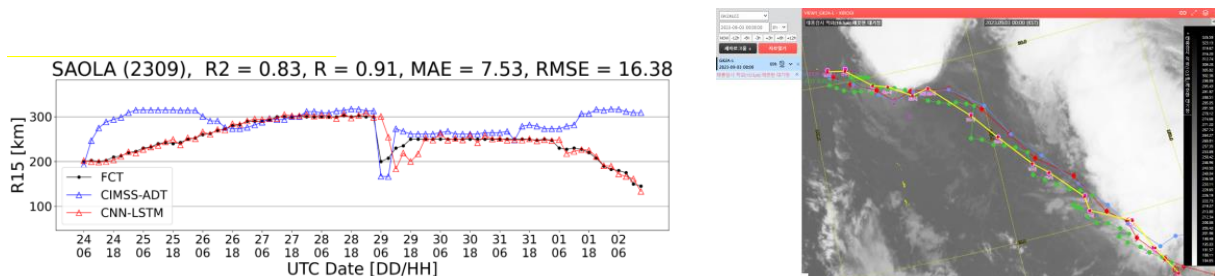


Figure II-8 The graph shows the 15-m/s (34kts) wind radii (R15) of Typhoon SAOLA (2309). The black line represents KMA’s analysis, and the blue line is CIMSS-ADT’s R15. The AI-based R15 is represented by the red line, which exhibits a similar pattern to KMA’s analysis data (left). A comparative image for the Typhoon KIROGI (2312) case displays the AI-based typhoon center (NTC/KMA), Korean-ADT (green line), SDT (red line), and SAREP (blue line) on NMSC’s integrated analysis system (right).

KMA has conducted a couple of official development assistance (ODA) programs. Through ODA programs, GK2A typhoon-related products for typhoon analysis were introduced, and analyzing techniques were shared with users by NMSC and NTC/KMA at two international training courses.

The training courses were:

1. Satellite-based Typhoon Analysis, 2022 Invitational Training Course on Capacity Building for Enhanced Severe Weather Response Utilizing an Integrated Typhoon Monitoring and Forecasting Platform in Lao PDR, November 24–29, 2022 in South Korea (face-to-face)

2. Satellite-based Typhoon Analysis, 2023 Local Training on Capacity Building for the GK-2A Satellite Data Receiving and Analysis System for Forecasting and Warning of Natural Disasters in Cambodia, March 25–31, 2023 (face-to-face)



Figure II-9 A local training program in Cambodia on March 29, 2023 (left and center). 2022 Invitational Training Course for Lao PDR in South Korea (right).

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:

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	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. Construction 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 members 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.

Currently, it has reached the stage to demonstrate the application of the established hydrological data quality management system in the target TC members countries. Figure II-10 illustrates the application of the established hydrological data quality control management system for the observed rainfall data in Laos P.D.R, Philippines, and Thailand. These demonstrations have informed that the established hydrological data quality management system works accordingly to its designed purpose where positive feedbacks were given by the target TC members where the established system do help them efficiently in managing and controlling the quality of the hydrological data collected in their countries. More demonstrations and hands-on learning sections will be held in near future to allow the local practitioners in the target TC members countries to get familiar with the operating procedures of the established hydrological data control management system so that they will adopt the system in solving the problems in real life.

The 5th phase project do not stop there and in fact it aims more than that. Apart from the hydrological data quality control management, it also aims to provide a reliable Extreme Flood Forecasting System (EFFS). Figure II-11 shows the interfaces of the EFFS. The EFFS system has yet been applied in the TC members countries as it is still in the stage of developing and final tuning. The eye catching feature of EFFS is that it will cooperate with artificial intelligence (A.I) for flood forecasting. 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 members countries would be benefited from integrating the A.I in the EFFS as they might be able to predict a flood event more easier and faster.

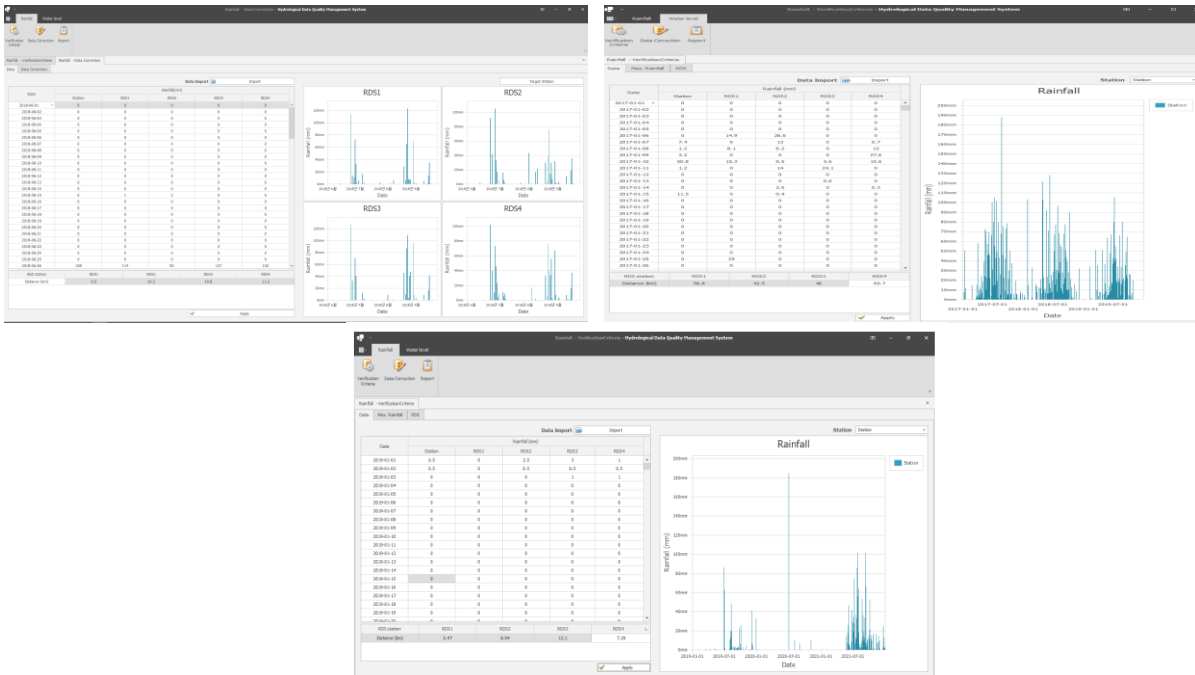


Figure II-10 Interfaces of Application of the Established Hydrological Data Quality Control Management System in Laos, P.D.R (upper left), Thailand (upper right), and Philippines (bottom)

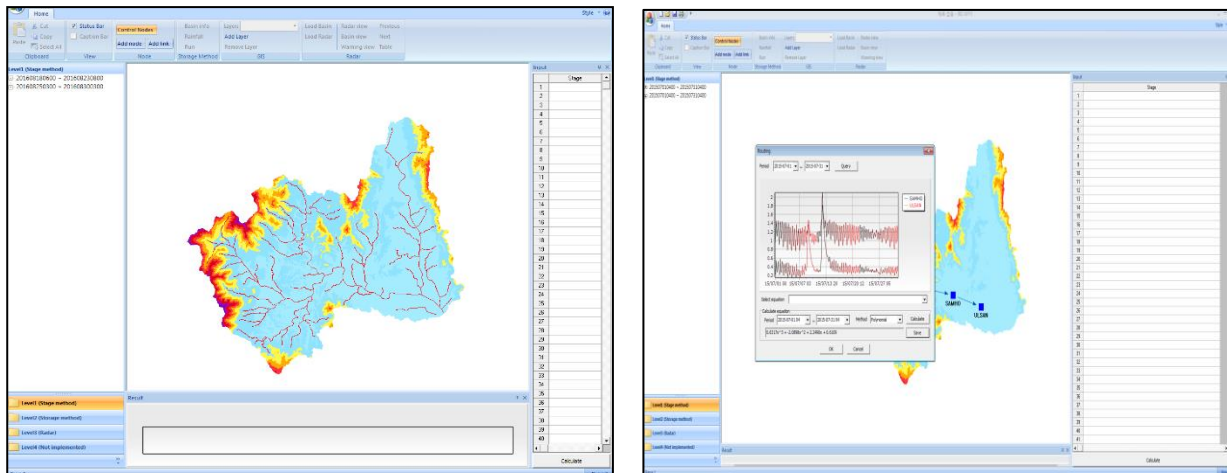


Figure II-11 Interfaces of Extreme Flood Forecasting System (EFFS)

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

There were some restrictions on face-to-face project discussions with pilot target members of TC. Nevertheless, this situation was secured through online meetings and virtual communications. In the next step, there will be a face-to-face meeting of this project and practical application, directly linkage to DB of hydrological data in TC Members.

Through the project, it is expected that capacity building for hydrological data quality control of TC Members will be improved and qualified hydrological data can be reduced the uncertainty of flood forecasting.

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.

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. Enhancing Flood Forecasts and Providing Customized Flood Information

Main text:

From June to September in 2023, the four major Flood Control Offices in Republic of Korea (ROK), namely Han River, Nakdong River, Geum River, and Yeongsan River have already issued total of 71 flood watches and 22 flood warnings. It has increased significantly in relative to last year as there were only 28 watches and 8 warnings have been issued in 2022. Flood watch is issued when the river discharge has achieved 50% of its carrying capacity while warning will be issued when the river discharge has exceeded 70% of its capacity. Increased flood watches and warnings in 2023 indicated that rainfall intensity was increased and raining duration time was shorten in relative to previous years.

Rainfall of summer (June to August) in ROK has been characterized by continuous raining caused by seasonal rain front but not until recently, the rainfall pattern and characteristics have been noticeably distinguished from the past due to unstable atmosphere. The present rainfall seems more closely to tropical heavy rainfall. Changes of rainfall pattern and characteristics have eventually taken its toll on especially the low lying areas near to the rivers. In mid-July, a record-breaking heavy rainfall poured down in the central region of ROK, resulting a river embankment collapsed and 17 vehicles in a tunnel near to the collapsed embankment were submerged within lighting seconds. 14 innocents were killed in this incident.

ROK was also hit by typhoon KHANUN on 10th Aug 2023. It was the first typhoon that crossed the Korea Peninsular from north to south since 1951. The consequences were the heaviest monthly rainfall in August had been recorded in eastern regions since 1968. In nationwide, 361 cases of facility damages were filed, more than 15,000 evacuees were temporarily evacuated and 2 casualties were found. Even though typhoon KHANUN swept across the entire Korea Peninsular, damages that induced from the typhoon has been reduced to minimal due to implementation of early preparation and issuing of early warning to the high risk residents.

The Ministry of Environment of ROK has been planning on enhancing and improving the flood forecast by integrating flood forecast with artificial intelligence technology. AI-based flood forecasting strategies and technologies from a mid to long-term perspective will be 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 only the meteorological forecast data without conducting hydrological and hydraulic simulations.

Apart from that, AI and *Digital Twin* technologies have been introduced to experimentally simulate an urban flooding forecast in Dorim-cheon basin, a frequently flooded area located at south-west of Seoul as illustrated in Figure II-12. River flooding and urban inundation information which is visualized in a 3D digital space that is about similar to reality, is expected to be available through the *Digital Twin* technology.

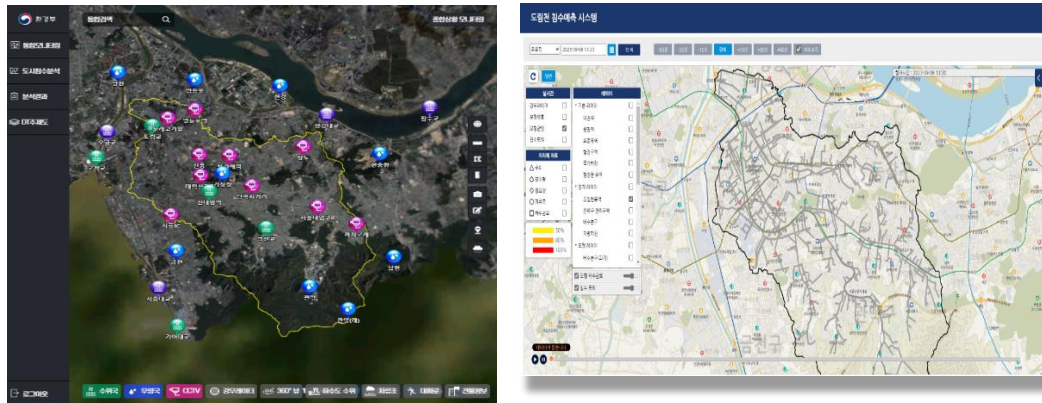


Figure II-12 Urban Flood Forecasting System for Dorim-cheon in Seoul based on Digital Twin

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:

Integrated

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

DRR

16. Enhance Members’ disaster risk reduction techniques and management strategies.

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. Capacity Building / Knowledge sharing in DRR

Main text:

NDMI hosted the Capacity Building / Knowledge sharing in DRR program in the Philippine and Lao PDR on 25th and 27th April 2023 respectively. 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 7 experts and total around 20 experts attended the program including NDMI, PAGASA and DMH. Mr. Marcus Aydlett, the Vice Chair of WGDRR, Mr. Michael Fu from TCS and 4 experts from NDMI made a presentation on disaster management and the detailed subject is as follows.

- Impacts-Based Communications and Reaching the Last Kilometer (Mr. Marcus Aydlett)
- Strategic Plan 2022-2026(Mr. Michael FU)
- Introduction on international cooperation project in NDMI(Dr. Chihun Lee)
- Understanding of Disaster Scientific Investigation and Activities(Dr. Seungyong Choi)
- NDMI Overview and main work (Ms. Eunji Seo)
- The disaster victims policy in South Korea(Ms. Jiyu Kim)
- Disaster relief policy for disaster victims in Korea(Ms. Hyesun Lim)



Figure II-13 Capacity Building and Knowledge Sharing in DRR program in the Philippine in 2023



Figure II-14 Capacity Building and Knowledge Sharing in DRR program in Lao PDR in 2023

NDMI has signed MOA and MOU with PAGASA and DMH for the continuous global disaster risk reduction project and will continue this program next year in Japan.

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

- NDMI is planning to hold knowledge sharing program in Japan in 2024

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.

Meteorology

- 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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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 ARWS in Danao and Argao 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 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 Danao and Argao City, NDMI chose the six areas for WP, the six areas for RG, and the six areas for WG in Danao and Argao City. In addition, NDMI conducted the training and educational program in September for local officials and the residents in the Philippines (Figure II-16).

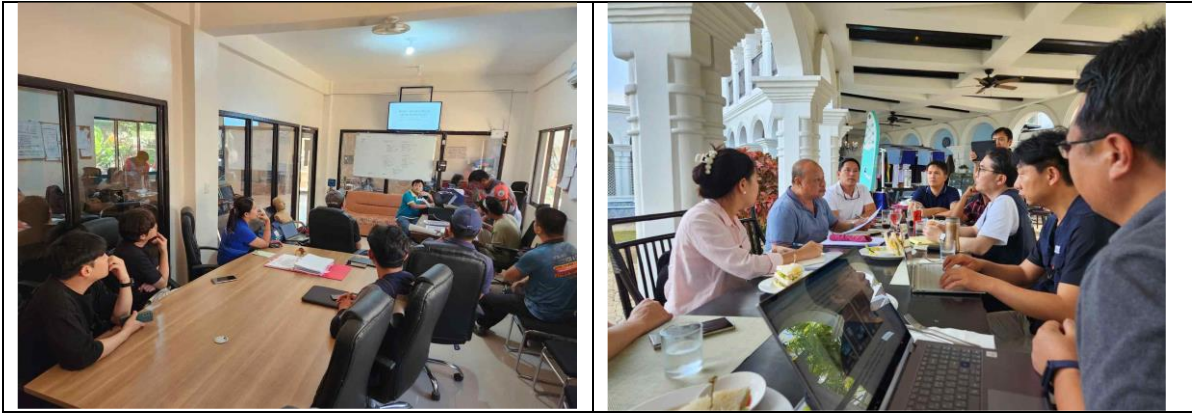


Figure II-15 Pictures of having meeting with PAGASA



Figure II-16 Pictures of Conducting Field Survey in the Philippines



Figure II-17 Pictures of Training and Educational Program in the Philippines

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

- NDMI will implement the project at Olongapo and La paz province in the Philippines in 2024 and conduct pre-feasibility study for the Philippines and Lao PDR in 2024

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	✓

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11. The 18th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction

Main text:

The 18th Annual Meeting of Typhoon Committee Working Group on Disaster Risk Reduction (TC WGDRR) was held in Ulsan, Republic of Korea from 13 to 16 June 2023. Around 40 representatives from international organizations, universities and TC members participated in the meeting and discussed international cooperation for reducing disaster risk around the world. The topic for the annual meeting was “Future of Disaster Risk Reduction : Leveraging Technology to Adapt Climate Change.” In the meeting, TC members shared disaster management policies, information, and current status of technology development related to disaster risk reduction. The members reviewed 2023 Annual Operation Plans (AOPs) and discussed a tentative AOP with budget in 2024. In addition, Advisory Working Group had a meeting face to face.

Table II-3 Tentative Annual Operations Plans (AOPs) with budget in 2024

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	-	4	Benefit Evaluation of Typhoon DRR	6,000
5	Sharing Information related to DRR	-	6	Making Educational Video	3,000
Total Budget (USD)			21,500		



Figure II-18 Pictures of the 18th 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	

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12. Sharing Information Related to DRR

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

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

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Disaster Risk Reduction information sharing	2	4	Re: Sharing Information (lega... by DRR TCS Tue Nov 15, 2016 11:41 am

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TOPICS	REPLIES	VIEWS	LAST POST
ENFORCEMENT DECREE OF THE FRAMEWORK ACT ON THE MANAGEMENT OF DISASTERS AND SAFETY <small>by DRR Korea » Thu Nov 02, 2017 9:08 am</small>	0	873	by DRR Korea Thu Nov 02, 2017 9:08 am
Framework act on the management of disaster and safety in the Republic of Korea <small>by DRR Korea » Thu Nov 02, 2017 8:55 am</small>	0	546	by DRR Korea Thu Nov 02, 2017 8:55 am
USA Stafford Act <small>by DRR USA » Tue Oct 31, 2017 2:16 pm</small>	0	530	by DRR USA Tue Oct 31, 2017 2:16 pm
Thailand's Act 2007 and National Plan 2015 <small>by DDPM, Thailand » Fri Dec 02, 2016 3:33 pm</small>	0	960	by DDPM, Thailand Fri Dec 02, 2016 3:33 pm

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Figure II-19. TC WGDRR Forum Website (<http://www.typhooncommittee.org/forum/viewforum.php?f=12>)