MEMBER REPORT

ESCAP/WMO Typhoon Committee
11th Integrated Workshop

REPUBLIC OF KOREA

24-28 October 2016
Cebu, Philippines

CONTENTS

I. Overview of Tropical Cyclones which have affected/impacted Member's area in 2016

1. Meteorological Assessment (highlighting forecasting issues/impacts)

The track of Tropical Cyclones (TCs) such as MERANTI (1614), MALAKAS (1616) and CHABA (1618) that had impacts on the Korean Peninsula and Korea Meteorological Administration (KMA)'s warning zone in 2016, as shown in [Fig.1-1]. In particular, CHABA (1618) had direct impacts on the Peninsula on 4 to 5 October.

CHABA struck Jeju Island and southern regions of the Korean Peninsula. It caused the largest damage among TCs occurred in the month of October. CHABA passed through the southeastern coast of Jeju on 4 to 5 October and approached nearby Busan. The typhoon dropped huge amount of rainfall with strong wind, heading towards East Sea of Korea. During the TC passage, huge amount of rainfall was poured: more than 600 mm or more on mountain area in Jeju; 100~300 mm in southern and southeastern parts of the Korean Peninsula.

Strong wind of 49 m/s was observed in Gosan, western part of Jeju. Also violent wind was experienced in some regions. Destructive wind whose maximum wind speed was up to 50 m/s overturned an excavator, knocking street trees down. It also caused a power outage, inundation and left ten people dead or missing.

MALAKAS affected parts of marine forecast zones of South Korea as it passed through the southern part of Jeju, approaching the southern coast of Kyushu, Japan. Maintained its intensity as a strong typhoon with minimum pressure of 935 hPa, the typhoon struck Ieo Island, and the southern sea off Jeju at dawn on 19 September. MALAKAS affected the South Sea and the southeastern sea of the Korean Peninsula until it ripped through Kyushu, Japan in the morning on 20 September. Although the TC affected only the marine forecast zone, no serious damage was caused to the Peninsula. During the TC, 114 mm of rainfall was reported on a mountain top in Jeju with a maximum wind speed of 18.7 m/s.

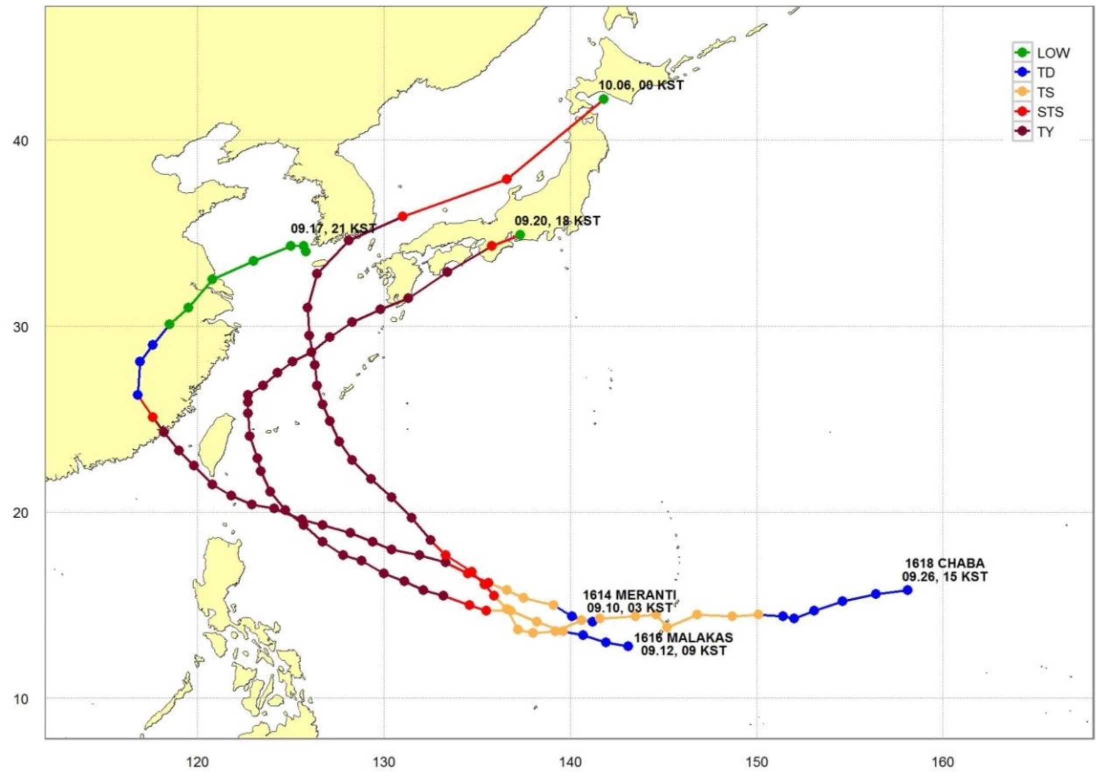


Figure 1-1. TC tracks that affected the Korean Peninsula in 2016

Meanwhile, typhoon MERANTI weakened into a tropical depression on 15 September at 3pm, on the southeastern part of China and it redeveloped into an extratropical cyclone on 17 September, as moving towards the South Sea of Korea, and dropped huge amounts of rain on the nation. Under the influence of depression on 19 September, heavy rainfall of more than 100 mm was recorded. Some regions suffered inundation of houses, roads and farm crops ahead of harvest due to torrential rain of more than 200 mm [Fig.1-2].

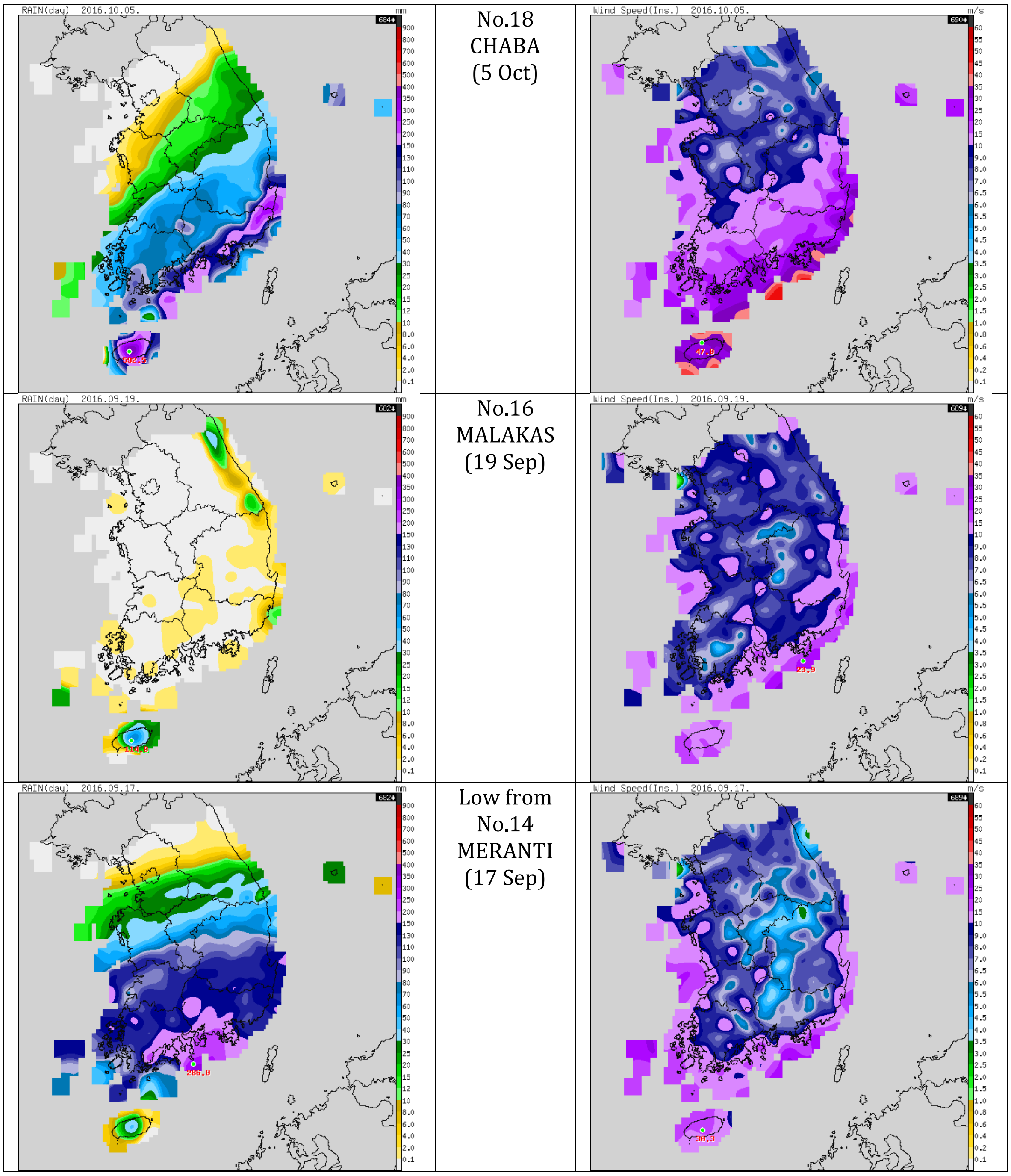
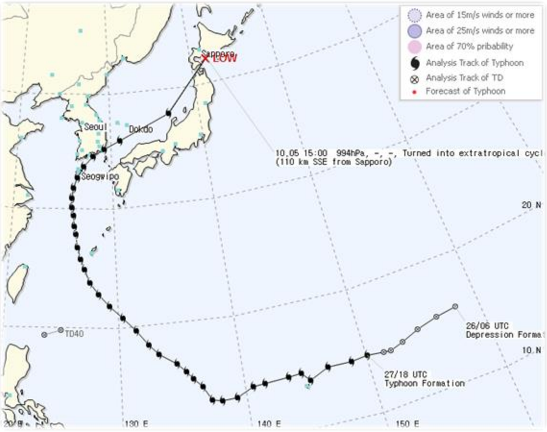


Figure 1-2. Spatial distribution of rainfall (left), typhoon name & impact date (mid) and wind gust (right) on the Korean Peninsula affected by typhoons.

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

Of 18 typhoons which occurred until early October 2016, the 18th CHABA was the only one landed in the Republic of Korea. CHABA developed into a typhoon in the east sea of Guam, USA on 28 September and strengthened near the sea of Okinawa, Japan on 5 October at 11 am. On 5 October at about 11 am, CHABA changed its direction and landed on Busan, the Republic of Korea, occurring huge damage and finally changed into the extratropical cyclone in south southeast sea of Sapporo, Japan. [Fig.1-3 (a)] The 18th CHABA inflicted a lot of damage on Jeju Island and the region of Gyeongsangnam-do, especially Busan and Ulsan Metropolitan City. The flood warning was issued for Taehwagang(river) on the region of Ulsan and river overflow and urban inundation have caused the number of casualties and damage of properties.

a) the 18th CHABA



b) the 16th MALAKAS

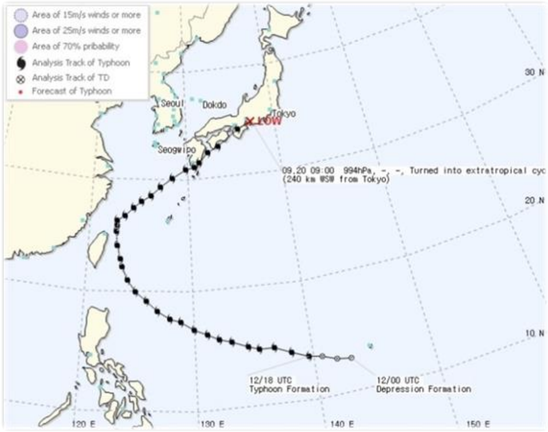


Figure 1-3. Paths of the 18th CHABA and the 16th MALAKAS

Besides, Korea was affected by the 14th typhoon MERANTI and the 16th MALAKAS. MERANTI developed into a typhoon in west-northwest sea of Guam on 10 September, and weakened as a tropical cyclone (TC) in west of Fuzhou, China on 15 September, occurring a lot of casualties. The MALAKS developed into a typhoon in west sea of Guam on 13 September. By changing the direction through the northeast sea of Taiwan, it landed in Japan recording historic heavy rainfall and occurring damages such as aircraft cancellation and power outage. Finally it changed into an extratropical cyclone on 20 September in the west-southeast land of Tokyo, Japan. [Fig.1-3 (b)] In the case of Korea, the successive occurrence of the two typhoons caused heavy rainfall more than 100 mm (some place more than 200 mm) on the south provinces of Korea, and the amount was 3-4 times greater compared with the same period of past years. Due to the heavy rainfall, some roads were flooded and flood forecast was issued in the downstream of Nakdonggang (River). But on the other hand, the heavy rainfall brought the benefit of securing water storage at the dam: 354 million tons of Nakdonggang basin, 45 million tons of Geumgang basin and 12.5 million tons of Yeongsangang basin.

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

The 18th Typhoon CHABA hit the southern parts of the Republic of Korea in 5 October, 2016. By the Typhoon CHABA, seven people were dead and three people were missing. Also, there were devastating damages in Jeju, Busan, and Ulsan city. Ulsan, the place where NDMI is located, received as much as 139 mm of rainfall in 1 hour and it was the highest value since monitoring rainfall record has been began. Last 6 October, NDMI executed field investigation for disaster damage assessment in Ulsan. Taewha Traditional Market is one of the affected regions and the causes were analyzed as follow. 1) Heavy rainfall over 500-year recurrence interval, 2) Characteristic of watershed such as steep slope, 3) River level rise affected by high water of tide, and 4) Drainage problem resulting from covering over river. Bancheon Apartment had serious damages that over 1,000 vehicles was submerged and water supply was cut off. It seemed that the over flow dam without flood control capability, located at upper Taewha-river, increased the risk of flooding. 1,200 military personnel supported municipal workers deal with the recovery of the damage.

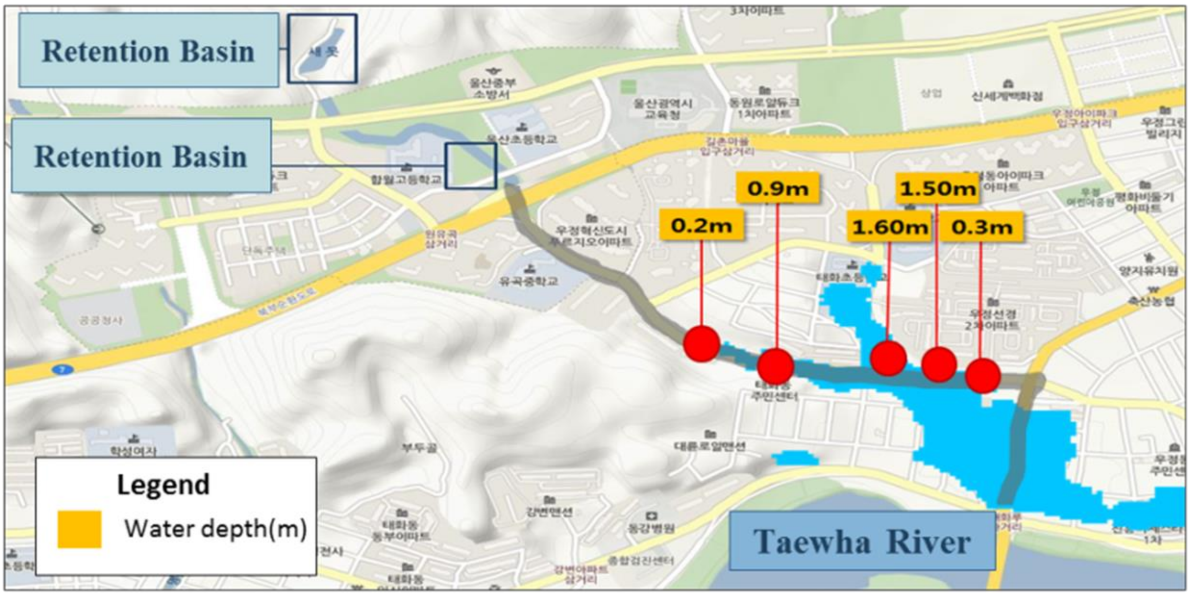


Figure 1-4. Inundation Depth around Taewha River, Korea

Figure 1-5. Inundation in Ulsan, Korea

II. Summary of progress in Key Result Areas

TC Members' Report
Summary of Progress in KRAs

Title of item 1 :
Extension of TC forecast information

Main text :

The National Typhoon Center (NTC)/KMA has been operating a national service since May 2015, which provides information on a tropical depression (TD) that has possibility to strengthen into a tropical storm (TS) within twenty-four hours and to affect South Korea at its post-stage. TD and TS information that had been offered separately have been merged and provided together since January 2016. Institution of TD information in TS information has caused an alert on TCs and enabled continued provision of information even when TS weakens into TD and continues to have influence on the Korean Peninsula. With pre-typhoon and post- typhoon information provided, the service is expected to contribute to effective preparedness against possible damages by TCs [Fig.2-1].

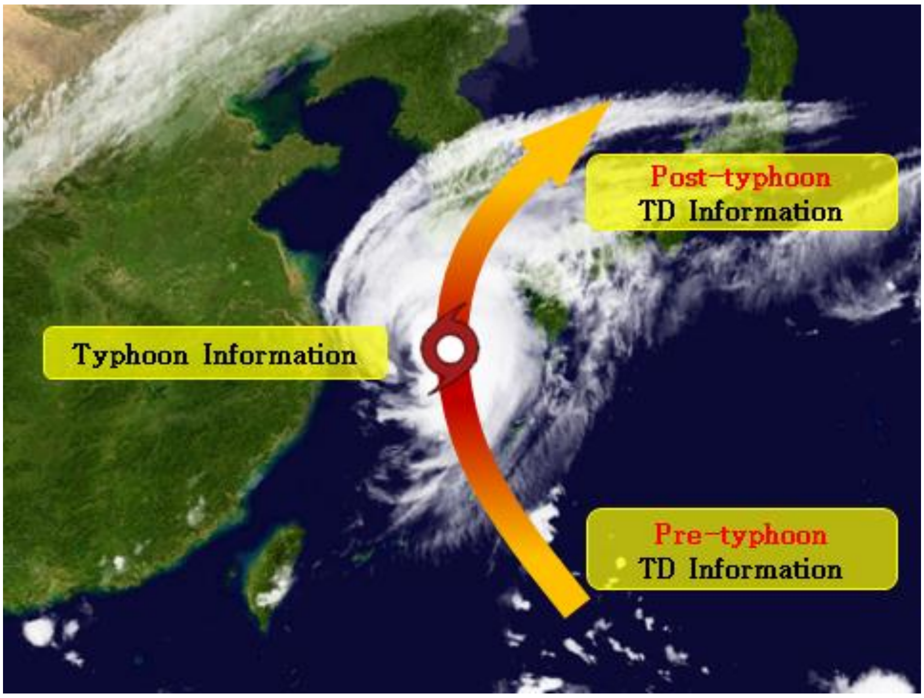


Figure 2-1. Extension of TC forecast information [KMA]

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

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology		√				√	

Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 2 :
Tropical Cyclone Best-Track Announcement in 2015

Main text:

KMA made an official announcement about the production of best-track data on the twenty-seven typhoons formed in the Northwest Pacific Ocean in 2015. KMA had independently developed the post-analysis system [Fig.2-2] and announced the best-track data on eight TCs which affected the Korean Peninsula in 2014 to 2015 on a trial basis [Fig.2-3]. Data shows errors in real-time analysis and the characteristics of climatological change of typhoons using post-analysis data on typhoon location, intensity, and size after the typhoon's dissipation and is of great value for the objective verification with numerical model results. TC best-track data can also be utilized as criteria for typhoon preparedness. Besides, analysis techniques accumulated through the process of data production is expected to significantly improve the typhoon forecast.

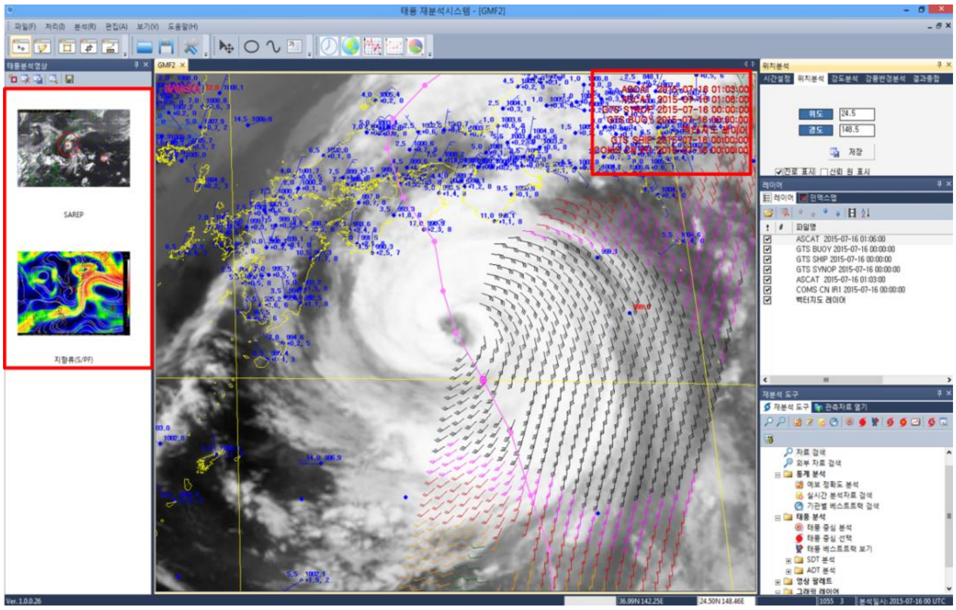

Figure 2-2. Post-analysis system at KMA

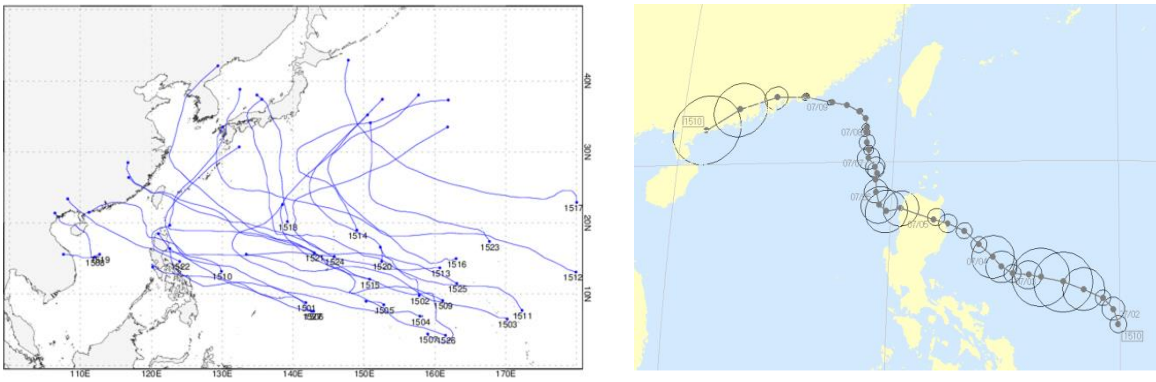

Figure 2-3. The best-tracks in 2015 and the best-track of 1510 LINFA

Identified opportunities/challenges, if any, for further development or collaboration: We intend to progressively produce Best-track data of recorded typhoons in the Northwest Pacific.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology		√				√	
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 3 : **Capacity Building on the Typhoon Analysis and Forecast**

Main text :

As a part of the Training and Research Coordination Group Fellowship Program (TRFP) of the ESCAP/WMO Typhoon Committee, the NTC/KMA has carried out the Fellowship Program for many typhoon experts from the members of Typhoon Committee, since 2001. In 2016, three typhoon forecasters from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and the Thailand Meteorological Department (TMD) were trained for two weeks (1 to 14 May 2016) by the experts of the NTC and the National Meteorological Satellite Center (NMSC) of the KMA.

The trainees received training and conducted research on optimizing typhoon forecast using Typhoon Analysis and Prediction System (TAPS) as well as on the genesis and dissipation of tropical cyclones. They enthusiastically performed their missions, then drafted and completed a training report. In addition, they improved their typhoon analysis and forecast skills as well as shared their ideas and plans for utilizing the TAPS [Fig.2-4].

At the end of the program, they visited the KMA headquarters in Seoul, and the NMSC in Jincheon. It was a good opportunity for us to introduce the current status of typhoon analysis and forecast, and educate them on how to analyze and forecast typhoons on site.

Figure 2-4. Training and research in progress at NTC (May 2016, Korea)

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

The Fellowship Program will be continued the next year in Jeju Island, the Republic of Korea where the NTC/KMA is located. The overall travel cost for the participants (including round-trip tickets and allowances during their stay, if available, will be supported by KMA. The circular letter offering the KMA's fellowship program will be sent to the members by the TCS at least a month before the commencement. Anyone from Typhoon Committee member countries who are interested in operational and research fields of TC forecasts are encouraged to apply for the program.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology						√	
Hydrology							
DRR							
Training and research						√	

Resource mobilization or regional collaboration						√	

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Title of item 4 :

Co-Hosting the 9th Korea- China Joint Workshop on Tropical Cyclones

Main text :

The NTC/KMA and the Shanghai Typhoon Institute of China Meteorological Administration (STI/CMA) have co-hosted a joint workshop on tropical cyclones every year since 2008.

This year, the 9th Korea-China Workshop was held on 16 to 20 May, at the NTC/KMA in Jeju [Fig.2-5]. More than fifty experts in typhoon and related fields from KMA, CMA, seven Korean universities, and other organizations joined the workshop. The workshop was comprised of five sessions of Numerical Approach, Impacts, Analysis, Climate, and Statistics about Tropical Cyclones, and twenty-two presentations including two keynote speeches.

Through the following cooperative conference, and visiting the National Meteorological Center and IT Center at the headquarters of KMA in Seoul, the delegates from KMA and CMA discussed forecasts, data sharing processes, and the future collaboration activities. The workshop served as a great opportunity to enhance the mutual relationship between the two operational agencies.

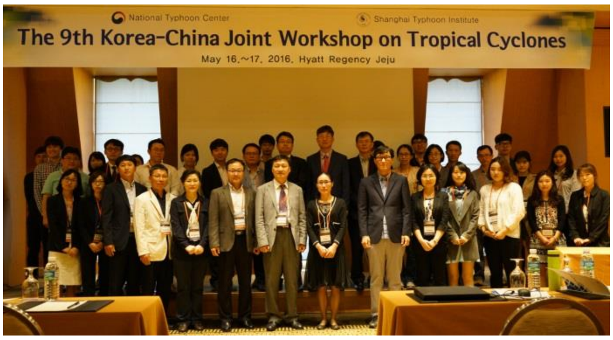

Figure 2-5. The 9th Korea-China Joint Workshop on Tropical Cyclones: Group photo (left), Cooperative Conference (right).

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

Delegates from the NTC/KMA and STI/CMA agreed to exchange observation data and TC seasonal forecasts and had a discussion for future collaboration activities. And the 10th workshop would be held in China in the upcoming year.

<u>Summary Table</u> of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology						√	√
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 5 :

The web-based portal to provide the products of seasonal typhoon activity outlook for TC Members

Main text :

KMA has provided the seasonal typhoon activity prediction results for the summer and fall of 2016 through the website for TC members (http://gtaps.kma.go.kr/TSP/index.php). The Summer typhoon activity outlook was issued in late May. According to the summer outlook information, 7-10 typhoons tend to be generated in the Northwest Pacific and passage frequency is above normal in the eastern area of the Philippines and below normal in the South China Sea. The prediction for fall season was issued on 25 August 2016 [Fig.2-6]. According to the fall prediction result, 8-12 typhoons tend to be generated in Northwest Pacific and passage frequency is above normal in the eastern area of Japan and below normal in the eastern area of the Philippines and China.

The information about the number of typhoon genesis and track pattern is produced based on the results of three types of models: multi-regression model, global dynamical model, and hybrid model of statistical and dynamical method.

Users can find a variety of information about the tropical seasonal prediction on the website, including prediction products, model information, model verification, and climate monitoring.

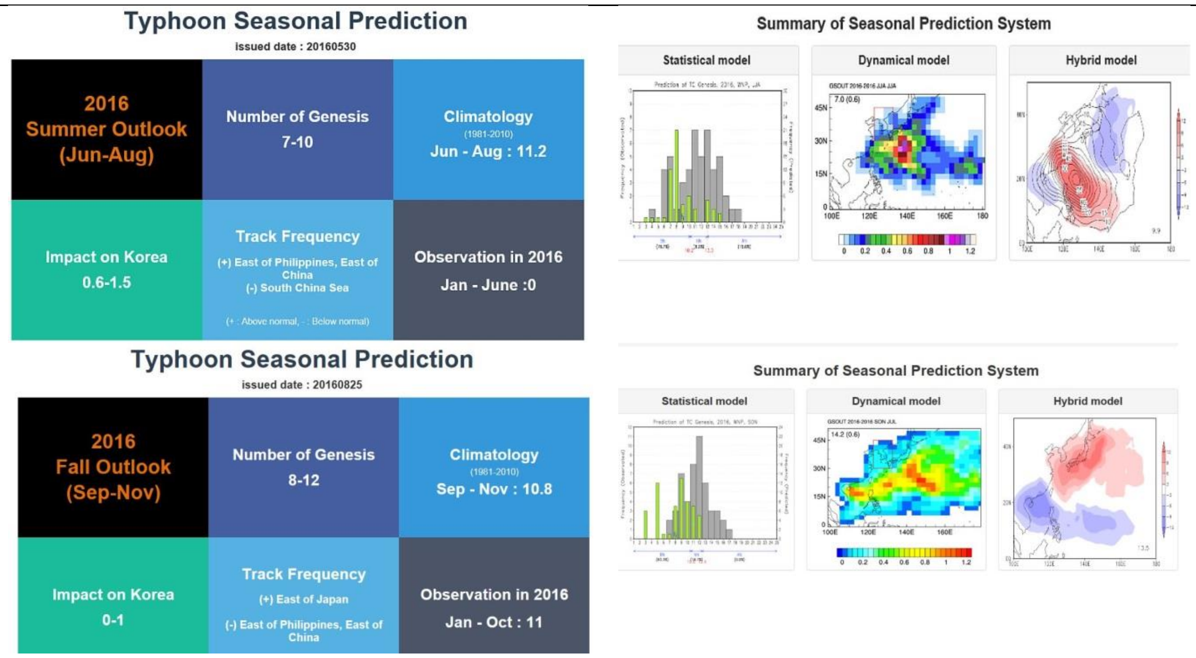

Figure 2-6. The KMA's seasonal typhoon activity outlook website: summer Outlook (upper left), fall Outlook (lower left), model prediction results during Jun.-Aug.(upper right) and Sept.-Nov. (lower right).

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

KMA plans to keep providing the seasonal typhoon activity outlook for the summer and fall of 2017 through the website for TC members. The website will be upgraded and typhoon seasonal prediction systems will be improved in order to expand service provision.

<u>Summary Table</u> of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√	√				√	
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 6 :
Implementation of Typhoon Analysis and Prediction System (TAPS) in the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)

Main text:

KMA has transferred the technology of Typhoon Analysis and Prediction System (TAPS) including the training course for typhoon forecasters to TC members since 2011, which requested support for the operational forecasting of tropical cyclones. The NTC/KMA carried out the TAPS technology transfer to TMD and DMH in 2015 with the web-based TAPS package where users can access remotely to the server (Internet address: http://gtaps.kma.go.kr).

The NTC/KMA carried out the TAPS technology transfer to the Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) from 13 to 14 Oct, 2016. The transfer included three lectures and three practice classes for the staff of PAGASA in the Philippines, which show typhoon forecast process and the TAPS structure [Fig.2-7].

During the visit period, the KMA staff introduced the TAPS and related program like TAPS data supporting system, and helped members to install the TAPS each machine, and performed demonstration of typhoon forecasts using TAPS.

Figure 2-7. TAPS introduction and typhoon forecast training in PAGASA conducted by two experts (Seong-hee Won and Seul-gi Lee) from NTC/KMA.

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

Summary Table of relevant KRAs and components (Please tick boxes. You can tick more than one as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√						
Hydrology							
DRR							
Training and research						√	

Resource mobilization or regional collaboration						√	

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Title of item 7 :
Improvement of TC analysis using COMS and Microwave data

Main text:

The NMSC/KMA has operationally analyzed tropical cyclone intensity performed by the Advanced Dvorak Technique (from AODT v.6.3.0. in 2007 to ADT v.8.1.3 in 2015) using only infrared (IR) data of a geostationary satellite adopted from SSEC/UW-Madison (Space Science Engineering Center/University of Wisconsin-Madison).

To upgrade the newest version of ADT, we are testing ADT v.8.2.1 (called as ADT821) using IR data of geostationary satellite and passive microwave (PMW) satellite data such as GCOM-W1/AMSR2, GPM/GMI, and DMSP/SSMIS in 2016. TC intensity performed by ADT v.8.2.1 using IR and PMW data is more accurate than the previous version ADT v.8.1.3 (called as ADT813).

As shown in [Fig. 2-8], an example of estimated mean sea level pressure (MSLP) of 10th Typhoon 'LIONROCK' in 2016. The intensity of ADT using PMW (red curve) more closely follows rapid intensification than that of without PMW (green). More accurate maximum intensity was resulted.

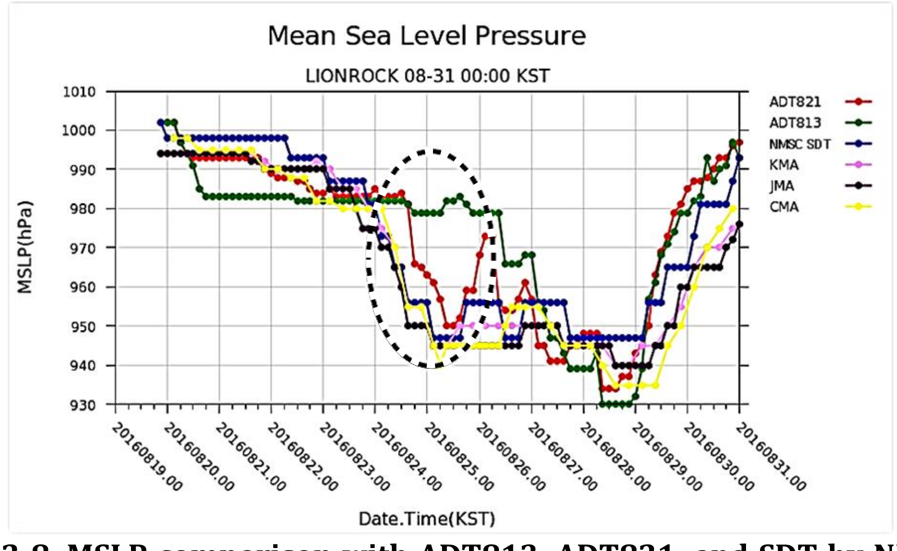

Figure 2-8. MSLP comparison with ADT813, ADT821, and SDT by NMSC and KMA of the 10th Typhoon LIONROCK in 2016

The NMSC/KMA developed an algorithm for retrieving sea surface wind speed under rain-free and rain conditions using the low frequency bands (6.9 GHz and 10.7 GHz) of PMW satellite observations such as GCOM-W/AMSR-2 and GPM/GMI. We are receiving sea surface wind data of the low frequency bands (5.3 GHz, 10.7 GHz, and etc.) of an active scatterometer and a PMW satellite such as METOP-A and METOP-B/ASCAT, DMSP/SSMIS, and CORIOLIS/WINDSAT.

We produce radii of 15m/s (R15) and 25m/s (R25) wind speed of TC using the sea surface wind data of those multi-MW satellite. The wind products of MW data are close to observation at weaken state of TC located near Korea area. We produce also radii of R15 and R25 wind speed using wind of ECMWF that estimate wind for no observation area of MW. R15 and R25 from the multi-MW satellite and ECMWF have been provided to the users of KMA every 3-hour with quasi-real time.

[Fig. 2-9] is an example of R15 and R25 produced from GPM/GMI and ECMWF. R15 of north-western side of no observation area of GPM/GMI data is possible to estimate using wind of ECMWF as reference. It shows estimated wind using a) GPM/GMI 10.7GHz at 06:21UTC and b) ECMWF wind analyzed at 06:00UTC. Blue line on the red color and red line on the purple color denote R15and R25 wind speed respectively.

a) GPM/DMI b) ECMWF WIND

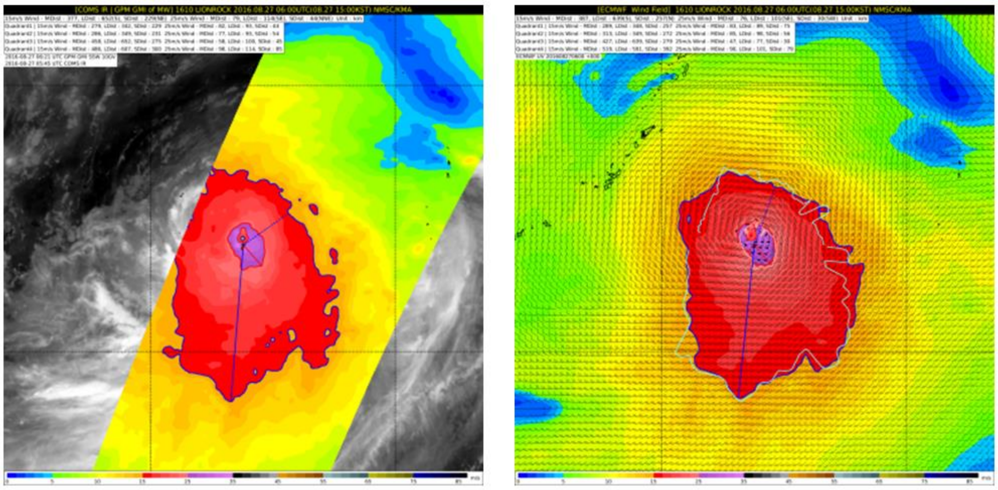

Figure 2-9. Radii of 15 m/s and 25 m/s wind speed of the 1610 LIONROCK on 27 August, 2016.

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

Summary Table of relevant KRAs and components (Please tick boxes. You can tick more than one as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√					√	
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 8 :
Typhoon impact forecasts (pilot)

Main text:

With regard to increasing demand for information to ensure people's safety and protect their property (WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services, 2015), KMA is now promoting typhoon impact forecasts to support emergency managers to make better decisions for the preparedness of hydro-meteorological hazards. This year, KMA has started it as a pilot project on typhoon.

Because of its uncertainty, accurate typhoon track prediction is becoming the biggest challenge for us to offer appropriate early-warnings. To overcome the limit of deterministic weather forecasts, we are currently using Ensemble Prediction System (EPS). KMA attempted to offer information which contains overall EPS results. Through the typhoon impact forecasts, KMA produced the risk map of rain & wind accompanied by typhoon during a forecast period of 1 to 3 with using EPS [Fig.2-10]. The risk level of rain & wind is calculated by combining potential impacts and its likelihood. With the risk map, the public would be able to access the information about when and where the potential impacts occur.

a) Rain b) Wind

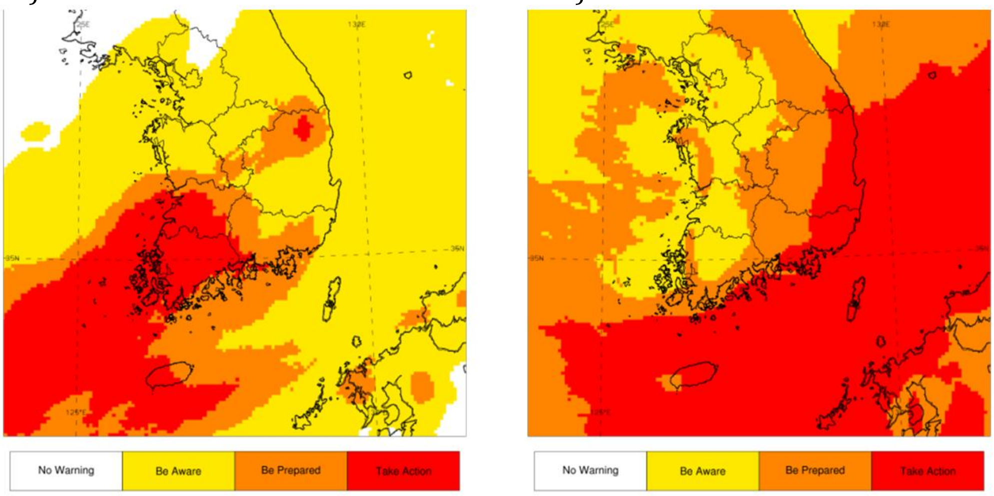

Figure 2-10. The KMA's risk map of rain & wind accompanied by typhoon

KMA assessed the risk level of typhoon impact by combining potential impacts and its likelihood (EPS result). Potential impacts are assessed by using meteorological thresholds (rain accumulation, gust speed) differing from areas with different vulnerability based on disaster database in Korea. Likelihood is assessed from EPS by counting how many ensemble members predict phenomenon exceeding threshold. Finally, the risk level is driven by a risk matrix which combines potential impacts and its likelihood [Fig.2-11].

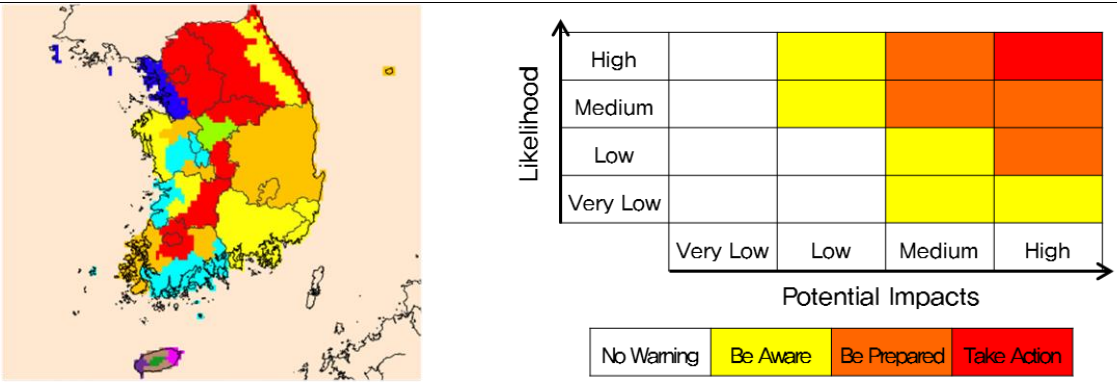

Figure 2-11. An example of rain threshold (left) and the risk matrix (right)

The product of 'Typhoon impact forecasts' is designed to provide decision makers with information about the level of risk posed by a rain & wind caused by a typhoon in the day 1~3 forecast period. It is also designed to easily be understood and disseminated for the users. This information will aid in preparedness and readiness in the community.

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

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology	√					√	
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 9 :
Development of the Extreme Flood Forecasting System (AOP2)

Main text:

Han River Flood Control Office (HRFCO) of MOLIT, Republic of Korea has developed an extreme flood forecasting system which presents step-by-step models for flood forecasting to strengthen the response capacity of member countries against flood. This year, the system (called the LEVEL1-module) built in 2014 was modified based on the members' reviews. At the same time, the LEVEL2-module using a rainfall-runoff model and the LEVEL3-module using radar precipitation have been developed. The utilization of the system with LEVEL1 to 3 would become more applicable by the test using the hydrological data from pilot countries, Thailand, Philippines and Laos. Moreover, the outcomes of three field surveys conducted from 2012 to 2014 and the wrap-up meeting held in 2015, Busan in the Republic of Korea contributed to analyzing the current status of flood forecasting in the member countries and to finding alternatives to improved problems. It is expected these achievements will be a real help to enhance the capacity of flood forecasting and contribute to reducing casualties and socio-economic damage caused by flood in the TC region.

The completely-developed system and its operation manual will be released in 2017 through an in-depth review by the members with modification and complement.

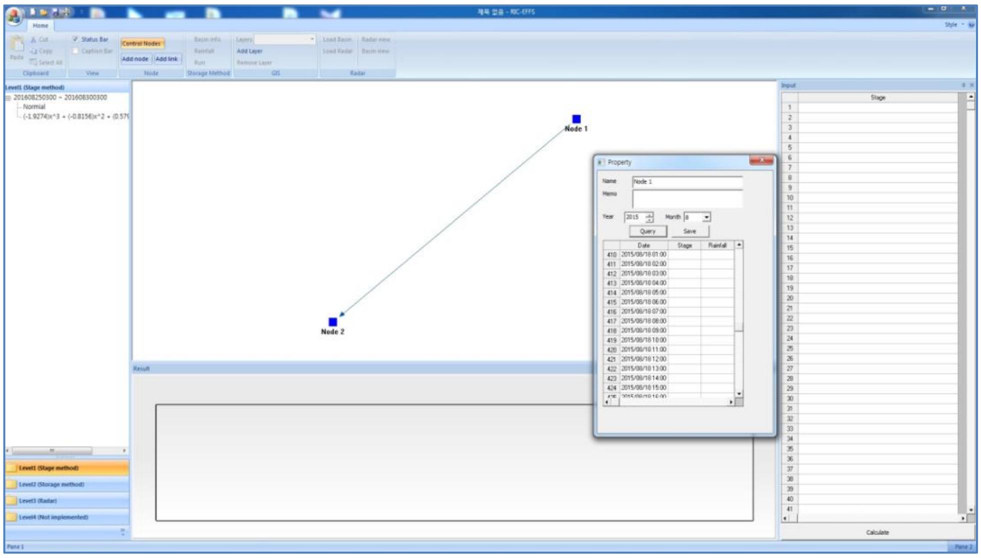

Figure 2-12. Platform of extreme flood forecasting system

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

<u>Summary Table</u> of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology	√						
DRR							

Training and research							
Resource mobilization or regional collaboration							

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Title of item 10 :
Establishment of Extreme Flood Risk management Guideline (AOP6)

Main text:

A guideline for responding to extreme flood is being established to help the member countries strengthen their own capabilities of flood response in practical working field thorough understanding the current status of flood management and flood vulnerability. The guideline consists of the definition of extreme flood, hydrological data quality control, flood forecasting & warning, structural/non-structural flood control measurements, dam operation and extreme flood adaptation. Also, it presents actual cases in the member countries according to each section. This year a draft in English was developed and is being reviewed by the members.

For ensuring higher usability of the guideline, a working group, representatives at expert level from the member countries, will be composed and review to modify and edit the guidelines at the 11th TC IWS. The final version of the guideline will be released at the 12th TC IWS in 2017.

1) Introduction

2) Framework of Extreme Flood Risk Management
- Extreme Flood Definition
- Framework of Extreme Flood Response
- Status of TC member Flood Forecasting

3) Hydrological Data Monitoring
- Standards & Rules of Hydrological Data Monitoring in International Organization
- Status of TC member

4) Forecasting and Warning
- Standards & Rules of Flood Forecasting in International Organization
- Status of TC member
- Framework of Flood Forecasting for Extreme Flood (LEVEL1-LEVEL4)

5) Structural Extreme Flood Control Measures
- General Structural Flood Control Measures
- Status TC members of Structural Flood Control Measures
- Structural Flood Control Measures for Extreme Flood

6) Non-structural Extreme Flood Control Measures
- General Non-structural Flood Control Measures
- Status TC members of Non-structural Flood Control Measures
- Non-Structural Flood Control Measures for Extreme Flood

7) Dam Operation
- Status of Dam Operation for Flood Control in TC Regions
- Dam Operation for Extreme Flood Control

8) Extreme Flood Adaptation
- Framework of Extreme Flood Adaptation

Figure 2-13. Contents of the extreme flood risk response guideline

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

In order to improve the quality of the Extreme Flood Risk management Guideline, the working group including at least one representative from member countries, will be composed at this 11th IWS. The working group demands to feedback consistently with HRFCO until the completion of the Guidelines

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology		√					
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 11:
Rainfall Radar Data Utilization for Accuracy and Lead Time in Flood Forecasting

Main text:

The Ministry of Land, Infrastructure and Transport (MOLIT) of Republic of Korea is currently operating a total of six (6) rainfall radars to improve the accuracy of flood forecasting through the rainfall estimate accuracy. This year, Rain Radar Integrated Operating System (RRIOS), established for efficient operation of these rainfall radars in 2015, is being tested and verified. Also, the rainfall data from RRIOS can be utilized to the flood forecast model simulation and compared with the data of existing rain radar system to improve the rainfall estimate accuracy.

The data produced by rainfall radar is being used as information for flash flood forecasting, as well as inputs for a flood forecasting model used in HRFCO.

The extreme flood forecasting system developed by HRFCO, MOLIT which leads AOP2, also, includes a flood estimate module (level-3) using radar data. The module is capable to utilize the estimated and forecasted radar data as a input, basin rainfall, so it can be helpful to increase the practical use.

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

<u>Summary Table</u> of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology				√			
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 12:
Sharing Flood Information for Facilities Management in Waterfront Area

Main text :

A flood information system which provides inundation forecast information is being built to help local government authorities manage waterfront areas, including a park, a camping site, and a bike path etc., safely against flooding. This system has been built to estimate flood depth and flood area by expanding flood forecasting results at major points spatially. And it is planned to create and deploy a flooding chart for a field staff to refer to it prior to flood occurrence.

A flood information system for waterfront area management is built primarily for waterfront districts in Hangang (River) and Yeongsangang(River), respectively, and the system and its service will be expanded gradually according to the importance of waterfront distract and the number of users. Especially, this year the system was expanded to Hangang River Park areas of Hangang(River) basin with jurisdiction in Seoul Metropolitan Government and then, a site survey was conducted to compare and verify estimated outcomes with actual flood event occurring on 5 July. The analysis on a site survey will be reflected in supplementing the forecasting system.

Figure 2-14. Flood forecasting for waterfront and a field site

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

<u>Summary Table</u> of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology					√		
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 13: **Providing Flash Flood Forecasting Information for Local Governments**

Main text:

Flash flood forecasting information using the level ‘Interest’, ’Caution’, ‘Alert’ and ‘Serious’ which compares rainfall estimates by rainfall radar with pre-calculated flash flood guidance (FFG) has been shared with local authorities to secure pre-evacuation time in mountainous and urban areas.

The information provided is water level by stage such as ‘knee level’ and ‘waist level’ so that the person in charge can recognize the information easily. Also, a graphical distribution is transmitted to the staff’s smartphone.

Currently, test service in Nakdonggang (River) basin is being conducted and the service area will be expanded in accordance with expansion of rainfall radar installation.

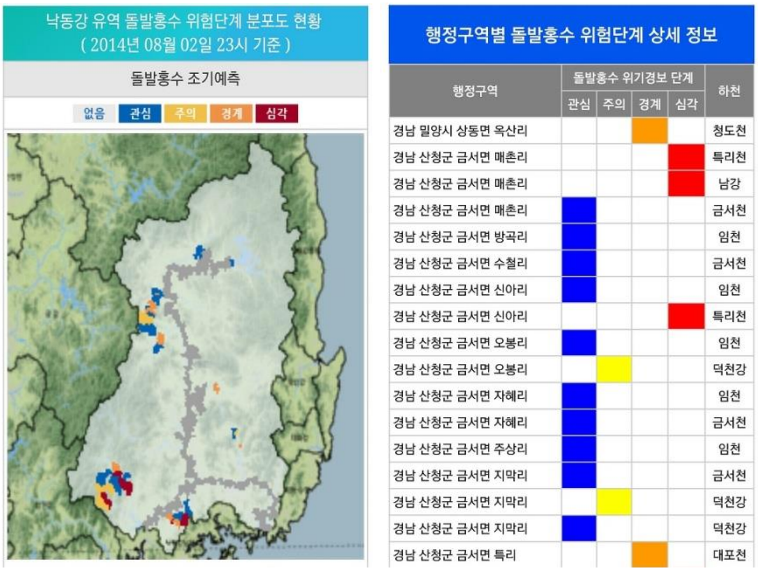

Figure 2-15. An example of flash flood forecasting information for Korean local governments.

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

<u>Summary Table</u> of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology						√	
DRR							

Training and research							
Resource mobilization or regional collaboration							

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Title of item 14:

The 5th Meeting and Workshop of TC WGH and WGH Homepage

Main text:

Since the 1st WGH Meeting in 2012, the 5th UNESCAP/WMO Typhoon Committee WGH meeting and workshop hosted by Han River Flood Control Office was held on 5 to 8 September in Seoul, the Republic of Korea. A total of 20 delegations and participants from China, Japan, Laos, Malaysia, Philippines, the Republic of Korea, Thailand, USA, Vietnam and TC secretariat participated in the event. Especially, the Workshop was proceeded under a theme "Extreme Flood Forecasting System and Practical Guideline for the TC Region" and participants to discuss deeply about the usability of extreme flood forecasting system and practical guideline. Additionally, in the 5th meeting of TC WGH, the progress on AOP projects, future plan and proposed AOP were shared.

Figure 2-16. The 5th Meeting and Workshop of TC WGH (September 2016, Seoul)

The TC WGH web-page (http://tcwgh.hrfco.go.kr) as a part of AOP2 project is being operated to share opinions and to exchange data among TC member countries effectively. The information and data needed to be shared can be updated at the request by the member countries.

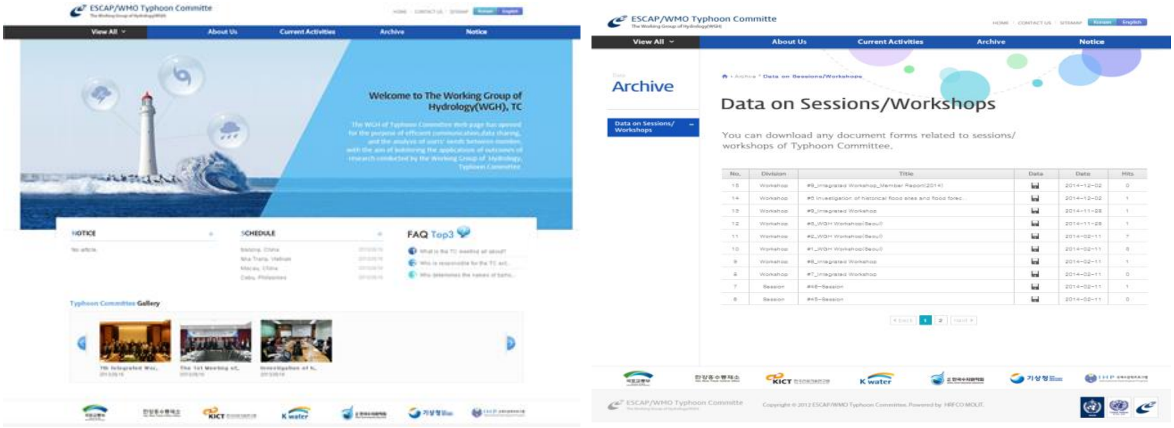

Figure 2-17. Screenshot of TC WGH homepage

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

The WGH workshop and meeting will be continued in next year in Seoul, the Republic of Korea supported by HRFCO, MOLIT. Additionally, the training course will be connected with the workshop and meeting to enhance the utilization of the Extreme flood forecast System (EFFS) of member countries.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology						√	
DRR							
Training and research							
Resource mobilization or regional collaboration							

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Title of item 15:
2016 Vietnam and Lao PDR Project by NDMI

Main text:

3 years ago, from 2013 to 2015, NDMI and PAGASA implemented Northern Mindanao Project in Philippines where were enormous damages caused by Typhoon WASHI in 2011 to enhance the resilience of communities to flash flood. The first year of project focused on the selection of the pilot area, the installation of Automatic Rainfall Warning System (ARWS), and test operation of Flash Flood Alert System (FFAS). In the second and third year, it expanded the target area and installed the intelligent CCTV developed by NDMI for wider flood monitoring scope and better data collection accuracy. In January 2016, NDMI-PAGASA-City of Cagayan de Oro held the completion ceremony of the project and discussed how to efficiently maintain and manage the system.

In May 2014, there were the requests of the implementation of the project from Lao PDR and Vietnam on the 9th Annual Workshop of the Working Group on DRR. Prior to the beginning of the project, a feasibility study was launched in order to assess the scale, period, and scope of the project. With regarding to the feasibility study, NDMI dispatched the experts to perform the field investigation and share NDMI's DRR technologies and Policies on Lao PDR and Vietnam.

In 2016, the first phase of the new project to build up the capacity against flash flood was launched in Lao PDR and Vietnam. It aims at selecting an appropriate pilot area and installing the ARWS and FFAS. The system will be installed in Lao Cai located 280 km north-west of Hanoi, Vietnam where the flood damage is frequently occurring but there is not enough alert system. To expand the range of siren influence from the warning post, it was recommended to set up the telegraph pole over 15 m in community hall and village office. The systems in Vietnam are scheduled to be installed in December.

Nam Song River basin in Vang Vieng is densely populated area in Lao PDR. As the number of tourists in Vang Vieng increases, there is a growing need for the accurate warning system to save more lives. Although there is a warning system operated manually depending on the river level, it is not automatic system. Thus NDMI and DMH (Department of Meteorology and Hydrology) decided to install the two sets of ARWS included rainfall gauges, water level gauges, and warning posts and FFAS in Vang Vieng, In September, NDMI finished the first year's work of the installation and test operation of systems. The warning posts are installed at the village hall and elementary school. In order to establish the warning criteria, it is very important to analyze hydrological model for Nam Song River basin. Accordingly, NDMI will conduct the river survey because there is not enough data for development of the model. AlsoNDMI and DMH discussed the issue that FFAS could be relocated when National Flood and Drought and Early Warning System Center will be established.

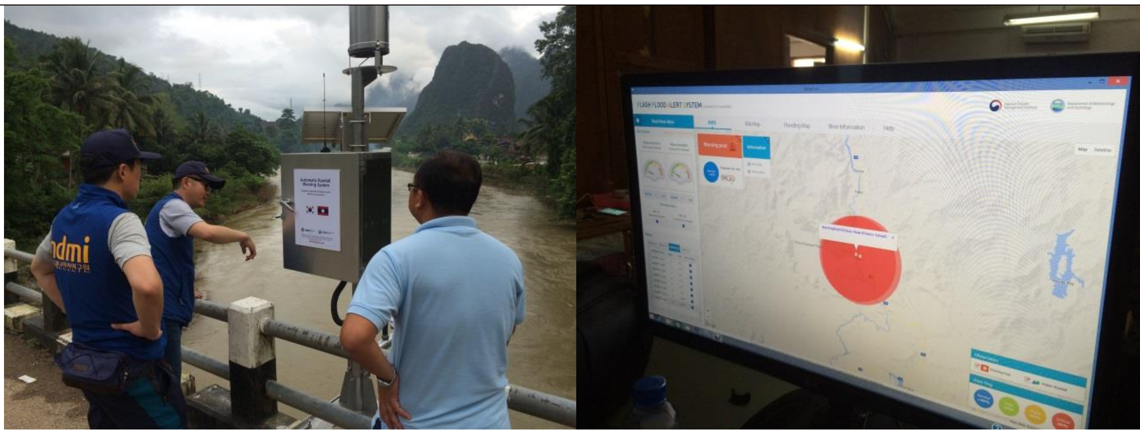

Figure 2- 18. Installation of the rainfall gauge (left) and FFAS system (right)

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

In order to strengthen and consolidate the project, additional sets of ARWS and FFAS will be installed in 2017. In addition, data validation will be performed to ensure the quality of the observed rainfall and water level data from ARWS constructed in Philippines.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							
DRR					√		
Training and research						√	
Resource mobilization or regional collaboration							

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Title of item 16:
Upgrade of the functions in Typhoon Committee Disaster Information System (TCDIS)

Main text:

TCDIS (Typhoon Committee Disaster Information System) has been developed for sharing disaster information with TC member countries throughout a GIS Web-based platform. For minimizing the loss of life, economic and environmental damages caused by Typhoon in Asia and Pacific area, NDMI has been upgrading the functions in TCDIS since 2012. A search function in TCDIS was renewed to choose each option (central pressure, wind speed, location of Typhoon, and direction) for finding similar past Typhoon. In 2016, NDMI modified the method of data collection to encourage the participation of member countries. If there is request from TC members, NDMI will distribute new TCDIS manuals that describe in detail process.

Upgrade of the functions in TCDIS

In 2016, TCDIS is expected to deliver functions in 1) Auto-reporting function and 2) Expansion of Database of Typhoon tracking from CMA, JTWC, and JMA. Auto-reporting function makes it easier to compare the similarity between the oncoming and past typhoon. Also, it could complete a document as it enters the analyzed key results automatically. In addition, TCDIS established Database expansion for typhoon forecast agency including CMA, JMA and JTWC. So, in new version of TCDIS, real-time forecasting information from CMA, JMA and JTWC can be updated.

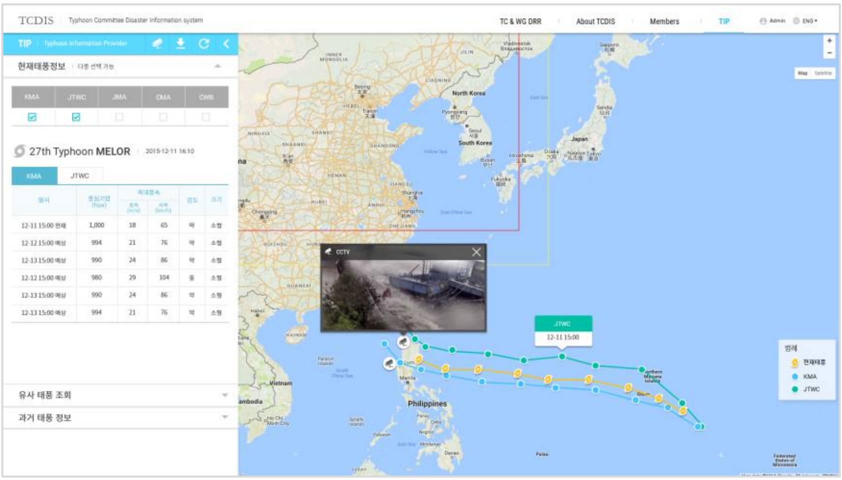

Figure 2-19. Screenshot of the upgraded TCDIS homepage

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

Information in TCDIS should be upgraded on regular bases within the TC member countries to sustain the system. In order to encourage involvement of the member countries, NDMI will distribute new manual to explain the process for providing the typhoon information from member countries.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							

DRR						√	
Training and research						√	
Resource mobilization or regional collaboration						√	

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Title of item 17:
The 11th WGDRR Annual Workshop

Main text:

The 11th Working Group Disaster Risk Reduction Annual Workshop was held in Ulsan, Republic of Korea from 24 to 27 May 2016. There were twenty more participants to attend the workshop from 8 countries and 8 AWG members, as well as participants from international organizations including UNESCAP, WMO, and the scholars from Tohoku University and Danang University.

The main agenda of the 11th WGDRR Annual Workshop was “Promoting Knowledge Sharing within WGDRR” and participants discussed the new issues related to disaster management and the lessons learned from the past disasters. This year is the first time that the annual workshop was held in Ulsan, where NDMI relocated their office from Seoul and also, it was first time to invite AWG members to discuss SSOP Project Phrase II and TC new Strategic Plan.

Figure 2-20. The 11th WGDRR Annual Workshop in Ulsan, Korea

The presentations in the 11th WGDRR Annual Workshop were as follow;

1) Briefing SSOP-II Proposal for discussion (Jinping Liu/TCS)
2) Development of the Strategic Plan for 2017-2021 (Raymond Tanabe/NOAA, Hawaii)
3) Opportunities and Challenges to Typhoon Committee Cooperation (Le-Huu Ti/Danang Univ.)
4) Building Resilience to Natural Disaster in Asia and the Pacific (Sungeun Kim, UNESCAP)
5) WMO DRR Activities in Support of the 2030 Development Agenda (Taoyong Peng/WMO)
6) How TC Should Follow up with the Sendai Framework for DRR (Yuichi Ono/Tohoku Univ.)
7) Including Older People in DRR (Barrie Lei/TCS)
8) Member's report-China (Yunxia Zhang/ NDRCC)
9) Recent Natural Disaster in Japan, Case of Hyogo (Kazuhito Koide/ADRC)
10) E-manuals, New Strategies to Strengthen the Capacities of On-scene Responders (Sangkyu Rheem/NDMI)
11) Disaster Management Experience in Lao PDR (Bounteum Sysouph./MNRE)
12) Member's report-Macau (Fong Peng Leong/Macau Security Forces Coordination Office)
13) Member's report-Malaysia (Mazlan Daly/NDMA)
14) Member's report-USA (Kenneth Kleeschulte/NOAA, Guam)
15) Disaster Policy and Management in Vietnam (Viet Tien Nguten/NDPC)

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

The WGDRR Annual Workshop was held in Ulsan, as NDMI moved their office from Seoul to Ulsan. Because Ulsan is one of the highly developed cities for the automobile and chemical industries in the Republic of Korea, disaster risk management is really important. Throughout WGDRR, it is expected to strengthen capability for disaster risk reduction in member countries.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							

DRR							√
Training and research							
Resource mobilization or regional collaboration							√

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Title of item 18:
2016 NDRCC & NDMI Knowledge Exchange in China

Main text:

In 48th Annual TC Session, held in Hawaii, USA on 21-27 February 2016, it was decided to conduct the Expert Mission in China. In the 11th TC WGDRR Annual Workshop, National Disaster Reduction Center in China (NDRCC) and NDMI agreed to have the joint workshop for knowledge sharing. The objective of this knowledge sharing is to share knowledge and information across two main technical areas: 1) Disaster risk reduction (DRR), including prevention, early warning systems, disaster management system, and emergency operations. 2) International Cooperation between China and Korea for Disaster Risk Reduction. The Knowledge Exchange was successfully held in Beijing, China on 26-27 September 2016 and the schedule was arranged to visit two organizations including NDRCC and CMA.

During the Knowledge Sharing, NDMI introduced the disaster prevention technologies for DRR; 1) Frequency Analysis for Rainfall Data (FARD), 2) Urban Flood Analysis Model (UFAM), 3) Flash Flood Alert System (FFAS), 4) Smart Disaster Management System (Smart Big Board, Smart Disaster Investigation, and Smart CCTV) and 6) TC Disaster Information System (TCDIS). Furthermore, they discussed future strategies for international cooperation between China and Korea for TC.

Figure 2-20. 2016 Expert Mission in NDRCC(left) and CMA(right) in Beijing, China

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

WGDRR has been conducting Expert Mission since 2009 and it is the first Expert Mission held in China. With Knowledge Exchange, it is expected that there will be more opportunities for the cooperation in Disaster Risk Reduction between China and Korea.

Summary Table of relevant KRAs and components (please tick boxes, can be more than one, as appropriate):

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							
DRR							√
Training and research							
Resource mobilization or regional collaboration							√

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