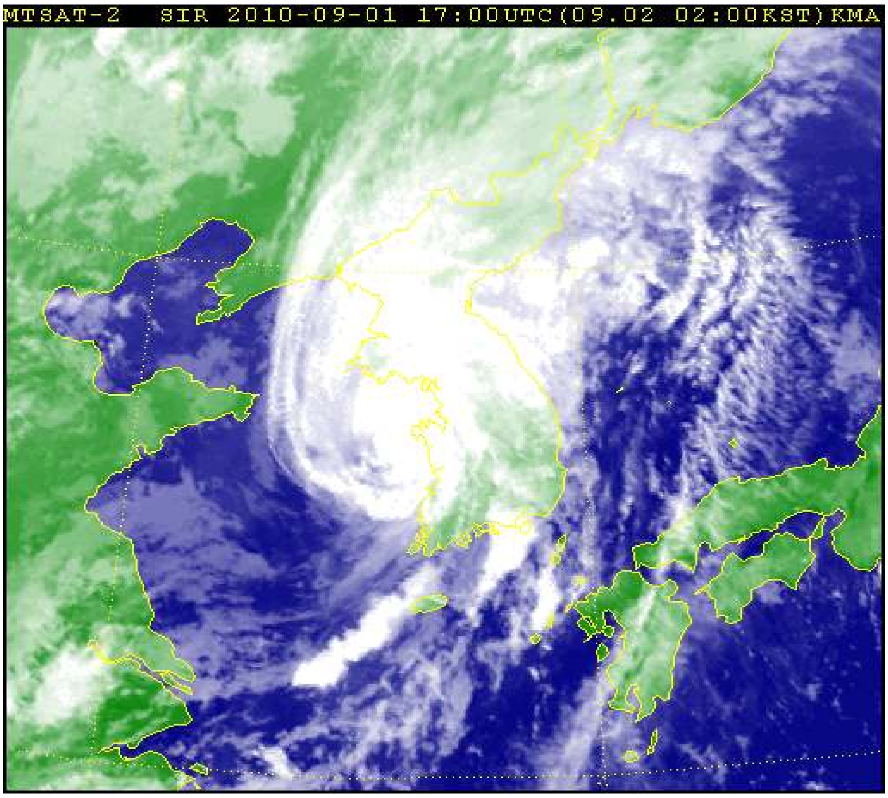
MEMBER REPORT

ESCAP/WMO Typhoon Committee

43rd Session



17-22 January 2011

Jeju, Republic of Korea

REPUBLIC OF KOREA

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CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area in 2010

1. Meteorological Assessment (highlighting forecasting issues/impacts)

This year three typhoons, Dianmu (1004), Kompasu (1007) and Malou (1009), affected the Korea peninsula between August and September. These three typhoons formed in one month over 20N, and details about the track, intensity and forecast are as follows:

- <u>Typhoon 'DIANMU(1004)'</u>

Typhoon Dianmu (1004) was formed at 21:00 KST on 8 AUG 2010 400 km southeast from Taiwan. Although SST around the area was 28-29^{o}C, providing favorable conditions for typhoon development, the typhoon did not develop as much as expected. As it moved north, this typhoon intensified with time by 980 hPa (09:00-21:00 KST 10 AUG), but started to weaken after making landfall. The central pressure during the passage over the southern coastal area of the Korean peninsula was 990 hPa, and the same intensity was maintained after the typhoon moved over to the East Sea. After leaving the Korea peninsula, the system continued to rapidly move northeast and quickly weakened following its extratropical transition at 15:00 KST on 12 AUG 2010 (Fig. I-1-1)

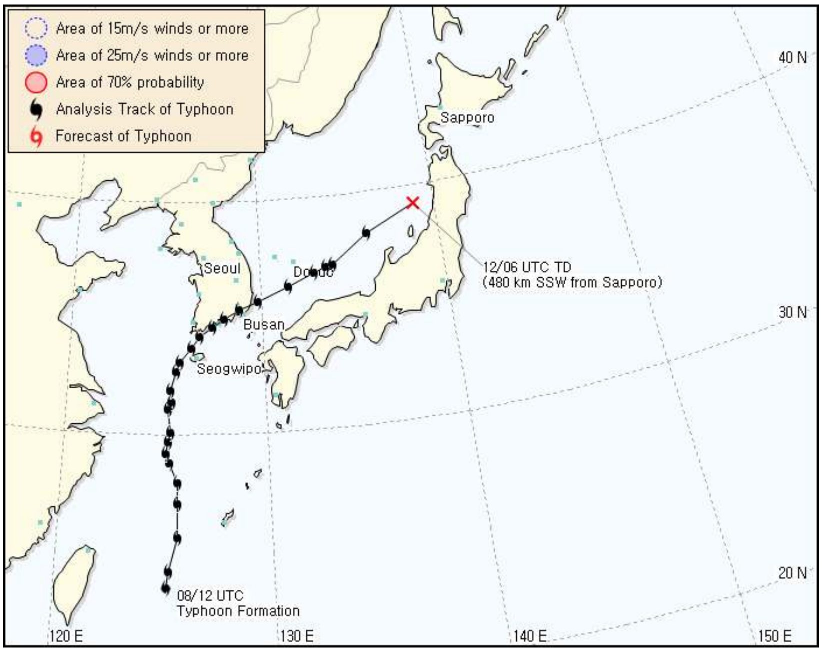
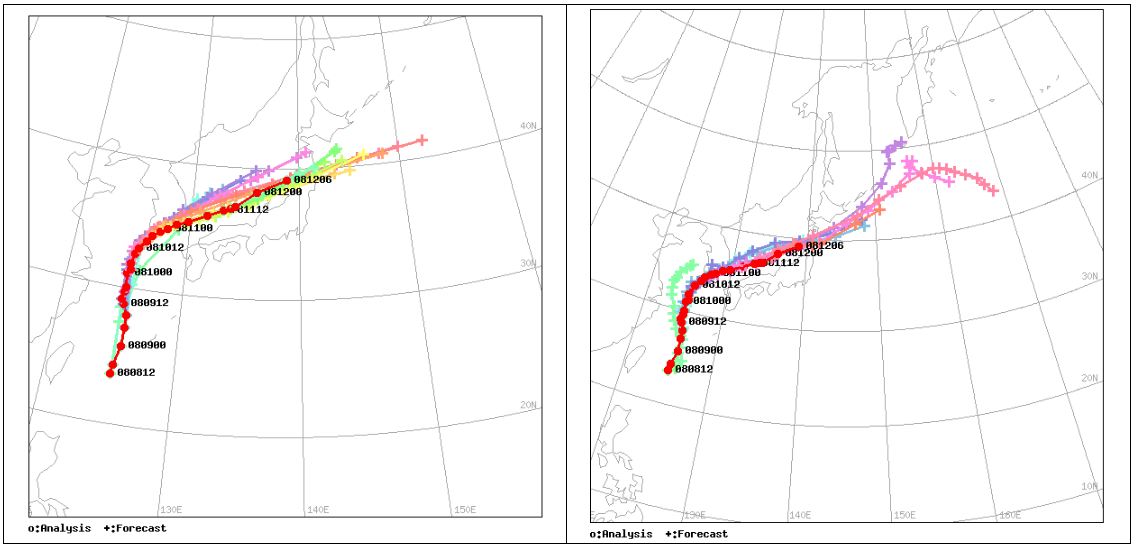


Fig. I-1-1. Track of typhoon "DIANMU (1004)"

The track of typhoon Dianmu (1004) showed a straight northward-moving pattern following its generation, until the cyclone turned northeastward. It landed at Dohwa-myun, Gohung-gun, Jeolla province at 05:00KST on 11 AUG 2010, moved along the southern coastline of the Korean peninsula, and went out around Ulsan, Korea, 9 hours later. The total lifetime of this typhoon was 90 hours (3 days 18 hours) and the extratropical transition occurred at 15:00 KST on 12 AUG.

When the typhoon formed, the central pressure during the initial stage was 994 hPa and SST was high (about 28-29^{o}C); however, the ocean heat content was not enough to accelerate the intensification of the typhoon. The typhoon did not intensify because the point of genesis was around 23.5N, and the typhoon moved directly north, not staying long enough in a high-heat energy area. The central pressure just before the landfall (09:00-21:00 KST 10 AUG) was about 980 hPa, which was the strongest value in this typhoon lifetime, the wind speed was 31 m. The intensity stayed at the same level as the typhoon moved along the southern coast of Korea. This was a small-sized typhoon, whose 15-m/s wind speed radius recorded 300 km on 10 AUG.

The typhoon was expected not to move fast because of the strong ridge of the low pressure system around Yeonhae-ju and the rapidly developing North Pacific High, which causing stagnation of upper air movement. Even the moving speed was slow in the initial stage as expected, it became speed up after turning since the North Pacific High moved the southeast. In general, forecasts of the typhoon track were good until the typhoon underwent the extratropical transition; however, the track forecast error was about 314 km/48 hours because of the error in predicting the moving speed.



(a) KMA | (b) UM model

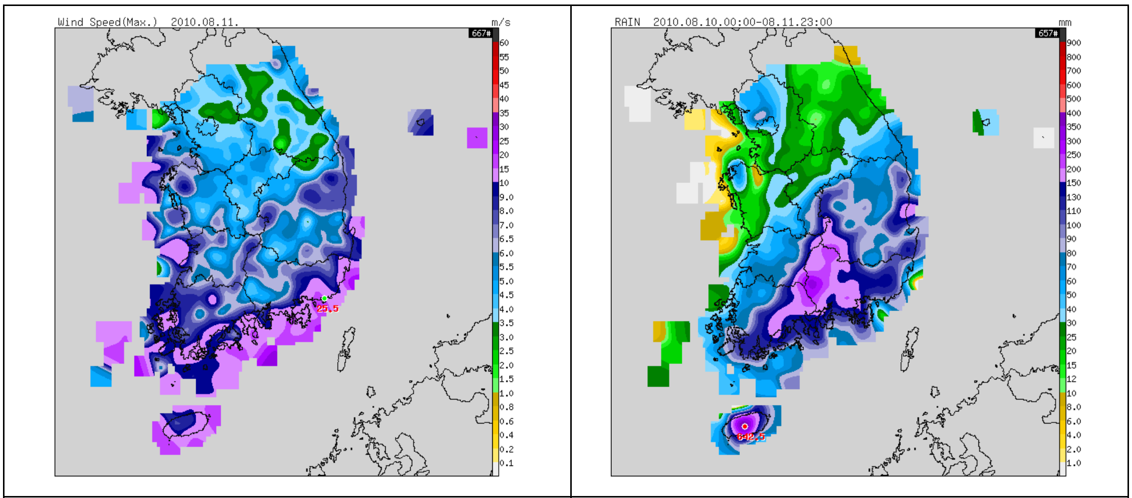
Fig. I-1-2. (a) KMA and (b) UM track forecasts of typhoon “DIANMU(1004)”

Table. I-1-1. Time-based changes of position and intensity of Typhoon "Dianmu(1004)".

(: approaching, : passing, : going out)

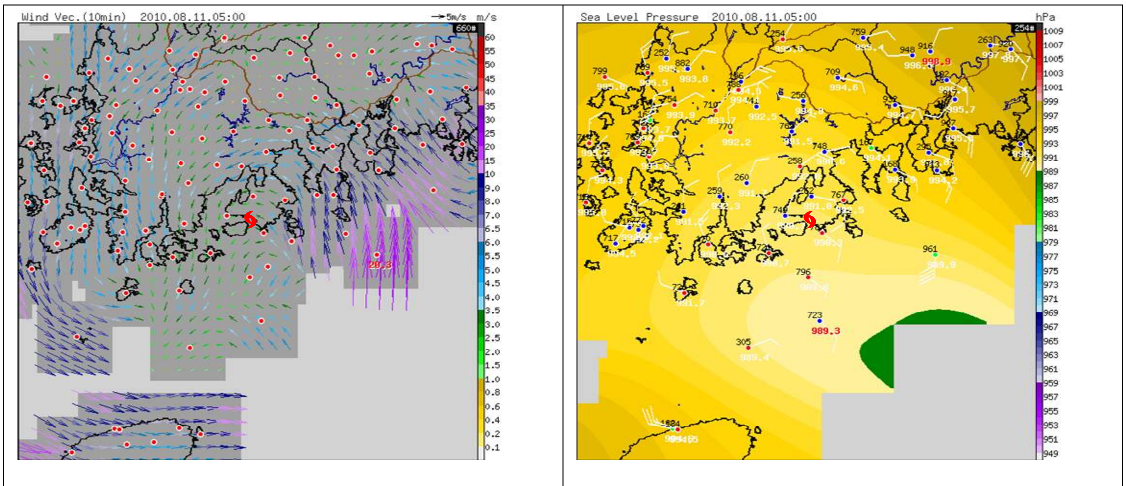
Date, Time (KST)	Lat. (N)	Lon. (E)	Moving Direction	Moving Speed (km/h)	Central Pressure (hPa)	Maximum Sustained Wind (m/s)	Int.	Radius of 15 m/s (km)	Direction/ short radius
08082100	23.6	125.1	N	19	994	21	TS	100	
08090300	24.3	125.2	N	16	992	22	TS	120	NW/100
08090900	25.7	125.6	NNE	27	990	24	TS	200	NW/150
08091500	27.1	125.6	N	26	985	27	STS	250	NW/180
08091800	28	125.6	N	34	985	27	STS	250	W/200
08092200	28.8	125.2	NNW	25	985	27	STS	250	W/200
08100000	29.2	125	NNW	25	985	27	STS	250	W/200
08100300	29.7	125.1	NNE	19	985	27	STS	250	W/200
08100600	30.1	125.2	NNE	16	985	27	STS	300	W/230
08100900	31.1	125.1	N	38	980	31	STS	300	W/250
08101200	31.4	125.3	NNE	13	980	31	STS	300	W/250
08101500	31.9	125.2	N	19	980	31	STS	300	W/250
08101800	32.7	125.5	NNE	32	980	31	STS	300	W/250
08102100	33.1	125.7	NNE	17	980	31	STS	300	W/250
08110000	33.7	126.3	NE	29	985	27	STS	250	W/200
08110300	34.2	126.7	NE	23	985	27	STS	200	W/150
08110600	34.6	127.4	ENE	27	990	24	TS	180	W/150
08110900	34.9	128	ENE	22	990	24	TS	150	NW/80
08111200	35.3	128.8	ENE	29	990	24	TS	120	NW/70
08111500	35.6	129.8	ENE	33	990	24	TS	120	NW/70
08111800	36.2	131.5	ENE	56	990	24	TS	120	NW/70
08112100	36.7	132.9	ENE	46	992	22	TS	120	NW/70
08120000	36.9	133.6	ENE	23	992	22	TS	120	NW/70
08120300	37	134	ENE	13	995	20	TS	120	NW/70
08120900	38.2	136	ENE	37	995	20	TS	120	NW/70
08121500	39.2	138.8	ENE	45	998		-		

The accumulated precipitation on 10-11 AUG 2010, around the top of Halla Mountain in Jeju, recorded over 642.5 mm, and the maximum wind speed was 25.5m/s and the gust was 40.7m/s at the Busan radar site on 11 AUG 2010 (Fig. I-1-3). Some of the observations taken during this period are also included below (Fig. I-1-4-Fig. I-1-5):

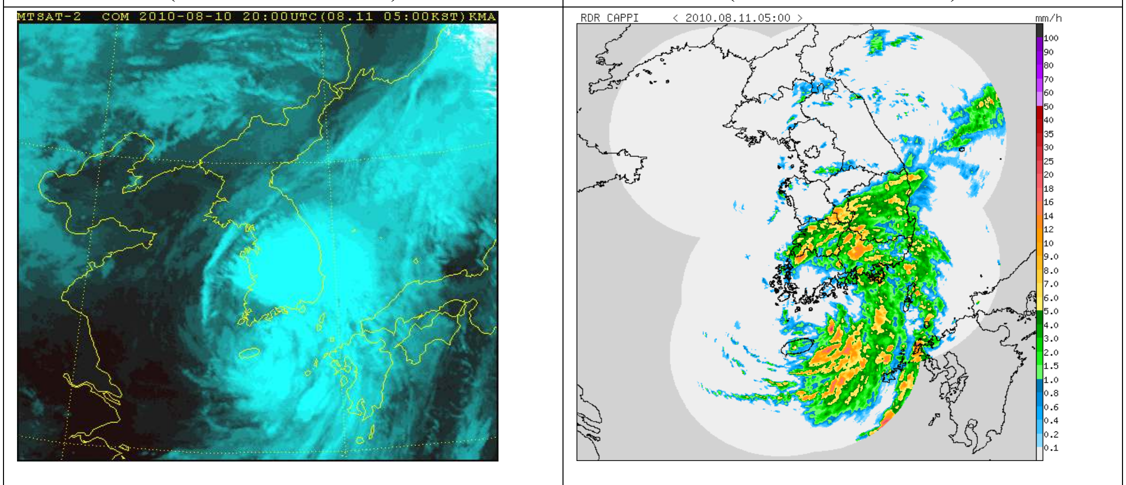


(a) 11 AUG 2010 | (b) 10-11 AUG 2010

Fig.I-1-3. Distribution of (a) maximum wind speed on 11 AUG, and (b) precipitation on 10-11 AUG when typhoon DIANMU approached Korea

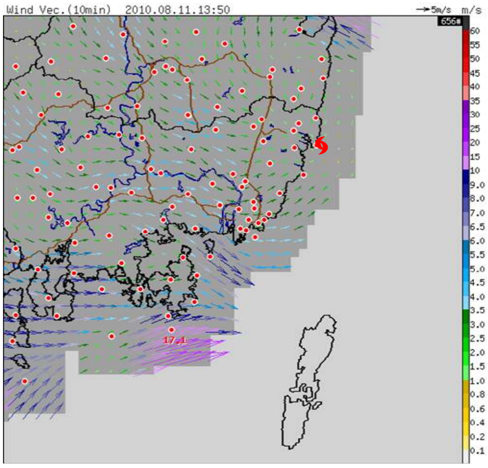


AWS Surface Wind Vector (05:00 KST 11 AUG) | AWS Mean Sea Level Pressure (05:00 KST 11 AUG)

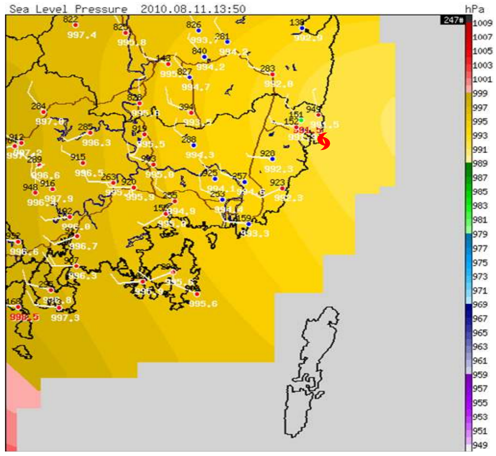


Satellite Image (05:00 KST 11 AUG) | Radar Image (05:00 KST 11 AUG)

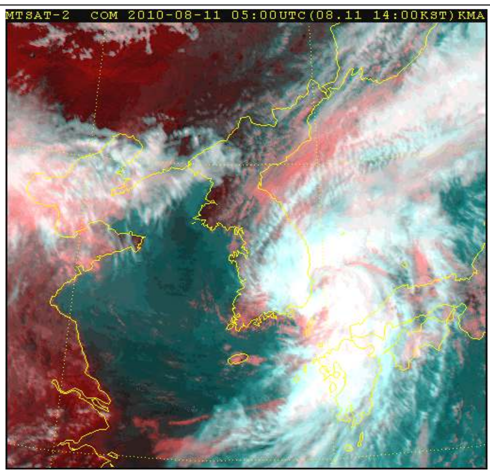
Fig.I-1-4. Observations and images of DIANMU's landing (05:00KST 11 AUG)



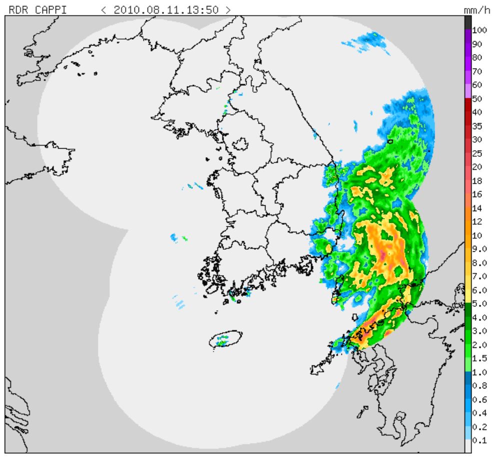
AWS Surface Wind Vector
(13:50 KST 11 AUG)



AWS Mean Sea Level Pressure
(13:50 KST 11 AUG)



Satellite Visible Image (14:00 KST 11 AUG)



Radar Rainfall Image (13:50 KST 11 AUG)

Fig.I-1-5. Observations and images of DIANMU's seaward exit (13:50 KST 11 AUG)

- **Typhoon 'KOMPASU(1007)'**

Typhoon Kompasu (1007) formed at 21:00 KST on 29 AUG, 880 km southeast from Okinawa (21.2^{o}N, 134.4^{o}E). It started weak in strength and small in size. At 04:00 KST on 1 SEP, it approach the southern part of Jeju Island and made landfall on 06:35 KST on 2 SEP in the midwestern part of the Korean peninsula, and exited over the East sea at 10:50 KST later that day. Although it was relatively small in size, the intensity of Kompasu was strong enough to cause wind damage on the right-hand side of the track. Due to the relatively low SST of the Yellow Sea, the typhoon gradually weakened during its passage. However, the typhoon started moving faster and caused damage in to areas immediately to the east of the track, including the vicinity of Seoul, Gyeonggi Province, South Chungcheong Province, Gangwon Province, Jeolla Province, and Jeju. Because of the fast moving typhoon, the accompanying rainfall was short in duration and sporadic, and caused little damage. The heaviest rainfall was concentrated in the northern part of Gyeonggi Province and North Korea, recording 150-200mm. The rainfall amount over Jeju Island and Mt. Jiri exceeded 200 mm due to orographic effects.

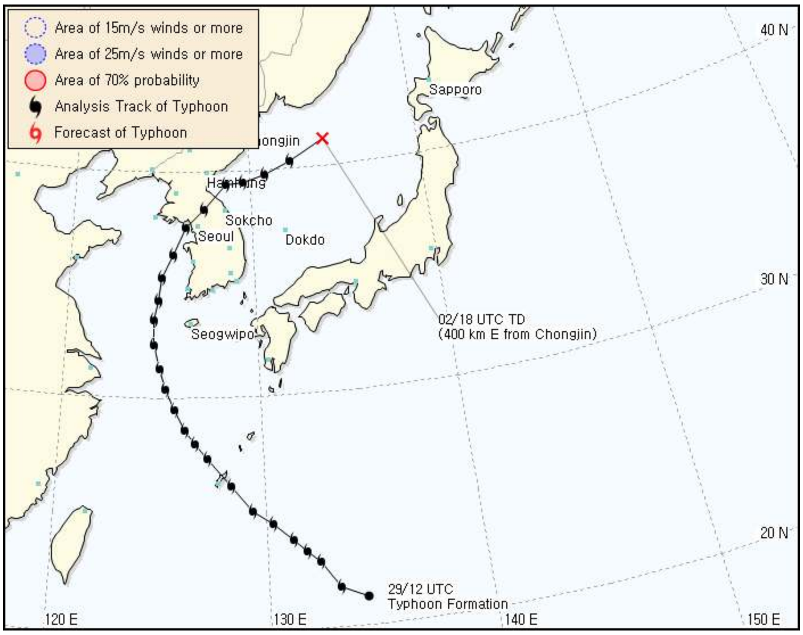


Fig. I-1-6. Track of typhoon "KOMPASU(1007)", which affected Korea

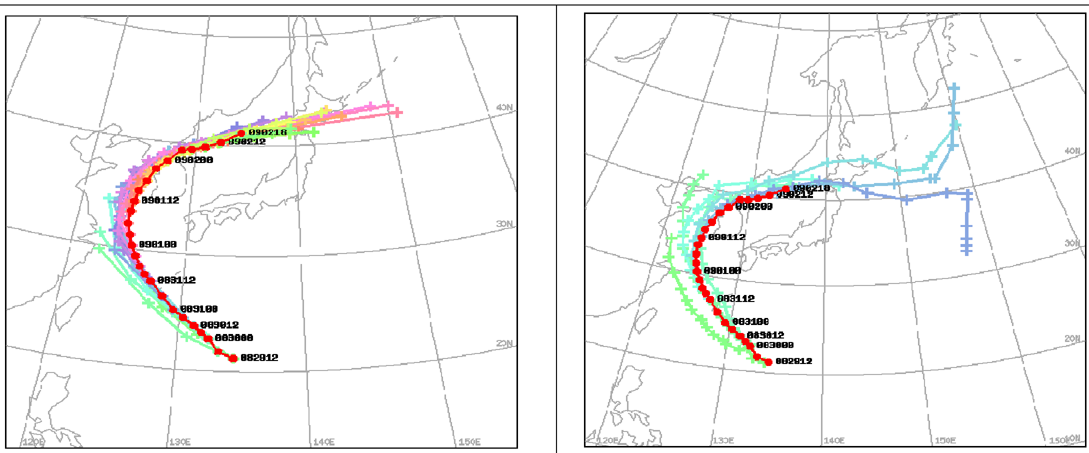
Kompasu moved along the boundary of the North Pacific High and its intensity peaked at 10:00 KST on 31 AUG. It moved northward at a speed of 20-40 km/h up to 28N and turned northeastward on the night of 1 SEP. It made landfall in the southern part of Ganghwa-gun at 06:35 KST on 2 SEP, and moved at a speed of 40-50 km/h until it went out at 10:50 KST later that day at Goseong-gun, Gangwon Province. Kompasu underwent extratropical transition over the ocean 400 km east of Chungjin (41.2N, 134.5E) at 03:00 KST on 3 SEP.

The SST over the Western Pacific was 1 degree above normal when Kompasu formed. As it moved over the high-SST region, the typhoon intensified to a 'strong' typhoon with a central pressure of 960 hPa and maximum wind speed of 40 m/s (144 km/h). Kompasu maintained its intensity as the typhoon moved through a region where the SST was 2-3 degrees higher and decreased as it passed 180 km west of Seogwipo, Jeju Island, and turned NNE.

Table. I-1-2. Time-based changes of position and intensity of Typhoon “KOMPASU(1004)”.
(: approaching, : passing, : going out; Intensity … W: weak, N: normal, S: strong)

Date, Time (KST)	Lat. (N)	Lon. (E)	Moving Direction	Moving Speed (km/h)	Central Pressure (hPa)	Maximum Sustained Wind (m/s)	Int.	Radius of 15 m/s (km)	Direction/ short radius
08292100	21.2	134.4	W	18	1000	18	W	220	
08300300	21.7	133.2	WNW	23	996	19	W	250	
08301000	22.8	132.4	NW	25	992	21	W	280	
08301600	23.3	131.8	NW	14	985	27	N	300	
08302100	23.8	131.2	NW	14	980	31	N	350	SW300
08310300	24.5	130.3	NW	20	970	36	N	450	SW400
08310900	25.1	129.4	NW	19	960	40	S	450	SW400
08311500	26.2	128.4	NW	27	960	40	S	300	SW250
08312100	27.4	127.3	NW	29	960	40	S	300	NW250
09010000	28.0	126.7	NW	30	965	38	S	300	NW250
09010300	28.6	126.2	NW	28	965	38	S	300	NW250
09010600	29.5	125.7	NNW	38	965	38	S	300	NW250
09010900	30.4	125.2	NNW	38	960	40	S	300	SW250
09011200	31.3	124.9	NNW	35	960	40	S	300	SW250
09011500	32.3	124.6	NNW	39	965	38	S	280	W230
09011800	33.4	124.6	N	41	965	38	S	250	W230
09012100	34.3	124.8	NNE	34	970	38	S	240	W200
09020000	35.3	125.0	NNE	38	970	38	S	240	W200
09020300	36.3	125.6	NNE	42	975	36	S	220	NE200
09020600	37.5	126.3	NNE	50	985	27	N	180	NW150
09020900	38.3	127.3	NE	42	990	24	W	150	NW130
09021200	39.4	128.6	NE	56	990	24	W	150	NW130
09021500	39.5	129.6	E	29	995	20	W	130	NW100
09021800	39.8	130.6	ENE	39	995	20	W	130	NW100
09022100	40.3	132.4	ENE	47	998	18	W	100	NW80
09030300	41.2	134.5	ENE	34	1008				

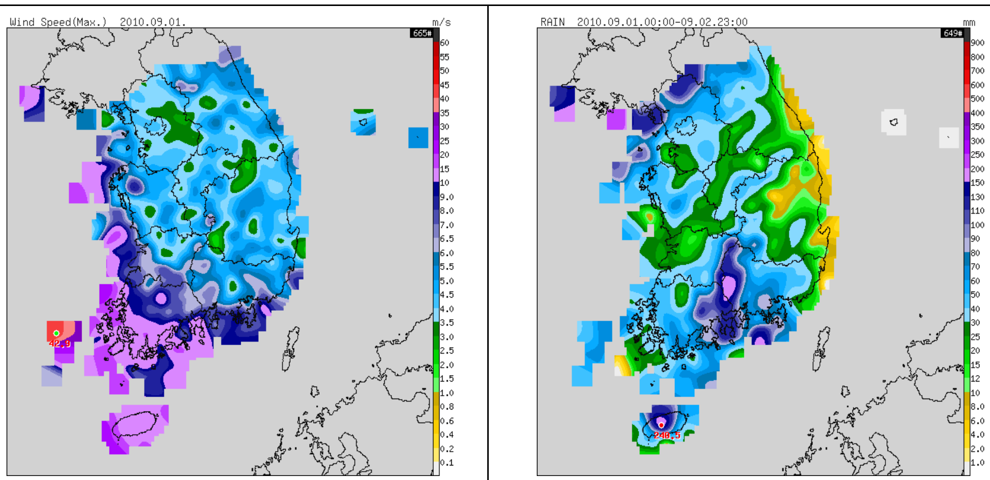
The track of Kompasu was forecasted as moving along the boundary of North Pacific High. The predicted track matched the best track, although the speed of movement was faster than predicted. A typhoon is usually expected to slow down while it changes direction; however, the southerly movement of a strong wind axis from an upper level jet stream accelerated the movement of Kompasu, and the predicted track was further north than the best track. The track forecast error was 375 km for 48-hour predictions.



(a) KMA | (b) TWRF (typhoon model)

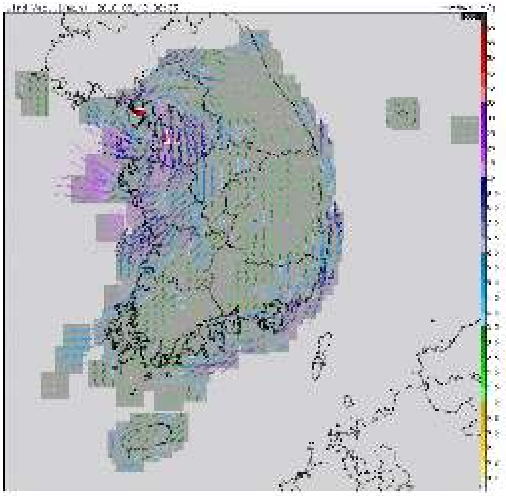
Fig. I-1-7. (a) KMA and (b) TWRF (typhoon model) track forecasts of typhoon "KOMPASU(1007)"

The recorded extreme values while Kompasu passed through the land area was as follows: the accumulated precipitation on 1-2 SEP, near the top of Halla mountain in Jeju was 240.5 mm; the maximum wind speed on 1 SEP at Hong-do Island in the Yellow Sea was 42.9m/s and the gust was 52.4m/s (Fig. I-1-8). Other observational data during the Kompasu passage through the Korean peninsula are shown below (Fig. I-1-9-Fig. I-1-10).

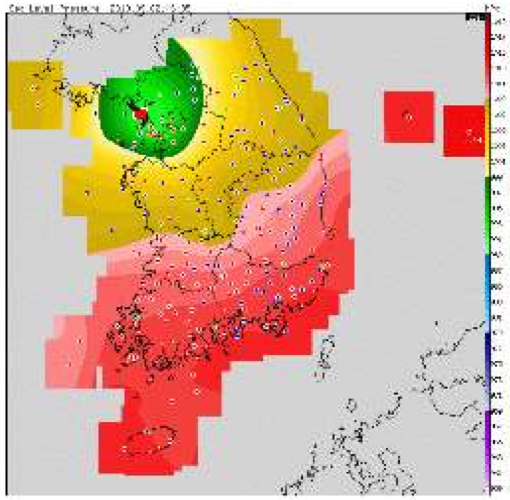


(a) 1 SEP 2010 | (b) 01-02 SEP 2010

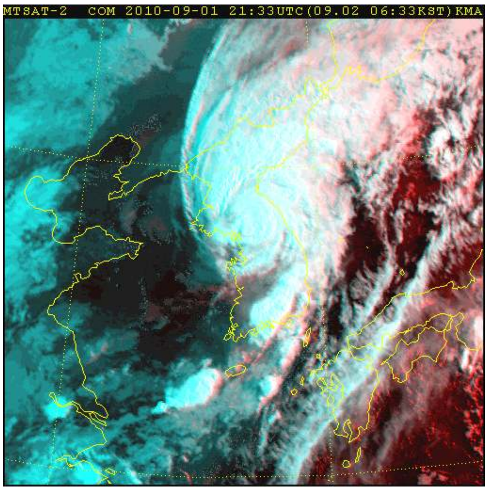
Fig. I-1-8. Distribution of (a) maximum wind speed and (b) precipitation during typhoon KOMPASU's approach toward Korea



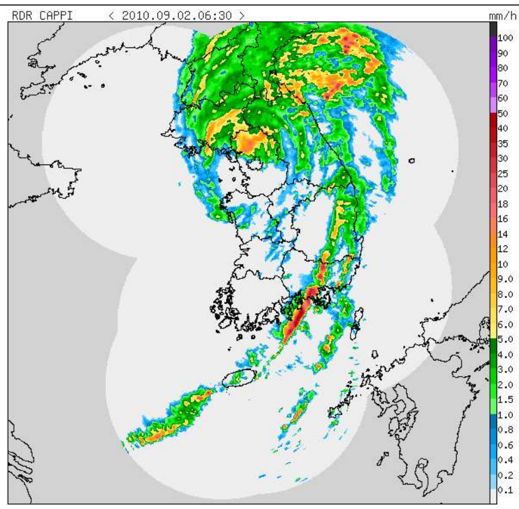
AWS Wind vector
(06:35 KST 02 SEP)



AWS Mean Sea Level Pressure
(06:35 KST 02 SEP)

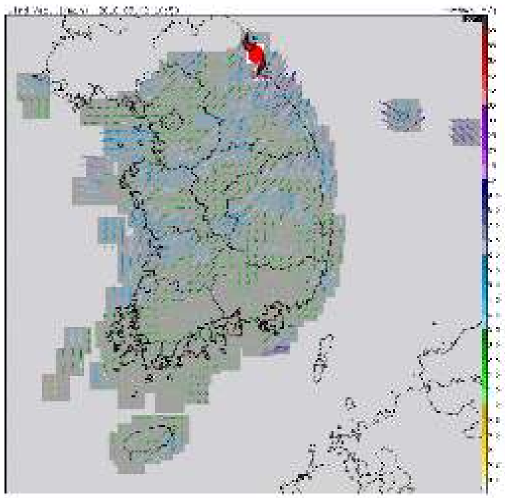


Satellite Image
(06:33 KST 02 SEP)

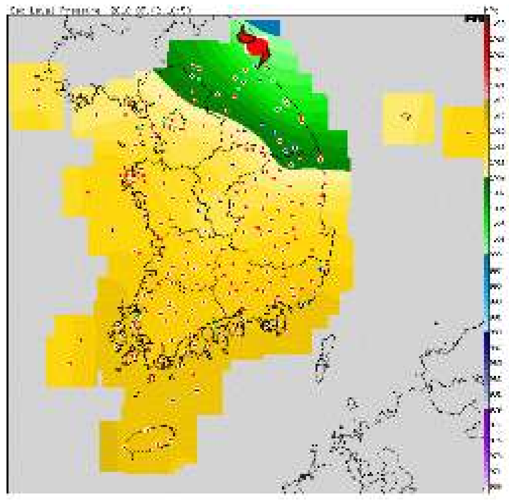


Radar Image
(06:30 KST 02 SEP)

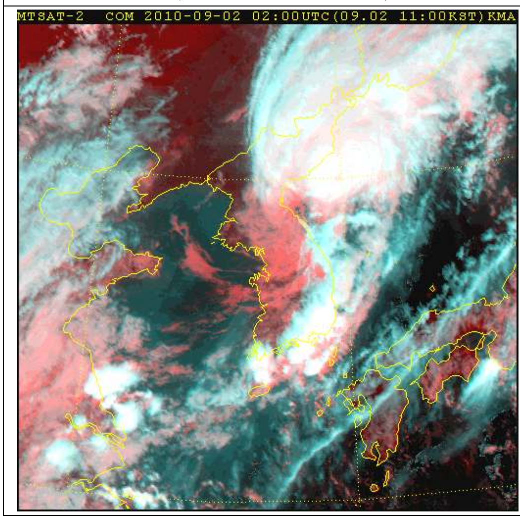
Fig. I-1-9. Observations and images of KOMPASU's landing (06:35 KST 02 SEP)



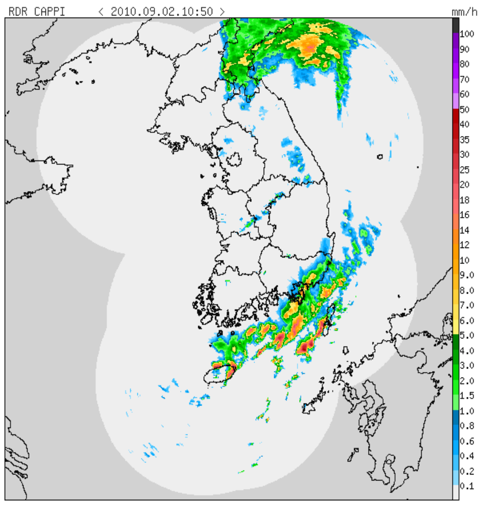
AWS Wind Vector
(10:50 KST 02 SEP)



AWS Mean Sea Level Pressure
(10:50 KST 02 SEP)



Satellite Image
(11:00 KST 02 SEP)



Radar Image
(10:50 KST 02 SEP)

Fig. I-1-10. Observations and images of KOMPASU's seaward exit (10:50 KST 02 SEP)

-<u>Typhoon 'MALOU (1009)'</u>

Typhoon Malou (1009) formed on 15:00 KST on 03 SEP, 470 km southeast from Okinawa (23.2^{o}N, 130.9^{o}E). This typhoon stayed in the 'Weak' category in intensity and the 'Small' category in size throughout its lifetime. The lowest central pressure was 990 hPa and the maximum wind speed was 24m/s. The northward moving Malou turned northeastward when it passed south of Seogwipo, Jeju Island, on the afternoon of 06 SEP. It moved over the South Sea, crossing the Korean Strait on 07 SEP, and did not make landfall on the Korean peninsula. Malou underwent extratropical transition at 09:00 KST on 08 SEP, 310 km southeast of Dokdo (Fig. I-1-11).

When it formed, Malou was expected to move along the Yellow Sea due to extension of the North Pacific High. However, the North Pacific High shrank north-south and expanded east-west after 06 SEP, and the typhoon moved eastward instead of moving north. This was attributed to the fact that the center of the North Pacific High also moved south and expanded east-west as the upper-level jet stream moved south over Japan.

From a structural point of view, Malou had the shape of a 'right-half-only' rain band. This was due to the strong westerly, which was resisted by the easterly, and the subsequent shrinking of the rain band. Another feature of Malou was its slow movement, which caused heavy rainfall in the region of Jeju Island and southeastern part of the Korean peninsula. There was little wind impact from the typhoon due to its relatively small size.

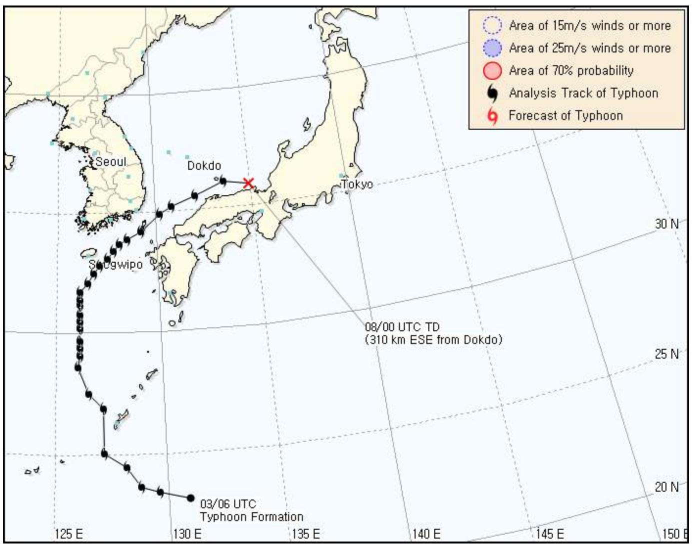


Fig. I-1-11. Track of typhoon "MALOU(1009)"

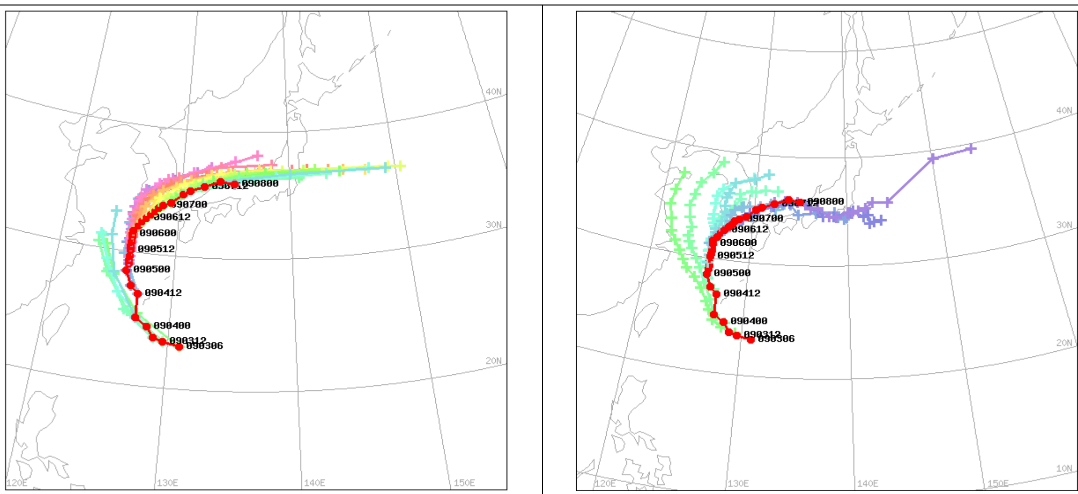
Malou moved northward at a speed of 15-34km/h up to 28N and entered the typhoon warning area at 15:00 KST on 04 SEP and the emergency alert area at 10:00KST on 05 SEP. It slowed down to 12 km/h after 12:00 KST on 05 SEP. This slow movement can be attributed to the North Pacific High, which lingered longer than usual, and a cold continental high-pressure system which prevented the northward movement of the typhoon.

Like the 7^{th} typhoon KOMPASU, which had a similar track, because of upper-level mixing of sea water, the ocean heat content was relatively low. The cold upper air resided over the Korean peninsula during the typhoon period. These two effects contributed to the ‘Weak’ character of Malou throughout its lifetime. Dividing the typhoon’s life into three phrases—the developing stage, the fully-developed stage, and the retreating stage—the extension of the North Pacific High to the west strengthened the vorticity of the typhoon during the developing stage of Malou (15:00 KST 03 SEP-03:00 KST 06 SEP). The southward movement of an upper-level jet stream and the retreating North Pacific High during the fully-developed stage of the typhoon (09:00 KST 06 SEP-09:00 KST 07 SEP) caused the sudden eastward turn. The central pressure of Malou at this stage was 985 hPa and the maximum wind speed was 25m/s. The moving speed slowed to 5 km/h, allowing sufficient time to absorb energy from the warm ocean surface. When Malou crossed the South Sea and the Korean Strait, the upper trough caused its weakening and accelerated its movement up to 45 km/h (15:00 KST 07 SEP-09:00 KST 08 SEP).

As the upper Ridge near Yeonhaeju and the North Pacific High kept their strength, the typhoon was expected to move more slowly. The typhoon slowed as forecasted due to the strong ridge around Yonhaeju. Because of the southeastward movement of the North Pacific High, Malou moved eastward over the South Sea instead of moving northward. It speeded up after turning northeast. Overall, the forecasted track was further north than the best track and the forecasted speed was slower than the observed speed. The track forecast error was 267 km for 48-hour predictions.

Table. I-1-3. Time-based changes of position and intensity of Typhoon "MALOU(1009)". (Intensity … W: weak, N: normal, S: strong)

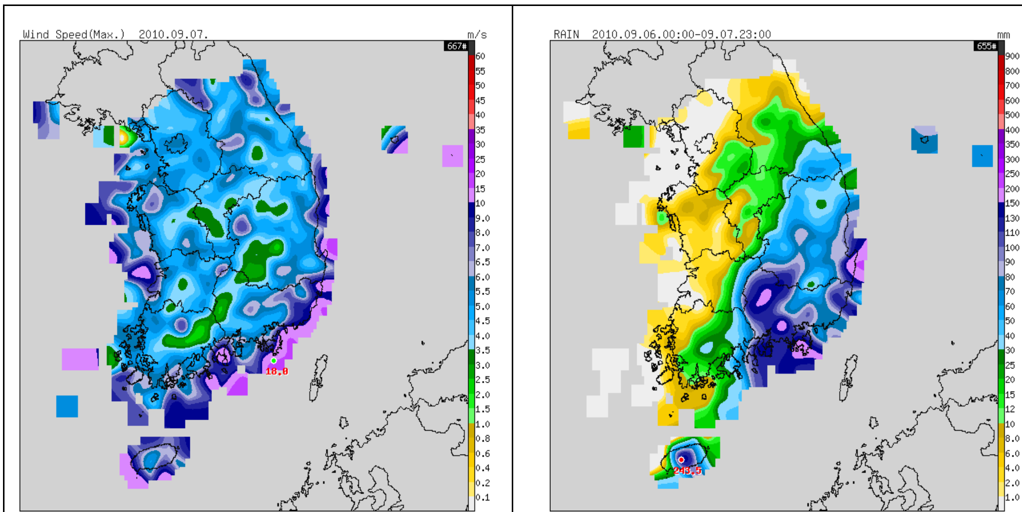
Date, Time (KST)	Lat. (N)	Lon. (E)	Moving Direction	Moving Speed (km/h)	Central Pressure (hPa)	Maximum Sustained Wind (m/s)	Int.	Radius of 15 m/s (km)	Direction/ short radius
09031500	23.2	130.9	WNW	15	1000	18	W	200	
09032100	23.5	129.6	WNW	23	1000	18	W	200	
09040300	23.7	128.8	WNW	15	996	19	W	220	
09040900	24.5	128.2	NW	18	996	19	W	220	
09041500	25.1	127.2	NW	21	996	19	W	220	
09042100	26.9	127.2	N	34	994	21	W	250	
09050300	27.5	126.5	NW	17	994	21	W	250	
09050900	28.6	126.0	NNW	22	994	21	W	220	
09051200	29.1	126.1	N	19	994	21	W	220	
09051500	29.4	126.1	N	12	994	21	W	220	
09051800	29.7	126.1	N	12	994	21	W	220	
09052100	30.2	126.1	N	19	994	21	W	220	
09060000	30.5	126.1	N	12	994	21	W	220	
09060300	30.8	126.1	N	12	994	21	W	220	
09060600	31.2	126.1	N	15	994	21	W	220	
09060900	31.4	126.1	N	8	990	24	W	240	
09061200	31.7	126.1	N	12	990	24	W	240	
09061500	32.1	126.5	N	20	990	24	W	200	
09061800	32.5	126.8	NE	18	990	24	W	180	
09062100	32.8	127.1	NE	15	990	24	W	180	
09070000	33.1	127.5	NE	17	990	24	W	160	
09070300	33.4	127.8	NE	15	990	24	W	160	
09070600	33.7	128.1	NE	15	990	24	W	160	
09070900	33.9	128.5	ENE	15	990	24	W	160	
09071200	34.2	129.2	ENE	25	990	24	W	160	
09071500	34.9	130.2	NE	41	996	19	W	140	
09071800	35.2	130.8	ENE	22	996	19	W	140	
09072100	35.6	132.1	ENE	42	996	19	W	140	
09080400	36.1	133.6	ENE	25	998	18	W	120	
09080900	35.9	134.9							



(a) KMA | (b) typhoon model – TWRF

Fig. I-1-12. (a) KMA and (b) TWRF (typhoon model) track forecast of typhoon MALOU (1009)

The recorded extreme values while the Malou passed in land area was like following. The accumulated precipitation on Sep. 6~7, near top region (elevation: 1673m) of Hanla mountain in Jeju was 243.5mm. The maximum wind speed on Sep. 6 at GeeGui island in South Sea was 17.7m/s and the gust was 27.2m/s. On Sep. 7, at Maemul island, the maximum wind speed was 18 m/s and the gust was 24.1m/s (Fig. I-1-13).



(a) 2010. 09. 07. | (b) 2010. 09. 06~07.

Fig. I-1-13. Distribution of (a) maximum wind speed and (b) precipitation during the period that typhoon MALOU approached to Korea

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

- Typhoon ‘KOMPASU (1007)’

The 7th typhoon ‘KOMPASU’ formed near Okinawa of Japan at 9 P. M. on 21 AUG 2010. It was a small typhoon. Then the typhoon approached the west of the Korean Peninsula. The typhoon developed to medium-sized typhoon over Korea.

The typhoon moved northward at a speed of 20-40km per hour until north latitude 28°. After the morning of 01 SEP, the typhoon started moving faster, at an average speed of around 40 km per hour.

As the strong winds downed trees in the metropolitan area, blocking the road a subway station, and causing great confusion over power outages. The damage was compounded in the absence of appropriate travel restrictions, school or work hours delay. The damage was less severe in Jeju Island and North Jeolla Province as the center of the storm passed at a distance.

The estimated damage is as follows:

5 missing persons, 112 injured

Property damage: 167 billon Won

Recovery process: 16,000 ha of paddies in South Chungcheong province were damaged.
Government measures to support implementation of the special aid.

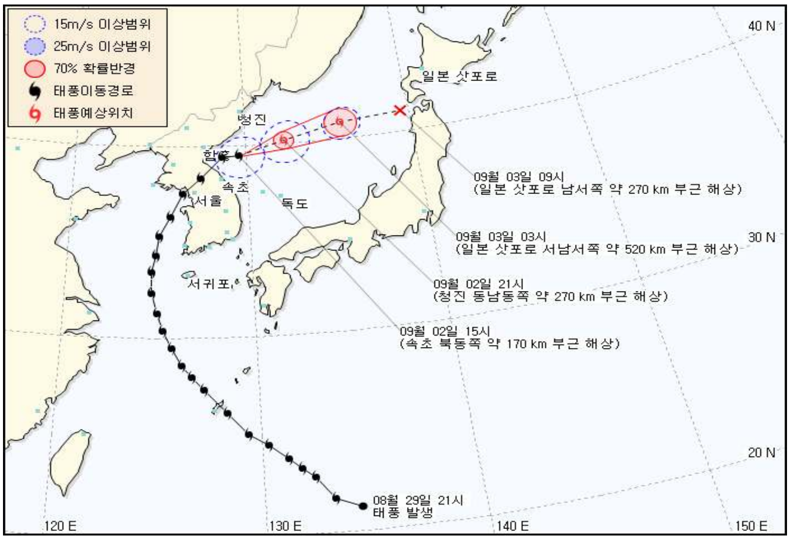


Fig.I-2-1. Typhoon ‘KOMPASU’ track

(Source: KMA, www.KMA.go.kr)

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

Over the weekend of 28-29 AUG, the eighth tropical depression in the northwestern Pacific Ocean formed and strengthened into the tropical storm Kompasu at 12:11 a.m. on 29 AUG; it appeared as a tightly wound storm. The convection continued to strengthen, and by 8 a.m. on Monday, 30 AUG, KOMPAS had attained typhoon strength, with maximum sustained winds approaching 138.4 km/h. Kompasu was about 386.2 nautical km southeast of Kadena, Japan, near 23.7 North and 131.2 East. It was moving northwestward at nearly 12.9 km/h and kicking up 5.18-m high seas. It was expected to curve to the north-northeast and then to become extratropical before reaching the Korean peninsula. NASA's Terra satellite flew over the northwestern Pacific Ocean at 10:30 p.m. on 30 AUG and miraculously managed to capture Tropical Storm Lionrock, Tropical Storm Namtheun, and Typhoon Kompasu on a single image (Fig. I-3-1). Two of these tropical cyclones, shown in Fig. I-3-1, were expected to merge, while the other was headed for a landfall in China. On 31 AUG, at 1 a.m., Kadena Air Base did not yet report tropical-storm-force winds from Typhoon Kompasu. Kadena Air Base did report, however, that the sea level pressure dropped to an amazing 44 mb in less than two hours, indicating that the typhoon was approaching. On 31 AUG, at 5 a.m., Typhoon Kompasu had maximum sustained winds nearing 175.4 km/h and was 72.4 nautical km east-southeast of Kadena AB, Japan. After impacting Kadena Air Base, Typhoon Kompasu was expected to turn north then northeast, and to track over the Korean peninsula into the East Sea. The other two tropical cyclones, Tropical Storm Lionrock and Tropical Storm Namtheun, were forecasted to merge in the next few days. The cyclone was expected to track over Okinawa within the next few hours, and to continue on a northwestward track for the next 12 to 24 hours, then cross the Korean peninsula (from western to eastern Korea) into the East Sea, cross northern Japan, and exit into the northwestern Pacific Ocean by 04 SEP.

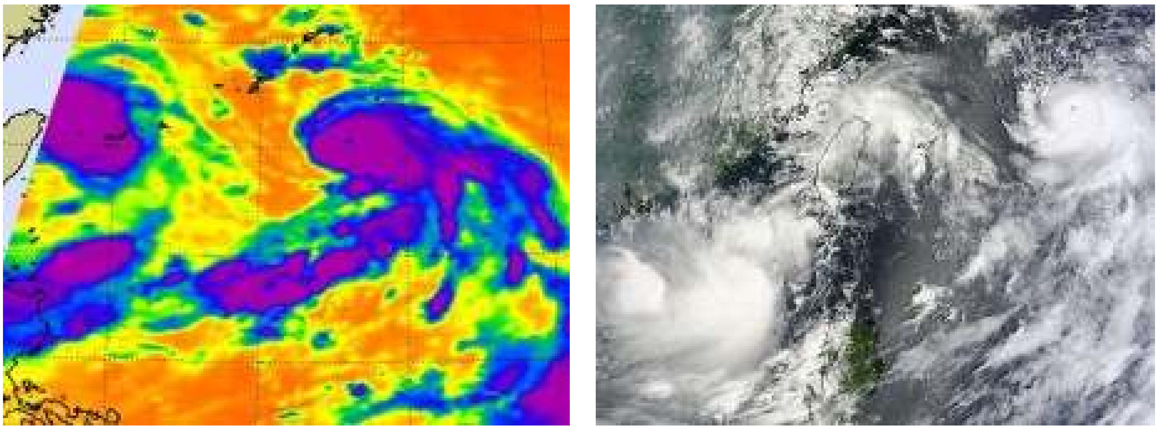


Fig. I-3-1. 31 AUG 2010. Infrared imagery from the AIRS instrument on NASA's Aqua satellite: Tropical Storm Lionrock (lower left), Tropical Storm Namtheun (center), and Typhoon Kompasu (top right) off the Asian coast.

The seventh typhoon of the year made landfall on the west coast of Ganghwa Island at 6:35 a.m., then passed over Cheorwon, about 80 km northeast of Seoul, at a speed of 23 km/h, at 9:00

a.m., according to the Korea Meteorological Administration (KMA). KMA issued typhoon warnings for Seoul, Gyeonggi Province, and South Chungcheong Province, forecasting the tropical storm to move to the East Sea on Thursday afternoon. Kompasu, which means “compass” in Japanese, was the strongest tropical storm to hit the Seoul metropolitan area in 15 years.

Fig. I-3-2. The moderate-resolution imaging spectroradiometer (MODIS) on NASA’s Aqua satellite captured this natural-color image of Typhoon Kompasu approaching the Korean peninsula.

Fig. I-3-3. On 2 SEP, a tree was knocked down and hit a running car in Gyeonggi.

Winds of 84.3 km/h were recorded on Hong-do Island, off the nation’s southwest coast, as of 8 a.m., marking the strongest winds to hit the Korean peninsula since 2000, when a gust speed of

93.8 km/s was reported on the peninsula. The maximum wind speed reached 47.5 km/s in the eastern parts of Seoul, which is powerful enough to destroy shoddily built houses.

Fig. I-3-4. On 02 SEP, trees lay on the ground after being torn out while Typhoon Kompasu was battering Chuncheon.

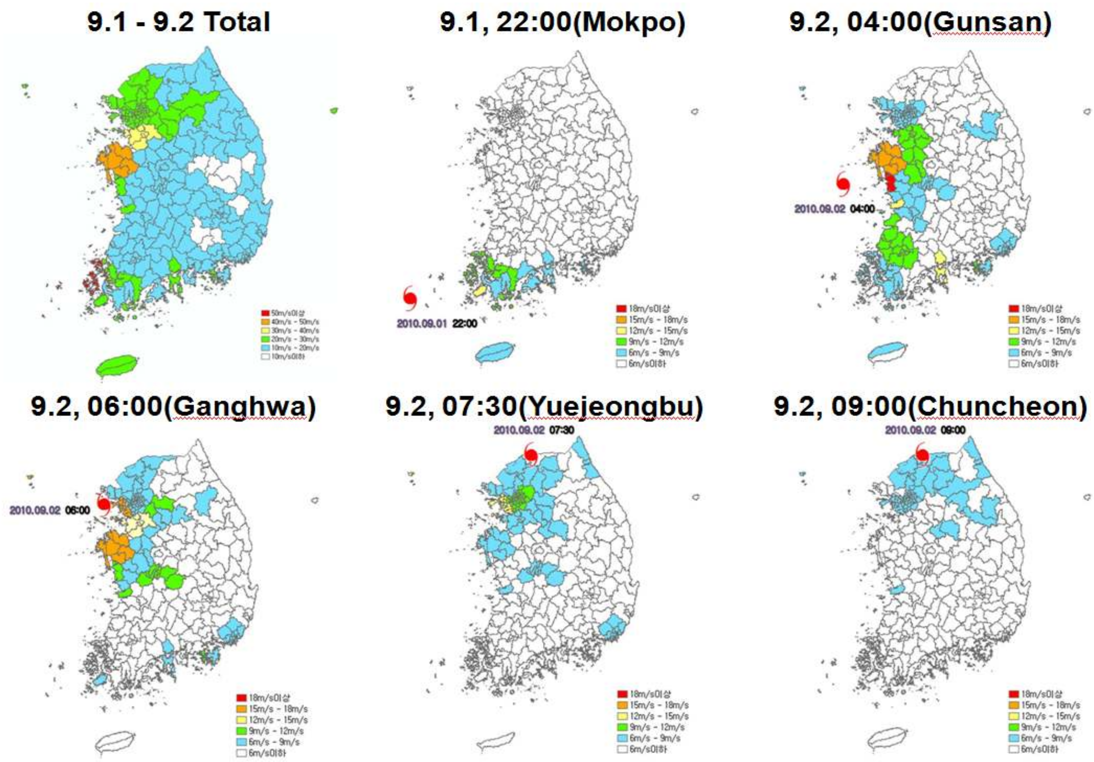


Fig. I-3-5. Time series of the wind speed contour map with typhoon locations.

Due to the relatively fast movement of the storm, much of the damage was caused by the intense winds, which recorded up to 52.2 m/s at 03:30 on 02 SEP in Incheon. At that time, Munhak Stadium in Incheon sustained substantial damage as gale-force winds shredded the roof of the structure (Fig. I-3-7). The damage to the stadium amounted s USD 8.3 million. The time series of the wind speed contour map with typhoon locations is shown in Fig. 5. The velocity distributions with time are also plotted in Fig. I-3-6.

Typhoon Kompasu was the typhoon with the fifth highest wind speed ever recorded in Korea, after Typhoon Maemi, which hit the country in 2002 and recorded the highest wind speed (60.48 m/s), Typhoon Praperon (2000) with the second highest (58.8 m/s), Typhoon Gonpas (2010) with the third highest (52.9 m/s), and Typhoon Nari (2006) with the fourth highest (52.9 m/s).

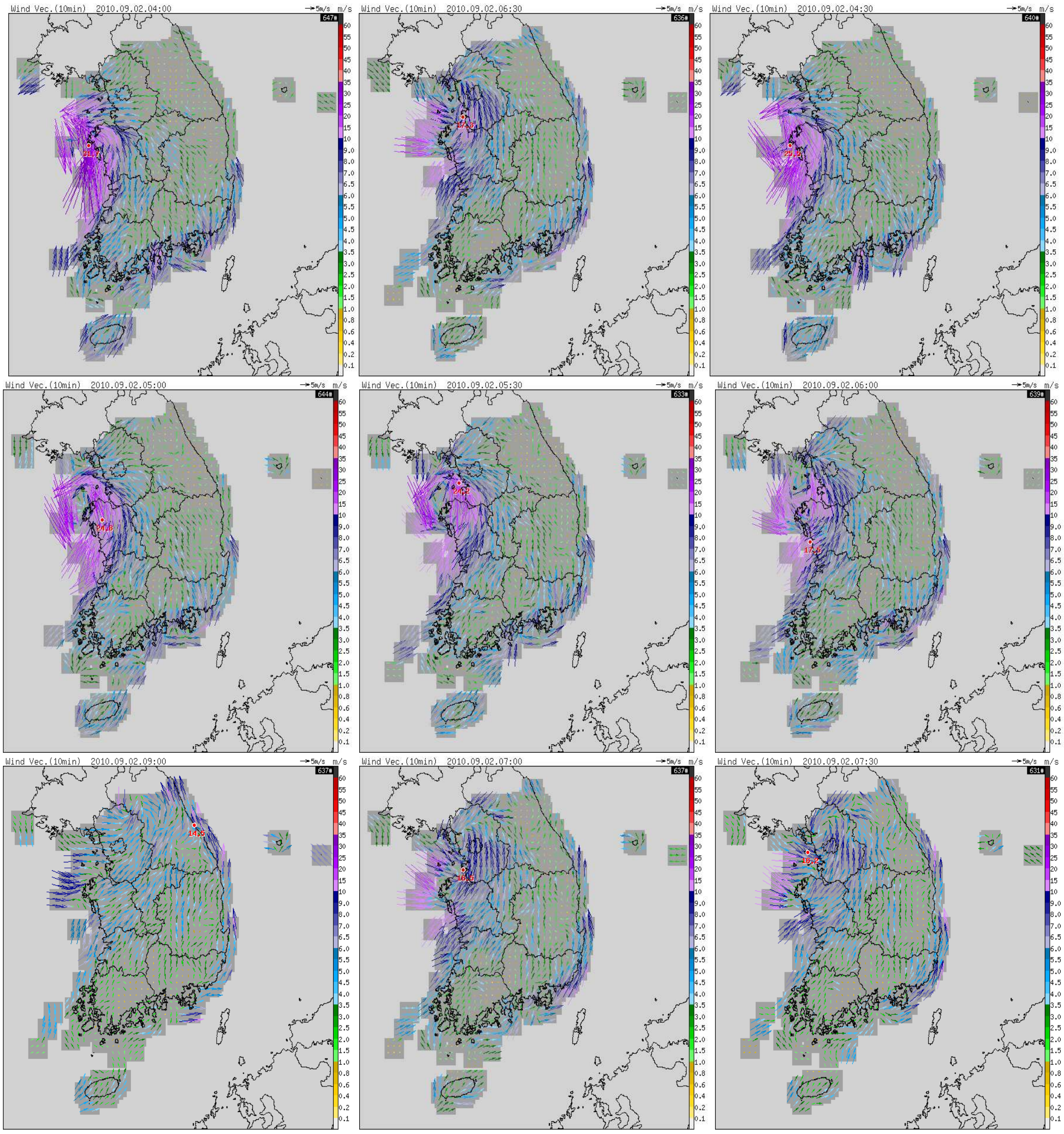


Fig. I-3-6. Time series of the velocity distributions

Fig. I-3-7. The canvas roof of Munhak Stadium in Incheon was shredded by the gale-force winds of Typhoon Kompasu, which pounded the nation on the morning of 02 SEP 2010, canceling flights, wiping out orchards, and causing commuter chaos in the metropolitan areas.

The heaviest rains fell in Ganghwa, where a 131.5-mm rainfall was recorded. Throughout South Korea, high winds and torrential rains cut the power supply to an estimated 1.56 million residences. According to the Korea Electric Power Corporation, the power outages cost USD 1.34 million. Service on three of the subway lines was interrupted during the morning hours of 03 SEP. A massive power outage affected the mass transportation, disrupting the operations of Subway Line 1, which links Seoul to Incheon and Suwon, and of the above-ground section of Subway Line 4, which links the capital to Ansan on the west coast. Although the Seoul city government quickly dispatched 270 buses to ferry the stranded subway passengers, tens of thousands of commuters suffered from congestion on the wet roadways, some blocked by trees felled by 21-m/s winds (Fig. I-3-8). The operations of the manufacturing plants in Ansan's industrial complex were halted by a power blackout. According to the National Emergency Management Agency (NEMA), power outages also affected at least 130,000 houses in South Chungcheong Province, South Jeolla Province, and Gwangju City.

Fig. I-3-8. The traffic around the subway stations became very heavy during the morning rush hours of 03 SEP as commuters stranded in the stations opted for buses when service on three of the subway lines was interrupted.

Four people were killed by debris blown around by the storm. An 80-year-old man in Seosan, South Chungcheong Province was killed after being hit by a flying roof tile. In Bundang on the southern outskirts of Seoul, a broken tree branch hit and killed a 37-year-old man who was leaving for work, while a 38-year-old resident of Bucheon, to the west of the capital, was injured by a cover flown off a food cart. Four people were injured by broken glass in Tae-an, South Chungcheong Province. The emergency rooms of Seoul’s major hospitals were crowded with people who had been injured by fragments of broken windows and downed trees. The agricultural-product damage was also estimated to be astronomical as the owners of the rice paddies and pear, grape, and apple farms along the west coast reported extensive damage from the strong winds. Roughly 10,000 ha of agricultural land were inundated in the storm, resulting in widespread losses. The storm also killed at least 80,000 chickens. In South Chungcheong Province, 7,650 Anmyeon pine trees, regarded as the best lumber in the region, were destroyed. Of these trees, 1,750 were more than 50 years old and averaged 24 m in height. On 03 SEP, the officials estimated the damage at USD 58.3 million.

The Seoul Metropolitan Office of Education issued emergency instructions, asking the elementary and middle schools in the capital city to delay the beginning of their classes by two hours. In a related measure, all the public and private kindergartens were closed for the day. A total of 128 domestic and international flights were cancelled at airports nationwide. All early morning, flights were canceled at Gimpo International Airport in Seoul while Incheon International Airport, west of Seoul, canceled or diverted nearly 20 international flights scheduled for early Thursday morning. At least 148 ferry trips from Mokpo in South Jeolla Province to Jeju Island were suspended

Fig. I-3-9. A towering wave crashed over the walls of Sinan. Around 60 flights to South Korea had to be cancelled because of the storm.

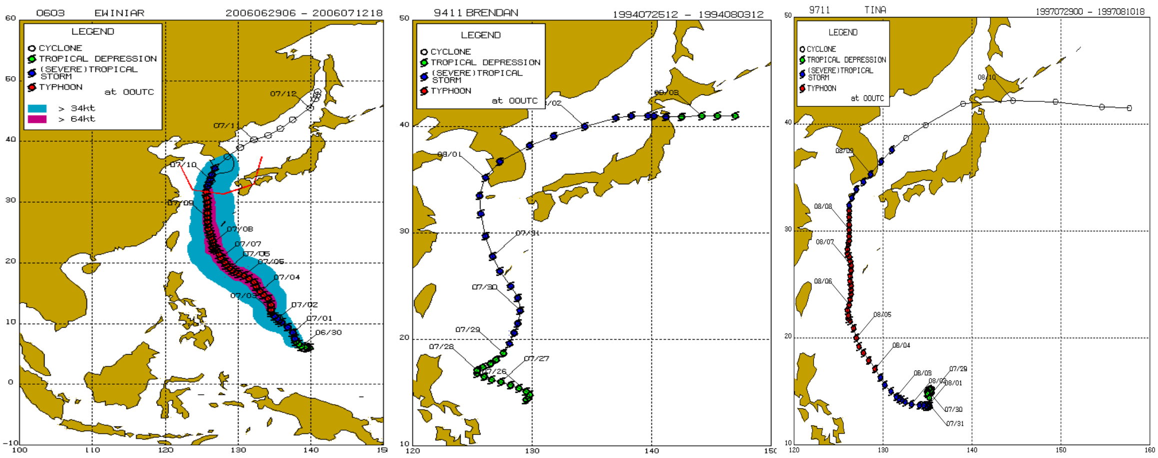
On 30 AUG, the Korea Metrological Administration (KMA) issued a typhoon warning for Jeju Island and for the nearby areas. The Minister of Public Administration and Security instructed the heads of provincial governments to prepare thoroughly for the typhoon as it “may cause tremendous damage.”

Daecheong Dam in North Chungcheong Province began to discharge water early Wednesday so as to make room for upstream water. Kompasu was also expected to take its toll on North Korea, which had already been suffering at that time from torrential rains and consequent flooding in its northern regions. The Seoul government estimated that more than 5,000 residents in the cities near North Korea’s border with China had been evacuated. All the disaster-management agencies were instructed to “take all possible steps to minimize the damage.” In the wake of the storm, NEMA announced that 29,000 government officials, soldiers, and volunteers were working on clearing the debris and restoring the power. By the evening of 02 SEP, electricity had been restored in 98% of the affected households. Roughly USD 22 million was set aside as relief funds for the residents affected by the storm. The National Tax Service decided to extend its deadlines to allow victims to first recover from the ravages of the typhoon.

Fig. I-3-10. Soldiers and volunteers fixing a ravaged vinyl greenhouse.

Fig. I-3-11. Soldiers and volunteers trying to recover a chicken farm destroyed by the typhoon.

On 01 SEP, the Web-GIS-based Typhoon Committee Disaster Information System (WGTCDIS) estimated that Kompasu, the eighth storm of the season, was moving on a track similar to those of Typhoon Ewnia in 2006, Typhoon Brenden in 1994, and Typhoon Tina in 1997, which caused "huge damage" on the Korean peninsula, according to a statement shown in Fig. I-3-12. Fig. I-3-10 shows that Typhoon Nora is the typhoon most similar to Typhoon Kompasu.



(a) Ewinia (2006) ***(b) Brenden (1994)*** ***(c) Tina (1997)***

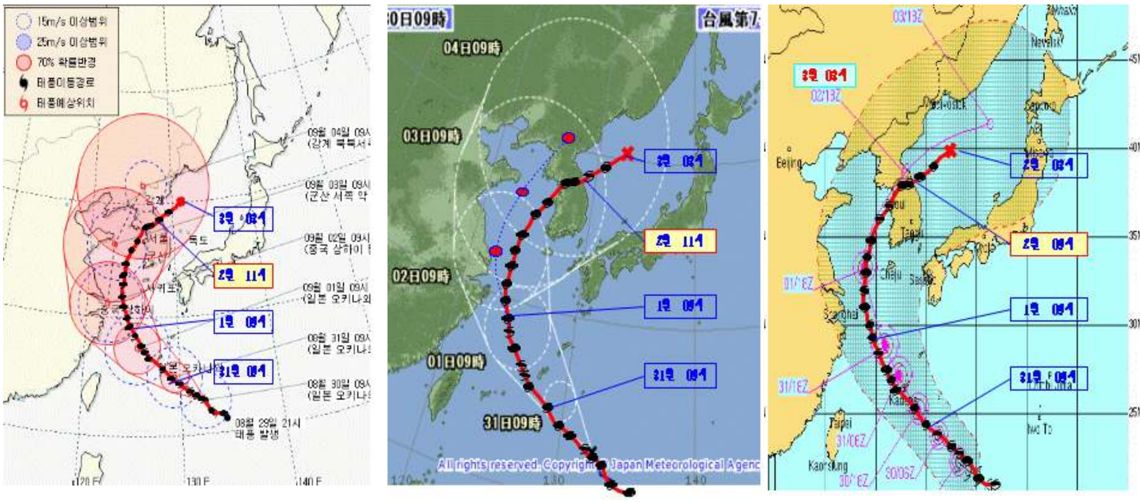
Fig. I-3-12. Estimated typhoon trajectories similar to those of Typhoon Kompasu.

The characteristics of and estimated damages wrought by the typhoons are listed in Table I-3-1. Strong winds led to severe damages, such as shredded roof structure and vinyl greenhouses, while intense precipitation did not lead to large damage. Typhoon Kompasu wrought more damage than similar typhoons, even though its central pressure and rainfall were nearly equivalent to those of the other typhoons.

Table I-3-1. Comparison of the characteristics of and the estimated damage wrought by Typhoon Kompasu and similar typhoons that affected the Korean peninsula

	Ewinia (2006)	**Brenden (1994)**	**Tina (1997)**	**Kompasu (2010)**
Rainfall (mm)	970	89	987	135
Death (person)	5	28	2	4
Damages (M$)	3.4	0.67	0.51	58.3
Central Pressure (hPa)	970	992	980	985
Max. Wind Speed (m/s)	31	30	20	52
Damaged Area	CN, GN, GB, JEJU	CN, CB, GN, GB	CN, GN, GB, JEJU	CN, GN, GB, JEJU

The typhoon trajectories estimated by KMA, JMA, and JTWC are compared in Fig. 13. The results show that JTWC best estimated the trajectory of Typhoon Kompasu. These estimated results were used as input data of WGTCDIS for estimating similar typhoon trajectories, as shown in Fig. I-3-13.



(a) KMA *(b) JMA* *(c) JTWC*

Fig. I-3-13. Comparison of typhoon trajectory estimations.

4. Regional Cooperation Assessment (highlighting regional cooperation successes and challenges)

- Nil.

II. **Summary of progress in Key Result Areas** (For achievements/results which apply to more than one Key Result Area, please describe them under the most applicable Key Result Area. Then, at the end of the description, place in parentheses ( ) the other applicable Key Result Areas)

1. Progress on Key Result Area 1: **Reduced Loss of Life from Typhoon-related Disasters.** (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- **A Campaign for the Prevention of Typhoons**

KMA (Korea Meteorological Administration) conducted a campaign for the prevention of typhoons and created a promotional video to attract public attention and to minimize damage-causing typhoons.

It was shown at approximately 1,100 locations from 1 August 2010 to 30 September 2010 on broadcast, web site and electronic display boards of government and public institutions all over Korea, raising public awareness of typhoon-related disasters.

- **Expert Meeting on Typhoon Activity and Disaster Prevention 2010**

The National Typhoon Center (NTC) of the Korea Meteorological Administration (KMA) held an expert meeting to establish prevention measures against typhoon-related disaster for this year on 5-6 April 2010 in Jeju, Korea. Over 40 experts on typhoon research and forecast and decision-makers from the Ministry of Public Administration and Security, the National Institute for Disaster Prevention, the Korea Water Resources Corporation, Seoul National University, Jeju Special Self-governing Province, etc. participated in this meeting, and discussed their typhoon outlooks for the year. There had been no injuries or damage from typhoon in the last two years. However, some studies showed that two or three typhoons may land on the Korea Peninsula this year (In fact, three typhoons (Dianmu (1004), Kompasu (1007), and Malou(1009) affected Korea). Also, methods were introduced to prepare against typhoons and minimize losses through organization. Participants agreed to reinforce their mutual cooperation and KMA outlined its plan to expand its typhoon forecast out to 5 days.

Fig. II-1-1. Participants in the expert meeting on typhoon activity and disaster prevention 2010 held on 5-6 April 2010, Jeju, Korea.

- **Workshop on the Seasonal Prediction of Typhoon Activity**

A workshop on the seasonal prediction of typhoon activity hosted by NTC/KMA was held on 23-24 August 2010, at Seogwipo KAL Hotel in Jeju, Korea. The main theme was “the current condition and autumn prediction of typhoons in 2010.” Experts from several fields such as meteorology, oceanography, hydrology, disaster prevention, and journalism participated in this workshop and presented their research findings about the frequency, track, strength, activity, etc. of typhoon and typhoon-related phenomena such as La Nina, Madden-Julian oscillation (MJO) and Arctic Oscillation (AO). Participants noted that typhoon generation frequency in the Northwest Pacific would be small in number and stronger than the normal year in intensity. In particular, many expected Korea to be directly affected by at least one or two more typhoons in the course of the year.

Fig.II-1-2. Typhoon expert workshop participants. 23-24 August 2010, Jeju, Korea

- 5-Day Typhoon Forecast (Experimental and Domestic version)

NTC/KMA plans to extend the typhoon forecast period from 3 days to 5 days in 2010, including for domestic service and its experimental version. This extension of forecasting time was expected to help prepare against typhoons approaching Korea, and to make a valuable contribution towards reducing typhoon damage. KMA’s 5-day forecast was possible due to the improvement of numerical model predictions as well as intensified monitoring ability using satellite-based observations. Although this forecast system was operated on an trial basis in 2010, KMA plans to transition it to an operational system after 2011 following a thorough review of this year’s forecast outputs.

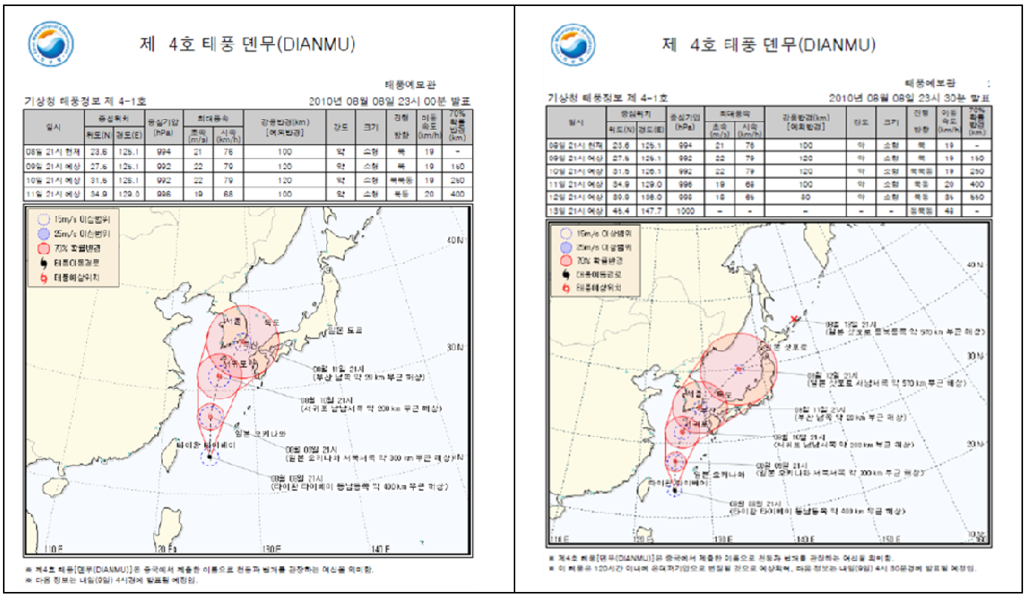


Fig. II-1-3. An example of 3-day (left) and 5-day (right) forecast of Typhoon Information

- Establishment of a “Special Typhoon Risk Management Team”

A “Special Typhoon Risk Management Team” was launched in 2010. The team is composed of experts from the National Meteorological Center, the National Satellite Meteorology Center, the Weather Radar Center, and the National Typhoon Center. The main objective of this team is timely and reliable typhoon information service to the public for mitigating typhoon damage. The team, located at the National Typhoon Center, is summoned when a typhoon is expected to affect Korea within 48 hours.

b. Hydrological achievement/result

- <u>Research Project on Next-Generation Flood Defense Technology</u>

As a possible effect of climate change and increased rainfall, life and property damage caused by floods is rapidly increasing in frequency, scale, and diversity.

Flood protection technology has strong regional characteristics. Simply introducing technology from abroad is not an option, and the technology is not the fruit of corporate R&D, but rather of government-level efforts.

■ The aim of this study is to:

Rebuild the system

Reduce the risk

Ready the nation against floods

■ The research contents are as follows:

1. Flood Forecasting using IT/ST

1-1 : Advanced Flood Monitoring Technology

1-2 : Improved Technology for Flood Forecasting by Applying Meteorological Information

1-3 : Diversified Technology for Spatial Flood Forecasting in River Basin

1-4 : Development and Application of Rainfall Radar System

1-5 : Development of Hand-held Flood Monitoring Assistants Based on LBS

2. Flood Defense Capacity

2-1 : Nationwide Flood Control Planning Assessment and Standardization

2-2 : Design Technology for Flood Control

2-3 : Improvement of Laws and Guidelines related to Flood Control

2-4 : Standardization for River Structure Certification

3. Watershed Flood Defense

3-1 : Optimized Technology for Watershed Flood Control

3-2 : Extreme Flood Management Resulting from Failure of Hydraulic Structure

3-3 : Flood Protection Considering the Change in Future Environment

3-4 : Non-structural Measures and Assessment Technology

3-5 : Emergency Action Planning System against Extreme Floods

4. Flood Management System

4-1 : Flood Information Visualization and Transmission Technology

4-2 : Real-time Flood Control System using Satellites

4-3 : Integrated Flood Disaster Management System

4-4 : Integrated National Flood Prevention System

Based on these research findings, the national flood defense and management system will be built so as to reduce human damage by 5% and property damage by 30%. Skill level is to increase by 80% relative to developed countries. The government should contribute to the prevention of flooding by maximizing land conservation and use efficiency. Flood disaster-safe construction aims to improve the quality of life.

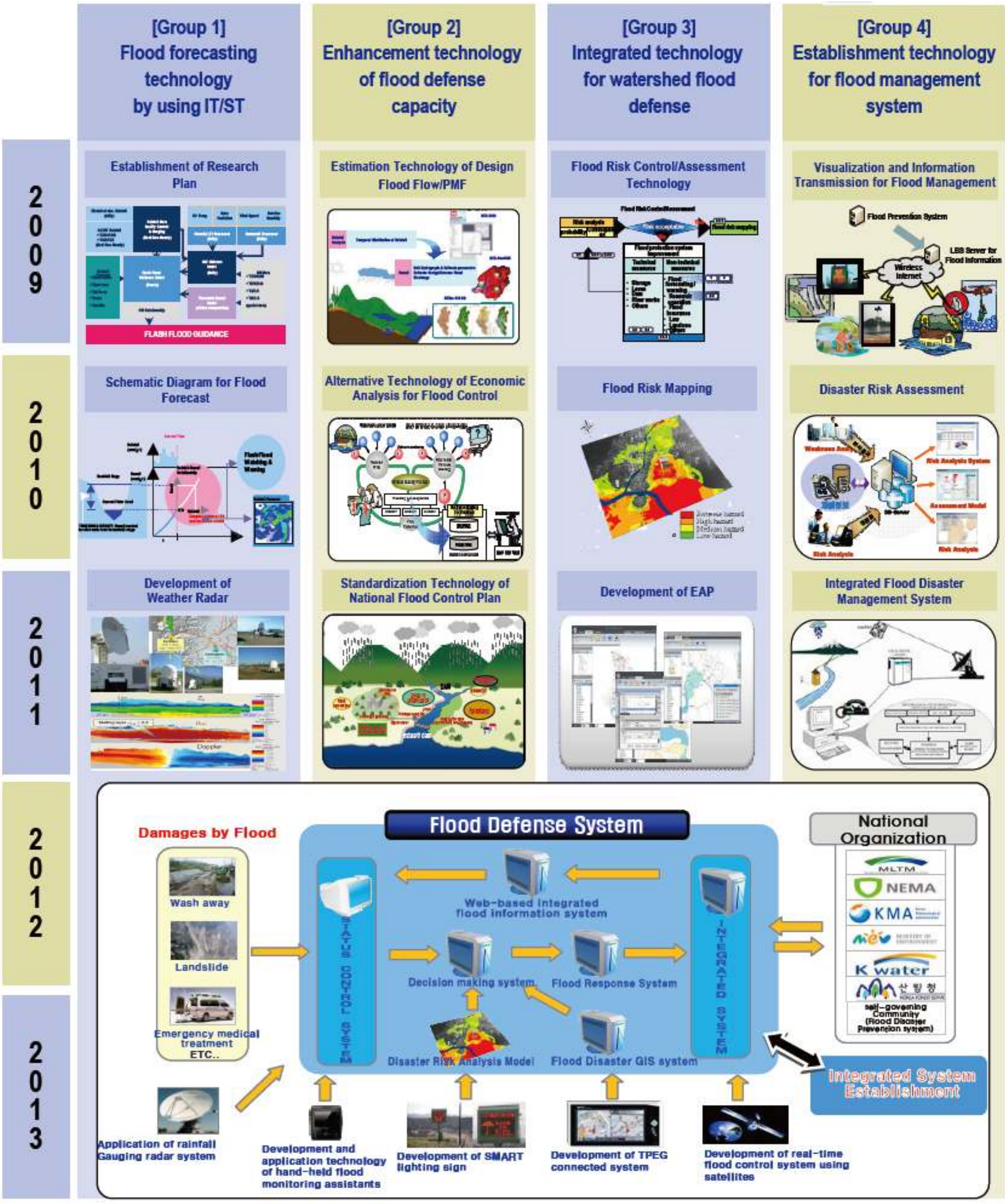


Fig. II-1-4 Research plan

- Four Major Rivers Restoration Project

At present, one of the most important policies promoted by the Korean Government is 'the Four Major Rivers Restoration Project'. This project's principal aim is to prevent 200-year return frequency flood and to offer a safer river environment. To improve safety from flood, existing small dams are reinforced and many small dams are constructed.

To strengthen river basins small- and middle-sized dams will be constructed. The yearly repeated flood can be reduced by the method of form dredging.

Main objectives by basin are as follows:

Han river	- Flood stage drop with dredging (0.4-3.9m) - Flood control capacity increase to settle retention reservoir - Flood safety increase with old levee reinforcement (131 km)
Geum river	- Flood defense measure: increasing flood control ability upto100 million ㎥
Nakdong river	- Water security ability reinforcement through addition of eight small dams - Rapid flood defense and water-stage drop of drainage gate by increasing installation of estuary dam
Yeongsan river	- Flood defense measure: increasing flood control ability upto120 million ㎥

The current progress is as follows:

- Ministry of Land, Transport and Maritime Affairs
  : 95 new constructions on schedule
  : Core contents such as small dams and dredging to be 60% complete by year end
- Ministry for Food, Agriculture, Forestry and Fisheries
  : Construction to raise 96 reservoir banks in progress
  : Yeongsan river estuary dam improvement construction began in March 2010 and will be complete in 2012
- Ministry of Environment
  : Facility reinforcement of total phosphorus treatment
  (Projects to improve water quality: 1,281 sites)

Fig. II-1-5 Epo small dam in Han river

Fig.II-1-6 Gumnam small dam in Gum river

(Sources; www.4rivers.go.kr/ www.mltm.go.kr)

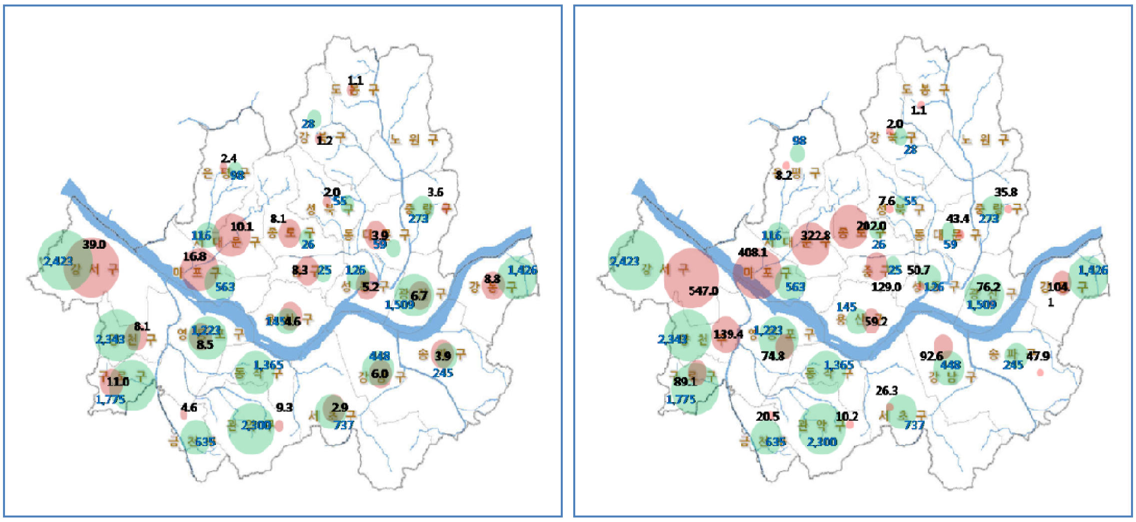
c. Disaster Risk Reduction (DRR) Achievements/results

- <u>Heavy rainfall in Seoul and Gyeonggi</u>

This year's Chuseok holiday was marked by heavy rainfall, which flooded roads and houses and caused power outages in Seoul. KMA posted a heavy rain warning for Seoul on Tuesday, September 21. KMA forecasted 30- to 100-mm rains in Seoul until Tuesday and most areas nearby recorded more than 177.8 mm. The western area near the Yellow Sea experienced scattered rains from Tuesday night to Thursday morning. Western Gangseo-gu in Seoul had precipitation reaching up to 222 mm/h as of 3:15 p.m. on Tuesday. The precipitation in Gimpo, Gyeonggi Province, and Incheon was expected to reach 50-150 mm/h.

Severe rains cut off sections of the 16 major roads in Seoul, and about 100 households in the western Seoul area experienced power outages. Fig. II-1-7 shows the total number of flooded homes within an hour and three hours. Statistics show that a total of 17,943 homes were damaged, including 2,423 in Gangseo-gu, 2,343 in Yangcheon-gu, and 2,300 in Gwanak-gu.

During the torrential rains, after the flooding of the homes and buildings, many requests for help with the water drainage systems were received. On September 21, heavy rains forced the evacuation of nearly 12,000 people and were blamed for at least one death in South Korea. It took the country by surprise when over-279.4-mm rains fell as millions of people were heading home for Chuseok, the Korean equivalent of Thanksgiving. One fisherman was killed, and at least one other person was injured when an apartment wall collapsed. The rains damaged about 15,000 homes, but the electricity was restored in almost 3,000 homes. Those affected by the storm received cash payments from the local government as assistance for their living expenses.



(a) One-hour period *(b) Three-hour period*

Fig. II-1-7. Distribution of flooded homes in the Seoul area.

Fig. II-1-8. Basement of a house flooded due to the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-9. Parking lot around buildings flooded due to the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-10. South Korean men pushing a stalled car during the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-11. A man steps across floodwater to board a passenger bus amidst the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-12. Motor vehicles braving the floods during the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-13. South Korean rescue team members searching for missing persons during the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-14. Motor vehicles braving the floods during the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-15. A subway station flooded due to the heavy rains on 21 September 2010 in Seoul, South Korea.

Fig. II-1-16. South Korean rescue team members search for missing persons during the heavy rains on 21 September 2010 in Seoul, South Korea.

The main issues that were raised after the damage from the severe rains were estimated were (i) drainage capacity problems; (ii) inflow of rain water into the lower-level areas and catchment basin capacity deficiency; and (iii) pumping capacity deficiency and inexperienced pumping station operation. The detailed causes of the damages, and the measures that were taken to address them, are listed in Table II-1-2.

Table II-1-2. Detailed causes of the damage, and the measures that were taken to address them

Main Issues	Detailed Causes of Damage	Measures
Drainage capacity problems	Flow capacity deficiency in the drainage channel	Reestablishment of a drainage design standard
	Drainage overflow by the continually rising channel stream surface	Strengthening of the strategies for reducing rainfall runoff
	Underground-space inundation by the overflowing sewage channel	Establishment of an integrated drainage basin operating system
	Decreased channel discharges due to sediments in the drainage channel	Provision of assistance for evacuation of lower-area residents
Inflow into lower areas and catchment basin capacity problems	Inflow of rainfall water into lower-area homes	Installation of a water pump to block inflow of water into homes
	Catchment basin capacity deficiency	Expansion of catchment basins, and reduction of debris flow, including sediments
Pumping capacity and operating problems	Drainage basin size and pumping capacity deficiency	Expansion of pumping capacity to a level matching 30 years' worth of rainfall
	Inexperienced pumping station operation	Development of an integrated operating system

d. Research, training, and other achievements/results

- <u>Development of a flashflood prediction system for DRR in mountainous areas</u>

"Guerrilla storms" and localized heavy rains have increased in frequency in recent years in South Korea, leading to serious disasters, especially in the mountainous areas. These rainfall patterns are the direct cause of flashfloods, which cause considerable damage in both urban and mountainous areas. Furthermore, the trend of the damages caused by flashfloods shows that their magnitude increases with time.

In the city regions, casualties from flashfloods are not serious, but property damage is considerable. On the contrary, flashfloods occurring in mountainous areas can give rise to many casualties. The National Institute for Disaster Prevention (NIDP) plans to minimize casualties in the valleys of mountainous areas by estimating the extent of a flashflood three hours before it occurs, and by issuing an early warning within 20-40 minutes of its occurrence.

To this end, the Flashflood Forecasting System (FFFS), shown in Fig. II-1-18, has been established. MAPLE can predict three-hour rainfall data in 4,272 unit basins. Although MAPLE can precisely forecast rainfall characteristics less than three hours before the event, it still needs to adjust its forecast results, which NIDP does via data integration between MAPLE and AWS in this study, as shown in Fig. II-1-19. Among the stations, 345 (including the existing stations) were selected for the issuance of warnings. In the existing stations, rainfall is monitored and checked by Flashflood Guidance Rainfall for warning issuance purposes. New warning stations estimate rainfall via AWS and MAPLE, and then issue a warning if the rainfall is expected to cross over the threshold. The accuracy is verified through a separate expert system, which predicts rainfall by comparing it with previous measurements, and the warning criteria are regularly checked.

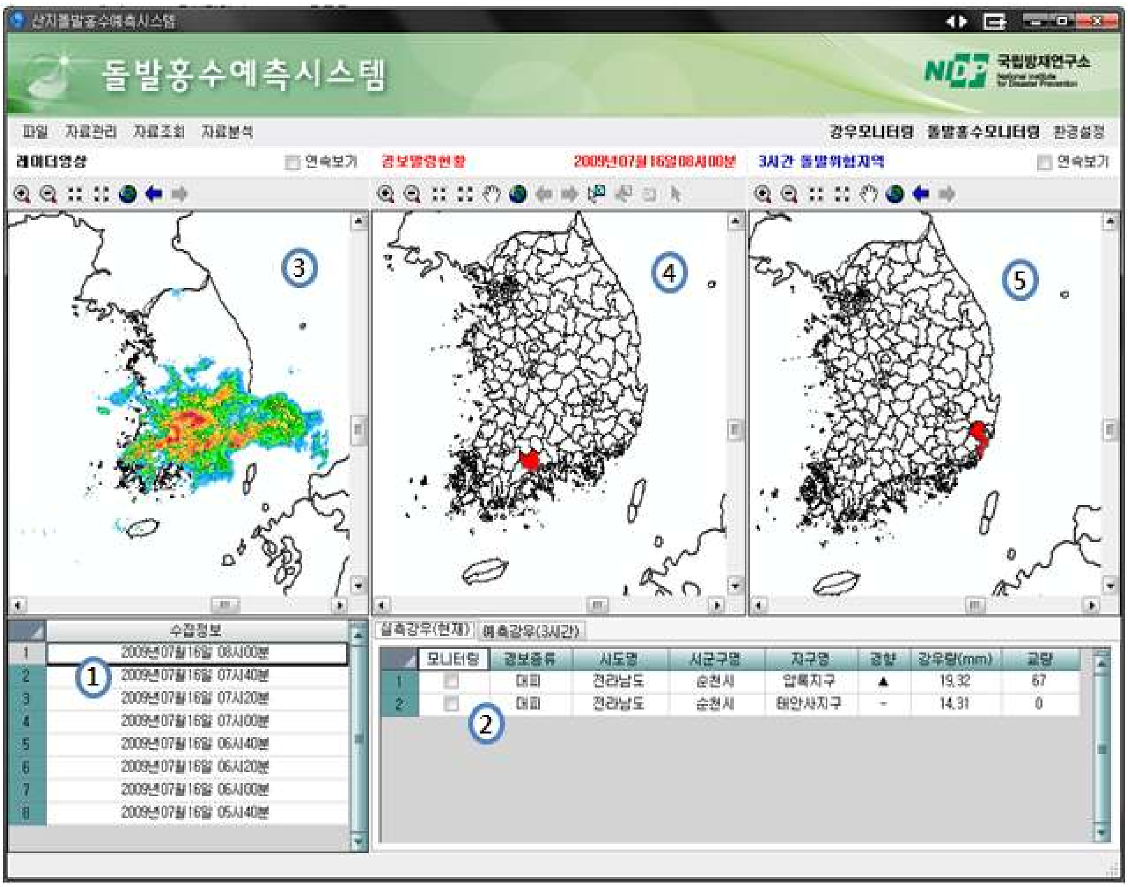


Fig. II-1-18. The main window of the system.

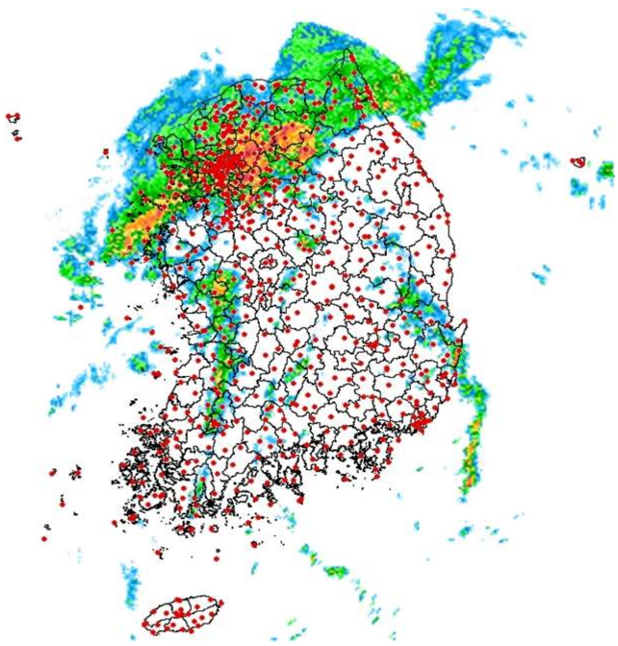


Fig. II-1-19. MAPLE data, AWS stations, and data integration.

When a flashflood risk area is identified, a warning message will be delivered to the pre-designated persons via SMS or e-mail, as shown in Fig. II-1-20. The warning information delivered via SMS will be concise and will include the warning time and the current situation in each district. More detailed information will be delivered via e-mail. Window ① is for SMS delivery (under installation), and window ② is the e-mail delivery window.

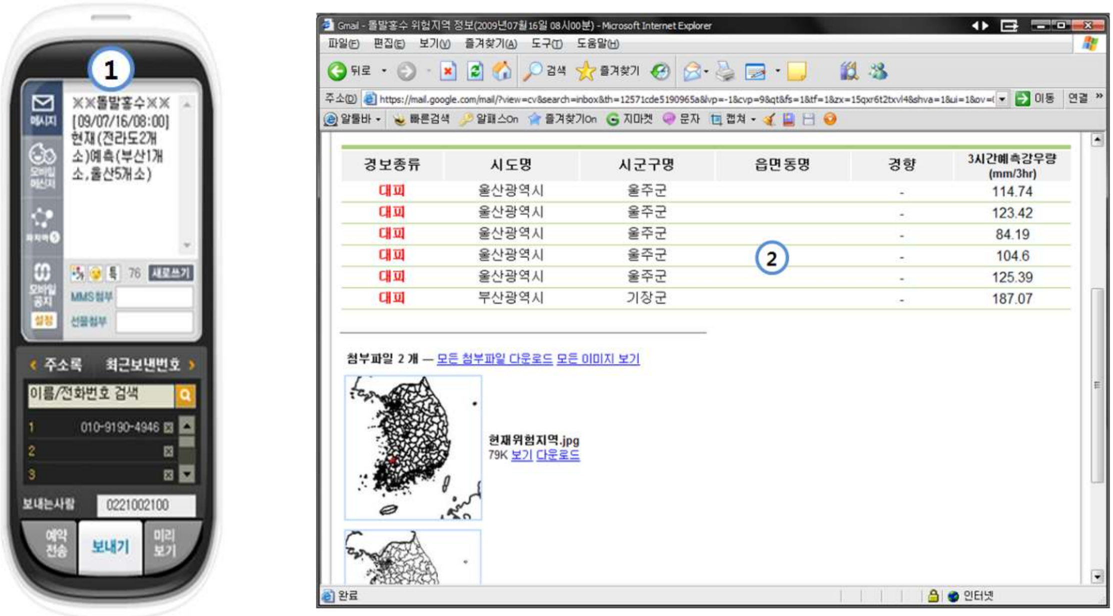


Fig. II-1-20. Dissemination of the warning degree via SMS or e-mail.

NIDP also published a manual for FFFS, through the Typhoon Committee (TC). This manual can be used for disaster risk reduction education and for international responses to climate change and related flashflood events, as it contains valuable examples and concrete system figures. This FFFS manual will help each country understand disaster behavior and the appropriate disaster mitigation strategy based on statistics and reports.

- **Domestic activities in wind-related DRR**

The wind code for buildings and other structures was renewed in 2009, after five years of study funded by the Ministry of Land, Transport, and Maritime Affairs (MLTM). Climate change and associated extreme-wind effects were studied to update the wind code, and the zonal classification based on the basic wind speed was slightly modified from the 2005 code. It is still based, however, on the 10-minute averaged value, and no special attention was directed to the coastal area of typhoon-prone regions. The recent wind damage wrought by Typhoon Kompasu shows that the revised wind code must take into account wind-borne debris.

The Natural Disaster Prevention Act of Korea specifies ten types of structures that require regulations and codes for wind-resistant design: buildings, airports, parks, roads and bridges, cables, cranes and lifts, bulletin boards, power lines, ports, and railways. The act also specifies two kinds of legal operations for local governments. The first consists of establishing a mitigation plan for natural disasters, including wind-related disasters, for all of the 234 local governments of South Korea. The plan should include a survey and evaluation of natural disasters in the region, and should summarize the risk with the corresponding mitigation measures. Each local government is required to renew the plan every five years. Since 2007, more than 100 local governments have established such plans, some of which are still under review by the central government. The second legal operation for local governments is to assess the natural-disaster risk of a planned development whenever a change in land cover or topography takes place.

The Natural Disaster Insurance Act of Korea has been in effect since 2004, and NEMA and three major insurance companies are involved with insurance matters. The act stipulates that the policyholder pays about half of the premium while NEMA pays the other half. Since it took effect in 2006, many policyholders have benefited from the insurance. One of the critical issues regarding the insurance act is the determination of insurance rates for insured properties, whose risks are never identical. As very little claims data has been accumulated and as natural disasters are caused by unforeseen meteorological phenomena, a statistical method has been developed [3], and a wind hazard map has been produced, as shown in Fig. II-1-21.

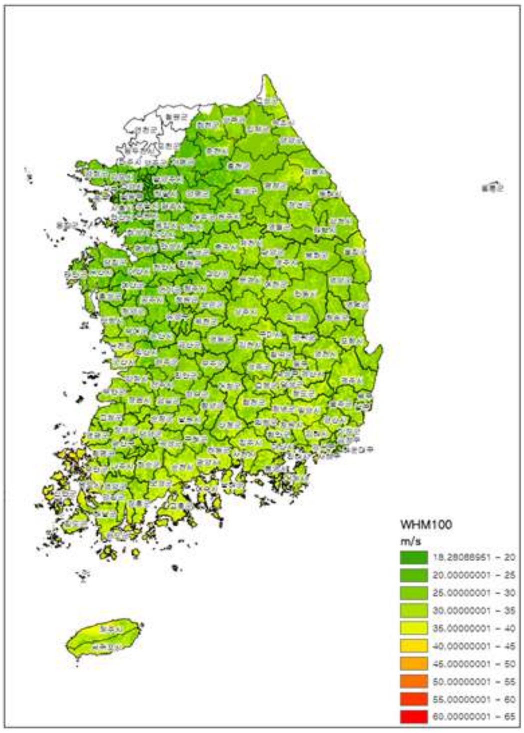


Fig. II-1-21. Wind hazard map.

As neither the local governments nor the insurance companies had a wind risk assessment methodology, such a method was developed through collaborative research by universities and IT companies, with funding from NEMA. As risk consists of hazard and vulnerability, extreme-wind-speed analysis and typhoon Monte Carlo simulation are carried out for the Korean peninsula while vulnerability has been studied using both the statistical and experimental approaches. The developed method was integrated into the Web-GIS code (Fig. II-1-22).

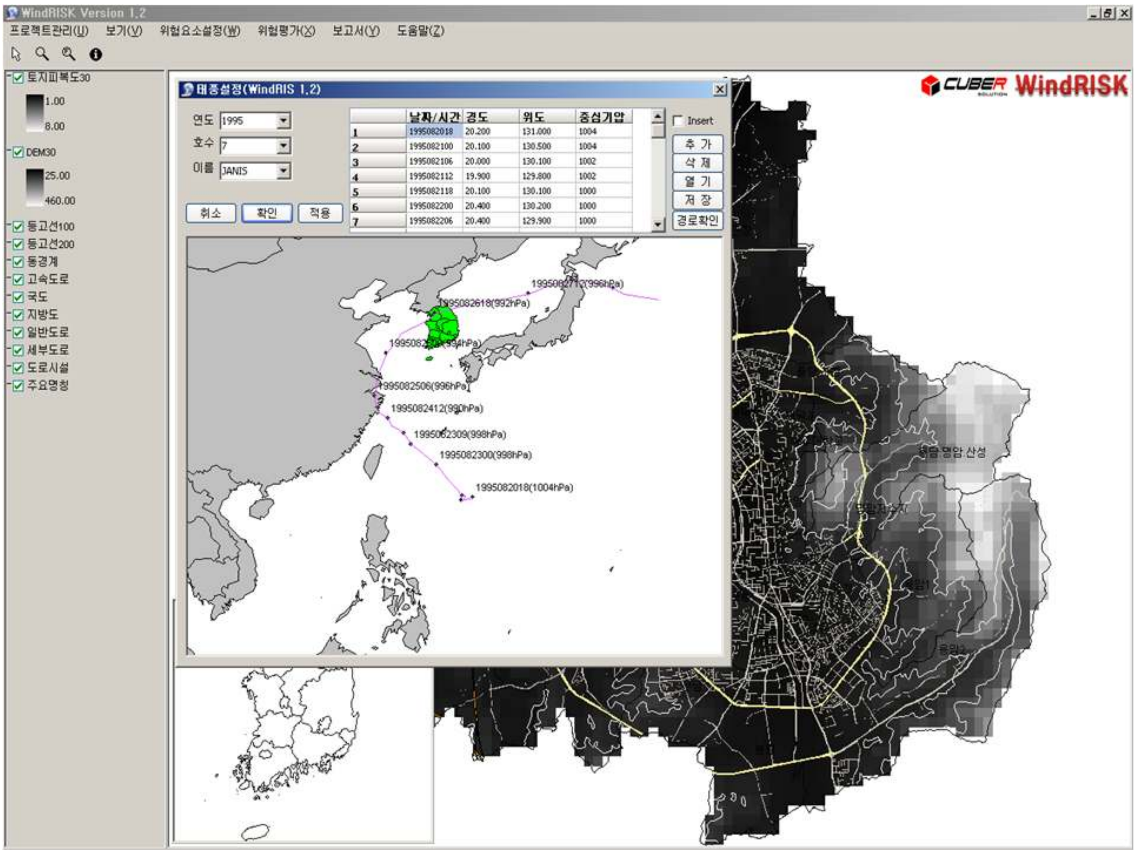


Fig. II-1-22. Web-GIS-based wind risk assessment.

In this regard, NEMA recently organized a collaborative research project on the effects of climate change on the resistant capabilities of structures. The study, which covers rainfall, strong wind, snowstorms, and sea level rise, started in 2008 and will continue until 2011. To estimate extreme winds in the future, researchers conducted downscaling of various GCMs and prediction of extreme winds. In addition, the intensity of a typhoon is postulated to be dependent on SST, and a model that takes this fact into consideration has been developed.

With the common interest in sharing information regarding typhoons and related damage, a committee on typhoons was organized in 2007-2009 to establish WGTCDIS, which appears on the TCDIS website (www.tcdis.org). WGTCDIS supplies information regarding the extent of damage from typhoons and tropical cyclones that affect the country, without any estimation of loss. With its representative chairing the Disaster Prevention Subcommittee, NIDP implemented an estimation system with Web-based GIS for the South Korean provinces, building a historic database on climate and disaster reporting, with some statistical models. Fig. II-1-23 shows WGTCDIS.

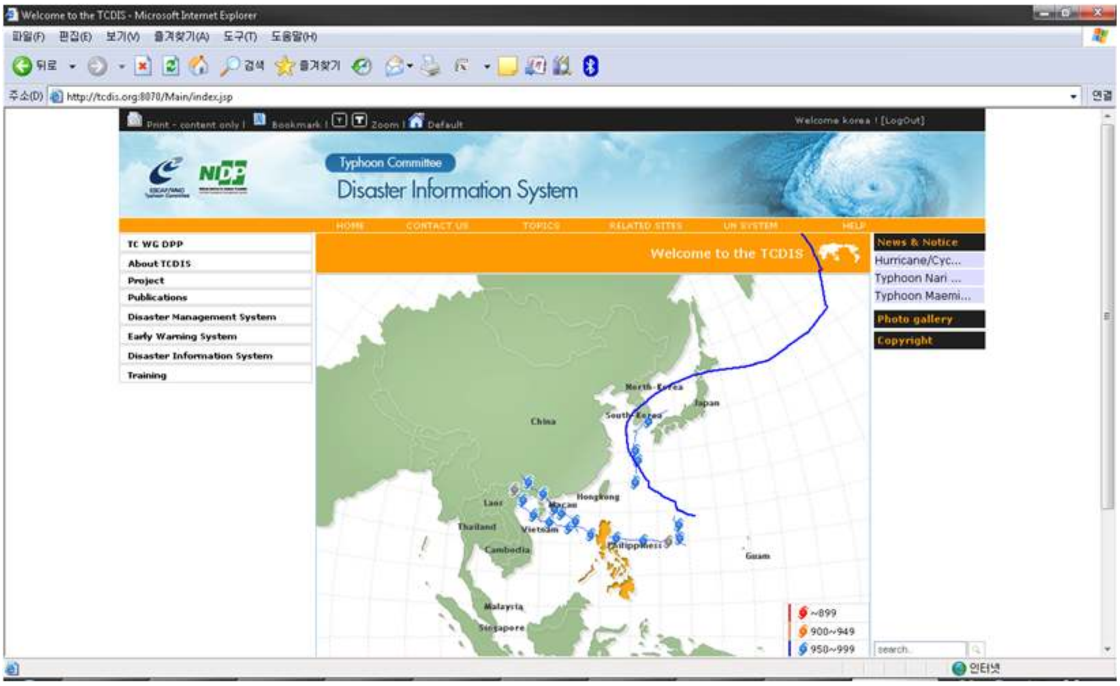


Fig. II-1-23. WGTCDIS shows the estimated trajectories of the other typhoons that affected South Korea, compared with that of Typhoon Kompasu.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

1. Progress on Key Result Area 2: **Minimized Typhoon-related Social and Economic Impacts.** (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- <u>Monitoring of typhoon effect on the Changjiang Diluted Water Using an ocean forecasting system</u>

The freshwater discharge of the Changjiang River is the third largest in the world after the Amazon River and the Congo River. In the coastal ocean, this massive amount of freshwater discharge influences not only the marine ecosystem and circulation in the East China Sea but also those in the Yellow Sea. The behavior of the Changjiang Diluted Water (CDW) shows a remarkable seasonal variation. In winter, the outflow of CDW extends southward along the coast, and northeast toward Jeju Island, Korea, in summer. As a result, the CDW with an isohaline of 30 psu in winter occasionally causes severe damage to the fishery industry, especially along the coast of Jeju Island.

Strong typhoons affect this low salinity field in summer. It is difficult to predict the behavior of CDW around Jeju Island because spatial and temporal variations of CDW vary from one summer to another. Therefore, the offshore extensions and pathway of CDW during the typhoon period are still poorly understood despite numerous numerical studies on the movement of the CDW plume. This study shows the influence of Typhoon Dianmu (1004) on CDW using a high-resolution operational ocean forecasting system and satellite observation data.

The ocean forecasting system of NIMR/KMA is based on ROMS (Regional Ocean Modeling System). ROMS is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a wide range of applications. The ROMS covers the northwestern Pacific Ocean from 115°E to 150°E and from 20°N to 52°N with an 8-km horizontal resolution including the Yellow Sea, the East China Sea and the East Sea, and marginal seas around Korea. The model has up to 20 vertical levels depending on the bottom topography. Open boundary data are obtained from a data assimilative global model (Estimating the Circulation and Climate of the Ocean: ECCO). Atmospheric boundary conditions such as sea winds and heat flux are obtained from RDAPS (Regional Data Assimilation and Prediction System), KMA's weather forecasting system. ROMS provides 48-hour ocean field predictions at 00UTC every day using RDAPS input data. Seasonal discharge amounts of the Chanjiang River are obtained from the RivDis 1.1 database.

The simulated CDW shows a patch structure of low-salinity water detached from the plume between the Changjiang and Jeju Island. The model simulation of this study clearly shows the differences in the CDW field before and after typhoon Dianmu's passage (1004). Before Dianmu's passage, the salinity of CDW was about 22-28 psu along the western part of Jeju Island. However, once the typhoon passed, the CDW salinity increased to 28-30 psu (Fig. II-2-1). Also, the sea temperature decreased from 28-29°C to 23-27°C. The effects of the typhoon lasted over 1 week. The model simulation results show a good agreement with satellite and hydrographic observation data. This study focuses on the effect of the typhoon on CDW using a 3-D high-resolution ocean forecasting system driven by real-time assimilated atmospheric conditions. According to our simulation results, we could identify rapid increase and decrease in CDW salinity and temperature, respectively. The ocean forecasting system used in this study can be applied to monitor and forecast CDW behavior in real time. The forecasted CDW fields would serve as useful information to the fishery industry.

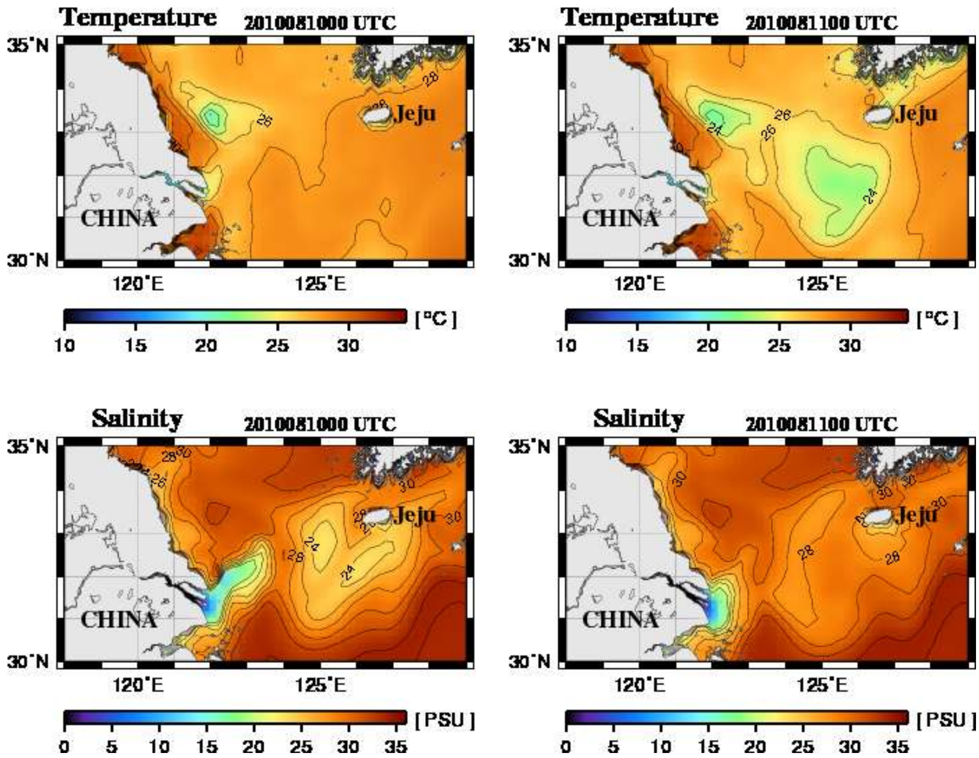


Fig. II-2-1. Simulated temperature (upper) and salinity (lower) fields before (00 UTC, 10 August 2010) and after (00 UTC, 11 August 2010) the passage of Typhoon Dianmu (1004)

b. Hydrological achievement/result

- **<u>Development of an Assessment System for Flood Control Measures</u>**

Currently, the frequency and intensity of typhoons and floods in the region including the south-east Asia region have increased due to accelerating urbanization, industries, highly dense land use, heavy construction of infrastructures and especially climate change impacts. This phenomenon threatens not only human lives but is also causing significant economic loss, which is gradually on the rise. Therefore, it is necessary to develop and build more advanced and standardized methods to judge the efficiency of flood control plans, and to establish a comprehensive and integrated system to evaluate optimal measures for flood control by eliminating uncertainties of socio-economic impacts. Economic loss due to floods in South Korea is continuously rising, recording an increase by a factory of 11 over 30 years. A similar trend is true of the rest of the world.

The project entitled ‘Assessment System for Flood Control Measures on Socio-economic Impacts’, led by the Ministry of Land, Transport and Maritime Affairs (MLTM), Republic of Korea, was launched in 2008. As shown in Fig. II-2-2, this long-term project will be completed by 2011.

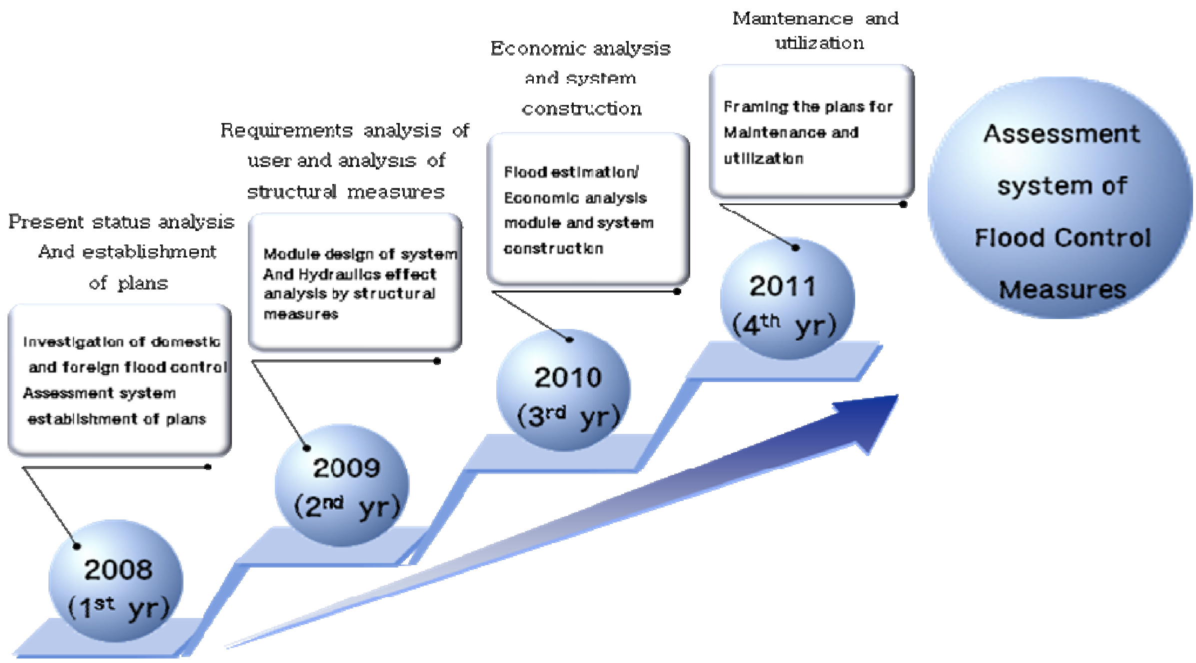


Fig. II-2-2. Annual Task Target (2008 to 2011)

The importance of basin-unit flood control measures is clearly recognized. To reduce loss and damage due to floods, it is necessary to develop basin-unit flood control measures, instead of general, long-term one-dimensional river-unit flood measures. However, current weaknesses of basin-unit flood control measures are as follows:

1) Deduction and selection of flood control measures relying on experts' experiences;
2) Absence of a unified procedure or system;
3) Estimation of the economical efficiency of flood control measures relying solely on structural damages

Moreover, standards for selecting flood control measures are not clear, and most of them are vague and confusing. Although basin-unit flood control became more important with the introduction of the basin integrated flood control project, there is no integrated process or system to assess and prepare basin-unit flood control plans.

The eventual purpose of this research is to establish a standardized and integrated assessment system of flood control measures and those flood control measures will eventually be put to practical use in member countries of the Typhoon Community to reduce socio-economic damage due to typhoons and floods in the region. An assessment system would make it possible to implement pre-assessment to select optimized economic flood control measures. As a result, member countries would be able to develop their own capacity against floods and strengthen international cooperation with other member countries as well.

1) Proposal of a scheme to construct an integrated assessment system for flood control measures
2) Establishment of a scheme to select optimal economic flood control measures
3) Construction of a viable assessment system for TC members

- ***Construction of a reasonable and integrated assessment system for flood control measures***
- ***Use as a future pre-assessment system***

Research for the upcoming year will concentrate on the following:

: D/B construction for flood damage estimation;

: Module construction for flood damage cost estimation by flood frequency;

: Module construction for analysis of structural measures;

: System construction of flood area estimation and economic evaluation of flood damage

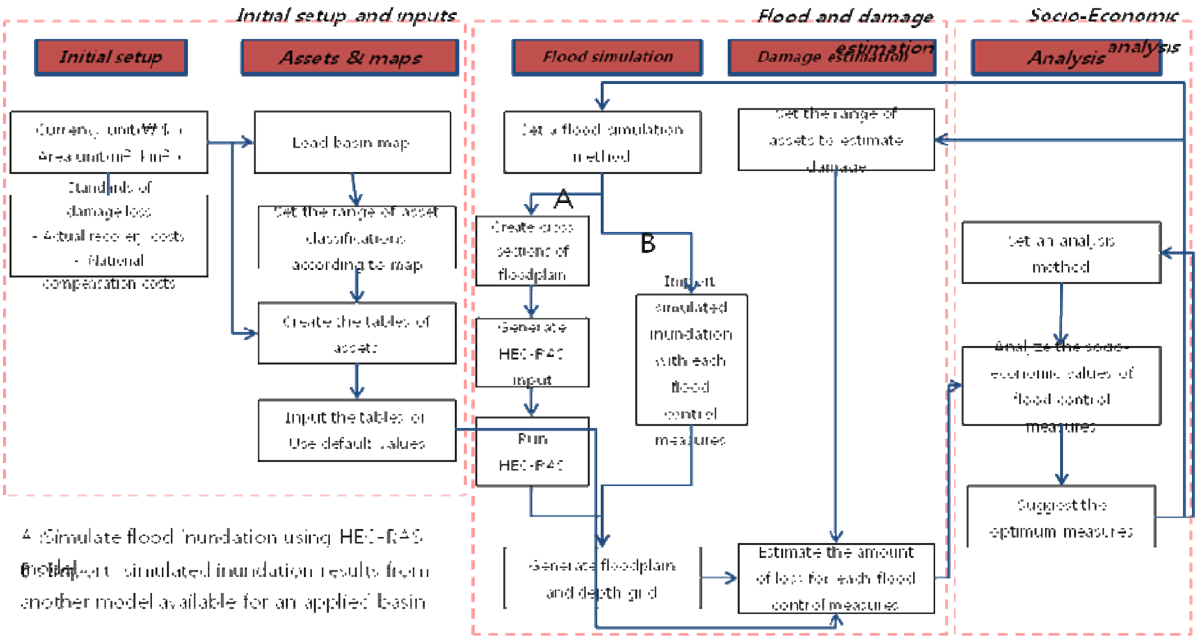
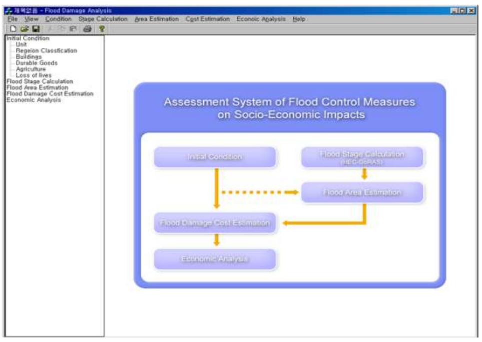


Fig. II-2-3. Flow chart

This project is to be completed in 2011 with the establishment of an integrated and comprehensive assessment system of flood control measures to minimize socio-economic damage from floods. Ultimately, the final assessment system will be utilized to establish more efficient flood control measures and to strengthen technical and information oriented cooperation among member countries in the region.



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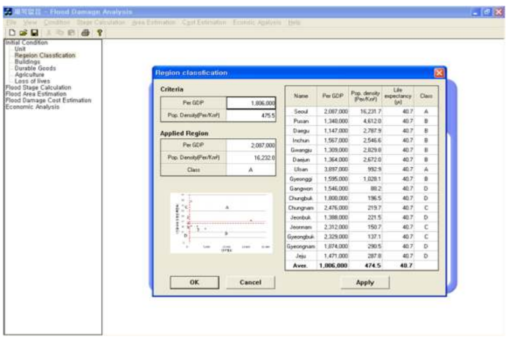

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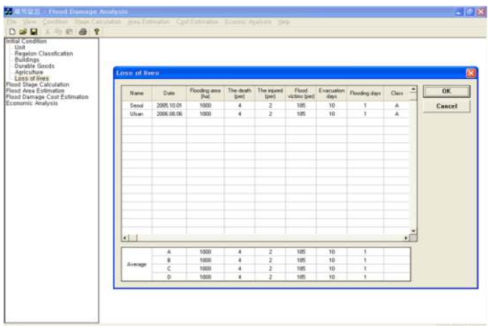

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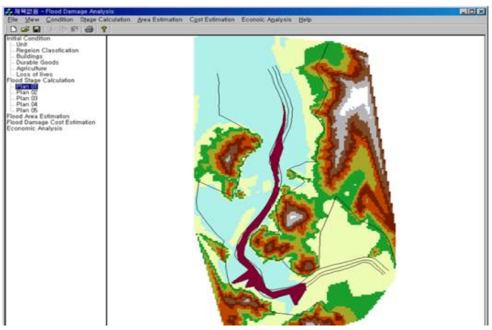


< Flood simulation >

Fig. II-2-4. Assessment System for Flood Control Measures

c. Disaster Risk Reduction (DRR) Achievements/results

- <u>Foundation of a promotion corps for reinforcing vulnerable zones</u>

NEMA established a promotion corps on 28 October 2009 to reinforce vulnerable zones and to activate the economies in the vulnerable zones. To strengthen disaster prevention in disaster-vulnerable zones, rural streams, and construction sites, the Korean government will allocate a USD 488 million budget for 2010. The promotion corps organized a technical support team consisting of NIDP employees and experts from the private sector to prevent budget wastage and to prepare countermeasures for vulnerable zones. This year, the improvement projects for 190 disaster-vulnerable zones is to be completed.

d. Research, training, and other achievements/results

- <u>Disaster Management Education Training Program</u>

NEMA's National Disaster Management Institute (NDMI) invites high-ranking officials from local governments to participate in a disaster management education training program. It offers a total of 75 courses every year: eight elementary courses, 48 expert courses, and 19 other courses. It also offers education programs for foreigners, with support from the Korea International Cooperation Agency (KOICA), where participants can learn South Korea′s experience with national disaster control including the country′s national disaster information and prediction/prevention systems. NDMI invited high-ranking officials from Bangladesh to participate in one such disaster management education training program, co-sponsored by NEMA and KOICA. The ten-member Bangladeshi delegation was also exposed to traditional Korean culture during the three-week program. Bangladesh, which suffers tremendous damage from floods every year, decided to send overseas ten high-ranking public officers responsible the country's disaster management, to learn about disaster preparedness from industrialized countries in an effort to advance the country's disaster control system. NDMI also ran a disaster management education program for government officials from Paraguay in May 2008 and plans to expand its cooperation with other countries by offering disaster management education to public servants from ten other countries, including China, Nicaragua, and Indonesia, in the second half of 2010.

To cope with disasters and to minimize loss of life and property, each local government implements full readiness and close coordination in disaster situations. The DRR staff members receive education during the Disaster Preparedness Period to enhance their ability to cope with natural disasters. The program includes planning, managing critical situations, applying damage investigation methods, and studying relevant legal mechanisms. To enhance prompt responsiveness to disasters, exercises under computer-simulated disaster conditions, a comprehensive disaster prevention exercise, and region-specific emergency drills are conducted in each district. The exercises under computer-simulated disaster conditions, hosted by all national and local disaster prevention headquarters, aim to develop the ability to manage disasters. For the region-specific emergency drills, the local governments carry out their own emergency drills to fit the local conditions. For the national-level comprehensive disaster management exercises, exercises focusing on strengthening close coordination between the related agencies and on developing disaster situation management ability are provided. The training program includes life saving, emergency relief, and recovery measures for lifeline facilities.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

2. Progress on Key Result Area 3: **Enhanced Beneficial Typhoon-related Effects for the Betterment of Quality of life.** (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- Nil.

b. Hydrological achievement/result

- Nil.

c. Disaster Risk Reduction (DRR) Achievements/results

- Nil.

d. Research, Training, and Other Achievements/Results

- Nil.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

3. Progress on Key Result Area 4: **Improved Typhoon-related Disaster Risk Management in Various Sectors.** (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- <u>Improvement of typhoon analysis, forecast, and validation system</u>

The National Typhoon Center continues to support typhoon forecasters by transitioning the upgraded TAPS-2 (Typhoon Analysis and Forecasting System - 2) to operations. The typhoon forecast period was tentatively extended from 3 days to 5 days from June of 2010. KMA’s 5-day forecast could be realized because of increased numerical model predictability as well as intensified monitoring ability using satellite-based observations. There has been new typhoon database development for improving the integrated management of scattered typhoon-related data. The new searching engine of the typhoon database system can extract and arrange data by typhoon name, typhoon formation and extinction dates, and by typhoon intensity and size.

- <u>Patent registration of the Typhoon Information Search System</u>

The Typhoon Information Search System had its patent registered on 25 October 2010. This system provides an easy tool for searching past typhoons by track, typhoon formation location, etc. This system is currently limited to internal use but will be open to the public through the National Typhoon Center website within the next year. The algorithm of this system is also applied to TAPS-2 for use by forecasters for searching similar types in previous years.

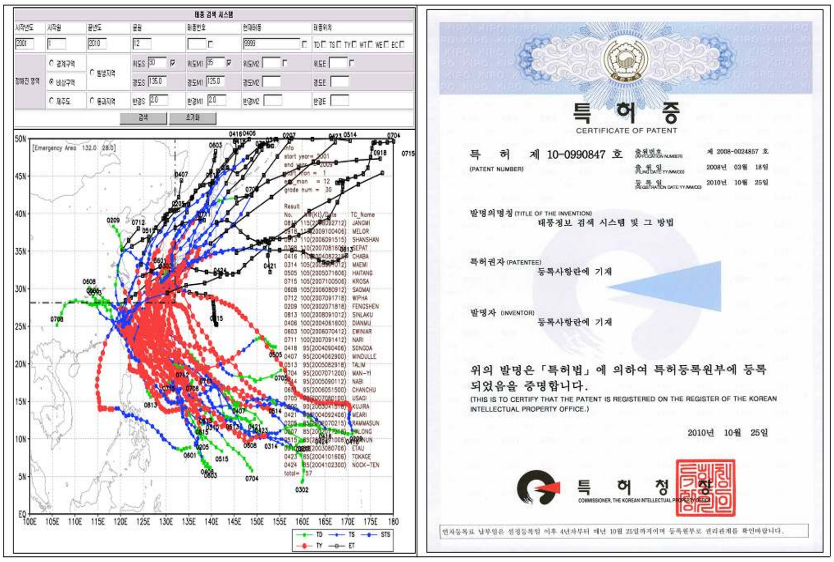


Fig. II-4-1. Typhoon Information Search System and its recently registered patent

b. Hydrological achievement/result

- <u>Central joint improvement task force for climate change</u>.

The aim of this task force is not limited to restoration in the wake of a typhoon, but permanent disaster preparation by installation of improved measure.

■ Basic course

: Establishment of advanced countermeasure system;

: Preparation of manual on abnormal climate disasters;

: Country reinforcement for disaster damage protection;

: System improvement of disaster management and countermeasures

■ Implementation strategy

: Expansion of protection investments;

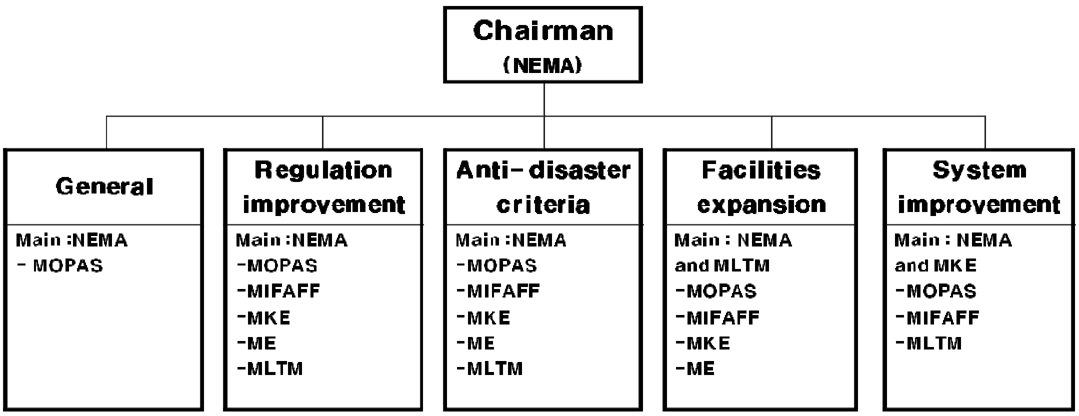
: Establishment of strong wind protection plans for urban areas;

: Heavy snow protection plan reinforcement based on voluntary and responsibility;

: Advanced disaster countermeasure system reinforcement;

: Common people support plan improvement based on self-support willingness;

■ Organization



■ Improvements (Flood, Wind, Snow)

: Adjustment of anti-disaster criteria in light of climate change;

: Expansion of rain discharge reducing facility;

: Dewater pump ability improvement;

: Sewage pipe and river maintenance improvement;

: Steep slope-land maintenance and criteria reinforcement

c. Disaster Risk Reduction (DRR) Achievements/results

- Enhanced WGTCDIS

NIDP formally opened WGTCDIS, which makes it possible to share TC member countries' disaster information (e.g., typhoon-related damage, disaster management system, early warning system) and to service various functions, such as tracking similar typhoons, retrieving information regarding damages wrought by previous disasters, providing meteorological information, and analyzing regional-weather risks.

Promotion of the value of WGTCDIS to the TC member countries, led by NIDP, will continue in 2011. The TC member countries, such as the Philippines, Lao PDR, Thailand, Cambodia, and the USA, provided GIS, metrological, and disaster information for WGTCDIS by the end of 2009, and NIDP sponsored an expert mission to set up WGTCDIS for the TC member countries, and to improve their usage of WGTCDIS. The enhancement of WGTCDIS and the establishment of a methodology for assessing the socioeconomic impacts of disasters, led by NEMA, will be continued in 2011. NIDP will continue to collect such information, to prepare brochures containing related information, and to present a report on these activites at the 6th WGDPP meeting to be held in Seoul, South Korea, in 2011. The review of the progress of the WGTCDIS project and the enhancement of TC's effectiveness and efficiency in accomplishing its purpose, as stated in the Statute of the Typhoon Committee, will also continue in 2011. WGDPP will participate in a focused, integrated WGM, WGH, WGDRR, TRCG, and AWG workshop, with the specific deliverables defined, to review the progress of the WGTCDIS project and to map out future activities of WGDRR.

For the extension of the ongoing WGTCDIS project, the validation of Vietnam's WGTCDIS is necessary, and the typhoon- and typhoon-damage-related data of the new members are needed. There were communications with Vietnam to identify joint activities and to inform the other TC member countries of the validation of its WGTCDIS. Thailand, Lao PDR, the Philippines, Cambodia, and the USA will prepare data for developing their respective WGTCDISs. After building WGTCDIS for five TC member countries, an expert mission must be formed and deployed, to which the members will supply information regarding their respective WGTCDISs and application thereof. The expert team will be organized during a TC session and will visit the TC member countries when their respective WGTCDISs have been established.

In 2011, WGTCDIS is expected to improve in convenience and user accessibility by integrating the two afore-mentioned services and by providing abundant and varied contents to TC members. Moreover, WGTCDIS will be applied to five other TC member countries: Thailand, Lao PDR, the Philippines, Cambodia, and the USA.

d. Research, Training, and Other Achievements/Results

- Nil.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

4. Progress on Key Result Area 5: **Strengthened Resilience of Communities to Typhoon-related Disasters.** (List progress on the **Strategic** Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- Nil.

b. Hydrological achievement/result

- Nil.

c. Disaster Risk Reduction (DRR) Achievements/results

- Nil.

d. Research, Training, and Other Achievements/Results

- Nil.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

5. Progress on Key Result Area 6: **Improved Capacity to Generate and Provide Accurate, Timely, and understandable Information on Typhoon-related Threats.** (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- <u>Improving Typhoon Initialization of Global Data Assimilation and Prediction System (GDAPS) in KMA</u>

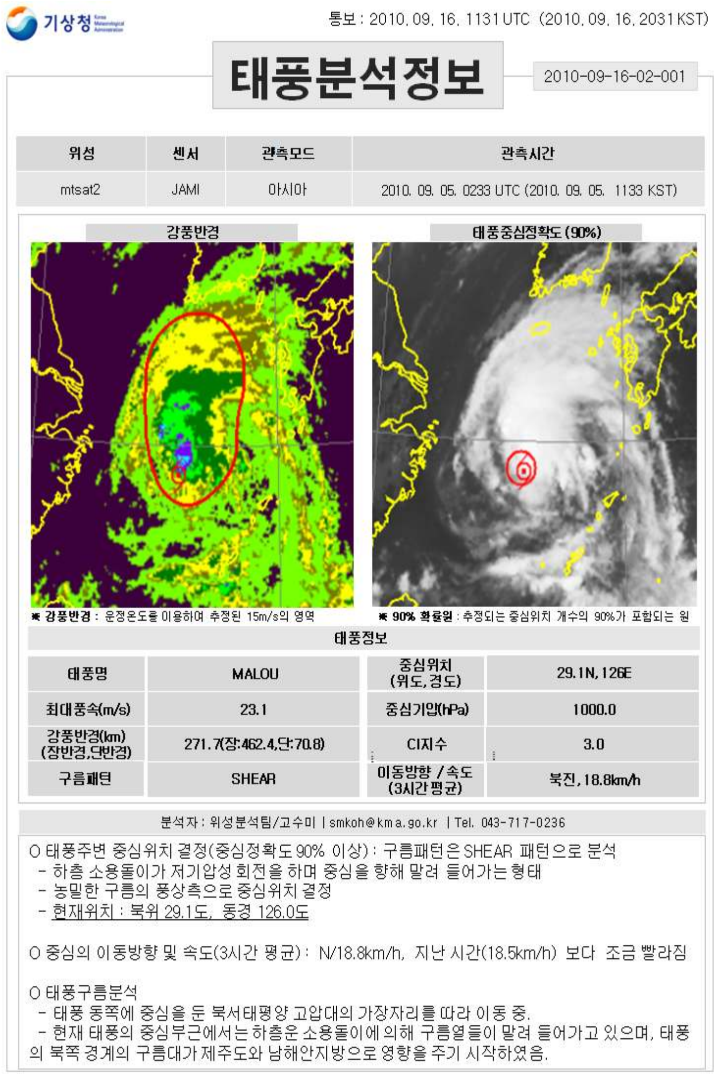
The Global Data Assimilation and Prediction System (GDAPS) of KMA is composed of three systems: an observations processing system (OPS), a 4D-Var data assimilation system (DA), and a forecast system (FS). DA produces initial conditions for FS based on observations processed by OPS. To overcome data sparseness problems, artificially produced bogus winds data are added to observations. In the case of typhoons, initialized using bogus winds data, the location is corrected but the intensity is still too weak. Since the underestimated intensity forecast degrades the accuracy of track forecast, a new typhoon initialization method using both bogus winds and bogus sea level pressure is developed. Case experiments were performed for 2009 and 2010 typhoons to investigate the impact of bogus data on the track and the intensity forecasts. The results show that, in most cases, using both bogus wind and bogus SLP produces more accurate forecasts in track as well as in intensity. The new typhoon initialization scheme is implemented into the GDPAS in December 2010, and is expected to improve the track forecasts of GDPAS in the next typhoon season.

- <u>Successful launch of COMS and operational provision of satellite-based typhoon analyses</u>

Korea's first geostationary satellite, COMS (Communication, Ocean, and Meteorological Satellite), was successfully launched from the Arianespace launch site in Kourou, French Guiana, at 21:41 UTC on 26 June. Following its launch, COMS reached its nominal position at 128.2E on the geostationary orbit on 6 July and entered test mode on 10 July. The first MI visible image was acquired on 12 July, and the first IR image, on 11 August, after a successful outgassing period. COMS MI (Meteorological Imager) data service is expected to start in early 2011, following 6 months of In-Orbit Test, which will verify the performance of the satellite system and payloads.

The KMA has been providing satellite analyses about the typhoon's center and intensity since 2000 using data from the MTSAT-1R/2 satellite. KMA's typhoon analysis system is a user-friendly web-based system developed in 2006 based on the Advanced Objective Dvorak Technique (AODT) of SSEC/UW-Madison (Space Science Engineering Center/University of Wisconsin-Madison). In 2010, KMA upgraded version 6.3 of its web-based typhoon analysis system to 7.2.3, and improved the algorithm for estimating the 15 m/s radius of strong winds for the case of shear pattern using QuikSCAT and ASCAT data.

The KMA has also developed a system to produce satellite-based typhoon analysis reports (such as Fig. II-6-1). These reports will include essential typhoon information such as location of the center, maximum wind speed, central pressure, 15m/s radius of strong wind, mean wind speed/direction for 3 hours, typhoon pattern and accuracy of typhoon center estimations. Comments from satellite analysts on the location of the typhoon center will be also included. The analyses based on COMS data will be provided on an operational basis by satellite analysts to forecasters 4 times a day (or 8 times a day in the event of emergencies) via the KMA intranet after 2011.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태풍분석정보

2010-09-16-02-001

위성	센서	관측모드	관측시간
mtsat2	JAMI	아시아	2010. 09. 05. 0233 UTC (2010. 09. 05. 1133 KST)

강풍반경

태풍중심정확도 (90%)

※ 강풍반경 : 운정온도를 이용하여 추정된 15m/s의 영역

※ 90% 확률원 : 추정되는 중심위치 개수의 90%가 포함되는 원

태풍정보

태풍명	MALOU	중심위치 (위도, 경도)	29.1N, 126E
최대풍속(m/s)	23.1	중심기압(hPa)	1000.0
강풍반경(km) (장반경,단반경)	271.7(장:462.4,단:70.8)	CI지수	3.0
구름패턴	SHEAR	이동방향 / 속도 (3시간 평균)	북진, 18.8km/h

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O 태풍주변 중심위치 결정(중심정확도 90% 이상) : 구름패턴은 SHEAR 패턴으로 분석
- 하층 소용돌이가 저기압성 회전을 하며 중심을 향해 말려 들어가는 형태
- 농밀한 구름의 풍상측으로 중심위치 결정
- 현재위치 : 북위 29.1도, 동경 126.0도

O 중심의 이동방향 및 속도(3시간 평균) : N/18.8km/h, 지난 시간(18.5km/h) 보다 조금 빨라짐

O 태풍구름분석
- 태풍 동쪽에 중심을 둔 북서태평양 고압대의 가장자리를 따라 이동 중.
- 현재 태풍의 중심부근에서는 하층운 소용돌이에 의해 구름열들이 말려 들어가고 있으며, 태풍의 북쪽 경계의 구름대가 제주도와 남해안지방으로 영향을 주기 시작하였음.

Fig. II-6-1. Sample of typhoon analysis report provided by satellite analysts on an operational basis

- **<u>Change of KMA's Ensemble Prediction System</u>**

KMA's Ensemble Prediction System was replaced by the one constructed based on the Unified Model (UM) in December 2010. The new Ensemble Prediction System has the same resolution as the deterministic global prediction system (N320L50), and is composed of 24 members. The method to generate initial perturbation is ETKF (Ensemble Transform Kalman Filter), and physical perturbations, such as RP (Random Parameter) and SKEB (Stochastic Kinetic Energy Backscatter), are added during model simulations. The UM-based Ensemble Prediction System products including typhoon track prediction data (Cyclonic XML) will be provided to TIGGE in the near future.

- **<u>Completion of National Center for Meteorological Supercomputing (NCMS) / Installation of Supercomputer No. 3</u>**

The center in Ochang, Chungcheongbuk-do, whose construction was completed on 29 March 2010, began operations with 26 staff members and 35 contract engineers. The computer system is the third supercomputer for KMA and consists of an interim component (Cray XT5), an initial component (Cray XT5) and a final component (Cray XE6). The new system is dedicated to NWP operations (data assimilation and prediction) and associated higher-priority application models as well as lower-priority R&D contributions. Seventeen different numerical models run on the machine to produce forecast products two to four times daily and deliver them to forecasters at the KMA headquarters.

The older computer system (Cray X1E) is dedicated to generating IPCC climate change scenarios for the next two years.

Fig. II-6-2. National Center for Meteorological Supercomputing

Supercomputer "Haeon"

Supercomputer XE6 "Haedam"

Installation Year	December 2010
System Name/System Model	Haeon, Haedam / Cray XE6
Theoretical peak performance	379TF x 2
Maximal LINPACK performance	316TF x 2
Total Memory	119.8TB
Disk (Shared File system)	2.5PB
Backup Library	800TB / 4PB

Fig. II-6-3. Specifications of KMA Supercomputer No. 3 (Cray XE6)

- Establishment of the Weather Radar Center

The increasing frequency of high-impact weather (HIW) events such as localized downpours and typhoons, possibly associated with global warming, has greatly stimulated the community's need and demand for reliable weather information. As a result, there is a growing emphasis on radar data, which are used not only for real-time HIW monitoring but also as input data for numerical prediction and hydrological models. There is accordingly a particularly pressing need to have in place an optimal radar operation framework so as to maximize the accuracy of radar observations. The Weather Radar Center (WRC) was established in April 2010 to operate the weather radar system in Korea more effectively and to support sharing of radar data and develop technologies for data analysis including data quality control, QPE (Quantitative Precipitation Estimation) and QPF (Quantitative Precipitation Forecast). A primary goal of WRC is to become the nation's radar data hub for coordinating all radar data available in Korea.

Fig. II-6-4. Signboard hanging ceremony for the Weather Radar Center

- <u>Data assimilation using UM/VAR system for operations</u>

KMA started to operate UK Met Office's Unified Model (UM, N312, 50 levels) for global prediction in May 2010. At the same time, Regional UM (12km, 38 levels) was also adopted for operations. The global 4D-Var system with a 6-hour window is applied to the operation of global UM. KMA NWP centre has increased data usage in UM/VAR system for the first UM operation year. As planned, GPS-RO and SSMI/S were added to the data assimilation (DA) process at KMA. As a result, 5 types of satellite data including ATOVS, IASI and AIRS data are used for direct assimilation. AMV and Scatterometer sea wind from ASCAT and ERS are used for DA at present.

(i) Data Assimilation for operational UM

Currently, KMA's global 4D-Var DA system processes approximately 80% of the observations used in the UK Met Office (UKMO) DA system (Fig. II-6-5) as well as local observations taken by KMA. Efforts to increase data acquisition for assimilation will be continued. KMA has also recently started to review specific technologies to apply to the pre-process stage for quality flagging in DA.

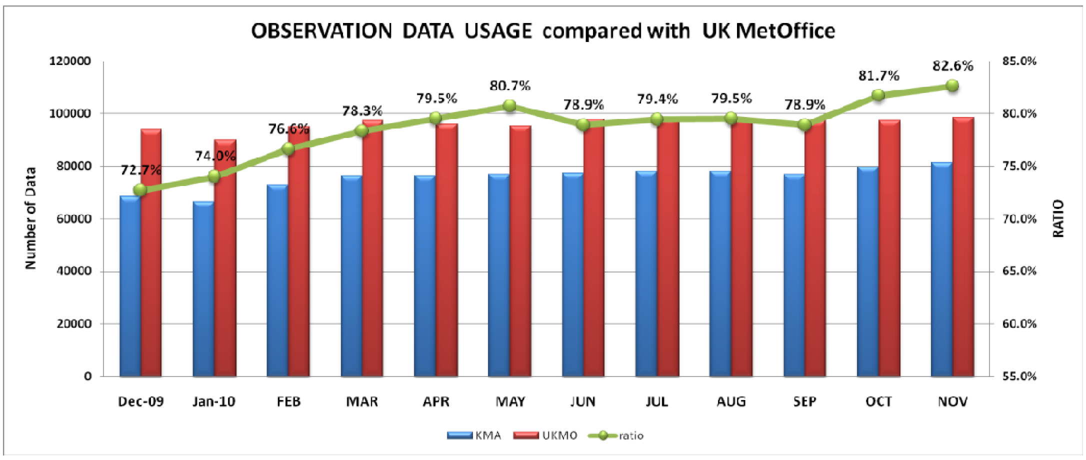


Fig. II-6-5. Increment of data amount in the data assimilation system from Dec 2009 to Nov 2010.

(ii) Improved use of AMV

KMA-AMV, produced using MTSAT-1R and KMA's updated algorithm[1] with UM background, was introduced in the UM cycle and its quality and impact on model forecast was evaluated. The performance of AMV extracted by using UM background was compared with that extracted by using GDAPS[2] background for two weeks from 16 to 31 Oct 2009. The RMSE and bias[3] of AMV whose QI exceeds 0.8 seem to have improved, when UM is used for background (after that UM-BG AMV). However, the impact of UM-BG AMV on forecast was not as pronounced, even though the quality of UM-BG AMV itself was improved relative to radiosonde wind. One of the main reasons why UM-BG AMV does not have much impact on the forecast is thought to be related to the experimental environment, where all other data are already being assimilated (Fig. II-6-6).

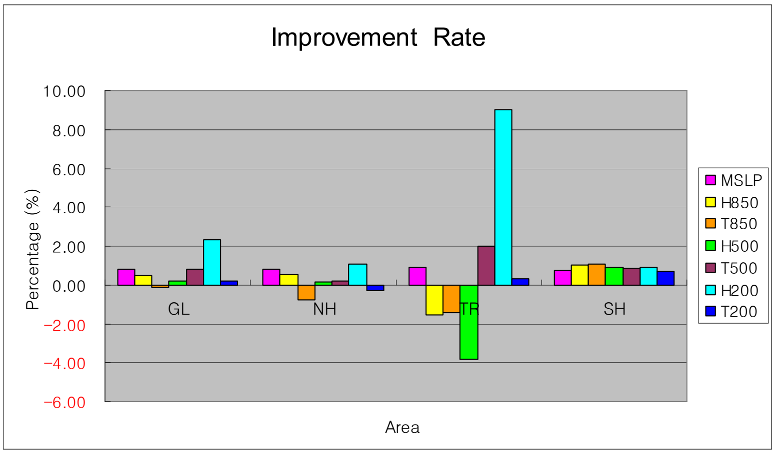


Fig. II-6-6. Improvement rate of UM-BG AMV cycle against GDAPS-BG AMV (averaged for whole forecast hours). UM-BG AMV and GDAPS-BG AMV refer to the AMV extracted with UM and GDAPS background, respectively.

- <u>Plans for data assimilation of UM/VAR system at KMA</u>

(i) The use of high-resolution of UM global and regional VAR

KMA is preparing operation of the UM global model at high resolution (N512, 70 levels) and the UM regional model (12-km, 70 levels) for East Asia. According to the UM application plan, the 4D-Var data assimilation system in the high-resolution global and regional UM is also being tested for operation.

(ii) Improved use of COMS product

COMS products will be released by March 2011 after testing in NMSC4. COMS AMV, clear-sky radiance and SST will be used for operational data assimilation at KMA. According to

[1] KMA has developed the AMV retrieval algorithm for the purpose of applying it to COMS.
[2] GDAPS: The previous global model which was in use since 1997 prior to adoption of UM
[3] Where RMSE and bias were compared with radiosonde wind
[4] National Meteorological Satellite Center of KMA

the science plan agreed with the U.K. Met Office, AMV will be used in operations by August 2011 and clear-sky radiance will be introduced to operations in 2012.

The AMV based on the further updated KMA algorithm and UM background will be tested continuously. KMA will also start to run regional data assimilation over East Asia. KMA-AMV will also be applied to regional data assimilation. At present, the full-disk AMV is being used for data assimilation at 6-hour intervals. Hourly AMV of the northern hemispheric half disk is being tested for operational use. KMA expects to improve regional prediction of its operational models.

- **New charts for typhoon forecast**

Typhoon-exclusive charts have been added to KMA's typhoon information pool. Most typhoons that affect the Korean territory are born in the northwest Pacific region, which was not fully covered by the previous analysis and prognostic charts. The typhoon information in this area is very important for monitoring the early stages of typhoons or tropical cyclones. All existing typhoon-relative charts have expanded to include the Northwest Pacific region reaching over the equator and the integrated numerical model charts displaying JMA, ECMWF, KMA UM and UK MetOffice UM numerical prediction, have been newly added. The new charts have been helping typhoon forecasters make the best decision since the summer of 2010.

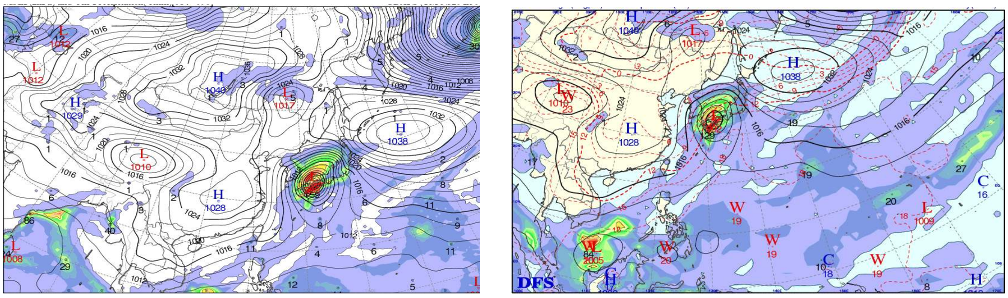


Fig. II-6-7. Previous prognostic chart (left) and typhoon-exclusive prognostic chart (right). The latter chart now includes the Northwest Pacific.

Additionally, the typhoon messages issued at Japan typhoon center was also no more used in weather analysis chart and the typhoon messages issued at KMA are replaced to make weather charts. The small change could contribute to more independent typhoon operations at KMA.

- **KOICA Project –Establishment of an Early Warning and Monitoring System for Disaster Mitigation in Metro Manila**

The Republic of Korea has been conducting a three-year (2009-2012) project "*Establishment of an Early Warning and Monitoring System for Disaster Mitigation in Metro Manila*" under the sponsorship of the Korea International Cooperation Agency (KOICA), aiming at establishing a weather and flood forecasting model for an early warning and monitoring system at the Pasig-

Marikina River basin, mitigating the impact of natural hazards through accurate analysis of real-time data collected from the early warning system, and strengthening the relationship between the Republic of Korea and the Philippines in the field of weather forecast and disaster management.

The \$3-million project was initiated by KOICA and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) in the wake of the high-impact by Typhoon Ketsana, the most devastating typhoon to hit Manila in September 2009. The Korea Meteorological Administration (KMA) contributes to this project by providing consultation on the project management. KMA also shares expertise in the fields of information and communication, meteorology and hydrology by dispatching experts and providing training.

The early warning and monitoring system will include an observation network of 4 AWSs, 7 rain gauges and 10 water level gauges; and a warning network linking the PAGASA headquarters, 7 local governmental offices and 20 warning posts with a wireless communication system (see Fig. II-6-8).

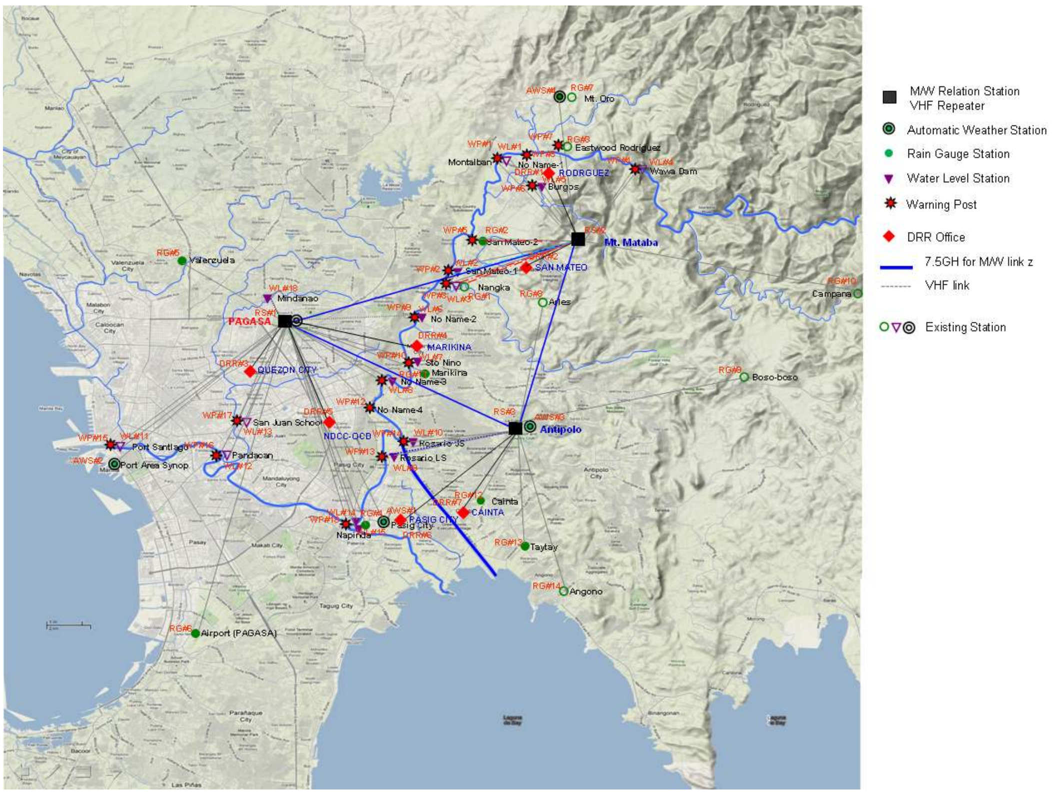


Fig. II-6-8. Network of the Early Warning and Monitoring System for Disaster Mitigation in Metro Manila

b. Hydrological achievement/result

- <u>Construction of a Quality Control System for National Hydrological Data</u>

This study aims at developing standards on quality control for hydrological data, constructing a national quality control system for hydrological data for the Han River water system from 2007, and expanding it to the Nakdong River, the Geum River and the Yeongsan River in 2011. This year, standards on quality control for hydrological data for the Yeongsan River water system were developed, and the national quality control system for hydrological data for the Yeongsan River water system was constructed and reinforced.

This year's project consisted of the following components:

: Planning of quality control system for the Yeongsan river control center;

: Field application and management of quality control system;

: Construction and improvement of quality control computer system;

: System connection of standard hydrological database

Quality control methods according to hydrological data and observation methods of rainfall and water levels, which are continuous time series hydrological data, can be largely classified into three the following three categories:

- Inspection of hydrological observatories and management of checked results (Field quality control);
- Automatic review and handling of hydrological data (Automatic quality control);
- Manual review and handling of hydrological data (Manual quality control)

Regarding quality control of hydrological data, a computer-based full automation system is difficult to realize and may have undesirable consequences. Therefore, the process of manual review and handling is necessary for all data, and outlier determination rule and treatment procedures and methods should be determined in advance. Fig. II-6-9 presents the quality control procedures, general data management method for time-series hydrological data; this procedure was applied to the Yeongsan River area.

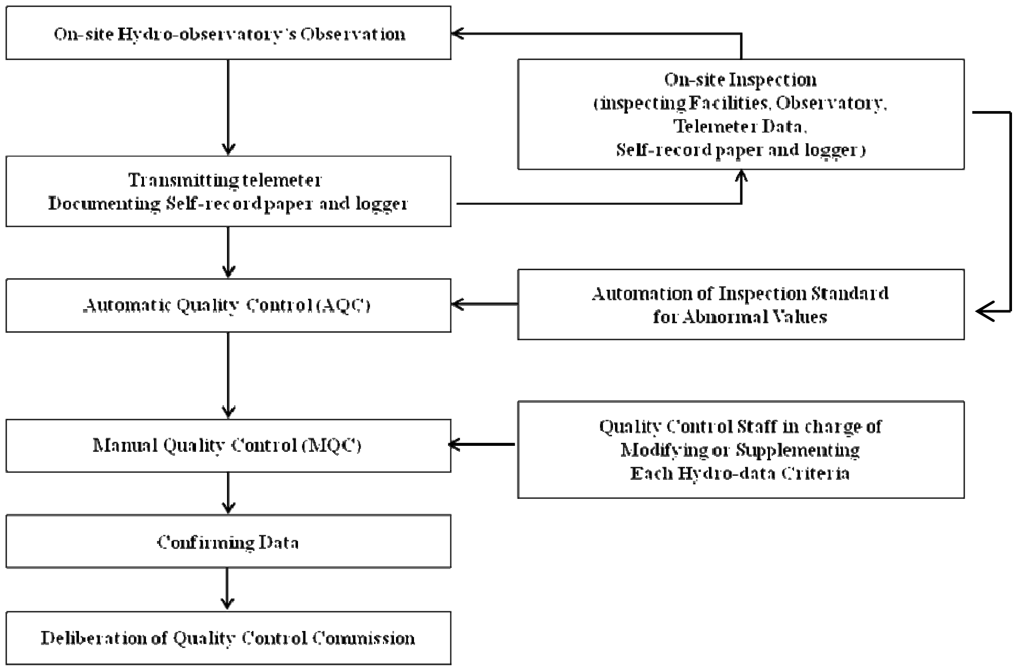
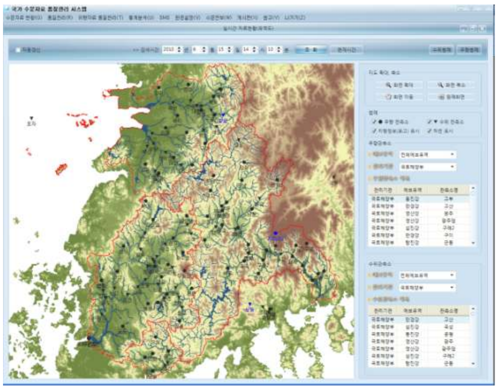


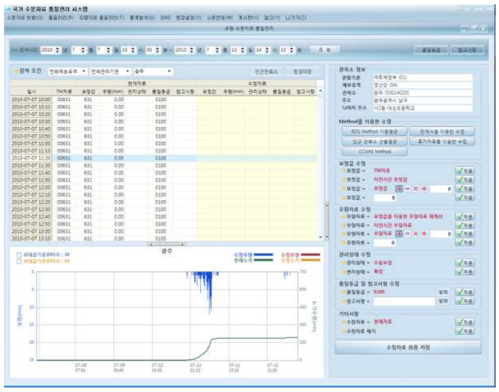
Fig. II-6-9. The Quality Control Procedure of Time-series Rainfall Volumes and Water Levels Data

To build the quality control system for the Yeongsan River area this year, the research committee assessed the status of quality control at the Yeongsan River Flood Control Center, and analyzed the function and status of the data management system in use. The committee prepared a quality control method for water flux volume data with rainfall volume and water level data, and adjusted the quality control system accordingly.

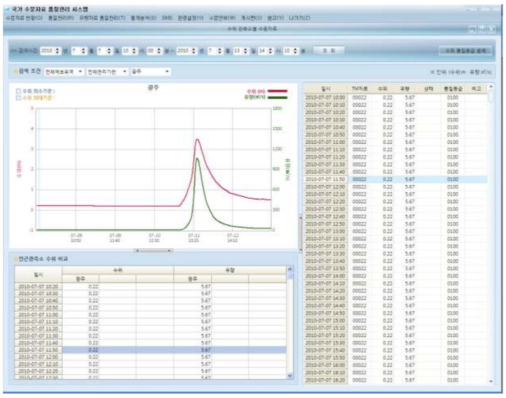
The research committee will forge a consensus among experts on the importance of hydrological observations, hydrological data management and quality control by continuously promoting projects to improve the quality of national hydrological data. The committee will also support various national activities for ensuring a minimal quality of life for the public by actively managing water resources and informing the public about the importance of national water resources, which are expected to contribute significantly to a positive change in public perception of water resources related activities.



(a) Status of basins



(b) Rain data inquiry



(c) Water-stage data inquiry

(d) Rain data revision using regression curve

Fig. II-6-10. Display of Quality Control System

c. Disaster risk reduction (DRR) achievements/results

- Nil.

d. Research, Training, and Other Achievements/Results

- Nil.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

6. Progress on Key Result Area 7: **Enhanced Typhoon Committee's Effectiveness and International Collaboration.** (List progress on the Strategic Goals and Associated Activities in the Strategic Plan and progress on the 2010 Typhoon Committee Annual Operating Plan goals)

a. Meteorological achievement/result

- <u>**TC-TRCG Typhoon Research Fellowship at KMA**</u>

KMA invited two typhoon experts from the Thai Meteorological Department (TMD), Thailand, and the National Hydro-Meteorological Service (NHMS) of Viet Nam from September to November in 2010. The invited experts participated in a training course on typhoon forecast and joint research. This activity was implemented as a part of the Typhoon Committee Research Fellowship and aims to provide training opportunities in typhoon forecasting for Typhoon Committee members and to contribute to the development of typhoon forecast. Mr. Kamol Promasakha na Sakolnakhon, modeling expert from the Numerical Weather Prediction Subdivision, Weather Prediction Bureau, TMD, and Mr. Tran Quang Nang, forecaster from the Short-range Meteorological Forecasting Division, National Center for Hydro-meteorological Forecasting of NHMS, performed their missions well at NTC/KMA. They raised understanding for typhoon forecast through the experience such as user-practice and operational work from learning about Typhoon Analysis and Prediction System-2 (TAPS-2) in September. After completing the one-month forecasting training, the fellowship recipients also conducted joint research for the development of a statistical model for the seasonal prediction of typhoon genesis frequency and the function improvement of TAPS-2 from October to November with NTC forecasters. The research findings are to be submitted to local journals or to be published as research papers.

Fig. II-7-1. Presentation by research fellowship recipient (left); the fellowhip recipients with NTC staff at the NTC front entrance on 19 Nov. 2010 (right)

- **Joint Research Program with the NHMS of Viet Nam**

The objective of this project is to directly establish KMA's typhoon analysis and prediction system at the NHMS of Viet Nam, in light of the numerous differences between Korean and Vietnamese meteorological forecast in general and tropical cyclone forecast in particular, which will inevitably pose a challenge in installing and applying TAPS-2 in Viet Nam in the absence of a concrete plan. KMA invited two NHMS forecasters to NTC, Jeju, to help NHMS develop a plan for the future integration of TAPS-2 into the NHMS system. The invited forecasters were seconded to NTC of KMA for 3 months, during which time they acquainted themselves with the TAPS-2 system and learned practical forecasting skills with guidance from NTC forecasters through OJT (on-the-job training).

- **The 3rd Korea-China Joint Workshop on Tropical Cyclones**

KMA and China Meteorological Administration (CMA) co-hosted the third joint workshop on tropical cyclones, which was held on 20-23 December 2010, at Hyatt Hotel in Jeju, Korea. Almost 50 experts in typhoons and related fields participated from KMA's National Typhoon Center, Korea Meteorological Satellite Center, Weather Radar Center, National Center for Meteorological Supercomputing, and Numerical Weather Prediction Division, KORDI, the Korea Water Resources Corporation, the Air Force of the Republic of Korea, three Korean universities, and CMA's Shanghai Typhoon Institute, Shanghai Weather Center, and Shanghai Centre for Satellite Remote-Sensing and Application. 18 papers were presented at the workshop on a wide range of topics such as typhoon-related forecasting technology, prediction in the upcoming year, modeling, and analysis of observations. The workshop reached a consensus on supporting the mission of each organization involved in the areas of numerical modeling, automatic weather station data, radar, satellite data, and typhoon best track data.

b. Hydrological achievement/result

- Participation in the TC Integrated Workshop in Macao (2010)

On 4-10 September 2010, the ‘2010 UNESCAP/WMO Typhoon Committee Integrated Workshop’ was held in Macao. Many experts and researchers from 14 member countries in the regions participated in the workshop to share advanced science and to discuss typhoon-related issues in the region.

Experts from many Korean organizations took part in this workshop to share developed techniques and strategies relevant to water-related disasters caused by typhoons with their counterparts from other member countries, especially developing countries.

The content of the activities is as follows:

: Participation in the typhoon hydrological component meeting;

Preparation of hydrological component action plans for 2010 and participation in meeting;

: Presentation of research findings

Sharing research findings of flood damage reducing plan

: Proposal to host workshop

Proposal to host workshop on ‘Assessment system for flood control measures on socio-economic impacts’ during the 43rd TC Session

Expected effects are as follows:

: International status and influence reinforcement through research result promotions performed by MLTM

: Used to reflect future policy through understanding of activities and technical trends of member countries and relevant organization

Fig. II-7-2. TC Integrated Workshop in Macao, September 2010

c. Disaster risk reduction (DRR) achievements/results

- 4th Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR)

The 4th Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR; Fig. II-7-3) was held in Songdo, Incheon on 25-27 October, under the main theme of "Disaster Risk Reduction through Climate Change Adaptation." Along with disaster management ministers from 62 nations, more than 800 participants attended the international conference to discuss mutual cooperation and common resolution in the Asian region for disasters induced by climate change, such as typhoons and heavy rains. The event participants included three heads of state (the Prime Ministers of Nepal, Bhutan, and Viet Nam), representatives from UN agencies, the Vice President of the Asian Development Bank (ADB), the Commissioner of the European Commission (EU), and representatives of different NGOs.

Fig. II-7-3. AMCDRR conference

AMCDRR is the only official international ministerial conference for disaster management in the Asian region. It has been sponsored by the United Nations International Strategy for Disaster Reduction (UNISDR) secretariat since 2005 for DRR in the Asian region in the wake of the tsunami that hit South Asia in December 2004. As mentioned earlier, the overarching theme of the conference was "Disaster Risk Reduction for Climate Change Adaptation," with particular focus on (1) the convergence of DRR and climate change adaptation (CCA); and (2) the available information and green technologies. The objectives of the 4th AMCDRR were:

- to review the action taken by the national governments and other stakeholders for the implementation of HFA as a follow-up to the Beijing Action for Disaster Risk Reduction in Asia, the Delhi Declaration, and the Kuala Lumpur Declaration;

- to establish a practical and problem-solving cooperation system against extreme disasters due to climate change;
- to execute technical and tangible solutions using available cutting-edge technologies and policies for DRR in the Asian region; and to identify various ways of sharing climate information and technical developments in the field of disaster management.

Data show that although only 38% of the global disasters happen in Asia, 90% of the global-disaster victims are found therein. Therefore, Asia is the most disaster-vulnerable area in the world, and because of the difference in the disaster management systems and technical levels of the Asian countries, it is difficult to elicit practical cooperation within the region. The meeting participants agreed on the adoption of Incheon REMAP and Action Plan, an action plan composed of five-year projects to be implemented to equip each nation's disaster management system with CCA. The action plan also reorganized disaster prevention standard and vulnerability analysis through a systematic study of the disaster status and climate ideas in the Asia-Pacific region, so as to strengthen the Asian countries' disaster management capacities. The action plan was also designed to introduce a global website and technology related to climate change and disaster prevention by building a CCA technology-information platform, and to improve Asian countries' response capabilities by sharing good and bad large-disaster cases.

South Korea demonstrated leadership in the disaster prevention area in relation to climate change by hosting the Asian ministerial conference and encouraging Asian countries to support the declaration on DRR through CCA. Especially, at this conference, South Korea suggested that Incheon REMAP and Action Plan be adopted in the Asian region, and an agreement was reached regarding the enhancement of national prestige by building a platform for sharing climate change information and technologies among the Asian countries. To contribute to DRR in the Asia-Pacific region, NEMA will provide South Korea's excellent up-to-date disaster prevention systems, such as WGTCDIS and the Earthquake Disaster Response System, to each country in the region free of charge.

During the aforementioned conference, Climate Change Adaptation and Disaster Risk Reduction Exhibition (2010 CADRE) was held, providing an opportunity for international marketing and export by introducing disaster prevention and CCA technologies using South Korea's developed IT. 2010 CADRE consisted of four pavilions with specific themes: Four-River Special Hall, Climate Change Adaptation Hall, Storm and Flood Damage Prevention Hall, and Earthquake Disaster Prevention Hall. Through this exhibition, South Korea's excellent technologies related to climate change countermeasures and Green Growth were introduced to the other Asian countries. A number of side events were held on 25 October and while the conference was in session, where various disaster-related issues other than those caused by climate change were discussed. In particular, South Korea prepared some side events for the discussion of automatic response methods for disasters like typhoons and earthquakes, which are global issues, such as an event where WGTCDIS and the Earthquake Disaster Prevention System were introduced. This conference departs from the previous ideal and declaratory international conference and instead offers practical solutions to climate-change-related problems that every country faces.

- Working Group on Disaster Risk Reduction (WGDRR) meeting

In its 39 years of existence, TC has been repeatedly recognized as an outstanding regional body that has integrated meteorological, hydrological, and DRR contents into an action plan to produce meaningful results. The purpose of this WGDRR meeting (Fig. II-7-4) is for TC to identify the regional areas, goals, and activities where WGDRR wants to continue to produce meaningful results so as to save lives, mitigate the damage wrought by typhoons, and decrease the socioeconomic impact of typhoon-related events. Due to the TC member countries' highest typhoon-related disaster risk, it was agreed that the DRR activities be specifically focused on such countries, particularly in the areas of urban flashfloods, landslides, and marine accidents. While supporting the upgrade of WGTCDIS activities, the TC member countries also considered activities to strengthen the management strategies for typhoon and tropical-cyclone disasters in Asia and the Pacific as additional WGDRR activities.

Fig. II-7-4. Commemorative photograph of the WGDRR meeting.

This year, the WGDRR meeting was opened as a side event of the AMCDRR conference. The theme of the WGDRR meeting was "Strengthening the Management Strategies for Typhoon and Tropical-Cyclone Disasters in Asia and the Pacific." The WGDRR session's aims were to:

- identify possible areas of cooperation between the DRR and CCA agencies as well as opportunities for promoting their active participation in the common and relevant regional and national activities and initiatives;

- discuss ways and means of improving cooperation and coordination in the planning and implementation of DRR and CCA programs on the regional, national, and subnational levels;
- discuss ways and means of developing, establishing, and promoting a database on various sectors for a region-wide disaster information system that will be accessible to all the TC member countries' decision makers, disaster services, communities, and others designated by the TC member countries; and
- establish and distribute an inventory of the TC member countries' existing disaster reduction techniques and management strategies.

To contribute to DRR in the Asia-Pacific region, WGDRR suggested the TC member countries' adoption of South Korea's excellent, up-to-date disaster prevention systems, such as WGTCDIS, for the action plan of AMCDRR.

d. Research, Training, and Other Achievements/Results

- Nil.

e. Regional Cooperation Achievements/Results

- Nil.

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil.

III. Resource Mobilization Activities

-Nil

IV. Update of Member's Working Groups representatives

1. **Working Group on Meteorology**

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   Fax : +82-2-836-2386
   E-mail: pb_int@kma.go.kr

2. **Working Group on Hydrology**

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   Fax : +82-2-590-9989
   E-mail: Malon@korea.kr

3. **Working Group on Disaster Prevention and Preparedness**

   Dr. Sangman Jeong
   Director, National Institute for Disaster Prevention
   135, Mapo-ro, Mapo-Gu, Seoul, 121-719, Republic of Korea
   Tel : +82-2-3271-3201
   Fax : +82-2-3271-3219
   E-mail: smjeong@korea.kr

4. **Training and Research Coordinating Group**

   Mr. Sangwook Park
   Senior Researcher, National Typhoon Center, Korea Meteorological Administration
   1622-1, Hannam-ri, Namwon-eup, Seogwipo, Jeju, 699-942, Republic of Korea
   Tel : +82-64-801-0224
   Fax : +82-64-805-0368
   E-mail: swpark@kma.go.kr

5. **Resource Mobilization Group**

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ROK Member Report Summary

This year, three typhoons—Dianmu (1004), Kompasu (1007) and Malou (1009)—affected the Korea peninsula between August and September. These three typhoons formed in one month over 20N. Kompasu was the typhoon with the fifth highest wind speed (52.2 m/s) ever recorded in the country (Typhoon Maemi, which hit the country in 2002, has the highest wind speed [60.48 m/s]). The strong wind downed trees in the metropolitan area blocking the road and subway station and there was great confusion due to power outages. There were 5 missing persons and 112 injured. Below is a list of key achievements in 2010 in each component:

1. Meteorological Component

- Campaign for the prevention of typhoon related disaster via broadcasting, internet (website) and display boards;
- NTC/KMA held an expert meeting to establish the prevention measures of typhoon-related disasters for this year on 5-6 April 2010 in Jeju;
- NTC/KMA hosted a workshop on the seasonal prediction of typhoon activity on 23-24 August 2010 in Jeju;
- NTC/KMA started experimental 5-Day typhoon forecast this year;
- The operation of “Special Typhoon Risk Management Team” began in 2010.
- Monitoring of typhoon effect on the Changjiang diluted water using an ocean forecasting system of NIMR/KMA;
- NTC/KMA upgraded TAPS-2 (Typhoon Analysis and Forecasting System) ;
- NTC/KMA registered the patent for ‘The Typhoon Information Search System’ on 25 October;
- Korea’s first geostationary satellite, COMS (Communication, Ocean, and Meteorological Satellite), was successfully launched on 26 June and KMA has also developed a system to produce satellite-based typhoon analysis reports;
- Completion of the National Center for Meteorological Supercomputing (NCMS) and installation of Supercomputer No. 3 Cray XE6 on 29 March at NCMS;
- Co-organization of the 3rd China-Korea Joint Workshop on Tropical Cyclones, 20-23 Dec., in Jeju.

2. Hydrological Component

- Research Project on Next-Generation Flood Defense Technology;
- Four Major Rivers Restoration Project;
- Development of the ‘Assessment System of Flood Control Measures on Socio-economic Impacts’;
- Central Joint improvement task force for climate change is organized by NEMA;
- Construction of the Quality Control System for National Hydrological Data;
- Participation in the TC Integrated Workshop in Macao 4-10 September;
- The 4th Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) was held in Songdo, Incheon on 25-27 October.

3. Disaster Risk Reduction component

- Development of a flashflood prediction system for Disaster Risk Reduction in mountainous areas;
- Development of Web GIS based wind risk assessment system;
- Foundation of a promotion corps for reinforcing vulnerable zones;
- NEMA-hosted Disaster Management Education Training Program;
- NIDP formally opened WGTCDIS, which makes it possible for TC member countries to share disaster information
- Working Group on Disaster Risk Reduction (WGDRR) meeting was held during the 4th Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR).