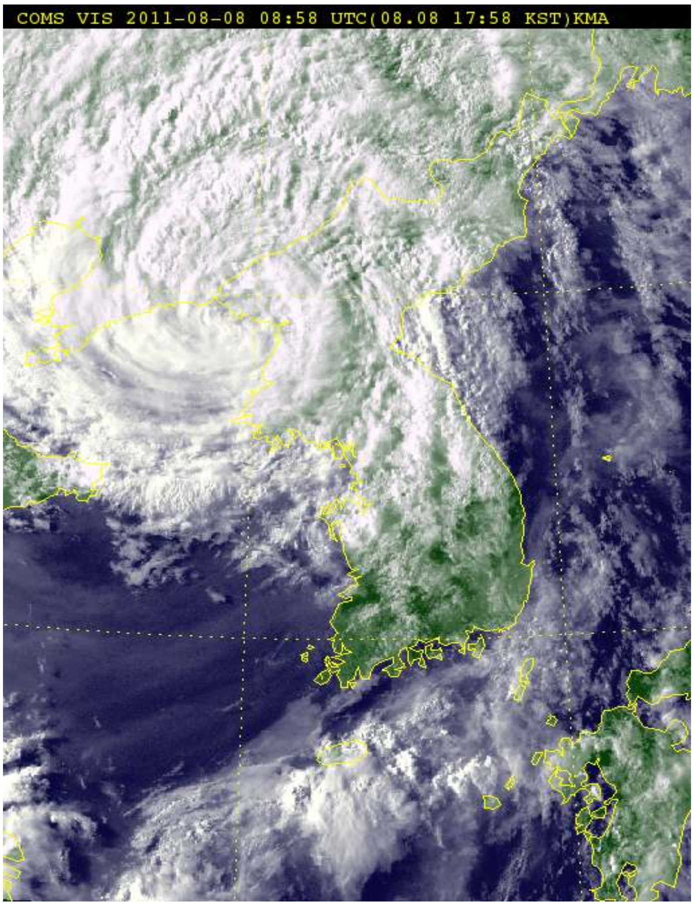
MEMBER REPORT

ESCAP/WMO Typhoon Committee

44th Session



6-11 February 2012

Hangzhou, China

REPUBLIC OF KOREA

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CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area in 2011

1. Meteorological Assessment (highlighting forecasting issues/impacts)

This year three typhoons, Meari (1105), Muifa (1109), Talas (1112), directly affected Korean peninsula between June and August, and one typhoon Kulap (1114) for indirect influence. The Meari was recorded the only typhoon in June whose path was along Yellow Sea. The detailed information about the track, intensity and forecast of those four typhoons are described below.

a. Typhoon 'MEARI(1105)'

The fifth typhoon Meari (1105) was formed at 18UTC on 20 June 2011 as TD in Philippine Sea. It developed as TS on 06UTC 22 June with central pressure of 998hPa. The SST (29℃) and ocean heat content was favorable for intensification of Meari to strong mid-size typhoon (central pressure: 970hPa, maximum sustained wind speed: 36ms^{-1}). It rapidly moved north along Yellow Sea and became Extratropical Low on 06UTC 27 June after landing 80km ESE of Shinuiju city in North Korea (Fig. I-1-1).

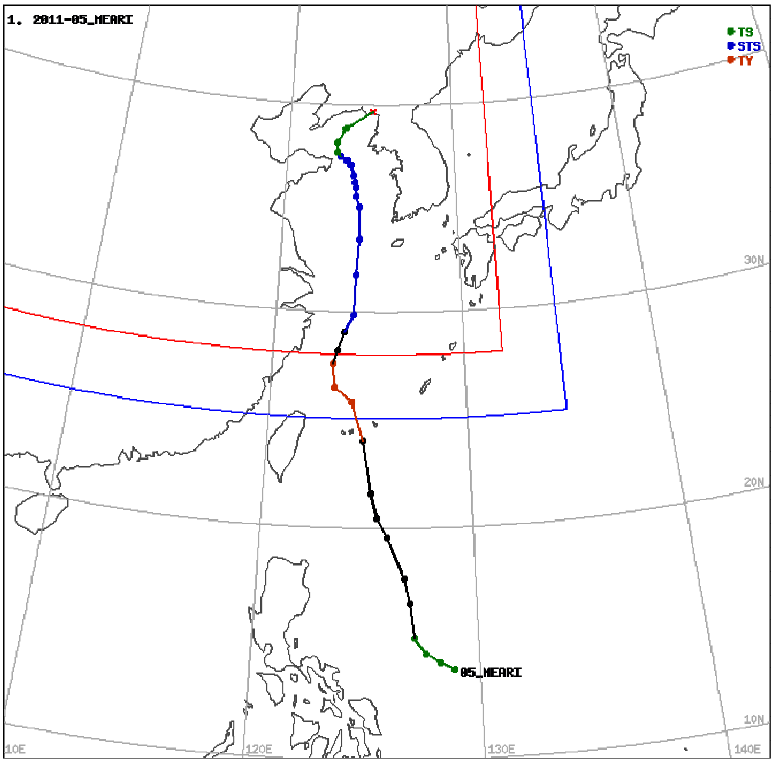


Fig. I-1-1. Track of typhoon "Meari (1105)"

The Meari was recorded the only typhoon in June which moved straight northward along Yellow Sea. The North Pacific High extended further north-south direction rather than usual westward. As the track showed straight northward path, it was difficult to locate the turning position. The typhoon usually moves along the periphery of North Pacific High. In normal years, it is extended in east-west direction affecting to south of China. This year June, however, it was more elongated to north-south direction, and caused northward movement. The SST and ocean heat content was favorable for Meari's intensification.

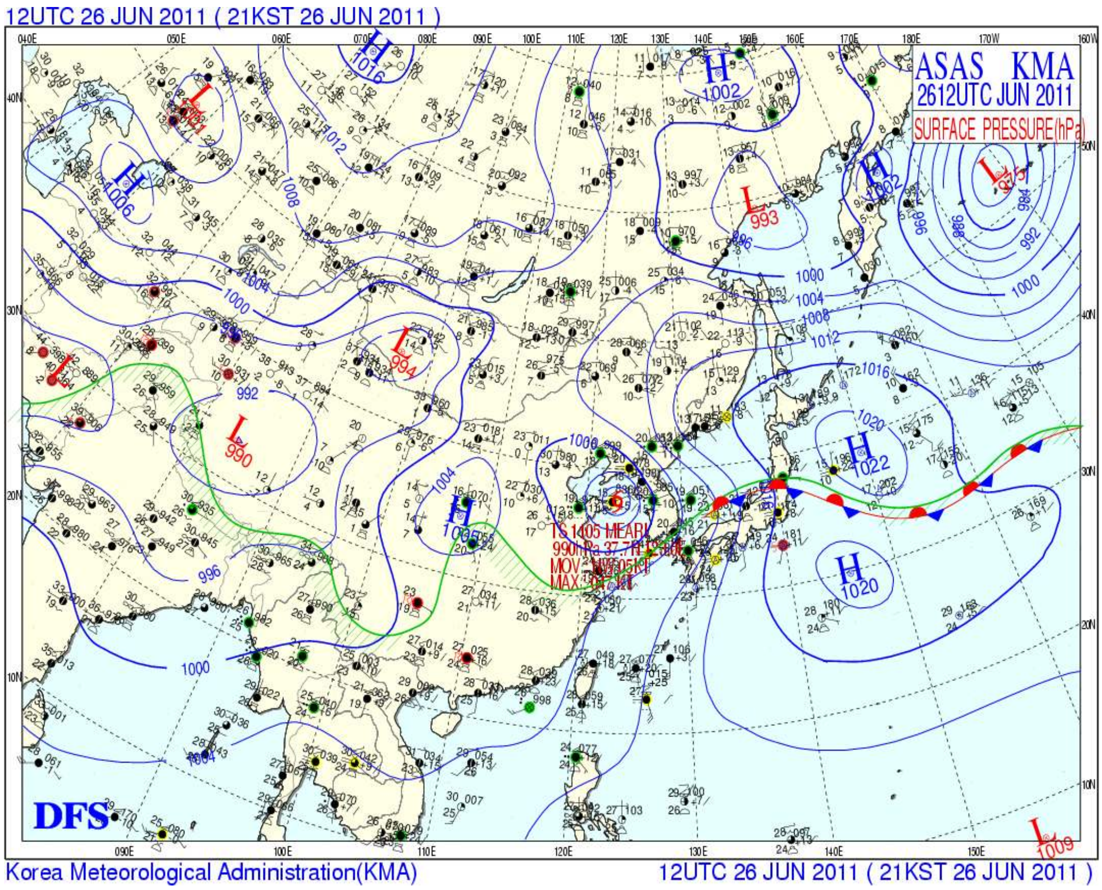
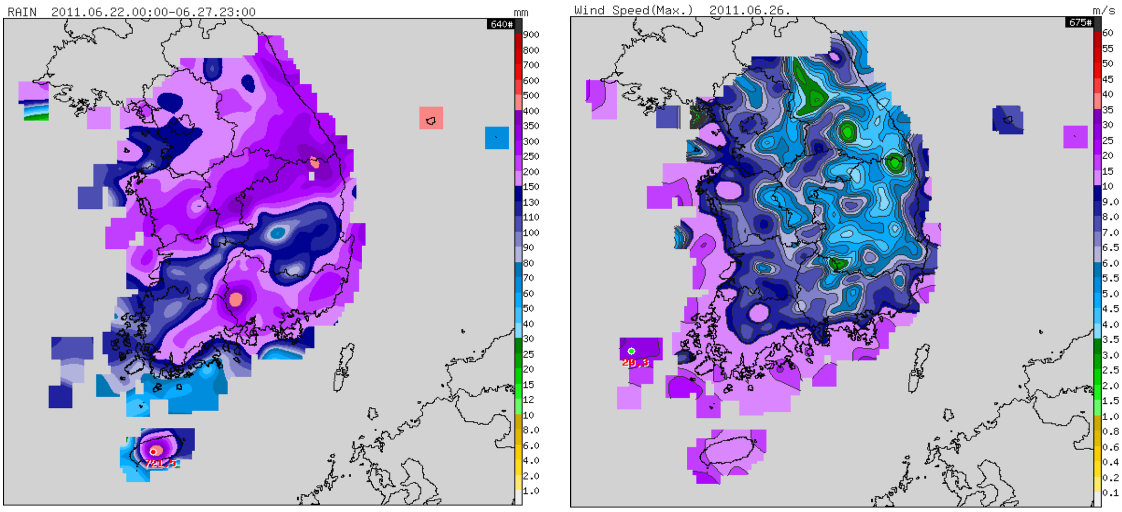


Fig. I-1-2. Surface pressure analysis chart in 12UTC 26 June when the Meari passed over Yellow Sea

The western coast area of Korean peninsula which is located in the east of typhoon movement (risk semi-circle of typhoon) caused high wind and heavy precipitation which was record breaking for June observation. Due to interaction with Chang-Ma front, the rainfall amount recorded 20~700mm and the spatial difference of precipitation was high with geographical locations. The Chang-Ma periods began 22 June in Korean peninsula and the Meari provided heat and moisture which might enhance the precipitation in Seoul. The 6 days of consecutive rainfall in Seoul made new record for longest days of continuous precipitation since 1981.



(a) accumulated rainfall(22~27 June) (b) Daily maximum wind velocity (26 June)

Fig. I-1-3. (a) accumulated rainfall and (b) daily maximum wind speed, while the Meari influence to Korean peninsula

Table 1-1-1. Breaking of wind speed and rainfall records by Typhoon 'Meari'

(a) Breaking of day maximum wind velocity of moment

Weather station	Number one record(m/s)	Old record(year)	Start day of observation
Heuksando	34.8	30.5 (2001)	1997. 01. 01
Jindo	29.3	28.1 (2002)	2001. 11. 03
Munsan	14.8	14.2 (2008)	2001. 12. 07
Goheung	21.5	20.3 (1996)	1972. 01. 22

(b) Breaking of day maximum wind velocity of moment in June

Weather station	Number one record (m/s)	Old record(year)	Start day of observation
Heuksando	26.0	19.5 (2006)	1997. 01. 01
Jindo	12.9	12.0 (2001)	1971. 07. 15

(c) Breaking of day maximum rainfall in June

Weather station	Number one record (mm)	Old record(year)	Start day of observation
Ulsan	164.0	138.5 (2003)	1932. 01. 06

(d) Breaking of one-hour maximum rainfall in June

Weather station	Number one record (mm)	Old record(year)	Start day of observation
Sancheong	37.0	32.0 (2006)	1972. 01. 24

The 48 hour track forecast tendency of KMA shows westward bias in the early phase of Meari while eastward bias in the later phase. It was forecasted slower than actual movement. The overall 48 hour track forecast error was 236.9km. The general forecast tendency is considered being consistent throughout forecast periods.

KMA 1105 MEARI

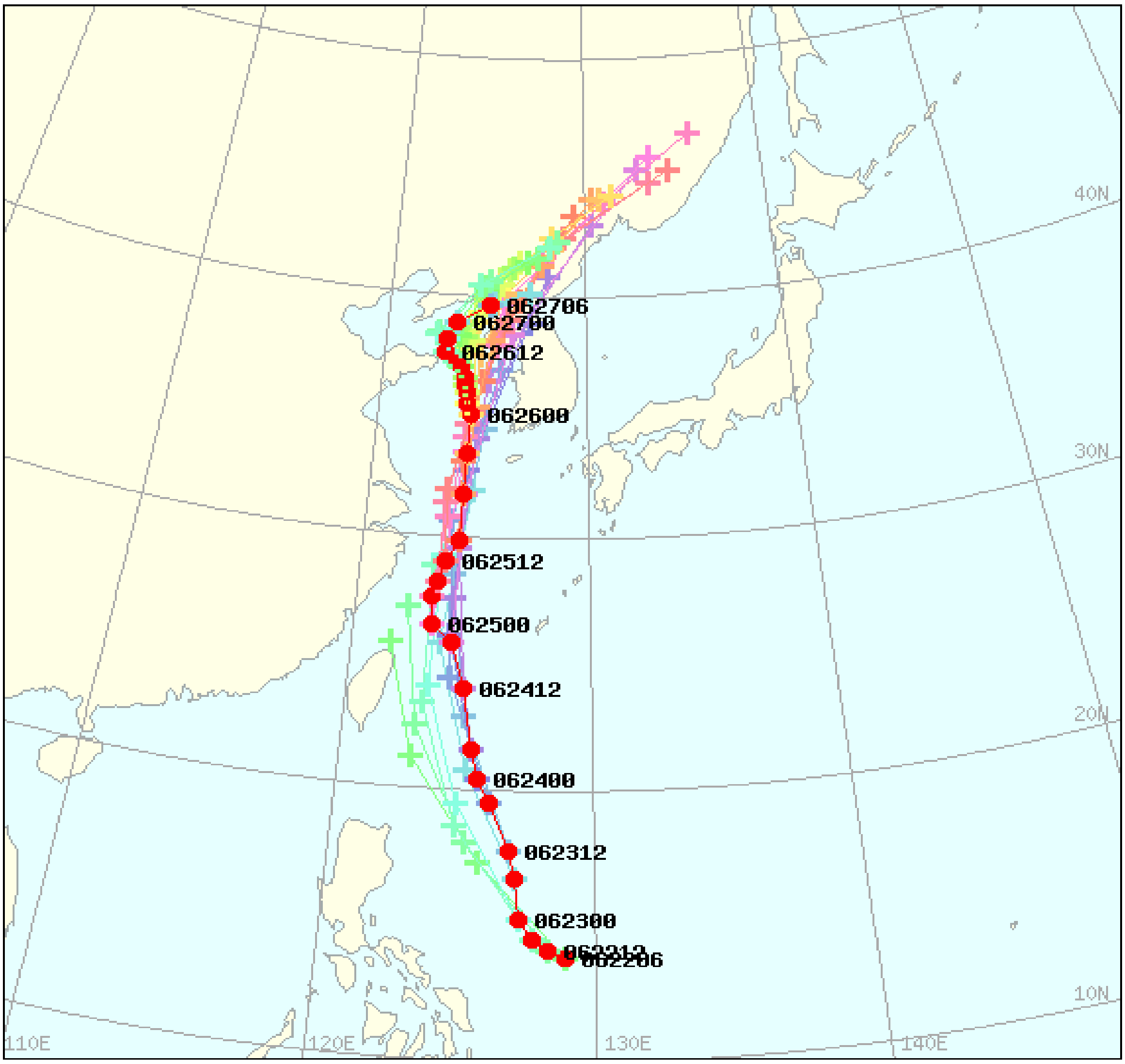


Fig. I-1-4. KMA track forecast of typhoon "Meari (1105)"

Table1-1-2. Time-based changes of position and intensity of Typhoon "Meari (1105)"

(: 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
06221500	13.8	128.9	WNW	18	998	18	TS	350	-
06222100	14.1	128.3	WNW	13	994	21	TS	350	SW/200
06230300	14.5	127.7	WNW	14	994	21	TS	350	SW/300
06230900	15.2	127.2	NNW	16	994	21	TS	350	SW/300
06231500	16.7	127.0	NNW	19	990	24	TS	350	SW/300
06232100	17.8	126.8	NNW	23	990	24	TS	300	SW/250
06240300	19.6	126.0	NNW	23	990	24	TS	400	SW/350
06240900	20.5	125.5	NNW	26	985	27	STS	400	SW/350
06241500	21.6	125.5	NNW	25	985	27	STS	400	SW/350
06242100	24.0	124.8	NNW	26	980	31	STS	400	SW/350
06250300	25.8	124.2	N	27	975	34	TY	420	SW/380
06250900	26.5	123.3	NW	20	970	36	TY	430	SW/380
06251500	27.6	123.2	N	30	975	32	STS	400	SW/350
06261800	28.2	123.4	NNE	30	975	31	STS	480	W/300
06252100	29.1	123.7	N	26	975	31	STS	480	W/300
06260000	29.9	124.2	NNE	30	980	30	STS	480	W/300
06260300	31.8	124.3	N	71	985	27	STS	450	W/300
06260400	31.8	124.3	N	71	985	27	STS	450	W/300
06260600	33.5	124.4	N	64	985	27	STS	430	W/300
06260900	35.1	124.4	N	60	985	27	STS	380	NE/320
06261000	35.6	124.2	NNW	59	985	27	STS	380	NE/320
06261100	36.0	124.2	N	45	985	27	STS	380	NE/320
06261200	36.3	124.1	NNW	35	988	25	STS	350	E/300
06261300	36.6	124.0	NNW	35	988	25	STS	350	E/300
06261400	37.1	123.8	NNW	59	988	25	STS	330	E/280
06261500	37.3	123.6	NW	29	988	25	STS	300	E/250
06261800	37.5	123.2	WNW	14	988	25	STS	280	W/200
06262100	37.7	123.0	NW	10	990	24	TS	280	WNW/200
06270300	38.2	123.0	N	10	990	24	TS	130	S/100
06270900	38.9	123.5	NNE	15	992	22	TS	100	S/70
06271500	39.7	125.1	ENE	28	996	-	-	-	-

b. Typhoon 'Muifa(1109)'

The 9th typhoon Muifa was formed on 28 July, at the west of Guam. It passed west of Jeju island on 6 August afternoon and moved along Yellow Sea. It was landed near Shinuiju city on 09UTC 8 August and was weaken as a tropical depression on 00UTC 9 August.

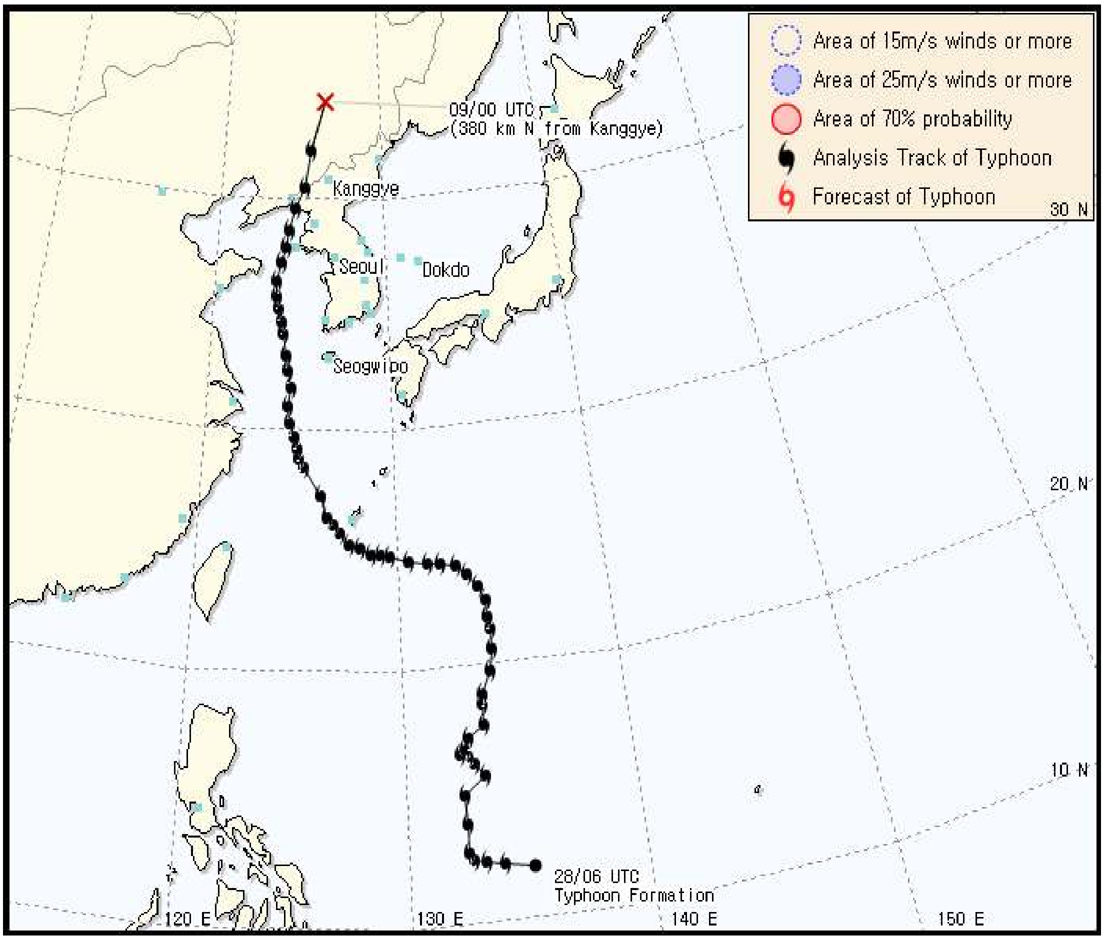
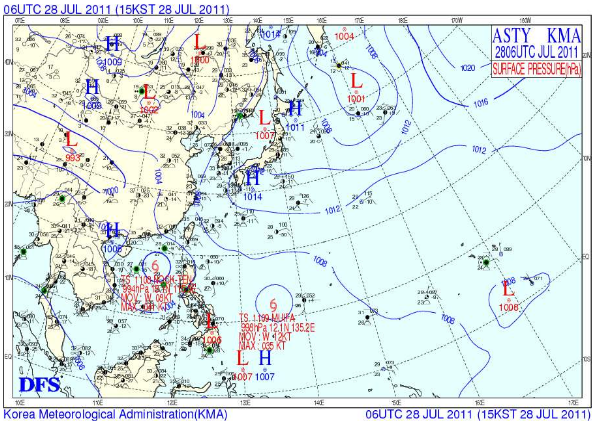
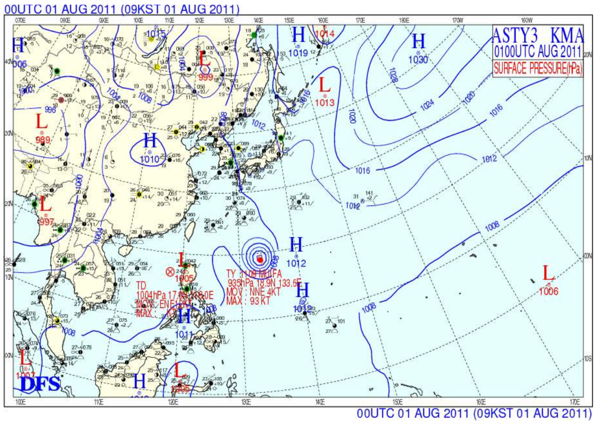


Fig. I-1-5. Track of typhoon "Muifa (1109)"

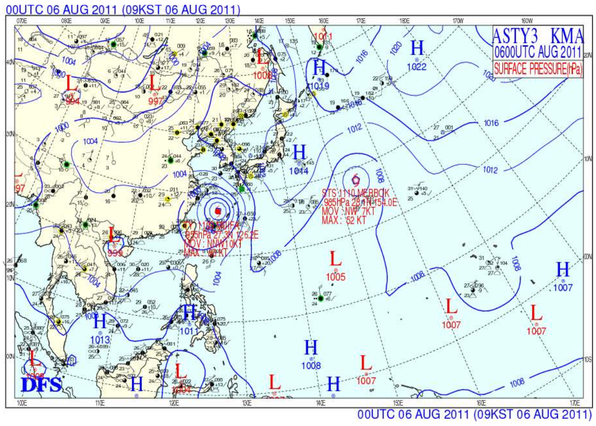
The North Pacific High, which was extended in east-west direction on latter part of July, became contracting zonally and extending in north-south direction than usual years. This cause the Muifa keep moving northward without turning to east along the Yellow Sea. The track of Muifa was similar to that of the 5th typhoon Meari in June and it became the 2nd typhoon which had path along the Yellow Sea and landed in North Korea.



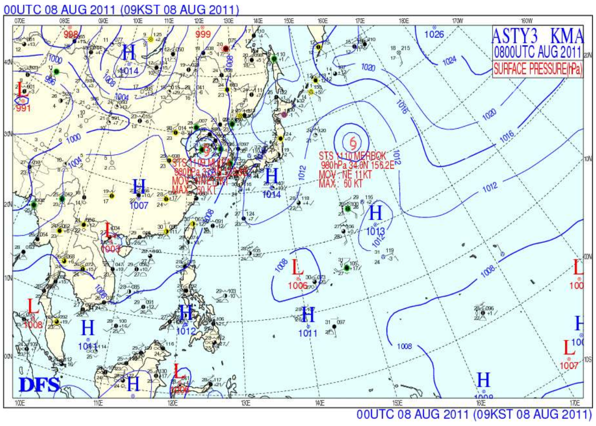
(a) 7. 28. 06UTC



(b) 8. 1. 00TC



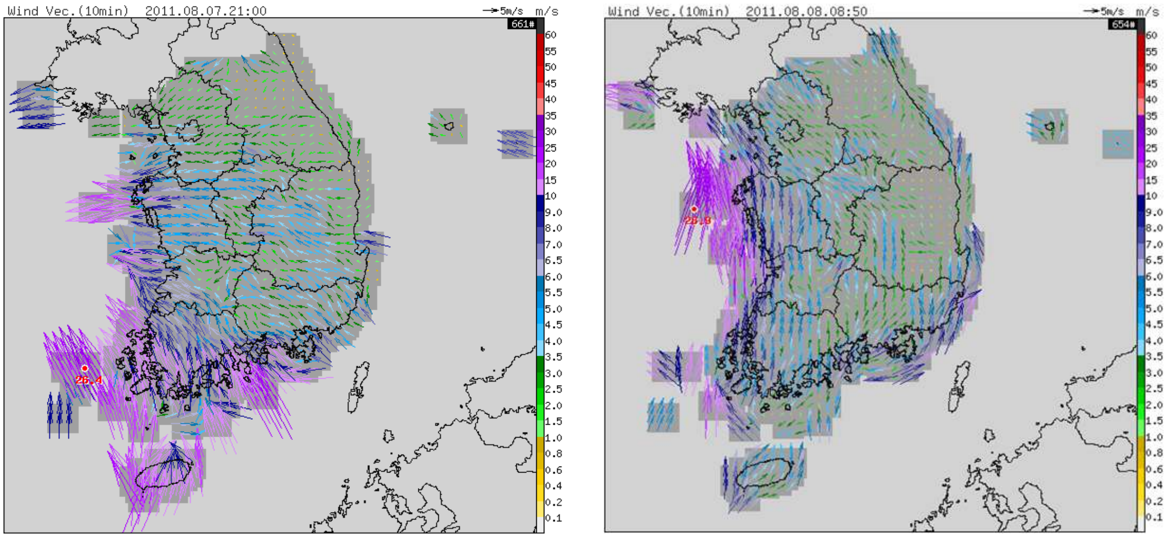
(C) 8. 6. 00UTC



(d) 8. 8. 00UTC

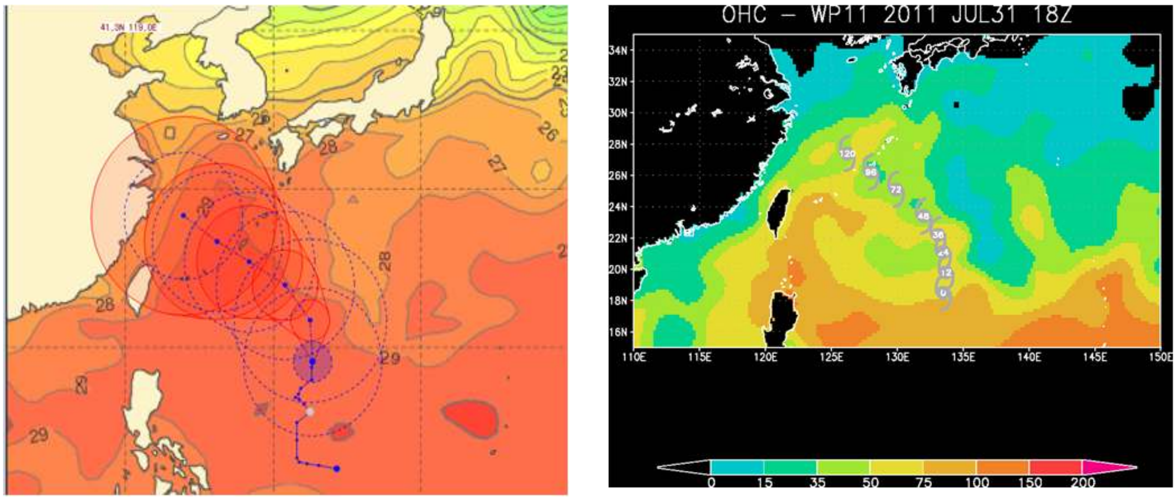
Fig. I-1-6. Surface pressure analysis chart from 06UTC 28 July to 00UTC 8 August

The western coast and southern islands area of Korean peninsula which is located in the east of typhoon movement (risk semi-circle of typhoon) caused high wind. The Jeju island, southern coast, and Jiri high mountain area was especially recorded heavy precipitation owing to consistent southerly wind of Muifa. The slow movement of Muifa over warm ocean condition in southern Korean peninsula induced longer typhoon affect than usual in Jeju island and Jeolla province even after the typhoon passed over. The wind speed over 10 ms^{-1} kept blowing 10 hours in Jeju island, which was record breaking of wind and precipitation for August observation.



(a) 8. 7. 12UTC (b) 8. 8. 00UTC

Fig. I-1-7. The AWS observed wind vector on 7 and 8 August



(a) Sea surface temperature (7. 31. 00UTC) (b) Ocean heat content (7. 31. 18UTC)

Fig. I-1-8. The sea surface temperature(a) and ocean heat content(b) in early stage of Muifa

Meanwhile, the 10th typhoon Merbok was formed on 06UTC 3 August and was weaken as an extratropical low on 12UTC 9 August. It passed over east of Japan and kept distance against Muifa. It was analyzed as the interaction between Muifa and Merbok was not found.

The 48 hour track forecast tendency of KMA shows southwestward bias after the Muifa turned left. It was forecasted slower than actual movement. In early stage of typhoon, the strength of North Pacific High was expected keeping all the way of Muifa duration. However, the North Pacific High was shrunk to eastward and the Muifa moved along Yellow Sea as the case of 5th typhoon Meari, instead of landing to Sandong province of China. The overall 48 hour track forecast error was 176km. The general forecast tendency is considered being consistent throughout forecast periods.

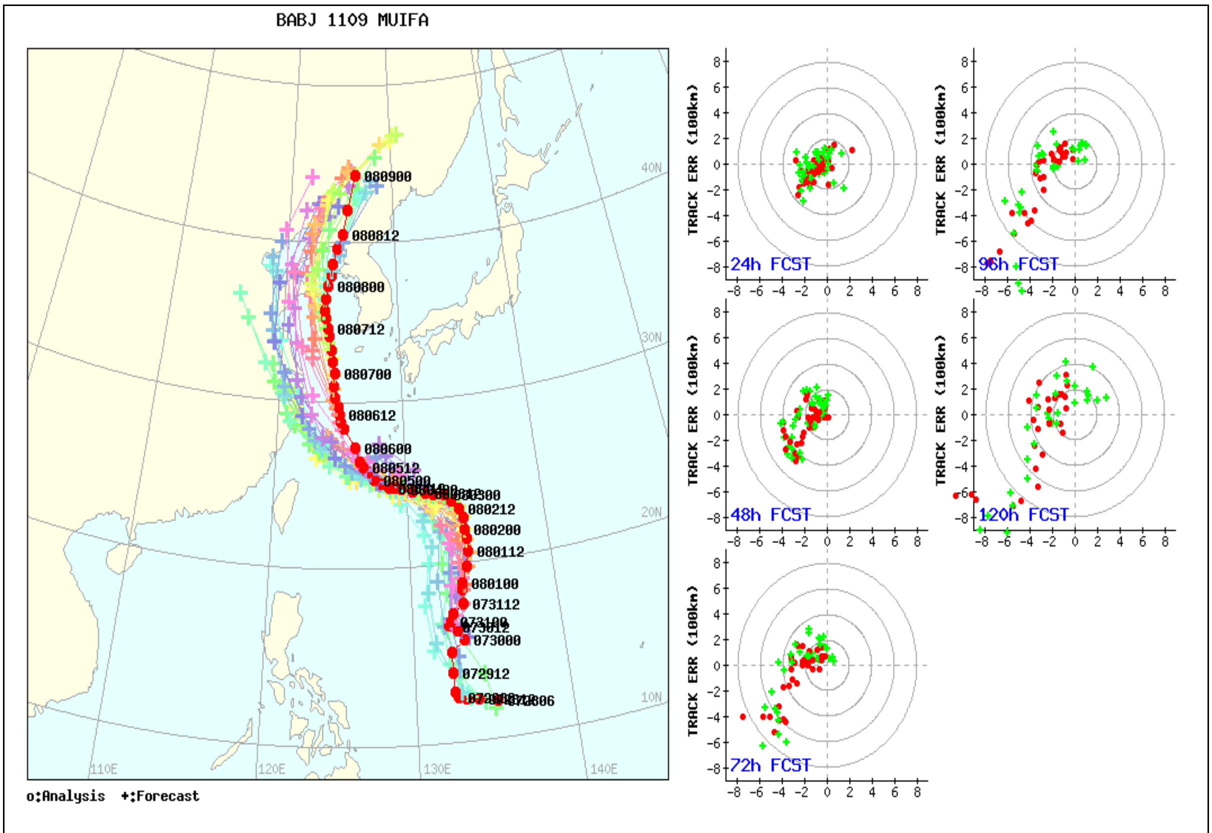


Fig. I-1-9. KMA track forecast of typhoon "Muifa (1109)"

Table I-1-3. Time-based changes of position and intensity of Typhoon "Muifa (1109)"

(: 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
07281500	12.1	135.2	W	22	998	18	TS	200	-
07282100	12.3	134.0	W	23	996	19	TS	220	-
07290300	12.4	133.2	W	15	992	22	TS	220	-
07290900	12.5	132.7	W	10	992	22	TS	220	-
07291500	12.8	132.5	NNW	7	990	24	TS	250	-
07292100	13.9	132.5	N	21	990	24	TS	250	-
07300300	15.0	132.5	N	21	990	24	TS	250	-
07300900	15.7	133.4	NE	21	980	31	STS	300	-
07301500	16.2	133.0	NW	12	970	36	TY	350	-
07302100	16.5	132.7	NW	8	945	45	TY	500	-
07310300	16.6	132.4	WNW	6	935	48	TY	550	-
07310900	16.8	132.6	NE	6	930	50	TY	580	-
07311500	17.2	132.8	NNE	9	930	50	TY	580	-
07312100	17.7	133.5	NE	16	930	50	TY	580	-
08010300	18.5	133.5	N	15	930	50	TY	580	-
08010900	18.9	133.6	NNE	8	935	48	TY	530	-
08011500	19.8	134.0	NNE	19	945	45	TY	500	-
08012100	20.7	134.2	NNE	18	945	45	TY	500	-
08020300	21.5	134.2	N	15	945	45	TY	500	-
08020900	22.0	134.1	NNW	10	945	45	TY	500	-
08021500	22.7	134.1	N	13	945	45	TY	500	-
08022100	23.3	133.8	NNW	13	945	45	TY	500	-
08030300	23.8	133.3	NW	13	945	45	TY	500	-
08030900	24.2	132.8	WNW	12	945	45	TY	500	-
08031500	24.3	132.0	W	14	945	45	TY	500	-
08032100	24.4	131.4	W	11	945	45	TY	500	-
08040300	24.5	130.5	W	16	945	45	TY	500	-
08040900	24.7	129.6	WNW	16	945	45	TY	500	-
08041500	24.8	129.1	W	9	945	45	TY	500	-
08042100	24.8	128.7	W	7	945	45	TY	500	-
08050300	25.1	128.1	WNW	12	945	45	TY	500	-
08050900	25.3	127.6	WNW	10	945	45	TY	500	-
08051500	25.8	127.1	NW	13	945	45	TY	500	-

08052100	26.1	126.8	NW	8	945	45	TY	500	-
08060300	26.4	126.5	NW	8	950	43	TY	450	-
08060900	27.3	126.2	NNW	18	955	41	TY	450	-
08061500	28.5	125.3	NW	27	955	41	TY	430	-
08061800	28.9	125.0	NW	18	960	40	TY	430	W/400
08062100	29.3	124.9	NNW	16	960	40	TY	430	W/400
08070100	29.8	124.8	NNW	19	965	38	TY	430	W/400
08070300	30.4	124.5	NNW	25	965	38	TY	430	W/380
08070600	31.1	124.4	N	27	965	38	TY	430	W/350
08070900	31.9	124.5	N	30	965	38	TY	430	W/350
08071200	32.6	124.3	NNW	27	970	36	TY	430	w/350
08071500	33.3	124.2	N	27	970	36	TY	400	W/350
08071800	34.2	124.0	NNW	34	975	34	TY	390	W/350
08072100	34.7	123.9	N	19	975	34	TY	390	W/350
08080000	35.3	123.7	NNW	24	975	34	TY	390	W/350
08080300	35.8	123.6	NNW	19	975	34	TY	350	W/300
08080600	36.5	123.6	N	26	980	31	STS	330	W/300
08080900	37.3	123.8	NNE	31	980	31	STS	330	W/290
08081200	38.0	124.1	NNE	28	982	29	STS	260	NE/180
08081500	38.7	124.2	N	27	988	27	STS	260	ENE/150
08081800	39.7	124.6	NNE	39	990	24	TS	190	-
08082100	40.6	125.1	NNE	37	990	24	TS	150	-
08090300	42.2	125.5	NNE	31	992	22	TS	120	-
08090900	44.4	126.4	NNE	43	996	-	-	-	-

c. Typhoon 'TALAS(1112)'

The 12th typhoon Talas (1112) was formed on 00UTC 25 August 600 km northwest from Guam(17.8°N, 141.4°E). In early stage of northward slow movement, it was developed as a 'very strong' typhoon with 945hPa central pressure and 45 ms^{-1} maximum wind on 29 August. As it moved farther northward, due to relatively low ocean heat condition, the Talas did not strengthened anymore and stayed as 'strong', 'mid-sized', 38 ms^{-1} maximum wind on 31 August. It landed south-west-south of Osaka Japan on 3 September and weakened to Extratropical Low on 5 September Sea 240km east-north-east of Dok-Do at East Sea. The Talas entered KMA forecast Alert Zone (north of 25°N, west of 135°E), and closely approached to Emergency Zone (north of 28°N, west of 132°E).

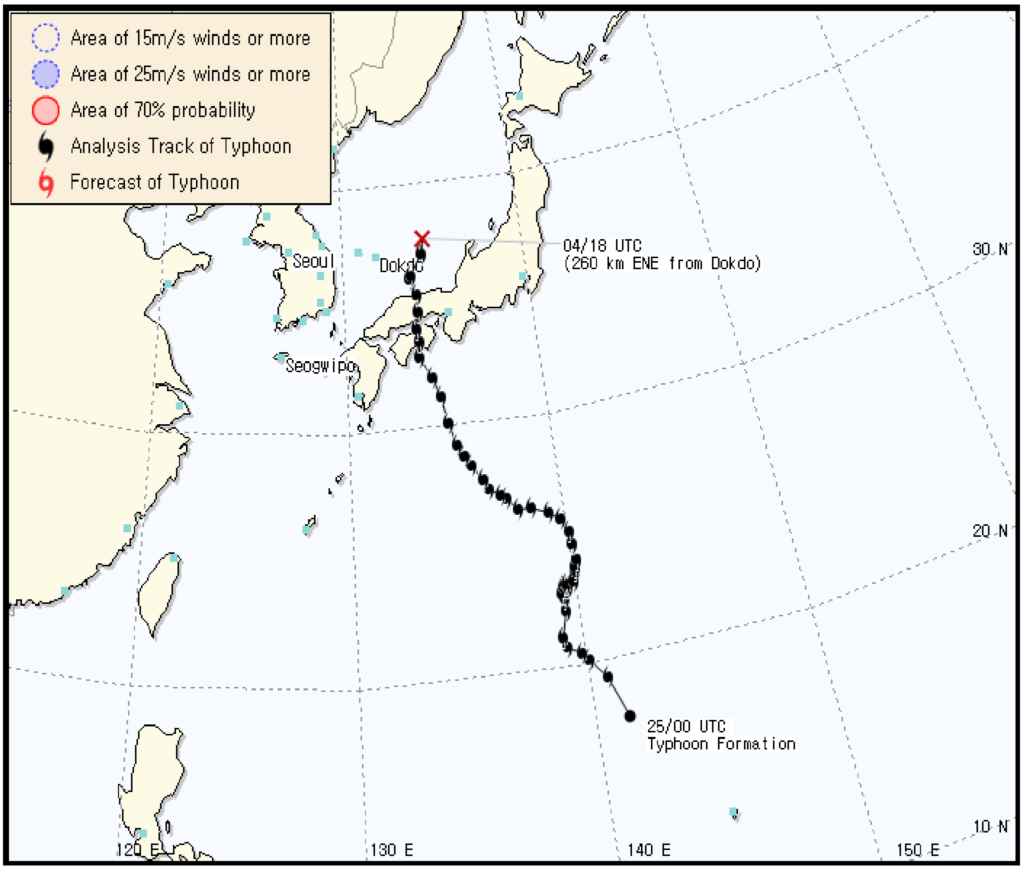
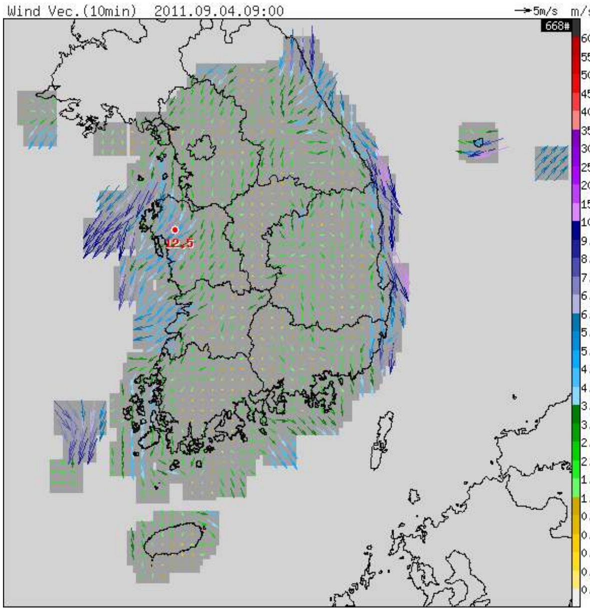
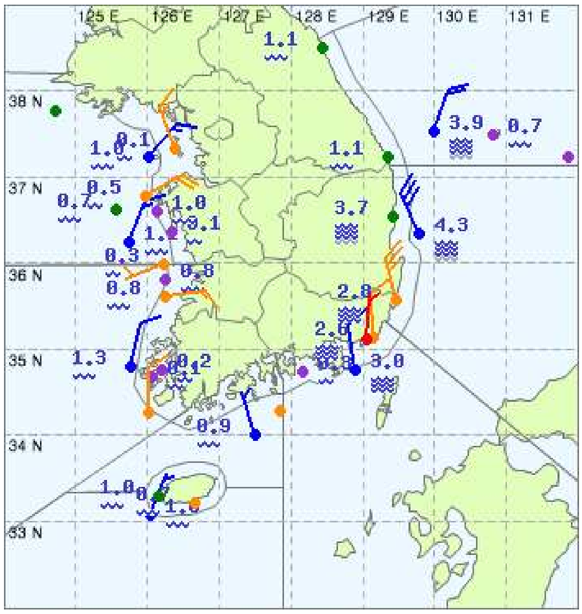


Fig. I-1-10. Track of typhoon "Talas (1112)"

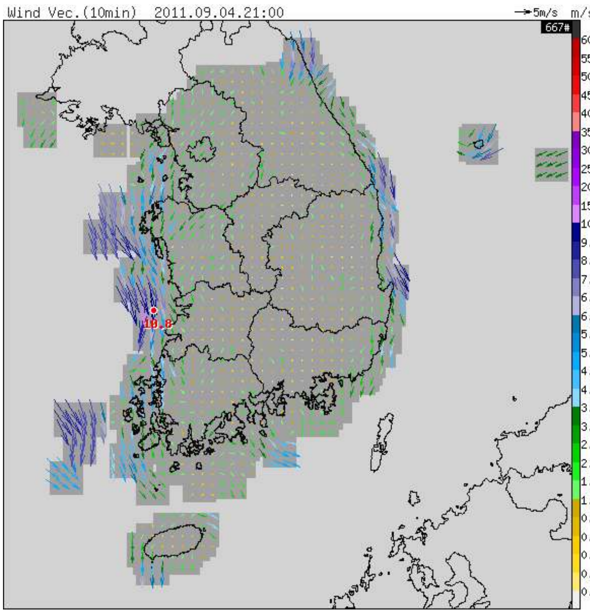
Although the Talas did not enter KMA Emergency Zone, there was direct impact on South Sea and East Sea with high ocean wind wave warning. The ocean wind wave warning was substituted by higher level typhoon warning on 3 September. Due to high ocean wind wave (4~5m significant wave height) on East Sea, there was inundation damage along the coast line of Gangwon province (east coast of Korean peninsula).



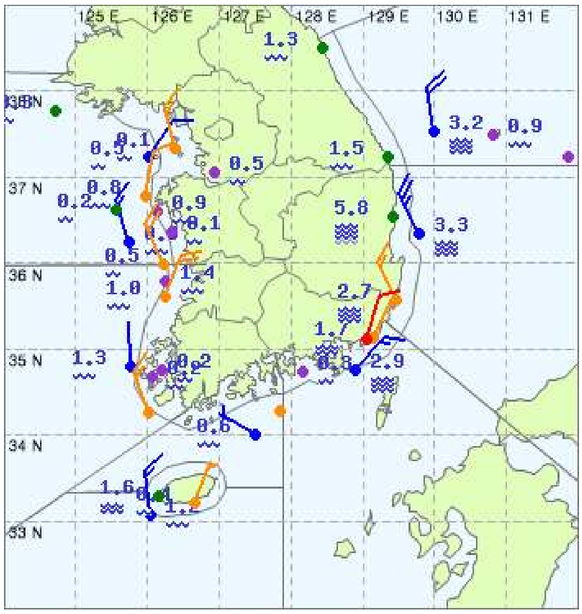
(a) AWS observed wind vector (9. 4. 00UTC)



(b) Buoy observed wind barb (9. 4. 00UTC)



(c) AWS observed wind vector (9. 4. 12UTC)



(d) Buoy observed wind barb (9. 4. 12UTC)

Fig. I-1-11. The AWS and Buoy wind observation when Talas(1112) was located in East Sea

The 48 hour track forecast tendency of KMA shows northeastward bias after the Talas turned left on 30 August. It was forecasted faster than actual movement. The overall 48 hour track forecast error was 180km. The general forecast tendency is considered being consistent throughout forecast periods.

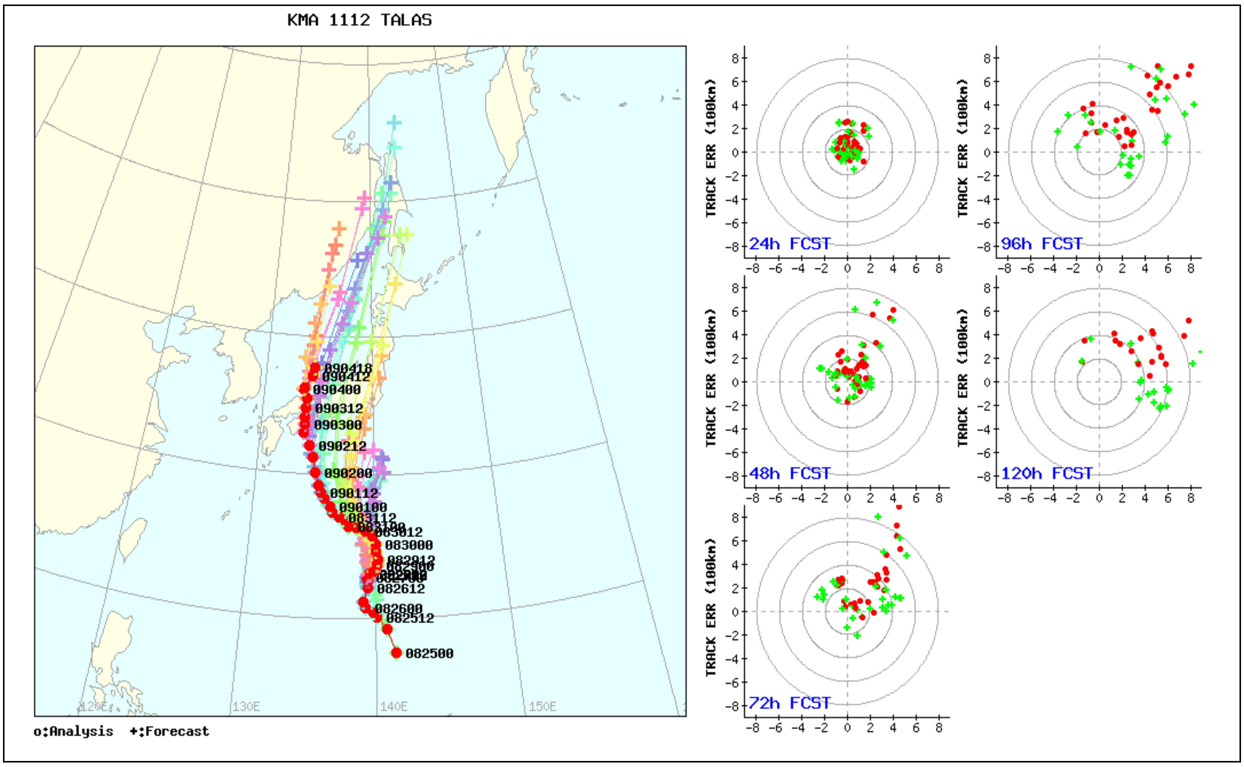


Fig. I-1-12.KMA track forecast of typhoon "TALAS (1112)"

Table I-1-4. Time-based changes of position and intensity of Typhoon "Talas (1112)"

(: 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
08250900	17.8	141.4	NNW	13	998	18	TS	200	-
08251500	19.4	140.8	NNW	32	996	19	TS	200	-
08252100	20.2	140.1	NW	20	994	21	TS	250	W/200
08260300	20.5	139.8	NW	8	990	24	TS	300	SW/250
08260900	20.8	139.2	WNW	12	985	27	STS	320	SW/250
08261500	21.2	139.1	NNW	8	980	31	STS	300	SW/250
08262100	22.2	139.4	NNE	12	980	31	STS	300	SW/250
08270300	22.7	139.4	N	9	980	31	STS	330	SW/270
08270900	22.9	139.3	NNW	5	980	31	STS	330	SW/270
08271500	23.1	139.4	NNE	5	980	31	STS	380	-
08282100	23.2	139.6	SE	2	980	31	STS	380	-
08280300	23.1	139.6	N	1	980	31	STS	380	-
08280900	23.2	139.6	N	2	980	31	STS	380	-

08281500	23.2	139.5	W	2	980	31	STS	380	-
08282100	23.2	139.6	E	2	980	31	STS	380	-
08290300	23.3	139.9	ENE	6	975	32	STS	400	-
08290900	23.7	140.1	NNE	8	975	32	STS	400	-
08291500	23.8	140.1	N	2	975	32	STS	400	-
08292100	24.1	140.2	NNE	6	970	32	STS	400	-
08300300	24.7	140.1	N	12	965	35	TY	420	-
08300900	25.2	140.1	N	10	965	38	TY	420	-
08301500	25.8	139.8	NNW	13	965	38	TY	420	-
08302100	26.1	139.3	WNW	11	965	38	TY	420	-
08310300	26.4	138.5	WNW	15	965	38	TY	420	-
08310900	26.4	137.9	W	10	965	38	TY	420	-
08311500	26.9	137.4	NW	13	965	38	TY	420	-
08312100	27.1	137.1	WNW	7	965	38	TY	420	-
09010300	27.4	136.6	NW	10	965	38	TY	420	-
09010900	27.8	136.4	NW	9	965	38	TY	420	-
09011500	28.4	135.9	NW	14	965	38	TY	420	-
09012100	28.8	135.6	NW	9	965	38	TY	420	-
09020300	29.3	135.3	NNW	11	965	38	TY	420	-
09020900	30.2	135.0	NNW	18	965	38	TY	420	-
09021500	31.3	134.7	NNW	21	970	36	TY	400	-
09022100	32.1	134.4	NNW	32	975	32	STS	400	N/350
09030300	33.0	133.8	NW	20	975	30	STS	360	NW/300
09030900	33.6	133.9	N	12	980	30	STS	360	SW/300
09031500	34.1	133.8	NNW	10	985	27	STS	360	SW/300
09032100	34.8	133.9	N	14	988	25	STS	350	SW/300
09040300	35.5	133.9	N	13	992	24	TS	350	SW/300
09040900	35.2	133.6	NNW	14	994	21	TS	330	NW/300
09041500	36.3	133.7	NNE	3	994	21	TS	200	SSE/140
09042100	37.2	134.4	NE	20	994	21	TS	200	S/140
09050300	37.8	134.5	N	11	996	-	-	-	-

d. Typhoon 'KULAP(1114)'

The 14th typhoon Kulap(1114) was formed when the North Pacific High expanded to westward after the typhoon Talas(1112) and the typhoon Noru(1113) moved to mid-latitude. It was on 03UTC 7 September 940km east-south-east of Okinawa Japan (21.5°N, 135.4°E).

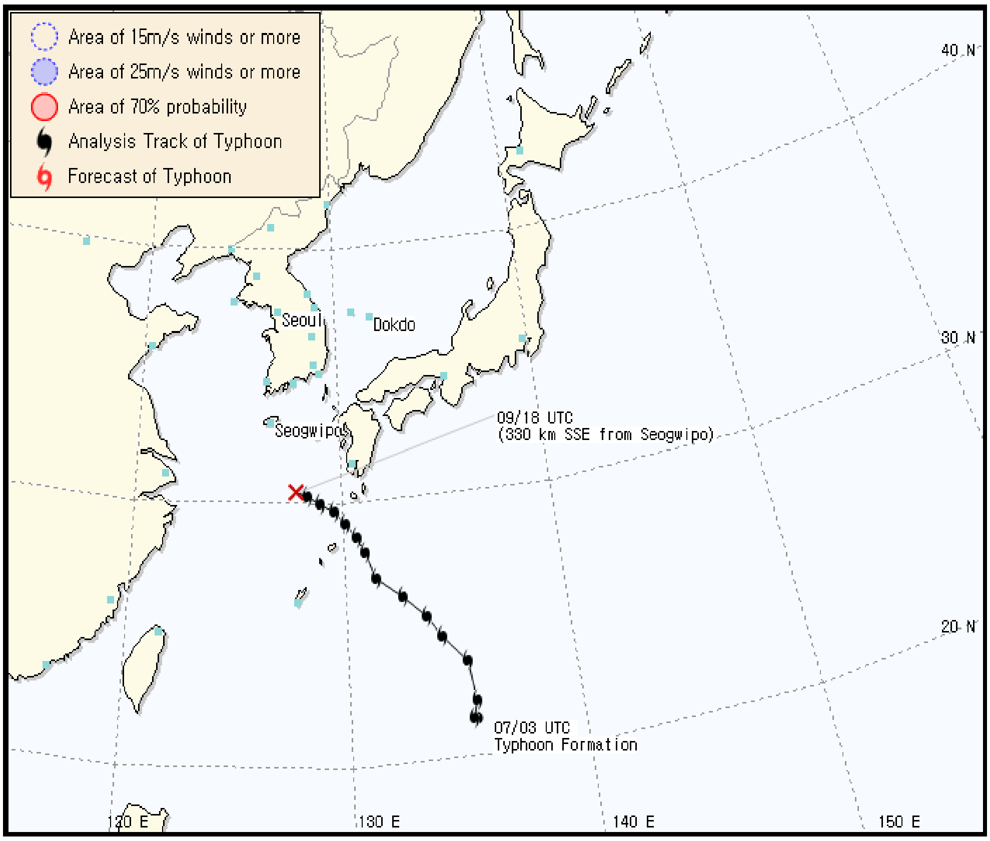
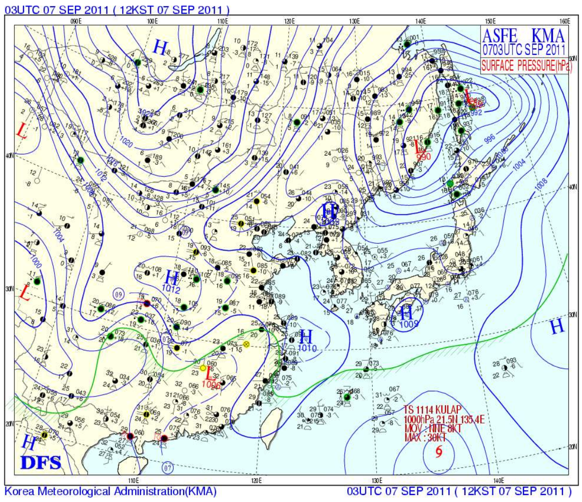
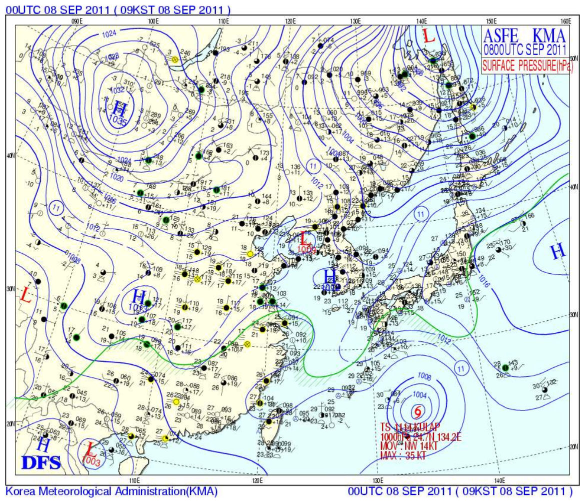


Fig. I-1-13. Track of typhoon "Kulap (1114)"

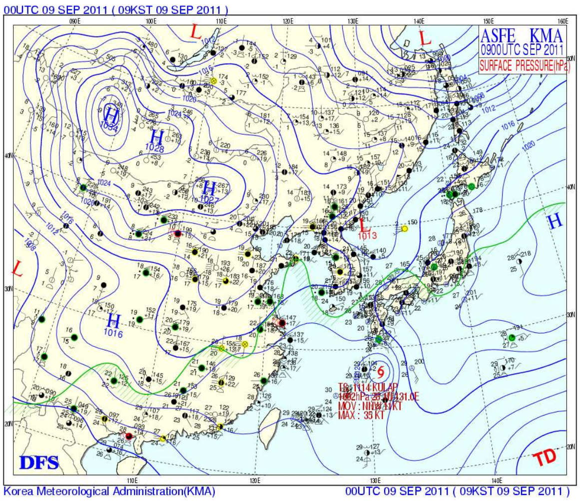
The Kulap was expected becoming Tropical Depression within 48 hours after it was formed, because dry air intrusion in lower troposphere and low cyclone index might hinder further development of typhoon. However, the Kulap sustained 66 hours as 'weak' and 'small-sized' typhoon. In early stage, the Kulap moved fast northward along the lower troposphere mean layer wind and slowed its movement speed when it was blocked by east-west high pressure belt. It became Tropical Depression on 18UTC 9 September 330km south-south-east of Jeju island.



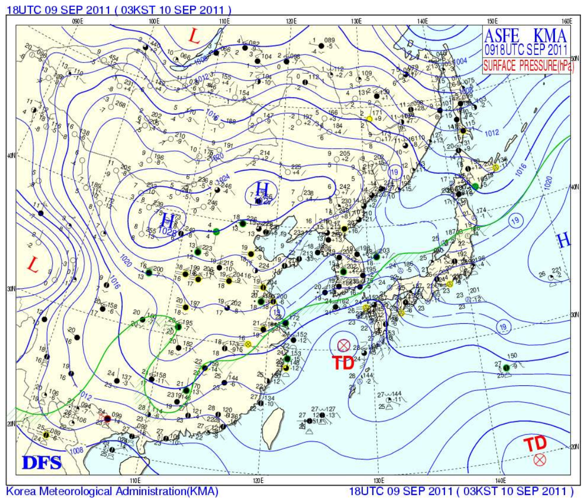
(a) 9. 7. 03UTC



(b) 9. 8. 00TC



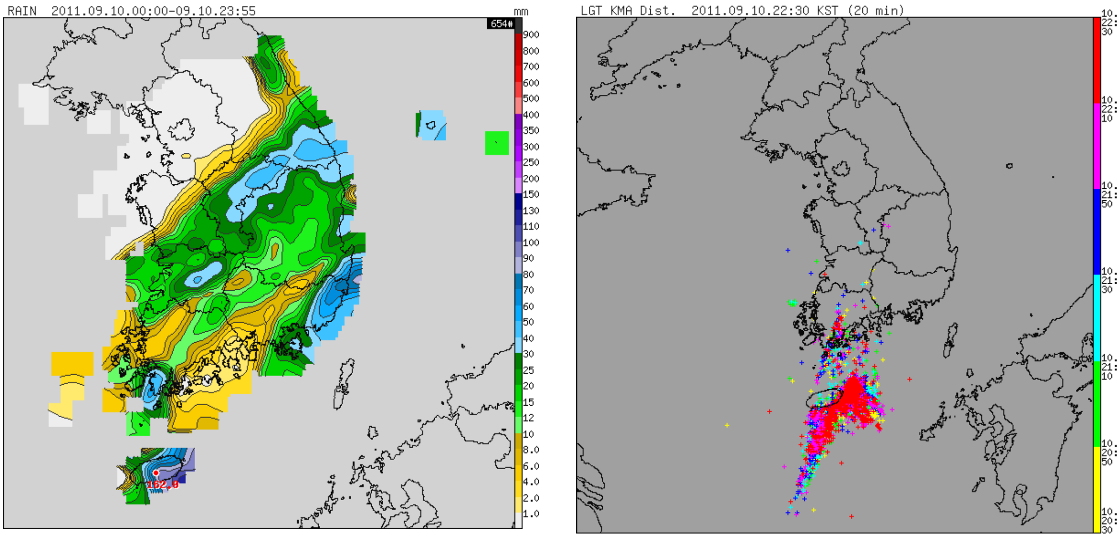
(C) 9. 9. 00UTC



(d) 9. 9. 18UTC

Fig. I-1-14. Surface pressure analysis chart from 03UTC 7 September to 18UTC 9 September

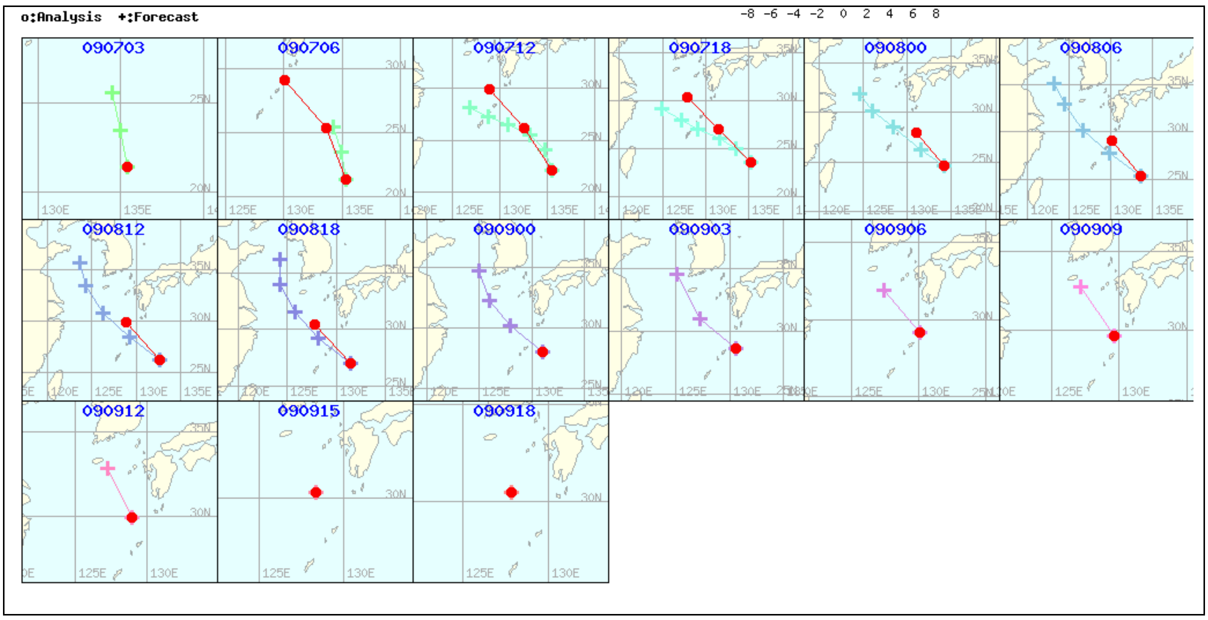
After the Kulap was weaken to Tropical Depression, it kept moving northward near to Jeju island. The cold upper air over Jeju island caused very unstable condition which brought lightening and heavy precipitation (40mm/h) during 1345KST 10 September ~0845KST 11 September. It also recorded heavy rainfall in southern province of Korea.



(a) Daily accumulated rainfall amount (9. 10) (b) lightening distribution (9. 10)

Fig. I-1-15. ***(a)Daily accumulated rainfall amount and (b)lightening distribution on 10 September***

The 48 hour track forecast tendency of KMA shows southwestward bias. It was forecasted slower than actual movement. The overall 48 hour track forecast error was 577km. The track forecast error was rather large due to abrupt change of movement speed.



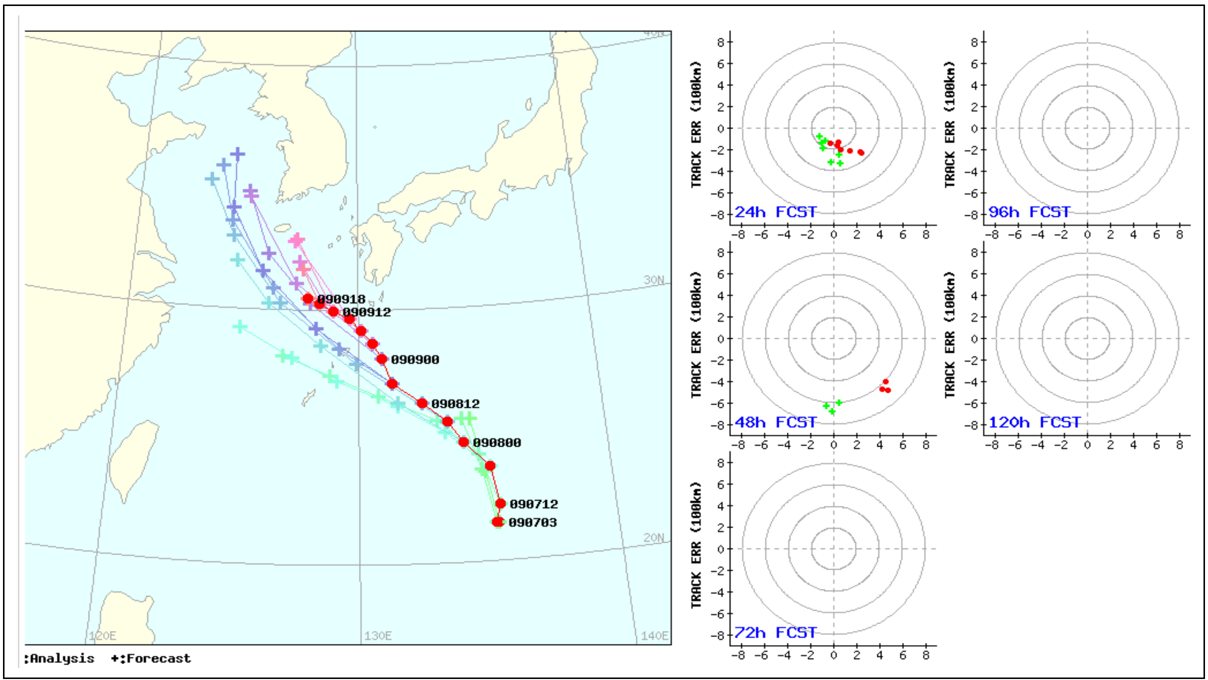


Fig. I-1-16.KMA track forecast of typhoon "Kulap (1114)"

Table I-1-5. Time-based changes of position and intensity of Typhoon "Kulap (1114)"

(: 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
09071200	21.5	135.4	NNE	15	1000	18	TS	100	-
09071500	21.5	135.3	W	4	1000	18	TS	120	-
09072100	22.2	135.5	NNE	14	998	17	TS	150	-
09080300	23.7	135.2	NNW	29	998	18	TS	150	-
09080900	24.7	134.2	NW	26	1000	18	TS	150	-
09081500	25.5	133.6	NW	18	1000	18	TS	150	-
09082100	26.3	132.6	NW	22	1002	18	TS	150	-
09090300	27.1	131.4	NW	25	1002	18	TS	150	-
09090900	28.1	131.0	NNW	20	1002	18	TS	150	-
09091200	28.7	130.6	NW	26	1002	18	TS	120	-
09091500	29.2	130.1	NW	25	1004	17	TS	100	-
09091800	29.7	129.6	NW	25	1004	17	TS	100	-
09092100	30.0	128.9	WNW	26	1006	18	TS	100	-
09100000	30.3	128.3	WNW	23	1006	18	TS	80	
09100300	30.5	127.8	WNW	18	1008	-	-	-	-

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

a. Typhoons in Korea, 2011

According to the report announcing the collected data by October in 2011, twenty typhoons occurred in the Northwest Pacific region. Three out of them which are Typhoon Meari (No.5), Muifa (No.9) and Talas (No.12) affected Korea directly. In Korea, Typhoon Kulap (No.14) and Roke neared the emergency zone (northwestern region at 28 degrees north latitude) and 132 degrees east longitude) and affected indirectly. This year all major typhoons did not reach the inland of Korea; instead, they passed through the sea or arrived in North Korea.

Especially Typhoon Muifa (No.9) was stronger and moved at slow speed, so the strength and lower speed of Typhoon Muifa as passing over the warm sea stroke Jeju Island and the west coast region for hours and significantly damaged the areas. In the case of Juju Island, the high wind at speed exceeding 10 m/s lasted for 10 hours and it caused 5 billion (KRW) lost. Nationally, it was estimated that the heavy rainfall caused approximately 100 billion (KRW) property damage and 7 casualties.

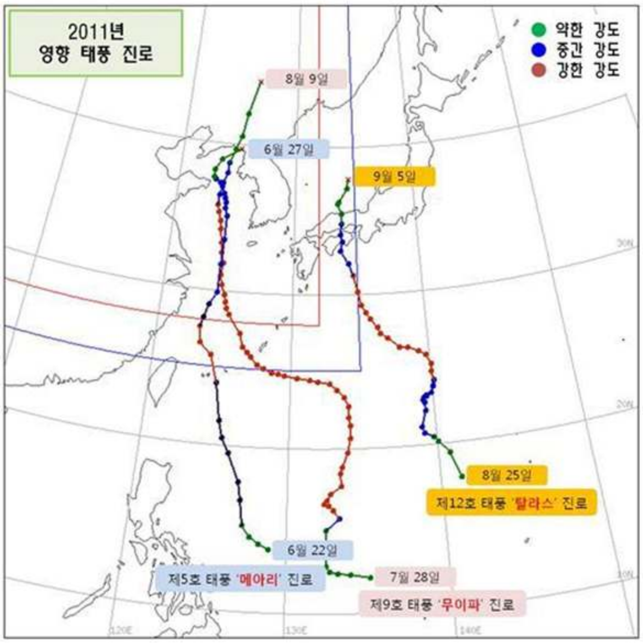


Fig.I-2-1. Typhoon tracks in 2011
(Sources; KMA, www.KMA.go.kr)

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

a. Socio-Economic Assessment of Typhoon Muifa

Among 21 tropical storms of the year of 2011 spawned in the West Pacific, three tropical storms hit Korea shown in Fig. I-3-1. Muifa, the ninth typhoon of the year of 2011 spawned in the West Pacific, was heading northward from waters 250 kilometers west of Incheon which is located 80 kilometers southwest of Seoul. As of 8 August morning, typhoon warnings were being issued in the capital area of Seoul, Gyeonggi and Incheon and the southern provinces of South Chungcheong, South and North Jeolla as well as the metropolitan cities of Daejeon and Gwangju. The warnings were also in effect for the Yellow Sea and the western part of the south sea.

As it swept through the lower half of South Korea's west coast on 7 August, the typhoon killed one person. Some 220 people were left homeless in the southern coastal city of Yeosu after a downpour accompanying Muifa flooded their homes. South Jeolla Province, one of the regions hit hardest from the typhoon, reported power failure for some 150,000 households and several ruined roads. The total property damages were 218.3 M US dollars such as 85.1 of Chunnam, 78.1 of Chunbuk, 47.3 gyungnam, 4.9 of Jeju, 1.0 of Chungnam and 1.9 of Chungbuk. Hundreds of flights between Jeju Island and Seoul were canceled due to the typhoon and ensuing heavy rains on Sunday while passenger ships and other fishing boats were also moored in the Yellow Sea.

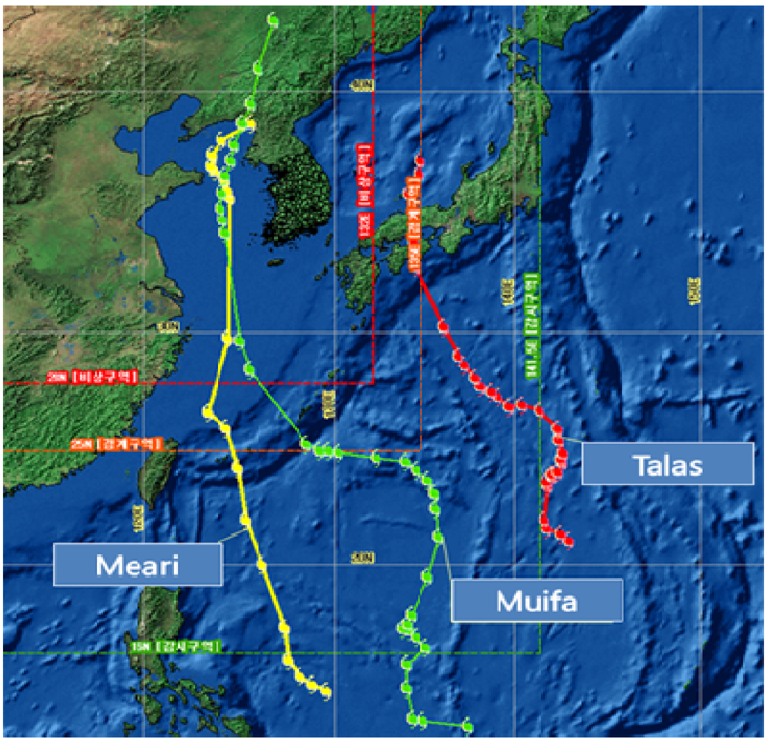


Fig. I-3-1 Typhoon Trajectories of three tropical storms hit Korea.

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 2011 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

- Expert Meeting on the Typhoon Activity and Disaster Prevention 2011

The NTC/KMA held "the Expert Meeting on Seasonal Typhoon Outlook and the Prevention of Disaster Caused by Typhoon" on April 18 2011 in Seogwipo, Korea. A total of 60 experts from several organizations related to typhoon disaster prevention such as Seoul National University, Pusan National University, Kongju National University, Jeju National University, and Korea Water Resources Cooperation as well as KMA. Participants had a discussion on the frequency of typhoons that affect the Korean Peninsula, in particular the outlook on genesis of typhoon in the western North Pacific in 2011. They agreed to work together to improve assessment method of typhoon outlook and identify the relationship between typhoon activity and global warming.

Fig. II-1-1. Participants in the expert meeting on typhoon activity and disaster prevention held on 18 April 2011, Jeju, Republic of Korea

- **Development of TAPS (Typhoon Analysis and Prediction System) English version**

TAPS has been developed and operationally used in KMA (Korea Meteorological Administraion) for the typhoon forecast generated in North western Pacific. Its English version was also developed for technical transfer into developing countries in 2011. The transfer of TAPS has been currently conducting to Veitnam. This tool helps to reduce the time to forecast typhoon track and central pressure more efficiently. The main functions of TAPS are follows: it helps to display typhoon intensity, track, the area of 15m/s, 25m/s winds or more, the area of 70% probability of typhoon can be displayed simultaneously. Also, it can help to search the past typhoons in the selected region, to show the track forecasts of other countries (RSMC, JTWC, etc) and to display the overlaped current weather chart (850 hPa stream line , SST, 500 hPa height, etc.) and many model results.

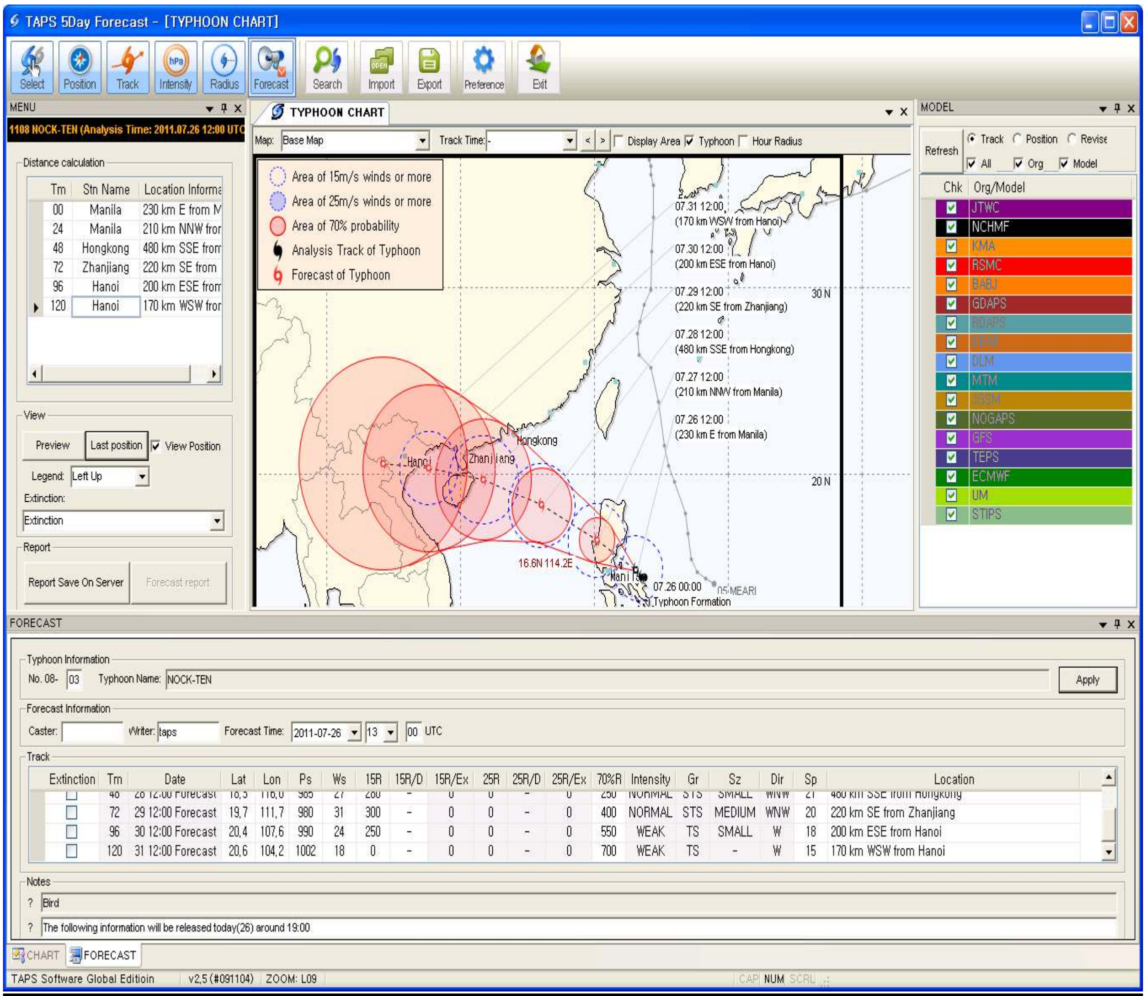
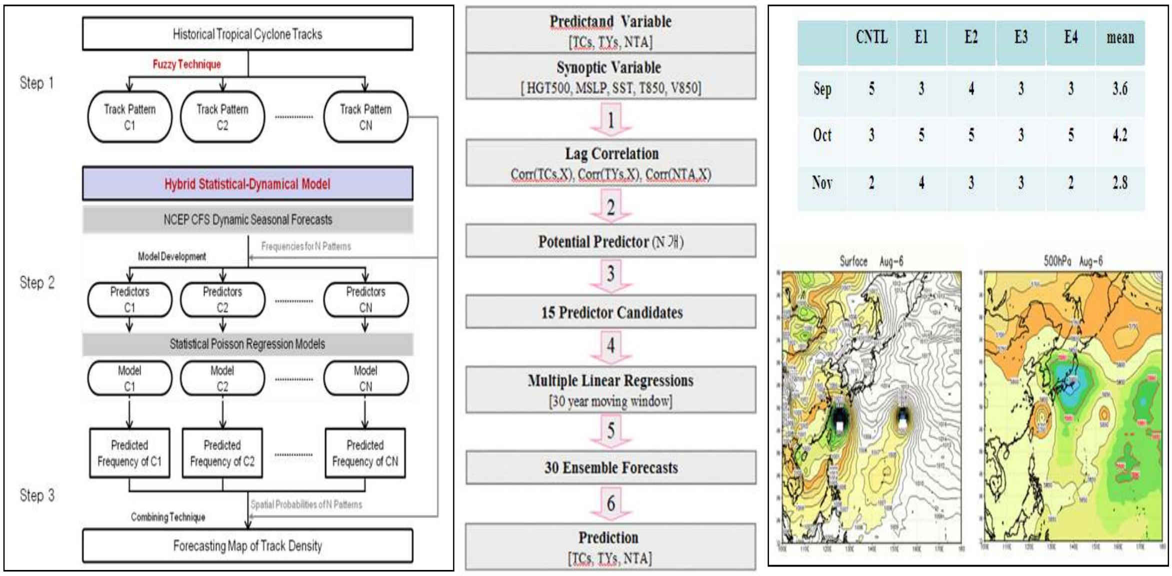


Fig. II-1-2. Examples of typhoon forecast by using TAPS in English version

- **Test operational running of typhoon seasonal prediction systems**

NTC/KMA operates three types of seasonal prediction systems for forecasting typhoon genesis frequency and track patterns. For each season, three-month prediction is made one month prior to the target season. The seasonal prediction outputs consist of monthly statistics for the total number of typhoon occurrences in the western North Pacific (WNP), information on typhoons that would affect the Korean peninsula, possible track patterns. The official seasonal typhoon prediction is determined by consensus of the three systems, the NTC-COAPS system based on FSU/COAPS[1] 3D primitive equation global spectral model ensembles at a resolution of T126L27 (a Gaussian grid spacing of 0.94º), the NTC-KNU[2] system based on multiple linear regression model, and the NTC-SNU[3] system based on hybrid type of statistical-dynamical model. The Climate Prediction Division disseminates the prediction information to the public. A web-based seasonal typhoon prediction system which is under construction will enable us to make easy access to seasonal prediction product of each system. KMA and BoM[4] will exchange data for dynamical seasonal prediction such as NTC-COAPS and POAMA[5]-BoM based on the collaboration plan in 2011. When the plan is implemented as planned, we expect to expand our coverage to the Indian Ocean and the southern hemisphere.



Hybrid Statistical-Dynamical Model **Regression Model** **Dynamic model Ensemble**

Fig. II-1-3. KMA's typhoon seasonal prediction systems

1 FSU/COAPS: Florida State University/ Center for Ocean-Atmospheric Prediction Studies
2 KNU: Kongju National University
3 SNU: Seoul National University
4 BoM: Bureau of Meteorology, Australia
5 POAMA: Predictive Ocean and Atmosphere Model for Australia

b. Hydrological Achievements/Results

- **<u>Research Project of Flood Defense Technology for Next Generation</u>**

The project of Flood Defense Technology for Next Generation is launched to develop advanced technologies for national flood defense capacity. The final goal of the project is to develop and enhance the technologies for Food Forecasting for Next Generation, Flood Control Capacity Increase, and Integrated Bain wide Flood Control Techniques for Future, National Flood Management System (Fig. II-1-4).

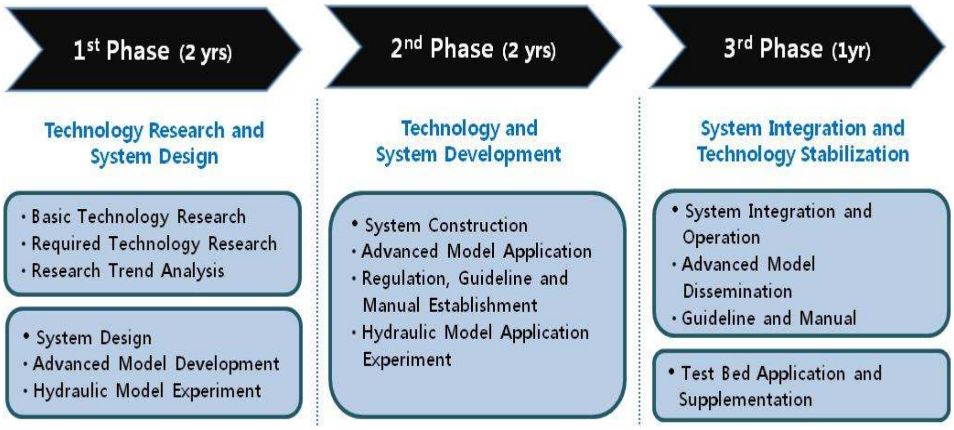
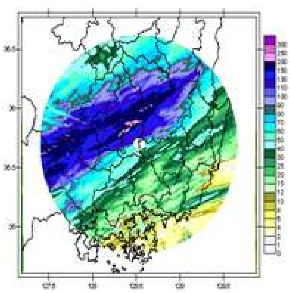


Fig. II-1-4. Plan of the project

The objectives of the project are as follows:

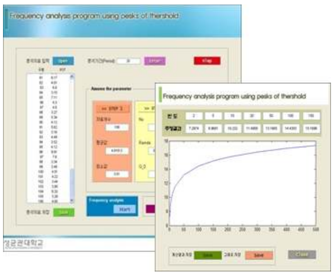
. National Flood Control Master Plan Assessment and Standardizing of Technology
. Standardization Technology for Certifying the River Embankment and Floodgate
. Optimum Technology Development for management of Basin Flooding
. Management Technology Development for Extreme Flood caused by the Hydraulic Construction Failure
. Enhancement of Non-structural Urban flood Control Measures and its Assessment Techniques Development

Major achievements in 2011 are in Fig II-1-5.

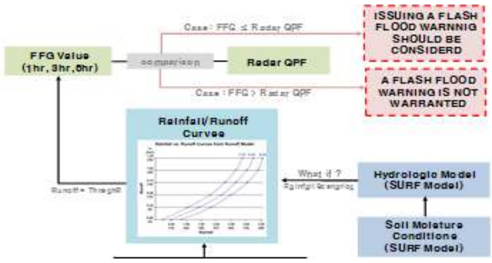


a) Development of radar rainfall data quality control technology

b) Development of unsteady flow hydraulic experimental equipment



c) Development of flood stage frequency analysis program



d) Keynote design of flash flood forecasting system

Fig. II-1-5. Research contents in detail, 2011

- **Four Major Rivers Restoration Project**

The Four Rivers Restoration Project aims to encourage local communities to pursue regional development through river restoration by preventing water-related disasters, securing water resources, improving water quality, and creating multi-purpose spaces along the rivers. As of December 1, 2011, 89% of the entire process was completed (99.7 % of weirs, 99.6 % of dredging and 40.3% of dams) (Fig. II-1-6).

16 weirs and floodgates in the Korean major rivers were constructed (Fig. II-1-7), small hydropower stations at 6 weirs already started generating electricity. By the end of this year, 4 stations will be completed and 6 more station will start operating in 2012. Bicycle lanes in Han River, Geum River and Yeongsan River have been almost completed, and the lanes in Nakdong River will be constructed by the end of December, this year.

With respect to flood prevention of the project, water level decreased by 2~4 meters at major spots of the mainstreams although there was record-heavy rainfall in flooding season in 2011 and it is expected that water shortage problems will be solved by constructing weirs, dredging and increasing agricultural reservoir capacity through this project. The 139 km^2 ecological park was created along rivers to increase river-friendly spaces. The 1,592 m long bicycle lane is very much enjoyed by the public and will contribute to promoting tourism industries. In addition, the eco-friendly small hydropower station generating the electricity which is capable of handling 5,800 households in total annually was introduced in UNEP Green Economy Report 2011 as a good case of Green Growth.

This year, the entire process of the project has been completed, but various relevant projects such as a walking tour program and historical relics research activity along rivers will be introduced continuously to increase the beneficial outcomes of the project for the future. Also, the comprehensive analysis of the project outcome will be implemented after the remaining projects are completed. (for more information, please visit www.4rivers.go.kr and www.mltm.go.kr).

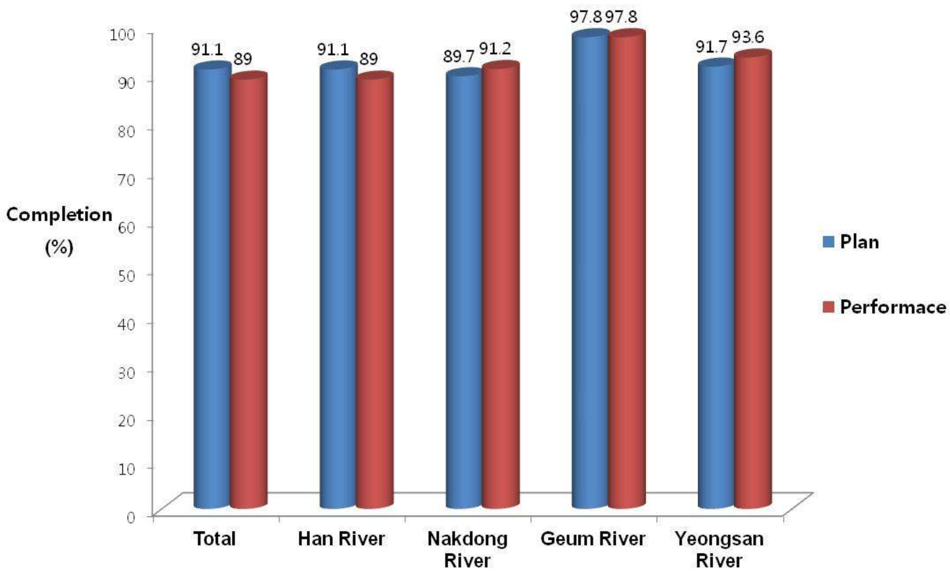


Fig. II-1-6. Completion of the project (as of December, 2011)

a) Yeoju weir in Han River

b) Baeje weir in Geum River

c) Changyeong weir in Nakdong River

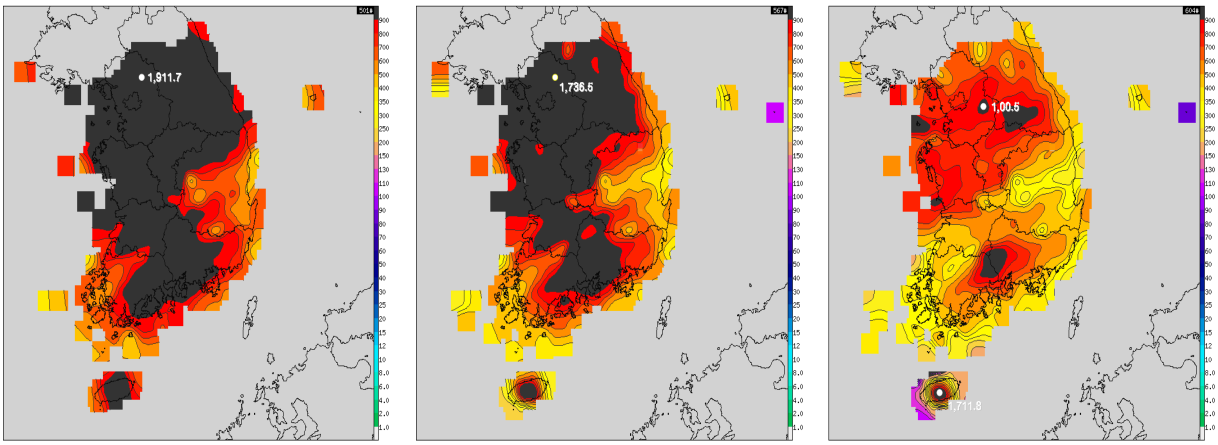
d) Junsa weir in Yeongsan River

Fig. II-1-7. Weir Construction in four rivers

c. Disaster Prevention and Preparedness Achievements/Results

- **<u>Heavy Rainfall in Seoul, Gyeonggi and Gangwon</u>**

During summer seasons from June to September in 2011, the torrential localized rainfall and three typhoons damaged Korea, poring over than 1000mm of rain in the 44 rainfall gauge stations which is 2.6 times of average value of 17 stations, flooding the urban area and killing 51 people from landslides (Fig. II-1-8(a)). Three days rain of 587.5mm during 26 - 28 July in Seoul, the most rainfall since Korea began gathering weather data in 1907, was 40% of annual total rainfall. The 50 days rain from 22 June to 10 August was exceeded annual total rainfall in the six regions as follows: 1736.5mm of rain in Dongduchun, 1608.8mm of rain in Seoul, 1589.3mm of rain in Yangpyong, 1565.3mm of rain in Ganghwa, 1465.8mm of rain in Chuncheong, 1265.5mm of rain in Incheon (Fig. II-1-8(b)). The torrential localized rainfall and three typhoons during summer seasons left 63 people dead and 747.7 M US dollars of property damages (Fig. II-1-8(c)).



(a) Summer Season (6.1~9.31) (b) 50 Days (6.22~8.10) (c) Flood Season (6.22~7.16)

Fig. II-1-8. Contour Distribution of Accumulated Rainfall

A record downpour on 27 July left 39 people dead and eight missing in Korea. Some 620 people were left homeless, while the power at 66,093 homes was cut off and 720 homes were inundated. Seoul was paralyzed once again by torrential rain. Heavy downpours began on afternoon of 26 July and continued sporadically until 28 July. Accumulated rainfall recorded until 10 p.m. on 27 July was 579mm in Yangju, 545mm in Pocheon, 527.5mm in Dongducheon, 517mm in Hanam, and 503mm in Gapyeong, Gyeonggi Province, 465mm in Seoul and 440.5mm in Chuncheon, Gangwon Province. The amount of rain that fell on Seoul from 26 to 27 July beat the previous record precipitation for the month of 390.6 mm recorded on July 10, 1940. A tributary of the Han River running through Gonjiam, about 50 km south-east of Seoul, overflowed and killed five residents, Storms have battered the central region of the country since late Tuesday, causing rivers to burst their banks, disrupting travel and triggering power cuts. Swelling waters at a stream in Gwangju, Gyeonggi Province killed six people, and three bodies were found after a landslide in Paju just north of Seoul.

The rain submerged some subway lines, main highways (Fig. II-1-9) and low-lying parts of the capital, creating hellish conditions for commuters. Parts of Gwanghwamun in downtown Seoul were submerged in waist-deep water, causing traffic to come to a halt (Fig. II-1-10). Police blocked some 20 areas in the capital, trapping millions of commuters in their vehicles and causing many to report late to work.

(a) Main highways in Gangnam-Gu (b) Subway lines in Gangnam-Gu

Fig. II-1-9. Heavy downpours cause flooding (i) main highways and (ii) subway lines in Gangnam-Gu in downtown Seoul, Korea

(a) Main highways in Gwanghwamun (b) Subway lines in Gwanghwamun

Fig. II-1-10. Heavy downpours cause flooding (i) main highways and (ii) subway lines in Gwanghwamun in downtown Seoul, Korea

The downpours triggered a landslide at a mountain resort in Chuncheon early morning in 26 July, killing 13 students from Inha University in Incheon who were there doing volunteer work at a nearby elementary school during their summer vacation (Fig. II-1-11).

Another landslide in a suburb in southern Seoul buried dozens of houses and killed 17 residents. A landslide in Woo-myun mountain (Fig. II-1-12 and Fig. II-1-13) which was caused by the downpours, has shocked South Koreans. Fast-moving muddy water filled the streets of the capital, forcing some commuters to scramble onto the roofs of their partially submerged cars to safety. The heavy rain has so far left about 620 people homeless and flooded 720 houses and about 100 vehicles throughout and 23 roads were closed.

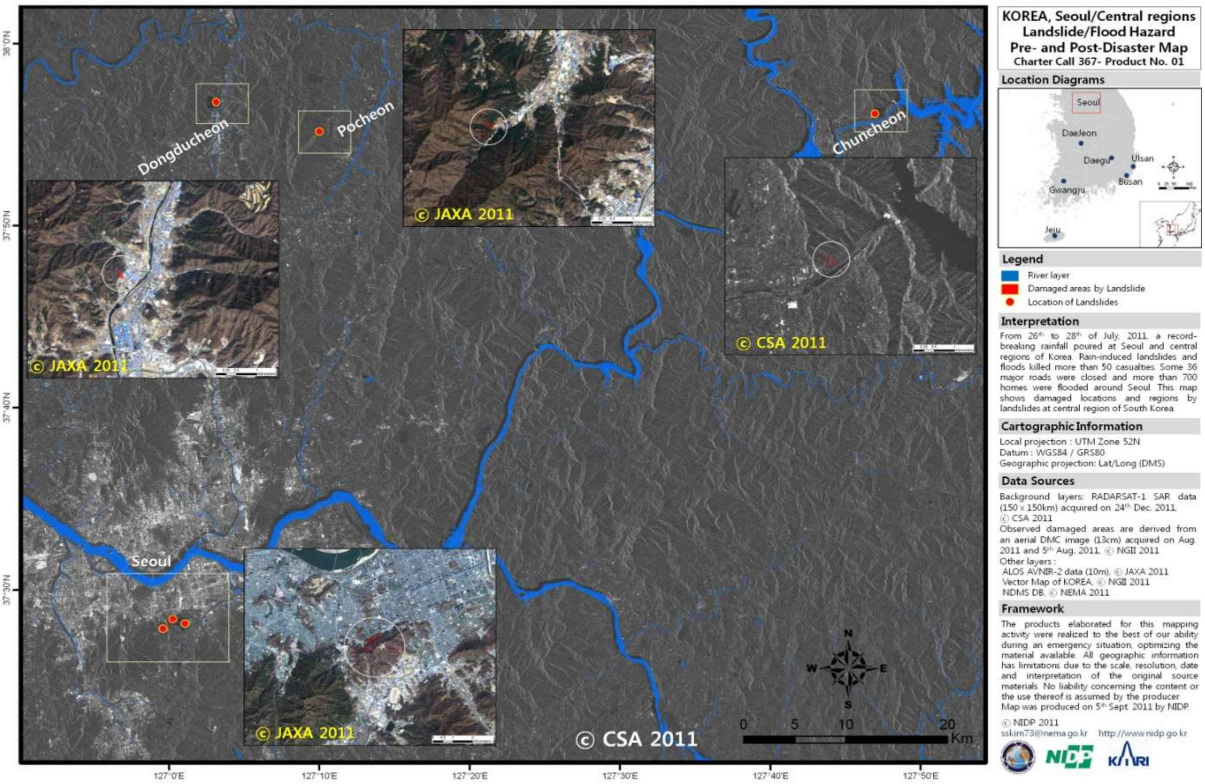


Fig. II-1-11. Langslide Hazard Map in Seoul, Gyeonggi and Gangwon Provinces

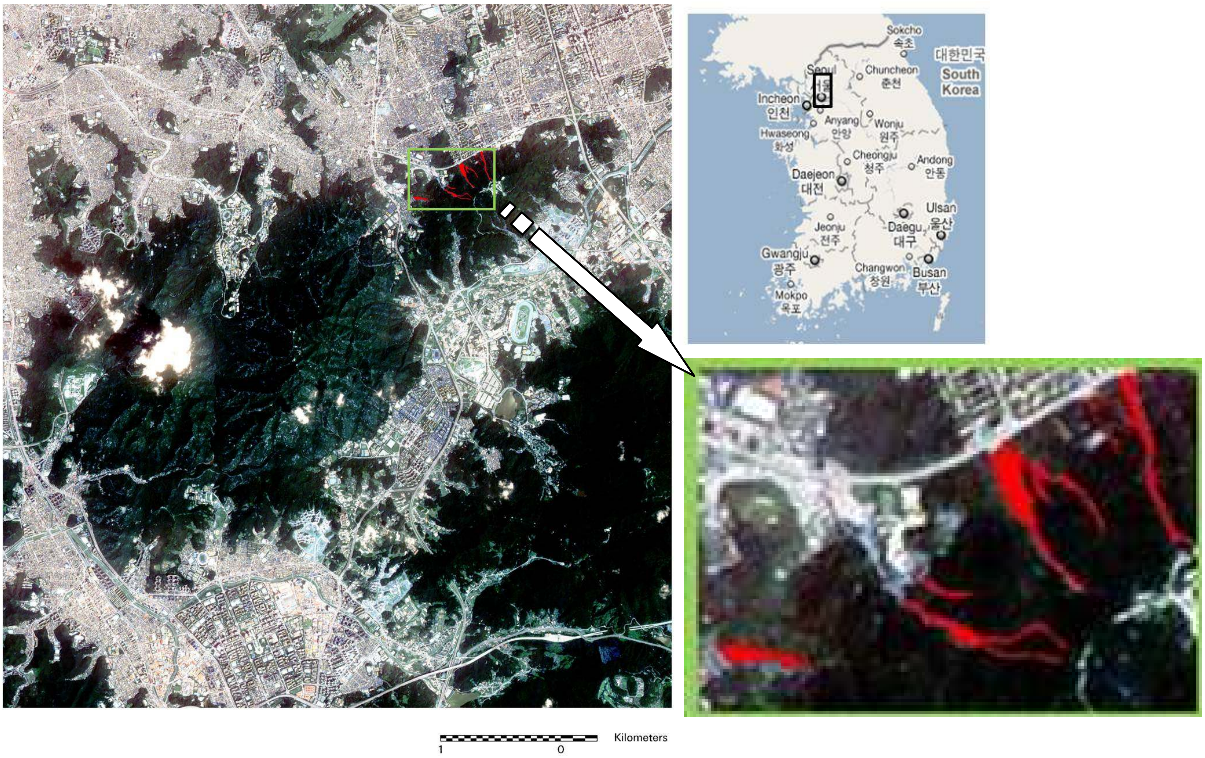


Fig. II-1-12. Langslide Hazard Map in Woo-myun mountain

(a) Apartment in Gangnam (b) Street in Gangnam

Fig. II-1-13. Fast-moving muddy water filled the (a) apartments and (b) streets in in Gangnam-Gu in downtown Seoul, Korea

People in Seoul, where smartphones are ubiquitous, posted dozens of photos on Twitter and Facebook showing inundated streets and mud-covered cars. Many complained Seoul had neglected to prepare for the deluge. For timely warning and management flood disasters in urban area, National Disaster Management Institute (NDMI) suggested a new project of smart emergency dissemination network system to collect posted information and photos from smartphone users and disseminate warning massages to persons in dangerous area to escape and drive to control coming into damaged or inundated area. This project will be started in January 2012.

d. Research, Training, and Other Achievements/Results

- Nil

e. Regional Cooperation Achievements/Results

- Nil

f. Identified Opportunities/Challenges for Future Achievements/Results

- Nil

2. **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 Achievements/Results**

- Nil

b. **Hydrological Achievements/Results**

- **Development of the Assessment System of Flood Control Measures on socio-economic impacts (ASFCM)**

The project entitled 'Assessment System of flood Control Measures on the Socio-economic Impacts' led by the Ministry of Land, Transport and Maritime Affairs (MLTM), Republic of Korea, was started in 2008 to establish the guideline for flood control measures regarding socio-economic impacts in TC member countries. As shown in Fig. II-2-1, this long-term project is proceeding to be applied in member countries in 2012 according to each year scheme.

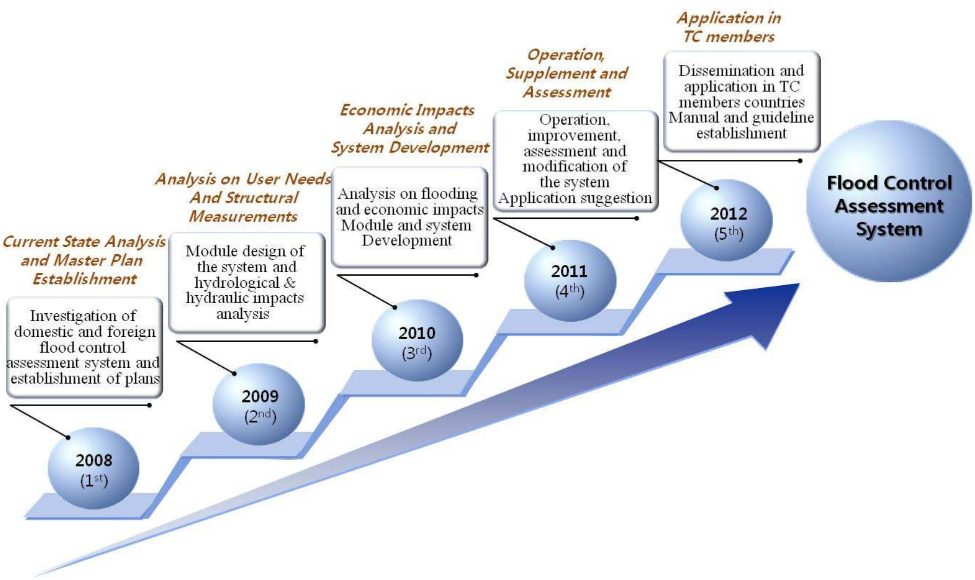


Fig. II-2-1. Annual task target (2008 to 2012)

In general, the criteria for selecting a flood control measure is not clarified and but ambiguous, so it is required to resolve the existing problems caused by the absence of integrated process or system to assess flood control measures efficiently. To achieve this, the objective and integrated assessment system of flood control measures has been developed and it will be applied in TC member countries to reduce socio-economic damages caused by typhoons and flood.

The assessment system was already built in 2010, and this year, modification and supplement of the system has been implemented. In addition, a guideline for assessment and usual manual in Korea are major outcomes. Base on that, both of a guideline and user manual will be translated into English and distributed to maximize the application capacity in member countries.

The assessment system of flood control measures consists of five modules in Fig. II-2-2. The input sections for socio-economic assessment and for HEC-RAS simulation to estimate flood stage were constructed. And the section for computing expected flood inundation areas according to estimated flood stage was built and the module for economic analysis to make ultimate assessment possible was developed. Fig II-2-3. shows the main page of the assessment system.

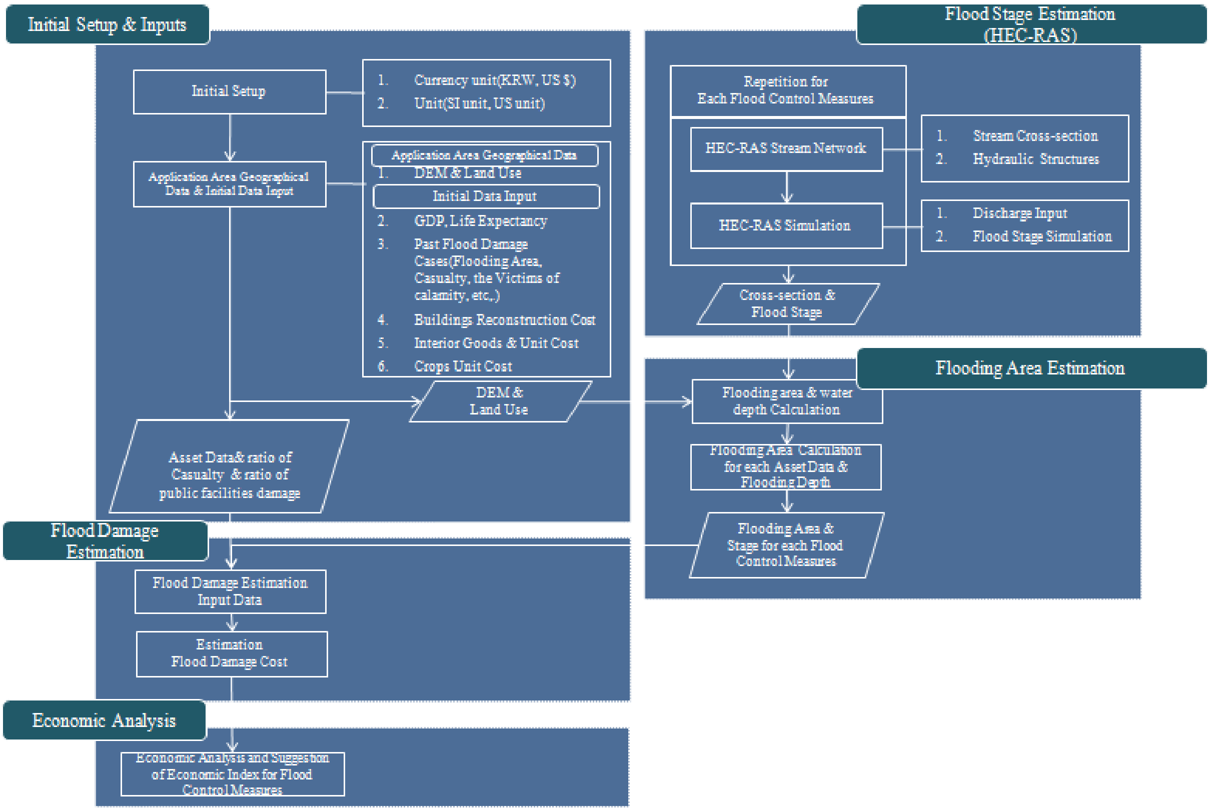
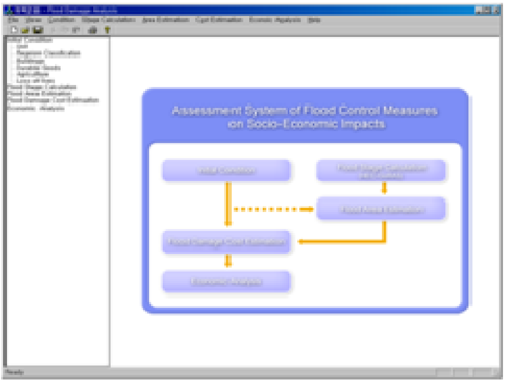
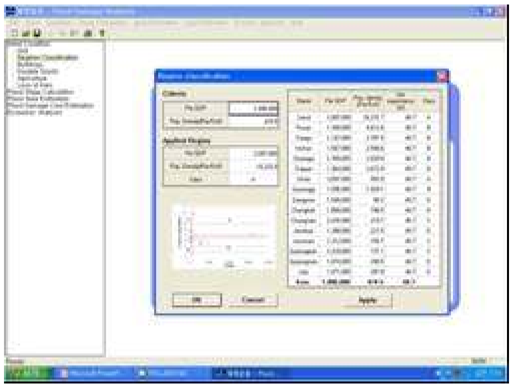


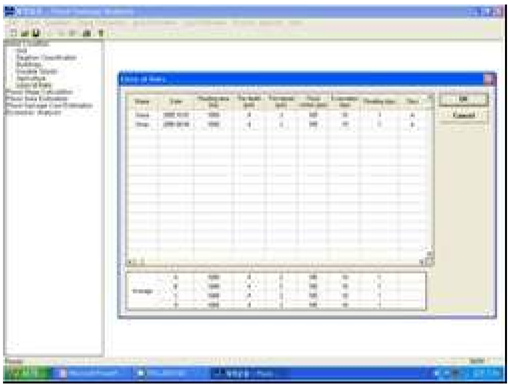
Fig. II-2-2. ASFCM Framework Flow Chart



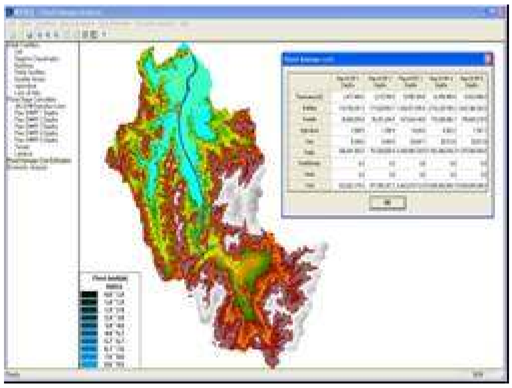
a) Main page



b) Economic analysis: Regional Classification



c) Economic analysis: Human damage



d) Economic analysis: final results

Fig. II-2-3. ASFCM System

c. Disaster Prevention and Preparedness Achievements/Results

- **<u>Foundation of promotion corps for complementary of vulnerable zones</u>**

National Emergency Management Agency (NEMA) established the promotion corps on 29 November 2011 for complementary of vulnerable zones and activating regional economy which regions are included in vulnerable zones. For the reinforcement of disaster prevention on disaster vulnerable zones, rural streams, and construction sites, government will support budget of 556 million US dollars for 2012. The promotion corps organized the technical support team including governmental officers of NDMI and nongovernmental professors to protect the budget wastes and to prepare the countermeasures of vulnerable zones. In this year, improvement projects for 190 disaster vulnerable zones will be completed.

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 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 Achievements/Results

- Nil

b. Hydrological Achievements/Results

- Nil

c. Disaster Prevention and Preparedness 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

4. 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 2008 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

- Nil

b. Hydrological Achievements/Results

- **<u>Comprehensive Disaster Management Measures responding to Climate Change</u>**

In Korea major cities, the annual average temperature has increased about 1.8 ℃ for last one hundred years, and this figure is two times more than the increase of global average temperature, 0.75℃. Rainfall has increased by 17 % for the same period, but the number of days with rainfall has decreased by 18 %. In addition, localized heavy rainfall with higher intensity has been increased and become more frequent. According to climate change and abnormal meteorological phenomenon, anticipatory responding measures are established and advanced disaster control system is constructed by the paradigm shift of the existing system. Under the office of Prime Minister, The Task Force regarding Public-Private Partnership was formed and Comprehensive Disaster Management Measures was established by conducting field investigation, analyzing the inefficiency of the existing policies by governmental sectors, and collecting experts' opinions.

Fig. II-4-1. Keynote of Disaster Management responding to Climate Change

To set up the comprehensive master plan, 163 sub-unit projects for climate change response and unban disaster control were reviewed. The keynotes and major strategies of disaster control measures responding to climate change are shown in Fig. II-4-1, and 28 core projects in 9 areas of 5 strategies were established (Fig. II-4-2).

The expected results of the project are as follows:

- Efficient disaster control by timely forecasting
- Prevention of Flood and urban inundation caused by localized heavy rainfall
- Prevention of casualties by reducing disaster vulnerability and risk in sphere of living
- Prompt actions by building integrated disaster management system
- Cultivation of national disaster prevention capacity for the future

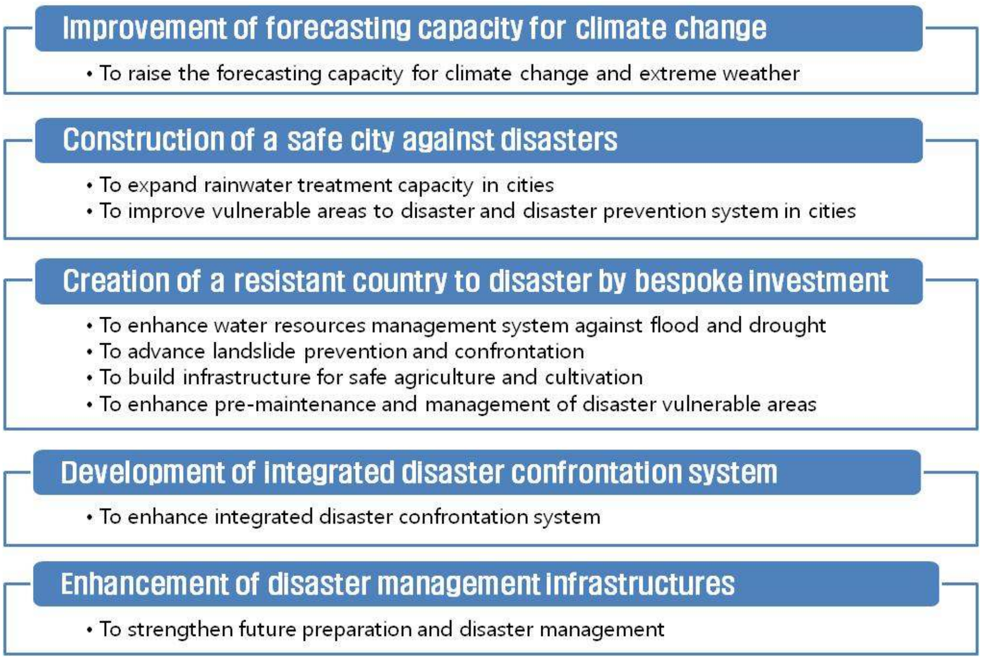


Fig. II-4-2. Core projects of the project in detail

- **Flood Risk Mapping**

Since 1999, the flood risk map design project including expected inundation areas and depth has been implemented to provide basic information on river flooding for the local governments and relevant authorities and it will be completed for all Korea national rivers by 2015. The information on a map is applied to establish effective disaster prevention policies. According to the flood risk map, it will be possible to implement forecast and early warning for flooding inundation in vulnerable areas. In addition, casualties and property damages can be reduced by using the map as a part of flood control measures. The map will be applied to make a disaster hazard map, a flood insurance rate map, and basic data for emergency response planning (Fig. II-4-3 and Fig. II-4-4).

Fig. II-4-3. Flood risk map (paper-type map)

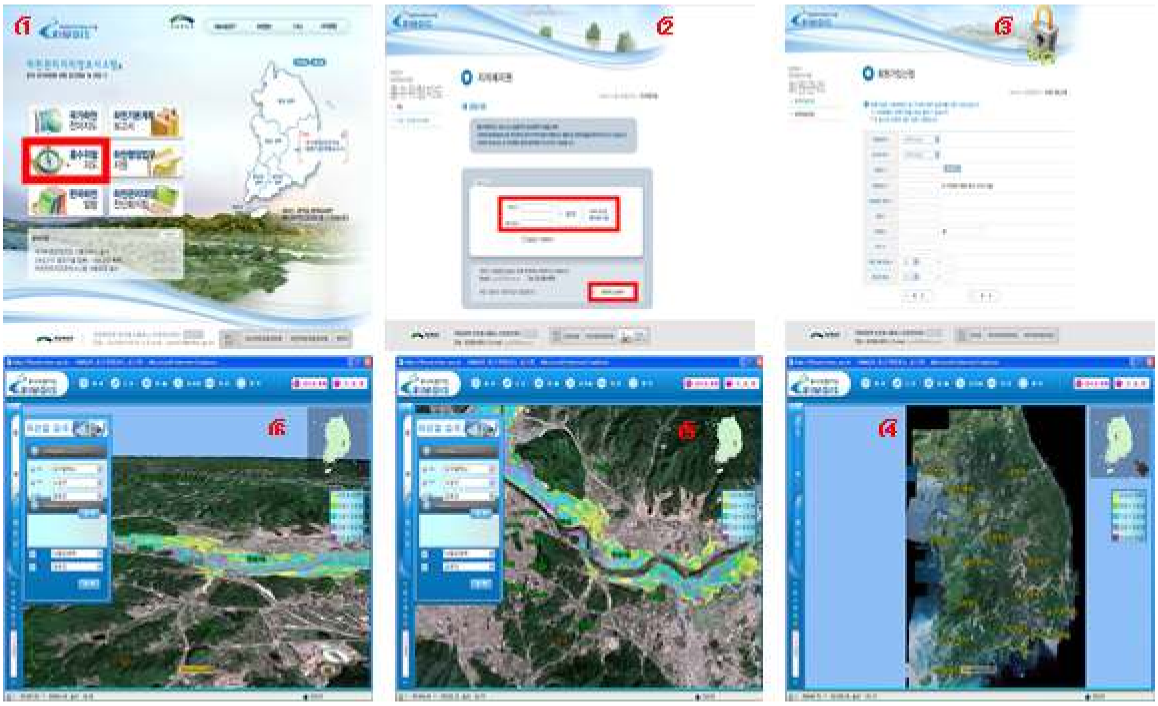


Fig. II-4-4. Online-system of the flood risk map (digital map) (RIMGIS, http://www.river.go.kr)

c. Disaster Prevention and Preparedness Achievements/Results

- Enhanced WEB GIS Based Typhoon Committee Disaster Information System

The WGTCDIS contributes to typhoon related disaster risk reduction in Asia and the Pacific region though timely and efficient way of information sharing via its website (www.tcdis.org). The WGTCDIS can also be used as a platform to share disaster information, knowledge and experiences, good practices, and other information related to typhoon related disaster risk reduction. The WGTCDIS have two main systems such as information shearing system and disaster information system. The information shearing system is to shear general information such as early warning systems and disaster management systems of Members, publications, news and photos regarding on TC and WGDRR activities and projects of WGDRR. The disaster information system is to give information of typhoon trajectories determined by nearest neighbor method (NNM) to minimize correlation errors regarding on typhoon trajectory and central pressure and to estimate damages from rainfall and wind speed which is determined by determined typhoon trajectory.

GeoLinking Services (GLS) for Displaying the Typhoon Related Disaster Information

In order to display the typhoon related disaster information, GeoLinking approaches were employed as shown in Fig. II-4-5. The log-in page shown as ① of Fig. II-4-5 will appear when the disaster information system menu is clicked. When you type ID and Password and click the log in button, the map of TC Member will be shown as ② of Fig. II-4-5. To get the account for ID and password, you visit the upper center corner of the main page and click the Recommend button. If the button is clicked, you can write a letter to ask for an account to web master with the information such as name, affiliate, and the reason of account open. After checking the purposes, the web master will send the ID and Password to you by e-mail described in your request letter. The Typhoon Information menu has all the information of the typhoons from 1951 to 2010, which are stored in database including GIS. Similar typhoon can be checked out by the computer program running modeling and the algorithm in background mode. When the observation data are inserted, the predicted track and the estimation of loss can be simulated. When you select the Typhoon list menu tab, all the typhoon names from 1951 to 2010 are listed below the Typhoon list menu shown in ③ of Fig. II-4-5. You either click a name of typhoon or you can insert specific period from one date to another date, then the information on the typhoon will be shown. If a typhoon name is clicked, the icon of typhoon eye, its pressure and track will be displayed. The character "I" icon is clicked, detailed information will be shown in table which includes latitude, longitude and central pressure and be shown. When you select the Similar Typhoon search tab, a box will be displayed to insert the date, longitude and latitude, and central pressure can be inserted as shown in ③ of Fig. II-4-5. To facilitate the input process, the text file can be imported. The detailed track information can be saved and exported as a text file format. Disaster Information shows all the damage related information based on the data obtained from the member countries.

Web GIS based system enables user to choose region or province of interest, the enhance view of which is shown to allow user to select any particular data displayed in the map. Another way of display the disaster information is to select a particular typhoon and then, related disaster data and information are shown in the Web GIS based system. The Regional Risk Analysis menu shows the historical data of damage when the expected precipitation and wind velocity. Assuming that the regional conditions such as terrain has not changed much, the estimation can be made based on the trend in the past. The damages can be inferred from the historical data for each region. Regional estimated data can be compared. The result can be listed in the middle of window, and total loss and public facility damages can estimated by region, when the name of region is clicked. In the WGTCDIS, two ways of risk assessment have been established for the members during typhoon. One of the representative tools for risk assessment is HAZUS-MH developed by FEMA of USA, which is based on the physical and statistical technology to evaluate the strength of hazard and predict damage considering the assets in the region of interest. Scientific and logical method used in HAZUS-MH allows users to estimated gross amount of damage in the event of hurricanes; however, the depth and the level of analysis are somewhat unrealistic when the data cannot be collected in such a level, which is the case for WGTCDIS. Instead, a statistical approach employed by Geoscience of Australia is more appropriate for risk assessment in regional or national level employed in WGTCDIS. Natural Hazard Mapping produced by Geoscience of Australia is online system which provides disaster information for flood, earthquake and landslide using web-GIS system. The WGTCDIS incorporates such an approach to enable users to access disaster information. The Web GIS based system enables user to choose region or province of interest, the enhance view of which is shown to allow user to select any particular data displayed in the map (④ of Fig. II-4-5). When user click the menu of Image located in the bottom of the Tool Bar, the image icons are displaced as the local area had experienced damages shown in ⑤ of Fig. II-4-5. When user click any interesting image icon displaced in the GIS map, the photo images and information such as media, report and portal information will be presented shown in ⑥ of Fig. II-4-5.

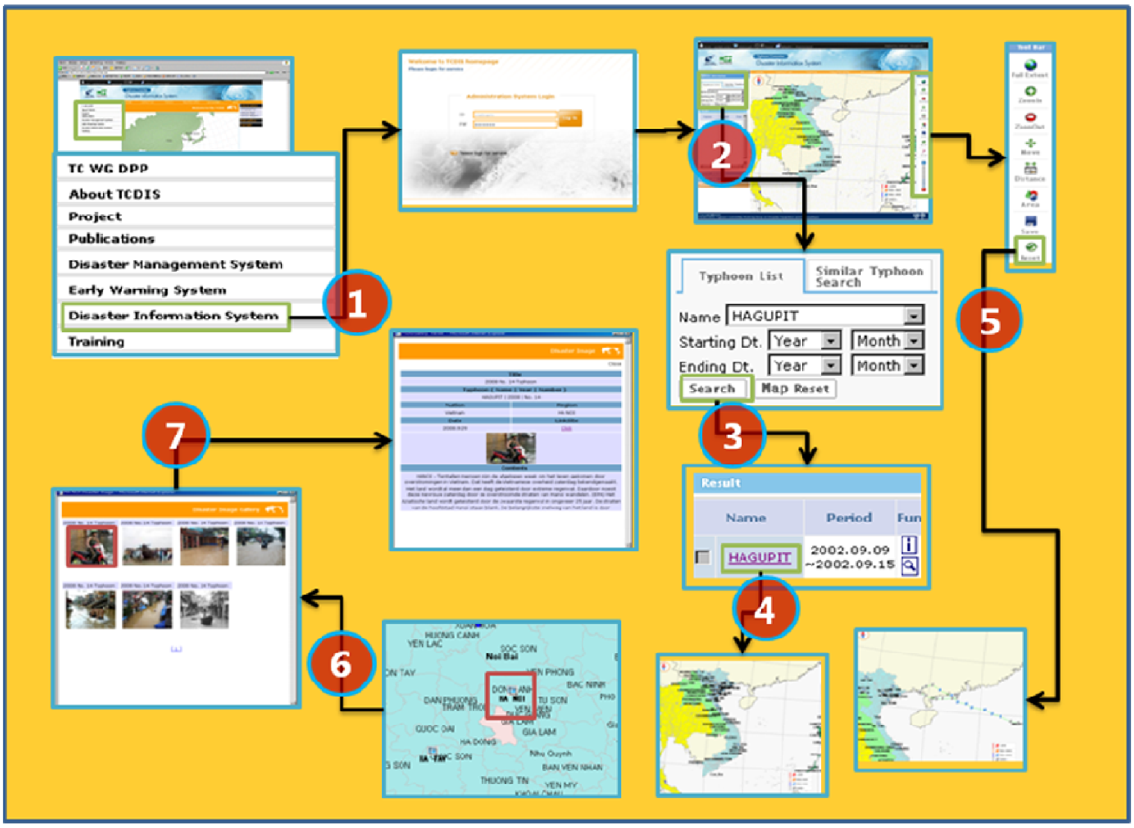


Fig. II-4-5. Example of GeoLinking services to display the typhoon related disaster information

Typhoon Trajectories Estimation

Three important data for the warning and management of typhoon related disasters are i) meteorological information of past typhoons such as path, central pressure, maximum wind speed; ii) meteorological records for wind speed and rainfall rate at each weather station during typhoons; iii) damage records during typhoons. The meteorological information of past typhoons is statistically processed using NNM (Nearest Neighbor Method) to match a past typhoon which is the most similar to the present typhoon forecasted by meteorological agencies in the world. The technique uses NNM (Nearest Neighbor Method), a pattern analysis for random phenomenon, to classify past typhoons similar to the typhoon of interest (Silverman, 1986). NNM estimates and classifies nearest neighbor density function for target data (projected path and pressure of the typhoon of interest) and reference data (past typhoons) to select a past typhoon which is the most similar to the typhoon of interest.

Determination of weights for each factor in multi-dimensional NNM is very essential because it decides relative importance. In general statistics, the aggregated weights can be obtained from sensitivity test for its factor; however, the general mean value theorem cannot be applied to the meteorological information of the typhoons because of its non-stationary characteristics. Hence, the relative magnitude of each factor affecting wind speed is used to determine the weights. However, it was found that the relative weights often produced prejudiced information generating similar typhoons with large margin of error in trajectory as well as central pressure. Also, this method considers only the similarity of path and the magnitude of pressure not the similarity of spatial ranges covered by the typhoon, which is essentially a function of path and strength of the typhoon. As a result, the damage induced by the typhoons is not match the general acceptance.

In the WGTCDIS, the similarity analysis is upgraded to use spatial correlation as a measure of similarity. As an example, Fig. II-4-6 shows the scattered plots for maximum wind speeds and central pressures recorded for 1547 typhoons from 1951 to 2007 in RSMC best tracks. It clearly shows a high correlation of 91%. Using the improved method, the similarity analysis for typhoon MAEMI (2003) was retried to find that typhoon SARAH (1959) has about 89% of similarity and much improved compared to the previous results as shown Fig. II-4-7.

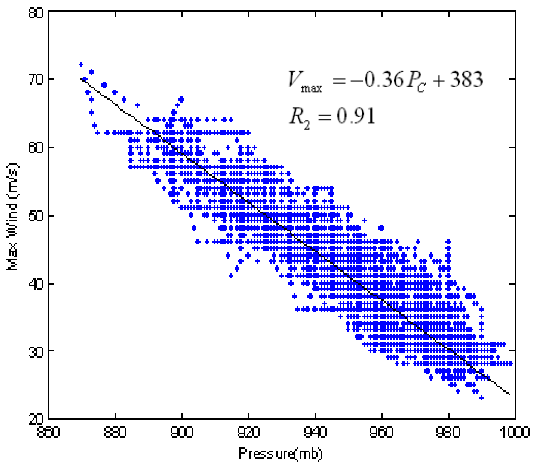
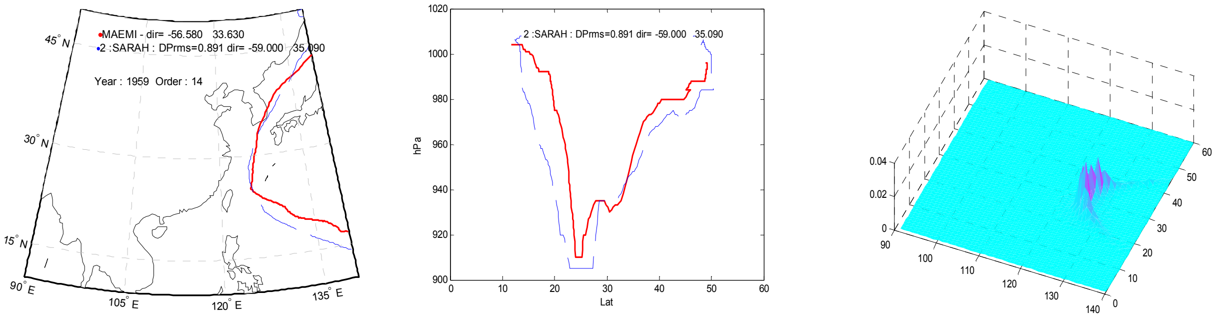


Fig. II-4-6. Correlation of maximum wind speeds and central pressures recorded for 1547 typhoons from 1951 to 2007 in RSMC best tracks. In which V_{max} is the mum velocity and P_c is the central pressure



(a) Comparison of typhoon trajectories (b) Comparison of central pressure distribution (c) Correlation coefficient = 91%

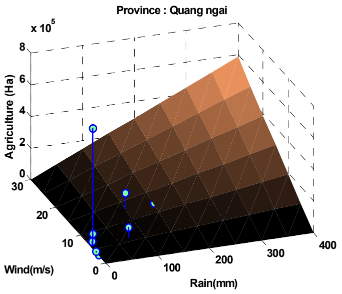
Fig. II-4-7. Similarity Analysis for Typhoon MAEMI using Improved Meth. In which ———: trajectory of Typhoon Maemi (2003) and - - - - - - : trajectory of Typhoon Sarah (1959).

Localized Damages Estimation

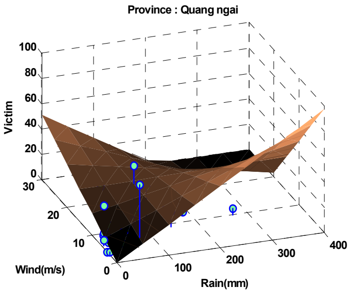
Once the most similar typhoon of past is statistically found, the damage of the typhoon can be rough estimation of projected damage. Another way of predicting typhoon damage uses local meteorological damage and weather reports during past typhoons. For each typhoon event, wind speed and rainfall rate have been recorded at each weather station, in which the accumulated rainfall rate and the maximum wind speed can be representative factors of hazard in the regional area. After each typhoon event, most of regional authorities in TC Members investigate and record physical and economical damages. Using both data, the amount of damage can be correlated with the corresponding regional weather information, which presents the functional trend of damages as dependent variable and weather information as independent variables.

Two risk assessment methods were established for the TC members in the WGTCDIS. One of the representative tools for risk assessment is HAZUS-MH, developed by FEMA in USA, which is based on the physical and statistical technology for evaluating the strength of the hazard and for predicting the damage that a typhoon may cause considering the assets in the region of interest. The scientific and logical method used in HAZUS-MH allows the users to estimate the gross amount of damage in the event of a typhoon, but the depth and level of analysis are somewhat unrealistic when the data cannot be collected on such a level. The other risk assessment method, a statistical approach employed by Geoscience of Australia, is more appropriate for risk assessment on the regional or national level, for which purpose it is employed by the WGTCDIS. Natural Disaster Hazard Mapping, produced by Geoscience of Australia, is an online system that provides disaster information on floods, earthquakes, and landslides using a Web GIS based system. The WGTCDIS incorporates such an approach to enable its users to share typhoon disaster information and typhoon-related disaster risk assessment results.

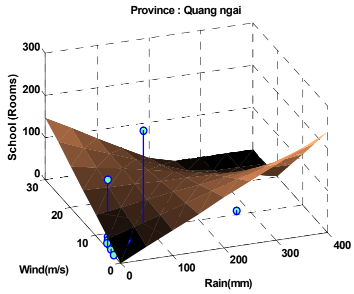
The Kernel density function (KDF) is used to estimate the typhoon-related damages considering the localized vulnerability of the region of interest. The localized KDFs of typhoon-related damages can be established by using historical rainfall and maximum wind speed data, as shown in Fig. II-4-8. Fig. II-4-8 shows a local area that incurred various typhoon-related damages due to various factors.



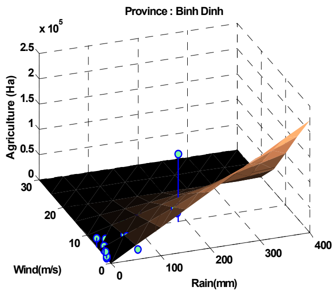
(a) Agricultural



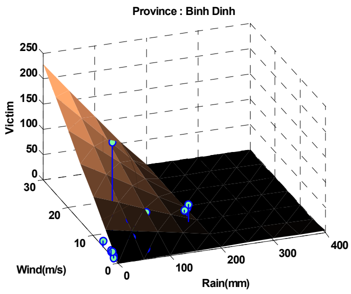
(b) Human life



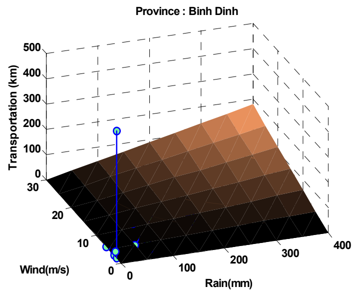
(c) School



(d) Agricultural



(e) Human life



(f) Transportation

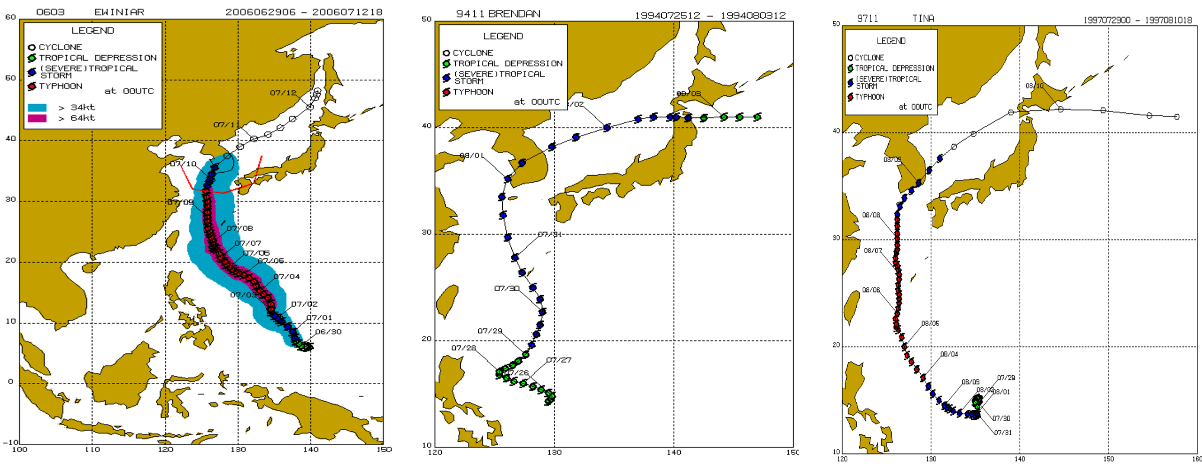
Fig. II-4-8. Estimated results of typhoon-related damages.

Promote value of WEB GIS based TCDIS (WGTCDIS) to TC Members, led by NIDP, will be continued in 2012. TC Members such as Philippines; Lao, PDR, Thailand, Cambodia and USA will provide GIS, metrological and disaster information for the WGTCDIS by end of 2009 and NIDP will offer the expert mission to set up WGTCDIS for TC Members and improve usage of the WGTCDIS. Enhance WGTCDIS and establish methodology to assess the socio-economic impacts of disasters, led by NEMA, Republic of Korea, will be continued in 2011. NIDP will continue to collect that information and make brochures and report by 6th WGDPP meeting, Seoul, Korea in 2011. Review progress of WGTCDIS project and enhance the Typhoon Committee's effectiveness and efficiency in meeting its purpose stated in the Statute of the Typhoon Committee will be continued in 2011. WGDPP will participate in a focused, integrated WGM, WGH, WGDRR, TRCG, and AWG Workshop with specific deliverables defined and to review progress of WGTCDIS project and future activities of WGDRR.

For extending WGTCDIS as ongoing project, validation of WGTCDIS of Viet Nam is necessary and typhoon and damage related data of new members are needed. Viet Nam further communicates to identify joint activities and inform the members for validation WGTCDIS of Viet Nam. Thailand, Lao PDR, Philippines, Cambodia and USA will prepare data for developing WGTCDIS of each Member. After building WGTCDIS for five TC Members, it is needed to Expert Mission for the members to give information of WGTCDIS and application of system. Expert Team will be organized on the TC Session and go to members when member will finish establishment of the member's WGTCDIS.

In 2011, the WGTCDIS will improve in more convenience and accessibility to user by integrating two services above mentioned and by providing abundant and various contents to members. Also, WGTCDIS is going to be applied to another more five members: Thailand, Lao PDR, Philippines, Cambodia and USA.

At September 1, the WEB GIS Based Typhoon Committee Disaster Information System (WGTCDIS) estimates Kompasu, the eighth storm of the season, is moving on a similar track to 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. II-4-9.



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

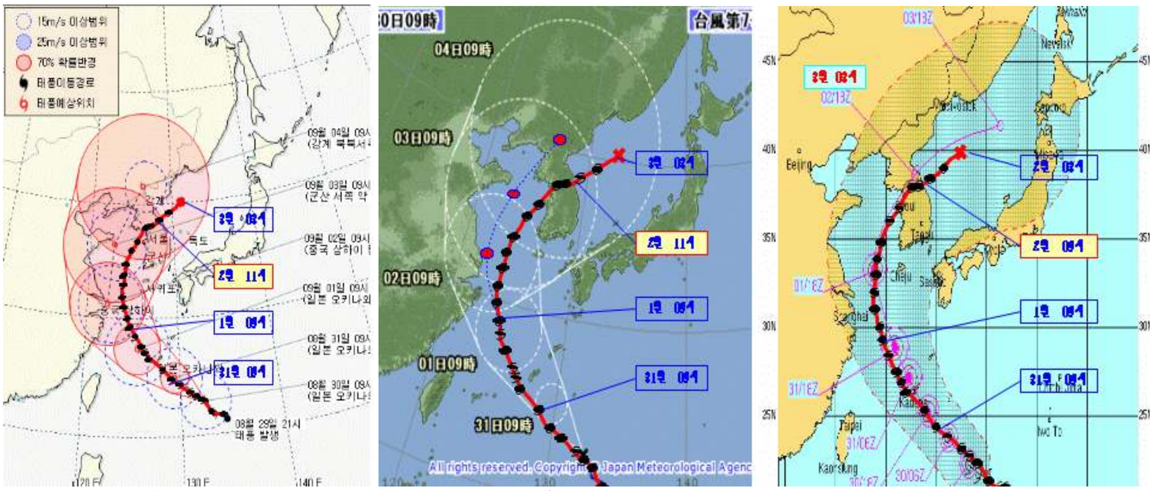
Fig. II-4-9. Estimated similar typhoon trajectories with typhoon Kompasu.

The characteristics and regarding damages of estimated typhoons are listed in Table II-4-1. Strong wind leads to severe damages of shredding the roof structure and vinyl greenhouse while intense precipitation didn't lead big damages. Typhoon Kompasu have more damages than other similar typhoons in spite of central pressures and rainfalls are almost same.

Table II-4-1. Comparisons of the characteristics and regarding damages of estimated typhoons and Kompasu.

	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 estimated typhoon trajectories among KMA, JMA and JTWC were compared shown in Fig. II-4-10. The result show that JTWC estimates best trajectory of typhoon COMPASU. These estimated results were used for input data of WGTCDIS to estimate similar typhoon trajectory shown in Fig. II-4-10.



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

Fig. II-4-10. Comparisons of Typhoon Trajectory Estimation.

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 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 2008 Typhoon Committee Annual Operating Plan goals)

   a. **Meteorological Achievements/Results**
      - Nil

   b. **Hydrological Achievements/Results**
      - Nil

   c. **Disaster Prevention and Preparedness 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 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 2008 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

- Provision of COMS Data and Satellite-Based Typhoon Analysis

COMS (Communication, Ocean, Meteorological Satellite) began its official operation providing satellite images and meteorological products on 1 April 2011 after its successful orbit testing. COMS images on the northern hemisphere (on an interval of 15 minutes) and on the Korean peninsula land (8 times an hour) help weather forecasters better understand typhoon's track, structure, intensity and center location when a typhoon approaches the peninsular. Fig. II-6-1 shows COMS local image when the 9th typhoon-MUIFA was making landfall in North Korea at 08:58UTC on 8 August 2011.

In 2005, KMA developed a user-friendly web-based typhoon analysis system based on the Advanced Objective Dvorak Technique (AODT) of SSEC/UW-Madison Space Science Engineering Center/University of Wisconsin-Madison. In 2011, KMA enhanced the accuracy by upgrading Advanced Dvorak Technique (ADT) of the typhoon analysis system from ver. 7.2.3 to ver. 8.1.3 and adjusting the algorithm for calculating the radius of strong winds for the Northwest Pacific region. Now, we are developing a system for monitoring precipitation and wind of typhoon using microwave satellite data such as AMSR-E, SSM/I and TMI. This system will be integrated into the web-based typhoon analysis system, thereby enhancing our capability to watch typhoon risks along with COMS images.

Reflecting forecasters' voices, KMA has been providing satellite-based typhoon analysis reports 4 times a day or 8 times a day in an emergency situation since 2010 (via the KMA intranet since 2011). This report includes essential typhoon information such as location of the center, maximum wind speed, central pressure, 15m/s radius of strong wind, average 3-hour wind speed/direction, typhoon pattern, and comments from satellite analysts and grounds for typhoon center estimations.

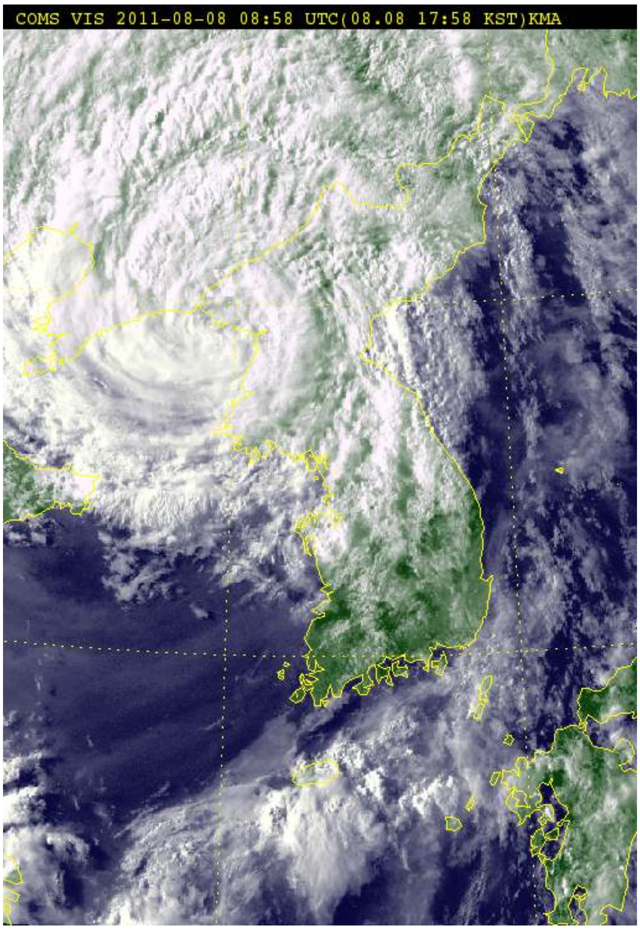


Fig. II-6-1. COMS local visible image when the 9th typhoon- MUIFA was making landfall in North Korea at 08:58UTC on 8 August 2011.

- Cross-governmental Radar Integration Project

In Korea, three agencies, Korea Meteorological Administration (KMA), Ministry of Land, Transportation and Maritime affairs (MLTM) and Ministry of National Defense (MND), are currently managing a total of 28 operational weather radars and plan to introduce about 3 more radars to meet their own mandates such as severe weather monitoring and forecasting, hydrological management and flood forecast, and military operation support (MLTM is running 7 units and MND 9).

On 30 June 2010, these tri-agencies signed an MOU to share weather-precipitation radars with each other and made a basic plan on 24 Nov 2010.

Expected benefits of cross-governmental radar integration are: addressing observation blind spots and expanding observation coverage by building a cross-governmental radar observation system; improving public service and developing source technology by carrying out joint R&D activities; and saving budget by sharing expensive imported radar resources.

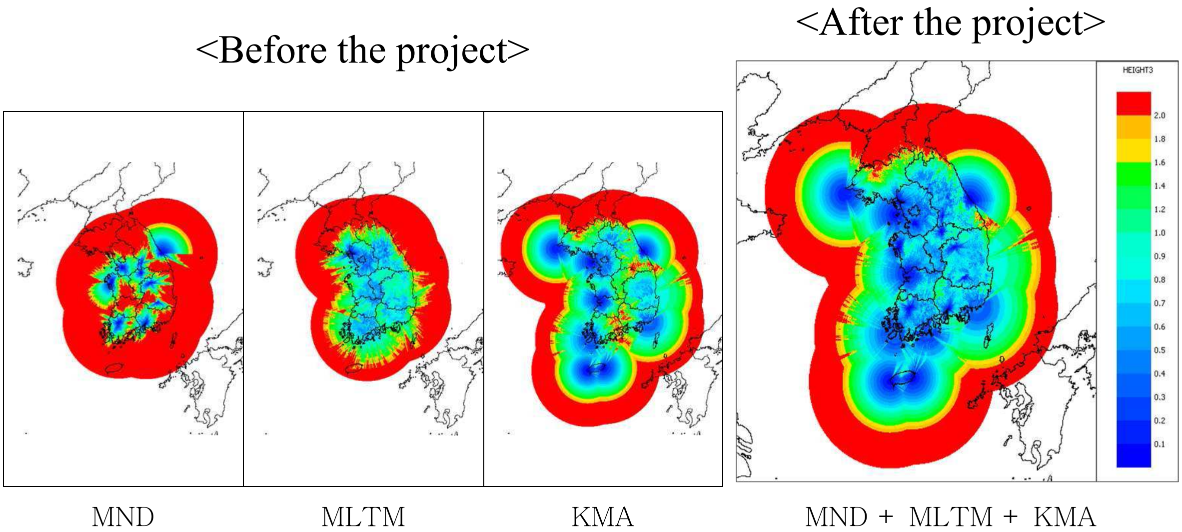


Fig. II-6-2. Expanded coverage by building a cross-governmental radar observation system

Fig. II-6-3. MND, MLTM and KMA signed an MOU to share weather-precipitation radars with each other on 30 June 2010.

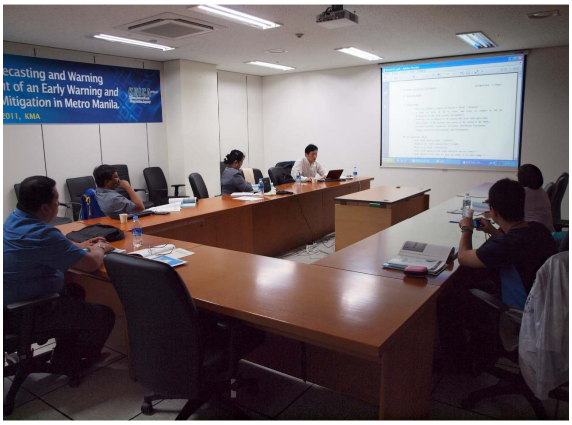
- **<u>KOICA Project - The Establishment of an Early Warning and Monitoring System for Disaster Mitigation in Metro Manila</u>**

The Project entitled "The Establishment of an Early Warning and Monitoring System for Disaster Mitigation in Metro Manila" is on the right track expected to be accomplished within the year 2011.

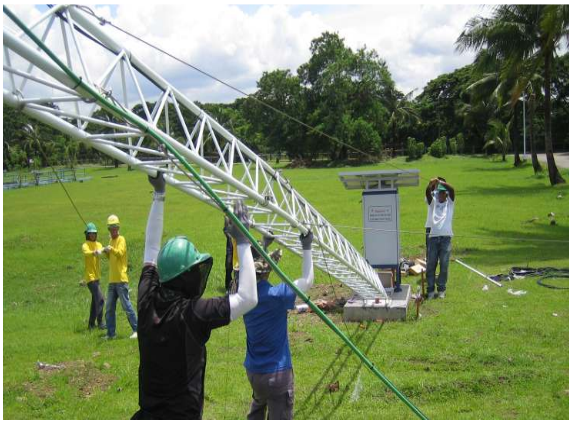
The three-year $300M KOICA Project is aiming at establishing a food forecast and warning system for the Pasig-Marikina River basin. The system is expected to contribute to reducing property and human losses by providing timely flood warnings and information to the Metropolitan citizens.

Flood forecasts will be made using observations from four AWSs, seven rain gauges and ten water level gauges through three relay stations, and warning messages will be issued through the twenty warning posts alongside the rivers and seven emergent warning units installed at local DRR offices.

In line with the Project, the Korea Meteorological Administration (KMA) conducted a training on flood forecasting for five PAGASA staff members on 19-30 September 2011 in Seoul.



Training Course on Flood Forecasting and Warning



Installing Equipment_Warning Post　　Installing Equipment_AWS

Fig. II-6-4. KMA's KOICA Project

b. Hydrological Achievements/Results

- **National Hydrological Data Quality Control System**

This system is to implement the quality control of hydrological raw data which collected various sites. Firstly this system had developed for Han River water system since 2007. And the system has been expanded to Nakdong River, Geum River and Yeongsan River by 2010. This year the national quality control system developed in Flood Control Office in four major rivers was modified and complemented and a system upgrade plan for the future was suggested. .

The main contents of the research are as follows in 2011:

: System operation, complementation and assessment in four major rivers
: System GUI upgrade and modification
: Suggestion of future application and upgrade plan
: Quality control task guideline and system manual

Regarding quality control of hydrologic data, computer-based automation system is hard to be realized and may cause undesirable results. Therefore, the process of manual review and handling is necessary for all data, and outlier determination rule and treatment procedures and methods should be established. Fig. II-6-5 presents the quality control procedures, data management method for time-series' hydrological data generally.

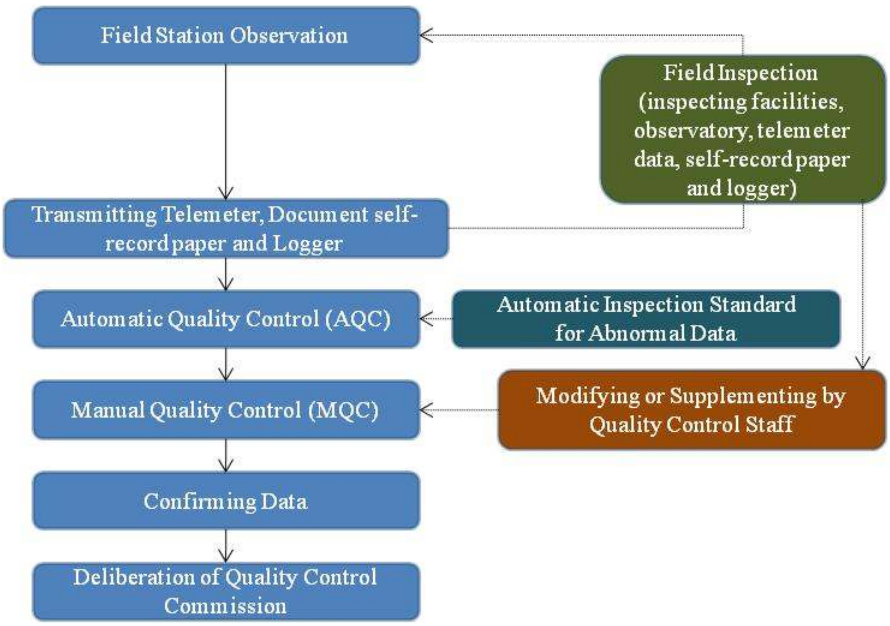


Fig. II-6-5. Quality Control Procedure of Time-series' Rainfall and River Stage Data

- **<u>National Rain Radar Installation and Operation</u>**

The project to establish national rain radar network is a government-driven project to prevent damage from natural disasters. In order to improve the accuracy of flood forecast on major rivers nationwide, and to detect unexpected floods, a total of 11 rain radars(6 large and 5 small radars) will be installed and operated by 2015.

At present, total three radars which were installed in the Imjin River basin (Imjin River Rain radar), the Nakdong River basin (Biseulsan Rain radar), and the South Han River basin (Sobaeksan Rain radar) are operated. Fig. II-6-6 shows locations for rain radar installation and the observation scale map.

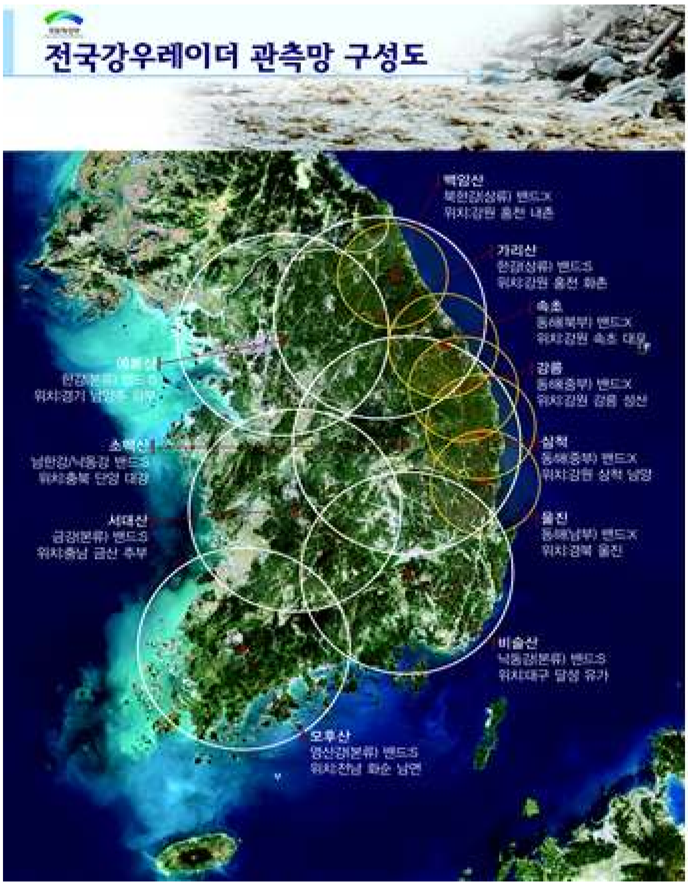


Fig. II-6-6. National Rain radar Network

c. **Disaster Prevention and Preparedness 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

7. 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 2008 Typhoon Committee Annual Operating Plan goals)

a. Meteorological Achievements/Results

- <u>43rd Session of ESCAP/WMO Typhoon Committee</u>

The National Typhoon Center/Korea Meteorological Administration (NTC/KMA) hosted the 43rd Session of UNESCAP/WMO Typhoon Committee attended by 11 typhoon committee members, 5 international organizations (UNESCAP, WMO, TCS, ADRC, and RIMES), and 2 observers (Russia and Indonesia) on 17-22 January, 2011.

At this 43rd Session, NTC/KMA was suggested to carry out more projects and support TCS for its members, particularly for Asia which is vulnerable to typhoon damage. Assuming the Presidency of the Typhoon Committee, KMA contributed to promoting high-quality typhoon monitoring and forecasting techniques.

Fig. II-7-1. The 43rd Session of ESCAP/WMO Typhoon Committee held on 17-22 January 2011, Jeju, Republic of Korea

- 2011 UNESCAP/WMO TC Integrated Workshop, Vietnam

2011 UNESCAP/WMO TC integrated workhop had held from 7 to 11 November 2011, in Nha Trang, Viet Nam. The main theme was "Damage Assessment Methodology and Pre-Assessment of Typhoon Landfall Impact" and Experts from many organizations such as meteorology, hydrology and disaster prevention presented in this workshop. And KMA also reviewed the progress of the on-going AOPs since the 43rd TC Session and reported the future plans.

- Transfer of TAPS (Typhoon Analysis and Prediction System) technology
  - KMA has developed an English version of TAPS for technology transfer.
  - KMA has a plan to deliver and install the system in Vietnam
  - KMA has conducted a training course for typhoon forecaster from PAGASA (Philippin Atmospheric Geophysical and Astronomical Services Administration) through TRCG Fellowship Scheme, from September to November in 2011 and plans to continue it next year.

- Seasonal prediction system
  - KMA has developed the seasonal prediction system and it has been used in operation.

Fig. II-7-2. Participants in 2011 TC integrated workshop held on 7-11 November 2011, Nha Trang, Viet Nam

- **International Workshop on Tropical Cyclone-Ocean Interaction in the Northwest Pacific**

On 11-13 May 2011, in Seogwuipo, Korea, the NTC/KMA held the "International Workshop on Tropical Cyclone-Ocean Interaction in the Northwest Pacific" attended by 50 domestic and foreign experts on typhoon-ocean interaction from U.S. (NOAA, 4 research institutes and universities), Japan (Kyoto University), Taiwan (National Taiwan University) and Korea (8 research institutes incl. the Korea Ocean Research and Development Institute).

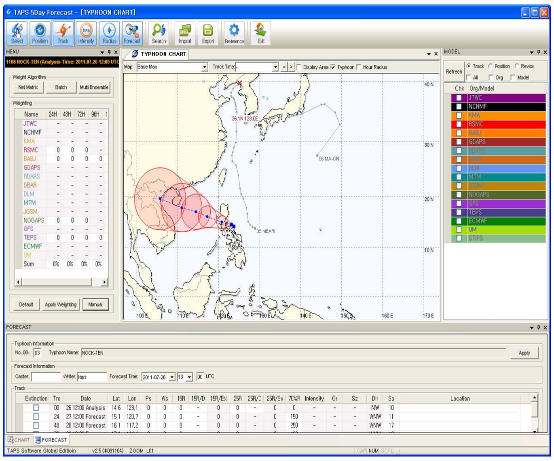
Participants made 35 presentations in 7 sessions (incl. poster session), sharing research information on observation, theories, and modeling for better understanding of the interaction between typhoon tracks and the western North Pacific Ocean conditions and had an intensive discussion on the dynamic process of atmosphere-ocean interaction and application of dynamic atmosphere-ocean coupling model. The 3rd workshop will be held in National Taiwan University.

Fig. II-7-3. Participants in international workshop on tropical cyclone-ocean interaction in the Northwest Pacific held on 11-13 May 2011, Jeju, Republic of Korea

- KMA's TAPS Technical Transfer and Typhoon Research Fellowship

As part of KMA's efforts to transfer typhoon forecasting technologies to developing countries, TAPS (Typhoon Analysis and Prediction System) English version has been developed. NTC/KMA surveyed local conditions of the first beneficiary, National Hydro Meteorological Service of Vietnam (NHMS), by dispatching engineers and trained three meteorologists from the Service on utilizing TAPS. After hardware configuration of the local system in Viet Nam is decided, KMA plan to transfer English version of TAPS next year.

In addition, participating in Training and Research Coordination Group (TRCG) Fellowship Program of the Typhoon Committee, NTC/KMA had trained 7 typhoon experts from other countries until 2010. This year, we offered the training program to one expert each from the Thailand Meteorological Department (TMD) and the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) from Sep to Nov. Trainers were able to complete the course on typhoon forecasting process without language barriers thanks to the newly developed TAPS English version. In 2012, for more efficient education, we plan to start the course in non-typhoon season, April or May, complete it in three months.



(a) English version of TAPS

(b) Presentation of research fellowship students

Fig. II-7-4. KMA's transfer activities of the Typhoon Analysis and Prediction System (TAPS) technology

- **<u>The 4th Korea-China Joint Workshop on Tropical Cyclones</u>**

National Typhoon Center (NTC) at KMA and Shanghai Typhoon Institute (STI) at CMA co-hosted the fourth joint workshop on tropical cyclones, which was held on 19 December 2011, at Sports Hotel in Shanghai, China. 13 papers were presented at the workshop on a wide range of topics such as boundary layer impact on tropical cyclone, dynamical or statistical seasonal prediction systems, initialization scheme for TC forecast model, typhoon information processing systems, assimilation of Doppler radar radial winds, long-term trend in typhoon climate, best-track generation from historical data, and satellite based typhoon analysis. The participated organizations besides NTC/KMA and STI/CMA were Korea Meteorological Satellite Center, Chinese Academy of Meteorological Sciences, International Pacific Research Center at Univ. of Hawaii, Key Laboratory for Mesoscale Weather at Nanjing University, Shanghai Center for Remote Sensing and Application, and Typhoon and Marine Weather Forecasting Center at CMA.

Fig. II-7-5. Participants in 4th Korea-China Joint Workshop on Tropical Cyclones held on 19 December 2011, Shanghai, China

b. Hydrological Achievements/Results

- **Hosting the WGH's Seminar of 43th Session in the Republic of Korea**

From January 17 to 22 in 2011, the WGH seminar, '2011 UNESCAP/WMO Typhoon Committee 43 th Session' was held in the Republic of Korea by the TC members suggestion at the '2010 UNESCAP/WMO Typhoon Committee Integrated Workshop in Macao. During this seminar, 12 experts including WGH chair (Mr. Minoru Kamoto) participated to share the ASFCM theoretical background, flood stage estimation model (HEC-RAS), and system procedure in detail.

Fig. II-7-6. WGH Seminar of 43th Session in Republic of Korea, January 2011

- **Hosting the ASFCM Workshop in the Republic of Korea**

From May 23 to 24 in 2011, the ASFCM Workshop was held at the Han-River Flood Control Office in the Republic of Korea. At the previous seminar of the 43 th session, participants concluded the UFRM pilot city's application and its participation at this ASFCM project. Therefore, MLTM hosted the ASFCM workshop with UFRM pilot city participants and leading country (china). Workshop contents are as follow,

- ASFCM theoretical background and object of this project
- Demonstration of flood stage estimation (HEC-RAS)
- Demonstration of ASFCM system and discussion on modification & complementation
- Introduction of flood forecasting & inundation mapping by Han-River Flood Control Office
- Field trip (Anseong stream watershed)

During this seminar, UFRM pilot city participants suggested the sustainable cross-cut cooperation and agreed on sharing the each member's input data for the system

Fig. II-7-7. ASFCM Workshop in Republic of Korea, May 2011

- **Participating in the 2011 UNESCAP/WMO TC Training Workshop, Thailand**

From August 30 to September 2 in 2011, the TC Training Workshop was held at Thai Meteorological Department in Thailand, inviting experts from China and Republic of Korea. Professionals from Korea presented the estimation of flood stage simulation model (HEC-RAS) and ASFCM system application of UFRM pilot cities (Thailand, Philippine, and Vietnam).

Fig. II-7-8. Training Workshop in Thailand, August in 2011

- **Participating in the 2011 UNESCAP/WMO TC Integrated Workshop, Vietnam**

From November 6 to 11 in 2011, the workshop, '2011 UNESCAP/WMO Typhoon Committee Integrated Workshop' was held in Vietnam. During this workshop, many experts and researchers from 12 member countries in the region participated to share advanced knowledge and to discuss typhoon-related issues.

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

Activity contents are as follows:

: Attendance of the typhoon hydrological part meeting
Making of hydrological part action plans in 2011 and attendance of meeting

: Result present of studying research
2011 research results and future application plan

: Suggestion of next new project
Confirmation of the final new project plan and contents at next 44th session

Expectancy effects area as follows:

: International status and influence reinforcement during research result promotion performed by MLTM

: Used to reflect future policy during understanding of Activities and technical trends of member countries and relevant organizations

Fig. II-7-9. TC Integrated Workshop in Vietnam, November 2011

c. Disaster Prevention and Preparedness Achievements/Results

- **<u>Expert Mission</u>**

The Working Group on Disaster Risk Reduction (WGDRR) commenced implementation of its first project, the Typhoon Committee Disaster Information System in 2005. WGTCDIS is a platform for information exchange among the TC Members. It has been noted that hitherto not all members have submitted the required information for implementation of the WGTCDIS. In this respect, the TC decided that an expert mission would be conducted in 2008 to promote the WGTCDIS and to assist members in data collection and entry to the WGTCDIS.

Typhoon Committee Secretary (TCS) announced the launch of the third WGDRR Expert Mission through circular letter to members. Members interested in receiving the Expert Mission (Thailand, Lao People's Democratic Republic and Cambodia) notified TCS of their intention to participate. TCS, together with Chair of WGDRR selected 3 candidates as recipient members and notified the recipient members. Each recipient member nominated a focal point to liaise with TCS and relevant local stake-holders and as well as make suitable logistical arrangements for the Expert Mission. A mission plan was prepared and agreed upon by the recipient members and TCS. The expert team, as well as the focal points of recipient members had a coordination meeting during the sixth workshop of WGDRR, to fine-tune the mission plan for each recipient member.

Objectives

The main objectives of the third Expert Mission are to (i) introduce analytical methods included in the WGTCDIS, (ii) educate and train how can estimate the typhoon trajectory and the typhoon related damages, (iii) introduce the distributed rainfall runoff model developed by NIDP for developing GIS based hazard map to assess flood risk in low land area or urban area, (iv) collect disaster related information regarding on the WGTCDIS, (v) identify needs and gaps on operating the WGTCDIS as early warning system and disaster risk management and (vi) discuss public out-reach projects regarding on disaster risk management.

Programs

For educating and training the WGTCDIS and identifying the gaps and needs on operation of WGTCDIS from the respective recipient members, expert mission was planned. The program of the third Expert Mission performed during 7-13 August, 2011 was shown in Table II-7-1. Main program of the Expert Mission was for training WGTCDIS and collecting disaster information. Main outcomes were the education and training of the WGTCDIS and conclusion of cooperation works to modify the WGTCDIS by validation with new coming typhoons.

Table II-7-1. Program of the third Expert Mission in 2011.

Members	*Date*	*Contents*
Thailand	8.8.	· 09:00-10:00 *Opening and Expert Mission Briefing* · 10:00-11:00 *Presentation of the WEB-GIS based TCDIS (WGTCDIS)* · 11:00-12:00 *Presentation of Numerical Model for establishing Hazard Map* · 13:30-14:30 *Disaster Management System of the Thailand* · 15:00-17:30 *Training and Practice* · 17:30-18:00 *Discussion for Future Projects*
Lao PDR	8.9.	· 15:00-16:00 *Opening and Expert Mission Briefing* · 16:00-17:00 *Presentation of the WEB-GIS based TCDIS (WGTCDIS)* · 17:00-18:00 *Presentation of Numerical Model for establishing Hazard Map*
Lao PDR	8.10.	· 09:00-10:00 *Disaster Management System of the Lao PDR* · 10:00-12:30 *Training and Practice* · 12:30-13:00 *Discussion for future projects*
Cambodia	8.11.	· 09:00-10:00 *Opening and Expert Mission Briefing* · 10:00-11:00 *Presentation of the WEB-GIS based TCDIS (WGTCDIS)* · 11:00-12:00 *Presentation of Numerical Model for establishing Hazard Map* · 14:00-18:00 *Training and Practice*
Cambodia	8.12.	· 09:00-10:00 *Disaster Management System of the Cambodia* · 10:00-11:00 *Discussion for future projects* · 14:00-18:00 *Make a Expert Mission Report*

The third mission was led by the WGDRR Chair and two invited experts to form the expert team as determined by the requirements indicated by the recipient members. An expert team was organized which two experts are joined from Republic of Korea and Olavo Rasquinho from TCS to promote usages of the WGTCDIS and identify needs and gaps of recipient Members in relation to the implementation of the WGTCDIS, explore whether there is a need for public out-reach projects in relation to the Early Warning

System, the Disaster Risk Management System, and any disaster risk reduction measures in the recipient members. The name and roles of three expert members are listed in Table II-7-2.

Table II-7-2. Expert members participated in the third Expert Mission in 2011.

Name	Role	Specialty
Sangman Jeong	- Expert Mission Leader - Brief on Expert Mission	Chair of WGDRR
Olavo Rasquinho	- Support for Expert Mission - Mission Report	TCS
Tae Sung Cheong	- Presentation of WGTCDIS - Presentation of Rainfall-Runoff Model	Secretary of WGDRR

Three TC Members such as Thailand, Lao PDR and Cambodia were joined on the Expert Mission in 2008 which recipient Members, organizations and number of participants are listed in Table II-7-3.

Table II-7-3. Recipient Members and organization of the first Expert Mission in 2008.

Recipient Members	Organization	Participants
Thailand	Department of Disaster Prevention and Mitigation	11
Lao PDR	Department of Meteorology and Hydrology	14
Cambodia	Department of Meteorology	16

Expert Mission of Thailand

The brief of mission such as objectives, programs, activities of WGDRR and role of expert members were introduced in the Expert Mission of Thailand. The detailed analytical methods were presented to educate basic theories and algorithms estimating similar typhoon trajectory and localized typhoon related damages. Also participants had been trained on learning methods to estimate the similar typhoon trajectory and the typhoon related damages based on determined typhoon trajectories and to promote usage of the WGTCDIS.

For the flood disaster risk management, the distributed rainfall runoff model developed by NIDP was also introduced to Thailand Members. This model can be used for developing GIS based hazard map to assess flood risk in low land area or urban area when rainfall is forecasted. The hazard map overlapped GIS information can support useful information for decision making such as locations of shelters, utilities, dangerous area, hospital, etc, escape route from risk area and damages calculated from house and land use information.

The typhoon related disaster information were surveyed for building the Thailand's own WGTCDIS and standard disaster database to share information and integrated assessment of typhoon related damages. Also future collaboration works for providing disaster information to calibrate estimation method in the WGTCDIS and upgrade the WGTCDIS and the disaster management system and early warning system operated in Thailand were discussed to find gaps and needs. Fig. II-7-10 shows the representative photos collected from the Expert Mission in Thailand.

(a) Commemorative photograph with Thailand Members (b) Brief on the Expert Mission

Fig. II-7-10. Representative photos of Expert Mission of Thailand in 2011.

In the expert mission, disaster management system shown in Fig. II-7-11(b) operated in Thailand was introduced and discussed to identify needs and gaps on operating the WGTCDIS as early warning system and disaster risk management in Thailand. The database structure for universal standard, effective methods for information sharing and technology transferring were discussed. Cooperation projects were also discussed to promote the WGTCDIS and to assist members in data collection and entry to the WGTCDIS. For calibration and validation of WGTCDIS, cooperation works to provide disaster information, compare of estimated results with measured real typhoon and damages information and upgrade or enhance the WGTCDIS are very important. The main results from the Expert Mission in Thailand were following as (i) the abilities of public prevention between nations in the typhoon area were reinforced and (ii) through the expert mission, the way for organizing the international disaster management community has been paved.

(a) Presentation of the WGTCDIS and Rainfall Runoff Model (b) Disaster Control Center of Thailand

Fig. II-7-11. Representative photos of Expert Mission of Thailand in 2011.

The future work plan for developing Thailand's own WGTCDIS was agreed in the Expert Mission. Thailand members will provide the disaster information for the WGTCDIS by end of 2011. Then NIDP will prepare report to submit UNESCAP in which annual assessment report and disaster information collected from Thailand, expert mission report and Thailand's own WGTCDIS established by NIDP will be included.

Expert Mission of Lao PDR

The brief of mission such as objectives, programs, activities of WGDRR and role of expert members were introduced in the Expert Mission of Lao PDR. The detailed analytical methods were presented to educate basic theories and algorithms estimating similar typhoon trajectory and localized typhoon related damages. Also participants had been trained on learning methods to estimate the similar typhoon trajectory and the typhoon related damages based on determined typhoon trajectories and to promote usage of the WGTCDIS.

For the flood disaster risk management, the distributed rainfall runoff model developed by NIDP was also introduced. This model can be used for developing GIS based hazard map to assess flood risk in low land area or urban area when rainfall is forecasted. The hazard map overlapped GIS information can support useful information for decision making such as locations of shelters, utilities, dangerous area, hospital, etc, escape route from risk area and damages calculated from house and land use information.

The typhoon related disaster information were surveyed for building the Lao PDR's own WGTCDIS and standard disaster database to share information and integrated assessment of typhoon related damages. Also future collaboration works for providing disaster information to calibrate estimation method in the WGTCDIS and upgrade the WGTCDIS and the disaster management system and early warning system operated in Lao PDR were discussed to find gaps and needs. Fig. II-7-12 and Fig. II-7-13 show the representative photos collected from the Expert Mission in Lao PDR.

(a) Commemorative photograph with Lao PDR Members

(b) Brief on the Expert Mission

Fig. II-7-12. Representative photos of Expert Mission of Lao PDR in 2011.

In the expert mission, disaster management system shown in Lao PDR was introduced and discussed to identify needs and gaps on operating the WGTCDIS as early warning system and disaster risk management in Lao PDR. The database structure for universal standard, effective methods for information sharing and technology transferring were discussed. Cooperation projects were also discussed to promote the WGTCDIS and to assist members in data collection and entry to the WGTCDIS. For calibration and validation of WGTCDIS, cooperation works to provide disaster information, compare of estimated results with measured real typhoon and damages information and upgrade or enhance the WGTCDIS are very important. The main results from the Expert Mission in Lao PDR were following as (i) the disaster information for five years from 2005 to 2009 were collected to establish the Lao PDR's own WGTCDIS, (ii) the abilities of public prevention between nations in the typhoon area were reinforced and (iii) through the expert mission, the way for organizing the international disaster management community has been paved.

(a) Presentation of the Lao PDR's Disaster Management System

(b) Expert Mission Team with Administrator

Fig. II-7-13. Representative photos of Expert Mission of Lao PDR in 2011.

The future work plan for developing Lao PDR’s own WGTCDIS was agreed in the Expert Mission. NIDP will establish Lao PDR’s own WGTCDIS and prepare report to submit UNESCAP by end of October in which annual assessment report and disaster information collected from Lao PDR, expert mission report and their own WGTCDIS established by NIDP will be included.

Expert Mission of Cambodia

The brief of mission such as objectives, programs, activities of WGDRR and role of expert members were introduced in the Expert Mission of Cambodia. The detailed analytical methods were presented to educate basic theories and algorithms estimating similar typhoon trajectory and localized typhoon related damages. Also participants had been trained on learning methods to estimate the similar typhoon trajectory and the typhoon related damages based on determined typhoon trajectories and to promote usage of the WGTCDIS.

For the flood disaster risk management, the distributed rainfall runoff model developed by NIDP was also introduced. This model can be used for developing GIS based hazard map to assess flood risk in low land area or urban area when rainfall is forecasted. The hazard map overlapped GIS information can support useful information for decision making such as locations of shelters, utilities, dangerous area, hospital, etc, escape route from risk area and damages calculated from house and land use information.

The typhoon related disaster information were surveyed for building the Cambodia’s own WGTCDIS and standard disaster database to share information and integrated assessment of typhoon related damages. Also future collaboration works for providing disaster information to calibrate estimation method in the WGTCDIS and upgrade the WGTCDIS and the disaster management system and early warning system operated in Cambodia were discussed to find gaps and needs. Fig. II-7-14 and Fig. II-7-15 show the representative photos collected from the Expert Mission in Cambodia.

(a) Commemorative photograph with Cambodia Members (b) Brief on the Expert Mission

Fig. II-7-14. Representative photos of Expert Mission of Cambodia in 2011.

In the expert mission, disaster management system shown in Cambodia was introduced and discussed to identify needs and gaps on operating the WGTCDIS as early warning system and disaster risk management in Cambodia. The database structure for universal standard, effective methods for information sharing and technology transferring were discussed. Cooperation projects were also discussed to promote the WGTCDIS and to assist members in data collection and entry to the WGTCDIS. For calibration and validation of WGTCDIS, cooperation works to provide disaster information, compare of estimated results with measured real typhoon and damages information and upgrade or enhance the WGTCDIS are very important. The main results from the Expert Mission in Cambodia were following as (i) the abilities of public prevention between nations in the typhoon area were reinforced and (ii) through the expert mission, the way for organizing the international disaster management community has been paved.

(a) Presentation of the Cambodia's Disaster Management System

(b) Training of WGTCDIS

Fig. II-7-15. Representative photos of Expert Mission of Thailand in 2011.

The future work plan for developing Cambodia's own WGTCDIS was agreed in the Expert Mission. NIDP will prepare report to submit UNESCAP by end of 2011 in which annual assessment report and disaster information collected from Cambodia, expert mission report and Cambodia's own WGTCDIS established by NIDP will be included.

- **<u>Working Group on Disaster Risk Reduction (WGDRR) meeting</u>**

During its 39 years of existence, the Typhoon Committee has been repeatedly recognized as an outstanding regional body who has integrated the actions and plans of the meteorological, hydrological, and Disaster Risk Reduction components to produce meaningful results. The purpose of this WGDRR meeting (Fig. II-7-16) is for the Typhoon Committee to identify regional areas, goals, and activities which the WGDRR wants to continue to produce meaningful results for saving lives, mitigating damage, and decreasing social and economic effects from typhoon-related events. Due to its highest typhoon-related disaster risk, it was agreed to specifically focus DRR activities on the TC Members, in particular in the area of urban flash flooding, landslides and marine accidents.

While supporting the upgrading of the WEB GIS Based Typhoon Committee Disaster Information System (WGTCDIS) activities, the Strengthening on Management Strategies for Typhoon and Tropical Cyclone Disasters in Asia and the Pacific is being discussed by the Members as additional WGDRR activities in this meeting.

Fig. II-7-16. Commemorative photograph of WGDRR meeting

In this year, Lunching Seminar of 2011 Global Assessment Report on Disaster Risk Reduction was opened as a side event of WGDRR Workshop (Fig. II-7-17).

Fig. II-7-17. Commemorative photograph of Lunching Seminar of 2011 Global Assessment Report on Disaster Risk Reduction

All participants of WGDRR Workshop visited the National disaster Management Center and discussed role of NEMA and NDMI and disaster management structure, strategy and technologies regarding on disaster management (Fig. II-7-18).

Fig. II-7-18. All participants of WGDRR Workshop are watching introduction movie of NEMA in the National disaster Management Center

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 Members' Working Groups representatives

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ROK Member Report Summary

This year three typhoons, Meari (1105), Muifa (1109), Talas (1112), directly affected Korean peninsula between June and August, and one typhoon Kulap (1114) for indirect influence. The Meari was recorded the only typhoon in June which moved straight northward along Yellow Sea. The Muifa has shown similar track as Meari. The North Pacific High extended further north-south direction rather than usual westward. As the track has shown straight northward path, it was difficult to locate the turning position. The typhoon usually moves along the periphery of North Pacific High. In normal years, it is extended in east-west direction affecting to south of China. This year June and July, however, it was more elongated to north-south direction, and caused northward movement. Below is a list of key achievements in 2011 for each component:

1. Meteorological Component

- The National Typhoon Center/Korea Meteorological Administration (NTC/KMA) hosted the 43rd Session of UNESCAP/WMO Typhoon Committee attended by 11 typhoon committee members, 5 international organizations (UNESCAP, WMO, TCS, ADRC, and RIMES), and 2 observers (Russia and Indonesia) on 17-22 January, 2011.
- COMS (Communication, Ocean, Meteorological Satellite) began its official operation providing satellite images and meteorological products on 1 April 2011 after its successful orbit testing. COMS images on the northern hemisphere (on an interval of 15 minutes) and on the Korean peninsula land (8 times an hour) help weather forecasters better understand typhoon's track, structure, intensity and center location when a typhoon approaches the peninsular.
- The NTC/KMA held "the Expert Meeting on Seasonal Typhoon Outlook and the Prevention of Disaster Caused by Typhoon" on 18 April, 2011 in Seogwipo, Korea.
- On 11-13 May 2011, in Seogwipo, Korea, the NTC/KMA held the "International Workshop on Tropical Cyclone-Ocean Interaction in the Northwest Pacific" attended by 50 domestic and foreign experts on typhoon-ocean interaction from U.S. (NOAA, 4 research institutes and universities), Japan (Kyoto University), Taiwan (National Taiwan University) and Korea (8 research institutes incl. the Korea Ocean Research and Development Institute).
- NTC/KMA has started official 5-Day typhoon forecast this year.
- As part of KMA's efforts to transfer typhoon forecasting technologies to developing countries, TAPS (Typhoon Analysis and Prediction System) English version has been developed.
- NTC/KMA started operating three types of seasonal prediction systems for forecasting typhoon genesis frequency and track patterns. The official seasonal typhoon prediction is determined by consensus of the three systems, the NTC-COAPS system based on FSU/COAPS 3D primitive equation global spectral model ensembles at a resolution of T126L27 (a Gaussian grid spacing of 0.94º), the NTC-KNU system based on multiple linear regression model, and the NTC-SNU system based on hybrid type of statistical-dynamical model.
- As part of Training and Research Coordination Group (TRCG) Fellowship Program of the Typhoon Committee, NTC/KMA had trained 2 typhoon experts from the Thailand Meteorological Department (TMD) and the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) from September to November.
- Co-organization of the 4th China-Korea Joint Workshop on Tropical Cyclones, 19-23 Dec., in Shanghai, China.

2. Hydrological Component

- The project of Flood Defense Technology for Next Generation is launched to develop advanced technologies for national flood defense capacity.
- The Four Rivers Restoration Project aims to encourage local communities to pursue regional development through river restoration by preventing water-related disasters, securing water resources, improving water quality, and creating multi-purpose spaces along the rivers. As of December 1, 2011, 89% of the entire process was completed (99.7 % of weirs, 99.6 % of dredging and 40.3% of dams).
- The project entitled 'Assessment System of flood Control Measures on the Socio-economic Impacts' led by the Ministry of Land, Transport and Maritime Affairs (MLTM) is proceeding to be applied in member countries in 2012 according to each year scheme.
- According to climate change and abnormal meteorological phenomenon, anticipatory responding measures are established and advanced disaster control system is constructed by the paradigm shift of the existing system. Under the office of Prime Minister, The Task Force regarding Public-Private Partnership was formed and Comprehensive Disaster Management Measures was established by conducting field investigation, analyzing the inefficiency of the existing policies by governmental sectors, and collecting experts' opinions.
- This year the National Quality Control System developed in Flood Control Office in four major rivers was modified and complemented and a system upgrade plan for the future was suggested.
- From May 23 to 24 in 2011, the ASFCM Workshop was held at the Han-River Flood Control Office.
- Participating in the 2011 UNESCAP/WMO TC Training Workshop, Thailand and the 2011 UNESCAP/WMO TC Integrated Workshop, Vietnam.

3. Disaster Prevention and Preparedness component

- For timely warning and management flood disasters in urban area, National Disaster Management Institute (NDMI) suggested a new project of smart emergency dissemination network system to collect posted information and photos from smartphone users and disseminate warning massages to persons in dangerous area to escape and drive to control coming into damaged or inundated area.
- National Emergency Management Agency (NEMA) established the promotion corps on 29 November 2011 for complementary of vulnerable zones and activating regional economy which regions are included in vulnerable zones.
- The WEB GIS Based Typhoon Committee Disaster Information System (WGTCDIS) has been improved in more convenience and accessibility to user by integrating two services above mentioned and by providing abundant and various contents to members. Also, WGTCDIS is going to be applied to another more five members: Thailand, Lao PDR, Philippines, Cambodia and USA.
- For educating and training the WGTCDIS and identifying the gaps and needs on operation of WGTCDIS from the respective recipient members, expert mission was planned. The program of the third Expert Mission performed during 7-13 August, 2011 for three member countries – Thailand, Lao PDR, and Cambodia. Main outcomes were the education and training of the WGTCDIS and conclusion of cooperation works to modify the WGTCDIS by validation with new coming typhoons.
- NIDP formally opened WGTCDIS, which makes it possible for TC member countries to share disaster information.
- The 6th International workshop of Typhoon Committee Working Group on Disaster Risk Reduction (WGDRR) was held on 25-26 May, in Incheon. During this workshop, the Lunching Seminar of 2011 Global Assessment Report on Disaster Risk Reduction was opened as a side event of WGDRR Workshop.