MEMBER REPORT

ESCAP/WMO Typhoon Committee
10th Integrated Workshop

(Macao, China)

26 – 30 October 2015
Kuala Lumpur, Malaysia

CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area in 2015

1. Meteorological Assessment (highlighting forecasting issues/impacts)

Three tropical cyclones affected Macao in the calendar year of 2015, including Kujira (1508), Linfa (1510) and Mujigae (1522) successively. The annual number of tropical cyclones was lower than the annual average of 6.0, while none of these tropical cyclones required the hoisting of Tropical Cyclone Signal No. 8 (gale wind signal). (Figure 1)

Tropical storm Kujira (1508)

On 20 June 2015, a tropical depression was formed over the South China Sea, moving northwards. At 8 p.m. on 21 June, the tropical depression intensified into a tropical storm and was named KUJIRA(1508), moving northwards at 12km/h.

KUJIRA was closest to Macao at 6 p.m. on 22 June, passed by the ocean at about 460 km southwest of Macao, and made landfall at the coast of Wanning city of Hainan at 6:50 p.m. on the same day. KUJIRA turned northwest afterwards. On 23 June, it passed through the Province of Hainan, which then made landfall along the northern coast of Vietnam at 8 a.m. on 24 June and dissipated inland.

Signal No. 1 had been hoisted for over 34 hours and moderate to fresh winds was recorded over the bridges in Macao.

Date	Time*	Hoisted Signal
21 / JUNE	22:15	No.1
23 / JUNE	08:30	All signals were lowered

Typhoon Linfa (1510)

On 2 July 2015, a tropical depression was formed over the Pacific Ocean at the east of Philipines, moving north-northwest. At 8 p.m. on the same day, the tropical depression intensified into a tropical storm and was named LINFA(1510). Then at 8 p.m. on 4 July, LINFA further intensified into a severe tropical storm. It made landfall at the Luzon Island of the Philipines in the morning on next day, then crossed over the northern part of the Philipines and moved into the South China Sea in the afternoon, moving west-northwest at 16 km/h. At 2 p.m. on 6 July, LINFA weakened into a tropical storm, and was slowing down. At 2 p.m. on the next day, LINFA intensified again into a severe tropical storm, moving slowly northwards, and kept a certain distance away from Macao to the east. LINFA turned to move west-northwest on 8 July at night, and was moving towards the eastern part of Guangdong. At 6 p.m. on 9 July, LINFA further intensified into a typhoon, moving west at 15 km/h.

At around 12 p.m. on 9 July, LINFA made landfall at the Lufeng city of Guangdong, which continued to move westward into the inland of Guangdong and was rapidly weakened. LINFA was closest to Macao at 1 a.m. on 10 July, passed by Macao at about 40km to the north inland. At last, LINFA dissipated inland of Guangdong.

The highest signal being hoisted was No. 3 as strong winds were recorded over Macao for 20 hours on the bridges.

Date	Time*	Hoisted Signal
8 / JULY	21:30	No.1
9 / JULY	17:30	No.3
10 / JULY	04:00	All signals were lowered

Typhoon Mujigae (1522)

At 2 p.m. on 30 September 2015, a tropical depression was formed over the Pacific Ocean at the east of Philipines(12.0°N, 130.0°E), moving northwest. The tropical depression crossed over the Luizon Island of the Phillipines in the moring on 2 October, moving into the South China Sea. It then intensified into a tropical storm and was named MUJIGAE(1522)(16.3°N, 120.0°E), moving west-northwest, and entered the 800 km alert zone of Macao at 6 p.m. on the same day. Then at 4 a.m. on 3 October, MUJIGAE further intensified into a severe tropical storm(17.9°N, 116.3°E), continued moving west-northwest. At 5 p.m. on the same day, MUJIGAE intensified into a Typhoon(19.1°N, 114.1°E), moving west-northwest at 20 km/h, towards the Leizhou Penisula.

MUJIGAE was closest to Macao at 1 a.m. on 4 October, passed by Macao at about 270 km to the south-southwest. At around 2:10 p.m. on the same day, MUJIGAE made landfall at the Zhanjiang city of Guangdong, which then continued to move northwest into the inland of Guangxi. MUJIGAE gradually weakened and finally dissipated in the inland of Guangxi.

Date	Time*	Hoisted Signal
2 / OCTOBER	22:00	No.1
3 / OCTOBER	18:30	No.3
5 / OCTOBER	11:00	All signals were lowered

*All time mentioned above is in local time.

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

Nil.

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

Macao was hit by three tropical cyclones in 2015, yet none of them was strong enough to merit the hoisting of typhoon signal no. 8. During the passage of Linfa, a total of 5 cases were reported to Civil Protection Operational Centre including felled trees, swinging advertising structures and concrete spalling.

Date/Time		Name	The Highest Signal Hoisted	Incidents (cases)							
Start	End			Flooding	Landslide	Felled Trees	Billboards/ Awnings/ Windows/ Walls (Collapsed/ Tottering)	Scaffoldings/ Fencings/ Crane (Collapsed/ Tottering)	Power cables/ Lampposts (Collapsed/ Tottering)	Death / Injuries	Others
21-06-15 22H15	23-06-15 08H30	KUJIRA (1508)	1	0	0	0	0	0	0	0	0
08-07-15 21H30	10-07-15 04H00	LINFA (1510)	3	0	0	3	1	0	0	0	1
02-10-15 22H00	5-10-15 11H00	MUJIGAE (1522)	See remarks*								

Table 1: Damages caused by tropical cyclones in Macao during 2015

* The information will be updated in due course, when available.

Two rainstorm warnings were issued in 2015. The following table shows that the downpour caused minor damages to Macao.

Date	Duration	Incidents (cases)									
		Flooding	Felled Trees	Buildings collapsed/ Concrete spalling	Billboards collapsed or tottering	Scaffoldings collapsed or tottering	Windows collapsed or tottering	Awnings collapsed or tottering	Landslide	Deaths / Injuries	Others
21-07-15	07H00-09H30	0	0	1	0	0	0	0	0	0	0
4-10-15	11H25-12H25	See remarks*									

Table 2: Damages caused by rainstorms during 2015

* The information will be updated in due course, when available.

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

Nil.

II. Summary of progress in Key Result Areas

TC Members' Report
Summary of Progress in KRAs

Item 1: Improved the ability of weather forecast and nowcasting

The new generation of dual-polarization S-band Doppler radar has been operating since early March 2014. The new weather radar provides high quality meteorological products, which enhances the ability to locate precipitation, calculate its motion, estimate its type (rain, hail, etc.), and forecast its future position and intensity. Thus, the new radar greatly improves the ability and effectiveness of weather nowcasting in severe weather. In addition, the new radar allows for the determination of the storms structure and analyzing their potential to cause severe weather.

In 2015, some optimization to the radar parameters settings has been done, which enables a better operational efficiency. The real-time radar images are available in the Macao Meteorological and Geophysical Bureau (SMG) website, which enables the public to get the latest weather information (Figure 2).

To enhance the ability in analyzing and providing early warning during severe weather such as tropical cyclone and rainstorm, a brand new wind profiler has been purchased and planned to install by the end of this year. Meanwhile, to enhance the ability in real-time upper atmosphere monitoring, a new surface-based radiometer and a new lightning detector have been purchased, which are planned to install and put into operation by the end of this year and early next year respectively.

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

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

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

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Item 2:
Enhanced public weather service and public education

Advances in technology and communications have changed the way information is being collected, integrated, disseminated and shared. These changes have altered users' expectation in such a way that they expect the information to be delivered to them whenever they want it, wherever they want it and customized to their personal preferences according to their needs, especially during severe weather situations. To respond to these expectations, SMG has optimized its warning system for severe weather, by means of strengthening the communication and coordination with relevant departments, issuing pre-warning message prior to possibility of heavy rainfall in the website, extending the effective time for thunderstorm warning, and to upload all relevant real-time information to our website including flooding conditions, precipitation amount and radar images. The information can help the public to arrange in advance their planning and minimize the Social and Economic Impacts. SMG has also enhanced the communication with the government departments during severe weather, especially tropical cyclones and rainstorm to promote better awareness and preparedness.

In order to further enhance our public weather service, we have re-structured SMG's mobile website. This enables optimum use of technology in the provision of weather information in ways that will satisfy the users. This facilitates the availability of public forecasts and warnings through mobile applications. The weather information and warning messages acquired through either our official website or this newly mobile website can help in taking timely and appropriate actions for the public. We expect this upgrade to enable a better delivery of meteorological information, as well as severe weather warnings, to the general public. Furthermore, SMG has been discussing with media (TDM) to explore the possibility in providing real-time weather information through the video systems installed in public buses.

Meanwhile, to take care of the needs in receiving Macao weather information for cross-border student, SMG has registered and opened up the official "WeChat" account, the "WeChat" account enables the public to get the latest weather information, including weather warnings, weather forecasts, air quality forecasts, tropical cyclone information, etc. By means of the utilization of this social network, this broadens the area for the provision of meteorological information service.

Moreover, to improve our information dissemination in borders, SMG reached a consensus with Zhuhai Meteorological Bureau to exchange information about important severe warning. For instance, through cooperation with the immigration department, severe warning messages from both Macao and Zhuhai will be shown in the electronic display of the immigration building in Portas do Cerco (Border Gate)(figure 3, 4). Also, SMG has planned to provide real-time weather information through the electronic display in the Outer Harbour Ferry Terminal.

As for public education, to increase the knowledge and interest of students in meteorology, SMG will give lectures on different topics in schools every year, each topic will be prepared in two versions, one for primary schools and the other for secondary schools. Schools can choose between Chinese, Portuguese and English as their preferred language for lectures. To comply with the schools' schedule, the lectures this year was arranged from September 2014 to June 2015. There were over 4000 people from 19 schools registered for the lectures. Meanwhile, the program of Automatic Weather Station in schools has been launched, by providing schools with the automatic meteorological instruments, technical

support, basic knowledge on meteorology and organizing events, the program can increase students' knowledge and interest in natural science.

Moreover, in order to let citizens have a better understanding of our operations as well as the meaning of different warnings, SMG offers visit for citizens and different parties. Up to September 2015, around 650 students and citizens were recorded visiting the SMG headquarter.

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

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

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

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Item 3:
Training on Severe Weather Forecasting and Effective Warning System

In March 2015, a training course on Dual-polarization radar was held in the Hong Kong Observatory, the course was mainly presented by Dr.Dusan Zrnic, who is an expert in radar meteorology from the NOAA National Severe Storms Laboratory(NSSL). SMG was invited to participate in this course, and the outcome from the course was positive, which greatly improves SMG's ability in the effective use of their newly installed dual-polarization radar.

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

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

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

Training and research				✓			
Resource mobilization or regional collaboration							

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Item 4:
To facilitate regional weather information and real-time data exchange

SMG cooperates with Guangdong to receive the products of Global/Regional Assimilation and Prediction System (GRAPES), and enhanced the development of numerical forecasting as well as the ability of weather nowcasting in the region.

To facilitate regional real-time data exchange, the quality of the communication connection between SMG and Guangdong Meteorological Bureau has been upgraded, with an improved bandwidth of 2M now. In addition, Guangdong Meteorological Bureau provides SMG with another two more servers for data retrieving.

Moreover, an official VPN has established between SMG and HKO for fast data transferring. Various data will be exchanged through this VPN connection, including radar raw data and the "Short-range Warning of Intense Rainstorms in Localized Systems(SWIRLS)" nowcasting system data from HKO. According to the plan, this VPN will shortly replace the existing ISDN connection, which is currently in use. SMG is also in contact with CMA in China to discuss the receiving of data through CMACAST.

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

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

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Item 5:
Zhuhai-Macao Cooperate to establish an integrated meteorological monitoring network in the estuary of Pearl River

Macao, China is located in the west bank of Pearl River Delta in South China. In order to reinforce the monitoring capacity on the estuary of the Pearl River during the approach of tropical cyclone from South China Sea, SMG has been cooperating with Zhuhai Meteorological Bureau to establish an integrated meteorological monitoring network on the estuary of the Pearl River from 2014 to 2016. During the first stage of the cooperation, Dong Ao Island was chosen as the location for the first monitoring station to be built, and construction work has been ongoing to install instruments including wind profiler, automatic weather station, thunderstorm detector and tide gauge. These instruments will put into operation in the first season of 2016. Following the agreement in 2015 (Figure 5), the second monitoring station will be built in the Hebao Island of Zhuhai City.

Moreover, in order to provide better, high-quality, face to face communication with Zhuhai Meteorological Bureau, SMG purchased a new video conference system, it allows forecasters to have discussion in weather forecast, especially during the typhoon.

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

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

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

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Item 6:
Disaster Risk Reduction

Slope safety has been one of the great concerns for Macao SAR Government. Regular inspection on slopes is conducted by Land, Public Works and Transport Bureau (DSSOPT) ahead of typhoon season. Besides, the Bureau is also responsible for slope reinforcement and maintenance in order to eliminate the landslide risk(Figure 6). In 2015, the number of high-risk slopes is reduced from 5 to 4, while the number of medium-risk slopes is reduced from 57 to 46.

The following table demonstrates the distribution of slopes in Macao according to landslide risk level.

	High Risk	**Medium Risk**	**Low Risk**	**Total**
Macao Peninsula	2	15	65	82
Taipa	1	15	38	54
Coloane	1	16	48	65
Total	4	46	151	201

Table 3: Distribution of slopes in Macao according to the landslide risk level

In addition, DSSOPT also set up Taipa Hill Slope Automatic Monitoring System which is Macao's first "slope automatic monitoring system". The system enables remote monitoring on the state of the slope and on-site information will be collected and transferred to Macau Laboratory of Civil Engineering in a timely manner, so that relevant government departments can take early preventive measures to ensure slope safety.

Regarding the prevention of death and serious injury from falling trees and branches, Civic and Municipal Affairs Bureau (IACM) carries out regular inspection in order to detect the diseases affecting the trees (Figure 7) and remove those which are deemed dangerous. In 2015, over 370 dangerous trees were removed and over 3,000 trees were trimmed to protect public safety.

Prior to typhoon season, the Labour Affairs Bureau urges the construction industry to take relevant preventive measures on construction sites, and comply strictly with the relevant provisions of "Safety Guidelines for Construction Sites during Typhoon Season" to protect the safety of workers and public.

As for flood prevention, several upgrade initiatives for the drainage system were proposed. These include: upgrading drainage system in old districts involving the renewal of existing pipes and dividing them into two separate systems to handle rainwater and sewage respectively (Figure 8); installing pumping stations near the sea to cope with sudden rainstorms; as well as constructing an embankment in Inner Harbour, where is one of the flooding blackspots in Macao. The construction of embankment, together with water barriers and mobilised floodgates is expected to be completed by the end of 2015, aiming to mitigate the effect of flooding, astronomical tides and saltwater intrusion.

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

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

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

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Item 7:
Drill and Emergency Plan with Government Departments and Organizations in Preparation for Severe Weather

The SMG Emergency Plan was revised and rehearsed in 2015 to ensure the provision of meteorological services, including tropical cyclone forecasts and warnings, in all-weather.

Macao Security Forces Coordination Office staged an annual typhoon drill in April. The drill which simulated the hoisting of typhoon signal No. 8 involved more than 1,200 participants from 27 public and private entities. The purpose of the drill is to test coordination and communication among members of Civil Protection System and strengthen interdepartmental efforts in dealing with typhoon-related incidents. (Figure 9)

Meanwhile, SMG hold regular meetings with different government departments and organizations, to review their operation workflow with SMG under severe weather, and will identify opportunities to improve in the future.

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

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

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

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Item 8:
Strengthened Resilience of Communities to Typhoon-related Disasters

Government departments like IACM hold regular meetings with the public to discuss options and exchange opinions on how to improve Macao's flooding problems, as well as to introduce their upcoming flooding mitigation projects (Figure 10).

Moreover, Macao SAR Government has also launched a WeChat account, together with an electronic display device, at the Border Gate checkpoint in order to release typhoon-related information to the public.

Furthermore, lawmakers passed a bill regulating employers to buy insurance for their employees if the latter must work when the typhoon signal no. 8 or higher is hoisted. The cost of the insurance should be about 0.4 percent of the wages of the respective employees. This bill will further protect the employees' rights especially for those who are requested to report for duty during typhoons.

In 2015, Macao Security Forces Coordination Office continues to promote public awareness on disaster prevention through distributing disaster prevention brochures and broadcasting video clips on television.

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

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

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

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Item 9:
Enhanced Typhoon Committee's Effectiveness and International Collaboration.

In 2015, Macao Security Forces Coordination Office delegated representatives to participate in the meetings organised by Typhoon Committee as well as TC Working Groups. These include the 47th Session of Typhoon Committee held in Bangkok, Thailand; the 10th Meeting of WGDRR held in Seoul, Korea; as well as the 10th Integrated Workshop held in Kuala Lumpur, Malaysia.

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

Nil.

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

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

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Others

The Macao SAR Government continues contributing the Endowment Fund to support the operation of Typhoon Committee Secretary through 2018.

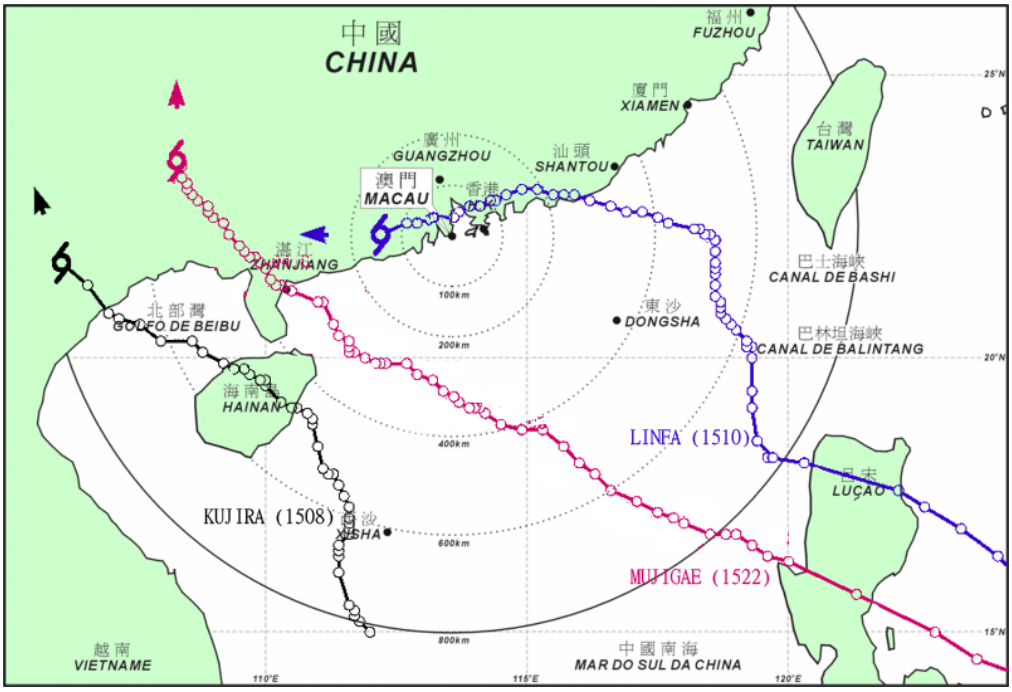

Figure 1 Tropical cyclone tracks in 2015.

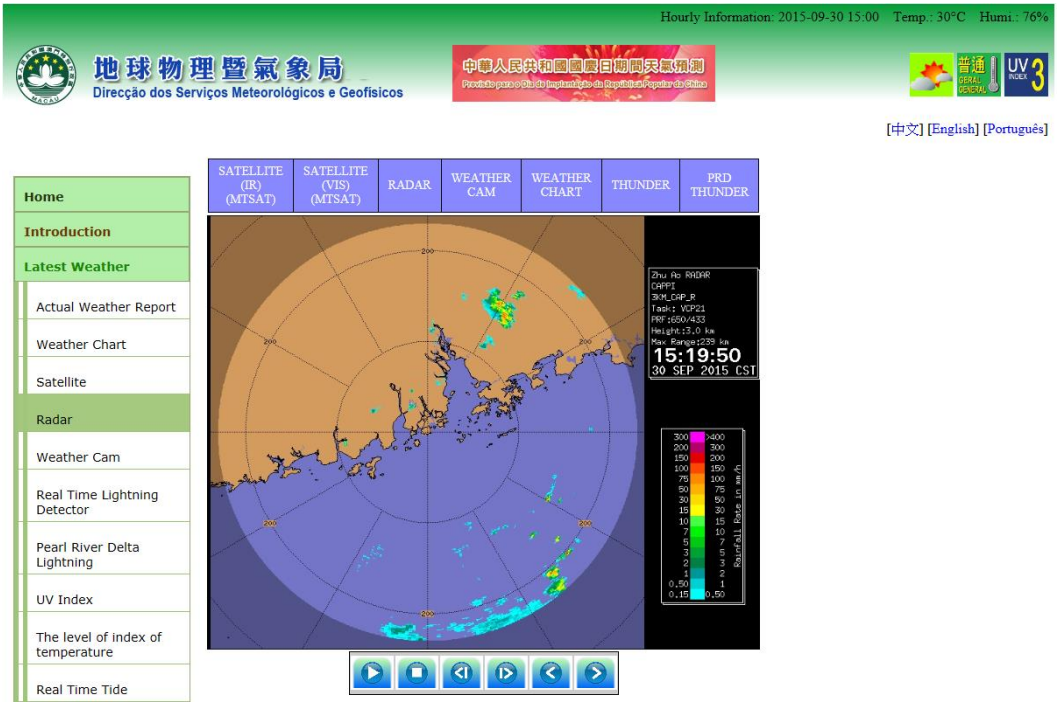

Figure 2 Radar image available on Macao SMG website.

Figure 3 Severe weather warning(testing content) from SMG and Zhuhai Meteorological Bureau displayed in the departure building.

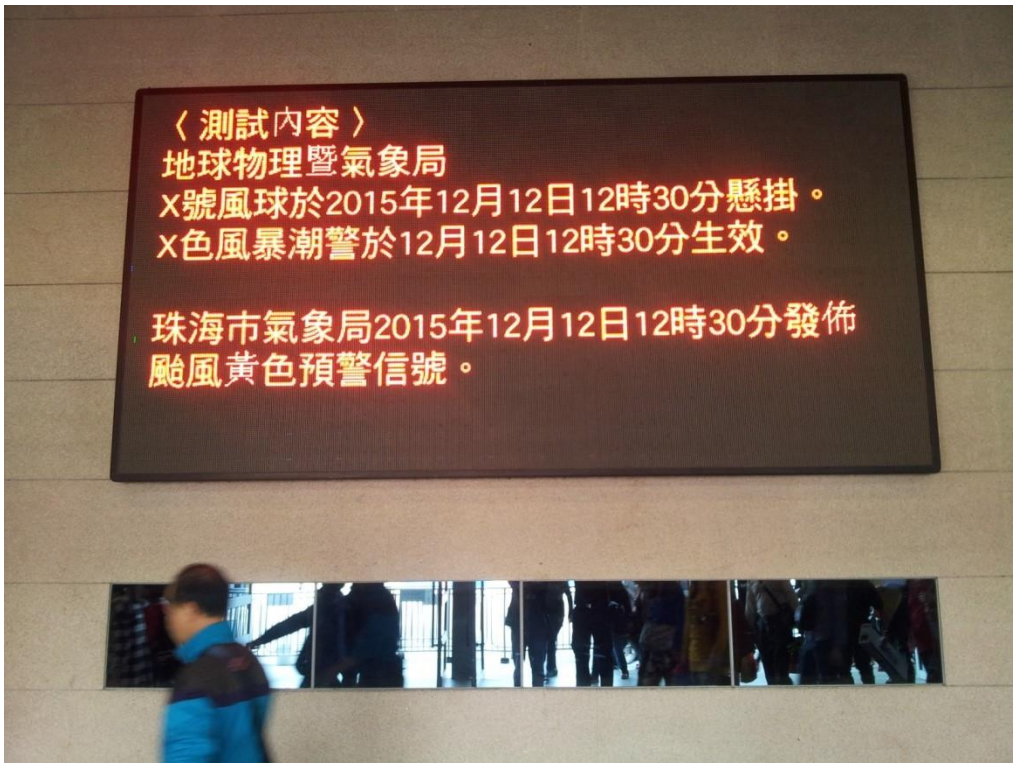

Figure 4 Severe weather warning(testing content) from SMG and Zhuhai Meteorological Bureau displayed in the arrival building.

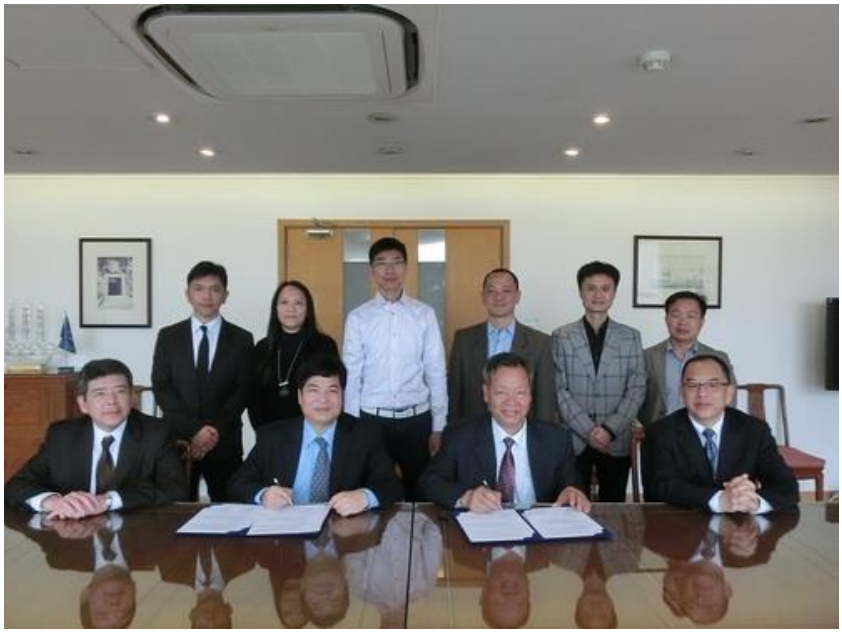

Figure 5 Signing the cooperation project agreement for 2015 between Macau SMG and Zhuhai Meteorological Bureau.

Figure 6 DSSOPT undertake reinforcement for potentially dangerous slopes.

Figure 7 IACM staffs utilise instrument to detect diseases affecting the trees.

Figure 8 Drainage system is upgraded in old districts.

Figure 9 Macao Security Forces Coordination Office staged the yearly typhoon drill in April.

Figure 10 IACM organised meeting to introduce their upcoming mitigation project to the public.