MEMBER
REPORT
Macao, China

ESCAP/WMO Typhoon Committee
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CONTENTS

I. Overview of tropical cyclones which have affected/impacted Member's area since the last Committee Session

1. Meteorological Assessment (highlighting forecasting issues/impacts)
2. Hydrological Assessment (highlighting water-related issues/impact)
3. Socio-Economic Assessment (highlighting socio-economic and DRR issues/impacts)
4. Regional Cooperation (highlighting regional cooperation and related activities)

II. Summary of Progress in Priorities supporting Key Result Areas

1. Enhancement of public weather service strategy
2. Upgrade of forecast tools and systems
3. Improving the "Tropical Cyclone Interdepartmental Video Meeting" mechanism
4. Personnel capacity-building
5. Promotion of the knowledge of meteorology and disaster risk reduction
6. Annual Emergency Exercise
7. Public Education and Promotion among communities and schools

I.   Overview of tropical cyclones which have affected/impacted Member's area since the last Committee Session

1. Meteorological Assessment (highlighting forecasting issues/impacts)

5 tropical cyclones affected Macao, China in 2023, including Typhoon Talim (2304), Super Typhoon Doksuri (2305), Super Typhoon Saola (2309), Strong Typhoon Haikui (2311) and Super Typhoon Koinu (2314). Their tracks and the highest issued Tropical Cyclone Signals in Macao are shown in Fig. 1 and Table 1 respectively. Their meteorological influences on Macao are described below in details.
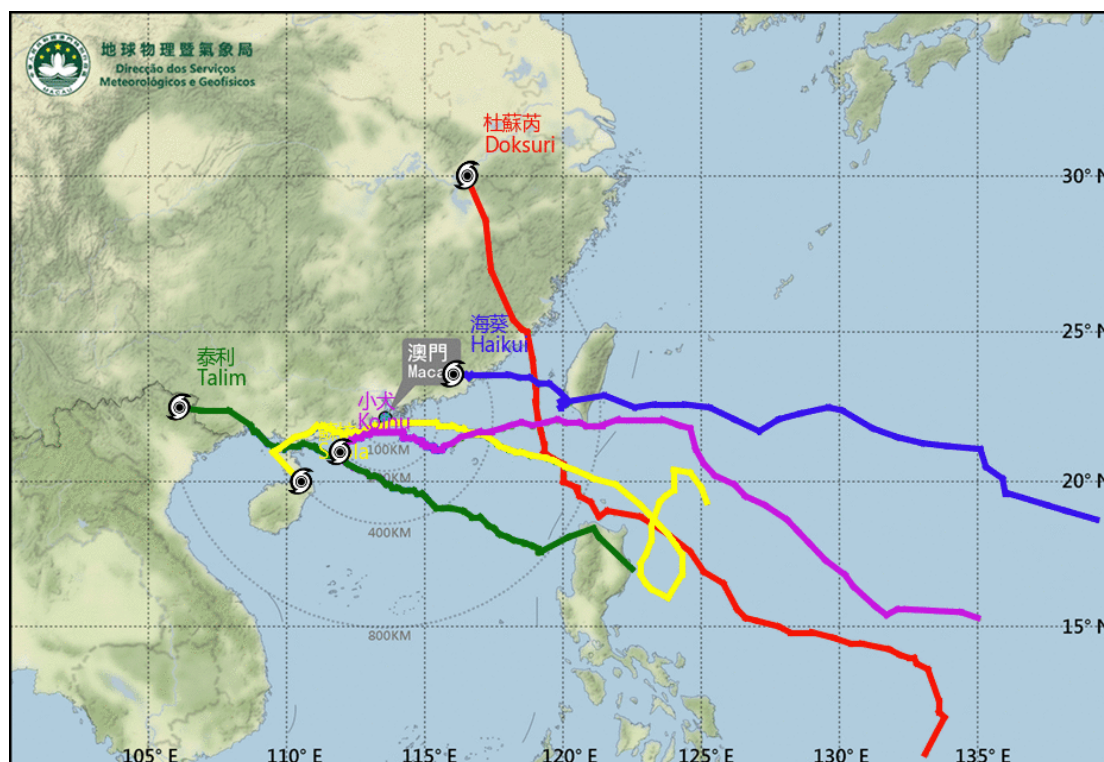

Figure 1   *Tracks of tropical cyclones affecting Macao, China in 2023.*

Typhoon Talim (2304)

Talim formed over northern Luzon on 14th July and entered the South China Sea later that day. On the next day, Talim intensified into a tropical storm and move steadily west-northwest towards western coast of Guangdong. It came closest to Macao on the morning of 17th, about 220 km to the south-southwest of the territory, then reached its peak intensity in the afternoon as a typhoon, with maximum wind of 140 km/h near its centre. Talim made landfall over the coast of Zhanjiang in that evening and finally dissipated over northern Vietnam on the early morning of 19th July.

Talim was the first tropical cyclone to affect Macao in 2023. Under the influence of Talim, winds in Macao reached up to 79.6 km/h with maximum gust of 100.8 km/h, necessitating the issuance of the Tropical Cyclone Signal No.8. Furthermore, Talim induced a storm surge in Macao, leading to the issuance of blue storm surge warning. Flooding occurred in low-lying areas, with water levels reaching approximately 0.33m high.

Super Typhoon Doksuri (2305)

   Doksuri formed over Philippine Sea on 20th July. The next day Doksuri intensified into a tropical storm and moved generally northwestward. It reached its peak intensity on 25th and 26th as a super typhoon, with maximum wind of 200 km/h near its centre and continued to track west-northwestward. Doksuri entered the Luzon Strait on 26th and turned to move in a north-northwestward direction towards Fujian. It came closest to Macao on the early morning of 28th, about 560 km to the east of the territory, then made landfall later in the morning over the coast of Jinjiang, Fujian. Finally, it dissipated inland on the morning of 29th.

   Since Doksuri maintained a considerable distance from Macao, its direct impact on the territory was insignificant. However, due to the influence of its outer subsidence airflow, the weather in Macao was very hot on 26th and 27th July.

Super Typhoon Saola (2309)

   Saola formed over Philippine Sea on 24th August and intensified into a tropical storm later that day. In the following days, Saola moved slowly and made an anti-clockwise loop on the sea east of Luzon Island. It then moved west-northwestward and passed through the Luzon Strait on 30th, steadily towards the coast of Guangdong. Meanwhile, it reached its peak intensity on that day and the following day as a super typhoon, with maximum wind of 220 km/h near its centre. Saola came closest to Macao at 1 a.m. on 2nd September, about 30 km to the southeast of the territory, then made landfall over the coast of Zhuhai in the early morning and turned to move west-southwestward, roughly parallel to the western coast of Guangdong. Finally, it dissipated over Hainan Island on the evening of 3rd September.

   Tropical cyclone signal No. 10 was issued for the first time in three years as Saola edged closer to the city shortly after midnight on 2nd September. Under the direct impact of Saola, winds in Macao reached up to 106.6 km/h with maximum gust of 147.2 km/h, and the red storm surge warning was issued.

Strong Typhoon Haikui (2311)

   Haikui formed over the northwestern Pacific Ocean. It entered Macao's area of responsibility on 30th August as a severe tropical storm and reached its peak intensity on 3rd Septermber as a strong typhoon, with maximum wind of 170 km/h near its centre. Haikui made landfall over eastern Guangdong on the morning of 5th. It came closest to Macao that evening, about 320 km to the east-northeast of the territory, when it was about to dissipate over inland Guangdong.

   Since Haikui weakened considerably as it tracked closer to the city over inland Guangdong, winds in Macao did not strengthened significantly. However the remnant of Haikui and a trough associated with it lingered over Guangdong in the following week. Under its influence, heavy showers started to affect Macao on the evening of 7th September. The accumulated daily rainfall on 8th was around 200 mm in some parts of Macao.

Super Typhoon Koinu (2314)

   Koinu formed over Philippine Sea on 29th September and intensified into a tropical storm the following morning. It reached its peak intensity on 3rd October as a super typhoon, with maximum wind of 185 km/h near its centre. It then moved westward and entered the South China Sea on 5th. Koinu slowed down and turned to move west-northwestward towards the Pearl River Estuary on 7th October. Koinu came closest to Macao at 3 a.m. on 9th October, about 50 km to the south of the territory. It then skirted the coast of western Guangdong and weakened. Finally, Koinu dissipated off the western coast of Guangdong later that evening.

   Koinu was the third tropical cyclone that necessitated the issuance of TC signal No.8 in the year. Although Koinu was very close to the territory, the size of its circulation was small and its intensity weakened as it approached the city. Winds in Macao reached up to 57.2 km/h. Furthermore, due to the combined effect of Koinu and the northeast monsoon, heavy showers continued to affect Macao on 9th October. Nearly 300 mm of rainfall was recorded during the passage of Koinu.

Start Date	End Date	Name	The Highest Signal
14 Jul, 2023	18 Jul, 2023	Talim	No. 8
26 Jul, 2023	28 Jul, 2023	Doksuri	No. 1
30 Aug, 2023	03 Sep, 2023	Saola	No. 10
04 Sep, 2023	05 Sep, 2023	Haikui	No. 1
05 Oct, 2023	09 Oct, 2023	Koinu	No. 8

Table 1 *The Tropical Cyclone Signals issued by Macao Meteorological and Geophysical Bureau during the tropical cyclones affected period.*

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

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

Macao was hit by five tropical cyclones in 2023. Two of them resulted on issue of typhoon signal no. 8 ("Talim" and "Koinu"), one of them resulted on issue of typhoon signal no. 10 ("Saola") and the remaining only resulted on issue of typhoon signal no.1("Doksuri" and "Haikui"), which caused minor damages to Macao.

Tropical cyclones "Talim" and "Koinu" have caused 2 people injured respectively. 32 incidents were reported for "Talim" and 19 incidents were reported for "Koinu". (refer to the following tables for more details)

Tropical cyclones "Saola" brought strong wind and heavy rain to Macao for a long period of time. Typhoon signal no.10 and the fourth level (red) storm surge warning had been issued. It means that the water level in the low lying area in Macao was expected to be 1.5 to 2.5 meter above road level. The highest wind speed in the centre had reached 220 km/h, as a result, 107 incidents were reported and 1 person injured. (refer to the following tables for more details)

Tropical cyclones "Saola" is the fourth typhoon signal no.10 issued in 7 years in Macao, following "Hato" in 2017, "Mangkhut" in 2018 and "Higos" in 2020. Compared with 1968 to 2016 (49 years period) in which only four typhoon signal no. 10 were issued, the frequency of issuing typhoon signals no.10 has increased significantly in recent years.

Date/Time		Name	The Highest Signal Hoisted	Incidents (cases)									
Start	End			Flooding	Landslide	Fallen Trees	Buildings collapsed/ Concrete spalled off	Billboards/ Awnings/ Windows/ (Collapsed/ Tottered)	Scaffoldings / Fencings/ Crane (Collapsed/ Tottered)	Power cables/ Lampposts (Collapsed/ Tottered)	Injuries	Death	Others
14/7/2023 22H30	18/7/2023 10H30	Talim 2304	8	0	0	5	6	15	1	0	2	0	5
26/7/2023 22H00	28/7/2023 12H30	Doksuri 2305	1	0	0	0	0	0	0	0	0	0	0
30/8/2023 16H30	3/9/2023 00H00	Saola 2309	10	3	0	37	5	52	8	1	1	0	1
4/9/2023 04H00	5/9/2023 23H00	Haikui 2311	1	0	0	0	1	0	0	0	0	0	0
5/10/2023 05H00	9/10/2023 17H00	Koinu 2314	8	1	1	1	0	8	1	0	2	0	7

Table 2 *Damages caused by tropical cyclones in Macao during 2023*

As compared with 6 rainstorms (red or black level) in 2022, there were only five rainstorm warning signals (red or black level) issued in 2023. One of the most occurred public emergency in Macao SAR was flooding caused by rainstorm. Flooding occurs in flooding blackspots and sometimes landslide occurs during heavy rainstorm. In recent years, Macao SAR Government has taken flood control and drainage improvement measures to alleviate the problem. This year, the Civil Protection Operation Center collected comments from different departments and will update the related emergency plan. And will continue educating citizens about actions to be taken during rainstorm occurs, and also broadcast rainstorm warning signals in serious situation to the public.

Incidents (cases)											
Start	End	Flooding	Fallen Trees	Buildings collapsed/ Concrete spalled off	Billboards collapsed or tottered	Scaffoldings collapsed or tottered	Windows collapsed or tottered	Awnings collapsed or tottered	Landslide	Injuries	Others
01-06-2023 07H00	01-06-2023 08H30	0	0	0	0	0	0	0	0	0	1
14-06-2023 22H50	15-06-2023 01H45	2	0	0	0	0	0	0	3	0	2
08-09-2023 04H25	08-09-2023 07H55	0	0	0	0	0	0	0	0	0	0
08-09-2023 11H40	08-09-2023 13H30	1	0	0	0	0	0	0	2	0	1
15-09-2023 21H20	15-09-2023 22H35	2	0	0	0	0	0	0	3	0	0

Table 3 *Damages caused by rainstorms during 2023*

4. **Regional Cooperation (highlighting regional cooperation and related activities)**
   Nil.

II. Summary of Progress in Priorities supporting Key Result Areas

1. Enhancement of public weather service strategy

Main text:

With regard to severe weather service provided to the general public, specifically information dissemination service, SMG started to make a shift to a "First qualitative, then quantitative" strategy.

For example, SMG prepares and releases infographics posts 3-4 days before a severe weather system affects Macau. Posts are released via various online channels, including SMG website and mobile App, WeChat, and other social media. Then 1-2 days before the predicted severe weather such as rainstorms, alert messages are released, which include more information regarding the time range and severity of the weather. Next, when the rain region approaches, a special alert is released to the general public and to relevant public departments. Finally, when a rainstorm is imminent or is occurring, SMG issue the official rainstorm warning signals.

This service approach allows the public to be more prepared and well informed about the severe weather, and also allows the public adequate time to take precautions according to different risk management needs.

Figure 2 *Shift of public weather service strategy of SMG.*

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

Priority Areas Addressed:
Meteorology
▪ Develop and enhance typhoon analysis and forecast techniques from nowcast to medium-range, and seasonal to long-range prediction.

DRR
▪ Enhance Members' disaster risk reduction techniques and management strategies.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	✓
Preparedness and response capabilities	

Contact Information:
Member: Macao, China
Name of contact for this item: Mr. LOK Chan Wa
Telephone: +853 88986273
Email: cwlok@smg.gov.mo

2. Upgrade of forecast tools and systems

Main text:

In the face of the impacts brought by tropical cyclones, storm surges, and rainstorms, SMG continuously improve its tools to enhance forecast techniques and capacities. SMG upgraded its nowcasting system for precipitation in 2023 by introducing a forecast method based on machine learning technology by using the S-band radar data of Zhu-Ao Radar of the past 7 years as training data to predict radar echoes development in next two hours, in addition to the existing method of optical flow. Furthermore, a lightning nowcasting system has also been introduced based on the above methods to produce lightning forecast information.

On the other hand, SMG upgraded its tropical cyclone and storm surge integrated analysis system. Forecast data are incorporated with historical tropical cyclone data in statistical analysis to calculate and output the probabilities of different levels of tropical cyclone and storm surge warning signals in a risk matrix format, in such a way to provide objective basis and scientific support for meteorological operation decision-making during tropical cyclones.
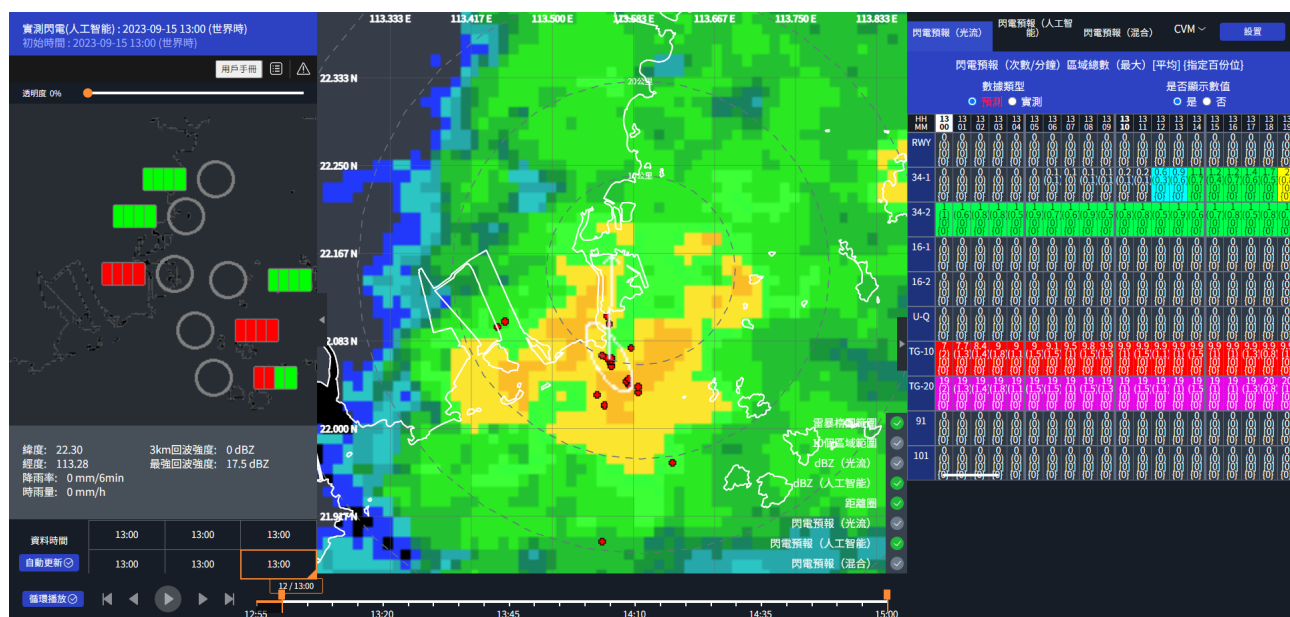

Figure 3 *Nowcasting system for precipitation and lightning of SMG.*

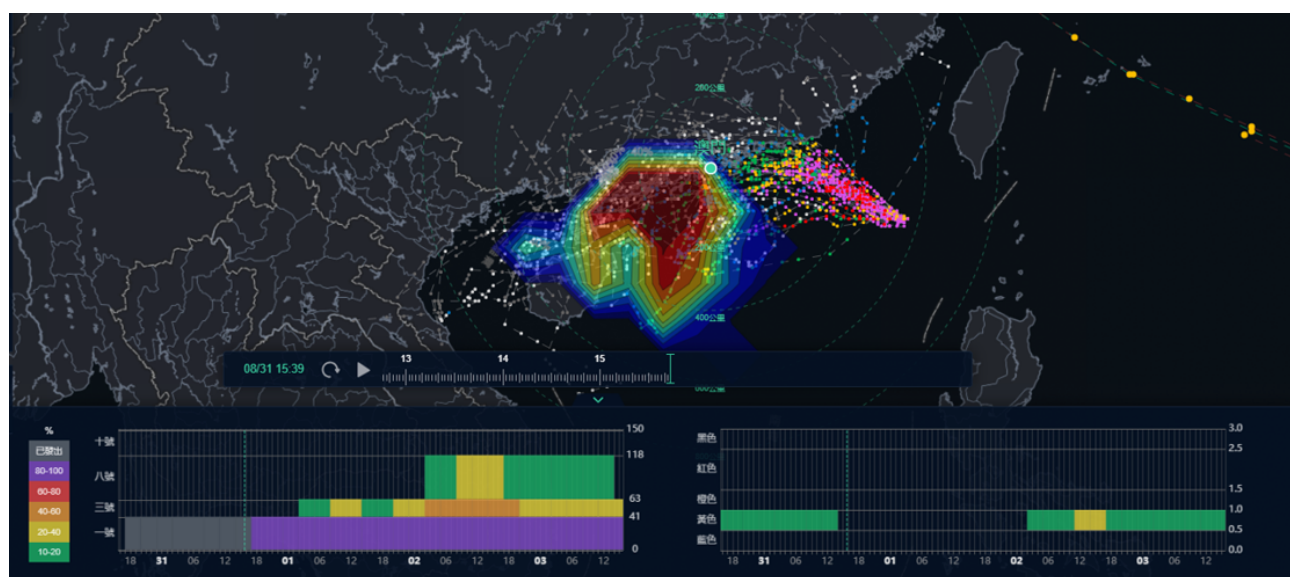***Figure 4*** *Tropical cyclone and storm surge integrated analysis system of SMG.*

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

Priority Areas Addressed:

Meteorology
- Develop and enhance typhoon analysis and forecast techniques from nowcast to medium-range, and seasonal to long-range prediction.
- Enhance and provide typhoon forecast guidance based on NWP including ensembles, weather radar and satellite related products, such as QPE/QPF.

Hydrology
- Strengthen capacity in effective flood forecasting and impact-based early warning, including hazard mapping and anticipated risk based on methodological and hydrological modelling, and operation system development.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:
Member: Macao, China
Name of contact for this item: Mr. LOK Chan Wa
Telephone: +853 88986273
Email: cwlok@smg.gov.mo

3. Improving the "Tropical Cyclone Interdepartmental Video Meeting" mechanism

Main text:

In order to help the relevant members of the Civil Protection Structure to better respond to the impact of tropical cyclones, SMG continues to implement the "Tropical Cyclone Interdepartmental Video Meeting" mechanism in 2023. Every time when a tropical cyclone is foreseen to affect Macao, SMG arranged an interdepartmental video meeting among relevant member departments in the Civil Protection Structure ahead of time. During the meeting, SMG reports to the members the current situation and forecast of the tropical cyclone, and SMG also provides information regarding possible scenarios of the tropical cyclone development, possible time period and degree of impact on Macao, and also information on the risks and forecast uncertainties.

The goal of the above mechanism is to let the relevant departments obtain the latest and most accurate official information regarding the forecast and possible impact of tropical cyclones. Meanwhile, it will allow more time for the departments to make appropriate preparations in response to the development of the tropical cyclones and the associated risks. This aims to achieve the purpose of improving the efficiency of disaster risk reduction work of Civil Protection.

As an effort to continuously enhance the effectiveness of the above mechanism, SMG distributed questionnaires in early 2023 to all member departments to collect opinions about their experience regarding the video meeting in 2022, and SMG made adjustments to the content and information presented in the video meeting accordingly to better cater to the needs of the member departments. In addition, 3 additional departments were introduced into the mechanism in 2023, bringing the total number of participating departments to 19, to allow for more relevant departments to benefit from the mechanism.

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

Priority Areas Addressed:
DRR
▪ Enhance Members' disaster risk reduction techniques and management strategies.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	✓
Preparedness and response capabilities	

Contact Information:
Member: Macao, China
Name of contact for this item: Ms. CHANG Sau Wa
Telephone: +853 88986180
Email: swchang@smg.gov.mo

4. Personnel capacity-building

Main text:

In order to enhance the ability and knowledge of meteorological staffs, SMG staffs engaged in capacity-building activities. These include off-line lectures held by WMO RTC Nanjing and training course held by National Marine Environment Forecasting Center of China, on-line training courses organized by China Meteorological Administration Training Centre (CMATC), and also workshops and seminars including TC Integrated Workshop, RSMC Tokyo Attachment Training, among others.

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

Priority Areas Addressed:
Meteorology
- Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	
Detection, observation, monitoring, analysis, and forecasting	✓
Warning dissemination and communication	
Preparedness and response capabilities	

Contact Information:
Member: Macao, China
Name of contact for this item: Ms. CHANG Sau Wa
Telephone: +853 88986180
Email: swchang@smg.gov.mo

5. Promotion of the knowledge of meteorology and disaster risk reduction

Main text:

SMG make use of its "Meteorological Science Popularization and Education Base" as a platform to organize diverse public education and outreach activities for different age groups and communities. SMG continued to organize the "Tropical Cyclone and Storm Surge Exchange Meeting" for members of the Civil Protection system in 2023 to deepen their understanding of meteorological forecast operation and to make an effort to establish a common language between SMG and the emergency response departments and strengthen the collaboration among members of the Civil Protection structure.

In addition, SMG organized "Getting Closer to Meteorology: Diverse Services for All" exchange meetings targeting social welfare organizations and parent-teacher associations in 2023, aiming to deepen understanding of meteorological knowledge and enhance the collaborative capabilities of the general public in dealing with meteorological disasters.

Furthermore, SMG organized other activities in 2023, including the "Meteorology Open Day" event as part of the 2023 World Meteorological Day celebration, and interactive family activities such as "Family Fun Meteorology Visit" and "Meteorology Fun Exploration" to allow the public to learn and gain awareness about meteorological science.

SMG also organized activities targeting different age groups in cooperation with the Macau Science Center in 2023. "Campus Meteorological Monitoring Competition" was held to allow secondary school students to set up monitoring instruments and analyze data to gain in-depth understanding of weather phenomena and atmospheric environment. "Weather Theaters" were organized to promote meteorology knowledge for primary school students. "Appreciating Clouds, Understanding Weather" activities were first held in 2023 to raise awareness and knowledge of weather conditions among citizens of different age groups.

Figure 5 *"Tropical Cyclone and Storm Surge Exchange Meeting" of SMG.*

Figure 6 *"Meteorology Open Day" of SMG.*

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

Priority Areas Addressed:
DRR
▪ Enhance Members' disaster risk reduction techniques and management strategies.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	
Preparedness and response capabilities	✓

Contact Information:
Member: Macao, China
Name of contact for this item: Ms. CHANG Sau Wa
Telephone: +853 88986180
Email: swchang@smg.gov.mo

6. Annual Emergency Exercise

Main text:

      The annual emergency exercise, simulating the in force of "Low-Lying Areas Evacuation Plan for Storm Surge during Tropical Cyclones" was held. The Evacuation Plan aims to strengthen communication and coordination among members of the Civil Protection Structure and the efficiency of the emergency plans among different participating departments. Residents were also welcome to participate the emergency exercise as education activity and familiarize with evacuation procedures, routes and operation of emergency shelters.

      When storm surge reaches the Third Level Warning or above, the Civil Protection Structure will be activated simultaneously with the stage of Immediate Prevention or higher classification by Chief Executive declaration in accordance with the relevant provisions of the "Civil Protection Law".

      Civil Protection Volunteers participated to the annual emergency exercise to assist in restoring normal living order. Meanwhile, the issue of alert signal and messages was also tested at the same time through Macao SAR Government app "Macao One Account" and WeChat mini programme of "Peaceful and Safe Macao".

      In order to give the Macao residents and tourist easy to remember the Assistance and enquiry hotline of the Civil Protection Operations Centre "113" hotline was setup in this year.

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

Priority Areas Addressed:
DRR
▪   Enhance Members' disaster risk reduction techniques and management strategies.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	
Preparedness and response capabilities	✓

Contact Information:
Member: Macao, China
Name of contact for this item: Mr. Fan Ka Wa
Telephone: +853 82900310
Email: copc@fsm.gov.mo

7. Public Education and Promotion among communities and schools

Main text:

In order to enhance the emergency response capabilities and the self-protection awareness of Macao residents in emergency situation, Unitary Police Service committed to strengthen the education and sharing information of disaster prevention among communities and schools.

The Unitary Police Service maintains liaison and cooperation with social associations. Starting from April 2023, the Unitary Police Service has been conducting specific training courses for Civil Protection Community Liaison Mechanism. As of November, a total of 13 specific training courses have been held. The purpose of these courses is to enhance the awareness and capabilities of disaster prevention and response among members of various social associations, in order to deepen the joint-action capabilities between the police and the public. The course content is divided into two parts, including theoretical learning and on-scene exercises.

On the other hand, Education and Youth Bureau, in cooperating with Unitary Police Service, prepared the "Disaster Prevention Plan for School", The planning also cooperate with Macao Customs Service, Public Security Police Force, Judicial Police and Fire Services Bureau to carry out jointed disaster prevention education project for primary and secondary schools in Macao SAR. In addition, Unitary Police Service in cooperating with Education and Youth Bureau, shared disaster prevention and risk avoidance information to Macao's higher education institutions for the first time this year.

For the purpose of strengthening the students' knowledge of different public emergency, there were exercises about: Fire prevention, Storm Surge Evacuation Plan in Low-lying Areas During Typhoon, Suspicious person breaks into school. After the exercises, conclusions will be made and opinions and advices will be provided.

Priority Areas Addressed:
DRR
- Enhance Members' disaster risk reduction techniques and management strategies.

Key Pillars of UN's Early Warnings for All (EW4All) Initiative Addressed:

Key Pillars of EW4All	Please ✓ the related pillar(s)
Disaster risk knowledge and management	✓
Detection, observation, monitoring, analysis, and forecasting	
Warning dissemination and communication	
Preparedness and response capabilities	✓

Contact Information:
Member: Macao, China
Name of contact for this item: Mr. Fan Ka Wa
Telephone: +853 82900310
Email: copc@fsm.gov.mo

Appendix I - Priority Areas of Working Groups for the Strategic Plan 2022-2026

WG	Priorities
Integrated	1. Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.
	2. Strengthen cross-cutting activities among working groups in the Committee.
	3. Enhance collaborative activities with other regional/international frameworks/organizations, including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.
Meteorology	4. Enhance the capacity to monitor and forecast typhoon activities particularly in genesis, intensity and structure change.
	5. Develop and enhance typhoon analysis and forecast techniques from nowcast to medium-range, and seasonal to long-range prediction.
	6. Enhance and provide typhoon forecast guidance based on NWP including ensembles, weather radar and satellite related products, such as QPE/QPF.
	7. Promote communication among typhoon operational forecast and research communities in Typhoon Committee region.
	8. Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.
	9. Enhance RSMC capacity to provide regional guidance including storm surge, in response to Member's needs.
Hydrology	10. Improve typhoon-related flood (including riverine flood, flash flood, urban flood, and coastal flood) monitoring, data collection and archiving, quality control, transmission, processing, and sharing framework.
	11. Enhance capacity in typhoon-related flood risk management (including land-use management, dam operation, etc.) and integrated water resources management and flood-water utilization.
	12. Strengthen capacity in effective flood forecasting and impact-based early warning, including hazard mapping and anticipated risk based on methodological and hydrological modelling, and operation system development.
	13. Develop capacity in projecting the impacts of climate change, urbanization and other human activities on typhoon-related flood disaster vulnerability and water resource availability.
	14. Increase capacity in utilization of advanced science and technology for typhoon-related flood forecasting, early warning, and management.
DRR	15. Provide reliable statistics of mortality and direct disaster economic loss caused by typhoon-related disasters for monitoring the targets of the Typhoon Committee.
	16. Enhance Members' disaster risk reduction techniques and management strategies.
	17. Evaluate socio-economic benefits of disaster risk reduction for typhoon-related disasters.
	18. Promote international cooperation of DRR implementation project.
	19. Share experience/knowhow of DRR activities including legal and policy framework, community-based DRR activities, methodology to collect disaster-related information.