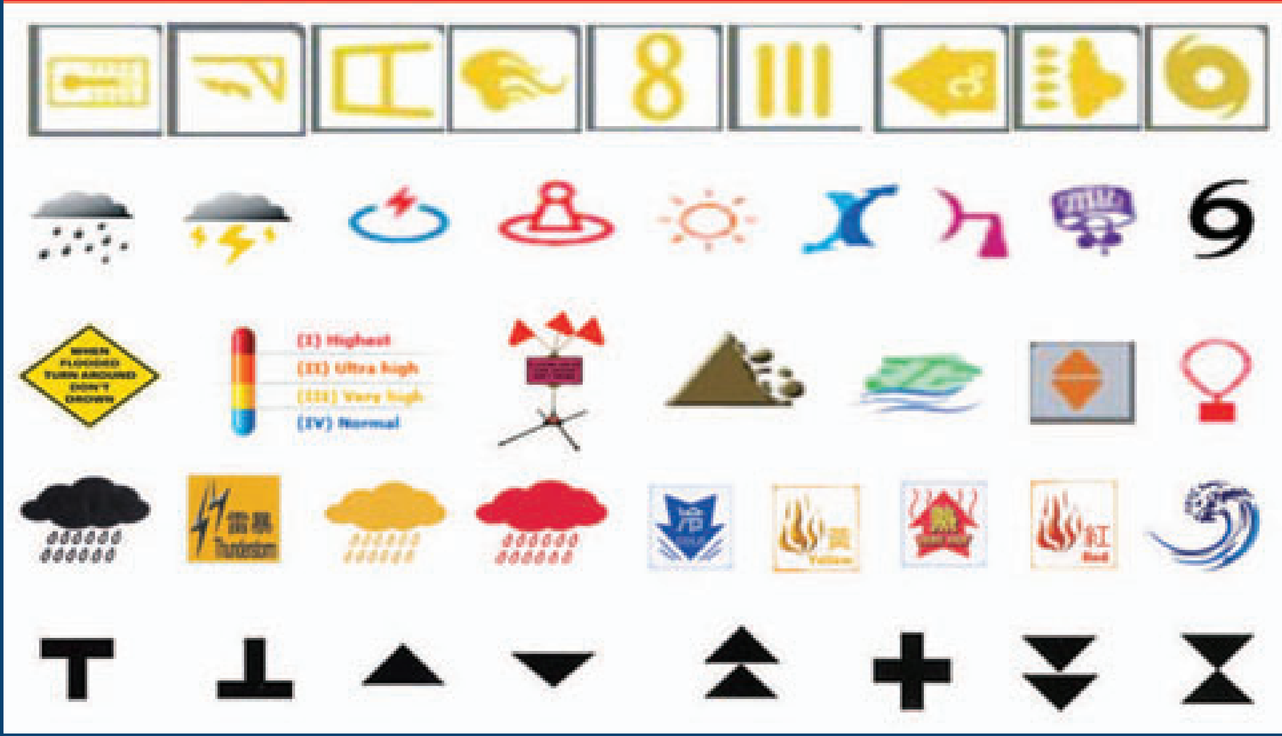

Report on UN ESCAP/WMO Typhoon Committee Members Early Warning System

UNITED NATIONS
Economic and Social Commission for Asia and the Pacific

World Meteorological Organization
Weather • Climate • Water

Warning Signals ***From Hongkong, Japan, Macao, USA, Korea***

Report on UN ESCAP/WMO Typhoon Committee Members
Early Warning System
By National Institute for Disaster Prevention (NIDP)
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NOTE

Contents

Foreword

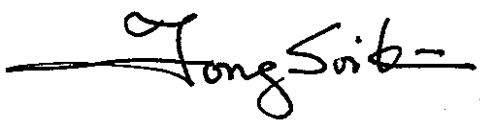
In recent decades, with increase of typhoon's magnitude owing to climate change, typhoons have caused a massive loss of life and negative long-term social, economic and environmental consequences. Vulnerable societies have been deeply affected by these typhoons throughout the Asia-Pacific region, in particular in developing countries with less coping capacity. In last year, cyclone NARGIS was a strong tropical cyclone that caused the worst natural disaster in the recorded history of Burma and the lack of an effective early warning system had raised the damages.

One of the most effective measures for disaster preparedness is a well-functioning early warning system that delivers accurate information dependably and in a timely manner. And the importance of early warning has been underlined in international activities of World Meteorological Organization (WMO) and Typhoon Committee. WMO's programs related to monitoring the atmosphere, oceans and rivers provide the crucial time-sequenced information that underpins the forecasts and warnings of hydrometeorological hazards. And WMO's global network of Regional Specialized Meteorological Centres (RSMCs) and World Meteorological Centres (WMCs) provide information sources, analysis and forecasts that enable the NMHSs to provide early warning systems and guidelines for various natural hazards such as tornadoes, winter storms, tropical cyclones, cold and heat waves, floods and droughts.

UNESCAP/WMO Typhoon Committee (TC) has participated in 2008 Expert Mission of Working Group on Disaster Prevention and Preparedness (WGDPP) and identified needs and gaps of participating members in Expert Mission in relation to the implementation of database for early warning systems (EWS). WGDPP developed Typhoon Committee Disaster Information System (TCDIS) to estimate trajectory of typhoon from the optimization analysis based on central pressure and location of typhoon and the expected damages from estimated typhoon's central pressure, precipitation, wind speeds which enable the TCDIS to provide early warning system and guide line for reduce damages of typhoon disasters.

This report reviews and the early warning system of 12 countries of 14 TC Members and highlights the importance of early warning for mitigation of typhoons in Asia-Pacific area. It describes some analysis of organizations and dissemination systems of TC Members. I wish to express my appreciation to the author, Waon Ho Yi, Chairperson with WGDPP, Tae Sung Cheong, WGDPP Secretary and focal point TC Members.

Early warning system and early action is the key to deal with damages from typhoons and should be an integral part of disaster risk reduction planning in Asia-Pacific region countries. I urge the TC Member having an interest in developing a better early warning system through continuous works like this research and collecting information to implement database for building of early warning system to mitigate damages from typhoons in Asia-Pacific area



Fong Soi Kun
Chairman, Typhoon Committee

Introduction

Nature has proven, time and again, that hazards do not recognize political boundaries. Addressing the impacts of trans-boundary hazards requires concerted actions of governments, organizations, and individuals, not only in the more immediate emergency relief, rehabilitation and reconstruction phases, but also, importantly, in long-term disaster prevention and mitigation. The Typhoon Committee Working Group for Disaster Prevention and Preparedness (TCWGDPP) Members meet in the 38th session of the Typhoon Committee in 2005 and agreed to establish a regional typhoon early warning system in the Asian region, and develop national and regional human and institutional capacity and promote transfer of know-how, technology and scientific knowledge in building and managing a regional early warning system and disaster management through international cooperation and partnership.

As a first step in gathering information for the survey, the TCDPP (Typhoon Committee for Disaster Prevention and Preparedness) Secretariat requested information on Nations' capacities and gaps in early warning through Governments' permanent missions to the Asia region. 12 Governments responded, including: China, Hong Kong, Japan, Lao PDR, Macao, Malaysia, Philippines, Republic of Korea, Republic of Singapore, Thailand, United States, Viet Nam. To involve the relevant United Nations and other organizations in the process, the TCDPP secretariat requested information from the TCDPP Member organizations on early warning capacities and gaps, and established the aforementioned TCDPP Working Group. The Working Group agreed that the survey should be mainly based on existing information and make use of existing resources and organizations. Such sources include reports submitted by countries to the Working Group Chair for the Annual Meeting on Disaster Prevention and Preparedness (2005). Early warning capacities and gaps were extrapolated from 12 TC Members' reports and synthesized in a matrix. With the guidance of the Working Group Chair, a questionnaire was developed and sent to the Working Group Members with the goal of obtaining consistent information on activities and experiences of the Working Group Members involved in different aspects of early warning systems. The completed questionnaires and the results of additional research were compiled and summarized in a matrix reproduced in TCDIS (Typhoon Committee for Disaster Information System).

The objectives of the early warning system report are following as: (i) to collect and report of early warning systems (EWSs) of 12 TC Members; (ii) analysis the disaster management systems of each TC Member to make guideline and support early warning related information to reduce the typhoon related disasters. The early warning system report are collected from 12 TC Members and reported. The recommendations for the early warning system were also reported to define the needs and gaps of participating Members by developed guideline. The GIS and damages information database for the early warning systems are implemented in the TCDIS to find similar typhoon trajectory and to estimate typhoon related damage and shear the early warning system to reduce damages and for the disaster prevention and preparedness.

Early Warning System

The Working Group met at the 3rd meeting of the TCDPP to discuss progress on gathering information from organizations. In addition to new and existing country reports and inputs from international agencies, the survey included the review of regional reports prepared for the TCDIS and other specialized early warning reports. The information was analyzed and synthesized in a draft report that was shared with a small group of experts in TCDIS of Korea in 11-20 May 2008. The members meeting provided guidance that such early warning arrangements should build on existing institutions and mechanisms, strengthen and upgrade national systems, link national mechanisms with sub-regional and regional capabilities, integrate early warning with preparedness, mitigation and response (end-to-end), and must be integrated into existing warning systems to promote a multi-hazard approach to make the system sustainable.

The experts identified capacities and gaps for each of the early warning components based on the draft report, the materials reviewed and their expertise. The most salient capacities and gaps were subsequently captured in the survey report. The consultative draft report was shared with this group of experts and the TCDPP Working Group. Subsequently, the document was revised and presented at the Third Workshop on TCDIS, Seoul, Korea, 10 to 11 April 2008. The meeting recognized the TCDPP Working Group readiness to serve as a regional center or focal point for a multi-nodal typhoon early warning arrangement in the region, and its goal to strengthen its capacity, including the incorporation of additional technological capabilities. Its purpose is to enable deploy of the warning system to prepare for the danger and act accordingly to mitigate its effects or possibly avoid it. The warning system for typhoon and floods encompasses a wide range of meteorological information such as warnings and advisories to further forecasts. Its objective is to meet the comprehensive needs for the protection of life and property and the enhancement of the national socio economic activities in various sectors including the general public, industries and transportation.

During the last integrated workshop in Beijing, China held in September 2008, a final call for the submission of the requested EWS of the 12 TC Members which responded earlier was done and agreed by the group. In the Typhoon Committee Integrated Workshop on Beijing (2008.9.22-26), WGDPP Members agreed to develop formatted early warning system for each TC Member including following contents such as: (i) Introduction (Outline of EWS); (ii) Information for Server Weather Preparedness (Methods of forecast to mitigate possible disasters, Information of meteorological observatories, network and Forecast terms, etc.); (iii) Flood Monitoring and EWS (Warning systems or equipments, Methods of warning dissemination); and (iv) Warning Criteria (Classes of warning and criteria).

The early warning systems of TC Members were summarized and defined to make guideline of the typhoon related disaster management system. The summary of 12 early warning systems is described in Table 1. For the summary 5 items are categorized such as main disaster, early warning system, warning dissemination sources, warning criteria which items are selected from 12 disaster management system. The warning criteria are categorized by 6 disaster types such tropical cyclone, tsunami, strong monsoon, thunderstorm, heavy rain, and strong wind in the Table 1. Most countries are suffering from the damages by floods and typhoon and are gathering the information from the stations of each

Table 1 Summary of early warning system of 12 TC Members and remarks

Items	China	Hong Kong, China	Japan	Lao PDR	Macao, China	Malaysia	Philippines	Republic of Korea	Singapore	Thailand	USA	Viet Nam	Remarks
Main Disaster	Floods, Earthquakes, Typhoons, Storm Surges	Floods, Typhoons, Storm surges, Thunderstorm	Floods, Earthquakes, Typhoons, Storm surges	Floods, Flash flood Droughts	Floods, Typhoons, Thunderstorm	Floods, Typhoons, Thunderstorm	Floods. Earthquakes, Typhoons	Floods, Typhoons	Floods, Typhoons, Thunderstorm	Floods, Typhoons	Floods, Typhoons	Floods, Typhoons	Floods, Earthquakes, Typhoons, Storm Surges
Early Warning System	SCSMEX	DSD TIPS	GMDSS	NDMC PDMC DDMC	LEWS	NGDC EWARNS	CBEWS IDNDR	CBS M DNMBS AVN S, ARW DNBS, DWBSs	SMS TEWS	TEWS	NOAA WREAS SS	TEWS	Each Disaster's EWS Local Based EWS
Warning Dissemination	Sirens, Calls, Website, Mass Media, Satellite	Siren, Calls, SMS, Websites, Mass Media	Calls, Website, Mass Media, Satellite	Calls, Mass Media	Calls, SMS, Website, Facsimile	Sirens, Calls, SMS, Website, Mass Media, Facsimile	Mass Media	Sirens, Calls, SMS, Website, Mass Media	Sirens, Websites, Mass Media, Facsimile	Sirens, Mass Media	Sirens, Calls, Website, Mass Media, Satellite		Sirens, Calls TC Websites, Mass Media, Facsimile Satellite
Warning Information Sources	CMA Stations	Stations Website	Stations Website	DMH Stations Website	Stations Website	Stations Website	Stations Website	KMA Stations Website	Stations Website	PTWC JMA Stations	NOAA Stations	PTWC JMA Stations	NOAA, PTWC, JMA, KMA, Stations
Warning Criteria													
-Tropical Cyclone	8 phases				8 phases			2 phases			4 phases	4 phases	2-8 phases
-Tsunami										1 phase	2 phases		1-2 phases
-Strong Monsoon								2 phases					2 phases
-Thunderstorm						1 phase							1 phase
-Heavy Rain	3 phases					3 levels		2 phases	2 phases		1 phase	2 phases	1-3 phases
-Strong Wind						3 categories		2 phases	2 phases		1 phase		1-3 phases

country for early warning.

The formulation of early warning, weather information and forecast of the TC Members makes use of varied tools which aid them to accurately provide information to the general public. The meteorological observational network in KMA, for example, is consists of various fields of observation such as surface, upper-air, ocean, weather satellite, weather radar, and seismology. Generally, available tools includes satellite and radar information, data from all available information sourced locally, regionally and globally. Several modeling tools and computer models are also used to reinforce analysis and forecast from existing satellite data through simulation. Forecast equipment is continuously upgraded to meet the demands and immediate need to protect the general public from possible harm. For other developing countries however, specifically Lao PDR, there is currently insufficient information and observed data due to deficiency of the observation system and the need to further develop the current communication gap in the observation and corresponding data provision. Improvement of weather monitoring and forecasting are also significantly achieved because of the availability of high resolution satellite data from NOAA, MTSAT and models available from JMA.

1. ORGANIZATION IN-CHARGE OF WEATHER AND HYDRO-METEOROLOGICAL HAZARDS FORECASTS AND EARLY WARNING ISSUANCE

Each in the 14 TC Members have identified agencies for the formulation of an end-to-end weather and climate analysis and forecast as well as an agency responsible for the dissemination of warnings and advisories, including the appropriate preparation for a possible disaster to concerned agencies, decision-makers, news agencies and most likely to-be-affected communities. Most notable is the effort to simplify and translate graphically the available technical warning information so that these may be understandable to the general populace. Establishment of Community-based early warning systems is currently practice in most of the TC Members. It is worthy to note that the Philippines and Thailand are very strong in pushing their initiatives on this. Meteorological Bureaus/Observatories in partnership with the Security Coordination Office in the case of Macao and Disaster Prevention Departments in other countries has also realized an agreement of real time distribution of information on civil protection with all electronic and newspaper media and telecommunication companies in order to disseminate information widely. Moreover, hot lines of multi-function are also provided to the public to seek for help and inquiry.

2. KINDS OF WARNING/ADVISORIES ISSUED FOR HYDRO-METEOROLOGICAL HAZARDS

As each TC Member has almost unique characteristics when it comes to hydro-meteorological hazards presence, there are several warning/advisories issued related to this, in addition to regular weather forecasts. These warnings/advisories have also several criteria. The kinds of warnings and advisories issued in TC Members are listed in Table 2.

Table 2 Kinds of warnings/advisories issued in TC Members

Tropical Cyclone Alert and Warning	Climate Prediction	Storm Surge / High or Rough Sea Conditions
Severe Weather System Bulletins	Annual / Monthly / Seasonal Climate Outlook	Heavy Rains
Aviation Forecast	Farm Weather Forecast and Advisories	Lightning Risk Alert
Shipping / Gale Warning	Strong Monsoon	High Temperature Advisory / Warning
Flood Advisory / Warning	Thunderstorm	Strong winds due to Squall
High Surf and Coastal Inundation	Flashflood Watch and Warning	

3. THE MAIN NATURAL HAZARDS

It is difficult to define main damage factor of each TC Member but, in most member countries, the main natural hazards come from the severe weather conditions such as heavy rain, typhoon, and tropical cyclones. The sources of damages of each country are listed in the Table 3. Table 3 shows that floods caused by localized heavy rain or flash flood are main sources of great damage in all TC Members. In Lao PDR, drought is also main factor of severe damage. The typhoon is main factor of severe damage in Thailand but most TC Members have damages from the typhoon.

Table 3 Weather conditions of TC Members causing disaster

◎ : severe ○: general

Weather Condition / Country	Floods	Droughts	Earthquakes	Typhoons	Storm surges	Thunderstorm
China	◎	○	○	○	○	
Hong Kong,China	◎			○	○	○
Japan	○		○	○	○	
Lao P.D.R.	◎	◎				
Macau	○			○		○
Malaysia	○			○		○
Philippines	◎		○	○		
Republic of Korea	○			○		
Singapore	○			○		○
Thailand	○			◎		
USA	○			○		
Vietnam	○			○		

4. SEVERE WEATHER PREPAREDNESS AND WARNING SYSTEMS

Each country's early warning system was analyzed and reported in this research. The early warning systems operated by each TC Members are listed in the Table 4. The China National Climate Center (CNCC) was established to predict and analysis climate change and its associated impacts. China has the South China Sea Monsoon Experiment (SCSMEX) which is one of large-scale experiment systems for flood forecasting and warning system. In Hong Kong, China, under the CPND, the Hong Kong Observatory (HKO) maintains a close watch on the weather and issues early warning to the general public, when severe weather is expected to affect Hong Kong, China. HKO utilizes the multiple model consensus method to forecast the movement of tropical cyclones: TIPS. Local flood warning systems have been installed by Drainage Services Department (DSD) at flood prone villages to inform the villagers when the flood water reaches a predetermined alert level. The JMA of Japan is responsible for the analysis and forecast of tropical cyclones and for the sea area surrounded by the equator, 60 degrees north latitude line, 100 degrees east longitude line and the international dateline for the operational marine meteorological information service in the framework of Global Marine Distress and Safety System (GMDSS). The NEMA of Korea takes the responsibility of flood forecasting services. Six different early warning systems now operate to reduce damages from natural disasters in Korea. Forecasting in Lao PDR actually is not as efficient as it could be. Macao Meteorological and Geophysical Bureau (SMG) is an official organization for the meteorological services that provides severe weather warnings. SMG has a real-time lightning detecting system to monitor a region of 48kms around Macao every minute.

Table 4 Operating Early Warning System of TC Members

EWS / Countries	Flood Forecasting and Warning system	Typhoon Analysis and Forecast	Marine Forecasts and warnings	Seismic monitoring system	Tsunami Early Warning System
China	○				
Hong Kong, China	○	○(TIPS)			
Japan		○	○ (GMDSS)		
Lao PDR					
Macau					
Malaysia	○				
Philippines	○				
Republic of Korea	○				
Singapore				○	○
Thailand					
USA					
Vietnam					

The Malaysia Meteorological Department (MMD) under the Ministry of Science and Innovation (MOSTI) has established a multi-hazard early warning center. MMD intensifies closer monitoring of weather situation and also issues special weather forecasts for east coast states of Peninsular Malaysia. The Department of Irrigation and Drainage (DID) to date has installed about 375 telemetric stations in 38 river basins for flood monitoring and floods forecasting operations during the floods seasons. In Philippine, two agencies are responsible for issuing early warning on disastrous events: the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). There should be an inter-barangay and inter-agency cooperation on flood monitoring and disaster warning. The National Environment Agency (NEA) provides weather surveillance and multi-hazard warning services on a 24/7 basis to the public, industry and relevant agencies in Singapore. Singapore has established a seismic monitoring system and Tsunami Early Warning System (TEWS). In Thailand, Thai Meteorological Department, Royal Irrigation Department, Department of Water Resources and Disaster Forecasting and Warning of Electricity Generating Authority of Thailand (EGAT) Public Co. Ltd are the main agencies to forecast the disaster warning on their own function. The Weather Forecast Office (WFO) Guam issues all forecasts and most warnings for Micronesia, including tropical cyclone warnings for 37 islands. These are usually based on TC forecasts from the Joint Typhoon Warning Center (JTWC).

5. DISSEMINATION OF FORECASTS AND WARNING

The methods to inform and disseminate an emergency to the villagers are diversified in respective countries, but what have been improving in speedy and accuracy is right. The dissemination methods of TC Members are listed in following Table 5.

Table 5 Operating Early Warning System of TC Members

Methods / Countries	Sirens	telephone calls	SMS	Organization website			Mass Media	Satellite	Facsimile
				by PC	by 3G mobile phone	by PDA			
China									
Hong Kong, China	○	○	○	○	○	○	○		
Japan		○		○			○	○	
Lao P.D.R.		○					○		
Macau		○	○	○		○			○
Malaysia	○	○	○	○			○		○
Philippines							○		
Republic of Korea	○	○	○	○			○		
Singapore	○			○			○		○
Thailand	○						○		
USA	○	○		○			○	○	
Vietnam									

Abstract of Early Warning System

The Early Warning Systems (EWSs) of 12 TC Members were collected and analyzed to make the guidelines. The information was subjected to a quality control process managed by the WEB-GIS based TCDIS platform for the promotion of the EWS. The first step was an editing process to ensure that information met the basic requirements of relevance and completeness. The second step involved the review and assessment of the information against the guidelines developed by expert reviewer. Also, needs and gaps of participating members in relation to the implementation of the DMS were identified by analysis information collected from each country. The abstracts of EWSs collected from 12 TC Members were reported to shear information and reduce the gap of participating members.

1. EARLY WARNING SYSTEM OF CHINA

Country : China

Submitting Organizations :

Department of Water Hazard Research,
China Institute of Water Resources and
Hydropower Research

Primary Contact : DU Xiao He
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Abstract : Because of the variations in monsoons, yearly rainfall totals fluctuate greatly, especially during the flooding season. The duration and intensity of rainfall in flooding season is main factor to reduce typhoon related damage in China's West Pacific Subtropical High Pressure (WPSHP) systems. Apart from WPSHP, some other important meteorological factors are included such as westerly belts, low-level jets, and short waves. These meteorological factors act to bring southern moisture to China, forcing northern cool air masses to clash with southern warm air masses, thereby producing rain in China. Nearly all past floods have resulted from this type of weather system. Over the last 530 years, flooding frequency has increased obviously in the last 200 years. There is a tight connection between such change and a degraded ecological environment. The main effects of human activities on the basins are: (i) Deforestation along the river basins has resulted in much soil loss. Mud and sand carried with the floods has been deposited on the riverbed, especially in the middle reaches of the river. The riverbed in Jing-Jiang now is 8-15m higher than the flood plain; (ii) Increasing population, many lakes have been enclosed for cultivation. For example, the number of lakes is down from 856 (1930s) to 577 (1990s) in the Jiang-Han plain. The diminishing number and size of lakes along the river weakens the attenuation of flood peaks. Further, many lakes are separated from the river, causing a rapid decrease in the river flood storage capacity. The China National Climate Center (CNCC) was founded in January 1995 to predict and analysis climate change and its associated impacts. Its focus is placed on short-term (monthly, seasonal, and inter-annual scale) climate prediction and studies of climate change induced by anthropogenic activities. During 1996-2000, CNCC is establishing the first integrated operational system, based on the implementation of a national study of China's short-term climate prediction system.

2. EARLY WARNING SYSTEM OF HONG KONG, CHINA

Country : Hong Kong, China

Submitting Organizations :

Assistant Director,
Hong Kong Observatory

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Abstract : Hong Kong, China is located just within the tropics. It experiences both extremely wet and dry seasons. The main natural hazards which threaten the territory are severe weather conditions such as heavy rain, thunderstorms, tropical cyclones and storm surges - all of which can lead to floods, landslips and other mishaps. They may result in casualties, and cause disruption to transport and other essential services. The Hong Kong Observatory (HKO), a government department in Hong Kong maintains a close watch on the weather. Hong Kong Meteorological Centre shown in Figure 1 is manned 24 hours a day. The Centre is responsible for issuing daily weather forecasts as well as forecasts for the next 7 days. When severe weather is expected to affect Hong Kong, the HKO will issue early warning to the general public and maintain close contacts with disaster prevention authorities so that appropriate measures can be taken to prevent and mitigate possible disasters. HKO operates a range of weather monitoring equipment shown in Figure 2 which provides the meteorological data essential for the operation of various severe weather warning systems. The equipment includes a territory-wide network of automatic weather stations for measuring wind, pressure, temperature, humidity and rainfall, a network of cameras and visibility meters for providing real-time weather photos and visibility information, a lightning location network for detecting lightning, two Doppler weather radars for detecting the intensity and movement of rain areas, another Doppler weather radar and two LIDAR (LIght Detection And Ranging) systems for detecting micro bursts and wind shear at the Hong Kong International Airport. HKO also receives imageries from a variety of weather satellites.

3. EARLY WARNING SYSTEM OF JAPAN

Country : Japan

Submitting Organizations :
Deputy Director, International Office for Disaster Management Cabinet Office, Gov. of Japan
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Tel: +81 3) 35039394
Abstract : In case a hazardous weather condition is expected, JMA delivers various plain messages including warnings, advisories and bulletins to the general public and disaster prevention authorities so that appropriate measures can be taken to mitigate possible hazards. These messages are issued by Local Meteorological Observatories (LMOs) for each of the sub-divisions in their respective prefectures; a total of 370 sub-divisions are designated all over the country as of March 2006, in consideration of their meteorological characteristics and local administrative boundaries. Warnings are issued when weather conditions are expected to be catastrophic and meet warning criteria, while advisories are issued when weather conditions are expected to be disastrous and meet advisory criteria but are expected to remain below the warning criteria. Bulletins give information to supplement the warnings and advisories. Bulletins are issued also from District Meteorological Observatories (DMOs) or JMA Headquarters according to the scale or severity of concerning disturbances. They include information not only for severe weathers but also for possible disasters. For example, sediment disaster bulletins are issued jointly with municipalities, in particular, when sediment-related disasters due to heavy rain are expected with high possibility in a few hours. All such information is delivered to the public through

mass media and directly to disaster prevention authorities from JMA Headquarters and/or DMOs. JMA takes the responsibility of flood forecasting services, which are performed in collaboration with central and local government agencies. These services include flood warnings, advisories and bulletins covering 248 rivers (as of January 2006) throughout the country, which were designated by the aforementioned agencies as the rivers with the potential for flood disasters. Flood forecasting systems for 207 rivers out of 248 are managed jointly by JMA and the River Bureau of the Ministry of Land, Infrastructure and Transport (MLIT), and 41jointly by JMA and civil engineering bureaus of prefectural governments.

4. EARLY WARNING SYSTEM OF LAO PEOPLE'S DEMOCRATIC REPUBLIC

Country : Lao People's Democratic Republic
Submitting Organizations :
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Department Meteorology and Hydrology
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Abstract : Since the largest portion of the Lao population lives in rural areas and depends largely on subsistence agriculture, they are most vulnerable to periodic flooding. This paper reviews the actual flood forecasting and flood warning system currently used that include structural and non-structural measurer. Flood forecasting started during the 1970 Mekong flood season, on a trial basis, to demonstrate the feasibility of a centralized forecasting system using advanced computer techniques and application of mathematical models called "SSARR model". Based on the observations and recommendations cited above, flood forecasting and warning systems in Lao PDR is going to be improved such as: Improvement of weather and flood forecasting capacity in the near future from : Installation of C band Doppler Radar and MTSAT-IR satellite receiving will operate in Mach 2006 under Japan's Crant Aids project, Improvement of Meteorological and Hydrological Services for Lao PDR an ongoing Project of technical cooperation assistance from Jica; project on Meteorological and Hydrological network and facilities for weather forecasting in 2005 and for the future plan 2006-2010.

5. EARLY WARNING SYSTEM OF MACAO, CHINA

Country : Macao, China
Submitting Organizations :
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Abstract : Macao located at the west bank of Pearl River Delta in South China, is the intersection of Mainland China and South China Sea. It is also located at the south of tropic of Cancer. The winds directions in winter and summer are opposites. Therefore, Macao is in the monsoon region and from the climate classification is considered mild and rainy in summer. The most comfortable period begins from the middle of October to December. March and April is the seasonal interchange period. The wind direction along the coastal region of South China is mainly easterly to southeasterly, which will increase the temperature and humidity. Beside some occasional wet weather, fog, drizzle and low visibility days, the weather is mainly fine in spring. The summer in Macao is longer than the other sea-

sons. Because of hot and wet conditions, the severe weather such as thunderstorm and heavy rain always occur from May to September. Waterspout can be seen occasionally. Meanwhile from May to October, tropical cyclones occur frequently which make the highest records of precipitation, temperature, rainy days and thunderstorms.

6. EARLY WARNING SYSTEM OF MALAYSIA

Country : Malaysia

Submitting Organizations :

Department of Irrigation and Drainage, Hydrology and Water Resources Division

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Abstract : Due to rapid infrastructure development, flash flood occurrence in the country has been on the increase and it can happen several times each year leading to massive disruption in business activities with immense socio-economic and financial impacts. Flash flood is normally caused by severe storms such as squall-lines or thunderstorms which are localized with rainfall of high intensity and short durations (2 to 5 hours). Thunderstorms occur throughout the year but are most likely to happen in the inter-monsoon periods, namely April to May and October to November. Over land, thunderstorms frequently develop in the afternoon and evening hours while over the sea, thunderstorms are more frequent at night. Sometimes the thunderstorm cells are small and localized but can be severe with intense lightning activities, heavy rainfall and strong wind gust. The severe thunderstorms with high intensity rainfall and short duration may cause flash flood in major cities and towns. The Malaysia Meteorological Department (MMD) under the Ministry of Science and Innovation (MOSTI), has established a multi-hazard early warning center in 2005 to monitor and issue early warnings on severe weather, high sea conditions, earthquake and tsunami. The centre operates 24 hours a day, 7 days a week to closely monitor the weather and earthquake/tsunami situations so that early warning on severe weather and tsunami can be issued to the relevant agencies, media and public, including the National Security Division of Prime Minister Department, in a timely manner. During the northeast monsoon season, MMD intensifies closer monitoring of weather situation and also issues special weather forecasts for east coast states of Peninsular Malaysia.

7. EARLY WARNING SYSTEM OF PHILIPPINE

Country : Philippine

Submitting Organizations :

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Abstract : The Philippines lies on the western rim of the Pacific and is part of the Circum-Pacific seismic belt. It lies between two active major plates: the Pacific plate and Eurasian plate. The country uses the modified Rossi-Forel Earthquake intensity scale to measure the strength of earthquakes. At least five earthquakes occur every day. A total of 74 destructive earthquakes have been registered since 1599. The latest and most destructive earthquake in the country was in July 21, 1990 which affected 23 provinces, killing 1,666 people and resulting in damages put at 12.2 billion pesos or US $305 million (CDRC, 1992: 62-68). As a consequence of typhoons and even ordinary monsoon rain, flooding is very common in both urban and rural areas. The National Mapping Resource and Information Agency said that one hundred and two areas in the Philippines are in danger of being submerged by flood waters. It was reported that ten harbors and ports nationwide experienced a 100 centimeter rise in the mean sea level (MSL) at high tide. The average increase in MSL in Manila is 1.75 centimeters. The worst flood was the Ormoc flash flood which killed 8,000 people in 1991 (CDRC, 1992: 48-55). The flood happened in the morning but it took less than four hours for the water to rise to about ten feet, washing people into the sea. Two agencies are responsible for issuing early warning on disastrous events: the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). PHIVOLCS issues warnings on volcanic activities and earthquakes while PAGASA disseminates information on weather changes and climate conditions and undertakes typhoon and flood forecasting and monitoring. PAGASA has limited capabilities to issue on-time and accurate early disaster warning. Nevertheless, the PAGASA issues flood warnings in Metro Manila. The meteorologists of PAGASA base their information from rainfall intensity, elevation and past history of flood occurrence in the area. In a typhoon associated flood, inundation warning is incorporated into a typhoon prediction. The PAGASA Data Center also gathers inputs from the Effective Flood Control Operations System (EFCOS) Project that was completed on October 16, 1993 (DPWH, 1994). The EFCOS Project's main features are a telemetry system that is controlled at the Rosario Master Control Station. However, most town and city councils are not equipped with information that facilitates an efficient disaster warning and emergency evacuation. For example, there are no available flood maps that will indicate which areas are at risk, nor what flood depths are to be expected on certain flood magnitudes. There could be an exception and this is Solidum's 1986 flood map that was cited by Punongbayan in 1987. The map was supposedly based on the watermarks of 15-16 August 1986 floods.

8. EARLY WARNING SYSTEM OF REPUBLIC OF KOREA

Country : Korea

Submitting Organizations :

National Institute for Disaster Prevention,
National Emergency Management Agency

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Abstract : Nature has proven, time and again, that hazards do not recognize political boundaries. Addressing the impacts of trans-boundary hazards requires concerted actions of governments, organizations, and individuals, not only in the more immediate emergency relief, rehabilitation and reconstruction phases, but also, importantly, in long-term disaster prevention and mitigation. The Typhoon Committee Working Group for Disaster Prevention and Preparedness (TCWGDPP) Members meet in the 38th session of the Typhoon Committee on 2005 and agreed to establish a regional typhoon early warning system in the Asian region, and develop national and regional human and institutional capacity and promote transfer of know-how, technology and scientific knowledge in building and managing a regional early warning system and disaster management through international cooperation and partnership.

9. EARLY WARNING SYSTEM OF SINGAPORE

Country : Singapore

Submitting Organizations :

National Environment Agency,

Meteorological Services

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Abstract : While Singapore is relatively free from natural hazards, it is affected by severe weather such as heavy rain, thunderstorms and lightning and occasionally by strong winds and high temperatures. To a lesser extent, it is also affected indirectly by natural hazards occurring further away, such as tremors from earthquakes and ash from volcanic eruptions. Disaster monitoring and preparedness can prevent natural hazards from becoming disasters. The National Environment Agency (NEA) provides weather surveillance and multi-hazard warning services on a 24/7 basis to the public, industry and relevant agencies in Singapore. The severe weather and hazards encountered in Singapore, together with the monitoring and management systems in place at NEA, are described below. Drainage system is designed with a capacity to cope with floods from very heavy rain that occurs once in 5 years. The drainage code has a deliberate requirement to raise low-lying grounds in conjunction with redevelopment proposals and this helps to reduce the severity of floods caused by heavy rain. To help alleviate the impact of floods, NEA provides heavy rain advisory and warning to various agencies for enhancing preparedness for expected heavy rain. Heavy rain warnings are also issued to the public via the media. A Sumatra Squall is a line of thunderstorms, which develops over Sumatra or the Straits of Malacca and subsequently propagates eastward to affect Peninsular Malaysia and Singapore. To help alleviate the impact of squalls or tropical cyclones (rare as it may be), NEA provides heavy rain and strong winds advisory and warning to various agencies for enhancing preparedness for expected heavy rain and strong winds. The warnings are also issued to the public via the media.

10. EARLY WARNING SYSTEM OF THAILAND

Country : Thailand

Submitting Organizations :

Chief, Foreign Relations Sub-Bureau

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Abstract : The early warning system in Thailand could divide into 2 levels. In the national level, there are many organizations to take responsibility for the task relevant disaster warning. Thai Meteorological Department, Royal Irrigation Department, Department of Water Resources and Disaster Forecasting and Warning of Electricity Generating Authority of Thailand (EGAT) Public Co. Ltd are the main agencies to forecast the disaster warning on their own function. Therefore, Thailand’s Early Warning Information from these agencies will be transferred to the people via mass media and agencies concerned and Department of Disaster Prevention and Mitigation (DDPM) will transmit the information through mechanism of Ministry of Interior to provinces, districts and local organizations. After Tsunami disaster triggered the 6 southern provinces of Thailand on 26 December 2004, the government reviewed disaster early warning system to develop the system more efficiency and to make more confidence in safety in

the country. In 2005, the cabinet appointed the Committee on Early Warning System Development which comprise the representatives of the departments concerned, will be responsible for making the decision as to when a warning should be issued. The National Early Warning Center has been set up to carry out the early warning system. Moreover, for the regional warning system, Thailand contributed to establish the Voluntary Trust Fund in Tsunami Early Warning Arrangements in the Indian Ocean and Southeast Asia in September 2005.As the initiated country, Thailand pledged the amount of US$ 10 million dollar as seed money. The Fund is under the administration of UNESCAP and has already provided financial grant to a number of projects submitted by competent agencies and institutions from many countries in the region. In the local level, the rain gauge and manual disaster siren have been installed in the flood prone areas. This device is employed for observing and notifying of local flood conditions, forecasts and warnings. The rain gauge is extremely low cost and very simple to use. The villagers will be trained to measure, record and read the daily amount of rainfall. Whenever the amount of rainfall exceeds the predefined normal level, the villager in charge of surveillance signal the warning by using the manual siren device to notify the village headman to disseminate the warning through the village news broadcast center.

11. EARLY WARNING SYSTEM OF USA

Country : USA

Submitting Organizations :

Meteorologist-in-Charge

Weather Forecast Office (WFO)

Primary Contact : Genevieve C. Miller.

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Abstract: Various systematic early warning systems listed in Table 1 have been established and are operating in USA. Most early warning systems rely on communications systems and people. The level of sophistication varies with jurisdiction and population. The USA funds weather stations in Guam, the Republic of Palau (ROP) (1), the Republic of the Marshall Islands (RMI) (1), and the Federated States of Micronesia (FSM) (3). The FSM includes the States of Yap, Chuuk, Pohnpei, and Kosrae. The Weather Forecast Office (WFO) Guam issues all forecasts and most warnings for Micronesia, including tropical cyclone warnings for 37 islands. WFO Guam provides direct early warning support to emergency managers in Guam and the Commonwealth of the Northern Mariana Islands (CNMI). WFO Guam provides early warning support to the other island emergency managers through their respective weather service offices. The Weather Service Office (WSO) in Pohnpei supports both Pohnpei State and Kosrae State. The ROP WSO, the RMI WSO, and the FSM WSOs provide local flood warnings with guidance from WFO Guam.

12. EARLY WARNING SYSTEM OF VIET NAM

Country : Viet Nam

Submitting Organizations :

Dept. DYKE Management

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Abstract: Warnings are issued when heavy rain is expected to exceed 25mm per 12 hours in an area where the number of stations reporting such event is the total number of stations in that region.

Typhoon warnings are issued for all activating TCs (including tropical depressions) in the South China Sea; TCs originated in the eastern part of 120°E, southern of 5°N and northern of 22°N which might move to the South China Sea within the next 12h to 24h. The Committee for Flood and Storm Control (CCFSC) of Ministries and sectors established by their Ministers and chaired by the Leaders of Ministries and sectors. Duties of these CFSCs are (i) for developing and implementing the flood and storm control plans of their ministries and sectors, protecting materials and facilities, technologies and human resources directly managed by their ministries and sectors; (ii) for managing materials and preserved means to serve flood and storm control and damage recovery according to their managerial functions; and (iii) for providing materials, technologies and means managed by their ministries and sectors to support and respond to emergency events, as appointed by the Central Committee for Flood and Storm Control

Suggestions and Recommendations

1. SUGGESTIONS

1.1 The key elements of early warning system

The objective of people-centered early warning systems is to empower individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life and damage to property and the environment. A complete and effective early warning system comprises four inter-related elements, spanning knowledge of hazards and vulnerabilities through to preparedness and capacity to respond. Best practice early warning systems also have strong inter-linkages and effective communication channels between all of the elements.

Risk Knowledge

Risks arise from the combination of hazards and vulnerabilities at a particular location. Assessments of risk require systematic collection and analysis of data and should consider the dynamic nature of hazards and vulnerabilities that arise from processes such as urbanization, rural land-use change, environmental degradation and climate change. Risk assessments and maps help to motivate people, prioritize early warning system needs and guide preparations for disaster prevention and responses.

Monitoring and Warning Service

Warning services lie at the core of the system. There must be a sound scientific basis for predicting and forecasting hazards and a reliable forecasting and warning system that operates 24 hours a day. Continuous monitoring of hazard parameters and precursors is essential to generate accurate warnings in a timely fashion. Warning services for different hazards should be coordinated where possible to gain the benefit of shared institutional, procedural and communication networks.

Dissemination and Communication

Warnings must reach those at risk. Clear messages containing simple, useful information are critical to enable proper responses that will help safeguard lives and livelihoods. Regional, national and community level communication systems must be pre-identified and appropriate authoritative voices established. The use of multiple communication channels is necessary to ensure as many people as possible are warned, to avoid failure of any one channel, and to reinforce the warning message.

Response Capability

It is essential that communities understand their risks; respect the warning service and know how to react. Education and preparedness programs play a key role. It is also essential that disaster management plans are in place, well practiced and tested. The community should be well informed on options for safe behavior, available escape routes, and how best to avoid damage and loss to property.

1.2 Key Actors for early warning system

Developing and implementing an effective early warning system requires the contribution and coordination of a diverse range of individuals and groups. The following list provides a brief explanation of the types of organizations and groups that should be involved in early warning systems and their functions and responsibilities. Communities, particularly those most vulnerable, are fundamental to people-centred early warning systems. They should be actively involved in all aspects of the establishment and operation of early warning systems; be aware of the hazards and potential impacts to which they are exposed; and be able to take actions to minimize the threat of loss or damage.

Local governments, like communities and individuals, are at the centre of effective early warning systems. They should be empowered by national governments, have considerable knowledge of the hazards to which their communities are exposed and be actively involved in the design and maintenance of early warning systems. They must understand advisory information received and be able to advise, instruct and engage the local population in a manner that increases public safety and reduces the possible loss of resources on which the community depends.

National governments are responsible for high-level policies and frameworks that facilitate early warning and for the technical systems that predict and issue national hazard warnings. National governments should interact with regional and international governments and agencies to strengthen early warning capacities and ensure that warnings and related responses are directed towards the most vulnerable populations. The provision of support to local communities and governments to develop operational capabilities is also an essential function.

Regional institutions and organizations play a role in providing specialized knowledge and advice which supports national efforts to develop and sustain early warning capabilities in countries that share a common geographical environment. In addition, they encourage linkages with international organizations and facilitate effective early warning practices among adjacent countries.

International bodies can provide international coordination, standardization, and support for national early warning activities and foster the exchange of data and knowledge between individual countries and regions. Support may include the provision of advisory information, technical assistance, and policy and organizational support necessary to aid the development and operational capabilities of national authorities or agencies.

Non-governmental organizations play a role in raising awareness among individuals, communities and organizations involved in early warning, particularly at the community level. They can also assist with implementing early warning systems and in preparing communities for natural disasters. In addition, they can play an important advocacy role to help ensure that early warning stays on the agenda of government policy makers. The private sector has a diverse role to play in early warning, including developing early warning capabilities in their own organizations. The media plays a vital role in improving the disaster consciousness of the general population and disseminating early warnings. The private sector also has a large untapped potential to help provide skilled services in form of technical manpower, know-how or donations (in-kind and cash) of goods or services.

The science and academic community has a critical role in providing specialized scientific and technical input to assist governments and communities in developing early warning systems. Their expertise is central to analyzing natural hazard risks facing communities, supporting the design of scientific and systematic monitoring and warning services, supporting data exchange, translating scientific or technical information into comprehensible messages, and to the dissemination of understandable warnings to those at risk.

2. RECOMMENDATIONS

The provision of a wide range of forecasts, warnings and advisories services to a variety of users, from policy-makers, decision-makers down to the people at the community level is a difficult task at hand. However, the strengthening in each TC Members' capability in this particular field can be easily achieve by first, sharing of the necessary and basic information which are usable from one country to another ; second, is to build the human capacity of the professionals in this field thru an experts exchange program and third, is to pool the resources (financial and human) to help the developing countries to cope with the demands of equipment acquisition and/or upgrade to further aid them in coming with an accurate hydrological and meteorological database thru the availability of sufficient information and spatial detail. Finally, the transition of a warning and advisories into concrete actions in disaster preparedness and appropriate response such as contingency planning, conduct of regular drills and exercise to educate and prepare the people at the community and identification of appropriate response protocols at all levels must all be realize to ensure the resilience of communities to disasters.

Conclusions

The EWSs of 12 TC Members were collected and analyzed to make the guidelines to consider all elements of effective early warning system such as the assessment of risk, the technical warning service, the communication needs, and the preparedness of those at risk. The information was subjected to a quality control process managed by the WEB-GIS based TCDIS platform for the promotion of EWS. The first step was an editing process to ensure that information met the basic requirements of relevance and completeness. Altogether 12 information for each system was entered into the WEB-GIS based TCDIS. The second step involved the review and assessment of the information against the guidelines developed by expert reviewers. Also, needs and gaps of participating members in relation to the implementation of the EWS were identified by analysis information collected from each country. The summary of 12 EWS and all information collected from 12 TC Members were uploaded in the WEB-GIS based TCDIS and reported in the Appendix to shear information and reduce the gap of participating members. The summary of EWS, abstracts, and recommendations reported in this study will help to reduce the gap of participating members and to reduce the typhoon related damages.

The results show that the cooperation works among TC Members are important key to reduce the typhoon related damages and disaster prevention and preparedness in TC area. The Republic of Korea, a leader of the WGDPP would organize regular meetings and briefings to public officials responsible for disaster prevention and preparedness in TC area, as well as implement public out-reach projects on EWS for considering climate changes. We expect that the WEB-GIS based TCDIS would be used to find the typhoon trajectory in the TC area and estimate typhoon related damages for the disaster prevention and preparedness and damage assessment.

References

The International Strategy for Disaster Reduction (ISDR) www.unisdr.org/hfa

UN ESCAP/WMO Typhoon Committee, www.typhooncommittee.org

United Nations ESCAP, www.unescap.org

Report on UN ESCAP/WMO Typhoon Committee Members Early Warning System

Appendix Ⅱ

CHINA

Introduction

Every year, China is affected by severe flooding, which causes considerable economic loss and serious damage to towns and farms. China has experiences of frequent natural disasters, including floods, droughts, earthquakes, forest fires, snow, typhoons, and marine disasters. History records more than 1000 floods, including the 1998 floods in the middle and lower reaches of the Yangtze River, Nen River, and Songhua River (Ministry of Water Resources, 1999). Flooding seriously affects people's lives and productivity (Wang, 1999).

Precipitation anomalies are key flooding mechanisms. It is commonly known that the East Asia Monsoon generally controls China's climate, which means that most of China's annual total rainfall occurs during the summer season. Because of the variations in monsoons, yearly rainfall totals fluctuate greatly, especially during the flooding season. The duration and intensity of rainfall during the flooding season is affected mainly by West Pacific Subtropical High Pressure (WPSHP) systems. Apart from WPSHP, some other important meteorological factors include westerly belts, low-level jets, and short waves. These meteorological factors act to bring southern moisture to China, forcing northern cool air masses to clash with southern warm air masses, thereby producing rain in China. Nearly all past floods have resulted from this type of weather system.

Over the last 530 years, flooding frequency has increased obviously in the last 200 years. There is a tight connection between such change and a degraded ecological environment. The main effects of human activities on the basins are: (i) Deforestation along the river basins has resulted in much soil loss. Mud and sand carried with the floods has been deposited on the riverbed, especially in the middle reaches of the river. The riverbed in Jing-Jiang now is 8-15m higher than the flood plain; (ii) Increasing population, many lakes have been enclosed for cultivation. For example, the number of lakes is down from 856 (1930s) to 577 (1990s) in the Jiang-Han plain. The diminishing number and size of lakes along the river weakens the attenuation of flood peaks. Further, many lakes are separated from the river, causing a rapid decrease in the river flood storage capacity.

The China National Climate Center (CNCC) was founded in January 1995 to predict and analysis climate change and its associated impacts. Its focus is placed on short-term (monthly, seasonal, and inter-annual scale) climate prediction and studies of climate change induced by anthropogenic activities. During 1996-2000, CNCC is establishing the first integrated operational system, based on the implementation of a national study of China's short-term climate prediction system. Figure A-1 is the operational flow chart of CNCC.

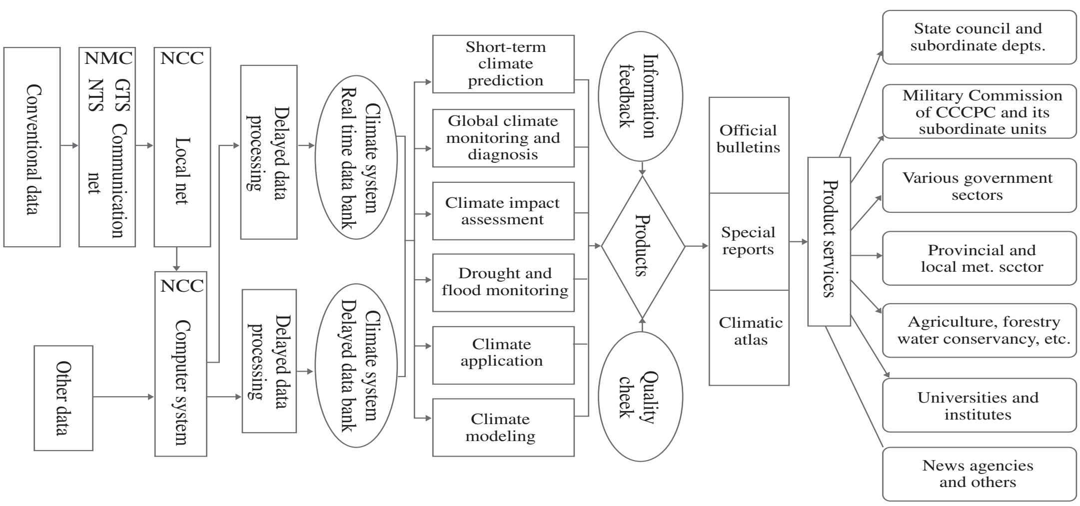


Figure A-1. The operational flow chart of the CNCC

Flood Forecasting and Warning System

The South China Sea Monsoon Experiment (SCSMEX) is a large-scale experiment to study the water and energy cycles of the Asian monsoon regions. The goal is to provide a better understanding of the key physical processes responsible for the onset, maintenance and variability of the monsoon over Southeast Asia and southern China, which in turn will lead to improved flood predictions.

The WMO/M1 Committee of Atmospheric Sciences, WCRP CLIVAR Monsoon Program and the Pacific Science Association jointly sponsor SCSMEX. It involves the participation of all major countries and regions of East and Southeast Asia, as well as Australia and the U.S. Visible images are available through Chinese Geostationary Satellite FY-II, which was launched on June 10, 1997. The strong convective activity over the South China Sea and the vicinity is noteworthy.

SCSMEX consists of five components following as: (i) A pilot study component (1996-1998) for climatological data analysis, including satellite OLR, GPCP, re-analysis, pilot stations and mooring sites, planning of IOP strategies; (ii) A field experiment phase (May 1 to July 31, 1998) for routine and enhanced four times daily upper air sounding in stations around the SCS, hourly surface observations, ATLAS buoys, dual Doppler radar observations on ship and on islands, Integrated Sounding Systems, aerosondes, PBL measurements, air-sea fluxes, ocean survey ships; (iii) A satellite component (1996-2000) for rainfall estimates from TRMM, deep convective indices and cloud track wind, visible and IR cloud information from GMS and FY-II, surface wind from ERS-II, moisture data from SSM/I and sea surface temperature and outgoing long wave radiation AVHRR; and (iv) A data analysis component (1998-2002) for analysis and interpretation of special and routine observations obtained during the field phase. (v) Modeling component (1996-2002) for mesoscale model simulations, GCMs, nested mesoscale models global and regional 4-D assimilation.

The SCSMEX field phase is being closely coordinated with the GEWEX Asian Monsoon Experiment (GAME). In this program, dual Doppler radar coverage is collocated with an ATLAS buoy, which measures rainfall, surface meteorology and subsurface oceanic temperature and salinity. The TRMM satellite flying over the region provides spatial rainfall coverage on a broader scale over the SCS and the adjacent areas. With such a system, the forecasts of monsoons and various meteorological parameters may improve.

HONG KONG, CHINA

Introduction

Hong Kong, China is located just within the tropics. It experiences both extremely wet and dry seasons. The main natural hazards which threaten the territory are severe weather conditions such as heavy rain, thunderstorms, tropical cyclones and storm surges - all of which can lead to floods, landslips and other mishaps. They may result in casualties, and cause disruption to transport and other essential services.

Information for Severe Weather Preparedness

The Hong Kong Observatory (HKO), a government department in Hong Kong maintains a close watch on the weather. Hong Kong Meteorological Centre shown in Figure A-2 is manned 24 hours a day. The Centre is responsible for issuing daily weather forecasts as well as forecasts for the next 7 days. When severe weather is expected to affect Hong Kong, the HKO will issue early warning to the general public and maintain close contacts with disaster prevention authorities so that appropriate measures can be taken to prevent and mitigate possible disasters.

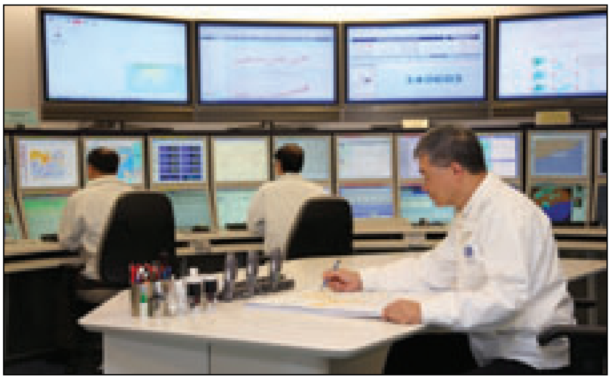


Figure A-2. Hong Kong Meteorological Centre

HKO operates a range of weather monitoring equipment shown in Figure A-3 which provides the meteorological data essential for the operation of various severe weather warning systems. The equipment includes a territory-wide network of automatic weather stations for measuring wind, pressure, temperature, humidity and rainfall, a network of cameras and visibility meters for providing real-time weather photos and visibility information, a lightning location network for detecting lightning, two Doppler weather radars for detecting the intensity and movement of rain areas, another Doppler weather radar and two LIDAR (LIght Detection And Ranging) systems for detecting micro bursts and wind shear at the Hong Kong International Airport. HKO also receives imageries from a variety of weather satellites.

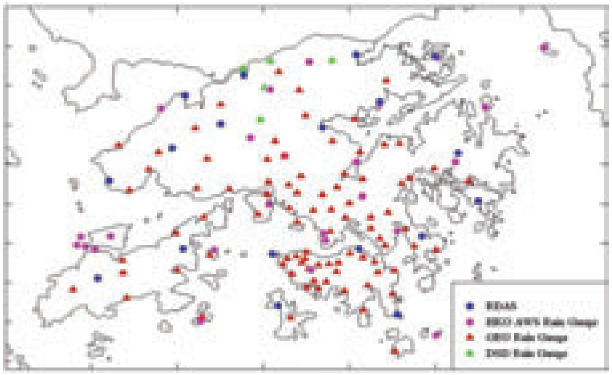
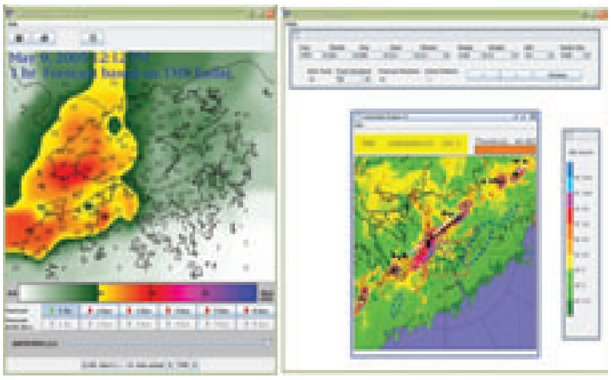


Figure A-3. Automatic rain gauge network in Hong Kong operated by various government departments

HKO uses computer models to simulate and predict the evolution of weather systems over East Asia and the western North Pacific, and uses model prognoses as the basis for forecasting the weather in Hong Kong and the adjacent seas. The HKO has developed and is operating a now casting system called SWIRLS (Short-range Warning of Intense Rainstorms in Localized Systems) shown in Figure A-4 to predict rapidly developing rainstorms. Using radar and rain gauge data, SWIRLS provides a forecast of the rainfall distribution over Hong Kong up to 6 hours ahead. The forecast is updated every six minutes to support the issuance of warnings for heavy rain in Hong Kong.



(a) Rainfall Forecast Viewer (b) G-TRACK Viewer

Figure A-4. SWIRLS products

HKO utilizes the multiple model consensus method to forecast the movement of tropical cyclones. The Observatory has developed a Tropical Cyclone Information Processing System (TIPS) which supports the production and display of the forecast track shown in Figure A-5 using the multiple model consensus method. The TIPS also provides estimation of critical data such as the time for the local onset of strong winds or gales and the distance of closest approach etc based on the forecast intensity and track of the tropical cyclone. The TIPS renders support to decision making in respect of the issuance of tropical cyclone warning signals.

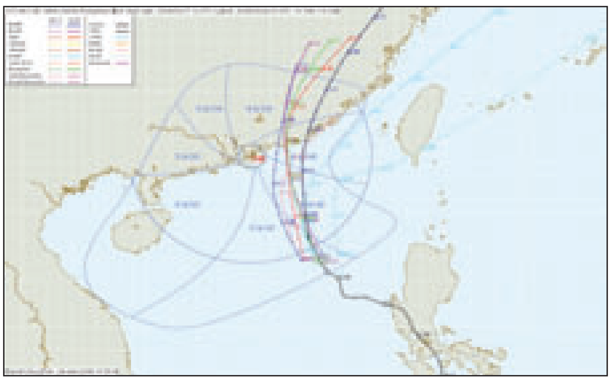


Figure A-5. Tropical Cyclone Information Processing System (TIPS)

1. Long range forecasts

The Observatory provides an annual outlook and seasonal forecast for the public. In formulating the annual outlook, the main factors bearing on the short range climate in Hong Kong, namely, the El Nino-Southern Oscillation (ENSO), monsoon in the preceding winter and Quasi-Biennial Oscillation (QBO) have been identified. At the beginning of a year, HKO assesses the climate factors impacting on the annual climate and formulates the forecasts, which would be announced to the general public in March, before the commencement of the rain and tropical cyclone season. The forecasts consist of the total rainfall expected in Hong Kong during the year and the tropical cyclone activity, i.e., the number of tropical cyclones expected to affect Hong Kong.

As part of its seasonal forecasting initiative, HKO adapted a suite of Global-Regional Climate Model (G-RCM) developed by Experimental Climate Prediction Centre (ECPC) of the University of California at San Diego with a long-term view of providing objective guidance for formulating seasonal forecast. To formulate the seasonal forecasts for Hong Kong, the forecasters analyze and consolidate the G-RCM outputs and dynamical forecasts from various international centres. HKO has commenced the provision of Seasonal forecasts in summer 2007. The forecast consisting of the mean temperature and total rainfall given in categories (i.e. below normal, near normal and above normal) is made available to the public on the HKO web site.

Flood Monitoring and Early Warning System

1. Alerting the public

The reduction of casualties due to natural disasters in Hong Kong in the past few decades is achieved principally through high standard building codes, effective early warning systems, community preparedness for weather-related hazards and contingency planning and coordination among relevant government departments and organizations for natural disaster. The comprehensive Contingency Plan for Natural Disasters (CPND) provides a proven framework for emergency responses in natural disasters (http://www.info.gov.hk/sb/eng/emergency /pdf/ndi saster.pdf).

The plan stipulates the triggering mechanism for the activation of the CPND and spells out the responsibility of various departments and non-government organizations for each type of weather-related hazards such as tropical cyclones, rainstorms, flooding and landslides. A bottom-up approach is adopted in which the emergency response is kept as simple as possible by limiting the number of departments and agencies involved. The amount of communication within the emergency response system is minimized by delegating necessary authority and responsibility to those at the scene of an emergency. Under the CPND, the HKO will be responsible for originating all weather-related warnings, tsunami warnings and general precautionary announcements to the public and providing meteorological or tsunami-related advice to other government departments/agencies.

2. Flood monitoring and alerting

The HKO issues the rainstorm warning to alert the public of heavy rain and possible flooding in Hong Kong. Flooding occurs when rainfall is so high that natural or engineered drainage fails to drain away the surface runoff. Floods are usually fairly transient in urban areas in Hong Kong. In the northern New Territories where the catchment area is relatively large and the slope is gentle, it takes some time (usually of the order of a couple of hours) for the rainwater to accumulate and to drain away. The resulting floods may therefore last up to a few hours.

2.1 Northern New Territories

The HKO will issue the Special Announcement on Flooding in the northern New Territories whenever heavy rain affects the northern New Territories with hourly rainfall at reference rain gauges in the area reaching a preset level. The announcement is broadcast by radio and television to the public, and will be updated at appropriate intervals until heavy rain ceases. The special announcement supplements routine weather forecasts by drawing attention to potential flooding in the northern New Territories due to heavy rain. It is intended to prompt the residents there to take precautionary measures against flooding and to alert farmers fish farm operators, engineers, contractors and others who are likely to suffer losses from flooding. The announcement also alerts the relevant government departments and organizations to take appropriate actions, such as opening of temporary shelters, search and rescue operations, closure of individual schools and relief work.

Local flood warning systems shown in Figure A-6 have been installed by Drainage Services Department (DSD) at flood prone villages to inform the villagers when the flood water reaches a predetermined alert level. The warnings are disseminated through flood sirens or through automatic telephone calls to the village representatives. Flood shelters will also be made available during emergencies to provide an adequate safety net for the majority of flood affected residents. Long term engineering improvement work to minimize flood losses is underway.

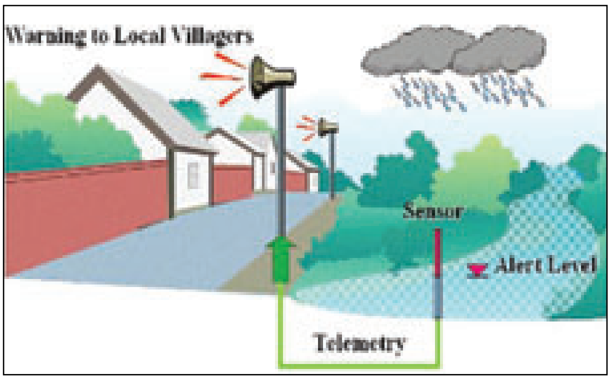


Figure A-6. Schematic layout of flood warning system

2.2 Urban Areas

The area around Wing Lok Street in Sheung Wan is a low-lying area. During high tide, sea level is close to the ground level and the underground storm water drains are filled with seawater. Coupled with rainstorm event, it is much more difficult to discharge the storm water to the sea. As a result, the area is more susceptible to flooding during the coincidence of high tide and rainstorm.

To solve the flooding problem in Sheung Wan, DSD is constructing storm water intercepting drains and pumping station to pump storm water of the low-lying area to the sea. With the progressive completion of the works, flooding problem in the low-lying area in Sheung Wan will be alleviated before the wet season of 2009. Before that, DSD will, in conjunction with relevant departments, step-up patrolling and cleansing of drains to ensure the drainage system is in good condition. DSD has also provided the service of Sheung Wan Flood Watch starting from April 2006. The objective of the service is to alert the residents in that area to possible flooding so that they can take appropriate measures to protect their life and property. The alert will be disseminated to registered residents by SMS messages. To strengthen the service, DSD has set up a Flood Watch Telephone Hotline from which residents may also obtain the latest situation of the Sheung Wan Flood Watch anywhere and anytime.

3. Storm surge advisories

Tropical cyclones in the vicinity of Hong Kong often cause rises in sea level above the normal tide level. Whenever flooding by sea water is expected in low-lying areas during passage of tropical cyclones, advice on storm surge will be given by the HKO in tropical cyclone warning bulletins. In issuing the storm surge advisories, the HKO makes reference to the forecast of the storm surge using the SLOSH model as well water level data collected from a tide gauge network in Hong Kong.

4. Early warning of severe weather

When severe weather is expected to affect Hong Kong, the HKO will issue early warning to the general public and emergency units to facilitate appropriate response actions to be taken to minimize loss of life and property. The warnings include tropical cyclone warning, rainstorm warning, landslip warning and thunderstorm warning which are described in details in Section 4 of warning criteria.

5. Status of Natural Disaster Warning Systems

Weather information, forecasts and warnings on hazardous weather for the public are issued and broadcast through a variety of dissemination channels, including the Observatory website and the Dial-a-weather service, press, radio and television stations (Figure A-7). Television weather programme are produced and presented daily by professional meteorologists of HKO for television broadcast.

Radio and television remain the most popular channel for the public to obtain weather warnings and advisories. The Observatory website (http://www.hko.gov.hk), in addition, provides ample supplementary weather data for those more technically minded individuals to support their operational decision making. For communication with government departments, tailored made web-pages, short message service (SMS) and email haves grown in popularity in recent years with advance in technology, in comparison with fax and telephone.

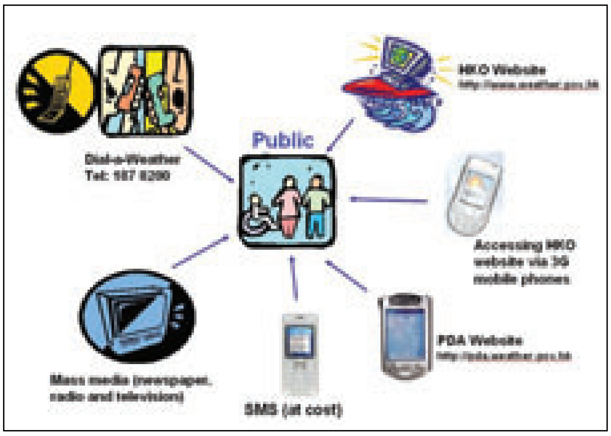


Figure A-7. Dissemination of weather information to the public

Warning Criteria

In Hong Kong, HKO is responsible for issuing warnings against severe weather (http://www.hko.gov.hk/wservice/severe.htm). A brief description of the severer weather warnings with the warning criteria are given below.

1. Tropical Cyclone Warning Signal

Tropical cyclone warning signals are to warn the public of the threat of winds associated with a tropical cyclone. Tropical cyclone advisory bulletins are issued at hourly intervals once a Tropical Cyclone Warning Signal is issued. The bulletins contain information on the location and movement of the tropical cyclone, its intensity and the likely effects on Hong Kong. Advice to the public on the precautions to be taken is also given. The Table A-1 gives the different signals of the tropical cyclone warning system and their meanings:

Table A-1. Tropical cyclone warning system

Signal No.	Meaning
1	A tropical cyclone is centred within about 800 kilometres (km) of Hong Kong and may affect the territory.
3	Strong wind is expected or blowing generally in Hong Kong near sea level, with a sustained speed of 41-62 kilometres per hour (km/h), and gusts which may exceed 110 km/h, and the wind condition is expected to persist.
8 NE, 8SW, 8 NW, 8 SE	Gale or storm force wind is expected or blowing generally in Hong Kong near sea level, with a sustained wind speed of 63-117 km/h from the quarter indicated and gusts which may exceed 180 km/h, and the wind condition is expected to persist.
9	Gale or storm force wind is increasing or expected to increase significantly in strength.
10	Hurricane force wind is expected or blowing with sustained speed reaching upwards from 118 km/h and gusts that may exceed 220 km/h.

2. Strong Monsoon Signal

The Strong Monsoon Signal is issued when winds associated with the summer or winter monsoon are blowing in excess of or are expected to exceed 40 kilometres per hour near sea level anywhere in Hong Kong. In very exposed places, monsoon winds may exceed 70 kilometres per hour.

When the Strong Monsoon Signal is in force, precautionary announcements are broadcast at regular intervals to remind the public to take precautions against strong gusty winds associated with the monsoon. In Hong Kong, winter monsoon normally blows from the north or from the east while summer monsoon typically blows from the southwest. Monsoon signal is not used to warn winds associated with tropical cyclones.

3. Rainstorm Warning

The rainstorm warning system is designed to alert the public about the occurrence of heavy rain which is likely to bring about major disruptions, and to ensure a state of readiness within the essential services to deal with emergencies. There are three levels of warning: Amber, Red and Black. The Amber Rainstorm Warning Signal gives alert about potential heavy rain that may develop into Red or Black Rainstorm Warning Signal situations. It also signifies possible flooding in some low-lying and poorly drained areas. The Red Rainstorm Warning Signal listed in Table A-2 warns the public of heavy rain which could cause serious road flooding and traffic congestion, and may affect schools and public examinations. The Black Rainstorm Warning Signal indicates there are major disruptions and inclement weather. People should stay home or take shelter in a safe place.

Table A-2. Rainstorm warning system

Signal	Criteria for issuance
Amber	Heavy rain has fallen or is expected to fall generally over Hong Kong, exceeding 30 millimetres in an hour, and is likely to continue.
Red	Heavy rain has fallen or is expected to fall generally over Hong Kong, exceeding 50 millimetres in an hour, and is likely to continue.
Black	Very heavy rain has fallen or is expected to fall generally over Hong Kong, exceeding 70 millimetres in an hour, and is likely to continue.

4. Landslip warning

The HKO in consultation with the Geotechnical Engineering Office operates the Landslip Warning to alert the public of a high chance of landslips as a result of persistent heavy rainfall. When the rainfall in the preceding 21 hours, together with the forecast rainfall in the next three hours exceed a preset level (which has been correlated with the occurrence of numerous landslips in Hong Kong in the past), the Landslip Warning will be issued by the HKO. The Warning is aimed at predicting the occurrence of numerous landslips. Isolated landslips which cannot be predicted will occur from time to time in response to less severe rainfall when the Warning is not in force. On the issuance of such a warning, a Landslip Special Announcement will be sent to the local radio and television stations for broadcast to the public and the announcement will be updated at regular intervals until the likelihood of landslips has diminished.

5. Thunderstorm warning

Whenever thunderstorms are expected to affect Hong Kong in the short term (within one to a few hours), a Thunderstorm Warning will be issued by the HKO. Thunderstorm warnings are issued irrespective of whether thunderstorms are widespread or isolated. When gusts associated with the thunderstorms exceeding 70 km/h are expected, the gust information will also be included in the warning.

6. Tsunami Warning

The HKO monitors warning messages issued by the major tsunami warning centres, including the Pacific Tsunami Warning Centre and keeps a close watch on the sea water levels recorded by tide gauges in Hong Kong. In the event of a tsunamigenic earthquake affecting Hong Kong, the HKO will issue a Tsunami Warning to the public.

JAPAN

Introduction

In case a hazardous weather condition is expected, JMA delivers various plain messages including warnings, advisories and bulletins to the general public and disaster prevention authorities so that appropriate measures can be taken to mitigate possible hazards. These messages are issued by Local Meteorological Observatories (LMOs) for each of the sub-divisions in their respective prefectures; a total of 370 sub-divisions are designated all over the country as of March 2006, in consideration of their meteorological characteristics and local administrative boundaries. Warnings are issued when weather conditions are expected to be catastrophic and meet warning criteria, while advisories are issued when weather conditions are expected to be disastrous and meet advisory criteria but are expected to remain below the warning criteria.

Bulletins give information to supplement the warnings and advisories. Bulletins are issued also from District Meteorological Observatories (DMOs) or JMA Headquarters according to the scale or severity of concerning disturbances. They include information not only for severe weathers but also for possible disasters. For example, sediment disaster bulletins are issued jointly with municipalities, in particular, when sediment-related disasters due to heavy rain are expected with high possibility in a few hours. All such information is delivered to the public through mass media and directly to disaster prevention authorities from JMA Headquarters and/or DMOs.

JMA takes the responsibility of flood forecasting services, which are performed in collaboration with central and local government agencies. These services include flood warnings, advisories and bulletins covering 248 rivers (as of January 2006) throughout the country, which were designated by the aforementioned agencies as the rivers with the potential for flood disasters. Flood forecasting systems for 207 rivers out of 248 are managed jointly by JMA and the River Bureau of the Ministry of Land, Infrastructure and Transport (MLIT), and 41jointly by JMA and civil engineering bureaus of prefectural governments.

Weather Forecasts

1. Very Short-range Forecasting of Precipitation and Precipitation Nowcast

A Very Short-range Forecast of Precipitation is issued every thirty minutes to provide forecasts of one-hour precipitation amounts shown in Figure A-8 for the next six hours with 1-km spatial resolution. This forecast is derived from the combination of the Mesoscale Model (MSM) predictions and the extrapolation of Radar-AMeDAS composite precipitation data, which is radar-observed precipitation calibrated with in-situ rain gauge of AMeDAS, River Bureau, Road Bureau and local governments.

Precipitation Nowcast provides 10-minute precipitation forecasts with 1-km spatial resolution up to one hour ahead for disaster prevention activities on swiftly growing convections. It is issued every 10 minutes within three minutes after every radar observation.

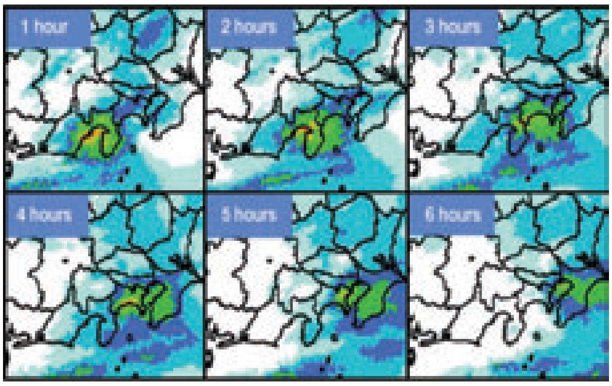


Figure A-8. Very Short-range Forecast of Precipitation

2. Forecast up to two days ahead

Daily forecasts in plain text form for today, tomorrow and the day after tomorrow are issued three times a day at 0500, 1100, and 1700 Japan Standard Time (JST) for a total of 141 forecast blocks across the country (as of March 2006). These daily forecasts contain information about weather, winds, coastal ocean waves, maximum/minimum temperatures and probabilities of precipitation.
Further to the forecasts in plain text, JMA provides forecasts in graphic form such as Area Distribution Forecasts and Time Sequence Forecasts. Area Distribution Forecasts show spatial distributions of weather, precipitation and maximum/minimum temperatures for the whole country with a spatial resolution of 20km x 20km.

Time Sequence Forecasts provide weather, temperatures and wind speed/directions in 3-hour intervals for 141 forecast blocks across the country. Both forecasts are issued at the same time as the daily forecasts.

3. One-Week Forecast

One-week Forecast covers a seven-day period starting from the following day of the issue of the forecast. It is issued daily at 1100 and 1700 JST to provide day-to-day forecasts of weather, precipitation probability and maximum/minimum temperatures for 58 prefectural areas of the country. Ensemble prediction techniques have been employed as the main basis of the one-week forecast. Ensemble prediction results have much contributed to the improvement of the accuracy of one-week forecast.

4. Other Short-range Forecasting Services

Fire weather alerts are issued to prefectural authorities to support for their fire fighting efforts, when meteorological conditions such as low relative humidity and strong winds raise the risk of fire. Photo-chemical smog bulletins are proper bases for prefectural governments to announce photo-chemical smog alarms. These bulletins provide outlooks on the concentration of photochemical oxidants in the air for the day or the following day.

5. Long-range Forecast

In the long-range forecasts, weather outlooks up to several months ahead are provided. These outlooks offer a prognosis on temperature, precipitation and sunshine duration for one month forecasts in three categories: "above normal", "near normal", and "below normal". Ensemble prediction techniques play an increasing role in the long-range forecasting and are used as a unique basis for one-month forecasts. Ensemble prediction techniques are applied for three-month and warm/cold season outlooks in combination with statistical techniques.

Typhoon Analysis and Forecast

JMA is responsible for the analysis and forecast (Figure A-9) of tropical cyclones in the Northwestern Pacific as the Regional Specialized Meteorological Center (RSMC) Tokyo-Typhoon Center, one of the six tropical cyclone RSMCs within the framework of the World Weather Watch (WWW) Programme of the World Meteorological Organization (WMO). JMA issues Typhoon Bulletins eight times a day to provide information on tropical cyclones including analysis and forecast on its location, intensity and movement. The Bulletins are sent to the relevant organizations in the country as well as National Meteorological and Hydrological Services (NMHSs) in the Northwestern Pacific area to support their operations. When a tropical cyclone exists in the vicinity of Japan or is moving onshore, the Bulletin is issued on an hourly basis.

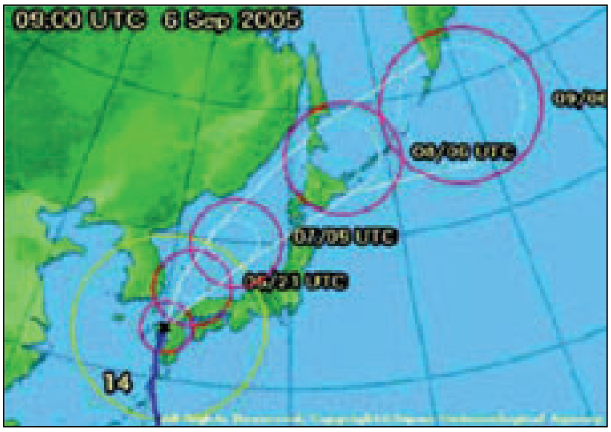


Figure A-9. Typhoon track forecast

Marine Forecasts and Warnings

Marine meteorological forecasts (Figure A-10) and warnings such as those of gale, storm, typhoon and fog are provided for the safety and efficiency of shipping, fisheries and offshore activities. JMA is responsible for the sea area surrounded by the equator, 60 degrees north latitude line, 100 degrees east longitude line and the international date line for the operational marine meteorological information service in the framework of GMDSS (Global Marine Distress and Safety System). In the winter season, sea ice forecasts and bulletins are also issued for the Sea of Okhotsk.

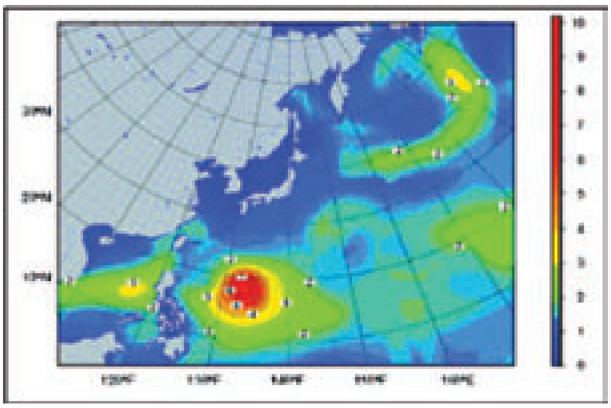


Figure A-10. Ocean Wave Forecast

Dissemination of Forecasts and Warnings

For the dissemination of forecasts and warnings, JMA maintains telephone auto-answering service for the public and direct communication links between meteorological offices and central/local governments as well as the mass media. Furthermore, JMA has been actively introducing new information technologies into the meteorological information services. A high-speed communication network called the Information Network for Disaster Prevention (INDiP) shown in Figure A-11 is an example for effective and rapid dissemination of information in both text and graphic forms. The INDiP connects each LMO/DMO and JMA Headquarters to complement the traditionally established communication network for the more user-friendly provision of meteorological information, in particular warnings and advisories, directly and individually to disaster prevention authority of each prefecture, Towns/Cities and to the mass media.

Information for maritime users is transmitted by the JMA radio facsimile broadcast (JMH) operated by JMA and fishery radio communications. It is also disseminated within the framework of the Global Maritime Distress and Safety System (GMDSS) via the NAVTEX broadcast service of the Japan Coast Guard for the seas in the vicinity of Japan, and via the Safety-Net broadcast service for ships in the high seas through INMARSAT, the maritime satellite.

Nowadays the Internet is playing one of vital roles for JMA to disseminate wide-ranged meteorological information on not only forecasts but also historical and current observational data including other organization's data to the public.

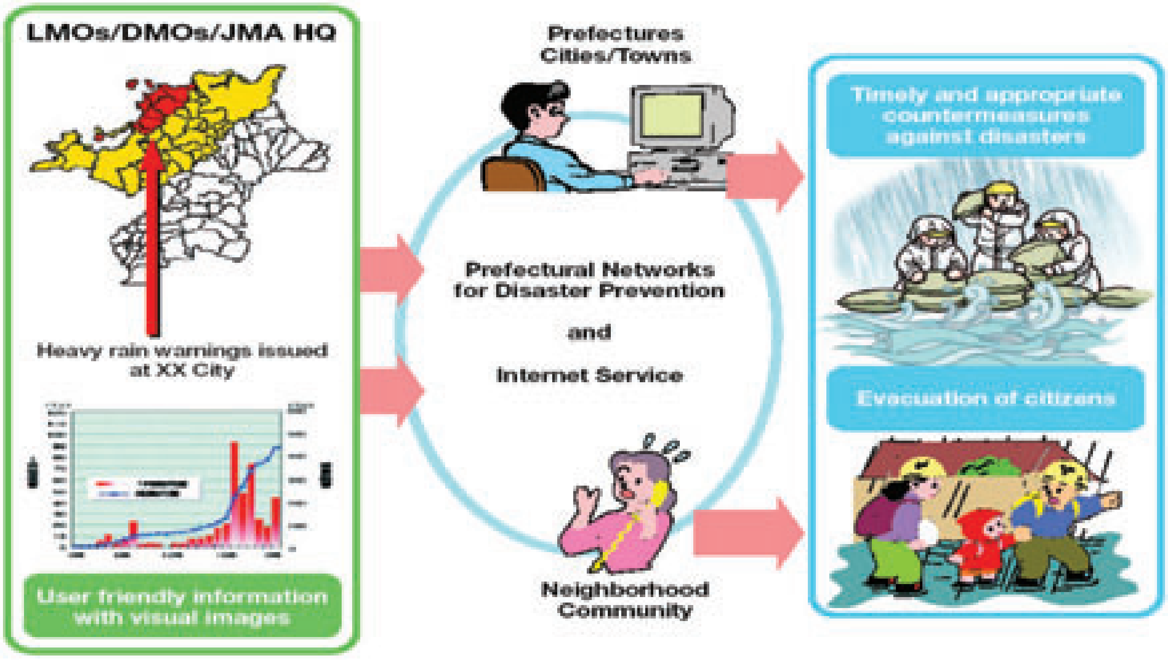


Figure A-11. Image of information flow to users through INDiP

LAO PDR

Introduction

The Lao People's Democratic Republic, in abbreviation Lao PDR is an elongated country in the Northwest-Southeast direction has a total area of 236.800km2. Geographically, the Lao PDR is dominated by two features : The mountains of the North and East and the Mekong river and its eastern bank tributaries with torrential flow regime. The climate is tropical monsoon with alternating wet and dry season from November-April. Since 1966, the country has experienced 25 floods of different magnitudes, and duration. Although, floods and droughts are the mains hazards, floods of high magnitude have occurred more frequently eg,.. In 1995 flood with 8,300 ha inundated, the recent flood in 2005 has also 87,725 ha inundated according to the latest report.

Drought has also occurred in 2005 with damaged areas 1,125 ha. Since the largest portion of the Lao population lives in rural areas and depends largely on subsistence agriculture, they are most vulnerable to periodic flooding. This paper reviews the actual flood forecasting and flood warning system currently used that include structural and non-structural measurer. Flood forecasting started during the 1970 Mekong flood season, on a trial basis, to demonstrate the feasibility of a centralized forecasting system using advanced computer techniques and application of mathematical models called "SSARR model". Since then the operation has been carried out annually says seasonally during the flood season from July to October. The large flood in 1978 and the severe flood in 1981 in the Vientiane plain called for the expansion of the forecasting programmed to cover flood forecasting for major tributaries and inflow forecasting for existing reservoirs in the basin, especially for Nam Ngum reservoir. Prior to 1984 the flood forecasting and warning system in Lao PDR are largely based on the Lower Mekong river basin wide flood forecasting operation.

It is recalled that a series of recommendation for Lao PDR were made by the missions to the Typhoon Committee area on flood loss prevention and management in East Asia from November-December 198-March 1988. Detail of recommendation for promoting flood loss prevention activities are: (i) implementation of flood loss prevention projects in Lao PDR, such as the flood control project in the Vientiane plain making use of external assistances; (ii) since restriction of land use based on flood risk an analysis is effective to prevent and mitigated flood damage; (iii) it is recommended to review the existing flood forecasting and warning systems and flood mitigation schemes to ensure comprehensive flood loss prevention and management with a view to maximize on feasible projects in the whole country; (iv) n reviewing the existing flood forecasting and warning systems, forecasting system should be improved using new techniques such as remote sensing to predict high water levels of the Mekong river, rainfall data gathering network needs to be strengthened in order to provide advances warning for possible flooding from the reibutaries usually in flashy conditions; (v) in order to improve the flood forecasting systems in Lao PDR, it is essential to establish additional rain gauge and water gauge station and rehabilitate existing ones, particularly in the Nam Ngum and Nam Lick river basins. Introduction of radar systems for meteorological purposes and establishment of telecommunication systems would be of great significance in flood forecasting; (vi) in formulating flood mitigation schemes, it would be important to preserve retention function of existing swamps and if possible to include retarding ponds in the system taking future land use plan into account; (vii) in addition to the projects in the Vientiane plain, consideration should be given to promotion of flood loss prevention project in the Sebang hieng and Sedone basins, as they are some of the most important areas for agricultural production in the country; (viii) as the first step of the project promotion in the Sebang hieng and Sedone basins establishment of flood forecasting and warning systems in the basins should be given serious consideration in the Sebang hieng and Sedone basins is recommended; (ix) training of adequate number of personnel to operate the present and projected equipment requirement for successful operation of the flood forecasting and qarning systems, therefore assistance from international agencies and donor countries would be required to augment the government's efforts.

Based on the observations and recommendations cited above, flood forecasting and warning systems in Lao PDR is going to be improved such as : Improvement of weather and flood forecasting capacity in the near future from : Installation of C band Doppler Radar and MTSAT-IR satellite receiving will operate in Mach 2006 under Japan's Crant Aids project, Improvement of Meteorological and Hydrological Services for Lao PDR an ongoing Project of technical cooperation assistance from Jica; project on Meteorological and Hydrological network and facilities for weather forecasting in 2005 and for the future plan 2006-2010(assistance from Vietnam government).(United Nations, 1988)

Main Risks and Disaster Affecting Area

The main hazards in Lao PDR are flood and droughts both are dependent on the amount of rainfall. If there is less than 2,000mm rainfall in the year, drought sensitive areas will be effected. More than 200mm in 2 days certainly leads to floods along the Mekong plain. Cyclones are therefore not direct hazard, since their force in normally diminished once they have reached Lao from the South China Sea, but they can product flood as a consequence of heavy rainfall. Up to three cyclones hit the country annually, while flood, droughts and land-slight occur irregularly.

Another virulent hazard is deforestation. It is direct hazard to the effects of "Normal" hydro-meteo phenomena, causing an increase of the surface runoff in quantity and velocity (natural flood mitigation is lost). In recent years natural disasters resulting from climate abnormalities have occurred more frequently especially drought and flood. The natural disaster are recorded droughts and floods from 1966-2005 which is shown in Table A-3.

Table A-3. Rainstorm warning system

No	Year	Types of Damage	Damage Cost(US$)	Place of Damage
1	1966	Large flood	13,800,000	Central
2	1967	Drought	5,120,000	Central and Southern
3	1968	Flood	2,830,000	Southern
4	1969	Flood	1,020,000	Central
5	1970	Flood	30,000	Central
6	1971	Large flood	3,573,000	Central
7	1972	Flood and Drought	40,000	Central
8	1973	Flood	3,700,000	Central
9	1974	Flood	180,000	
10	1975	Drought	Not available	Central
11	1976	Flash flood	9,000,000	Central
12	1977	Severe Drought	15,000,000	Northern
13	1978	Large flood	5,700,000	Central and Southern

No	Year	Types of Damage	Damage Cost(US$)	Place of Damage
14	1979	Flood and Drought	3,600,000	North(D), Southern(F)
15	1980	Flood	3,000,000	Central
16	1981	Flood	682,000	Central
17	1982	Drought	Not available	
18	1983	Drought	50% damaged	
19	1984	Flood	3,430,000	Central and Southern
20	1985	Large flood	1,000,000	Northern
21	1986	Flood	2,000,000	Central and Southern
22	1987	Drought	5,000,000	Central and Southern
23	1988	Drought	20,000,000	Southern
24	1989	Drought	100,000	Southern
25	1990	Flood	3,650,000	Central
26	1991	Flood and Drought	302,151,200	Central
27	1992	Flood, Drought and Forest fires	21,827,927	Central(F) and Northern(D)
28	1993	Flood and Drought	21,150,000	Central and Southern
29	1994	Flood	21,150,000	Central and Southern
30	1995	Flood	15,300,000	Central
31	1996	Large flood and Drought	10,500,000	Central
32	1997	Flood and Drought	1,860,300	Southern
33	1998	Drought	5,762,715	Northern and Southern

1. Flood

1.1 Description of the Hydrological context

The three villages are part of Champassak district. Ban Tha Deua and Ban Tha Teng are located along the Mekong and separated by one tributary, Tha Teng River. Ban Hai is very close to the archeological, pre-Angkorian site Wat Phou, on the other side of the road along the Mekong. Phabang tributary crosses the village. Ban Hai also receives quick rainfalls from the surronding hills in rainy season.

1.2 Impacts of flood

There has never been any person dying during flood periods in the three villages. There is no record of diseases linked to the 1978 flood. However Ban Hai records every year the diseases appearing in the community after the flood period. In 2004, around 30 people caught malaria or dengue fever, and 12 got serious diarrhoea. The two other villages usually do not record any health problems due to flood. Health issues can be highly problematic, as access to health care is not easy in rainy season. The three villages do not have any small primary health care unit and people have to move to the district hospital. For Ban Tha Teng and Ban Tha Deua, it is far more than 1 hour by car or motorbike to access to the hospital in rainy season. The road is even inaccessible in flood season (August and September).

2. Drought

2.1 Definition of drought and its limits

Most villagers define drought as a period characterized by water shortage for domestic and agriculture shortage. But other interviewees considered the dry season as drought period. Water shortage threshold also differ according to individuals. Thus many different years were quoted as serious drought years. The biggest fear towards drought among villagers is the lack of water and lack of food. Most villagers wish to know when they should start to save rice and water in case of on-coming drought.

2.2 Water availability

The tributaries do not dry out in dry season but can reach a very low level. People do not complain about dried wells or boreholes, so groundwater seems to persist in dry season. The main problem is the lack of water for agriculture. In Ban Hai, there is no irrigation system, so it is impossible to get two crops per year. In Ban Tha Teng and Ban Tha Deua, the irrigation system does not work very well and some crops cannot be irrigated in dry season. There are every year crop losses (mainly vegetables) and animals dying by lack of water or food. The last two years (2004 and 2003) seem more serious than the period 2000-2002. In 2003 and 2004 one fifth of the population interviewed lost crops, animals or caught diseases because of drought (one tenth of the interviewees in 2000, 2001 and 2002).

2.3 Characterization of serious droughts

It is particularly difficult to highlight a historical year of drought in the three villages. 14 different dates were quoted by interviewed households. This is linked to the problems of drought definition that we already mentioned. Nevertheless the most common reference among interviewees is 1981. 1976, 1979 and 2004 were also reported by a good number of interviewees. 27% of the households interviewed during this survey consider that there is drought in their village every year. Most of them gave the following indicators: water shortage for domestic and agriculture use, livestock dying, malaria cases, crops destroyed. When interviewees talked about serious droughts, they generally said it last one month. For usual droughts (every year), most interviewees report a three-month duration, but this data should be considered carefully because some interviewees confused drought period with the whole dry season.

When villagers describe the situation of a historical year of drought, 84% of interviewed households first highlight water shortage for agriculture. 42% reported they faced food shortage, 35% lost livestock and 40% caught diseases. Villagers generally complain about their lack of forecasting. All households never anticipated the drought at any historical year. All interviewees report they never know if there will be drought, and if it will be serious. Most of them observe nature and the Mekong level but that does not help them to anticipate a drought. Yet 20% reported they managed to get prepared to drought by saving rice and water. Two thirds of the interviewees would like to be warned before drought becomes dangerous, and would like to get more data about rainfalls. For example if the meteorological section manages to produce more than one-week forecast about rainfalls, villagers would like to be warned three days or one week in advance to gather rice and start to save water.

2.4 Area affected, losses & damages

The biggest drought crises brought important crop losses: 84% of interviewed households lost crops. The few households who remember their losses register 85% to 100% of paddy field destroyed. However very few people lost animals, and only 3 households reported diseases due to drought. It is worth noticing that 80% households reported that there was soil salinization because of drought.

Early Warning and Alert Procedures

1. Forecasting

1.1 Ability to forecast the crisis

In Champassak province weather forecast relies on the provincial meteorological and hydrological stations. The Waterways section of Champassak province is responsible for 17 water stations on the Mekong. They measure the water level of the River. The meteorological section of Champassassak province owns: (i) 9 water stations on the tributaries of the Mekong; (ii) 1 water station on the Mekong; (iii) 5 meteorological stations (measuring humidity, temperature, etc.); and (iii) 13 rainfall stations

The two sections have to report everyday all data to the national level (department of Hydrology and Meteorology section, under Ministry of Agriculture and Forestry / Division of Waterways, under MCTPC2). Theoretically they should provide a lot of data but only few data reach the national level, because of maintenance and information deficiencies: (i) at the Waterways section, the head of the division gets the water level only from one station (Pakse station, close to his office). For the 16 other stations, the staffs in charge of collecting water levels everyday do not go to the stations and do not communicate with the head of the Waterways section. They do not get their salary for this task (lack of budget) and have neither transportation means nor communication tools; (ii) the meteorological stations rather have maintenance problems for their equipment: only 2 water stations (out of 9 in total) still work (on Sedong and Thammouane tributaries). Nevertheless the staff regularly sends information. Many of them use their private mobile phones.

Once the national authorities get all data from all provinces, they process data and establish weather forecast. The local level does not make any analysis of the data they daily collect. Nevertheless they adapt it for TV and radio programs, by adding advice in case of specific climate conditions, like serious flood. At the national level, the Department of Hydrology and Meteorology (DHM) is member of WMO branch in Hong Kong and has access to the international data base. The DHM can provide daily forecast, one-week and monthly forecast.

1.2 Efficiency of the forecasting

According to the Hydrology Department, the methodology defined for information exchanges is quite good, as local authorities send input data to the national level quickly, and the national authorities' feedback is quick as well. But the fundamental problem is that input data are not accurate, because not complete. Forecasting should be efficient, but in practice many deficiencies occur. There is actually a great lack of budget: local authorities do not have efficient communication tools. Government staff at the provincial and district level can not use office phones because they cannot pay the bills. They cannot afford paper and ink for their fax neither. Many station staffs do not transmit data because they do not have communication means on the field.

Forecasting in Lao P.D.R. actually is not as efficient as it could be, for the reasons we already mentioned: (i) many input data are not collected by local authorities (no transport and no communication means; (ii) many stations are out of order because of low maintenance; Thus input data reaching the national level can be considered as potentially reliable but not complete.

The equipment in the main meteorological station in Pakse is quite old (French measurement tools) and is going to be renewed thanks to Japanese grant aid. The meteorological section of Champassak province got congratulations by the national level last year for their assiduity and efficiency at work, compared to the other provinces. Champassak province staff all use their private mobile phones to communicate their data to Pakse and to the national level. They complain of the lack of communication means, especially for the employees collecting data at the stations throughout the province. Interviewed villagers generally reported that they get warned by the head of village one day before the flood, at best. They would be happy to be informed at least two days in advance, especially to save their big animals (prepare their move to highland).

Local authorities collect input data that they transmit directly to the national authorities, without analyzing them. National departments process and analyze data before sending them back to the provincial level. The processed data do not differ a lot from the input data (check with interview of local authorities), as they are only completed with water levels and rainfalls in all other Lao provinces. Nevertheless, the Waterways section has set up a water level alert when the Mekong river overpasses 12 meters. Champassak district also has informal signs (Mekong level in Champassak district) helping to anticipate flood. It can happen that district officers visit heads of villages to warn them about flood before receiving any message from the province. Villagers try to know if their area will be flooded, by observing the nature. Most of them report they watch or listen to the weather forecast on TV and radio, but what they all find efficient is the observation of the elephant trunk plant and the Mekong level. Every year they manage to know if there will be a flood, but they do not know when, how intense it will be and how long it will last. 2005 was an intense rainy season, and most villagers knew in July that there would be heavy rains this year. Indeed in August the Mekong reached 12.5 m, which is an alert threshold. (ISLAND, 2007)

Dissemination of the Forecast and Alerts

1. Responsibilities and stakeholders

All administration levels are involved in forecast dissemination, from the data collection to its broadcasting. Non-institutional stakeholders are NGOs involved in disaster management and disaster relief, like World Vision, Lao Red Cross, Oxfam, etc (Table A-4). They sometimes take part to the dissemination of forecasting during their projects, such as World Vision providing forecast data to the agriculture section of Champassak district during the CBDM project.

Table A-4. Summary of the stakeholders' roles in disseminating forecast

Role and responsibility	Authority / organization	Administration level	Information / action	Efficiency
Collect data	Waterways section	Province	Water levels of the Mekong	Only 1 station / 17 workin
	Meteorology section	Province	Water levels of the Mekong tributaries, rainfalls, humidity, temperatures...	Only 2 water stations / 9 working Rainfalls data reliable
	Heads of vilage	Village	Water levels of the river crossing the village	Data collecting role (VDPU programme) not implemented
Process and analyze data	Hydrology and Meteorology Department	National	Receives data from all provinces and analyze them	Get few data
	Waterways division, MCTPC	National	Receives data from Waterways section of the province and send them to the Hydrology and Meteorology Department. Complete data with international climate overview (Asia)	Information flow efficient

Role and responsibility	Authority / organization	Admini-stration level	Information / action	Efficiency
Broadcast weather fore-cast	Hydrology and Meteorology Department	National	Sends processed data back to the provinces	Information flow effi-cient
	National and local TV National and local radio	National and pro-vincial	Broadcast weather forecast	51% of interviewed Households watch TV weather program (44% for radio)
	Waterways section	Province	Sends national data to district office	Sends information to cabinet office:the agriculture section does not get the data. Sends post mails (3 day delay)
	Meteorological section	Province	Send provincial data after national analysis to local TV and local radio, and to agri-culture section of district	Efficient collabora-tion with TV and radio. Communication with the districts is prob-lematic as for Water-ways section, espe-cially since World Vision's project fin-ished.
Early Warning for flood	Waterways section	Province	Reports to his head office (which reports to the Gover-nor's office) and to the district office	Phone calls simulta-neously with meet-ings at the provincial and district level
	DDMO / agri-culture section	District	Comes to villages to warn the head of village	No communication means to call the vil-lage authorities, dis-trict officers have to visit all villages in flood-prone areas.
Early Warning for flood	Head of village	Village	Visits all villagers with the unit chiefs to warn the whole population	The head of village complains about the lack of time to warn all villagers

Role and responsi-bility	Authority / organization	Admini-stration level	Information / action	Efficiency
Disaster pre-paredness	DDMO / agri-culture section	district	Helps the villagers to get pre-pared (prepare boats, gather rice, move to high-land...)	Never applied in most villages, as VDPU volunteers left the villages.
	World Vision	NGO	Set up VDPUs and organized training sessions for disaster preparedness	Works in villages where the VDPU members still live in the village and hold public responsibili-ties
Response to disasters	DDMO / agri-culture sectio	district	Provides relief to villagers affected by flood damages	This action depends on budget alloca-tions obtained by NDMO
	PDMO (NDMO at provincial level)	Province	- Coordinates relief actions for villagers affected by flood damages - Records losses and dam-ages to NDMO	
	Lao red Cross	Province	Provides relief to villagers affected by flood damages	Population affected by disasters have to move to the store-house
Education to disasters	NDMO	National	Edited books for children (adapted to their level of edu-cation) about disasters and risks management	No means to equip all schools with dis-aster education books

NB : **NDMO** : National Disaster Management Office (Ministry of Labour and Social Welfare)

PDMO : Provincial Disaster Management Office (NDMO contact person at local level, Department of Labour and Social Welfare of Champassak province)

DDMO : District Disaster Management Office (NDMO contact person at local level, Agriculture section of Champassak district)

MCTPC : Ministry of Communication, Transport, Posts and Construction

References

United Nations, proceeding of the expert grup meeting on comprehenshive flood loss prevention and management Bangkok , 17-21 October1988

ISLAND, Reports of field surveys in Champassak District, LAO P.D.R., 29 August 2007

MACAO, CHINA

Introduction

Macao located at the west bank of Pearl River Delta in South China, is the intersection of Mainland China and South China Sea. It is also located at the south of tropic of Cancer. The winds directions in winter and summer are opposites. Therefore, Macao is in the monsoon region and from the climate classification is considered mild and rainy in summer. The most comfortable period begins from the middle of October to December.

March and April is the seasonal interchange period. The wind direction along the coastal region of South China is mainly easterly to southeasterly, which will increase the temperature and humidity. Beside some occasional wet weather, fog, drizzle and low visibility days, the weather is mainly fine in spring.

The summer in Macao is longer than the other seasons. Because of hot and wet conditions, the severe weather such as thunderstorm and heavy rain always occur from May to September. Waterspout can be seen occasionally. Meanwhile from May to October, tropical cyclones occur frequently which make the highest records of precipitation, temperature, rainy days and thunderstorms.

Information for Severe Weather Preparedness

Macao Meteorological and Geophysical Bureau (SMG) is an official organization responsible for the meteorological services that provides severe weather warnings. In order to have the severe weather messages reached to the citizens without delay, SMG has set up a series of warning signals messages and distributes these messages to COPC and a list of relative services. In general, warning is distributed in text format and track chart will also be attached during tropical cyclone warning

1. Monitoring

SMG operates round-the-clock, receives cloud image data from satellites routinely, exchanges meteorological data with regional centers those includes radar, wind profiler, Pearl River Delta lightning location network and weather parameters from automatic weather station. SMG has a real-time lightning detector, monitoring a region of 48 kms around Macao every minute. There are 13 AWS (Figure A-12) distributed in Macao peninsula, Taipa island, 3 bridges connecting the above two places and Coloane island. One of them, located at SMG headquarter is the synop station of Macao. From the data received of the above stations and lightning early warning system (Figure A-13), we could monitor the thunderstorm, heavy rainfall and strong wind, disseminate these warnings to the citizens promptly.

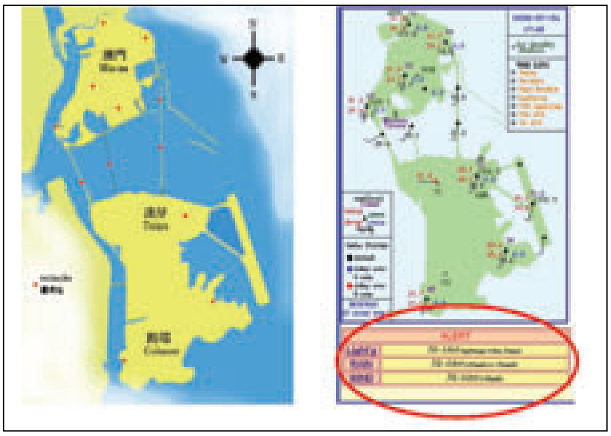


Figure A-12. Macao Meteorological Stations Fig.2 AWS data and lightning early warning system

Figure A-13. Tropical Cyclone track and mobile web

2. Transmission of information

SMG disseminates the latest warning messages and reports to the public and organizations through television, radio, Macao weather information telephone inquiry system, facsimile, telephone hotline, internet, mobile web, SMS and cell broadcast.

3. Exercises

To prevent the majority disaster, COPC holds the exercise once a year that simulates an approaching tropical cyclone. SMG is conducting rainstorm exercise with cooperation with the Education Department. Weather Monitoring Center of SMG also has emergency exercise and joins the International Nuclear Emergency Exercise.

The warning message of flooding

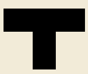
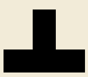
Some low-lying areas in Macao might have slight flooding and sea water flow backward during the rainstorm, because of astronomy tide, storm surge or the sum up of them. SMG introduces JMA storm surge model for forecasting, appending with the high tide time to disseminate the message of possible flooding. To reduce the risks of flooding, SMG monitors in real-time the amount of precipitation in different stations, distributes the flooding information to the public and other civil departments.

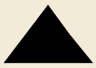
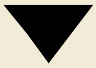
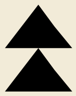
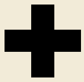
Warning Criteria

1. Tropical Cyclone

There are approximately 5.6 tropical cyclones that might affect Macao every year. SMG hoists typhoon signal shown in Table A-5 when there is tropical cyclone is less than 800 km from Macao SAR. Except signal no.1 and no.9, all other signals would be hoisted according to the wind speed recorded. SMG disseminates tropical cyclone information, directly from SMG Weather Monitoring Center to the television or radio hourly when the signal No. 8 or above is hoisted.

Table A-5. Meaning of Tropical Cyclone Signals and the relevant recommended safety precautions

Number of Signals	SHAPE OF SYMBOLS DISPLAYED		MEANING OF SIGNAL	RECOMMENDED SAFETY PRECAUTIONS
	DURING THE DAY	AT NIGHT		
1			Alert signal: the centre of a tropical cyclone is less than 800 kilometers from MSAR and may later affect the MSAR	Check the safety of objects which might be carried or destroyed by the winds such as fences, scaffoldings, flower pots, antennae (aereals), etc. Keep boats and small crafts in the nearby shelters.
3			The centre of a tropical cyclone follows a pattern of movement that winds to be experienced in MSAR may possibly range from 41 to 62 km/h and gusts about 110 km/h.	Lead ships and other sailing crafts into safety shelters or ports. Check the safety of doors and windows. Clear drains and rain collectors of obstructions. Follow bulletins broadcasted by radio, television and others electronics communications devices.

Number of Signals	SHAPE OF SYMBOLS DISPLAYED		MEANING OF SIGNAL	RECOMMENDED SAFETY PRECAUTIONS
	DURING THE DAY	AT NIGHT		
8NW			The center of a tropical cyclone is nearing and winds recorded in MSAR, from the quarter indicated, may possibly range from 63 to 117 km/h with gusts reaching about 180 km/h.	Casses of all schools are suspended. Children should remain indoors. Doors and windows should be safely bolted. Conclude all precautionary safety measures. Bridges will close to all traffics at any moment, pending prior notice. Television and radio stations broadcast round-the-clock.
8SW				
8NE				
8SE				
9			The center of a tropical cyclone is approaching MSAR and it is expected that MSAR might be severely affected.	Circulation of pedestrians and vehicles should be reduced the minimum; Reinforce doors and windows with crossbars or heavy furniture;
10			The center of the on-coming tropical cyclone shall strike at the immediate approaches of MSAR. The mean wind speed should exceed 118 km/h with gusts of great intensity.	Follow recommendations and warnings through informations media oftenly; Beware - a temporary calm in the midst of hurricane force winds generally indicates that the center of the tropical cyclone is over MSAR.

2. Strong Monsoon

Macao located in the East Asia Monsoon area, affected by the Southern China Sea summer monsoon and winter monsoon, citizens would face dangerous by strong wind while the monsoon is activated. Meaning of the Strong Monsoon Signal are listed in Table A-6.

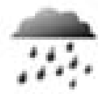
Table A-6. Meaning of Tropical Cyclone Signals and the relevant recommended safety precautions

Signal	Night signal	Meaning of the signal
Black Ball 		Strong monsoon winds of exceeding 41 km/h is recorded in MSAR.

3. Rainstorm

Rainy season in Macao is between April and September, heavy rainfall is recorded usually in May and June, flooding may appear in low-lying lands, traffic jam in main road and landslip in different areas.

Meaning of rainstorm warning signal



The precipitation amount over Macao Special Administration Region, in general, is expected to be about 50mm in the coming two hours.
The rainstorm warning will not be issued during the hoisting of the tropical cyclone signal n.o 8 or above.

Recommendation

When rainstorm warning is issued, the public and private entities should take adequate prevention measures.
When rainstorm warning is issued, the public of Macao are advised:
* to stay in safe places;
* to avoid moving to the flooding areas.

4. Thunderstorm

Thunderstorm could be seen through the year, July and August are more frequently than other months.

Meaning of Thunderstorm Warning

When thunderstorm is being observed over the Macao Special Administration Region or is predicted to move into the region, the thunderstorm warning will be issued.
The thunderstorm warning will not be issued during the hoisting of the tropical cyclone signal n.o 8 or above.
Effective from 1st July 2004.

Recommendation

When thunderstorm warning is issued, the public and private entities should take adequate prevention measures.
When thunderstorm warning is issued, the public of Macao are advised:
* to stay indoor;
* to avoid to stay in field, highland or beside a tree;
* to avoid to take any activity over the water or outdoor;
* to avoid to touch any metal and wet object, or any object that can cause electrical shock;
* to beware the strong winds caused by the instable weather.

MALAYSIA

Introduction

The weather in Malaysia is mainly influenced by two monsoon regimes, namely, the Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March. The Northeast monsoon is the major rainy season in the country. Occasionally, the Northeast monsoon brings heavy rains which may cause severe floods to the east coast states of Peninsular Malaysia during the months November till January and January till early March over the western part of Sarawak and Sabah. The widespread heavy monsoon rain normally lasts for 2 to 3 days. In severe cases, it can last for 3 to 8 days and may affects the west coast states of Peninsular Malaysia.

Due to rapid infrastructure development, flash flood occurrence in the country has been on the increase and it can happen several times each year leading to massive disruption in business activities with immense socio-economic and financial impacts. Flash flood is normally caused by severe storms such as squall-lines or thunderstorms which are localized with rainfall of high intensity and short durations (2 to 5 hours). Thunderstorms occur throughout the year but are most likely to happen in the inter-monsoon periods, namely April to May and October to November. Over land, thunderstorms frequently develop in the afternoon and evening hours while over the sea, thunderstorms are more frequent at night. Sometimes the thunderstorm cells are small and localized but can be severe with intense lightning activities, heavy rainfall and strong wind gust. The severe thunderstorms with high intensity rainfall and short duration may cause flash flood in major cities and towns.

Malaysia is located between equator and 8oN shown in Figure 1. The latitudinal location prevent our country from being vulnerable to the direct impact of typhoon and tropical storms except in December 1996 (TS Greg) and December 2001 (TS Vamei). However, the presence and the close proximity of the tropical cyclones may alter the regional tropospheric synoptic circulation that will affect the weather in Malaysia particularly on the rainfall as well as the coastal waters depending on the storm intensity and distance from the area of interest. The tail effects of the tropical cyclones may bring widespread heavy rain and rough seas over the coastal waters of Sabah, Sarawak and northwest and east coast of Peninsular Malaysia.

Information for Severe Weather Preparedness

1. Multi-Hazard Early Warning Centre

The Malaysia Meteorological Department (MMD) under the Ministry of Science and Innovation (MOSTI), has established a multi-hazard early warning center in 2005 to monitor and issue early warnings on severe weather, high sea conditions, earthquake and tsunami. The centre shown in Figure A-14 operates 24 hours a day, 7 days a week to closely monitor the weather and earthquake/tsunami situations so that early warning on severe weather and tsunami can be issued to the relevant agencies, media and public, including the National Security Division of Prime Minister Department, in a timely manner. During the northeast monsoon season, MMD intensifies closer monitoring of weather situation and also issues special weather forecasts for east coast states of Peninsular Malaysia.

Figure A-14. Multi-hazard early warning center in Malaysia

2. Observational Networks

MMD makes use of various latest technologies, such as well distributed automatic weather stations, surface and upper-air stations, weather radars and satellites, and lightning detecting sensors, as well as weather information receives from all over the world through the Global Telecommunication System (GTS) and Internet to monitor the weather development over our region. MMD observational network consists of 40 synoptic observation stations, 108 AWS, 8 upper-air observation stations, 11 weather radar stations.

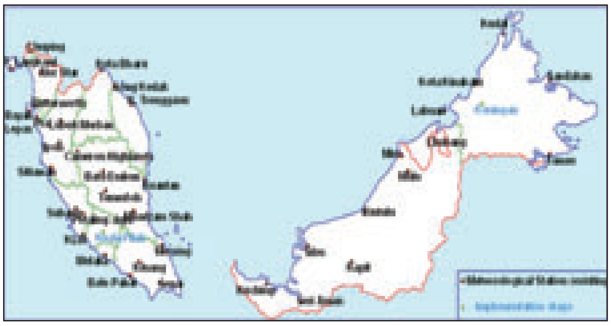


Figure A-15. Location of Meteorological Stations

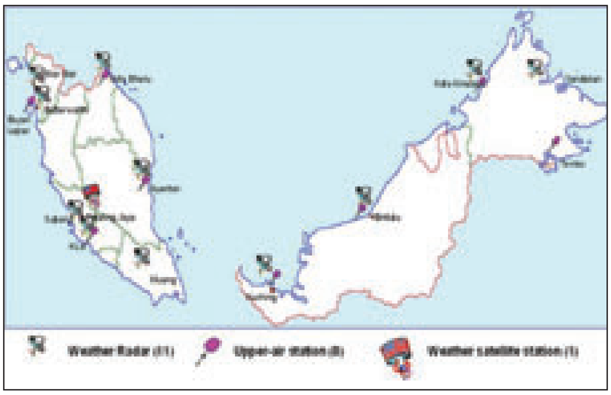


Figure A-16. Location of Weather Radar, Upper-air and Weather Satellite Stations

The reception of satellite data helps to improve the quality of weather forecasts. MMD receives and processes data from FY-2C, FY-2D and MTSAT geostationary meteorological satellite. For the polar orbiting satellites, MMD receives and processes satellite data from the NOAA Series (16 and 18) and FY-1D polar orbiting satellites. In tandem with new technological developments in meteorological satellites, MMD acquired a new receiving and processing system for X-band polar orbiting satellites namely TERRA and AQUA.

MMD has established the National Tsunami Early Warning System following the catastrophic tsunami of 26 December 2004. The system includes 14 seismic stations and networks of 6 tide gauges, 3 tsunami buoys and 4 coastal cameras that are also useful for monitoring the weather as well as the sea conditions over the sea and coastal regions. The data from these networks are received and displayed real-timed in the multi-hazards monitoring and warning center. The 6 tidal gauges are located at Porto Malai (Langkawi), Pulau Perak and Teluk Bahang over the Northwestern part of Peninsular Malaysia, Pulau Perhentian in the northeast region of Peninsular Malaysia and at Kudat and Lahad Datu in Sabah. To enhance monitoring of the sea condition, sea level data are also acquired from other regional and international networks such as GLOSS and networks in the Indian Ocean region. The three (3) deep ocean tsunami buoys also have wind, wave and current, air and water temperature information. The first buoy was installed near Pulau Rondo, Sumatra on 30 Dec 2005. The second buoy was installed near Layang-Layang Island in the South China Sea on 7 March 2006 and the third buoy will be deployed in the Sulu Sea soon. The four (4) coastal cameras were installed at Batu Feringghi, Pasir Panjang and Kuala Muda in Penang, and Pantai Cenang (Langkawi) to enhance the monitoring of sea conditions as well as weather over the areas.

3. Numerical Weather Prediction Products

MMD uses products of numerical weather models to predict the weather development over our region. MMD has been running on operational basis MM5 (The Fifth-generation Mesoscale Model) and 3-D variational (3DVAR) system. Operation of the MM5 consists of twice daily runs at 36-km and 12-km resolutions for South-East Asia and Malaysia domain respectively, and provides forecasts of up to 72 hours. For the issuance of high sea warnings, MMD uses WAM and JMA Storm Surge (with consent from JMA) models. MMD is implementing the WRF numerical model to enhance its weather forecasting operations. MMD also uses various information and numerical modeling products from advanced meteorological centres such as the ECMWF, NOAA, JMA, JTWC, KMA and others for the issuing of severe weather and high sea warnings.

4. Long Range Weather Outlook and Forecasts

MMD issues three types of long-range forecasts: 1-month ENSO update, 6-month weather forecast and seasonal weather outlook. The 1-month ENSO update is issued monthly, on or before the 15th of each month. The ENSO information is based on the monthly ENSO diagnostics and outlook produced by Climate Prediction Center (CPC), NOAA. This update is uploaded on our department's website for public access. The 6-month weather forecast is issued monthly. It includes monthly precipitation forecast at the state and sub-regional level. This forecast is mainly based on the ECMWF's global precipitation forecast and is uploaded on our departments website on or before the 23rd of each month for public access. MMD also issues seasonal weather outlook four times a year. The northeast monsoon weather outlook, which carries information on the rainfall forecast and forecast sea conditions for the monsoon season from November to March. This report is issued in October using an ensample of seasonal forecasts for the region from various international centers. The southwest monsoon weather outlook, which carries information on the rainfall forecast and haze conditions for the monsoon season from June to August. This report is issued in May. Two intermonsoon weather outlook, which carries information on the rainfall forecast for the periods from March to May and September to October are issued in February and August respectively. These seasonal weather outlook reports are send to all the relevant ministries and agencies in hard copy and they also available online for public access from the department°Øs website

Flood Monitoring and Early Warning System

The Department of Irrigation and Drainage (DID) to date has installed about 375 telemetric stations in 38 river basins for flood monitoring. A total of 405 manual river gauges and 1019 stick gauges in floods prone areas have been set up to provide additional information during the floods season. As part of the local floods warning system, about 272 automatic floods warning sirens and 147 floods warning boards are being operated.

A web-based and online early warning system known as "The Debris and Mudflow Warning System for Cameron Highlands in the State" has been developed by the working group on hydrology under the Regional Cooperation Project and Implementation Programme (RCPIP). Similar project will be expanded to other area namely Bukit Damansara, Kuala Lumpur which is prone to land slide. The implementation of floods hazard mapping projects has been initiated for the districts of Muar and Kota Tinggi in the southern region of Peninsular Malaysia. The districts will be the target area for this pilot project (2007-2010) as they were severely hit by the recent December 2006 and January 2007 floods.

1. Floods Forecasting and Warning (basin in operation)

Floods forecasting operations were carried out during the floods seasons by the respective DID state offices with technical assistance from the National Flood Forecasting Centre at DID Headquarter. The river basins which have been provided with forecasting models are summarized in the Table A-7.

Table A-7. River basin forecasting models

No	River Basin	Catchment Area (km2)	Forecasting Point	Forecasting Model
1	Muda River	4,300	2	Stage Regression
2	Perak River	14,700	3	Stage Regression
3	Muar River	6,600	2	Linear Transfer Function
4	Batu Pahat River	2,600	2	Stage Correlation
5	Johor River	3,250	2	Regression Model
6	Pahang River	29,300	3	Linear Transfer Function and Stage Regression (back-up)
7	Kuantan River	2,025	1	Tank Model
8	Besut River	1,240	1	Stage Regression
9	Kelantan River	13,100	2	Tank Model and Stage Regression
10	Golok River	2,175	1	Stage Regression
11	Sadong River	3,640	1	Linear Transfer Function
12	Kinabatangan River	17,000	1	Linear Transfer Function
13	Sg Klang	1280	5	Flood Watch

Some of the floods forecasting models were being revised with a view to evaluate their performance and subsequently to make necessary improvement where and when necessary. The improvement on facilities and forecasting tools and models had helped DID to enhance its early warning system for hydrological related hazards, especially on floods. Timely and appropriate preventive and mitigation actions can be taken to reduce loss of lives and socio-economic damages.

Severe Weather and Flood Warning Dissemination System

MMD multi-hazard early warning centre uses advanced communication technology to disseminate severe weather, earthquake and tsunami information and early warnings to all the relevant personnel, disaster management agencies, government agencies, broadcasting stations, print media.

1. Mobile phone Short Messaging Service (SMS) to selected users

The increasing of mobile phone user make it a primary tools for transmitting warning and disaster related information. The SMS system is for the delivery of information, advisory or warning messages related to the disaster event including earthquake, tremor, tsunami, and severe weather to decision makers, disaster management agencies, media and cellular service providers for public dissemination.

2. Telefaxes,

Even though traditional fax is becoming less popular, it is still one of the most reliable means of document transmission to both the public and private sector. MMD telefax server is connected to the fixed lines of Telekom Malaysia for automatic faxing all relevant severe weather, seismic and tsunami advisory/warnings to the relevant agencies. The telefax system also serves as a backup to the recipient.

3. TV Broadcast System

TV broadcast system is an effective means of dissemination of the warning and other information related to natural disasters. MMD has established a mini-studio in 2006 and works very closely with Radio Television Malaysia (RTM) to broadcast weather information live on daily basis.

4. Fixed-phone Line Alert System

MMD, with the cooperation with Telekom Malaysia Berhad (TM), had initiated Fixed Line Alert System (FLAS) or Disaster Alert System (DAS) that enable the government to disseminate tsunami early warning messages to selected community via fixed telecommunication line provided by TM. Although the system is initially developed for tsunami warning, MMD is planning to incorporate early warnings for other type of disasters, such as weather related hazards and disasters. The system provides short and precise messages timely to a large number of the targeted community.

5. Public Announcement System (Siren)

Sirens are intended to provide immediate notification of an emergency to people who are within the affected area. MMD has installed 13 sirens located at strategic beach and coastal areas to provide tsunami warnings to relevant areas that may be hit by tsunami. Additional 10 sirens will be installed in 2009. MMD is planning to utilise the sirens and incorporate warnings for other weather related hazards

6. Web-pages and Internet

Web pages and Internet are commonly available means for Malaysians to access to relevant information on close to real time basis. MMD maintains a website www.met.gov.my that provides updated information on weather forecasts, severe weather warnings, earthquakes and tsunami warnings.

7. Red Flag and Notice Board System for Strong Wind Warning

The high seas and strong wind advisories/warnings are issued to various official agencies involved in disaster mitigation management and relief, agencies involved in marine activities, radio and TV stations, and media. The advisory/warning is also sent to agencies that operate the visual warning stations as shown in Figure A-17.

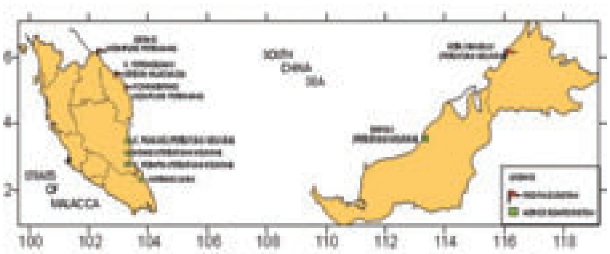


Figure A-17. Location of visual strong wind warning system in Malaysia

MMD had also made available its operational intranet web site to a few disaster management agencies, such as the National Security Council of the Prime Minister Department and the Drainage and Irrigation Department, to assess to all the information on weather development and forecasts and warnings so as to enhance their operation in disaster mitigation and management.

The Department of Irrigation and Drainage (DID) Malaysia has installed about 272 automatic floods warning sirens and 147 floods warning boards as part of the local floods warning system. The InfoBanjir website (http://infobanjir.water.gov.my) which provides river height and rainfall information in near real-time continues to be enhanced and improved in terms of IT technology, hardwares, procurement and network expansion as well as its contents to meet the customer's requirement. The automated flood alerting and information dissemination system of InfoBanjir using Short Message System (SMS) which was initially meant only for DID flood operation managers, was now being expanded to include flood relief officers of other related agencies e.g. Malaysian Meteorological Department, Police, Army, State Public Defence Department etc. It is aimed at providing early warning and response action in flood operation.

In addition, a SMS flood warning system and services (SMSFWS) was developed and operated for the Damansara River basin, Selangor (a major tributary of Klang River) after a major flash flood hit the area on 26 February 2006. The system is designed to provide warning to the local residence of an impending flood event via "bulk SMS broadcasting" services to personal hand phones. This is on top of the flood warning sirens provided in the designated areas. It is aimed at providing early warning to the local resident on the impending flood occurrence in the vicinity of TTDI Jaya, Shah Alam and surrounding areas which are affected by the flood water from the swelling Sungai Damansara.

Criteria for Issuing Severe Weather Advisories/Warnings

MMD performs continuous monitoring of the weather and sea conditions in the country and issue advisories and warnings whenever is necessary. The types of advisories/warnings issued by MMD are as follows:

1. Thunderstorm Warnings

Thunderstorms warnings, irrespective of whether the thunderstorms are widespread or isolated, issued by MMD are intended to give short term (within one to a few hours) notices of the likelihood of thunderstorms affecting any part of Malaysian that may cause flash floods in the low lying areas.

2. Heavy Rain and Strong Wind Warnings Over the Land

This warning will be issued for the possibility of the occurrence of heavy monsoon rain, strong winds or heavy rain associated with low pressure system, tropical depression, tropical storm and typhoon affecting the land areas in Malaysia. This warning is categorised into 3 warning levels listed in the Table 2.

3. Strong Winds and Rough Seas Advisories/ Warnings For Malaysian Waters

In general, strong wind and rough sea conditions occur over our waters mainly during the northeast monsoon period (November to March) and also the presence of tropical storms or typhoon in the vicinity of our coastal waters. The strong winds and rough seas warnings issued by MMD are divided into three main categories shown in Table A-8.

Table A-8. Warning categorised into 3 warning levels

No.	Warning Stages	Criteria	Possible Impact
1	YELLOW	Possibility of a monsoonal surge in the next 24 to 48 hours.	
2	ORANGE	Moderate monsoon rain is currently occurring or expected to occur in the next few hours. Low-pressure system/tropical depression with sustained wind speed of 50 - 60 kmph accompanied by moderate to heavy rain. Strong wind with sustained wind speed of 50-60 kmph (whole tree in motion; inconvenience felt when walking against wind) with slight to moderate rain and has lasted for the last 2 hours.	Flooding over low-lying areas and areas by river banks. Thatched/zinc roofs can be blown off by the wind.
3	RED	Heavy widespread monsoon rain is currently occurring or expected to occur in the next few hours. Tropical storm/typhoon with sustained wind speed of al least 60 kmph accompanied by moderate to heavy rain. Strong wind with sustained wind speed of at least 60 kmph (breaks twigs off trees; generally impedes progress when walking against wind; structure damage occurs) with moderate to heavy rain has lasted for the last 2 hours.	Flooding over low-lying areas and areas by the river banks. Swift water currents can be dangerous to children playing besides monsoon drains and river banks. Thatched/zinc roofs can be blown off by the wind.

PHILIPPINES

Introduction

In February to March, 2000 more than 80,000 people were evacuated due to the eruption of Mount Mayon in the southern part of Luzon. As of May, this year, more than 300,000 people have been evacuated in the southern island of Mindanao because of the war between government forces and Muslim secessionist groups. These are just examples of the recent natural and man-made disasters that welcomed the country at the beginning of the new millenium. The country seems to be following the trend in the past decade where, despite the United Nations' declaration of the 1990s as the International Decade for Natural Disaster Reduction, the Philippines experienced its worst earthquake, volcanic eruption and flash flood in the last century.

As an archipelago of 7,100 islands and located between the South China Sea and the Pacific Ocean, the Philippines lies in the path of turbulent typhoons, with about 20 typhoons occurring in the Philippine area of responsibility annually; an average of 9 typhoons actually cross the country (Brown, Amadore,Torrente,1991: 195-196). From 1995-1999, the average number of disastrous typhoons that hit the country per year was seven, although it should be noted that El Nino affected the country in 1997-1998 (NDCC, 2000).

The Philippines lies on the western rim of the Pacific and is part of the Circum-Pacific seismic belt. It lies between two active major plates: the Pacific plate and Eurasian plate. The country uses the modified Rossi-Forel Earthquake intensity scale to measure the strength of earthquakes. At least five earthquakes occur every day. A total of 74 destructive earthquakes have been registered since 1599. The latest and most destructive earthquake in the country was in July 21, 1990 which affected 23 provinces, killing 1,666 people and resulting in damages put at 12.2. billion pesos or US $305 million (CDRC, 1992: 62-68).

There are more than 200 volcanoes distributed in five volcanic belts. Among the most active volcanoes are Mts. Mayon, Taal, Hibok-Hibok, Bulusan and Canlaon. The most recent and destructive volcanic eruption was by Mt. Pinatubo in Central Luzon in June, 1991. The Department of Social Welfare and Development reported 773 deaths, 184 injuries and 23 missing. The NDCC reported that 276,748 families or 1,253,926 individuals had been adversely affected (CDRC, 1992: 70-75). The eruption of Mt. Pinatubo resulted also in the emergence of lahars which continue to flood the lowland areas of Pampanga. This year's eruption of Mt. Mayon in February affected 80,000 evacuees but no eruption-related casualty was reported.

As a consequence of typhoons and even ordinary monsoon rain, flooding is very common in both urban and rural areas. The National Mapping Resource and Information Agency said that one hundred and two areas in the Philippines are in danger of being submerged by flood waters. It was reported that ten harbors and ports nationwide experienced a 100 centimeter rise in the mean sea level (MSL) at high tide. The average increase in MSL in Manila is 1.75 centimeters. The worst flood was the Ormoc flash flood which killed 8,000 people in 1991 (CDRC, 1992: 48-55). The flood happened in the morning but it took less than four hours for the water to rise to about ten feet, washing people into the sea.

Table A-9 shows the most common natural disaster incidents in the country for the past five years, 1995-1999. The first four disaster events are typhoon related, though flood generally takes place even with just monsoon rain. It can be observed that most of the recent natural disasters happened in the early 1990s, the start of the International Decade for Natural Disaster Reduction which also started the beginning of greater disaster consciousness and disaster management work among the NGO as seen in the succeeding sections.

Table A-9. River basin forecasting models

Disaster Incidents	No. of Occurrences 1995-1999	Annual Average	Number of Persons Affected	Number of Casualties
Typhoon	37	7	19,610,029	1,973
Flooding	143	27	4,942,255	434
Landslide Avalanche	49	10	68,209	115
Tornado	38	8	4,905	15
Earthquake	87	17	769	11
Red Tide	11	2	56,359	7
Volcanic eruption	1	-	5,986	-
Drought	5	1	963,523	-
Pest Infestation	23	5	166,950	2
Big wave	3	-	859	-
Total	397	-		2,557

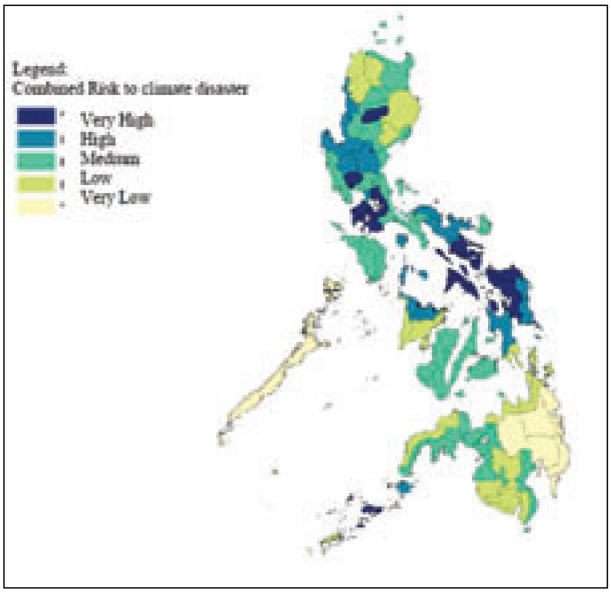


Figure A-18. Combined Risk to Climate Disaster

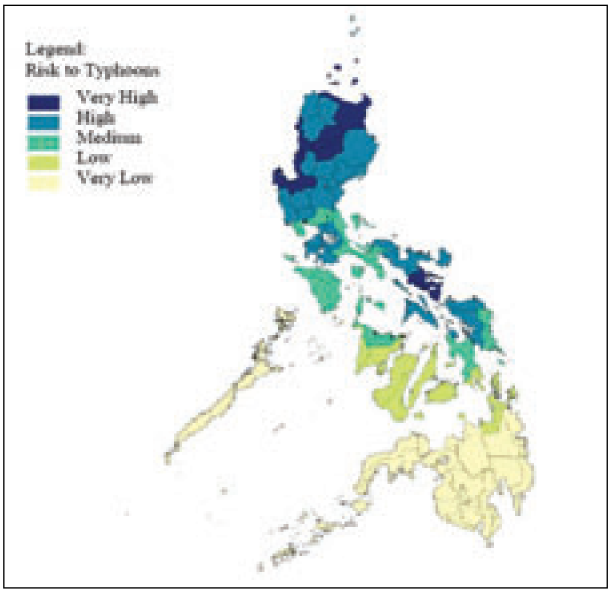


Figure A-19. Risk to Typhoons

Flood warning system in the metropolis

Two agencies are responsible for issuing early warning on disastrous events : the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). PHIVOLCS issues warnings on volcanic activities and earthquakes while PAGASA disseminates information on weather changes and climate conditions and undertakes typhoon and flood forecasting and monitoring. PAGASA has limited capabilities to issue on-time and accurate early disaster warning. Nevertheless, the PAGASA issues flood warnings in Metro Manila. The meteorologists of PAGASA base their information from rainfall intensity, elevation and past history of flood occurrence in the area. In a typhoonassociated flood, inundation warning is incorporated into a typhoon prediction. The PAGASA Data Center also gathers inputs from the Effective Flood Control Operations System (EFCOS) Project that was completed on October 16, 1993 (DPWH, 1994). The EFCOS Project's main features are a telemetry system that is controlled at the Rosario Master Control Station. The DPWH notes that it operates by gathering "real time rainfall and water level data obtained from two rainfall gauge stations at Boso-Boso and Mt. Oro, and from nine water level gauge stations... The same real time data is sent and monitored at the Napindan HCS, DPWH Central Office and Data Information Center of PAGASA via Antipolo Relay Station (op cit., 13)." As indicated by the DPWH's 1994 report, it is now possible to determine in advance the magnitude/size of flood emanating from the upper Marikina Watershed.

However, most town and city councils are not equipped with information that facilitates an efficient disaster warning and emergency evacuation. For example, there are no available flood maps that will indicate which areas are at risk, nor what flood depths are to be expected on certain flood magnitudes. There could be an exception and this is Solidum's 1986 flood map that was cited by Punongbayan in 1987. The map was supposedly based on the watermarks of 15-16 August 1986 floods.

Flood disaster warning system

The flood disaster warning system should be improved (Tayag and Punongbayan, 1994). There should be an inter-barangay and inter-agency cooperation on flood monitoring and disaster warning. Most of all the information should be immediately fed to broadcast media, such as in radio and television news and public service programs.

There is also a need to come up with a list of barangays that are perennially inundated. The usefulness of barangay officials in disseminating warnings is salient. They should be trained to understand the warnings that are issued by PAGASA or the agency should translate their scientific lingo to lay person's terms to initiate clear information dissemination and warning issuance. Barangay officials of annually flooded sites must be provided with radio systems during the flooding season that is connected to PAGASA monitoring stations. Barangay officials must also be provided with loud speakers that they can use during the flood season so they can announce forthcoming events to their constituents. The roving reporters of radio stations that are equipped with radio transmitters may be asked to issue flood-warning messages to barangay officials during the flood season. However, this may serve to heighten the discouraging lack of public response to inadequate disaster warning (Arroyo, 1991).

Warning issuance is not going to be effective unless the people are informed of what to do during flood episodes. The NDCC's plan to organize Disaster Coordinating Committees (DCCs) in the communities should be implemented specially in most disaster prone areas (NDCC, 1988; Banzon-Bautista, 1993). The DCC workers of MMDA should hold more disaster mitigation and recovery workshops in urban poor neighborhoods. The Barangay Disaster Preparedness training must be implemented and be made mandatory to barangays that are annually flooded. This will inform the constituents of what things to do, and build a support network that they can rely on during emergency periods. The MMDA-DCC workers should not focus their training activities on exclusive neighborhoods or middle-class or high-income communities who can sponsor the costs of holding disaster preparedness sessions. These sessions are important because they can lay the groundwork for a neighborhood-based disaster mitigation and recovery that is oriented to community development.

Community level vulnerability assessment and baseline data management

The local government and the MMDA should be under the direction of the NDCC during disaster periods. The DCCs should be in close coordination with the local government officials even during non-disaster periods. They should initiate vulnerability assessment on the community level. This task will determine the groups that are at risk and identify their local capabilities during emergency periods. The local government, with the help of barangay residents, should identify flood shelters, for example, convents, churches, school buildings and other elevated structures. Subsequent assignment of families at risk to the identified flood shelters should be made to facilitate orderly evacuation. The government should initiate the production of evacuation maps that locate government facilities that can aid in disaster operations (Dymon & Winter, 1991; NAMRIA, 1994). The National Mapping and Resource Information Authority (NAMRIA), the local governments and the DLGCD (Department of Local Government and Community Development) should combine their technical resources to facilitate this activity.

There are some issues that are intertwined with vulnerability to flood hazards among the diverse groups in Metro Manila. They are: gender relations that place a heavy burden on females, patterns of residential segregation that isolate wealthy communities, and temporal and global patterns of flooding that have a disproportionate effect on impoverished groups.

REPUBLIC OF KOREA

Introduction

Nature has proven, time and again, that hazards do not recognize political boundaries. Addressing the impacts of trans-boundary hazards requires concerted actions of governments, organizations, and individuals, not only in the more immediate emergency relief, rehabilitation and reconstruction phases, but also, importantly, in long-term disaster prevention and mitigation. The Typhoon Committee Working Group for Disaster Prevention and Preparedness (TCWGDPP) members meet in the 38th session of the Typhoon Committee on 2005 and agreed to establish a regional typhoon early warning system in the Asian region, and develop national and regional human and institutional capacity and promote transfer of know-how, technology and scientific knowledge in building and managing a regional early warning system and disaster management through international cooperation and partnership.

As a first step in gathering information for the survey, the TCDPP (Typhoon Committee for Disaster Prevention and Preparedness) secretariat requested information on Nations' capacities and gaps in early warning through Governments' permanent missions to the Asia region. Fourteen Governments responded, including: Cambodia, China, Democratic People's Republic of Korea, Hong Kong, Japan, Lao PDR, Macao, Malaysia, Philippines, Republic of Korea, Republic of Singapore, Thailand, United States, Viet Nam. To involve the relevant United Nations and other organizations in the process, the TCDPP secretariat requested information from the TCDPP member organizations on early warning capacities and gaps, and established the aforementioned TCDPP Working Group. The Working Group agreed that the survey should be mainly based on existing information and make use of existing resources and organizations. Such sources include reports submitted by countries to the Working Group chair for the Annual Meeting on Disaster Prevention and Preparedness (2005). Early warning capacities and gaps were extrapolated from 14 country reports and synthesized in a matrix. With the guidance of the Working Group chair, a questionnaire was developed and sent to the Working Group members with the goal of obtaining consistent information on activities and experiences of the Working Group members involved in different aspects of early warning systems. The completed questionnaires and the results of additional research were compiled and summarized in a matrix reproduced in TCDIS (Typhoon Committee for Disaster Information System).

The Working Group met at the 3rd meeting of the TCDPP to discuss progress on gathering information from organizations. In addition to new and existing country reports and inputs from international agencies, the survey included the review of regional reports prepared for the TCDIS and other specialized early warning reports. The information was analyzed and synthesized in a draft report that was shared with a small group of experts in TCDIS of Korea, 11-20 May 2008. The members meeting provided guidance that such early warning arrangements should build on existing institutions and mechanisms, strengthen and upgrade national systems, link national mechanisms with sub-regional and regional capabilities, integrate early warning with preparedness, mitigation and response (end-to-end), and must be integrated into existing warning systems to promote a multi-hazard approach to make the system sustainable.

The experts identified capacities and gaps for each of the early warning components based on the draft report, the materials reviewed and their expertise. The most salient capacities and gaps were subsequently captured in the survey report. The consultative draft report was shared with this group of experts and the TCDPP Working Group. Subsequently, the document was revised and presented at the Third Workshop on TCDIS, Seoul, Korea, 10 to 11 April 2008. The meeting recognized the TCDPP Working Group readiness to serve as a regional center or focal point for a multi-nodal typhoon early warning arrangement in the region, and its goal to strengthen its capacity, including the incorporation of additional technological capabilities. Its purpose is to enable the deploy of the warning system to prepare for the danger and act accordingly to mitigate against or avoid it. The warning system for typhoon and floods encompasses a wide range of meteorological information such as warnings and advisories further to forecasts. Its objective is to meet the comprehensive needs for the protection of life and property and the enhancement of the national socio economic activities in various sectors including the general public, industries and transportation.

Information for Severe Weather Preparedness

In case a hazardous weather condition is expected, KMA delivers various plain messages including warnings, advisories and bulletins to the general public and disaster prevention authorities so that appropriate measures can be taken to mitigate possible hazards. These warning messages are issued by Local Meteorological Observatories (LMOs) for each of the sub-divisions in their respective prefectures; the meteorological observational network in KMA consists of various fields of observation such as surface, upper-air, ocean, weather satellite, weather radar, and seismology. There are 94 weather stations, 464 Automatic Weather Stations (AWS), 20 Asian dust (Hwangsa called in Korea) observation stations, five moored buoys, and one observation ship in operation. The KMA network includes 77 synoptic observation stations, the Base station of Oceanic-Meteorological Observation (BOMO), ten upper-air observation stations, ten weather radar observations, ten aviation meteorological stations and 35 seismological observations. For the reception of satellite data, MESDAS-II, including three Medium-scale Data Utilization Stations (MDUS), is in place and operating. KMA is also operating Korea Global Atmosphere Watch Observatory in Anmyeon Island.

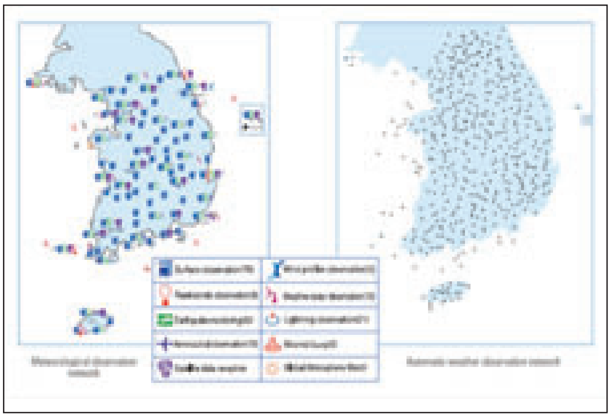


Figure A-20. Local Meteorological Observation Networks

1. Long range forecasts

KMA produces three types of long-range weather forecasts: 1-month, 3-month (seasonal), and 6-month forecast (experimental). The 1-month forecasts are issued three times a month and include temperature, precipitation, and air pressure pattern for the next 30 days. The 3-month forecasts which are produced at monthly basis include the trends of temperature, precipitation including special seasonal events such as Asian dust, Typhoon and Changma for the next 3 months. The 6-month forecast is issued two times a year (May and November). The system run schedule and products are listed in Table A-10.

Table A-10. Basic properties of system run schedule and products

<table>
<tr><th>1-month forecast</th><th colspan="2">3-month forecast</th><th>6-month forecast</th></tr>
<tr><td>Issue Date</td><td>° 3rd , 13th, and 23rd day of each month</td><td>° 23rd day of each month</td><td>° 23rd day of May and Nov.</td></tr>
<tr><td>Spatial resolution</td><td colspan="2">2.5 ° × 2.5°</td><td>-</td></tr>
<tr><td>Spatial coverage</td><td colspan="2">Global</td><td>-</td></tr>
<tr><td>Lead time</td><td colspan="2">About 3 weeks</td><td>-</td></tr>
<tr><td>Output typ</td><td colspan="2">Images</td><td>-</td></tr>
<tr><td>Forecast type</td><td colspan="3">Three type categories : above, below and near normal
The anomalies are based on model climatology obtained from a 24 year database(1979 to 2002).</td></tr>
<tr><td>Contents</td><td>° 10-day mean temperature and precipitation
° 30-day mean temperature and precipitation</td><td>° 1-month mean temperature and precipitation
° 3-month mean temperature and precipitation
*1Asian dust outlook
*2Typhoon outlook
*3Changma outlook</td><td>° 1-month mean temperature and precipitation (Jun. to Nov./Dec. to May)</td></tr>
<tr><td>Forecast area</td><td>Temperature : whole Korea
Precipitation : whole Korea</td><td>Temperature : whole Korea
Precipitation : whole Korea</td><td>Temperature : whole Korea
Precipitation : whole Korea</td></tr>
</table>

*1. Asian dust outlook is issued in late February including frequency and density of Asian dust expected to affect Korea for the upcoming Spring.
*2. Typhoon outlook is issued in late May and Aug. regarding number of Typhoon expected to affect Korea for the upcoming Summer and Fall.
*3. Changma outlook is issued in late May regarding or duration and intensity of Changma .

2. Extended range forecasts (10 days to 30 days)

For the extended range forecast system, KMA has been operating global climate model with predicted sea surface temperature (2-Tier system). To predict the global sea surface temperature as a boundary condition for the 2-tier system, the global ocean forecasting system has been developed as a combined system of dynamical and statistical models. The global long-range forecasting system, using global climate models, is also being developed, and the SMIP2/HFP-type climatology for each model is produced for removing model bias and improving predictability. The operational extended forecasts system is based on the global spectral model, GDAPS (Global Data Assimilation and Prediction System) with horizontal resolution of T106 and 21 vertical levels of hybrid sigma-pressure coordinate. For the Ensemble forecasts, we utilize 20 ensemble members by lagged average method with about 15-day forecast lead-time

3. Global sea surface temperature forecasting system

The El Nino prediction system (Kang and Kug, 2000) is based on the intermediate ocean and statistical atmosphere model. The ocean model differs from the Cane and Zebiak (1987) model in the parameterization of subsurface temperature and the basic state. The statistical atmosphere model is developed based on the singular value decomposition (SVD) of wind stress and SST. To reduce the uncertainty of initial field on the ENSO model, the breeding technique is applied. In the case of an ideal experiment, it works for better predictability, while for our El Nino prediction model, its effect is not so clear because it has weak nonlineality. Therefore, it shows some possibilities to contribute the improvement of predictability for the complicated future ENSO prediction using coupled GCM.

In order to improve the western Pacific SST prediction, KMA introduced the heat flux formula and vertical mixing parameterization to the ocean model. The initialization of the model is done by combining observed SST and wind stress. Wind stress is calculated by using the 925hPa wind of NCEP/NCAR reanalysis data. The method with calculated wind stress for initialization has a better forecast skill than that with FSU wind stress in recent predictions (Kug et al., 2001). In addition, the present prediction is attended with random noise considered weather noise, and generates many sets of prediction. Our approach for random noise is similar to Kirtman and Schopf (1998). Then, to correct the systemic error in the prediction model, the statistical model is also applied. The used Coupled Pattern Projection Model (CPPM, Lee and Kang 2003) is a kind of pointwise regression model, and the main idea of the model is to generate realization of predictions from projections of covariance patterns between the large-scale predictor field and regional predictions onto large-scale predictor field at the target year. By applying this model to the dynamic model results and compositing the results from both the dynamical and statistical models, the predictability over the tropical Pacific is improved than before.

To predict the whole global SST, a statistical global SST prediction system is being developed by combining Coupled Pattern Projection Model (CPPM), Lagged Linear Regression Method (LLRM), El Nino prediction model, and persistence method. In the tropical Pacific, predictions produced by El Nino prediction model are used, and in other regions the best results between CPPM, LLRM, and persistence are used. The LLRM is one of the point wise statistical model based on the lag relationship between the global SST and ENSO index and the optimal lag is selected by the hindcast process in the model. This is developed to determine predict the Indian SST prediction. Using this global ocean forecasting system, the boundary conditions for the global climate model are also produced.

4. Long range forecasts (30 days up to two years)

The long range forecast system is the same as the extended range forecast system described in section 1 except the forecast range. The official products of extended range forecasts are 3-categorical forecasts of temperature and precipitation over Korea for the upcoming 3 months. For the long range forecasts, we also utilize the multi model ensemble (MME) technique which has been developed and operated by APEC Climate Center (APCC). The APCC collects the historical and real-time forecast data of 15 different models from 8 countries and constructs the automatic MME input data producing system. The APCC has developed various MME techniques for deterministic and probabilistic seasonal predictions. For deterministic forecast, three kinds of linear MME techniques are used, namely biased and unbiased simple composite, weighted combination of multi-models based on SVD, and MME with statistical corrections. For probabilistic forecast, three tercile ranges are determined by ranking method based on the percentage of ensemble members from all the participating models in those three categories. Moreover, regional MME system version MME I-IV has been developed for Asian Monsoon region.

Flood Monitoring and Early Warning System

1. Advisory and Bulletin Services in Collaboration with River Management Authorities

The NEMA (National Emergency Management Agency) takes the responsibility of flood forecasting services, which are performed in collaboration with central and local government agencies. These services include flood warnings, advisories and bulletins covering 222 control points in five main rivers (as of January 2008) throughout the country, which were designated by the aforementioned agencies as the rivers with the potential for flood disasters. Flood forecasting systems for 222 rivers out of 2831 are managed jointly by NEMA and the River Bureau of the Ministry of Land, Transport and Maritime Affairs (MLTMA), KMA and civil engineering bureaus of prefectural governments. The flood forecasting systems was started from 1974 in Han River basin after then it was extended into 5 main river basins including the Han River such as the Nakdong River, the Geum River, the Sumjin River, and the Youngsan River in which hourly discharges and depths are automatically collected by Telemeter (T/M) established at 222 control points listed in Table A-11. The computer systems established in five rivers are listed in Table A-12.

Table A-11. The telemeter established at control points in five rivers

River Basin	Original			Now		
	Rainfall	Water Surface Elevation	Measuring Density (km2/No.)	Rainfall	Water Surface Elevation	Measuring Density (km2/No.)
Han River	38	17	64	124	70	210
Nakdong River	56	47	138	98	66	243
Geum River	35	24	101	58	43	169
Sumjin River	23	16	233	22	18	223
Youngsan River	14	19	56	29	25	116

Table A-12. The computer systems established in five rivers

River Basin	Original		Now	
	Type	Year	Type	Year
Han River	CDC 3170 (TR Type) No Back-up function	1974	TICOM II Backup MICRO VAX	1994
Nakdong River	TANDEM 16 (DUAL CPU)	1987	TANDEM CLX 720 (DUAL CPU)	1992
Geum River	TANDEM CLX 610 (MONO CPU)	1991	TANDEM CLX 610 (MONO CPU)	1991
Sumjin River	TANDEM CLX 610 (MONO CPU)	1990	TANDEM CLX 610 (MONO CPU)	1990
Youngsan River	TANDEM CLX 610 (MONO CPU)	1992	TANDEM CLX 610 (MONO CPU)	1992

2. Rainfall-Runoff Numerical Model

The rainfall-runoff in five rivers was calculated by the storage function method (SFM) in Korea. The forecasting system was changed dramatically from Han River Forecasting System started at 1983 to the Integrated Forecasting System at 2006. The history of forecasting system is listed in Table A-13.

Table A-13. The history of forecasting system

Years	Forecasting System
1983	The Han River Forecasting System upgrade to reflect the Chungju multi-objective reservoir construction effects
1994	Establishment of flood database management system
1996	Development of flood forecasting system for Ansung-Cheon
	Development of on-line system for flood forecasting
	Development of 5 rivers integrated operating system for flood management
1997	Extend 5 rivers forecasting system to 12 rivers forecasting system
	Development of 12 rivers integrated operating system for flood management
2000	Development of National Early Warning System
2003	Improvement of National Early Warning Syste
2004	Improvement of National Early Warning System to Local Warning Syste
2005	Connecting of Early Warning System with the Raider Analysis Module
2006	Standardization of hydrology information for Early Warning System

3. Status of Natural Disaster Warning Systems

From conventional, commercial electronic display boards to cutting-edge information technologies, six different early warning systems now operate against natural disasters in Korea: i.e. the Cell Broadcasting Service (CBS) mobile phone message system, automatic verbal notification system, auto-

Table A-14. The warning system related in natural disaster

No	Equipment/System	Installation set	Target for info.	Alert method	Management host
1	CBS Mobile-Phone Disaster Notification Message Broadcasting System	37.5 Million Users	CBS User 23 Million	Message broadcasting (Mobile Phone)	Central
2	Automatic Verbal (Text) Notification System	234 set nation wide	Civil official, head of government offices and specific regional residents – about 550,000 people	Guidance-information broadcasting (wire and mobile phones, etc)	Regional
3	Automatic Rainfall Warning System	148 set nation wide	Valley, Mountain, Public places, holiday-makers, campers, etc	Warn-alarming, guidance-information broadcasting	Regional
4	Disaster Notification Board System	299 set nation wide	The specific regional residents, holiday-makers, etc	Propagation and notification of disaster by wording through electronic board	Regional
5	TV Disaster Warning Broadcasting System	3997 set nation wide	Disaster Prevention & Countermeasures Headquarters at each local provinces and each regional administrative offices and its related institutes.	Auto TV Power-On, Volume-Up, broadcasting the situation	Central
6	Radio Disaster Warning Broadcasting System	5 area	Residents, Holiday-makers, etc	Auto Audio Amp Power-On, Alarming and Guidance-information broadcasting	Regional

matic rainfall warning system, disaster notification board system, TV disaster warning broadcasting systems, and radio disaster warning broadcasting system using the radio data system (RDS). The warning system related in natural disaster is listed in Table A-14.

The CBS mobile phone disaster message notification system broadcasts disaster information to mobile phone users with a special receivable ID at the base station transceiver subsystem. Unlike the short message service, which is a point-to-point individual transmission, the CBS system can transmit messages nationwide or to local areas, simultaneously or independently. Serviceable telecoms companies and targeted areas were selected in November 2004, after which users' responses were analyzed and an interactive system was set up in Korea's National Emergency Management Agency (NEMA) in 2006. So far, the system has broadcast 57 warnings to more than 19 million mobile phone users - that is, 39 for heavy snows and roadblocks, nine for wildfires, three for tsunamis, three for gusts and heavy rains, and three for drought and yellow dusts. This system has several advantages. Information reception is possible via an equipped CBS module without additional hardware, so nationwide broadcasting is possible. This system is suitable for real-time warning services because multi-user transmissions are available simultaneously by broadcasting characteristics. The service cost is low, independent of the number of users. Users can easily select, confirm, and delete information. This system, however, has some weaknesses. For a start, it is terminal-oriented - without a mobile terminal or CBS module, information cannot be received. If the terminal is turned off, no information is available even with a CBS module. The reception rate is another problem. The disaster information is not available in radio-dark areas and there is no automatic confirmation method to check whether or not users have received disaster information. The Cell Broadcasting Service in the natural disaster warning system is shown in Figure A-21.

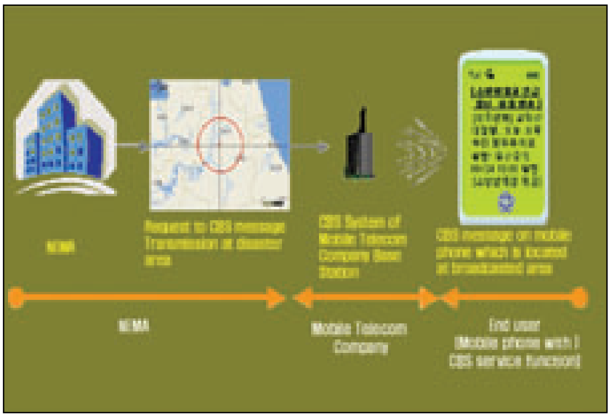


Figure A-21. The Cell Broadcasting Service in the natural disaster warning system

The second system for early warning is the automatic verbal notification system. Automatic voice notification equipment located at the local disaster management headquarters can issue warnings using fixed or mobile telephones, village broadcast amplifiers and any available communication tools when inundation and other disasters are imminent. When rain precipitation, river level, or any emergency data in a specific area are analyzed, persons to be informed are chosen and a disaster warning is issued using 32 exclusive emergency communication networks. The system database covers more than 550,000 people such as emergency managers and local residents in 234 central and regional districts. For an effective response, call sequencing has

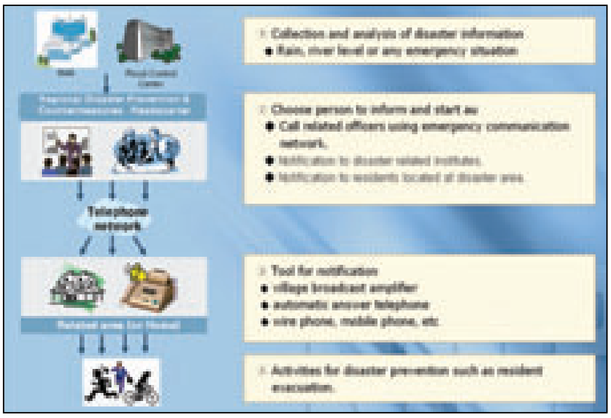


Figure A-22. The Automatic Verbal Notification System in the natural disaster warning system

been set up. The first call goes to the village amplifier in a disaster-prone area, so that people in the vicinity can obtain general information about the imminent disaster situation. A second call goes to the village chief, who can personally deliver the information and encourage people to evacuate to a safe place. The final call goes to the related public organizations and officers in the targeted area. The Automatic Verbal Notification System in the natural disaster warning system is shown in Figure A-22.

The third system is for localized rainfall warning (Figure A-23). After a one night flash flood killed 95 campers and hikers in the Jiri National Park in 1998, the local observatory system needed to be expanded to monitor local torrential rains which cannot be easily observed at regional level. The automatic rainfall warning system can measure rainfall in the upper stream, analyze discharge and velocity of river flow in a specific basin and calculate the water level downstream. When the water level exceeds certain criteria, early warnings and evacuation orders can be issued. In this system, water level is automatically observed at the observing station established in the upper and middle area of mountain valley.

When rainfall is actually measured in the observation station in the upper stream shown in Figure A-24, which is powered by batteries and sunlight, the runoff and time of concentration can be determined using a computer program verifying various parameters. The velocity of flow is also determined using the computer program for multidimensional display or by Manning's formula for a simple profile. Since hazard criteria are known by actual tests based on velocity and water level, a dangerous water level can be detected. The amount of rainfall accumulating in 20 minutes is used to determine whether warning and evacuation orders need to be issued using the alarm station. The control station and field display post also help to organize the system and inform people about it. This localized rainfall warning system (Figure A-25) is one of the most effective early warning systems in Korea. It is an actual-input based early warning system using real-time monitoring. The Korean Government established 136 systems, investing more than USD60 million between 1996 and 2003. An additional 125 systems will be completed by 2009 at a cost of about USD40 million.

Figure A-23. Conceptual Figure of the Automatic Rainfall Warning System in the natural disaster warning system

Figure A-24. Measuring Station of the Automatic Rainfall Warning System in the natural disaster warning system

Figure A-25. Warning Stations of the Automatic Rainfall Warning System in the natural disaster warning system

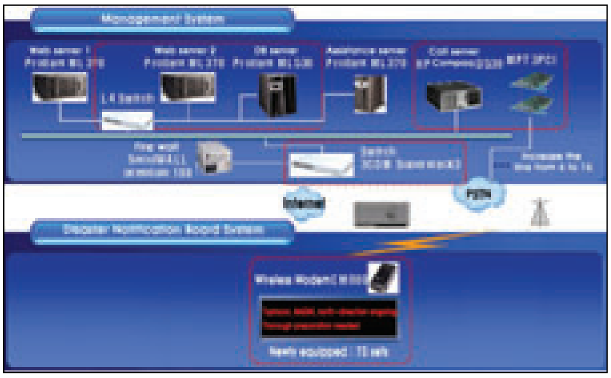


Figure A-26. The Disaster Notification Board System in the natural disaster warning system

The fourth system uses electronic bulletin boards exclusively to display disaster information and warnings. This disaster notification board system is 1.2 metres high and half a meter wide and can display a maximum of 20 words. It can be attached to buildings, or can stand alone with a five-meter-high support. Currently, 299 systems are installed in disaster-prone areas such as beaches, mountain areas, public parks and lowlands. As soon as disaster information becomes available through the Korea Meteorological Administration, NEMA and local headquarters select a standard message and activate the system using the Internet. The Disaster Notification Board System in the natural disaster warning system is shown in Figure A-26.

The fifth early warning system is the TV disaster warning broadcasting system, which is based on automatic TV turn-on/off functions. Since night time is most vulnerable to disasters, these systems enable TV systems to turn on or even change the channel with automatic volume-up so people receive urgent disaster information even if they are sleeping or watching other channels. This system broadcasts urgent disaster information as sound or screen messages using the broadcasting station°Øs equipment and a special receiver connected to the home TV set. The Korea Broadcasting System (KBS) is the primary service responsible for broadcasting disaster information. Currently 3,997 TV sets with special receivers are in operation at central and local disaster management headquarters, at each of the administrative offices, and at related organizations. These are to be expanded for the general public. The TV Disaster Warning Broadcasting System in the natural disaster warning system is shown in Figure A-27.

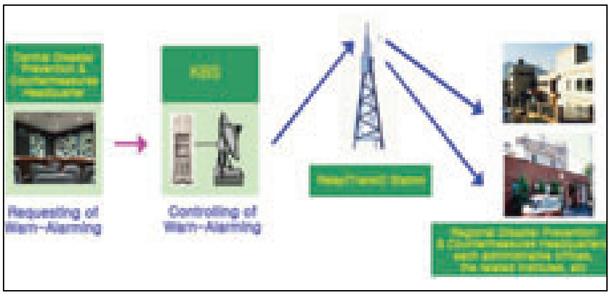


Figure A-27. The TV Disaster Warning Broadcasting System in the natural disaster warning system

Similar to the TV disaster warning broadcasting system, the sixth early warning system that the Korean Government is focusing on is the radio disaster warning broadcasting system using RDS (Figure A-28). This system is based on technology that can automatically turn a radio on or off, and can activate Agora's amplifying speaker systems. The system can be applied to any facility that has internal speaker systems, such as a movie theatre or shopping centre. KBS is also responsible for broadcasting specific disaster information. The system

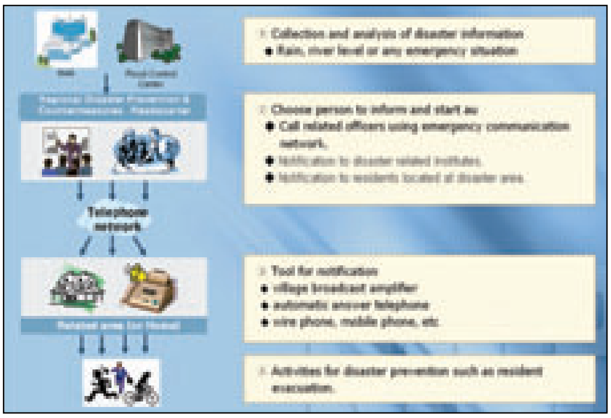


Figure A-28. The TV Disaster Warning Broadcasting System in the natural disaster warning system

does not interfere with the existing FM signals, but it requires an RDS encoder to be installed. The system consists of three main sub-systems, i.e. control, transmission, and warning broadcasting panels. These panels should have an emergency power supply and be resistant to lightning damage. Also, the system is capable of various warning durations and messages. During Typhoon Maemi in 2003, radio disaster warning broadcasting systems using RDS in five areas were activated, and disseminated the appropriate disaster information.

Warning Criteria

The warning criteria are defined by common meteorological terms, subject to multiple interpretations, that are used by agencies preparing local storms forecasts and warnings.

1. Strong Wind

Strong wind may be mentioned in severe weather watches/warnings, if it will have a significant impact on the general public. The following strong wind intensity classes will be used in the forecasting and warning functions of concerned agencies:

▶ Strong Wind Advisory

• Strong wind is expected in the land, with a sustained speed of more than 14 m/s. Gusts may exceed 20 m/s

• Strong wind is expected in the mountainous area, with a sustained speed of more than 17 m/s. Gusts may exceed 25 m/s

▶ Strong Wind Warning

• Strong wind is expected in the land, with a sustained speed of more than 21 m/s. Gusts may exceed 26 m/s

• Strong wind is expected in the mountainous area, with a sustained speed of more than 24 m/s. Gusts may exceed 30 m/s

2. Heavy Rain

The Weather Prediction Center issues daily severe weather outlooks describing forecast coverage of heavy rain across the conterminous Korea. The terms used and their definitions are:

▶ Heavy Rain Advisory

• Heavy rain is expected exceeding 80 mm per 12 hours

▶ Heavy Rain Warning

• Heavy rain is expected exceeding 150 mm per 12 hours

3. Typhoon

Primary hazards in a typhoon are wind, hail, flash flooding, and lightning. Flash flooding and lightning may be mentioned in severe weather watches/warnings, if it will have a significant impact on the general public. The following thunderstorm intensity classes will be used in the forecasting and warning functions of concerned agencies:

▶ Typhoon Advisory

• Strong wind or heavy rain are expected to meet the condition of Strong Wind Advisory or Heavy Rain Advisory due to Typhoon

▶ Typhoon Warning

• Strong wind is expected exceeding 17 m/s or heavy rain is expected exceeding 100 mm due to Typhoon

The typhoon warning level issued by the Weather Prediction Center is listed in Table A-15 and typhoon warning issued in 2007 is listed in Table A-16.

Table A-15. Typhoon Warning Level

Year	Level 3	Level 2	Level 1
Wind (m/s)	17-24	25-32	exceeding 33
Rain (mm)	100-249	250-399	exceeding 400

Table A-16. Typhoon Warning issued in 2007

Intensity	Name	Signal	Issuing	Canceling
Typhoon	MAN-YI (No. 4)	Typhoon Advisory	2007-07-13 18:00	2007-07-14 03:00
		Typhoon Warning	2007-07-14 03:00	2007-07-14 16:00
		Typhoon Advisory	2007-07-14 16:00	2007-07-14 21:00
Typhoon	USAGI (No. 5)	Typhoon Advisory	2007-08-02 18:00	2007-08-03 07:00
Typhoon	NARI (No. 11)	Typhoon Advisory	2007-09-15 20:00	2007-09-16 03:00
		Typhoon Warning	2007-09-16 03:00	2007-09-16 21:10

SINGAPORE

Introduction

While Singapore is relatively free from natural hazards, it is affected by severe weather such as heavy rain, thunderstorms and lightning and occasionally by strong winds and high temperatures. To a lesser extent, it is also affected indirectly by natural hazards occurring further away, such as tremors from earthquakes and ash from volcanic eruptions.

Disaster monitoring and preparedness can prevent natural hazards from becoming disasters. The National Environment Agency (NEA) provides weather surveillance and multi-hazard warning services on a 24/7 basis to the public, industry and relevant agencies in Singapore. The severe weather and hazards encountered in Singapore, together with the monitoring and management systems in place at NEA, are described below.

1. Heavy Monsoon Rain/Floods

The climate of Singapore is divided into two main seasons, the Northeast Monsoon and the Southwest Monsoon season, separated by two relatively short inter-monsoon periods. During the Northeast Monsoon season between December and early March, prolonged rain spells each lasting for a few days to a week are quite common in the early part of the monsoon season (December-January).

A heavy monsoon rain spell can cause flooding but the frequency of floods is relatively low owing to the improved drainage over the years. Our drainage system is designed with a capacity to cope with floods from very heavy rain that occurs once in 5 years. The drainage code has a deliberate requirement to raise low-lying grounds in conjunction with redevelopment proposals and this helps to reduce the severity of floods caused by heavy rain. The ground levels of our reclaimed sites are at least 1.25 m above the highest tide. Singapore had not experienced any major flood since 1990. However, localised flash floods can still happen sometimes especially when heavy rain coincides with high tides.

To help alleviate the impact of floods, NEA provides heavy rain advisory and warning to various agencies for enhancing preparedness for expected heavy rain. Heavy rain warnings are also issued to the public via the media.

2. Lightning

Being located in the equatorial part of the tropics, showers with thunder are common in Singapore. On average, the island experiences 180 thunder-days in a year. The thundershowers are usually of short-duration lasting less than 2 hours. They can occur anytime of the year but most common during the inter-monsoon periods (April-May, October-November).

Lightning activities are invariability associated with thundershowers. Most of the high-rise buildings in Singapore are installed with lightning arrestors, which provide good protection to the buildings and their vicinity. As Singapore is quite built-up with tall buildings, the impact of lightning is relatively minimal. However, isolated cases of lightning fatalities have been reported from time to time. There were 7 incidents reported between the year 2000 and 2005, resulting in 5 fatalities and 15 injuries.

NEA provides services using SMS and fax to subscribed customers alerting the users on high probability of lightning. The subscribers are normally golf courses and construction companies which conduct activities in large open spaces.

3. Strong Winds due to Sumatra Squall or Tropical Cyclones

A Sumatra Squall is a line of thunderstorms, which develops over Sumatra or the Straits of Malacca and subsequently propagates eastward to affect Peninsular Malaysia and Singapore. The squalls can form any time of the year except during the Northeast Monsoon Season. Most of the squalls affect Singapore in the predawn hours and early morning, and can bring about substantial rainfall and moderate or strong wind gusts. A Sumatra squall with a gust (temporary rise in wind speed) of 50 to 70 km per hour is not uncommon. The highest gust ever recorded was 144 km per hour in the western part of Singapore.

On 26th December 2001, Tropical Storm "Vamei"developed at 1.4° N 105.9° E in the South China Sea. It strengthened quickly, tracked west-northwestward and made landfall along east coast of Malaysian state of Johor At about 0830 UTC on December 27 (approximately 60 km northeast of Singapore). The storm brought 36 hours of continuous moderate to heavy rain and caused flooding and mudslide in Malaysia. Numerous flights to Singapore Changi Airport were disrupted due to strong cross winds (WSSS METAR reported west-northwesterly winds at 23 knots gusting up to 36 knots). Rough sea with waves of up to 3 meters height was reported by wind surfers off the coast of Changi.

Even though the development of a revolving tropical cyclone near the equator is thought to be rare (where Coriolis force is almost absent), the above event demonstrated the need to provide timely alert to relevant response agency so that the possible impact of the cyclone can be minimized.

To help alleviate the impact of squalls or tropical cyclones (rare as it may be), NEA provides heavy rain and strong winds advisory and warning to various agencies for enhancing preparedness for expected heavy rain and strong winds. The warnings are also issued to the public via the media.

4. High Temperature

In Singapore, high temperature condition occurs mainly during the inter-monsoon months, from late March to May/June. This is due to the combined effect of increased solar heating (the sun is over or near equator) and also the relatively light wind condition during the period. The high temperature condition is made worse if there is also a lack of rain (for example during a dry spell).

The condition of extreme high temperature can be hazardous for the very young or very old or those with medical problems due to heat exhaustion and dehydration. This work instruction outlines the guidance on the timely issuance of high temperature advisory/warning to the relevant response agencies.

Annex D describes the details of the warning system for the issuance of high temperature.

5. Volcanic Ash

Ash cloud arising from violent volcanic eruptions is potentially deadly to aircraft and passengers as ash melting in the hot section of the aircraft engine can lead to loss of thrust and possible engine failure. In June 1982 a British Airways 747 suffered severe damage and had all four engines flame out upon encountering ash from Mt Galunggung in Indonesia, descending to 12000 feet before being able to restart some engines and make an emergency landing in Jakarta. Three weeks later the same incident happened to a Singapore Airlines 747. This time, the aircraft lost two engines and also made an emergency landing. Since then, there have been many aircraft encounters with volcanic ash.

The World Meteorological Organisation and the International Civil Aviation Organisation have worked together to set up nine Volcanic Ash Advisory Centres (VAAC) around the world to provide advisories on the location and movement of clouds of volcanic ash. Singapore receives the advisories from by the Darwin VAAC whose area of responsibility includes Indonesia, Papua New Guinea and part of the Philippines. This area has seen some of the biggest eruptions known to history.

At NEA, the advisories received from Darwin VAAC and other centres, complemented by wind forecasts and satellites images depicting the volcanic ash plume, are used to warn aircraft of volcanic ash cloud so that air routes can be planned to avoid ash contact. As volcanic ash can affect air quality, advisories are also issued to the public if necessary via the media.

6. Smoke Haze

Since the 1990s, smoke haze arising from land and forest fires in Indonesia has become a more regular occurrence in the ASEAN region. These annual fires are largely attributed to land clearing practices using fires in Indonesia by plantation owners and farmers.

Following the severe smoke haze episodes in 1994 and 1997/98 which adversely affected the air quality in several ASEAN countries, ASEAN adopted a Regional Haze Action Plan (RHAP). Under the plan, the ASEAN Specialised Meteorological Centre (ASMC), hosted by NEA, has been tasked to expand its role to include the monitoring of land and forest fires and resulting smoke haze in the ASEAN region. Working in collaboration with the National Meteorological Services of ASEAN member countries, ASMC has been proactively involved since 1994, in the following activities: (i) provision of assessment on weather and climate outlook to alert users of conditions that are likely to lead to significant incidents of fire and smoke haze; (ii) surveillance of fires and smoke haze in the region and make available the monitoring results to users through the ASMC Intranet; (iii) development and collaborative programmes to continuously enhance the capacity in the monitoring of environmental disasters; and (iv) regional projects to strengthen the support and technical capabilities of National Meteorological Services in ASEAN.

To facilitate the timely dissemination of a wide range of products for smoke haze monitoring to government agencies and organisations involved in RHAP related activities, the ASMC Intranet was launched in 1998. Some of the monitoring products include processed satellite images, hotspot maps showing detailed hotspot locations and haze maps showing detailed hotspot locations, wind forecasts, seasonal regional climate prediction, and monthly review and outlook of weather and haze.

On the home front, NEA has set a Haze Task Force (HTF) comprising 23 ministries/agencies to reduce the impact of smoke haze (fine particulate matter) on the health and well-being of the general public. The HTF has put in place a comprehensive Haze Action Plan (HAP) for every ministry/agency to adopt a standard operation procedure to deal with the haze episode. The HAP is activated in accordance with the levels of fine particulate matter in the air.

Early Warning System

1. Singapore Seismic Monitoring System

Singapore has established a seismic monitoring system since 1996. The system comprises four seismic stations. With the completion of the first phase of the seismic upgrade in March 2006, we are able to exchange data in real-time with Malaysia, Indonesia, Australia and the Global Seismographic Network (Fig. 1). The upgraded system is also able to integrate data received from regional seismic network, and process the data automatically to enable us to detect and assess earthquakes with greater speed and accuracy.

In March 2007, obsolete equipment in our network was replaced during the second phase of the upgrade to enhance the reliability of the network. In addition, one new station with a GSN sensor (to provide redundancy for our existing GSN station) and two new stations with sensors for gathering data on the impacts of earthquake tremors on structures built on reclaimed land will be installed. The operation of the second GSN station will enhance the reliability and quality of our seismic monitoring data for fast and accurate detection of tsunamigenic earthquakes. The new stations are expected to be installed by 3Q 2008.

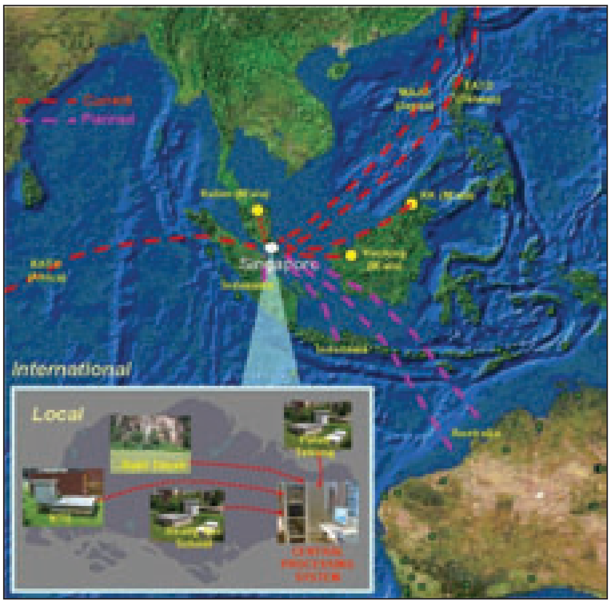


Figure A-29. Integration of Singapore' local seismic network with the Global Seismic Network (GSN)

Figure A-29 Integration of Singapore' local seismic network with the Global Seismic Network (GSN)

With the upgraded seismic monitoring system, earthquakes in the region can be detected automatically within the first few minutes of occurrence. NEA will disseminate the earthquake advisories to all relevant agencies within the first 5-10 minutes of detection. Earthquake advisories would include information on the date, time, magnitude and location of the earthquake.

To manage tremor incidents, a disaster management operation known as Operation Tremor has been put in place with the Singapore Police Force (SPF) as the Incident Manager. The operation involves the activation of various other key agencies such as the Singapore Civil Defence Force (SCDF), BCA and Housing Development Board (HDB). Once Operation Tremor is activated, structural engineers from BCA and HDB will check the affected buildings to ensure they are structurally safe. The police will assist in crowd control and provide information to the public through information desks, telephone hotlines and media. When all affected buildings have been inspected and declared structurally safe, SPF will, in consultation with all the agencies concerned, terminate Operation Tremor.

2. National Tsunami Early Warning System

Singapore is relatively sheltered from tsunamis by the surrounding landmasses and the shallow waters of the Straits of Malacca and South China Sea. Nevertheless, the destructive Indian Ocean Tsunami of 26 Dec 04 highlighted the need for countries in the region to be prepared for such disasters. Although the probability of tsunamis hitting Singapore is extremely low, the potential serious consequences of such disasters on both lives and the economy indicated that it is prudent to build up Singapore's tsunami early warning capability.

For this purpose, NEA has developed the Singapore's Tsunami Early Warning System (TEWS) with local universities. As part of the system, NEA has established links with regional/international tsunami warning centres to receive alerts and advisories of tsunamis that may affect Singapore. In addition, NEA has also put in place monitoring networks to access real time data from key seismic stations and sea level monitoring stations in the region to facilitate detection of tsunamis that may affect Singapore.

2.1 Tsunami Modeling Capability

NEA is working with the local tertiary institutes in the development of tsunami modelling capabilities. The outputs from this project would enable the agency to issue timely warnings/advisories and to help the relevant response agencies formulate their response plans. The project is targeted to be completed by August 2008. The key components of this project are tsunami source identification and modeling and Tsunami modeling (generation, propagation and run-up).

2.2 Visualization

A Graphical User Interface (based on Geographical Information System) has been implemented to integrate the different data from earthquake sources to model outputs for operational monitoring and assessment of potential tsunamigenic events. The system receives seismic data from the real-time seismic monitoring system as the trigger to launch the tsunami model runs and assimilates sea level data from the region to fine-tune the model outputs.

3. Tide Monitoring System

Besides seismic monitoring, it is important to have real-time sea-level data to confirm if a tsunami has indeed been generated, and to monitor its propagation. Singapore taps on data that is available on the Global Telecommunications System (GTS) to for sea-level monitoring for the occurrence of tsunamis.

In addition, the Maritime Port Authority (MPA) of Singapore maintains a network of 12 tidal gauges around our coastal waters. The data from the Tanjong Pagar station is available to the warning centre in NEA in real-time for the purposes of high tide and tsunami monitoring. The data from this tidal gauge will also be made available to the international network on the GTS by 3Q 2008.

Multi-agency Response Plan

NEA is co-ordinating a task force involving key government agencies involved in tsunami monitoring, response and mitigation. The agencies include the Police, SCDF, MPA, Public Utilities Board as well as agencies operating facilities located near the coasts and on the surrounding islands. A response plan based on scenarios of tsunamigenic earthquakes occurring in the Andaman Sea north of Sumatra and in the South China Sea near Manila is being put in place with the following objectives: (i) mitigate the impact of a tsunami on Singapore by provision of early alerts and warnings to all relevant response agencies to take early preventive actions; (ii) manage the consequences of a tsunami affecting Singapore

The role of NEA as the incident manager of tsunami incidents is to monitor and disseminate timely alerts and warnings to the response agencies and to the public. SCDF will take over as the incident manager during the consequence management phase to lead and coordinate multi-agency rescue operations.

Recent Major Disaster

1. Tremors in Singapore

While earthquakes do not occur in Singapore, the island has been affected by tremors caused by large distant earthquakes, mainly in Sumatra. Tremors that affect Singapore are usually caused by earthquakes occurring along the Sunda Trench, off the west coast of Sumatra, and the Great Sumatra Fault. These earthquakes are typically between

400 and 700km away from Singapore. Because of our distance from these seismic zones, tremor intensities experienced in Singapore are generally low and no serious damage has been reported in Singapore due to earthquakes in Sumatra in the past.

The current building codes of the Building & Construction Authority (BCA) require all buildings to be constructed to withstand certain amounts of forces that could be brought to bear laterally on the buildings, e.g. forces due to wind loads or lateral forces equivalent to 1.5% of the weight of the building, whichever is greater. This provides some degree of robustness, which may increase if there are also structural elements such as lift cores and Civil Defence shelters.

Warning Criteria

1. Heavy Monsoon Rain/Floods

During NE monsoon from November through March, prolonged and widespread heavy rain lasting for a day or longer (usually 2 to 7 days) may affect Singapore and southern Johore. In some of the past cases, the daily rainfall could surpass 200 mm. Apart from monsoon rain, Singapore could also experience short burst of heavy showers/thunderstorms any time of the year. These thunderstorms often last one to two hours with rain intensity temporarily going above 100 mm per hour. During these weather conditions, localized to scattered flooding may occur, especially in low lying areas and when the intense rain coincide with high tides. This work instruction defines the criteria for the timely issuance of heavy rain warning and advisory.

1.1 Prolonged Monsoon Heavy Rain Advisory

Prolonged Monsoon Heavy Rains Advisory shall be issued when a NE monsoon surge is forecast to affect Singapore within the following 2 to 3 days and there is indication of the rain would be widespread and at least intermittently heavy. The advisory shall be issued by D or N1N2 forecaster with consultation with SMO/CMO of MMO. Time permitting, a discussion panel, comprising of other senior officers may be called. The advisory is then kept under constant review for further update, issuance of heavy rain warning or cancellation.

1.2 Prolonged Monsoon Heavy Rain Warning

A Prolonged Monsoon Heavy Rain Warning shall be issued when all the following criteria are met: (i) observed radar and/or satellite rainfall intensity exceeding 20 mm/hr upwind of Singapore and expected to affect Singapore within the next few hours; (ii) expected duration of moderate to heavy rain exceeding 9 hours. If the heavy rains coincide with high tides (within 1 hour), the tide information shall be included in the warnings. The warning shall be kept under constant review. If the prolonged heavy rains are no longer expected, an update indicating the latest weather outlook shall be issued. If the prolonged heavy rains are expected to continue, an extension of the warning shall be issued 3 hours prior to expiry.

1.3 Short-Duration Heavy Rain Warning

A Short Duration Heavy Rain Warning shall be issued when 2 or more of the following criteria are met: (i) observed rain with intensity > 25 mm/hour, (ii) observed radar-echo tops with height > 10 km; (iii) observed radar-echoes movement with speed < 15 km/hour. This may be inferred from the 5000-10000 ft wind as detected by the wind profiler; and (iv) observed/expected area affected > 20% of Singapore island within next half-hour. If the heavy rains coincide with high tides (within 1 hour), the tide information shall be included in the warnings. The warning shall be kept under constant review. If the heavy rain is no longer expected, the warning shall be cancelled immediately.

1.4 Issuance of Warning/Advisory

Duty Forecaster shall issue the warning and advisory using MOLAR on the Forecaster's Network PC. Duty Forecaster shall pass the hardcopy of the warnings to TSO for manual facsimiles.

2. Lightning

Lightning is a discharge of electricity that originates from thunder clouds or thunderstorms. These storm clouds are usually in the active stage of development and hence typically accompanied with moderate to heavy showers and gusty winds. The build-up of electrical charges within these clouds are thought to be related to the collisions between different size raindrops, small ice particles, hailstones or graupel as a result of the intense vertical motion within convective clouds.

Singapore has one of the highest incidences of lightning strikes in the world. Over the past years, there were reports of lightning-caused damages and casualties. To help reduce the lightning hazards for various industries with high lightning exposure, MMO provides lightning watch service to subscribers at designated locations. The following section lists down the guidance for the timely issuance of lightning risk alert/warning, including description on scenarios associated with high or very high lightning risk. Section 3 describes the interfaces for the timely issuance of lightning risk alert.

2.1 Guidance for the Timely Issuance of Lightning Risk Alert/Warning

The alert/warning shall be issued with ample lead-time if thunder clouds or thunderstorms are observed or expected to develop within 6 km radius of each designated location, or are observed to develop and move towards the 6km radius of each designated location.

2.2 Issuance of Warning/Advisory

The warning and advisory shall be issued using SWIFT on the Forecaster's Network PC. SMS messages and Facsimiles are automatically sent out by SWIFT upon issuance. The hardcopy of the warnings shall be passed to TSO for verification of the automatic transmission.

3. Strong Winds due to Sumatra Squall or Tropical Cyclones

On 26th December 2001, Tropical Storm "Vamei" developed at 1.4° N 105.9° E in the South China Sea. It strengthened quickly, tracked west-north-westward and made landfall along east coast of Malaysian state of Johor at about 0830 UTC on December 27 (approximately 60 km northeast of Singapore). The storm brought 36 hours of continuous moderate to heavy rain and caused flooding and mudslide in Malaysia. Numerous flights to Singapore Changi Airport were disrupted due to strong cross winds (WSSS METAR reported west-northwesterly winds at 23 knots gusting up to 36 knots). Rough sea with waves of up to 3 meters height was reported by wind surfers off the coast of Changi.

Even though the development of a revolving tropical cyclone near the equator is thought to be rare (where Coriolis force is almost absent), the above event demonstrated the need to provide timely alert to relevant response agency so that the possible impact of the cyclone can be minimized. This work instruction outlines the guidance for the timely issuance of Strong Wind Advisory/Warning.

3.1 Strong Wind Advisory/Warning

SMO/CMO of MMO (or other senior officers) shall be recalled for duty when criteria for issuance of strong wind advisory/warning are met. Prior approval from DGMS / Head (OSD) is required for the issuance of the advisory/warning. The advisory/warning shall be issued when a tropical cyclone of storm category or higher is forecast to affect Singapore within the following 12 hours with mean surface winds reaching 34 knots or more. The advisory/warning shall be kept under constant review for further update, in consultation with SMO/CMO of MMO. If the tropical cyclone is no longer expected to affect Singapore, an advisory indicating downgrading/stand-down of the warning shall be issued.

3.2 Issuance of Warning/Advisory

The warning and advisory shall be issued using SWIFT on the Forecaster's Network PC. The hardcopy of the warnings shall be passed to TSO for dissemination by fax according to distribution list.

4. High Temperature

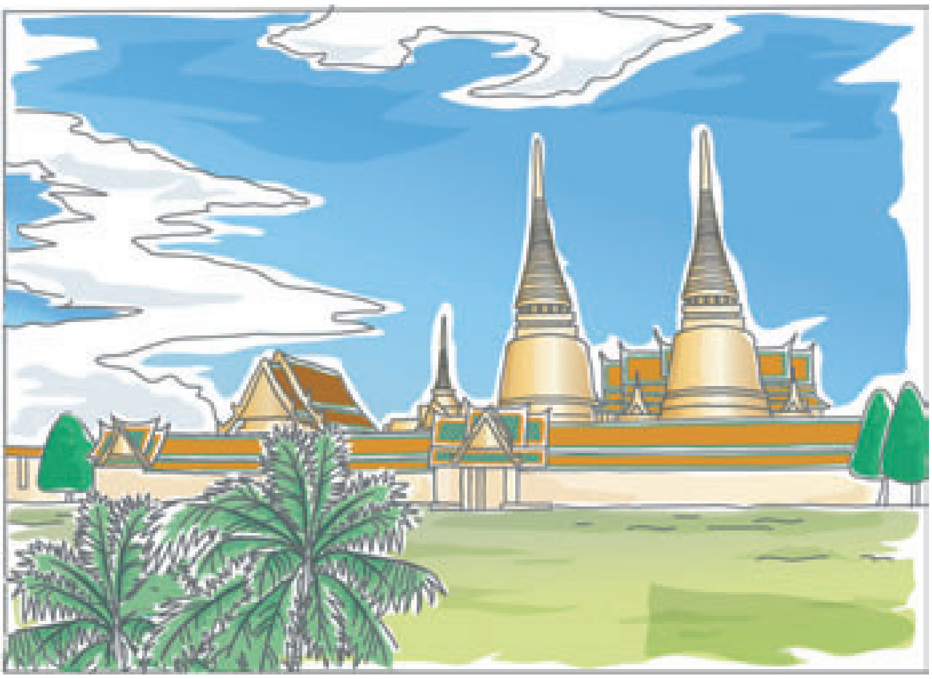
In Singapore, high temperature condition occurs mainly during the inter-monsoon months, from late March to May/June. This is due to the combined effect of increased solar heating (the sun is over or near equator) and also the relatively light wind condition during the period. The high temperature condition is made worse if there is also a lack of rain (for example during a dry spell). The condition of extreme high temperature can be hazardous for the very young or very old or those with medical problems due to heat exhaustion and dehydration. This work instruction outlines the guidance on the timely issuance of high temperature advisory/warning to the relevant response agencies.

4.1 High Temperature Advisory/Warning

High temperature advisory/warning shall be issued in consultation with SMO/CMO of MMO. A discussion panel, comprising of other senior officers shall be called. Prior approval from DGMS / Head (OSD) is required for the issuance of the advisory/warning. The advisory/warning shall be issued when a dry and hot spell is observed and is forecast to affect Singapore over the next few days. The advisory/warning shall be kept under constant review for further update, in consultation with SMO/CMO of MMO. If the dry and hot spell is no longer expected to affect Singapore, an advisory indicating downgrading/stand-down of the warning shall be issued.

4.2 Issuance of Warning/Advisory

The warning and advisory shall be issued using SWIFT on the Forecaster's Network PC. The hardcopy of the warning/advisory shall be passed to TSO for dissemination by fax according to the distribution list.



THAILAND

Introduction

Thailand is located in the tropical area between latitudes 5° 37'N to 20° 27'N and longitudes 97° 22'E to 105° 37'E. The total area is 513,119 square kilometers or around 200,000 square miles. In term of the climate pattern and meteorological conditions Thailand may be divided into 5 parts i.e. Northern, Northeastern, Central, Eastern and Southern Parts.

Thailand is under the influence of southwest and northeast monsoon. It will be the cause of depression tropical storm and typhoon. The southwest monsoon starts in May and brings a stream of warm moist air from the Indian Ocean towards the country causing abundant rain over the country. In October is the period of the northeast monsoon which brings the cold and dry air from the anticyclone in China mainland over major parts of Thailand, particularly the Northern and Northeastern Parts. In the Southern Part, this monsoon causes mild weather and abundant rain along the eastern coast of the part.

The onset of monsoons varies to some extent. Southwest monsoon usually starts in mid-May and ends in mid-October while northeast monsoon normally starts in mid-October and ends in mid-February. In every year, depression or typhoon affected Thailand and caused the heavy rain and inundation over the country (Table A-17). Figure A-30 show that the static will show the rainfall during 1971?2000 and the frequency of tropical cyclones moving through Thailand during 54 years (1951-

Table A-17. Seasonal rainfall (mm) in various parts of Thailand

Region	Winter	Summer	Rainy	Annual rainy days
North	105.5	182.5	952.1	123
Northeast	71.9	214.2	1,085.8	117
Central	124.4	187.1	903.3	113
East	187.9	250.9	1,417.8	131
South				
East Coast	759.3	249.6	707.3	148
West Coast	445.9	383.7	1,895.7	176

Base on 1971-2000 period

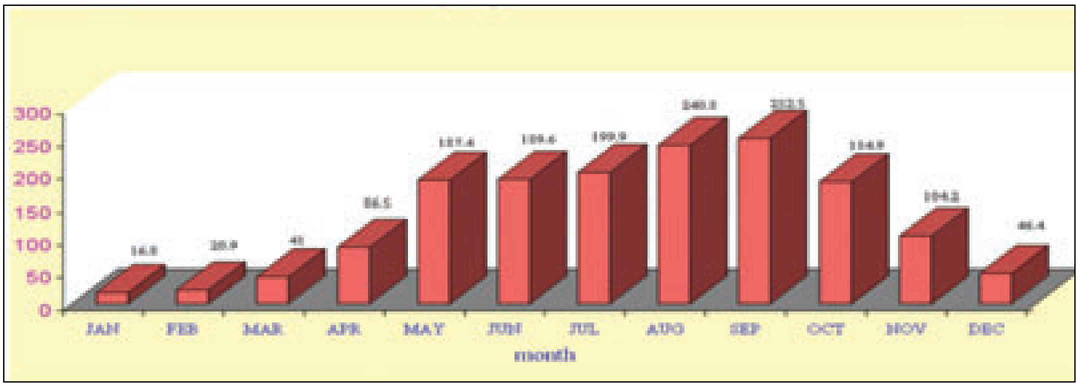


Figure A-30. The frequency of tropical cyclones moving through Thailand during 54 years (1951 - 2004); Sources: Thai Metrological Department (http://www.tmd.go.th/en)

Thailand Major Typhoon and Damages

Since 1962, Thailand has many experiences on the tropical storm which caused the heavy rainfall and flash flood. In October 1962, Thailand confronted with Typhoon "HARRIET" and wipe out The Talumphuk Cape Coastline of Nakhon Si Thammarat province, 870 deaths 160 missing, 422 injured, 16,170 unsheltered and the properties damages about 960 million bath.

Later on 4 November 1989 ," the typhoon "GAY"with the speed near center at 120 km. /hr. reached landfall at Pathio and Tha Sae districts, Chumporn province . The 4 southern provinces; Chumporn, Prachuap Kiri Khan, Susat Thani and Ranong and 2 eastern provinces; Rayoung and Trat were influenced and caused 602 deaths, 5,495 injured, 422 affected villages, 42,947 households and the properties damages about 11,686 million bath. Prachuap Khiri Khan province is one of the province was struck by the typhoon "LINDA in November 1997which 11 provinces in the south and the east of Thailand were affected.

The latest was Typhoon Xangsane hit many provinces in the north of Thailand. They caused the severe damage in the country. After hitting the Philippines on 28 September 2006, Typhoon Xangsane landed on Vietnam on 1 October and swept a number of central and central highlands provinces. Then on 2 October, the Typhoon moved to Thailand had considerably weakened to tropical depression but still brought heavy rain and flash flood in the northern provinces. The Department of Disaster Prevention and Mitigation reported the severe damage areas were in 47 provinces, 439 districts and 16,039 villages, 290 deaths, 4,315,438 effected people, 1,255,625 households and the properties damages about 6,433 million bath.

Early Warning System

The early warning system in Thailand could divide into 2 levels. In the national level, there are many organizations to take responsibility for the task relevant disaster warning. Thai Meteorological Department, Royal Irrigation Department, Department of Water Resources and Disaster Forecasting and Warning of Electricity Generating Authority of Thailand (EGAT) Public Co. Ltd are the main agencies to forecast the disaster warning on their own function. Therefore, Thailand's Early Warning Information from these agencies will be transferred to the people via mass media and agencies concerned and Department of Disaster Prevention and Mitigation (DDPM) will transmit the information through mechanism of Ministry of Interior to provinces, districts and local organizations.

After Tsunami disaster triggered the 6 southern provinces of Thailand on 26 December 2004, the government reviewed disaster early warning system to develop the system more efficiency and to make more confidence in safety in the country. In 2005, the cabinet appointed the Committee on Early Warning System Development which comprise the representatives of the departments concerned, will be responsible for making the decision as to when a warning should be issued. The National Early Warning Center has been set up to carry out the early warning system.

Moreover, for the regional warning system, Thailand contributed to establish the Voluntary Trust Fund in Tsunami Early Warning Arrangements in the Indian Ocean and Southeast Asia in September 2005.As the initiated country, Thailand pledged the amount of US$ 10 million dollar as seed money. The Fund is under the administration of UNESCAP and has already provided financial grant to a number of projects submitted by competent agencies and institutions from many countries in the region.

In the local level, the rain gauge and manual disaster siren have been installed in the flood prone areas. This device is employed for observing and notifying of local flood conditions, forecasts and warnings. The rain gauge is extremely low cost and very simple to use. The villagers will be trained to measure, record and read the daily amount of rainfall. Whenever the amount of rainfall exceeds the predefined normal level, the villager in charge of surveillance signal the warning by using the manual siren device to notify the village headman to disseminate the warning through the village news broadcast center.

Concerned Forecasting and Warning Organizations

1. Thai Meteorological Department

Thai Meteorological Department (TMD) is the main agency having role in forecasting and natural disaster warning overall the country by using the highly effective system: Metrological Telecommunication System, Computer Network System, and Numerical Weather Prediction System as well as Telemetering & Flood Forecasting System in order to analyze and generate the data in time. TMD forecasting both daily and 7- day forecast will be distributed to the media; televisions, radios and newspapers and presented on TMD website.

The process of disaster warning operation can summarized in 4 steps as follows:

(i) Collecting weather data with regards to atmospheric pressures contour line, wind speed and wind direction, temperature, humidity, cloud cover, rainfall and natural phenomena.

(ii) Incorporation data into weather map. The weather data in each station will depend on global Telecommunication System (GTS) through incorporating weather data of each station on weather map in the form of symbols determined by World Meteorological Organization (WMO).

(iii) Analyzing data. At present, Thai Meteorological Department develops model and computer with high performance to assist in calculation in association with knowledge, skill and experience or weather forecast officers. Analysis of weather data will vary according to the characteristics of obtained data.

(iv) Arranging weather forecast news and warning of weather condition that may be dangerous. Thai Meteorological Department will disseminate daily weather forecast to concerned government organizations, mass communication media and people who are members of daily weather news via post ,fax, radio station, all TV channels, newspapers and internet

For the efficiency, accuracy and timely information and forecasting, TMD set up metrological stations, 66 synoptic stations, 34 agro meteorological stations and 18 hydro meteorological stations and 20 weather radar stations around the country .

2. Royal Irrigation Department

Royal Irrigation Department is responsible for flood forecasting and warning in river basin of Thailand with the application of Telemetering & Flood Forecasting System and mathematic models. In general river basin, previous hydrological statistics will be analyzed to find relations between water level and water amount in different periods and time taken for water to travel from upstream station to downstream station to predict flood. In particular river basin, the hydrological telemetering system will be installed to flood forecasting and warning in real time operation for efficient water management.

3. Electricity Generating Authority of Thailand (EGAT) Public Co. Ltd

Electricity Generating Authority of Thailand (EGAT) Public Co. Ltd have responsibility for monitoring and forecasting quantity of water that will flow into the reservoirs under EGAT's obligation and giving suggestion on releasing water from the reservoir. The technologies which have been used in disaster forecasting and warning are history statistics on forecast water quantity that will flow into the reservoir and mathematical model adjusted to calculate water quantity and mathematical model to study behavior of water flow in project.

4. Department of Water Resources

Department of Water Resources (DWR) has been established according to the Bureaucratic Reform in October 2002 to be in charge of water resources in the country. Nowadays, DWR set up the Water Crisis Operation Center to collect and analyze water information for determining disaster prone areas.

5. National Disaster Warning Center

National Disaster Warning Center (NDWC) has been established after the Tsunami struck 6 southern of Thailand on December 26, 2004. The main mission is to study information on each disaster, giving disaster warning and disseminating news on disaster severity, monitoring disaster closely, training and educating staffs and people about disaster escape, response and mitigation. Apart from warning on Tsunami, it provides warning on multi-hazard i.e. earthquake, flood and landslide, storm.

Presently, National Disaster Warning Center carries out installing warning tower. The first phase of the warning towers were set up completely in 6 southern Andaman coastal provinces and planned to install the tower in the risk areas around the countries. It is stipulated that it should be at least 4 warning towers in each provinces. Furthermore, it has cooperated with private sector to set up warning system through SMS to mobile phone of all staffs, MPs, provincial governor and head of government organizations.

6. Department of Disaster Prevention and Mitigation

After the Bureaucratic Reform in October 2002, the government established the Department of Disaster Prevention and Mitigation (DDPM), Ministry of Interior to carry out the task and responsibility of the disaster prevention and mitigation. According to Disaster prevention and Mitigation Act 2007, DDPM was designed to be the principle disaster prevention and mitigation organization implementing efficiently the disaster management of the country and the secretariat of Disaster Prevention and Mitigation Committee.

DDPM's organization is comprised of the divisions in the Headquarter, 18 DDPM Regional Centers, and 75 Disaster Prevention and Mitigation Provincial Offices cover the whole country to be its administrative mechanisms in provincial level. The role of DDPM concerning to disaster early warning is to receive the information from Thai Metrological Department and distributes the information to the local organizations via the mechanism of Ministry of Interior and reports the events to the cabinet. However, DDPM has lunched many projects to warn and prepare the people particular in the disaster prone areas as follows:

(i) Installation of Rain Gauge and Manual Warning Siren in Disaster Risk Areas Since 2003, Department of Disaster Prevention and Mitigation allocated the budget for installing the rain gauges and providing manual warning sirens in the disaster prone villages. The rain gauge and the manual warning siren are the basic tool of the community which they have been used to measure the rainfall and warn the people. Presently, DDPM has installed rain gauges cover 75 provinces and trained the villagers in the community to measure, record, forecast and warning.

Figure AII-31. Rain Gauge, Manual Siren and User Guide

(ii) "Mr. Disaster Warning" Project

DDPM has initiated "Mr. Disaster Warning" Project in the flood prone areas to enhance capacity of the community in risk assessment and early warning. DDPM has collaborated with related disaster management organizations: Department of Provincial Administration, Department of Local Administration, The Meteorological Department, National Park Wildlife and Plant Conservation Department, and National Disaster Warning Centre to design "Mr. Disaster Warning"training course. Nowadays, the 7,817 people in the flood prone areas to be trained in this project. The villagers in the flood areas have consented that this project can reduce the loss of lives and properties in the village.

References

Department of Disaster Prevention and Mitigation.2005. Master Plan for Flood, Windstorm and Mudslide Hazards Prevention, Mitigation and Recovery Services in Emergency Period (5-Year Master Plan) Final Report

http://en.wikipedia.org

http://www.disaster.go.th

http://ioc3.unesco.org

http://www.reliefweb.int

http://www.tmd.go.th

USA

ntroduction

Various systematic early warning systems listed in Table A-18 have been established and are operating in USA. Most early warning systems rely on communications systems and people. The level of sophistication varies with jurisdiction and population. The USA funds weather stations in Guam, the Republic of Palau (ROP) (1), the Republic of the Marshall Islands (RMI) (1), and the Federated States of Micronesia (FSM) (3). The FSM includes the States of Yap, Chuuk, Pohnpei, and Kosrae. The Weather Forecast Office (WFO) Guam issues all forecasts and most warnings for Micronesia, including tropical cyclone warnings for 37 islands. WFO Guam provides direct early warning support to emergency managers in Guam and the Commonwealth of the Northern Mariana Islands (CNMI). WFO Guam provides early warning support to the other island emergency managers through their respective weather service offices. The Weather Service Office (WSO) in Pohnpei supports both Pohnpei State and Kosrae State. The ROP WSO, the RMI WSO, and the FSM WSOs provide local flood warnings with guidance from WFO Guam.

Table A-18. Seasonal rainfall (mm) in various parts of Thailand

No	Equipment/System	Installation Set	Target for Info
1	NOAA Weather Radio	Guam and the CNMI only	230,000 users
2	Emergency Alert Syste	Guam and the CNMI only	230,000 users
3	AM Radio	All islands but Chuuk State	400,000 users
4	FM Radio	All major islands	350,000 users
5	Siren Systems	Rota, CNMI and Guam military only	18,500 users
6	HF Radio	Primary for outer islands; back-up for others	50,000 primary
7	VHF/Marine Radio	All major island	10,000
8	Ham Radio	Primarily Recovery	500 operators
9	Satellite Phone	All Weather Offices & high-level Gov't; last resort	250 at key agencies
10	Emergency phone net	Key Gov't agencies; Guam and Saipan	1,000 at key agencies
11	Police, Fire, Mayors, Chiefs	All major islands; chiefs on outer islands	100,000 contacts
12	Automated Weather Info Processing System	Guam Weather Office	15 forecaster
13	Internet Webpage	Servers in the US mainland	250,000 users
14	Television	Guam, Saipan, Rota, Tinian, Palau	260,000 users

1. Strong Wind

2. High Surf and Coastal Inundation

2.1 Facts concerning high surf and coastal inundation

WFO Guam issues high surf advisories and high surf warnings for all of the major Micronesian islands. For the outer islands, WFO Guam issues guidance for ROP, each of the States of the FSM, and the RMI in the form of Special Weather Statements. The respective jurisdictions then notify the outer islands via HF radio. High surf advisories and warnings are discontinued for a location when that location is under a TC watch or warning. Criteria differ for differing locations depending on the vulnerability (Table A-19). For example, high surf on the south coasts of Kosrae State and the atolls of the RMI is only 7 feet (2.2 m) since the reefs are narrow there and these islands are exposed to swells generated by strong southern hemisphere storms.

Table A-19. Criteria of high surf warnings for all of the major Micronesian islands

Location	Exposure	Advisory Criteria	Warning Criteria
Guam & CNMI	N, S, W	9 ft (2.8 m)	15 ft (4.6 m)
Guam & CNMI	E	12 ft (3.7 m)	15 ft (4.6 m)
ROP	N, S, W	9 ft (2.8 m)	15 ft (4.6 m)
ROP	E	12 ft (3.7 m)	15 ft (4.6 m)
FSM			
Yap, Chuuk, Pohnpei	N, S, W	9 ft (2.8 m)	15 ft (4.6 m)
Yap, Chuuk, Pohnpei	E	12 ft (3.7 m)	15 ft (4.6 m)
Kosrae	N, W	9 ft (2.8 m)	15 ft (4.6 m)
Kosrae	S, E	8 ft (2.5 m)	15 ft (4.6 m)
RMI	W	9 ft (2.8 m)	15 ft (4.6 m)
RMI	E, N	12 ft (3.7 m)	15 ft (4.6 m)
RMI	S	8 ft (2.5 m)	15 ft (4.6 m)

3. Heavy Rain

3.1 Facts concerning heavy rainfall forecasts

WFO Guam issues flash flood and flood watches and warnings and urban and small stream flood advisories for Guam and the CNMI (Table A-20). Mudslides, when expected, are handled as part of the flash flood watch and warning. WFO Guam issues guidance for the Republic of Palau (ROP), each of the four States of the Federated States of Micronesia (FSM) and the Republic of the Marshall (RMI). Since the RMI islands are all low coralline islands, flash floods and mudslides do not occur. The guidance is usually in the form of a Special Weather Statement. Flood forecast products continue to be issued even when TC watches and warnings are in force. Mudslide forecast criteria have been developed for the high islands of Micronesia.

Table A-20. Criteria of heavy rainfall warnings for all of the major Micronesian islands

Location	Critical Rainfall for Mudslides	Issue When Forecast Rainfall is
Guam & CNMI	15 in (380 mm) in 36 hr	10 in (250 mm) in 36 hours
Guam & CNMI	10 in (250 mm) in 24 hr	7 in (178 mm) in 24 hr
Guam & CNMI	Continued 0.75 in/hr 19 mm/hr	Continued 0.50 in/hr 13 mm/hr
ROP	8 in (250 mm) in 24 hr	5 in (178 mm) in 24 hr
	Continued 0.75 in/hr (19 mm/hr)	Continued 0.50 in/hr (13 mm/hr)
FSM		
Kosrae, Chuuk, Pohnpei	15 in (380 mm) in 36 hr	10 in (250 mm) in 36 hours
Kosrae, Chuuk, Pohnpei	10 in (250 mm) in 24 hr	7 in (178 mm) in 24 hr
Kosrae, Chuuk, Pohnpei	Continued 0.75 in/hr 19 mm/hr	Continued 0.50 in/hr 13 mm/hr
RMI	No Hazard	

4. Tropical Cyclone

4.1 Facts concerning tropical cyclone (TC) warnings for Micronesia

WFO Guam issues all TC warnings for 37 islands in Micronesia as selected by the various jurisdictions. WFO Guam issues Tropical Cyclone Advisories when a TC moves into its area of responsibility. These are usually based on TC forecasts from the Joint Typhoon Warning Center (JTWC). On rare occasions, WFO Guam may deviate from the JTWC forecasts. WFO Guam uses 1-minute averaged winds for sustained winds. Tropical Storm and Typhoon Watches and Warnings are based on the arrival of 39-mph (34-knot) winds (tropical storm-force). Watches and warnings key the specific island jurisdictions to set their local Conditions of Readiness, which in turn, trigger specific response actions.

4.2 Watch and Warning criteria for Micronesia

- Tropical Storm Watch-Tropical storm-force winds of 39-mph (34-kt) are possible at the specified location within the next 48 hours.

- Typhoon Watch-Tropical storm-force winds of 39-mph (34-kt) associated with a typhoon are possible at the specified location within the next 48 hours.
- Tropical Storm Warning-Tropical storm-force winds of 39-mph (34-kt) are expected at the specified location within the next 24 hours.

• Typhoon Warning-Tropical storm-force winds of 39-mph (34-kt) associated with a typhoon are expected at the specified location within the next 24 hours.

4.3 Conditions of Readiness (COR) criteria for Micronesia

• COR 4-Tropical storm-force winds of 39-mph (34-kt) are possible at the specified location within the next 72 hours. All jurisdictions remain in COR 4 all year.

• COR 3-Tropical storm-force winds of 39-mph (34-kt) are possible at the specified location within the next 48 hours.

• COR 2-Tropical storm-force winds of 39-mph (34-kt) are expected at the specified location within the next 24 hours.

• COR 1- Tropical storm-force winds of 39-mph (34-kt) are expected at the specified location within the next 12 hours or are occurring.

Most jurisdictions proceed the COR with either Tropical Storm or Typhoon, depending on the expected worst conditions; e.g., Tropical Storm COR 3, Typhoon COR 1. Guam does not add the tropical storm or typhoon designation, but issues instructions based on the expected actual speed, storm surge and rainfall. The Pohnpei State Governor does not set Conditions of Readiness, but instead sets a State of Emergency based on the Watches and Warnings. When a Tropical Storm or Typhoon Watch or Warning is issued for a specific location, in addition to the Advisories, WFO Guam issues a Local Statement. The Local Statement includes Watches and Warnings in effect, basic preparation information, latest storm information, and very specific wind, storm surge and rainfall information. These are updated every 6 hours or as needed.

VIET NAM

Heavy rain

Warnings are issued when heavy rain is expected to exceed 25 mm per 12 hours in an area where the number of stations reporting such event is ≥ the total number of stations in that region.

Tropical cyclone

Tropical cyclones warnings are issued for all activating TCs (including tropical depressions) in the South China Sea; TCs originated in the eastern part of 120°E, southern of 5°N and northern of 22°N which might move to the South China Sea within the next 12h to 24h (www.nchmf.gov.vn).

1. Warning criteria

1.1 Tropical depression warning

"Far TD warning" is issued for TDs activating in the eastern part of 120°E, southern of 5°N and northern of 22°N which probably move into the South China Sea in the next 24h.

"South China Sea TD warning" is issued for TDs activating in the South China Sea and having its center's position to the nearest point of Viet Nam coastline more than 500km; or having its center's position to the nearest point of Viet Nam coastline from 300km to 500km without possibility to move towards Viet Nam's territory in the next 24h.

"Near TD warning" is issued for TDs having its center's position to the nearest point of Viet Nam coastline less than 300km; or having its center's position to the nearest point of Viet Nam coastline from 300-500km with possibility to directly affect to Viet Nam in the next 24h.

"Overland TD warning" is issued for TCs having landed but still keeping the maximum wind speed of 6-7 Beaufort scale.

1.2 Tropical storm warning:

"Far TS warning" is issued for for TSs activating in the eastern part of 120°E, southern of 5°N and northern of 22°N which probably move into the South China in the next 24h.

"South China Sea TS warning" is issued for TSs crossing 120°E into the South China Sea; or TSs originating in the South China Sea having its center's position to the nearest point of Viet Nam coastline more than 1000 km; or when TSs having its center's position to the nearest point of Viet Nam coastline from 500km to 1000km without possibility to move towards Viet Nam's territory within the next 24-48 hours.

"Near TS warning" is issued for TSs having its center's position to the nearest point of Viet Nam coastline from 500-1000 km with possibility to move to move towards Viet Nam's territory within the next 24-48 hours; or when TSs having its center's position to the nearest point of Viet Nam coastline from 300km to 500km without possibility to move towards Viet Nam's territory within the next 24-48 hours.

"Urgent TS warning" is issued for TSs having having its center's position to the nearest point of Viet Nam coastline from 300-500 km with possibility to move to move towards Viet Nam's territory within the next 24-48 hours; or when TSs having its center's position to the nearest point of Viet Nam coastline less than 300 km; or when TSs having landed over Viet Nam but still keeping the maximum wind speed of 8 Beaufort scale; or when TSs having landed over other countries but still keeping the maximum wind speed of 8 Beaufort scale with possibility to directly affect to Viet Nam in the next 24-48 hours.

Flood

Flood warnings are issued for all major rivers in Viet Nam. "Flood warning" is issued when the water level may reach the alert level III (Table A-21). "Urgent flood warning" is issued when the water level is higher than the alert level III with possibility to continue raising.

Table A-21. List of main rivers be issued flood warning

No.	Name of River	Hydro. Station	Water level (m) alert			Lead time.
			I	II	III	
1	Hong	HaNoi	9.5	10.5	11.5	24-36-48h
2	Da	Hoa Binh	21.0	22.0	23.0	12h-24h
3	Thao	Yen Bai	30.0	31.0	32.0	12h-24h
4	Thao	Phu Tho	17.5	18.2	18.9	12h-24h
5	Lo	Tuyen Quang	22.0	24.0	26.0	12h-24h
6	Lo	Vu Quang	18.3	19.5	20.5	12h-24h
7	ThaiBinh	Pha Lai	3.5	4.5	5.5	24h-36h
8	Cau	Dap Cau	3.8	4.8	5.8	12h-24h
9	Thuong	Phu Lang Thuong	3.8	4.8	5.8	12h-24h
10	LucNam	Luc Nam	3.8	4.8	5.8	12h-24h
11	HoangLong	Ben De	3.0	3.5	4.0	12h-24h
12	Ma	Giang	3.5	5.0	6.5	24h
13	Ca	Nam Dan	5.4	6.9	7.9	24h
14	La	Linh Cam	4.0	5.0	6.0	12h-24h
15	Gianh	Mai Hoa	3.0	5.0	6.0	6h-12h
16	Huong	Hue	0.5	1.5	3.0	6h-12h
17	ThuBon	Cau Lau	2.1	3.1	3.7	12h-24h
18	TraKhuc	Tra Khuc	2.7	4.2	5.7	6h-12h
19	Con	Tan An	5.5	6.5	7.5	12h-24h
20	DaRang	Tuy Hoa	2.0	2.8	3.5	12h-24h
21	Tien	Tan Chau	3.0	3.6	4.2	5 days
22	Hau	Chau Doc	2.5	3.0	3.5	5 days

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