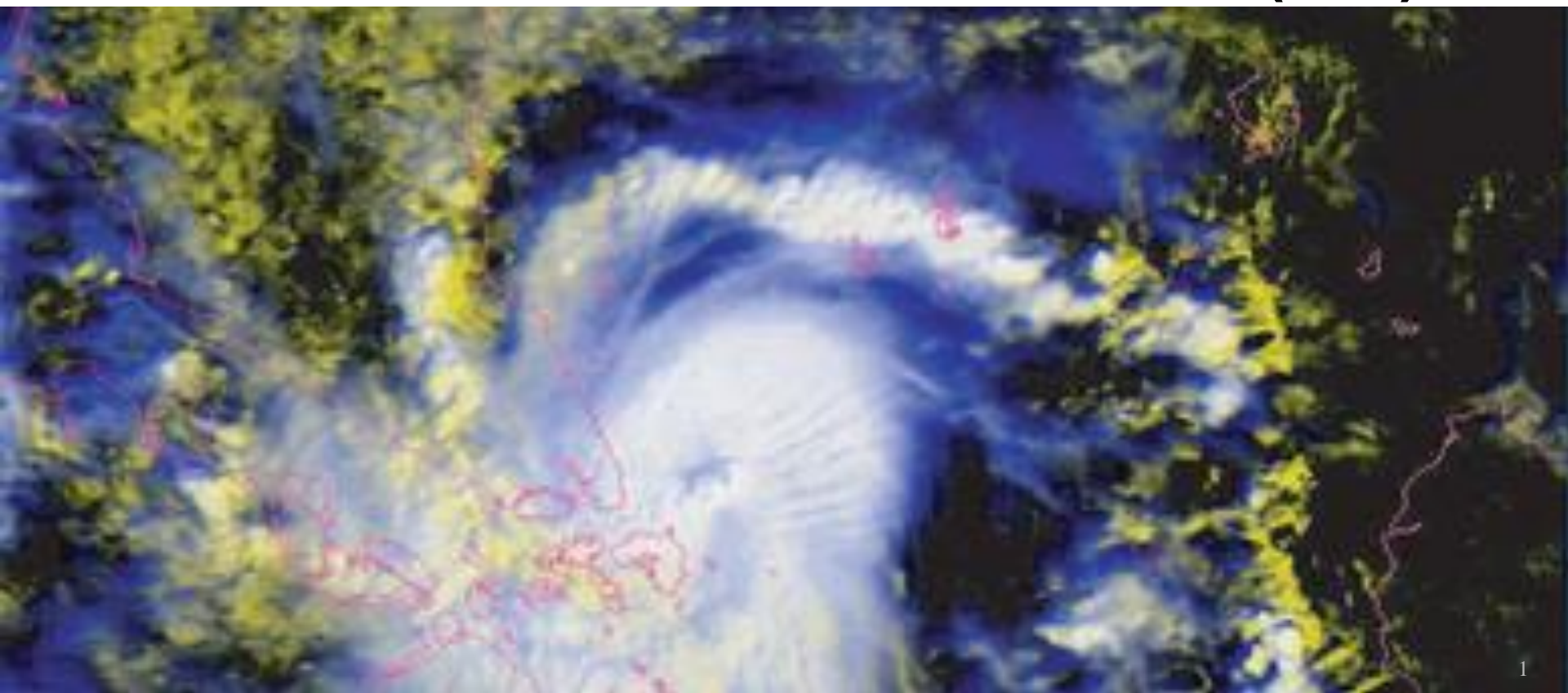


Impact of Tropical Cyclones “Malaysia's Experience”

**NURSALLEH K CHANG @ NURSALLEH BIN KASIM
MALAYSIAN METEOROLOGICAL DEPARTMENT (MMD)**



OUTLINE

❖ Introduction

- MMD Main Services, General Climate

❖ Observation System

- Surface, Upper Air, Radar, Satellite Receiver, Ocean

❖ Effect of TC over SCS and Malaysia

- Direct Hit, Tail effect, Heavy Rain, Strong Wind/High Seas, Borneo Squall line (BSL), Storm/Wind Surge

❖ Case Study / Model Verification and Validation

❖ Monitoring and Early Warning System

❖ Conclusion

MMD Main Services



Weather Forecasts



Seismology & Tsunami Warnings



Marine Meteorology & Oceanography



Weather Modification



Climatology



Environmental Meteorology



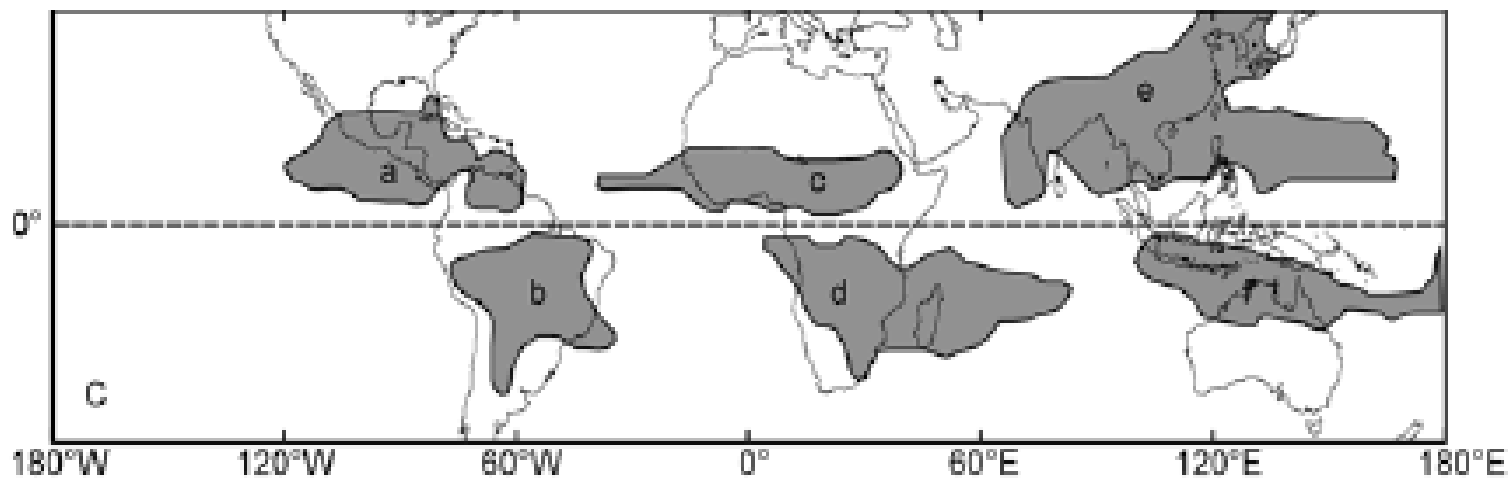
Agrometeorology



Training

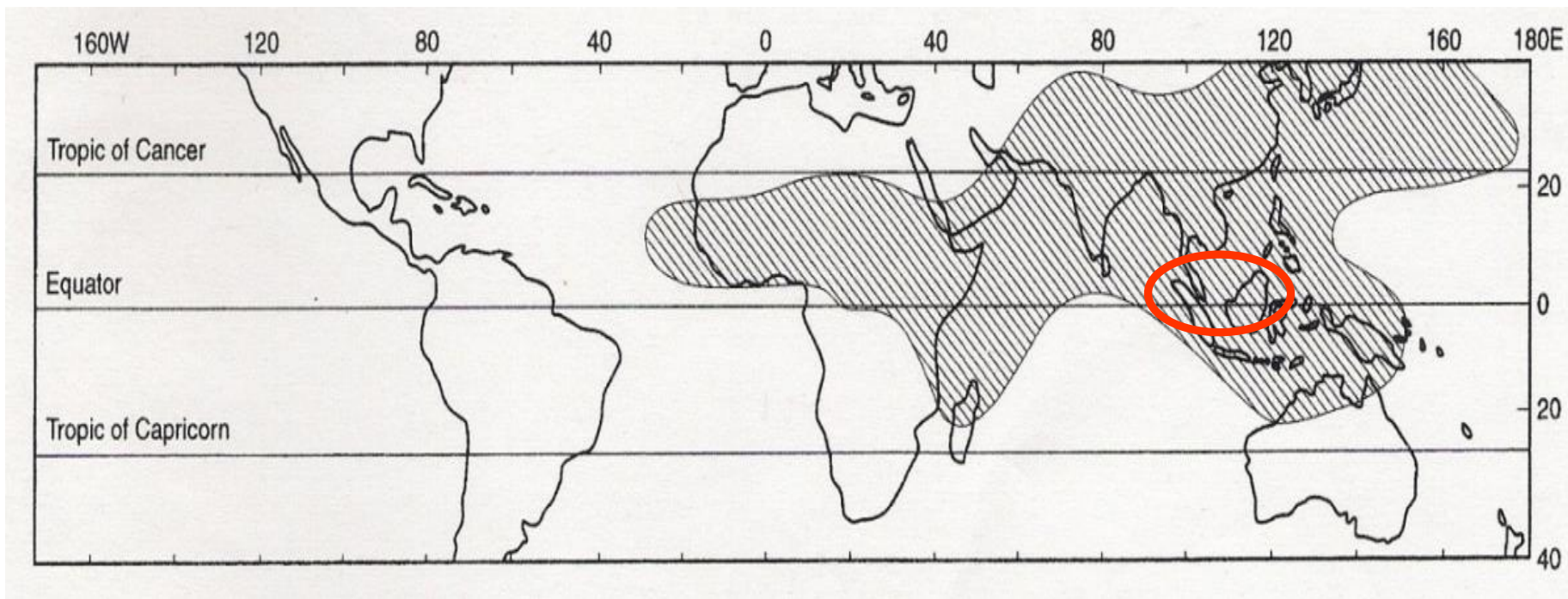
GENERAL CLIMATE OF MALAYSIA

Monsoon Regime (based on rainfall)



Wang & Ding (2006)

Monsoon Regime (based on wind)



Ramage (1971)

Three Types of Season

(based on the wind flow patterns) :

1. North East monsoon (Nov-March) *Boreal Winter*:

- Steady easterly or northeasterly winds of 10 to 20 knots prevail
- Surges of cold air from the north (cold surges) bring heavy rainfall to Malaysia (east coast states of Peninsular Malaysia are mostly affected)

2. **South West monsoon** (May-Sept) *Boreal Summer* :

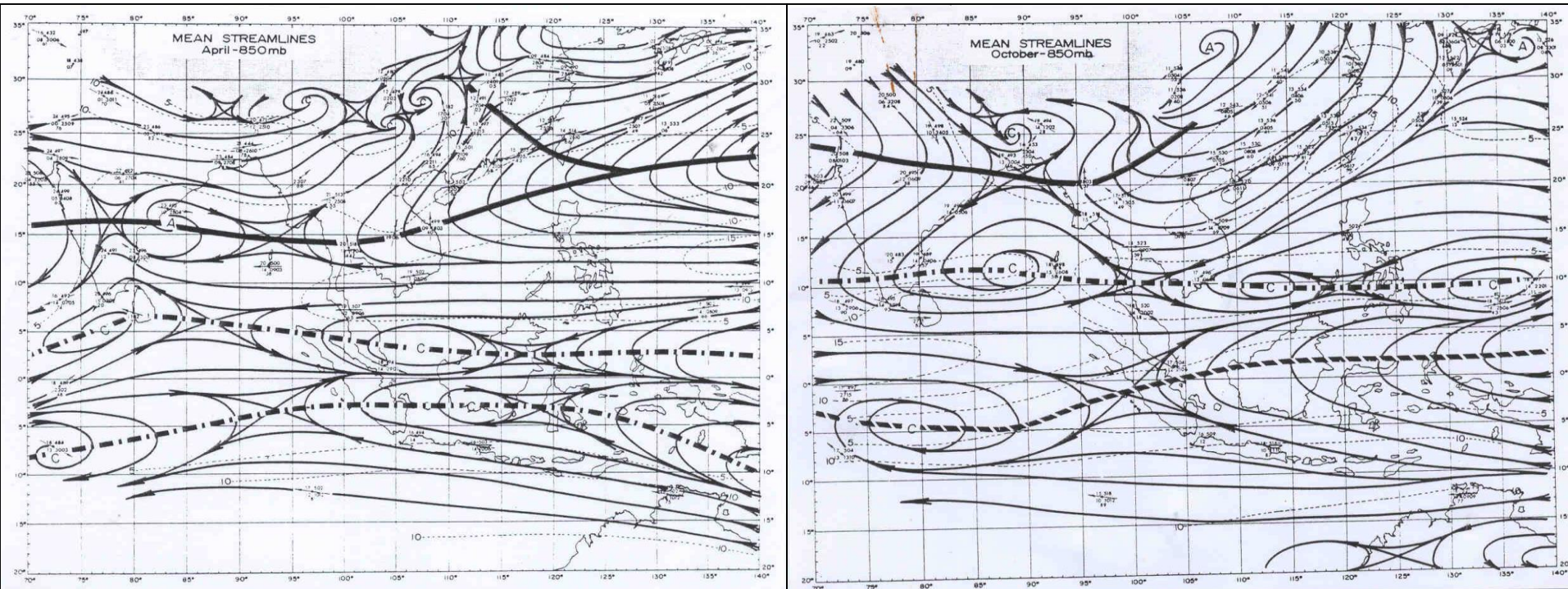
- the prevailing wind flow is generally southwesterly and light, below 15 knots
- During the months of August to September, when TC frequently develop over the west Pacific and move westwards across the Philippines, southwesterly winds over the northwest coast of Sabah and Sarawak region may strengthen reaching 20 knots or more
 - tail effect of TC over Malaysia (especially over Sabah)

3. Inter monsoon (Apr & Oct):

- winds are generally light and variable
- the equatorial trough lies over Malaysia
- Local effect : **Mushroom** TSRA

Mean Streamline for April and October (Inter Monsoon)

850hPa



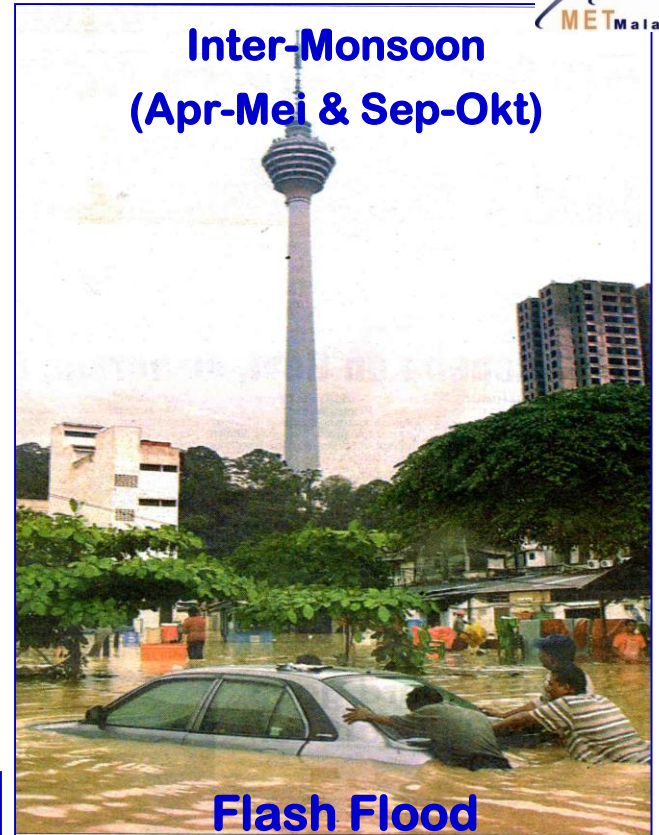
Severe Weather in Malaysia

Nort-East Monsoon (Nov – Mac)



Monsson Flood

**Inter-Monsoon
(Apr-Mei & Sep-Okt)**



Flash Flood

**South West Monsoon
(June–August)**



Haze



**Tropical Cyclone
(May – Nov)**



**Strong Winds and
Rough Seas**

OBSERVATION NETWORK

DATA ACQUISITION

METEOROLOGICAL STATION (45)



UPPER AIR STATION (8)



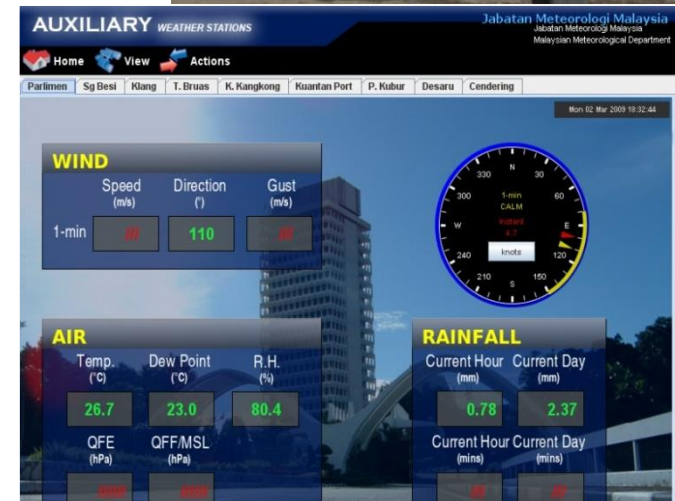
WEATHER CAMERA STATION (17)



RADAR STATION (12)



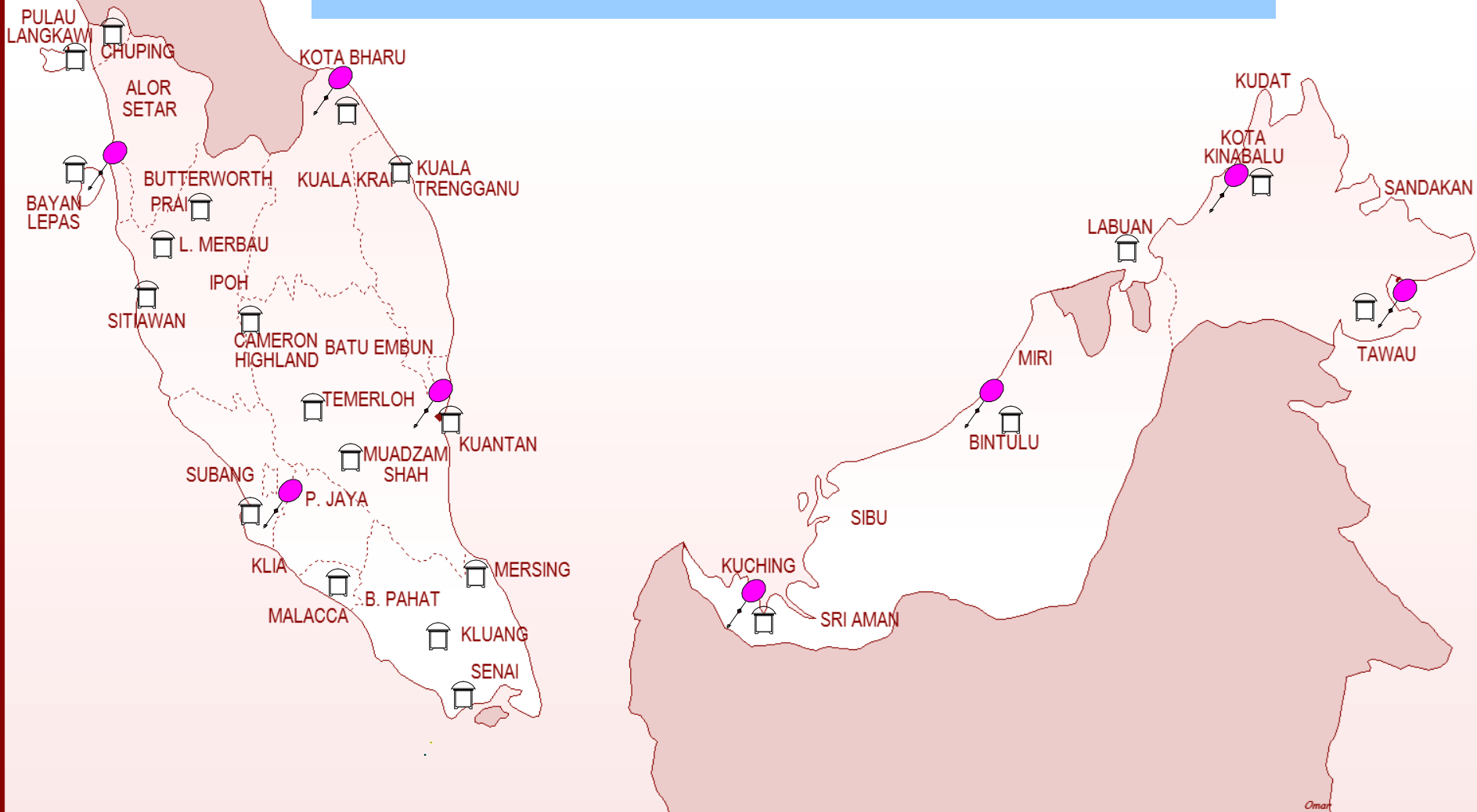
GROUND RECEIVING STATION (1)



AUXILIARY STATIONS(339)

- AWS (141)
- Climatological Station (39)
- Rainfall Station (159)

Upper Air and Synop Surface Observation Principal Station Network

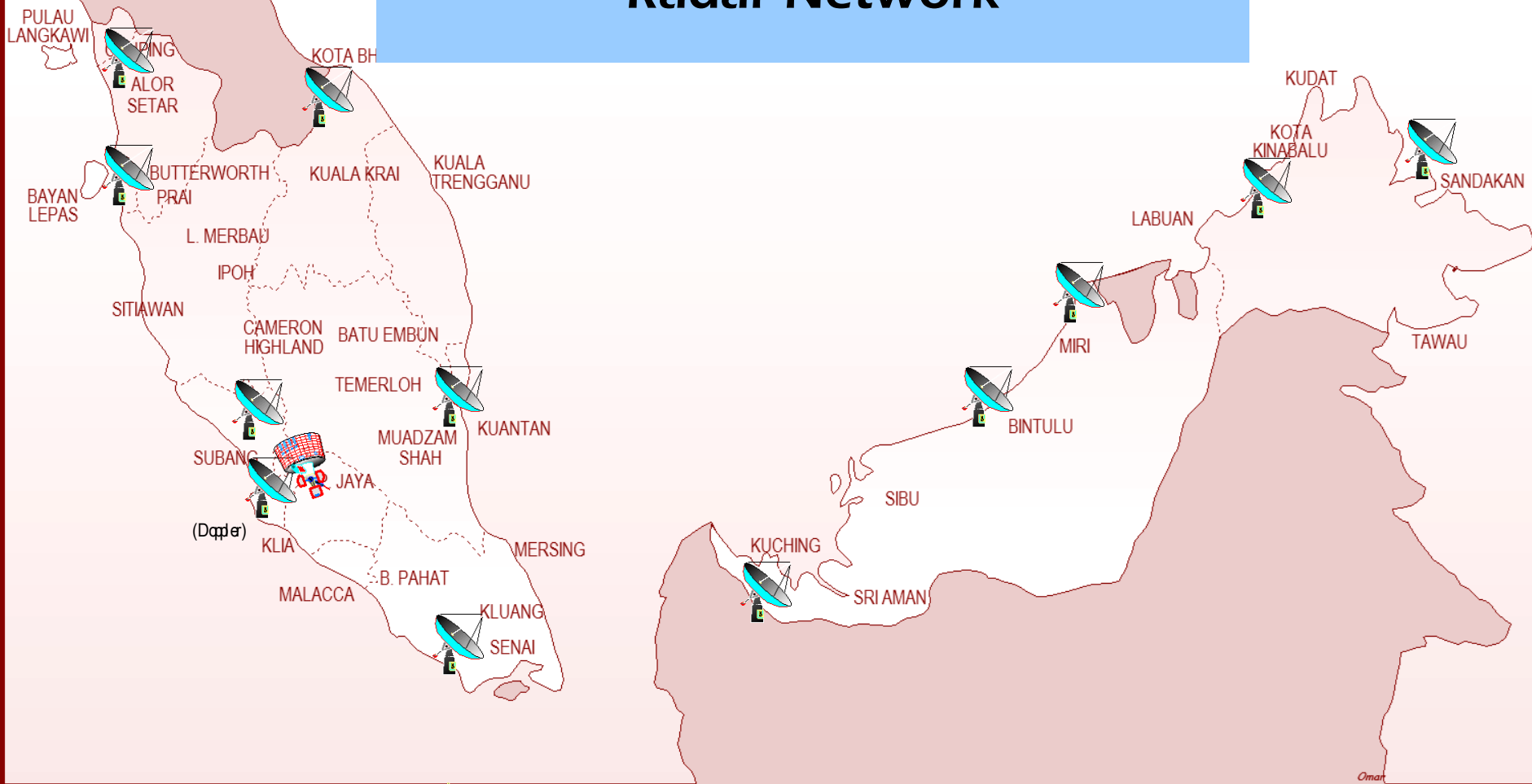


Upper Air
Station (8)



Principal Synop Surface
Observation Station (22)

Satellite and Radar Network



Satellite Satation (1)

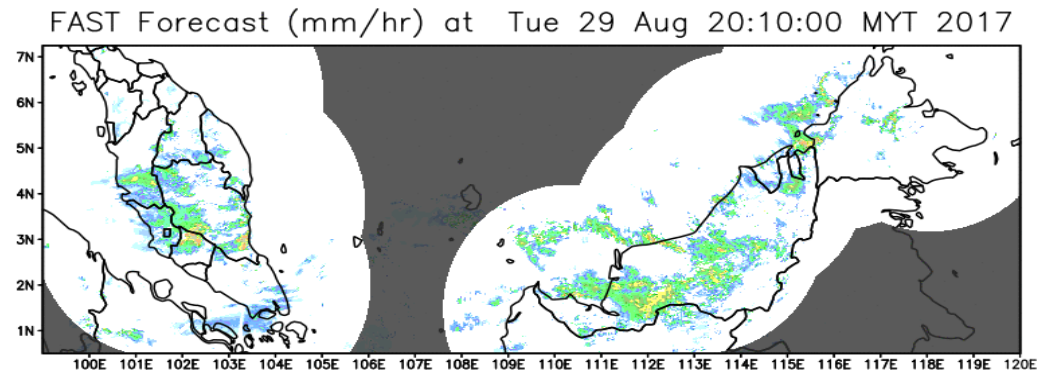


Radar Station (12)

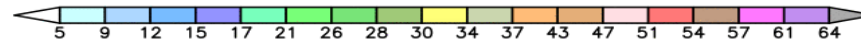
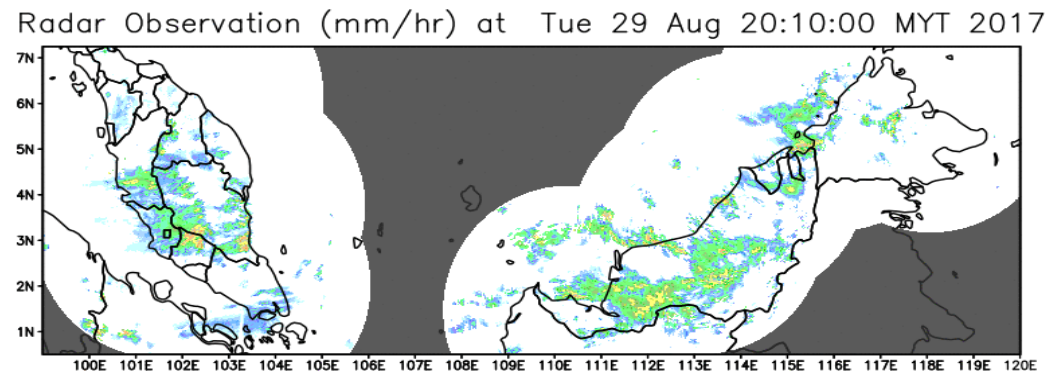
Radar Observation Coverage with nowcasting system from HKO (SWIRLS) → FAST

MALAYSIA TUE 29 AUG 2017 8PM – 11 PM NOWCAST

NOWCAST



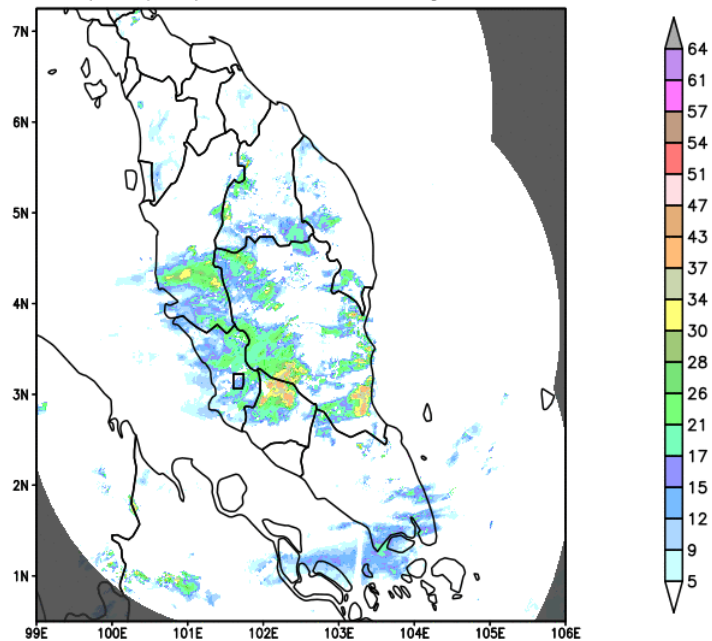
OBSERVED



PENINSULAR MALAYSIA TUE 29 AUG 2017 8PM – 11 PM NOWCAST

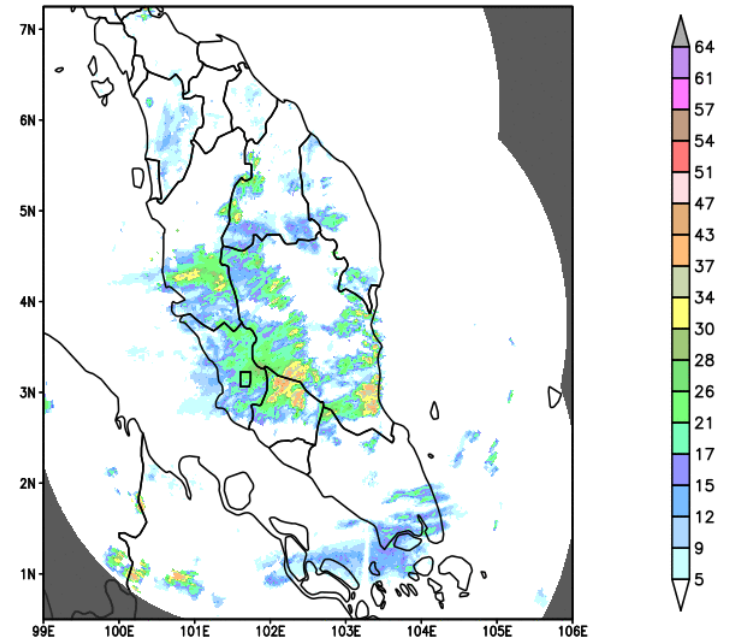
NOWCAST

FAST Forecast (mm/hr) at Tue 29 Aug 20:10:00 MYT 2017



OBSERVED

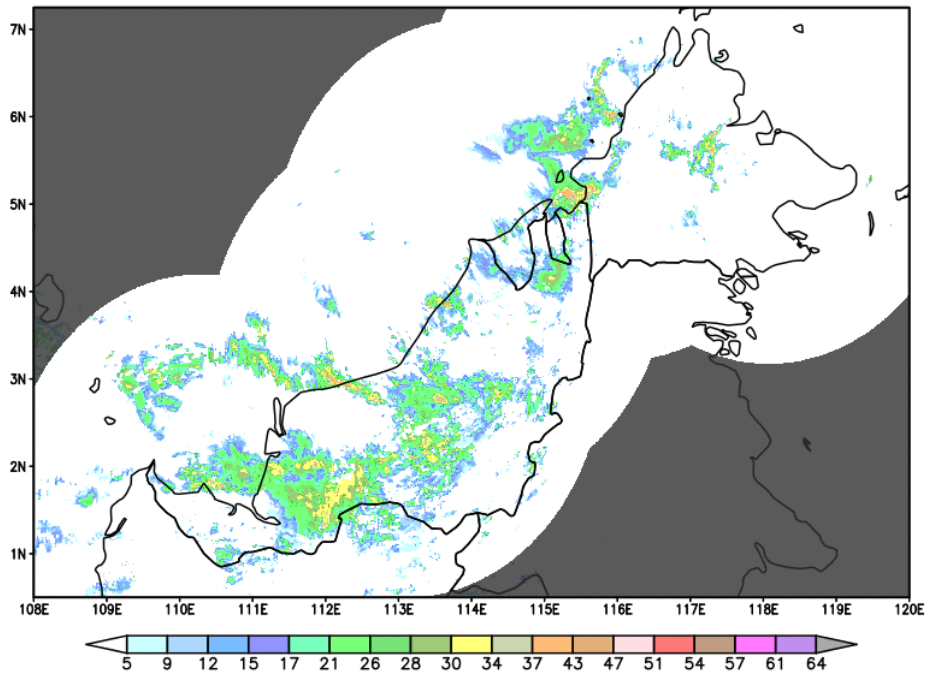
Radar Observation (mm/hr) at Tue 29 Aug 20:10:00 MYT 2017



SARAWAK/SABAH TUE 29 AUG 2017 8PM – 11 PM NOWCAST

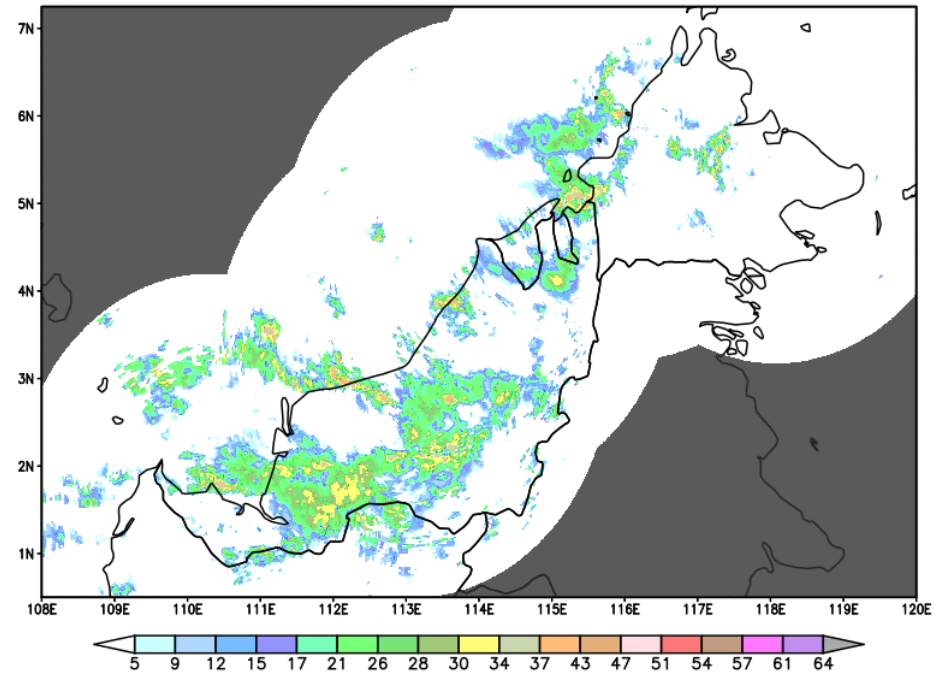
NOWCAST

FAST Forecast (mm/hr) at Tue 29 Aug 20:10:00 MYT 2017



OBSERVED

Radar Observation (mm/hr) at Tue 29 Aug 20:10:00 MYT 2017



Main Meteorological Offices (10)



KLIA Meteorological Office



Central Forecasting Office



Gong Kedak Meteorological Office

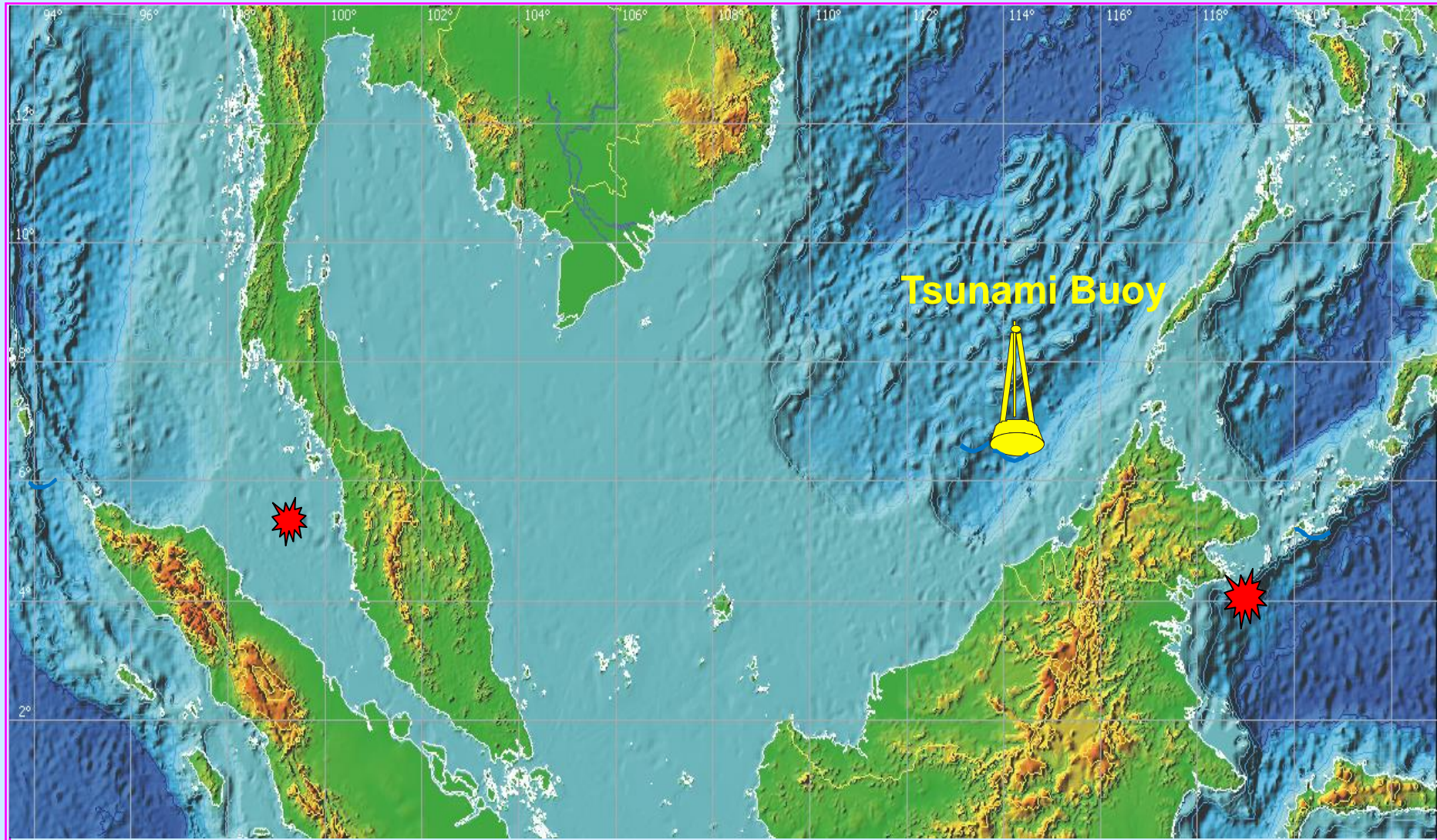
Marine Observational Network

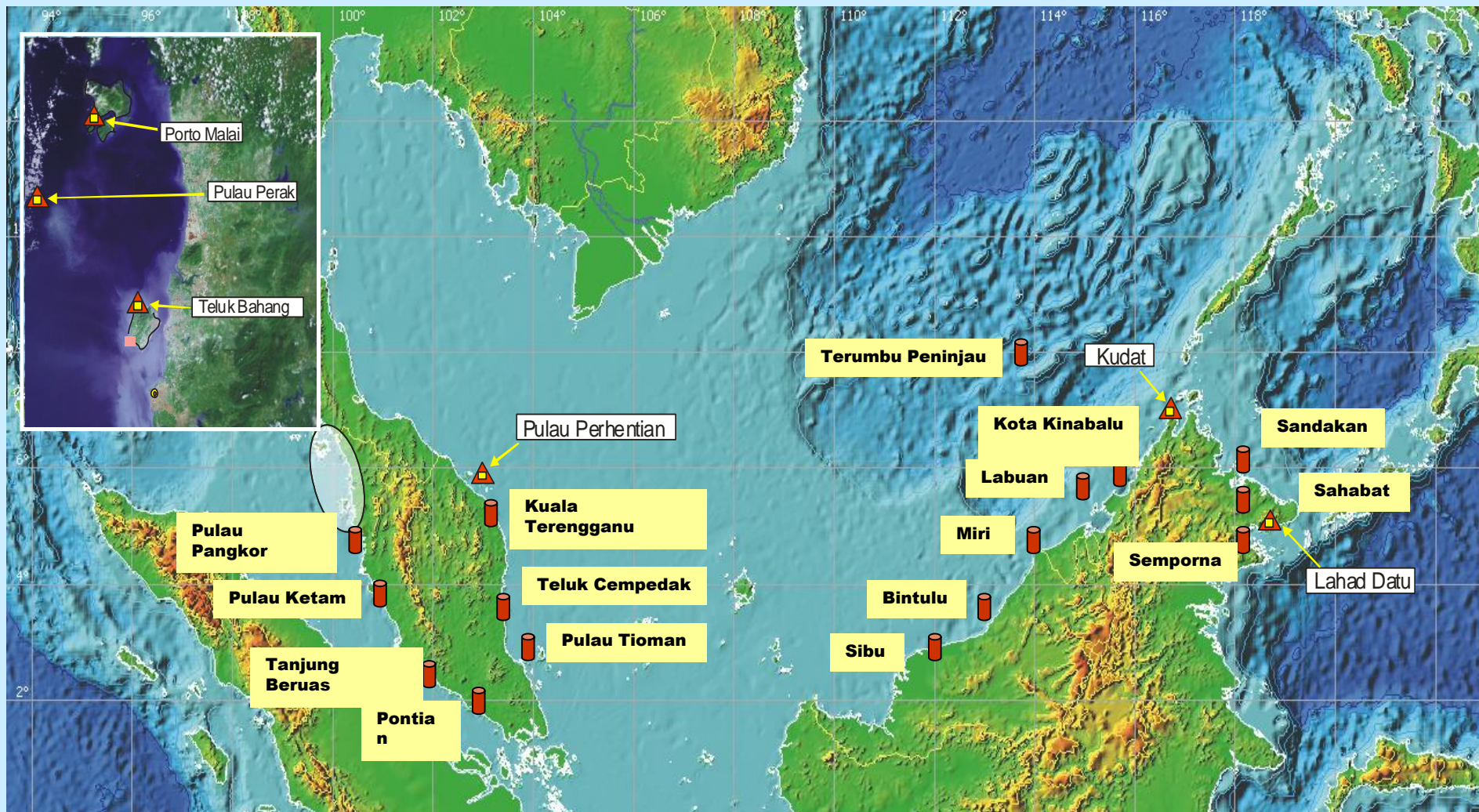
- 4 Acoustic Doppler Current Profiler (ADCP) and 2 Recording Doppler Current Profiler (RDCP) -real time

- Data from various agencies : Royal Navy, Marine Dept, Oil & Gas, Scientific Expedition etc

- Voluntary Observing Ship (VOS)





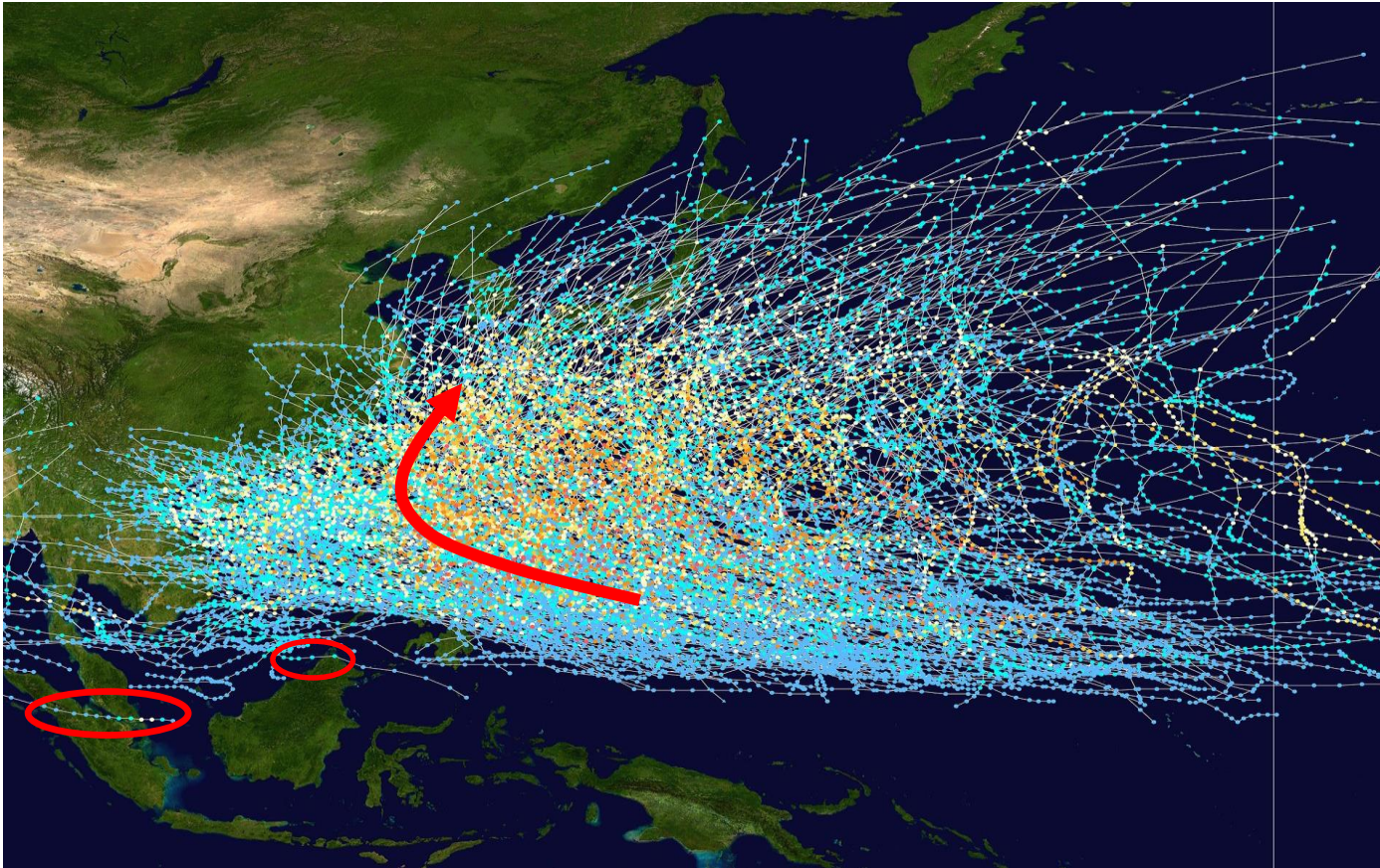


THE EFFECT OF TROPICAL CYCLONE TOWARDS MALAYSIA WEATHER

Past Tropical Cyclone Events In Malaysia

- Tropical Storm Greg (Dec 1996) : *Direct Hit*
- Tropical Storm Hilda (Jan 1999) : *Tail Effect*
- Typhoon Vamei (Dec 2001) : *Direct Hit*

Mean path of West Pacific originated Tropical Cyclone from 1980 - 2005



- The normal passage of TC is westwards across the Philippines, recurring northeastwards as they approach the Asiatic land mass
- Malaysia may experience effect of TC

- **TC formation in Southern South China Sea is rare :**
 - Based on past records, Malaysia suffered 2 direct strikes from TC mainly during this period

- Generally month of **August and September** is the peak season of TC in WNP
- According to *Zuki, Z. M., and A.R Lupo (2008)*, **November and December** are the peak of TC occurrence (most of TS status) over SSCS about 1 TC per year
- Associated with the ITCZ movement
- Study showed During La Nina (El Nino) years were more (less) occurrence

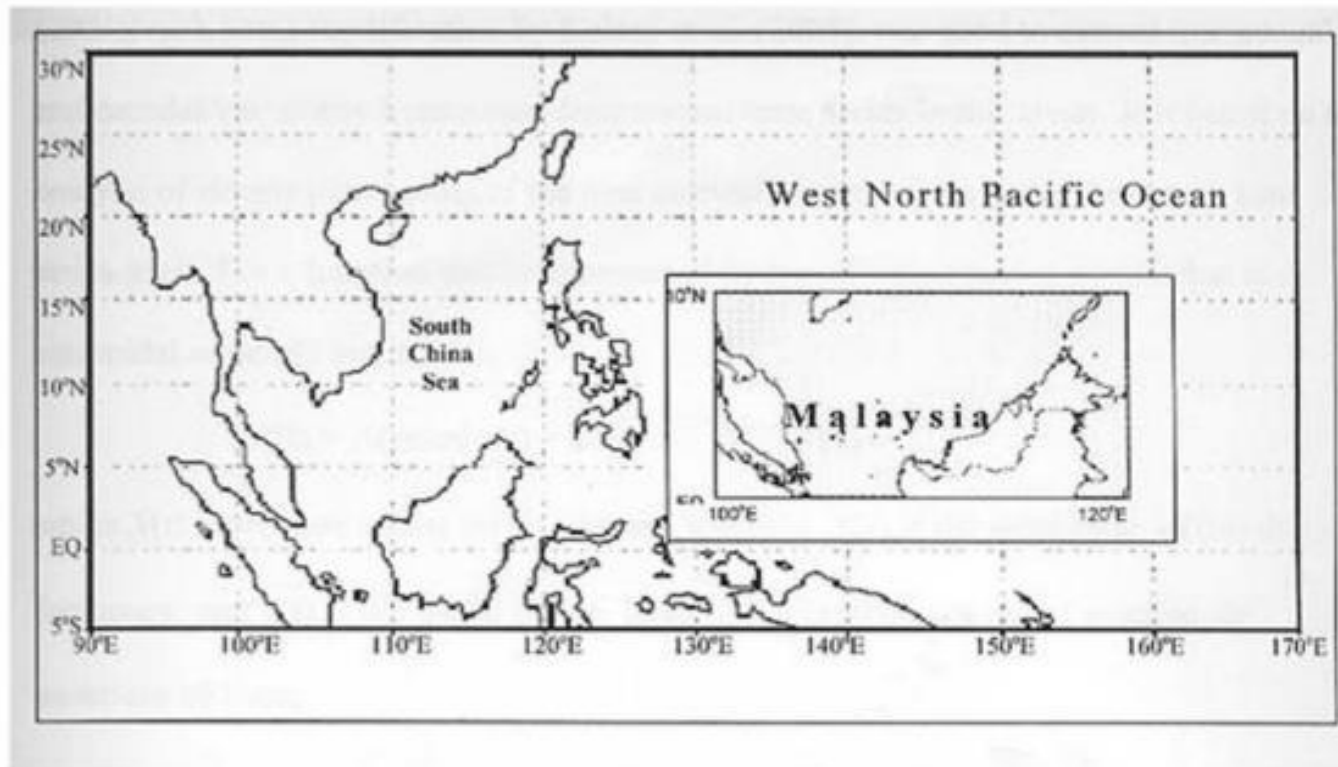
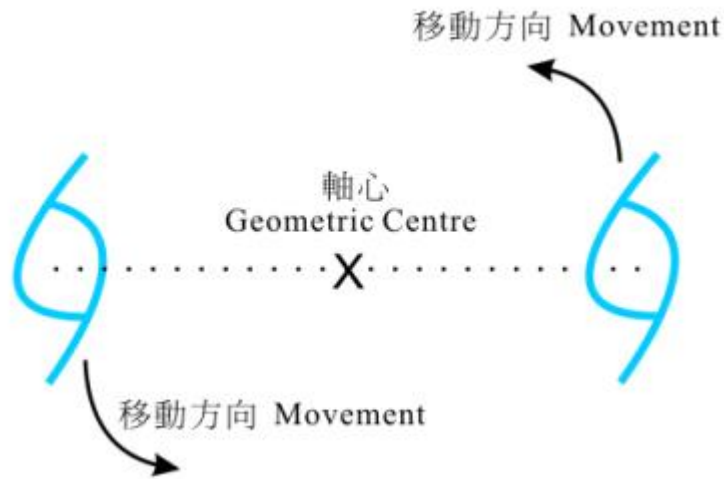


Figure 1. A map of the South China Sea and part of the west North Pacific Ocean. A map of the study area and Malaysia are indicated in the inset.

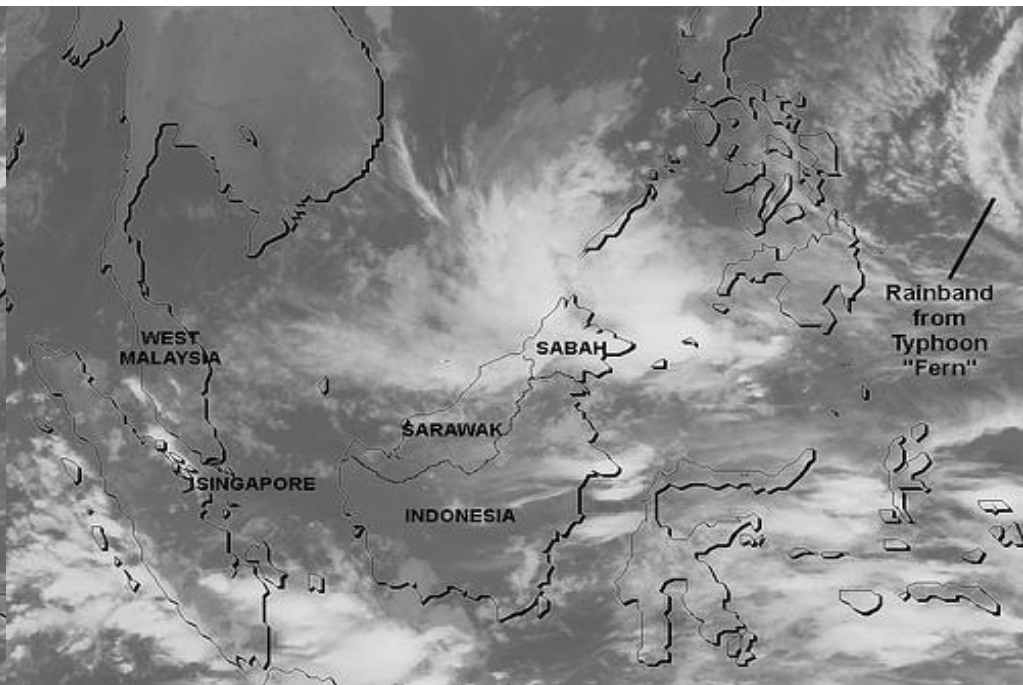
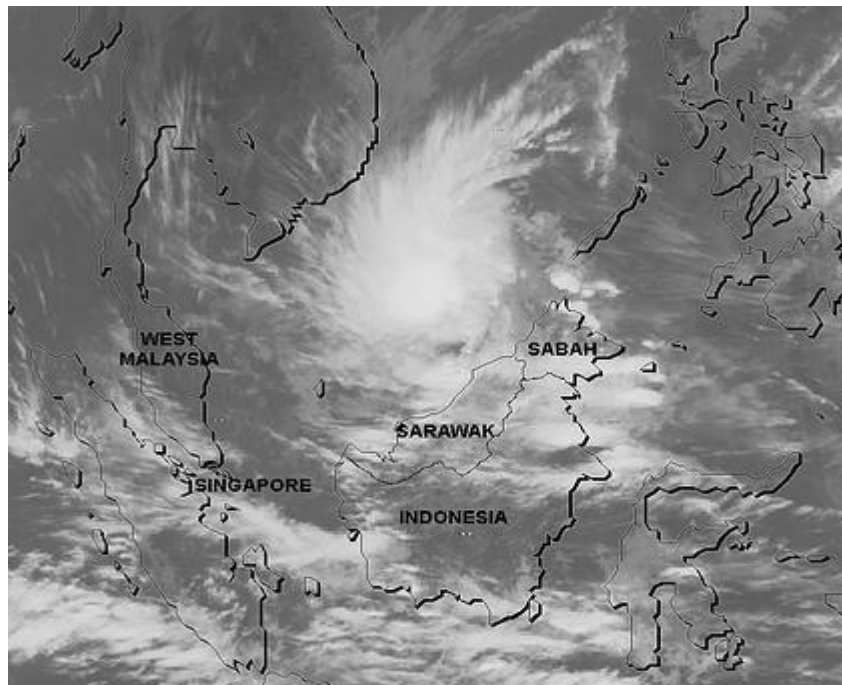


- Formed in the South China Sea as TD on Dec 21
 - Headed east-southeastward, strengthened into the final TS on the 24th
 - After reaching a peak of 45 knots winds it crossed the northern part of Borneo on the 25th.
 - Continued east-southeastward until dissipation on the 27th, south of the Philippines
-
- Caused flooding and severe mudslides in Sabah
 - Leaved more than 4,000 people homeless
 - Destruction of coral reefs
 - Fatalities : **238 people**
 - Damage : **\$52 million USD**

TS Greg : What actually happened?



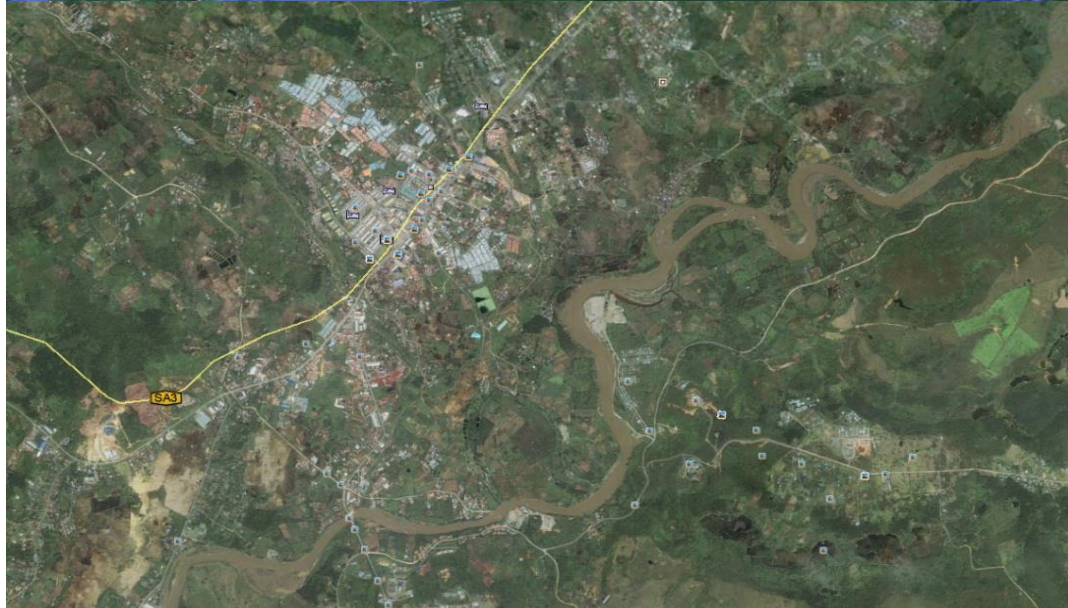
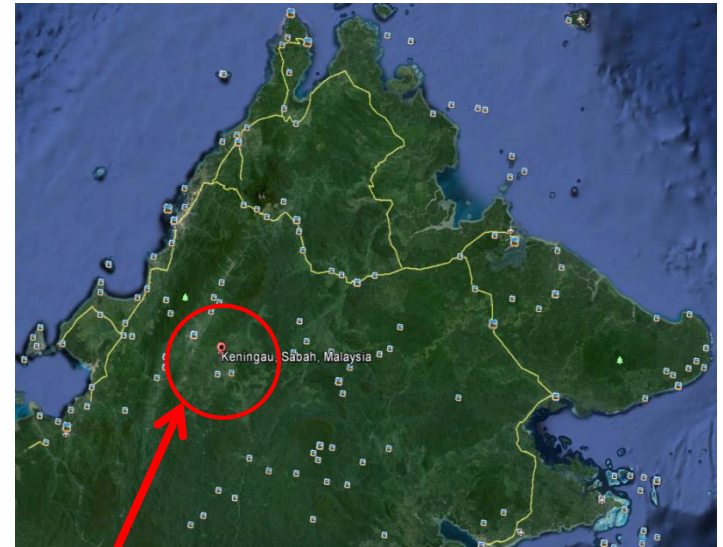
An example of Fujiwhara Effect
between TS Greg and Typhoon
Fern



Impacts of Tropical Storm Greg

- TS Greg moved into Sabah at around 251600Z (**Christmas night**), depositing heavy rains that triggered floods and caused rivers to overflow their banks.
- The storm affected a total of 17,000 people from 226 villages along Sabah south west coast. It destroyed 4,925 houses and killed 230 people (as reported at that time)
- Tropical Storm Greg is the most devastating Tropical storm that ever hit Malaysia with an estimated economic loss around USD 280 million.

Impacts of Tropical Storm Greg



**The affected
Pegalan River,
Keningau (inland)**

**Heavy rain from
Greg cause it to
flood with enormous
volume of water and
mud.**

Impacts of Tropical Storm Greg



Limbawan village is one of the most affected during TS Greg



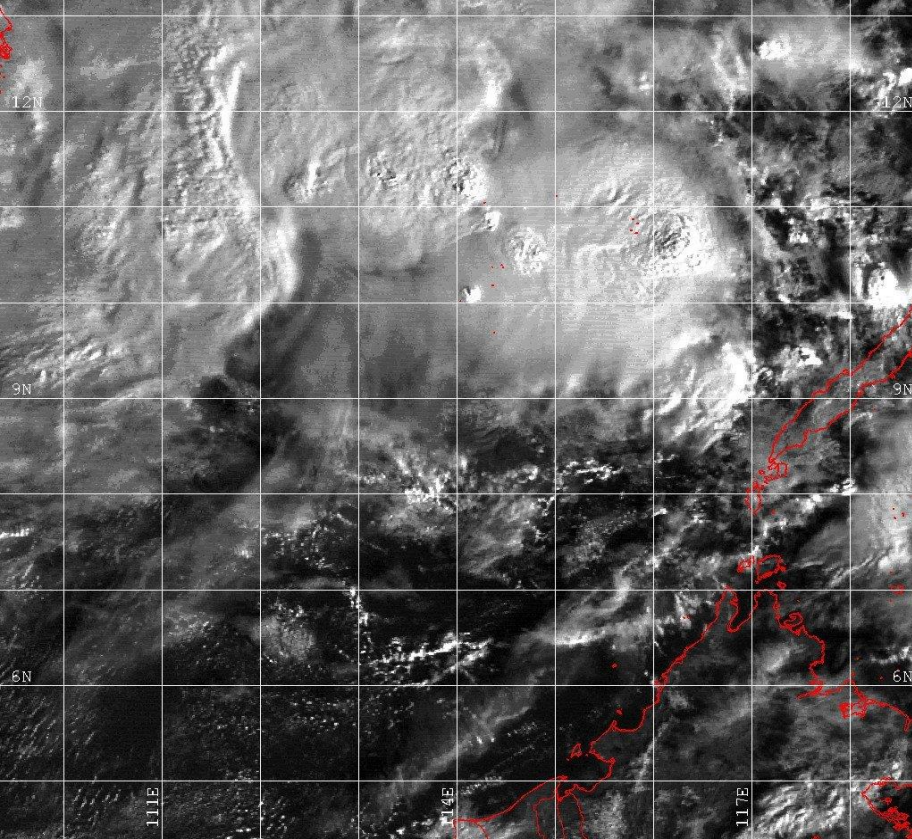
KENINGAU, 29 DIS 1996 – Jumlah mayat yang terkorban dalam Tragedi Ribut di Sabah meningkat apabila pihak tentera dan orang awam menemui beberapa lagi mayat. Seorang pemuda yang kehilangan ahli keluarga cuba mengenal pasti salah satu mayat yang dikeluarkan di kampung Limbawan, Sabah.



Tropical Storm Hilda (Jan 1999)



- **Stretched out from the NW Borneo coast early on Jan 4**
- **Developed into a TD and moved slowly to the north away from the Borneo coast, becoming TS Hilda early on Jan 6**
- **Tail effect to west coast of Sabah**

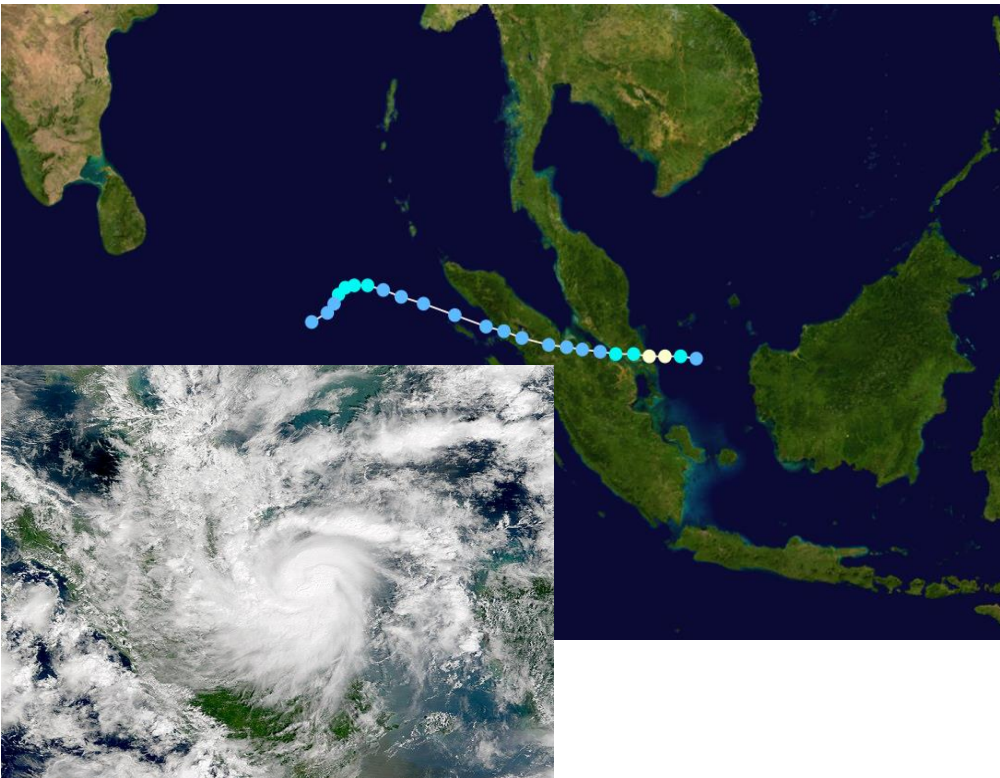


- **Caused flooding and landslides in Sabah**
- **Fatalities : 6 people**
- **Damage : \$1.3 million USD**

Impacts of Tropical Hilda



Flood from heavy rain in Penampang Sabah caused by TS Hilda

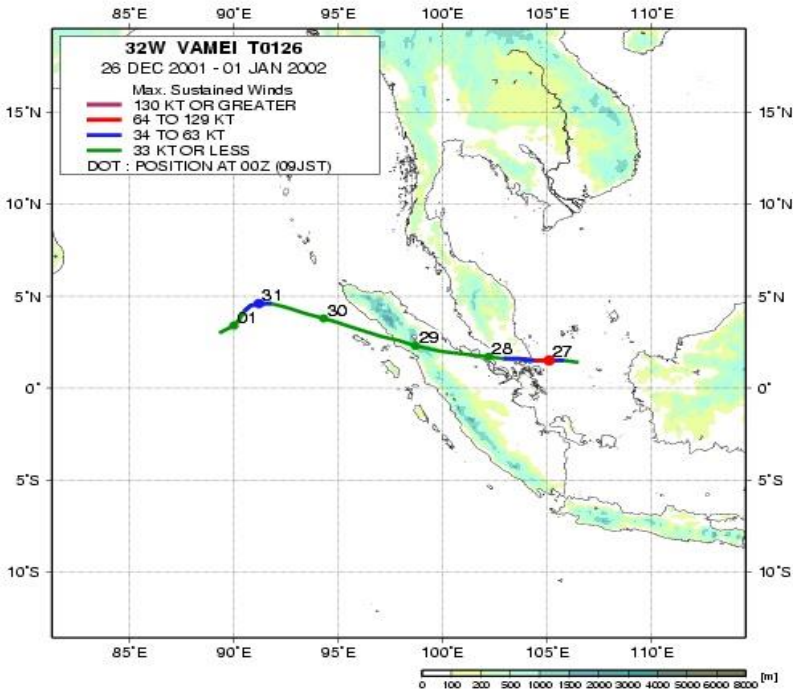


- Developed on Dec 26 at 1.4°N in the South China Sea
- Strengthened quickly and made landfall along extreme southeastern Malaysia
- Rapidly dissipated over Sumatra on Dec 28, and the remnants eventually re-organized in the North Indian Ocean



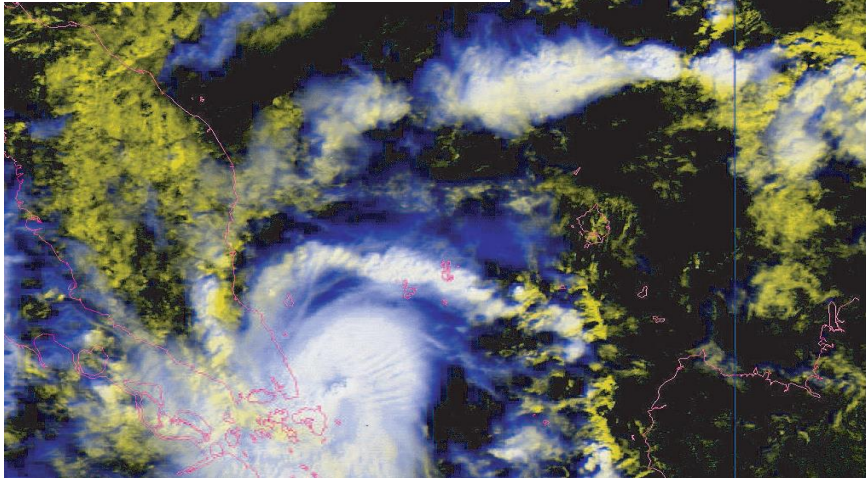
- Brought flooding and landslides to Southeastern Peninsular Malaysia
- Fatalities : 5 people
- Damage : \$4.2 million USD
: **\$3.6 million USD**
(Lei and Zhou,2012)

Typhoon Vamei : Rare Typhoon of the Equator?



Satellite imagery of Typhoon Vamei on 27th December 2001

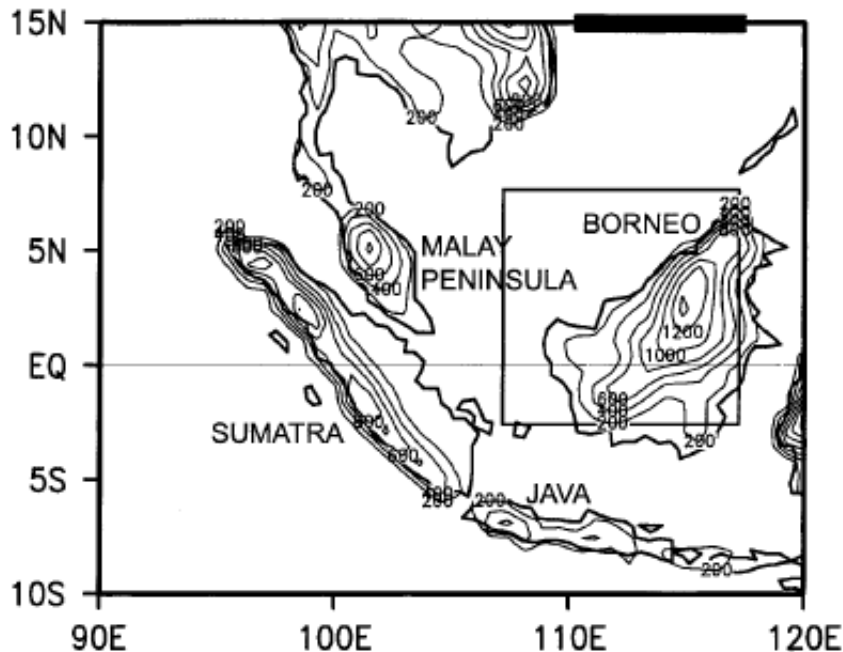
This rare event was first detected by observations of typhoon strength winds from a US navy ship, and the existence of an eye structure was confirmed by satellite and radar imageries



Was the first recorded within 1.5 degree of the equator

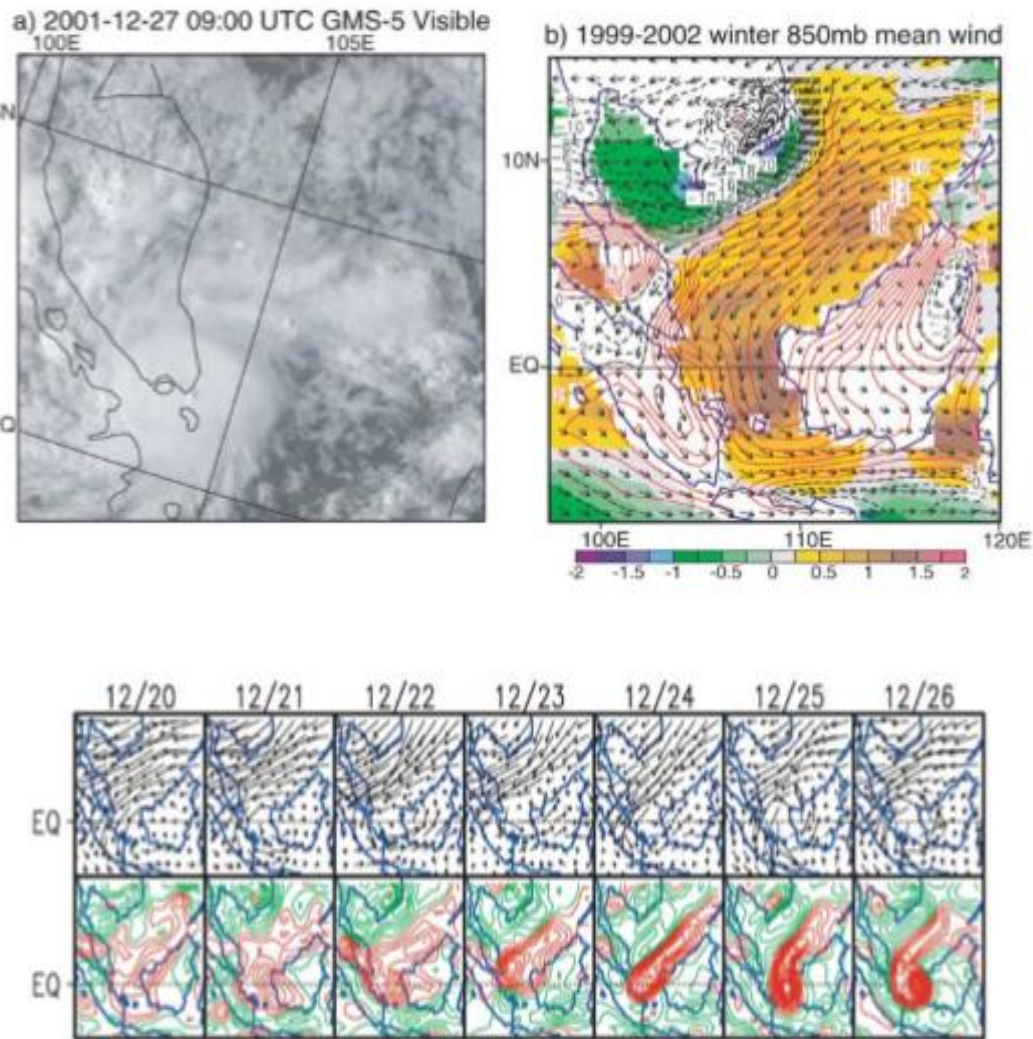
Borneo Vortex (BV) role during NE Monsoon

- According to **Chang et. al. (2005)**, BV enhance convection and increase low level wind convergence over SCS but it will suppress the convective activity over its surrounding area



*The Borneo vortex is said to have occurred whenever a closed counter-clockwise circulation on the 925-hPa wind field within the area of 107.5°E – 117.5°E, 2.5°S – 7.5°N was observed. The region of interest was depicted in the rectangular black box in **Figure 8**. This criteria was also used in Chang et al. (2005).*

CHANG ET AL.: TYPHOON VAMEI EQUATORIAL FORMATION



- A strong cold surge event interacting “***spinning top effect***” with the BV that move and stay over narrow SCS water between Borneo and Peninsular Malaysia.
- As pointed out by Chang et al., the most intriguing question is not how Vamei could form so close to the equator, but is why such a formation was not observed before then suggested by Chang et al. (2003)
- In other word, such near equator typhoon **can reoccur in the future.**

NOGAPS $1^\circ \times 1^\circ$ 850 hPa wind and vorticity (red positive, green negative) at 00 UTC 20–26 December 2001

Borneo Squall Line (BSL)



Figure 2: Squall line over Sembulan, Kota Kinabalu, Sabah on 12 June 2012 (left), squall line over Sembulan that was reported by the Sabah Times newspaper (middle) and squall line which produced a waterspout over Bintulu, Sarawak on 18 October 2014 (right)

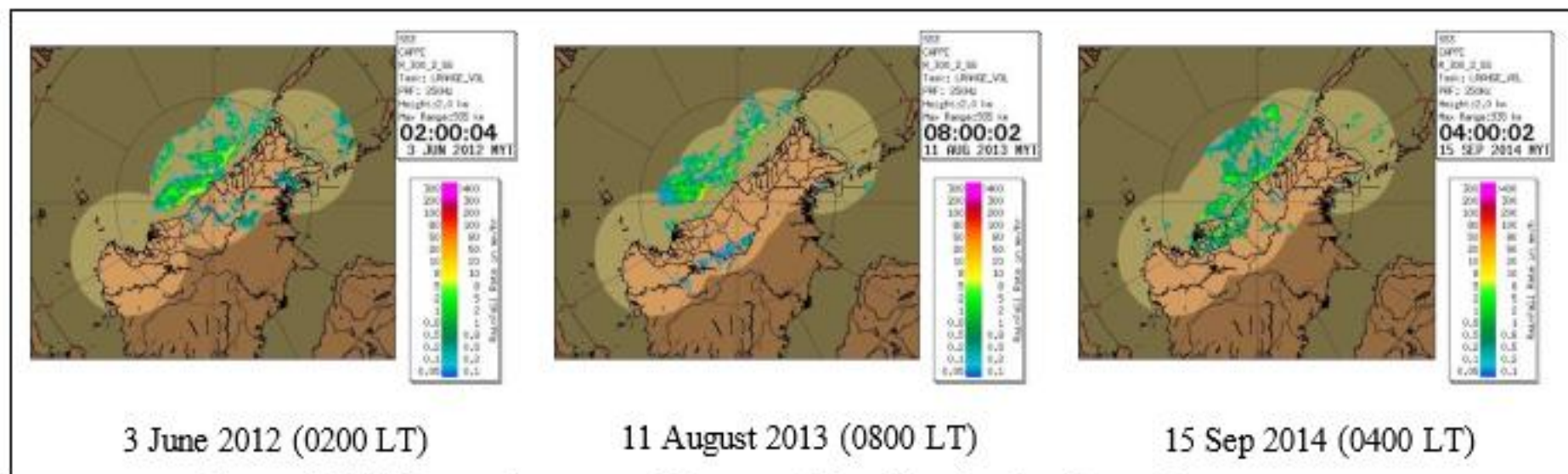


Figure 6: BSLTCs over the waters off Borneo as inferred by the radar observations

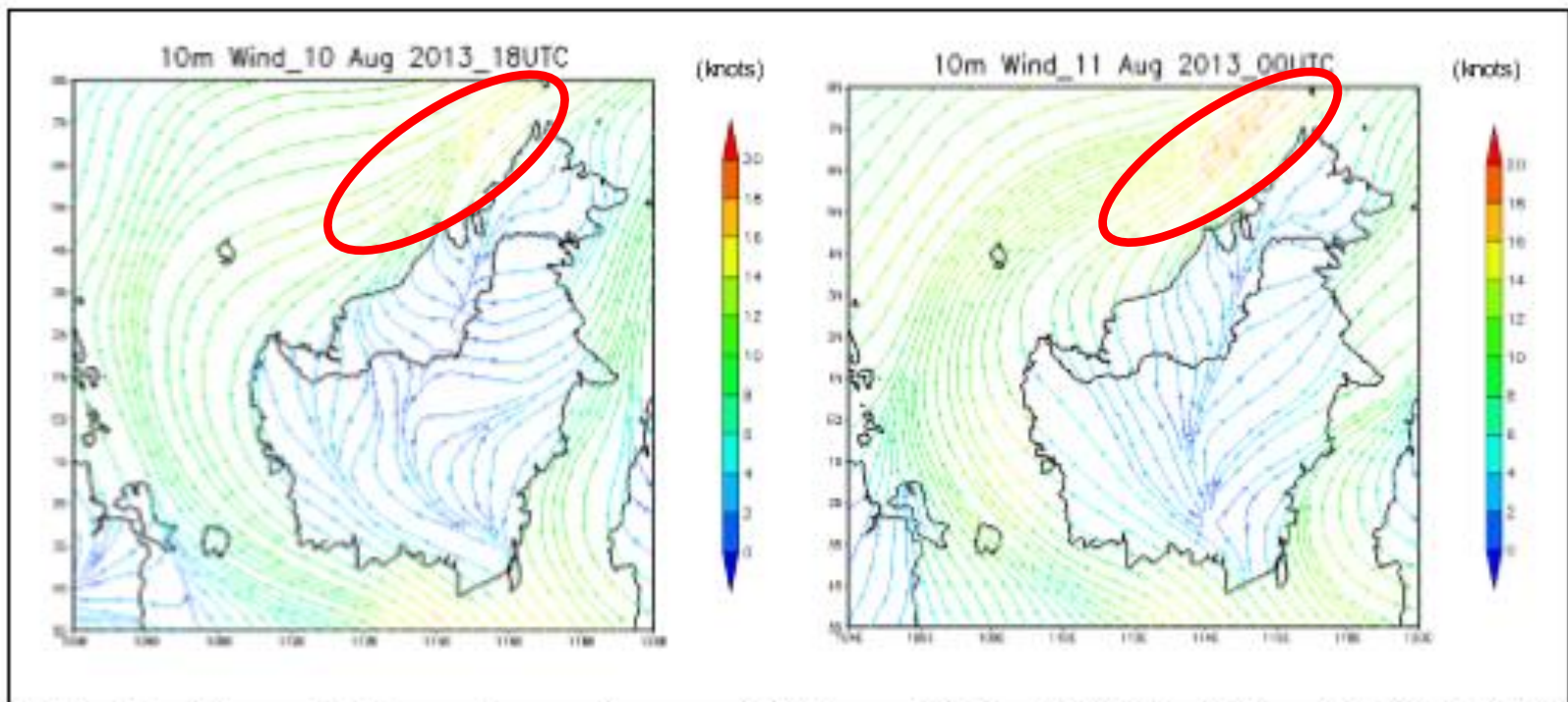
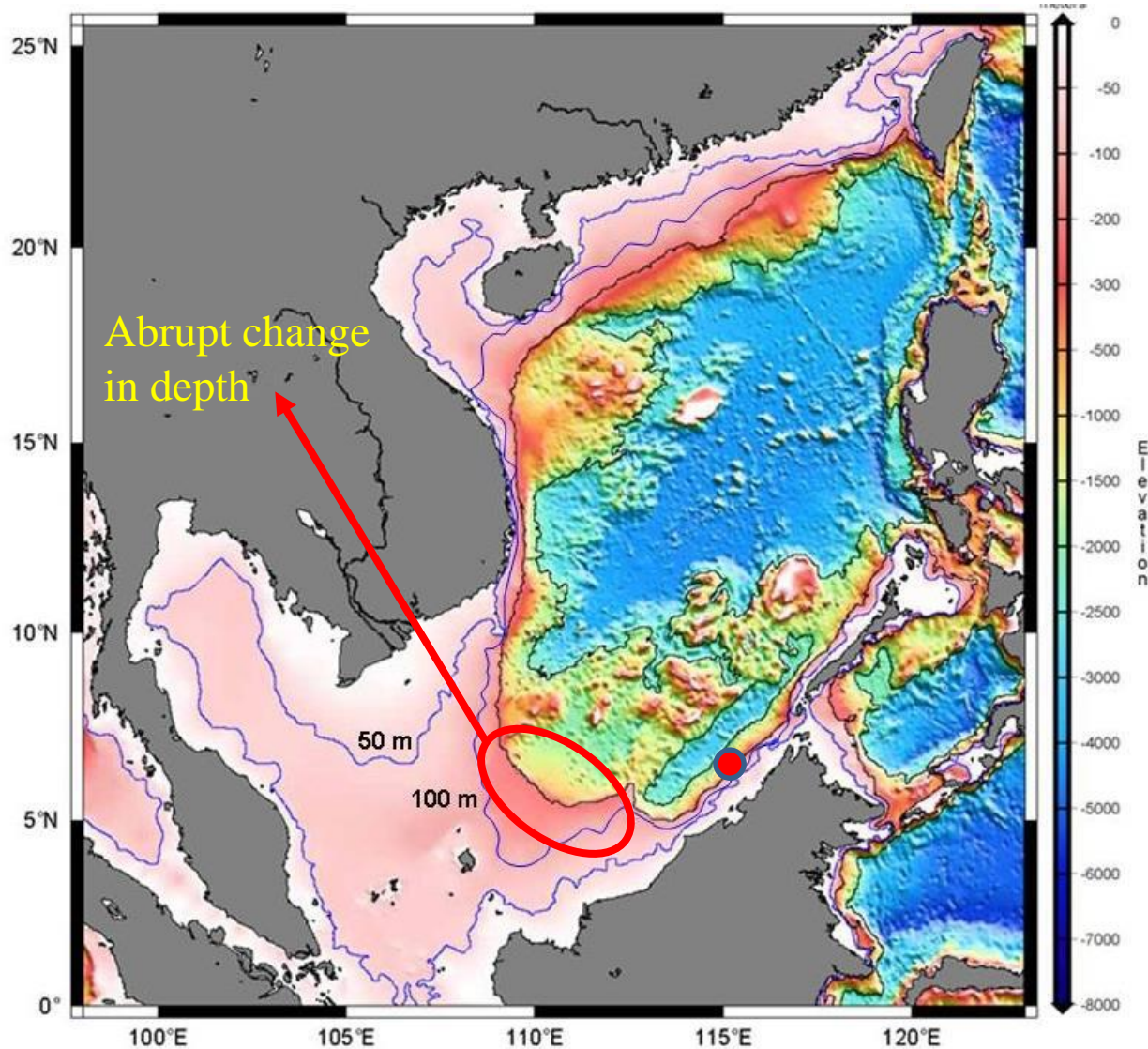


Figure 9(i): The 10-m wind streamline analyses on 11 August 2013 at 0200LT (left) and 0800LT (right) over Borneo represented the synoptic features of BSLTC. Present synoptic system, Typhoon Utor (location at 0800LT: Latitude: 14.5°N , Longitude: 125.9°E , with maximum wind near the centre: 85 knots)

- Recent study by Fadila et.al (2016, MMD Publication 6/2016) shows that TC presence over Borneo adjacent water can triggered BSL formation
- Strong convergence parallel to Borneo coastline and refreshing of SW Monsoon wind flow

JMA-MMD MRI III WAVE/ JMA STORM SURGE MODEL VERIFICATION AND VALIDATION

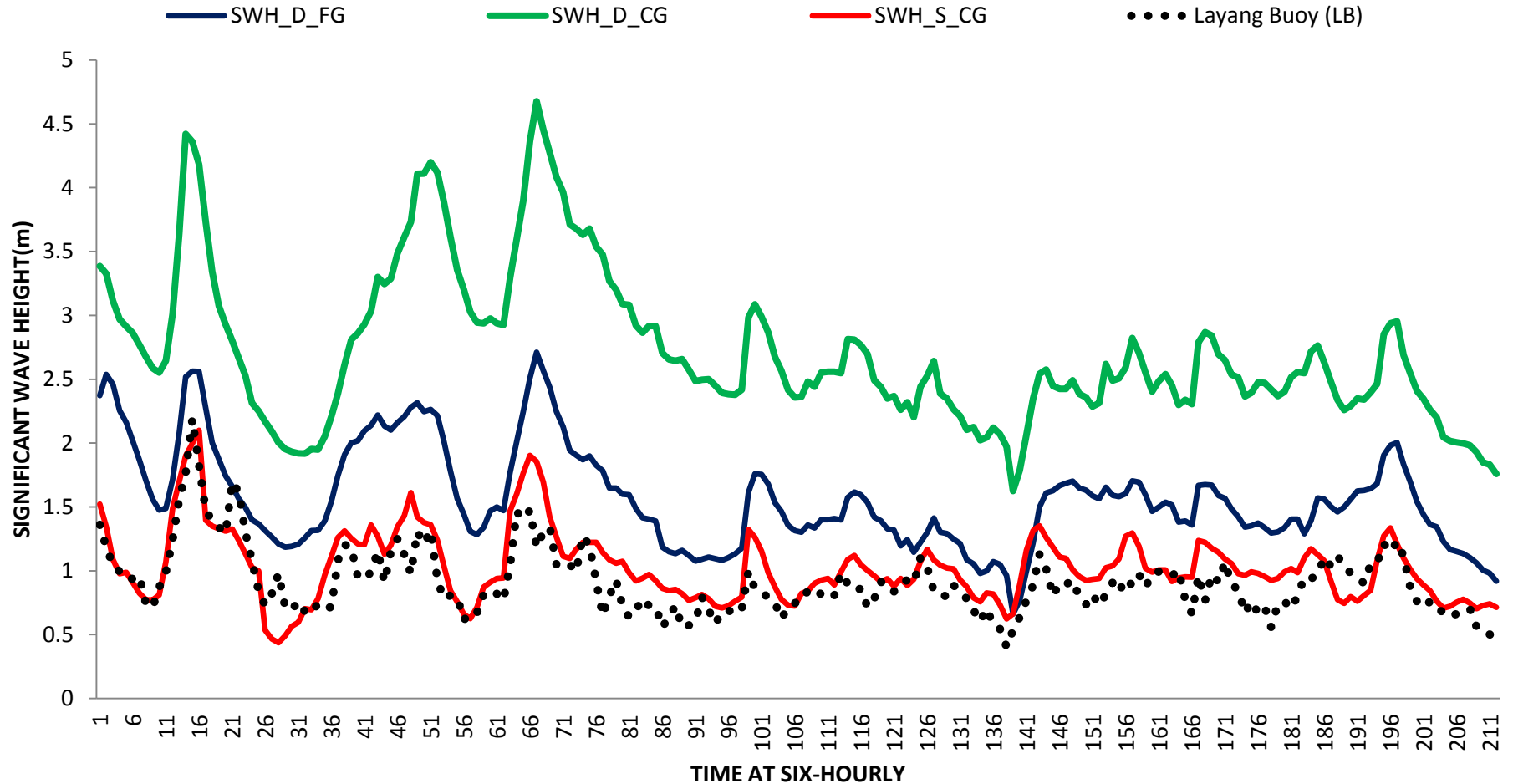
Bathymetry over SSCS



- Wind generally light
- Complex bathymetry
- Not enough to generate high seas/swell
- TC cross over to West Philippines will be good for :
 - ✓ Case study
 - ✓ Tuning wave model

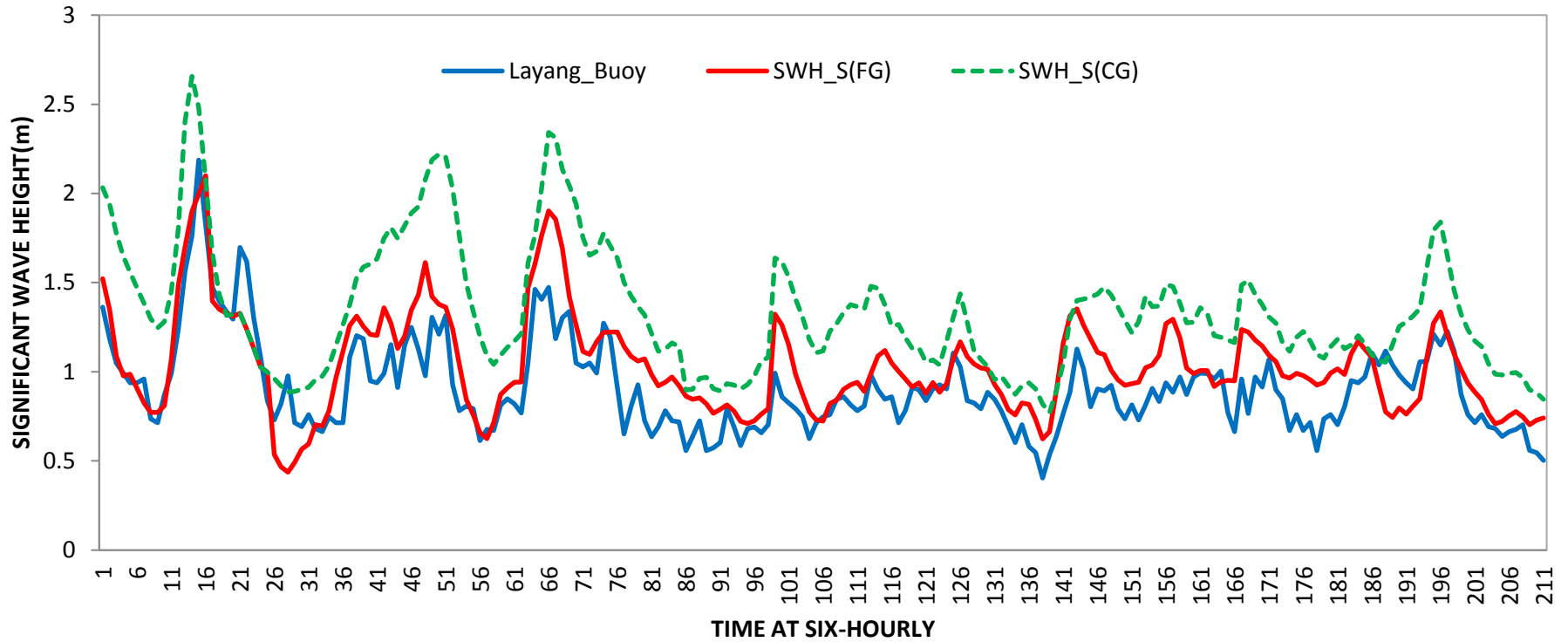
The quality of numerical wave forecast output is strongly depend on the regional characteristics such as bathymetry and the wind field (Mazarakis *et al.*, 2012)

WAVE MODEL VERIFICATION RESULTS



1st January - 28th February 2013 during TS Sonamu and Typhoon Shanshan

MEAN SIGNIFICANT WAVE HEIGHT



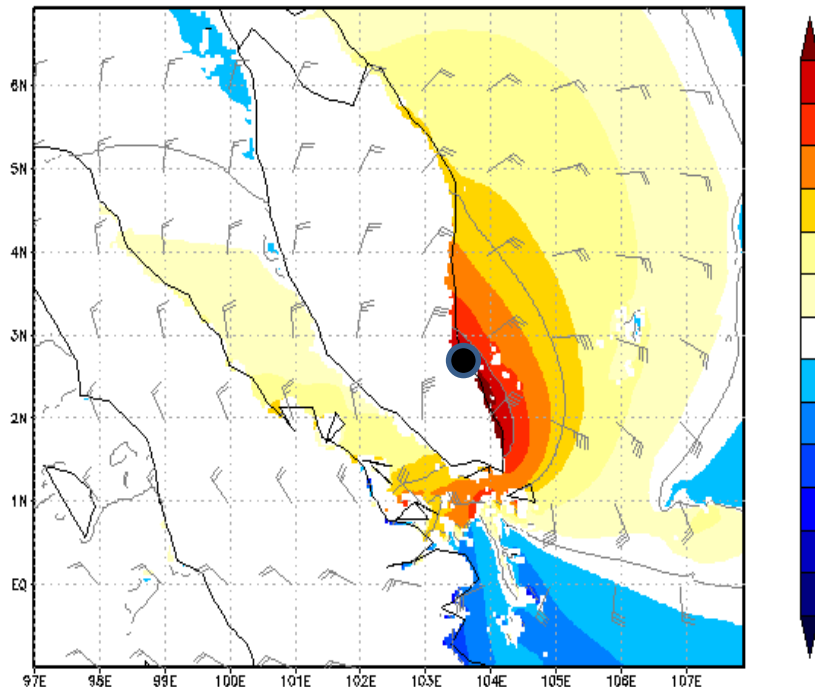
Fine grid simulation of JMA- MRI III_S wave model show better accuracy

Reasonable High accuracy obtained

PARAMETER	MAE	RMSE	SI	CC
WSPD_CG	1.23	1.60	0.19	0.62
WSPD_FG	0.92	1.17	0.16	0.75
SWH_S(CG)	0.44	0.50	0.37	0.75
SWH_S(FG)	0.17	0.21	0.21	0.80

Typhoon Vamei – JMA-MMD Storm Surge Model simulation

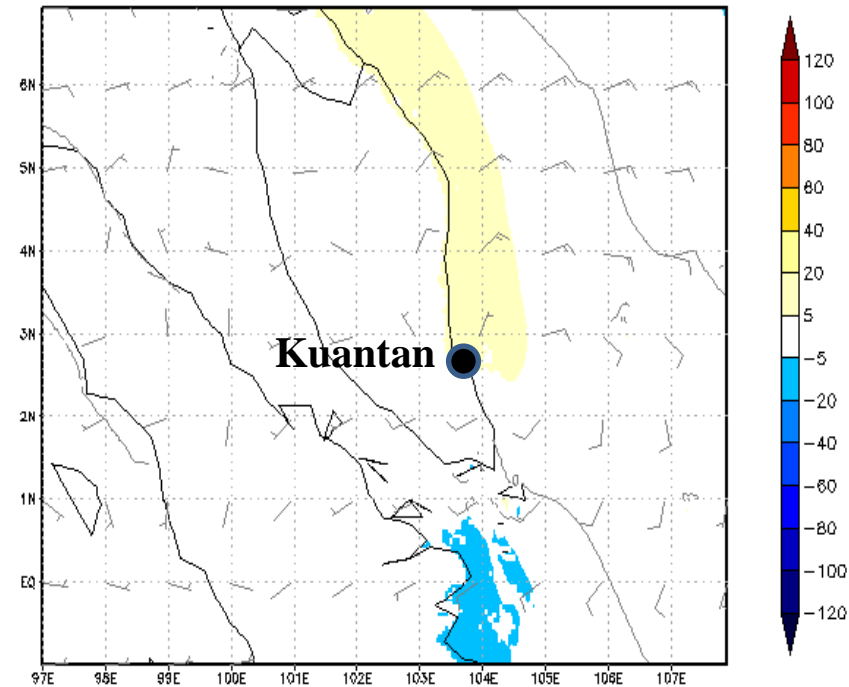
07Z27DEC2001



Best Track

Parameterized wind

07Z27DEC2001

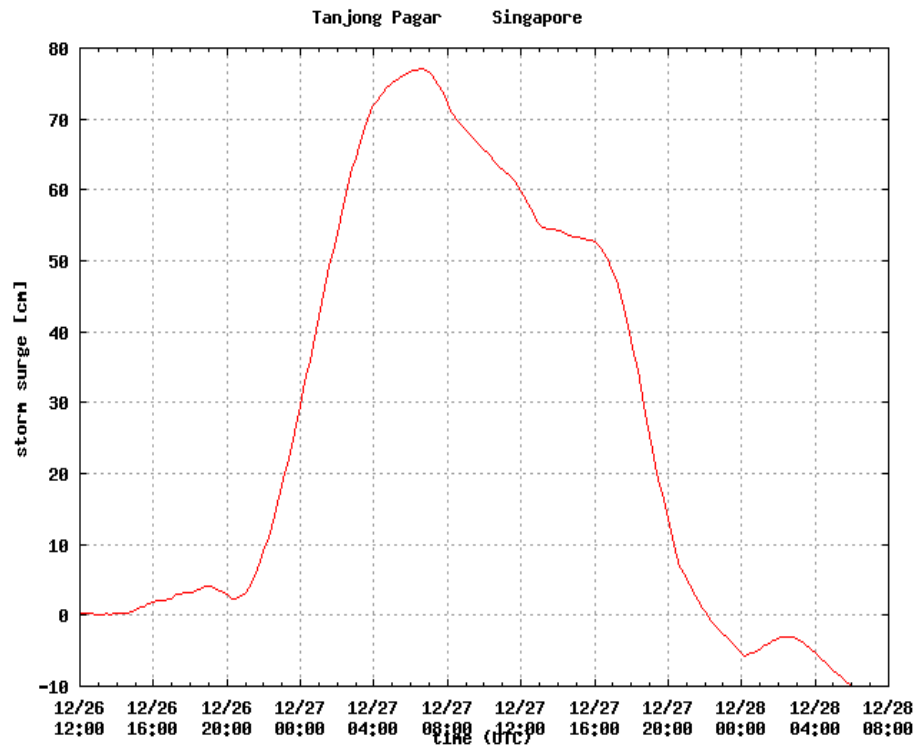


JMA GSM

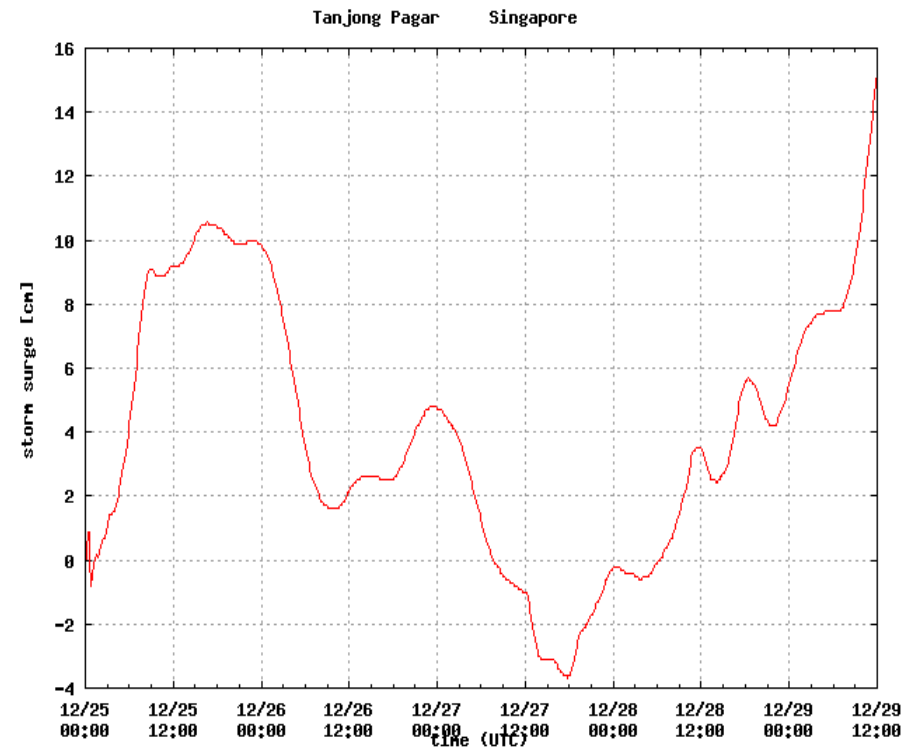
NWP wind field

Overestimation occurred for Best track input field – No topography effect

Typhoon Vamei – JMA-MMD Storm Surge Model Time series

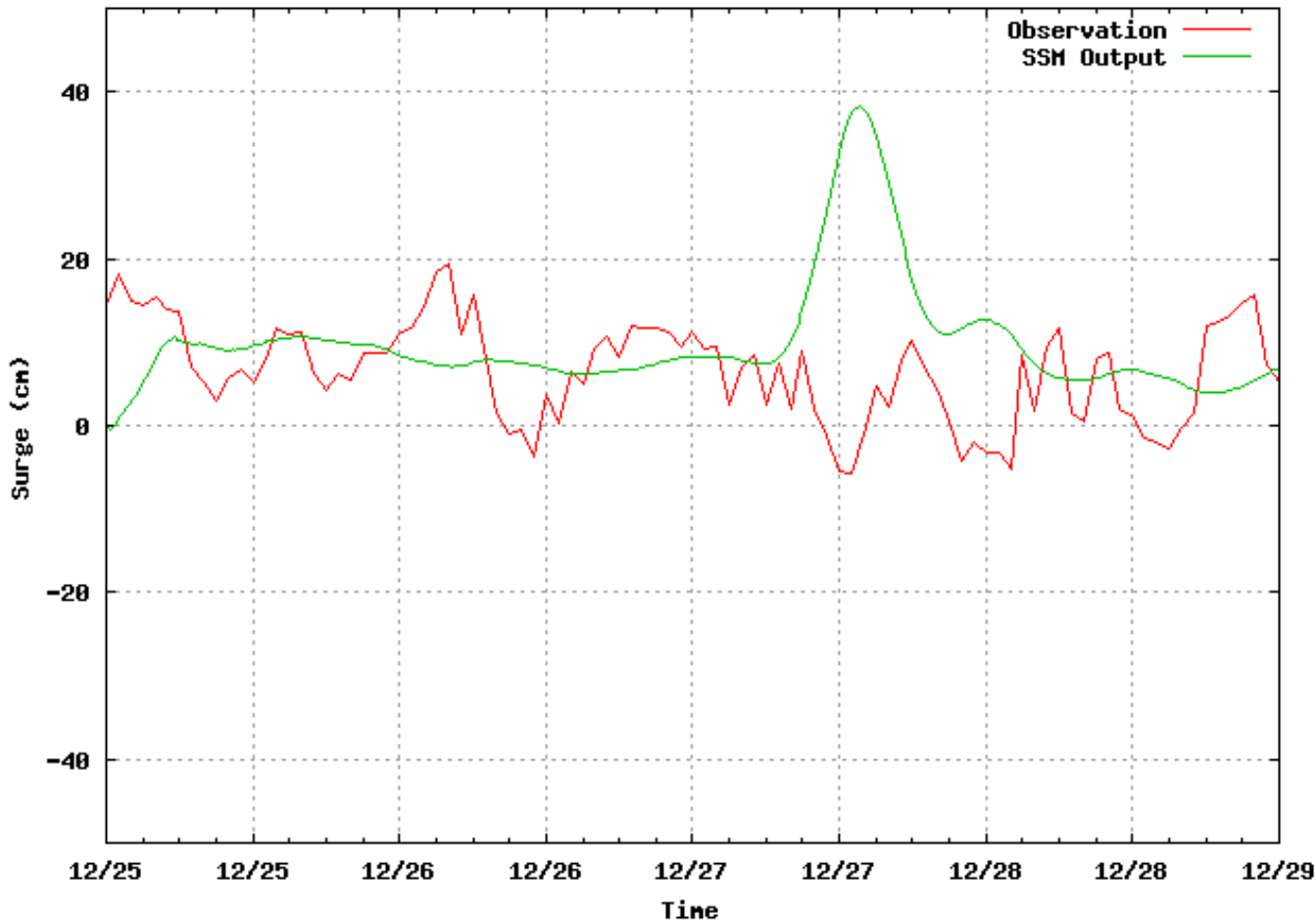


Best Track



JMA GSM

Comparison between observation and SSM result for Kuantan for 2001



Overestimation
occurred for simulation
using track data
(RSMC)

NWP wind and pressure
forcing is more realistic

Need to improve NWP
atmospheric field :
Typhoon bogussing in
MMD mesoscale model?

Model output deviates from observation. Possible : over-estimate wind speed from NWP during Vamei ?

Stations show slower wind / no surge → Vamei was a typhoon during landfall ?

MONITORING AND EARLY WARNING SYSTEM

Warning Center

Joint Typhoon Warning Center Products

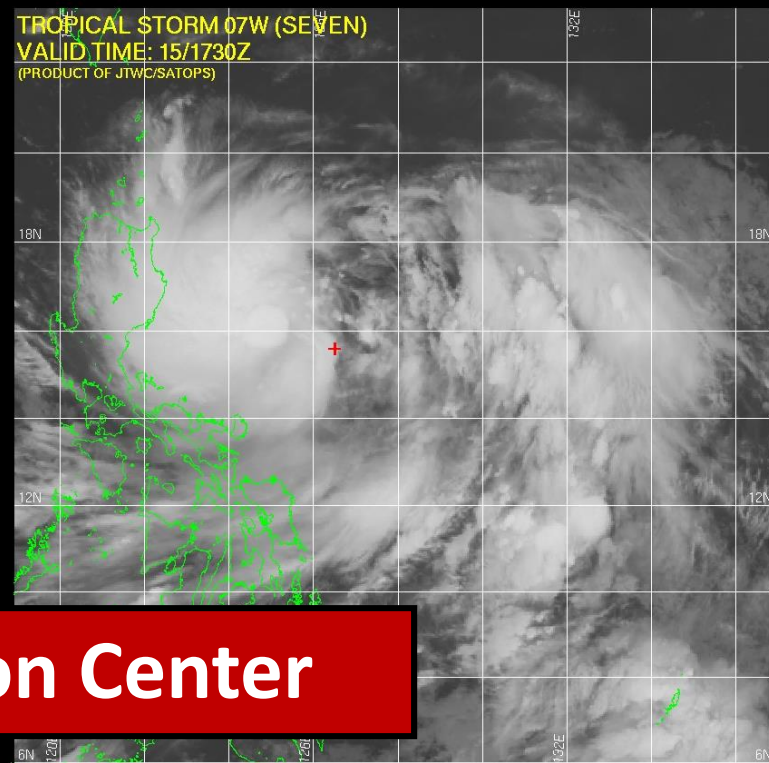
Products on this website are in the public domain and are not to be used for official agency or the appropriate Weather Center.

Notice to our users: The Joint Typhoon Warning Center (JTWC) is a United States Navy command. The website is not a DoD website and is not subject to the DoD Information Security Policy. DoD customers can access all operational products at <https://oceanography.navy.mil> (CAC).

Current Northwest Pacific/Northern Indian Ocean

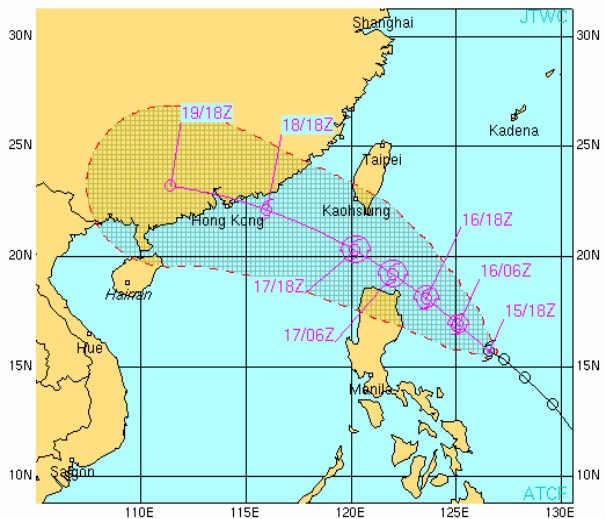
• Tropical Storm 07W (SEVEN)
Issued at 15/2100Z
- TC Warning Text
- TC Warning Graphic

WTPN51 PGTW 152100
WARNING ATCP MIL 07W NWP 090715201806
2009071518 07W SEVEN 003 01 300 08 SATL 060
T000 157N 1266E 035
T012 169N 1251E 040 R034 030 NE QD 025 SE QD 020 SW QD 030 NW QD
T024 181N 1234E 045 R034 035 NE QD 025 SE QD 030 SW QD 035 NW QD
T036 192N 1211E 045 R034 035 NE QD 025 SE QD 030 SW QD 035 NW QD
T048 203N 1198E 045 R034 035 NE QD 025 SE QD 030 SW QD 035 NW QD
T072 221N 1175E 045 R034 035 NE QD 025 SE QD 030 SW QD 035 NW QD
T096 232N 1162E 045 R034 035 NE QD 025 SE QD 030 SW QD 035 NW QD
AMP
096HR D
SUBJ: TROP
1. TROPICAL
UPGRADED
01 ACTIV: WDPN31 PG
MAX SUST: MSGID/GEN
WIND RAD SUBJ/PROGNOSTIC REASONING FOR TROPICAL DEPRESSION 07W WARP
RMKS/
WARNING: 1. FOR METEOROLOGISTS.
151800Z 2. 12 HOUR SUMMARY AND ANALYSIS.



JTWC Typhoon Center

VALID TIME: 15/1000Z
(PRODUCT OF JTWC/SATOPS)



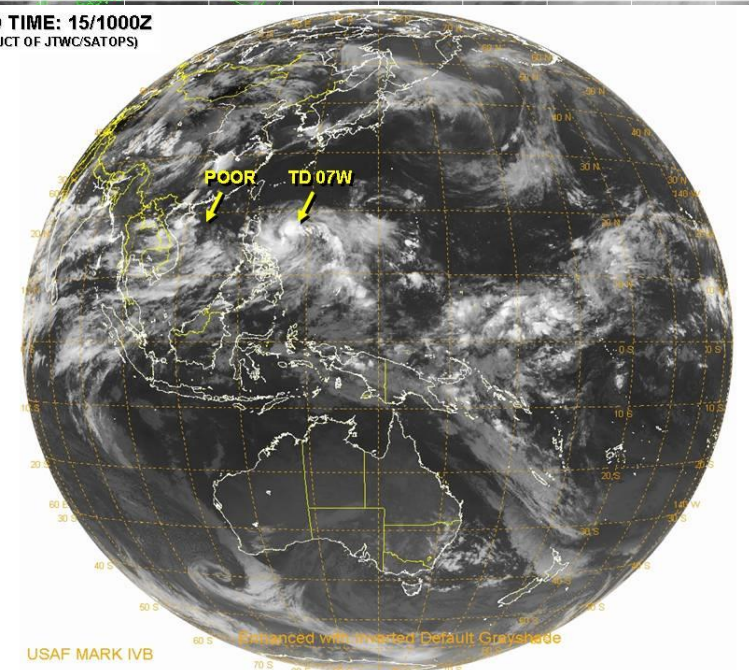
TROPICAL STORM 07W (SEVEN) WARNING #3
151800Z POSIT: NEAR 15.7N 126.6E
MOVING 300 DEGREES TRUE AT 08 KNOTS
MAXIMUM SIGNIFICANT WAVE HEIGHT: 11 FEET

DATE	TIME	POSIT	INTENSITY
15/18Z	15/18Z	15.7N 126.6E	035 KTS
16/06Z	16/06Z	16.9N 125.1E	040 KTS
16/18Z	16/18Z	18.1N 123.4E	045 KTS
17/06Z	17/06Z	20.3N 119.8E	045 KTS
17/18Z	17/18Z	22.1N 117.5E	045 KTS
18/06Z	18/06Z	23.2N 116.2E	045 KTS
19/18Z	19/18Z	23.2N 116.2E	045 KTS

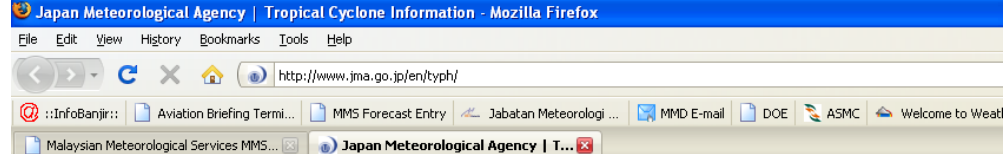
CPR TO:	NM	DTG
MANILA	257	16/17Z
CLARK AB	246	16/22Z
TAIPEI	287	18/01Z
HONG KONG	18	19/03Z
HANOI	332	19/18Z

BEARING AND DISTANCE	DIR	DIST (NM)	TAU (HRS)
CLARK AB	45	249	24
MANILA	35	258	24
CLARK AB	357	305	48
HONG KONG	109	356	48
MANILA	352	345	48
TAIPEI	134	297	48
HONG KONG	97	101	72
TAIPEI	240	352	72

○ LESS THAN 34 KNOTS
● 34-63 KNOTS
● MORE THAN 63 KNOTS
● PAST 6 HOURLY CYCLONE POSITS IN BLACK
● FORECAST CYCLONE POSITS IN COLOR



JMA Typhoon Track



Japan Meteorological Agency

Home Weather/Earthquake News Releases Services For

Home > Weather and Earthquakes > Tropical Cyclone Information

Tropical Cyclone Information

Select Track Forecast or Wind Probability 3-Day Track and Intensity Forecast Print

Tropical Cyclone All Tropical Cyclones

Click on the tropical cyclone to see the enlarged map of its forecast.

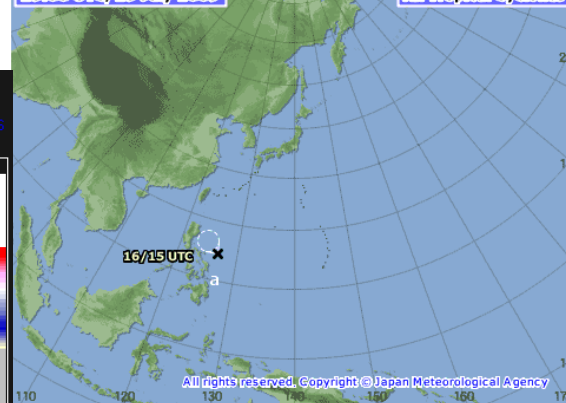
00:00 JST, 16 July 2009

Notes

15:00 UTC, 15 July 2009

All Tropical Cyclones

Close TD a



TD	
Issued at 15:55 UTC, 15 July 2009	
<Analyses at 15/15 UTC>	
Scale	-
Intensity	-
Center position	N14°40'(14.7°) E126°40'(126.7°)
Direction and speed of movement	W 10km/h(6kt)
Central pressure	1000hPa
Maximum wind speed near the center	15m/s(30kt)
Maximum wind gust speed	23m/s(45kt)
<Forecast for 16/15 UTC>	
Intensity	-
Center position of probability circle	N16°30'(16.5°) E124°40'(124.7°)
Direction and speed of movement	NW 10km/h(6kt)
Central pressure	1000hPa

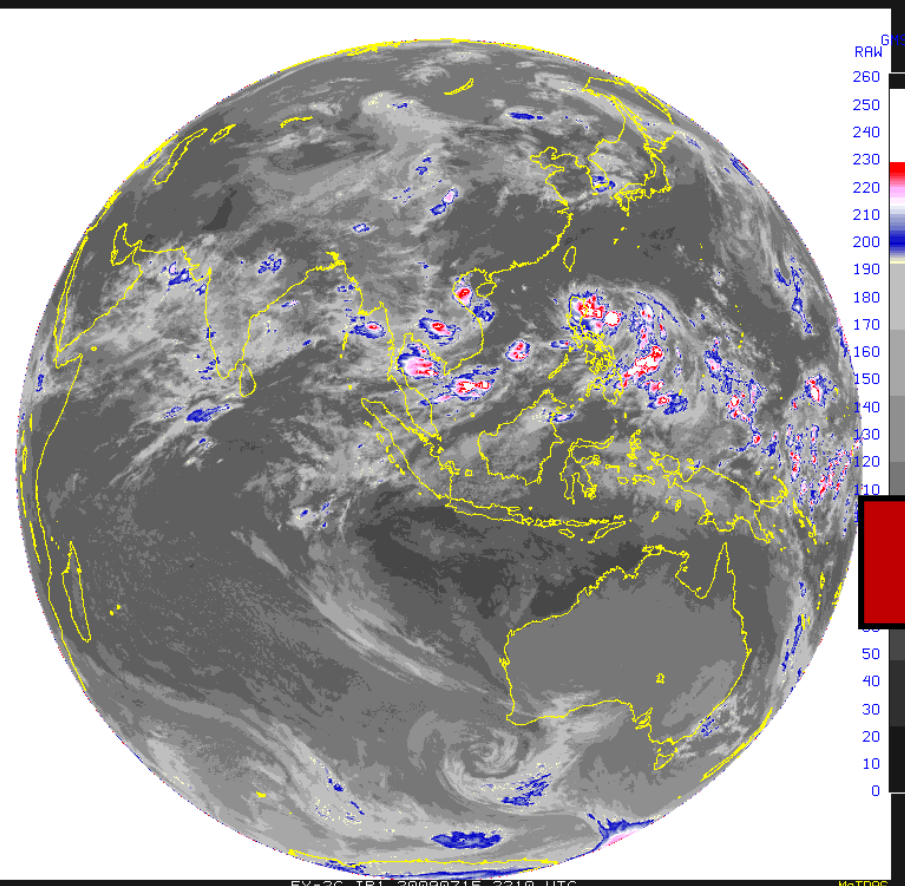
All rights reserved. Copyright © Japan Meteorological Agency

At this website, tropical depressions are identified by an alphabet for users' convenience. This alphabet is not assigned in chronological order. When tropical depressions have developed to tropical storms, typhoon numbers are assigned instead.

FY-2E

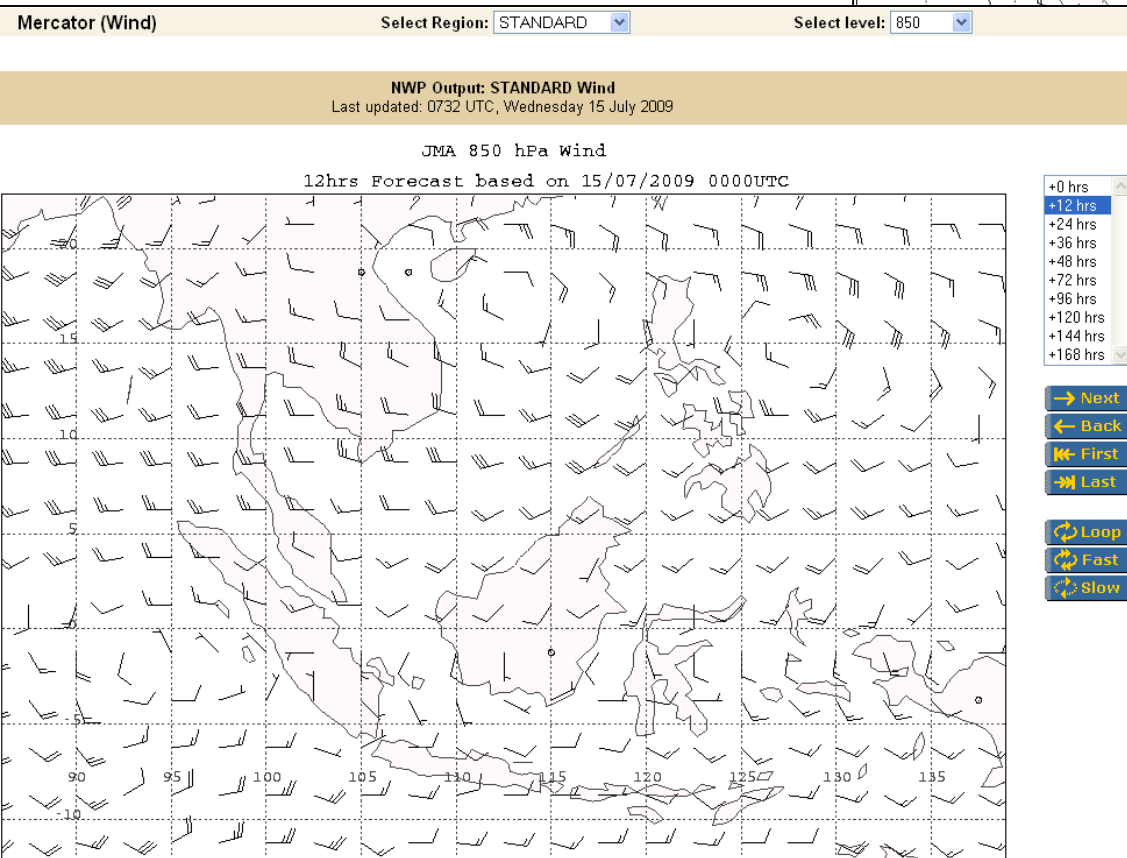
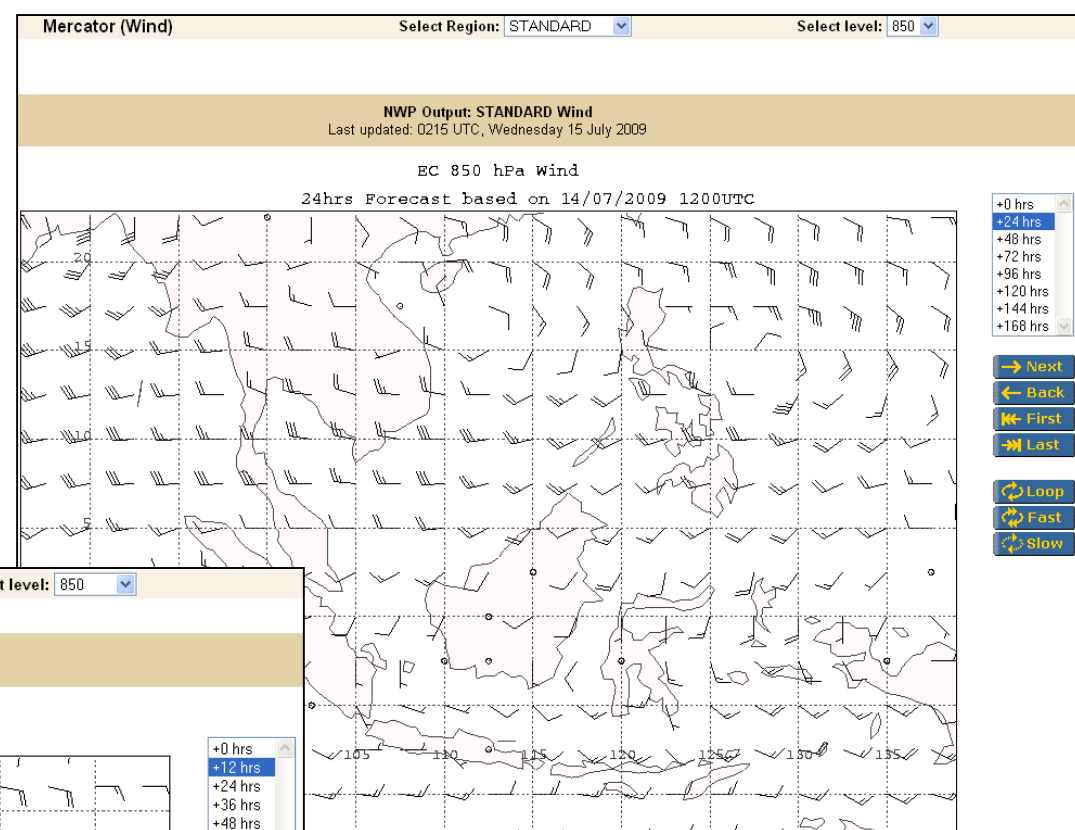
HIMAWARI

NEW!!!



EC Wind Chart

Wind chart (850 hPa) – useful to detect areas of strong winds over Malaysia waters



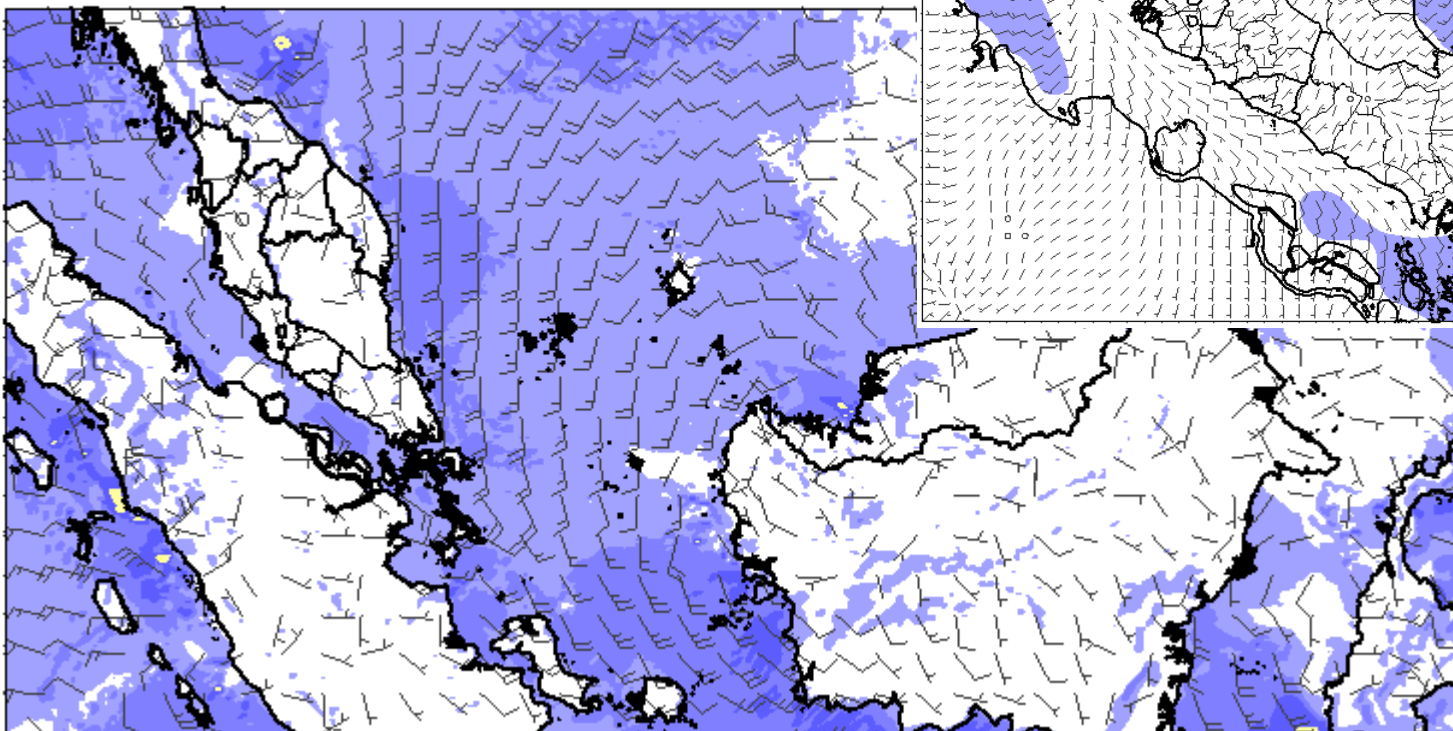
JMA Wind Chart

MMD WRF MODEL

High Resolution (1km) WRF
mesoscale Model → Wind and
other fields

Surface Wind Speed (kts)

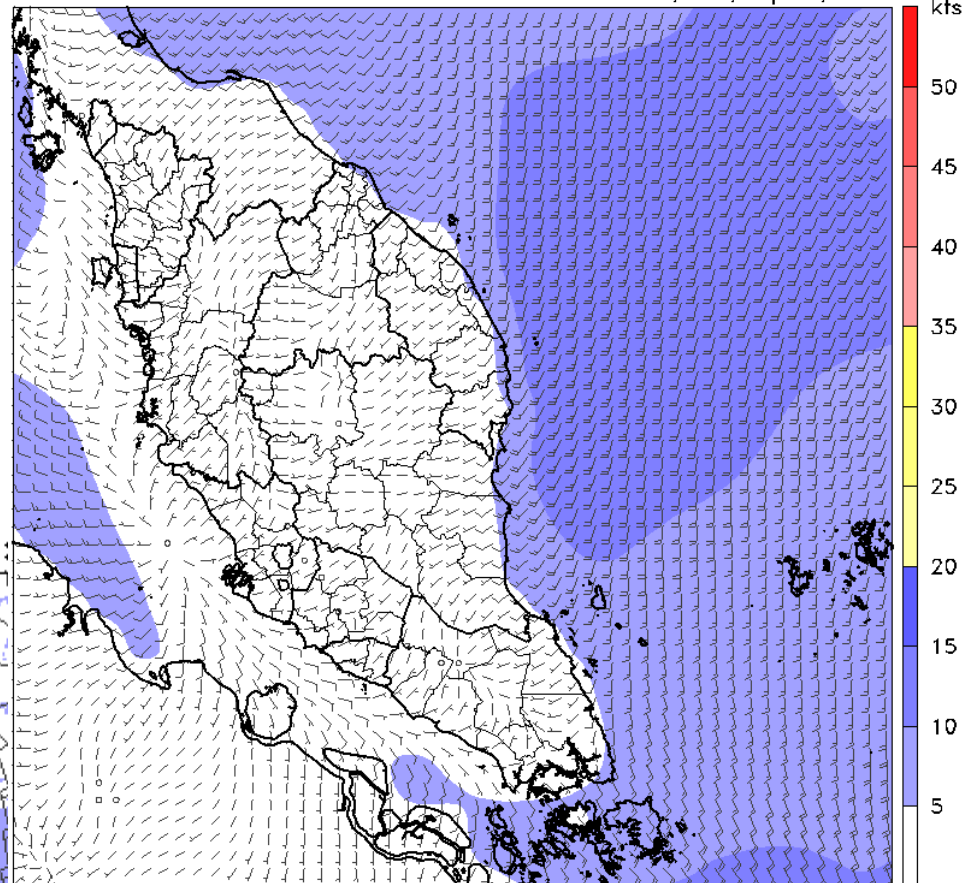
Forecast hour: 18



Surface Wind Speed (kts)

Forecast hour: 0

Valid: 0800 MYT, Mon, Sep 04, 2017



Regional Storm Surge Watch Scheme

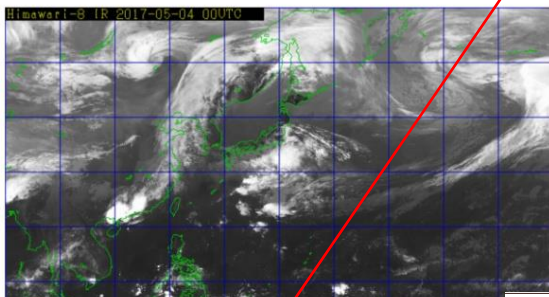


Regional Storm Surge Watch Scheme (<https://tynwp-web.kishou.go.jp/>)

Numerical Typhoon Prediction Website

RSMC Tokyo - Typhoon Center

HOME Advisories Obs./Analysis Forecast/NWP **Surge/Wave** Publication Data



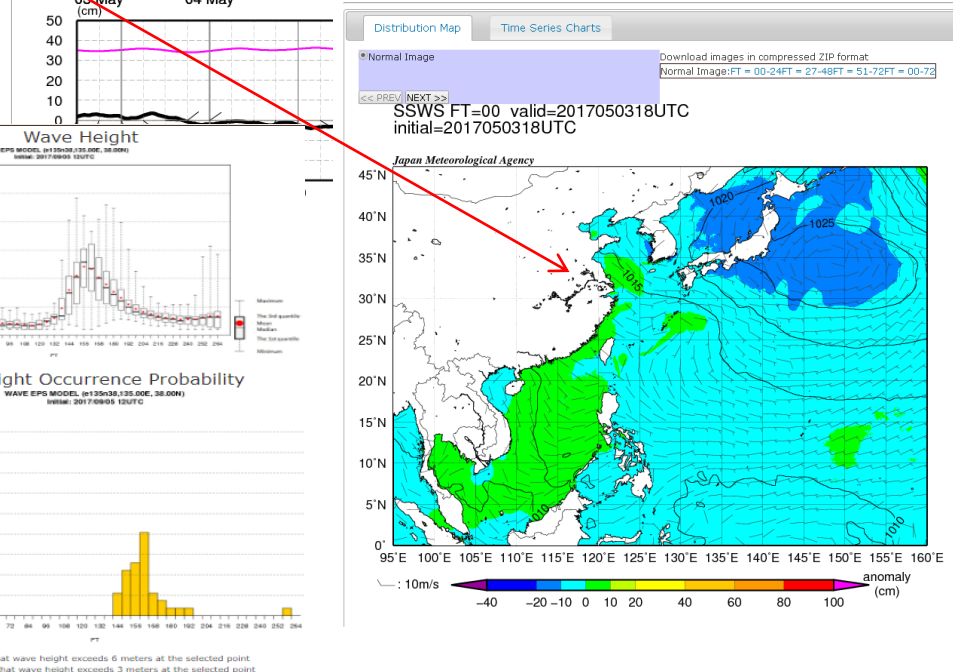
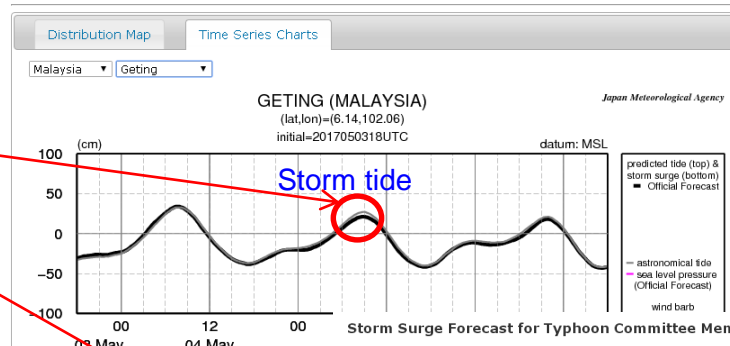
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About this site

The Numerical Typhoon Prediction (NTP) Web Site presents numerical predictions of tropical cyclone tracks performed by major NWP centers in the world, and other products useful for tropical cyclone analysis and forecast. This service is provided as part of the activities of the RSMC Tokyo - Typhoon Center for the ESCAP/WMO Typhoon Committee (TC) to facilitate better tropical cyclone forecasting and warning operations by

Storm Surge Forecast for Typhoon Committee Members



Warning Criteria for Tropical Cyclones

Warning Stages	Criteria
Orange	Low-pressure system/tropical depression with sustained wind speeds of 50 - 60 kmph accompanied by moderate to heavy rain.
Red	Tropical storm/typhoon with sustained wind speeds of at least 60 kmph accompanied by moderate to heavy rain.

MMD EARLY WARNING SYSTEM

WEATHER MONITORING, FORECASTING AND WARNING SYSTEM



**Radar
Observation**



**Surface
Observation**



**Marine
Observation**



**Aircraft
Observation**



**Weather
Camera**

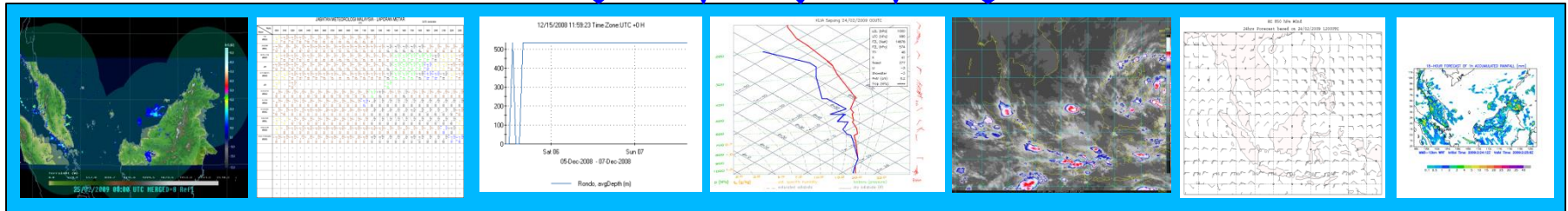


**Upper Air
Observation**

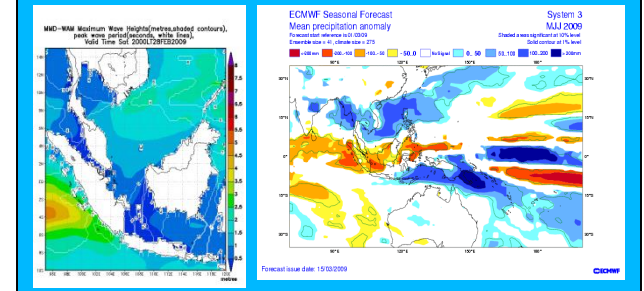
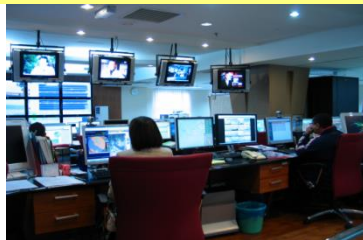
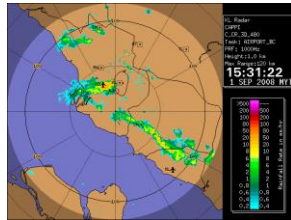
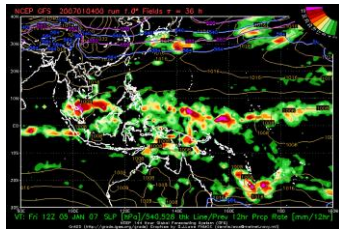


**Satellite
Observation**

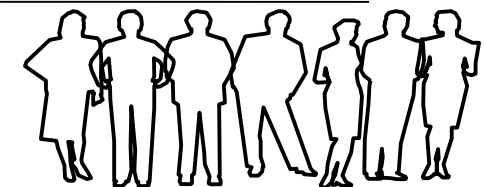
Data Collection and Analysis



Weather Forecast Centre



Warning Dissemination



Public

Dissemination of Sea Condition, Weather Forecast and Warning

MMD WEBSITE




SOCIAL MEDIA : FACEBOOK, TWITTER

MASS MEDIA – TV , RADIO & NEWSPAPER



JMM SHORT MESSAGE SERVICE & METEOROLOGICAL INFORMATION SYSTEM



MMD SMS INFORMATION SYSTEM

celcom Enterprise Messaging Service

02-Mar-2009 08:40PM

[Malaysia Meteorological Service , Msia Meteorological]
Help | My Preferences | Logout

New Broadcast | Schedule a Broadcast | New Bulk Broadcast

List of Broadcasts

Found (5956) Page (1)

Content	StartDate	Type	ShortName	Status	Action
1. AMARAN R/PETIR & HJN LEBAT 4.50pm 2/3/09 R/petir,h/lebat & angin kencang yg turun di Sabah; Bhgn Kudat(Daerah Kota Marudu), Pantai Barat(Daerah Kota Belu, Turan, K. Kinabalu & Penampang), Pedalaman(Daerah Sipitang & Keningau) & Sandakan(Daerah Kinabatangan & Tongod) dijangka dijangka berterus sehingga m/m, 2/3/09 Created on March 02, 2009 05:22PM	02-Mar-2009 05:22PM	Normal	METEOR	✓	
2. KEMASKINI AMARAN R/PETIR & HJN LEBAT 4.35pm 2/3/09 R/petir,h/lebat & angin kencang yg turun di Kelantan(K. Bharu, Tumpat, Pasir Mas, T. Merah, Machang & Pasir Puteh), Kedah (Pulau Langkawi, Kbg Pasu, Kuala Muda, Kulim, Bdr Baharu, Pendang & Yan), P. Pinang(Seberang Perai & P. Pinang), Perak(K. Kangsar, Kinta, Manjung & Perak Tngg) & Johor(Pahat) dijangka berterus sehingga m/m, 2/3/09 Created on March 02, 2009 05:21PM	02-Mar-2009 05:21PM	Normal	METEOR	✓	

SMS

CRITERIA FOR THE ISSUANCE OF STRONG WIND AND HIGH SEAS WARNING

Warning Stage	Criteria	Possible Impact
Yellow	Possibility of a monsoonal surge in the next 24 to 48 hours.	
Orange	➤ Moderate monsoon rain is currently occurring or expected to occur in the next 24 hours.	Flooding over low-lying areas and areas by river banks.
	➤ 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.	Thatched/zinc roofs can be blown off by the wind.
Red	➤ Heavy widespread monsoon rain is currently occurring or expected to occur in the next few hours.	Flooding over low-lying areas and areas by the river banks.
	➤ Tropical storm/typhoon with sustained wind speed of at least 60 kmph accompanied by moderate to heavy rain.	Swift water currents can be dangerous to children playing besides monsoon drains and river banks.
	➤ 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 and has lasted for the last 2 hours.	Thatched/zinc roofs can be blown off by the wind.

CONCLUSIONS

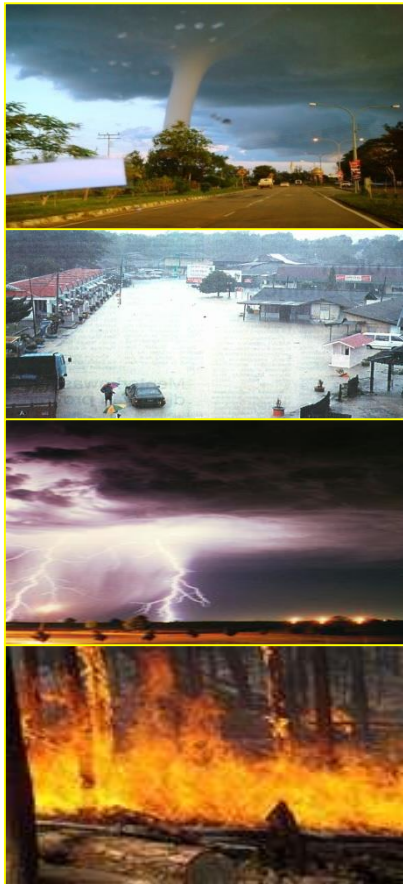
- **Although Malaysia is not located on the common WNP TC track, TC has significant impact to the weather.**
- **TC that cross over to Western Philippines provide a valuable information in marine model verification/validation**
→ *tuning*
- **Inadequate coverage of observational stations: automatic weather and marine stations, and radar.**
- **Huge cost of acquiring and maintaining observational instruments and systems.**
- **Low level of awareness on disaster due to limited capacity and resources to educate the **POLITICIAN** / public.**

STRATEGIES FOR IMPROVEMENT

- **Establishing observational stations at strategic locations and upgrading existing ones.**
- **Operationalization of advanced numerical models especially high resolution storm surge and wave models.**
- **Enhancing the dissemination of warnings through various telecommunication channels.**
- **Conducting regular disaster awareness programs.**

PEOPLE-CENTRED MULTI-HAZARD EARLY WARNING SYSTEM

RISK KNOWLEDGE



OBSERVATION & WARNING SYSTEM



DISSEMINATION & COMMUNICATION



RESPONSE CAPACITY



Severe Weather Awareness Programs



EXHIBITIONS



DIALOGUES



COMMUNITY PARTICIPATION



MEDIA SESSIONS

STRATEGIES FOR IMPROVEMENT

- **Identify risk areas and propose to the local authority to produce inundation maps for high risk zones.**
- **Collaboration with local authority involved in disaster management on data sharing, local and international agencies on tropical cyclone research (Blue Ocean Strategy)**

Thank You

Terima
Kasih

