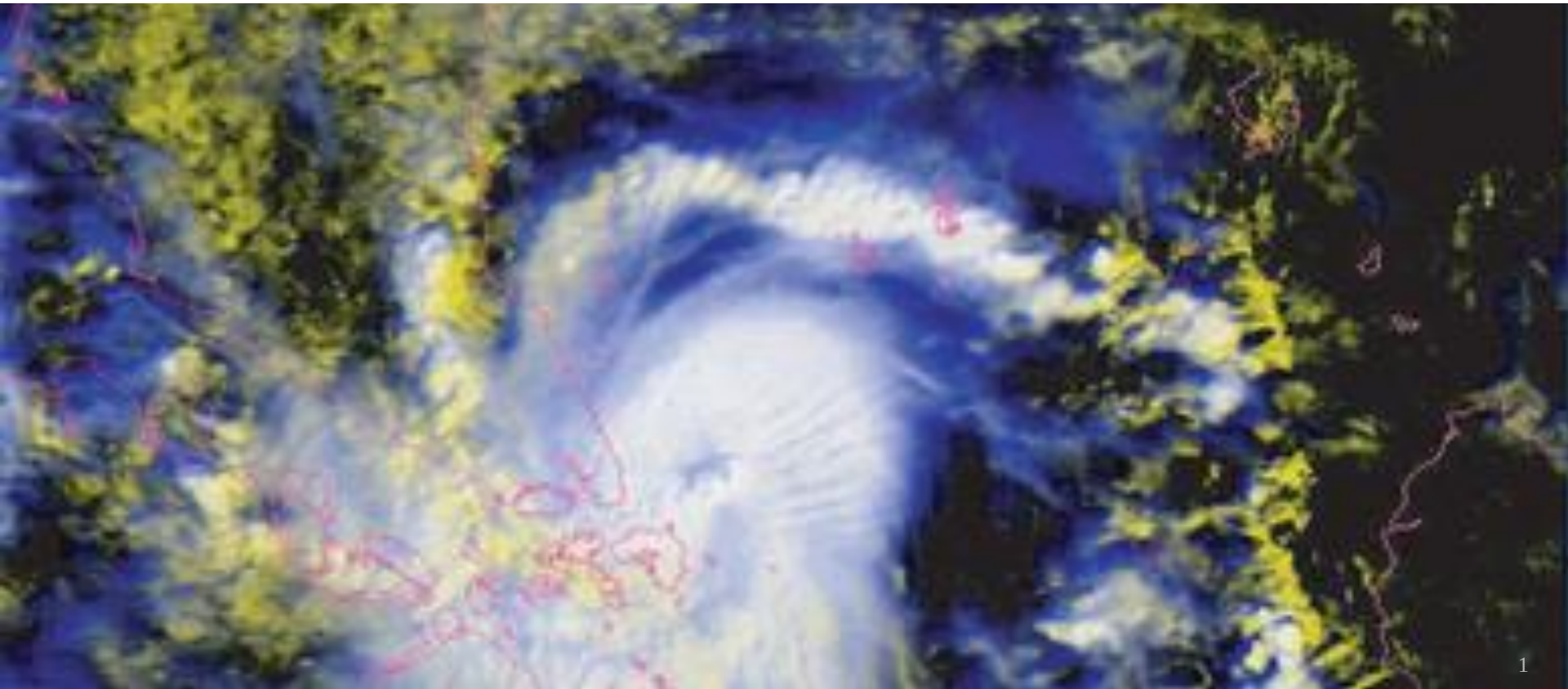
Impact of Tropical Cyclones "Malaysia's Experience"

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

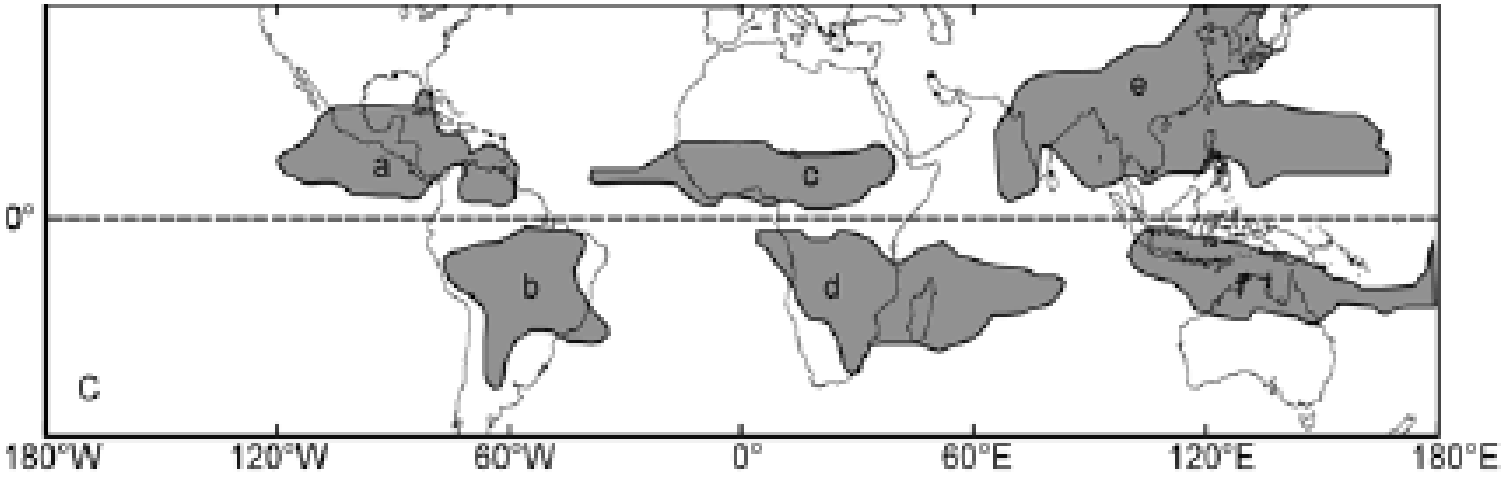
Environmental Meteorology

Agrometeorology

Training

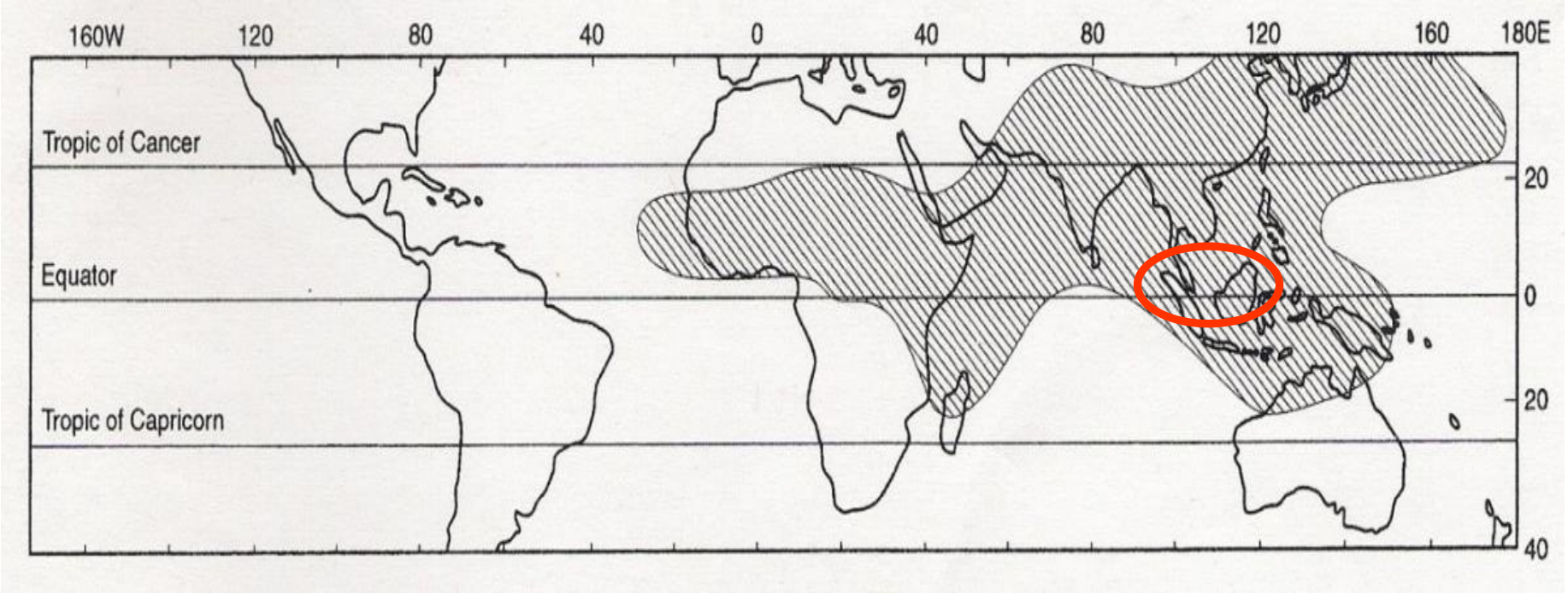
GENERAL CLIMATE OF MALAYSIA

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

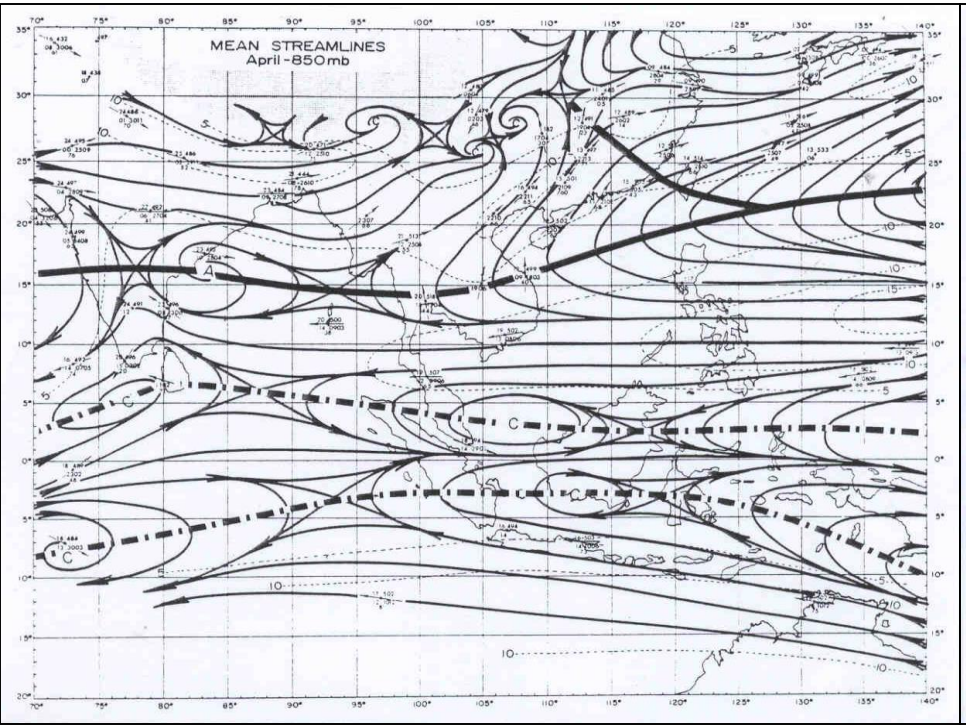
- During the months of August to September, when TC frequently develop over the west Pacific and move westwards across the Philippines, southwesterly winds over the northwest coast of Sabah and Sarawak region may strengthen reaching 20 knots or more

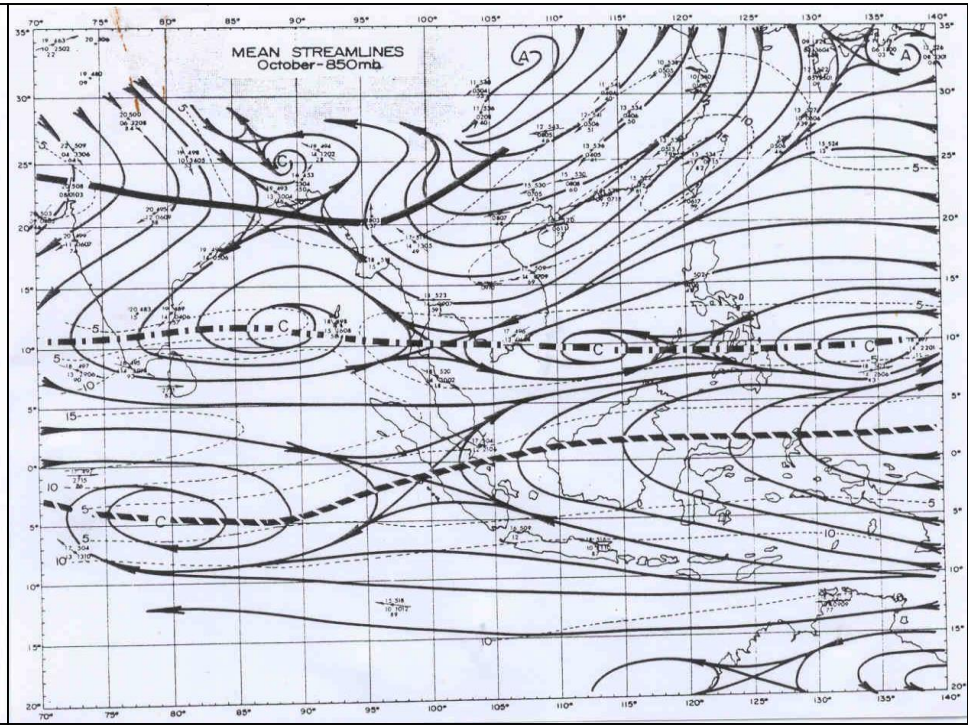
  – tail effect of TC over Malaysia (especially over Sabah)

3. **Inter monsoon** (Apr & Oct):
   - winds are generally light and variable
   - the equatorial trough lies over Malaysia
   - Local effect : ***Mushroom*** TSRA

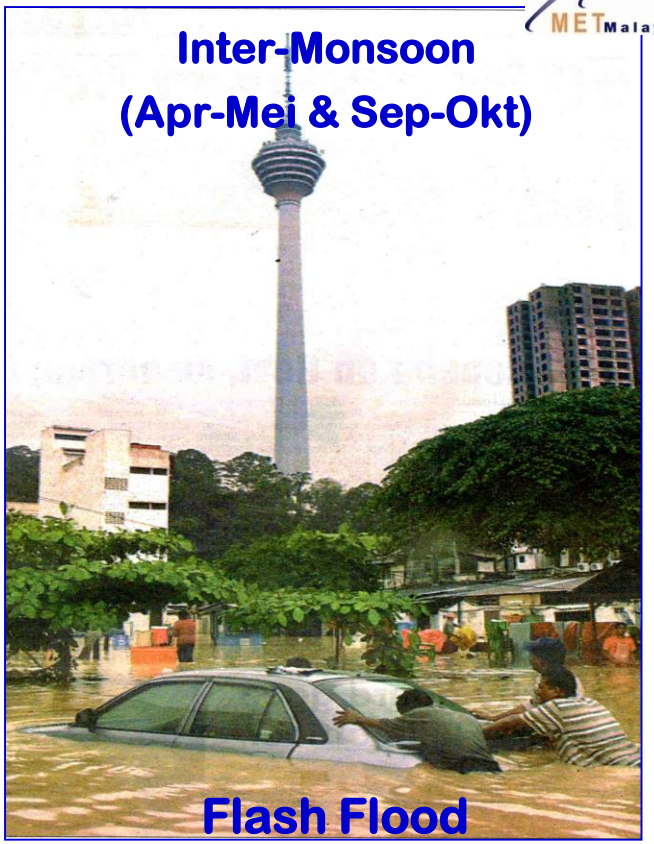
Mean Streamline for April and October (Inter Monsoon)

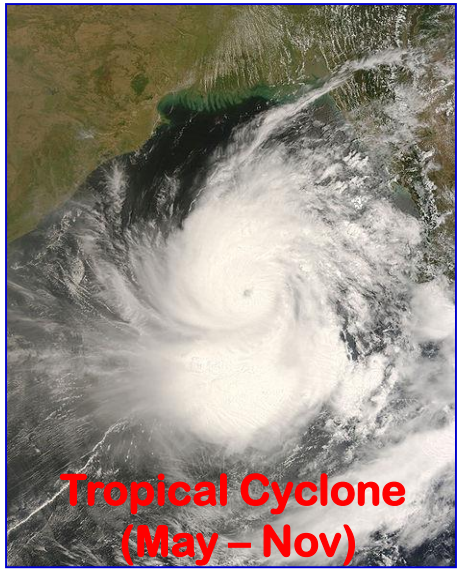
850hPa





Severe Weather in Malaysia





OBSERVATION NETWORK

DATA ACQUISITION

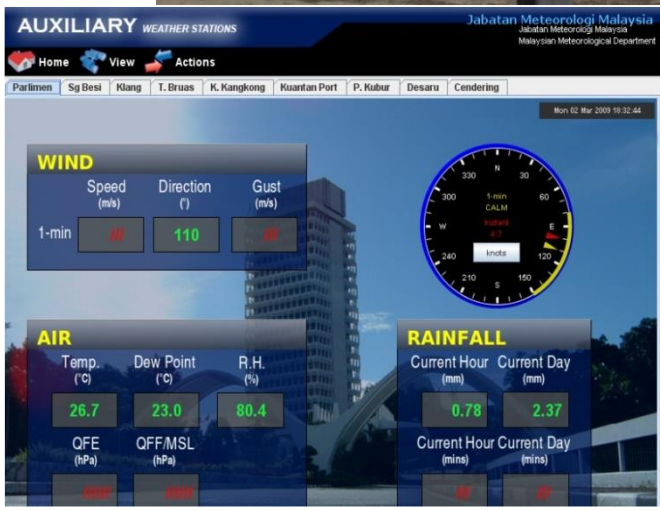
METEOROLOGICAL STATION (45)

UPPER AIR STATION (8)

WEATHER CAMERA STATION (17)

RADAR STATION (12)

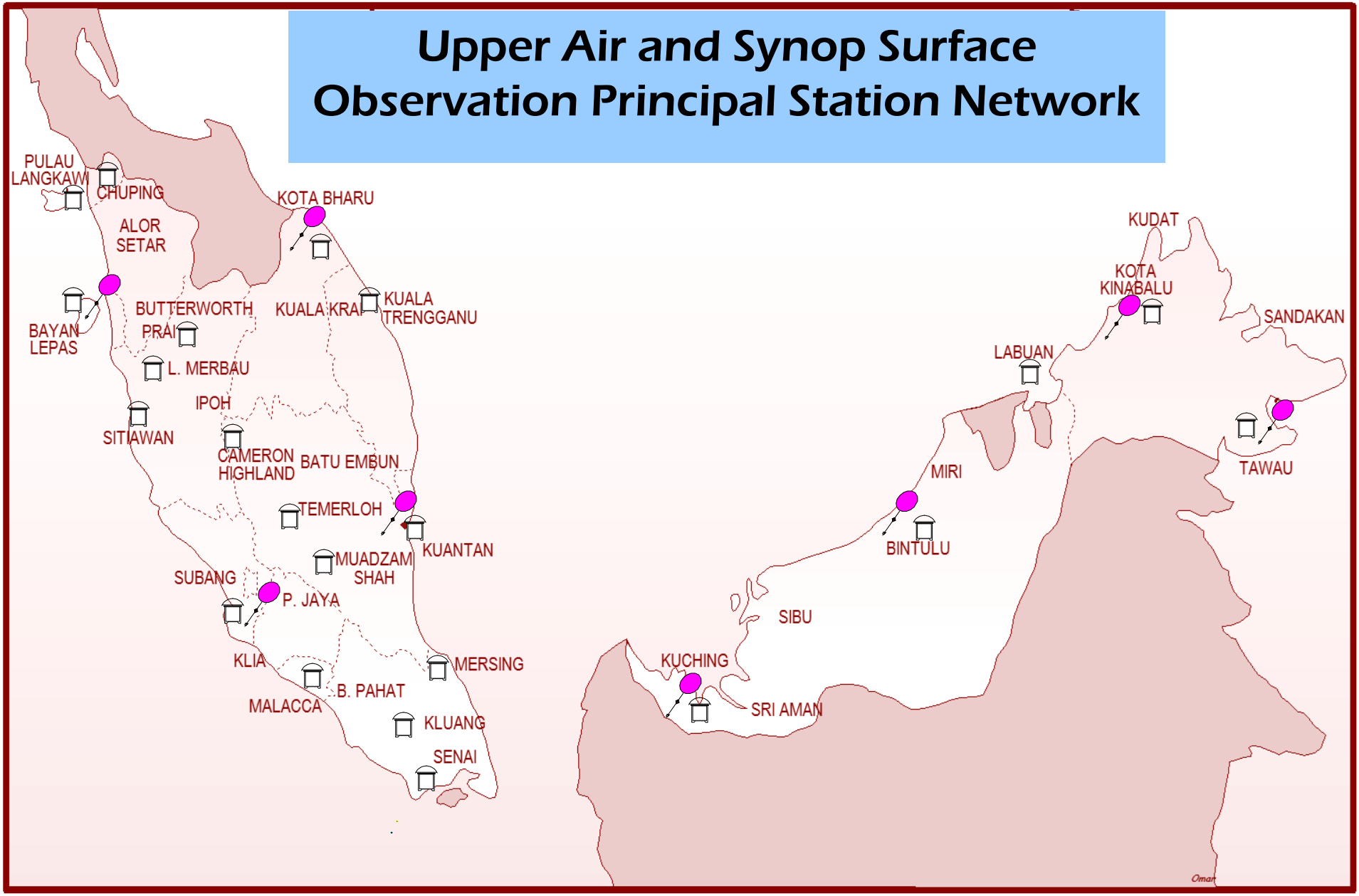
GROUND RECEIVING STATION (1)



AUXILIARY STATIONS(339)

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

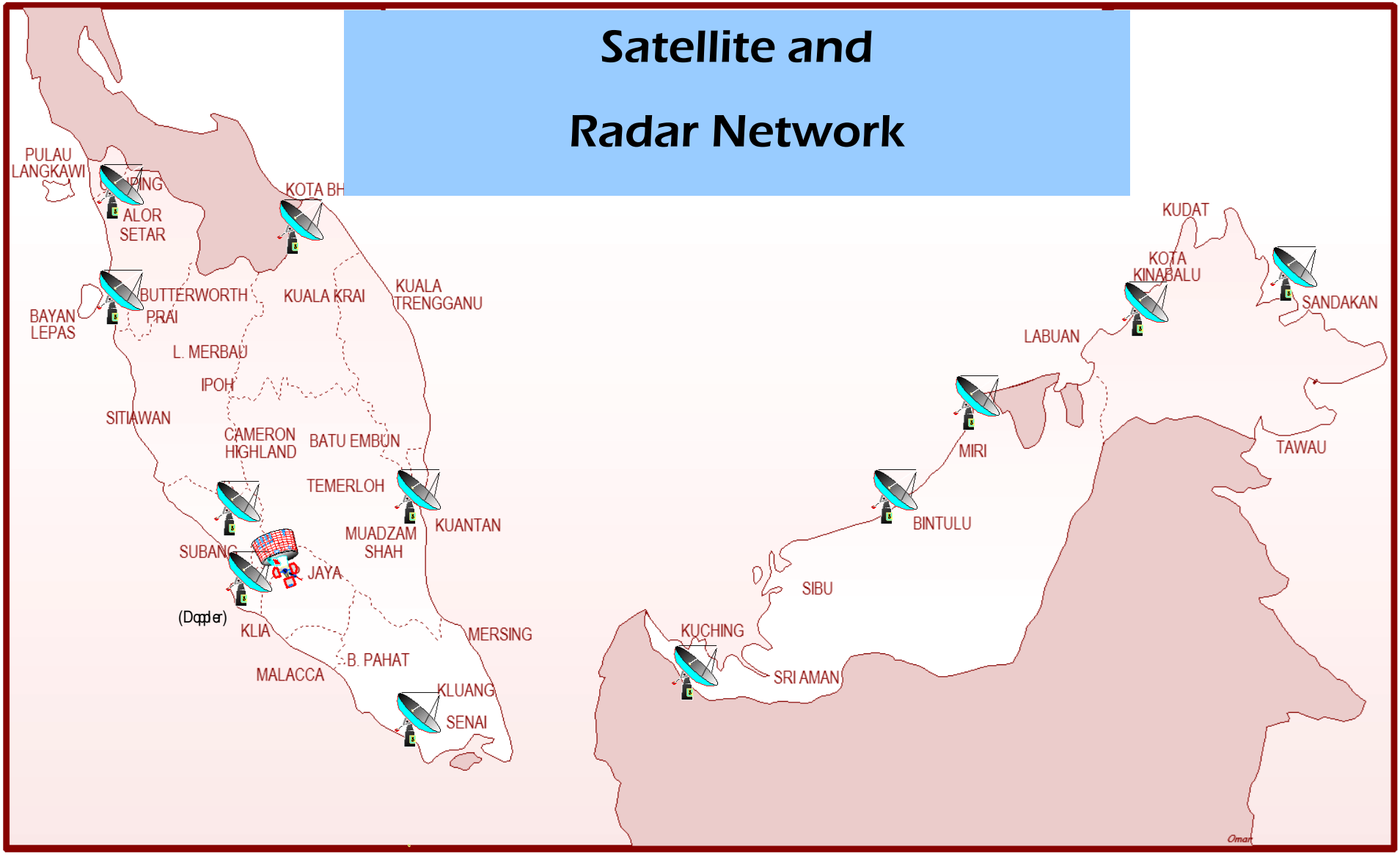
Upper Air and Synop Surface Observation Principal Station Network



Upper Air Station (8)

Principal Synop Surface Observation Station (22)

Satellite and Radar Network



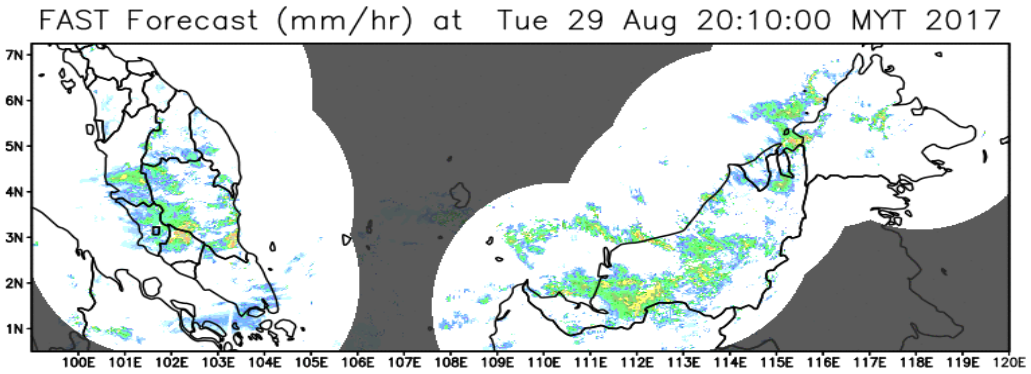
Satellite Satation (1)

Radar Station (12)

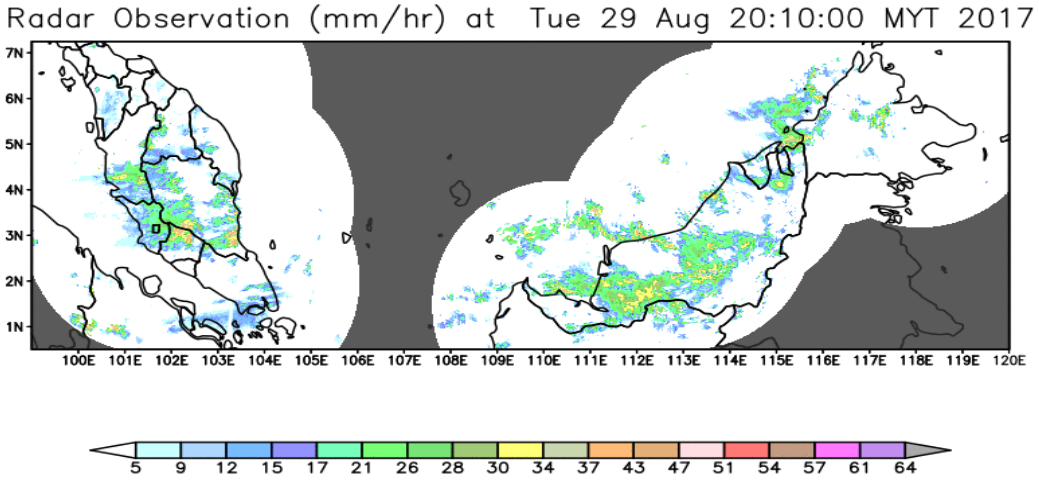
Radar Observation Coverage with nowcasting system from HKO (SWIRLS) → FAST

MALAYSIA TUE 29 AUG 2017 8PM – 11 PM NOWCAST

NOWCAST

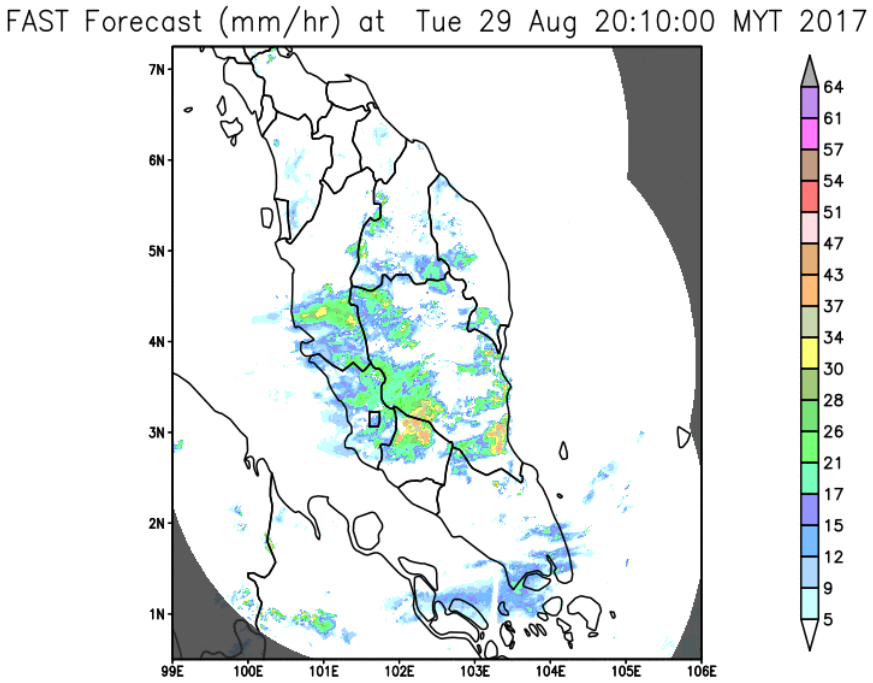


OBSERVED



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

NOWCAST



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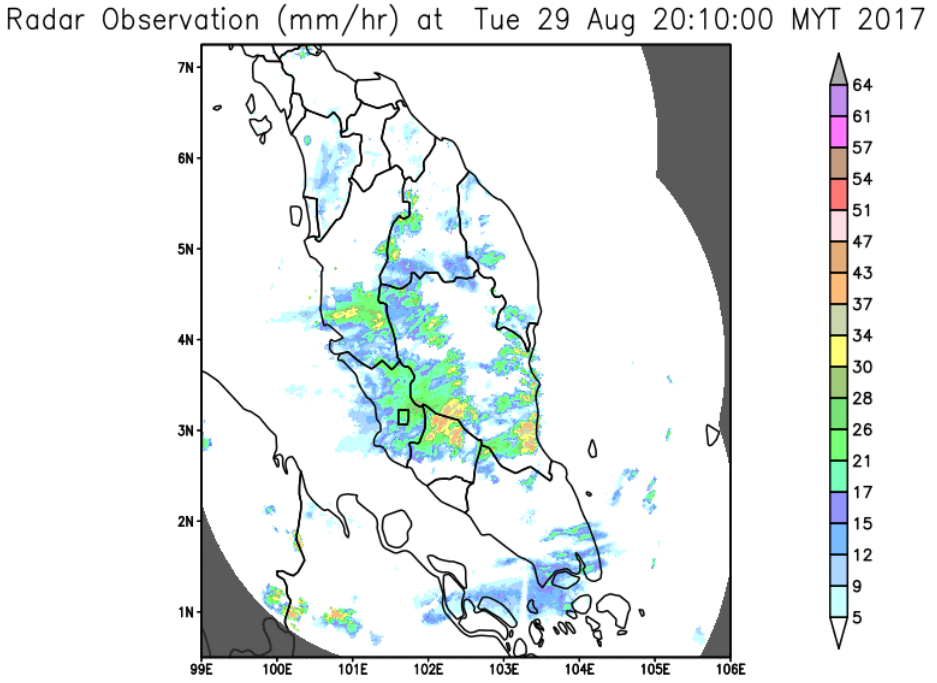
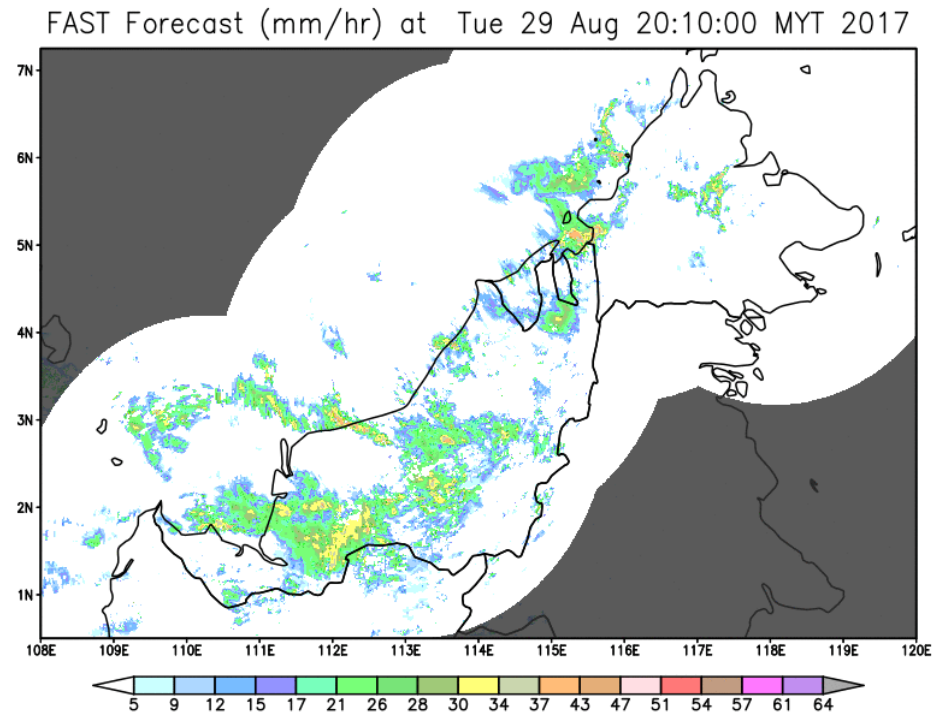
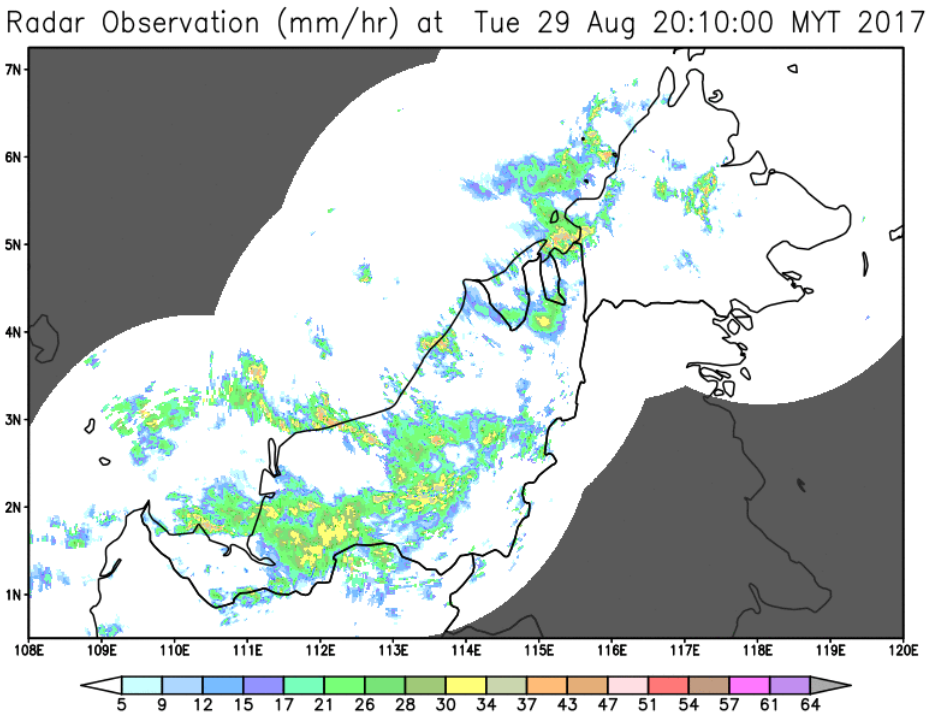


SARAWAK/SABAH TUE 29 AUG 2017 8PM – 11 PM NOWCAST

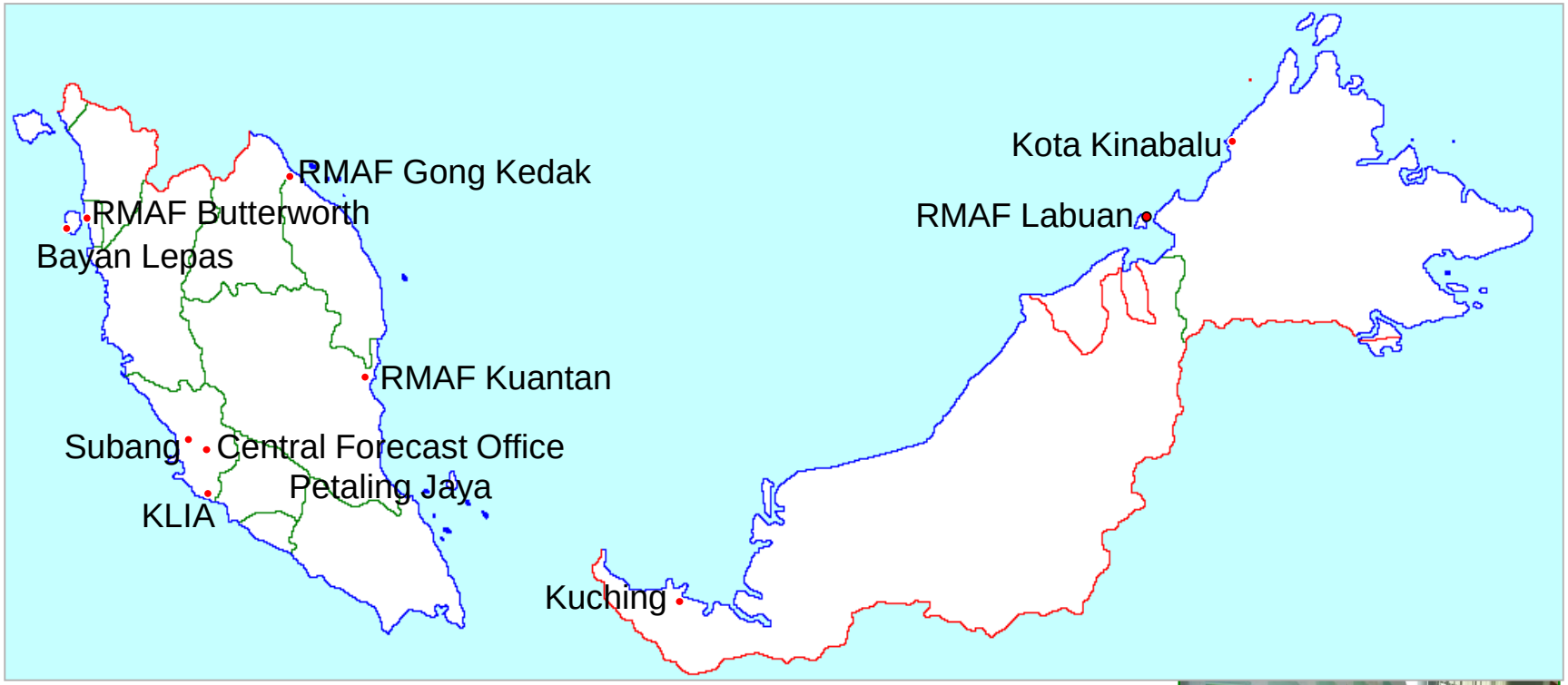
NOWCAST



OBSERVED



Main Meteorological Offices (10)



KLIA Meteorological Office

Central Forecasting Office

Gong Kedak Meteorological Office

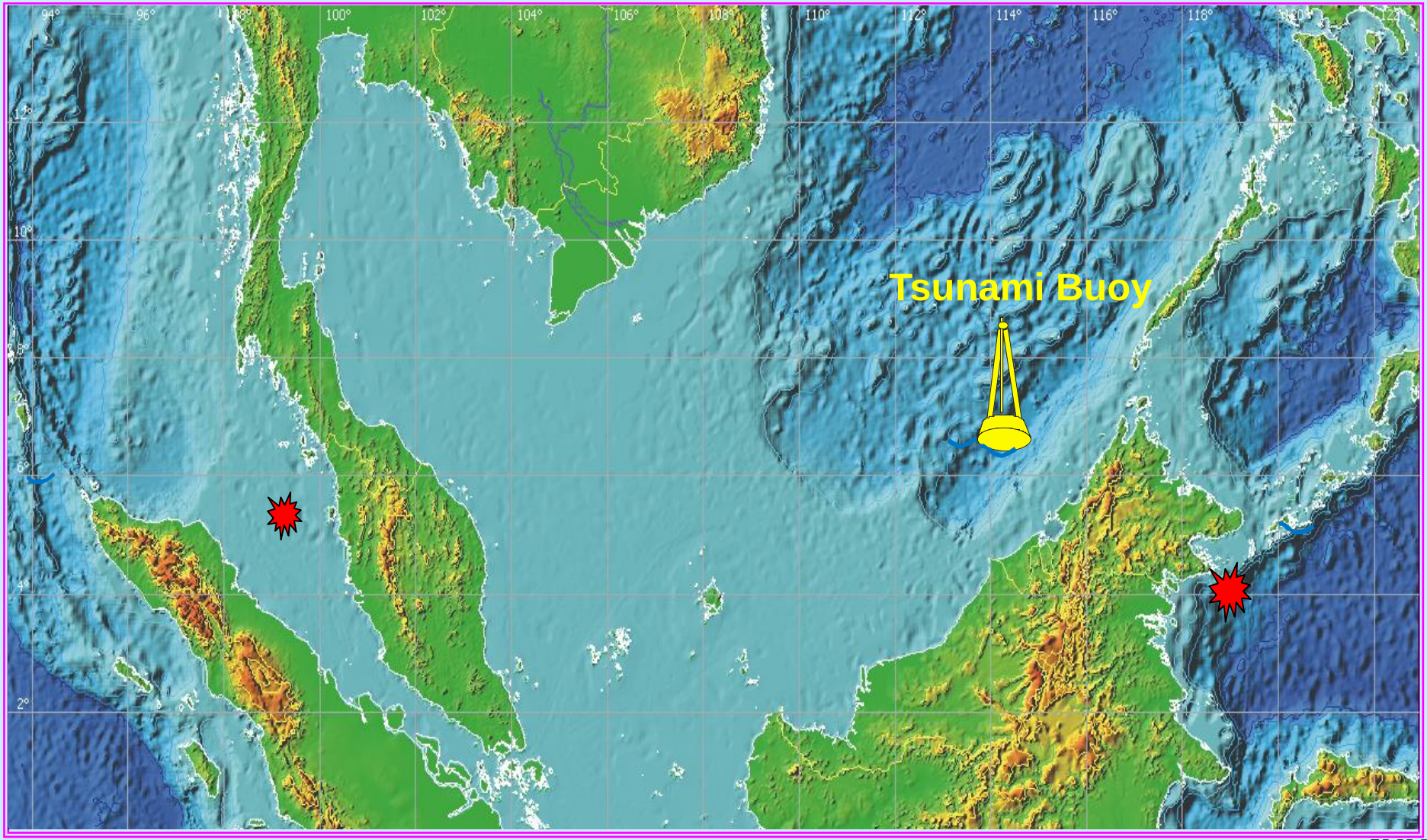
Marine Observational Network

- 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

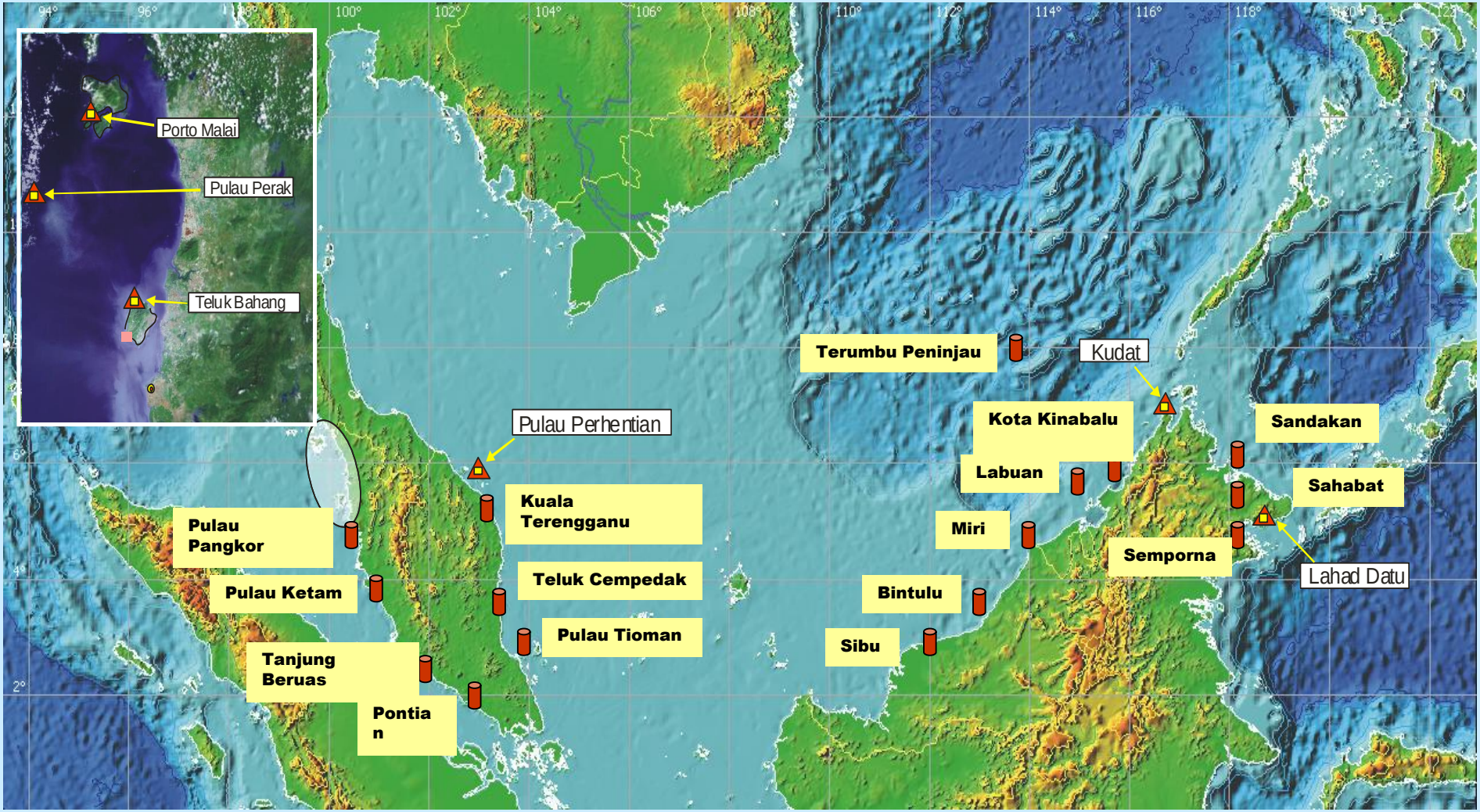
- Voluntary Observing Ship (VOS)

Tsunami Buoy



JMM

Tide Gauge Network



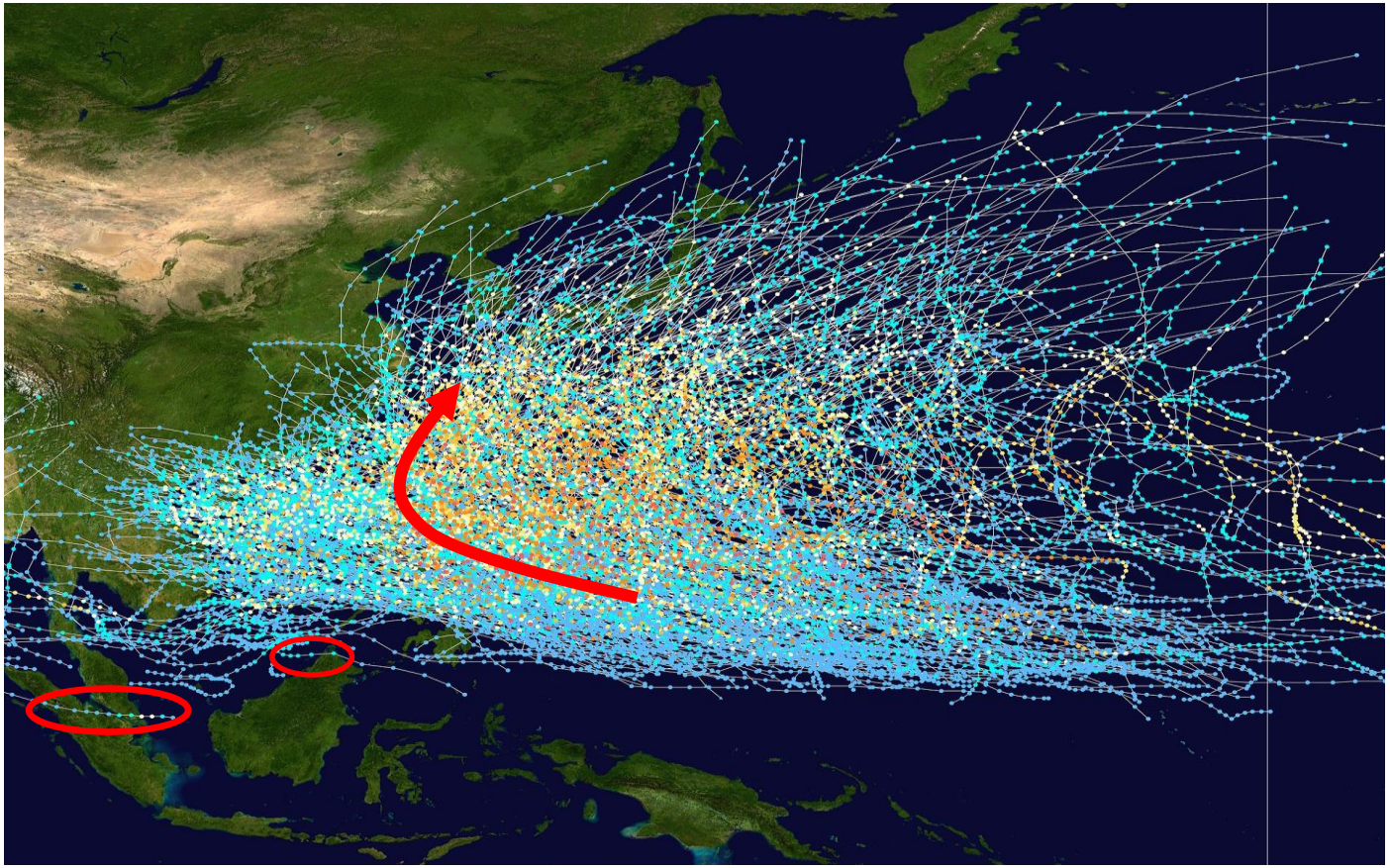
JMM

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

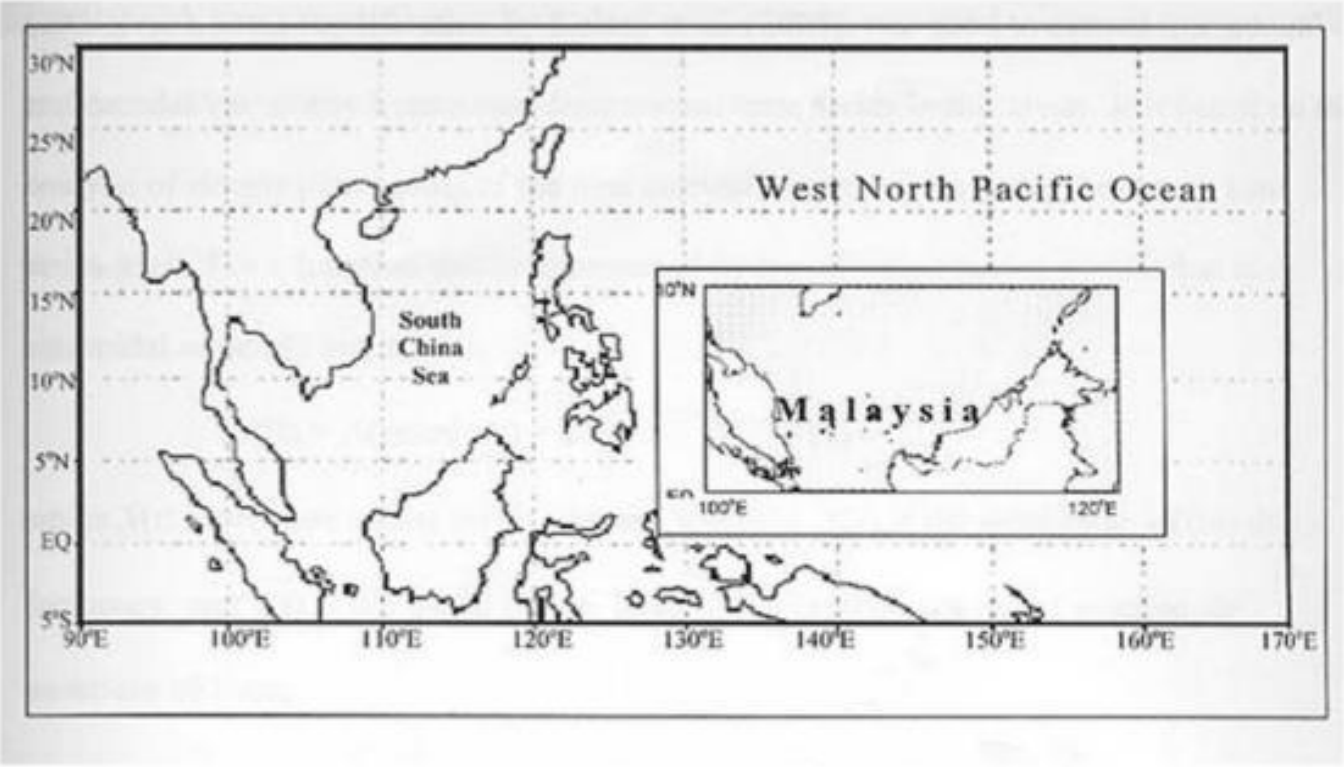
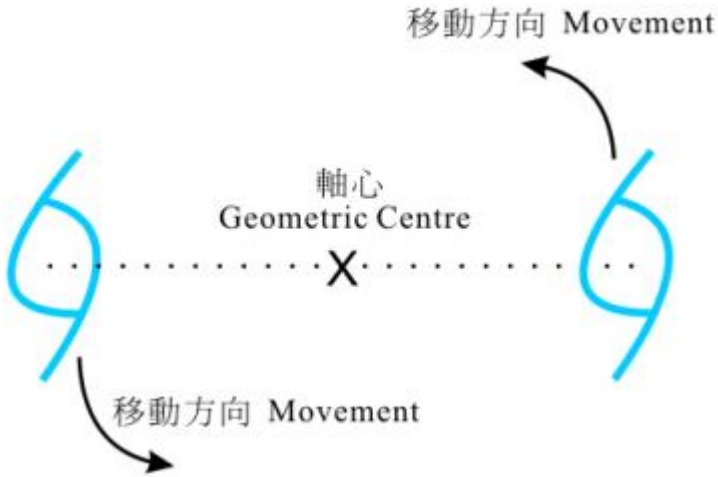


Figure 1. A map of the South China Sea and part of the west North Pacific Ocean. A map of the study area and Malaysia are indicated in the inset.

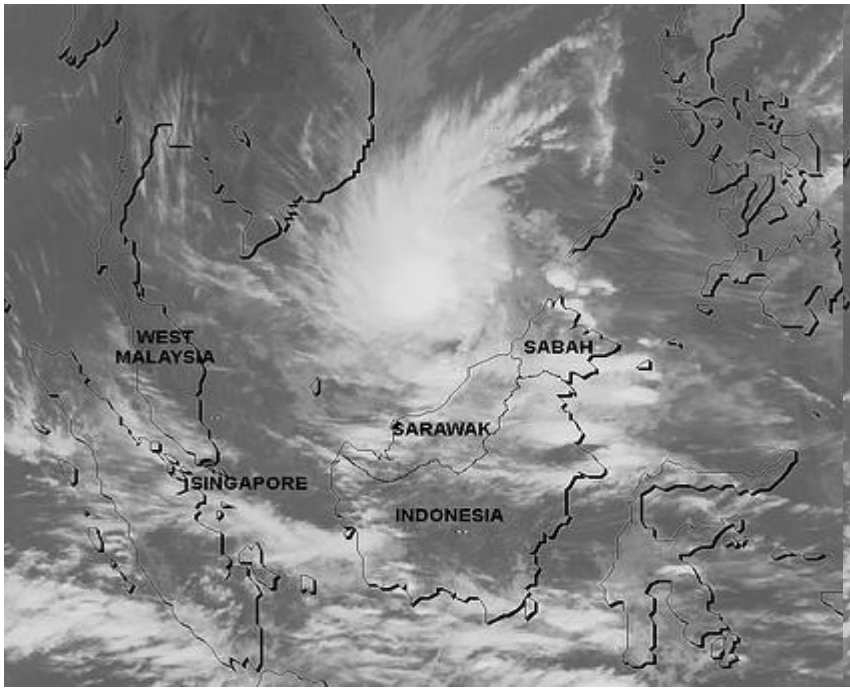
- Formed in the South China Sea as TD on Dec 21
- Headed east-southeastward, strengthened into the final TS on the 24th
- After reaching a peak of 45 knots winds it crossed the northern part of Borneo on the 25th.
- Continued east-southeastward until dissipation on the 27th, south of the Philippines

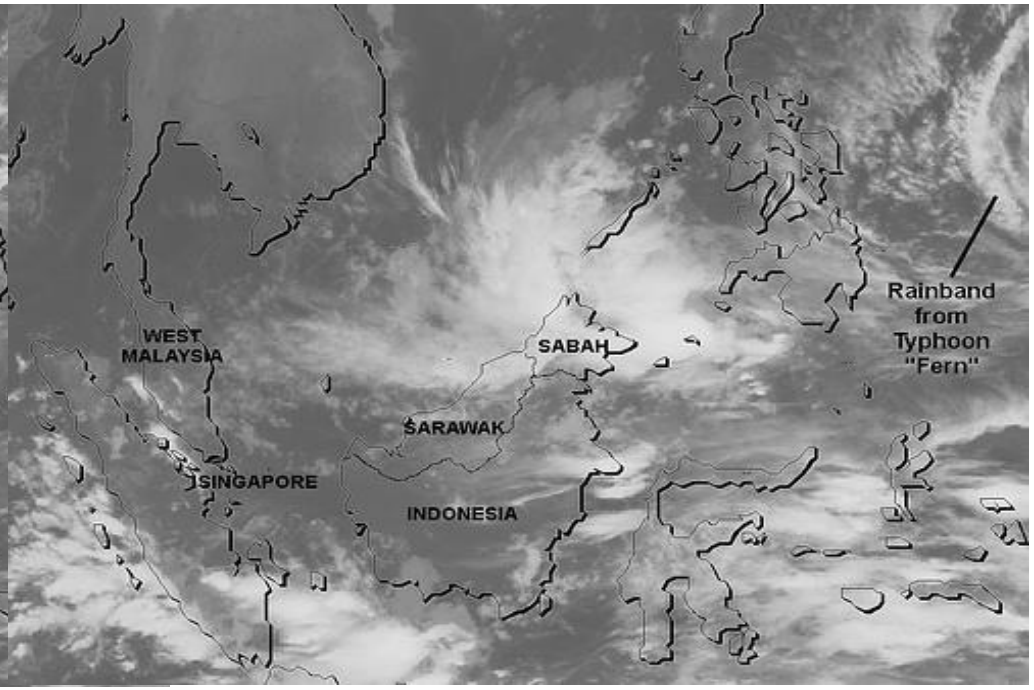
- Caused flooding and severe mudslides in Sabah
- Leaved more than 4,000 people homeless
- Destruction of coral reefs
- Fatalities : **238 people**
- Damage : **$52 million USD**

TS Greg : What actually happened?



An example of Fujiwhara Effect between TS Greg and Typhoon Fern





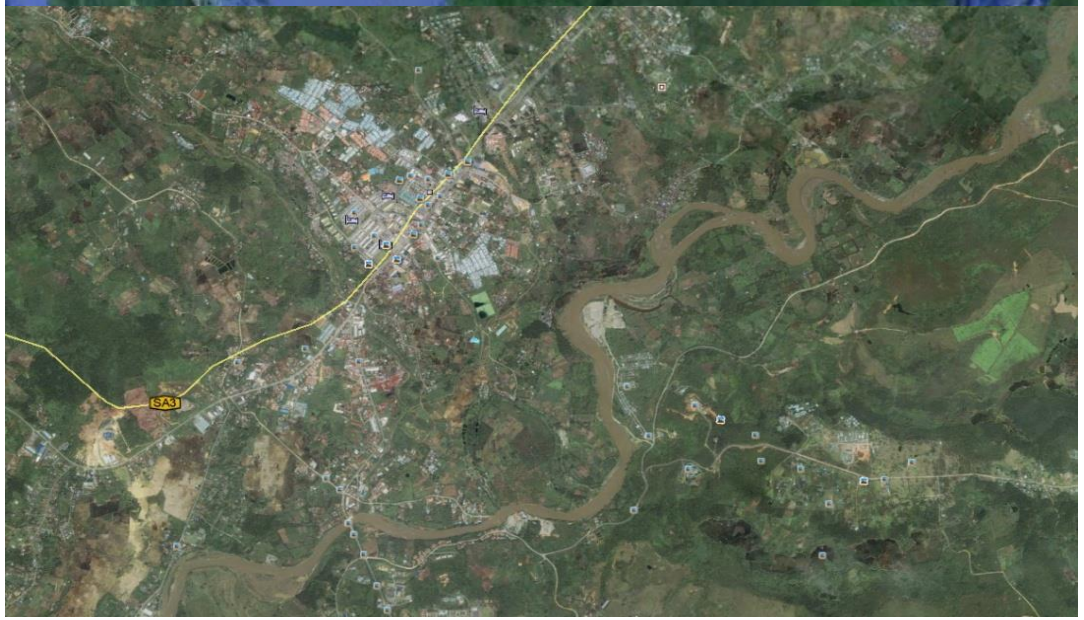
Impacts of Tropical Storm Greg

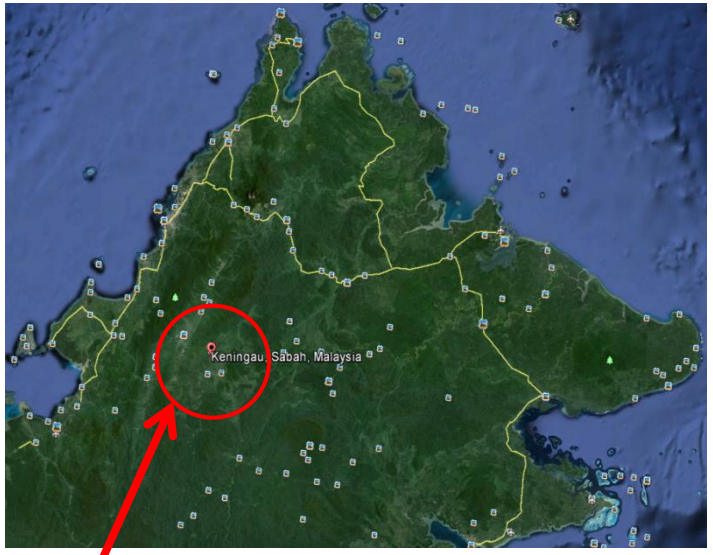
- TS Greg moved into Sabah at around 251600Z (**Christmas night**), depositing heavy rains that triggered floods and caused rivers to overflow their banks.

- 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)

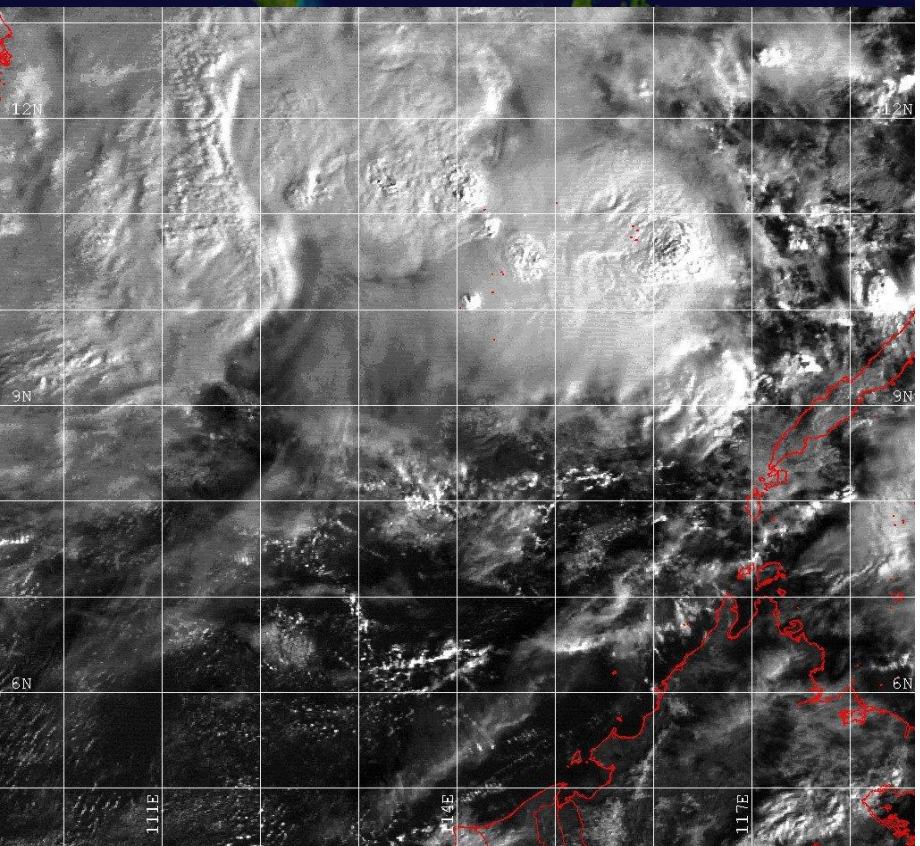
Heavy rain from Greg cause it to flood with enormous volume of water and mud.

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)

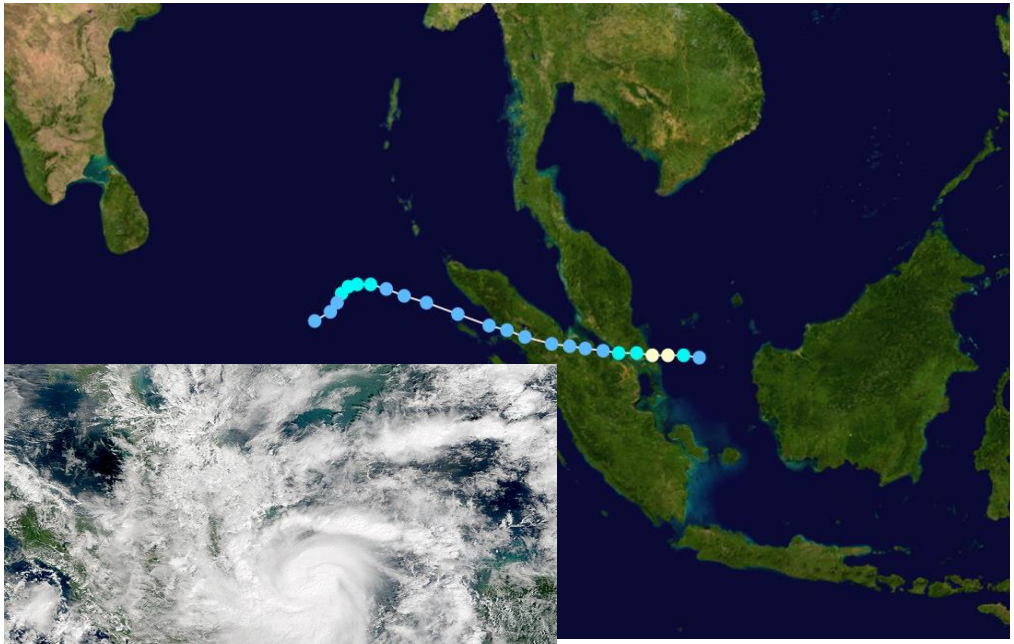


- **Stretched out from the NW Borneo coast early on Jan 4**
- **Developed into a TD and moved slowly to the north away from the Borneo coast, becoming TS Hilda early on Jan 6**
- **Tail effect to west coast of Sabah**

- **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

Five swept away by mudslide

By ZUHRIN AZAM AHMAD and LAM LI

PEKAN NANAS: Five people, including a mother and her three children, were swept away into a river during a mudslide at the foot of Gunung Pulai, late Thursday night.

Rescuers have so far recovered only one victim, Salina Abas, 34, some 500m away from her demolished house.

Johor Deputy CPO Senior Asst Comm 1 Abu Bakar Said said the woman's body was found at about 7.30am yesterday among piles of tree trunks and debris carried by the mudslide.

The search and rescue operation for the remaining missing victims continued up to late yesterday.

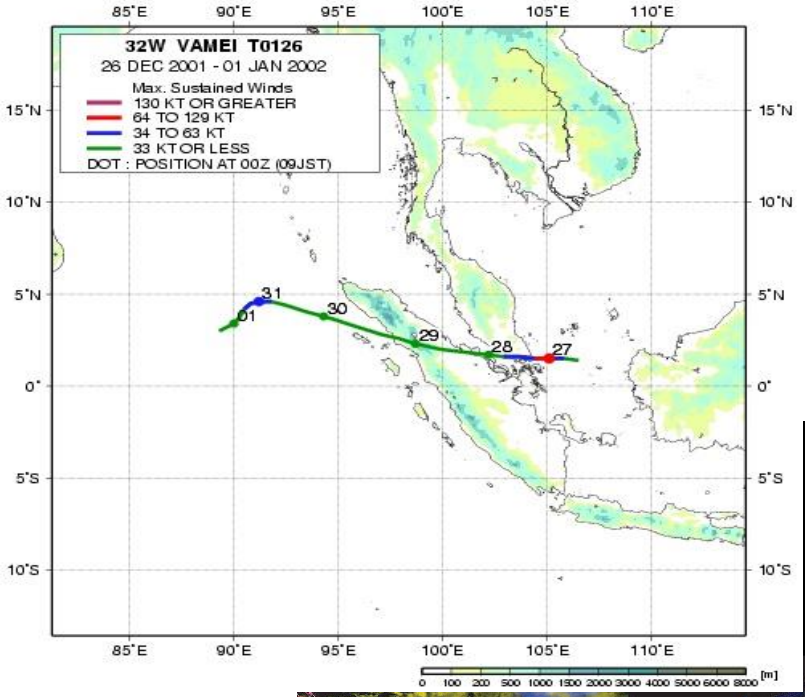
The missing are three of Salina's

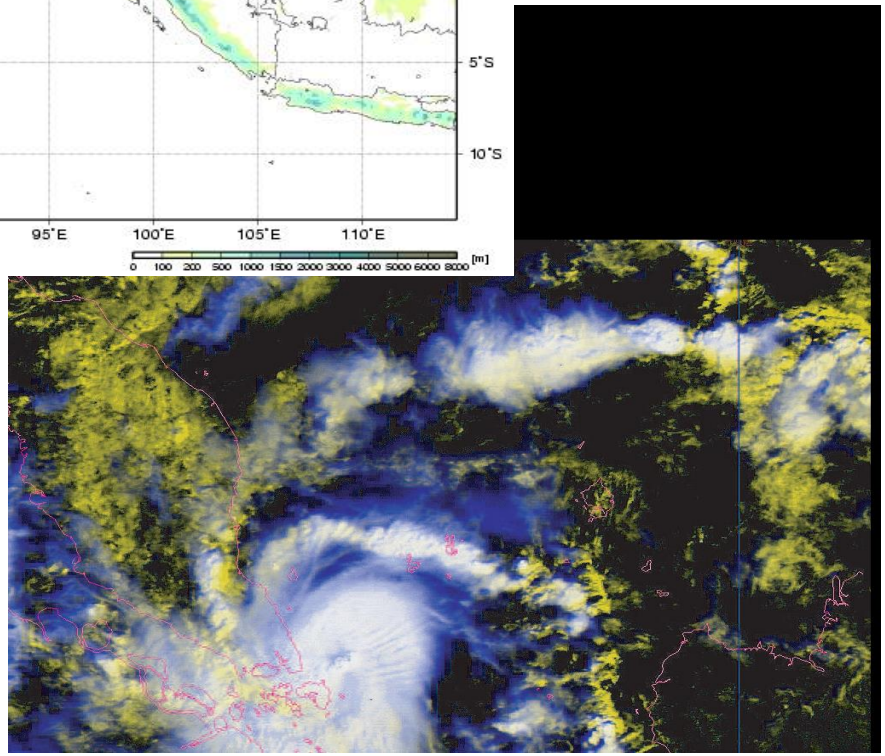
● TURN TO PAGE FOUR

TOUGH TASK ... search and rescue team members going through logs and other debris washed down by a mudslide that occurred at the foot of Gunung Pulai near Pekan Nanas late on Thursday. — IBRAHIM MOHTAR

- 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?





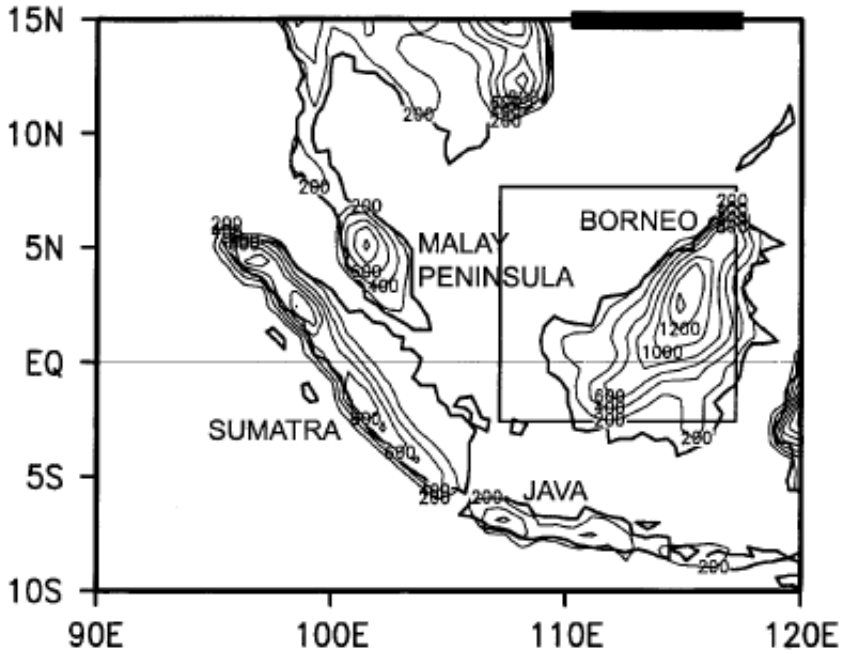
Satellite imagery of Typhoon Vamei on 27th December 2001

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

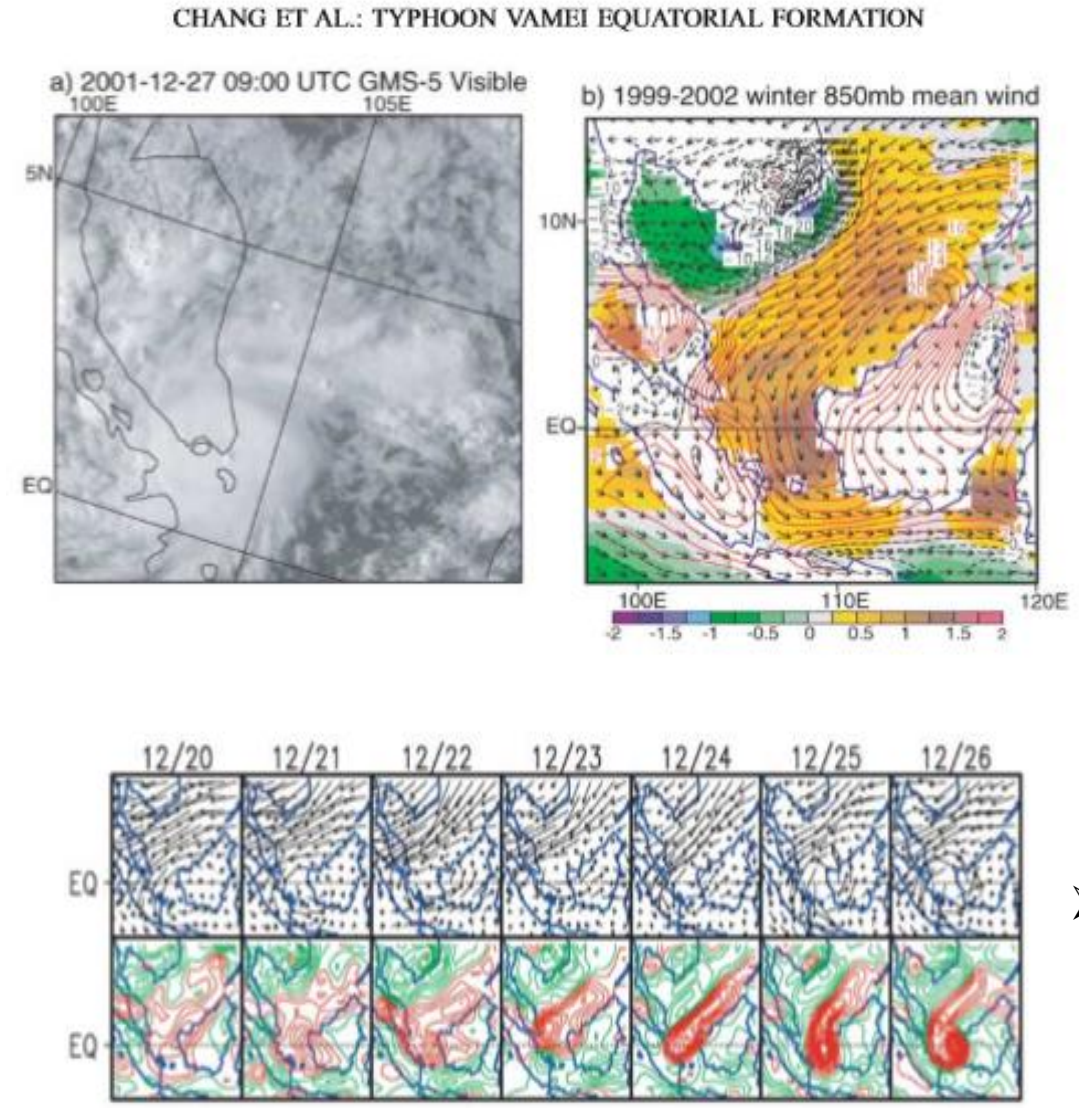
Was the first recorded within 1.5 degree of the equator

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).*



NOGAPS 1° × 1° 850 hPa wind and vorticity (red positive, green negative) at 00 UTC 20–26 December 2001

- 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**.

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)

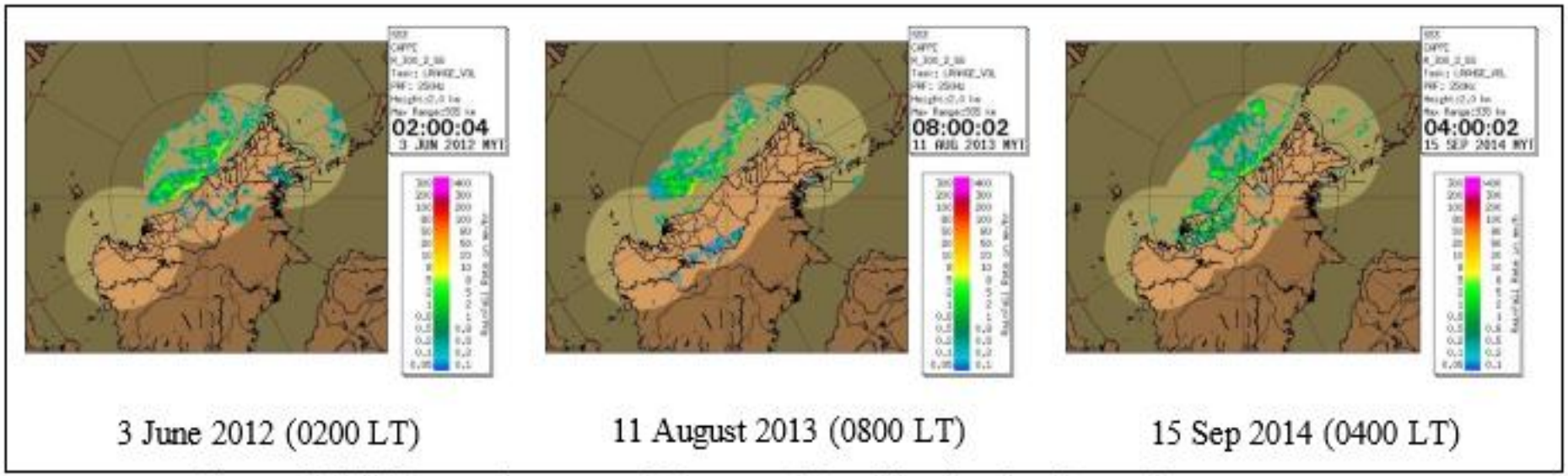


Figure 6: BSLTCs over the waters off Borneo as inferred by the radar observations

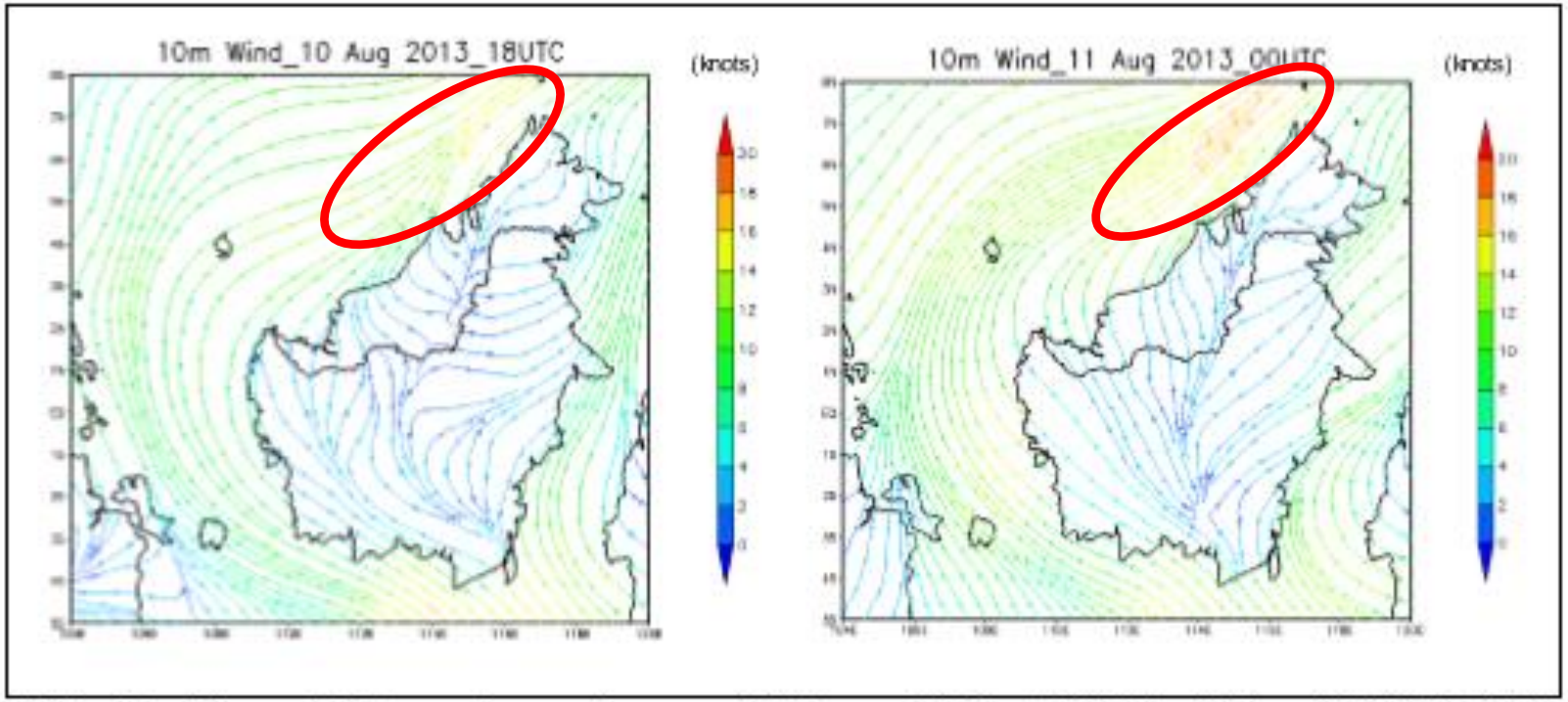


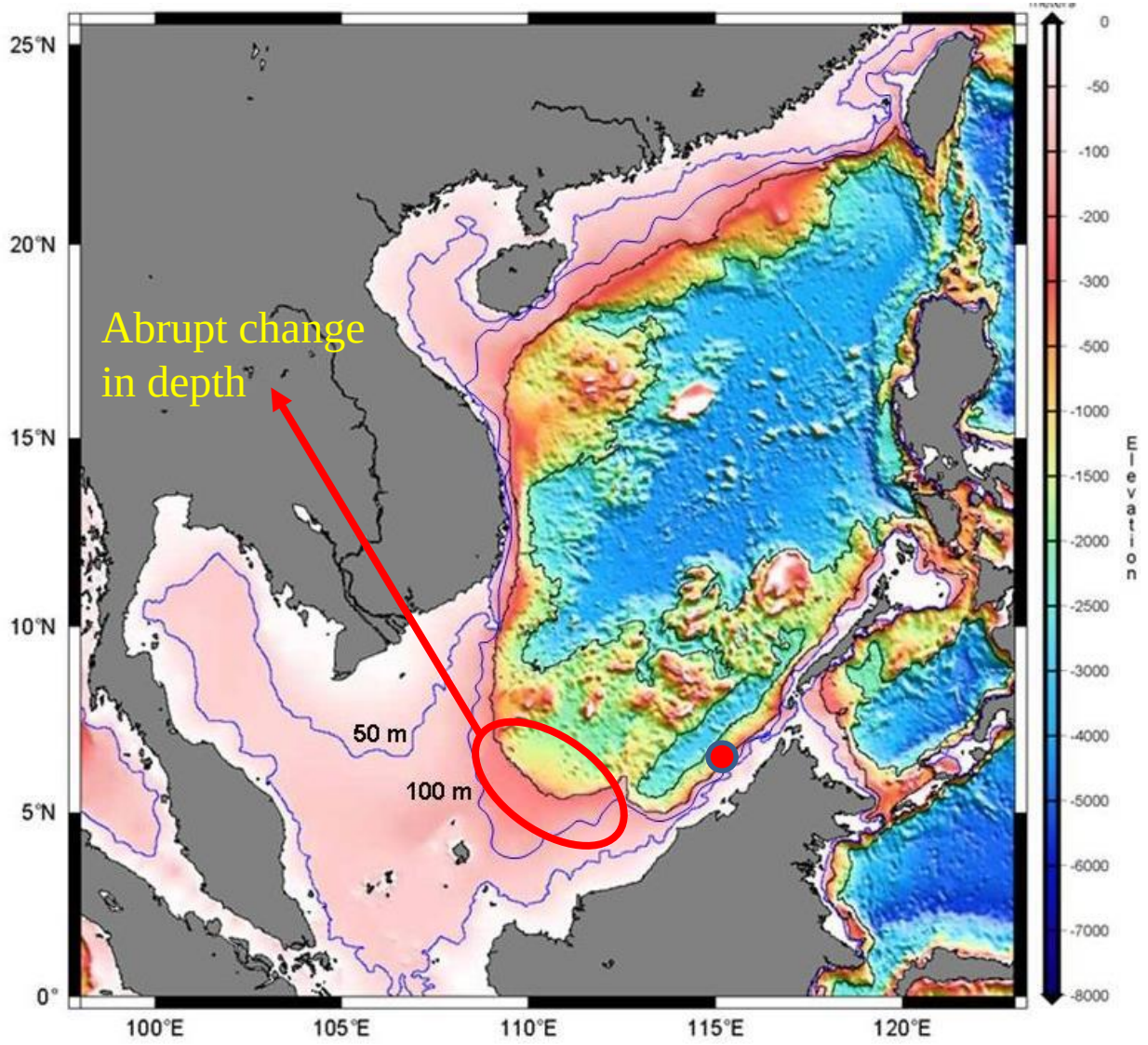
Figure 9(i): The 10-m wind streamline analyses on 11 August 2013 at 0200LT (left) and 0800LT (right) over Borneo represented the synoptic features of BSLTC. Present synoptic system, Typhoon Utor (location at 0800LT: Latitude: 14.5^{0}N, Longitude: 125.9^{0}E, with maximum wind near the centre: 85 knots)

- 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

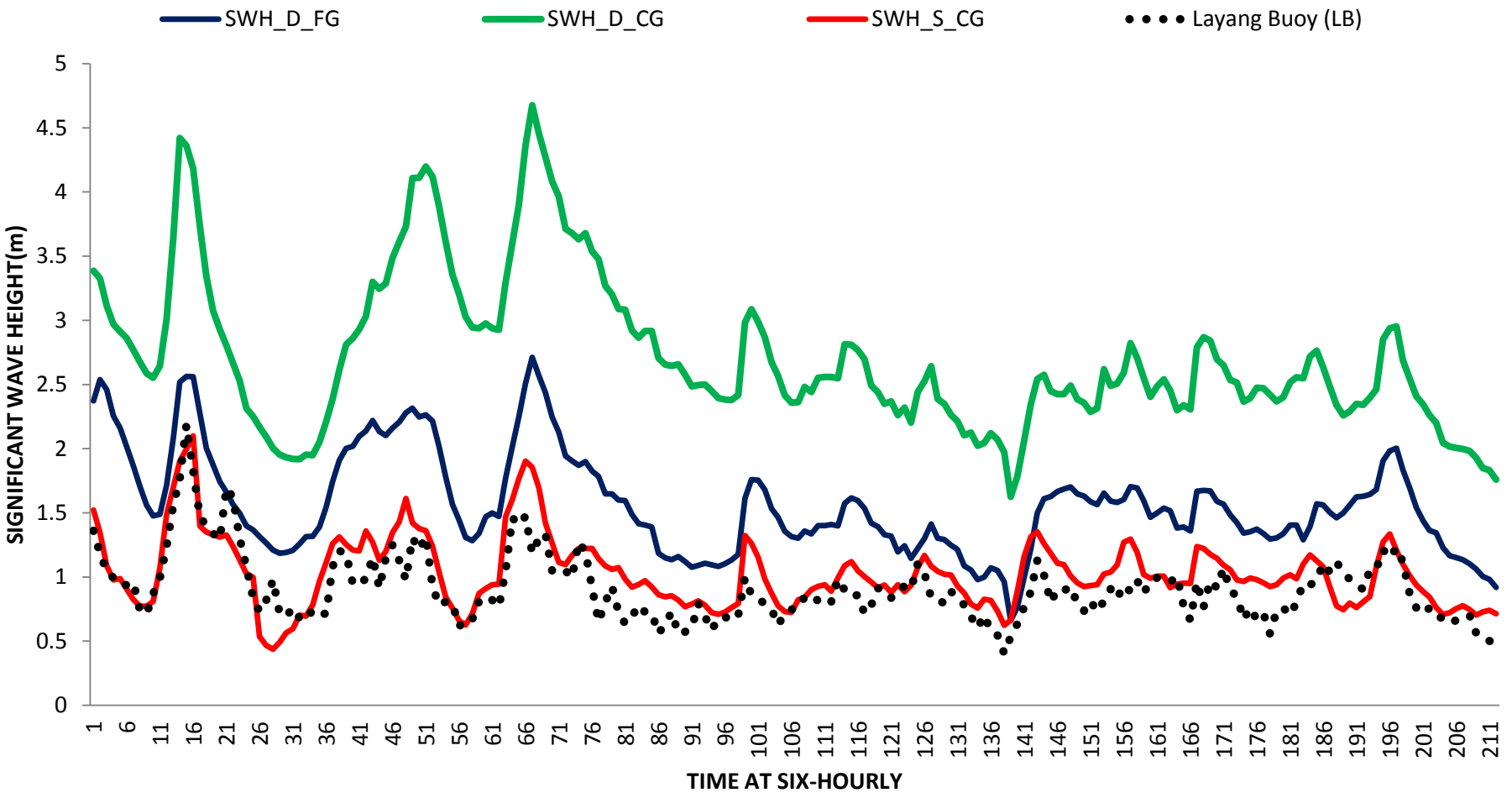
Bathymetry over SSCS



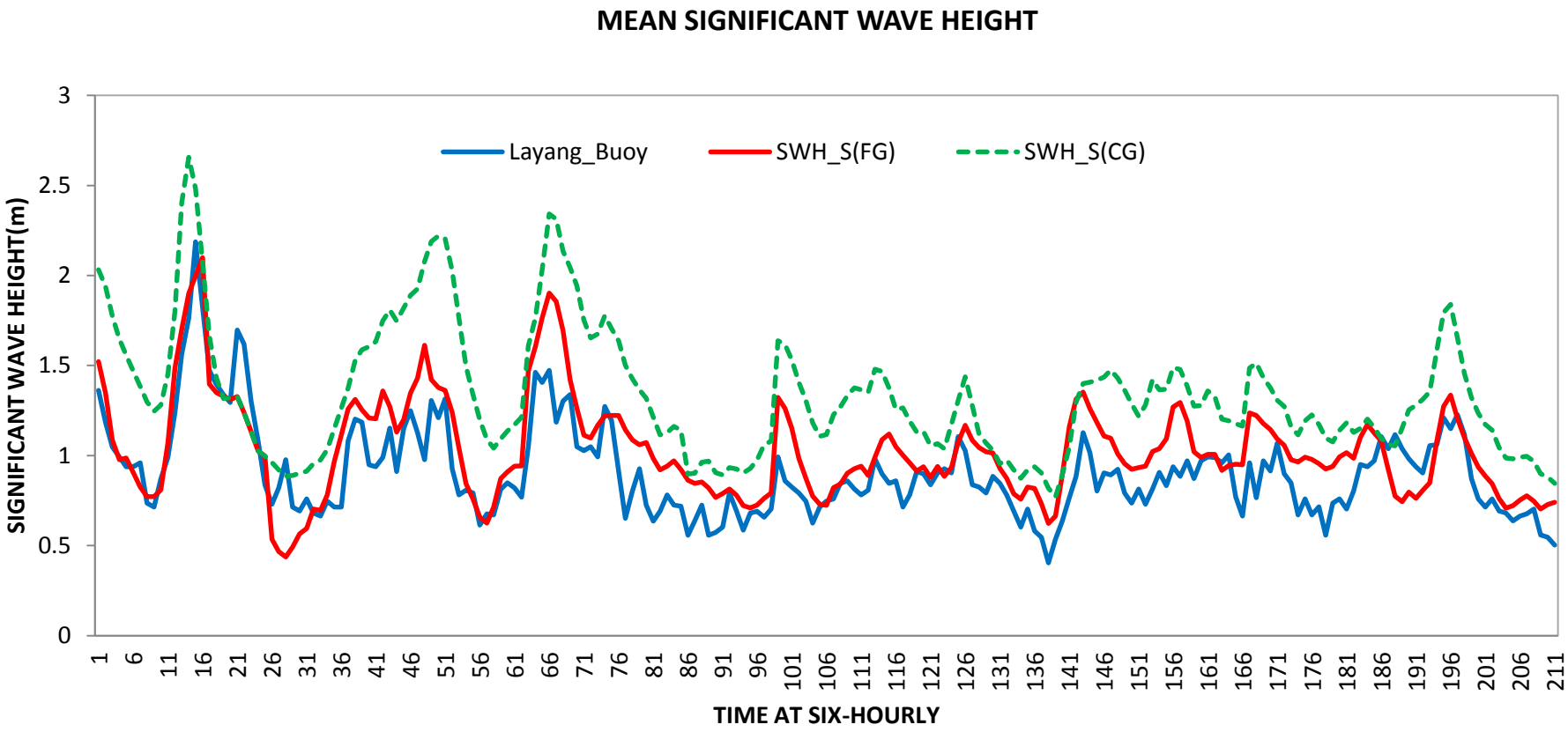
- **Wind generally light**
- **Complex bathymetry**
- **Not enough to generate high seas/swell**
- **TC cross over to West Philipines will be good for ：**
  - ✓ **Case study**
  - ✓ **Tuning wave model**

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

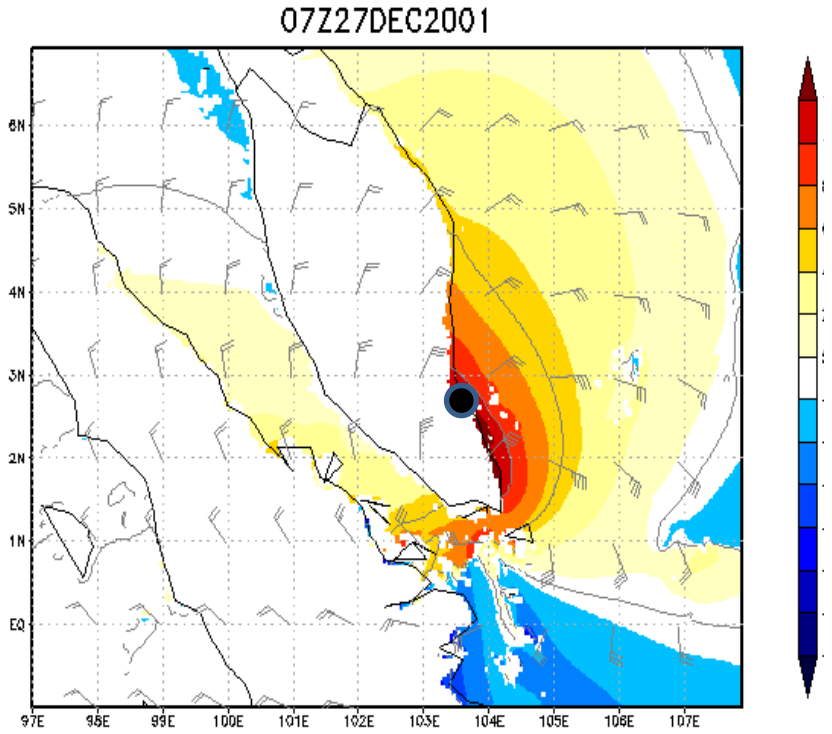


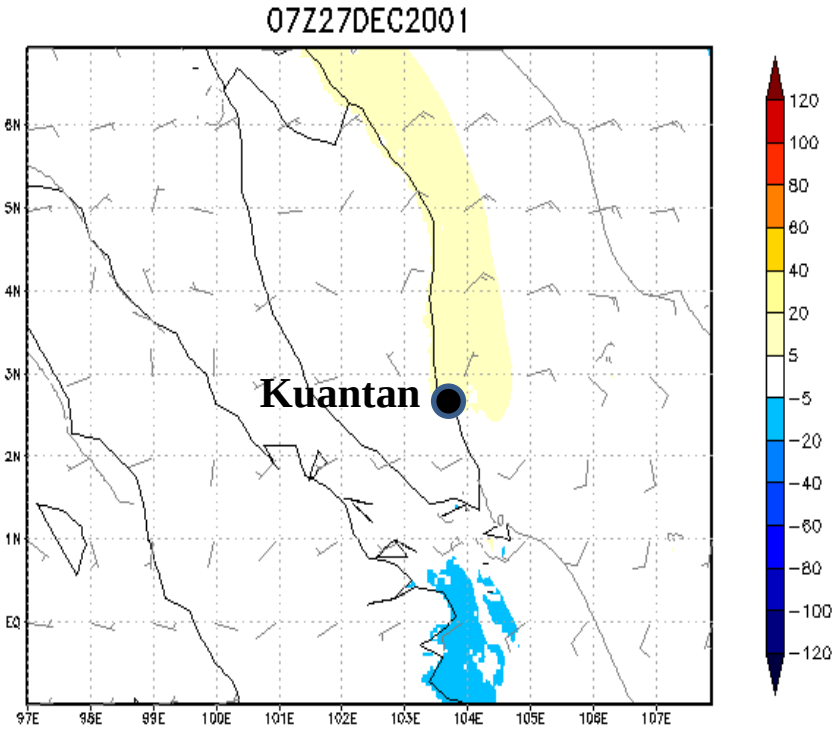
Fine grid simulation of JMA- MRI III_S wave model show better accuracy

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





Best Track

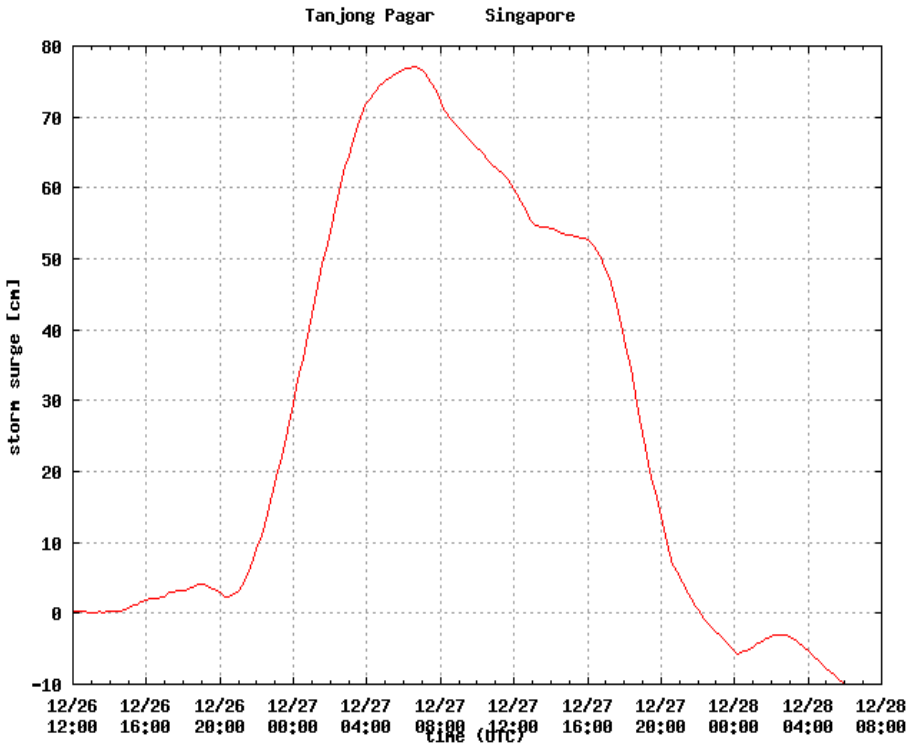
Parameterized wind

JMA GSM

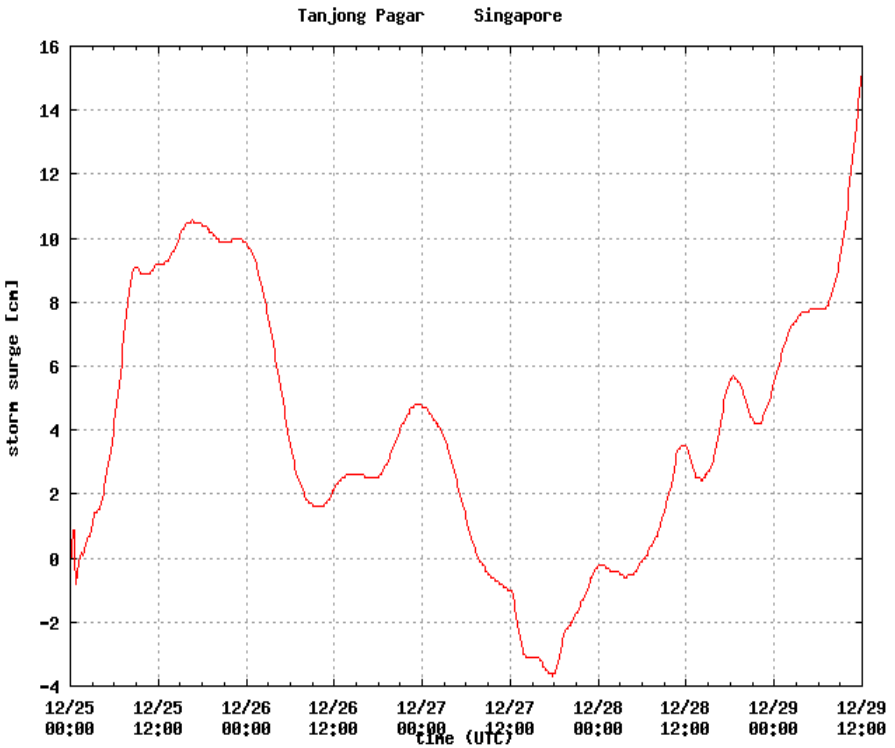
NWP wind field

Overestimation occurred for Best track input field – No topography effect

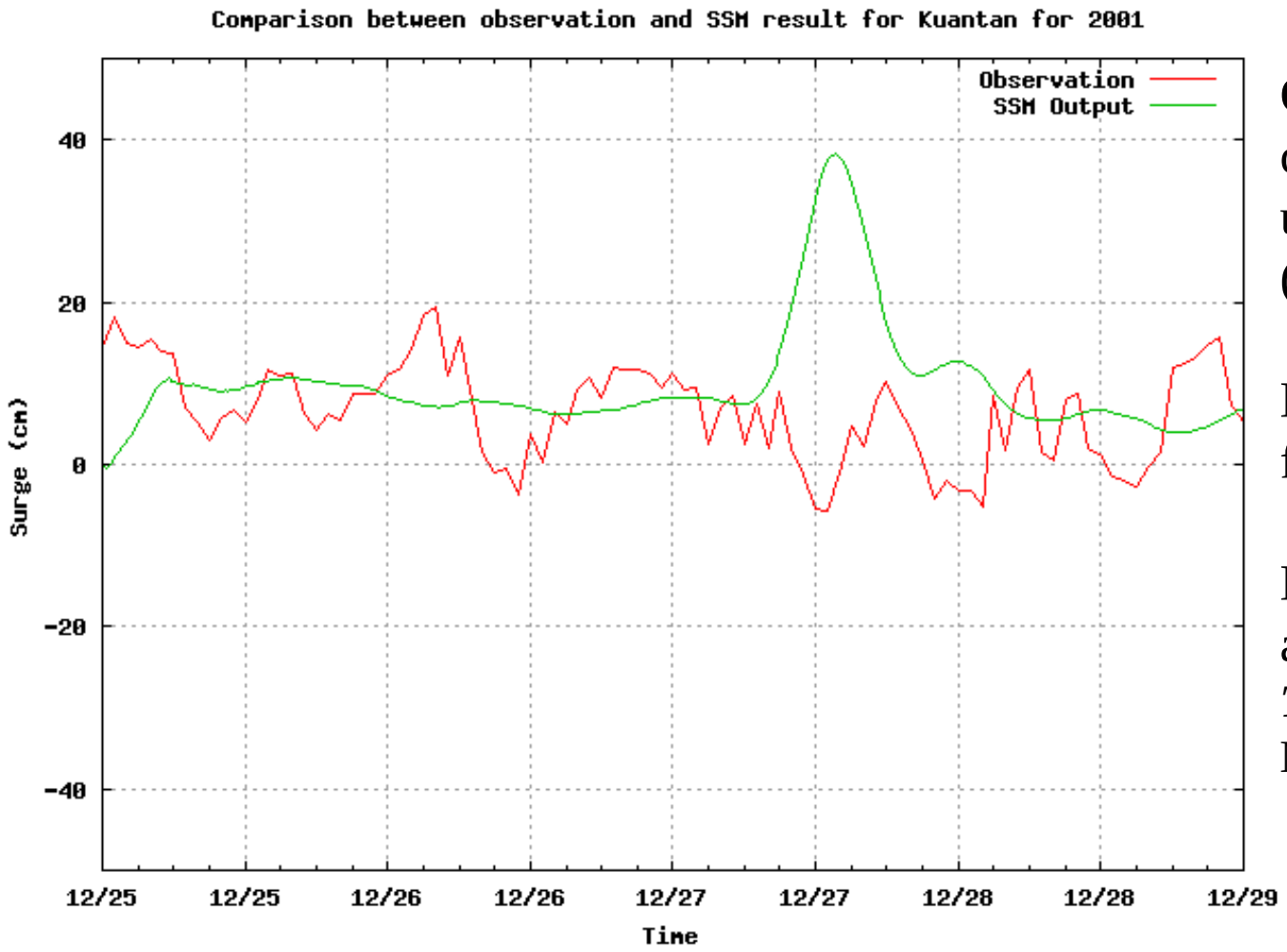
Typhoon Vamei – JMA-MMD Storm Surge Model Time series



Best Track



JMA GSM



Overestimation occurred for simulation using track data (RSMC)

NWP wind and pressure forcing is more realistic

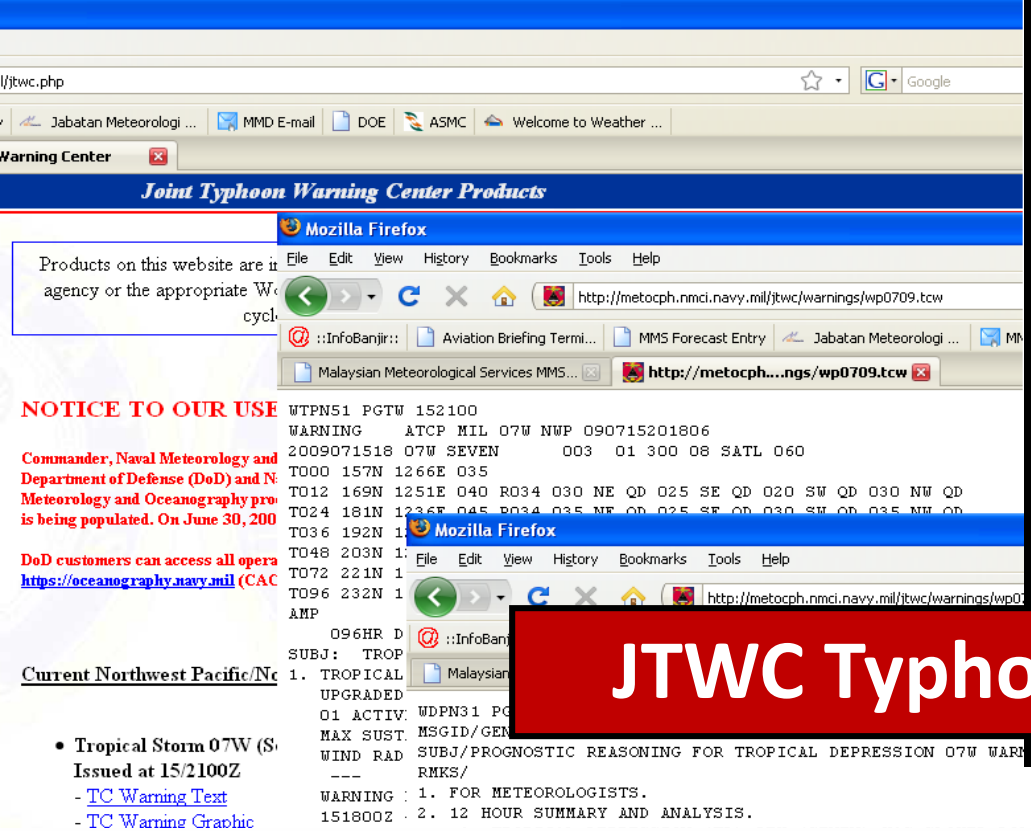
Need to improve NWP atmospheric field : ***Typhoon bogussing*** in MMD mesoscale model?

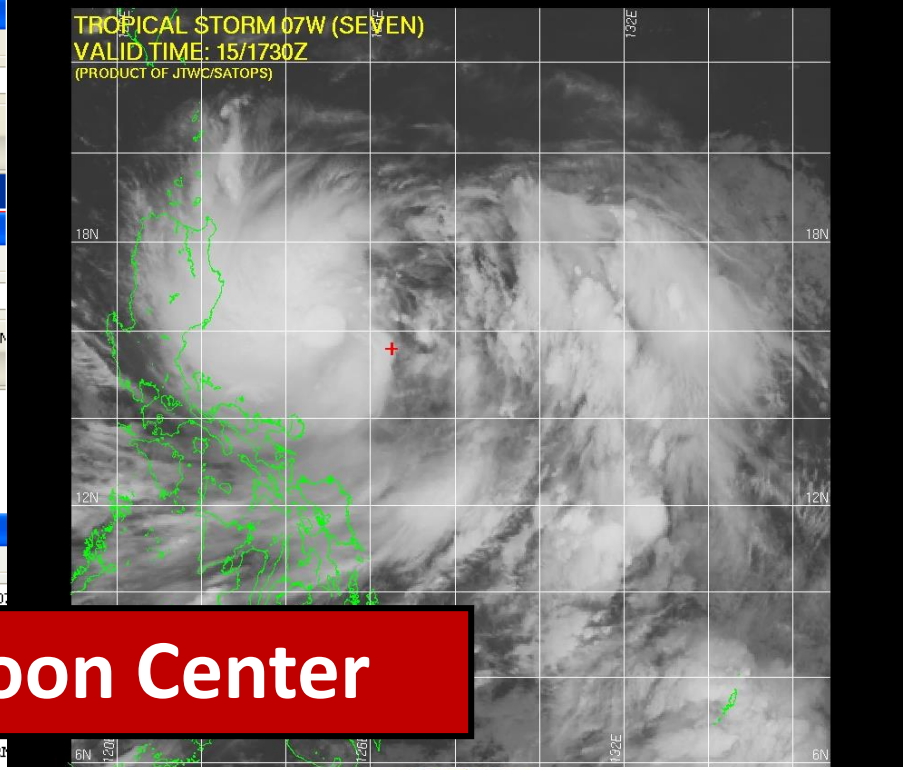
Model output deviates from observation. Possible : over-estimate wind speed from NWP during Vamei ?

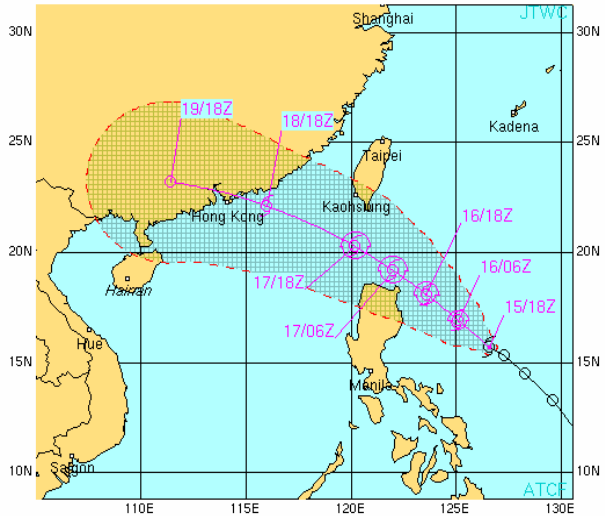
Stations show slower wind / no surge → Vamei was a typhoon during landfall ?

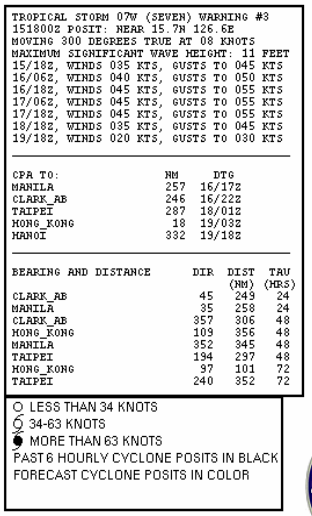
MONITORING AND EARLY WARNING SYSTEM

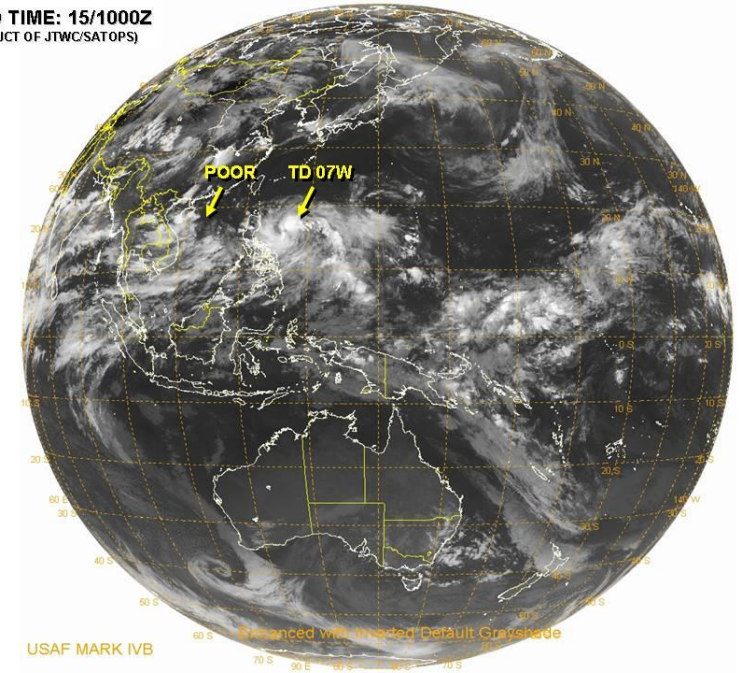
JTWC Typhoon Center



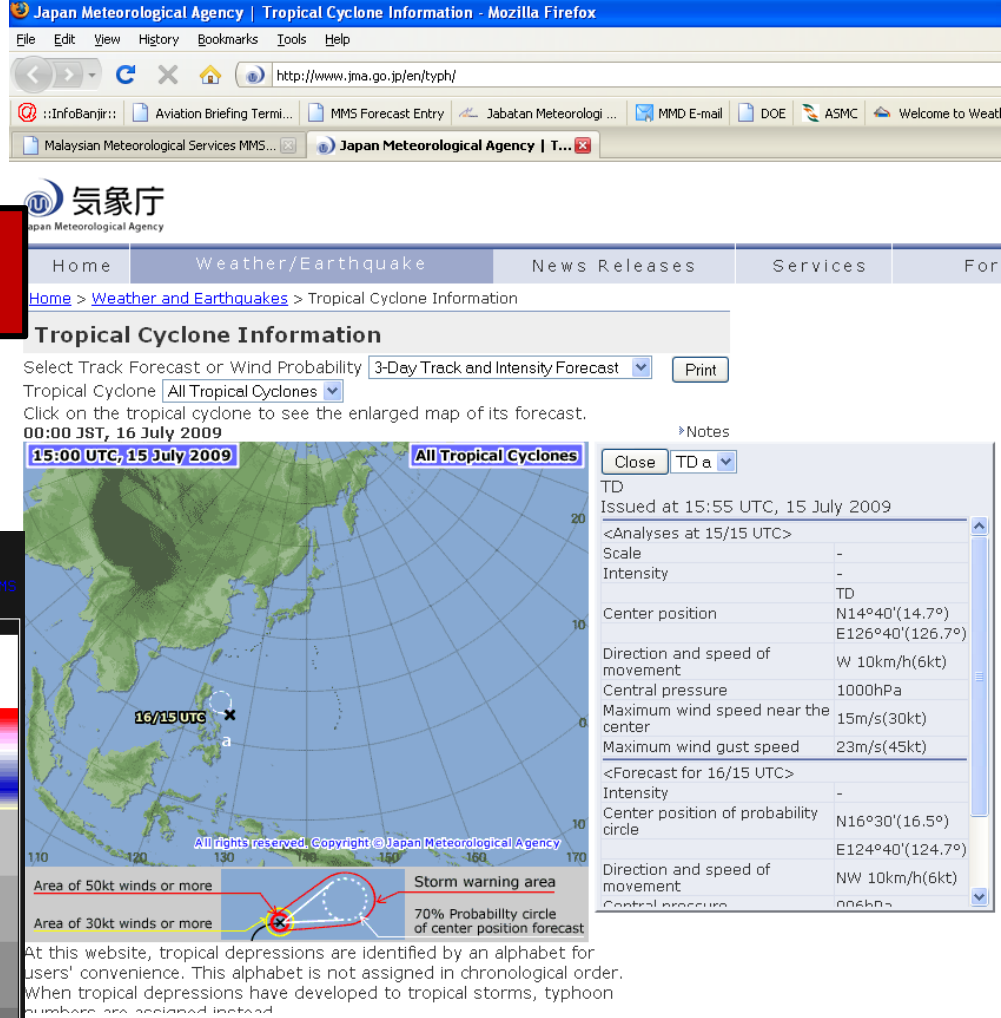


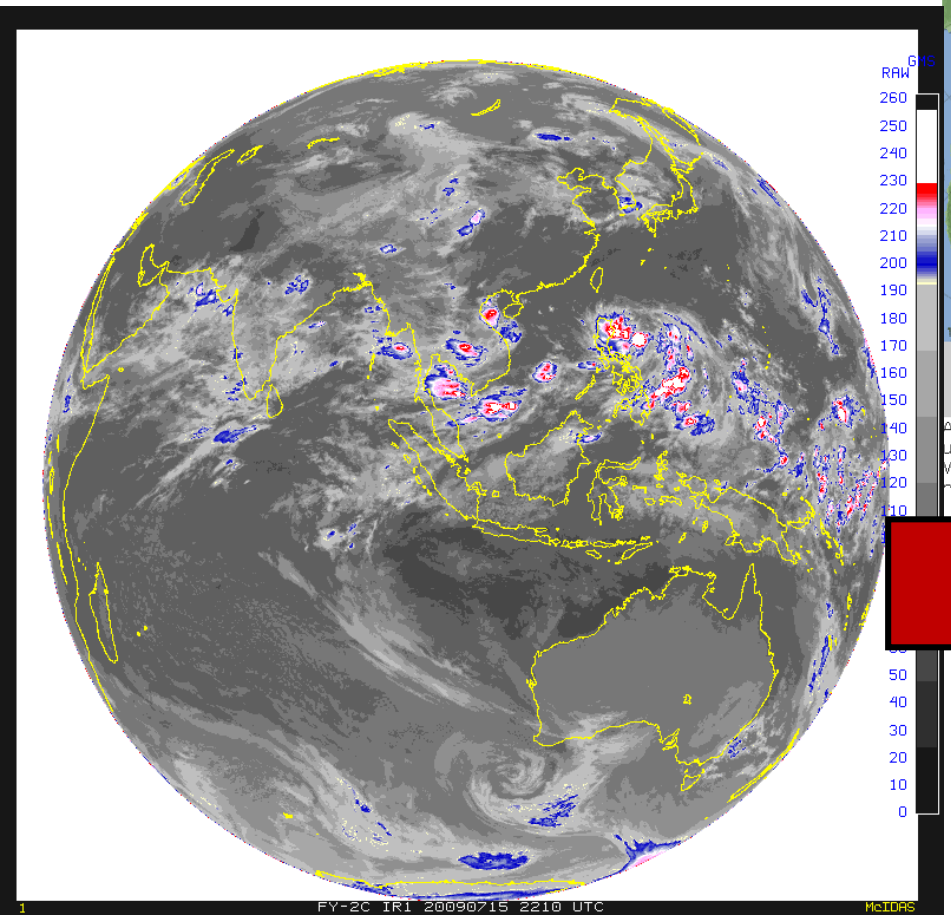






JMA Typhoon Track





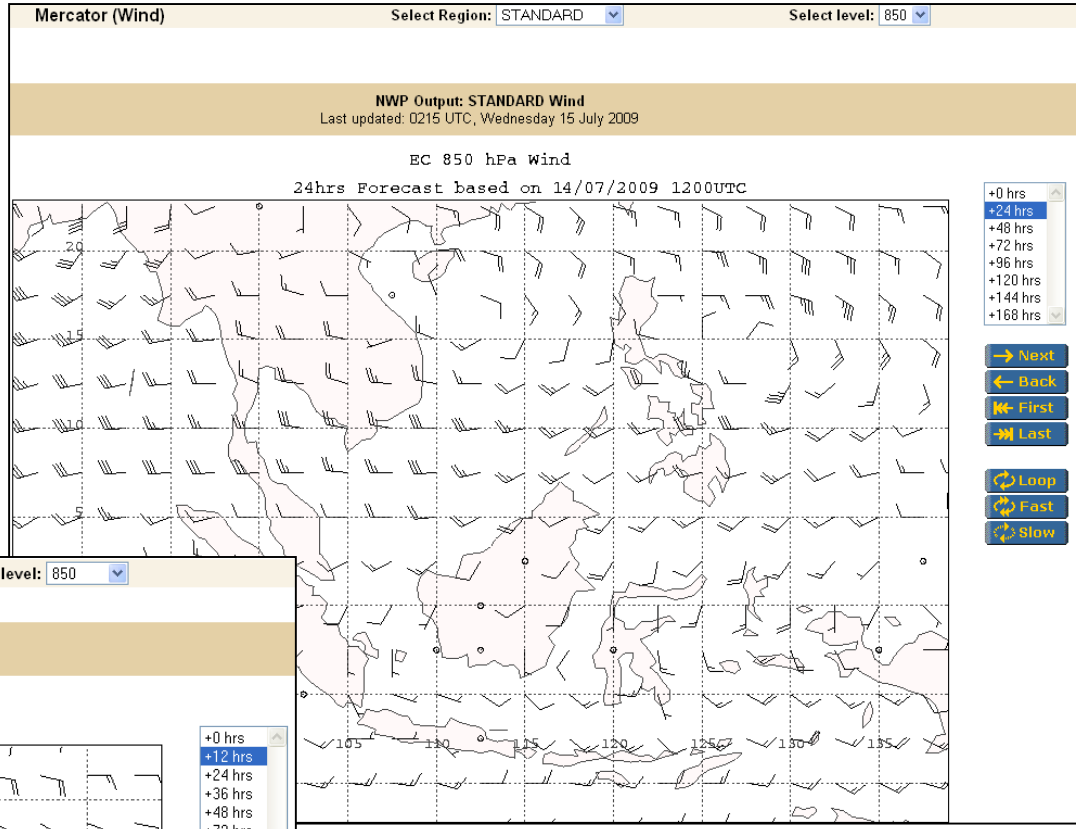
FY-2E

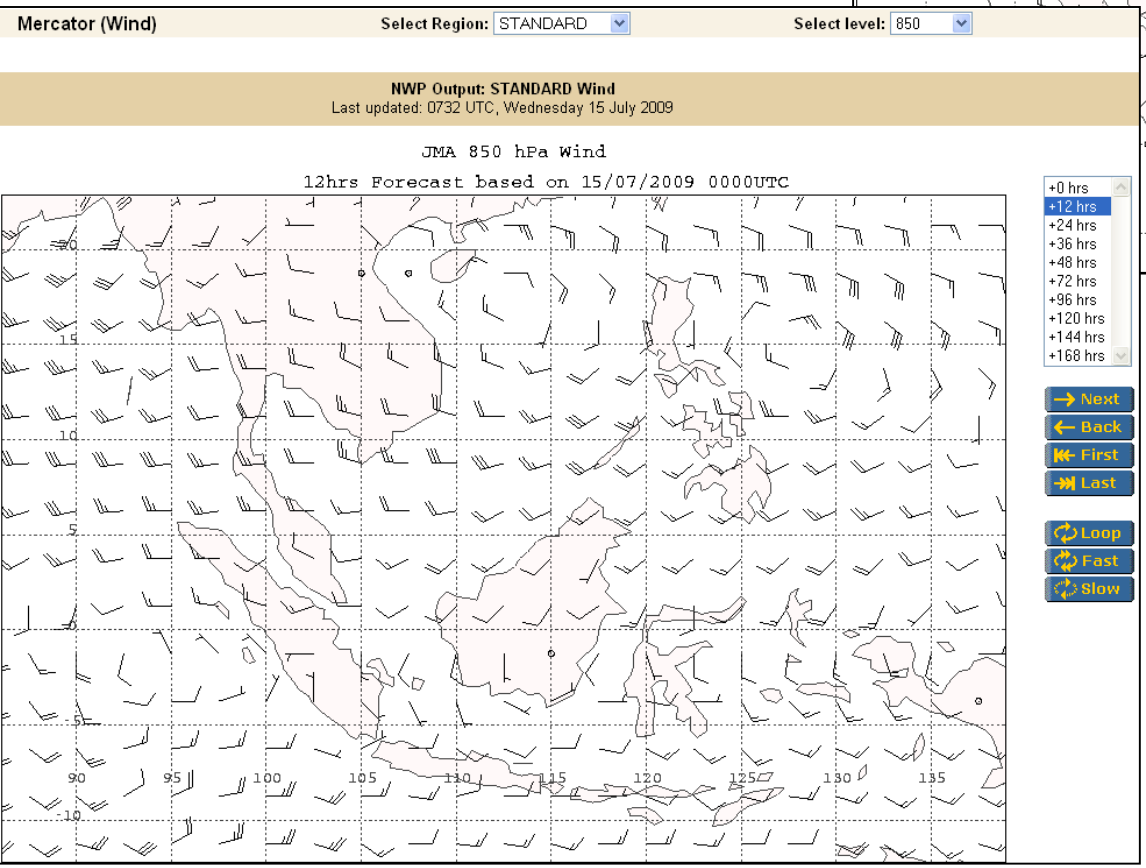
HIMAWARI

NEW!!!

EC Wind Chart

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

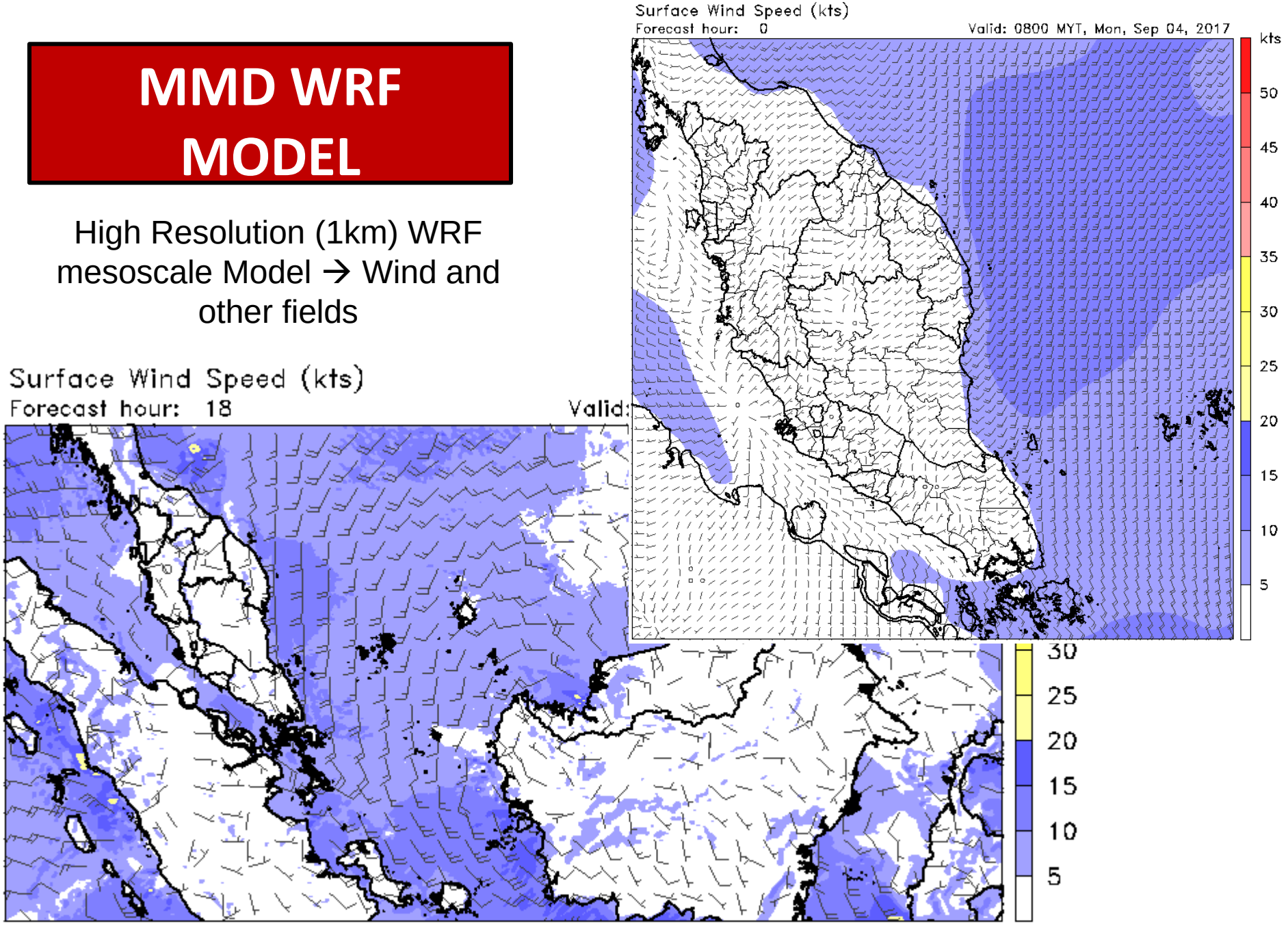




JMA Wind Chart

MMD WRF MODEL

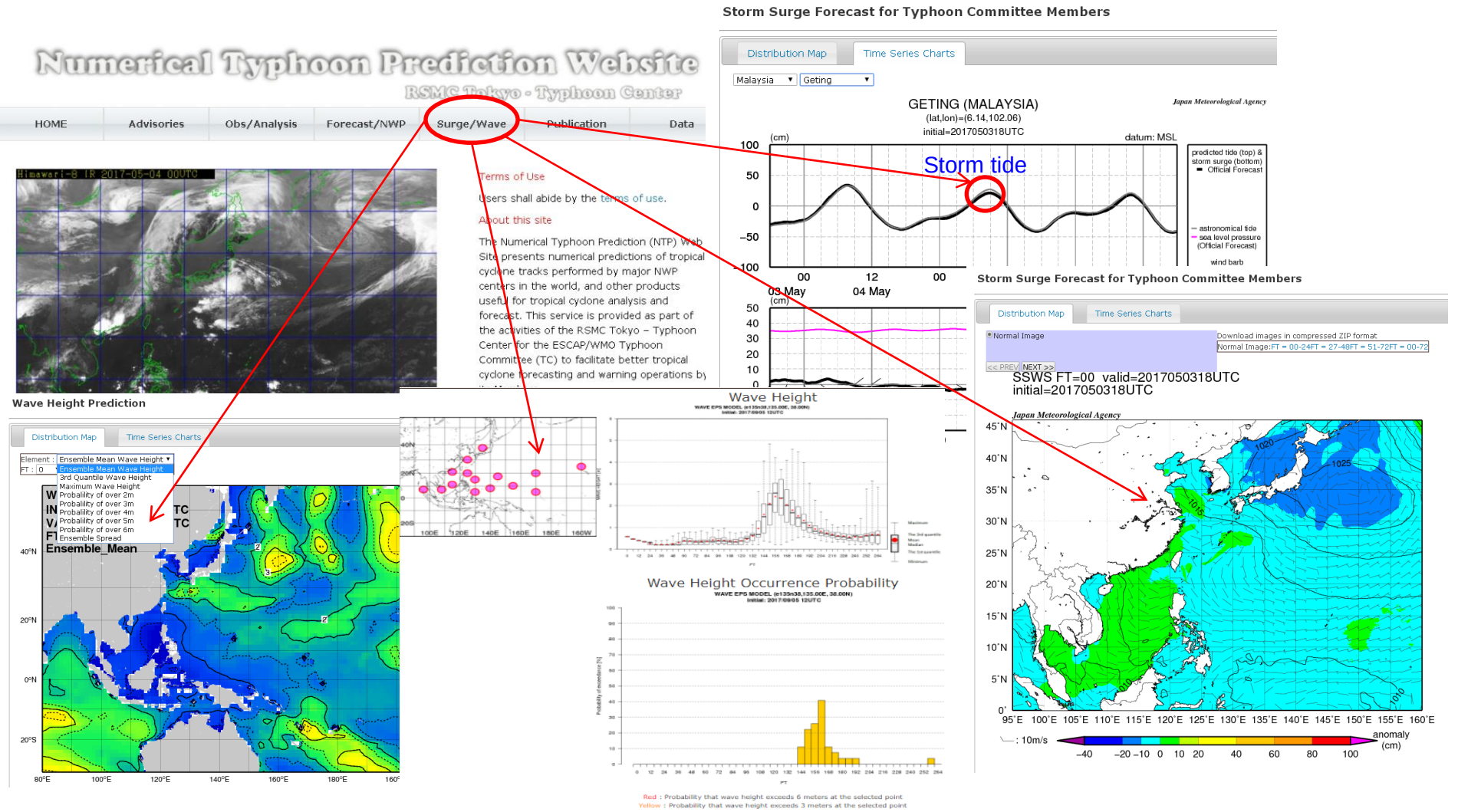
High Resolution (1km) WRF mesoscale Model → Wind and other fields



Regional Storm Surge Watch Scheme

JABATAN METEOROLOGI MALAYSIA
KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI

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



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

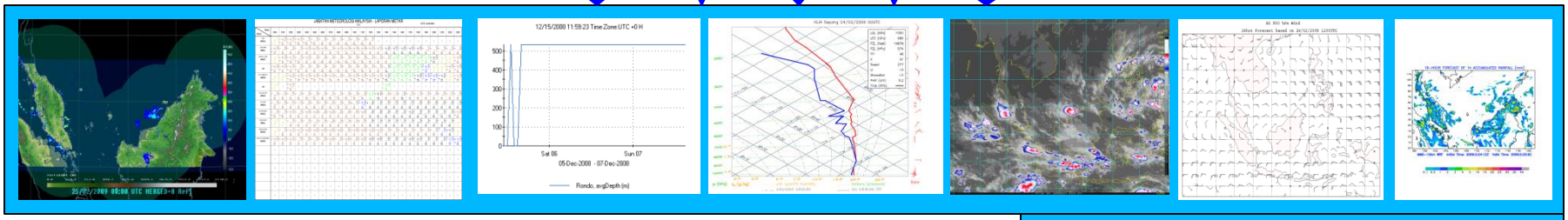
Aircraft Observation

Weather Camera

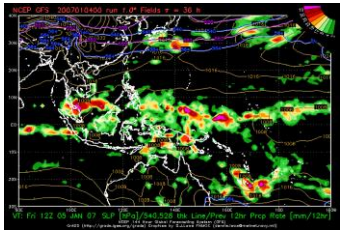
Upper Air Observation

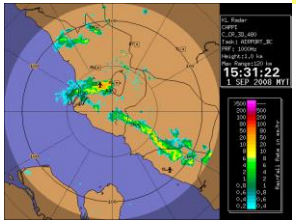
Satellite Observation

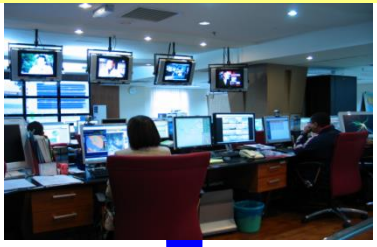
Data Collection and Analysis

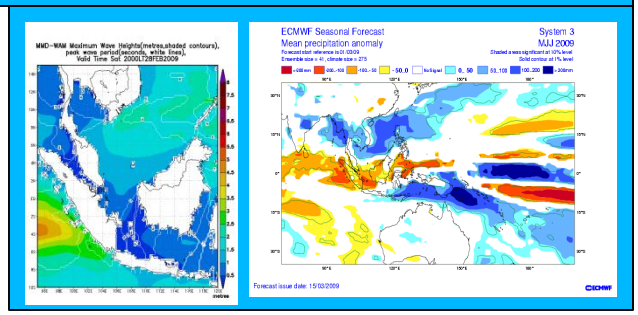


Weather Forecast Centre

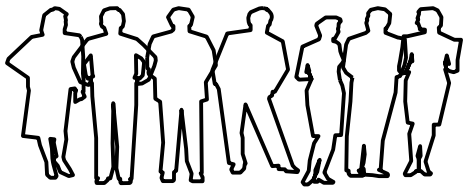








Warning Dissemination



Public

Dissemination of Sea Condition, Weather Forecast and Warning

MMD WEBSITE

SOCIAL MEDIA : FACEBOOK, TWITTER

MASS MEDIA – TV , RADIO & NEWSPAPER

MMD SMS INFORMATION SYSTEM

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. ➢ Tropical storm/typhoon with sustained wind speed of at least 60 kmph accompanied by moderate to heavy rain.	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.
	➢ 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.**

- **Colloboration 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