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TECO 50

Analysis of the Cyclonic Vortex and Evaluation of the Performance of the Radar Integrated Nowcasting System (RaINS) during the Heavy Rainfall Episode which Caused Flooding in Penang, Malaysia on 5 November 2017

Research and Technical Development Division
Malaysian Meteorological Department

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Outline

1. Introduction
2. Objectives
3. RaINS
4. Data
5. Observational Analysis
6. Performance of RaINS
7. Concluding Remarks

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Introduction

- Estimated loss of about USD 77 million
- Around 4,500 people evacuated
- Lost of life – 7 people.

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Objective

- To study the capabilities and performances of RaINS during this event

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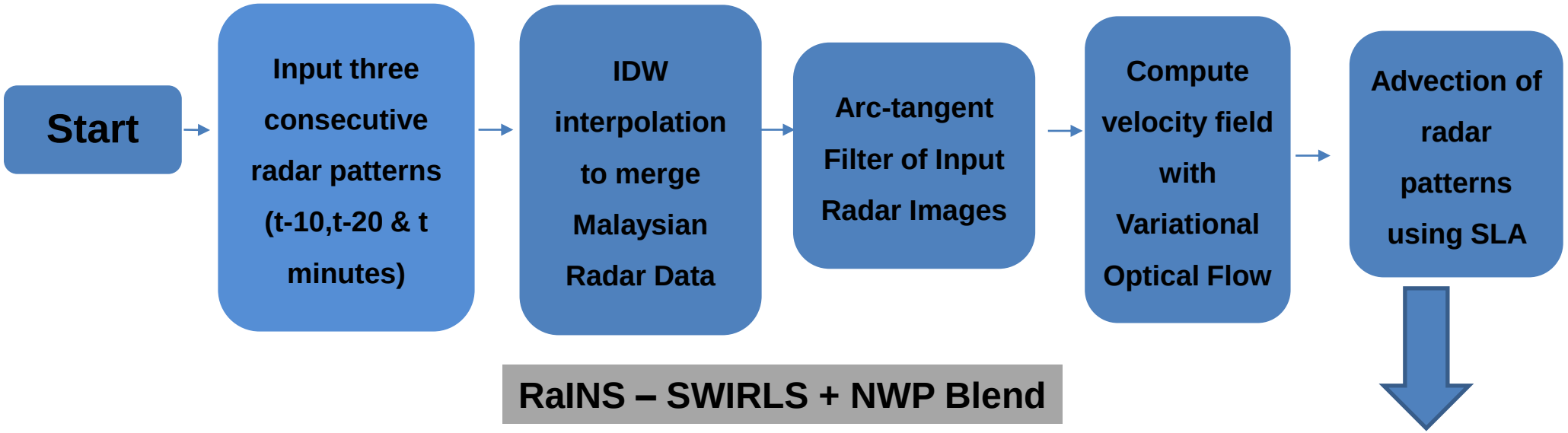
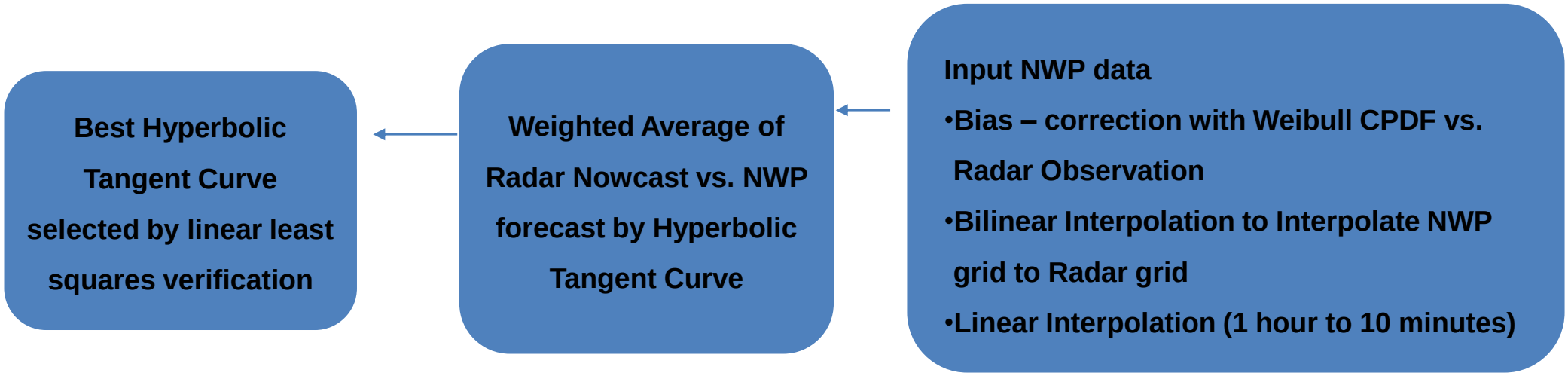
RaINS

SWIRLS – Pure Advection



RaINS – SWIRLS + NWP Blend



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Data: Radar

Parameter	Reflectivity (dBZ)
Radar Data	Constant Plan Position Indicator at 2KM
Horizontal resolution	833 m
Range	300 km
Number of Grid points	720 x 720
Update cycle	10 minutes
Station	12
Integrated	Inverse distance weighting power 1, take maximum value of station

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Data: NWP

Parameter	Maximum vertical Reflectivity (dBZ)
Model version	WRF-ARW (3.9.1.1)
Horizontal resolution	1 km
Horizontal grid	Arakawa-C
Vertical coordinates	Terrain following, hydrostatic, pressure vertical coordinate
Number of grid points	2196 x 771 x 50
Update cycle	6 hours
Initial condition	GFS - 1 degrees
Boundary condition	GFS - 1 degrees
Nesting	3 way nesting (9km,3km,1km)
Observations assimilated	None
Map projection	Mercator
Parameterization	Thompson Scheme Microphysics Dudhia Shortwave Scheme & RRTM Longwave Scheme Yonsei University Scheme (YSU) PBL Scheme No convective parameterization scheme

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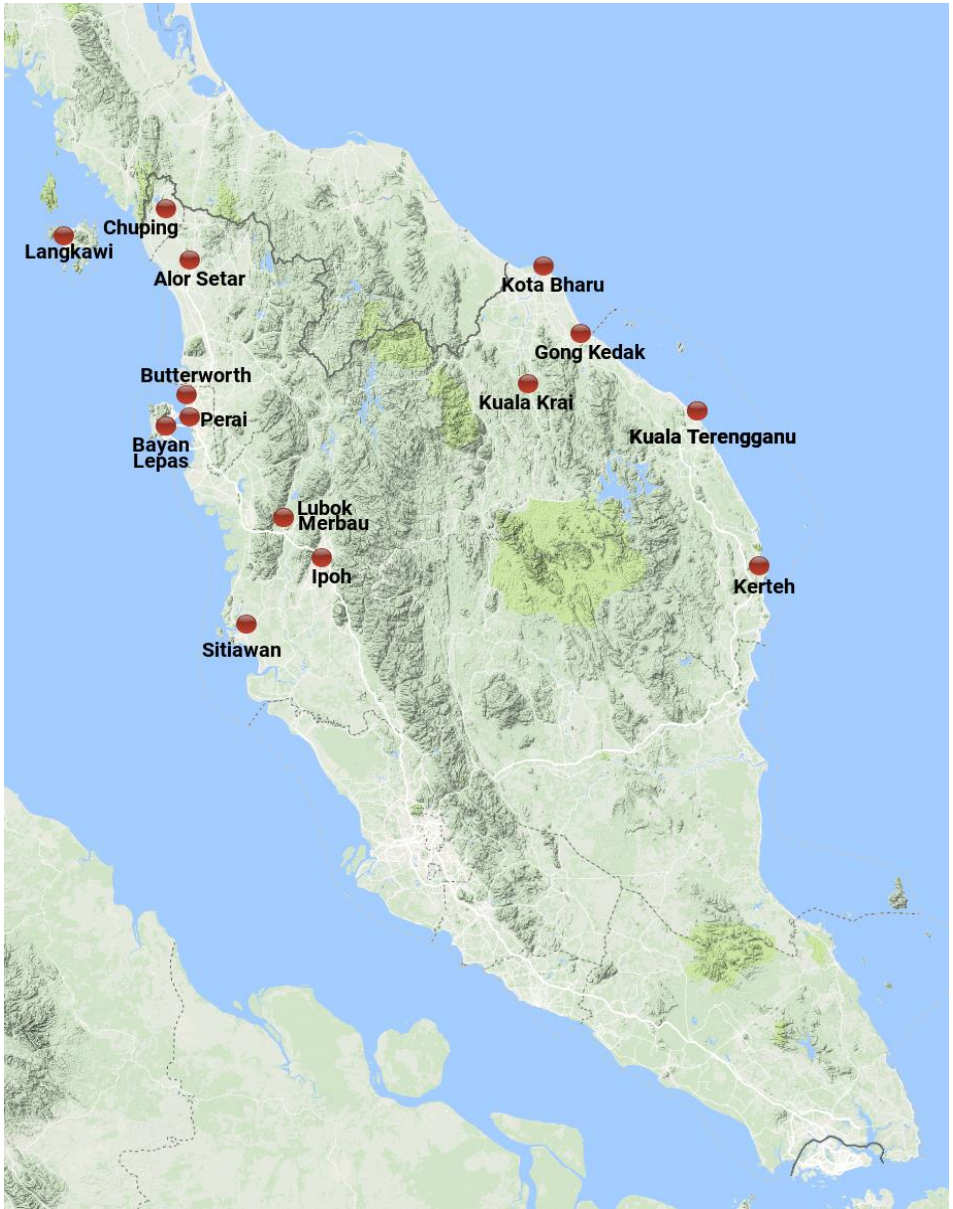
Data: Station rainfall



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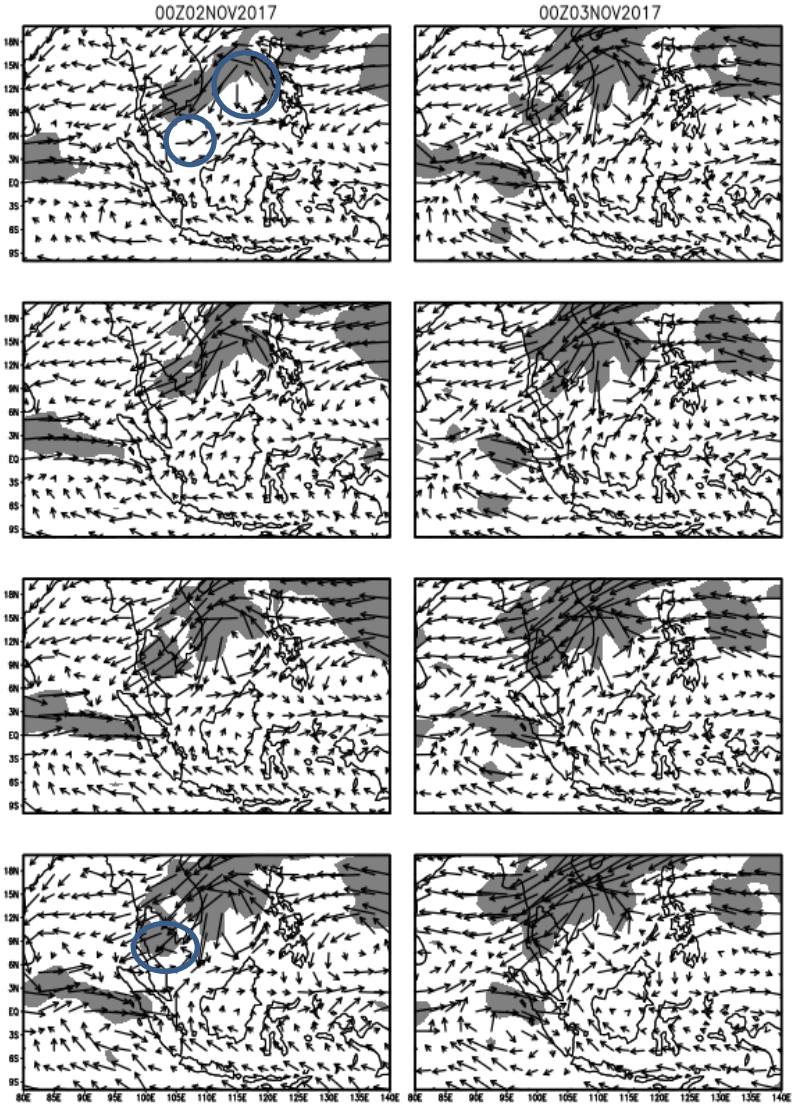
Observational Analysis –JRA55



- Initially- q.stationary cyclonic vortex at 850hPa in the southern SCS, last week of October 2017.
- Embedded in the monsoon trough, NE-SW orientation.
- Perturbed by the presence of Typhoon Damrey.
- Vortex strengthen, extending up to 500hPa.
- Moved to northeast coast, stationary until it moves to west coast of PM

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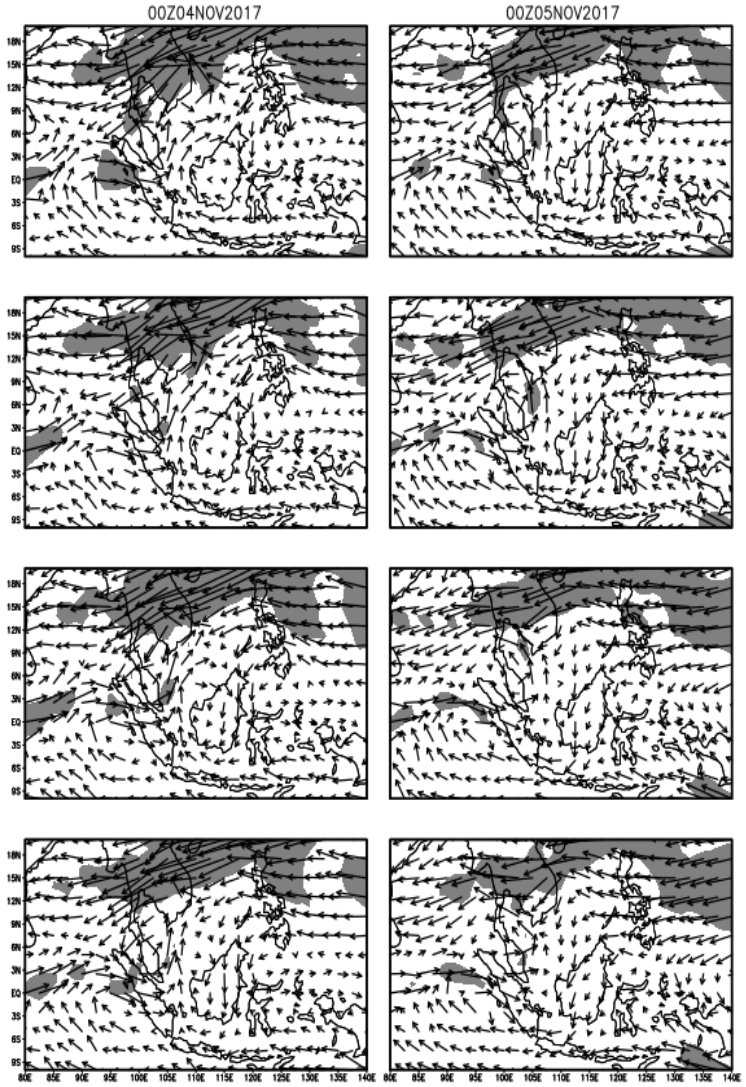
Observational Analysis

Wind Analysis :



- The vortex remained stationary in Penang for almost 30 hours (18Z 03 Nov – 06Z 05 Nov 2017).
- Upper level divergence persisted from 3rd Nov – 5 November

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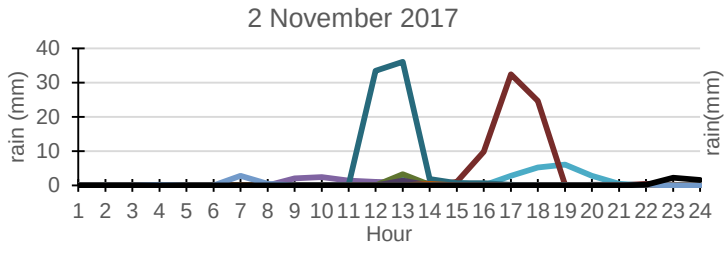
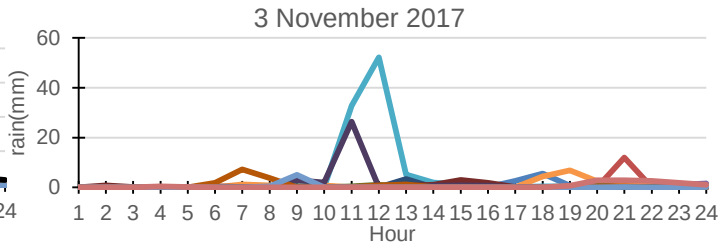
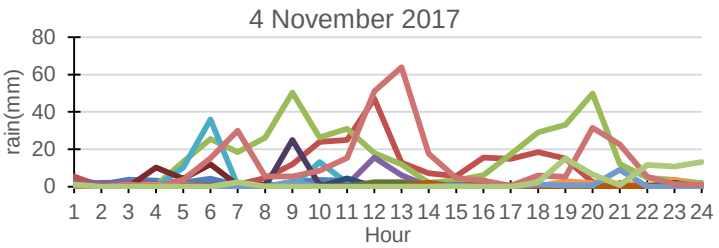
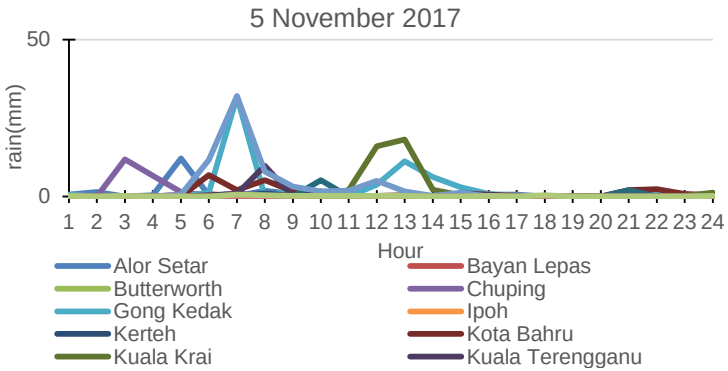
Observational Analysis

Rainfall Variation :









- Heavy rainfall first recorded in Kuantan 11Z 02 Nov 2017
- Move progressive north in tandem with the vortex movement
- Continuous rain found at the edge of vortex
- Vortex core, heavier rain was recorded.
- 2 maxima in mainland, 1 max in island

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RaINS - VERIFICATION

1. GRID-CONTINGENCY TABLE

		OBSERVED	
		YES	NO
FORECAST	YES	HITS	FALSE ALARM
	NO	MISS	CORRECT NEGATIVES

2. HIT THRESHOLD > 10 dBZ

3. PROBABILITY OF DETECTION (POD)

- Ratio of accurate yes forecast
- 0.5 is half my yes forecast is accurate
- $$POD = \frac{HITS}{HITS + MISS}$$

4. FALSE ALARM RATE

- Ratio of inaccurate yes forecast
- 0.5 is half my yes forecast did not occur
- $$FAR = \frac{FALSE\_ALARMS}{FALSE\_ALARMS + HITS}$$

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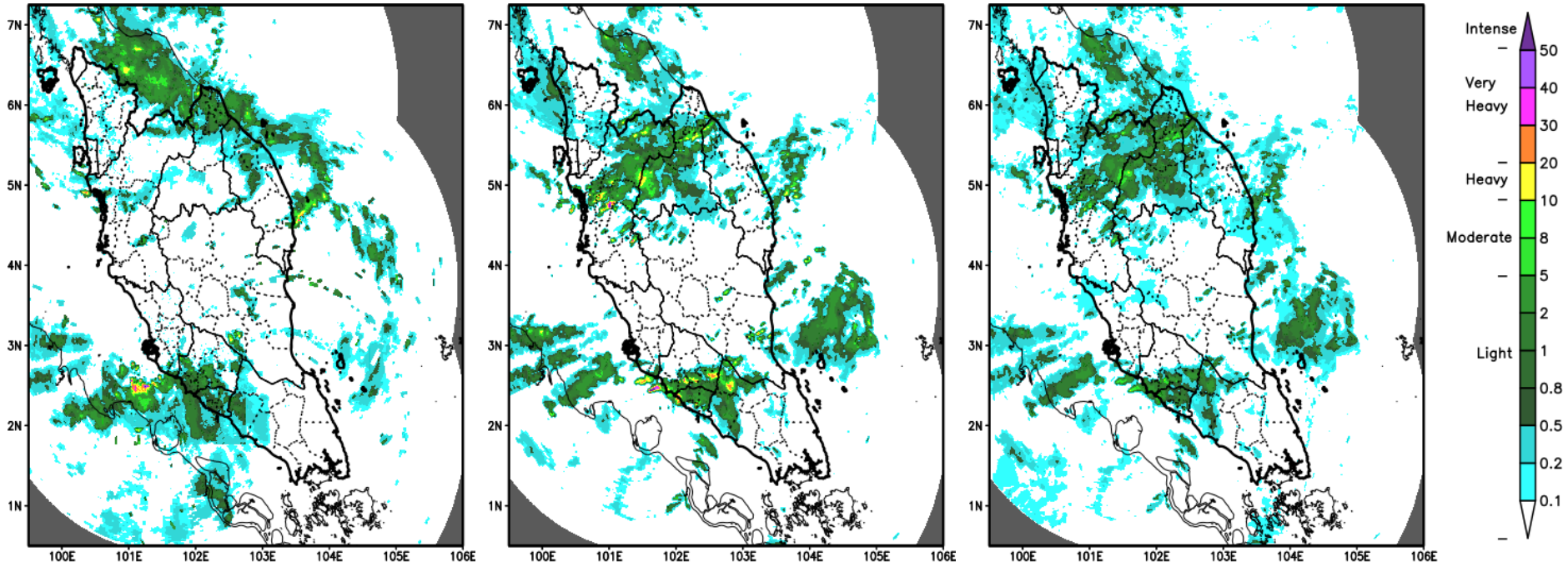
RaINS - VERIFICATION

AVERAGE 8 RADAR OBSERVATION
Versus
AVERAGE NOWCAST AT 3 HOURS LEAD TIME
(3 November, 6 pm - 5 November, 4 am 2017)

RADAR OBSERVATION	SWIRLS NOWCAST	RaINS NOWCAST



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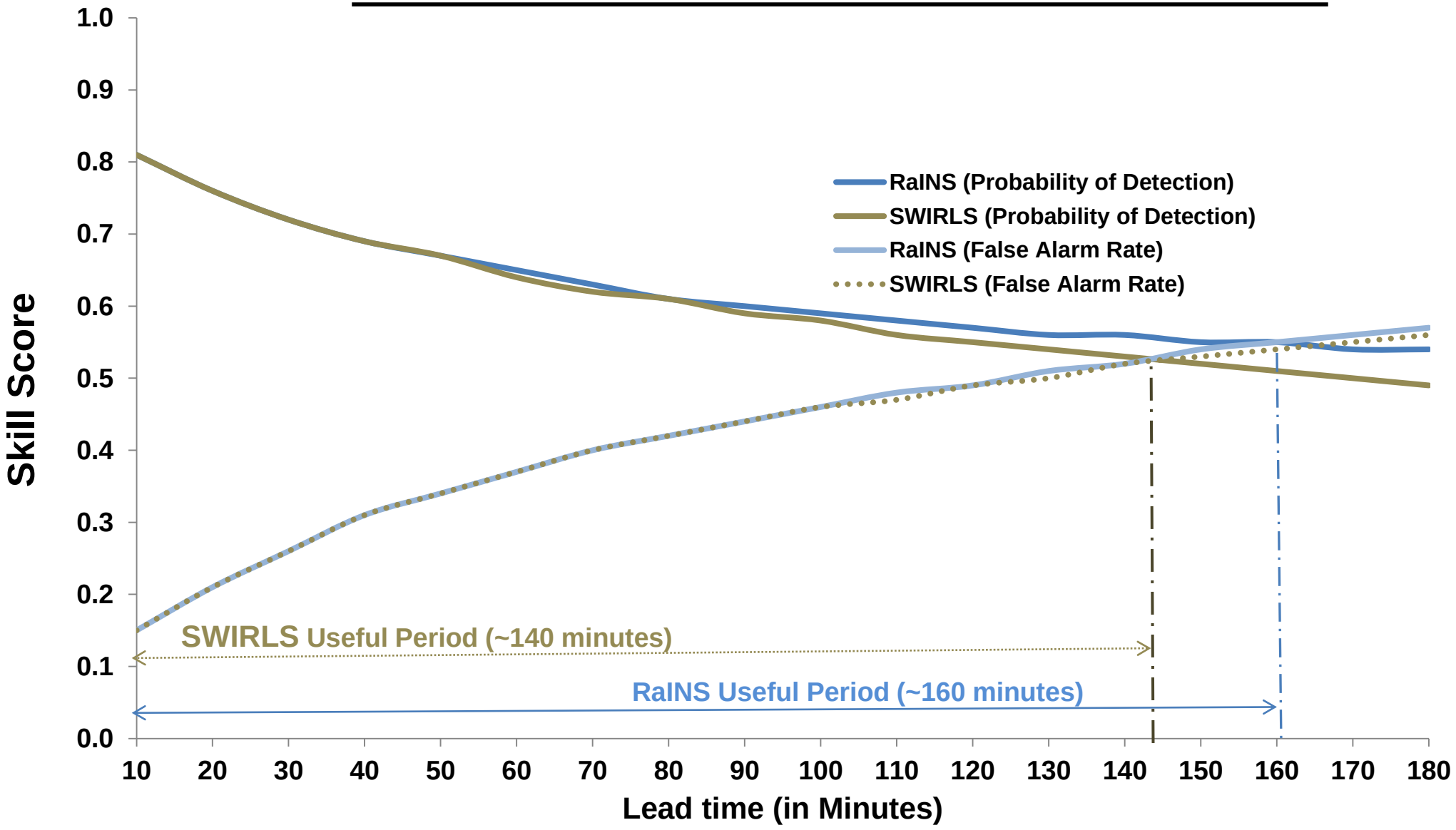
RaINS – VERIFICATION

RaINS vs. SWIRLS Skill Scores for Threshold > 10dBZ



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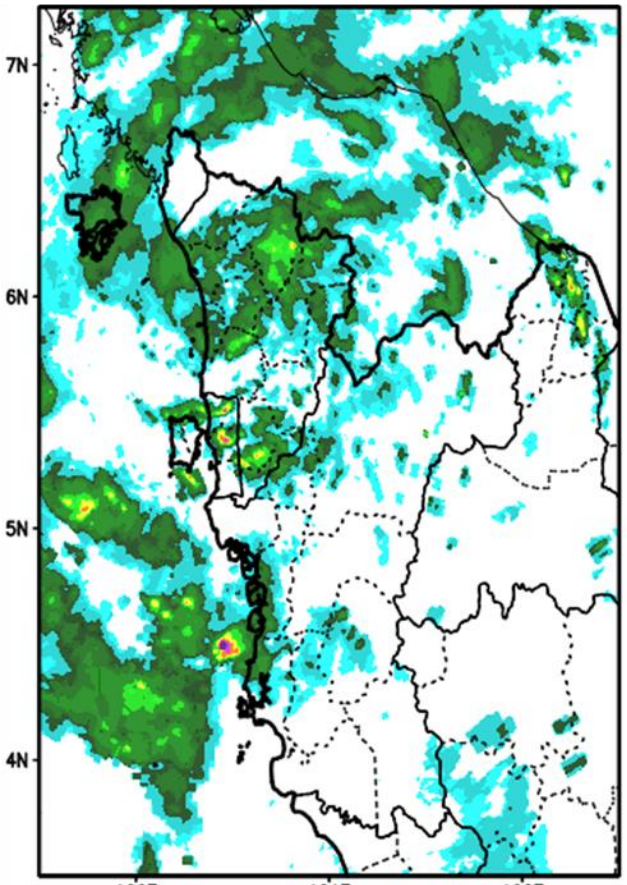
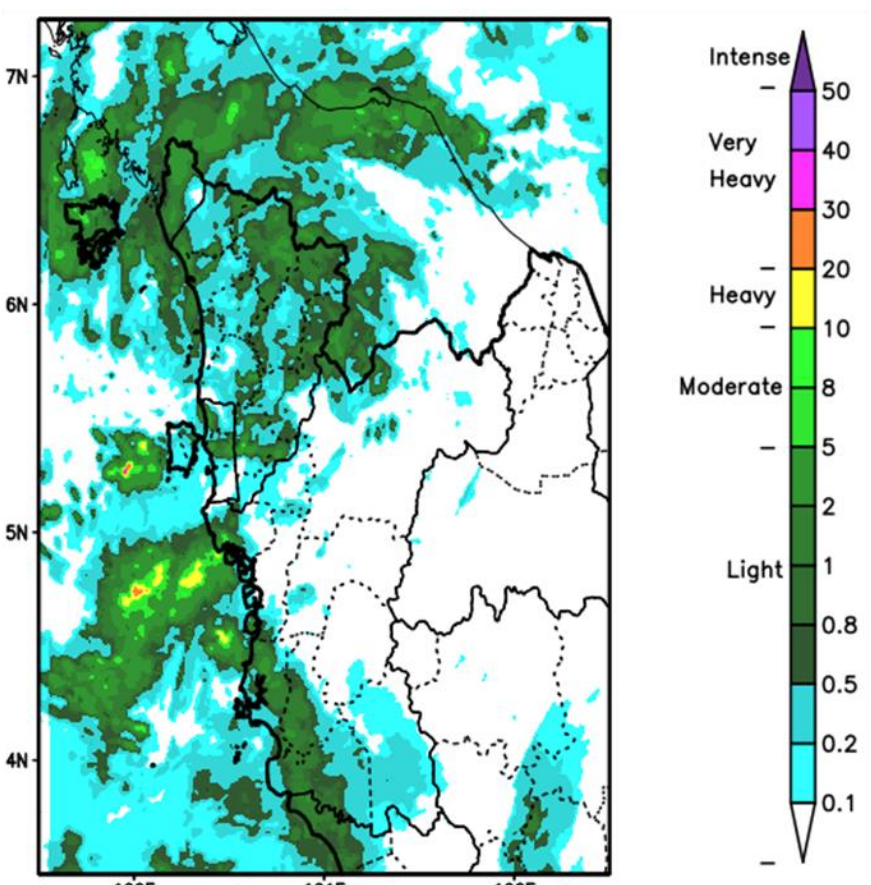
RaINS - VERIFICATION (Initial)
2 stations

AVERAGE RADAR OBSERVATION
Versus
AVERAGE NOWCAST AT 3 HOURS LEAD TIME
(Initial Stage, 12 noon - 2.50pm, 4 November 2017)

RADAR OBSERVATION



RaINS NOWCAST



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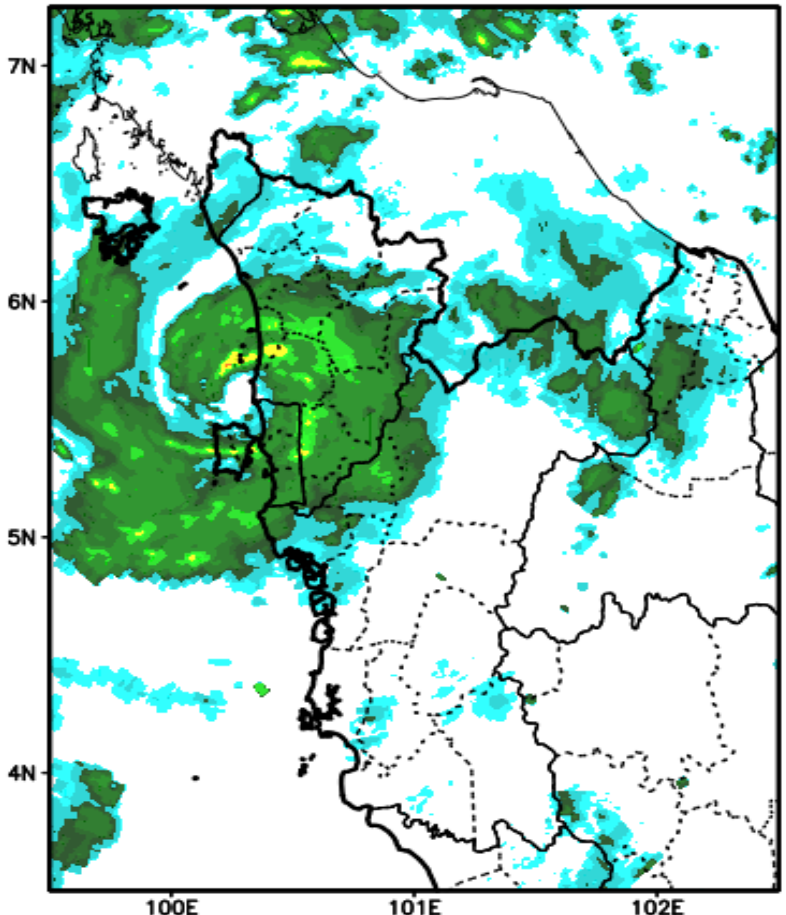
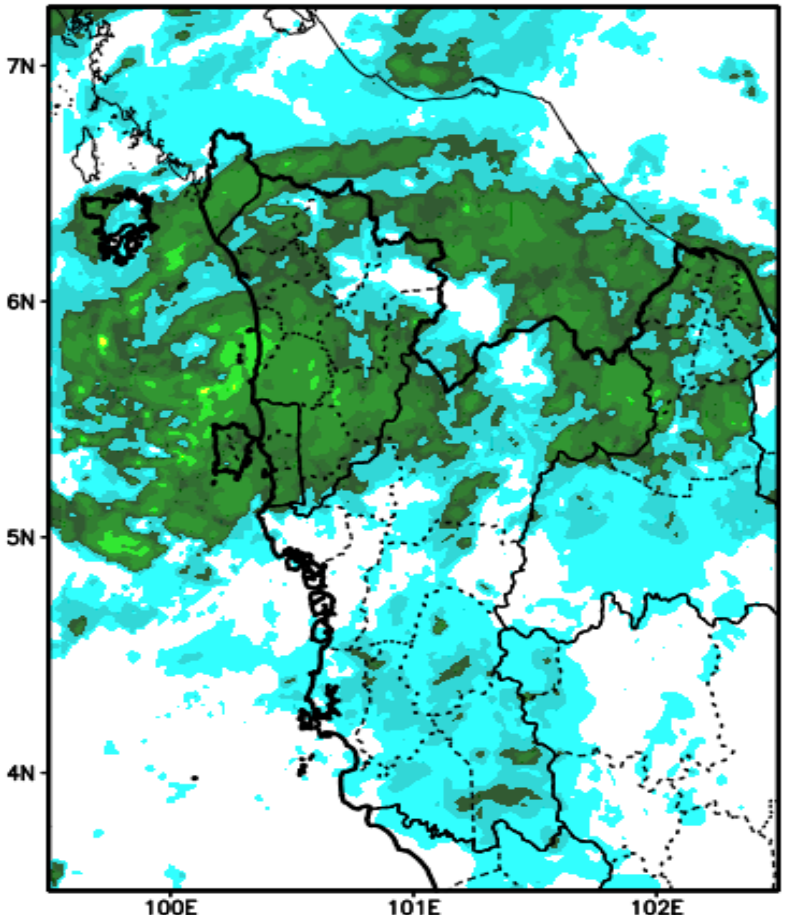
RaINS - VERIFICATION (Mature)

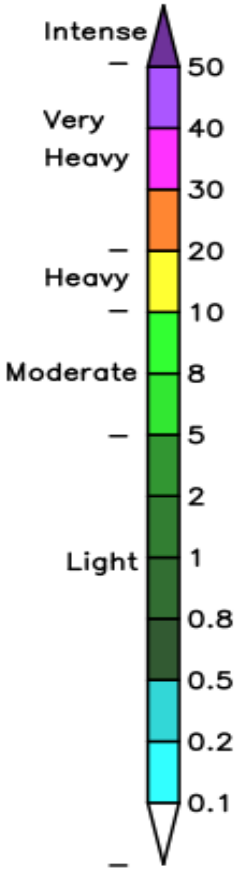
AVERAGE RADAR OBSERVATION
Versus
AVERAGE NOWCAST AT 3 HOURS LEAD TIME
(Mature Stage, 9pm - 11.50pm, 4 November 2017)

RADAR OBSERVATION



RaINS NOWCAST





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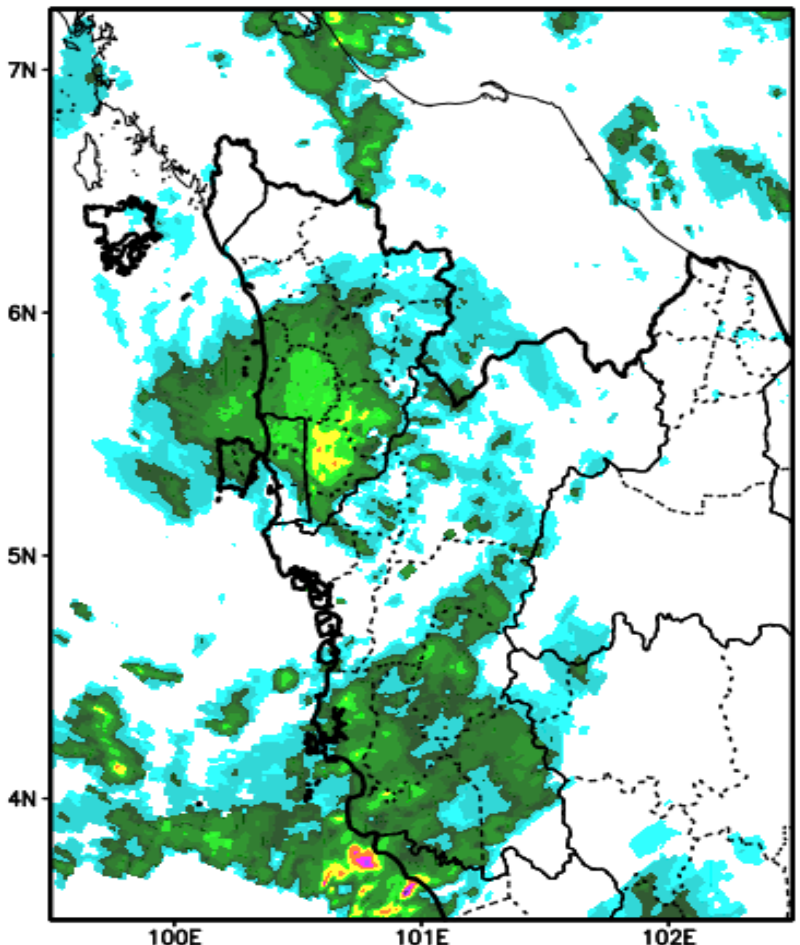
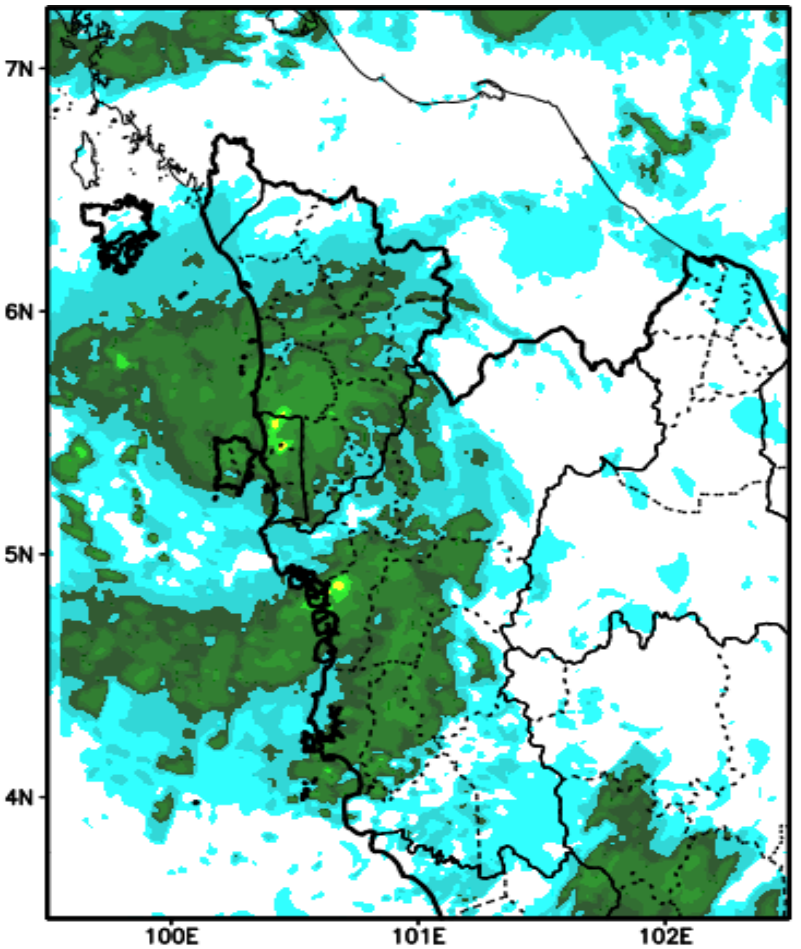
RaINS - VERIFICATION (Decaying)

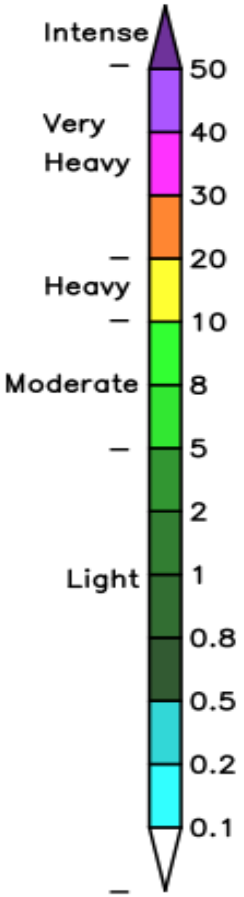
AVERAGE RADAR OBSERVATION
Versus
AVERAGE NOWCAST AT 3 HOURS LEAD TIME
(Decaying Stage, 6am - 8.50am, 5 November 2017)

RADAR OBSERVATION



RaINS NOWCAST





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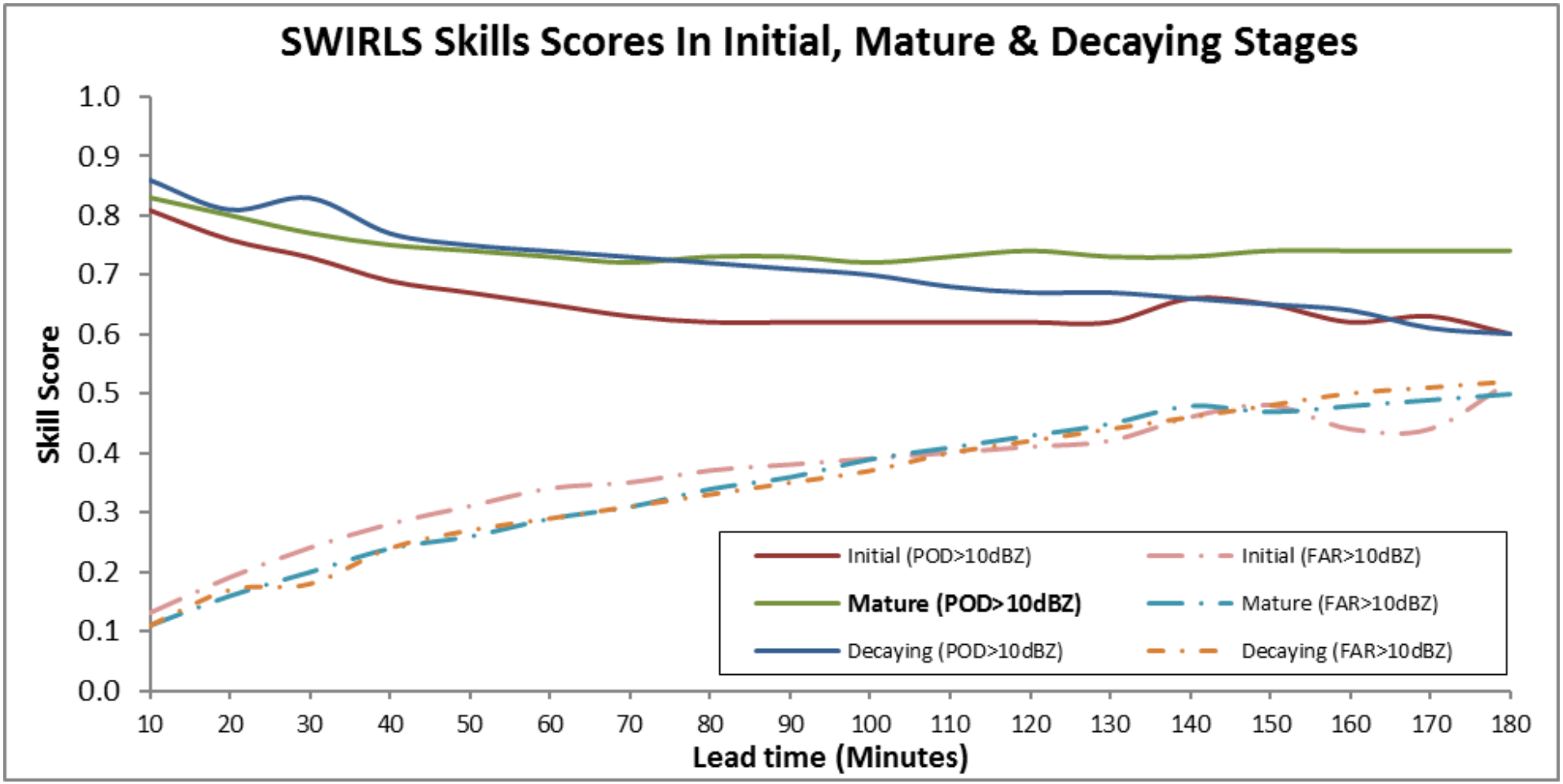
RaINS – VERIFICATION
2 radar stations



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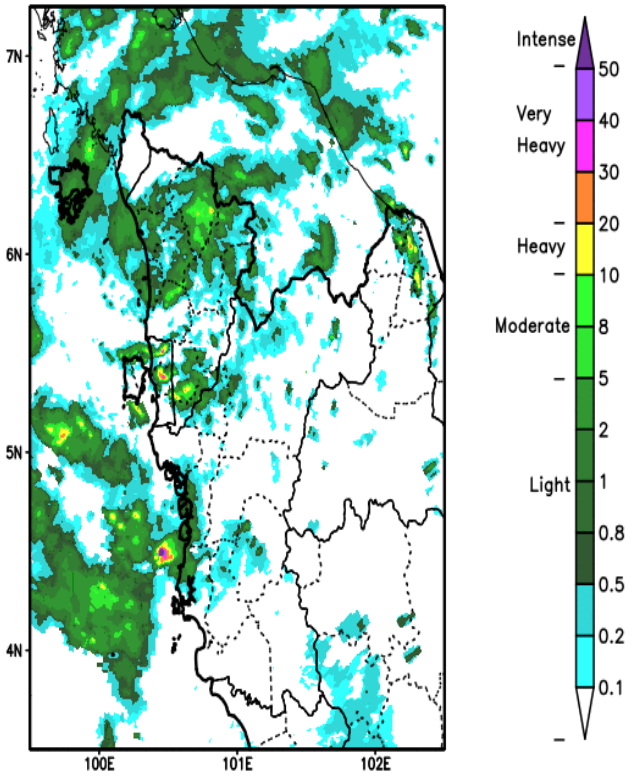
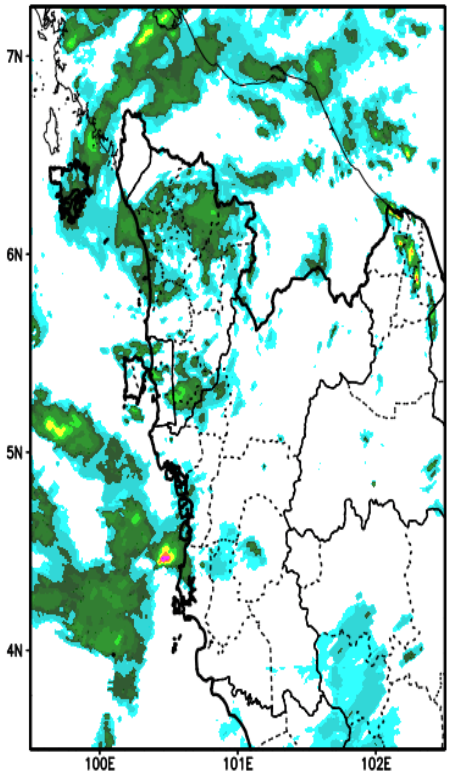
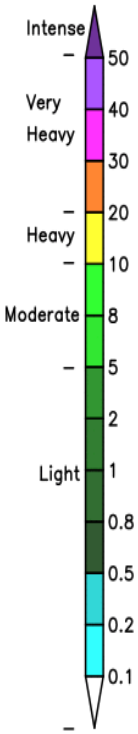
INITIAL STAGE

Radar Observation (mm/hr) at Sat Nov 4 12:00:00 2017



RaINS v1.5 Nowcast (mm/hr) at Sat Nov 4 12:00:00 2017





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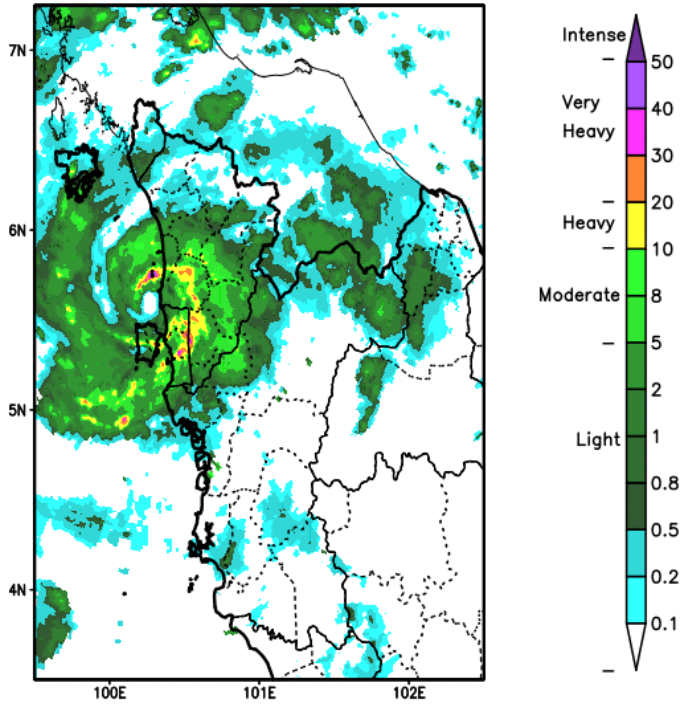
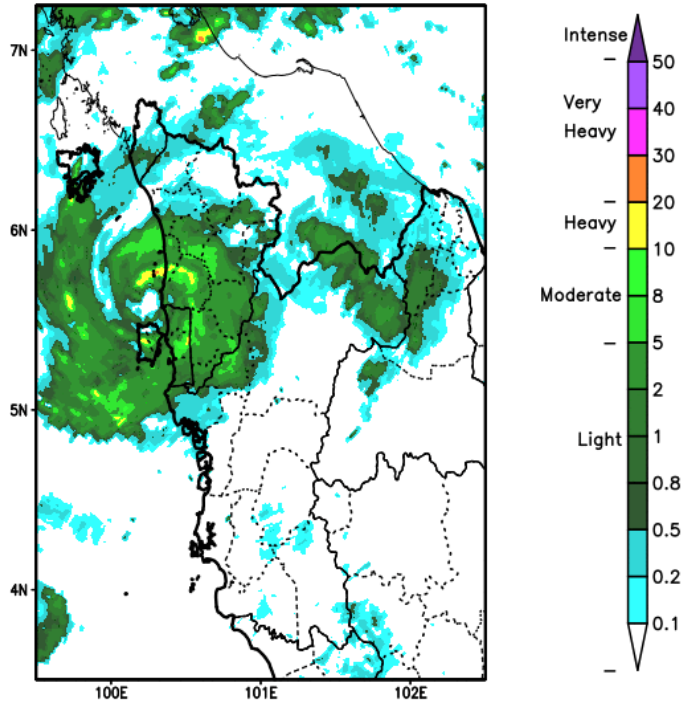
MATURE STAGE

Radar Observation (mm/hr) at Sat Nov 4 21:00:00 2017



RaINS v1.5 Nowcast (mm/hr) at Sat Nov 4 21:00:00 2017



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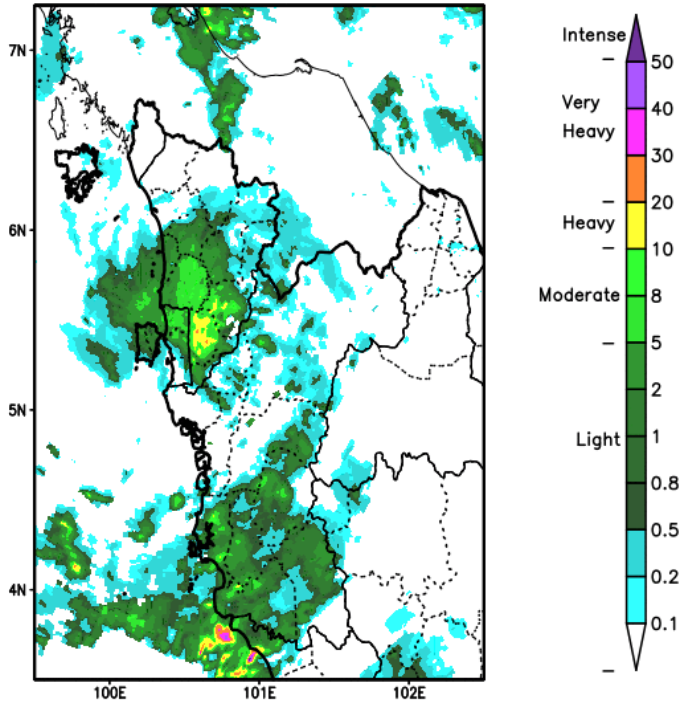
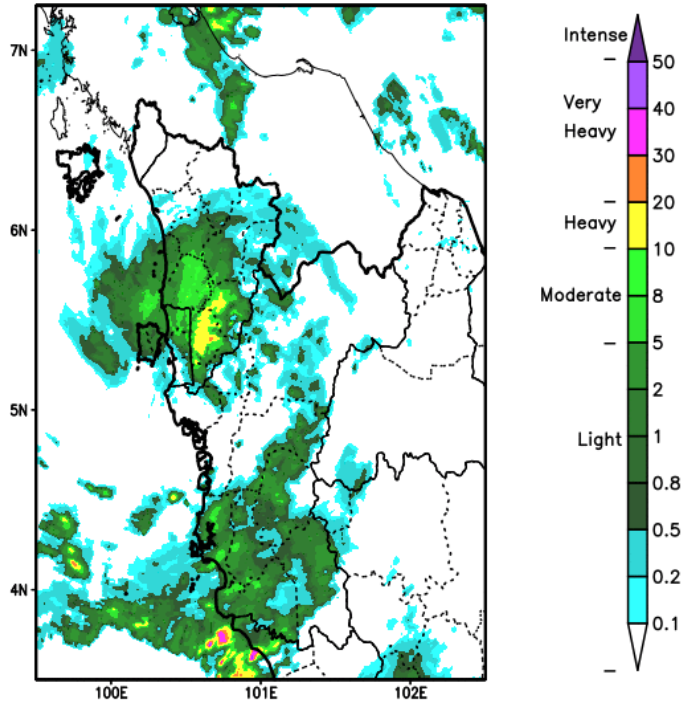
DECAYING STAGE

Radar Observation (mm/hr) at Sun Nov 5 06:00:00 2017



RaINS v1.5 Nowcast (mm/hr) at Sun Nov 5 06:00:00 2017



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Concluding Remarks

- Vortex originated from stationary vortex embedded in monsoon trough.
- Track westward, causing heavy rainfall to the NE coast of PM.
- Anchored in Penang for almost 30 hours.
- Brought long and rainy days to NW states of PM.
- Heavy rainfall were found in the mainland of Penang with 2 maxima, diurnal characteristics.
- RaINS performances during this storm is reasonably good.
- Best performances when the storm in mature stage.

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