NUMERICAL SIMULATIONS OF THE DECEMBER 2014 HEAVY RAINFALL EVENT IN THE EAST COAST S OF PENINSULAR MALAYSIA USING WRF MODEL

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OBJECTIVES

- To simulate the extreme rainfall event using WRF
- To examine the sensitivity of the simulations to deep convective parameterization.

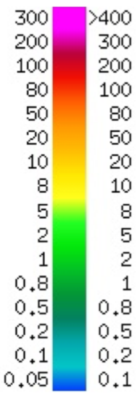
INTRODUCTION

- Flood in December 2014:
  - The worst in decades
  - Kelantan was affected the most.
  - 140,000 evacuees
  - 14 deaths
  - 4 missing persons.
- Synoptic condition - strong cold surge wind from 15 to 25 December 2014) with persistence northeasterly and deep penetration of Pacific easterly over Peninsular Malaysia.
- Numerical simulation was conducted to improve understanding of the predictability of this event.

CASE DESCRIPTION

(a) 0000 UTC (b) 0300 UTC (c) 0600 UTC (d) 0900 UTC

(e) 1200 UTC (f) 1500 UTC (g) 1800 UTC (h) 2100 UTC



Maximum intensification of rainfall could be seen between 0900UTC and 1200UTC

FIGURE. Rain rate (mm/hr) on 17 December 2014 from radar observation. (source: Malaysian Meteorological Department).

DATA AND METHODS

- Using WRF Version 3.7.1
- Integrated over 36 hours, beginning from 16 Dec 2014, 1200 UTC until 18 Dec 2014, 0000 UTC
- Initial and boundary data:
  - GFS 0.5^{o}
  - 6-hour interval.
- 3 nested domains (36 km, 12 km and 4 km)
- Two-way nested run
- 30 vertical levels.

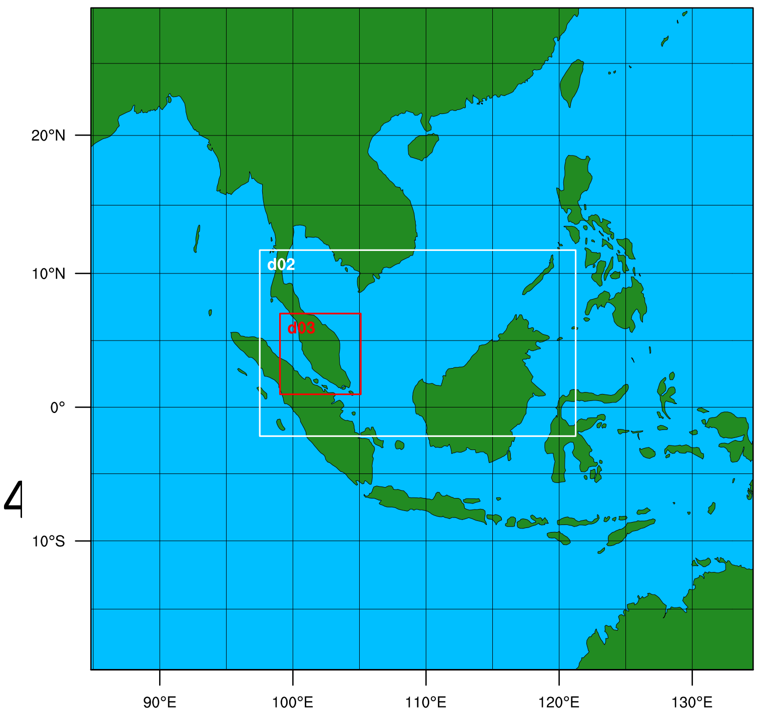


FIGURE 6. Three nested domains configuration of the WRF simulation.

DATA AND METHODS

- Physics options:
  - WRF Single-Moment 3-class scheme for microphysics,
  - RRTM scheme and Dudhia scheme for atmospheric radiation,
  - 5-layer thermal diffusion for land surface
  - Yonsei University scheme for planetary boundary layer.
  - Different combination of cumulus parameterization schemes (Table 1) were used at different domains and the simulation result were examined.
  - Experiment with different initialization analyses (ECMWF and GFS) and lateral boundary conditions were also carried out.

DATA AND METHODS

TABLE 1. Different combination of cumulus parameterization schemes. :

Exp	Parameterization schemes		
	Domain 1	Domain 2	Domain 3
1	Kain-Fritsch	Kain-Fritsch	-
2	Kain-Fritsch	Kain-Fritsch	Kain-Fritsch
3	BMJ	BMJ	-
4	BMJ	BMJ	BMJ
5	Multiscale KF	Multiscale KF	-
6	Multiscale KF	Multiscale KF	Multiscale KF
7	NSAS	NSAS	-
8	NSAS	NSAS	NSAS
9	New Tiedtke	New Tiedtke	-
10	New Tiedtke	New Tiedtke	New Tiedtke

DATA AND METHODS

TABLE 2. Experiments for practical predictability.

EXP	Initial analysis	Lateral boundary	Cumulus scheme
CNTL36KM	GFS	GFS	KF
CNTL4KM	GFS	GFS	None
ERAic	ECMWF	GFS	None
ERAbc	GFS	ECMWF	None

RESULT AND DISCUSSION

1. CP schemes

- Combination without cumulus schemes to the innermost domain gives better forecast. The WRF Model was able to resolve explicitly rainfall.
- The best rainfall was produced by combination of Multiscale KF-Multiscale KF-None. In terms of intensity and location of cloud clusters, this combination gives the closest match to the TRMM satellite observation as in Fig. 8(a).
- Although the location of the most intense rainfall was slightly to the southwest, the model was able to capture the intensity and spread of the convective cloud clusters This shows that WRF Model is able to simulate the heavy rainfall event.

RESULT AND DISCUSSION (CPS)

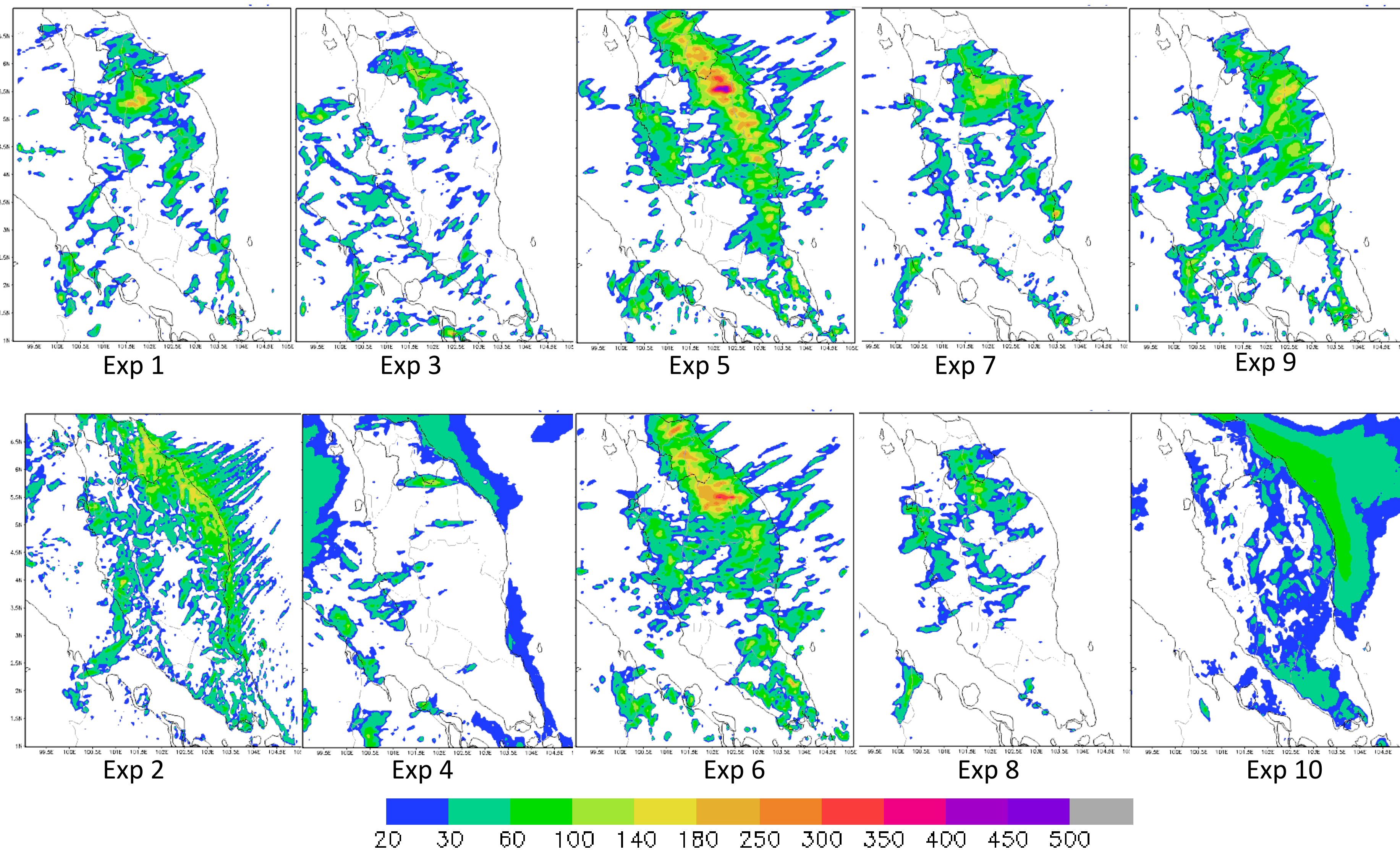


FIGURE 7(i): (a) Exp 1, (b) Exp 2, (c) Exp 3, (d) Exp 4, (e) Exp 5, (f) Exp 6, (g) Exp 7, (h) Exp 8, (i) Exp 9, and (j) Exp 10.

RESULT AND DISCUSSION

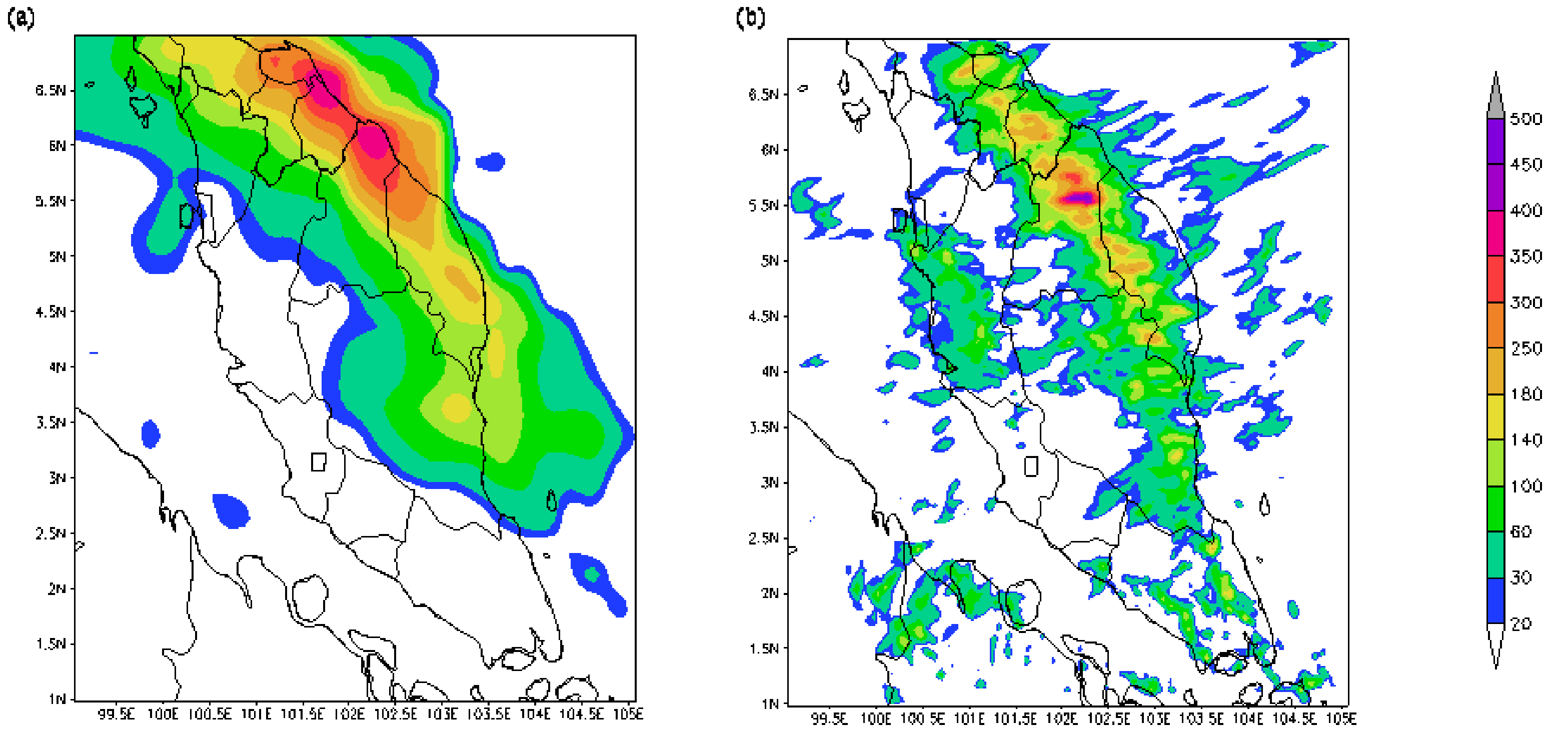


FIGURE 8. (a) The TRMM accumulated 24-hour rainfall (mm), (b) WRF simulation for EXP5 on 17 December 2014.

RESULT AND DISCUSSION

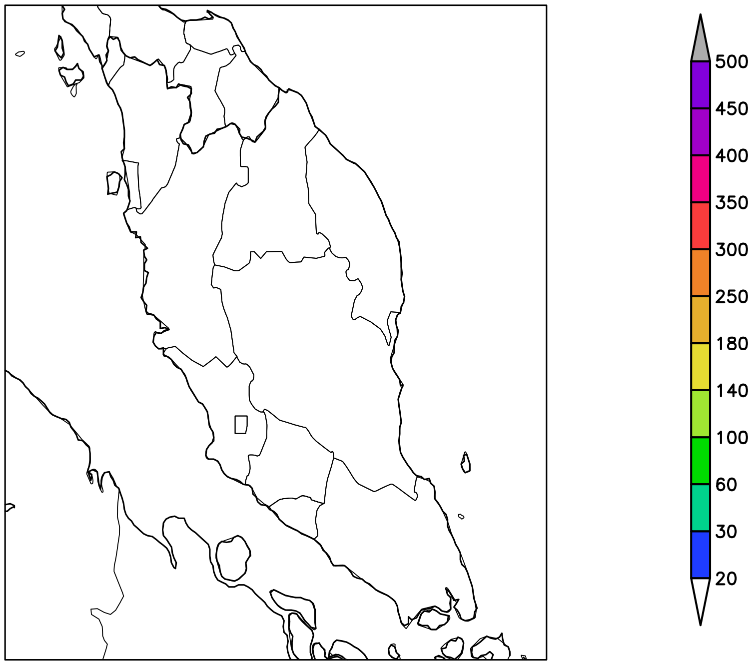


FIGURE 9. 24-hr accumulated rainfall (mm) for (a) CNTL36KM, and (b) CNTL4KM.

CONCLUSION

- The high resolution WRF Model used in this study captures considerably well some of the features of heavy rainfall event on 17 December 2014.
- It is found that cumulus schemes gives huge difference to the intensity and location of predicted rainfall. The combination of Multiscale Kain Fritch for the outer domains and no cumulus scheme at the innermost domain gives the best agreement with the observation.
- The WRF model was able to predict the event considerably well both qualitatively and quantitatively with the right combination of cumulus parameterization.