

Central Weather Bureau 2020
Conference on Weather Analysis and Forecasting

Time-Lagged Cloud-Resolving Ensemble Quantitative Precipitation Forecasts for An Extreme Rainfall Event in Central Vietnam

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13~15 Oct., 2020, Taipei, Taiwan, R.O.C.

Outlines:

1. Introduction

2. Data

3. Experiment setup

4. Evaluation methods

5. Results and Discussions

6. Conclusions

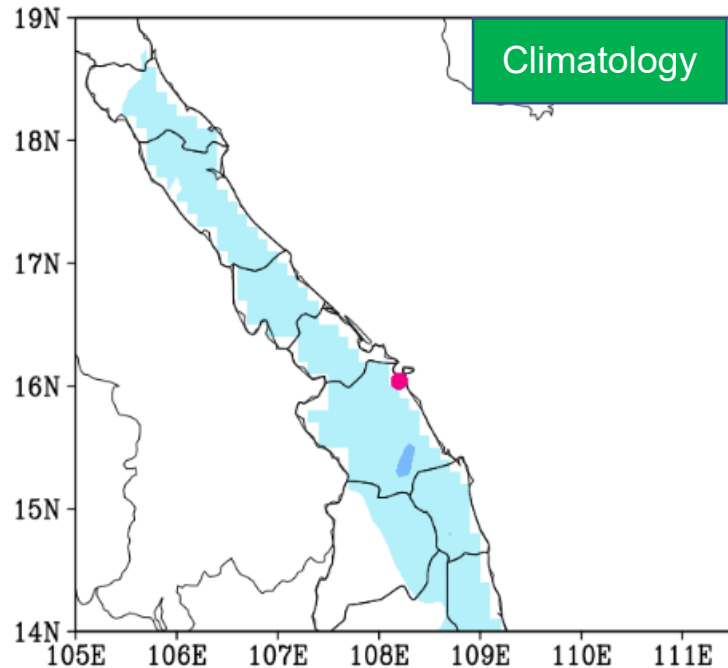
1. Introduction – THE CASE STUDY

Between 09 December and 12 December 2018, a record-breaking rainfall was observed along the coast of central Vietnam. Causes tens of thousands of homes flooded, at **least 13 deaths** and one missing,.... (**hereafter – the DEC2018**).

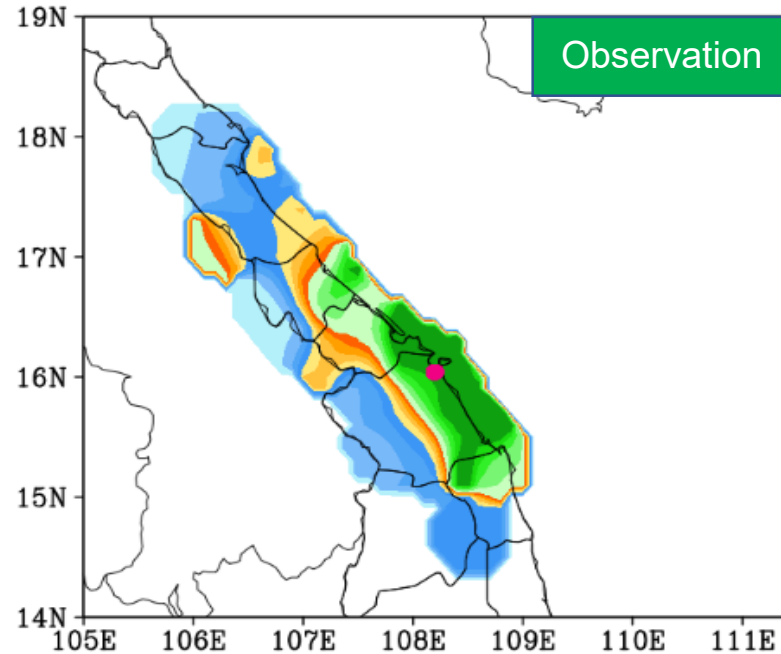


1. Introduction – THE CASE STUDY

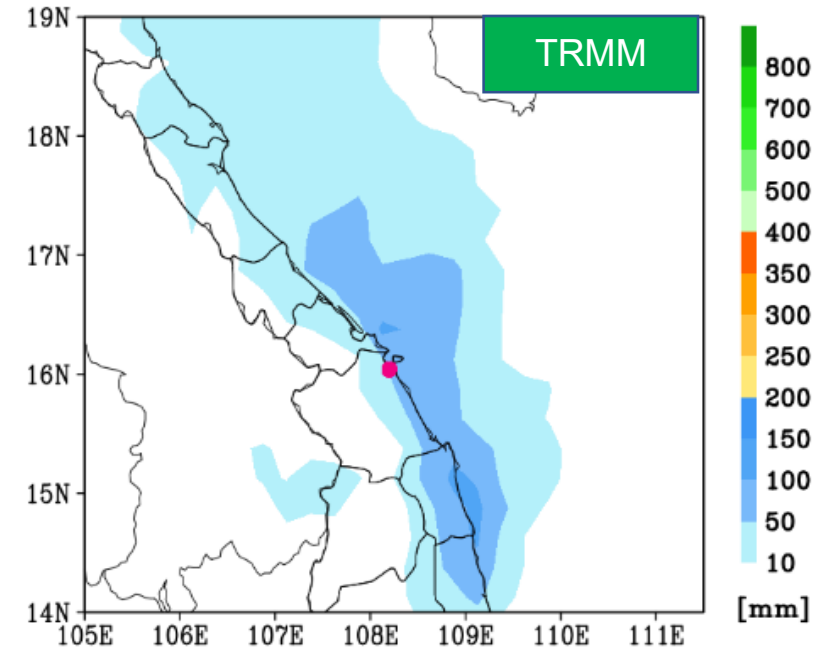
72-h accumulated rainfall (mm, 12 UTC 8 – 12 UTC 11 Dec) by:



*Averaged of the period (1980–2010),
derived from the VnGP data.*



Derived from 69 observation stations



*Derived from NASA
TRMM IMERG*

At some stations, rainfall sums recorded reached over **900 mm**.

1. Introduction – THE HIGH-RESOLUTION AND TIME-LAGGED APPROACH

In recent years, some studies have shown high skill in quantitative precipitation forecasts (QPFs) for extreme rainfall produced by typhoons in Taiwan using the CReSS model with high-resolution and time-lagged approach (e.g, [Wang et al. 2016](#); [Wang 2015](#); [Wang et al. 2014](#); [Wang et al. 2013](#))

Cloud-Resolving Storm Simulator (CReSS): A cloud model developed and maintained by the Hydrospheric Atmospheric Research Center (HyARC) of Nagoya University, Japan since 1998 (Tsuboki and Sakakibara 2002, 2007)..

	Low-resolution ensemble forecasts	High-resolution deterministic forecasts	High-resolution forecasts using time-lagged ensemble
Rainfall	Avg	Very good	Very good
Track	Avg	Good	Very good
Intensity	Avg	Good	Good
Striking probability	Avg	—	Good/very good
Lead time	Avg	Poor	Very good
Grid spacing	5 km	—	2.5 km
Fine-domain size	750 km × 900 km	—	1860 km × 1360 km
Forecast range	3 days (72 h)	—	8 days (192 h)
Forecast frequency	Every 6 h	—	Every 6 h

CReSS

([Wang et al. 2016](#))

2. DATA

✓ Reanalysis data:

ERA-Interim: horizontal resolution: $0.25^\circ \times 0.25^\circ$

Interval time for download:

The DEC2018: 12 UTC 8 -12 UTC 11 Dec

Climate data: Every December, 1980-2010.

✓ Initial data:

NCEP GFS analysis data, horizontal resolution:

$0.25^\circ \times 0.25^\circ$ with 26 levels

Interval time for download

Every 6 hours from 12 UTC 3 Dec to 12 UTC 10 Dec

✓ Observation data:

69 stations over central of Viet Nam

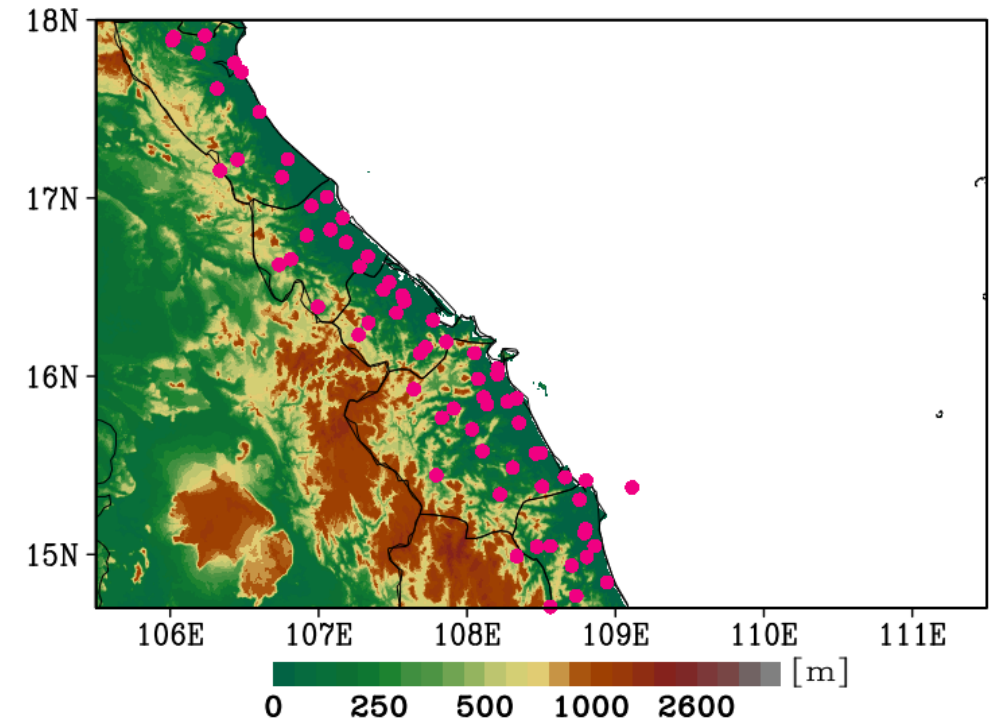
✓ Satellite data:

TRMM multi-satellite precipitation analysis 3B42

Version 7, horizontal resolution $0.25^\circ \times 0.25^\circ$

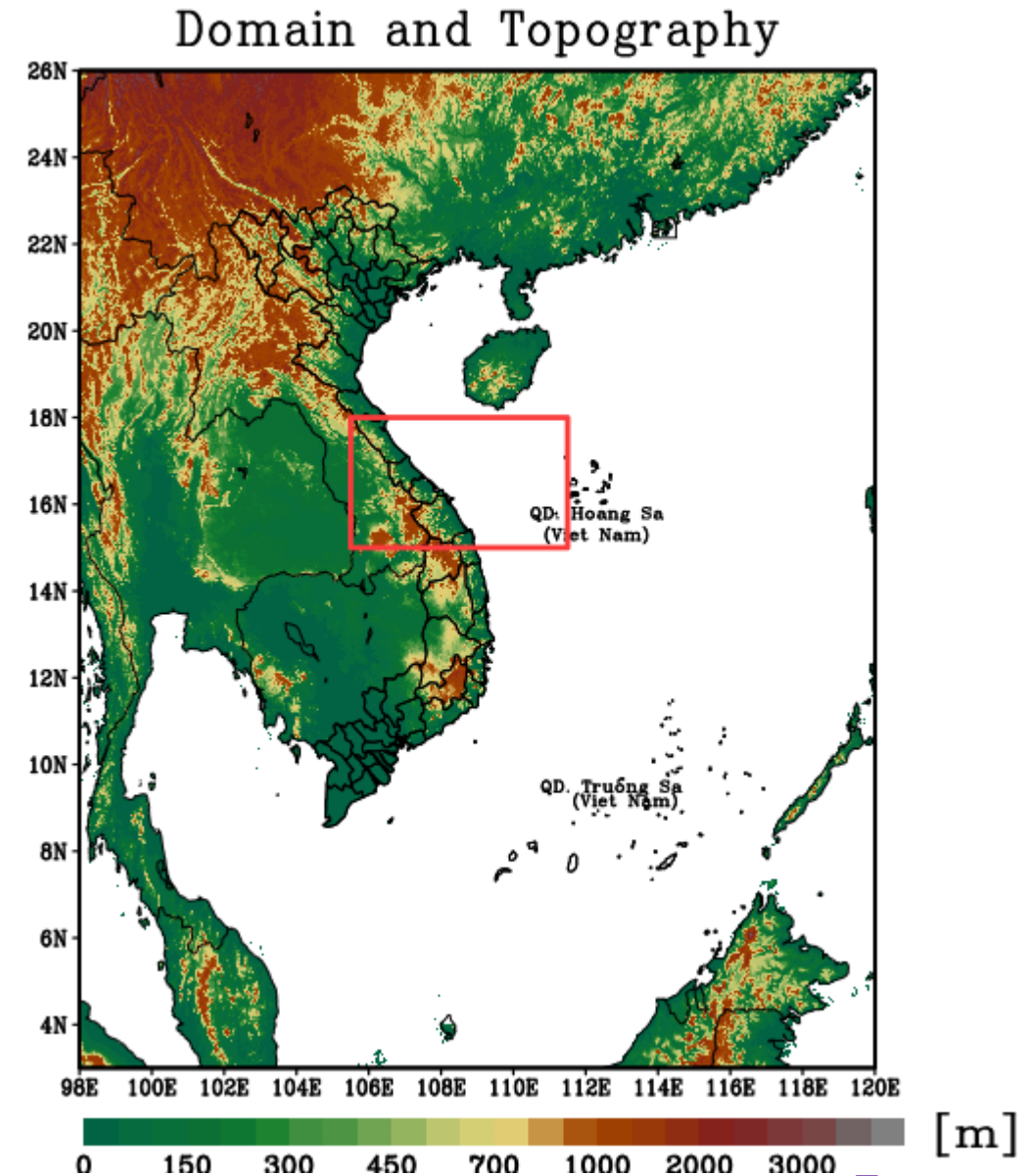
Interval time: 12 UTC 8 Dec to 12 UTC 11 Dec

The study area and 69 rainfall stations (pink)



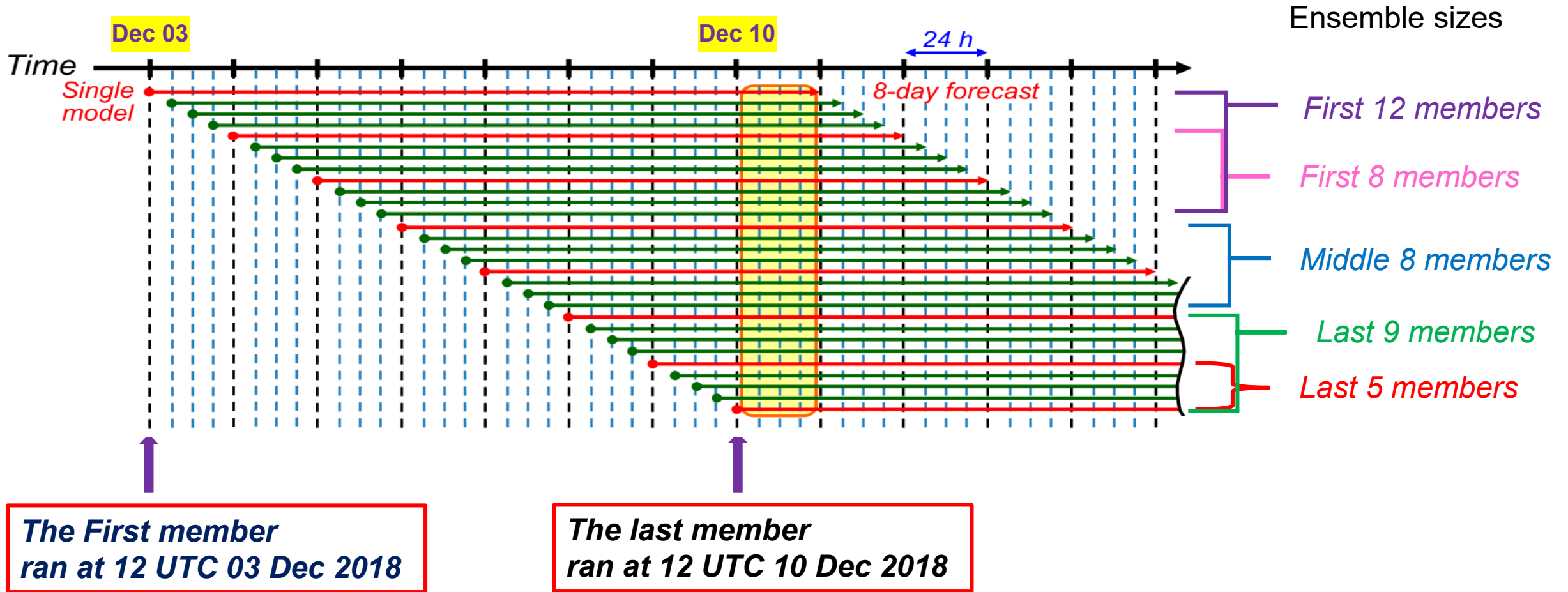
3. EXPERIMENTS SETUP

Domain setup and basic configuration in this study	
Model	Cloud-Resolving Storm Simulator (CReSS), version 3.4.2 (<i>Tsuboki and Sakakibara 2002, 2007</i>)
Domain size	3N – 26N; 98E – 120E
Grid dimensions (x,y,z)	912 x 900 x 60
Grid spacing	2.5 km x 2.5 km x 0.5 km
Projection	Mercator
Frequency of forecast	Four time per day (00, 06, 12, 18 UTC)
Forecast range	8 days (192 hours)
Topography and SST	Real at $(1/120)^\circ$ and NCEP analyses on a $0.25^\circ \times 0.25^\circ$ grid
Cloud microphysics	Bulk cold-rain scheme (six species)
Ensemble size	29 members



3. EXPERIMENTS SETUP

A Strategy to run members (Wang et al. 2016)



4. EVALUATION METHODS FOR QPF_s

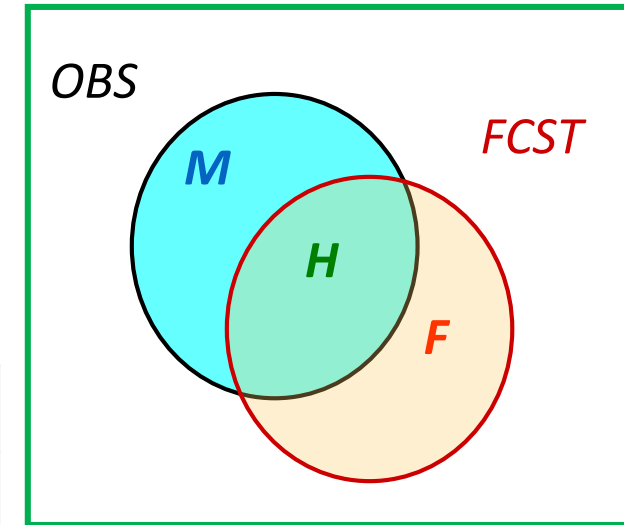
1. The visual verifications

2. The statistical indices (Statistical methods in the atmospheric sciences by Daniel S.Wilks, second edition 2006)

		Event observed		
		Yes (≥ Threshold)	No (<Threshold)	Marginal total
Event Forecast	Yes (≥ Threshold)	Hit (H)	False alarm (F)	Fc Yes
	No (<Threshold)	Miss (M)	Corr.non-event (CN)	Fc No
	Marginal total	Obs Yes	Obs No	Sum total (n)



Name	Formula	Perfect score	Worst score
Frequency Bias (BS)	$(H+F)/(H+M)$	1	$\ll 1$ or $\gg 1$
Probability Of Detection (POD)	$H/(H+M)$	1	0
False Alarms Ratio (FAR)	$F/(H+F)$	0	1
Threat Score (TS)	$H/(H+M+F)$	1	0



4. EVALUATION METHODS FOR QPF_s

3. The Fraction Skill Score (FSS) (Roberts 2005; Roberts and Lean 2008)

$$\text{FSS} = 1 - \frac{\frac{1}{N} \sum_{i=1}^N (P_f - P_o)^2}{\frac{1}{N} \sum_{i=1}^N P_f^2 + \frac{1}{N} \sum_{i=1}^N P_o^2}$$

Where:

N – The number of observation station

p_f - The forecast values

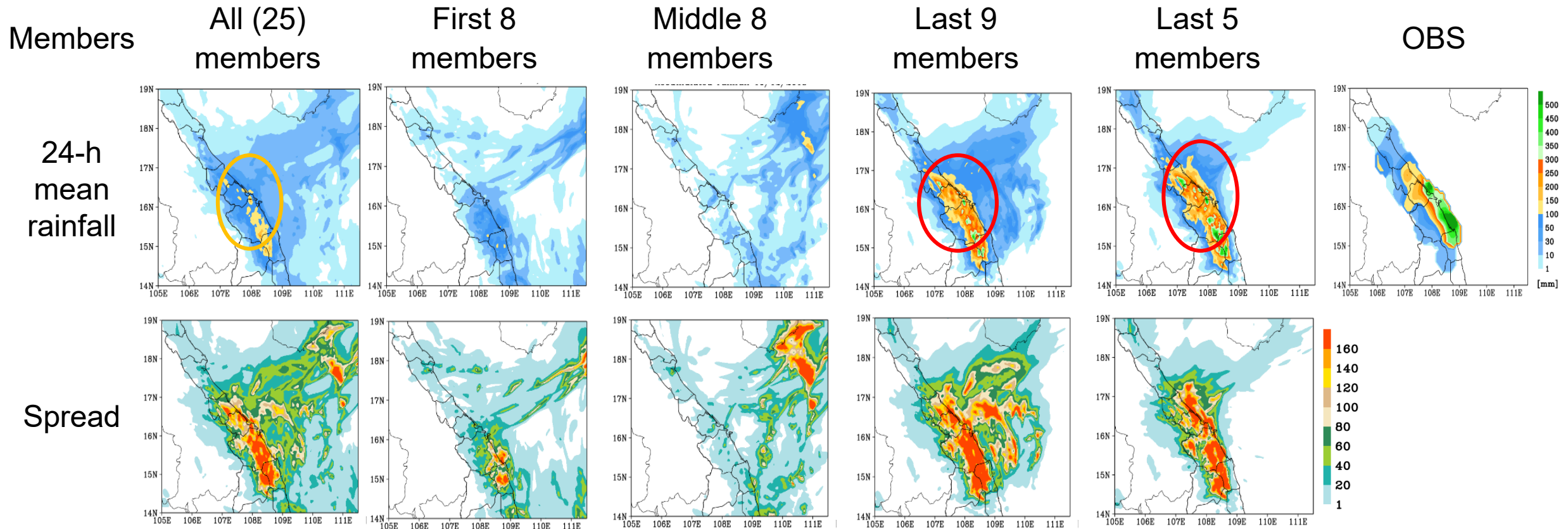
p_o - The observed values

- FSS's score shows that a forecast with perfect skill has a score of 1; a score of 0 means zero skill.

5. RESULTS AND DISCUSSION

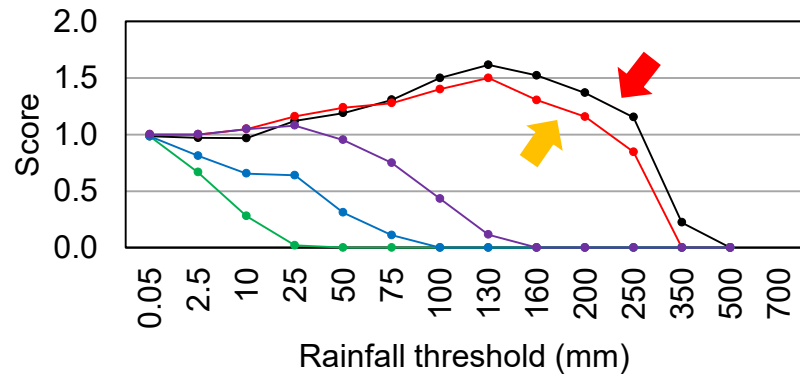
ENSEMBLE MEAN

Average 24-h accumulate rainfall and its spread (mm) for 10 Dec 2018

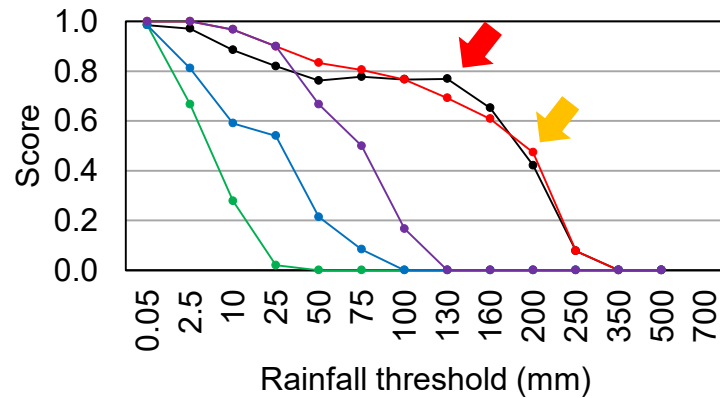


5. ENSEMBLE MEAN - 10/12/2018

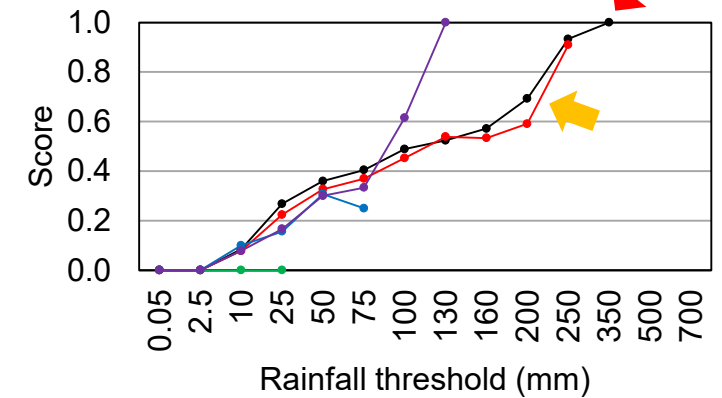
Frequency Bias



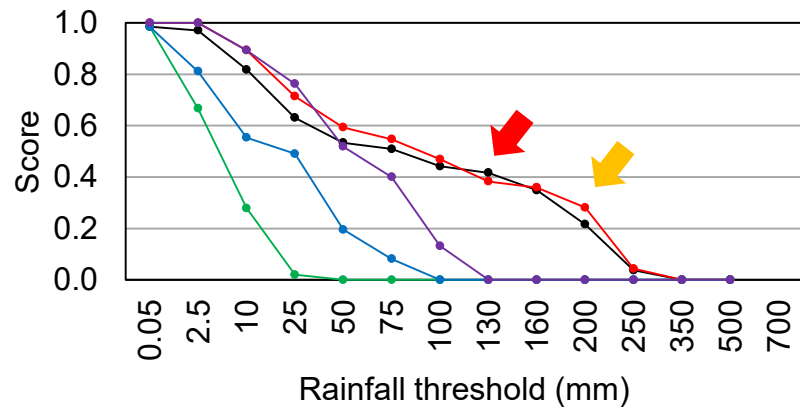
Probability Of Detection



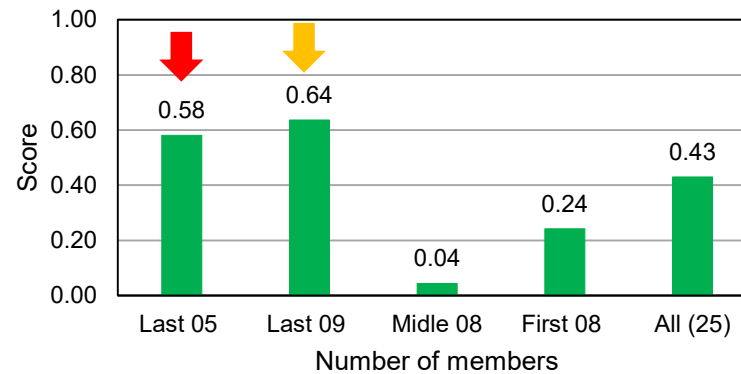
False Alarms Ratio



Threat Score



Fraction Skill Score



- Last 5 members
- Last 9 members
- Mid-8 members
- First 8 members
- 25 members

Max rainfall at obs stations:
 644.4 mm (Nui Thanh)
 539.2 mm (Cau Lau)
 517 mm (Thang Binh)
 446.8 mm (Ky Phu)

Probability distribution generated by the time-lagged ensemble for 24-h rainfall (12 UTC 9 Dec to 12 UTC 10 Dec)

Last 5 members

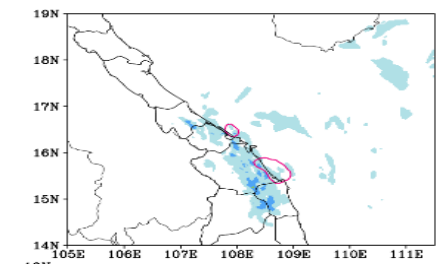
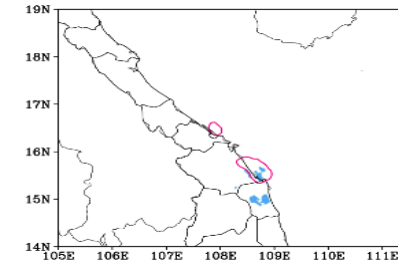
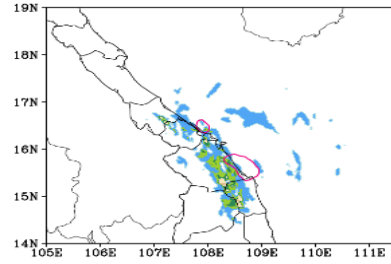
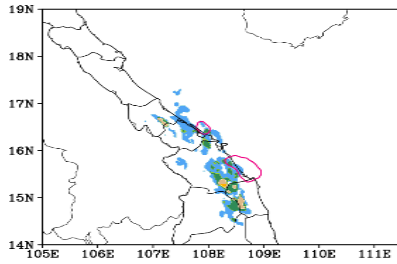
Last 9 members

Middle 8 members

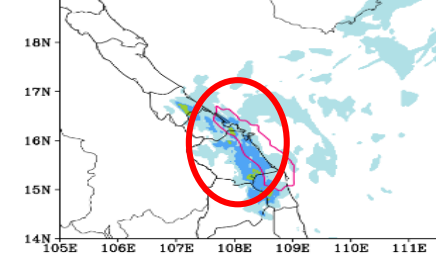
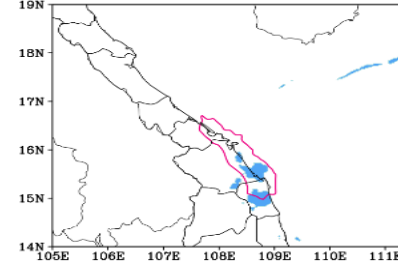
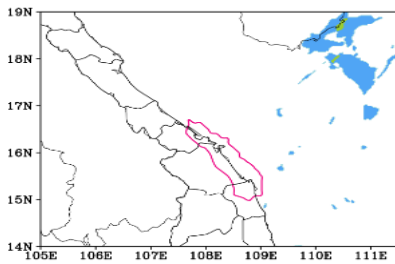
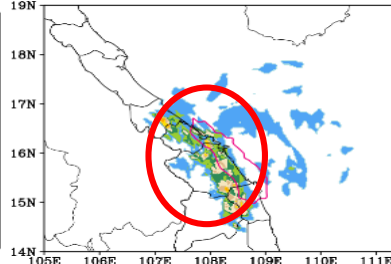
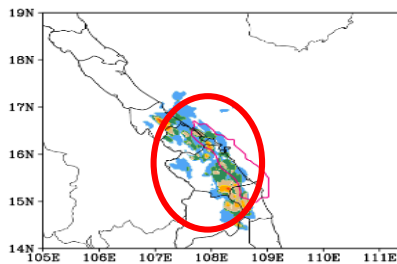
First 8 members

25 members

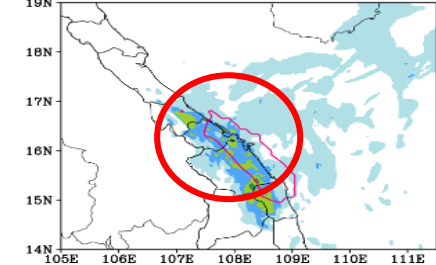
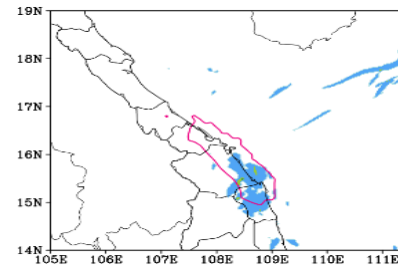
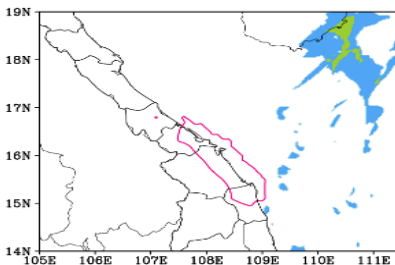
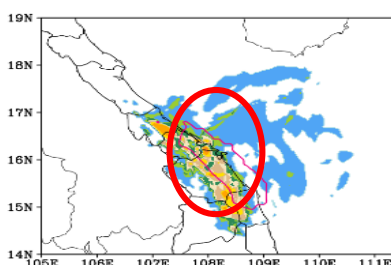
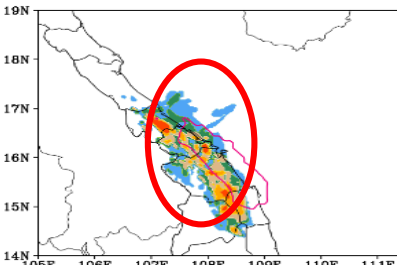
450 mm



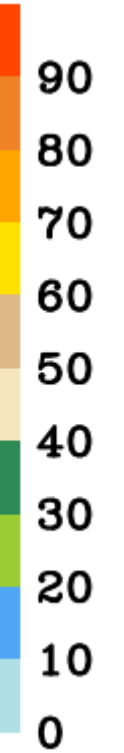
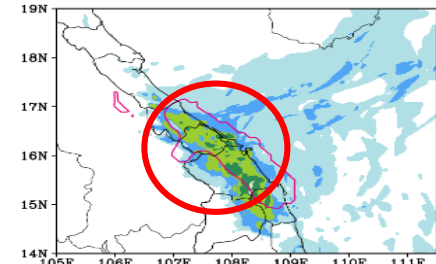
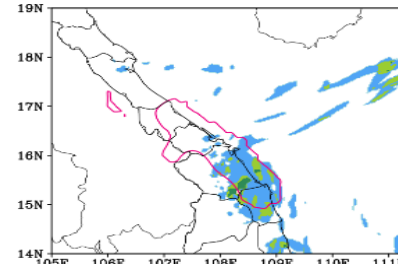
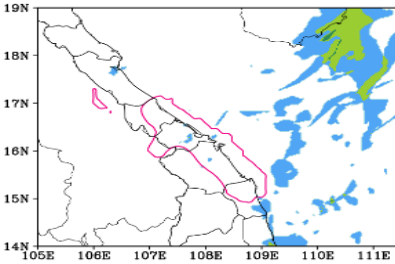
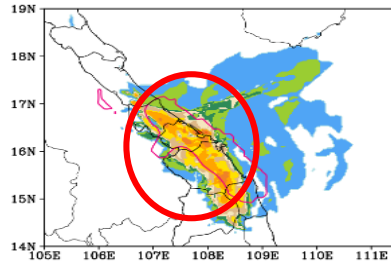
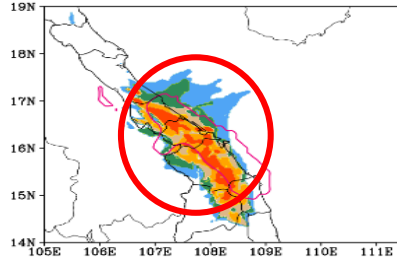
300 mm



200 mm



100 mm

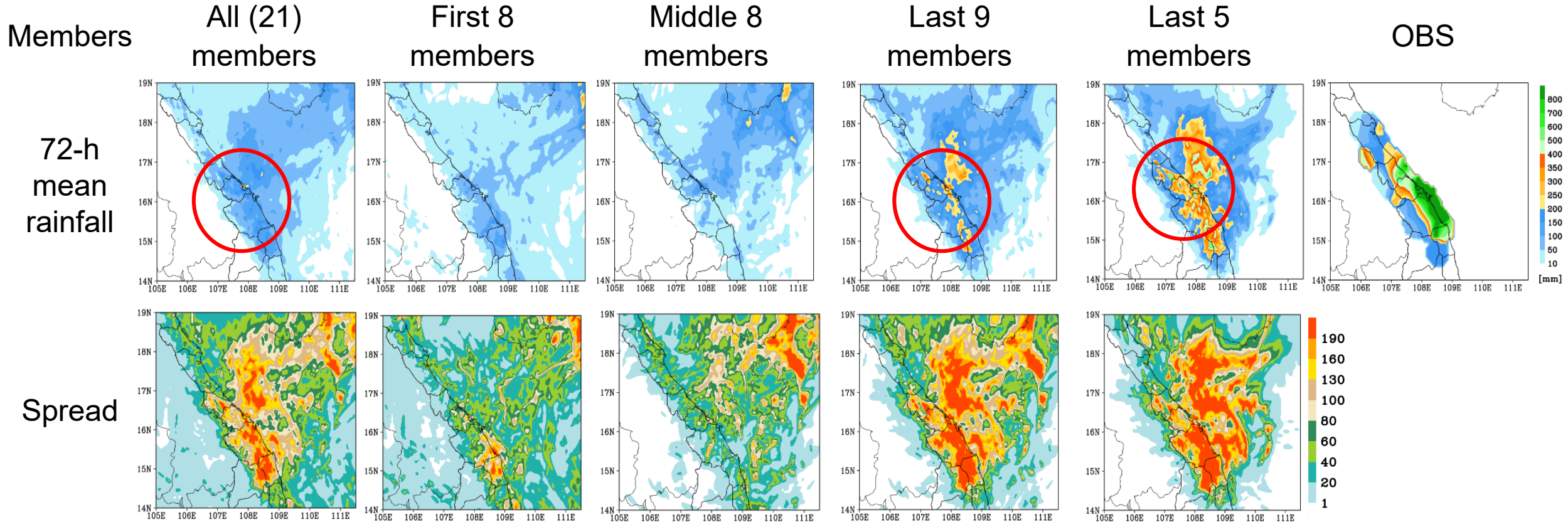


(%)

5. RESULTS AND DISCUSSION

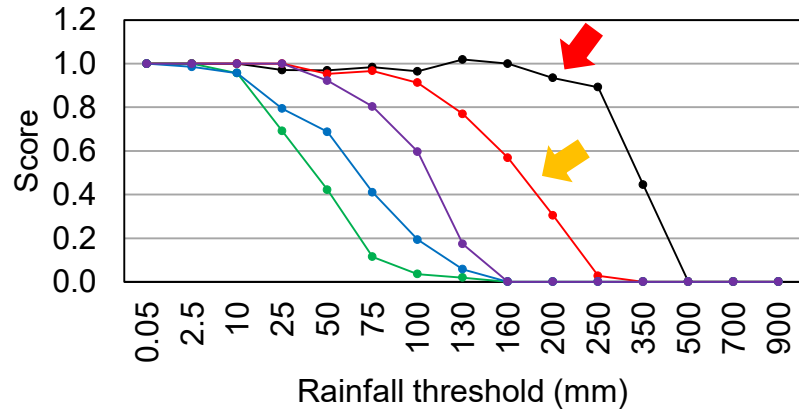
ENSEMBLE MEAN

Average 72-h accumulate rainfall and its spread (mm) for 8-11 Dec 2018

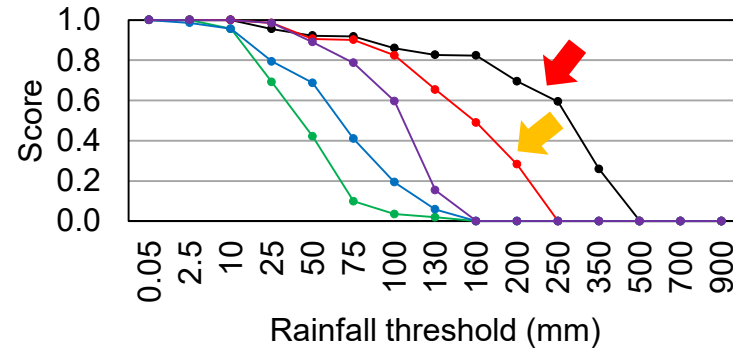


5. ENSEMBLE MEAN– 72 h (8-11/12/2018)

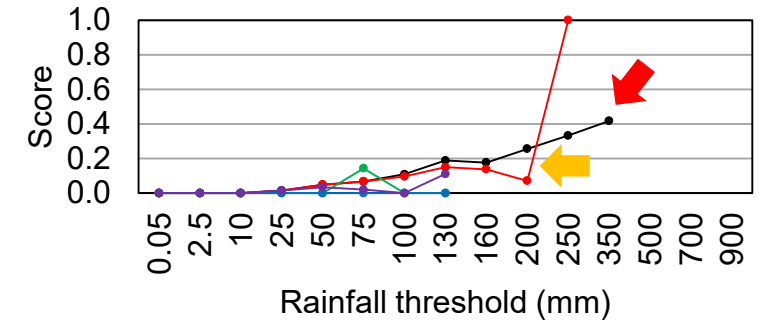
Frequency Bias



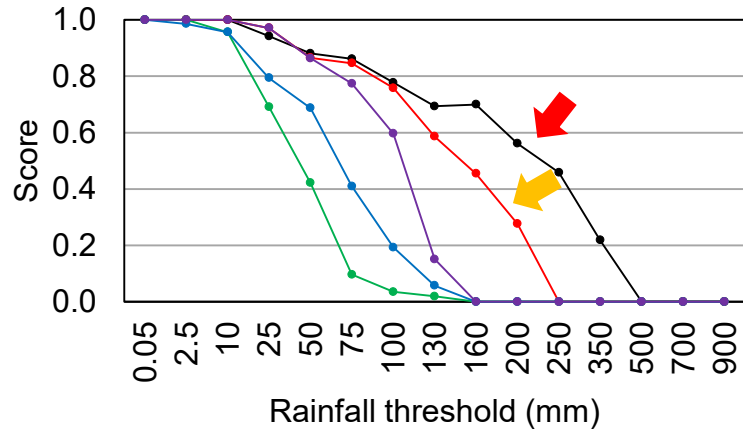
Probability Of Detection



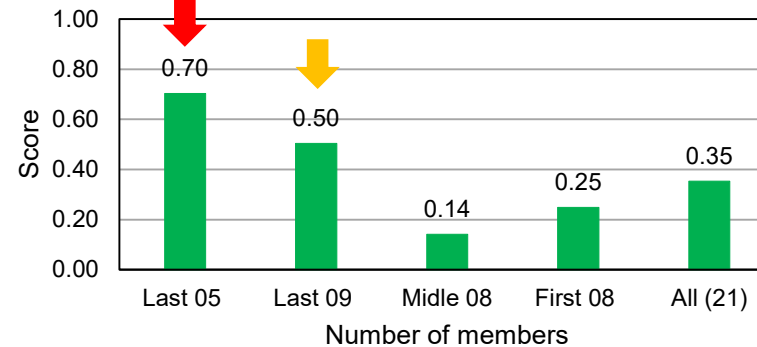
False Alarms Ratio



Threat Score



Fraction Skill Score



Max rainfall at obs stations:
 1054 mm (Thang Binh)
 1004 mm (Bach Ma)
 983 mm (Da Nang)

- Last 5 members
- Last 9 members
- Mid-8 members
- First 8 members
- 21 members

Probability distribution generated by the time-lagged ensemble for 72-h rainfall (12 UTC 8 Dec to 12 UTC 11 Dec)

Last 5 members

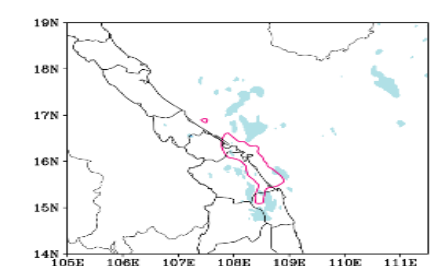
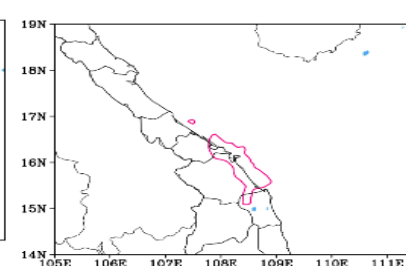
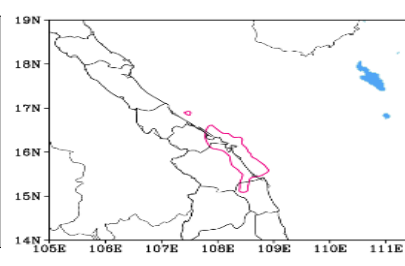
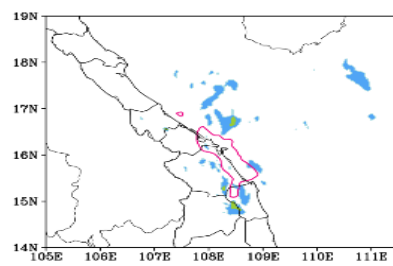
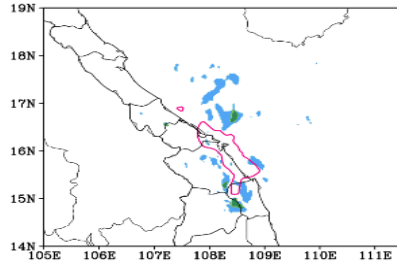
Last 9 members

Middle 8 members

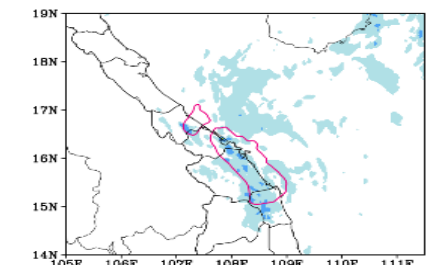
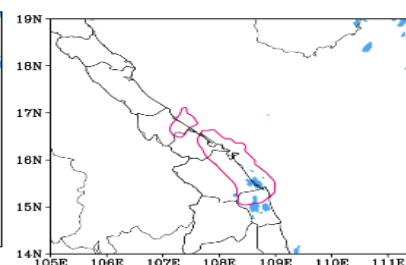
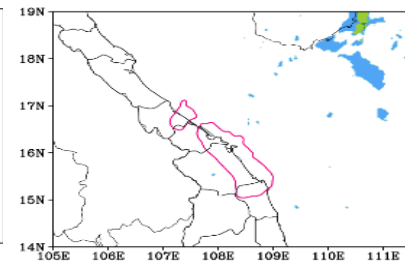
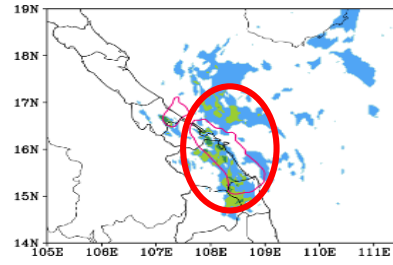
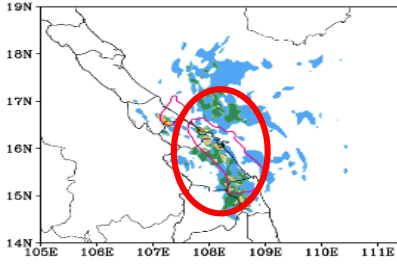
First 8 members

21 members

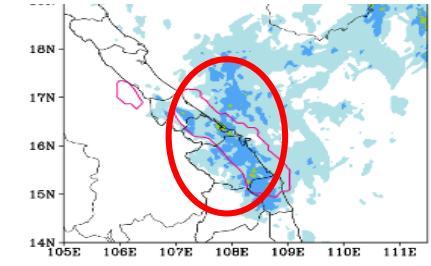
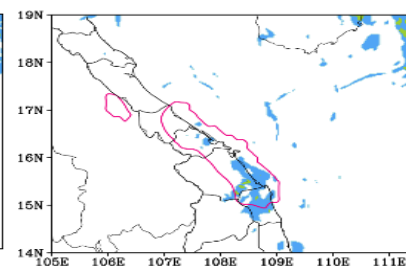
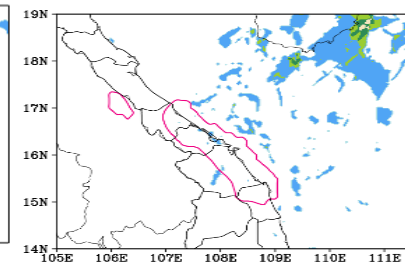
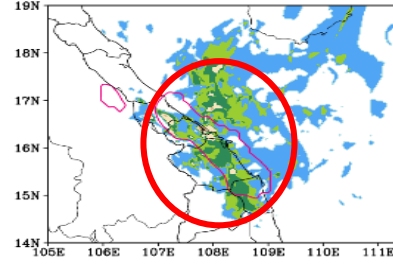
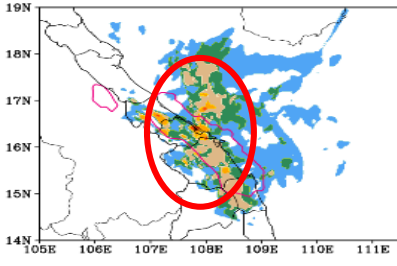
800 mm



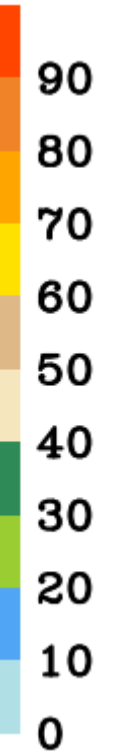
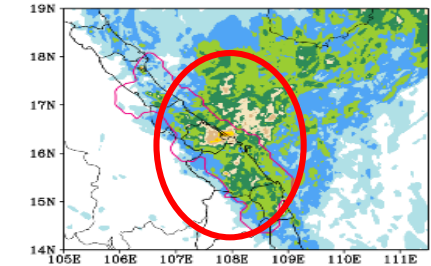
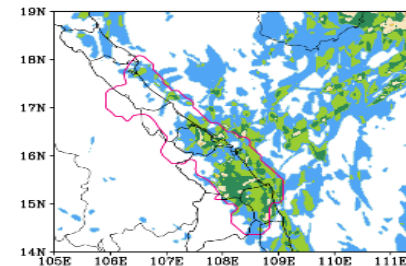
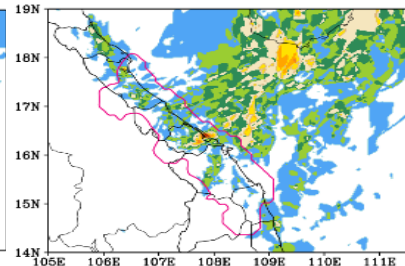
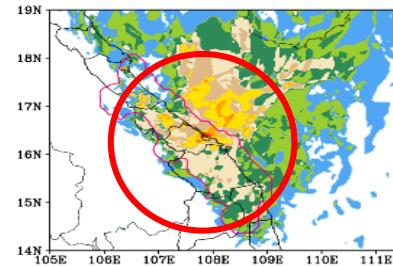
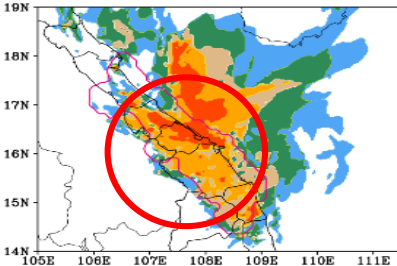
500 mm



300 mm



100 mm



(%)

6. CONCLUSION

This study focused on predictive testing an extreme precipitation event that occurred on 8 - 11 December 2018 along the coast of central of Vietnam, and evaluates its predictability in the High-Resolution Time-Lagged Ensemble Prediction System using the CReSS Model. The major findings of this research can be summarized as follows:

- *CReSS has high skills in heavy-rainfall QPFs for this case, not only at lead time day 1 but also in days 2 and 3.*
- ✓ The FSS scores for the 24-h rainfall of Dec 10 at the lead time day 1, day 2, day 3 is 0.6, 0.64, respectively.
- ✓ FSS scores for the 72-h rainfall is 0.7 at lead time day 1 and 0.5 at lead time day 2.
- *It is challenge to achieve the prediction of QPF for rainfall thresholds greater than 100 mm with lead time longer than 3 days.*

This is the first time a cloud-resolution model (CReSS) has been applied to forecast extreme rainfall in Vietnam, and the results are very impressive.

Thank you for your attention!