A study on evaluation method for predictability of persistent heavy rainfall events over East Asia based on ensemble forecast

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1. Introduction

- The Persistent Heavy Rainfall (PHR) is the most influential extreme weather event in Asian summer monsoon season, which has attracted intensive interests of many scientists.
- A new verification method applied to evaluate the predictability of PHR is investigated. By use of operational global ensemble forecasts from China Meteorological Administration (CMA), a metrics called Index of Composite predictability (ICP) based on Equitable Threat Score(ETS) of 24h accumulated precipitation and Root Mean Square Error(RMSE) of Height at 500hPa is established to identify "good" and "poor" forecast from ensemble members.
- Moreover, by using ICP, two PHR events that occurred in Yangtze River region were analyzed. By identifying two members with the best and worst forecast performance and comparing the differences between initial condition errors, its growth, and the key weather systems impact on PHR, the rationality and reliability of ICP are analyzed. This research would lay a foundation for the assessment of predictability of PHR and mechanism of error growth in NWP model.

2. Data and Methodology

2.1 Data the two PHR events

- This T213-based ensemble prediction system includes 15 members with the horizontal resolution of 0.5625°.
- The observations are the precipitation observed from 2412 stations offered by National Meteorological Information Center of China.

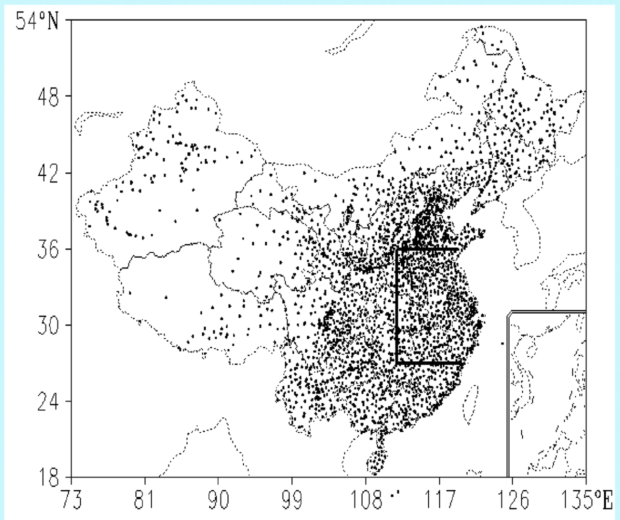


Fig. 1 Distribution of 2412 stations in China. The area constrained by three black lines and the east coast is taken as the Huaihe River Basin in this paper.

Two of the longest events are selected from the PHR events which are not affected by typhoon systems in Huaihe river basin between 2009 and 2011. The integrated intensity of Event I is the third among the PHR rainfall events in Huaihe River Basin from 1950 to 2010, which makes it an excellent representation of PHR events.

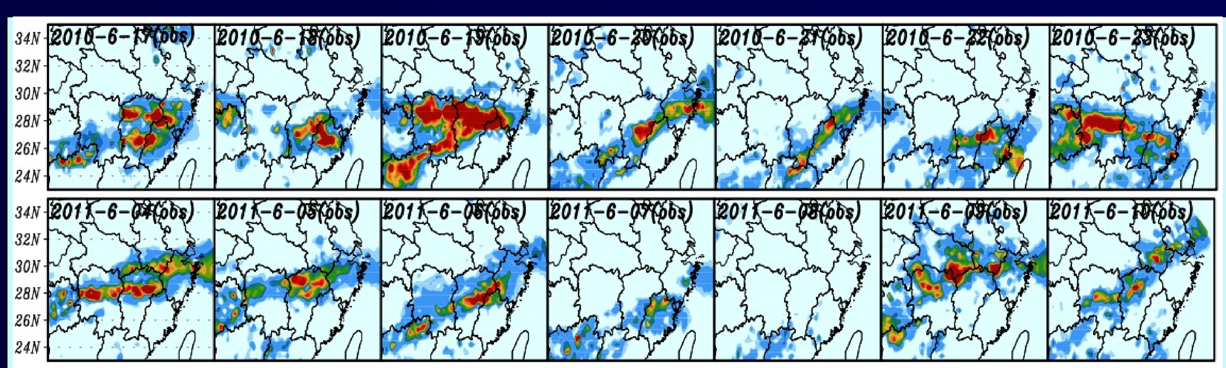


Table. 1 Precipitation of the two persistent heavy rainfall events in Huaihe river basin from 2010 to 2011

Events	Date (mm.dd)	Total Number of stations	amount of daily precipitation /mm
Event I (June 17- June 25, 2010)	6.17	54	8521.8
	6.18	39	5391.0
	6.19	91	13211.0
	6.20	35	4774.7
	6.21	11	2621.8
	6.22	18	3021.7
	6.23	31	4967.2
	6.24	50	7160.6
	6.25	6	2201.3
Event II (June 4- June 12, 2011)	6.04	77	9064.4
	6.05	34	5907.5
	6.06	33	6441.8
	6.07	10	1988.6
	6.08	0	104.0
	6.09	54	8873.8
	6.10	35	5688.5
	6.11	20	3260.0
	6.12	19	4114.3

2.2 Methodology of ICP

To evaluate and compare the ensemble members' forecast ability during the two PHR events,we defined ICP(Index of Composite Predictability) based on the ensemble forecast,Specific mathematical process is as follows:

- 1) Consistency processing of verification index.
The purpose of this step is to unifiy two types verification index.Make it the greater NIV value, the better the forecast.

$$NIV = \begin{cases} IV & \text{score value is the first type} \\ -1\times IV & \text{score value is the second type} \end{cases} \quad (1)$$

- 2) Compare the NIV of individual ensemble member to the average NIV of all members each time.

$$AV_m^{\ i} = \frac{NIV_m^{\ i} - \sum_{m=1}^{M} NIV_m^{\ i} / M}{\sum_{m=1}^{M} NIV_m^{\ i} / M} \quad (2)$$

- 3) The definition of ISV (Index of Composite Predictability). By the definition of ISV (AVm), it may have diverse results by choosing different verification index for a particular ensemble member.

$$ISV(AV_m) = \sum_{i=1}^{IFT} AV_m^{\ i} / IFT \quad (3)$$

- 4. ICP model for the persistent heavy rainfall
For persistent heavy rainfall (PHR), choose two verification indexes toconstruct ICP model for this weather event.

$$ICP_m = \begin{cases} ISV(ETS_m)+ISV(RMSE_m), & ISV(ETS_m)\times ISV(RMSE_m)\geq 0 \\ 0 & else \end{cases} \quad (4)$$

3 Results and discussion

3.1 "good member" and "poor member" from ICP scores

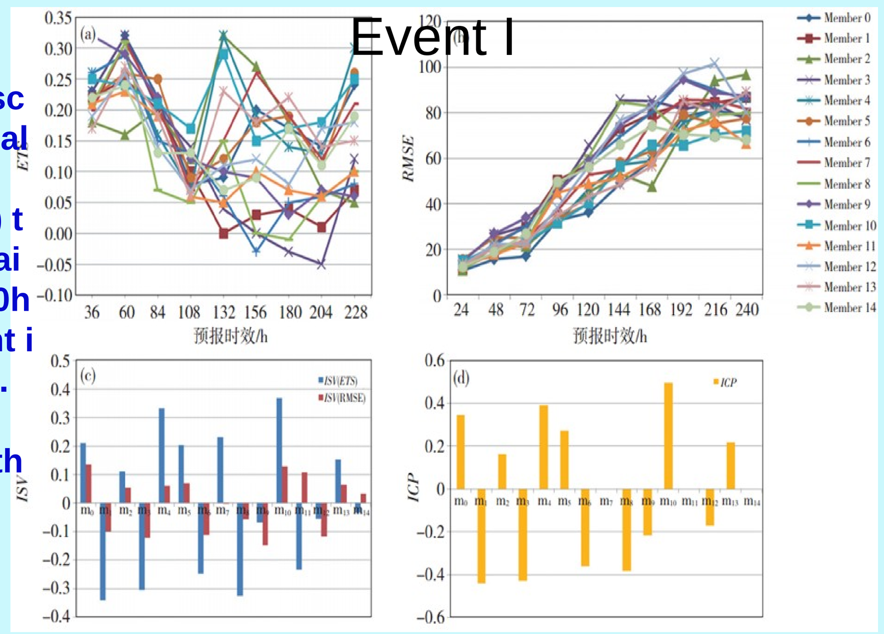


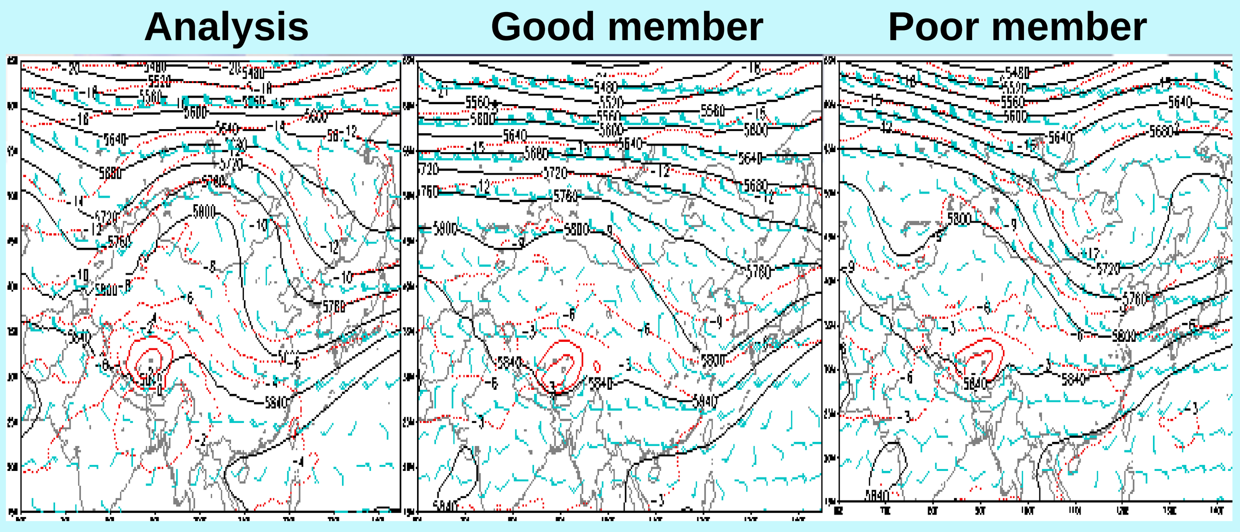
Fig.3 The verification scores of each individual member for the PHR event I. (a) the ETS of moderate rain. (b) the RMSE of 500hPa geopotential height in East Asia (red bars). (c) ISV(ETS) (blue bars),ISV(RMSE). (d) the ICP of

- Accoding the rank of ICP ,it is easy to see the "good member" is member 10 and "poor member" is member 1.

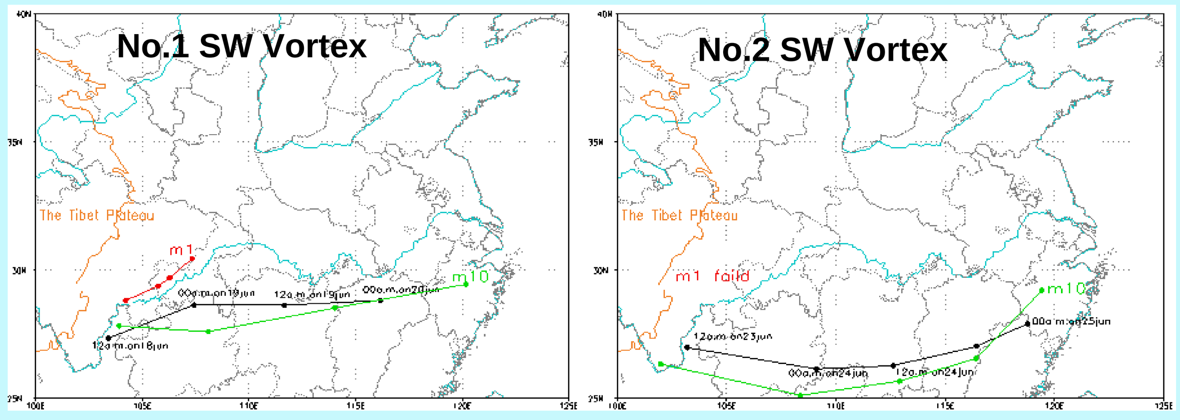
3.2 The Predictability for PHR events

By using the "good member" and "poor member" identified from ICP scores, the predictability of large scale general circulation, meso-scale weather systems and the predictions on precipitation intensities and locations will be analyzed.

Large scale general circulation

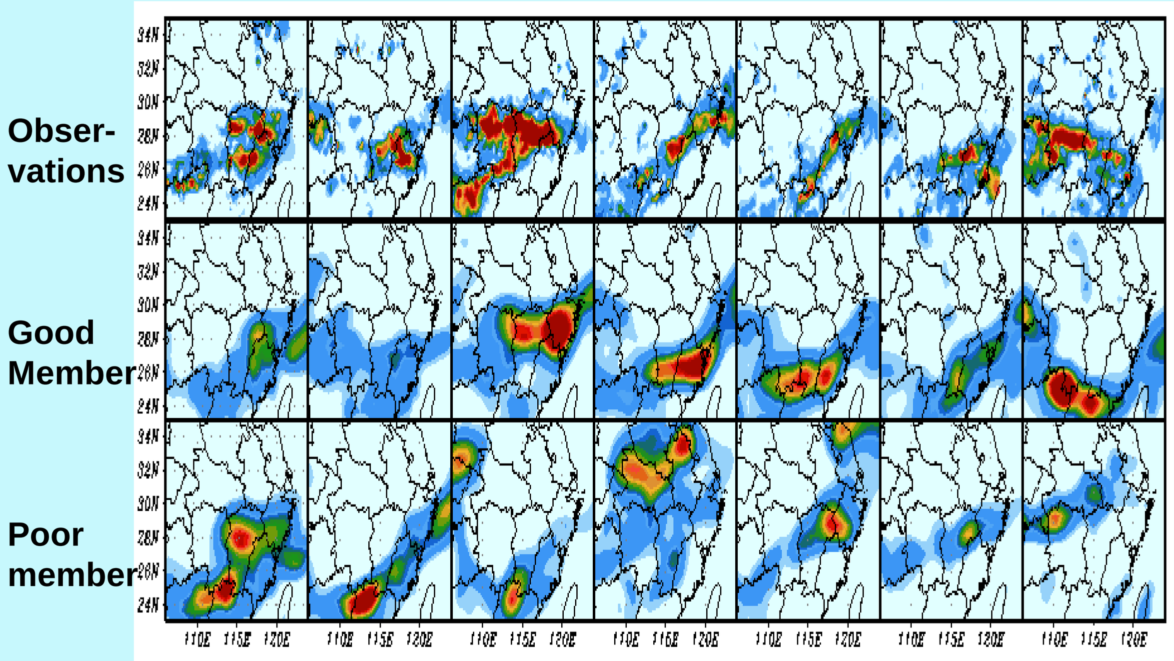


Mesoscale weather system- SW votex



- The "good member"has better performance in predicting the Mongolian high and mesoscale weather system than that of "poor member

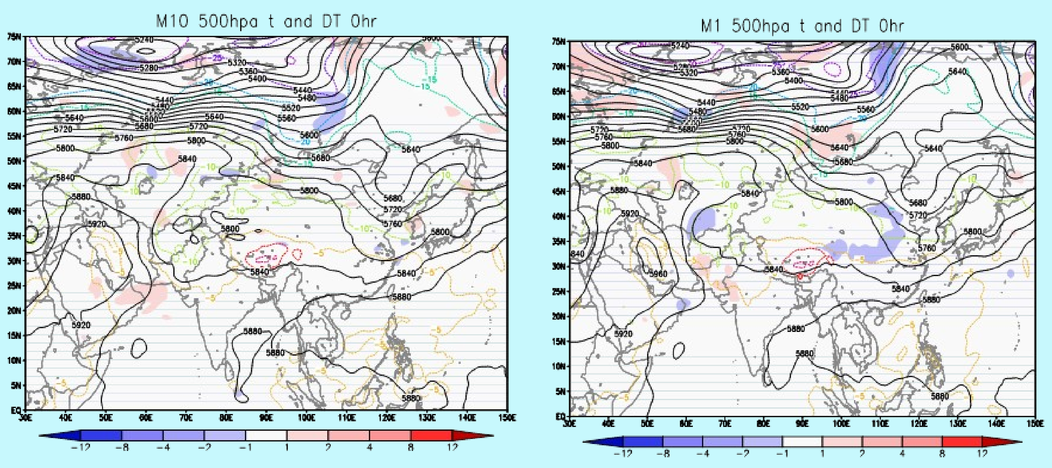
Precipitation forecast



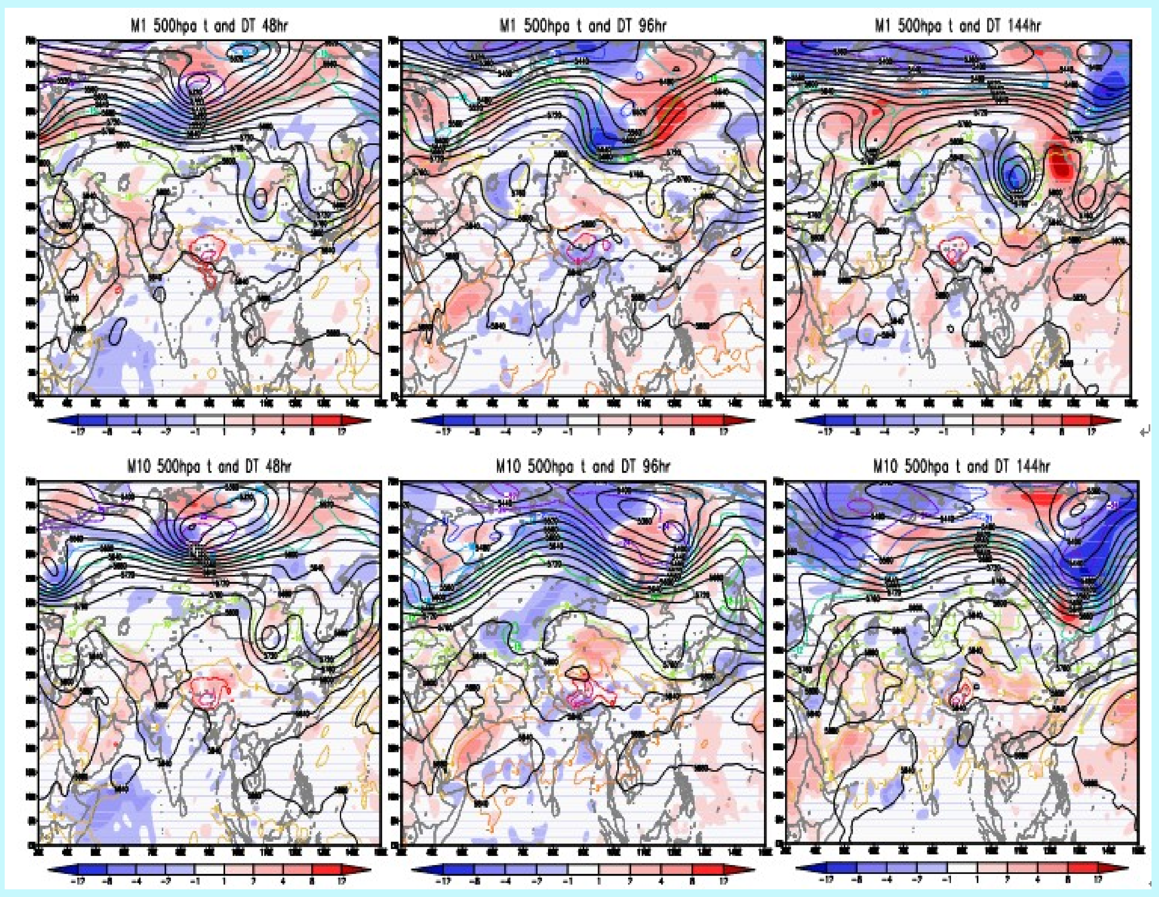
- The precipitation amount and the rain belt predicted by "good member" are much closer to the observations.

3.3 The initial error growth of "good member" and "poor member"

Initial temperature errors at 500hPa of event I



Initial temperature errors and evoluation at 500hPa



Evolution of temperature errors (shaded area) of "poor member"(up) and "good member" (down) at 500 hPa. The black contours are isobars, and the color contours are isothermals.

4. Conclusions

- A metrics called Index of Composite predictability (ICP) based on (ETS) and(RMSE)is established.
- The maximum and minimum value of ICP corresponds to the best and the worst performance of members respectively.
- The forecasts between the "good member" and "poor member" differed greatly in terms of the large scale circulation, mesoscale systems and precipitation.
- Accurate forecasting of heavy precipitation is the key success factor for the prediction of persistent heavy rainfall events, which is closely associated with the prediction on the genesis and development of mesoscale systems.
- The comparisons of the error growth between "good member" and "poor member" reveal that most of the temperature errors exist in the high latitudes and polar areas and grow rapidly with time, especially the errors on the trough.

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