

# Inter-comparison of Spatial Verification for Landing Typhoon Precipitation Forecast

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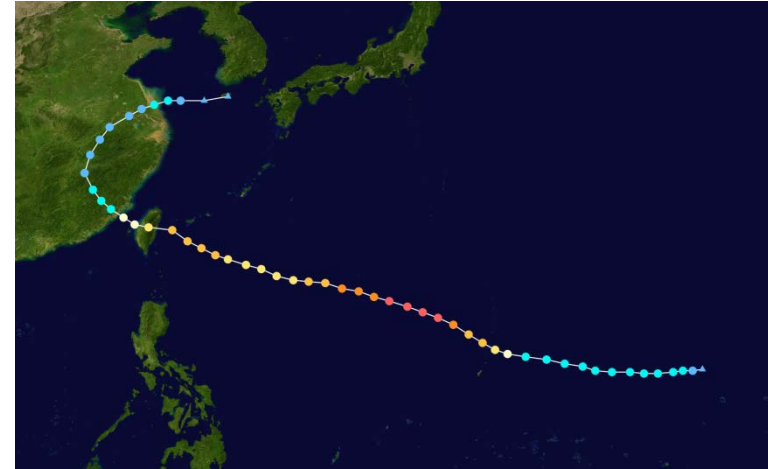
# Outline

- Overview of Typhoon Soudelor
- Spatial verification for landing precipitation
- Summary

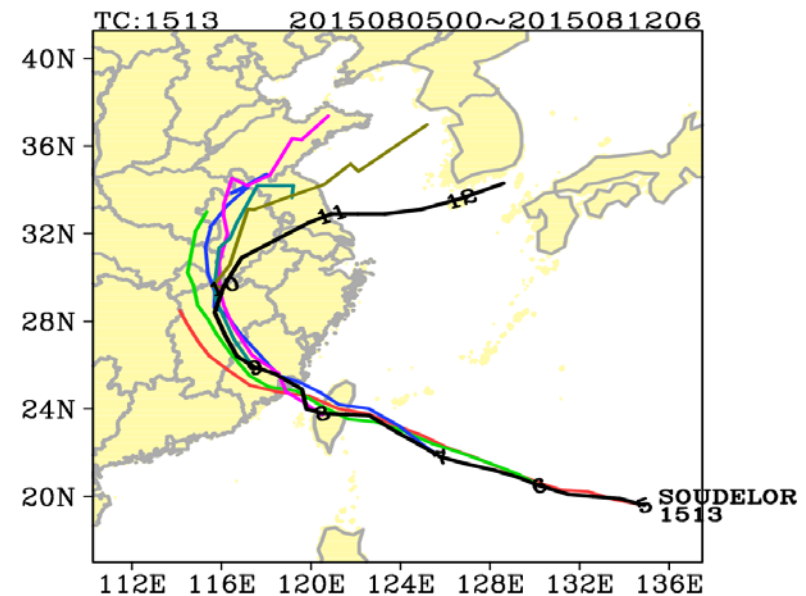


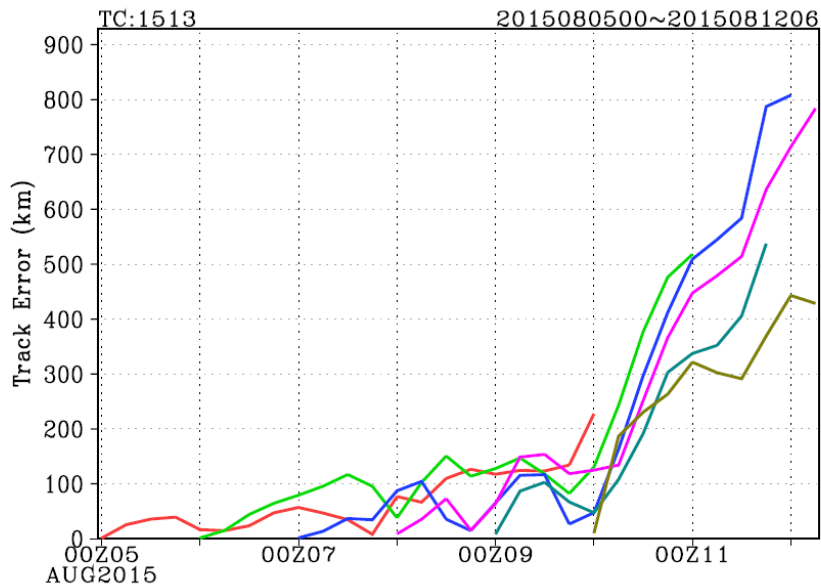
# TY Soudelor

Formed as TS in 12UTC July 30 2015, making landfall in Fujian on August 8 and brought torrential rains from August 9-10. The heaviest rains fell in Jiangsu Province, peaking at 467 mm.

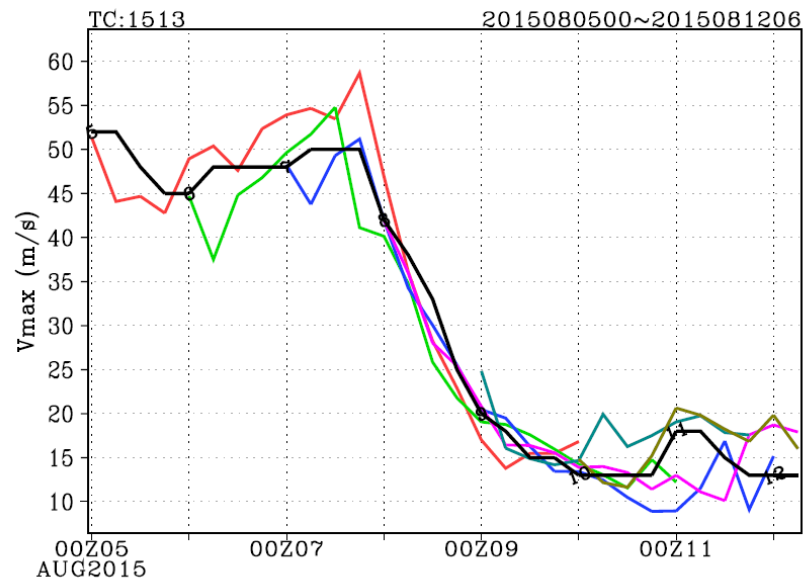
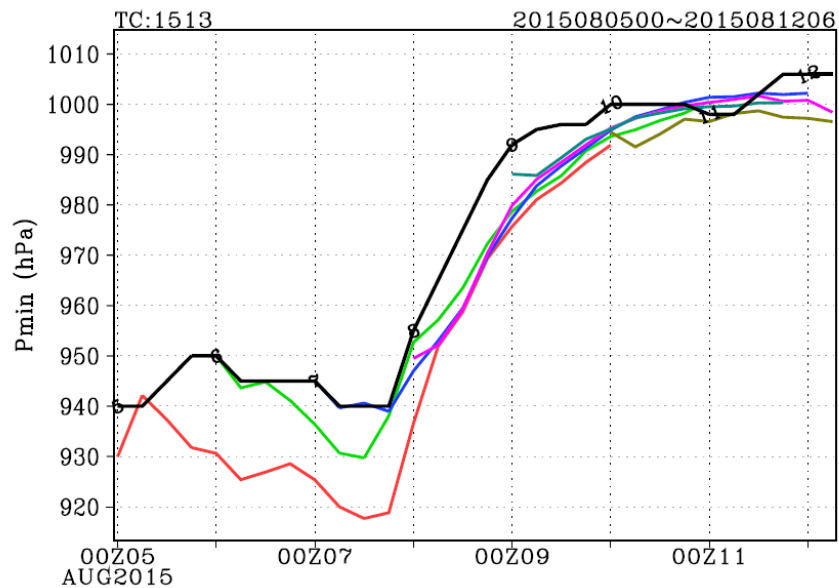


- GRAPES-Meso (TYM)
- 9 km (601 × 567)
- 120 hrs Fcst
- Select 5 leading time fcst results for rainfall on AUG 10
- Initial from 00 UTC AUG 5 – 00 UTC AUG 9



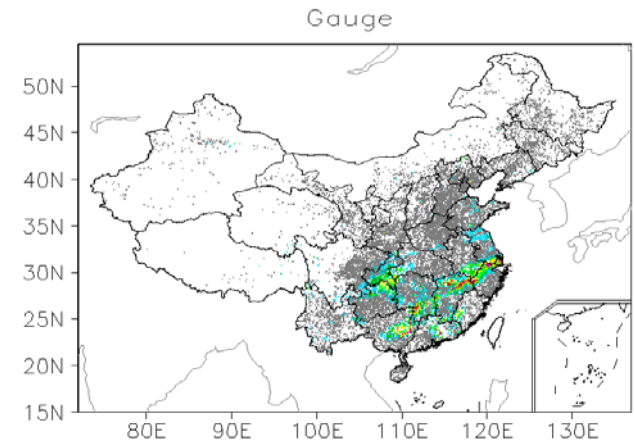
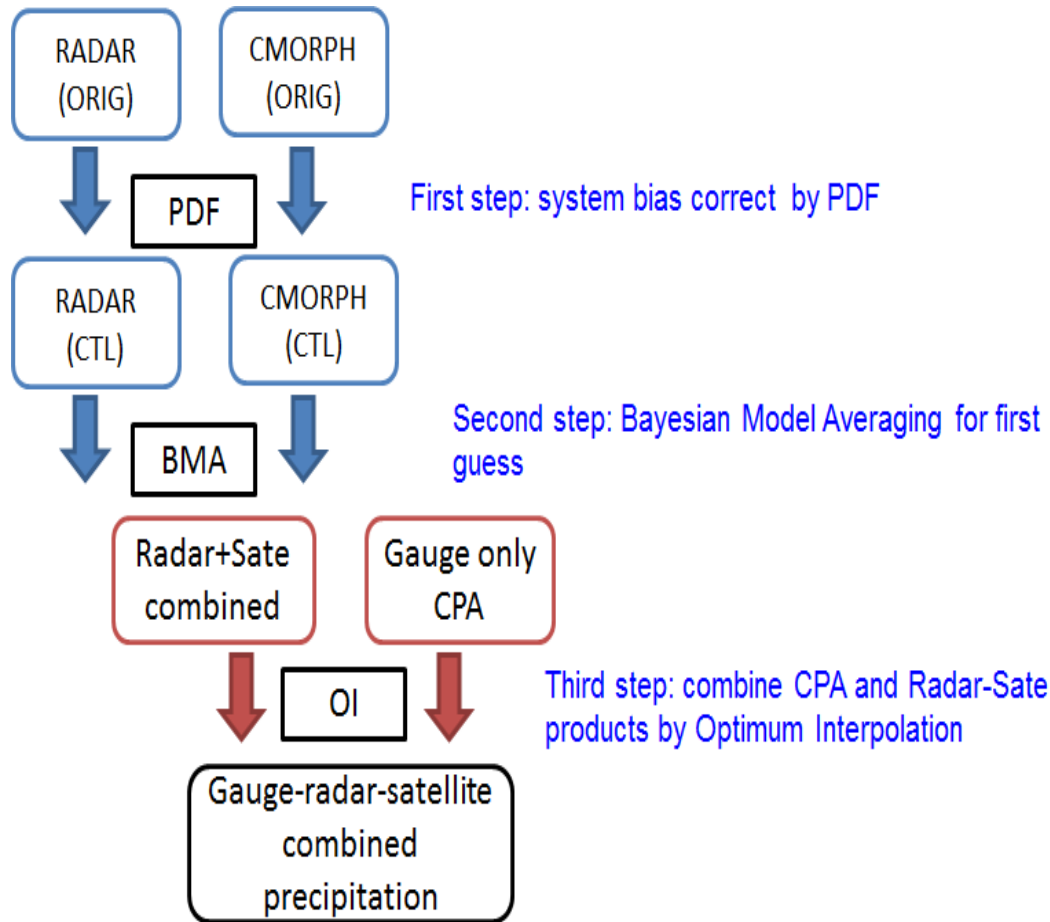


- ◆ Track error is less than 200 km before AUG 10
- ◆ Pressure is lower than OBS
- ◆ Max wind is equivalent to OBS



# Analysis Data

- Period: 20150810 24h precipitation
- Analysis: Chinese combined precipitation data (CMP)
- resolution: 5km & 1h



	0.1° resolution			0.05° resolution		
	CC	RMSE	Bias	CC	RMSE	Bias
CPA	0.6340	1.0374	-0.0143	0.6632	1.0088	-0.0111
RADAR	0.5291	1.1343	-0.0557	0.5650	1.1124	-0.0486
CMORPH	0.4451	1.1892	-0.0371	0.4481	1.2117	-0.0402
CMP (CPA+CMORPH)	0.6331	1.0408	-0.0133	0.6596	1.0115	0.0012
CMP (CPA+CMORPH+RADAR)	0.6556	1.0286	-0.0128	0.7183	0.9405	-0.0040

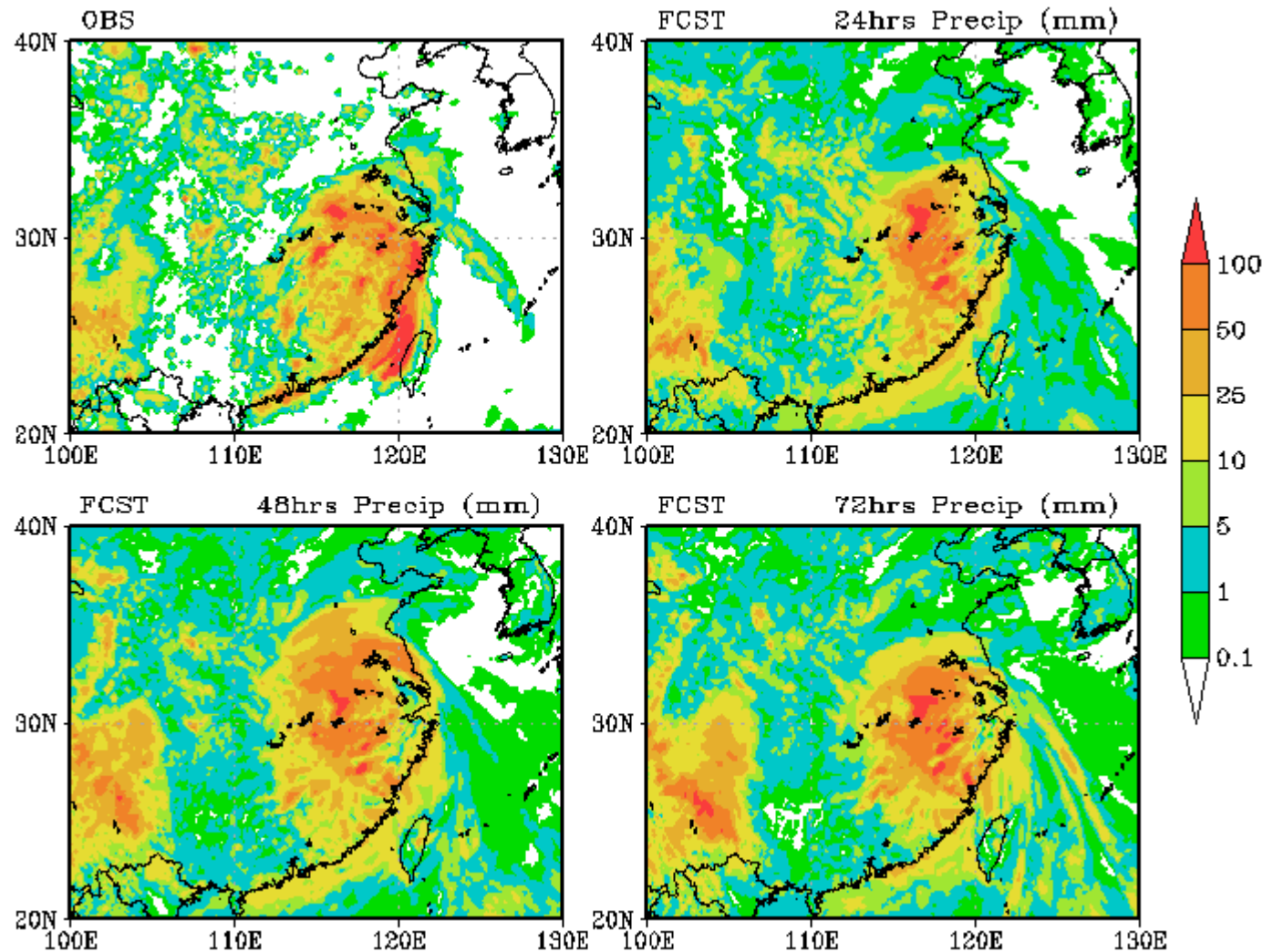
# Verification

24hr accu precip

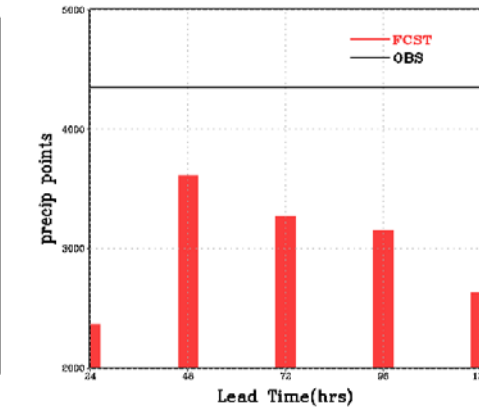
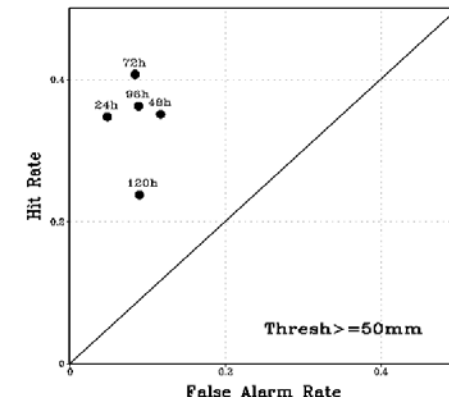
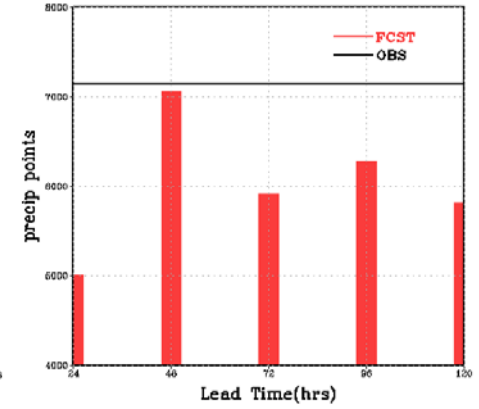
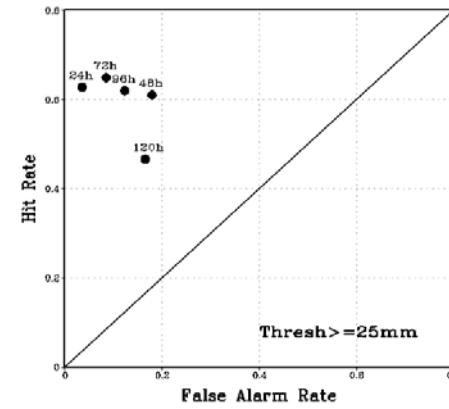
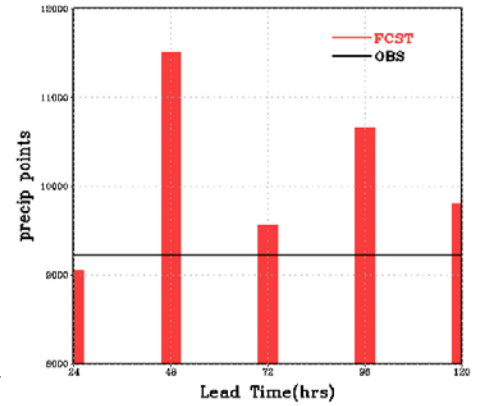
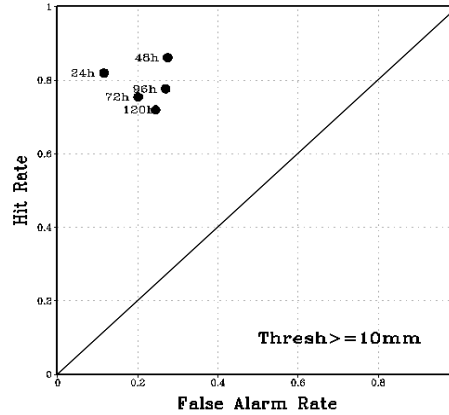
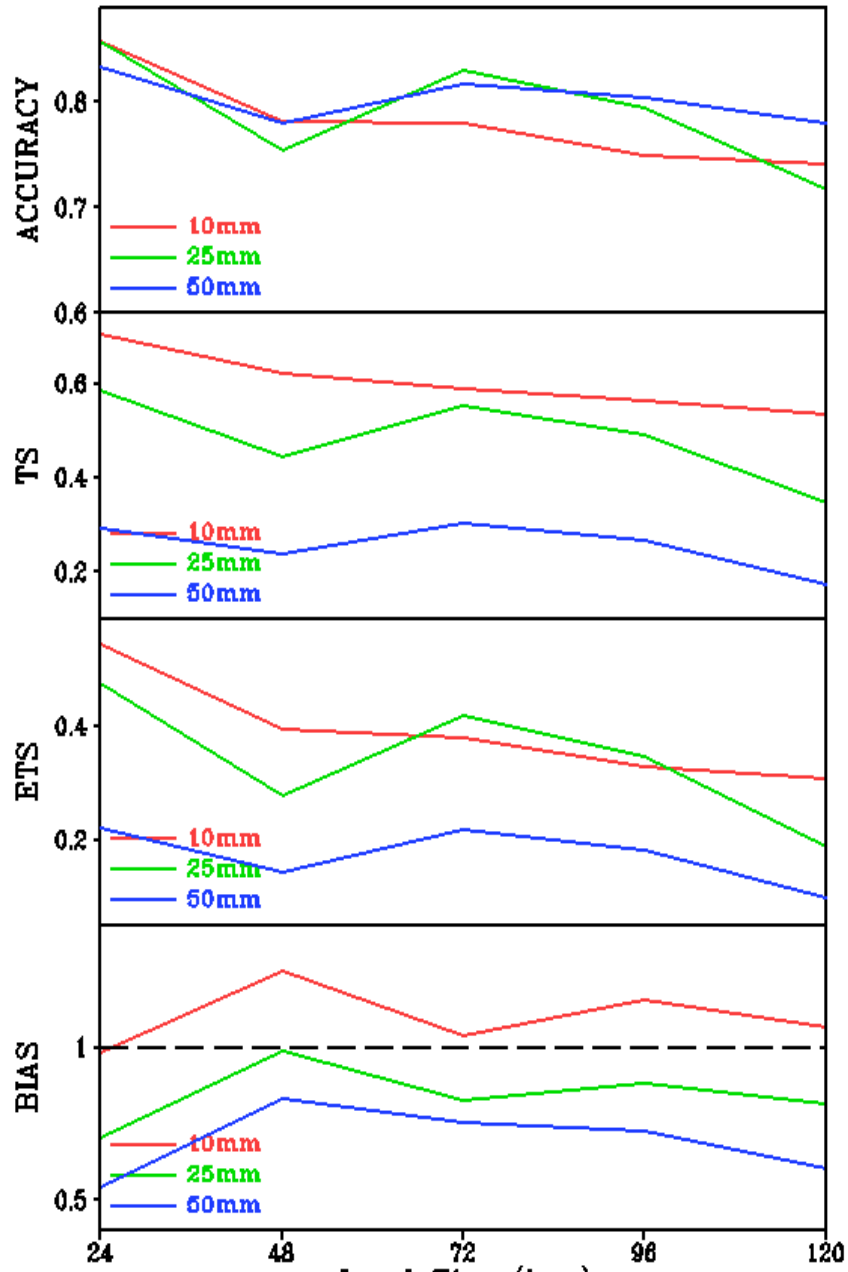
Valid:

2015081000

Res:10km



# Skill Scores



# MODE

Model: GRAPES-meso

OBS: Chinese merged precipitation data (CMP)

Resolution: 10km (0.1×0.1 deg)

Leading time: 24、48、72、96、120h

Valid date: 2015081000

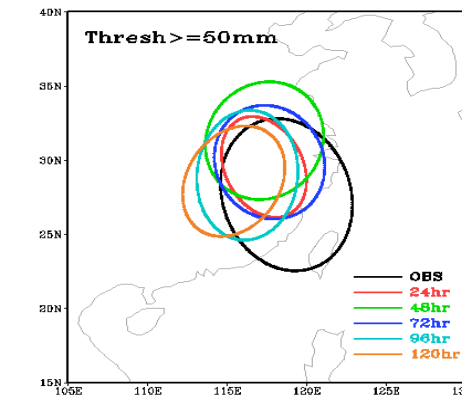
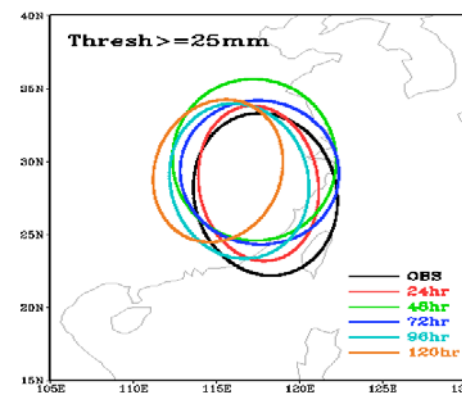
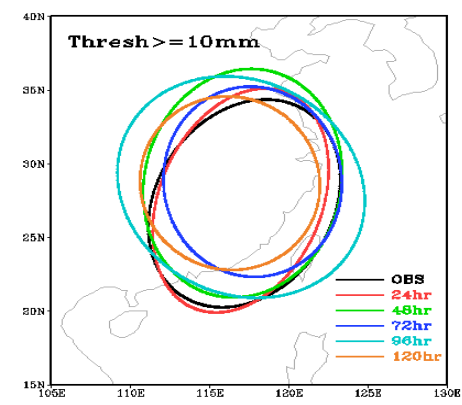
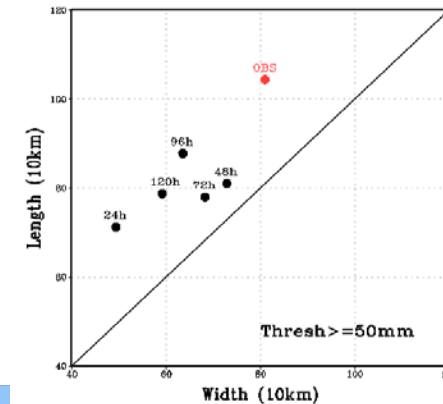
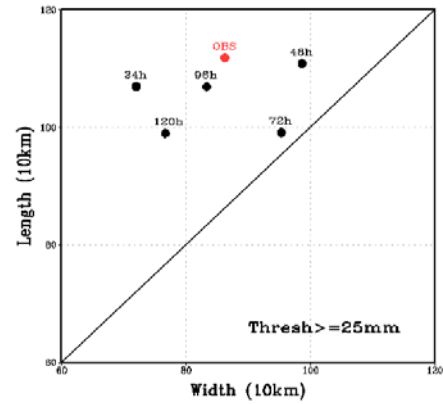
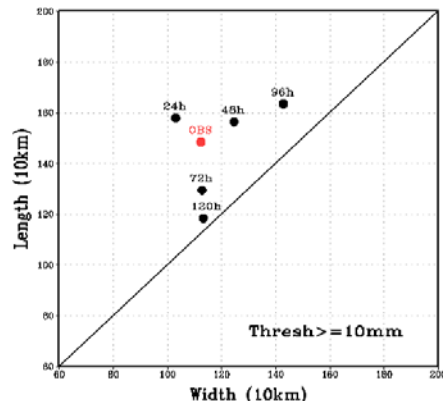
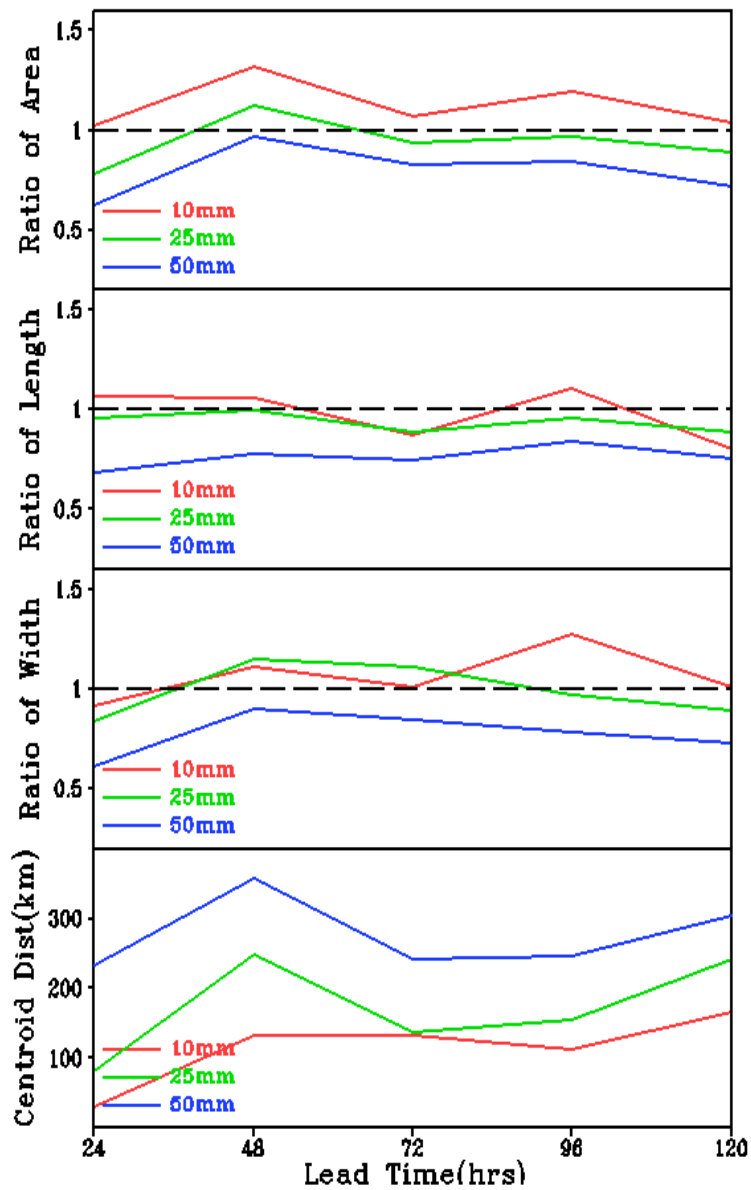
Domain: 20-35N ; 110-125E

151×151

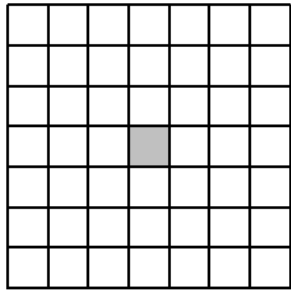
Thresholds : 10mm、25mm、50mm



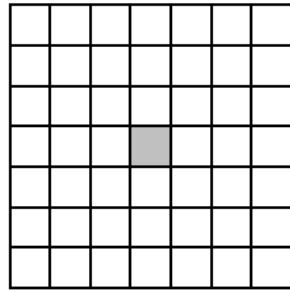




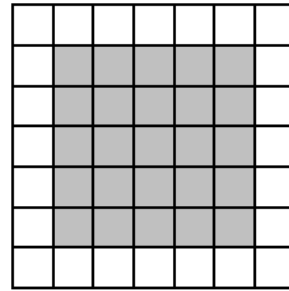
# Upscaling



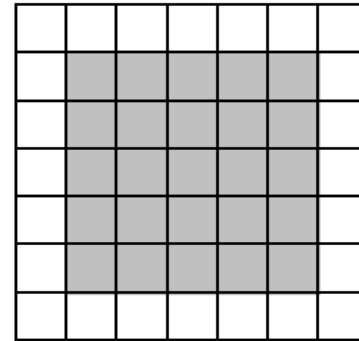
observation



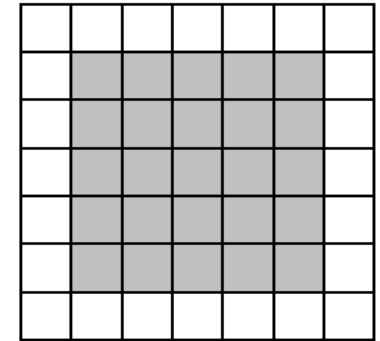
matched forecast  
(traditional  
verification)



matched forecast  
(fuzzy verification)



observation  
(fuzzy verification)



matched forecast  
(fuzzy verification)

$$\langle I_y \rangle_s = \begin{cases} 0 & \langle \bar{Y} \rangle_s < \text{threshold} \\ 1 & \langle \bar{Y} \rangle_s \geq \text{threshold} \end{cases}$$

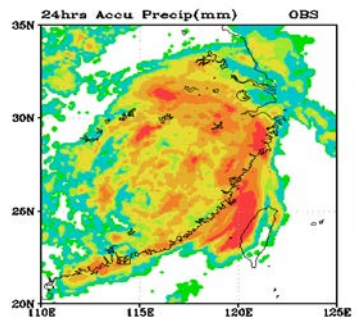
Scales: 10、30、50、90、170 km

Leading time: 24、48、72、96、  
120h

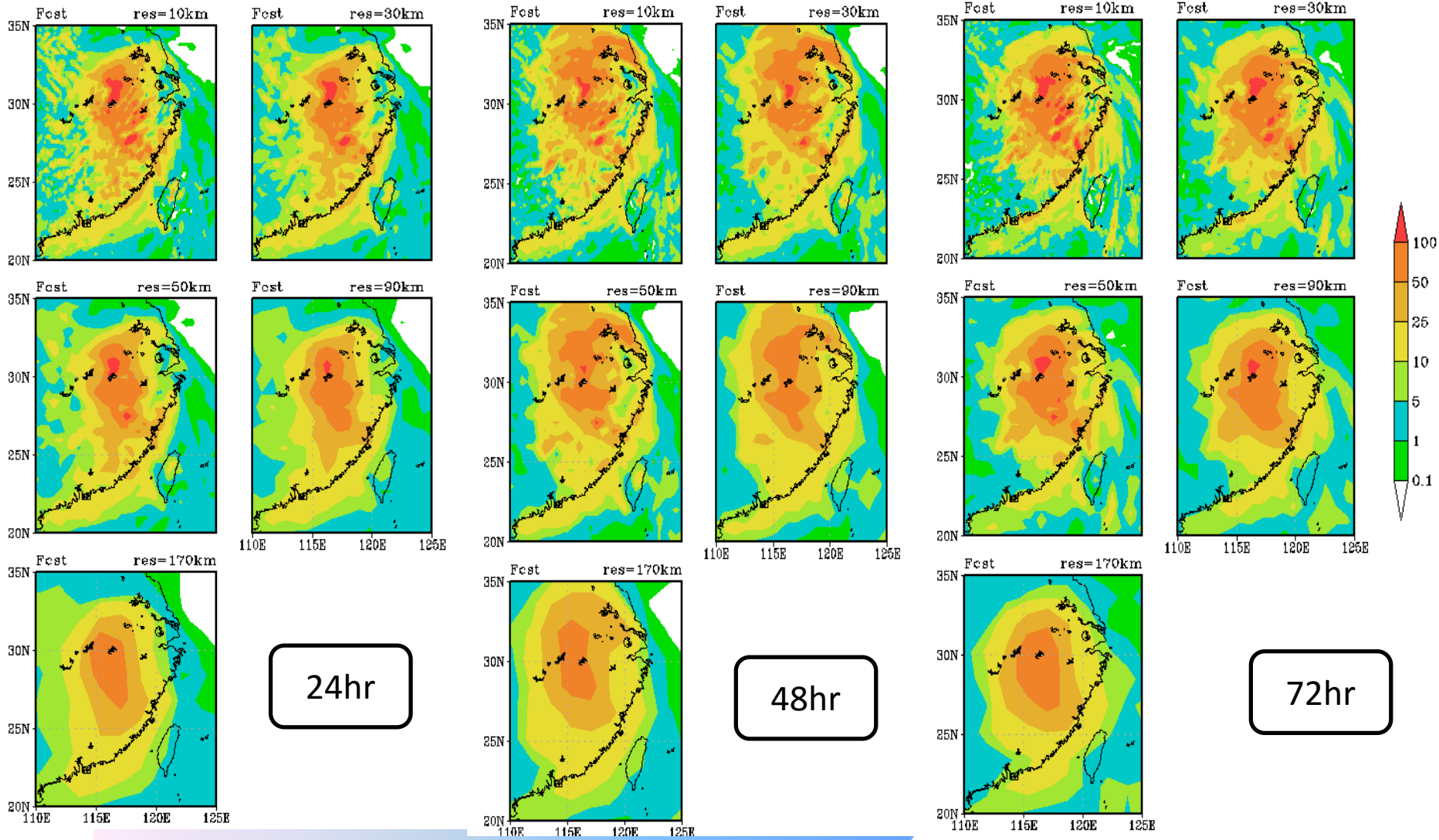
Valid date: 2015081000

Thresholds : 10mm、25mm、50mm

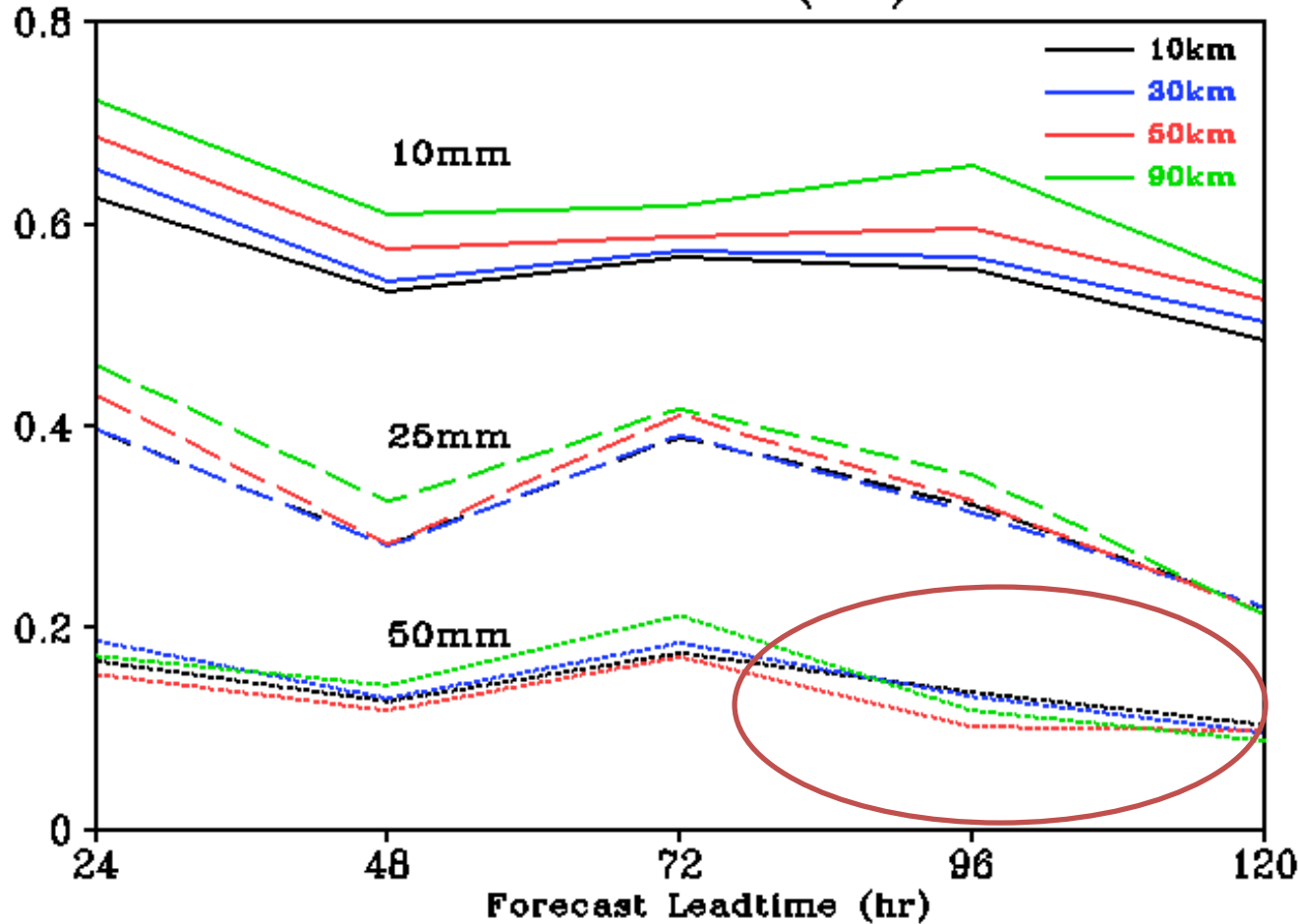




OBS



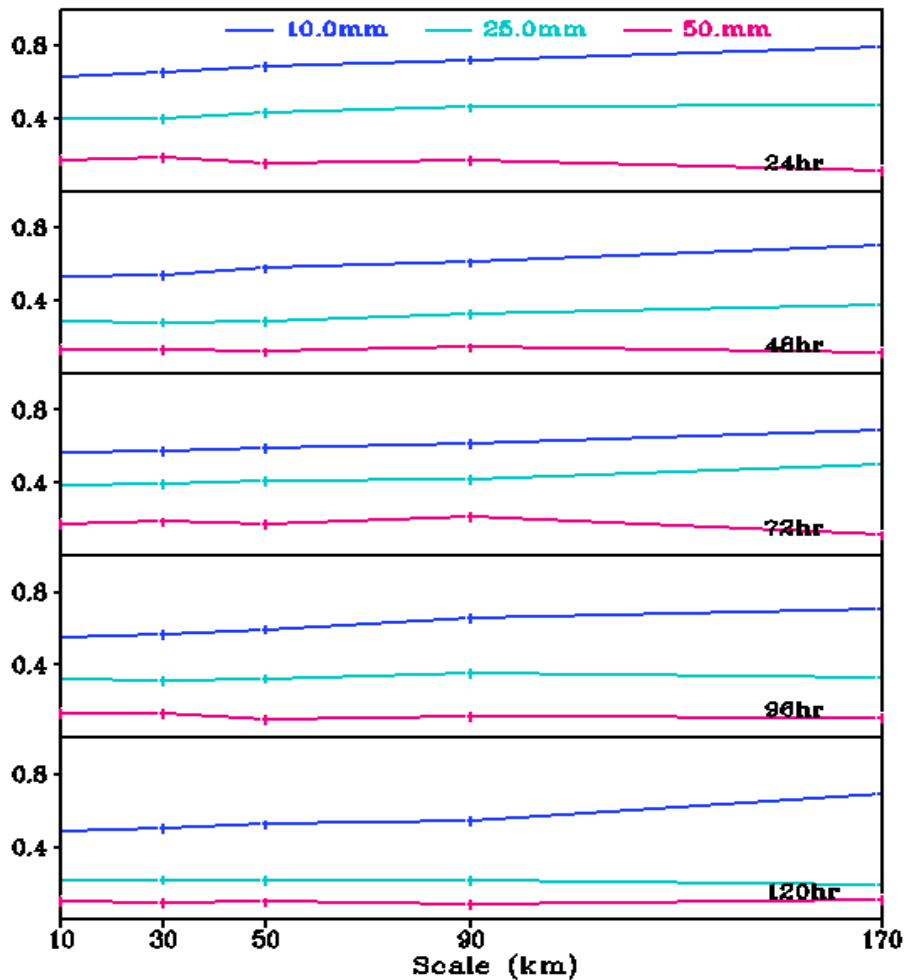
# Fractions TS (CSI)



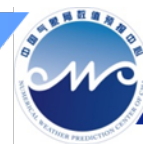
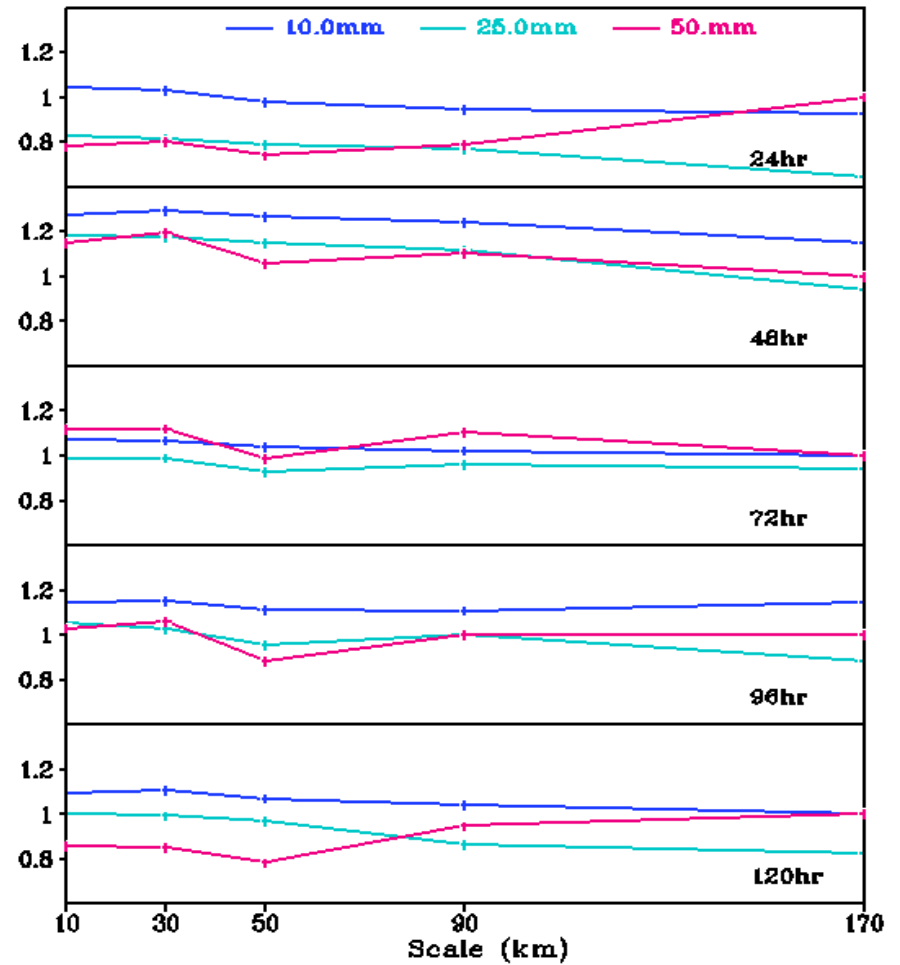
Big uncertainty  
in long lead-time  
(96-120h) for  
heavy rain



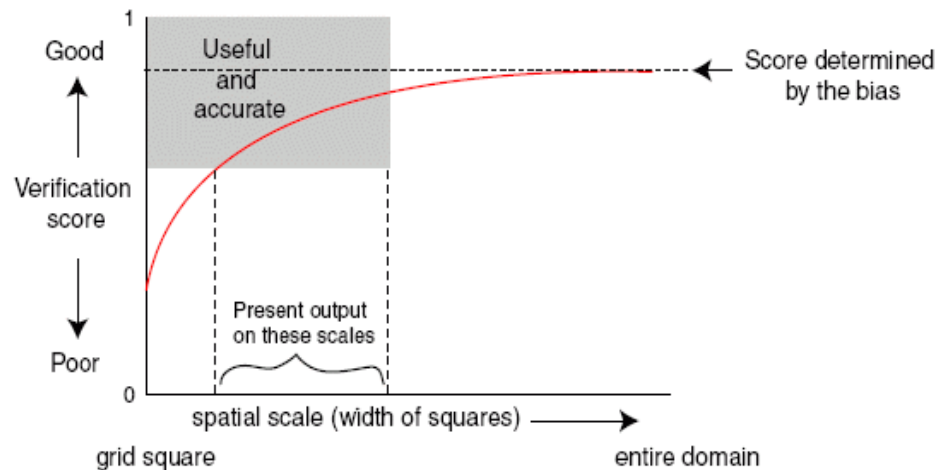
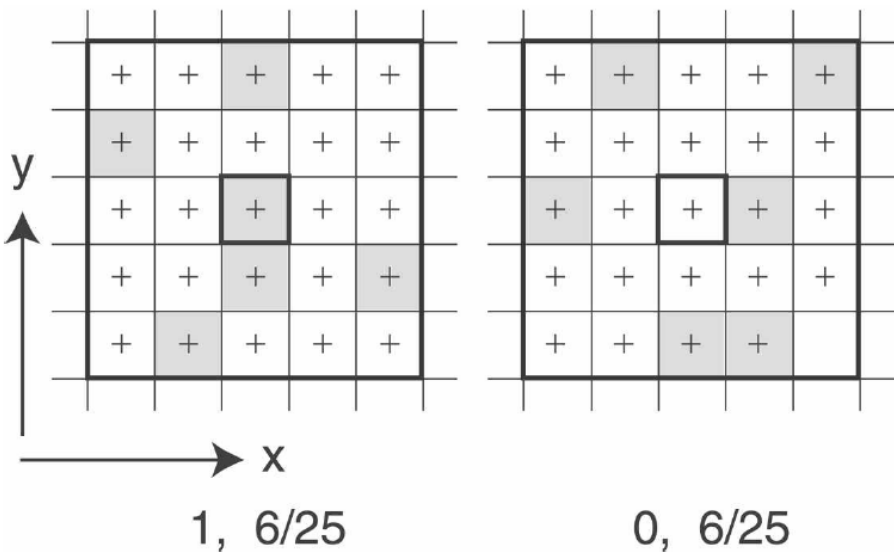
### Fractions TS (CSI)



### Fractions BIAS



# Fraction Skill Score (FSS)



$$FBS = \frac{1}{N} \sum_N (\langle P_y \rangle_s - \langle P_x \rangle_s)^2$$

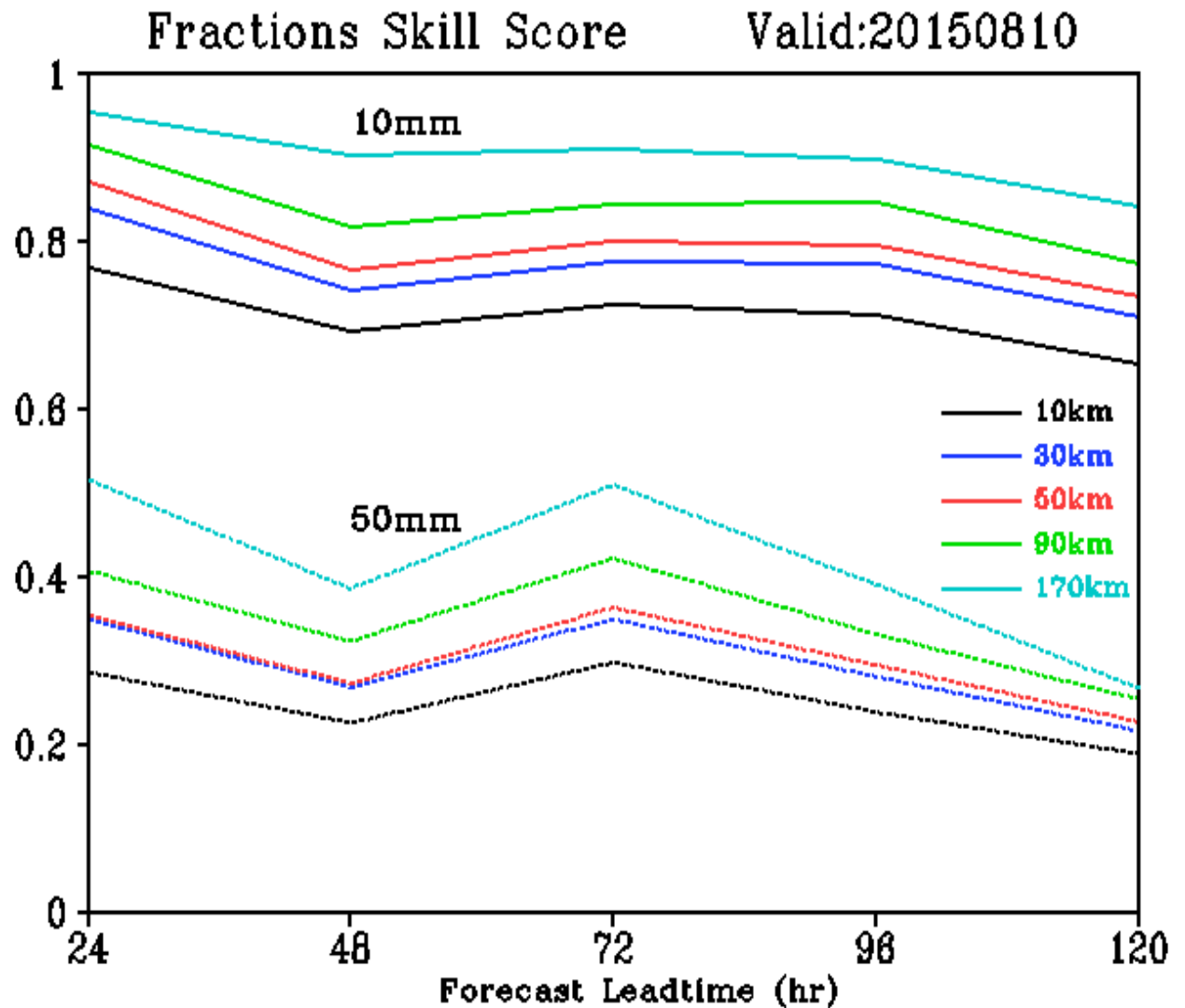
$$FSS = 1 - \frac{FBS}{\frac{1}{N} \left[ \sum_N \langle P_y \rangle_s^2 + \sum_N \langle P_x \rangle_s^2 \right]}$$

$$FSS_{\text{useful}} = 0.5 + fo/2$$

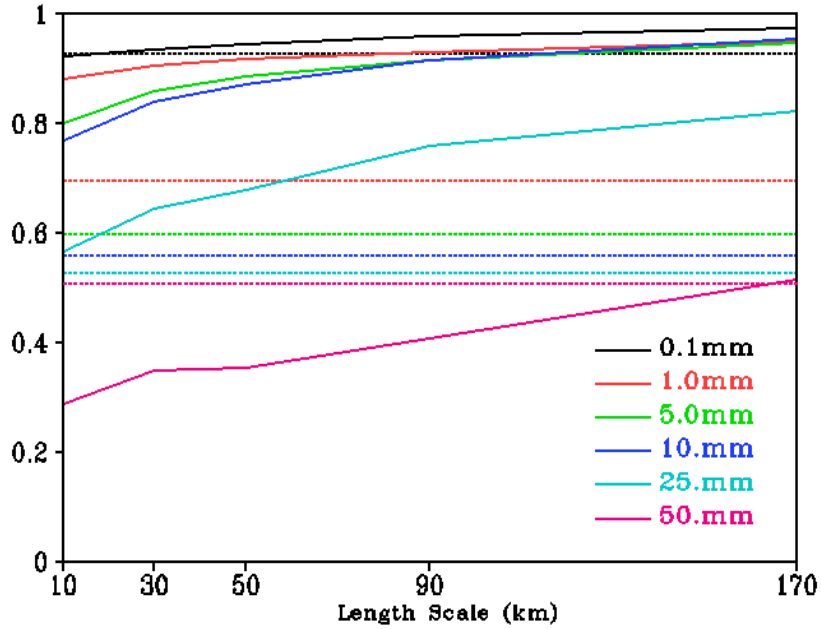


FSS decrease  
with leading  
time

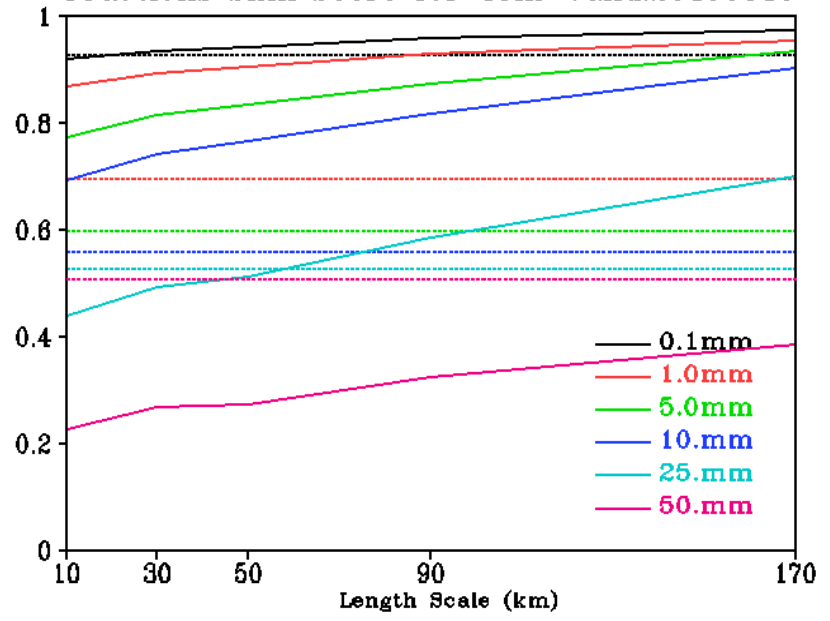
Lowest skill  
score in 48hr  
fcst



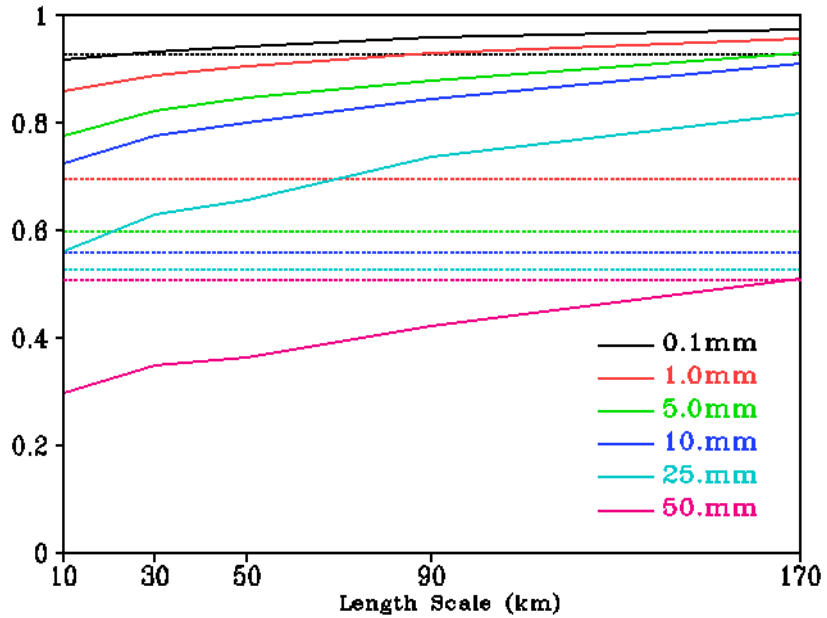
Fractions Skill Score for 24hr Valid:20150810



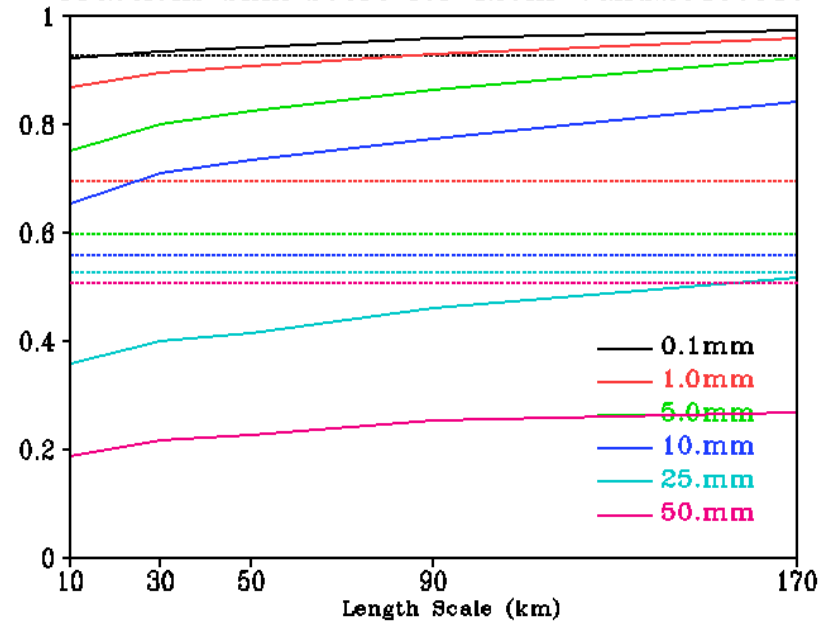
Fractions Skill Score for 48hr Valid:20150810



Fractions Skill Score for 72hr Valid:20150810

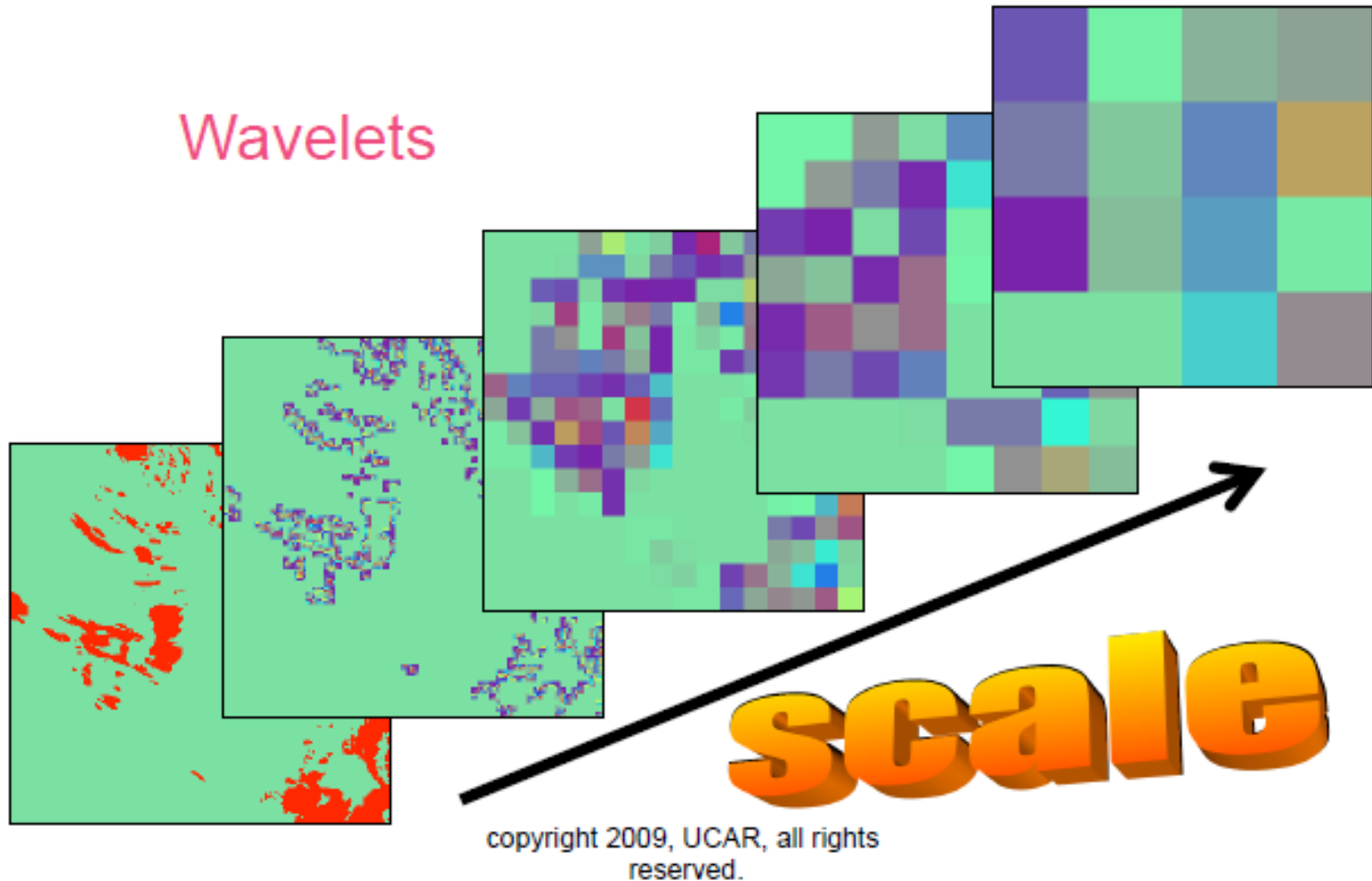


Fractions Skill Score for 120hr Valid:20150810





# Wavelet Analysis



At what scales does forecast have biggest contribution ?



$$I_{Y'} = \begin{cases} 1 & Y' > u \\ 0 & Y' \leq u \end{cases} \quad I_X = \begin{cases} 1 & X > u \\ 0 & X \leq u \end{cases} \quad Y': \text{fcst} \quad X: \text{obs}$$

$$Z = I_{Y'} - I_X. \quad MSE = \overline{Z^2} = \sum_{l=1}^L \overline{Z_l^2} = \sum_{l=1}^L MSE_l,$$

MSE skill score:  $SS = \frac{MSE - MSE_{\text{random}}}{MSE_{\text{best}} - MSE_{\text{random}}} = 1 - \frac{MSE}{2\varepsilon(1 - \varepsilon)},$

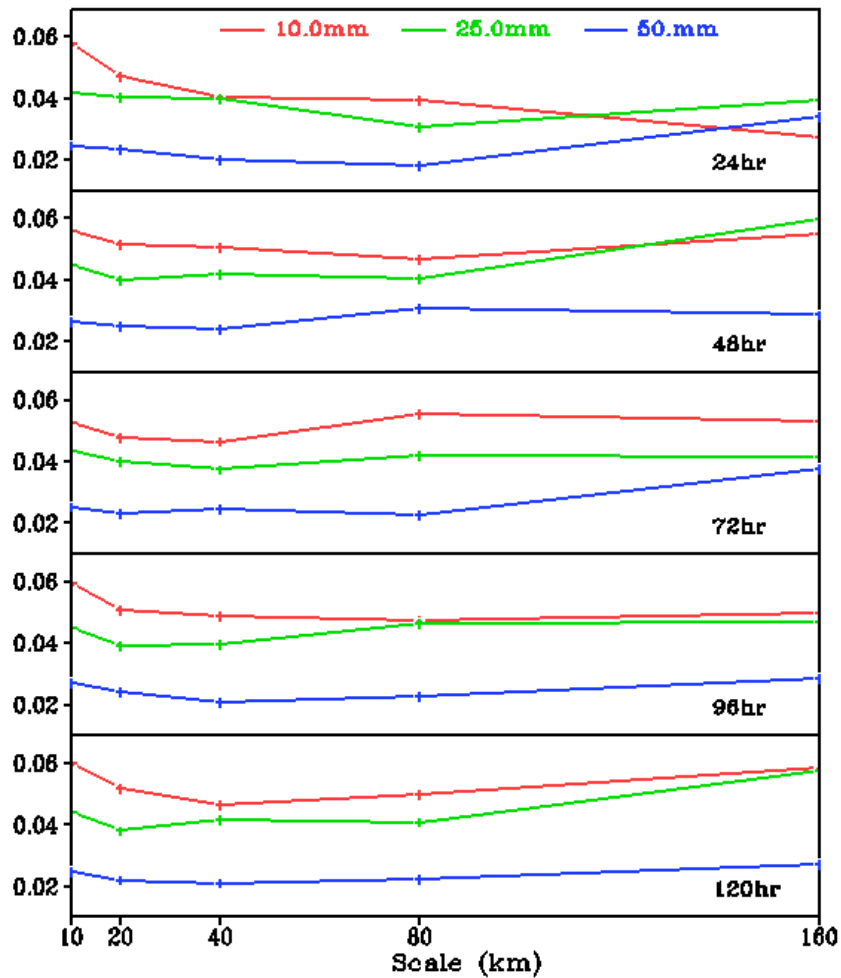
Energy En:  $En(X) = \frac{1}{n} \sum_{i=1}^n x_i^2.$

Energy relative difference:  $En \text{ rel diff} = \frac{[En(F) - En(O)]}{[En(F) + En(O)]}.$

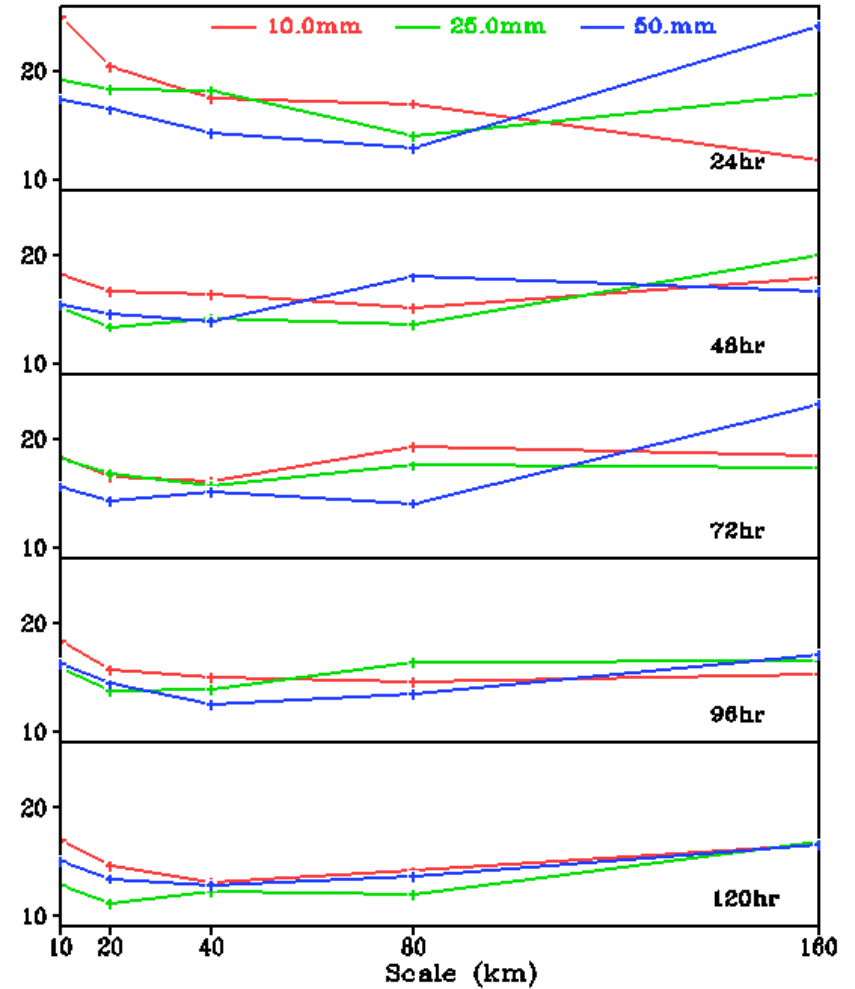
-- From Intensity-Scale technique (Casati 2004 & 2009)



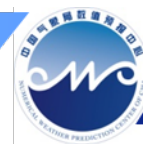
Binary field MSE



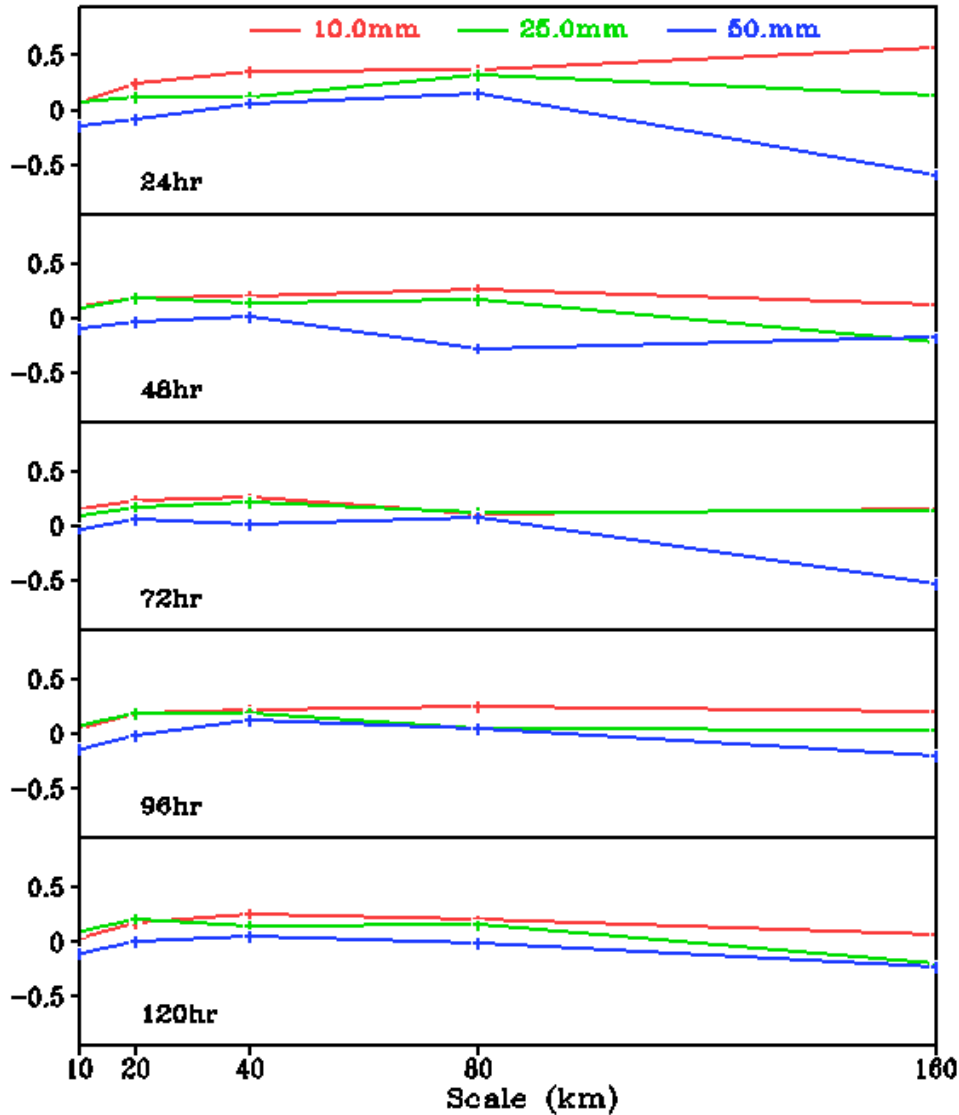
Binary field MSE%



Large MSE in 160km resolution

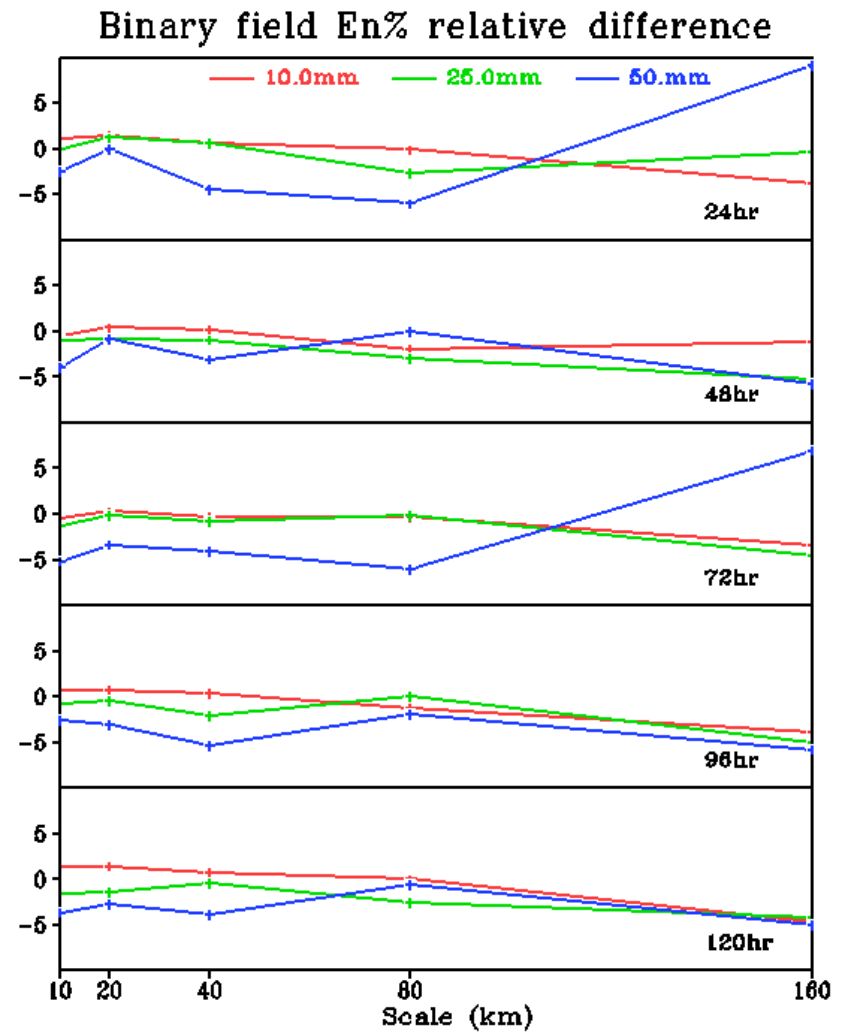
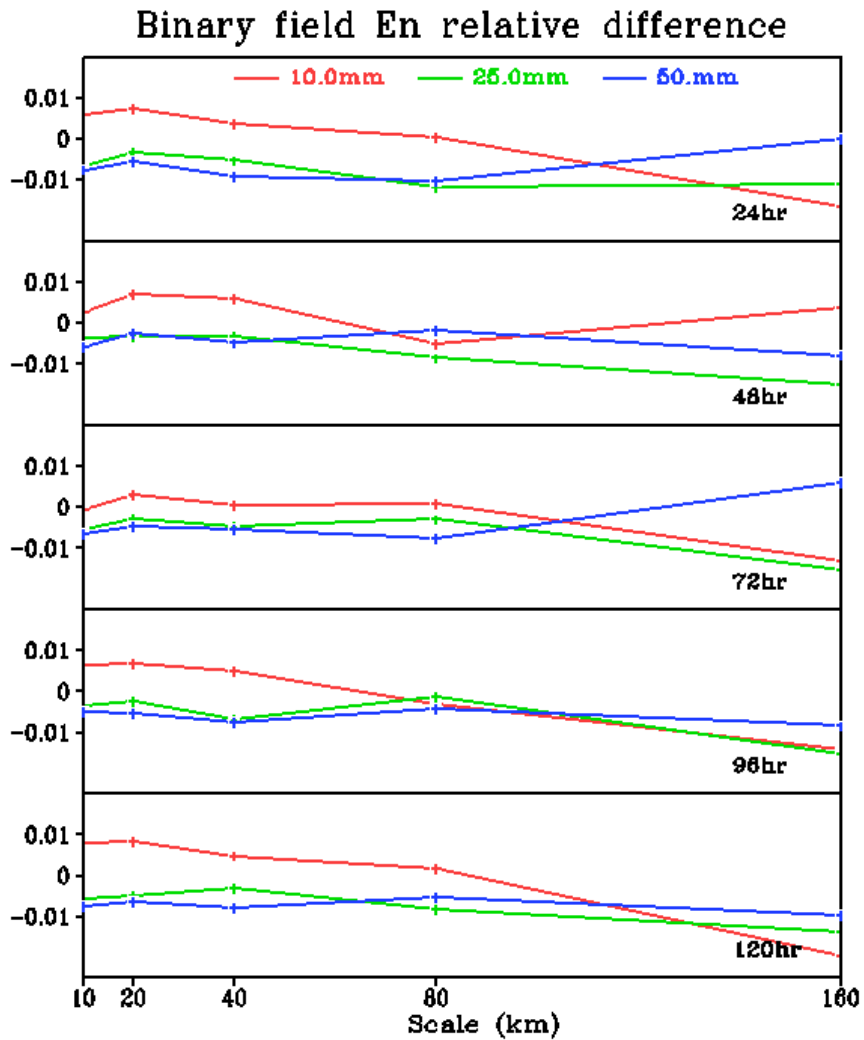


# Binary field MSE skill score

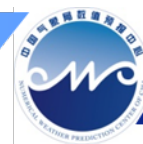


For the 160-km scale, it is displaced almost entire storm length.  
So in 10mm thresholds exhibits negative skill





48hr over-forecast in 80km resolution and show different trend with other lead times



# Summary

- ❑ Besides traditional skill score, spatial verification methods can be possible to quantify forecast skill in terms of structure and scales.
- ❑ 48hr precipitation simulation shows lowest skill, it is mainly due to storm position error.
- ❑ Combined spatial techniques together is an effective way to diagnose forecast contribution.



**Thanks for your attention**

