Object-Based Verification and Evaluation for different types of Severe Convection Forecasting Products

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Introduction

According to the characteristics of severe convective weather and the requirements to focus on various factors, object-based verification method is developed to find the potential value of forecasts. First of all, convection objects are identified in both forecasts and observations based on intensity and area which meet certain requirements. Then objects in the two datasets are matched according to the area, distance and morphology. After that, objects in forecasts are verified in five aspects, grade TS score, grade size, distance of center of gravity, cross-correlation and morphology (axial and ellipticity). Finally, based on the evaluation preference of users, verification scores by weighted average and evaluation for area, position and shape are provided. Three types of severe convection forecasting products, such as QPF, REF, or convection probability product of the Chinese Meteorological Administration (CMA) SWAN (Severe Weather Analysis and Nowcasting) system, are verified by this object-based method. This method can provide quantitative verification in coincidence and deviation for area, position or intensity. It also can explain why the regular verification scores (such as TS score) are low. More effective verification and evaluation

Methodology

- First of all, convection objects, such as convective cells and severe convective weather area, are identified in both forecasts and observations based on intensity and area which meet certain requirements.
- Then objects in the two datasets are matched according to the area, distance and morphology.
- After that, objects in forecasts are verified in five aspects, grade TS score, grade size, distance of center of gravity, cross-correlation and morphology (axial and ellipticity).
- Finally, based on the evaluation preference of users, verification scores by weighted average and evaluation for area, position and shape are provided.

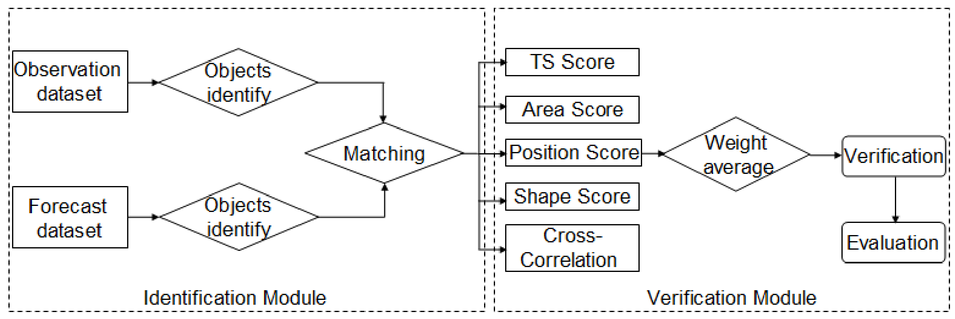

Fig. 1 The flow chart of object-based verification method

Results and Discussion

- QPF of the Shanghai Central Meteorological Observatory NoCAWS (Nowcasting and Warning system) are verified by this object-based method.

Evaluation is provided, such as 'Forecast object1(FO1) is 15% bigger than observation object3(OO3). The gravity of FO is 15kms northwest. The ellipticity of FO is 28% larger and the major axis is 7% shorter. The FO is banding.'

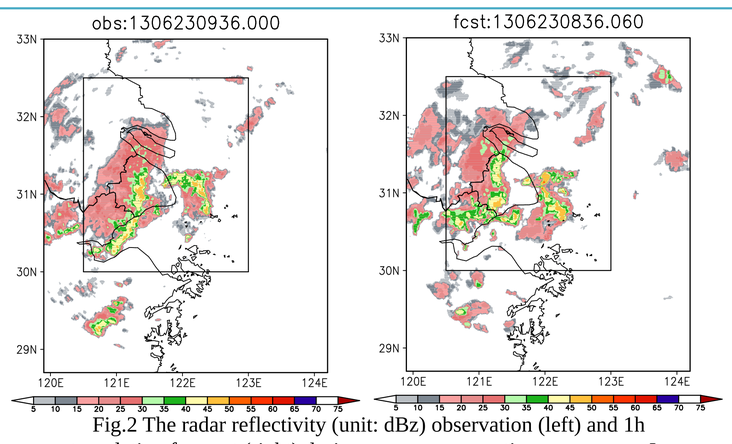

Fig.2 The radar reflectivity (unit: dBz) observation (left) and 1h extrapolation forecast (right) during a severe convective progress on June 23, 2013.

Fig.3 The objects identified in both forecasts (red) and observations (green) on web during the severe convective progress on June 23, 2013.

Object-based verification of severe convective progress on June 23, 2013

Objects content		FO1	OO3	FO3	OO6
Grade TS Score	30.0～49.9dBz	0.2572		0.1946	
	50.0～75.0dBz	0.0000		0.0068	
	TS Score	0.1286		0.1007	
Grade area Score	30.0～49.9dBz	0.7717		0.7960	
	50.0～75.0dBz	0.5756		0.4669	
	Area Score	0.6736		0.6314	
Position Score		0.7797		0.7737	
Cross-Correlation		0.3702		0.3513	
Shape Score	ellipticity	0.3621		0.5147	
	axial	0.6352		0.4022	
	Shape Score	0.4987		0.4585	
Verification Score		0.4902		0.4631	
Area Evaluation		Forecast object (FO) is bigger.		Forecast object is smaller.	
Position Evaluation		The gravity of FO is northwest.		The gravity of FO is southwest.	
Shape Evaluation		The ellipticity of FO is large and the major axis is short. The FO is banding.		The ellipticity of FO is large and the major axis is long. The FO is massive.	

- REF of the Chinese Meteorological Administration (CMA) SWAN (Severe Weather Analysis and Nowcasting) system are verified by this object-based method.

Evaluation is provided, such as 'Forecast object1 (FO1) is 54% smaller. The gravity of FO is 16kms northeast. The ellipticity of FO is 53% smaller and the major axis is 2% shorter. The FO is liner.'

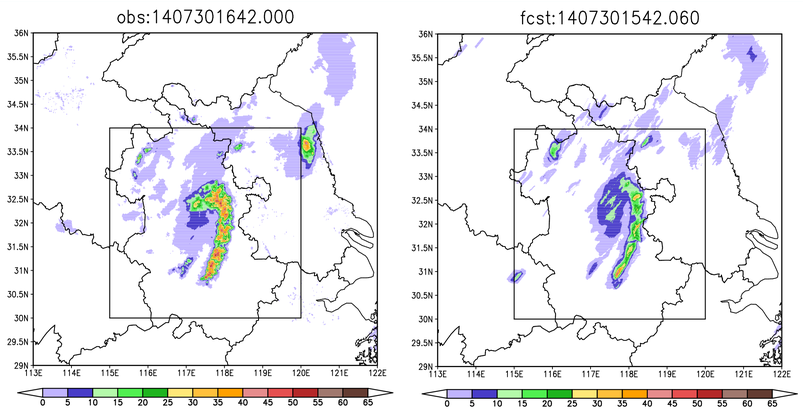

Fig.4 The QPE (left) and QPF (right) (unit: mm) on July 30, 2014

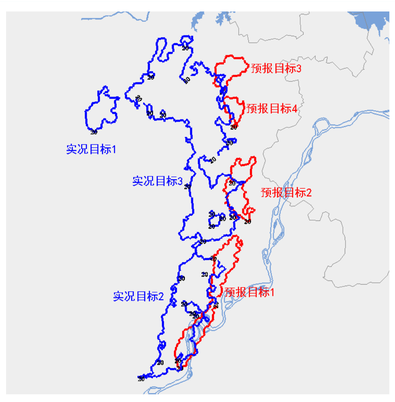

Fig.5 The objects identified in both forecasts (red) and observations (blue) in SWAN during short-term heavy rain on July 30, 2014.

Object-based verification of short-term heavy rain on July 30, 2014

Objects Content		FO1	OO2
Grade TS Score	20.0～29.9mm	0.1126	
	30.0～49.9mm	0.0418	
	≥50.0mm	0	
	TS Score	0.0515	
Grade Area Score	20.0～29.9mm	0.8936	
	30.0～49.9mm	0.3890	
	≥50.0mm	0	
	Area Score	0.4275	
Position Score		0.7633	
Cross-Correlation		0.2504	
Shape Score	ellipticity	0	
	axial	0.9890	
	Shape Score	0.4945	
Verification Score		0.6088	
Area Evaluation		Forecast object (FO) is smaller.	
Position Evaluation		The gravity of FO is northeast.	
Shape Evaluation		The ellipticity of FO is smaller and the major axis is shorter. The FO is liner.	

- Convection probability product of the forecasters are verified by this object-based method.

The observation data is based on the grid convective analysis of lightning.

Evaluation is provided, such as 'Forecast object2 (FO2) is 52% bigger. The gravity of FO is 34kms northeast. The ellipticity of FO is 59% smaller and the major axis is 41% longer. The FO is massive.'

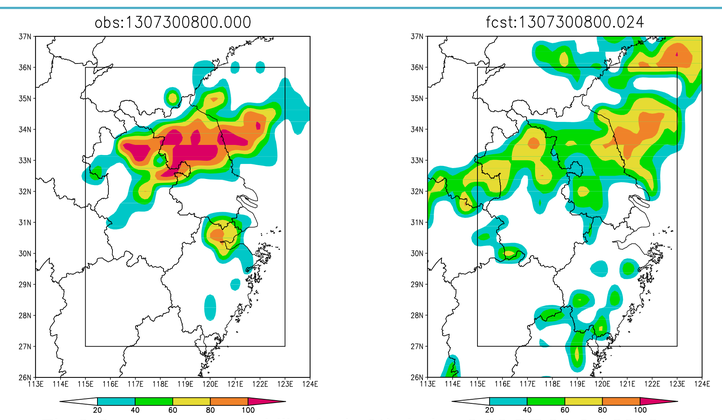

Fig.6 Convection probability (unit: %) during 8:00 BT 30 Jul 2013 and 8:00 BT 31 Jul 2013(left), and convection probability forecast (unit: %) initiating at 8:00 BT 30 Jul 2013(right)

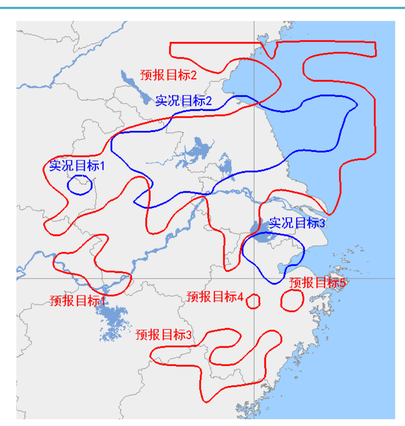

Fig.7 The objects identified in both forecasts (red) and observations (blue) of convection probability on July 30, 2013.

Object-based verification of convection probability on July 30, 2013

Objects Content		FO2	OO2
Grade TS Score	40.0～59.9%	0	
	60.0～79.9%	0	
	≥80.0%	0.2927	
	TS Score	0.0976	
Grade Area Score	40.0～59.9%	0.3585	
	60.0～79.9%	0.3617	
	≥80.0%	0.6327	
	Area Score	0.4509	
Position Score		0.4057	
Cross-Correlation		0.5617	
Shape Score	ellipticity	0	
	axial	0.6910	
	Shape Score	0.3455	
Verification Score		0.3723	
Area Evaluation		Forecast object (FO) is bigger.	
Position Evaluation		The gravity of FO is northeast.	
Shape Evaluation		The ellipticity of FO is smaller and the major axis is longer. The FO is massive.	

Conclusions

- According to the characteristics of severe convective weather and the requirements to focus on various factors, object-based verification method is developed to find the potential value of forecasts.
- This method can provide quantitative verification in coincidence and deviation for area, position or intensity. It also can explain why the regular verification scores (such as TS score) are low.
- More effective verification and evaluation information, combined with above elements, is provided for forecasters.

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FURTHER INFORMATION
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