Assessment and selection of regional automatic weather stations in China based on RRR principle of WMO

GUO Jianxia

Email: guo_jianxia@163.com

Meteorological Observation Center of CMA

BOSTON, U.S.A

1/13/2020

Coauthors: Pei Chong, Zhang Wenlong,Xue Zhengzheng, KangJiaqi, Shao Changliang, Chen Yizhi, Chen Dongdong, Xu Chonghai,Tian Weihong, Xin Yu

Outline

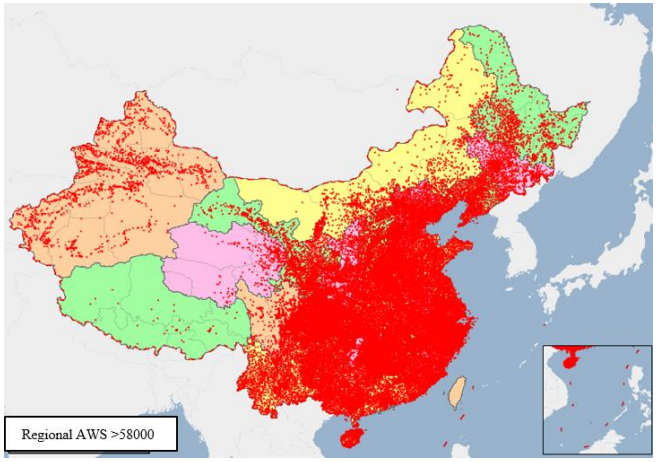
- Motivation
- Key questions
- Main Methods & Results
- Conclusions and discussions

Outline

- Motivation
- Key questions
- Main Methods & Results
- Conclusions and discussions

Motivation

- China has a huge number of AWS, different support, different construction and management standards
- The density of national AWS is not enough to meet the increased needs of high-resolution numerical forecast system and the small and medium severe weather capture.
- Considering the cost economy, decided to select a batch of sites from the regional AWS, upgrade their construction and management level to the national network.

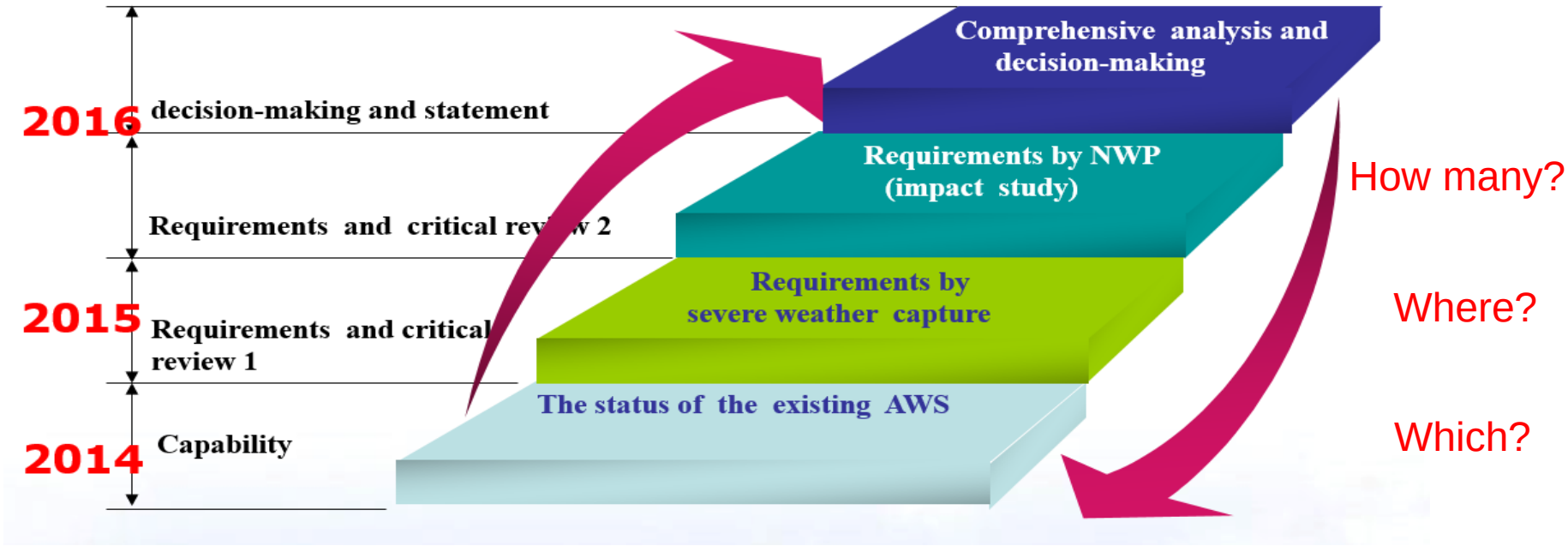


Key questions

- Where?
- Which?
- How many?

Main Methods & Results

Following WMO RRR, mutual-study among obs., forecast and services _ Requirements Vs Capabilities for circulations



Main Methods & Results

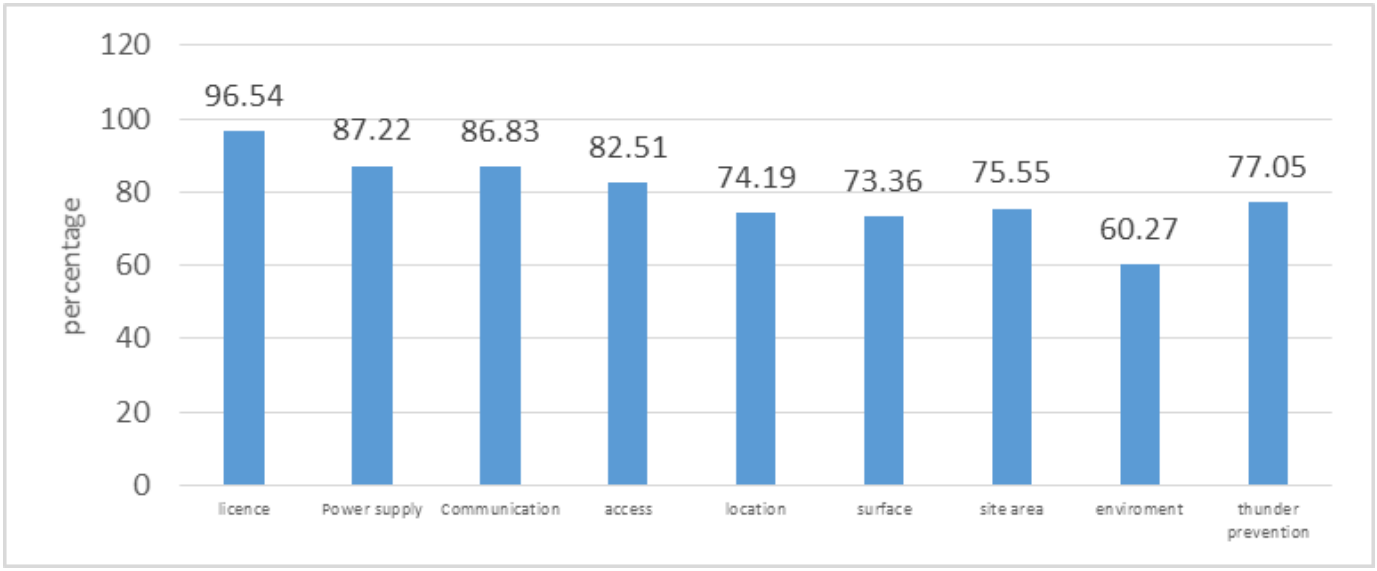
- Capabilities evaluation---Step 1 (2014)

	Category	Indicator	Minimum requirements	Weight points
1	Equipment	license	Equipment with the Equipment license from CMA	20
2	Guarantee	Power supply	Good power supply, will not cause more than 72 hours work stop due to power supply problems	10
3		Communication	Good Communication, will not cause more than 72 hours work stop due to Communication problems	10
4		Access	Good Traffic, will not cause more than 72 hours work stop due to Traffic problems	10
5	Site	Instrument installation location	Land station installed on the ground; rivers and lakes station installed in a dedicated platform	10
6		land cover conditions	Grass, natural bare land	10
7		Site area	Large enough, no interaction between the observation instruments	10
8		Surrounding environmental conditions	No influence on the observation of the shelter and cause abnormal changes in the meteorological elements of the source of interference, the data is better representative.	10
9		Thunder prevention	Thunder prevention satisfies the requirement of automatic station Thunder prevention technology standard	10

Provincial and local meteorological services all over the country participated in the work. Greatly contribute to the judgment of site credible.

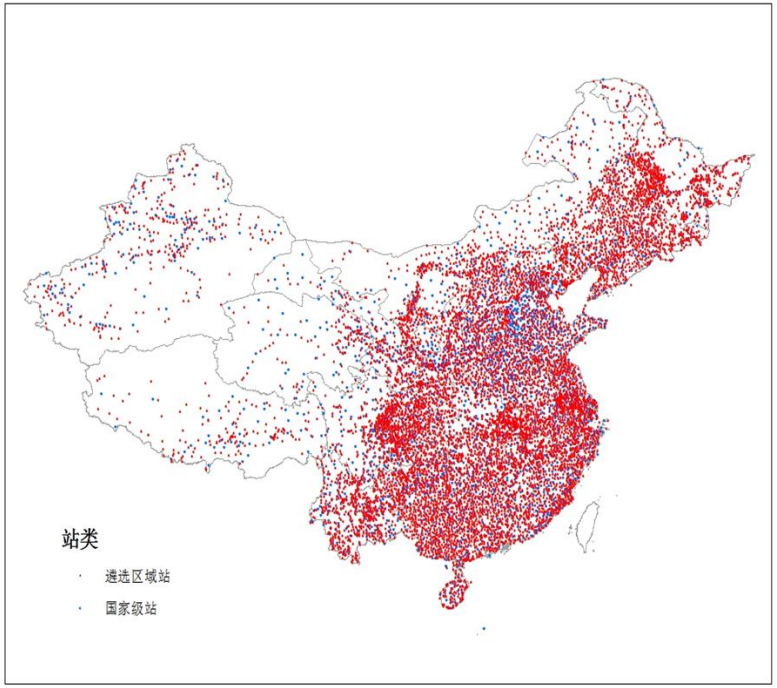
Main Methods & Results

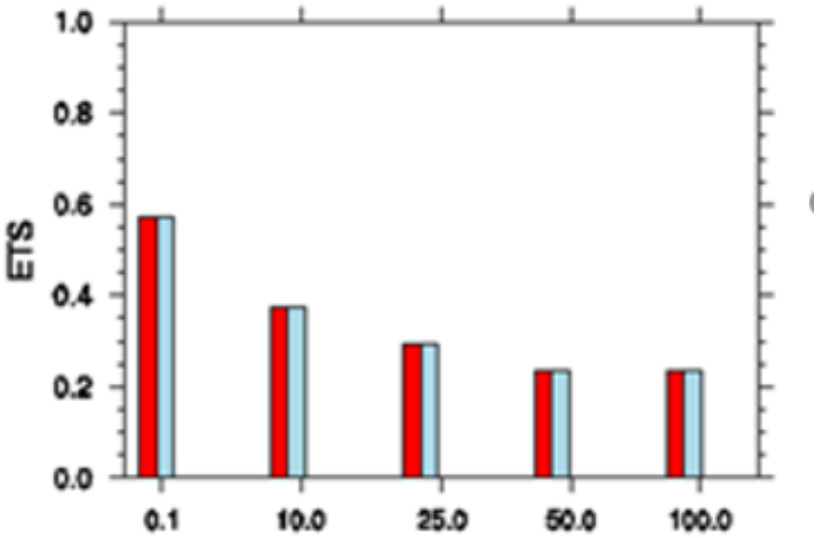
- The situation of the regional AWS



There are more than 30,000 regional AWS is reliable for our selection.

Main Methods & Results



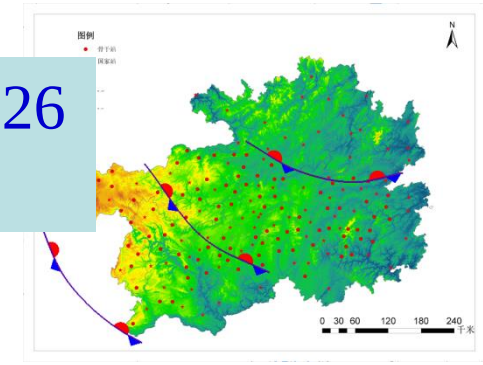


9819 were selected and recommended to NWP center for evaluation. Unfortunately, no good results.

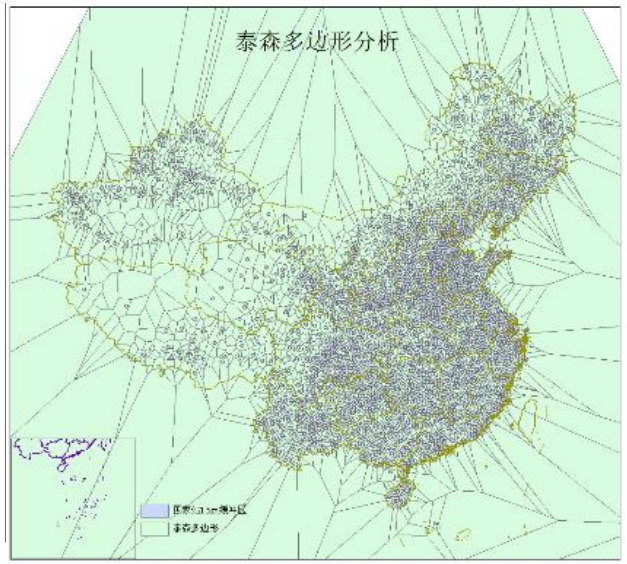
Main Methods & Results

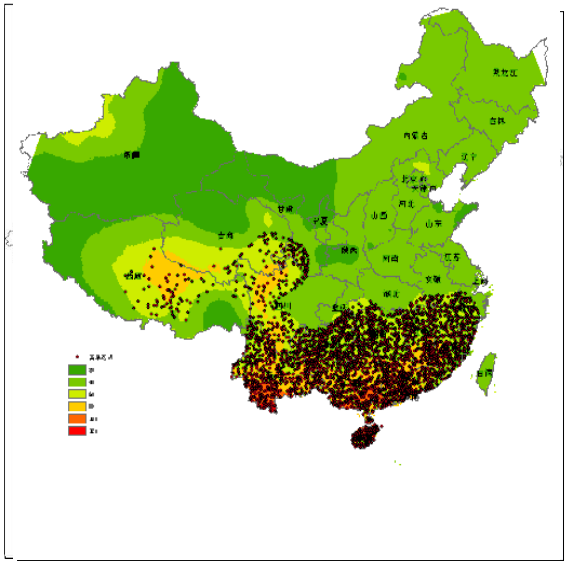
- Requirements analysis---- Step 2 (2015)
  - Weather systems analysis
    - Focus on 7 types of weather systems that may induce the severe weather.(low pressure ,convergence line, low vortex, low trough, front, shear line, the subtropical high)
    - Scale, activity area
  - High-impact /severe weather analysis
    - Focus on 4 kinds of high-impact /severe weather (heavy rain, wind, hail and thunderstorm)
    - Occurrence source, developing and weakening area, moving route and other sensitive areas.

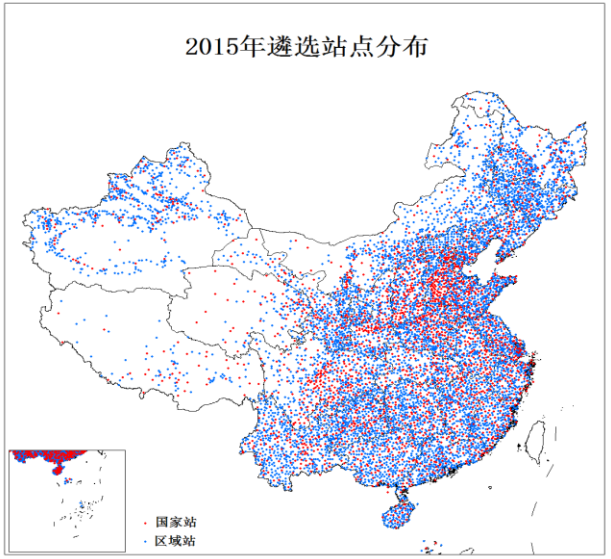
Forecasters from 31 province did the analysis. 14626 AWS were selected.



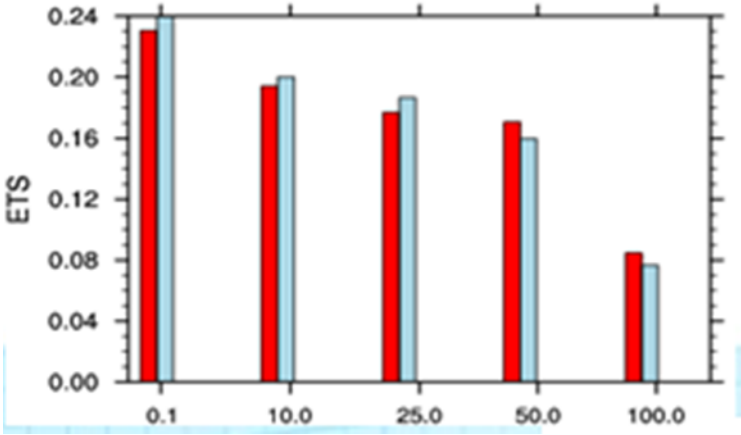
Main Methods & Results







6638 were selected into NWP for evaluation， some positive results appeared.

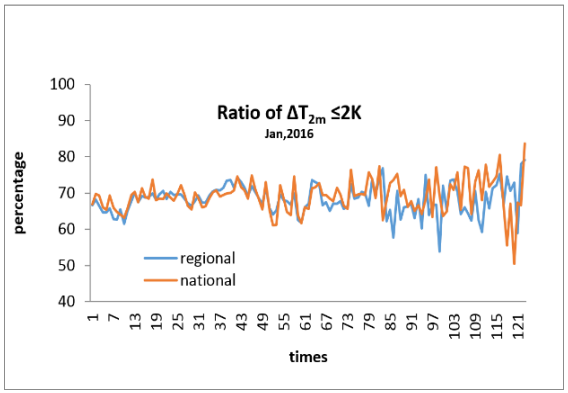


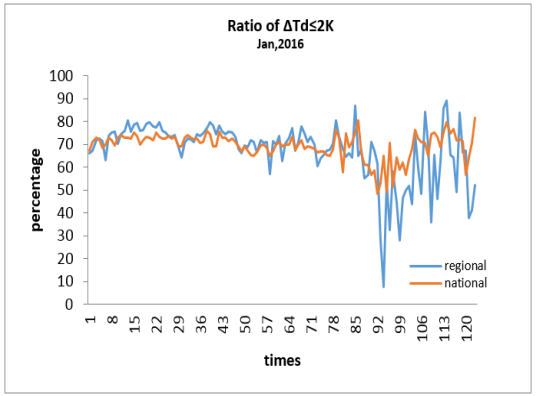
Main Methods & Results

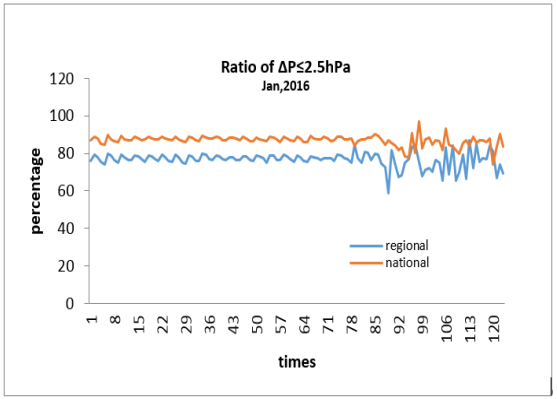
- NWP requirements analysis----Step 3 (2016)
  - Impact study
    - OSEs, OSSEs, FSO
    - Case study, Batch test by operational model.
    - Density variation test for the economic selections.
  - As the complex condition, different region had different impact results.

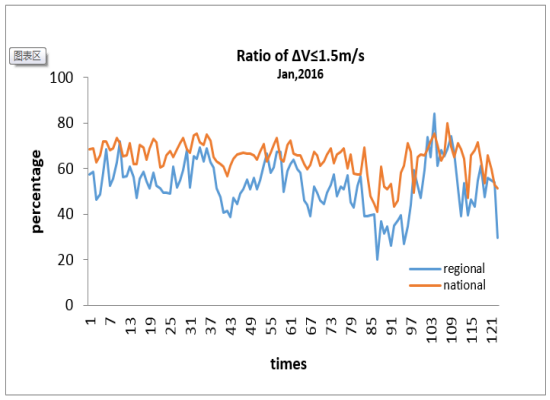
National and 8 regional NWP centers participated in the work.

Main Methods & Results









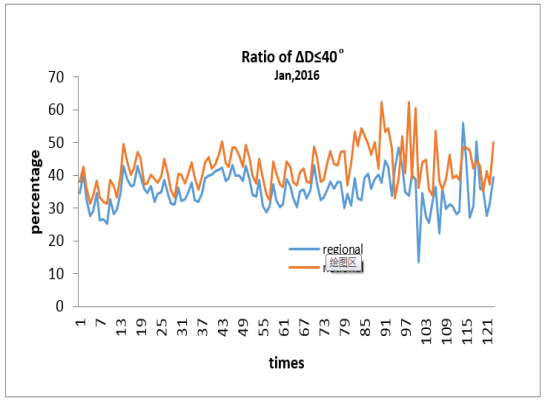


Fig.4. The comparison of the deviation level against the EC analysis field between the regional AWS and the National AWS

It is obvious that the data quality of the regional AWS can basically meet the requirements of numerical prediction.

Main Methods & Results

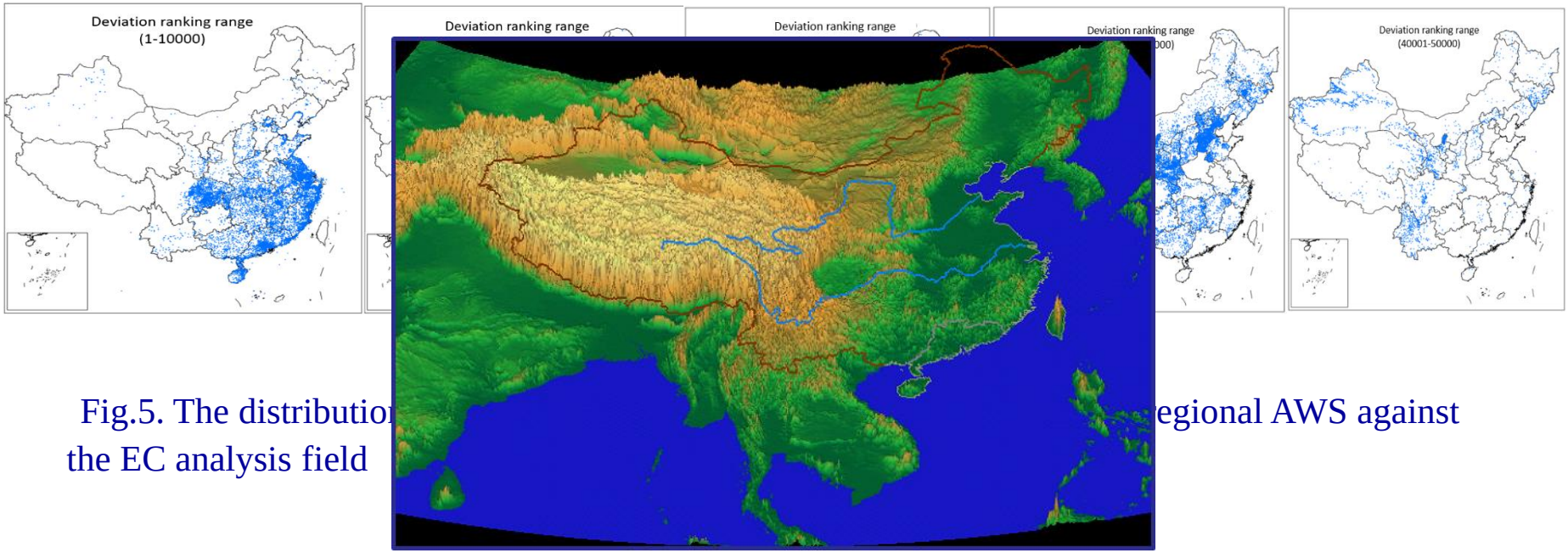


Fig.5. The distributio egional AWS against the EC analysis field

The sites move from the southeastern to the Midwest part of China, explaining the reason of the deviation may be associated with complex terrain.

Main Methods & Results

Numerical prediction system

- Model: GRAPES and WRF
- Assimilation methods: 3DVAR, 4DVAR, and ADAS.
- Assimilation scheme for AWS: Ruggiero scheme, Guo scheme (centre of China region).

INSTITUTE/CMA	NMC	MOC	north of China	east of China	south of China	centre of China	northeast of China	southwest of China	Xinjiang China	Northwest of China
SCOPE	Nationwide	Nation wide	Beijing/Tianjin/Hebei/Shanxi/Neimenggu	Jiangsu/Zhejiang/Anhui/Fujian/Jiangxi/Shandong/Shanghai	Guangdong/Guangxi/Hainan	Hubei/Henan/Hunan	Liaoning/Jilin/Heilongjiang …	Sichuan/Yunnan/Guizhou/Tibet/Chongqing	Xinjiang	Gansu/Shaanxi/Qinghai/Ningxia
QC	GRAPES	MDOS	MDOS	MDOS	MDOS	OPERATION	MDOS	MDOS	MDOS	OPERATION
MODEL	GRAPES	WRF	WRF	WRF	GRAPES	WHMM	WRF	SWC-WARMS	WRF	WRF
ASSIMILATION	3DVar	3DVar	3DVar	4DVar	3DVar	3DVar	3DVar	ADAS	3DVar	3DVar
SENSITIVITY TEST	osse+ose	density	density+ batch	density+ batch	density	density	density+ batch	density	density+ batch	density+ batch

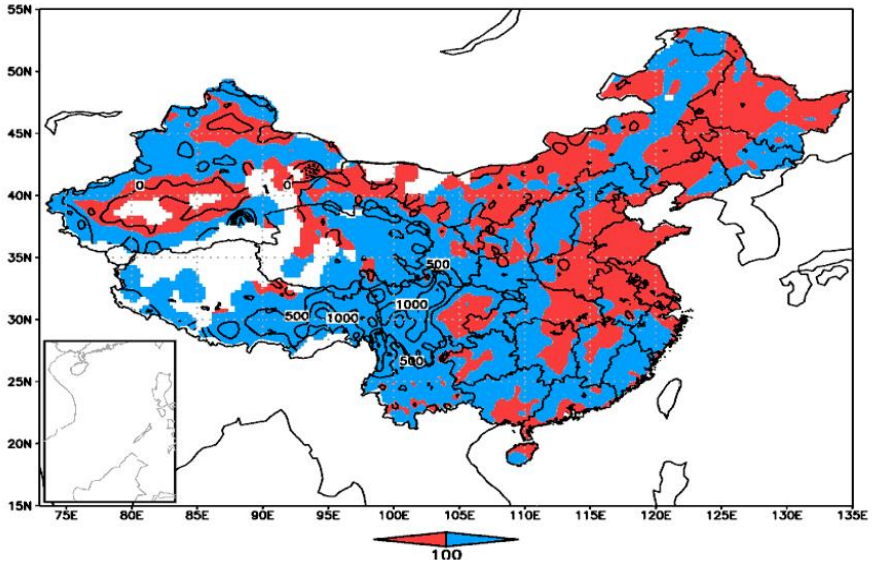
Main Methods & Results

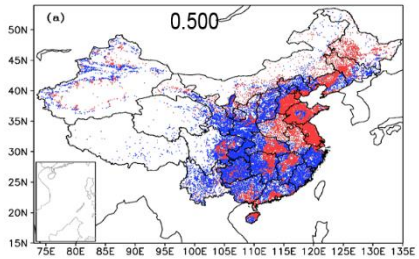
Strategy of numerical experiments

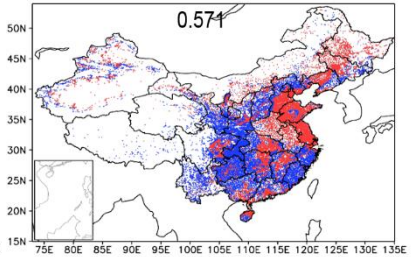
- Density experiments: 100%,90%, 80%,70%,60%,50%, 0% of 14626 regional AWS are supplied for the OSEs.
- Case study: 47 strong convection weather cases, which cover China's major heavy precipitation weather patterns, were studied.
- Batch test: FSO.
- OSSEs in the main land and some target area.

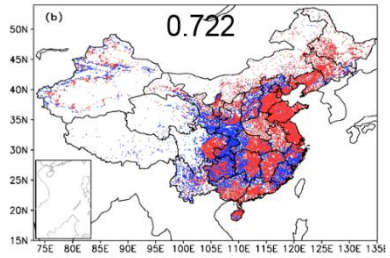
Main Methods & Results

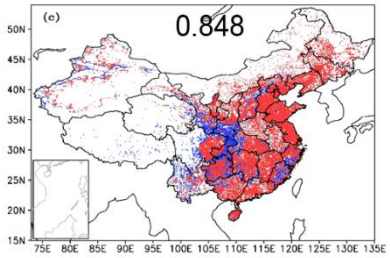
Black list analysis











- Due to the altitude difference between the topography and the model terrain in most parts of China is greater than 100m.Many AWS were refused by the model.
- Increase the model resolution, the effect is limited.
- Tolerance to 300 m altitude difference threshold, the rate of assimilated AWS increased to 84.8%.

Main Methods & Results

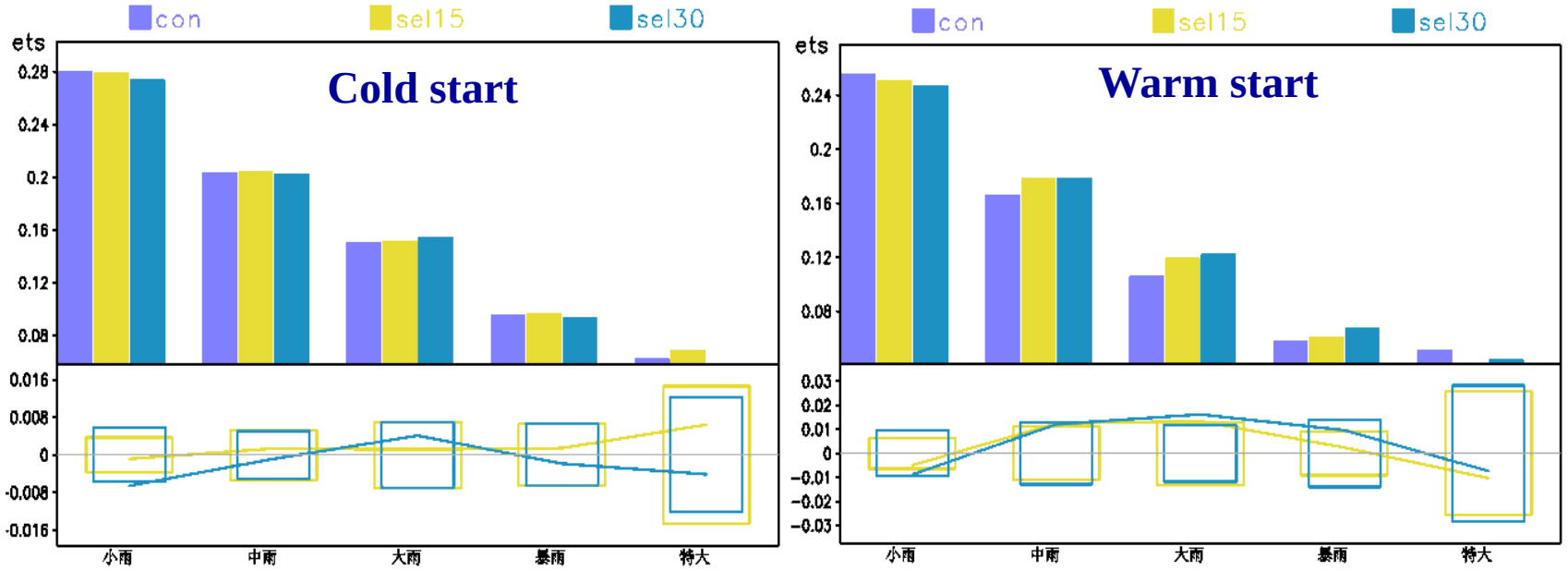
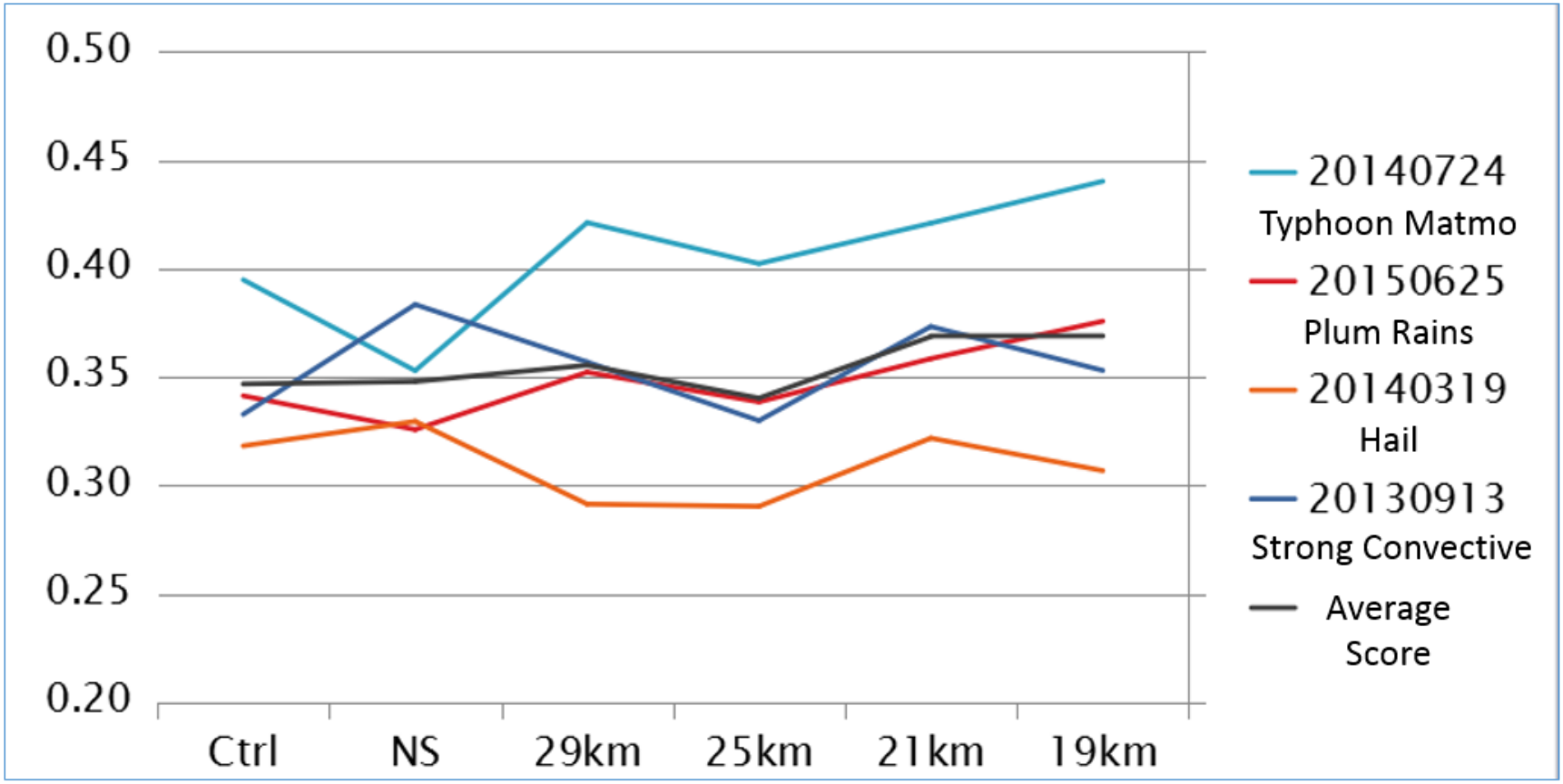


Fig.8. The forecast score of two kinds of density experiments by NMC

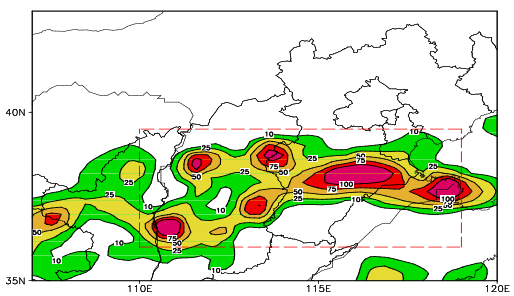
15 days continuous batch test by NMC shows that the forecast score of heavy rainfall of 15km in cold started run, and 30km in warm started are better.

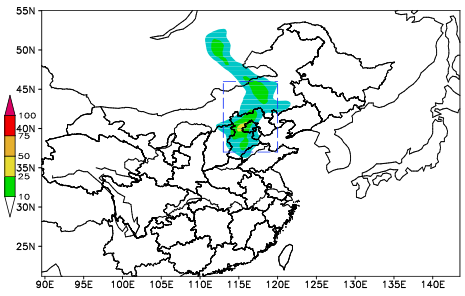
Main Methods & Results



The sensitivity of the forecast score to the AWS density is varies with the cases. Some cases show negative effect.

Main Methods & Results





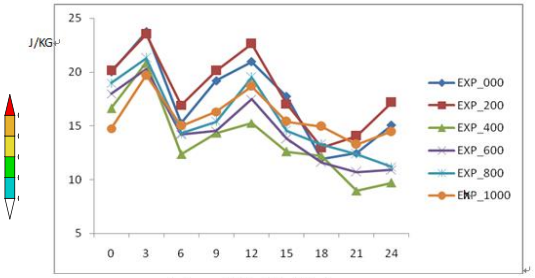
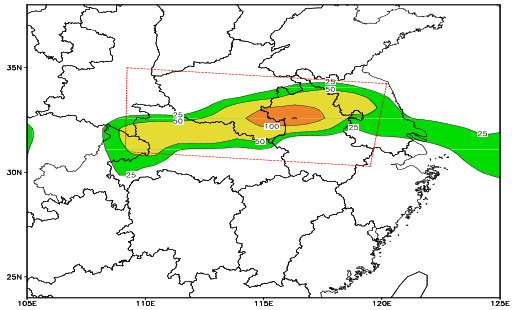
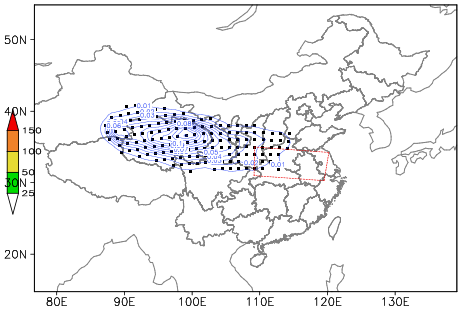
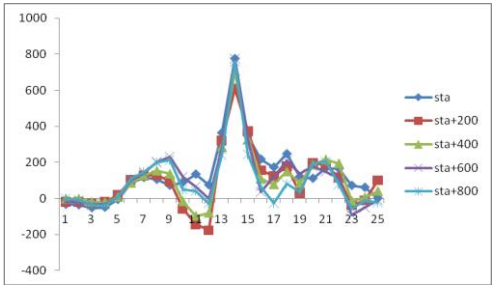
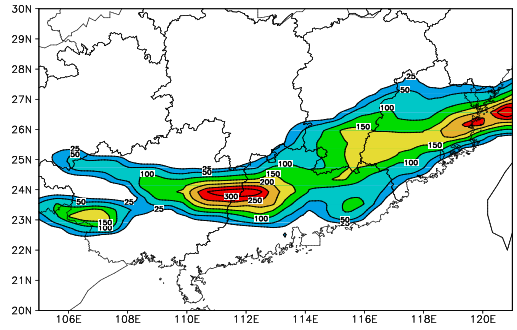


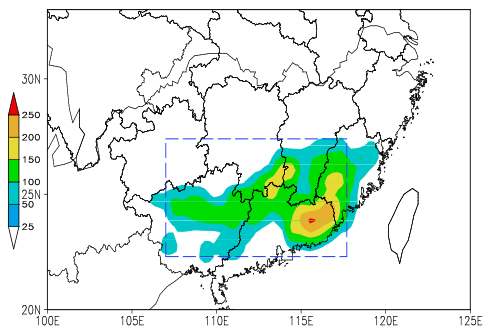
图 7 DTE 差值随时间的演变（10^5J/KG）

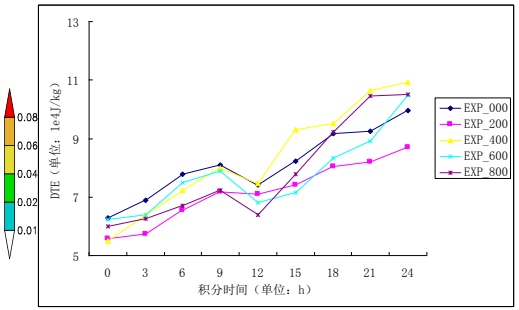












OSSEs in the sensitive area show the AWS is not the denser the better.

Main Methods & Results

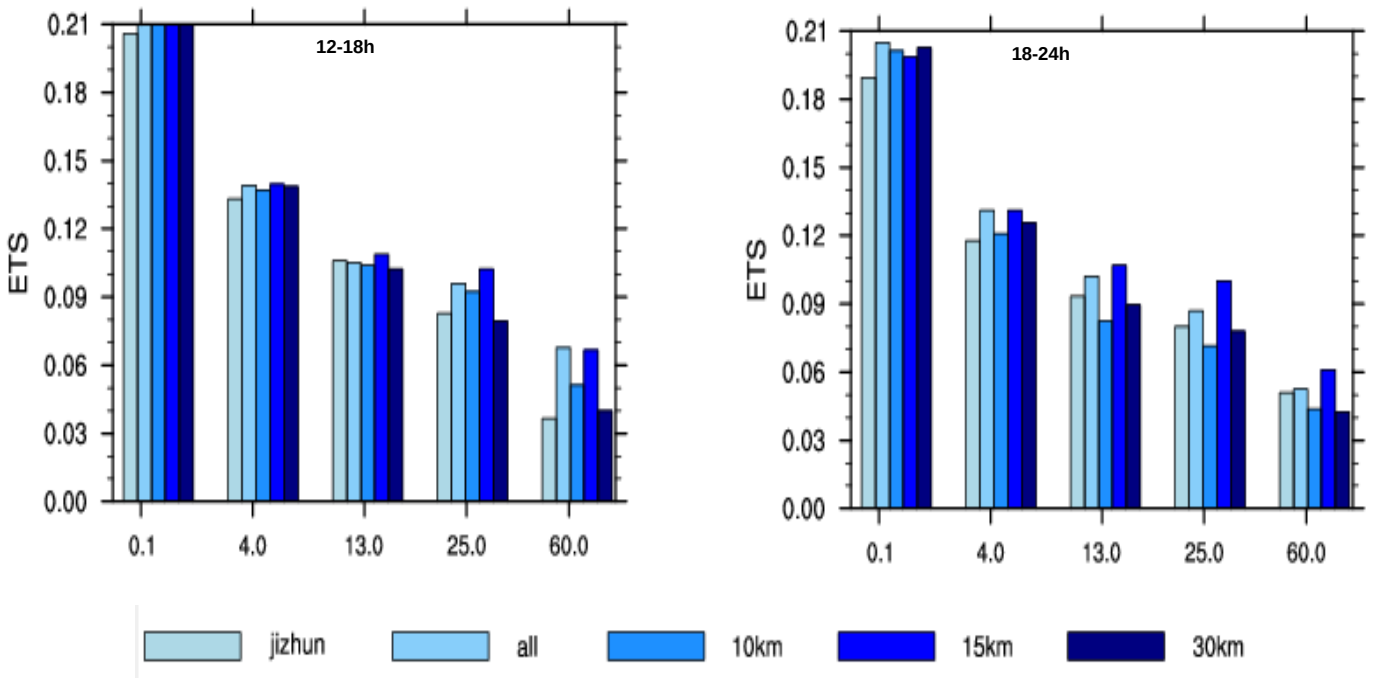
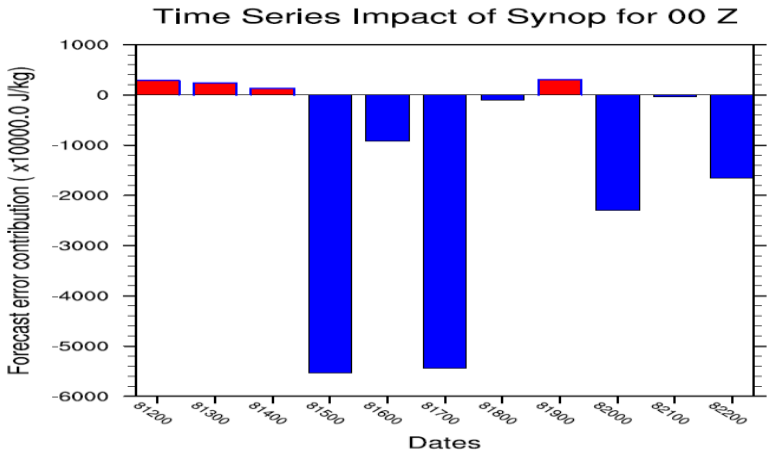
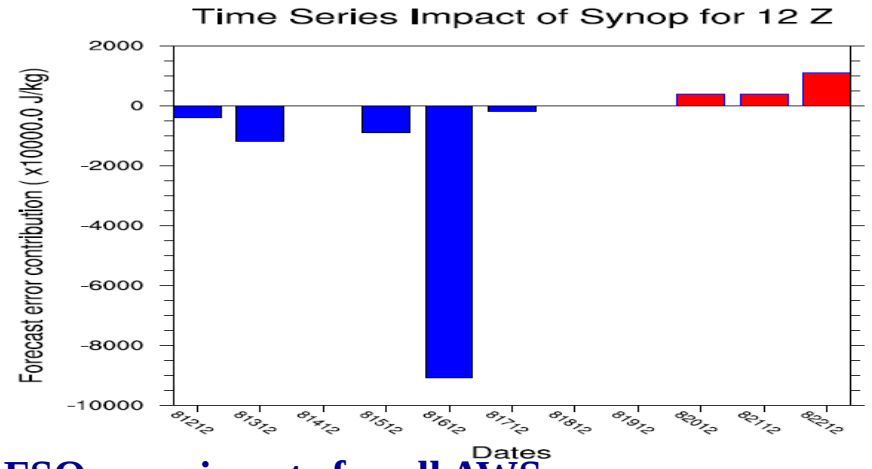


Fig.11. the forecast score of rainfall in OSSEs of different density of AWS

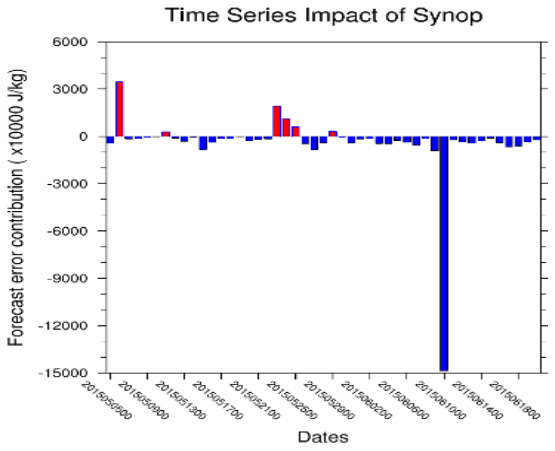
OSSEs by GRAPES :15 km resolution may improve the heavy rainfall forecast score of 12-24 hours, the more denser of AWS, not the better of the forecast score.

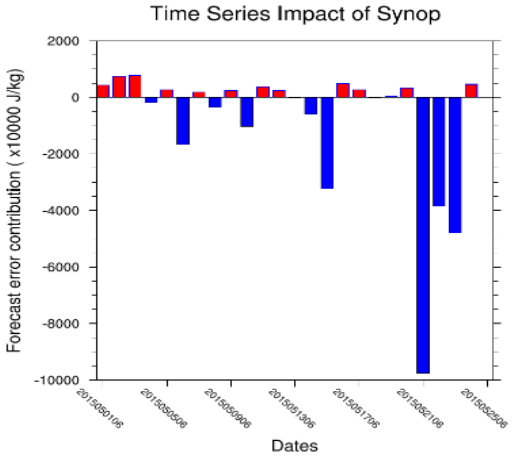
Main Methods & Results

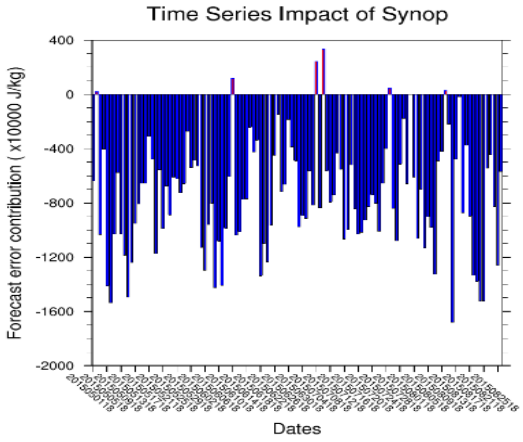




The results of 10 days FSO experiments for all AWS



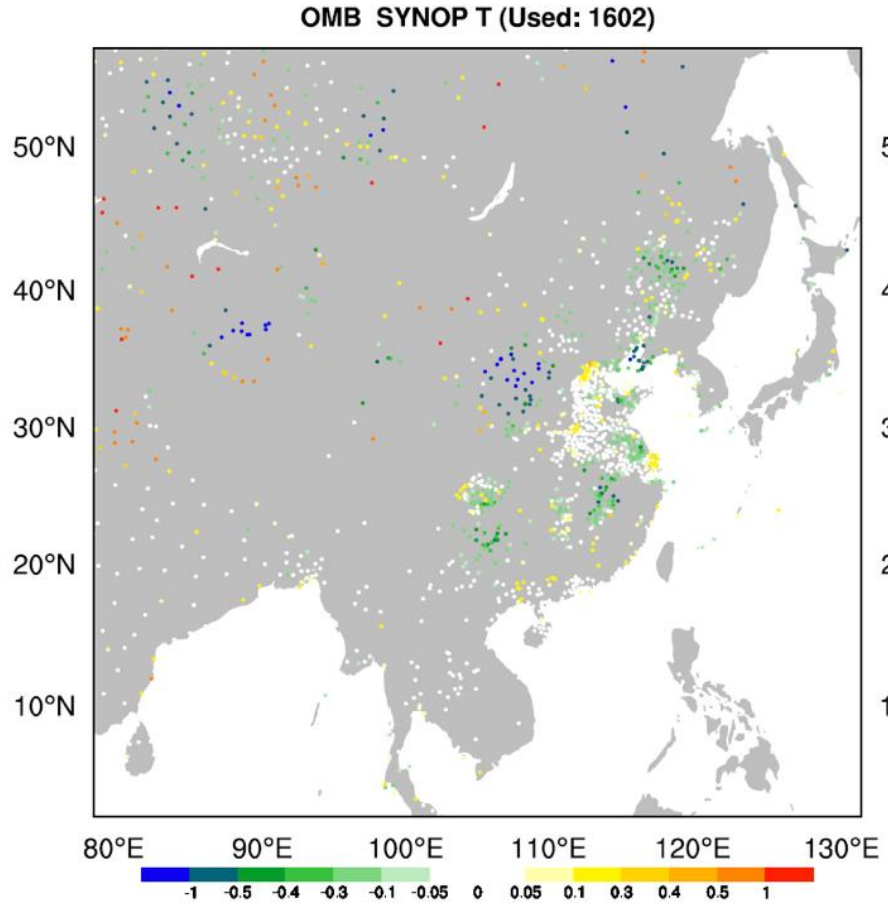


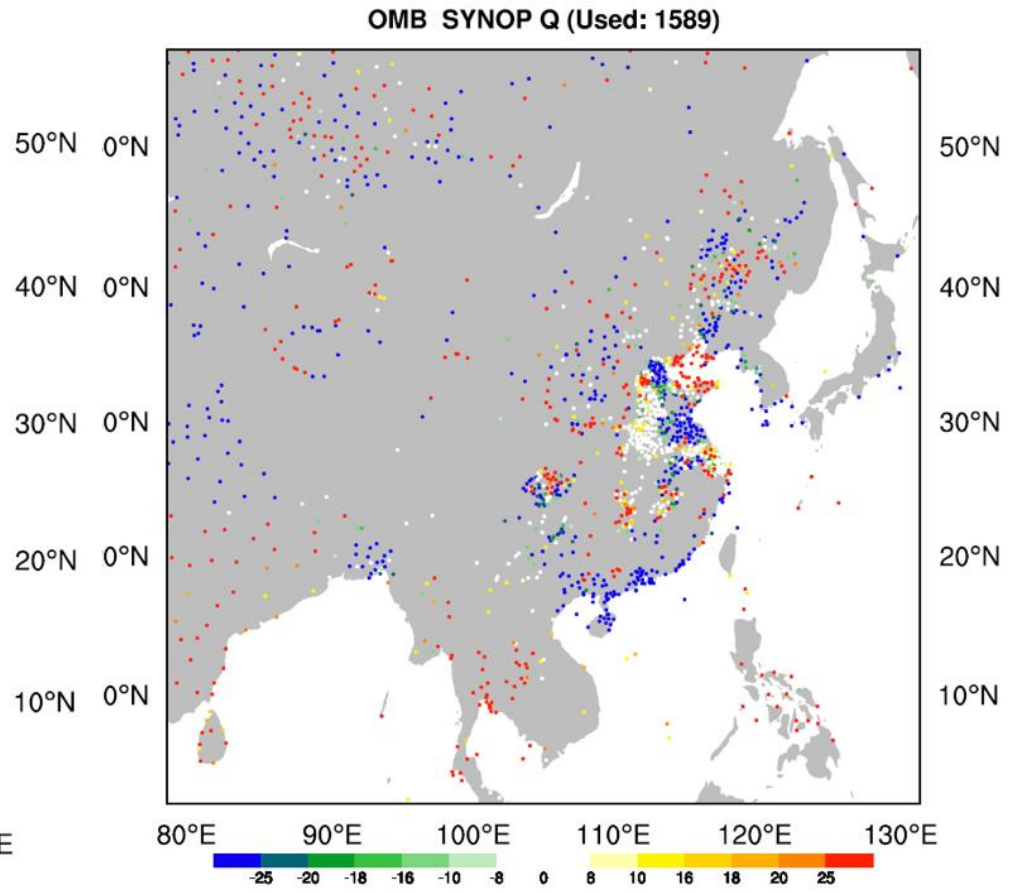


The results of 3 months experiments for Midwest part of China

The contribution of the AWS varies with the start time of the day. The positive contribution is more than the negative contribution.

Main Methods & Results



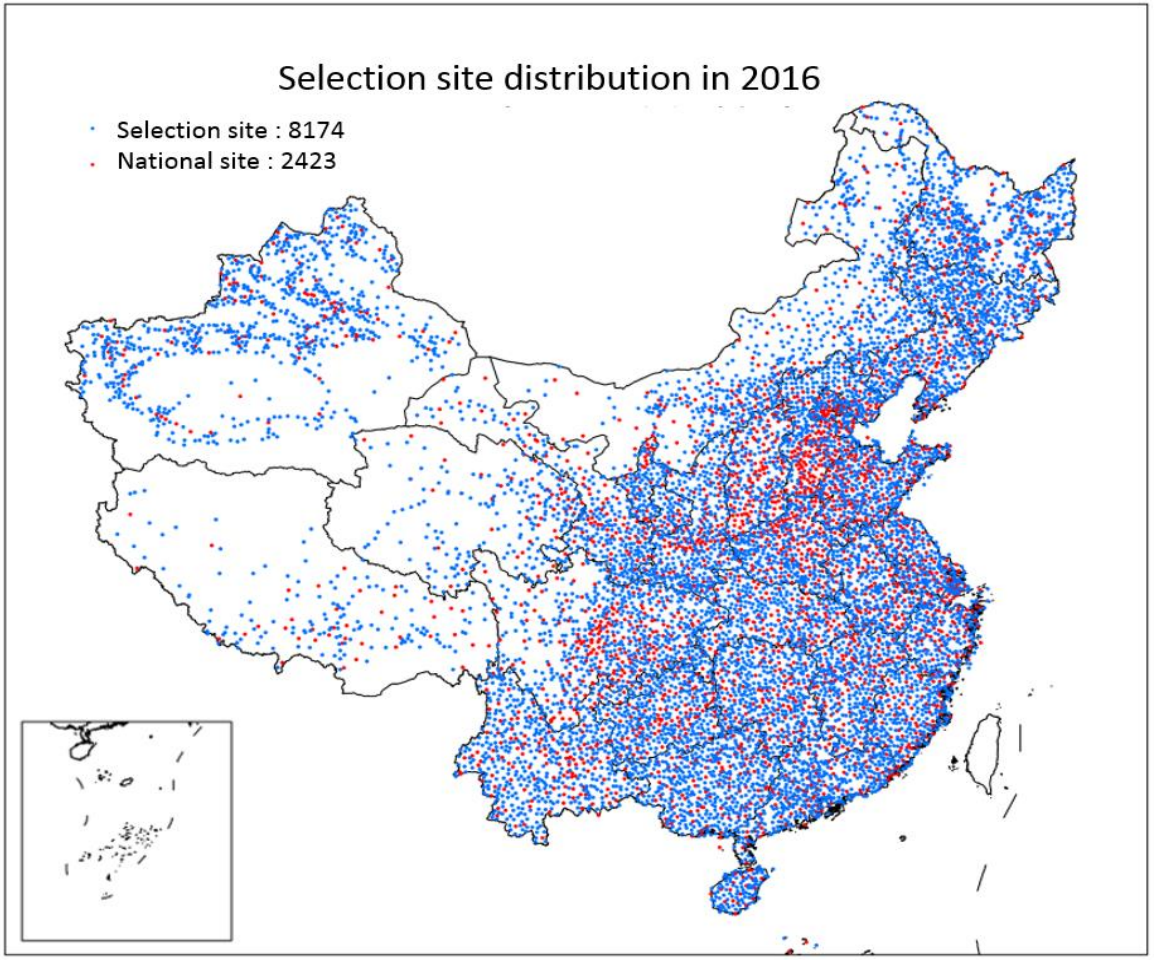


The contribution of each AWS can be determined at each run.

Main Methods & Results

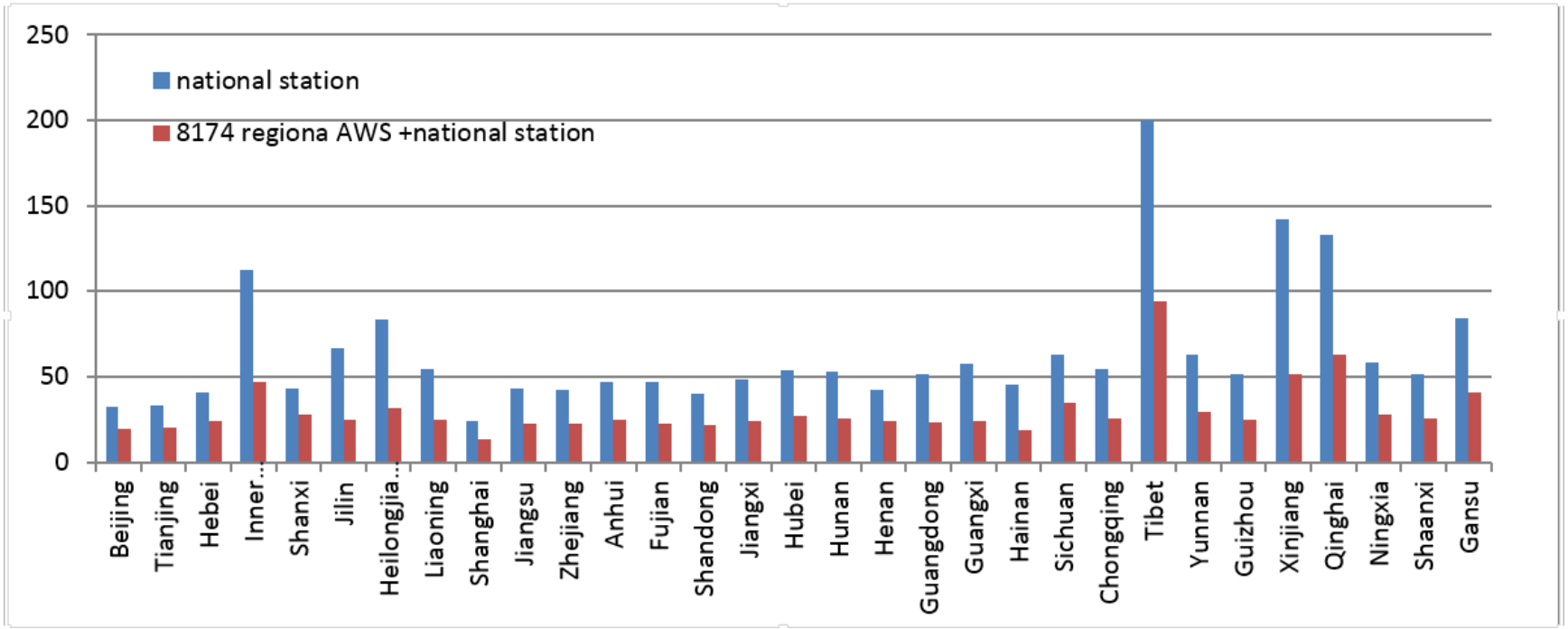
- Decision making----Step 4 (2016)
  - Density control: 15km for the whole country and 10km for the key area;
  - Fist priority to the AWS with positive contributions to the numerical predication;
  - Second priority to the AWS by synoptic analysis needs.
  - The observation condition is the basic reference to choose the AWS.

Main Methods & Results



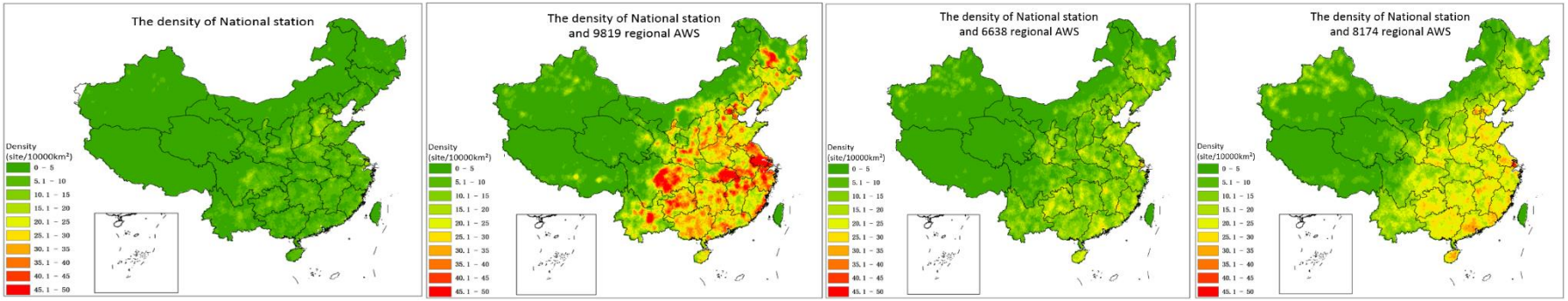
The final scheme of selected regional AWS. Total of AWS are 10597.

Main Methods & Results



The changes of the average distance of national AWS.

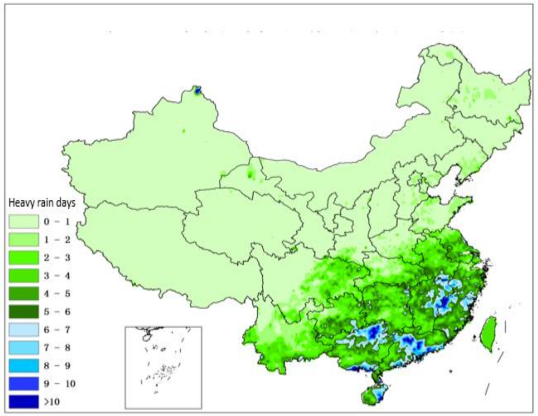
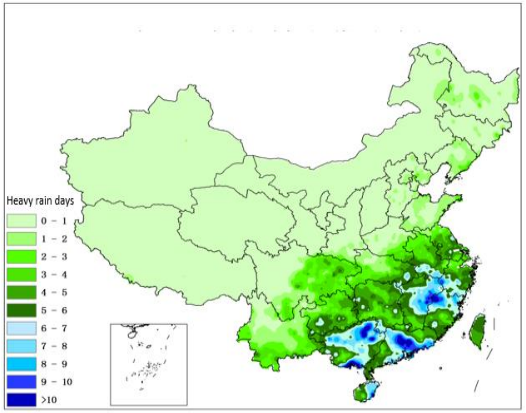
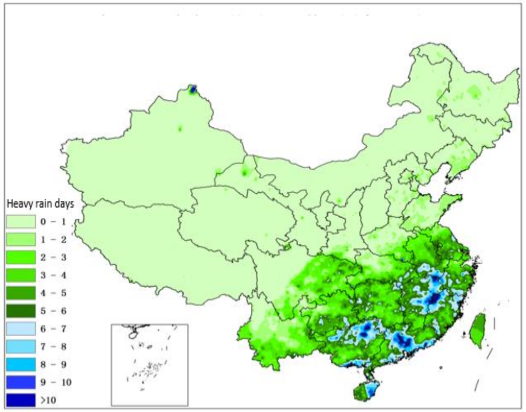
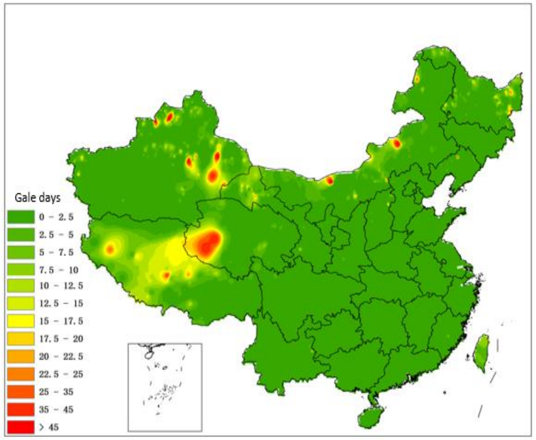
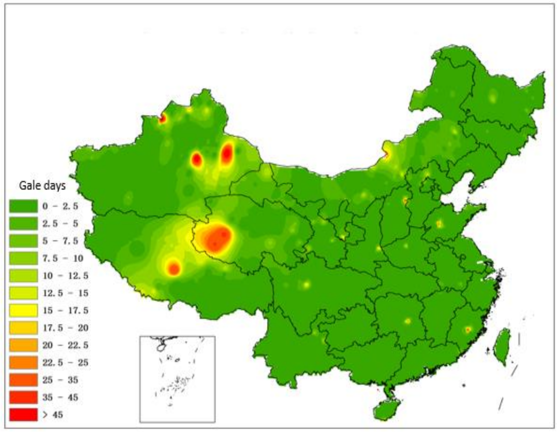
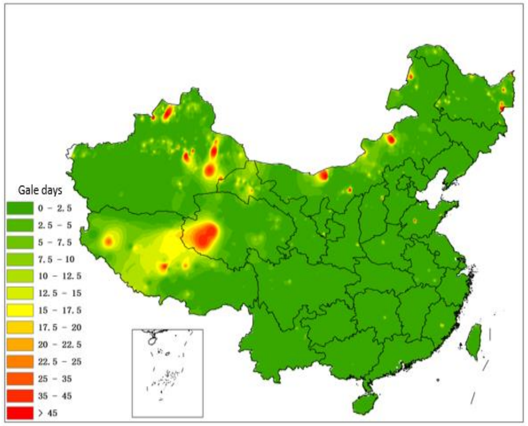
Main Methods & Results



The AWS density changes with the project process

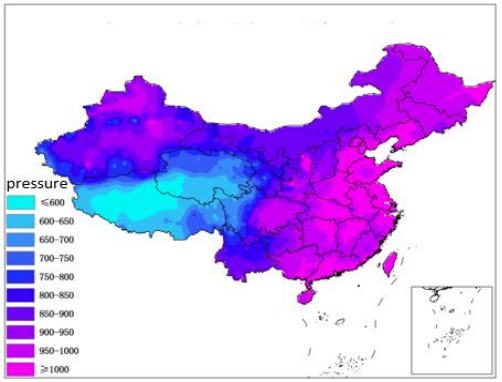
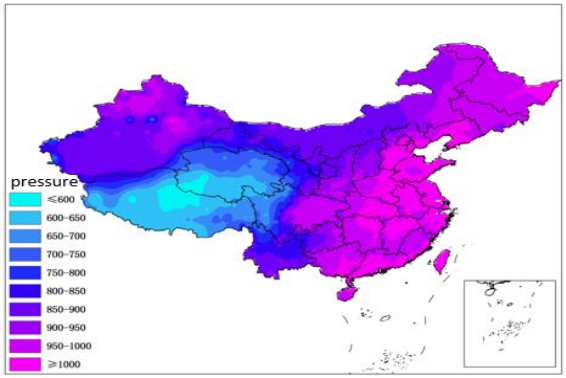
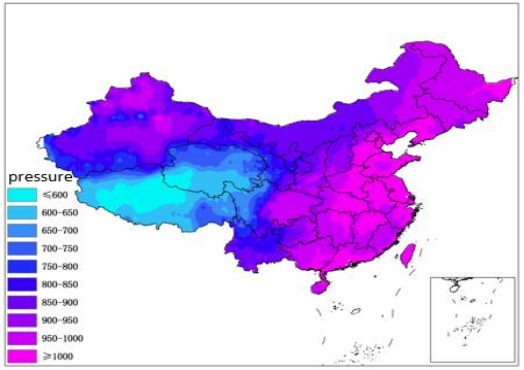
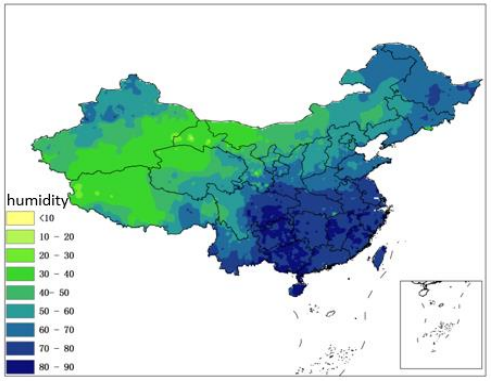
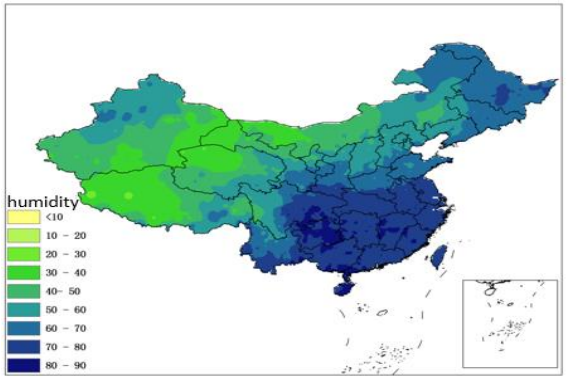
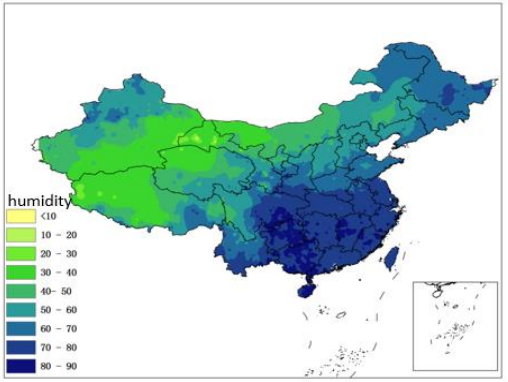
Reasonable distribution at present stage.

Main Methods & Results

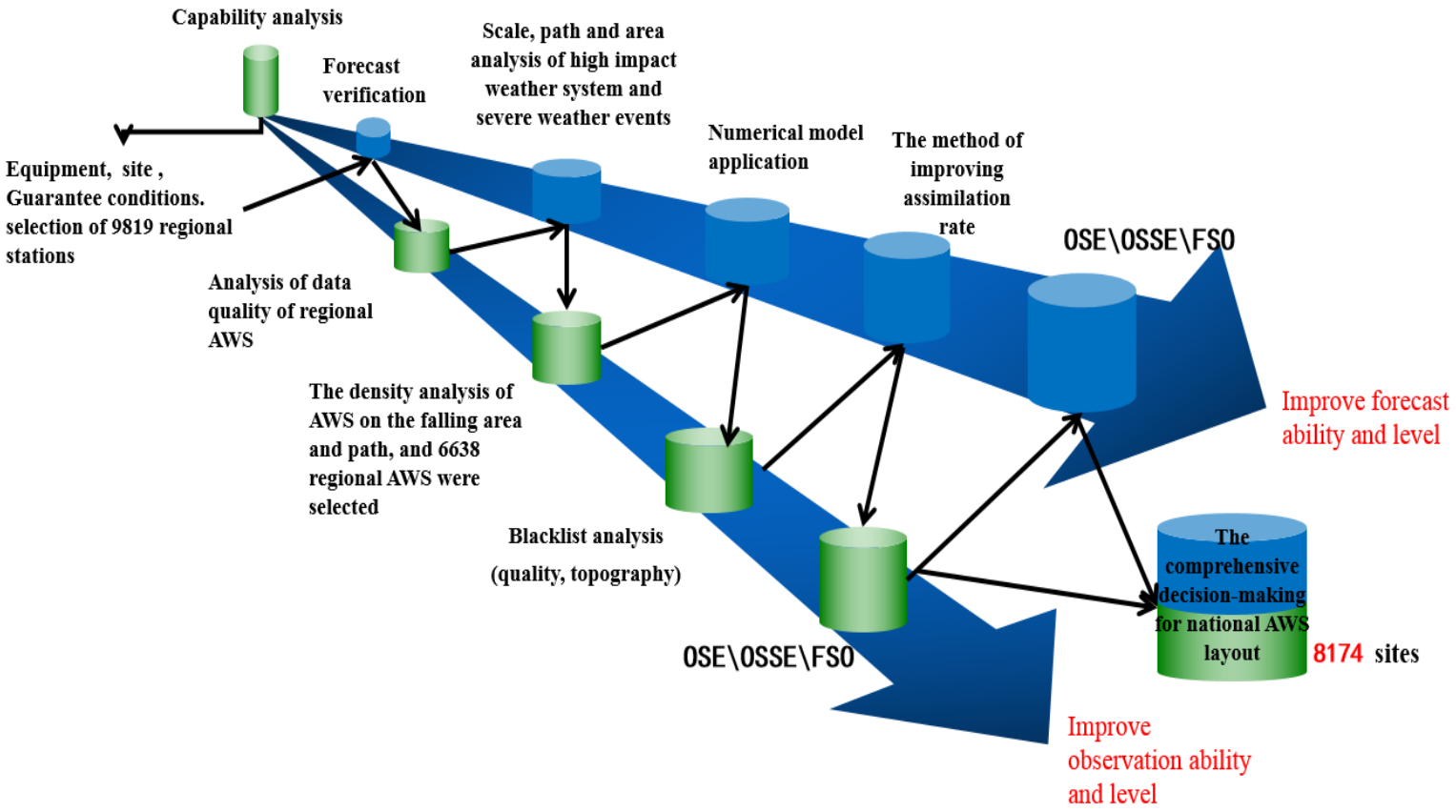
	All AWS	National AWS	Final scheme
Heavy rain days			
Gale days			

Using all AWS data from 2014 to 2015, to verify the capability of the final AWS network.

Main Methods & Results

	All AWS	National AWS	Final scheme
Surface air pressure			
humidity			

Conclusions and discussions



- This work is a huge system engineering project, different levels of observation and prediction department involved in.
- Benign interaction between observation and prediction is established.

THANK YOU!