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

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Outline

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

- Decision-making and statement
- Requirements and critical review 1
- Requirements and critical review 2
- The status of the existing AWS
- Requirements by NWP (impact study)
- Comprehensive analysis and decision-making

2014
Capability

2015
Requirements and critical review 1

2016
Decision-making and statement

Which?
Where?
How many?
### Main Methods & Results

- **Capabilities evaluation---Step 1 (2014)**

<table>
<thead>
<tr>
<th></th>
<th>Category</th>
<th>Indicator</th>
<th>Minimum requirements</th>
<th>Weight points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment</td>
<td>license</td>
<td>Equipment with the Equipment license from CMA</td>
<td>20</td>
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<td>2</td>
<td>Power supply</td>
<td></td>
<td>Good power supply, will not cause more than 72 hours work stop due to power supply problems</td>
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<tr>
<td>3</td>
<td>Guarantee</td>
<td>Communication</td>
<td>Good Communication, will not cause more than 72 hours work stop due to Communication problems</td>
<td>10</td>
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<td>4</td>
<td>Access</td>
<td></td>
<td>Good Traffic, will not cause more than 72 hours work stop due to Traffic problems</td>
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<tr>
<td>5</td>
<td>Instrument</td>
<td>Installation location</td>
<td>Land station installed on the ground; rivers and lakes station installed in a dedicated platform</td>
<td>10</td>
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<tr>
<td>6</td>
<td>Site</td>
<td>land cover conditions</td>
<td>Grass, natural bare land</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Site area</td>
<td></td>
<td>Large enough, no interaction between the observation instruments</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>Surrounding</td>
<td>environmental conditions</td>
<td>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.</td>
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<tr>
<td>9</td>
<td>Thunder</td>
<td>prevention</td>
<td>Thunder prevention satisfies the requirement of automatic station Thunder prevention technology standard</td>
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</table>

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.
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.
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 distribution of every 10000 rank based on the deviation of the regional 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).

<table>
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<tr>
<th>INSTITUTE/CMA</th>
<th>NMC</th>
<th>MOC</th>
<th>north of China</th>
<th>east of China</th>
<th>south of China</th>
<th>centre of China</th>
<th>northeast of China</th>
<th>southwest of China</th>
<th>Xinjiang China</th>
<th>Northwest of China</th>
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<td>Jiangsu/Zhejiang/Anhui/Fujian/Jiangxi/Shandong/Shanghai</td>
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<td>Hubei/Henan/Hunan</td>
<td>Liaoning/Jilin/Heilongjiang</td>
<td>Sichuan/Yunnan/GuiZhou/Tibet/Chongqing</td>
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<td>Gansu/Shaanxi/Qinghai/Ningxia</td>
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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.
• 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%.
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.
The sensitivity of the forecast score to the AWS density is varies with the cases. Some cases show negative effect.
OSSEs in the sensitive area show the AWS is not the denser the better.
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;
  – First 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

Selection site distribution in 2016
- Selection site: 8174
- National site: 2423

The final scheme of selected regional AWS. Total of AWS are 10597.
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.
Using all AWS data from 2014 to 2015, to verify the capability of the final AWS network.
Main Methods & Results

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!