The national obligations of Meteorological Service for highway

- meet especially the needs of society and public safety
- provide real weather information for Government, Transport Department and the Public

Highway Transportation network of China is steadily improved and perfected.

By the end of 2017, the mileage of expressway had reached 0.13 million kilometers.
Meteorological service operation for highway

- **Monitoring (hourly)**
  - Road weather factors
    - Rainfall, visibility, windspeed, air temperature, humidity, weather phenomena...
  - Road state
    - Road surface temperature, road condition, snow depth...

- **Forecasting**
  - Key region hazards prone region, potential point...
  - Key period of time hazards affect period, festival...
  - Extreme weather
    - Typhoon, rainfall...

- **Risk assessment**
  - Traffic hazards
    - Low visibility, rainfall, freezing rain and snow, gale

- **Warning**
Monitor factors:
- visibility
- air temperature
- rainfall
- humidity
- wind
- road surface temperature
- road condition

Monitor time: 10 minutes interval
Developed the monitoring products

provide 6 types of road weather monitoring products one by one hour
Developed the forecast products

1-3day weather forecast for 3h interval

Road information station → verification
  ↓
intelligent grid forecast (5*5KM) → numerical model output (3*3KM)
  ↓
data blending
  ↓
space downscaling
  ↓
correction
  ↓
road sector
  ↓
  → rainfall, windspeed, air temperature, visibility

Multi-model integration
Statistical downscaling
Road weather stations
ArcGIS spatial analysis
Real-time observation data
Highway dynamic segmentation technology
Roll correction
Result verification
Developed the risk assessment products

Extend to impact forecast

Risk investigation → risk zoning → Risk assessment → Service products based on impact of hazards

Risk Assessment of Meteorological Disasters of Highway

- **Hazard**
  - Low Visibility
  - Freezing Rain and Snow
  - Rainfall
  - Gale

- **Sensitivity**
  - slope/relief amplitude
  - soil or rock type
  - river and lake distribution
  - vegetation coverage ratio

- **Exposure**
  - population density
  - vehicle flow
  - vehicle ownership
  - highway mileage density
  - density of road network

- **Vulnerability**
  - highway blocked
  - traffic accident
  - casualty
  - economic loss
  - risk hidden danger point

- **Capabilities**
  - local financial budget
  - per capita GDP
  - per area GDP

Risk = Hazard × Exposure × Vulnerability × sensitivity × Disaster Prevention and Mitigation Capabilities
Risk Warning Products of Meteorological hazards of Highway

<table>
<thead>
<tr>
<th>Type</th>
<th>Forecast period of validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Visibility</td>
<td>24h</td>
</tr>
<tr>
<td>Gale</td>
<td>24h</td>
</tr>
<tr>
<td>Rainfall</td>
<td>72h</td>
</tr>
<tr>
<td>Freezing Rain and Snow</td>
<td>240h</td>
</tr>
</tbody>
</table>
Meteorological hazards: Typhoon, heavy rain, fog, snow

Warning the affected road sections for 24-72 hours in advance
Service Media

China Weather Website
Users requirements
Current situation of road accidents

**Road accident characteristic:**

- The average annual accident rate caused by adverse weather is 20% in recent 5 years.
- The serious traffic accidents caused by adverse weather rised from 10% to 40%.
- Adverse weather is the main factor which inducing serious traffic accidents.
Traffic adverse weather

From 2012 to 2014, the program of the national road traffic meteorological disaster survey was implemented, which was sponsored by China Meteorological Administration (CMA).

Types of meteorological factors which inducing road accidents

- Heavy precipitation: 36.5%
- Fog: 11.9%
- Other: 12.8%
- Icy pavement: 15.5%
- Snowy road surface: 20.2%
- dumpling fog: 3.1%

Data from Ministry of Public Security Traffic Control Bureau
Decision-making users requirement

- Service has played important roles on transport management, operation dispatch, emergency rescue.
- Played weakly roles on road construction, road maintenance, traffic technology research.

- The demand of meteorological factors is different between Traffic department and meteorological department.
- Traffic department pay more attention to the road icing, fog, snow cover, snowfall, freezing rain and strong rainfall.
observation forecast warning assessment

demand time
- monitoring: hourly
- forecast: 3-12 hours
- assessment: daily, monthly, quarterly.
- warning: 24 hour

demand channel
- Website, sharing platform, mobile client are the most convenient

Decision-making users requirement providing channel

observation

forecast

waring

assessment

demand time of monitoring product

demand time of forecast product

demand time for early warning

demand time for evaluation product
Public user's requirement

• demand product
  observation, forecast and early warning for disaster weather such as fog, and road icing, strong rainfall

• access channel
  access to road weather information through television, mobile phones, website

All users are urgently in need of precise and timely meteorological information
Gap

proportion of factors for monitoring network

<table>
<thead>
<tr>
<th>Factor</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall</td>
<td>94.6%</td>
</tr>
<tr>
<td>Air temperature</td>
<td>83.2%</td>
</tr>
<tr>
<td>Pressure</td>
<td>24.8%</td>
</tr>
<tr>
<td>Humidity</td>
<td>34.3%</td>
</tr>
<tr>
<td>Wind speed</td>
<td>56.4%</td>
</tr>
<tr>
<td>Visibility</td>
<td>24.4%</td>
</tr>
<tr>
<td>Road temperature</td>
<td>8.8%</td>
</tr>
<tr>
<td>Road condition</td>
<td>4.2%</td>
</tr>
<tr>
<td>Sunlight time</td>
<td>6.8%</td>
</tr>
<tr>
<td>Radiation</td>
<td>2.2%</td>
</tr>
<tr>
<td>Others</td>
<td>11.8%</td>
</tr>
</tbody>
</table>

lack of road temperature and condition observation

strengthen the construction of monitoring network for road traffic

strengthen quality assurance and control for observation data

Distribution of RWIS

number is scarce and not well-distributed
Gap

Improve the technology to enhance accuracy and spatial-temporal resolution of service product

- Strengthen the multi-resource data application on service such as radar, satellite, camera video data
- Using emerging technology to optimize forecast method such as machine-learning, artificial-intelligence technology
- Strengthen the research on dumpling fog, road temperature and condition model
- Promote impacted and disaster risk forecast on road
Gap

Improve mechanism of department cooperation

- Strengthen data sharing such as road information, traffic flow, traffic accident, traffic blocking data
- Strengthen requirement feedback and service benefit evaluation mechanism, establish the normalized operation process
- Strengthen the construction of highway meteorological warning release channels, integrate bilateral information publishing channels
- Strengthen technical cooperation and standard setting
Opportunity

- Cooperate with transport department to carry out project and standard setting
- Carry out services with the help of social resource to provide location-based and on-demand service for the public
Thanks !
2017年全国公路交通行业气象服务的贡献率为1.11%，效益值约为142.60亿元。

In 2017, the contribution rate of meteorological services in the national highway transportation industry was 1.11%, and the benefit value was about 14.260 billion yuan.

2017年全国公路交通行业气象服务的综合效率、技术效率和规模效率平均值分别为0.841、0.887、0.949。规模效率接近1，技术效率与1的差距较大，即在科技创新、技术研发及管理水平方面需要改善和优化。
national highway metro-disaster survey

- **metro-disaster**: fog, strong rainfall, dumpling fog, snow cover, road icing
- **derived disaster**: landslide, debris flow

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disaster risk data base

disaster risk potential point
road segmentation and data blending

• correct method

verification

summer rainfall

<table>
<thead>
<tr>
<th>评价</th>
<th>06h</th>
<th>12h</th>
<th>18h</th>
<th>24h</th>
<th>30h</th>
<th>36h</th>
<th>42h</th>
<th>48h</th>
<th>54h</th>
<th>60h</th>
<th>66h</th>
<th>72h</th>
<th>78h</th>
<th>AVG</th>
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<tbody>
<tr>
<td>正确</td>
<td>0.465</td>
<td>0.440</td>
<td>0.462</td>
<td>0.461</td>
<td>0.460</td>
<td>0.423</td>
<td>0.444</td>
<td>0.444</td>
<td>0.445</td>
<td>0.447</td>
<td>0.473</td>
<td>0.423</td>
<td>0.450</td>
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</tr>
<tr>
<td>订正后</td>
<td>0.834</td>
<td>0.698</td>
<td>0.844</td>
<td>0.833</td>
<td>0.824</td>
<td>0.591</td>
<td>0.618</td>
<td>0.549</td>
<td>0.579</td>
<td>0.688</td>
<td>0.582</td>
<td>0.559</td>
<td>0.595</td>
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</tr>
<tr>
<td>强度不符</td>
<td>0.083</td>
<td>0.096</td>
<td>0.091</td>
<td>0.086</td>
<td>0.080</td>
<td>0.076</td>
<td>0.073</td>
<td>0.076</td>
<td>0.092</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>订正后</td>
<td>0.092</td>
<td>0.119</td>
<td>0.095</td>
<td>0.101</td>
<td>0.080</td>
<td>0.072</td>
<td>0.076</td>
<td>0.089</td>
<td>0.077</td>
<td>0.093</td>
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<tr>
<td>查报</td>
<td>0.146</td>
<td>0.165</td>
<td>0.124</td>
<td>0.131</td>
<td>0.127</td>
<td>0.149</td>
<td>0.121</td>
<td>0.124</td>
<td>0.146</td>
<td>0.146</td>
<td>0.173</td>
<td>0.143</td>
<td></td>
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</tr>
<tr>
<td>订正</td>
<td>0.071</td>
<td>0.073</td>
<td>0.074</td>
<td>0.078</td>
<td>0.083</td>
<td>0.065</td>
<td>0.064</td>
<td>0.092</td>
<td>0.103</td>
<td>0.107</td>
<td>0.118</td>
<td>0.109</td>
<td>0.090</td>
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</tr>
<tr>
<td>订正后</td>
<td>0.321</td>
<td>0.309</td>
<td>0.322</td>
<td>0.335</td>
<td>0.315</td>
<td>0.346</td>
<td>0.347</td>
<td>0.322</td>
<td>0.346</td>
<td>0.315</td>
<td>0.312</td>
<td>0.332</td>
<td>0.335</td>
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</tr>
<tr>
<td>天报</td>
<td>0.236</td>
<td>0.235</td>
<td>0.197</td>
<td>0.229</td>
<td>0.215</td>
<td>0.235</td>
<td>0.231</td>
<td>0.272</td>
<td>0.251</td>
<td>0.266</td>
<td>0.232</td>
<td>0.233</td>
<td>0.234</td>
<td></td>
</tr>
</tbody>
</table>

precision of bary forecast

air temperature

24h maximum air temperature error : 1.18 - 1.67
24h minimum air temperature error : 1.07 - 1.71
Data processing and risk grade classification based on GIS technology.

For risk warning, taking the numerical prediction products as the dynamic input for hazard risk factors, also using historical statistics result for the other factors.
<table>
<thead>
<tr>
<th>Target Strata</th>
<th>Criteria Layer</th>
<th>Hazard</th>
<th>Index Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low Visibility</td>
<td>low visibility (&lt;500m) frequency</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>low visibility (&lt;500m) intensity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainfall</td>
<td>precipitation of rainfall intensity ≥10mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>precipitation of rainfall frequency ≥10mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>heavy rainfall duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>freezing process duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Freezing Rain and Snow</td>
<td>cumulative rainfall of freezing process</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>rainfall duration of freezing process</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>freezing frequency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gale</td>
<td>mean wind (≥8.0m/s) frequency</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>mean wind (≥8.0m/s) duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>extreme wind (≥13.9m/s) frequency</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>crosswind (≥8.0m/s) frequency</td>
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<td></td>
<td>Sensitivity</td>
<td>Rainfall</td>
<td>Slope/relief amplitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>soil or rock type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Freezing Rain and Snow</td>
<td>river and lake distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vegetation coverage ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>altitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>road slope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>road aspect (shady or sunny slope)</td>
</tr>
<tr>
<td></td>
<td>Exposure</td>
<td>Low Visibility, Rainfall, Freezing Rain and Snow, Gale</td>
<td>population density</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>vehicle flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>density of road network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>vehicle ownership</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>highway mileage density</td>
</tr>
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<td></td>
<td>Vulnerability</td>
<td>Low Visibility, Rainfall, Freezing Rain and Snow, Gale</td>
<td>highway blocked</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>traffic accident</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>casualty</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>economic loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>risk hidden danger point</td>
</tr>
<tr>
<td></td>
<td>Capabilities</td>
<td>Low Visibility, Rainfall, Freezing Rain and Snow, Gale</td>
<td>local financial budget</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>per capita GDP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>per area GDP</td>
</tr>
<tr>
<td>Hazard Factor</td>
<td>Measure</td>
<td>Time Resolution</td>
<td>Time Length</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------</td>
<td>-----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Rainfall</td>
<td>precipitation</td>
<td>hourly</td>
<td>1951-2012 (62a)</td>
</tr>
<tr>
<td>Low Visibility</td>
<td>visibility</td>
<td>Quartic a day</td>
<td>1980-2014 (35a)</td>
</tr>
<tr>
<td>Gale</td>
<td>10-minute average wind speed,</td>
<td>hourly</td>
<td>2005-2014 (10a)</td>
</tr>
<tr>
<td></td>
<td>extreme wind speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezing Rain and</td>
<td>precipitation, air temperature,</td>
<td>daily</td>
<td>1958-2013 (56a)</td>
</tr>
<tr>
<td>Snow</td>
<td>ground surface temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Risk Warning of Meteorological Disasters of Highway

### Hazard Prediction Data (Dynamic)

<table>
<thead>
<tr>
<th>Hazard Factor</th>
<th>Measure</th>
<th>Resolution</th>
<th>Time Length /Period of Validity</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Visibility</td>
<td>visibility</td>
<td>station(2421)</td>
<td>3h/84h</td>
<td>Cuace/corrected</td>
</tr>
<tr>
<td>Gale</td>
<td>10m wind speed</td>
<td>0.25°*0.25°</td>
<td>Max/24h</td>
<td></td>
</tr>
<tr>
<td>Rainfall</td>
<td>Precipitation of 6 hours</td>
<td>5km*5km</td>
<td>6h/72h</td>
<td>CMA Forecast Ensemble</td>
</tr>
<tr>
<td>Freezing Rain and Snow</td>
<td>R, T2m, Ts</td>
<td>0.25°*0.25°</td>
<td>24h/240h 3h/240h</td>
<td></td>
</tr>
</tbody>
</table>

Forecast Time: 08/20 o’clock
(Gale Forecast Time: 08 o’clock)
disaster risk zoning

- rainfall
- gale
- low visibility
- freezing rain and snow