Air quality monitoring development and application in China

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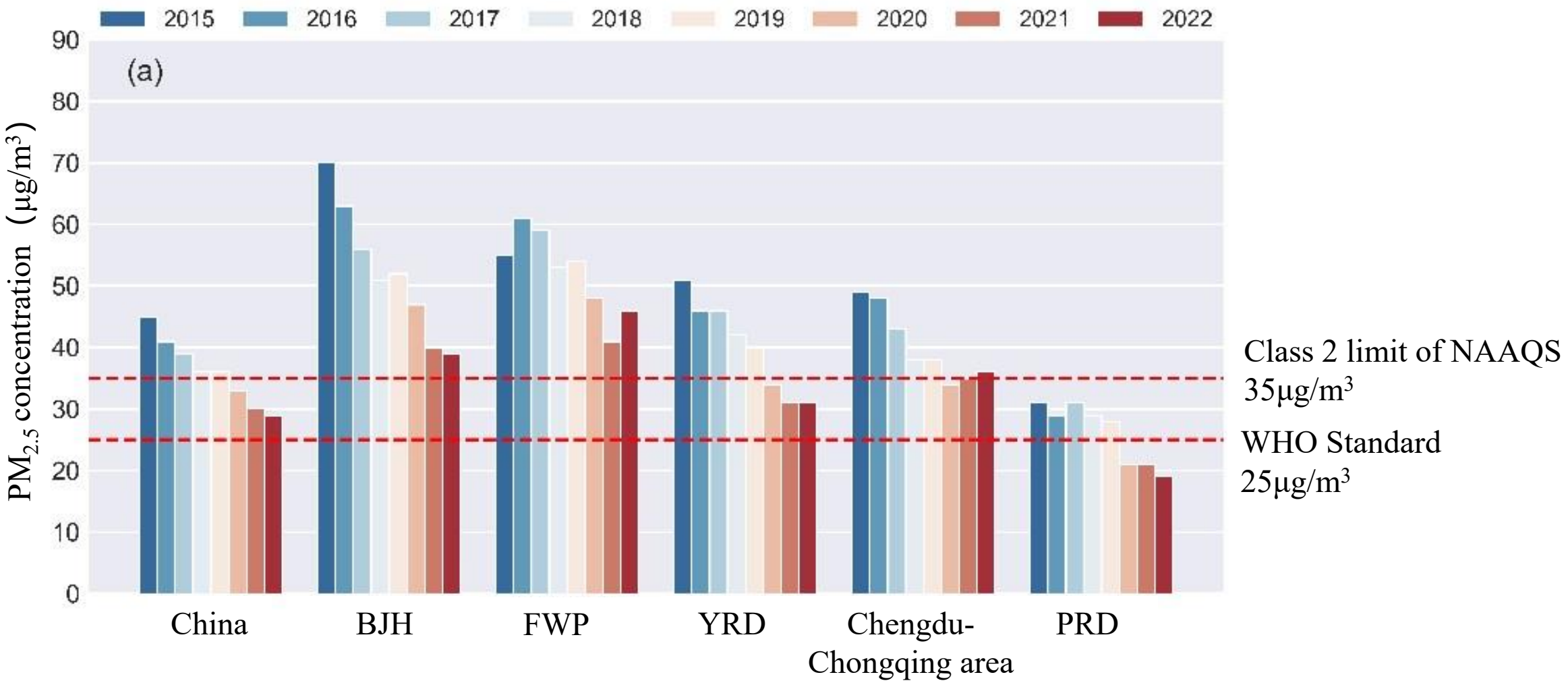
Contents

Precise Air Improvement based on big-data monitoring

- Major economic and social development decisions, as well as the construction and development of ecological civilization, require a correct assessment of the environmental quality
- Developing various environmental protection and control plans, determining key areas, indicators, and measures for pollution prevention and control, requires the support of scientific environmental monitoring data
- Accurate reduction and control of environmental pollution, ecological red line supervision, and early warning of resource and environmental carrying capacity require environmental monitoring to provide trend analysis, risk prediction, source analysis, and tracking

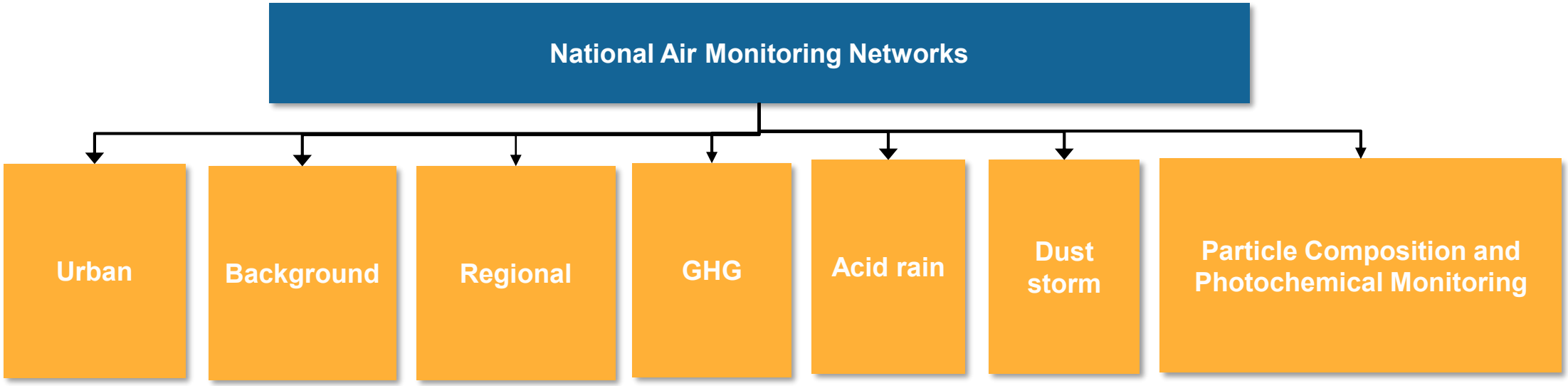
Contents

Improvement of $PM_{2.5}$ pollution in PRC



National Air Monitoring Networks Development

- Expanding and establishing a multi-scale monitoring network that encompasses regional, city, county and township levels to effectively monitor air quality across various spatial scales
- Increasing the coverage of administrative divisions at the county level from 31.4% to 96.4%
- Supporting refined pollution control and tracking the sources of pollution for effective management



Source: CNEMC

Building an integrated urban-county-township air quality monitoring network-National

☐1,734 national monitoring stations for urban environmental quality in cities

- ➢During the 14th Five-Year Plan period, the number of national monitoring stations for urban environmental quality increased to 1,734, resulting in a more balanced and rational distribution

☐64 regional environmental air quality monitoring stations

- ➢By the end of 2018, 64 regional stations were fully networked
- ➢Operation and maintenance tasks were entrusted to provincial stations

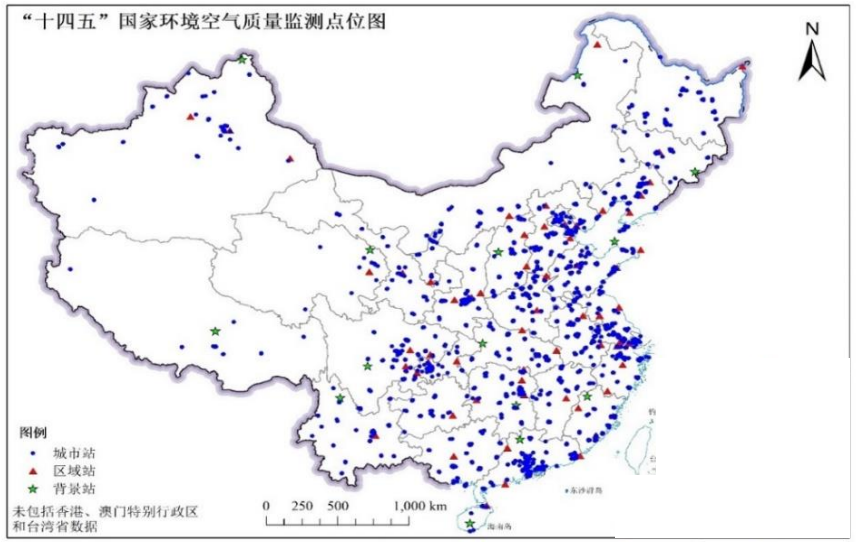
☐16 national background air quality monitoring stations since 2008

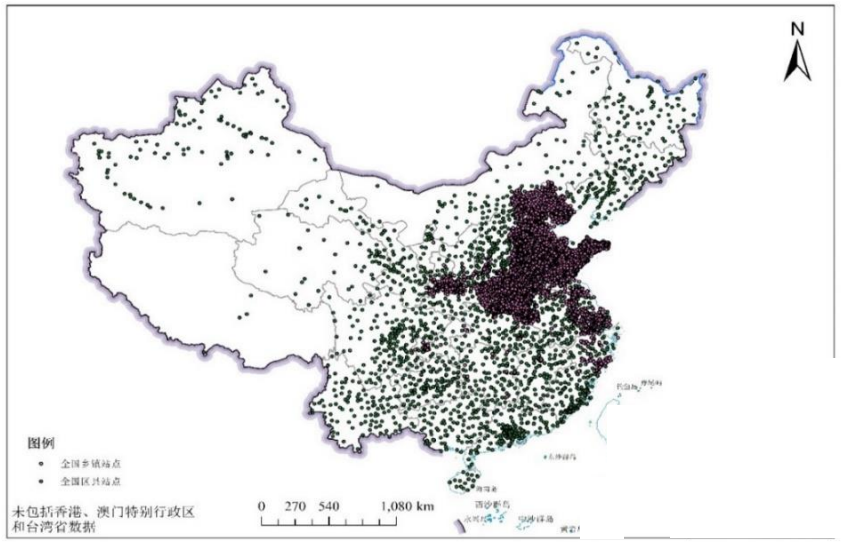
- ➢In 2021, monitoring of regional greenhouse gases was conducted at nine stations

Source: CNEMC

Building an integrated urban-county-township air quality monitoring network-Local

- **10,588 local automatic monitoring stations for environmental air**
  - 3503 county-level stations
  - 7085 township-level stations
- **Three-levels monitoring network of cities-counties-townships, which effectively supports regional air pollution prevention and control**





Source: CNEMC

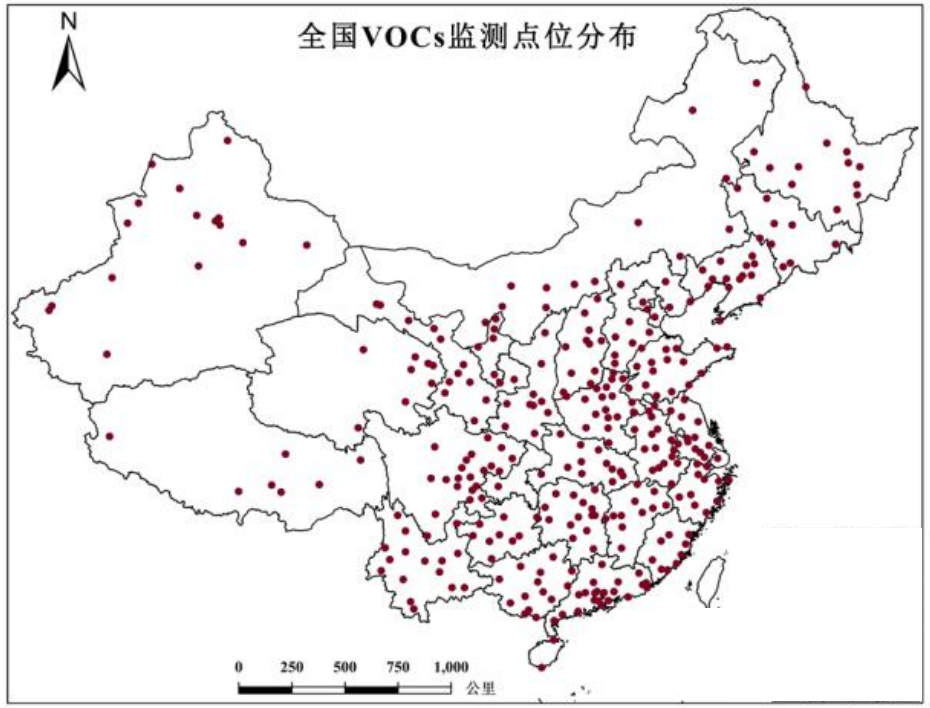
Particle Composition and Photochemical Monitoring Network

PM:

- **166 cities with 194 automated monitoring stations** connected to CNEMC
- **Manual monitoring** of PM composition has been carried out in **94 cities with 97 monitoring stations**

PAMS:

- **167 cities** have implemented automatic monitoring of VOCs and are all connected to CNEMC
- **308 cities** have implemented NMHC automatic monitoring



- ✓ To monitor components in $PM_{2.5}$ and analyze the contribution of different pollution sources in each city
- ✓ Analyze the composition, active substances, photochemical intermediates, and influencing factors of VOCs
- ✓ Analyze causes of photochemical pollution in various cities

Source: CNEMC

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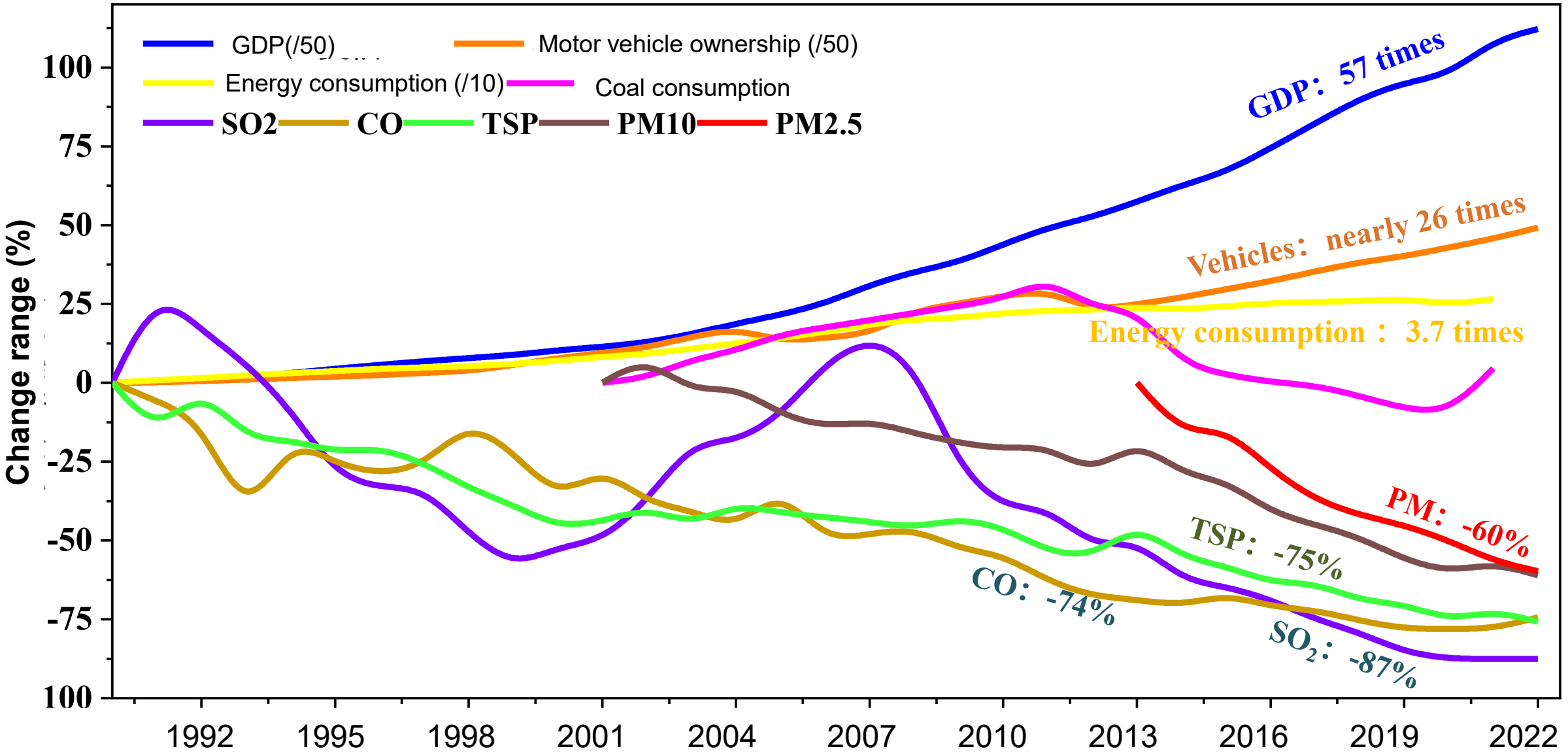
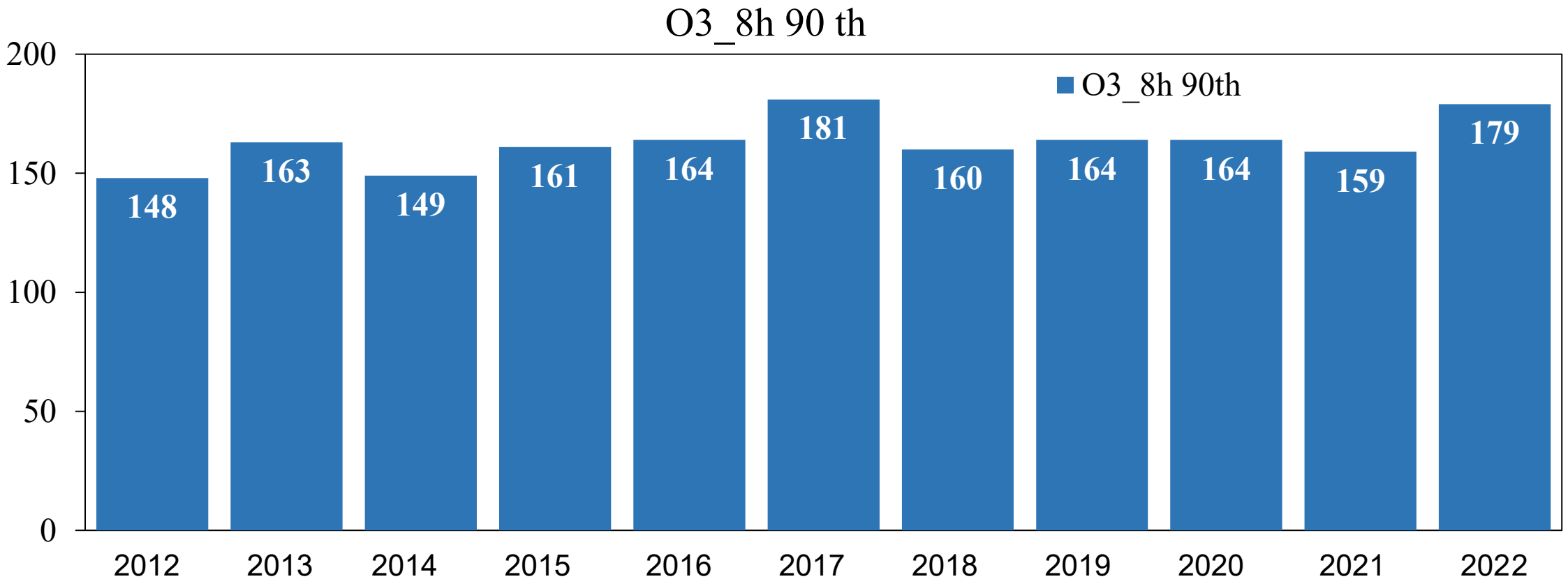
Air Quality Improvement in Shanghai, PRC



Fluctuation of O_3 in Shanghai, PRC

- **O_3: The concentration shows a fluctuating and increasing trend, increasing from 0.148mg/m³ in 2012 to 0.180mg/m³ in 2022**



Ambient air monitoring systems in Shanghai

Conventional network

19 national control and 54 district evaluation

6 Conventional + 5 meteorological parameters

Traffic network

7 transportation stations, port grid monitoring, and taxi mounted mobile monitoring

Conventional factors, benzene derivatives, NMHC, BC, etc

Industrial Zone network

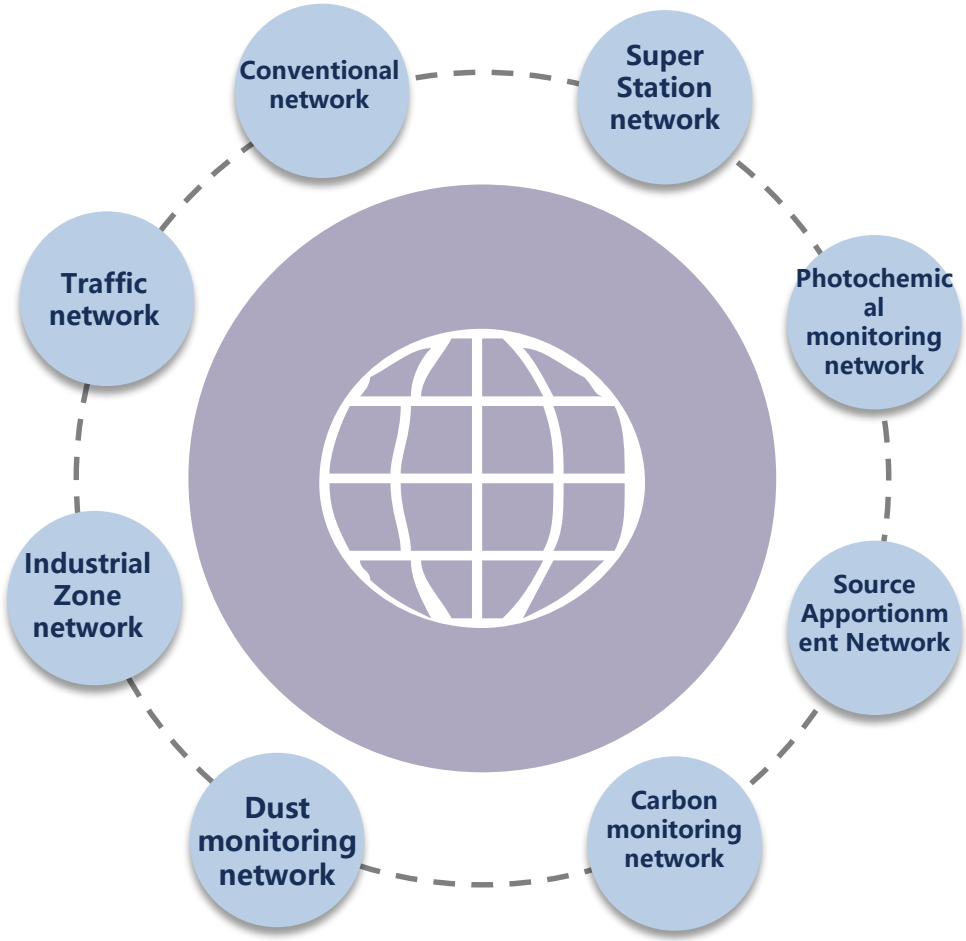
74 automatic monitoring stations

More than 40 sets of VOCs component automatic monitoring equipment

Dust monitoring network

3600+monitoring points

Covering construction sites, roads, docks, and mixing plants



Super Station network

1 key station+2 auxiliary stations

Photochemical monitoring network

Relying on conventional network and super station network

VOCs pilot monitoring

Source Apportionment Network

6 manual sampling points for $PM_{2.5}$ chemical components

Business monitoring

Ions, OC/EC, Elements, Organic Matter

Carbon monitoring network

8 greenhouse gas CO_2 monitoring stations

AQI monitoring network

19 national stations+35 district stations

The number of national control evaluation points increased from 9 to 19 in the 14th Five Year Plan period

Monitoring Network for Key Industrial Zones

74

74 monitoring stations

- Since 2013, **automatic monitoring** stations have been built in the key industrial parks

40+

Over 40 sets of VOCs component automatic monitoring instuments

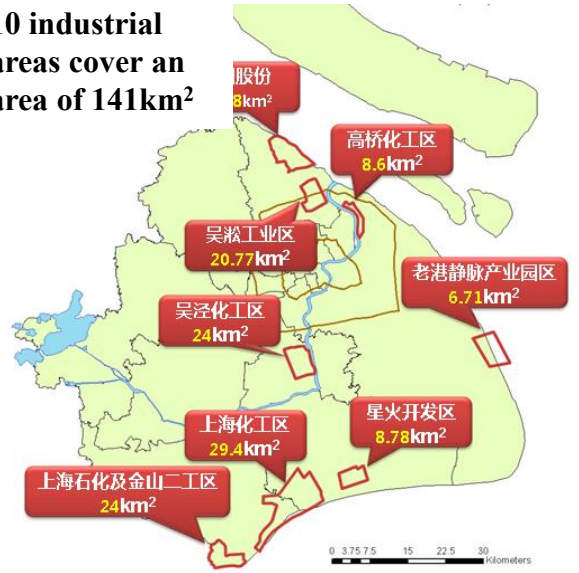
- automatic monitoring equipment, covering GC-FID, GC-MS, optical method equipment

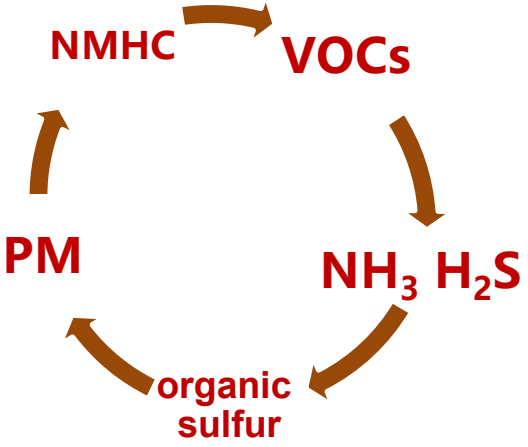
3

3 types of monitoring station

- Three types of stations, including **park stations, boundary stations, and surrounding stations**, are combined with mobile vehicles to achieve full coverage of industrial zone emission sources, boundaries, and surrounding residential areas.

10 industrial areas cover an area of 141km²

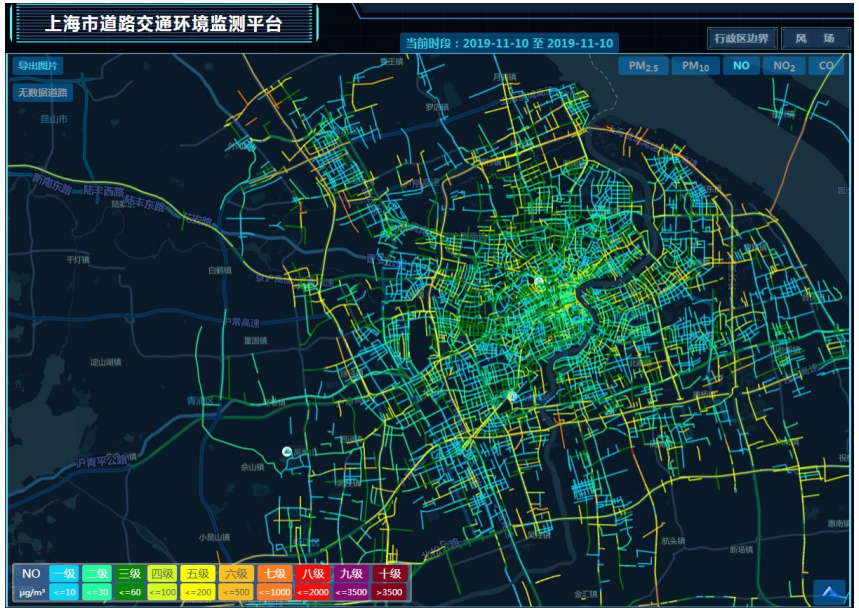


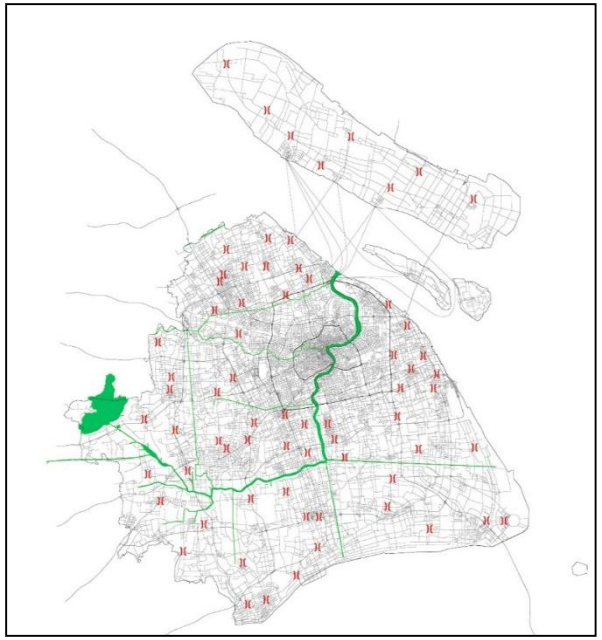


Multimodal Traffic Environment Monitoring Network – Conventional + NMHC + BTEX + BC

- **During the "14th Five Year Plan period", Shanghai will build a comprehensive traffic environment monitoring network**

  Standard station: Using conventional instruments for monitoring and evaluating the current traffic environment
  Micro station: Fixed sensor monitoring for comprehensive monitoring of traffic pollution emissions and diffusion impacts
  Mobile monitoring: Onboard small-sized sensor for real-time monitoring of road pollution conditions





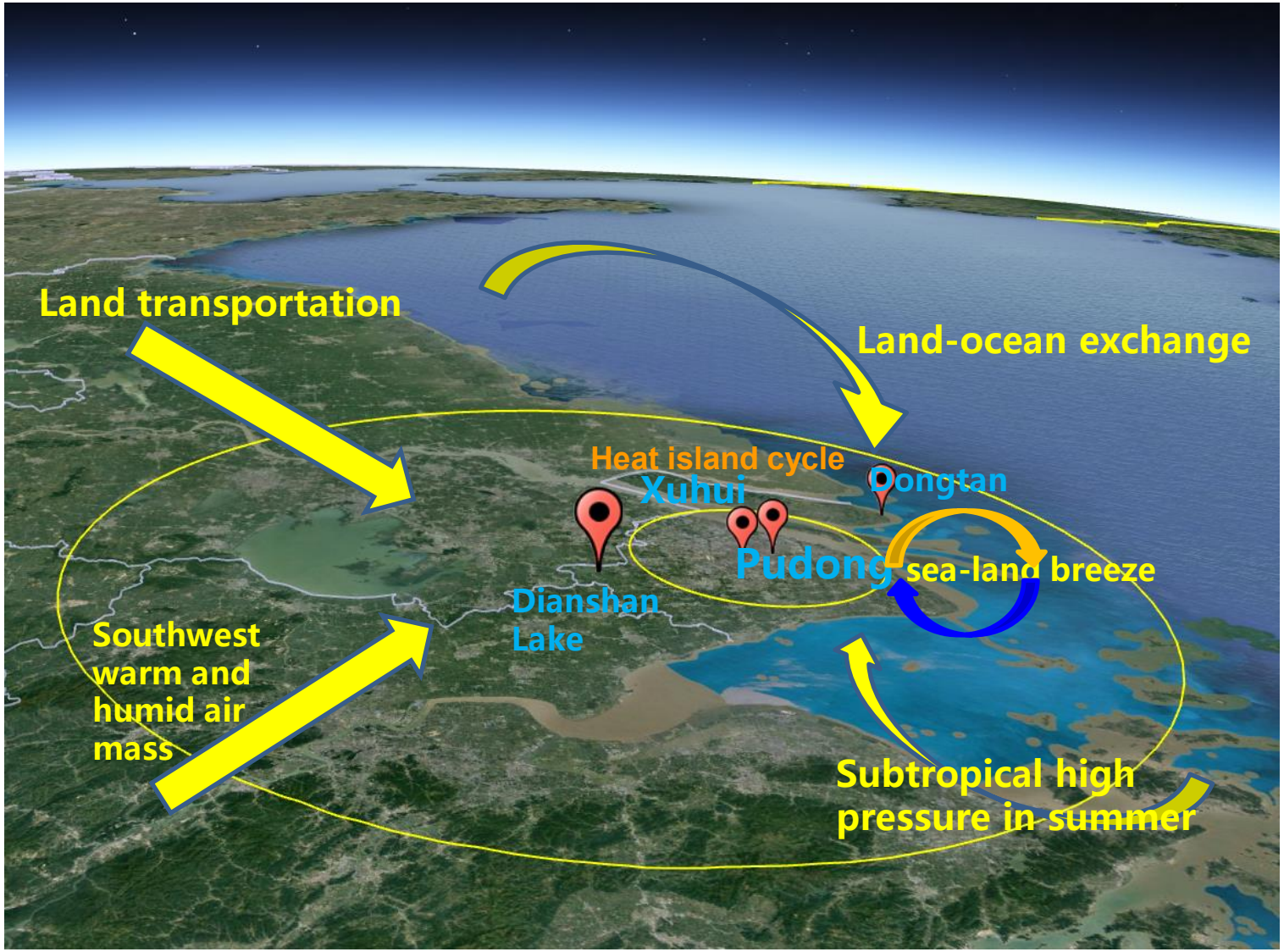
Dust online monitoring network: covering construction sites, storage yards, mixing plants and roads

- Total 6400 online dust monitoring points in 2022. Among them, there are 5560 monitoring points for construction sites, 30 monitoring points for roads, 350 monitoring points for docks, and 470 monitoring points for mixing plants

Platform of online monitoring equipment for dust and noise in Shanghai

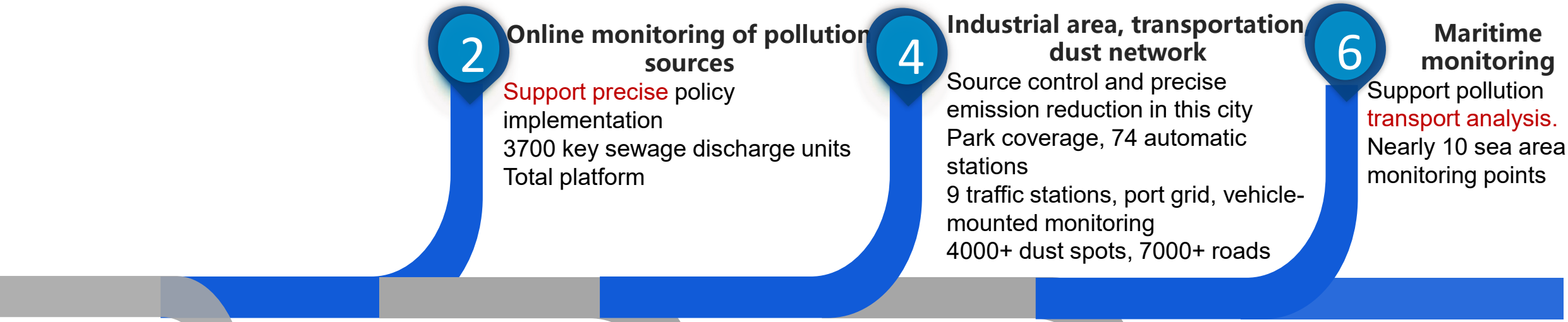
Super station network: 1 main and 3 auxiliary scientific network observation

- 1 regional Dianshan Lake Core Station: Regional representativeness, supporting regional joint prevention and control, regional forecasting and early warning
- 2 auxiliary stations: A representative station in the urban area of a mega city
- Dongtan auxiliary station: Large-scale long-distance cross regional transportation monitoring, supporting national level prevention and control policies



Comprehensive Monitoring System for Major Event Support

Air Quality Assessment	Accurate prediction and forecasting	Regional pollution source supervision	Supervision of key sources in this city	Regional pollution causes and joint prevention	Heat emission point control	Controlled area transportation



1

Environmental quality Monitoring

Support accurate regional research and judgment

421 national and provincial control points

2

Online monitoring of pollution sources

Support precise policy implementation

3700 key sewage discharge units

Total platform

3

Super station component monitoring

Cause analysis, precise control

Regional evaluation, transmission analysis

24 stations in shared area

4

Industrial area, transportation dust network

Source control and precise emission reduction in this city

Park coverage, 74 automatic stations

9 traffic stations, port grid, vehicle-mounted monitoring

4000+ dust spots, 7000+ roads

5

Navigation and UAV aerial survey

Spotting hot spots and enforcing the law by tapping acupoints

8 aerial vehicles and 2 drones

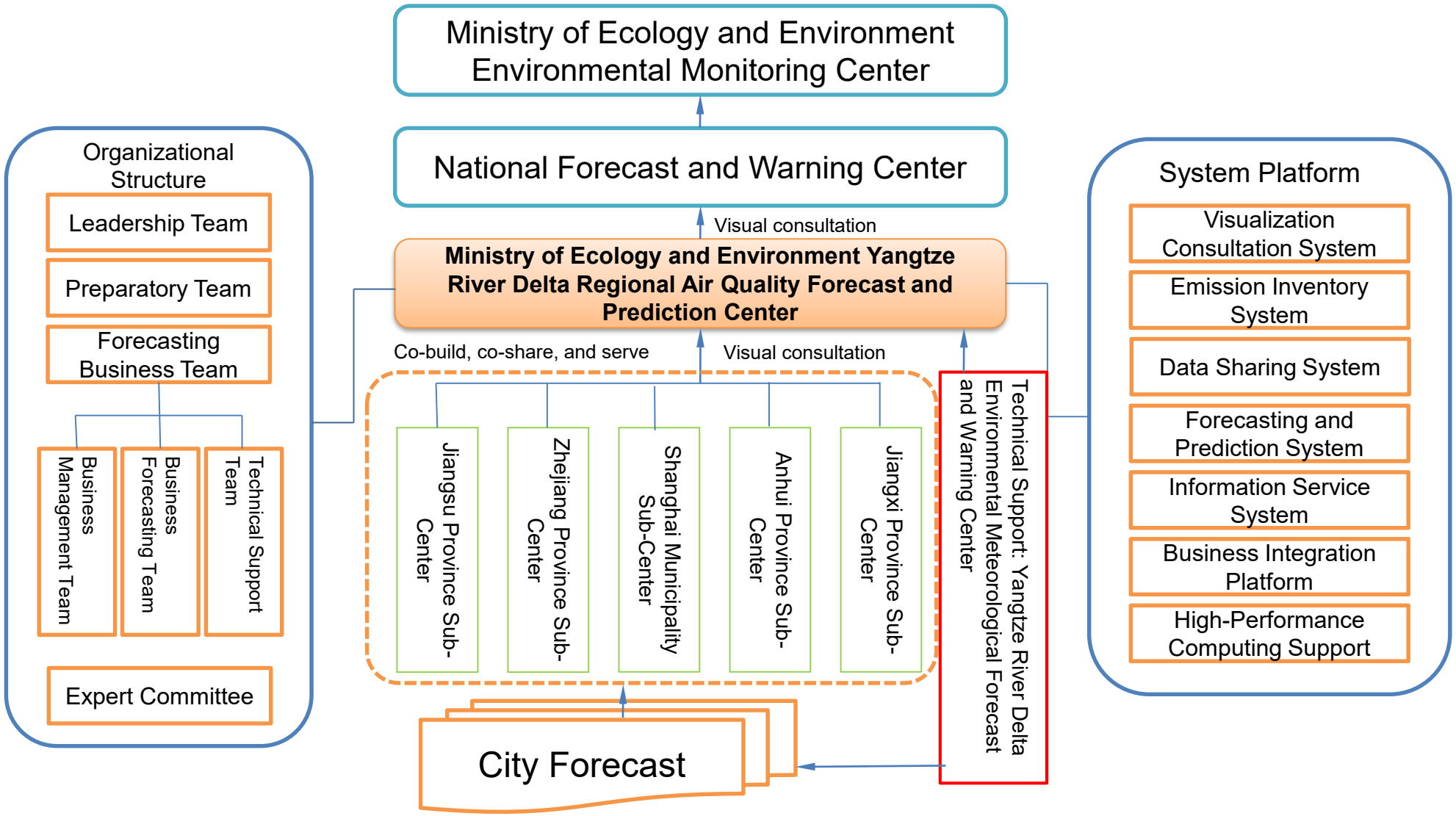
6

Maritime monitoring

Support pollution transport analysis.

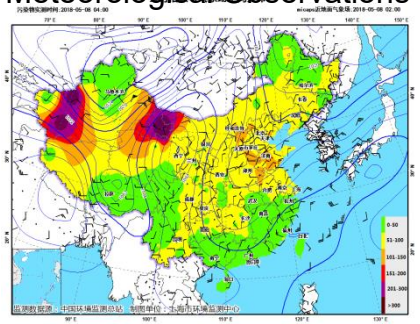
Nearly 10 sea area monitoring points

Overall framework of the Yangtze River Delta Regional Air Quality Forecasting Center

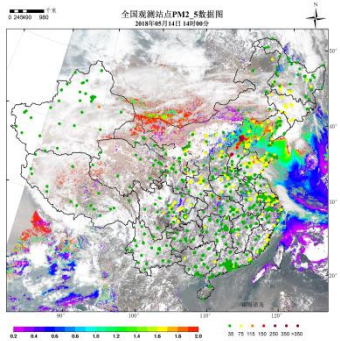


Regional Air Quality Forecasting Platform for YRD

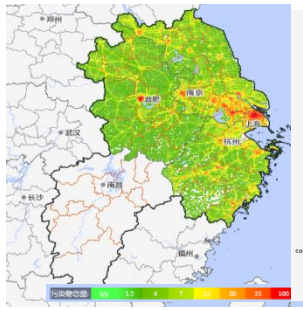
Real-time Concentration and Meteorological Observations



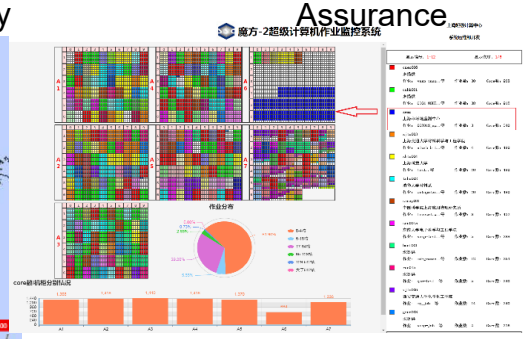
Satellite Retrieval



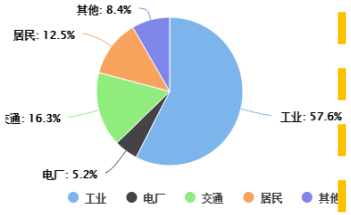
Fine-Grained Emission Inventory



Supercomputing Technology Assurance

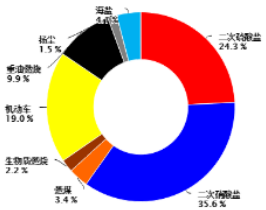


Model Source Apportionment

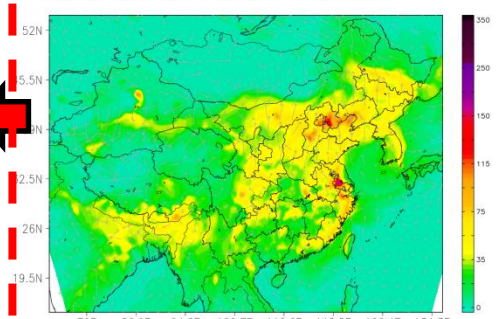


VS

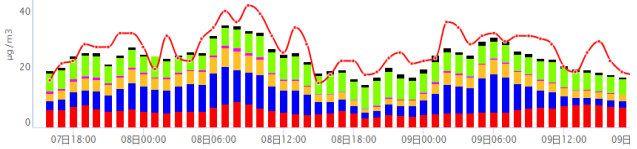
Comprehensive Source Apportionment



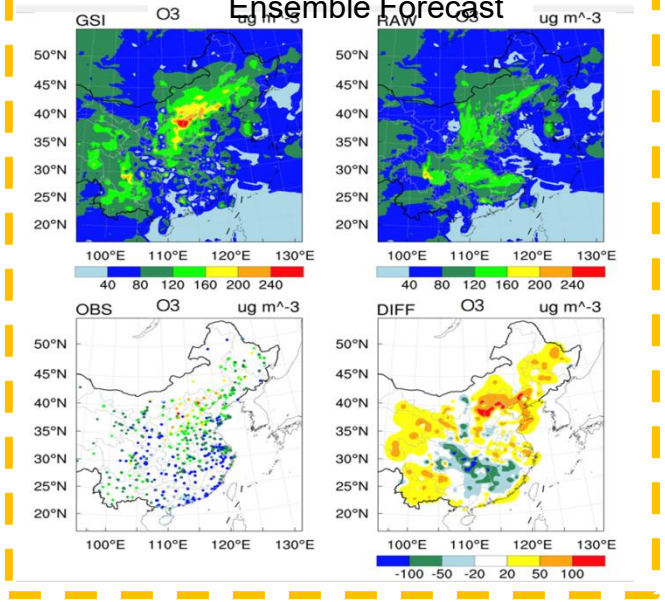
Multi-Model Ensemble Forecast System



Superstation

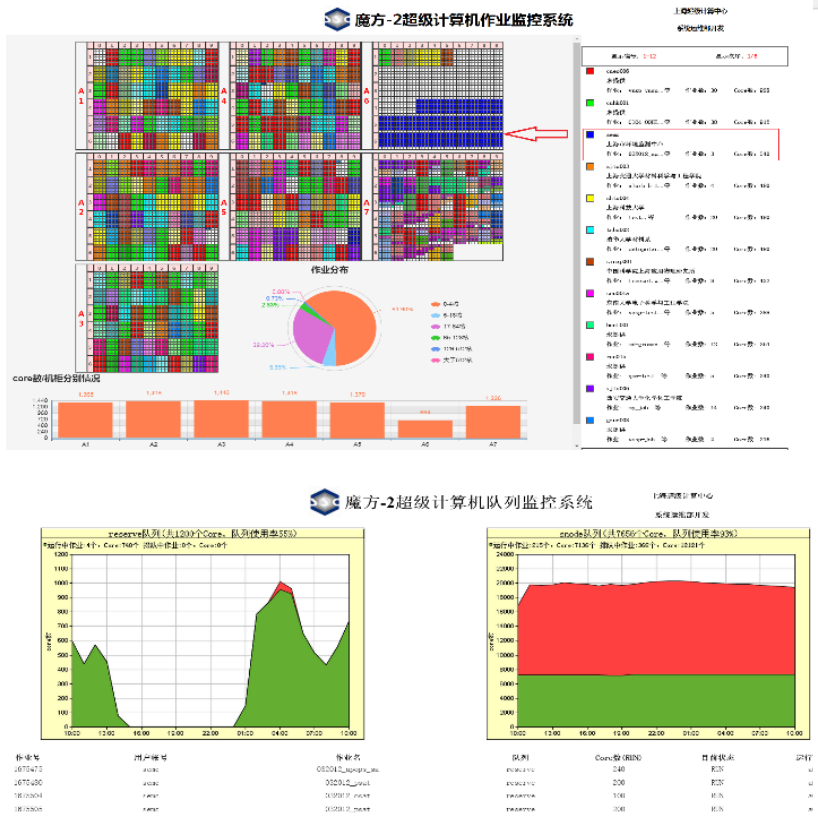


Real-time Assimilation Ensemble Forecast

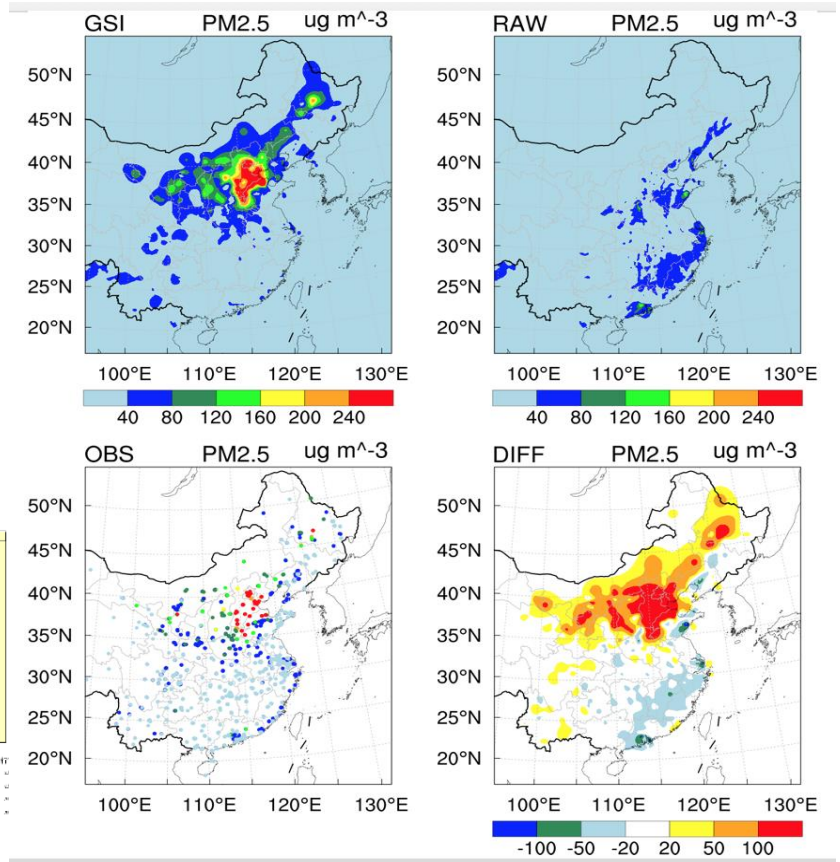


Key Technologies and Innovations

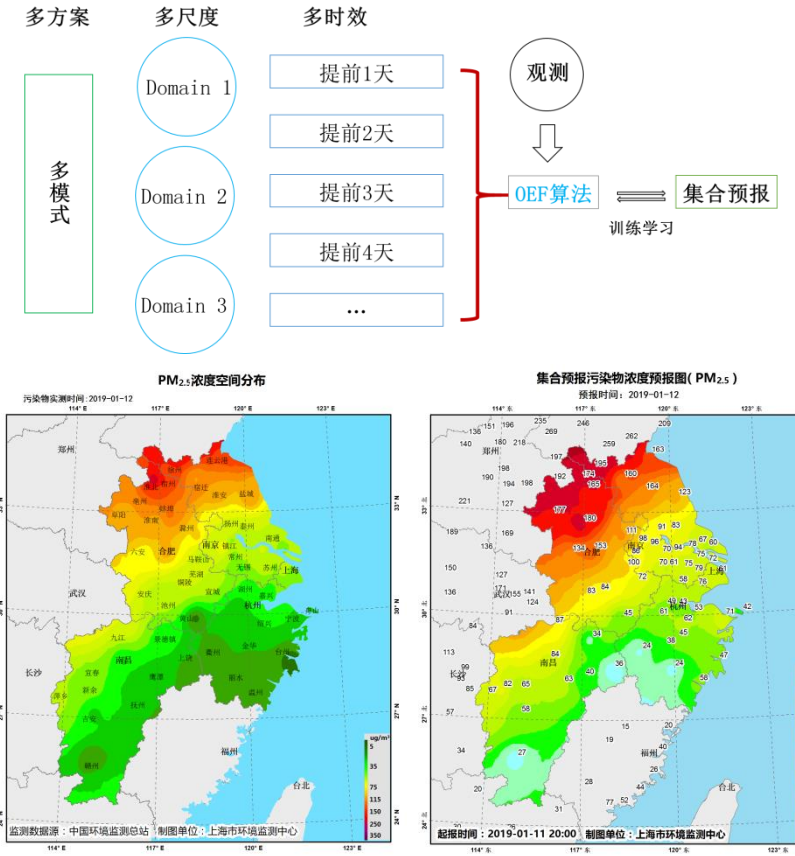
Centralized Supercomputing Support



Real-time Chemical Data Assimilation Technology



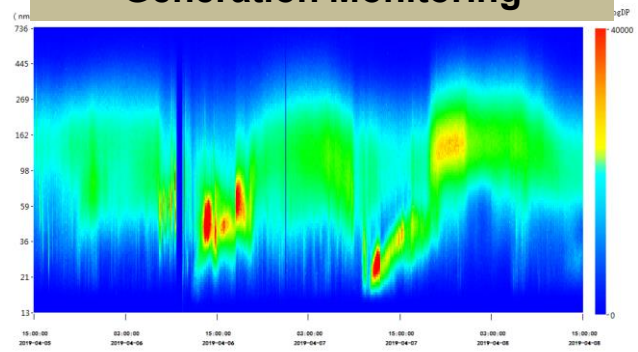
Machine Learning-Based Ensemble Forecasting Technology



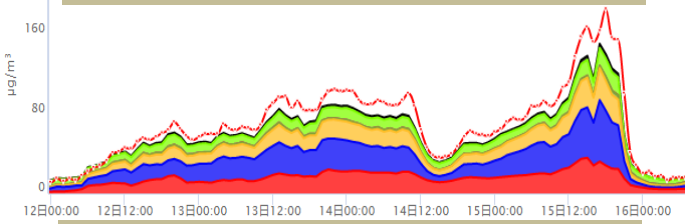
Effectively promoted the improvement of air quality forecasting accuracy in Shanghai and the Yangtze River Delta region

Integration of Pollution Diagnosis Technologies

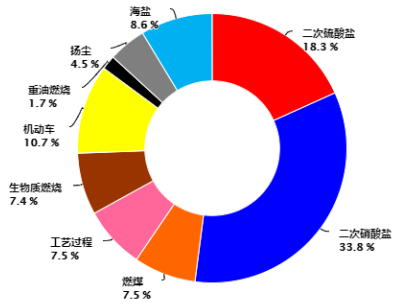
Superstation Fine Particle Generation Monitoring



Superstation Component Monitoring



Comprehensive Source Apportionment of $PM_{2.5}$



$PM_{2.5}$ Superstation Observation and Online Comprehensive Source Apportionment

+

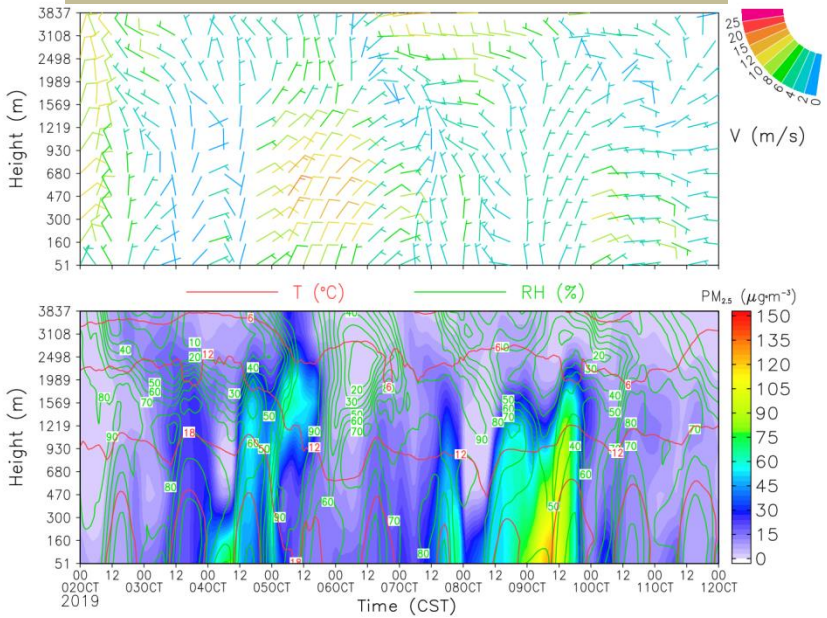
O_3 Vertical Distribution and Analysis of Its Active Components

+

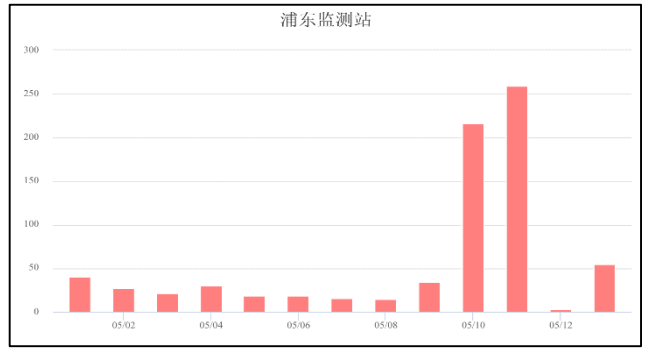
Multi-Model Ensemble Forecast, Vertical Distribution, and Component Analysis

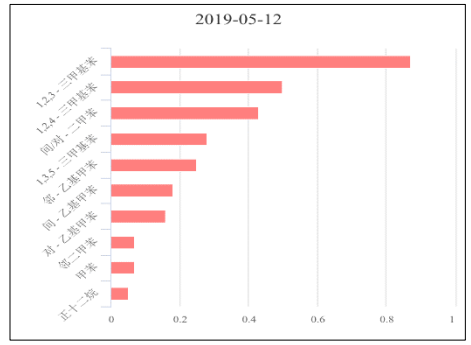
→ Integrate critical factors of $PM_{2.5}$ and O_3 pollution for assessment and prediction of control measures

$PM_{2.5}$ and O_3 Numerical Forecast

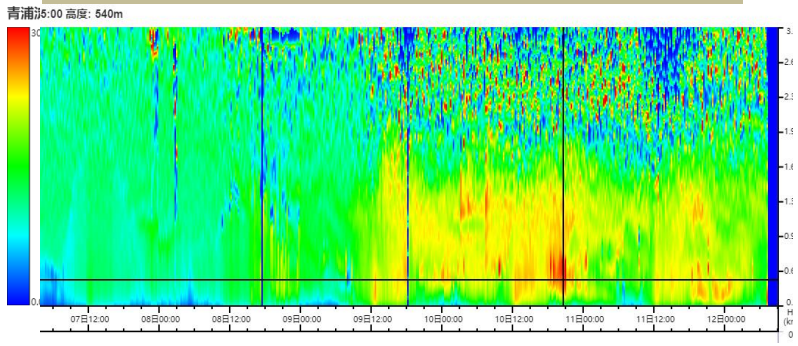


OFP analysis（ VOCs ）



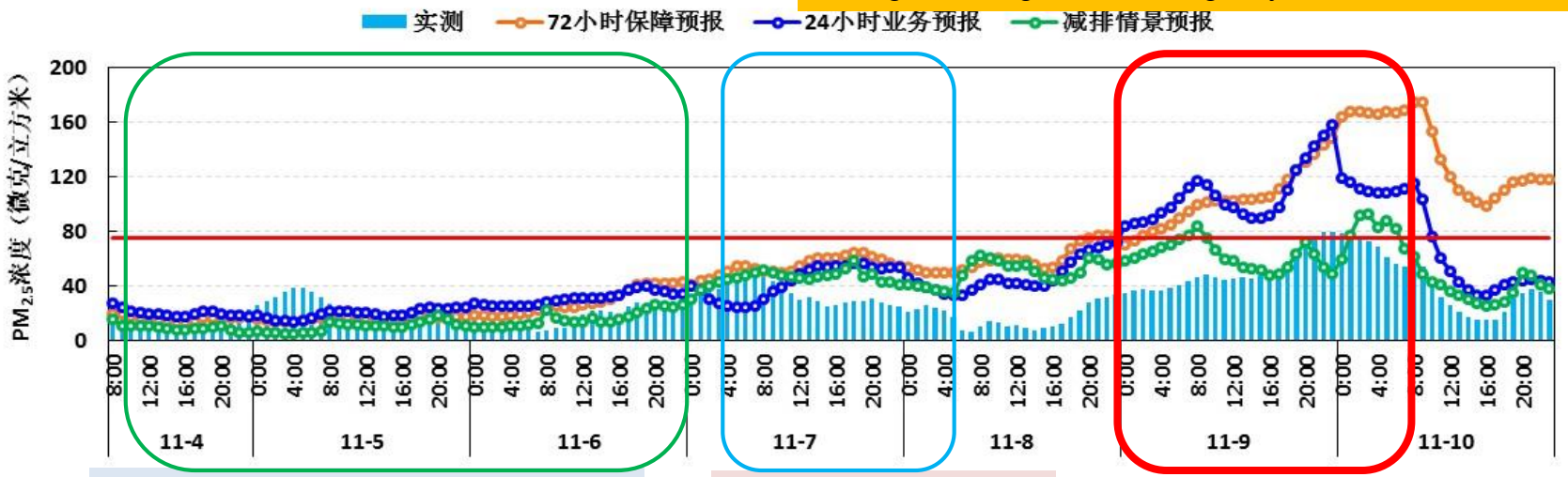


Ozone Lidar Vertical



Integration of Pollution Diagnosis Technologies

On November 8, the orange warning was initiated, and Shanghai strengthened emergency emission reductions.



Influenced by the low-pressure trough, southeast wind

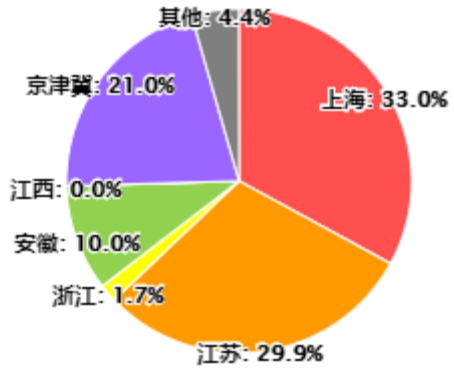
High-pressure front, northwest wind

Near the high-pressure center

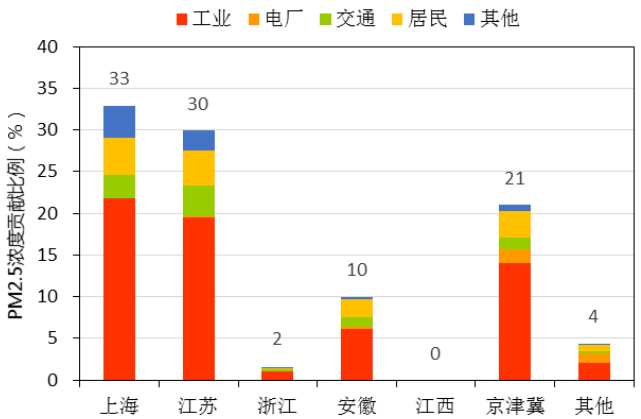
Scenario Simulation Effect Evaluation: Scenario simulations based on emission reduction plans yield concentrations closer to actual conditions, allowing assessment of pollution control measures by comparing with baseline emission inventory forecasts.

- Routine Business Forecast: Providing pollution trend analysis.
- Model Source Analysis: Identifying key areas and industries for pollution control.
- Backward Trajectories: Offering references for pollution transport ranges.

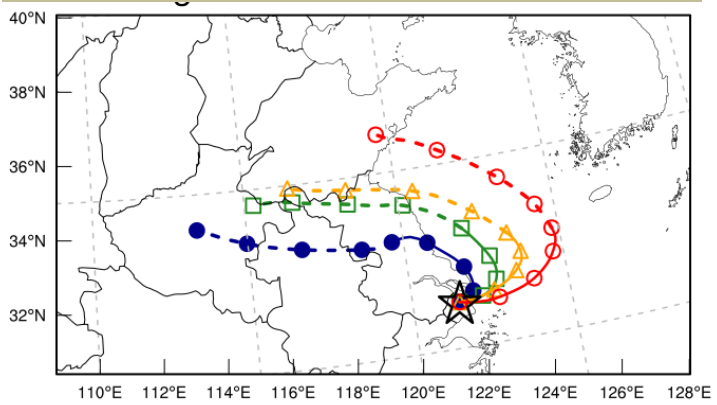
Regional Source Analysis



Key Industry Source Analysis



Pollution Air Mass Trajectories



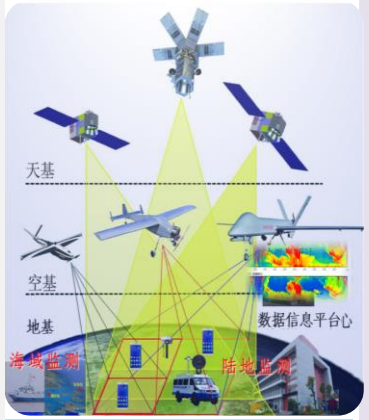
Contents

Establishing a smart monitoring system based on sensing technology

Socio-economic activity big data

Integrated atmospheric smart monitoring of environmental pollution sources on Earth, in the sky, and in space

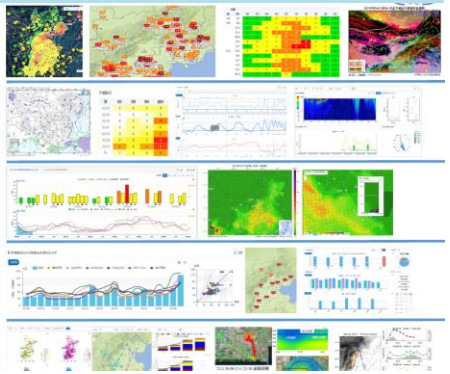
Air quality, industrial monitoring
Traffic monitoring, super station network
Navigation monitoring, sea area monitoring
Remote sensing monitoring, pollution sources
Dynamic inventory, source profiles
Meteorological monitoring and emission inventory



Accurate forecasting and prediction

平台五大主要功能

监测分析	气象分析	预报分析	评估分析	综合分析
污染与气象联动分析	实况气象资料回顾	空气质量时间变化	模式预报评估	组分时间变化分析
空间高值筛查	国内外气象预报资料整合	污染分布空间变化	业务预报评估	组分空间变化分析
空气质量统计评价	中长期气候趋势预测	污染物垂直演变	周边城市预报评估	VOCs综合分析
遥感及污染同化分析	风、温廓线分析	精细化预报结果	预报人员评估	走航及雷达分析



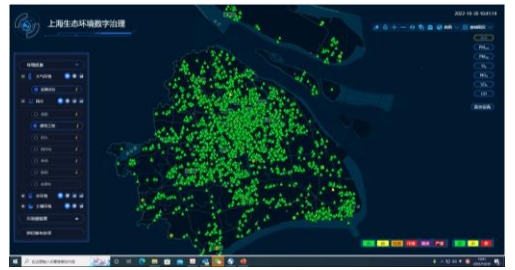
Big data integration

Deep learning
Machine learning
Knowledge graph

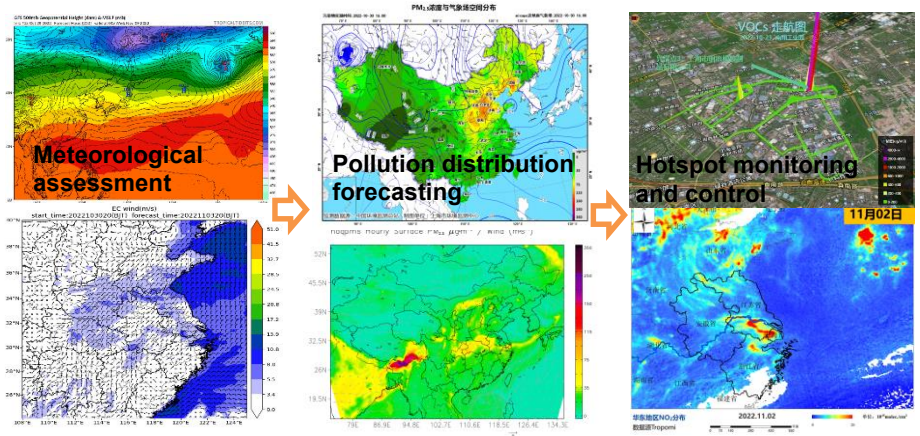
Integrated platform - Smart Brain

Data assimilation
Model simulation
Scientific mechanism

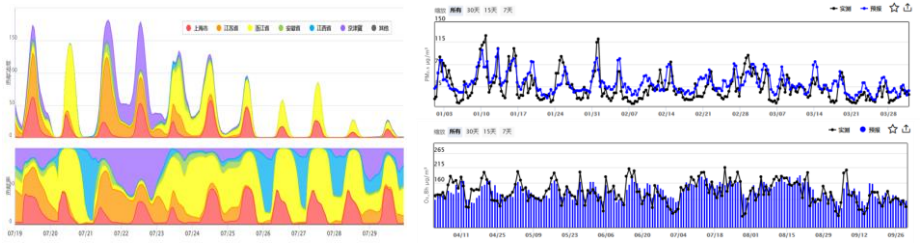
Smart integrated applications



1. Smart screening of pollution hotspots, closed-loop precision control



2. Precision warning, assessment, and control of pollution events



3. Source attribution and scientific support for medium to long-term forecasting to inform policy

4. Closed-loop monitoring, control, and assessment, combining both short-term and long-term support for precise, science-based pollution control in accordance with the law.

Exploring environmental health and ecological impact monitoring and early warning

Utilizing high-precision exposure assessment techniques and extensive epidemiological big data, we conduct health risk monitoring of key atmospheric environmental factors in Shanghai, exploring the research on the Shanghai Air Quality Health Index.

Researching the establishment of the Shanghai Air Quality Health Index

Health data

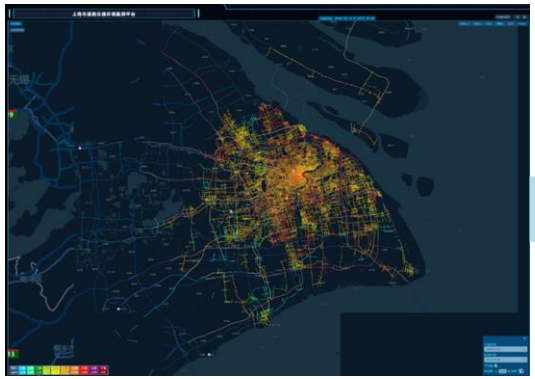
- **Collect daily disease-specific mortality numbers from the Centers for Disease Control and Prevention (CDC).**
- **Collect disease-specific resident healthcare utilization data from the Health Insurance Bureau, including outpatient, emergency room, and inpatient visits.**
- **Disease classification coding using ICD-10, covering major cardiovascular and respiratory diseases.**
- **Individual information, including age, gender, and education.**

Exposure data

- **Real-time atmospheric pollutant concentrations: $PM_{2.5}$, PM_{10}, O_3, SO_2, NO_2, CO.**
- **Online monitoring data for $PM_{2.5}$ components' concentrations.**
- **Daily average temperature and relative humidity.**

- **Establishing exposure-response curves for atmospheric pollution and resident health**
- **providing a more comprehensive reflection of air quality and its impact on health**

Conduct urban traffic environment monitoring and health impact assessment

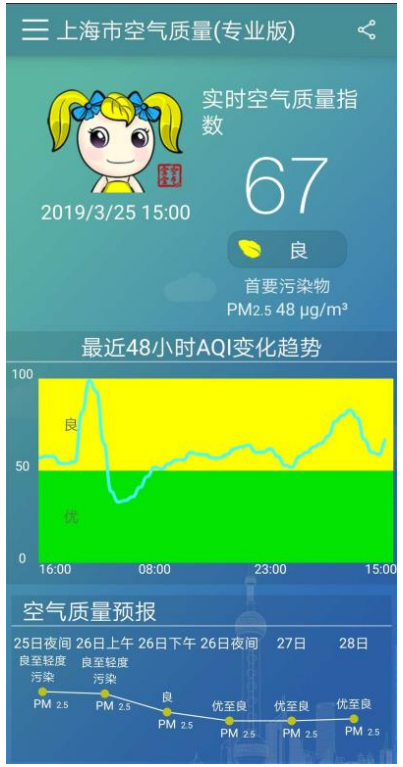


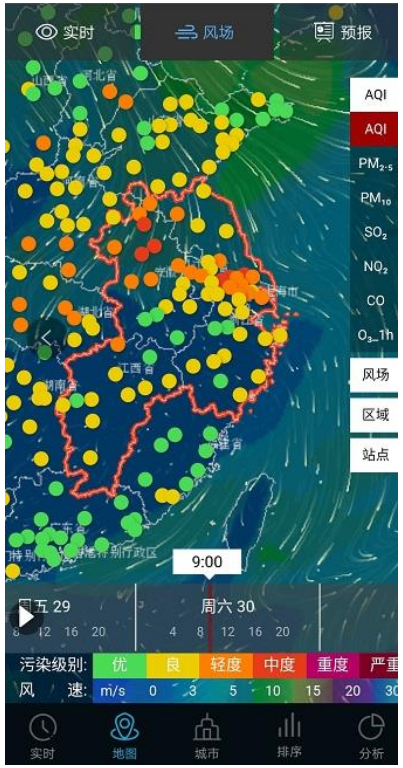
Integrating the traffic environmental air quality monitoring network (standard stations, vehicle-mounted mobile and fixed micro stations)

Conducting health exposure assessment for traffic-related air pollution and establishing a Traffic Environmental Health Index

With a service-oriented approach, innovate public service models

- Promote the refinement of the time and spatial scales in air quality forecasting, enhance the accuracy of regional and urban forecasting products, continuously develop diverse urban and regional-level forecast service products
- Expand the impact of forecast service products for better public service





Thanks !

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