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The National Research Program for Heavy Air Pollution Control in JJJ+ Region:

From Science & Technology to the Solutions



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Background and Organization

Key Research Outcomes

Support for Air Quality Improvement

Background

Heavy Smog in Beijing-Tianjin-Hebei and its Surrounding Areas (JJJ+ Region)

- The heavy air pollution episode in the winter season of 2016-2017 lasted for more than a week and affected a broader range of cities. The AQI of Shijiazhuang, Handan, Xingtai, etc. exceeded 500, with $PM_{2.5}$ concentration 7 times higher than the national air quality standards. The peak of $PM_{2.5}$ hourly concentration in Xingtai and Beijing was as high as 710 µg/m³ and 526 µg/m³ respectively
- □ The frequent heavy pollution in the **Beijing-Tianjin-Hebei and its surrounding areas (JJJ+ Region,** covering about 280k km² and 200M people) has become a highly concerned topic of the whole society



Air pollution situation on Jan. 1st, 2017

PM_{2.5} Concentration Calendar in the JJJ+ Region ("2+26" cities) during 2013-2020

Organization and Implementation National Research Program for Heavy Air Pollution Control in JJJ+ Region

In April 2017, the State Council of P.R. China decided that the Ministry of Ecology and Environment (MEE) would take the lead in the National Research Program for Key Issues in Air Pollution, combining the Ministry of Science and Technology (MOST) and other ministries, the Chinese Academy of Sciences (CAS), China Meteorological Administration (CMA), academic institutes and universities, etc. to focus on the causes and mitigation of heavy air pollution in the JJJ+ Region



 The Ministry of Ecology and Environment, established the National Joint Research Center for Air Pollution Control (NAPC), with Chinese Research Academy of Environmental Sciences (CRAES) as the main supporting institute, uniting other related ministries and scientific research institutes, including 295 institutes and more than 2,900 scientific researchers

Organization and Implementation Implementation of "One City, One Solution" Program

- □ "One City, One Solution" Program were carried out for "2+26" cities in the JJJ+ Region, which was called the "last mile" from scientific research outcomes to the actions of local governments
- The 28 research teams for "2+26" cities provided science and technology for the solutions of air pollution control for local governments



Science-based Air Quality Management

Research guidebook

Source Appointment Results for "2+26" cities

Organization and Implementation Strengthening of Data Quality Control and Sharing



Data quality control: unified standards, establish a unified quality control system for multi-source observation data

- □ Technical regulations for data quality control were published
- □ A full-process data quality control system has been established

Data sharing platform:

- AQI monitoring, meteorological observation, PM_{2.5} chemical composition network, etc., with data capacity of 2.3TB
- □ More than 5,500 times of platform login, retrieval and download



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Support for Air Quality Improvement

1. Causes of Heavy Air Pollution <u>Integrated Space-Air-Ground Monitoring and Observation Network</u>

Established the largest 3-D (Space-Air-Ground) monitoring and observation network for JJJ+ region

□ The mechanism of heavy air pollution in autumn-winter seasons in the JJJ+ region was systematically revealed based on the comprehensive research, including integrated observation, source apportionment, emission inventory and model simulation





Technical ideas for systematic research

1. Causes of Heavy Air Pollution

Main Sources of PM_{2.5} in JJJ+ region: Industry, Bulk Coal and Diesel Vehicles

- □ In the fall and winter of 2018-2019, on heavy pollution days, the contributing concentrations of industry, coal combustion, and motor vehicles were 1.8 times, 2.1 times, and 1.7 times higher, respectively, compared with the good air quality days
- Heavy pollution is mainly affected by industry, bulk coal and vehicle exhausts, which should be the focus of emission reduction control, especially for eliminating heavy air pollution



PM_{2.5} sources in 2018–2019 autumn-winter season



1. Causes of Heavy Air Pollution Major Pollutant Emission Trends

- Since 2013, emissions of major air
 pollutants in JJJ+ Region have
 decreased significantly, but are
 still at a high level
- The emission intensity of pollutants in "2+26" cities is 2~5
 times higher than the national average and 3~14 times higher
 than that of the United States

Relative changes in emissions during 2000-2018 in JJJ+ Region



1. Causes of Heavy Air Pollution

High NOx and VOCs Concentrations Contribute to a Highly Oxidizing Atmosphere

- At molecular level, the evolution of "atmospheric free radicals gaseous pollutants molecular clusters fine particles" has been explored, deepening the scientific knowledge of the formation mechanism of secondary PM_{2.5}
- Strong atmospheric oxidation capacity due to high NOx and VOCs concentrations is an important driver of heavy pollution formation







1. Causes of Heavy Air Pollution

Unfavorable Meteorology Leads to a Significant Reduction of Environment Capacity

- The region is located on the south-east side of the Taihang Mountains and the Yanshan Mountains, typically with weak winds and a "warm cover" structure, which was unfavorable for dispersion
- Unfavorable meteorology conditions lead to a significant reduction in environment capacity. Heavy air pollution is easily induced when the near-surface wind speed is <2 m/s, the height of the boundary layer is <500 m, and the relative humidity is >60%



1. Causes of Heavy Air Pollution Three Major Pollution Transport Channels in the JJJ+ Region

- Using comprehensive observation and numerical simulation to study nearly a hundred heavy air pollution episodes, three main transport channels in the southwest, southeast, and east were identified
- □ Quantifying the inter city transport flux. For example, during the heavy air pollution episodes, the contribution of regional transport to PM_{2.5} in Beijing reached as high as 45% to 70%





2. High Resolution Emission Inventory High Spatial and Temporal Resolution Emission Inventory

Combined with the needs of air quality management, developed high-spatial and temporal-resolution emission inventory for JJJ+ Region
 Dynamic emission inventory in "2+26" cities has been realized, so as to refine the time resolution from year to month to day and flexibly grasp the trend of emissions



Technical roadmap for dynamic emission inventory compilation

- ▼ Stationary sources: **76,000**→ **190,000**
- ▼ Time resolution: year → month → day
- Type of pollutants: $3 \rightarrow 7$
- Spatial resolution: $10 \text{ km} \rightarrow 3 \text{ km}$



Fine grid inventory for "2+26" cities

2. High Resolution Emission Inventory Major Pollutant Emissions vs. Environment Capacity

- □ The emissions of major pollutants exceeded the environmental capacity by more than 50% (except SO₂), and the exceedance is 80%~150% in some cities, which is the major cause of heavy PM_{2.5} pollution
- Comprehensively mapped out the spatial distribution of major pollutants and contribution from industry: the junction area among Hebei-Shandong-Henan provinces and cities along the Taihang Mountains gathered a large number of iron and steel, building materials enterprises and other high-energy-consuming, highly-polluting enterprises, is the "hot spot" of air pollution

Emissions and average annual capacity of pollutants in "2+26" cities (unit: 10⁴ tons)

Pollutants	Emission (2018)	Capacity (approx.)
Primary PM _{2.5}	95	80
SO_2	74	105
NO _x	232	160
VOCs	219	110
NH ₃	141	80





Emissions in 2018

Environmental capacity

2. High Resolution Emission Inventory Monthly Variation of Emission Inventory

- High temporal resolution emission inventory in
 "2+26" cities has been developed, refining the time resolution from year to month to day
- Primary PM emissions in JJJ+ Region peaked as high as double to triple the annual average during the heating season, especially from Dec. to Jan.; Meanwhile, NOx and VOCs emissions reached lowest in Jan.&Feb. because of the Spring Festival

Primary PM_{2.5}

~?0^{.9}.

京津冀及周边地区 -●- 长三角 -●- 汾渭平原

250

200

150 -

100 -

50 -

0

-50

2019-1

10, is

(%)

次PM2.5排放距平百分比



NOx



2. High Resolution Emission Inventory Power Plants vs. Coal Boilers vs. Household Combustion

- Identified clean energy
 replacement of bulk coal as the
 key issue of energy
 restructuring in JJJ+ region,
 contributing most to the
 reduction of PM_{2.5} pollution
- Promoted the clean energy in
 JJJ+ region, not only
 improving air quality, but also
 enhancing people's quality of
 life during the heating season



3. Emission Control Technologies in Key Sectors Energy: Ultra-low Emission Standards for Coal Boilers

The breakthrough of ultra-low emission technologies and key instruments for coal boilers led to the emission reduction by about 90% for 280 Million kW units of coal power plants in JJJ+ Region, and also industrial coal boilers, supporting the establishment of the largest clean energy system worldwide



3. Emission Control Technologies in Key Sectors Industry: Whole Process Emission Control for Ion&Steel Factories

The development of "ultra-low emissions from stacks, refined control of fugitive emissions, and clean freight transportation" technology system for the ion&steel industry, along with the building materials industry, led to the emission reduction by 50%-70% for the above industries in JJJ+ Region, supporting the unprecedented retrofit campaign of key industries in the region



3. Emission Control Technologies in Key Sectors Transportation: Solution Package for "Vehicles, Fuel, Road and Enterprises"

- Developed a rapid identification, precise screening, and remote monitoring technology system for excessive emissions from diesel trucks, proposed a transportation structure adjustment plan
- Supported the preparation and implementation of the "Three Year Action Plan for Promoting Transportation Structure Adjustment (2018-2020)" and "Action Plan for Diesel Truck Pollution Control"



Supporting the National VI standards and the "Action Plan for Diesel Truck Pollution Control"



Decision Platform for "Flow-Emission-Concentration-Control"

4. Decision-Making Support Tools Emission-Air Quality Rapid Response Models

- **Established rapid response models of emissions and air quality,** and developed a technical support
 - platform for two-way regional air quality regulation and integrated scientific decision-making.
- Taking the target PM_{2.5} concentration as a constraint, strengthening the influence of physical transport and chemical transformation, **increased the spatiotemporal resolution of environmental capacity**



Conceptual model of atmospheric environmental capacity



4. Decision-Making Support Tools

Emergency Response Technical System and Platform for Heavy Air Pollution

Established and upgraded the regional heavy pollution response technology system to enhance dynamic and refined management

Technical system for joint emergency response to heavy air pollution



 Build a science and technology support platform to enhance the Beijing Winter Olympic Games and other mega-events air quality management





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Support for air quality improvement Technical Support for the Rapid Improvement of Air Quality

- □ Between 2016 and 2020, Beijing witnessed a 48% decline in $PM_{2.5}$ concentration (from 73 µg/m³ to 38 µg/m³) and a 71% reduction in the number of heavy pollution days (from 34 to 10)
- □ The "2+26" cities achieved a reduction of the $PM_{2.5}$ concentration by 30% and the number of heavy pollution days by 60%, while cutting the carbon emissions by 200 million tons
- In JJJ+ Region, the "dream" for clean air and blue skies of 200 million people are becoming reality



Improvement of Air Quality in Beijing

The air quality of "2+26" cities has been greatly improved

Support for air quality improvement Technical Support for the Rapid Improvement of Air Quality

- □ Air pollution control brought co-benefits of carbon emissions reduction and vice versa
- In 2020, P.R. China released the Action Plan for Carbon Dioxide Peaking before 2030 and Carbon Neutralization by 2060
- The Chinese government is gradually improving the carbon trading market and promoting the development of a green, low-carbon and circular economy



Support for air quality improvement Scientific Communication to the General Public

□ In response to hot issues of air pollution, expert voices were timely delivered to the public for scientific understanding and social consensus, with a total of 1000+ articles and 35M+ reads **Established an publicity matrix platform**, including the production and release of popular science propaganda films such as "Air Pollution and Control" and "Why Pollution During the Spring Festival", and easy-tounderstand and public-to-use products, such as micro-videos, illustrations and flashs, etc.





Thanks for Your Attention!