ChiNorBC project
Workshop on Emissions inventories and preliminary modelling results

On 15th December 2021, th Workshop on Emissions inventories and preliminary modelling results was held in Beijing and virtually on zoom co-chaired by the Chinese Academy of Environmental Sciences (CRAES) and the Norwegian Environment Agency (NEA) as the main implementing partners of the project. Representatives from the Norwegian Embassy in Beijing, the Norwegian Environment Agency and the Chinese Academy of Environmental Sciences attended the workshop and delivered speeches (See attached Agenda and presentations).

The Chinese Academy of Environmental Sciences and the Norwegian Environment Agency are implementing agencies of the ChiNorBC Project, while Chinese Academy for Environmental Planning, Norwegian Institute on Public Health and Center for International Climate and Environmental Research-Oslo, Norway are the collaborators of the project.

The meeting featured detailed presentations and discussions on the project overview, Chinese /Norwegian/European control measures, construction of black and organic carbon emission inventoris for ChiNorBC project, regional/global model performance evaluation, and health impacts of BC/OC.
At the workshop, the project team and experts had an in-depth exchange on the above. Experts from Peking University commented on the results of the emission inventory of the ChiNorBC Project, and affirmed the scientific rationality of the research methods, ideas and technical approaches of the emission inventory based on the ChiNorBC project, as well as the importance of motor vehicle and domestic emission sources. The meeting helped to strengthen the links and cooperation between the various outputs of the project to ensure the smooth implementation of the project's research work and to further deepen Sino-Norwegian cooperation in the environmental field.


Project Task Progress（项目任务进展）
CRAES:
Finished


Chinese-Norwegian Project on Emission, Impact, and Control Policy
for Black Carbon and its Co-benefits in Northern China

Chinese-Norwegian Project on Emission, Impact, and Control Policy for Black Carbon and its Co-benefits in Northern China (ChiNorBC)

Agenda

Workshop on Emissions inventories and preliminary modelling results

Time: **16:00-19:00 (CST) / 9:00-12:00(CET)**

Date: Wednesday 15th December 2021

Venue: 1st Meeting Room, Bei Yuan Hotel Beijing

（北苑大酒店,第一会议室）

(Zoom Meeting ID: 829 4911 1206 Password:123456):

https://zoom.us/j/82949111206?pwd=T1Q1MEhFNDRJZ1BhQmNEY3JXSkwvdz09

Simultaneous translation in Chinese and English online

Time (Beijing time / Oslo time)	**Content**	**Speaker**
Moderator: Dr. Hu Jingnan, director of Institute of Atmospheric EnvironmentAEI, CRAES		
16:00-16:30 / 09:00-09:30	Opening remarks	Christoffer Grønstad, Royal Norwegian Embassy, Beijing
		André Kammerud, Norwegian Environment Agency
Moderator: Dr. Hu Jingnan		
16:30-16:40 /	Introduction to the WS of ChiNorBC Project	Dr. Cheng Miaomiao, CRAES, China

09:30-09:40		
16:40-16:55/ 09:40-09:55	China's status on BC/OC control	Dr. Cheng Miaomiao, CRAES, China
16:55-17:05/ 09:55-10:05	Relevant Norwegian/European control measures in the context of the ChiNorBC project.	Dr. Vigdis Vestreng/ Dr. Scott Randall, NEA, Norway
17:05-17:30 / 10:05-10:30	Construction of a black carbon emission inventory for ChiNorBC project	Dr. Zhi Guorui CRAES, China
17:30-17:40 / 10:30-10:40	Comments: ChiNorBC emissions in context of recent global inventories Comments on BC emission inventory for ChiNorBC	Dr. Marianne Tronstad Lund, CICERO, Norway Prof. Shen Guofeng, Peking University, China
17:40-18:00 10:40-11:00	Questions	
18:00-18:05/ 11:00-11:05	Coffee Break	
Moderator: Dr. Vigdis Vestreng, Norwegian Environment Agency (NEA)		
18:05-18:15/ 11:05-11:15	Model performance evaluation based on high-resolution latest emission inventory in China	Dr. Du Xiaohui CRAES, China
18:15-18:20/ 11:15-11:20	First results from OsloCTM3 using updated Chinese emissions	Dr. Marianne Tronstad Lund, Senior Researcher, CICERO, Norway
18:20 -18:35/ 11:20-11:35	Health Effects of BC	Prof. Wei Yongjie, CRAES, China
18:35-18:55 / 11:35-11:55	Discussion (20 min)	

18:55-19:00 / 11:55 / 12:00	Concluding remarks	Camilla Schreiner, Head of section for Climate Science and Air Quality, NEA, Norway
		Dr. Cheng Miaomiao, CRAES, China

List of participants:

Chinese Research Academy of Environmental Sciences (CRAES)

1. Meng Fan, Deputy Chief Engineer
2. Hu Jingnan, Institute of Atmospheric Environment
3. Cheng Miaomiao, Institute of Atmospheric Environment
4. Zhi Guorui, Institute of Atmospheric Environment
5. Wei Yongjie, State Key Laboratory of Environmental Criteria and Risk Assessment
6. Wang Yanjun, Vehicle Emission Control Center
7. Zhu Xiaoyan, Institute of Atmospheric Environment
8. Jin Wenjing, Institute of Atmospheric Environment
9. Du Xiaohui, Institute of Atmospheric Environment
10. Li Zhigang, State Key Laboratory of Environmental Criteria and Risk Assessment
11. Zhu Xiaojing, State Key Laboratory of Environmental Criteria and Risk Assessment

Chinese Academy for Environmental Planning（CAEP）

12. Wang Xuying, Institute of Atmospheric Environment

Peking University

13. Prof. Shen Guofeng

Royal Norwegian Embassy, Beijing

1. Christoffer Grønstad, Counsellor Environment
2. Liu Yinglang, Senior Project Officer

Norwegian Environment Agency (NEA)

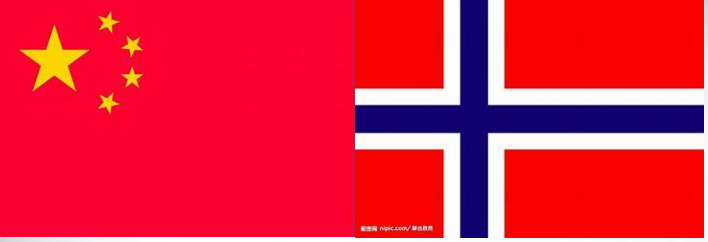
3. André Kammerud, Head of section for the High North and Bilateral Relations
4. Camilla Schreiner, Head of section for Climate Science and Air Quality
5. Scott Randall, Senior Adviser, Section for Climate Science and Air Quality
6. Ingeborg Rønning, Senior Adviser, Section for Emission Inventories and Analysis
7. Ole- Kristian Kvissel, Senior Adviser, Section for Climate Science and Air Quality
8. Tor Skudal, Senior Adviser, Section for the High North and Bilateral Relations
9. Vigdis Vestreng, Senior Adviser, Section for Climate Science and Air Quality

Center for International Climate Research (CICERO)

11. Marianne Tronstad Lund, Senior Researcher

Norwegian Institute of Public Health (NIPH)

12. Shilpa Rao-Skirbekk, Senior researcher
13. Per Everhard Schwarze, Senior researcher
14. Marit Låg, Senior researcher



Workshop of **ChiNorBC** Project

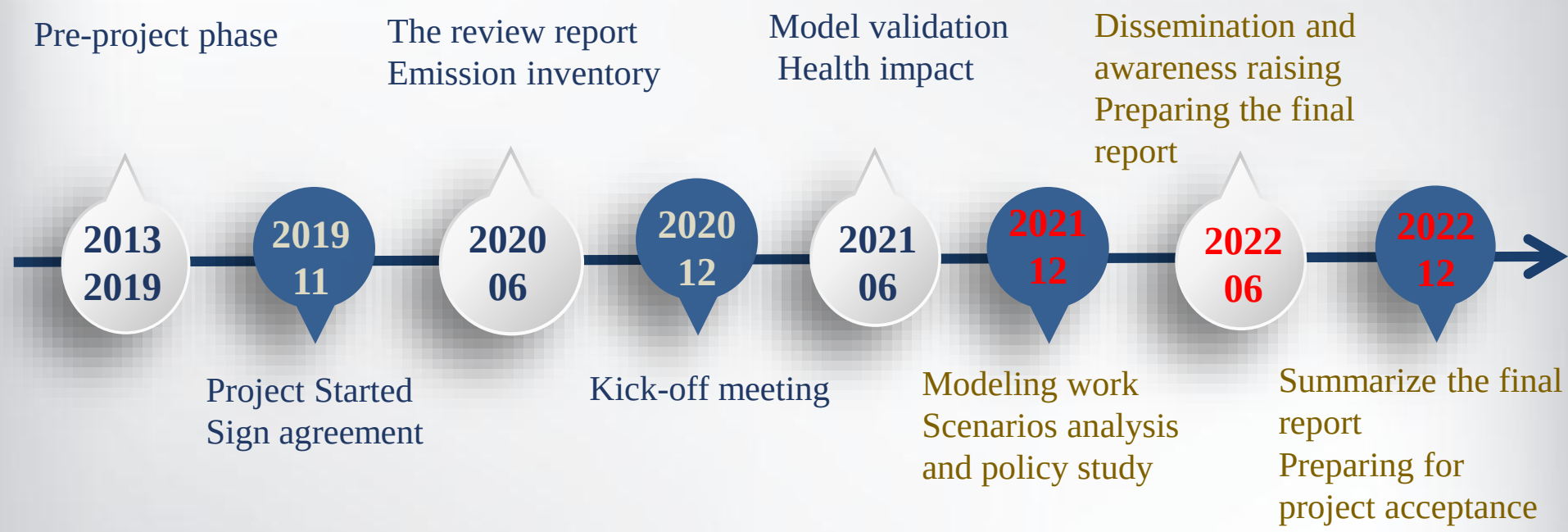
Chinese-Norwegian Project on Emission, Impact, and Control Policy for Black Carbon and its Co-benefits in Northern China

Dr. Cheng Miaomiao
Chinese Research Academy of Environmental Sciences (CRAES)

Dr. Vigdis Vestreng, Senior Adviser,
Norwegian Environment Agency (NEA)

Beijing, China 2021.12.15

ChiNorBC

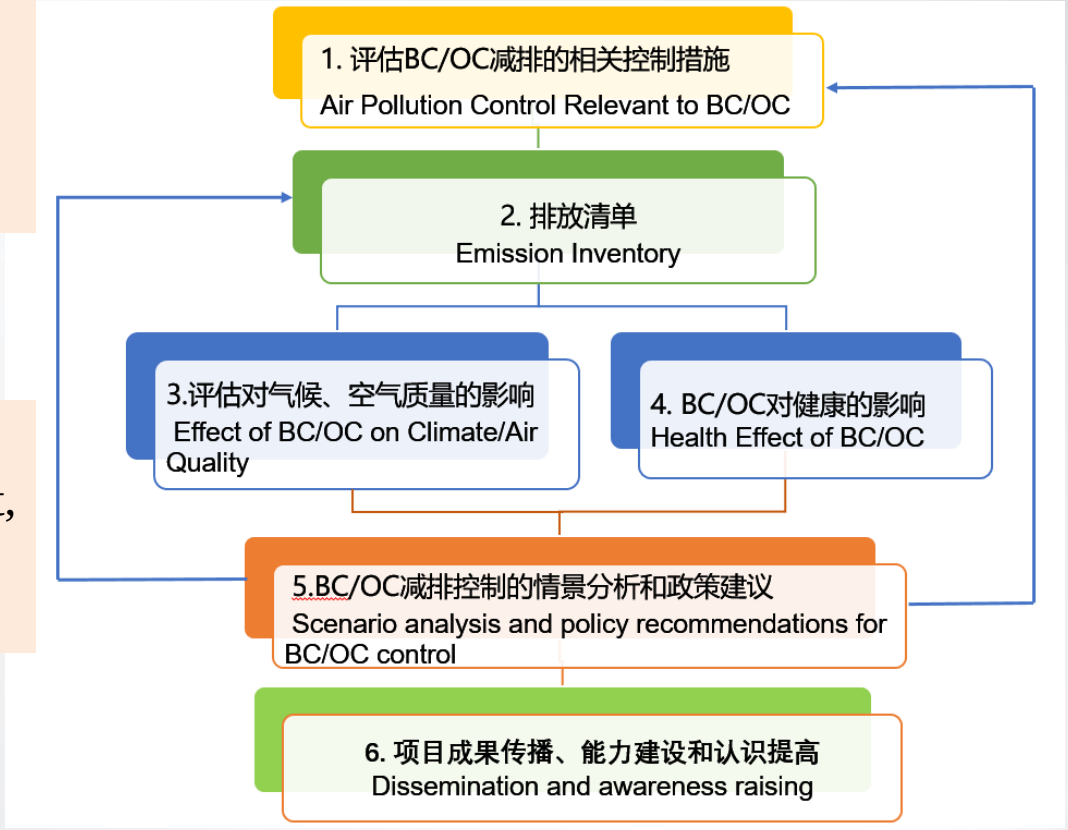

Pre-project phase
2013
2019
2019
11
Project Started
Sign agreement
The review report
Emission inventory
2020
06
2020
12
Kick-off meeting
Model validation
Health impact
2021
06
2021
12
Modeling work
Scenarios analysis
and policy study
Dissemination and
awareness raising
Preparing the final
report
2022
06
2022
12
Summarize the final
report
Preparing for
project acceptance

ChiNorBC

Long-term Objective

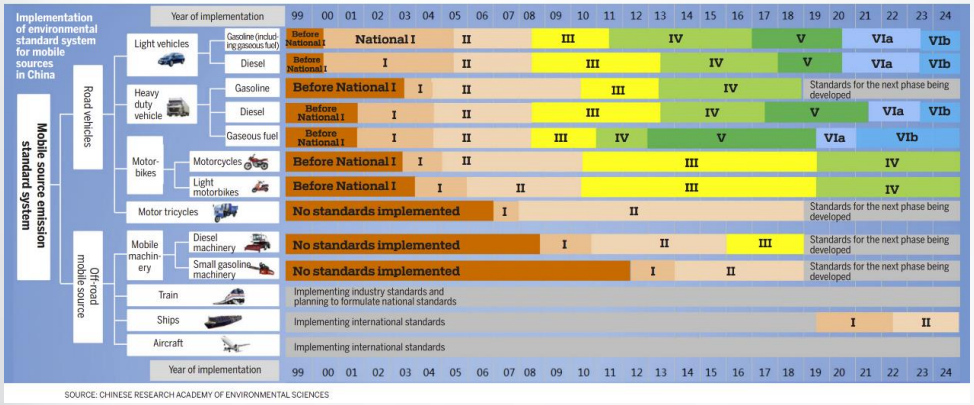
- Improve air quality and reduce the negative impacts of BC/OC on air quality, health, and climate in northern China.

Based on the objective of the project, mainly have **6** tasks.



Project Progress

Task 1: Policies reviewing



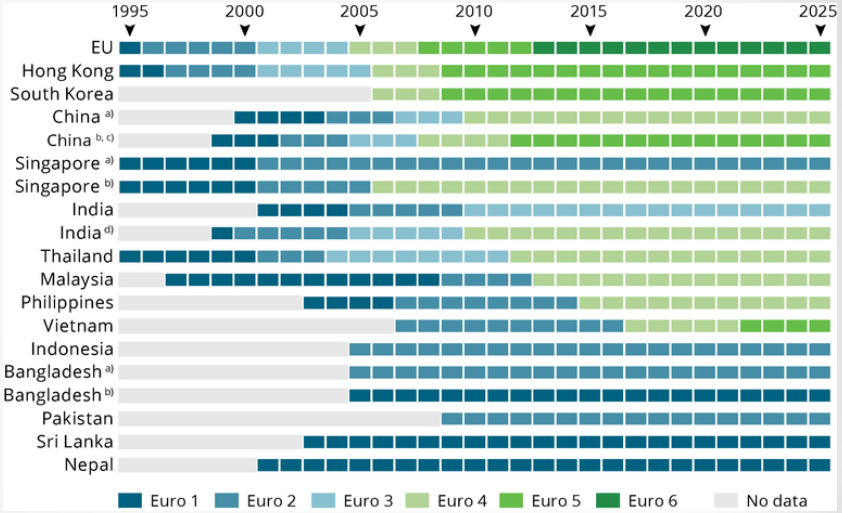
- **China**

Pollution Control of "Fuel, Road, Vehicle". E.g. Strengthen vehicle emission standards. In less than two decades, China has raised the standards for vehicle emissions from National I to National V.

- **Norway**

The EU has adopted stringent emission standards for various vehicle categories which also apply in Norway.

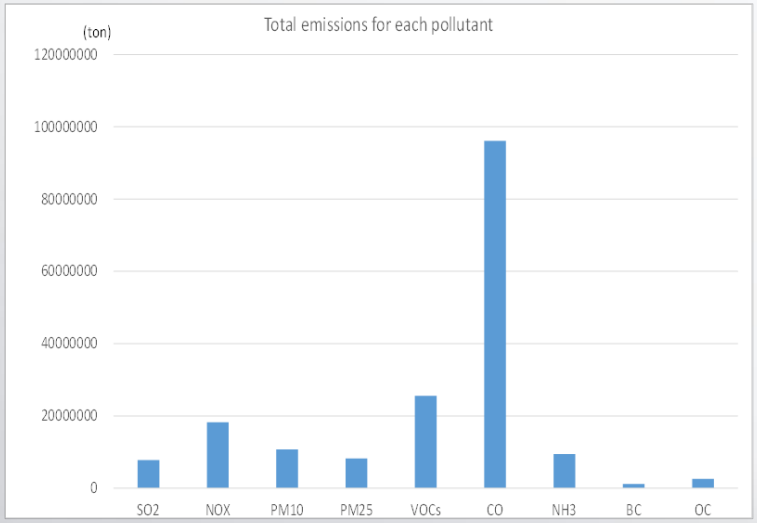
Norway has set out ambitious national goals for rapid transition to electric mobility through incentives such as tax breaks and reduced toll fares

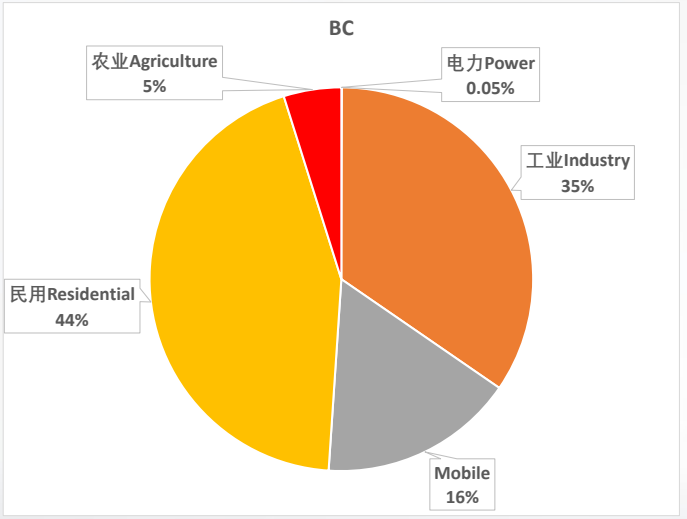


Project Progress

Task 2: BC/OC emissions

- Finalized Review Report on the BC/OC emissions of Output 2.
- Preliminarily Finalized ChiNorBC2018 inventories for national & northern China. Pollutants include Ozone precursors: NOx, CO, nmVOC as well as $PM_{2.5}$/PM_{10}, BC, OC, SO_2 and NH_3.
- Prepared a Working Report for inventory preparation.

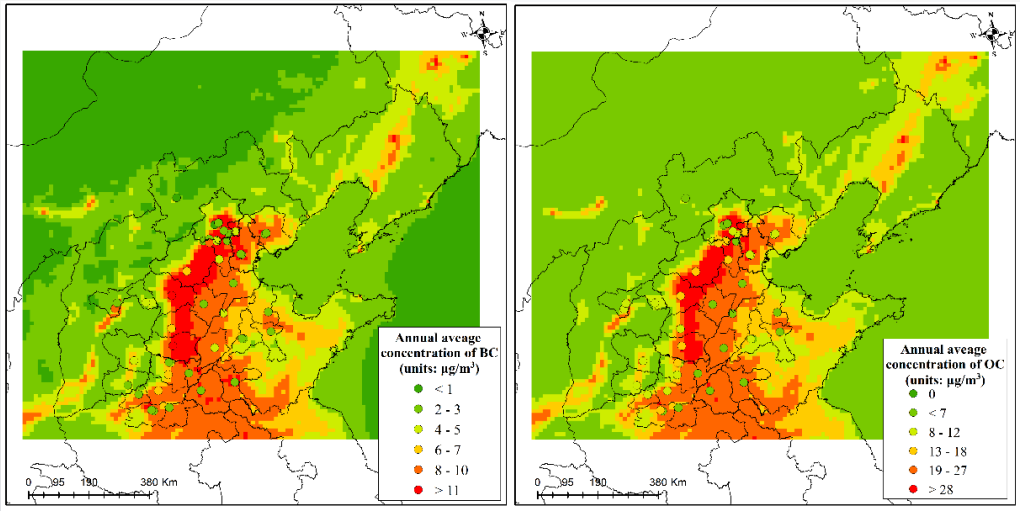




Project progress

Task 3：Model setup and evaluation

- **A literature review has been completed：** the impact of BC/OC on air quality and climate change.
- **Monitoring datasets：** Collected and processed air quality monitoring data(BC, OC, O_3, NO_2, CO, SO_2, $PM_{2.5}$ and PM_{10} , etc.) to meet assessment needs.
- **CMAQ modeling framework setup：** Simulation Area and Grid Settings
- **Evaluating the performance for current emission inventories**

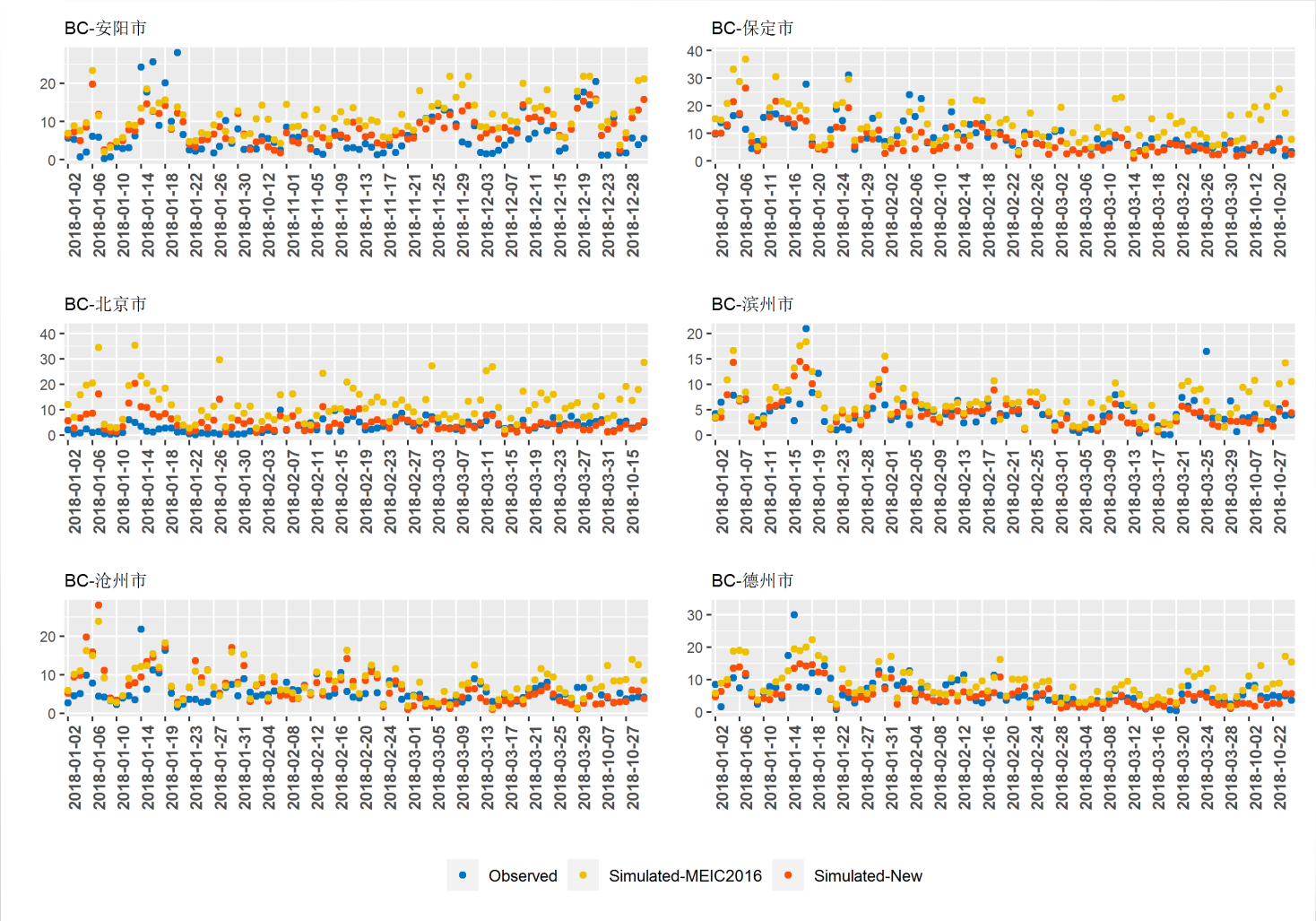


The spatial distribution of observed and simulated for BC/OC in January-March and October-December 2018 (The colored circle indicates the concentration at the monitoring station; the colored matrix grid indicates the simulated concentrations)

Project progress

Task 3：Model setup and evaluation

- **Evaluating the performance for new emission inventories and make high-resolution (12 × 12 km)**



Project progress

Task 4: Health effects

- We have completed a review of the health effects of black carbon, and published part of this in the Environmental Sciences Research.
- We have finished the meta analysis of health effects of BC in long/short term exposure.
- We sampled $PM_{2.5}$ in three site Miyun, Chaoyang and Baoding in different seasons and analyzed over 40 chemical compositions in the past three years.
- We have done the animal and cell exposure experiments of BC.
- We have done part of cell exposure experiments of $PM_{2.5.}$

- To do the animal experiments of $PM_{2.5}$ in chambers.
- To do the cell experiments of $PM_{2.5.}$
- To do the source apportionment for attributing the health effects to different sources and to rank the risks of health effects by sources.
- To finish the final project report.

Project progress

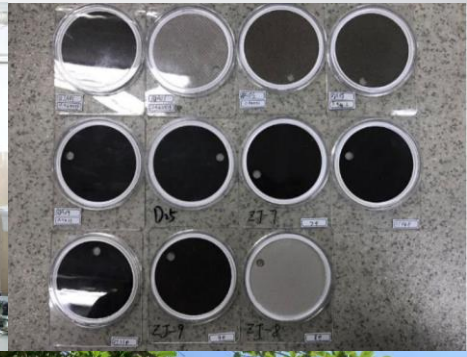
Task 4: Health effects

$PM_{2.5}$ -- Miyun/Chaoyang/Baoding

2019: 45 sets of $PM_{2.5}$ samples, autumn and winter.

2020: 42 sets of $PM_{2.5}$ samples, autumn and winter.

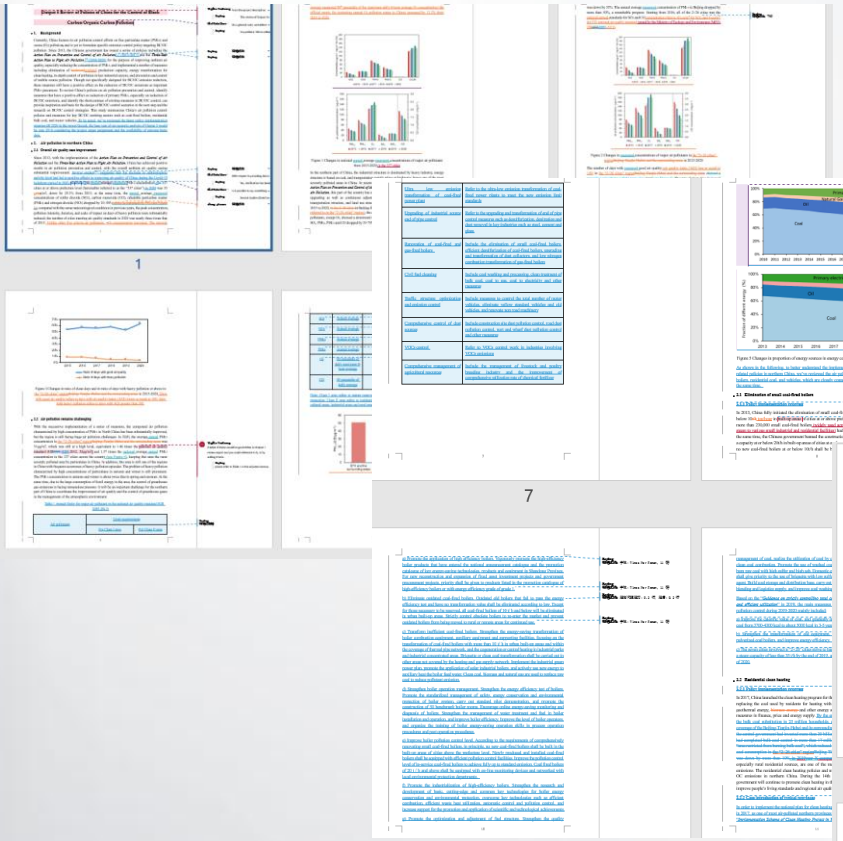
2021: 84 sets of $PM_{2.5}$ samples, spring, summer, autumn and winter.



$PM_{2.5}$ sampling, chemical composition analysis and biological experiments.

Project progress

Task 5: Scenario analysis

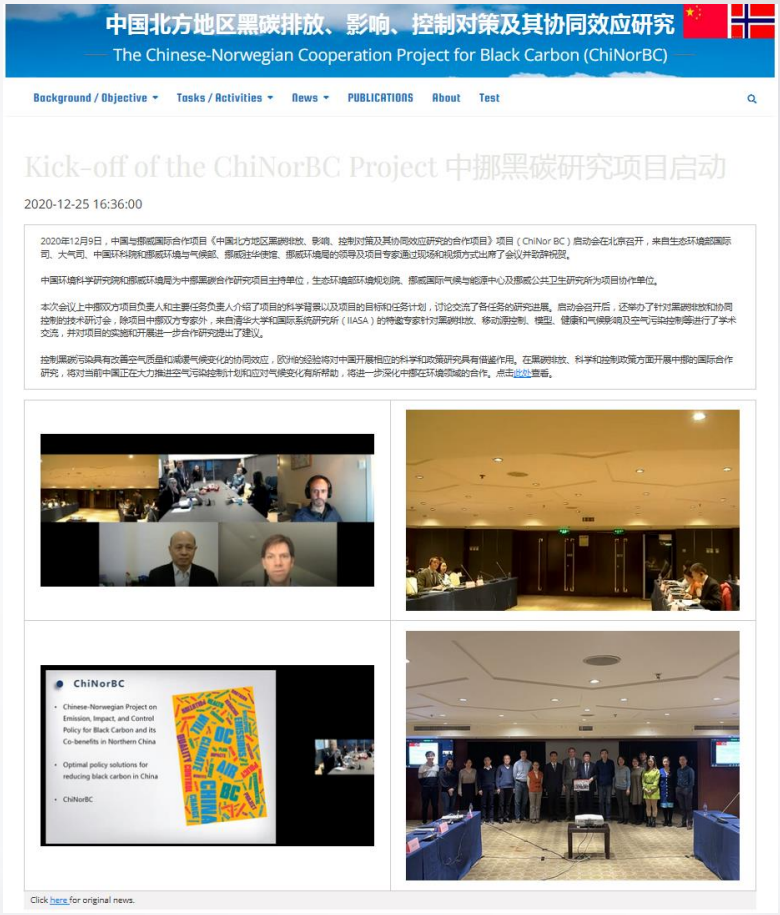


- Finished the revision of review report regarding the last round of comments.
- Working on the BC/OC emission estimation for the three scenarios (BAU、EOP、ABC).

Project progress

Task 6: Documents updates on website

- Established a website for disseminating the results of ChiNorBC
- Updated the Kick-off news, documents, review reports

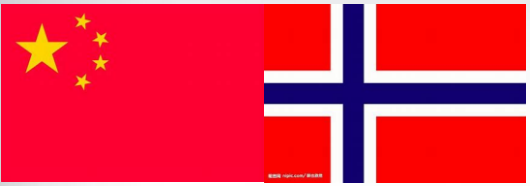


http://chinorbc.net/

Project progress

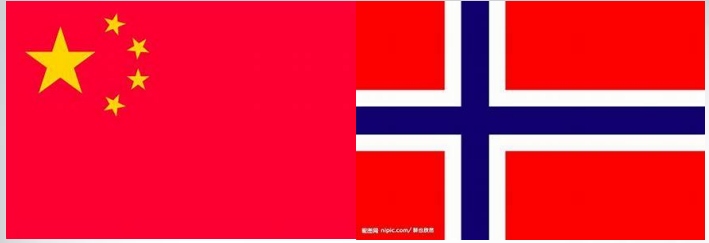
Next steps

- Publish the review report
- Update national & regional (northern China) emissions inventory of 2018 and scenarios, if necessary
- Evaluate the effects on air quality and CC according to the updated emission inventories
- Evaluate the effect on health both sides of China and Norway
- Assess the co-benefits on emission reduction, air quality improving and climate change of BC/OC under different scenarios
- Finish the final report



Thank You!



China’s status on BC/OC control

Cheng Miaomiao

Chinese Research Academy of Environmental Sciences **(CRAES)**

Beijing, China 15 October 2021

Content

I. **Strengthening environmental and climate regulation and institutional arrangement**

II. Sector specific plans, policies and regulations in China

III. Gaps and needs to optimize policy making

IV. Highlights for emission, impact, and control policy for BC/OC

Content

I. Strengthening environmental and climate regulation and institutional arrangement

II. Sector specific plans, policies and regulations in China

III. Gaps and needs to optimize policy making

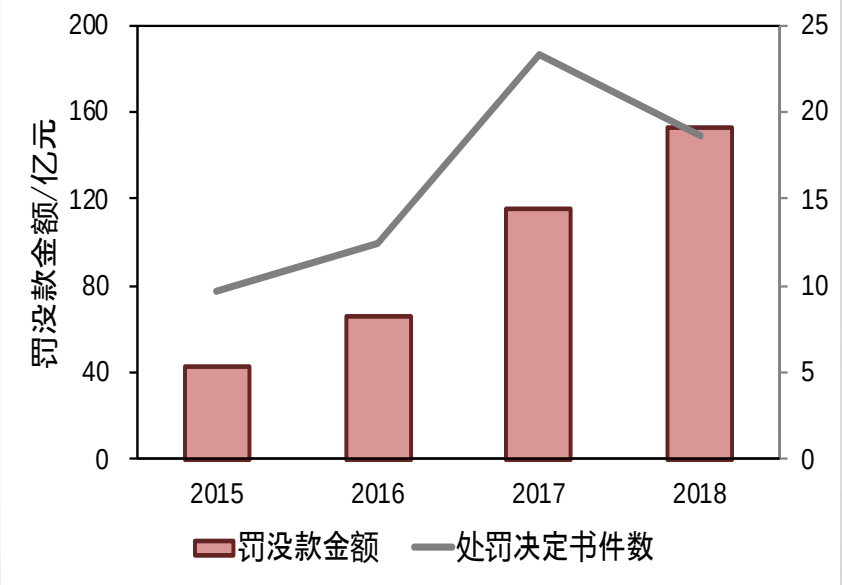
IV. Highlights for emission, impact, and control policy for BC/OC

Strengthening environmental and climate regulation and institutional arrangement

1. Improving legal framework for improving air quality

- Actively construct a legal framework for air pollution prevention and control. Since 2013, laws and regulations covering all areas of air pollution control has been revised and implemented.
- Enforcement of environmental laws were strengthened. Since 2015, the amount of administrative penalty fines imposed has increased year by year.

2013年以来修订和实施的法律列表
《中华人民共和国环境保护法》 Environmental Protection Law
《中华人民共和国大气污染防治法》 Law on the Prevention and Control of Atmospheric Pollution
《中华人民共和国环境影响评价法》 Law on Environmental Impact Assessment
《中华人民共和国环境保护税法》 Environmental Protection Tax Law
《中华人民共和国防沙治沙法》 Law on Prevention and Control of Desertification
《中华人民共和国节约能源法》 Law on Energy Preservation



Strengthening environmental and climate regulation and institutional arrangement

2. Carbon Peak and Carbon Neutrality Action in China

- Xi said China has included carbon peaking before 2030 and carbon neutrality before 2060 in its overall plan for ecological conservation, and promoted the development of a green and low-carbon circular economy in an all-round way in 2020.
- Achieving the ambitious goals of carbon emissions and carbon neutrality will not be easy and will require a Herculean effort.

Industry	• China's manufacturing industry is still in the middle and low end of the international value chain, product energy consumption and material consumption are high, the value-added rate is low, economic restructuring and industrial upgrading tasks are arduous
Coal-used	• coal consumption is relatively high, still more than 50% of Chinese energy consumption, the intensity of carbon dioxide emissions per unit of energy is about 30% higher than the world average, the task of optimizing the energy structure is arduous
GDP energy	• the unit GDP energy consumption is very high, 1.5 times the global average, and 2-3 times that of OECD countries, and the task of establishing a green low-carbon economic system is extremely arduous

Strengthening environmental and climate regulation and institutional arrangement

2. Carbon Peak and Carbon Neutrality Action in China

- China is actively promoting carbon trading pilot work

In 2011, China has launched the carbon market pilot work. Seven provinces and cities have launched local pilot carbon emissions trading system (ETS)

In 2015, the establishment of a national carbon ETS was announced

From 2016 to 2020, drafts for the construction plan and management measures of the carbon emission trading market will be issued successively

In January 2021, the Administrative Measures for National Carbon Emission Trading Rights (Trial) was officially released.

The national carbon ETS launched online trading on 16 July 2021.

Strengthening environmental and climate regulation and institutional arrangement

3. Standards and Action Plans on air quality improvement

- China's ambient air quality standards were first issued in 1982, and subsequently revised in 1996, 2000 and 2012. In February 2012, the Ambient Air Quality Standard **(GB3095-2012)** was published.

Name of Pollutant	Average Time	Concentration Limits		Unit
		Grade I *	Grade II *	
SO_2	Annual average	20	60	μg/m³
	24-hour average	50	150	
	1-hour average	150	500	
NO_2	Annual average	40	40	
	24-hour average	80	80	
	1-hour average	200	200	
CO	24-hour average	4	4	mg/m³
	1-hour average	10	10	
O_3	Average in the top consecutive 8-hour period	100	160	μg/m³
	1-hour average	160	200	
PM_{10}	Annual average	40	70	
	24-hour average	50	150	
$PM_{2.5}$	Annual average	15	35	
	24-hour average	35	75	

Index	Grade	Category	Health Recommendations
0-50	I	Excellent	Outdoor activities are recommended
51-100	II	Good	Outdoor activities are OK
101-150	III	Mild pollution	Susceptible populations should reduce heavy outdoor activities
151-200	IV	Moderate pollution	Susceptible populations would be significantly affected
201-300	V	Heavy pollution	Everyone should reduce outdoor activities
>300	VI	Serious pollution	Try not to stay outdoors

Strengthening environmental and climate regulation and institutional arrangement

3. Standards and Action Plans on air quality improvement

In 2012, BTH, YRD, PRD and other key regions and municipalities directly under the central government and provincial cities;

In 2013, 113 key cities and the national environmental protection model city for environmental protection;

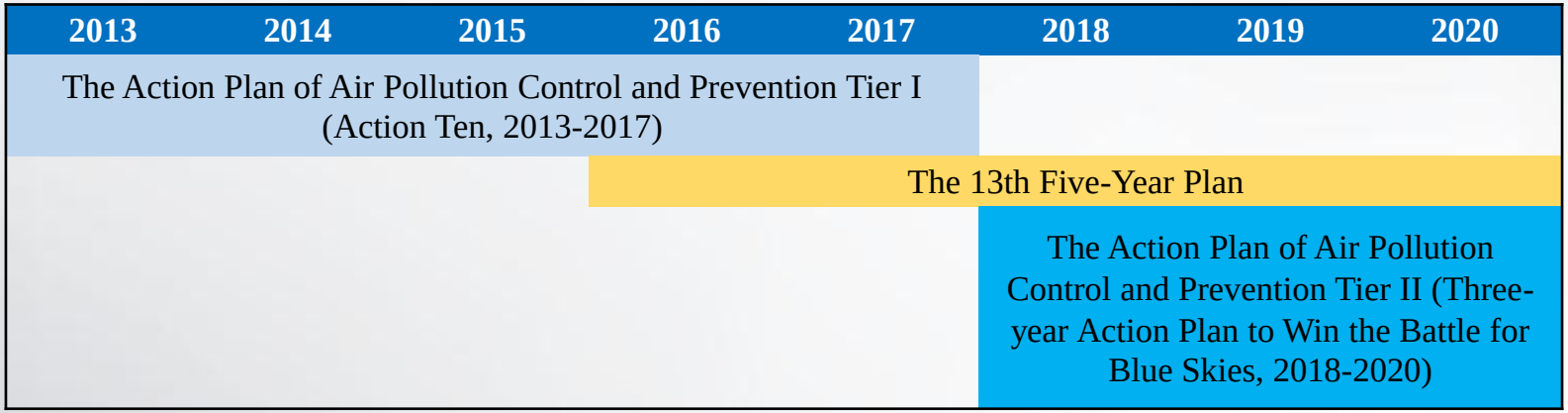
In 2015, all cities at prefectural level and above

In 2016, nationwide implementation of the new standard

Strengthening environmental and climate regulation and institutional arrangement

4. Air Pollution Prevention and Control Action Plans

- **Air Pollution Prevention Action Plan (2013-2017)**
- **The 13th Five-Year Plan for ecological and environmental protection (2016-2020)**
- **the Three-Year Action Plan to Win the Blue-Sky Defense War (2018-2020)**



Strengthening environmental and climate regulation and institutional arrangement

4. Air Pollution Prevention and Control Action Plans

- **Ten measures of Air Pollution Prevention Action Plan (2013-2017)**

1. Intensify the comprehensive control-measures, reduce pollutant emission.
2. Adjusting and optimizing industrial structure, promote the transformation and upgrading of economy.
3. Accelerate the technical transformation of enterprises, improve the scientific and technological innovation ability.
4. Speed up the adjustment of energy structure, increase the supply of clean energy
5. Investment projects must be strictly access to energy conservation and environmental protection,
6. Give play to the role of market mechanism, improve environmental economic policies.
7. Amplify the system of laws and regulations, strict supervision and management in accordance with the law.
8. Establish regional coordination mechanism, carrying out the regional environmental governance as a whole.
9. Establish monitoring and early warning emergency system
10. Clarifying the responsibilities of all parties

Strengthening environmental and climate regulation and institutional arrangement

4. Air Pollution Prevention and Control Action Plans

- **Main measures of the Three-Year Action Plan to Win the Blue-Sky Defense War (2018-2020)**

1. Adjusting and optimizing industrial structure, and promote the development of green industry
2. Speed up the adjustment of energy structure, and build a clean low carbon efficient energy system
3. Actively adjust the structure of transportation, develop green transportation system.
4. Optimization adjustment of land use structure, promote the non-point source pollution control
5. Action implementation of major projects, greatly reduce pollutant emission
6. Strengthening zone from spreading, effectively cope with heavy pollution weather
7. Improve the system of laws and regulations, improve environmental and economic policies
8. Strengthen basic capacity building, strict environmental law enforcement inspectors
9. Clearly implement the responsibilities of all parties and mobilize the whole society to participate widely

Strengthening environmental and climate regulation and institutional arrangement

4. Air Pollution Prevention and Control Action Plans

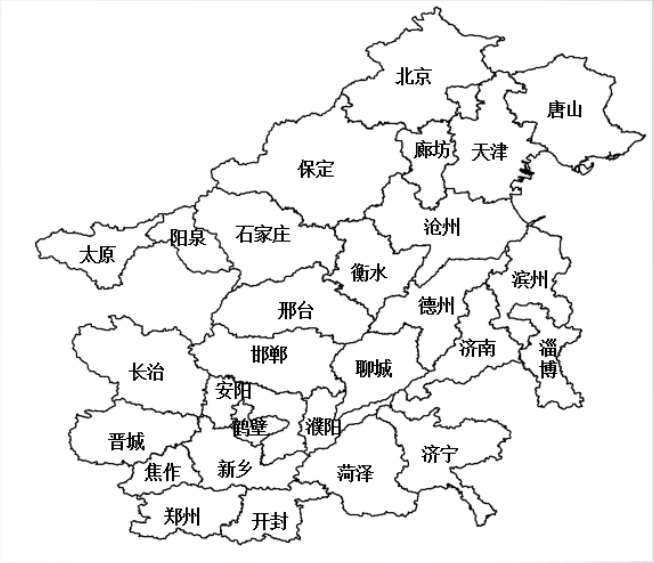
- **Science and Technology Support**

The national key fund of Tacking Key Problems in Air Pollution Control in BJ-TJ-HE and surrounding areas

- **Researchers:** National Joint Research Center for Tacking Key Problems in Air Pollution Control – more than 1500 researchers
- **"one city, one policy"** – 28 tracking research working groups that for long-term research and technical guidance in 2+26 cities were build .

大气重污染成因与治理攻关

Tacking Key Problems in Air Pollution Control



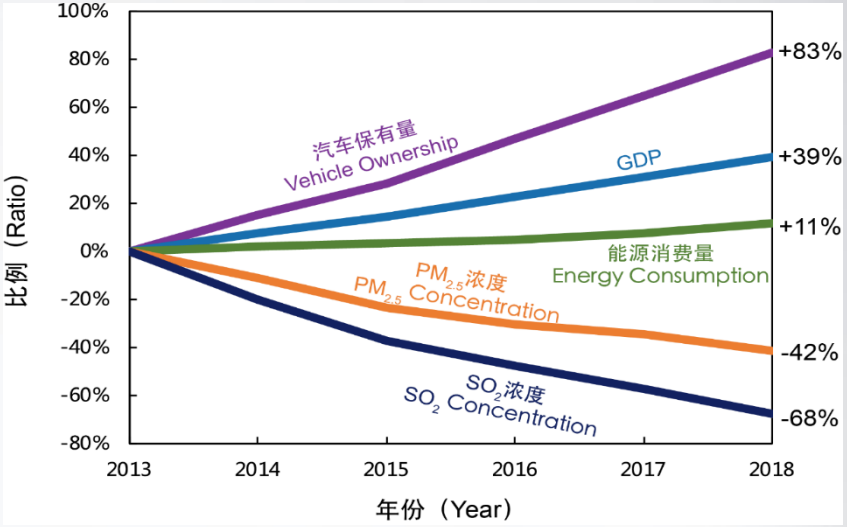
- **Key areas**: BJ-TJ-HB and surrounding area
- **Key points**: Regional and urban haze control during autumn and wintertime

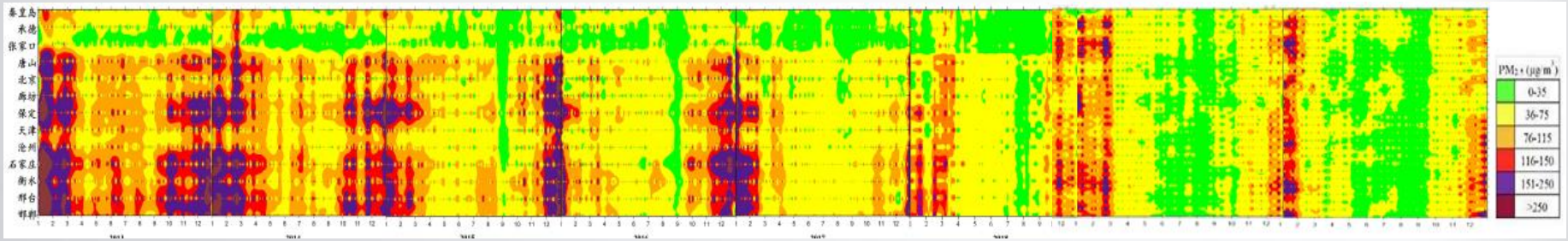
Strengthening environmental and climate regulation and institutional arrangement

4. Air Pollution Prevention and Control Action Plans

- **Target achievement**

Since 2013, China's economy and energy consumption have continued to grow. Meanwhile, air quality in China has improved significantly and heavy pollution days has decreased notably.



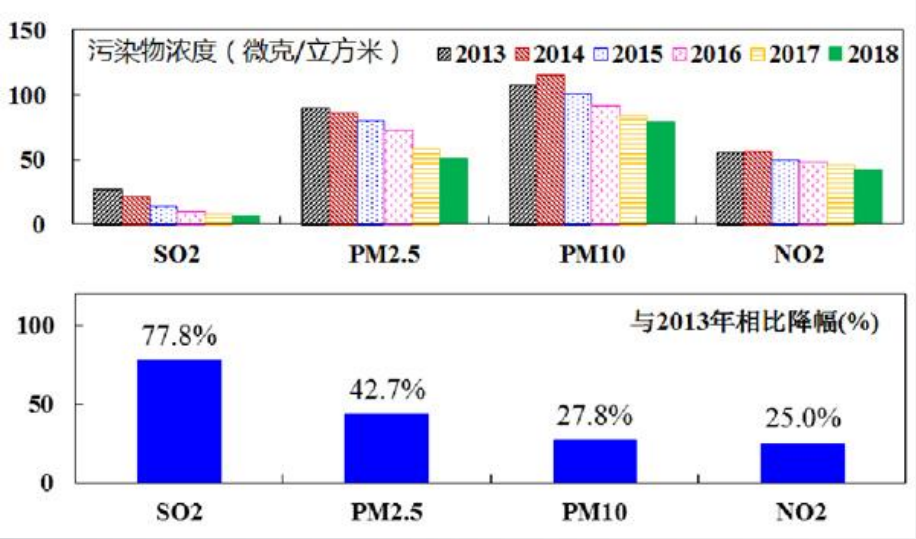


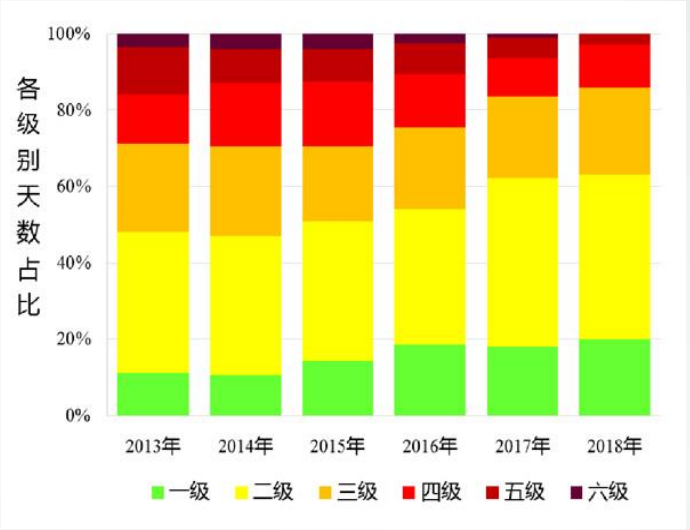
Strengthening environmental and climate regulation and institutional arrangement

4. Air Pollution Prevention and Control Action Plans

- **Target achievement**

Beijing's air quality has been significantly improved, the annual average concentration of major pollutants have dropped remarkable, the proportion of fairly good air quality days has increased year by year, and the number of heavy pollution days have been decreasing.





Content

I. Strengthening environmental and climate regulation and institutional arrangement

II. Sector specific plans, policies and regulations in China

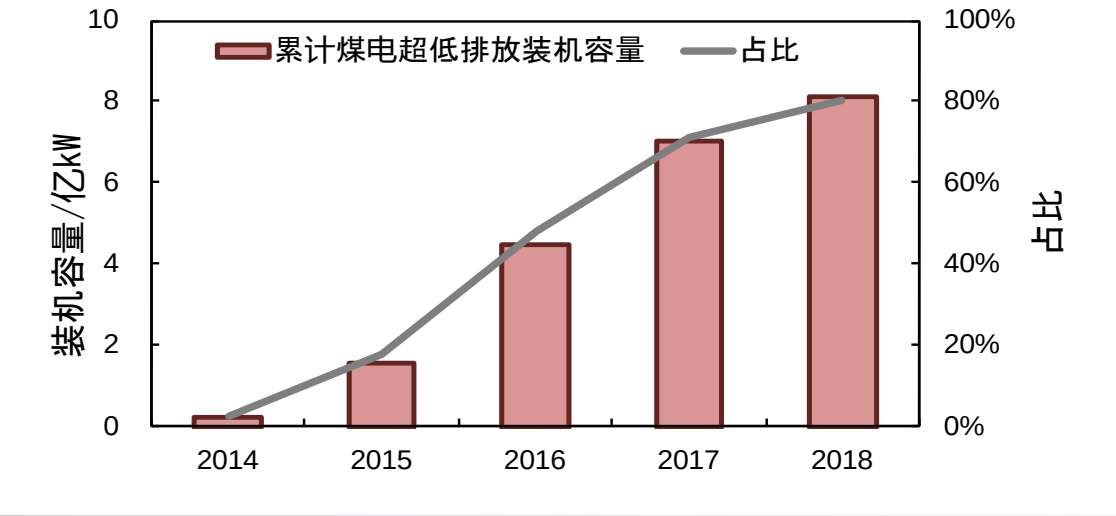
III. Gaps and needs to optimize policy making

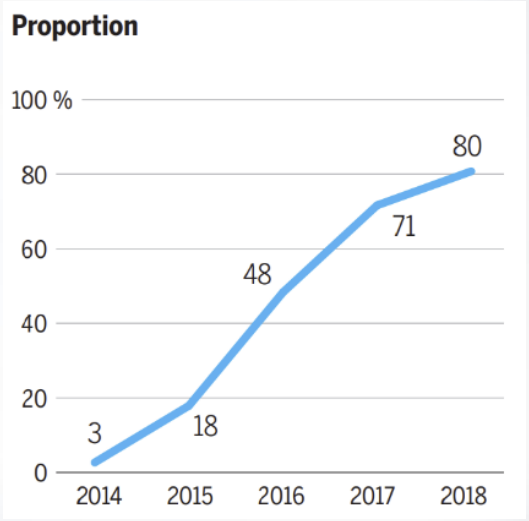
IV. Highlights for emission, impact, and control policy for BC/OC

Sector specific plans, policies and regulations in China

1. Upgrading Industrial Standards and Companies

- **China has been pushing ahead with pollutant emissions control of industrial enterprises**. Since 2013, a total of 15 standards for key industries such as cement and petrochemical industries were released or revised.
- **Strengthen industrial emission standards.** Ultra-low emission and energy-saving transformation of coal-fired power plants was launched in 2014. By the end of 2018, the capacity of China's coal-powered generators with ultra-low-emissions reached more than 810 million kilowatts, accounting for over 80 percent of the country's total installed capacity of coal-power generating units





(SOURCE: CHINESE ACADEMY OF ENVIRONMENTAL PLANNING)

Sector specific plans, policies and regulations in China

2. Industrial Restructuring

Phase out outdated industrial capacity

Between 2013 and 2017, China had slashed production of steel by 200 million tons, cement by 250 million tons, plate glass by 110 million weight cases, and coal-fired units by 25 MW, and barred the production of 140 million tons of nonconforming steel

during the period 2013 – 2017, this structure-focused measure led to the reduction of 2.08 Tg, 1.23 Tg, and 0.69 Tg abatements in SO_2, NOx, and primary $PM_{2.5}$ emissions, respectively

Upgrades on industrial boilers

From 2013 to 2017, more than 200,000 small coal boilers (≤7 MW) were shut down and phased out in urban areas. Large operating boilers were extensively equipped control devices according to the new emission standard.

abatements of 5.54 Tg (34% of all abatements) and 0.71 Tg (20% of all abatements) in SO_2 and primary $PM_{2.5}$ emissions

Phase out small and polluting factories

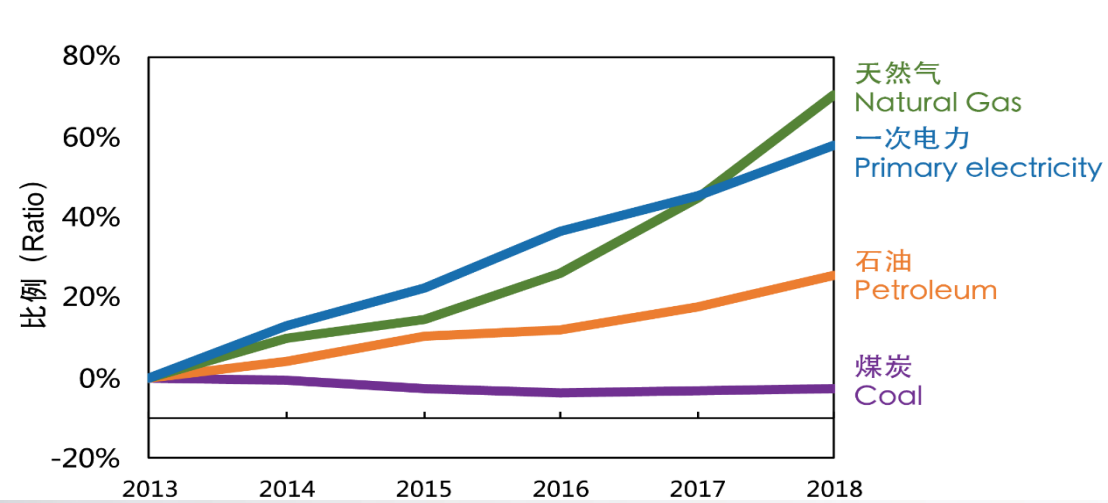
In 2017, China launched a campaign to investigate and crack down on such companies, and 62,000 of them, involved in air pollution, were investigated and disposed of in the “2+26” city cluster in Beijing-Tianjin-Hebei and neighboring areas

This measure yielded 10%, 3% and 9% of regional abatements in SO_2, NOx and $PM_{2.5}$ emissions, respectively

Sector specific plans, policies and regulations in China

3. Optimizing Energy Structure

- Between 2013 and 2018, the proportion of coal consumption in primary energy had dropped from 67% to 59%, curbing the trend of rapid growth of coal consumption.
- Setting Coal Quality Standards and Eliminating Small Boilers
- Promote clean fuels for heating in the residential sector

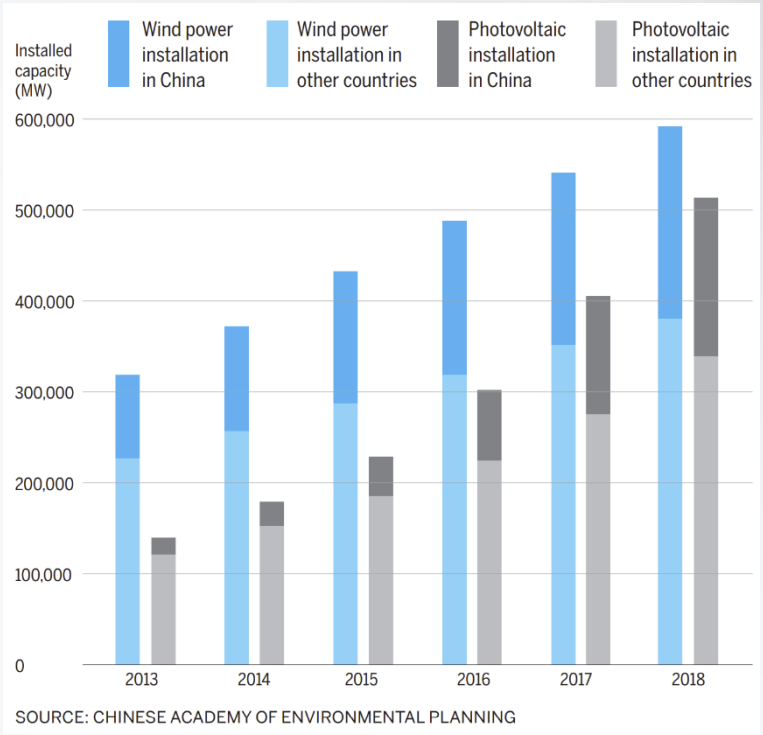


Items	anthracite coal No.1	anthracite coal No.2	bituminous coal No.1	bituminous coal No.2
Volatile matter	≤12%	≤12%	≤37%	≤37%
Ash	≤16%	≤30%	≤16%	≤25%
Sulfur	≤0.5%	≤1%	≤0.5%	≤1%
Mercury	≤0.25 μg/g			
Arsenic	≤20 μg/g			
Phosphorus	≤ 0.1%			
Chlorine	≤0.15%			
Fluorine	≤200 μg/g			

Sector specific plans, policies and regulations in China

3. Optimizing Energy Structure

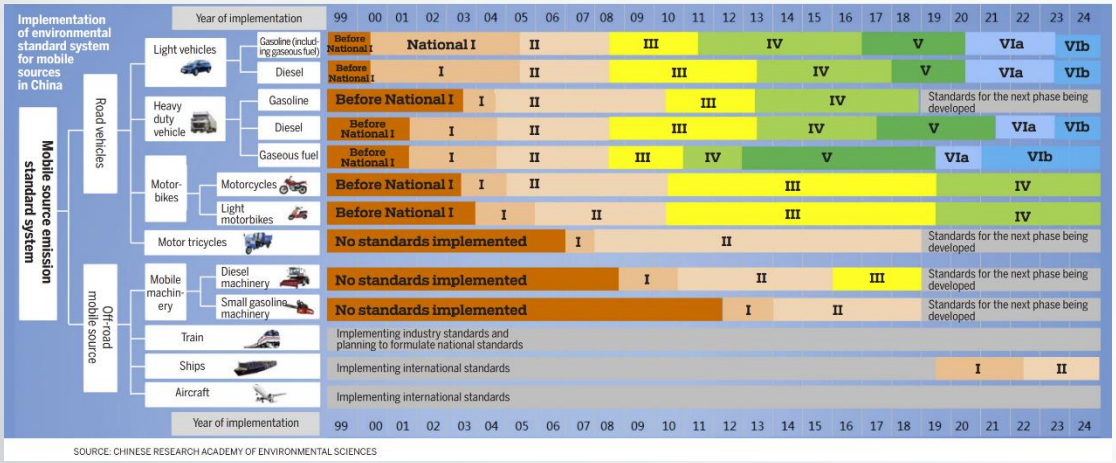
- Clean Energy Development
- Since 2013, the installed capacity of wind power and photovoltaic power in China has maintained high growth.
- By the end of 2018, the installed capacity of hydropower, wind power and photovoltaic power was 35,000 megawatts, 18,000 megawatts and 17,000 megawatts, respectively.
- The non-fossil energy power capacity grew to about 40 % of the total installed capacity. The proportion of clean energy in the primary energy increased from 15.5% to 22.1%



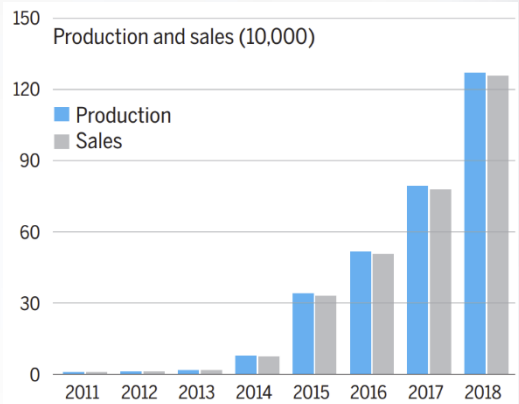
Sector specific plans, policies and regulations in China

3. Pollution Control of "Fuel, Road, Vehicle"

- Coordinated pollution control of "Fuel, Road, and Vehicles". National V emission standard has been implemented to all vehicles, and the fuel is in line with the emission standard. Since July 2021, National VI emission standard of heavy-duty diesel vehicles has been implemented, as an result that nitrogen oxides and particulate matter limits were reduced by 77% and 67% compared with the national V standards.
- Strengthen vehicle emission standards, Push for Low-Sulfur Fuel, Restructuring Transportation, New Energy Vehicles, Eliminate old and "Yellow Label" vehicles, In-Use Motor Vehicle Supervision System, Ship Emission Control Zone



SOURCE: CHINESE RESEARCH ACADEMY OF ENVIRONMENTAL SCIENCES

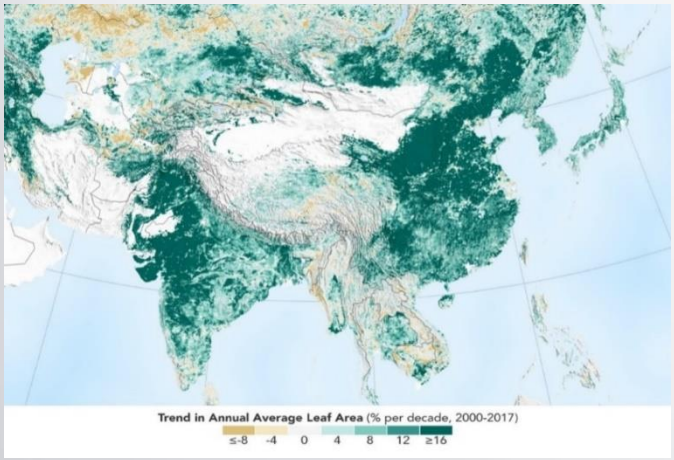


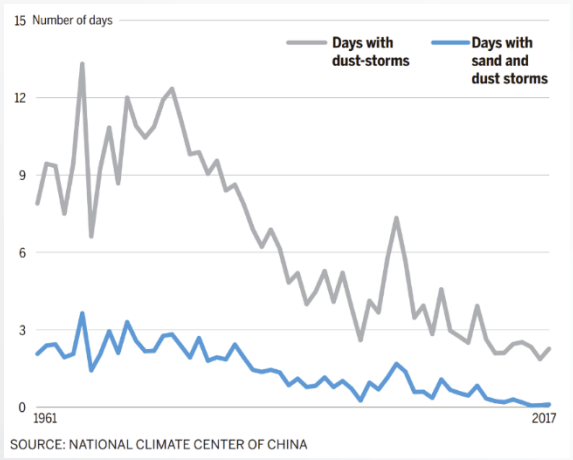
SOURCE: CHINA ASSOCIATION OF AUTOMOBILE MANUFACTURERS, CHINESE RESEARCH ACADEMY OF ENVIRONMENTAL SCIENCES

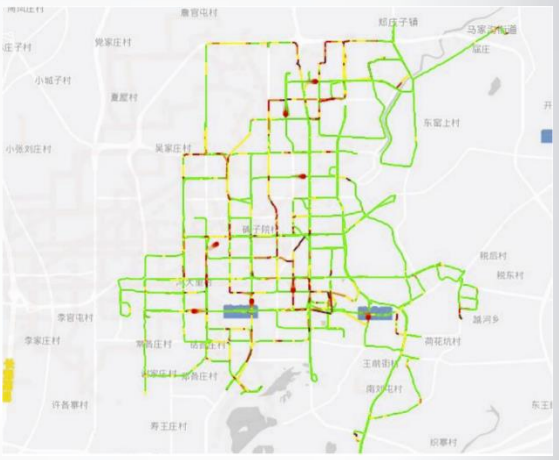
Sector specific plans, policies and regulations in China

3. Pollution Control of "Fuel, Road, Vehicle"

- Building an ecological security barrier in the sand control zone in northern China for wind-proofing and sand-fixing. Forest coverage rate has been increasing continuously.
- With large-scale afforestation, the occurrence of dust storms has reduced markedly. Over the past 60 years, the average numbers of days with sand and dust storms in northern China have dropped 0.46 days/10 years.
- Strengthening comprehensive utilization of straw and management of dust. The monitoring data is presented on a GIS map, forming a trajectory map of the cleanliness of urban roads, which visually reflects the level of road dust pollution.







Data analysis of China's afforestation efforts by NASA

Content

I. Strengthening environmental and climate regulation and institutional arrangement

II. Sector specific plans, policies and regulations in China

III. Gaps and needs to optimize policy making

IV. Highlights for emission, impact, and control policy for BC/OC

Gaps and needs to optimize policy making

As relatively new fields, the emissions, impact, and control policy for BC/OC and its co-benefits remain very challenging tasks, especially in regards to policy making and planning. The challenges or constraints faced include:

Practical studies are needed

- **Knowledge and awareness of governmental officials need to be enhanced**
- **Legislation need to be improved**

Narrowed the uncertainties of BC/OC emissions

- **Links between scientists and governments need to be established**
- **Lack of experience**

Content

I. Strengthening environmental and climate regulation and institutional arrangement

II. Sector specific plans, policies and regulations in China

III. Gaps and needs to optimize policy making

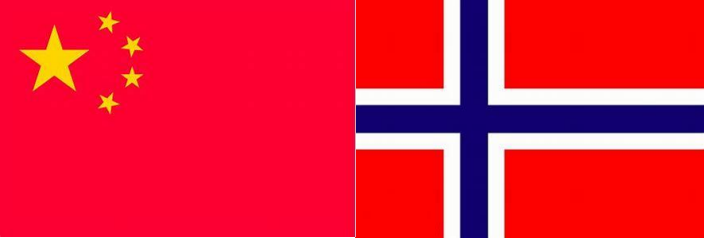
IV. Highlights for emission, impact, and control policy for BC/OC

Highlights for emission, impact, and control policy for BC/OC

- **Updated emission inventory for the change of energy structure**. Taking the residential heating as example, where residential coal consumption continues to decrease and instead by natural gas or electricity, emissions from residential combustion source should be updated based the constantly updated activity data and emission factors.
- **Updated emission inventory for the transportation restructuring**. China's emission standards of vehicles continue to tighten, strictly control the number of heavy-duty diesel trucks, and significantly increase the production and sales of new energy vehicles since 2013. Emission inventories for the transportation sector need to be updated with the latest transportation restructuring data.
- **Multi-effect evaluation**. With the obviously improvement of air quality in China and further reduction of BC/OC concentrations, there is an urgent need to track and assess its multi-effect on health, air quality and climate in order to provide guidance for Chinese medium and long-term air environment management.

Thank You!



Chinese-Norwegian Project on Emission, Impact, and Control Policy for Black Carbon and its Co-benefits in Northern China
Workshop December 15, 2021
中国-挪威合作中国北方地区黑碳排放、影响、控制对策及其协同效应研究项目启动会

Output 1: Review of BC/OC emissions and control measures in China and Norway

Dr. Vigdis Vestreng, Senior Advisor,
Norwegian Environment Agency (NEA)

Scott Randall, Senior Advisor,
Norwegian Environment Agency (NEA)

Ingeborg Rønning, Senior Advisor,
Norwegian Environment Agency (NEA)

Beijing, China 2021.12.15

Purpose of Output 1

- Document an overview of status for both countries
- Knowledge-sharing between both countries
- Gaps & needs for the project and after

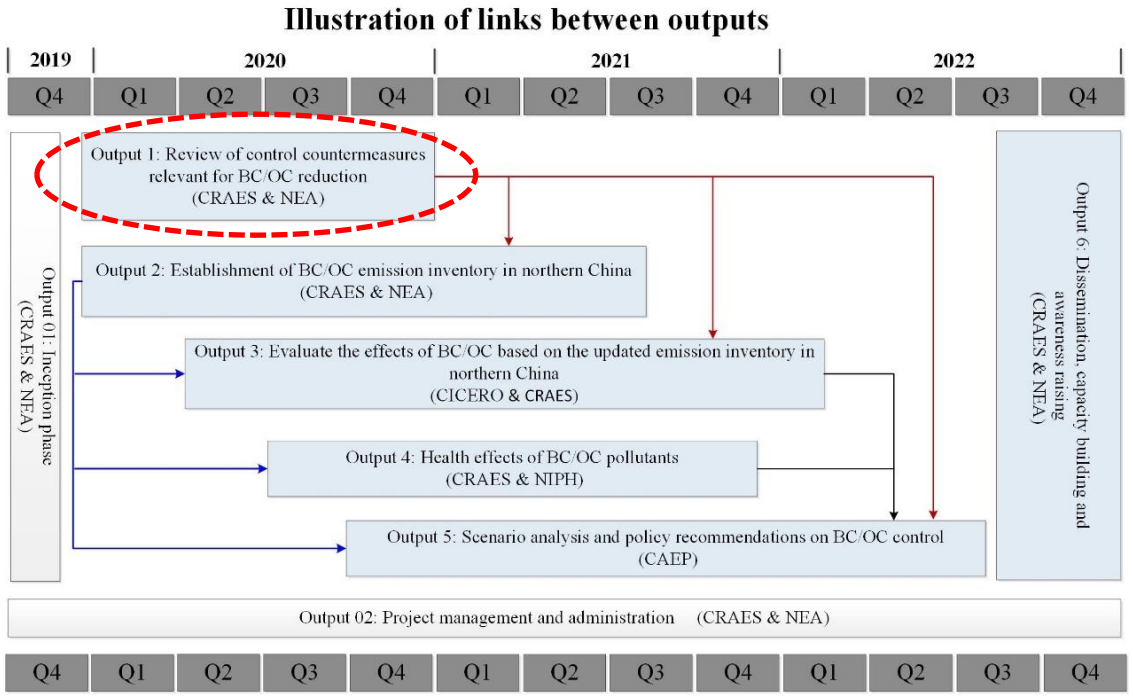


Figure 2 from Project Document

Report overview

- Review of status in China with gaps & needs
- Review of status in Norway with details on policies and integrated analysis

Table of Contents from Output 1 Review Report

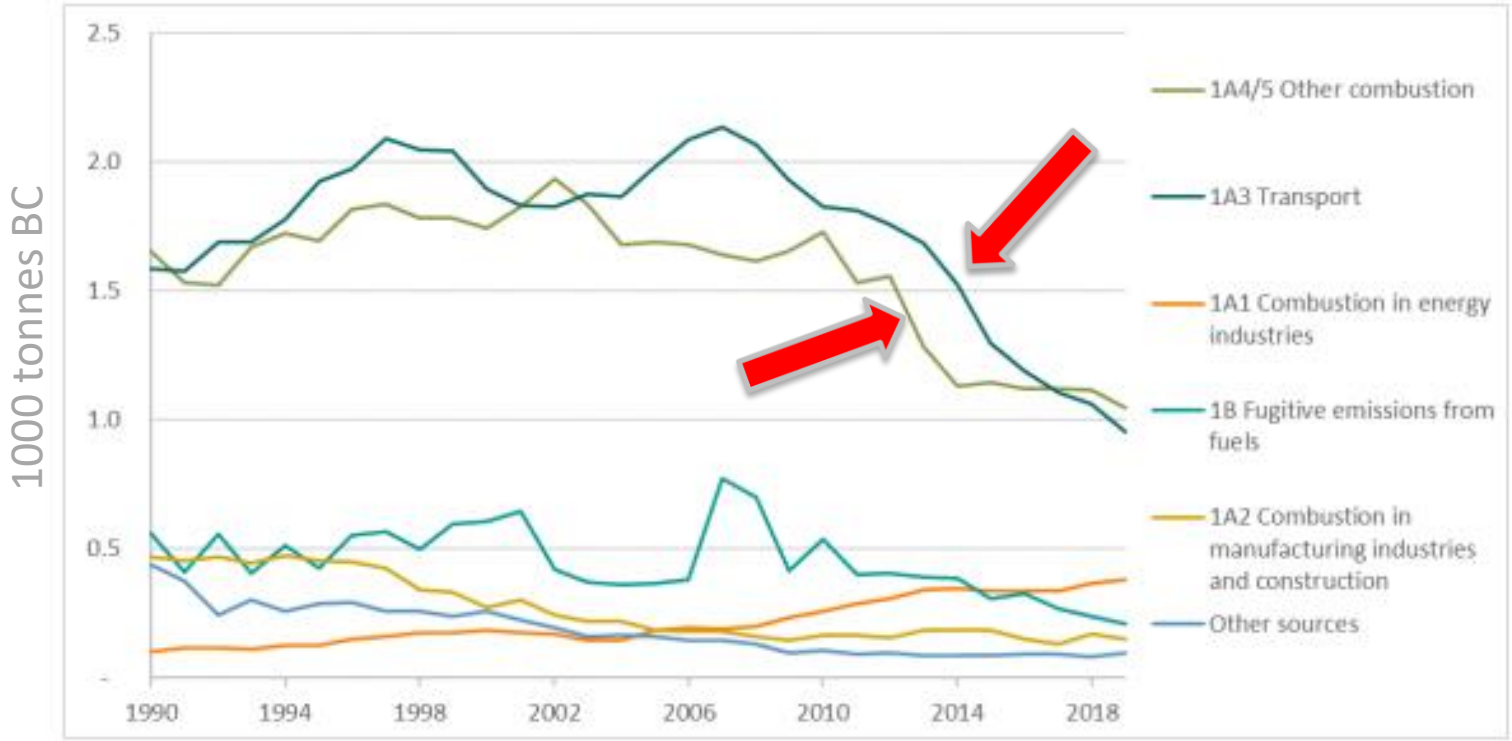
Norway quick facts

- There are approximately **5.4 million** residents in Norway.
- The number of residents in the EU is approximately 447 million.
- Norway is not an EU member but has special agreements though EEA.
- Norway has an area of 385207 km².
- The Norwegian coastline is over 2650 km long.
- GDP for Norway is $350 billion.
- The per capita GDP is $64856.

Photo: Scott Randall

Status of emissions in Norway

- 41% reduction in BC emission since 1990
- Primary reductions from
  - transport and
  - residential wood burning
- Norway has fine-scale emission modells for many sectors with high spatial and temporal resolutions.



Trends in BC emissions, 1990-2019. 1000 tonnes

Regulations and targets in Norway

- Air Quality (PM) regulations stricter than EU:

		EU Air Quality Directives limit values	National legal limit value	*Proposed national legal limit value**	National goals	Air quality criteria
PM10	Daily	50 µg/m^3 (max 35 exceedances)	50 µg/m^3 (max 30 exceedances)	*50 µg/m^3 (max 15 exceedances)*	n/a	30 µg/m^3
	Annual	40 µg/m^3	25 µg/m^3	*22 µg/m^3*	20 µg/m^3	20 µg/m^3
PM2.5	Daily	n/a	n/a	*n/a*	n/a	15 µg/m^3
	Annual	25 µg/m^3	15 µg/m^3	*12 µg/m^3*	8 µg/m^3	8 µg/m^3

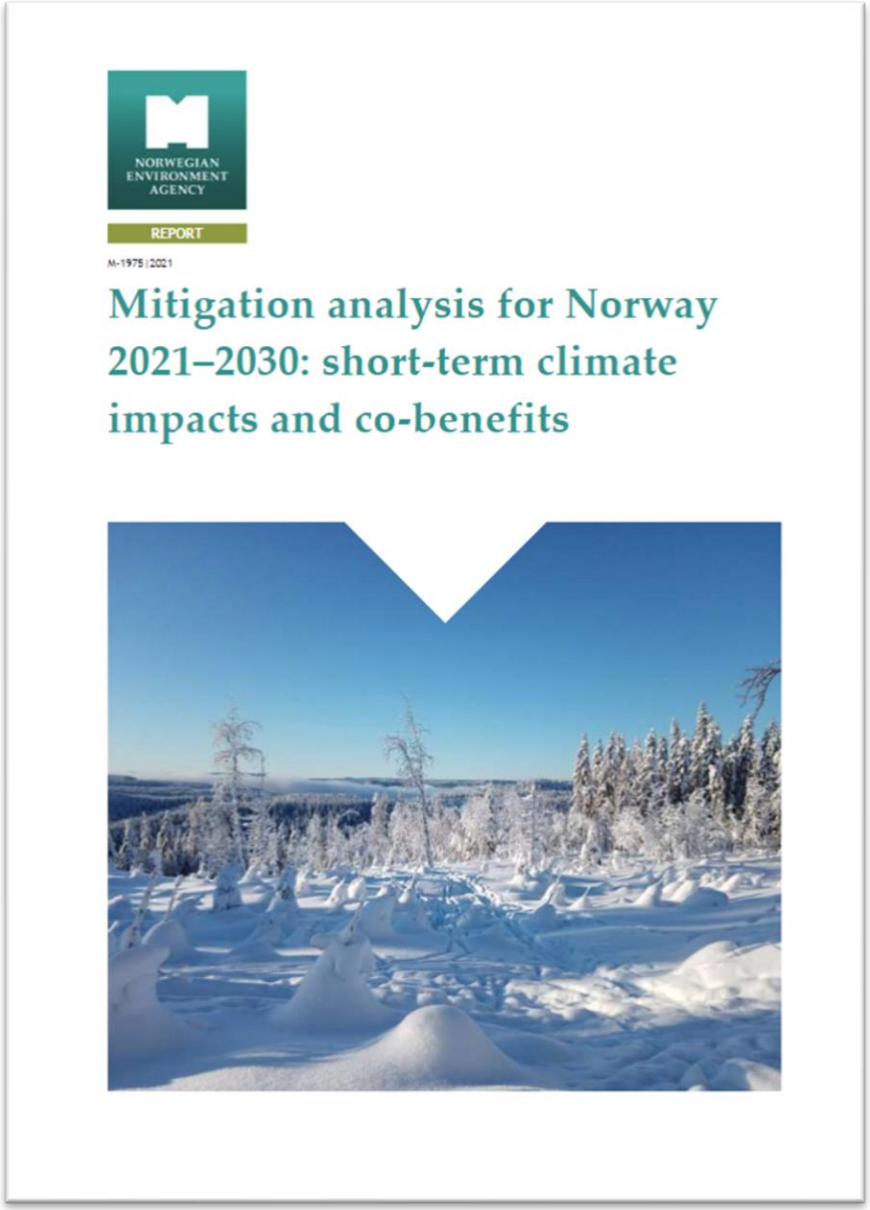
*National legal limit values have been proposed changed from 2022 and onwards

- Ambitious climate targets:
  - 30% reduction in GHG emissions by 2020 (Kyoto protocol)
  - 50% reduction in GHG emissions by 2030 (Paris agreement)
  - Climate neutral by 2030 and low-emission society by 2050 (Norwegian Climate Change Act)

Integrated analysis in Norway

2013-2021 NEA studies analysing both SLCF- and GHG-measures show:

- 1.5 x climate impact from BC emissions in Norway compared to the global average.
- BC-measures also reduce CO_2.
- CO_2 also has large short-term climate effect.
- Measures reducing BC and with co-benefits for climate and air quality:
  - Accelerated replacement of old wood-burning stoves
  - Zero growth in passenger car traffic in the largest urban areas
  - Shoreside electric power to ships at berth
  - Electrification and hydrogen for ferries
  - 100% of new local buses and passenger cars are electric by the end of 2025



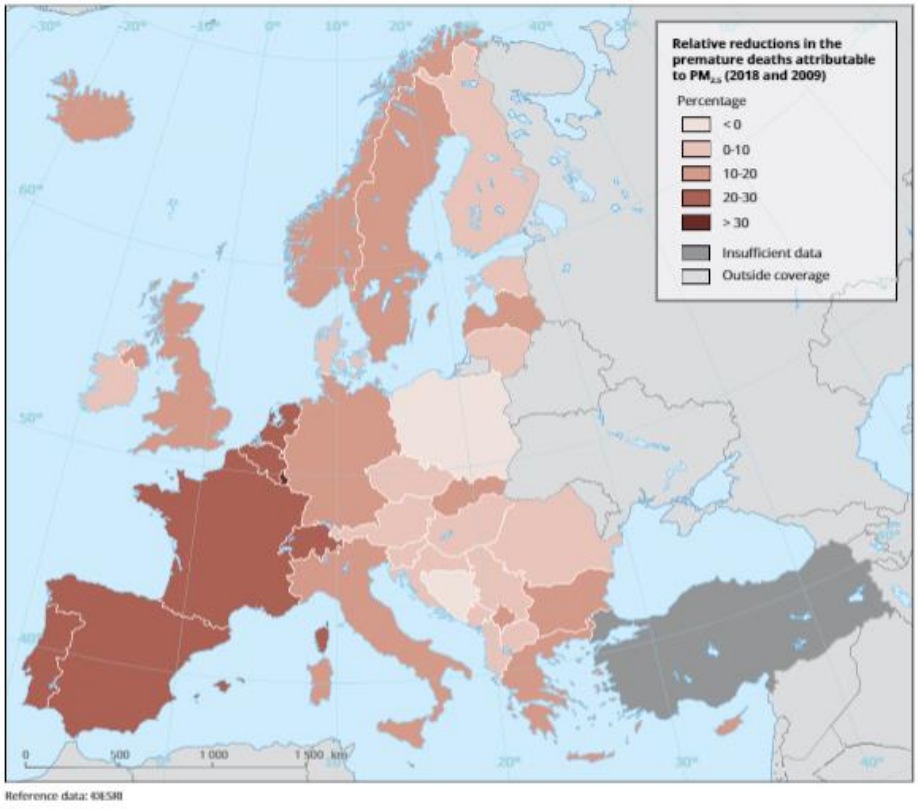
https://www.miljodirektoratet.no/publikasjoner/2021/mars-2021/mitigation-analysis-for-norway-20212030-short-term-climate-impacts-and-co-benefits/

Health impacts in Norway

- Reduction of impacts from PM2.5 in Europe
- 1,400 premature deaths from PM2.5 in Norway

Premature deaths from air pollution exposure in Norway compared to the EU, 2018 (Source: EEA)

Country	Population (x1000)	Annual mean (PM2.5)	Premature Deaths (PM2.5)
Norway	5,296	6.40	1,400
EU-28	507,558	13.20	379,000
Total	539,742	13.50	417,000

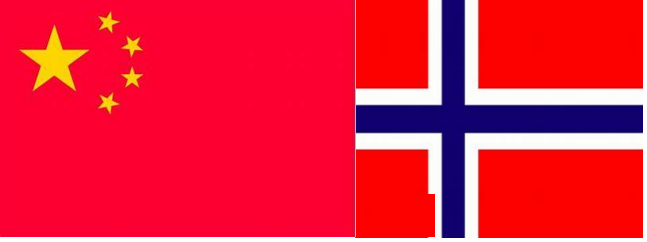


Relative reductions in premature deaths from PM2.5 in Europe, 2018 and 2009 (Source: EEA)

Conclusions

- BC emissions are decreasing, primarily due to transport and residential wood burning
- However, Norway continues with strengthening mitigation and laws
- Integrated analysis between climate change and air quality
- Continued investigation of health effects and impacts from PM

Photo: Scott Randall



中国-挪威黑碳合作研究项目：排放清单和初步模拟结果研讨会

ChiNorBC project: Emission inventories and preliminary modelling results

中挪黑碳项目中国北方地区BC/OC排放清单

Construction of a BC/OC emission inventory of northern China in the context of ChiNorBC project

支国瑞
ZHI Guorui

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Beijing, China 2021.12.15

Outline报告提纲

- 任务背景　　Background
- 方法逻辑　　Methodology
- 清单构建　　Establish BC inventories for ChiNorBC
- 清单介绍　　Describe ChiNorBC inventories

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Background任务背景

2013年，中挪双边对话，探讨开展短寿命气候强迫因子合作的可能性

In 2013 China and Norway initiated a dialogue on the possibility of cooperating on Short-Lived Climate Forcers

2019年11月，中国商务部与挪威外交部达成协议，决定开展中国北方黑碳排放、影响、控制政策及协同效益的项目

The Norwegian Ministry of Foreign Affairs (MFA) and the Chinese Ministry of Commerce (MOFCOM) entered into an agreement on 29 November 2019 for the project titled “Chinese-Norwegian Project on Emission, Impact, and Control Policy for Black Carbon and its Co-benefits in Northern China”

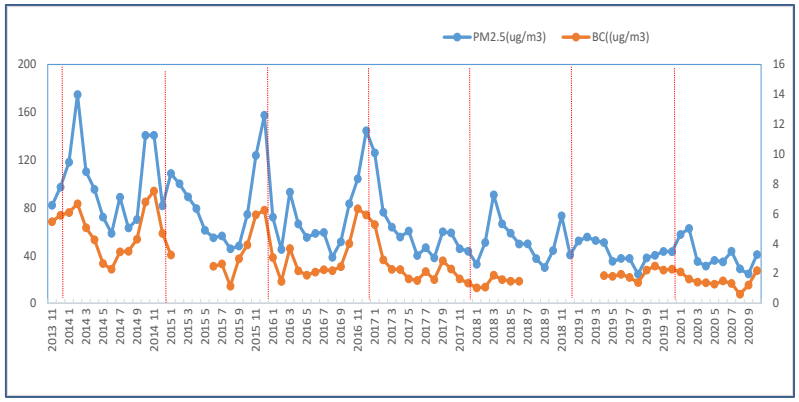
项目的课题2为“建立中国北方地区BC/OC排放清单”。我们的工作据此展开

Output 2 titled “Establishment of BC/OC Emissions Inventory for Northern China” is one of the Outputs in the project. In accordance with the project documents, we began to construct new inventories, national China, and northern China

Background任务背景

传统南北供暖线
Traditional North-south heating dividing line

项目划定的中国北方地区
Northern China for this project



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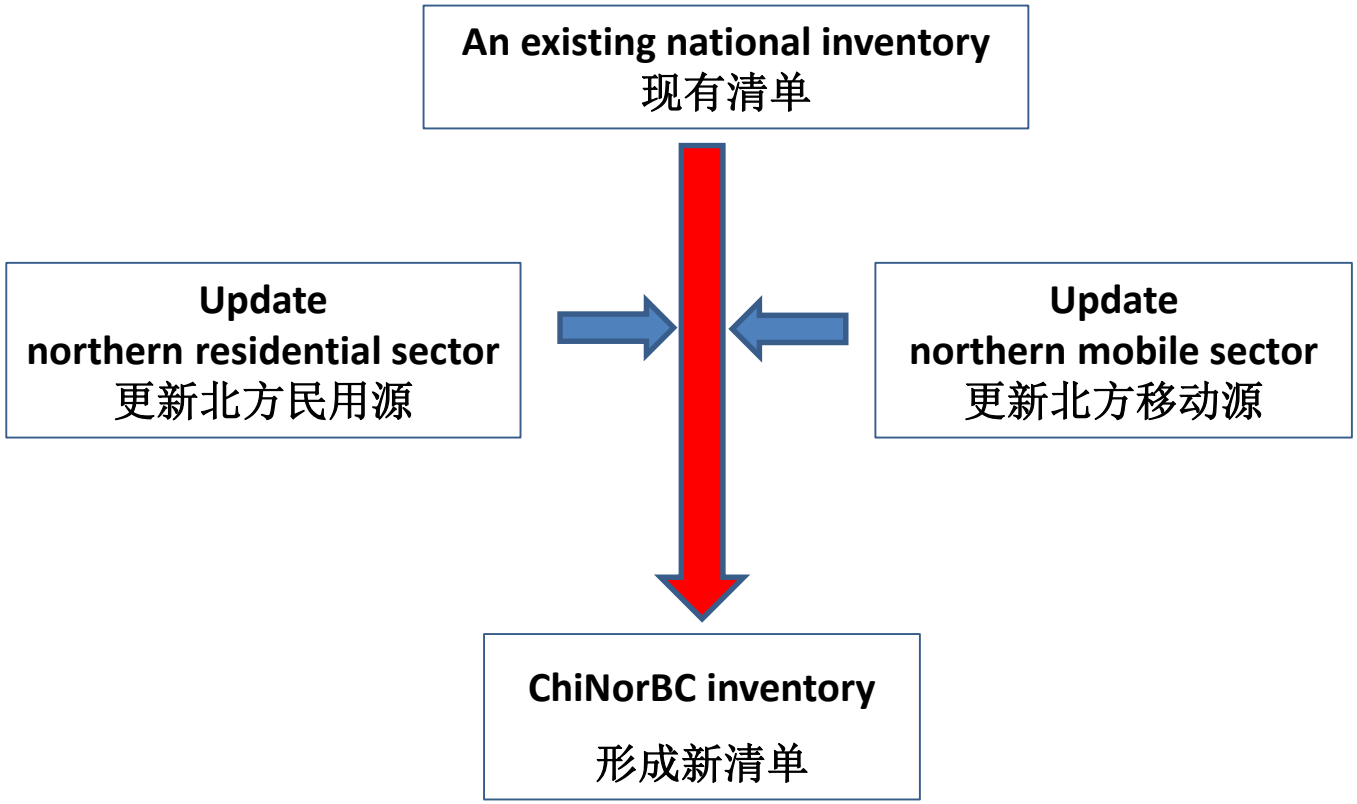
Methodology方法逻辑



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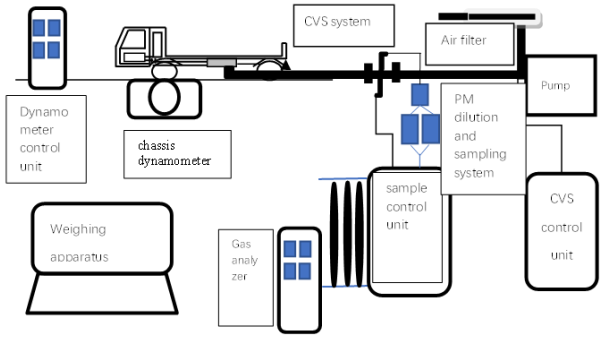
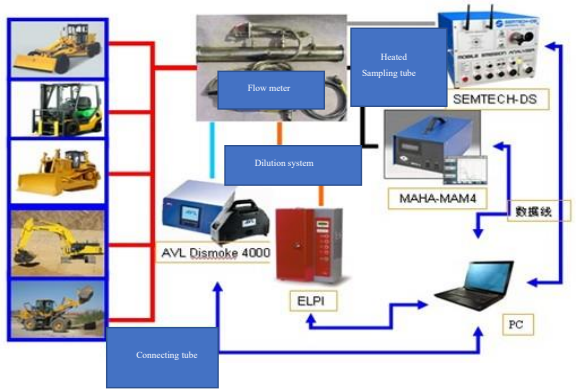
Mobile-measure EFs移动源测试

Test system



For the emission level IV diesel vehicles (China phase IV), BC was sampled with the vehicles run on the chassis dynamometer

For the level V diesel engines (China phase V), BC was sampled with the engines installed on the engine bench



For off-road machineries, BC was sampled with the portable emission measurement system (PEMS) installed on the machineries

On-site test






Mobile-Sample analysis and EFs calculation分析与计算

The EC\OC\TC(EC+TC) could be measured by DRI 2001A. The PM could be weighed by the weighing apparatus. The proportion of EC\OC to the TC could be expressed by $K_{EC/TC}$ and $K_{OC/TC}$, calculated by the following formula.

$$K_{EC/TC}=\rho(EC)/\rho(TC)*100 \quad (1)$$

$$Koc_{/PM}=\rho(EC)/\rho(TC)*100 \quad (2)$$

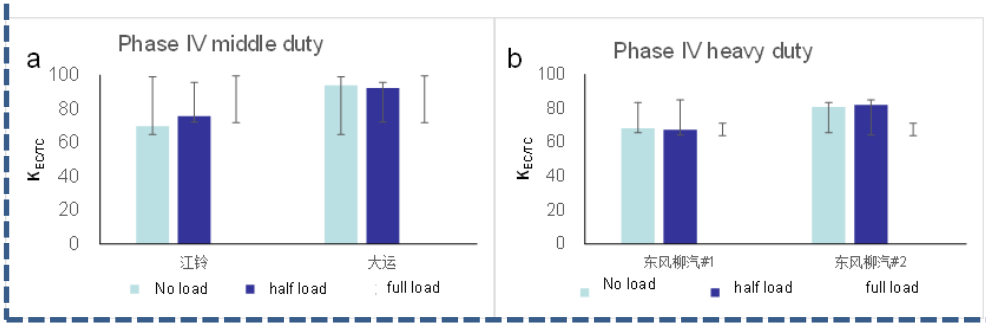
The ratio of EC in the PM is $K_{EC/PM}$, expressed use the following formula.

$$K_{EC/PM}=\rho(EC)/\rho(PM)*100 \quad (3)$$

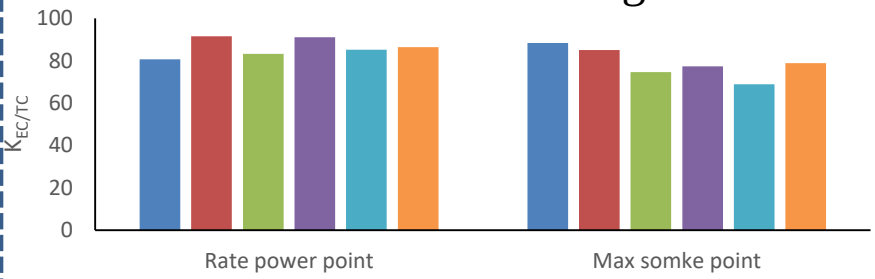
The ratio of OC in the PM is $K_{OC/PM}$, expressed use the following formula.

$$K_{OC/PM}=\rho(oC)/\rho(PM) \quad (4)$$

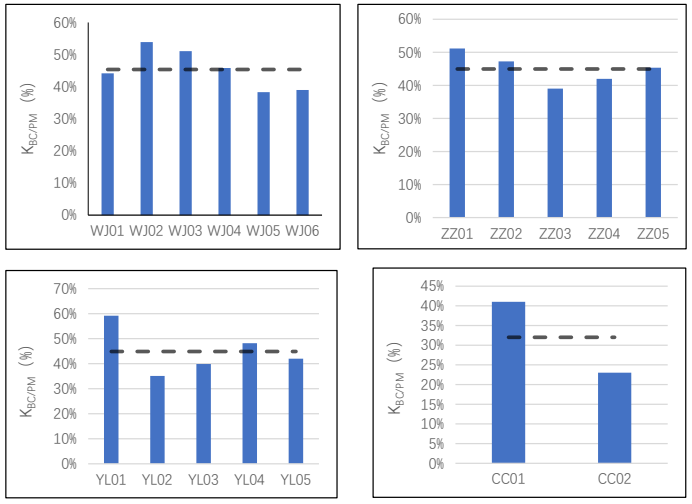
Phase IV diesel vehicle



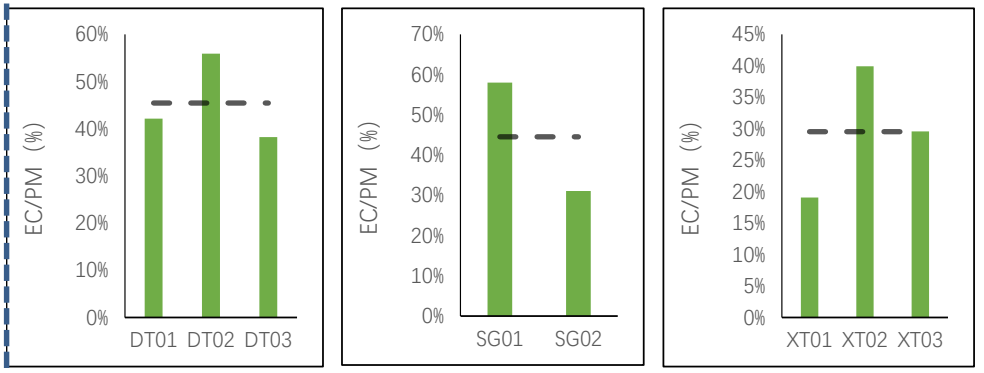
Phase V diesel engine



Construction machineries



Agriculture machineries



Mobile-BC/OC ratios and PM EFs

BC/OC ratios

Mobile source category	Fuel type	China II and China I		China III		China IV		China V	
		BC	OC	BC	OC	BC	OC	BC	OC
Vehicle	Diesel	0.51	0.32	0.56	0.32	0.66	0.21	0.72	0.21
	Gasoline	0.27	0.58	0.27	0.58	0.27	0.58	0.27	0.58
Off-raod construction machinery	Diesel	0.31	0.44	0.45	0.33	/	/	/	/
Off-raod agriculture machinery	Diesel	0.31	0.44	0.45	0.33	/	/	/	/

For the BC/OC emission factors(E_{BC},E_{OC}) by g/km, we use the BC/OC ratios($\mathbf{K_{BC/PM}}$,$\mathbf{K_{OC/PM}}$ as showed in Table4) to multiply the PM emission factors(E_{PM20}), as showed by the formula below:

$$E_{BC}=E_{PM10}*K_{BC/PM} \quad (5)$$

$$E_{OC}=E_{PM10}*K_{BC/PM} \quad (6)$$

PM_{10} emission factors of road motor vehicles(Guideline)

			China 1	China 2	China 3	China 4	China 5
Passenger Vehicle	Light Duty	Gasoline	0.029	0.012	0.008	0.003	0.003
		Diesel	0.070	0.058	0.036	0.034	0.034
	Medium Duty	Gasoline	0.067	0.020	0.012	0.007	0.007
		Diesel	0.516	0.174	0.164	0.118	0.059
	Large Duty	Gasoline	0.177	0.080	0.049	0.049	0.049
		Diesel	1.092	0.980	0.439	0.280	0.140
Truck	Light Duty	Gasoline	0.067	0.020	0.012	0.007	0.007
		Diesel	0.299	0.290	0.114	0.064	0.013
	Medium Duty	Gasoline	0.177	0.080	0.049	0.049	0.049
		Diesel	1.006	0.303	0.190	0.110	0.022
	Heavy	Gasoline	0.177	0.080	0.049	0.049	0.049

PM10 emission factors of off-road machineries (Guideline)

Power Range	Fuel Type	Before China 1	China 1	China 2	China 3
Power<37kW	Diesel	1.2	1	0.95	0.55
37<Power<56kW	Diesel	1.0	0.85	0.40	0.35
75<Power<130kW	Diesel	0.8	0.7	0.3	0.25
Power>130kW	Diesel	0.7	0.54	0.20	0.18

Mobile-Recommended EFs确定排放因子

Table 10 BC/OC emission factors of on road vehicles (g/kW.h)

			China 1		China 2		China 3		China 4		China 5	
			BC	OC	BC	OC	BC	OC	BC	OC	BC	OC
Passenger Vehicle	Light Duty	Gasoline	0.00783	0.01682	0.00324	0.00696	0.00216	0.00464	0.00081	0.00174	0.00081	0.00174
		Diesel	0.0357	0.0224	0.02958	0.01856	0.02016	0.01152	0.02244	0.00714	0.02448	0.00714
	Medium Duty	Gasoline	0.01809	0.03886	0.0054	0.0116	0.00324	0.00696	0.00189	0.00406	0.00189	0.00406
		Diesel	0.26316	0.16512	0.08874	0.05568	0.09184	0.05248	0.07788	0.02478	0.04284	0.01239
	Large Duty	Gasoline	0.04779	0.10266	0.0216	0.0464	0.01323	0.02842	0.01323	0.02842	0.01323	0.02842
		Diesel	0.55692	0.34944	0.4998	0.3136	0.24584	0.14048	0.1848	0.0588	0.1008	0.0294
Truck	Light Duty	Gasoline	0.01809	0.03886	0.0054	0.0116	0.00324	0.00696	0.00189	0.00406	0.00189	0.00406
		Diesel	0.15249	0.09568	0.1479	0.0928	0.06384	0.03648	0.04224	0.01344	0.00936	0.00273
	Medium Duty	Gasoline	0.04779	0.10266	0.0216	0.0464	0.01323	0.02842	0.01323	0.02842	0.01323	0.02842
		Diesel	0.51306	0.32192	0.15453	0.09696	0.1064	0.0608	0.0726	0.0231	0.01584	0.00462
	Heavy Duty	Gasoline	0.04779	0.10266	0.0216	0.0464	0.01323	0.02842	0.01323	0.02842	0.01323	0.02842
		Diesel	0.35292	0.22144	0.28458	0.17856	0.1512	0.0864	0.10008	0.03212	0.0216	0.0063

Table 11 BC/OC emission factors of off- road machineries (g/kW.h)

Machinery Type		Before China 1		China 1		China 2		China 3	
		BC	OC	BC	OC	BC	OC	BC	OC
Construction Machinery	Excavators (100kW)	0.248	0.352	0.217	0.308	0.093	0.132	0.1125	0.0825
	Bulldozer (120kW)	0.248	0.352	0.217	0.308	0.093	0.132	0.1125	0.0825
	Loader (135kW)	0.217	0.308	0.1674	0.2376	0.062	0.088	0.081	0.0594
	Forklift (40kW)	0.31	0.44	0.2635	0.374	0.124	0.176	0.1575	0.1155
	Roller (110kW)	0.248	0.352	0.217	0.308	0.093	0.132	0.1125	0.0825
	Pave machinery (80kW)	0.248	0.352	0.217	0.308	0.093	0.132	0.1125	0.0825
	Grader (110kW)	0.248	0.352	0.217	0.308	0.093	0.132	0.1125	0.0825
	Others (Diesel) (30kW)	0.372	0.528	0.31	0.44	0.2945	0.418	0.2475	0.1815
Agriculture Machinery	Larger and Medium Tractor (29.2kW)	0.372	0.528	0.31	0.44	0.2945	0.418	0.2475	0.1815
	Small Tractor (9.6kW)	0.372	0.528	0.31	0.44	0.2945	0.418	0.2475	0.1815
	Combine Harvester (42.5kW)	0.31	0.44	0.2635	0.374	0.124	0.176	0.1575	0.1155
	Irrigation Machinery (14.9kW)	0.372	0.528	0.31	0.44	0.2945	0.418	0.2475	0.1815
	Others (Diesel) (3.0kW)	0.372	0.528	0.31	0.44	0.2945	0.418	0.2475	0.1815

Table 12 BC factors of ships from literatures

Literature	EF/(g/kg fuel)	Method
Lack D.A,, Light absorbing carbon emissions from commercial shipping, Geophys. 25 Res. Lett., 35, 2008	0.36-1	Optical
Agrawal, H., Emission Measurements from a Crude Oil Tanker at Sea, Environmental Science & Technology, 42 (19).2008	0.1	Thermal
Corbett, J.J., Updated emissions from ocean shipping. Journal of Geophysical Research: Atmospheres, 108, 4650,2003	0.37	/
Petzold, A., Recommendations for reporting "black carbon" measurements. Atmospheric Chemistry and Physics, 13,2013	Average 0.179±0.018 0.06（85%load） 0.36（10%load）	Thermal
Naya Olmer, Bryan Comer.et al. Greenhouse gas emissions from global shipping,2013-2015 Detailed methodology,ICCT,2017	stroke, 50%laod HFO:0.49(g/kg fuel) Distillate:0.26(g/kg fuel)	/

Mobile-Investigation of vehicle population机动车数量及结构

light duty passenger car population by emission level and province

		China 5	China 4	China 3	China 2	China 1
Beijing		447449	3257699	1419952	0	0
Tianjin		231915	1686732	637918	64944	0
Hebei		1383844	8501583	1255838	1007307	1200004
Shanxi		555546	3466128	956614	833590	150813
Inner Mongolia		368925	2553960	799253	397037	694039
Liaoning		561299	3521438	1036501	595418	1306001
Jilin		298785	2165715	587236	330307	377987
Heilongjiang		358769	2328053	716383	404724	388477
Shanghai		461458	2417809	617133	0	0
Jiangsu		1872303	10682729	2633167	1795305	0
Zhejiang		1509916	7240285	2551891	1959646	1107849
Anhui		972645	4668367	860935	533139	65139
Fujian		622027	3369934	800655	664292	153488
Jiangxi		660391	3030878	601424	340276	57122
Shandong		1638043	10908704	2945890	2170791	1512736
Henan		1587458	8259368	1665634	1074905	421509
Hubei		881973	4527429	805096	533847	206449
Hunan		947773	4611720	879646	391847	228862
Guangdong		2310807	11350716	2812094	2801691	320629
Guangxi		652454	2853336	588345	287847	680327
Hainan		136630	572257	156921	120821	140764
Chongqing		510769	2695912	471820	0	0
Sichuan		1182321	6539272	1616687	695544	467
Guizhou		632013	2746160	473590	322206	109301
Yunnan		650711	3653039	912322	614489	162071
Tibet		34357	141868	32776	30242	103427
Shan'xi		668639	3591187	912221	443060	0
Gansu		237661	1627504	347293	162085	220935
Qinghai		88465	571522	116450	18973	101363
Ningxia		98133	682245	171177	101132	100163
Xinjiang		312979	1781666	388636	103400	647305

Annual On-road Vehicle Kilometers travelled by types

Vehicle Type	VKT（km）
Small, micro passenger cars	18000
Medium passenger cars	31300
large passenger cars/Coach	58000
light-duty, micro size truck	30000
Medium duty truck	35000
Heavy duty truck	75000

Mobile-Investigation of vehicle population机动车数量及结构

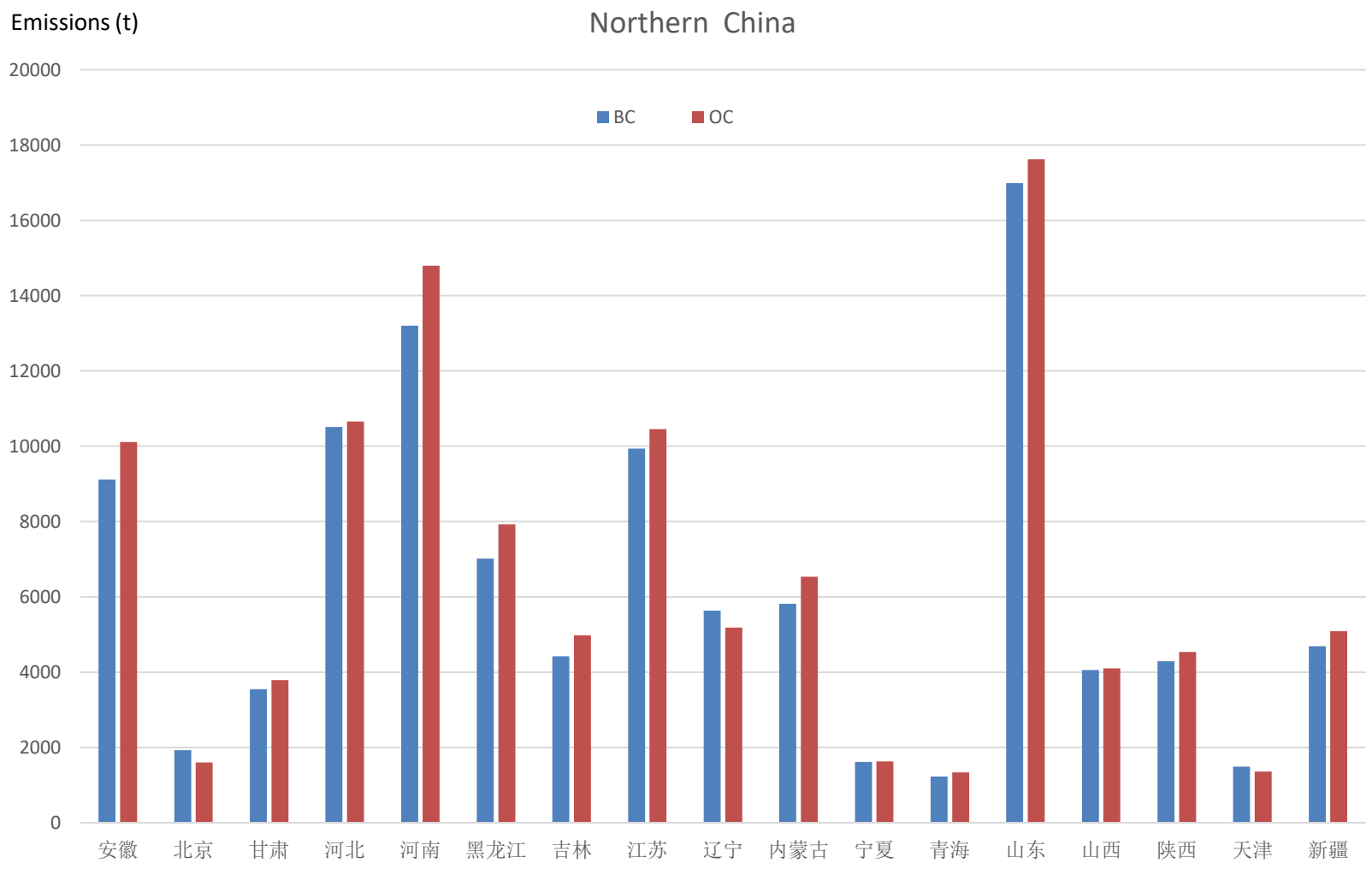
Inland water and costal vessels passenger and cargo turnover by province in 2018

Provinces	Cargo turnover 10^8t*km	Passenger turnover 10^8person*km
Beijing	0	0
Tianjin	1326.6	0.21
Hebei	490.88	0.19
Shanxi	0.13	0.08
Inner Mongolia	0	0
Liaoning	6317.59	6.05
Jilin	0.2	0.18
Heilongjiang	6.08	0.36
Shanghai	27990.8	0.79
Jiangsu	6121.94	3.47
Zhejiang	9352.5	6.3
Anhui	5630.88	0.39
Fujian	6209.37	2.75
Jiangxi	238.11	0.34
Shandong	1835.52	12.76
Henan	1021.75	0.61
Hubei	2850	4.74
Hunan	458.96	3.63
Guangdong	24177.41	11.13
Guangxi	1590.64	3.29
Hainan	774.27	4.10
Chongqing	2238.53	5.59
Sichuan	270.13	1.91
Guizhou	45.07	6.77
Yunnan	17.33	3.02
Tibet	0	0
Shaanxi	0.52	0.62
Gansu	0.05	0.13
Qinghai	0	0.1

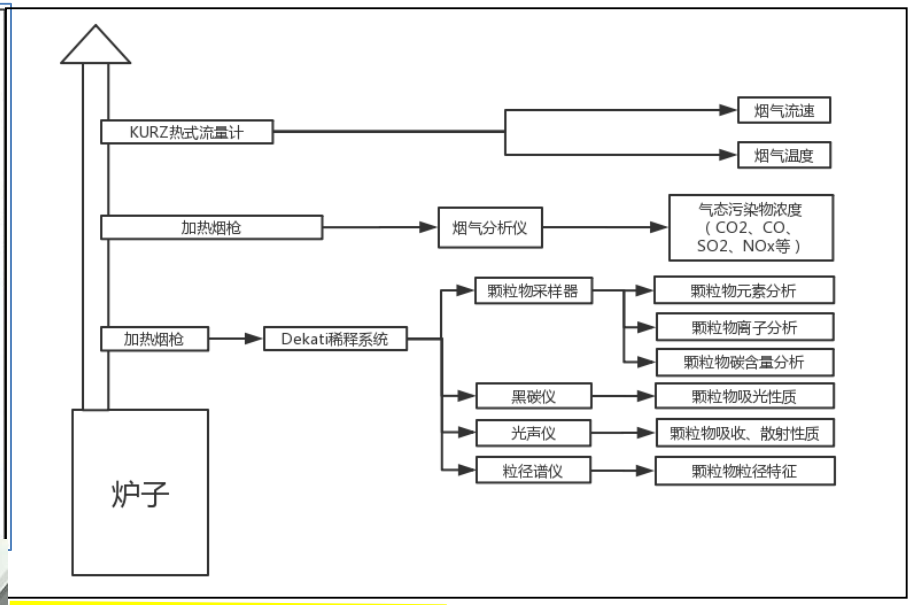
Recommend working hours of non-road machineries per year

Types		Working hours per year
Construction machinery	Excavators	770
	Bulldozers	770
	Loaders	770
	Forklifts	770
	Road rollers	770
	Pavers	770
	Graders	770
	Others	770
Agricultural machinery	Large and medium tractors	500
	Small tractors	500
	Combine Harvester	150
	Drainage and irrigation machinery	380

Mobile-Emissions



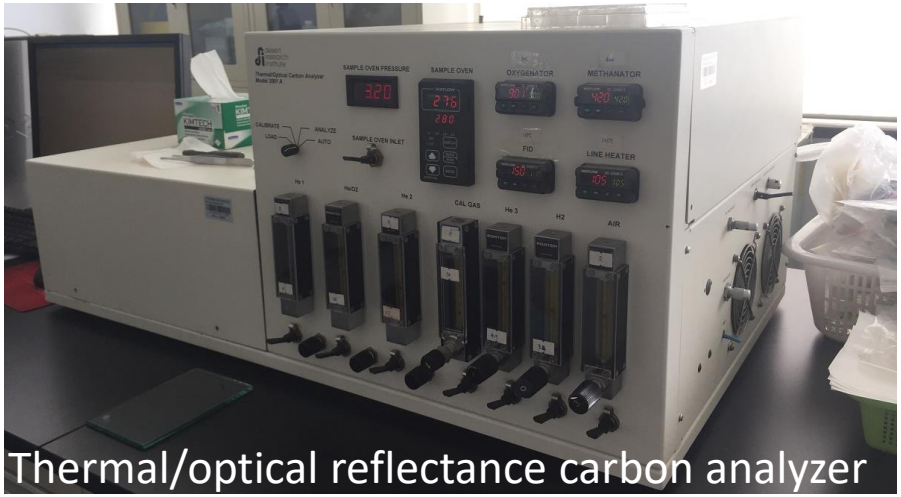
Residential-measure EFs民用源测试



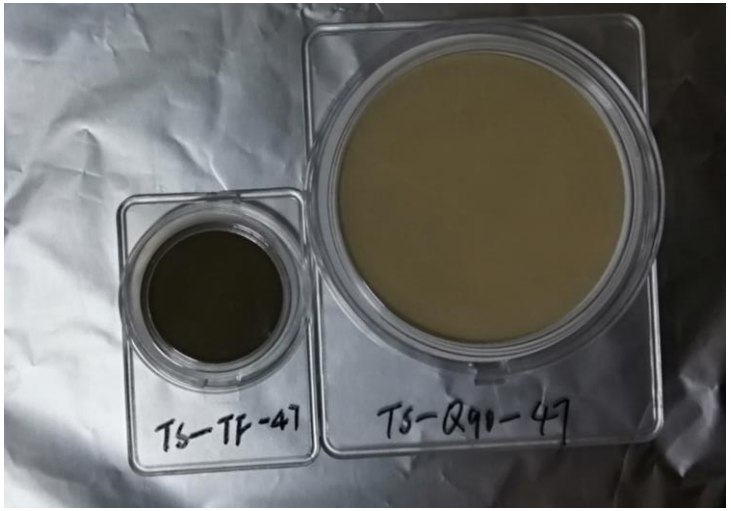
No.	V_{daf}%	Ash%	C_{FIX}%	M%
Y1	36.63	12.41	49.42	10.96
Y2	31.26	4.60	64.47	1.69
Y5	40.72	27.13	42.88	0.74
Y9	9.94	11.35	79.5	0.43
X1	4.75	9.07	86.08	0.62
X2	15.18	25.00	63.37	0.27

- 烟气稀释器
- 烟气温速测量
- 红外多成分测量
- 吸收散射测量
- 黑碳测量
- 粒径测量
- 颗粒物采样

Residential-measure EFs民用源测试



Thermal/optical reflectance carbon analyzer



$EFx = \rho \times A \times 10^{-6} / (M1-M2) \times F/f$

x —OC, EC

ρ—mass of x per unit area of loaded filter (μg/cm^2)

A—the area of loaded filter (cm^2)

M1—the mass of a fuel before combustion (kg)

M2—the mass of a fuel after combustion (kg)

F—the total flow rate of flue gas in the chimney (displayed by Kurz)

f—the flow rate of sampled flue gas (determined by FPS-4000)

No.	BC(kg/t)		OC(kg/t)	
	Chunk	Briquette	Chunk	Briquette
Y1	7.63	-	11.52	-
Y2	1.08	-	4.28	-
Y5	2.26	-	10	-
Y9	0.25	-	1.66	-
X1	-	0.17	-	0.71
X2	-	0.08	-	0.52
Mean	2.805	0.125	6.865	0.615

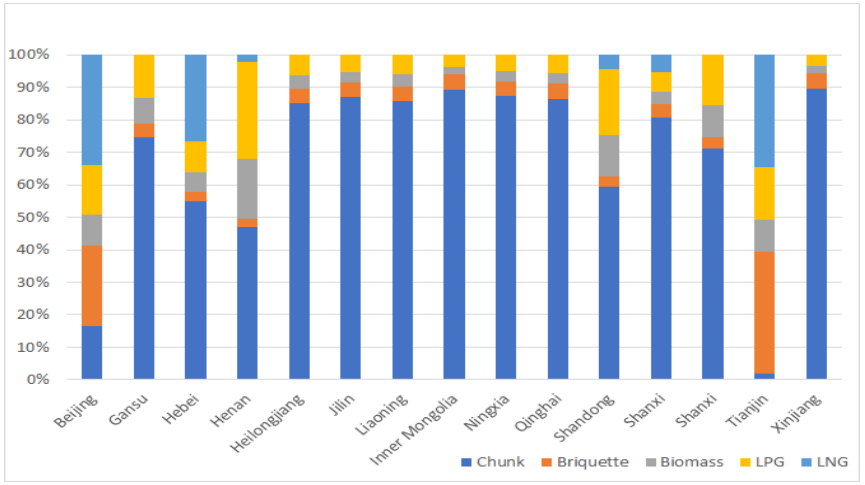
Residential-recommend EFs确定EFs

As described in the roadmap, the final EF value of a pollutant from a sample is the result of possibly 3 data origins: measured by this project, extracted from literature, and available in MEE guidelines. If one origin lacks in EF data, the other two origins keep working without considering the one not available

	Data origin	BC	OC	$PM_{2.5}$	NOx	CO	VOCs	NH_3
Chunk	Literature	2.13	4.37	10.40	1.35	159.40	1.64	1.03
	MEE	2.63	3.12	6.25	1.20	118.00	2.13	
	Measurement	2.81	6.87					
	Mean	2.52	4.79	8.33	1.28	138.70	1.89	1.03
	sd	0.35	1.91	2.93	0.11	29.27	0.35	
Briquette	Literature	0.17	3.11	4.79	0.26	90.52	1.10	0.70
	MEE	0.17		0.83	1.23	72.00		
	Measurement	0.13	0.62					
	Mean	0.15	1.86	2.81	0.75	81.26	1.10	0.70
	sd	0.03	1.76	2.80	0.69	13.10		

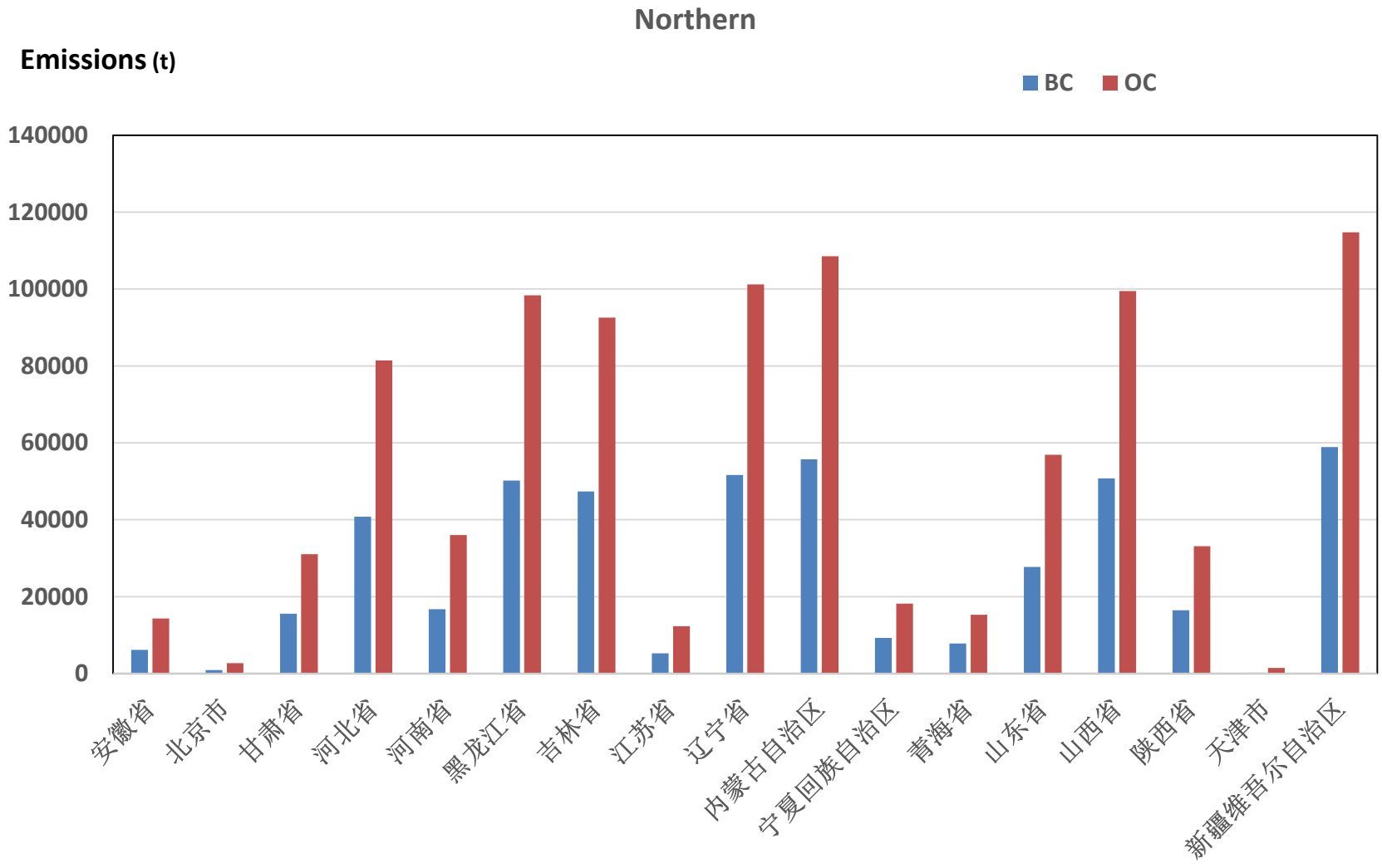
Residential-recommend ALs确定活动水平

As described in the roadmap, the final activity level （AL）for each province is from our field investigation or literature reports or statistics or a balanced consideration of them, with field investigation preferred. For example, China has been promoting clean energy for northern China's rural household winter heating and the coal-to-gas or coal-to-electricity shift rates are mostly from governmental releases. Furthermore, to cover all energy types related to residential sector, the data of biomass fuel and gaseous fuel are also compiled. Now, CRAES team has built a dataset for each province



Province	Chunk	Briquette	Biomass	LPG	LNG
	10^4 t	10^4 t	10^4 t	10^4 t	10^8 m^3
Beijing	30	45	25	12	36
Gansu	602	32	93	43	0
Hebei	1580	83	242	113	450
Henan	614	32	344	160	18
Heilongjiang	1966	103	129	60	0
Jilin	1859	98	98	46	0
Liaoning	2025	107	127	59	0
Inner Mongolia	2192	115	80	37	0
Ningxia	365	19	18	9	0
Qinghai	307	16	17	8	0
Shandong	1051	55	318	148	46
Shanxi	1987	105	134	63	75
Shanxi	634	33	123	57	0
Tianjin	3	52	20	9	28
Xinjiang	2319	122	78	36	0

Residential-Emissions排放

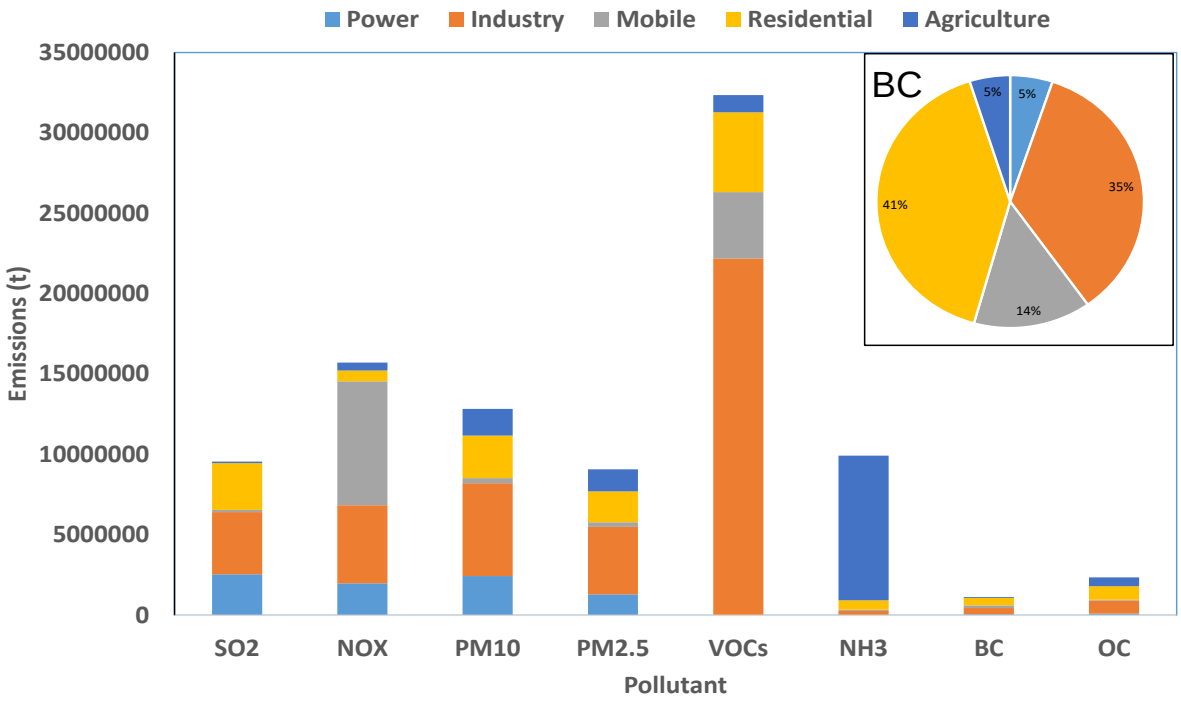


Outline报告提纲

- 任务背景 Background
- 方法逻辑 Methodology
- 清单构建 Establish BC inventory for ChiNorBC
- 清单介绍 Describe ChiNorBC inventory

The existing inventory-XING2018现有清单

Regrouped sector	XING2018 sector
Power generating	Power plant
Industrial	Industry combustion; Industrial process (Cement, steel, cement, other industrial process),
Residential	Domestic fossil fuel; domestic biofuel;
Mobile	Road transport; non-road transport
Agricultural	Open burning; livestock; fertilizer application

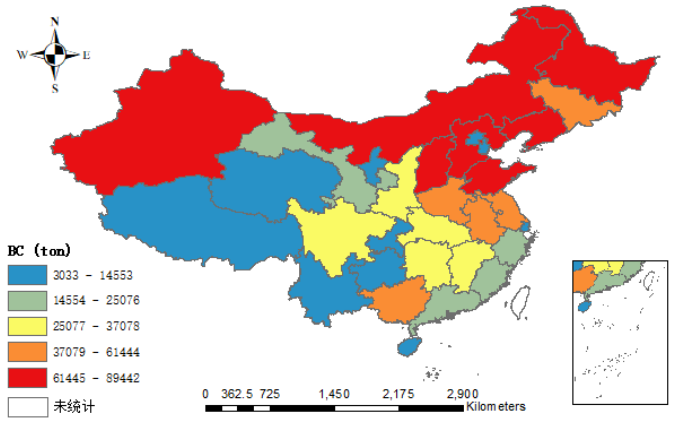


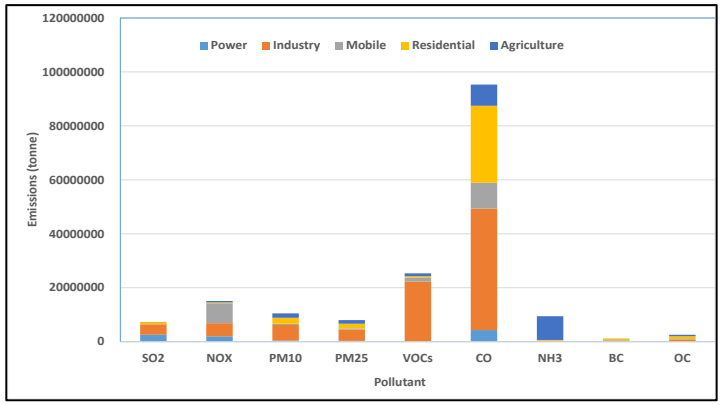
(Unit: 10^4t)

Sector		SO2	NOX	PM10	PM25	VOCs	NH3	BC	OC
Power	电力	255	198	244	130	0	0	6	11
Industry	工业	386	485	577	419	2219	27	40	81
Mobile	交通	14	772	31	29	412	9	16	6
Residential	民用	291	66	265	192	497	57	46	83
Agricultual	农业	9	50	166	137	106	900	6	55
Total	总和	955	1572	1283	907	3235	993	113	235

ChiNorBC 2018 inventory 新建清单2018

National



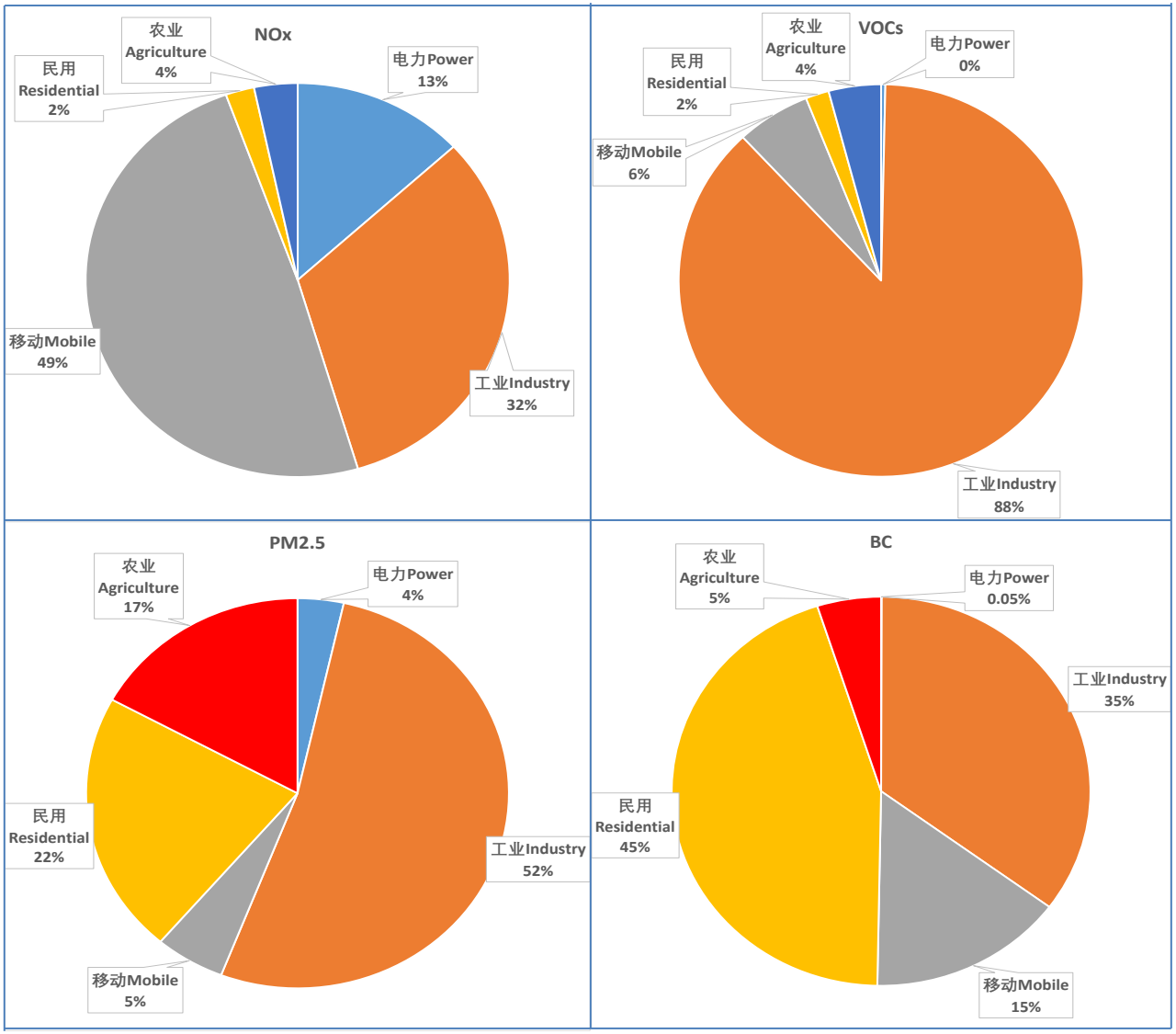


Northern

Unit: t

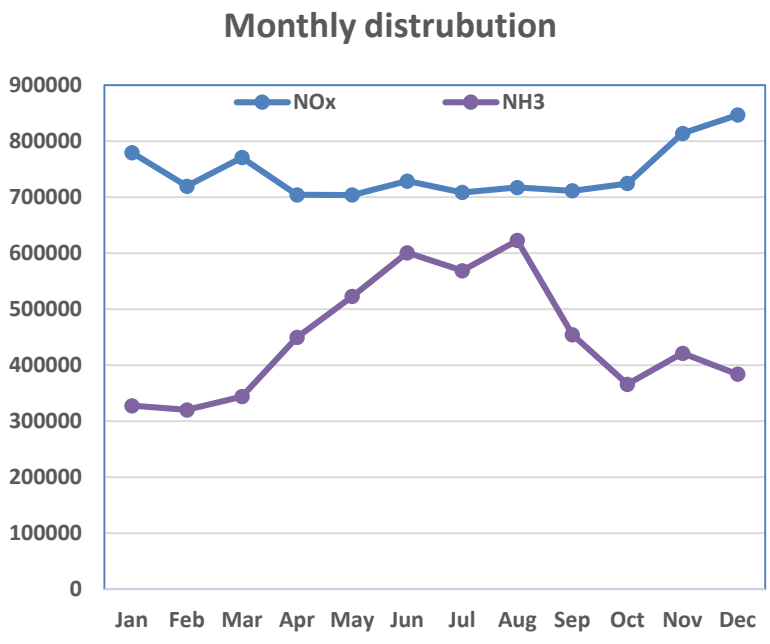
省（Province)	SO2	NOX	PM10	PM25	VOCs	CO	NH3	BC	OC
安徽省	325476	790984	541064	416158	968110	3673191	390504	43494	136862
北京市	8711	129010	19778	15566	479292	507052	18871	3033	4923
甘肃省	152942	283952	171555	128531	263352	1708768	179739	21635	46581
河北省	526473	965132	1107631	814199	1379983	9969698	509629	89442	177000
河南省	252205	913384	596569	456682	1319031	5707519	833358	60871	136667
黑龙江省	206437	453624	466083	368822	585656	4597379	341368	71994	168507
吉林省	182979	332243	376021	294285	526350	3985426	276335	61444	134252
江苏省	288232	859679	598979	464638	2345449	5040605	441340	44363	134562
辽宁省	424757	597332	590366	447562	1118609	5925480	308027	74784	151134
内蒙古自治区	357818	601390	488607	374002	539555	5022573	389785	74026	152180
宁夏回族自治区	521832	165903	89109	65991	129538	1081614	63437	12369	24729
青海省	40658	89663	58182	43132	69948	672983	84951	9496	18021
山东省	477909	1315191	845845	654570	2347774	7275229	704112	72499	156992
山西省	488994	458452	633392	484243	628576	5889110	172618	76370	137582
陕西省	184334	397746	242718	176683	604827	2584250	261680	35127	59731
天津市	30642	125450	72995	54289	430177	743767	34606	4270	8432
新疆维吾尔自治区	264204	449028	442465	338305	499321	4607368	370109	71982	147117
加和Sum	4734603	8928163	7341359	5597658	14235548	68992012	5380469	827199	1795272

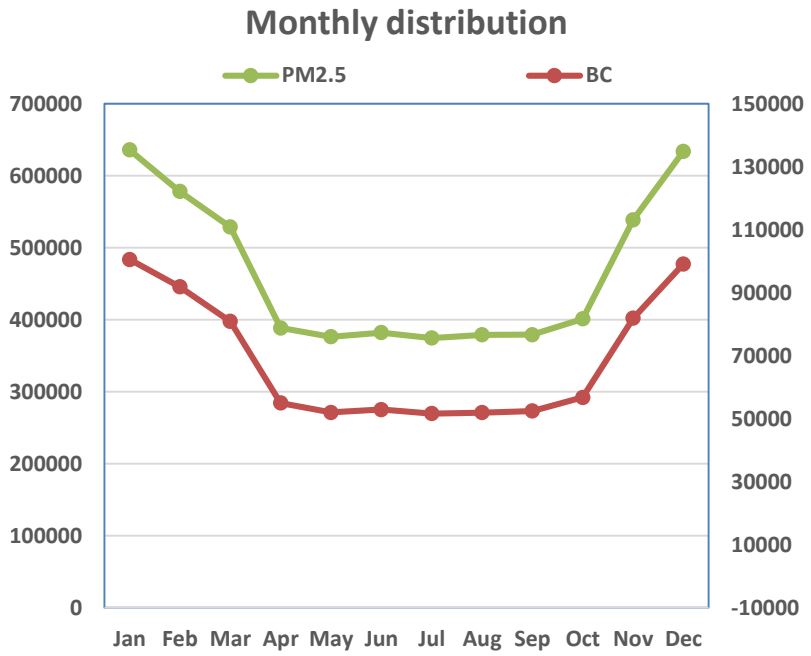
ChiNorBC 2018 inventory 新建清单2018



ChiNorBC 2018 inventory 新建清单2018

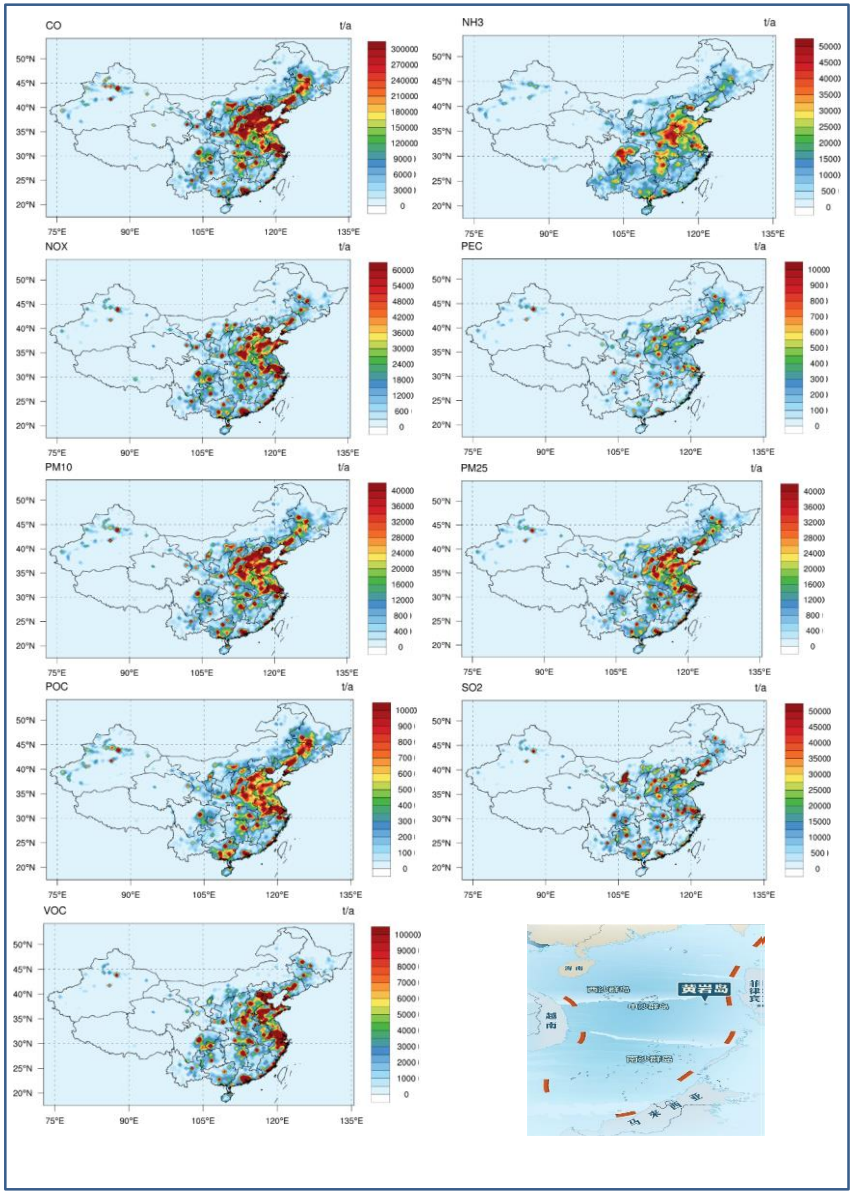
北方地区月度分布



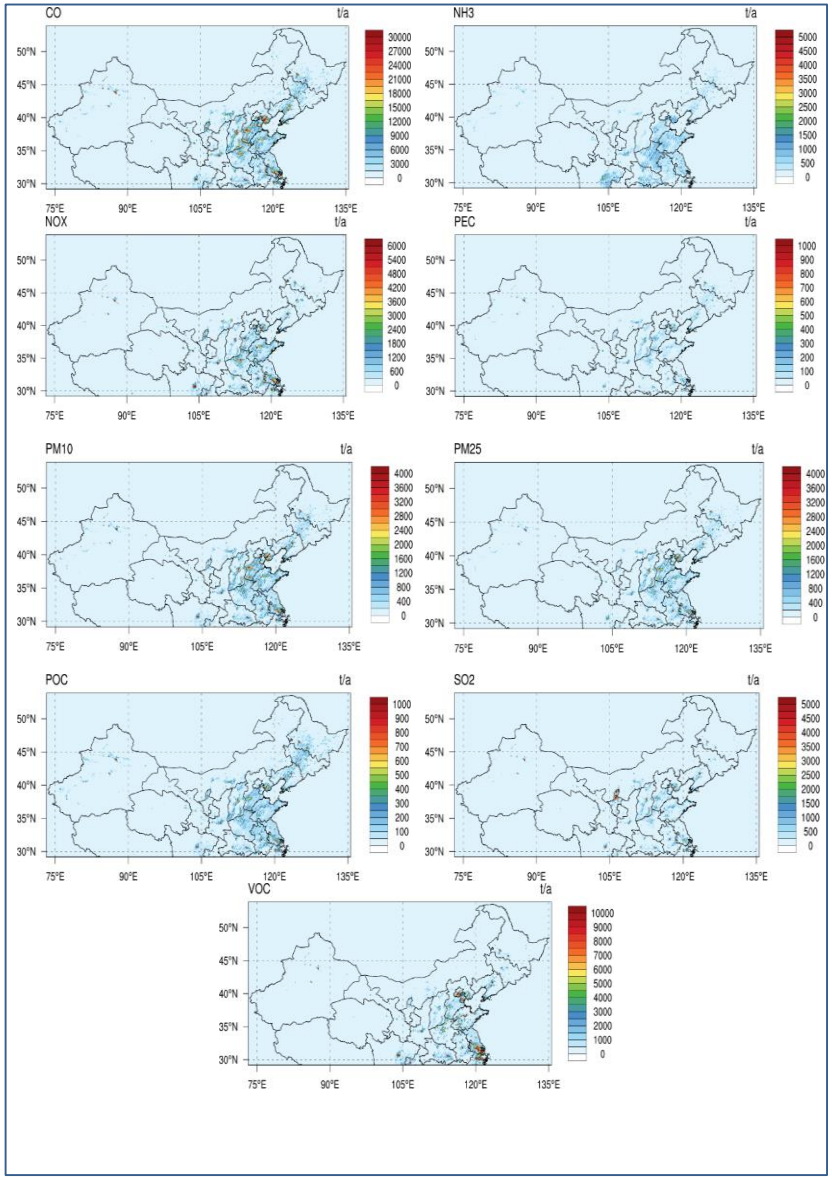


ChiNorBC 2018 inventory 新建清单2018

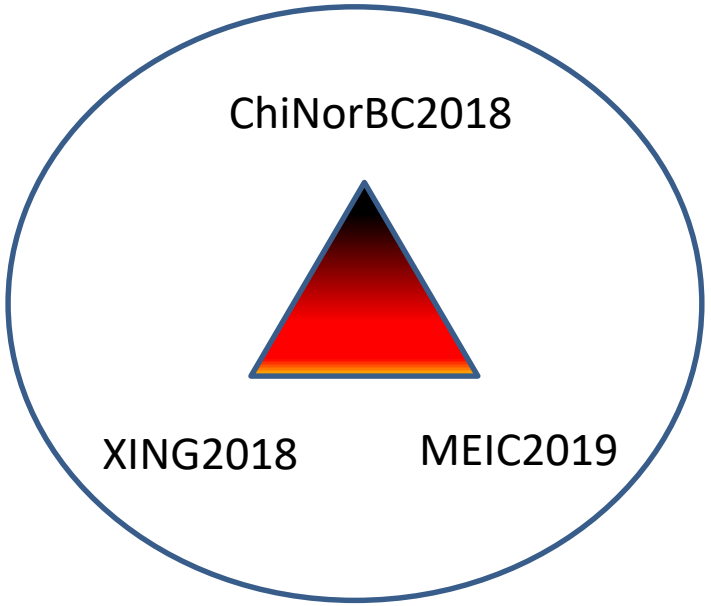
National 0.25*0.25



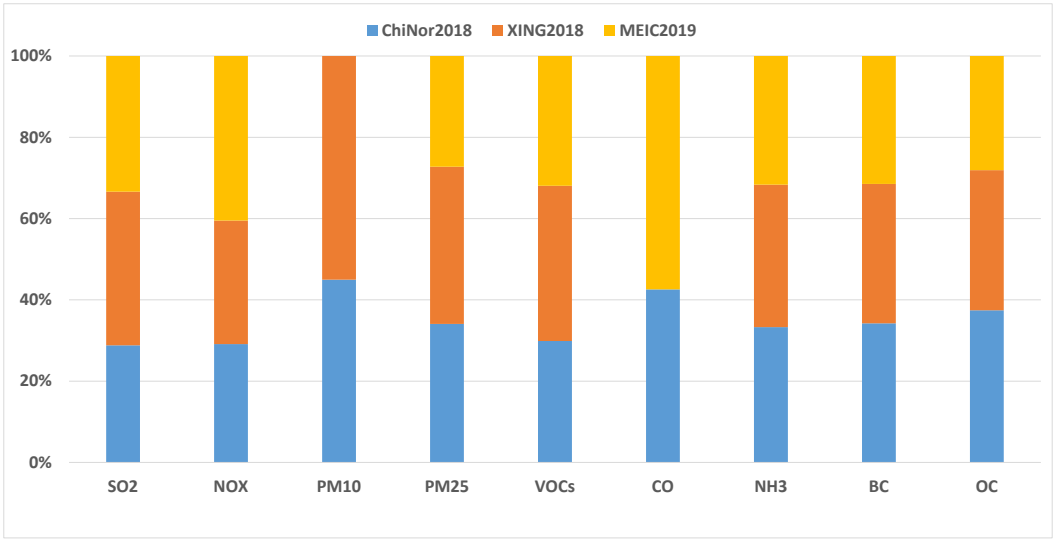
Northern 0.10*0. 10



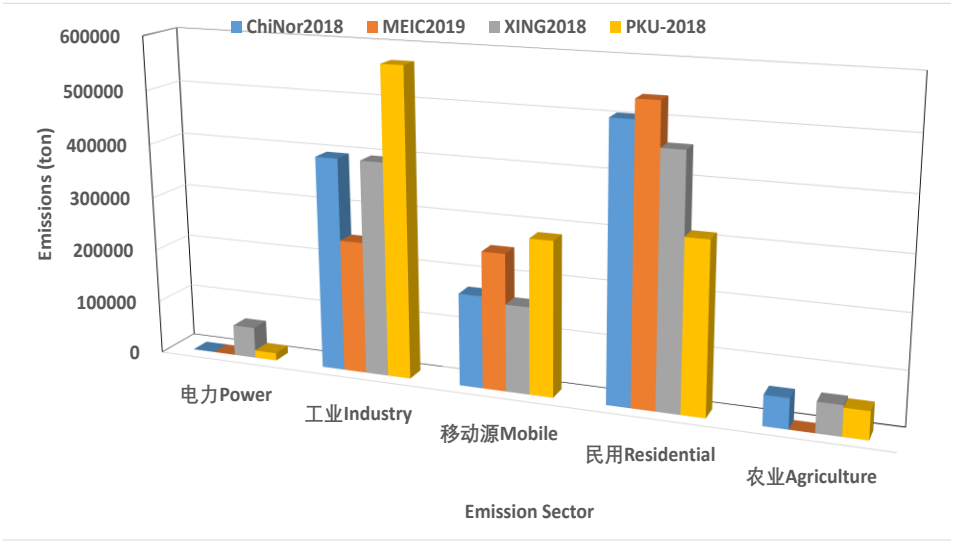
Comparison between inventories清单



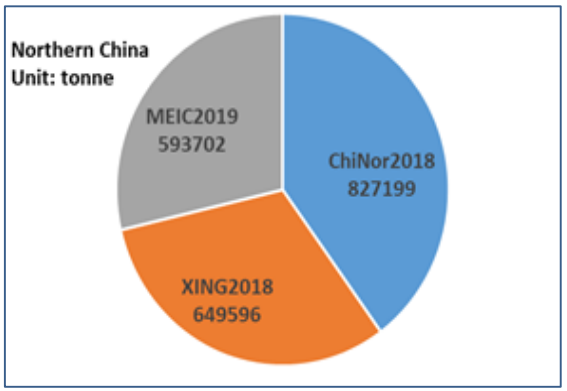
Comparison between Pollutant specific totals



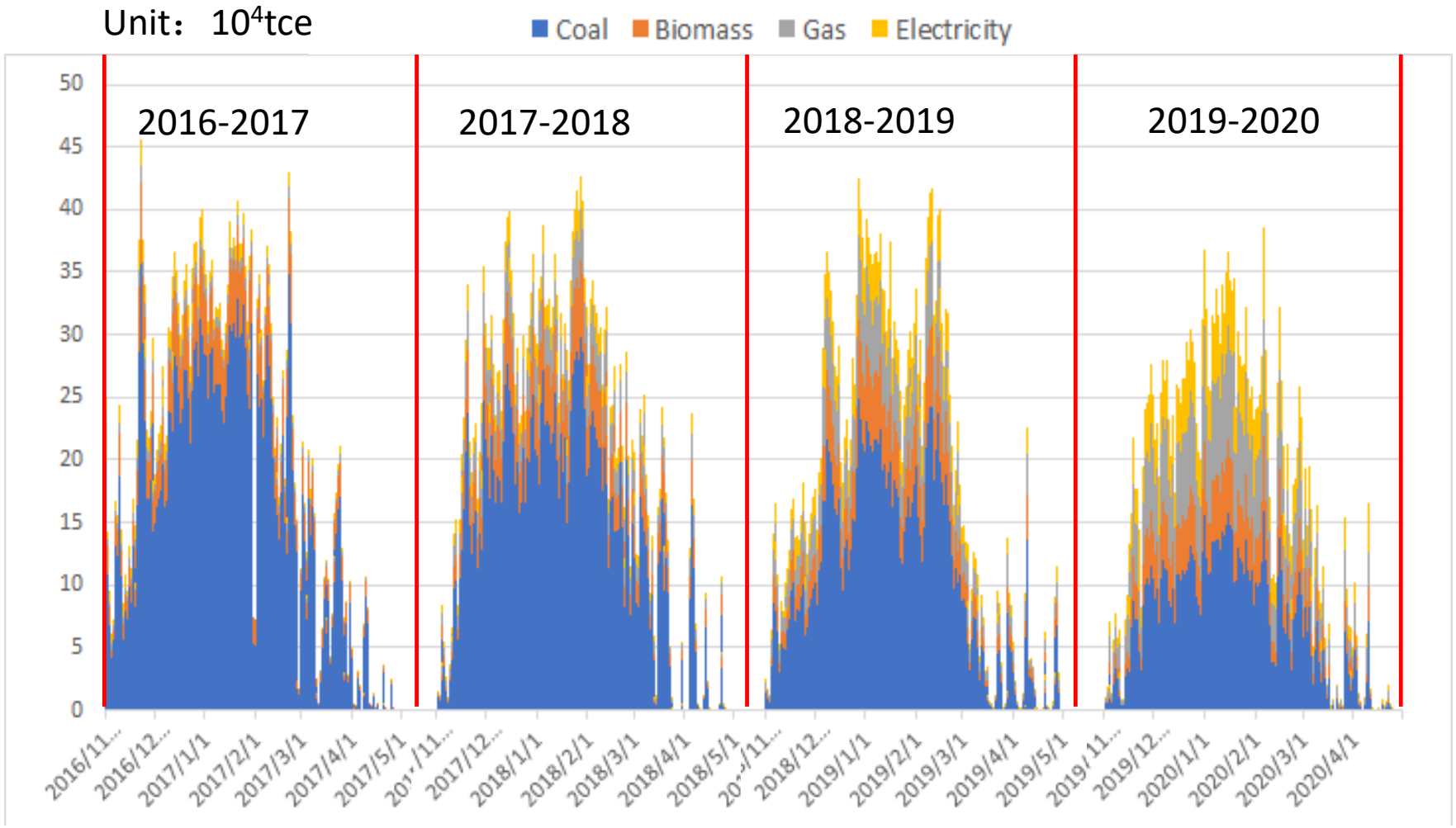
Comparison, sector-specific (national inventories)



Comparison, three inventories (northern China inventory)



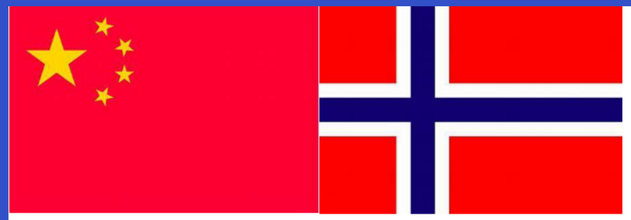
The Beijing-Tianjin-Hebei region and its surrounding areas everyday energy consumption



谢 谢！

Thank You!

CICERO

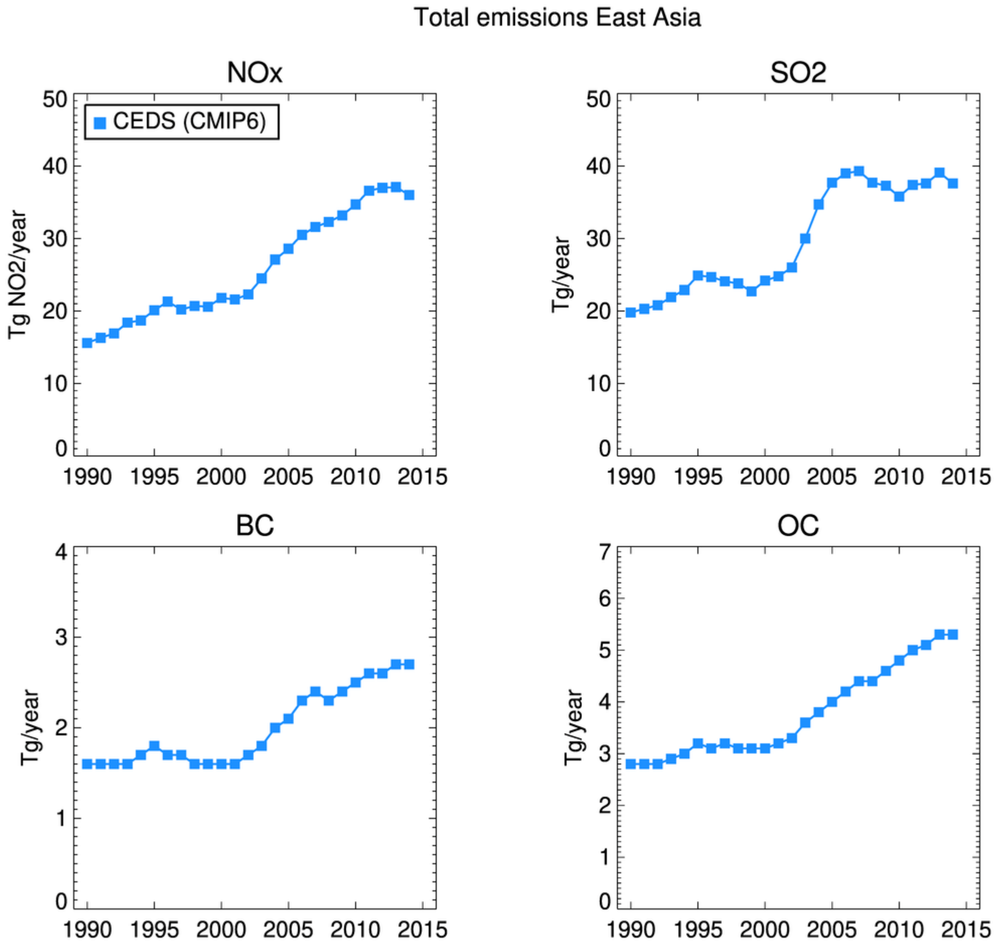


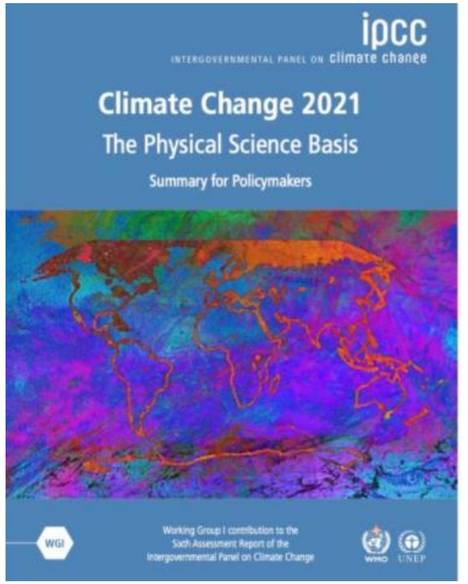
Chinese-Norwegian Project on Emission, Impact, and Control Policy for Black Carbon and its Co-benefits in Northern China Kick-off Meeting
中国-挪威合作中国北方地区黑碳排放、影响、控制对策及其协同效应研究项目启动会

ChiNorBC emissions in context of recent global inventories

Marianne T. Lund, research director, CICERO
ChiNorBC workshop December 15th 2021, Beijing/Zoom

Chinese emissions of aerosols and precursors overestimated in the emission inventory used for the CMIP6/IPCC AR6 work





Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization

Veronika Eyring[1], Sandrine Bony[2], Gerald A. Meehl[3], Catherine A. Senior[4], Bjorn Stevens[5], Ronald J. Stouffer[6], and Karl E. Taylor[7]

Chinese emissions of aerosols and precursors overestimated in the emission inventory used for the CMIP6/IPCC AR6 work

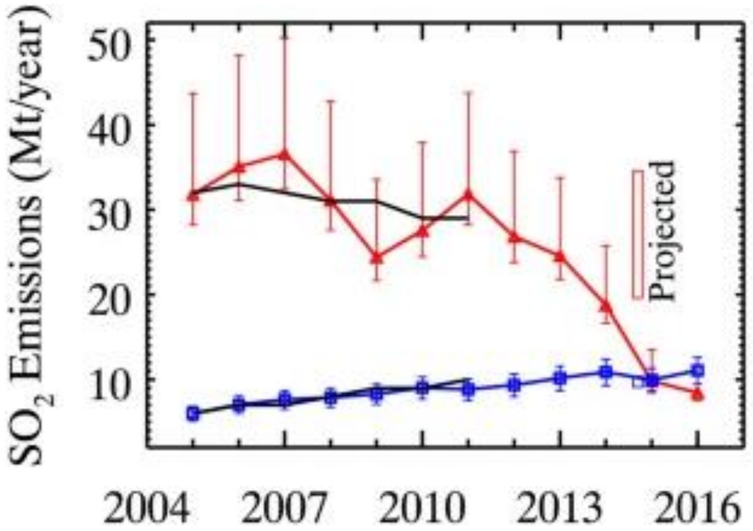
Article | Open Access | Published: 09 November 2017

India Is Overtaking China as the World's Largest Emitter of Anthropogenic Sulfur Dioxide

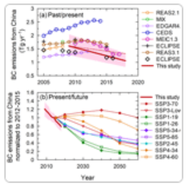
Can Li, Chris McLinden, Vitali Fioletov, Nickolay Krotkov, Simon Carn, Joanna Joiner, David Streets, Hao He, Xinrong Ren, Zhanqing Li & Russell R. Dickerson

Scientific Reports **7**, Article number: 14304 (2017) | Cite this article

15k Accesses | **157** Citations | **344** Altmetric | Metrics

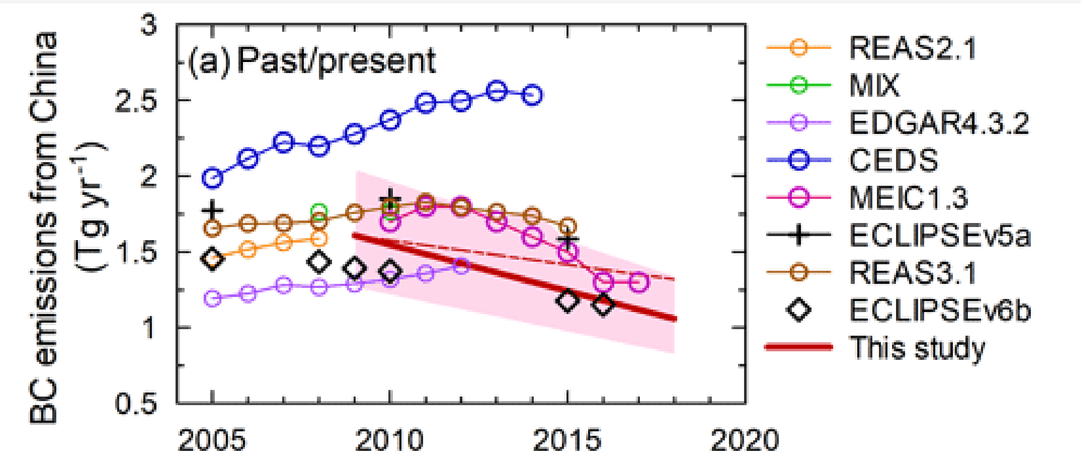


Rapid reduction in black carbon emissions from China: evidence from 2009–2019 observations on Fukue Island, Japan

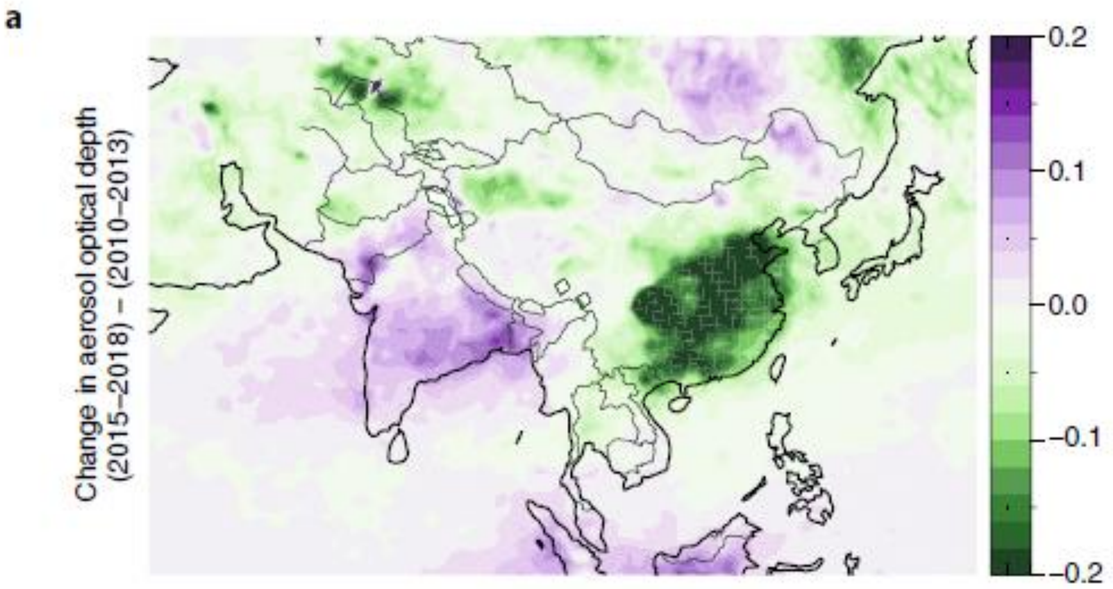


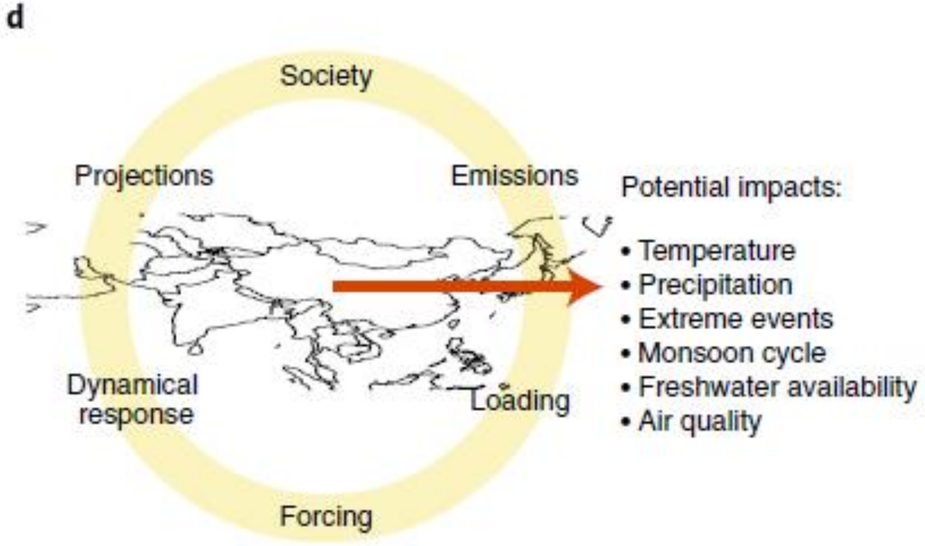
Yugo Kanaya[1,2], Kazuyo Yamaji[2,1], Takuma Miyakawa[1], Fumikazu Taketani[1,2], Chunmao Zhu[1], Yongjoo Choi[1], Yuichi Komazaki[1], Kohei Ikeda[3], Yutaka Kondo[4], and Zbigniew Klimont[5]

[1]Research Institute for Global Change (RIGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Kanagawa, 236-0001, Japan



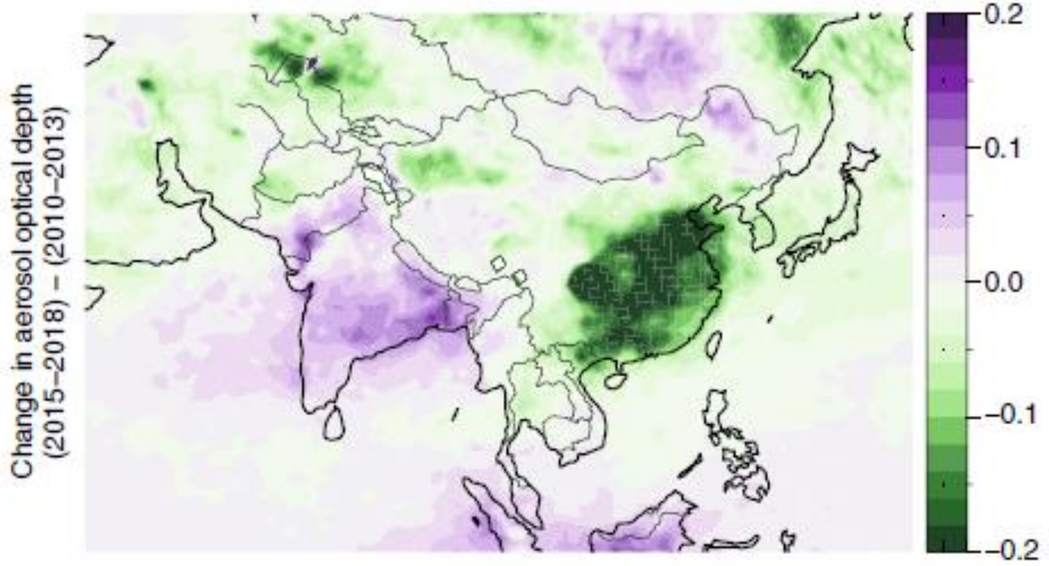
Rapid changes in pollution are evident from satellites – and are expected to have important but still poorly quantified climate and societal effects





Improved understanding of such implications is confounded by, among other things, uncertainty in emissions

a



d

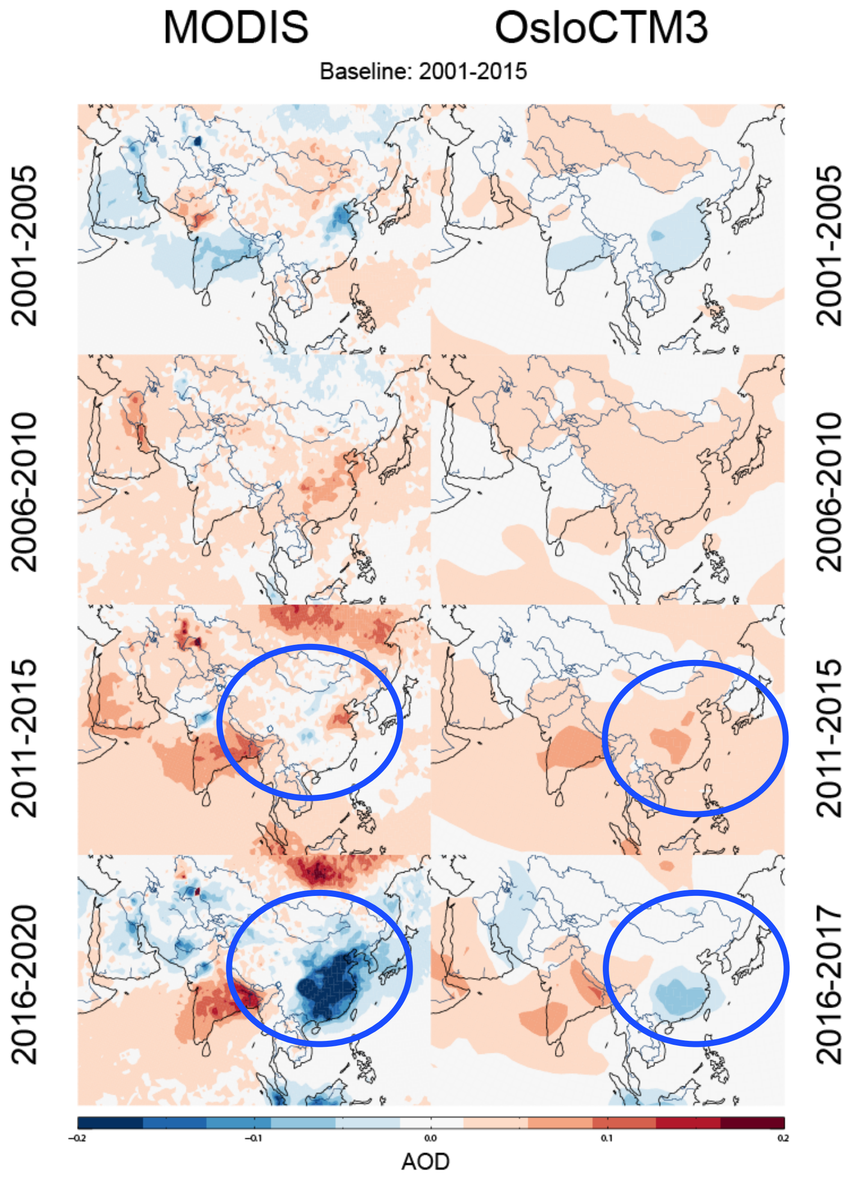
Article | Open Access | Published: 14 January 2021

Incorrect Asian aerosols affecting the attribution and projection of regional climate change in CMIP6 models

Zhili Wang, Lei Lin ✉, Yangyang Xu, Huizheng Che, Xiaoye Zhang, Hua Zhang, Wenjie Dong, Chense Wang, Ke Gui & Bing Xie

npj Climate and Atmospheric Science **4**, Article number: 2 (2021) | Cite this article

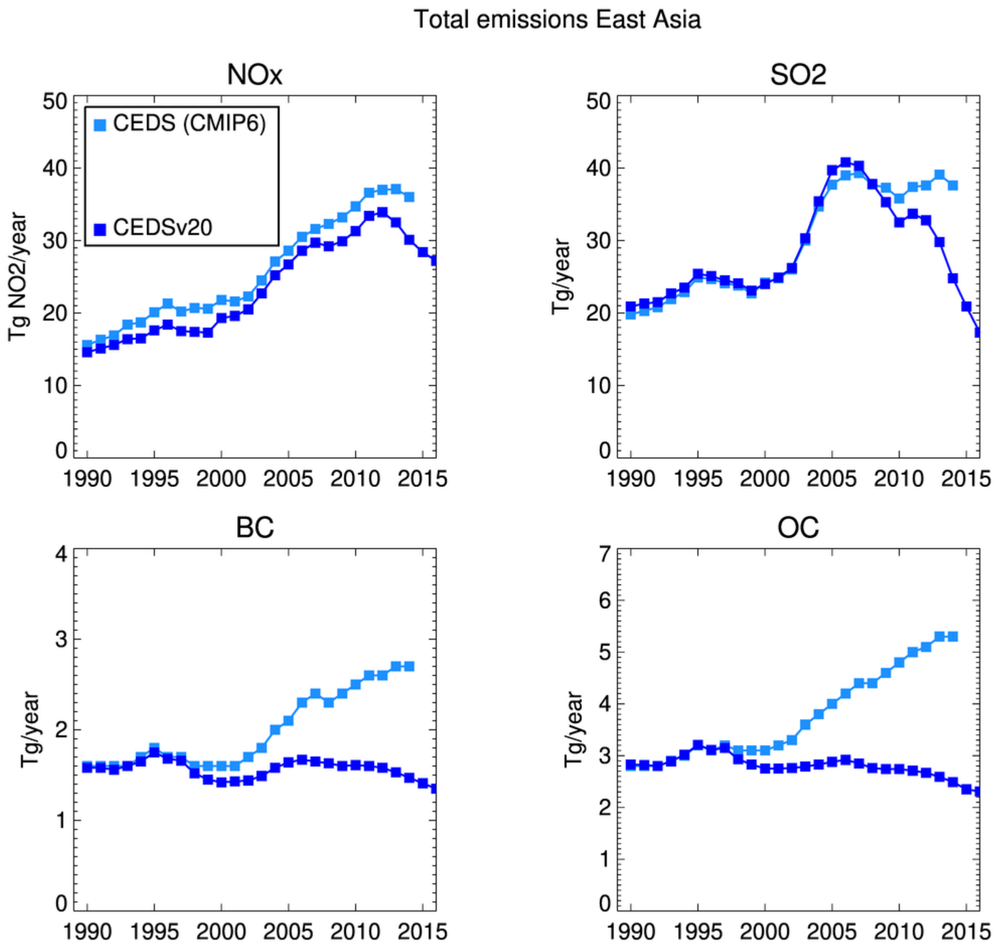
Observed declining trend not fully captured in modeling using the CEDSv17 emissions



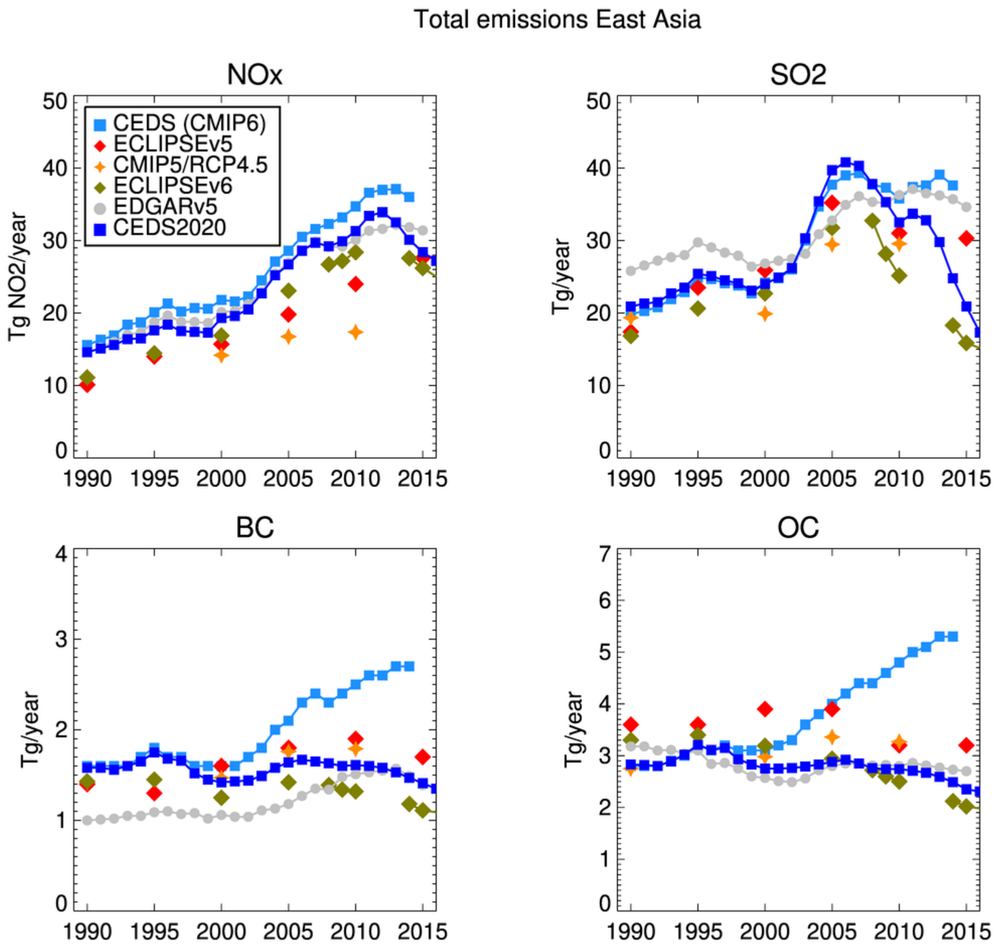
5 year differences (from the 2001-2015 baseline period) in aerosol optical depth.
Left: Satellite retrieval (MODIS)
Right: model (OsloCTM3) output

NB, preliminary results, please do not cite/distribute

Update of CEDS captures the recent decadal trend better



But there’s still a broad range in emission totals in inventories



Of additional importance;

- Seasonal cycle
- Spatial emission distribution
- Sector distributon
- …

°CICERO

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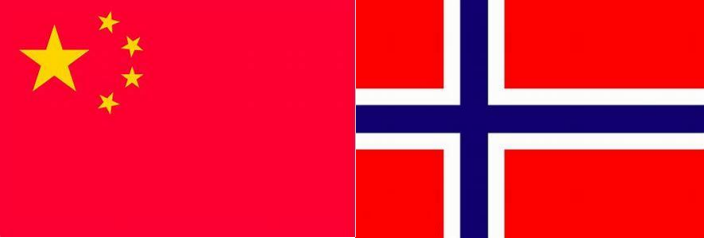


Output 3: Evaluation the effects of BC/OC based on the updated emissions inventory in northern China

课题3：基于中国北方地区最新排放清单的BC/OC影响评估

Model performance assessment based on high-resolution, up-to-date emission inventories in China

中国区域基于高分辨率的最新排放清单的模型性能评估

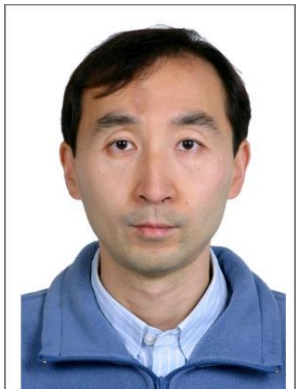
CRAES Chinese Research Academy of Environmental Sciences
中国环境科学研究院

CICERO Center for International Climate Research, Oslo, Norway
挪威奥斯陆国际气候研究中心

Beijing, China 2021.12.15

CRAES:

Du Xiaohui



Xu Jun

Meng Fan

Cheng Miaomiao

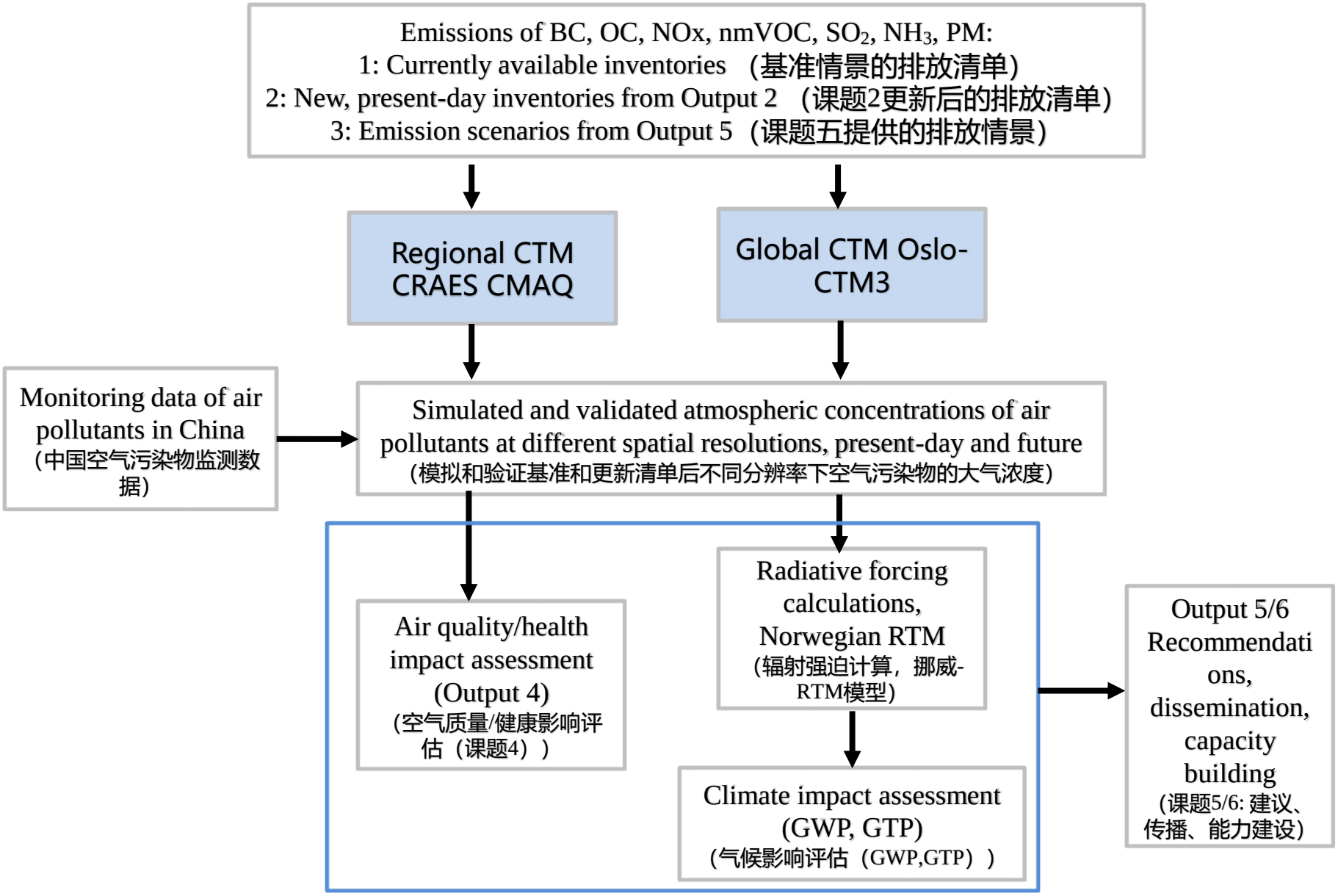
CICERO:

Marianne Tronstad Lund

Jan Fuglestvedt

Gunnar Myhre

Output and Tasks Description（任务描述 ）



● Project Task Progress（项目任务进展 ）

• CRAES：

Finished

Workplan	2020			2021			
	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Outcome 3 Evaluate the effects of BC/OC based on the updated emissions inventory in northern China							
3.1 Review air quality modeling knowledge for northern China			Finish				
3.2 Collect monitoring data of air pollutants (available O_3, NO_2, CO, SO_2, $PM_{2.5}$, PM_{10}, BC, OC, and VOCs) with regional and urban backgrounds. Make the data available for model evaluation.		Complete monitoring data collection					
3.3 Develop global chemical transport models (CTM) (Oslo-CTM3 from Norway) and a regional CTM from China (CRAES CMAQ) and evaluate model performance with special focus on the East Asian region.			Finish the model performance evaluation				
3.4 Compare the simulated atmospheric levels of air pollutants from a regional (36×36 km and 12×12 km) CTM (CRAES CMAQ from China) using current emission inventories against observations. Sites in both relatively clean areas and severely polluted areas will be chosen.				Finsh the compare between simulation and observation			
3.5 Update the emissions inventories (BC, OC, Ozone precursors: NOx, CO, nmVOC and as well as $PM_{2.5}$/PM_{10}, SO_2 and NH_3) for Oslo-CTM3 and the CRAES CTM (CMAQ) using updated information provided by Output 2. Assess the inventory using the observed atmospheric levels.						Finsh the update for the emissions inventory	
3.6 Make high-resolution (12 × 12 km) simulations upon requests from Outputs for northern China and provide simulated pollutant concentrations under a base-year dependent on emission and meteorological data availability (most likely 2017/2018) using CRAES CMAQ , supplemented by coarser resolution Oslo-CTM3 simulations.							Finsh the simulation under the base year

● Project Task Progress（项目任务进展 ）

- **CRAES：**

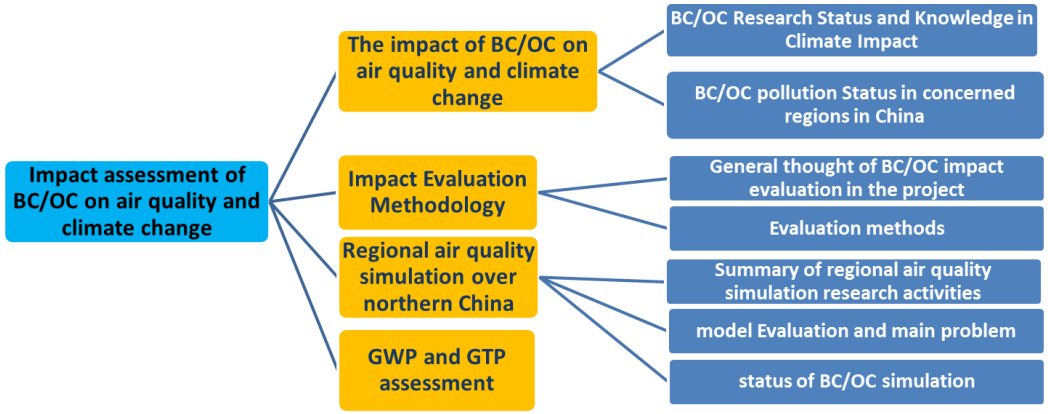
To be completed

	2021				2022
	1Q	2Q	3Q	4Q	1Q
3.7 Run models (Oslo-CTM3 and CRAES CMAQ) under conditions of different future emission scenarios provided by Output 5. Analyze and compare the simulated pollutant concentrations at the same areas as mentioned in 3.3 (East Asian Region).				Finsh the compare simulation result	
3.8 Make high-resolution (12 × 12 km) simulations upon requests from Outputs 4 (health) and 5 (policy) for northern China, and provide simulated concentrations to calculate air quality impacts of BC/OC from all emissions and specific sectors for northern China under future scenario emissions using CRAES CMAQ. Run Oslo-CTM3 using emissions from the same scenarios for calculation of radiative forcing.					Finsh the simulation under the future emission scenarios

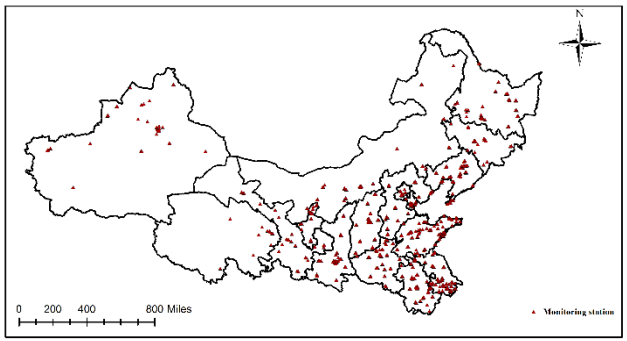
Project Tasks and Outputs（项目任务成果）

CRAES:

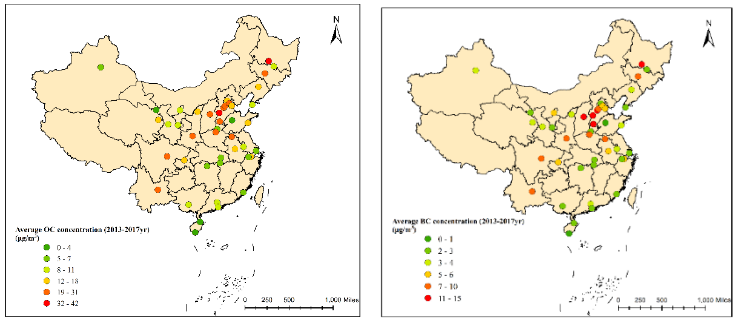
3.1 A literature review has been completed： the impact of BC/OC on air quality and climate change.（完成文献综述：BC/OC对空气质量和气候变化的影响。）



3.2 Monitoring datasets： Collected and processed air quality monitoring data(BC, OC, O_3, NO_2, CO, SO_2, $PM_{2.5}$ and PM_{10} , etc.) to meet assessment needs.（空气质量数据集：收集和处理空气质量监测数据（BC、OC、O_3、NO_2、CO、SO_2、$PM_{2.5}$、PM_{10}等），满足评价需要。）



The raw monitoring station.
空气质量国控站点分布



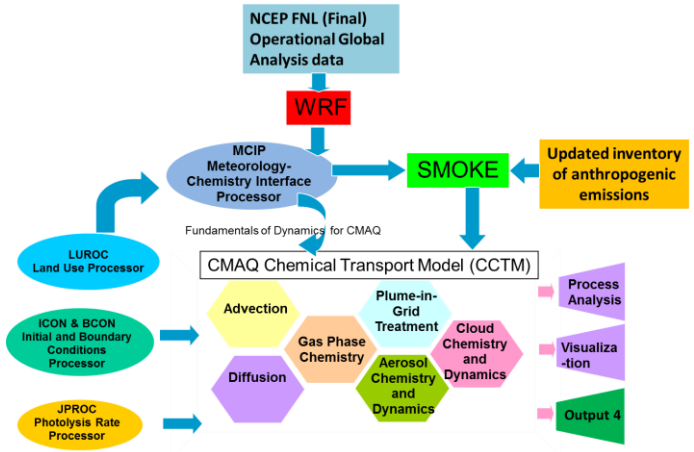
Distribution of aggregative BC/OC monitored concentrations collected in the literature and observations（文献收集及观测的BC/OC浓度空间分布）(Zhang Q , et al. Drivers of improved PM $_{2.5}$ air quality in China from 2013 to 2017).

Project Tasks and Outputs（项目任务成果）

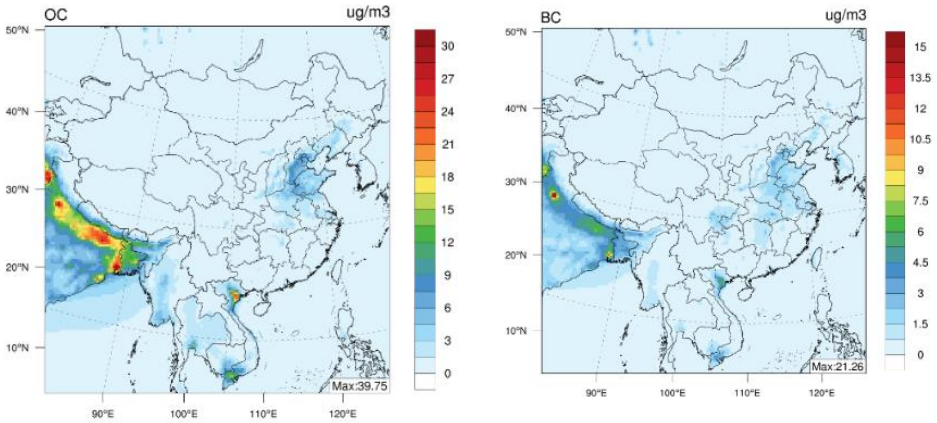
CRAES:

3.3 CMAQ modeling framework setup： Simulation Area and Grid Settings

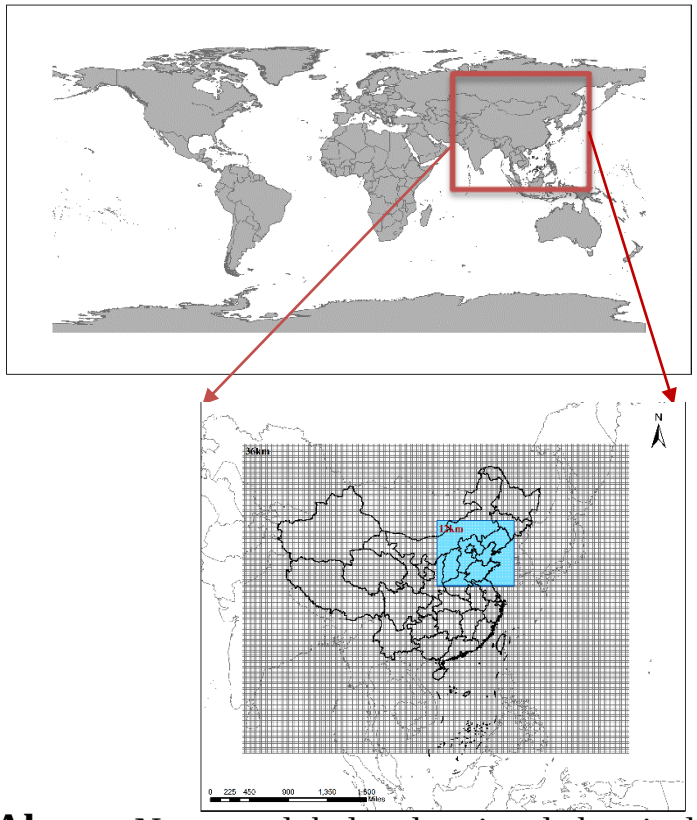
（CMAQ模拟框架搭建：模拟区域及网格设置）



Regional CTM – CMAQ model system



Used CMAQ to build a regional air quality modeling system and simulated air quality throughout 2018 based on existing emission inventories.（利用CMAQ建立区域空气质量建模系统，并基于现有排放清单模拟2018年全年的空气质量。）



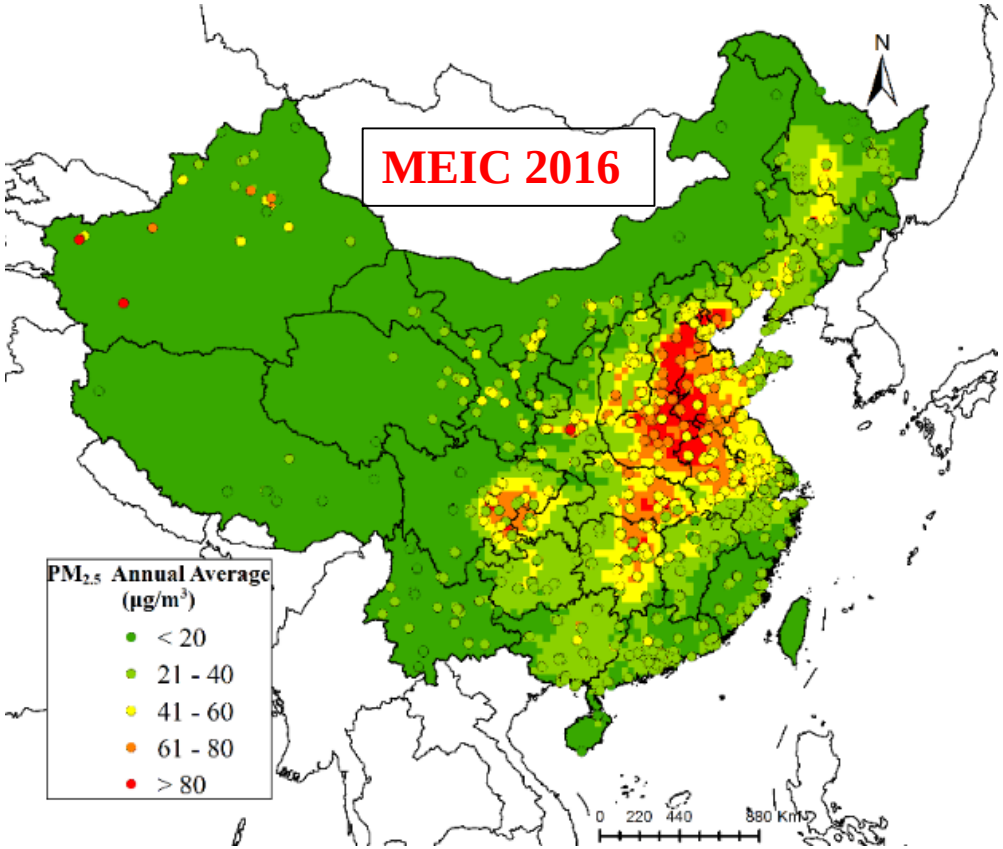
Above: Norway global and regional chemical transfer models domain at 12 by 12 km resolution.（上图：挪威全球和区域化学转移模型领域，分辨率为12×12公里。）

Bottom: CMAQ master and nested domains at 36/12 km resolutions.（下图：CMAQ主网格和嵌套网格区域，分辨率为36/12km。）

Project Tasks and Outputs（项目任务成果）

CRAES:

3.4 Evaluating the performance for current emission inventories （对当前排放清单的初步评估）：



- An underestimation of PM_{10} and CO;

（PM_{10}和CO低估）；

- An overestimation of the BC,OC,$PM_{2.5}$,O_3,SO_2 and NO_2.

（其他污染物存在不同程度的高估）。

Model performance statistics for simulated pollutants concentrations against observations over the China in 2018
（2018年中国区域模拟污染物浓度与观测数据的模型性能统计）

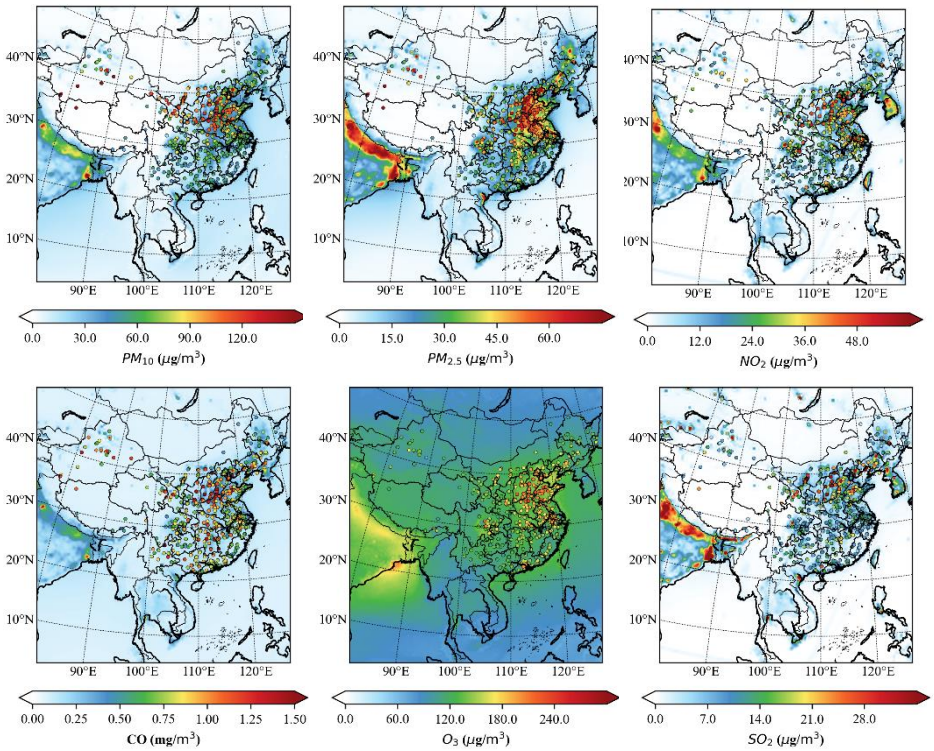
Species	NMB	NME	R
O_3	4%	18%	0.85
$PM_{2.5}$	24%	62%	0.61
PM_{10}	-25%	52%	0.44
SO_2	206%	215%	0.56
NO_2	19%	36%	0.76
CO	-13%	43%	0.63
OC	161%	173%	0.59
BC	169%	190%	0.53

Project Tasks and Outputs（项目任务成果）

CRAES:

3.5-3.6 Evaluating the performance for new emission inventories and make high-resolution (12 × 12 km)（对更新后的排放清单进行模型评估，并进行精细化分辨率的模拟）：

Conventional pollutants:



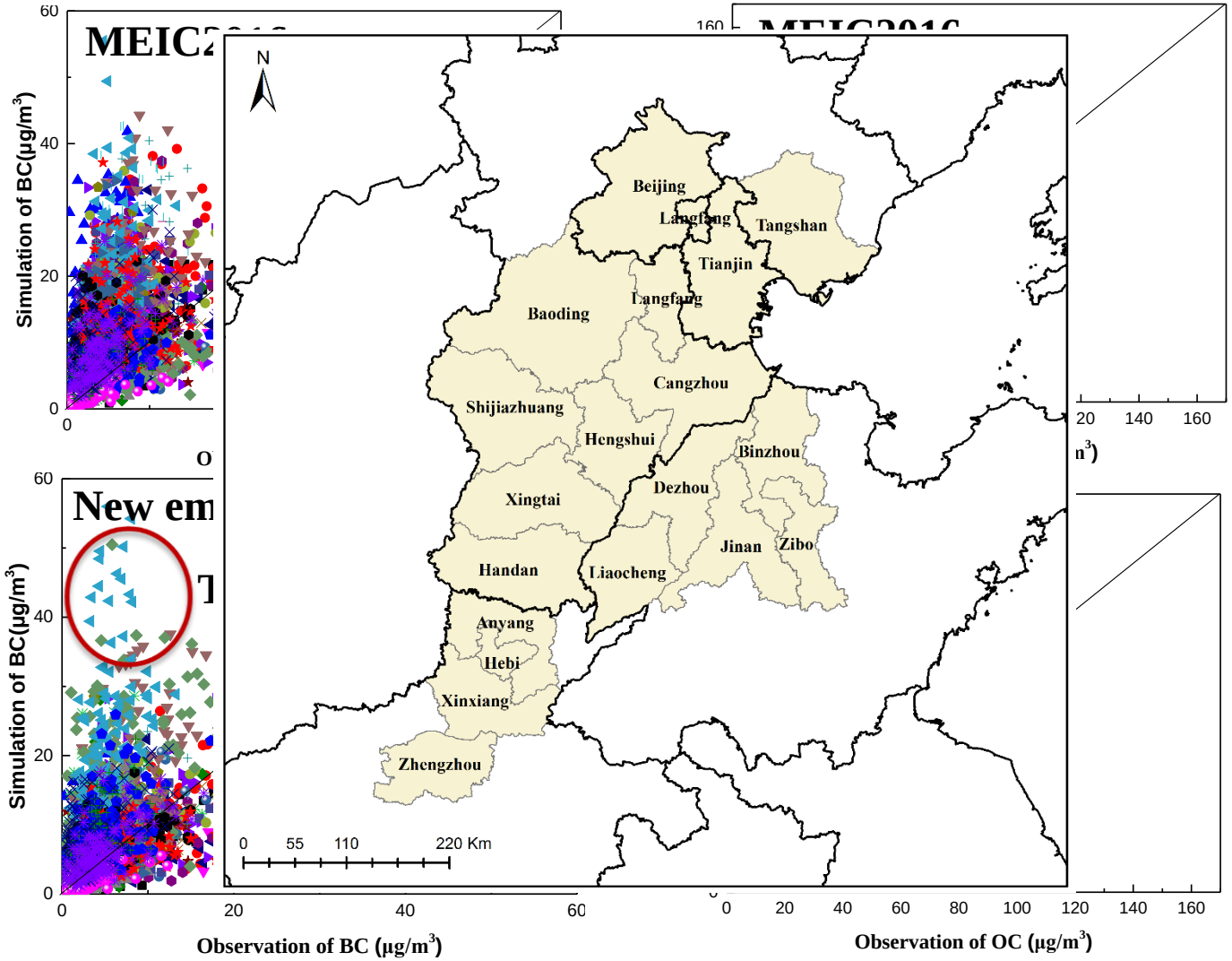
Model performance statistics for simulated pollutants concentrations against observations over the China in 2018
（2018年中国区域模拟污染物浓度与观测数据的模型性能统计）

Species	NMB	NME	R	
O_3	-4%	19%	0.85	-
$PM_{2.5}$	-17%	43%	0.69	↑
PM_{10}	-50%	56%	0.50	↑
SO_2	-19%	43%	0.69	↑
NO_2	-33%	37%	0.76	-
CO	-60%	60%	0.79	↑
OC	2%	50%	0.60	↑
BC	49%	78%	0.53	-

Project Tasks and Outputs（项目任务成果）

CRAES：

Model performance for simulated BC/OC against observations over 2+26 cities during 2018 heating season（2018年秋冬采暖季期间BC/OC模型评估结果）

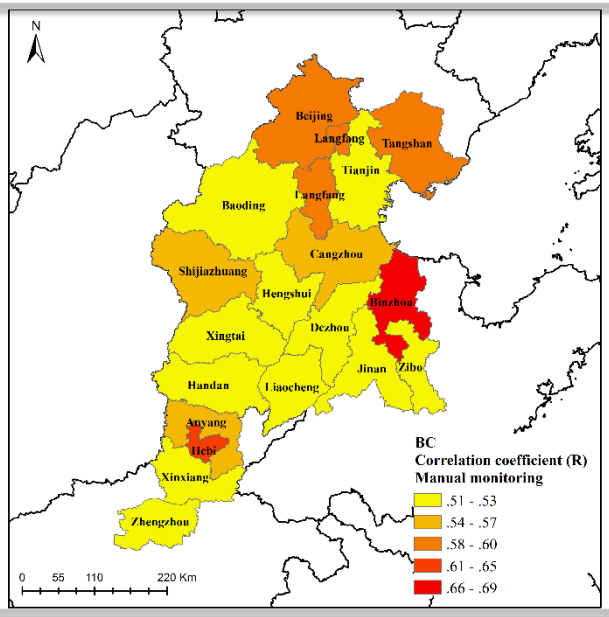


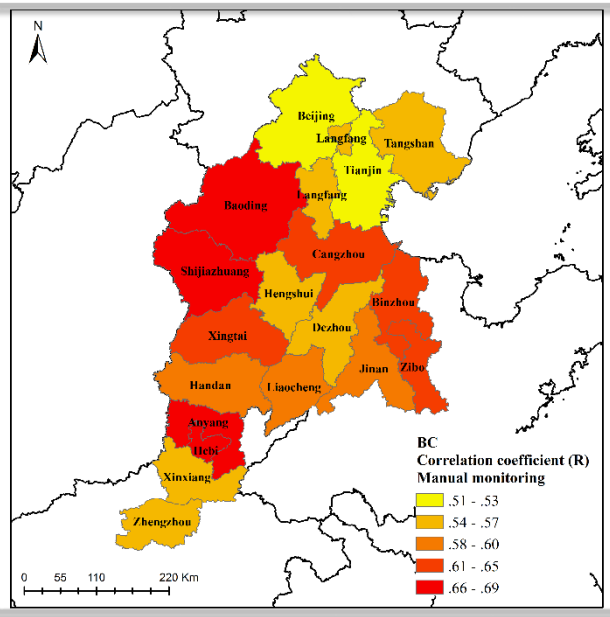
Manual monitoring：all cities

Comparison of Correlation coefficient (R)

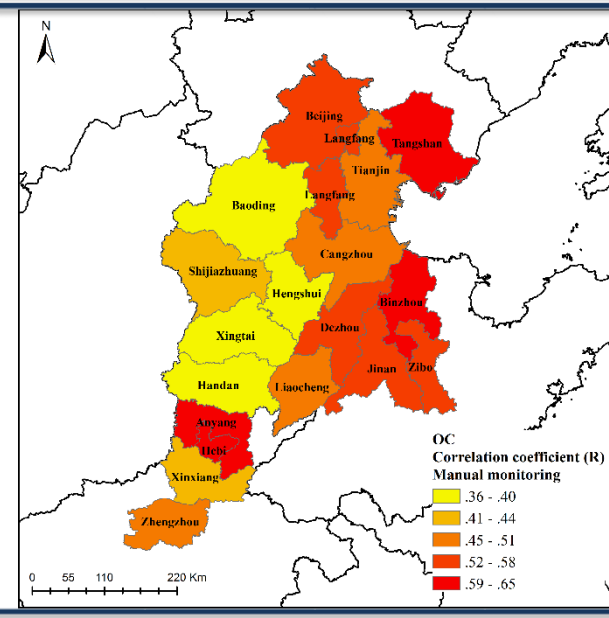
MEIC2016 | **New emission**

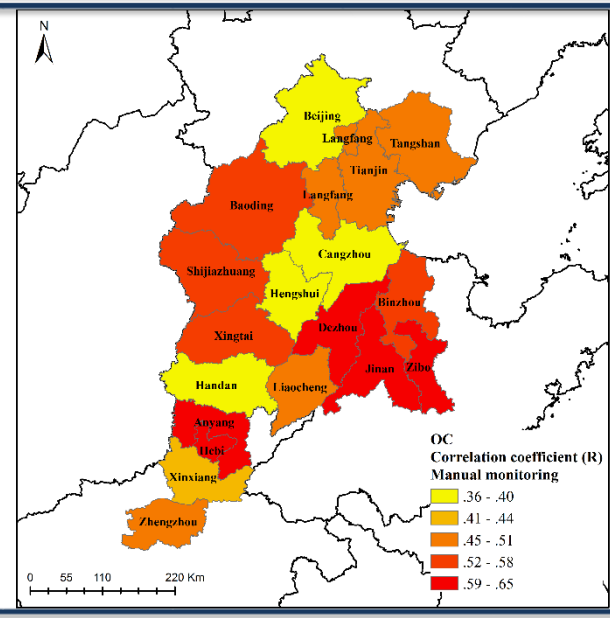
BC





OC

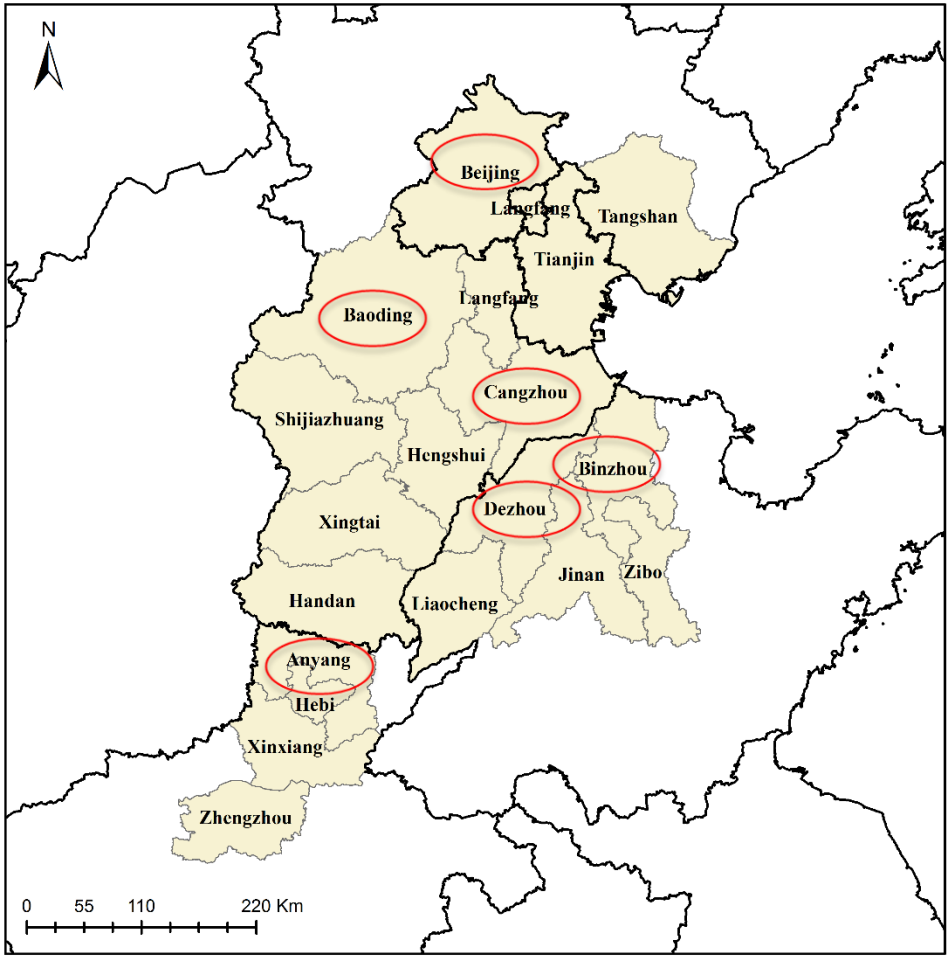




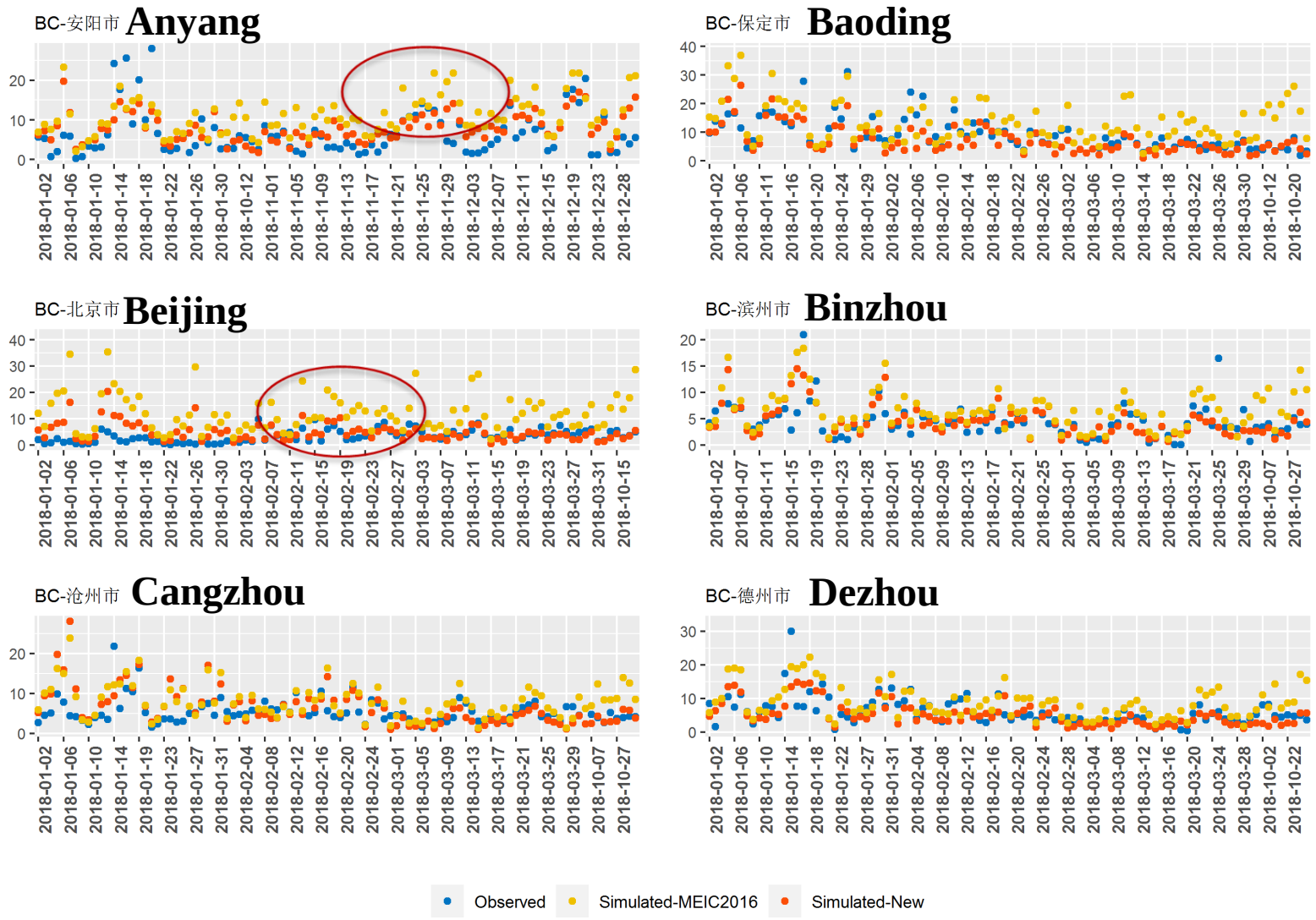
Project Tasks and Outputs（项目任务成果）

CRAES:

Time series comparison of MEIC2016 and new emission inventories for BC/OC concentrations in selected 2+26 cities （部分2+26城市MEIC2016和新排放清单模拟的BC/OC浓度时间序列对比）：



Project Tasks and Outputs（项目任务成果）

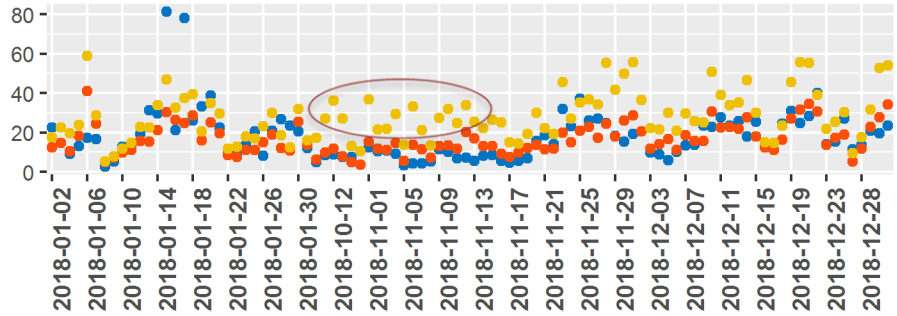


Time Series - Daily Average

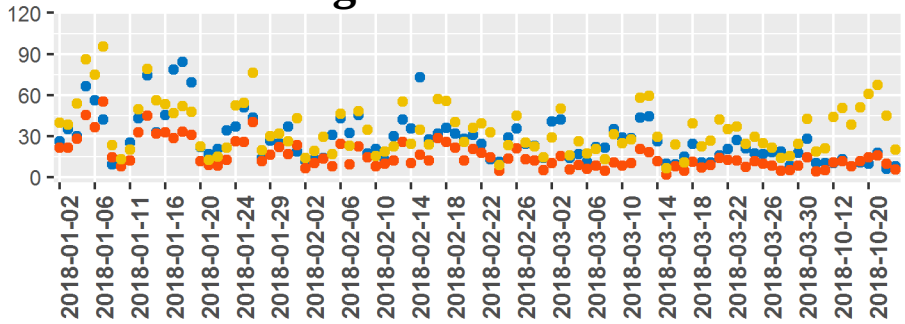
Manual monitoring

Project Tasks and Outputs（项目任务成果）

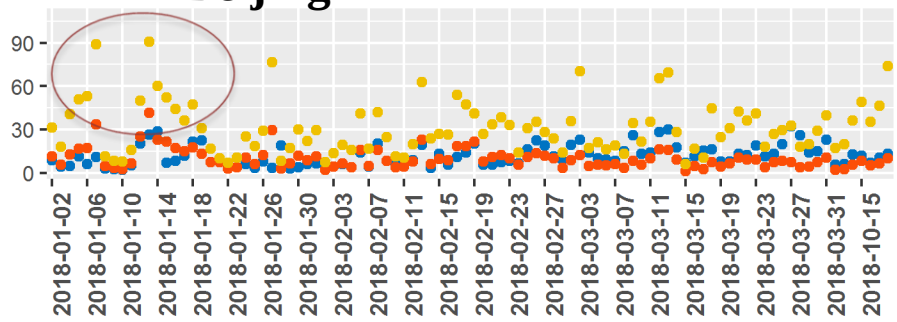
OC-安阳市 **Anyang**



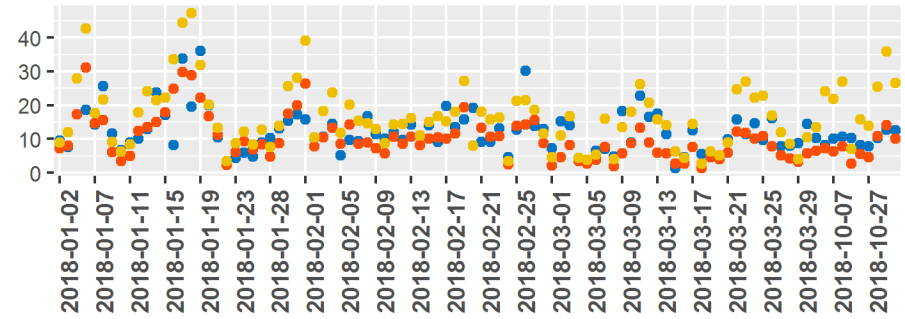
OC-保定市 **Baoding**



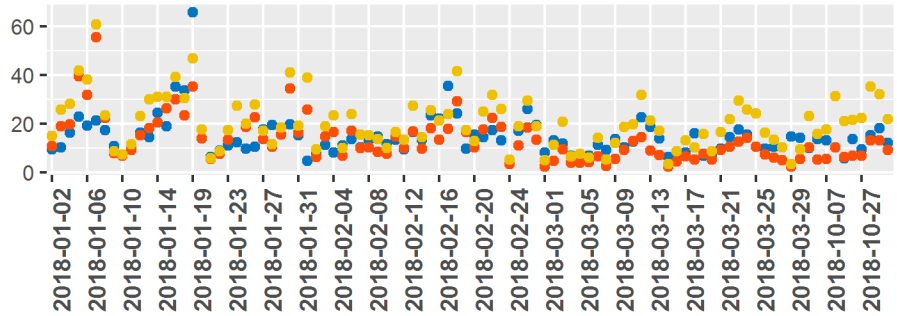
OC-北京市 **Beijing**



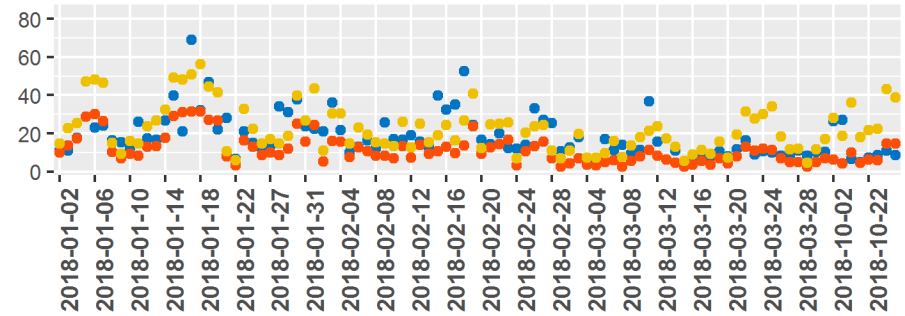
OC-滨州市 **Binzhou**



OC-沧州市 **Cangzhou**



OC-德州市 **Dezhou**



Observed　Simulated-MEIC2016　Simulated-New

Future Work Plan(下一步工作计划)

- Run models (**CRAES CMAQ**) under conditions of different **future emission scenarios provided by Output 5**. Analyze and compare the simulated pollutant concentrations at the same areas as mentioned in 3.3 (East Asian Region).

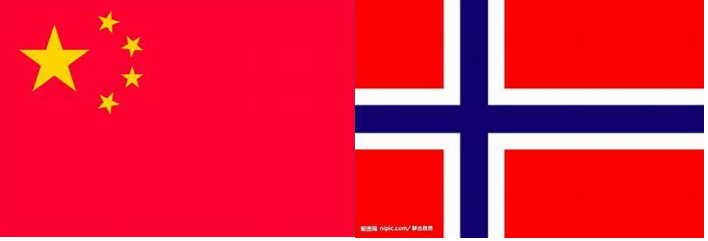
  （分析和比较由**课题5**提供的不同的未来排放情景下模型模拟的污染物浓度变化）

- Make high-resolution (12 × 12 km) simulations upon requests from Outputs 4 (health) and 5 (policy) for northern China, and provide simulated concentrations to calculate air quality impacts of BC/OC from all emissions and specific sectors for northern China under **future scenario emissions** using CRAES CMAQ.

  （根据**课题4和5**的要求提供不同排放情景下的高分辨率的模拟结果）

谢 谢！

Thank You!



Kickoff Meeting of Chinese-Norwegian Project
中国-挪威合作研究项目

黑炭的健康影响
Health Effects of BC

中国环境科学研究院

Chinese research academy of environmental sciences

挪方研究机构

Norwegian Institution of Public Health

Professor Yongjie Wei

Dr Zhigang Li

Dr Xiaojing Zhu

Dr. Per Schwarze

Dr. Shilpa Rao-Skirbekk

Dr. Marit Låg

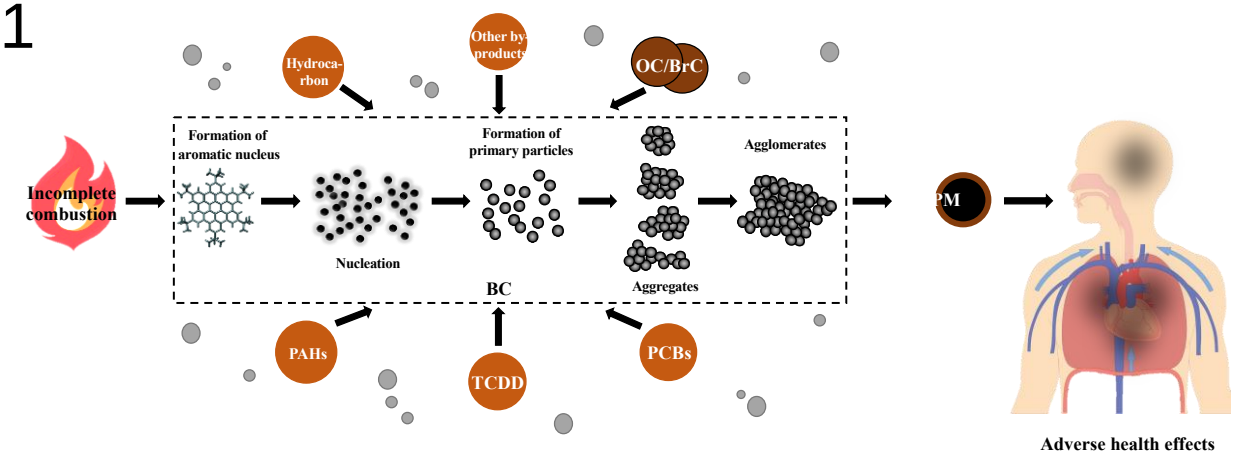
Beijing, China 2021.12.15

Outline

1. Background
2. Meta Analysis
3. Toxicology Study
4. Progress & Prospectives

Background

- Our work is in the Output 4-- Health Effects of BC, is to reveal the health effects of BC in $PM_{2.5}$ and To provide policymakers with a robust scientific basis for developing mitigation strategies for BC
- This output mainly include literature review, cell and animal study for understanding the toxicity of EC/$PM_{2.5}$
- BC has a very large specific surface area and can adsorb many chemicals that can have adverse health effects when inhaled
- WHO proposed health assessment of BC in the new AQG2021



Background--Study content

3. Review of literature and statistical analysis of existing studies

1. Sample particles (PM$_{2.5/1}$, BC/OC) collation

2. chemical characterization

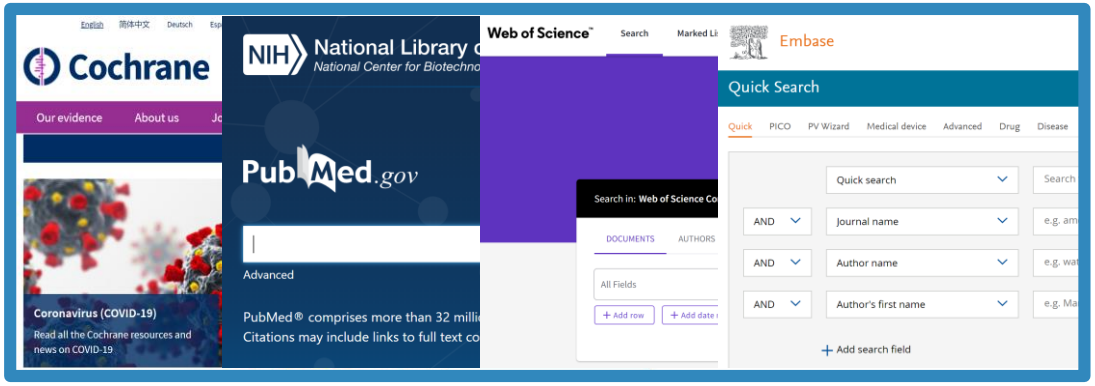
4.Animal study

6.Cell culture

5.Biomarkers

7. Identify the potential key drivers of adverse health effects

Meta Analysis-Review



No.	Searching formula
#1	"black carbon*" OR "elemental carbon … reflectance" OR "black… … "diesel exhaust particle*"
#2	"Air Pollution*" OR "Air Pollutant*" OR … OR "atmospheric pollut…
#3	"mortality" OR "mortalities" OR "case … "rate, crude death" OR "death rate*" OR "rate, death" OR "death" OR "mortality determinants" OR "determinant*, mortality" OR "mortality determinant" OR "mortality, differential" OR "incidence* … rate, secondary" OR "ra… …ary … "attack rate*" OR "rate, attack" OR "p… … OR "rate, person-time" OR "morbidity" OR "morbidities" OR "prevalence" OR "prevalences"
#4	"meta" OR "meta-analysis" OR "meta… … analyses" OR "metaanaly… … syntheses" OR "metasyntheses" OR "m… … "systematic review*"
#5	#1 AND #2 AND #3
#6	#1 AND #2 AND #3 AND #4

Pollutants

Air pollution

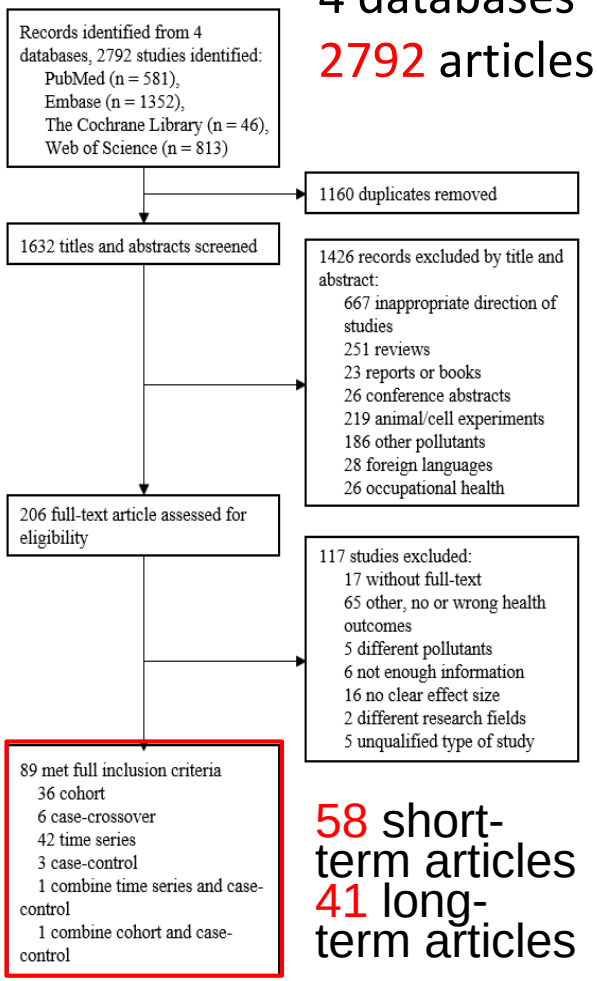
Health outcomes

Meta-analysis

Identification

Screening

Included



4 databases

2792 articles

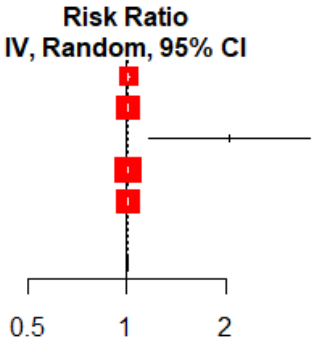
58 short-term articles

41 long-term articles

Meta Analysis-Short term exposure

Study	TE	SE	Weight	Risk Ratio IV, Random, 95% CI
Ballester.1996	0.01	0.0031	15.5%	1.01 [1.00, 1.02]
Ballester.2002	0.01	0.0018	28.0%	1.01 [1.00, 1.01]
Kim.2015	0.72	0.2869	0.0%	2.05 [1.17, 3.60]
Le Tertre.2002	0.01	0.0015	31.1%	1.01 [1.00, 1.01]
Sunyer.1996	0.01	0.0020	25.4%	1.01 [1.00, 1.01]
Total (95% CI)			**100.0%**	**1.01 [1.00, 1.01]**

Heterogeneity: $Tau^2 < 0.01$; $Chi^2 = 7.58$, df = 4 (P = 0.11); $I^2 = 47\%$
Test for overall effect: Z = 4.86 (P < 0.01)

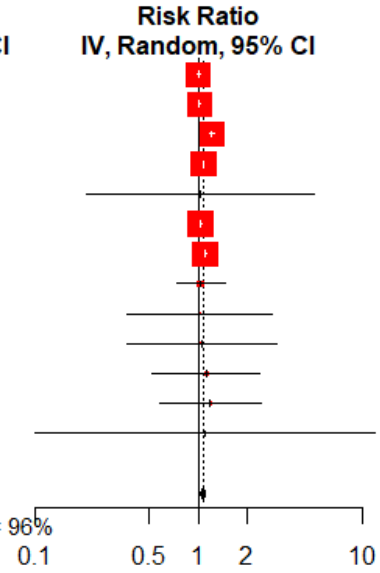


TM, CM, RM

Total mortality in association with a 10 μg/m^3 increase in BC

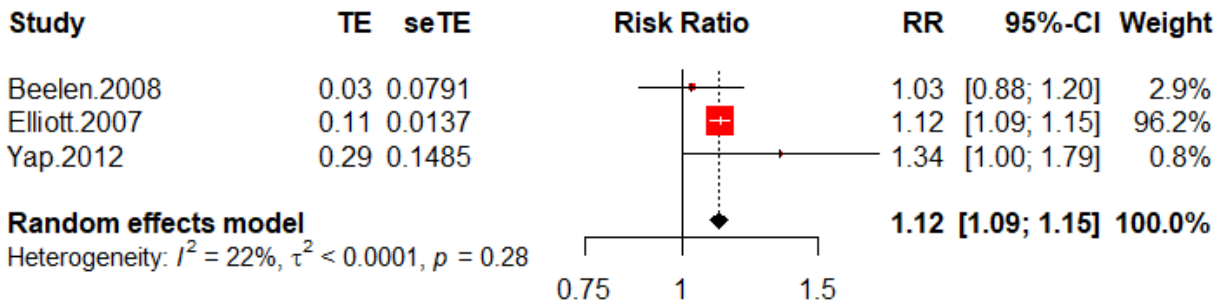
Study	TE	SE	Weight	Risk Ratio IV, Random, 95% CI
Ballester.1996	-0.00	0.0089	16.2%	1.00 [0.98, 1.02]
Ballester.2002	0.01	0.0038	16.8%	1.01 [1.00, 1.02]
Cakmak.2009	0.18	0.0149	15.2%	1.20 [1.17, 1.24]
Dab.1996	0.07	0.0048	16.7%	1.07 [1.06, 1.08]
Kim.2015	0.03	0.8137	0.0%	1.03 [0.21, 5.06]
Le Tertre.2002	0.03	0.0054	16.7%	1.03 [1.02, 1.04]
Sunyer.1996	0.09	0.0052	16.7%	1.10 [1.09, 1.11]
Yoo.2019	0.03	0.1734	1.0%	1.03 [0.73, 1.45]
Yoo.2019	0.01	0.5197	0.1%	1.01 [0.37, 2.80]
Yoo.2019	0.04	0.5382	0.1%	1.04 [0.36, 3.00]
Yoo.2019	0.11	0.3862	0.2%	1.11 [0.52, 2.37]
Yoo.2019	0.16	0.3617	0.2%	1.18 [0.58, 2.40]
Yoo.2019	0.09	1.2253	0.0%	1.09 [0.10, 12.07]
Total (95% CI)			**100.0%**	**1.06 [1.03, 1.10]**

Heterogeneity: $Tau^2 < 0.01$; $Chi^2 = 310.65$, df = 12 (P < 0.01); $I^2 = 96\%$
Test for overall effect: Z = 3.41 (P < 0.01)



Respiratory mortality in association with a 10 μg/m^3 increase in BC

Meta Analysis-Long term exposure



Lung cancer mortality in association with a 10 $\mu g/m^3$ increase in BC

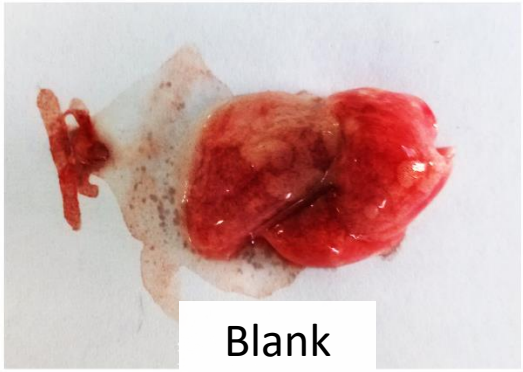
Brief Summary

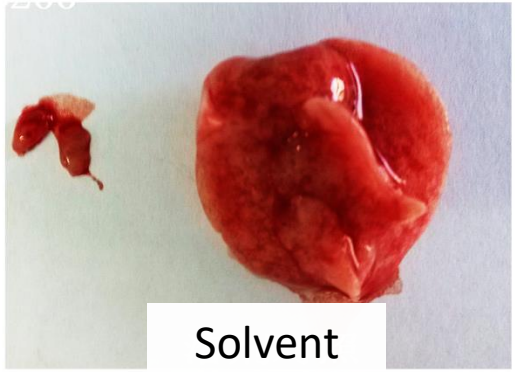
- Short-term exposure to BC was associated with increased total and respiratory mortality.
- Long-term exposure to BC was associated with increased lung cancer mortality only.

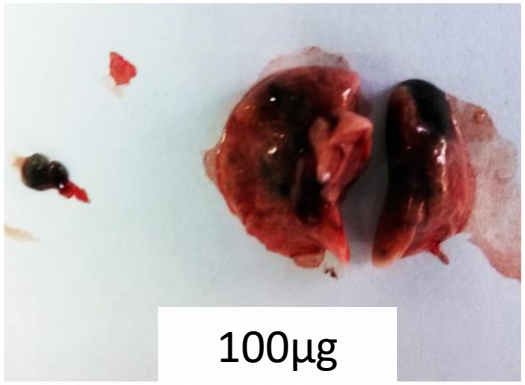
Toxicology Study-in vivo

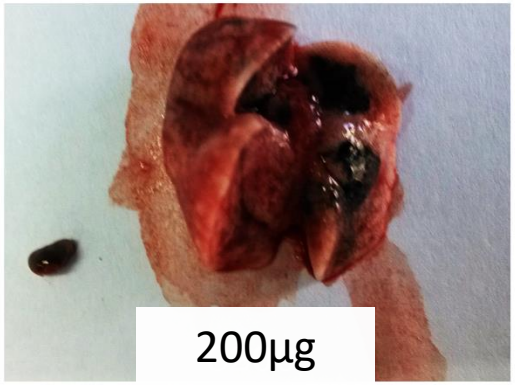
Animal study

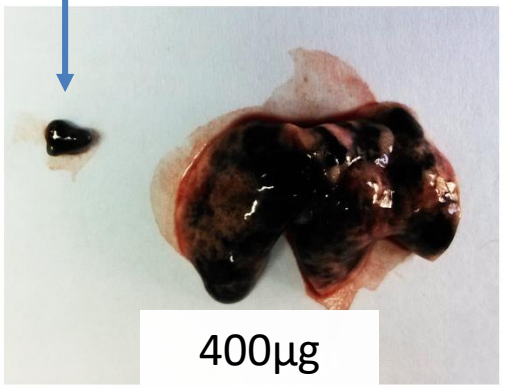
- C57BL/6 (n=7)，male mice，8-10weeks age
- 100μg ,200μg ,400μg twice a week for four weeks instillation





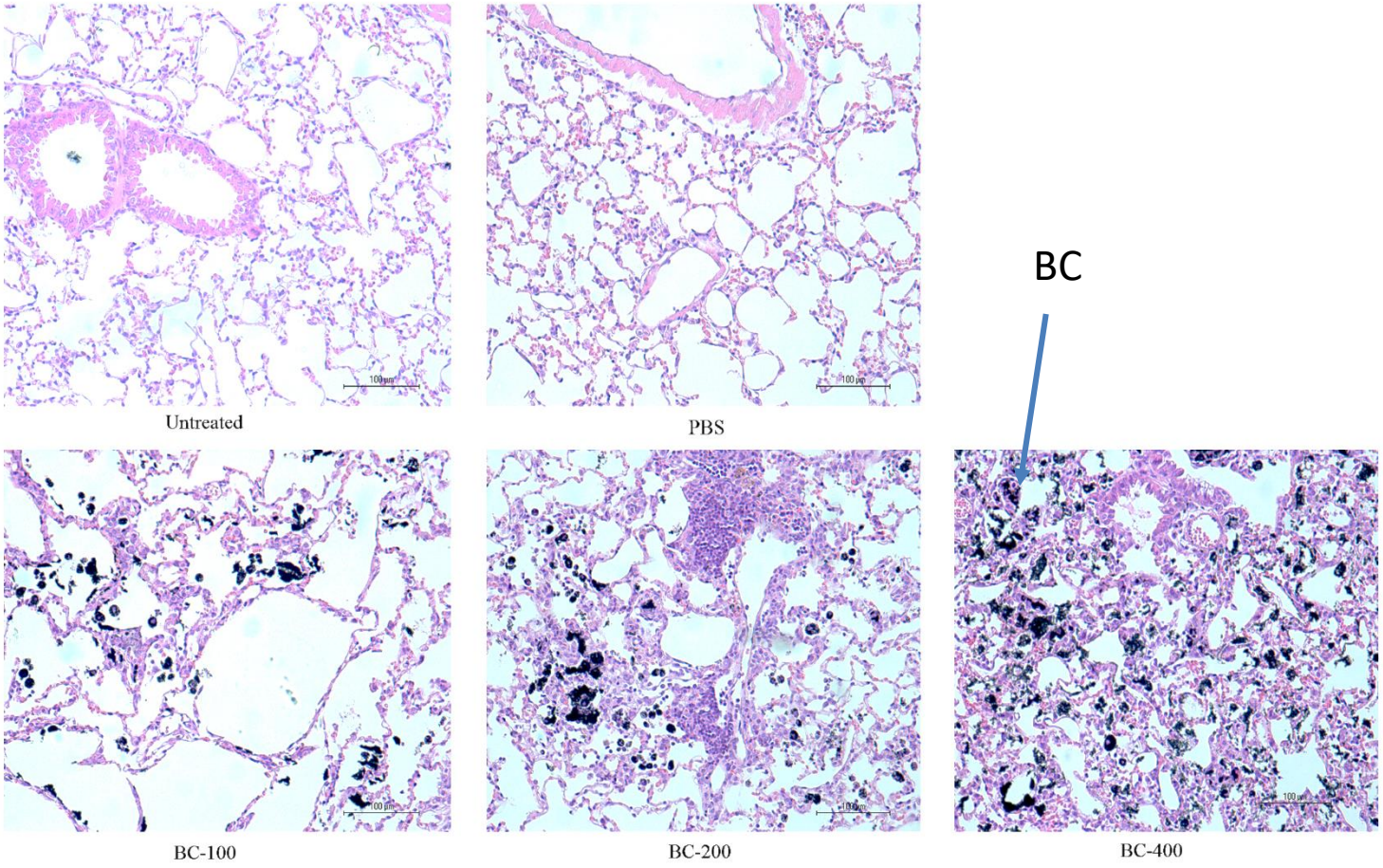






longitudinal section of lung

Toxicology Study-in vivo

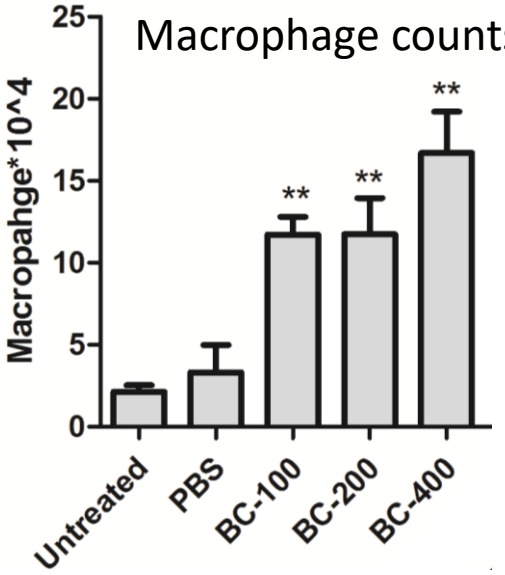


Histopathology of lung

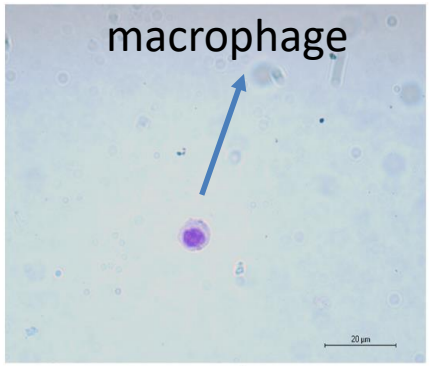
HE staining

Toxicology Study-in vivo

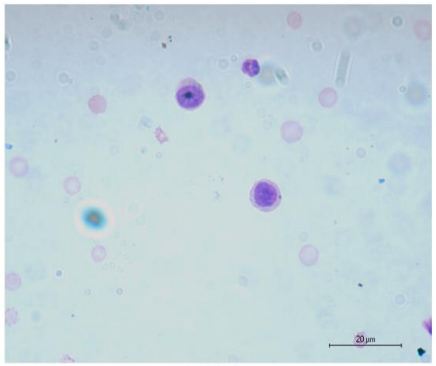
Bronchoalveolar Lavage Fluid (BALF)



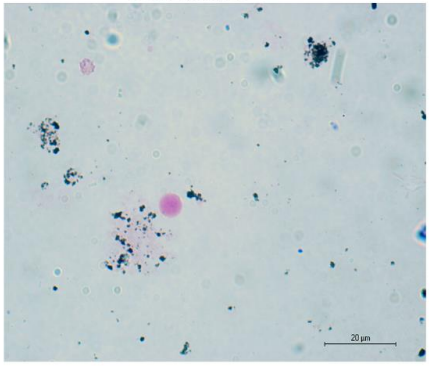
*P≤0.05,**P≤0.01,n=7



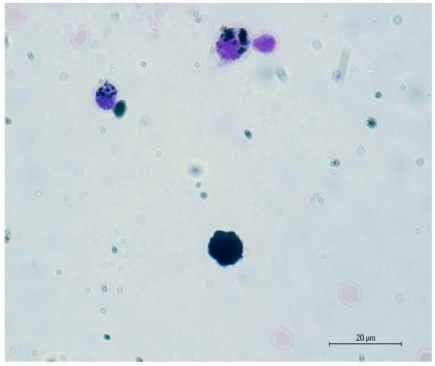
Untreated



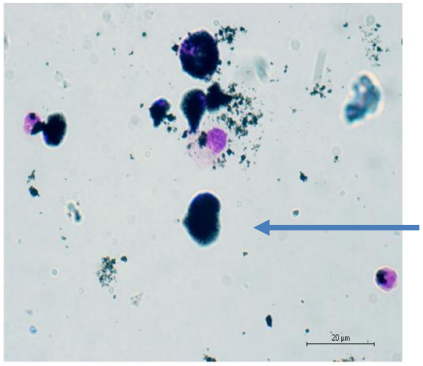
PBS



BC-100



BC-200

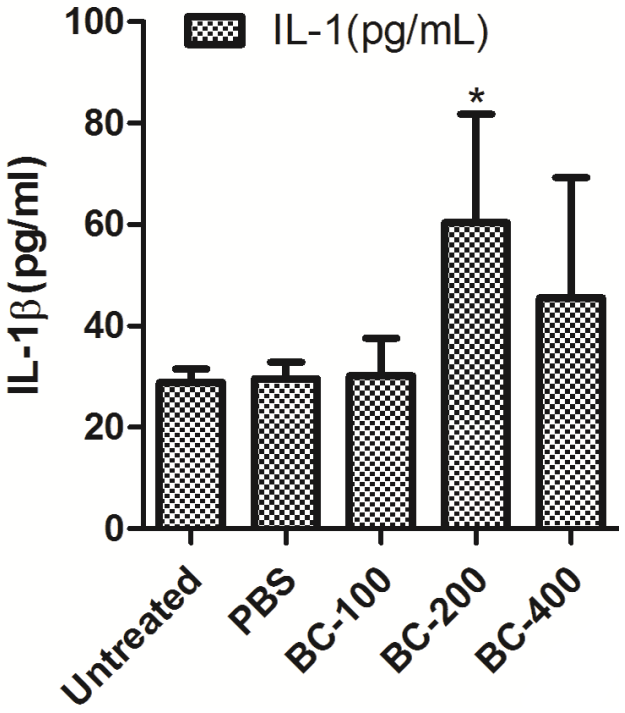


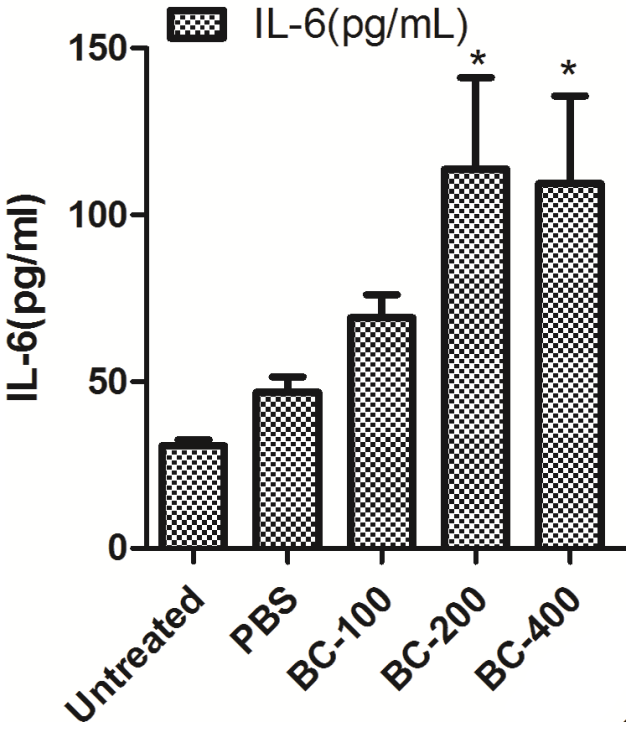
BC-400

Macrophage
Phagocyte BC

Diff quik staining

Toxicology Study-in vivo





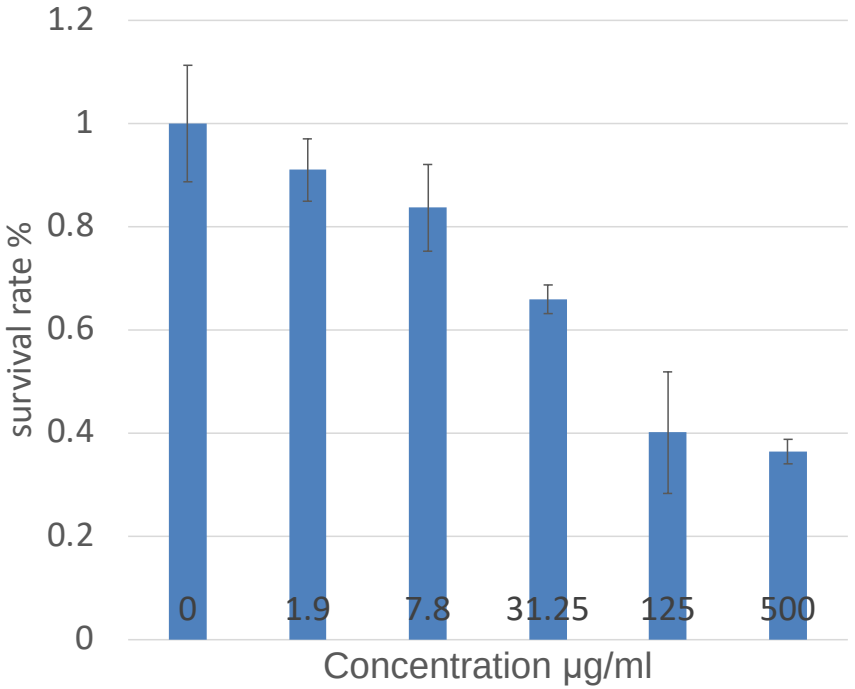
*$P \leq 0.05$,,n=7

Levels of cytokines in BALF

Toxicology Study-in vitro

Effect of BC particles on the survival rate of RAW264.7 cells by MTT assay

Conc.	Mean	Std. Deviation	N
0μg/ml	0.999999	0.113465	3
1.9μg/ml	0.910437	0.060583**	3
7.8μg/ml	0.837094	0.08424**	3
31.25μg/ml	0.660084	0.027622**	3
125μg/ml	0.401269	0.118001**	3
500μg/ml	0.364598	0.023692**	3



Brief Summary

- Inhaled BC can be deposited in the lungs
- Produce significant lung inflammation
- Can significantly affect cell proliferation

Progress and Perspectives

- We have completed a review of the health effects of black carbon, and published part of this in the Environmental Sciences Research
- We have finished the meta analysis of health effects of BC in long/short term exposure
- We sampled $PM_{2.5}$ in three site Miyun, Chaoyang and Baoding in different seasons and analyzed over 40 chemical compositions in the past three years
- We have done the animal and cell exposure experiments of BC

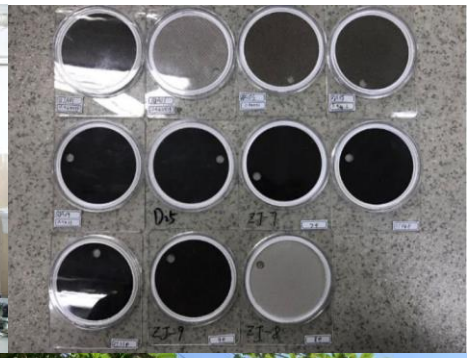
- To do the animal experiments of $PM_{2.5}$ in chambers
- To do the cell experiments of $PM_{2.5}$
- To do the source apportionment for attributing the health effects to different sources and to rank the risks of health effects by sources
- To finish the final project report

Progress and Perspectives

$PM_{2.5}$ -- Miyun/Chaoyang/Baoding ;
2019:45 sets of $PM_{2.5}$ samples， autumn and winter;
2020:42 sets of $PM_{2.5}$ samples ， autumn and winter
2021:84 sets of $PM_{2.5}$ samples ， spring, summer, autumn and winter








$PM_{2.5}$ sampling, chemical composition analysis and biological experiments


Thank You!

NIPH
Norwegian Institute of Public Health

ChiNorBC

Output 4: Health risk assessment of PM/BC/OC pollutants

15.12.21

Activity 4.6 (May 2021- June 2022)

Perform an *in vitro* study jointly in China and Norway, using different human multi-cell cultures mimicking different organs, to link the biomarkers from the animal studies (Activity 4.4/4.5) to exposure (Activity 4.1).

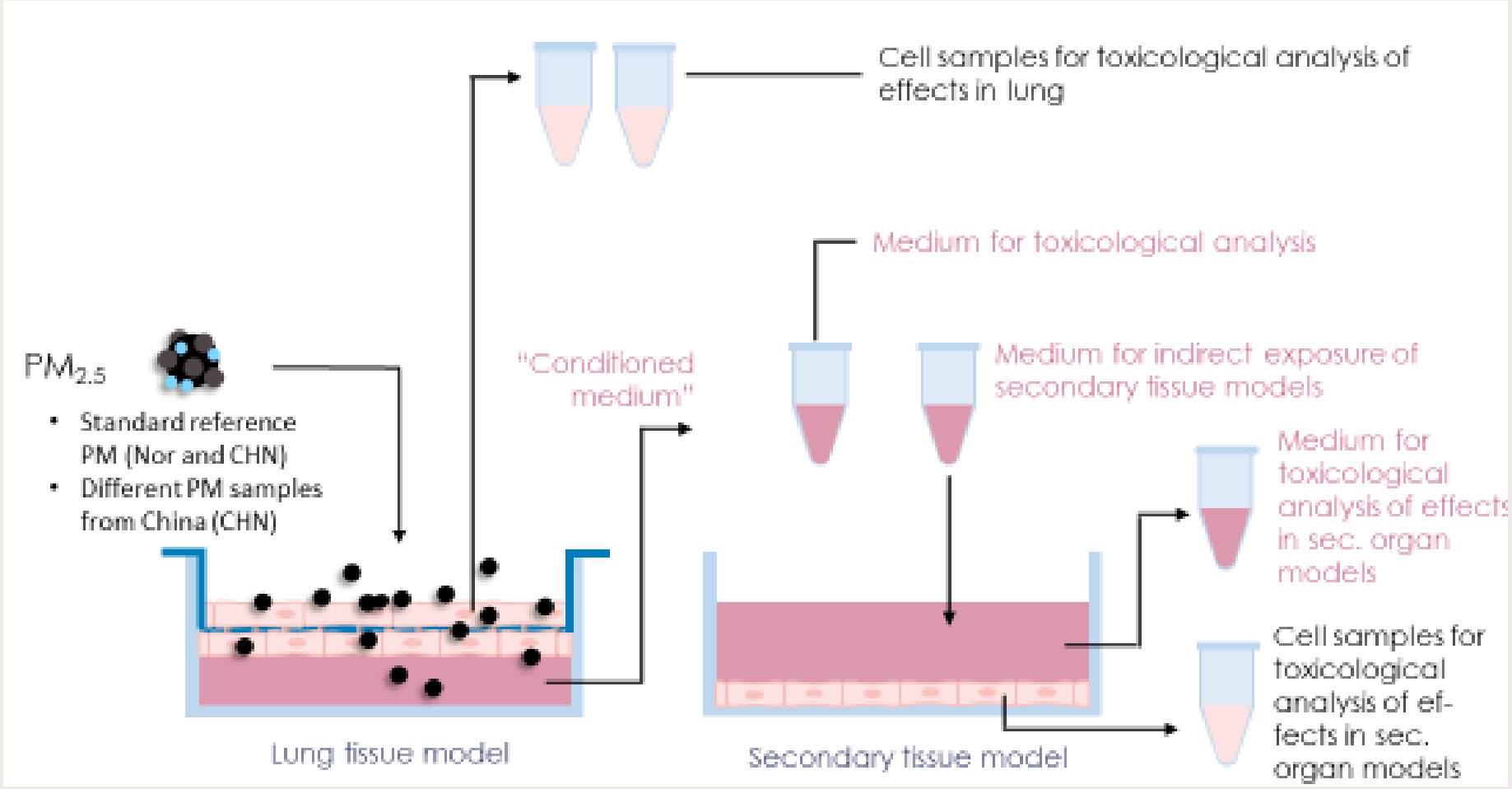
- The Norwegian part of the project (Marit Låg and Vegard S. Grytting) has been changed due to problems sending samples of ambient PMs from China to Norway
- Instead, we will use a standard reference PM (NIST SRM2786) and include particulate matter from Norwegian traffic pollution
- Due to the problems with receiving PMs we have developed and optimized our lung cell culture systems and the last weeks performed pilot studies
- The Chinese part will use the same reference PM in addition to the PM samples from different areas in Norther China in similar cell model systems

Activity 4.6 (cont)

Research Methods

- In vitro toxicity study of the standard reference PM and PM-samples from Norway in lung cell models. These PMs will be compared with PMs sampled in Northern China using:
  - Monocultures of relevant lung cells; epithelial lung cells and immune cells (differentiated THP-1 cells)
  - Advanced 3D co-cultures of epithelial cells, immune cells and endothelial cells
- Effects in advanced models of human secondary organs. Transfer of medium from the lung co-culture to liver- and neuronal cells
  - Liver spheroids
  - Neuronal cells
- Analyzing for biomarkers in the cell cultures. These relevant biomarkers included in adverse health outcomes in human will also be linked to biomarkers in the animal studies performed in China
  - *Inflammatory responses* in the lung, cardiovascular system and secondary organs. Release of pro-inflammatory mediators are important for asthma, COPD, heart infarct, stroke and neurological diseases
  - *Gene toxicity* and DNA damage response gene are important markers for lung cancer

Lung tissue model and tranfer to secondary models



Exposure to PMs in the lung tissue model:

- Submerged exposure of PMs in medium
- Air liquid interface exposure (ALI), more similar to the exposure after inhalation of PMs in humans