



Innovative Approaches to improve Air Quality: Implications from PRC's Journey

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PRC has promulgated a series of stringent policies since 2013



Goals of policies

Emission amount

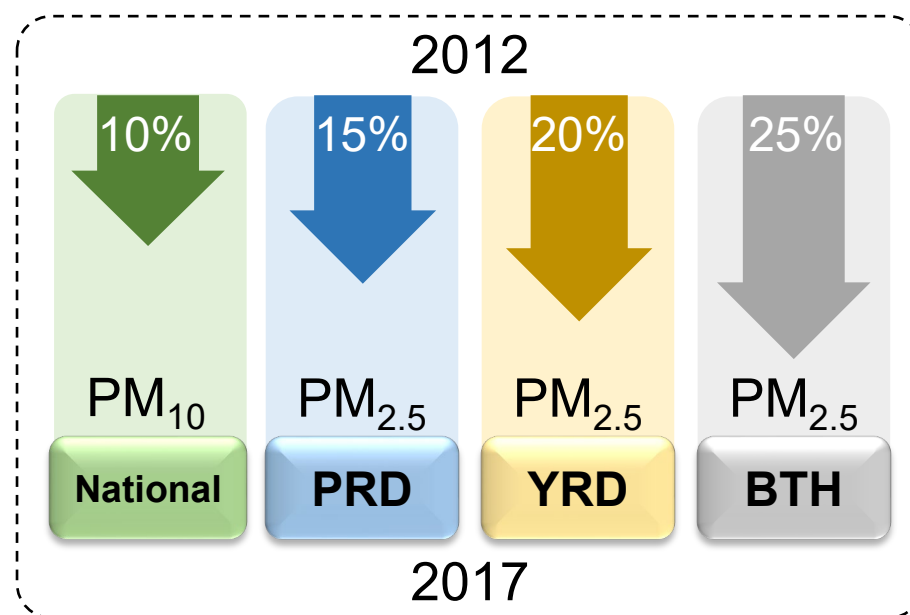


Ambient concentrations

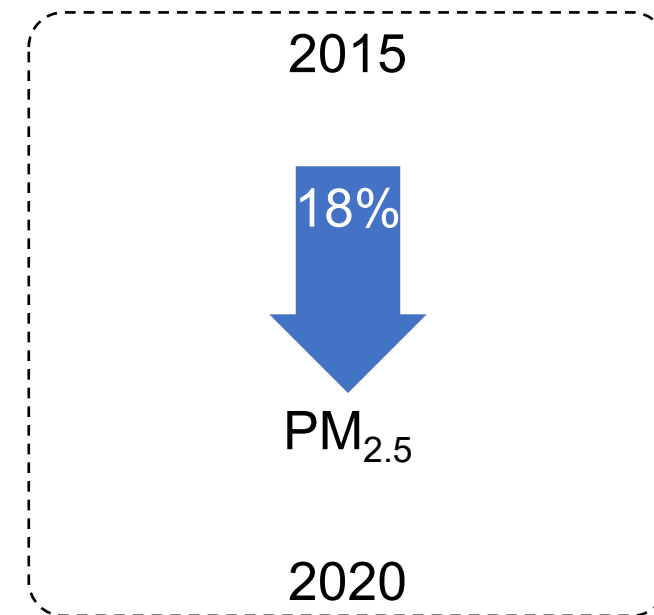
BTH

YRD

PRD



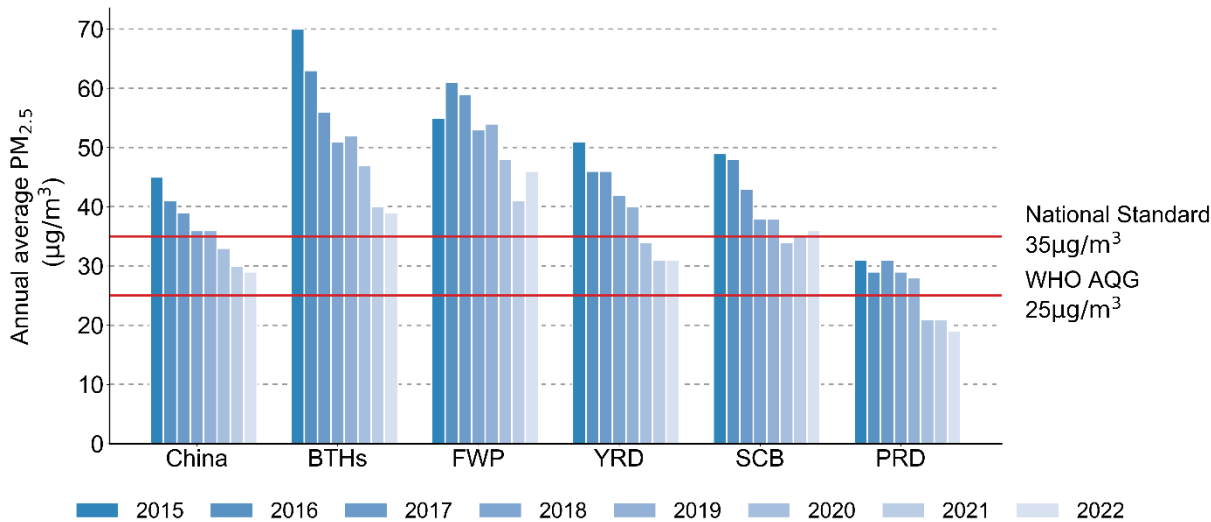
**Air Pollution Prevention and Control
Action Plan (2013–2017)**



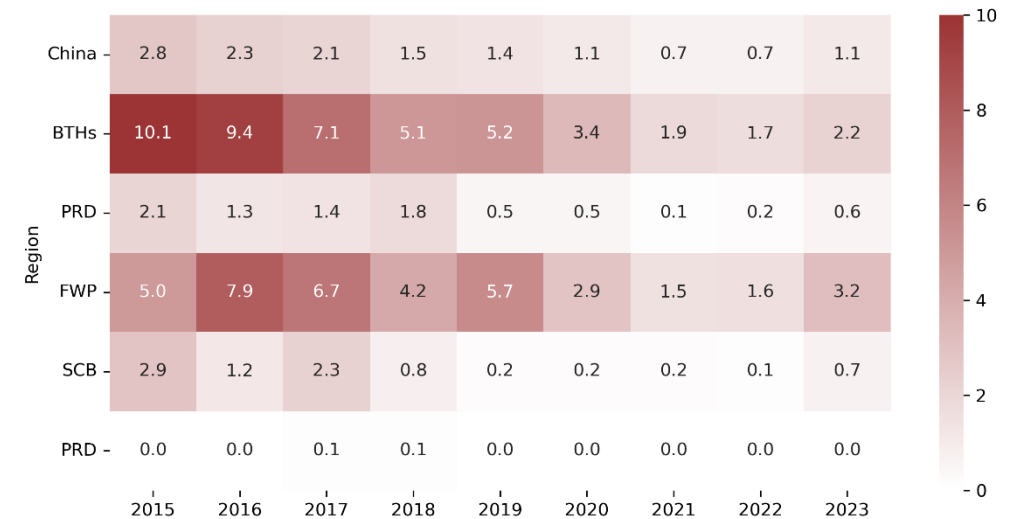
**Three-Year Action Plan for
Cleaner Air (2018–2020)**

Significant air quality improvements in China and its key regions

The annual PM_{2.5} concentrations in China and key regions from 2015 to 2022



Proportion of days with severe PM_{2.5} pollution and above in China and key regions from 2015 to 2022.



- With the effective advancement of China's air pollution control activities, the air quality has demonstrated significant improvement. Major air pollutants, particularly PM_{2.5}, have exhibited consistent year-on-year reductions, accompanied by a marked decrease in heavy pollution episodes both nationwide and in key regions.

CCAPP., 2023.

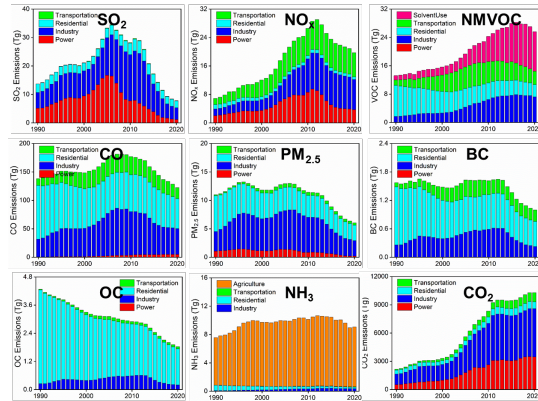
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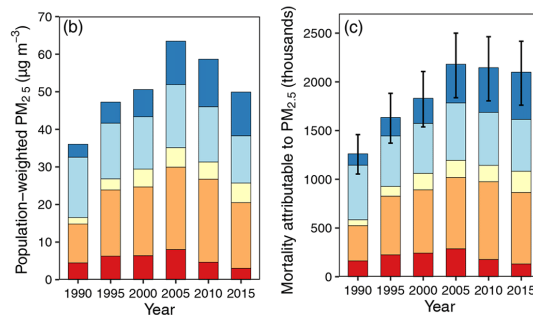
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Scientific supports serves as a critical foundation for policy making

Accurate emission characterization

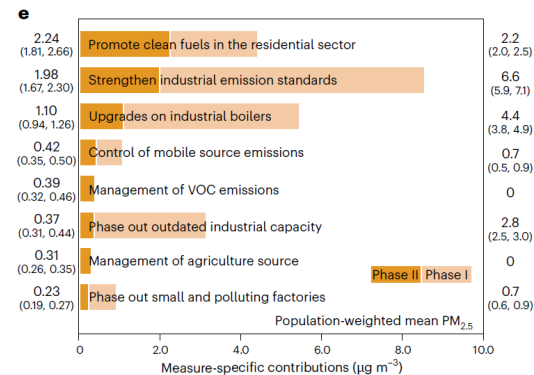


Pollution source appointment



Dynamic pollution monitoring

Control policy assessment



Policy making

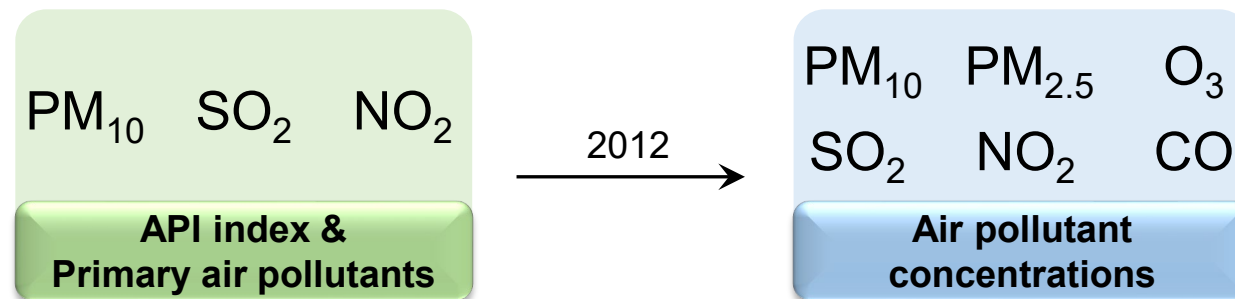


Air quality and emission data support achieving the policy goals

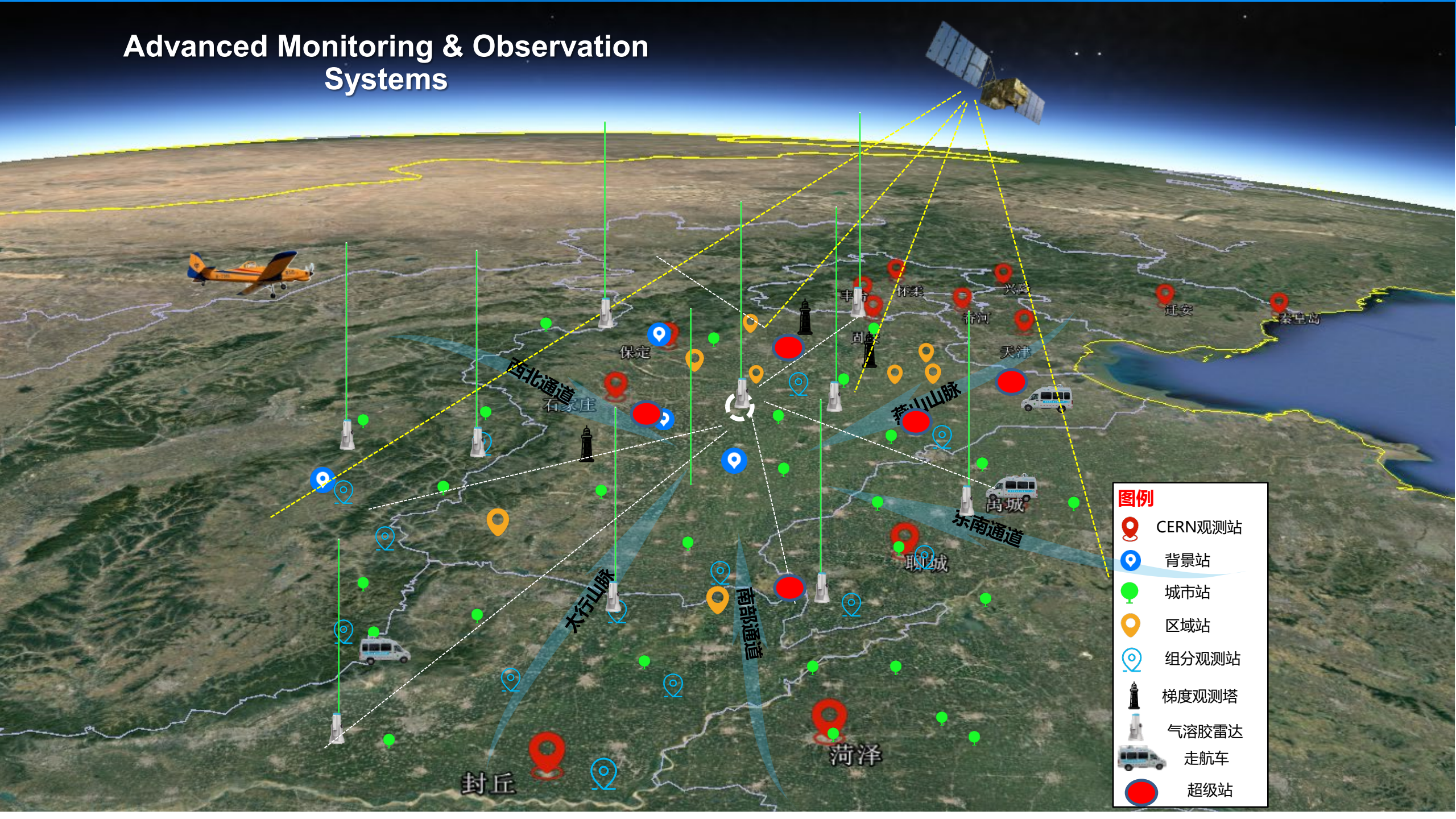
Air quality monitoring network development

74 cities (2012) → 168 cities (2018) → 339 cities (2021)

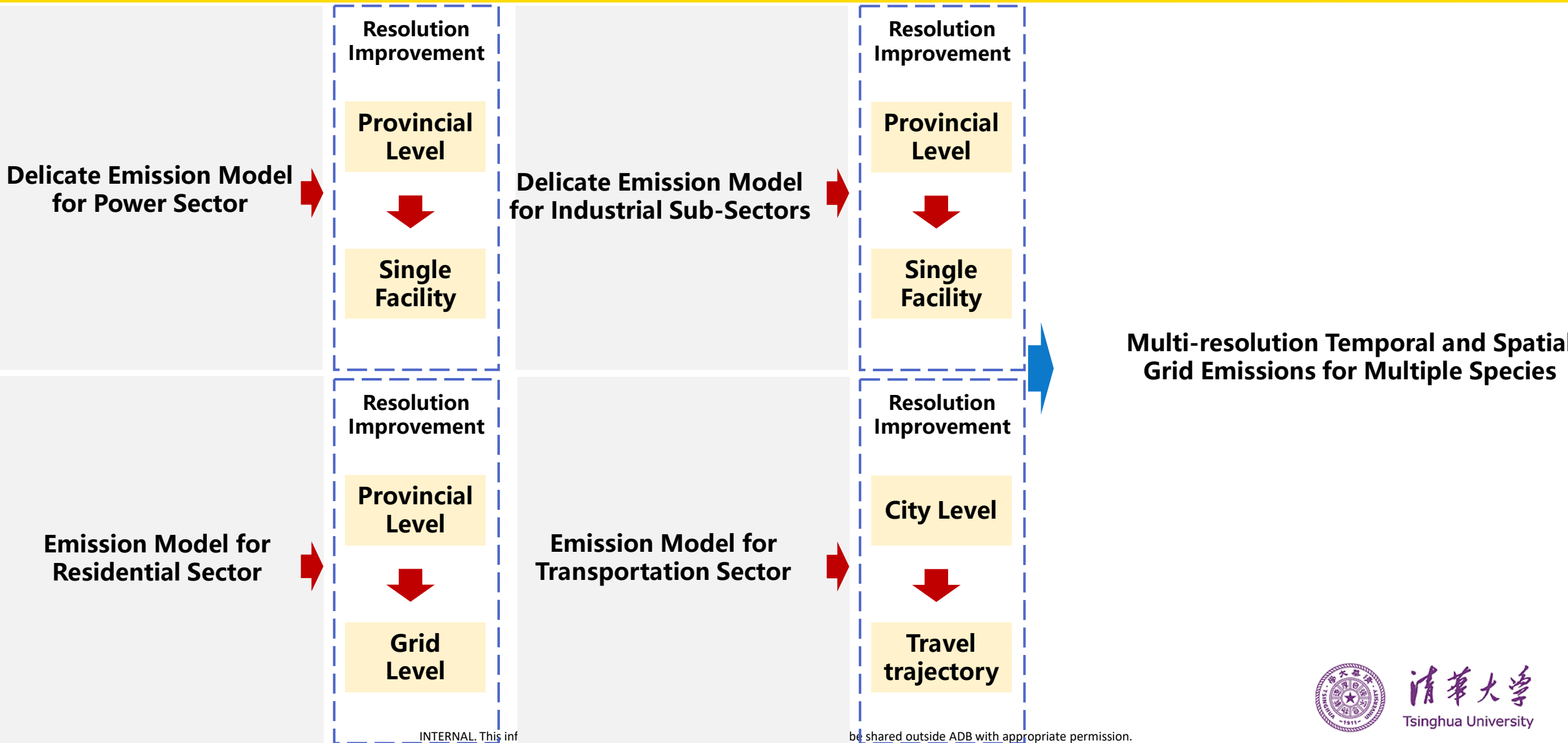
Monitored air pollutants updates



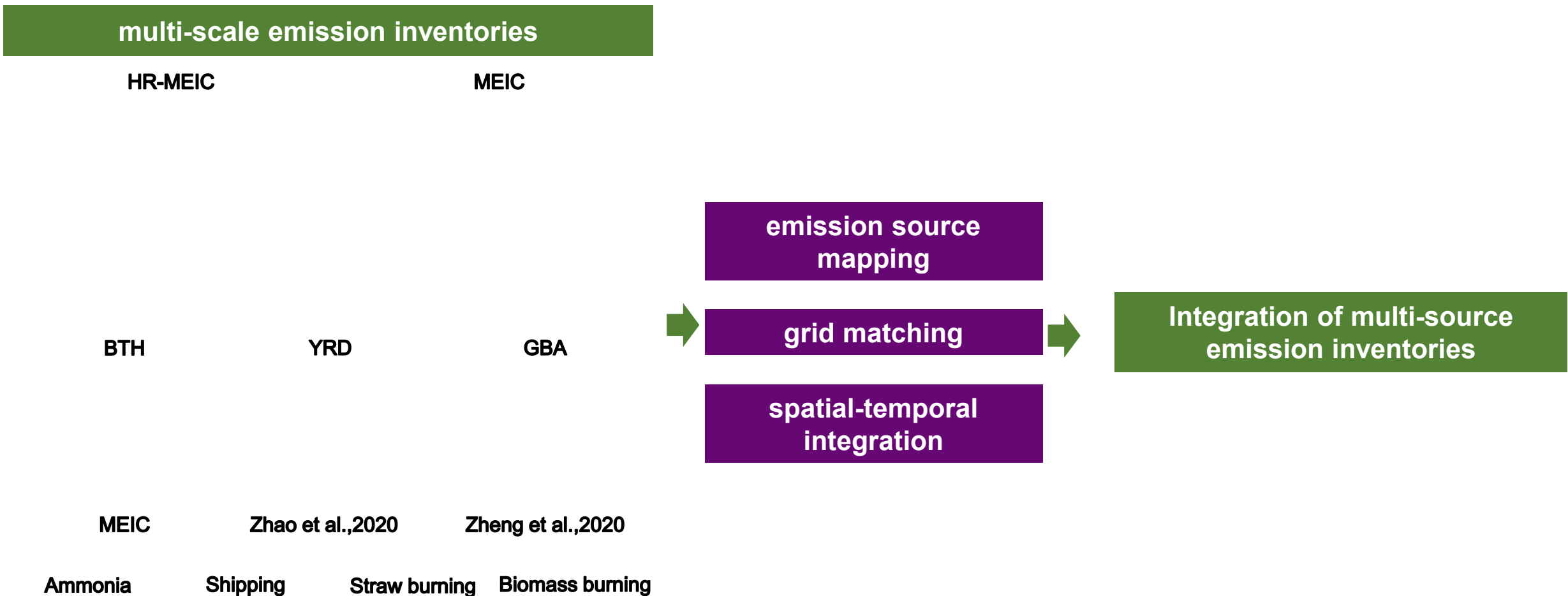
Advanced Monitoring & Observation Systems



Establishment of emission characterization framework: MEIC

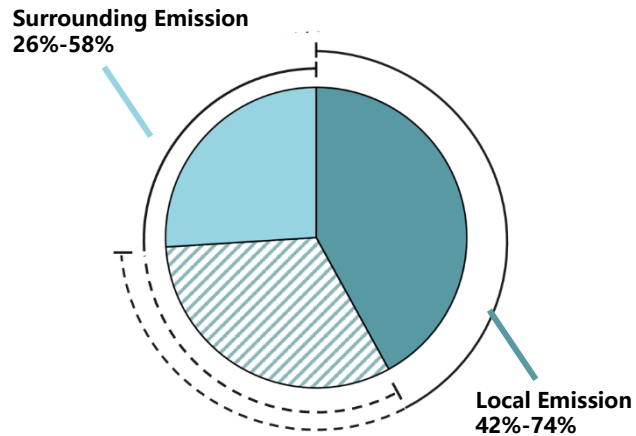


Air quality and emission data support achieving the policy goals

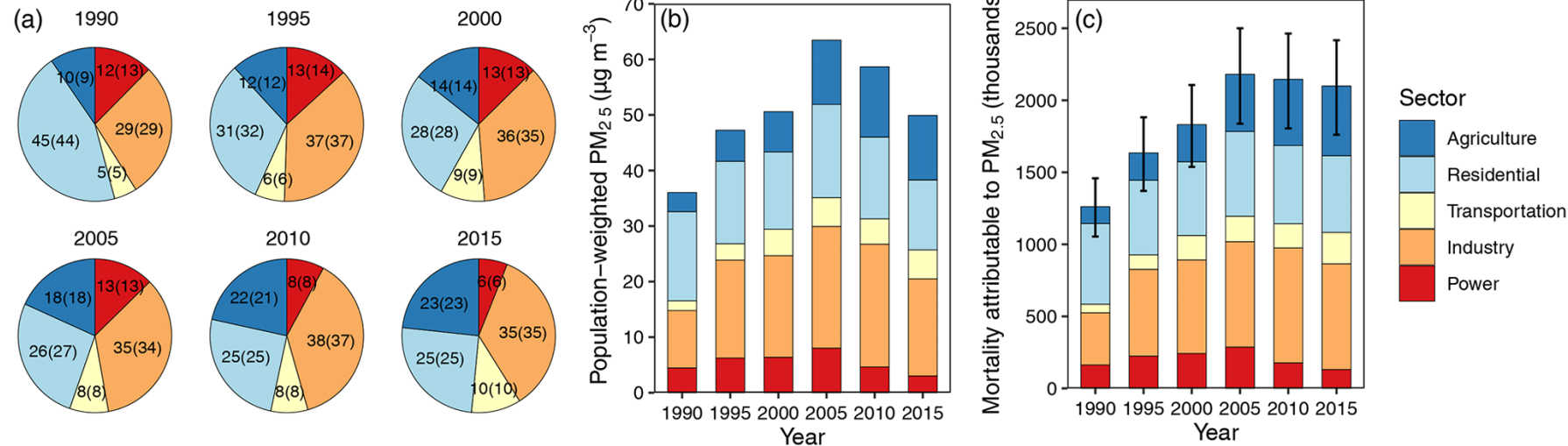


Source apportionment of major pollutants help set the direction for prioritized control strategies

Source apportionment of current PM_{2.5} in Beijing



Relative and absolute source contributions to national population-weighted PM_{2.5} concentrations



- In key cities such as Beijing, regional transport is a significant source of pollutants in addition to local emissions. At the current stage, 42-74% of PM_{2.5} in Beijing originates from local emissions, while 26-58% stems from surrounding areas.
- Source apportionment can further quantify emissions from various anthropogenic sectors. In China, PM_{2.5} emissions primarily emanate from residential and industrial sectors, with the proportion from the agricultural sector rising in recent years which requires close attention in the future.

Liu et al., ACP, 2020.

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Dynamic pollution monitoring frameworks: TAP

The methodology framework of Tracking Air Pollution in China (TAP)

<http://tapdata.org.cn/>

*Operational multi-source data
preprocessing module*

Multi-source data downloading
and preprocessing

Dynamic
emission
inventory



Near-real-time
numerical
simulation

*Long-term spatiotemporal
continuous data*

*Daily scale near-real-time
update*

Jul 2

Jul 3

Jul 4

Jul 5

PM_{2.5}

SO₂









Inversion methods for
atmospheric composition



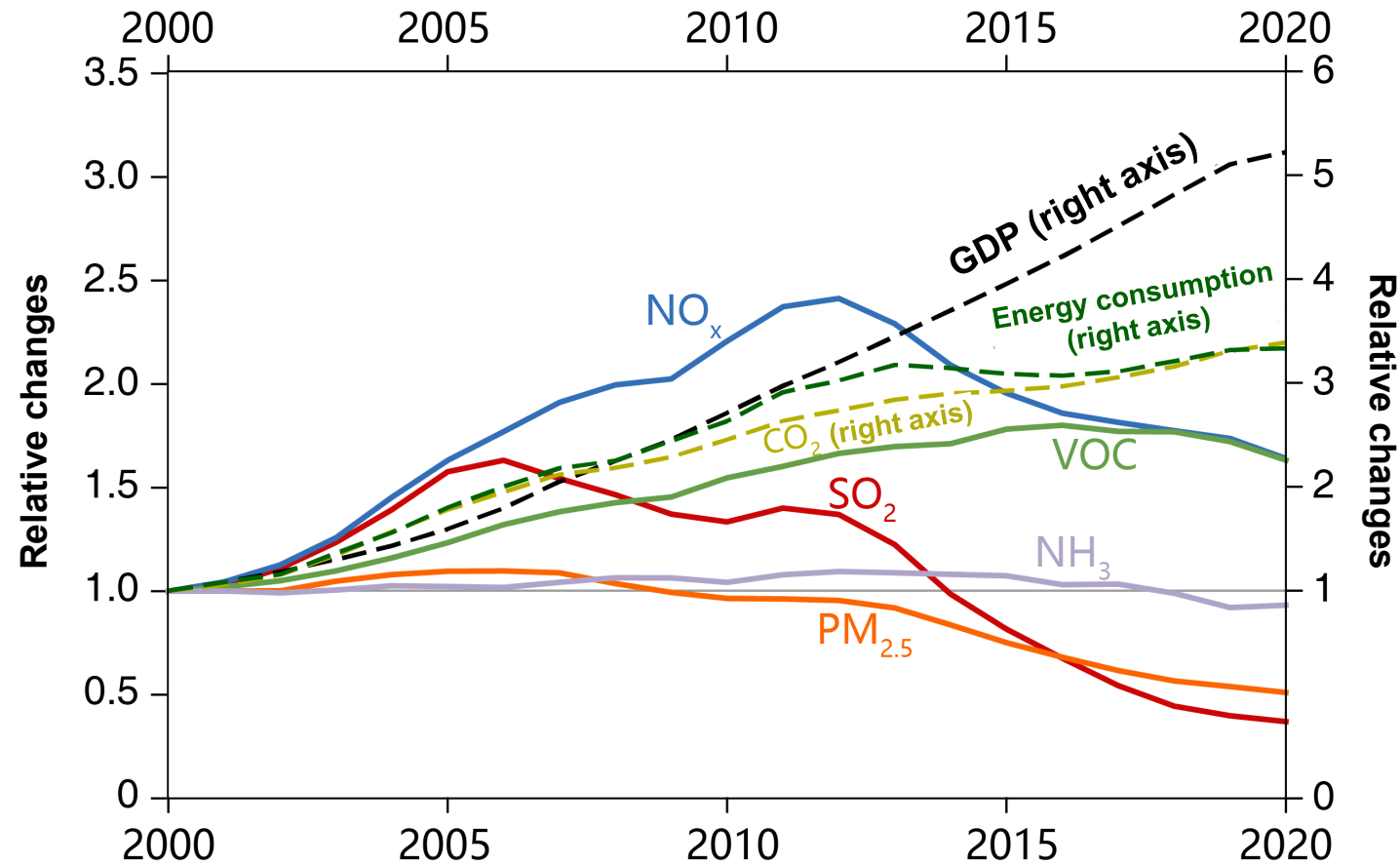
The screenshot shows the TAP website interface. At the top is a navigation bar with links: HOME, INTRODUCTION, DATASETS, PUBLICATIONS, USER SERVICE, TEAM, LINKS, and a language selector (EN). Below the navigation bar is a header image with the text 'Datasets'. Underneath, there are three main dataset categories, each with a description and download options:

- PM_{2.5} -1km**: Near real-time product since 2000 at a 1-km spatial resolution. Download options: Data Download.
- PM_{2.5} & species -10km**: Near real-time product since 2000 at a 10-km spatial resolution. Download options: Data Download, Map Download.
- O₃**: Near real-time product since 2013 at a 10-km spatial resolution. Download options: Data Download, Map Download.

Major clean air actions implemented 2013-2020

	2013	2014	2015	2016	2017	2018	2019	2020
 Ultra-low emission retrofits of coal-fired power plants	Deadline governance for desulfurization, denitrification and dust removal in the power industry			71% completed ultra-low emission retrofits		88% completed ultra-low emission retrofits		
 In-depth governance of non-power industries	Deadline governance for desulfurization, denitrification and dust removal in the steel, cement and flat glass industries			620 million tons of crude steel capacity started ultra-low emission retrofits				
 VOCs integrated control	Completed more than 50,000 VOCs control projects							
 Integrated control of coal-fired boilers	Phased out more than 200,000 small coal-fired boilers					Phased out more than 110,000 coal-fire boilers Basically eliminated coal-fired boilers		
 Clean heating in rural areas						Launched a pilot program for clean heating in winter in the northern region Completed the bulk coal substitution in 25		
 Mobile source emission control	Fully implemented National IV standard (National V Standard in key areas)			Fully implemented National V standard		Fully implemented National VI Standard for light vehicles		
	National VI Standard vehicle gasoline and diesel were fully supplied, and more than 27 million yellow-label and old vehicles were phased out							
 Integrated control of agriculture	The application area of soil testing and formulated fertilization technology reached 133 million hectares, and the open burning of straw was effectively controlled							
 Integrated control of fugitive dust	More than 230,000 cases of construction related fugitive dust were controlled nationwide; the machine sweeping rate of urban roads in key areas exceeded 90%; more than 30,000 hectares of mine land were restored; more than 10 million hectares of green land were newly created							

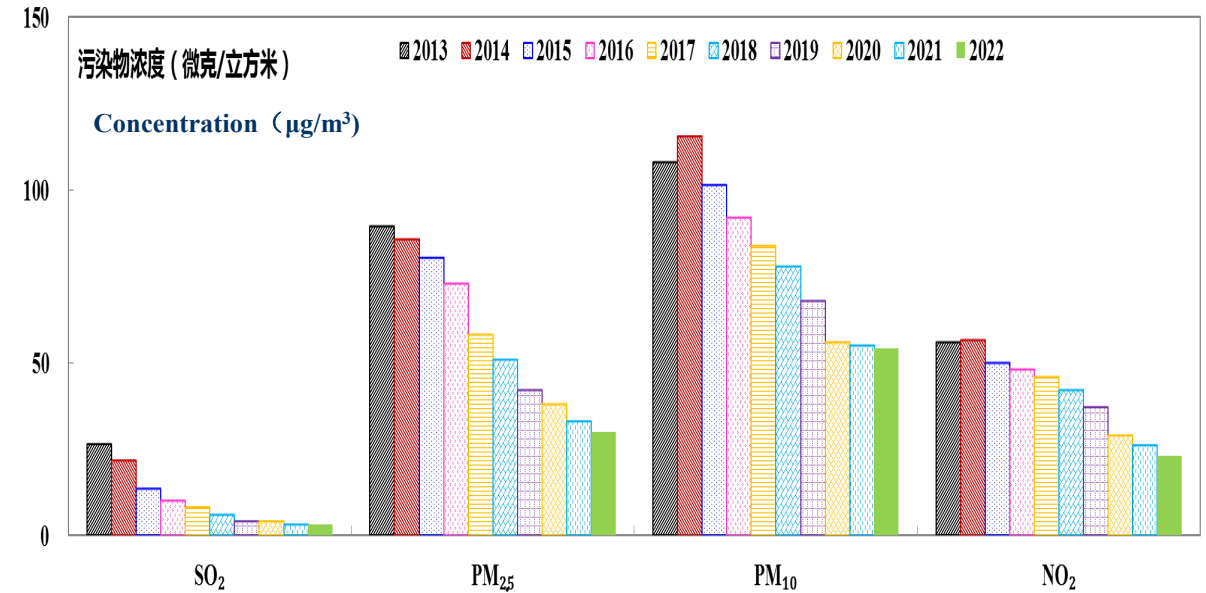
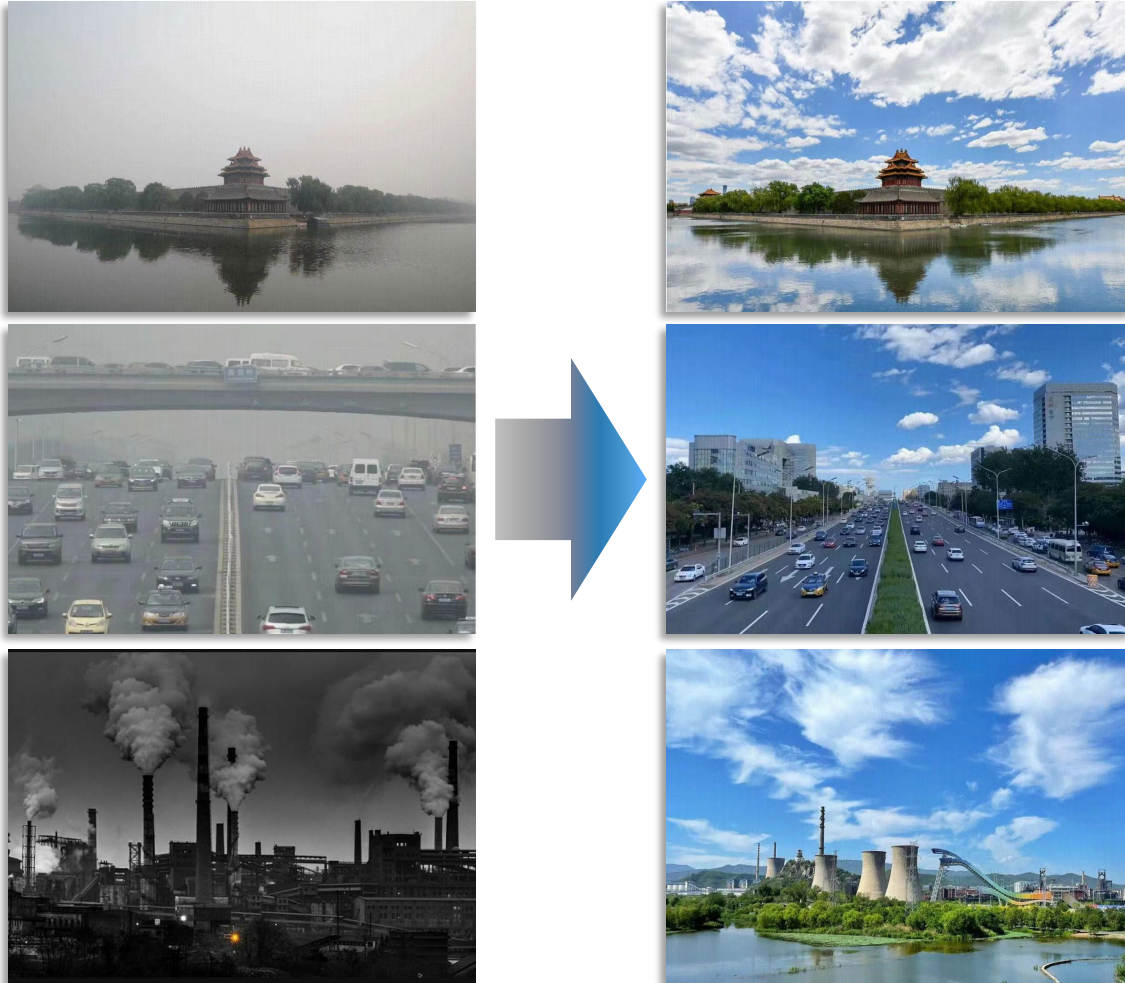
PRC's emissions of major air pollutants have been Suppressed



- SO₂, NO_x and primary PM_{2.5} emissions have peaked in 2006, 2012, and 2006 respectively. Emissions in 2020 have decreased by 77%, 32%, and 53% respectively compared to the peak.
- The VOCs and NH₃ emissions have been high for a long time. The first inflection point of VOCs and NH₃ emissions occurred in 2017, but the reductions are small.

In the past decade, air quality of Beijing met an overall and significant improvement

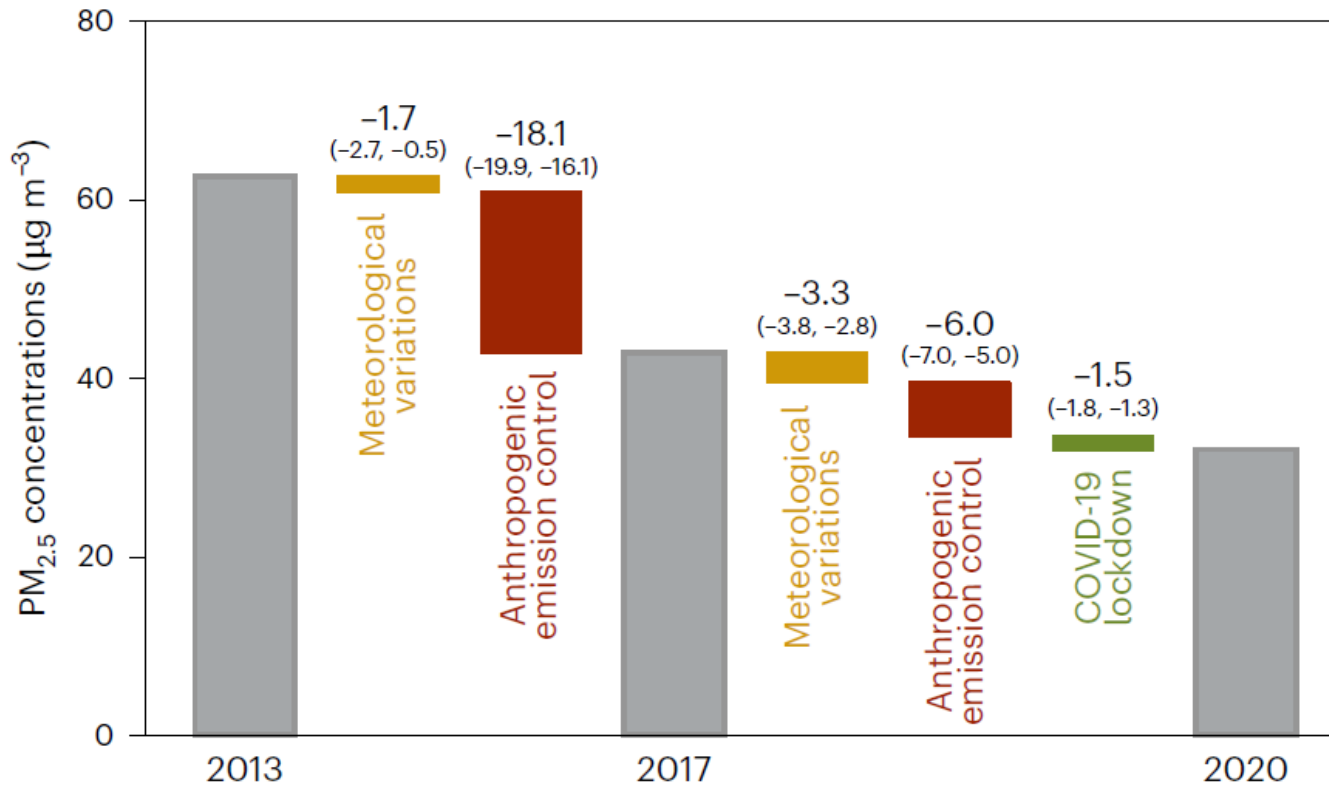
Over the past decade



Compared with 2013, in 2022, the annual average concentrations of Beijing's PM_{2.5}, PM₁₀, NO₂, SO₂ decreased by 66.5%, 50.0%, 58.9% and 88.7%

Assessment of air pollution control policies

Main drivers to the PM_{2.5} reductions from 2013 to 2020



- During 2013-2017, the ***Anthropogenic emission control*** is the main driver for the decrease of PM_{2.5} concentration.
- During 2017-2020, the ***Meteorological variations*** benefits the improvement of PM_{2.5} and the contribution is **30%**; the ***COVID-19 lockdown*** contributes **14%**; and the impact of ***Anthropogenic emission control*** has a share of **56%**.

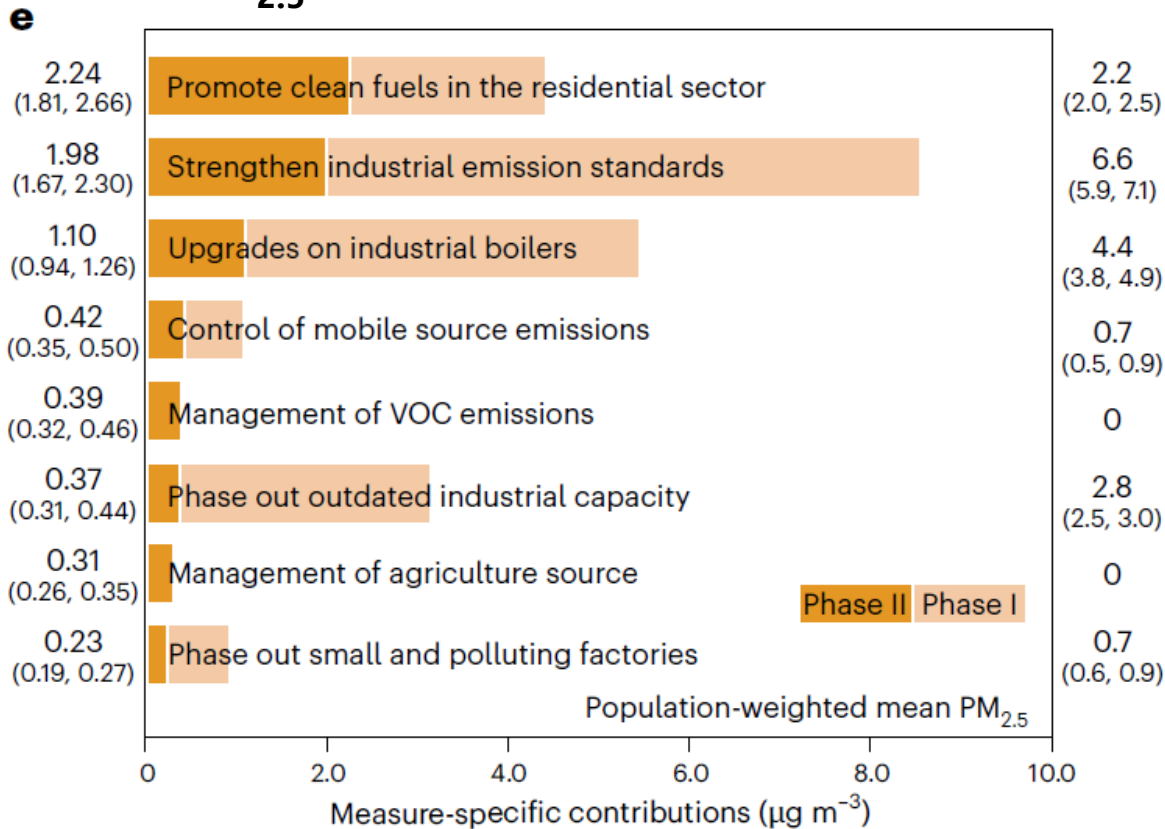
Zhang et al., PNAS, 2019; Geng et al., Nature Geoscience, 2024



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Assessment of air pollution control policies

Measure-specific contributions to PM_{2.5} reductions from 2013-2020

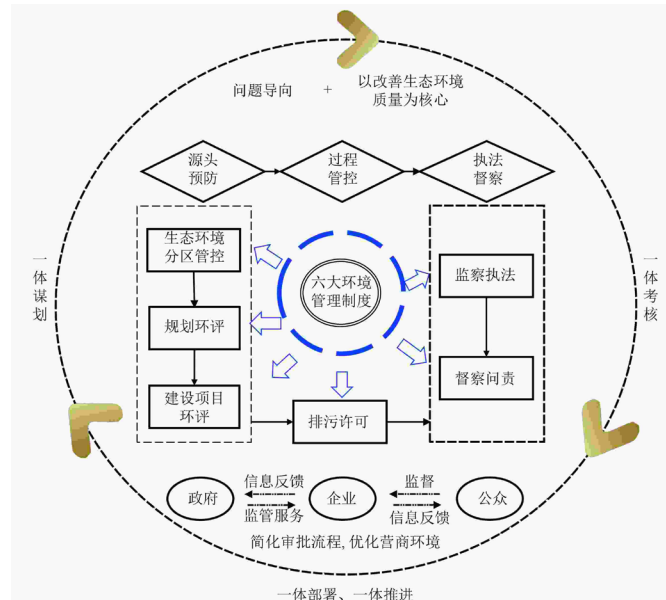


- The benefits of strengthening industrial emission standards, upgrades on industrial boilers, phasing out outdated industrial capacity, and phasing out small and polluting factories were lower in Phase II (2018-2020) than in Phase I (2013-2017).
- The benefits of promoting clean fuels in the residential sector, controlling of mobile source emissions, managing of VOC emissions, and managing of agriculture source were comparable or even better between Phase I (2013-2017) and Phase II (2018-2020).

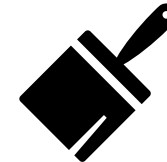
Outlook for future project design

Fundamental Capacity Building for Atmospheric Environment

Enhance the Regulatory Framework for Atmospheric Environment Management



Management of Key Emission Sources



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Thanks!

