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

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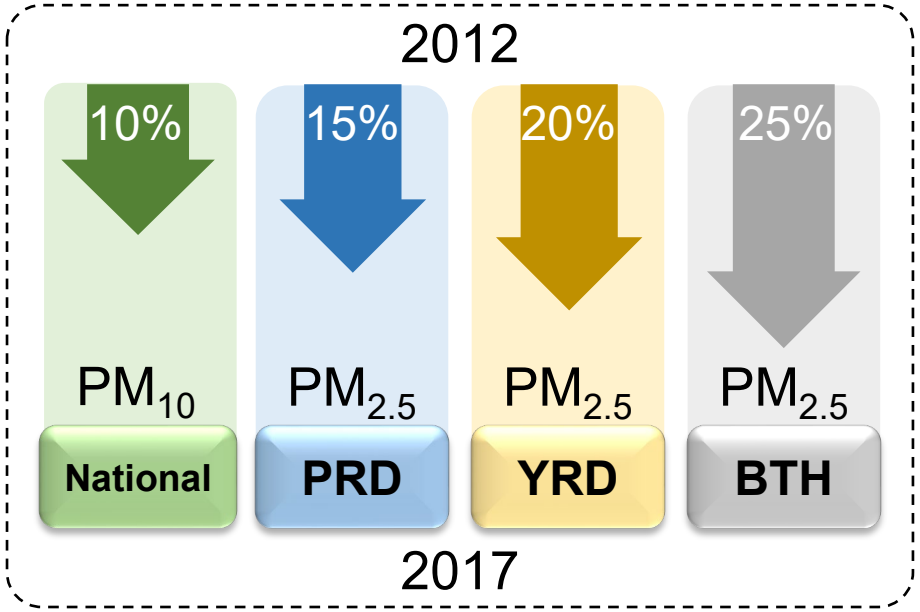
PRC has promulgated a series of stringent policies since 2013

Goals of policies Emission amount → **Ambient concentrations**

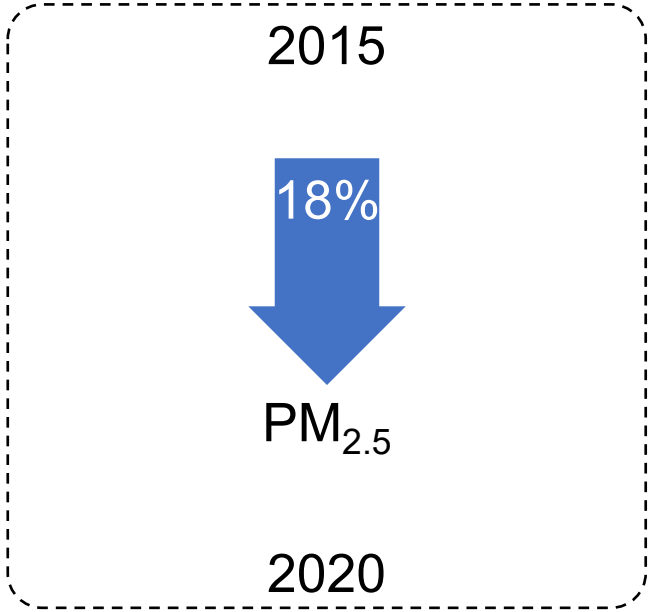
BTH

YRD

PRD



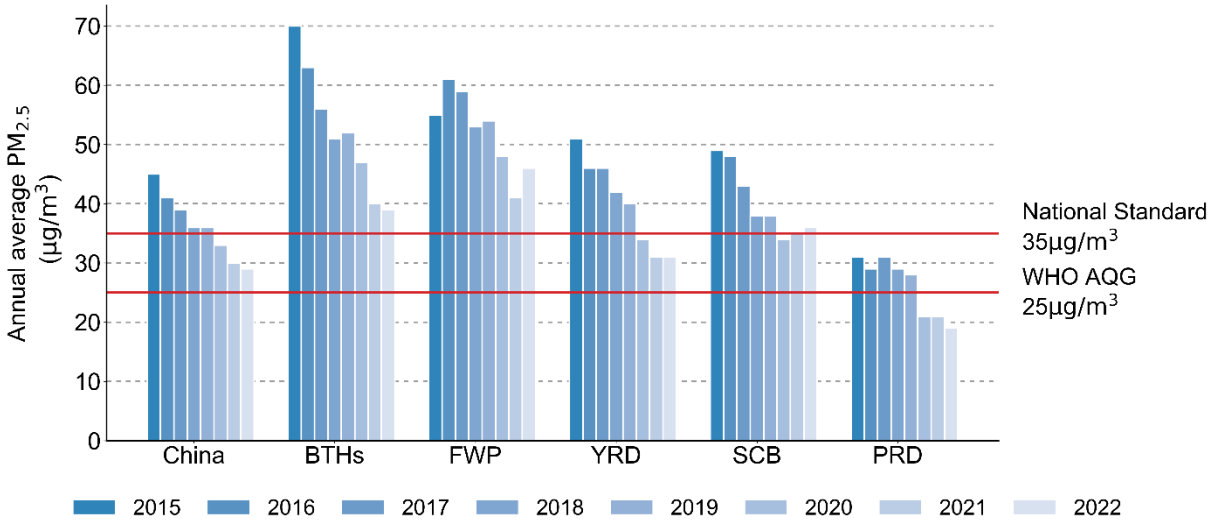
Air Pollution Prevention and Control Action Plan (2013–2017)



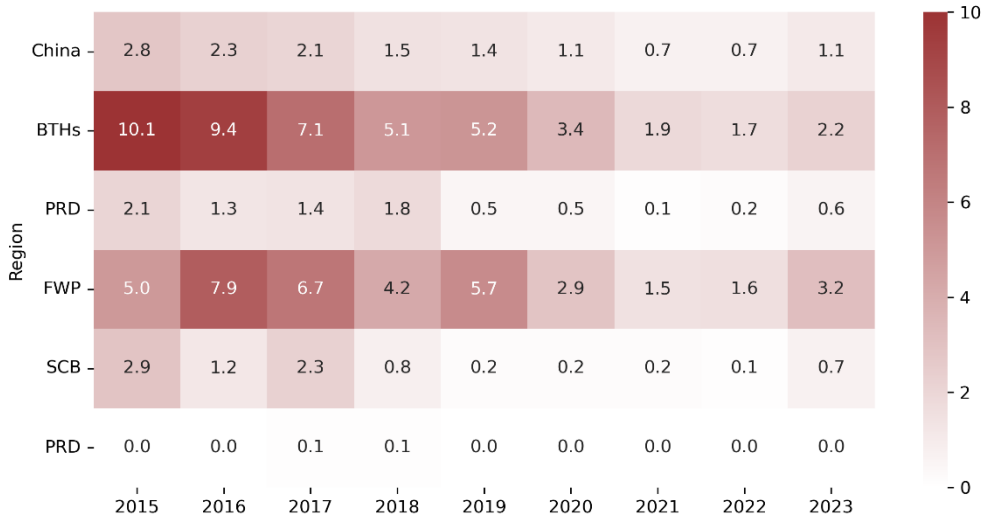
Three-Year Action Plan for Cleaner Air (2018–2020)

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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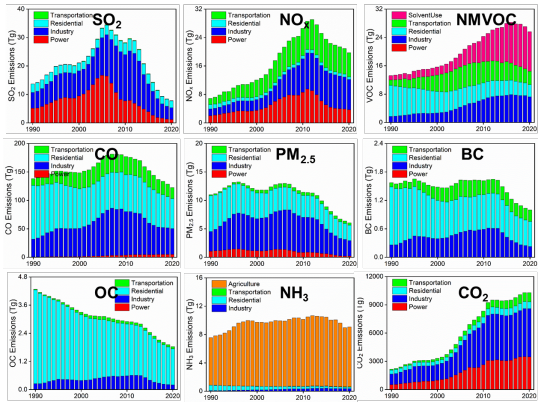
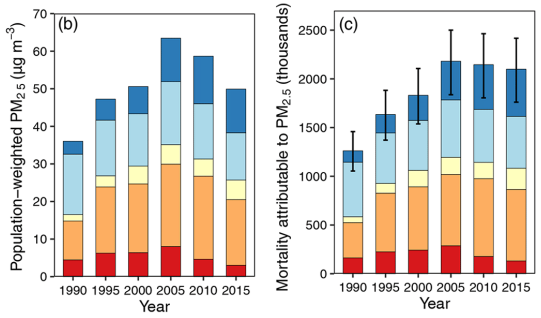
Scientific supports serves as a critical foundation for policy making

Accurate emission characterization

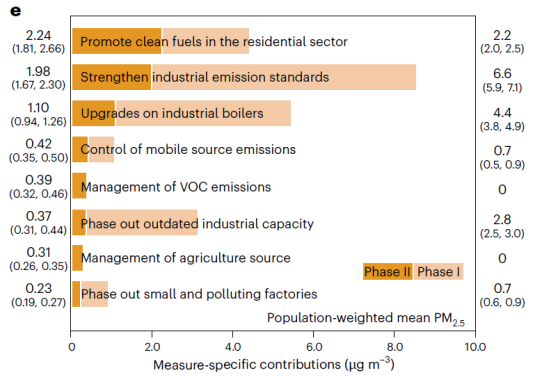


Dynamic pollution monitoring

Pollution source appointment



Control policy assessment



Policy making

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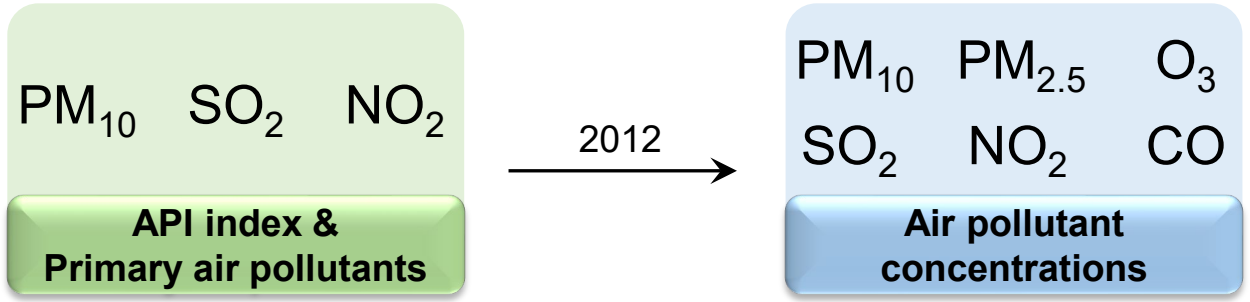
Air quality and emission data support achieving the policy goals

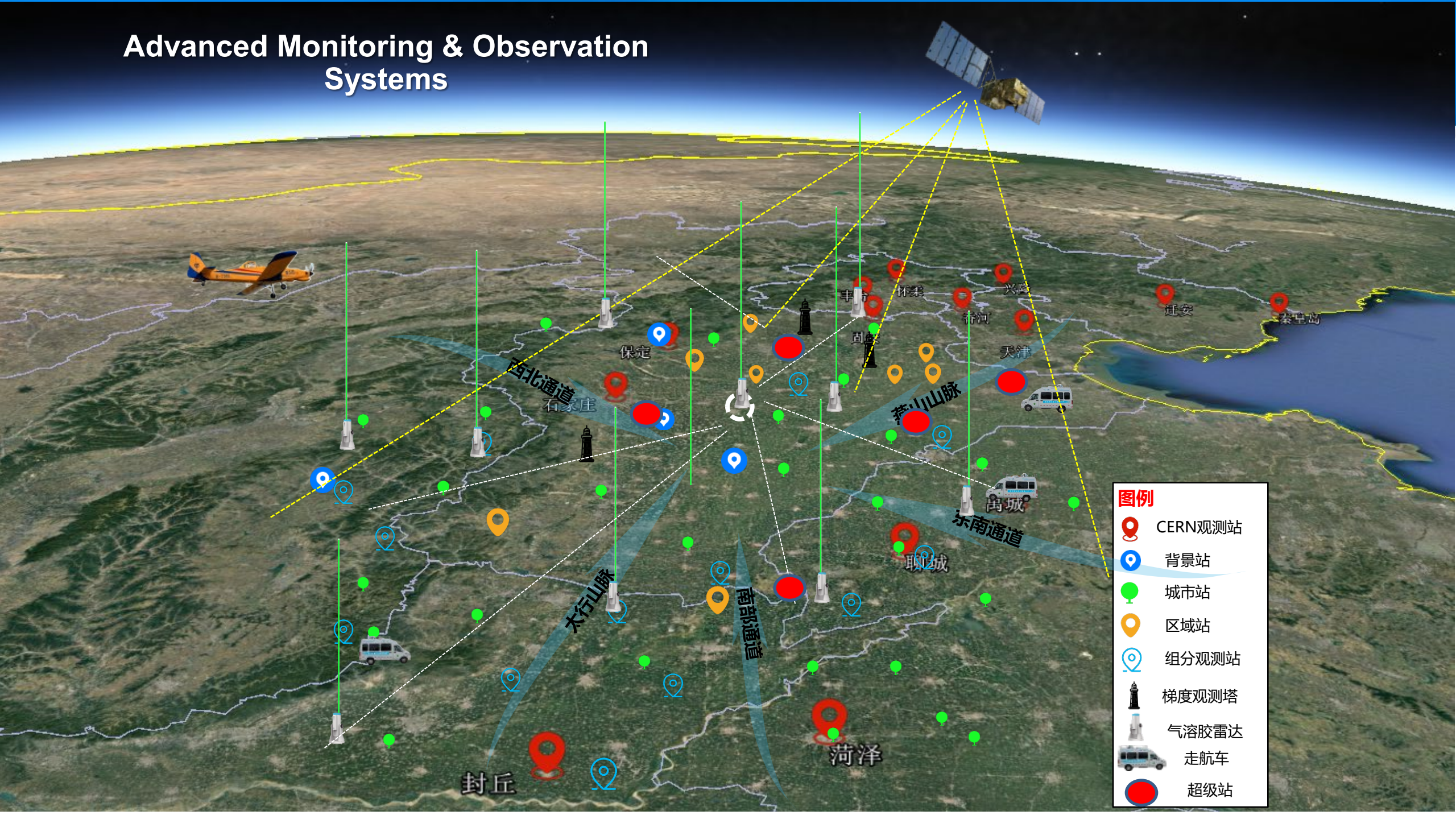
Air quality monitoring network development

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

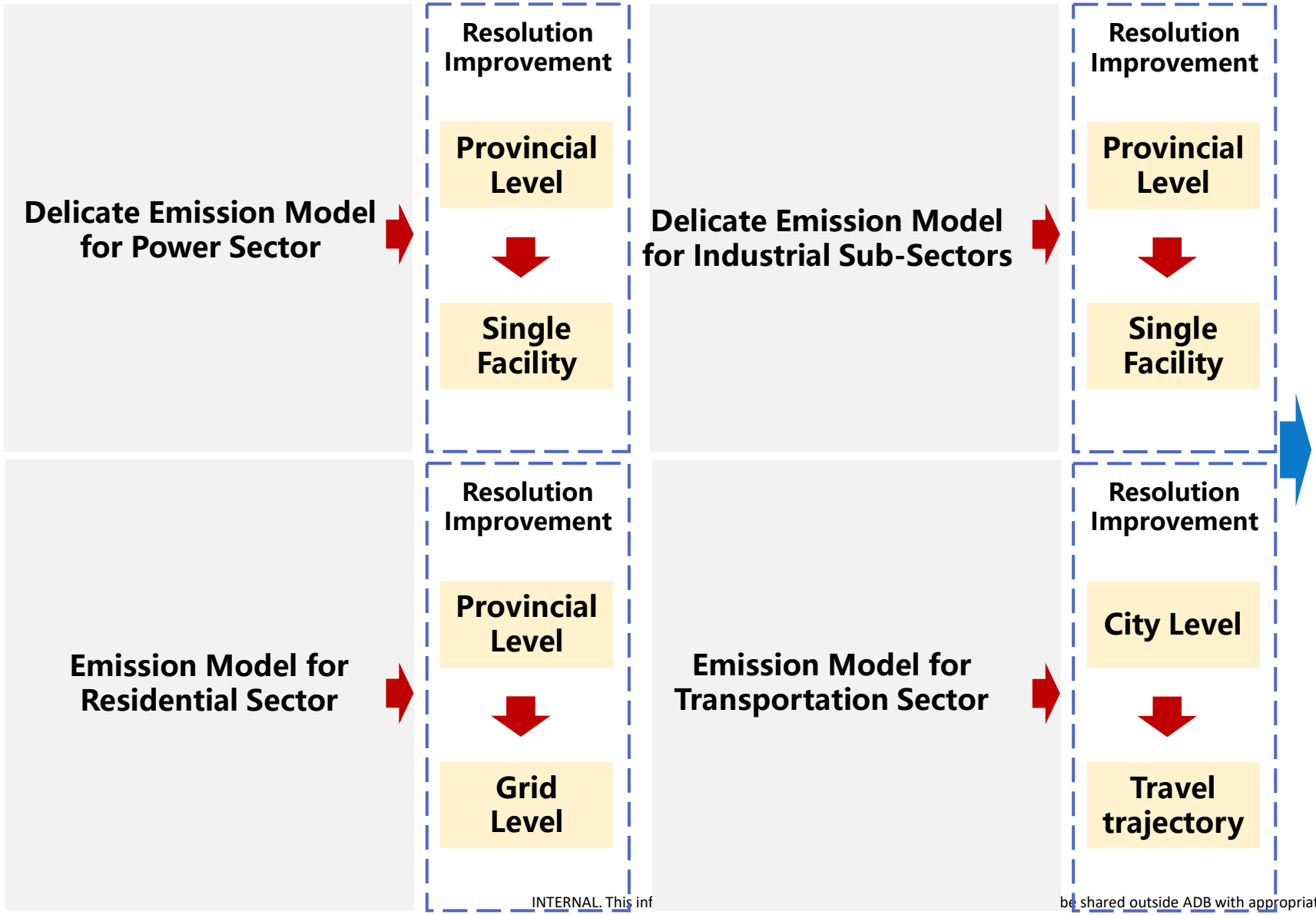
Monitored air pollutants updates



Advanced Monitoring & Observation Systems



Establishment of emission characterization framework: MEIC



Multi-resolution Temporal and Spatial Grid Emissions for Multiple Species

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Air quality and emission data support achieving the policy goals

multi-scale emission inventories

HR-MEIC MEIC

BTH YRD GBA

MEIC Zhao et al.,2020 Zheng et al.,2020

Ammonia Shipping Straw burning Biomass burning

Song et al.,2016 Liu et al.,2019 Zhou et al.,2021 Song et al.,2009

emission source mapping

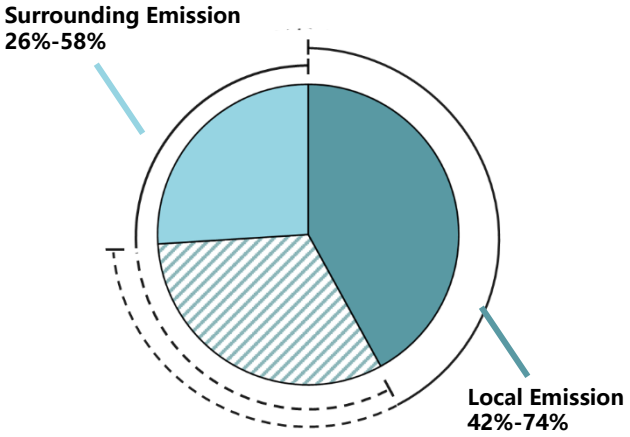
grid matching

spatial-temporal integration

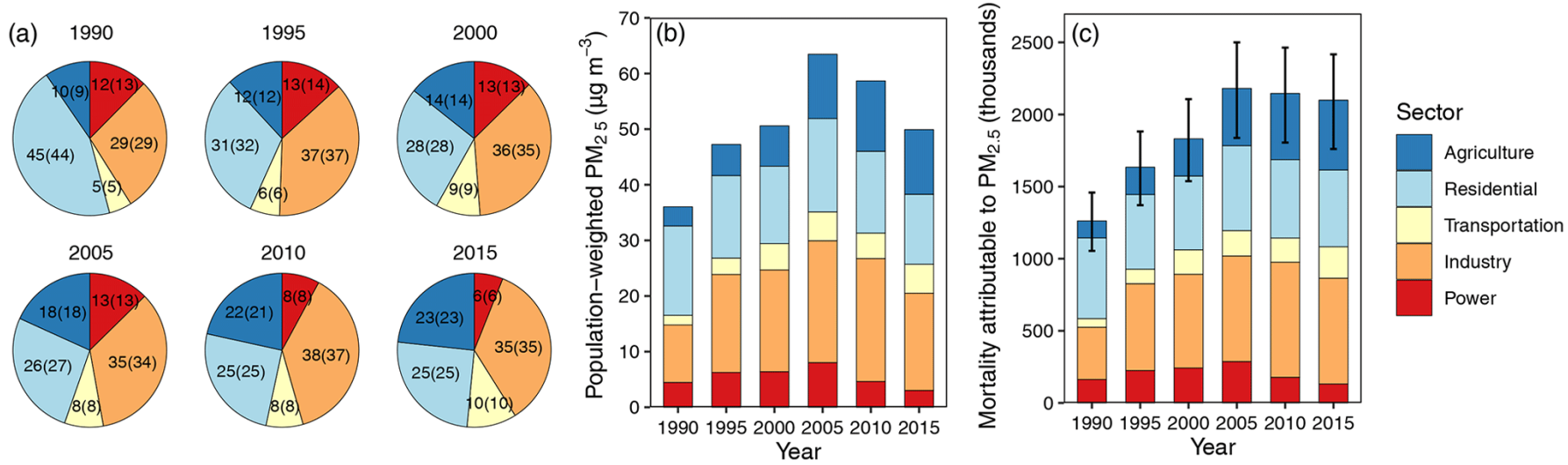
Integration of multi-source emission inventories

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

Source appointment 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

Inversion methods for atmospheric composition

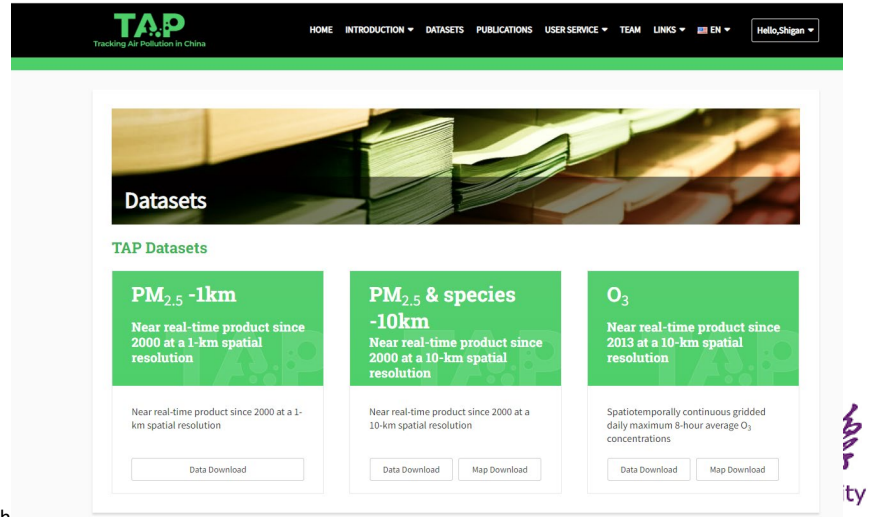
Long-term spatiotemporal continuous data

Daily scale near-real-time update

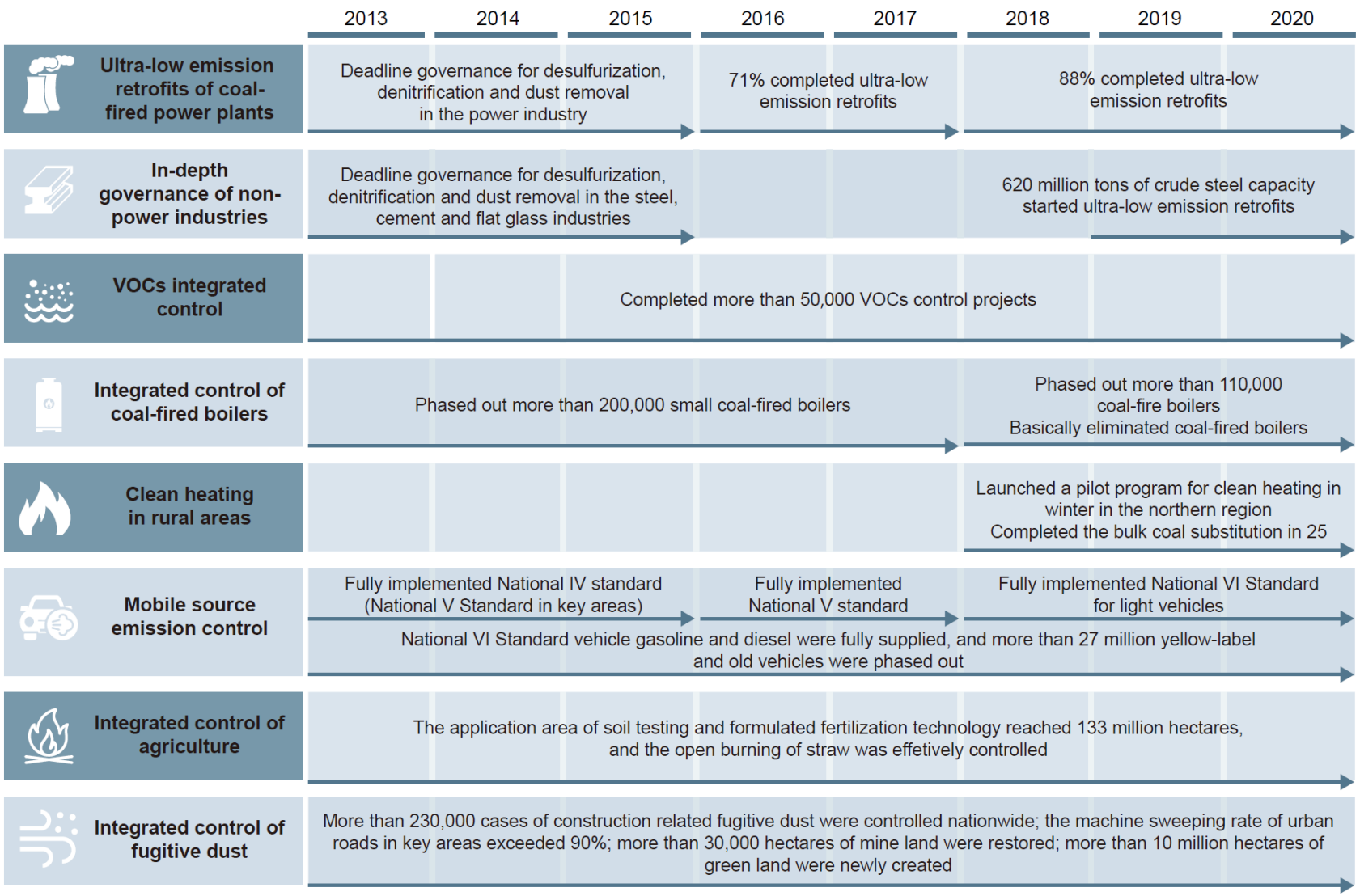
Jul 2 Jul 3 Jul 4 Jul 5

$PM_{2.5}$

SO_4^{2-}



Major clean air actions implemented 2013-2020



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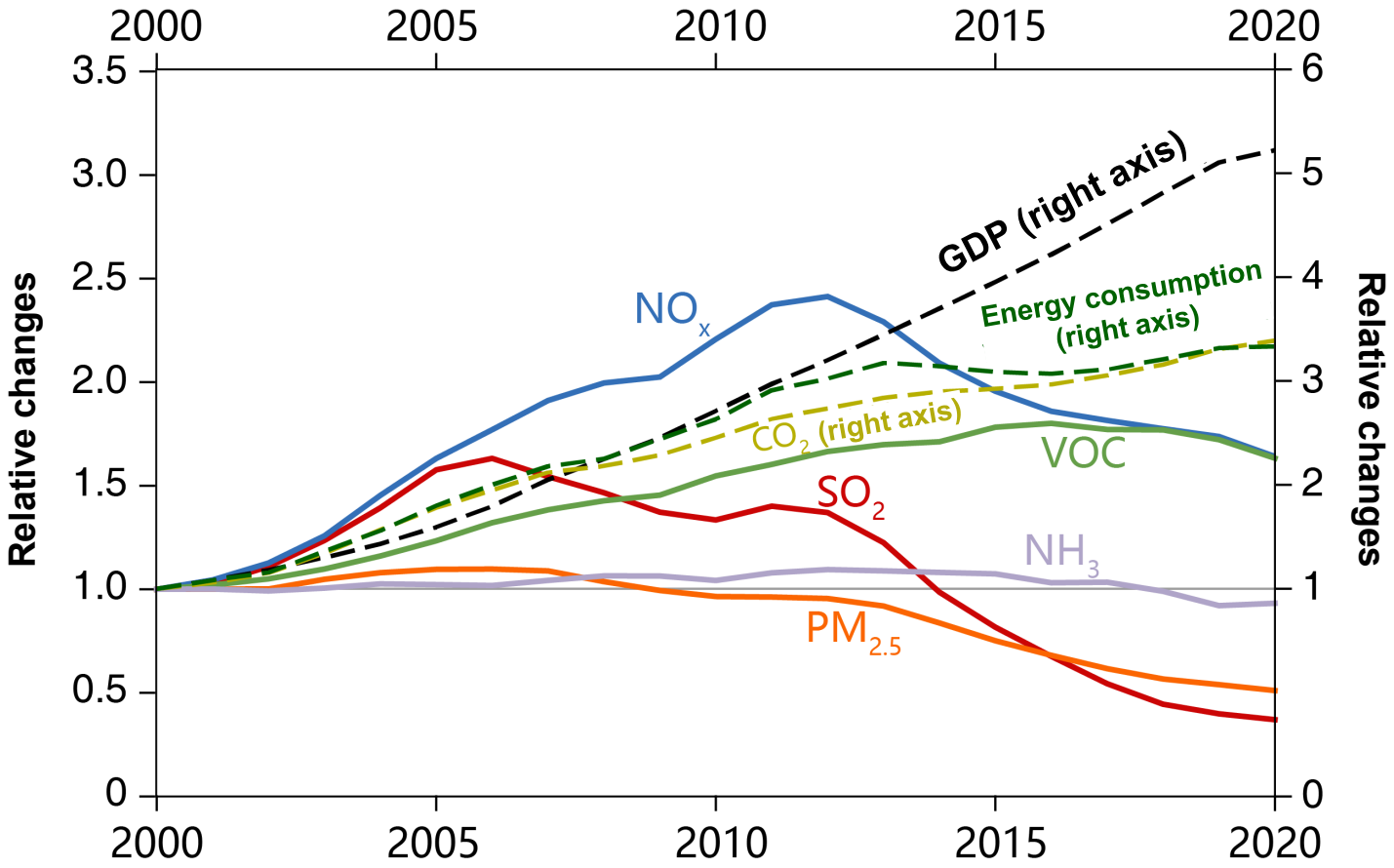
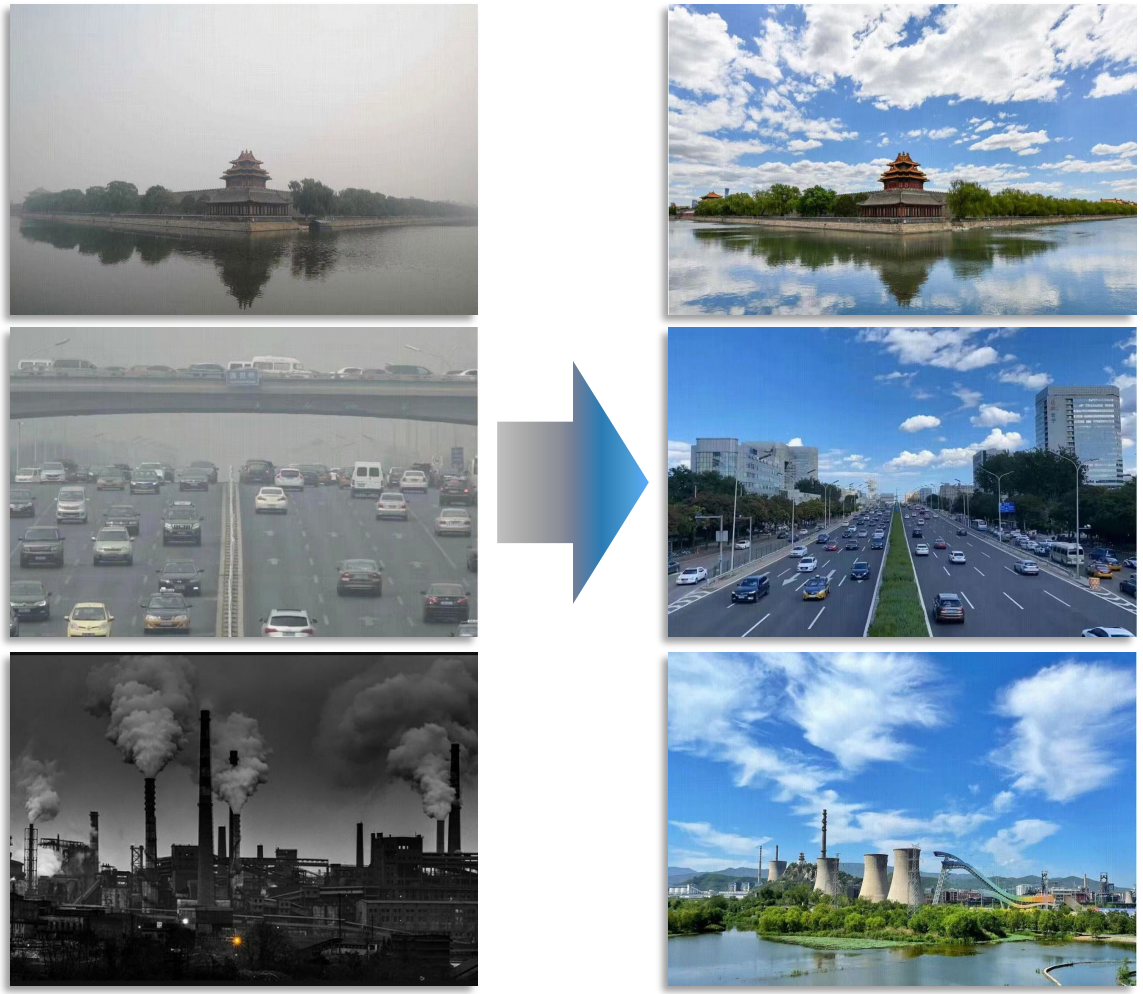
PRC's emissions of major air pollutants have been Suppressed

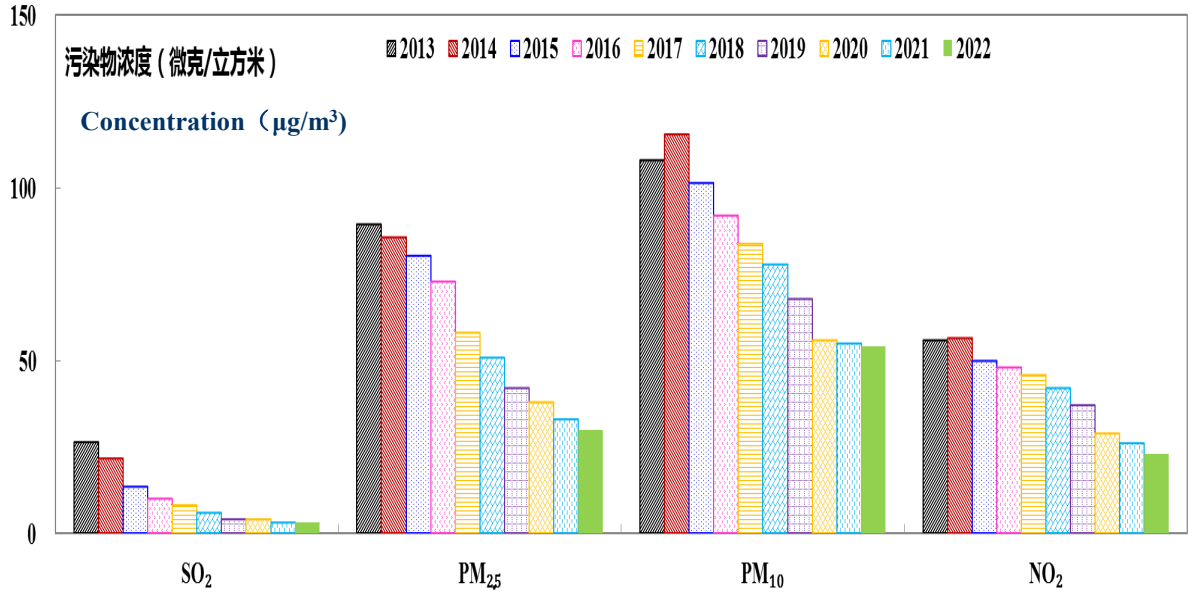


- SO_2, NO_x and primary $PM_{2.5}$ emissions have peaked in 2006, 2012, and 2006 respectively. Emissions in 2020 have decreased by 77%, 32%, and 53% respectively compared to the peak.
- The VOCs and NH_3 emissions have been high for a long time. The first inflection point of VOCs and NH_3 emissions 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

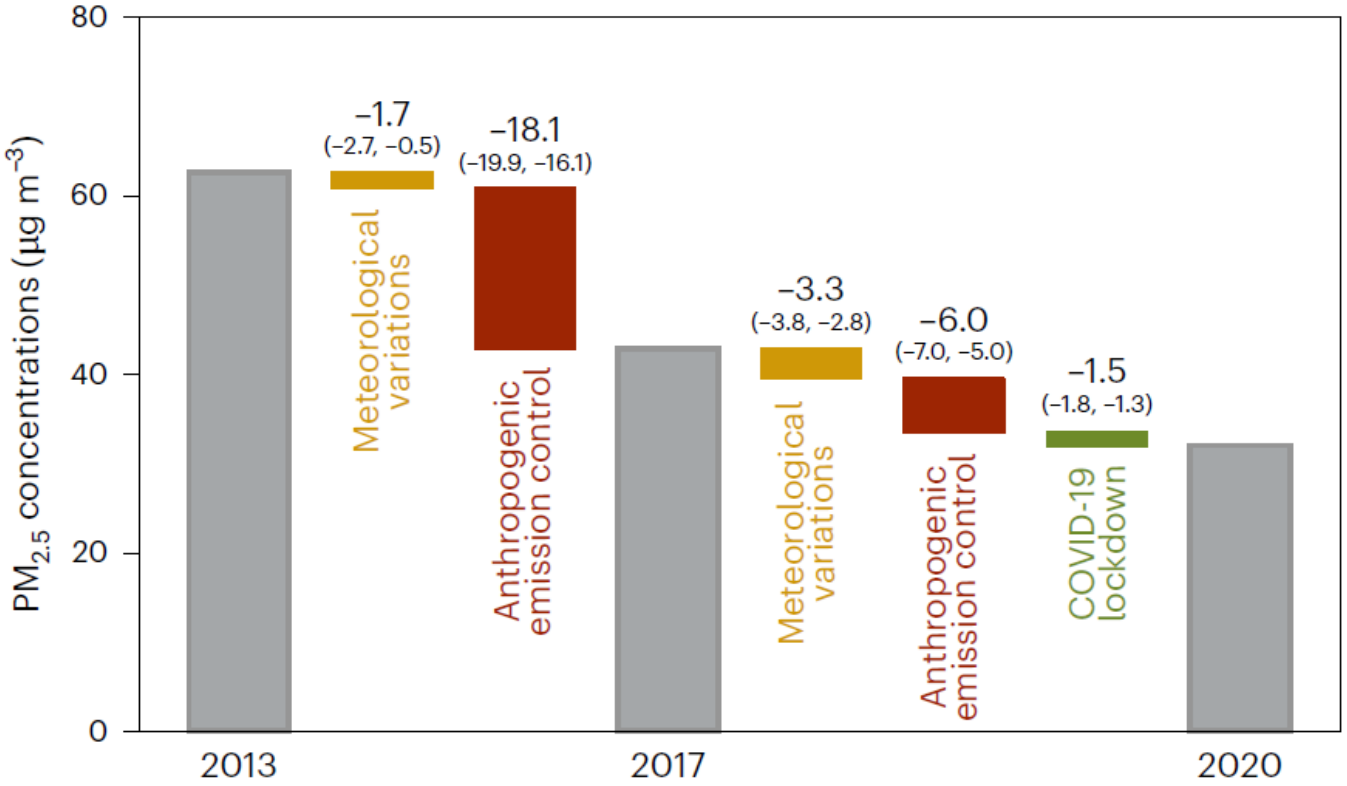




Compared with 2013, in 2022, the annual average concentrations of Beijing's $PM_{2.5}$, PM_{10}, NO_2, SO_2 decreased by 66.5%, 50.0%, 58.9% and 88.7%

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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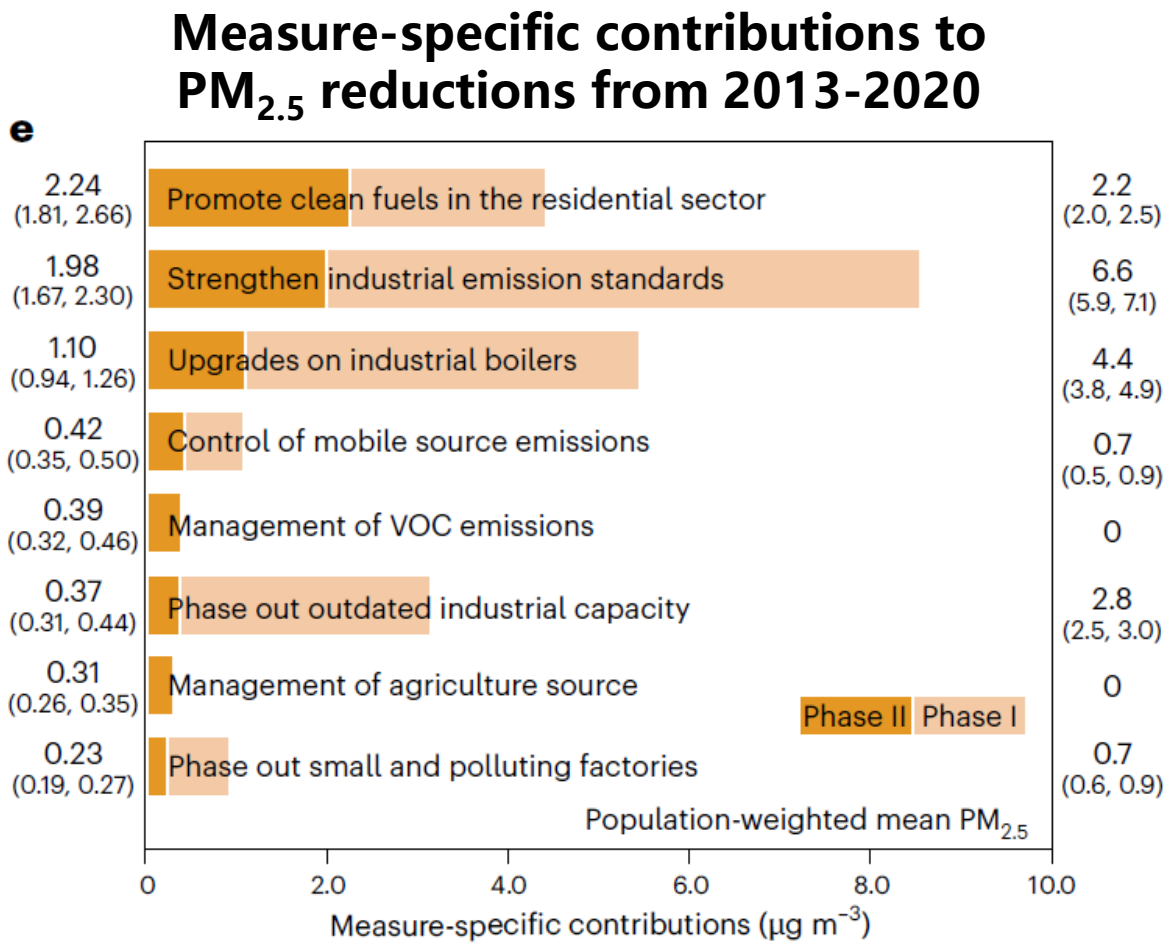
Assessment of air pollution control policies



- 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).

Geng et al., Nature Geoscience, 2024

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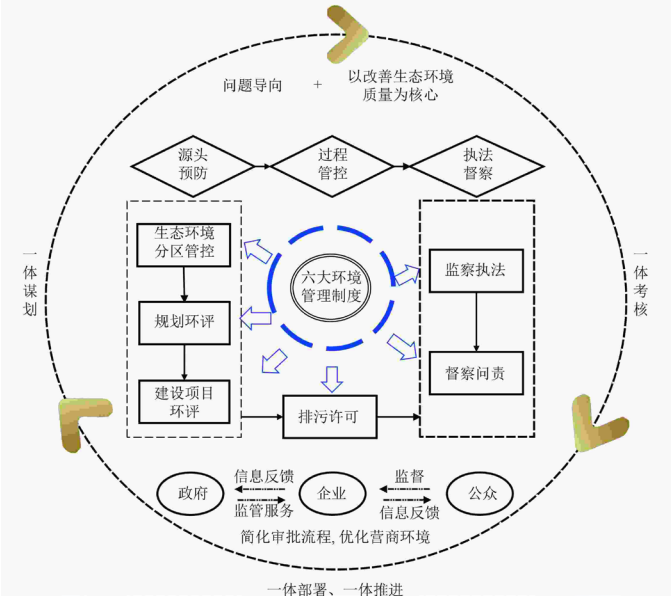
Outlook for future project design

Fundamental Capacity Building for Atmospheric Environment

Enhance the Regulatory Framework for Atmospheric Environment Management



Management of Key Emission Sources

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Thanks!