"Forum for Approaches to Air Pollution and Climate Action"
Integrated Approaches to Air Pollution and Climate Action: Monitoring, Technology, and Financing from Japan

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Next-Generation Monitoring and Assessment System for Air Pollution

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Introduction

- Air pollution, including ozone and PM2.5, remains a significant threat to human health and ecosystems.
- These pollutants are directly or indirectly linked to global environmental challenges, particularly climate change.
- Therefore, well-structured monitoring and assessment systems are essential for comprehensively understanding the current situation and evaluating future risks.
- Currently, in addition to conventional monitoring instruments, emerging technologies, such as satellite observations and low-cost sensors (LCS), offer new opportunities to obtain spatiotemporally diverse data.
- This presentation introduces the concept of a next-generation monitoring and assessment system for air pollution.

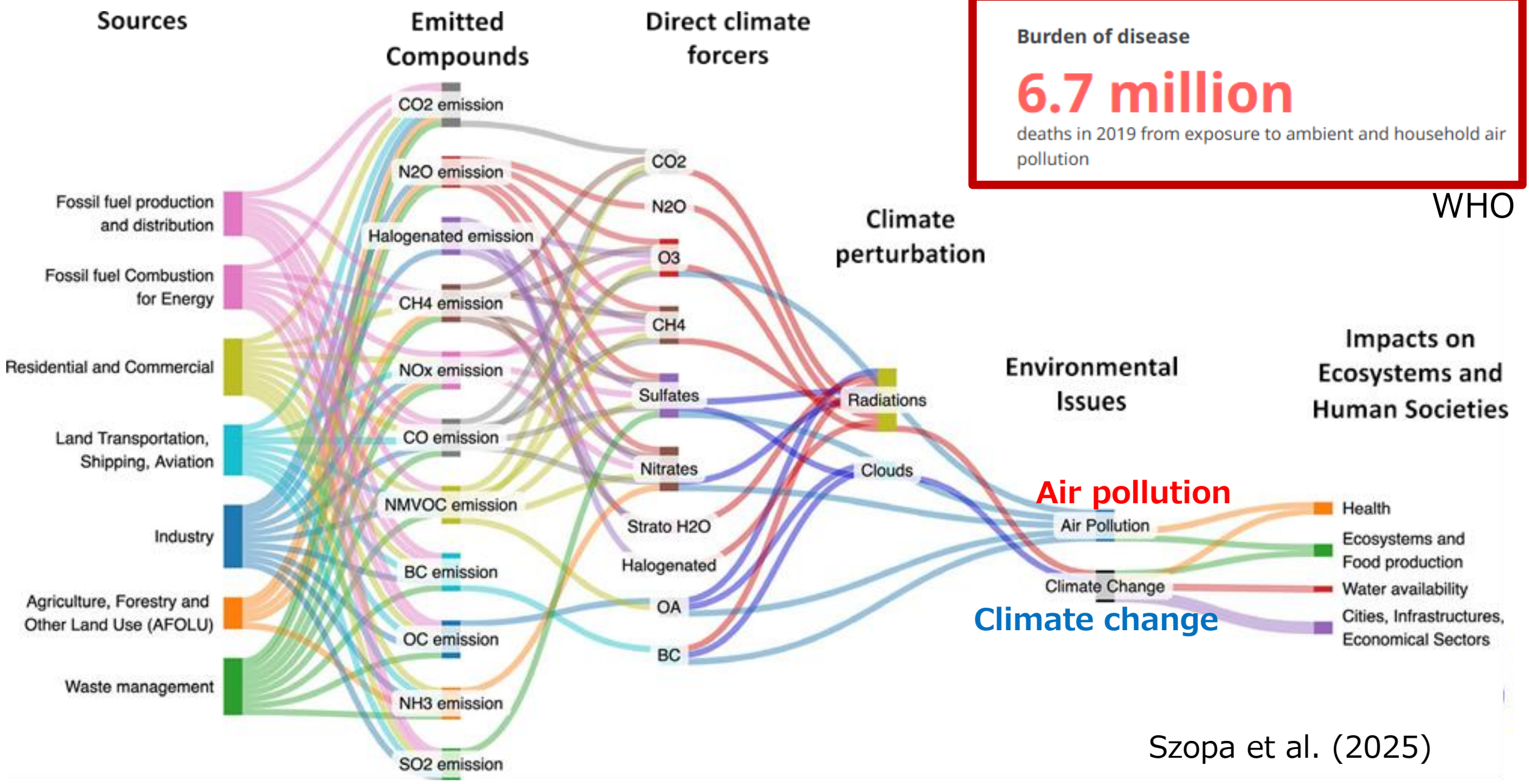
Air pollution as a threat to human society

Burden of disease

6.7 million

deaths in 2019 from exposure to ambient and household air pollution

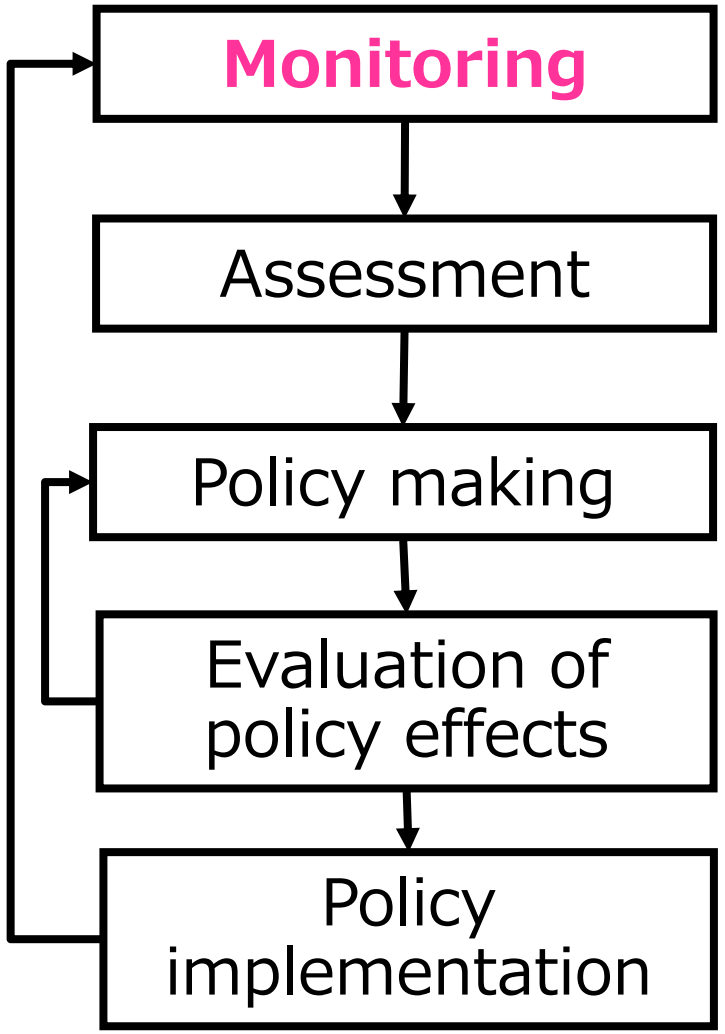
WHO



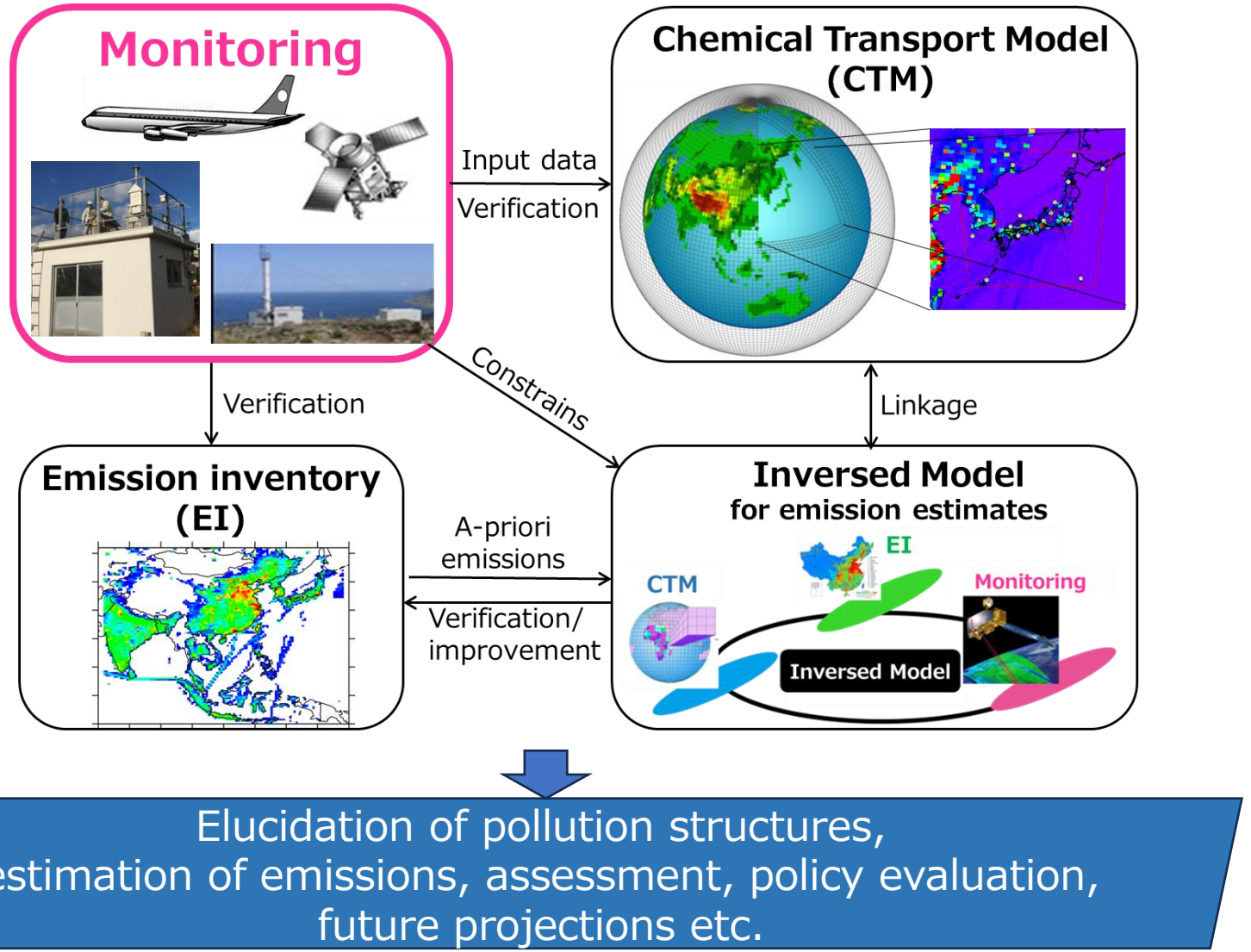
Szopa et al. (2025)

Air pollution management system

Flowchart



System tools



Limitation of ground monitoring stations

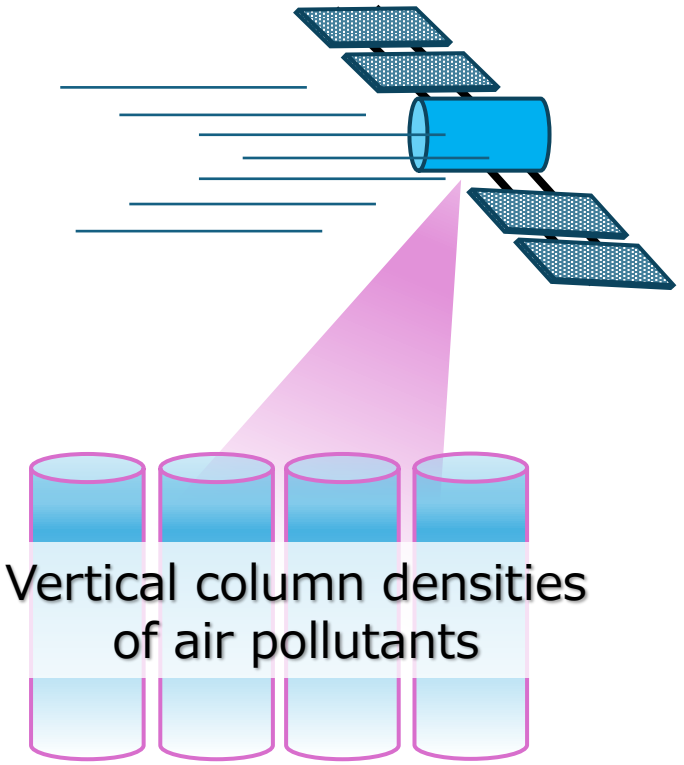
- Air pollution monitoring has been conducted for various media, including gases, particles, and rainwater.
- To obtain continuous, high-time-resolution (hourly) data for gaseous and particulate matter, conventional automatic monitors installed in an air-quality monitoring station are required.
- In addition to the initial costs of setting up such stations, these monitors also require regular maintenance, including calibration.
- Therefore, it is challenging to increase the number of monitoring stations and even to maintain the existing ones.

Kameda Station, Niigata City

Distribution of Monitoring Stations across Japan (e.g., SPM)

New technologies for updating monitoring (1)

- **Satellite observation**
  - ✓Provides wide-area data (unlike point measurements from conventional monitoring stations)
  - ✓Enables global coverage in a few days (e.g., within three days for the satellite GOSAT-GW, Japan)
  - ✓Useful for understanding the current situation over broad regions, including rural and remote areas such as agricultural and forested regions



The next speaker, Dr. Hiroshi Tanimoto will introduce the GOSAT-GW project in detail.

New technologies for updating monitoring (2)

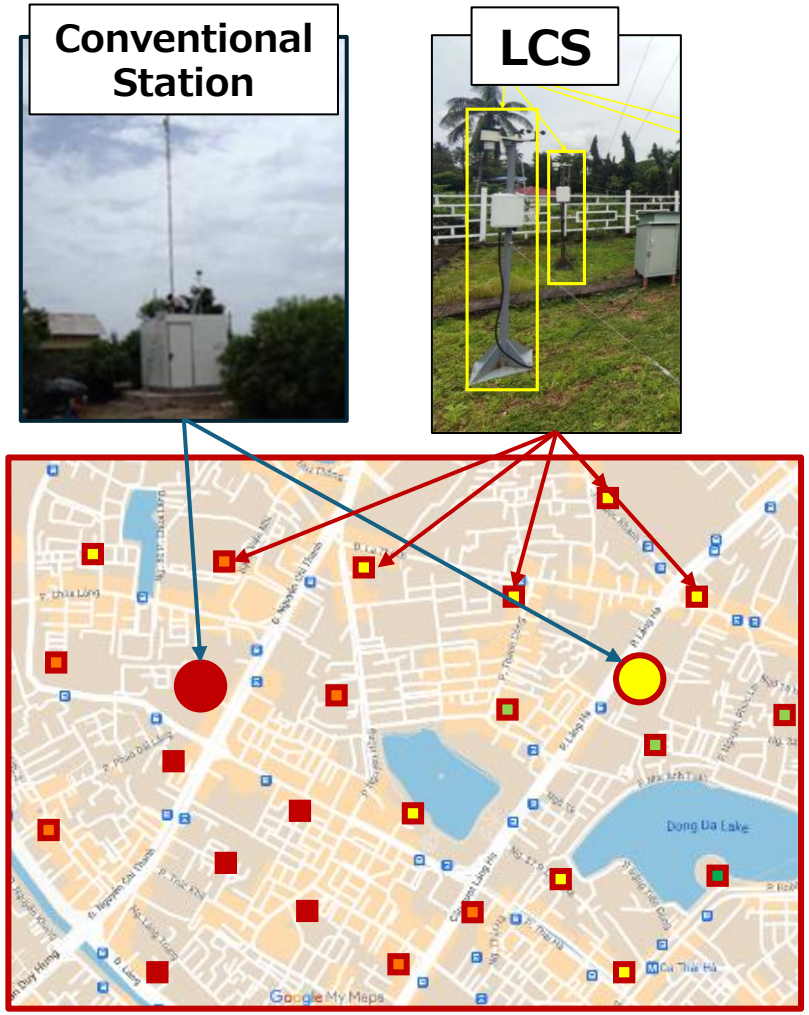
- **Low-cost sensors (LCS)**

✓Small devices, easy to install and add new monitoring points

✓Relatively low cost and can operate for several years without regular maintenance

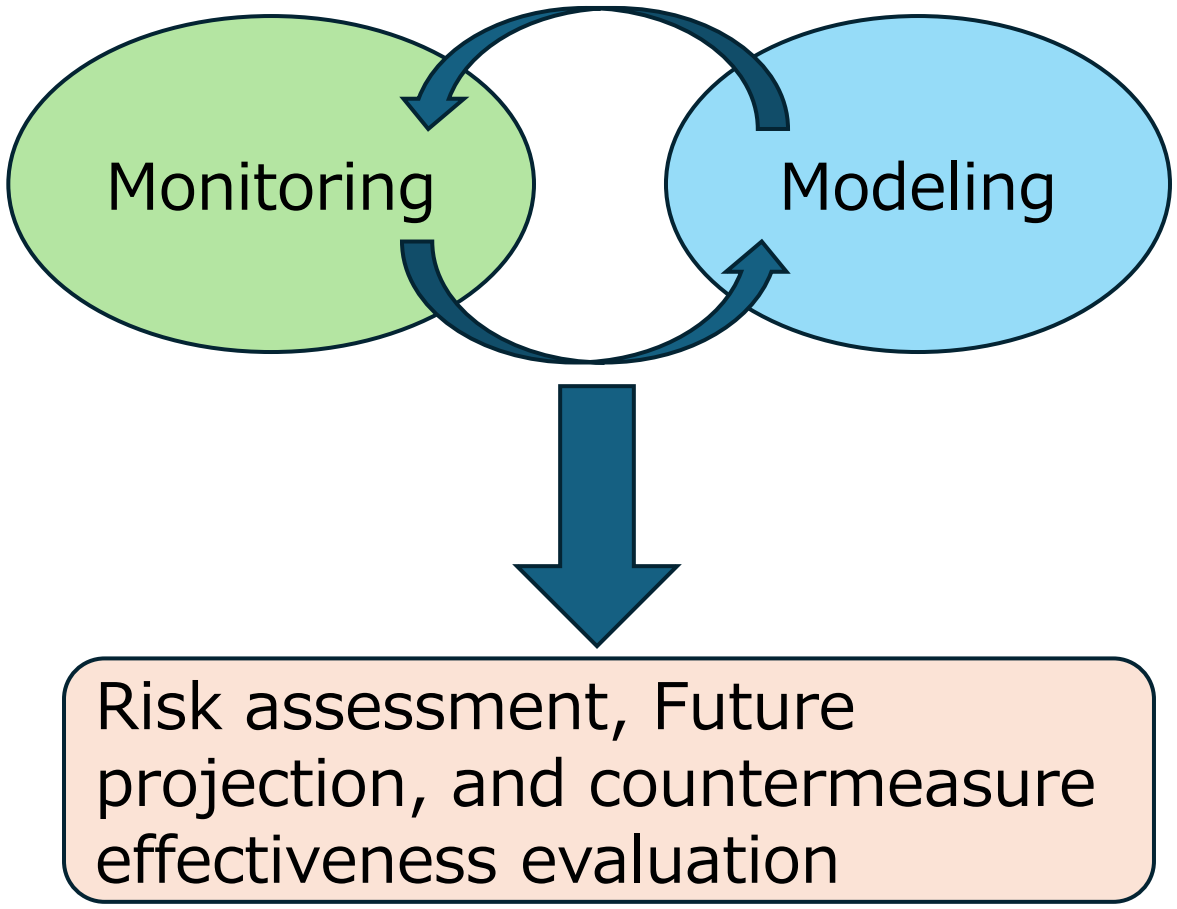
✓Useful for detailed understanding of concentration distributions within urban areas, in combination with conventional monitoring stations

✓Also useful for understanding areas that have not been monitored so far, such as agricultural and forested regions



The 3rd speaker, Dr. Keiichi Sato will introduce the LCS project in detail.

Linkage between Monitoring and Modeling



Informative for policy decision making

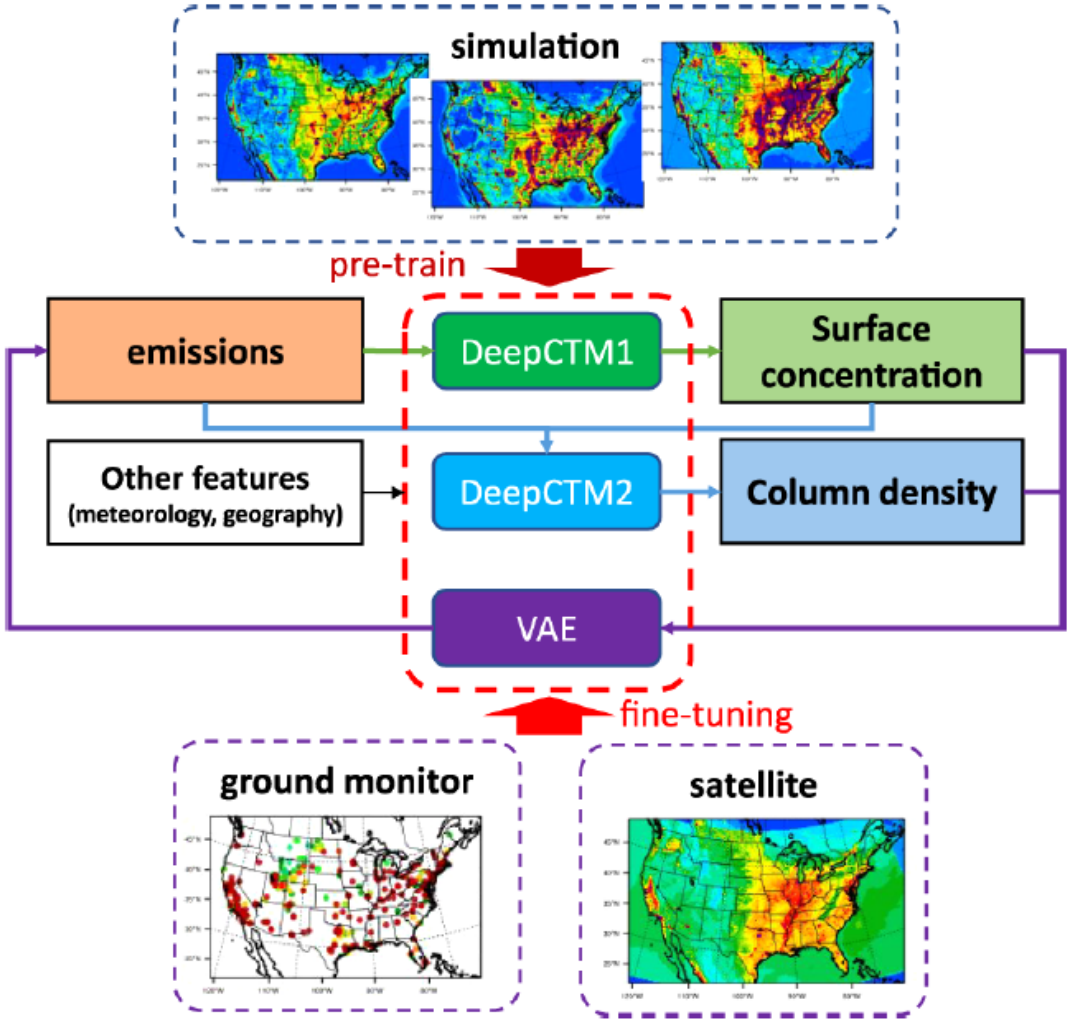
- Enables the integration of spatiotemporally diverse data produced by different monitoring approaches

  (including different time resolutions, frequencies, and spatial scales from the city level to the regional level)

- Essential for providing useful information for policy decision-making

Measurement-Model Fusion (MMF)

- Enables the integration of simulation modeling with monitoring data, including ground-based measurements, sensing data, and satellite observations
- Has been developed in combination with deep learning techniques (e.g., Xing et al. 2024)



Deep-learning fusion method proposed by Xing et al. (2024, EST)

MMF–Based Mapping of Nitrogen Deposition at the East Asian Scale

Measurement

EANET sites

Aircraft

Satellite

Ground-based stations

Chemical transport model

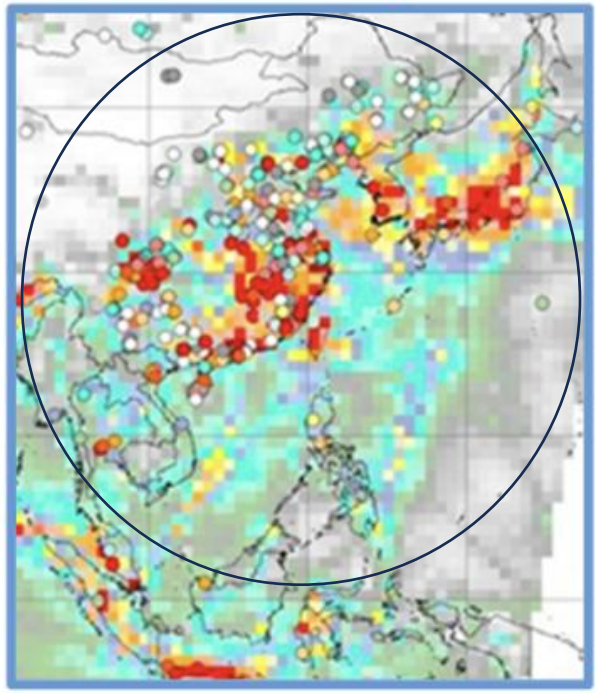
Emission inventory

Met. model

Model

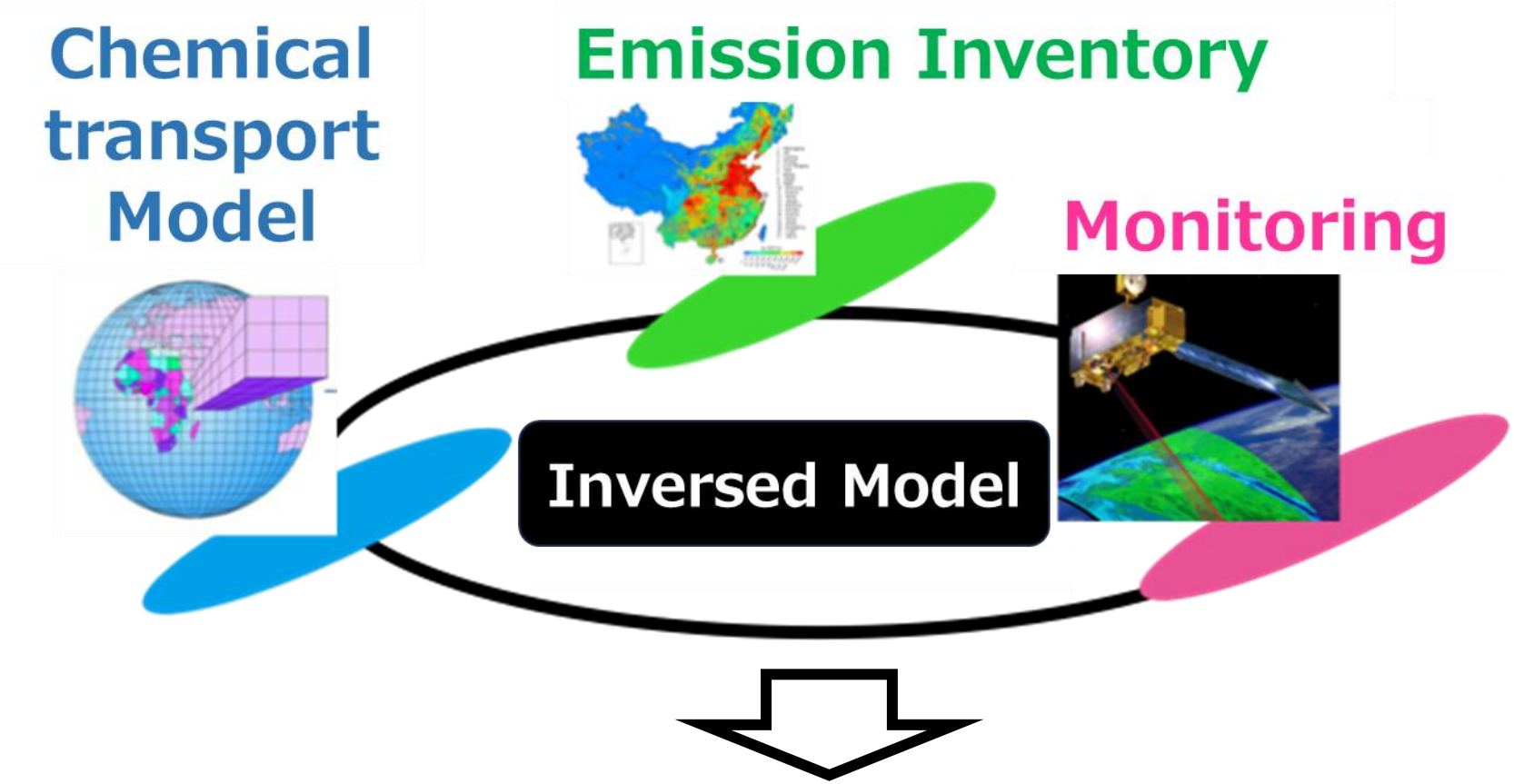
Data fusion (with AI)

Deposition Map Covering East Asia



Fu et al. 2022

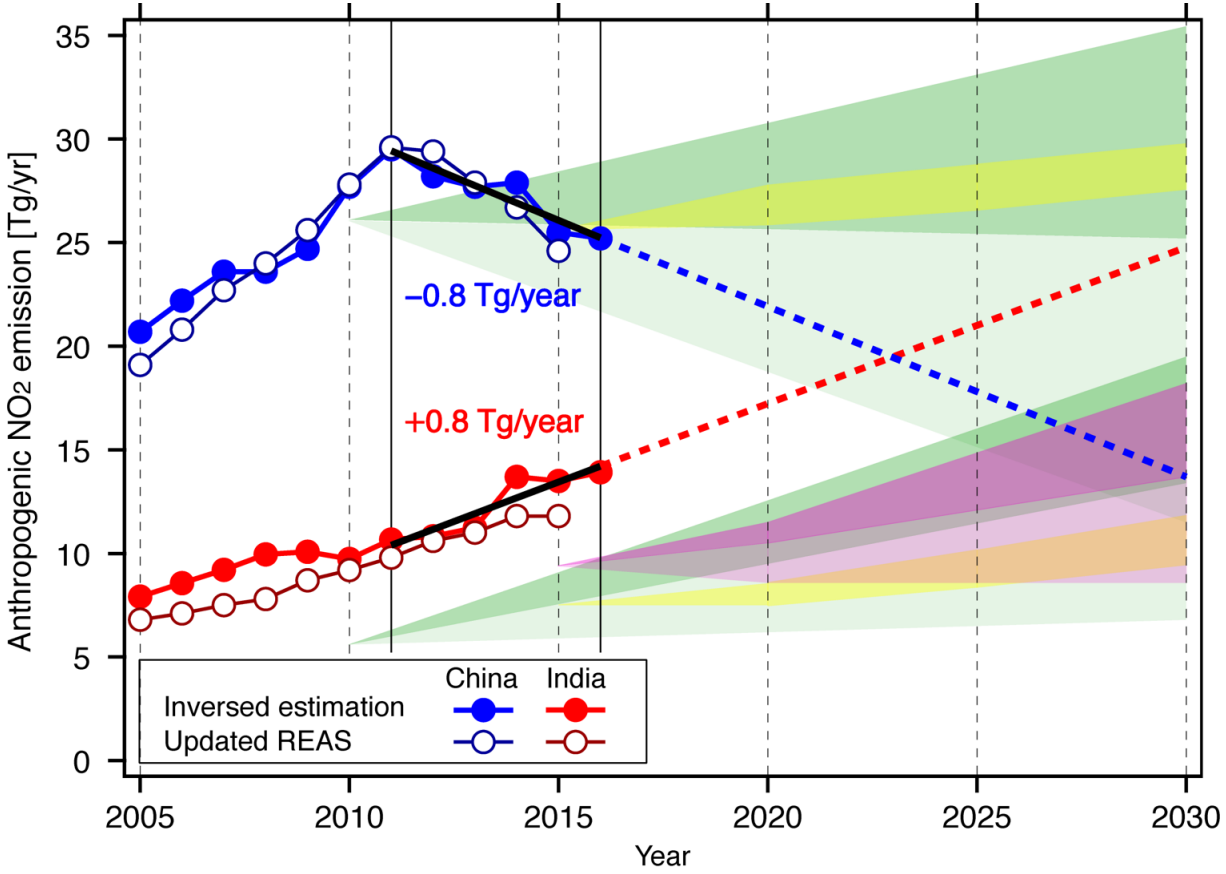
Inversed Modelling for Emission Estimation



- ✓ **Track changes in emissions and rapidly update inventories**
- ✓ **Reduce uncertainties in emission inventories**

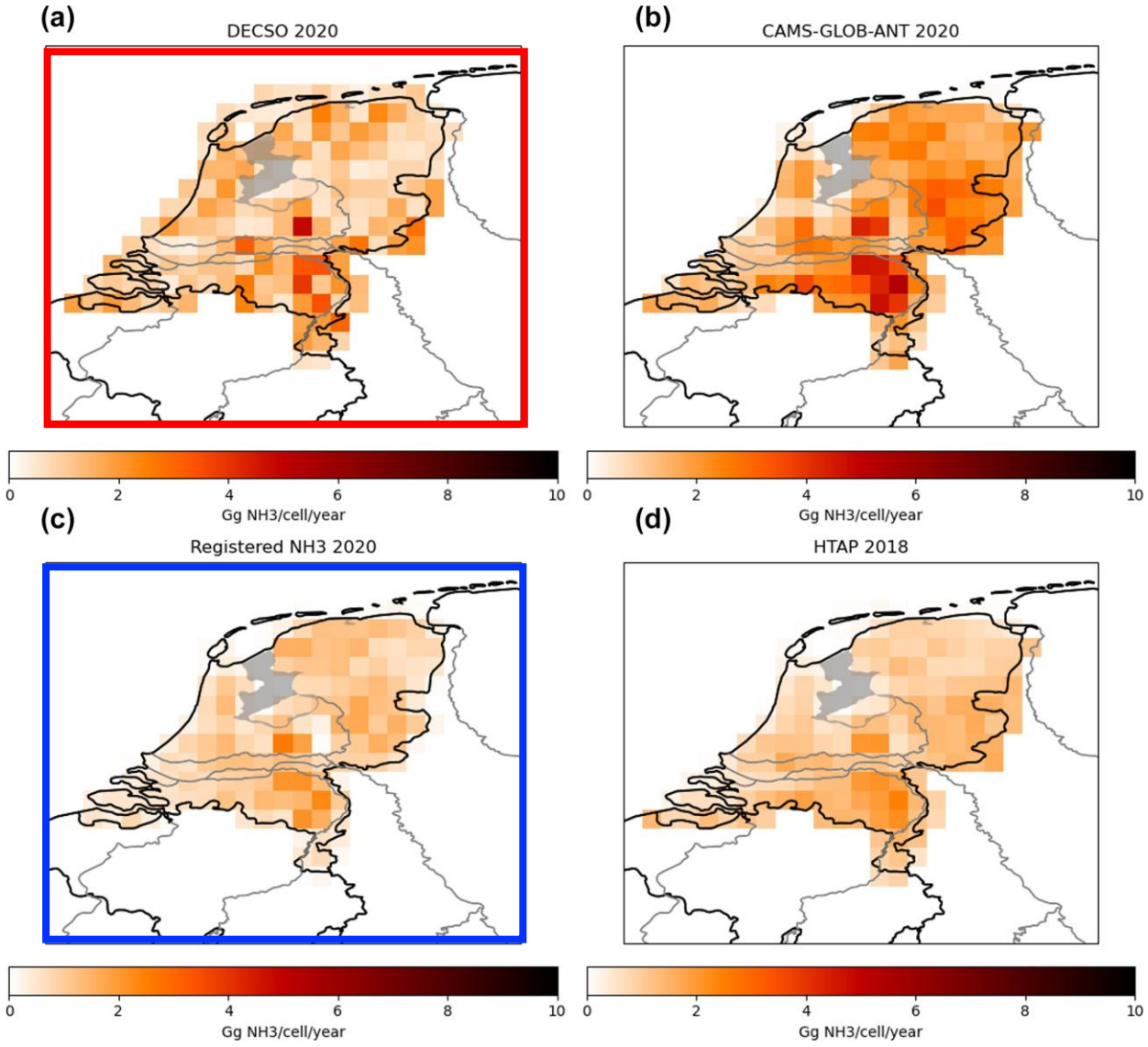
Examples of inversed modelling

NOx emission variation over China and India



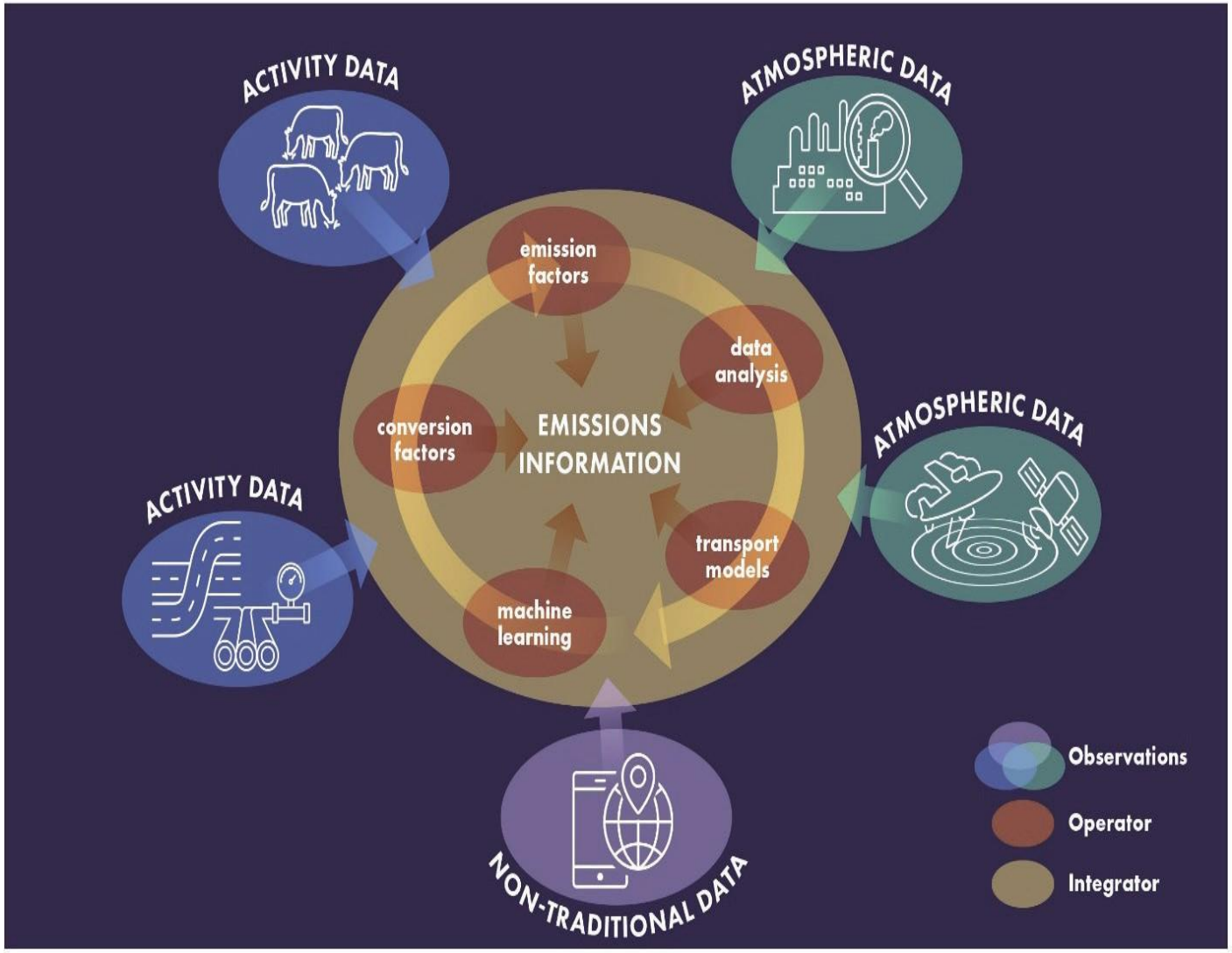
Itahashi et al. (2019)

NH_3 emissions in the Netherlands



Ding et al. (2024)

Hybrid approaches generate GHG emissions information

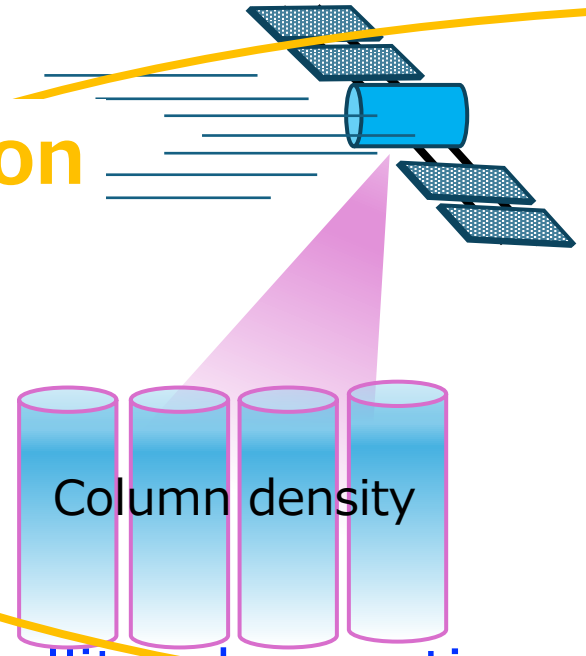


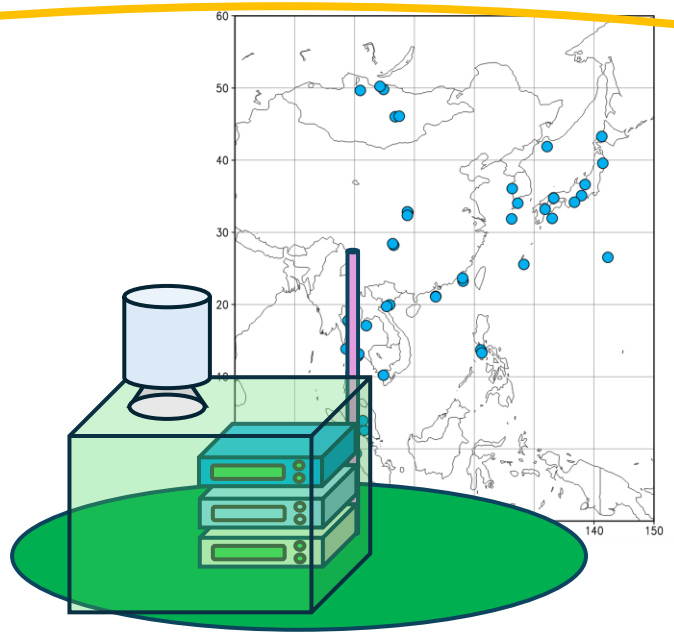
National Academies of Sciences, Engineering, and Medicine. 2022. Greenhouse Gas Emissions Information for Decision Making: A Framework Going Forward. Washington, DC: The National Academies Press. https://doi.org/10.17226/26641.

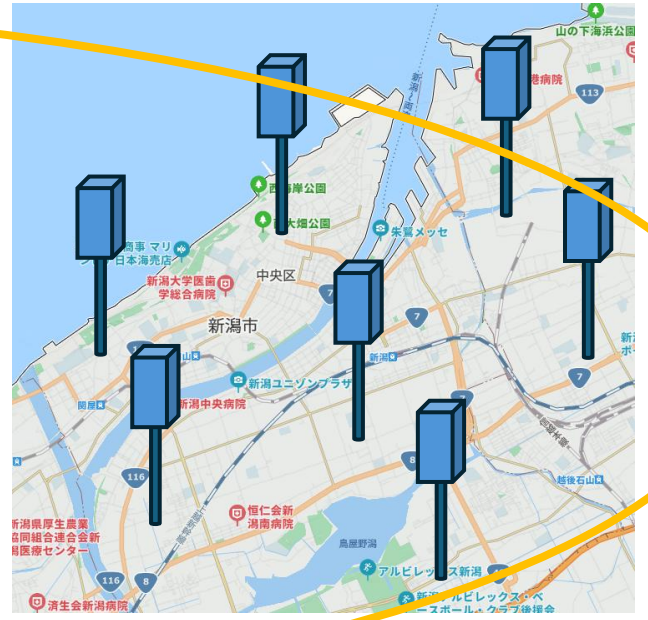
Hybrid approaches generate greenhouse gas emissions information through the combination and more complete integration of activity data (blue), nontraditional data (purple), and atmospheric data (green) that are modified by operator(s) (red) and integrated (gold).

Next-Generation Monitoring and Assessment System for Air Pollution in East Asia

Integration







	Satellite observation	Ground observation	Low-cost sensors
Data properties	Wide area	Long-term/Multiple substances simultaneously	Multipoint
Usage	Understanding the current situation over broad regions	Trend analysis/Mechanism elucidation	Detailed understanding of concentration distributions

Emission inventory, Chemical transport model, Inversed model, Impact assessment model ✚ AI

→ Risk assessment, future projection, and countermeasure effectiveness evaluation

Concluding remarks

- Air pollution remains a significant threat for human health and the global environment.
- Emerging technologies, such as satellite observations and LCS, offer new opportunities to obtain spatiotemporally diverse data (including different time resolutions, frequencies, and spatial scales from the city level to the regional level).
- Linkage between monitoring and modeling, such as the model-measurement fusion approach and inversed modeling, is essential for providing useful information for policy decision-making.
- Such a next-generation monitoring and assessment system for air pollution should be developed, especially in East Asia.