



AGENDA ITEM 10

Adoption of the Fifth Periodic Report on the State of Atmospheric Environment in East Asia (PRSAE5)

**The Twenty-sixth Session of the Scientific Advisory Committee (SAC26)
on the Acid Deposition Monitoring Network in East Asia
20-22 October 2026, Kuala Lumpur, Malaysia (Hybrid)**

Introduction

Establishment of the Drafting Committee (DC)

- At SAC24, based on the document EANET/SAC24/8/REV1, “the process for the development of the Fifth Periodic Report on the State of Acid Deposition in East Asia (PRSAD5)” was endorsed (EANET/SAC24/15 Report of the Session).
- At IG26, following Recommendations from SAC24 to IG26 were reported for PRSAD5:

III. **On the Process for the Development of the Fifth Periodic Report on the State of Acid Deposition in East Asia (PRSAD5)**, the SAC24 recommends to IG26 to:

- a. Endorse the establishment of the Drafting Committee (DC) of the Fifth Periodic Report, with nomination of the members by NFPs to be conducted after the IG26.
- b. Endorse the draft schedule of the DC and Lead Authors meetings and draft implementation plan and task the Network Center to organize the first DC meeting in April 2025.
- c. Endorse the proposed change of the title of the Fifth Periodic Report to be decided by SAC.

- In the Report of the session of IG26, the Session acted on the Recommendations of SAC24 for PRSAD5 as follows:
 - Agreed to initiate the preparation of the Fifth Periodic Report on the State of Acid Deposition in East Asia (PRSAD5) in 2025, with the process to be approved by PCs by email in the first quarter of 2025.
- The process of the preparation of PRSAD5 proposed by the Network Center for the EANET (NC) was reviewed and approved by PCs on 7 February 2025 by email.
- The DC of the PRSAD5 has been established.

DC members for PRSAE5

Country	Name
Cambodia	Mr. Chhay Por Ing
China	Dr. Yang Xiaoyang
Indonesia	Ms. Nevy Rinda Nugraini
Japan	Dr. Kazuhide Matsuda
Lao PDR	Mr. Sitthideth Nonthaxay
Malaysia	Mr. Mohan Kumar Sammathuria
Mongolia	Mr. Barkhasragchaa Baldorj
Myanmar	Dr. Kyu Kyu Sein
Philippines	Prof. Wilfredo M. Carandang
Republic of Korea	Prof. Taehyoung Lee (Chairperson)
Russia	Dr. Sergey Gromov
Thailand	Assoc. Prof. Dr. Sarawut Thepanondh
Vietnam	Dr. Le Ngoc Cau

Decisions of IG27

II. On the Process for the Development of the Fifth Periodic Report on the State of Acid Deposition in East Asia (PRSAD5)

- a. Approve the updated title, “**The Fifth Periodic Report on the State of Atmospheric Environment in East Asia (PRSAE5)**” endorsed by SAC25.
 - b. Approve the structure of chapters and contents of the PRSAE5 endorsed by SAC25.
 - c. Adopt the following recommendations by SAC25:
 - Regional Assessment (Part I) is, in principle, prepared based on the EANET data. Other monitoring data and literature such as peer reviewed paper can be used for reference purpose (not for direct evaluation).
 - d. Approve the implementation plan of the PRSAE5 endorsed by SAC25 and task the Network Center to organize the first Lead Authors Meeting in December 2025.
-

Format of the Periodic Report

Executive Summary

- **Summary for Policymakers**
- **Summary of Part I Regional Assessment**

Part I: Regional Assessment

- **The main activities of EANET and an assessment of the state of acid deposition and air pollution focusing on the special distribution, trend analysis, and possibly, impact assessment of acid deposition and air pollution in the region.**

Part II: National Assessment

- **National assessments from each participating country of EANET describing monitoring activities, air quality assessments, and control measures implemented at the national levels.**
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Regional Assessment: Structure of the Chapter

Chapter 1: Introduction

Chapter 2: Monitoring Data Quality

Box 1. Observational studies for sustainable monitoring in the EANET region

Chapter 3: Gas and Aerosol Concentration in East Asia

Box 2. Impacts of meteorological conditions on air pollution

Chapter 4: Wet and Dry Deposition in East Asia

Box 3. Nitrogen flow and management

Chapter 5: Impacts on Ecosystems in East Asia

Chapter 6: Summary and Recommendations for Future Activities

Annex: Introduction of EANET Project and related information

The LAs and CAs of the Regional Assessment for the PRSAE5

Chapters	Lead Authors (LAs)	Contributing Authors (CAs)	Note: Omit the title of all LAs and CAs
1. Introduction	Fan Meng (NC)	DC: Chhay Por Ing NC: Junichi Kurokawa, Ken Yamashita and Meihua Zhu	
2. Monitoring Data Quality	Sergey Gromov (DC)	DC: Kyu Kyu Sein NC: Kumiko Nakamura, Hiroyuki Sasaki, Azusa Sakaue, Hiroyuki Sase, and Junichi Kurokawa	
3. Gas and Aerosol Concentration in East Asia	Sarawut Thepanondh and Mohan Kumar Sammathuria (DC)	DC: Le Ngoc Cau, Taehyoung Lee, Nevy Rinda Nugraini, and Barkhasragchaa Baldorj Expert: Ji Dongsheng NC: Yusuke Kiriyaama, Keiichi Sato, Satomi Sugahara, and Akie Yuba	
4. Wet and Dry Deposition in East Asia	Kazuhide Matsuda (DC)	DC: Sergey Gromov and Sitthideth Nonthaxay Expert: Satomi Ban, Syuichi Itahashi, and Naoyuki Yamashita NC: Mari Futami, Mingqun Huo, Hiroyuki Sasaki, and Junichi Kurokawa	
5. Impacts on Ecosystems in East Asia	Atsushi Kume (Expert)	DC: Wilfredo M. Carandang, Expert: Sammy L. Ayatona, Roger C. Evangelista Jr., Masami Koshikawa, Ma. Fatima Anneglo R. Molina, Rieko Urakawa, V. Jeyanny A/P Vijayanathan, and Ekaterina Zhigacheva, NC: Yusuke Kiriyaama, Masayuki Morohashi, Azusa Sakaue, and Hiroyuki Sase	
6. Summary and Recommendations for Future Activities	Toshimasa Ohara and Siwaporn Rungsiyanon (NC)	DC: Xiaoyang Yang Expert: Duan Kuiquan NC: Junichi Kurokawa, Hiroyuki Sase, Keiichi Sato, Ken Yamashita, and Meihua Zhu	
Annex. Introduction of EANET Project and related information	Junichi Kurokawa (NC)	Network Center for the EANET (All members)	
Box	No. 1 Keiichi Sato (NC) No. 2 Junichi Kurokawa (NC) No. 3 Hiroyuki Sase (NC)	DC: Le Ngoc Cau (No. 2)	

National Assessment: Contents*

Chapter 1. Basic Information on National Monitoring Activities

1.1. Outline of the activities on acid deposition and air pollution in National Monitoring Plan

1.2. Monitoring program

1.3. Monitoring stations

1.4. Sampling and measurements

Chapter 2. Acid Deposition and Air Pollution in Each Participating Country and Their Environmental Impacts

2.1 State of acid deposition and air pollution

2.2 State of inland aquatic environment

2.3 State of soil and vegetation

2.4 State of catchment monitoring

2.5 Overall analysis

Chapter 3. Review of National Air Quality Management including Acid Deposition

Chapter 4. Conclusion or Summary

***The structure can be modified by each PC**

Executive Summary: Contents

➤ Summary for Policy Makers

□ Summary of Key Points

- ✓ About the PRSAE5
- ✓ Current status of EANET monitoring activities
- ✓ Data quality
- ✓ Overview of the analysis of monitoring results

□ Summary of State of Atmospheric Environment

- ✓ Gas and Aerosol Concentration in East Asia
- ✓ Wet and Dry Deposition of atmospheric substances
- ✓ Impact of Ecosystems in East Asia

□ Key Message to Policy Maker

- ✓ Protecting and Strengthening EANET's Scientific Foundation
- ✓ Supporting Alternative Monitoring Technologies and Closing Data Gaps
- ✓ Bridging Scientific Data with Policy Making
- ✓ Moving from Regional Data to Regional Strategies and Measures
- ✓ Building a Stronger Regional Platform for the Future
- ✓ Conclusion

➤ Summary of each Chapter or Regional Assessment

Implementation Plan for PRSAE5 after DC3/LAM3

Year	Month	Activities/Events	Deliverables
2026	29 JUL	The DC3/LAM3	Comments from the DC3/LAM3
	SEP	Circulation of the final draft of the PRSAE5 including Executive Summary to the DC and SAC members for approval	The final draft of the PRSAE5 including Executive Summary (to be approved by DC and SAC members)
	SEP	Circulation of the final draft of PRSAE5 including Executive Summary to NFPs for endorsement	The final draft of the PRSAE5 including Executive Summary (to be endorsed by NFPs)
	OCT	SAC26 Presentation of the final draft of the PRSAE5 including Executive Summary by the Chairperson of the DC for adoption by SAC26	The final draft of PRSAE5 including Executive Summary (adopted by SAC26)
	NOV	IG28 Presentation of the report of SAC26 including the final draft of the PRSAE5 by the Chairperson of SAC26 for endorsement by IG28	The final draft of PRSAE5 including Executive Summary (endorsed by IG28)
	DEC	Proofreading of the final draft of PRSAE5	The proofread and finalized PRSAE5
2026 2027	DEC -	Printing and distribution of PRSAE5	Publication of PRSAE5

Review of the PRSAE5

Part I: Regional Assessment

Chater 1: Introduction

1.1 Background

- General background related to the EANET and the periodic report

1.1.1 Preparation of the fifth periodic report

- General introduction of the periodic report including the brief process for preparing the PRSAE5

1.2 Brief introduction of the EANET

- Establishment and roles of the EANET
- Major activities and achievements of the EANET

1.3 Objectives

- The objectives of the EANET based on the "Instrument" and "Annex"

1.4 Institutional arrangement

- Overview of the roles and functions of each component of the EANET (Figure 1.4.1)

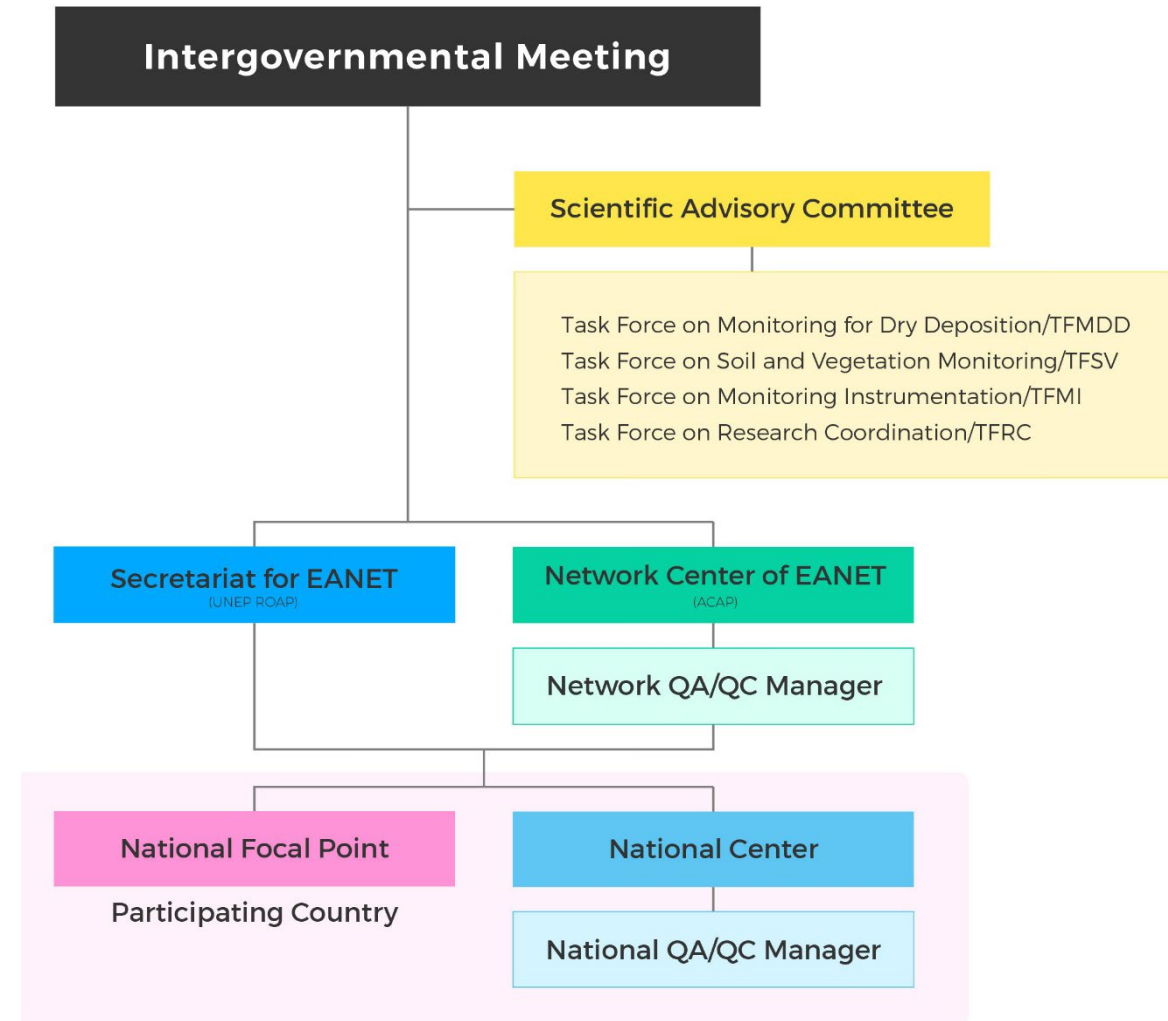


Figure 1.4.1 Institutional Framework for EANET

Chater 1: Introduction

1.5 EANET activities in 2000-2024

1.5.1 Main activities of the EANET

- Air concentration and acid deposition monitoring
- Compilation, evaluation, storage, and provision of data
- Promotion of quality assurance and quality control (QA/QC) activities
- Implementation of technical support and capacity building activities
- Promotion of research and studies related to air pollution and atmospheric deposition problems
- Promotion of public awareness activities
- Other relevant activities

1.5.2 EANET meetings

- Brief history of important EANET meetings

1.5.3 Monitoring activities

- Overview of EANET monitoring activities including monitoring interval, species, and parameters

1.5.4 Current status of monitoring activities as 2024

- Locations and related information of monitoring sites in 2024 (Figures 1.5.1 and 1.5.2, and Tables 1.5.1-1.5.3)



Figure 1.5.1. Locations of air concentration/acid deposition monitoring sites in 2024.

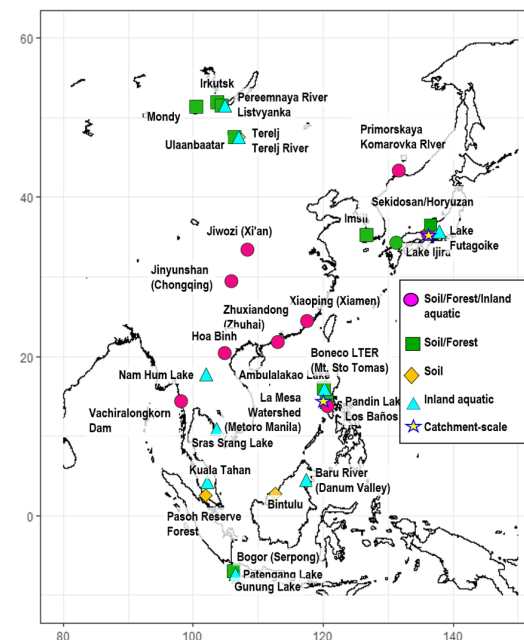


Figure 1.5.2. Locations of basic survey sites for ecological monitoring in 2024. 14

1.5.5 Research activities

- Promotion of scientific research on air pollution, acid deposition, and their ecological impacts, including monitoring methodologies, deposition estimation, air quality modeling, and emission inventories.
- Promotion of regional research collaboration and dissemination of scientific findings through fellowship programs, joint research projects, scientific publications, and EANET research platforms.

1.5.6 Capacity building activities

- Strengthening of technical and institutional capacities through individual and online training, technical missions, workshops, expert meetings, and the development and dissemination of technical manuals, guidelines, QA/QC reports, and training materials.
- Gradually expansion of capacity building to broader air quality management issues, including PM_{2.5}, ozone, to enhance monitoring and QA/QC capabilities and develop human resources in the Participating Countries.

1.5.7 Public awareness activities

- Promotion of public awareness and stakeholder engagement through regional and national workshops to share scientific knowledge, monitoring results, and experiences on air pollution and air quality management.
- Dissemination of information and enhancement of regional communication through the EANET website, newsletters, web stories, online workshops, and other digital tools to increase EANET's visibility and promote regional cooperation on air quality management.

Chater 2: Monitoring Data Quality

2.1 Introduction

- General introduction of QA/QC and related activities in the EANET

2.2 General procedure of QA/QC

2.2.1 Preparation of National Monitoring Plan

- Contents, objectives, and updates of the National Monitoring Plan (NMP)

2.2.2 Siting

- Classification of monitoring sites (Table 2.2.1)

2.2.3 Sampling and sample handling

- Appropriate sample collection, preservation, and storage procedures are applied in accordance with the monitoring manuals to ensure sample quality before analysis.

2.2.4 Chemical analysis

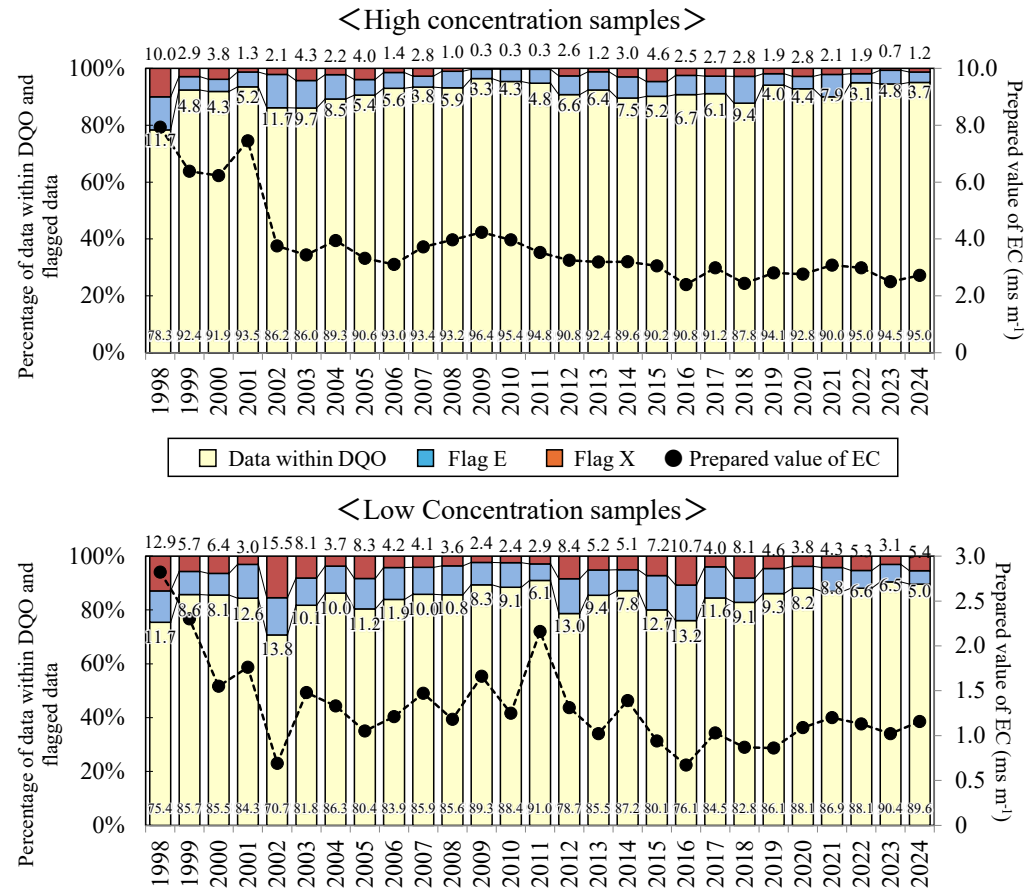
- Major ions and other relevant chemical properties of water and soil samples are analyzed using approved analytical techniques specified in the respective monitoring manuals.

2.2.5 QA/QC procedure prior to the data submission to the national and network center

- The quality of chemical analysis is evaluated using ion balance and conductivity checks, with reanalysis and further examination required when the established criteria are not met.
- Compliance with ion balance and conductivity criteria varied among EANET monitoring sites due to several factors.

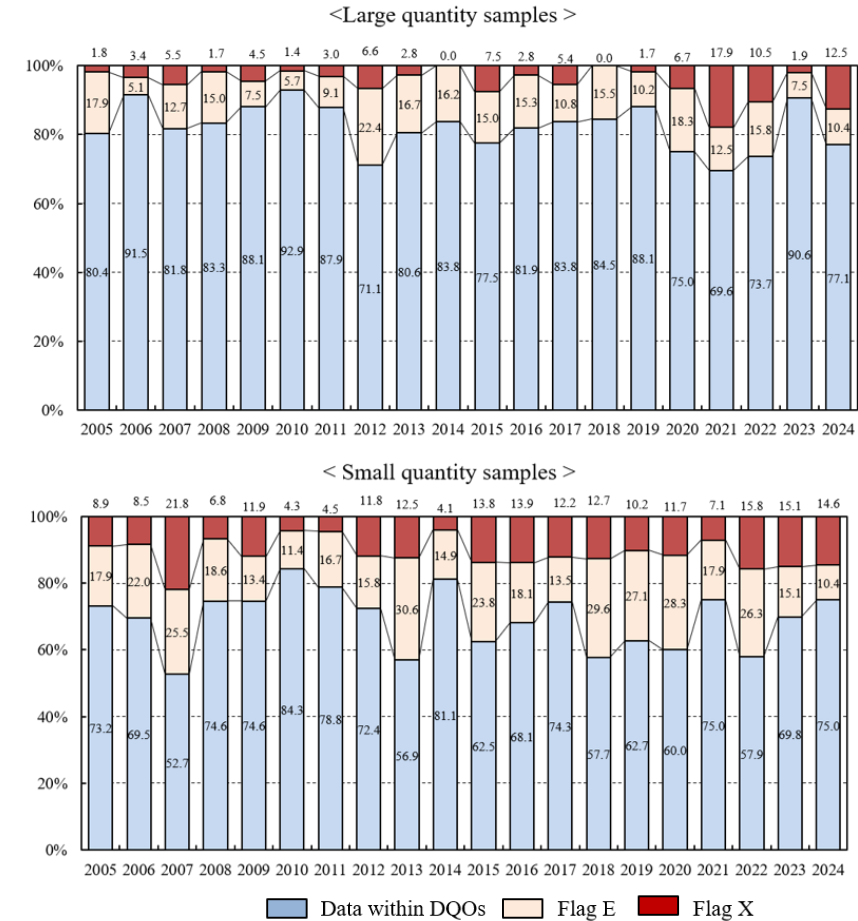
2.3. Evaluation of the Inter Laboratory-Comparison Projects

2.3.1 Wet deposition



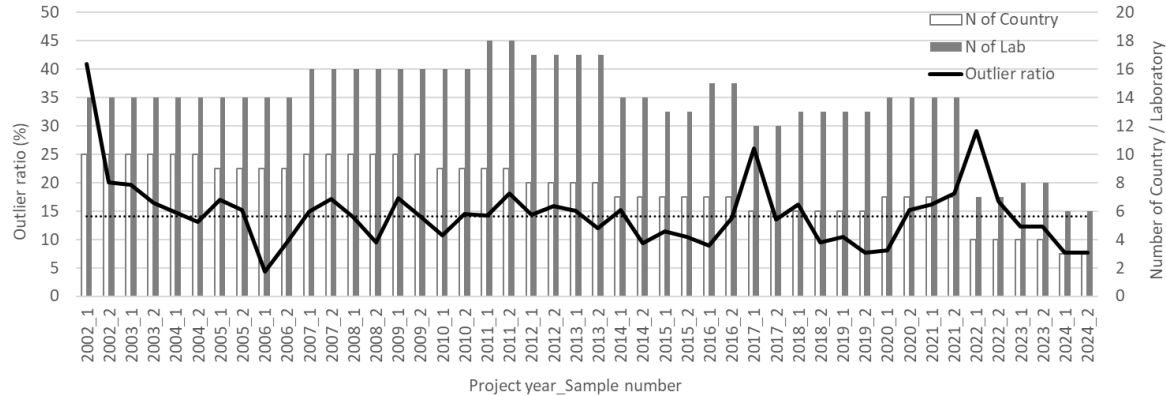
- The inter Laboratory-Comparison (ILC) surveys were conducted 27 times from 1998 to 2024, involving 21-37 laboratories from 13 countries. The percentage of data within the DQOs increased from 75.4-78.3% (1998) to 89.6-95.0% (2024).

2.3.2 Dry deposition



- The ILC surveys on filter pack analysis were conducted 20 times from 2005 to 2024. The percentage of data within the DQOs slightly increased from 73.2% (2005) to 75.0% (2024) for small quantity samples and decreased from 80.4% (2005) to 77.1% (2024) for large quantity samples.

2.3.3 Soil



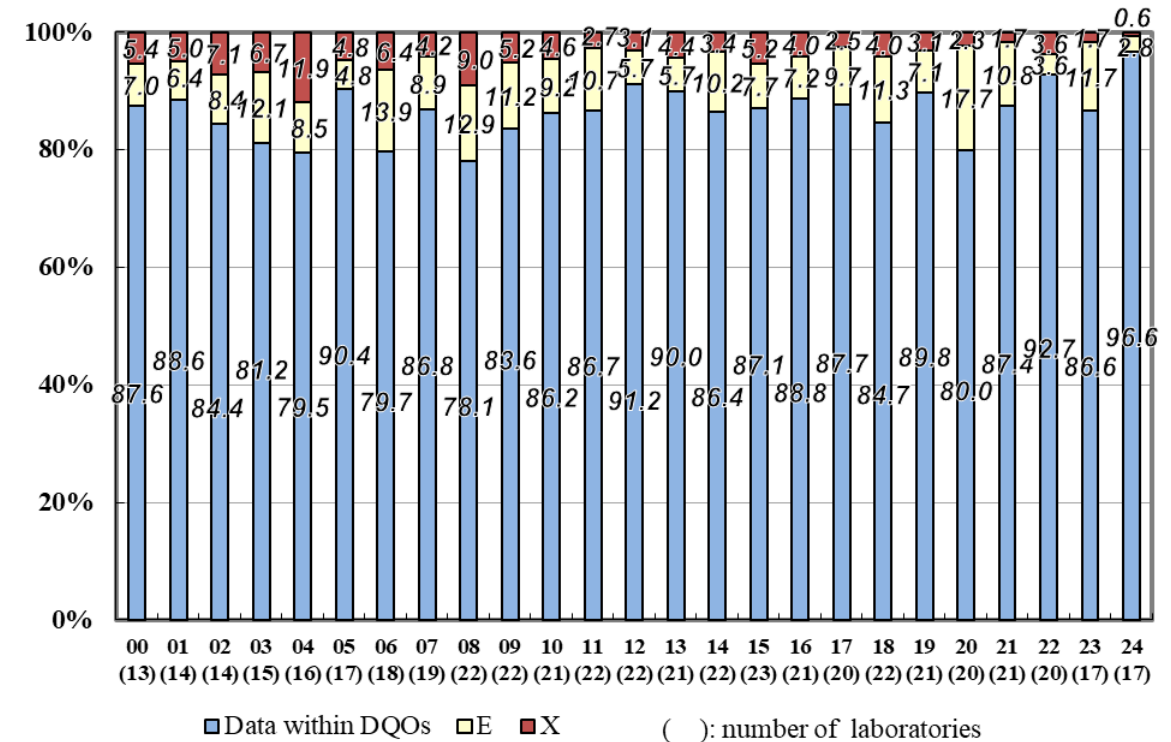
Change of the outlier ratio in all properties and laboratories from 2002 to 2024

Outlier ratio = $\{(N \text{ of entire dataset}) - (N \text{ of verified dataset})\} / (N \text{ of entire dataset})$.

The suffixes ‘_1’ and ‘_2’ denote the two types of the samples analyzed each year (e.g., 241s and 242s). The dotted line indicates the average outlier ratio from 2003 to 2023.

- The ILC project on soil analysis started in 1999, with prepared soil samples distributed annually to participating laboratories.
- Analytical results were statistically evaluated for outliers and laboratory precision using the Cochran and Grubbs methods. Although the outlier ratio decreased after 2002, it remained relatively high (10–25%) during 2003–2024.

2.3.4 Inland aquatic environment



- The Inter-Laboratory Comparison project on inland water analysis started in 2000 and has been conducted 25 times. Participating laboratories analyzed artificial inland water samples prepared by the NC using their routine analytical procedures.
- The percentage of data meeting the DQOs fluctuated in the early years but remained high in subsequent projects.

2.4 Evaluation of the regular measurement

2.4.1 Flow for the data reporting and verification

- **EANET monitoring data undergo an annual multi-step verification process involving National Centers, the Network Center, and external experts.**
- **The verified data are compiled into the Data Report, reviewed and approved by EANET bodies, and then published on the EANET website.**

2.4.2 Validation of the data for wet deposition

- **Annual wet deposition data quality is assessed using quality flags, ion balance (R1), and conductivity agreement (R2).**
- **Long-term trends in these indicators are evaluated to identify changes in data quality and support improvements in laboratory and analytical practices.**

2.4.3 Data completeness

- **Data completeness is evaluated against DQOs for wet and dry deposition monitoring to ensure reliable monthly and annual statistics.**
- **Regular assessment helps identify data gaps and operational problems and supports measures to improve data completeness.**

2.4.4 Site representativeness

- **Monitoring site characteristics are assessed to ensure appropriate classification, representativeness, and interpretation of EANET data.**

2.5 Conclusion and recommendations

- QA/QC activities are essential for ensuring reliable EANET monitoring data for regional assessment and policy development.
- The ILC Project and Technical Missions support the improvement and maintenance of laboratory analytical quality through performance assessment, technical discussion, and targeted support.
- Recommendation:
 - Monitoring sites should be properly selected, maintained, and regularly reviewed to ensure their representativeness and suitability.
 - Established monitoring methodologies and techniques should be maintained through adequate resources, knowledge transfer, and the development of SOPs.
 - Technical support by the NC should be strengthened through effective ILC activities, strategic Technical Missions, and needs-based capacity building and knowledge transfer.
 - QA/QC activities should adapt to new monitoring targets such as ozone and PM_{2.5}.
 - Information should be collected on emerging technologies and approaches, including low-cost sensors (LCSs), satellite observations, and the application of artificial intelligence (AI) **although they are not yet technically ready to serve as a main monitoring method under the EANET framework, but they have the potential to serve as complementary approaches.**

Chater 3: Gas and Aerosol Concentration in East Asia

Contents

3.1 Introduction

3.2 Monitoring methodology

3.3 Particulate Matter (PM_{2.5}, PM₁₀, Chemical Components)

3.4 Ozone (Surface ozone)

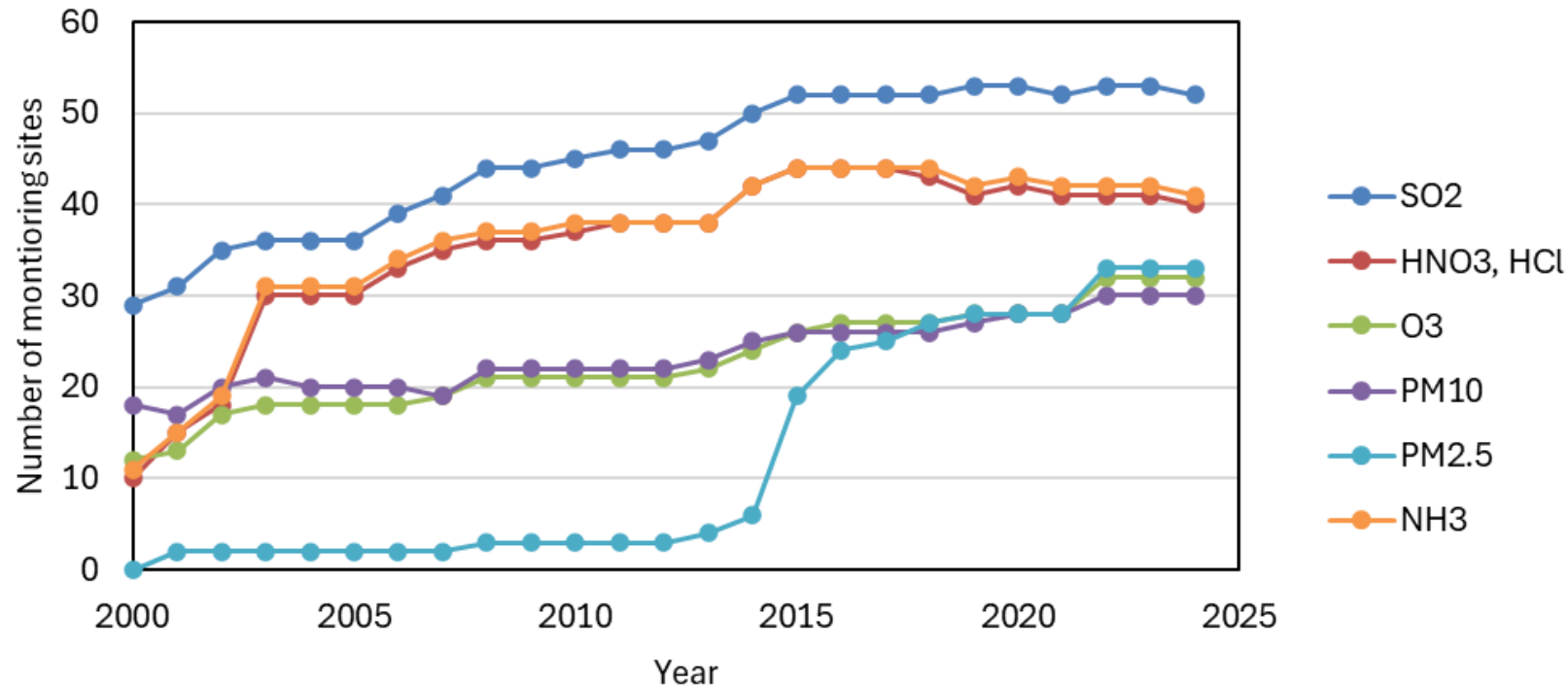
3.5 Other gas species

3.6 Summary and Recommendations

3.7 References

3.2 Monitoring methodology

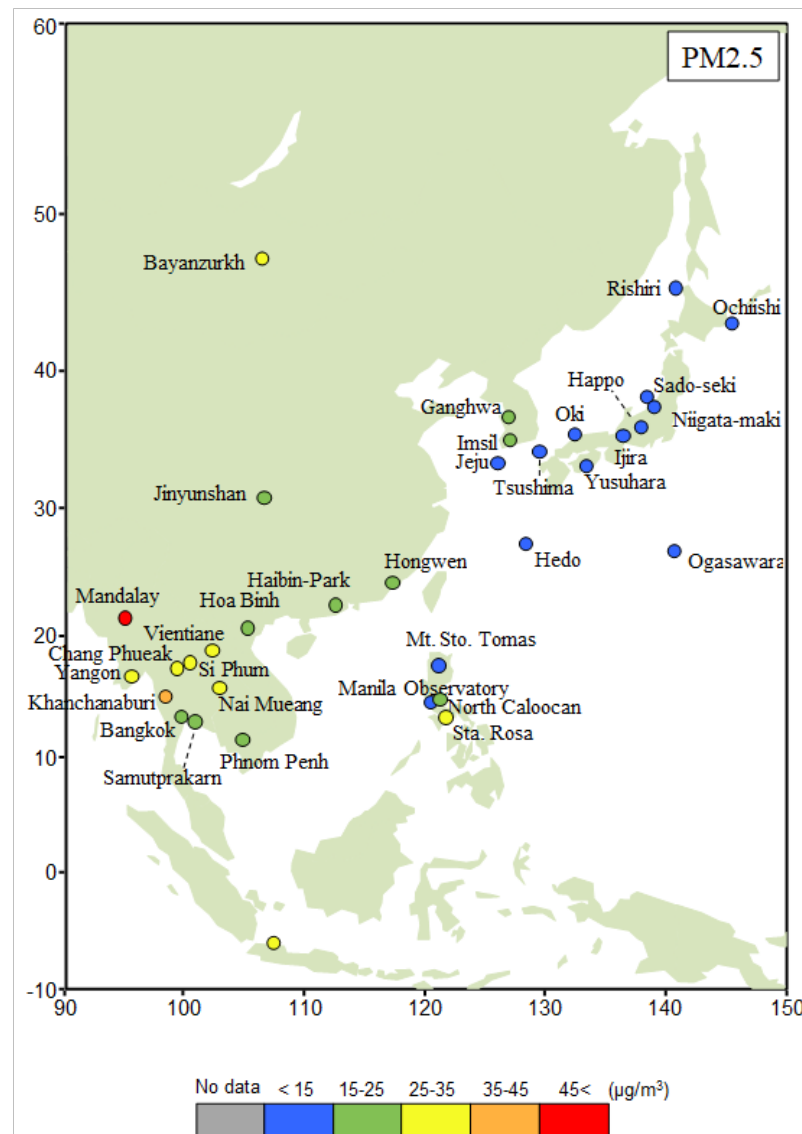
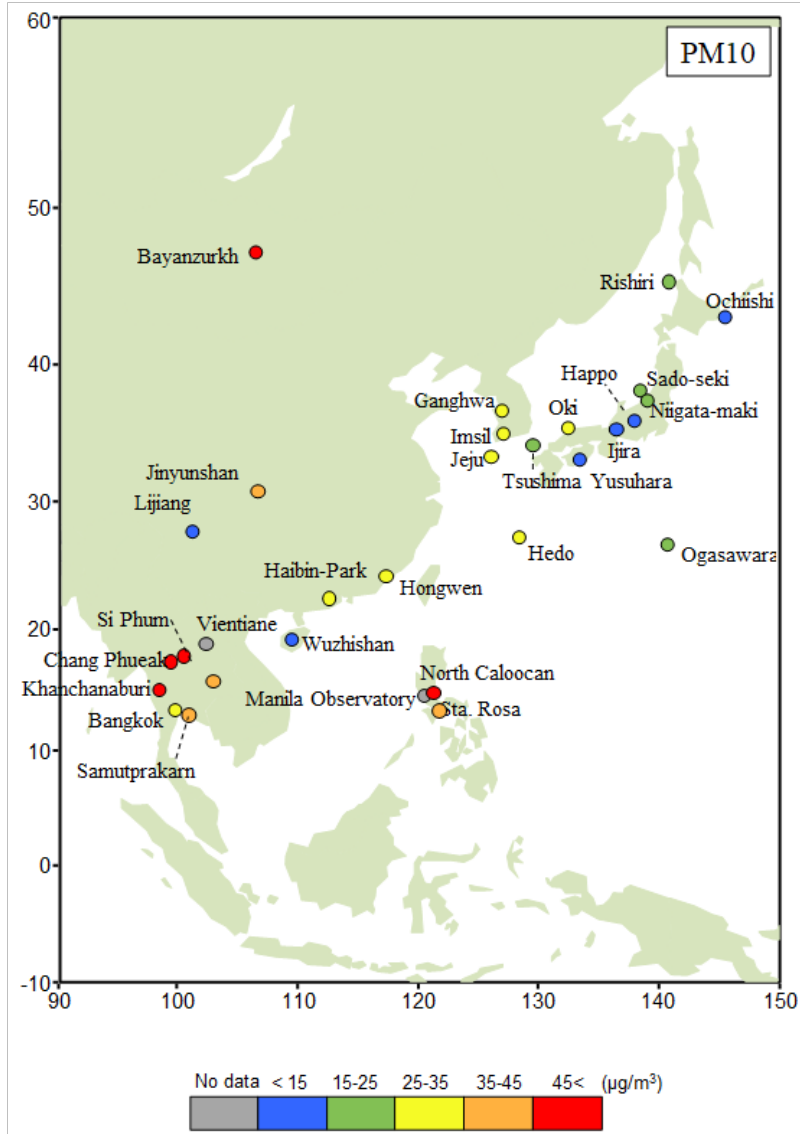
Annual variations of the number of gas and aerosol monitoring sites in EANET



- EANET uses a standardized monitoring framework to provide comparable observations of atmospheric gases and aerosols across East Asia.
- The framework includes site selection, instrumentation, sampling, and measurements of major pollutants such as SO₂, O₃, NO_x, NH₃, PM₁₀, PM_{2.5}, and particulate ions.
- Monitoring sites are categorized as remote, rural, or urban to represent regional background conditions, ecosystem impact, and urban air quality.

3.3.1 Spatial distribution of particulate matter

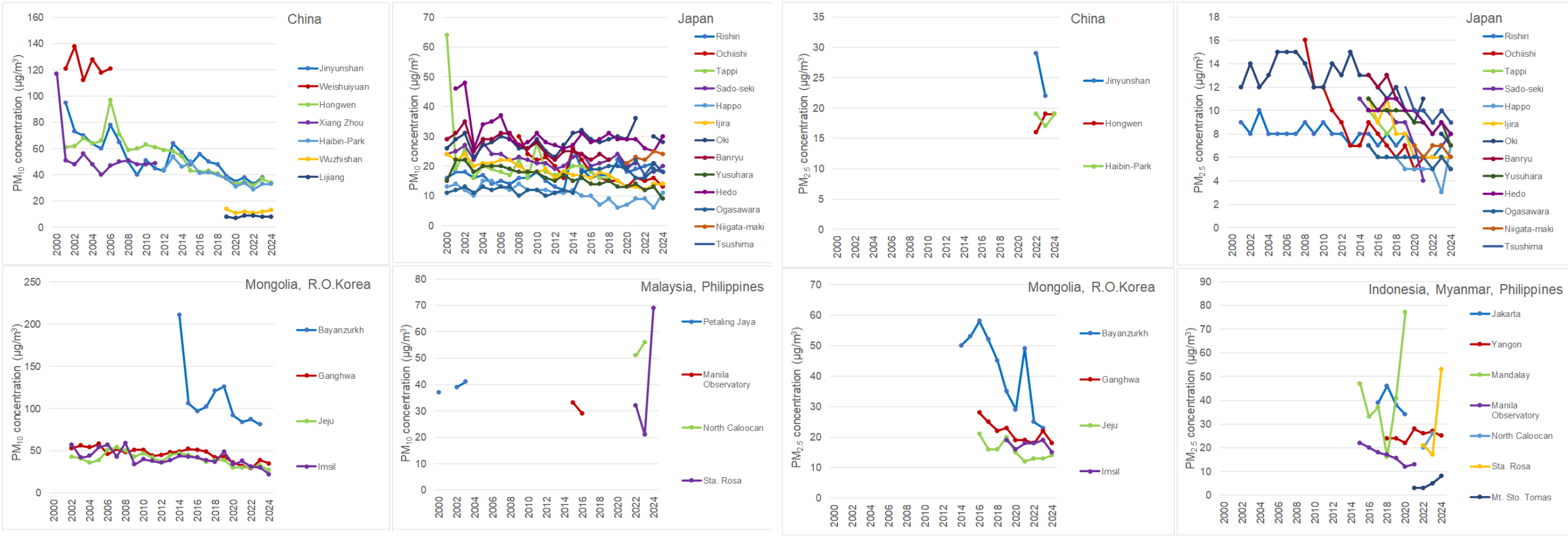
Spatial distribution map of PM₁₀ and PM_{2.5} concentrations (2020-2024)



- The spatial pattern of PM_{2.5} was broadly similar to that of PM₁₀, with the highest concentrations again observed in Mongolia and urban areas of mainland Southeast Asia.
- The highest PM₁₀ and PM_{2.5} concentrations ($>45 \mu\text{g m}^{-3}$) were observed at Ulaanbaatar, Mongolia), indicating severe particulate pollution associated with coal combustion and dust emissions.

3.3.2 Temporal trends of particulate matter

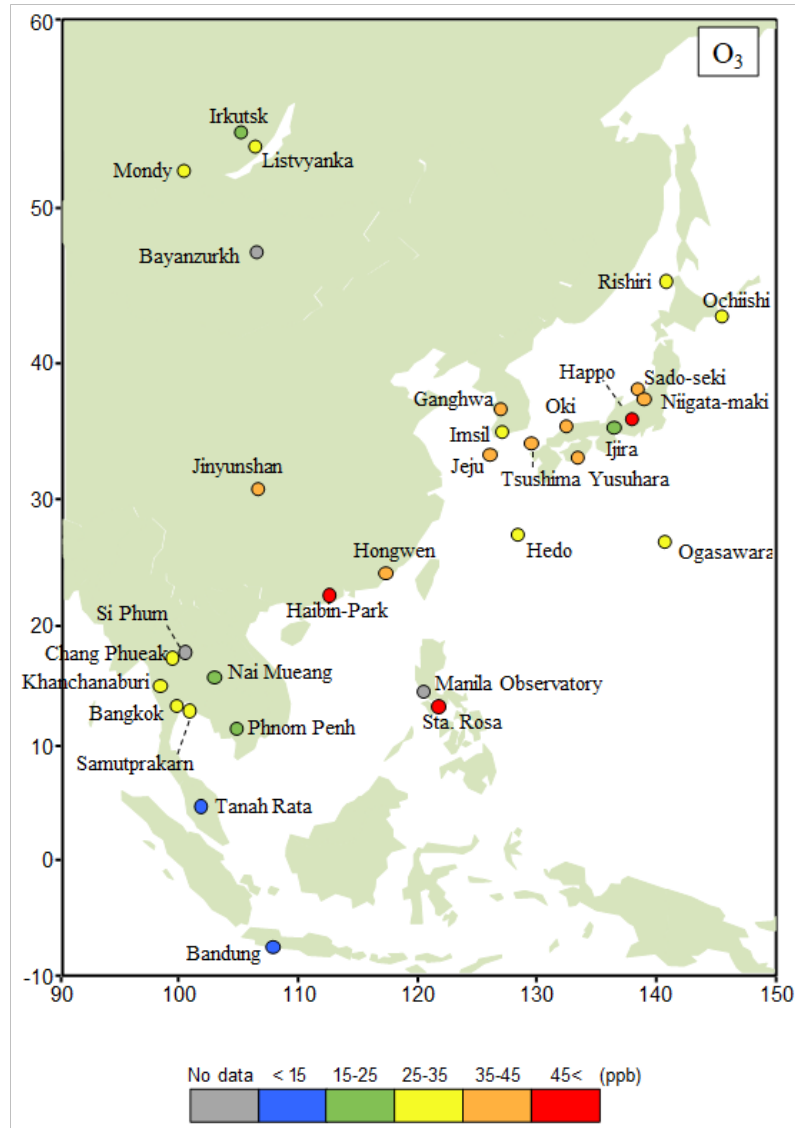
Annual variation of PM₁₀ and PM_{2.5} concentrations at respective EANET sites (2000-2024)



Annual PM₁₀ and PM_{2.5} concentrations generally decreased at many EANET sites between 2000 and 2024, particularly in China, Japan, and the Republic of Korea, reflecting the impact of emission control measures. In contrast, Mongolia and several Southeast Asian sites showed higher concentrations and greater year-to-year variability, influenced by coal combustion, biomass burning, and meteorological conditions

3.4.1 Spatial distribution of ozone

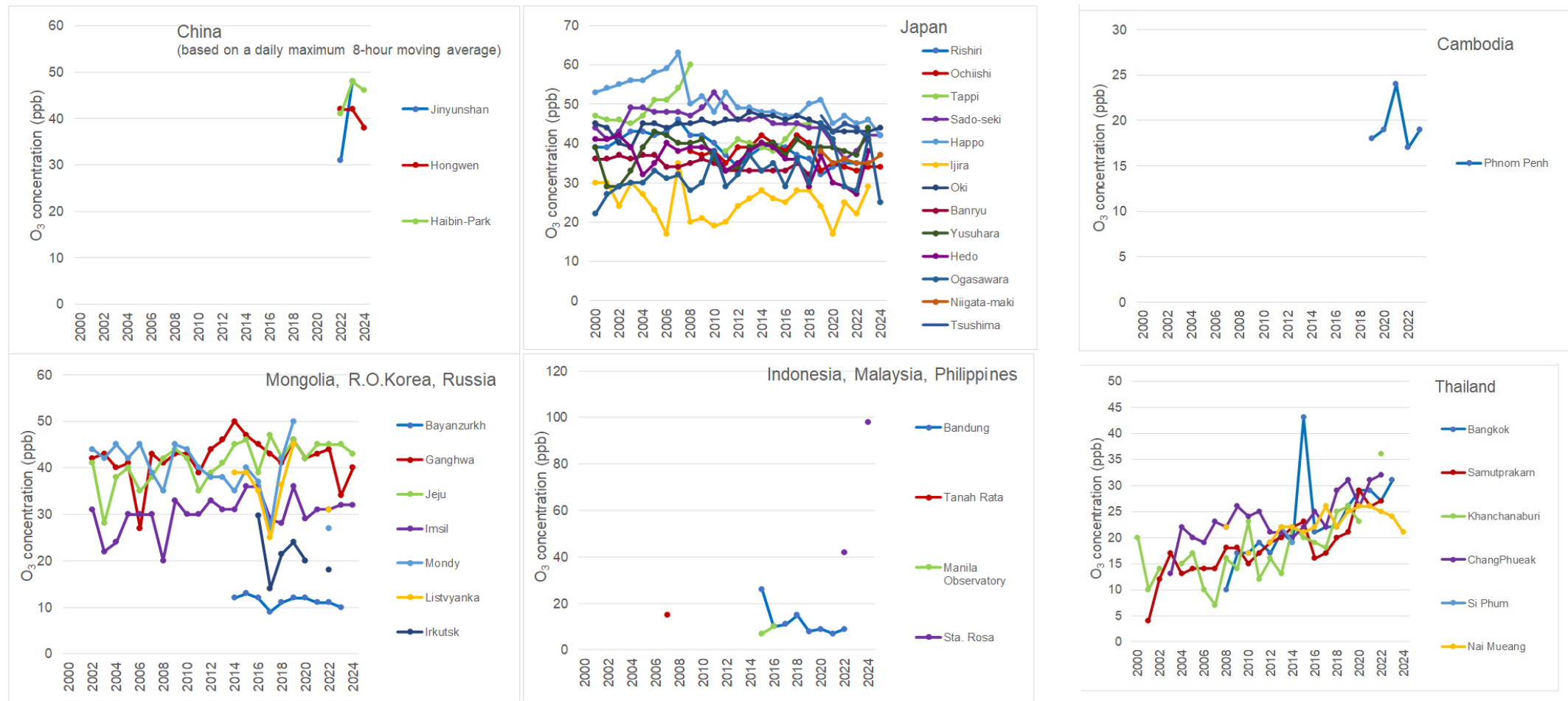
Spatial distribution map of O₃ concentration (2020-2024)



- Surface O₃ concentrations showed considerable spatial variability across the EANET region, with the highest levels generally observed at rural and remote sites rather than urban locations.
- The highest O₃ concentrations (>45 ppb) were recorded at Haibin-Park (China) and Sta. Rosa (Philippines), indicating strong regional photochemical production and transport influences.
- Elevated O₃ concentrations (35–45 ppb) were observed at several Japanese sites and at Jinyunshan (China), reflecting the influence of regional background ozone and long-range transport from continental source areas.

3.4.2 Temporal trends of ozone

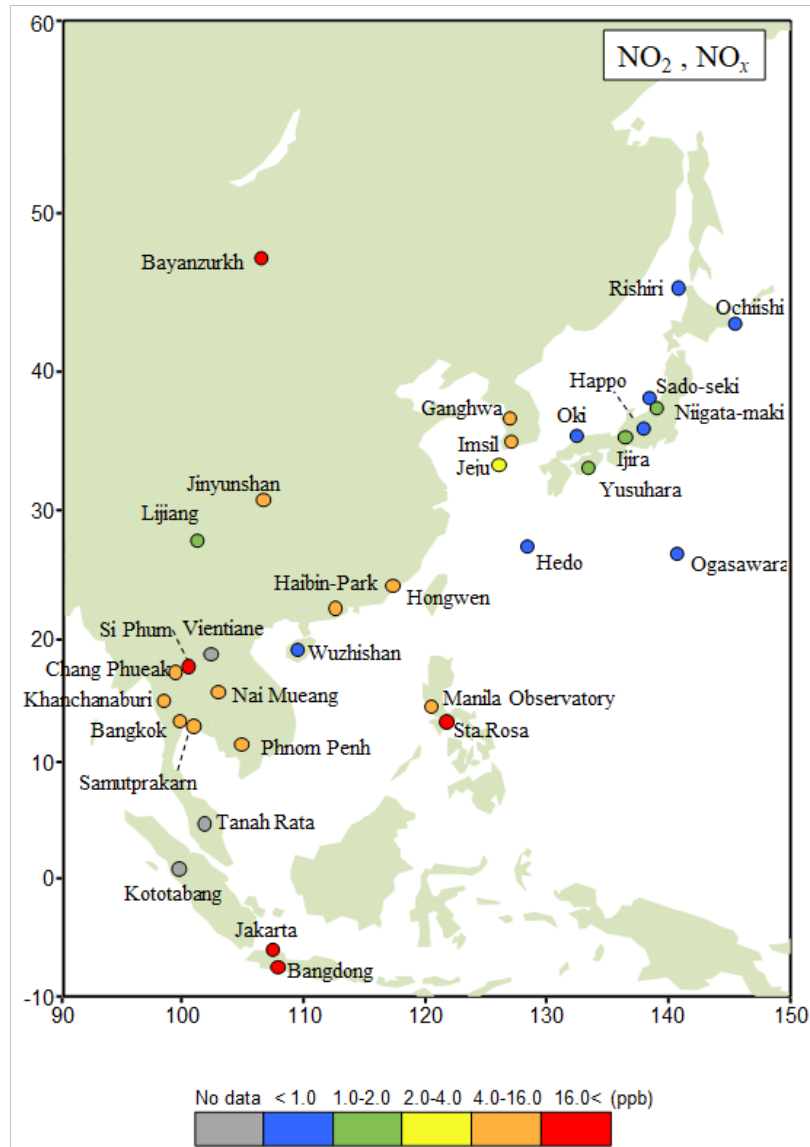
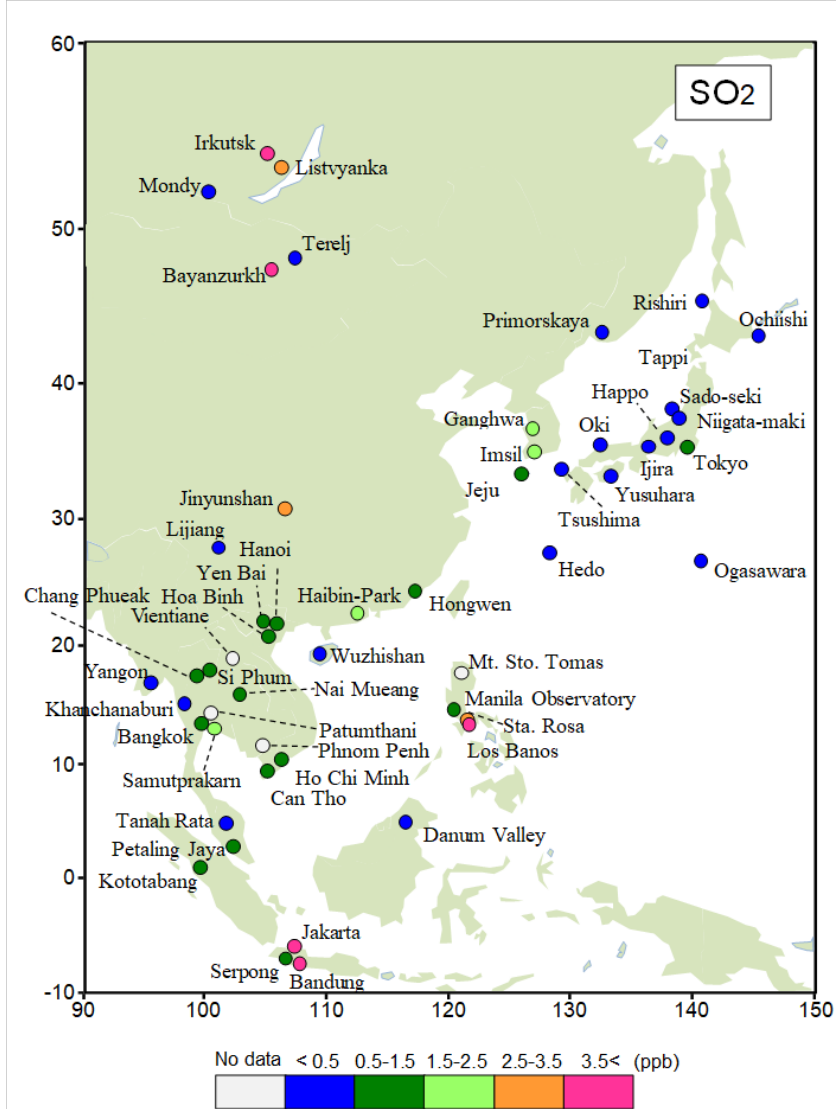
Annual variation of O₃ concentrations at respective EANET sites (2020-2024)



Japanese sites generally exhibited stable to slightly increasing concentrations over the long term, while Thai urban sites showed a clear increasing tendency, reflecting enhanced photochemical ozone production. In contrast, Mongolia, the Republic of Korea, and Russia displayed considerable year-to-year variability without a consistent trend.

3.5.1 SO₂ and NO₂

Spatial distribution map of SO₂ and NO_x, NO₂ concentrations (2020-2024)



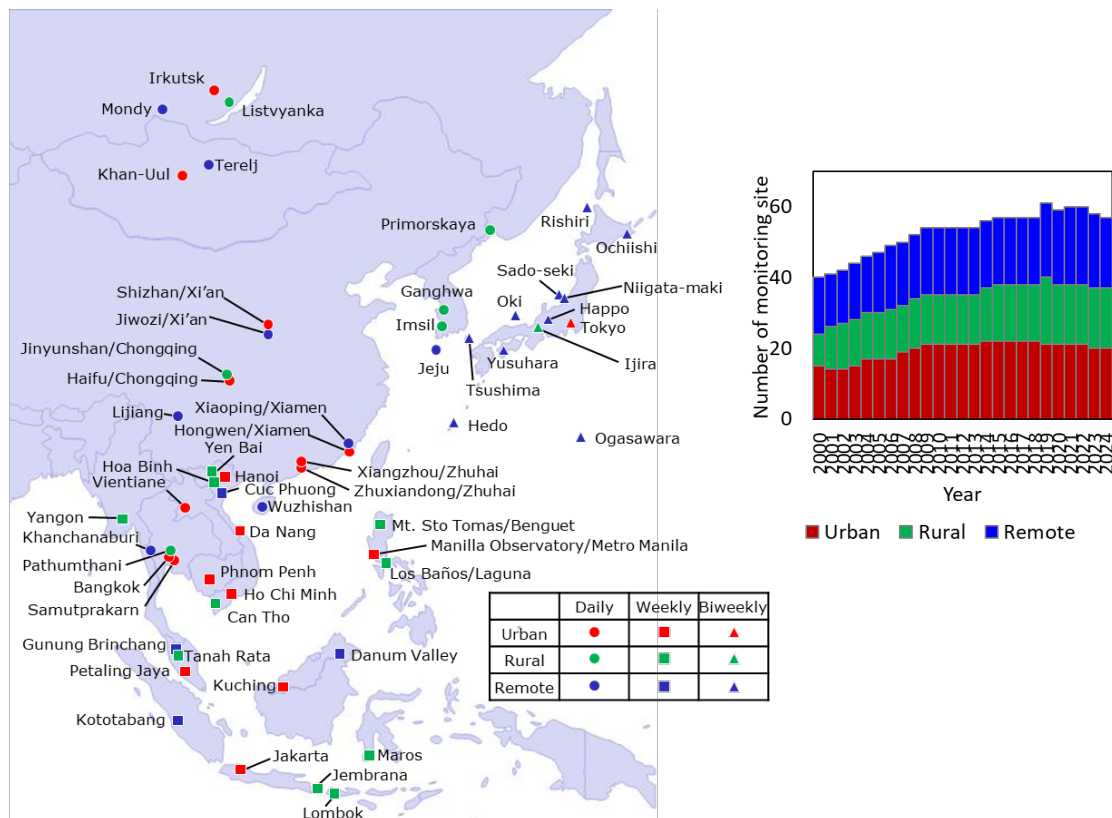
- SO₂ concentrations were generally low across the EANET region, with most monitoring sites recording levels below 0.5 ppb, indicating substantial reductions in sulfur emissions over recent decades.
- NO_x/NO₂ concentrations showed greater spatial variation than SO₂, with the highest levels occurring in urban areas affected by intensive traffic and combustion sources.

Chater 4: Wet and Dry Deposition in East Asia

4.1 Introduction

4.2 Monitoring methodology

4.2.1 Wet deposition

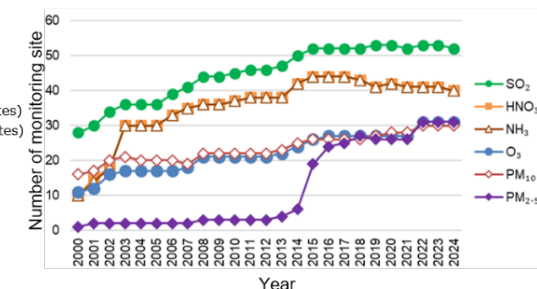


- The measured parameters: precipitation amount, electric conductivity (EC), pH, ion concentrations of SO_4^{2-} , NO_3^- , Cl^- , NH_4^+ , Na^+ , K^+ , Ca^{2+} , and Mg^{2+} (optionally F^- , NO_2^- , PO_4^{3-} , HCO_3^- , etc.).

4.2.2 Dry deposition



- AT: SO_2 , NO_x , NO , NO_2 , O_3 , PM_{10} , $\text{PM}_{2.5}$
- FP: SO_2 , HNO_3 , HCl , NH_3 , Particulate matter components (SO_4^{2-} , NO_3^- , Cl^- , NH_4^+ , Na^+ , K^+ , Mg^{2+} , Ca^{2+})
- PS: SO_2 , NH_3 , NO_2 , and O_3



Dry deposition was estimated using inferential method:

Dry deposition flux = Concentration x Deposition velocity (V_d)

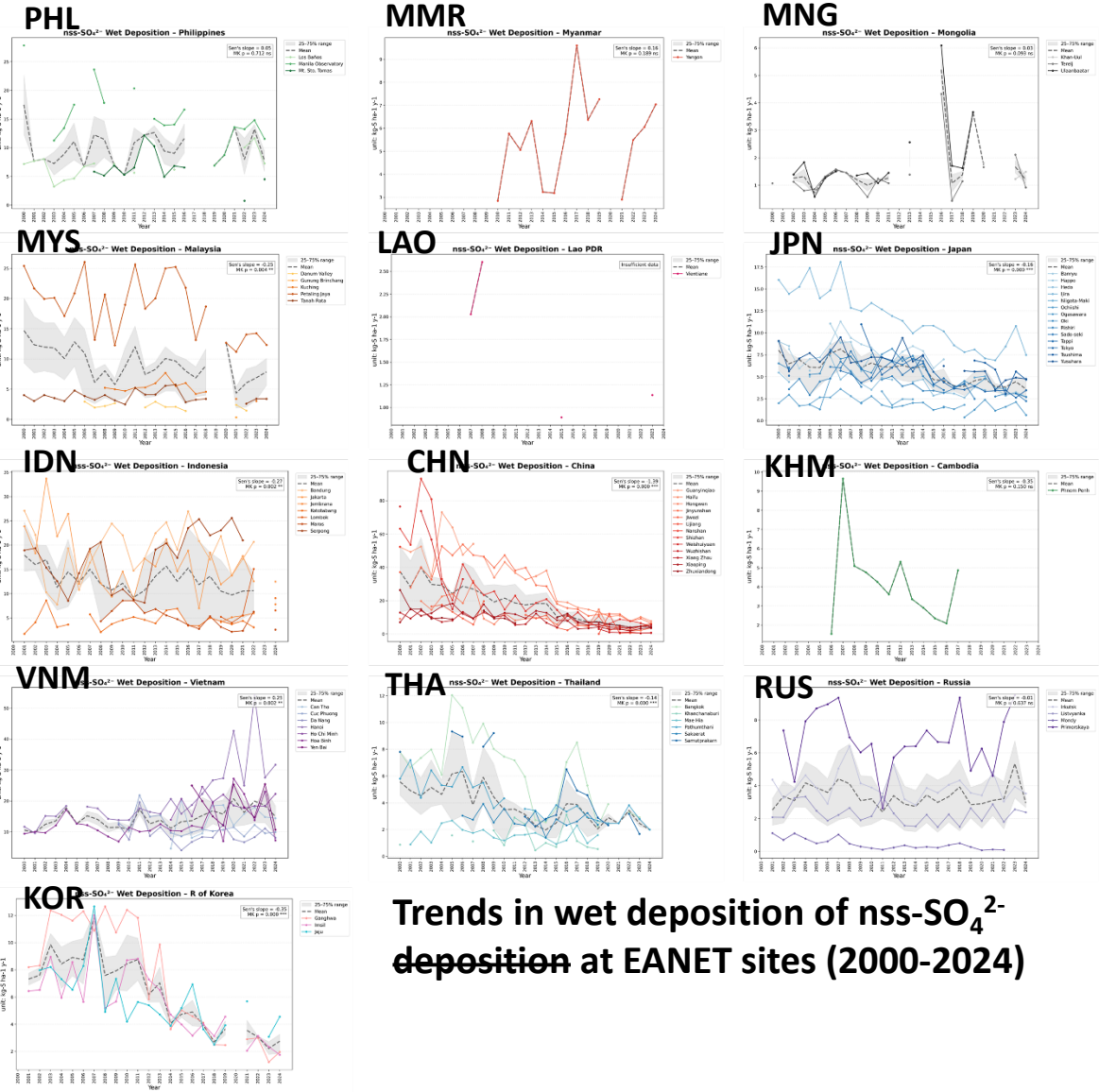
$$V_d = (R_a + R_b + R_c)^{-1} \text{ for gases}$$

$$V_d = (R_a + V_{ds}^{-1})^{-1} + V_g \text{ for particles}$$

R_a : Aerodynamic resistance, R_b : Quasi-laminar layer resistance, R_c : Surface resistance, V_{ds} : Surface deposition velocity, V_g : Gravitational setting velocity

4.3. Sulfate deposition in East Asia

4.3.1 Trend of sulfur deposition



Trends in wet deposition of nss-SO₄²⁻ deposition at EANET sites (2000–2024)

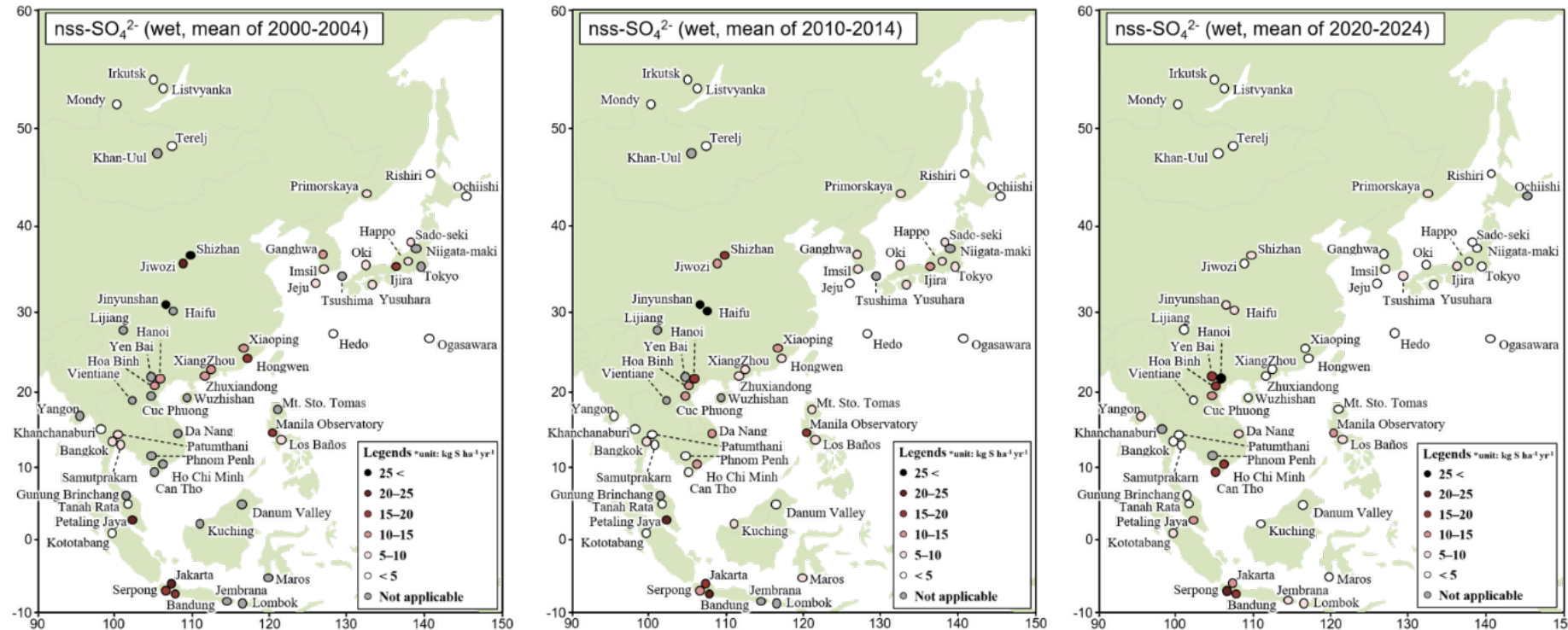
Table 4.1. Trends in wet deposition of nss-SO₄²⁻ (2000–2024) assessed by the Mann–Kendall test.

unit: kg S ha ⁻¹ y ⁻¹									
Country	Site	N	Z-score	Sen's slope	Trend	Country	Site	N	Z-score
Cambodia	Phnom Penh	12	-0.92	-0.31	No trend	Lao PDR	Vientiane	4	N/A
China	Haifu	17	-4.65	-2.36	Dec.	Malaysia	Danum Valley	11	-1.40
	Hongwen	24	-3.89	-0.69	Dec.		Gunung Brinchang	1	N/A
	Jinyunshan	24	-4.84	-2.24	Dec.		Kuching	13	-1.04
	Jiwozi	20	-3.21	-0.85	Dec.		Petaling Jaya	24	-2.31
	Lijiang	6	N/A	N/A	N/A		Tanah Rata	22	0.00
	Shizhan	25	-5.54	-1.90	Dec.	Mongolia	Khan-Uul	3	N/A
	Wuzhishan	6	N/A	N/A	N/A		Terelj	18	1.19
	Xiang Zhou	25	-3.57	-0.33	Dec.	Myanmar	Yangon	14	1.31
	Xiaoping	25	-3.81	-0.57	Dec.	Philippines	Los Baños	14	0.55
	Zhuxiandong	20	-4.19	-0.54	Dec.		Manila Observatory	17	-1.85
Indonesia	Bandung	22	0.58	0.09	No trend		Mt. Sto. Tomas	12	-0.48
	Jakarta	23	-2.01	-0.39	Dec.	R of Korea	Ganghwa	23	-4.12
	Jembrana	5	N/A	N/A	N/A		Imsil	23	-3.86
	Kototabang	22	1.16	0.07	No trend		Jeju	21	-0.69
	Lombok	5	N/A	N/A	N/A	Russia	Irkutsk	24	-0.87
	Maros	16	-2.75	-0.37	Dec.		Listvyanka	24	-0.57
	Serpong	21	2.45	0.47	Inc.		Mondy	22	-3.72
Japan	Happo	16	-3.38	-0.44	Dec.		Primorskaya	22	0.00
	Hedo	18	-1.36	-0.20	No trend	Thailand	Bangkok	23	-3.01
	Ijira	25	-5.30	-0.40	Dec.		Khanchanaburi	14	-0.88
	Niigata-Maki	4	N/A	N/A	N/A		Pathumthani	24	-4.84
	Ochiishi	13	-0.92	-0.13	No trend		Samutprakarn	16	-2.66
	Ogasawara	22	-1.24	-0.11	No trend	Vietnam	Can Tho	11	0.47
	Oki	19	-0.70	-0.09	No trend		Cuc Phuong	16	-0.95
	Rishiri	22	-2.09	-0.12	Dec.		Da Nang	16	-0.14
	Sado-seki	15	-1.78	-0.40	No trend		Hanoi	24	4.34
	Tokyo	17	-4.24	-0.34	Dec.		Ho Chi Minh	11	0.31
	Tsushima	6	N/A	N/A	N/A		Hoa Binh	25	1.38
	Yusuhara	23	-3.59	-0.16	Dec.		Yen Bai	9	-0.73

Notes: A site was classified as *Increasing (Inc.)* when its Z-score exceeded ±1.96 and the Sen's slope was positive, or *Decreasing (Dec.)* when the slope was negative. If the Z-score fell within ±1.96, the site was categorized as *No trend*. Sites with sample sizes of six or fewer observations were not included in the Mann–Kendall analysis.

- NE Asia shows significant decreases in nss-SO₄²⁻ wet deposition, consistent with reduction of SO₂ emissions and their influences.
- SE Asia shows more heterogeneous trends, with higher and more variable deposition at urban sites.
- Indonesia shows contrasting trends between Jakarta and Serpong, while Mongolia and Russia maintain consistently low deposition.

4.3.2 Spatial distribution of sulfur deposition

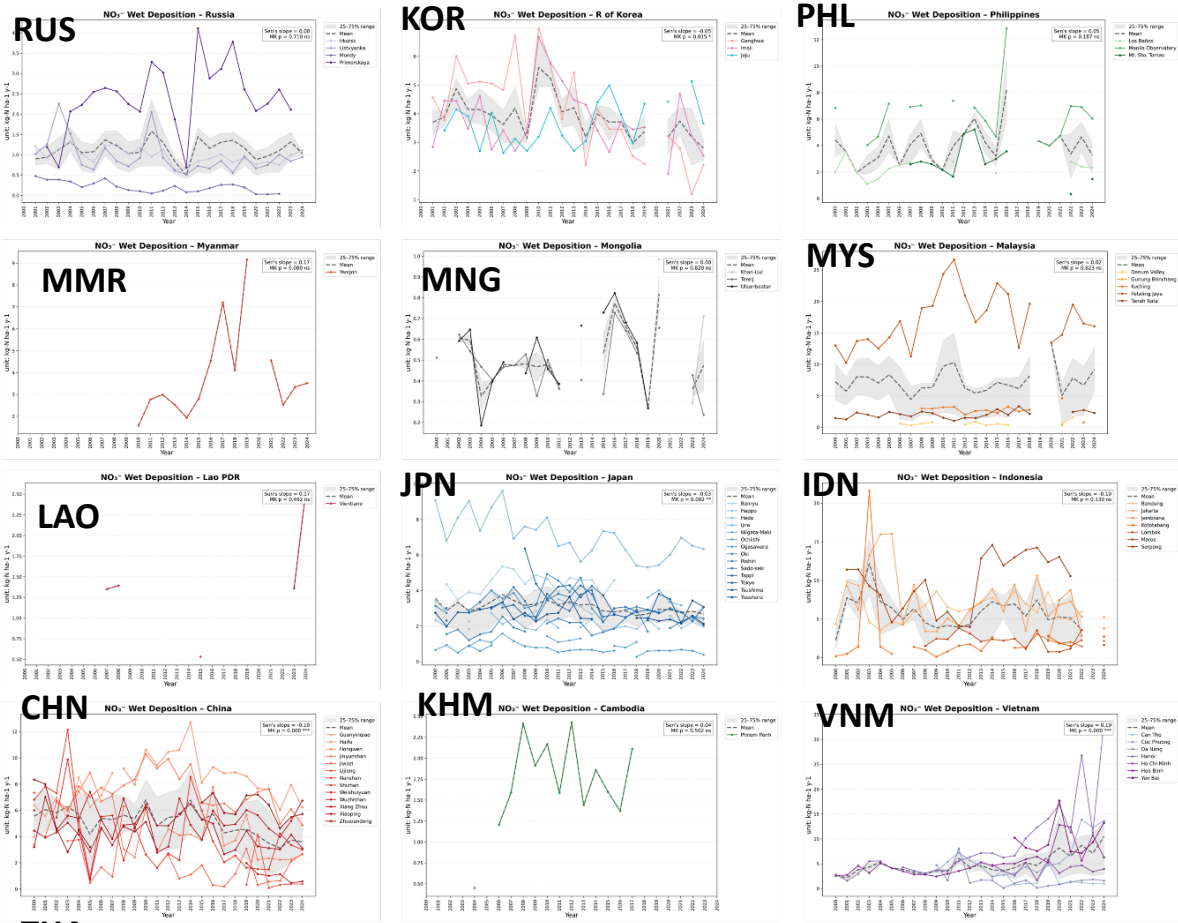


Spatial distributions of the mean wet deposition of nss-SO₄²⁻ for the period 2000–2004 (left), 2010–2014 (center), and 2020–2024 (right).

- **2000–2004:** High sulfur wet deposition was widespread, particularly in China and Indonesia, with high levels observed not only at urban but also at rural and remote sites.
- **2010–2014:** Sulfur wet deposition generally decreased from 2000–2004, although relatively high levels remained widespread in China, Malaysia, and Indonesia.
- **2020–2024:** Deposition further decreased, particularly in China, while the major hotspot shifted to Vietnam, where high deposition occurred at both urban and rural sites.

4.4. Nitrogen deposition in East Asia

4.4.1 Trend of nitrogen deposition



Trends in wet deposition of NO₃⁻ at EANET sites (2000-2024)

- Wet NO₃⁻ deposition shows more complex and less pronounced trends than nss-SO₄²⁻, with NE Asia generally showing shallow, non-significant, or slightly decreasing trends, reflecting NO_x emission controls, traffic, and regional transport
- SE Asia shows greater interannual variability and possible increases at some urban sites, likely associated with growing traffic and biomass burning; urban sites generally have higher and more variable NO₃⁻ deposition than remote sites.

Table 4.2. Trends in wet deposition NO₃⁻ (2000–2024) assessed by the Mann–Kendall test.

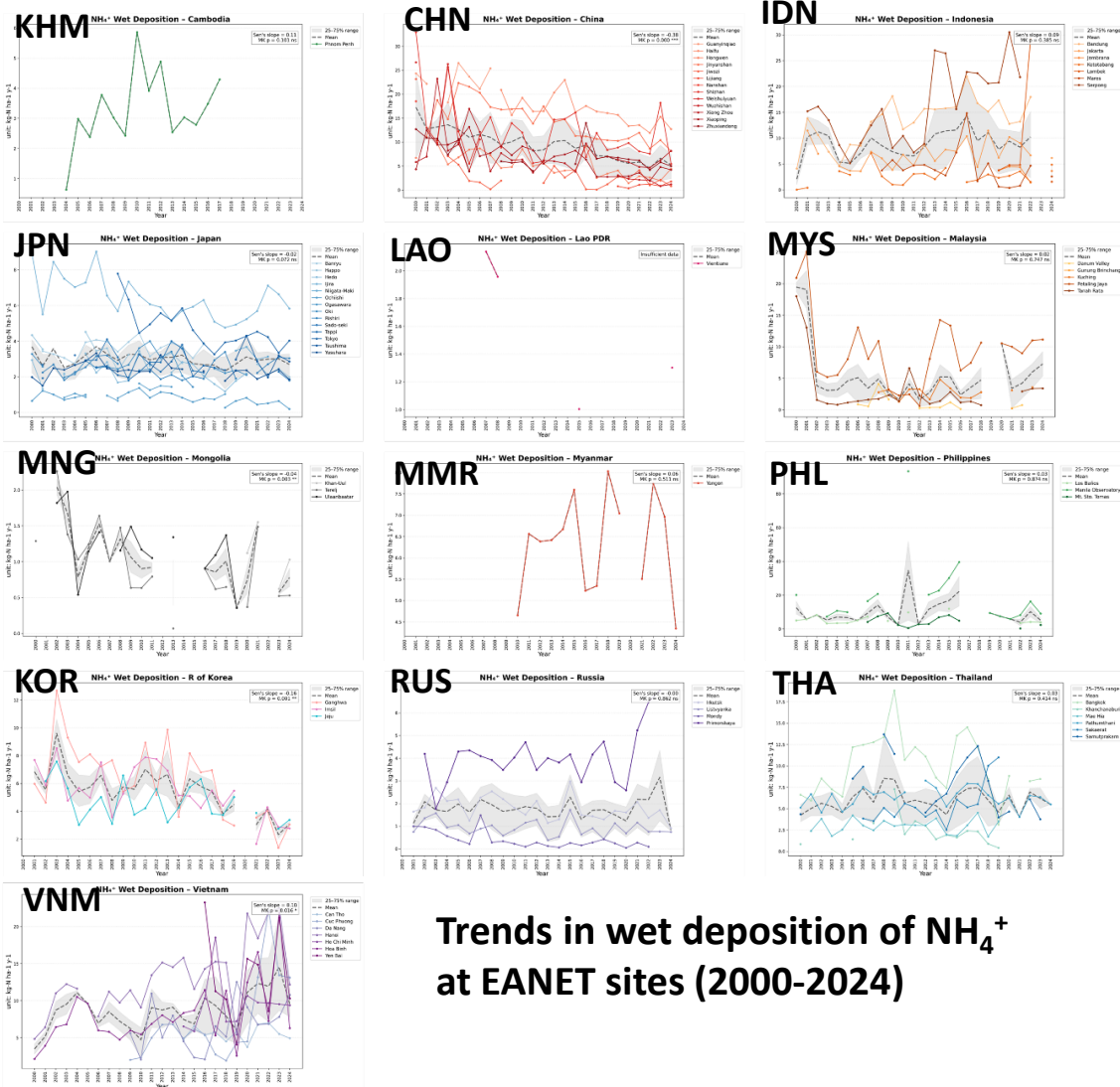
unit: kg N ha ⁻¹ y ⁻¹									
Country	Site	N	Z-score	Sen's slope	Trend	Country	Site	N	Z-score
Cambodia	Phnom Penh	13	0.67	0.04	No trend	Lao PDR	Vientiane	5	N/A
China	Haifu	17	-2.92	-0.22	Dec.	Malaysia	Danum Valley	11	0.47
	Hongwen	24	-3.10	-0.20	Dec.		Gaung Brinchang	1	N/A
	Jinyunshan	24	-0.82	-0.05	No trend		Kuching	13	-0.43
	Jiwozi	20	-1.20	-0.07	No trend		Petaling Jaya	24	1.71
	Lijiang	6	N/A	N/A	N/A		Tanah Rata	22	1.80
	Shizhan	25	-2.45	-0.19	Dec.	Mongolia	Khan-Uul	3	N/A
	Wuzhishan	6	N/A	N/A	N/A		Terelj	19	-0.56
	Xiang Zhou	25	1.89	0.06	No trend	Myanmar	Yangon	14	1.75
	Xiaoping	25	-2.64	-0.12	Dec.	Philippines	Los Baños	14	0.77
	Zhuxiandong	20	0.75	0.07	No trend		Manila Observatory	17	-0.12
Indonesia	Bandung	23	0.53	0.04	No trend		Mt. Sto. Tomas	12	-0.34
	Jakarta	23	-0.85	-0.09	No trend	R of Korea	Ganghwa	23	-3.38
	Jembrana	5	N/A	N/A	N/A		Imsil	23	-1.16
	Kototabang	22	2.37	0.06	Inc.		Jeju	21	1.78
	Lombok	5	N/A	N/A	N/A	Russia	Irkutsk	24	-2.41
	Maros	16	-1.04	-0.06	No trend		Listvyanka	24	-1.31
	Serpong	21	1.72	0.22	No trend		Mondy	22	-3.38
Japan	Happo	16	-2.30	-0.09	Dec.		Primorskaya	22	1.41
	Hedo	18	-1.06	-0.01	No trend	Thailand	Bangkok	23	0.58
	Ijira	25	-3.53	-0.11	Dec.		Khanchanaburi	14	-1.09
	Niigata-Maki	4	N/A	N/A	N/A		Pathumthani	24	-0.02
	Ochiishi	13	-0.43	-0.01	No trend		Samutprakarn	16	0.41
	Ogasawara	22	-2.31	-0.01	Dec.	Vietnam	Can Tho	11	-0.62
	Oki	19	-0.56	-0.01	No trend		Cuc Phuong	16	1.94
	Rishiri	22	2.54	0.04	Inc.		Da Nang	16	-0.86
	Sado-seki	15	-0.69	-0.04	No trend		Hanoi	24	5.18
	Tokyo	17	-2.92	-0.14	Dec.		Ho Chi Minh	11	0.00
	Tsushima	6	N/A	N/A	N/A		Hoa Binh	25	4.32
	Yusuhara	23	-2.38	-0.02	Dec.		Yen Bai	9	0.00

Notes: A site was classified as *Increasing (Inc.)* when its Z-score exceeded ±1.96 and the Sen's slope was positive, or *Decreasing (Dec.)* when the slope was negative. If the Z-score fell within ±1.96, the site was categorized as *No trend*. Sites with sample sizes of six or fewer observations were not included in the Mann–Kendall analysis.

Table 4.3. Trends in wet deposition NH_4^+ (2000–2024) assessed by the Mann–Kendall test.unit: $\text{kg N ha}^{-1} \text{y}^{-1}$

Country	Site	N	Z-score	Sen's slope	Trend	Country	Site	N	Z-score	Sen's slope	Trend
Cambodia	Phnom Penh	14	1.64	0.11	No trend	Lao PDR	Vientiane	4	N/A	N/A	N/A
China	Haifu	17	-3.25	-0.40	Dec.	Malaysia	Danum Valley	11	-1.25	-0.06	No trend
	Hongwen	24	-3.65	-0.24	Dec.		Gunning Brinchang	1	N/A	N/A	N/A
	Jinyunshan	24	-4.34	-0.52	Dec.		Kuching	13	0.92	0.03	No trend
	Jiwozi	20	-1.78	-0.17	No trend		Petaling Jaya	24	0.57	0.09	No trend
	Lijiang	6	N/A	N/A	N/A		Tanah Rata	22	0.39	0.02	No trend
	Shizhan	25	-1.70	-0.25	No trend	Mongolia	Khan-Uul	4	N/A	N/A	N/A
	Wuzhishan	6	N/A	N/A	N/A		Terelj	19	-2.94	-0.06	Dec.
	Xiang Zhou	25	-1.75	-0.11	No trend	Myanmar	Yangon	14	0.66	0.06	No trend
	Xiaoping	25	-3.90	-0.33	Dec.	Philippines	Los Baños	14	0.33	0.03	No trend
	Zhuxiandong	20	-2.17	-0.24	Dec.		Manila Observatory	17	-0.54	-0.15	No trend
Indonesia	Bandung	23	3.38	0.41	Inc.		Mt. Sto. Tomas	12	-0.62	-0.18	No trend
	Jakarta	22	1.24	0.12	No trend	R of Korea	Ganghwa	23	-3.01	-0.28	Dec.
	Jembrana	5	N/A	N/A	N/A		Imsil	23	-2.96	-0.17	Dec.
	Kototabang	20	1.14	0.08	No trend		Jeju	21	-1.54	-0.09	No trend
	Lombok	5	N/A	N/A	N/A	Russia	Irkutsk	24	-1.86	-0.03	No trend
	Maros	16	-1.31	-0.23	No trend		Listvyanka	24	-0.97	-0.01	No trend
	Serpong	21	2.26	0.72	Inc.		Mondy	22	-3.16	-0.03	Dec.
Japan	Happo	16	-2.75	-0.11	Dec.		Primorskaya	22	1.24	0.06	No trend
	Hedo	18	-1.14	-0.04	No trend	Thailand	Bangkok	23	0.32	0.03	No trend
	Ijira	25	-2.69	-0.10	Dec.		Khanchanaburi	14	-0.99	-0.11	No trend
	Niigata-Maki	4	N/A	N/A	N/A		Pathumthani	24	0.02	0.00	No trend
	Ochiishi	12	0.07	0.01	No trend		Samutprakarn	16	-1.04	-0.19	No trend
	Ogasawara	22	-2.82	-0.03	Dec.	Vietnam	Can Tho	11	0.31	0.04	No trend
	Okii	19	-0.91	-0.02	No trend		Cuc Phuong	16	1.85	0.64	No trend
	Rishiri	22	0.56	0.01	No trend		Da Nang	16	1.67	0.30	No trend
	Sado-seki	15	-1.39	-0.06	No trend		Hanoi	24	3.75	0.55	Inc.
	Tokyo	17	-2.76	-0.15	Dec.		Ho Chi Minh	11	0.47	0.16	No trend
	Tsushima	6	N/A	N/A	N/A		Hoa Binh	25	2.50	0.29	Inc.
	Yusuhara	23	-1.32	-0.01	No trend		Yen Bai	9	-0.31	-0.35	No trend

Notes: A site was classified as *Increasing (Inc.)* when its Z-score exceeded ± 1.96 and the Sen's slope was positive, or *Decreasing (Dec.)* when the slope was negative. If the Z-score fell within ± 1.96 , the site was categorized as *No trend*. Sites with sample sizes of six or fewer observations were not included in the Mann–Kendall analysis.



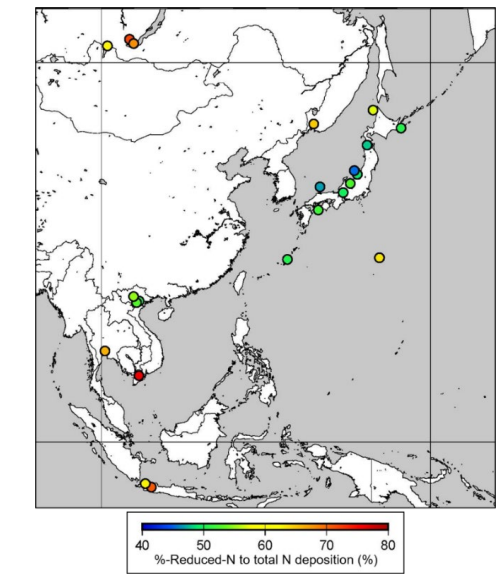
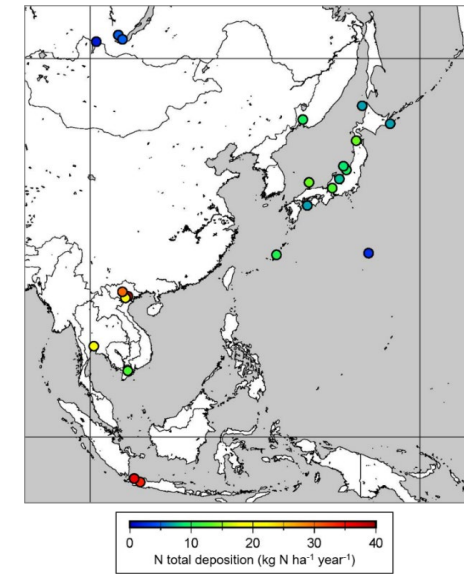
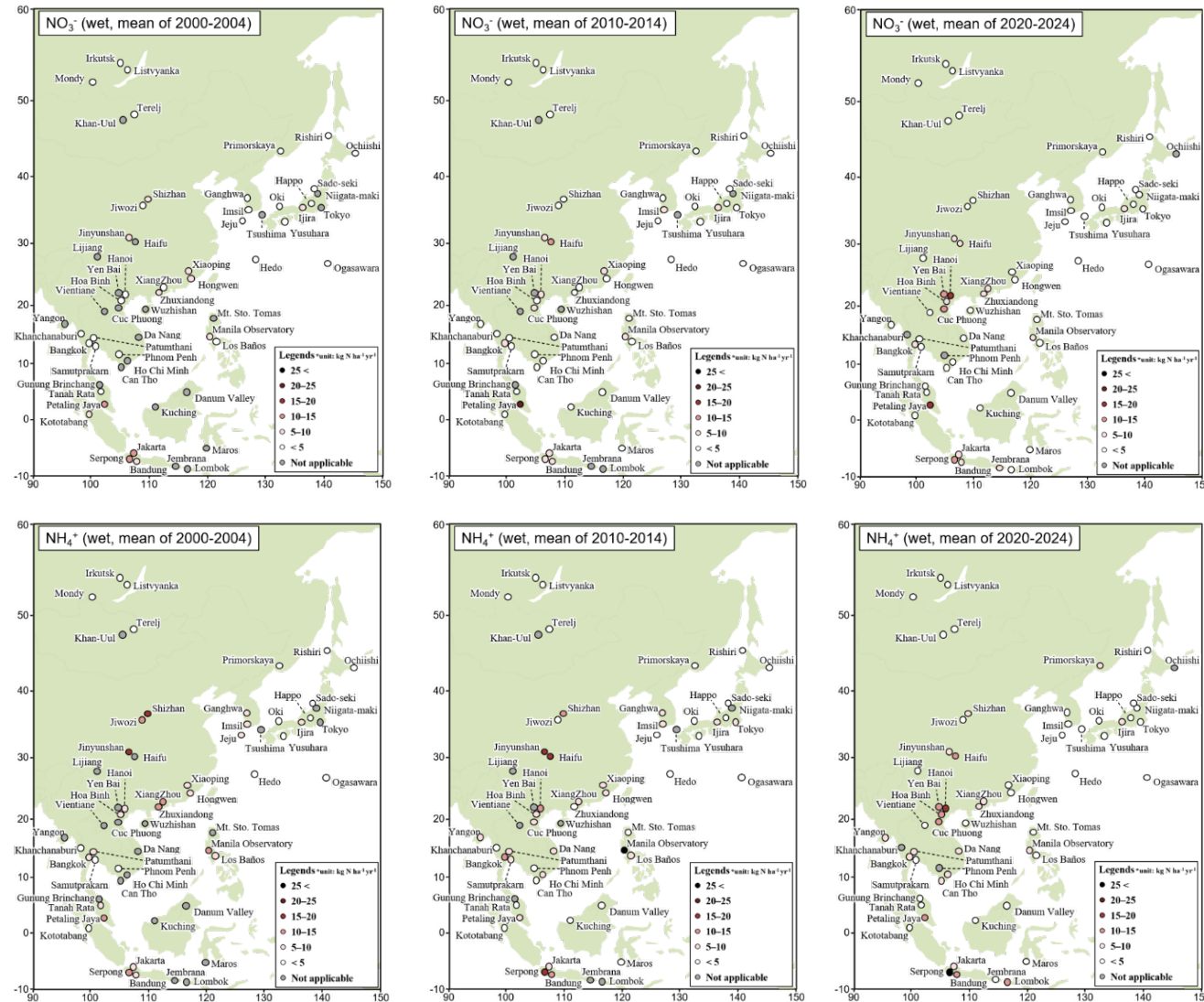
- Wet NH_4^+ deposition, largely associated with agricultural NH_3 emissions, shows substantial spatial and temporal variability, with generally stable to slightly decreasing trends in NE Asia.
- SE Asia shows seasonal variability and localized increases associated with agriculture, while relatively high NH_4^+ deposition can also occur at rural sites due to fertilizer use and livestock emissions.

4.4.2 Spatial distribution of nitrogen deposition

Total N deposition

Ratio of reduced N deposition to the total

33



- During 2015–2024, total nitrogen deposition was relatively high in SE Asia, exceeding $30 \text{ kg N ha}^{-1} \text{yr}^{-1}$ at sites in Indonesia and Vietnam, while remote sites in Russia and Japan showed low levels.
- Reduced nitrogen accounted for a large proportion of total nitrogen deposition across East Asia, with % reduced N exceeding 50% at most sites, including those with low total deposition.

- Five-year mean NO_3^- and NH_4^+ wet deposition shows substantial regional and temporal variation, with NH_4^+ generally exceeding NO_3^- and major hotspots in China, Malaysia, and Indonesia during 2000–2014.
- During 2020–2024, high nitrogen deposition persisted in China, Malaysia, and Indonesia, while new hotspots emerged in Vietnam, including rural and remote sites; Mongolia and Russia remained consistently low.

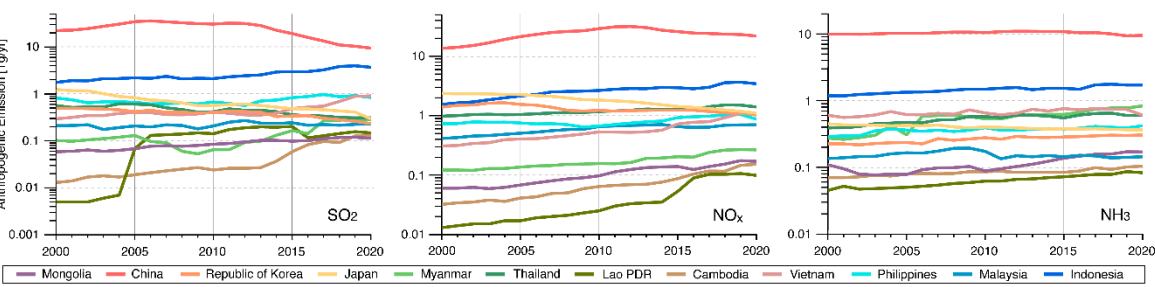
4.5. Precipitation chemistry in East Asia

- Precipitation acidity reflects the balance between acidic and neutralizing components. Strong neutralization by ammonia and crustal dust occurs in China, while limited neutralization at some SE Asian sites can lead to episodes of highly acidic precipitation.
- Precipitation acidity generally decreased in NE Asia over 2000–2024 as acidic components declined while neutralizing components remained substantial, whereas SE Asia showed greater variability and less consistent long-term trends.

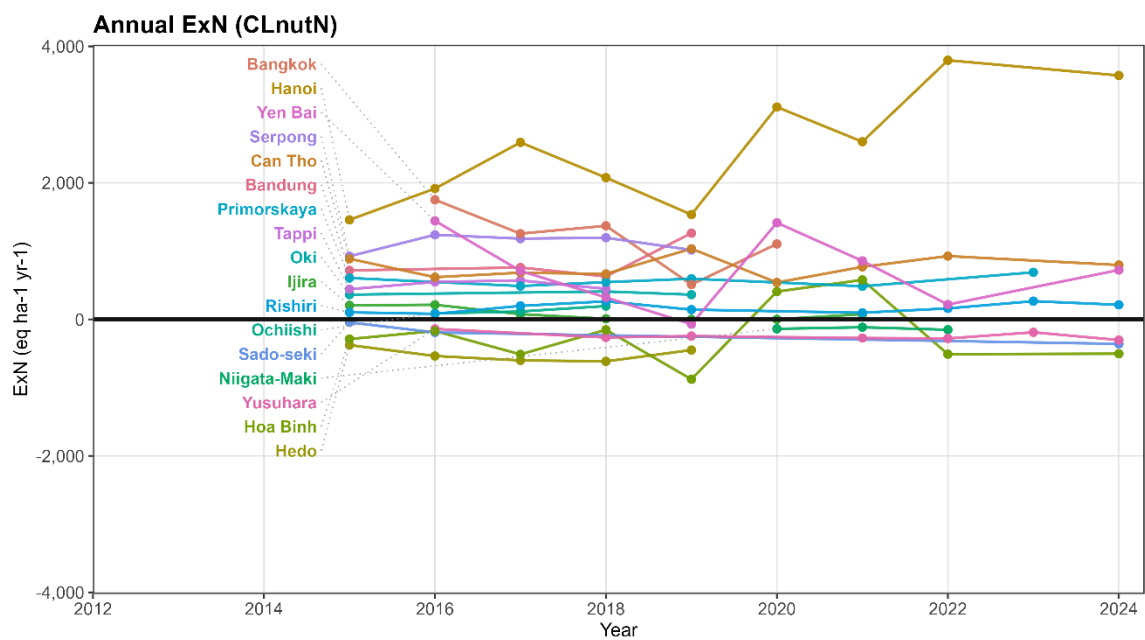
Long term trends of precipitation acidity (H^+) and concentrations of acids ($nss-SO_4^{2-}+NO_3^-$) and bases ($nss-Ca^{2+}+NH_4^+$) that acidified or neutralized precipitation in selected EANET sites (2000-2024).

4.6. Comprehensive discussion

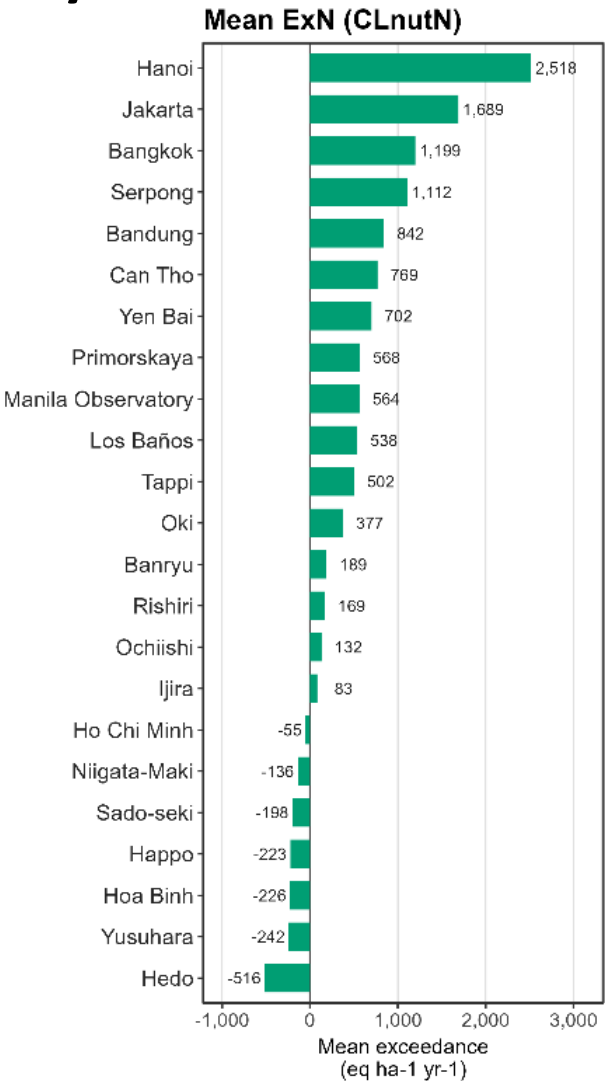
4.6.1 Emission trends / 4.6.2 Critical load analysis



Trends in anthropogenic emissions of SO₂, NO_x and NH₃ by country during the period 2000-2020



Temporal variation in the critical load exceedance of total N deposition for inland-water eutrophication. Only sites with at least three years of both wet and dry deposition data are shown.



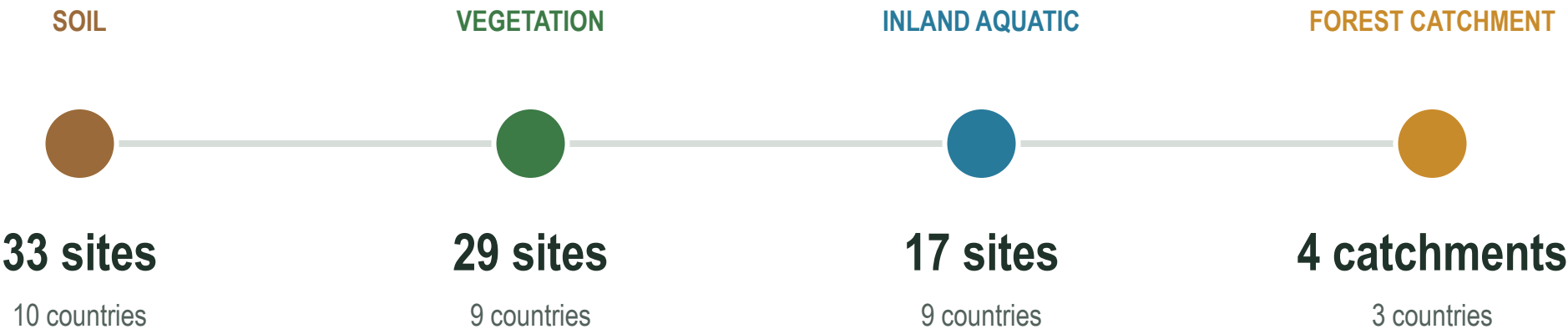
Critical load exceedances of total N deposition for inland-water eutrophication based on the data from 2015 to 2024.

- Long-term variations in anthropogenic emissions would affect ambient concentrations of air pollutants and, consequently, deposition.
- Wet deposition broadly reflects emission trends, decreasing in NE Asia and increasing at some SE Asian sites, while reduced N deposition reflects the growing importance of NH₃.
- Critical loads for eutrophication were exceeded at 20 of 27 sites, particularly around urban areas in SE Asia, indicating potential risks of N leaching in forest ecosystems under elevated atmospheric N deposition.

Chater 5: Impacts on Ecosystems in East Asia

Impacts on Ecosystems in East Asia

EANET Monitoring covers soil, vegetation, inland waters, and forest catchments



MONITORING METHOD

EANET technical manuals and guidelines

The manuals and guidelines cover soil and vegetation, inland aquatic environments, and catchment-scale monitoring.

Source: Executive Summary, Chapter 5 — monitoring sections 5.2–5.6

Soil formation, forest composition, and climate influence soil chemistry

Table 5.1 Results of PLS-R: VIP*s for soil chemical properties

	pH(H ₂ O)	pH(KCl)	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	Al ³⁺	H ⁺
- Soil type	0.62	0.83	0.93	0.54	0.39	1.22	1.18	1.51
- Forest type	0.46	0.73	1.00	1.04	1.44	0.71	0.92	0.81
- Mean annual precipitation	1.55	1.34	1.07	1.27	0.87	1.00	0.88	0.27
*, VIP (variable importance for projection) means the strength of each explaining variable.								

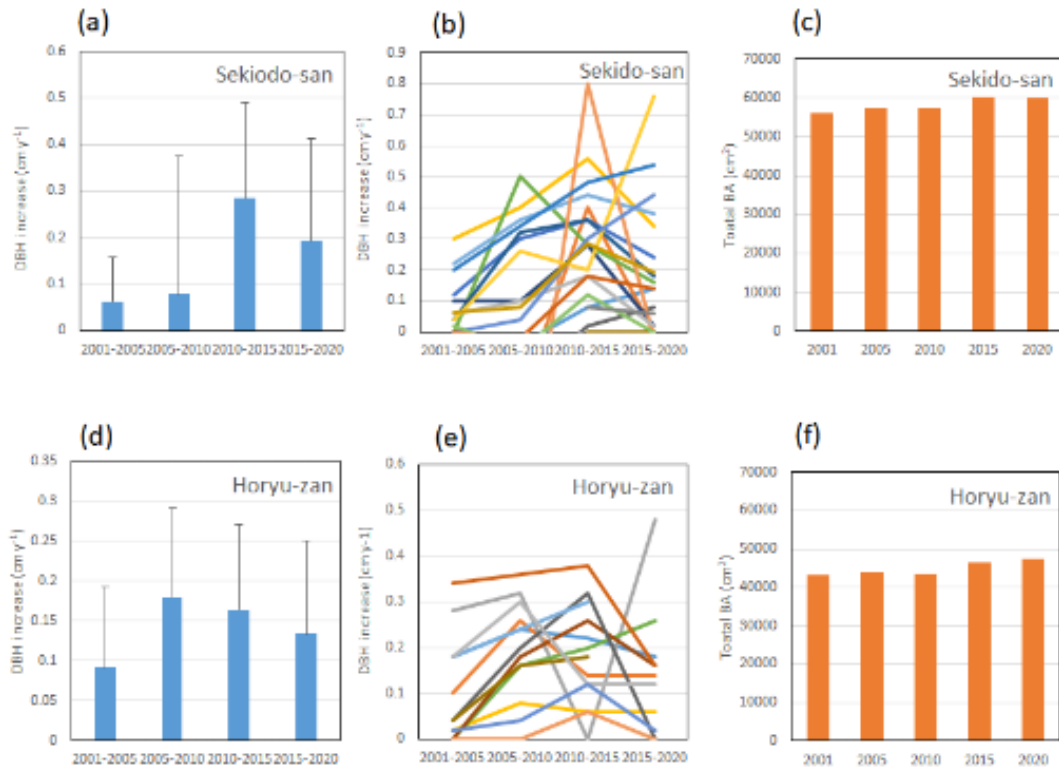
VIP expresses the strength of each explaining variable.

Soil type was dominant for Na⁺, Al³⁺, and H⁺, **Forest type was dominant for Ca²⁺, Mg²⁺, and K⁺**, **Annual precipitation was dominant for pH and several base cations**

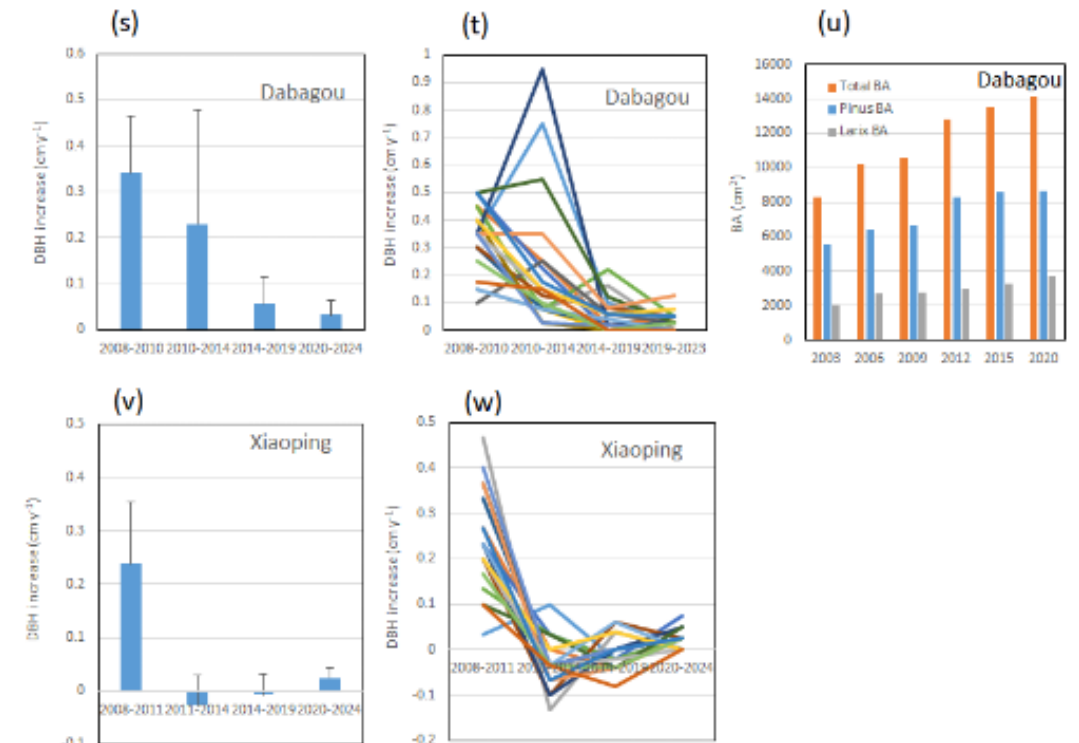
Forest growth patterns differed among stands and individual trees

Changes in DBH increase and total basal area differed greatly among stands and individual trees.

JAPAN — SEKIDO-SAN / HORYU-ZAN



CHINA — DABAGOU / XIAOPING



Long-term monitoring of identified trees is essential for evaluating the effects of air pollution.

Long-term changes in water chemistry varied widely among sites

The analyses point to site-specific processes rather than one consistent regional pattern.

TABLE 5.3 — SITES C1–L1

Site name		Duration		pH	EC	Alkalinity	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	NH ₄ ⁺	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺
Jinyunshan Lake	C1	2001-	2019	-0.70	2.22	4.17	0.40	2.63	-1.20	-2.64	0.06	1.32	3.16	-0.21
			2024	0.40	-0.73	4.79	-3.02	1.22	-4.32	-2.95	-2.44	0.72	0.01	-1.85
Xiaoping Dam	C2	2001-	2019	0.08	0.67	5.14	0.86	-0.71	-2.23	-0.82	-2.80	3.22	5.65	0.00
			2024	3.37	1.33	5.23	-0.44	-1.56	-2.72	-2.16	-1.70	4.10	5.70	-0.56
Jiwozi River	C3	2001-	2019	-1.69	-1.03	6.68	-2.30	0.61	-1.92	1.56	-0.68	1.55	-2.31	-0.38
			2024	-1.40	-4.63	6.01	-6.10	1.41	-3.35	2.17	-2.61	-1.09	-4.86	-3.61
Zhuxiandong Stream	C4	2004-	2019	-3.09	2.62	2.92	-5.45	4.17	-3.74	-3.42	0.52	0.71	0.21	1.58
			2024	-2.15	0.13	0.75	-7.35	4.74	-2.36	-5.97	2.11	0.35	-2.40	-0.96
Ijira Lake	J1	2000-	2019	1.51	-5.02	0.22	-1.98	-6.32	-7.05	-6.22	-5.28	-3.38	-4.11	-5.26
			2024	1.53	-6.42	0.80	-3.78	-8.14	-8.61	-6.78	-6.11	-3.76	-4.24	-6.33
Futago Lake oike	J3-1	2019-	2019											
			2024	0.83	1.10	2.01	-3.22	1.64	1.61		2.08	0.04	0.68	1.10
Futago Lake meike	J3-2	2019-	2019											
			2024	-1.21	-3.22	-0.73	-4.63	-2.05	0.646		0.833	-2.52	-2.62	-3.43
Nam Houm Lake	L1	2009-	2019	1.06	-1.33	-1.91	2.04	-1.66	-2.58					
			2024	-1.10	1.10	0.57	0.00	-0.93	-0.34	0.00	2.33	0.00	0.36	-0.54
Baru river	Ma3	2022-	2019											
			2024	-1.44	-2.92	-3.45	-2.62	1.71	1.25	2.16	-0.19	-2.62	-3.75	-3.30

TABLE 5.3 — SITES M03–V1

Site name		Duration		pH	EC	Alkalinity	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	NH ₄ ⁺	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺
Terelj river	Mo1	2002-	2019	-2.87	0.02	1.42	4.43	-1.46	-1.89	0.60	-1.50	-0.64	-1.00	-1.96
			2024	-4.05	-2.28	2.20	2.07	-3.28	-1.34	2.13	-1.03	0.15	-0.33	-1.93
Pandin Lake	P1	2004-	2019	-0.29	0.66	0.09	3.27	-1.72	0.46	0.05	0.74	-3.64	3.68	-0.28
			2024	0.91	0.69	-0.08	6.77	-3.81	0.43	-1.08	1.26	-3.46	2.08	2.03
Ambulalakaw Lake	P2	2005-	2019	1.01	1.17	-0.82	-2.05	-1.80	-0.02	-0.32	2.55	1.00	-0.12	0.91
			2024	1.90	4.59	-1.22	-2.23	-2.13	1.63	-0.77	-0.57	0.38	0.37	0.33
Pereemnaya River	R1	2004-	2019	-0.09	1.74	-1.64	3.96	-1.49	-1.31	-5.46	0.52	-1.67	3.78	-1.76
			2024	0.38	2.41	-1.73	4.57	-1.13	-3.38	-6.59	0.50	-0.93	4.38	-1.24
Komarovka River	R2	2005-	2019	-4.60	0.47	-2.32	3.20	5.70	0.33	0.68	3.12	3.74	1.33	-1.84
			2024	-2.89	-1.23	1.29	-0.67	0.85	0.36	-0.10	6.50	7.25	3.23	-1.45
Vachiralongkorn Dam 1	T1-1	2000-	2019	0.46	0.84	2.33	0.48	1.14	2.21	2.11	3.70	1.35	3.06	2.11
			2024	0.98	2.75	2.70	0.79	1.52	4.42	2.05	4.55	1.39	4.55	2.24
Vachiralongkorn Dam2	T1-2	2000-	2019	2.66	0.43	4.49	0.91	2.49	1.78	1.71	2.47	0.34	3.46	1.11
			2024	2.62	3.33	5.33	1.43	2.95	4.24	0.79	3.52	0.83	5.09	2.80
Hoa Binh Reservoir	V1	2000-	2019	-0.31	-1.49	-4.14	-0.04	3.66	2.49	-4.17	3.14	0.75	-2.48	-2.15
			2024	-0.50	-2.63	-4.96	-2.79	5.02	1.77	-1.47	2.48	3.55	-1.17	-6.14

p < 0.05 - +
p < 0.01 - +
p < 0.001 - +

Note : Value shows Z score, which indicates the increasing trend with positive values or the decreasing trend with negative values. Color shows significant levels.

Z-scores are shown; blue and red indicate significant positive and negative trends.

Some sites showed distinct changes in the most recent period.

Stream water responses to deposition were not always immediate

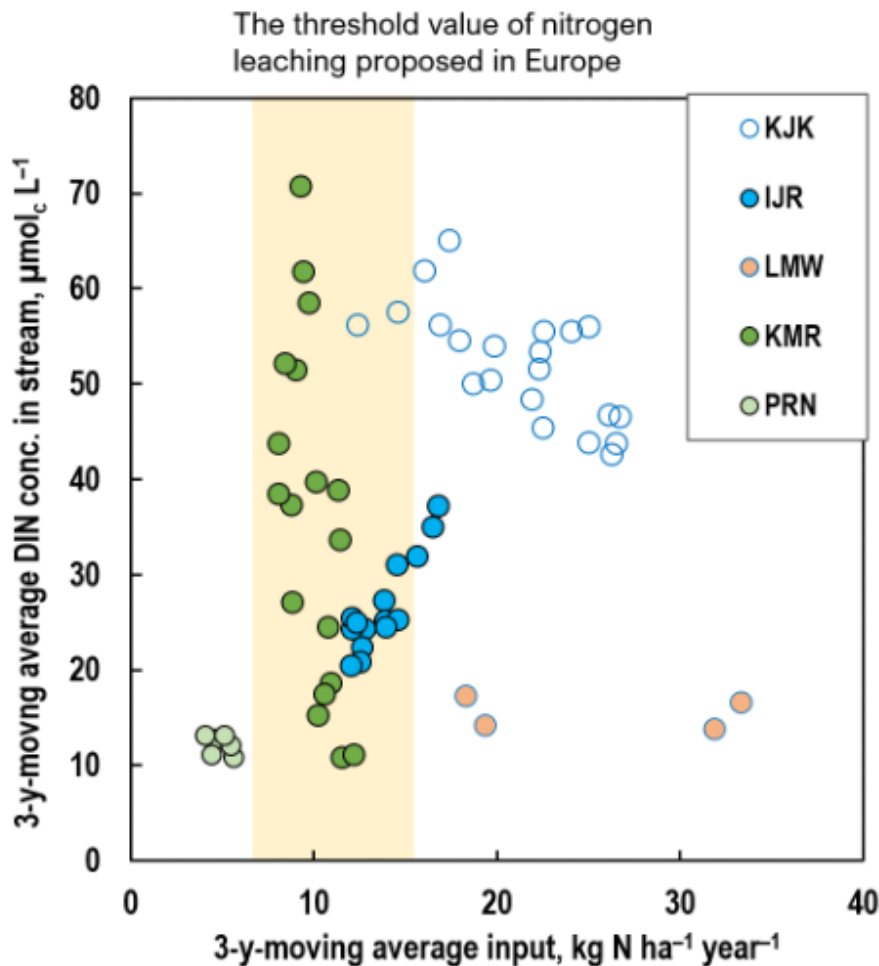


FIG. 5.2
Nitrogen input and DIN in stream water

IJR
At IJR, stream-water SO_4^{2-} and DIN decreased as atmospheric deposition declined, suggesting ongoing recovery.

OTHER SITES
At other sites, no clear relationship with atmospheric deposition was observed during the monitoring period.

Yellow band: European threshold, $7\text{--}15 \text{ kg N ha}^{-1} \text{yr}^{-1}$

Meteorological and hydrological conditions also influence sulfur and nitrogen leaching.

Ecosystem responses did not always match deposition changes

Meteorological, hydrological, geological, and internal biogeochemical processes strongly influence individual sites.

SOIL	Soil pH responses did not necessarily follow trends in atmospheric deposition.
VEGETATION	Long-term monitoring of identified trees is essential for evaluating the effects of air pollution.
INLAND WATER	At C1, C3, C4, and J1, sulfur- and/or nitrogen-related parameters recently decreased in both water and deposition.
CATCHMENT	At IJR, declining atmospheric deposition was accompanied by lower stream-water SO_4^{2-} and DIN.

CONTINUE **atmospheric deposition and ecosystem monitoring**
to evaluate delayed recovery, acidification, and changes in nitrogen retention.

Chater 6: Summary and Recommendations for Future Activities

6.1 Summary

6.1.1 Overview of state of atmospheric environment in East Asia

- East Asia is a global hotspot for air pollution and atmospheric deposition, requiring science-based environmental management. EANET has provided reliable, comparable long-term monitoring data through standardized QA/QC since 2000.
- PM_{2.5}, SO₂, and NO_x have declined in parts of East Asia, reflecting the benefits of emission controls.
- Surface O₃, biomass burning, and other sources remain important challenges as regional air pollution becomes more complex.
- Declining sulfur deposition contrasts with the growing importance of reactive nitrogen, particularly reduced nitrogen.
- Ecosystem responses vary among sites, highlighting the importance of continued integrated monitoring.
- Future priorities include strengthened monitoring, QA/QC, integrated assessment and modeling, and regional collaboration.

6.1.2-6.1.5: Summary for Chapter 2 - 5

6.2 Recommendations for future activities

6.2.1 General remarks

- Over the next five years, EANET should follow the current MTP, strengthening O₃ and PM_{2.5} monitoring and analysis and providing science-based information for atmospheric environment management.
- Priority should focus on three strategic perspectives: sustainable monitoring, nitrogen cycle and management, and meteorological impacts on air pollution.
- Sustainable monitoring should integrate monitoring networks, low-cost sensors, **satellite observations**, models, emission inventories, and AI, while strengthening technical capacity and international collaboration.
- Nitrogen management should strengthen long-term monitoring of reactive nitrogen and integrate observations, **satellite data**, and models to assess regional nitrogen deposition.
- Meteorological impacts should be assessed using long-term observations, atmospheric models, and AI to understand their influence on air pollution and predict future changes.
- **It should be noted that emerging technologies, including low-cost sensors, satellite observations, and AI-based technologies, are not yet sufficiently mature to serve as official monitoring methods under the EANET framework and should therefore be considered complementary approaches to conventional ground-based monitoring.**

6.2.2 Specific topics

6.2.2.1 Monitoring and QA/QC

- **EANET should strengthen sustainable monitoring and QA/QC, focusing on O₃, PM_{2.5} and their precursors, reactive nitrogen, long-term data quality, and emerging technologies.**
- **The long-term monitoring network should be sustainably maintained through proper site management, sufficient resources, knowledge transfer, harmonized methodologies, ILC activities, Technical Missions, and capacity building.**
- **Region-wide monitoring of O₃, PM_{2.5}, their chemical components and precursors, and reactive nitrogen deposition should be strengthened with appropriate QA/QC.**
- **Coordinated long-term observations of meteorology, air pollution, and atmospheric deposition should be strengthened to distinguish emission and meteorological influences.**
- **LCSs, satellite observations, and AI should complement ground-based monitoring, with appropriate evaluation and QA/QC, enabling EANET to respond to evolving scientific and policy needs.**

6.2.2.2 Assessing regional atmospheric environment

- **EANET should make fuller use of its reliable long-term monitoring data through integrated regional assessment to identify common trends, regional differences, emerging issues, and their underlying factors.**
- **Systematic assessment should focus on O₃, PM_{2.5} and their precursors, including spatial and temporal variations, long-term trends, seasonal patterns, and pollution episodes.**
- **Monitoring data should be integrated with emission inventories, meteorology, atmospheric models, source apportionment, and AI to clarify emission, transport, transformation, and deposition processes, supported by capacity building.**
- **Regional analyses should integrate data across countries and urban, rural, and remote sites, including atmospheric concentrations and deposition, to better understand regional transport and pollutant behavior.**
- **EANET should strengthen the science–policy interface through policy-relevant regional and thematic assessments, providing a common scientific basis for evidence-based environmental management and regional cooperation.**

6.2.2.3 Assessing impacts on ecosystems

- **EANET should continue long-term ecological monitoring and strengthen assessment of ecosystem responses to atmospheric deposition and air pollution, including O₃ and PM_{2.5}.**
- **Integrated assessment should link wet and dry deposition with soil, forest, and inland-water responses, including catchment-scale studies to understand long-term ecosystem changes.**
- **Greater emphasis should be placed on reactive nitrogen, including dry and total deposition, to assess nitrogen retention, accumulation, export, and potential ecosystem risks.**
- **Assessment of O₃ and PM_{2.5} impacts should be further developed by integrating atmospheric and ecological observations and improving relevant assessment methodologies.**
- **Meteorological and site-specific environmental factors should be considered in interpreting ecosystem responses, supporting assessment of ecosystem risks and recovery across East Asia.**

6.2.2.4 Other activities

- **EANET should strengthen supporting activities, including capacity building, technical support, science-based policy support, communication, and regional and international cooperation.**
- **Strategic capacity building should address established methods and emerging needs related to O₃, PM_{2.5}, data analysis, and new approaches, emphasizing practical training and knowledge transfer.**
- **Technical support should be tailored to country needs through Technical Missions, training, expert consultation, and systematic sharing of experience and good practices.**
- **Science-based policy support and communication should translate EANET findings into accessible indicators, guidance, visualization, and other information for policymakers, experts, researchers, and the public.**
- **Regional and international collaboration should promote knowledge exchange and scientific advances, strengthening EANET's role as a regional platform for atmospheric environmental management.**

Annex: Introduction of EANET Project and related information

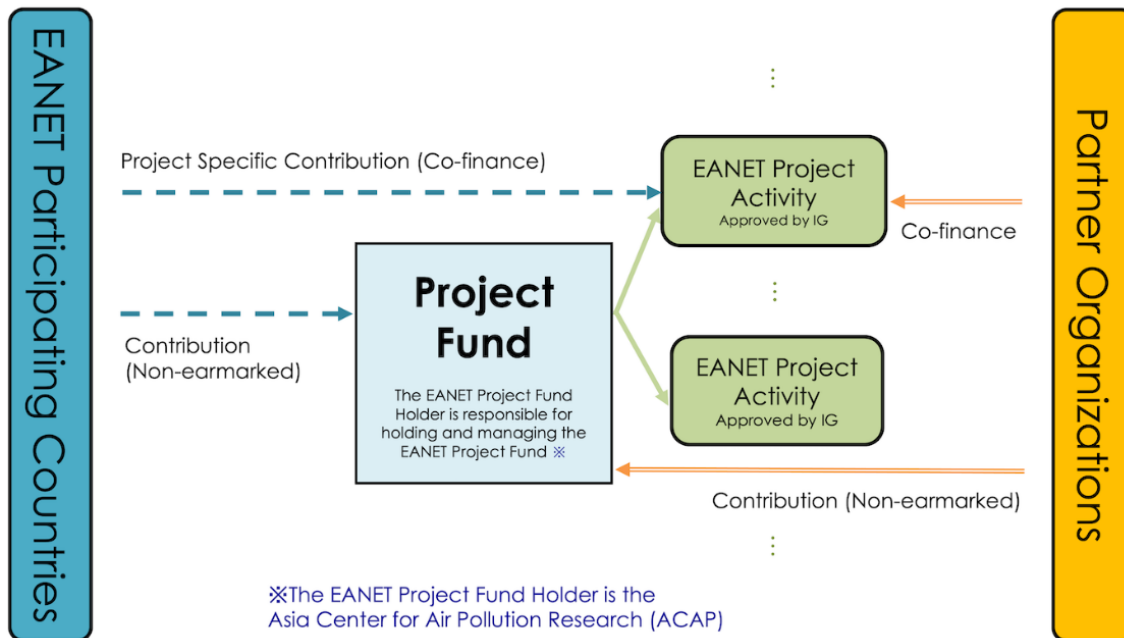
1. EANET Project Fund and Project Guidelines

- EANET Project Mechanism
- EANET Project Cycle
- EANET Project Criteria

EANET Project Criteria

- Activities should be within the EANET Scope (more information on the Scope of the EANET can be found in the Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET), and in the Annex to the Instrument.)
- The EANET Project Plan is in line with the principles defined in the EANET Project Fund and Project Guidelines.
- The EANET Project Plan clearly and reasonably indicates its objectives, activities, rationale to implement, tangible expected outputs, and outcomes.
- More than half of EANET Participating Countries (at least 7) are identified as beneficiaries directly and/or indirectly.
- Contents of the EANET Project Plans are considered and developed using criteria stated in ANNEX 3 of the Guidelines.
- Necessary resources other than from the EANET Project Fund (EPF) are secured or highly likely to be secured, while the allocation of EPF is the matter of the IG's decision.
- At least one Co-Financer in-kind, is secured or highly likely to be secured. In the case of a small project of which the total amount of required resources is 30,000 USD or less, a financial contribution other than from the EPF is not always required, while in-kind contribution is encouraged.
- In principle, the Project period is around one year. Some types of projects can set their period up to 3 to 5 years, provided that such a Project has a mechanism to be reviewed by IG on the implementation of the Project for IG's decision to continue or terminate.

EANET Project Fund Mechanism



The EANET Project Cycle

4. Completion Stage

Implemented activities, outputs and outcomes of the Project shall be reported to IG and relevant stakeholders, and then evaluated by IG.

3. Implementation Stage

Activities specified in the Project Plan will be implemented in line with it, and using the resources allocated from Project Fund.

1. Preparation Stage

The Project Lead develops a project proposal including objectives, activities, required resources, the requested amount from the Project Fund, implementation arrangements, and other key factors.

2. Approval Stage

The Intergovernmental Meeting on the EANET (IG) reviews the project proposal, and approves it if appropriate, as the Project Plan of EANET Project, including the allocated amount of the Project Fund.

2. Overview of the EANET Project Activities in 2022-2024

Table A1.1. EANET Projects conducted during 2022-2024.

2022	
Objective 1: Monitoring of acid deposition including related chemical substances with quality assurance and quality control (QA/QC)	
2022-02	Promotion of studies on the effects of acid deposition, including other priority chemical species on plants and ecosystems, especially on biogeochemical cycles on a catchment scale as well as regional impact assessment
2022-04	Workshop on national air-quality monitoring systems and methodologies with other related partners
2022-05	Research on expanding the regional air quality monitoring using the low-cost sensor and improving the capacity to the monitoring data to policymaking
2022-06	Promotion of studies on estimation of the source of air pollution of PM _{2.5}
Objective 3: Promotion of capacity building	
2022-10	Promotion of capacity building for personnel of the participating countries, including training courses, capacity building workshops, etc. for monitoring
2022-12	Promotion of research and technical cooperation on emission inventory to support the capacity building
2022-14	Intensive training for city government officials on air quality monitoring and related skills
2022-15	Learning Opportunity of IIASA Study on Urban and Rural Relations in atmospheric environment
2022-16	Promotion of studies on atmospheric simulation models to assess the trend of national and regional acid deposition, including related substances in East Asia through workshops, training courses, etc.
2022-17	Organize workshops or seminars for practitioners to learn the relationships mainly between atmospheric environment and human health, and atmospheric environment and ecosystem, and how to minimize the adverse effects in designing measures
2022-18	Learning Opportunity on Reducing Emissions from Open Burning (Alternatives to Burning Bans)
2023	

Objective 1: Monitoring of acid deposition including related chemical substances with quality assurance and quality control (QA/QC)	
2023-01	Studies on the effects of atmospheric deposition on ecosystems, from a catchment scale to a regional scale as a methodological study
2023-03	Methodology Study for Development of LCS Hybrid Air Quality Monitoring Network (HAQMN)
2023-04	PM _{2.5} source apportionment in pilot cities of EANET for recommendations on feasible reduction policy
Objective 3: Promotion of capacity building	
2023-02	The Feasibility for promoting VOCs related Capacity Building in the EANET
2023-05	Promotion of capacity building for personnel of the participating countries on monitoring
2023-06	The webinar workshop for capacity building on emission inventory for combustion sources
2023-07	Seminars for Acid Deposition/Air Pollution effects on human health and ecosystem
2023-08	Research Fellowship program
2024	
Objective 1: Monitoring of acid deposition including related chemical substances with quality assurance and quality control (QA/QC)	
2024-01	Studies on the effects of atmospheric deposition on ecosystems, from a catchment scale to a regional scale as a methodological study
2024-03	Methodology Study for Development of LCS Hybrid Air Quality Monitoring Network (HAQMN)
2024-04	PM _{2.5} source apportionment in pilot cities of EANET for recommendations on feasible reduction policy
Objective 3: Promotion of capacity building	
2024-02	Promoting VOCs related Capacity Building in the EANET
2024-05	The collaboration of Technical and Training (TNT) and capacity building program for personnel of the Participating Countries on monitoring
2024-06	Webinar for emission inventory of VOCs and its application for policy consideration
2024-07	Seminar for Particulate Matter Problem including Haze in Southeast Asia
2024-08	Next Generation Leadership Program in East Asia
2024-10	Stocktaking and Methodological Assessment Emissions Inventories and Source Apportionment of Air Pollution in Southeast Asia
2024-12	Seminar on Sustainable Nitrogen Management

3. Perspectives of EANET Projects in the Fifth Medium-Term Plans of the EANET (2026-2030)

EANET Projects are expected to address topics that are given priority within EANET and to undertake activities that respond to the needs of the EANET Participating Countries.

To provide a reference for considering such activities, the EANET Medium-Term Plan provides a list of potential project activities under each of the following three Outcomes expected from EANET activities:

- 1. Increased understanding on the state of air pollution and atmospheric deposition in East Asia is built through strengthened monitoring.**
- 2. Decision-makers at local, national and regional levels have increased access to evidence-based, policy-relevant information.**
- 3. Cooperation on the issues related to air pollution and atmospheric deposition in the region is increased.**

“Table A1.2. Initial list of potential project activities in the Fifth Medium-Term Plans of the EANET (2026-2030)” provides the list of potential project activities.

Box 1. Observational studies for sustainable monitoring in the EANET region

1. What observational studies have brought in the EANET region?

- Long-term observations since 2001 for understanding air pollution and ecosystem impacts in East Asia
- Harmonized monitoring data supporting scientific assessment and policy development

2. Key observational focuses under MTP (2026–2030)

- PM_{2.5}, its components, and surface O₃ and its precursors.
- Nitrogen species (NO_x and NH₃)
- Atmospheric deposition & ecological impacts

3. Ensuring sustainable monitoring during MTP (2026–2030)

- Maintenance, upgrade and continuity of existing ground observation sites
- Continue harmonized QA/QC and standardized methodologies across Participating Countries
- Capacity building and data sharing to strengthen regional consistency

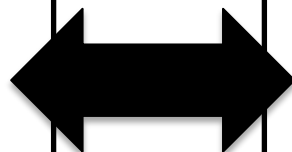
4. Towards sustainable monitoring in the EANET region

- Combine ground-based monitoring with new observation technologies (satellite observations, LCS)
- Utilize AI and data integration for better assessment
- Strengthening EANET as a solid foundation for sustainable regional monitoring

Box 2. Impacts of meteorological conditions on air pollution

How do meteorological conditions affect air quality?

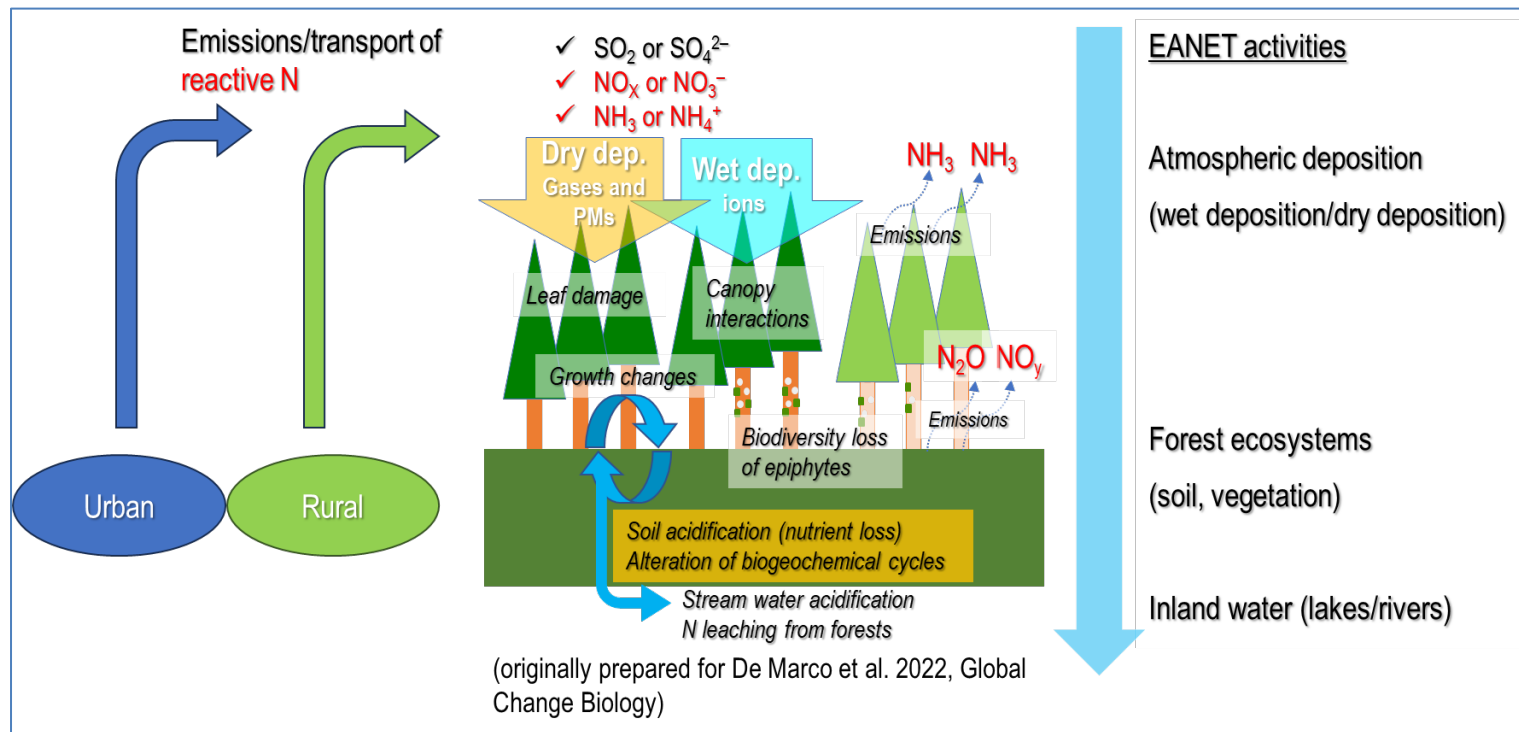
- Air pollutant concentrations are controlled by emissions, transport, diffusion, chemical reactions, and wet and dry deposition. Their lifetimes range from seconds to years, resulting in air pollution from local to hemispheric scales.
- Wind, solar radiation, temperature, and land–sea breezes strongly influence pollutant transport and photochemical ozone formation.
- Precipitation removes pollutants and suppresses biomass burning, whereas dry conditions increase pollutant accumulation and wildfire and biomass burning impacts.
- Temperature inversions trap pollutants near the surface, causing severe pollution episodes.
- Large-scale meteorological circulation strongly influences the spatial distribution of air pollutant concentrations and Asian dust (yellow sand).



Impacts of changing meteorology on air pollution

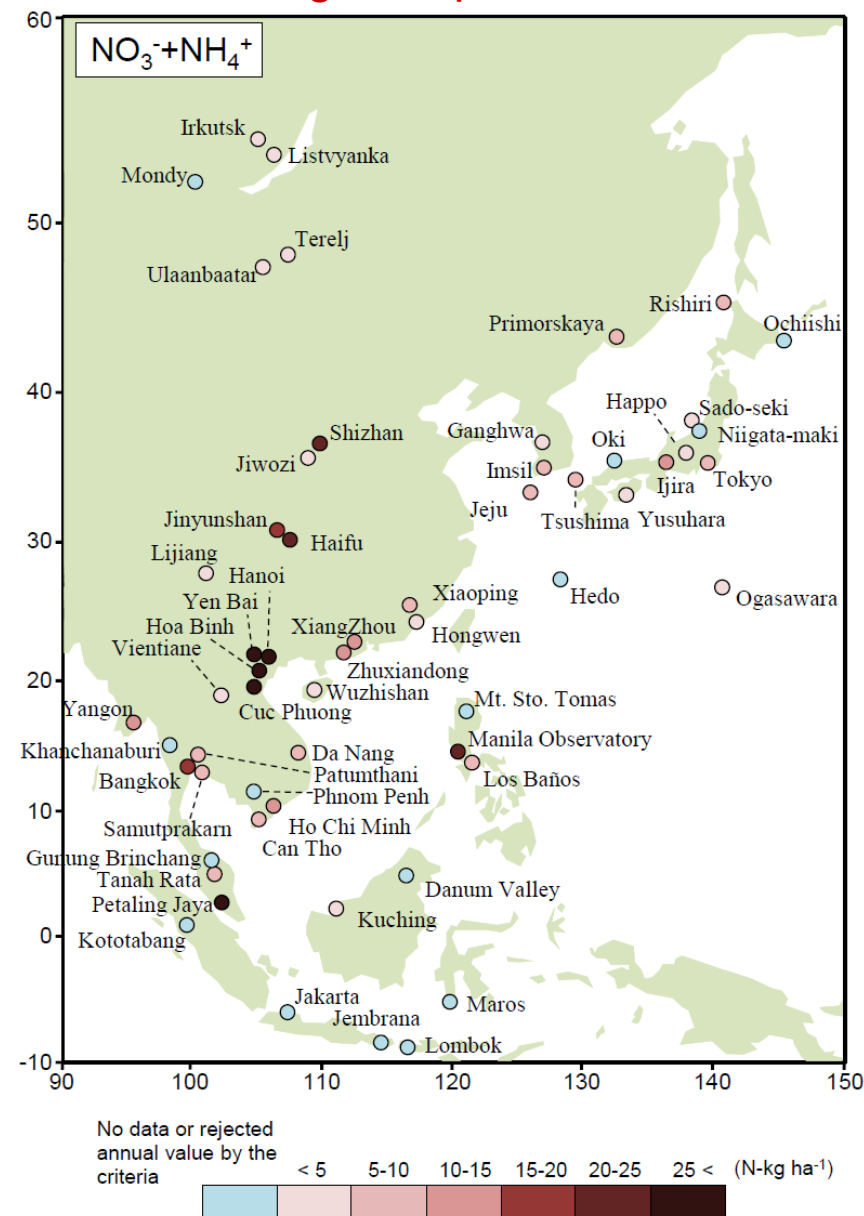
- Rising temperatures enhance photochemical ozone formation and increase anthropogenic and biogenic VOC emissions that are photochemically reactive and increase ozone concentrations
- Hot and dry conditions promote biomass burning, increasing PM_{2.5} concentrations, and may also influence Asian dust events.
- Changes in precipitation affect both atmospheric pollutant concentrations and wet deposition through changes in scavenging efficiency.
- Changes in local and large-scale wind fields alter pollutant transport, stagnation, and background concentrations.
- Understanding these meteorological impacts is essential for evaluating emission control measures and for developing EANET monitoring strategies and interpreting monitoring data.

Box 3. Nitrogen flow and management



- Atmospheric transport and deposition are essential processes in the nitrogen cycle. Through its monitoring activities, EANET has accumulated valuable data on reactive nitrogen.
- The Medium-Term Plan (2026–2030) calls for enhanced nitrogen management, focusing on expanded monitoring of NO_x , NH_3 , and their ionic species, including their concentrations, deposition, and ecological impacts.

Wet nitrogen deposition in 2024



Review of the PRSAE5 Executive Summary

Executive Summary: Contents

➤ **Summary for Policy Makers**

□ **Summary of Key Points**

- ✓ About the PRSAE5
- ✓ Current status of EANET monitoring activities
- ✓ Data quality
- ✓ Overview of the analysis of monitoring results

□ **Summary of State of Atmospheric Environment**

- ✓ Gas and Aerosol Concentration in East Asia
- ✓ Wet and Dry Deposition of atmospheric substances
- ✓ Impact of Ecosystems in East Asia

□ **Key Message to Policy Maker**

- ✓ Protecting and Strengthening EANET's Scientific Foundation
- ✓ Supporting Alternative Monitoring Technologies and Closing Data Gaps
- ✓ Bridging Scientific Data with Policy Making
- ✓ Moving from Regional Data to Regional Strategies and Measures
- ✓ Building a Stronger Regional Platform for the Future
- ✓ Conclusion

➤ **Summary of each Chapter of Regional Assessment**

Summary of Key Points

- **About the PRSAE5**

- Brief background of periodic report and introduction of the PRSAE5

- **Current status of EANET monitoring activities:**

- EANET Monitoring Framework, Monitoring Site Classification, Atmospheric Monitoring Network, Ecological Monitoring Network, and Quality Assurance and Quality Control (QA/QC)

- **Data quality**

- Further improvement of EANET data quality requires refinement of ILC evaluation, regular NMP updates, more effective Technical Missions, and strengthened monitoring and QA/QC practices.

- **Overview of the analysis of monitoring results**

- EANET observations show decreases in $\text{PM}_{2.5}$, SO_2 , and NO_x in parts of East Asia, reflecting the benefits of emission reductions.
- Surface O_3 , biomass burning, and coal combustion remain concerns, indicating increasingly complex regional air pollution.
- Sulfur deposition has decreased, while reactive nitrogen is increasingly important for ecosystem risks.
- Ecosystem responses vary among sites, highlighting the need for continued integrated monitoring.
- Overall, emerging challenges such as O_3 and reactive nitrogen require strengthened monitoring, assessment, QA/QC, and regional collaboration.

Summary of State of Atmospheric Environment

● Gas and Aerosol Concentration in East Asia

- EANET's long-term monitoring shows declines in PM_{2.5} at many sites and SO₂ and NO_x in China, while biomass burning and coal combustion remain important PM sources and contrasting O₃ trends and rising NH₃ highlight emerging regional concerns.
- Future priorities include strengthening long-term monitoring of PM_{2.5}, O₃, precursors, and reactive nitrogen, source apportionment, integrated modelling, QA/QC, and regional collaboration.

● Wet and Dry Deposition of atmospheric substances

- Sulfur deposition has decreased, particularly in Northeast Asia, while nitrogen deposition remains high and variable, with hotspots in Southeast Asia.
- Total nitrogen deposition is highest in Southeast Asia, dominated by reduced nitrogen, with critical-load exceedances indicating eutrophication risks.
- Declining acidity in Northeast Asia contrasts with variable Southeast Asian conditions, highlighting the need for stronger NH₃ monitoring and total deposition assessment.

● Impacts on Ecosystems in East Asia

- Long-term ecological monitoring shows variable soil and forest responses to declining sulfur deposition, while inland waters show no widespread acidification and some recovery, with catchments generally remaining nitrogen sinks.
- Ecosystem responses vary among regions and are influenced by multiple environmental and climatic factors, highlighting the need for continued integrated monitoring

Key Message to Policy Maker

- **Protecting and Strengthening EANET's Scientific Foundation**
 - EANET's long-term monitoring data are a valuable regional public good and scientific foundation for environmental policy. Maintaining their continuity, quality, and accessibility while expanding EANET's knowledge base to address emerging air pollution challenges should remain a core priority.
- **Supporting Alternative Monitoring Technologies and Closing Data Gaps**
 - Alternative monitoring technologies such as LCS can complement conventional monitoring and expand spatial coverage, but require appropriate guidance and QA/QC. EANET can support their effective integration to strengthen regional monitoring and address information gaps.
- **Bridging Scientific Data with Policy Making**
 - EANET should strengthen the science–policy interface by translating its scientific findings into clear and practical information for policymakers, building on its trusted regional network to support informed, science-based decision-making.

Key Message to Policy Maker

- **Moving from Regional Data to Regional Strategies and Measures**
 - EANET can support regional cooperation on transboundary air pollution by providing scientific evidence on regional trends, transport pathways, and common challenges, while maintaining its role as a trusted scientific basis for policy discussions.
- **Building a Stronger Regional Platform for the Future**
 - EANET should further develop as a regional platform connecting science, policy, and countries, making full use of its long-term data, technical expertise, new technologies, and established cooperation to support regional environmental management.
- **Conclusion**
 - Building on its trusted scientific foundation, EANET should integrate diverse data and technologies, strengthen the science–policy interface, and promote regional cooperation to translate scientific knowledge into informed policy and regional action.

Comments and Responses

Chapter 6	Descriptions
Comments	REV 22 SEP version (PDF p.6 to p.7, printed pages 180 to 181) Section 6.2.1, PDF p.6 (printed page 180), four instances. Comment: These four passages present satellite observations as work to be promoted during the current MTP period. As far as we understand, the MTP places satellite only under methodology exchange and capacity building, and states that such data will not be used as official data. As currently worded, they may be read as committing EANET to include satellite observations in monitoring work during this period. Suggested revision: Reword the reference to satellite observations so that it sits under methodology exchange and capacity building, and keep the qualification that such data enhance and supplement ground-based monitoring and are not used as official EANET data. The wording in the 20 SEP version of Chapter 6 could be used directly: "should complement rather than replace official ground-based EANET observations". The same wording also appears in the Chapter 6 summary (Executive Summary, PDF p.40) and should be revised at the same time.
Responses	Following description was added to the third paragraph of Section 6.2.1: It should be noted that emerging technologies, including low-cost sensors, satellite observations, and AI-based technologies, are not yet sufficiently mature to serve as official monitoring methods under the EANET framework and should therefore be considered complementary approaches to conventional ground-based monitoring. The text in red was added to the first sentence of “Sustainable Monitoring” : During the current MTP period, efforts under sustainable monitoring should focus on examining practical approaches for utilizing LCS, satellite observations, existing monitoring networks, and AI technologies as a compliment of ground-based EANET observations. The text in red was added to the fourth and fifth sentences in the fourth paragraph of Section 6.2.2.1: In particular, the utilization of satellite observation data, which can spatially complement the limited number of ground-based observations, has the potential to become a promising approach in the next MTP for advancing regional-scale monitoring of nitrogen dioxide (NO₂) and ammonia (NH₃). However, it should be noted that several technical challenges remain, including observational uncertainties, the conversion of column concentrations to ground-level concentrations, and the fusion of satellite and ground-based observation data using atmospheric models.

Executive Summary	Descriptions
Comments	Summary for Policy Makers (PDF p.10, printed page x) Conclusion, PDF p.10 (printed page x), one instance. Comment: This sentence lists satellite observations alongside conventional monitoring as data sources to be integrated, and may be misread as bringing satellite data into the regular data system. Suggested revision: Add "as complementary information" at the end of the sentence, or replace "satellite observations" with "other emerging technologies", consistent with the qualification in paragraph 10 of the MTP.
Responses	Summary for Policy Makers The text in red was added to the first sentence in the second paragraph of “Conclusion”: By integrating a broader range of air pollution data, including emission inventories, meteorological and modelling analysis, conventional monitoring, and complementary observations from alternative technologies such as low-cost sensors and satellite observations, EANET can help close important information gaps in understanding the current state of the atmospheric environment across East Asia. By strengthening the science-policy interface, it can help Participating Countries make better-informed decisions. 6. Summary and Recommendations for Future Activities Recommendations for Future Activities Following description was added to the third paragraph: It should be noted that emerging technologies, including low-cost sensors, satellite observations, and AI-based technologies, are not yet sufficiently mature to serve as official monitoring methods under the EANET framework and should therefore be considered complementary approaches to conventional ground-based monitoring.

Technical conditions for satellite data	Descriptions
Comments	Given the substantial uncertainty of satellite observations themselves, we suggest adding a short note on the technical conditions so that the wording matches the actual situation. For example, satellite retrievals of PM and other pollutants are affected by cloud cover, the vertical distribution of aerosols and surface reflectance, and their accuracy is far below that of ground-based monitoring; ground-based calibration sites in East Asia are sparse and unevenly distributed, so the data are not sufficiently representative; mainstream satellites pass over only once or twice a day, and the low temporal resolution makes it difficult to capture intra-day variations in pollutant concentrations. On these grounds, satellite observations are not yet technically ready to serve as a main monitoring method under the EANET framework.
Responses	Chapter 2 2.5 Conclusion and recommendations The text in red was added to the following sentence in the fourth bullet of the last paragraph of Section 2.5: In addition, information should be collected on emerging technologies and approaches, including low-cost sensors (LCSs), satellite observations, and the application of artificial intelligence (AI) although they are not yet technically ready to serve as a main monitoring method under the EANET framework, but they have the potential to serve as complementary approaches.

Actions Required

The SAC26 is invited to review the final draft of the PRSAE5 and provide comments and suggestions for necessary revisions to be adopted with modification by SAC26 and approved for publication by IG28.

Thank you



Secretariat for the EANET
UN Environment Programme for Asia Pacific
eanetsecretariat@un.org
www.eanet.asia
www.unep.org

Network Center for the EANET
Asia Center for Air Pollution Research
[https://www.acap.asia/en/](https://www.acap.asia/en/eanet@acap.asia)
eanet@acap.asia
