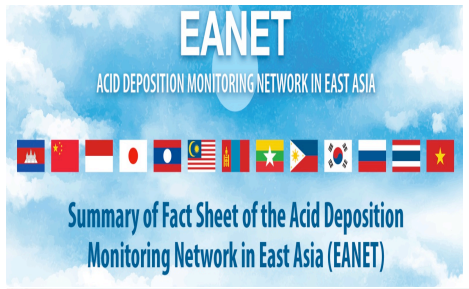
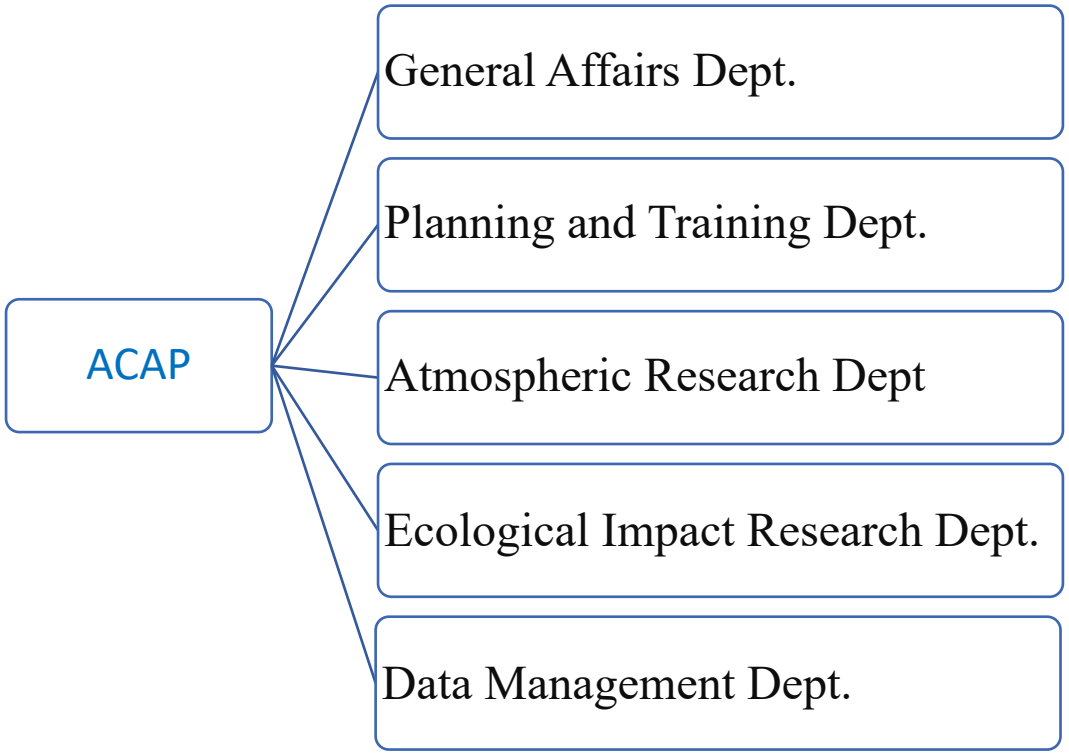
Air Quality and Acid Deposition

Asia Center for Air Pollution Research (ACAP)

Network Center of EANET

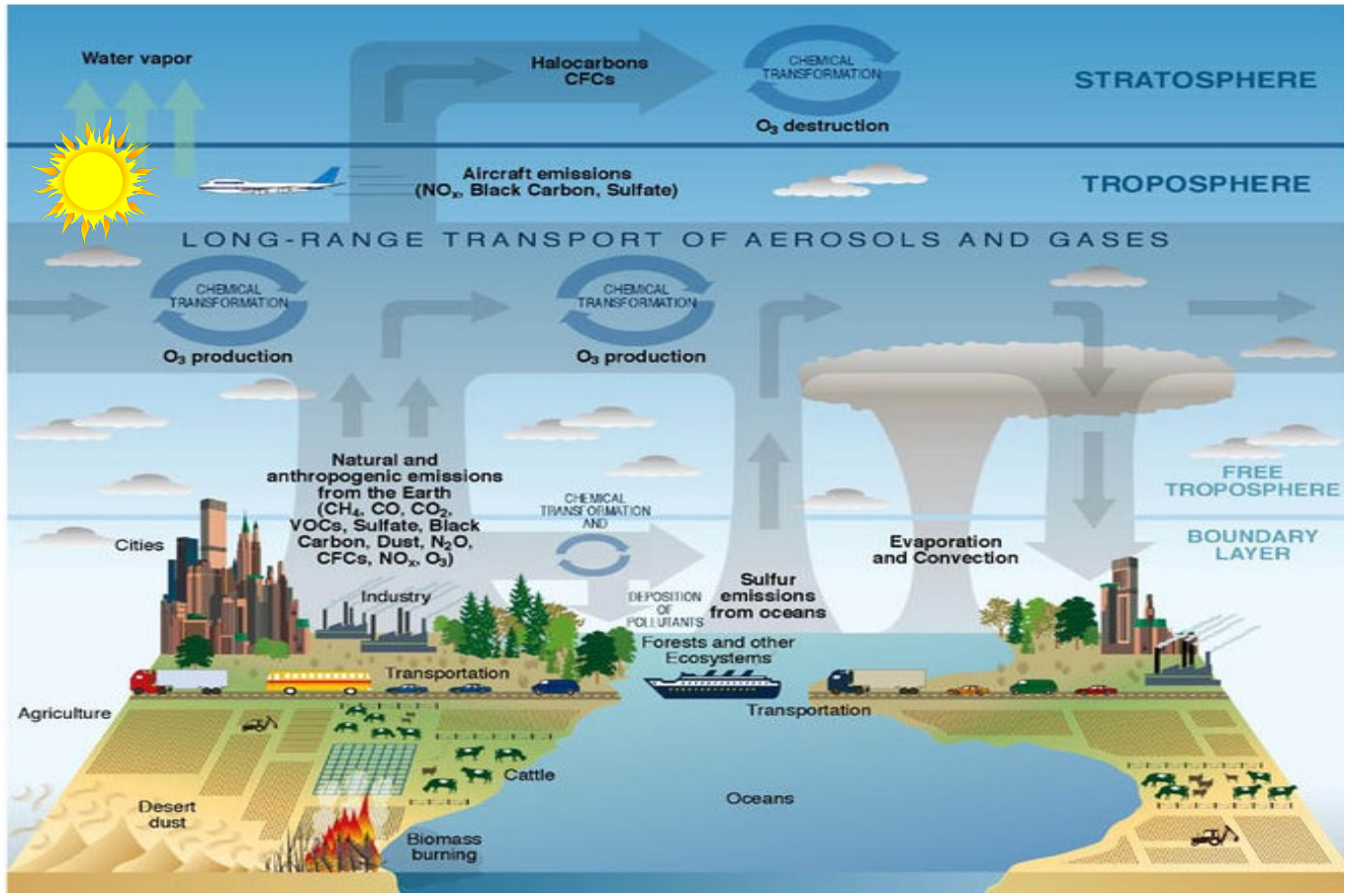
ACAP and Network Center of the EANET





- ACAP as **Network Center** for EANET
- Compilation, evaluation and storage of data
- EANET project. Research activities including monitoring methodologies improvement
- Technical support and capacity building
- Other research related to atmospheric environment
- Support the Intergovernmental Meetings (IG), the Scientific Advisory Committee (SAC), Working Group Meetings, Task Forces of EANET

Air Quality, Acid Deposition, and Climate Change Problems Interconnected



- In terms of targeted air pollutants, atmospheric processes, emission sources and control policy.
- All air pollutants deposited to the surface, either in their primary form or transformed form, some of which contribute to acid deposition.
- Some air pollutants such as BC, tropospheric (surface level) ozone, and PM are climate forcers, warming or cooling.

https://www.instructables.com/ATMOSPHERIC-OXYGEN-AND-ITS-INFLUENCE/

EANET – an Intergovernmental Initiative Started for Acid Deposition

Impact on Forests and Lakes (In Europe)

(By Dr.Kenichi SATAKE)

Damage on Materials

(By Yokohama Environmental Science Research Institute)

Established in 2001 by 13 countries.

Objectives:

- To **create a common understanding** of the state of acid deposition problems in East Asia;
- To **provide useful inputs for decision-making** at the local, national, and regional levels aimed at preventing, or **reducing adverse impacts on the environment** caused by acid deposition; and
- To **contribute to cooperation** on the issues related to acid deposition among the Participating Countries.

Scope Expansion of EANET in 2021(IG23)

Air Quality: SO_2,NO_2,CO, O_3, $PM_{2.5}$, PM_{10}, Toxic……

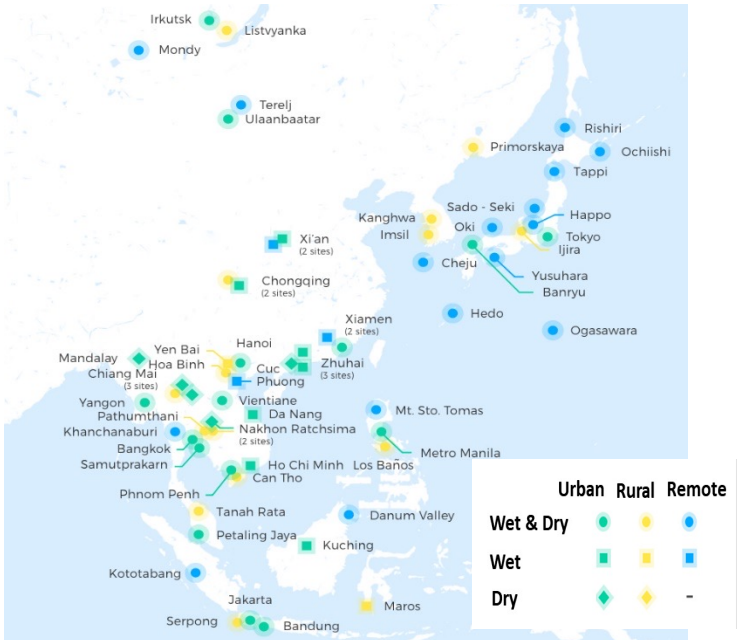
- East Asian region has experienced rapid economic growth since the late 20th century
- Largest air pollutant emissions in the world
- Severe air pollution

Primary: from emission sources SO_2, NOx, CO, BC, dust

Secondary: from chemical reactions O_3

Primary+ Secondary: $PM_{2.5}$(sulfate, nitrate, SOA) VOCs

Targeted Air Pollutants and Monitoring Activities of the EANET



- Monitoring sites: 54 air quality/dry deposition, 61 Wet deposition (rain, snow), 20 soil and vegetation, 19 inland aquatic environment(lake and river), 2 catchment
- Data and assessment report: annual report; periodic report (PRSAD ,every 5 years)
- Quality assurance/quality control (QA/QC): STM meeting, Inter Laboratory Comparison (ILC)
- Development/revision of technical guidelines, manuals
- Technical support and cooperation, training program

Supplementary Document (Annex) to the Instrument for Strengthening the EANET

Atmospheric Environment-related Substances		Item 4 Monitoring and Reporting	Item 5 Assessment	Item 6 Research Activities	Item 7 Education and Training	Item 8 Public Awareness	Item 9 Exchange of Information
SO_2		√	√	*	√	√	√
NO_x		√	√	*	√	√	√
NH_3		√	√	*	√	√	√
PM	PM2.5	√	√	*	√	√	√
	PM10	√	√	*	√	√	√
	TSP	√	√	*	√	√	√
	[DSS[a]]	√	√	*	√	√	√
	PM(inorganic ions)	√	√	*	√	√	√
	PM(metallic elements)	-	-	*	√	√	√
	PM(organic aerosols)	-	-	*	√	√	√
Precipitation Chemistry (ions, pH, EC)		√	√	*	√	√	6 √
Surface Ozone		√	√	*	√	√	√
CO		-	-	*	√	√	√
VOCs		-	-	*	√	√	√

[√: Applicable], [-: Not applicable], [*: Partly applicable]: see Item 3, para 4

[Note: Dust and Sand Storms(DSS) are suspended dust and sand caused by dust and sandstorms.]

Monitoring Sites of EANET

China

Cambodia

Indonesia

Japan

R. of Korea

Malaysia

Mongolia

Myanmar

Thailand

Philippines

Lao PDR

Russia

Vietnam

Facilities and Equipment

Laboratory (Training)

Gas Chromatograph Mass Spectrometer

Ion Chromatograph

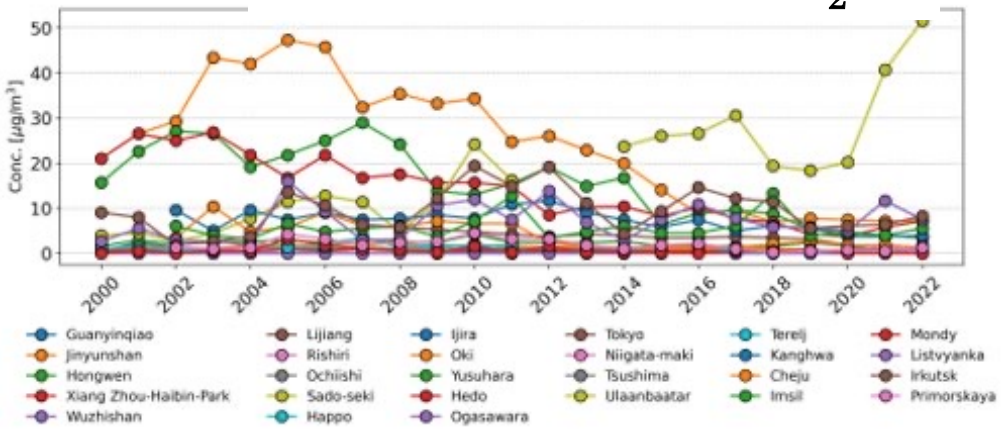
Scanning electron microscope

Laboratory (Atmospheric Research)

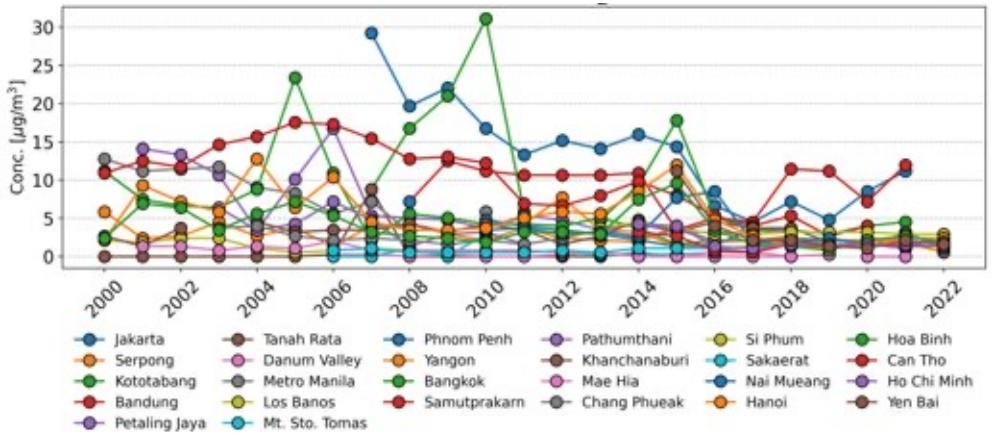
Research for Wet Deposition

Ambient SO_2 and precipitation SO_4^{2-} (2000-2022)

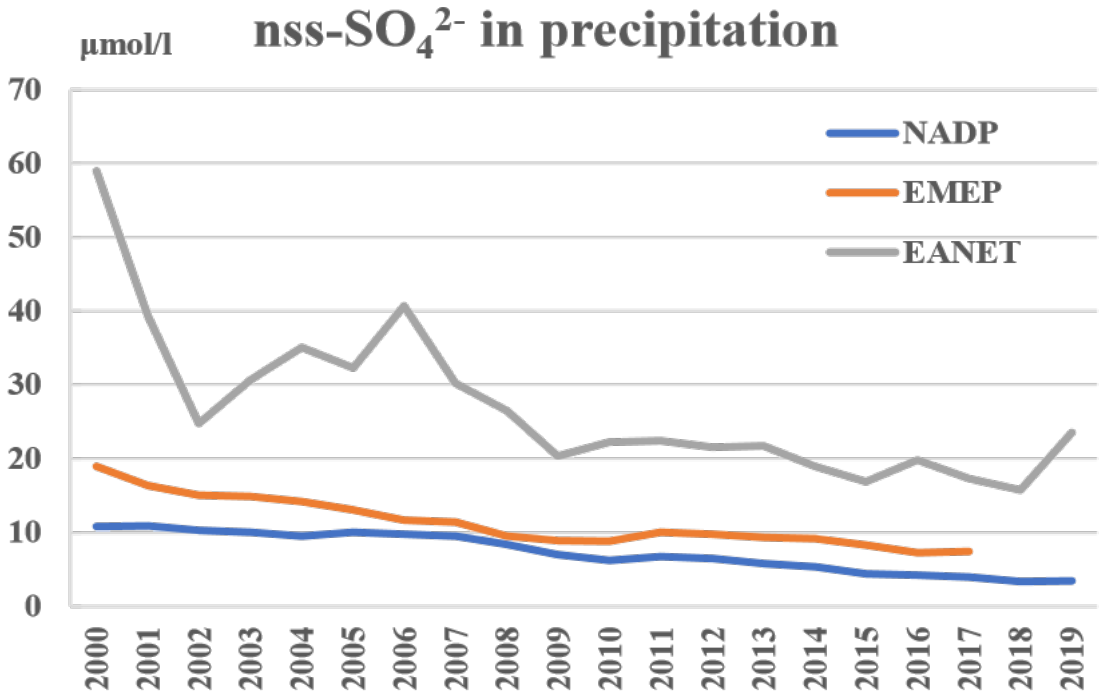
North-East Area : SO_2



South-East Area : SO_2



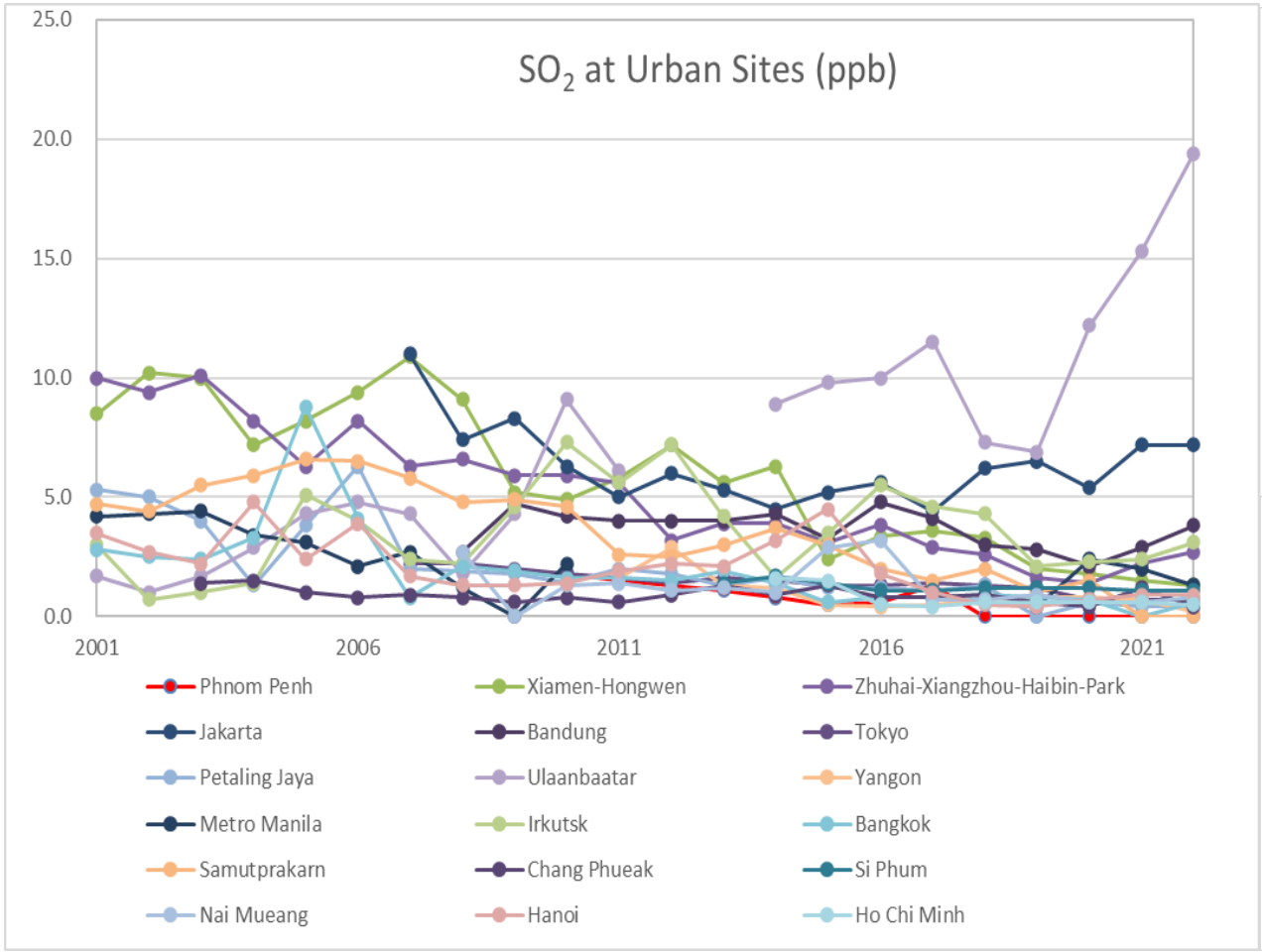
Conversion ratio for SO2 : x 2.66

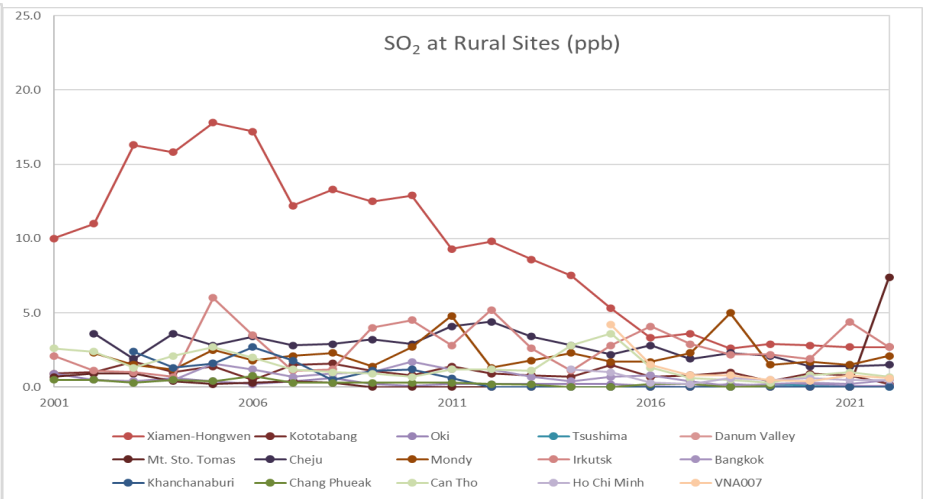


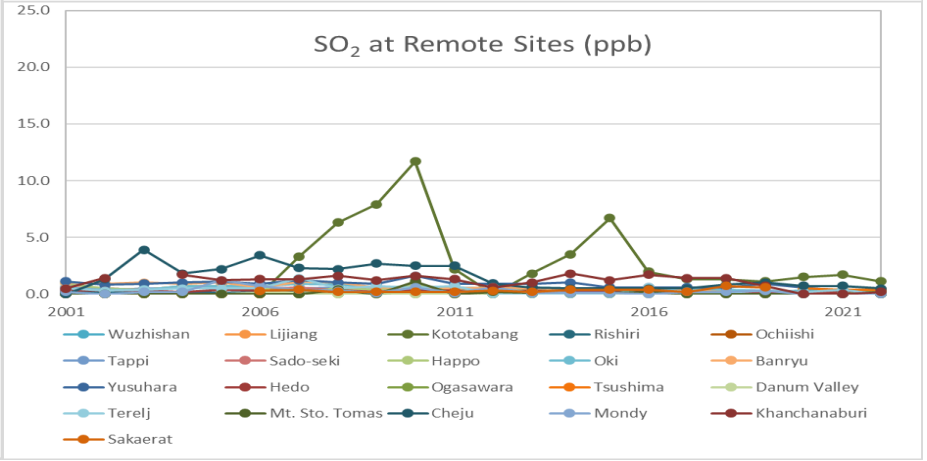
Annual average nss-SO_4^{2-} concentrations in precipitation from EANET, EMEP and NADP since 2000 to 2019

SO_2 related air pollution and SO_4^{2-}-acid deposition improved, especially in NEA, during past two decades. SO2 related problems in SEA may need more attention.

SO_2 Concentration (2001-2022): Regional and Local



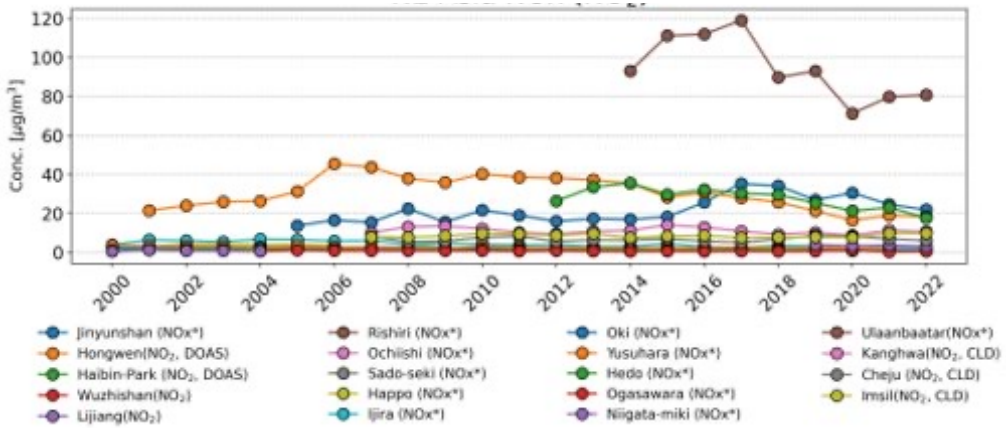




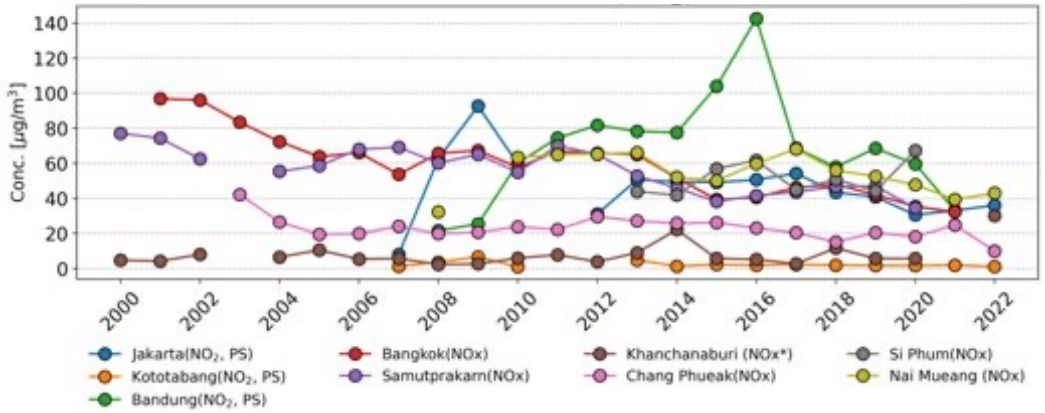
- SO_2 is primary air pollutants usually with significant local contributions. SO_2 was low at the Phnom Penh site showing no significant local sources.
- At most of EANET remote sites, SO_2 concentrations are at very low level.

Ambient NO_x(NO_2) and precipitation NO_3^- (2000-2022)

North-East Area : NOx (NO_2)



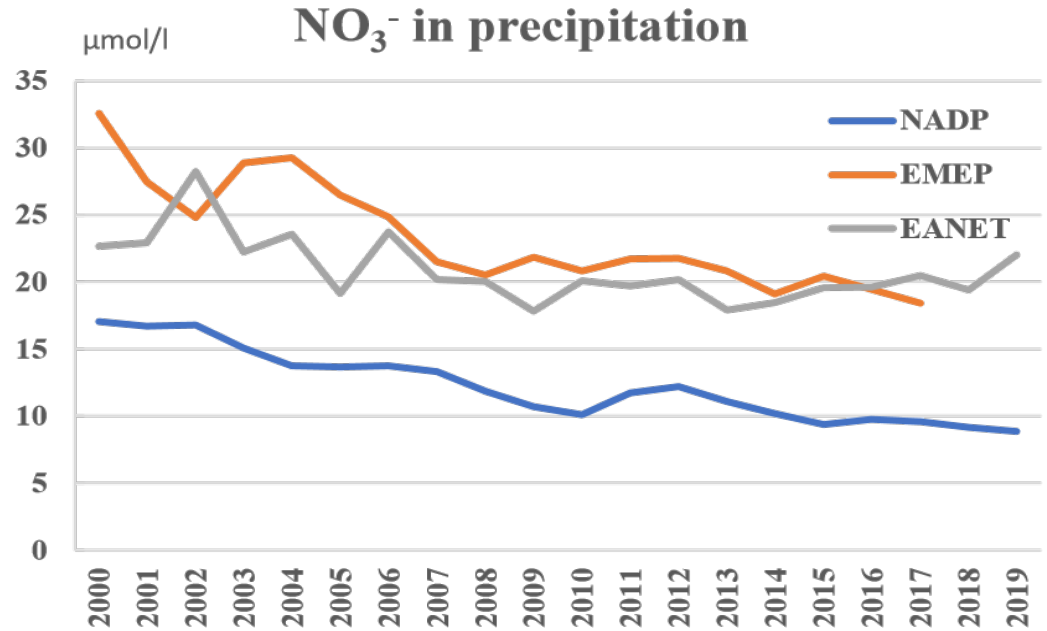
South-East Area : NOx (NO_2)



NOx* was regarded as NO2 for converted from ppb to μg/m³
Conversion ratio for NO_2 : x 1.92

All data appear even completeness <70%.

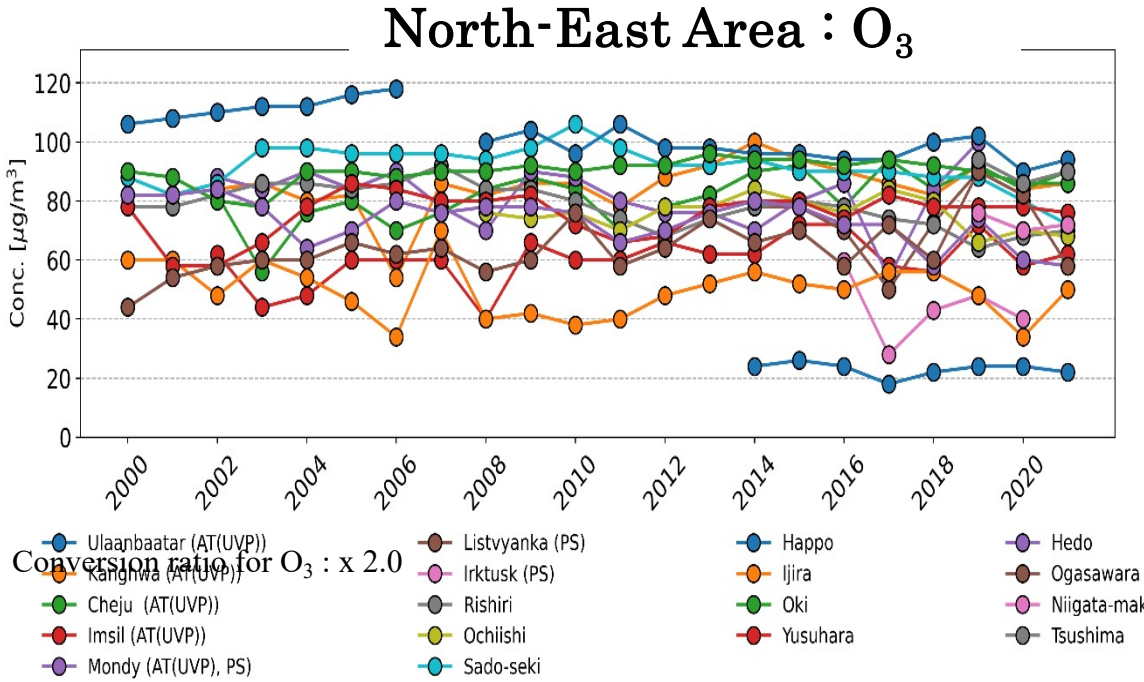
NO_3^- in precipitation



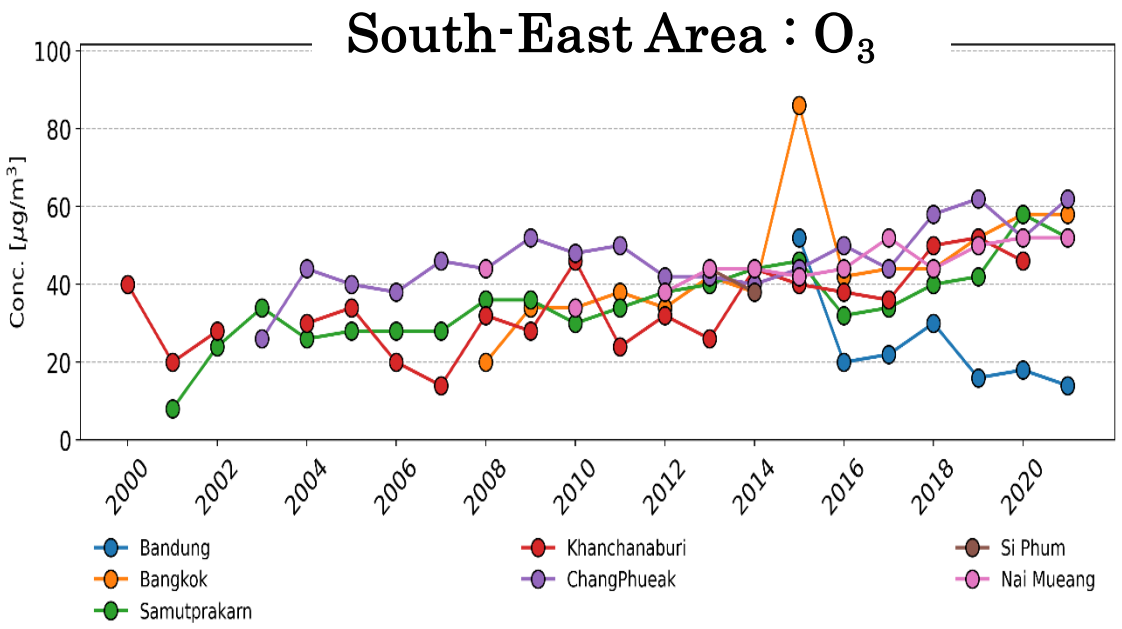
Annual average of NO_3^- concentrations in precipitation from EANET, EMEP and NADP since 2000 to 2019

- NOx and NO_2 are still at high levels. Mongolia had Philippines sites need attention.
- NO_3^- in precipitation showed a slightly decreasing trend.

Ambient Concentration of O_3 (2000-2021)

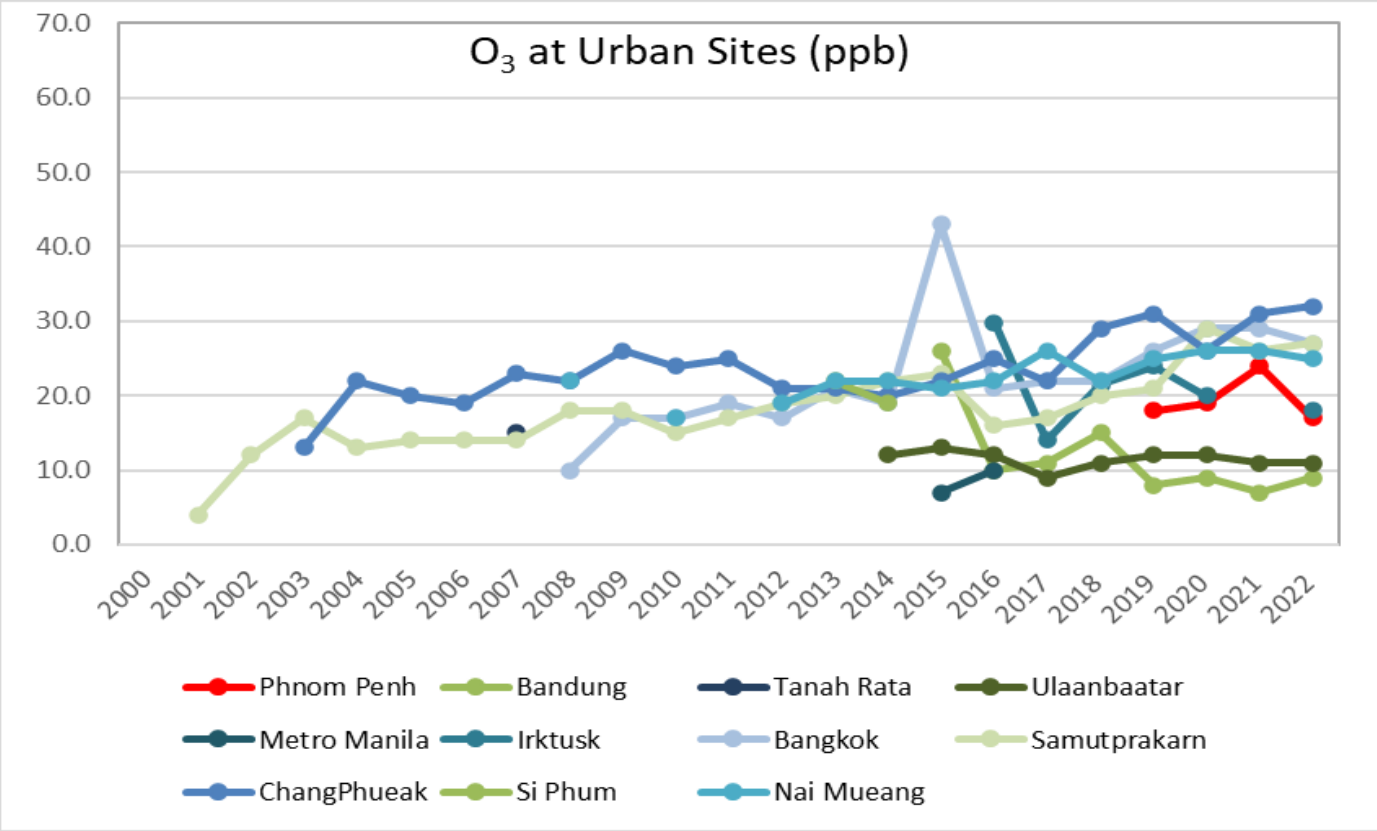


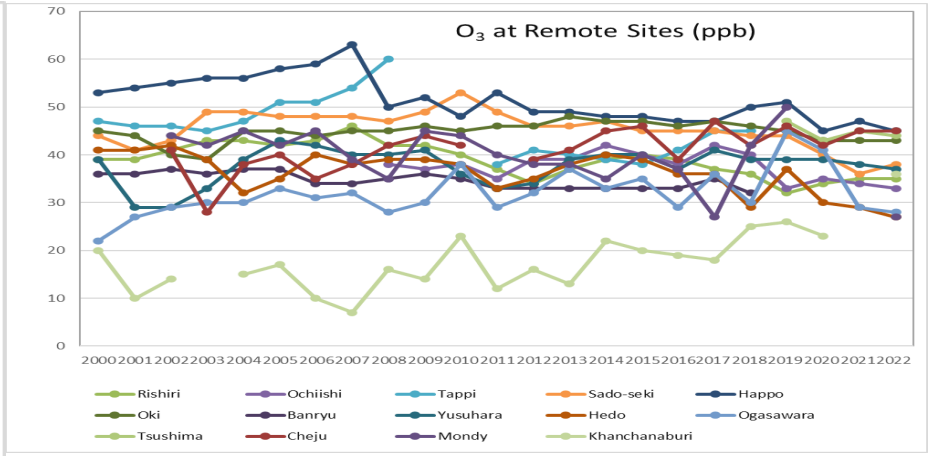
Conversion ratio for O_3 : x 2.0

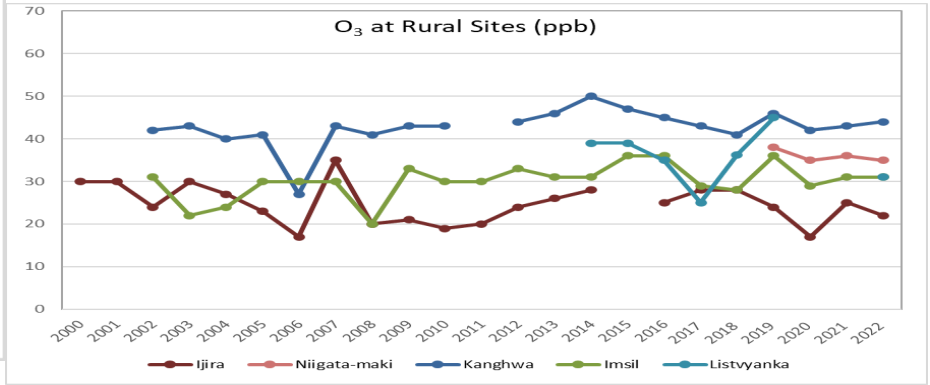


- O_3 is at a high level, and increasing trends of O_3 concentration are found in some countries, e.g. at sites of the Republic of Korea and Japan. Thailand had a creasing trend.
- The reasons for O_3 increase involve complicated processes.

O_3 Concentration (2001-2022): Regional and Local



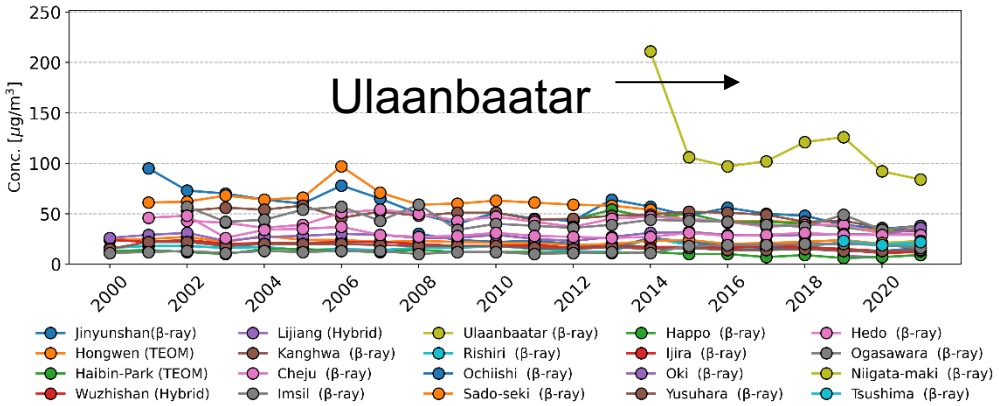




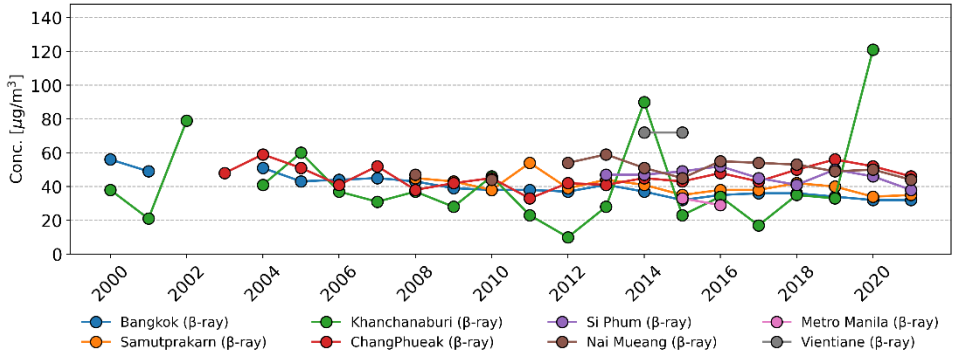
- O_3 is secondary air pollutants involved complicated photo-chemistry.
- Regional background O_3 concentrations are important for regional control policy. At most of remote sites O_3 are consistent at around 30-50ppb.
- O_3 concentrations at some urban and rural sites have bigger variations, due to the high precursors concentration NOx and VOCs, and NO titration.

Ambient Concentration of PM_{10} and $PM_{2.5}$ (2000-2021)

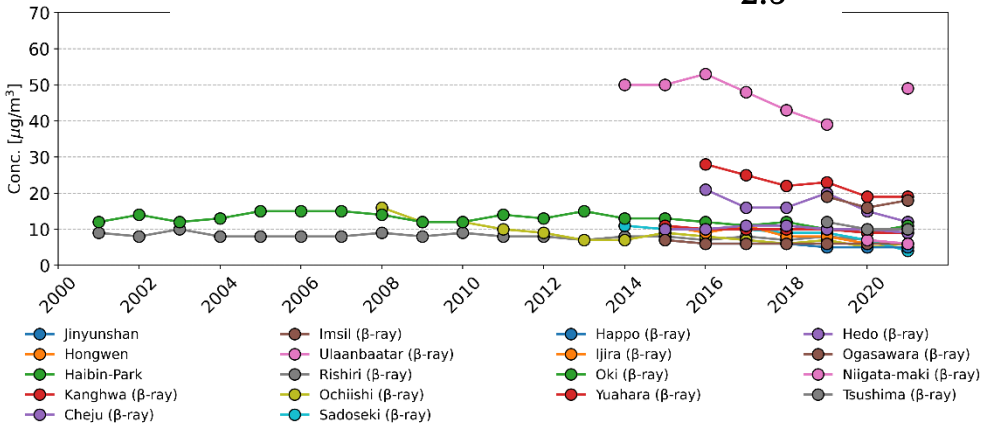
North-East Area : PM_{10}



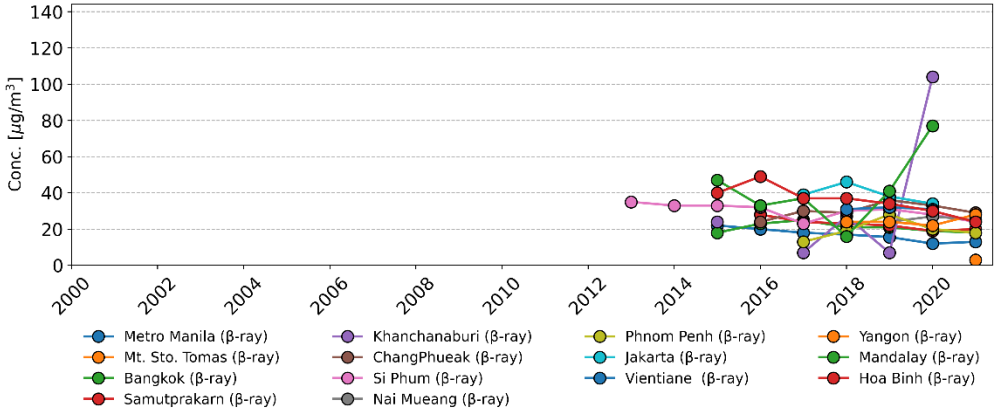
South-East Area : PM_{10}



North-East Area : $PM_{2.5}$



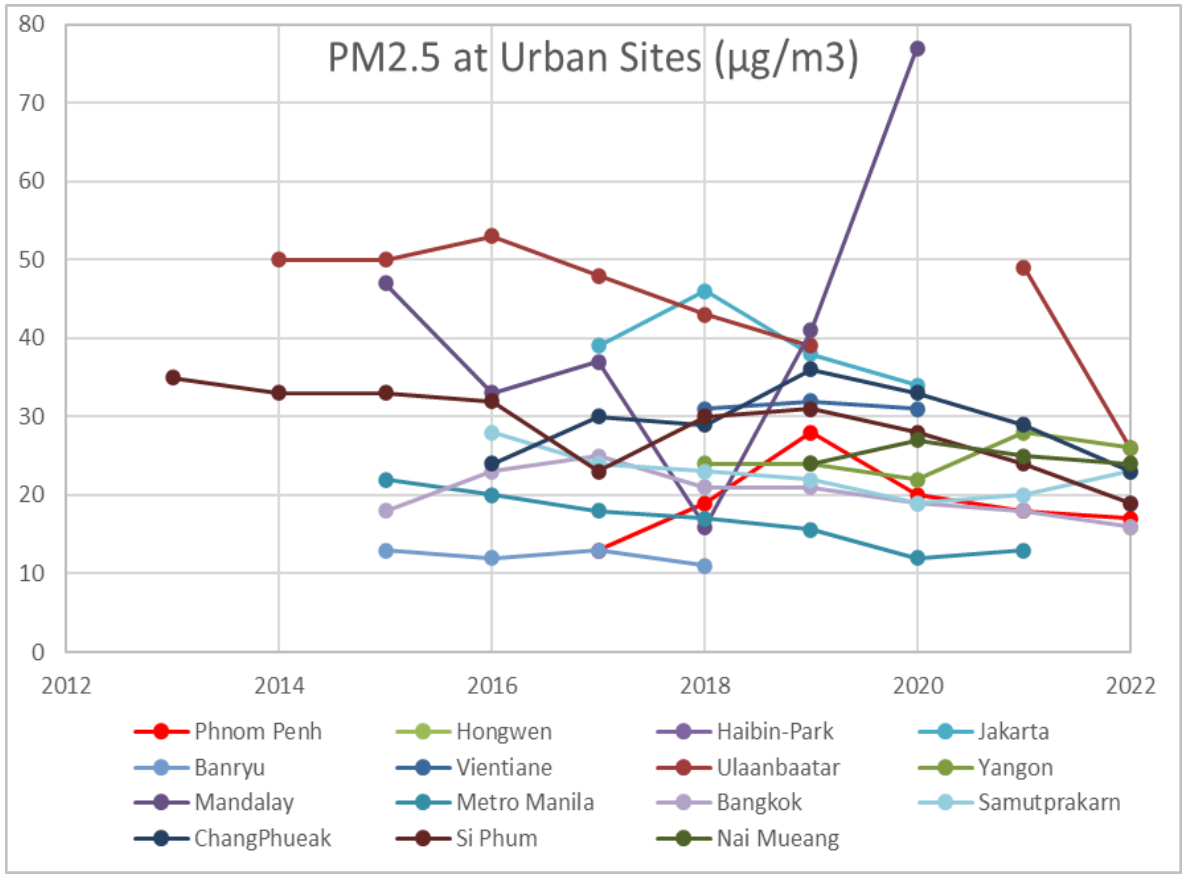
South-East Area : $PM_{2.5}$

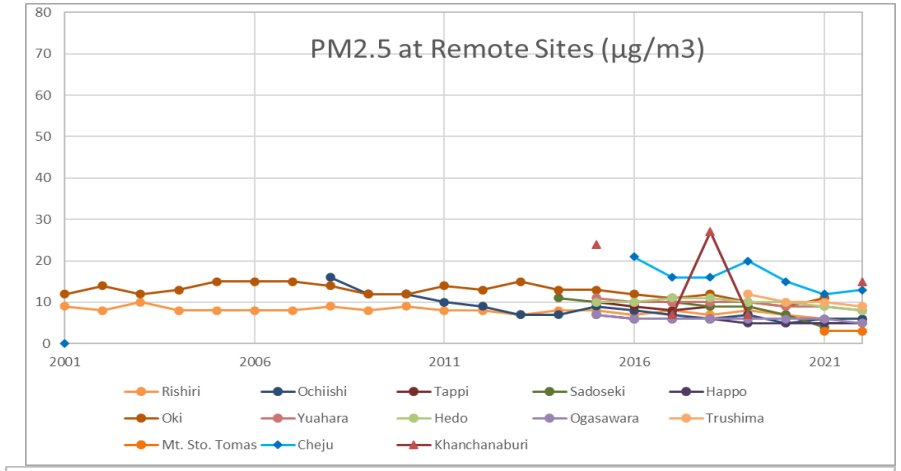


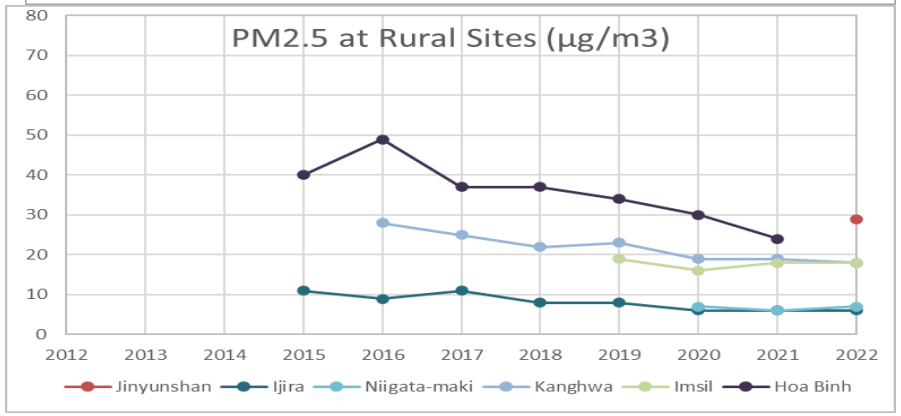
All data appear even completeness <70%,.

- No declining trend of PM_{10} and $PM_{2.5}$ in some countries. Ulaanbaatar of Mongolia, Jakarta of Indonesia, Hoa Binh of Vietnam reported the high PM_{10} concentrations.

$PM_{2.5}$ Concentration (2001-2022): Regional and Local

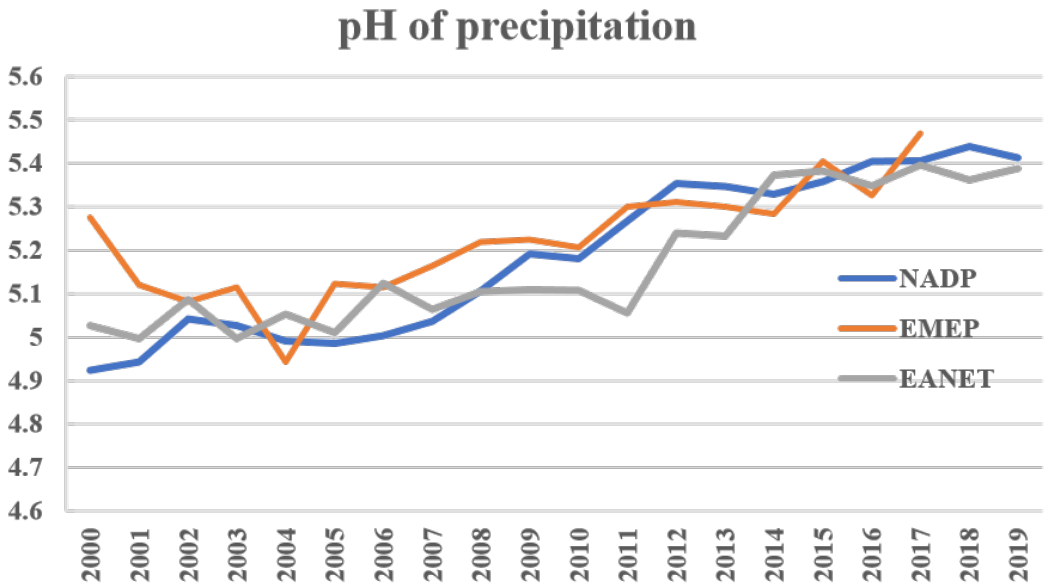






- $PM_{2.5}$ data from EANET remote sites showed a steady regional decreasing trend, especially in Northeast Asia region.
- $PM_{2.5}$ concentrations at some urban and rural sites were significantly higher than regional background concentrations, but still relatively low at Phnom Penh.

Wet Deposition of Acidic Substances in East Asia



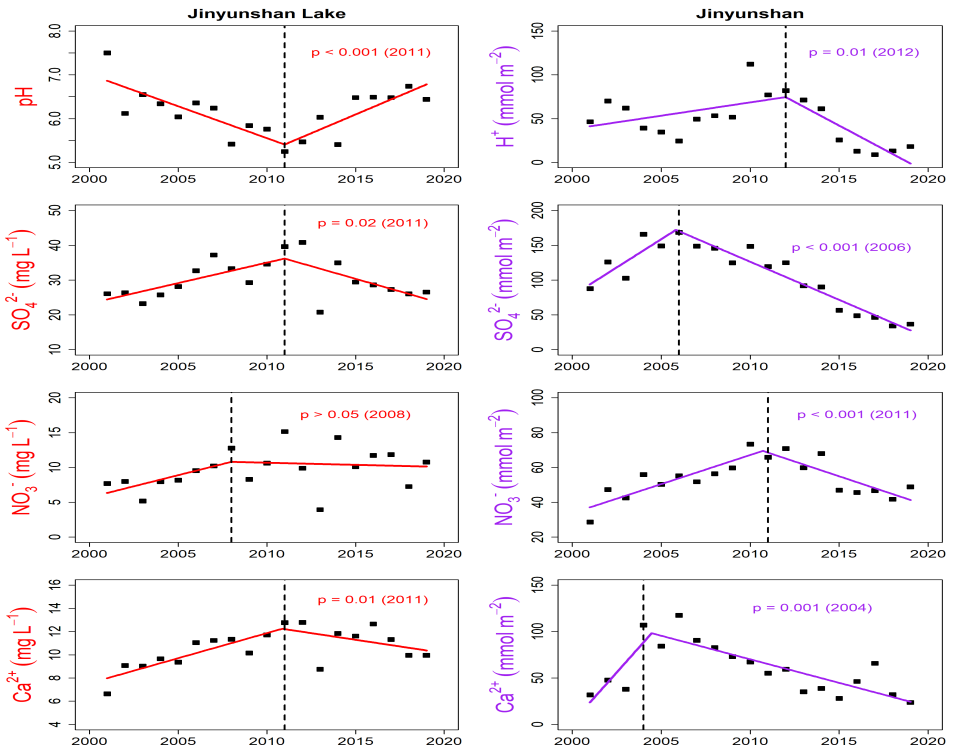
Annual pH of precipitation from EANET, EMEP and NADP since 2000 to 2019

	Network	Average concentration (2000 to 2019) µmol/l	Z score	P value
$nss\text{-}SO_4^{2-}$	EANET	31.4	Z=-4.32	p<0.001
	EMEP	11.3	Z=-4.92	p<0.001
	NADP	7.6	Z=-5.68	p<0.001
NO_3^-	EANET	20.7	Z=-2.56	p<0.05
	EMEP	23.4	Z=-4.17	p<0.001
	NADP	12.3	Z=-5.29	p<0.001
NH_4^+	EANET	37.9	Z=-3.67	p<0.001
	EMEP	27.5	Z=-2.58	p<0.05
	NADP	15.5	Insignificance	Insignificance
$nss\text{-}Ca^{2+}$	EANET	24.6	Z=-3.34	p<0.001
	EMEP	12.4	Z=-2.73	p<0.01
	NADP	4.2	Insignificance	Insignificance

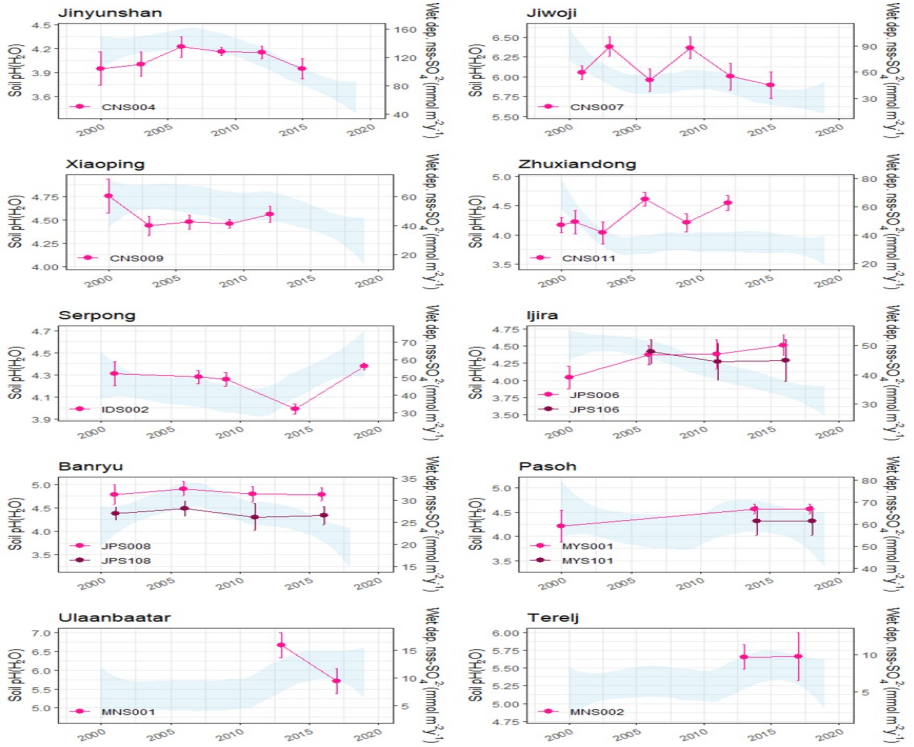
- Statistical trend analysis (Mann-Kendall) from EANET, EMEP and NADP
- SO_4^{2-} deposition decreased. Nitrogen depositions are still high (**Blue: declining trend)**

Long Term Impacts on Ecosystems

Long-term patterns of selected chemical variables at inland sites of Jinyunshan (CHN).



Temporal changes in the soil pH (H_2O) with the wet deposition of nss-SO_4^{2-}.



Note: line chart represents the soil pH (H_2O) and the band represents the variation of wet deposition nss-SO_4^{2-} derived from locally weighted scatter plot smooth (loess) with a 95% confidence interval.

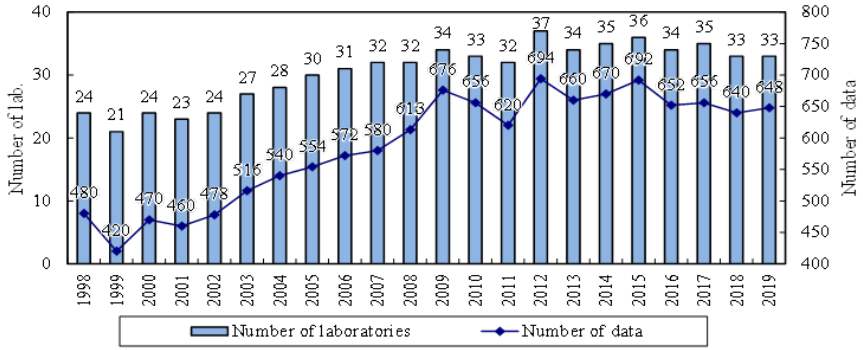
- Inland water chemistry in some lakes/streams suggesting recovery from acidification, corresponding to the trends of atmospheric deposition, e.q. nss-SO_4^{2-} declining in soil and wet deposition.
- Responses of soil chemical properties and tree growth are complicated, Long term monitoring is necessary.

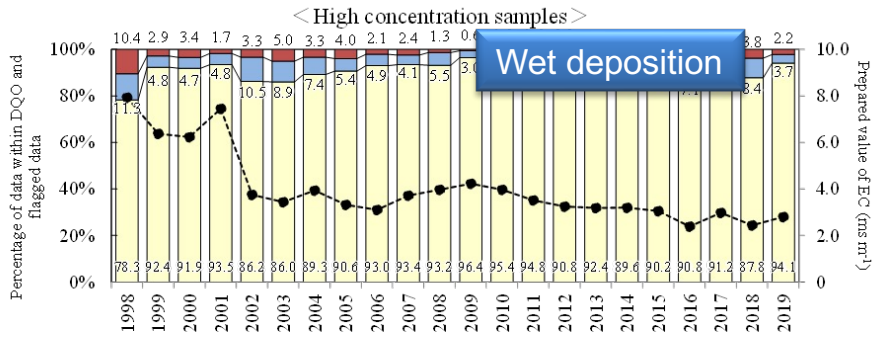
QA/QC of EANET

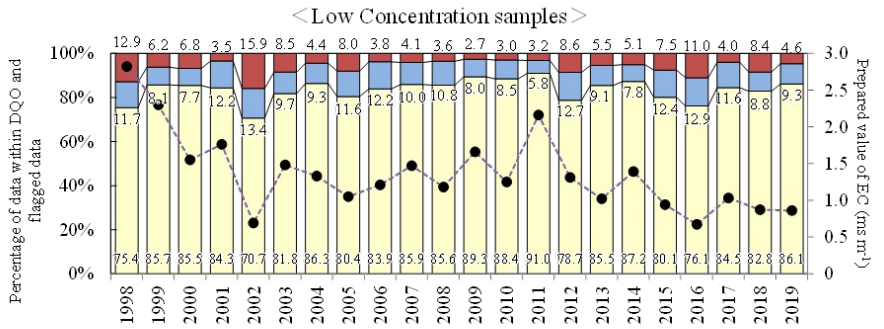
2.3 Evaluation of Inter-laboratory Comparison Projects (T. Khodzher, H. Machida, K. K. Sein)

Update of annual ILC projects of EANET QA/QC for 1998-2019 years (based on annual reports):

–Tracing of improvements in laboratory analytical performance for wet deposition;







Sample: Artificial Rainwater
Parameter to be measured: pH, EC, SO_4^{2-}, NO_3^-, Cl^-, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+
DQOs: ± 15%, flag "E" (±15%~ ±30%), flag X (<-30% or >30%)

DQO of other networks;

	pH	EC	SO_4^{2-}	NO_3^-	NH_4^+	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}
GAW (WMO)	0.07	7 %	7%	7%	7%	10%	10%	20%	15%	10%
EMEP	0.1	15%	10%	10%	15%	15%	15%	15%	15%	15%

EANET Projects in 2024 (Projects)

1. Studies on the effects of atmospheric deposition on ecosystems, from a catchment scale to a regional scale as a methodological study (continued from 2023)

3. Methodology Study for Development of LCS Hybrid Air Quality Monitoring Network (HAQMN) (continued from 2023)

4.$PM_{2.5}$ source apportionment in pilot cities in EANET for recommendations on feasible reduction policy (continued from 2023)

2.Promoting VOCs related Capacity Building in the EANET (feasibility study was done in 2022)

5. The collaboration of Technical and Training (TNT) and capacity building program for personnel of the participating countries on monitoring (continued from 2023)

6. Webinar for emission inventory of VOCs and its application for policy consideration

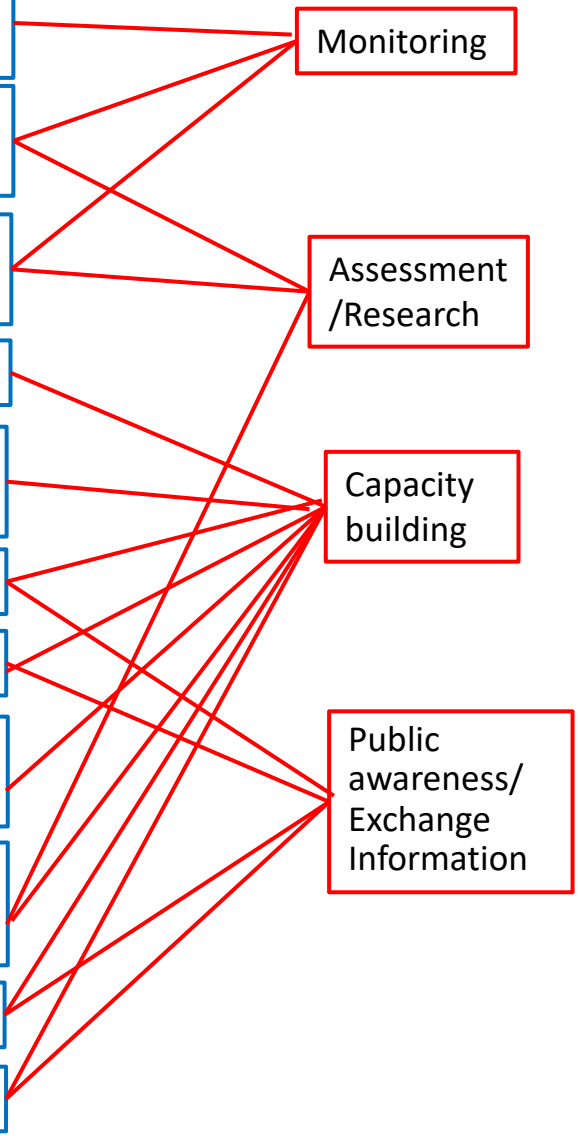
7.Seminar for Particulate Matter Problem including Haze in Southeast Asia

8. Fellowship for building leadership in Atmospheric Environment and Air Quality Management in East Asia

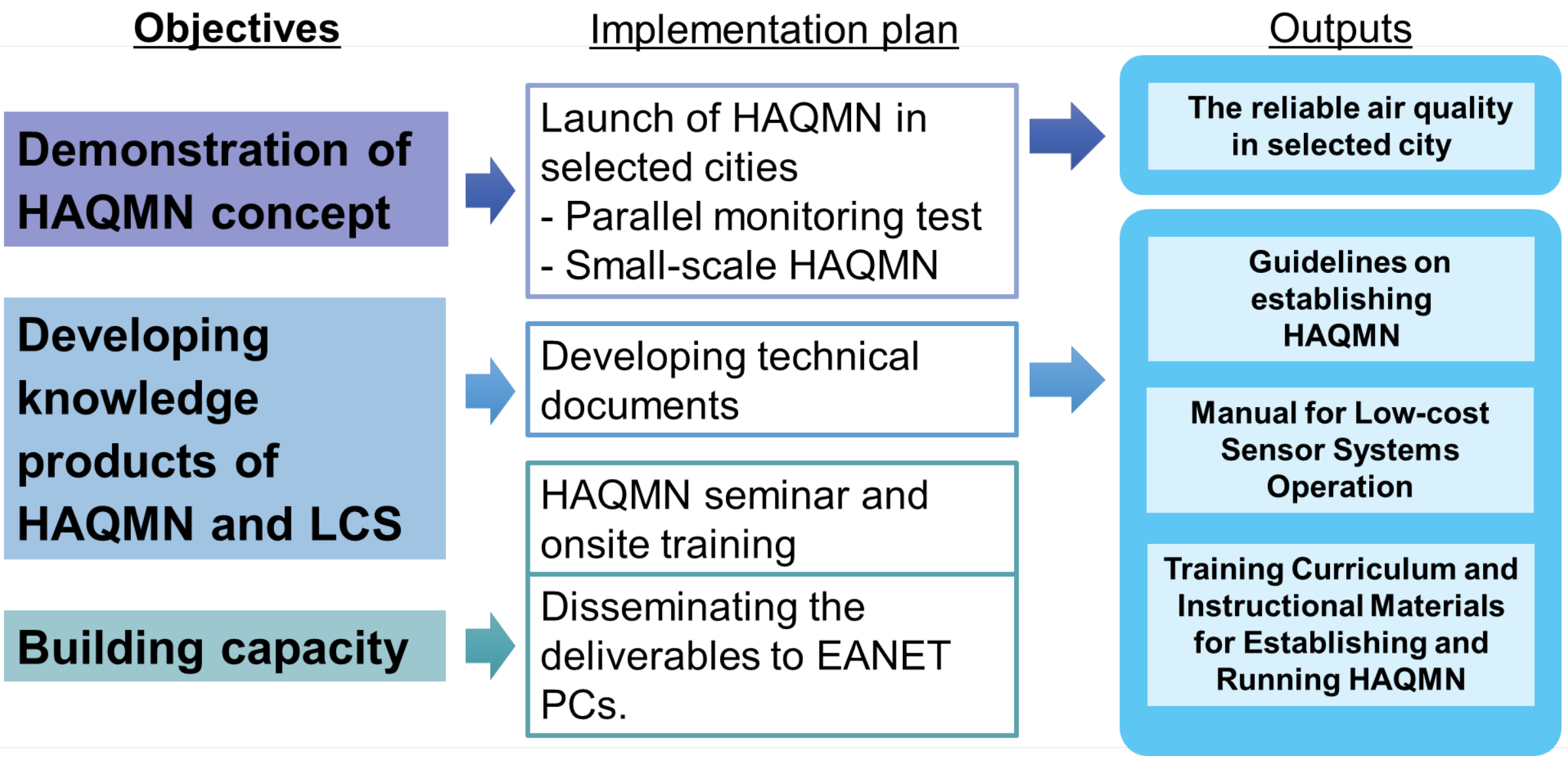
10. Stocktaking and Methodological Assessment Emissions Inventories and Source Apportionment of Air Pollution in Southeast Asia

11.Webinars on the application of Space-Based Instruments for Air Quality Monitoring

12.Seminar on Sustainable Nitrogen Management



Hybrid Air Quality Monitoring Network(HAQMN) Project

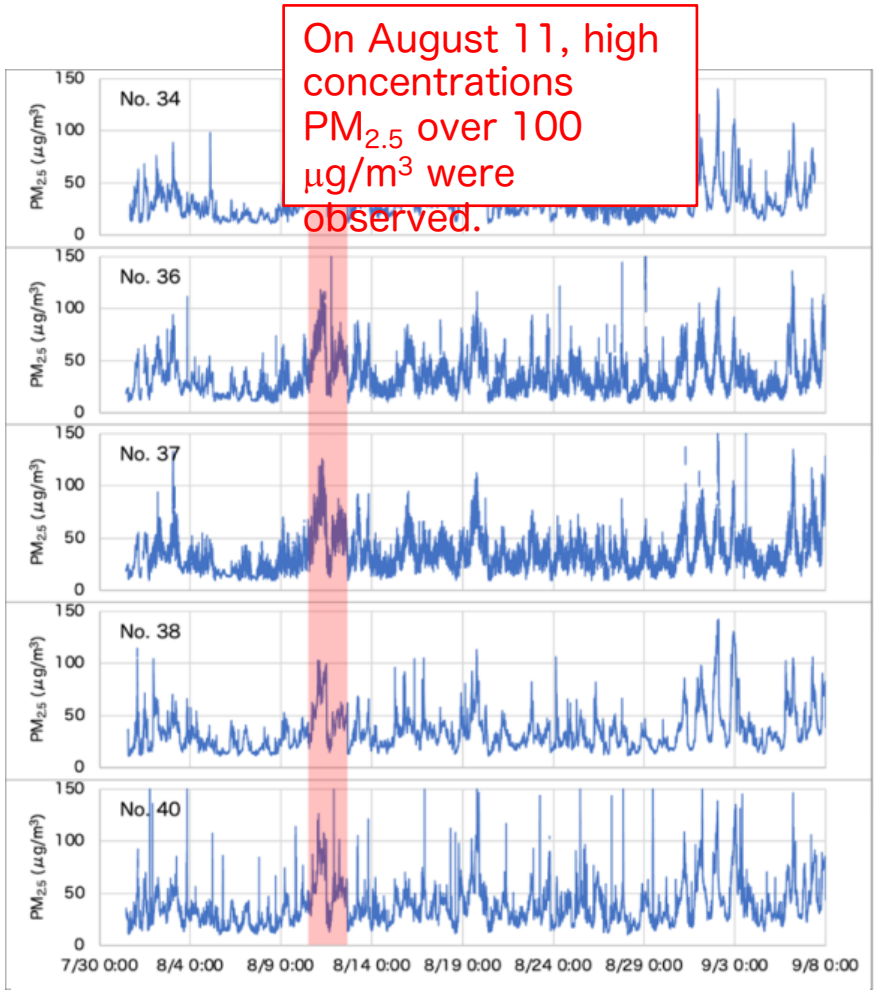


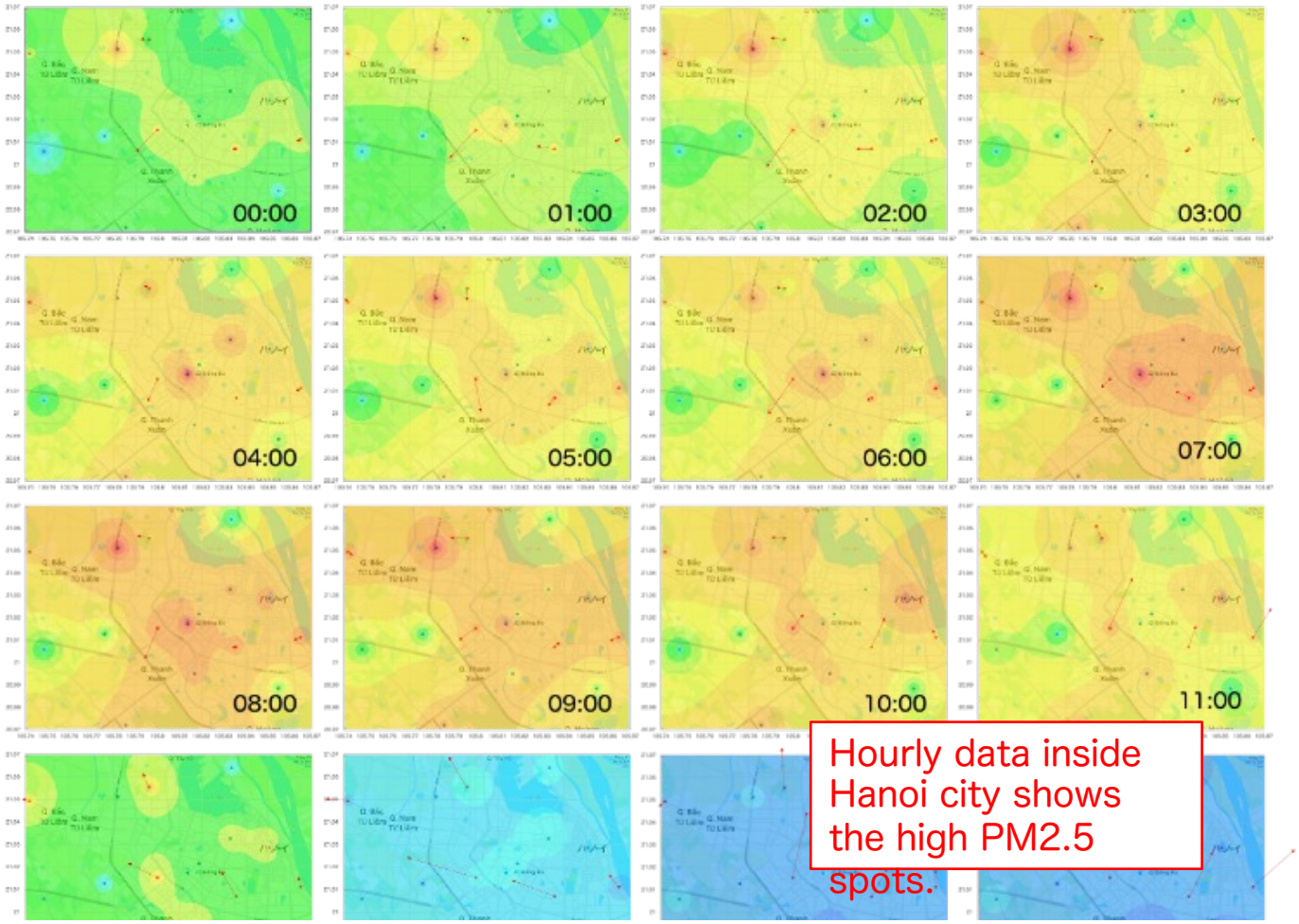
Hybrid Air Quality Monitoring Network(HAQMN) Project

Low-cost sensor (LCS) help to overcome the challenges to expand the monitoring network such as costs and skills.

EANET project will provide the knowledge how the practitioners can wisely select and use reliable LCS with the network of reference-level monitors in an integrated manner (HAQMN)

Air Quality Analysis using LCS data





Temporal and spatial distribution of PM2.5 can be obtained from LCS data.

Promoting VOCs related Capacity Building in the EANET

Project leader: **the Ministry of the Environment, Japan (MOEJ)**

Sub-projects

EANET VOCs Project

(1) Establish VOCs Measurement Methodology

(2) VOC Monitoring in Big Cities

(3) VOC Control and Management

Co-research

Methodology Development for the Study on the Contribution to Secondary Organic Aerosols (SOA) from VOCs

Ulaanbaatar **Manila** **Hanoi** **Phnom Penh**

Air Quality guideline — *Kessinee, Li*

Emission Inventories — *Meng, Ohara (Kurokawa)*

Emission Regulation for Shoe factories — *Kessinee, Li*

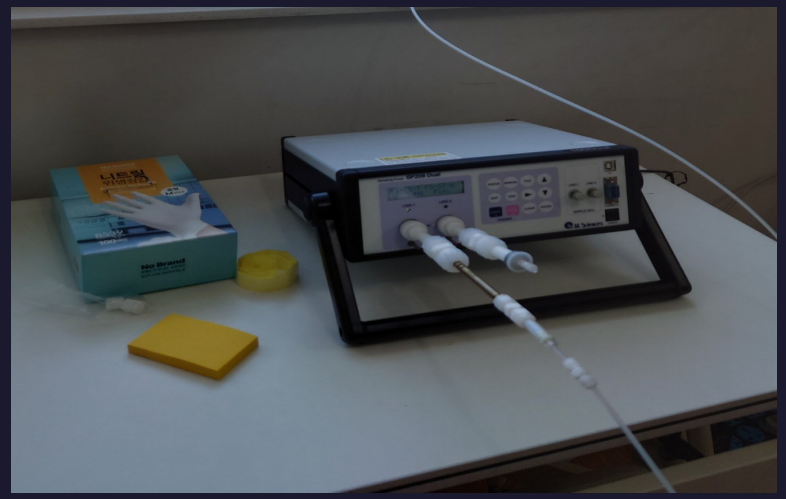
Monitoring Activities

Lee, Hoshi (Ichikawa, Huo)

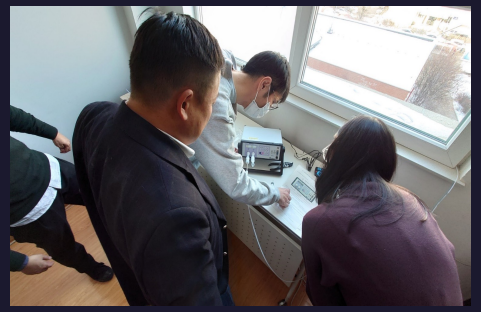
VOC AD Group

Activities Other Than Monitoring, Including Health Impact Assessment

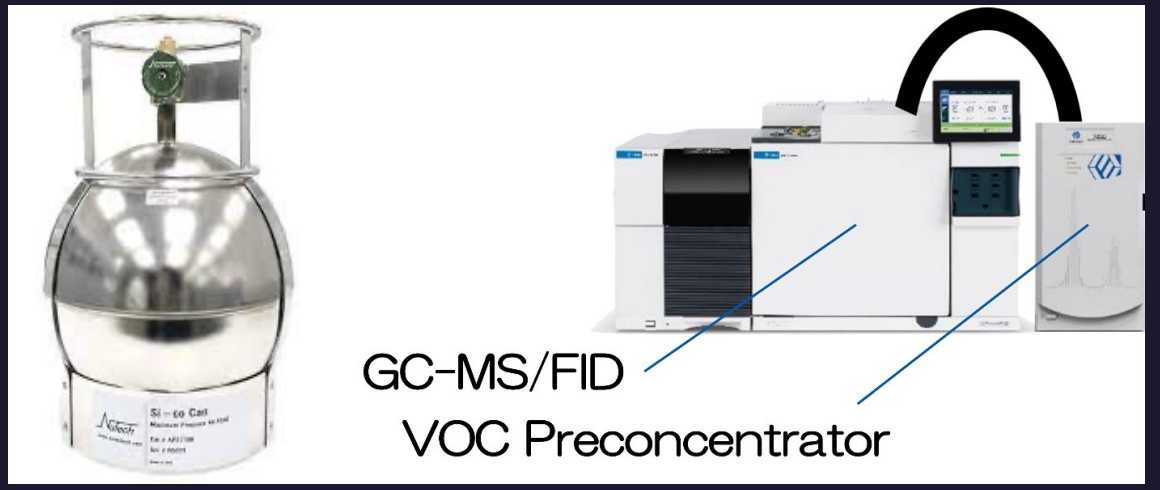
VOCs Measurements in Participating Countries Using Different Methodology

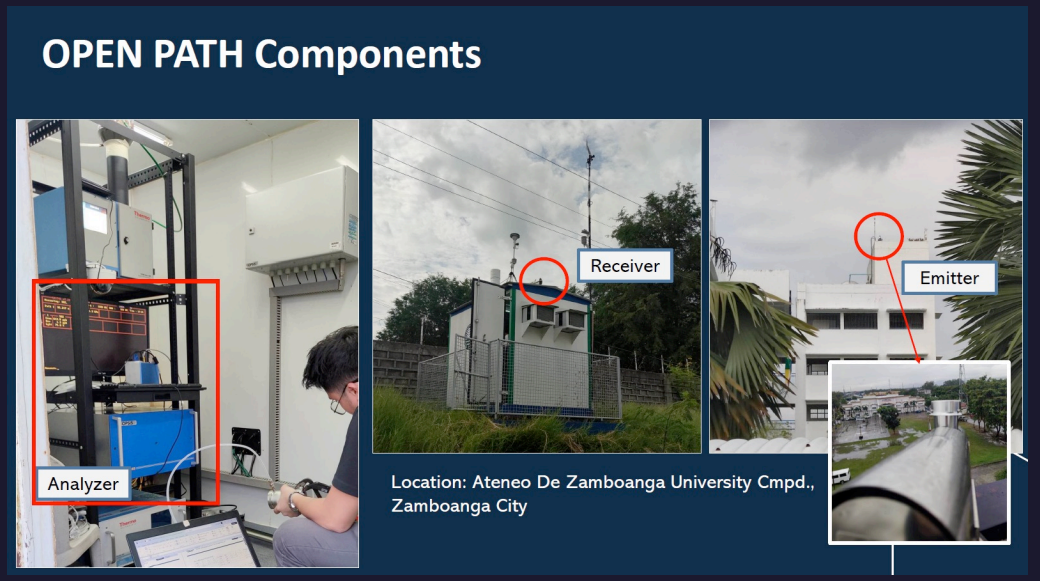


On-line monitor from Ewha Womans University, Korea



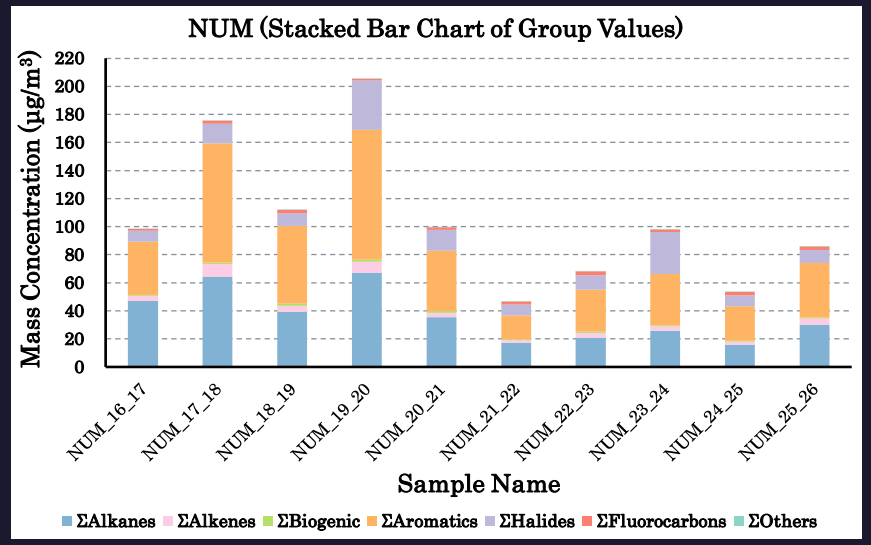
Install the Pump and Sorbent tubes for VOC monitoring at EANET Ulaanbaatar site and NUM sites, Ulaanbaatar, Mongolia



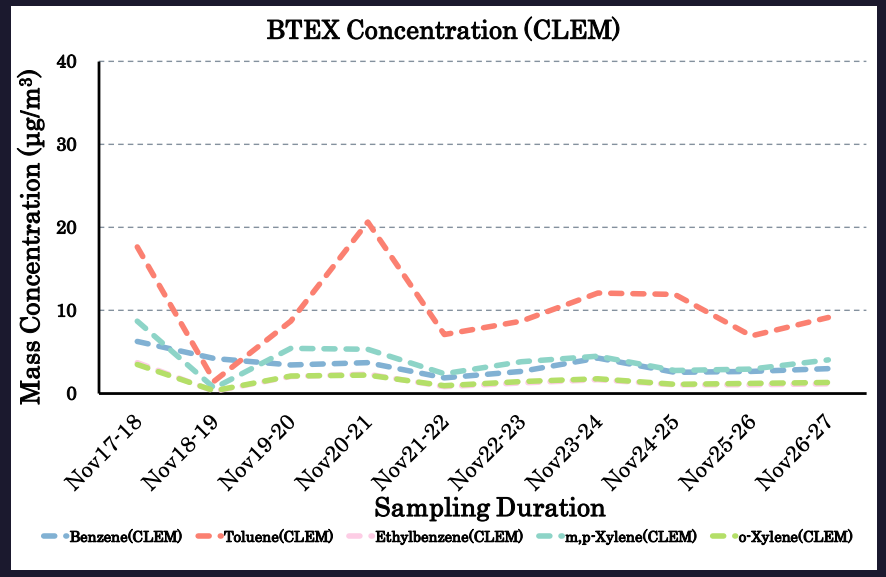


New GC/MS and DOAS method in Philippines

Primary Results of Measurements



VOC concentrations in Ulaanbaatar are significantly higher compared to Japan. Particularly Benzene, as a carcinogen substance, exceeds EPA and WHO guideline values.
Alkanes are also high, so the emission from car exhaust and gasoline station are also significant.



unit: μg/m^3

Compound	EPA[1]	WHO[2]	Japan Environmental Standard	Guideline value
Benzene	1.3~4.5	1.7	3	-
Trichloroethylene	2	23	130	-
Tetrachloroethylene	40	250	200	-
Dichloromethane	-	3000	150	-
Acrylonitrile	0.1	0.5	-	2
Chloroethene	2.3	10	-	10
Chloromethane	-	-	-	94
Chloroform	0.4	-	-	18
1,2-Dichloroethane	0.4	700	-	1.6
1,3-Butadiene	0.3	-	-	2.5

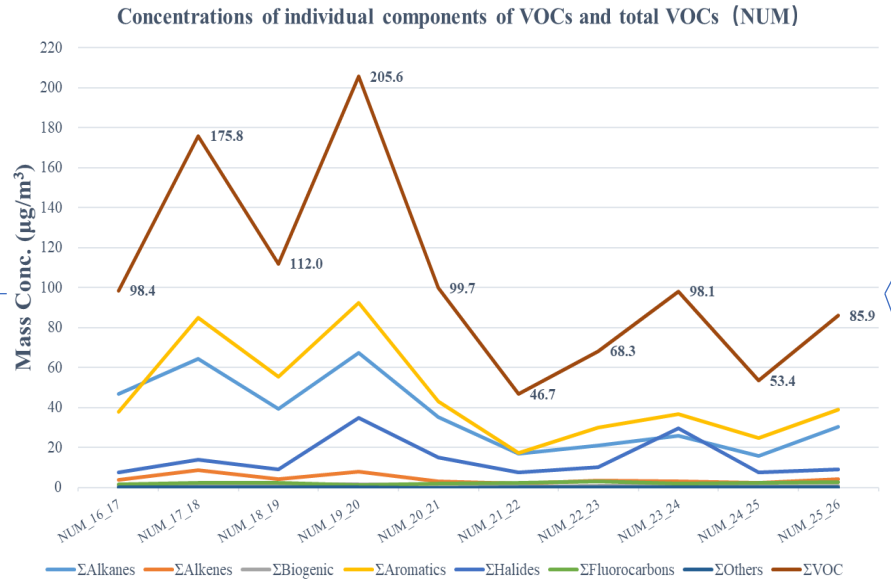
1) 10^{-5} risk level equivalents based on unit risk established by EPA
Ref : EPA Home Page Integrated Risk Information System (IRIS)
2) WHO Regional Office for Europe guideline values or 10^{-5} risk level equivalents
Dichloromethane and 1,2-dichloroethane are evaluated as daily averages
Ref : Air Quality Guidelines for Europe Second Edition(2000)

(Ichikawa, CESS)

Data Analysis: Impacts of VOCs on Health, Ozone and PM

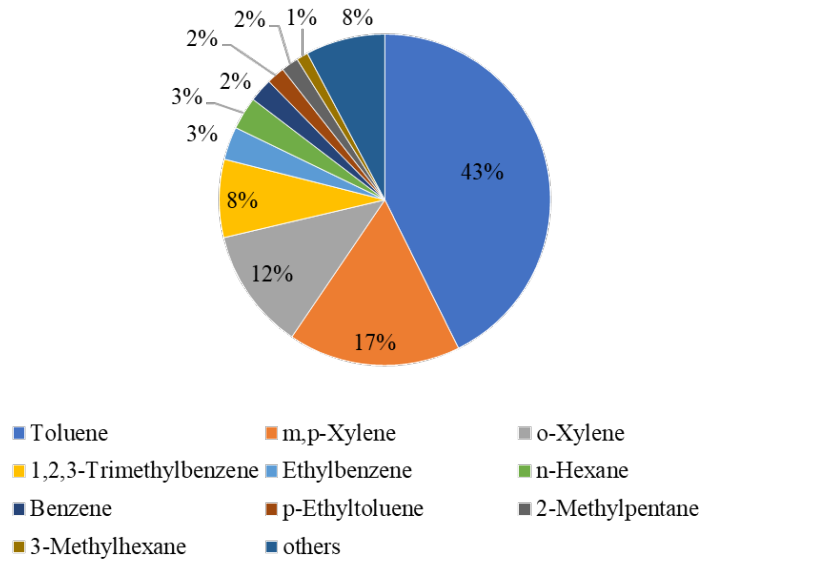
VOCs concentrations

Health Impacts

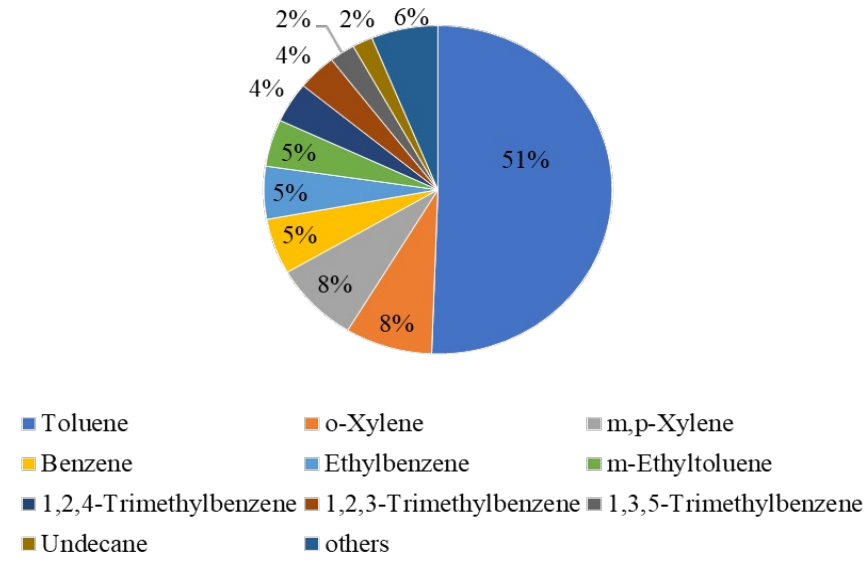


Daily variation of total VOCs and various types of VOCs concentrations at NUM

The OFP of the top ten VOCs and other with OFP

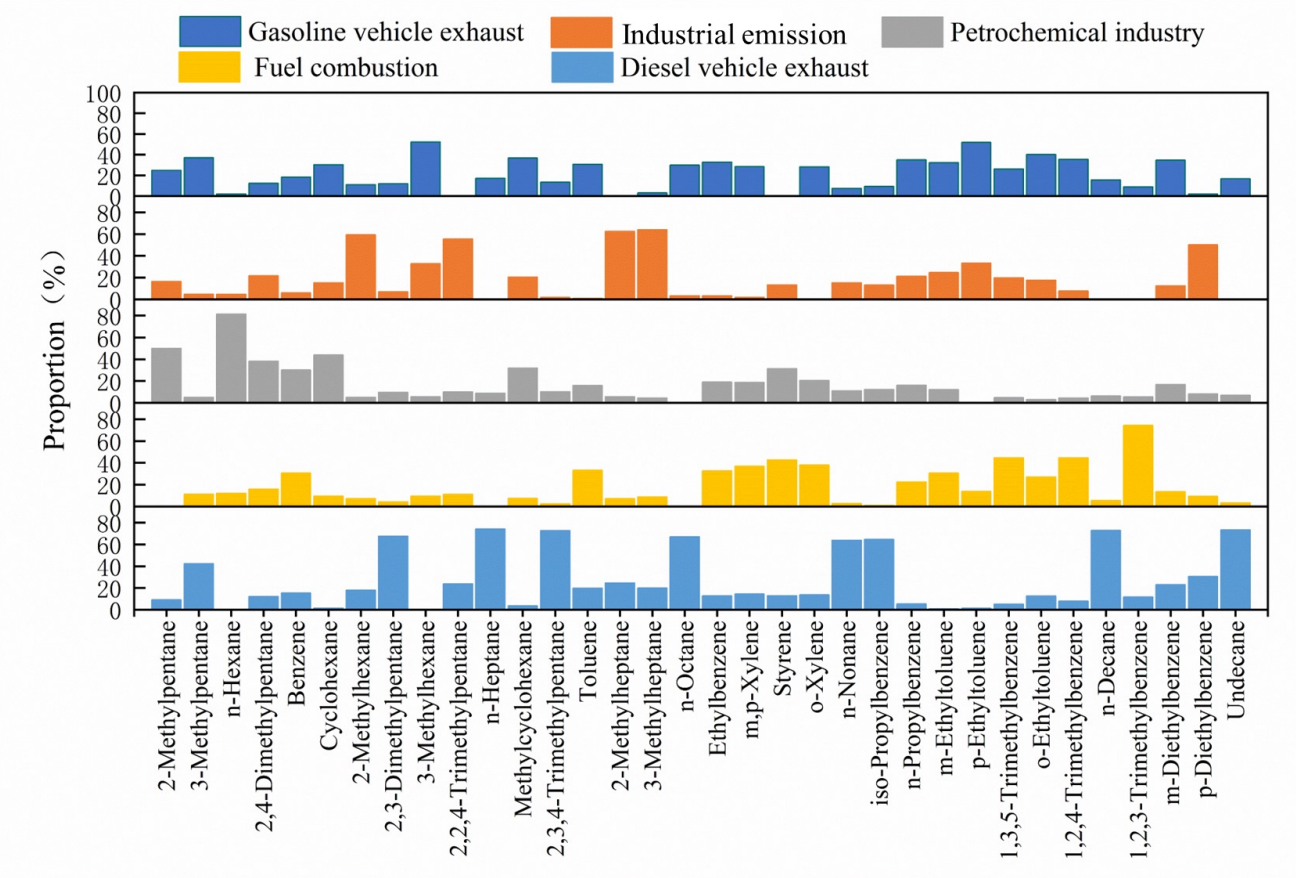


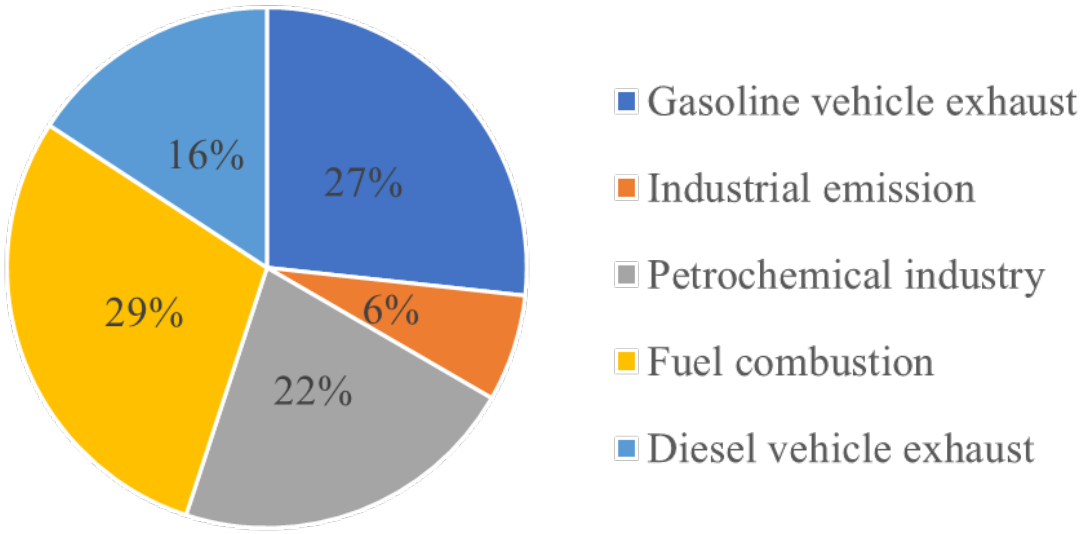
The SOAFP of the top ten VOCs and other



Online observation: source apportionment

- 5 sources including gasoline vehicle exhaust, industrial emission, petrochemical industry, fuel combustion, and diesel vehicle exhaust were found to be the major sources of VOCs.
- The pollution sources with the highest and lowest contribution to VOCs were fuel combustion(29%) and industrial emission(6%).



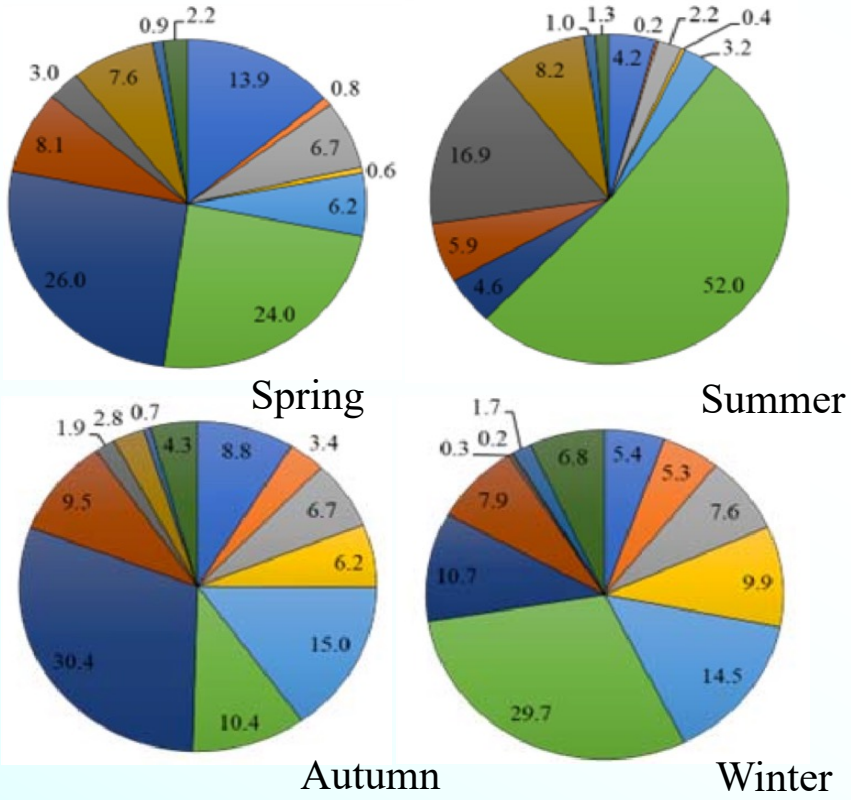


The proportion of concentration contribution of each pollution source

Studies on Source Apportionment of PM2.5 (EANET Project Activities 2023-03 and 2023-04)

Objectives

1. **Regional and seasonal characteristics of PM2.5 component**
2. **Identification of major sources of PM2.5 in pilot cities in EANET(using PM components information)**
3. **Research outcomes => policy actions**



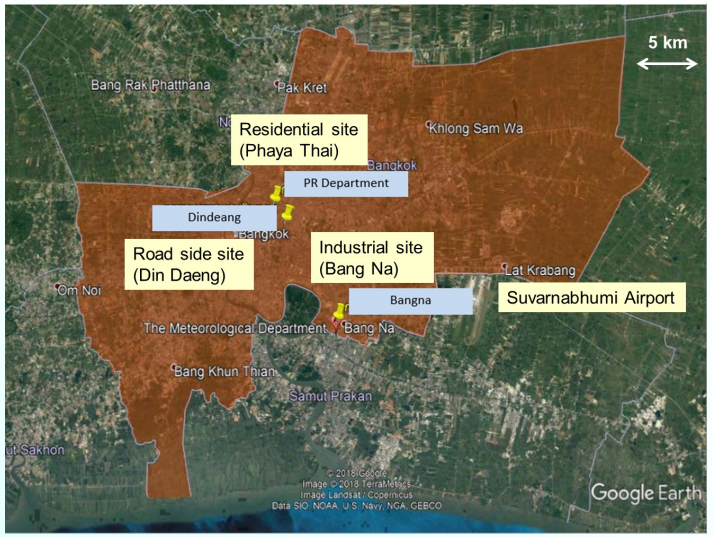
- Coal Combustion
- Seasalt
- Soil dust
- Plant combustion
- SO_4^{2-} aerosol
- NO_3^- aerosol
- Pinene aerosol
- $(COO^-)_2$ aerosol
- Isoprene aerosol
- Oil Combustion
- $(COO^-)_2$ aerosol
- Cooking

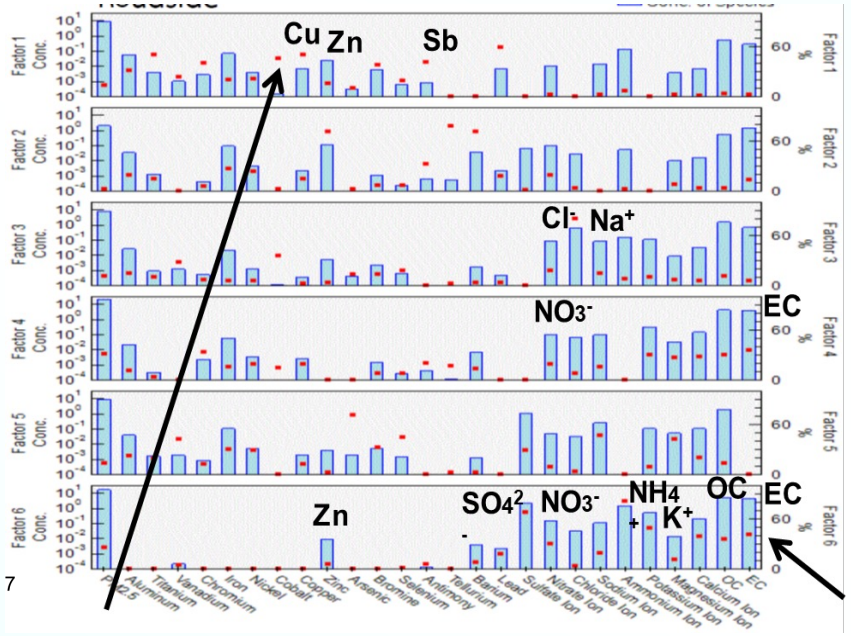
- In spring and autumn, the contribution of pinene aerosol was relatively large.
- In summer the contribution of SO_4^{2-} aerosol was the largest and the contribution isoprene aerosol was also larger compared to the other seasons.
- In winter, the contribution of SO_4^{2-} and NO_3^- aerosol was the large.

PM2.5 Source Contributions by PMF at Niigata-Maki, Japan (2018-2021)

Source apportionment results by Positive Matrix Factorization (PMF) at roadside site in Bangkok (November 2019 to April 2020)

Daily $PM_{2.5}$ observation at 3 sites in BMR

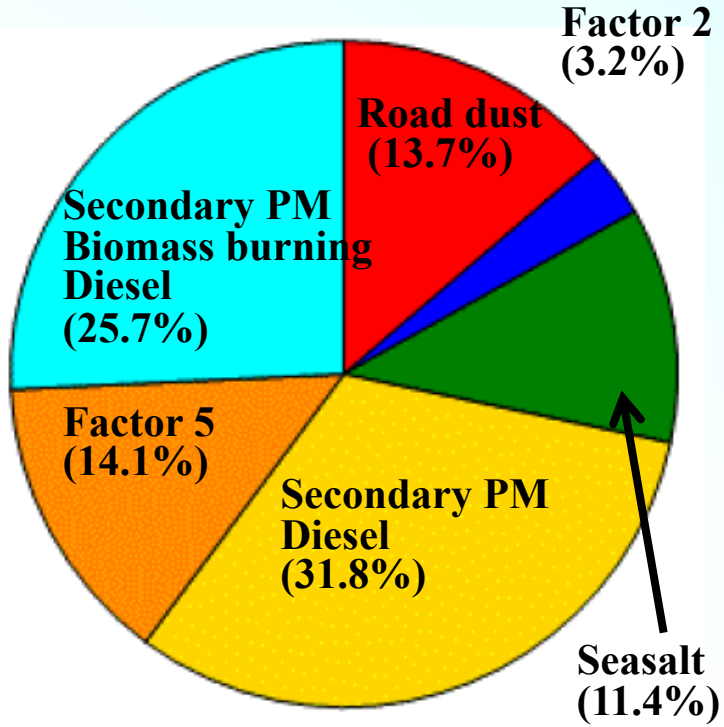




Factor 1 will be associated to road dust such as breakwear dust (Sb, Cu) and Tirewear dust (Zn) because of high % of components.

Factor 6 will be associated to Secondary PM (SO_4^{2-}, NH_4^+, NO_3^-), Biomass burning (OC, K+) and Diesel source (EC, Zn) because of high % of components.

Mean contribution of each source to PM2.5 estimated from PMF analysis



Development of High-Quality Datasets

- **High-quality datasets** have been developed through the implementation of QA/QC measures at the national levels and in the Inter-laboratory Comparison Projects.
- **Over 20 years of data are available for download on EANET website** (https://www.eanet.asia).
- Data analysis, data report in the East Asian region.

Participating countries

Monitoring data

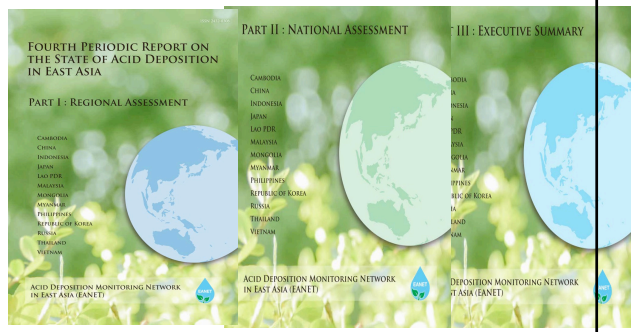
Network Center (ACAP)

Issuing of Data Report

- Data Report were published after adoption by the SAC every year

Issuing of PRSAD4 2021

PRSAD4 was approved by SAC11 and endorsed by IG13, and published in 2021



Technical Support and Capacity

- Technical support to the participating countries including dispatch of technical missions.
- Implementation and coordination of QA/QC activities
- Senior Technical Managers Meetings,
- Training and Fellowship:
  - The collaboration of Technical and Training (TNT) and capacity-building program for personnel of the Participating Countries on monitoring
  - Fellowship for building leadership in Atmospheric Environment and Air Quality Management in East Asia

THANK YOU VERY MUCH FOR YOUR ATTENTION !