GEMS validation campaign

Satellite Integrated Joint Monitoring for Air Quality study (SIJAQ)
Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ)

National Institute of Environmental Research
Environmental Satellite Center, SIJAQ team

GMAP & SIJAQ overview

SIJAQ : Satellite Integrated Joint monitoring (Studies) of Air Quality

Pre-SIJAQ(GMAP): GEMS Map of Air Pollution

Background

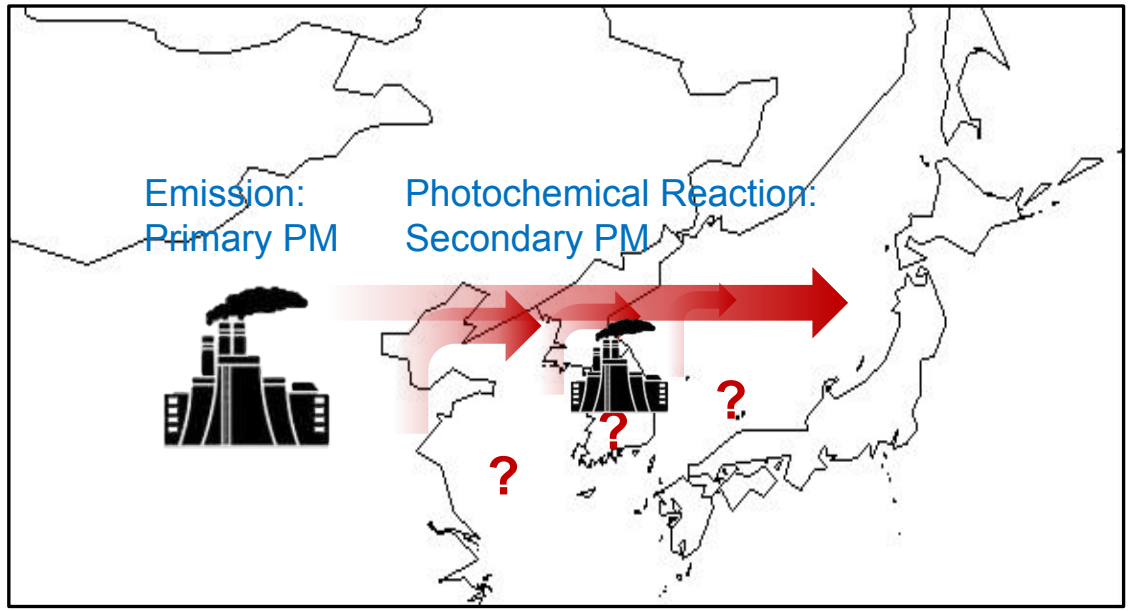
- Succession of KORUS-AQ (2016.5~6)
- In depth analysis on high PM pollution in winterValidaiton of Geostationary Environment Monitoring Spectrometer (GEMS), the world's first Geostationary Earth Orbit (GEO) environmental satellite

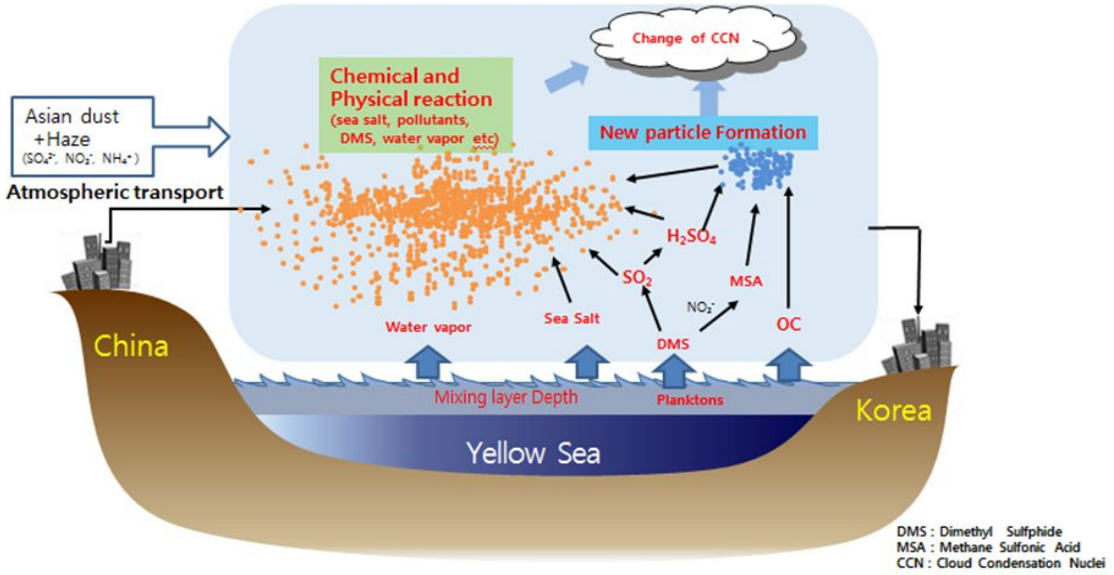
Time schedule for SIJAQ and GMAP

Pre-GMAP		1st GMAP	2nd GMAP	SIJAQ
~~2020. 4~5~~	+	2020.10.12~11.27	2021.10~11	2022.10~2023.06 → 2022.5~8, 2024.2~3

Main campaign

Satellite Integrated Joint Monitoring for Air Quality study (SIJAQ)





Purpose

- **Characterizing hot spots in East Asia**

  - Urban pollution, industrial complex, coal-fire power plant, biomass burning, volcanic eruption, wild fire, etc.

- **Investigating processes controlling high PM2.5 events in winter**

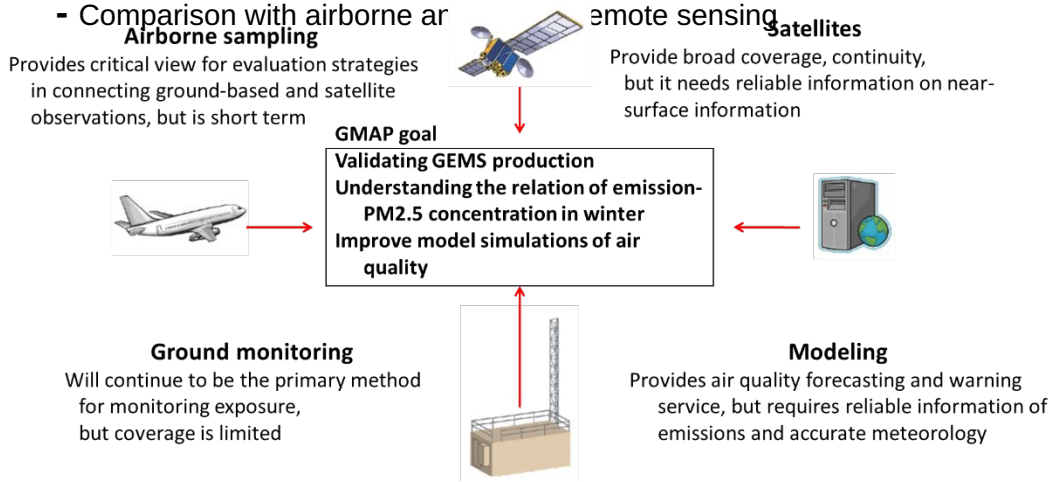
  - Unidentified aerosol formation mechanism (heterogeneous reaction, nighttime chemistry, meidum-range transport, etc.

- **Analyzing the impact of emission change**

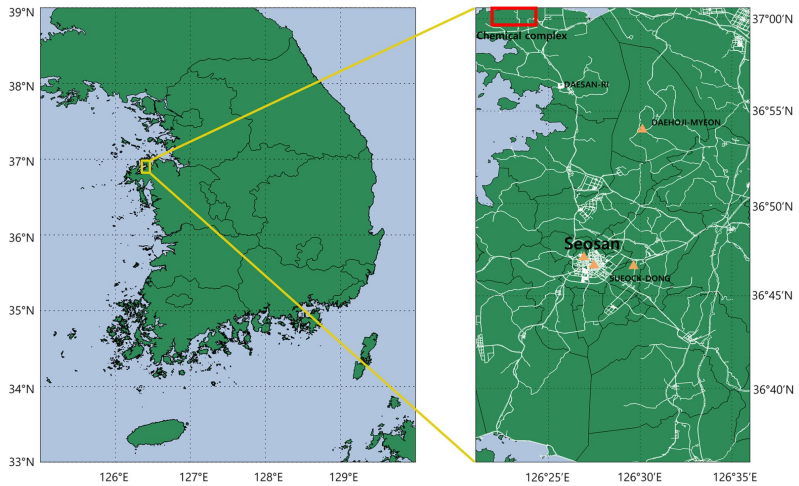
  - Recent change in energy-related and agricultural emissions in East Asia

- **Validating GEMS performance beyond Korea**

  - Comparison with airborne ar emote sensing



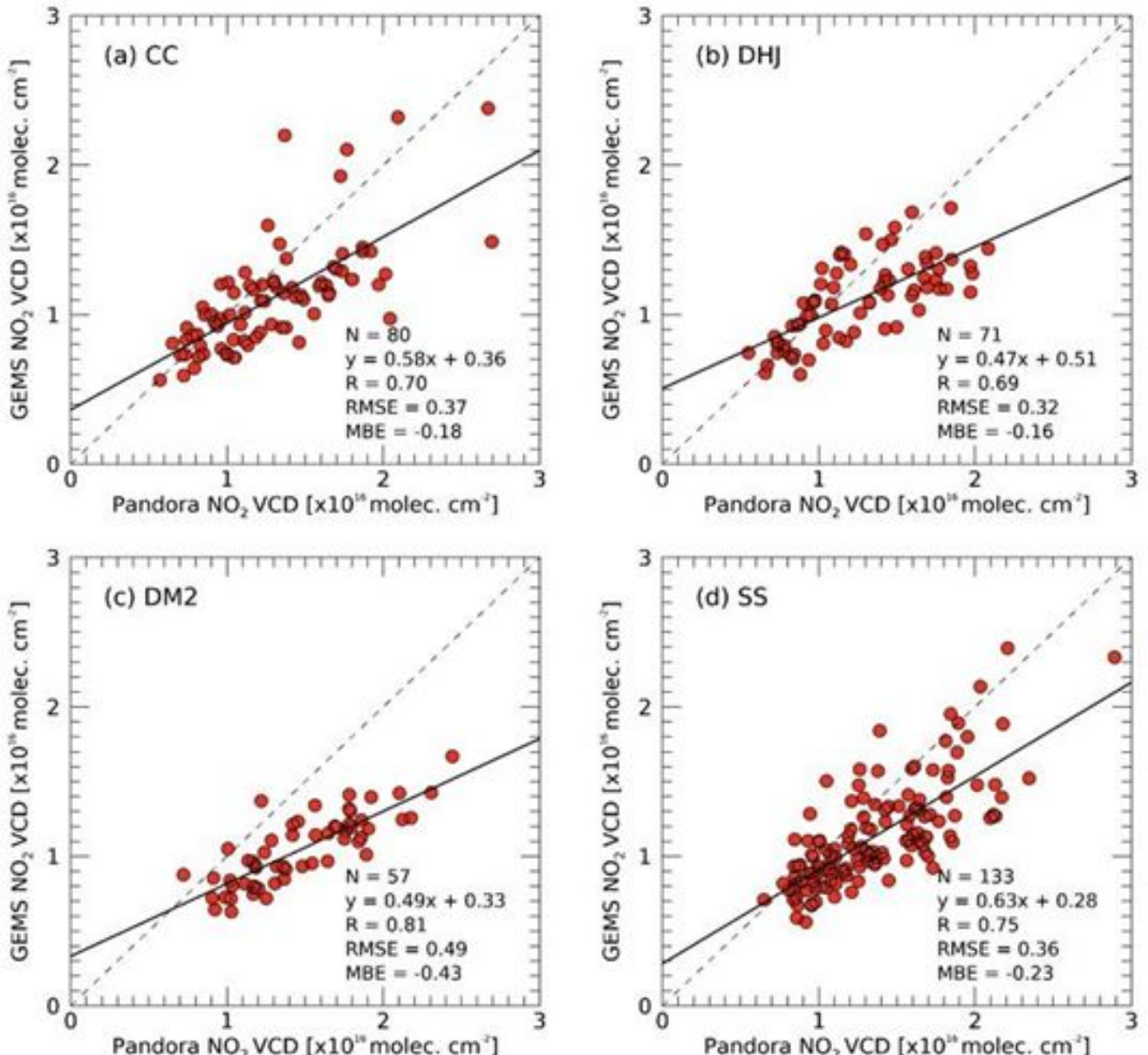
GMAP2020 (November 2020~January 2021) @ Seosan



	Latitude	Longitude	Period
Seosan (SS)	36.78° N	126.49° E	12 November–3 December 2020; 3 December 2020–27 January 2021
Seosan City Council (CC)	36.78° N	126.45° E	9 December 2020–31 January 2021
Daehoji (DHJ)	36.90° N	126.50° E	9 December 2020–17 January 2021
Dongmoon-2dong (DM2)	36.78° N	126.46° E	9 December 2020–3 January 2021

- Moderate correlation(*R*=0.62~0.78)
- Negative bias (MBE=−0.43~−0.17)
- Horizontal representativeness of Pandora observations (*R=0.69~0.81)*

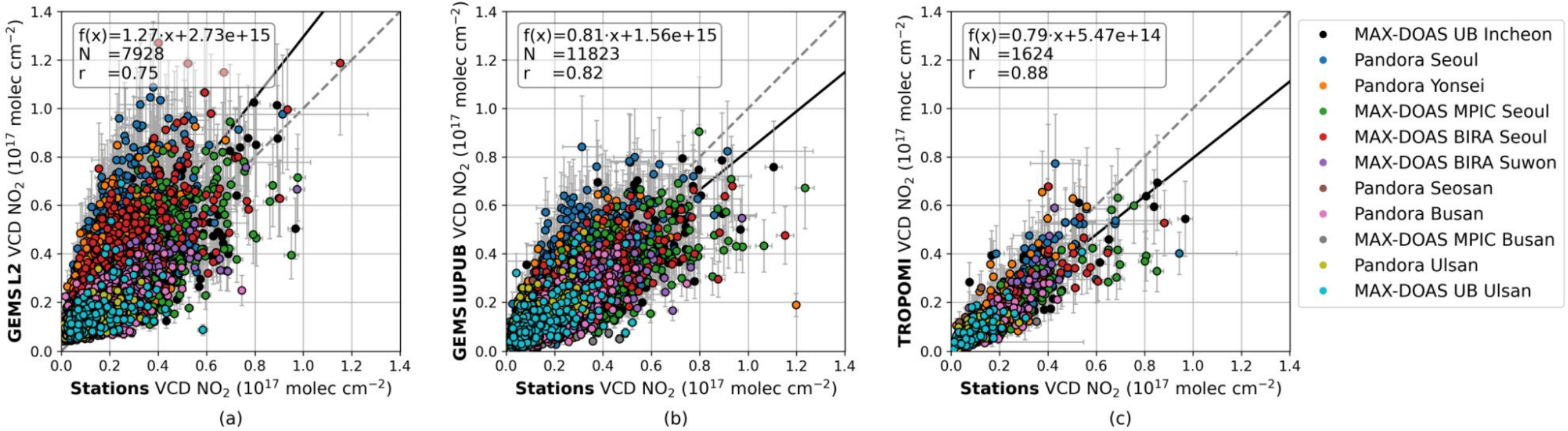
Kim et al., AMT, 2023



SIJAQ 2021 @ Seoul Metropolitan Area and Ulsan/Busan

Lange et al., EGUsphere, 2024

The GEMS L2 and ground-based tropospheric NO2 VCDs are correlated with a Pearson correlation coefficient of r = 0.75, with a slope of 1.27, a median relative bias of +64 %, and an offset of 2.73 × 10^{15} molec cm^{-2} .
With a slope of 0.81 and a median bias of -1 % for the GEMS IUP-UB and a slope of 0.79 and a median bias of -14 % for the TROPOMI product,

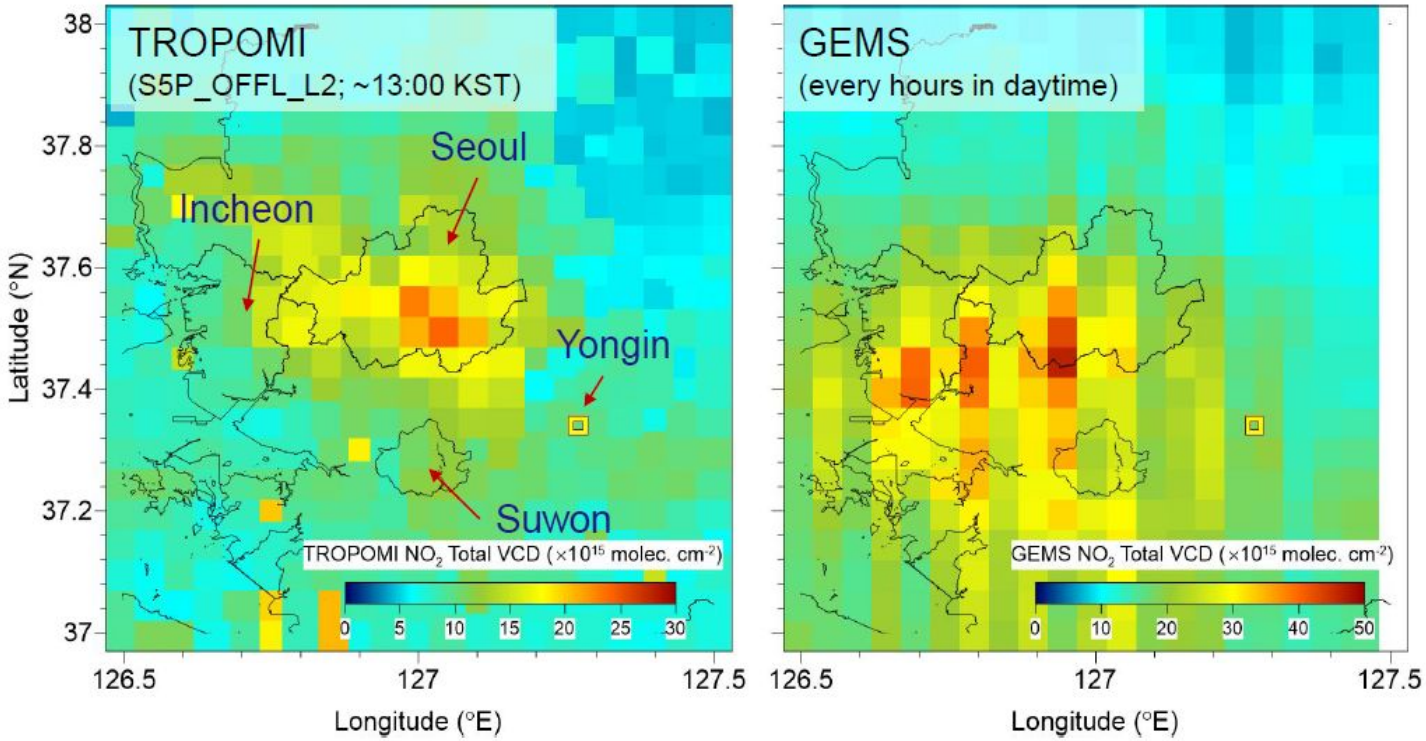


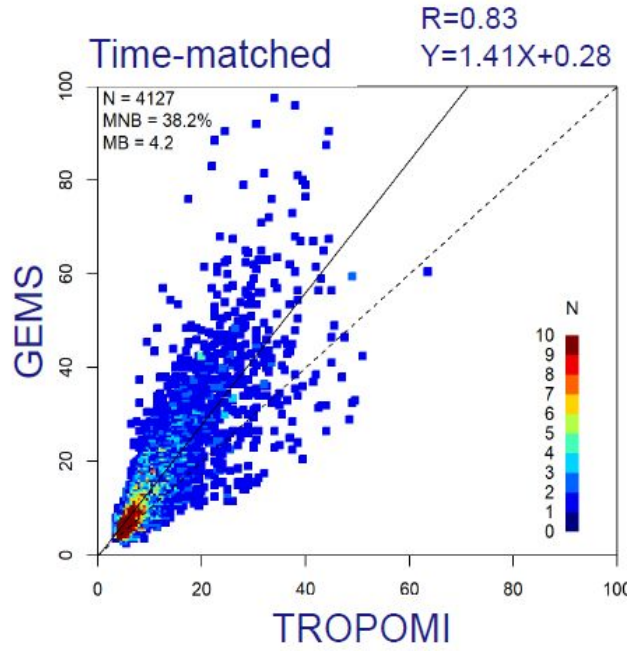
- Period: October 2021~up to December 2022
- The ground-based observations are considered co-located if they are taken within ± 20 min around the satellite observation. Measurements within this period are averaged and matched to the closest satellite observation within a radius of 5 km around the station site.

Results

Spatial distribution of NO_2 Total VCD over SMA region

October 2021, Lon & Lat by 0.05°, CF <0.3, QAflag and SZA <85°





- Slightly different spatial distribution pattern of NO_2 Total VCD between TROPOMI and GEMS, due to different sampling time.
- Time-matched GEMS NO_2 Total VCD > TROPOMI NO_2 Total VCD

SIJAQ/ASIA-AQ 1900D flight

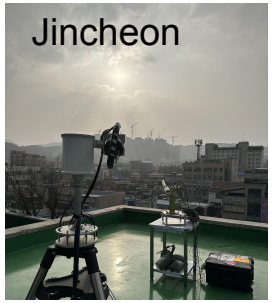
Instrument	Measuring item
HR-ToF-AMS	Organics, Nitrate, Sulfate, Ammonium, Chloride
SP2	rBC, Black carbon (50-500nm)
PCASP	Number concentration
PTR-ToF-MS	VOCs
CIMS	SO_2
LGR NH_3	NH_3
LGR CO	CO, CO_2, CH_4
Teledyne NO_2	NO_2
Teledyne O_3	O_3
TILDAS	HCHO
AIMMS-30	GPS, Temp. Hum., Pres. Widn

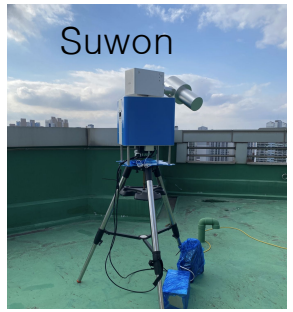
Instrument	Measuring item
Picarro/CRDS-2401m	CO_2, CH_4, CO, H_2O
Flask sampling	$\delta^{13}C$-CO_2, $\delta^{14}C$-CO_2, $\delta^{13}C$-CH_4

Instrument	Measuring item
Teledyne T500U	NO_2
HUFS	NO_2 (fast)
BrechtelTAP	Black carbon
Thermo43iQTL	SO_2
Thermo49iQ	O_3
LGR EAA-911	NH_3
LGR MCEA1-911	CO, CO_2, CH_4
OPC	$PM_{2.5}$
AIMMS-30	3-D wind

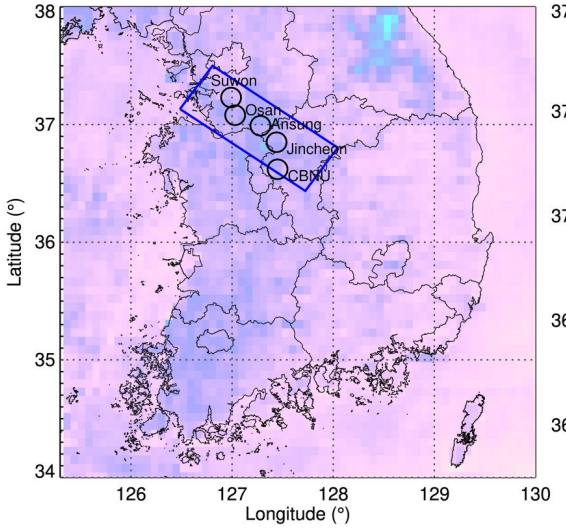
Instrument	Measuring item
EMSA	Trace gas column densities of NO2 and CH2O

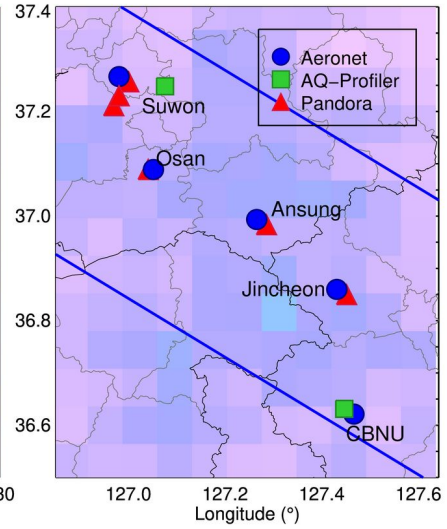
SIJAQ/ASIA-AQ ground remote sensing

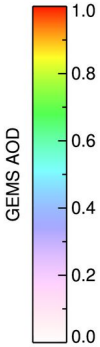


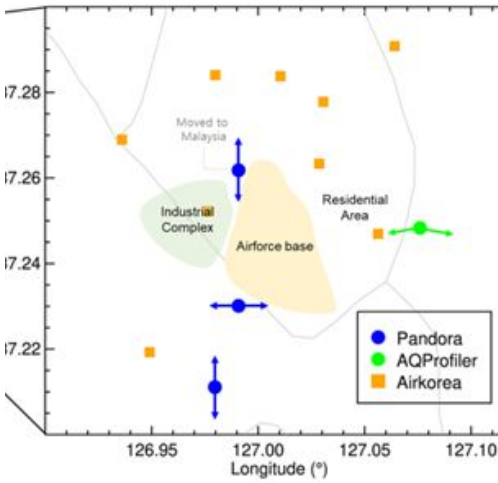


Instrument	Location	Latitude	Longitude	Azimuth angle
P191	Suwon-W	37.26	126.99	0°, 180°
P201	Suwon-E	37.23	126.99	90°, 270°
P229	Anseong	36.99	127.28	221°, 340°
P231	Suwon-USW	37.21	126.98	0°, 180°
P235	Osan	37.09	127.05	28°, 160°
P241	Jinchoen	36.85	127.44	23°
AQP-Circ	CBNU	36.63	127.46	42°, 327°
AQP-Rect	Suwon-Mega	37.25	127.08	100°, 260°





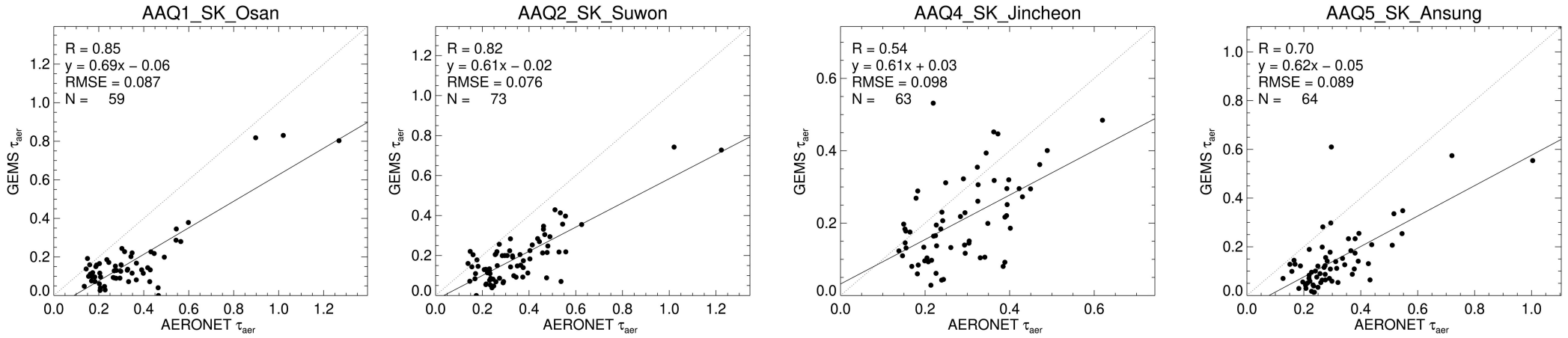




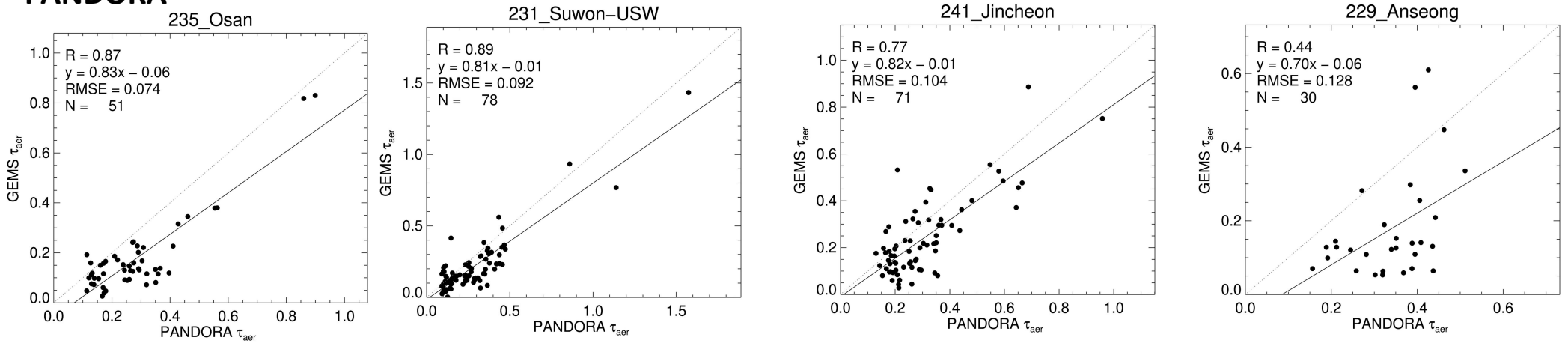
Validation of GEMS AOD against ground-based remote sensing AOD

Jeong et al., NIER report, 2024

AERONET

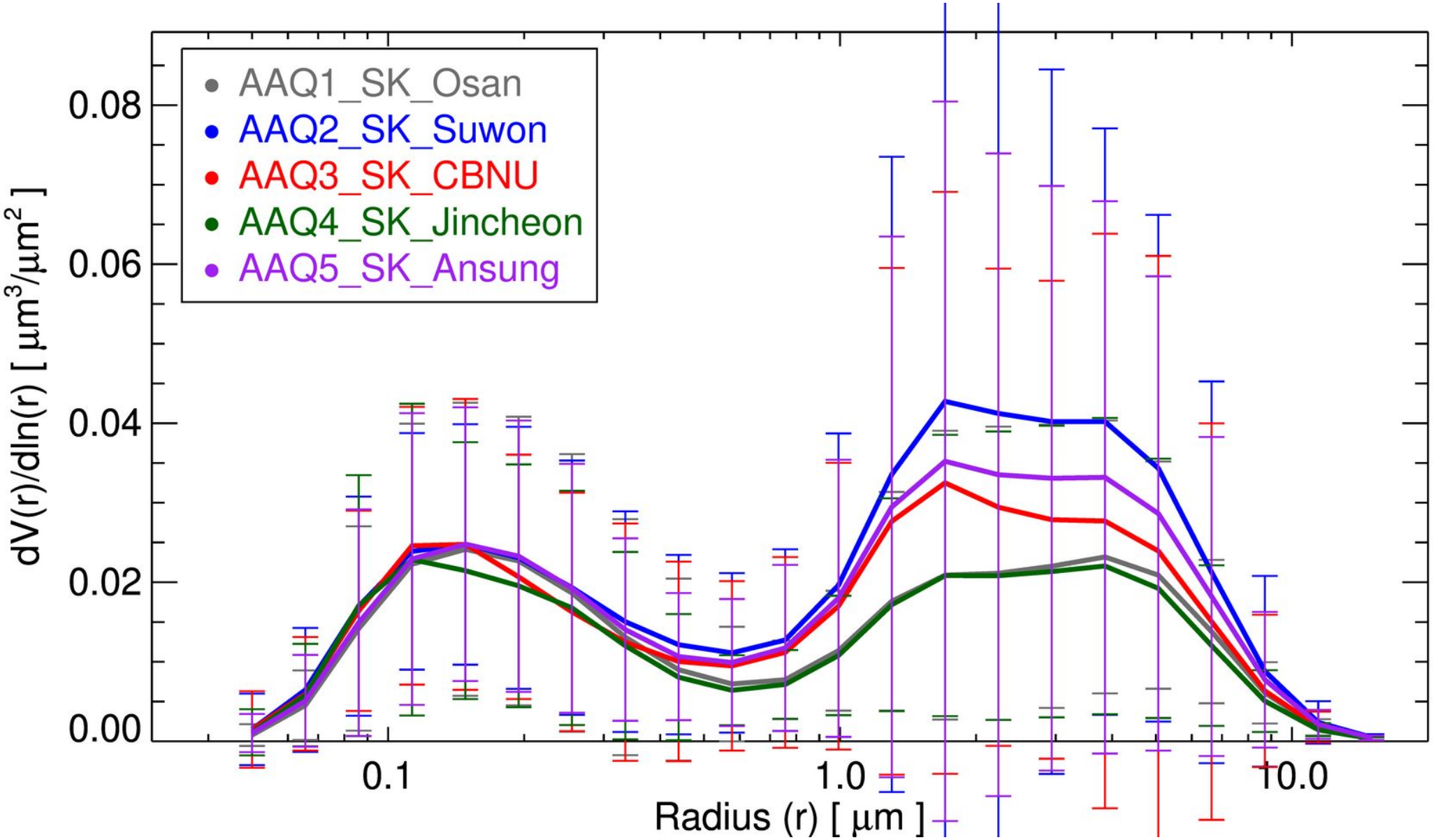


PANDORA



Volume particle size distribution

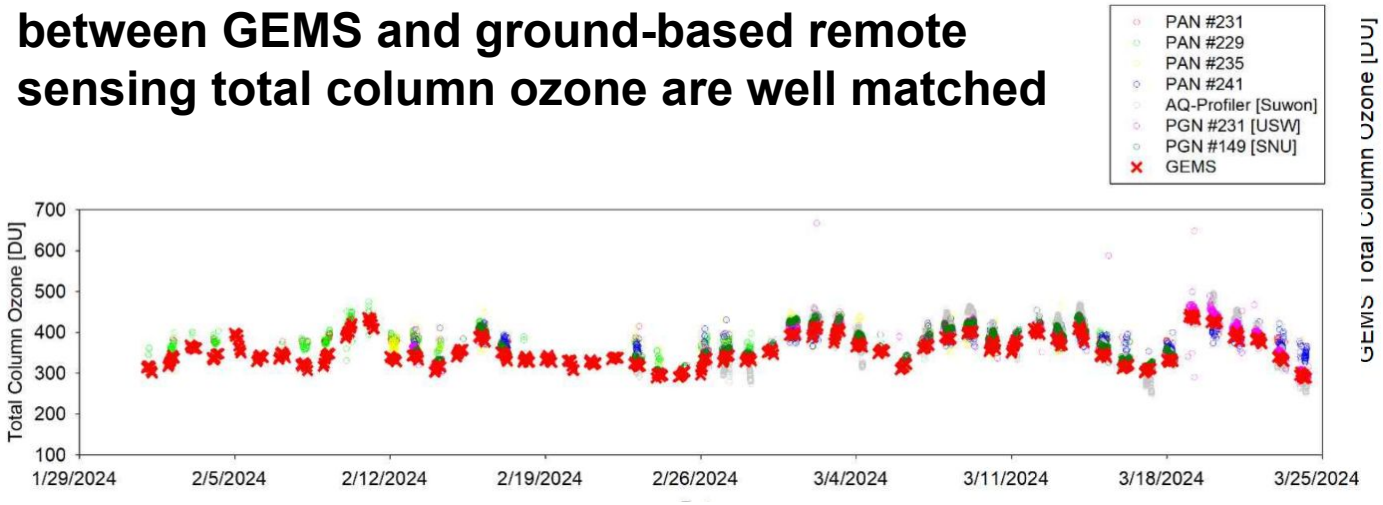
Jeong et al., NIER report, 2024



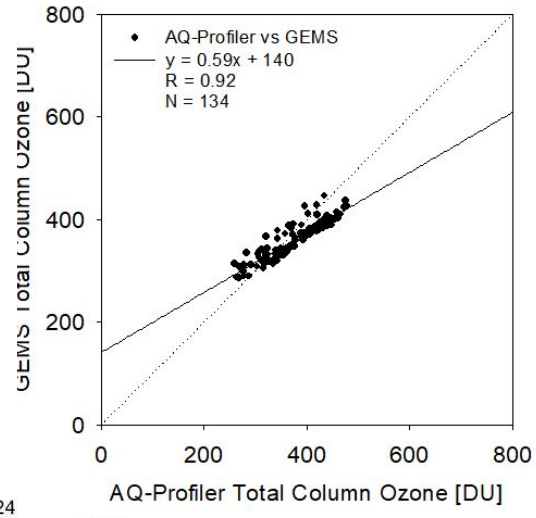
Validation of GEMS O_3 against ground-based remote sensing O_3

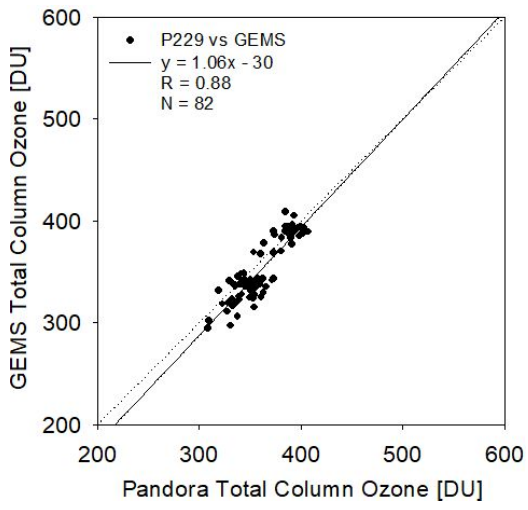
Jeong et al., NIER report, 2024

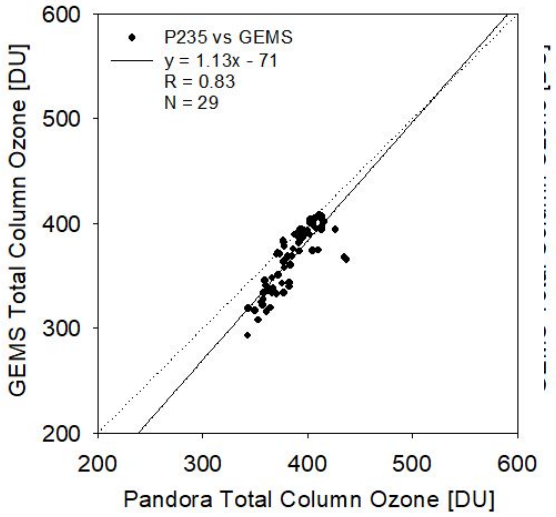
Temporal pattern of the ozone concentration between GEMS and ground-based remote sensing total column ozone are well matched

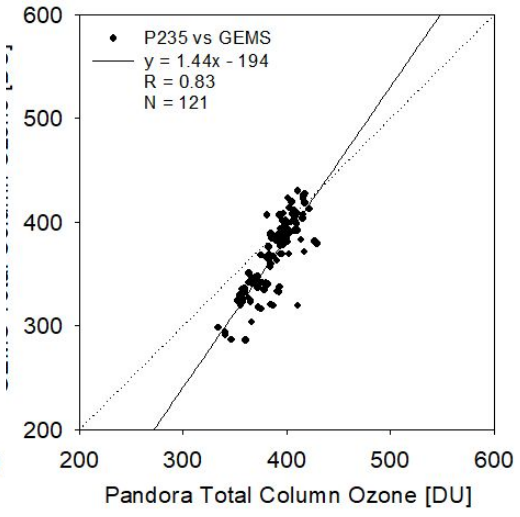


- The average data of 10 minutes before and after every 45 minutes, which is the observation time of GEMS, was compared.
- There are few data that match the U340 filter observation time and GEMS observation time for ozone production in the ground equipment observation schedule compared to GEMS data.





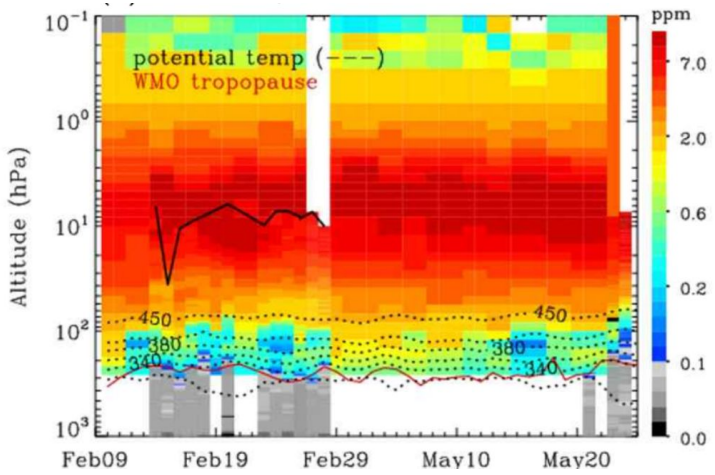




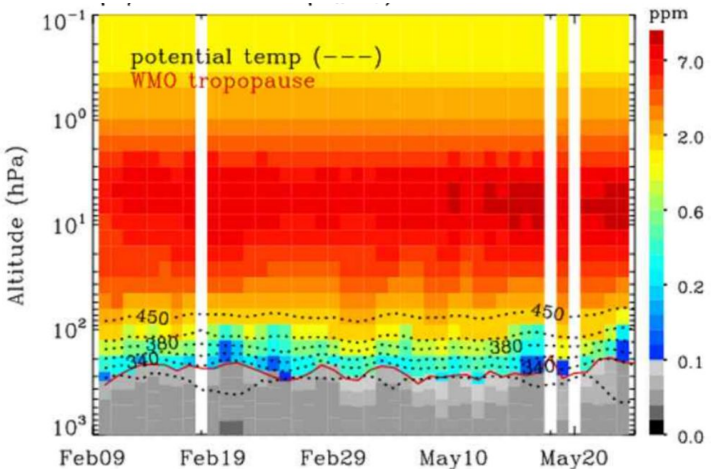
GEMS O_3 profile validation

Jeong et al., NIER report, 2024

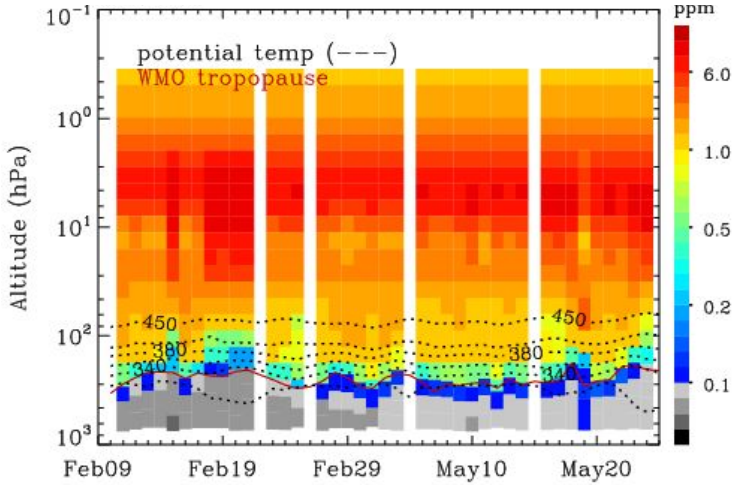
- MLS + ozone sonde

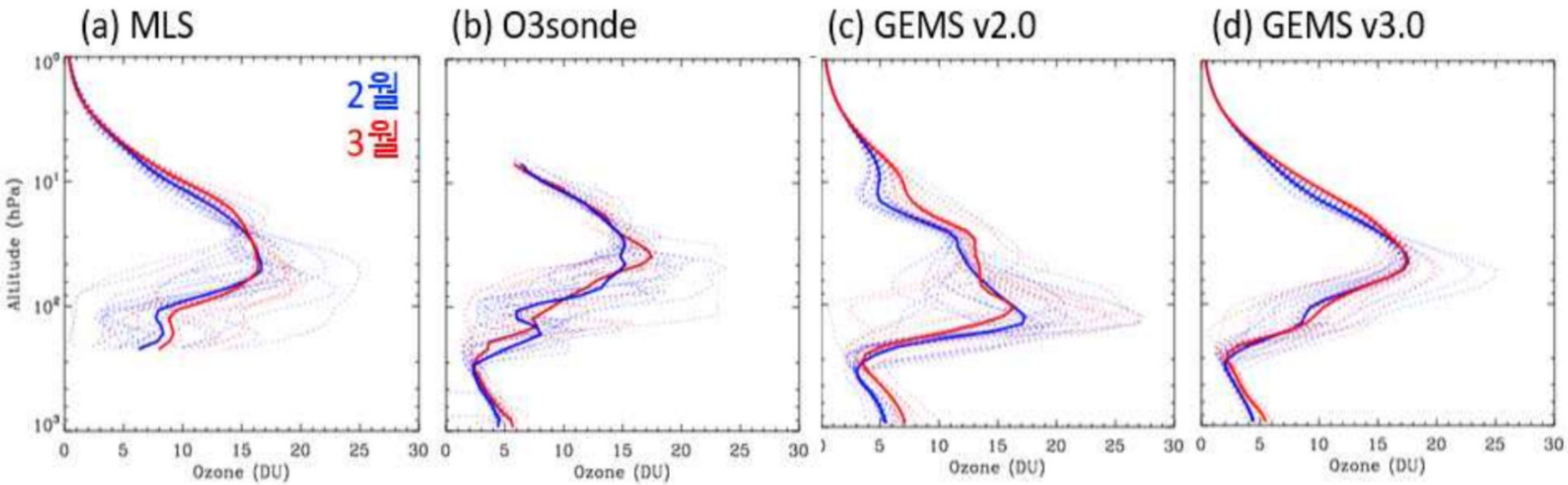


- GEMS v3.0



- GEMS v2.0

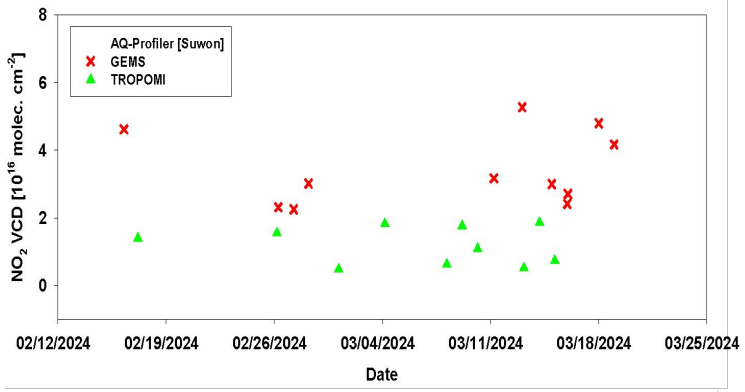


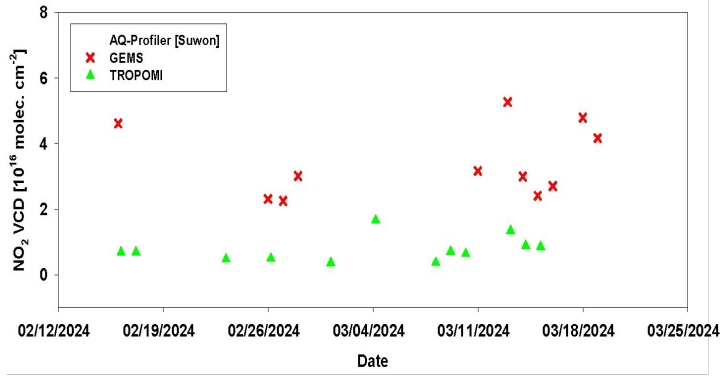


GEMS v3.0 Ozone is mostly underestimated around the tropopause, and tends to be overestimated in the middle stratosphere.

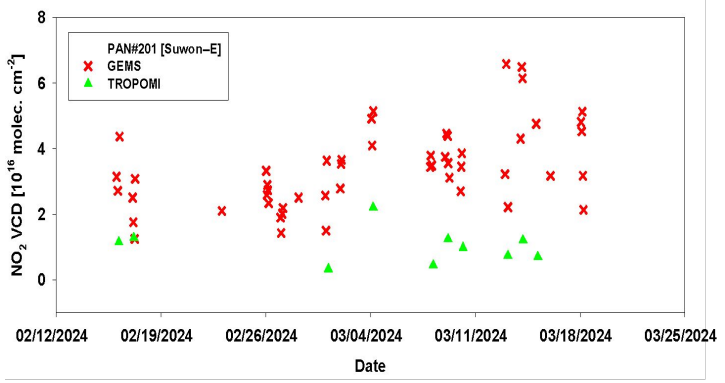
GEMS NO_2 VCD validation

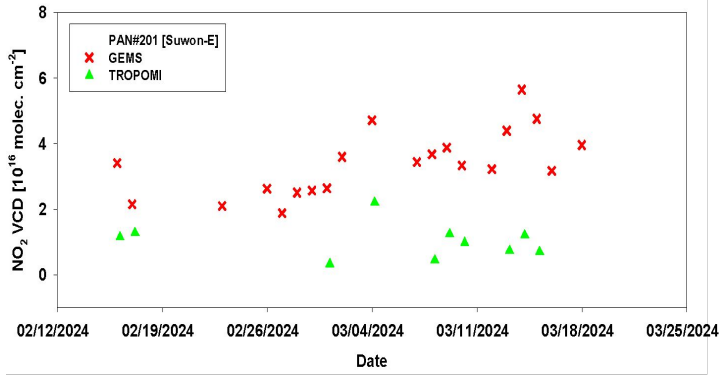
- **Suwon AQ-Profiler**



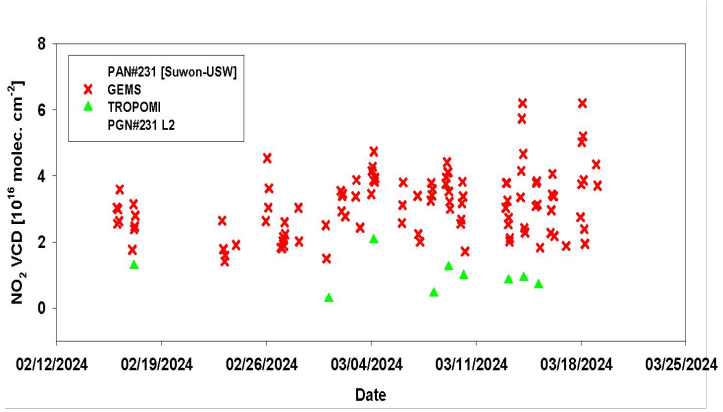


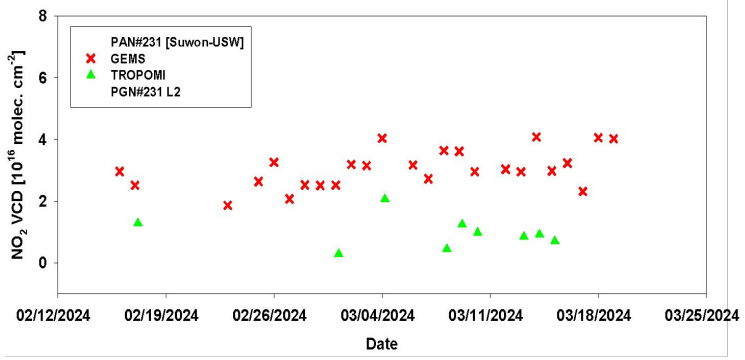
- **Suwon Pandora201**





- **Suwon Pandora231**





- Period: 2024. 02. 13 ~ 2024. 03. 24
- QA/QC
  - Residual < 1e−3, SCD fitting error < 10%
  - SZA < 75°

- GEMS: total VCD
  - SZA < 70°, VZA < 70°
  - cloud fraction < 0.3

- TROPOMI: Tropospheric VCD
  - quality flag > 0.75
- PGN L2 (quality flag ≤ 10)

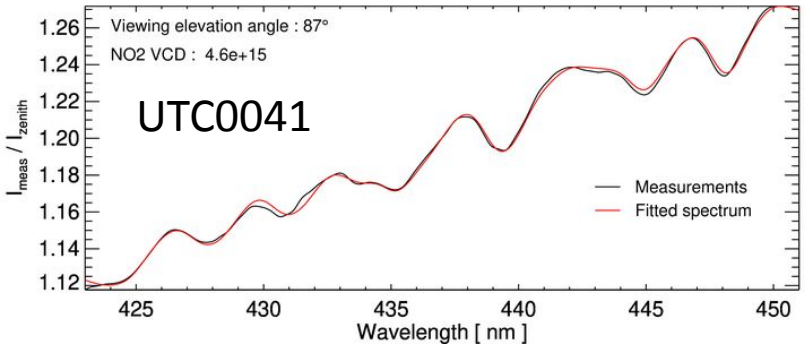
Jeong et al., NIER report, 2024

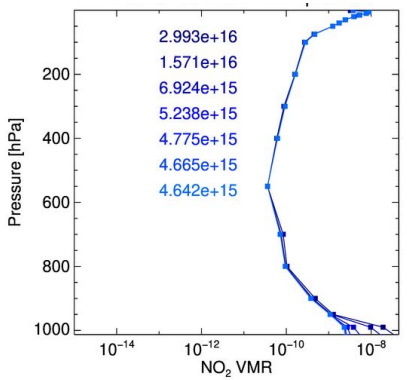
Validation of Pandora NO_2 profile

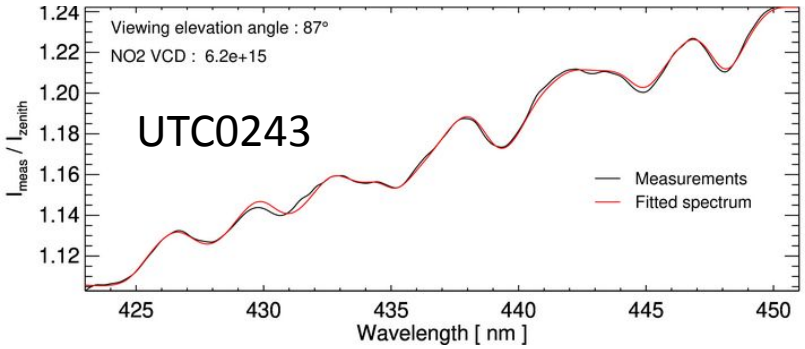
Sensitivity test on elevation angle was conducted using Pandora 191 (Extended)

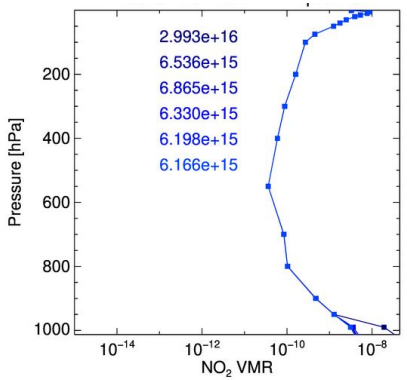
	3°	5°	10°	15°	90°
Case 1	O				O

E1 (azimuth angle: 0°)

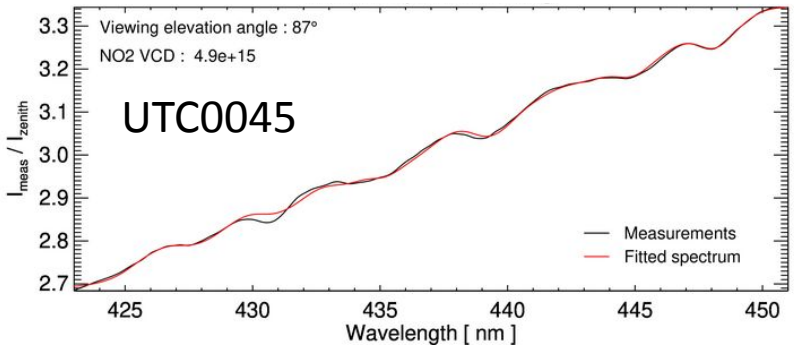


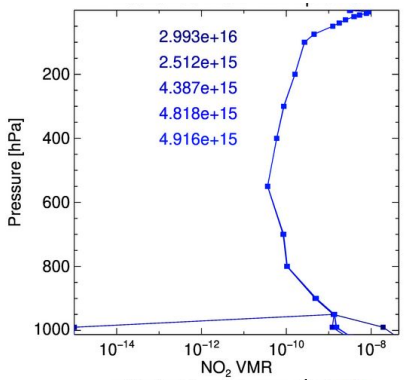


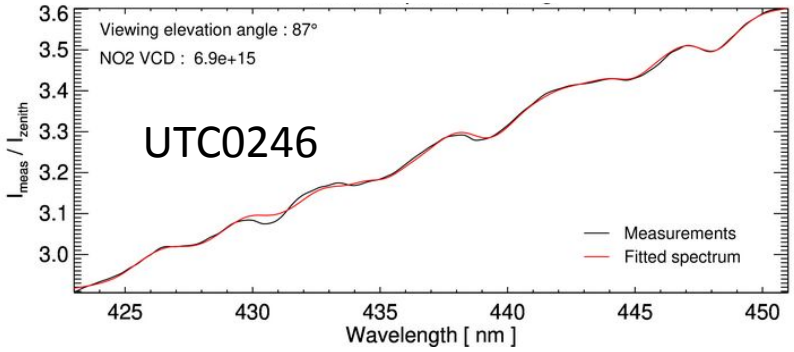


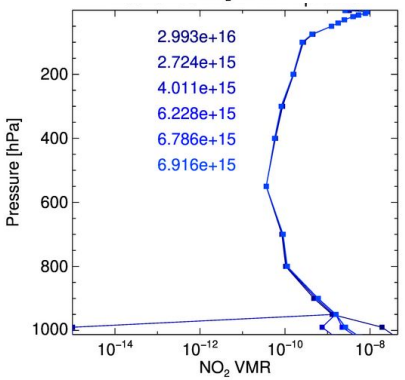


E2 (azimuth angle: 180°)









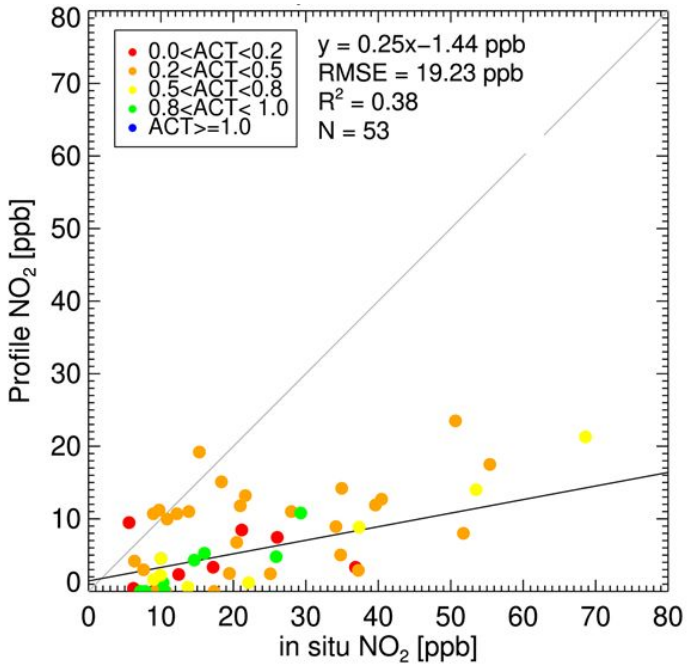
Jeong et al., NIER report, 2024

Validation of Pandora NO_2 profile against surface NO_2 concentration

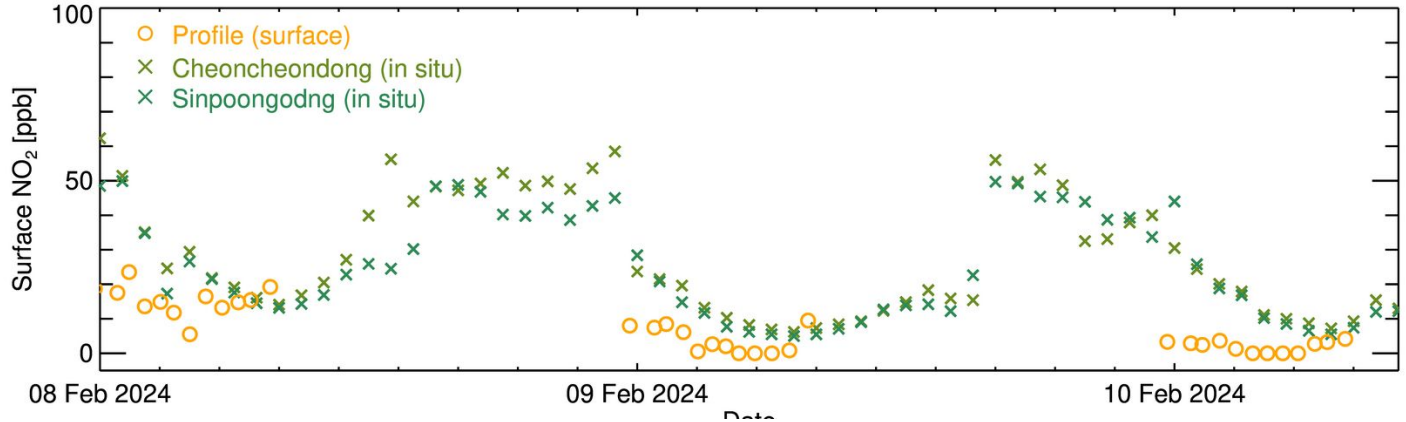
Jeong et al., NIER report, 2024

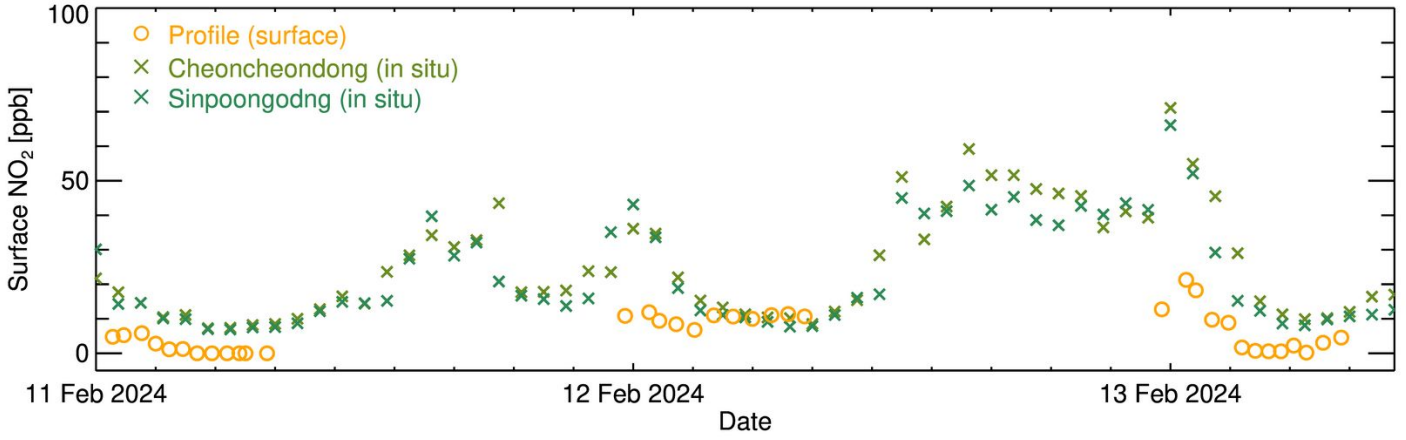
GEMS surface NO_2 followed the in-situ trend well. The sensitivity test improved the tendency to under-simulate the surface concentration, but it was still slightly lower than the in-situ.

Pandora version	P191 (Extended version)
Location	Suwon
Latitude, Longitude	37.26, 126.99



[AZI: 0°]





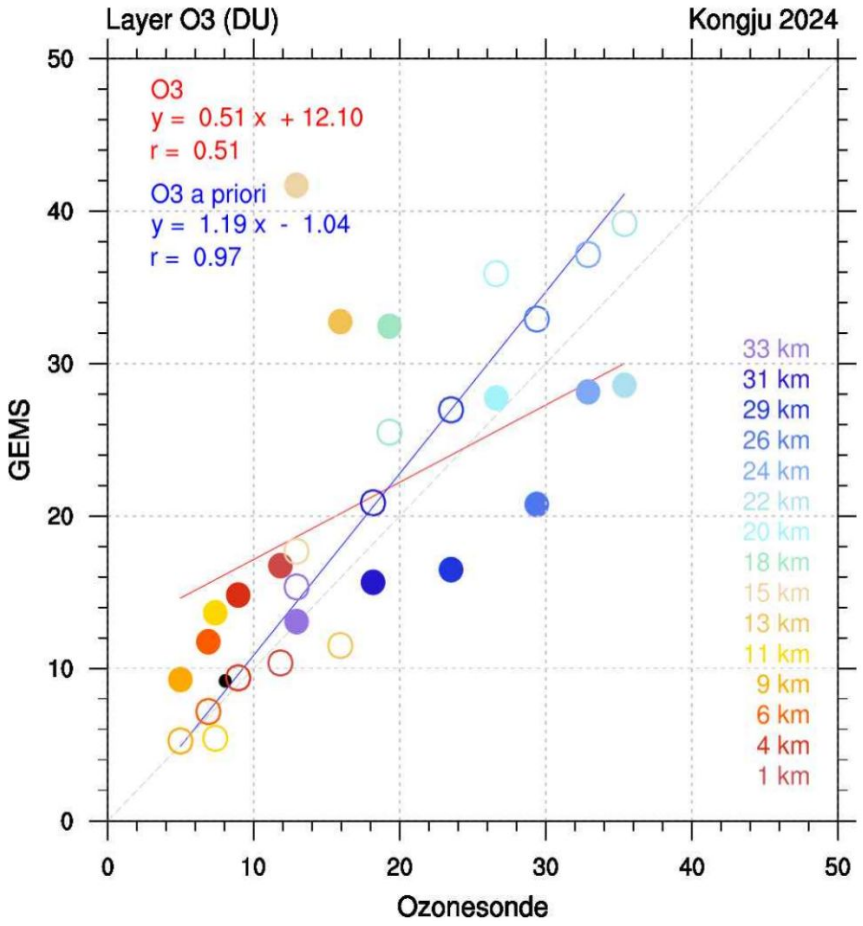
Validation of GEMS O_3 profile against sonde NO_3

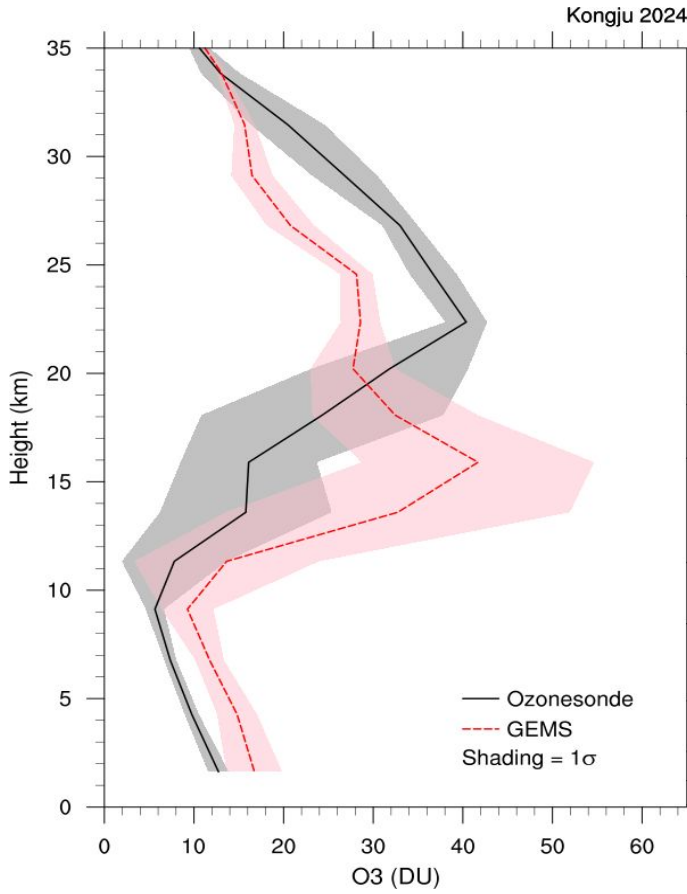
Jeong et al., NIER report, 2024

Korea

- at Kongju National University
- Total 11 ozone profiles generated (one at 3 PM)

GEMS a priori shows a high positive correlation of 0.97 with the sonde. However, GEMS ozone output showed a relatively lower correlation with the sonde, with a correlation coefficient of 0.51, which may be due to overestimation of ozone entrainment occurring in the upper troposphere and lower stratosphere

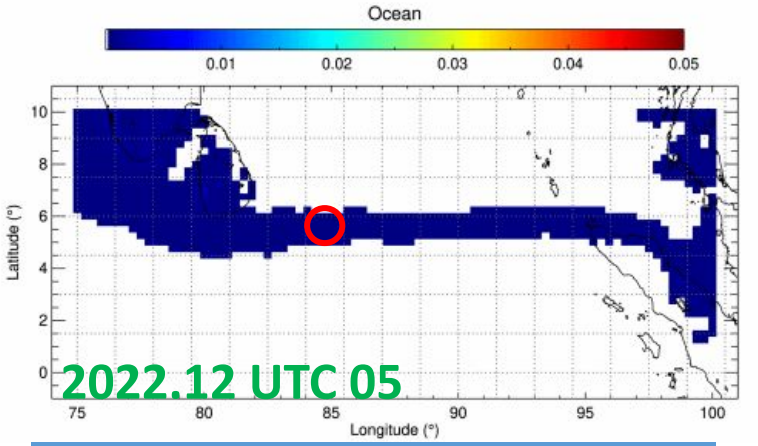




Comparison between GEOS-CHEM and TM5

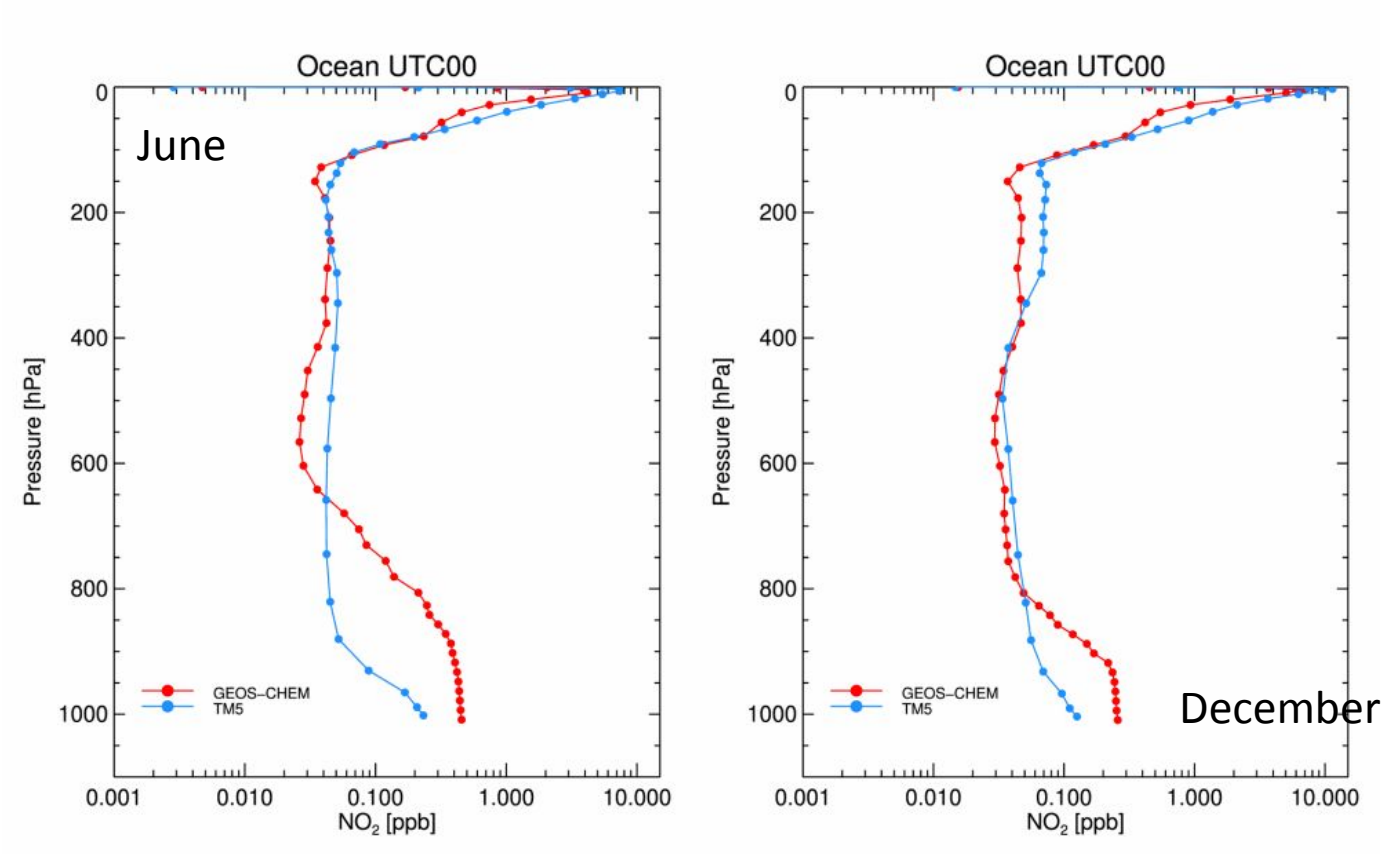
: Each profile, Ocean

Jeong et al., NIER report, 2024



	12 month
GEOS-CHEM longitude	84.375
GEOS-CHEM latitude	6.25
TM5 longitude	84.5
TM5 latitude	6.5

GEOS-CHEM TM5



- Similar patterns in June and December, UTC 00:00 and 12:00-16:00.
- Differences occur from 800 to 600 hPa, and the minimum values of each model are significantly different above the GEOSchem tropopause.

Summary

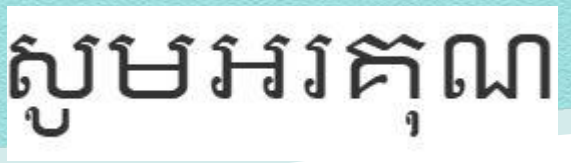
- SIJAQ data is being thoroughly validated and is expected to be released this year.
- In-depth analysis of ground/airborne/remote/modeling data is being conducted for winter PM formation and GEMS validation.
- All RSSR teams are scheduled to meet in Kuala Lumpur in January next year.

Thank you

Terima kasih

cảm ơn bạn

谢谢



감사합니다

Salamat

баярлалаа

ありがとうございました

ขอบคุณ