GEMS validation campaign -GMAP/SIJAQ-

NIER ESC

Donghee Kim, Soihee Ahn, Lim-Seok Chang

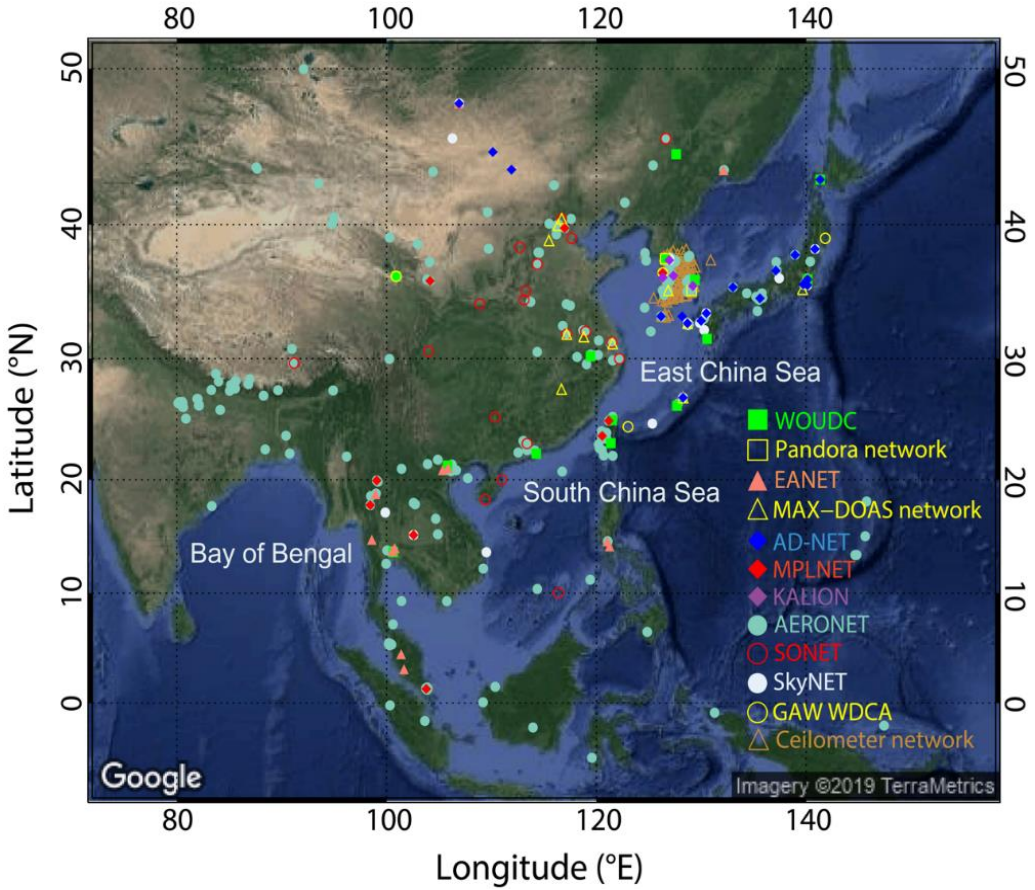
Contents

* SIJAQ: Satellite Integrated Joint monitoring of Air Quality
* GMAP: GEMS Map of Air Pollution

Research aircraft: Vertical profile

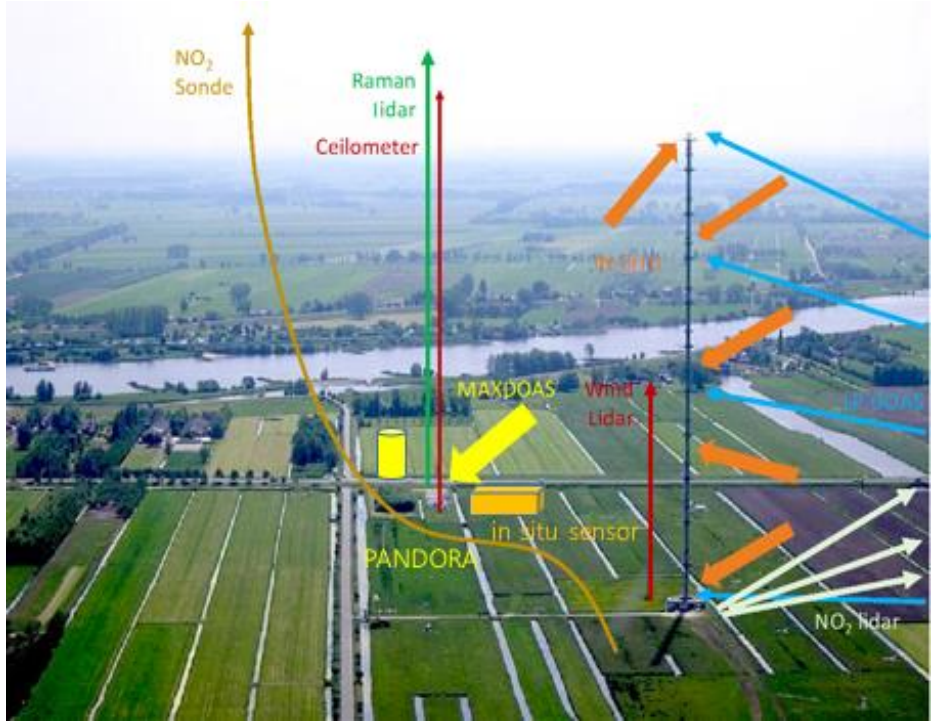
- Providing platform to researchers participating in the campaign
- Measuring vertical profiles of air pollutants

1 Remote sensing: Total column amounts



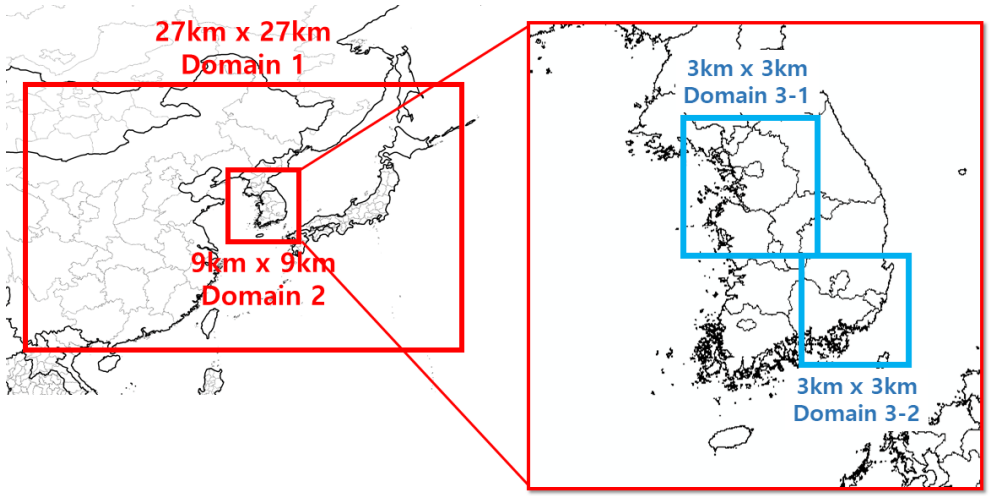
Utilizing existing networks in East Asia and incorporating Pandora Asia Network(PAN) into them for air quality monitoring and GEMS cal/val

Source: post-KORUS-AQ

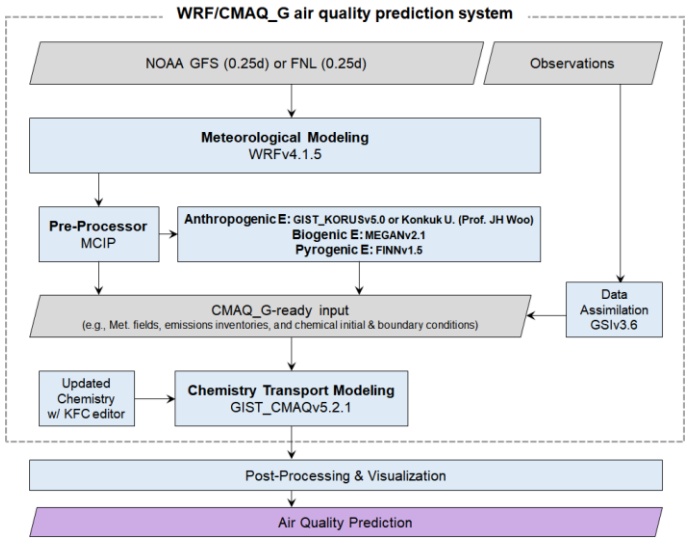


Establishing super site for a combination of airborne, ground-based and in-situ reference measurements in order to characterise the true diurnal variation accurately

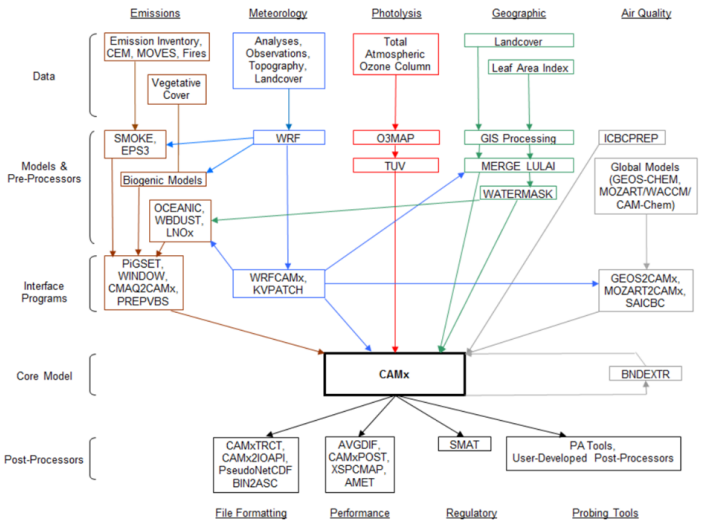
I Multi-model ensemble: Process analysis



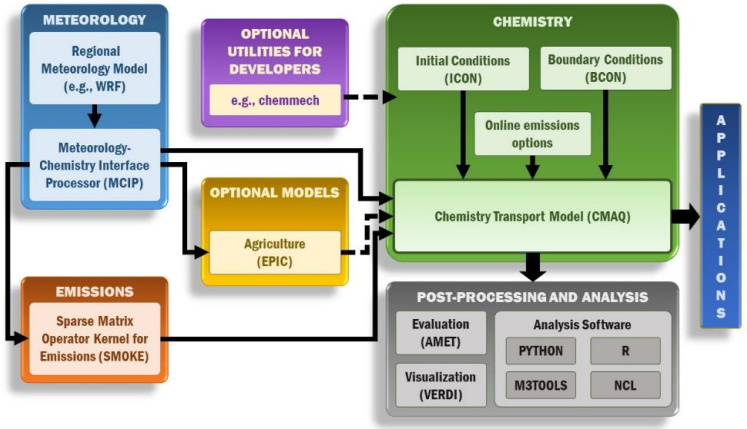
WRF/CMAQ-G



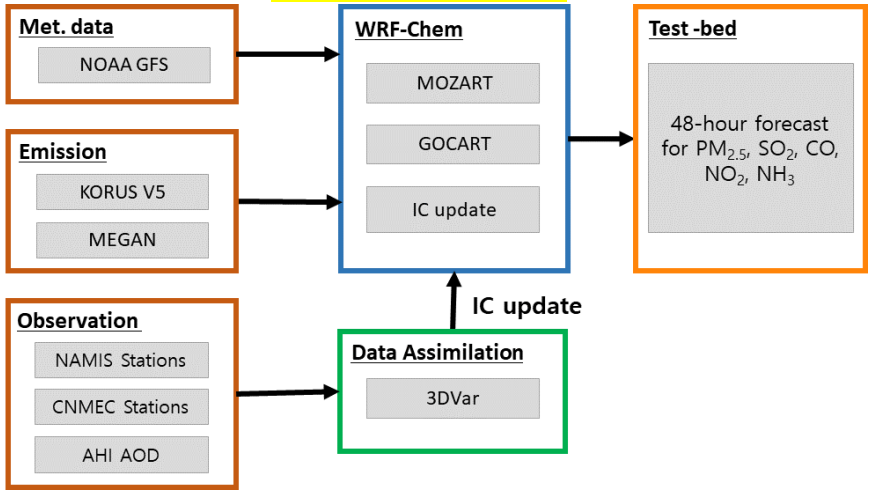
CAMx



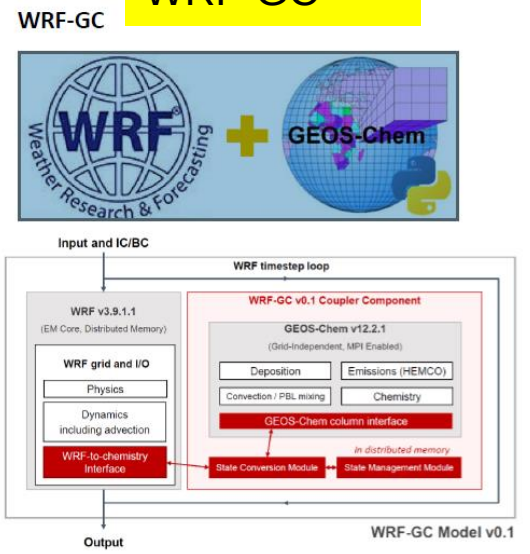
WRF/CMAQ



WRF-Chem



WRF-GC



1 GMAP2020

Period: 12 Oct.~27 Nov **Place: Seosan supersite**

< 충청권 대기환경연구소 >

< 서산시의회 옥상 >

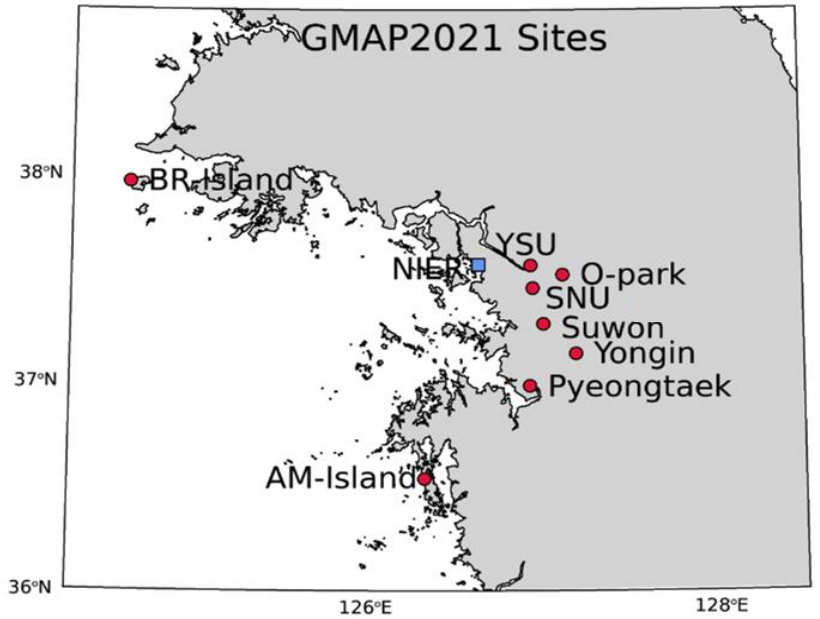
< 동문2동 행정복합센터 옥상 >

< 대산 K-water >

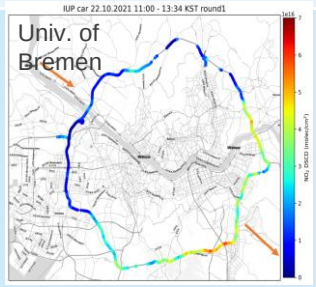
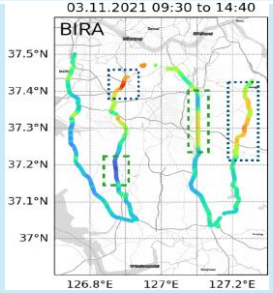
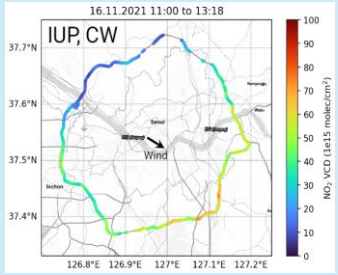
1 GMAP2021

Surface remote sensing observation: 18. Oct ~

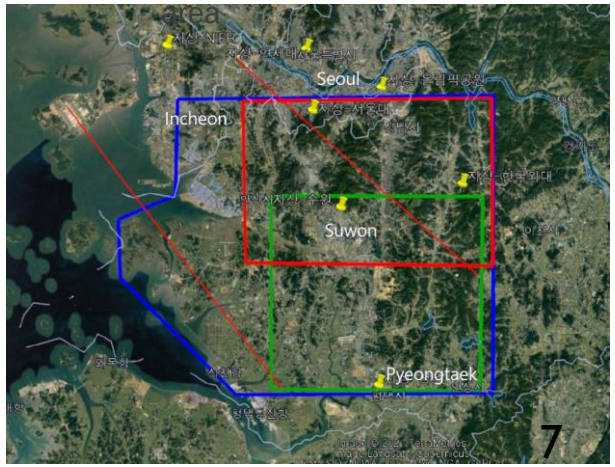
- Incheon: Max-DOAS (Bremen Univ.)
- Seoul: Max-DOAS (MPIC), Pandora (SNU, YSU)
- Suwon: Max-DOAS (BIRA)
- Pyeongtaek: Pandora #191 (NIER)
- BR-Island: Pandora #201 (NIER)
- AM-Island: Pandora #189 (NIER)
- Yongin: Max-DOAS (JAMSTEC)



Car-DOAS

Purpose	GEMS validation (10)		Investigation of local emission (3)
	*Pixel validation (4)	Linkage with **GCAS (6)	
Date	10/20, 10/28, 11/1, 11/2	11/3, 11/5, 11/12, 11/14, 11/17, 11/26	10/22, 10/27, 11/16
Car-DOAS Route			

GCAS observation



* Pixel validation: Investigation of inter-pixel homogeneity

** GCAS: Geostationary Coastal and Air Pollution Events Airborne Simulator

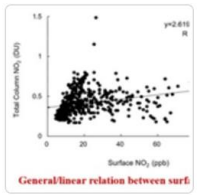
Atmos. Chem. Phys., 22, 10703–10720, 2022
https://doi.org/10.5194/acp-22-10703-2022

Article | Peer review | Metrics | Related articles

Research article

23 Aug 2022

Evaluation of correlated Pandora column NO_2 and in situ surface NO_2 measurements during GMAP campaign



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Impact of LPS on air quality on downwind in case of local circulation under weak synoptic forcing (Lim-Seok Chang et al., 2022, ACP)

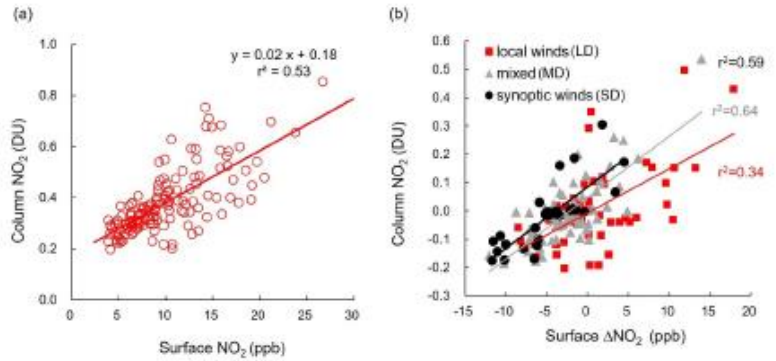
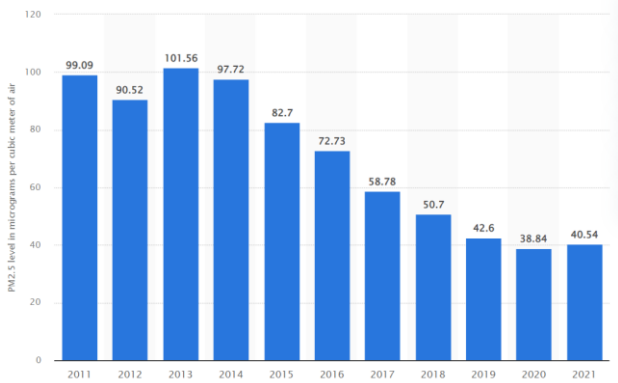


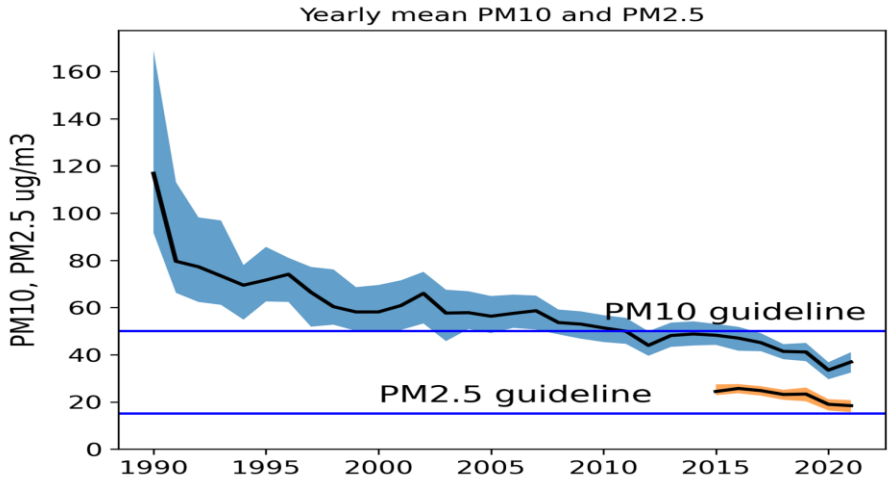
Figure 5. **(a)** Scatterplots of daytime measurements at site PA_4 **(a)** PC-NO_2 vs. SI-NO_2 under all meteorological conditions and **(b)** PC-NO_2 vs. surface NO_2 in each meteorological condition over a 1-year period (12 November 2020–30 October 2021). Here surface NO_2 = SI-NO_2 − (30 d moving average) SI-NO_2.

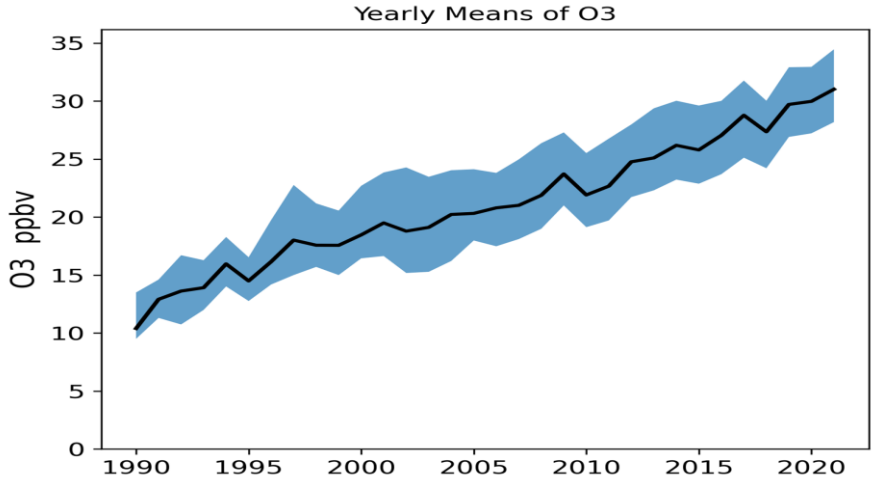
2 GMAP 2021

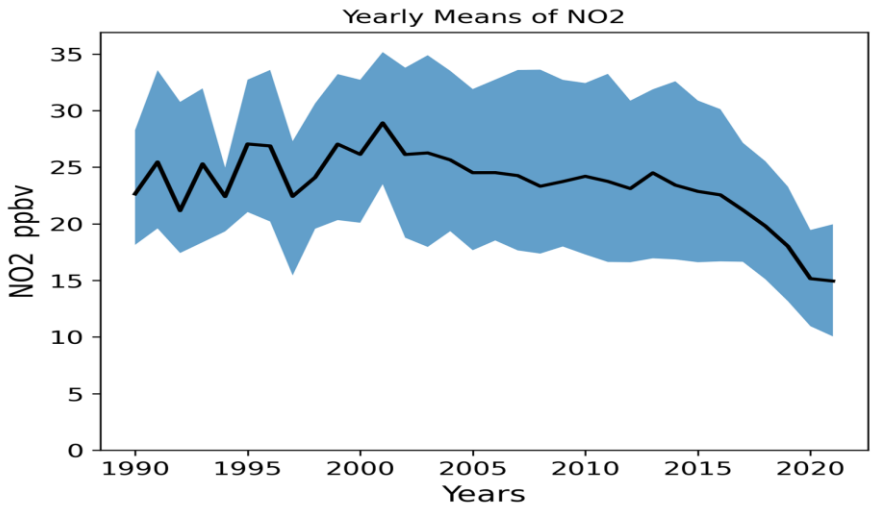
- 2016 vs 2021 PM_{10} -22%, $PM_{2.5}$ -28% NO_2 -34 % SO_2 -36% ,decrease, but O_3 +15 % increase

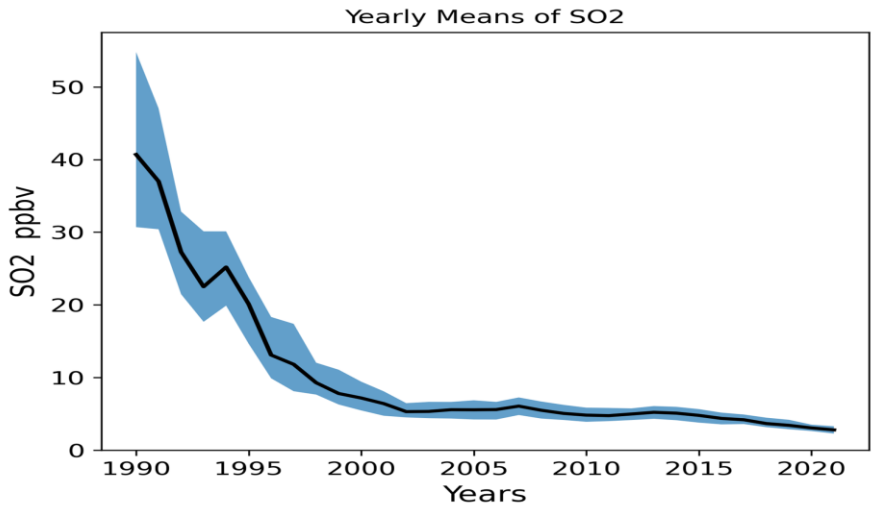
C. Textor, Jun 21, 2022







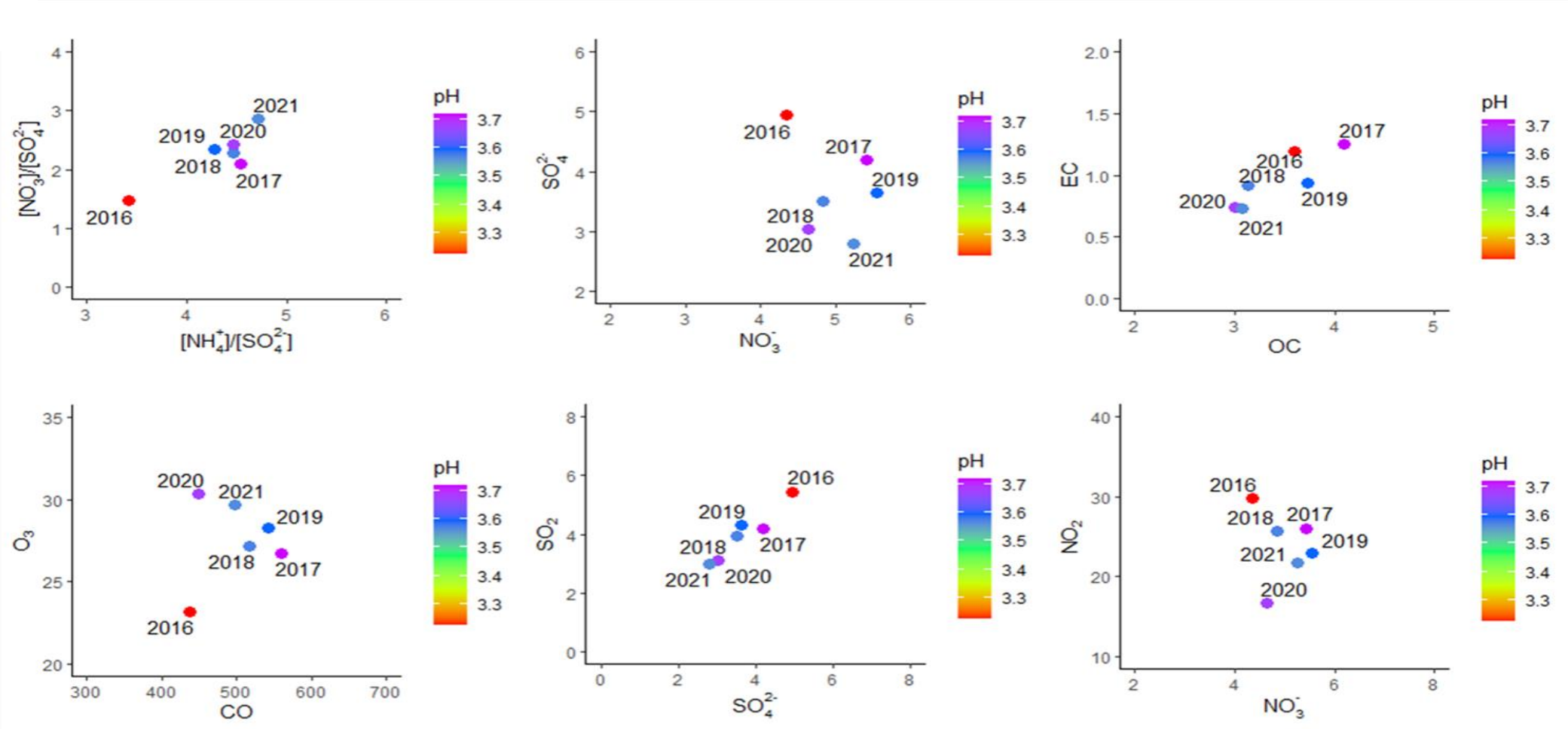




Source: Gangwoong Lee, HUFS

Source: Meehye Lee, Korea Univ.

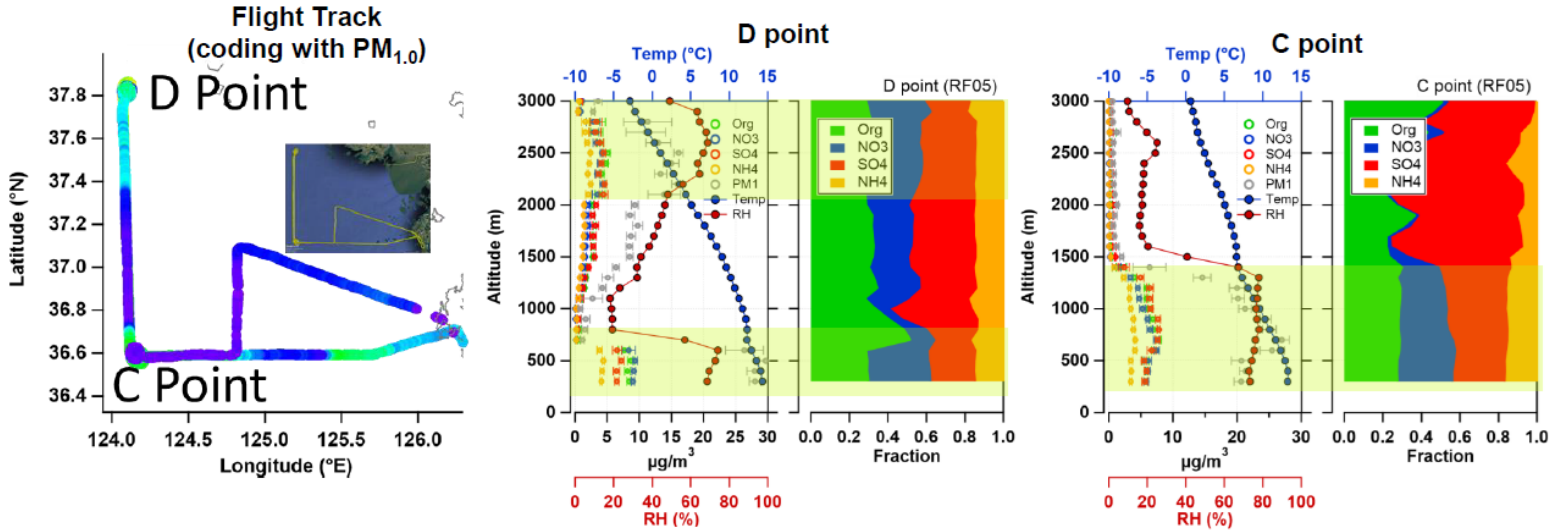
- SO_2 vs SO_4^-, EC vs OC : linear , NO_2 vs NO_3^- : non-linear

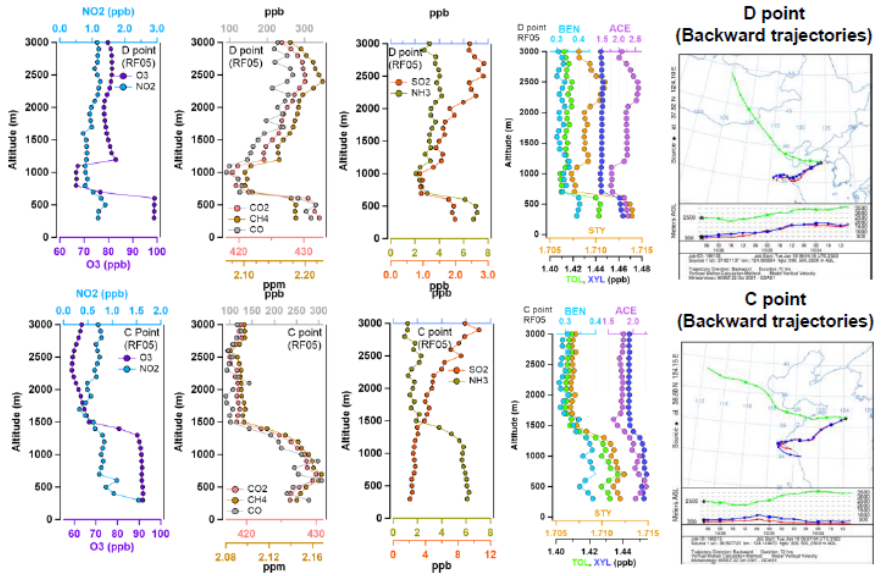


Period: 2016-2021, Place:Seoul, Target: $PM_{2.5}$ composition, precursor, aerosol pH

2 GMAP 2021: LRT case (Oct. 26, 2021)

- LRT plume detected in two layers over the West Sea (300-1300m, 2100-2900m)





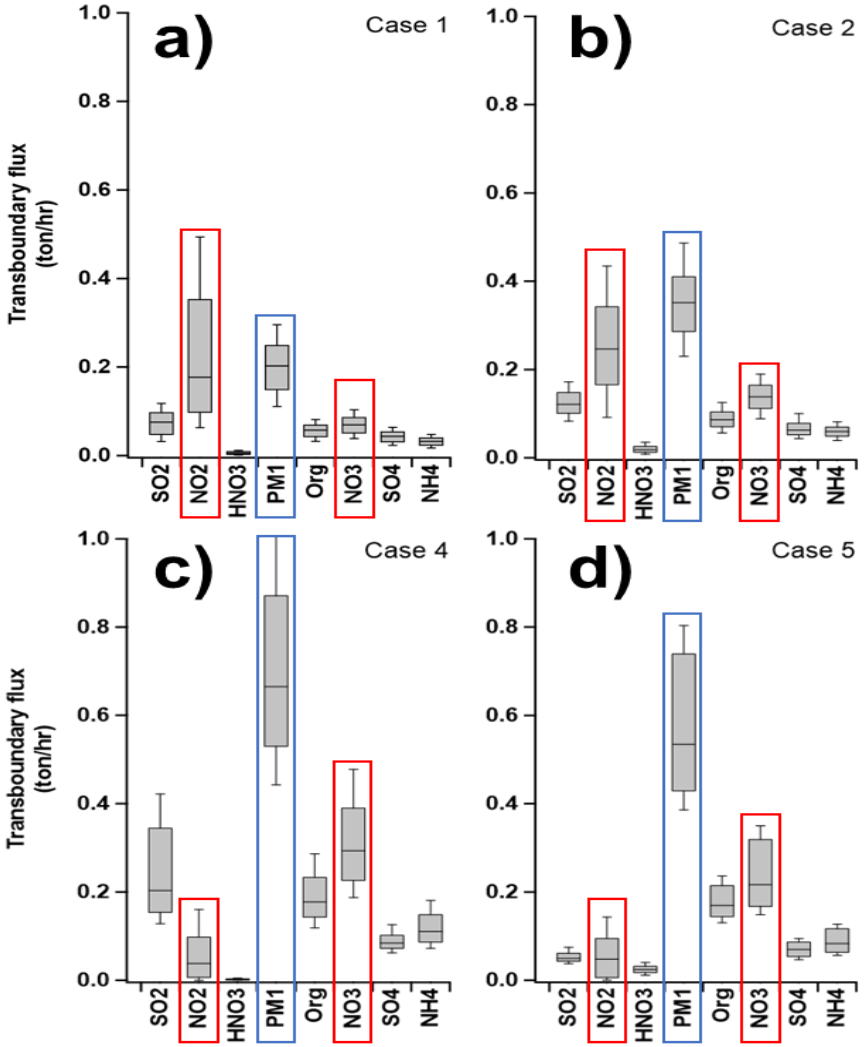
Source: Taehyung Lee, HUFS

day (in 2021)	|Vg| (m s^{-1})	Θ (degree)	ζ (x10^5 s^{-1})	Cloud Cover (%)	Weather phenomena	Nighttime MLH (km) Range (mean, median)	Daily maximum MLH (km)	Temp. (℃)	RH (%)	$PM_{2.5}$ (μg m^{-3})	RF_AIMMS-30
24 Oct.	5.2	350.4	0.3	3		0.21-0.33 (0.24, 0.23)	1.46	11.4	63.1	21	RF05: 0840-1132LST RF06: 1346-1643LST
25 Oct.	4.1	351.0	0.4	8		0.23-0.42 (0.31, 0.3)	1.43	11.7	64.5	20	
26 Oct.	4.6	324.3	-7.3	36	Mist	0.26-0.37 (0.32, 0.33)	1.21	13	74.5	26	RF07: 1333-1655LST
27 Oct.	13.6	313.0	3.7	25	Mist	0.2-0.37 (0.28, 0.27)	1.47	13.4	63.4	28	RF08: 0813-1049LST
28 Oct.	11.7	302.2	2.2	0		0.19-0.45 (0.35, 0.37)	2.7	12.7	54.6	14	

Source: Cheolhee Kim, Pusan Univ.

- Both PM and precursors can be long-range transported

From 2019 to 2021, six LRT cases analysis (’20, 12.10/11/22(AM,PM)/23, ‘21.10.26)



High NO_2 flux, low NO_3^- flux

Relatively low $PM_{1.0}$ flux

Precurors transported

Low NO_2 flux, high NO_3^- flux

Relatively high $PM_{1.0}$ flux

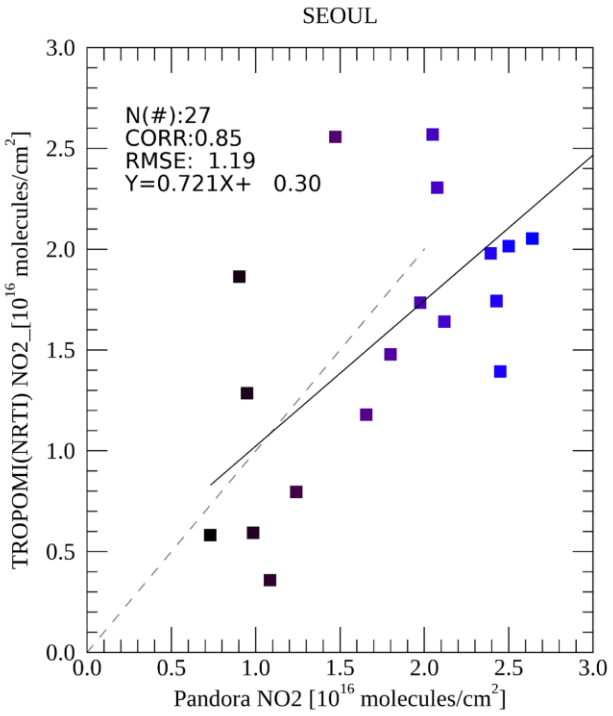
High portion of NO_3^- in $PM_{1.0}$

Source: Taehyung Lee, HUFS

2 GMAP 2021

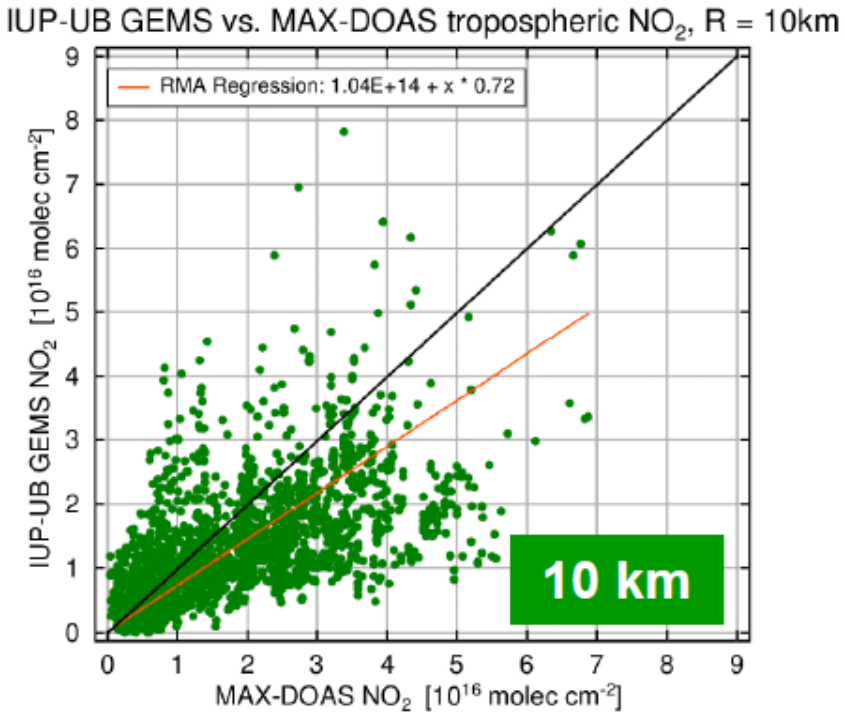
- High correlation, low bias, and high scatter (or rmse) for NO_2 VCD

18 Oct. ~ 18 Nov. 2021



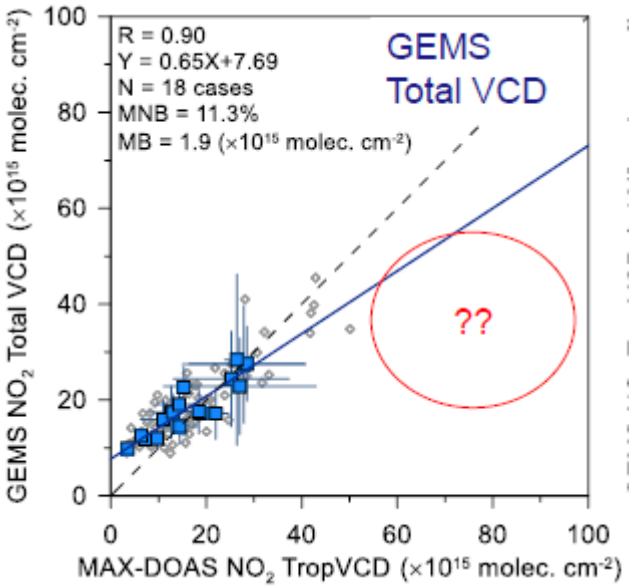
Source: Sangwoo Kim

GMAP 2021



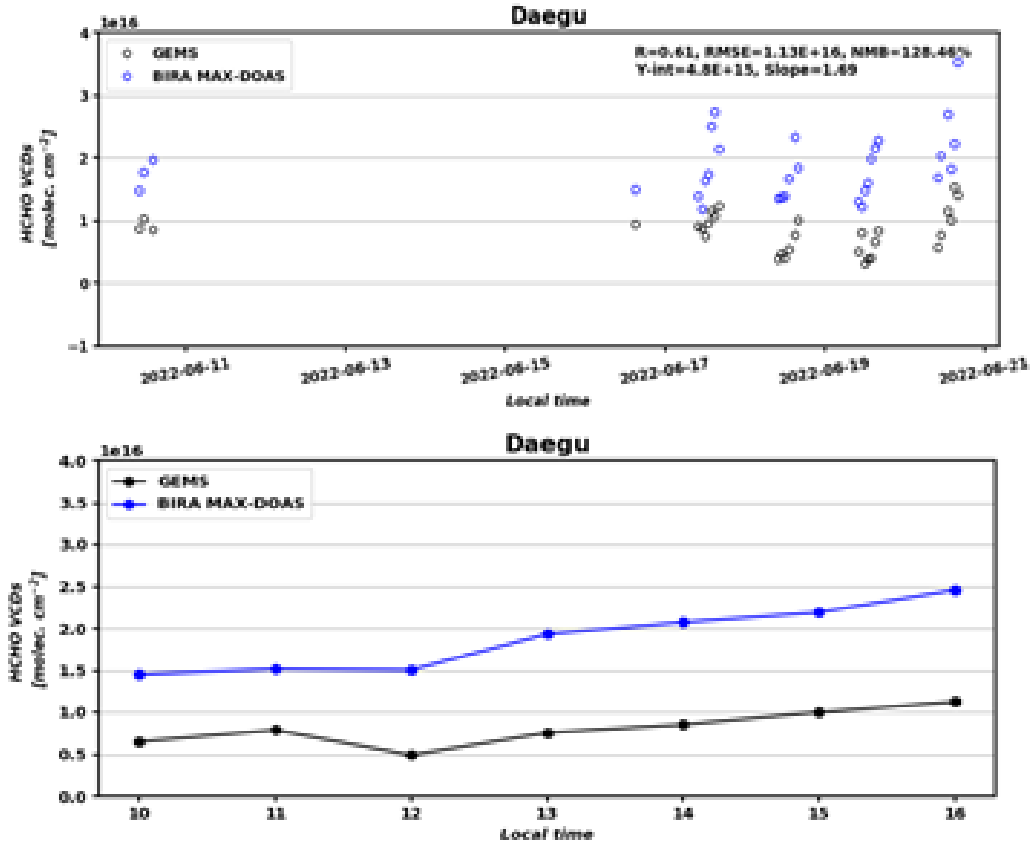
Source: Andreas Richter

±30 mins, Lon & Lat < 5 km, CF <0.3, and SZA <85°



Source: Yongjoo Choi

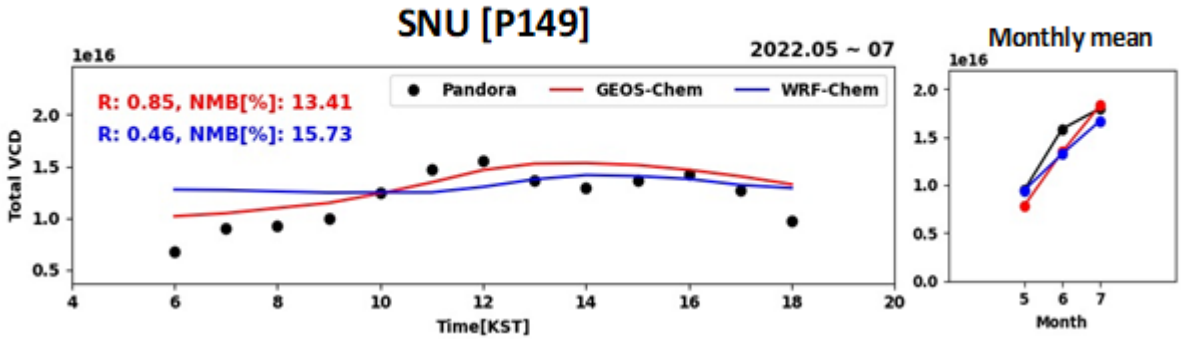
- **GEMS HCHO is in a significant correlation with MAX-DOAS HCHO and shows an increase in the afternoon**



Time: June 2022, Place: Daegu

HCHO VCDs daily variation (upper), diurnal variation(bottom).

GEMS(black), Pandora(blue).



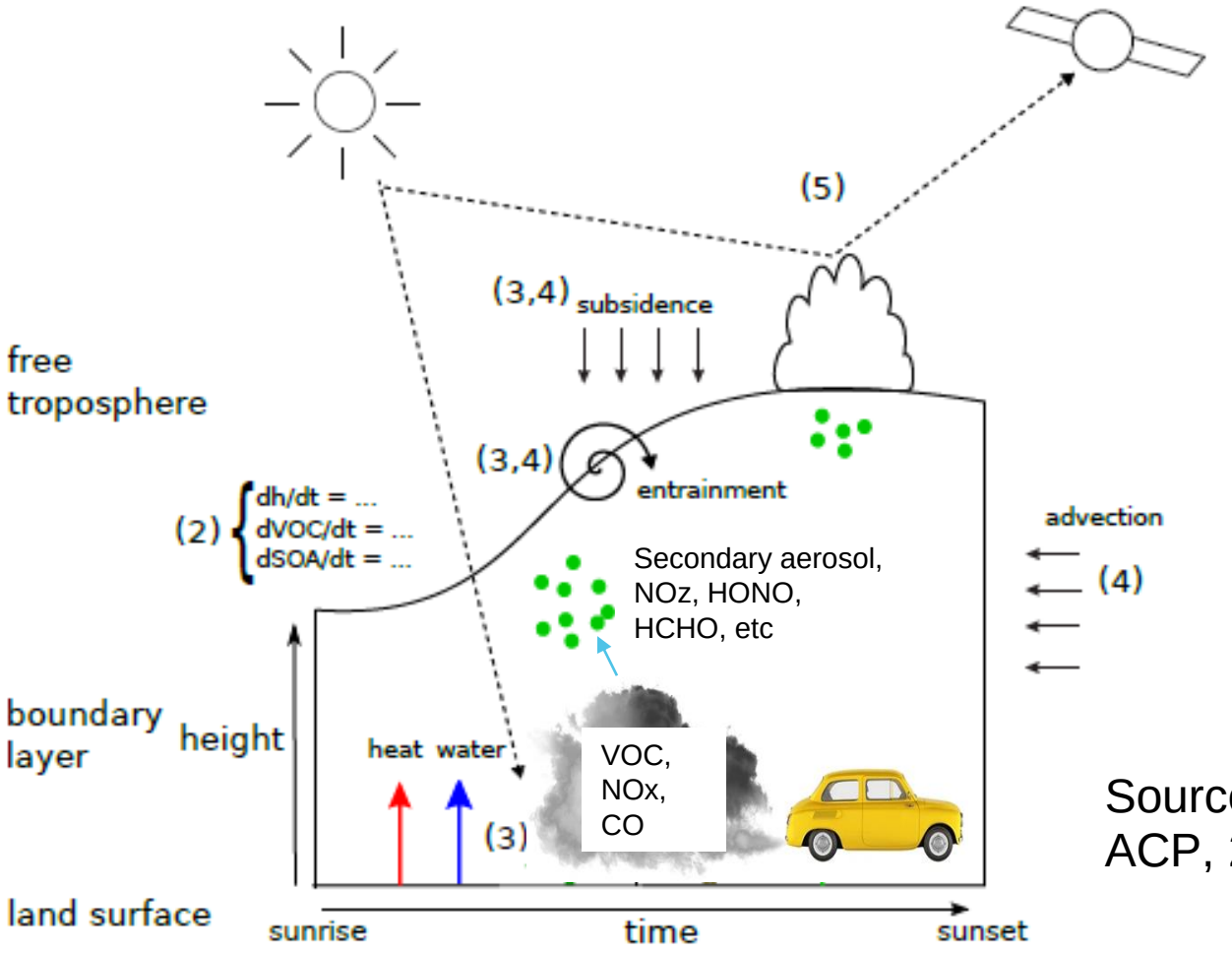
Time: May~July, 2022

Pandora and CTM HCHO VCD diurnal variation

Source: Rokjin Park, SNU

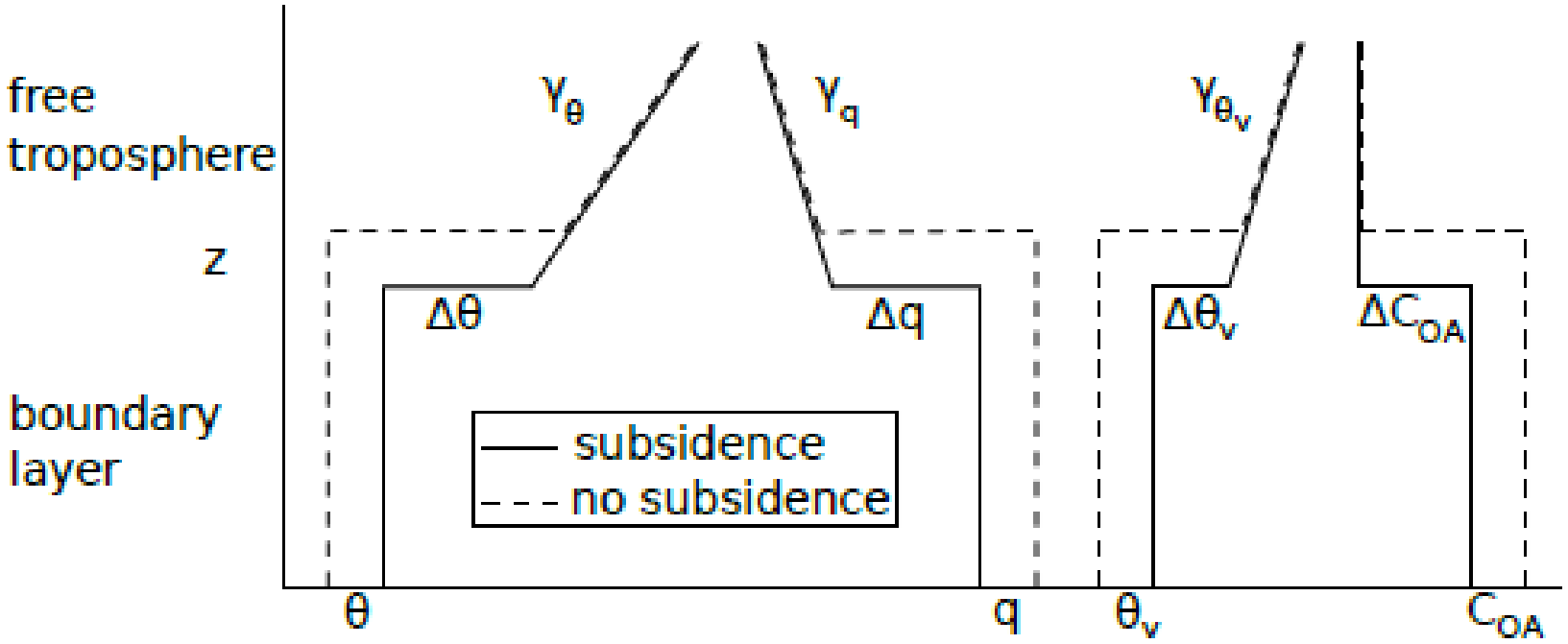
3 BOX model : MiXed Layer Chemisry (MXLCH) Model modified

Conceptual representation of the main processes in urban area



Source: Ruud H. H. Janssen, ACP, 2012

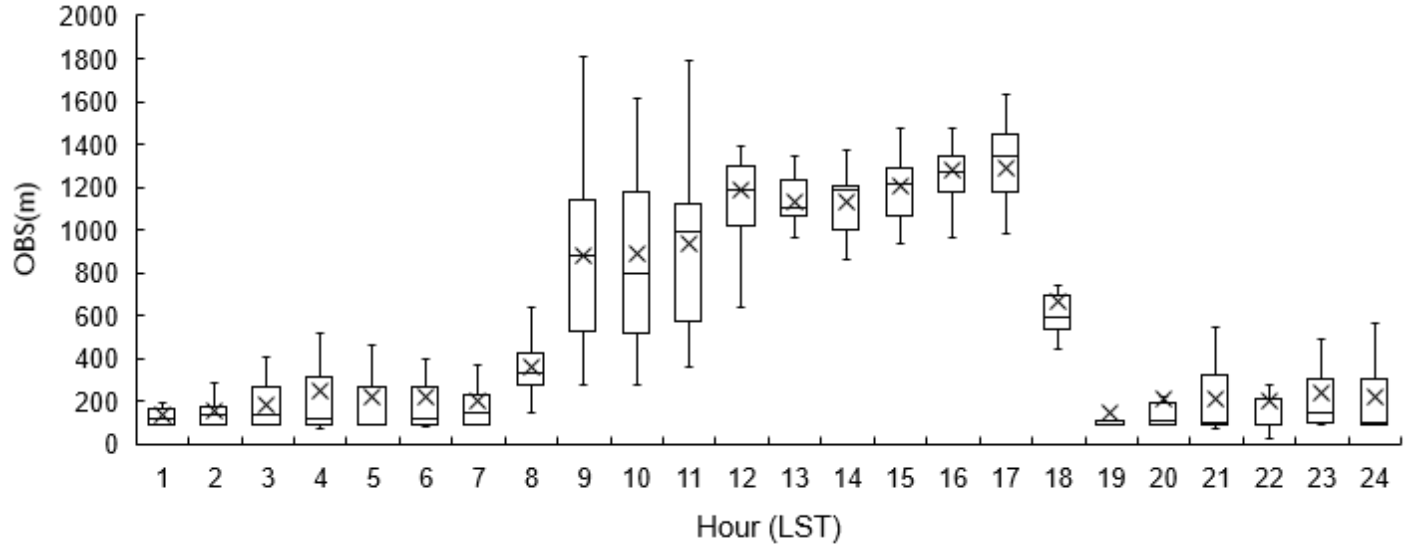
3 BOX model: MIXCH

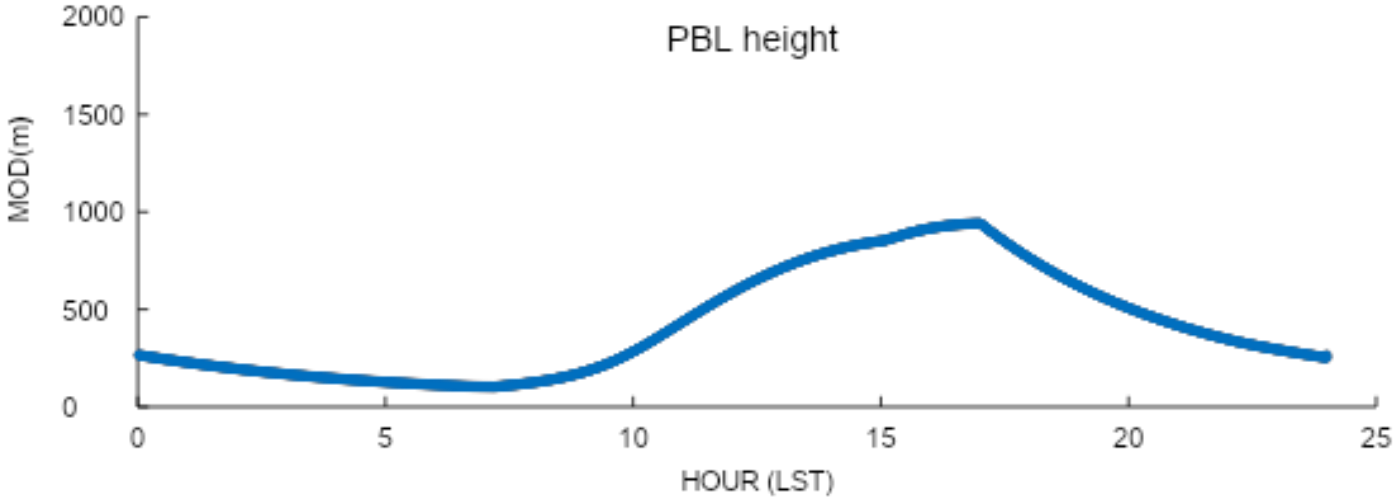


Sketches of the vertical profiles of , q, $_v$ and C_{OA}, in cases of subsidence and no subsidence. A indicates the jump of a scalar or reactant C defined as $\Delta C = C_{FT}$ -<C> and a γ_C the lapse rate of a scalar C in the FT.

Source: Ruud H. H. Janssen, ACP, 2012

3 Model result: PBL height

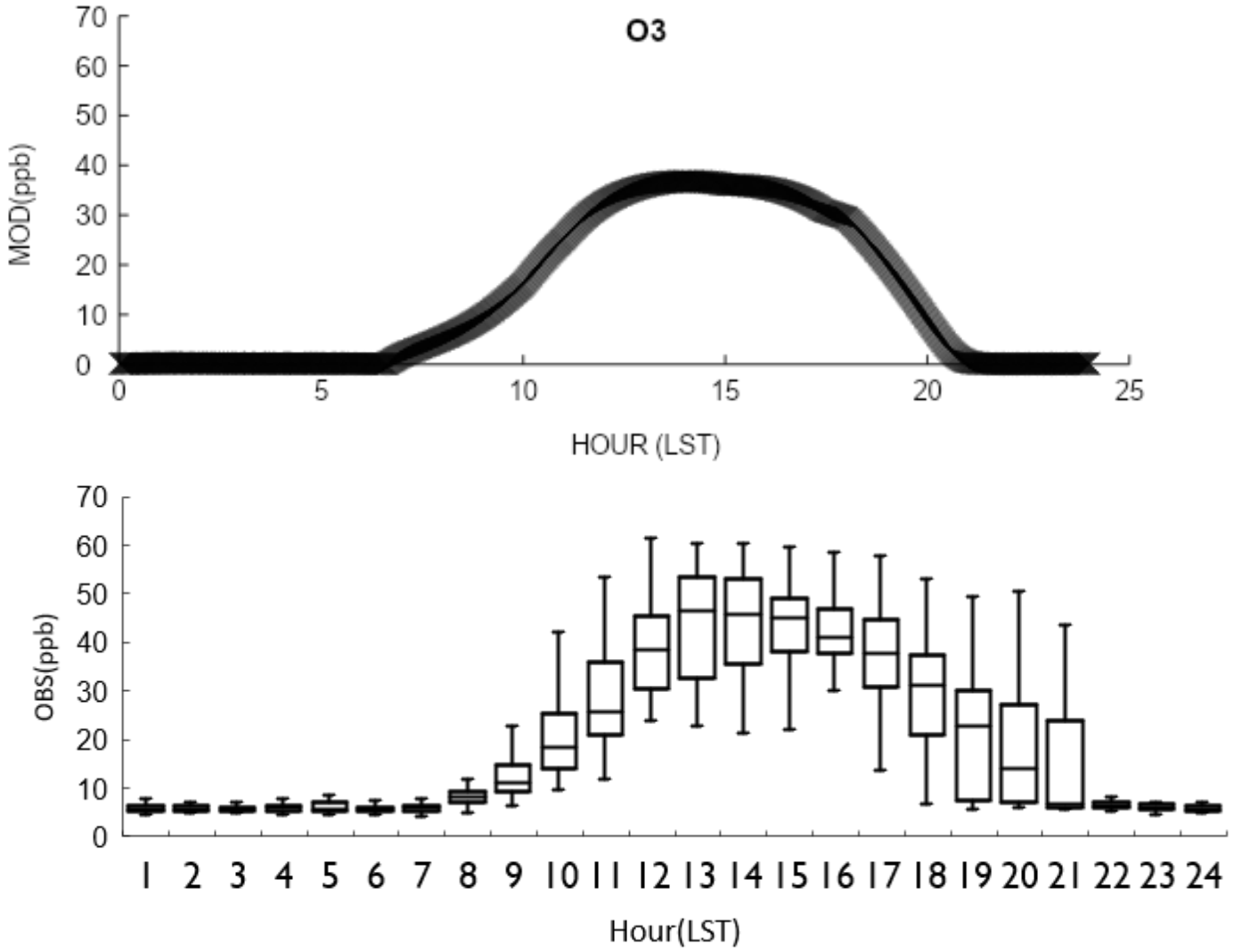




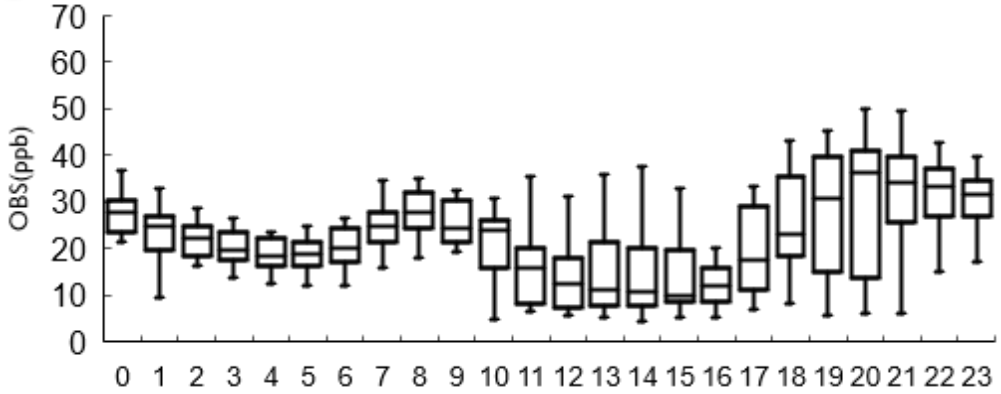
Observed PBL rapidly grows after sunrise and quickly falls down after sunset.

However,
Modeled PBL grows gradually and
and declines smoothly

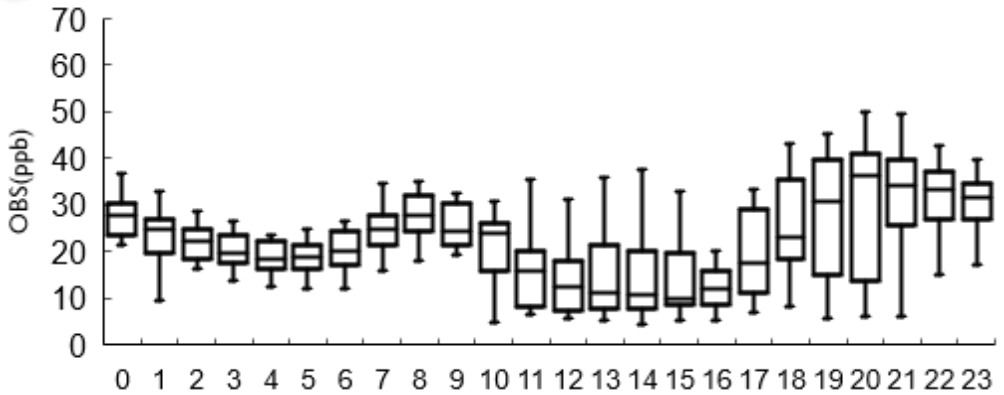
3 O_3 diurnal variation

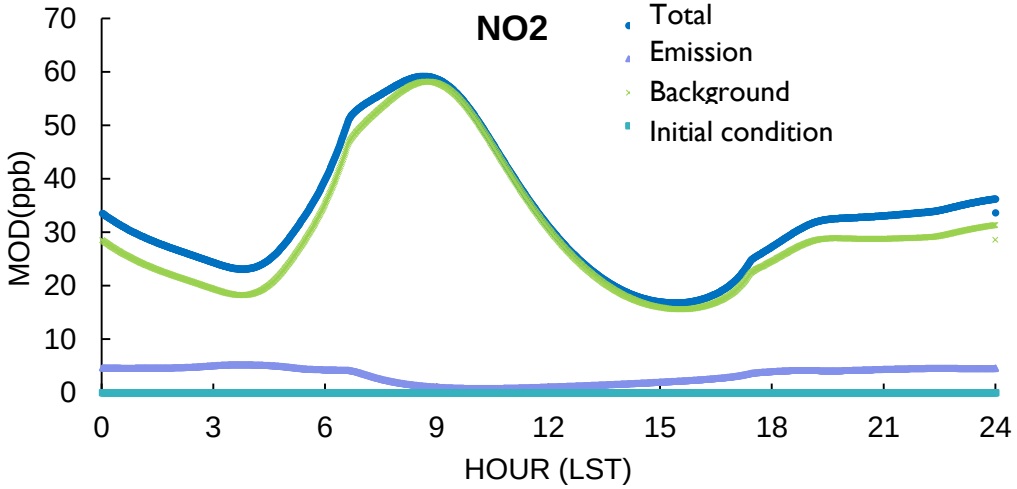


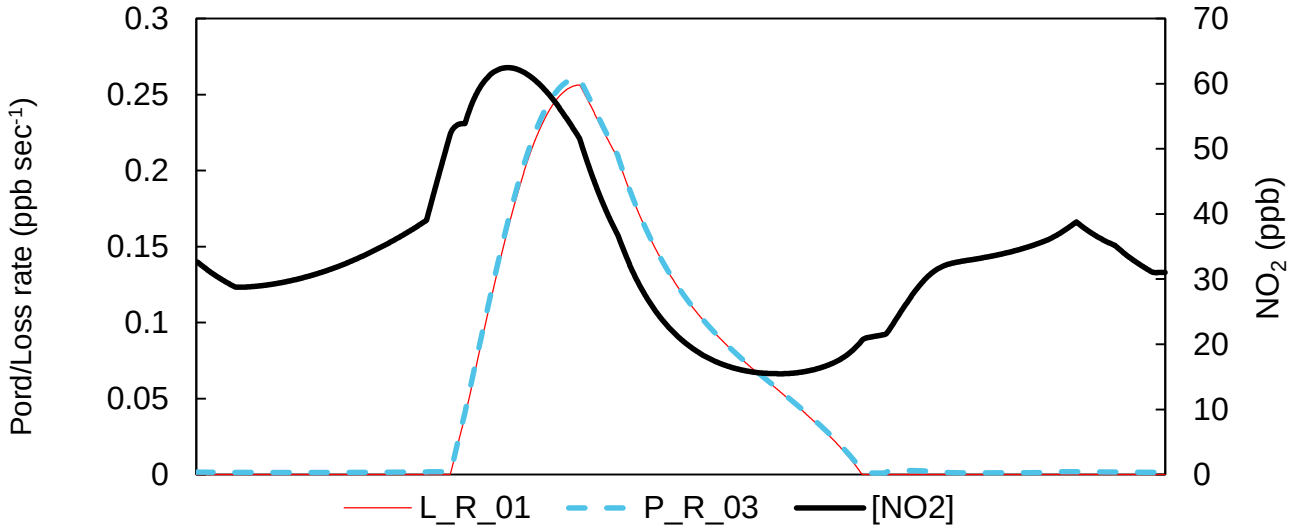
3 NO_2 diurnal variation



3 NO_2 diurnal variation



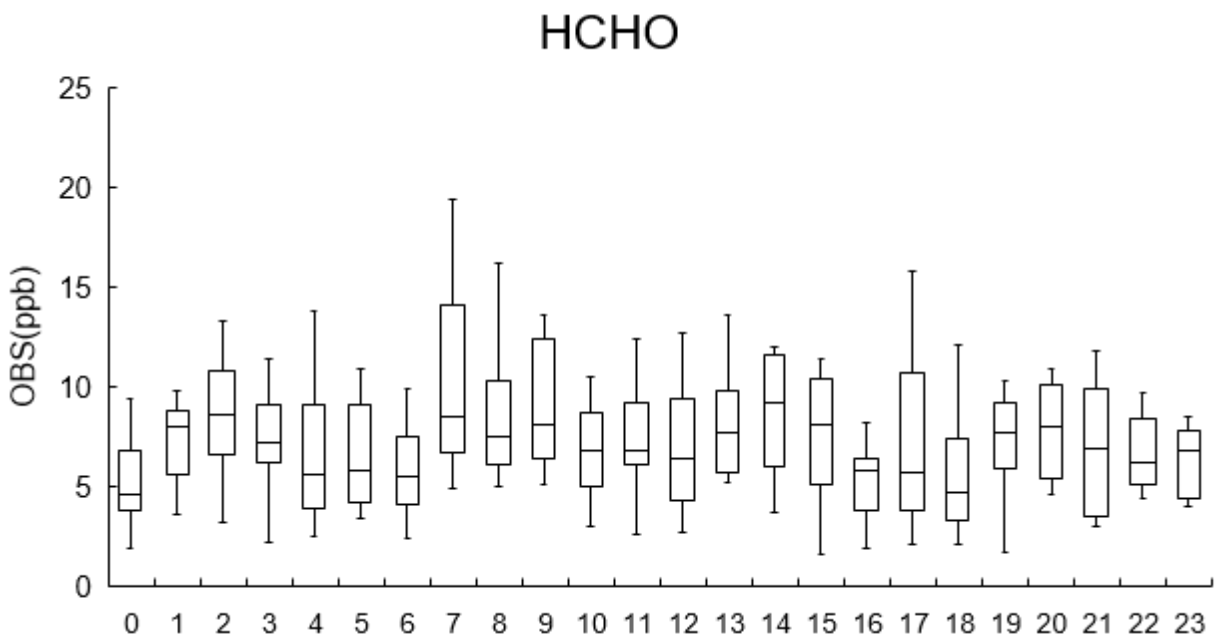




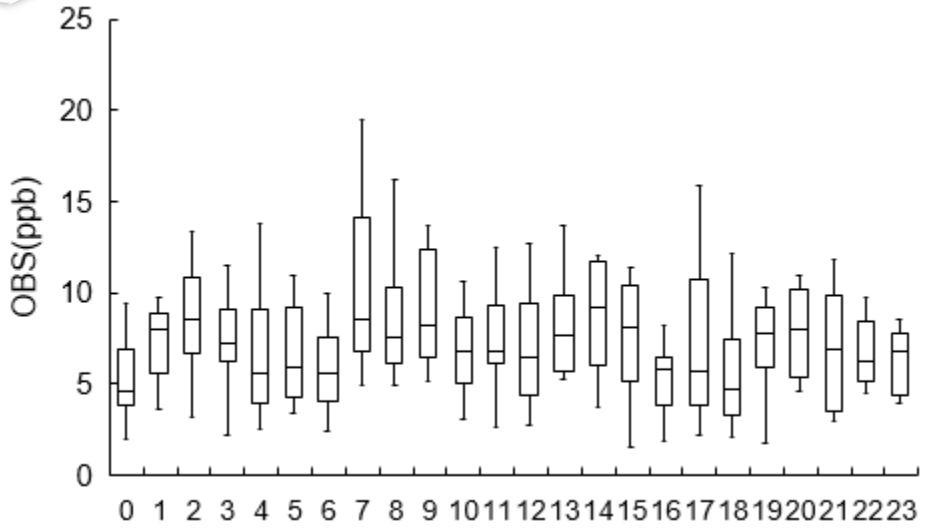
P_R_03	$O_3 + NO \rightarrow NO_2$	$1.8 \times 10^{-12} e^{\frac{1370}{T}}$
L_R_01	$NO_2 + h\nu \rightarrow O(^3P) + NO$	radiation dependent

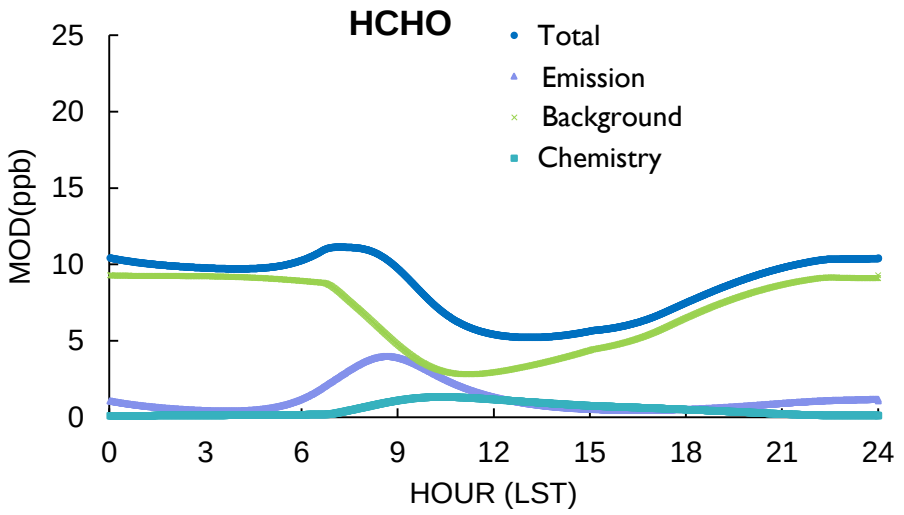
- NO2 is mainly produced by O3 + NO and is reduced to NO by photo dissociation. Production and loss reaction is in equilibrium, and emission and micrometeorology control NO_2 behavior.

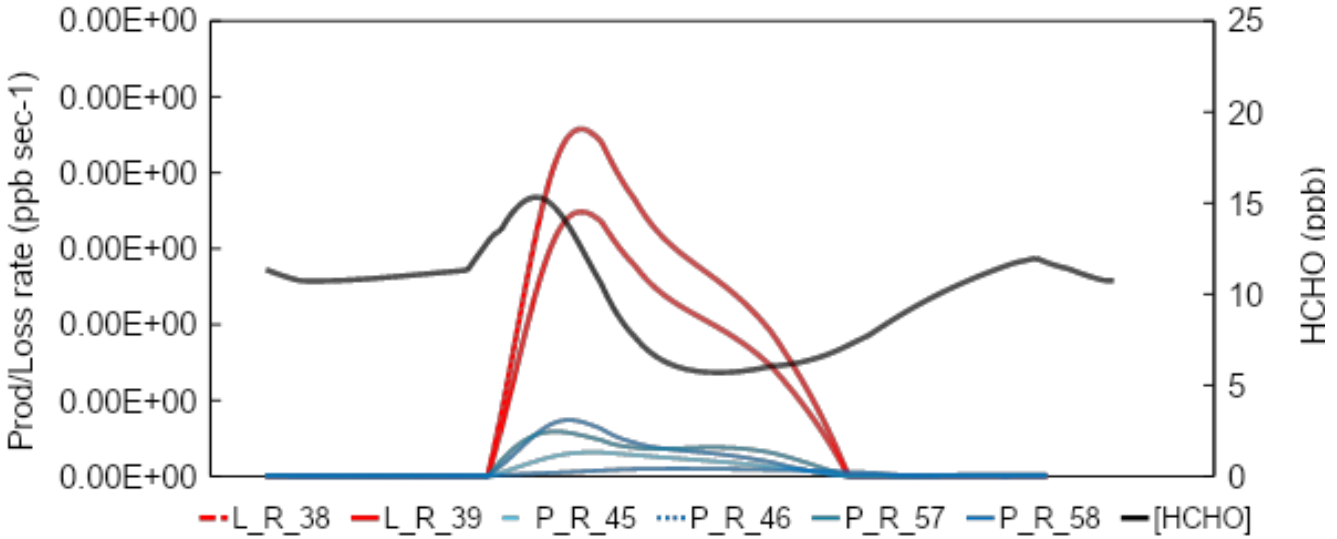
3 HCHO diurnal variation



3 HCHO diurnal variation

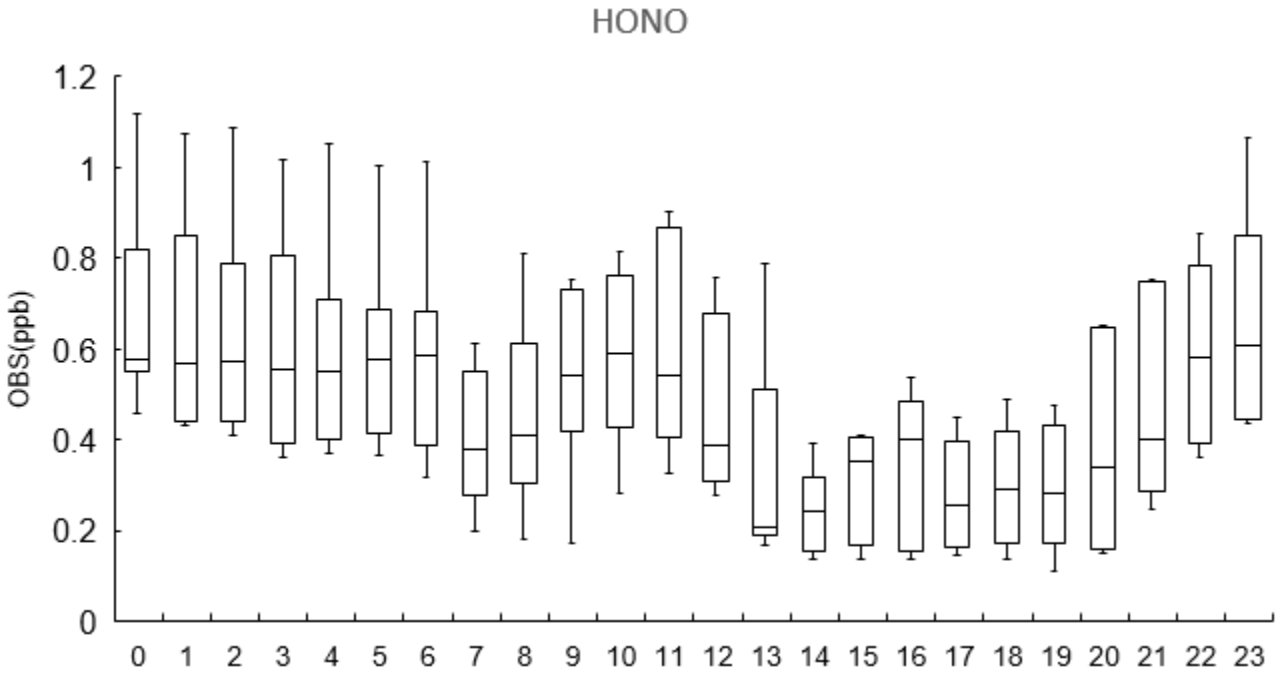




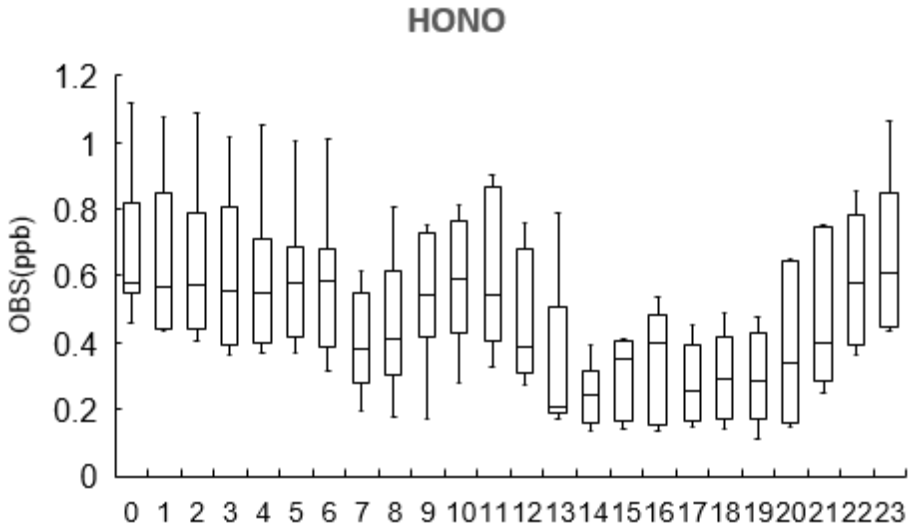


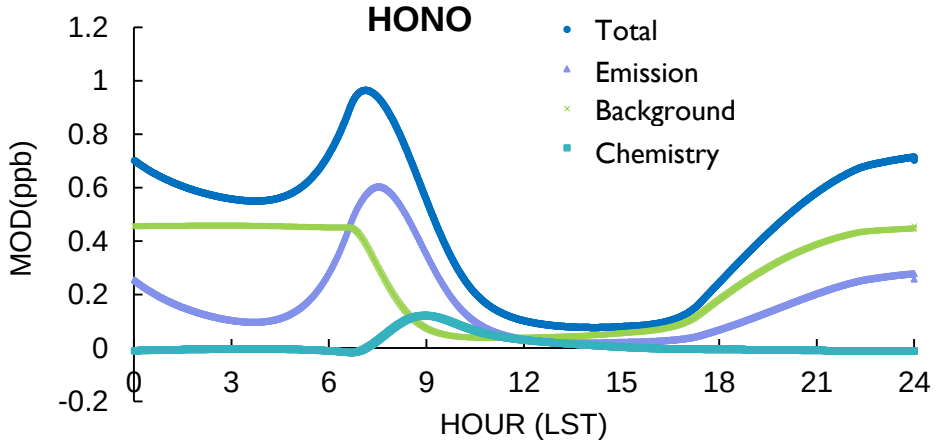
LR_38	$\mathrm{FORM} + h\nu \xrightarrow{2O_2} 2\,\mathrm{HO_2} + \mathrm{CO}$	radiation dependent
LR_39	$\mathrm{FORM} + h\nu \rightarrow \mathrm{CO}$	radiation dependent
PR_45	$\mathrm{ALD_2} + h\nu \xrightarrow{2O_2} \mathrm{FORM} + \mathrm{XO_2} + \mathrm{CO} + 2\,\mathrm{HO_2}$	radiation dependent
PR_46	$\mathrm{C_2O_3} + \mathrm{NO} \xrightarrow{O_2} \mathrm{FORM} + \mathrm{XO_2} + \mathrm{HO_2} + \mathrm{NO_2}$	$5.4 \times 10^{-12} e^{\frac{250}{T}}$
PR_57	$\mathrm{OH} + \mathrm{OLE} \rightarrow \mathrm{FORM} + \mathrm{ALD_2} + \mathrm{XO_2} + \mathrm{HO_2} - \mathrm{PAR}$	$5.2 \times 10^{-12} e^{\frac{504}{T}}$
PR_58	$\mathrm{O_3} + \mathrm{OLE} \rightarrow 0.50\,\mathrm{ALD_2} + 0.74\,\mathrm{FORM} + 0.33\,\mathrm{CO}$	$1.4 \times 10^{-14} e^{\frac{-2105}{T}}$

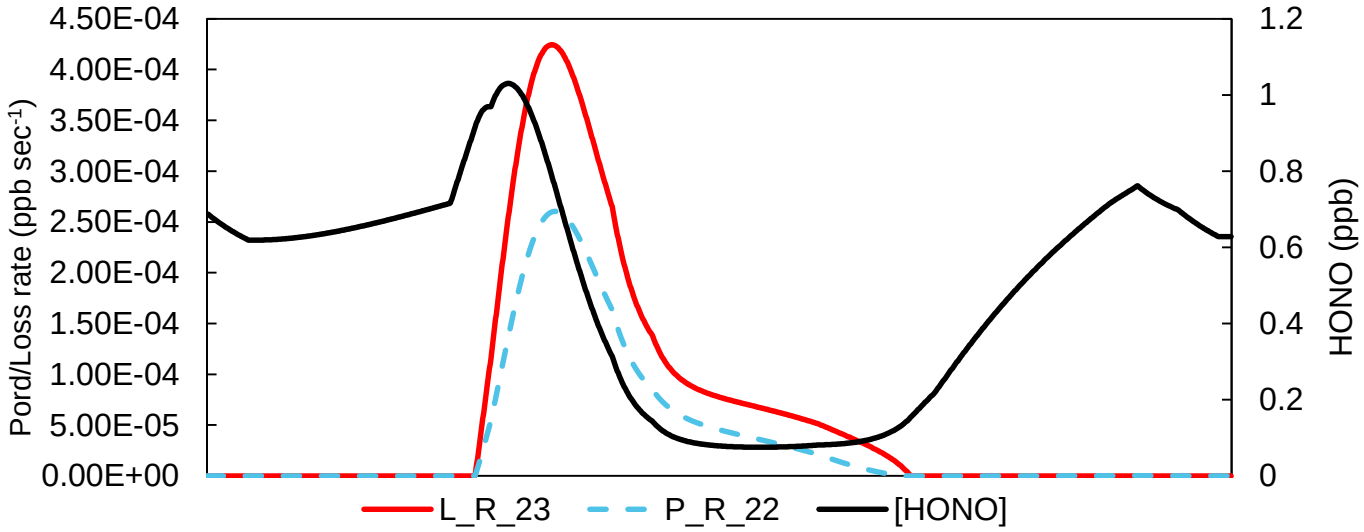
3 HONO diurnal variation



3 HONO diurnal variation





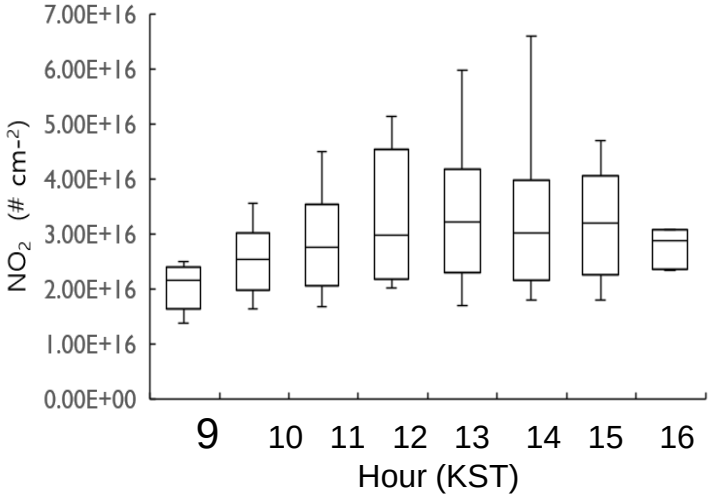


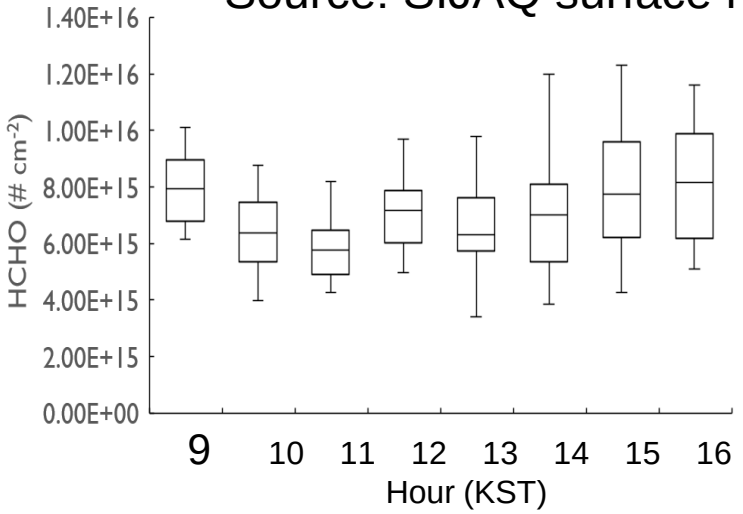
P_R_22	$OH + NO \xrightarrow{M} HONO$	$4.5 \times 10^{-13} e^{\frac{806}{T}}$
L_R_23	$HONO + h\nu \rightarrow OH + NO$	radiation dependent

3 GEMS NO_2 and HCHO VCD diurnal variation

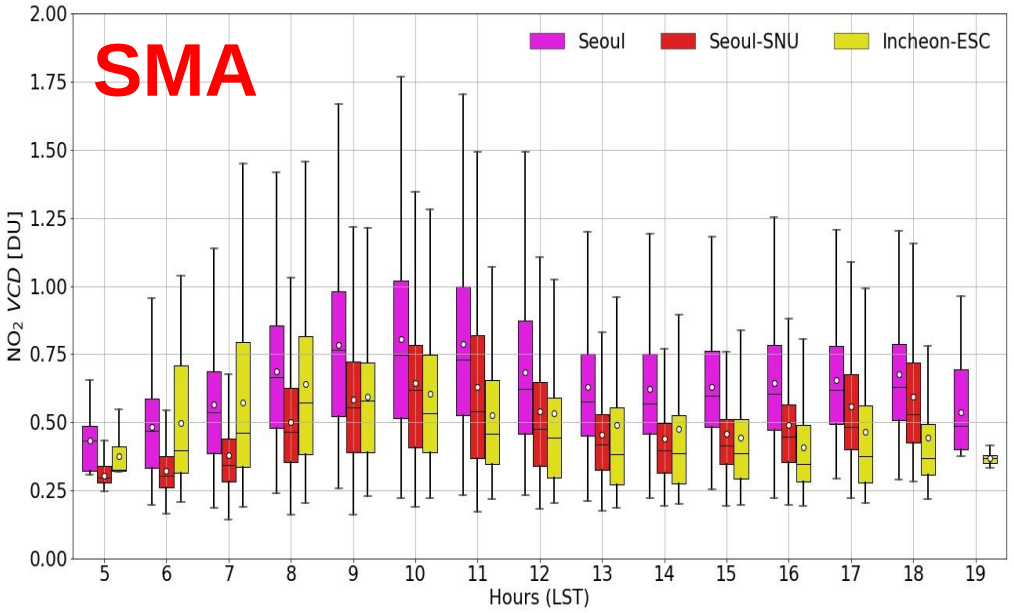
SIJAQ2021
GEMS

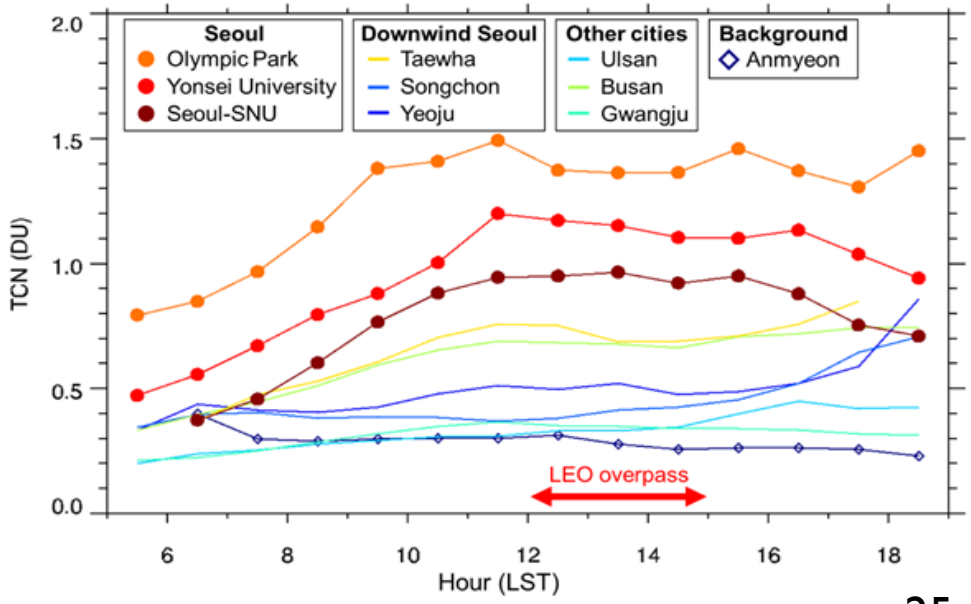
Source: SIJAQ surface remote sensing team





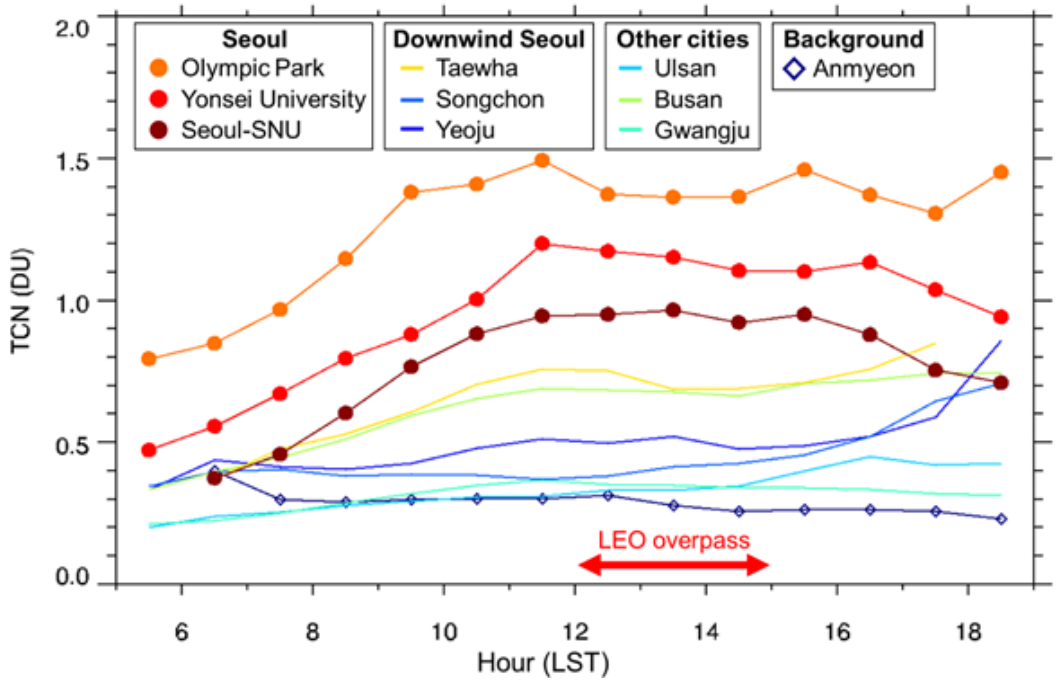
SIJAQ2021
Pandora



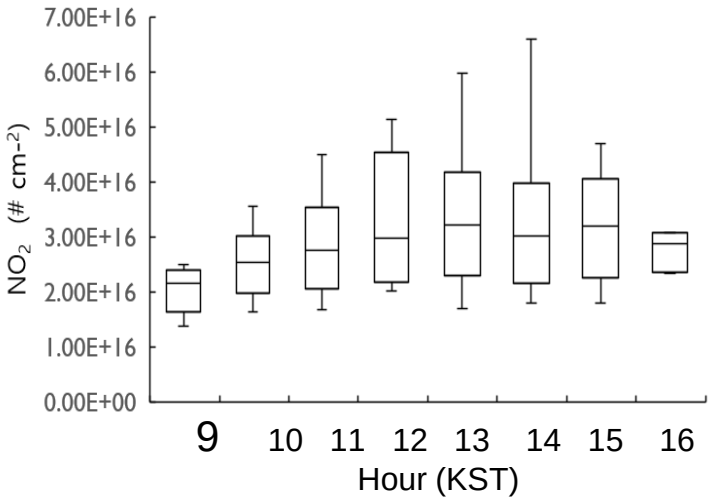


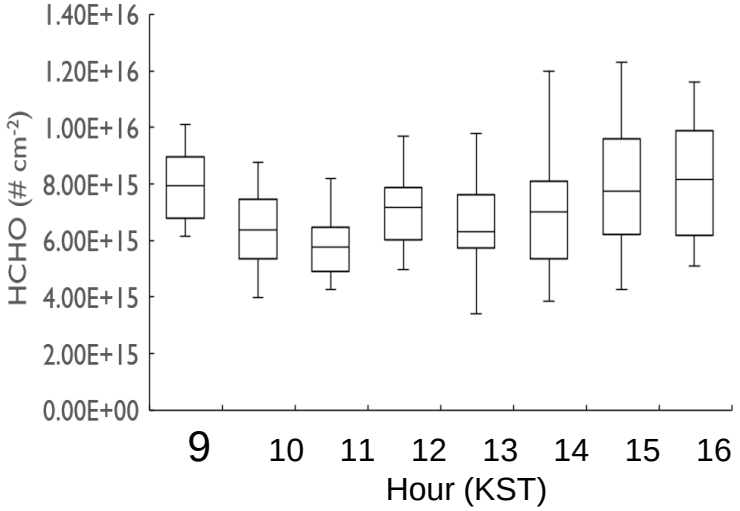
3 Pandora NO_2 VCD diurnal variation

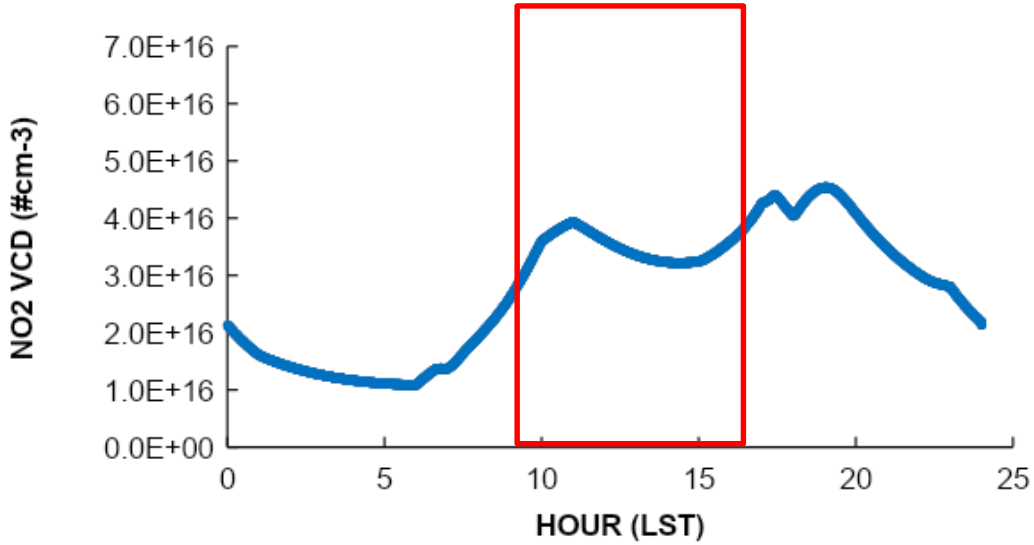
PANDORA No.	Site name	Classification	Data Period	Remarks
P163	Seoul-SNU	Seoul(urban)	Oct 11, 2019~May 31, 2021	PGN official
P39	Olympic Park	Seoul (urban)	Apr 29, 2016~Jun 14, 2016	KORUS-AQ
P40	Yonsei Univ.	Seoul (urban)	May 16, 2016~Oct 15, 2016	KORUS-AQ
P20	Taehwa	Downwind Seoul (rural)	Apr 11, 2016~Jun 12, 2016	KORUS-AQ
P35	Yeoju	Downwind Seoul (rural)	May 13, 2016~Jun 27, 2016	KORUS-AQ
P38	Songchon	Downwind Seoul (rural)	May 10, 2016~Jun 15, 2016	KORUS-AQ
P150	Ulsan	Metropolitan city (sub-urban)	Jul 25, 2019~Nov 4, 2020	PGN official
P17	Busan	Metropolitan city (urban)	Apr 6, 2016~Dec 28, 2020	PGN official
P26	Gwangju	Metropolitan city (urban)	May 1, 2015~Oct 17, 2016	KORUS-AQ
P21	Anmyeon	Background (rural)	Dec 31, 2015~Apr 7, 2016	KORUS-AQ

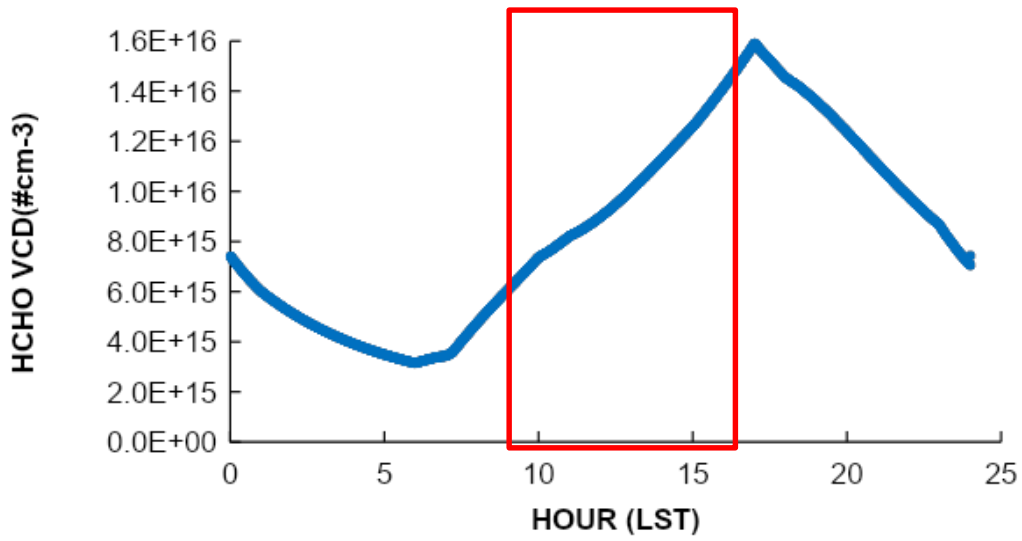


3 GEMS NO_2 and HCHO VCD diurnal variation

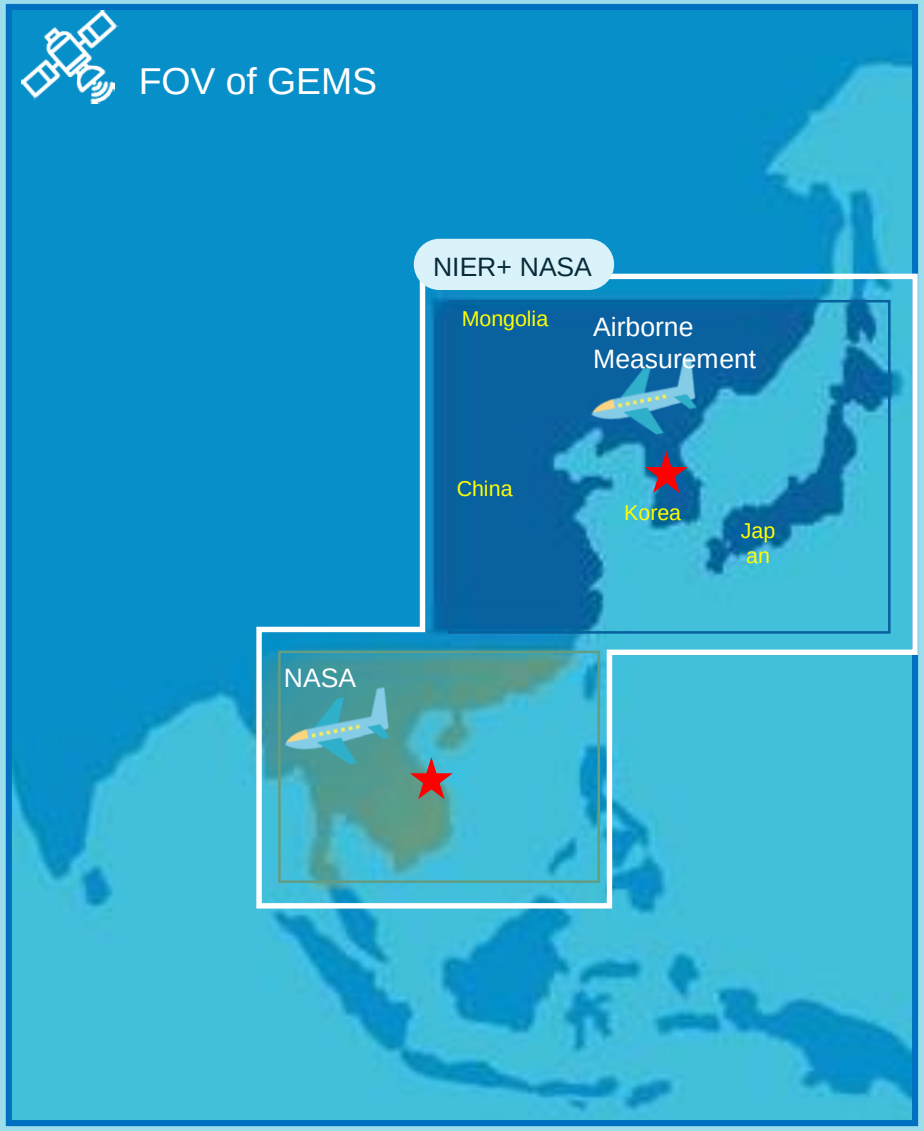








4 Future plan



Korea + NASA + Europe + Asia

Airborne sampling
Provides critical view for evaluation strategies in connecting ground-based and satellite observations, but is short term

Satellites
Provide broad coverage, continuity, but it needs reliable information on near-surface information

GMAP goal
Validating GEMS production
Understanding the relation of emission-PM2.5 concentration in winter
Improve model simulations of air quality

Ground monitoring
Will continue to be the primary method for monitoring exposure, but coverage is limited

Modeling
Provides air quality forecasting and warning service, but requires reliable information of emissions and accurate meteorology

Similar to KORUS-AQ

நன்றி

ขอบคุณ

谢谢

Thank you

ありがとうございました

cảm ơn bạn

감사합니다

Salamat

баярлалаа

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Reference

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