Agenda

<u>Science Team Telecon</u>

KORUS-AQ Science Team Meeting

KORUS-AQ publications

Science Presentations

- Ja-Ho Koo
- Rokjin Park
- Jung-Hun Woo

KORUS-AQ

Ministry of Environment
National Institute of Environmental Research

NASA

Second KORUS-AQ Science Team Meeting

27-31 August 2018; The Beckman Center at UC-Irvine; www.thebeckmancenter.org

This meeting is being reorganized to focus more specifically on the Final Science Synthesis Report to the Korean Ministry of the Environment scheduled for release in early 2019.

While we expect fewer attendees, this meeting is still open to all who wish to attend.

Those planning to attend need to be prepared to make presentations of research findings that are expected to be published by early next year and would be appropriate for a report to the Ministry of Environment. Also be prepared to contribute to the writing of the report.

There will be a process for submitting your intentions for the meeting to resolve any questions. We also need to hear from those who may not be able to attend, but have relevant material to contribute.

Progress on the broader science output of KORUS-AQ and associated publications will continue to be tracked through monthly telecons and conferences such as AGU.

Publications

Going forward, here are a few requirements that will help us to keep track of science team progress and ensure consistency among the published findings:

1) Anyone in the draft stage of manuscript writing should email their title and full author list to Jim Crawford. We will keep the list updated and shared at each monthly webex.
2) Authors are highly encouraged to present a summary of their analysis and findings during a monthly webex before submitting the paper.
3) Authors should also identify the target journal for their paper. We have not yet decided on whether a special issue will be commissioned, but this information may help us to decide whether to have a special issue or allow our papers to span many journals.
4) Double check to be sure that the most recent data is being used in your analysis (e.g., LARGE-APS size distribution data for DC-8 was updated today).
5) KORUS-AQ data doi's will become available in the near future. Please these doi's to reference the data used in your paper.
6) Intercomparison analyses of measurements are underway and will be presented in a future webex. If you are using variables measured by multiple groups, please be aware of and prepare to cite intercomparison results.

Publications (1)

Authors	Title	Journal	Status
Hwajin Kim, Qi Zhang, Jongbae Heo	Influence of Intense secondary aerosol formation and long range transport on aerosol chemistry and properties in the Seoul Metropolitan Area during spring time: Results from KORUS-AQ	Atmospheric Chemistry and Physics	Published
Najin Kim, Minsu Park, Seong Soo Yum, Jong Sung Park, Hye Jung Shin, Joon Young Ahn	Impact of urban aerosol properties on cloud condensation nuclei (CCN) activity during the KORUS-AQ field campaign	Atmospheric Environment	Under Review
W. Hu, D.A. Day, P. Campuzano-Jost, B.A. Nault, T. Park, T. Lee, P. Croteau, M.R. Canagaratna, J.T. Jayne, D.R. Worsnop, J.L. Jimenez	Evaluation of the new capture vaporizer for Aerosol Mass Spectrometers (AMS): Elemental composition and source apportionment of organic aerosols (OA).	ACS Earth Space Chemistry	Published
W. Hu, D.A. Day, P. Campuzano-Jost, B.A. Nault, T. Park, T. Lee, P. Croteau, M.R. Canagaratna, J.T. Jayne, D.R. Worsnop, J.L. Jimenez	Evaluation of the new capture vaporizer for Aerosol Mass Spectrometers: characterization of organic aerosol mass spectra	Aerosol Science and Technology	Published
Wenfu Tang, A. F. Arellano, J. P. DiGangi, Yonghoon Choi, G. S. Diskin, A. Agustí-Panareda, M. Parrington, S. Massart, B. Gaubert, Youngjae Lee, Dan-bee Kim, Jinsang Jung, Hong Jinkyu, Yugo Kanaya, Mindo Lee, A. M. Thompson, J. H. Flynn, and Jung-Hun Woo	Evaluating High-Resolution Forecasts of Atmospheric CO and CO2 from a Global Prediction System during KORUS-AQ Field Campaign	Atmospheric Chemistry and Physics	In prep
Wenfu Tang, L. K. Emmons, A. F. Arellano Jr., B. Gaubert, C. Knote, S. Tilmes, R. R. Buchholz, G. G. Pfister, D. R. Blake, N. J. Blake, J. P. DiGangi, Yonghoon Choi, G. S. Diskin, Jung-Hun Woo	Source Contribution to Carbon Monoxide during KORUS-AQ Using CAM-chem Tagged Tracers	Atmospheric Chemistry and Physics	In prep

Publications (2)

Authors	Title	Journal	Status
Eric Heim, et al.	Asian Dust Observed during KORUS-AQ Facilitates the Uptake and Incorporation of Soluble Pollutants during Transport to S. Korea; The Hwangsa Anthropogenic Model	TBD	In prep
Dan Goldberg, et al.	A high-resolution OMI NO2 product for Korea during KORUS-AQ and using it to derive NOx emissions in Seoul	TBD	In prep
Myungie Choi et al.	Assessment of aerosol optical properties from GOCI, MODIS, VIIRS, and MISR measurements over East Asia during 2016 KORUS-AQ campaign	TBD	In prep
Myungje Choi, Seoyoung Lee, et al.	Assessment of 3-D aerosol distribution for long-range transport and local emission using GOCI and ground, airborne, and satellite lidar measurement during 2016 KORUS-AQ	TBD	In prep
Heesung Chong, Seoyoung Lee, et al.	PCA-based trace gas retrievals from GeoTASO airborne measurements during KORUS-AQ	TBD	In prep
Heesung Chong, et al.	Surface NO2 volume mixing ratio estimated from total column observations of Pandora spectrometer during KORUS-AQ	TBD	In prep
Seoyoung Lee, Ja-Ho Koo, et al.	Regional transport effect to explain the aerosol concentration and variation in the Korean peninsula	TBD	In prep
Sujung Go, et al.	Imaginary part of refractive index derived from UV-MFRSR in Seoul, and implications for retrieving UV Aerosol Optical Properties for GEMS measurements	TBD	In prep
Hyungkwan Lim, et al.	Aerosol loading height retrieval from AHI using spatiotemporal variability during KORUS AQ	TBD	In prep

Publications (3)

Authors	Title	Journal	Status
Hyungkwan Lim, et al.	Intercomparison of aerosol optical depth data using AHI, GOCI and MI from Yonsei AErosol Retrieval (YAER) algorithm	TBD	In prep
Yeseul Cho, Ja-Ho Koo, et al.	Spatiotemporal properties of O3 and NO2 in the Seoul Metropolitan Area: comparison among total column, vertical profile, and surface patterns	TBD	In prep
Sang Seo Park, et al.	Temporal variation of total ozone without its variations at surface and stratosphere	TBD	In prep
Paul Romer, Ron Cohen, et al.	Constraints on aerosol nitrate photolysis as a potential source of HONO and NOx	TBD	In prep
W. Hu, P. Campuzano-Jost, D. A. Day, B. A. Nault, T. Park, T. Lee, A. Pajunoja, A. Virtanen, P. Croteau, M. R. Canagaratna, J. T. Jayne, D. R. Worsnop, J. L. Jimenez	Size distributions and ambient quantifications for organic aerosol (OA) in aerosol mass spectrometer (AMS) instruments with the new capture vaporizer (CV)	Journal of Aerosol Science	In prep
B. A. Nault, P. Campuzano-Jost, D. A. Day, J. C. Schroder, B. Anderson, A. Beyersdorf, D. R. Blake, W. H. Brune, J. D. Crounse, R. C. Cohen, Y. Choi, C. Corr, J. A. de Gouw, J. Dibb, J. P. DiGangi, G. Diskin, A. Fried, L. G. Huey, M. J. Kim, C. J. Knote, K. D. Lamb, T. Lee, D. D. Montzka, T. Park, A. E. Perring, S. E. Pusede, P. S. Romer, E. Scheuer, J. P. Schwarz, K. L. Thornhill, P. O. Wennberg, A. J. Weinheimer, A. Wisthaler, J. H. Woo, P. J. Wooldridge, and J. L. Jimenez	Secondary Organic Aerosol Production over Seoul, South Korea, during KORUS-AQ	Atmospheric Chemistry and Physics	In prep

Publications (4)

Authors	Title	Journal	Status
B. A. Nault, P. Campuzano-Jost, D. A. Day, J. C. Schroder, D. R. Blake, M. R. Canagaratna, J. A. de Gouw, F. Flocke, A. Fried, J. B. Gilman, T. F. Hanisco, L. G. Huey, B. T. Jobson, W. C. Kuster, B. Lefer, J. Liao, D. D. Montzka, I. B. Pollack, J. Peischl, B. Rappenglueck, J. M. Roberts, T. B. Ryerson, J. Stutz, P. Weibring, A. J. Weinheimer, E. C. Wood, and J. L. Jimenez	Quantification of the Rapid Photochemical Secondary Organic Aerosol Production Observed across Megacities around the World	Nature Geosciences or PNAS	In prep
B. A. Nault, P. Campuzano-Jost, D.A. Day, W. W. Hu, B. B. Palm, J. C. Schroder, R. Bahreini, H. Bian, M. Chin, S. L. Clegg, P. Colarco, J. Crounse, J. A. de Gouw, J. Dibb, M. J. Kim, J. Kodros, F. D. Lopez-Hilfiker, E. A. Marais, A. Middlebrook, J. A. Neuman, J. B. Nowak, J. Pierce, J. M. Roberts, E. Scheuer, J. A. Thornton, P. R. Veres, P. O. Wennberg, and J. L. Jimenez	Global Survey of Submicron Aerosol Acidity (pH)	Nature Geosciences or PNAS	In prep
D. Jeong, R. Seco, D. Gu, Y. Lee, B. Nault, C. Knote, T. Mcgee, J. Sullivan, J. L. Jimenez, P. Campuzano-Jost, D. Blake, D. Sanchez, A. Guenther, D. Tanner, G. Huey, R. Long, B. E. Anderson, S. R. Hall, Y.-J. Lee, D. Kim, J.-Y. Ahn, A. Wisthaler, and S. Kim	Integration of Airborne and Ground Observations of Nitryl Chloride in the Seoul Metropolitan Area and Its Impact on the Regional Oxidation Capacity During the KORUS-AQ 2016 Field Campaign	TBD	In prep
D. Sanchez, R. Seco, D. Gu, A. Guenther, D. Jeong, J. Mak, Y.-J. Lee, D. Kim, D. Blake, S. Herndon, D. Jeong, T. Mcgee, and S. Kim	OH Reactivity Budget Analysis at the Taehwa Research Forest During KORUS-AQ 2016	TBD	In prep

Publications (5)

Authors	Title	Journal	Status
Isobel Simpson, et al.	Characterization and source apportionment of VOCs in the Seoul Metropolitan Area	TBD	In prep
Kara Lamb, et al.	Regional influences on the direct radiative forcing from black carbon observed over S. Korea	JGR-Atmospheres	In prep
Jinkyul Choi, Rokjin J. Park, Hyung-Min Lee, Seungun Lee, Duseong S. Jo, Jaein I. Jeong, Daven Henze, Jung-Hun Woo, Soo-Jin Ban, Min-Do Lee, Cheol-Soo Lim, Mi-Kyung Park, Hye J. Shin, Seogju Cho, and David Peterson	Source attribution of PM2.5 for Korea during the KORUS-AQ campaign using GOES-Chem adjoint model	TBD	In prep
Yujin Ok, Rokjin J. Park, D. Blake, W. Brune, A. Weinheimer, A. Fried, J. Crawford, and J. Schroeder	Evaluation of simulated VOCs during the KORUS-AQ campaign and their effect on ozone production in Korea	TBD	In prep
Hyeonmin M. Kim, Rokjin J. Park, Jaein I. Jeong, Daun Jeong, Saewung Kim, and Seogju Cho	Effect of nitryl chloride chemistry on oxidation capacity in East Asia	TBD	In prep
Hyung-Min Lee, Rokjin Park, Hyeong-Ahn Kwon	Top-down estimate of isoprene emissions in East Asia using inverse modeling: implication of satellite retrievals from GOME-2 and OMI formaldehyde with KORUS-AQ aircraft observations	TBD	In prep
David Peterson, et al.	Meteorology Influencing Pollution Regimes and Transport during KORUS-AQ	TBD	In prep

Publications (6)

Authors	Title	Journal	Status
K. Miyazaki, T. Sekiya, D. Fu, K. Bowman, S. Kulawik, K. Sudo, T. Walker, Y. Kanaya, M. Takigawa, K. Ogochi, H. Eskes, F. Boersam, B. Gaubert, J. Barre, and L. Emmons, and the KORUS-AQ team	Evaluation of a multi-constituent chemical reanalysis during KORUS-AQ: Role of dynamics and emissions	JGR-Atmospheres	In prep
Changmin Cho, J. St. Clair, G. Wolfe, Jin Liao, Sukhan Jung, Dae il Kang, Jinsoo Choi, Myung-Hwan Shin, Jinsoo Park, T. Hanisco, Kyung-Eun Min	Top-down estimation of volatile organic compounds (VOCs) emission rates in petrochemical complex using airborne in-situ formaldehyde (HCHO) observation	Atmospheric Environment or ACP	In prep
Minsu Park, Najin Kim, Seong Soo Yum, Lee Thornhill, Bruce Anderson, Dong-Su Kim, Hyun-Jae Kim, Ha-Eun Jeon, Yun-Seo Park, Sang-Bo Lee	On the submicron aerosol distributions and CCN activity in and around the Korean Peninsula measured onboard the NASA DC-8 research aircraft during the KORUS-AQ field campaign	TBD	In prep
Jin Liao, T. Hanisco, G. Wolfe, J. St. Clair, J. Jimenez, P. Campuzano-Jost, B. Nault, A. Fried, E. Marais, G. Gonzalez Abad, K. Chance, H. Jethva, T. Ryerson, C. Warneke, A. Wisthaler	Towards a satellite-in situ hybrid proxy for organic aerosol abundance	ACP	In prep
Mark F. Lunt, Sunyoung Park, Shanlan Li, Stephan Henne, Alistair J. Manning, Anita L. Ganesan, Isobel J. Simpson, Donald R. Blake, Qing Liang, Simon O'Doherty, Christina M. Harth, Jens Muhle, Peter K. Salameh, Ray F. Weiss, Paul B. Krummel, Paul J. Fraser, Ronald G. Prinn, Stefan Reimann, and Matthew Rigby	Continued emissions of the banned ozone-depleting substance - carbon tetrachloride - from East Asia	Nature Geosciences	Submitted

Publications (7)

Authors	Title	Journal	Status
Herman, Jay, Elena Spinei, Jhoon Kim, Jae Kim, Woogyung Kim, Nader Abuhassan, Michal Segal-Rozenhaimer, Alexander Cede	NO2 and HCHO Measurements in Korea from 2012 to 2016 using a network of Pandora Spectrometer Instruments	AMT	Submitted
Spinei, E., N. Abuhassan, A Cede, M. Tiefengraber, M. Mueller, J. Herman, N. Nowak, B. Poche, S. Choi7, A. Whitehill, J. Szykman, V. Lukas, D. Williams, R. Long, Jin Liao, Jason St. Clair, Glenn Wolfe, Thomas Hanisco, Changmin Cho, Alan Fried, Petter Weibring, Dirk Richter, Robert Swap, James Walega	Pandora formaldehyde measurements during KORUS-AQ over Olympic Park and Taehwa (South Korea, April-June 2016)	AMT	Submitted
KORUS-AQ Leadership	KORUS-AQ Overview Paper	BAMS?	In prep

The effect of long-range transboundary transport on the Korean aerosol pollution during the KORUS-AQ campaign.

Seoyoung Lee[1], Jhoon Kim[1,2], Myungje Choi[1], Jaemin Hong[1], Hyunkwang Lim[1], Tom F. Eck[3], Brent N. Holben[3], Joon-Young Ahn[4], Jeong Soo Kim[4], and Ja-Ho Koo[1]

[1]Department of Atmospheric Sciences, Yonsei University, Seoul, Republic of Korea
[2]Harvard Smithsonian Center for Astrophysics, Cambridge, MA, USA
[3]NASA Goddard Space Flight Center, Greenbelt, MD, USA
[4]National Institute of Environmental Research, Incheon, Republic of Korea

Main motivation of this study

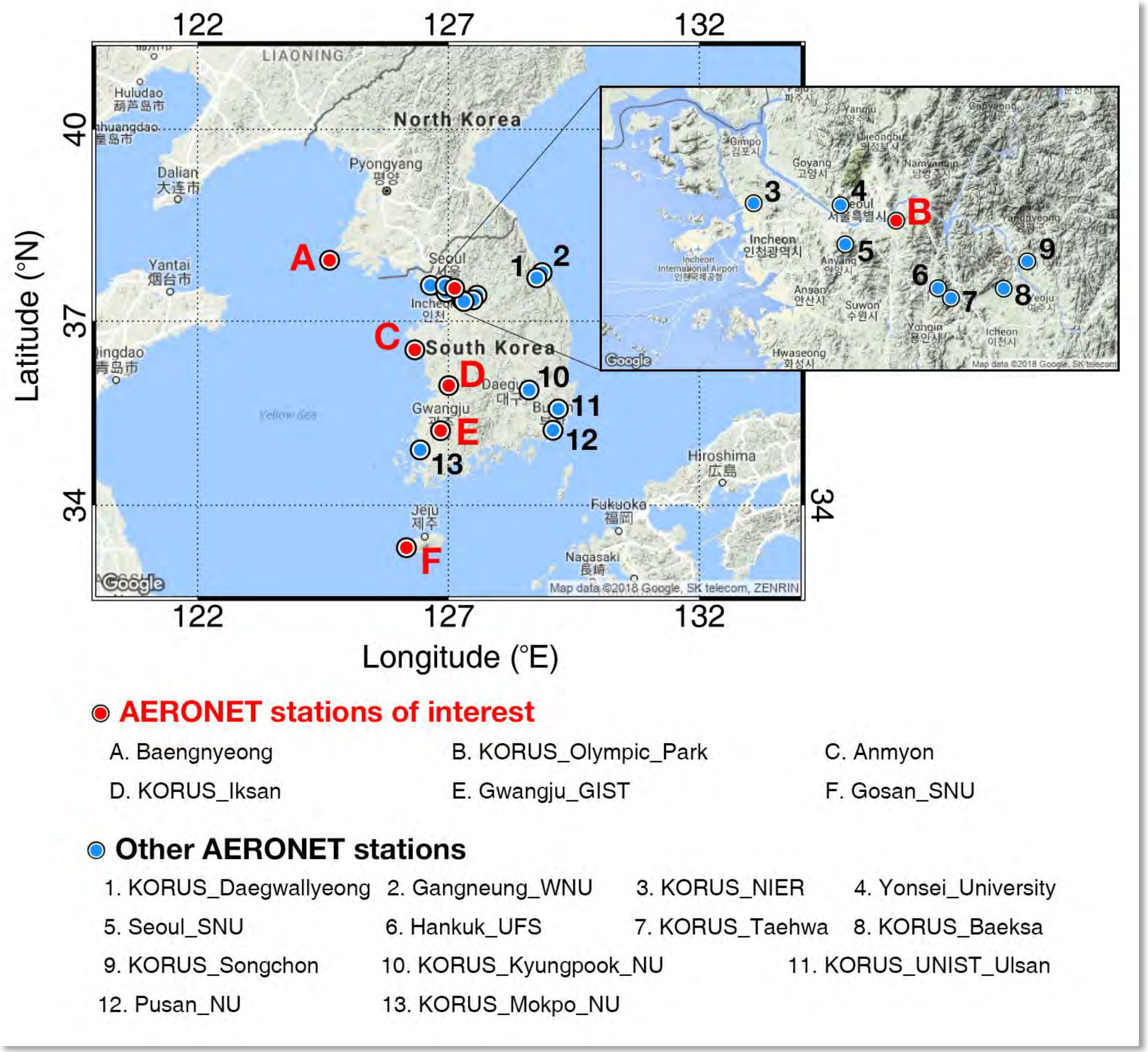
- Remote-sensing based investigation of long-range transboundary transport (LRTT) from the west of Korea to evaluate the transport effect to the Korean domestic air quality during the KORUS-AQ campaign.

Used data in this study

- AERONET version 2 and version 3 dataset: Aerosol optical depth (500 nm) and Angstrom exponent (440-870 nm)
- Satellite AOD measurements: Geostationary Ocean Color Imager (GOCI) and Advanced Himawari Imager (AHI) observations
- HYSPLIT-4 back-trajectory calculations, comparing with the FLEXPART back-trajectories provided from Christoph Knote.

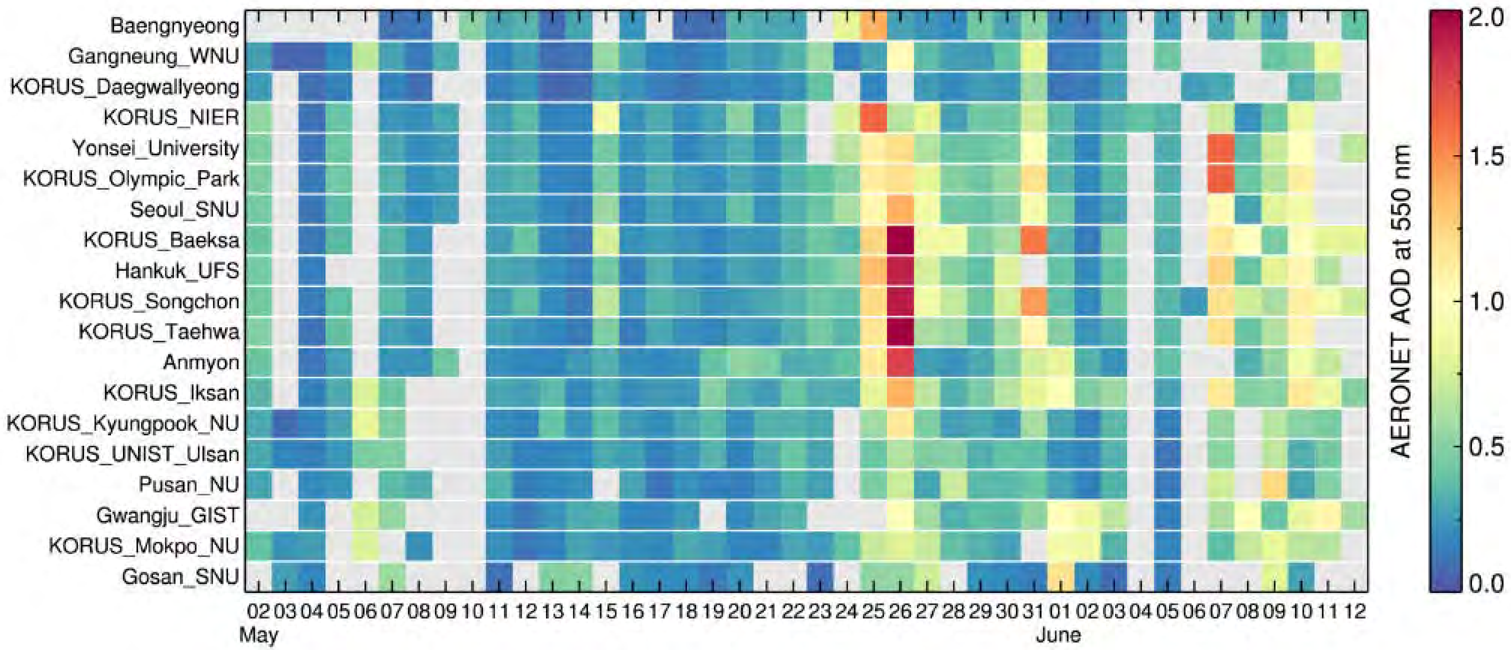
AERONET sites during the KORUS-AQ campaign

- For the research purpose (investigation of transport effect from the west), here we highlight the 6 sites located in the western part of Korean peninsula.

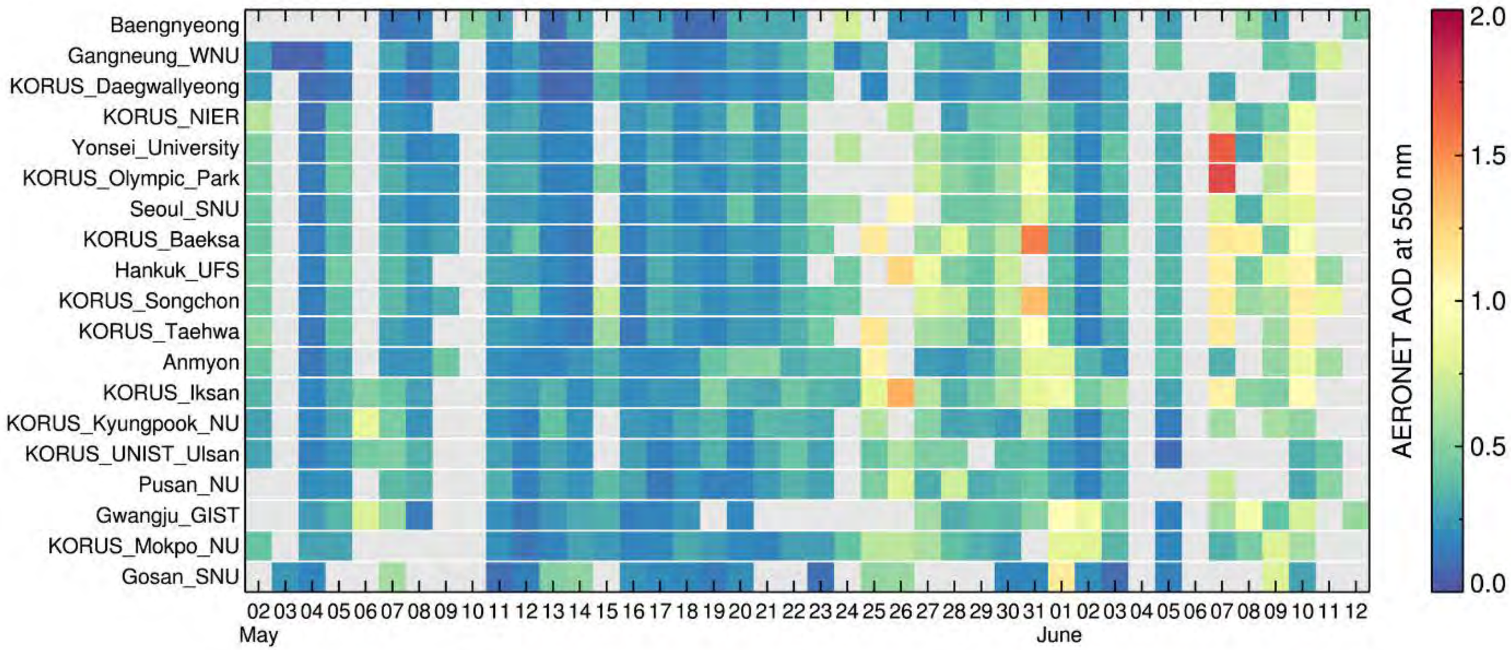


AOD at 500 nm

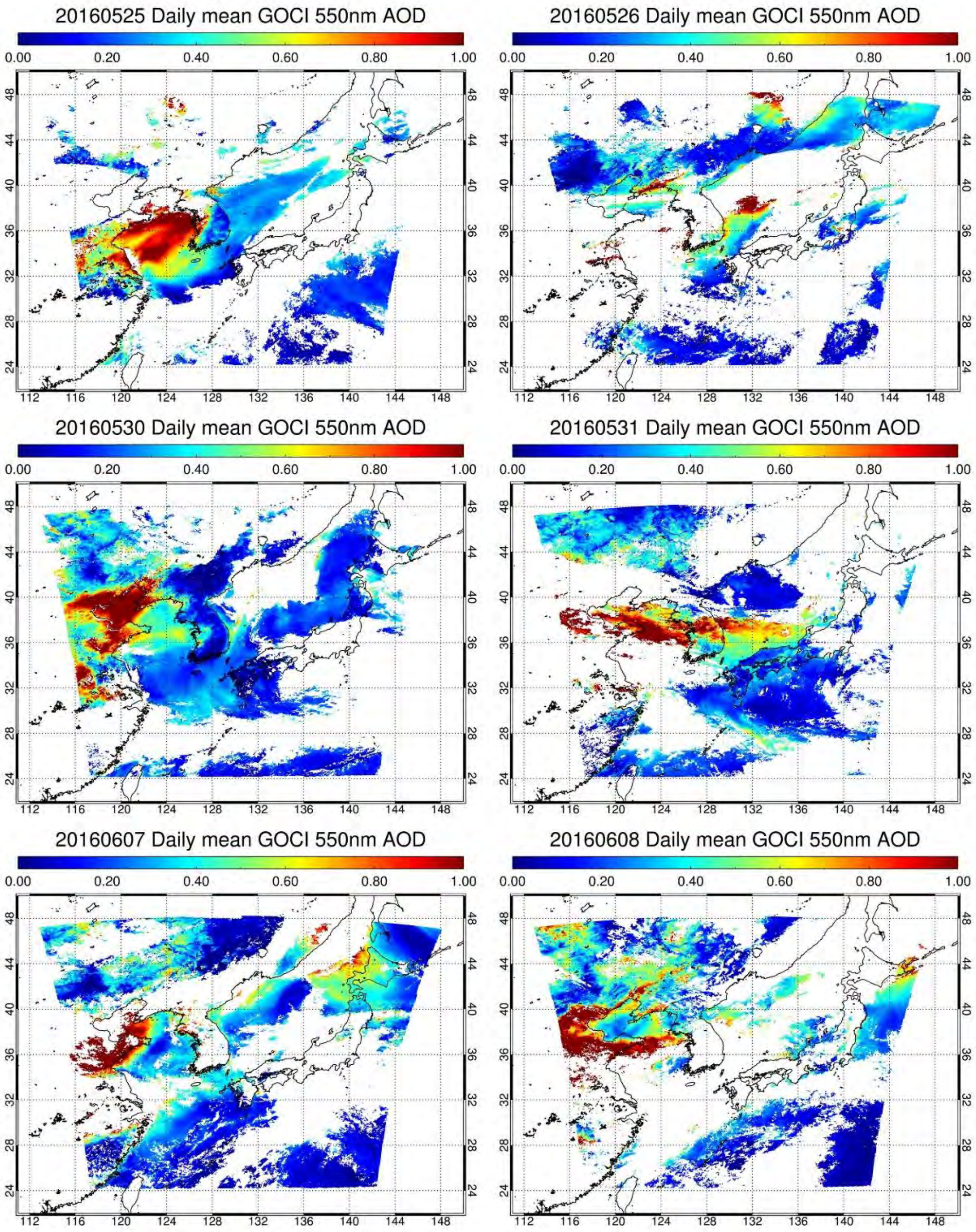
AERONET version 3
(Eck et al., 2018)



AERONET version 2



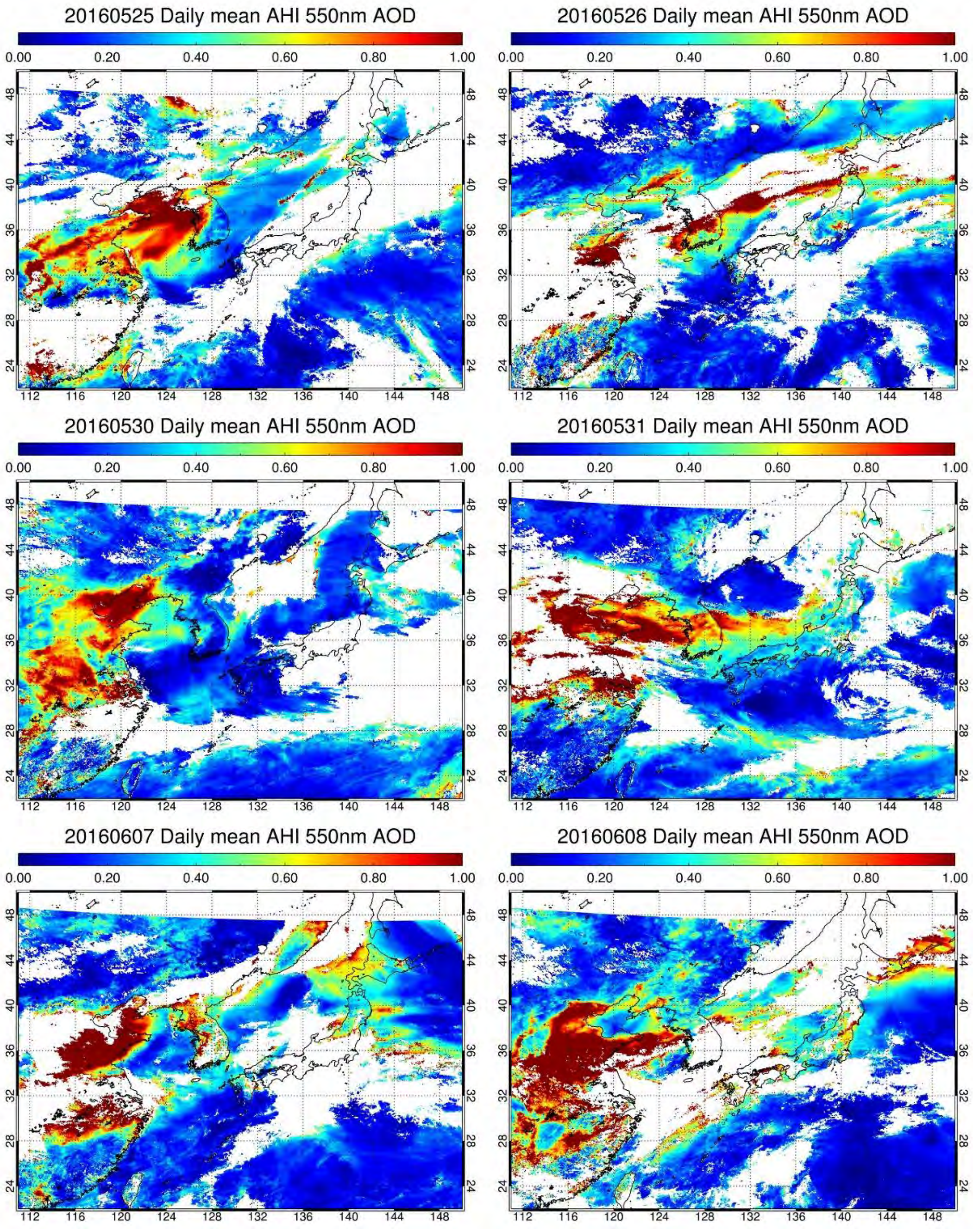
GOCI & AHI AOD



25-26 May

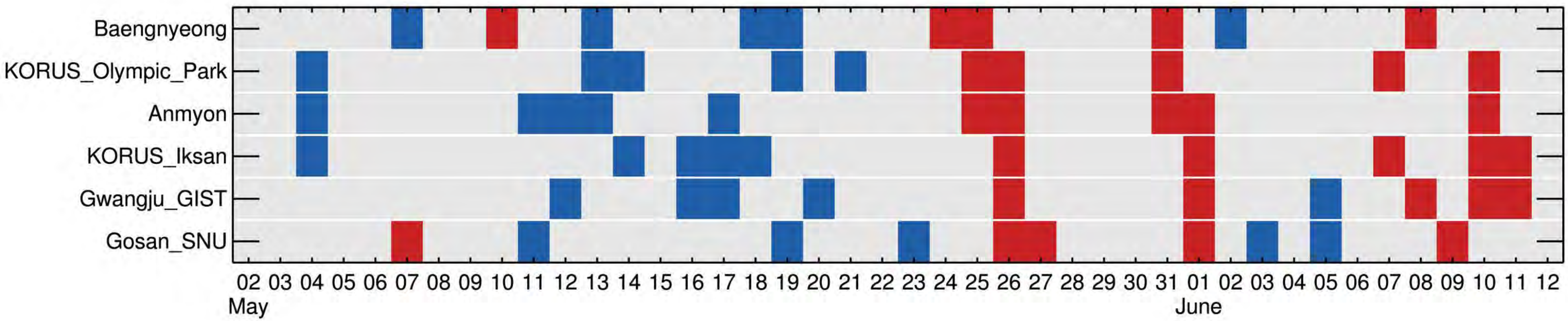
30-31 May

7-8 June



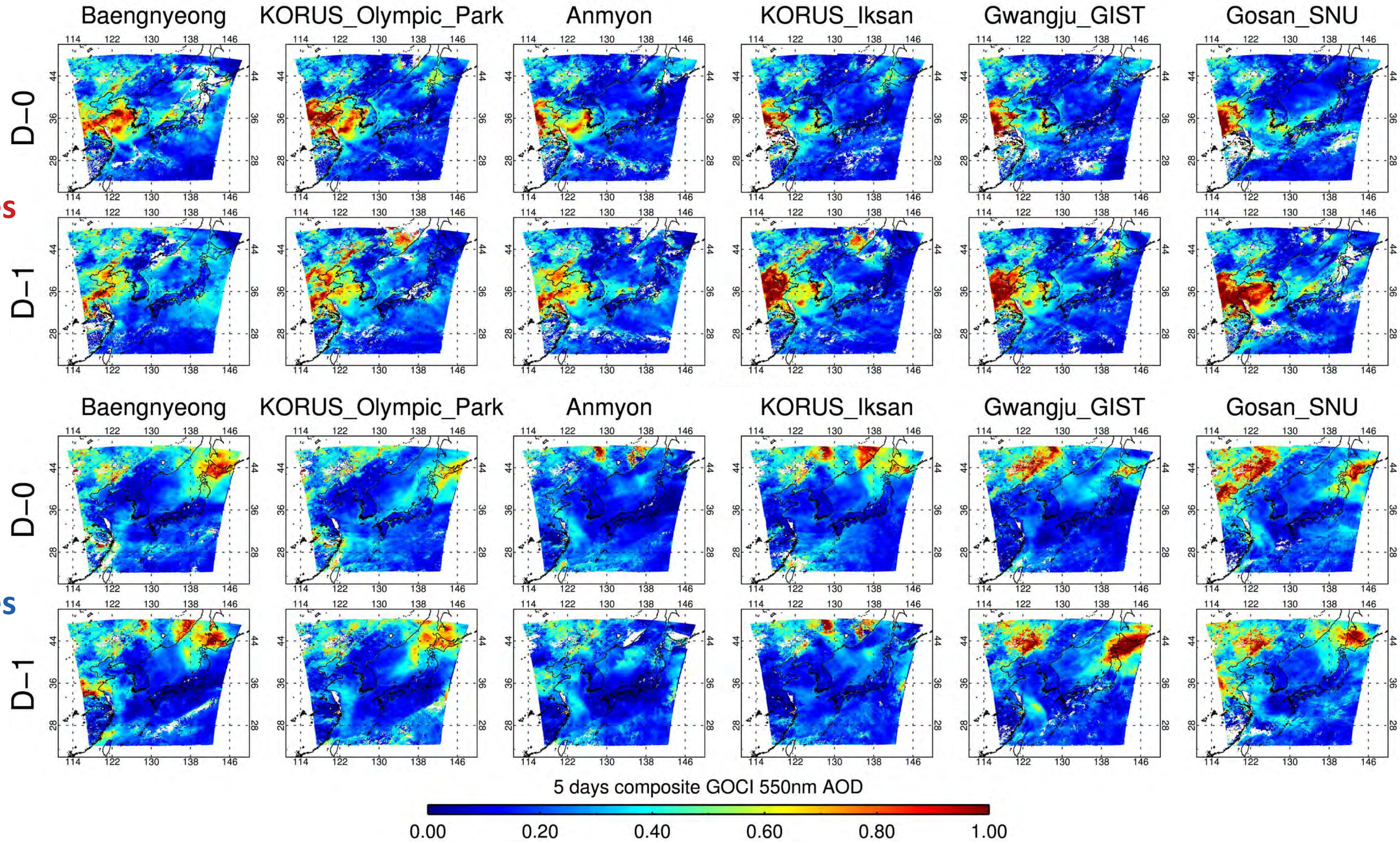
Extreme AOD composite analysis for each site

Highest AOD cases (5 days)   Lowest AOD cases (5 days)



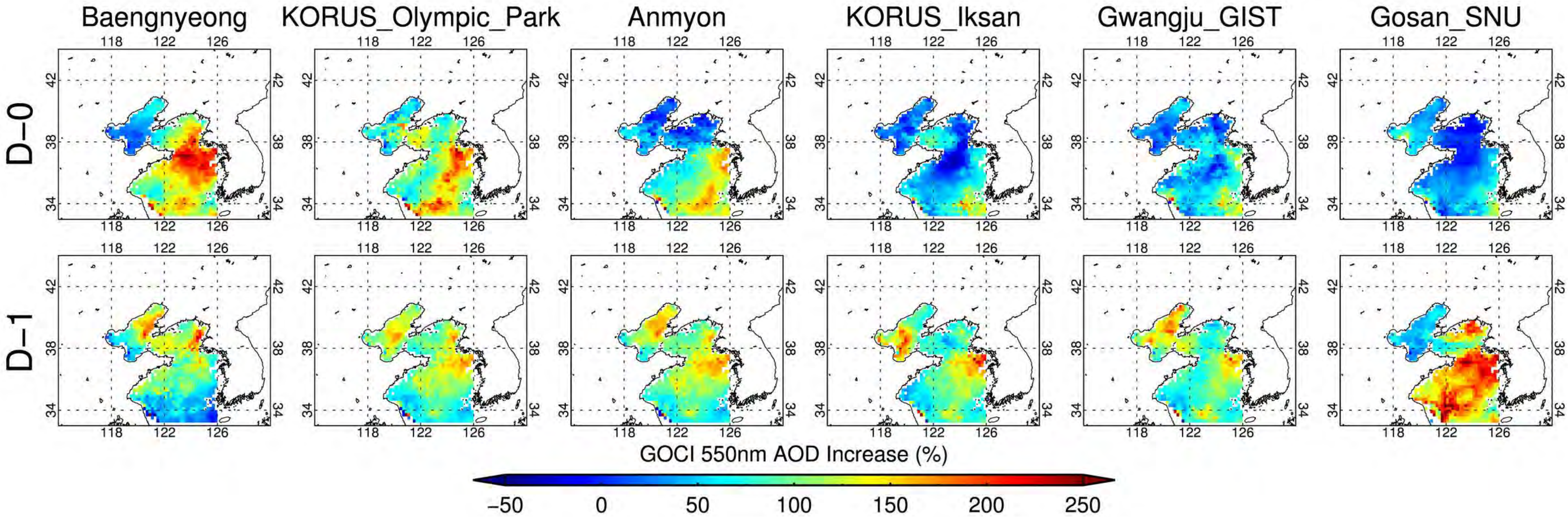
Highest AOD cases (5 days)

Lowest AOD cases (5 days)



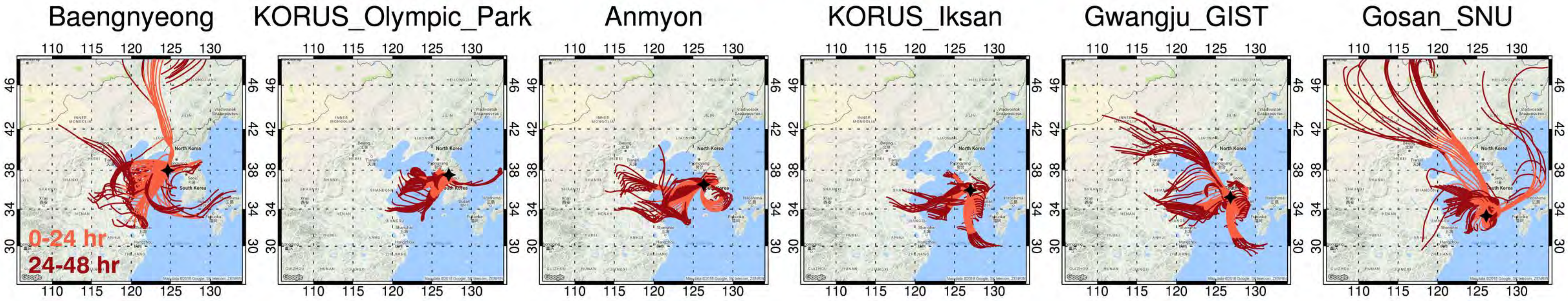
The range of AOD enhancement compared to the mean condition

AOD increase (%) = (5 day composite showing high AOD – Mean AOD)/mean AOD × 100

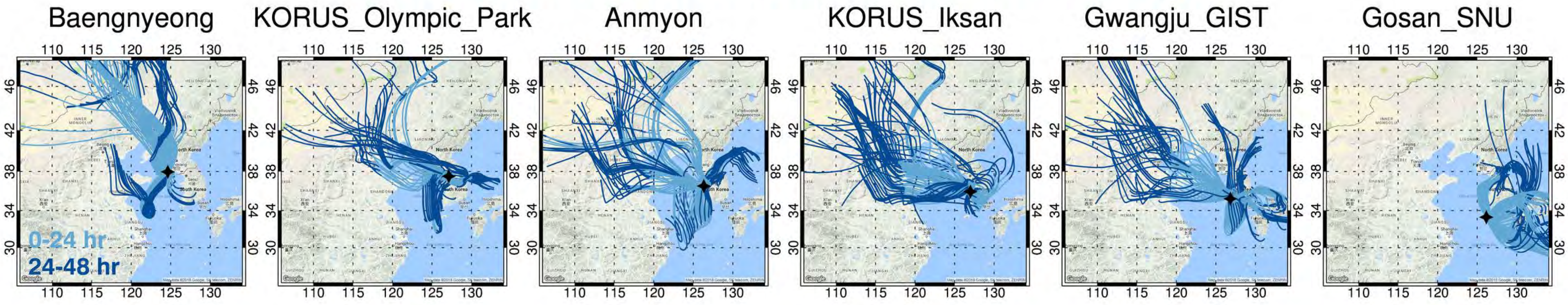


Spatial pattern of 2-day back-trajectories (HYSPLIT-4 calculations)

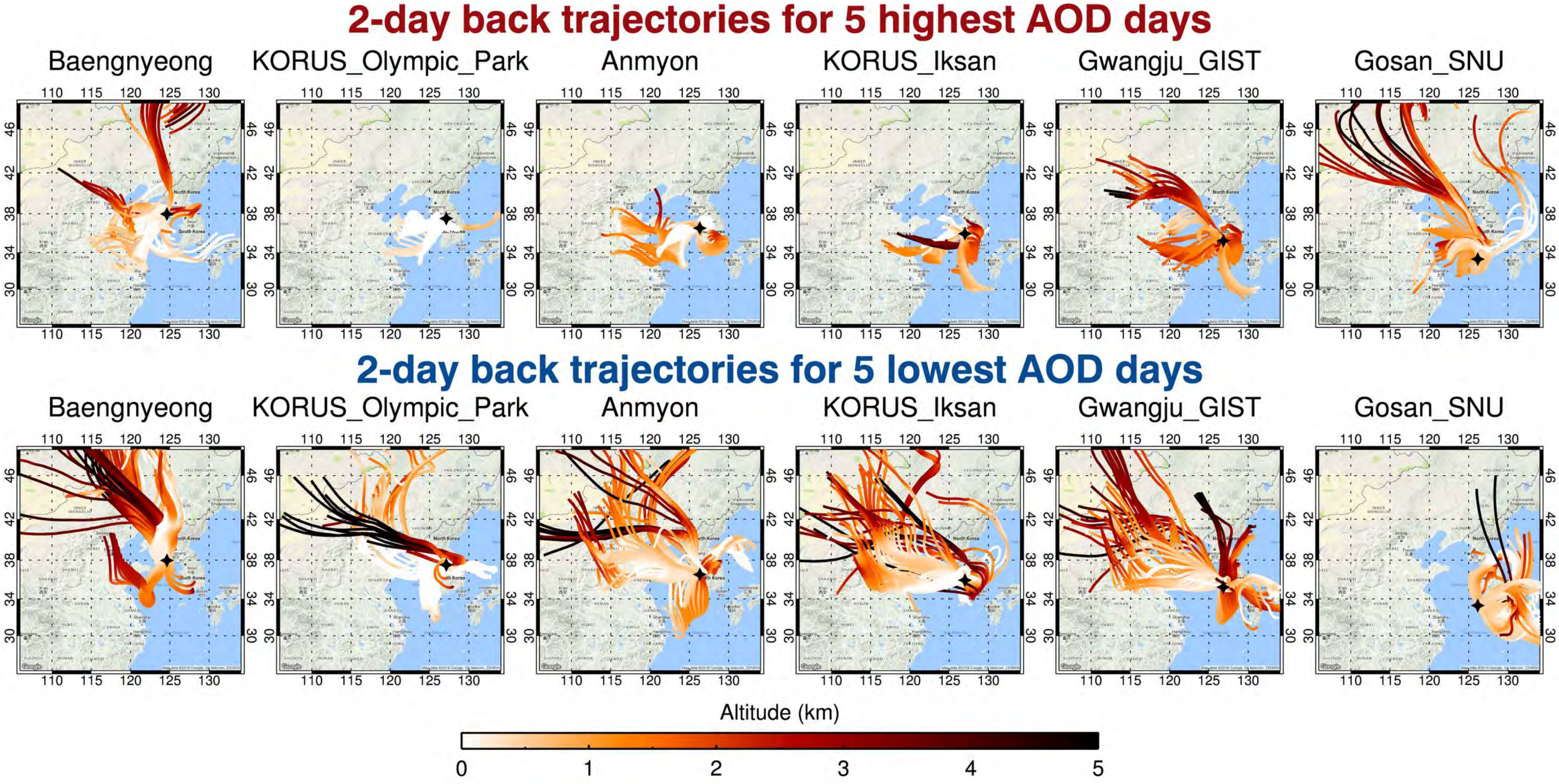
2-day back trajectories for 5 highest AOD days



2-day back trajectories for 5 lowest AOD days



Height variation of 2-day back-trajectories (HYSPLIT-4 calculations)

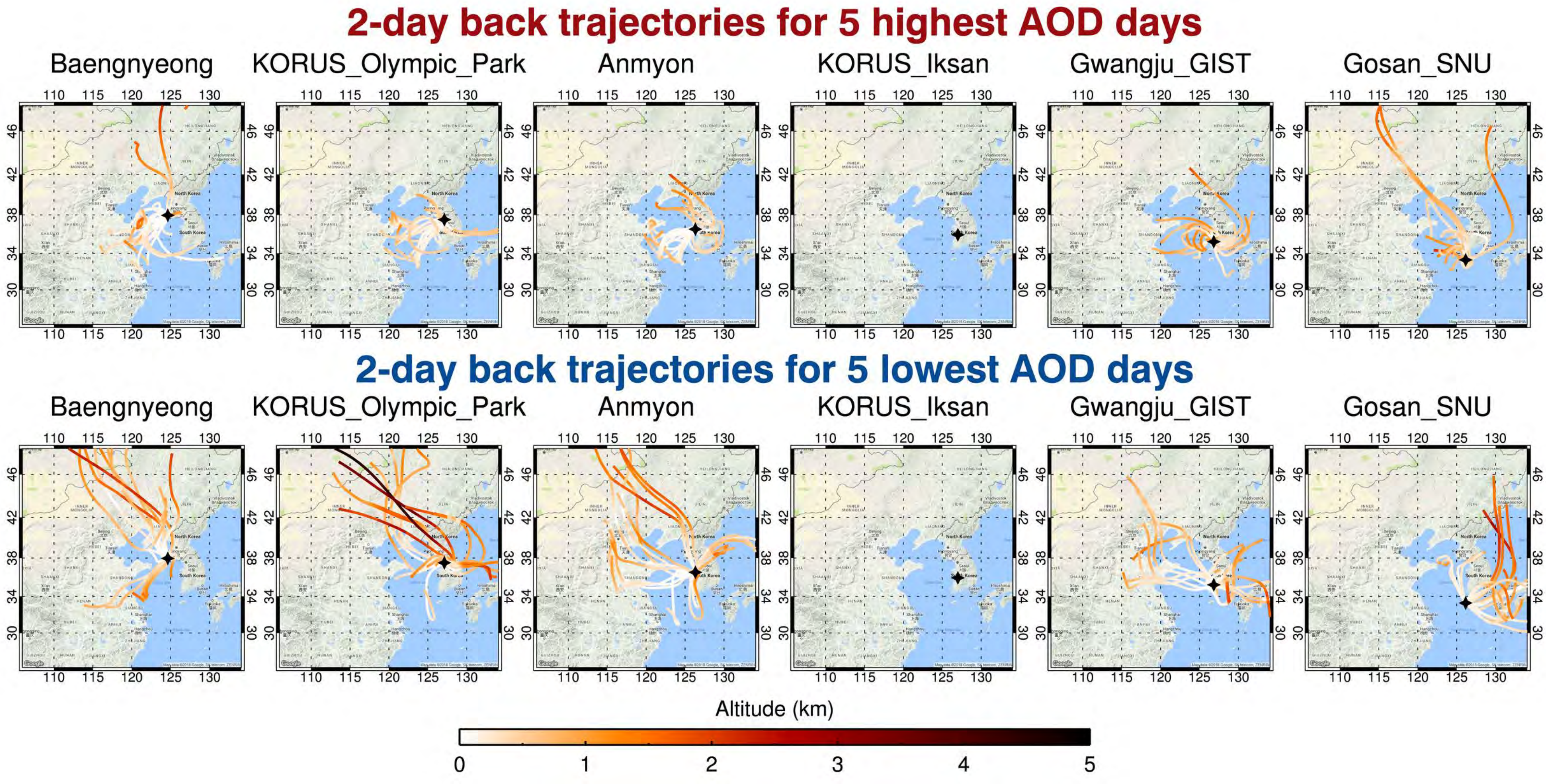


Comparison with FLEXPART results

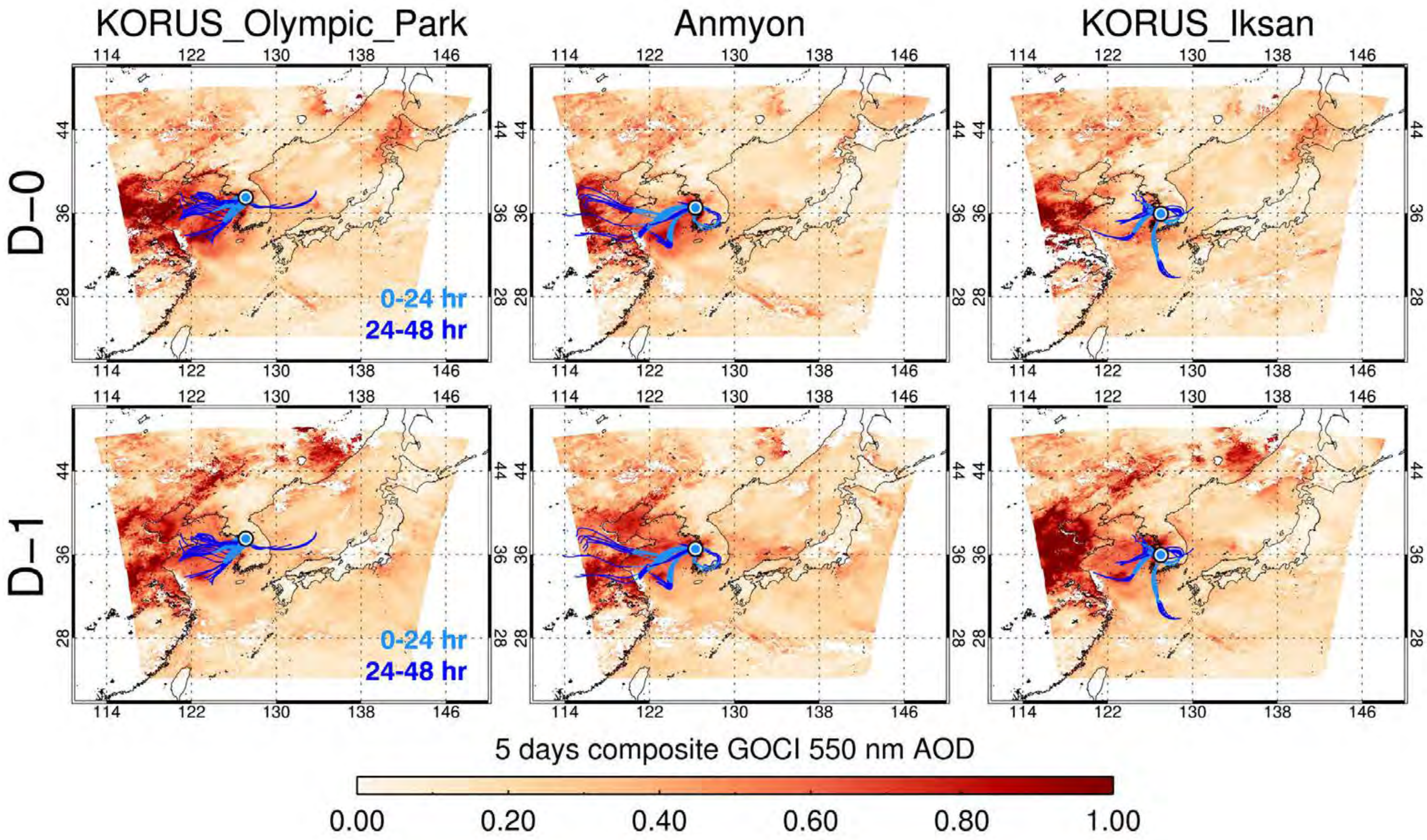
- FLEXPART Lagrangian Particle Dispersion Model (http://www.flexpart.eu)
- Christoph Knote (Meteorological Institute, LMU Munich, Germany)
- Trajectories driven by NCEP GFS analyses (+3 hours forecasts interlaced) on 0.25 degrees.
- Trajectories were calculated every 6 hours (0, 6, 12, 18 UTC) and particles were followed back in time for 10 days (120 hours).

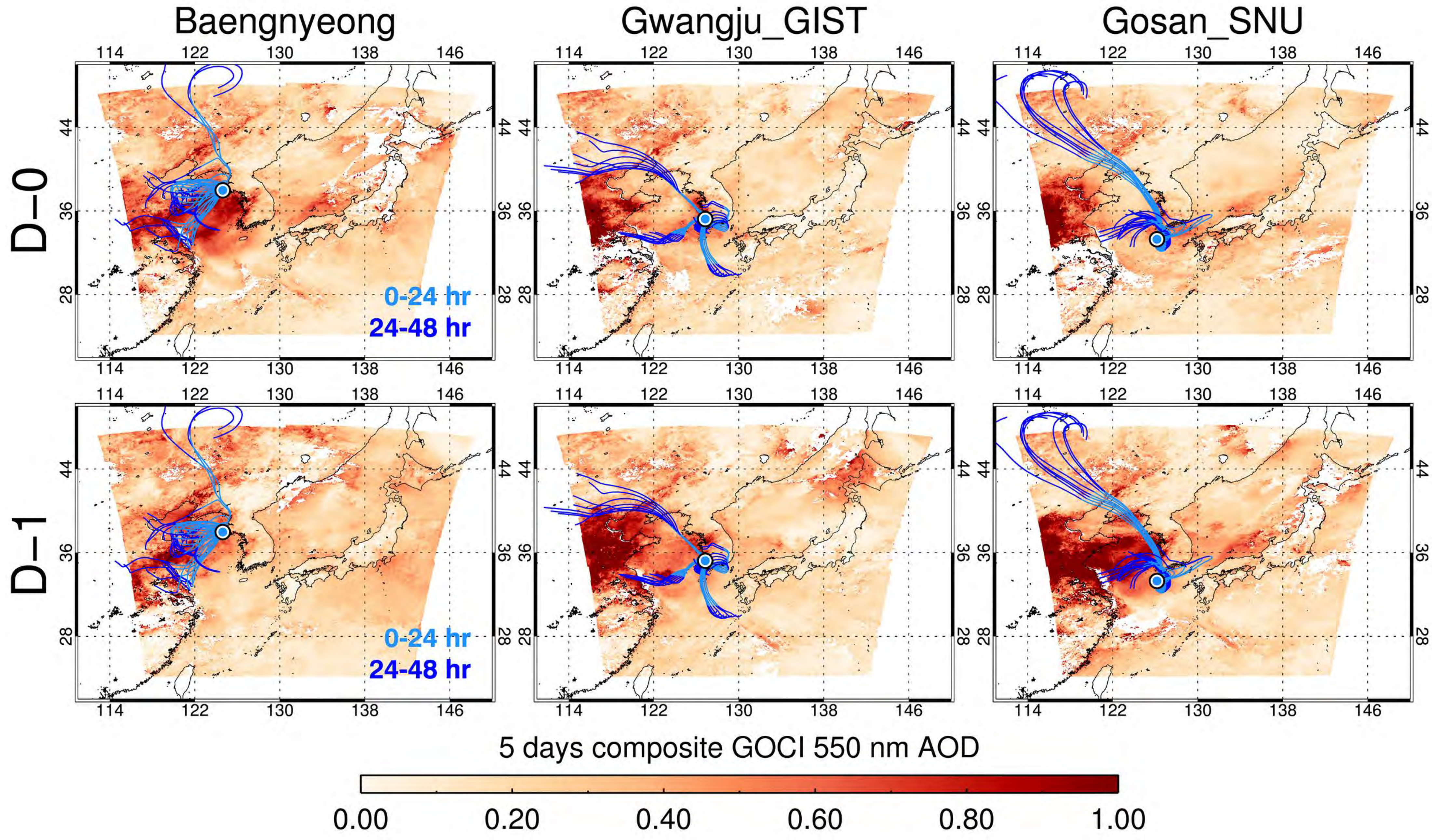
	HYSPLIT	**FLEXPART**
date	KORUS-AQ (2016.05.02-2016.06.12)	
Arrival height	500 m	0 m
Time interval	Every 1 hour	Every 6 hours (0,6,12,18 UTC)
MET data	NCEP GDAS (1 × 1°)	NCEP GFS (0.25 × 0.25°)
Comparison sites	Baengnyeong, Olympic Park, Anmyon, Gwangju, and Gosan	

Height variation of 2-day back-trajectories (FLEXPART calculations)



Combination of GOCI AOD and HYSPLIT 3-day back-trajectories
(for 5 highest AOD days)

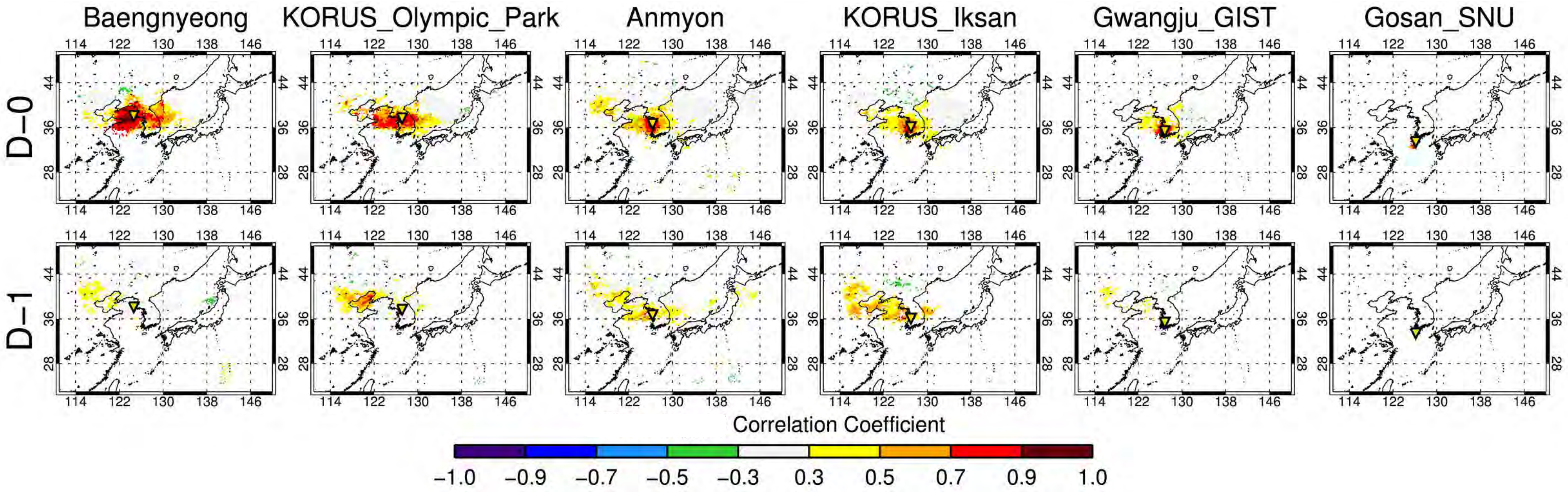




Baengnyeong
Gwangju_GIST
Gosan_SNU
D–0
D–1
0-24 hr
24-48 hr
5 days composite GOCI 550 nm AOD
0.00
0.20
0.40
0.60
0.80
1.00
114
122
130
138
146
44
36
28

Spatial correlations using GOCI AOD: A pixel including each site vs. other pixels

(data number > 20)



- Seoul Metropolitan Area seems generally under the influence of LRTT from the west
  - Correlation with the air condition of Shandon peninsula in a same day range
  - Correlation with the air condition of Jing-Jin-Ji (Beijing-Tianjin-Hebei) with a day time lag

Model inter-comparisons for aerosols and gases during KORUS-AQ

Rokjin J. Park[1] , Seungun Lee[1], Jinkyul Choi[1], Yujin Ok[1], Hyung-Ahn Kwon[1], Hyeonmin Kim[1], Heesoo Jang[1] and KORUS-AQ Team

1. School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

KORUS-AQ telecon. 19 June 2018

Multimodel Intercomparison : Participating Models

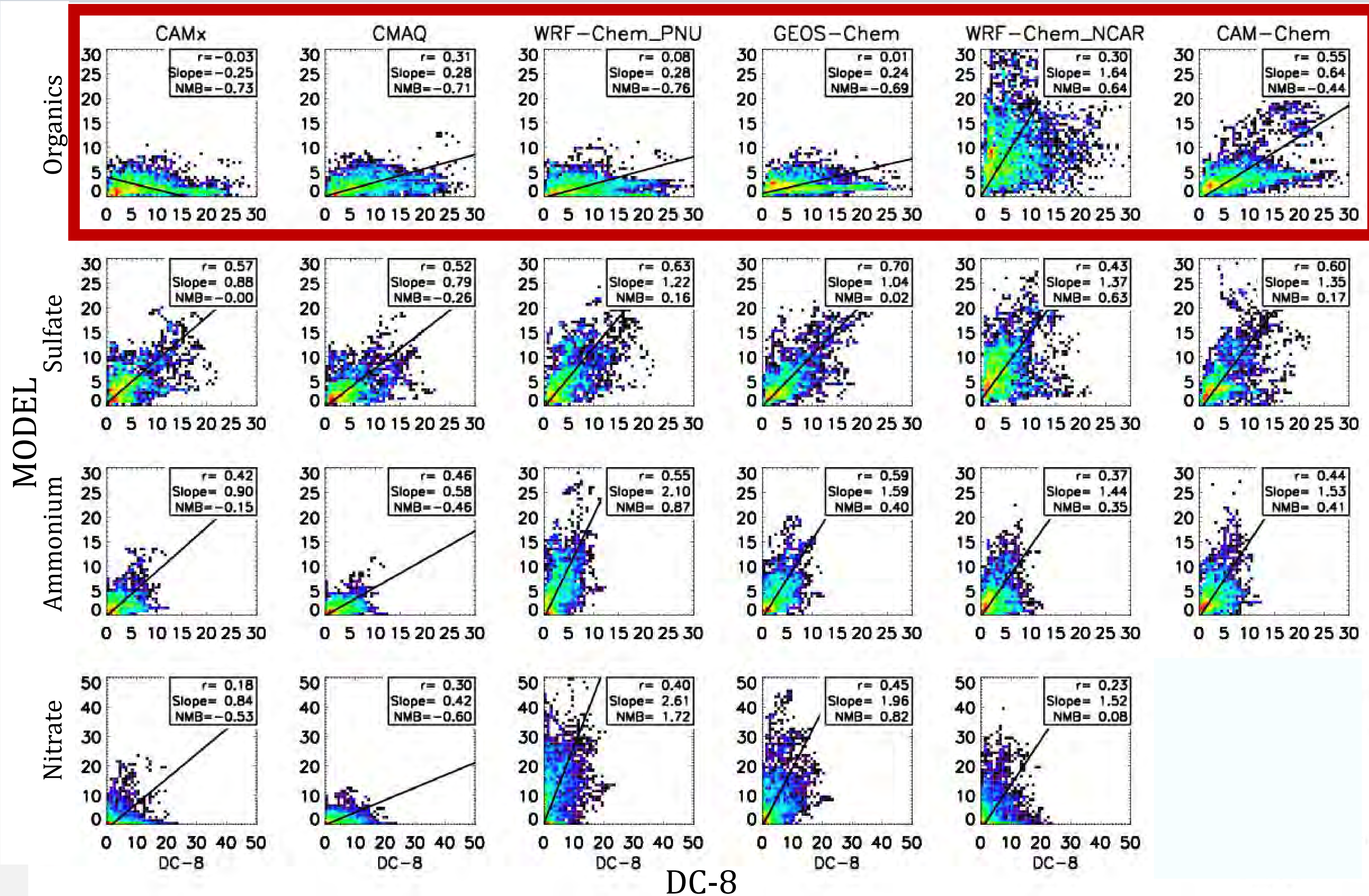
- Regional Models :
  1. CAMx (Ajou Univ., KOR)
  2. CMAQ (GIST, KOR)
  3. WRF-Chem (NCAR, US)
  4. WRF-Chem (PNU, KOR)
- Global Models :
  1. CAM-Chem (NCAR, US)
  2. GEOS-Chem (SNU, KOR)

Emission Inventories used during KORUS-AQ

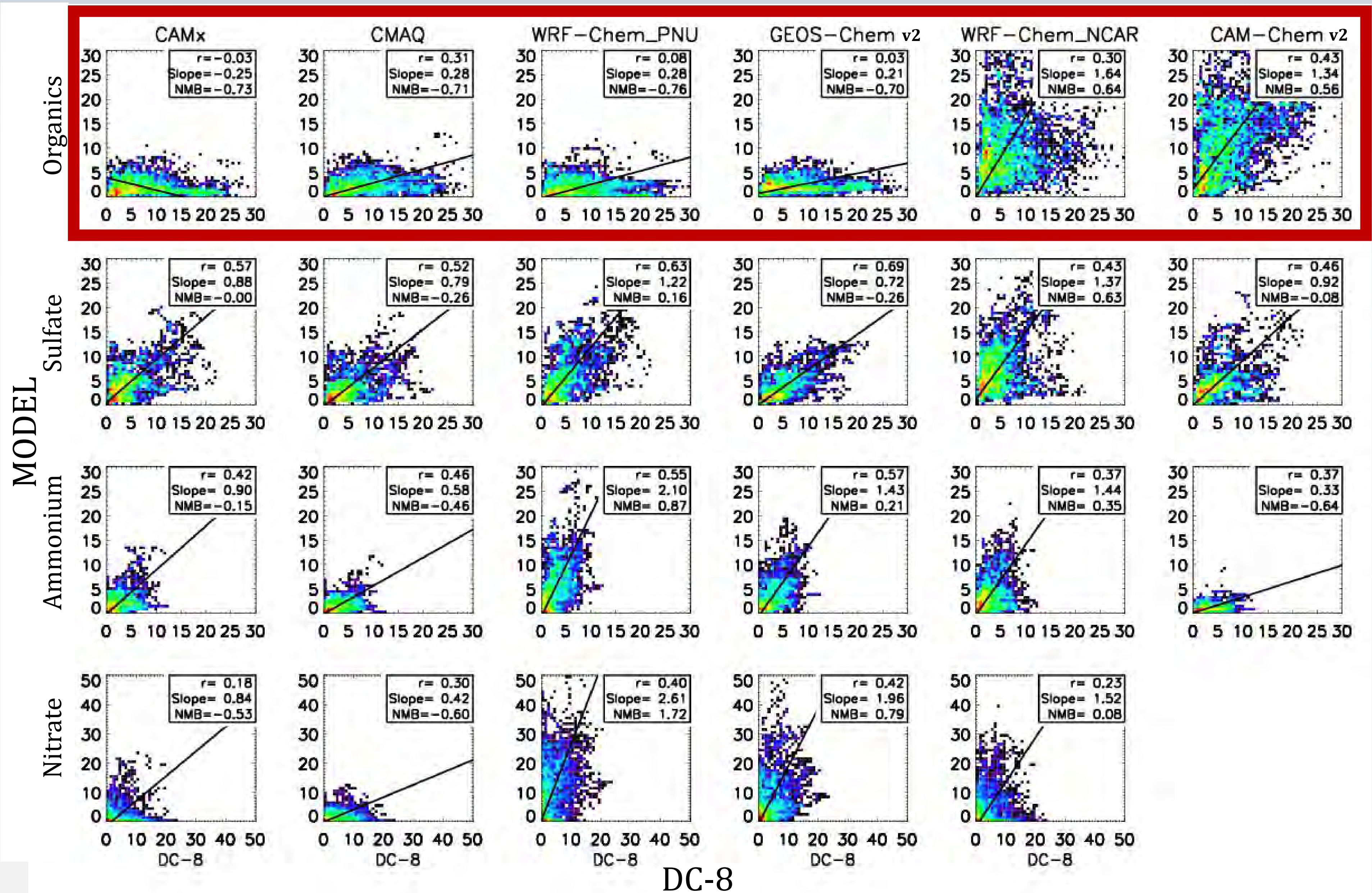
Comparisons of species emissions rates in South Korea

S.Korea Emission (ton/month)	KORUSv1	KORUSv2
NO	45300	47400
CO	61400	93200
NMVOC	38475	93582
SO_2	25900	27700
NH_3	25100	26100
OC	989	1930
BC	1010	1660

Multimodel Intercomparison for Aerosols (altitude < 2km)



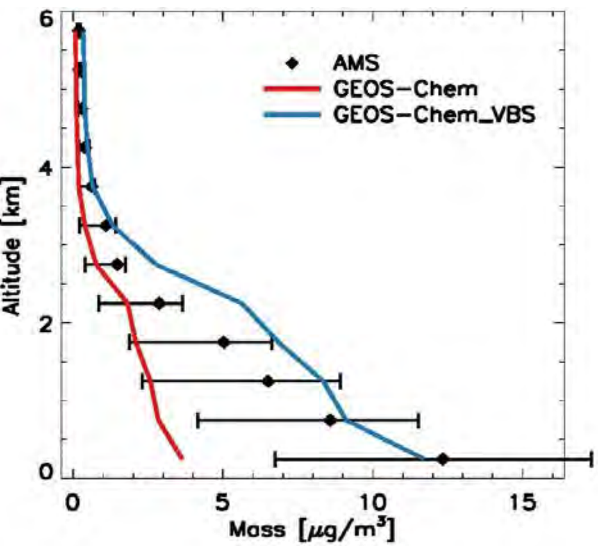
Multimodel Intercomparison for Aerosols (altitude < 2km)



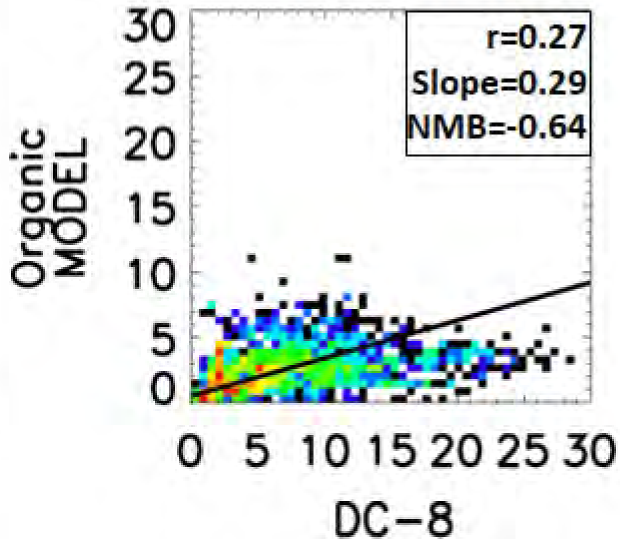
VBS scheme with KORUS v2 may improve OA simulations

Implementing VBS Approach for SOA Production

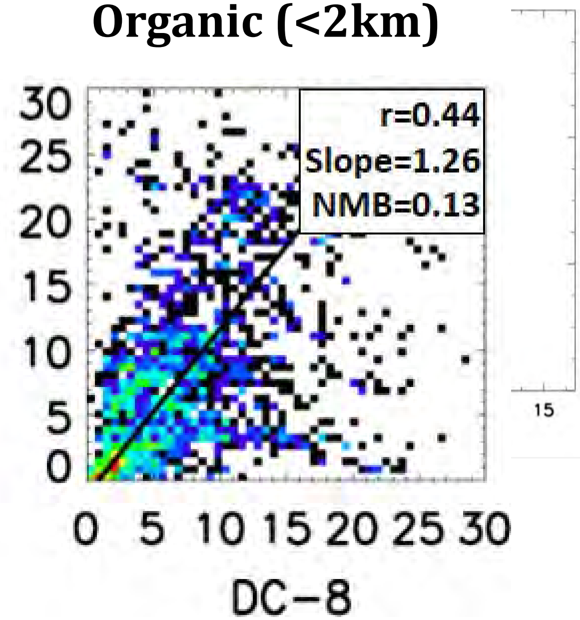
Vertical Profile
Organic Aerosol



GEOS-Chem
Organic (<2km)



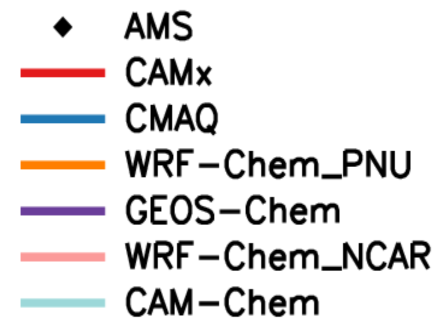
GEOS-Chem_VBS
Organic (<2km)



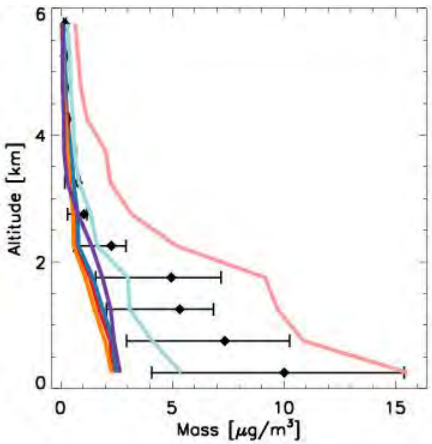
Mechanistic understanding on the formation and sources of organic aerosols in Korea is needed to improve models.

Multimodel Intercomparison for aerosols

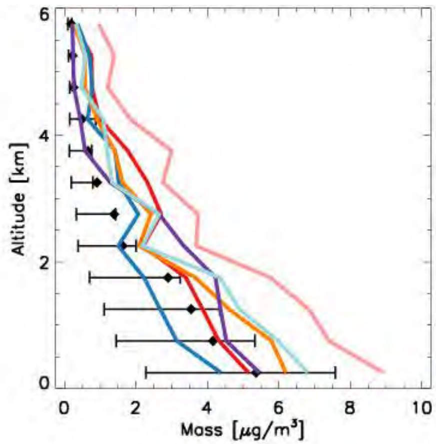
Vertical Profile Comparisons with DC-8 Observations (AMS)



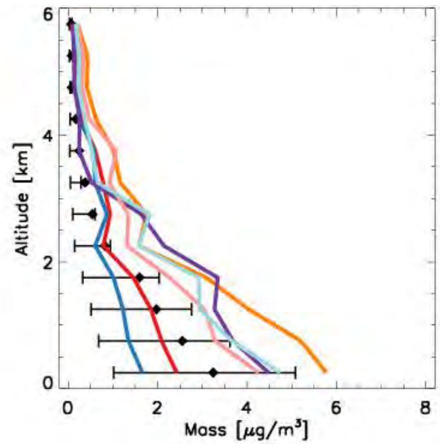
Organic



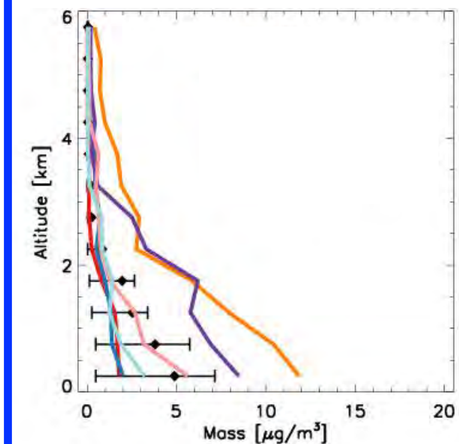
Sulfate



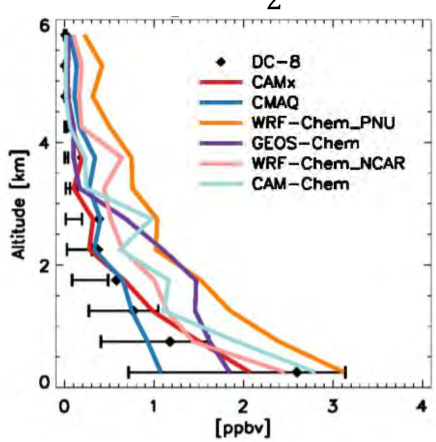
Ammonium



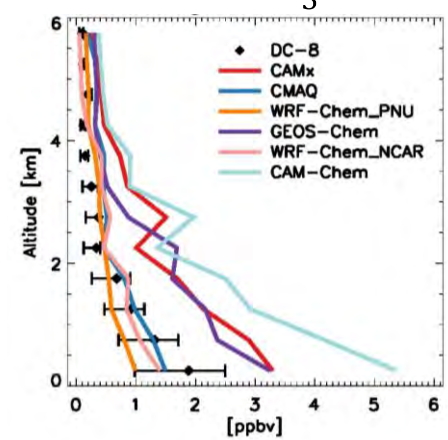
Nitrate



SO_2



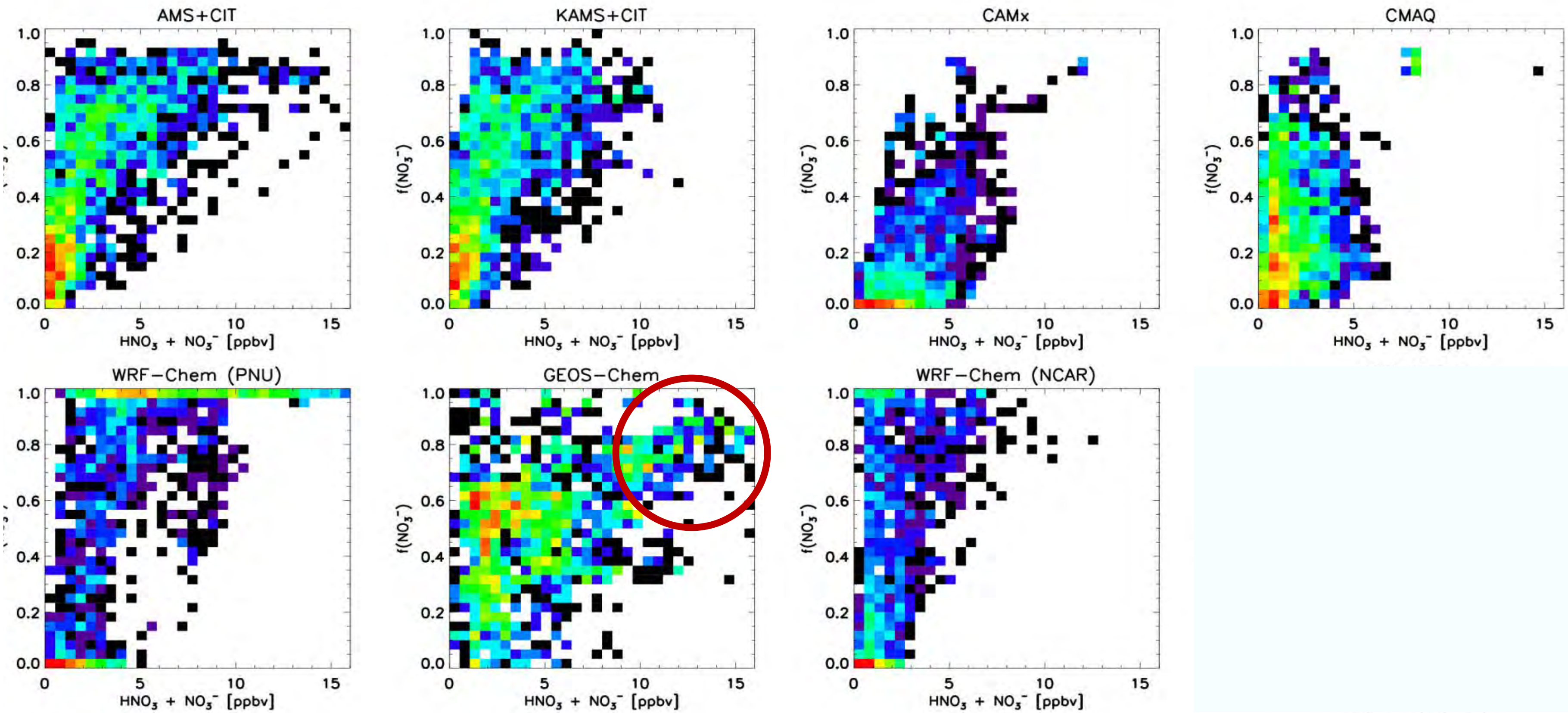
HNO_3



Multimodel Intercomparison for Aerosol Nitrate Partitioning

Fraction of particulate nitrate to total nitrate ($pNO_3 + HNO_3$)

Fraction of particulate nitrate

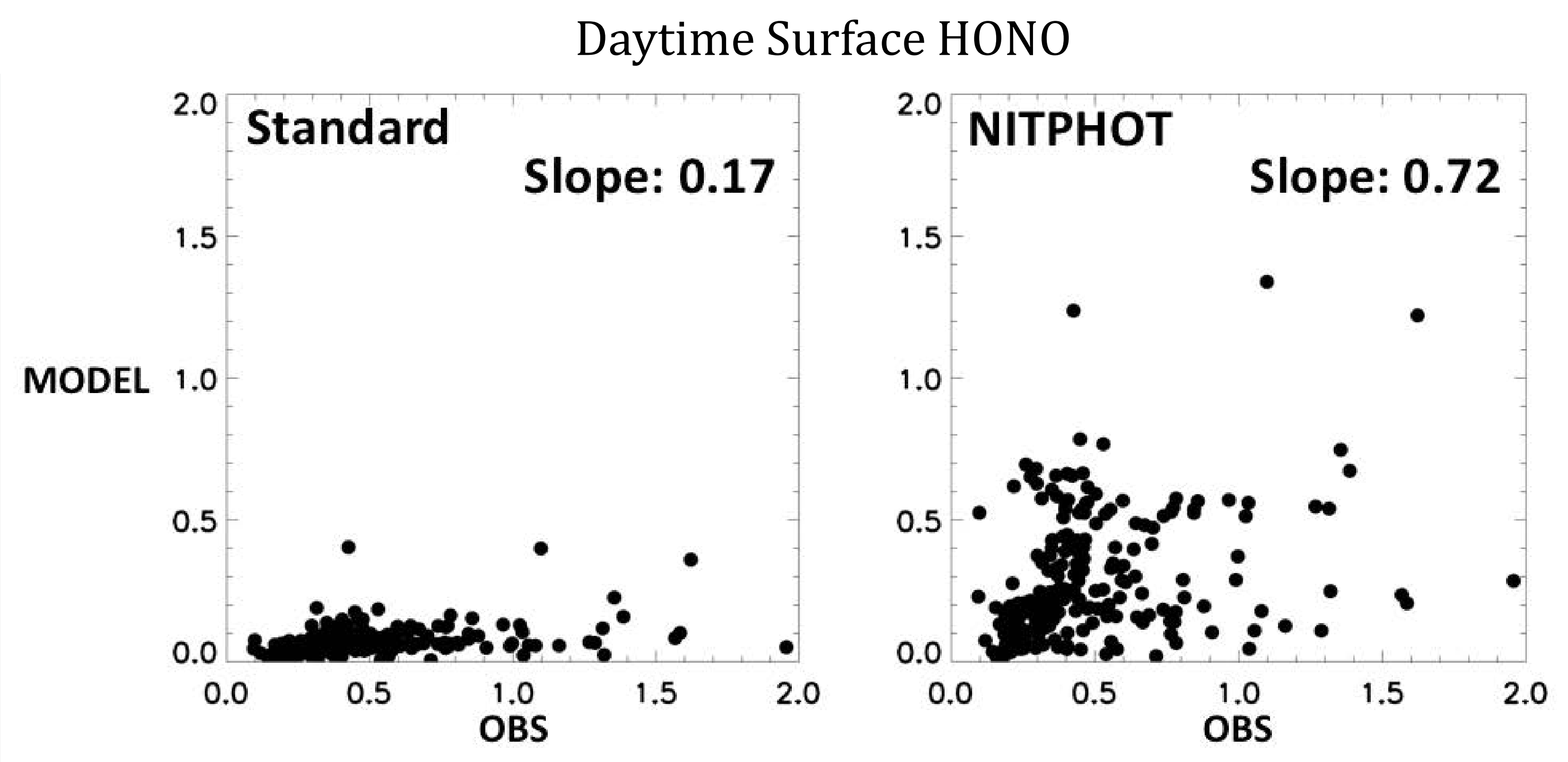


Total nitrate [ppbv]

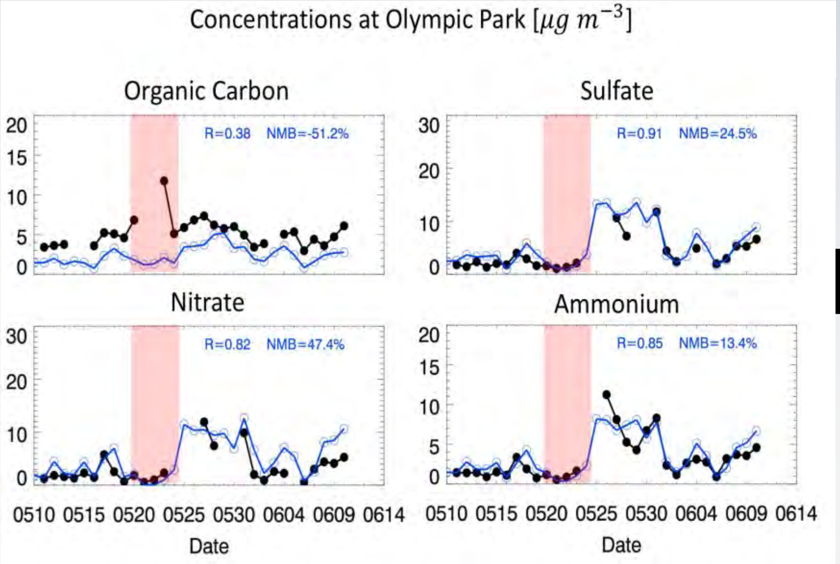
Photolysis of nitrate aerosol as a daytime source of HONO

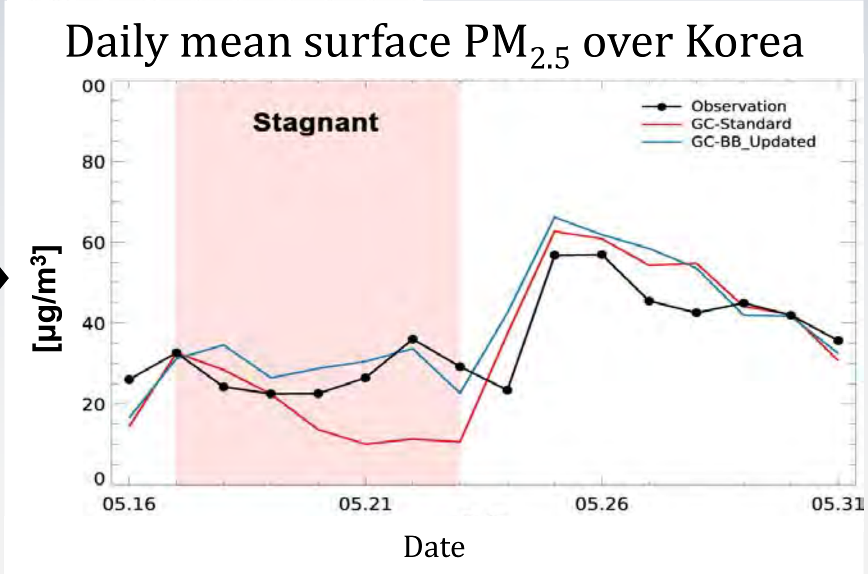
$$p(NO_3^-) \rightarrow \frac{1}{(a+1)} NO_2 + \frac{a}{(a+1)} HONO$$

Photochemical Aging of $PM_{2.5}$ in Urban Beijing Releases HONO

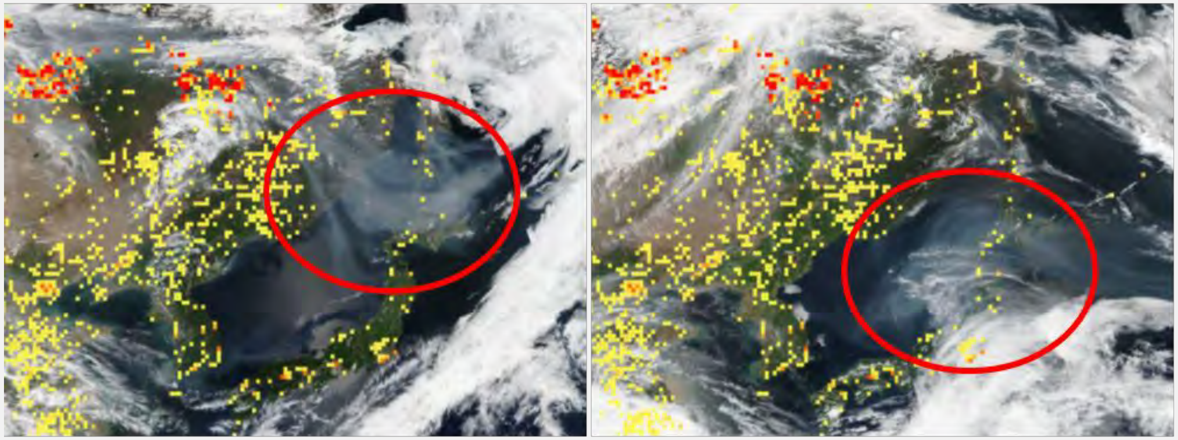


Models failed to reproduce observed PM2.5 during the stagnation period of the campaign.





Fire Count Map

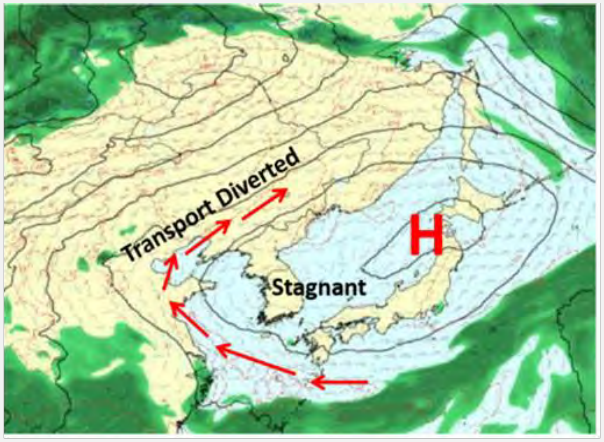


May 18th

May 20th

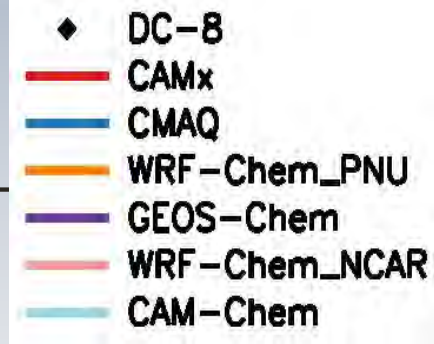
[NASA-FIRMS]

Stagnant 5/17-5/22 (Persistent High Pressure)

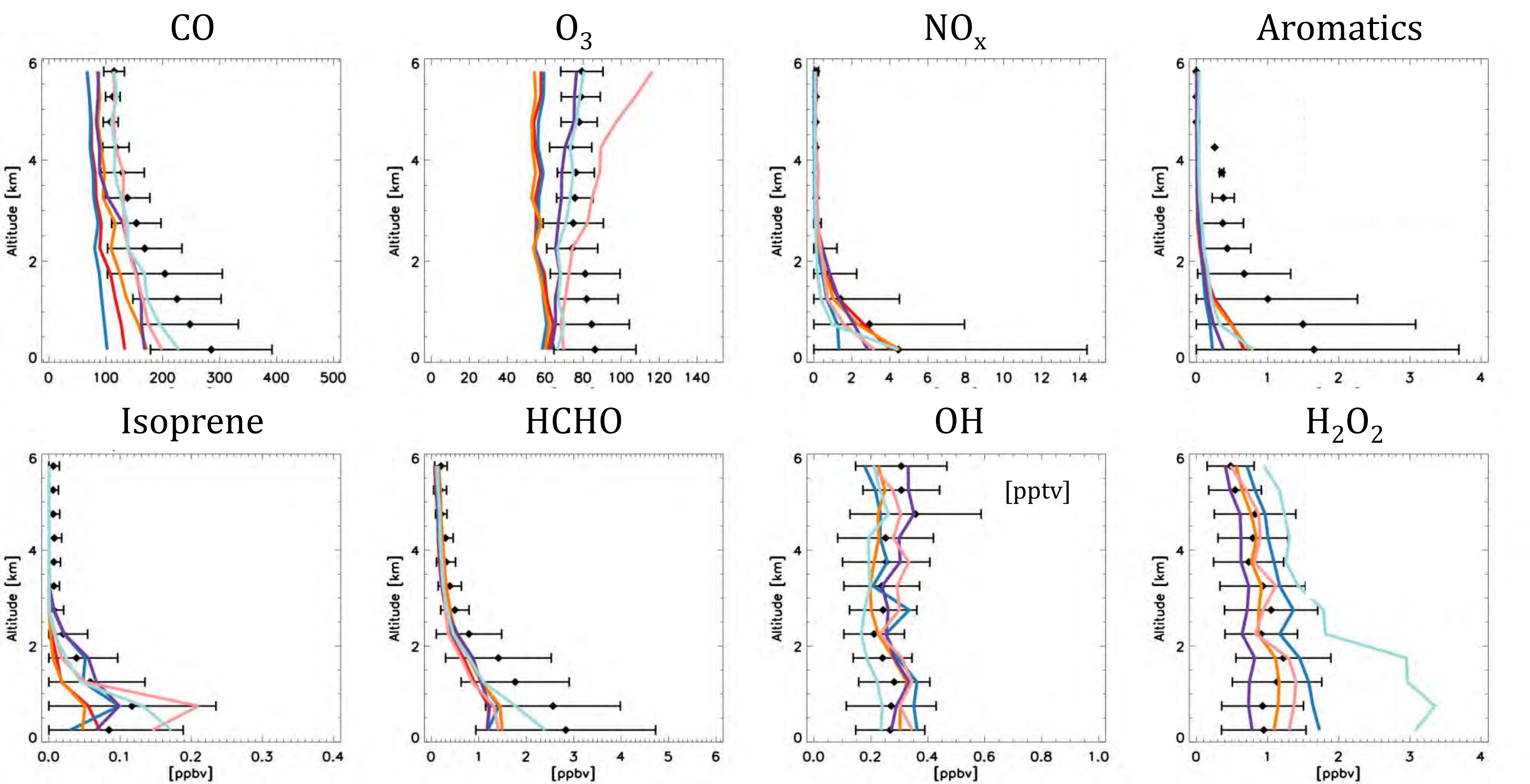


[KORUS-AQ-RSSR]

Multimodel Intercomparison for Gas



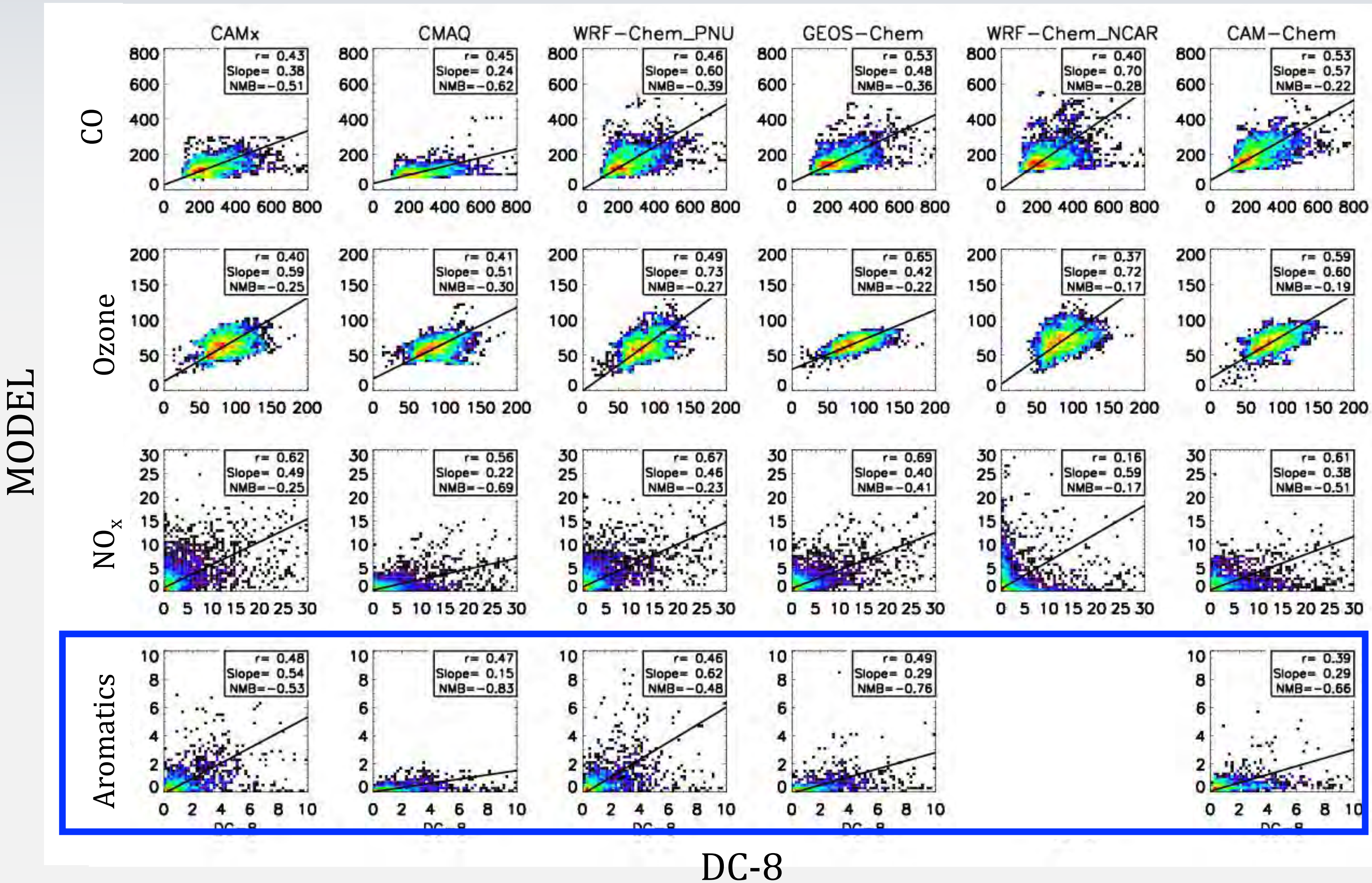
Vertical Profile Comparisons with DC-8 Observations



Units are [ppbv] except for OH

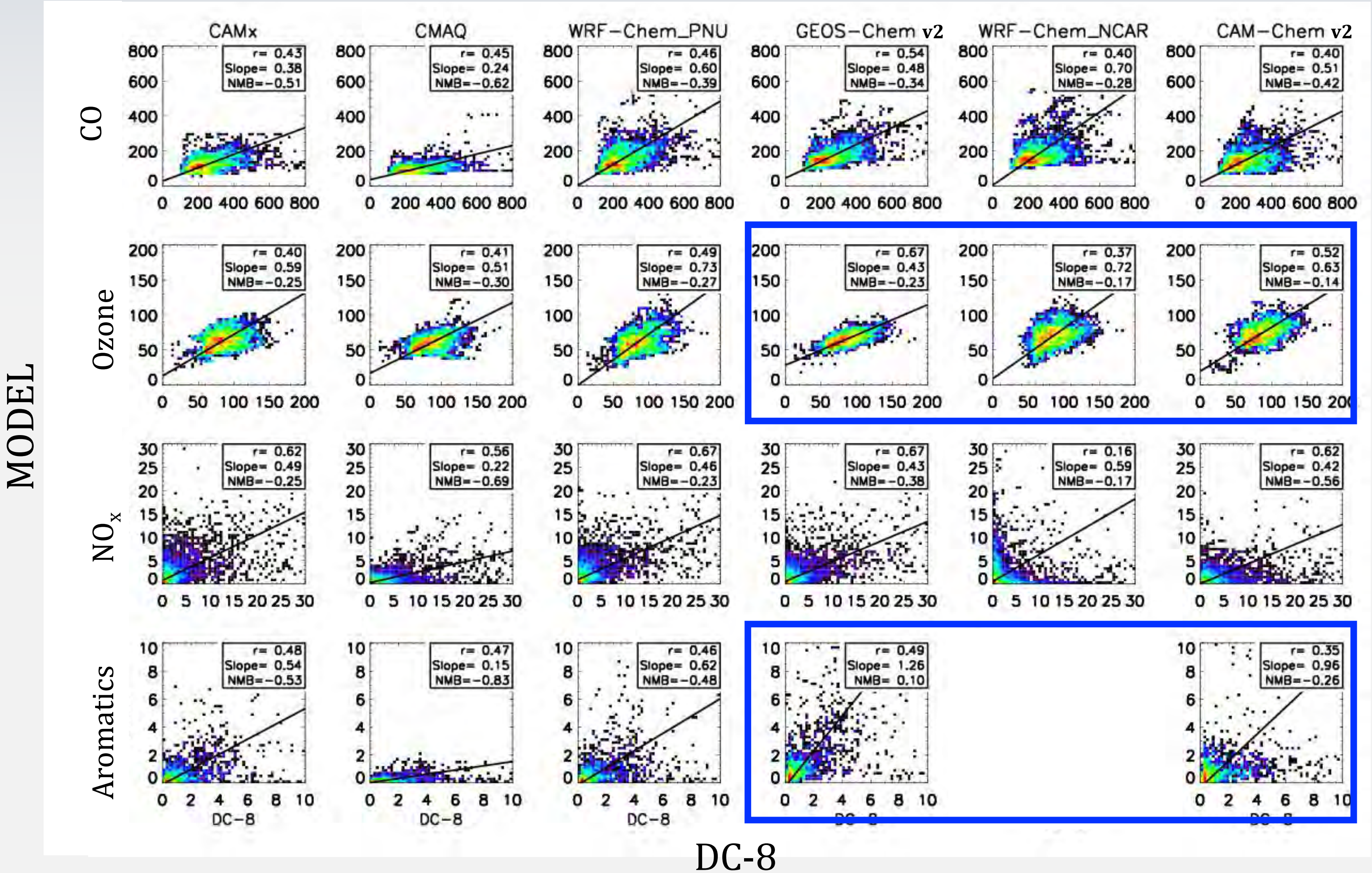
Multimodel Intercomparison for gases

Scatter Plot (Altitude < 2km)



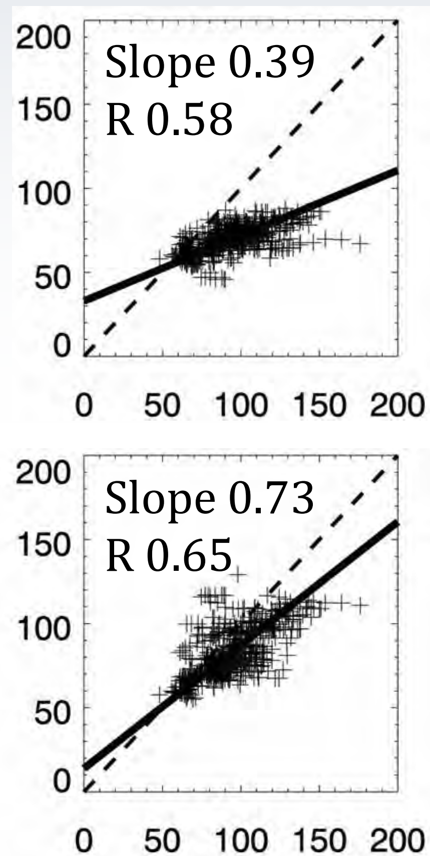
Multimodel Intercomparison for gases

Scatter Plot (Altitude < 2km)



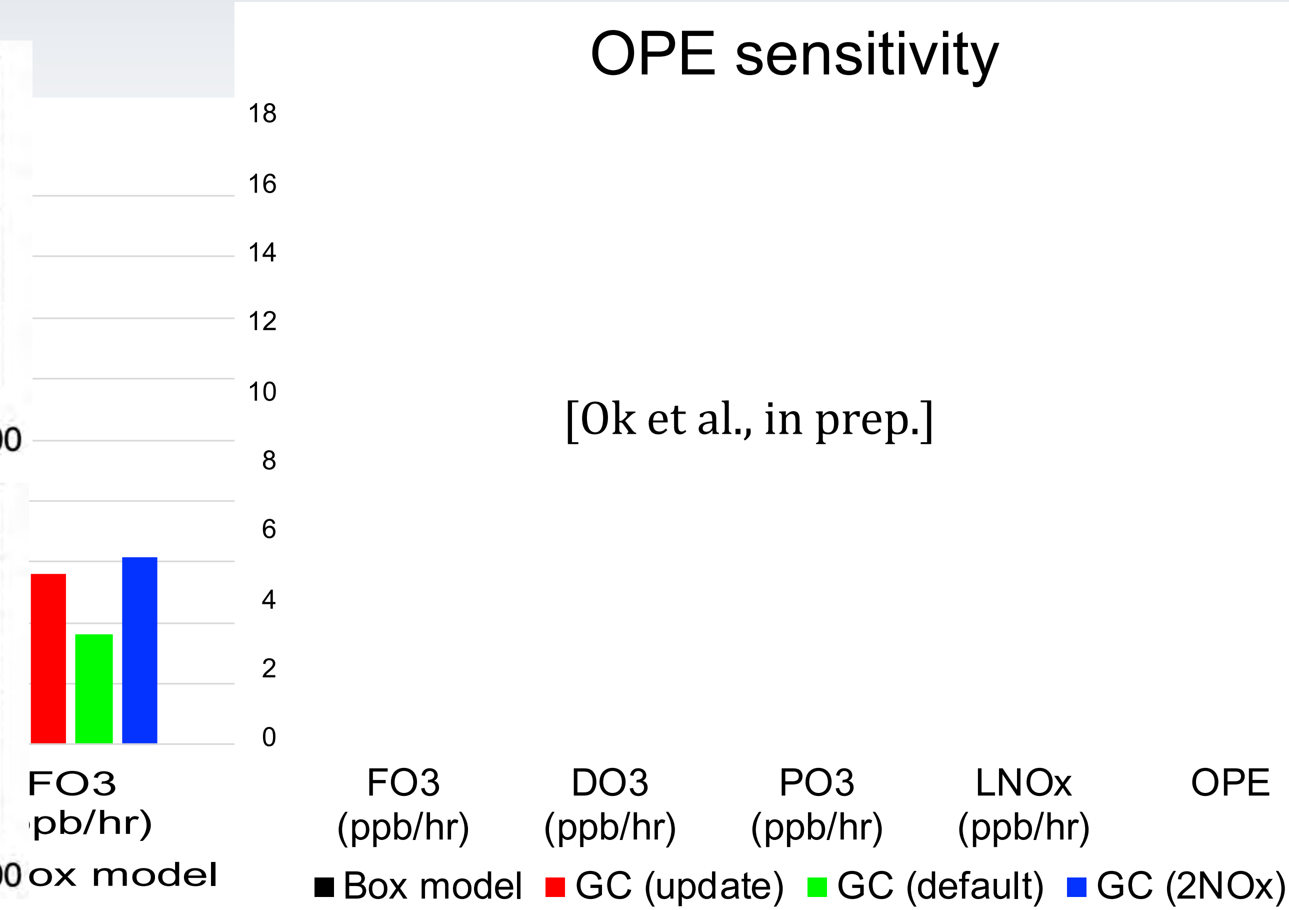
VOC-NO_x-O_x gas phase chemistry simulation

Simulated O_3 concentration (ppbv) and O_3 production efficiency



Model (GEOS-Chem)

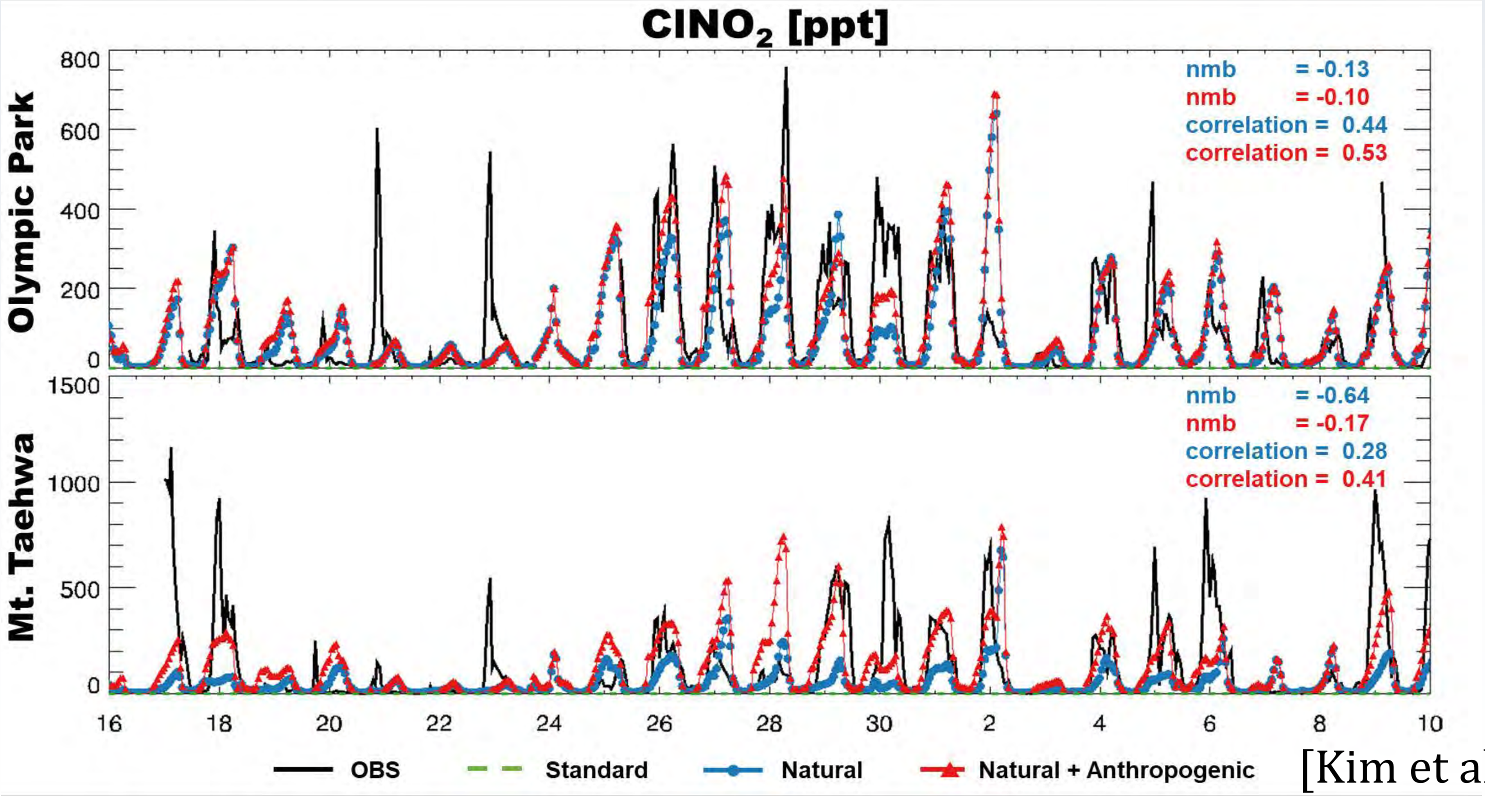
Observation (DC-8 <2 km)



*Box model: observation-constrained 0-D chemical box model (Courtesy of NASA LaRC)

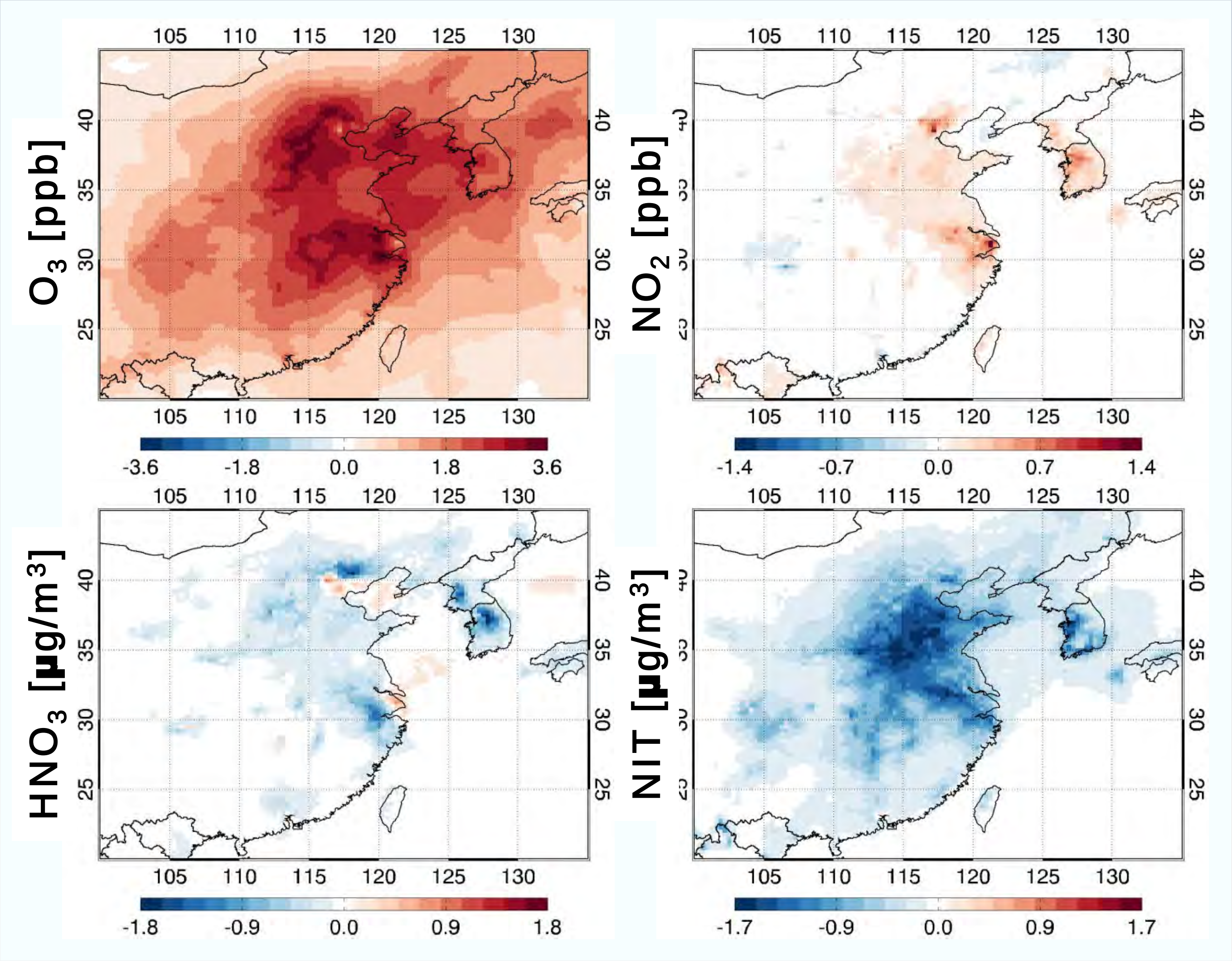
Comparisons of $ClNO_2$: GEOS-Chem vs. Observations

$ClNO_2$		Mean [ppt]	Max [ppt]	Median	R	NMB	NME	MB [ppt]	ME [ppt]
Olympic Park	OBS	85.54	757.00	24.67					
	Natural	57.09	592.56	19.39	0.39	-0.32	0.0012	-23.36	56.62
	Natural + Anthropogenic	90.98	690.28	38.67	0.53	0.10	0.0012	7.01	56.71
Mt. Taehwa	OBS	143.98	1331.40	34.17					
	Natural	49.14	675.14	23.75	0.28	-0.64	0.0013	-81.67	106.51
	Natural + Anthropogenic	110.52	787.43	50.94	0.41	-0.17	0.0013	-22.04	102.00



[Kim et al., in prep.]

Inclusion of $ClNO_2$ reduces biases in gases and aerosols in GEOS-Chem



O_3, NO_x

HNO_3, NIT

[Kim et al., in prep.]

Summary

- Models consistently underestimate organic aerosol concentrations.
- A large discrepancy among models is found for inorganic aerosols.
- Photolysis of nitrate aerosol could be important as a daytime source of HONO and additional loss of nitrate aerosol.
- Siberian forest fires have a significant impact on aerosol concentration during the KORUS-AQ.
- Aromatic VOCs play a significant role in the formation of ozone and organic aerosols in Korea along with nitryl chloride chemistry.
- Anthropogenic NH_3 and NO_x from the domestic sources and Chinese SO_2 contribute mostly to PM2.5 concentrations in Korea.

jwoo@konkuk.ac.kr

Evaluation of the Large Point Source Emissions in the KORUS-AQ Version 2.0 Emissions Inventory

Jung-Hun Woo[1], Minwoo Park[1], Younha Kim[1], Rokjin J. Park[2], Louisa Emmons[3]

and other KORUS-AQ members…

1 Konkuk University, Seoul, Korea

2 Seoul National University, Seoul, Korea

3 NCAR, Boulder, USA

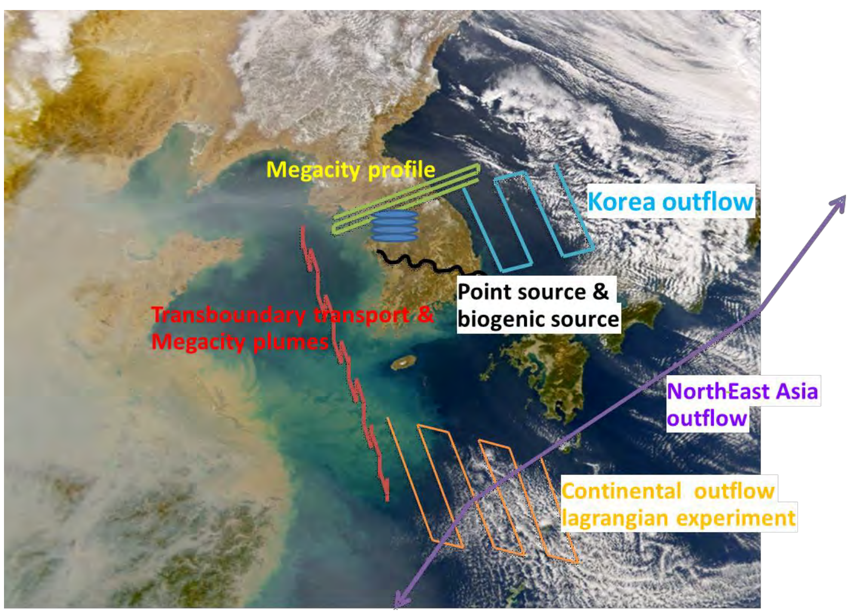
Base Emissions Inventory: NIER/KU-CREATE*

Science

- Better understanding of the factors controlling air quality
- Test and improve model simulations of air quality

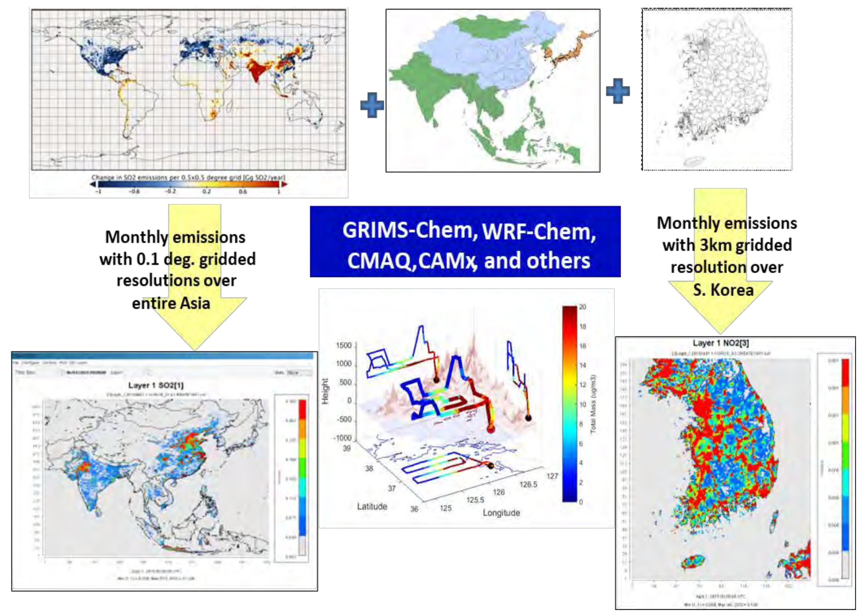
Societal Impact

- Provide guidance on measures to improve air q uality in Korea



- Anthropogenic Emissions Inventory
  - GAINS-Korea/Asia with national activities/policies
- Year 2010, Asia regions, ~300 SCCs
- Pols.: CO_2, NO_x, PM_{10}, $PM_{2.5}$, SO_2, VOC, NH_3, CO
- Biogenic(MEGAN), Biomass burning(BlueSky)

KORUS Emissions Inventory (ver. 1.0/2.0)



* Comprehensive Regional Emissions for Atmospheric Transport Experiments

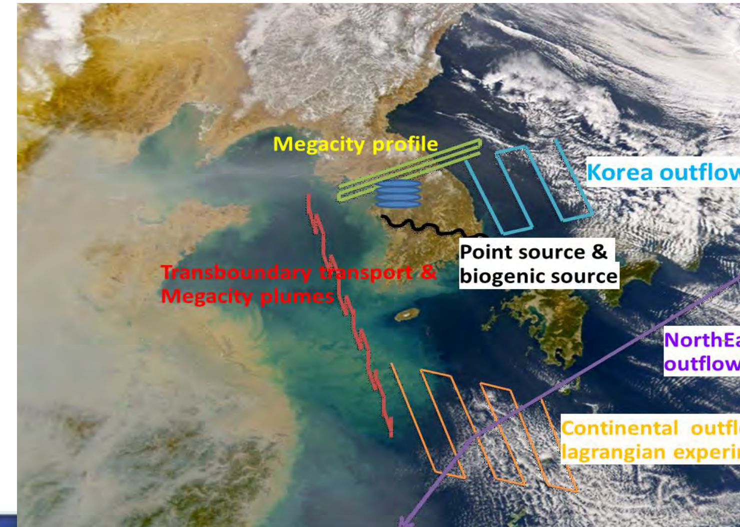
Research Objectives

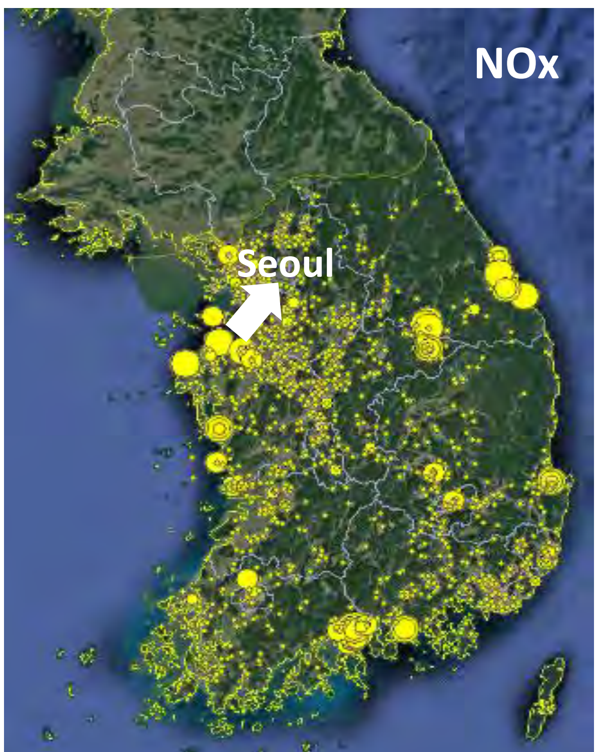
Objective A : Evaluation of Large Point Sources(LPSs) Emissions in Korea

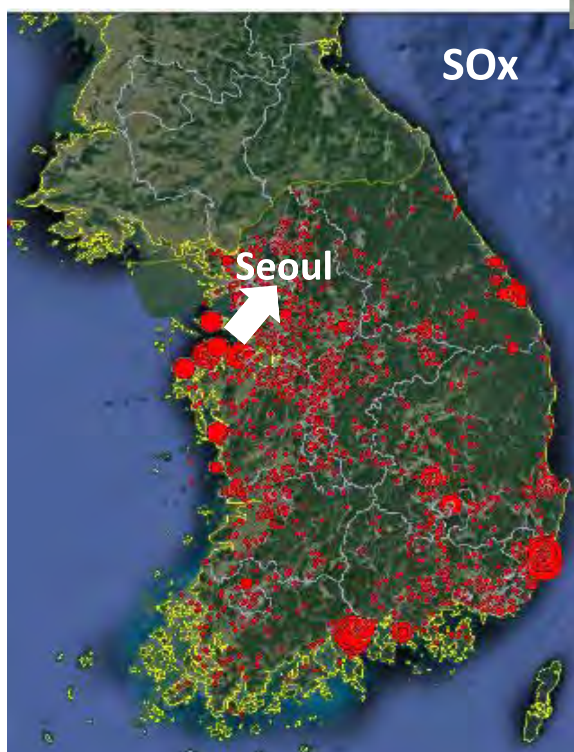
Objective B : Development of LPSs Inventory in China

Objective A : Evaluate Large Point Sources(LPSs) in Korea

Evaluate LPSs near Seoul
using KORUS-AQ flight measurement







Site of Large Amount Emission in 2016

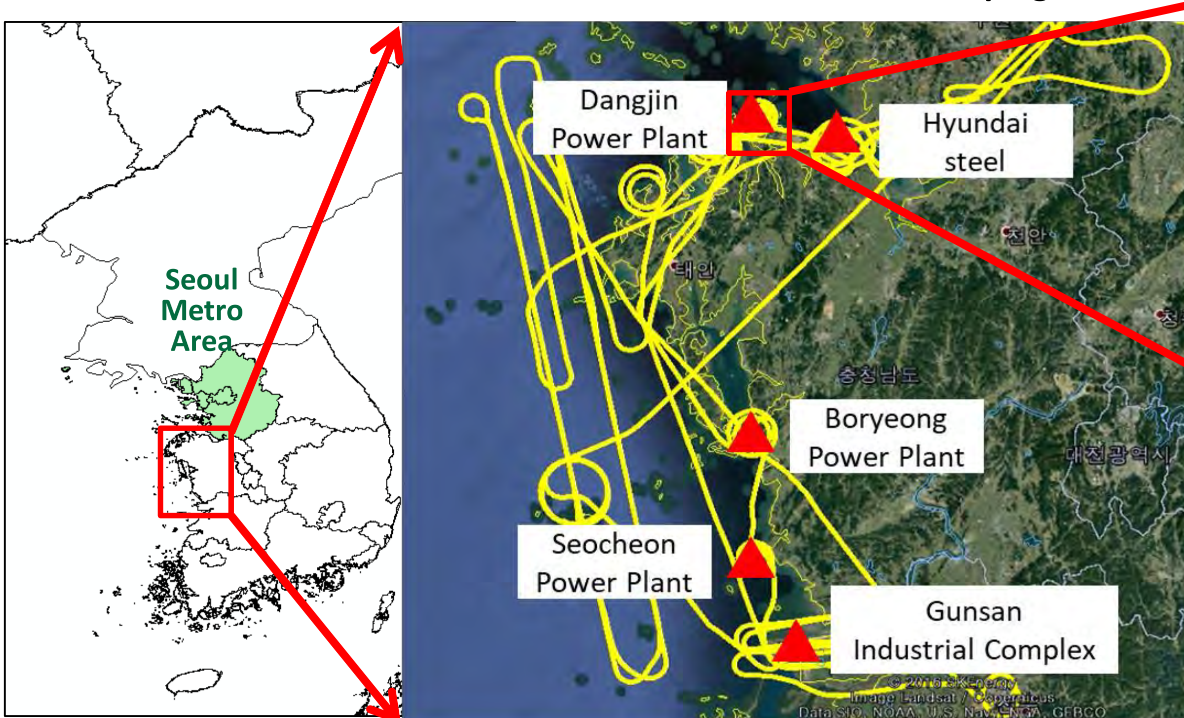
Rank	Site	NO_X (ton/yr)	Category
1	Samcheonpo Power	22,943	Power
2	Boryeong Power	16,788	Power
3	Taean Power	15,446	Power
4	Ssangyong Cement	13,270	Cement
5	Dangjin Power	11,853	Power
6	Tongyang Cement	11,278	Cement
7	Posco Gwangyang Works	11,126	Steel
8	Hyundai Steel	10,271	Steel
9	Posco	10,147	Steel
10	Hanil Cement	10,070	Cement

MOE, 2017

2. Evaluate Large Point Sources(LPSs) in Korea

2-1. Research Setting

KORUS-AQ aircraft field campaign

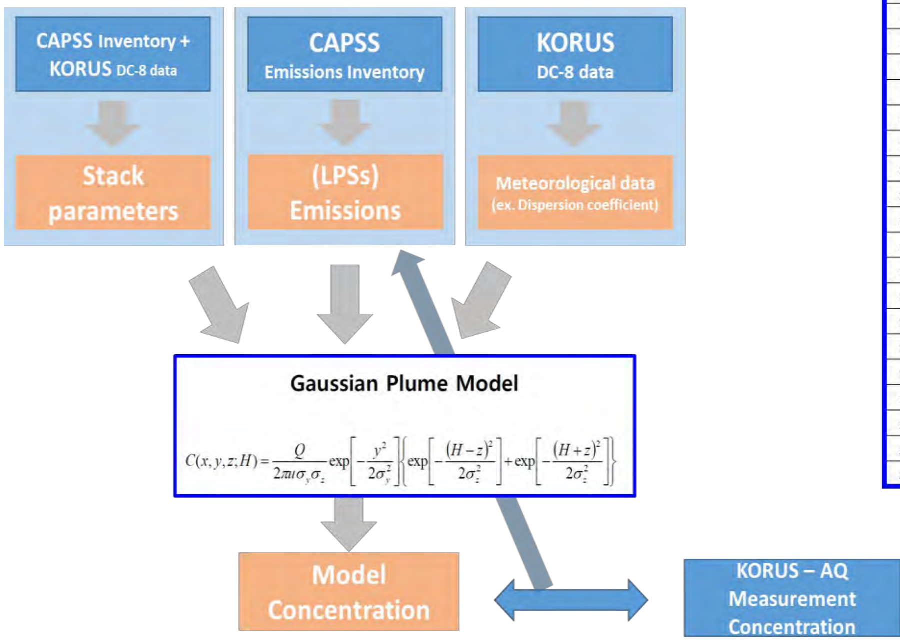


Circular Flight around Stack

Objective : Evaluate LPS(Large Point Source)
Emissions using the DC-8 flight (June 5, 2016)

- Large Power Plants and Industrial Complex are located at Chungcheongnam-do and Jeallabuk-do.
- Large Point sources (LPSs) influence largely to Seoul Metro(SMA)'s air quality.
- In particular, LPSs in Chungcheongnam-do put great impacts because they are close to SMA
- So, we wanted to evaluate the accuracy of CAPSS, which is Korea National Emissions Statistics using KORUS-AQ measurement

2-2. Method



Validation of emissions through comparison with measurements

		Dangjin PP	Hyundai Steel	Boryeong PP	Seocheon PP	Gunsan Industrial complex
Effective stack height, H (m)		357.9	282.7	307.7	282.7	74.6
Dispersion Coefficient, σ_y (m)		300	150	60	300	200
Distance, x (km)		2	0.8	0.1	1.7	2
Altitude, z (m)		342	353	362	346	310
Wind Speed, u (m/s)		2.3	2.4	2.1	2.9	2.2
emissions by CAPSS, Q (ton/yr)	NO_x	17,146	7,427	17,454	1,066	1,392
	SO_2	7,223	7,819	11,656	491	1,075

High concentration side

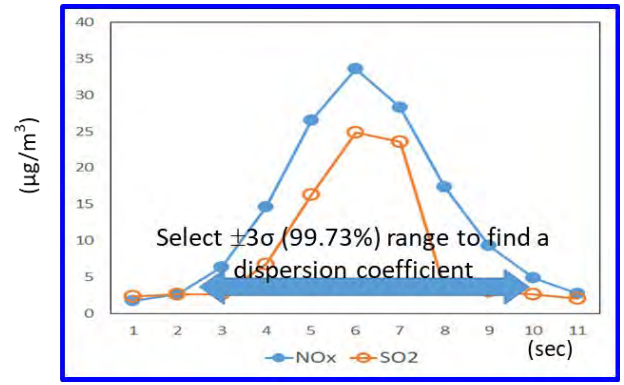
FID	Wind Speed(m/s)	Flight Height(m)
1	1	352
2	1	349
3	2	347
4	2	345
5	2	345
6	2	346
7	1	348
8	1	351
9	1	354
10	1	356
11	1	358
12	2	359
13	3	359
14	4	359
15	3	359
16	2	358
17	2	357
18	2	355
19	2	352
20	3	350
21	2	348
22	3	346

Calculation of Average Wind Speed

Opposite side

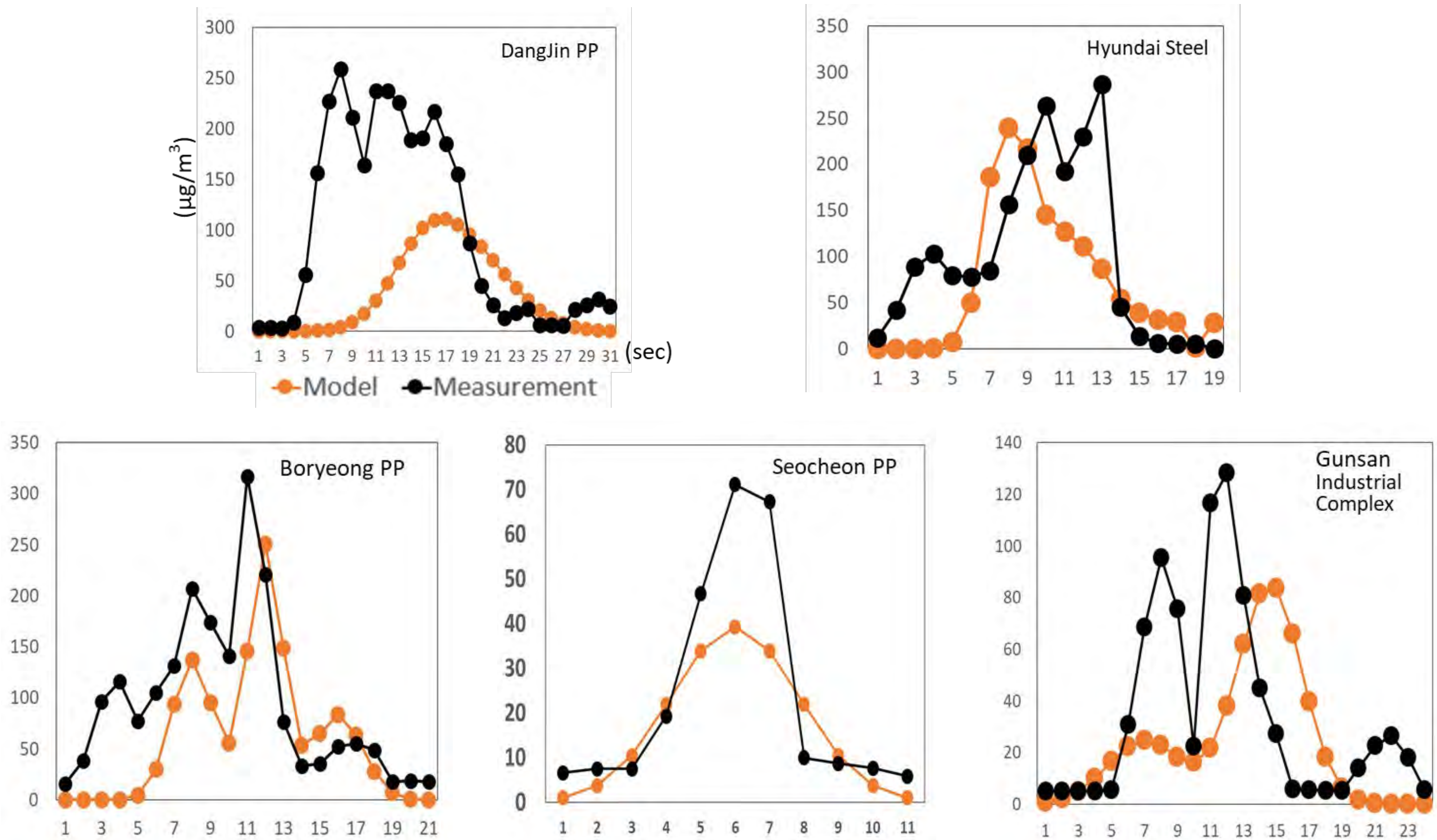
FID	Wind Speed(m/s)	Flight Height(m)
1	3	413
2	5	409
3	4	406
4	4	403
5	4	400
6	4	398
7	5	397
8	5	395
9	6	394
10	6	393
11	6	391
12	6	389
13	5	387
14	5	386
15	4	386
16	4	385
17	5	386
18	5	386
19	5	3863
20	4	387
21	4	387
22	4	388

Average between blue and red



- The Wind Speed and Flight Height values in blue and red circles were averaged to calculate 'U' and 'Z' at each LPSs
- 'X' is the distance from stacks to measurements, which also explains the wind direction.

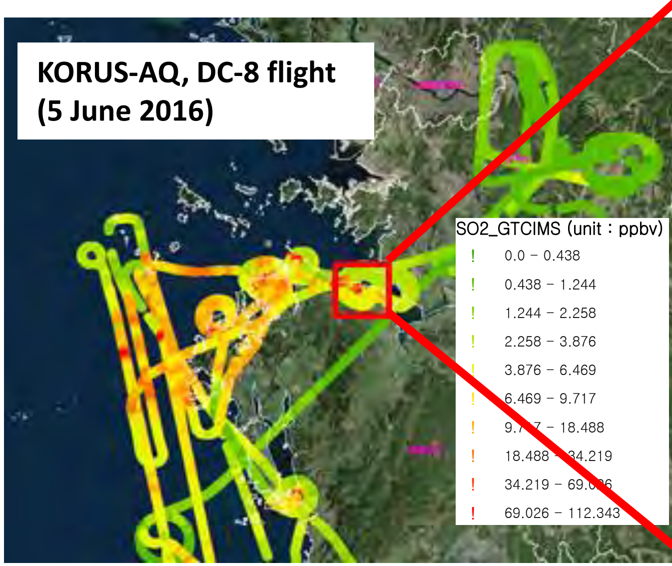
2-3. Result (SO_2)



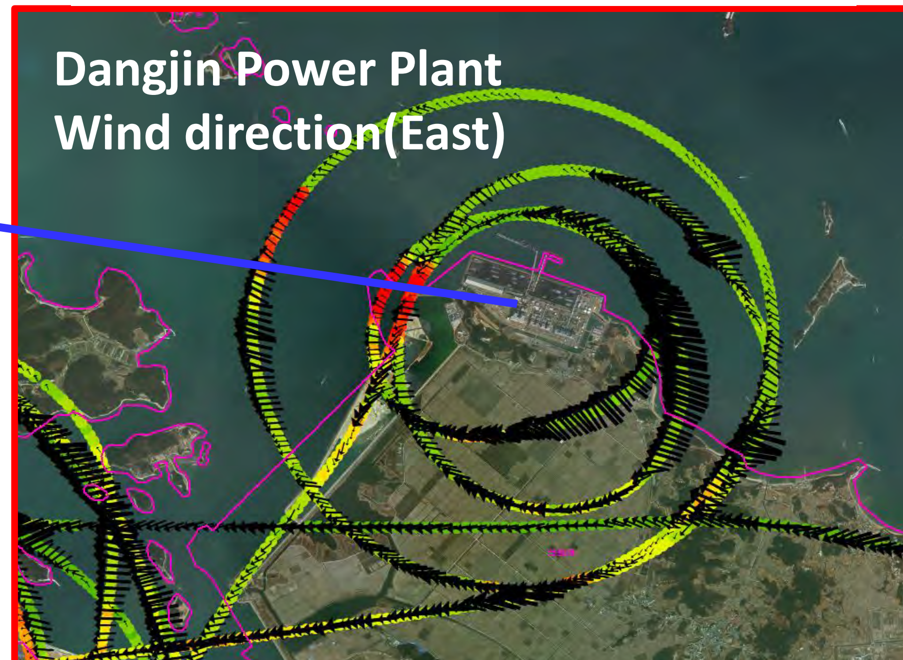
Up to 63% of possible under estimation of LPS emission

Concentration ratio (SO_2)	Dangjin PP	Hyundai Steel	Boryeong PP	Seocheon PP	Gunsan Ind. Comp.
Model/Meas.	0.37	0.64	0.78	0.5	0.56

2-3. Result (Dangjin PP)



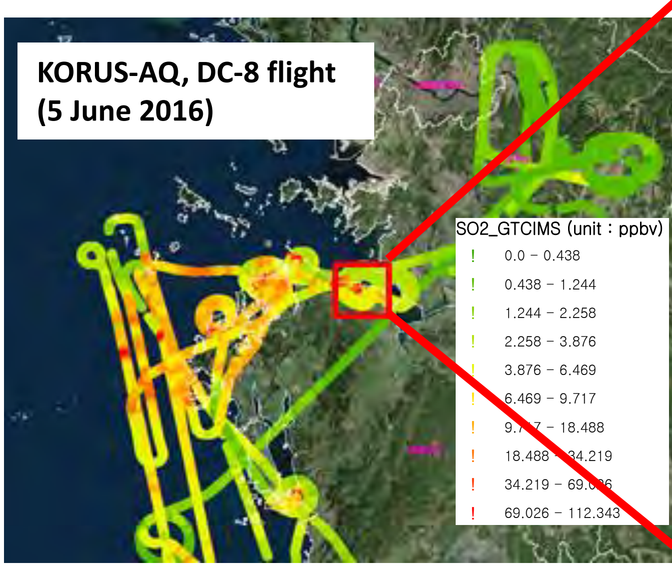
Source : In-situ CIMS measurements of PANs, SO2, and HCl



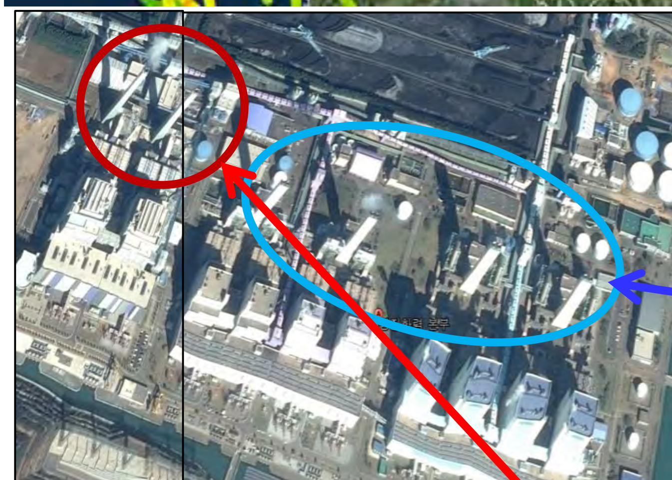
Only one-third of measured SO_2 concentrations were reproduced by LPS emissions!

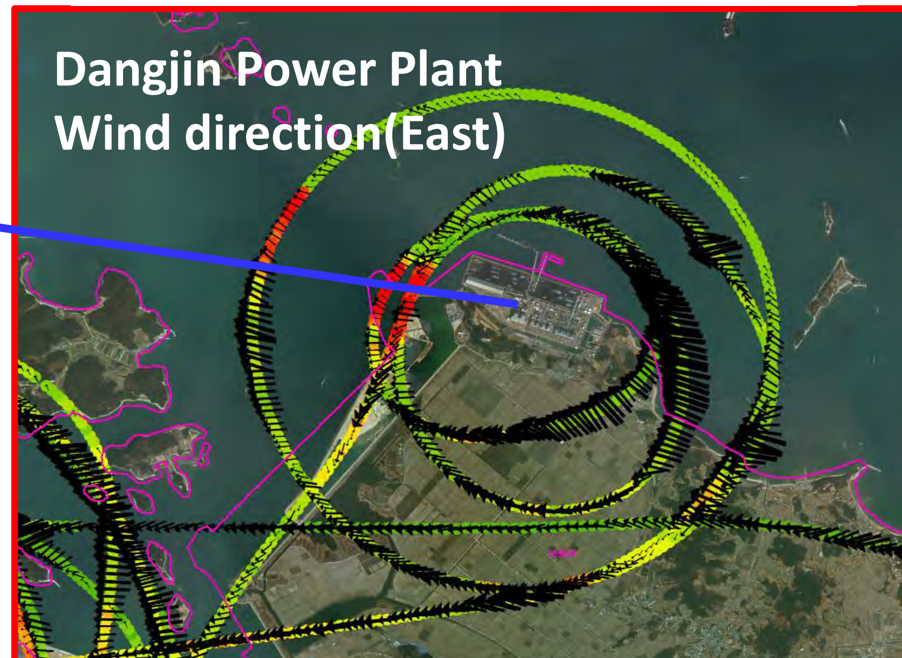
Ratio ($\frac{\text{Model}}{\text{Measurement}}$)	CAPSS 2013
SO_2	0.37

2-3. Result (Dangjin PP)



Source : In-situ CIMS measurements of PANs, SO2, and HCl





CAPSS 2013 : 4 Large Point Source Stacks

Updated CAPSS : 4 stacks plus 2 New Stacks

Ratio ($\frac{\text{Model}}{\text{Measurement}}$)	CAPSS 2013	Updated CAPSS
SO_2	0.37	0.71

2-4. Result of Korea LPSs inventory evaluation

		Dangjin PP		Hyundai Steel	Boryeong PP	Seocheon PP	Gunsan Ind. Comp.
		CAPSS2013	Updated				
NOx(ton/yr)		17,146	**25,719**	7,427	17,454	1,066	1,392
SO_2(ton/yr)		7,223	**10,835**	7,819	11,656	491	1,076
Reduction Facility		SCR	SCR	precipitate facility	SCR	electrostatic precipitator	electrostatic precipitator
Fuels		Bituminous coal, LNG, Cokes	Bituminous coal, LNG, Cokes	Flaming coal, Light oil	Bituminous coal, LNG	Anthracite, Bituminous coal, Heavy oil, Light oil	Heavy oil, LNG, Cokes
Model/Meas.	NOx	0.96	**1.51**	1.21	1.02	1.24	1.30
	SO_2	0.37	**0.71**	0.74	0.78	0.50	0.56

SCR : Selective Catalytic Reduction

- At 5 sites, **NOx emissions seem to be overestimated** (ratio from 0.96 to 1.51) and **SO_2 seem to be underestimated**(ratio from 0.5 to 0.78)
- Evaluation of the model-measurement ratio helped **improving emissions information** in case of the Dangjin Power Plant
- Using the multiple fuels could increase the uncertainty of the emission inventory

2-4. Result of Korea LPSs inventory evaluation (with chemical reaction)

		Dangjin PP		Hyundai Steel	Boryeong PP	Seocheon PP	Gunsan Ind. Comp.
		CAPSS2013	Updated				
NOx(ton/yr)		17,146	**25,719**	7,427	17,454	1,066	1,392
SO_2(ton/yr)		7,223	**10,835**	7,819	11,656	491	1,076
Reduction Facility		SCR	SCR	precipitate facility	SCR	electrostatic precipitator	electrostatic precipitator
Fuels		Bituminous coal, LNG, Cokes	Bituminous coal, LNG, Cokes	Flaming coal, Light oil	Bituminous coal, LNG	Anthracite, Bituminous coal, Heavy oil, Light oil	Heavy oil, LNG, Cokes
Model/Meas.	NOx	0.96	**1.30**	1.16	1.02	1.07	1.02
	SO_2	0.37	**0.71**	0.74	0.78	0.50	0.56

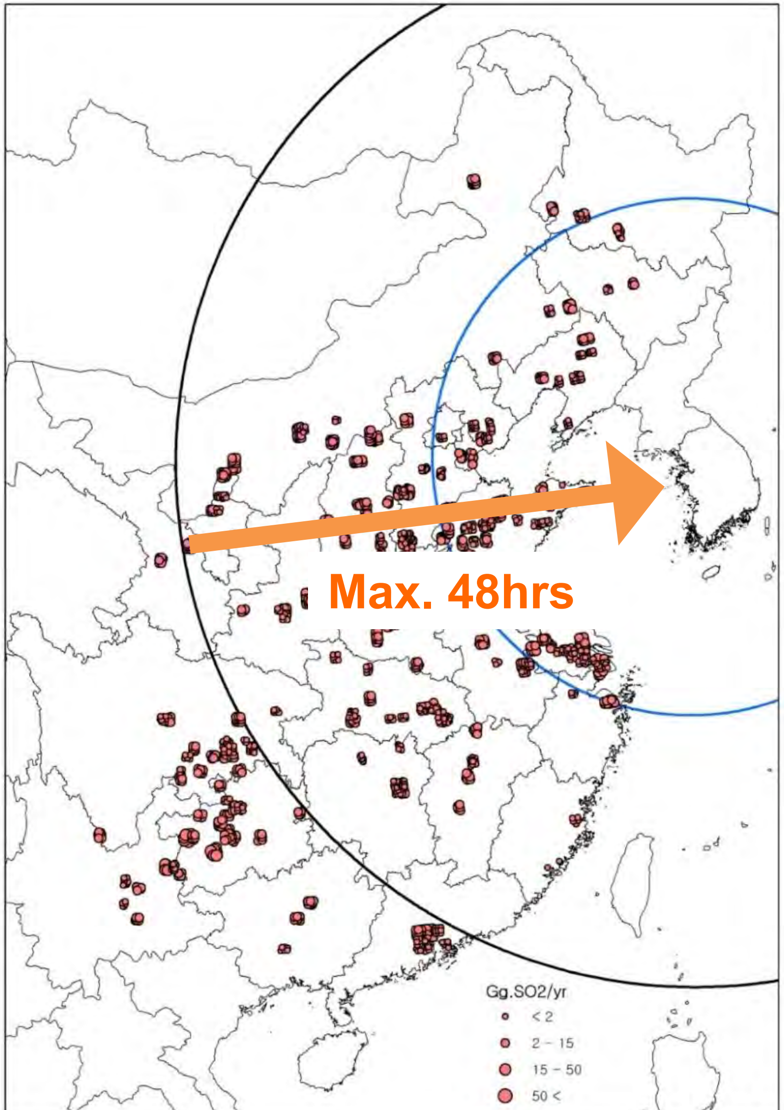
SCR : Selective Catalytic Reduction

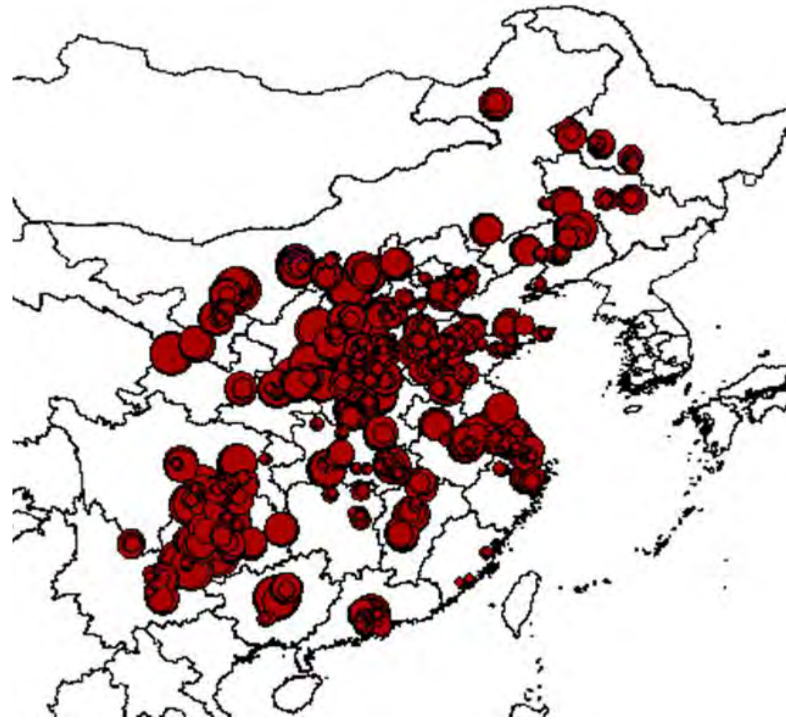
$$C(x,y,z;H)=\frac{Q\,e^{(-kt)}}{2\pi u\sigma_y\sigma_z}\exp\left[-\frac{y^2}{2\sigma_y^2}\right]\left\{\exp\left[-\frac{(H-z)^2}{2\sigma_z^2}\right]+\exp\left[-\frac{(H+z)^2}{2\sigma_z^2}\right]\right\}$$

- Chemical Atmospheric lifetime of NO2 and SO2 were considered Foy et al., 2015 and Lee et al., 2011, respectively.
- Applying chemical reaction (decay) made the agreement better, especially for NOx (up to 22%)

Objective B : Develop LPSs Inventory in China

: Importance of China LPSs to Air Quality in Korea





2

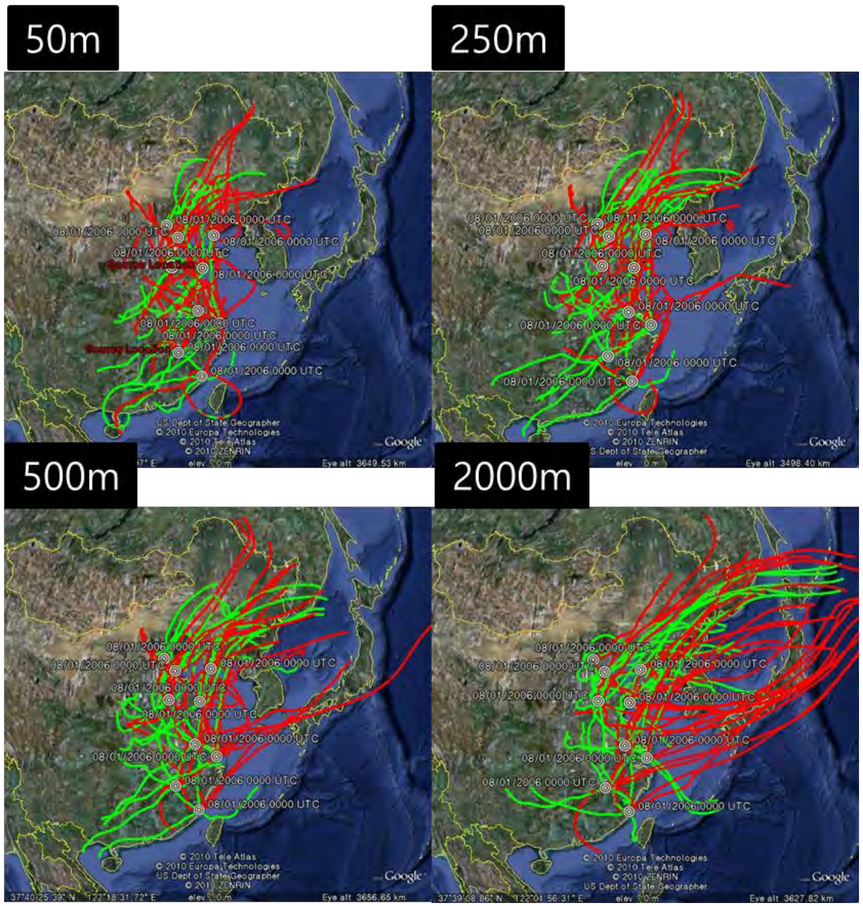
China LPS SO_2 Emission

Develop LPSs inventory in China
to improve CTM modeling for KORUS-AQ

3. Develop LPSs Inventory in China

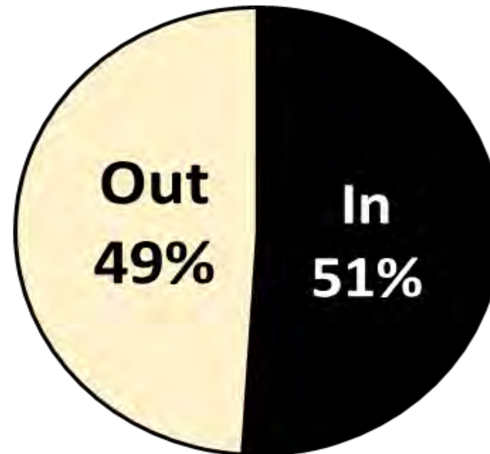
3-1. Background

- **Horizontal Transport by Vertical Injection Height (HYSPLIT)**

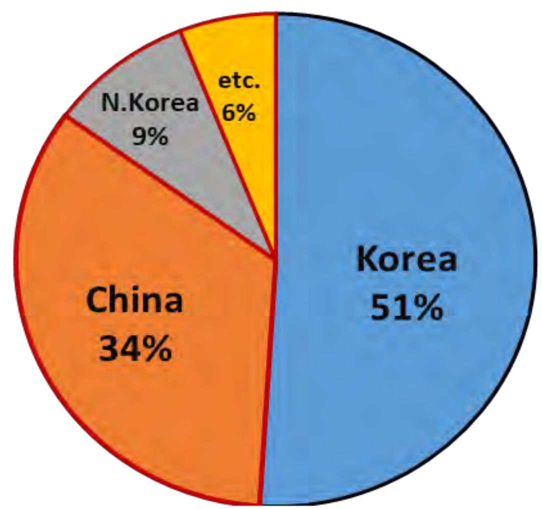


J. Woo, MICS, 2011

- **Local vs. Transboundary Contribution**



Seoul Metro
KORUS AQ, DC-8 flights



KORUS RSSR, NIER/NASA, 2017

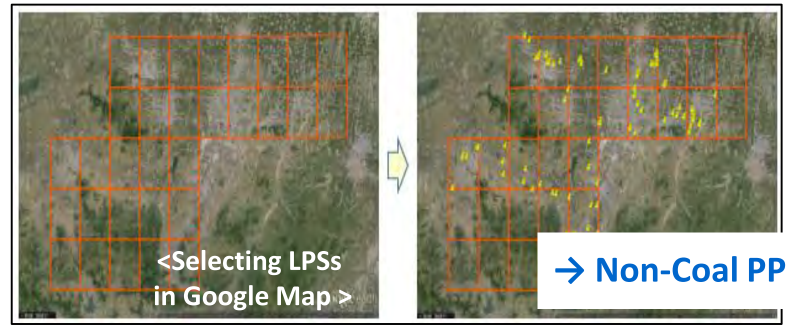
3-2. Research Setting

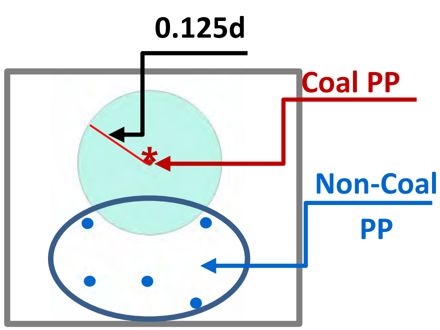
- **Global Coal Plant Tracker's info.**

  : location, status, operator, size, CO_2 emis.

- **HTAP_v2 dataset with 0.1˚×0.1˚ Grid map**

  : SO_2 emis. From Energy sector in 2010

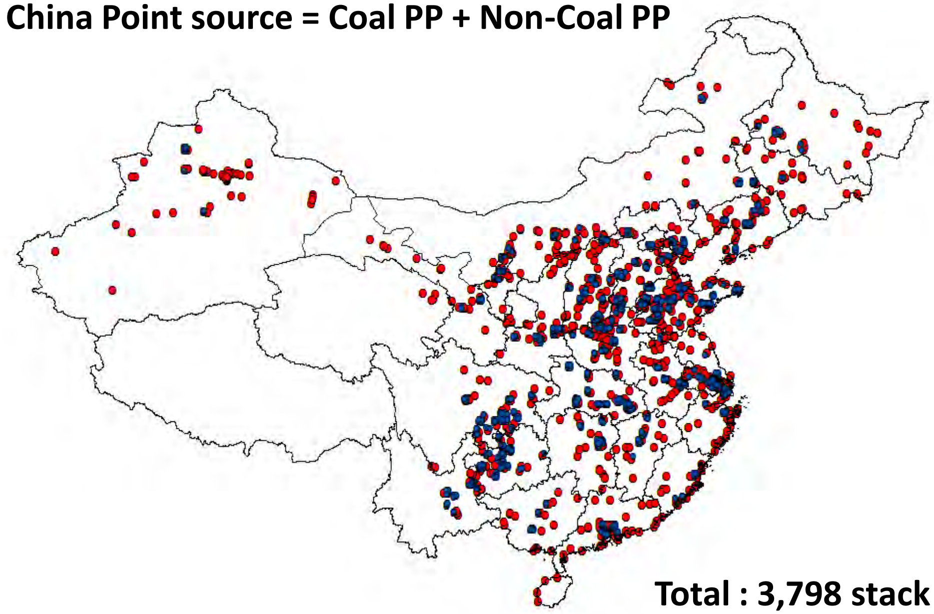




Red : Coal PP

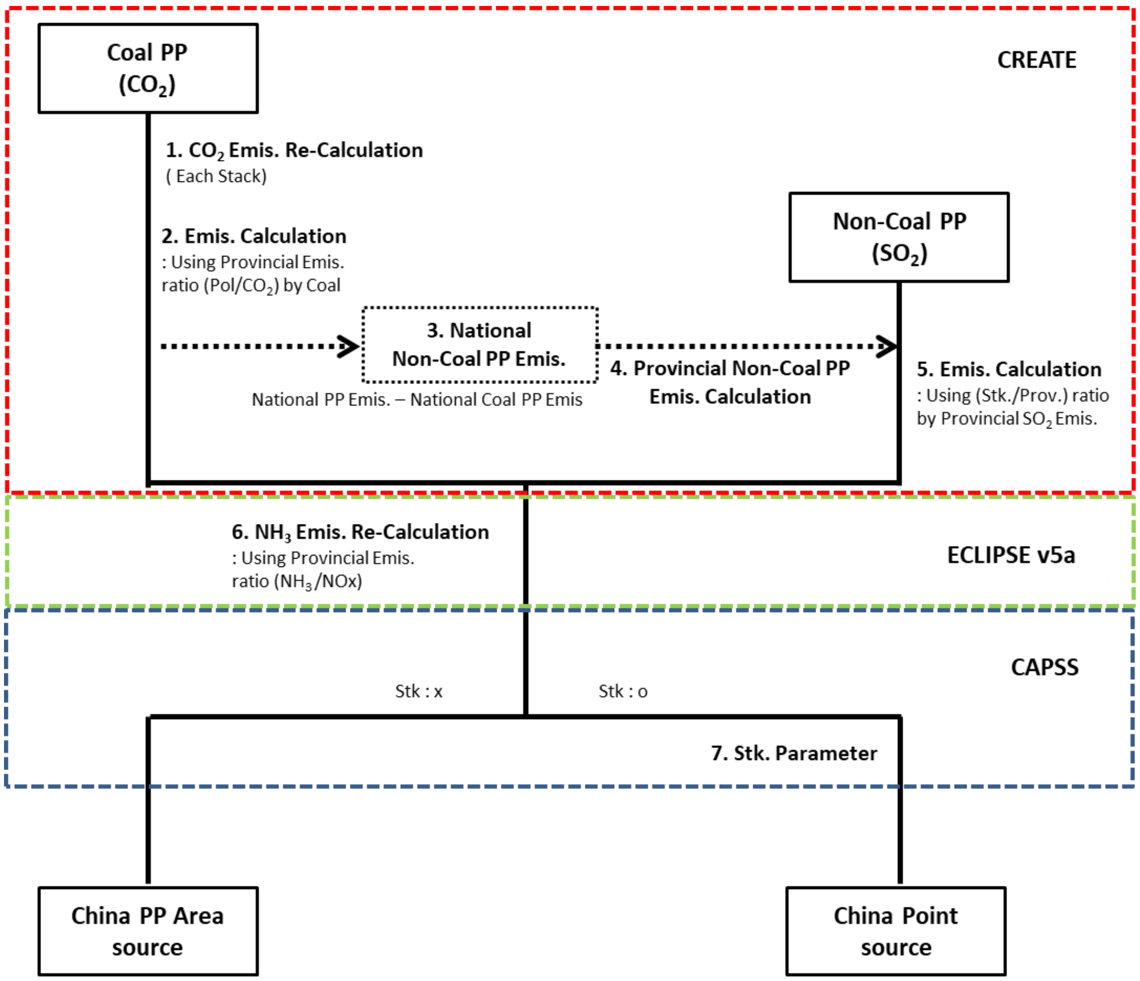
Blue : Non-Coal PP

China Point source = Coal PP + Non-Coal PP



3-3. Process of LPS emission inventory development in China

- **Procedure**



- **Data**

1. CREATE Power sector inventory

- NIER/KU-CREATE (Projected 2015)
- Anthropogenic Emissions Inventory Improved GAINS-Korea/Asia emissions using national info.,
- Asia regions, ~300 SCCs
- Pols.: CO_2, NO_x, PM_{10}, $PM_{2.5}$, SO_2, VOC, NH_3, CO

2. GAINS ECLIPSE v5a Scenario emissions

- Scenario in GAINS Framework
- Estimated from IEA Energy Data
- Assumption on effects of economic development and mitigation policies

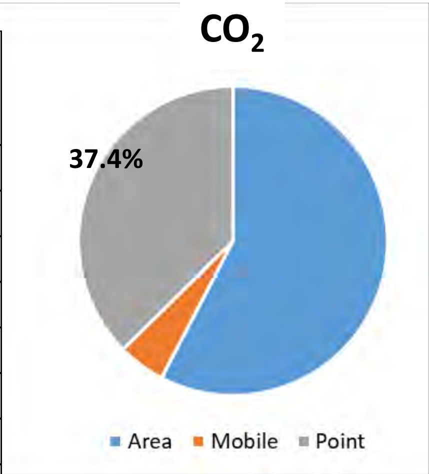
3. CAPSS (NEI of Korea)

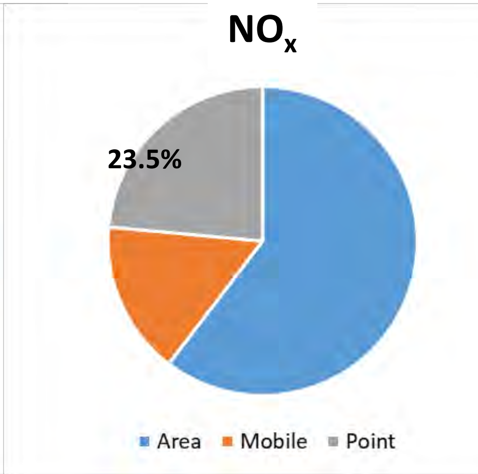
- Korea's Clean Air Policy Support System
- Includes stack parameters in the point source inve ntory

3-4. Inventory development result

Gg/yr

	① CREATE Power Sector (②+③+④)	② Coal PP [Point]	③ Non-Coal PP [Point]	④ Small Non-Coal PP [Area]
CO	520	478	37	6
CO_2	4,019,663	3,929,389	81,690	8,584
NH_3	121.92	119.78	1.93	0.20
NO_X	6,345	6,196	137	12
PM10	2,819	2,809	10	0.49
PM2.5	1,111	1,101	10	0.47
SO_2	8,847	8,765	78	4
VOC	102	94	8	0.55



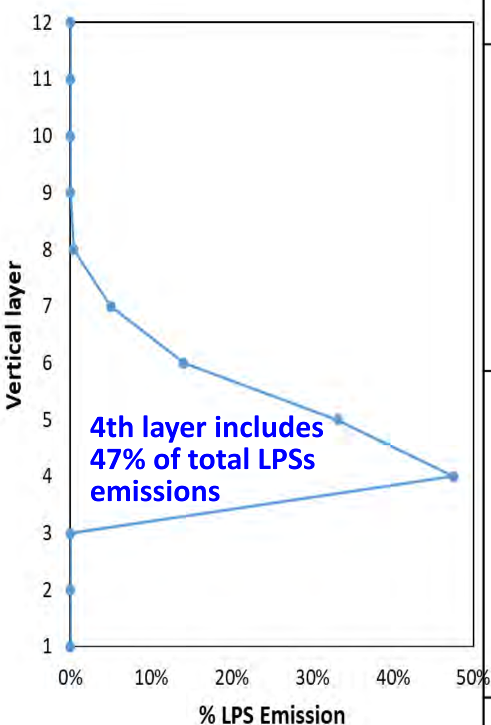


Power sector emissions were allocated to LPSs

- **Total 3,798 stacks** (Coal PP : 2,706 , Non-Coal PP : 1,092) were found as China Large Point Sources(LPSs)
- China Point source based on **Power Plant(PP) sector** in CREATE inventory.
- Power Plant(PP) sector emissions in the CREATE inventory were allocated to each stack.
- Of the total emissions, the power sector accounts for **37.4% of CO_2** and **23.5% of NO_X**.
- For **NH_3, the emissions increased 92 times** from the year 2010 level to correctly represent new installatio n of NO_X abatement technologies in China. The GAINS ECLIPSE v5a scenario was used.

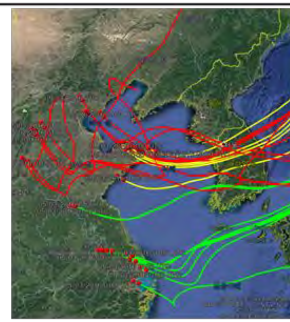
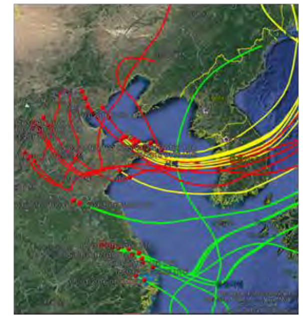
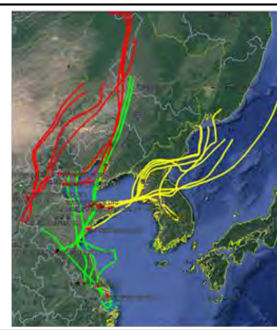
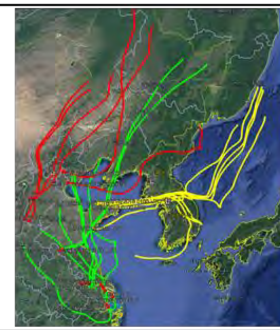
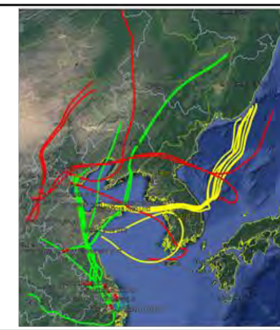
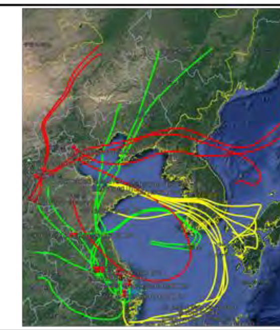
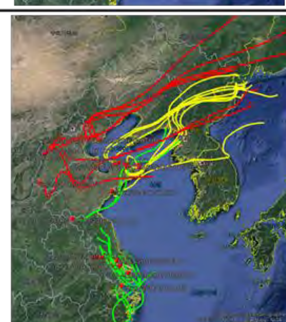
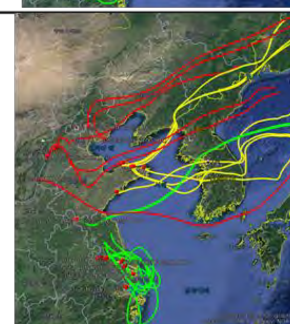
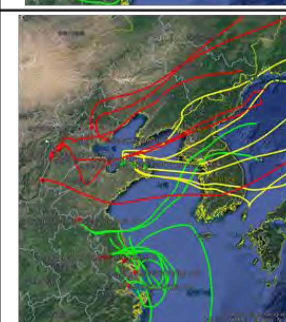
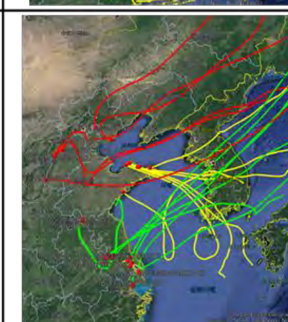
3-5. Evaluation of Transport

- **Point source emission vertical profiles**



- Date : May 3, 16, 23, 2016
    - Transboundary case during KORUS-AQ
- Location : JJJ, Shandong, YRD
- Injection height range
    - between 250m and 1,000m.

- **Horizontal Transport with respect to the injection height (HYSPLIT)**

	10m	250m	500m	1,000m
3rd. May				
16th. May				
23th. May				

4. Summary

- Large Point Sources(LPSs) emission inventories were evaluated(Korea) and improved(China) in support of NIER/NASA KORUS-AQ
- We have evaluated NO_X and SO_2 Emissions from 5 LPSs over that western part of South Korea (near SEOUL) using the DC-8 June 5th flight, CAPSS inventory, and measurement-driven Gaussian plume model
- Inter-comparison of modeled and measured concentration were conducted to understand validity of large point source emissions
- At 5 sites, NO_X emissions tend to be overestimated (ratio from 0.96 to 1.3) and SO_2 tend to be underestimated(ratio from 0.5 to 0.78). The ranges are, however, fair considering the averaging time of both dataset
- For China LPS inventory, total 3,798 stacks (Coal PP : 2,706 , Non-Coal PP : 1,092) were found
- From the analysis of injection layer height using SMOKE-Asia, 47% of the total emissions in the 4th layer, and most of emissions were injected between 250 and 1,000 meters
- Injection height affected much of their horizontal path, based on initial HYSPLIT modeling

AIS Research Group
@ Konkuk University

(Dr. Younha Kim, Mr. Chanjong Bu, Ms. Jinsu Kim, Mr. Yungu Lee, Mr. Jonseok Kim, Ms. Youjung Jang, Ms. Geunhye Park)

Thank You!

NASA/NIER
KORUS-AQ Team

대기정보시스템연구실
환경부지정 기후변화특성화대학원
Atmospheric Information Systems Research Group