ICAP Meeting, Tokyo, Japan, Jul 22-24, 2019

Merged aerosol products from GEO satellite observations

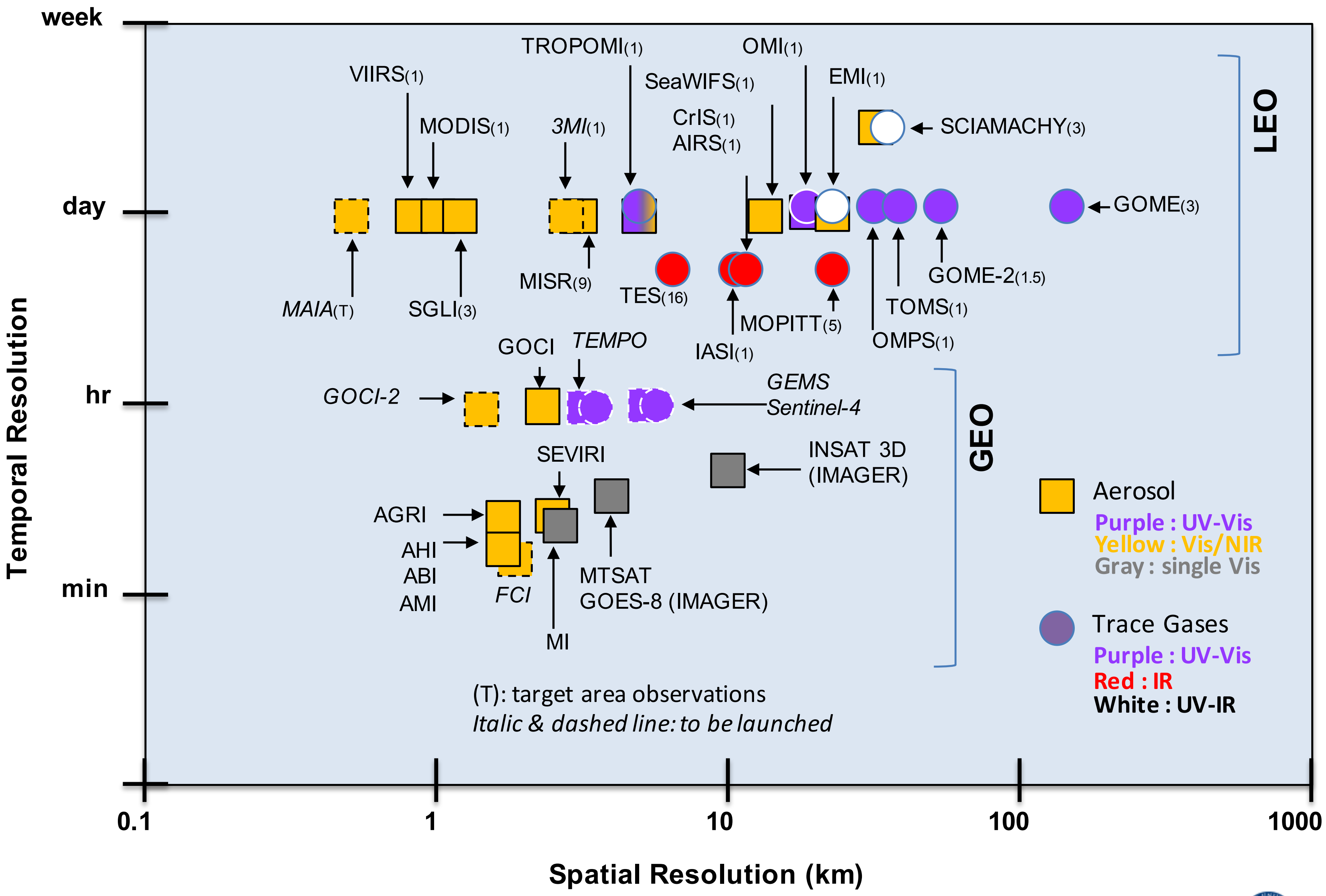
Jhoon Kim[1], Seoyoung Lee[1], Hyunkwang Lim[1], Sujung Go[1], Myungje Choi[1,2], Yesl Cho[1], Heesung Chong[1]

[1]Yonsei University, Seoul, Korea

[2]NASA JPL, Pasadena, CA

YONSEI UNIVERSITY

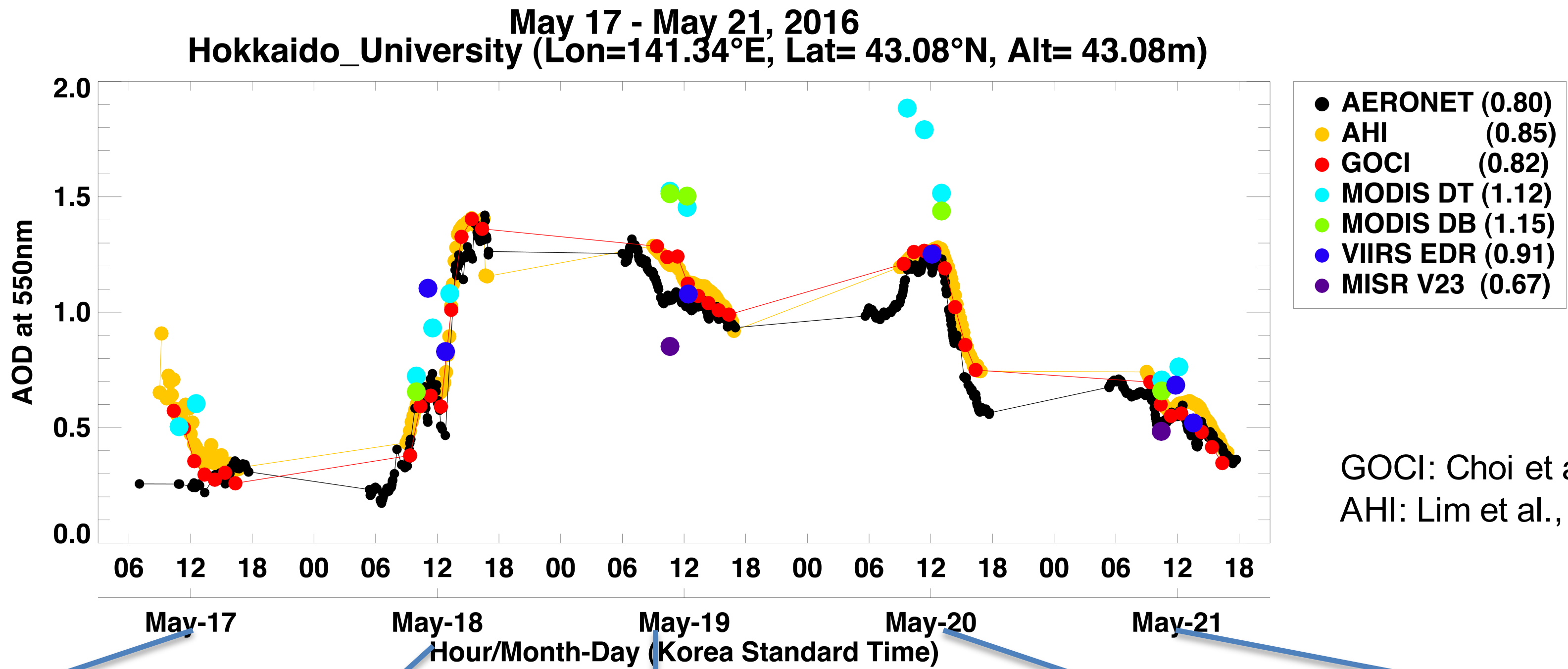
Development of Satellite RS for Aerosols & Gases



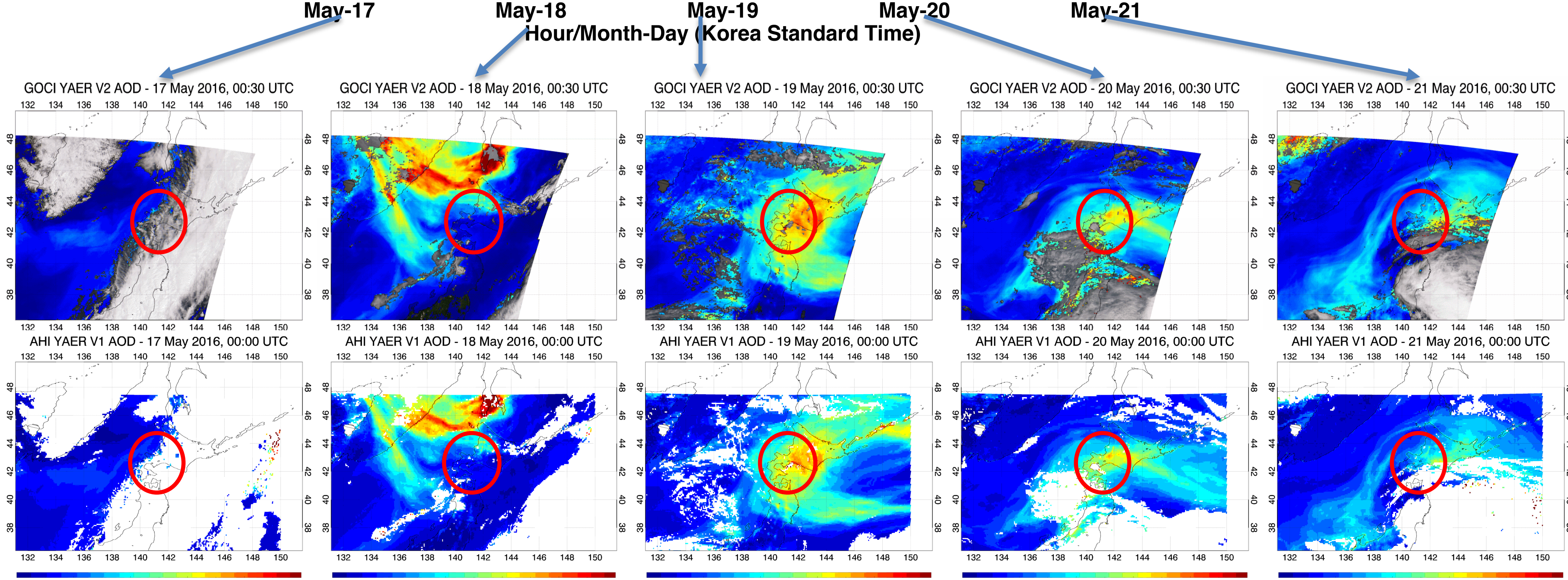
Kim et al.(submitted & revised, BAMS)

YONSEI UNIVERSITY

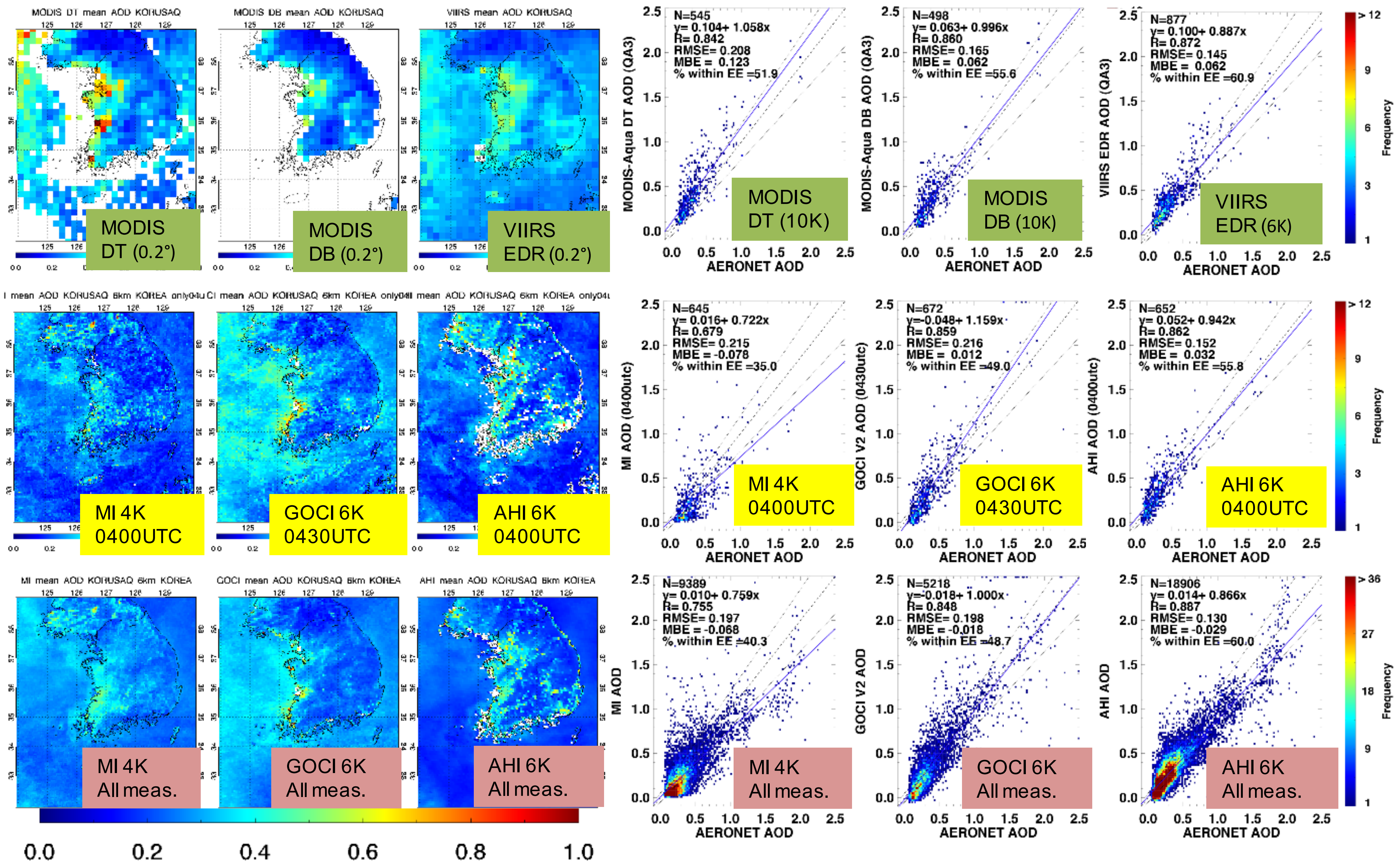
Diurnal variation for aerosol from GOCI and AHI



GOCI: Choi et al., AMT, 2018
AHI: Lim et al., RS, 2018



Mean AOD dist. and validation during the KORUS-AQ



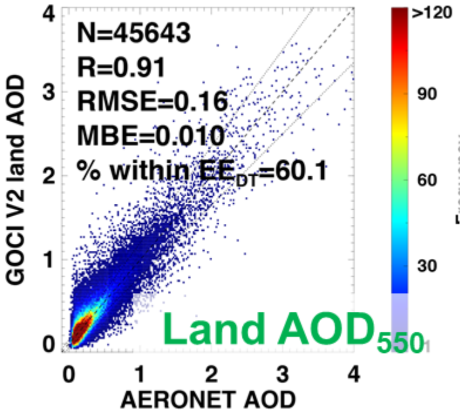
- High AOD over Western part of Korea

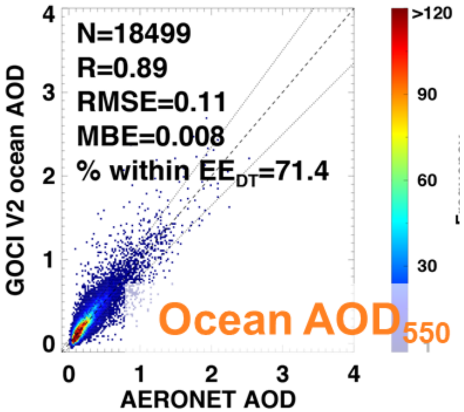
- More frequent GEO measurement
  → 10-30 times higher in No. of collocated data
- Similar accuracy with LEO

YONSEI UNIVERSITY

Validation of GOCI AOD, AE, FMF, and SSA (Mar 2011 − Feb 2016, 5-yr)

Collocation with 27 AERONET sites for land AOD, and 17 coastal sites for ocean AOD





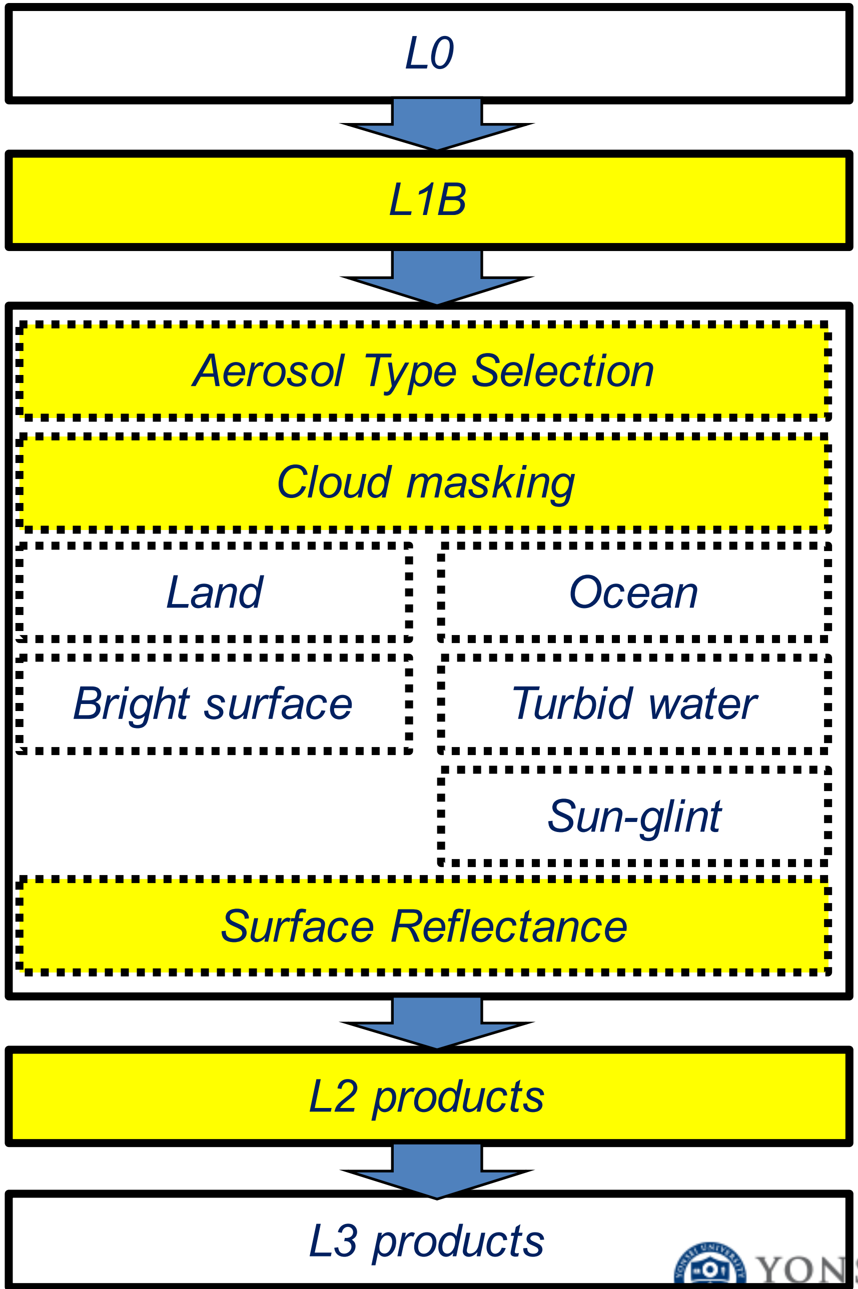
- $EE_{DT} = \pm (0.05 + 0.15 \times \text{AERONET AOD})$
- *AE, FMF, and SSA comparison: only for AERONET AOD > 0.3*
- Collocation criteria:
  (spatially) average satellite pixels **within 25 km** radius from AERONET sites
  (temporally) average AERONET data **within 30 min** from satellite measurement

Choi et al.(AMT 2018)

Merging aerosol property retrieval

- Possible Data Merging Step

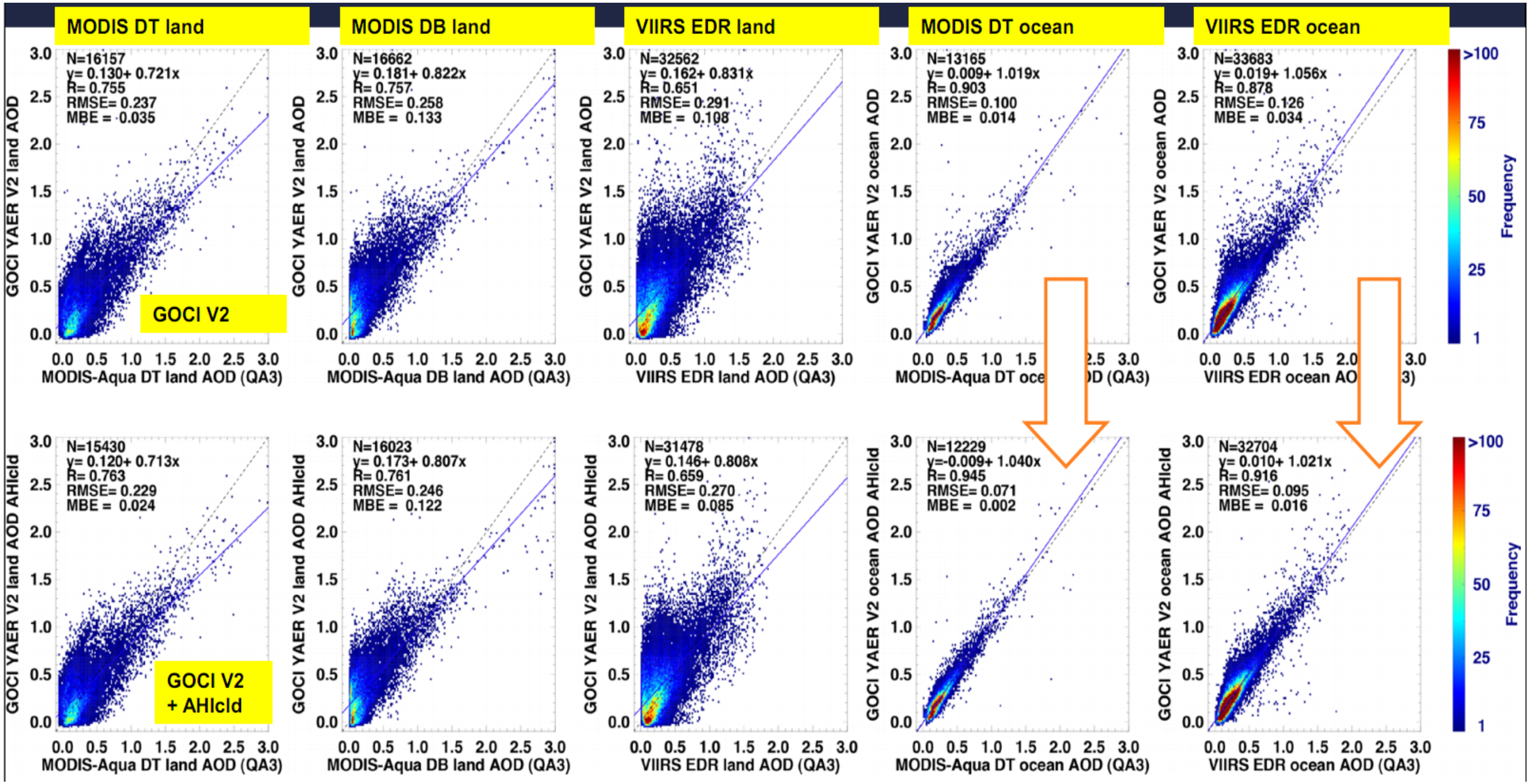
1) L1B radiation (Need to consider SRFa)
2) Aerosol Type (absorption+size)
3) IR Cloud masking
4) Spectral surface reflectance
5) L2 AOD Level



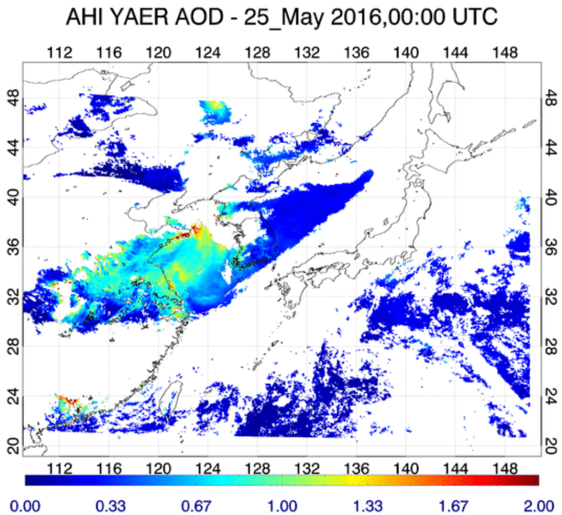
YONSEI UNIVERSITY

Merging : GOCI AODs with cloud masking by AHI IR

- **Comparison of GOCI results with MODIS & VIIRS**
  - Improvement in cloud masking over ocean, in particular

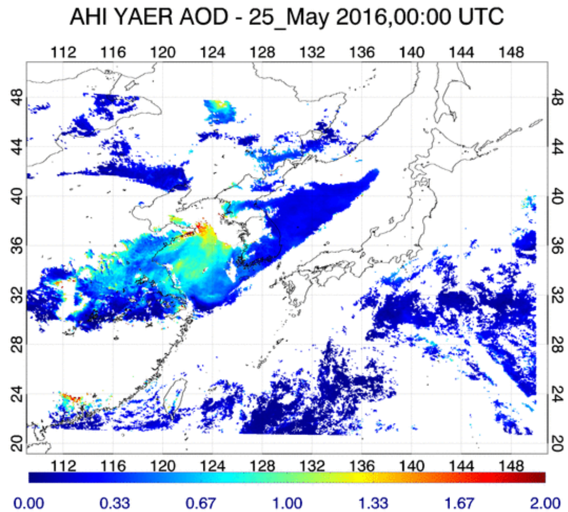


Data Merging: 25 May 2016(AHI+GOCI)



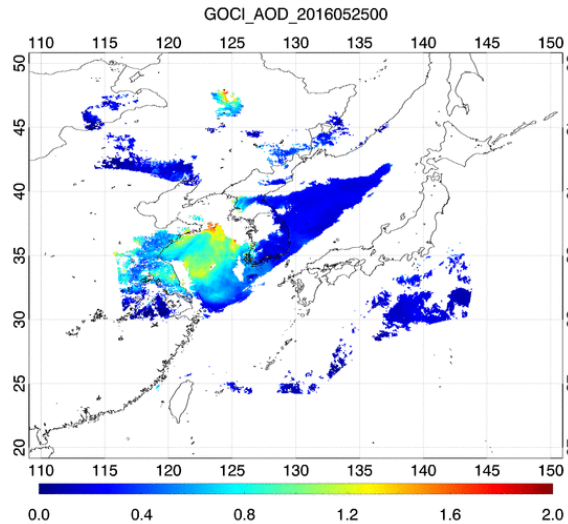
R=0.888
%EE = 60.6

AHI_ESR



AHI_MRM

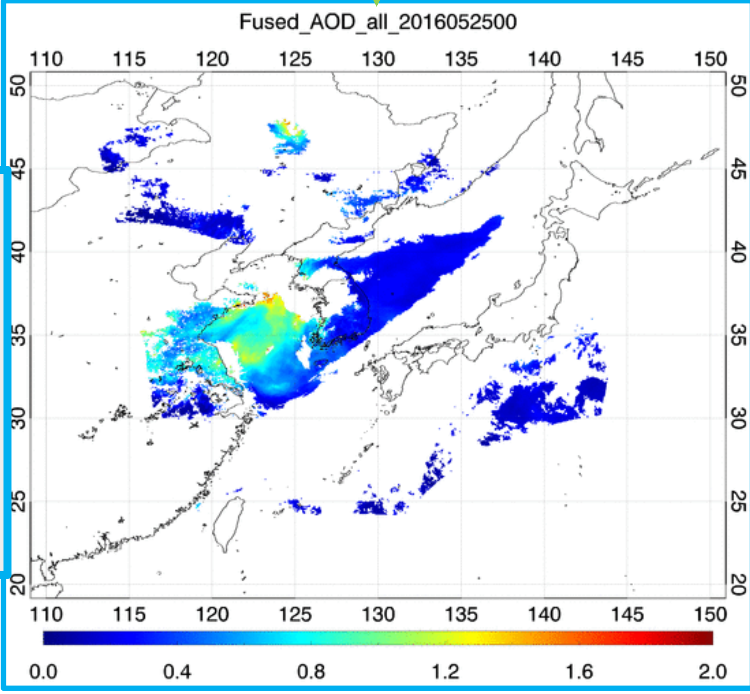
R=0.908
%EE = 63.5



GOCI

R=0.902
%EE = 61.8

Merged AOD



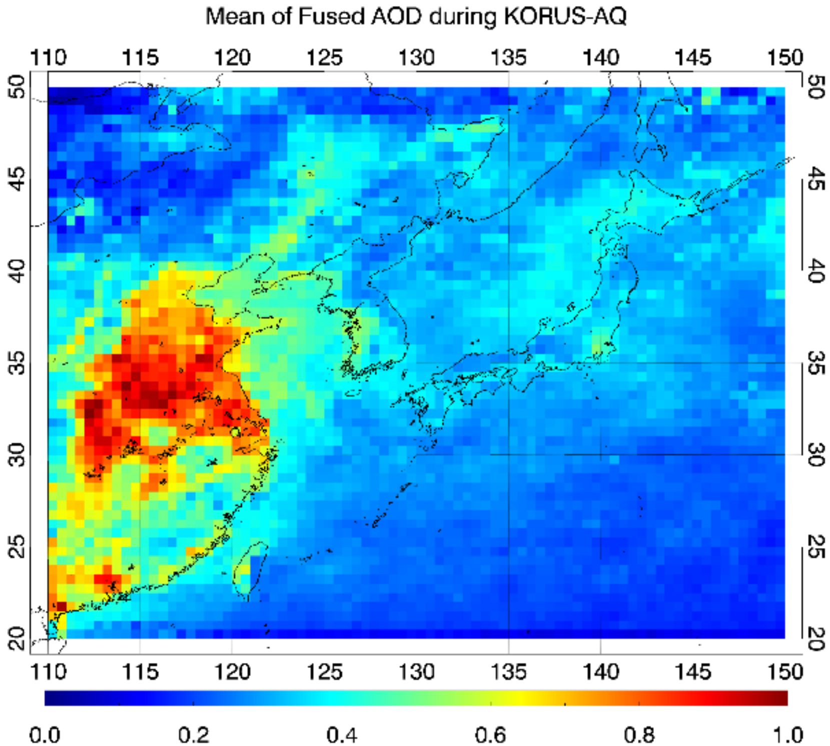
R=0.918
%EE = 73.4

- ✓ Resample AHI AOD with GOCI pixel.
- ✓ To estimate hourly AOD using 10-minute intervals dataset (Improvement of cloud mask).

GOCI: Choi et al., AMT, 2018
AHI: Lim et al., RS, 2018

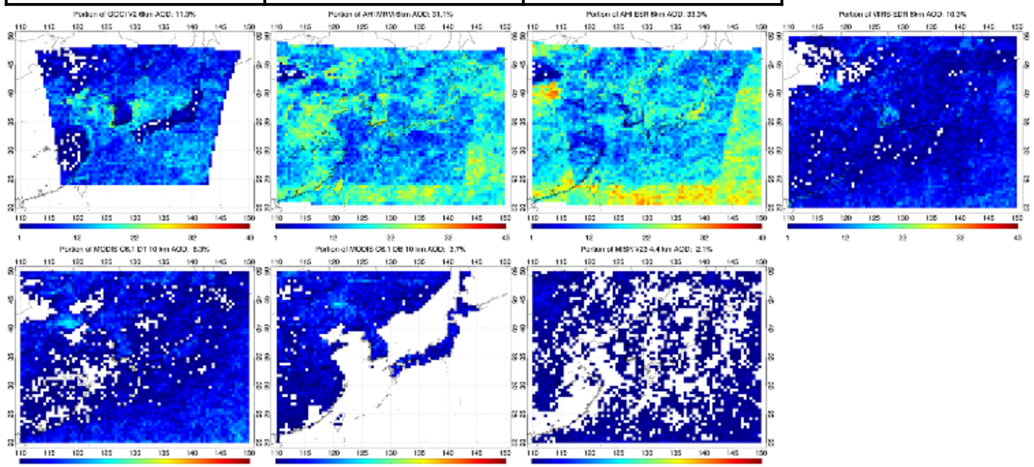
KORUS-AQ Daily Merged AOD product (0.5°×0.5° grid)

- Purpose: finding daily representative AOD from multiple LEO and GEO AOD products
- Study domain: 110-150°E, 20-50°N (0.5°×0.5° lon-lat grid resolution)
- Order of calculation
  1) Spatiotemporal mean for each product within each day
     - Spatial gridding for each scene, and temporal averaging for daily mean.
     - additional filtering based on *Hyer et al. (2011) to reduce cloud contamination*
  2) For each grid, select **median value AOD** product as daily representative AOD (only when at least two products are available)
  3) Average of daily fused AOD during the Campaign period (5/1-6/12)



Portion for Fused AOD

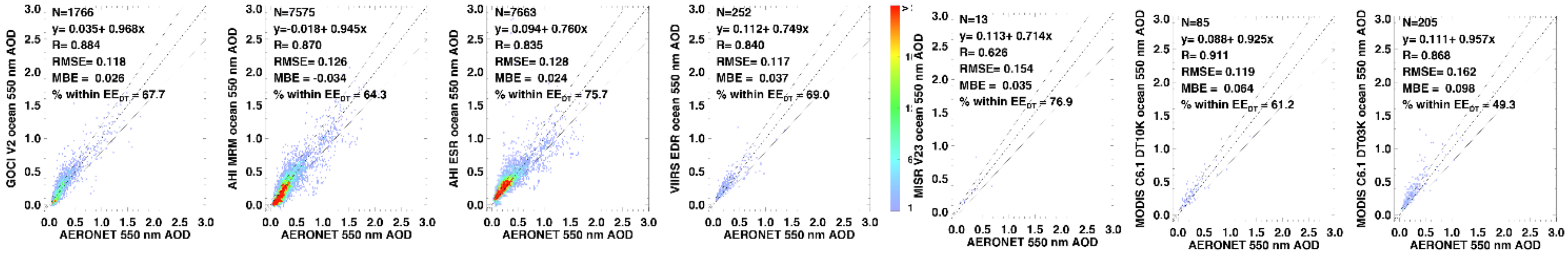
GOCI	AHI MRM	AHI ESR	VIIRS EDR
11.3%	31.1%	33.3%	10.3%
MODIS DT	MODIS DB	MISR	
8.3%	3.7%	2.1%	



AOD comparison btn AERONET and Satellite

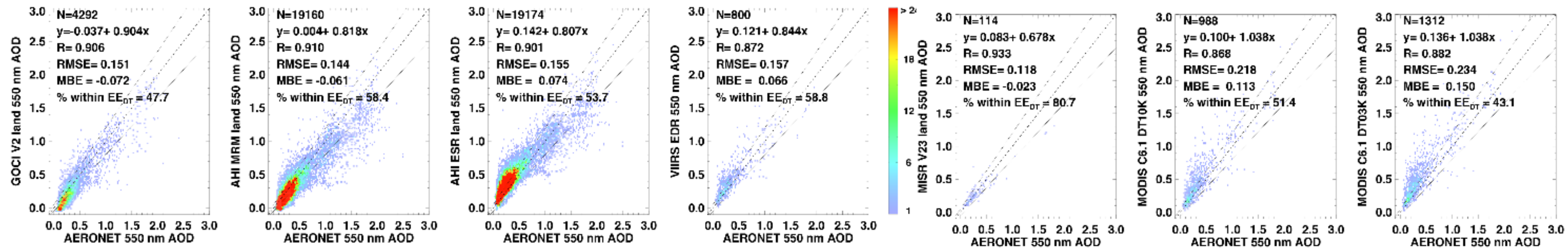
OCEAN

GOCI 6K | AHI_MRM 6K | AHI_ESR 6K | VIIRS 6K | MISR 4.4K | MDT10K | MDT03K

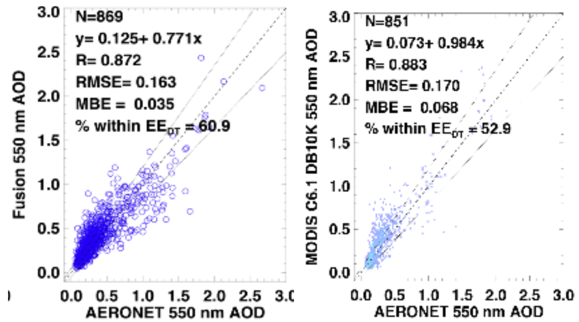


LAND

GOCI 6K | AHI_MRM 6K | AHI_ESR 6K | VIIRS 6K | MISR 4.4K | MDT10K | MDT03K



AOD fusion



MDB10K

- Bias for lowest AOD points

  over ocean

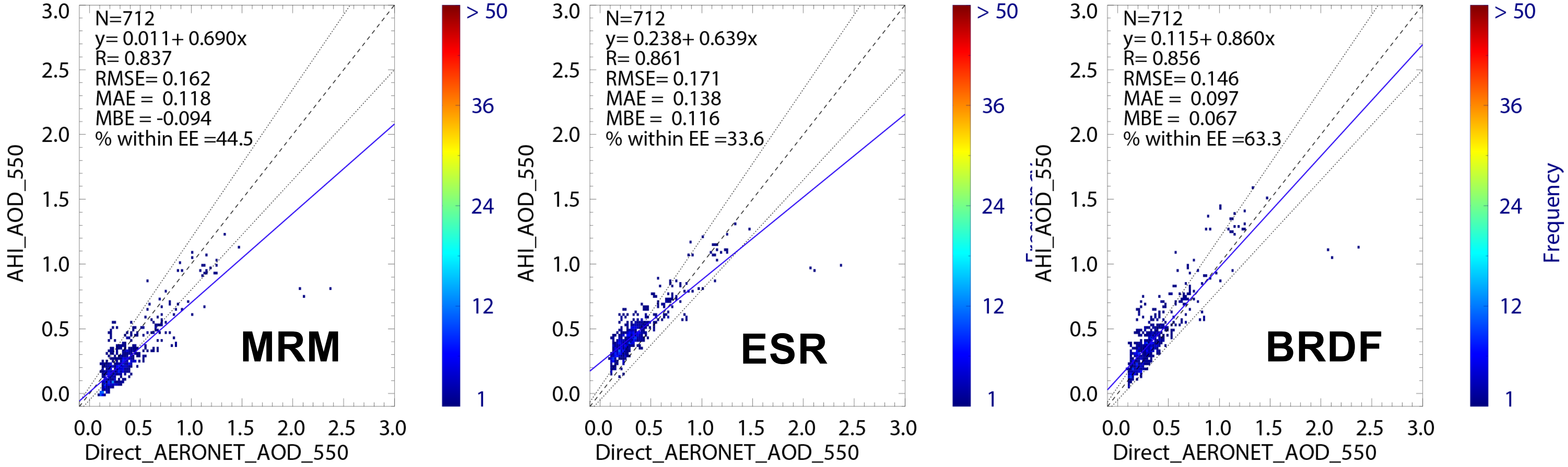
  - AHI_MRM < GOCI < 0 < AHI_ESR < VIIRS < DT10K < DT03K

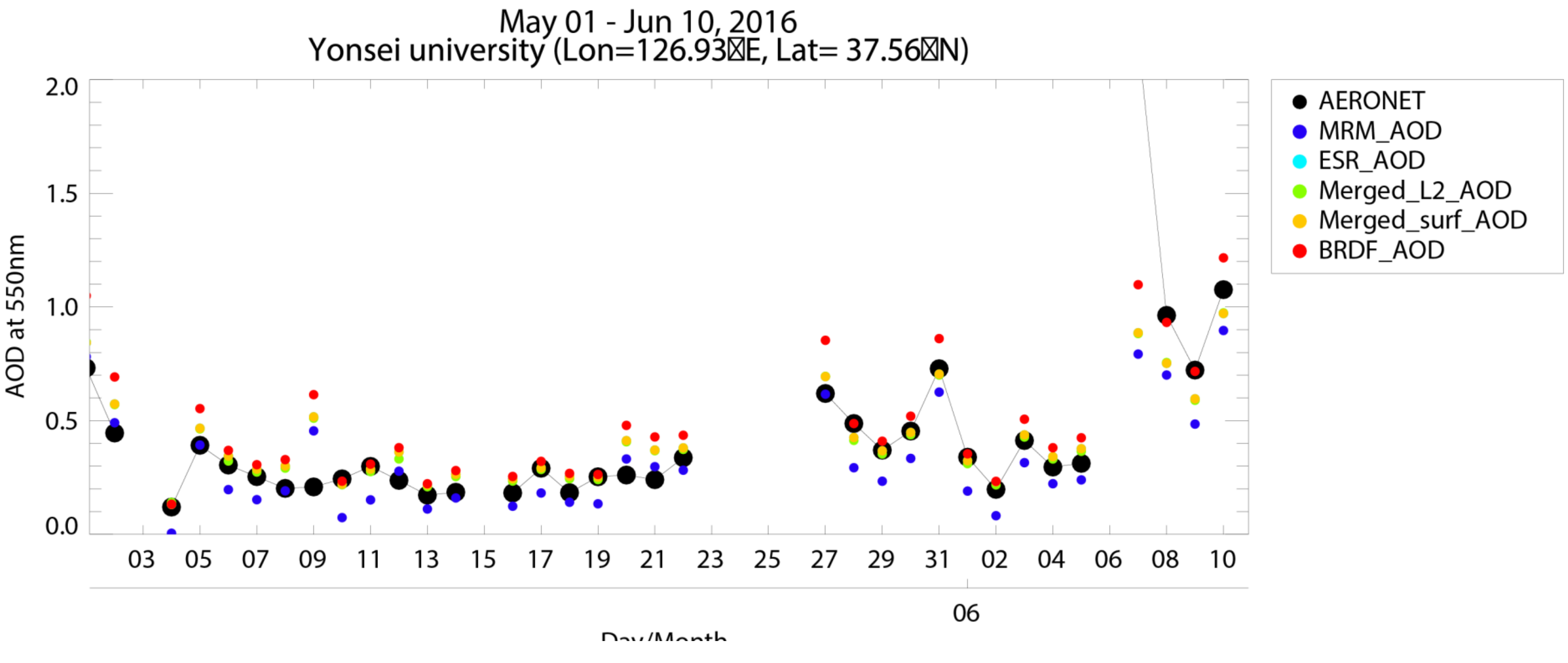
  over land

  - GOCI < AHI_MRM < 0 < DB < MISR < VIIRS < DT10K < DT03K < AHI_ESR

Comparisons of AOD from AHI MRM, ESR, BRDF during KORUS – AQ campaign

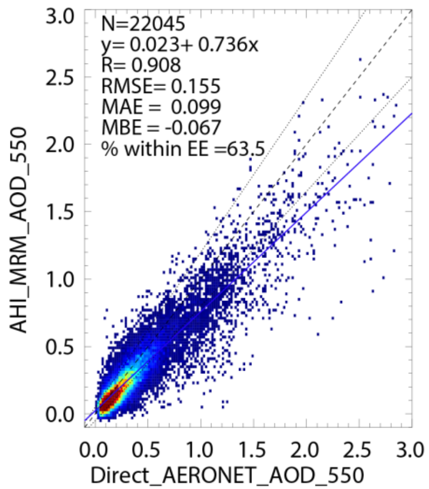
- Yonsei university



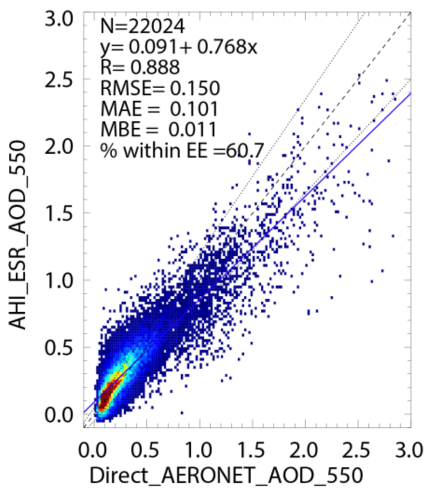


Results of MLE in 2016

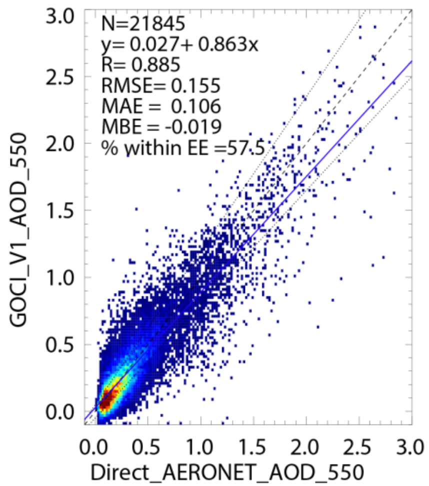
AHI_MRM



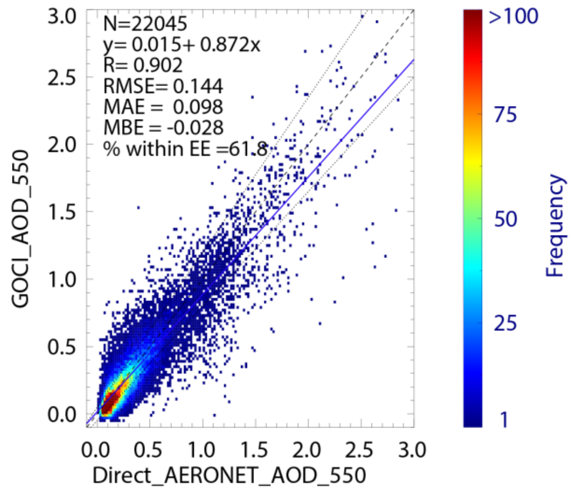
AHI_ESR

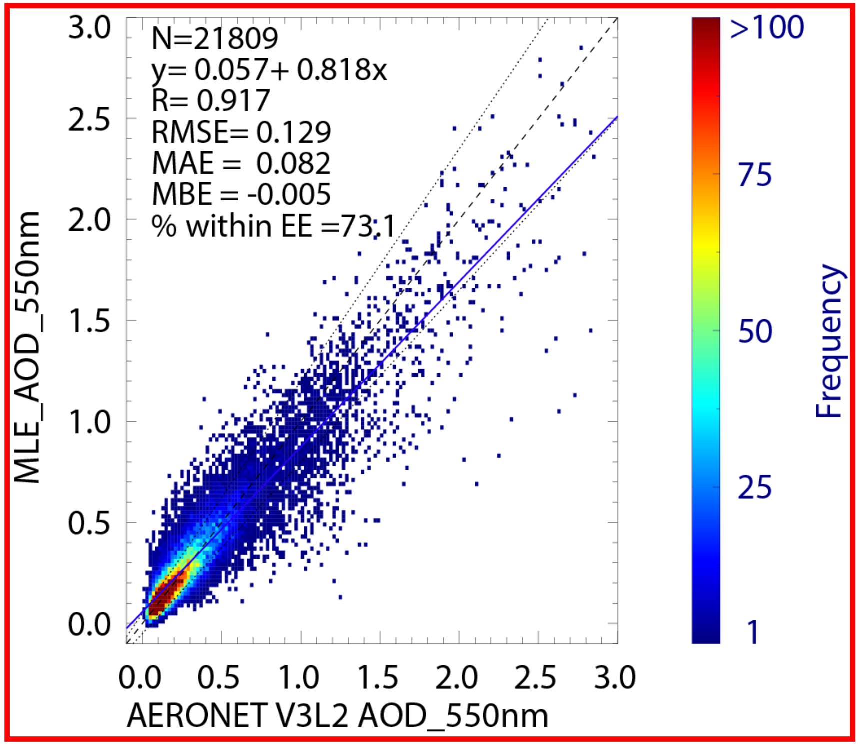


GOCI_V1

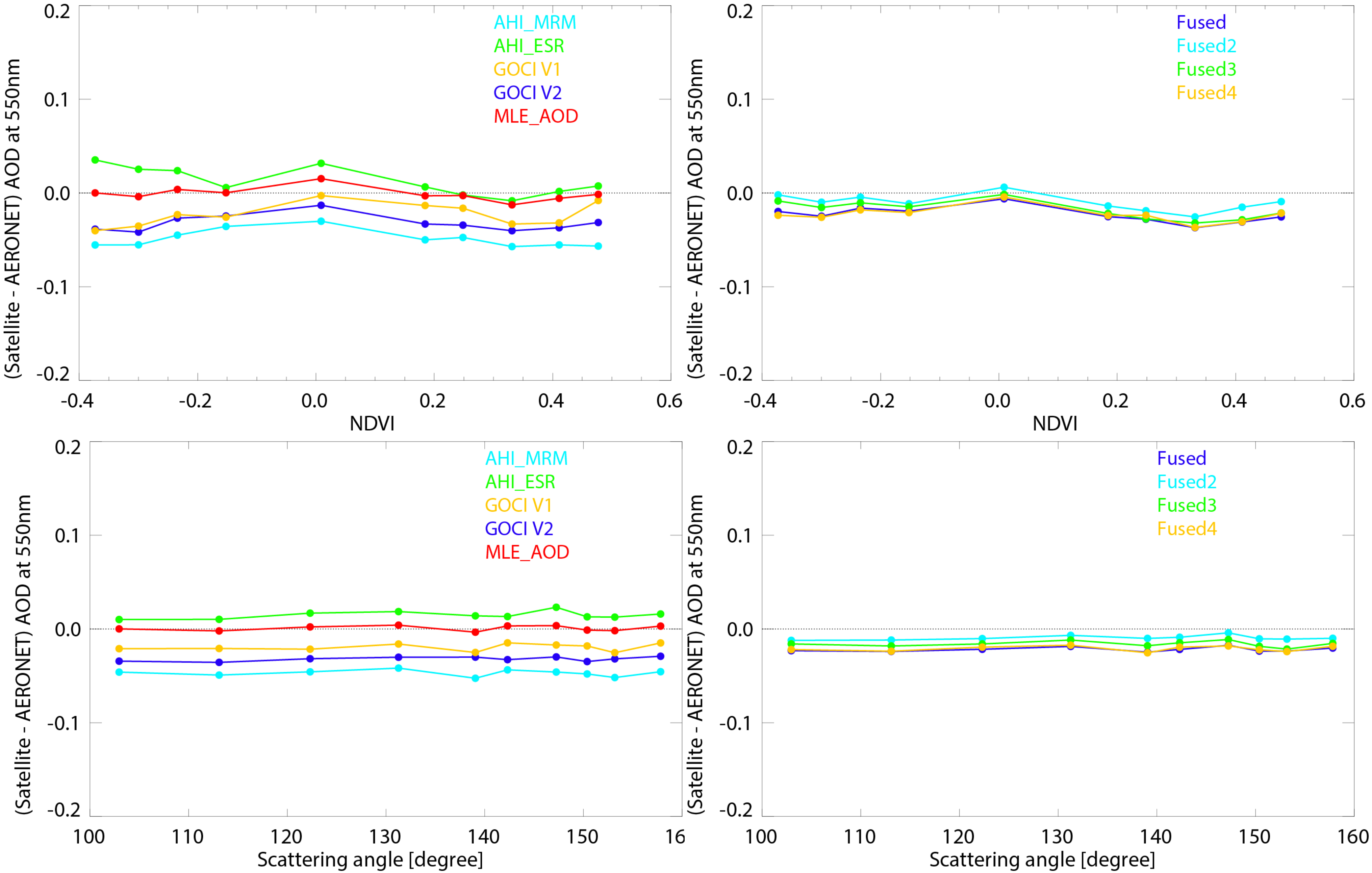


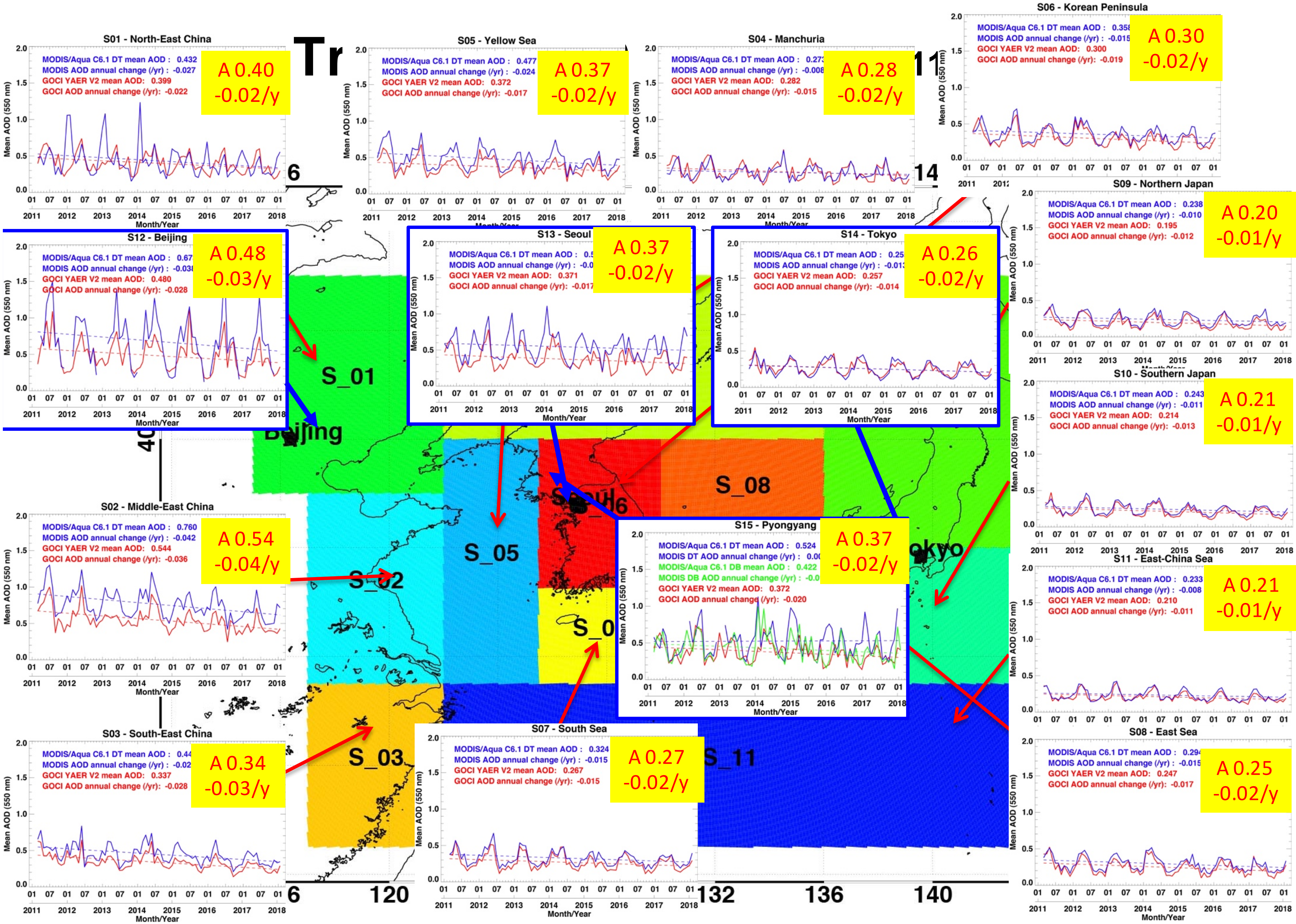
GOCI_V2





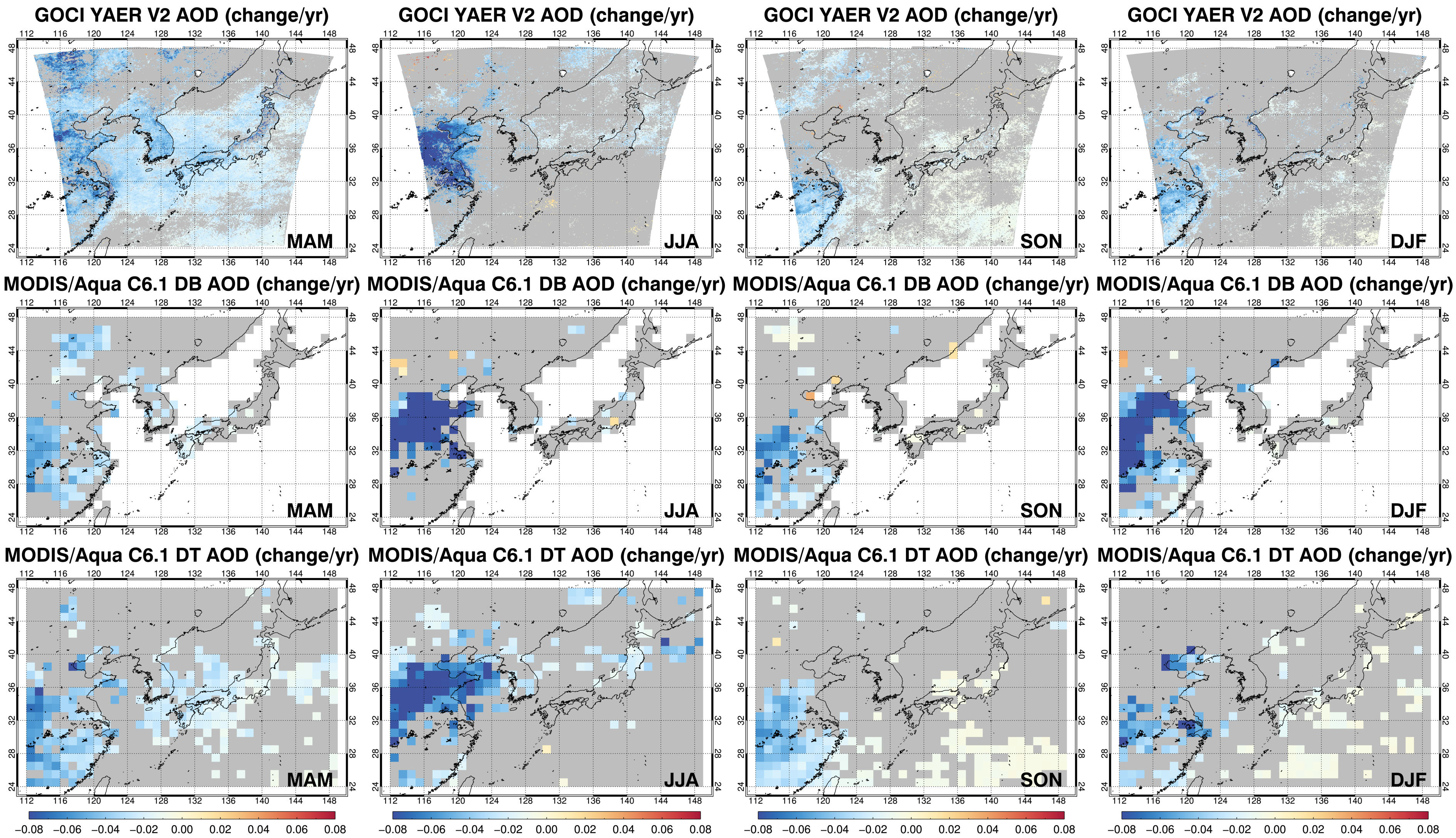
Comparison of Biases (2016)



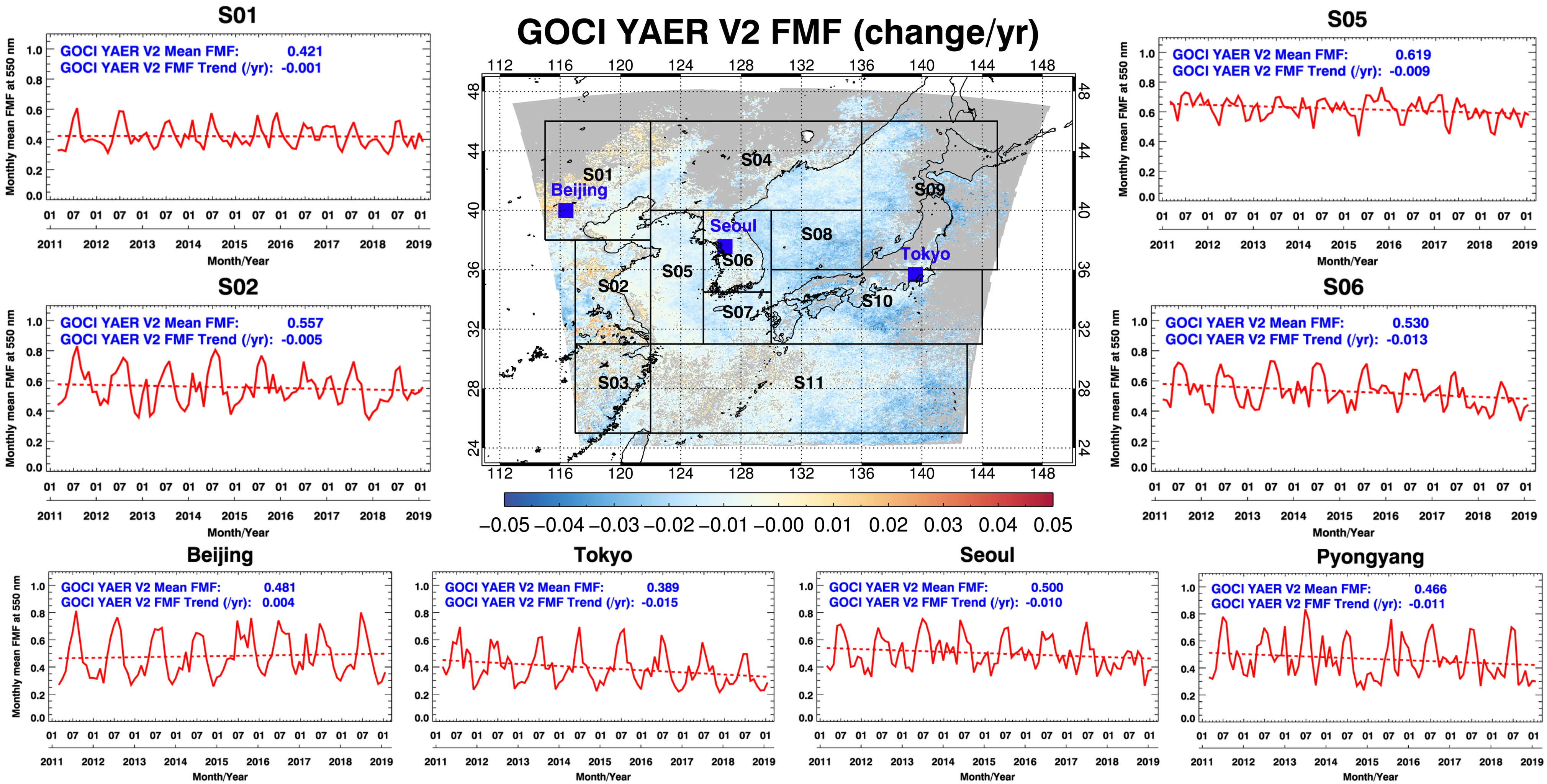


Kim et al. (2017) with update

Seasonal Trends in AODs (Mar 2011 - Feb 2018)

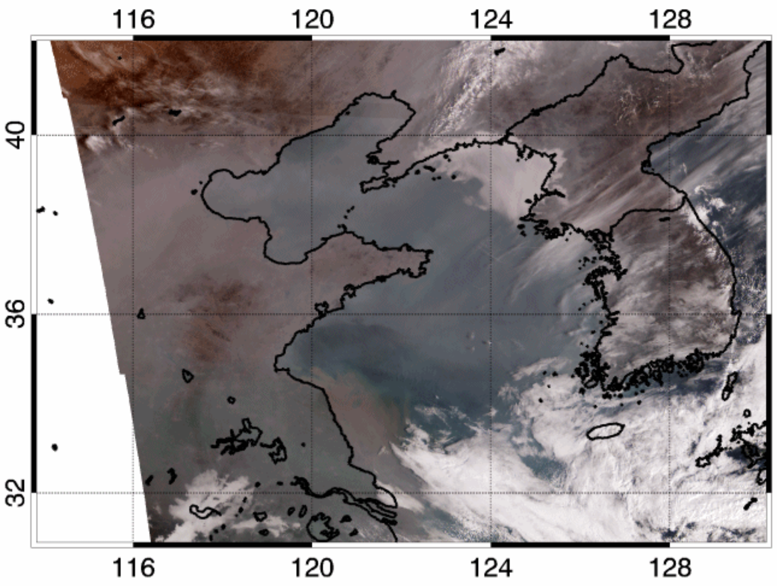


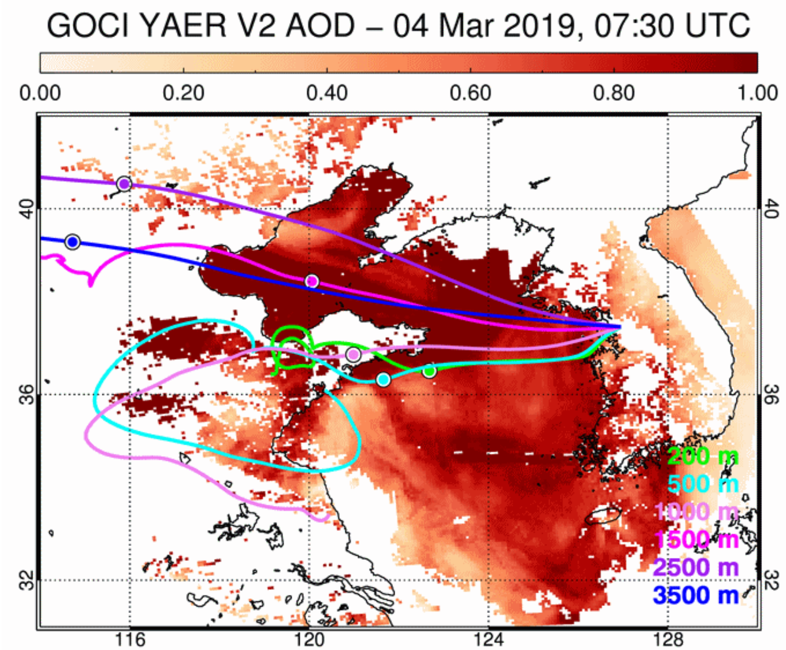
Trends in FMF (Mar 2011 - Feb 2019)

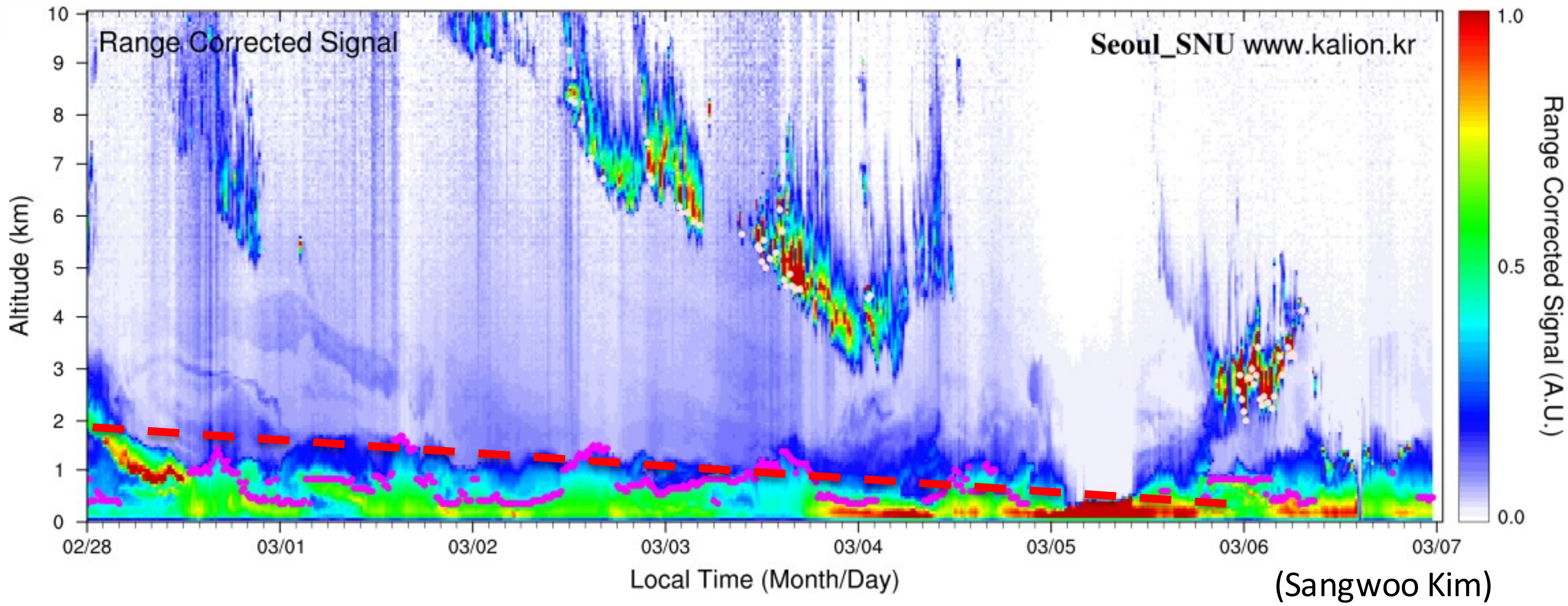


- Decreasing trend of FMF over East Asia from GOCI during 2011-2019.
- In Beijing, increasing trend from GOCI

Detection of Long Range Transport: case of March 4, 2019







(Sangwoo Kim)

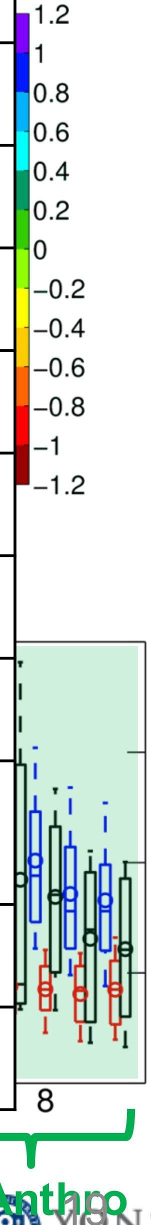
Channels from GEO Satellites over E. Asia

(unit: μm)

Channel No	Channel	AMI	AHI	MI	GOCI-1	GOCI-2	GEMS
1	VIS(blue)	0.470	0.46		- 0.412 0.443	0.380 0.412 0.443	0.3 – 0.5 1000 channels
2	VIS(green)	0.511	0.51		0.490 - 0.555	0.490 0.510 0.555	
3	VIS(red)	0.640	0.64	0.675	- 0.660 0.680 - 0.745	0.620 0.660 0.680 0.709 0.745	
4	VNIR	0.865	0.86		0.865	0.865	
5	SWIR	1.380					
6	SWIR	1.610	1.6				
			2.3				
7	MWIR	3.830	3.9	3.75			
8	MWIR(WV)	6.241	6.2				
9	MWIR(WV)	6.952	7.0	6.75			
10	MWIR(WV)	7.344	7.3				
11	TIR	8.592	8.6				
12	TIR	9.625	9.6				
13	TIR	10.403	10.4	10.8			
14	TIR	11.212	11.2				
15	TIR	12.364	12.3	12.0			
16	TIR	13.31	13.3				
Reference			Lim et al. (RS 2018)	Kim et al (IJRS 2008)	Choi et al (AMT 2016)	Choi et al (AMT 2018)	Kim et al (revised)

Data Assimilation of GOCI AOD data

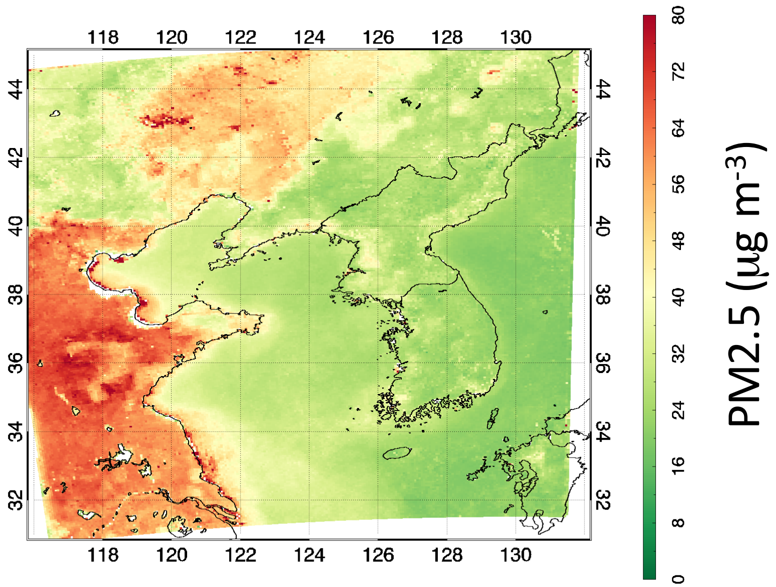
	Model / data used	Product
Park et al., ACP, 2014	CMAQ , DA	DA, to quantify long range transport
Saide et al., GRL, 2014	WRF-Chem, DA	DA, surface PM validation
Xu et al., ACP, 2015	GEOS-Chem	Surface PM2.5
Xiao et al., ACP, 2016	VIIRS, GOCI, MODIS AOD	Validation
Lee et al., GMD, 2016	CMAQ	To improve PM forecast
Jeon et al., GMD, 2016	CMAQ + STOPs v1.5	To Improve PM10 forecast
Pang et al., AE, 2018	WRF-Chem 3D Var	To improve PM2.5 forecast
Ed Hyre et al. JCSDA news., 2018	NAAPS	sub-daily variation comparison with model and observation (AERONET, GOCI, MODIS)
Lee et al., RSE, 2017	WRF-Chem, DA using OMI	Evaluation of DA using GOCI
Lennartson et al ACP, 2018	AERONET, GOCI, in-situ PM2.5, WRF-Chem	Comparison of diurnal variation of AOD and PM2.5

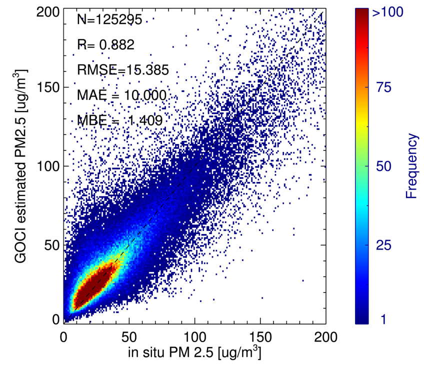


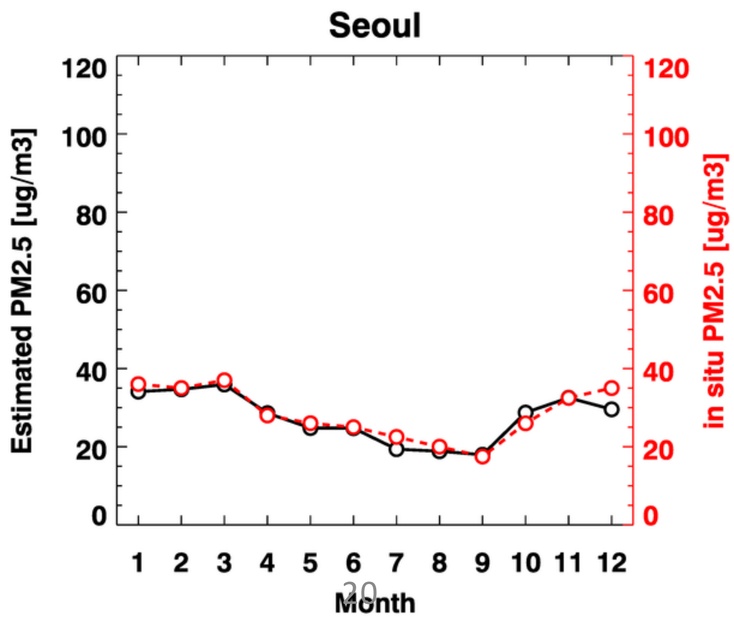
Saide et al., GRL 2014

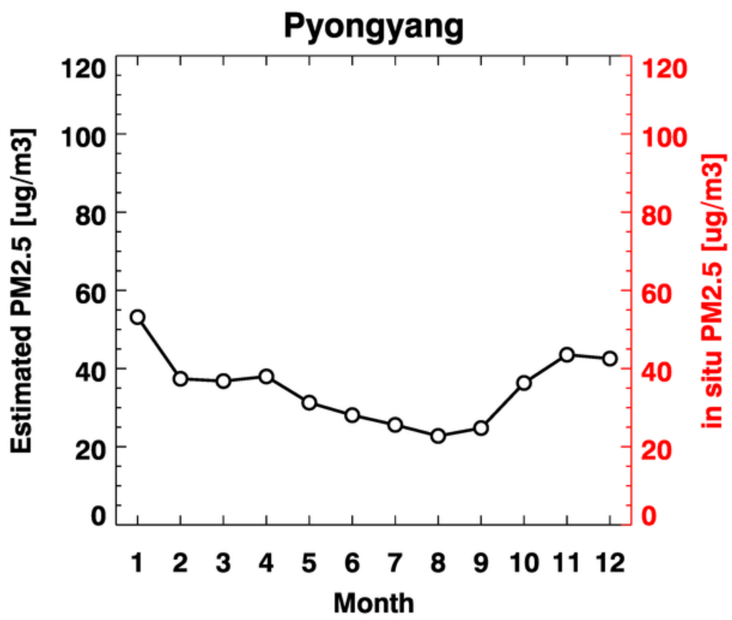
Column to Surface Concentration – Aerosol

- Machine Learning Algorithm
- Monthly average estimated PM2.5 and in situ $PM_{2.5}$, 2017

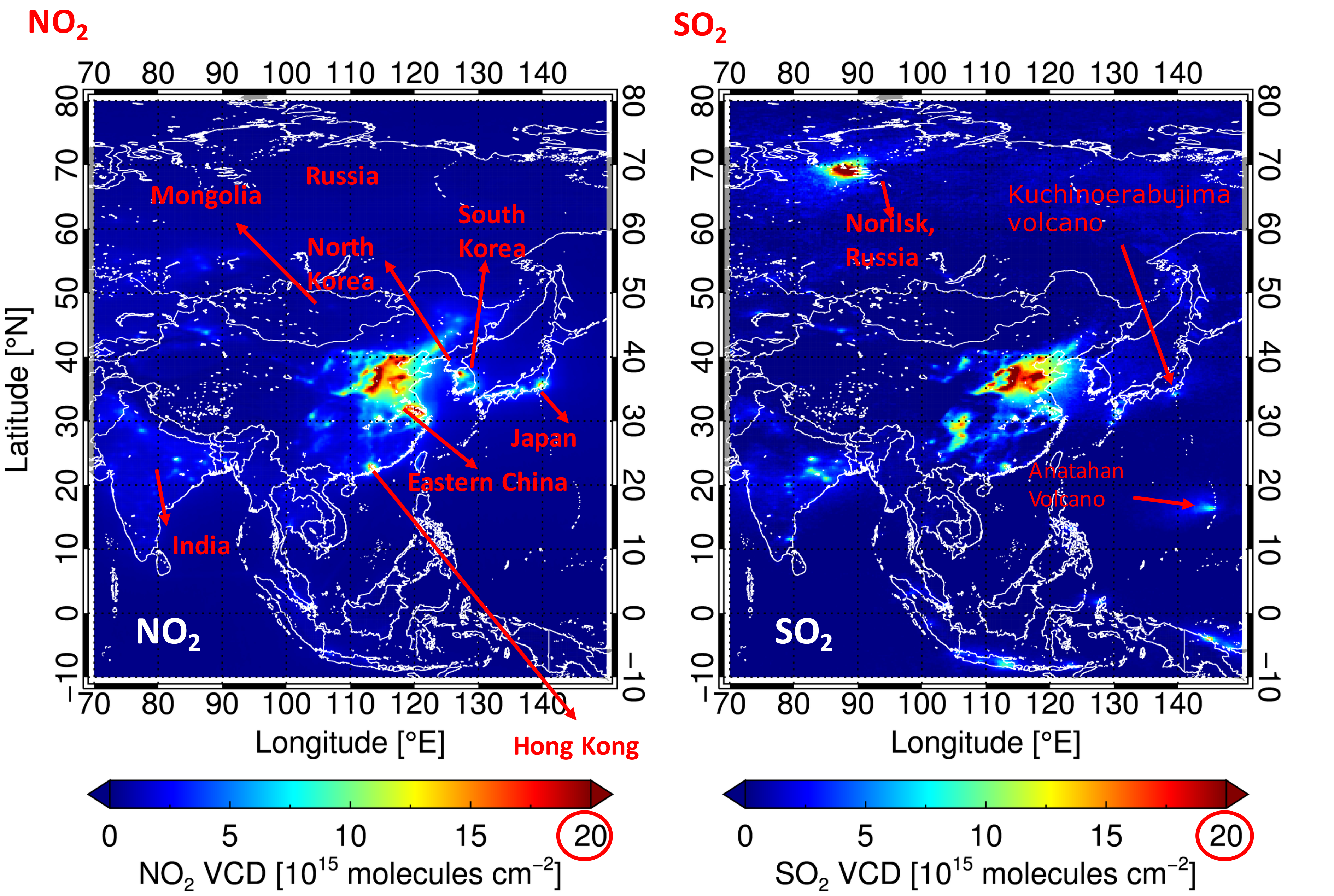




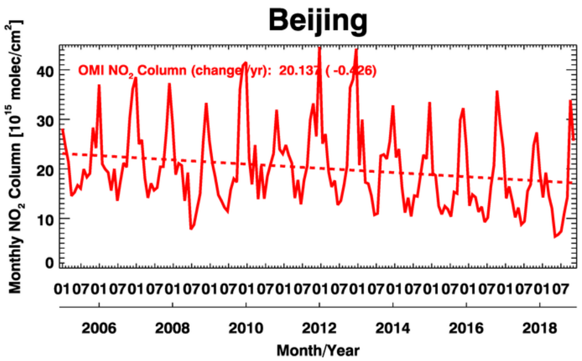




OMI mean tropospheric NO_2 & SO_2 VCDs (2005–2018)

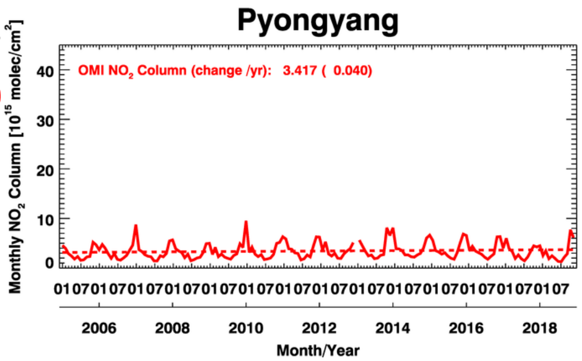


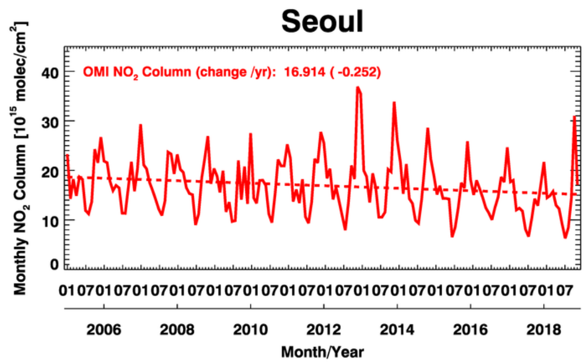
OMI mean tropospheric NO_2 VCDs & trends (2005–2018)

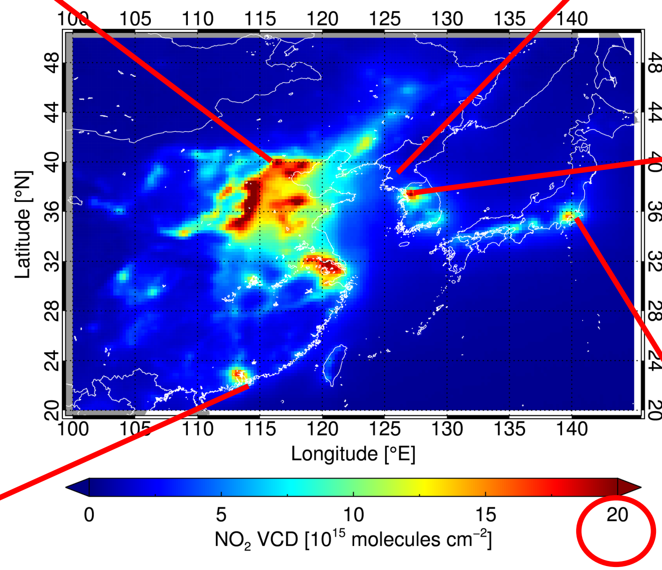


Mean: 20.137
Trend: -0.426
(10^{15} molecules/cm^2)

Mean: 3.417
Trend: +0.040
(10^{15} molecules/cm^2)

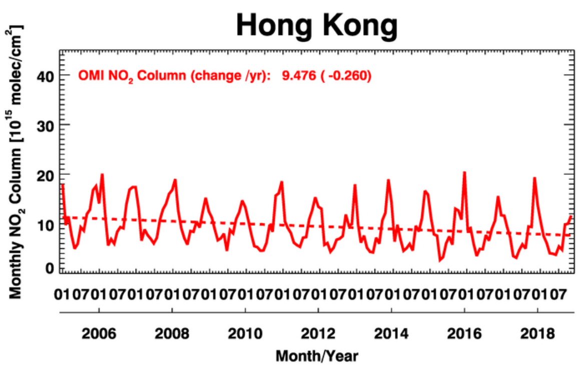




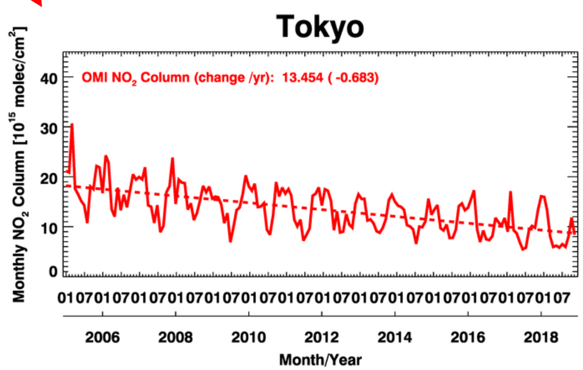


Mean: 16.914
Trend: -0.252
(10^{15} molecules/cm^2)

Mean: 9.476
Trend: -0.260
(10^{15} molecules/cm^2)

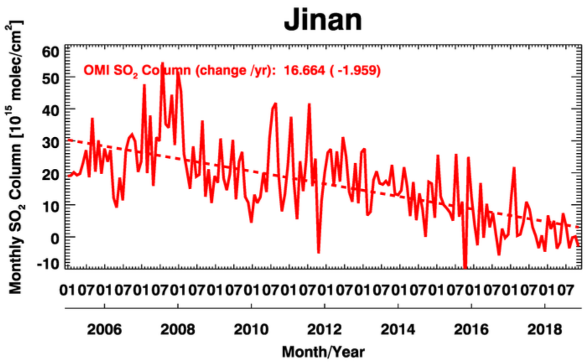


Mean: 13.454
Trend: -0.683
(10^{15} molecules/cm^2)

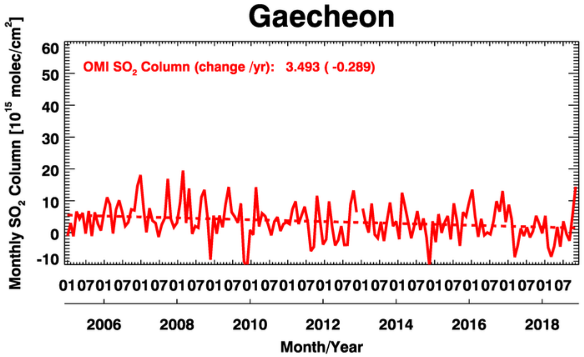


- All cities here but Pyongyang show decreasing trends of NO_2.

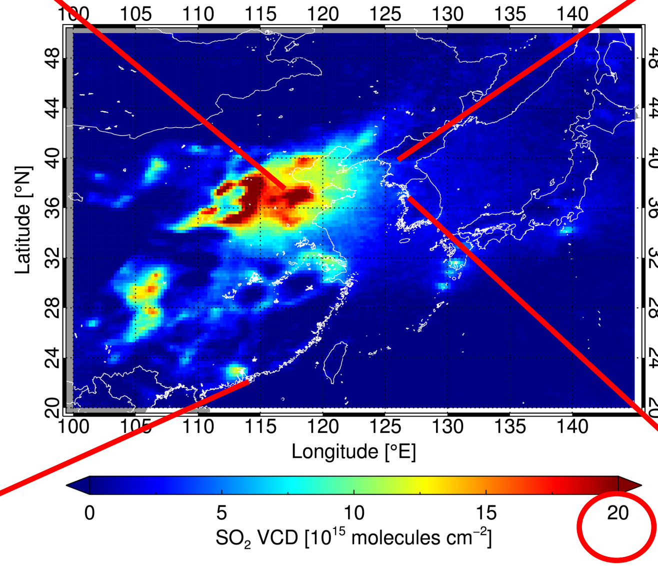
OMI mean tropospheric SO_2 VCDs & trends (2005–2018)



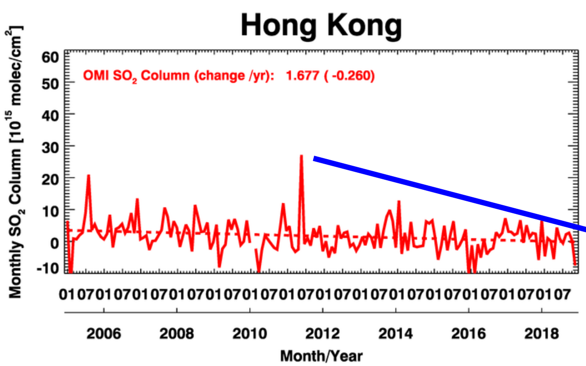
Mean: 16.664
Trend: -1.959
(10^{15} molecules/cm^2)

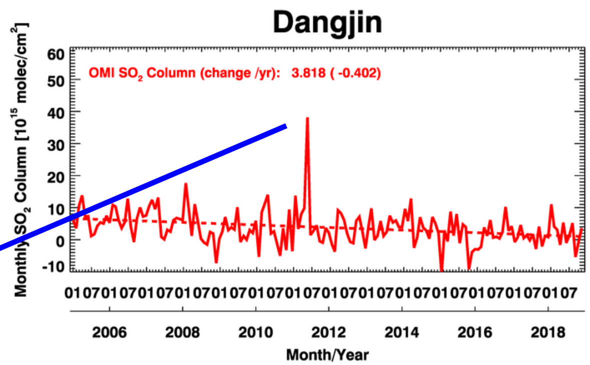


Mean: 3.493
Trend: -0.289
(10^{15} molecules/cm^2)



Mean: 1.677
Trend: -0.260
(10^{15} molecules/cm^2)





Nabro volcano eruption (2011.06.13)

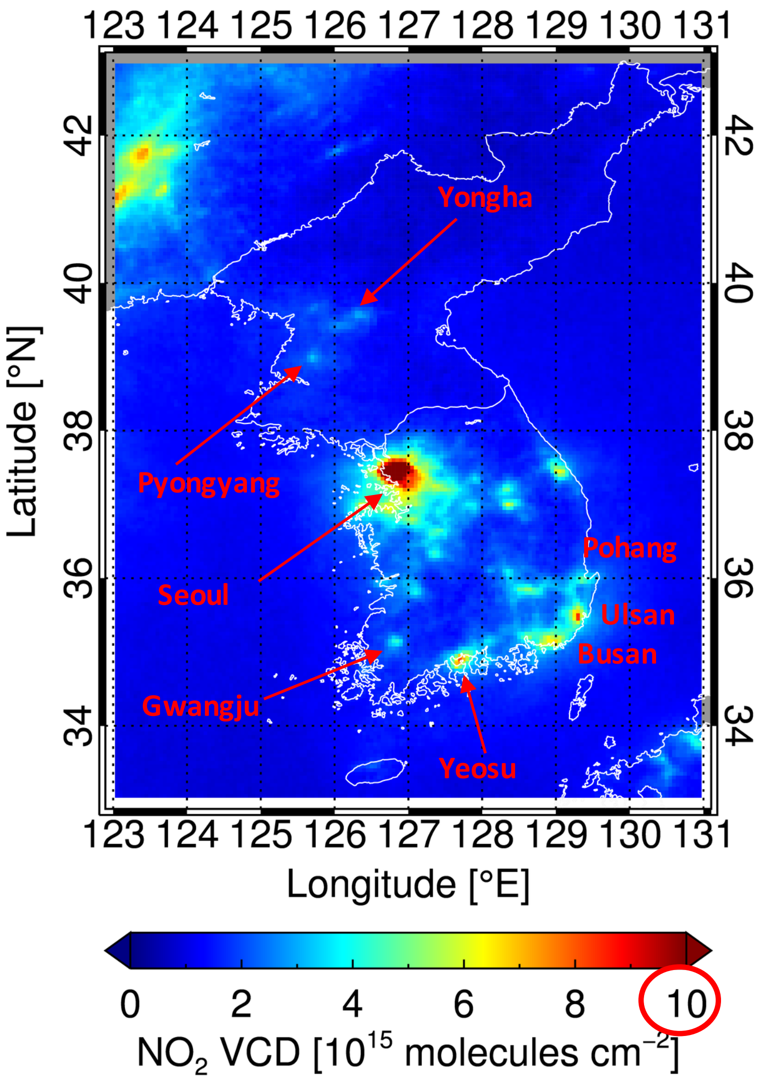
Mean: 3.818
Trend: -0.402
(10^{15} molecules/cm^2)

- All four cities show decreasing trends of SO_2.

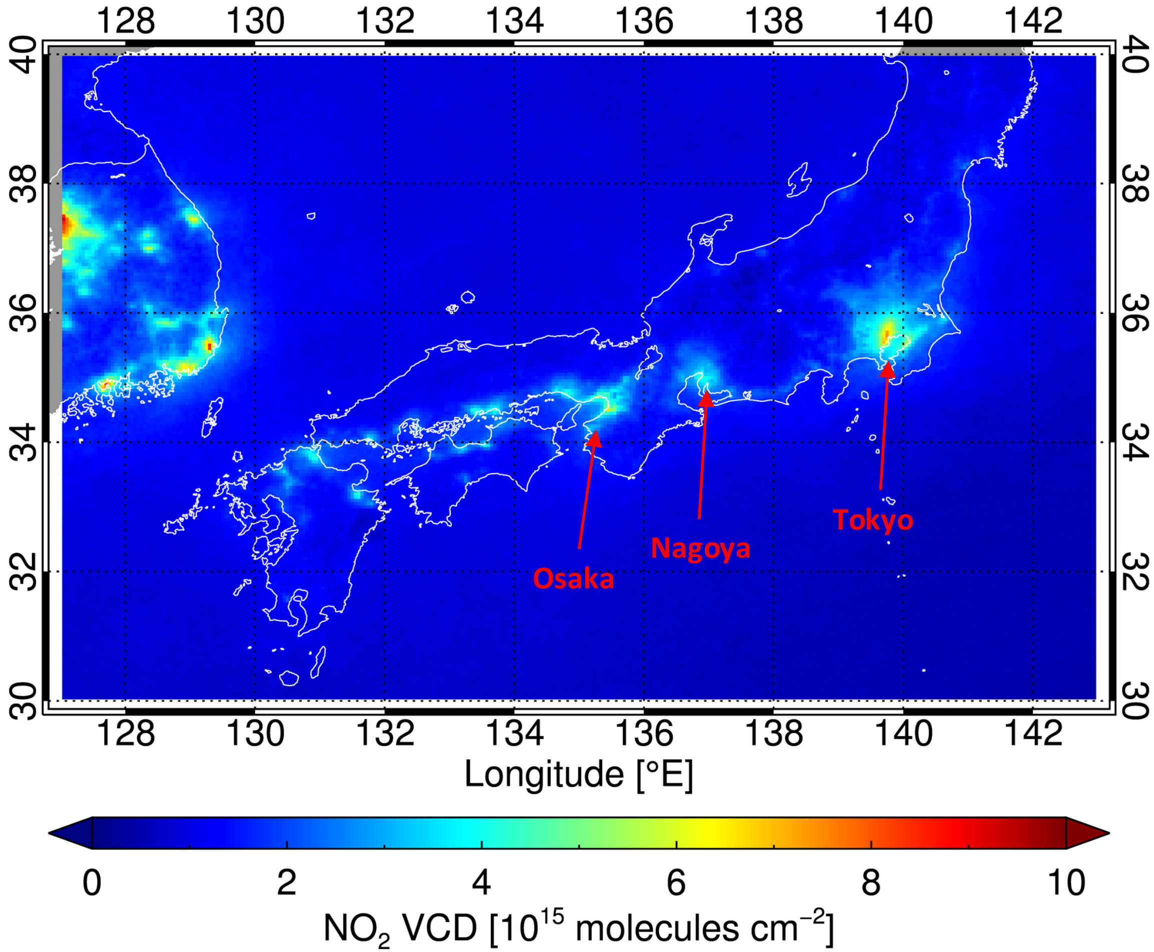
YONSEI UNIVERSITY

Oversampled TROPOMI tropospheric NO_2 VCDs in August 2018

South and North Korea



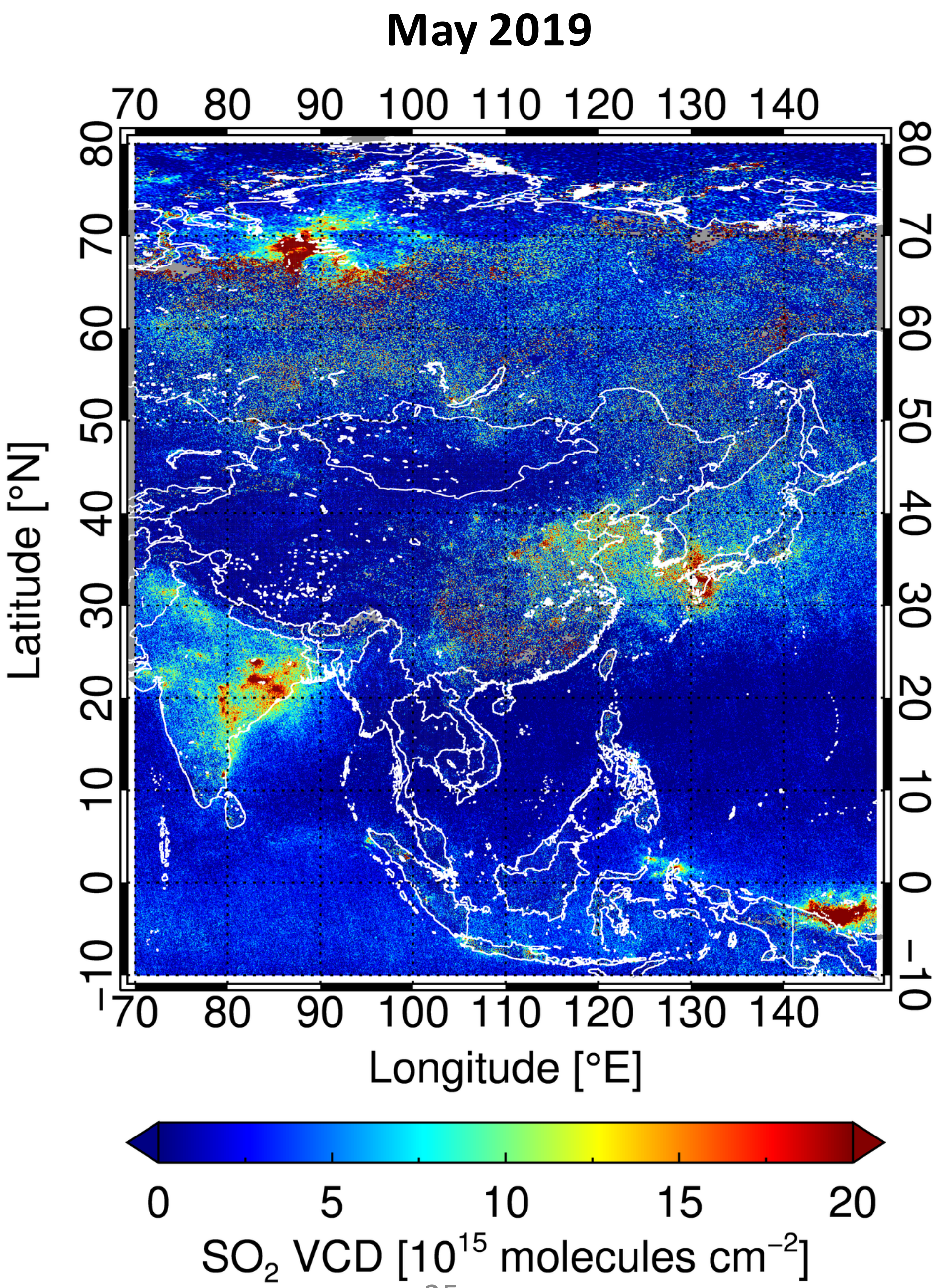
Japan

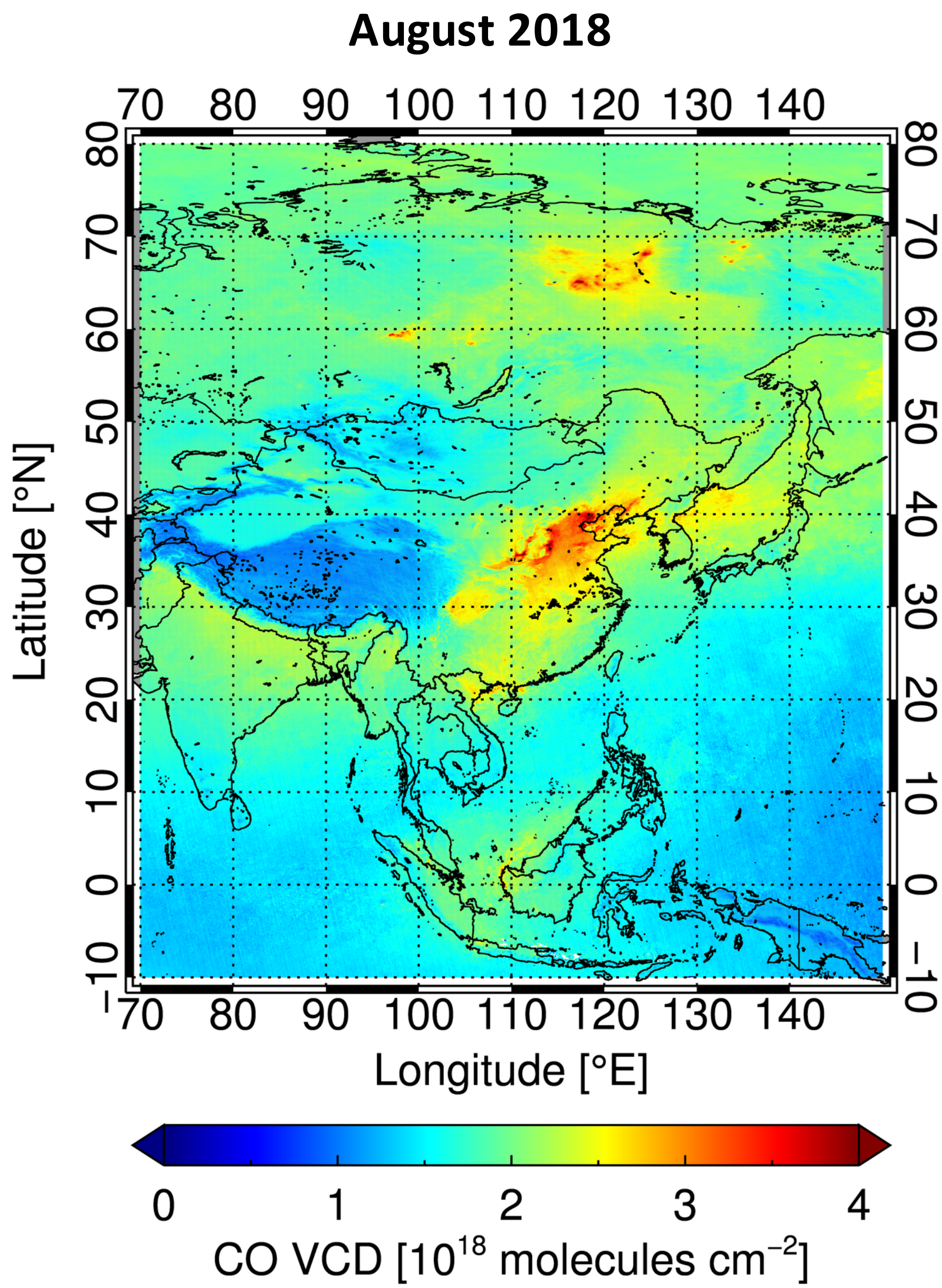


- Major cities and roads in Korea and Japan can be seen from the mean NO_2 map.

YONSEI UNIVERSITY

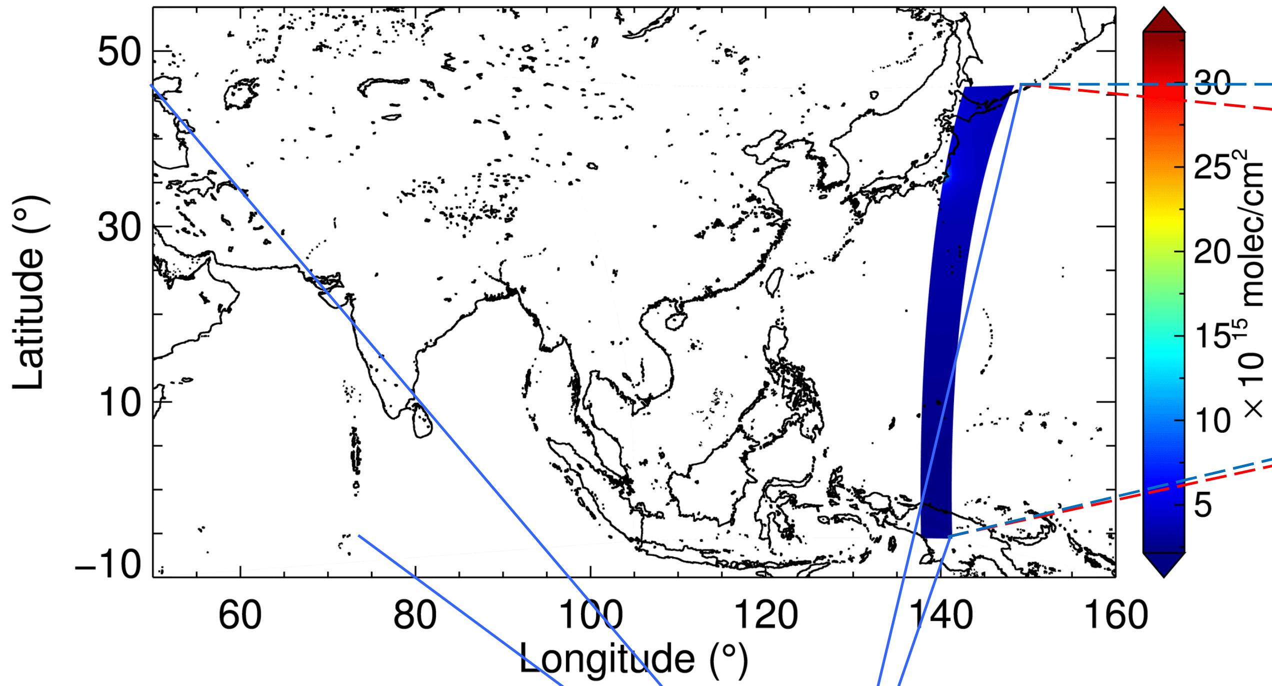
Oversampled TROPOMI tropospheric SO_2 and CO VCDs

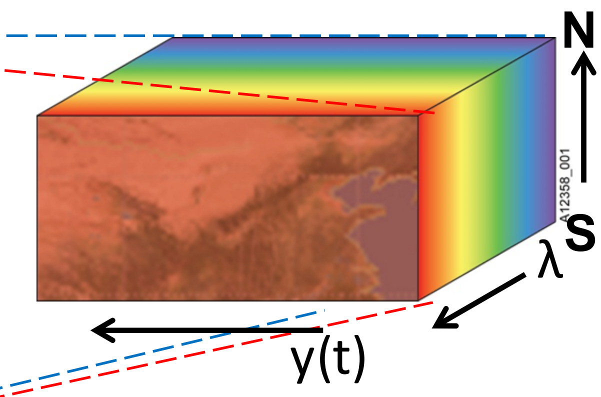




AMI onboard GK-2A launched last week
GEMS onboard GK-2B launch in a year

OMI mean NO_2 (from 2005 to 2014) over GEMS FOR

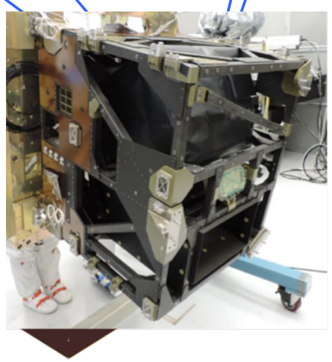




~11 M spectrum/day

Target species:

- O3,
- aerosols,
- NO2
- SO2
- HCHO



Launch schedule : Feb. 2020

Summary

- The retrieved GOCI V2 AOPs show reliable qualities against ground-based AERONET. YAER algorithm is being improved for GOCI-II with its higher spatial resolution of 250 m and additional channels in UV.
- Aerosol products from GOCI (hourly) and AHI (every 10 minute) YAER algorithm provide diurnal variation information of aerosols. Therefore, these can provide observational dataset for data assimilation with air-quality forecasting over Asia.
- Merged dataset from different satellites and algorithm provide improved results with reduced bias and better spatial coverage.
- Precursors of aerosols have been observed by LEO missions including OMI, TROPOMI, GOME, SCHIAMACHY etc., and will be observed by GEO missions from 2020.

Acknowledgement

AHI dataset – Yasko Kasai, GOCI – KIOST, AMI – KMA, GEMS – NIER