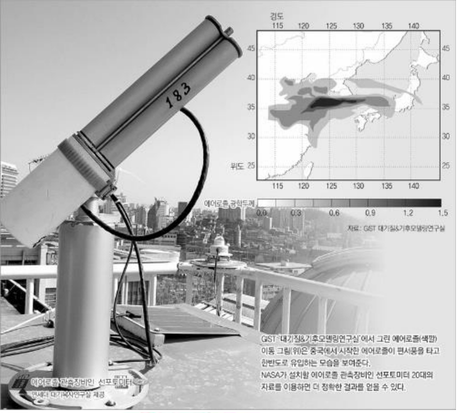
AERONET Science and Application Exchange 2024, College Park, MD, Sep 17-19, 2024



AERONET for Satellite Remote Sensing of Aerosol in Asia from Geostationary Earth Orbit

Jhoon Kim

Yonsei Lee Youn Jae Fellow Professor of Atmospheric Sciences,

Department of Atmospheric Sciences, Yonsei University, Seoul, Korea

AERONET activities in Korea

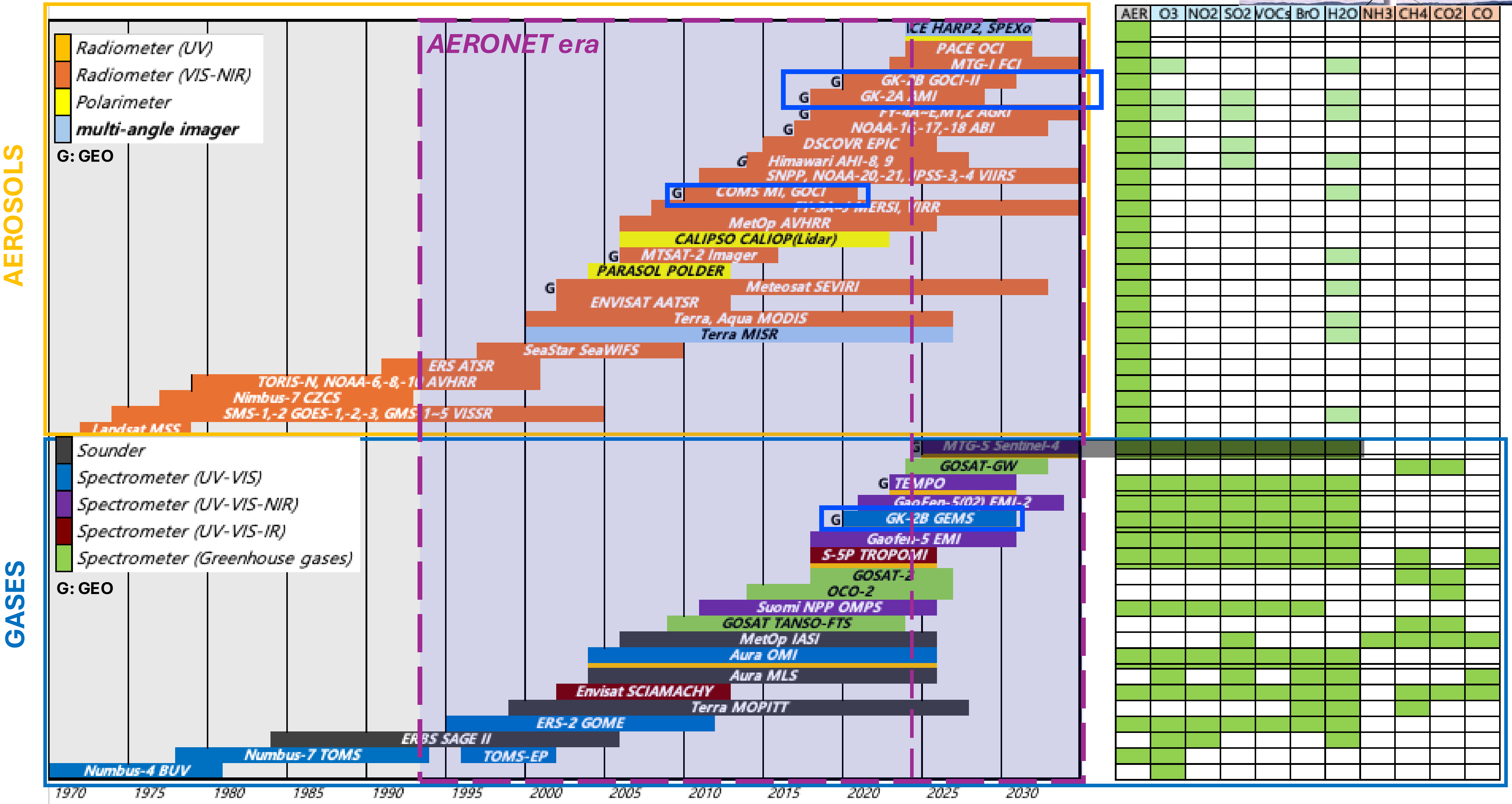
Songchon Elementary School (May, 2012)

DRAGON-NE Asia (2012)

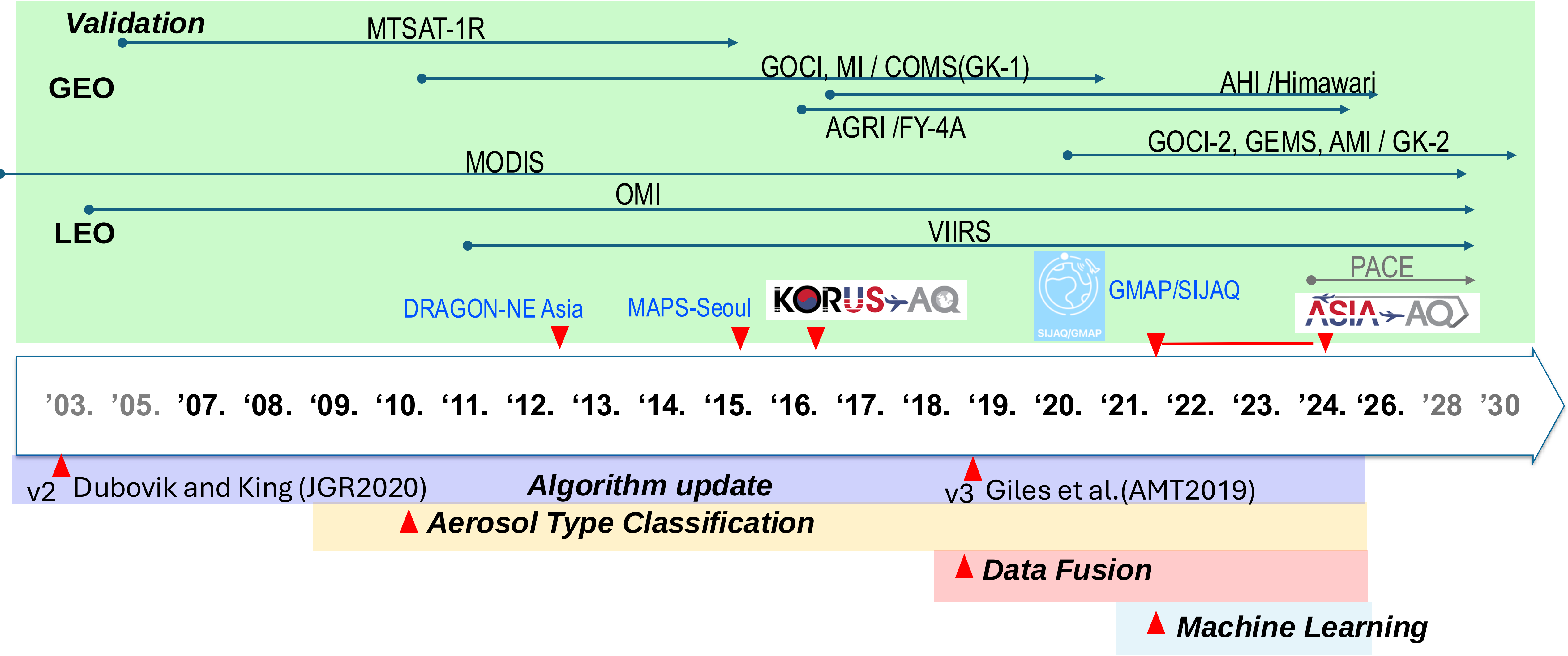
KORUS-AQ (2016)

ASIA-AQ (2024)

Contribution of AERONET in Satellite Remote Sensing of Atmosphere

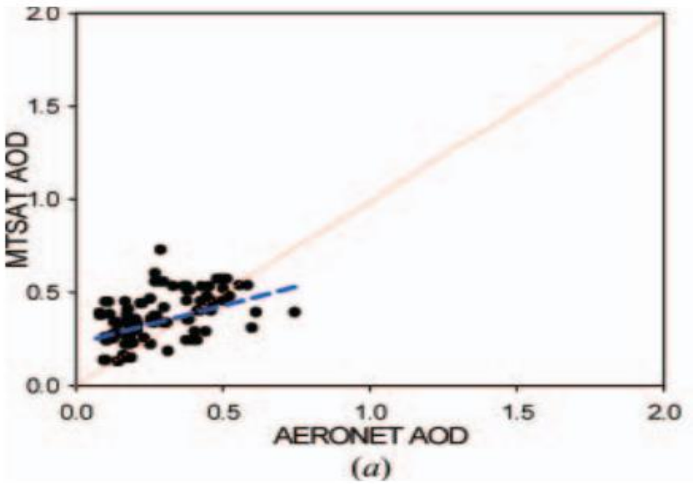


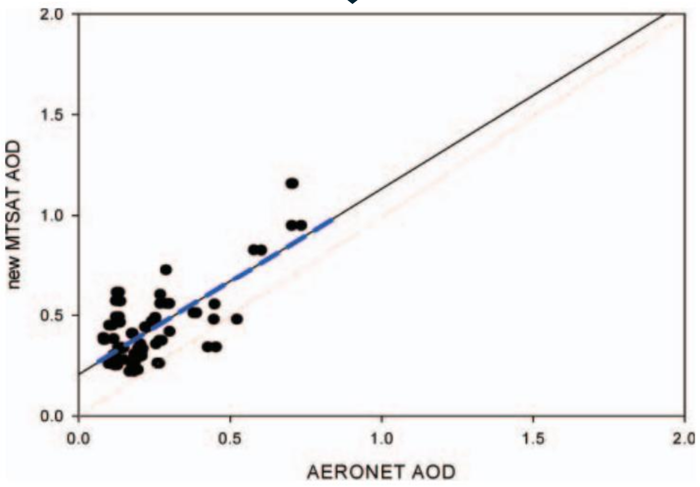
AERONET-related Studies wrt Satellite RS



Retrieving Aerosol Optical Depth using Visible and Mid-IR Channels from Geostationary Satellite MTSAT-1R

J. Kim et al. (IJRS, 2008)





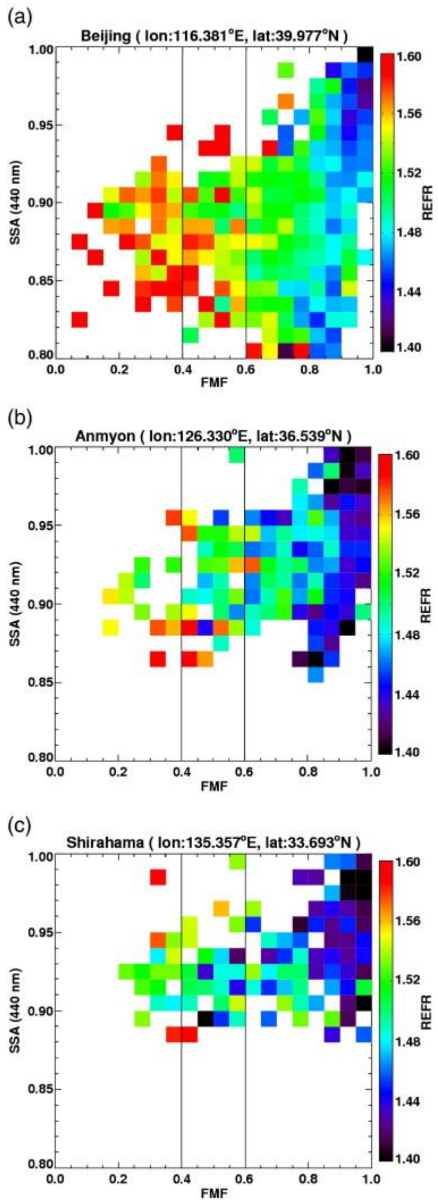
A new MTSAT AOD validated with AERONET

- February – March 2006 @ Anmyon site
- The retrieved AODs are compared with coincident AERONET values (within 30 minutes)
- The AOD values from the MTSAT-1R are averaged over 5x5 km

- A single visible algorithm has limitations in estimating surface reflectance due to clear-sky assumptions over a 30 day period
  - Errors retrieving accurate AODs in spring in the Asian dust-dominated season, when the vegetation growth changes rapidly
  - The visible band is very sensitive to the presence of aerosols, remnant reflectances at cloud edges, changes in surface conditions, etc.
- Better surface reflectance can be obtained regardless of aerosol presence with the aid of the mid-IR channel over a restricted area

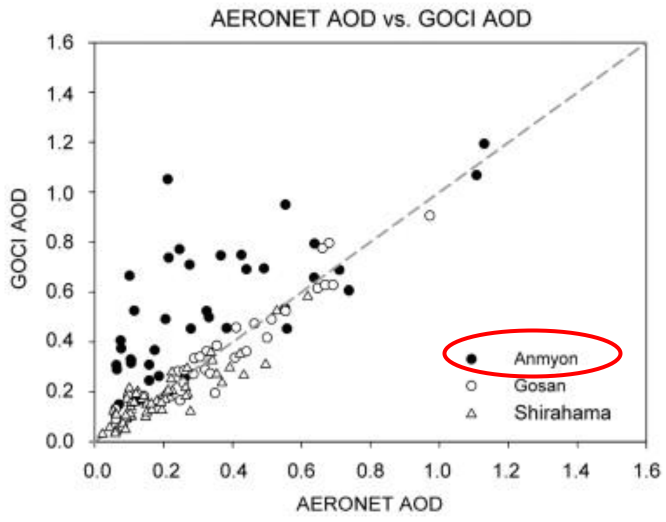
Algorithm for Retrieval of Aerosol Optical Properties over the Ocean from the GOCI

J. Lee et al. (RSE, 2010)



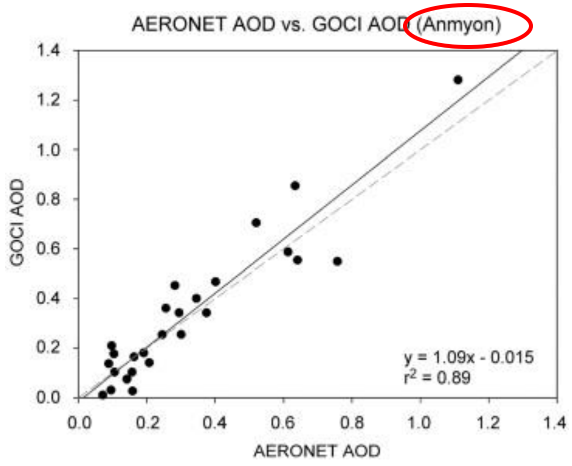
AERONET data used for the better aerosol model assumption

- Lookup tables are constructed based on **extensive analysis of aerosol optical properties obtained from AERONET**
- Daily mean Level 1.5 cloud-screened products from 2005 to 2007 are used to analyze aerosol optical properties.



AERONET data used for AOD validation

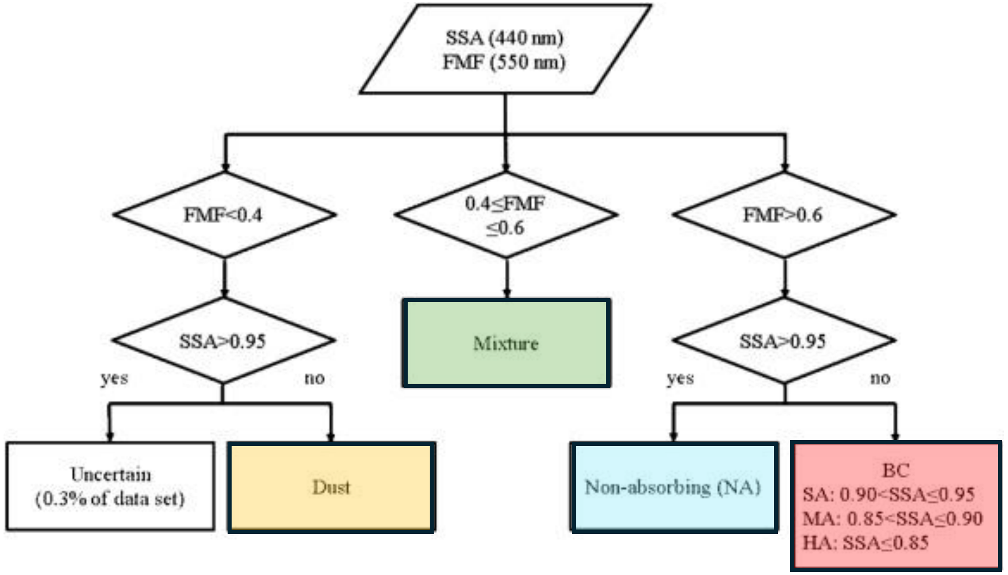
- The agreement at Anmyon station located close to the turbid water, i.e. yellow sea is poor
- Current algorithm overestimates AOD significantly.



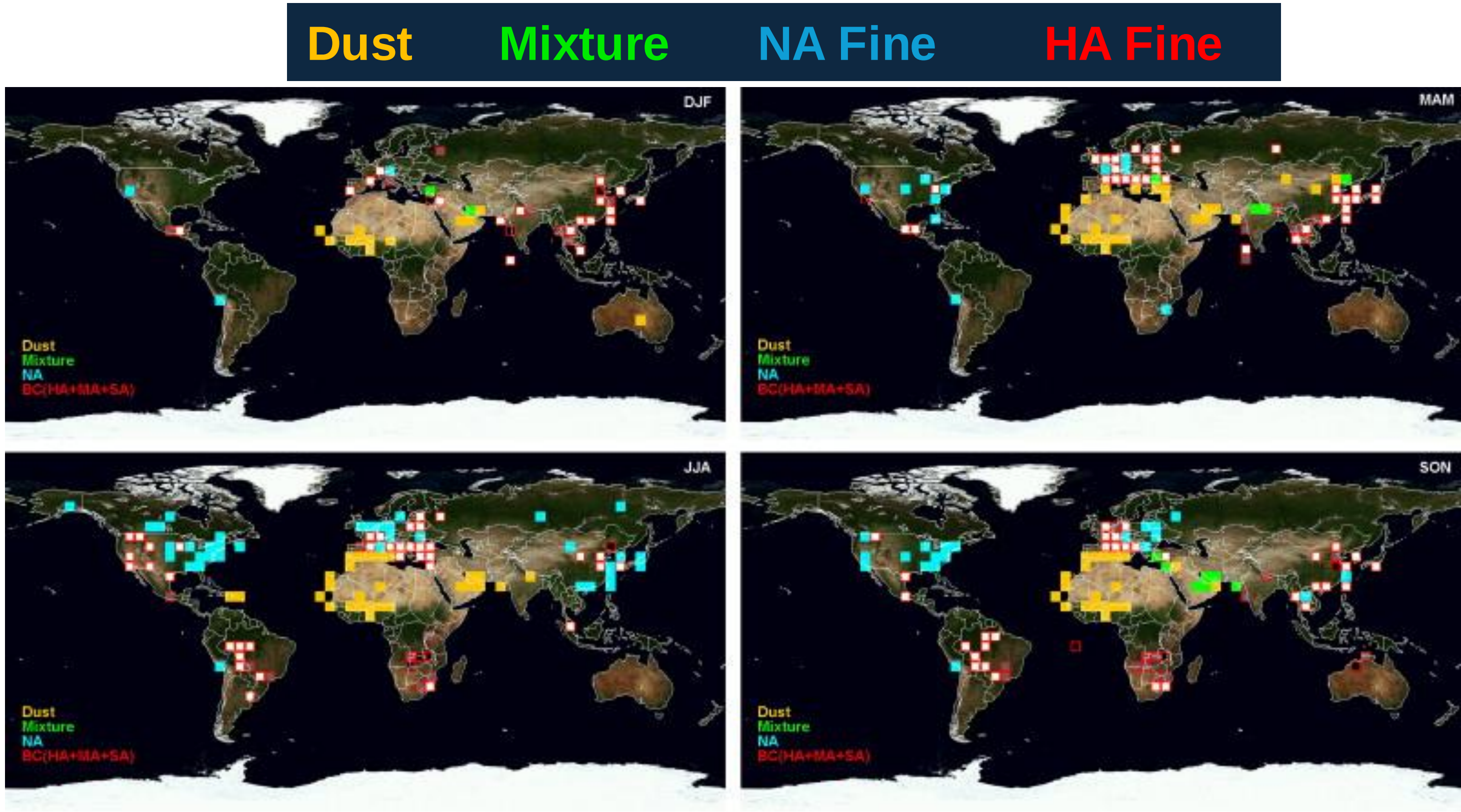
After turbid water correction at Anmyon station

Characteristics of Aerosol Types from AERONET sunphotometer measurements

J. Lee et al. (AE, 2010)



- Daily average L2 inversion products are used.
- FMF at 550 nm is used to determine the dominant size mode,
- SSA is used to distinguish absorbing from non-absorbing aerosols.



The most frequently detected aerosol type from all AERONET stations in a 5° × 5° grid box throughout the world for each season.

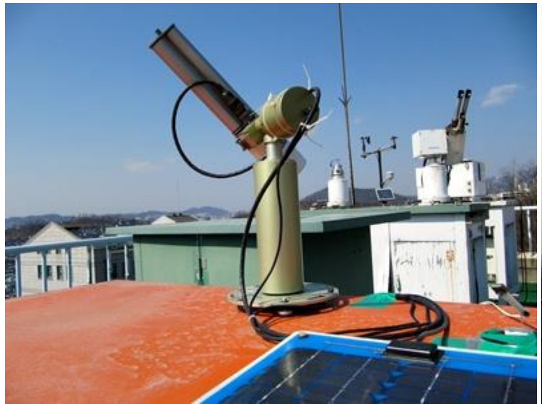
DRAGON-NE Asia (2012)

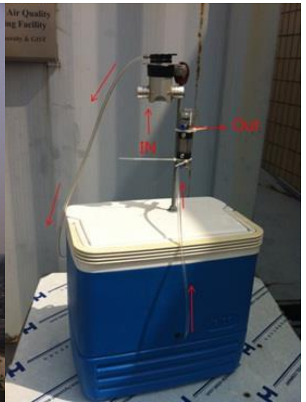
Atmos. Chem. Phys., 18, 655–671, 2018
https://doi.org/10.5194/acp-18-655-2018

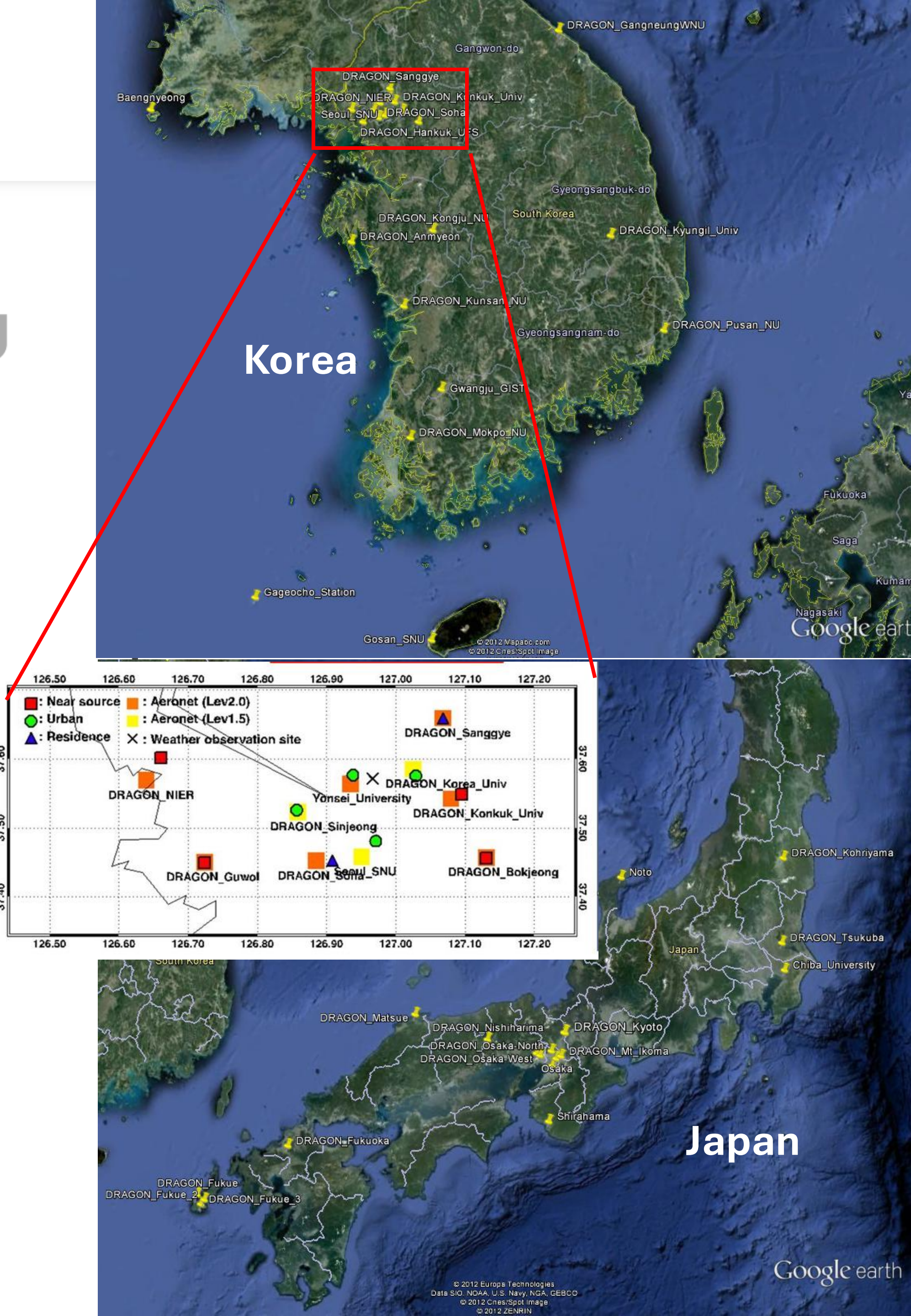
Atmospheric Chemistry and Physics
Open Access

An overview of mesoscale aerosol processes, comparisons, and validation studies from DRAGON networks

Brent N. Holben[1], Jhoon Kim[2], Itaru Sano[3], Sonoyo Mukai[4], Thomas F. Eck[1,5], David M. Giles[1,6], Joel S. Schafer[1,6], Aliaksandr Sinyuk[1,6], Ilya Slutsker[1,6], Alexander Smirnov[1,6], Mikhail Sorokin[1,6], Bruce E. Anderson[7], Huizheng Che[8], Myungje Choi[2], James H. Crawford[7], Richard A. Ferrare[7], Michael J. Garay[9], Ukkyo Jeong[1], Mijin Kim[2], Woogyung Kim[2], Nichola Knox[10], Zhengqiang Li[11], Hwee S. Lim[12], Yang Liu[13], Hal Maring[14], Makiko Nakata[15], Kenneth E. Pickering[1], Stuart Piketh[16], Jens Redemann[17], Jeffrey S. Reid[18], Santo Salinas[19], Sora Seo[20], Fuyi Tan[12,a], Sachchida N. Tripathi[21], Owen B. Toon[22], and Qingyang Xiao[13]

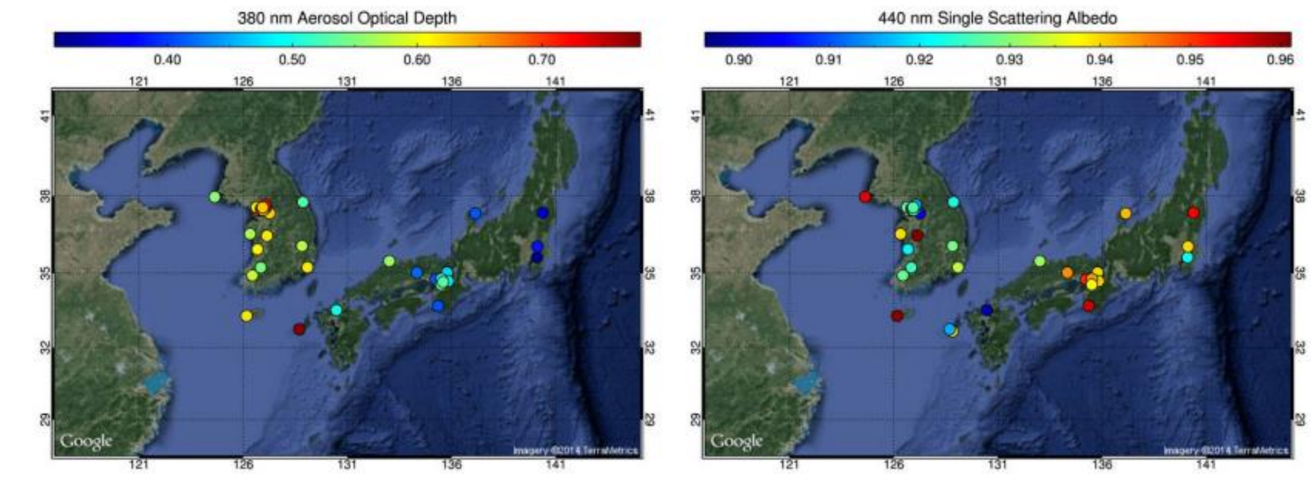






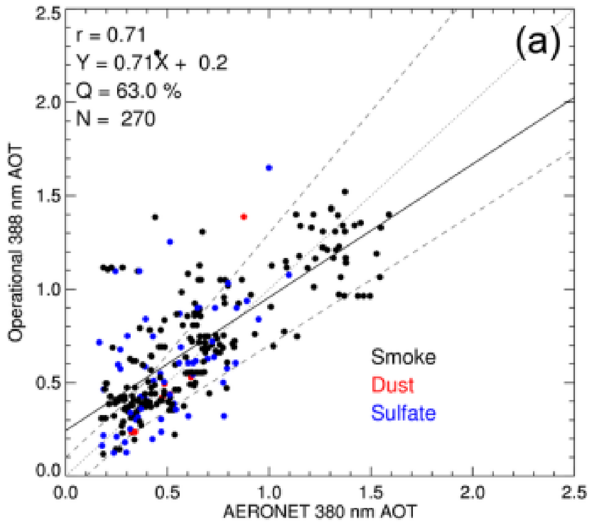
An Optimal-Estimation-based Aerosol Retrieval Algorithm using OMI near-UV Observations

U. Jeong et al. (ACP, 2016)

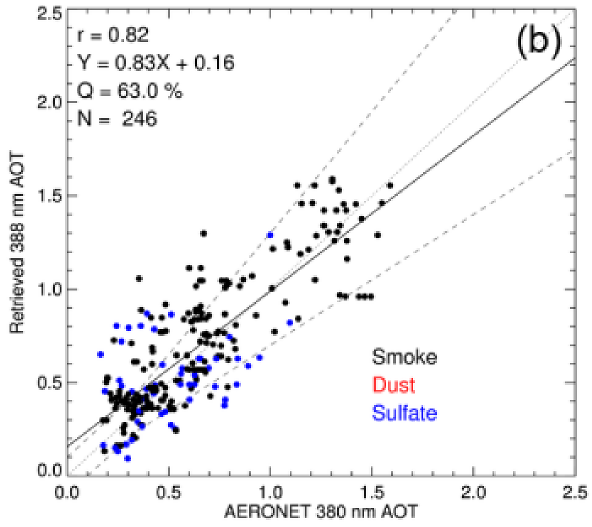


- The spatial and temporal domains for analysis were confined to the DRAGON-NE Asia 2012 campaign
- To validate and compare the retrieved aerosol products from OMI, level 2 campaign products were used from the AERONET

AOD validation

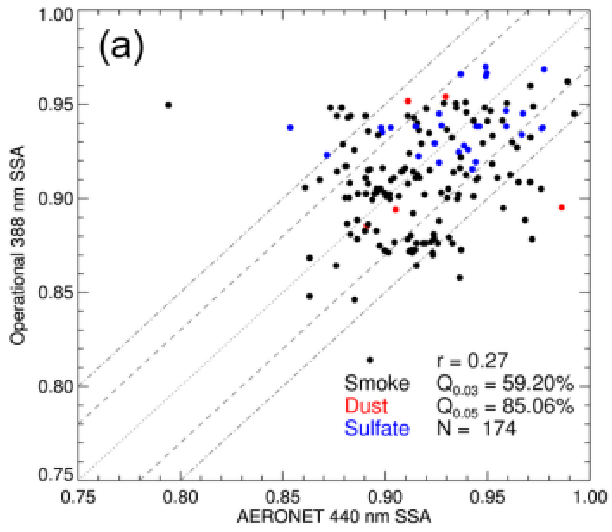


Operational OMI

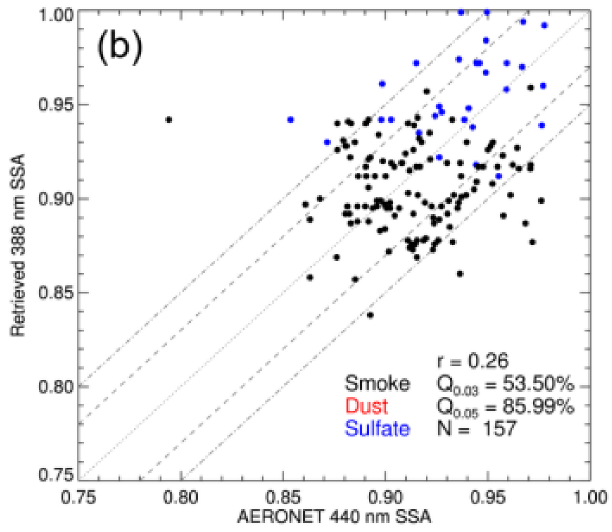


Jeong et al. OMI

SSA validation



Operational OMI

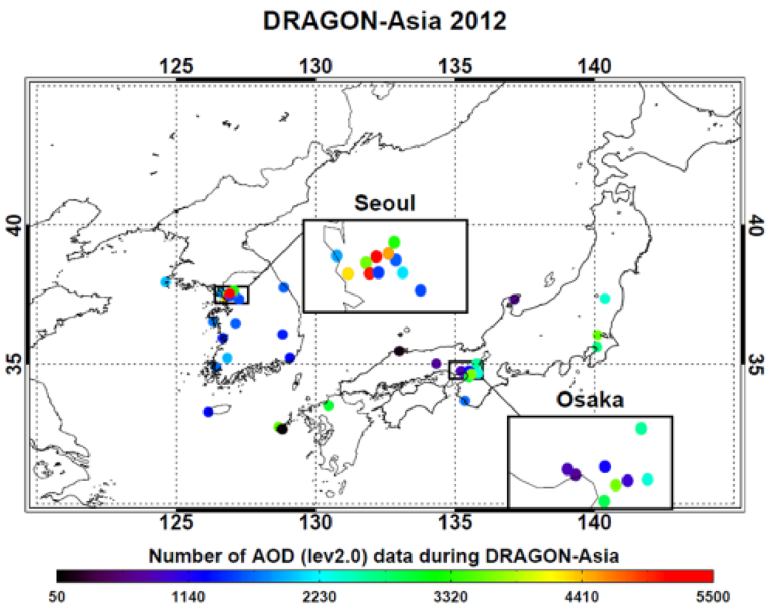


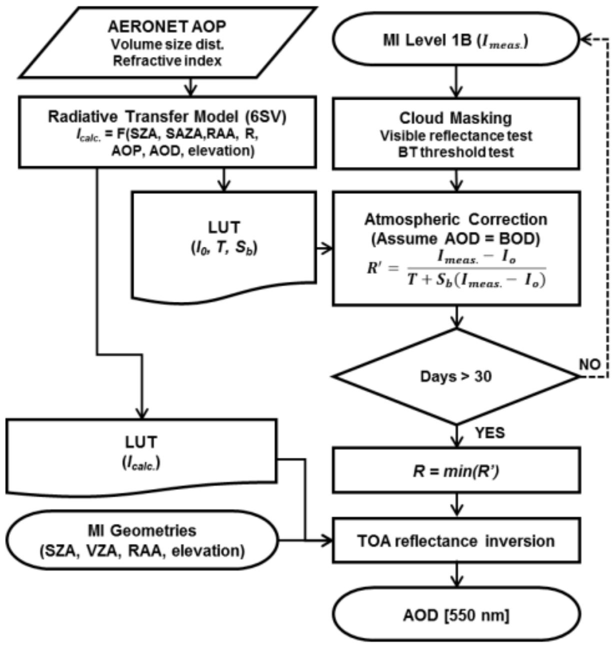
Jeong et al. OMI

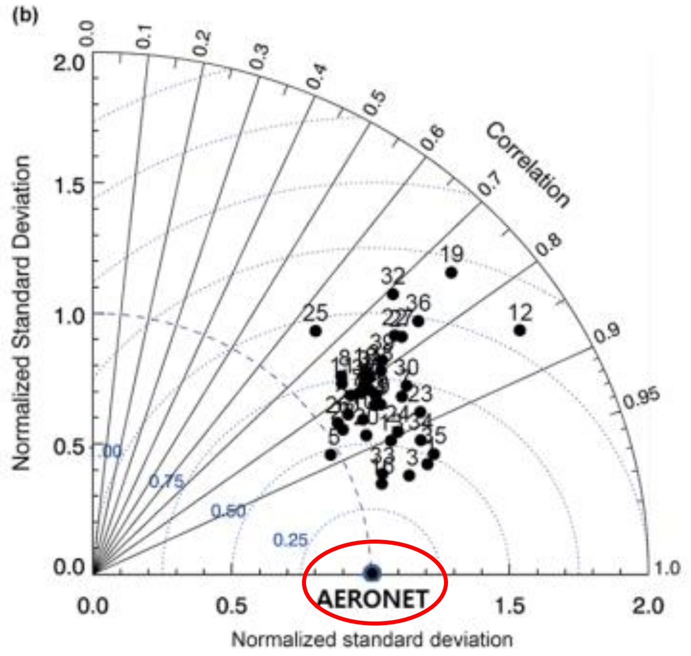
Aerosol Optical Properties Derived from the DRAGON-NE Asia campaign, and Implications for a Single-channel Algorithm to Retrieve Aerosol Optical Depth in Spring from Meteorological Imager (MI) Onboard the Communication, Ocean, and Meteorological Satellite (COMS)

M. Kim et al. (ACP, 2016)

- AERONET inversion data (level 2.0 daily products) over East Asia (20–50◦ N, 95– 145◦ E) were used to **analyze optimized AOPs**
- The retrieved volume size distribution and complex refractive indices are utilized to compute the spectral SSA
- Level 2.0 AOD data sets measured for the DRAGON-NE Asia 2012 campaign with more than 50 data points were used to **validate the retrieval results**.



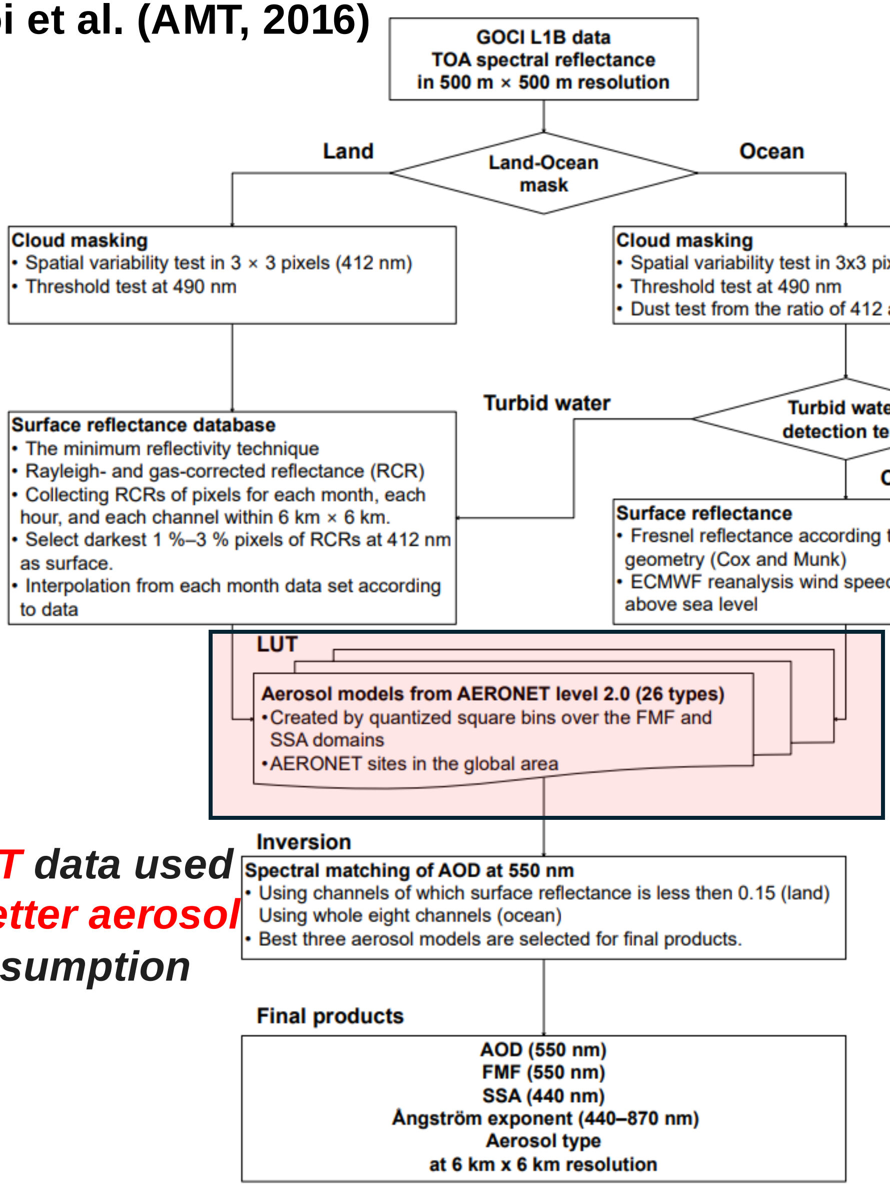




MI aerosol algorithm considers background AODs and critical reflectance to improve accuracy with given single channel limitations. (M. Kim, RSE, 2014)

GOCI Yonsei Aerosol Retrieval (YAER) algorithm and validation during the DRAGON-NE Asia 2012 campaign

M. Choi et al. (AMT, 2016)



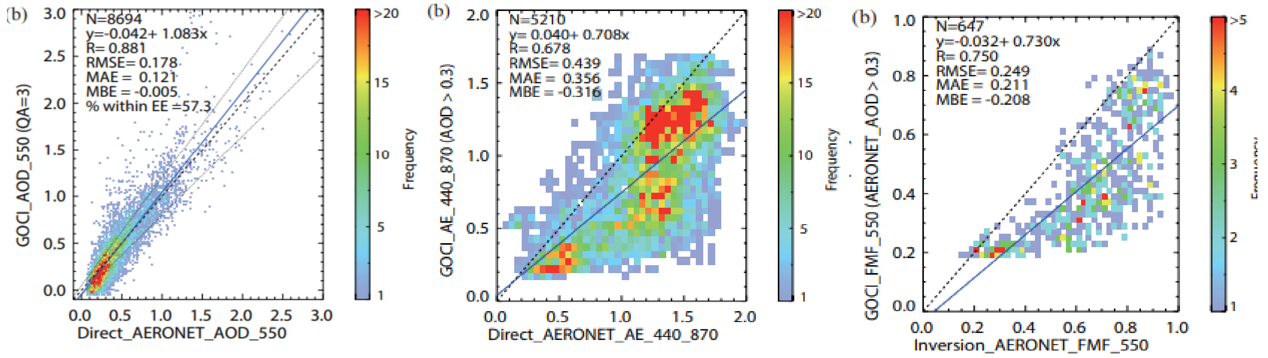
***AERONET** data used for the **better aerosol model** assumption*

$$\text{Final AOD at 550 nm} = \sum_{i=1}^{3} C_{\text{Model } i} \times \text{Averaged AOD}_{\text{Model}}$$

- Final AOD is calculated with spectral AODs for selected aerosol models.
- Other aerosol optical properties (AOPs) were also calculated with the combination of AERONET AOPs

AERONET data used for AOD validation

AOD **AE** **FMF**



ELEMENTA
Science of the Anthropocene

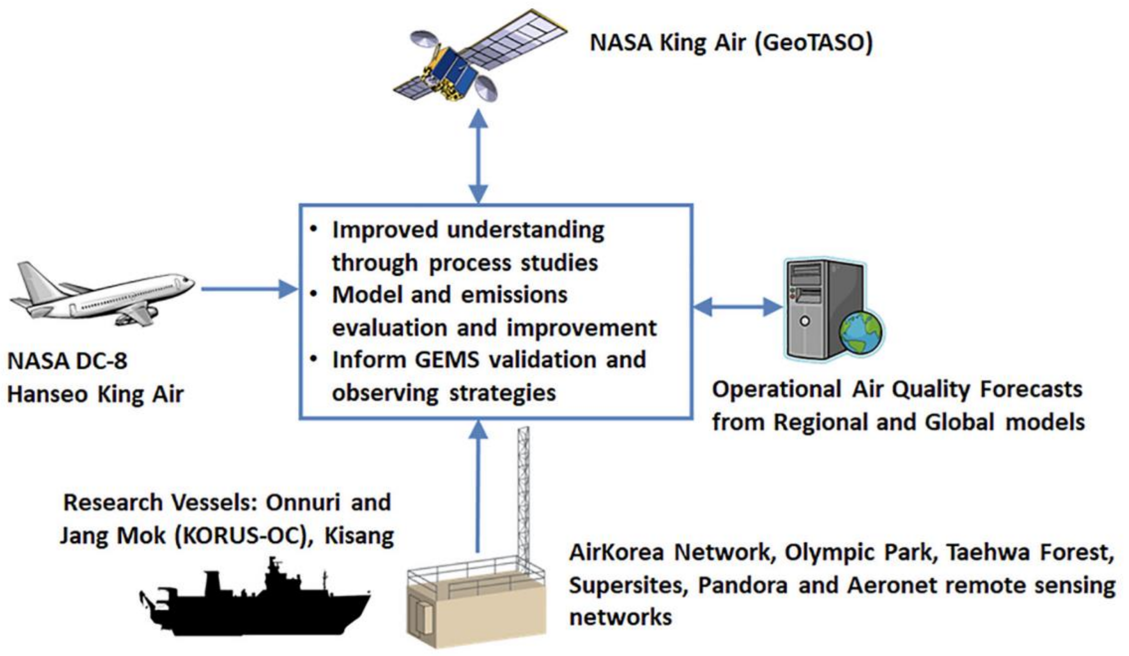
Crawford, JH, et al. 2021. The Korea–United States Air Quality (KORUS-AQ) field study. *Elem Sci Anth*, 9: 1. DOI: https://doi.org/10.1525/elementa.2020.00163

RESEARCH ARTICLE

The Korea—United States Air Quality (KORUS-AQ) field study

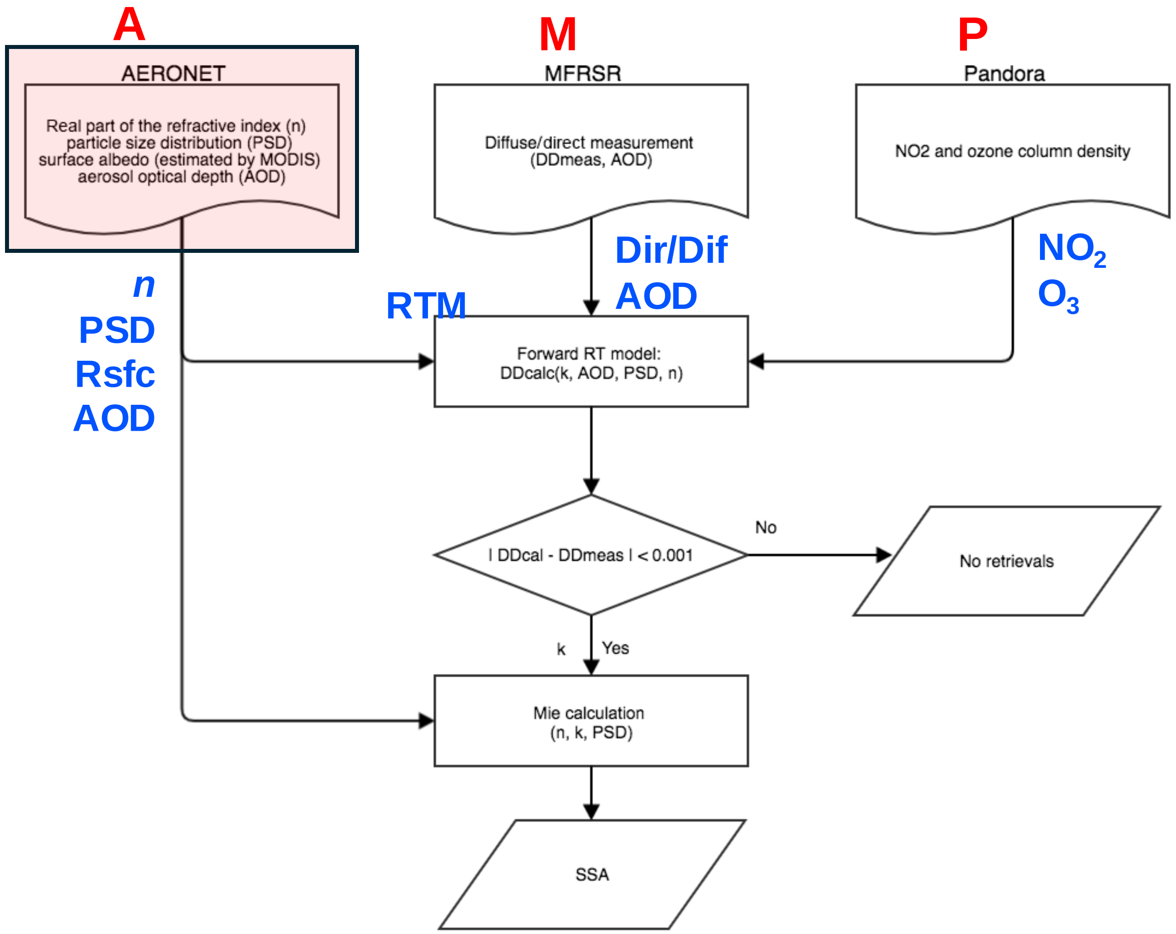
James H. Crawford[1]*, Joon-Young Ahn[2], Jassim Al-Saadi[1], Limseok Chang[2], Louisa K. Emmons[3], Jhoon Kim[4], Gangwoong Lee[5], Jeong-Hoo Park[2], Rokjin J. Park[6], Jung Hun Woo[7], Chang-Keun Song[8], Ji-Hyung Hong[2,9], You-Deog Hong[2,10], Barry L. Lefer[11], Meehye Lee[12], Taehyoung Lee[5], Saewung Kim[13], Kyung-Eun Min[14], Seong Soo Yum[4], Hye Jung Shin[2], Young-Woo Kim[2], Jin-Soo Choi[2], Jin-Soo Park[2], James J. Szykman[15], Russell W. Long[15], Carolyn E. Jordan[1,16], Isobel J. Simpson[13], Alan Fried[17], Jack E. Dibb[18], SeogYeon Cho[9], and Yong Pyo Kim[19]

The Korea–United States Air Quality (KORUS-AQ) field study was conducted during May–June 2016. The effort was jointly sponsored by the National Institute of Environmental Research of South Korea and the National Aeronautics and Space Administration of the United States. KORUS-AQ offered an unprecedented, multi-perspective view of air quality conditions in South Korea by employing observations from three aircraft, an extensive ground-based network, and three ships along with an array of air quality forecast models. Information gathered during the study is contributing to an improved understanding of the factors controlling air quality in South Korea. The study also provided a valuable test bed for future air quality–observing strategies involving geostationary satellite instruments being launched by both countries to examine air quality throughout the day over Asia and North America. This article presents details on the KORUS-AQ observational assets, study execution, data products, and air quality conditions observed during the study. High-level findings from companion papers in this special issue are also summarized and discussed in relation to the factors controlling fine particle and ozone pollution, current emissions and source apportionment, and expectations for the role of satellite observations in the future. Resulting policy recommendations and advice regarding plans going forward are summarized. These results provide an important update to early feedback previously provided in a Rapid Science Synthesis Report produced for South Korean policy makers in 2017 and form the basis for the Final Science Synthesis Report delivered in 2020.

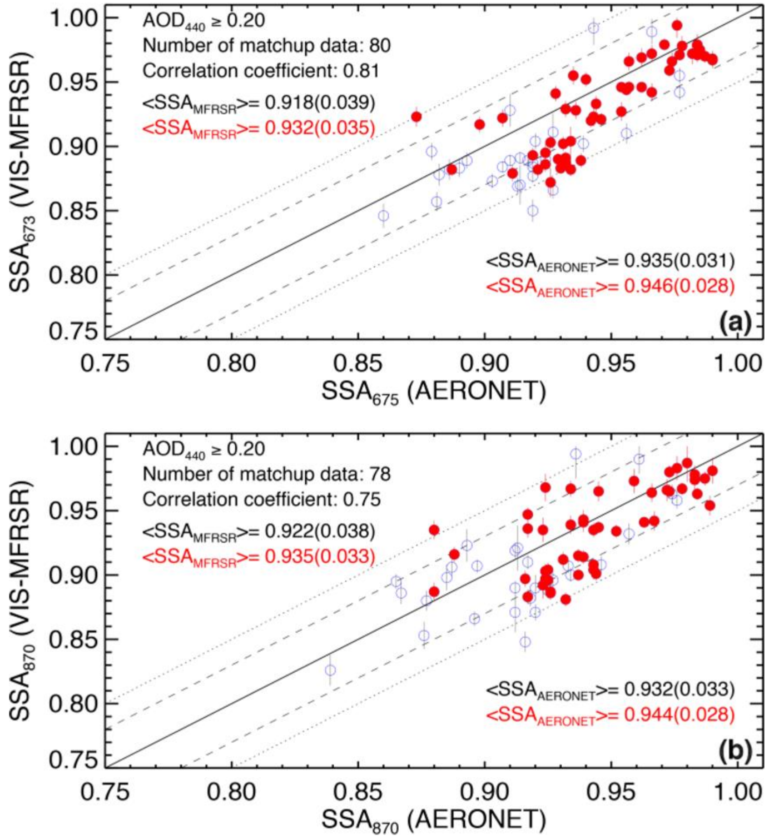


Comparisons of Spectral Aerosol Single Scattering Albedo in Seoul, South Korea

J. Mok et al., 2018



- This study compares the SKYNET SSA retrievals in extended UV–NIR wavelengths with the SSA derived from a combination of AERONET, MFRSR, and Pandora (AMP) inversions in Seoul, South Korea during and after KORUS-AQ international field campaign in 2016

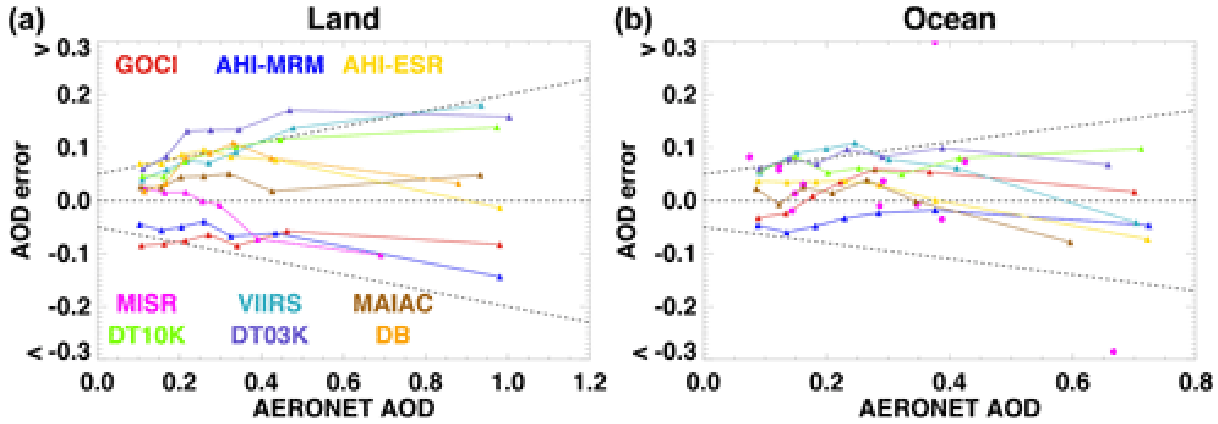


Validation, comparison, and integration of GOCI, AHI, MODIS, MISR, and VIIRS Aerosol Optical Depth over East Asia during the 2016 KORUS-AQ campaign

M. Choi et al. (AMT, 2019)

	GOCI	AHI	MODIS	VIIRS	MISR
Sensor/platform (orbit type)	GOCI/COMS (GEO)	AHI/Himawari-8 (GEO)	MODIS/Terra, Aqua (LEO)	VIIRS/Suomi-NPP (LEO)	MISR/Terra (LEO)
Swath for LEO or local coverage for GEO	2500 km × 2500 km area over East Asia centered at 36° N, 130° E	Full disk centered at 140.7° E	2330 km	3040 km	380 km
Algorithm version	Yonsei aerosol retrieval version 2	Yonsei aerosol retrieval	Dark Target Collection 6.1; Deep Blue Collection 6.1 (land only); Multi-Angle Implementation of Atmospheric Correction (MAIAC) Collection 6	Enterprise Processing system (EPS)	Version 23
Measurement time (local time)	1 h interval from 09:30 to 16:30 (eight times during daylight in total)	10 min interval for full-disk measurements (only 09:00–16:50 in this study)	10:30 for Terra, 13:30 for Aqua	13:25	10:30
Spatial resolution of aerosol products (nadir point for LEO)	6 km × 6 km	6 km × 6 km	10 km × 10 km and 3 km × 3 km for DT; 10 km × 10 km for DB; 1 km × 1 km for MAIAC	0.75 km × 0.75 km	4.4 km × 4.4 km
References	Choi et al. (2018); Choi et al. (2016)	Lim et al. (2018)	Gupta et al. (2016); Hsu et al. (2013); Levy et al. (2018); Lyapustin et al. (2018); Sayer et al. (2013)	Huang et al. (2016); Jackson et al. (2013); Zhang et al. (2016)	Garay et al. (2017); Witek et al. (2018)

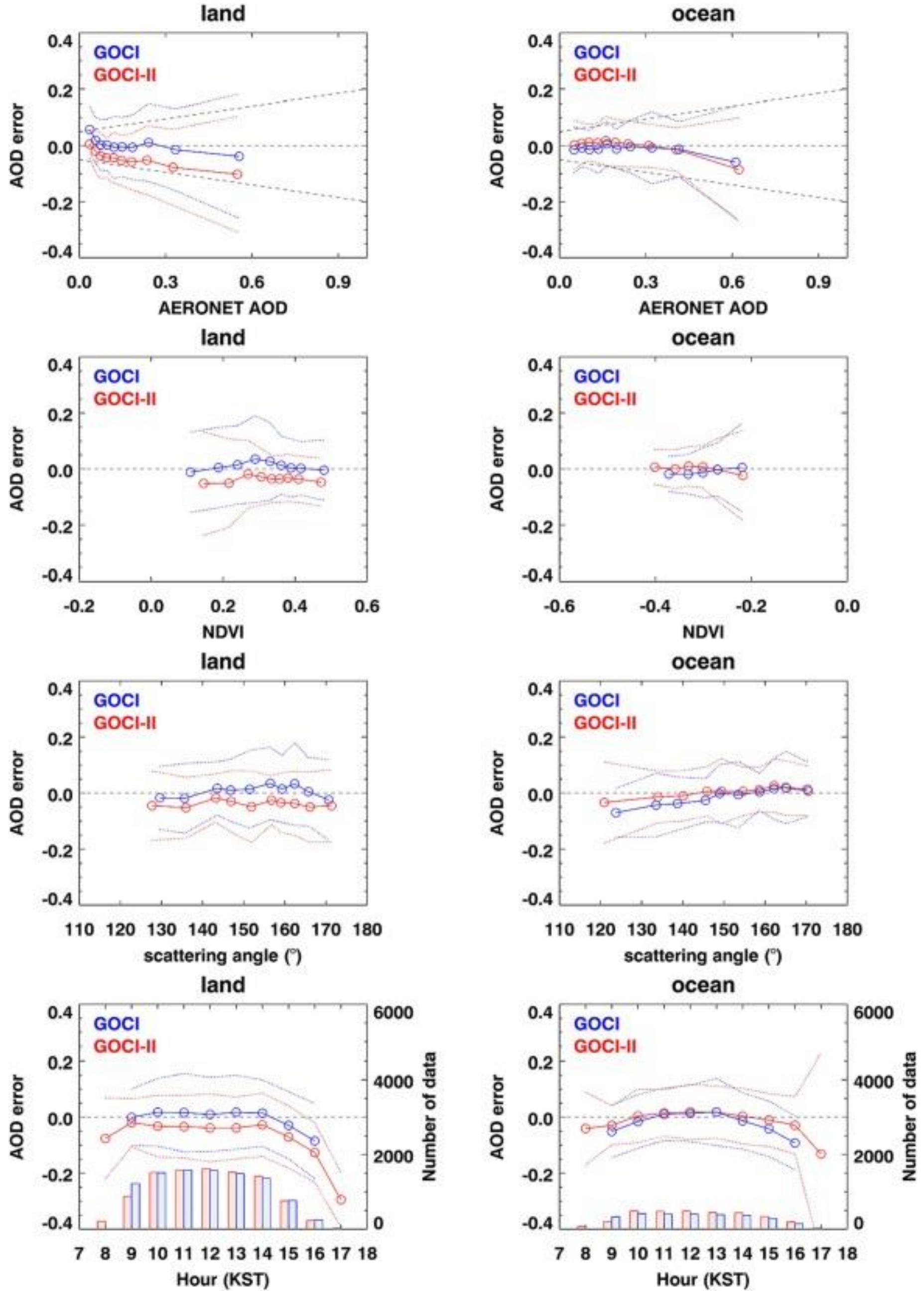
- To evaluate the various satellite AOD products during the 2016 KORUS-AQ campaign (1 May to 12 June 2016), AERONET of total 33 sites over East Asia, including 19 South Korean sites (Holben et al., 1998, 2018) were used.
- The AERONET version 3 level 2.0 AOD at 550 nm all-points data at a temporal resolution of a few minutes are used



Retrieval of Aerosol Optical Properties from GOCI-II Observations: Continuation of Long-term Geostationary Aerosol Monitoring over East Asia

S. Lee et al. (STE, 2023)

- Overlapped Period between GOCI-1 & 2 during Nov 2020 – Mar 2021
- GOCI-II has 13 channels including UV in 250 m resolution
- AERONET version 2 Level 2 all-point inversion data are used for the period up to July 2017.
- GOCI YAER algorithm: 26 aerosol models
- GOCI-II YAER algorithm: 6 aerosol models to reduce computational costs.



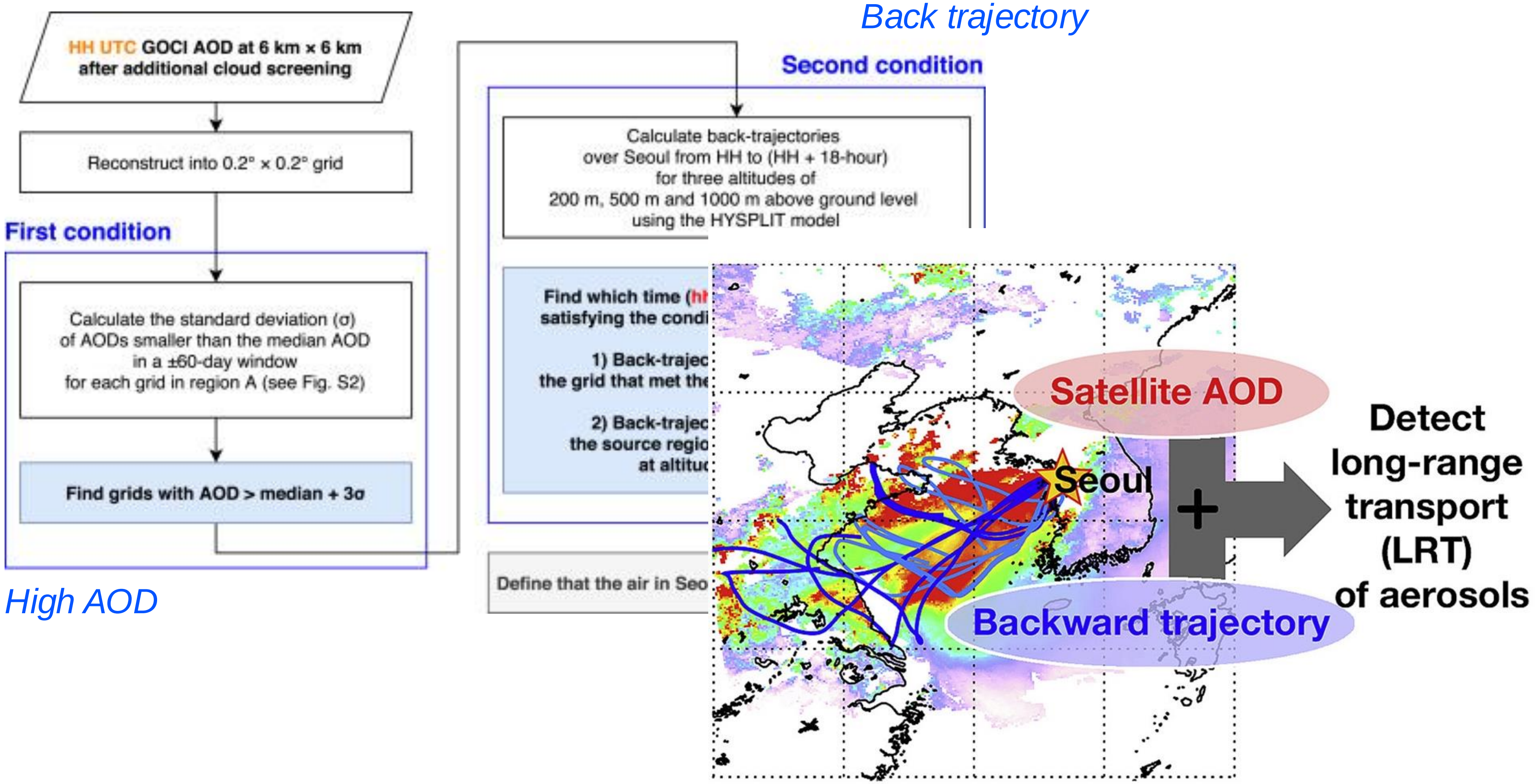
Aerosol model assumption using AERONET dataset

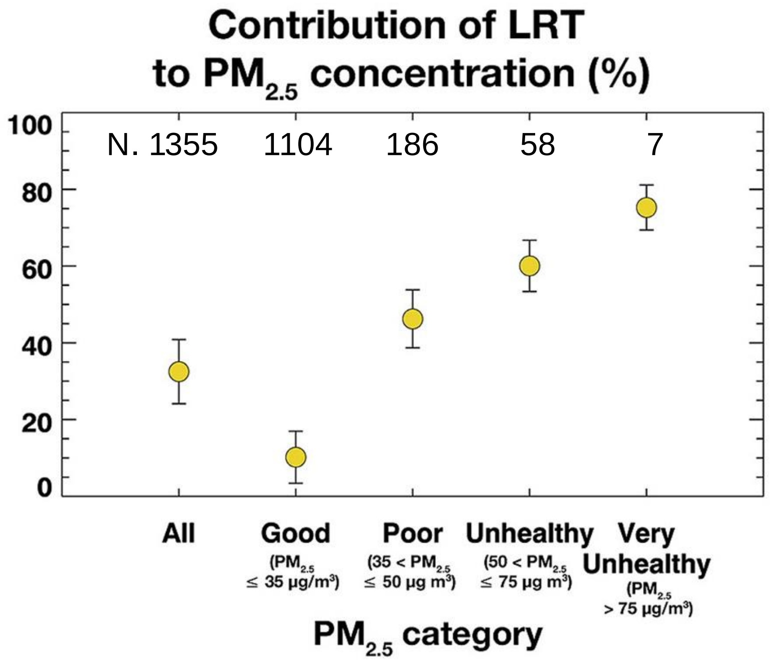
- AERONET SSA & FMF to classify six aerosol types: BC (HA, MA, SA), NA, mixture, and dust.
- The AOPs are averaged over three AOD ranges (0–0.5, 0.4–1.0, and 0.9–5.0) to account for the fact that *AOPs vary with AOD owing to hygroscopic growth effects or aggregation.*

AERONET for the validation of GOCI & GOCI-II

Assessment of Long-Range Transboundary Aerosols in Seoul, South Korea from Geostationary Ocean Color Imager (GOCI) and ground-based observations

S. Lee et al. (EP, 2021)



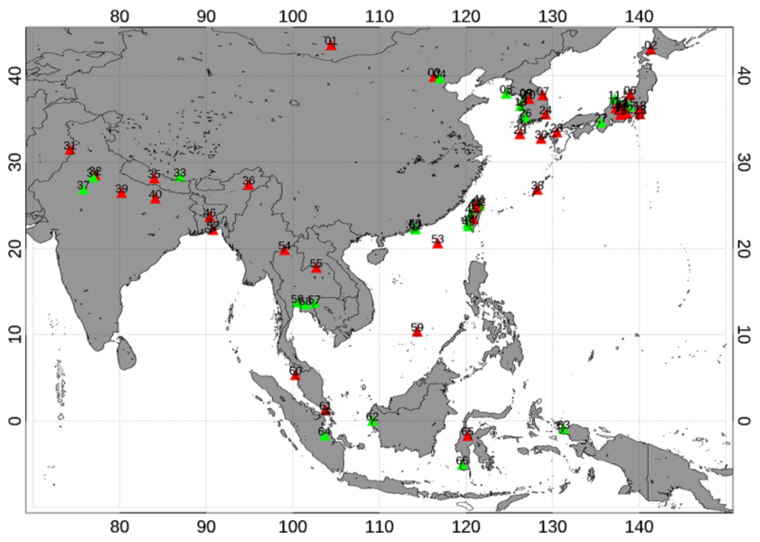


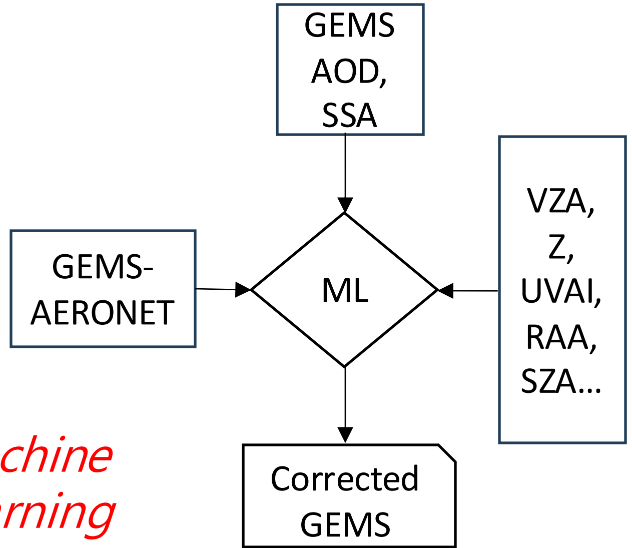
- To investigate the effects of LRT events, AERONET version 3 level 2.0 AOD data were used as data independent from satellite observations.
- AERONET data for 2015–2018 at Yonsei University, Seoul were used.

First Atmospheric Aerosol-monitoring Results from the Geostationary Environment Monitoring Spectrometer (GEMS) over Asia

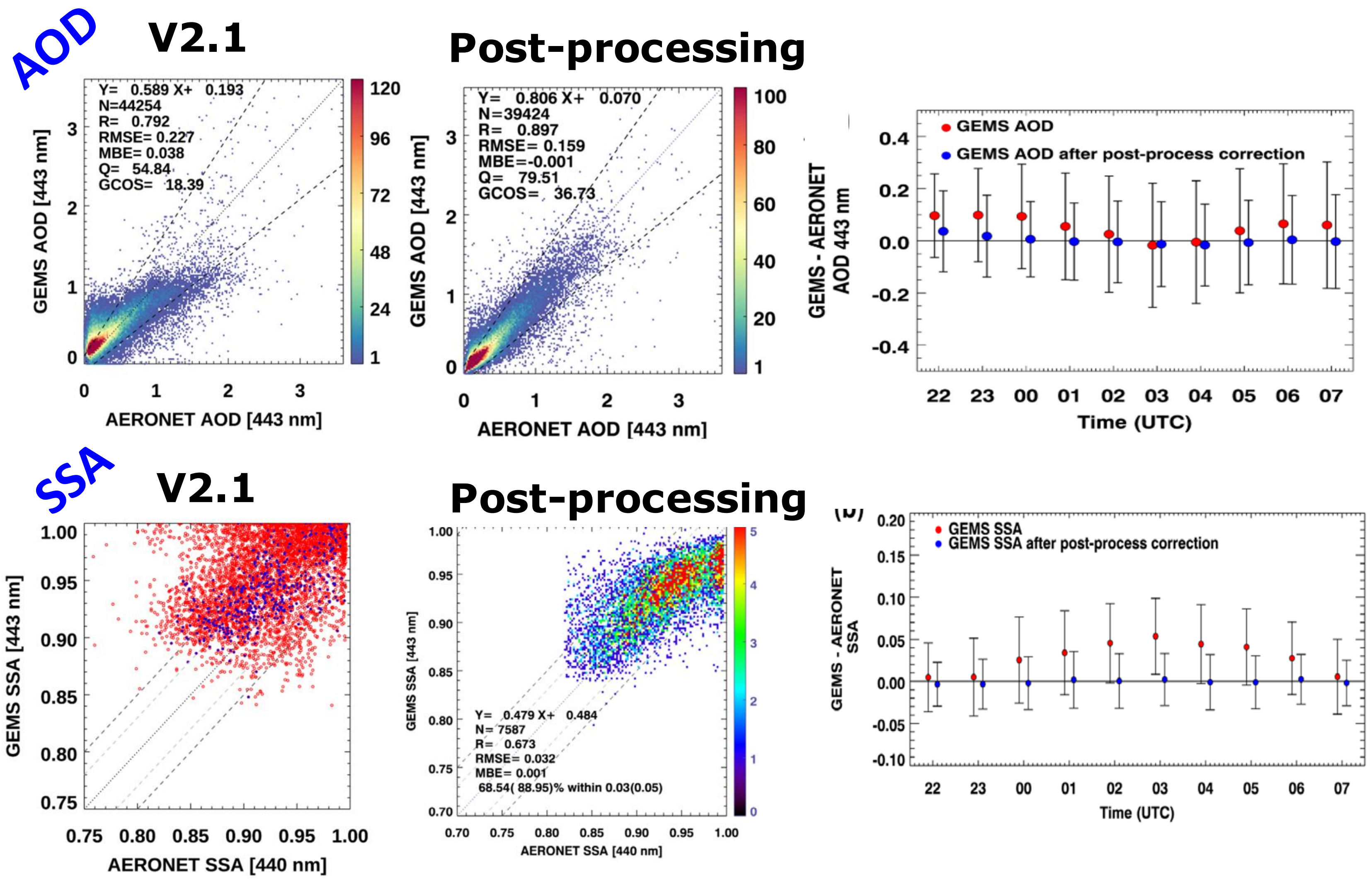
Y. Cho et al. (GEMS SI, AMT, 2024)

AERONET sites used for the GEMS AOD and SSA validation





Machine Learning

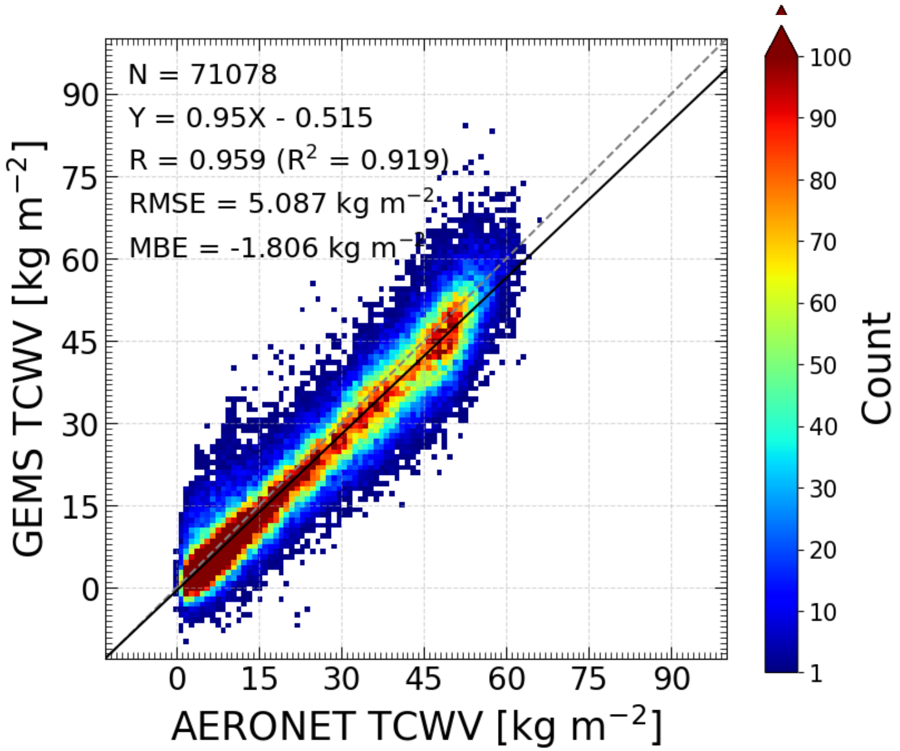


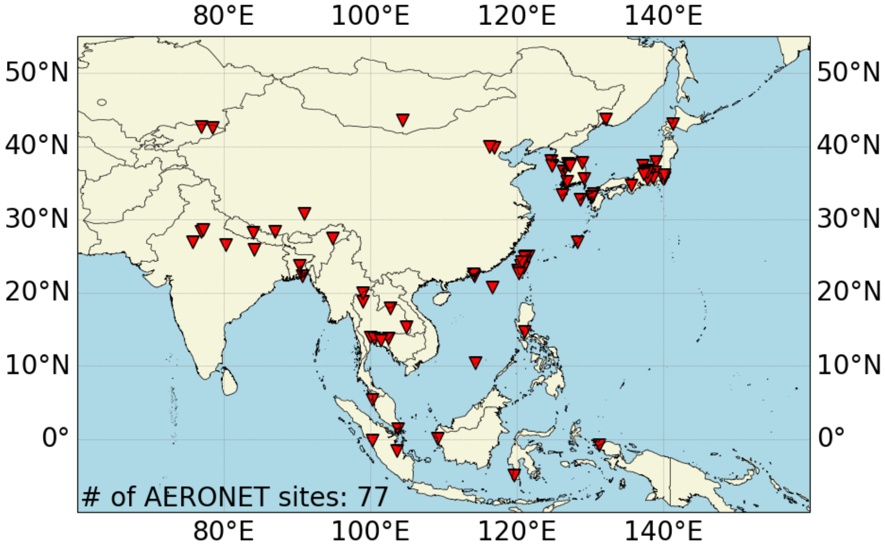
Validation of the GEMS AOD & SSA using AERONET in East Asia

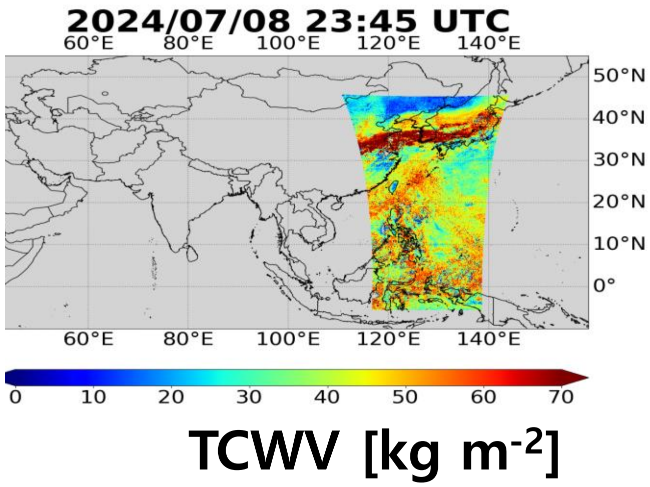
Total Column Water Vapor Retrievals from Geostationary Environment Monitoring Spectrometer (GEMS) in the visible blue spectral range

GEMS

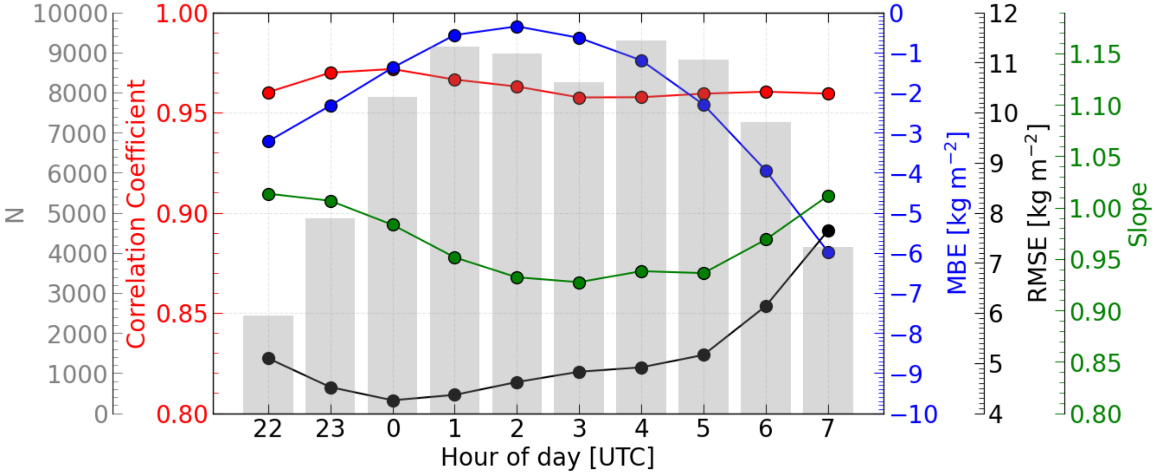
H. Cha et al., *in preparation*







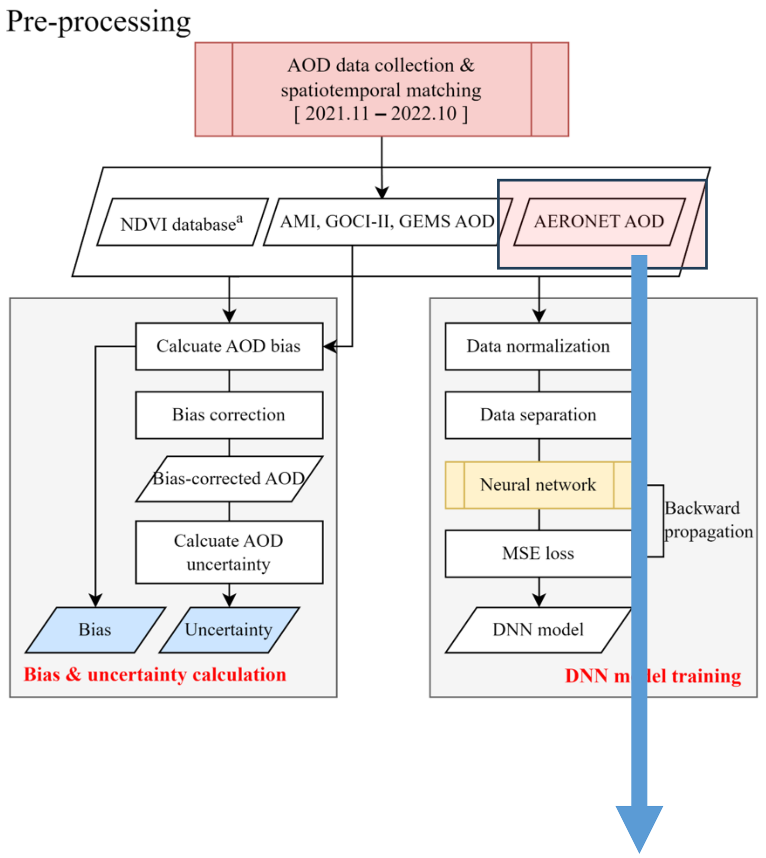
Hourly GEMS validation using continuous AERONET observations

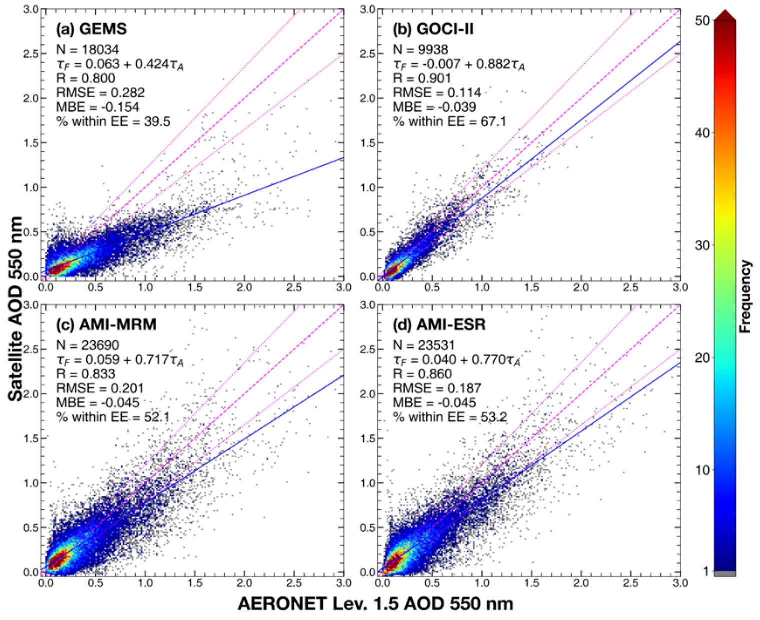


- Evaluation period: 1 March 2021 – 28 February 2023
- Reference datasets: AERONET ground-based Level 1.5 Version 3 precipitable water measurements

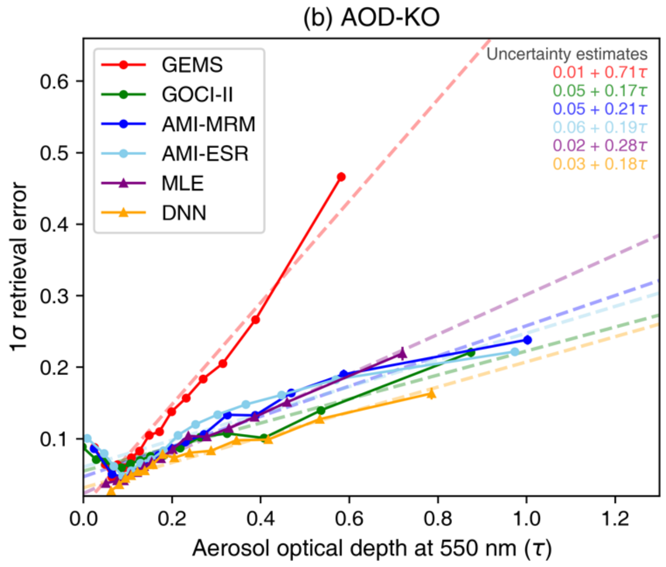
Aerosol Optical Depth **Data Fusion** with Geostationary Korea Multi-Purpose Satellite (GEO-KOMPSAT-2) Instruments GEMS, AMI, and GOCI-II: Statistical and **Deep Neural Network** methods

M. Kim et al. (GEMS SI, AMT, 2024)





GOCI-II, GEMS, AMI AOD validated from Nov. 2021 to Oct. 2022

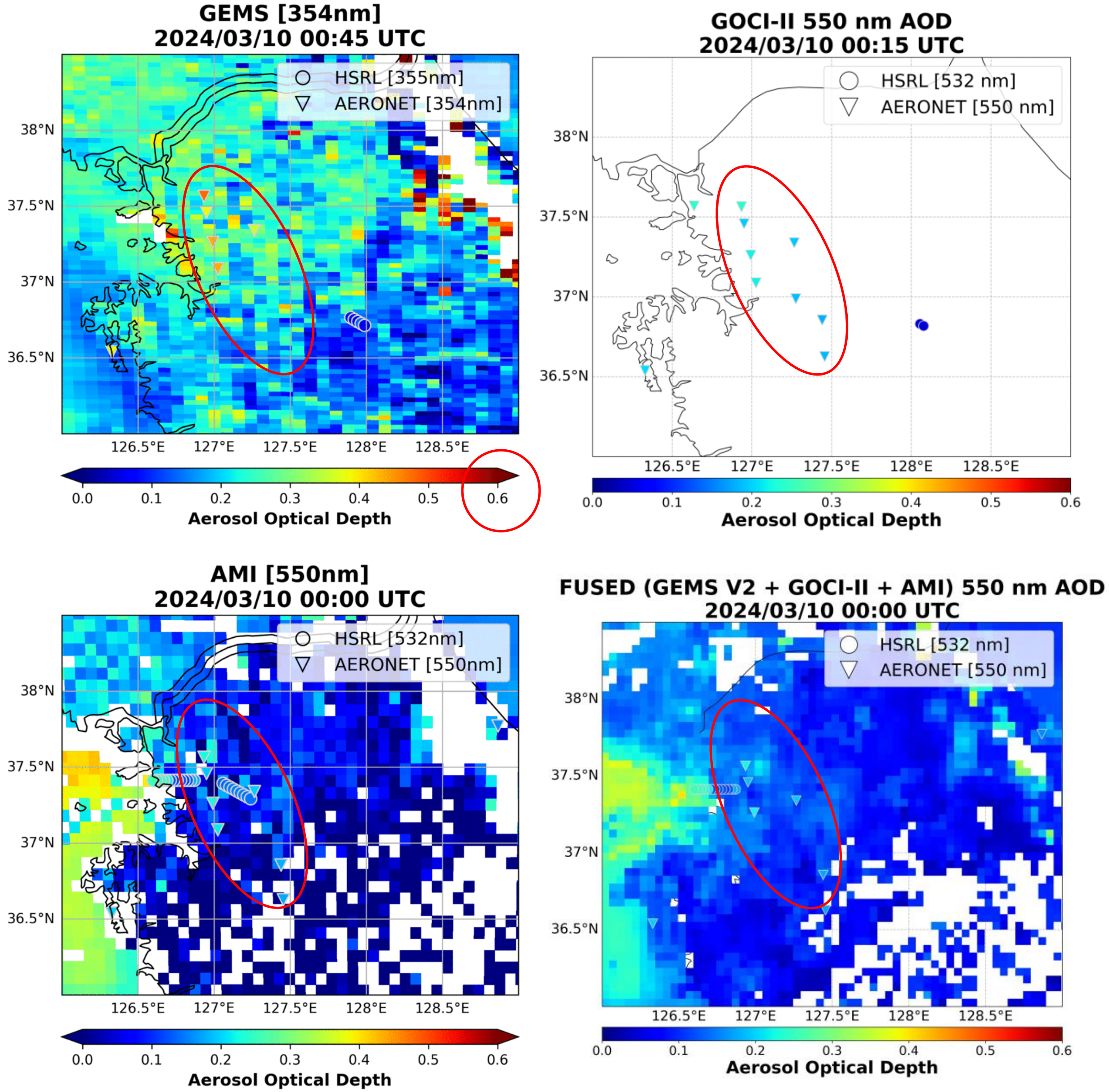


AERONET AOD:
1) Ground-truth for the pixel-level uncertainty calculation
2) Target for the deep learning model training

AOD uncertainty diagnosis using AERONET data

Comparison of GOCI-II, GEMS, AMI, Fusion AOD (2024/03/10Sun)

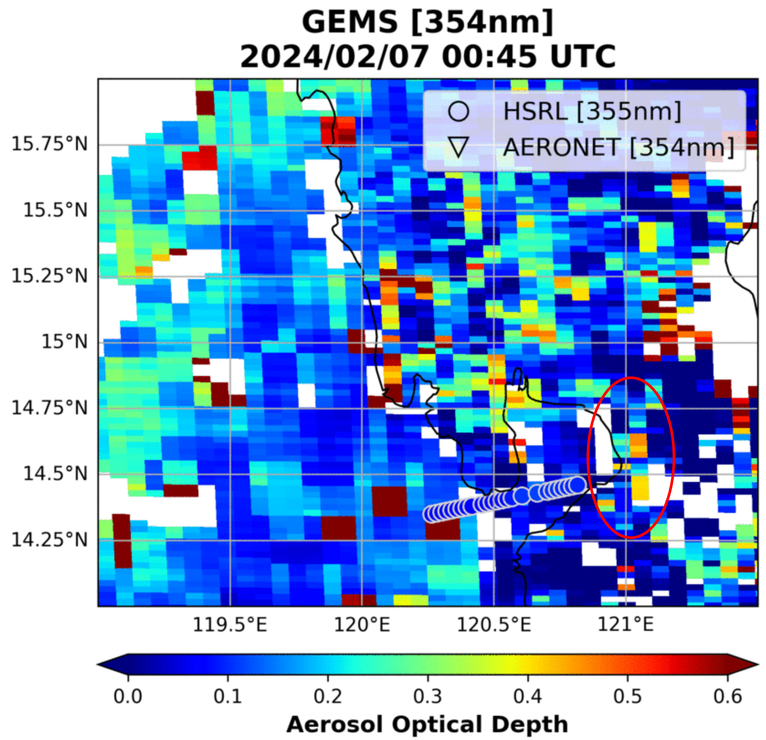
(S. Korea)



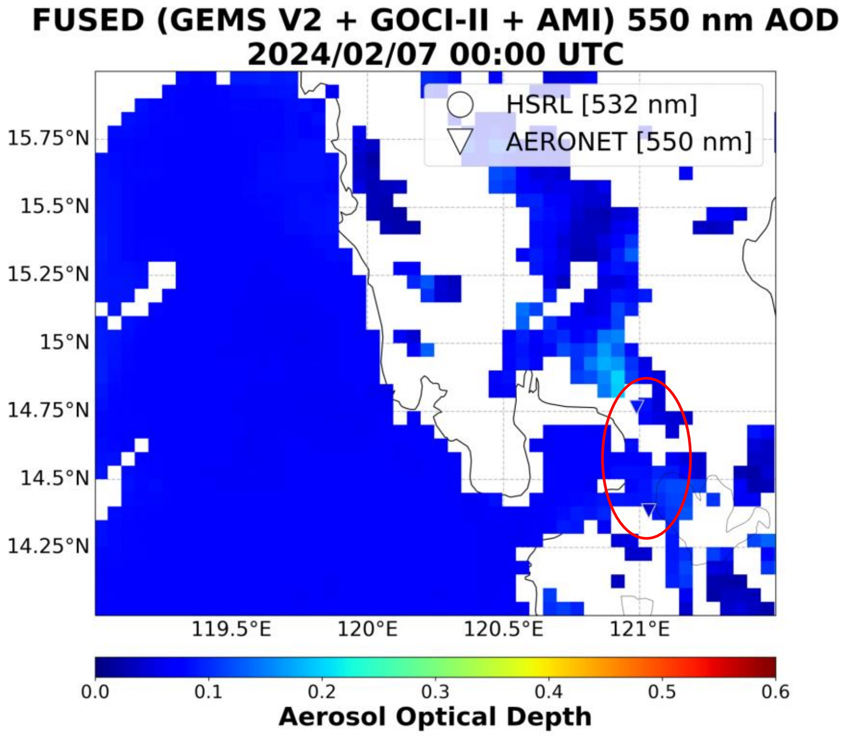
- High AOD gradients towards Seoul are observed by four satellite products, which implies the existence of local aerosols covering the city.
- The higher AOD around Seoul is in line with AERONET and HSRL measurements.

Comparison of GEMS, Fusion, AMI AOD (2024/02/07Thu)

(Philippines)



+30 min



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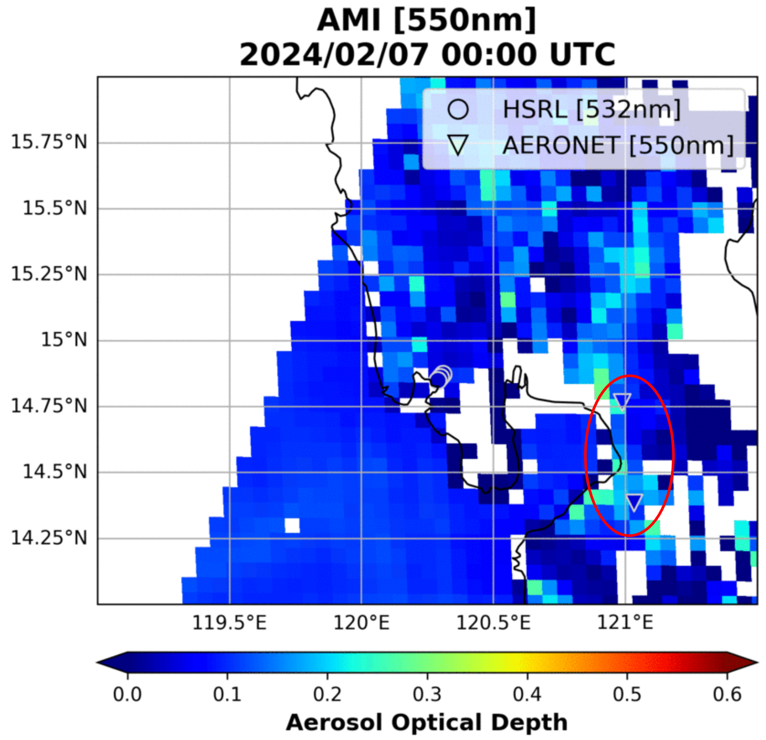
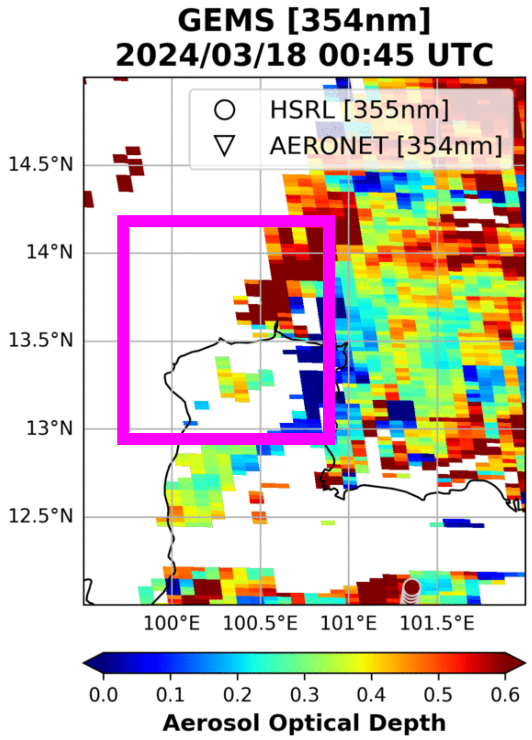


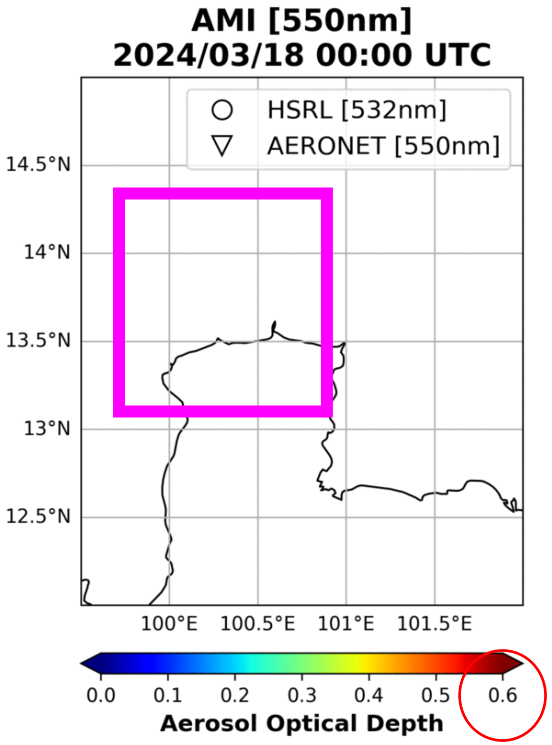
+10 min

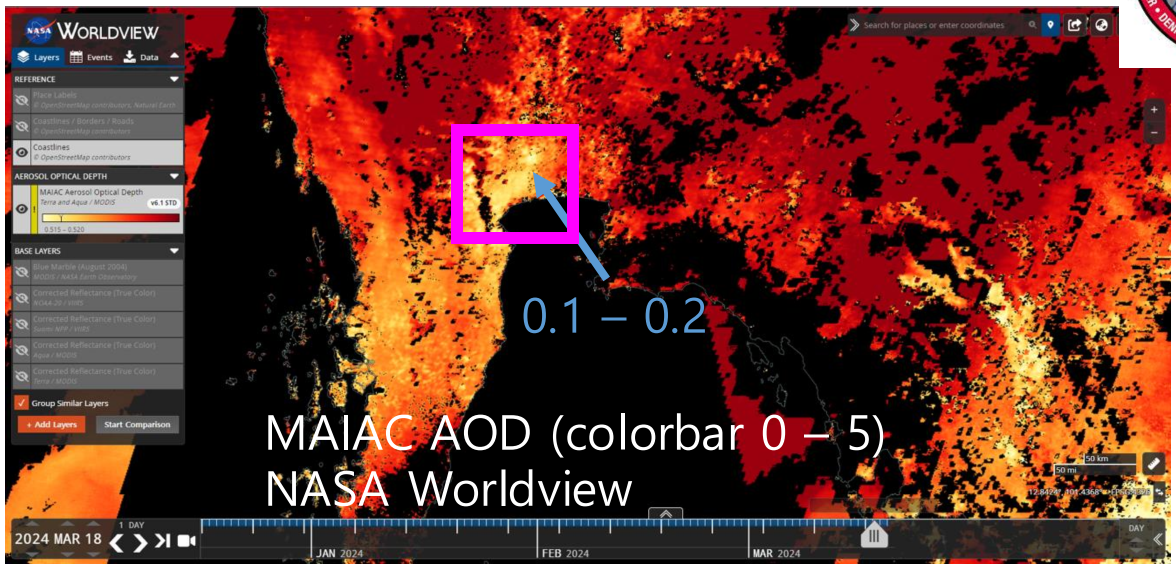
- HSRL and AERONET AOD within each satellite observation duration hour are shown with each satellite AOD.
- AMI AOD at 550 nm, GOCI-II AOD at 550 nm, Fusion AOD at 550 nm are compared with HSRL AOT at 532 nm.
- GEMS AOD at 354 nm is compared with HSRL AOT at 354 nm.

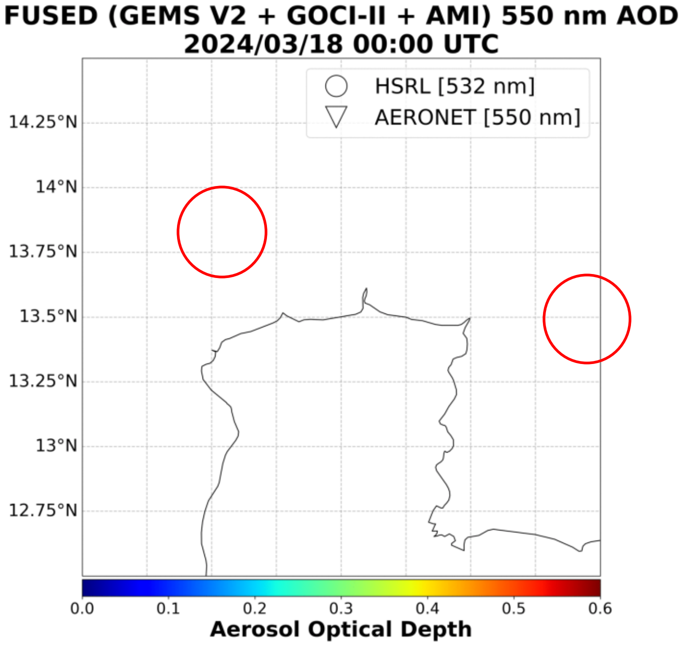
Comparison of GEMS, AMI, GOCI-II, Fusion AOD (2024/03/18)

(Thailand)









- GEMS, AMI and Fusion AOD catches the fire events of Thailand (represented as high AOD).
- Around Bangkok, comparatively lower AOD are captured by GEMS, AMI, Fused AOD and MAIAC.
  - High surface reflectance of AMI of the region, which is close to the critical reflectance, may have caused reduced sensitivity towards AOD

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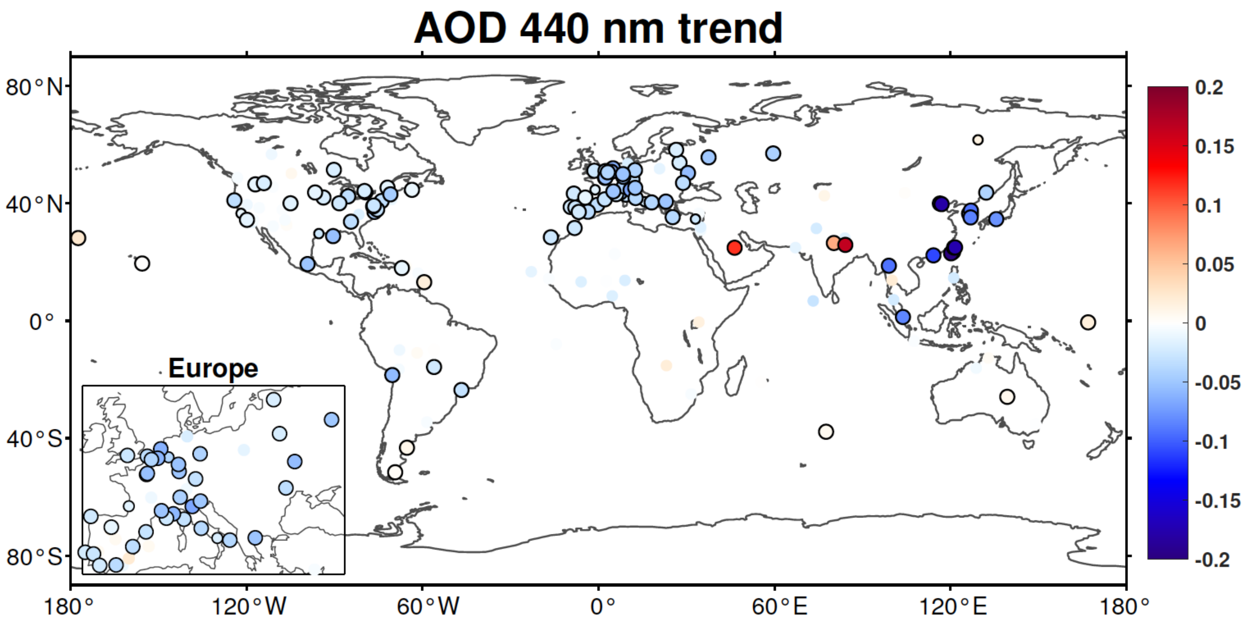
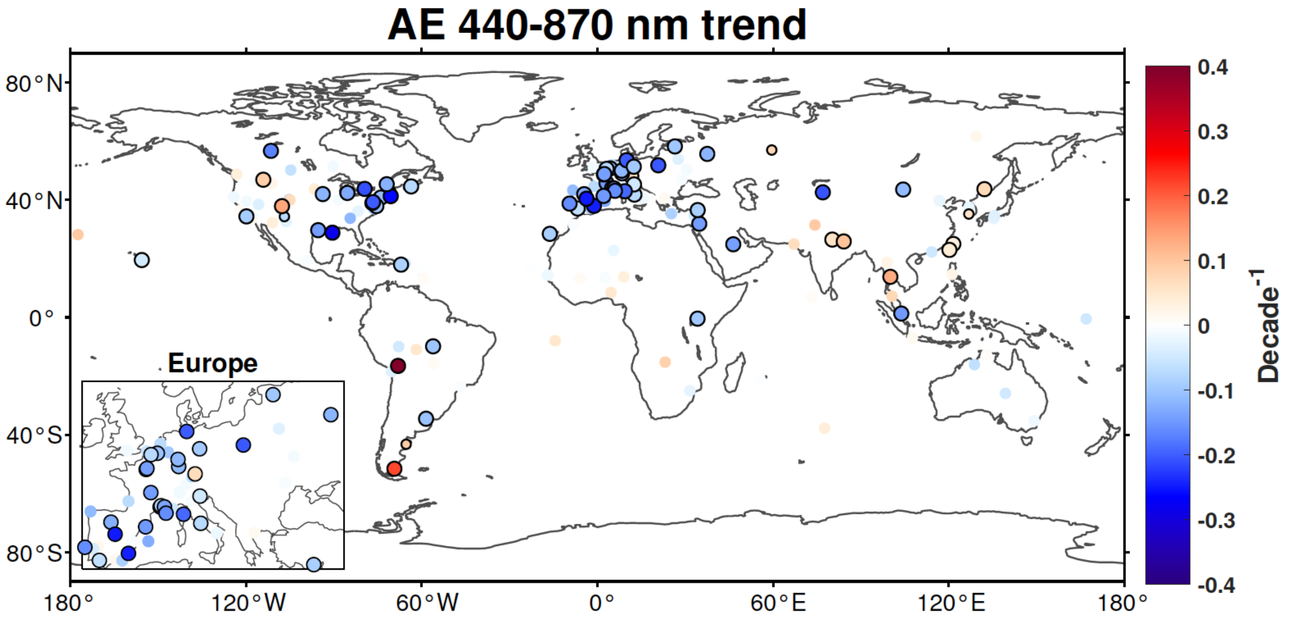
Long-term trends in aerosol properties derived from AERONET measurements

Zhenyu Zhang[1], Jing Li[1], Huizheng Che[2], Yueming Dong[1], Oleg Dubovik[3], Thomas Eck[4,5], Pawan Gupta[4], Brent Holben[4], Jhoon Kim[6], Elena Lind[4], Trailokya Saud[7], Sachchida Nand Tripathi[7], and Tong Ying[1]





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Jiwoo Lee
Yujin Chae

J. Lee (Ph.D., 2012)
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M. Kim (Ph.D., 2015)
NASA GSFC/MSU

W. V. Kim (Ph.D., 2017)
NASA GSFC/UMCP

M. Choi (Ph.D., 2017)
NASA GSFC/UMBC

Y. Cho (Ph.D., 2024)
NOAA/UMD

N. Cho (M.S., 2011)
NASA GSFC/UMBC

J. Mok (M.S., 2008)
NASA GSFC /SSAI

S. Go (Ph.D., 2020)
NASA GSFC/UMBC

S. Lee (Ph.D., 2021)
NASA GSFC/UMBC

H. Chong (Ph.D., 2021)
Harvard & Smithonian

M. Kim (Ph.D., 2024)
Yonsei University

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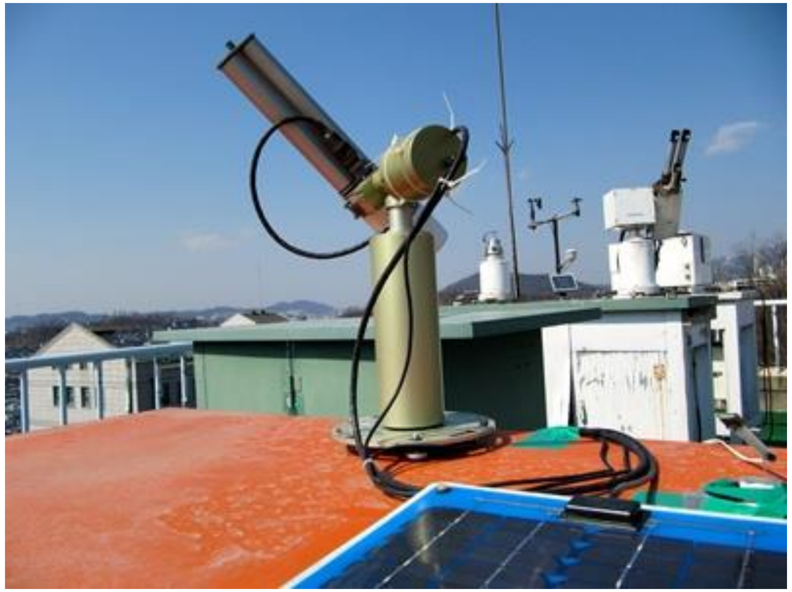

(Side Meeting during AGU Fall Meeting, San Francisco, 2012)

Thank you!