JMA/MRI Aerosol Prediction Model Overview

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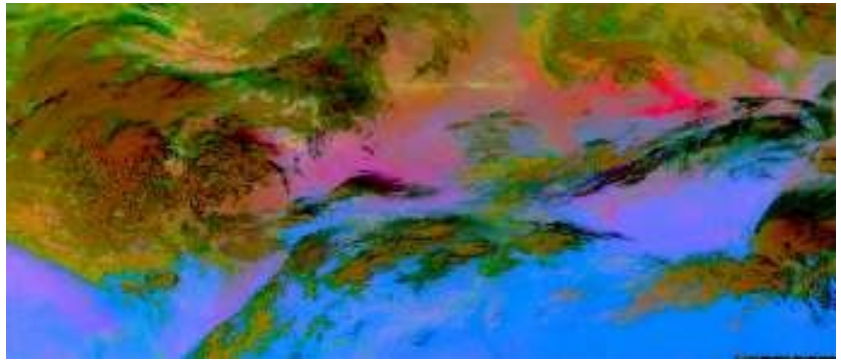
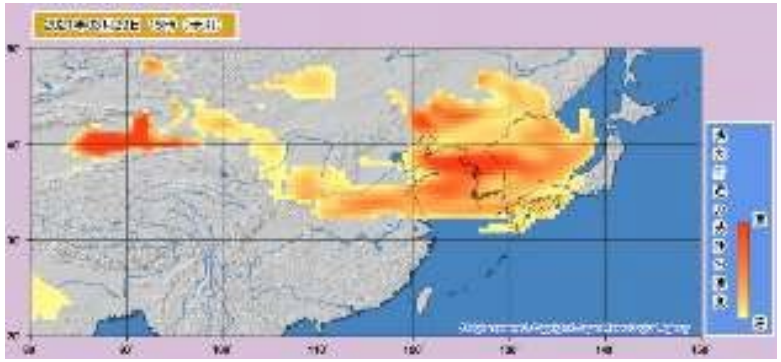
Outline

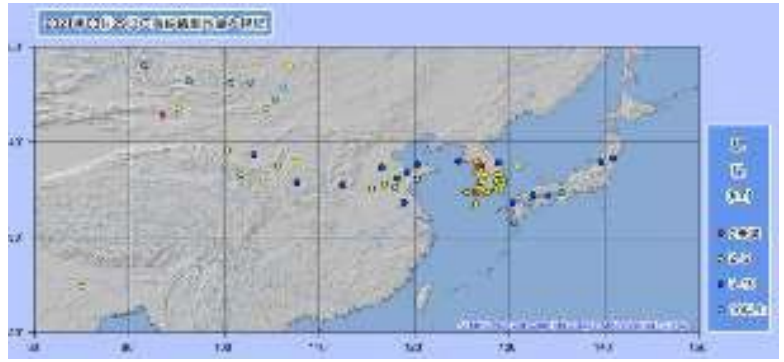
- Updates of the JMA operational global aerosol prediction model and data assimilation
- Feasibility study of the aerosol data assimilation of the GCOM-C SGLI aerosol product
- Plans

JMA operational aeolian dust Information

JMA has been providing Aeolian dust information based on numerical forecasts and observations since January 2004 (http://www.jma.go.jp/en/kosa).







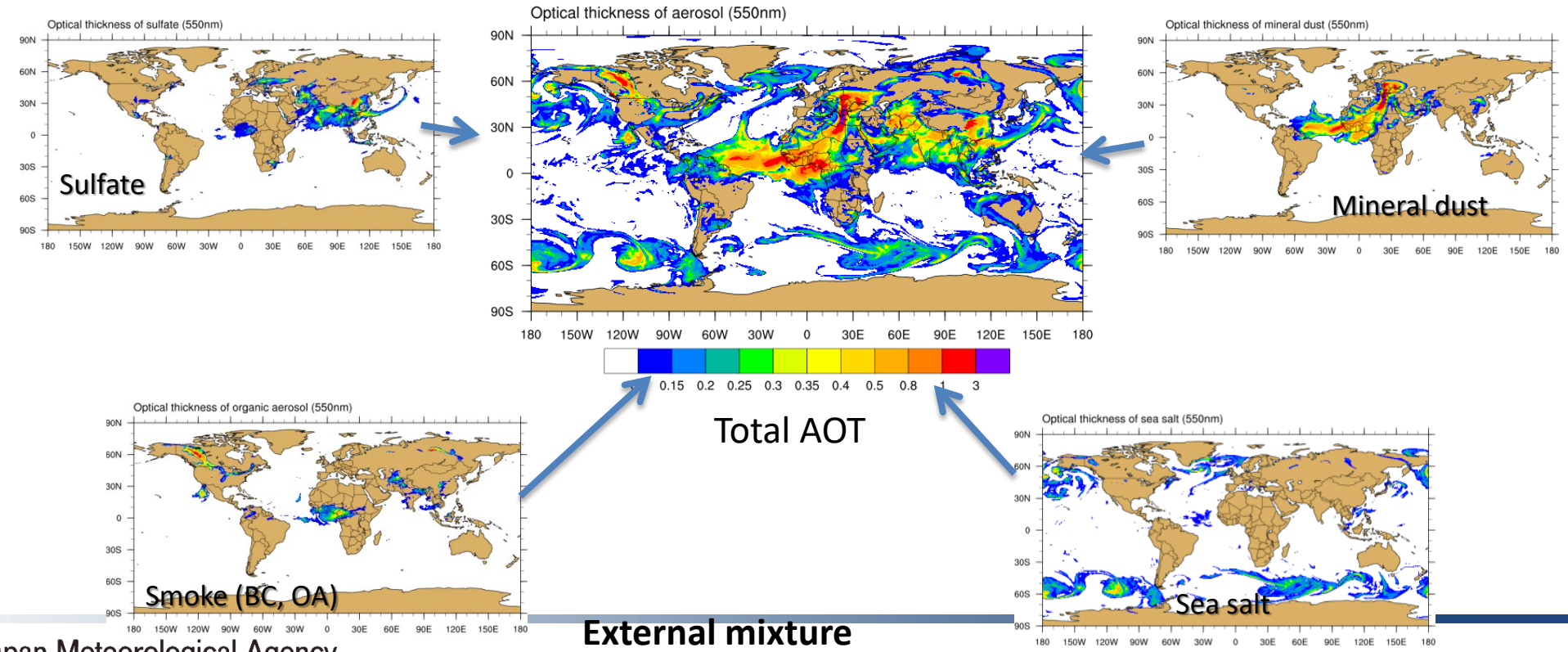
JMA operates a global aerosol model (TL479L40) for the prediction of aeolian dust.

The forecast charts up to 4 days ahead with the interval of 6 hours are updated once per day.

JMA also provides aeolian dust prediction results (GRIB2 format) for private weather services via the Japan Meteorological Business Support Center (JMBSC).

JMA/MRI Aeolian dust prediction model
(Model of Aerosol Species in the Global Atmosphere: MASINGAR)

- Sulfate, black carbon, organics, sea salt, and mineral dust are included
  - The emission flux of sea-salt, mineral dust, and dimethylsulfide are predicted based on the surface properties calculated by the atmospheric model.
  - Particle size distributions of sea salt and dust are expressed by sectional approach (10-bins from 0.2 to 20 μm)



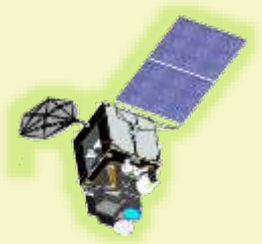
JMA operational aerosol prediction: update

- 2D-VAR AOT data assimilation has been applied to the JMA's operational aerosol forecast since January 2020.
  - Himawari-8 AOT product is used for the AOT data assimilation.

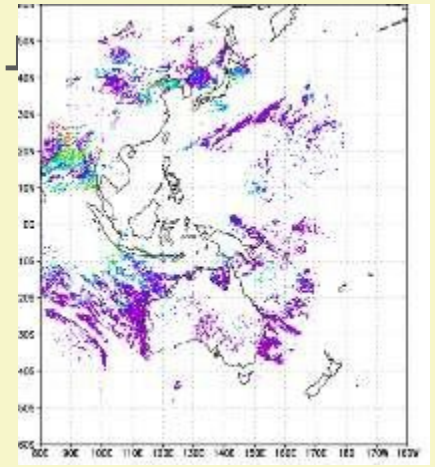
- The role of the JMA's geostationary meteorological satellites Himawari-8 and **Himawari-9** will be switched within this year to place Himawari-9 in the main observational role with Himawari-8 as back-up.

Data assimilation of the operational dust forecast

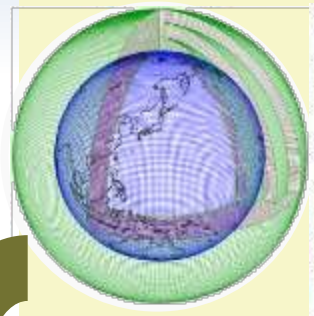
Himawari 8/9」

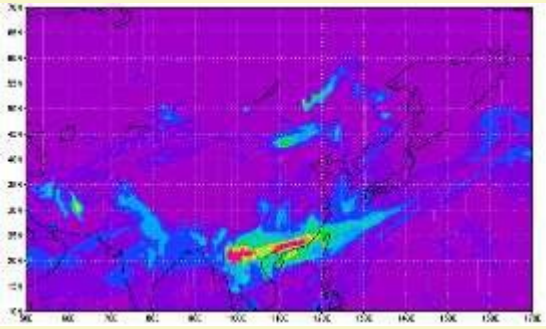


Observation



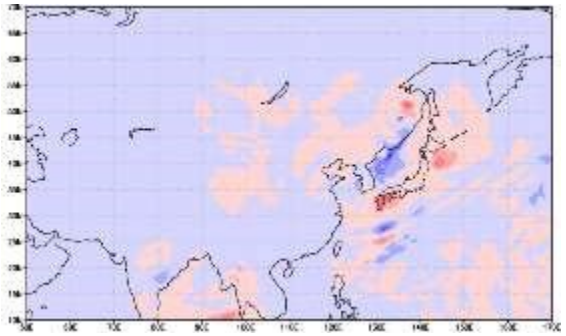
「MASINGAR mk -2」



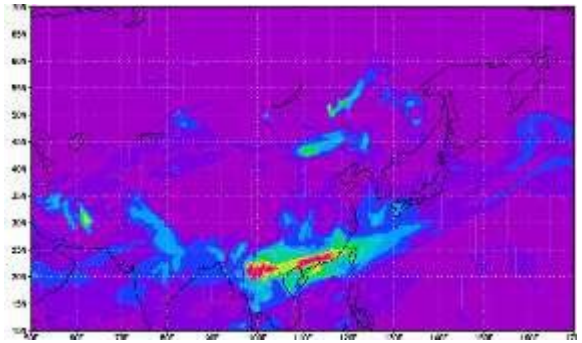


model

Data Assimilation



Increment



Analysis

Target: AOD

Frequency: Once per day

Method: 2D-Var

Area: Asia and Oceania

Aerosol data assimilation system

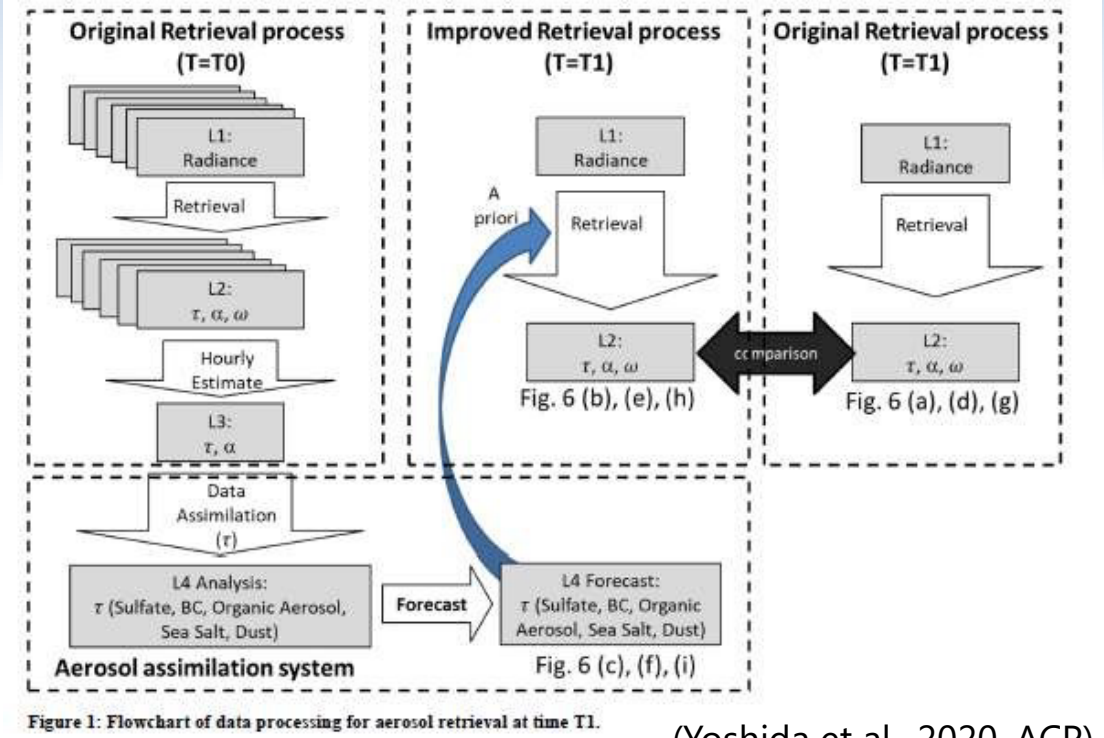
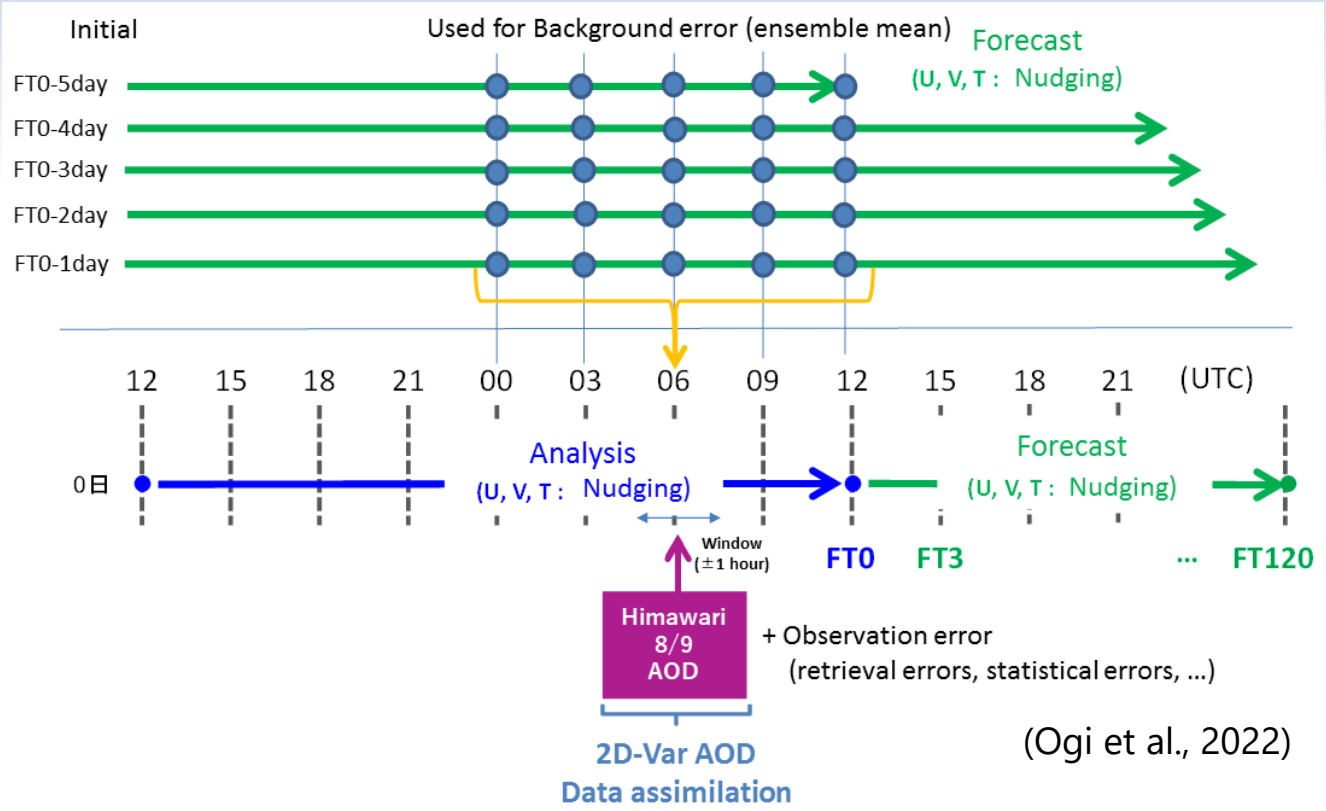


Figure 1: Flowchart of data processing for aerosol retrieval at time T1.

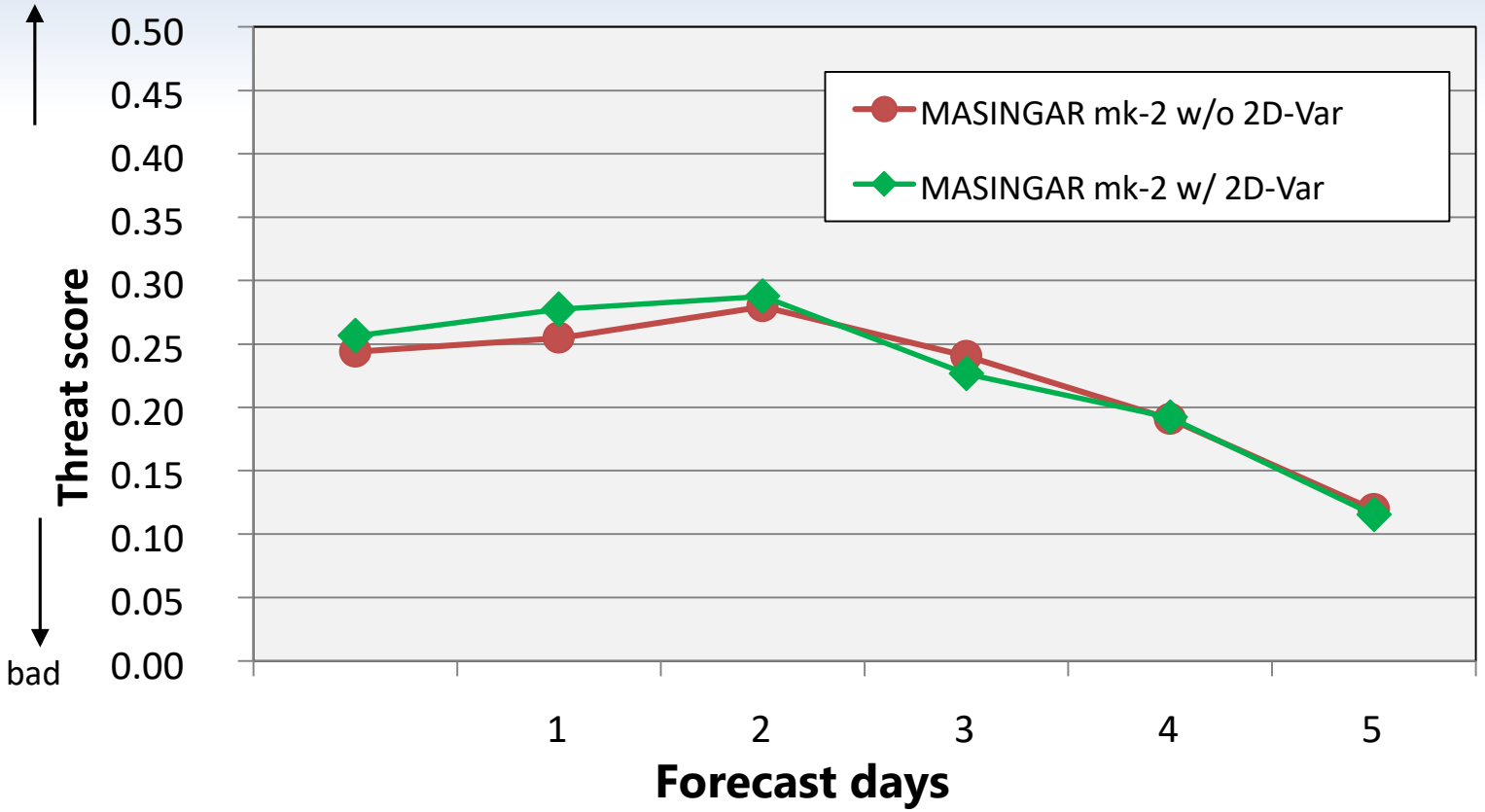
(Yoshida et al., 2020, ACP)



(Ogi et al., 2022)

We, JMA and JAXA, developed a new aerosol retrieval algorithm combining a numerical aerosol forecast. In the retrieval algorithm, the short-term forecast from an aerosol data assimilation system was used for a priori estimate instead of spatially and temporally constant values. The retrieval accuracy was improved by using the model forecast as compared with using constant a priori estimates. (Yoshida et al., 2020, ACP)

Verification for dust predictions against SYNOP observations



$$\text{Threat Score} = \frac{FO}{FO + FX + XO}$$

* Forecast threshold : 90 μg m^{-3}

(Ogi et al., 2022)

Dust predictions with Himawari-8 data assimilation generally resulted better threat scores.

FEASIBILITY STUDY OF THE AEROSOL DATA ASSIMILATION OF THE GCOM-C SGLI AEROSOL PRODUCT

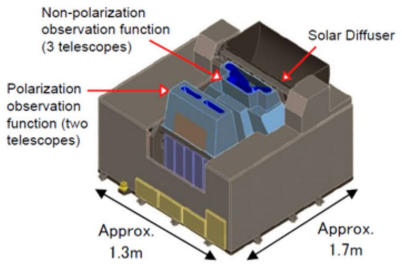
GCOM-C SGLI Aerosol product

Characteristics of SGLI

- Spectral channels: 19 spectral bands from Near UV to IR
- Resolution: 250 m / 1 km
- Polarization observation
- Multi-angle observation

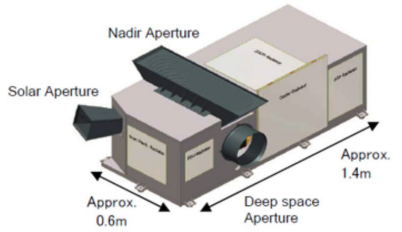
Visible and Near Infrared Radiometer (VNR)

Non-polarization nadir view (11ch)	Polarization/along-track slant view (2ch)
spatial resolution: 250m, swath: 1150km	spatial resolution: 1km, swath: 1150km



Infrared Scanner (IRS)

Shortwave infrared (SWI:4ch)	Thermal infrared (TIR:2ch)
spatial resolution: 250m/1km, swath: 1400km	spatial resolution: 250m, swath: 1400km



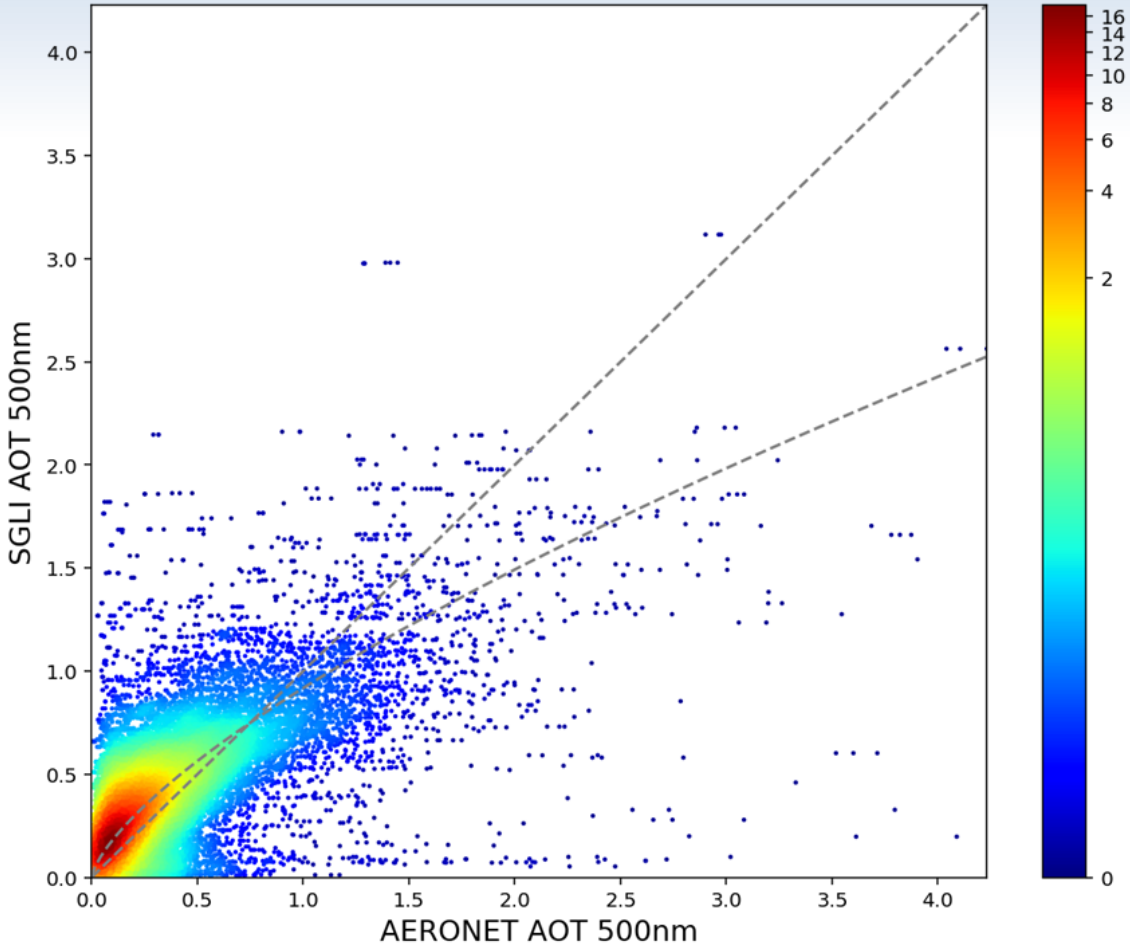
- Currently, SGLI version 3 product is provided by JAXA G-Portal website https://gportal.jaxa.jp/gpr/?lang=en

Experimental: Aerosol data assimilation using SGLI

- **NRT 2D-Var AOT data assimilation**
  - Simple 2D-Var aerosol data assimilation method (Yumimoto et al., 2017) for operational use.
  - Observation data is Himawari-8 AOT by JAXA/EORC retrieval method (Yoshida et al., 2018, Kikuchi et al., 2018) or MODIS AOT.
  - Applied for making aerosol reanalysis (JRAero v1.0, Yumimoto et al., 2017, GMD)
  - Applied for the JMA's operational dust prediction from January 2020.

- **SGLI Aerosol property product**
  - We use 500 nm AOT from the SGLI version 2 aerosol properties (ARNP) in the GCOM-C standard product.
  - L2 ARNP ➔(converted) Grid points:
    - every 3 hours
    - quality control based on QA flags, snow data, and cloud data.
  - We are now testing to apply the SGLI version 3 product.

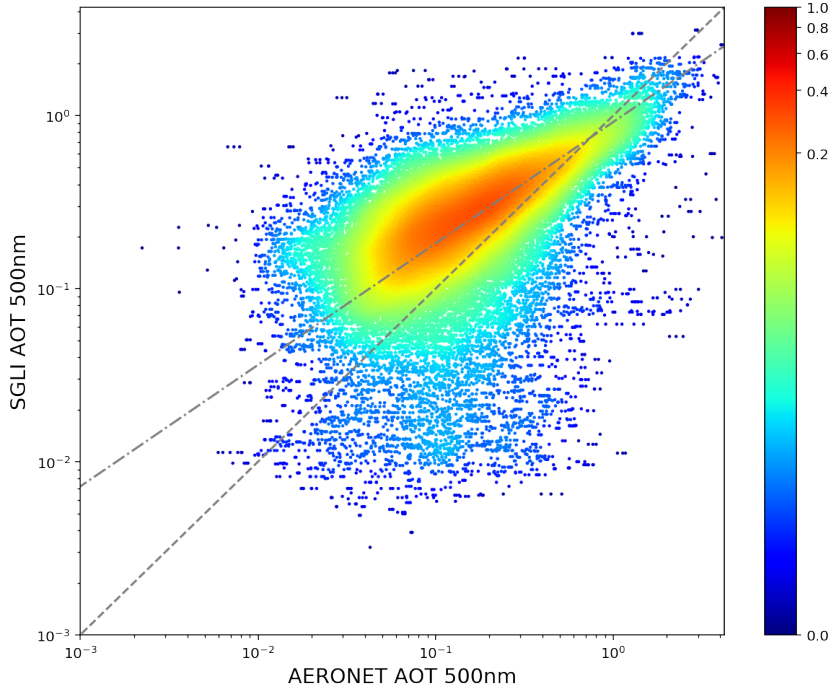
Comparison of SGLI ver.2 and AERONET lev.1.5 AOT



The figure on the right is a scatter plot of the stations from July 2019 to April 2020.

We compared gridded (~ 0.375 x 0.375°) SGLI 500 nm AOT to AERONET AOT.

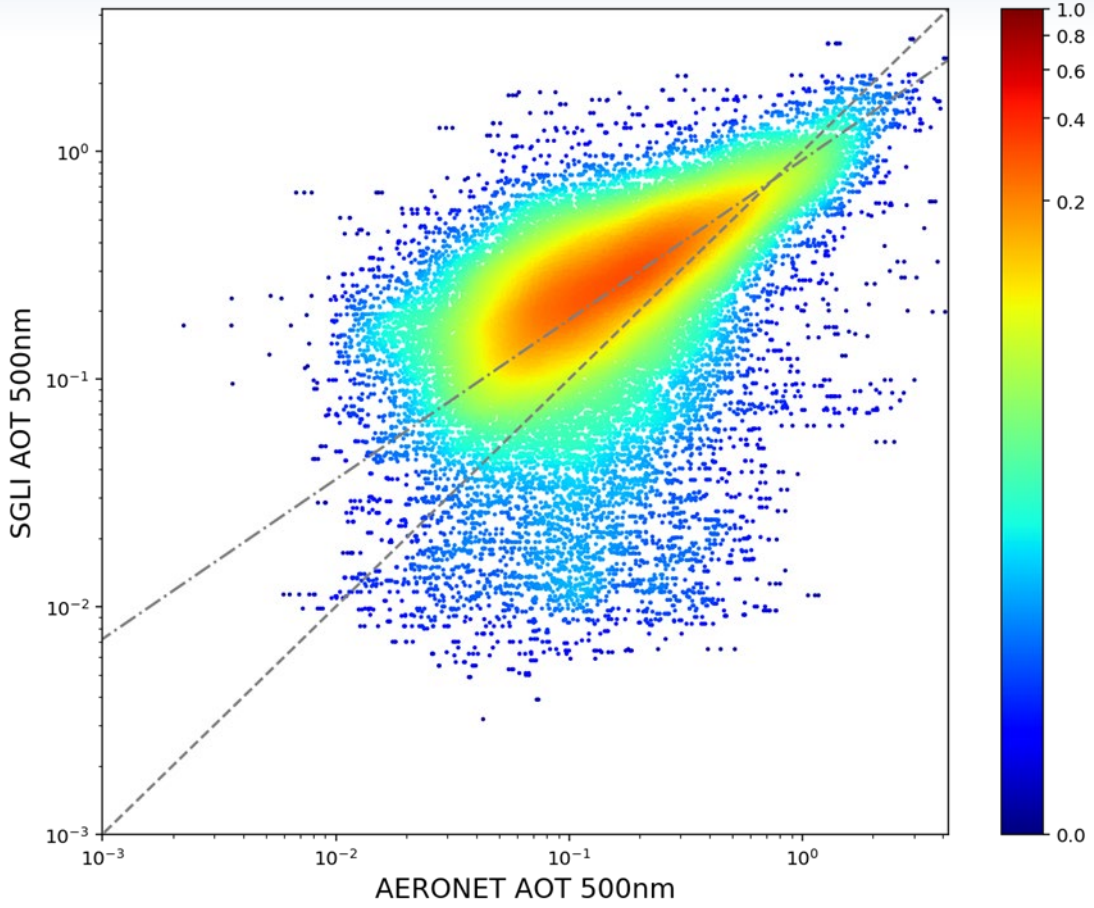
➔ some overestimations in small AOT area (AOT <~ 1).



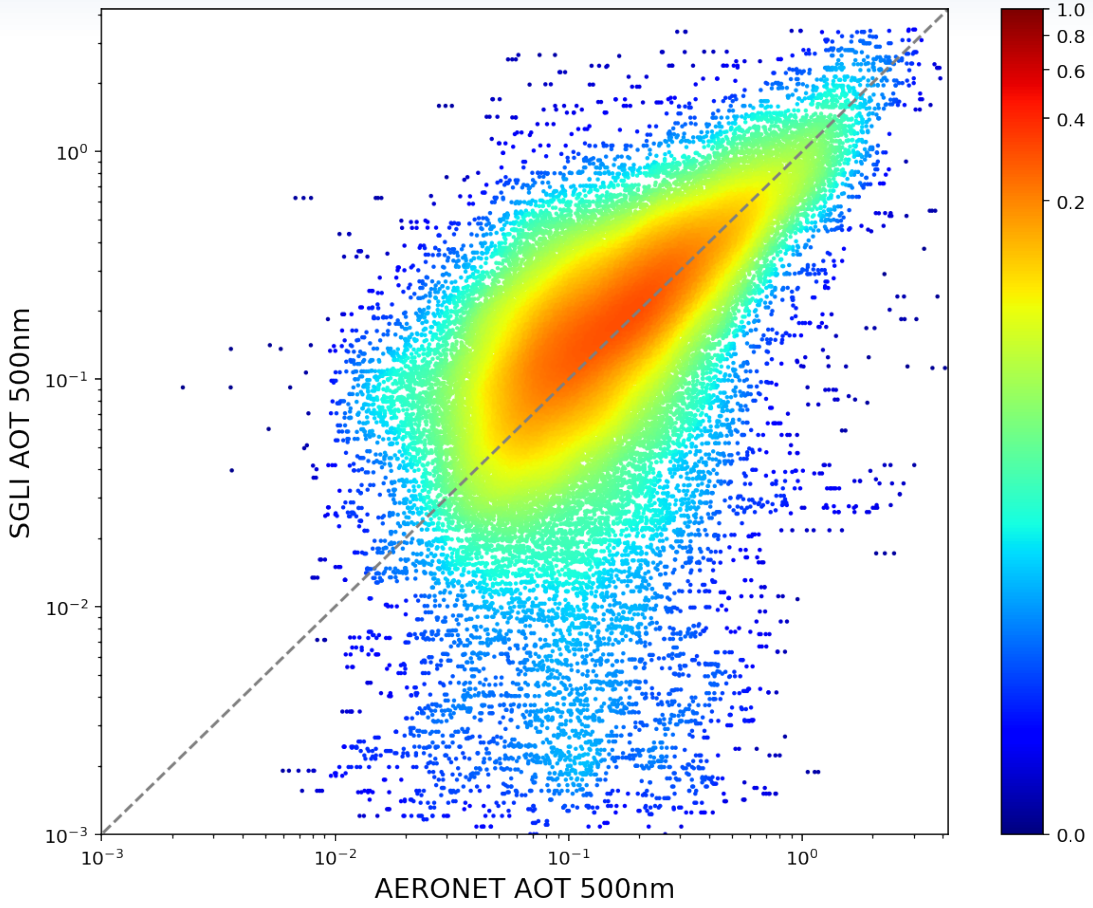
Log-log scale scatter-density plot

Application of the correction function

Before QC: SGLI vs AERONET AOT



After QC: Modified SGLI vs. AERONET AOT



$$\text{Modified SGLI AOT} = \exp(a\ (\text{AOT})\ - b\ ) + b$$

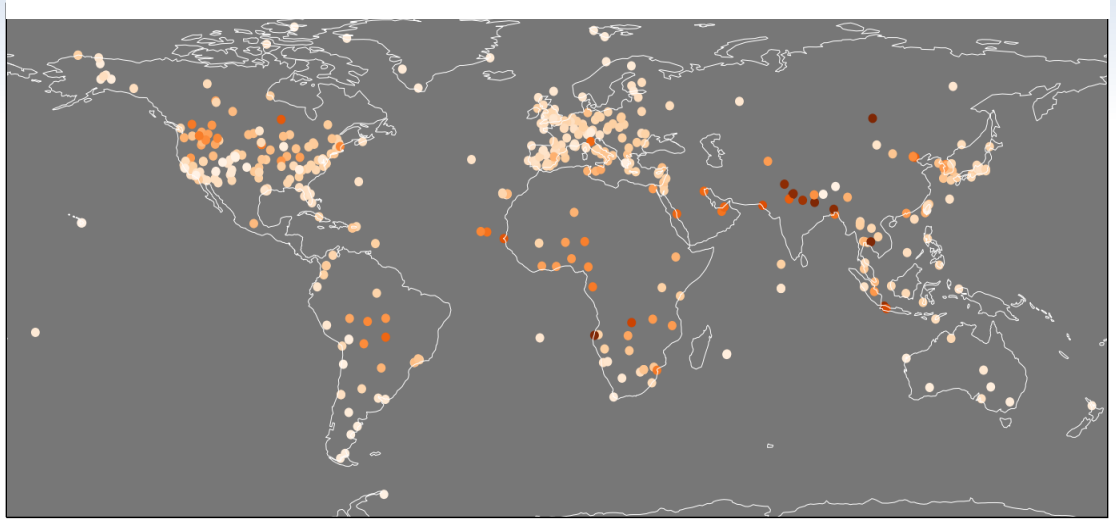
Score evaluations with AERONET lev. 1.5 500 nm AOT

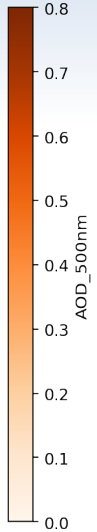
	RMSE Root mean square error	MB Mean bias	MNMB Modified normalized mean bias	R Correlation coefficient
SGLI DA	0.192	-0.035	-0.045	0.656
MODIS + AHI DA	0.195	-0.066	-0.322	0.682
No DA	0.205	-0.007	+0.037	0.654

Scores of the global AOT simulations against AERONET AOT. The number in red indicate the best scores, and blue indicate the second-best scores among the experiments.

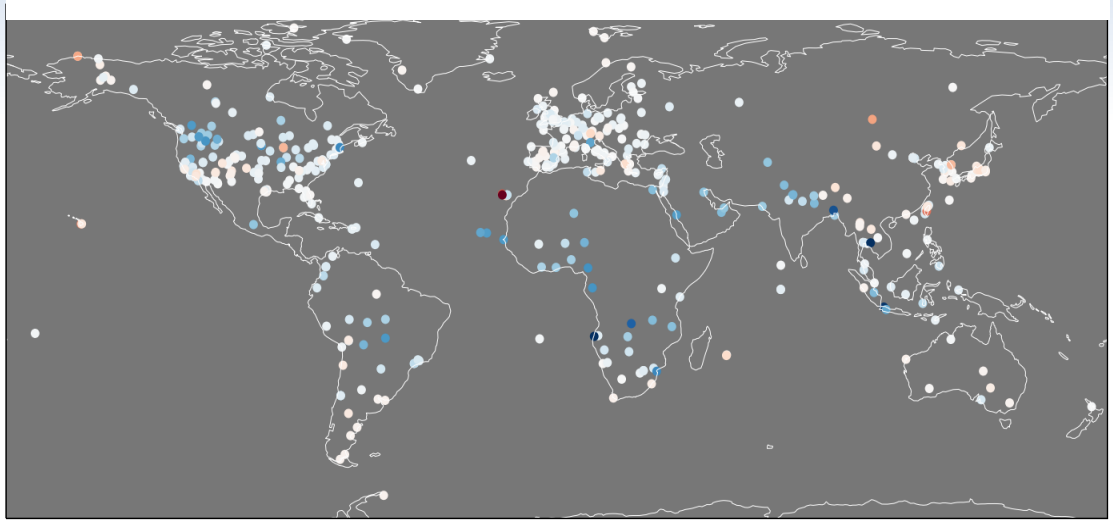
AOT distributions: AERONET vs simulations

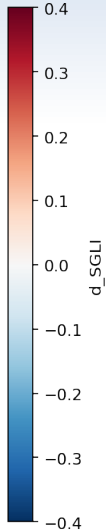
AERONET level1.5 500nm AOT



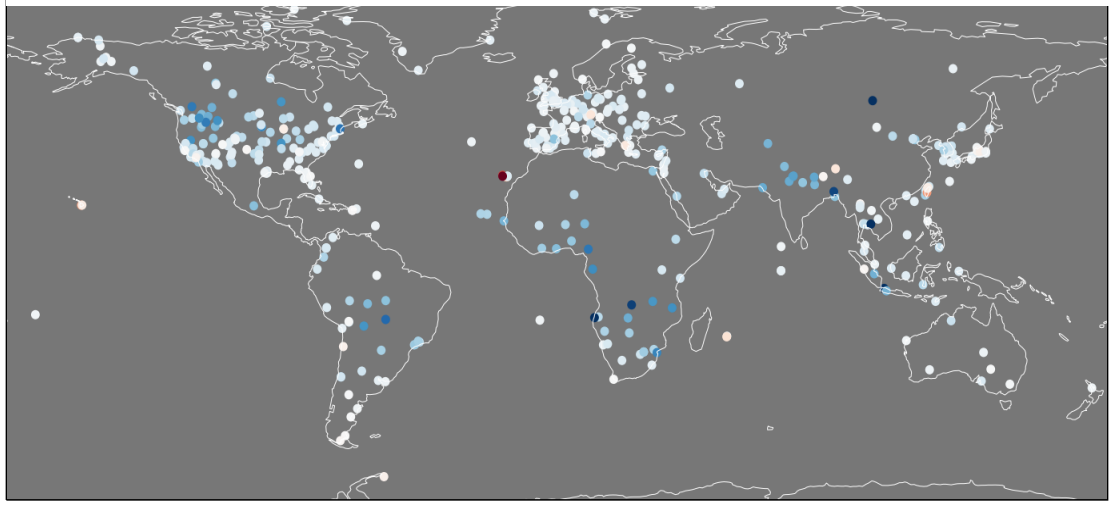


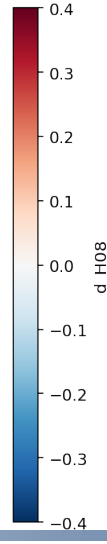
Diff. SGLI-DA AOT and AERONET AOT



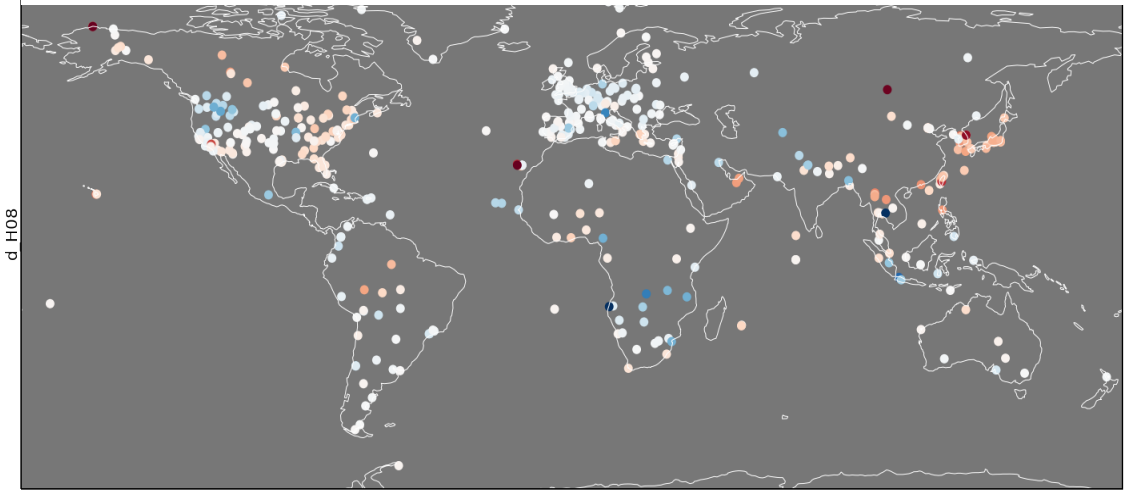


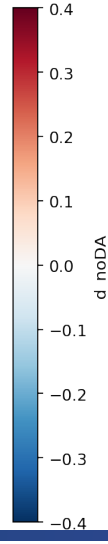
Diff. (MODIS+AHI)-DA AOT and AERONET AOT





Diff. Non-DA AOT and AERONET AOT





Future Plans

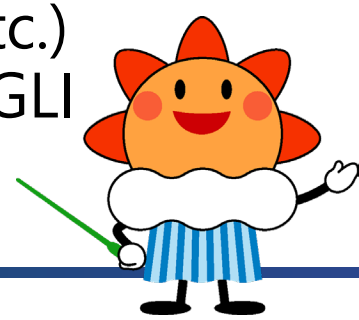
- Feasibility study of the application of the operational aerosol forecast (instead of monthly climatology) to the JMA's operational global prediction system
- Aerosol data assimilation using multiple satellite observations (AHI + SGLI)
- Aerosol data assimilation with an ensemble Kalman filter using EarthCARE observations

Acknowledgements

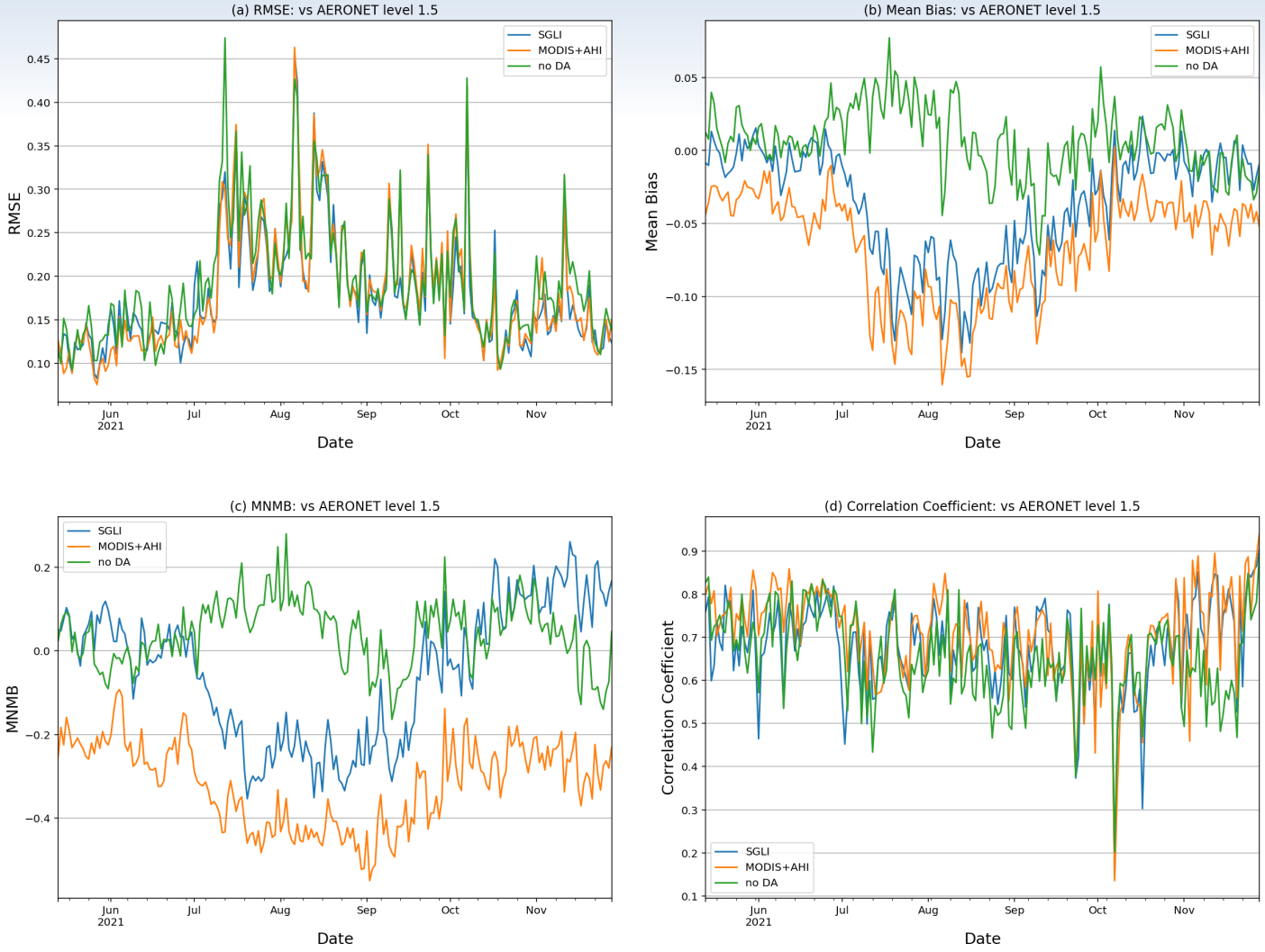
This study was supported by the JAXA Earth Observation Research Announcement (ER2GCN213) and Grant-in-Aid for Scientific Research B (16H02946). The following observation data were also used. We would like to thank

- SGLI standard products: JAXA G-Portal: https://gportal.jaxa.jp/
- JAXA Himawari Monitor: https://www.eorc.jaxa.jp/ptree/
- Aerosol observation data by NASA AERONET: https://aeronet.gsfc.nasa.gov/
- MODIS MCDAODHD (MODIS/Terra+Aqua L3 Value-added Aerosol Optical Depth - NRT): https://cmr.earthdata.nasa.gov/search/concepts/C1426395436-LANCEMODIS.html

Python and its libraries (Numpy, matplotlib, pandas, xarray, HoloViews, etc.) were used for the analysis and figure generation. For the processing of SGLI HDF5 format data, we used SPOT (SGLI Python Open Tool) (https://github.com/K0gata/SGLI_Python_Open_Tool).



Time series of the daily evaluation scores



- Both SGLI and MODIS+AHI DA show better RMSE and R.
  - MODIS+AHI exhibits lower bias in MB and MNMB.
  - RMSE, MB, and MNMB are worsened from July to September, when the intense smoke from vegetation fires increased the AOT in the Northern Hemisphere.
- The DA system tends to overly suppress the large AOT values caused by BB smoke.