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Development of an aerosol retrieval algorithm and aerosol properties from GOSAT-2/TANSO-CAI-2

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GOSAT-2/TANSO-CAI-2 (CAI-2)

The Greenhouse Gases Observing Satellite-2 (GOSAT-2) called "Ibuki-2"

GOSAT-2 Two Sensors :

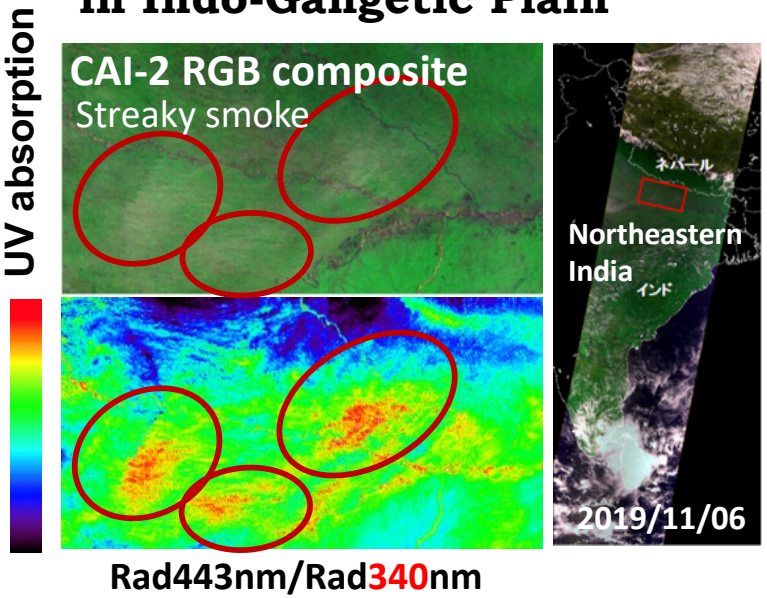
- TANSO-FTS-2 (Fourier Transform Spectrometer 2)
- **TANSO-CAI-2 (Cloud and Aerosol Imager 2)**
  - **CAI-2 has 340, 380nm (UV) with IFOV460m**
  - **Forward and Backward viewing to avoid cloud**

Specifications of CAI-2

	FORWARD					BACKWARD				
Band	1	2	3	4	5	6	7	8	9	10
Center of wavelength [nm]	339	441	672	865	1630	377	546	672	865	1630
Line of sight [degree]	+20					-20				
IFOV [m]	460				920	460				920
Swath [km]	~920 km									

Products :
Aerosol optical thickness@550, @1600nm, Ångström Exp.(AE), ePM2.5, BC volume fraction (BCF)
- Resolution 2km (Asian region) and 5km (The others)

Stubble burning in Indo-Gangetic Plain



strong UV absorption

Development Aerosol retrieval algorithm

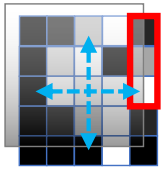
Land (v-MWPM)

Multi–Wavelength and -Pixel Method +NN*

(Hashimoto and Nakajima, JGR 2017)

Multiple pixels merits:

- Good for spatially heterogeneous Ag area like urban area
- Simultaneous retrieval of AOT and SSA (light absorption)
- Reduce random error occurred by each pixel of the sensor



$$R_1 = R_{1,a} + R_{1,g} \approx A_{1,g} + \tau \cdot [c_1 \cdot \omega P(\Theta) - c_2 \cdot A_{1,g}]$$
$$R_2 = R_{2,a} + R_{2,g} \approx A_{2,g} + \tau \cdot [c_1 \cdot \omega P(\Theta) - c_2 \cdot A_{2,g}]$$
$$\vdots$$

=0 (Independent of AOT*)

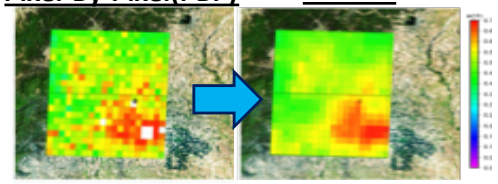
$$\Rightarrow \quad \boldsymbol{R} = \boldsymbol{f}(\boldsymbol{u}) + \boldsymbol{e}$$

R: Reflectance, τ : AOT, ω : SSA, $P(\Theta)$: Phase function, A_g: Surface albedo

Cost function (φ) : Optimal method + Smoothing constraint

$$\phi = [\boldsymbol{R} - \boldsymbol{f}(\boldsymbol{u})]^{\mathrm{T}} \mathbf{S}_e^{-1} [\boldsymbol{R} - \boldsymbol{f}(\boldsymbol{u})] + (\boldsymbol{u} - \boldsymbol{u}_a)^{\mathrm{T}} \mathbf{S}_a^{-1} (\boldsymbol{u} - \boldsymbol{u}_a) + \sum_{i=1} \gamma_i \cdot (\mathbf{B}_i + \mathbf{D}_i \boldsymbol{u})^{\mathrm{T}} (\mathbf{B}_i + \mathbf{D}_i \boldsymbol{u})$$

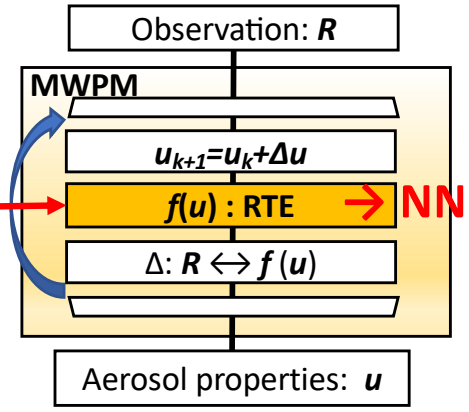
Pixel-By-Pixel(PBP) MWPM



AOT550@Beijing

- **PBP: 0.75±0.07**
- **MWPM: 0.63±0.03**
- **AERONET : 0.65**

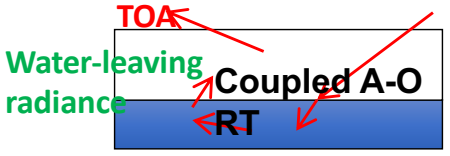
***RTE→NN: Accelerated by Neural network method by Takenaka et al. (2011)**

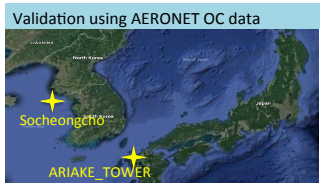


Ocean (SIRAW)

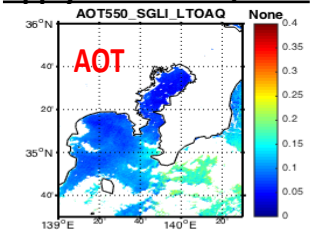
SImultaneous Retrieval of Aerosol and Water-leaving radiance (Shi et al., IEEE-TGRS 2020)

- Coupled atmosphere-ocean radiative transfer
- Neural network solver for TOA radiance and Water-leaving radiance**
- Retrieved parameters: AOT/Soot/Chla/Sediment/nLw…
- Turbid/Open waters

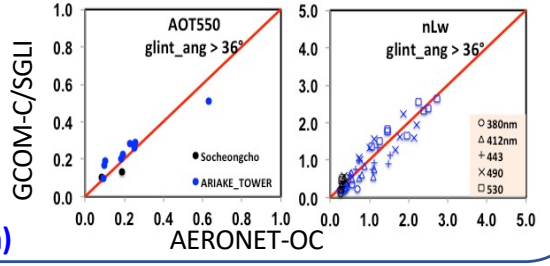




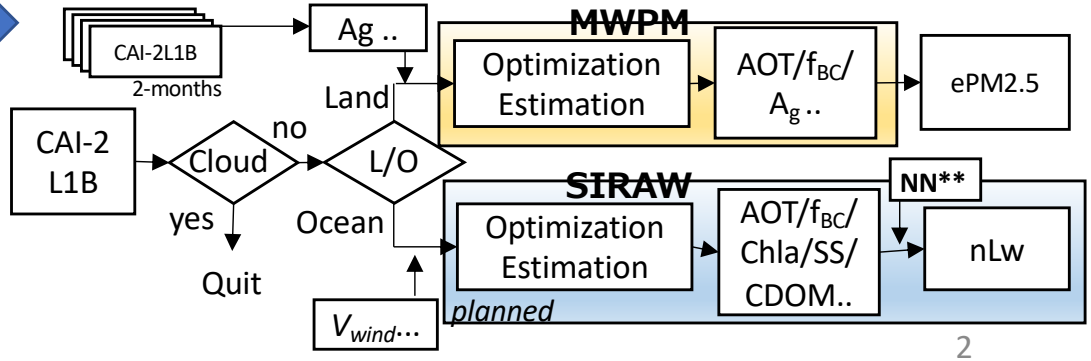
Apply to GCOM-C/SGLI



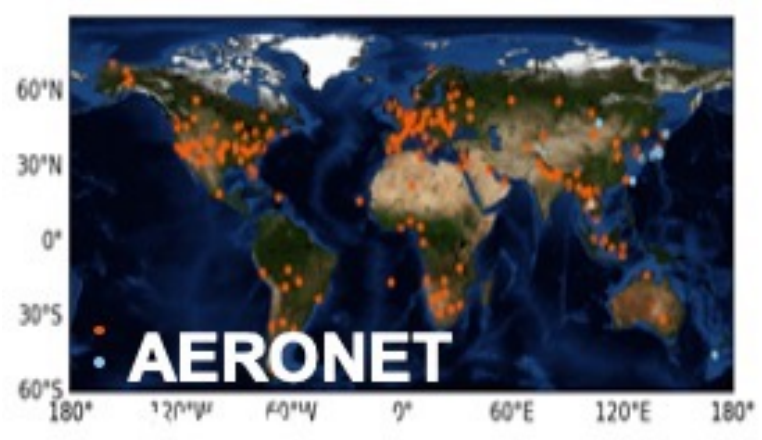
Tokyo Bay (250m resolution)



Aerosol retrieval flow:



Result: CAI-2 vs AERONET and SKYNET



AOT550 over Land by Ag

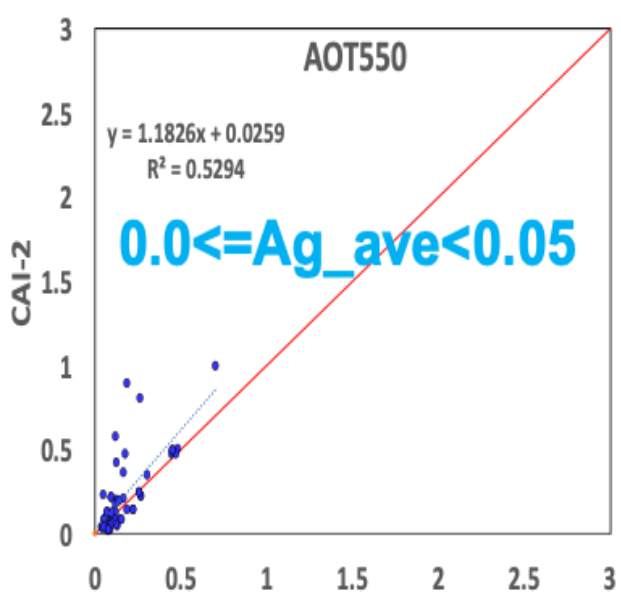
- Period: 2019/03 ~ 2020/02
- In-situ: AERONET & SKYNET
- OBS-AOT: nearest time
- CAI2-AOT: 5*5pixel mean

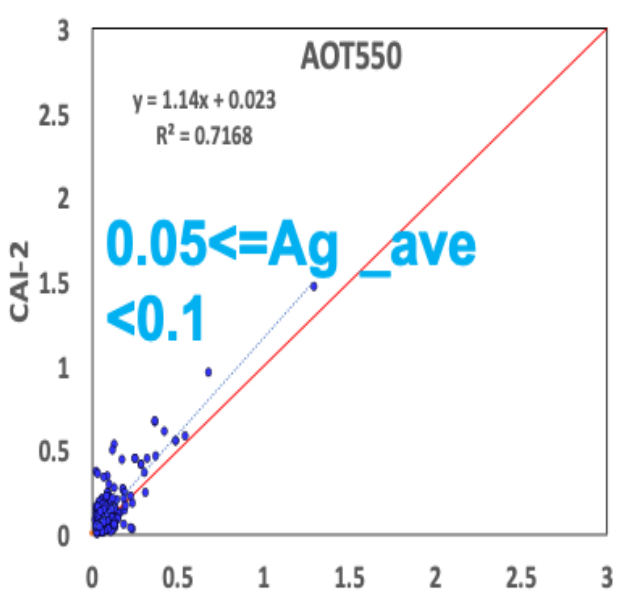
Quality Control (QC):

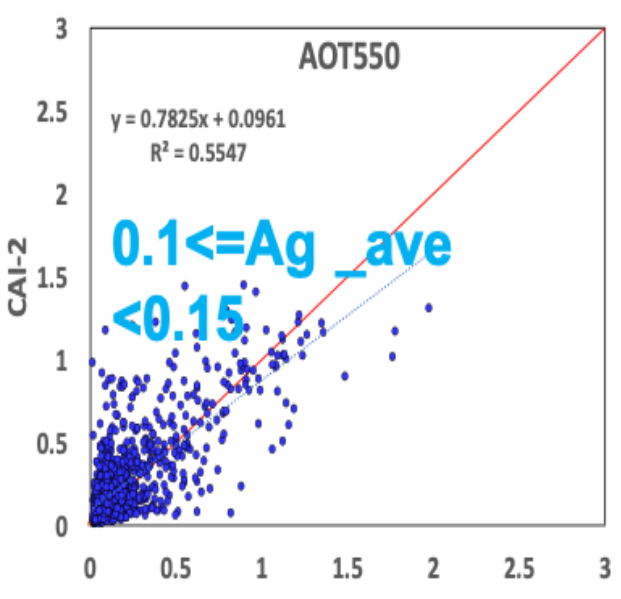
1. Optimizing rmsd <= 0.07
2. Cloud check:
   CCL* > 0.66 (Clear day) or
   max/min@band2 <=1.1

Ag_ave	RMSD	R
0.0 ~ 0.05	0.1642	0.7276
0.05 ~ 0.1	0.09782	0.8466
0.1 ~ 0.15	0.1946	0.7448

*CCL:
Clear confidence level
(Included in CAI-2 L2)







Result: Urban area Aerosol & time series

☐ Time series of AOT, AE and SSA340

- Period: 2019/03 ~ 2020/02
- In-situ: SKYNET Chiba Univ. sites
- Satellite: CAI-2, 5*5pixels mean

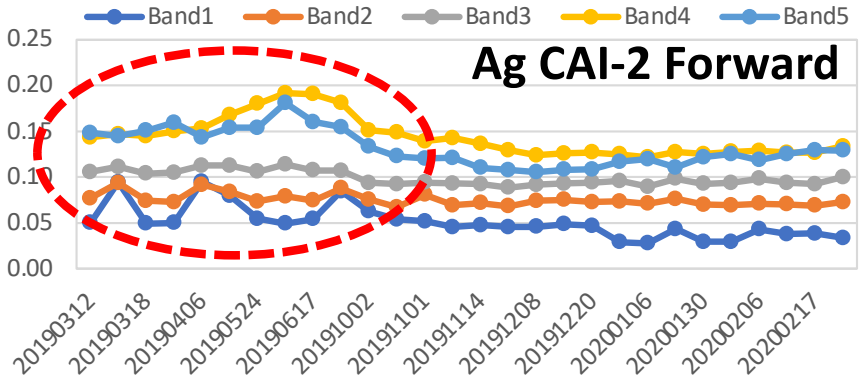
☐ QC :

- rmsd <= 0.07
- CCL > 0.66
- AOT Std. < 0.1

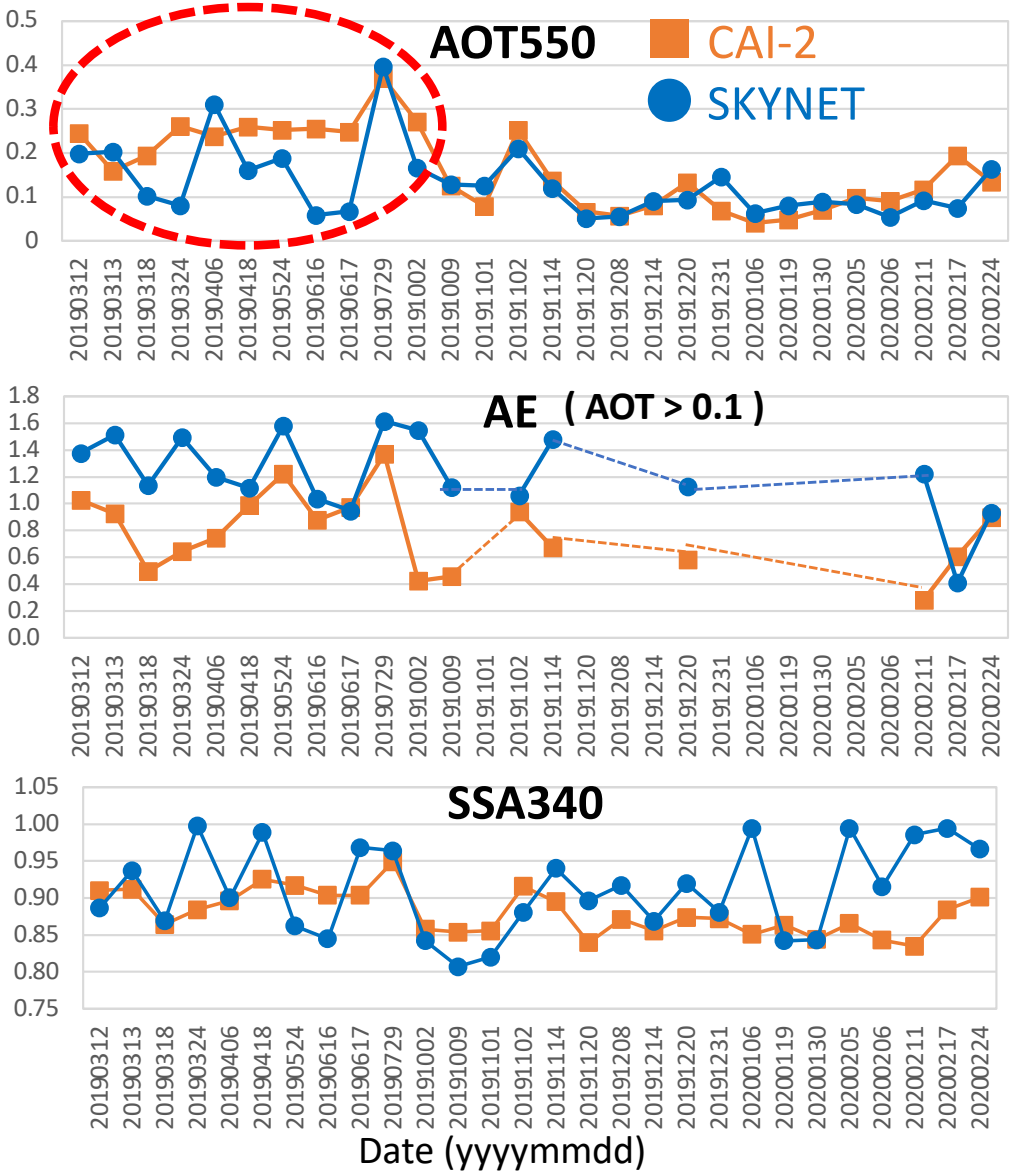
✓AOT: Overestimate March to June

✓AE: Underestimate tendency

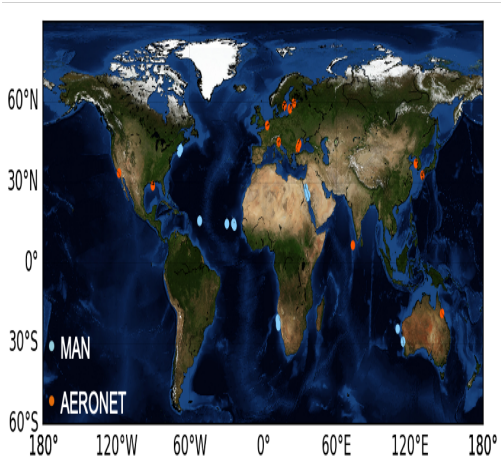
✓SSA340: Similar order with ground-based Obs.



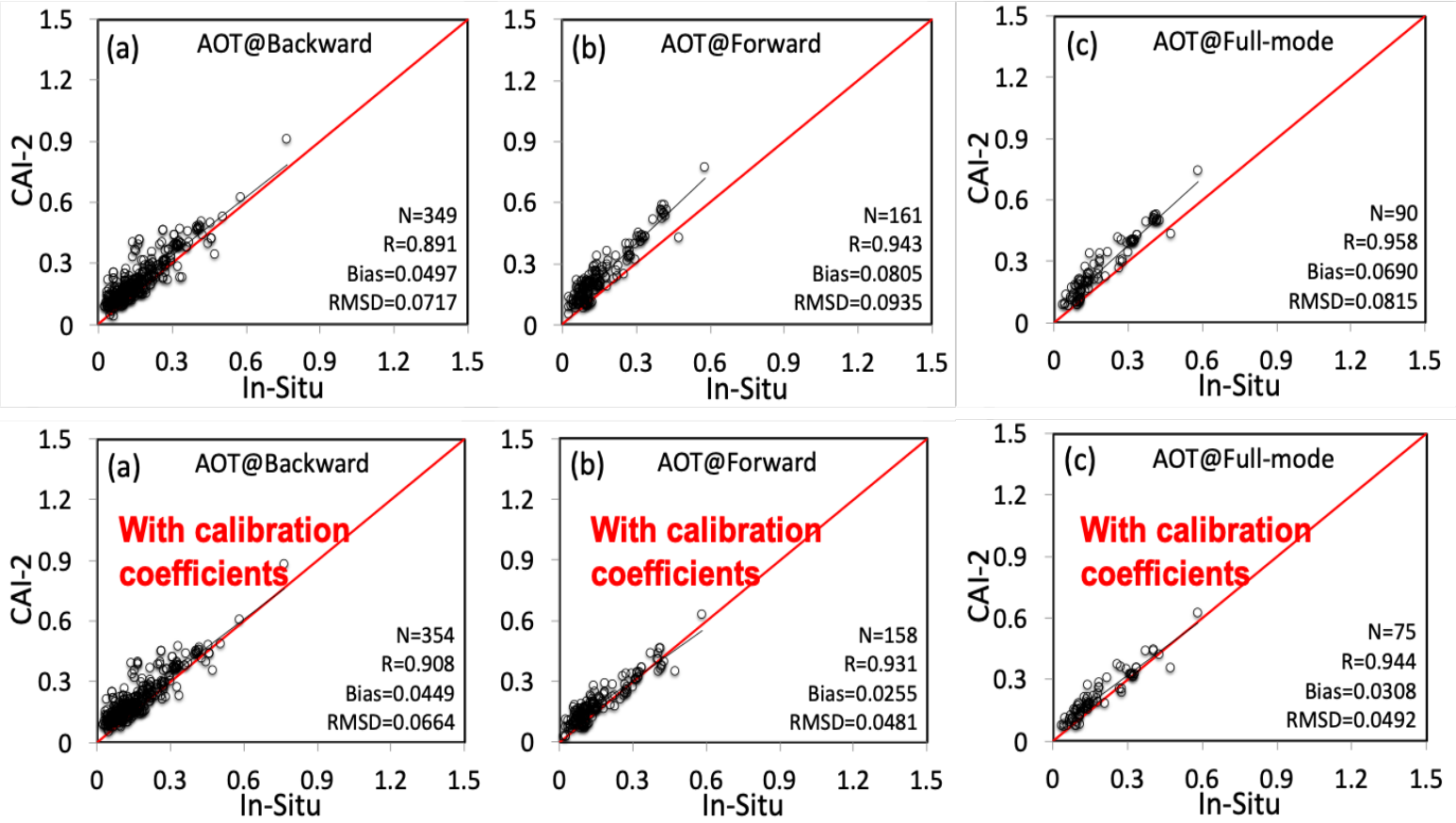
SKYNET Chiba Univ. (Urban Area)



CAI-2 Aerosol over Ocean by SIRAW



Validation of retrieved AOT based on GOSAT-2/CAI-2 L1b data from 201903 to 201911



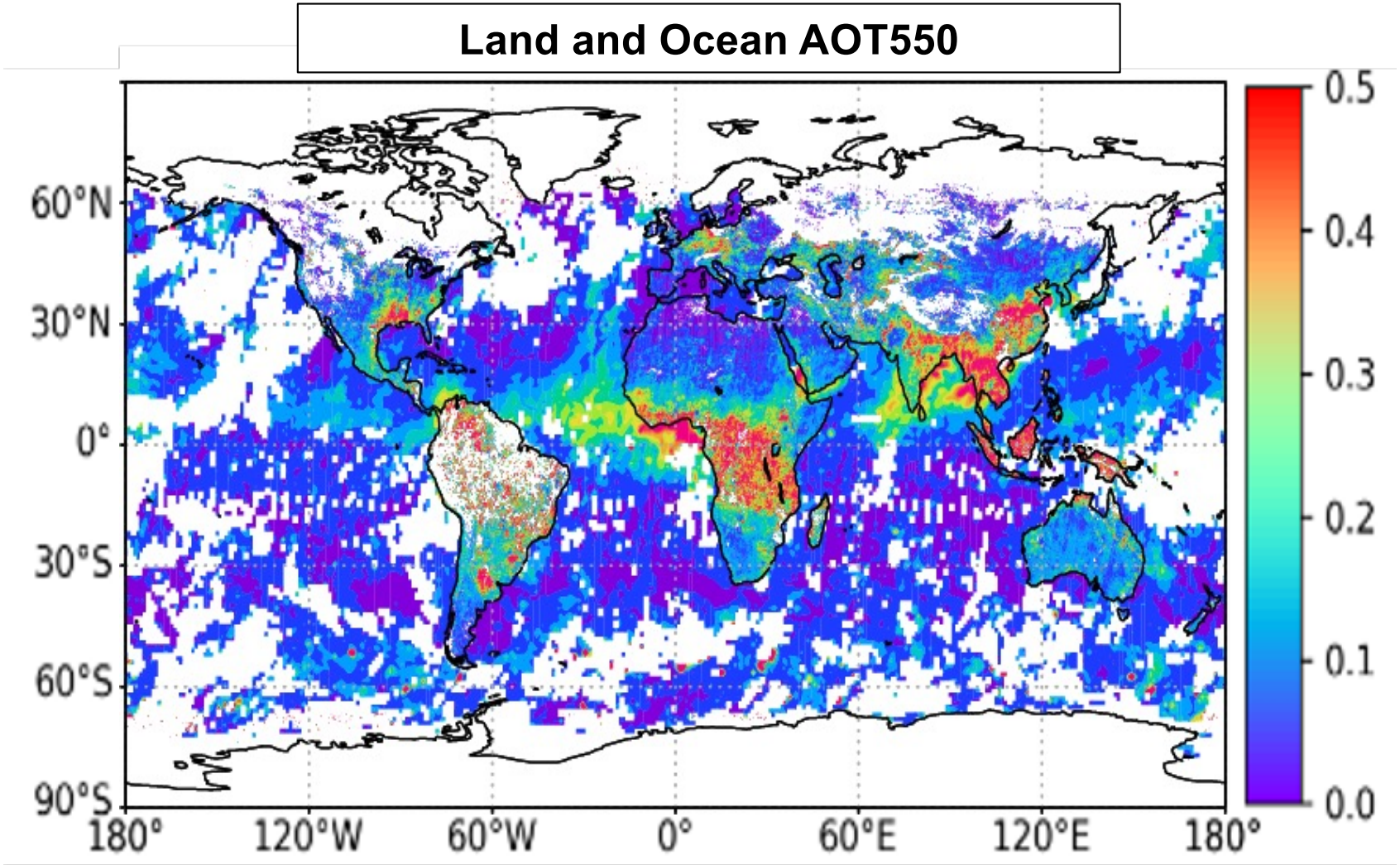
	band1	band2	band3	band4	band 5	band 6	band7	band 8	band9	band10
Calibration coefficient	0.90	0.90	0.92	0.88	0.88	0.95	0.95	0.95	1.02	0.95

- Those calibration coefficients are might caused by the GOSAT-2/CAI-2 spectral measurements or SIRAW algorithm itself, which should be investigated further based on more validation data in the next step.

Shi et al., IEEE-TGRS, 2020

CAI-2 aerosol retrieval over global region

- Land: v-MWPM (Hashimoto and Nakajima, 2017; Takenaka et al., 2011)
- Ocena: SIRAW (Shi et al, 2020)
- February and March 2019



Summary

☐ Aerosol retrieval algorithm (*v*-MWPM)

- Developed and applied to GOSAT-2/CAI-2 data
- Compared retrieved aerosol properties with ground-based observation such as SKYNET and AERONET
  - AOT is slightly overestimate tendency. RMSE~0.1 when Ag< 0.1
  - AE is underestimate tendency (→ Aerosol model)
  - 340nm have sensitivity to SSA and correlation with SKYNET SSA

☐ Aerosol retrieval algorithm over Ocean (SIRAW)

- Add ocean radiative transfer process and ocean properties
- Developed and applied to GOSAT-2/CAI-2 data (Shi et al., 2020)
  → AOT@Costal_area can be retrieved. AOT:R~0.9, RMSE~0.05.

☐ Future work

- Continue verification including ePM2.5 and BC fraction for data release
- Update the program over ocean v-MWPM to SIRAW

Thank you for your kind attention!!