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Air-Quality Monitoring over East Asia with Geostationary Satellite : GEMS, GOCI, AHI

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Introduction

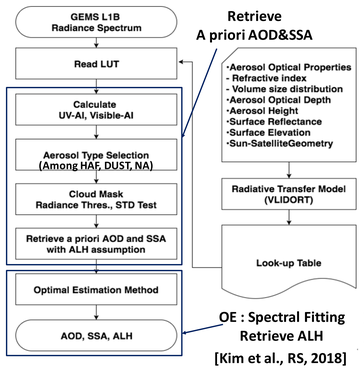
- Rapid industrialization and urbanization in Asia has raised serious concerns related to air quality and climate change. Geostationary satellite measurements in particular have been widely adopted to monitor the continuous variation of aerosols with high temporal resolution. Over Asia, serial geostationary satellite projects, such as the Geostationary Korea Multi-Purpose Satellite (Geo-KOMPSAT), the Feng-Yun (FY) and the Himawari have been operated by the Korean, Chinese and Japanese governments, respectively. [Kim et al., 2018] In Korea, the GEO-KOMPSAT-2 (GK-2) program comprises two satellites for multi-purpose applications in geostationary orbit : GEO-KOMPSAT-2A (GK-2A) for meteorological missions and GEO-KOMPSAT-2B (GK-2B) for ocean and environmental monitoring.
- In this study, we would like to present aerosol retrieval algorithm from GEMS, GOCI, and AHI which are for environmental monitoring mission, ocean monitoring mission, and meteorological mission, respectively.

Geostationary Environmental Monitoring Spectrometer

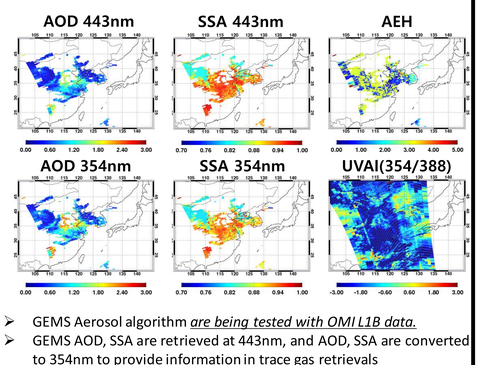
1. Instrument Specification

Location	128.2°E (Altitude : 35786 km)
Launch date	2019 or 2020
Channels (μm)	**1000 channels** (0.3 ~ 0.5) Scanning UV-VIS Spectrometer
Temporal resolution	1 hour (8 times/day) (30min imaging + 30min rest)
Spatial resolution	Gas : 7(NS) kmx8(EW) km , Aerosol : 3.5km (NS)x8(EW) km @ Seoul, Korea
Spectral resolution	<0.6nm (3 samples) (spectral sampling < 0.2nm)
Mission Lifetime	10 years
Field Of Regard(FOR)	N/S: 45°N～5°S, E/W: 75°E～145°E (E/W, Selectable)
Baseline products	O_3, NO_2, SO_2, HCHO, **Aerosols** (AOD, SSA, ALH), UVI, CHOCHO

2. Algorithm Flowchart



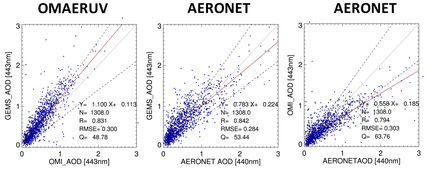
3. Retrieval Results of GEMS Aerosol (2005.02.28)



- GEMS Aerosol algorithm *are being tested with OMI L1B data.*
- GEMS AOD, SSA are retrieved at 443nm, and AOD, SSA are converted to 354nm to provide information in trace gas retrievals

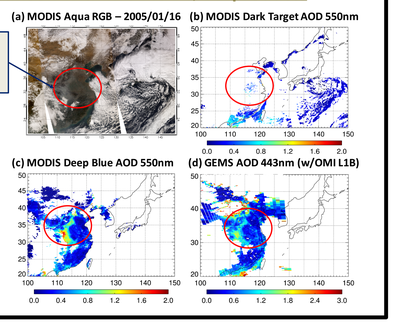
4. Validation Results

- Domain : 75°E-145°E, 5°S-45°N
- AERONET sites within 0.4°, ±30 minutes
- Period : 2005.01-2007.12
- AERONET lv.2 Direct AOD, OMAERUV
- Synthetic data, and TROPOMI L1B data will be used to test GEMS AOD algorithm in the future



5. Comparison with MODIS DT, DB products

Bright Surface in Winter

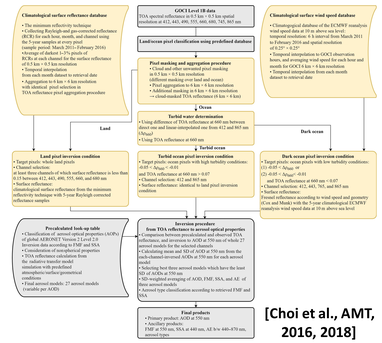


Geostationary Ocean Color Imager

1. Instrument Specification

	GOCI-I	GOCI-II
Data period	2011.03 ~ current (over 7yr)	Launched in 2019 or 2020
Number of spectral bands	8 (VIS/NIR)	13 (UV/VIS/NIR, Wideband)
Spatial resolution	500 m (Local Area Mode)	250-300 m (Local Area Mode) 1 km (Full Disk Mode)
Temporal resolution	1 hour (8 times/day)	1 hour (10 times/day)
Coverage	North-East Asia around Korea	North-East Aisa + Event Area, Full disk

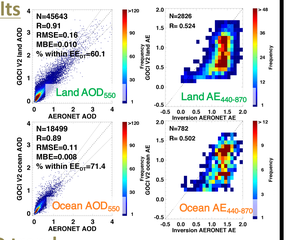
2. GOCI Yonsei aerosol retrieval algorithm



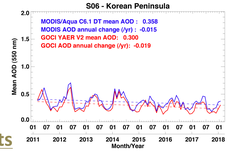
[Choi et al., AMT, 2016, 2018]

3. Validation Results

- Period: Mar 2011 – Feb 2016, 5-yr
- Collocation with 27 AERONET sites for land, 17 coastal sites for ocean
- AERONET sites within 25 km, ±30 minutes

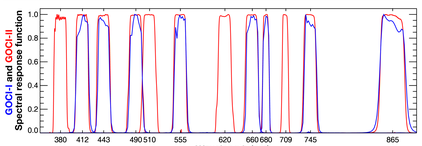


4. Long-term AOD trend



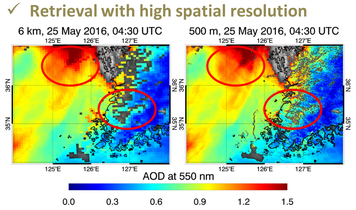
- GOCI and MODIS monthly AOD from 2011 to 2018 in Korean peninsula
- *A long-term AOD record over East Asia can be obtained from continuous observation using GOCI-I and GOCI-II.*

5. Aerosol retrieval for GOCI-II measurements



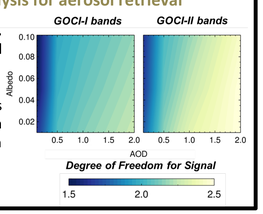
- **GOCI-I: 8 spectral bands, GOCI-II: 12 spectral bands**
1. A new feature of GOCI-II spectral bands compared to GOCI is the inclusion of UV band centered at 380 nm, which is advantageous to retrieve radiative absorptivity of aerosol over darker surface reflectance than visible band.
2. The spatial resolution of GOCI-II is 250 m and it is higher than GOCI-I spatial resolution (500 m).

✓ **Retrieval with high spatial resolution**



✓ **Information content analysis for aerosol retrieval**

- State vector: AOD at 550 nm, SSA at 443 nm, Aerosol loading height
- Aerosol type: Black carbon
- Using GOCI-II bands shows higher degree of freedom for signal (DFS) values than using GOCI-I bands

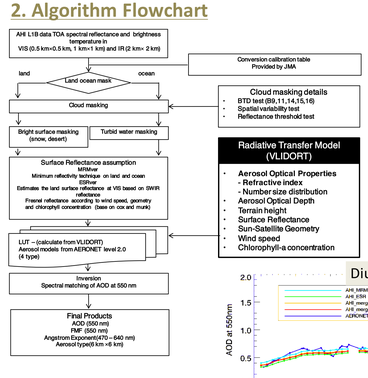


Advanced Himawari Imager

1. Instrument Specification

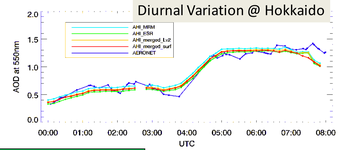
Location	140.7°E
Launch date	7. Oct 2014
Channels[μm]	0.47, 0.51, 0.64, 0.86, 1.6, 2.3, 3.9, 6.2, 6.9, 7.3, 8.6, 9.6, 10.4, 11.2, 12.4, 13.3
Temporal resolution	Every 10 minute (0240utc and 1440utc data are missing due to satellite attitude control from JMA)
Spatial resolution	0.5km ~ 2km
Mission Lifetime	15 years (meteorological mission 8 years)
Field Of Regard(FOR)	Full Disk

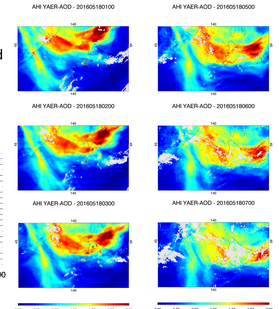
2. Algorithm Flowchart



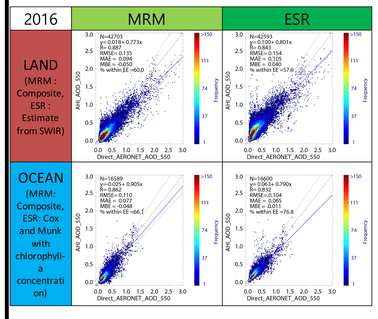
3. AOD Diurnal change in Hokkaido (2016.05.18)

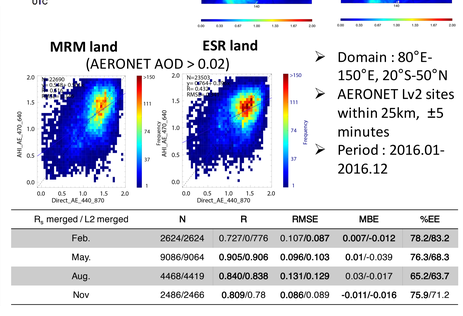
- N43.1, E141.2
- AHI_merged_Lv2 = Simple average between MRMver AOD and ESRver AOD
- AHI_merged_surf = Simple average between ρ_s(MRM) and ρ_s(ESR) are made before the inversion process.





4. Validation Results





- Domain : 80°E-150°E, 20°S-50°N
- AERONET Lv2 sites within 25km, ±5 minutes
- Period : 2016.01-2016.12

R_s merged / L2 merged	N	R	RMSE	MBE	%EE
Feb.	2624/2624	0.727/0/776	0.107/**0.087**	**0.007**/-0.012	**78.2**/83.2
May.	9086/9064	**0.905/0.906**	**0.096/0.103**	**0.01**/-0.039	**76.3**/68.3
Aug.	4468/4419	**0.840/0.838**	**0.131/0.129**	0.03/-0.017	65.2/**63.7**
Nov	2486/2466	**0.809**/0.78	**0.086**/0.089	**-0.011/-0.016**	**75.9**/71.2

Summary and Conclusions

- Aerosol retrieval algorithm from UV-Vis channel of GEMS, Vis-NIR channel of GOCI, and Vis-NIR-IR channel of AHI are demonstrated. By using these algorithms, the estimation of AOD, SSA, ALH, AE over Asia are available in Geostationary Earth orbit. Continuous monitoring of aerosol properties will contribute to an understanding of the role of Asian aerosols in climate change, as well as direct effects on public health. In the future, inter-comparison of aerosol products in geostationary satellites over Asia are needed to improve the accuracy of the aerosol products.

[References]
1. Choi, M., Kim, J., Lee, J., Kim, M., Park, Y. J., Jeong, U., ... & Song, C. H. (2016). GOCI Yonsei Aerosol Retrieval (YAER) algorithm and validation during the DRAGON-NE Asia 2012 campaign. Atmospheric Measurement Techniques, 9(3).
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