Retrievals of AOD, SSA, and ALH over Asia from GEMS data

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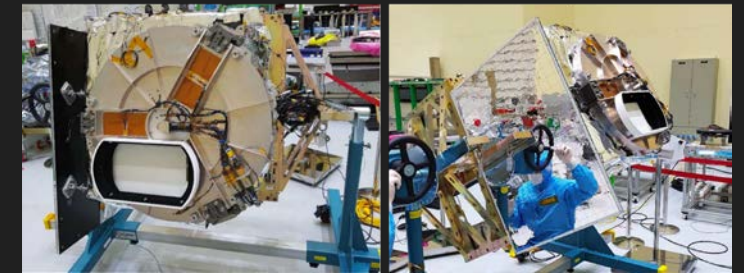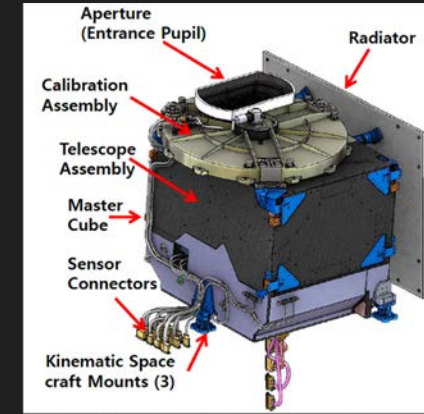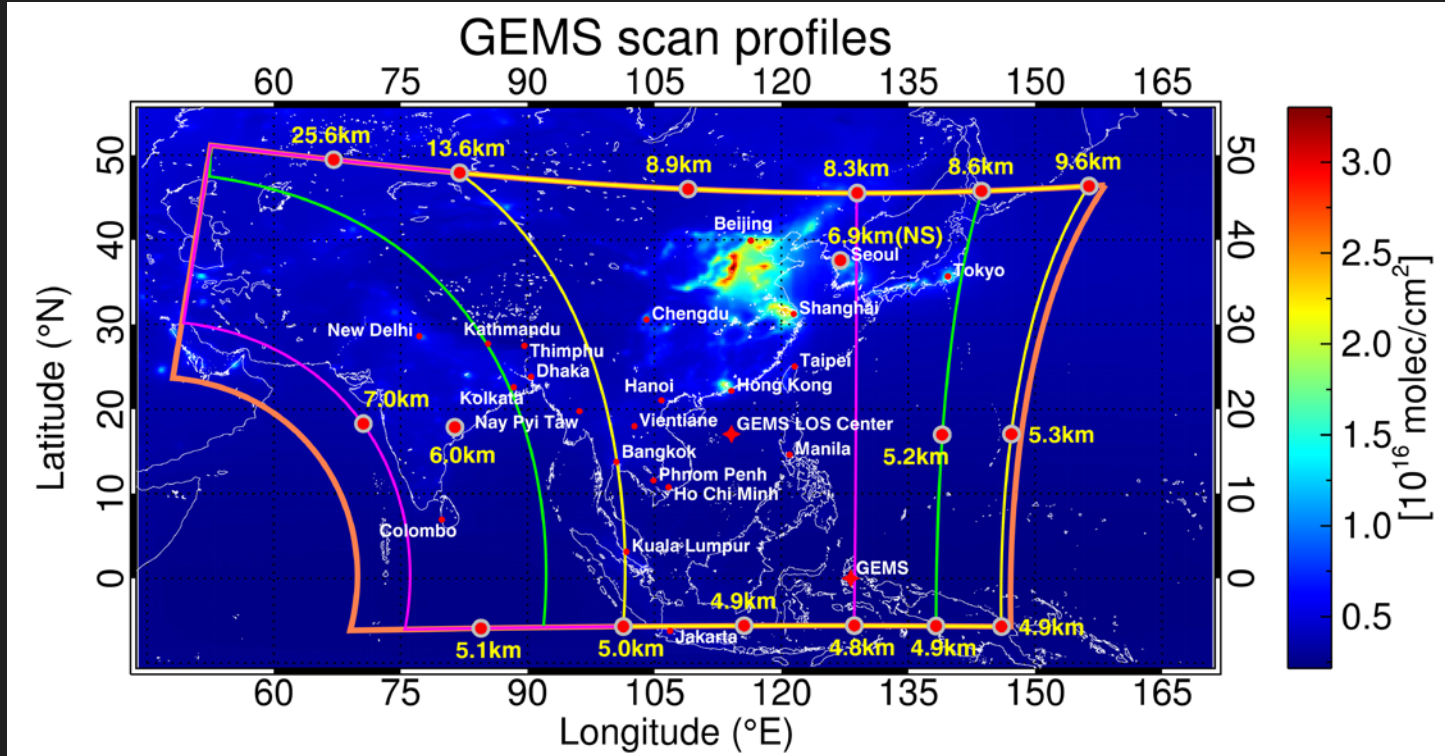[3]NASA Goddard Space Flight Center (GSFC), Maryland, USA

[4]National Institute of Environmental Research, Incheon, Republic of Korea

GEMS

GEMS scan profiles

(Kim et al., BAMS 2020)

	UV – VIS	
Wavelength range	300 – 500 nm	
FWHM	< 0.6 nm	
Temporal resolution	1 hour	
Spatial sampling @ Seoul [km²]	3.5 x 8 km² (Aerosol)	7 x 8 km² (Trace-gas)

No.	Date (KST)	Activity
0	2020.02.19	Transfer orbit injection (GK-2B launch)
1	2020.03.23	GEMS power on
2	2020.04.21	First GEMS measurements for Sun/Earth/LED
3	2020.04.23~	Daily operation (in-orbit test)

(Kim et al., 2018; Go et al., 2020 a, b)

From AERONET Inv. Data →
Using 3 models (HAF, DUST, NA)

Aerosol Classification

Pre-selected aerosol type

Spectral Diff of Normrad
(AOD=1)-(AOD=0)

UVAI

Courtesy of Dr. Mijin Kim

GEMS L1C
radiance, irradiance

IF L1C QF eq 0? — No → No Retrieval

Yes

GEMS L1C
Normalized Radiance
@ 354, 388, 412, 443, 477, 490 nm

Read Look-up Table
- Aerosol LUT (HAF, Dust, NA)
- AI LUT (AOD = 0)

GEMS L2 SFC →

Surface reflectance correction
- surface albedo 443 nm < 0.2
- surface albedo 477 nm < 0.2

Calculate
UV-AI, Visible-AI
- UVAI @ 354, 388 nm
- VISAI @ 477, 490 nm

Calculate
Aerosol Type
- Using UVAI, VISAI
(HAF, Dust, NA)

Cloud & Sun-glint mask

Retrieve a prior AOD and
SSA with ALH assumption
- two-channel method

Optimal Estimation Method

GEMS L2
AOD, SSA @ 443 nm, ALH

GEMS L2
AOD, SSA @ 354, 550 nm
based on selected aerosol type

Calculate AAOD

GEMS L2
AERAOD

GEMS Final Aerosol Products

- AOD and SSA at 354 nm, 443 nm, 550 nm
- UV aerosol index (354/388 nm)
- Visible aerosol index (477/490 nm)
- Aerosol Layer Height

Retrieve ALH with *Optimal Estimation*

$$Z_{aer} = \sum_{i-1}^{n} H(i) \left[\frac{B_{sc}(i)}{\sum_{i=1}^{n} B_{sc}(i)} \right]$$

Initial guess values
Retrieve AOD, SSA for assumed ALH

2channel method
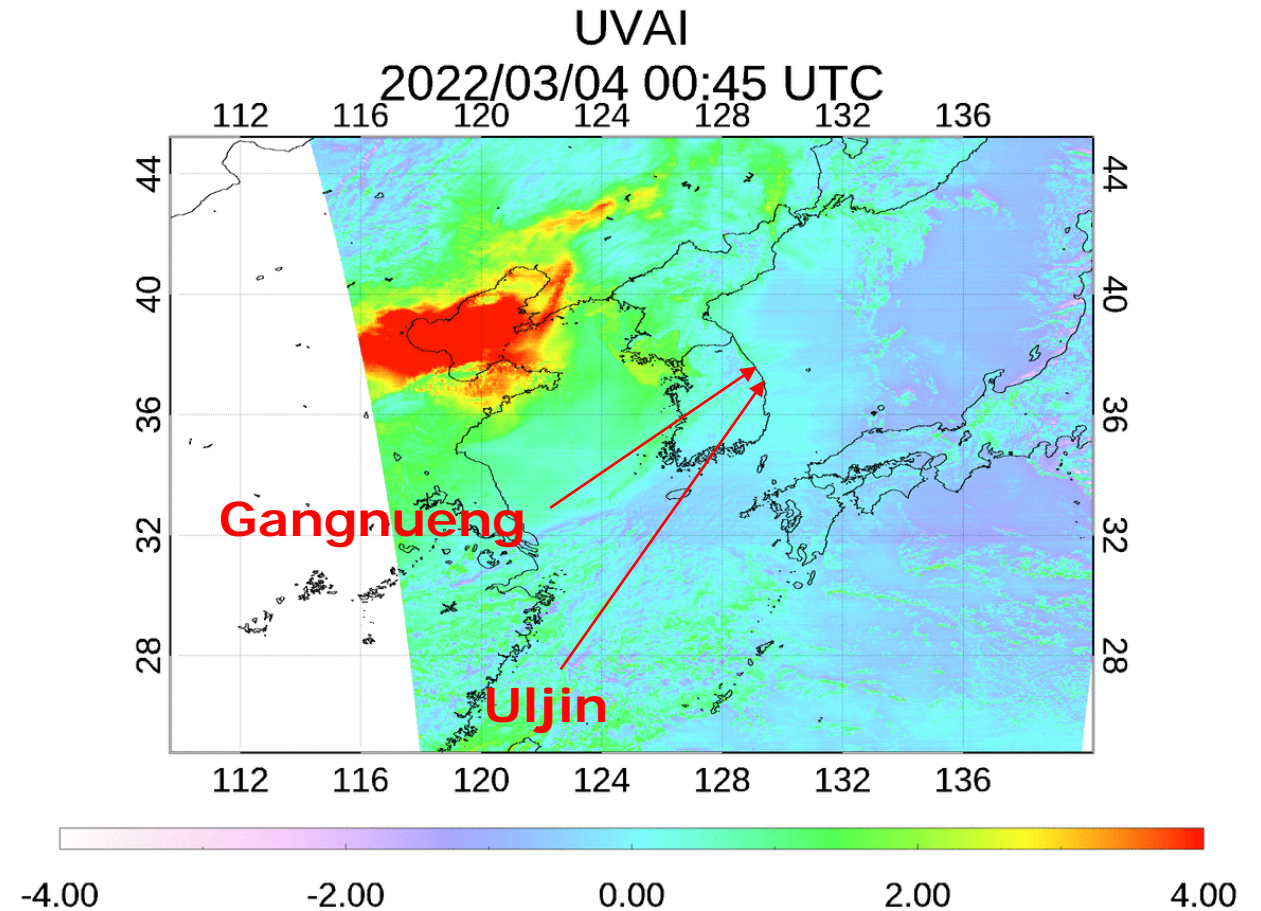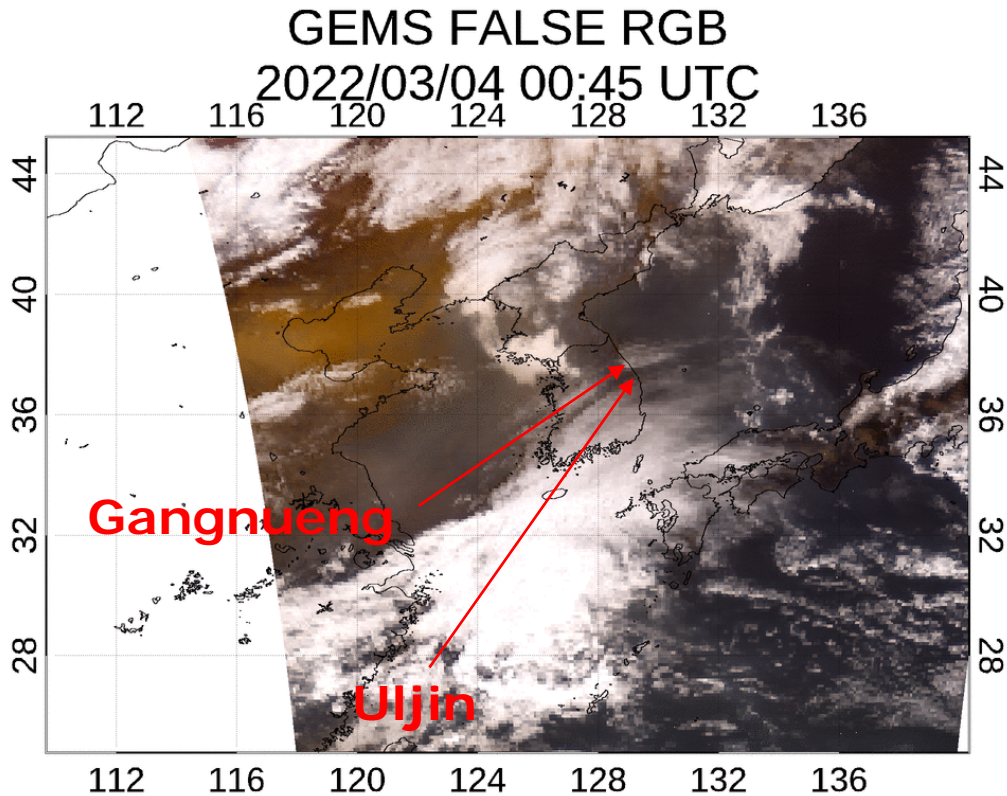
✓ **GEMS aerosol algorithm use 6 channels in UV-VIS wavelength which is sensitive to aerosol absorption information and height information.**
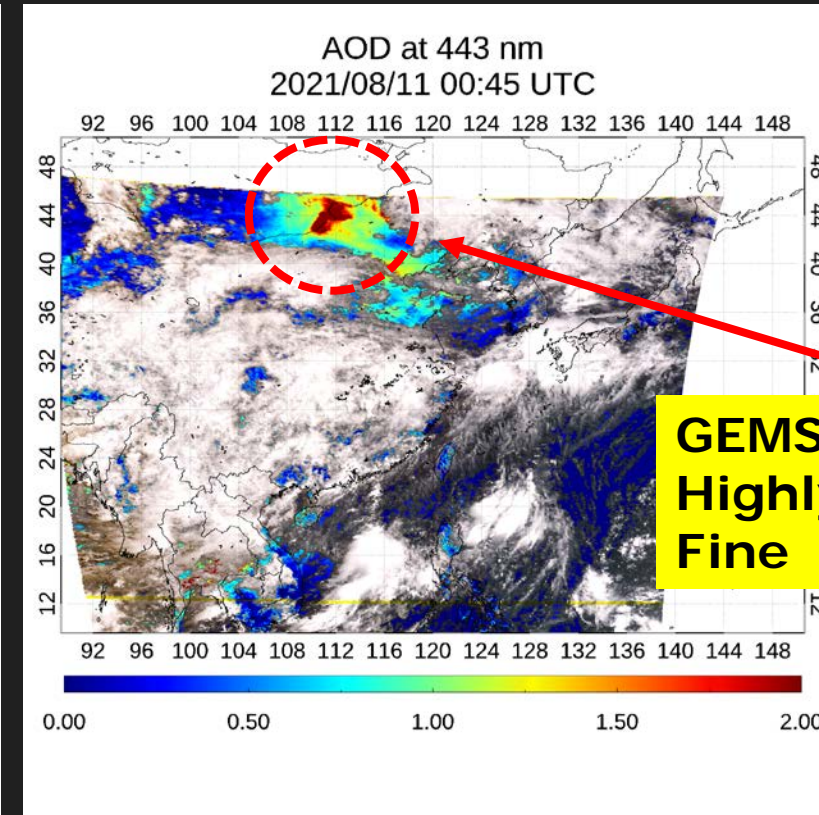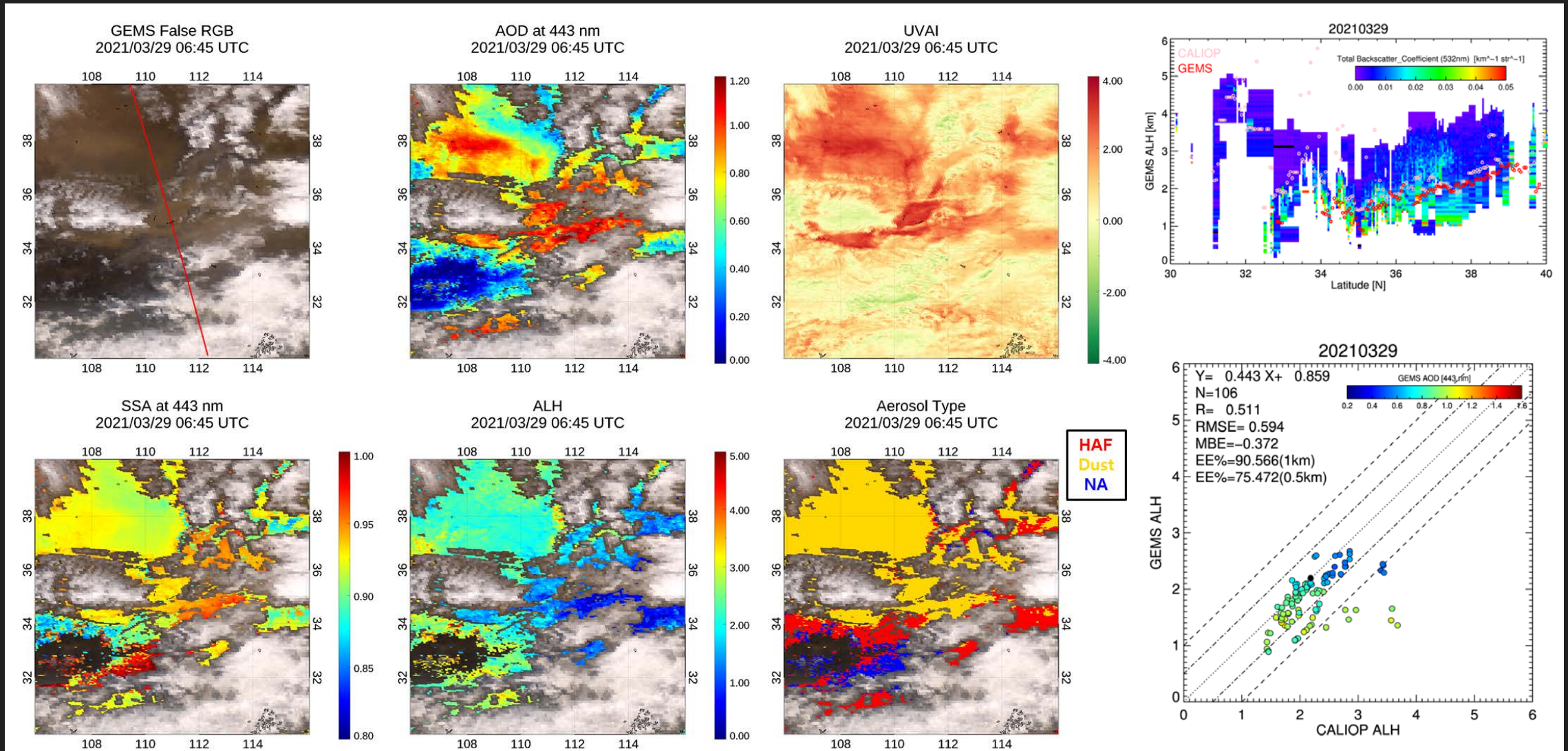
3

Results: Uljin/Samcheok wildfires

✓ **Wildfires in Uljin/Gangnueng, South Korea from March 4, 2022.**
✓ **Wildfire quickly spreads to about 15,000 acres (YONHAP NEWS, March 05, 2022).**

Results: Siberian wildfires

Siberian wildfires now bigger than all other fires in world combined

Huge fires have been fueled by the historic drought.

By **Patrick Reevell**
13 August 2021, 01:52 • 11 min read

SIBERIAN INFERNO
ABC NEWS PRIME
FIREFIGHTERS, LOCALS STRUGGLE AGAINST CLIMATE FUELED FIRE

Siberian wildfires now bigger than all other fires in world combined

ABC News' Patrick Reevell reports from Siberia on the unprecedented spread of wildfires as offi... **Read More**

AOD at 443 nm
2021/08/11 00:45 UTC

**GEMS Aerosol Type :
Highly Absorbing
Fine**

✓ **The fires have burned ~62,000 square miles across Russia since the start of the year (ABC NEWS, 13 August 2021).**
✓ **Smoke coming from the Siberian wildfires.**
✓ **With high UVAI and low VISAI, Highly Absorbing Fine (HAF) is selected as GEMS aerosol type in the smoke plume.**

✓ **GEMS ALH tracks CALOP ALH well from 34°N to 39 °N.**

(GEMS AOD > 0.2)

GEMS False RGB
2021/04/16 06:45 UTC

AOD at 443 nm
2021/04/16 06:45 UTC

UVAI
2021/04/16 06:45 UTC

20210416

SSA at 443 nm
2021/04/16 06:45 UTC

ALH
2021/04/16 06:45 UTC

Aerosol Type
2021/04/16 06:45 UTC

HAF
Dust
NA

20210416

Y= 0.827 X+ 0.333
N= 66
R= 0.898
RMSE= 0.379
MBE=−0.025
EE%=96.970(1km)
EE%=87.879(0.5km)
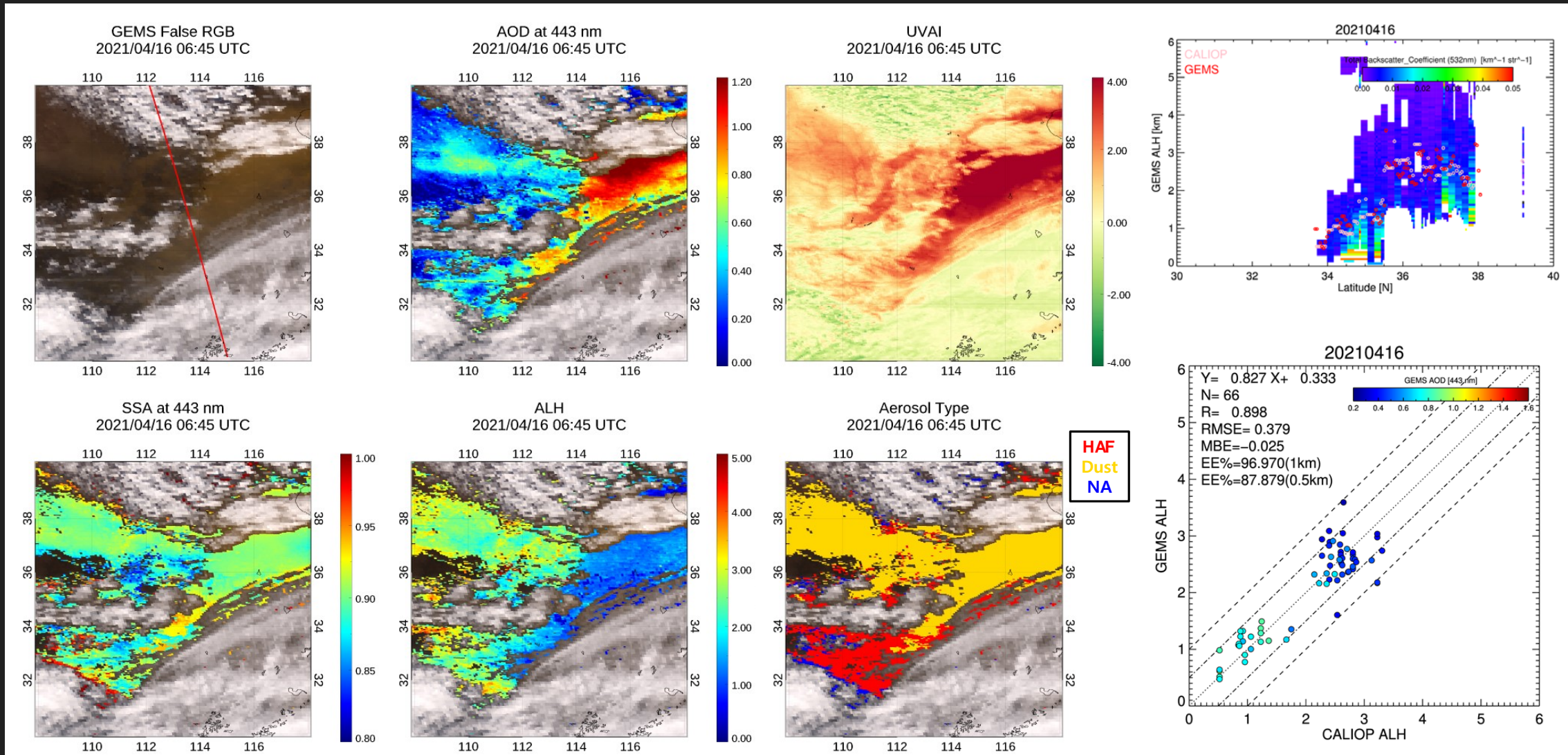
✓ **GMES ALH varies from 0.5 to 3.5 km and GEMS ALH performs well.**

(GEMS AOD > 0.2)

Comparison results for GEMS ALH with CALIOP data

✓ **Histogram of differences between GEMS ALH (GEMS AOD > 0.2) and CALIOP backscatter weighted aerosol height (CALIOP ALH)**

05:45 UTC	06:45 UTC	ALL
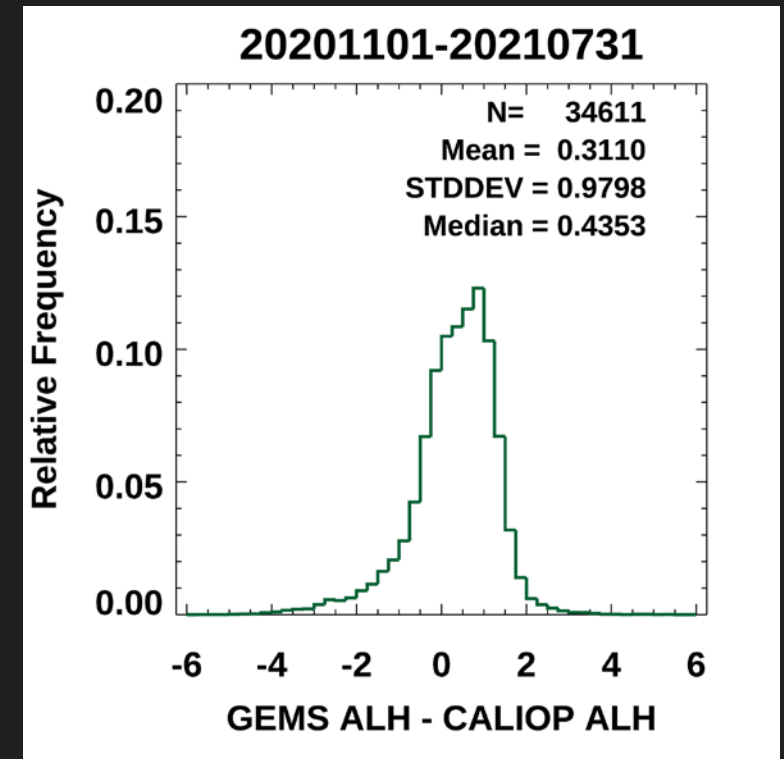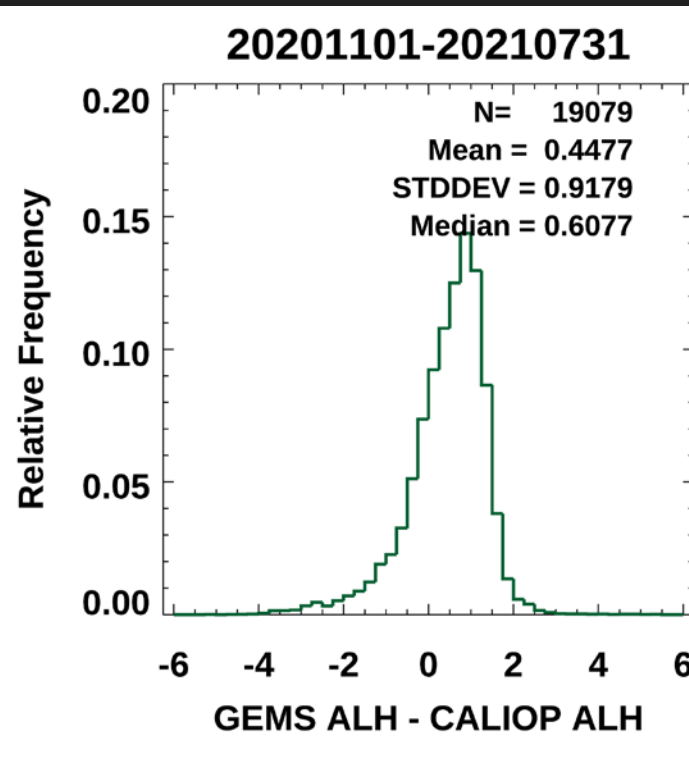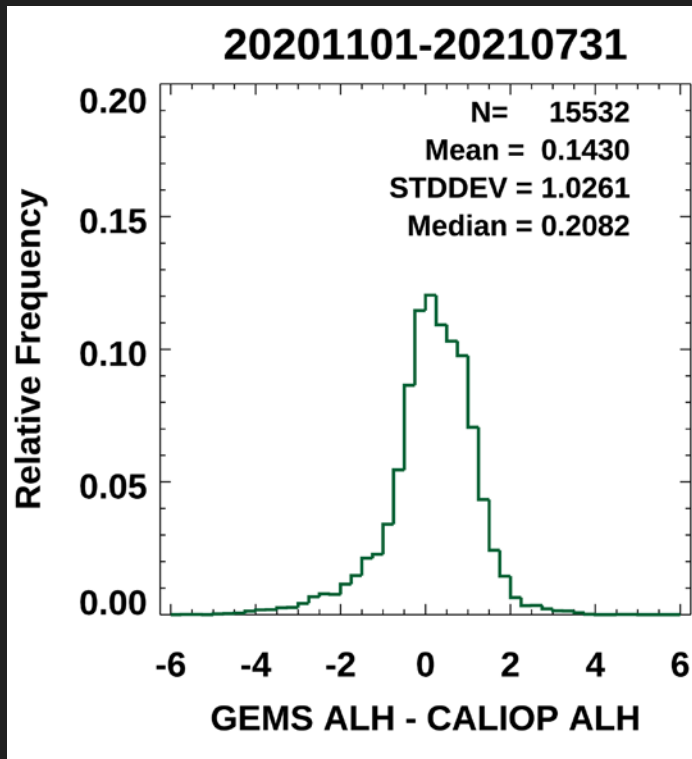
✓ Validation area   : GEMS entire area
✓ Validation period : 2020.11.01-2021.07.31
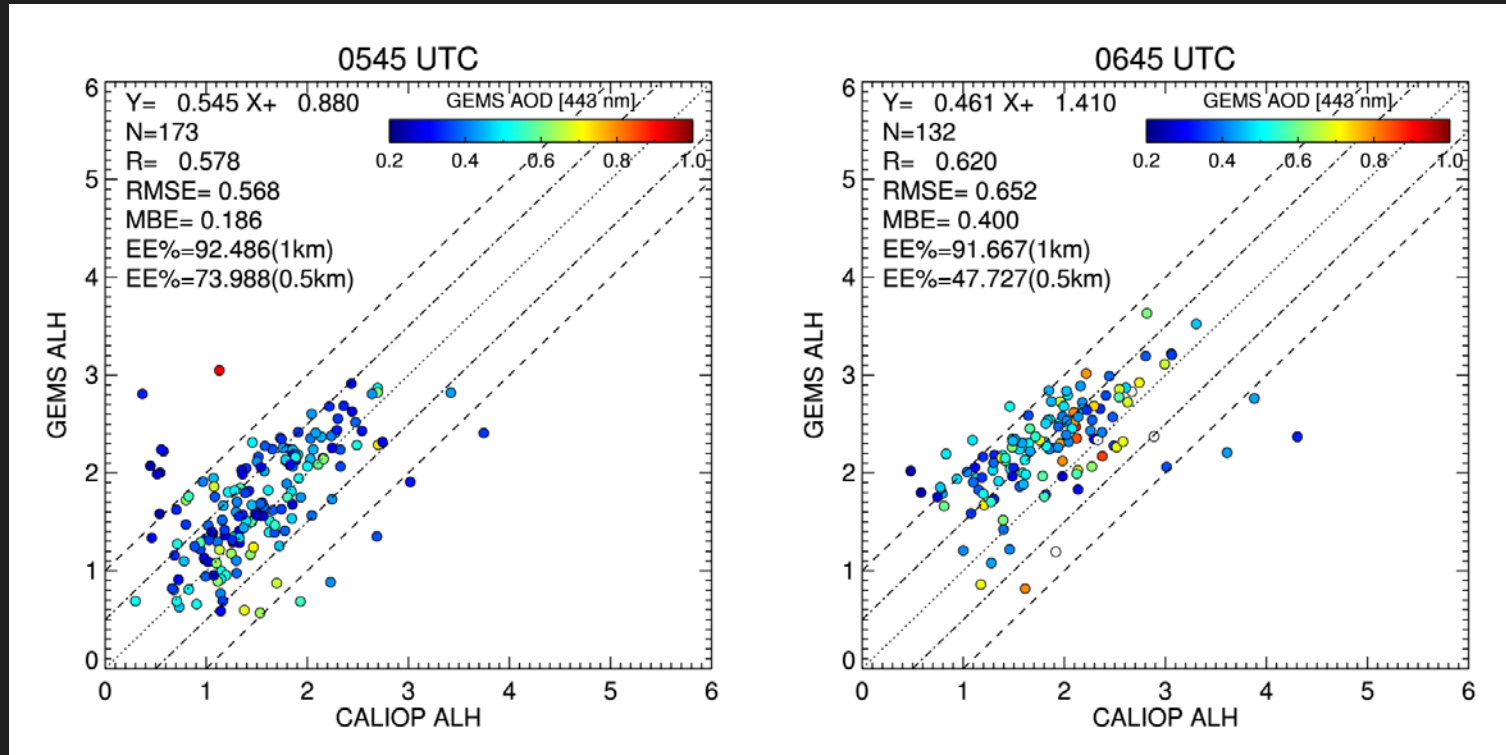✓ **GEMS ALH has a slight overestimation and shows different bias values depending on measurement time.**

Comparison results for GEMS ALH with CALIOP data

✓ **Scatterplots of averaged GEMS ALH (GEMS AOD > 0.2) versus CALIOP ALH**
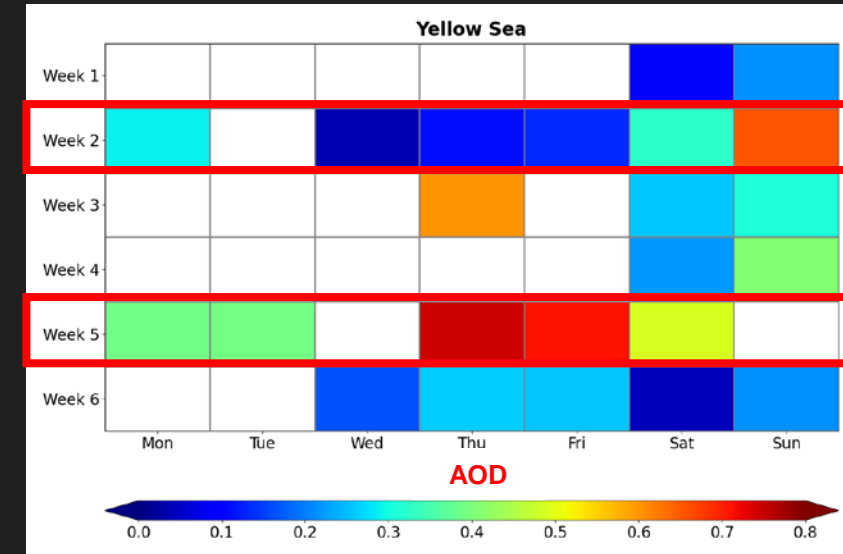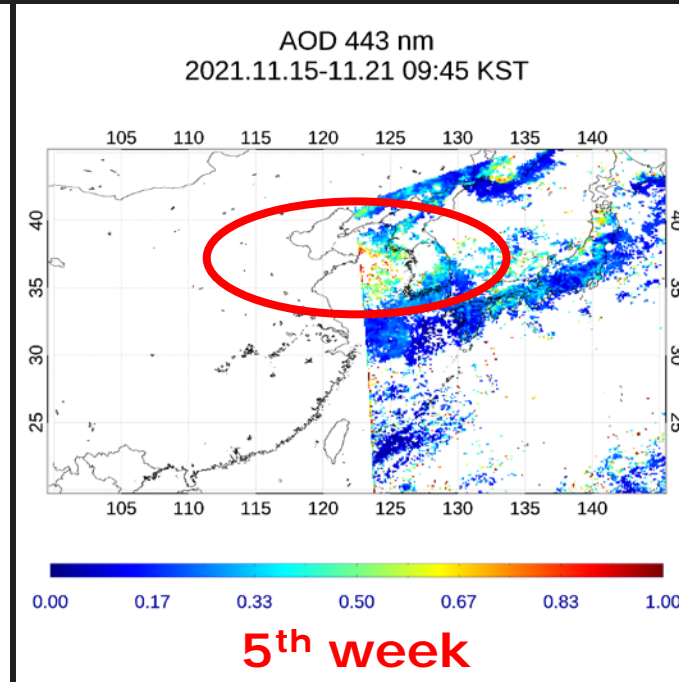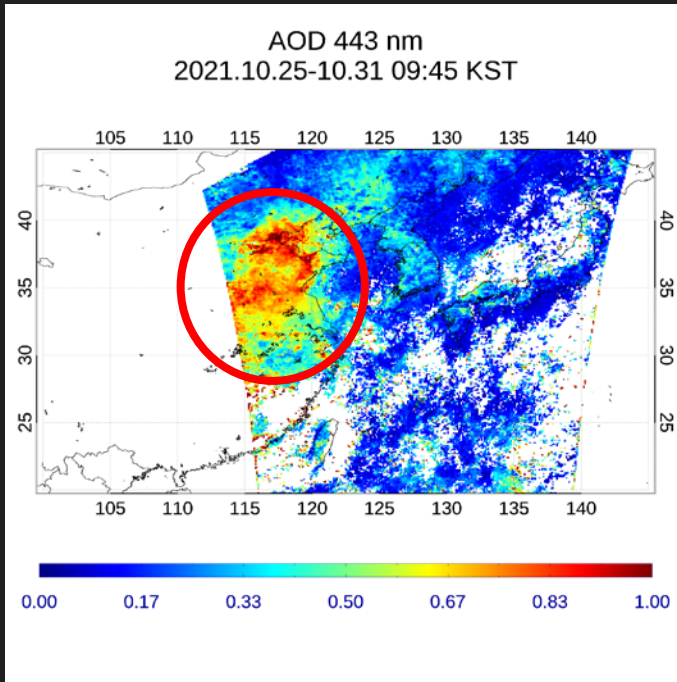

05:45 UTC   06:45 UTC

✓ **Validation area   : GEMS entire area**
✓ **Validation period : 2020.11.01-2021.07.31**
✓ **ALL collocated GEMS ALHs with CALIOP ALHs in one scene are averaged (one scene averaged ALH)**

Comparison results for GEMS aerosol products with AERONET data

GEMS AOD 443 nm

Y= 0.520 X+ 0.098
N=14907
R= 0.779
RMSE= 0.261
MBE=-0.095
Q= 51.07

GEMS SSA 443 nm

N= 5744&52.75(73.35)% within 0.03(0.05)
N= 2178&64.83(83.84)% within 0.03(0.05)
N= 483&79.92(93.58)% within 0.03(0.05)

GEMS AOD 443 nm > 0.0
GEMS AOD 443 nm > 0.3
GEMS AOD 443 nm> 0.7
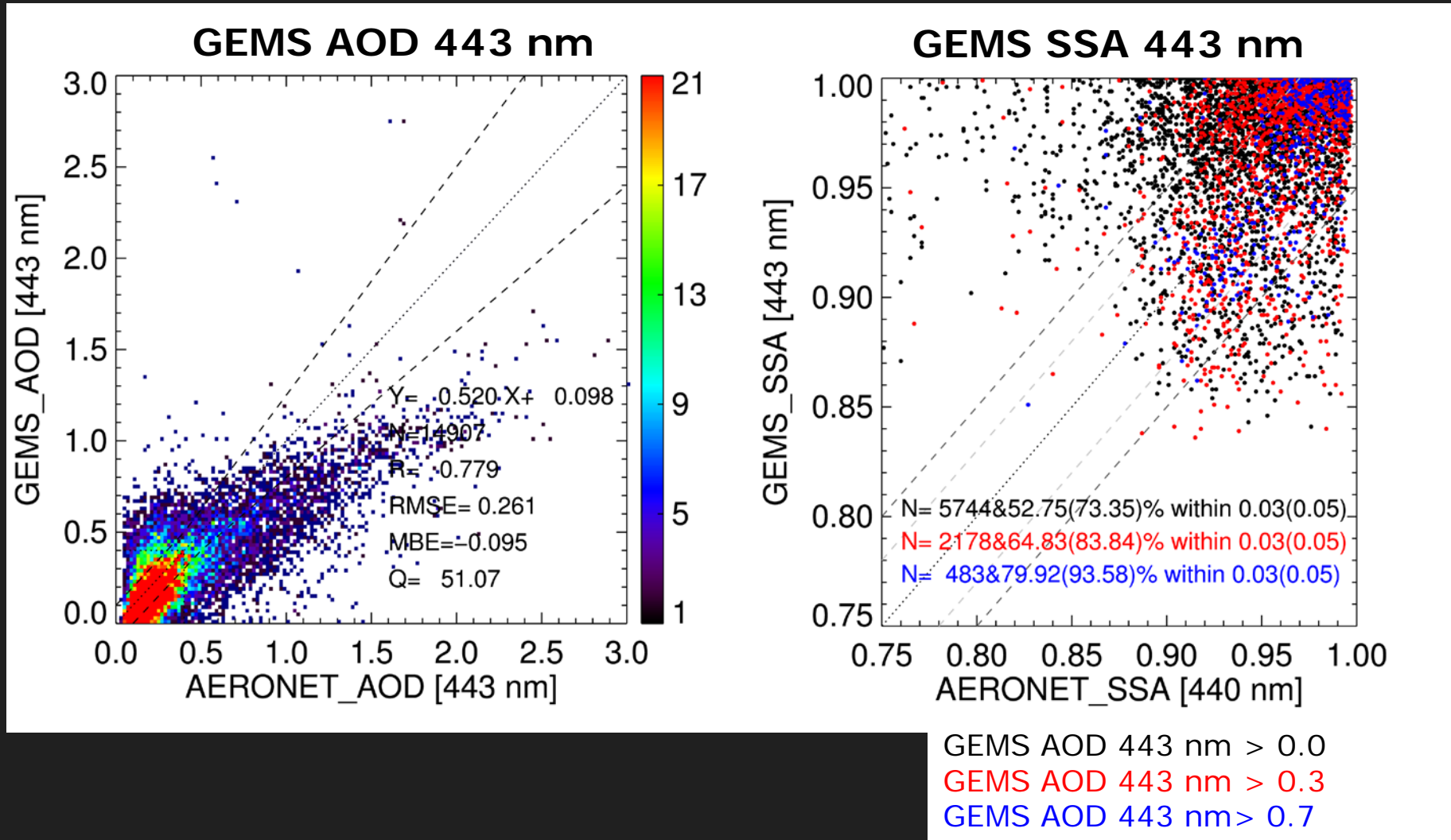
✓ **Validation area** : East Asia (100° E – 150° E, 20° N – 50° N)
✓ **Validation period** : 2021.03.01-2021.07.31
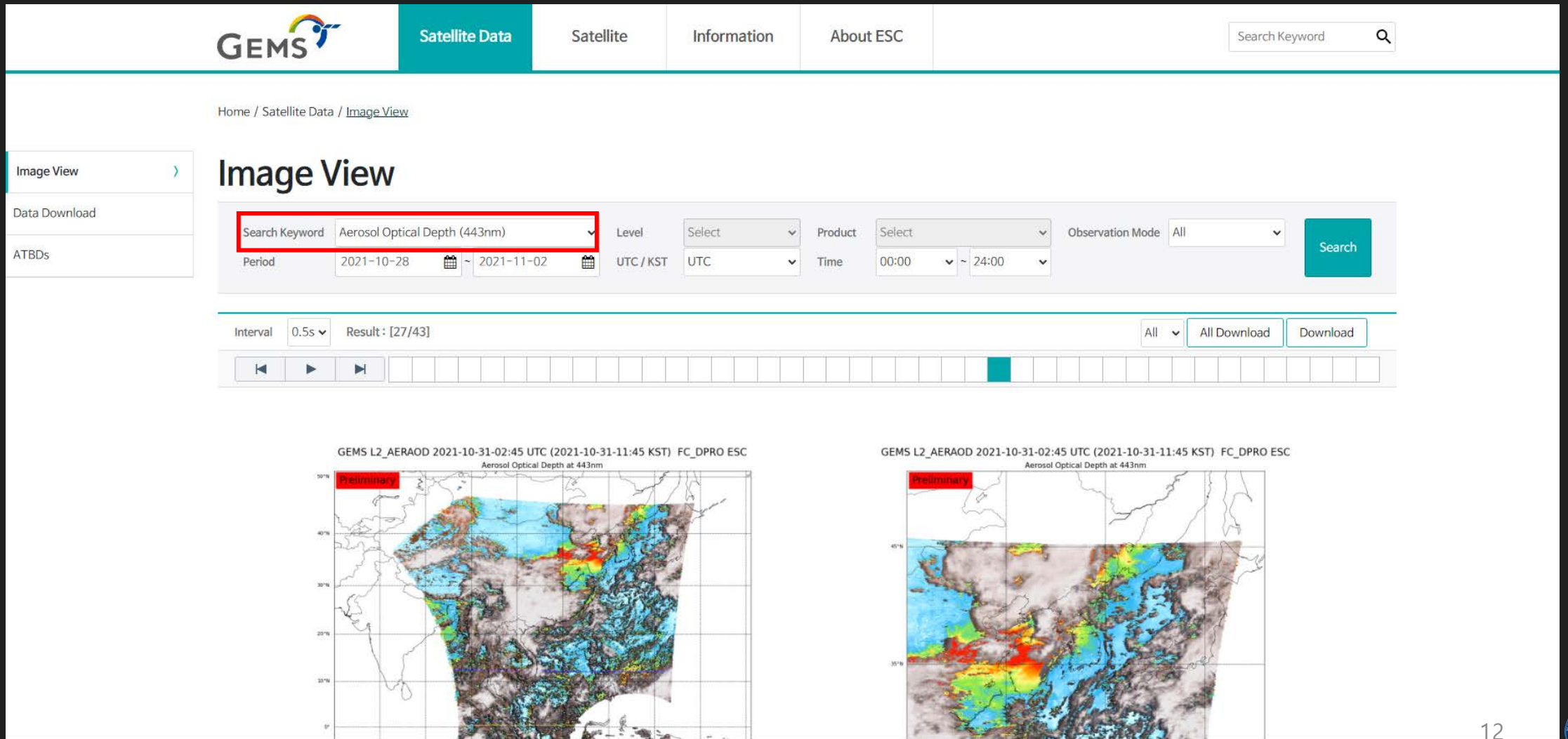
Application of GEMS aerosol products to air quality : GMAP Campaign

AOD 443 nm
2021.10.25-10.31 09:45 KST

AOD 443 nm
2021.11.15-11.21 09:45 KST

5th week

Yellow Sea

AOD

- ✓ 2nd week: High AODs over Eastern China but not strong influence on Korea
- ✓ 5th week: Long-range aerosol transport from Shandong (China)

- ✓ **The GEMS MAP of Air Pollution, GMAP Campaign field study are conducted from Oct. to Nov. 2021.**

- ✓ **To take a broad perspective on the spatiotemporal variability of pollutants throughout the GMAP2021 campaign, GEMS aerosol products is investigated focusing on the GMAP campaign period.**

GEMS images open to public

NIER website> https://nesc.nier.go.kr/product/view

Conclusion

✓ This study shows the retrieved results of Aerosol optical properties (AOD, UV & Visible AI and SSA) over Asia from Geostationary Environment Monitoring Spectrometer (GEMS) in 2020 - 2021.

✓ **We present GEMS aerosol retrieval results for high aerosol loading cases of wildfires and dust over East Asia.**

✓ Taking advantage of the sensitivity to aerosol absorption and aerosol height information in UV-Vis wavelengths, **GEMS aerosol algorithm retrieves Aerosol layer height (ALH) by optimal estimation.**

✓ The GEMS ALH is compared to the total backscatter coefficients measured from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP).

✓ Overall, GEMS ALH tracks CALIOP backscatter weighted aerosol height reasonably well. However, GEMS ALH shows positive bias with average differences of +0.143 km and +0.447 km in 05:45 UTC and 06:45 UTC, respectively.

✓ The GEMS AOD and SSA are validated against ground-based AERONET data showing very good results for AOD but poor results for SSA as expected.

✓ As the retrieved GEMS AOD shows biases with respect to AERONET AOD, the AOPs in the current version of the LUT will be updated in this year.

Thank you!