

GEMS after launch and operation

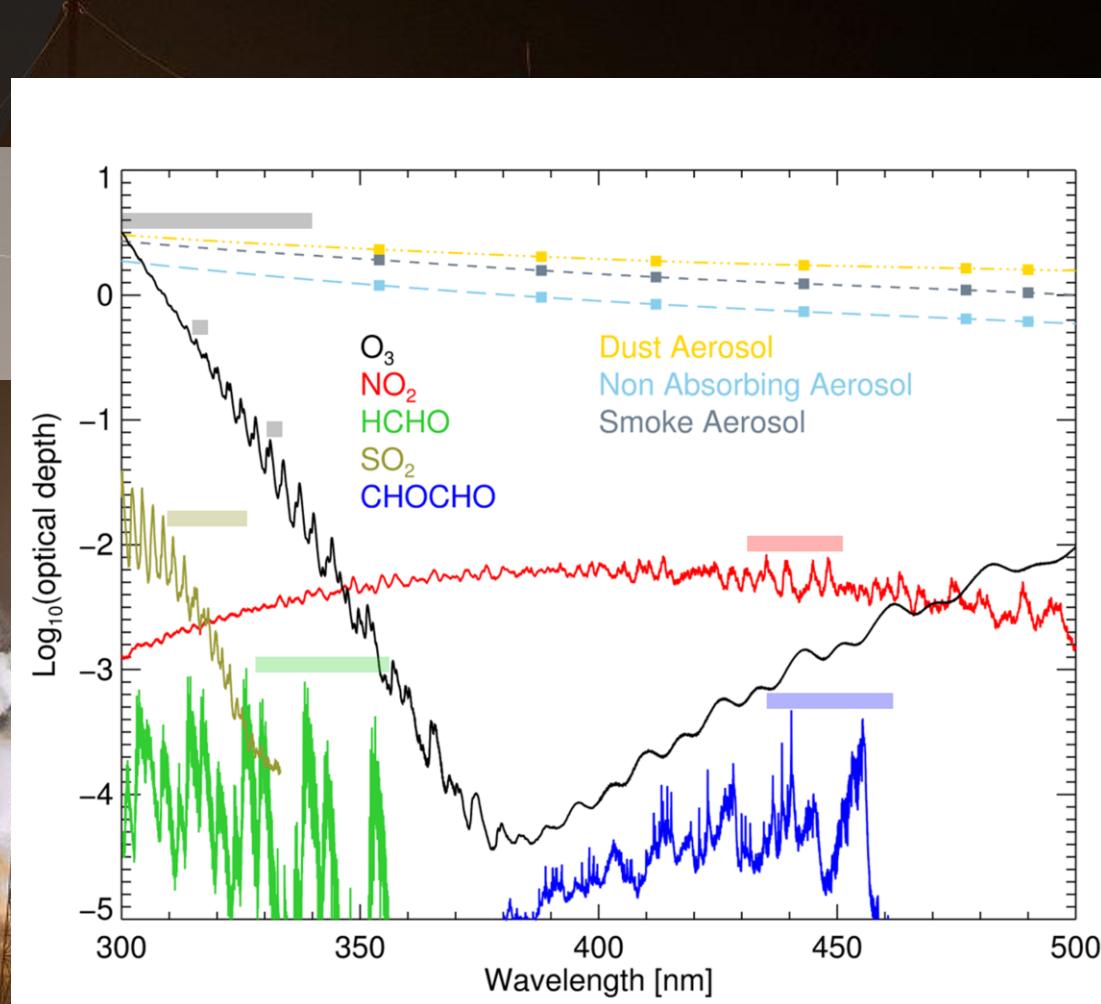


M.H. Ahn and J. Kim

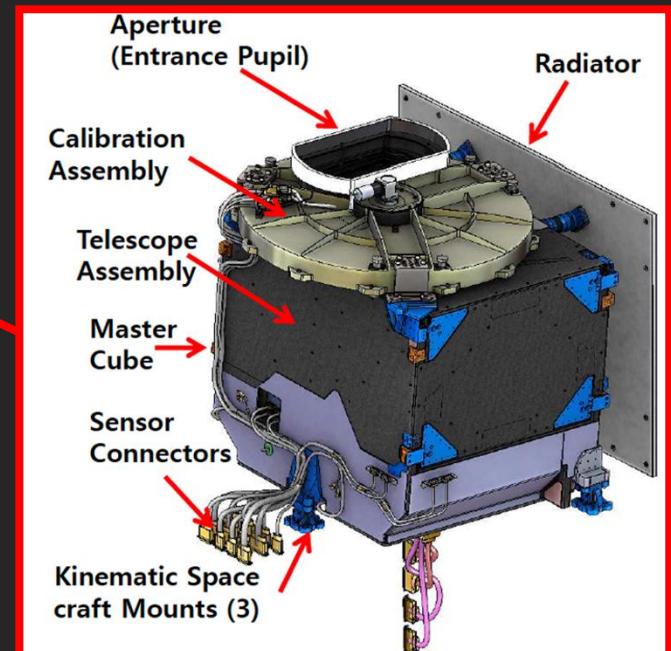
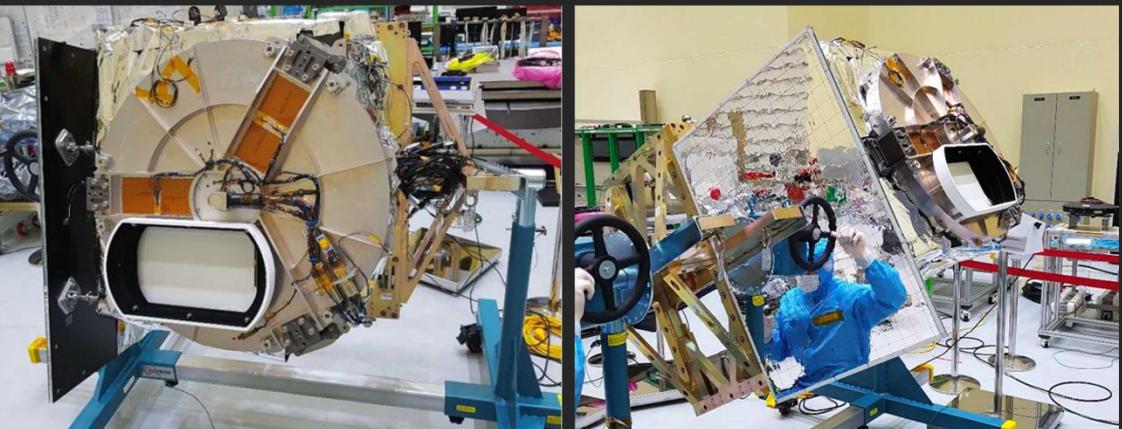
Dongwon Lee, Jae H Kim, Rokjin Park, Hanlim Lee, Chul H. Song, Yong-Sang Choi, Kwon Ho Lee, Jungmoon Yoo, Seon K Park, Kwang-Mog Lee, Chang-Keun Song, Sang-Woo Kim, Si-Wan Kim, Jongmin Yoon, Won-Jin Lee, Hyunkhee Hong, Chang-Suk Lee, Wonjun Choi, Yuha Kim, Kyung-Jung Moon, Dai Ho Ko, Seung-Hoon Lee, Yeseul Cho, Heesung Chong, Sujung Go, Sang Seo Park, Hana Lee, Seoyoung Lee, Mina Kang, Mijin Eo, Juseon Bak, Kanghyun Baek, Dae Sung Choi, Hyeong-Ahn Kwon, Jiwon Yang, Junsung Park, Kyung Man Han, Mikyung Choi, Haklim Choi, Ebony Lee, Gyuyeon Kim, Yesol Cha, Xiong Liu, Kelly Chance, Joris P Veefkind, Jassim A Al-Saadi, Ben Veihelmann, and GEMS Science Team

***Department of
Atmospheric Sciences,
Yonsei University,
Seoul, Korea**

P.I., GEMS



GEMS specifications



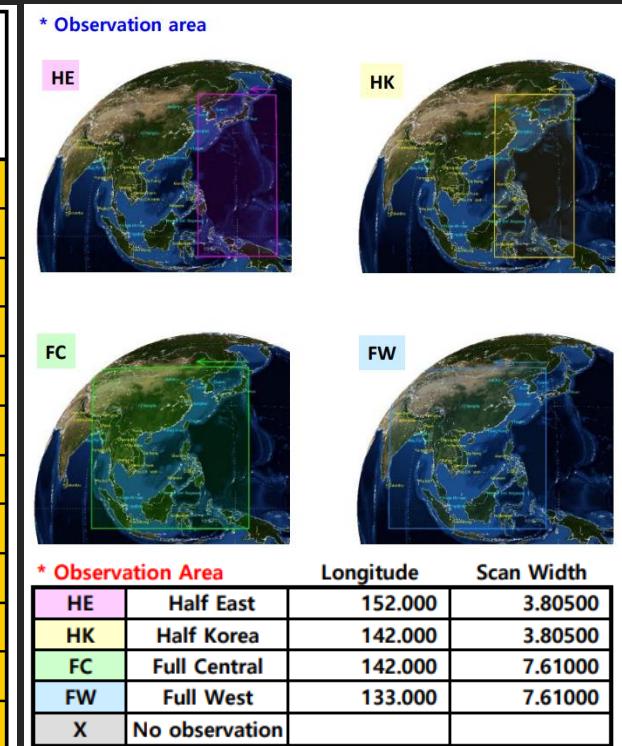
System Attributes	Requirements
Lifetime	>10 years
Field of regard	N/S range: 45°N–5°S E/W range: 75°E - 145°E Orbital position: 116.2°E-128.2°E
Ground sampling distance	< 3.5 km (N/S) at Seoul, Korea
Spectral range	300 to 500 nm
Spectral resolution	< 0.6 nm
Spectral sampling	< 0.2 nm
Signal-to-noise ratio	> 720 at 320nm > 1500 at 430nm
Spectral calibration accuracy	< 0.02 nm
Spectral calibration stability	< 0.02 nm (within daytime)

Kim et al. (BAMS 2020)

GEMS Operation

- ✓ GEMS performs measurements at (hh - 1):45 – hh:15, where hh represents hour.

No.	1	2	3	4	5	6	7	8	9	10	11	Total Observation Time
UTC	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	
KST	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	
Jan	X	X	HE	HK	FC	FW	FW	FW	X	X	X	6
Feb	X	X	HE	HK	FC	FW	FW	FW	X	X	X	7
Mar	X	HE	HK	FC	FC	FW	FW	FW	X	X	X	8
Apr	HE	HK	FC	FC	FC	FW	FW	FW	FW	X	X	10
May	HE	HK	FC	FC	FW	FW	FW	FW	FW	X	X	10
Jun	HE	HK	FC	FC	FW	FW	FW	FW	FW	X	X	10
Jul	HE	HK	FC	FC	FW	FW	FW	FW	FW	X	X	10
Aug	HE	HK	FC	FC	FW	FW	FW	FW	FW	X	X	10
Sep	HE	HK	FC	FC	FW	FW	FW	FW	FW	X	X	10
Oct	X	HE	HK	FC	FC	FW	FW	FW	X	X	X	8
Nov	X	X	HE	HK	FC	FW	FW	FW	X	X	X	6
Dec	X	X	HE	HK	FC	FW	FW	FW	X	X	X	6



GEMS L2 products



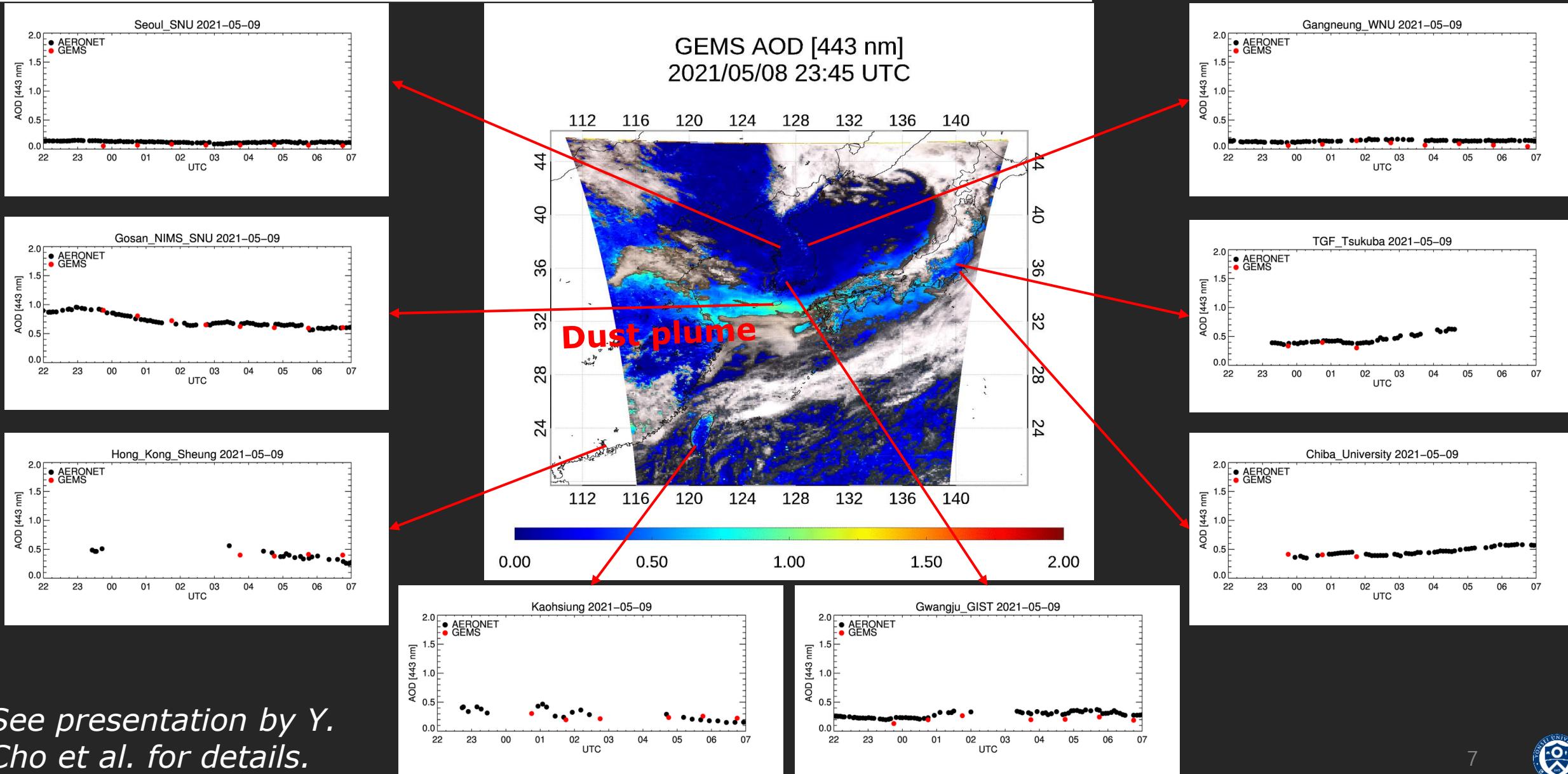
Product Group	Product	Product Group	Product
Aerosol	1) Aerosol Optical Depth	HCHO	12) Formaldehyde
	2) Single Scattering Albedo	CHOCHO	13) Glyoxal
	3) UV-VIS Aerosol Index	NO ₂	14) Tropospheric Nitrogen dioxide
AEH	4) Aerosol Effective Height		15) Stratospheric Nitrogen dioxide
Cloud	5) Effective Cloud Fraction	SO ₂	16) Sulfur dioxide
	6) Effective Cloud Pressure		17) UV Index
	7) Cloud Radiance Fraction	UVI	18) Plant Response Index
SFC	8) Surface Reflectance		19) DNA Damage Index
O3T	9) Total Ozone		20) VitaminD Synthesis Index
O3P	10) Tropospheric Ozone Profile	*Additional products of H ₂ O, BrO, HONO under development.	
	11) Stratospheric Ozone Profile		

Timeline since launch



No.	Date (KST)	Activity	Solar measurements with reference diffuser	GEMS power reset	GEMS observation area reset
0	2020.02.19	Transfer orbit injection (GK-2B launch)	2020.04.28	2021.03.20	2022.03.21
1	2020.03.06	GK-2B arrived successfully in orbit	2020.09.22	2021.06.21	2022.09.23
2	2020.03.23	GEMS power on	2020.12.20	2021.09.23	
3	2020.04.21	First GEMS measurements for Sun/Earth/LED			
4	2020.04.23~	Daily operation (in-orbit test)			
5	2021.03.22	L2 image file open (O3T, AERAOD, UVI, CLD)	2020.06.06	2020.11.02	2021.05.11
6	2022.06.28	L2 NetCDF file open (O3T, AERAOD, SO2, UVI, CLD)	2020.08.17	2020.11.03	2022.08.08
7	2022.08.31	L2 Version 2 update	2020.08.31	2020.11.11	2022.09.04
8	2022.11.30	L2 Version 2 NetCDF file open (all)			

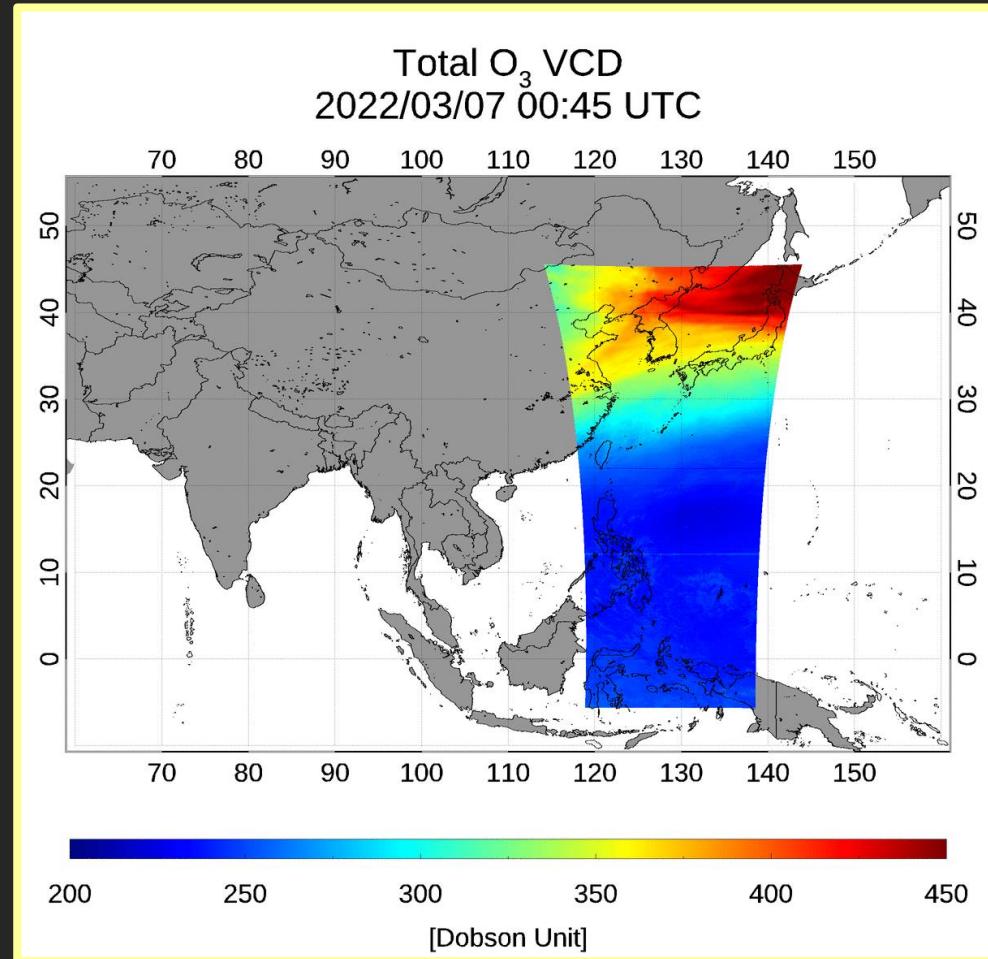
Results: Aerosol



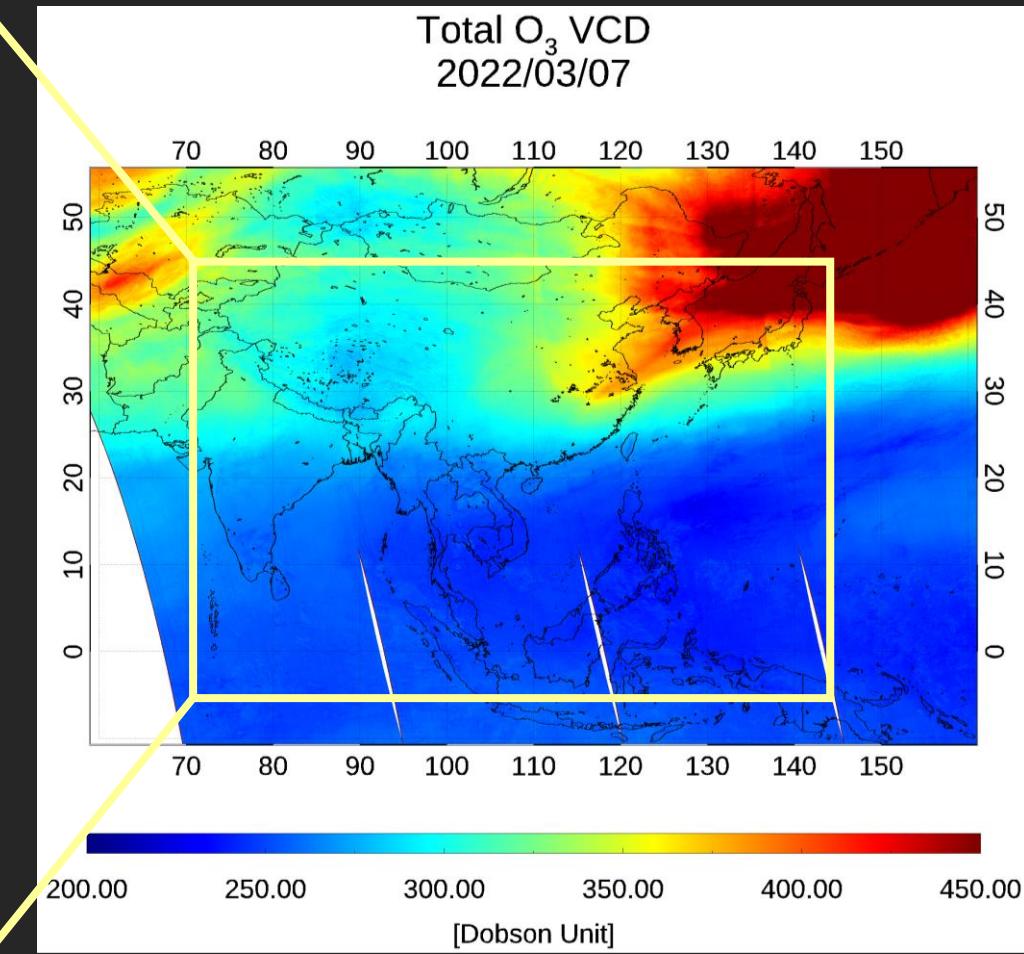
See presentation by Y.
Cho et al. for details.

Results: O₃

GEMS Ozone Total

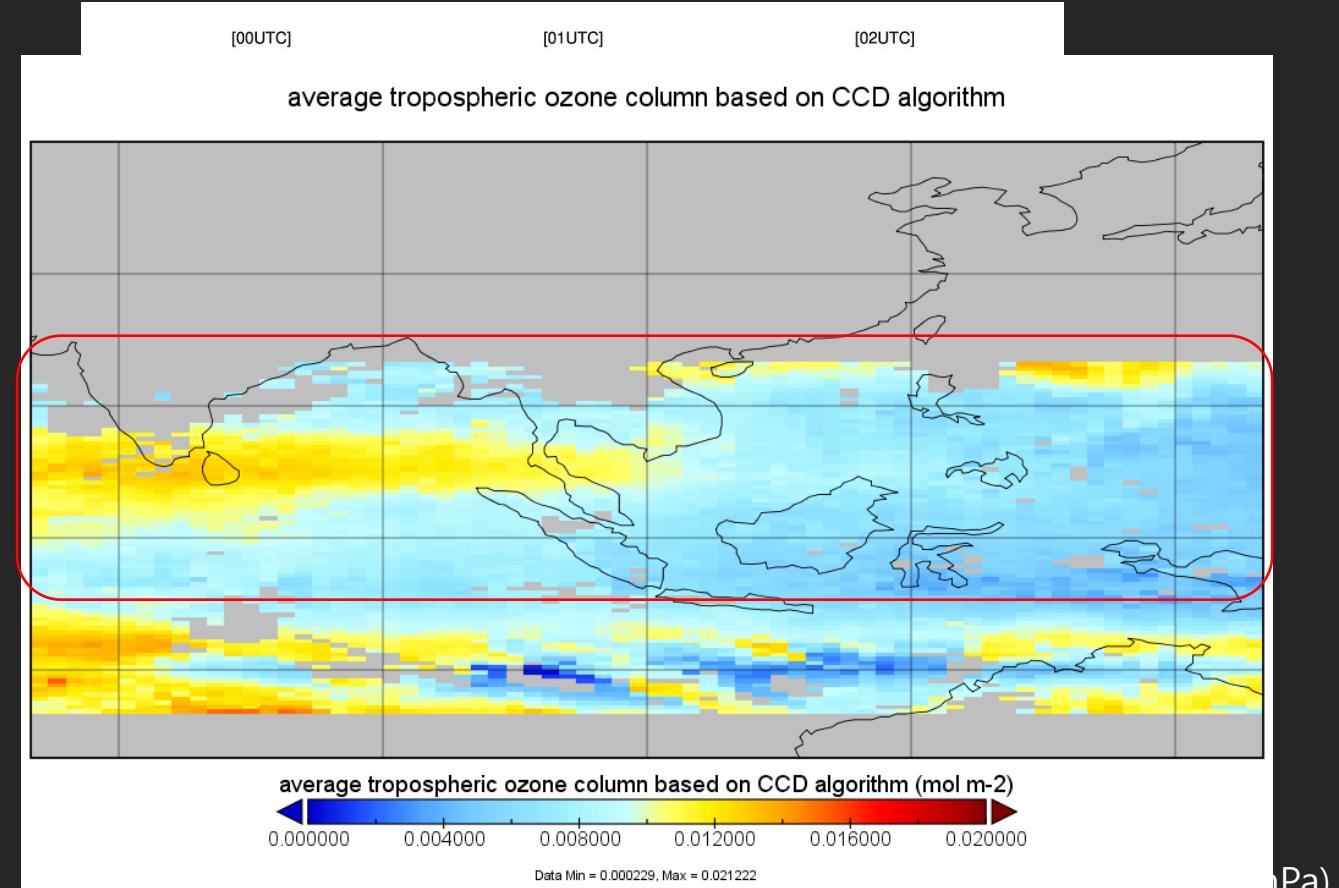
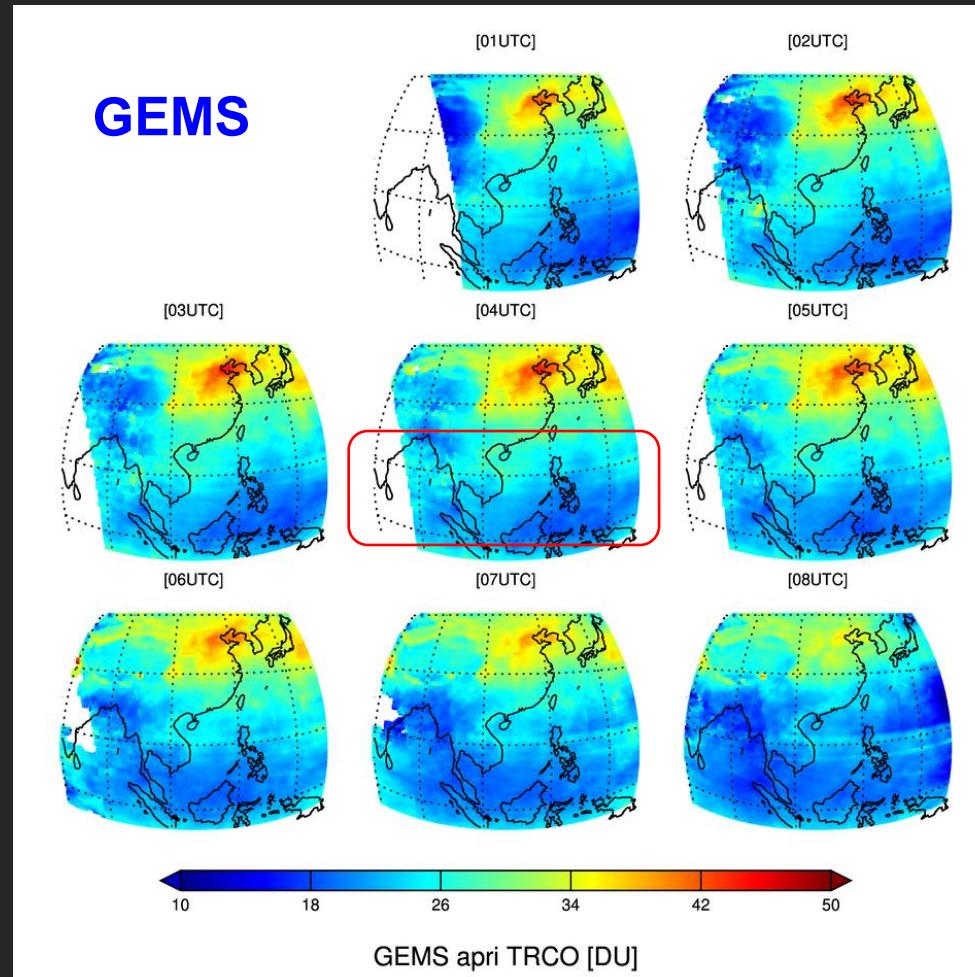


TROPOMI Ozone Total



See presentation by J.H. Kim et al. for details.

Results: Tropospheric Column Ozone



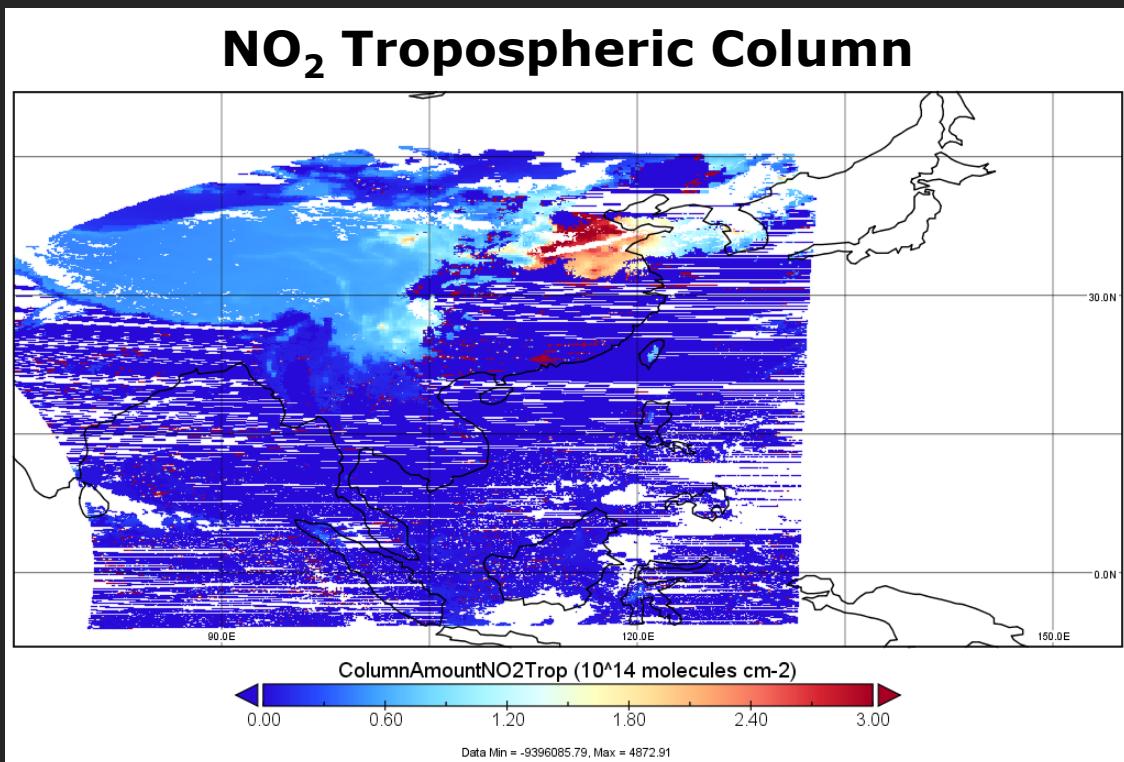
TROPOMI(20S-20N, 8.13-19 Average)

- ✓ Monthly mean of hourly GEMS and GEOS-Chem TrCO (Tropospheric Column Ozone), August 2020
- ✓ Tropospheric ozone from GEMS shows higher values than those from GEOS-chem in eastern China and southeast Asia.
- ✓ GEMS TrCO increases from 10 a.m. (01 UTC) to 3 p.m. (06 UTC), then decreases after, while GEOS-Chem values tends to remain till later afternoon.

Results: NO₂

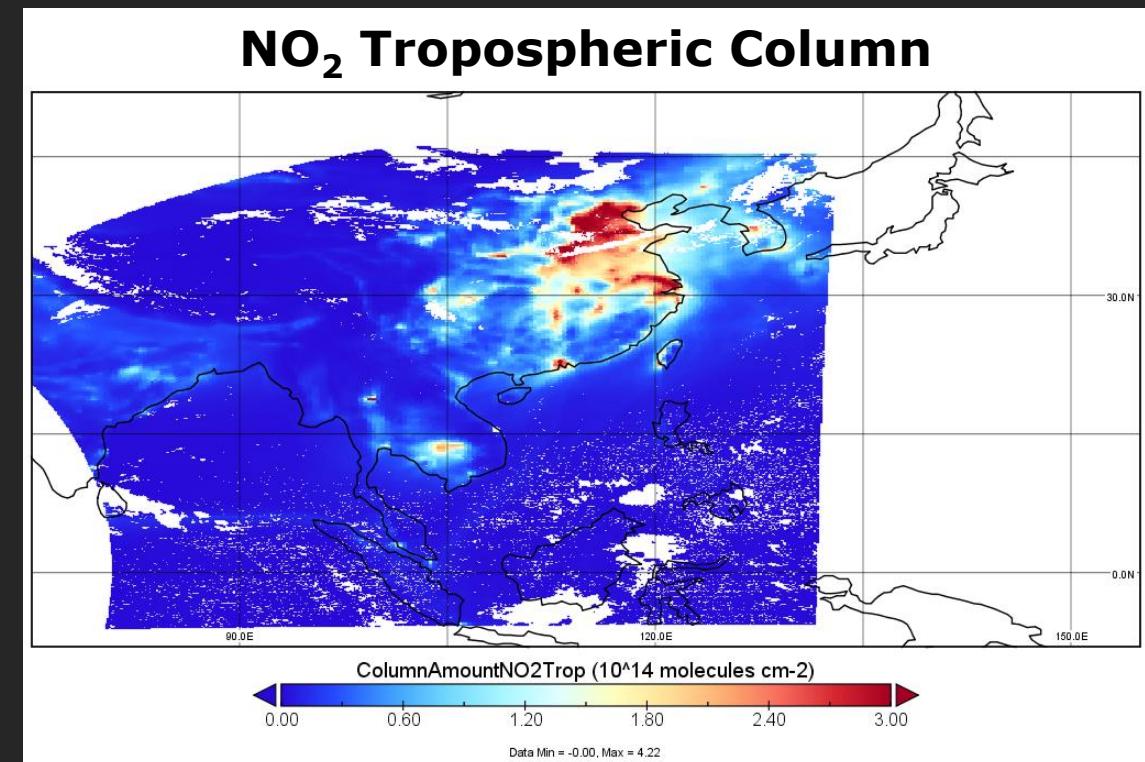
Version 1

A priori NO₂ profiles : WRF-Chem + CAM-Chem



Version 2

A priori NO₂ profiles : GEOS-Chem



- ✓ **January 15, 2021 03:45 UTC**
- ✓ **Dramatic improvement in Tropospheric Nitrogen dioxide from updated AMF.**

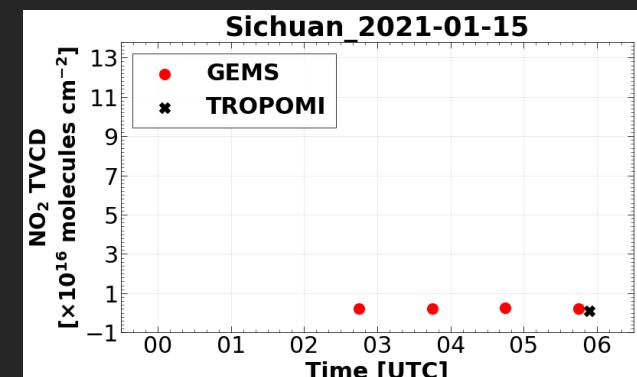
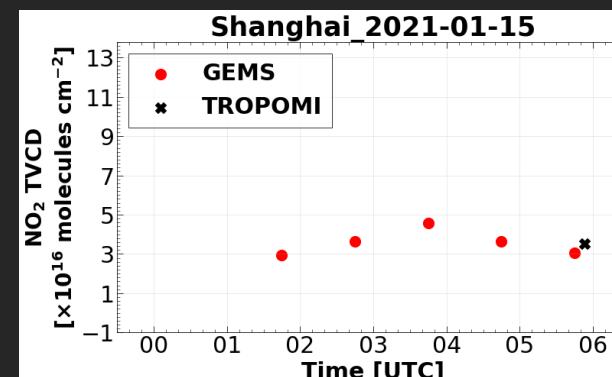
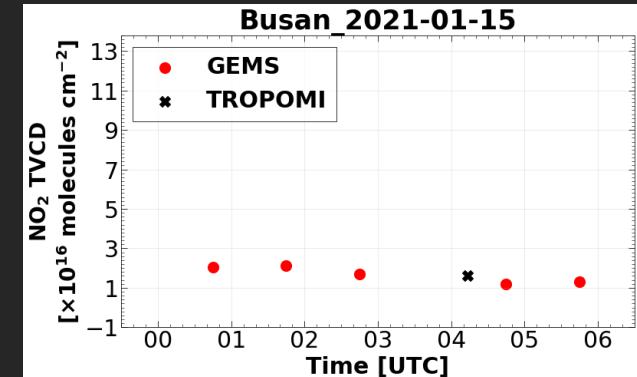
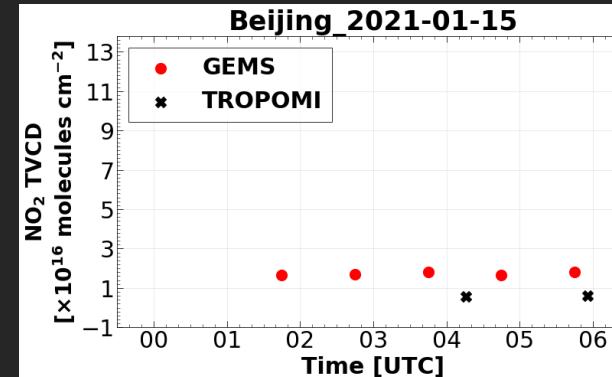
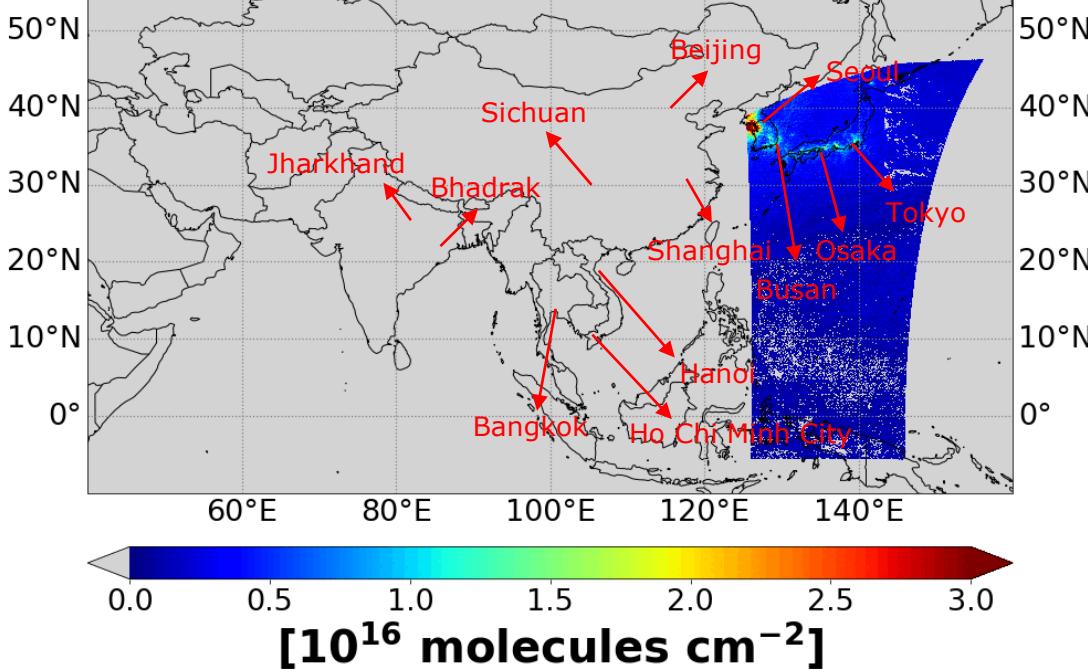
See presentation by J. Park et al. for details.

Results: NO₂

NO₂ Tropospheric Column

2021/01/15 00:45 UTC

60°E 80°E 100°E 120°E 140°E

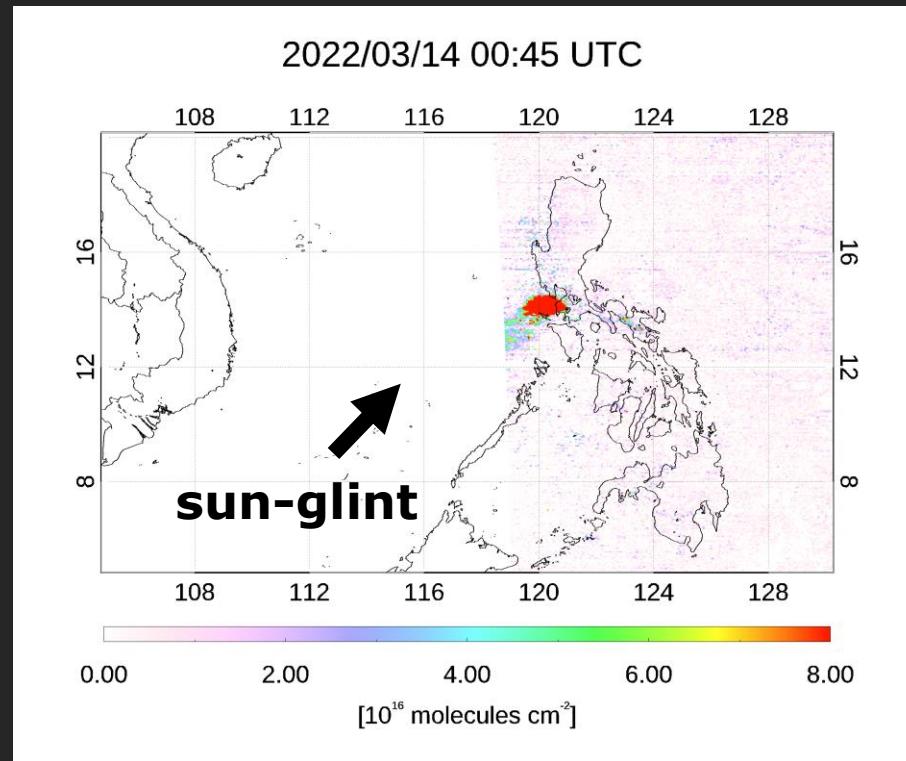


- ✓ Diurnal variation of NO₂ Total and Tropospheric Column on January 15, 2021.
- ✓ Clear NO₂ patterns were retrieved over urban and industrial areas.
- ✓ Ground-based validation of TROPOMI NO₂ v-2.2 data shows the negative bias of the stratospheric (-3%), tropospheric (-23%) and total (-5%) columns. (J. van Geffen et al., 2022)

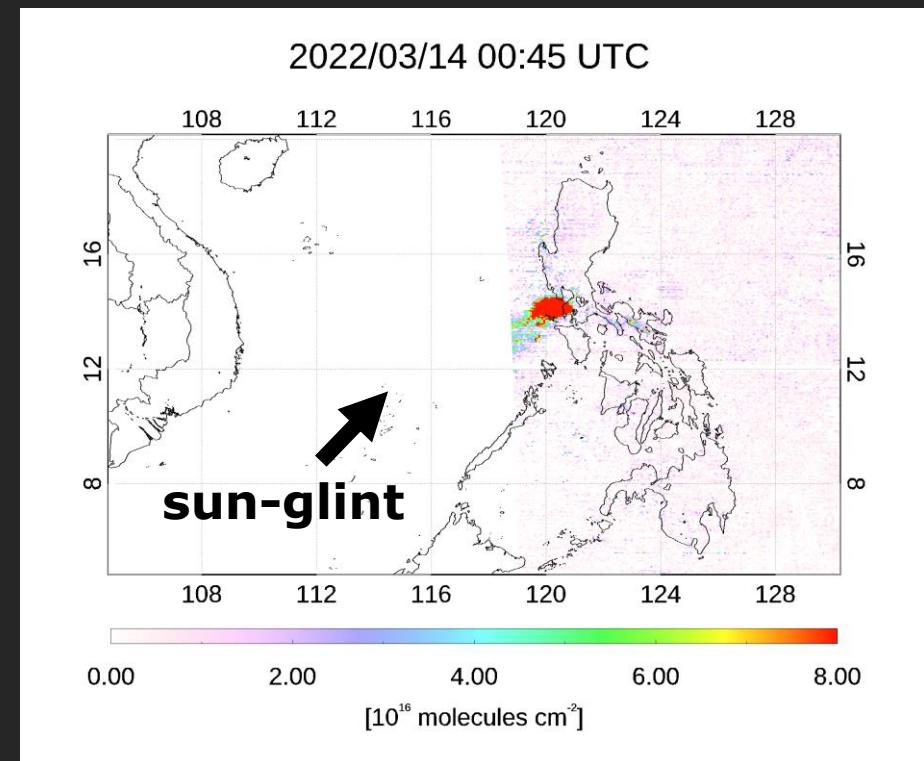
See presentation by J. Park et al. for details.

Results: SO₂

Version 1



Version 2



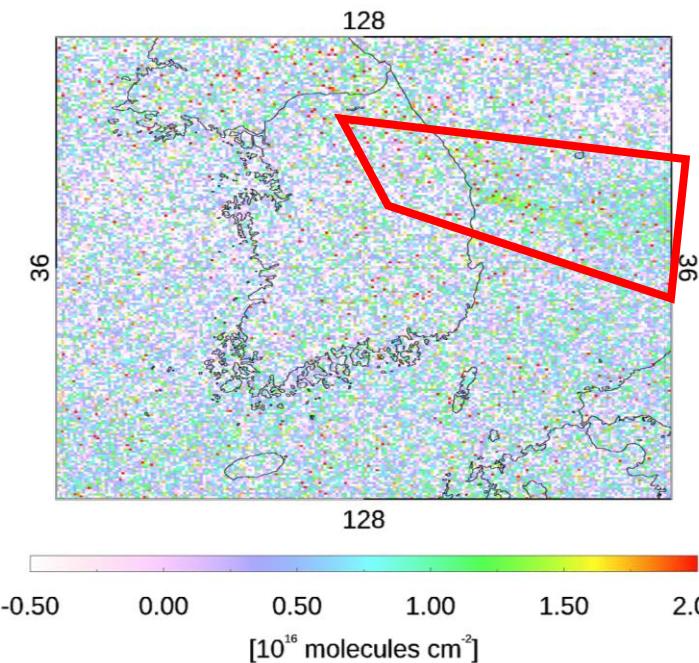
- ✓ Taal Volcano is located ~ 65 km south of Manila.
- ✓ Before volcanic eruption on March 26, 2022, GEMS captured SO₂ emitted from Taal volcano spreading to the Indochina Peninsula through the western coastal region of the Philippines (March 14, 2022).
- ✓ SO₂ retrieval is attempted on pixels in the sun-glint region.

See presentation by H. Lee et al. for details.

Results: HCHO and CHOCHO

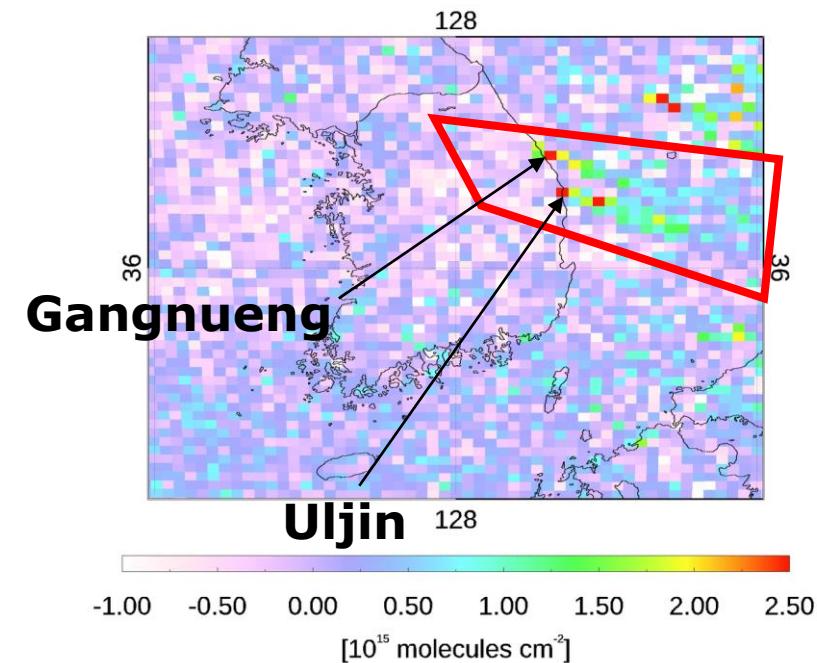
GEMS HCHO

2022/03/05 00:45 UTC

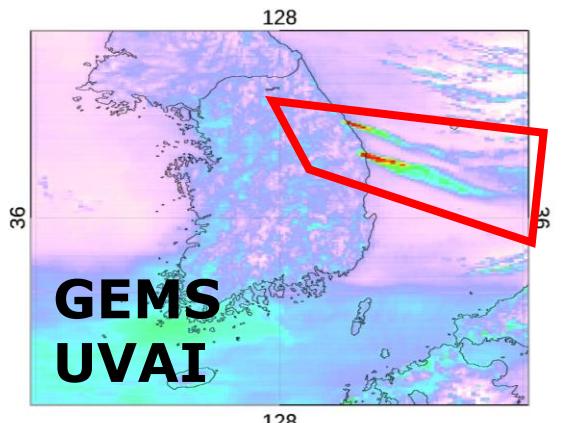


GEMS CHOCHO

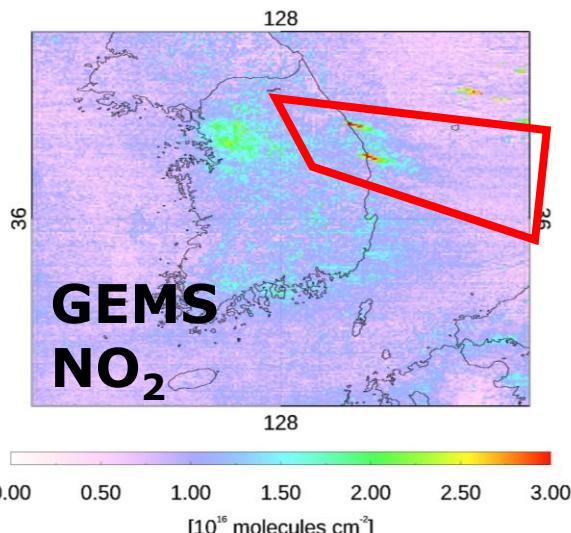
2022/03/05 00:45 UTC



2022/03/05 00:45 UTC



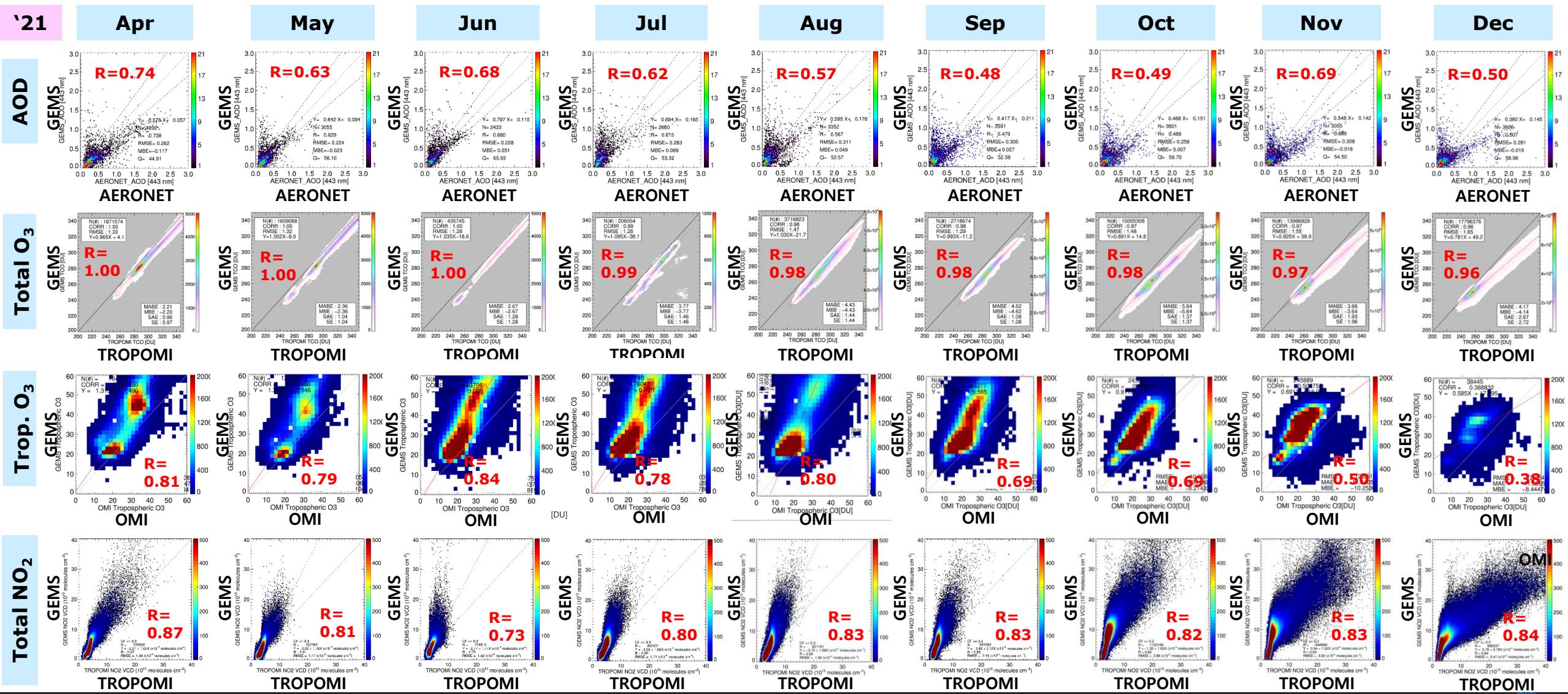
2022/03/05 00:45 UTC



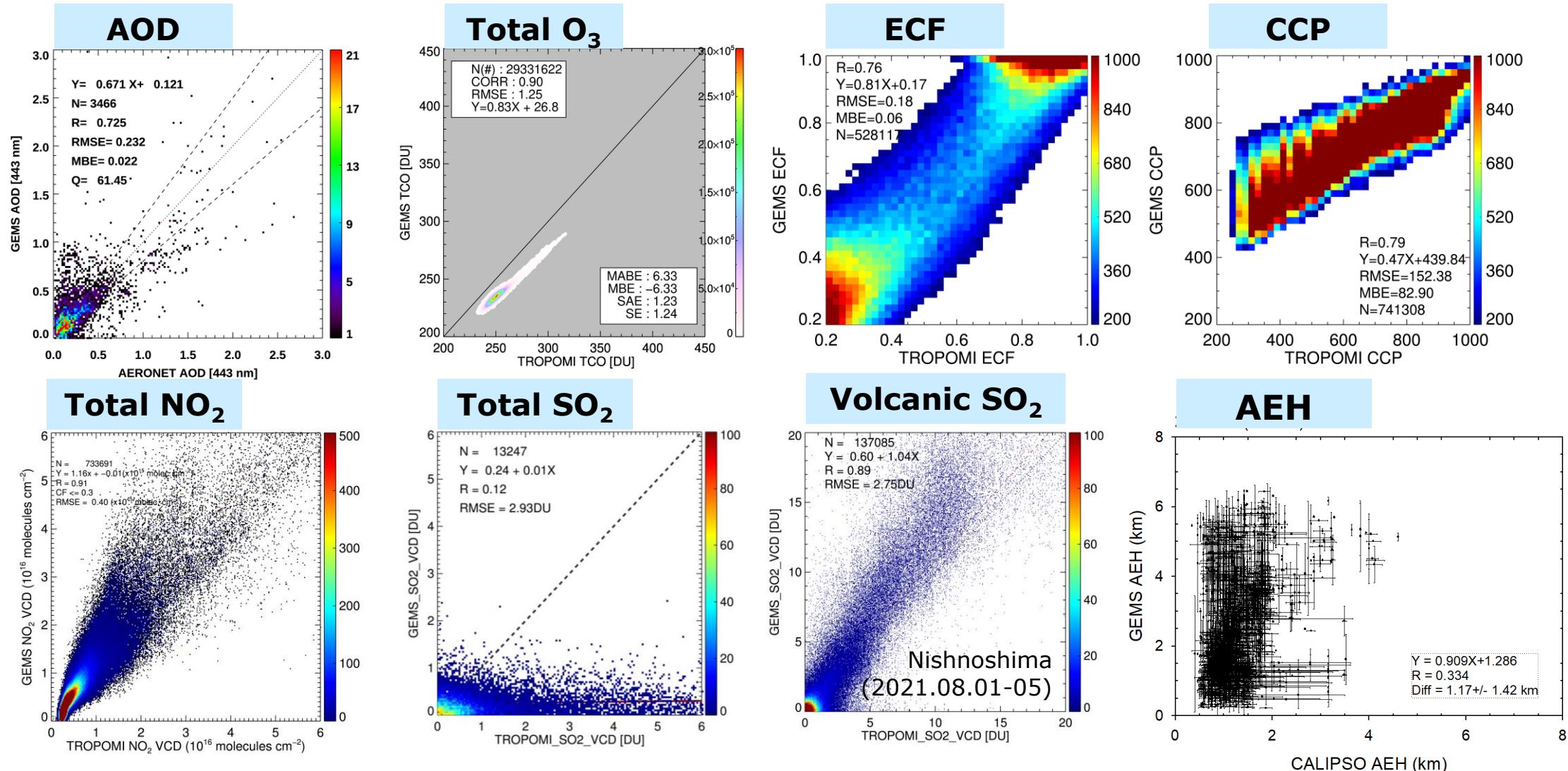
- ✓ Large wildfires in Uljin and Gangnueng, South Korea on March 5, 2022.
- ✓ HCHO and CHOCHO are abundant non-methane VOCs emitted by wildfires.
- ✓ GEMS detected the increase in HCHO, CHOCHO, UVAl, and NO₂.

See presentation by R. Park et al. for details.

GEMS validation results (Version 1.0.0) GEMS



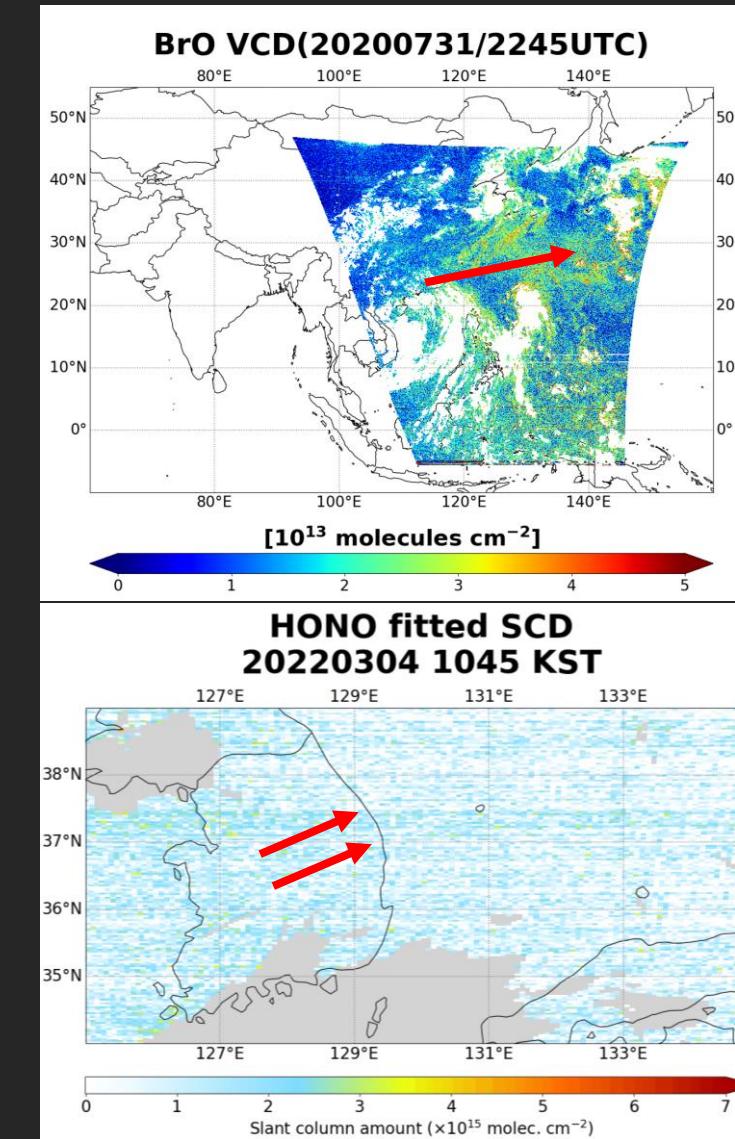
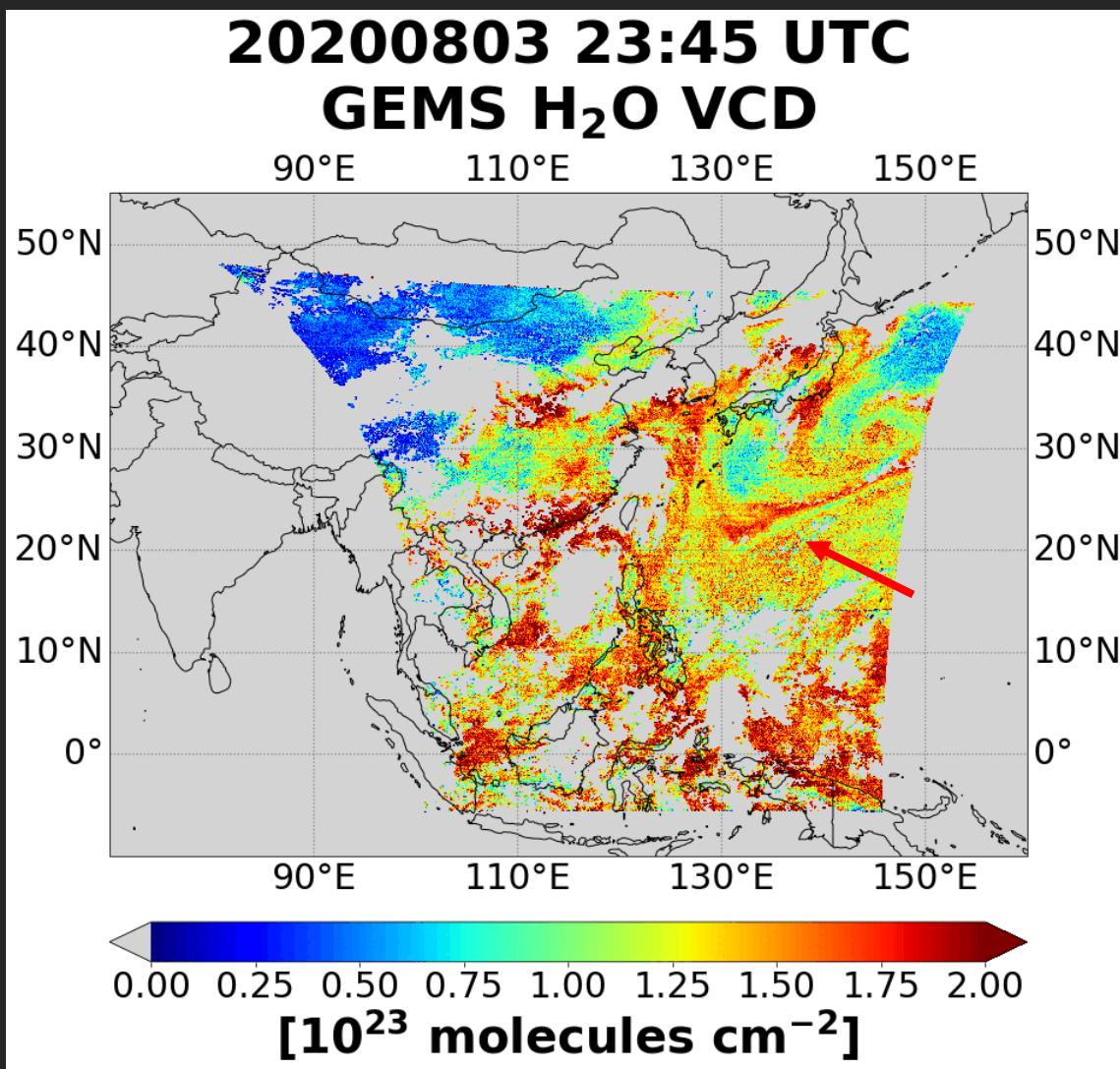
GEMS validation results (Version 1.0.4) GEMS



- ✓ January 2022
- ✓ Start Testing GEMS L2 algorithm Version 1.0.4.

Results: GEMS BrO, H₂O, HONO

20200803 23:45 UTC
GEMS H₂O VCD



- ✓ Additional products of H₂O, BrO, HONO under development.

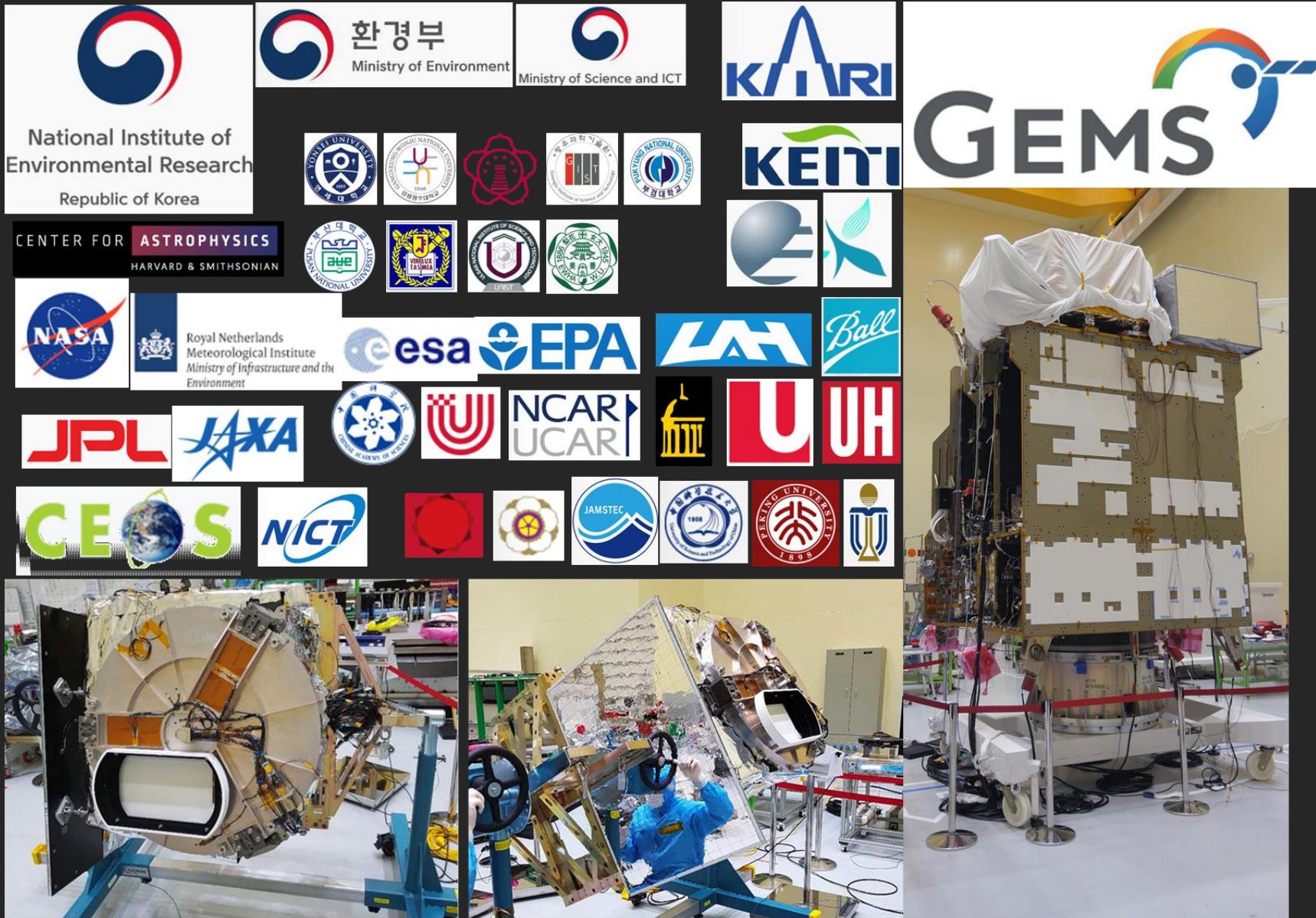
Please see poster of Cha et al. and Ahn et al. for details.

- Atmospheric river (H₂O), volcanic plume (BrO), and wildfire plume (HONO) signal are captured.

Conclusion

- ✓ GEMS has been successfully operating since its launch and IOT in 2020.
- ✓ Retrieved results of trace gases and aerosols by GEMS are presented, with validation.
- ✓ In version2, there are dramatic improvements in trace gases from updated AMF and the separation of stratospheric/tropospheric components. L2 algorithms have been updated for version 2 and the products will be released on November 30, 2022.
- ✓ The GEMS retrievals indicate good agreements from validation campaign, but still requires further improvement in L1 processing. We start testing new improvements for L1 processing including BTDF correction, but the updated L1 process is not included in version 2 (release date TBD).
- ✓ Despite of high correlation, CCP and NO₂ are overestimated, AOD is underestimated, and total O₃ shows systematic biases.
- ✓ Ongoing calibration/validation activities including the 2022 GMAP/SIJAQ campaign and international CAL/VAL team works are critical to diagnose and improve the overall data quality.
- ✓ Synergies with instruments onboard LEO (TROPOMI, OMPS, GF-5..) and upcoming GEO AQ satellites (TEMPO and Sentinel-4) are expected.

Acknowledgements



Thank you!