CEOS AC-VC, Tokyo, Jun 10-12, 2019

Overview of GEMS

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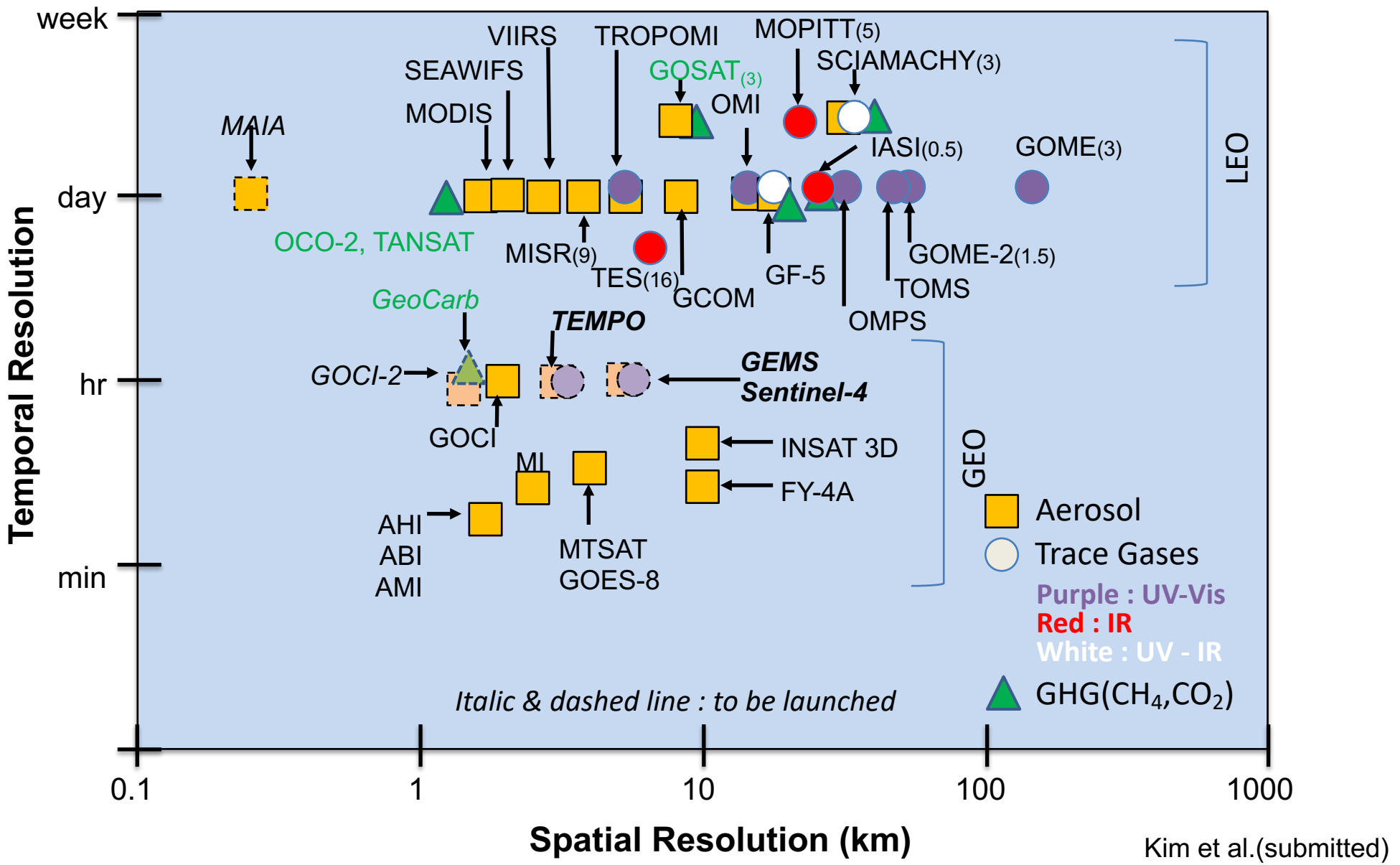
Development of Satellite RS for AC

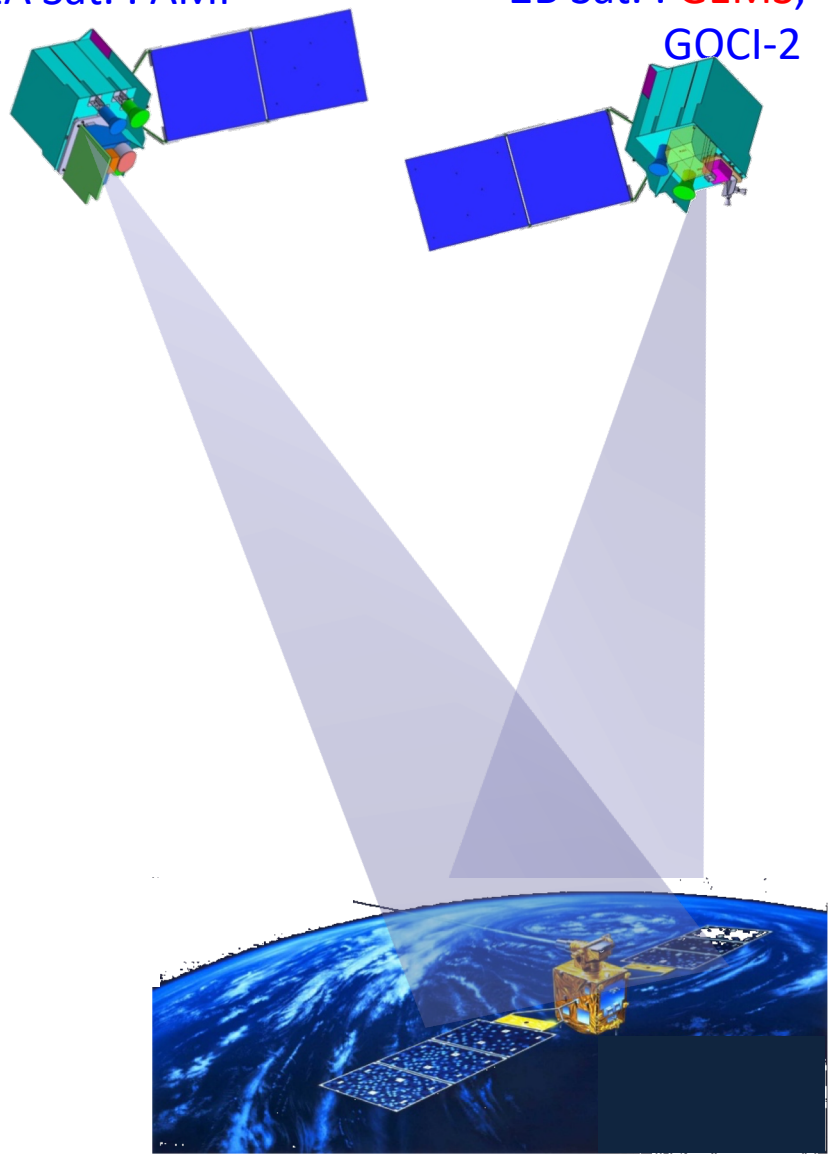


Kim et al.(submitted)

GEO-KOMPSAT 2

2A Sat. : AMI

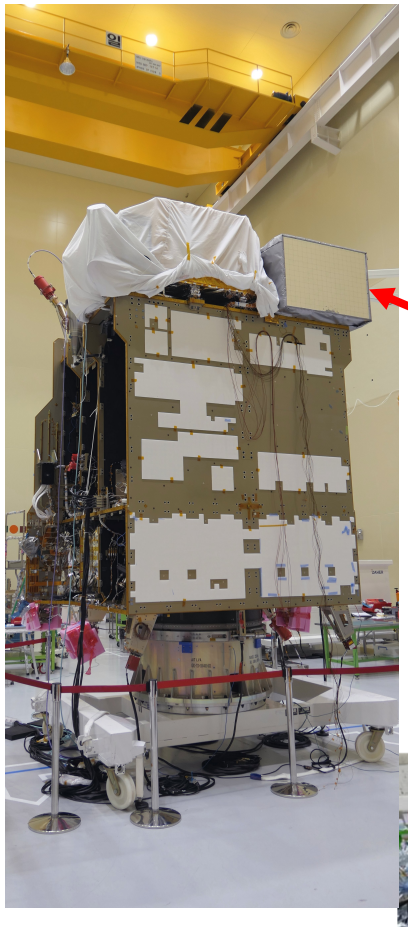
2B Sat. : GEMS, GOCI-2

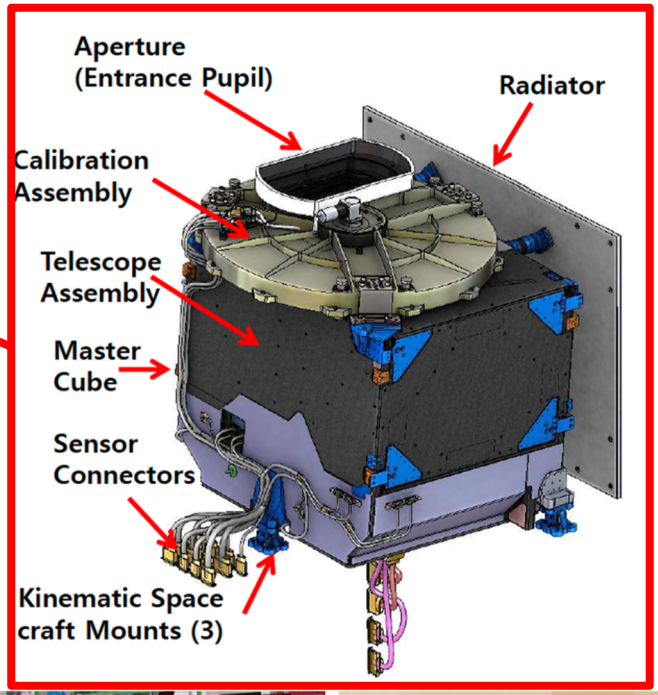


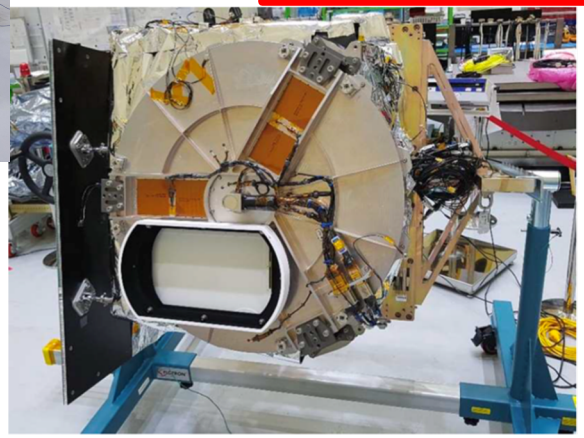
Specification

	GK 1 (COMS)		GK 2A	GK 2B	
Payload	MI	GOCI	AMI	GOCI-2	GEMS
Channels	5	8	16	13	1000
Spatial Resolution (km)	1 (Vis) 4 (IR)	0.5 @ Seoul	0.5/1(Vis) 2 (IR)	0.25 @ eq 1 (FD)	7 x 8 (gas) 3.5 x 8 (aerosol)
Temporal resolution	15 min	1 hour	10 min (FD)	1 hour (FD1/day)	1 hour
Spatial Coverage	NH / FD	E. Asia	NH / FD	E. Asia / FD	Asia
Wavelength range	0.6–13 um	412– 860 nm	0.4 – 13 um	375 – 860 nm	300-500 nm
FWHM	10~20 nm	10~20 nm	10~20 nm	10~20 nm	0.6 nm
Launch	June 27th, 2010		Dec. 2018	Before Mar. 2020	
Lifetime	7 years		10 years		
Location	128.1 °E		128.1 °E		

GEMS FLIGHT MODEL







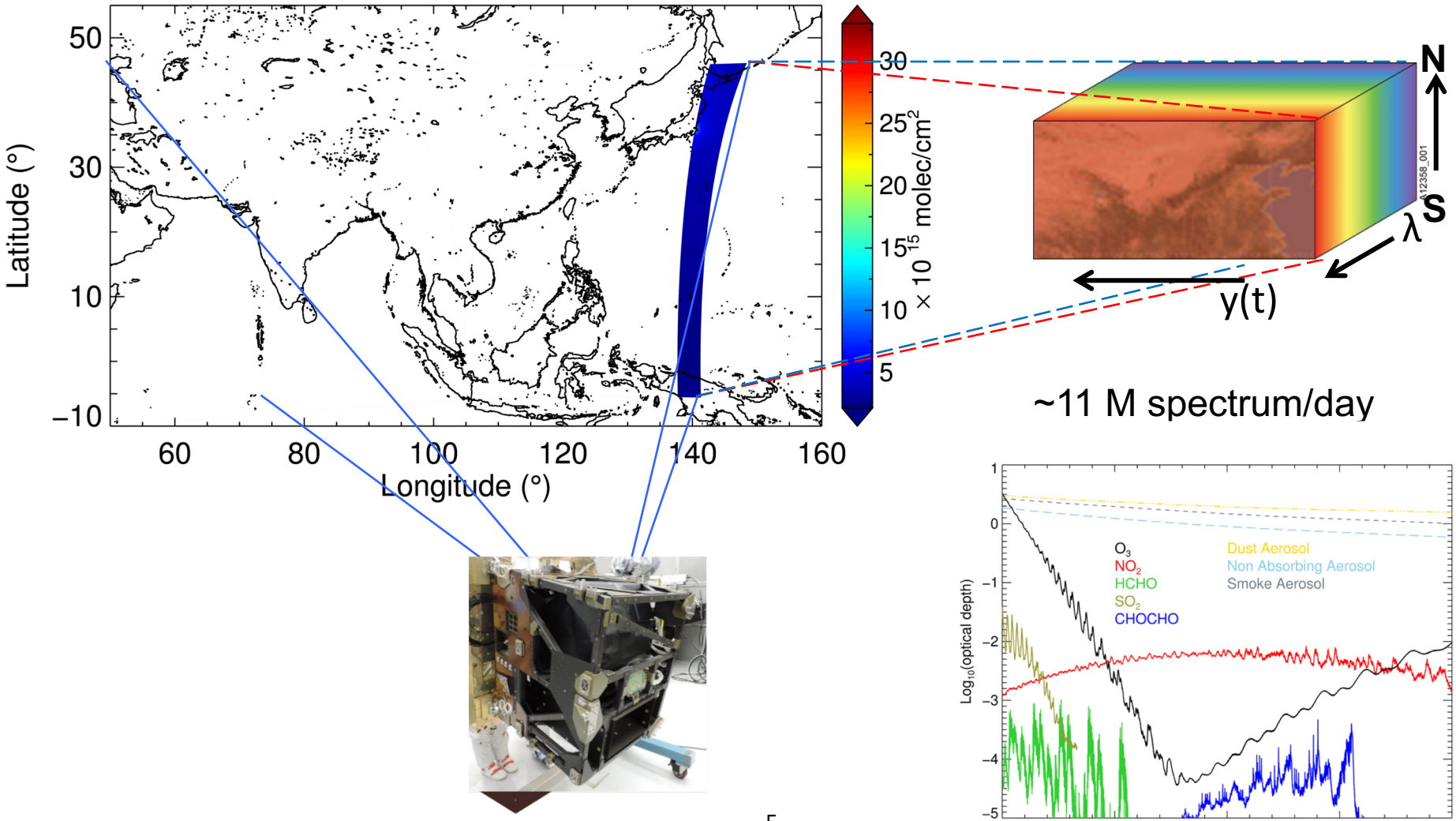
- ✓ Scanning UV-visible Spectrometer
- ✓ Onboard GK-2B

- ✓ Delivered to KARI in 2018
- ✓ Under AIT to GK-2B S/C
- ✓ Vibration Test finished
- ✓ Acoustic Test : last week
- ✓ Separation Shock Test : this week
- ✓ Thermal-Vac : Jul-Aug 2019
- ✓ PSR : Nov., 2019

- ✓ GK-2A launched in Dec., 2018
- ✓ Launch : likely in Feb., 2020 (Guiana Kourou)

GEMS E-W Scan Scenario

OMI mean NO_2 (from 2005 to 2014) over GEMS FOR



GEMS BASELINE PRODUCTS (21)

Num	Product	Importance	Min (cm^{-2})	Max (cm^{-2})	Nominal (cm^{-2})	Accuracy	Window (nm)	Spat Resol (km^2)@Seoul	SZA (deg)	method
3	**$TropO_3$ $StratO_3$ $TotalO_3$**	Oxidant Pollutant O_3 layer	$4x10^{17}$	$2x10^{18}$	$1x10^{18}$	3%(TOz) 5%(Stra) 20(Trop)	300-340	7 x 8	< 70	OE TOMS
4	**AOD AI SSA AEH**	Air quality Climate Public Health	0 (AOD)	5 (AOD)	0.2 (AOD)	20% or 0.1@ 400nm	300-500	3.5 x 8	< 70	Multi-λ O_2O_2 OE
1	**HCHO**	VOC proxy	$1x10^{15}$	$3x10^{16}$	$3x10^{15}$	$1x10^{16}$ cm^{-2}	328.5-356.5	7 x 8 x 4 pixels	< 50	DF
1	**CHOCHO**		$1x10^{14}$	$1x10^{15}$	$5x10^{14}$	$1x10^{15}$ cm^{-2}	435-461	7 x 8 x 4 pixels	< 50	DF
2	**$TropNO_2$ $StratNO_2$**	O_3 precursor	$3x10^{13}$	$1x10^{17}$	$1x10^{14}$	$1x10^{15}$ cm^{-2}	425-450	7 x 8 x 2 pixels	< 70	DOAS
1	**SO_2**	Aerosol precursor Volcano	$6x10^{8}$	$1x10^{17}$	$6x10^{14}$	$1x10^{16}$ cm^{-2}	310-330 340	7 x 8 x 4 pixels x 3 hours	< 50	DOAS PCA
4	**UVI VitD UVI DNA UVI Plant UVI**	Public health	0	12 62 25 48	6.8 33 mWm^{-2} 12 mWm^{-2} 25 mWm^{-2}	20%	300-360	7 x 8	< 70	Multi-λ RTM
2	**Surface Prop. (LER, BRDF)**	Environment	0	1	-	20%	300-500	3.5 x 8	< 70	Multi-λ
3	**ECF CCP CRF**	Retrieval Climate	0 (COD)	50 (COD)	17 (COD)	20%	300-500	7 x 8	< 70	O_2O_2 *RRS*

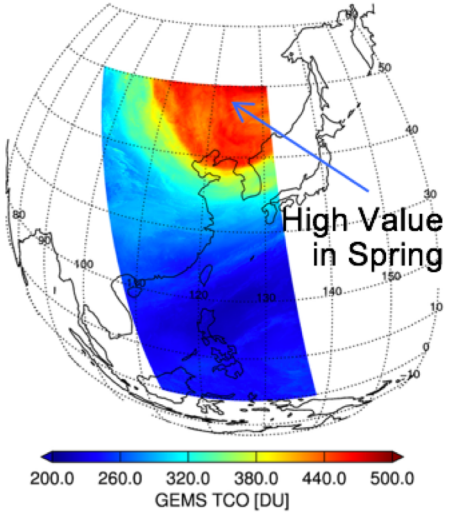
GEMS L2 Algorithm Test with TROPOMI L1b

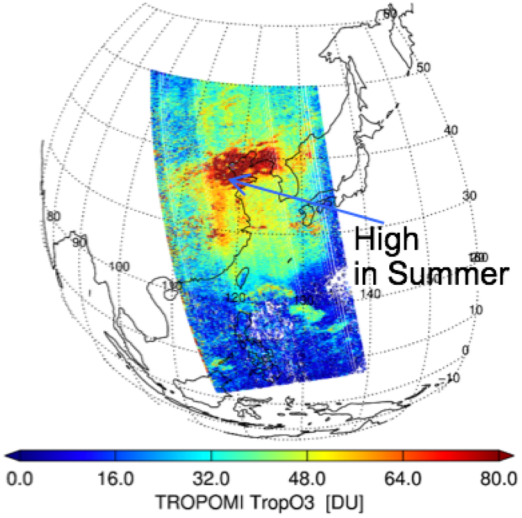
Total Ozone
2019.03.30

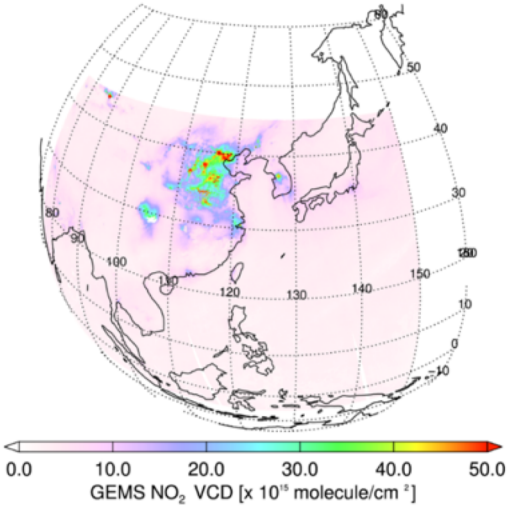
Trop Ozone
2018.08.08

NO_2
2018.12.14

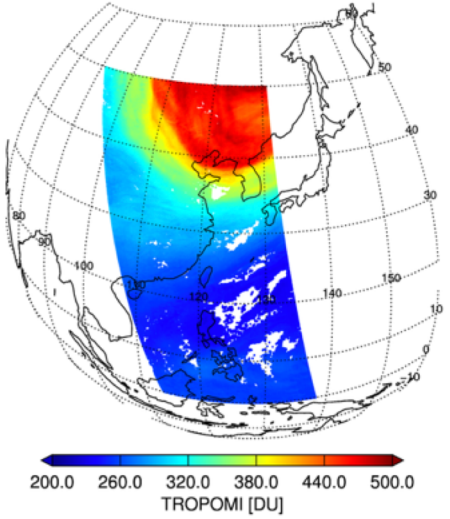
GEMS L2 Algorithm

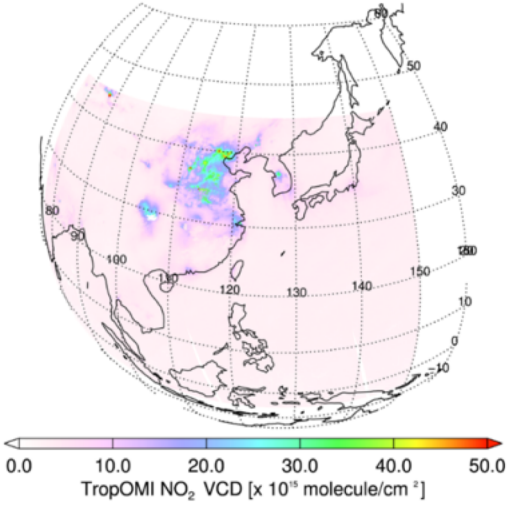






TROPOMI L2 (Operational)





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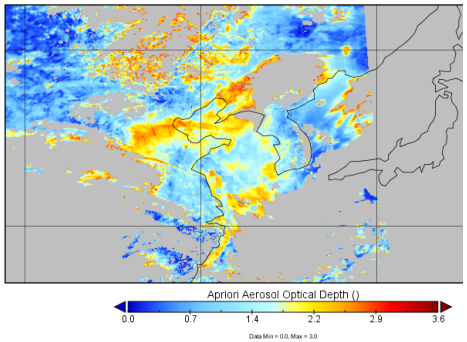
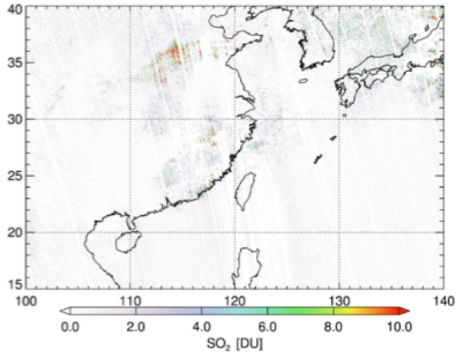
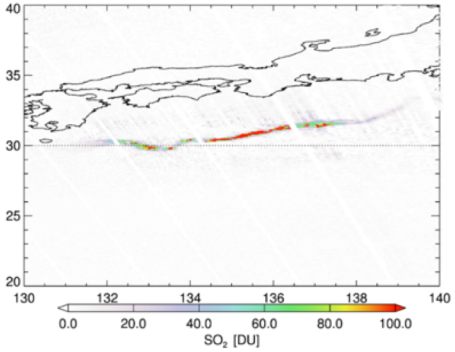
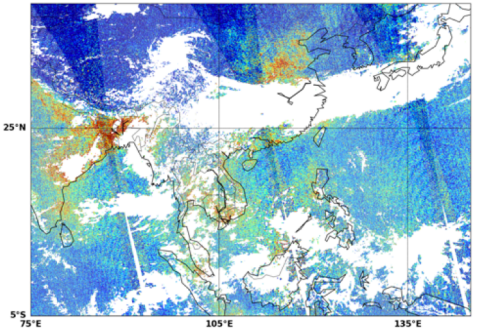
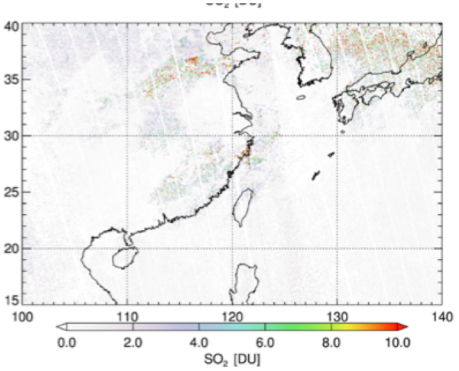
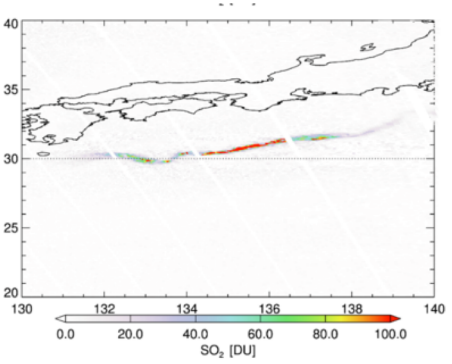
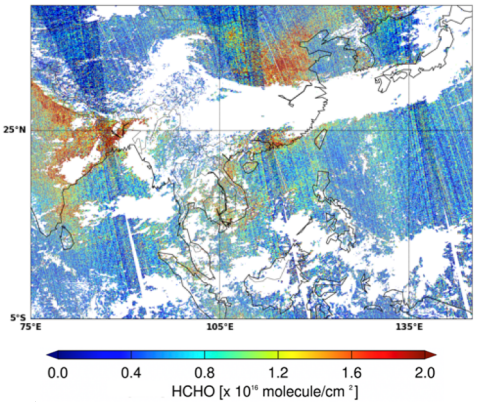
GEMS L2 Algorithm Test with TROPOMI L1b

	Aerosol 2019.03.4	**PBL SO2** 2019.02.19	**Volcanic SO_2** 2019.1.7	**HCHO** 2018.5.31
GEMS L2 Algorithm				
TROPOMI L2 (Operational)				
	Long range transport	Anthropogenic emission	The eruption of Kuchinoerabujima volcano	

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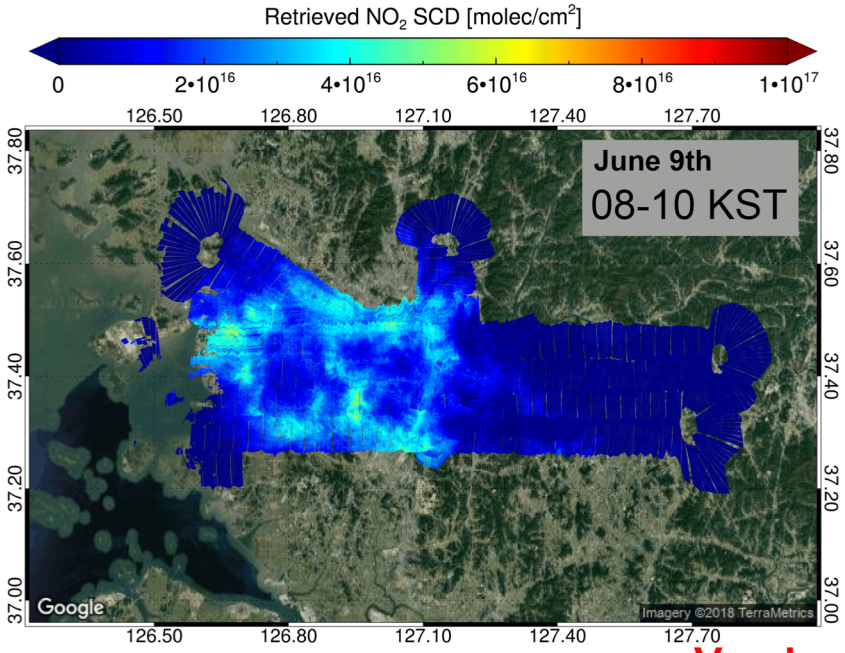
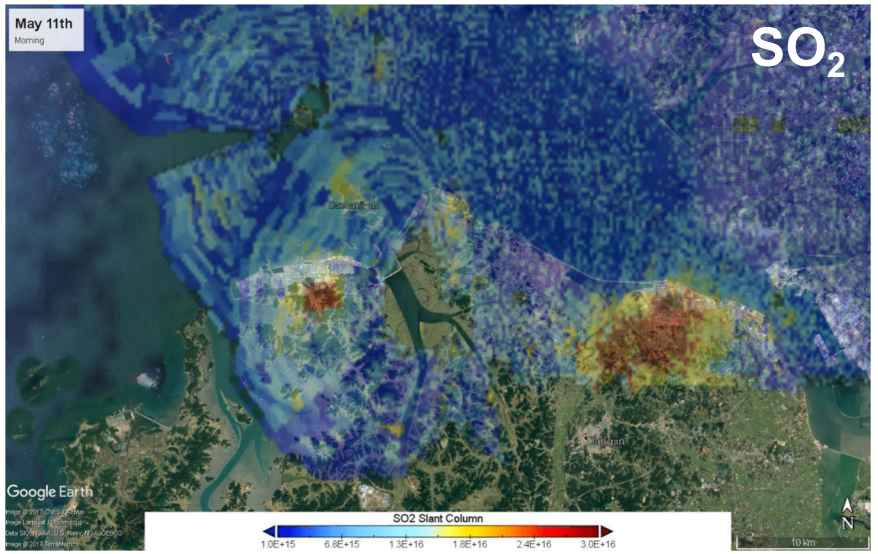
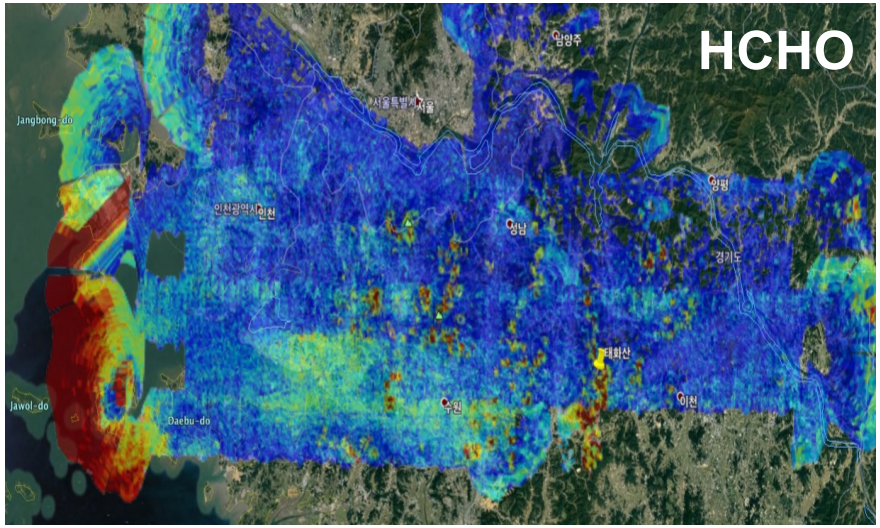
Algorithm Test with GEOTASO

- NO_2 : Emission from automobile detected, showing freeway structure. Increase in the late afternoon.
- SO_2: Point sources in west coast around power plants and steel mill captured well with the GeoTASO retrieval.
- HCHO : Many hot spots identified at the south of Seoul Metropolitan City





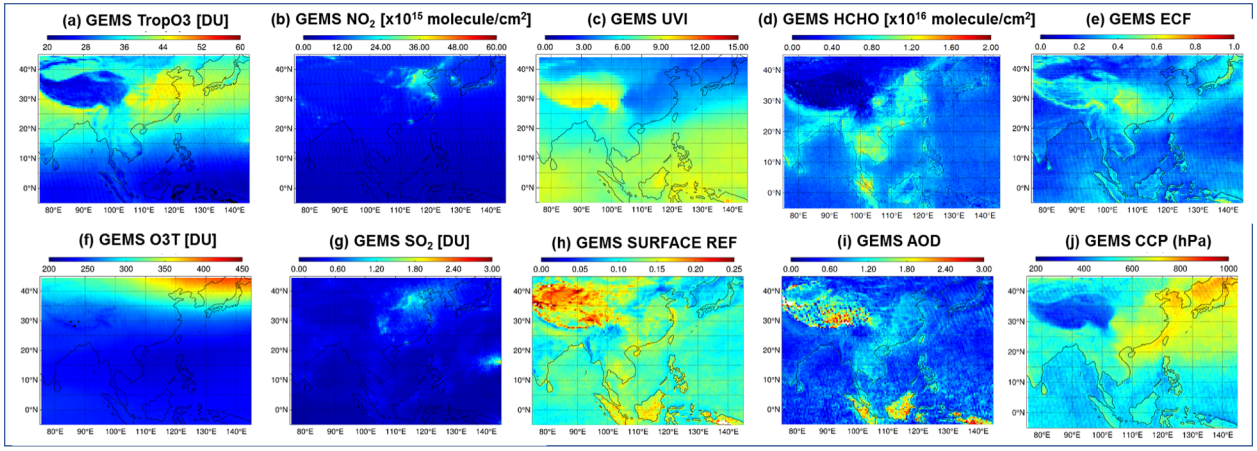


Version of L1B data: V2y

Scott Janz, Jay Al-Saadi

GEMS L2 Algorithm Test with OMI L1B

[Mean value of GEMS L2 simulated with OMI L1B (0.5° x 0.5°)]

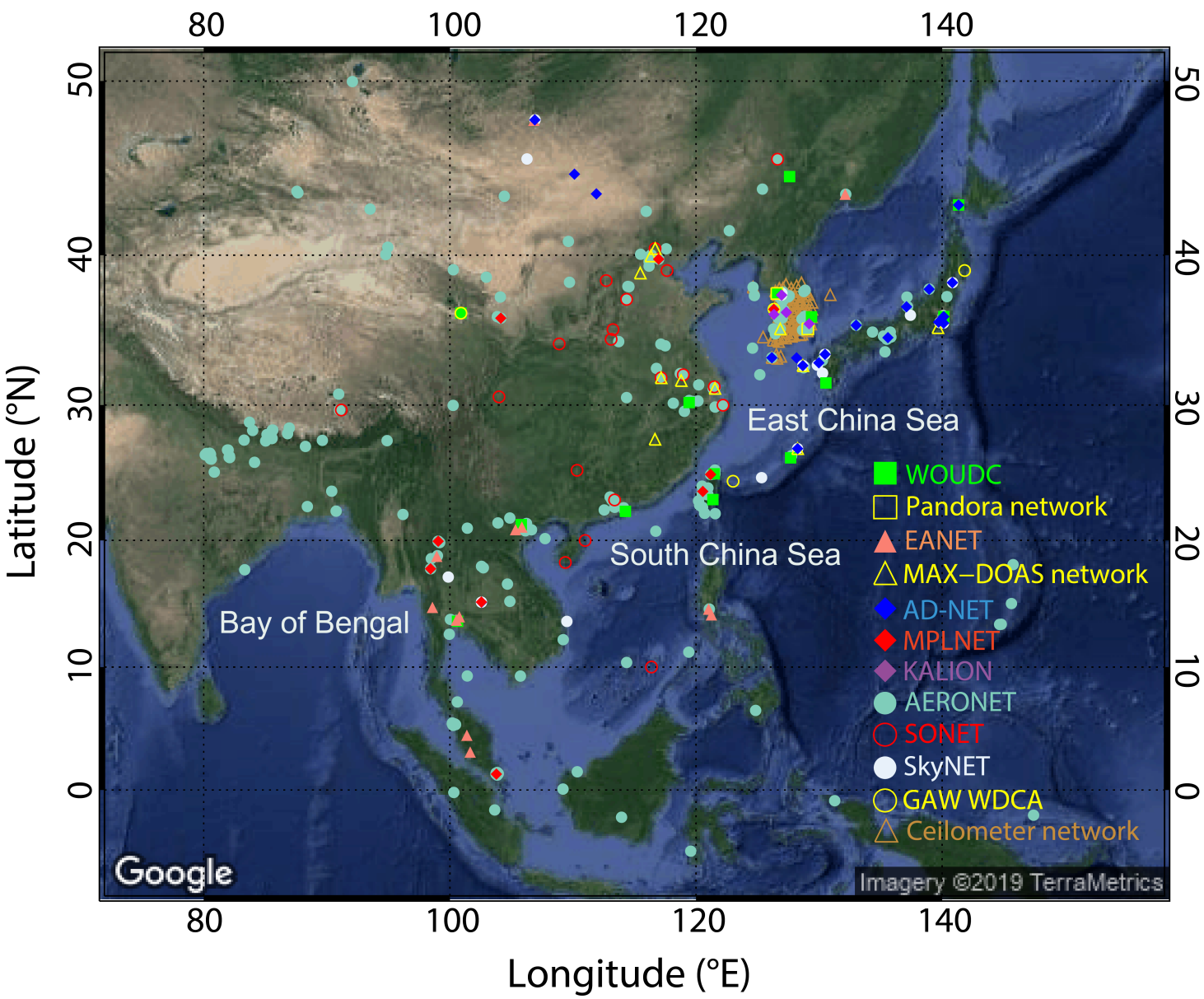


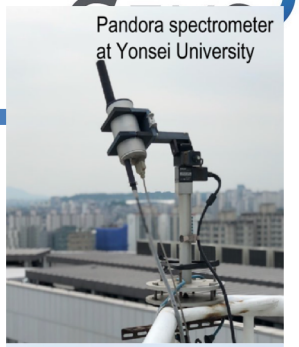
- Periods : 2005.01.01 – 2005.12.31
- Retrieved products were validated with ground-based measurement data or OMI Level 2 operational products.

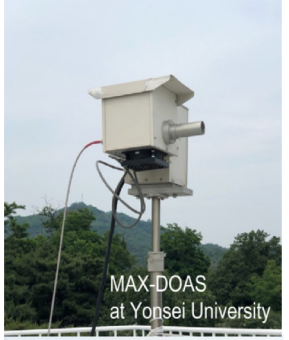
[Intercomparison results of GEMS algorithm using OMI L1b data V003]

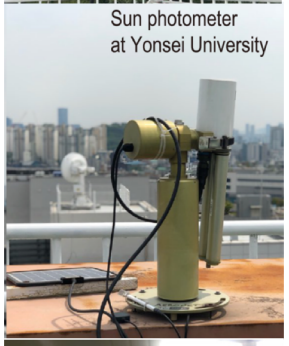
	Corr.(R)	Slope	Intercept	RMSE	References	Credits
O_3 (Total)	0.97	1.00	2 DU	2.53 DU	Brewer Spectro-photometer	Jae H. Kim
O_3 (Trop)	0.93	1.07	-3.14 DU	5.14 DU	Ozonesonde	
HCHO	0.92	1.01	3.3 x 10^{14} molec/cm^2	3.14 x 10^{15} molec/cm^2	OMI Products	Rokjin J. Park
NO_2	0.87	1.34	-2.29 x 10^{15} molec/cm^2	2.66 x 10^{15} molec/cm^2	OMI Products	Hanlim Lee
SO_2	0.75	0.72	0.15 DU	0.43 DU	OMI Products	
ECF	0.96	0.96	0.007	0.026	OMI Products	Yong-Sang Choi
CCP (ECF>0.2)	0.94	0.99	-28.45 hPa	68.11 hPa	OMI Products	
Surface Ref.	0.76	-	-	0.033	MODIS BRDF	Kwon-Ho Lee
AOD	0.85	0.83	0.16	0.27	AERONET	Jhoon Kim
UV Index	0.99	1.02	-0.07	0.54	OMI Products	

GEMS Validation Network









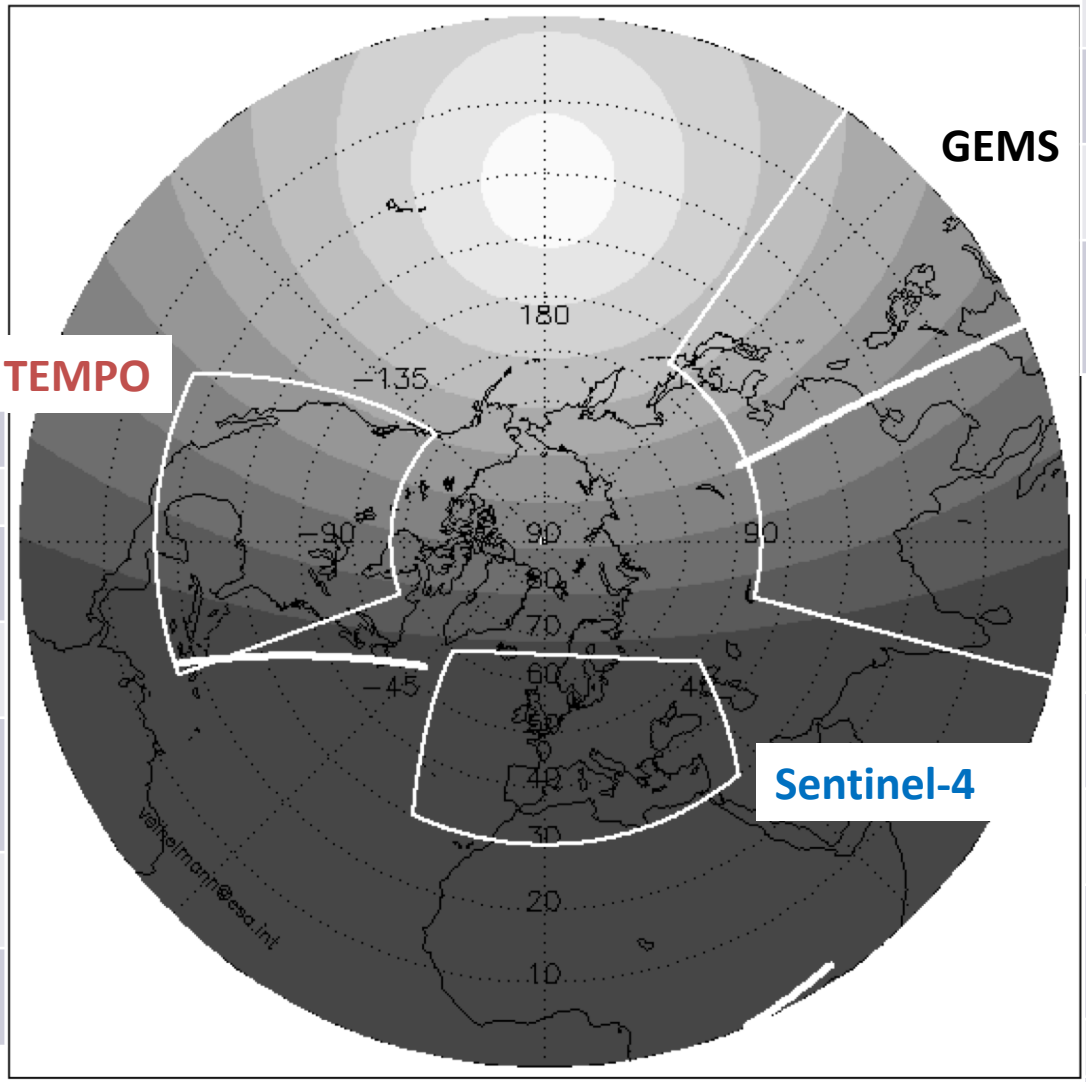
GEMS Validation Network

Network Name	Network Full-name	Instrument	Observation	Reference, (homepage)	GEMS Product	YSU, Seoul
WOUDC	World Ozone and Ultraviolet Radiation Data Centre	Dobson spectrophotometer	TO_3, O_3 umkehr	Fioletov et al. (1999), (https://woudc.org)	TO_3, O_3 profile	✓
		Brewer spectrophotometer	TO_3, O_3 umkehr, AOD, SO_2 total column density, UV irradiance, UV index		TO_3, SO_2, AOD, UV index	✓
Pandora network	Pandora network	Pandora spectrometer	Total columns of O_3, NO_2, HCHO, their vertical profiles	Herman et al. (2009), (https://pandora.gsfc.nasa.gov, http://pandonia.net)	TO_3, NO_2, HCHO	✓
EANET	Acid Deposition Monitoring Network in East Asia	Wet and dry sampler	Wet deposition (sulfate), dry deposition (concentrations of SO_2, NO_2, and O_3)	Sugimoto and Uno (2009), (http://www.eanet.asia)	SO_2, NO_2, Tropospheric O_3	
MAX-DOAS network	Multi-Axis Differential Optical Absorption Spectroscopy network	MAX-DOAS	Tropospheric NO_2, AOD	Kanaya et al. (2014) (https://ebcrpa.jamstec.go.jp/maxdoashp)	Tropospheric NO_2, AOD	✓
AD-NET	Asian dust and aerosol LIDAR observation network	LIDAR	Extinction coefficients of attenuated backscatter, aerosol, dust, spherical particle	Sugimoto and Uno (2001), (http://www-lidar.nies.go.jp/AD-Net)	AOD, AEH	
KALION	Korea aerosol LIDAR observation network		Attenuated backscatter coefficient, aerosol extinction coefficient	Kim et al. (2015), (http://www.kalion.kr)		
MPLNET	NASA Micro-Pulse LIDAR Network		Cloud heights, thin cloud extinction optical depths, cloud phase, aerosol height*, aerosol depolarization ratio profiles*	Welton et al. (2001) (https://mplnet.gsfc.nasa.gov)		
AERONET	Aerosol Robotic Network	Sun photometer	Size distribution, refractive index, phase functions, water vapor, Angstrom exponent, fine mode fraction, AOD, SSA	Holben et al. (1998), (https://aeronet.gsfc.nasa.gov)	AOD, SSA	✓
SONET	Sun–sky Radiometer Observation Network	Sun photometer		Li et al. (2018), (https://aeronet.gsfc.nasa.gov)		
SKYNET	Sky radiometer network	Sky radiometer	AOD, SSA	Takamura (2004), (https://www.skynet-isdc.org)		✓
SPARTAN	Surface PARTiculate mAtter Network	Air Photon	Mass concentration; Chemical components (e.g. BC, SO_4^{2-}, NO_3^-, NH_4^+)	Snider et al. (2015), (https://www.spartan-network.org/)	AOD, SSA, AI,	✓
GAW WDCA	Global Atmosphere Watch World Data Centre for Aerosols	Aerosol sampler	Aerosol particle number concentration, size distribution, light scattering coefficient, AOD	WMO/GAW report No. 153 (2003), (https://www.gaw-wdca.org)	AOD	
Ceilometer network	Ceilometer network	Lidar	Cloud bottom height, cloud fraction	Münkel et al. (2010) (https://data.kma.go.kr/data/)	Cloud fraction	✓

*Only available at AERONET observation times

A Day in the Life of the Constellation (May 31)

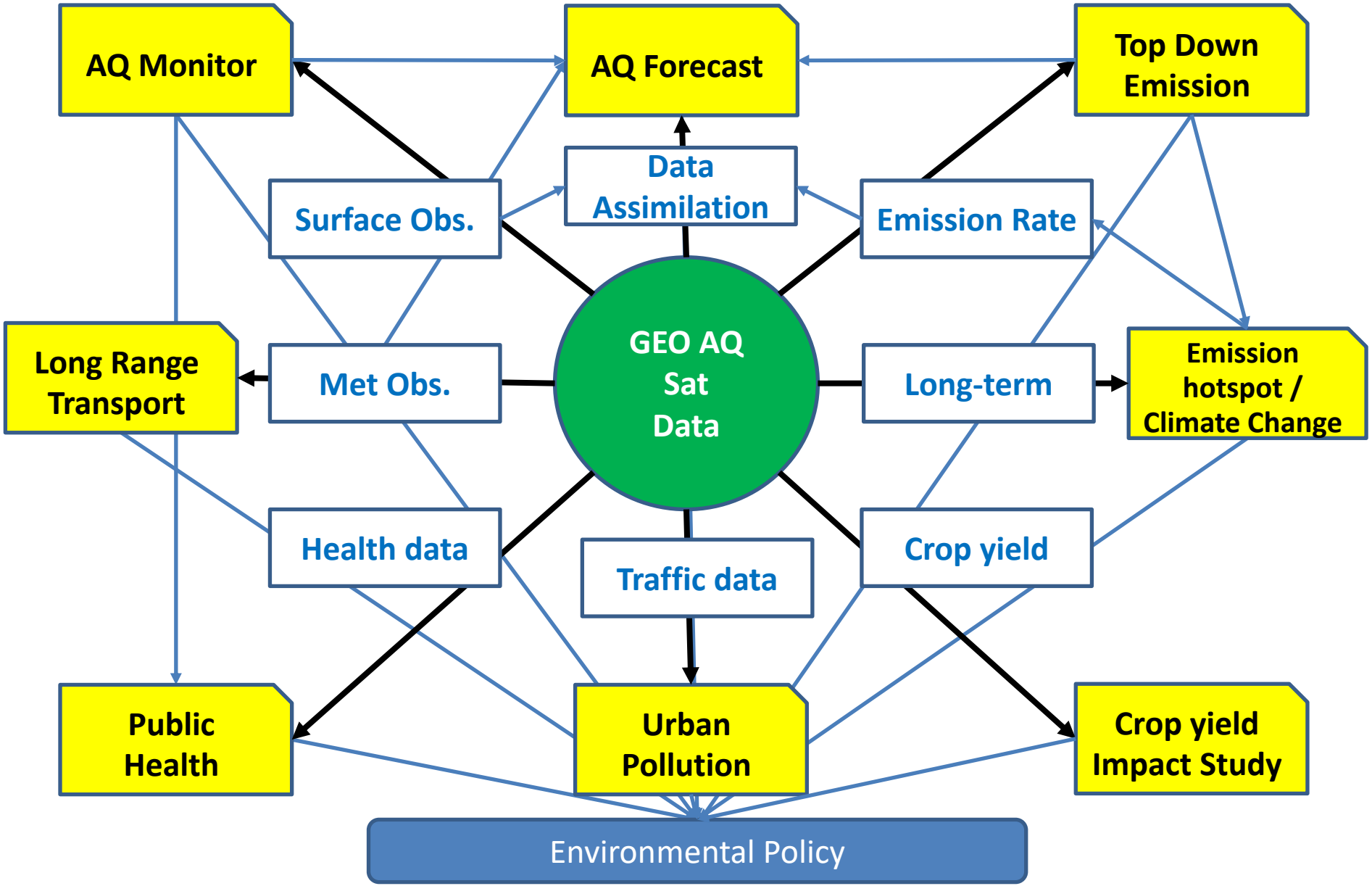
	TEMPO	GEMS	Sentinel-4
Revisit	1 hour	1 hour	1 hour
Status	Instrument delivery 2018	S/C AIT for GK-2B	Detailed Design, Phase C
Launch	2019-2021 pending host selection	Oct 2019 – Mar 2020	2021 (Flight Acceptance Review first instrument)
Payload	UV-Vis 290-490, 540-740 nm	UV-Vis 300-500 nm	UV-Vis-NIR 305-500, 750-775 nm
Products	O_3, trop. O_3, 0-2km O_3, NO_2, HCHO, SO_2, CHOCHO, AOD, AAI	O_3, NO_2, SO_2, HCHO, AOD, AI, AEH	O_3, trop. O_3, NO_2, SO_2, HCHO, AAI, AOD, height-resolved aerosol
Spatial Sampling	≤ 2.22 km N/S x 5.15 km E/W @35N	3.5 km N/S x 8 km E/W @38N	8 km x 8 km at 45N
Nominal product resolution	≤ 8.88 km N/S x 5.15 km E/W @35N	7 km N/S x 8 km E/W @38N (gas), 3.5 km N/S x 8 km E/W @38N (aerosol)	8.9 km N/S x 11.7 km E/W @40N
	+GOES-R/S ABI	+ AMI	+ MTG-I/S



w/TROPOMI, GF-5, MAIA @ LEO

Courtesy, Ben Veihelmann (graphic) & Jay Al-Saadi (data)

GEO AQ Sat Data Application & Service



SUMMARY

- GEMS is to be launched no later than March 2020, to form GEO AQ Constellation with TEMPO and Sentinel-4 in early 2020s.
- GEMS science algorithms Ver. 1 is to be delivered to GEMS Ground Station, ESC by the end of June. These algorithms have been tested with L1b data from OMI, TROPOMI, GEOTASO, and simulated radiance spectra, and validated.
- Overall, TROPOMI L2 operational algorithm and GEMS algorithm captured high concentration episodes well. Both products showed good agreement in spatial distribution for Total Ozone, NO_2, SO_2, HCHO, UV aerosol index. However, absolute values between the two products showed slight differences possibly due to the differences in algorithms, spectroscopic data, surface albedo and spectral calibration.
- Machine learning algorithm also showed possibility to estimate surface concentration from columnar measurements of GEMS for aerosols. Similar work is under the development for trace gases by NIER.
- GEO AQ data can be applied to diverse areas including public health, crop yield studies, climate changes, in addition to air quality monitoring.

CEOS

GEMS