Committee on Earth Observation Satellites

Status of GEMS*

*GEMS: Geostationary Environmental Monitoring Spectrometer

Environmental Satellite Center,

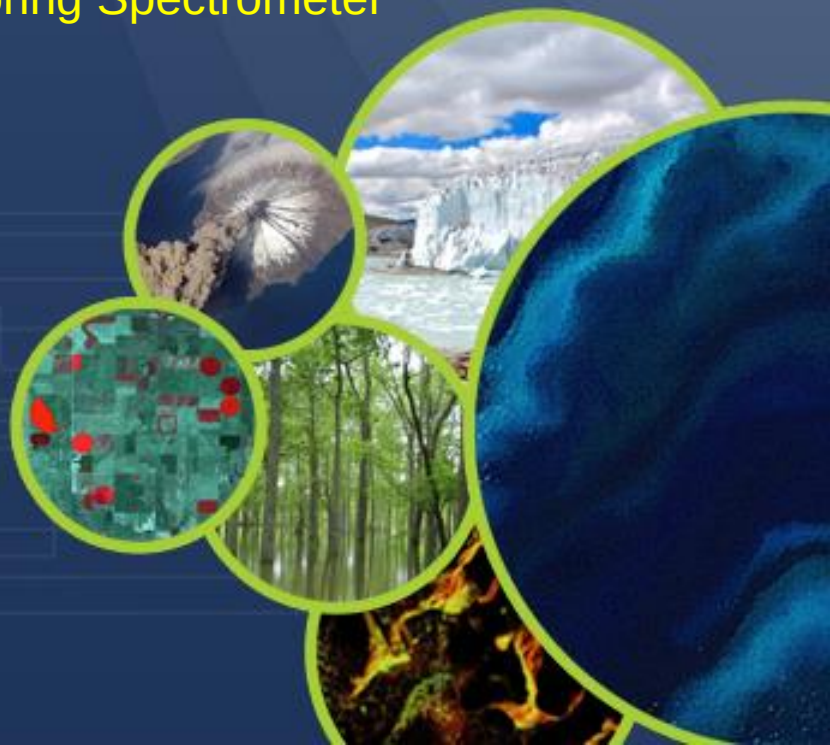
National Institute of Environmental Research

CEOS Plenary 2019

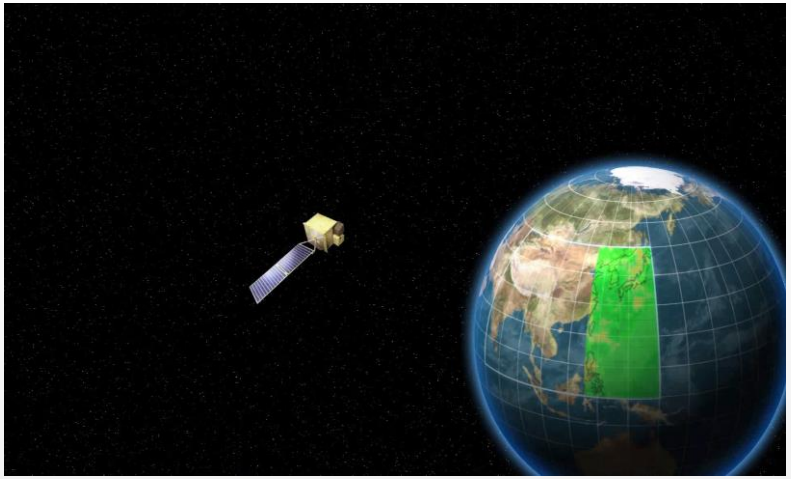
Agenda Item #3.6

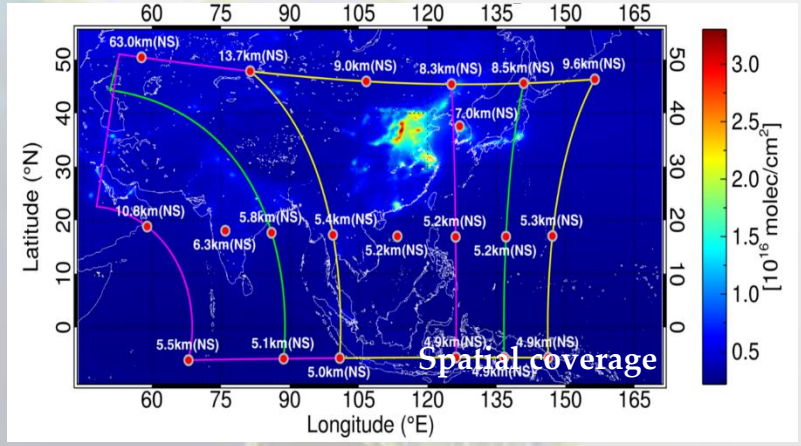
Ha Noi, Viet Nam

14 – 16 October 2019



GEMS: Geostationary Environmental Monitoring Spectrometer





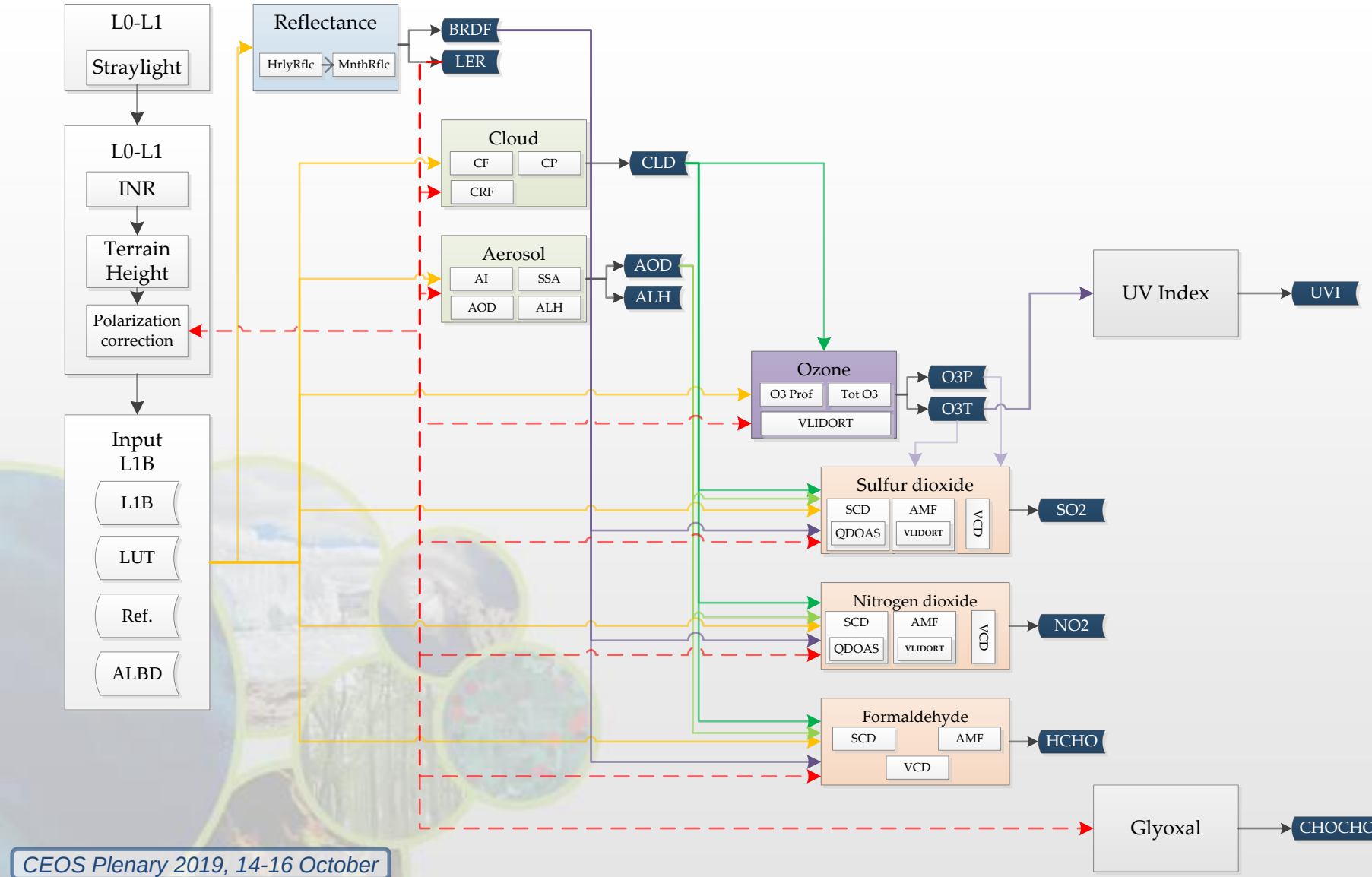
Spatial coverage

Targeted gases	**O_3, SO_2, NO_2, HCHO, CHOCHO, and aerosol, etc.**
Lifetime	10 Years
Spatial coverage	5,000 km × 5,000 km (5 °S – 45 °N, 75 °E – 145 °E)
Spatial resolution	7 km × 8 km @Seoul
Revisit time	8 times / day
Spectral range / FWHM	300 – 500 nm / 0.6 nm
Volume / Weight	1,050 mm × 1,200 mm × 900 mm / 160 kg
Orbit / Altitude / Longitude	Geostationary earth orbit (GEO) / 35,786 km / 128 °E

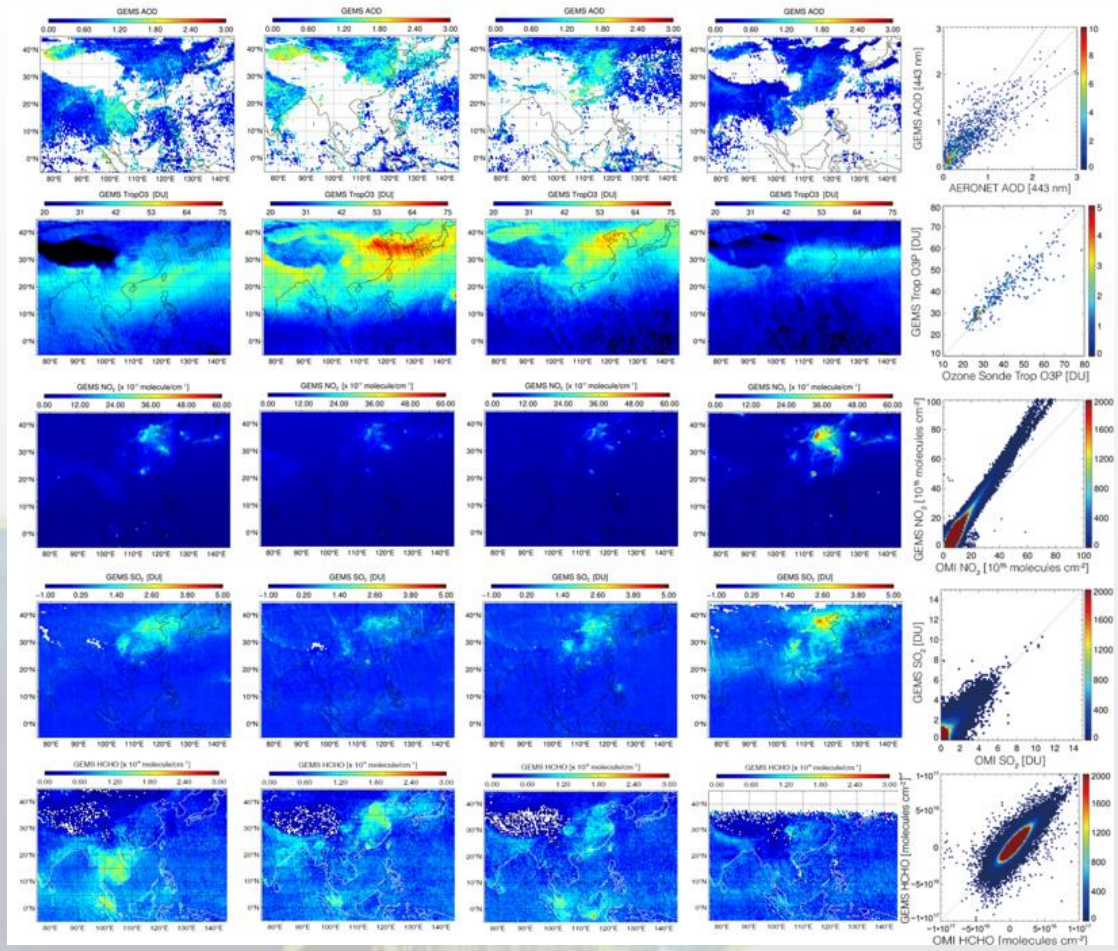
Products of GEMS

Product	Importance	Accuracy	Window (nm)	Spat. Resol. (km^2)@Seoul	SZA (deg)	Algorithm
TropNO_2 StratNO_2	O_3 precursor, pollutant	$1x10^{15}$ cm^{-2}	425-450	7 x 8 x 2 pixels	< 70	DOAS
SO_2	Aerosol precursor, Volcano	$1x10^{16}$ cm^{-2}	310-330	7 x 8 x 4 pixels x 3 hours	< 50 (60*)	DOAS + PCA
HCHO	VOC proxy	$1x10^{16}$ cm^{-2}	327-357	7 x 8 x 4 pixels	< 50 (60*)	BOAS
CHOCHO		$1x10^{16}$ cm^{-2}	437-452	7 x 8 x 4 pixels	< 50	
TotalO3, StratO3, TropO3	Oxidant Pollutant O_3 layer	3%(Total) 5%(Stra) 20(Trop)	300-340	7 x 8	< 70	OE TOMS
AOD, AI, SSA, AEH	Air quality Climate	20% or 0.1@ 400nm	300-500	3.5 x 8	< 70	Multi-λ O_2O_2
[Clouds] ECF, CCP, CRF	Retrieval Climate		300-500	7 x 8	< 70	O_2-O_2 RRS
Surface Property (LER, BRDF)	Environment		300-500	3.5 x 8	< 70	Multi-λ
UVI VitaD/DNA/Plant dose rate	Public health		300-360	7 x 8	< 70	Multi-λ

L2 Processor Interface of GEMS



Performance test of GEMS algorithms using OMI LV1B radiances



Aerosol	
Algorithm	Optimal estimation (OE)
Wavelength (nm)	354, 388, 443, 478, 490

Ozone (profile/total)	
Algorithm	OE / TOMS
Wavelength (nm)	300 – 340/ 312, 317

NO_2	
Algorithm	DOAS
Fitting range (nm)	432 – 451

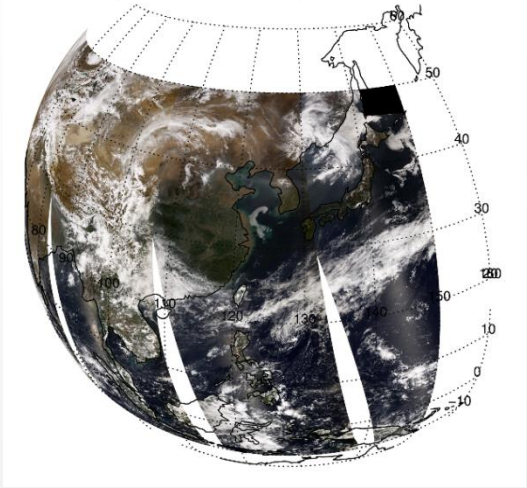
SO_2	
Algorithm	PCA + DOAS
Fitting range (nm)	310 - 326

HCHO (CHOCHO)	
Algorithm	BOAS
Fitting range (nm)	328 – 356 (435 – 461)

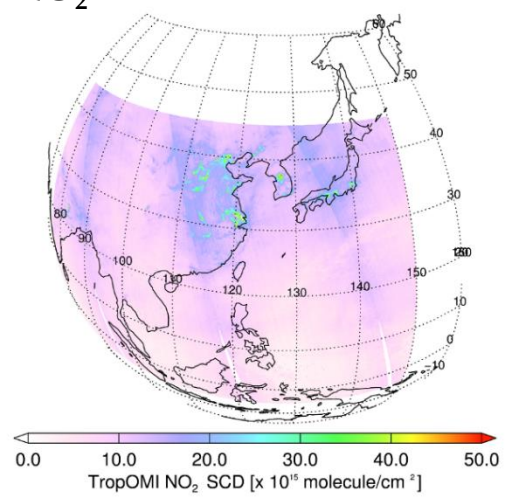
(Courtesy, GEMS algorithm team)

Performance test of GEMS algorithms using TROPOMI LV1B radiances

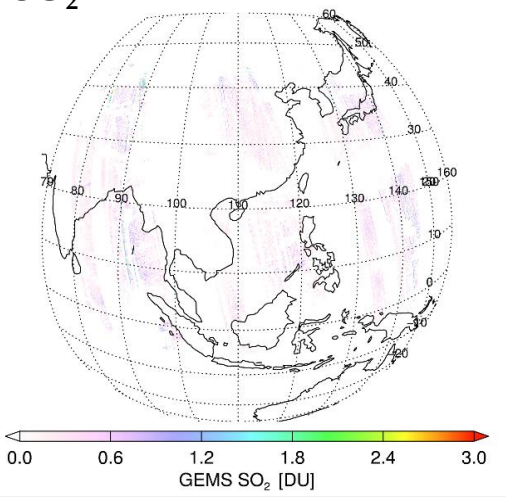
RGB (2018.04.19.)



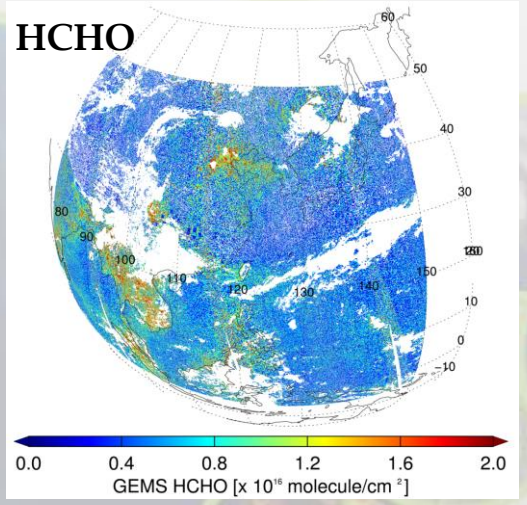
NO_2



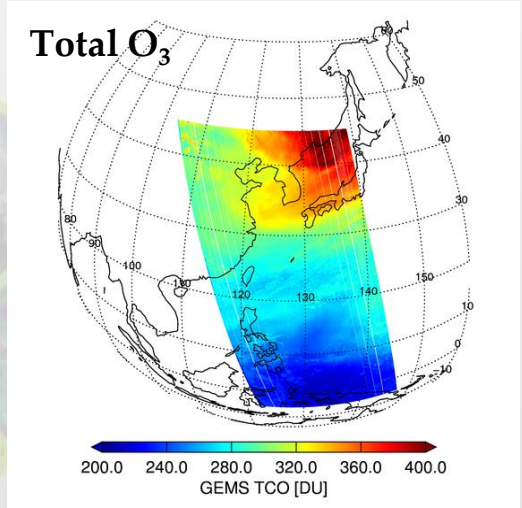
SO_2



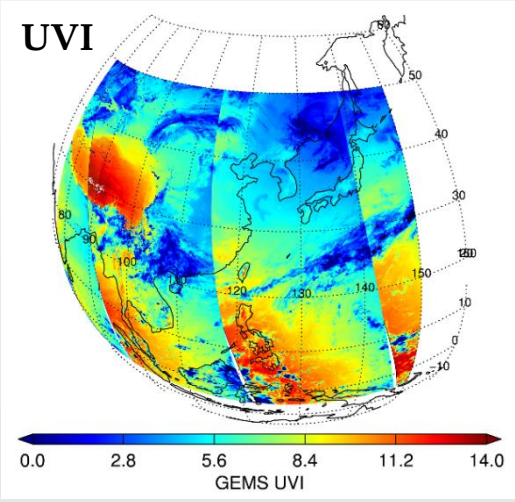
HCHO



Total O_3



UVI

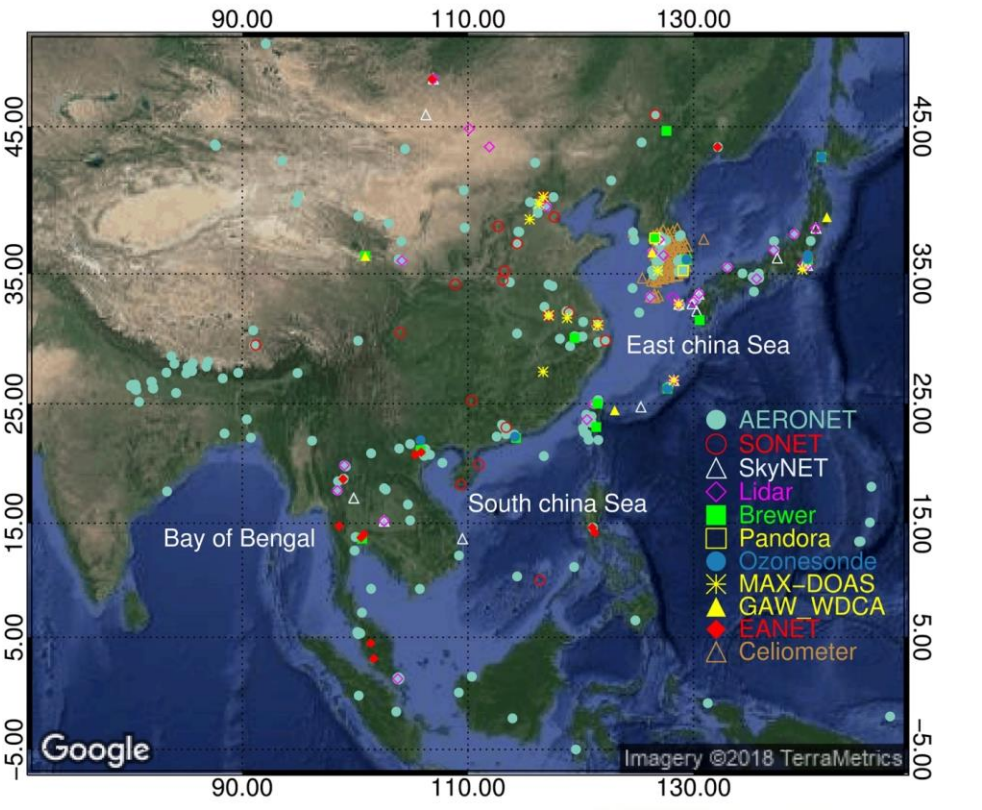


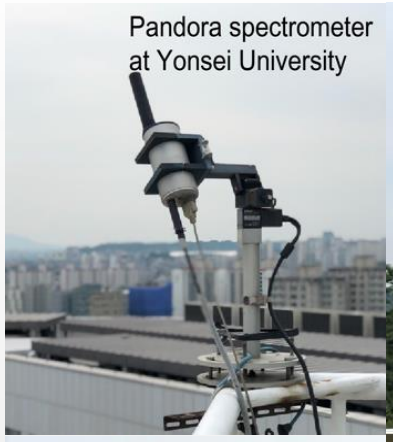
(Courtesy, GEMS algorithm team)

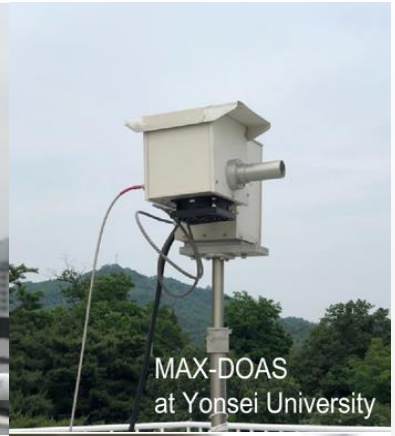
Evaluation of product accuracy

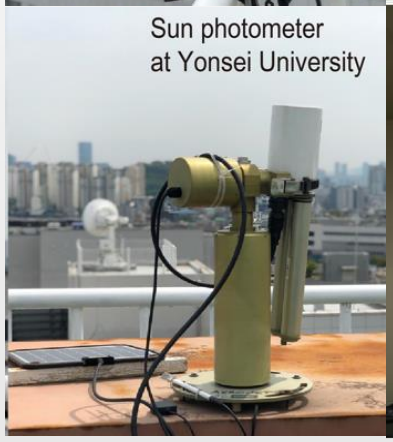
2017.12	Correlation coefficient (R)	a, Slope	b, Intercept	RMSE	Error (%)	*Reference*
O_3 (Total)	0.97	0.955	5.4 DU	*2.35%*	-	*Brewer Spectro-photometer*
O_3 (Trop)	0.79	0.89	1.91 DU	*6.48 DU (10-20%)*	2 DU *(7.29%)*	*Ozonesonde*
HCHO	0.86~0.88 (MAM/JJA/SON) 0.61 (DJF)	0.96 – 1.07	-1.4-3.1 x 10^{15}	-	-	OMI Products
NO_2	0.90~0.98	1.07~1.2	-0.99-1.22 x 10^{15}cm^{-2}	*N/A*	-	OMI Products
SO_2	0.98 0.66 (<1 DU) 0.72 (<3 DU)	0.4 0.89 0.81	0.06 DU 0.1 DU 0.06 DU	*N/A*	*53.5 %* - -	OMI Products Airborne
ECF	0.99	1.0	*0.03*	*0.03~0.05*	*N/A*	OMI Products
CCP	0.89	0.97	*-30*	*95*	*N/A*	OMI Products
Surface Refl. (BRDF)	0.8~0.9	*N/A*	*N/A*	*<0.1*	<40%	OMI Products MODIS BRDF
AOD	0.84	0.78	N/A	T/V	Q-value : 53.44%	*AERONET*

Ground observation network for CAL/VAL of GEMS products





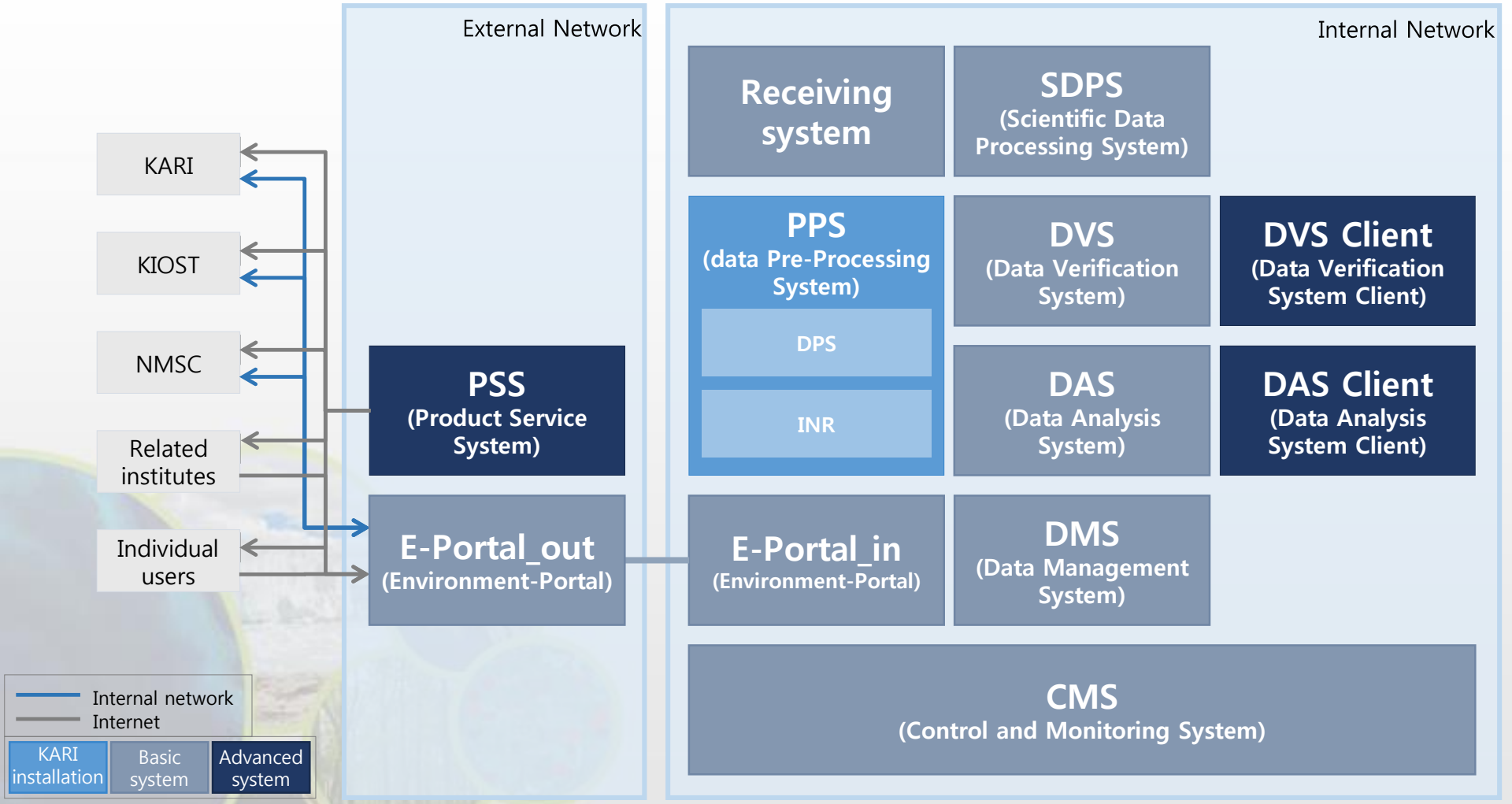




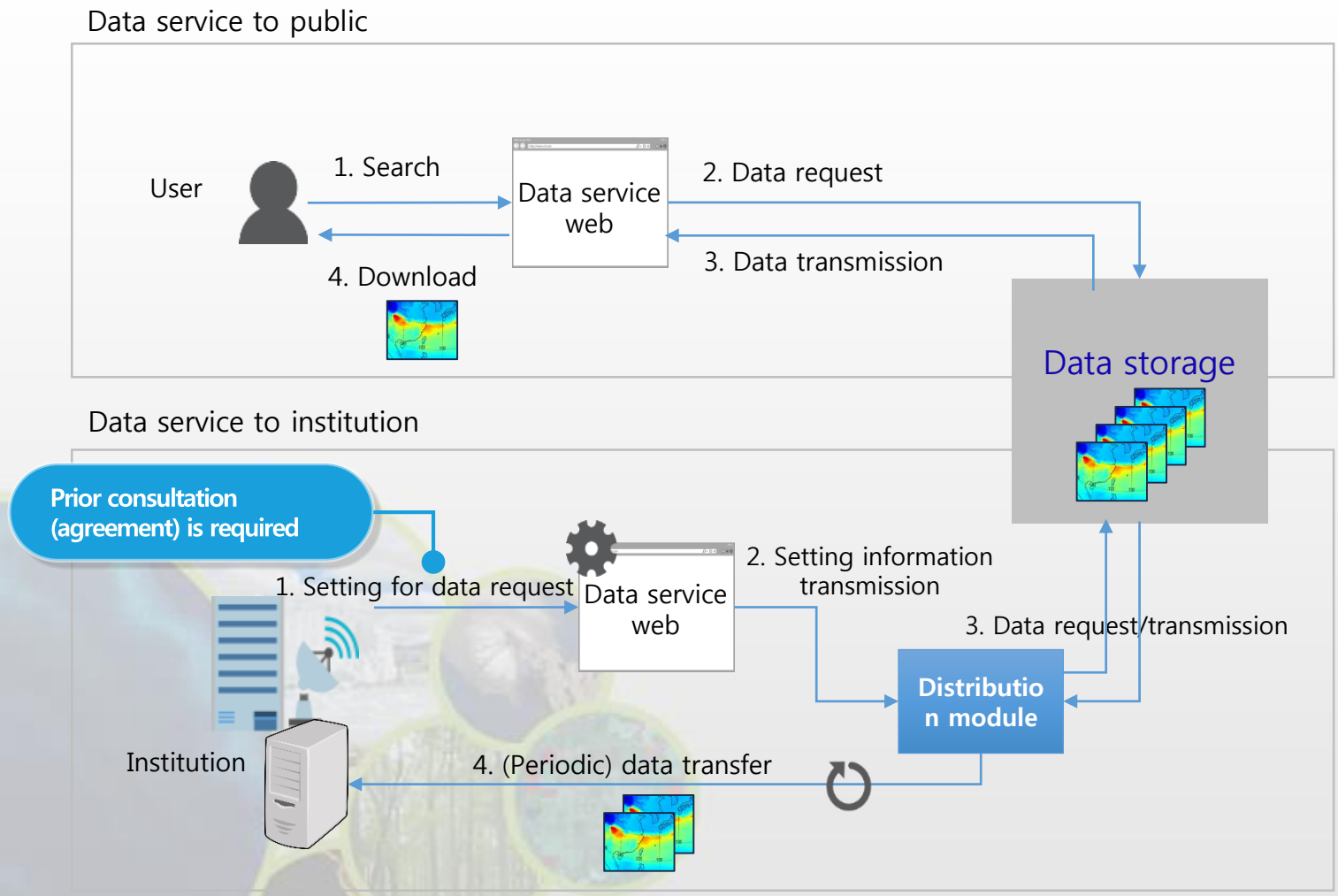
GEMS operation concept

Operational Concept	Explanation
Non-stop Operation	**Non-stop Operating ground station for 24hours and 365days** Securing stability and non-stop automation through active-active high stability multiplexing Constructing an operation system in emergencies and at all times Establishment of back-up system for each sub system
Real-time Service	**Acquisition in real-time and distribution in near-real-time** Distribution within 1hour after receiving RAW data Improvement of processing efficiency through algorithm parallelization
Operation for 10years	**Operating 10 years according to designed duration of GK2B operation** Considering expansion possibilities of hardware, software, network, and new facilities
Data archive	**Archiving all data in main storage, that is received and produced** Building storage system that can expand and meet storage requirements
Back-up system	**Constructing back-up system for data reliability** Non-stop Operating with rapid substitution in case of failure Establishment of back-up system to meet system operation concept and requirements
High Availability	**Achieving 99% or more operational availability for high-speed processing and customized services with Hot backup system**

GEMS operation system



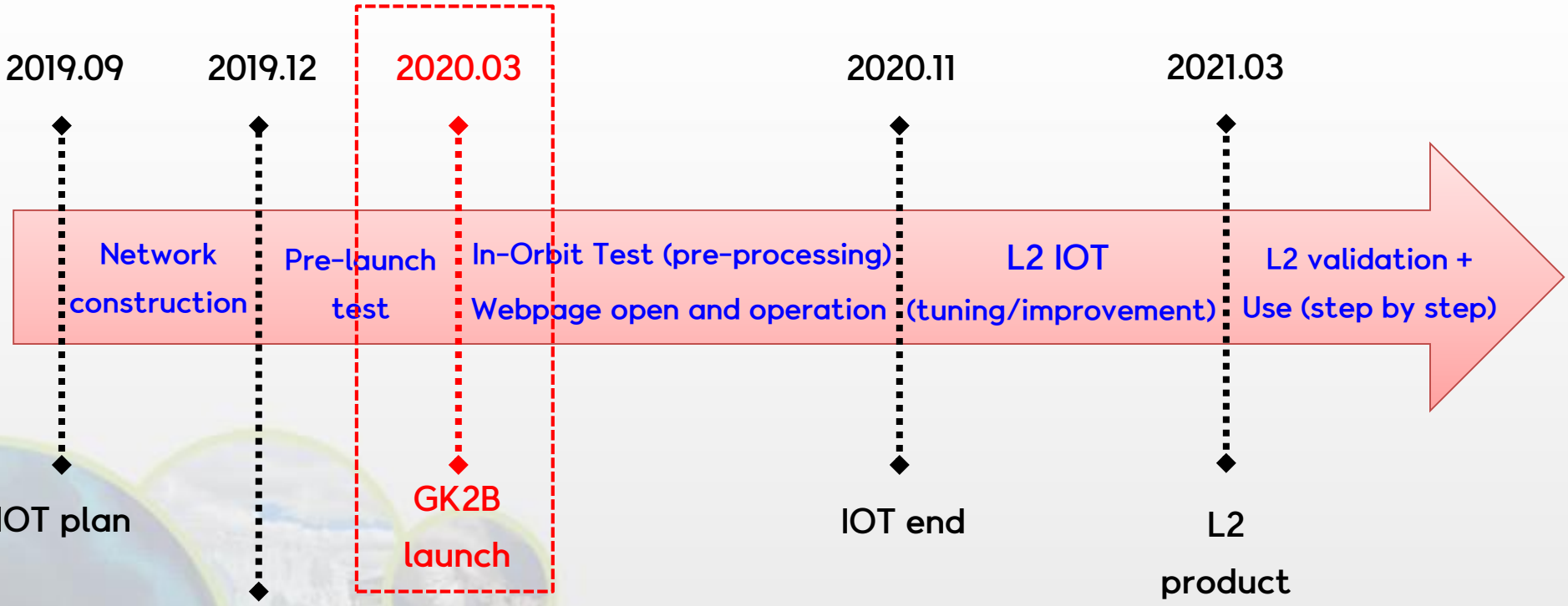
GEMS data distribution



Providing web-based service that is easy to access for general users

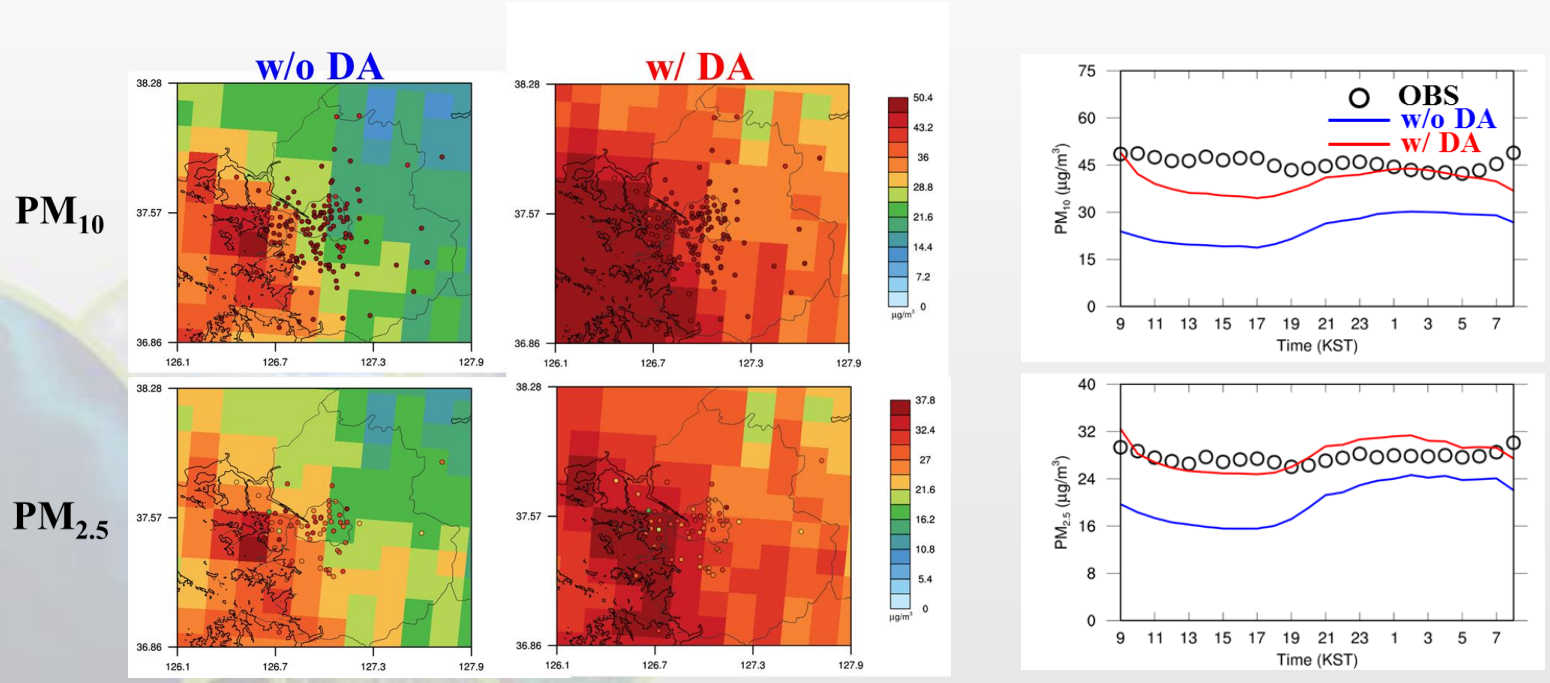
Providing sftp-based service for periodic/large data

GEMS IOT schedule



GEMS application

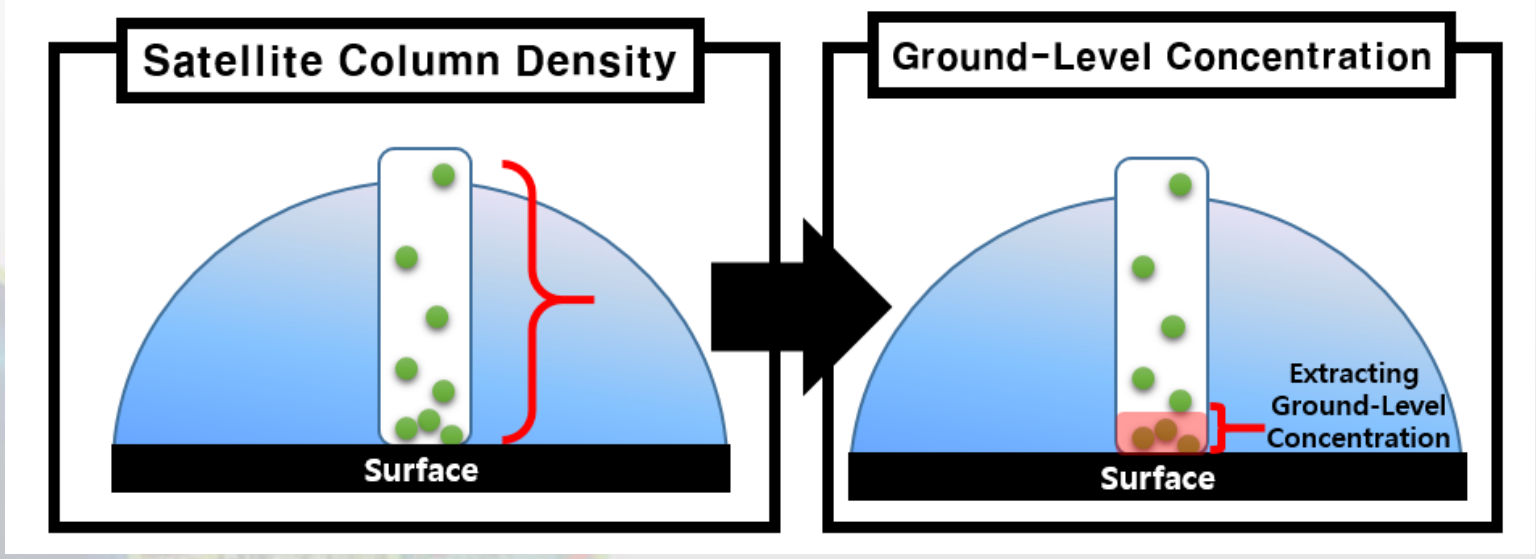
- Monitoring long-range transported pollutants.
- Estimating top-down emission inventories.
- Providing reliable initial conditions of chemistry-transport models (CTMs) for air quality forecasts via data assimilation (DA) techniques.



< PM forecasts during KORUS-AQ campaign (May 1 ~ June 12, 2016) >

A limitation of column density retrieved from GEMS

- Column density retrieved from satellite represents aerosol or trace gases abundance from surface to top of atmosphere.
- Air pollution concentration of near the surface is more important than column density, since those closely related to human health.

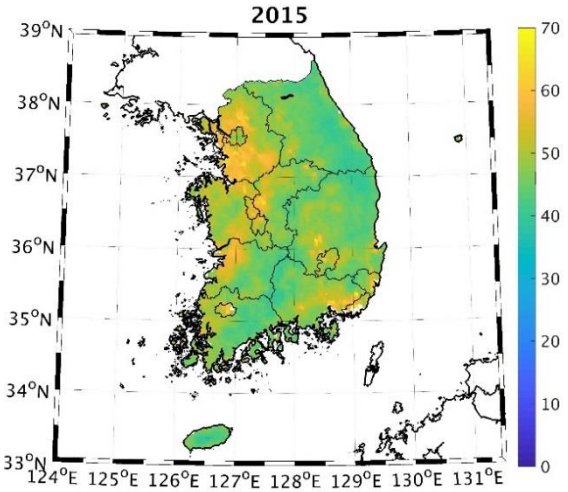


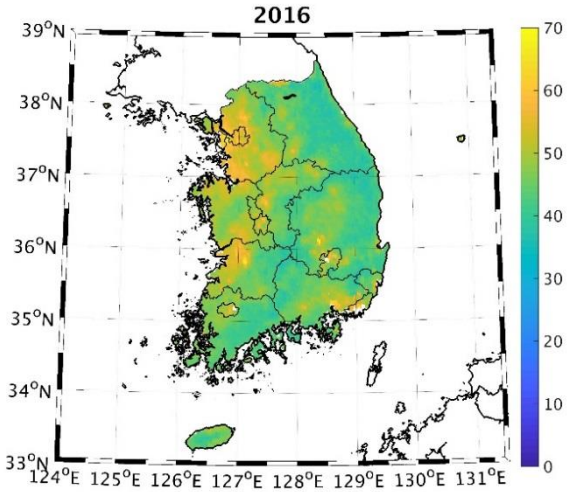
Estimation of surface PM2.5 concentration based on machine learning

- PM2.5 concentrations over Korea peninsula estimated based on machine learning is well described high value in winter season
- In addition, PM2.5 concentrations represent high value in April due to the influence of the yellow dust.

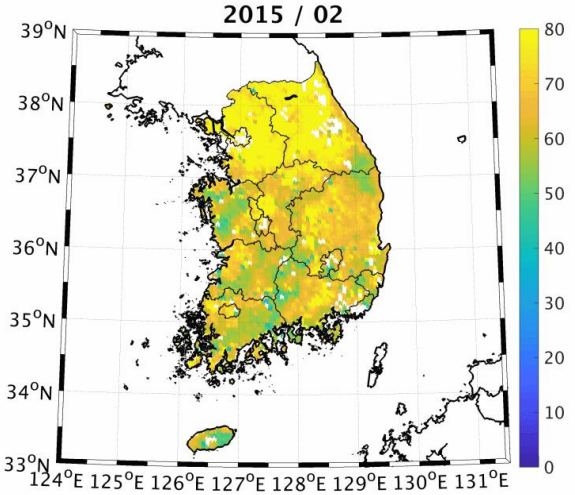
Yearly and monthly PM_{10} distribution (2015 ~ 2016)

Yearly

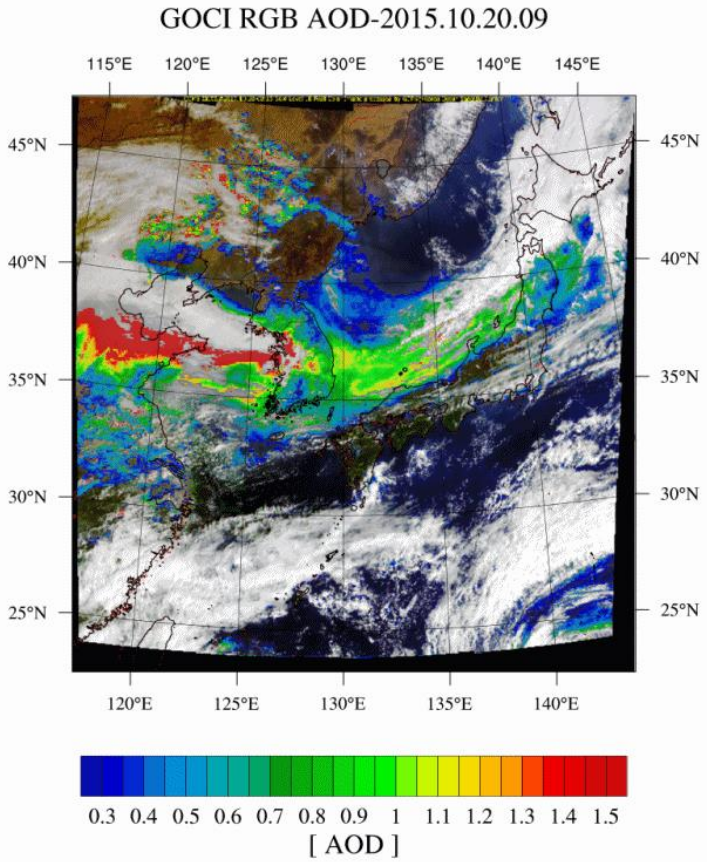


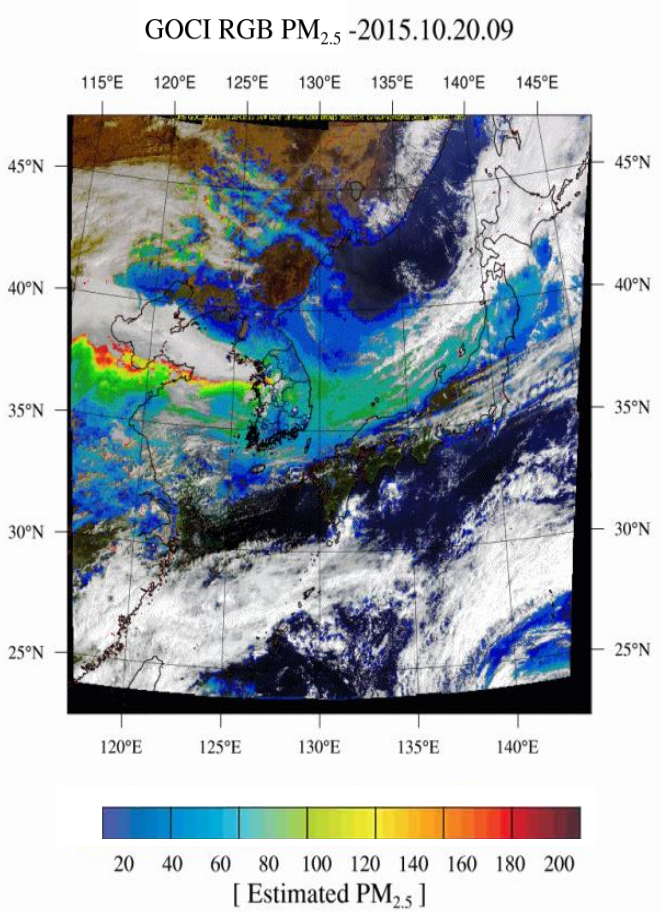


Monthly



Estimation of surface PM2.5 concentration using in-situ observation data





Presenter Guidance

- Presenters should name their files using the following convention:
  - AgendaItemNumber_LastName_Subject_Version.pptx *(e.g., 1.5_Holloway_Communications_v2.pptx)*
- ***Reporting to support discussion or decision is encouraged***, but historical context and detailed reporting should be provided as pre-meeting reading material or in background slides.
- Materials should explicitly highlight the decisions, endorsements, outcomes, or actions you are seeking at Plenary. The more explicit you are with the required actions, the better. Do feel free to propose draft action text for consideration – it may be revised, but will help with the efficient preparation of the Plenary actions record.
- Materials should be sent to matthew@symbioscomms.com and kim.e.holloway@nasa.gov
  - **Documents for endorsement:** no later than **October 1**
  - **Presentations:** no later than **October 8**