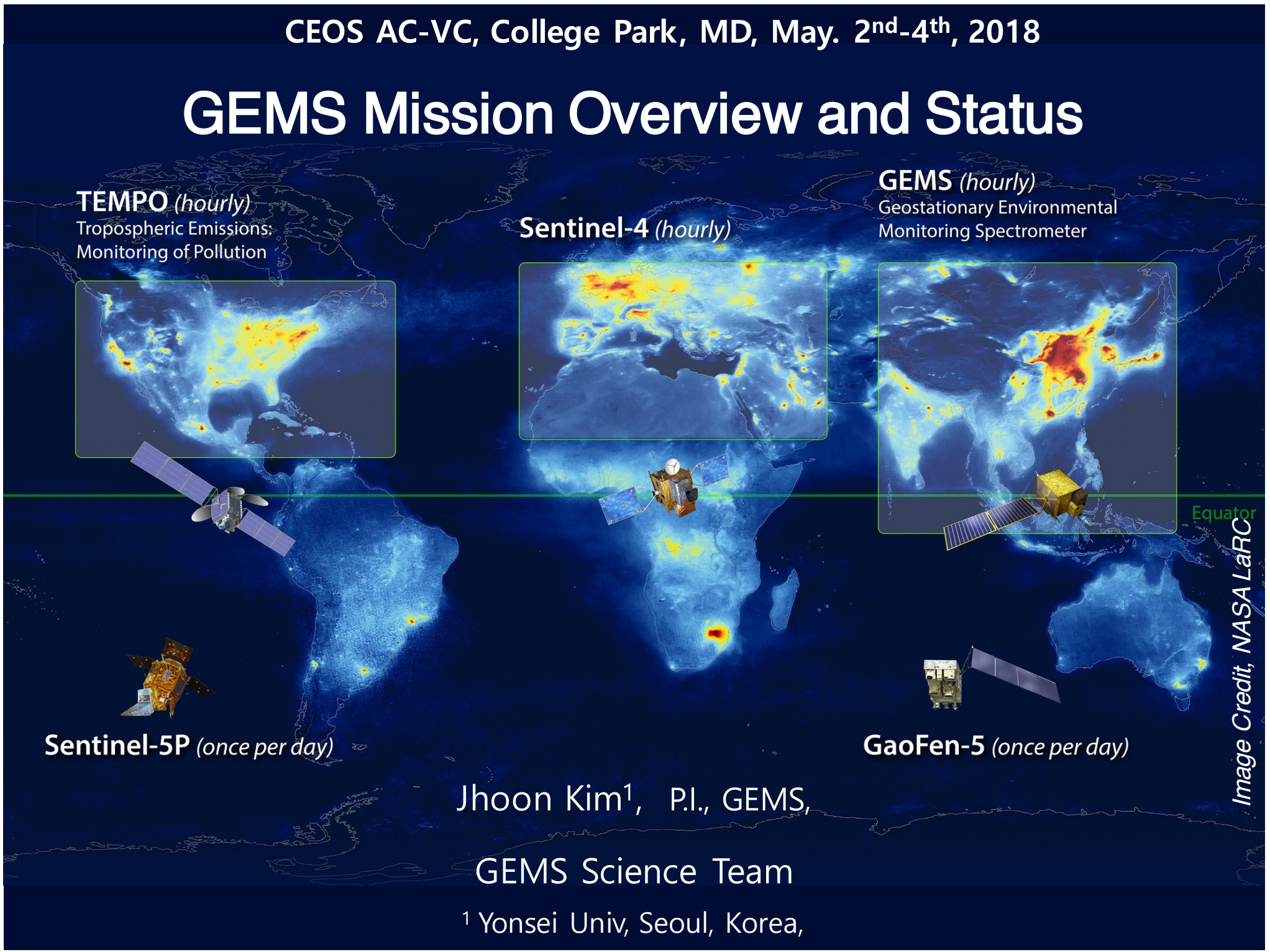
CEOS AC-VC, College Park, MD, May. 2nd-4th, 2018

GEMS Mission Overview and Status

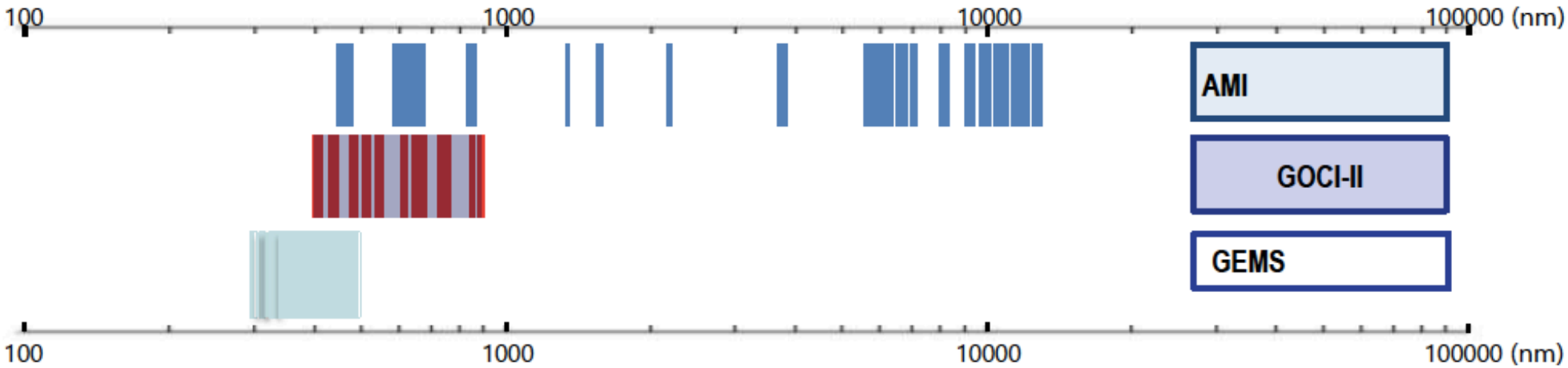


Jhoon Kim[1], P.I., GEMS,

GEMS Science Team

[1] Yonsei Univ, Seoul, Korea,

GK-2 Payloads



System Attributes	AMI (GK2A)	GOCI-II (GK2B)	GEMS (GK2B)
Spectral Range	470~1,330nm	370~885nm	300~500nm
Spatial Resolution	0.5~1km (VIS) 1~2km (IR)	< 250m (LA) < 1,000m (FD)	< 56Km^2 at Seoul
Spectral Resolution	400~1,000nm	10~40nm	0.6nm
No. of Channels	16	13	Hyper Spectral
Observation Coverage	FD, RA, ELA, LA	≥ 2,500×2,500km (LA) ≥+/-60deg (FD)	≥ 5,000km×5,000km, (45°N~5°S, 75°E~145°E)
Duty Cycle	FD : 6 times/hr	10 times/day Full Disc 1 time per day	≥ 8 times/day
Imaging Time	FD: 10 min, LA : 120 sec	≤ 30 min	≤ 30 min

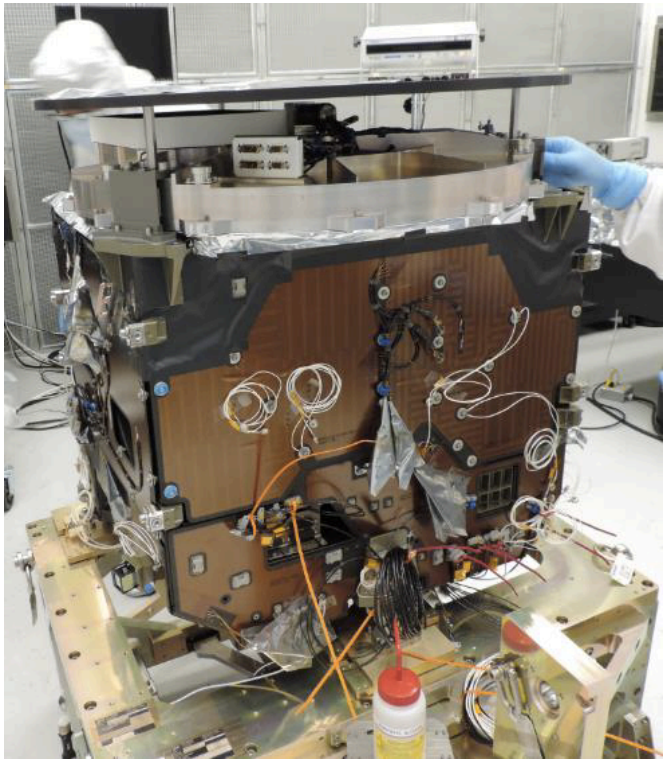
(Courtesy, KARI)

GEMS Instrument Flight Model

- Step-and-stare UV-Vis imaging spectrometer scanning at least 8/day in 30 min
- Daily solar and dark calibration

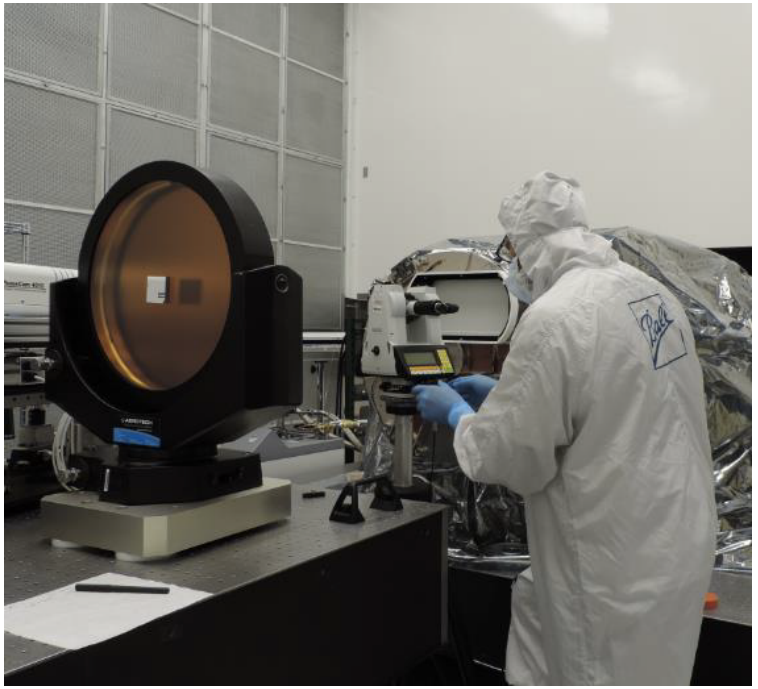
✓ Pre Shipment Review(PSR) finished in Jan. 26th, 2018, delivered to KARI in Feb., 2018

✓ GEMS launch window : Sep 2019 – Feb 2020



←*Thermal panel and CMA Installation*

Optical→ Alignment for Spatial Test



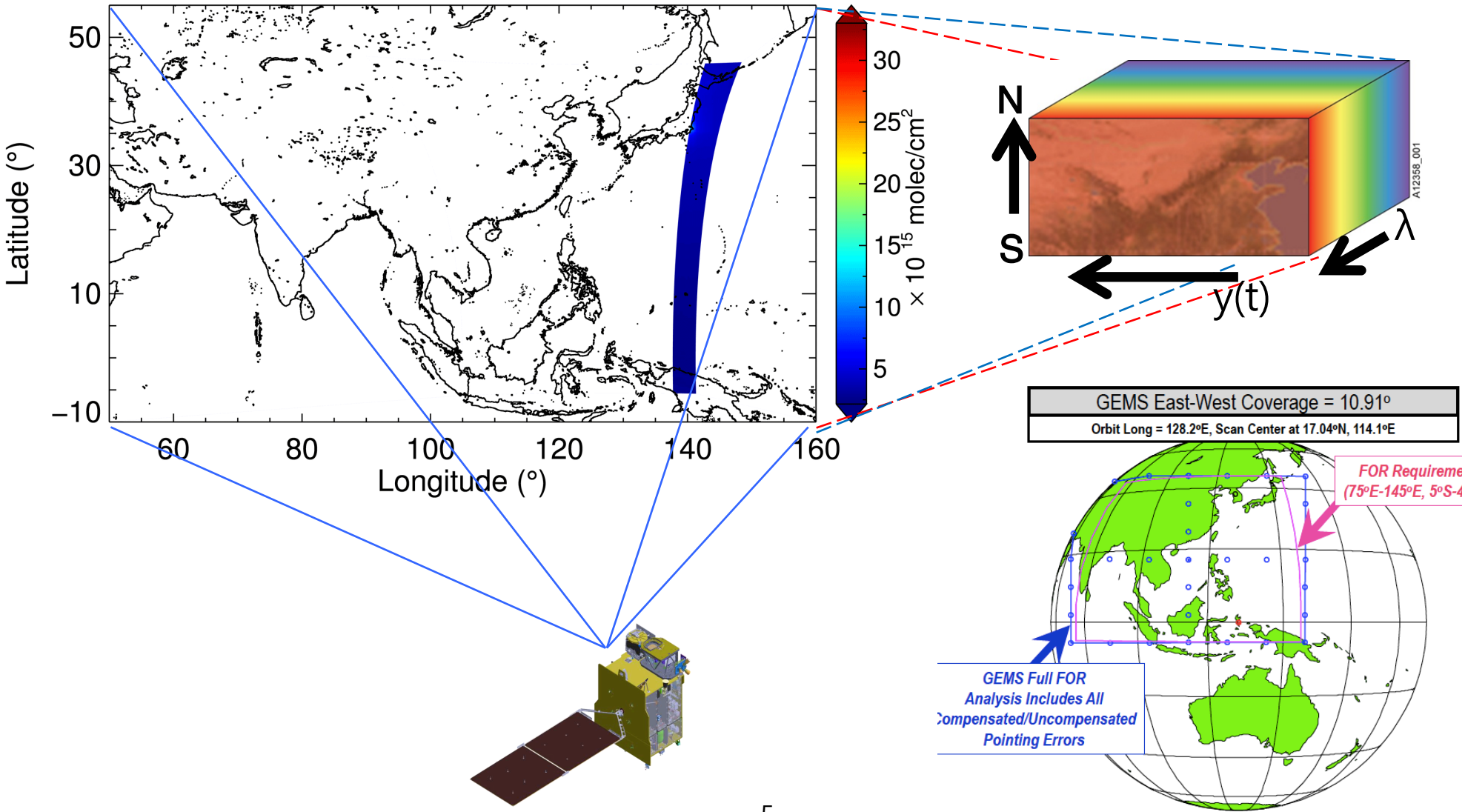
(Courtesy, KARI / BATC)

GEMS Products (16)

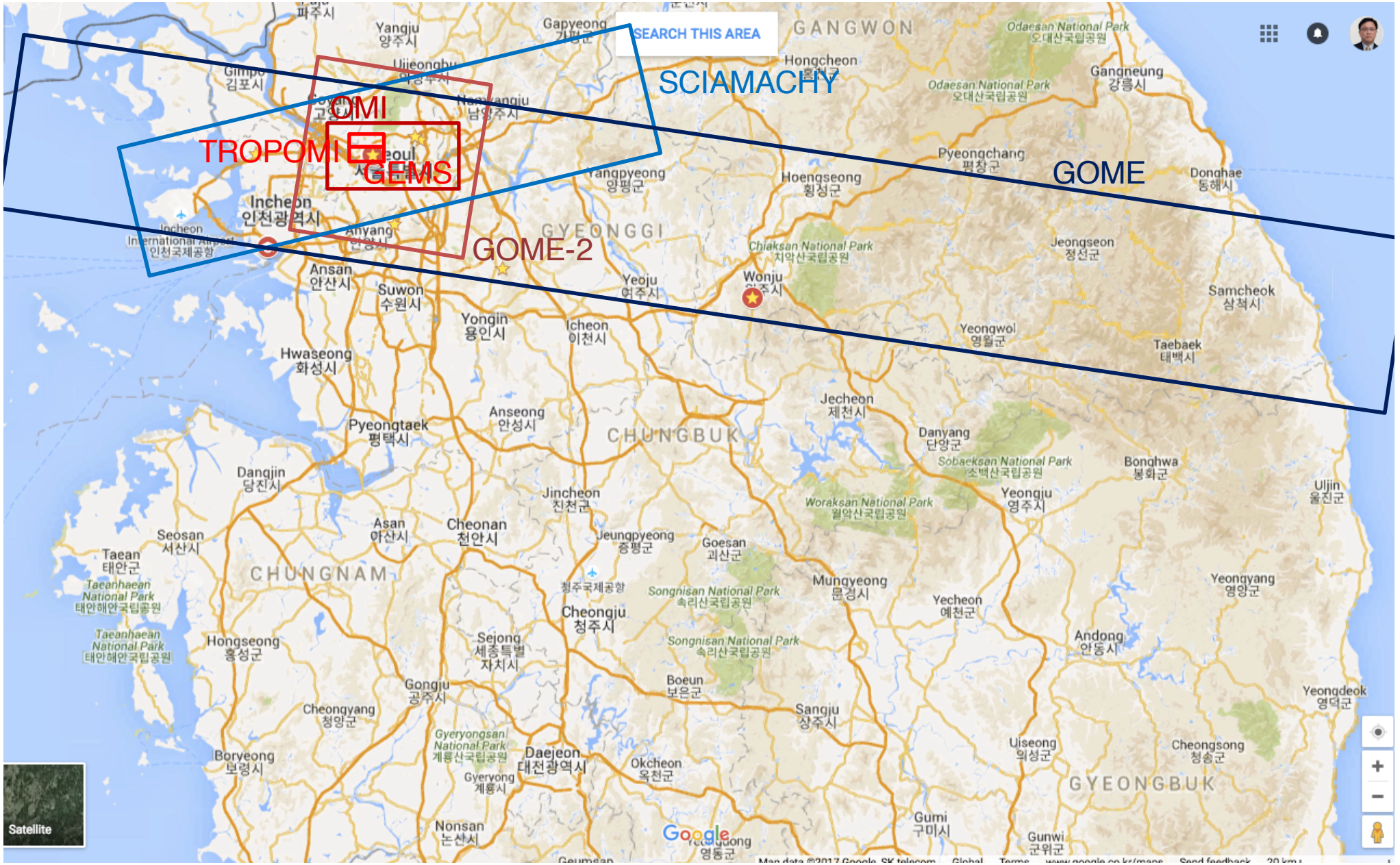
Product	Importance	Min (cm^{-2})	Max (cm^{-2})	Nominal (cm^{-2})	Accuracy	Window(nm)	Spat Resol (km^2)@Seoul	SZA (deg)	Algo-rithm
NO_2	O3 precursor	$3x10^{13}$	$1x10^{17}$	$1x10^{14}$	$1x10^{15}$ cm^{-2}	425-450	7 x 8 x 2 pixels	< 70	DOAS
SO_2	Aerosol precursor Volcano	$6x10^{8}$	$1x10^{17}$	$6x10^{14}$	$1x10^{16}$ cm^{-2}	310-330	7 x 8 x 4 pixels x 3 hours	< 50 (60*)	DOAS PCA
HCHO	VOC proxy	$1x10^{15}$	$3x10^{16}$	$3x10^{15}$	$1x10^{16}$ cm^{-2}	327-357	7 x 8 x 4 pixels	< 50 (60*)	DF
CHOCHO					$1x10^{16}$ cm^{-2}	437-452	7 x 8 x 4 px	< 50	
TropLO3 TropUO3 StratO3 TotalO3	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
AOD AI SSA AEH	Air quality Climate	0 (AOD)	5 (AOD)	0.2 (AOD)	20% or 0.1@ 400nm	300-500	3.5 x 8	< 70	Multi-λ O_2O_2
[Clouds] ECF CCP	Retrieval Climate	0 (COD)	50 (COD)	17 (COD)		300-500	7 x 8	< 70	O_2O_2 *RRS*
Surface Property	Environ-ment	0	1	-		300-500	3.5 x 8	< 70	Multi-λ
UVI	Public health	0	12	-			7 x 8	< 70	

GEMS

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



Spatial Resolution Comparisons



GEMS Processor

Earth Input (2112 * 1068)

Solar Input (2112 * 1068)

L0-1 Processor

- Dark Current correction (2112 * 1068)
- Stray Light (2048 * 1032)
- Spectral Calibration : squeeze, shift (2048 * 2)
- Radiometric Calibration (2048 * 2)

L1

INR

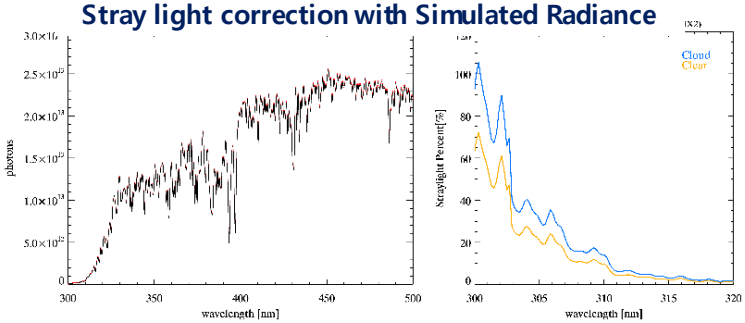
L1B

L1B-2 Processor

- Spectral Calibration (300-500nm, each fitting window)
- Surface Reflectance, Cloud
- Aerosol, O_3, NO_2, SO_2, HCHO, CHOCHO..

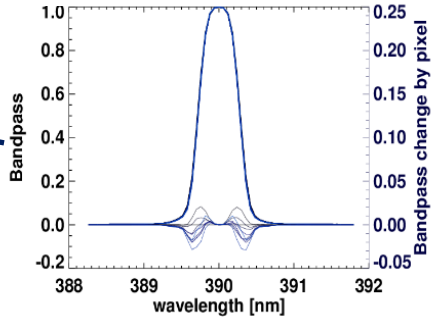
L2

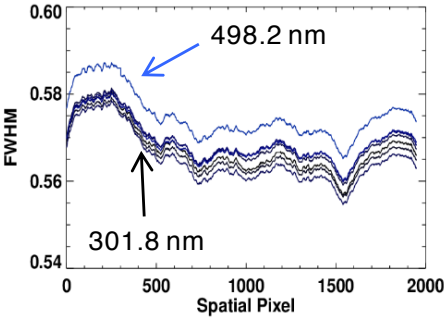
Stray light correction with Simulated Radiance



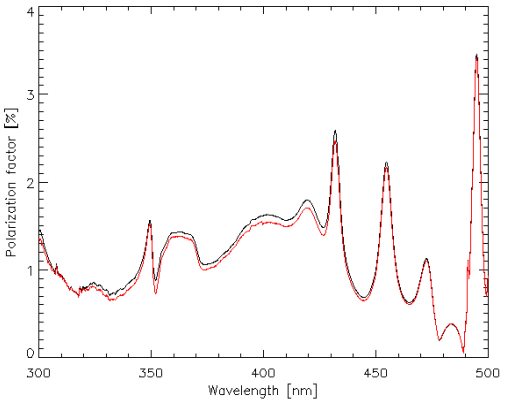
Dataset

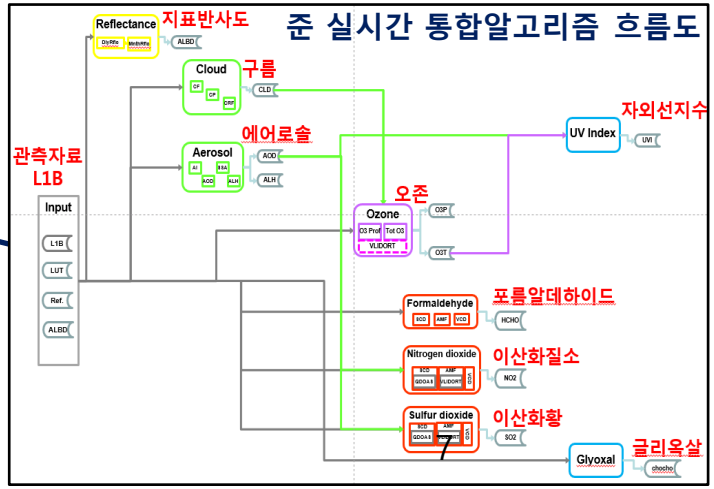
- Bandpass, FWHM Info
- Polarization





- INR
- Polarization Correction

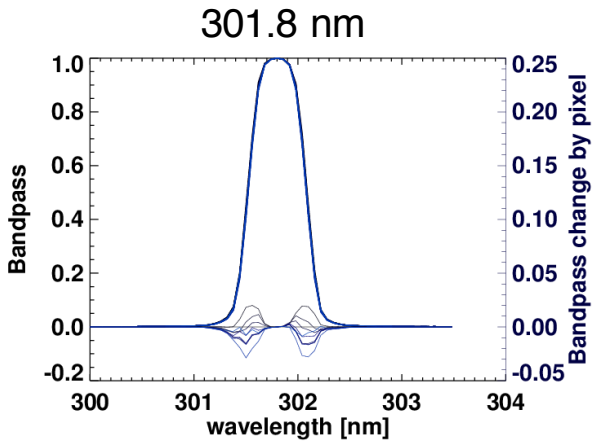


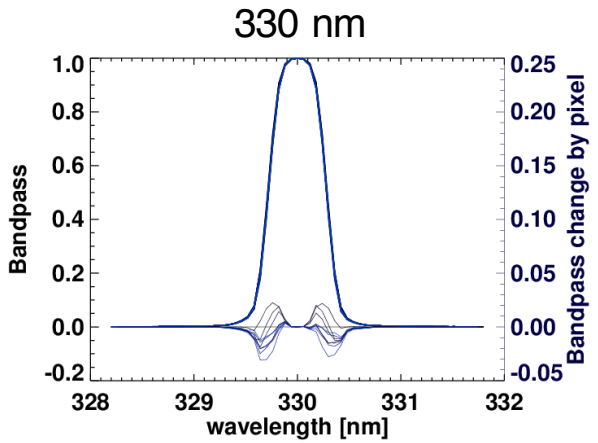


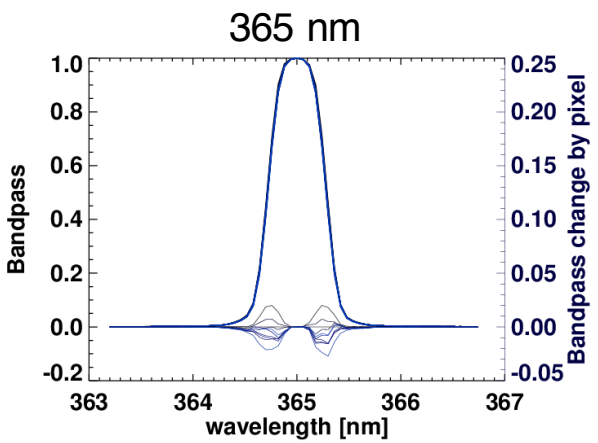
L0-1 Processor

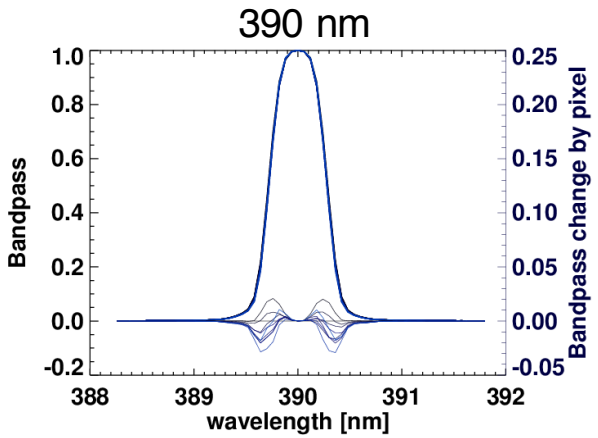
- Developed by BATC & KARI
- Dark correction :
  - fitting by temperature changes needed
- Smear correction :
  - ratio of frame transfer time to integration time, with previous frame effects considered
- *Straylight correction :*
  - *matrix, with 19x19 pixels aggregated due to computing time issue*
- Spectral calibration :
  - Reference solar spectrum convolved with GEMS bandpass functions, polynomial equation
- Onboard LED calibration :
  - for linearity, gain and PRNU(TBD)
- Polarization correction :
  - VLIDORT, Linear polarization sensitivity tests, LUT in collaboration with TEMPO team

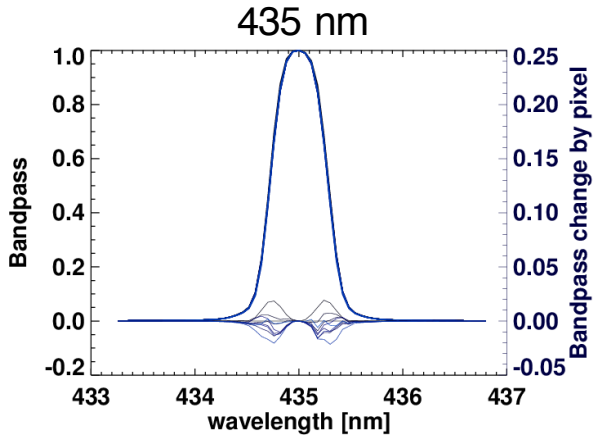
GEMS Bandpass

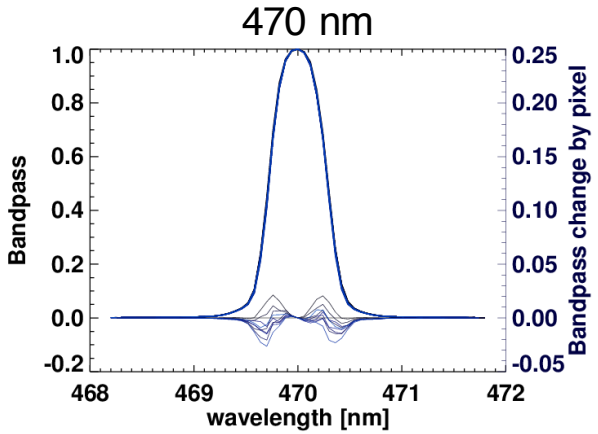


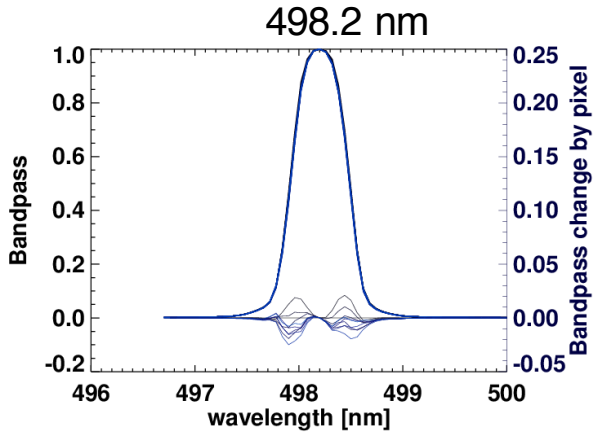


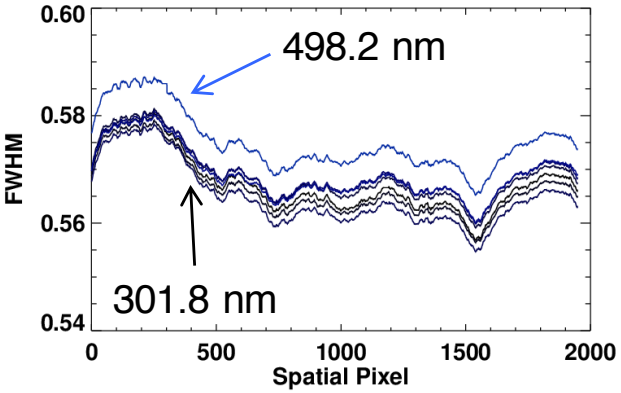






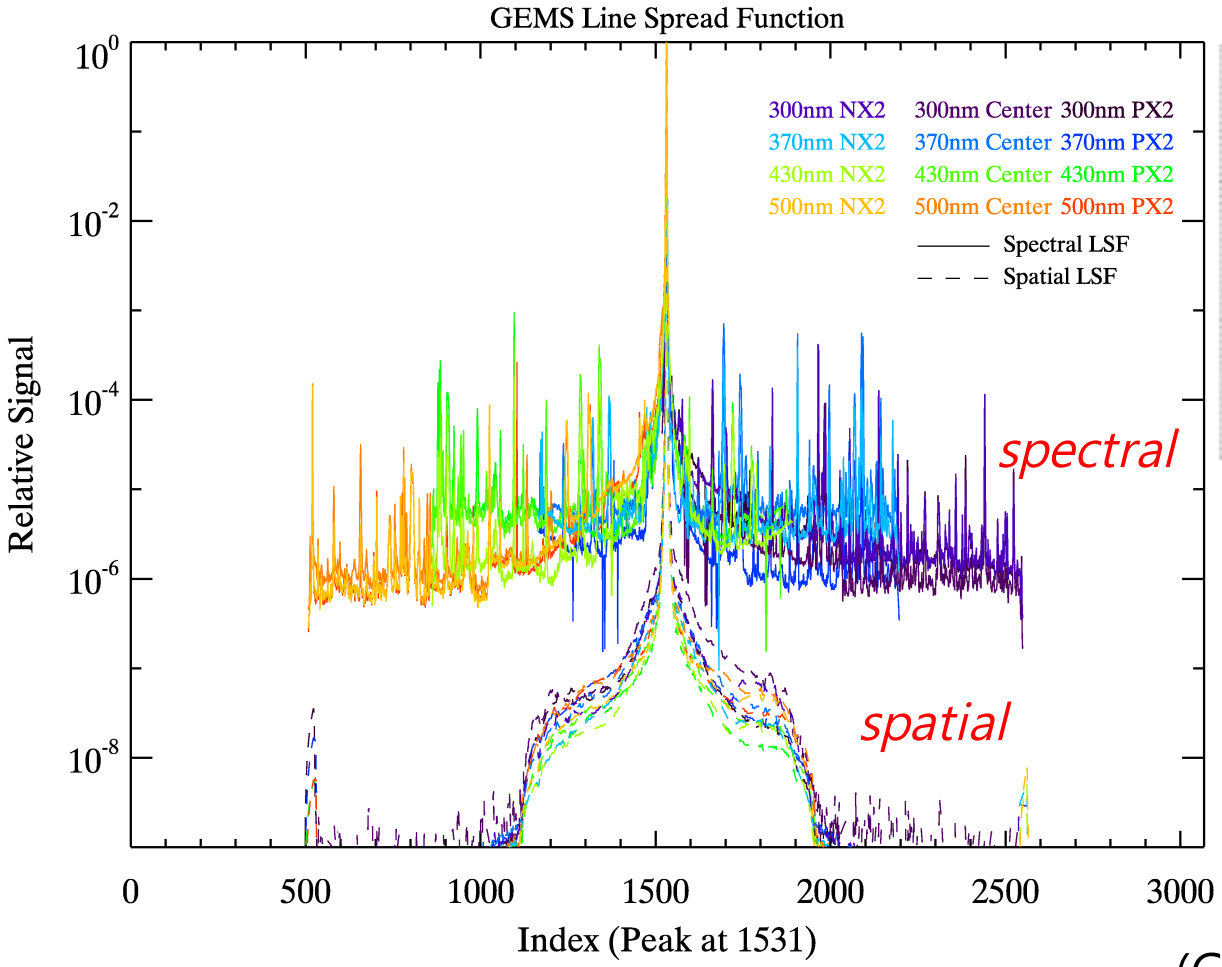


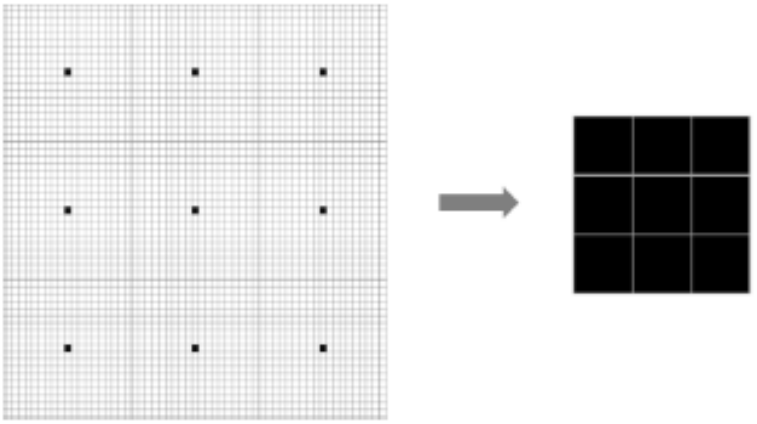




GEMS Straylight

- Spectral Spike
  - Compare to Spatial Line Spread Function, there are lots of spikes at Spectral Line Spread Function





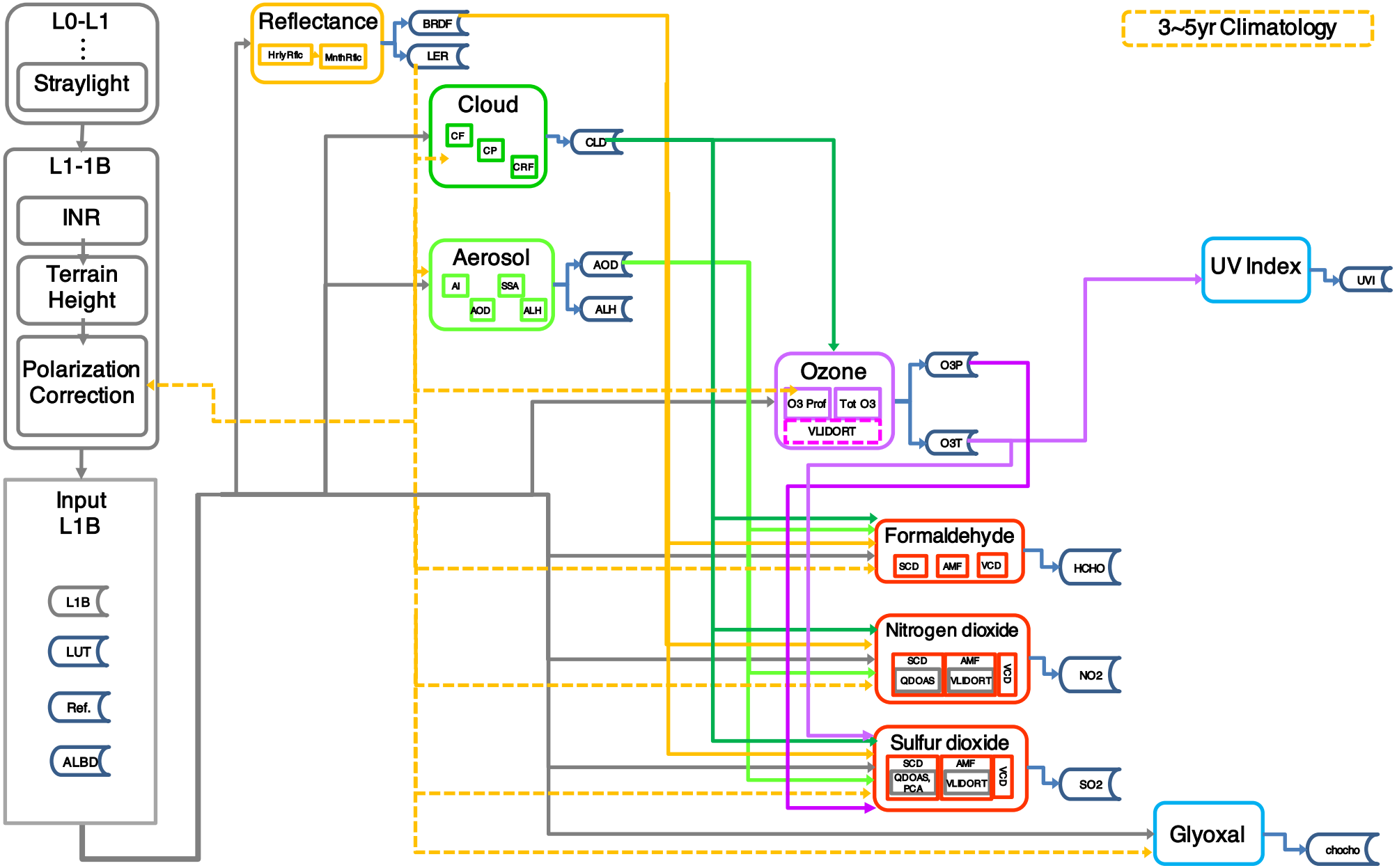
Reduce stray light matrix size 10^{12} to 10^{7} by selecting the center pixel of each 19*19 pixel box

(Courtesy, Mijin Eo and M.H. Ahn)

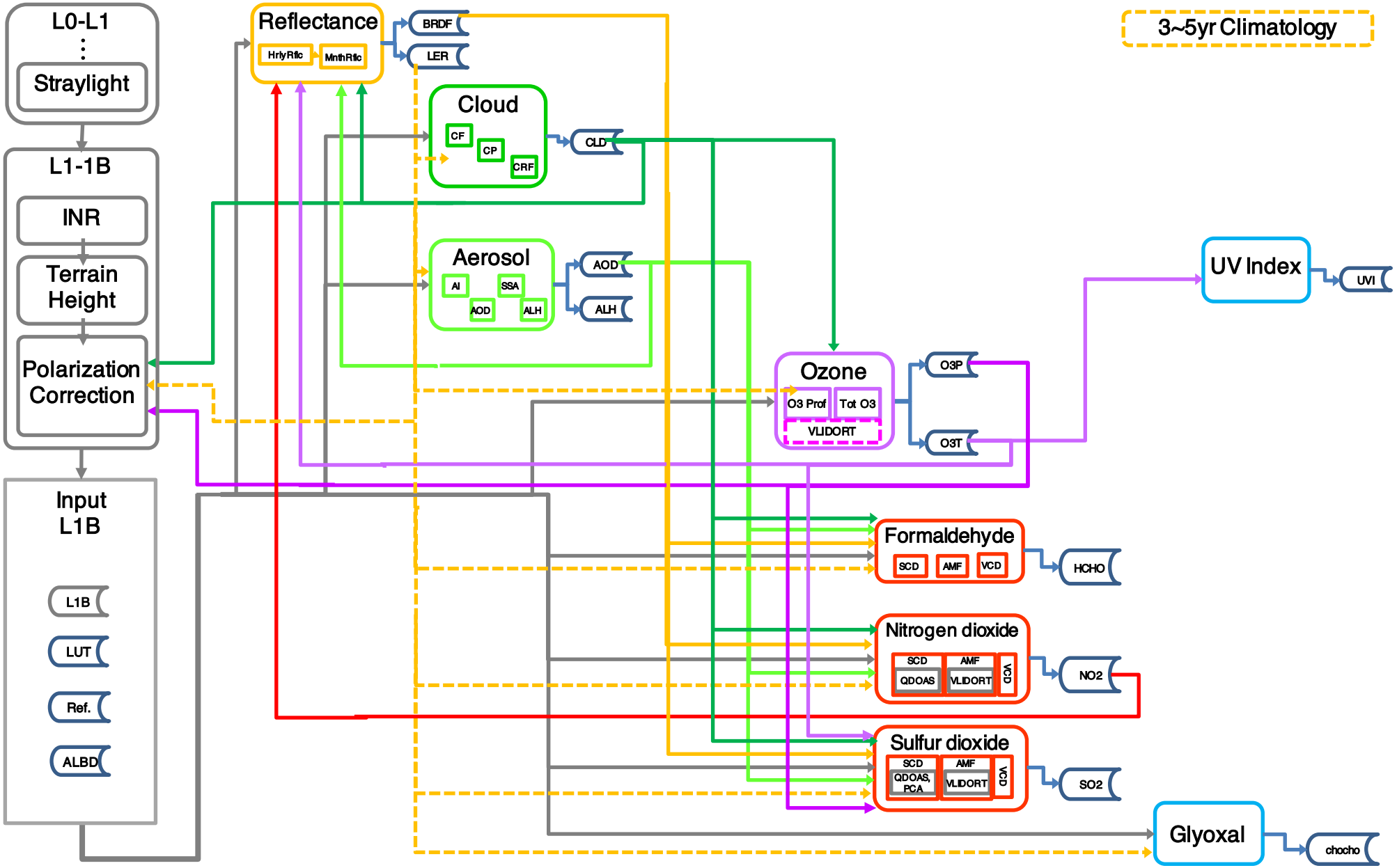
Polarization Factor

- Polarization factors are shown below for the characterization dataset provided by BATC.
- Instrument polarization modeling is required to scale the ground test measured results to the range of GEMS on-orbit scan mirror angles.

GEMS L2 Processor Interface : Daytime

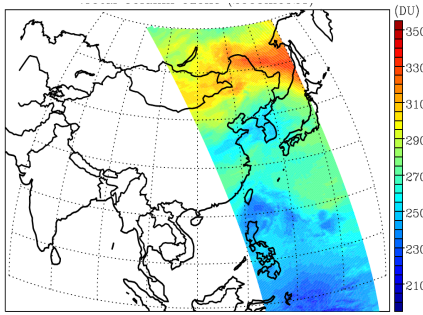


GEMS L2 Processor Interface : Night time

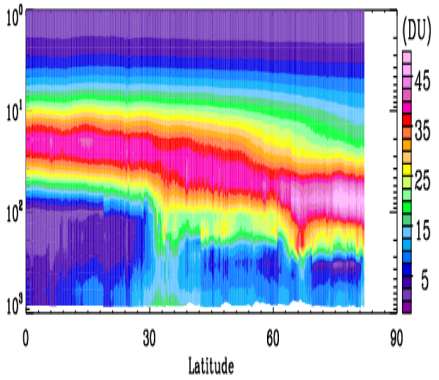


Examples of retrieved products using OMI L1b

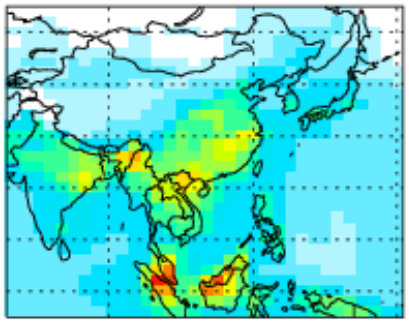
O3T



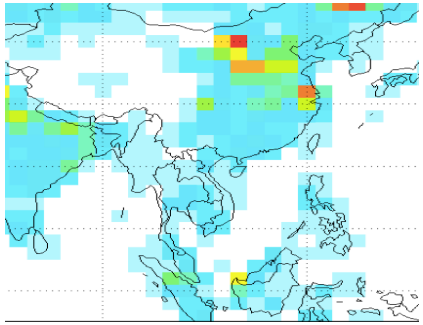
O3P



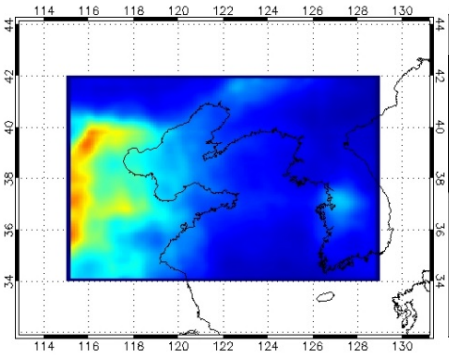
HCHO



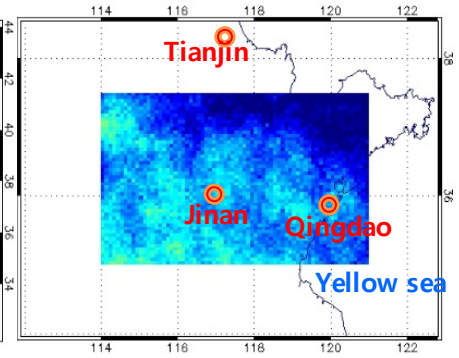
CHOCHO



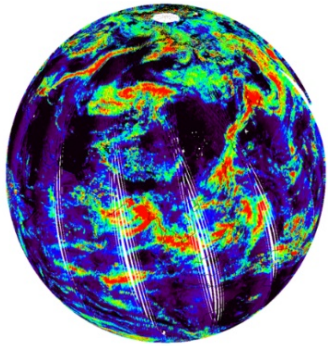
NO_2



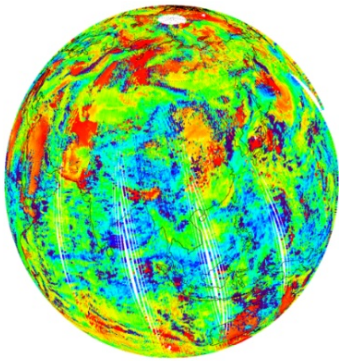
SO_2



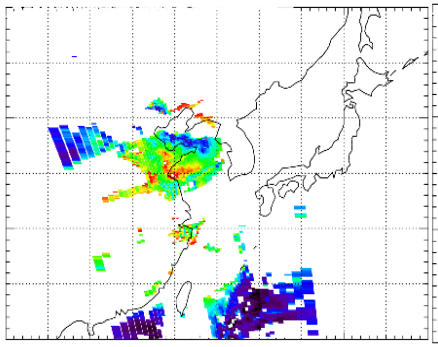
ECF



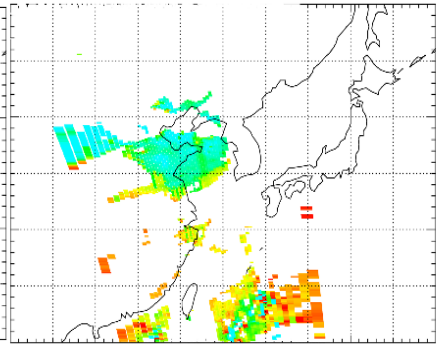
CCP



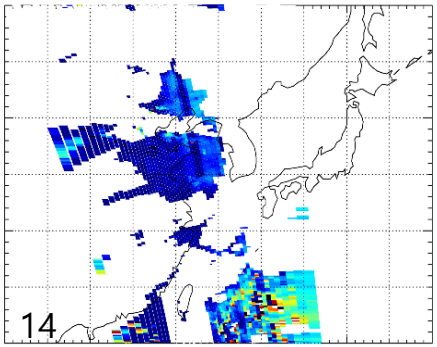
AOD



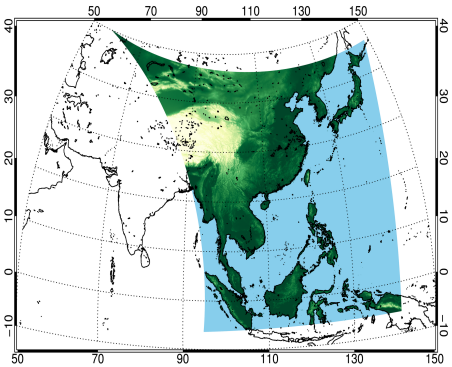
SSA



AEH

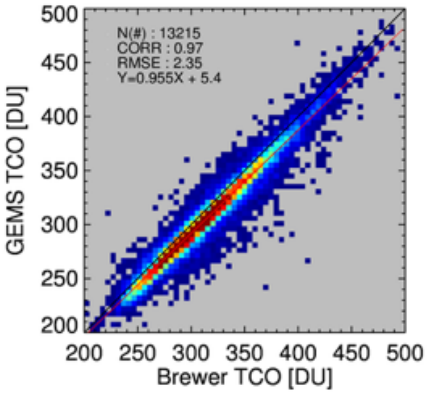


Terrain height

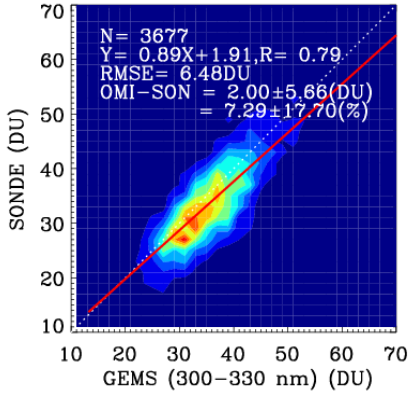


Intercomparison

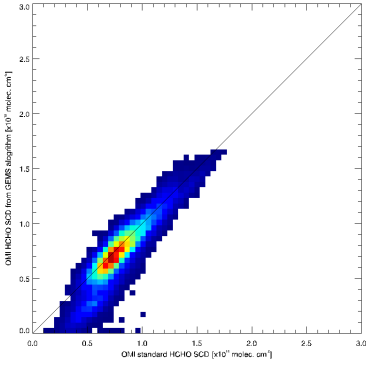
O3T



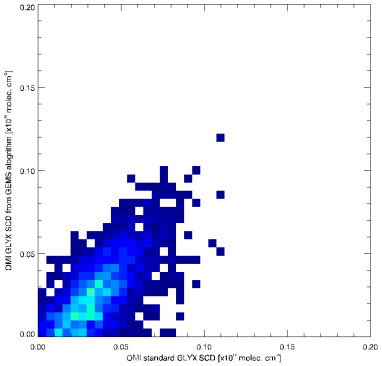
O3P



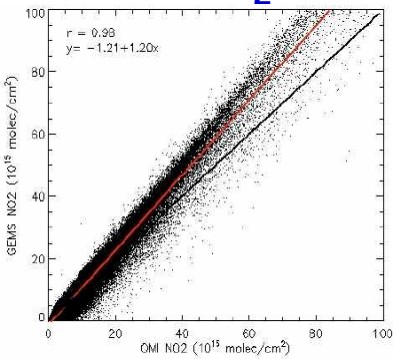
HCHO



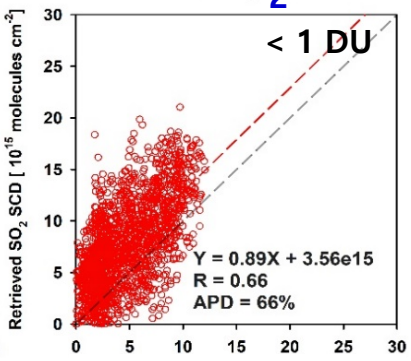
CHOCHO



NO_2



SO_2



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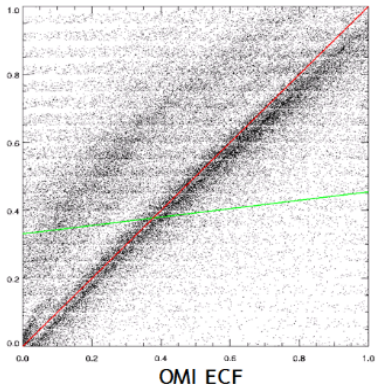
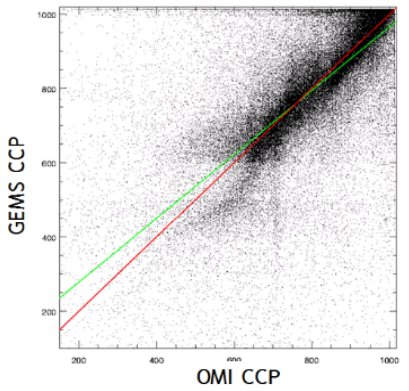
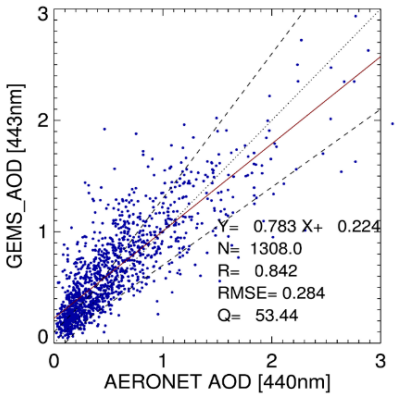


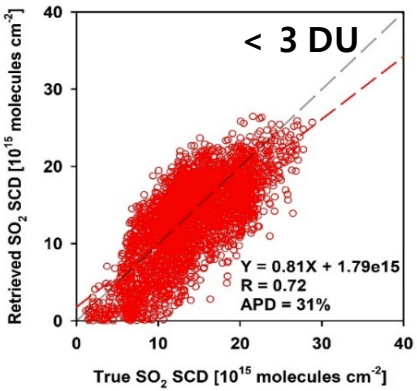
CCP



AOD



SO_2



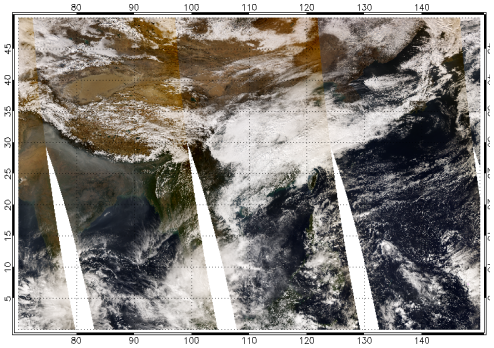
Credit :
Jhoon Kim (Yonsei U) – Aerosol
Y.S. Choi (EWU) - Cloud
Jae H. Kim (Busan NU) – O_3
Hanlim Lee (Pukyung NU) - NO_2, SO_2
Rokjin Park (SNU) – HCHO, CHOCHO
K.H. Lee (GWNU) – Sfc prod
M.H. Ahn (EWU) - calibration

Product accuracy evaluation

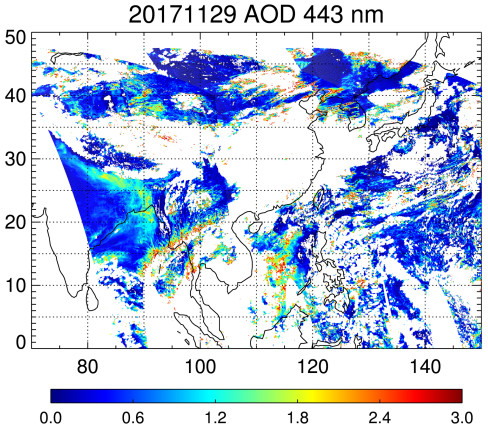
2017.12	Correlation coefficient (R)	a, Slope	b, Intercept	RMSE	Error (%)	*Reference*
O_3 (Total)	0.97	0.955	5.4 DU	*2.35%*	-	*Brewer Spectro-photometer*
O_3 (Trop)	0.79	0.89	1.91 DU	*6.48 DU (10-20%)*	2 DU *(7.29%)*	*Ozonesonde*
HCHO	0.86~0.88 (MAM/JJA/SON) 0.61 (DJF)	0.96 – 1.07	-1.4-3.1 x 10^{15}	-	-	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*

GEMS Algorithm Test using TROPOMI L1b Data (Nov 29, 2017)

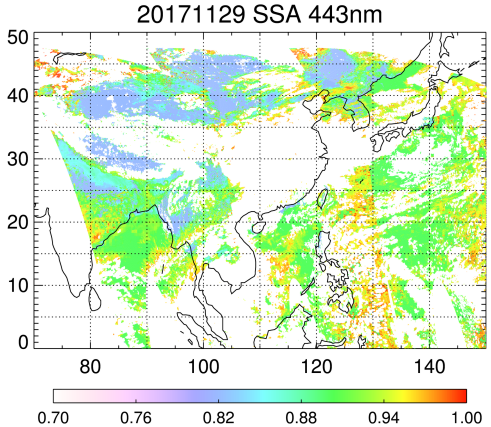
MODIS/Aqua RGB



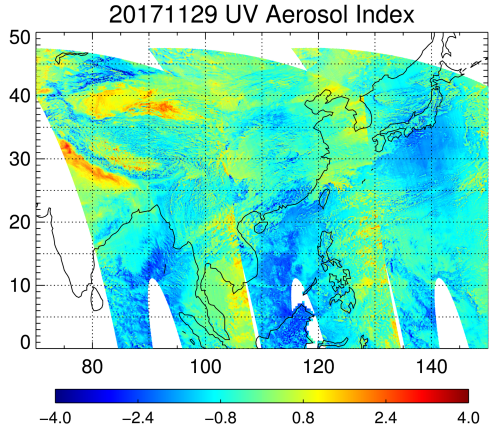
Retrieved AOD 443 nm



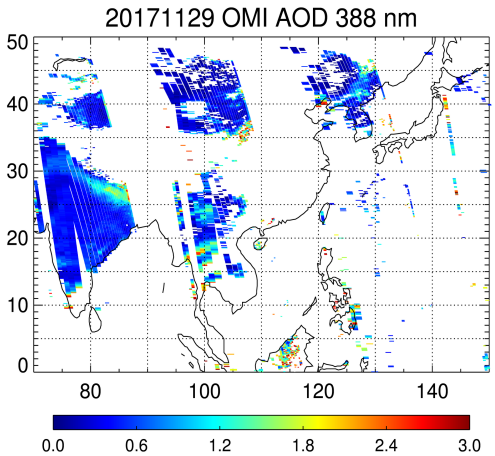
Retrieved SSA 443 nm



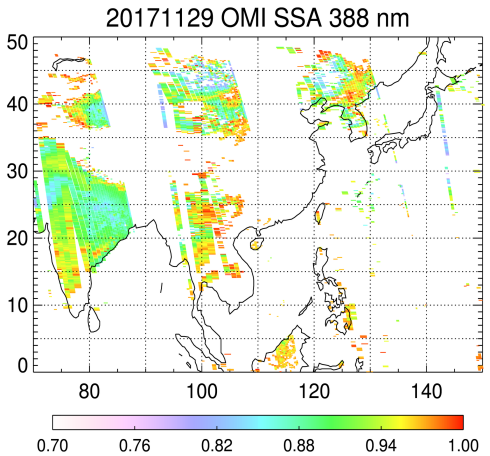
Retrieved UVAI



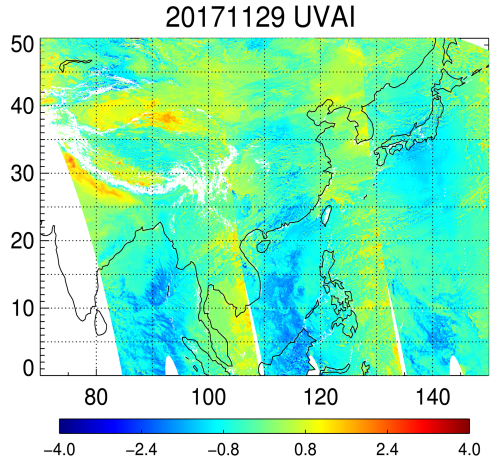
OMAERUV AOD



OMAERUV SSA

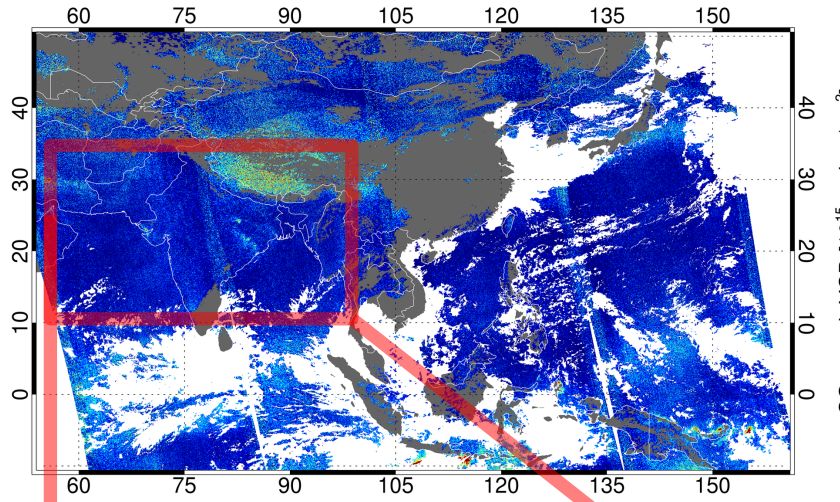


TROPOMI UVAI

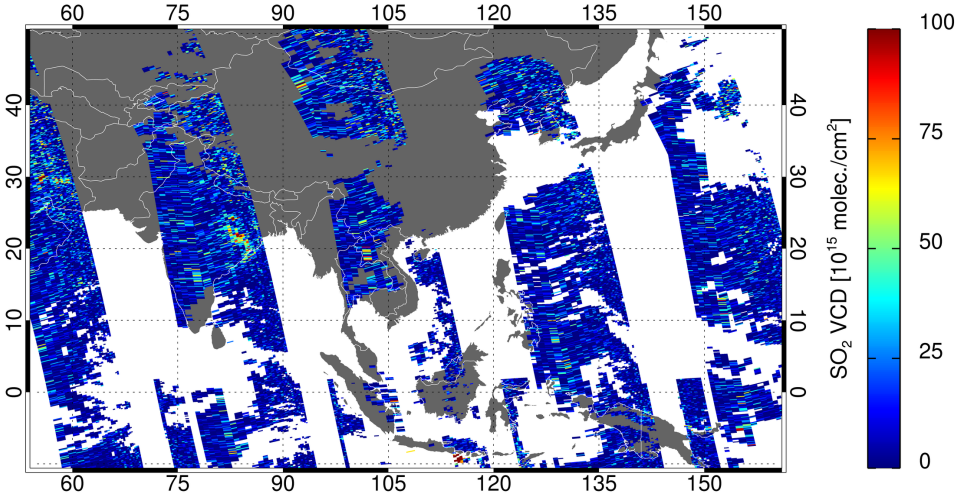


GEMS Algorithm Test using TROPOMI L1b Data

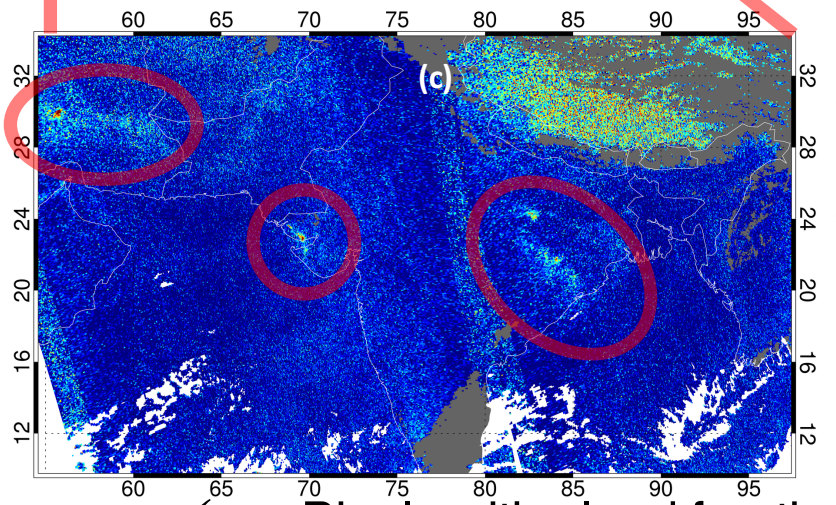
(a) Preliminary SO_2 retrieval using TROPOMI L1b with PCA-based algorithm for GEMS.



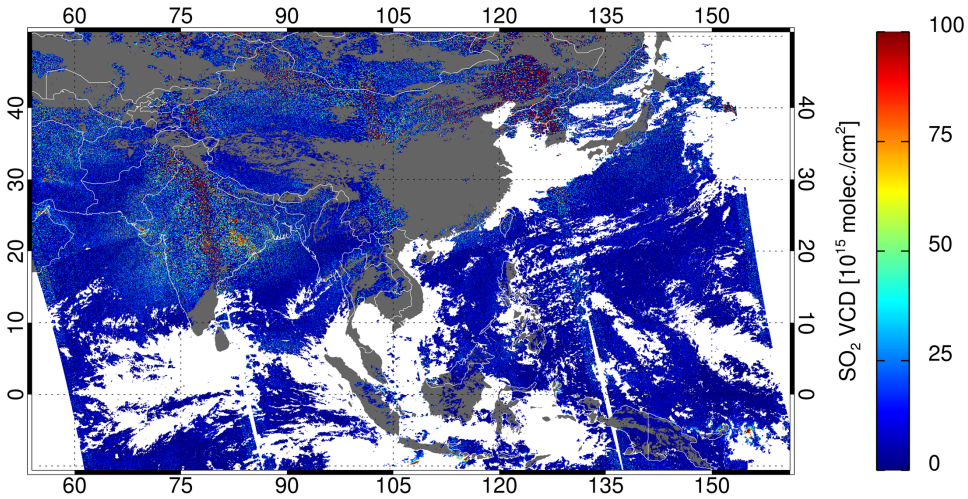
(b) OMI PCA SO_2 VCD (OMSO2 product; Li et al., 2013).



(c) Same as (a) but zoomed.



(d) TROPOMI Level2 SO_2 product.

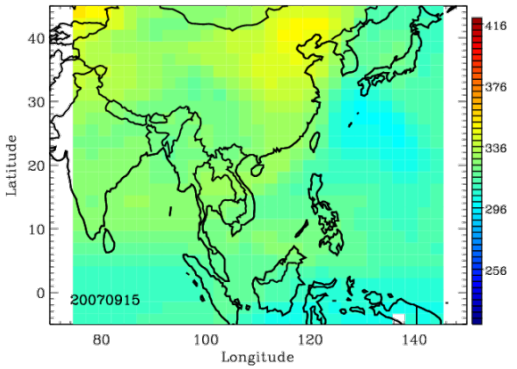


✓ Pixels with cloud fraction greater than 0.3 were excluded.

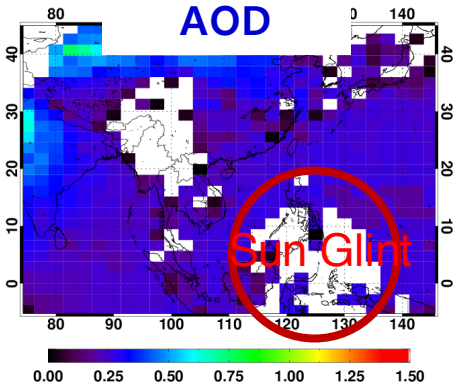
✓ Please note that the colorbar scales are different from one another.

Level 2 algorithm test with simulated radiance
- 2007.09.15 04 UTC -

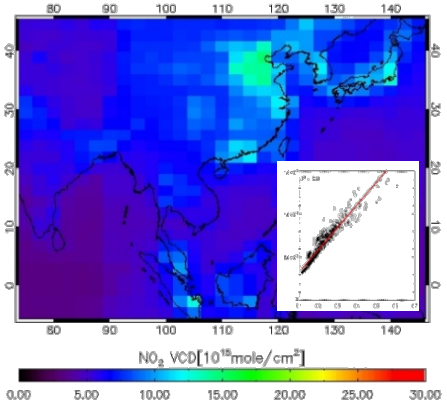
Retrieved TO3 (DU)



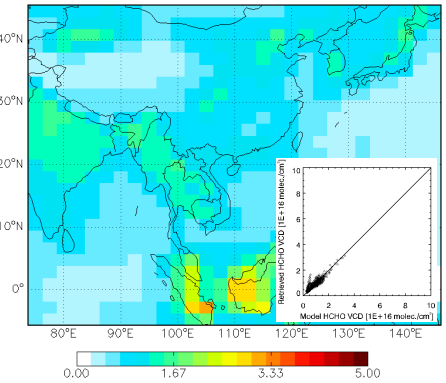
Retrieved AOD



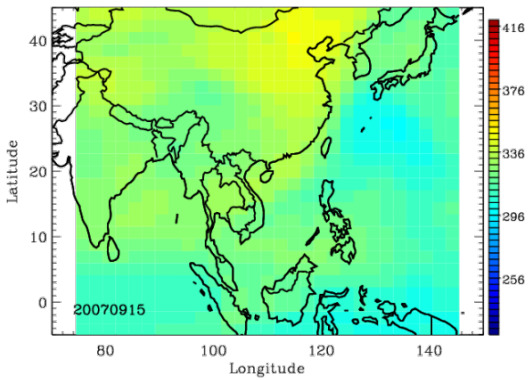
Retrieved NO_2



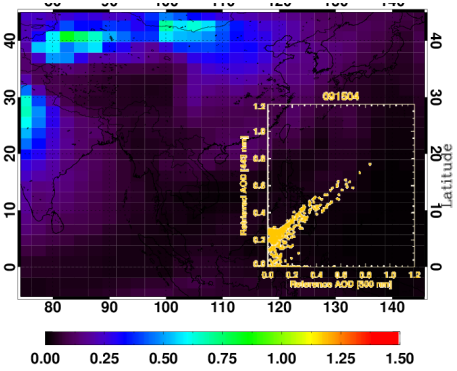
Retrieved HCHO



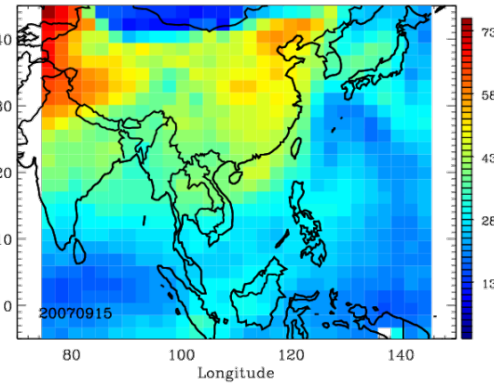
Simulated TO3 (DU)



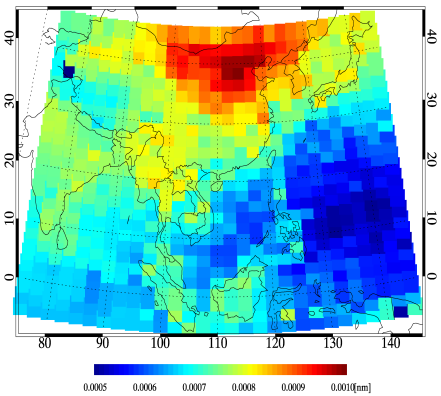
Simulated AOD



Tropospheric O3 (DU)

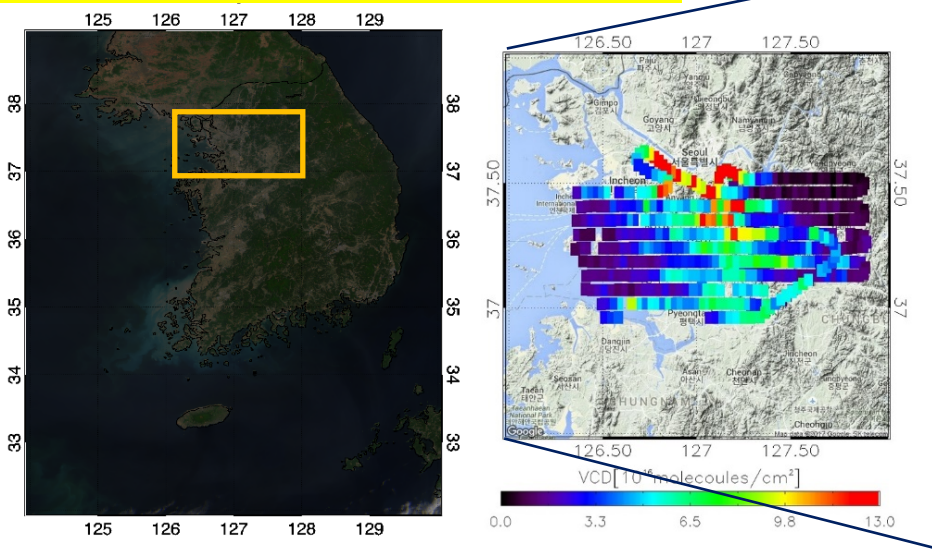


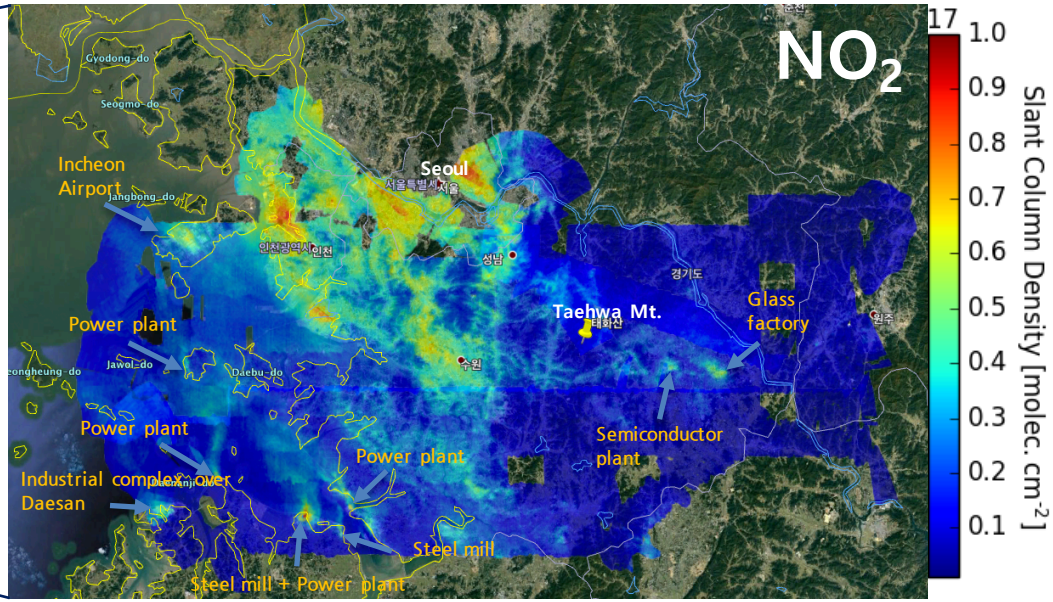
Wavelength Shift

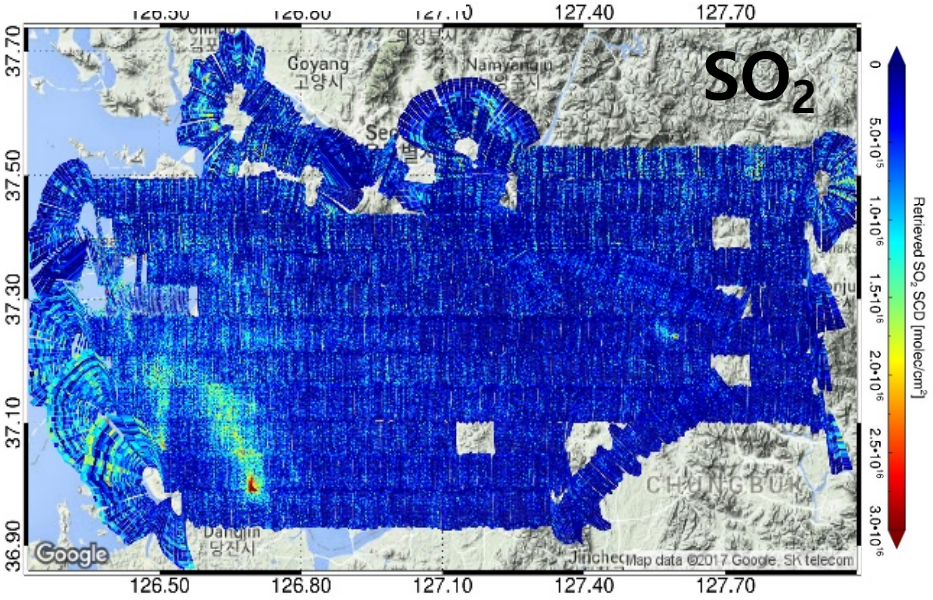


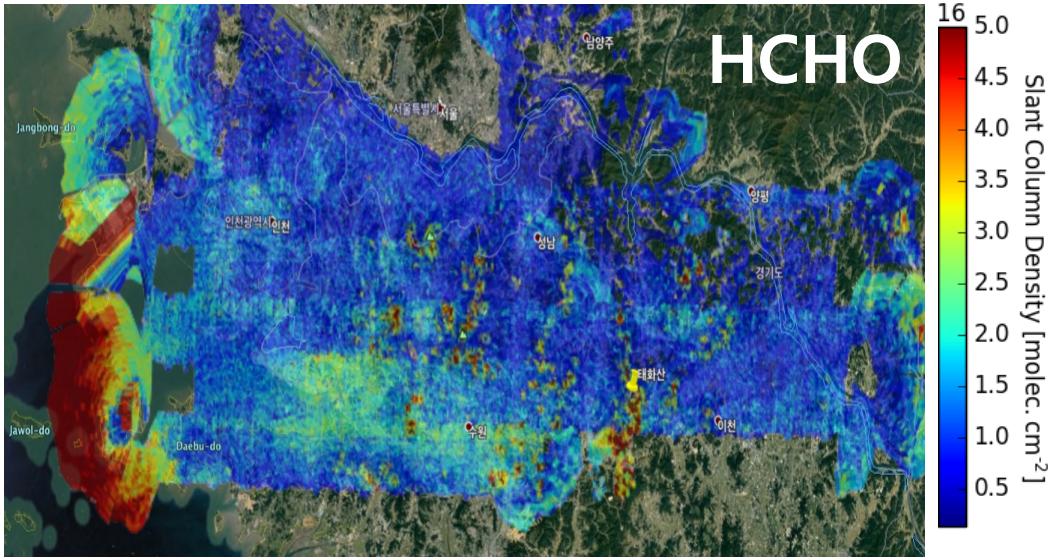
Algorithm test using GEO-TASO

May 17, 2016 (8-12 LST)



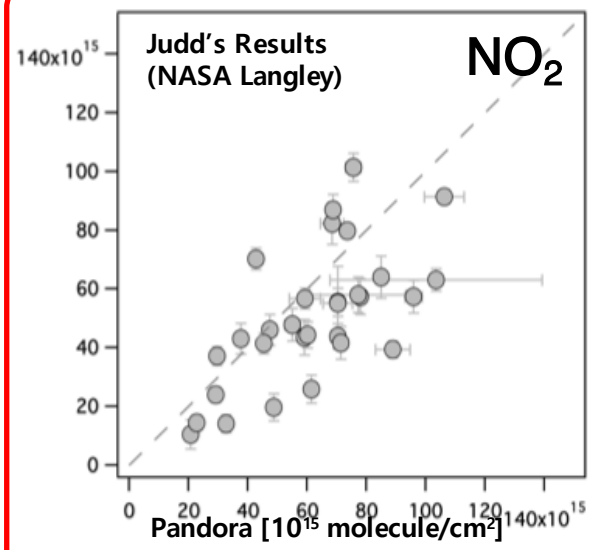


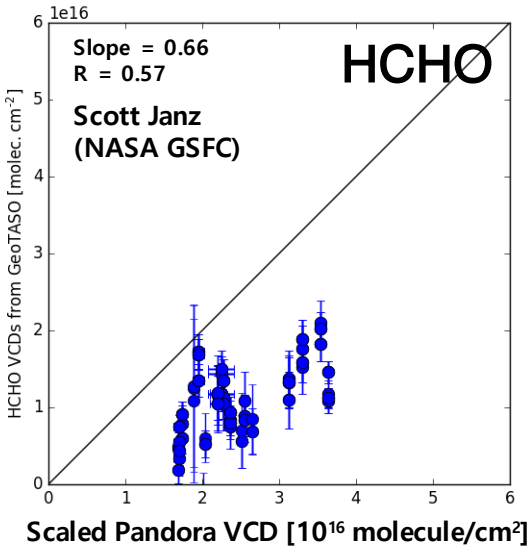




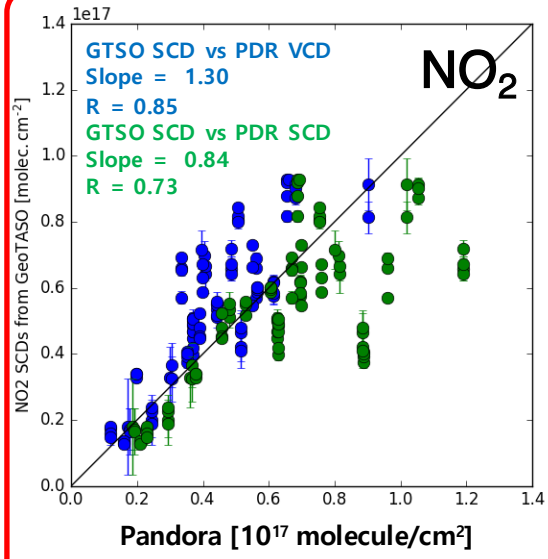
Validation of GEO-TASO with PANDORA

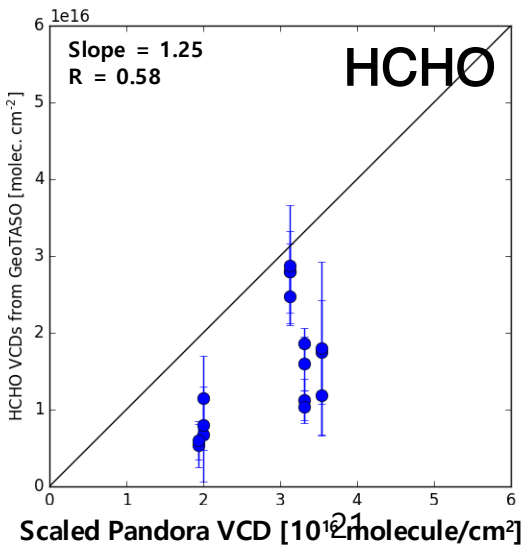
(NASA) Q-DOAS @Olympic Park



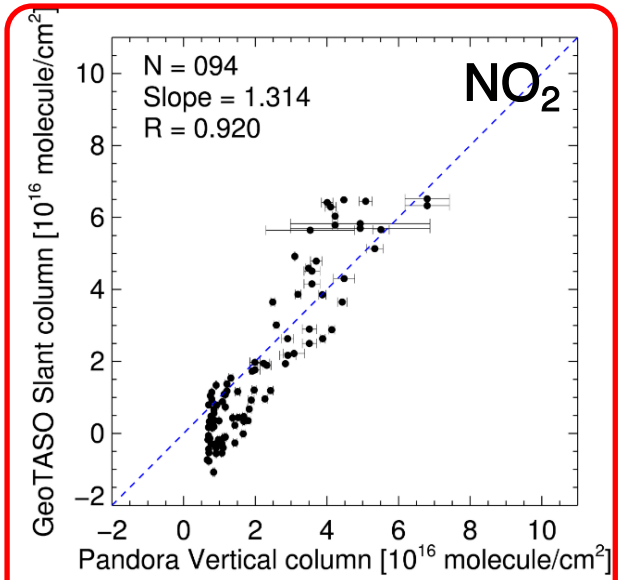


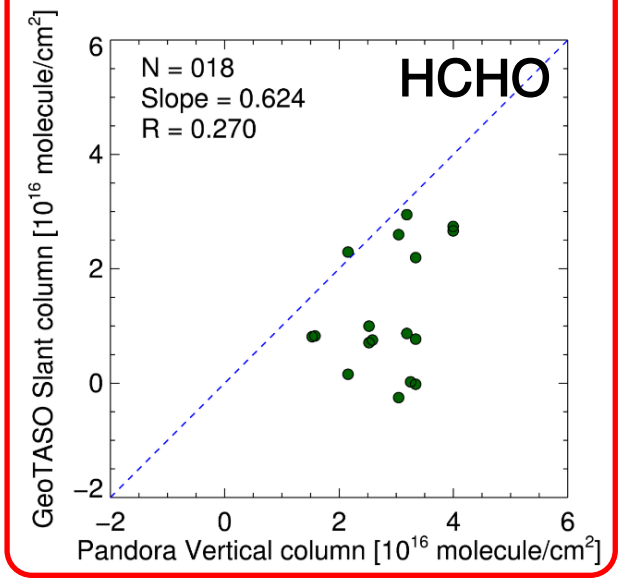
DF algorithm @Olympic Park





PCA-based algorithm @all sites

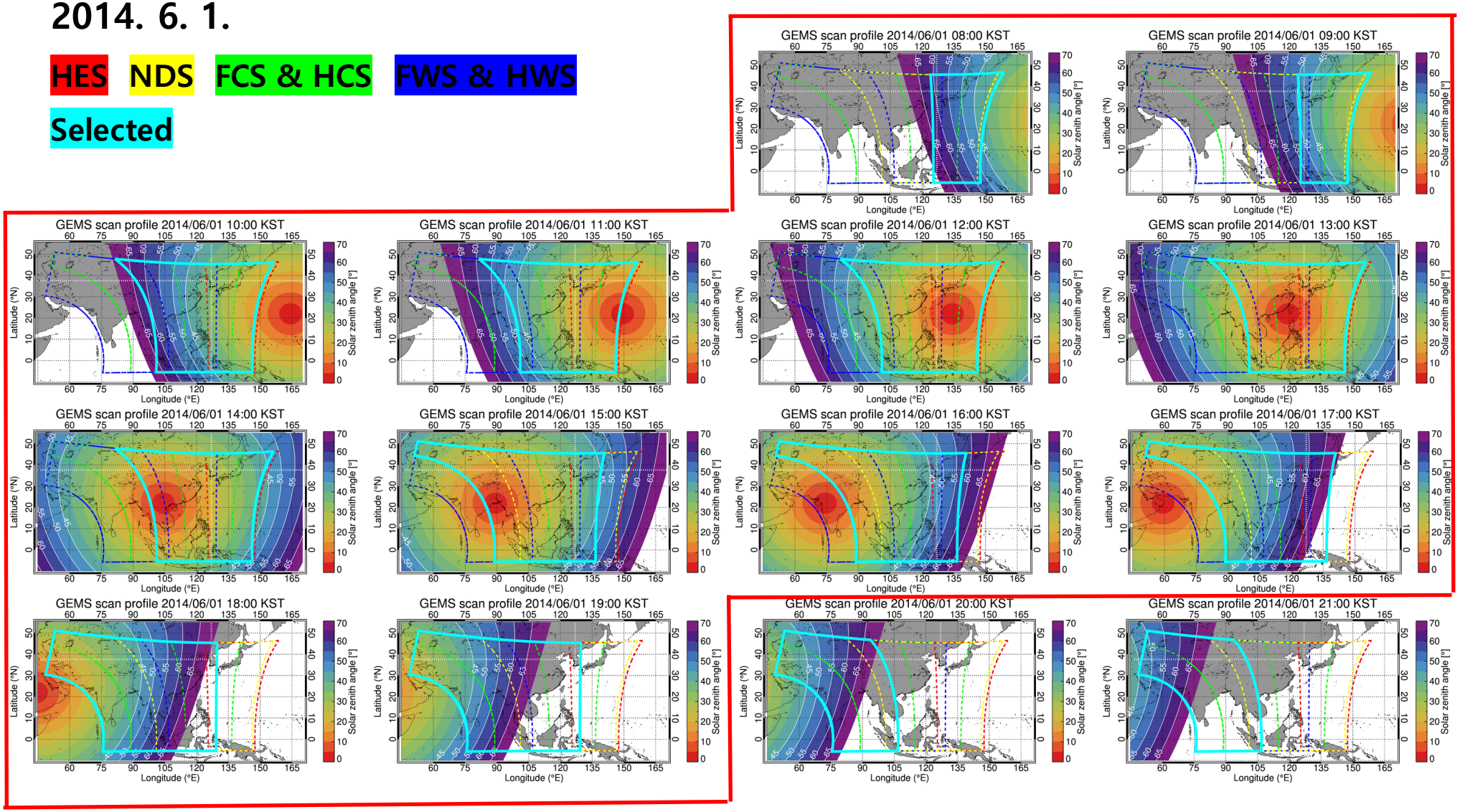




2014. 6. 1.

HES NDS FCS & HCS FWS & HWS

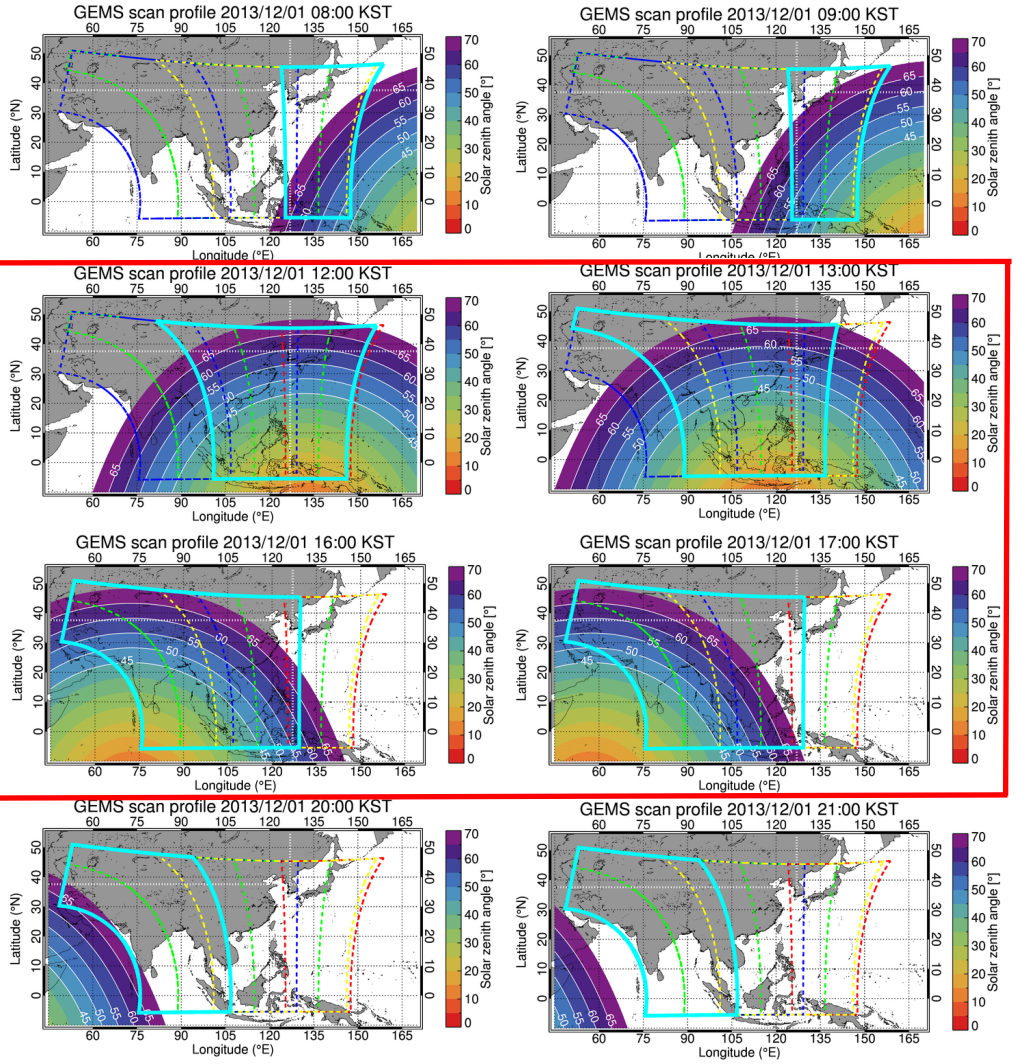
Selected



2013. 12. 1.

HES NDS FCS & HCS FWS & HWS

Selected



GEMS Ground Station at NIER

- Building to be completed soon
- Receiving and processing system to be installed by 2018

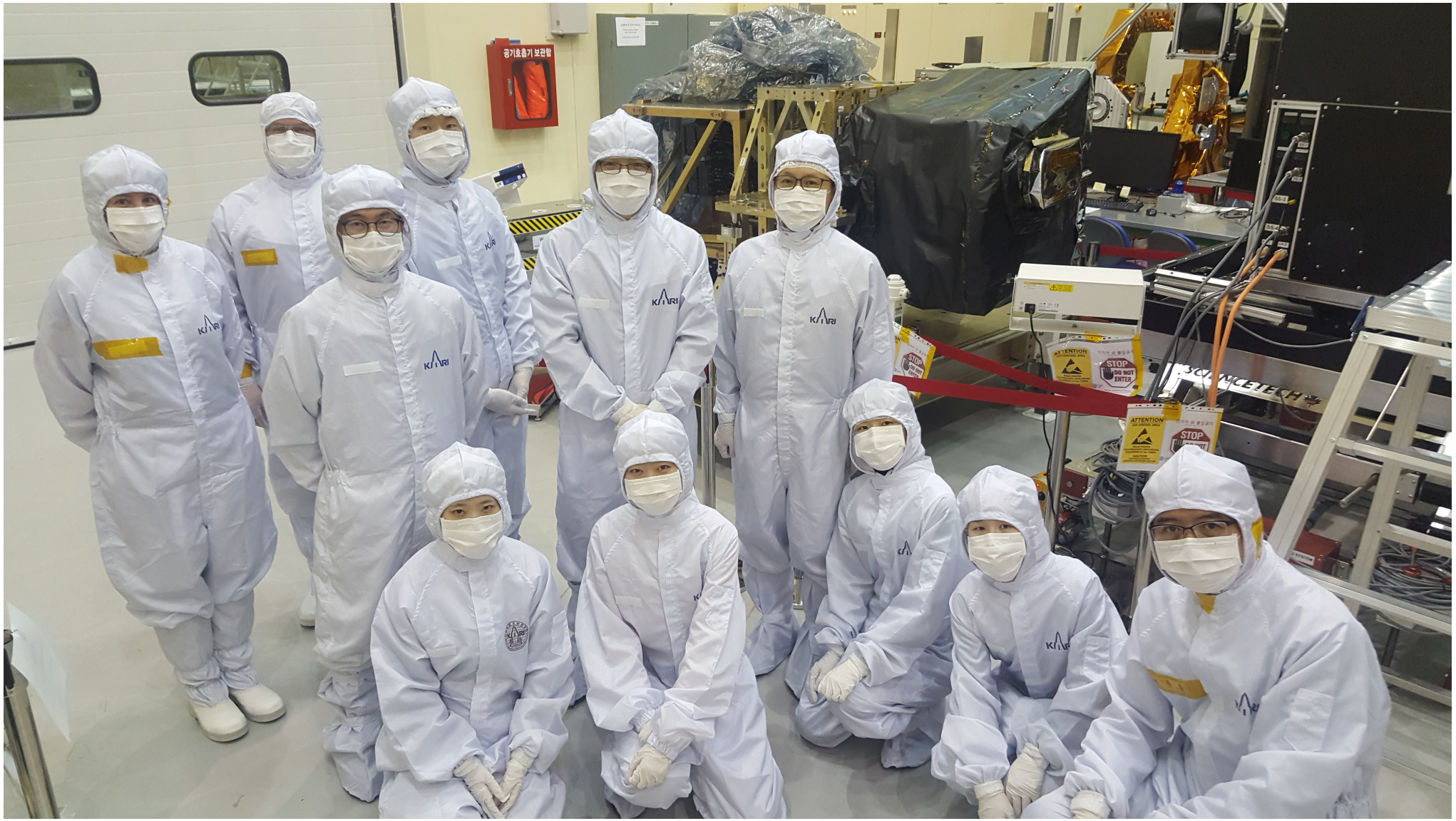
Summary

- GEMS flight model has been delivered to KARI after PSR on Jan 26th, 2018. The launch window for GEMS is Sep. 2019– Feb. 2020.

- First version of L0-1 algorithms are delivered but lack of correction for straylight, polarization, spectral calibration etc. which needs further im provements.

- L1b-2 algorithm for gases and aerosols show reasonable performances, but requires persistent improvement, including polarization, hourly retrieval in AMF, S/T separation etc.

- Preflight test results to characterize stray light, polarization, spectral accuracy, diffuser BTDF, dark current etc. can provide more accurate analysis on the GEMS performance and L2 algorithm.

- Synergy with AMI and GOCI-2 will provide more reliable products of aerosol and cloud products, which eventually improve the accuracy of trace gas column density.

GEMS at KARI, finally !