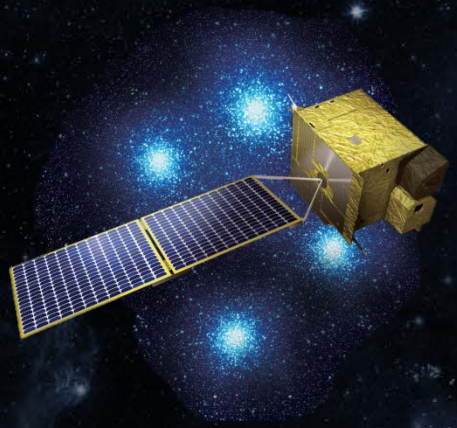
Committee on Earth Observation Satellites AC-VC-13, June 28th-30th, 2017



Status of Geostationary Environmental Monitoring Spectrometer, GEMS

Jongmin Yoon[1], Ara Cho[1], Jhoon Kim[2,3]

Xiong Liu[3], Kelly Chance[3], Jay Al-Saadi[4], Ben Veihelmann[5]

and GEMS Science Team

[1]National Institute of Environmental Research, Korea

[2]Yonsei University, Korea

[3]Harvard Smithonian Center for Astrophysics, Cambridge, MA

[4]NASA Langley Research Center, Hampton, VA

[5]ESA, ESTEC, Noordwijk, Netherlands

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GEMS Measurement principle

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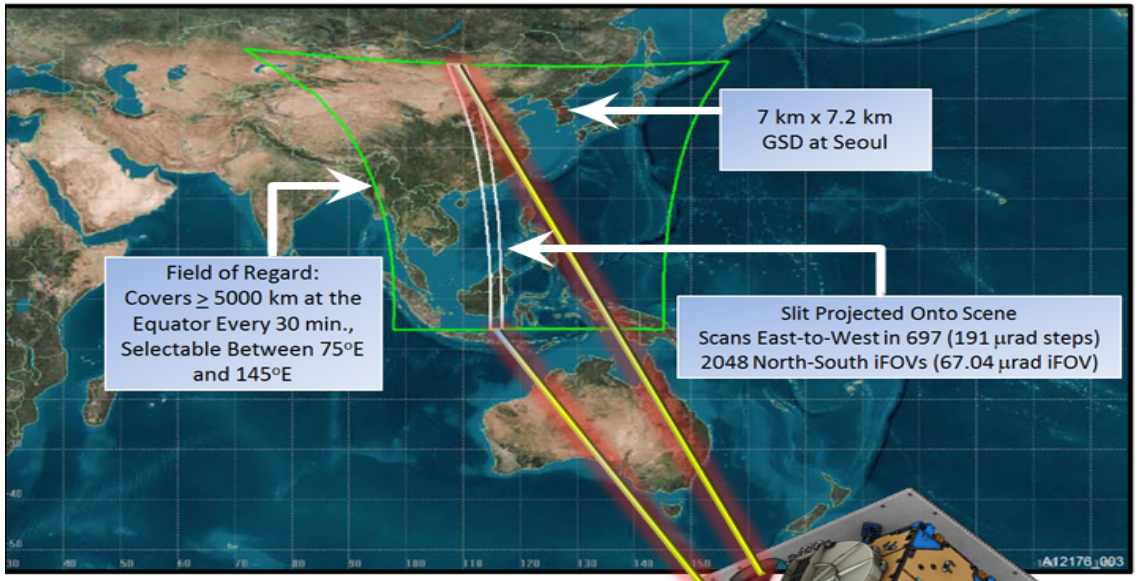
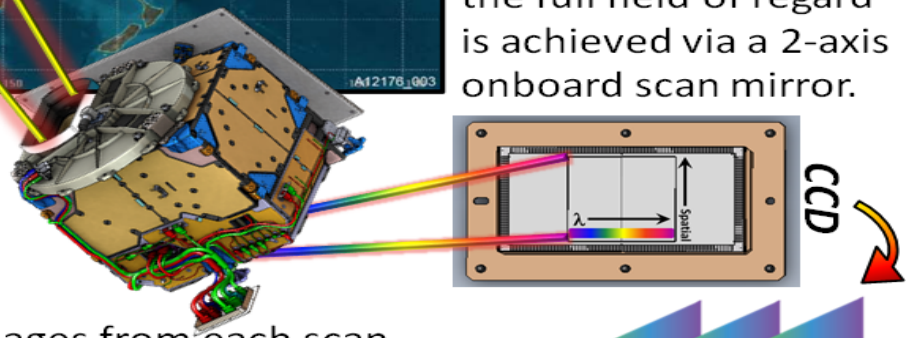
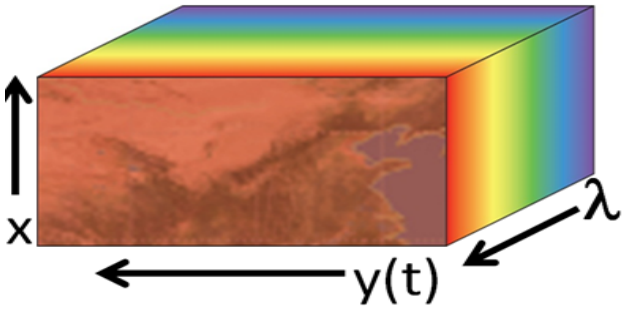
GEMS Measurement Concept



The GEMS system employs a 1032 x 2048 pixel CCD detector that operates from 300 -500 nm, which at a minimum, enables NO_2, SO_2, HCHO, O_3, and aerosol retrieval. The telescope projects the slit field of view onto the Earth, and the full field of regard is achieved via a 2-axis onboard scan mirror.

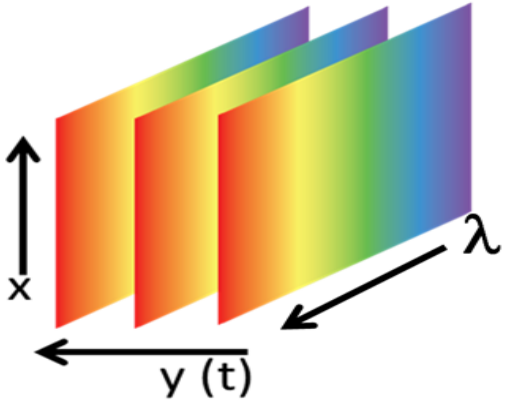


Ground processing spatially bins and geo-locates each co-added image.



Images from each scan mirror position are co-added on-board...

...Co-added images are then transmitted to ground.



International collaboration

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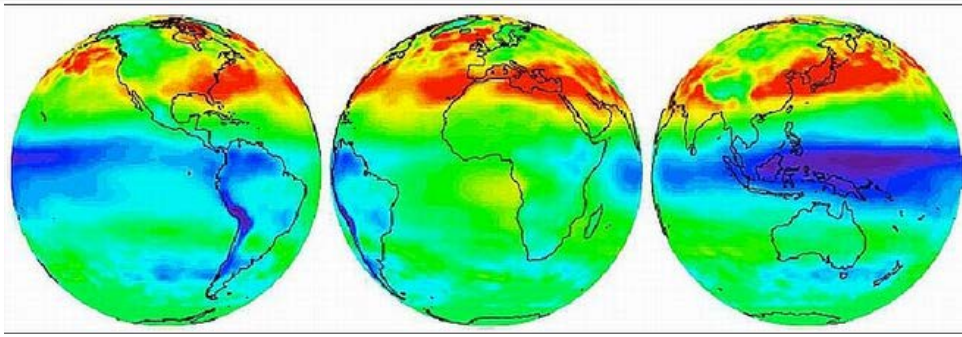
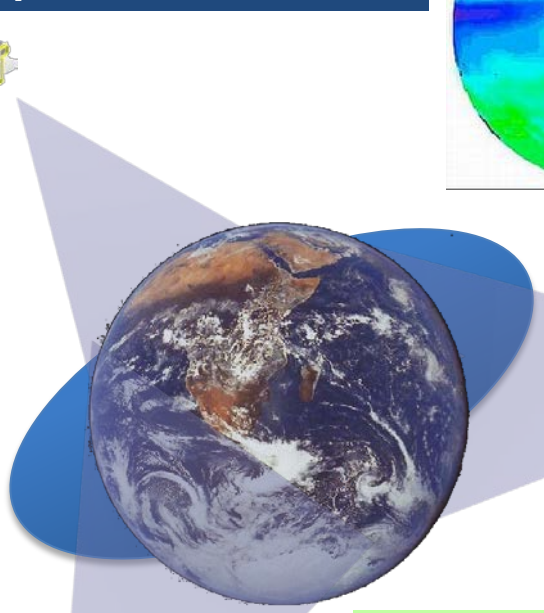
Constellation of GEO Mission for synergistic products



TEMPO
(America)

NASA EPA CfA

UV-Vis
290-690 nm



Ministry of Environment KARI

GEMS + AMI + GOCI2
GEO KOMPSAT
(Asia)

UV-Vis 300-500 nm

esa

UV-Vis-NIR
305-500, 750-775 nm

GMES S4 UVN
(Europe)

Constellation synergy
- Improving spatial and temporal coverage
  to monitor globalized pollutants & SLCF
- Sharing basic requirements on data products and
  instrument to maintain data quality
- Consolidating socio-economic benefit analysis
- Supporting QA and CAL/VAL

GEMS Instrument

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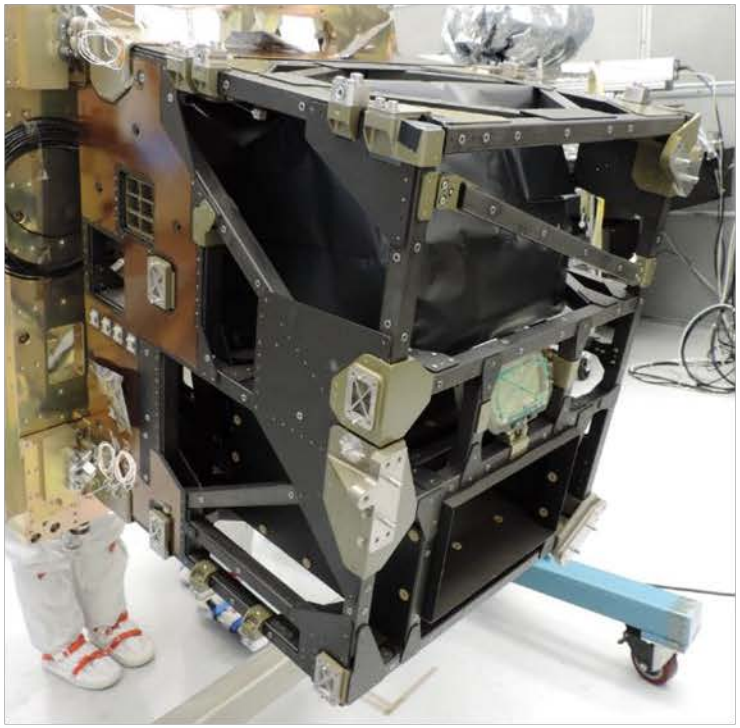
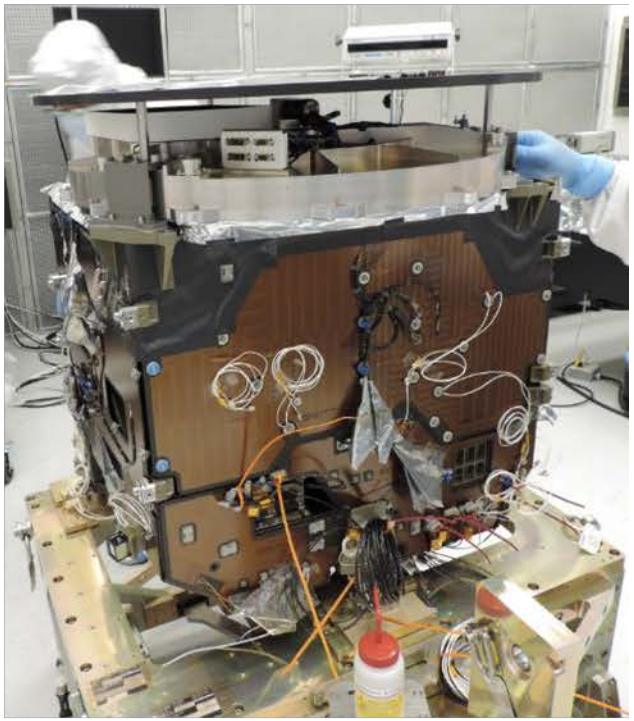
- Step-and-stare UV-Vis imaging spectrometer scanning at least 8/day in 30 min
- Daily solar and dark calibration
- Images coadded at each position + mirror move back < 30 minutes
- Diffusers for on-orbit solar calibration and onboard LED light source
- Redundant electronics for 10-year lifetime

✓ Preflight tests ongoing, to be delivered in September, 2017



← *Pre-thermal panel*

→ *Thermal panel and CMA Installation*



GEMS Status

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- **Schedule**
  - L1-2 Progress Evaluation & Review, June 2017; Grant renewed until 2020
  - PSR, August/September, 2017
  - Delivery September, 2017
  - AIT, 2017-2019
  - Launch, March 2019
- **AIT schedules at KARI**
  - Bus I&T: ~ November 2017
  - Payload I&T : Dec. 2017 – Feb. 2018
  - Antenna I&T : Mar – Apr. 2018
  - Thermal Vac test : May – Jul 2018
  - SA I&T : Jul – Aug 2018
  - Dynamic Test : Aug – Oct 2018
  - EMC Test : Nov 2018
  - Final Preparation : Dec 2018
  - Launch Campaign : Feb – Mar 2019

L0-L1b Processor

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- Under development by BATC & KARI
- Dark correction
  - –fitting by temperature changes added
- Smear correction :
  - –ratio of frame transfer time to integration time, with previous frame effects considered
- Straylight correction :
  - – matrix, Richardson-Lucy deconvolution,
- Spectral correction :
  - – 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

GEMS ground station

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- Building to be completed by Dec. 2017
- Receiving and processing system to be installed from Mar. 2018

GEMS Products (16)

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Product	Importance	Min (cm^{-2})	Max (cm^{-2})	Nominal (cm^{-2})	Accuracy	Window(nm)	Spat Resol (km^2)@Sel	SZA (deg)	Algorithm
NO_2	O3 precursor	$3x10^{13}$	$1x10^{17}$	$1x10^{14}$	$1x10^{15}$ cm^{-2}	425-450	7 x 8 x 2 pixels	< 70	BOAS 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*)	
HCHO	VOC proxy	$1x10^{15}$	$3x10^{16}$	$3x10^{15}$	$1x10^{16}$ cm^{-2}	327-357	7 x 8 x 4 pixels	< 50 (60*)	
CHOCHO					$1x10^{16}$ cm^{-2}	437-452	7 x 8 x 4 pixels	< 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
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	-		300-350	7 x 8	< 70	

Validation tests

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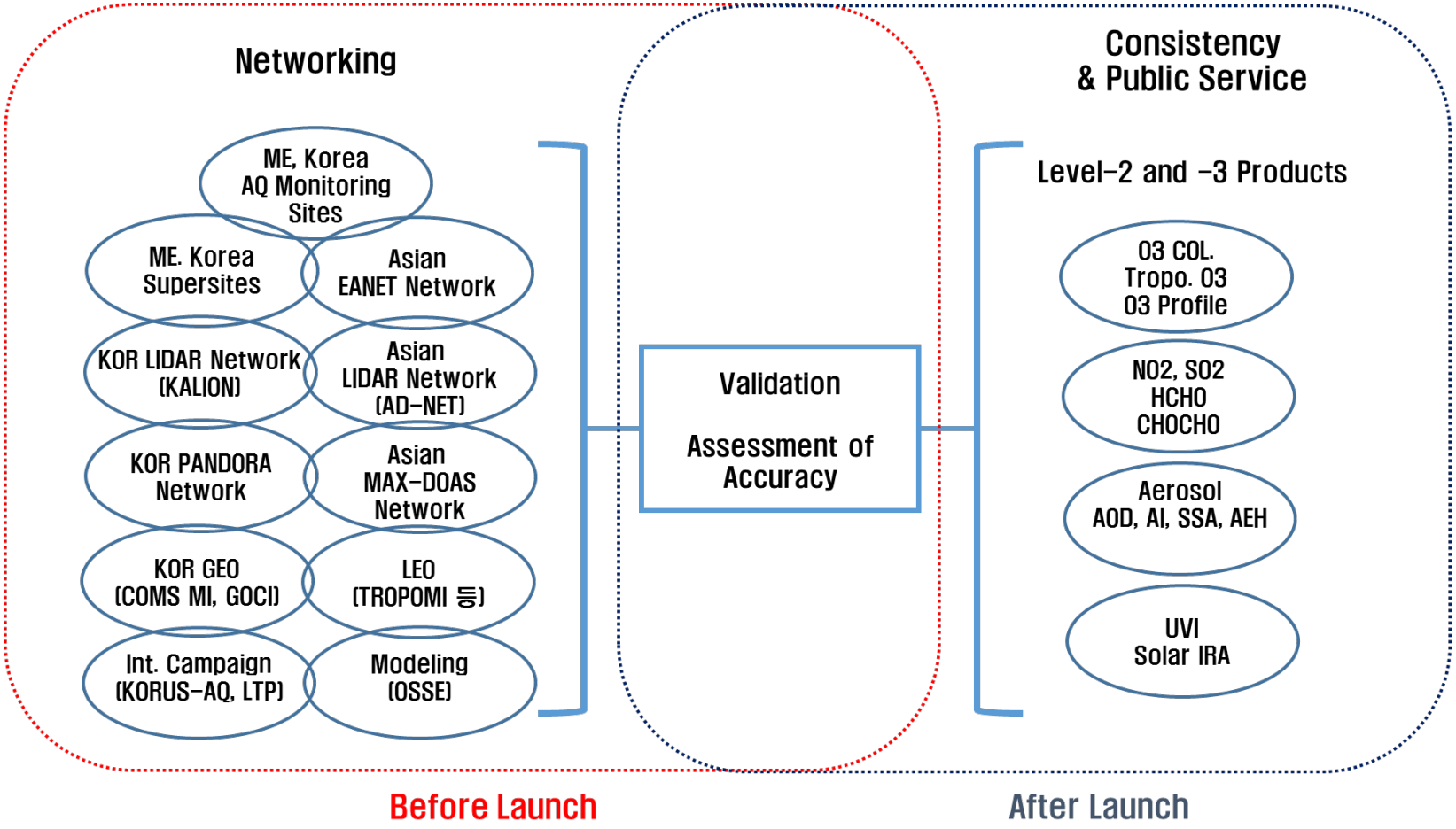
- NRT operation tests using OMI l1b data
- Blind test using proxy data from RTM and CTM



Examples of retrieved products using OMI

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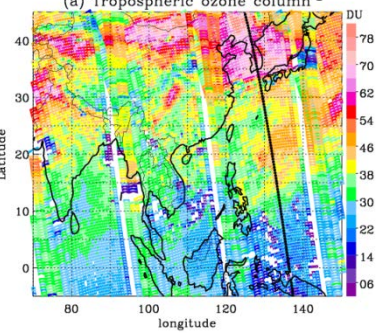
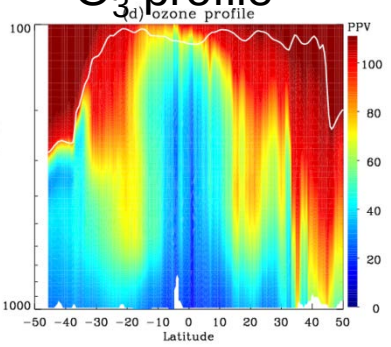
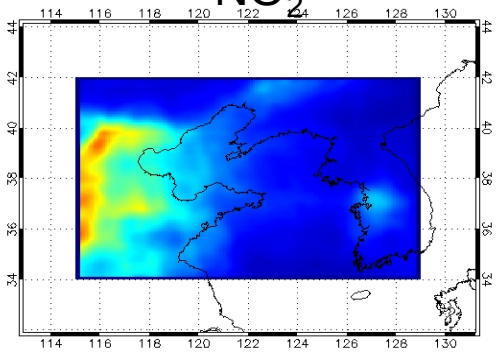
Troposp. O_3



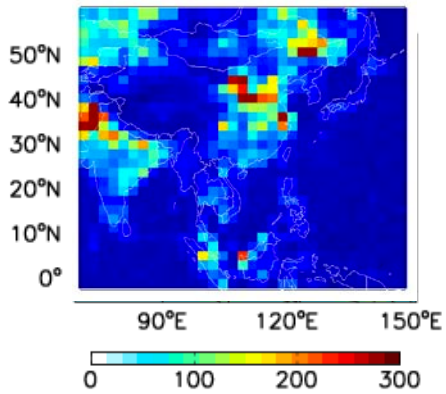
O_3 profile



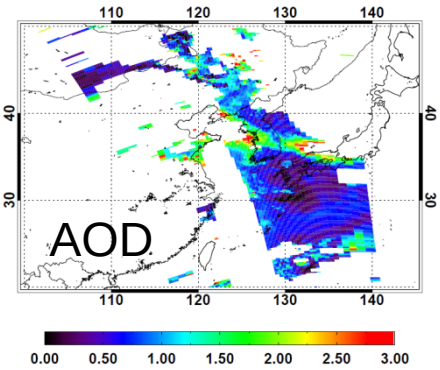
NO_2



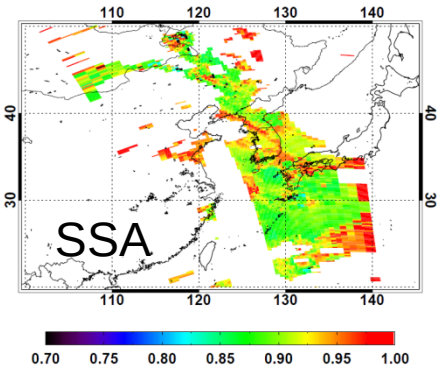
HCHO



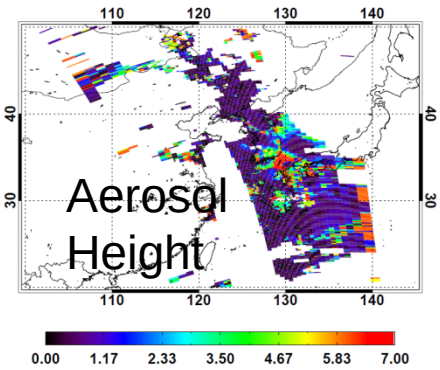
AOD [443 nm] from OMI2006m0408t0400

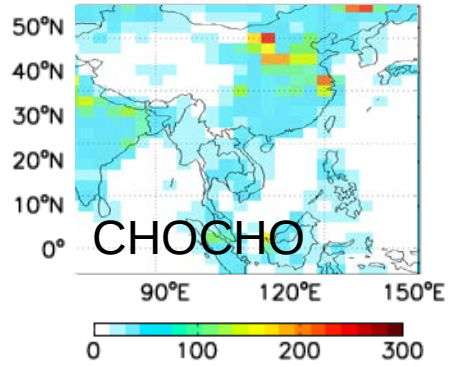


SSA [443 nm] from OMI2006m0408t0400

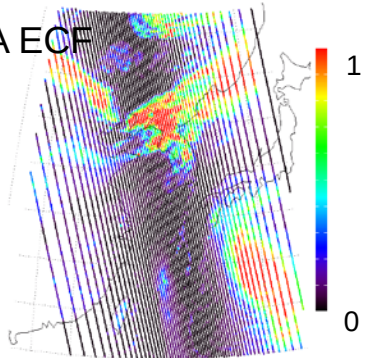


HGT from OMI [km]2006m0408t0400

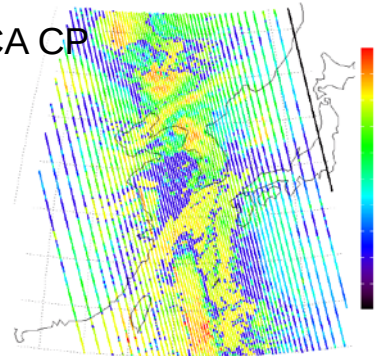




GCA ECF



GCA CP



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

Ozone

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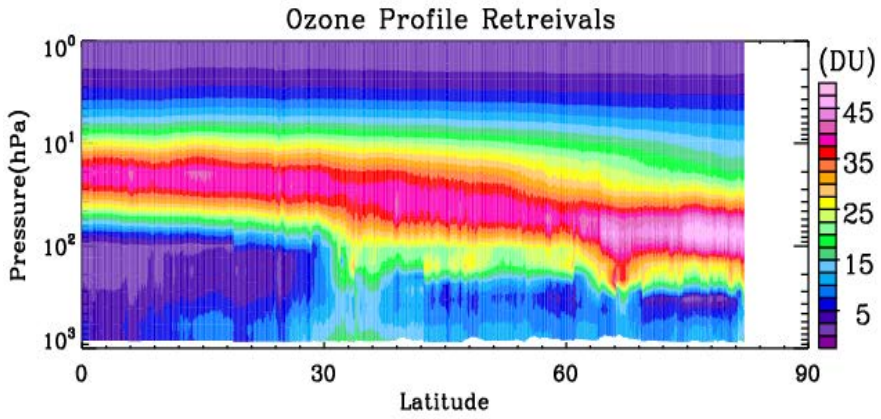
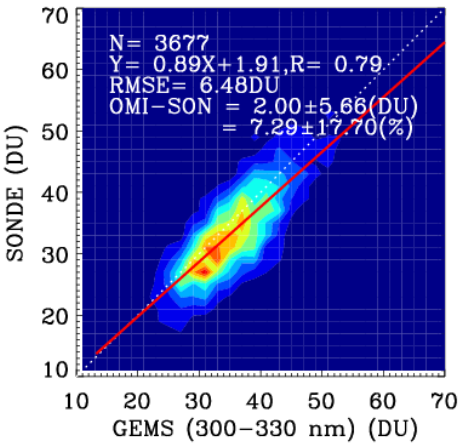
- **O3 Profile**

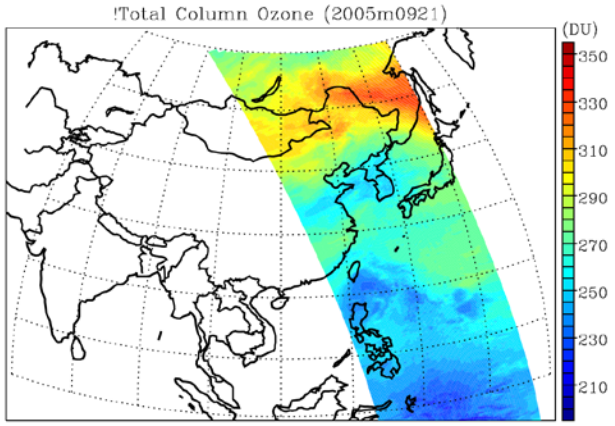


- **Validation with ozonesonde (2004-2008)**

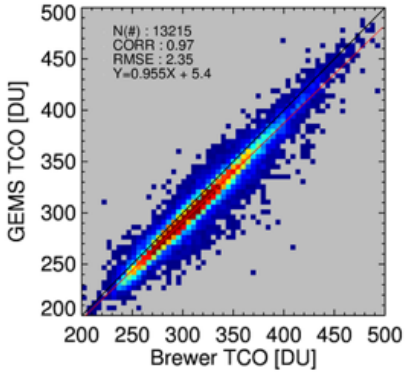


O3 (Trop.)	Target	Performance
R	0.5-0.8	0.79
Slope	0.5-0.9	0.89
Intercept	0-15 DU	1.91 DU
RMSE	5-10 DU (10-20%)	6.48 DU
Error (%)	3-6 DU (10-20%)	2 DU (7.29%)

- **Total O3**



- **Validation with Brewer (2005-2006)**



O3 (Total)	Target	Performance
R	0.82-0.97	0.97
Slope	0.83-0.97	0.955
Intercept	35.5 DU	5.4 DU
RMSE	7 %	2.35 %

(Juseon Bak, Gang Hyun Paik, Jae H. Kim)

NO2

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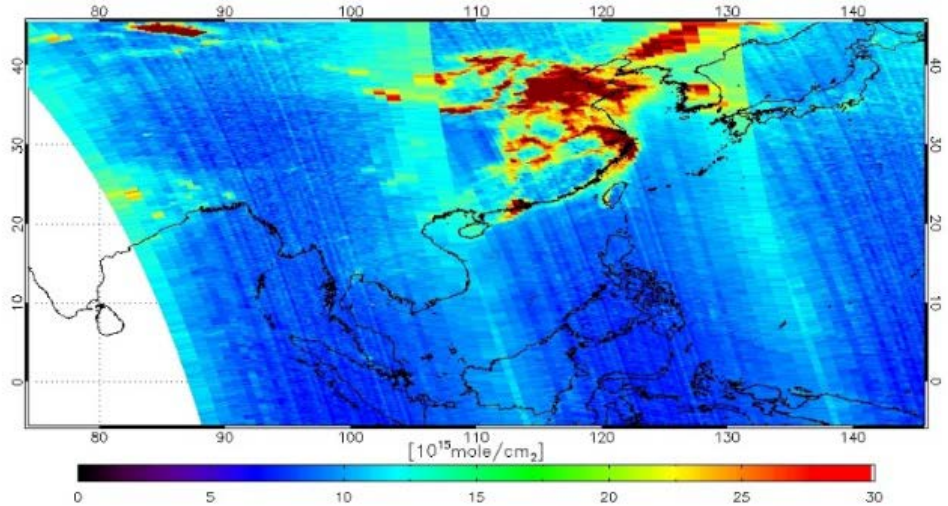
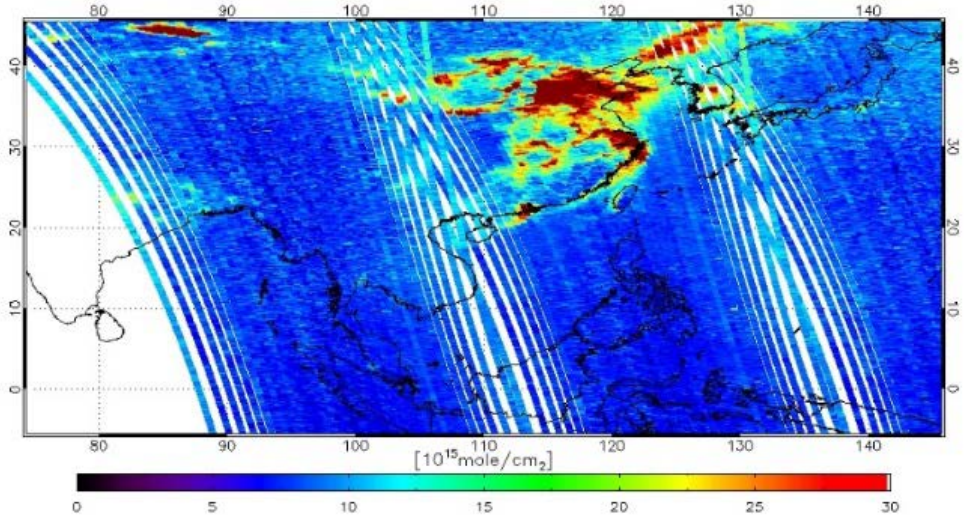
- **Validation with OMI L1b**

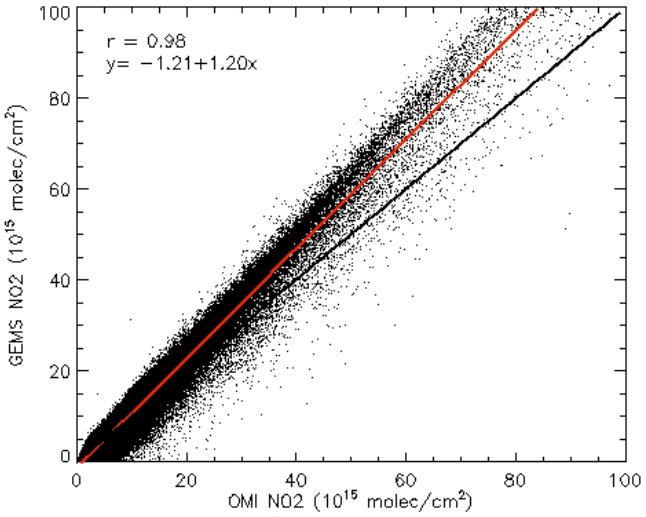
NO2 SCD (OMI L2)



NO2 SCD (GEMS algorithm)



March, 2015

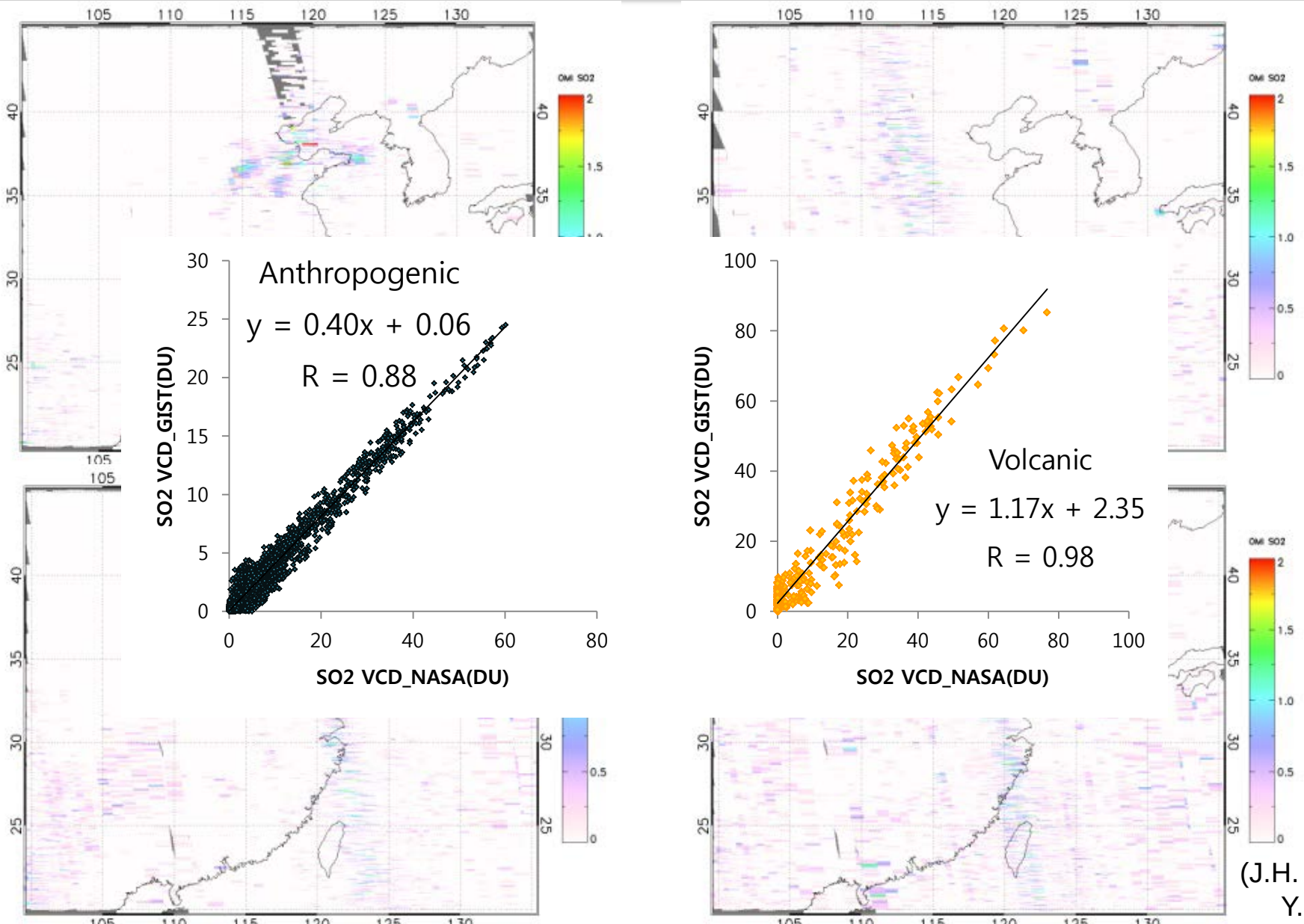


NO2	Target	Performance
R	0.8	0.98
Slope	0.5	1.2
Intercept	3.0 [10^{15}cm^{-2}]	1.2 [10^{15}cm^{-2}]

(Hyunkee Hong, Hanlim Lee)

SO2

National Institute of Environmental Research



(J.H. Jeong, Y.J. Kim)

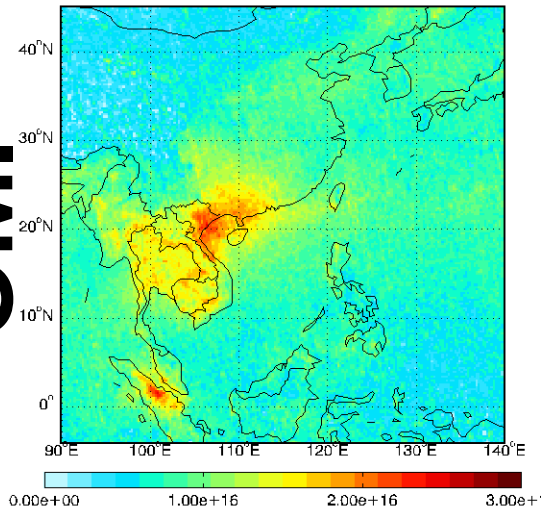
HCHO

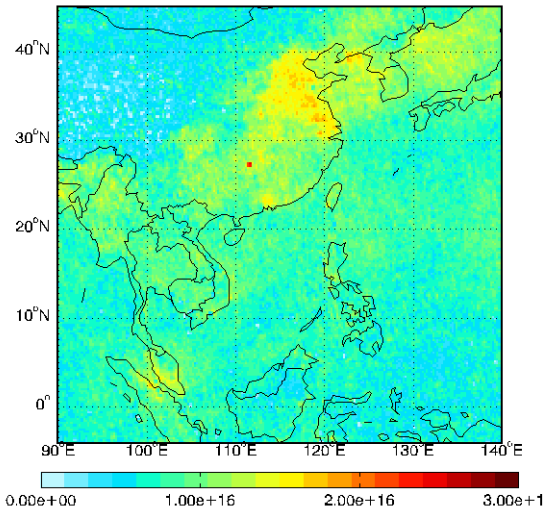
National Institute of Environmental Research

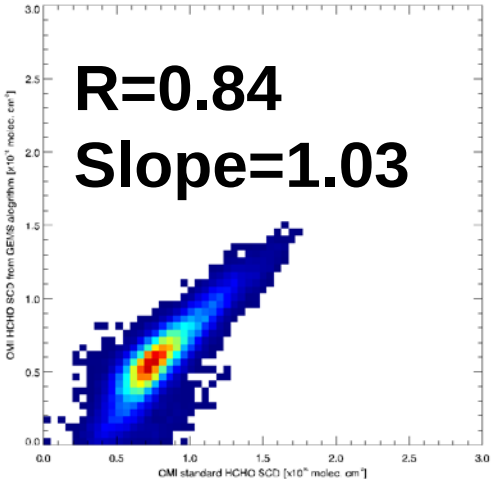
March

June

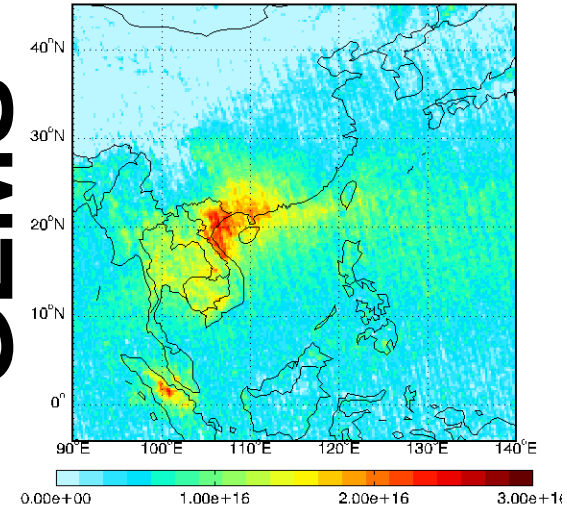
OMI

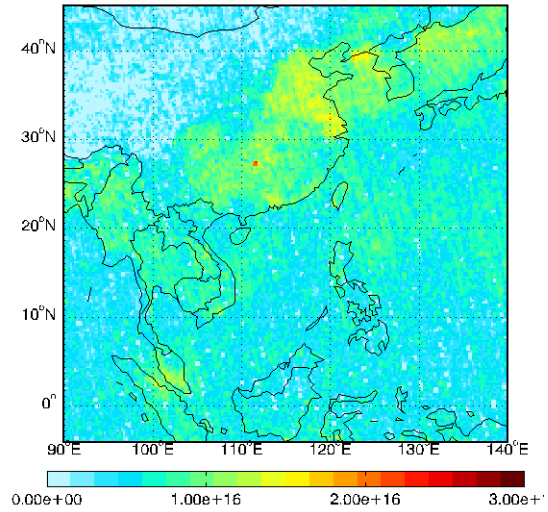


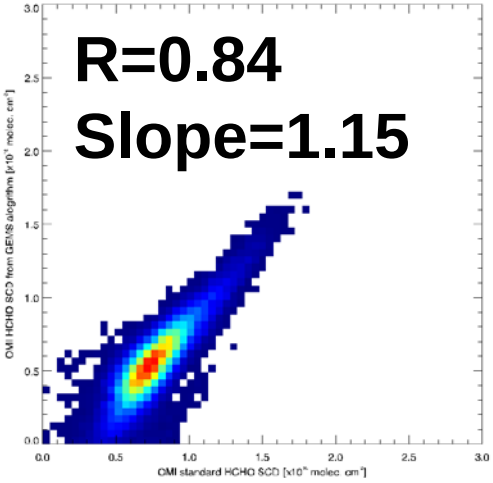




GEMS



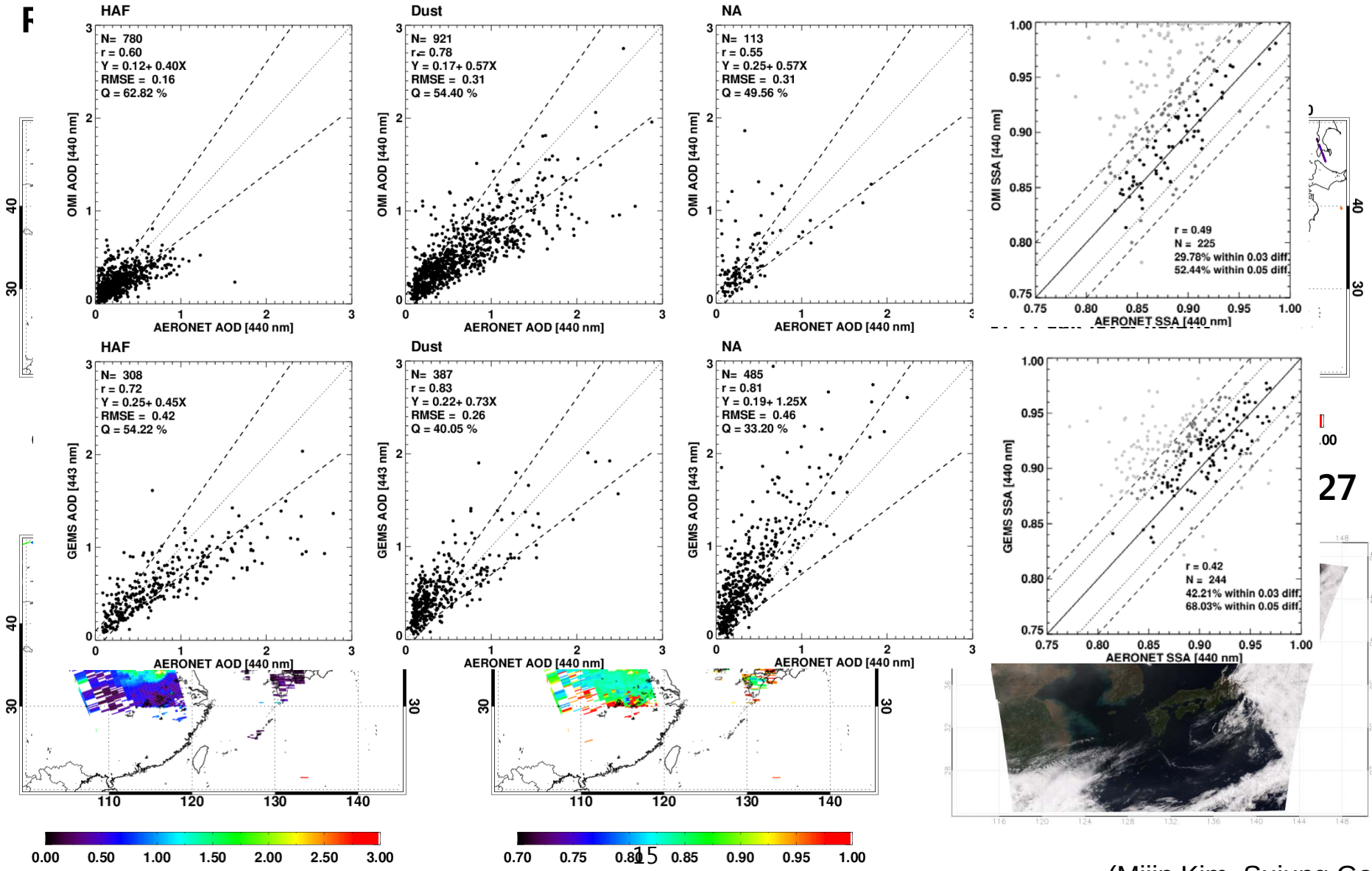




(Hyeongahn Kwon, Rokjin Park)

AOD, SSA, and HGT

National Institute of Environmental Research



(Mijin Kim, Sujung Go)

Summary

National Institute of Environmental Research

- L0-1 and L1-2 algorithms are under the development to be ready for the lau nch of GEMS in March 2019.

- L1-2 algorithm for gases and aerosols show reasonable performances, but requires further improvement, hourly retrieval in AMF, S/T separation in particular.

- Careful consideration of aerosol is required to retrieve trace gas concentration from geostationary satellite remote sensing, especially for absorbing aerosols in particular.

- 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, which eventually improve the accuracy of trace gas column density.

GEMS launch

National Institute of Environmental Research

GEMS will be launched in 2019!

French launcher Ariane 5 lifts off Arabsat-5A and South Korea's COMS satellites in French Guiana one minute after the launch window opened at 6:41 p.m. Saturday local time (GMT 0941). (Xinhua/AFP Photo)

National Institute of Environmental Research

THANK YOU