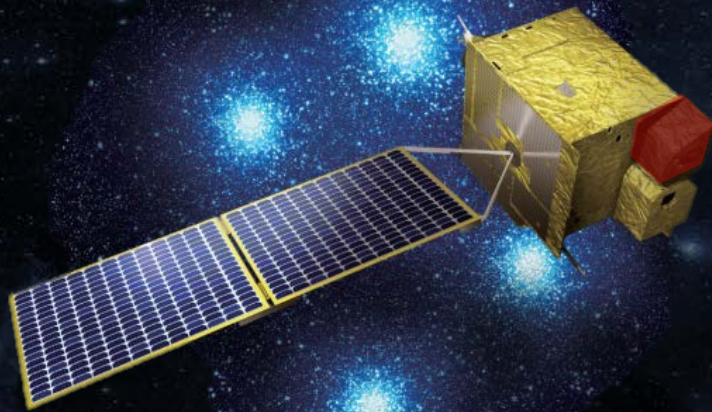


GEMS* ground system



*Geostationary Environment Monitoring Spectrometer

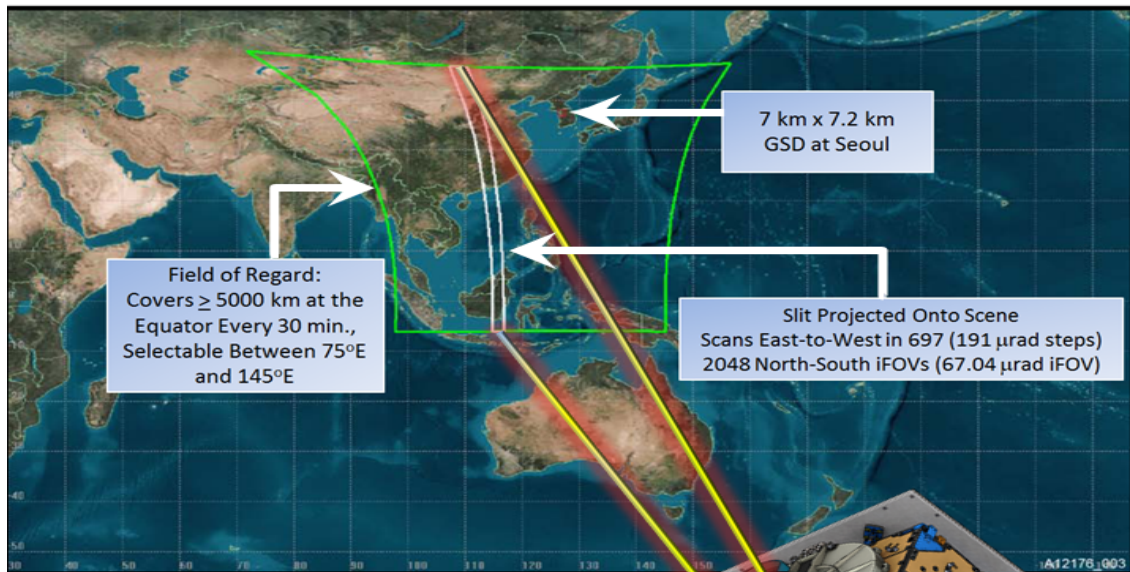
Presenter: Jongmin Yoon

Environmental Satellite Center

National Institute of Environmental Research, South Korea

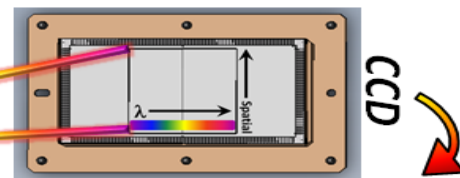
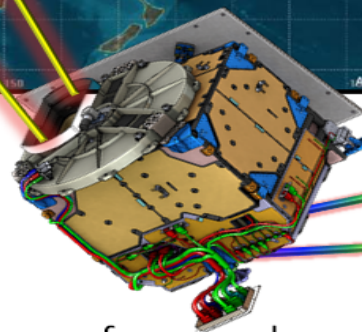
GEMS Measurement principle

GEMS Measurement Concept

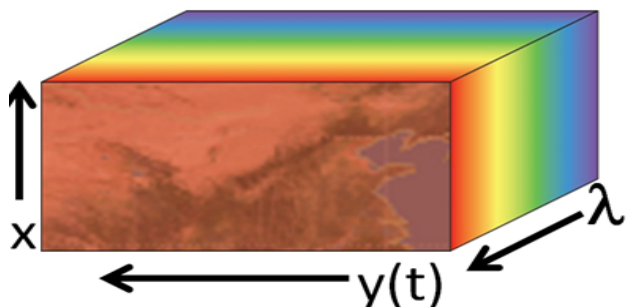


The GEMS system employs a 1032 x 2048 pixel CCD detector that operates from 300 -500 nm, which at a minimum, enables NO₂, SO₂, HCHO, O₃, and aerosol retrieval. The telescope projects the slit field of view onto the Earth, and the full field of regard is achieved via a 2-axis onboard scan mirror.

GEMS



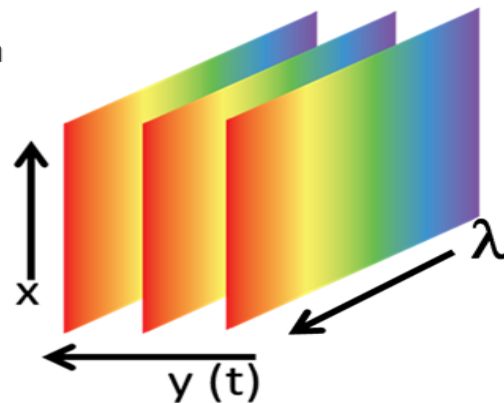
Ground processing spatially bins and geo-locates each co-added image.



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



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



GEMS Space Segment



- **GK-2B Satellite**
(Geostationary orbit)
 - Payloads: GEMS, GOCI-II
 - Lifetime > 10years
 - Launch : Oct. 2019~2020
(at French Guiana-Kourou)

- **Commanding & data downlink**
 - KARI(Daejeon, Korea)
: S-band TM & TC
 - NIER(Incheon, Korea)
: X-band
Data processing and service



Currently state and plans

- Level2 Algorithms developed for 16 species (~ 2017)
 - * Final 24 products will be tested for operation (2018~2019)
- New building(Environmental Satellite Center) and antenna system constructed (~2017)
- GEMS payload delivered to KOREA (Jan, 2018)
- CDR (Apr, 2018) and delta-CDR(May,2018) for Ground systems
- Install of operation S/W and H/W (Dec, 2018)
- S/W development for satellite data analysis (2018~2019)
- Development of algorithms for Level3 and Value added products (2018~2020)
- Launch (Oct., 2019~Mar., 2020)
- Data service for forecaster (2020~) and public(2021~)

Creating a new department for GEMS operation

- Environmental Satellite Center is a new department for GEMS operation (Apr, 2018)
- ESC consists of three teams :
 - 1) Development team
 - 2) Analysis team
 - 3) Operation team
- Construction of **GEMS ground station** was completed for **receiving, processing, management, and distribution** of data
 - Located in NIER, Incheon, South Korea
 - Dual Reflector type of 9m Antenna



Fig. Environmental satellite center in NIER

Role of Environmental Satellite Center

GEMS development team

- Routine control of data quality
- Calibration study
- Geophysical validation of products
 - DOAS, Pandora, ...
 - NIER announcement of opportunity call in 2019 to engage experts for the calibration and validation of GEMS select projects and release validation team, 2019~(TBD)
 - Cal/Val activity and feedback, 2020~
- Maintenance and update
 - Manage the updates of : calibration algorithm and tools
 - L1 and L2 processor algorithm
 - Quality control tools
 - Validation algorithms

Role of Environmental Satellite Center

Data analysis team

- Near real-time satellite data analysis for air quality forecast
 - Development of satellite data analysis system
 - Analysis of distribution characteristics of air pollutants from satellite data, target to forecasted materials
- Making a report for the extreme cases of air pollutants
 - Study for the contribution rate of air pollutants from overseas
 - Correction of bottom-up emission and analysis of how it was changed compared to the past

Role of Environmental Satellite Center

Operation team

- Operation of GEMS payload
 - Implement observation mission of GEMS
 - Establishment of daily GEMS observation plan
 - Verification of Real-time outlier
 - Products management
- Operation of GEMS ground segment
 - Check any faults of integrated data processing system
 - Management of network and security
- Data service system development
 - Collecting data requirements and feedback to the service system
 - Development and improvement of transmit techniques between GEMS ground segment and air quality forecasting system
 - Web-site management and data service to related organization
- International cooperation and sharing data with other countries

Main concept of ESC operation

Operational Concept	Explanation
Non-stop Operation	<p>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</p>
Real-time Service	<p>Acquisition in real-time and distribution in near-real-time Distribution within 1hour after receiving RAW data Improvement of processing efficiency through algorithm parallelization</p>
Operation for 10years	<p>Operating 10 years according to designed duration of GK2B operation Considering expansion possibilities of hardware, software, network, and new facilities</p>
Data archive	<p>Archiving all data in main storage, that is received and produced Building storage system that can expand and meet storage requirements</p>
Back-up system	<p>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</p>
High Availability	<p>Achieving 99% or more operational availability for high-speed processing and customized services with Hot backup system</p>

Each level of products

Level1B products

- Definition
 - Calibrated radiance data from 300nm to 500nm with navigation coordinate (not including of resampling)
- Measurement types
 - Earth, Working solar diffuser, reference solar diffuser, Dark current, Light Emitting Diode(LED)
- Format : NetCDF
- Data policy(TBD) : service for public in phases
 - First phase: air quality forecaster in NIER (L+8M IOT~)
 - Second phase: public(uploading data after all observation are finished in a day) (L+2Y~)

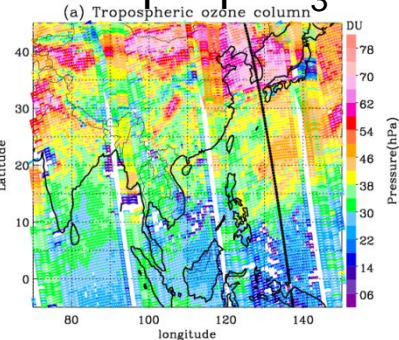
Each level of products

Level2 products

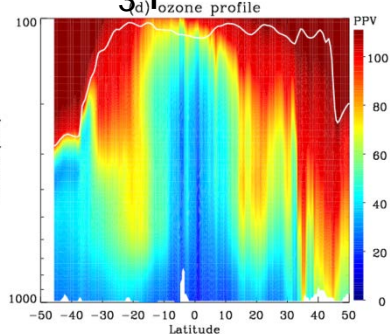
- **Definition**
 - Total column density or background products that are retrieved by level2 algorithms
- **Products**
 - Ozone, Aerosol, NO₂, HCHO, SO₂, CHOCHO, Cloud, Surface reflection, UVI, ...
- **Format : NetCDF**
- **Data policy(TBD) : service for public in phases**
 - first phase: air quality forecaster in NIER (L+8M IOT~)
 - second phase: public(uploading data after all observation are finished in a day) (L+2Y~)

Examples of Level2 products using OMI

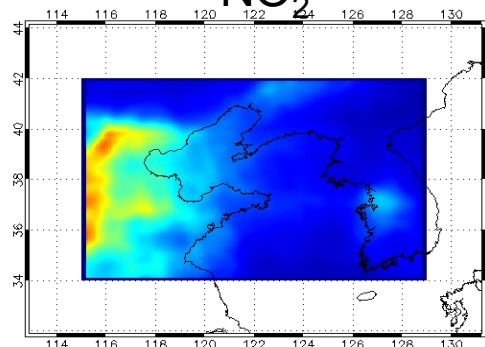
Troposp. O₃



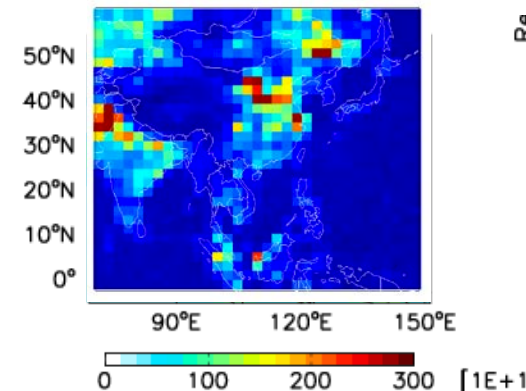
O₃ profile



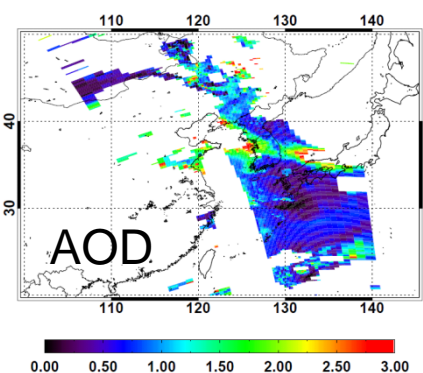
NO₂



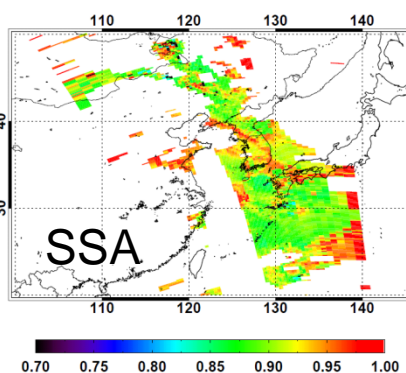
HCHO



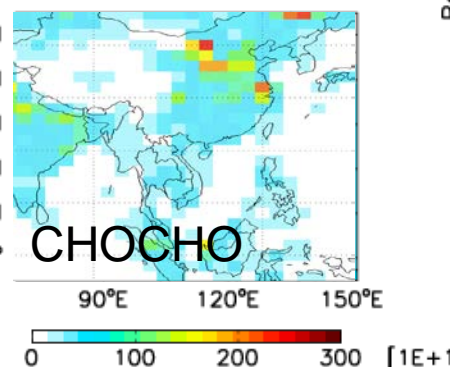
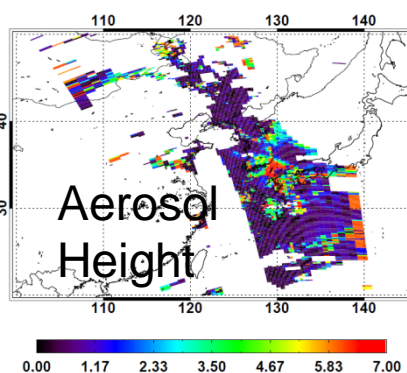
AOD [443 nm] from OMI2006m0408t0400



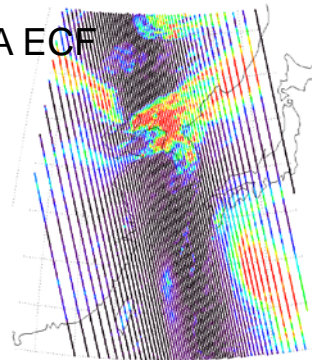
SSA [443 nm] from OMI2006m0408t0400



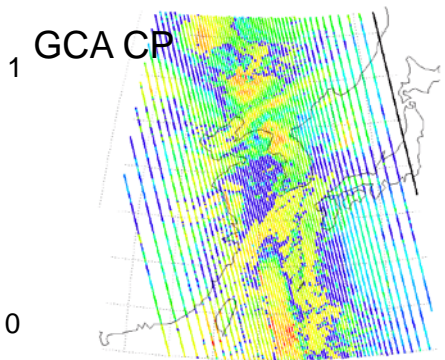
HGT from OMI [km]2006m0408t0400



GCA ECF



GCA CP



Credit :

- Mijin Kim (Yonsei U) – Aerosol
- Y.S. Choi (EWU) - Cloud
- Jae H. Kim (Busan NU) – O₃
- Hanlim Lee (Pukyung NU) - NO₂
- Rokjin Park (SNU) – HCHO, CHOCHO
- Y.J. Kim (GIST) – SO₂
- J.M. Yoo (EWU), M.J. Jeong (GWNU) – Sfc prod
- M.H. Ahn (EWU) - calibration

Each level of products

Product	Importance	Min (cm ⁻²)	Max (cm ⁻²)	Nominal (cm ⁻²)	Accuracy	Window(nm)	Spat Resol (km ²)@Sel	SZA (deg)	Algorithm
NO ₂	O ₃ 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 ₂ O ₂
ECF CCP	Retrieval Climate	0 (COD)	50 (COD)	17 (COD)		300-500	7 x 8	< 70	O ₂ O ₂ RRS
Surface Property	Environment	0	1	-		300-500	3.5 x 8	< 70	Multi- λ
UVI	Public health	0	12	-		300-350	7 x 8	< 70	

Each level of products

Level3 products

- **Definition**
 - Correcting low-quality pixel in Level2 products to improve retrieval accuracy and support more information to non-specialists with handling satellite data
 - Composing and averaging Level2 products in temporal and spatial with resampling work
- **Target** : NO₂, O₃, Aerosol
- **Format**: NetCDF(TBD)
- **Schedule**: Plan to undertake development these algorithms in Mar, 2018

Each level of products

Value added products

- **Definition**
 - Surface information of air pollutants and so on
- **Target** : NO₂, O₃, Aerosol(PM_{2.5}, PM₁₀)
- **Schedule**
 - Developed the draft algorithm for PM_{2.5} retrieval in 2017 and will improve it
 - Plan to undertake development the other algorithms in 2018

Development of surface concentration

- A draft of PM_{2.5} retrieval algorithm was developed for extracting fine aerosol information on the ground, that has significant effect on human body
 - Adopting the MLR(Multi Linear Regression) method
 - Consideration of the relationship between AOD and ground PM, weather conditions, and geographical conditions

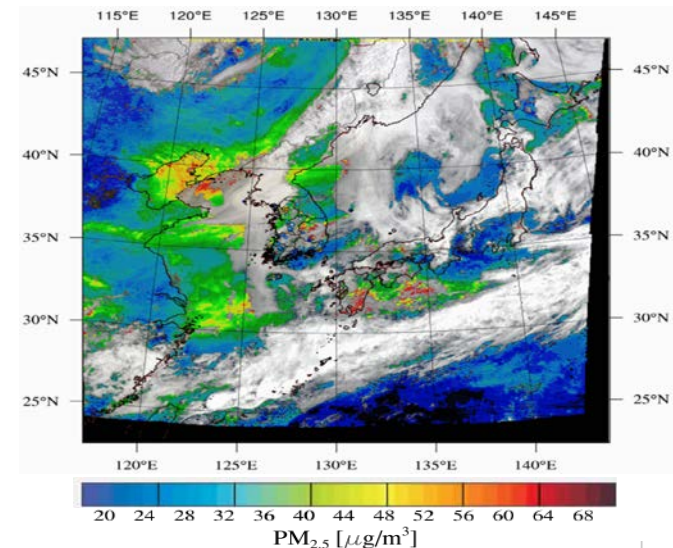
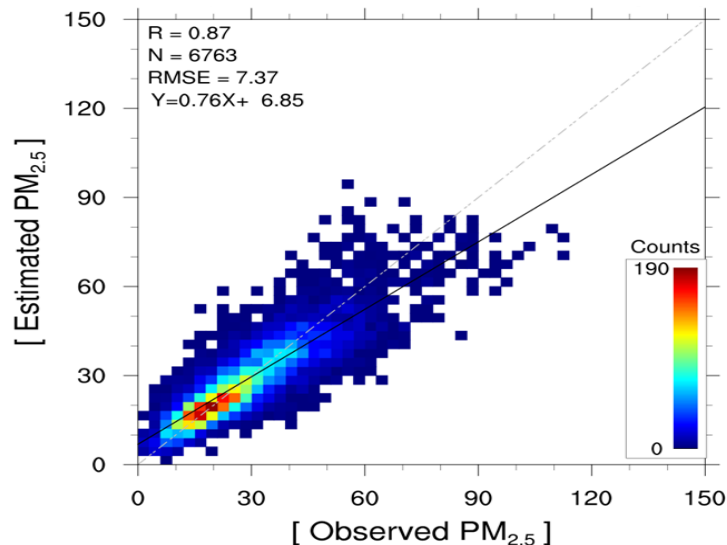


Figure: Scatter plots between estimated PM_{2.5} and observed PM_{2.5} in South Korea(left) and the spatial distribution over East Asia(right)

Operation Test Plan

Operation test for ground station system before launch

- **Tasks**

- Organically interworking between system modules in ground segments
- Reviewing functionality and appropriateness between operating systems
- Evaluating retrieval algorithms' accuracy

- **Detail schedule**

- (1st) Evaluating performance of data retrieval algorithms and validation modules (2018.10~2019.3)
- (2nd) Review of operational plan appropriateness, checking functionality of the integrated operating system and operational process (2019.4 ~ 2020)

Operation test for LEOP and IOT after launch(2020~2021)

- **Tasks**

- System functionality test using actual satellite observation data
- Fine-tuning algorithms for changes after launch

SUMMARY

- The **Ministry of Environment** (National Institute of Environmental Research) is developing a **geostationary environment satellite** for monitoring **air pollutants** over East Asia and **climate change** causing substances at all times.
- Expected products are **column density** such as O₃, NO₂, SO₄, HCHO, AOD, **periodic averaged and gridded data**(Level3), and **valued added products**
- **The Environmental Satellite Center** for GEMS is created and construction of data processing system is on-schedule, that will be stable and process data rapidly
- In the future, GEMS will be **launched in 2019~2020** and perform in orbit test for 8 months. **GEMS data will be serviced for public after 2021.**
- The GEMS will be used to **monitor air pollutants** such as long range transport and it will contribute to **improvement accuracy of air quality forecasting and emission data** with top-down approach.

Thank you for your attention!!!

