

GEMS* mission status in ground segment and application (including operation)

*Geostationary Environmental Monitoring Spectrometer

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Current status of GEMS mission



GEMS Space Segment

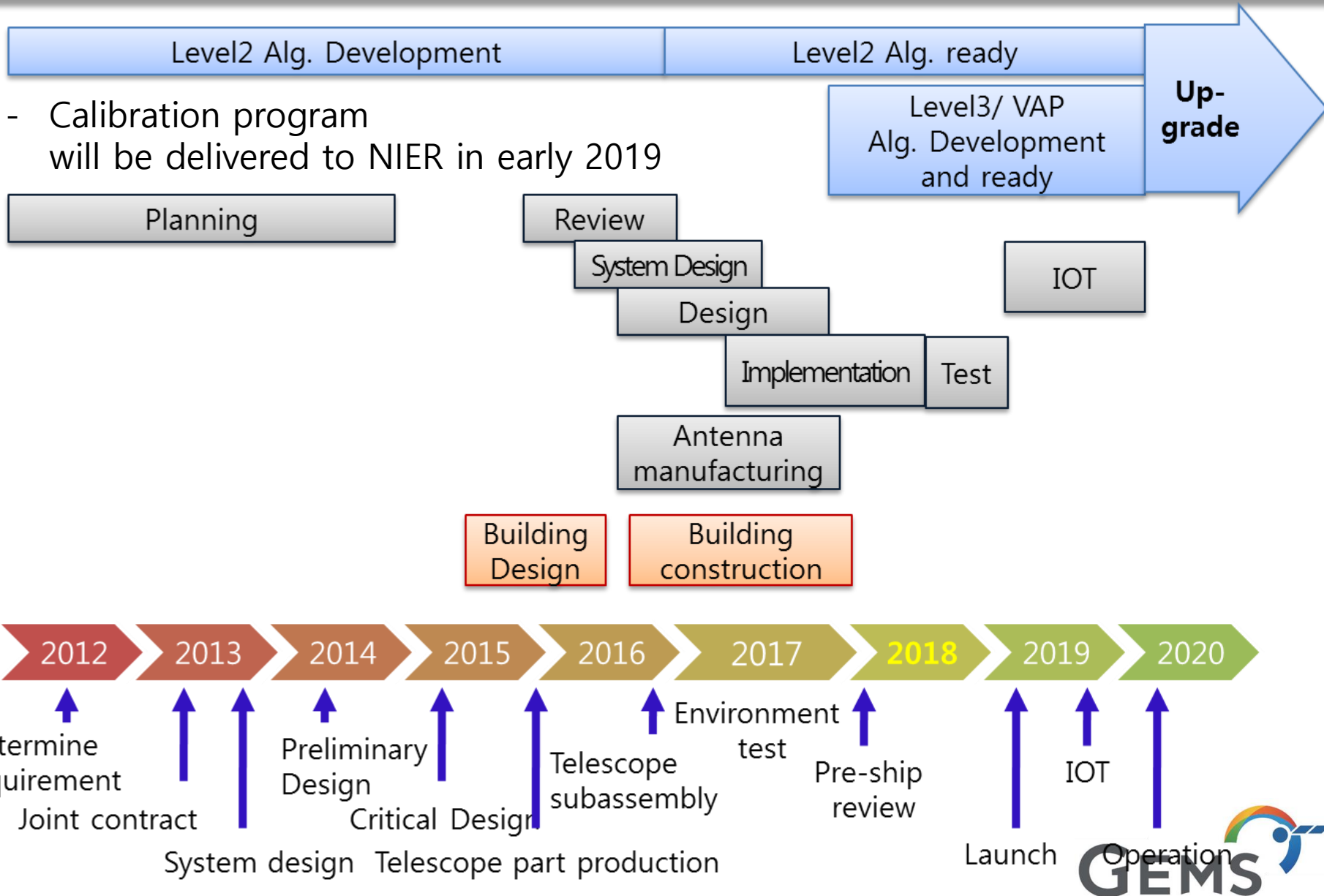


- **GK-2B Satellite**
(Geostationary orbit)
 - Payloads: GEMS, GOCI-II
 - Lifetime > 10years
 - Launch : Oct. 2019~2020 (at French Guiana-Kourou)

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



Roadmap of the GEMS mission



Currently state and plans

- Level2 Algorithms developed for 16 species (~ 2017)
 - * Final 24 products will be tested for operation (2018~2019)
- New building and antenna system constructed (~2017)
- GEMS payload delivered to KOREA (Jan, 2018)
- Creating a new department(Environmental Satellite Center) (Apr, 2018)
- Ground systems CDR (Apr, 2018), patch up the issues (May,2018)

- <Future>
- Installation 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)
- Launching (Oct., 2019~Mar., 2020)
- Data service for the forecaster (2020~) and for the public(2021~)

Creating a new department for GEMS operation

- Environmental Satellite Center is a 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, in Incheon, South Korea
 - Dual Reflector type of 9m Antenna



Fig. Environmental satellite center in NIER

Role of Environmental Satellite Center

GEMS development team

- Routine Quality Control
- Long-term Monitoring (sensor, ageing, ...)
- 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 the validation team, 2019
 - Cal/Val activity and feedback, 2020~
- Maintenance and evolution of Algorithms
 - Manage the updates of : calibration algorithm and tools
 - L1, L2, L3, VAP processor algorithm
 - Quality control tools
 - Validation algorithms

Role of Environmental Satellite Center

Data analysis team

- Analysis of air quality with near real-time satellite data for an air quality forecaster
 - Development of satellite data analysis system
 - Analysis of the distribution of the characteristics of air pollutants from the satellite data, targeting the forecasted materials
- Making a report for the cases of high concentration 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
 - Real-time verification to check 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 transmission techniques between GEMS ground segment and the air quality forecasting system
 - Web-site management and data service to the related organization
- International cooperation and sharing data with another country

Products and validation plan



Each level of products

Level1B product

- Definition
 - Calibrated radiance data from 300nm to 500nm with navigation coordinate (not including of resampling)
- Measurement types (TBD)
 - 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~)

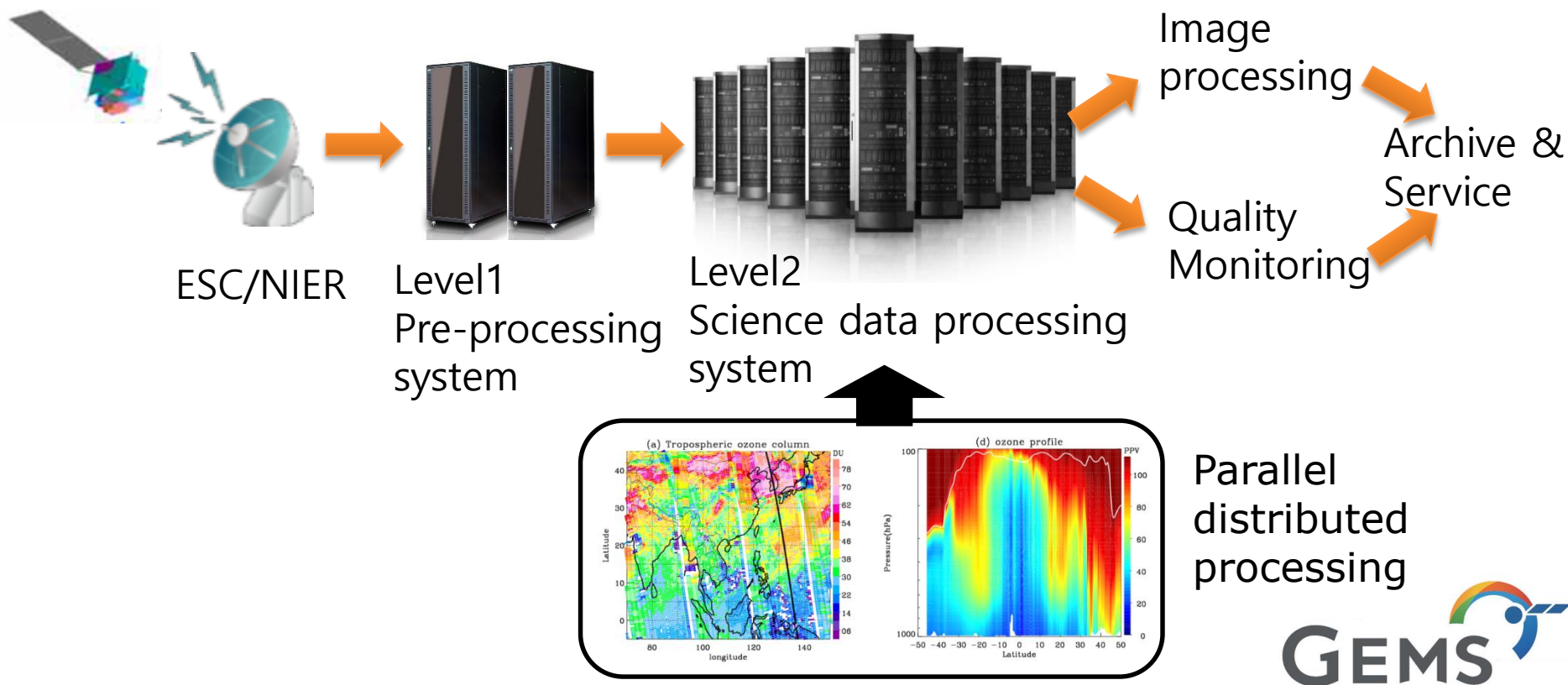
Each level of products

Level2 product

- **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 the 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~)

Optimization of Level2 algorithm

- The prototype of level2 algorithm was developed by algorithm science group(PI: Jhoon Kim) since 2012.
- **Optimization** of developed programs will be performed from 2018 to 2019.



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**: Binary(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 **PM2.5 retrieval algorithm** was developed for extracting **fine dust** 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**

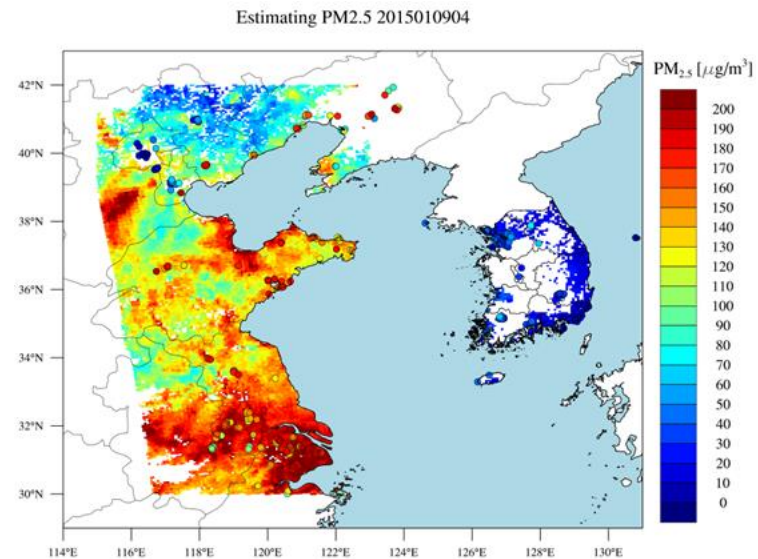
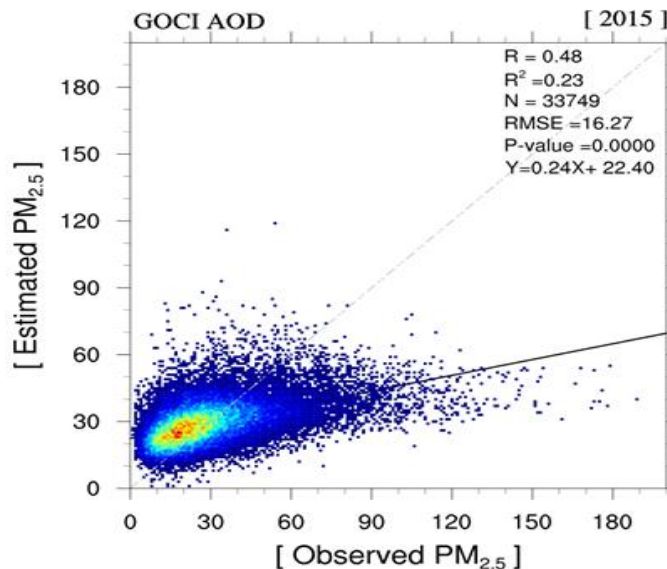


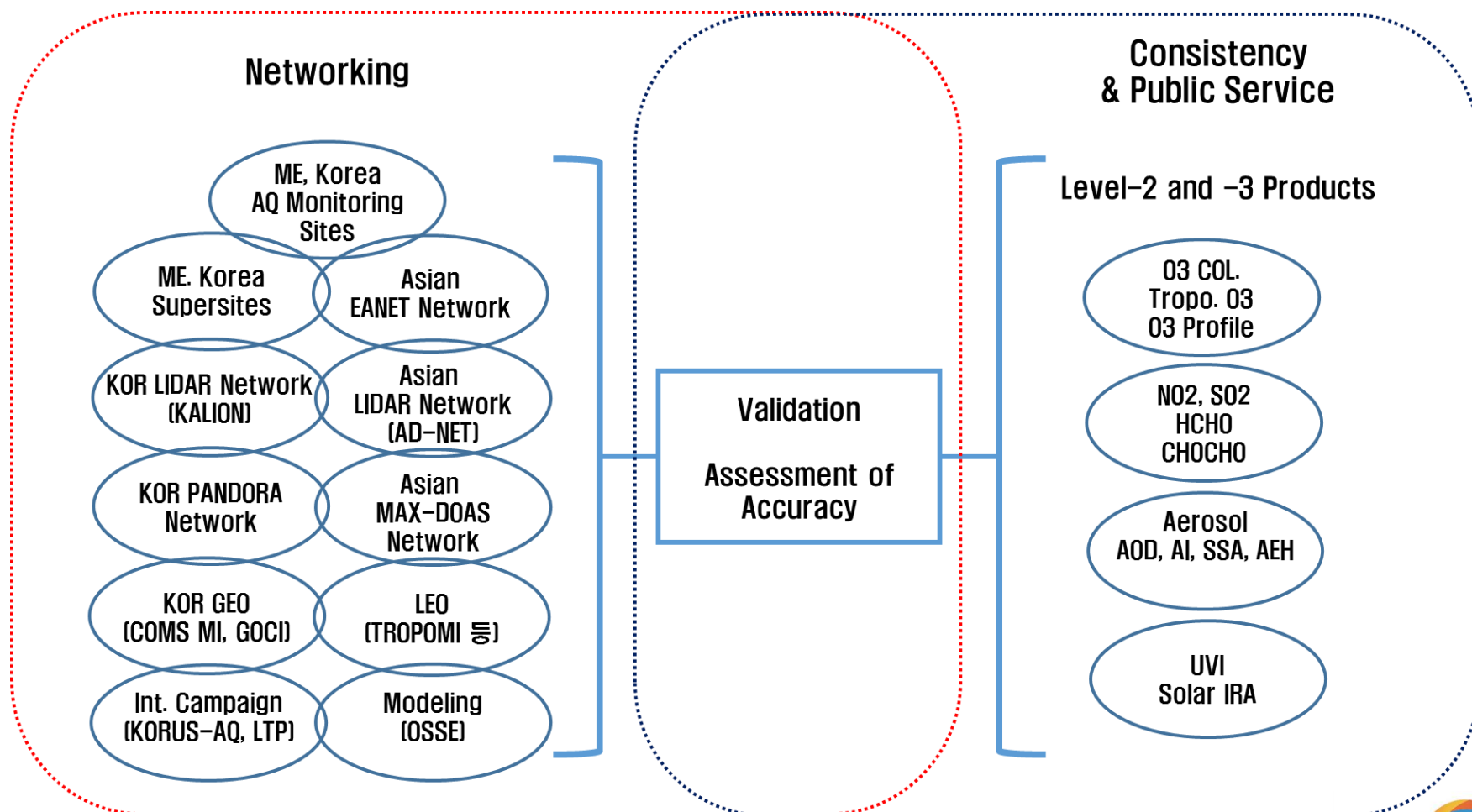
Figure: Scatter plots between estimated PM_{2.5} and observed PM_{2.5} in South Korea(left) and the spatial distribution in winter over East Asia

Validation plan

- Pre-launch
 - Development and optimization of **near real-time validation tools** such as comparison with other satellite data (2018~2019)
 - **Non real-time validation** such as comparison with surface observation data (2018~2019)
 - **Installation and test in ground segment system** (2019)
 - Confirmation of validation data (2019)
 - **Project call** to construct validation network in GEMS observation area (2019)
- Post-launch
 - **Validation activities after every major re-processing** expected to affect the data, in order to verify expected algorithm and data improvement
 - **Determination of the quality of new data products**
 - **Evaluation of mission data** against user requirements that may has evolved

Validation plan

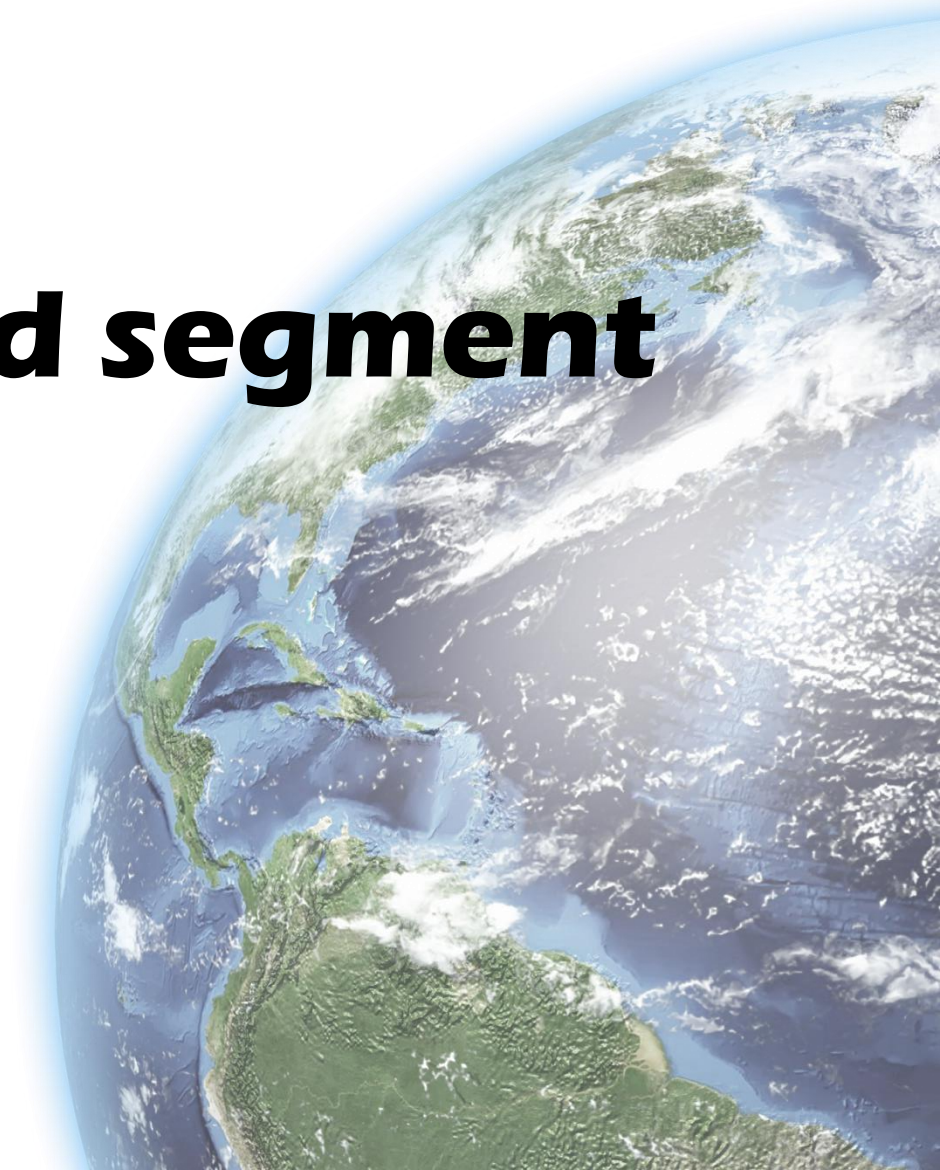
- Validation data (surface monitoring, MAX-DOAS, LEO...)



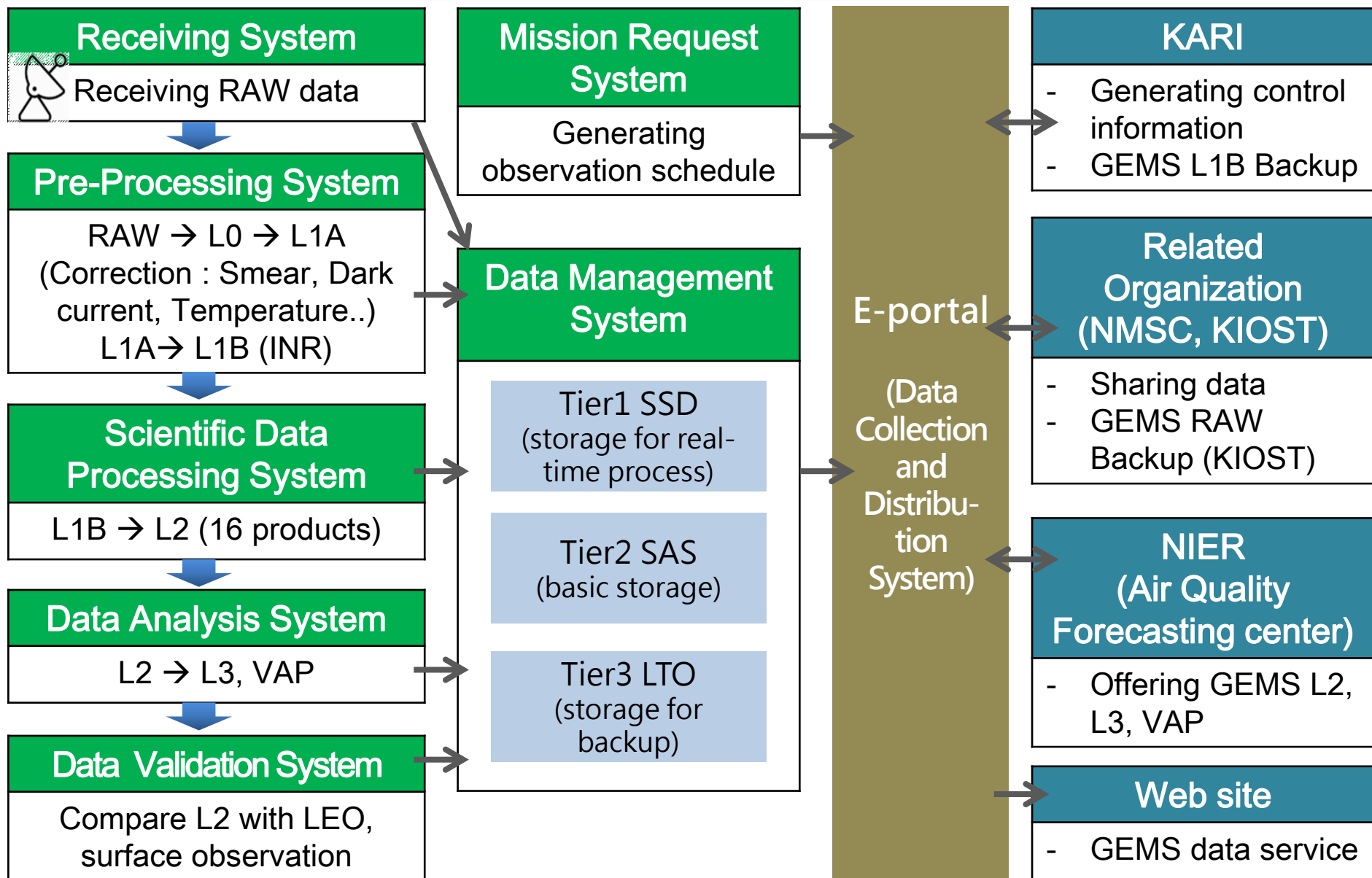
Before Launch

After Launch

GEMS ground segment



Data flow and Structure



Main concept of ground segment 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>

Test Operation Plan

Test operation 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 (2018.3~2018.12)
- (2nd) Review of operational plan appropriateness, checking functionality of the integrated operating system and operational process (2018.12 ~ launch)

Test operation for LEOP and IOT after launch(Launch + 8months)

- **Tasks**

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

Application and service plan



The roadmap of GEMS application

2016~2017

Forums with experts
→ Creating fusion application fields

Forums with non-experts
→ Exploring users and requirements

2018

Formulating data policy

Data service
Data format
Data type

2018~

Joining CEOS AC-VC

2016

Planning application

2017~

Development of surface concentration

2018~2019

Development of analysis technique

2016

Discovery of fusion application

2017

Design and planning of fusion products

2018~

Development of fusion products



GEMS data service plan(TBD)

- Via Landline (web-based service)
- Web-based service system will be constructed for 3years (2018~2020)
- For public, GEMS data will be available in a ESC website every day(TBD)
- For air quality forecaster, data will be serviced every hour
- Target products to service
 - GEMS Level1B(300~500nm, 0.6nm interval, TBD)
 - GEMS Level2 (16 products + more)
 - Scan every hour when sun is rising

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** 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.

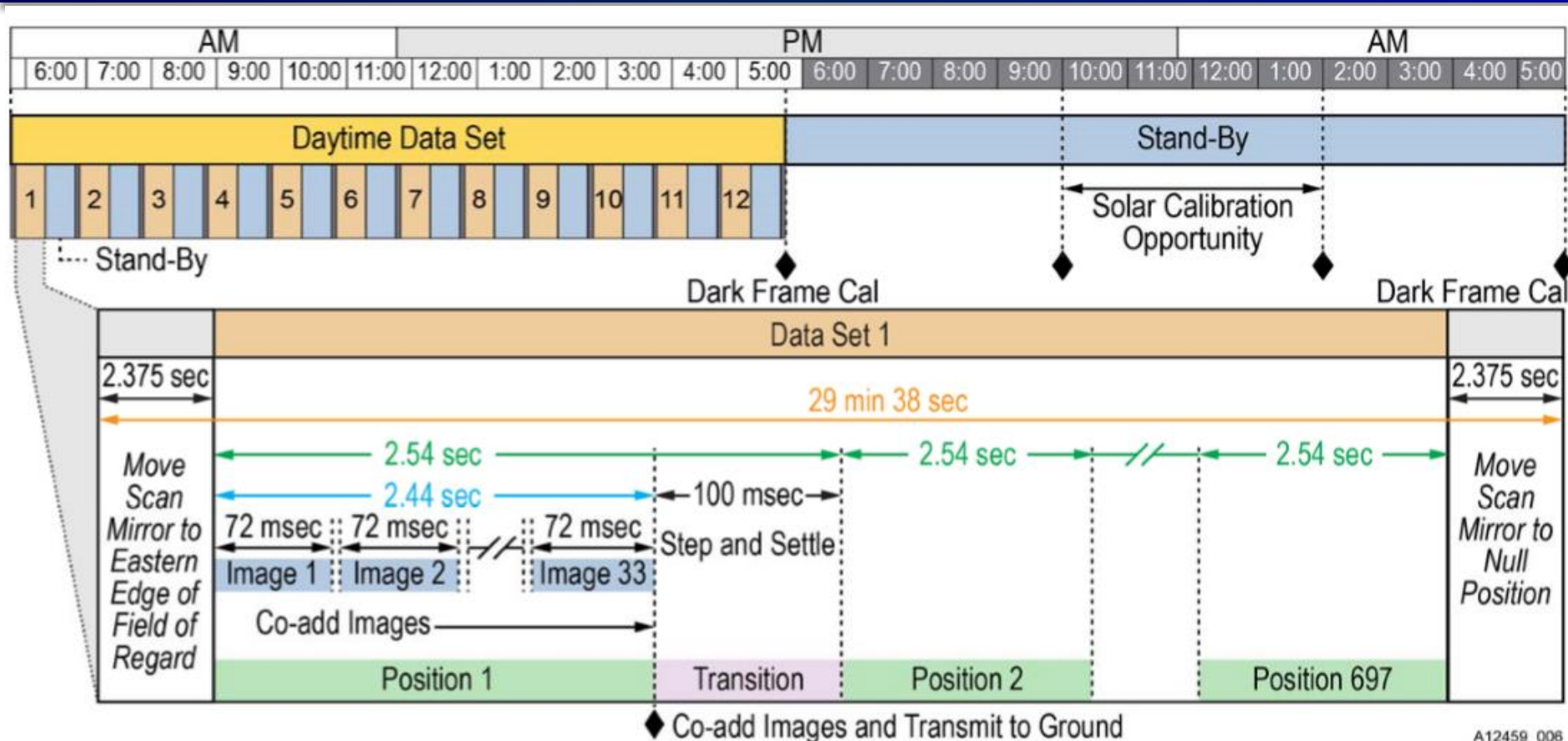


Thank you

Development plan of LEO GHG satellite

- Organized user requirement of LEO GHG Satellite 2016
- Preparing a report for the feasibility test 2017~2018
- Feasibility test for LEO GHG satellite 2019~2020 (TBD)
- Development of the LEO GHG satellite 2021~ (TBD)
- Launch (TBD)

Nominal daily operations and calibration



A12459_006

- 33 co-adds per mirror position meet SNR and 30 minute scan duration requirements
- 8-12 scans acquired per day, seasonally varying
- 2 Dark calibrations/day
- 1 Solar calibration opportunity per day at all times over the year

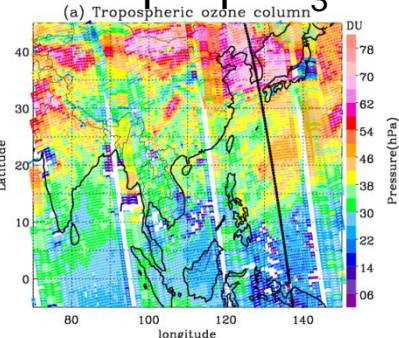
Nominal Daily operations and calibration

In-flight calibration observation plan

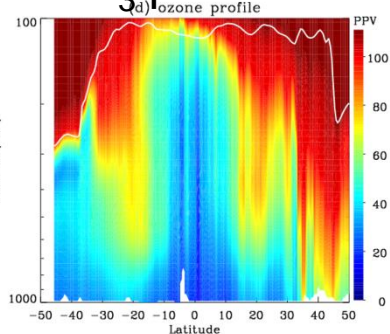
Activity	Frequency
Dark Imaging	Twice/day
Working Solar Diffuser Observation	Once/day
Reference Solar Diffuser Observation	Every 6 months
LED Light Source Linearity Sweep	Once/week

Examples of Level2 products using OMI

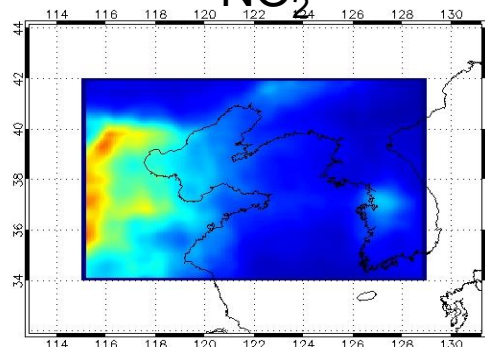
Troposp. O₃



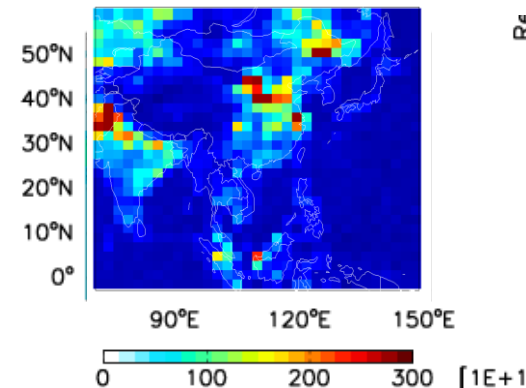
O₃ profile



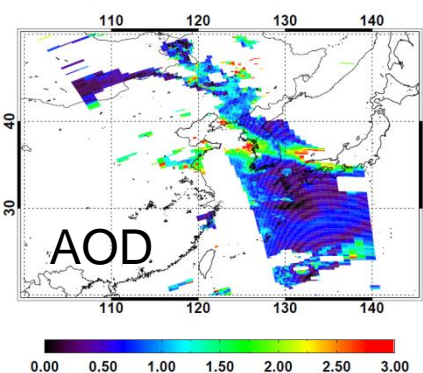
NO₂



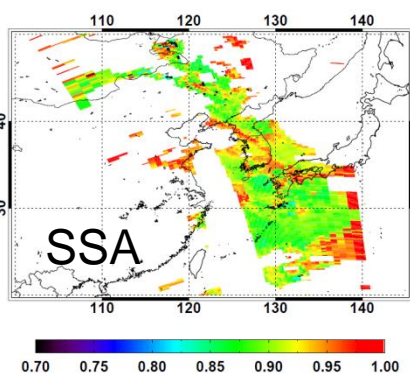
HCHO



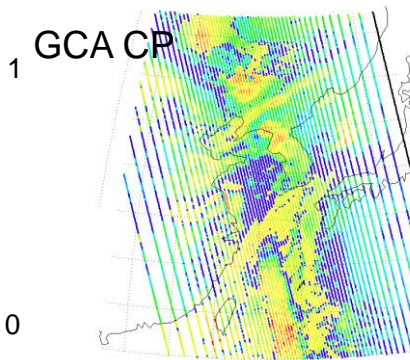
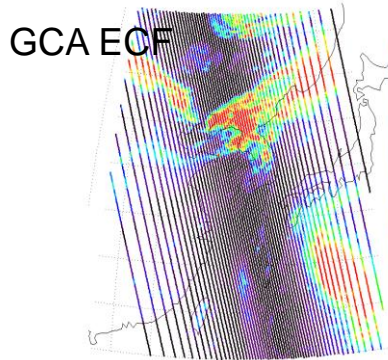
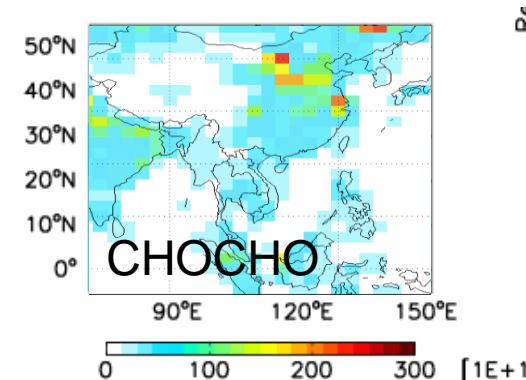
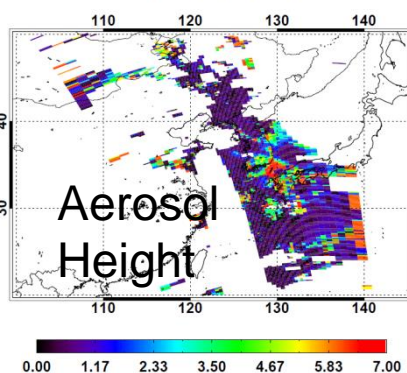
AOD [443 nm] from OMI2006m0408t0400



SSA [443 nm] from OMI2006m0408t0400



HGT from OMI [km]2006m0408t0400



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

GEMS Ground segment in ESC

Currently state and plans

- System requirement Jan. 2016~Jun. 2016
- System Design review Jan, 2017
- Preliminary Design Review Mar, 2017
- Critical Design Review Apr. 2018
- Delta-Critical Design Review May. 2018
- Construction of data processing room with servers Jun. 2018
- Realization of operation software Aug. 2018
- First stage of optimization of level2 algorithms Aug. 2018
- Integration test Sep.2018~Dec.2018
- Development of analysis and data service software in draft version Jun 2018~ Jun2019
- Final version Sep 2019~Dec.2020
- Launch Oct.2019~ 2020

Plans for LEO GHG satellite



Initiative of LEO GHG Satellite

Summary

- To monitor quantity and emission of greenhouse gas in global scale
- Two sensors will be developed
 - Near infrared hyper-spectrometer
 - Imager for aerosol and cloud correction (optional)
- In a part of the third phase mission of compact advanced satellite in KARI, Korea

Specification(TBD)

classification	specification
Weight / Size	150kg(payload) / 1.6x0.4x0.6(m)
Resolution	2km
Orbit height	705km
Channel	Three bands (0.76, 1.61, 2.06 μ m)
Target	CO ₂ , O ₂

