The 8th GEMS Science Team Meeting, September 25th-27th, 2017

GEMS Ground System and Application

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Ministry of Environment | National Institute of Environmental Research

GEMS data processing

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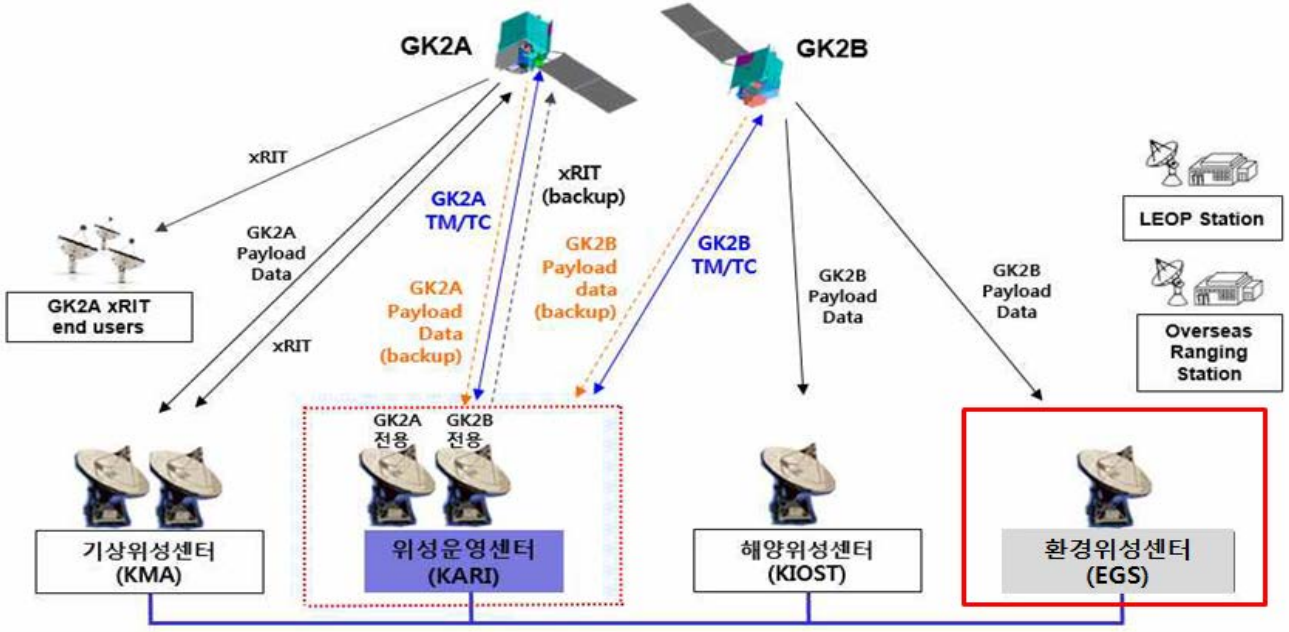
- **EGS, KARI, and KIOST will operate GK2B Satellite and they have each role of data processing.**
  - KARI is the SOC of GK2B and observation schedule is offered by EGS and KIOST
  - EGS is the data processing center of GEMS, getting raw data from a antenna and performing data production, distribution, and analysis
  - The first backup center of GEMS is KARI for Level1B and the second is KIOST for RAW data
- **AMI(KMA) and GOCI-2(KIOST) satellite data will be shared to improve GEMS level2**



EGS Operation

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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	**Setting up 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**

Operation Mode

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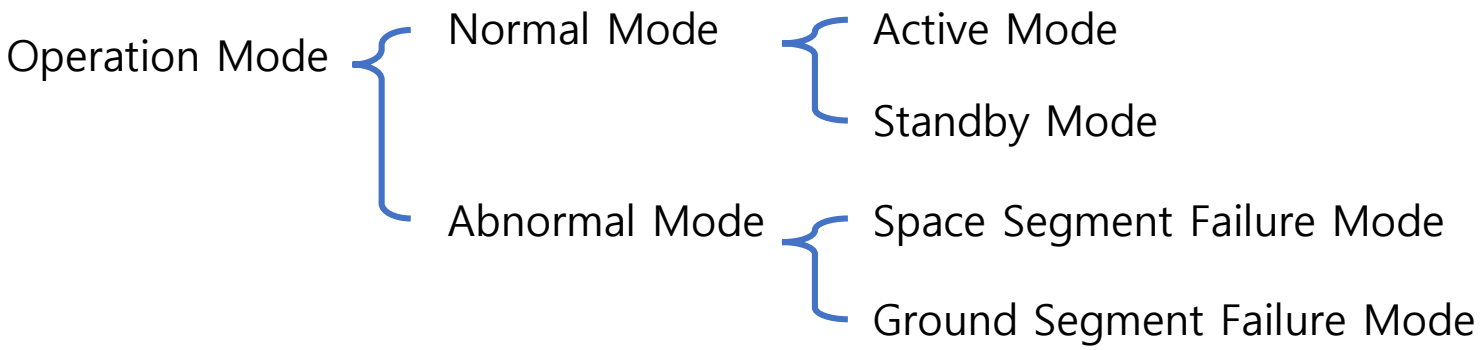

Operation Mode	Explanation
Normal Mode	**Basic operation mode**
Active Mode	- Processing automatically a series of processes such as receiving RAW data, preprocessing, processing, archiving, and distribution according to the GEMS observation schedule
Standby Mode	- Performing post processing, reprocessing, maintenance of system, and algorithm update
Abnormal Mode	**In case of error**
Space Segment Failure Mode	-Confirming error and making action when error is occurred from GEMS payload -Convening emergency response committee in 6 hours from error occurrence
Ground Segment Failure Mode	-Confirming error and making action when error is occurred from ground station -For example, in case of receiving failure, requesting back-up data from KARI or KIOST

Sub-systems

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Subsystem	Definition
EGS (Environment Ground Systems)	Preprocessing, processing, analyzing, archiving and distributing all products of GEMS
RF (Radio Frequency)	Receiving RAW data from antenna
PPS (Data Pre-processing System)	Producing Level1A and Level1B data through radiance correction and geometry correction
SDPS (Scientific Data Processing System)	Producing Level2 that is concentration of air pollutant from Level1B
DMS (Data Management System)	Saving and archiving all data in EGS
DAS (Data Analysis System)	Generating Level3 and value added products from Level2 and ancillary data
DVS (Data Verification System)	Analyzing the quality of all products and determining reprocessing of algorithms
CMS (Control and Monitoring System)	Monitoring and controlling each sub-system's operations, communications, security, errors and failures
E-Portal (Environment-Portal)	Performing data collection and distribution service

EGS Structure

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Roadmap

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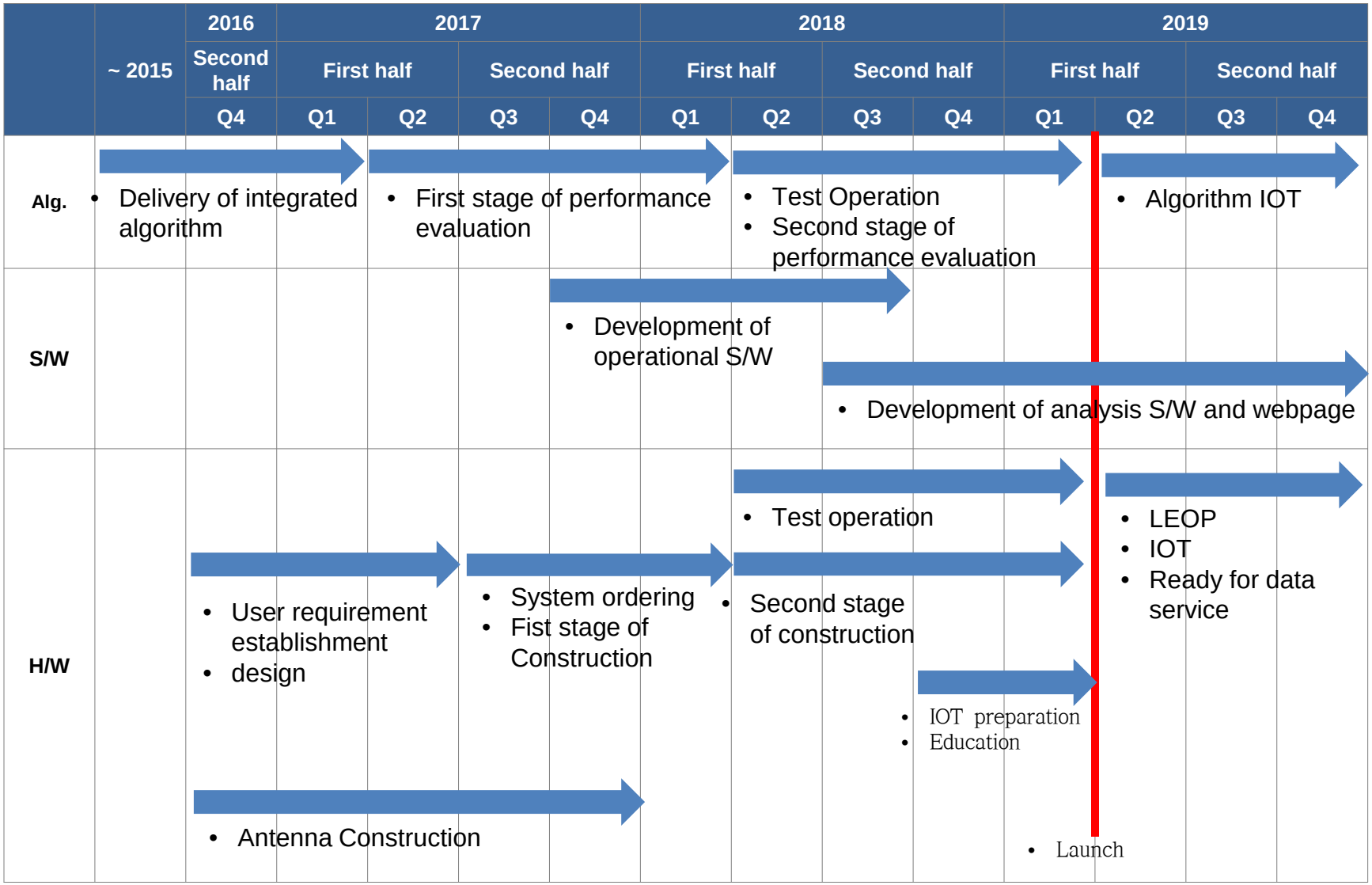

Application

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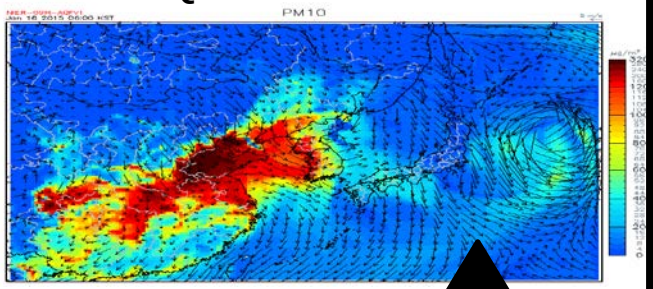
Improvement of Air Quality Model accuracy

- Core technology in AQF, Air Quality Model, has uncertainties

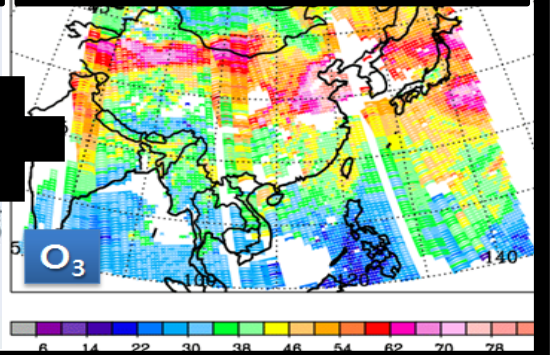
➔ Correct model with satellite data and observation as a reference in real time

AQF model

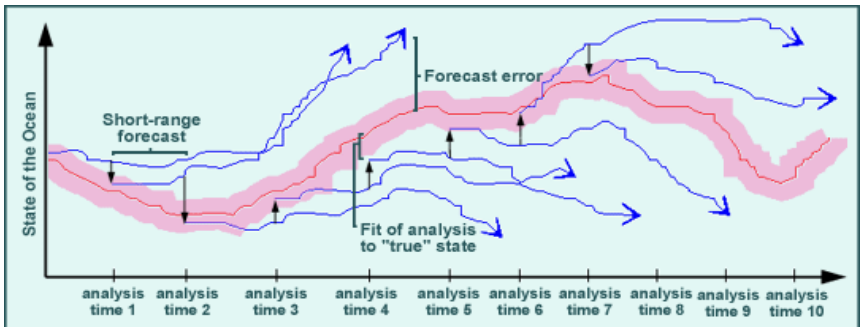


Surface

Satellite



Data assimilation



Application

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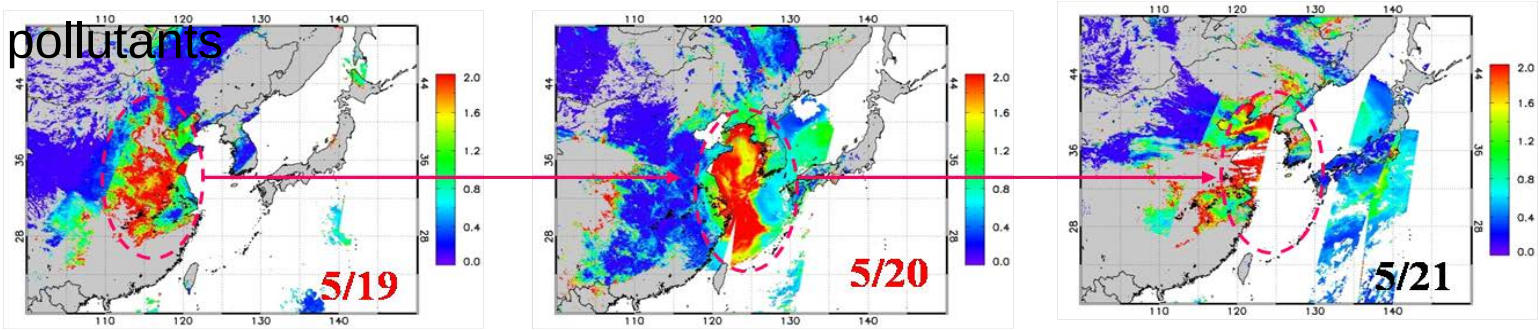
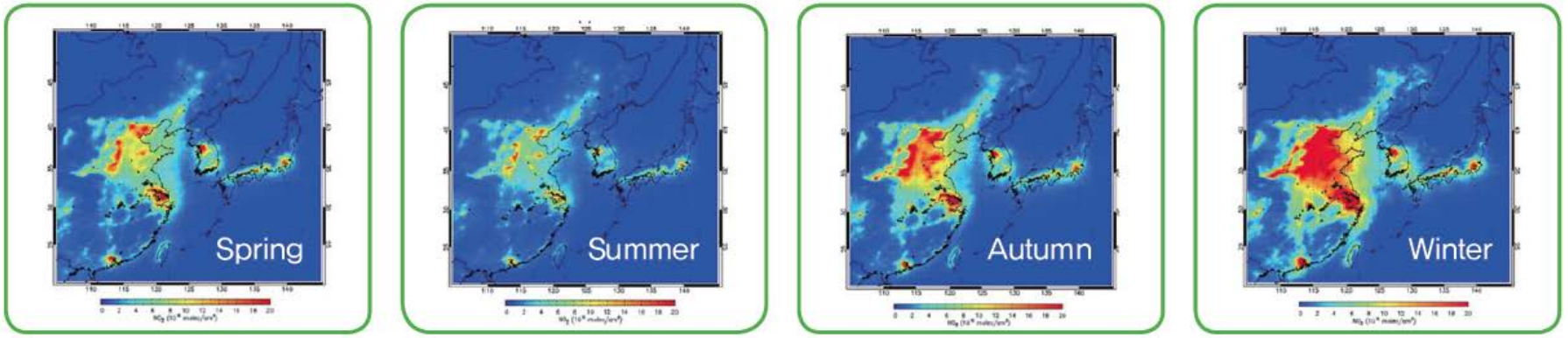
Monitoring of long-range transported air pollutants

- Monitoring of transboundary and transpacific transport of air pollutants



Continuous monitoring of air pollutants and causes of climate change

- Identifying spatio-temporal distribution and analyzing trends for air pollutants with satellite



Surface PM concentration

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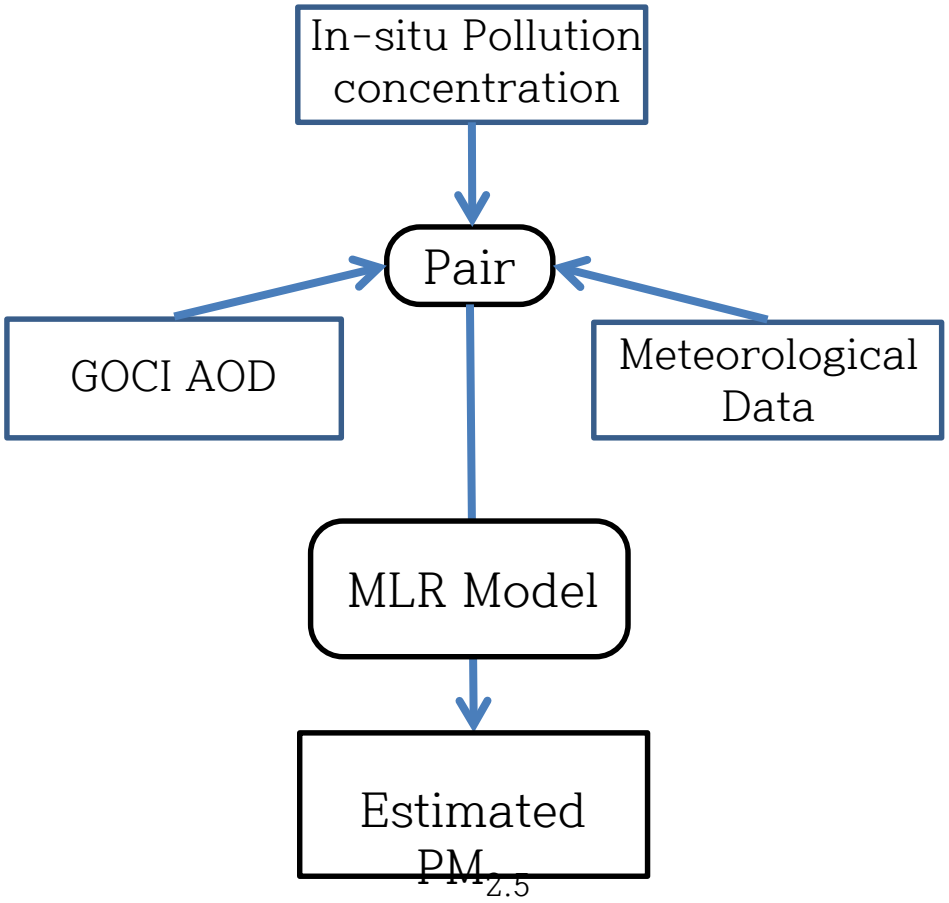

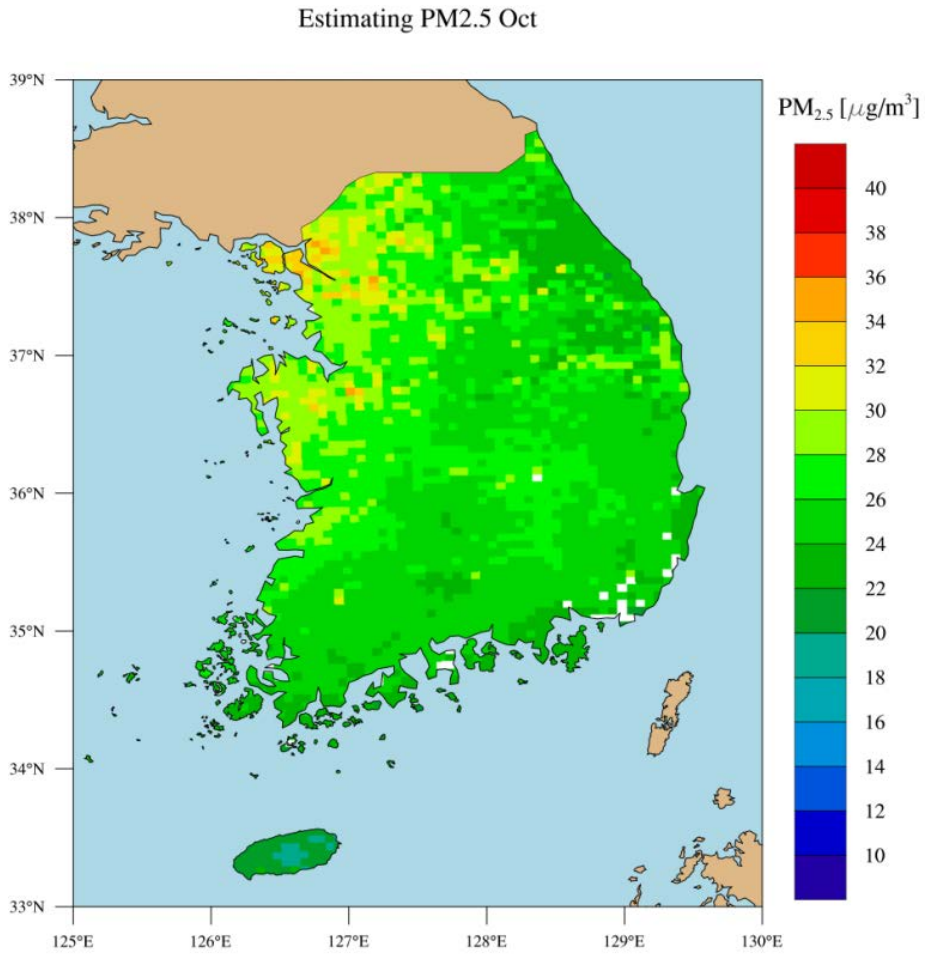

MLR : Multiple Linear Regression Model

$$PM2.5_{ij} = \beta_{0,ij} + \beta_{1,ij} \cdot AOD + \beta_{2,ij} \cdot PBLH + \beta_{3,ij} \cdot f(RH) + \beta_{4,ij} \cdot SZA + \beta_{5,ij} \cdot Temp + \beta_{6,ij} \cdot Wind\ Speed + \beta_{7,ij} \cdot NO_2 + \beta_{8,ij} \cdot O_3$$

Surface PM concentration

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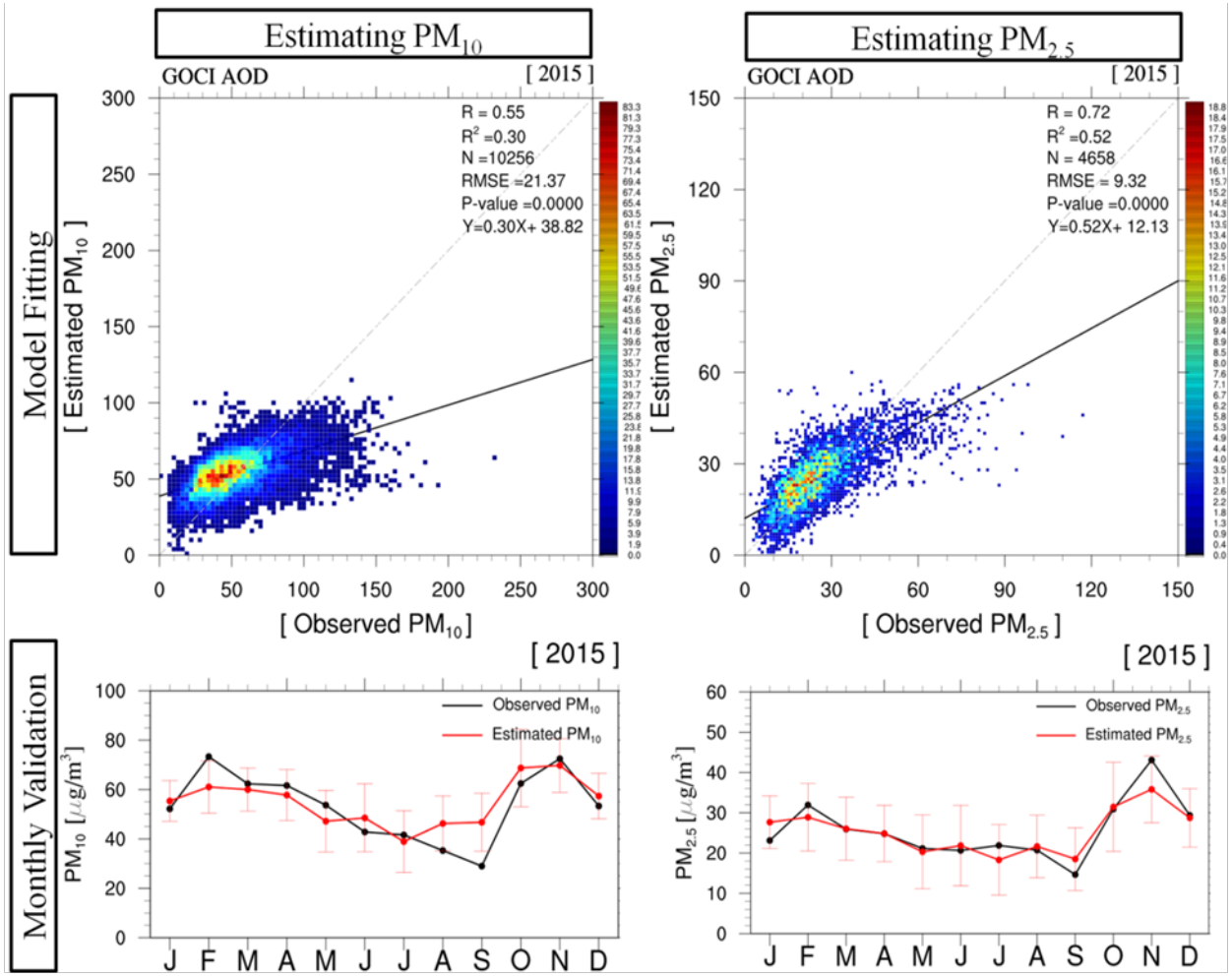

- The estimated PM values are highly correlated with observed one.
- For high concentration case, the MLR results is under-estimated to the observation.
- The seasonal patterns are similar, but there is also discrepancy in some months.
- The research area will be extended to megacity over East Asia.

Aerosol radiative forcing

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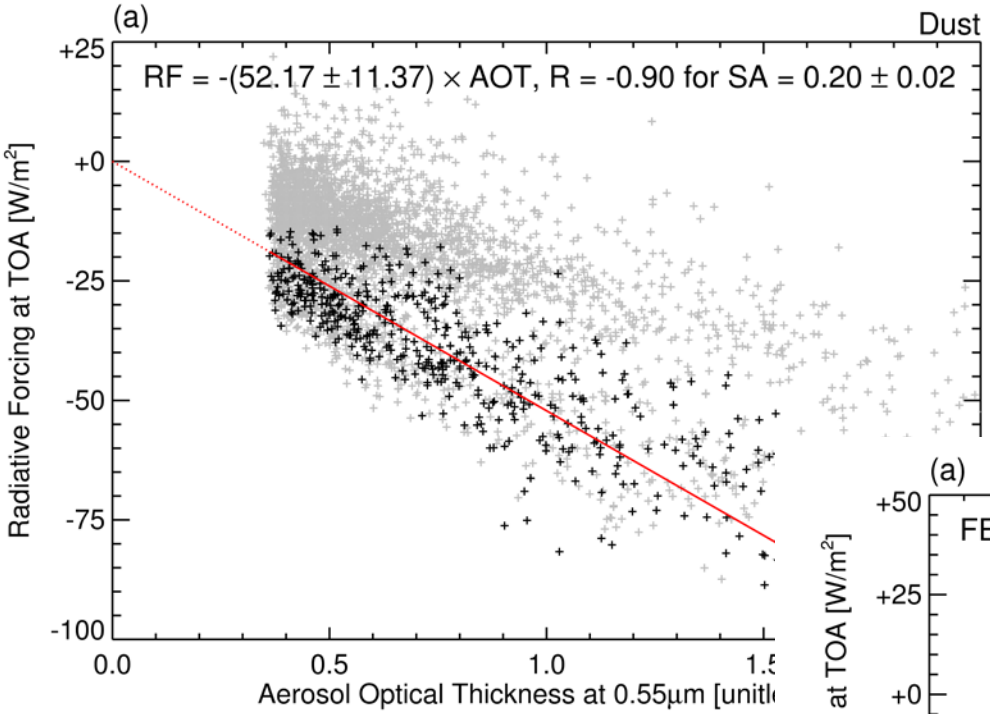

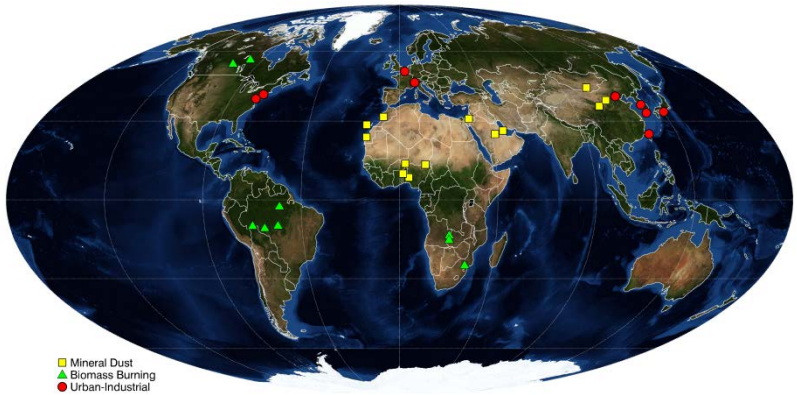

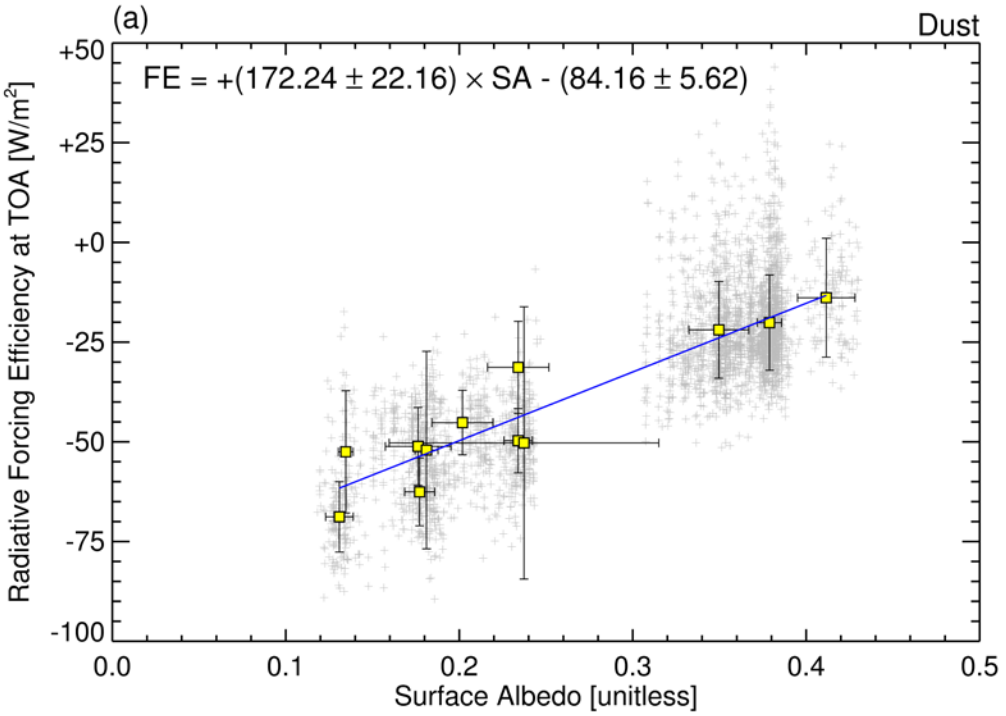

Aerosol radiative forcing

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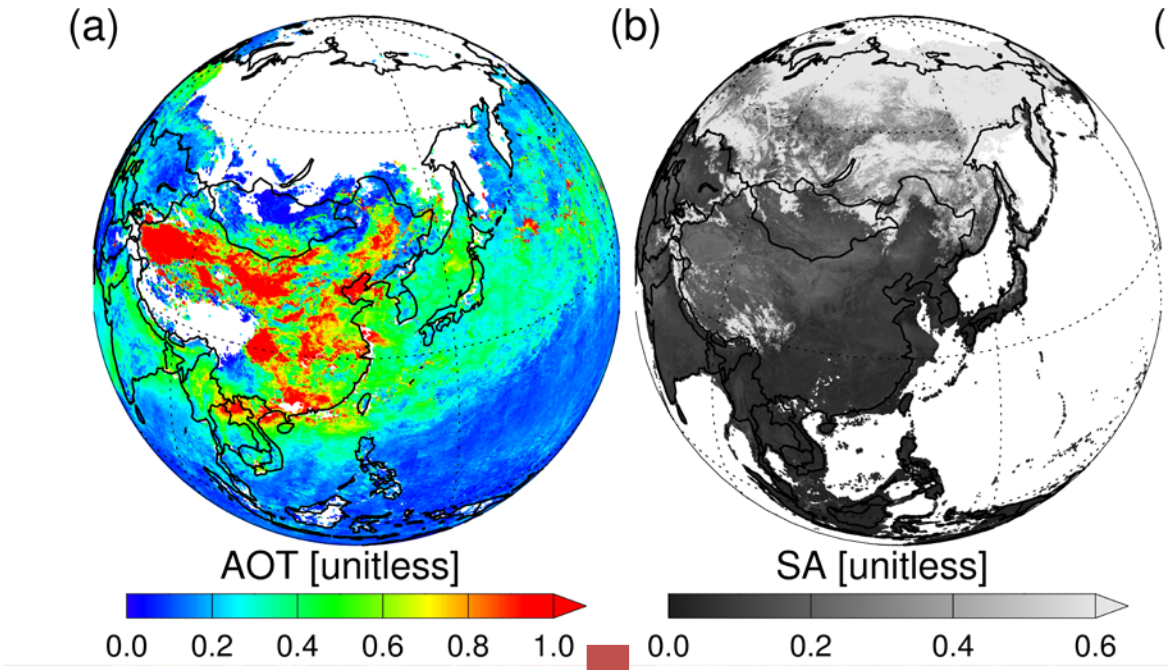

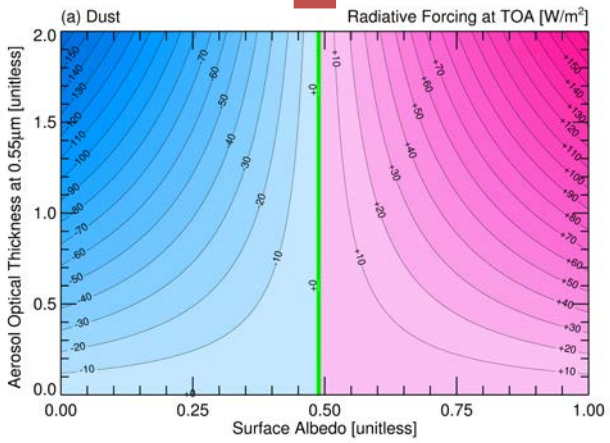

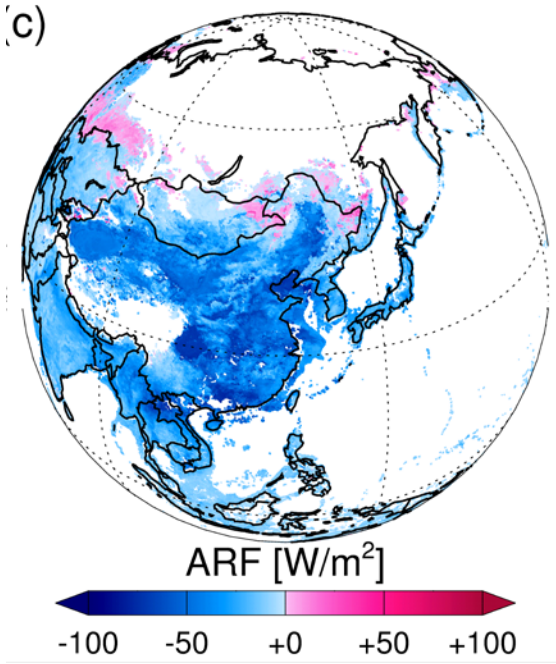

AK uncertainty in trend estimate

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$$\hat{\mathbf{x}} \cong \mathbf{x}_o + \mathbf{A}(\mathbf{x} - \mathbf{x}_o)$$

$$\Rightarrow \frac{\partial \hat{\mathbf{x}}}{\partial t} \cong \frac{\partial \mathbf{x}_o}{\partial t} + \frac{\partial \mathbf{A}}{\partial t}(\mathbf{x} - \mathbf{x}_o) + \mathbf{A}\left(\frac{\partial \mathbf{x}}{\partial t} - \frac{\partial \mathbf{x}_o}{\partial t}\right)$$

$$= \frac{\partial \mathbf{x}_o}{\partial t}(\mathbf{I} - \mathbf{A}) + \frac{\partial \mathbf{A}}{\partial t}(\mathbf{x} - \mathbf{x}_o) + \mathbf{A}\frac{\partial \mathbf{x}}{\partial t}$$

$$= \frac{\partial \mathbf{A}}{\partial t}(\mathbf{x} - \mathbf{x}_o) + \mathbf{A}\frac{\partial \mathbf{x}}{\partial t} \quad \because \frac{\partial \mathbf{x}_o}{\partial t} \approx 0$$

1. if $\mathsf{A} = \mathsf{I}\ (\partial \mathsf{A}/\partial t = 0)$, then $\frac{\partial \hat{\mathsf{x}}}{\partial t} = \frac{\partial \mathsf{x}}{\partial t}$

2. if $\mathsf{A} \neq \mathsf{I}$, but $\partial \mathsf{A}/\partial t = 0$, then $\frac{\partial \hat{\mathsf{x}}}{\partial t} = \mathsf{A}\frac{\partial \mathsf{x}}{\partial t}$

3. if $\mathsf{A} \neq \mathsf{I}$ and $\partial \mathsf{A}/\partial t \neq 0$, then $\frac{\partial \hat{\mathsf{x}}}{\partial t} = \frac{\partial \mathsf{A}}{\partial t}(\mathsf{x} - \mathsf{x}_o) + \mathsf{A}\frac{\partial \mathsf{x}}{\partial t}$

AK uncertainty in trend estimate

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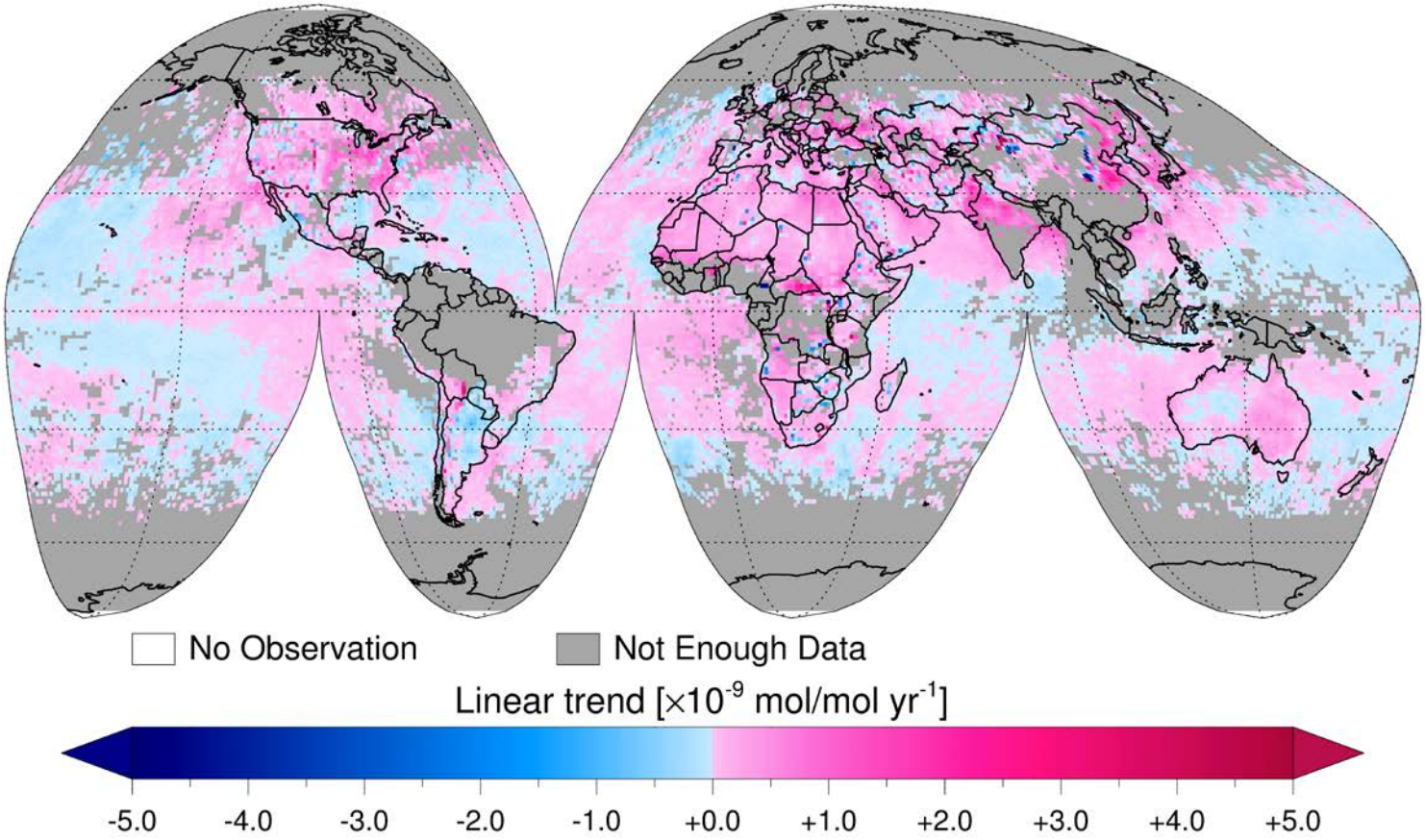
$$3a.\ \mathbf{x} = 0.5 \times \mathbf{x}_o \ (\text{i.e. } \partial\mathbf{x}/\partial t \approx 0 \text{ and } (\mathbf{x} - \mathbf{x}_o) < 0) \Rightarrow \frac{\partial \hat{\mathbf{x}}}{\partial t} = \frac{\partial \mathbf{A}}{\partial t}(\mathbf{x} - \mathbf{x}_o)$$



AK uncertainty in trend estimate

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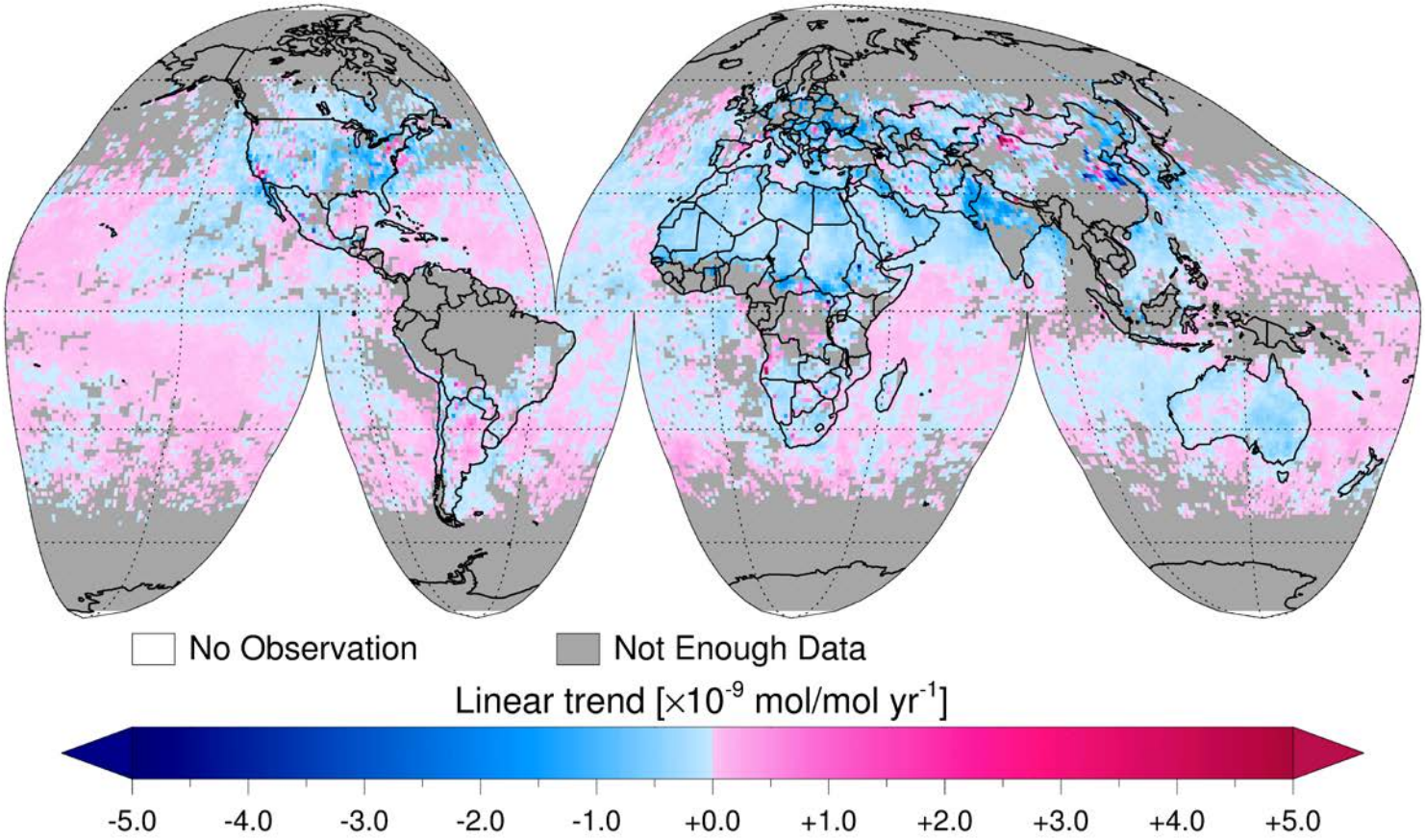
$$3b.\ \mathbf{x} = 1.5 \times \mathbf{x}_o \ (\text{i.e. } \partial\mathbf{x}/\partial t \approx 0 \text{ and } (\mathbf{x} - \mathbf{x}_o) > 0) \Rightarrow \frac{\partial \hat{\mathbf{x}}}{\partial t} = \frac{\partial \mathbf{A}}{\partial t}(\mathbf{x} - \mathbf{x}_o)$$



Summary

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- L0-1 and L1-2 algorithms are under the development to be ready bef ore the launch of GEMS in March 2019.
- Building will be completed by Dec. 2017 and receiving and processing systems will be installed from end of this year.
- Various application methods are currently under development for monitoring air quality, assessing radiative balance, and estimating long-term trend of air pollutions.
- 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

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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)

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THANK YOU