15th CEOS AC-VC @Tokyo

Status of the GEMS mission and air quality data analysis

Ara Cho

Environmental Research Center

National Institute of Environmental Research

ara87@korea.kr

CONTENTS

1 Introduction

Introduction

- In South Korea, the average level of **PM2.5** was **25.1 micrograms per cubic meter** in 2017, **the worst among 35 member states** of the Organization for Economic Cooperation and Development (OECD). The OECD average was 12.5 micrograms per cubic meter.
- Domestically, fine particles primarily come from emissions from diesel vehicles, ships, construction equipment and other operations involving the burning of fuels.
- The widespread perception in South Korea is that **a large proportion of the dust originates from industrial area in abroad**.
- To narrow the opinion gap with public and to monitor atmosphere environment in real-time, the state-run National institute of Environmental Research will **launch the GEMS payload** until **March, 2020**.
- GEMS is loaded aboard **GEO-KOMPSAT2B** which is **undergoing several tests until the launch period**.
- Air pollutants and causes of climate change including SO2, NO2, O3, HCHO and aerosols will be observed with UV-Visible hyper-spectral sensor in East Asia

2 GEMS mission status at NIER

GEMS mission status

The goal of GEMS mission

Monitoring status of air quality and climate change in East Asia

01 GEMS development

GEMS FAT, PSR (2018), Integrating between GEMS payload and GK-2B bus (2019)
Currently, planning IOT program and undergoing several tests before launch
GEO-KOMPSAT2B Launch: ~ March 2020 (IOT: Launch + 8months)

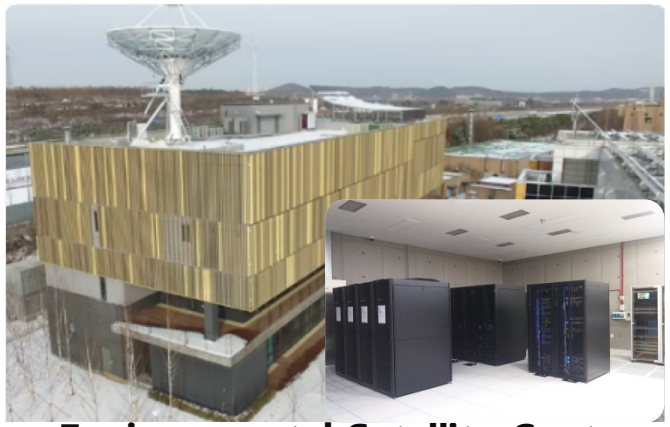
02 Ground segment & Algorithms

Constructed Ground system in Environmental Satellite Center (ESC) (2018)
Currently, evaluating L1-L2 algorithms in ESC

03 Research on atmosphere environment using satellite data

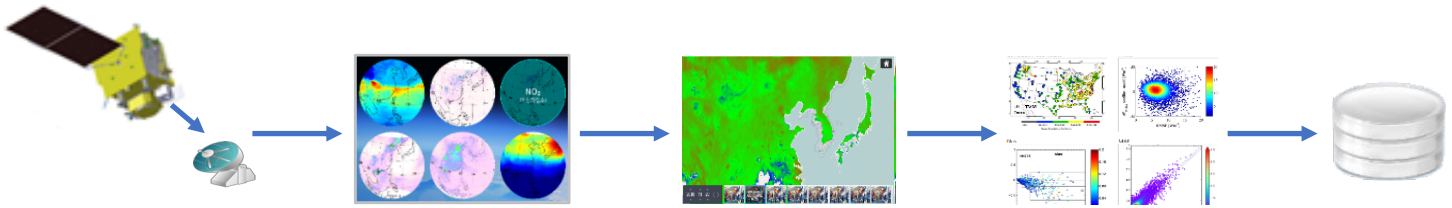
Set up a roadmap for research w.r.t. satellite utilization (2019)
Support a report to air quality forecaster including satellite data analysis

GEMS ground station – Environmental Satellite Center



Environmental Satellite Center

- Directly receiving GEMS RAW data
- Non-stop operating ground station
- Monitoring and analyzing quality of all level of GEMS data
- Acquisition and distribution satellite data in real-time



2019

Complement of Ground station — Test run

2020

Launch — LEOP/ IOT — Cal/ Val, Ready to data distribution

2021

~ Regular Operation(24-hour, 10-year) — Sharing data with institutes

Plan of Environmental Satellite Center as a ground segment

Distribution

[Supporting for..]

Public

National Air Quality Forecasting Center

University

Industry

NASA

ESA

KARI

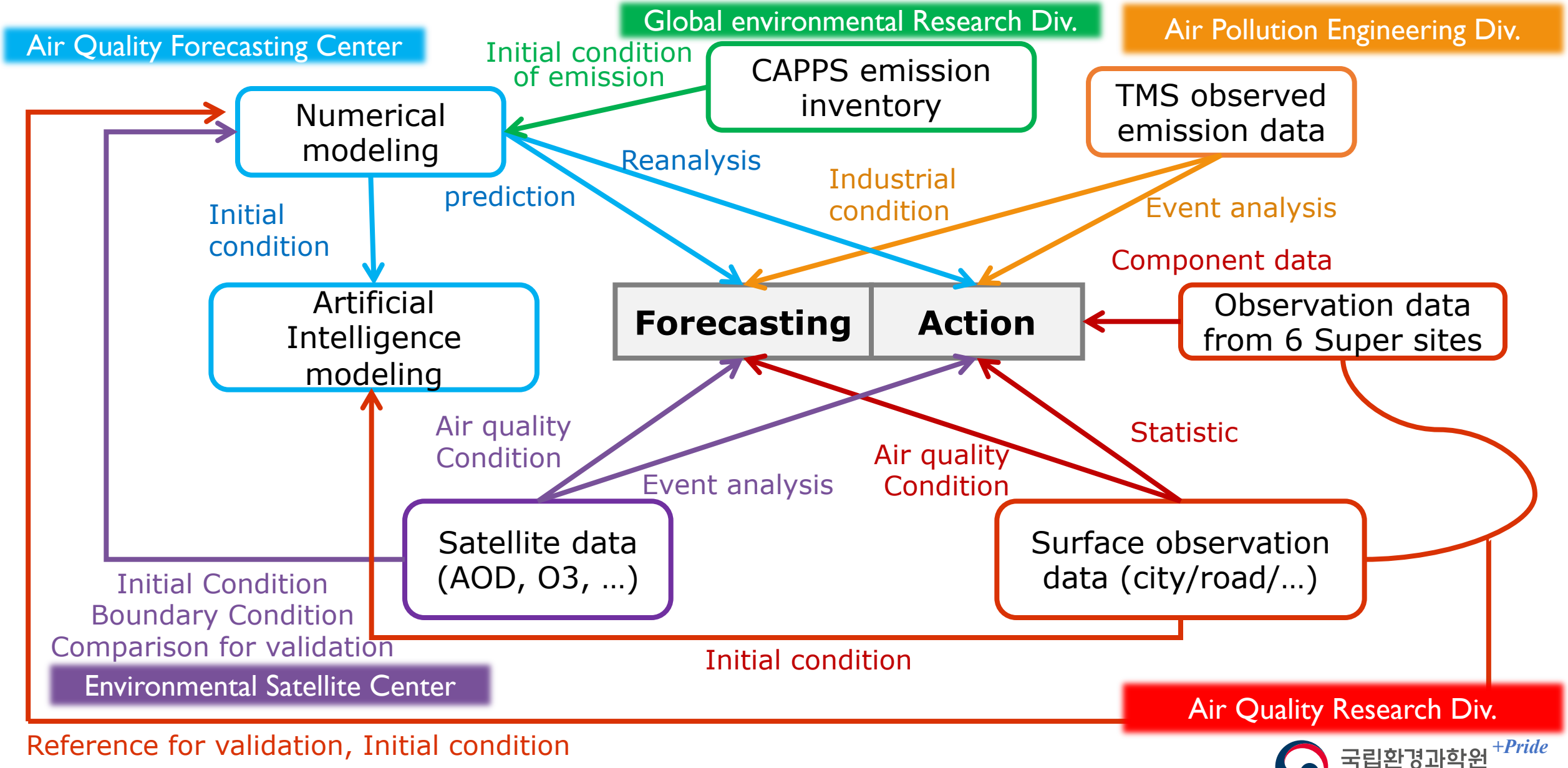
KOSC

NMSC

...

Sharing Satellite Data

Cooperation-system at NIER



3 Air quality data analysis

1 Offering a briefed report to air quality forecaster

- Making a report as for spatial and temporal distribution of **AOD, NO2, CO, SO2** using **GOCI** and **TROPOMI** data when PM2.5 or PM10 is "Unhealthy" or "Very unhealthy"

*GOCI: Geostationary Ocean Color Imager

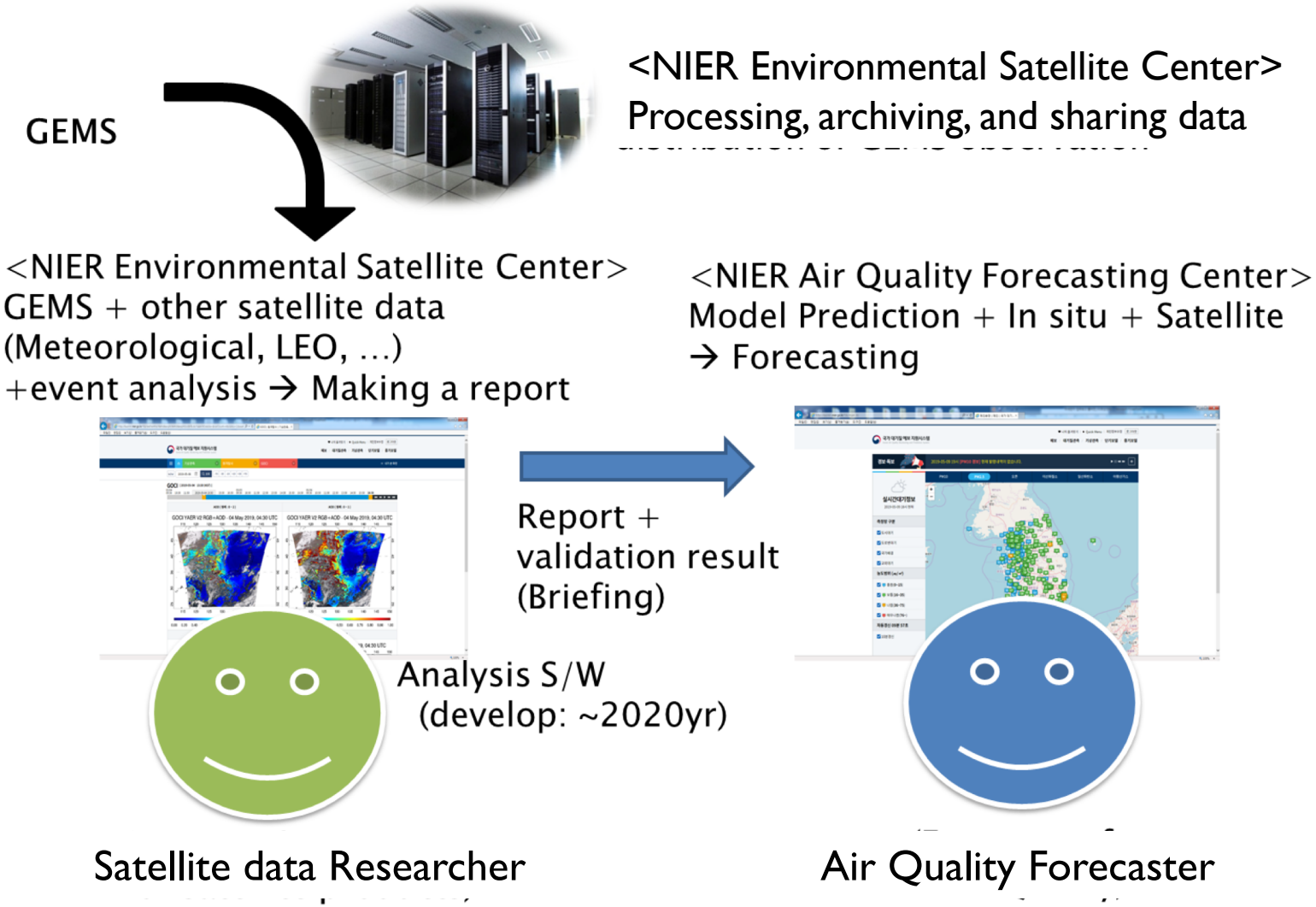
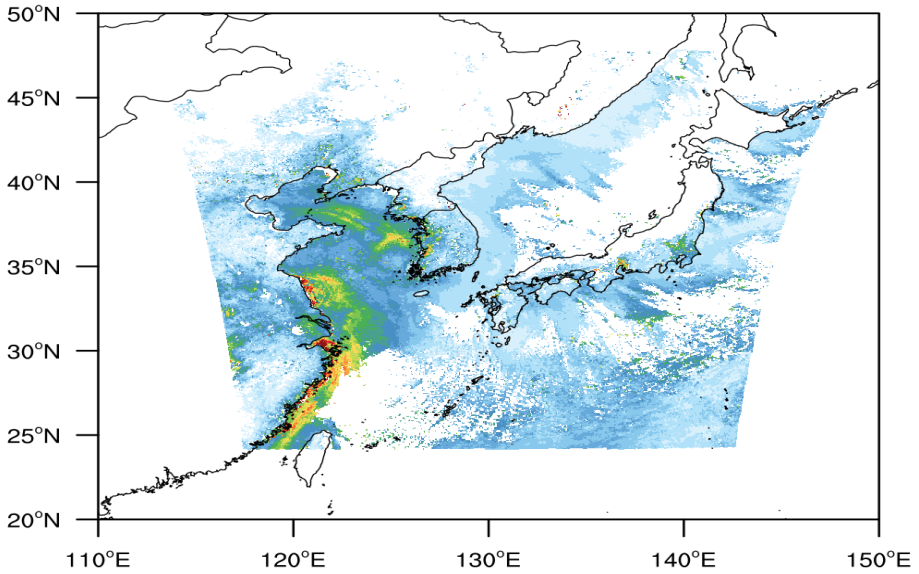


Figure. The simple diagram of data application for air quality forecasting

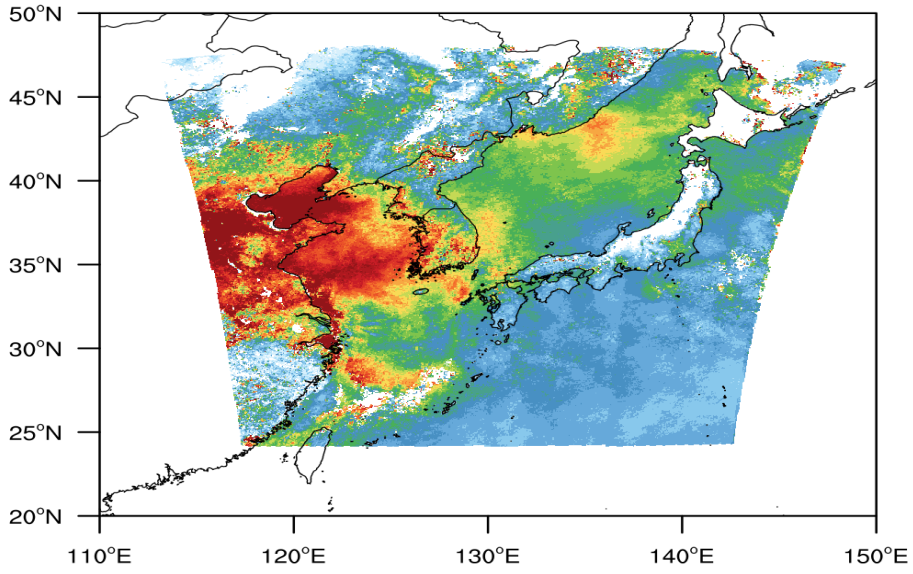
1 Offering a briefed report to air quality forecaster

- When **PM concentration** was **high "Unhealthy",** the **High value of AOD** is shown in Eastern China and western Korea, compared to the nomal condition in GOCI satellite data

Case 1: Normal condition (16-18, Jan., 2019)



Case 2: high concentration of PM (19,Feb. - 6,Mar., 2019)



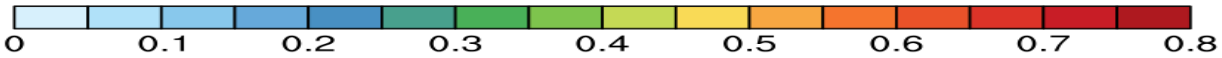


Figure. Averaged Aerosol Optical Depth(AOD) for normal condition and case of high PM concentration

1 Offering a briefed report to air quality forecaster

- TROPOMI **CO and NO2** have **similar distribution** to GOCI AOD.
- **Anthropogenic air pollutants is flowing from China to Korea** as in distribution of CO and NO2

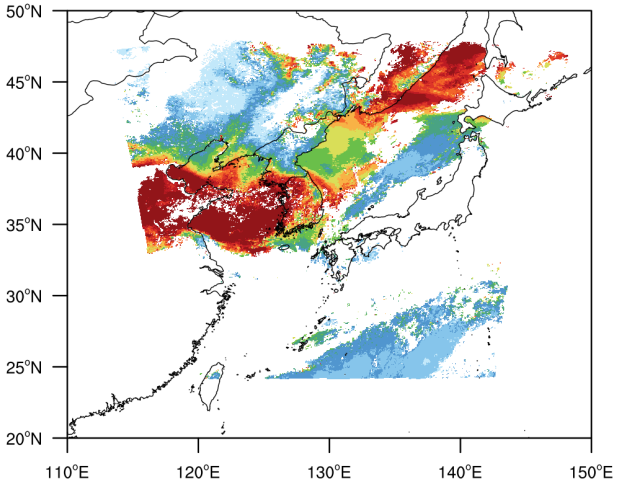
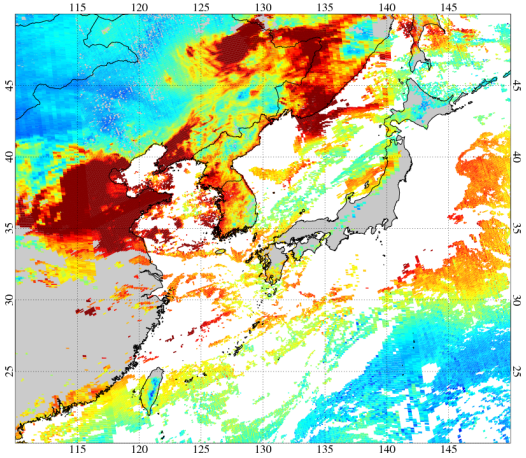
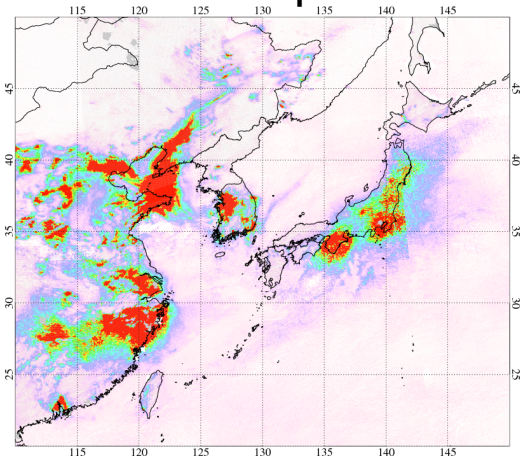
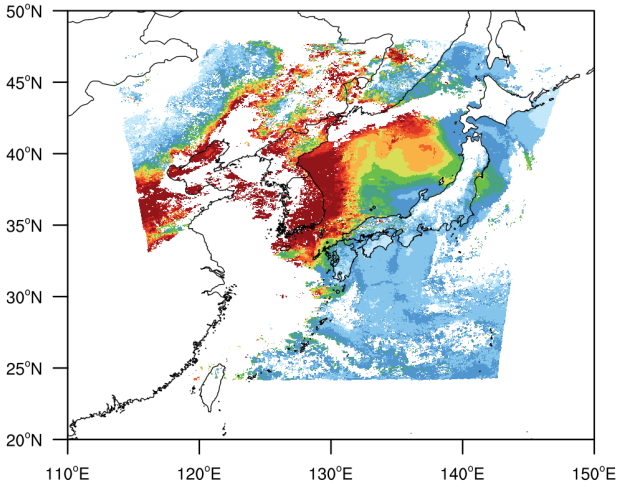
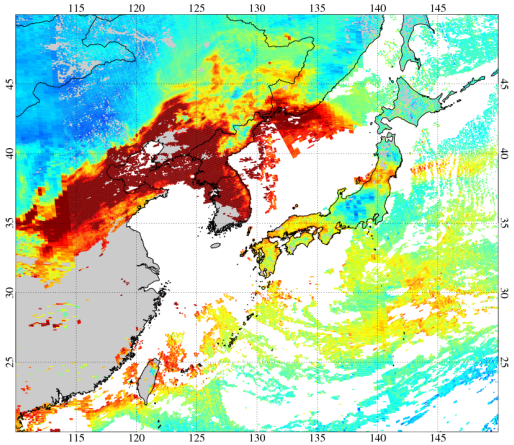
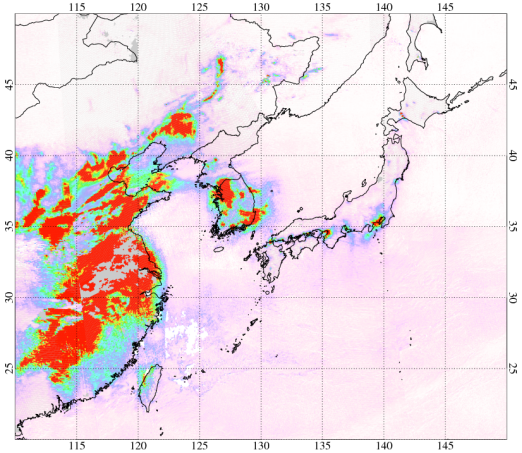
	GOCI AOD	TROPOMI Total Column CO	TROPOMI Trop. Column NO2
28. ,Feb. 2019			
5.,Mar. 2019			

Figure. Comparison among satellite products from GOCI and TROPOMI on the case of high concentration of PM

2 Providing an analyzed report for unusual event

- When **unusual event is occured**, such as chemical accident and volcanic eruption, providing analyzed report to **check a travel path** of air pollutants and **possibility of its influence to neighborhood**

COMS satellite images (13, Aug. 08:00, 09:00) | **MODIS satellite image**

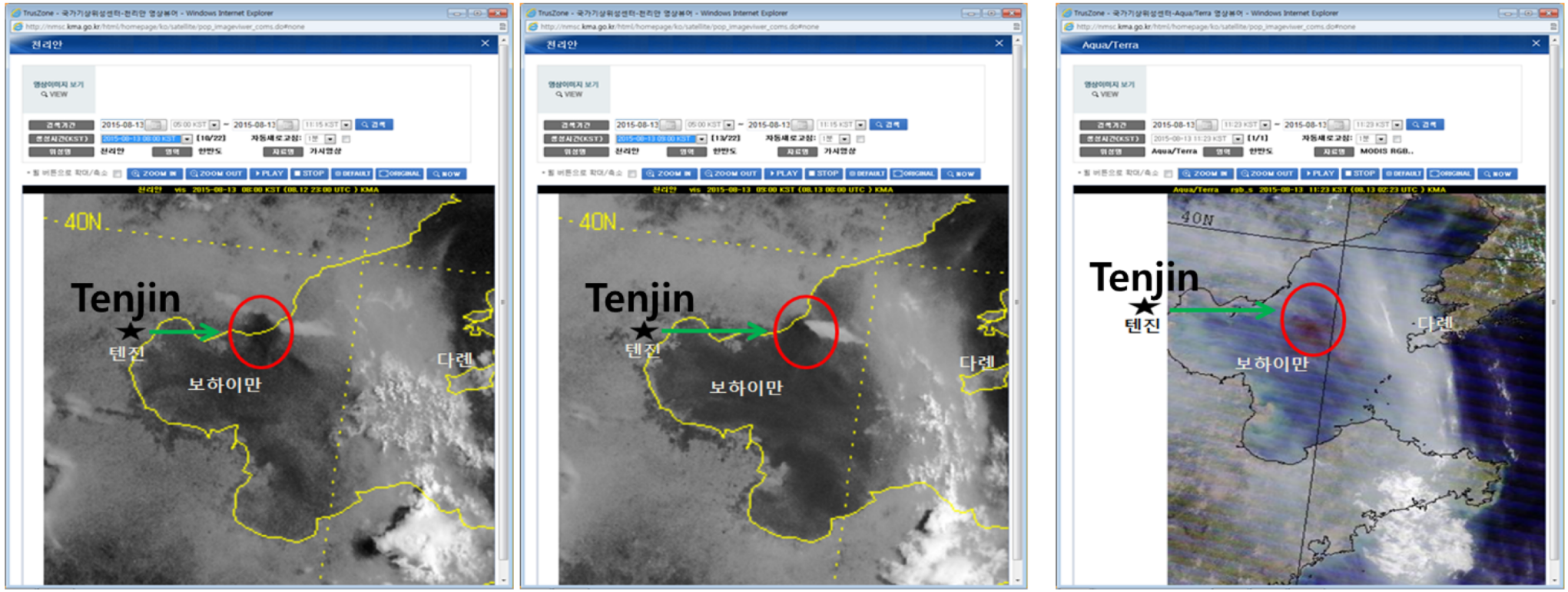
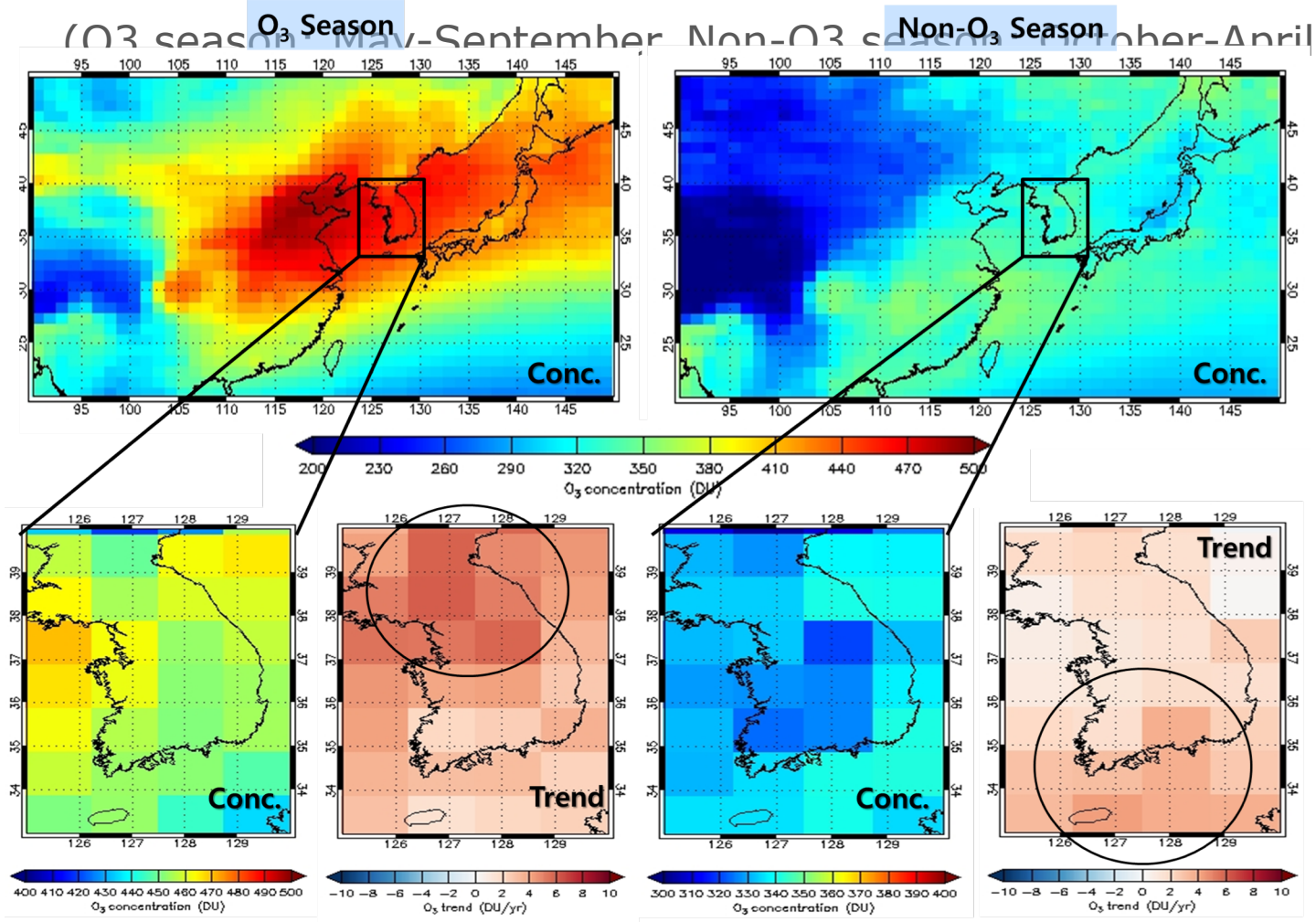


Figure. The example of data analysis for unusual event, which is chemical accident in Tenjin, China on 12, August, 2015.

3 Supporting environmental policy maker

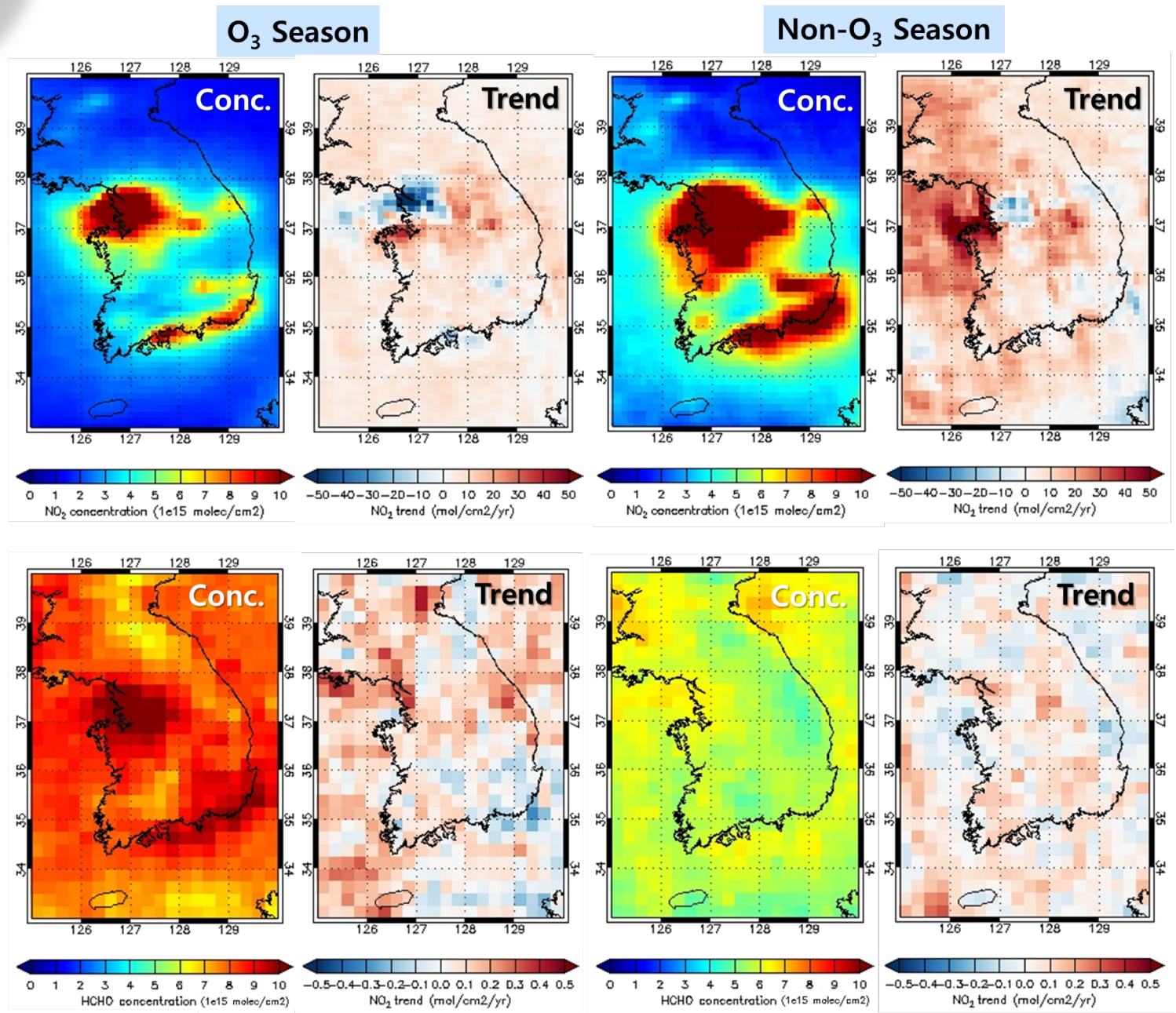
- Investigating **spatio-temporal distribution** and **variation** of air pollutants e.g. seasonal, trend
- Figure: 1) **high cocentration in O3 season** in **Korea, East China, and Japan**
  2) **increasing trend** at Seoul (**City**) in O3 season, and at Kosan in non-O3 season
  (O3 season: May-September, Non-O3 season: October-April / 2005-2014)



Trend (DU/year)	NE Asia	KOREA	Seoul	Gosan
O_3 Season	2.8	3.0	5.3	3.0
Non-O_3 Season	2.5	1.8	1.1	3.2
ALL	2.2	2.3	2.8	3.1

- Figure. Averaged concentration and long-term trend of Ozone for 10 years from OMI satellite.

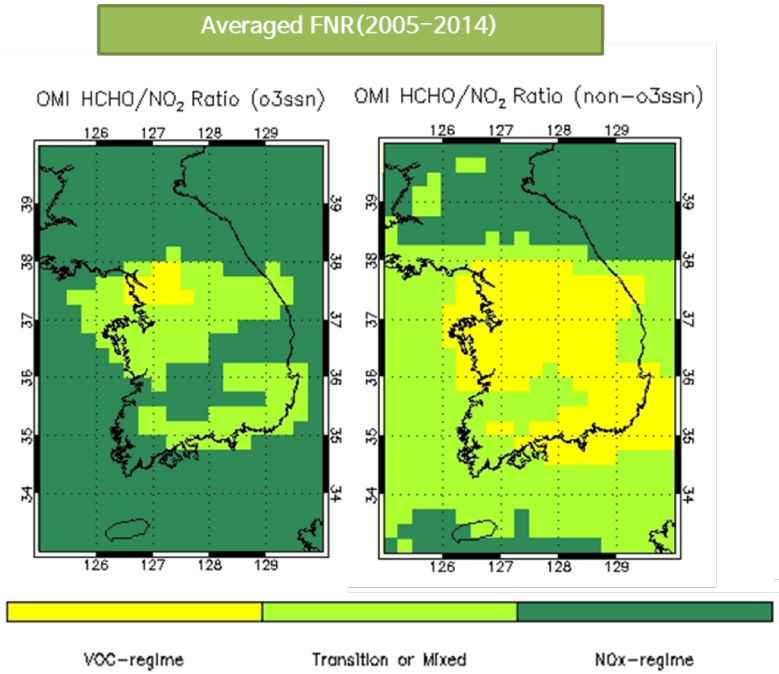
3 Supporting environmental policy maker



- **NO2 is abundant in cities and industry area** (Max: winter, Min: Summer).
- NO2 has **negative trend** in **Seoul Metropolitan Area**
- high concentrated HCHO is also **distribute largely in cities** and has no significant trend over South Korea (Max: Summer, Min: Winter)
- Figure. Averaged concentration and long-term trend of NO2 and HCHO for 10 years from OMI satellite.

4 Supporting environmental policy maker

- Calculating **FNR**(Formaldehyde to nitrogen dioxide) using satellite data to understand **efficient way to reduce ozone concentration**
- Averaged FNR: 1) O3 season: **NOx-regime prevails, VOC-regime over SMA**,
  2) Non-O3 season: **VOC-regime prevalis**



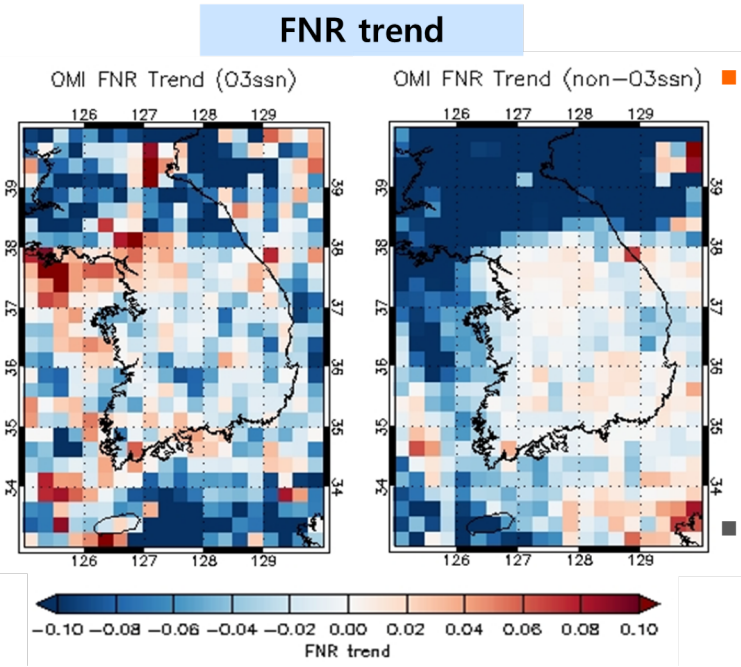


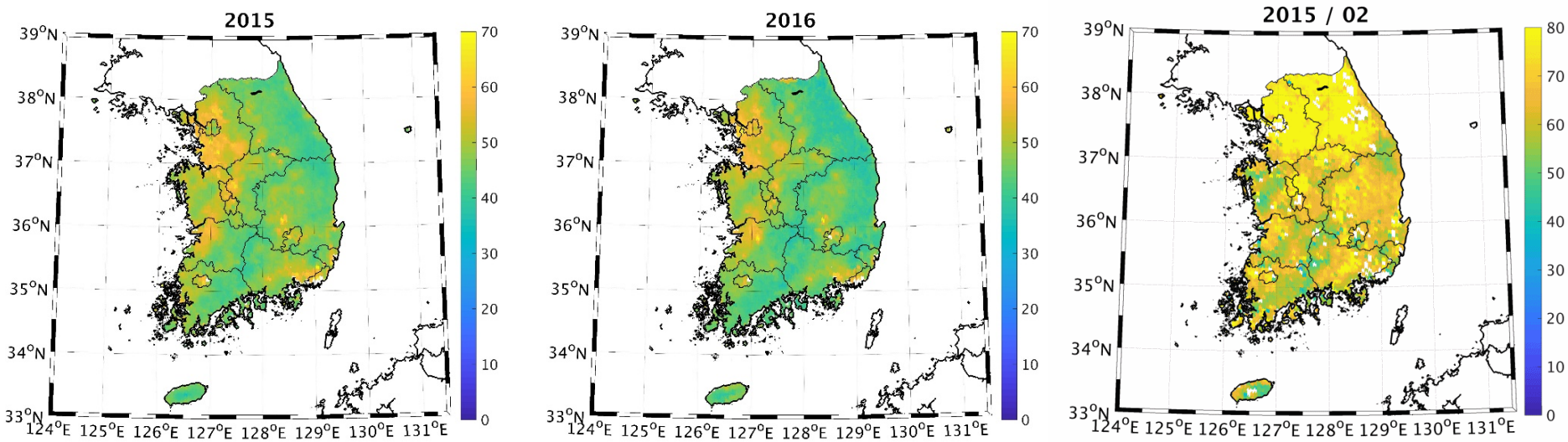
Figure. The averaged rate of formaldehyde to nitrogen dioxide(left) and its trend from 2005 to 2014 year over South Korea with OMI satellite data

- **Trend of FNR** for 10 years:
  1) O3 season: **VOC regime** changed to **mixed regime**
  - Due to implementation of emission controls, etc.
- 2) Non-O3 season: **NOx regime** is transfering slightly to **mixed regime**
  - Due to **increasing NO2 in North Korea and Yellow sea**

Estimation of surface PM2.5 concentration

- Air pollutant's concentration of **near the surface** is more important than column density, since those closely related to **human health.**
- To calculate PM2.5,

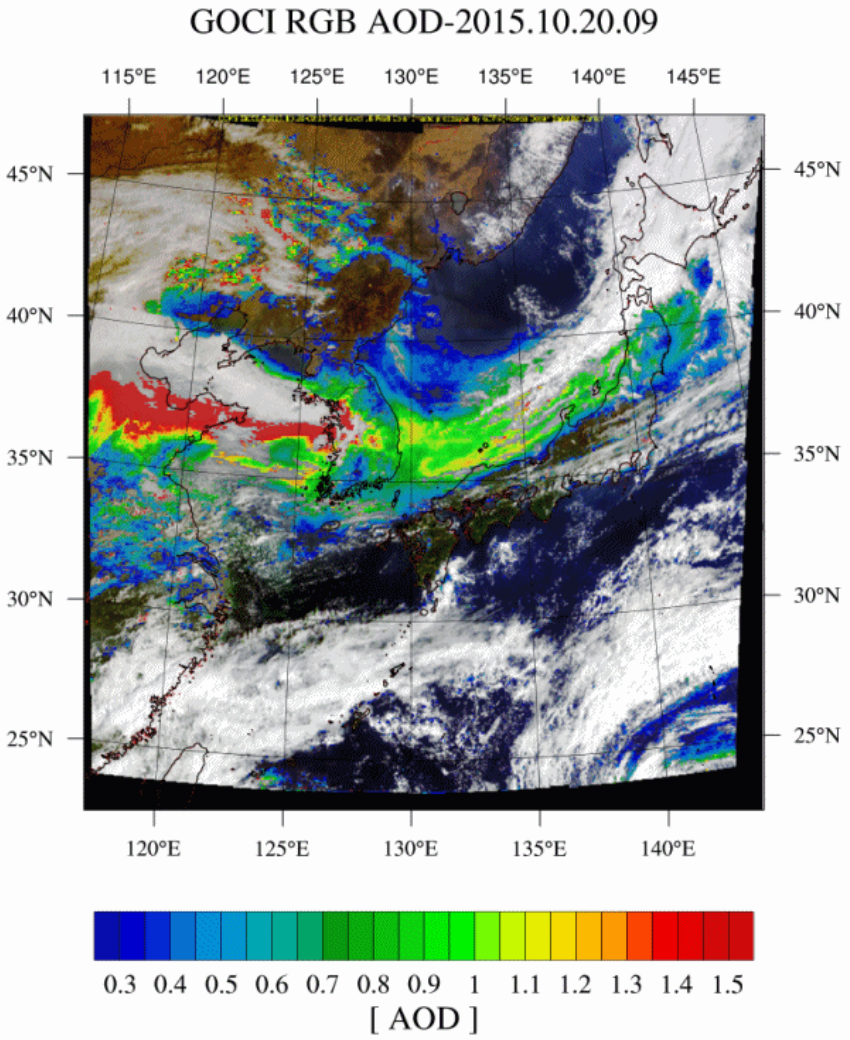
Yearly **Monthly**

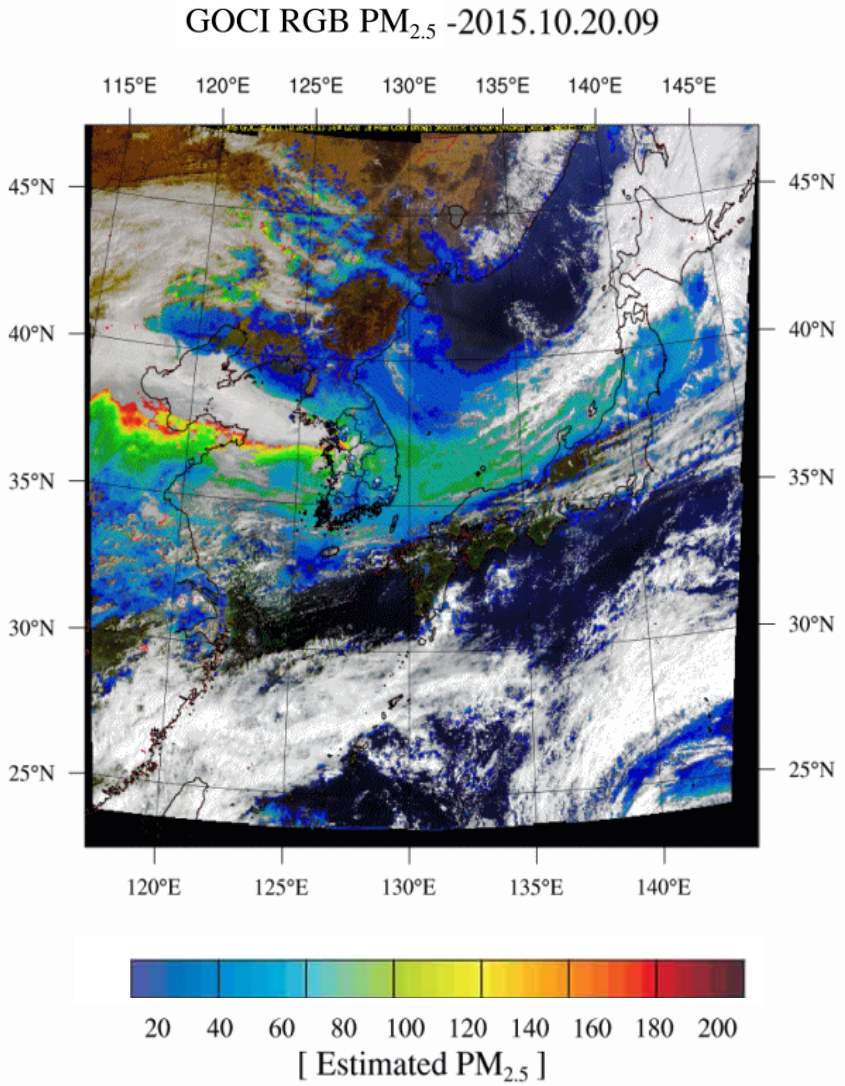


Credit:
UNIST(J.-H. Lim) ,
NIER

- PM2.5 concentrations over Korea peninsula estimated based on **machine learning** is well described **high value in Mega cities** (e.g. SMA, Busan, Kwangju,...) **in Winter**
- In addition, PM2.5 concentrations represent high value in April due to the **influence of the yellow dust.**

Estimation of surface PM2.5 concentration



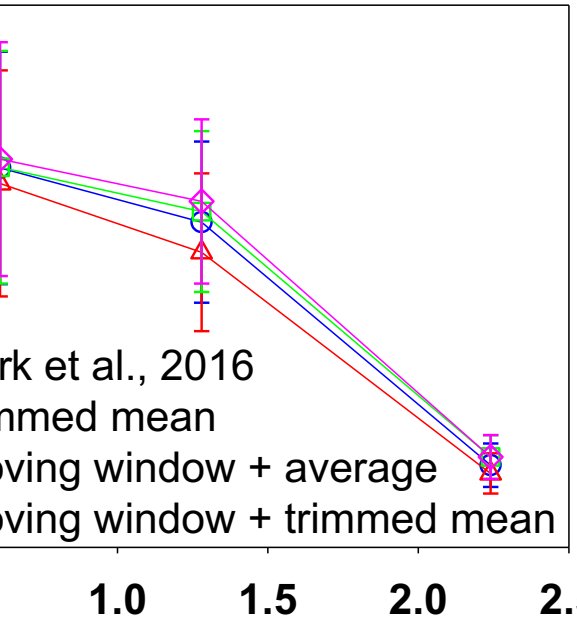


Deriving transported air pollutant's flux rate

Credit: Univ. Bukyeong (Prof. H-L.Lee), Univ.Yeonsei (Prof. J. Kim), Univ. Busan(Prof. J-H.Kim), NIER

- Developing algorithm to **detect and quantify** of plume generated and transported **from abroad**
- Material: SO2, Aerosol, Ozone(Challenging)

Dec, 2006

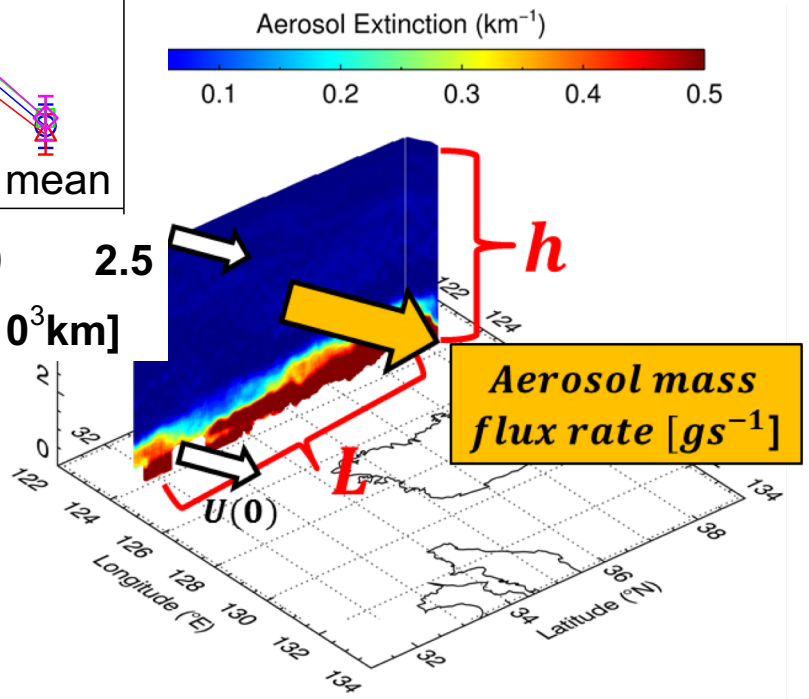


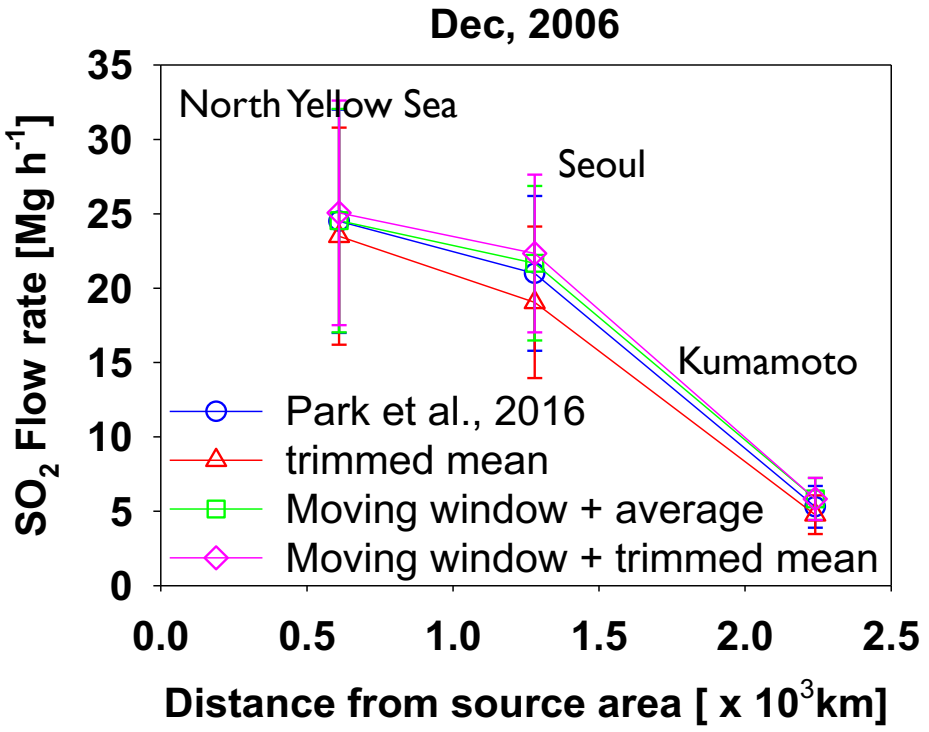
h concentration? & **high variability?** (using threshold)

h **backward trajectory model** (HYSPLIT)

ng **meteorological data** and **approximated profile data** (e.g. Atmospheric

neight)





4 Summary & Future plans

Summary of Application plan for GEMS

In a short term

- **Monitoring** and **tracking transported air pollutants** from abroad or **locally emitted one**
- Providing an analyzed report to **confirm an unusual event** such as chemical accident or fire
- Supporting **environmental policy maker** by providing science data from satellites

In a long term

- Estimating **surface PM2.5 concentration** from Aerosol Optical Depth
- **Deriving transported air pollutants flux rate** to help improve the scientific basis of emission
- **Constraining** air pollutant's **top-down emissions** to makeup drawbacks of bottom-up inventory
- **Providing reliable initial conditions** of chemistry-transport models for air quality forecasts via **data assimilation** techniques
- Obtaining detail information using data fusion techniques with LEO

Future plans and issue

Future plan of KEY application fields

- Changing application platforms from GOCI to GEMS data
- Extending study area from South Korea to Asia
- Improving the flux calculation technique condsidering detailed information of meteorology and chemical reaction

Expand the potential of application field

- Constraining Top-down emission of PM, NO2, SO2, and HCHO
- Estimating non-produced pixels and detailed information from data fusion with LEO
- Planning to hold many times of workshops to seek new products and to narrow the gap of needs from between customer and developer
- Defining and reducing uncertanty of GEMS products to be applied for the environmental policy, such as confriming effects from long-range transported air pollutants.

Application plan for GEMS

- In October 2018, the NIER officially joined the CEOS!
- We hope it will be discussed fruitfully and mutually regarding constellation flight and exchange of data and methodolodgies.

Thank you for your attention