16th CEOS AC-VC
2020.06.09

GEMS

GEMS validation activities

National Institute of Environmental Research
Lim-Seok Chang, Wonjoon Choi, Donghee Kim, Chang-seok Lee

GEMS validation activities

Announcement of Opportunity (AO)

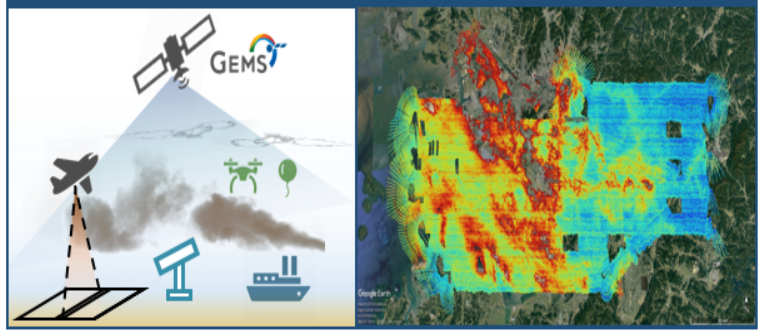
to harness professional knowledge and expertise of experienced scientists to perform validation and accuracy assessment of data and products of GEMS through independent data analysis

1. Evaluation of Level 2 retrieval algorithms
2. Assessment of regional errors and their sources
3. Comparison with other space-borne instruments
4. Comparison with ground-based and/or airborne measurements
5. Comparison of diurnal variations of each atmospheric species between GEMS measurements and modeling results
6. Assessment of the impact of auxiliary data used in product retrieval
7. Analysis of major error sources and error budget
8. Assessment of heterogeneous geographic effects

International collaboration

Pandora Asia Network (PAN)

Satellite Integrated Joint monitoring of Air Quality (SIJAQ)



GEMS AO information can be obtained from https://nesc.nier.go.kr

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Contents

01 GMAP & SIJAQ

1.1. introduction of GMAP & SIJAQ

GMAP : GEMS Map of Air Pollution
SIJAQ : Satellite Integrated Joint monitoring of Air Quality

Background

- Succession of KORUS-AQ (2016.5~6)

  → Further analysis on high-concentration air pollution in winter is required

  * KORUS-AQ: the Korea-United States Air Quality Study

- Need for validation and evaluation of the Geostationary Environment Monitoring Spectrometer (GEMS), which is world's first Geostationary Earth Orbit (GEO) environmental satellite

Timeline for GMAP and SIJAQ

Pre-GMAP	+	1st GMAP	2nd GMAP	SIJAQ
~~2020. 4~5~~ (delayed due to COVID-19)		2020.10.12~11.27 (depending on COVID-19)	2021.10~12	2022.10~2023.06

Main campaign

1.1 introduction of GMAP & SIJAQ

SIJAQ main tasks

1. Investigating unknown mechanism of secondary PM formation in winter
   - Observation based in-depth analysis of long range transport (LRT)
   - Modeling based impact assessment of emission change, LRT, chemical mechanism
   - Synthesis analysis
2. Mapping air pollution in Asia and large point source (LPS) characterization
   - Spatial and temporal variation of air pollutants in GEMS FOV
   - Measurement of air pollutants by ground supersite
   - Air pollution forecasting using CTM (CMAQ, WRF-Chem, Cams, Geos-Chem, etc.)
3. Cal/Val of GEMS products
   - GEMS algorithm and products, validation
   - Establishment of ground remote sensing monitoring network
   - Airborne remote sensing instrument development and application

1.1 introduction of GMAP & SIJAQ

Plan for SIJAQ and GMAP

Preparation phase

2020

- ✓ Korean steering committee kick off meeting (2020.6)
- ✓ Working group meeting for GMAP (2020.8,9)
- ✓ 1st GMAP implication (2020.10~11)

2021

- ✓ International steering committee organization (2021. 3)
- ✓ Field trip to basecamp in Seosan (2021.7)
- ✓ 2nd GMAP implication (2021.10~11)
  building platform integrating satellite/in-situ/aerial/modeling
- ✓ Working group meeting for SIJAQ (2021.12)

Execution phase

2022~2023

- ✓ SIJAQ implication (2022.10~2023.6)

2024

- ✓ Post-analysis, summary report for policy making and international cooperation

SIJAQ
- ~~Pre-GMAP~~
- 1st GMAP
- 2nd GMAP

01 1.2 Progress of 1st GMAP

Plan for 1st GMAP (2020)

Period

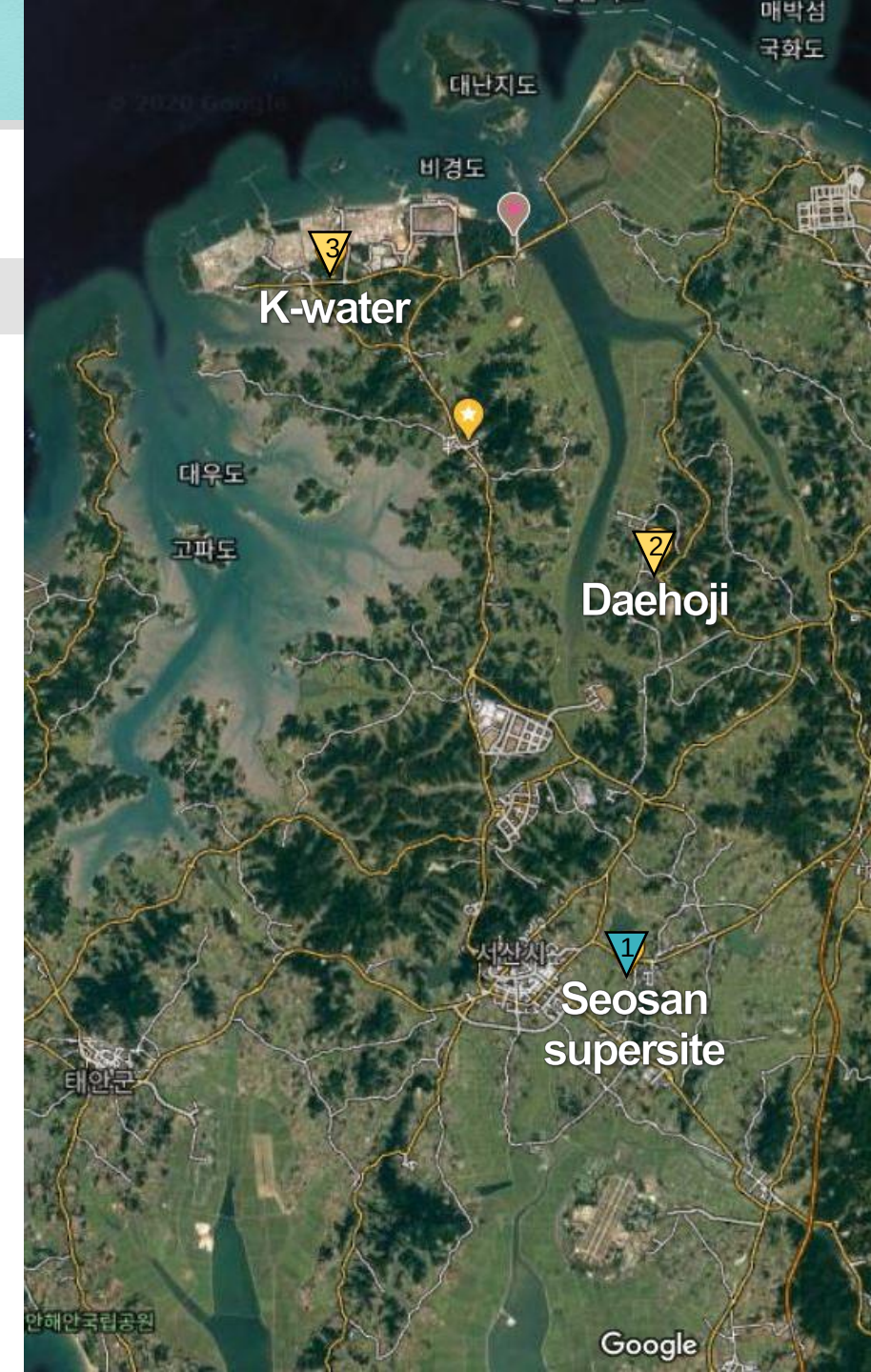
12 Oct.~27 Nov.
(tentative)

Place

Seosan supersite

Participating organization

- **Korea** : NIER, SNU, YSU, UNIST, PKNU
- **Other countries:**
  NASA, Univ. Bremen, MPI-C, BIRA, KNMI, Chiba Univ., JAMSTEC, etc.

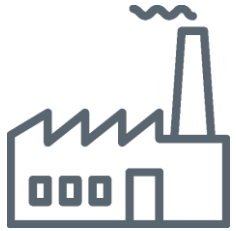


1.2 Progress of 1st GMAP

Objective of 1st GMAP (2020)

Validation of GEMS measurement

- GEMS L2 products (NO2, SO2, HCHO, O3, PM) are validated by ground-based FRM and airborne simulator (e.g., Pandora, GCAS)
  ※ GCAS : Geo-CAPE Airborne Simulator
- Inhomogeneity of trace gases within a pixel will be investigated
  (Pandora horizontal representativeness)



Impact of Large Point Source in Daesan complex on local air quality

- Chemical and physical evolution of large plume from Daesan petrochemical complex and Hyundai steel manufacture is monitored by remote sensing data and in-situ chemical data
- All measurement data are compared to each other and analyzed with the help of CTM

Basic investigation of high concentration fine dust in winter

1.2 Progress of 1st GMAP

Participating Instruments

Ground-based Fiducial Reference Measurement

- Instruments(operator) :
  PANDORA(NIER, NASA, SNU, UNIST, YSU, PNU), Sun photometer(YSU),
  MAX-DOAS (MPIC, Bremen Univ., BIRA)
- Measuring Item :
  SCD(SO2, NO2, O3, HCHO), AOD
  Vertical profile (SO2, NO2, HCHO, aerosol)

Airborne Simulator

- NASA :
  Geo-CAPE Airborne Simulator (GCAS)
- Measuring Item :
  VCD (SO2, NO2, HCHO)

Auxiliary

- Instruments(operator) :
  Ceilometer (YSU), Micro Pulse Lidar(PKNU), Radiosonde (lease), 10-m AWS tower (lease)
- Measuring Item :
  PBL Height, Cloud base height, Aerosol vertical distribution, T, Wind, RH, Pressure

In-situ chemical

- Instruments(operator) :
  NO2, CO, NH3, SO2, PM2.5 monitors, Ambient Ion Monitor, carbon aerosol analyzer
- Measuring Item :
  NO2, CO, NH3, SO2, PM2.5 mass, PM2.5 ionic components, EC/OC

1.2. Progress of 1st GMAP

Schedule of 1st GMAP (tentative)

October 2020

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	1	2	3
			Korean Thanksgiving Holiday			
4	5	6	7	8	9	10
					Hangul Day	
11	12 Site opening	13	14	15	16	17
	Installation and calibration					
18	19 Start	20	21	22	23	24
	Inter-comparison at Seosan					
25	26	27	28	29	30	31
	Relocation, installation and calibration					

November 2020

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 Opening event	3	4	5	6	7
	Main Campaign Phase					
8	9	10	11	12	13	14
	Main Campaign Phase					
15	16	17	18	19	20	21
	Main Campaign Phase					
22	23	24	25	26	27 Final Data meeting	28
	Main Campaign Phase					
29	30					

Period

6 weeks
(19 Oct.~ 27 Nov.)

Preceded by the full one week of 1week for installation and warm-up

Flight

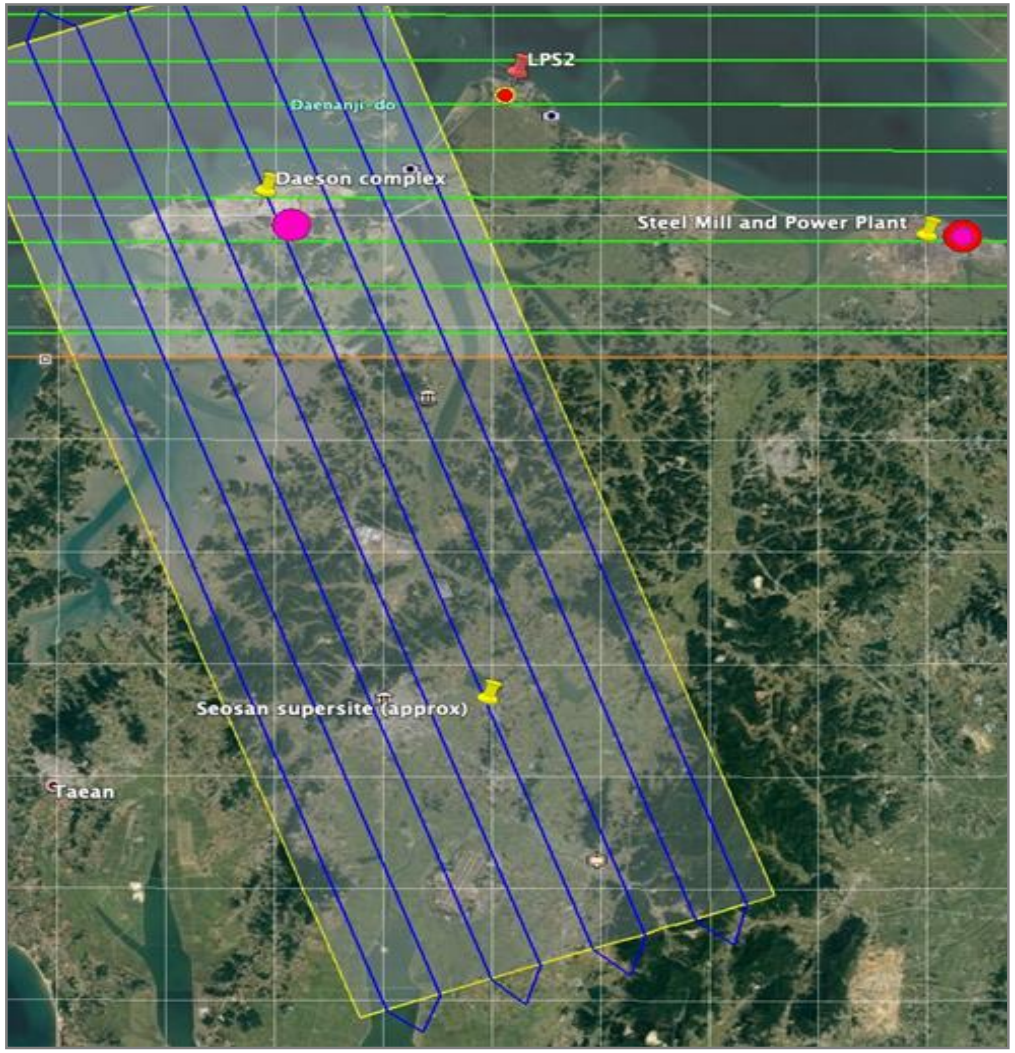
15 times
4 hours per flight
Total 60 hours

Daily briefing

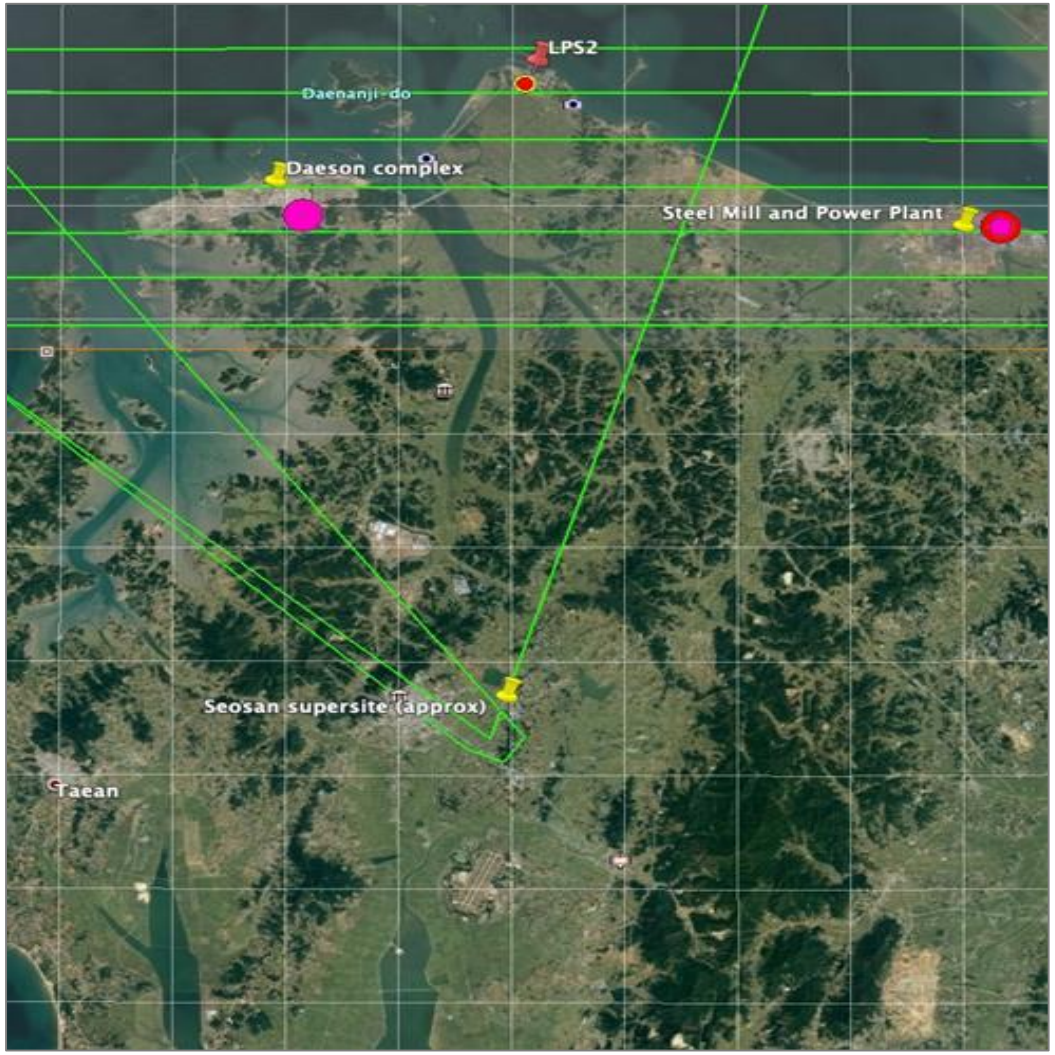
Flight path planning
Review on daily measurement

1.2. Progress of 1st GMAP

Expected flight path for 1st GMAP (2020)



Course A Course B



Course C

1.2. Progress of 1st GMAP

GMAP surface sites (tentative)

1. Seosan supersite

Main site

36.78˚N, 126.49˚E

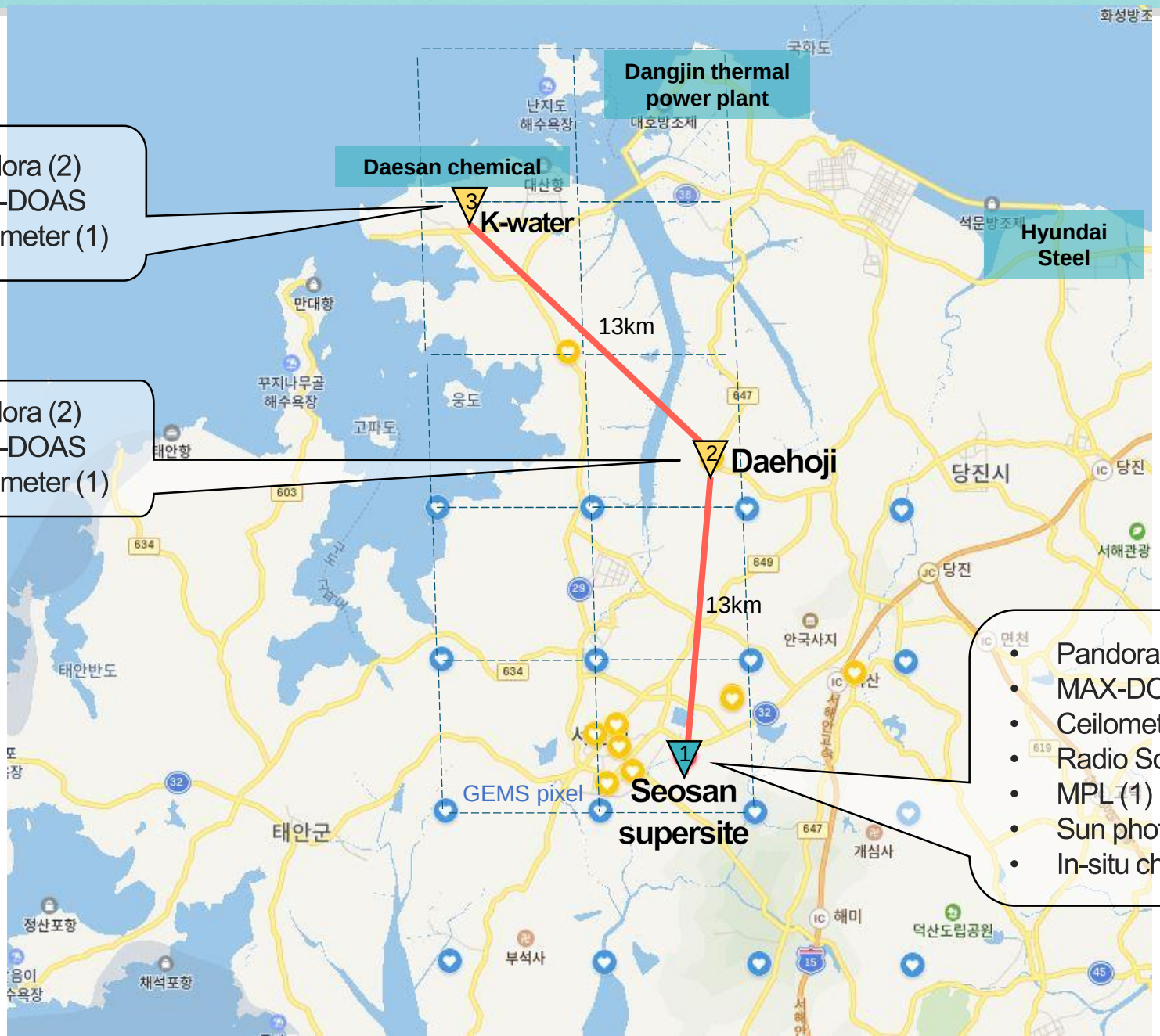
2. Daehoji Community Center

36.90˚N, 126.50˚E

3. K-water resource cooperation

36.99˚N, 126.38˚E

1.2. Progress of 1st GMAP



- Pandora (2)
- MAX-DOAS
- Ceilometer (1)

- Pandora (2)
- MAS-DOAS
- Ceilometer (1)

- Pandora (2)
- MAX-DOAS (2)
- Ceilometer (1)
- Radio Sonde (1)
- MPL (1)
- Sun photometer (1)
- In-situ chemistry

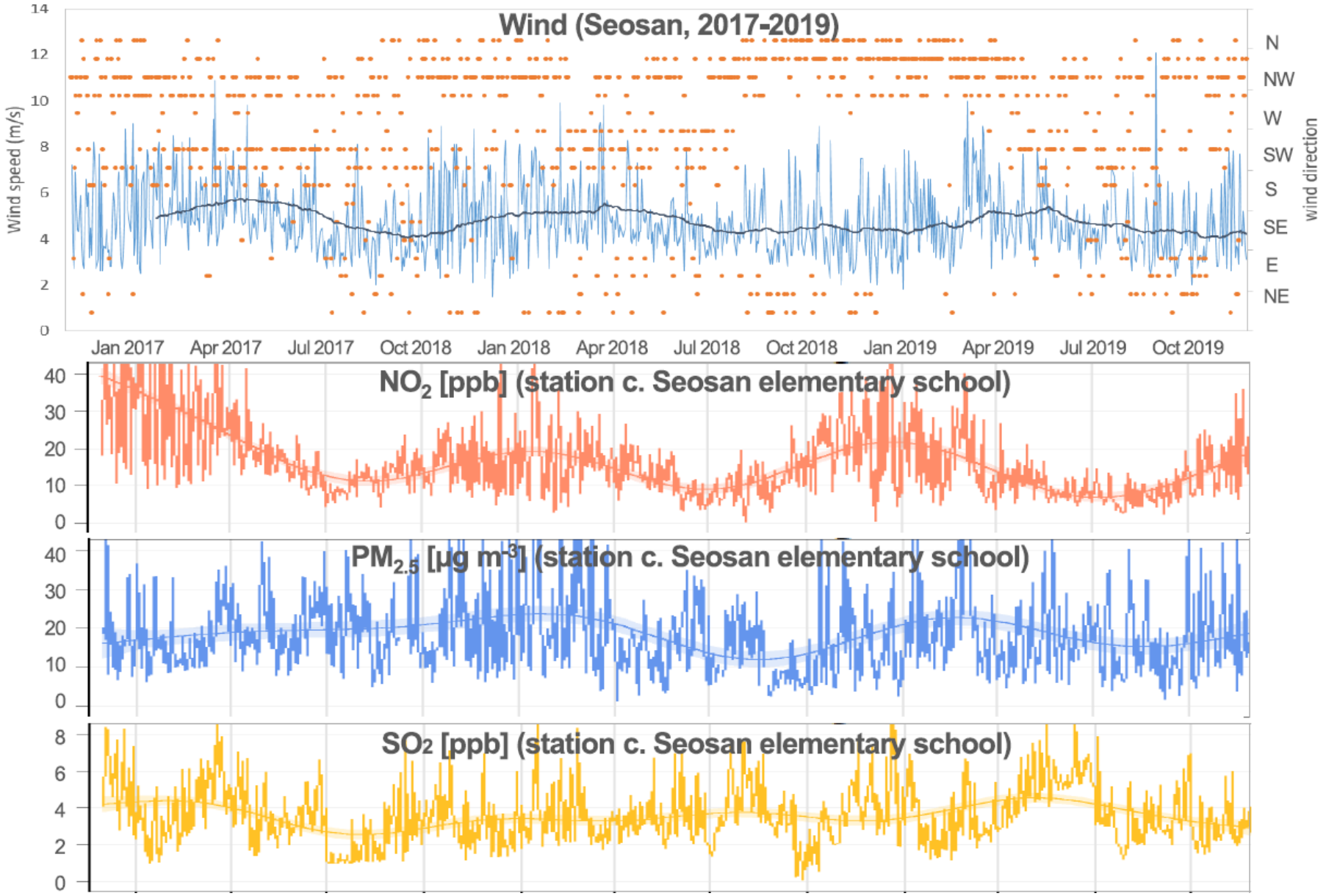
1.2. Progress of 1st GMAP

Site 3. K-water

01 1.2. Progress of 1st GMAP

Seosan Air Quality Characteristics based upon urban air quality monitoring and meteorological data (2017-2019)

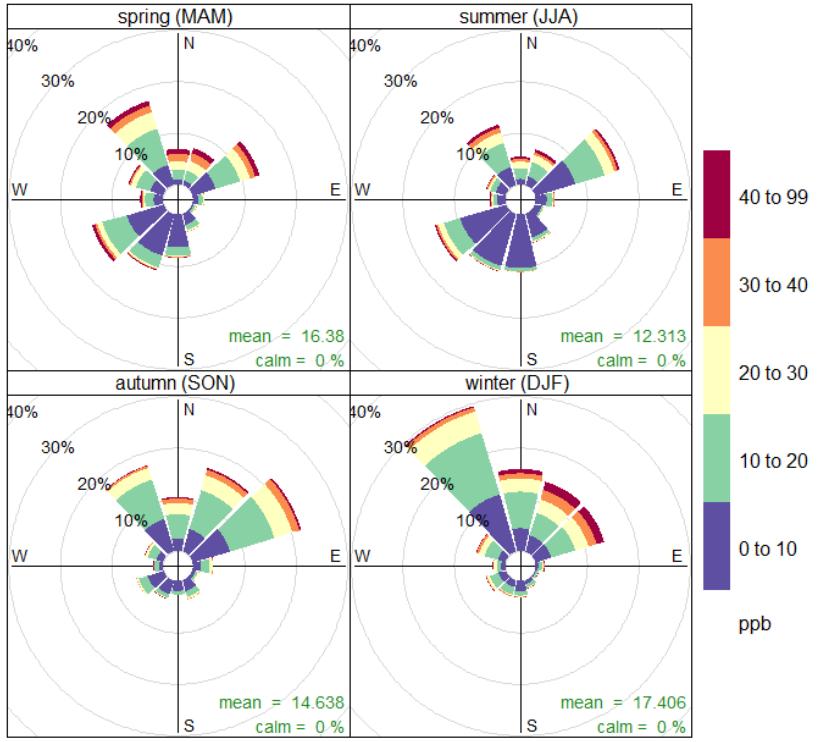
1.2. Progress of 1st GMAP



1.2. Progress of 1st GMAP

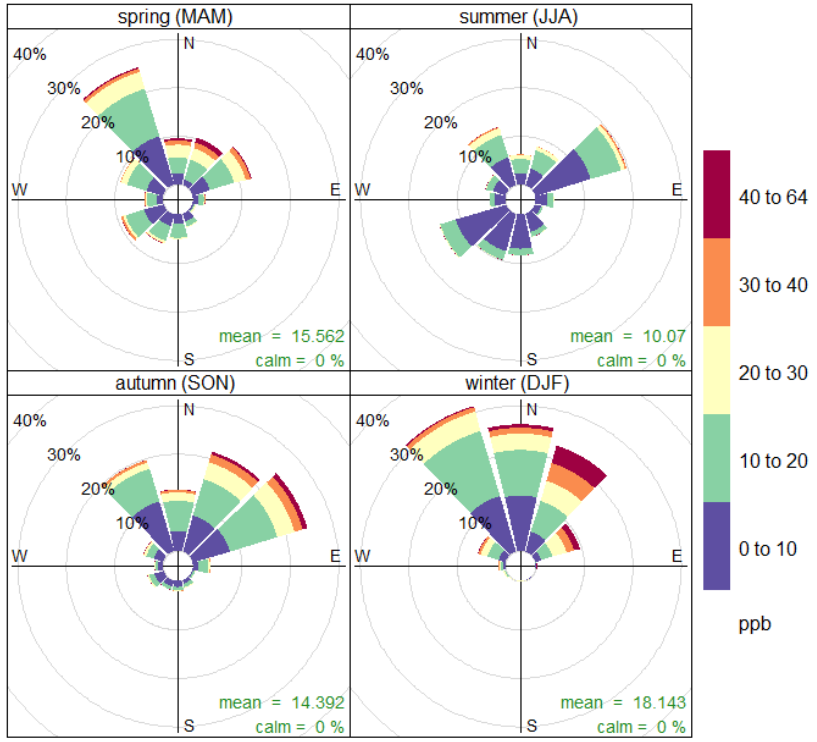
NO2 pollution rose

a. NO_2 (K-water)



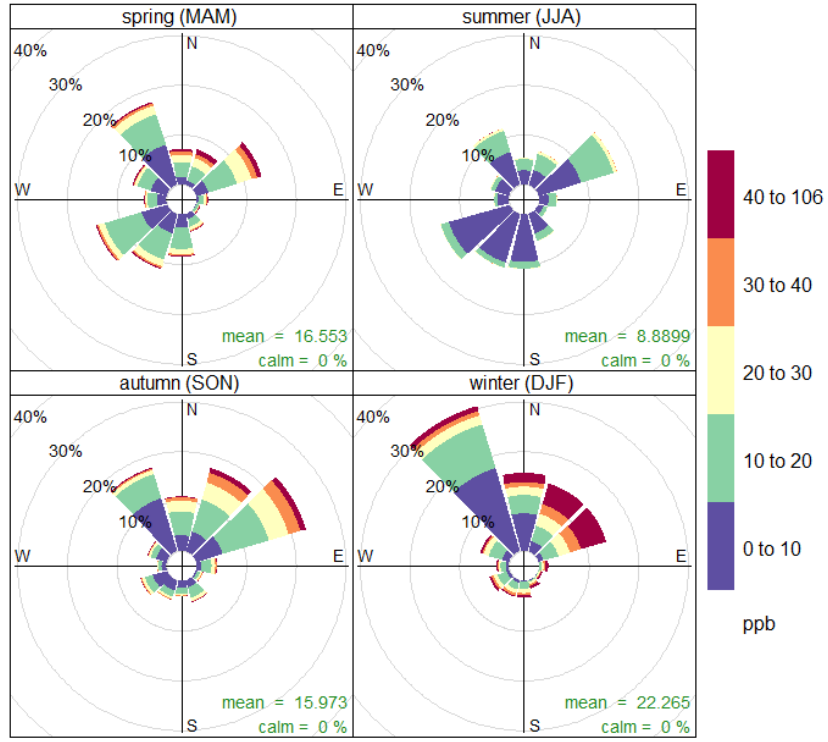
Frequency of counts by wind direction (%)

b. NO_2 (Daesan market)



Frequency of counts by wind direction (%)

c. NO_2 (Seosan elementary school)

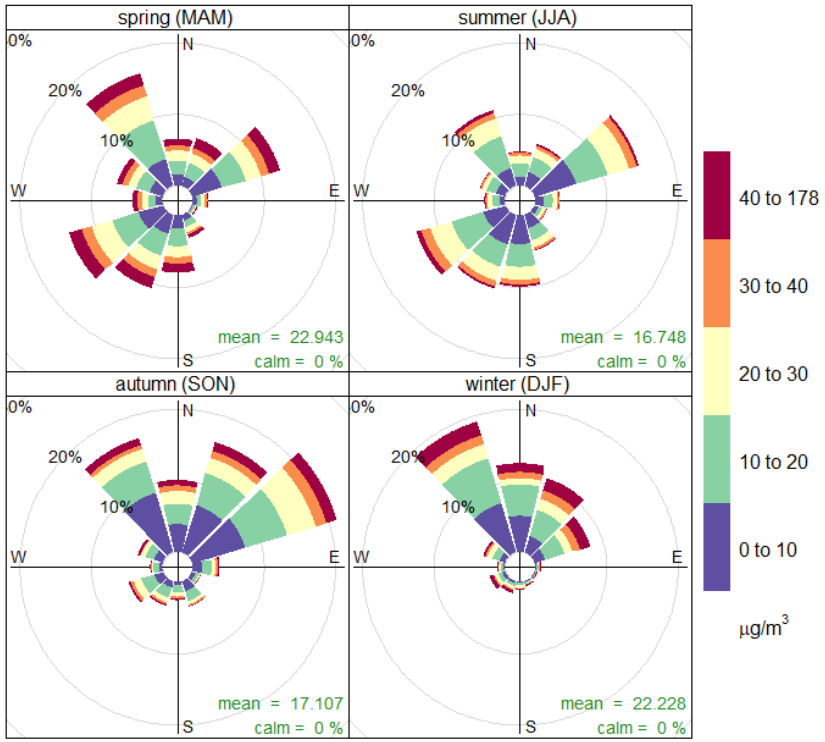


Frequency of counts by wind direction (%)

1.2. Progress of 1st GMAP

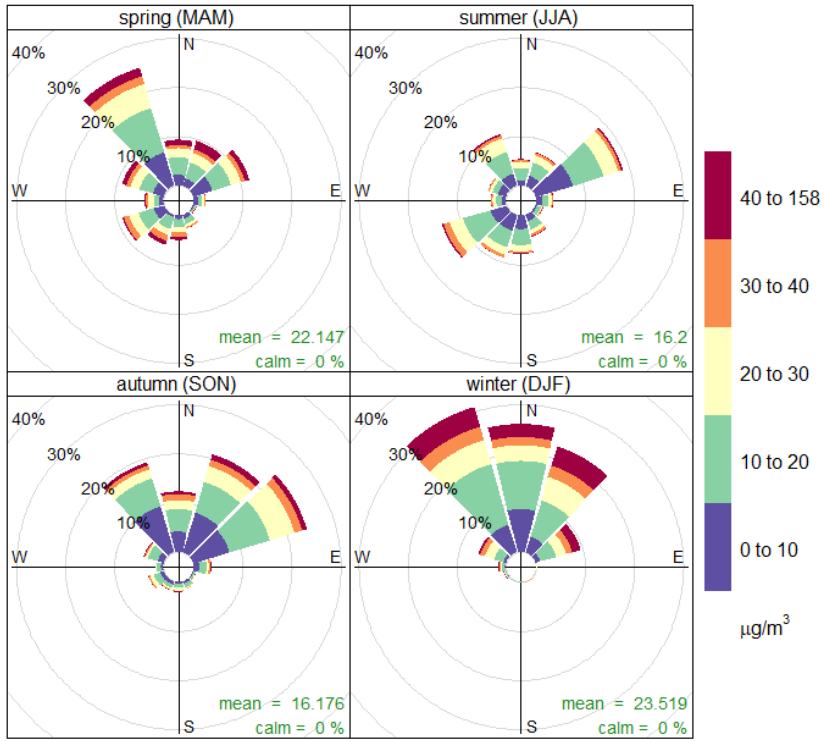
PM2.5 pollution rose

a. $PM_{2.5}$ (K-water)



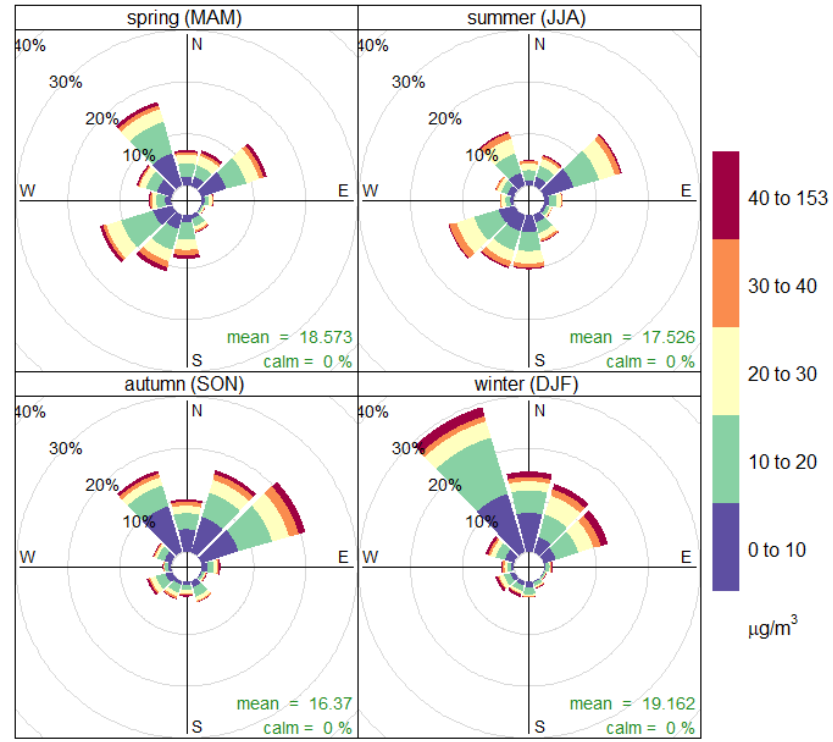
Frequency of counts by wind direction (%)

b. $PM_{2.5}$ (Daesan market)



Frequency of counts by wind direction (%)

c. $PM_{2.5}$ (Seosan elementary school)

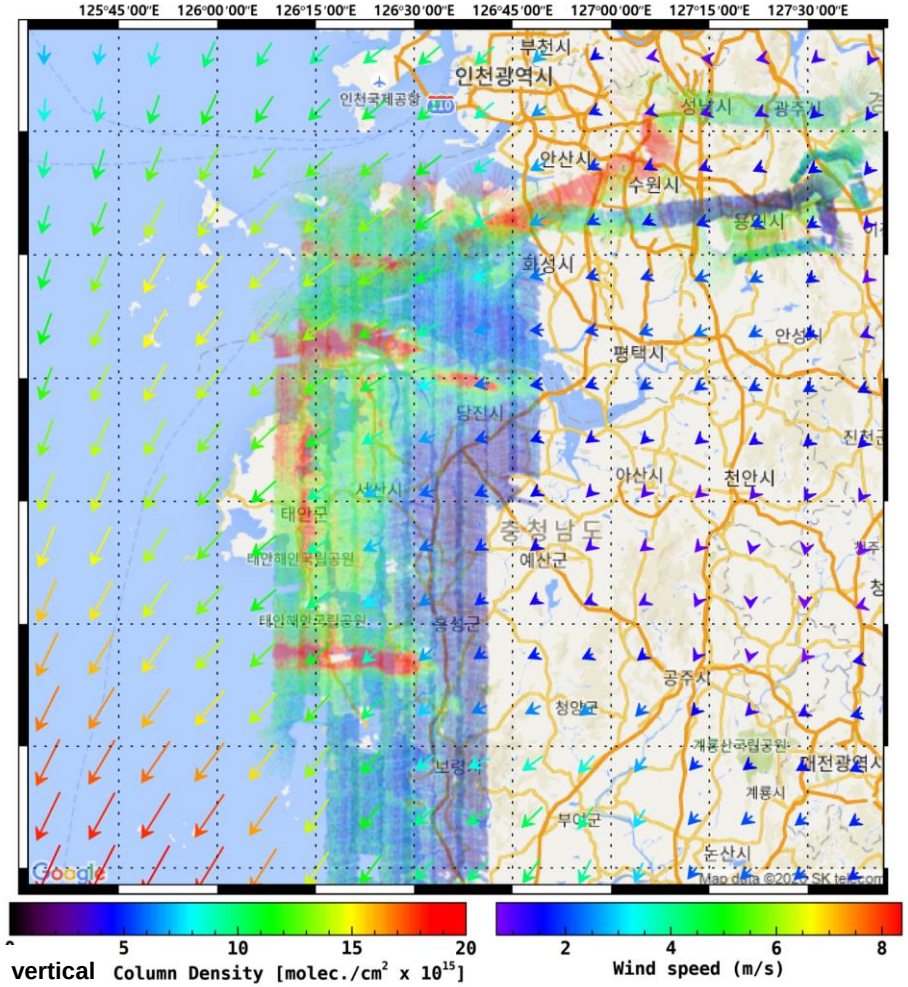


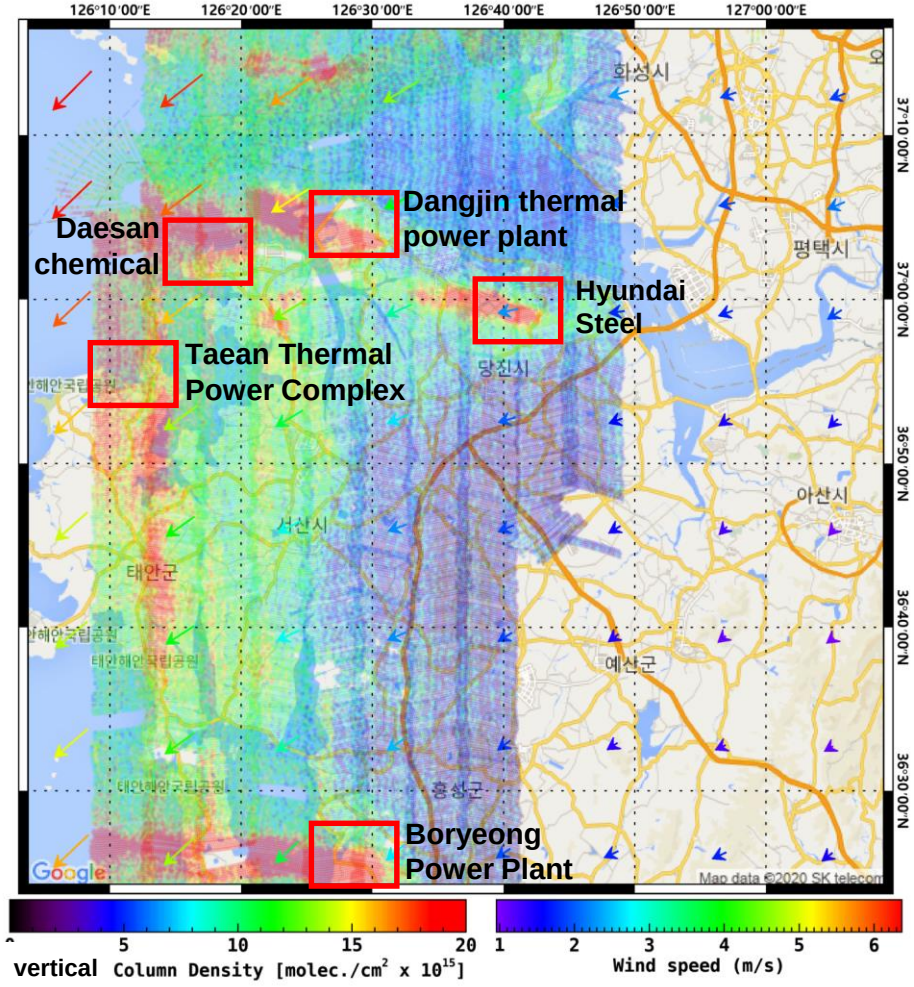
Frequency of counts by wind direction (%)

1.2. Progress of 1st GMAP

Geostationary Trace gas and Aerosol Sensor Optimization (GeoTASO)

NO2 Vertical Column Density (KORUS-AQ, June 5, 2016, Seosan)



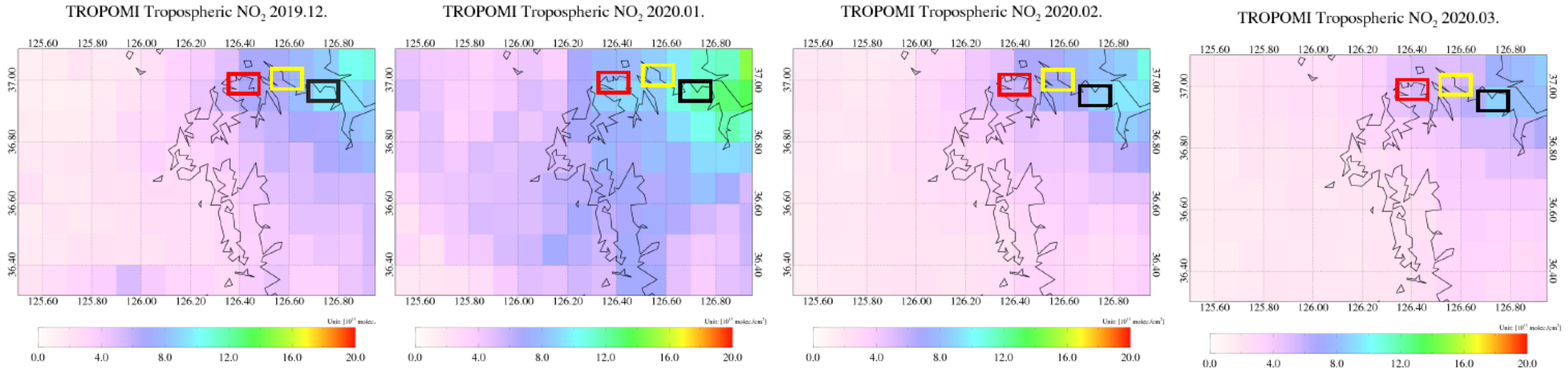


※ GeoTASO : Geostationary Trace gas and Aerosol Sensor Optimization

1.2. Progress of 1st GMAP

TROPOMI NO2 monitoring

NO_2 Vertical Column Density (TROOMI, L2, res. 0.1°X0.1°, for pixels with quality value>0.75)



Daesan chemical

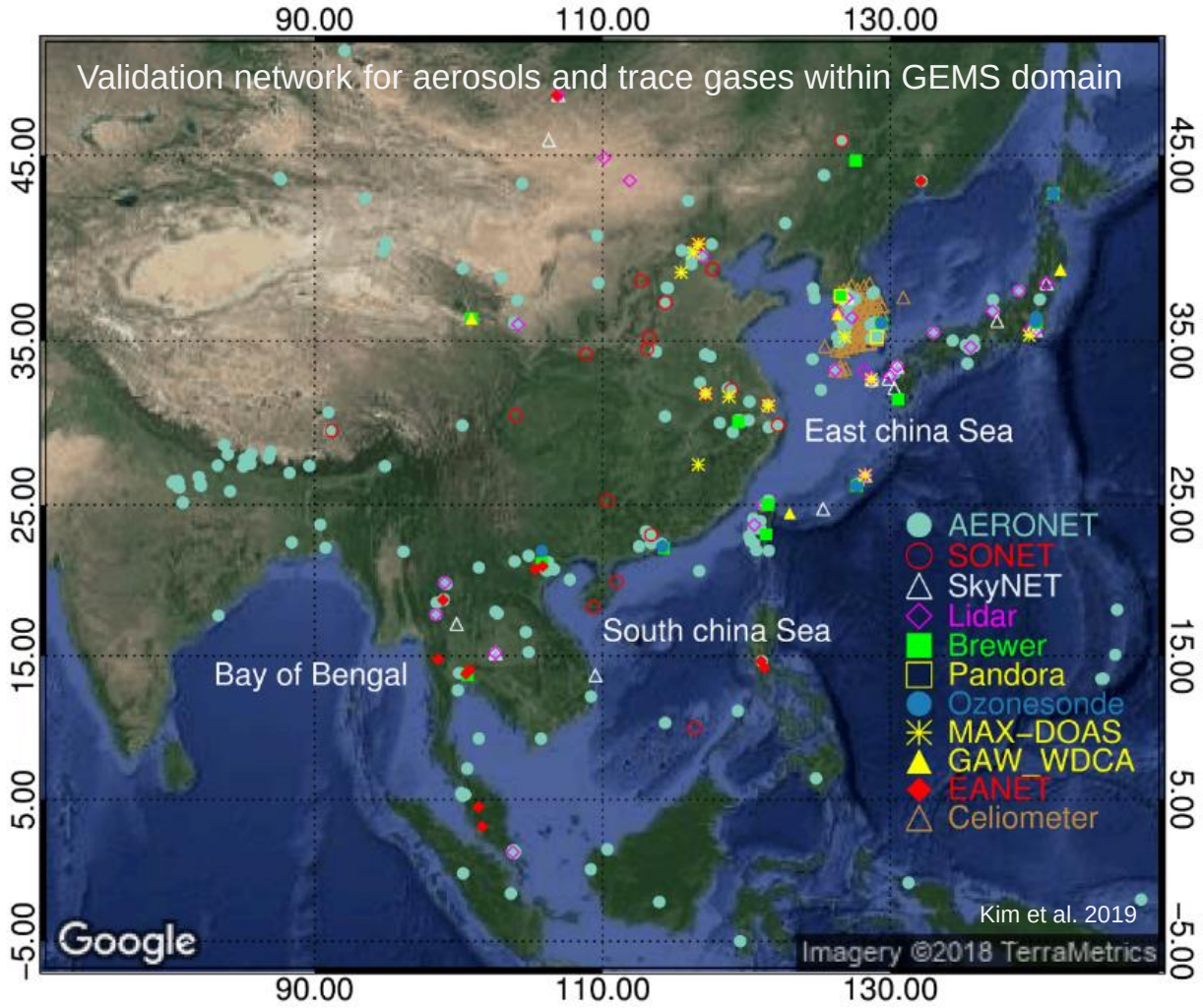
Dangjin thermal power plant

Hyundai Steel

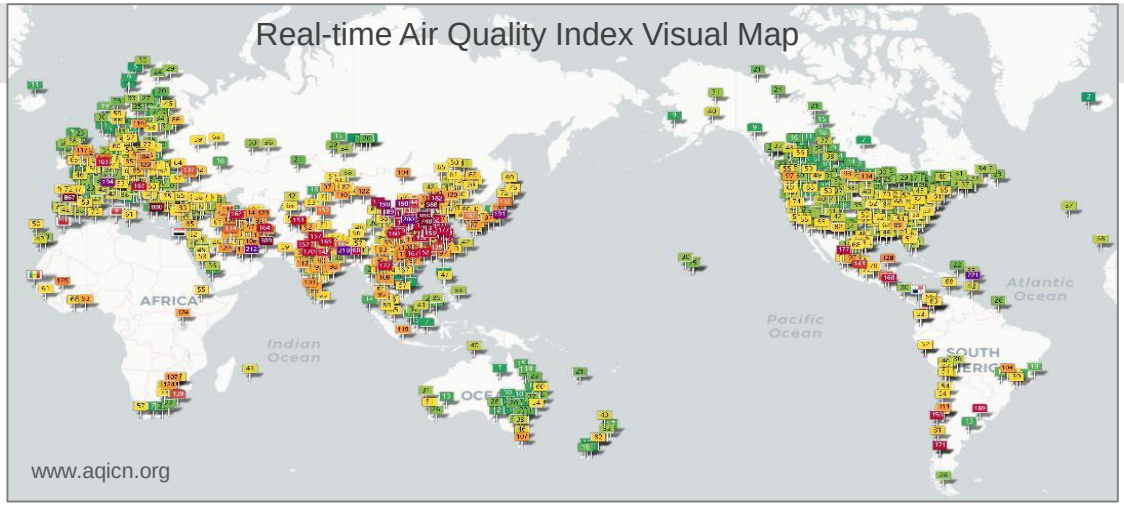
02 PAN

2.1. Introduction of PAN

A need for PAN



연대, 부산대, 치앙마이 판도라 표시



GEMS provides information on air quality from 36,000km away from Earth

- A variety of validation activities (network, AO, campaign) are needed
- More dense network of ground-based remote sensing instruments are needed in **Asia** to validate satellites (GEMS, TROPOMI,GOME-2, OMPS, etc.)

Pandora monitors local atmospheric composition and satellite data quality

- Comprehensive air quality monitoring
- Monitoring satellite data quality for the whole mission durations

2.1. Introduction of PAN

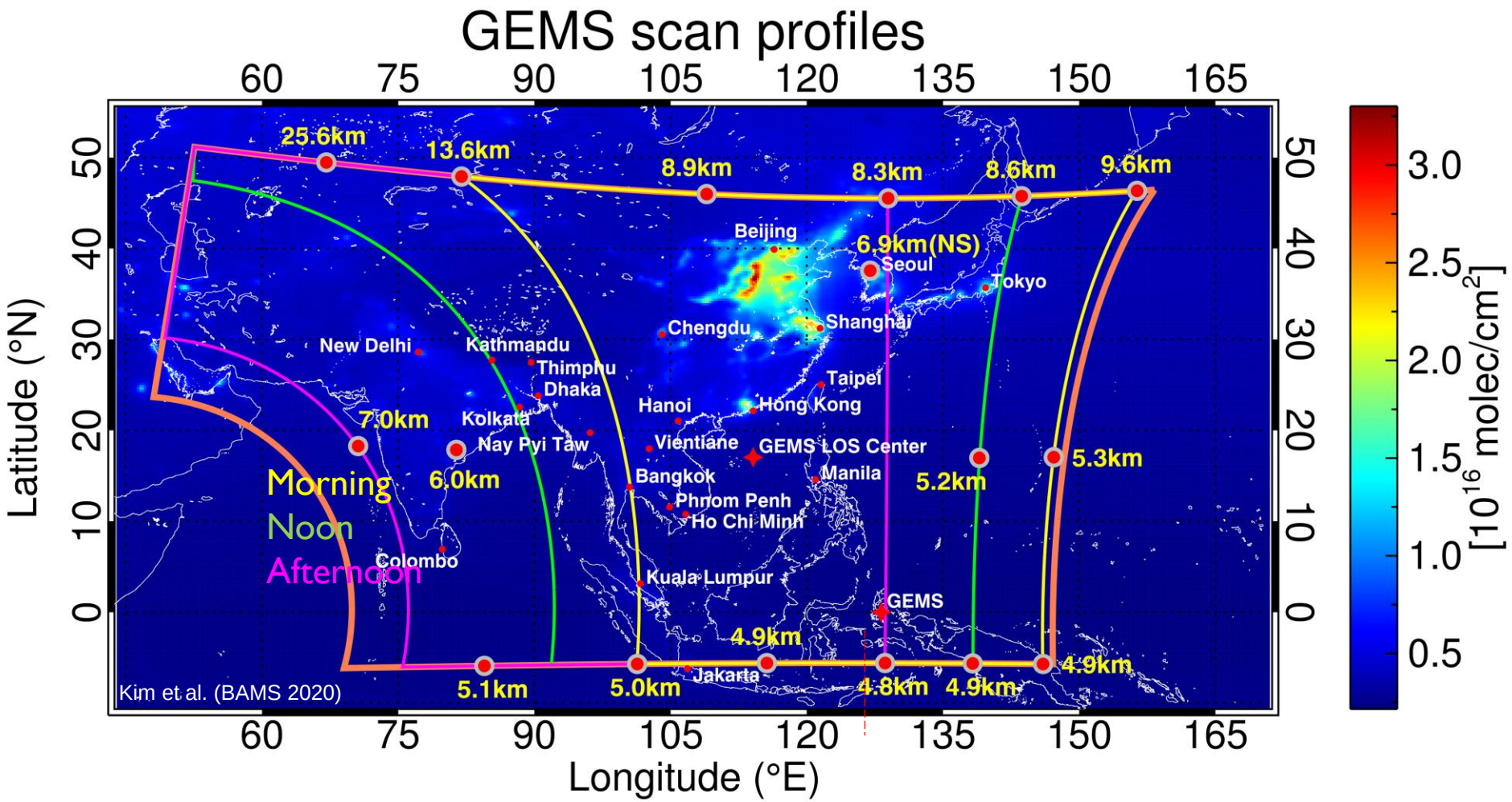
- Goal
  Install at least 1 Pandora set at the polluted area in each Asian country
  → Total 20 Pandora sets

- Period : 2020-2022

- Requirements for Pandora site
  1. Highly polluted area : Capital city or area vulnerable to wildfire and biomass burning
  2. Regional background area : Jeju, Korea / Phimai, Thailand / Cebu, Philippines

- Requirements for Pandora station
  1. 220/120VAC power supplied
  2. Ethernet or WiFi available
  3. Firm, fixed base for mounting (a tripod can be provided)
  4. Clear horizon (ie. minimal obstructions) to view the Sun
  5. National air quality monitoring station preferred

2.2 PAN partners



Countries in GEMS scan region

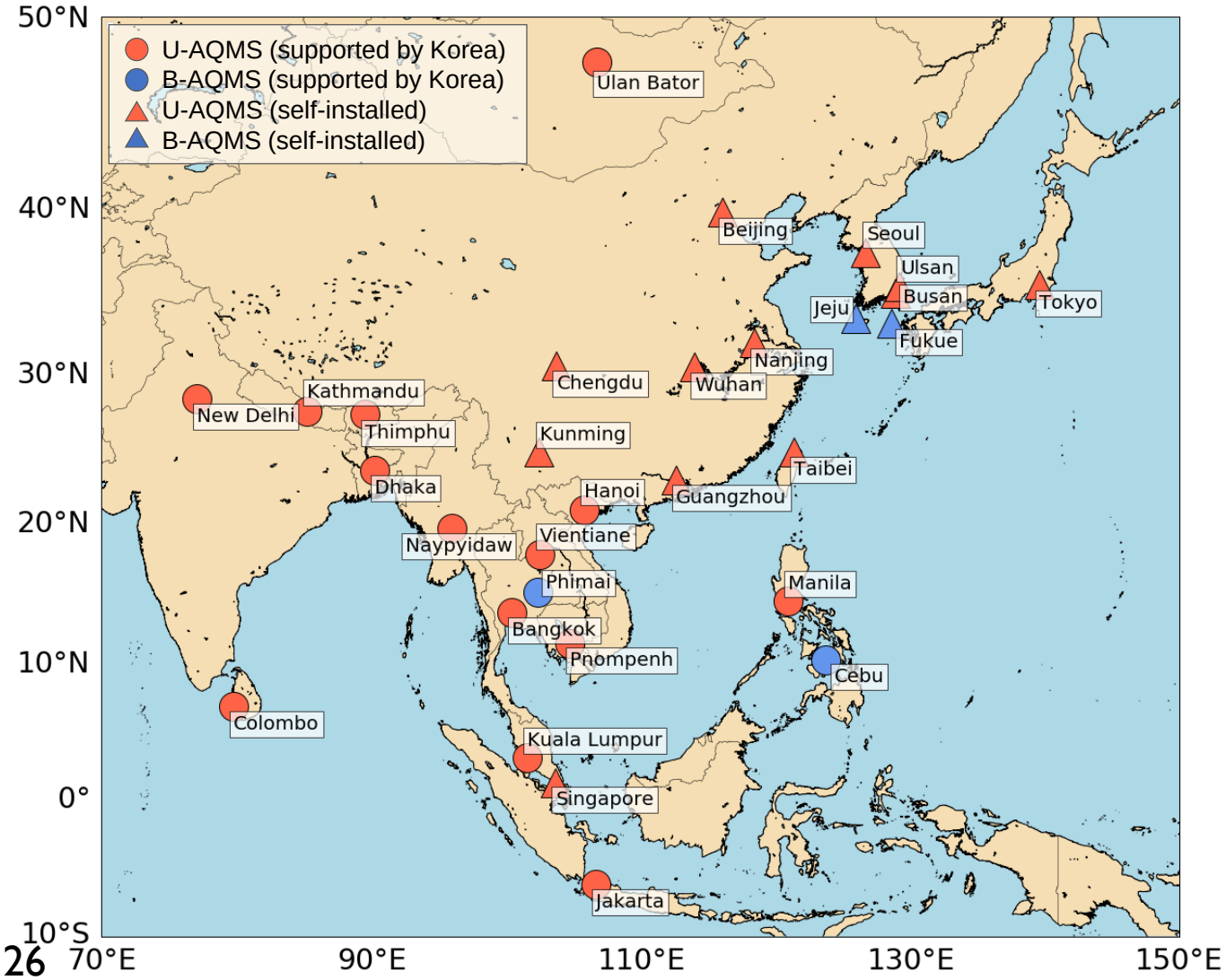
FOV

+

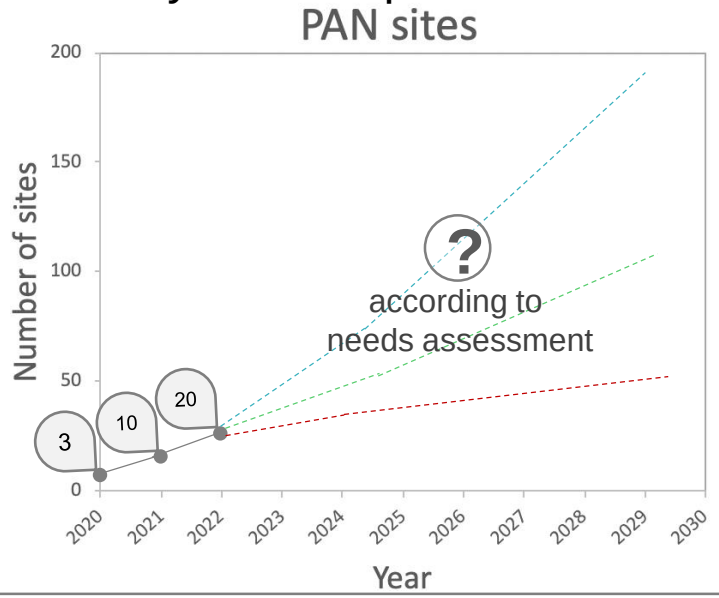
FOR

2.3 PAN site map

Expected PAN station distribution



PAN will start with a few stations and could be substantially scaled up in the future



PAN consists of two groups

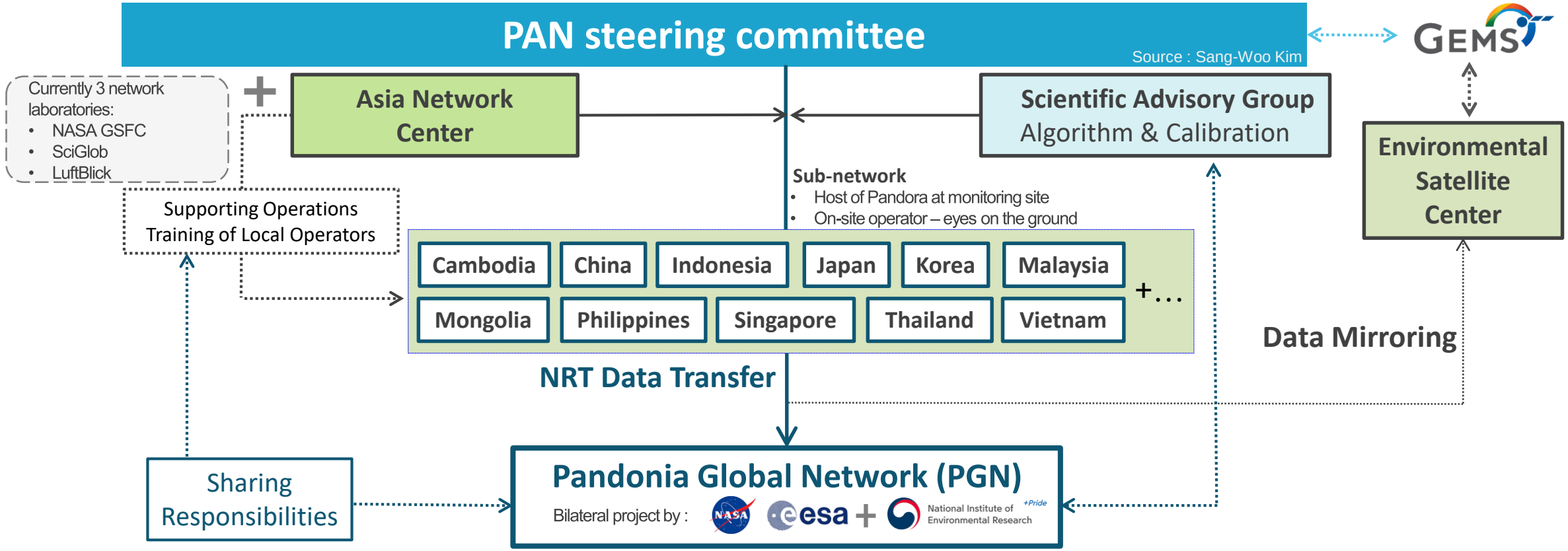
- Urban air quality monitoring stations (U-AQMS)

located on capital cities, industrial complexes, and areas prone to wildfires or biomass burning

- Background AQMS (B-AQMS)

free from direct influences of anthropogenic emissions such as the Atmospheric Brown Clouds (ABC) Asian background

2.4 PAN organization



Asia Network Center(ANC)

- ✓ Algorithm and software development
- ✓ Data processing/QA
- ✓ Laboratory calibrations
- ✓ Network operations

Korea Environment Corporation (KECO)

- ✓ Initial site deployment and setup
- ✓ Major site instrument repairs in consultation with ANC, SciGlob and NASA

2.5 PAN online conference

Pandora Asia Network (PAN) Online Conference

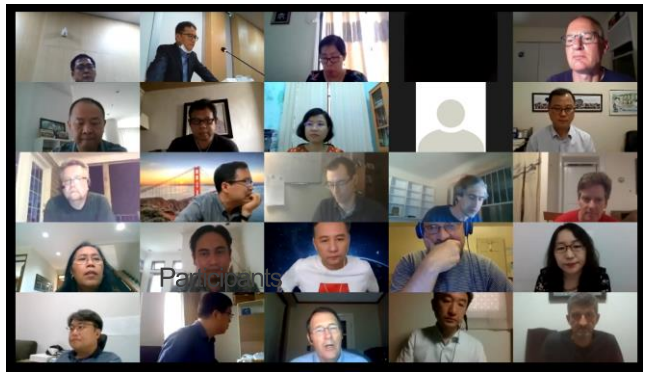
(28 may 2020. 10:00-14:00 Seoul, UTC+9)

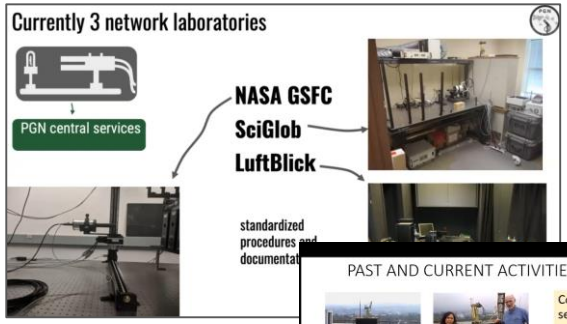
Chairperson: James H. Crawford

Time	Speaker	Title
10:00~10:05	President of NIER	Opening remarks
10:05~10:10	Deputy Executive Secretary of ESCAP	Welcoming remarks
10:10~10:15	President of KOICA	Welcoming remarks
10:15~10:30	Limseok Chang (NIER)	Introduction of PAN project
10:30~10:40	Keran Wang (ESCAP)	Introduction of Pan-Asia partnership
10:40~10:50	Jhoon Kim (YSU)	GEMS algorithms status
10:50~11:00	Kyunghwa Lee (NIER)	GEMS current status and application
11:00~11:20	Alexander Cede(Luftblick) Tom Hanisco (NASA)	PGN status and future plans
11:20~11:35	Nader Abuhassan and Matt Kowalewski (Sciglob)	Pandora overview
11:35~11:50	Jim Szykman (EPA)	EPA Experience with Pandora
11:50~11:55	Sangwoo Kim (SNU)	Pandora in Korea (PAN-Korea)
11:55~12:20	Break	
Short introduction to each of the Pandora Asia Network participants, including site details and research interests		
12:20~13:40	Abdus Salam	Bangladesh
	Kok Sothea	Cambodia
	Aijun Ding and Xuguang Chi	China (Nanjing)
	Jinyuan Xin	China (Chengdu)
	Puji Lestari and Didin Agustian Permadi	Indonesia
	Hitoshi Iire	Japan
	Yugo Kanaya	Japan
	Won Jun Choi	Korea
	Mohd Talib Latif	Malaysia
	Soyol-Erdene Tseren-Ochir	Mongolia
	Ohnmar May Tin Hlaing	Myanmar
	James Simpas	Philippines(Manila)
	Roland Otadoy	Philippines (Cebu)
	Liya Yu	Singapore
	Nguyen Thi Oanh Kim	Thailand (Bangkok)
	Ronald Macatangay	Thailand (Chiang Mai)
	Ly Bich Thuy	Vietnam(Hanoi)
	To Thi Hien	Vietnam (Ho Chi Minh)
13:40~13:55	Jim Crawford(NASA)	Short Discussion, Q&A
13:55~14:00	Director General of NIER	Closing remarks

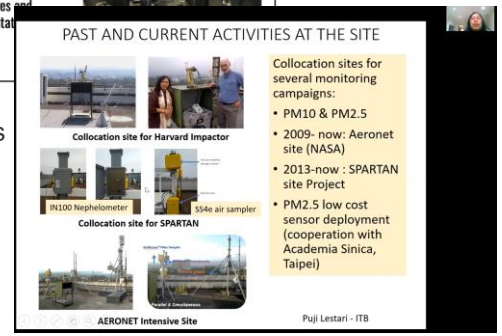
PAN Online Conference

- May 28, 2020 10:00-14:00 (Seoul time)
- Meeting registrants : 67
- Participating Asian Countries : 13 (Bangladeshi, Cambodia, China, etc)
- Participating organizations :
  NASA, UN ESCAP, Sciglob, Luftblick, EPA, KOICA, KECO, NIER etc.





Presentation :
Participating organizations



2.6 National Pandora network

Korean Pandora network establishment plan

2020

Planning on purchasing 3 Pandora spectrometers

Pandora sites (tentative)

NIER ESC (Incheon)
Seosan supersite
Jeju supersite

Type of Pandora to be purchased

1. Pandora 1S (single spectrometer) - standard
   wavelength range 280~530nm, resolution 0.6nm
2. Pandora 1S - extended
   wavelength range approx. 280 nm - 800 nm, resolution 1.1nm
3. Pandora 2S (dual spectrometer)
   wavelength range 310~370nm, resolution 0.08nm
   wavelength range 280~800nm, resolution 1.1nm

Pandora sites will be determined according to GMAP results

→ NIER ESC (Incheon)

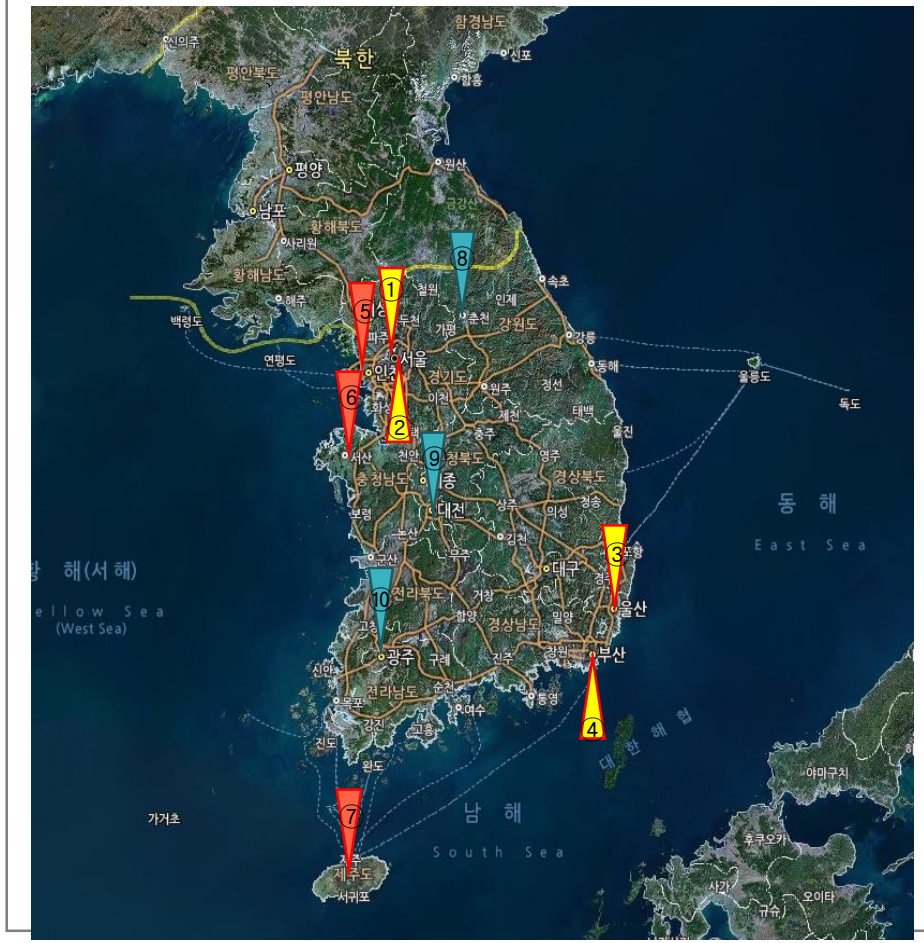
Three Pandoras will be implemented during the GMAP for comparison of differences between them

2021

Planning on purchasing 3 Pandora spectrometers

(Pandora type and installation sites : TBD according to GMAP results)

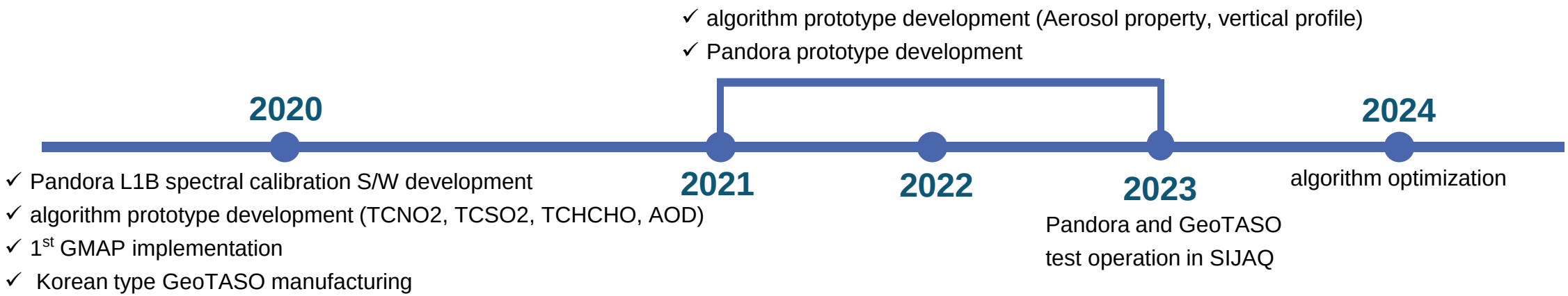
PAN-Korea map



2.7 Pandora H/W, S/W development

Development of Pandora and its algorithm, GeoTASO manufacturing for satellite validation

- Period : 2020-2024
- Needs :
  - Pandora algorithm development in order to support PM forecasting and real-time mo nitoring of air pollutants, which is more sensitive to air pollutants(NO2, SO2, O3, HCHO, and Aerosol Optical Depth(AOD)) in PBL than satellite algorithm
  - customized in east Asia
- Expected application :
  validation and improvement of GEMS data, SIJAQ implementation, etc.



2.7 Pandora H/W, S/W development

Development of Pandora algorithm for satellite validation

AOD profile algorithm absence

Uncertainty due to Aerosol physical information absence

Uncertainty due to Aerosol vertical profile error

Calculation of Aerosol microphysical property → Aerosol extinction profile calculation through sensitivity of O2-O2 absorption on aerosol → Vertical profile algorithm development of strong absorbing NO2 → Development ofVertical profile algorithm for other pollutants (e.g. HCHO)

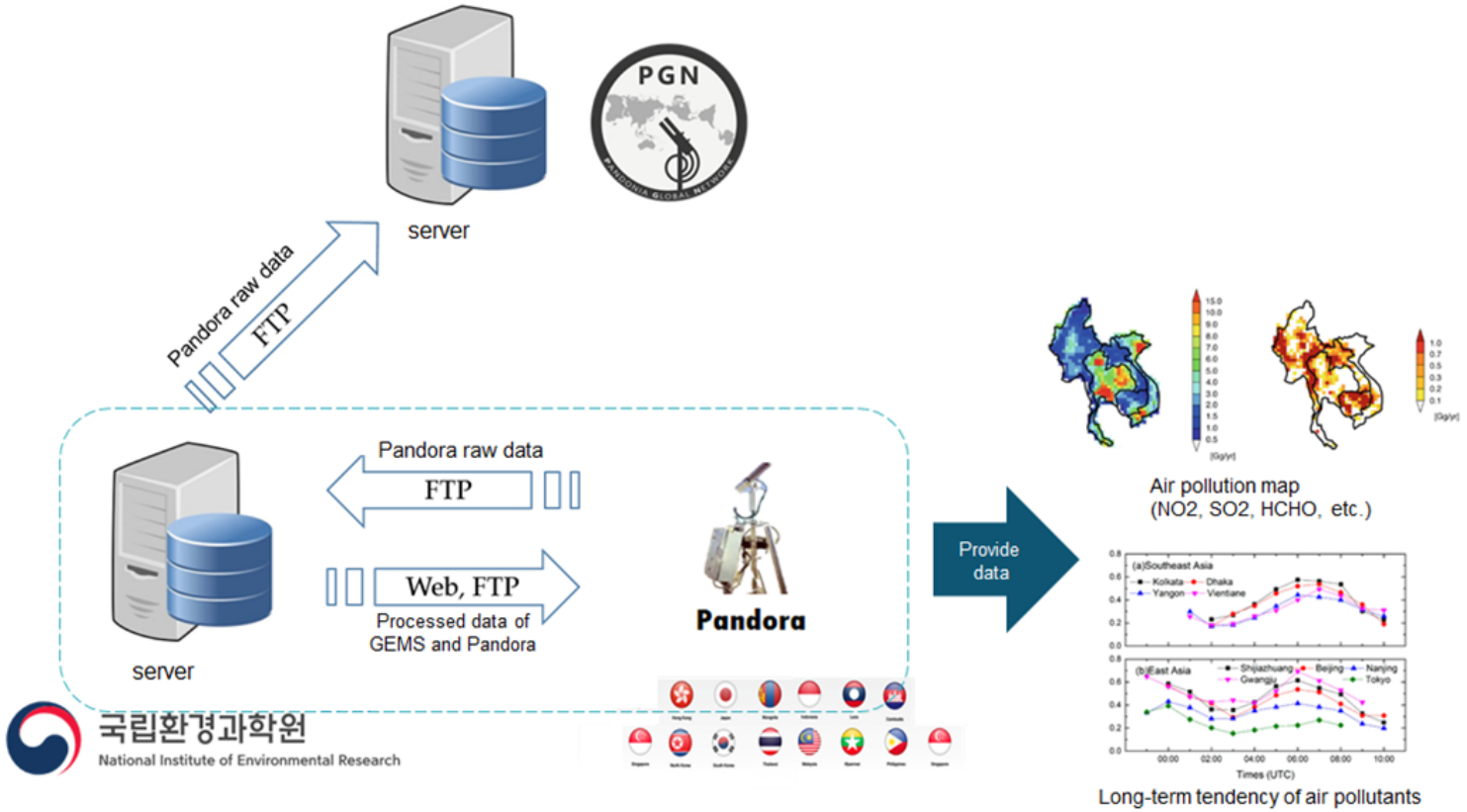
Microphysical properties of Aerosol

Vertical profile of aerosol and its microphysical properties

2.7 Pandora H/W, S/W development

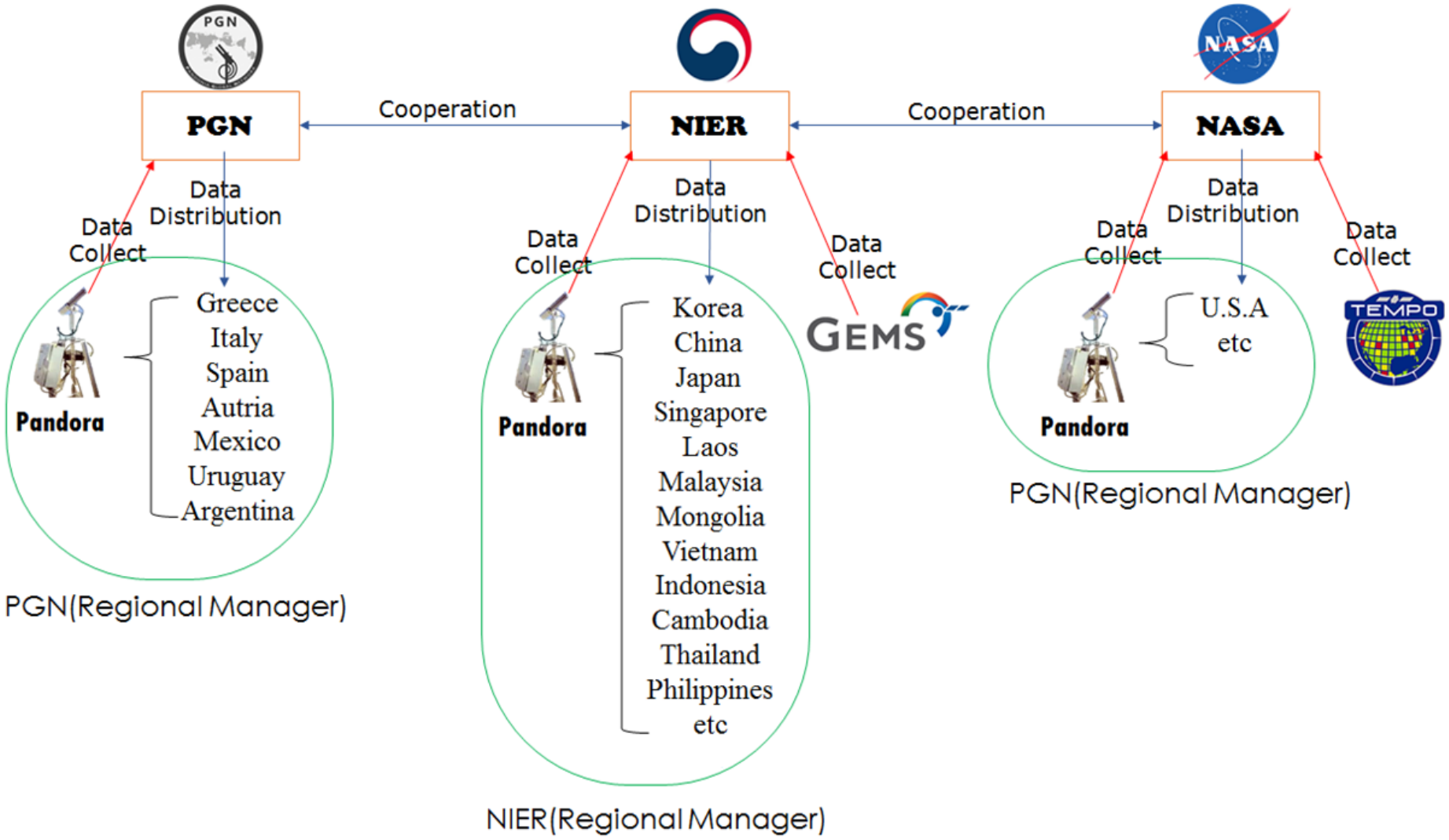
Establish of PAN data-processing system

- **Objective**
  Establish data-processing system for data collection, processing, storage, dissemination
- **Tasks**
  - Pandora data collection S/W development
  - Server construction for data collection, processing, storage , dissemination
  - Operation of data processing algorithm for collected Pandora data



2.7 Pandora H/W, S/W development

Establish of PAN data-processing system



03 AO

GEMS AO objectives

AO call is

to harness professional knowledge and expertise of experienced scientists to perform validation and accuracy assessment of data and products of GEMS through independent data analysis

1. Evaluation of Level 2 retrieval algorithms
2. Assessment of regional errors and their sources
3. Comparison with other space-borne instruments
4. Comparison with ground-based and/or airborne measurements
5. Comparison of diurnal variations of each atmospheric species between GEMS measurements and modeling results
6. Assessment of the impact of auxiliary data used in product retrieval
7. Analysis of major error sources and error budget
8. Assessment of heterogeneous geographic effects

Product		Importance	Window (nm)	Spatial resolution (km × km) at Seoul	Algorithm	Remark
NO_2	Trop	O3/aerosol precursor	432-450	7×8	DOAS	RD-04
	Strat					
SO_2		Aerosol precursor	310-326	7×8	DOAS-PCA	RD-05
		volcano	310-340			
HCHO		VOC proxy	328.5-356.5	7×8	DF	RD-06
CHOCHO			435-461	7×8	DF	RD-07
O_3	Trop	Oxidant, pollutant, Ozone layer	300-340	7×8	OE	RD-08
	Strat		300-340		OE	
	Total		317.5, 331.2, 331.2, 340, 380		TOMS	RD-09
Aerosol	AOD	Air quality, climate	354, 388, 412, 443, 477, 490	3.5×8	LUT, OE	RD-10
	UVAI				LUT	
	SSA				LUT, OE	
	AEH		477		O_2-O_2	RD-11
Cloud	ECF	Retrieval, climate	300-500	7×8	O_2-O_2	RD-12
	CCP		477			
	CRF					
Surface reflectivity		Retrieval, environment	300-500	3.5×8	Multi-channel, BRDF	RD-13
UVI	UVI	Public health	354	7×8	LUT	RD-14
	VitaD					
	DNA					
	Plant					

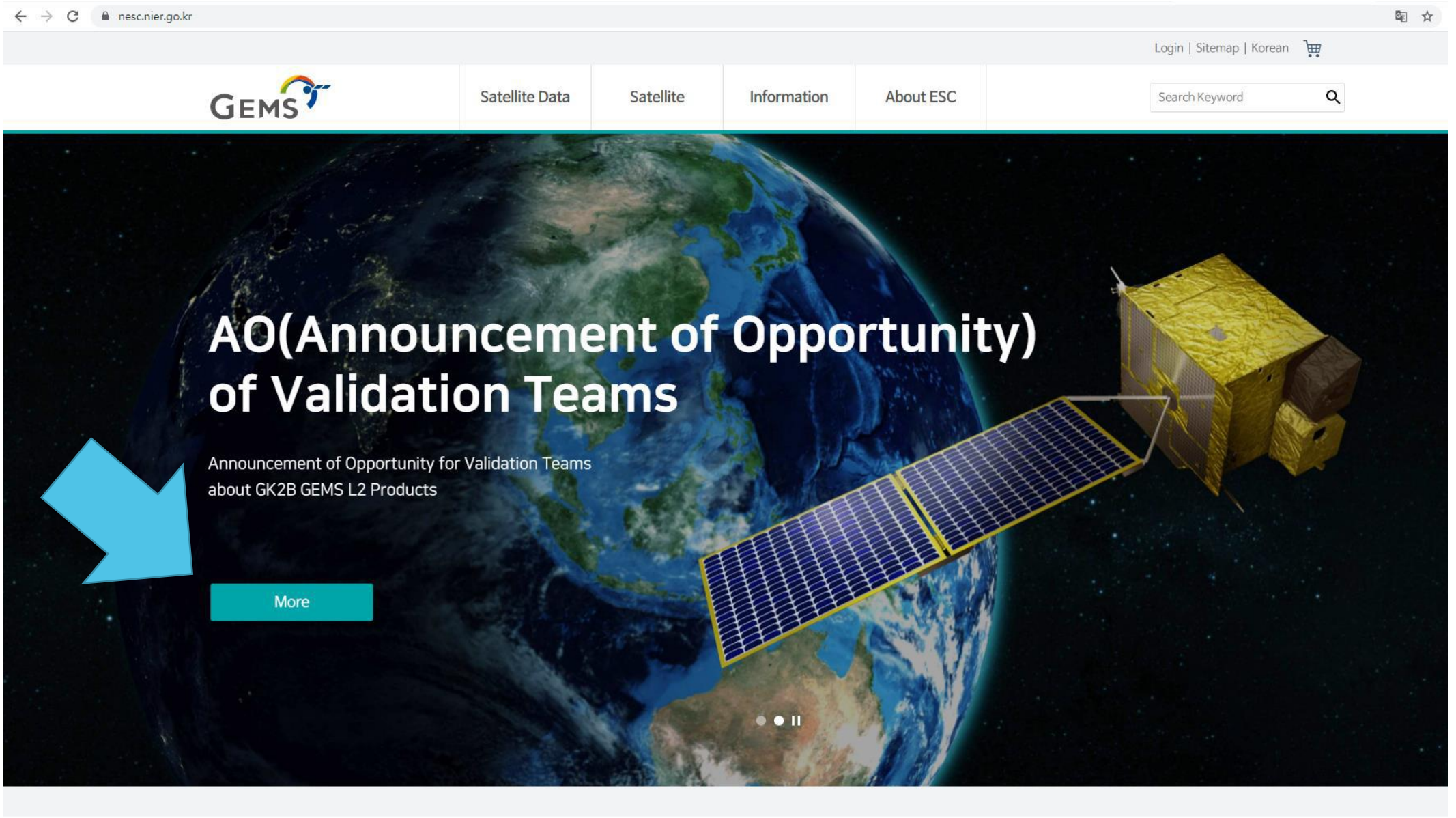
GEMS cal/val activities timelines

Step	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
GEMS Mission life	→	→	→	→	→	→	→	→	→	→			
Commissioning phase	→	→											
Exploitation phase			→	→	→	→	→	→	→	→			
Archive											→	→	→
On-orbit VAL	→	→	→	→	→	→	→	→	→	→			
Reprocessing						→	→	→	→	→	→	→	
Validation (post mortem)											→	→	→
Remark	1st project		2nd project		3rd project		4th project		5th project		6th project		

GEMS AO information can be obtained from https://nesc.nier.go.kr

Help desk: Dr. Changsuk Lee, leecs00@korea.kr

Announcement of Opportunity



Thank you

Terima kasih

cảm ơn bạn

谢谢

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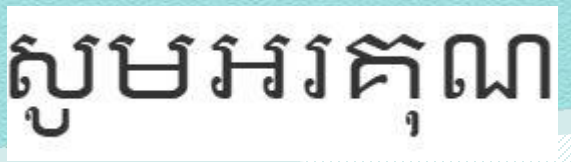

Salamat

баярлалаа

ありがとうございました

ขอบคุณ