

Introduction to Geostationary Environment Monitoring Spectrometer and Pandora Asia Network



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GEMS validation team
Environmental Satellite Center (ESC)
National Institute of Environmental Research (NIER)

Contents

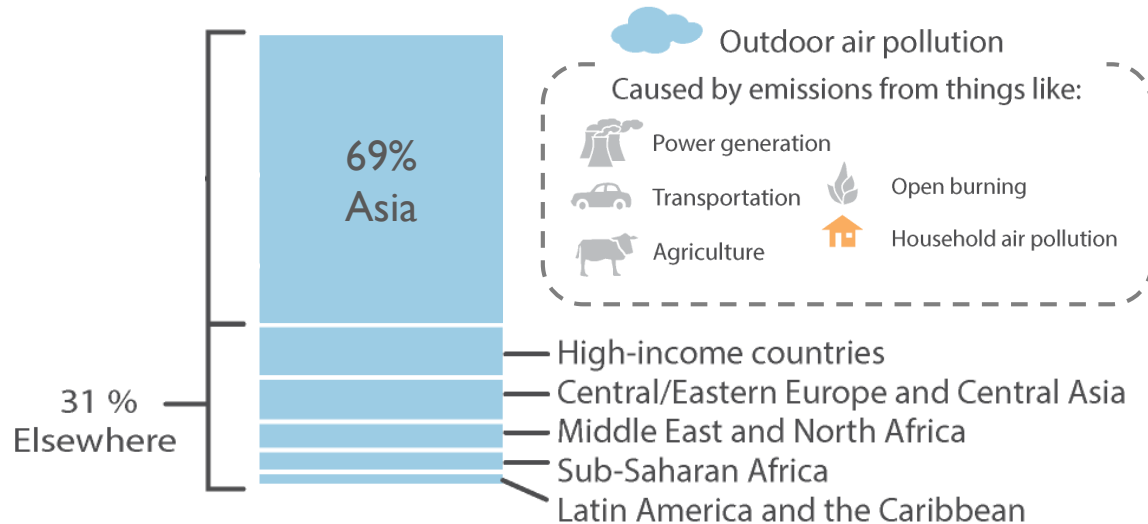
1. PAPGAPi overview
2. GEMS current status
3. PAN establishment plan
4. Summary



NO₂ pollution hot-spots around Asia



Nearly 3 million deaths from outdoor air pollution in 2017



*<https://www.healtheffects.org>



in-situ / ground-based monitoring

- Accurate and used for national statistics
- very narrow spatial coverage
- mostly concentrated in densely populated **cities**



Satellite observations

- providing data over wider areas of the **globe**
- particularly useful for regions where no surface monitors are installed

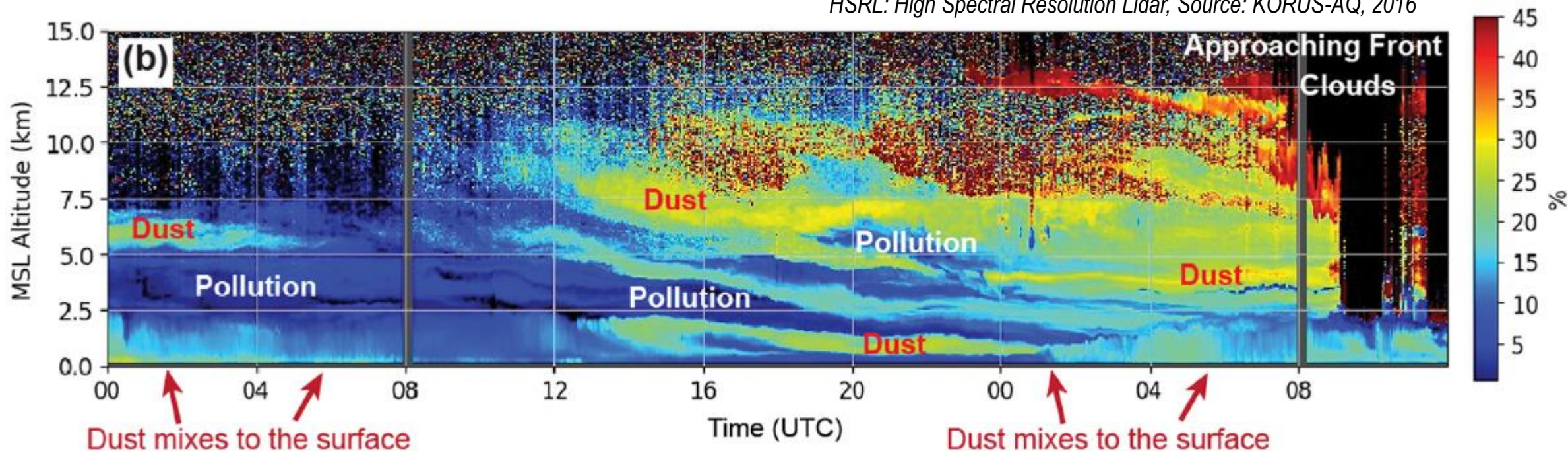


- **Satellite Validation**
- **Regulatory Compliance**
- **New Science & Applications**

(Source : Valin, online conference)

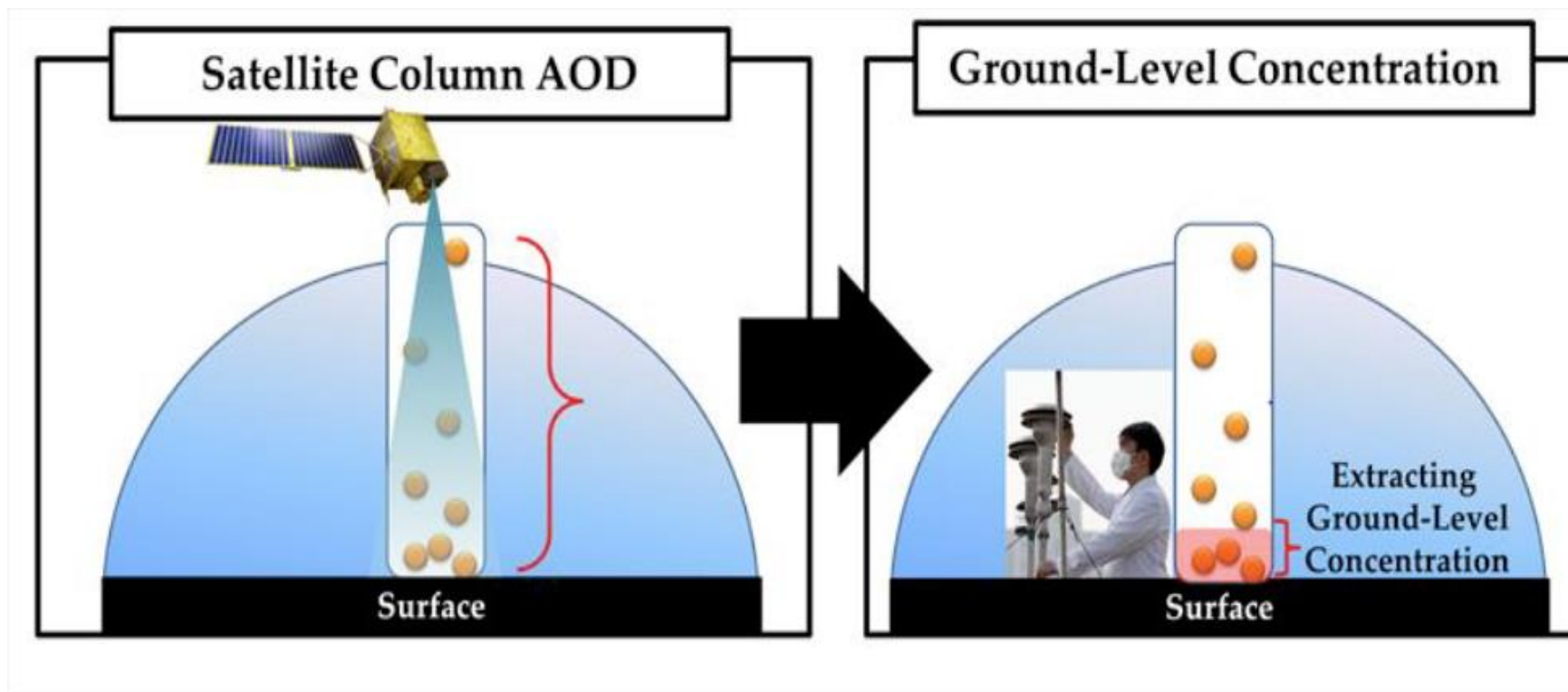
HSRL vertical profiles featuring complex layering of aerosol particles and dust transport

HSRL: High Spectral Resolution Lidar, Source: KORUS-AQ, 2016



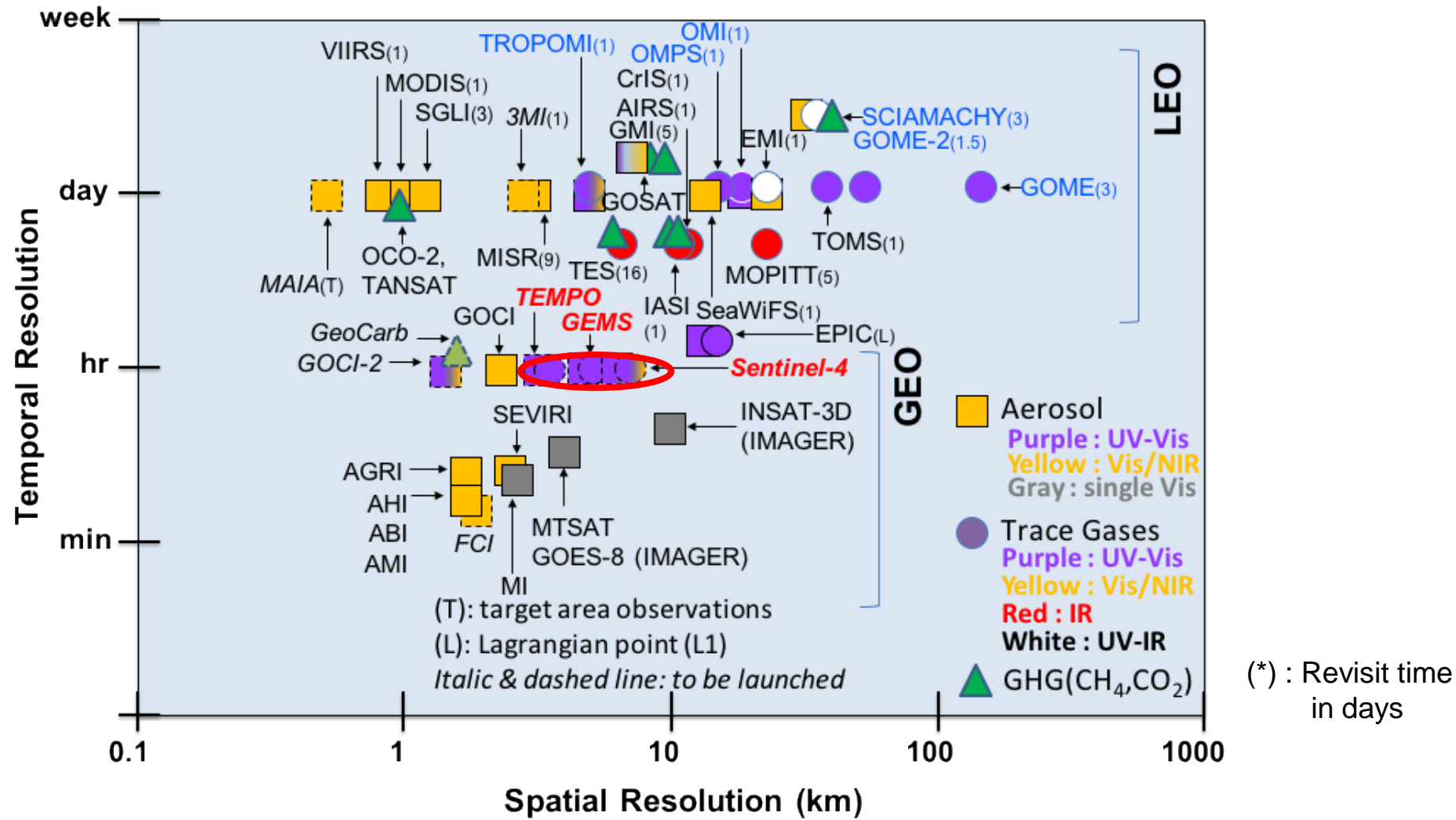
- Rapid change in weather conditions can produce a complex vertical profiles of pollution
- Use of satellite data helps to understand surface air quality

PAPGAPi Concept note (UN ESCAP, 2020)



- ✓ PANDORA
- ✓ LIDAR
- ✓ Ceilometer

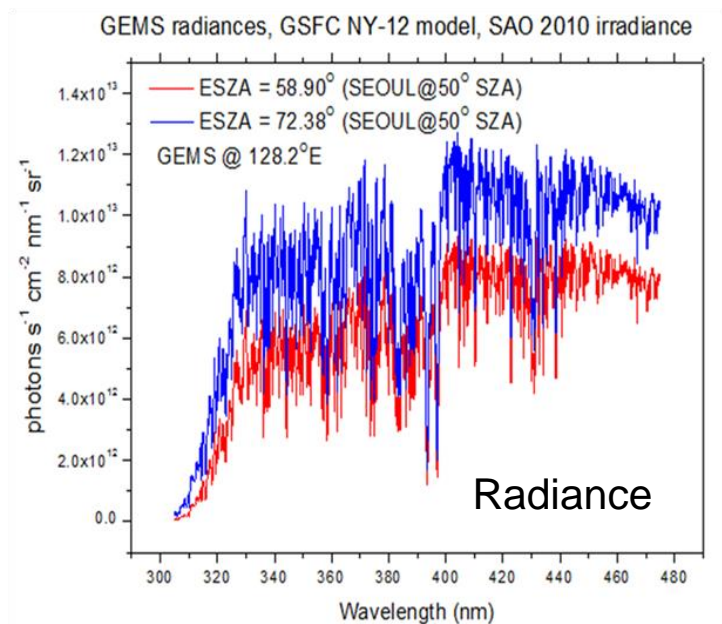
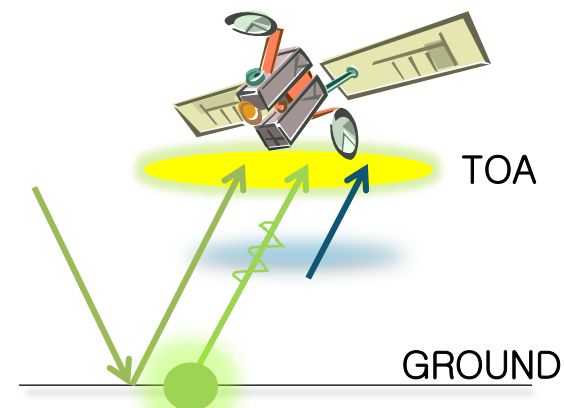
- ✓ NO2 analyzer
- ✓ O3 analyzer
- ✓ PM2.5 monitor
- ✓ SO2 analyzer



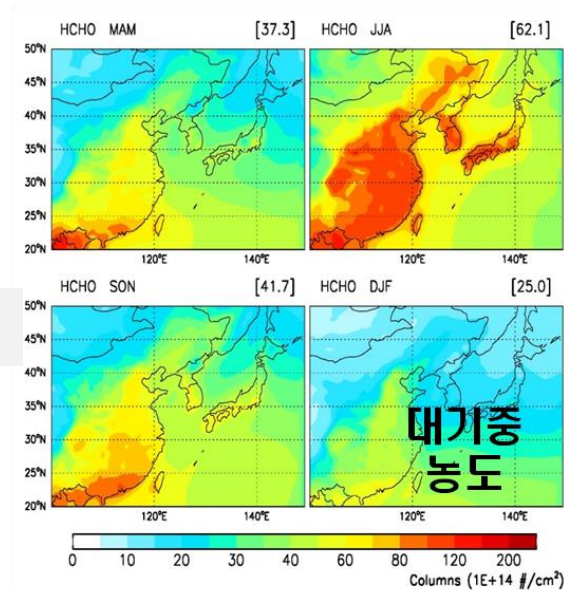
$$L(\lambda) = \frac{1}{\pi} R(\lambda) T_{\uparrow}(\lambda) (T_{\downarrow}(\lambda) E_{sun}(\lambda) \cos \theta + E_{\downarrow}(\lambda)) + L_{\uparrow}(\lambda)$$

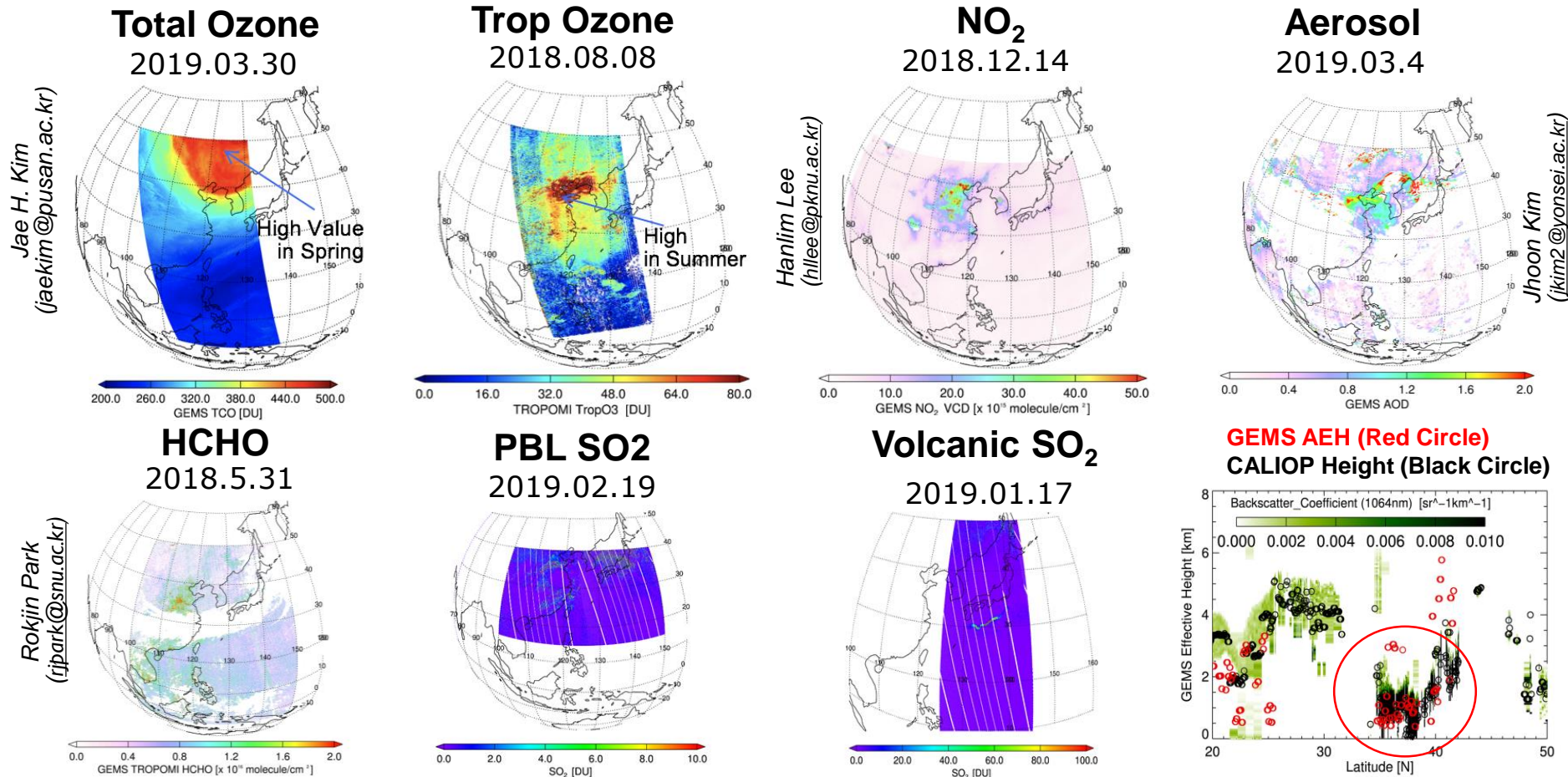
radiance at sensor
 surface reflectivity
 atmospheric transmittance (sensor path)
 atmospheric transmittance (sun path)
 direct irradiance
 sky irradiance
 path radiance

Credit: J. Kim

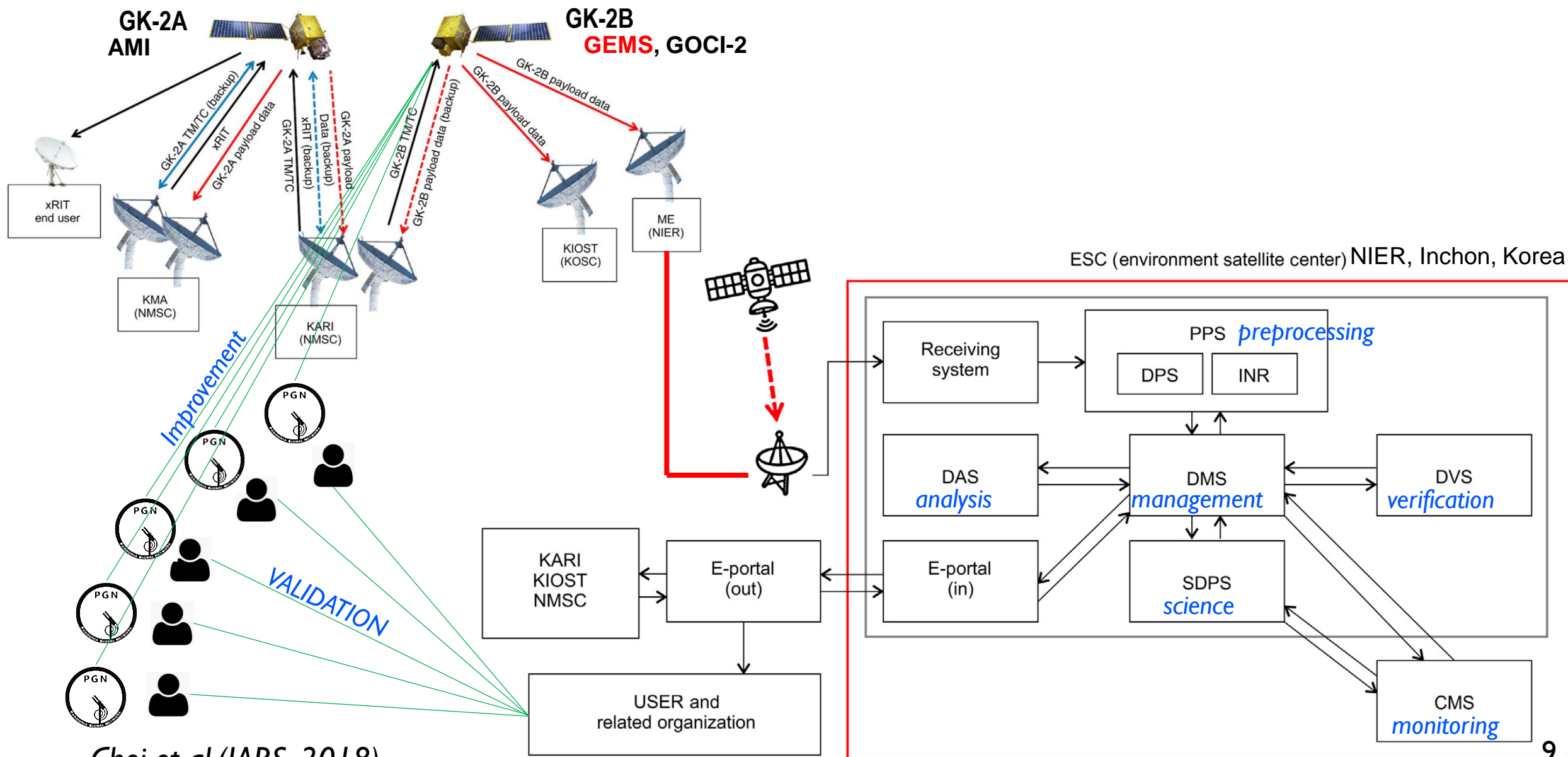
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O.I.
BOAS...

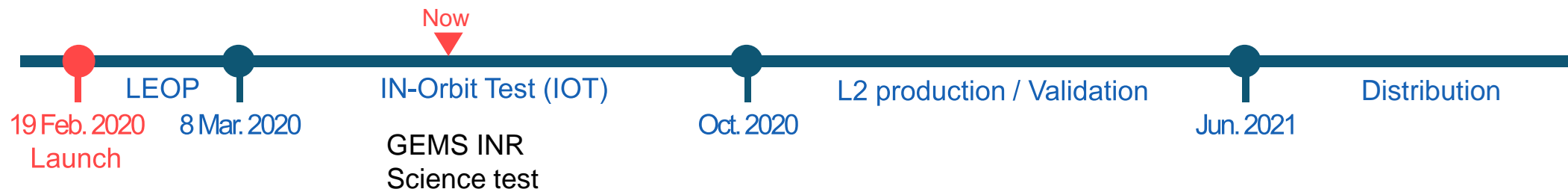
Algorithm





Courtesy by Jhoon Kim





* INR: Image Navigation and Registration



Announcement of Opportunity (AO)

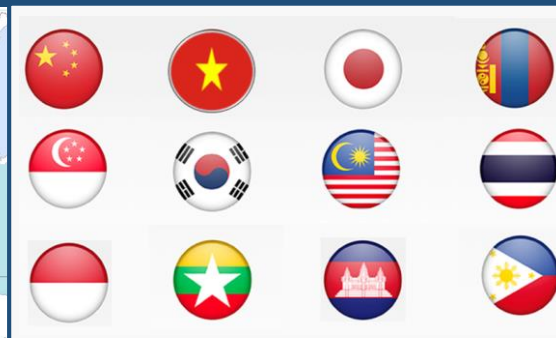
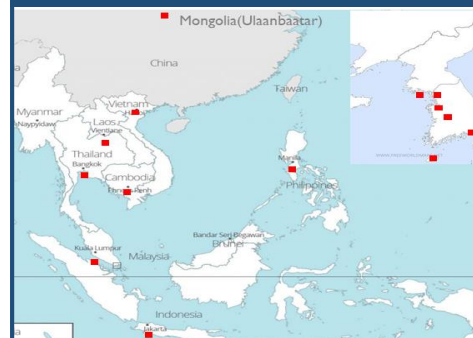
to harness professional knowledge and expertise of experienced scientists to perform validation and accuracy assessment of data and products of GEMS through independent data analysis

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

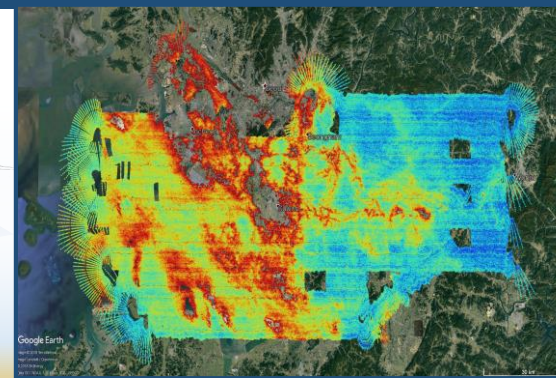
Refer to <https://nesc.nier.go.kr>

International collaboration

Pandora Asia Network (PAN)

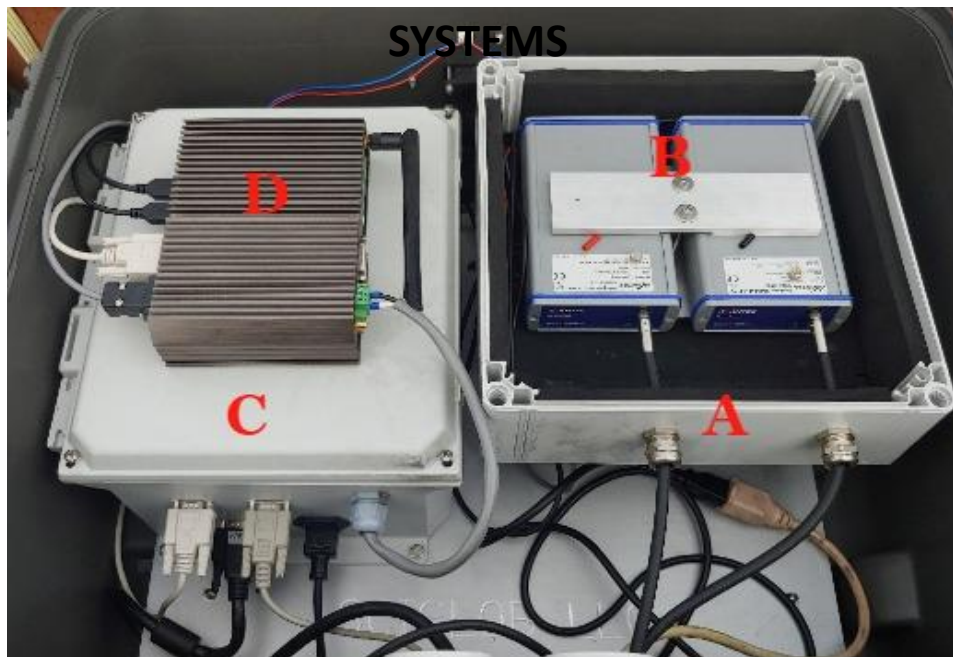


Satellite Integrated Joint monitoring of Air Quality (SIJAQ)



- **Pandora**, one of Fiducial Reference Measurements (FRM), is a **compact, modestly priced sun/sky/lunar passive UV/VIS grating spectrometer**.
- The **PAN** is a new network of ground-based remote sensing instruments dedicated to validate the scientific products of GEMS as well as low Earth orbit (LEO) satellites.
- Pandora monitors air quality and atmospheric composition in the region where it is installed, and it also serves monitoring satellite data quality for whole GEMS and LEO mission durations.
- **Priorities**
 1. Expanding Pandora stations and Supporting National and International Partners, sharing all with PGN
 2. Supporting Satellite (GEMS) validation activities
 3. Collaborative development of new operational algorithms
 4. Continued collaboration with AERONET, SONET, SKYNET, KALION, AD-NET.

PANDORA ENCLOSURE - INTERNAL SYSTEMS



- A - Spectrometer box (maintains spectrometer temperature)
- B - Spectrometer(s) (measure spectra)
- C - Electronics box (power and electronics)
- D - Control computer (runs control software)

PANDORA SUN & SKY SPECTROMETER



Comparison of Pandora with Dobson, Brewer, TOMS, OMI(TOMS, DOAS): $R^2 = 0.95 \sim 0.97$

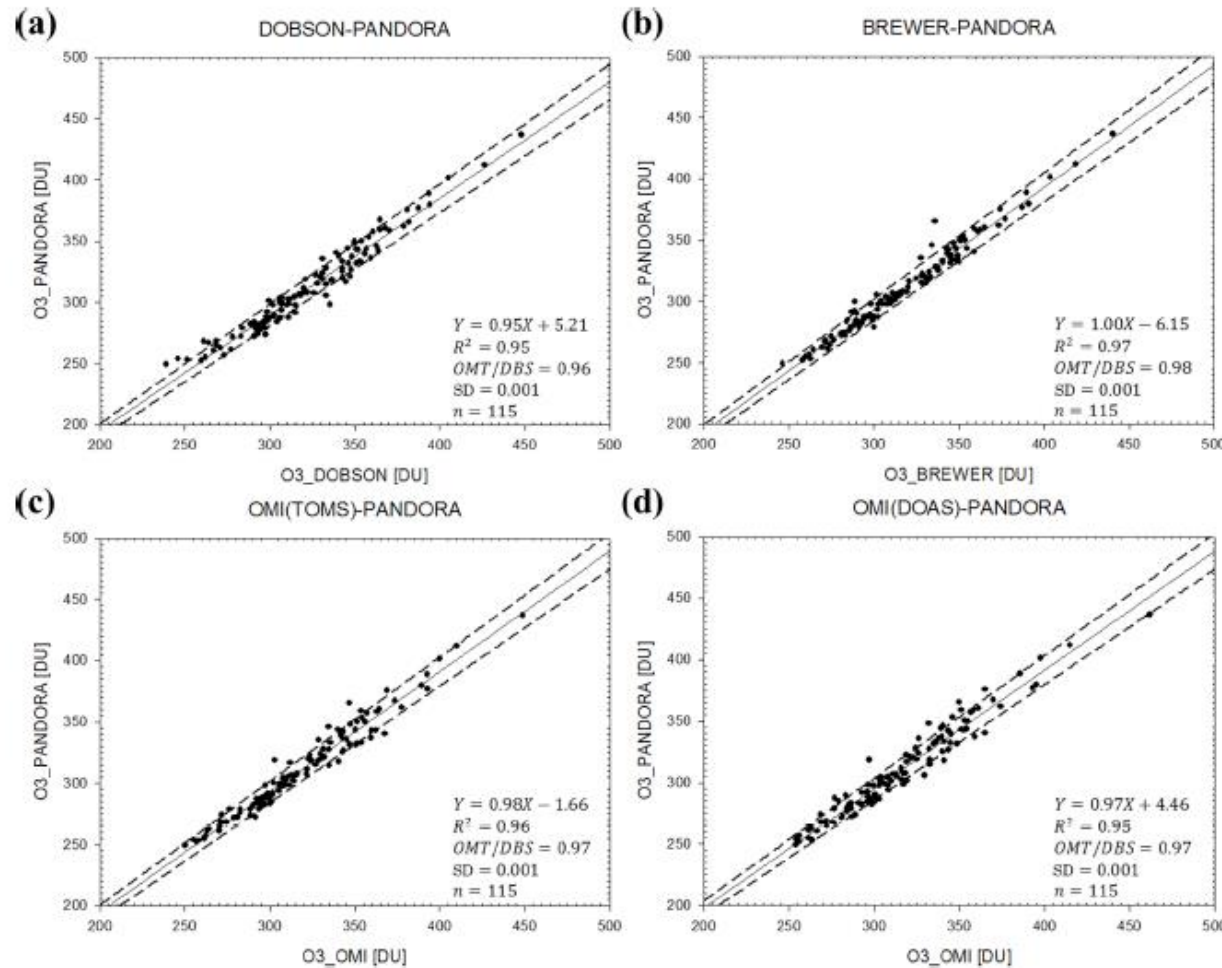
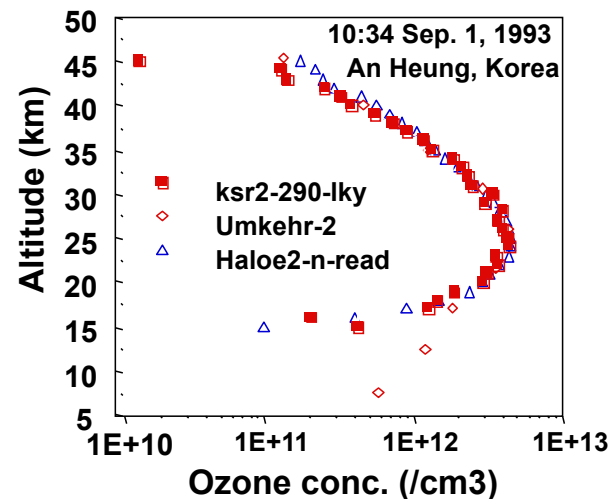
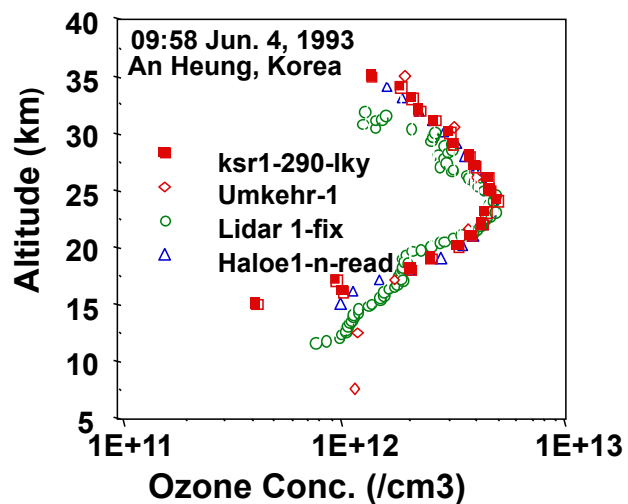
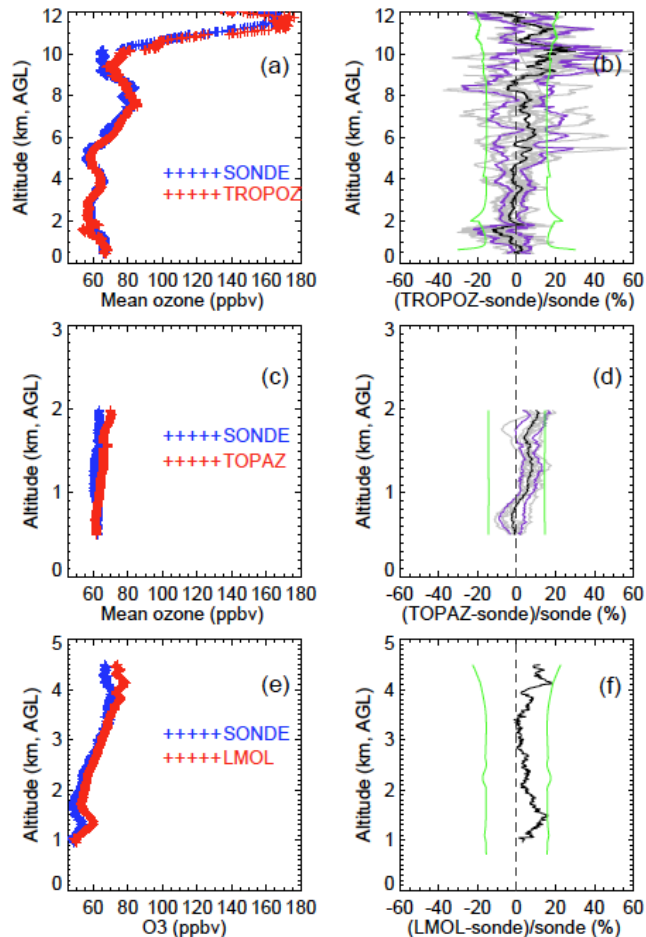
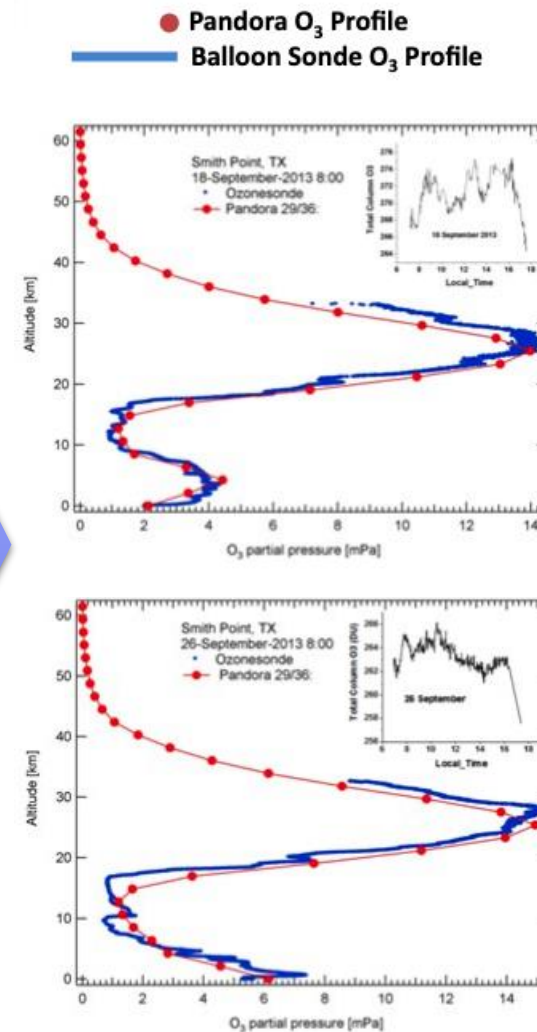


Figure 5. Intercomparison of daily TCO values from Pandora with Dobson (a), Brewer (b), and OMI (TOMS, c; DOAS, d). Solid lines represent regression lines, and dashed lines indicate an error range of $\pm 3\%$.

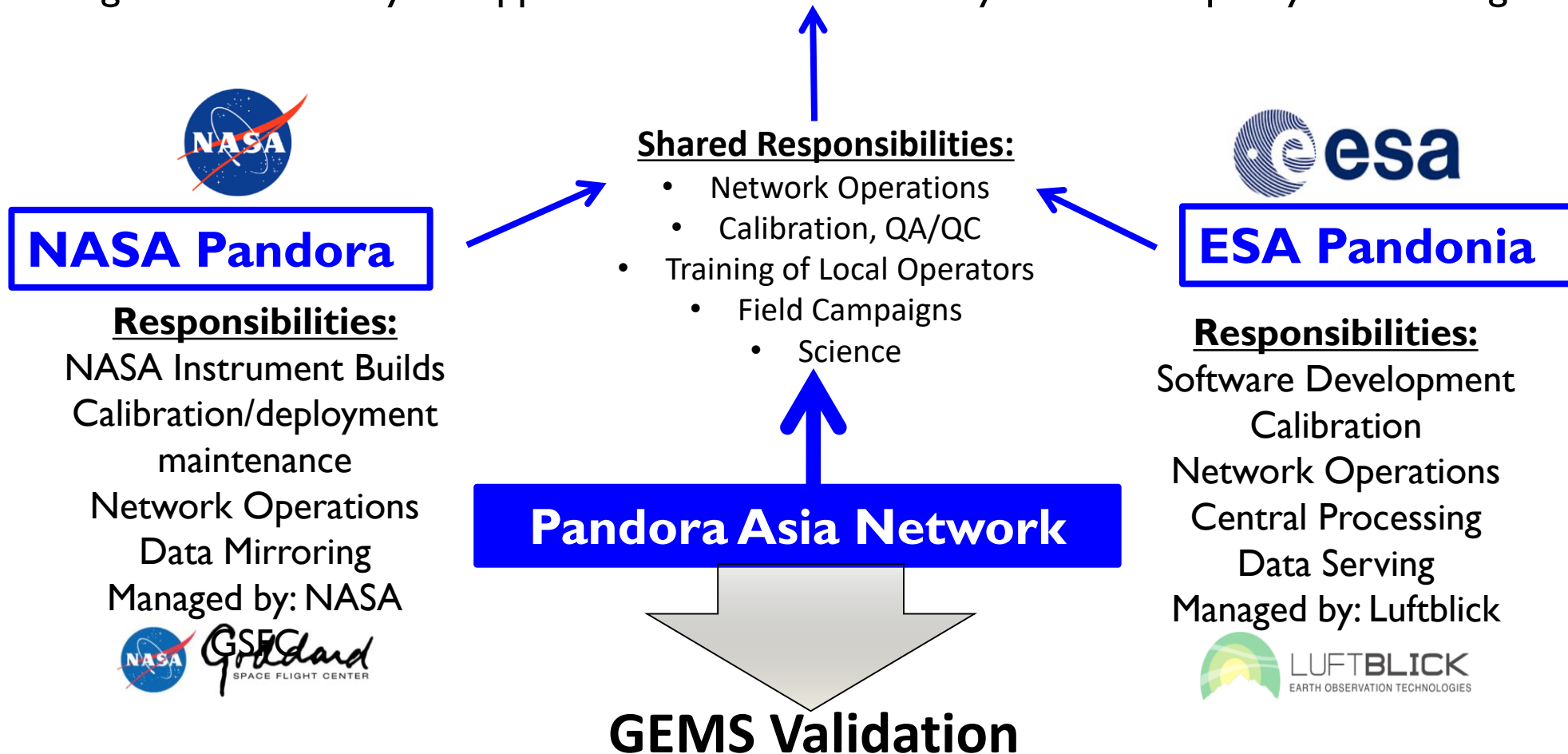
TOLNet during DISCOVER-AQ
and FRAPPÉ

Kim et al.(JGR 1997)

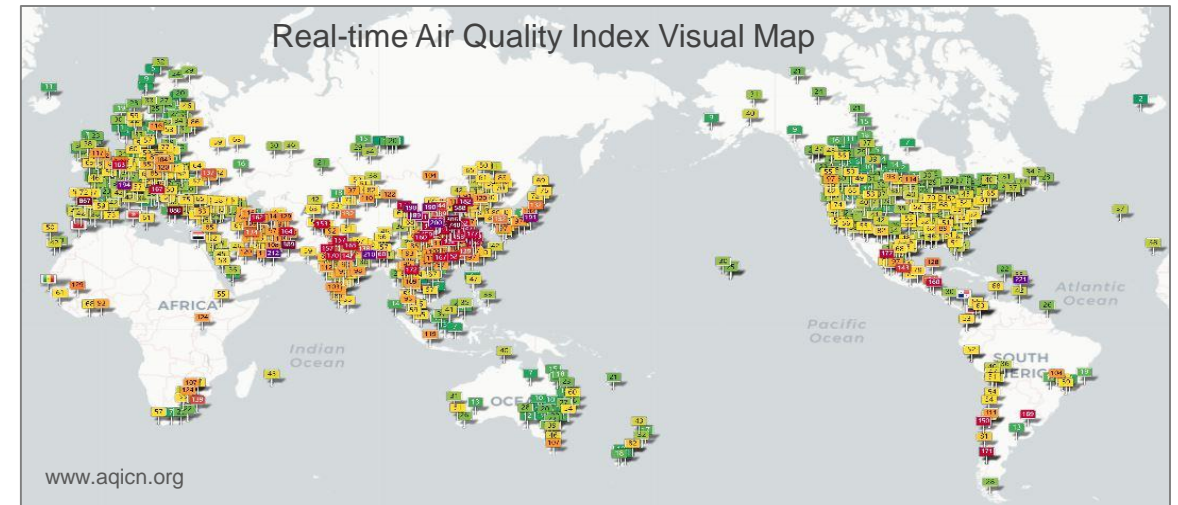
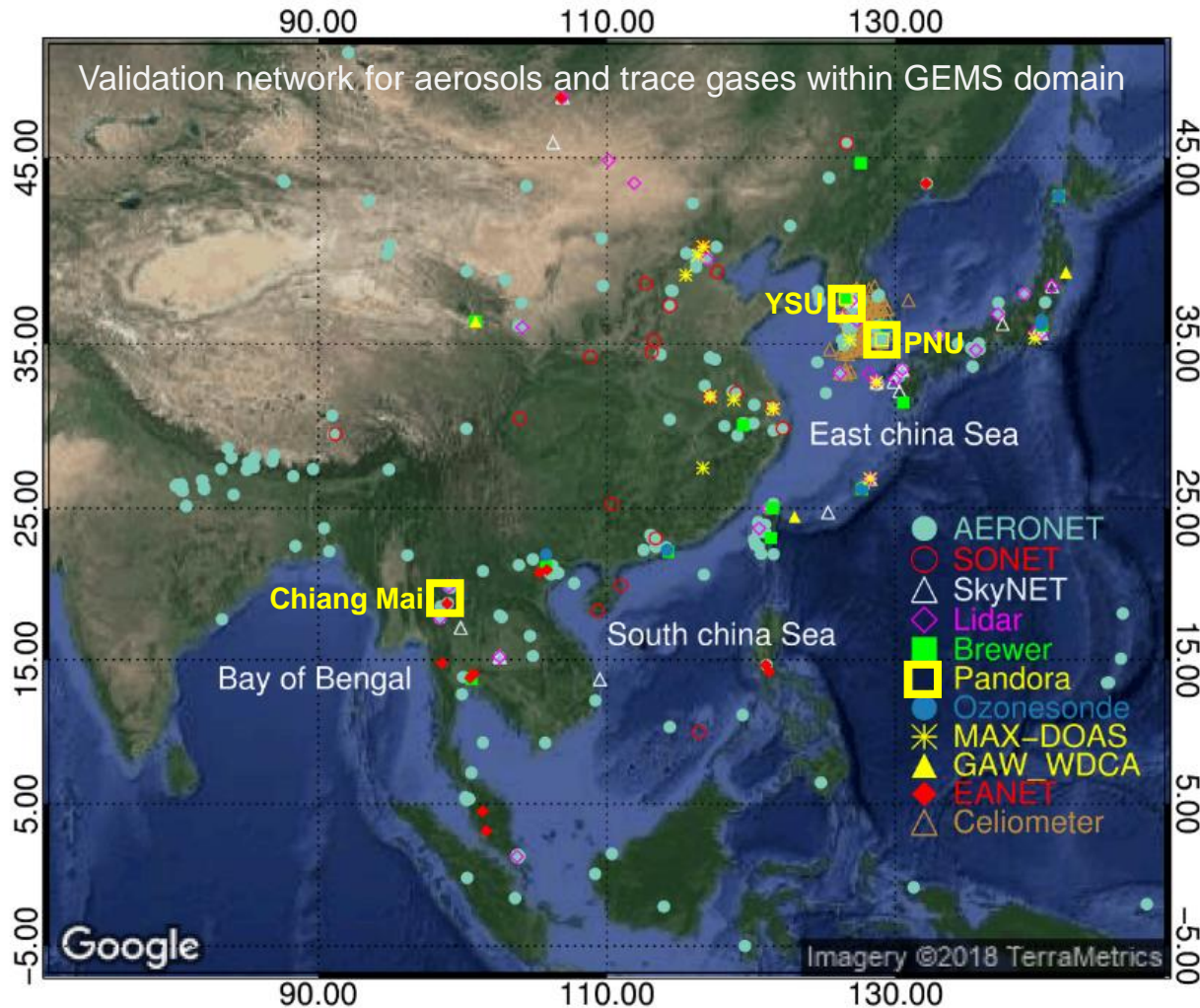
@ Boulder Atmospheric Obs.
Wang et al.(AMT 2017)PANDORA O₃ Profile

Jazmine Smal

Goal: expand and coordinate a global network of **standardized, calibrated** instruments and **systematically process** and disseminate the data to the greater global community in support of in-situ and remotely sensed air quality monitoring



✓ Current Pandora Map



GEMS monitors regional air quality from space

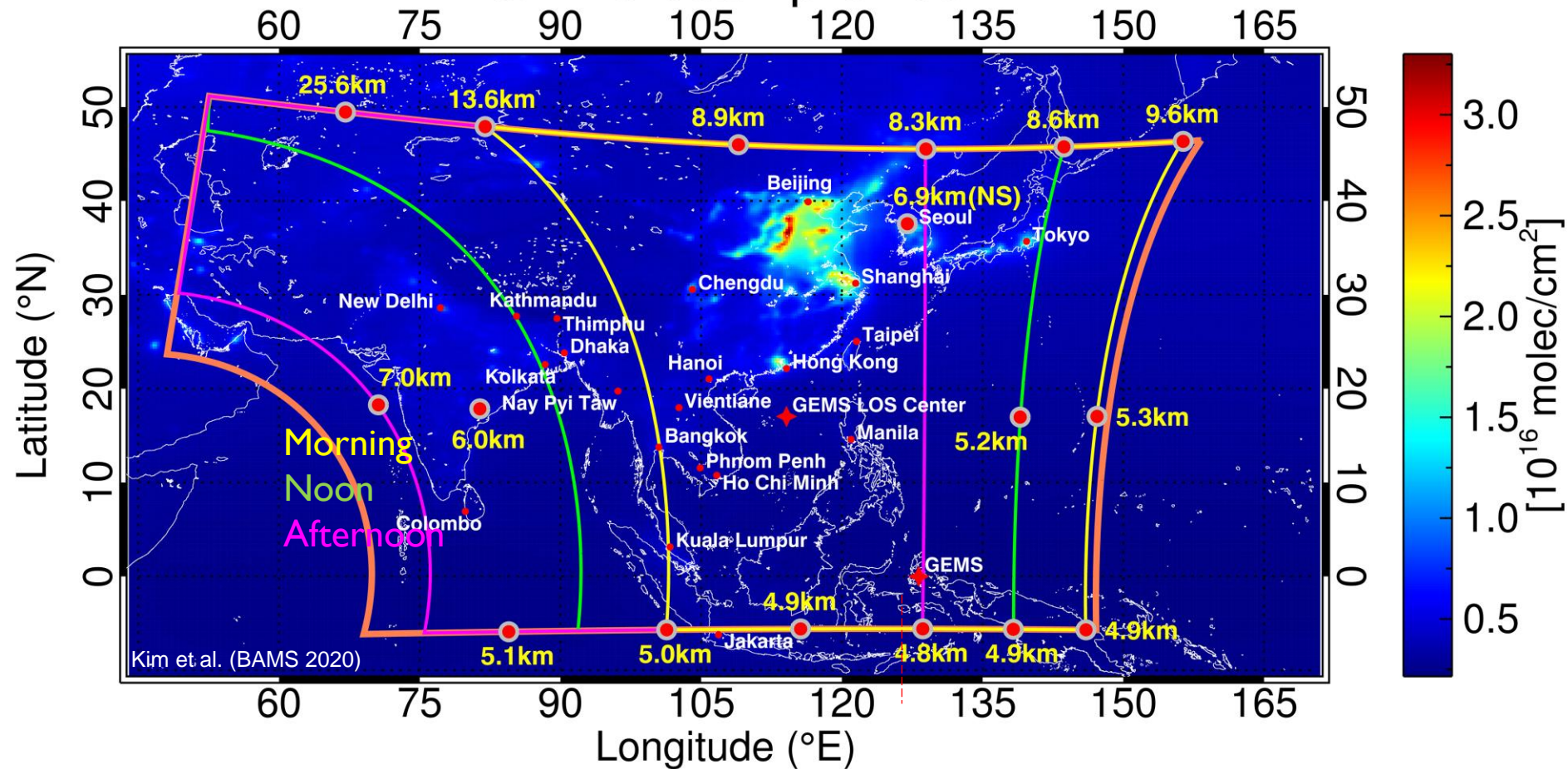
- A variety of validation activities (network, AO, campaign) are needed
- More dense network of ground-based remote sensing instruments are needed in **Asia** to validate satellites (GEMS, TROPOMI, GOME-2, OMPS, etc.)



Pandora monitors local air quality and atmospheric composition on the ground

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

GEMS scan profiles

Countries in
GEMS scan region

FOV

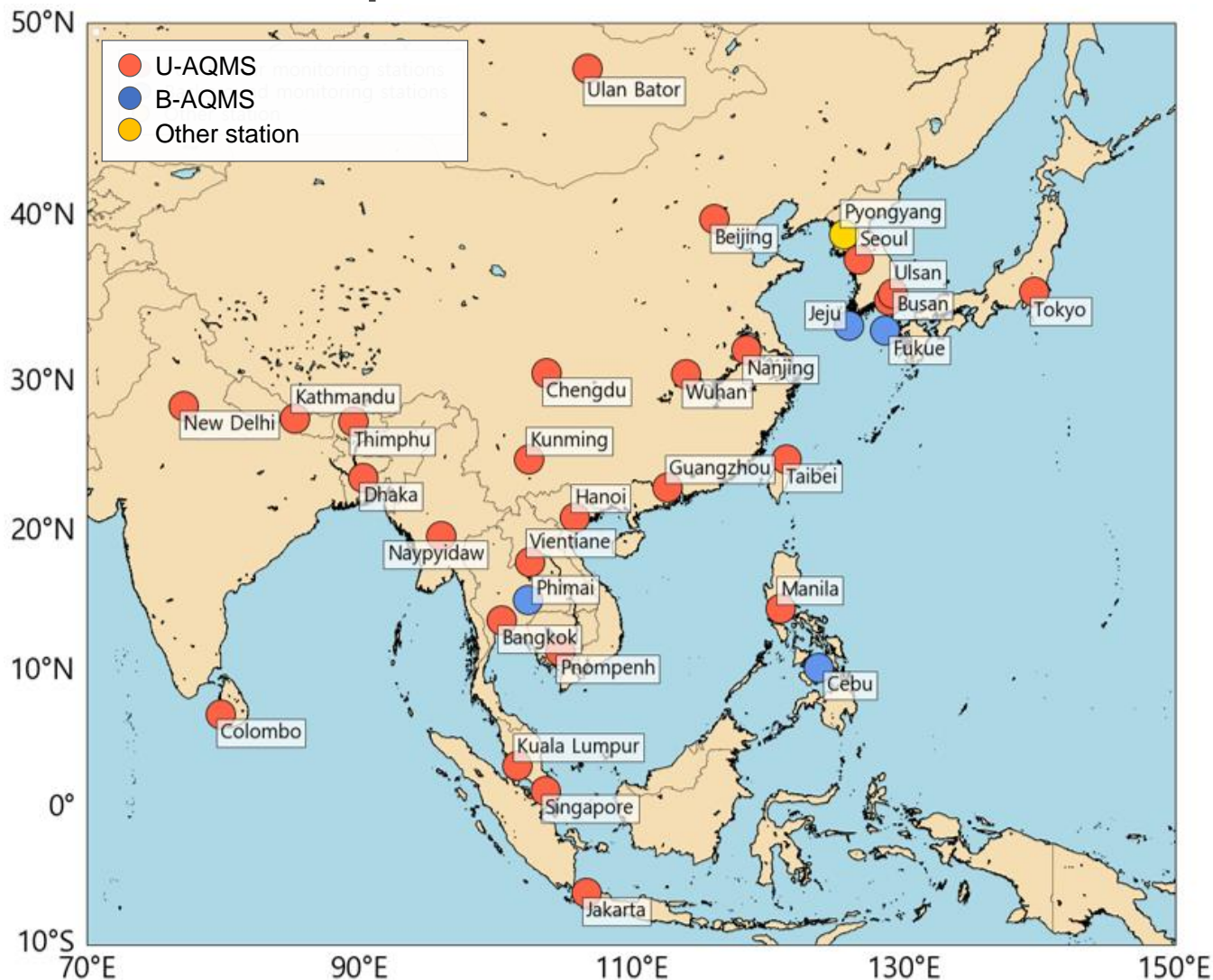


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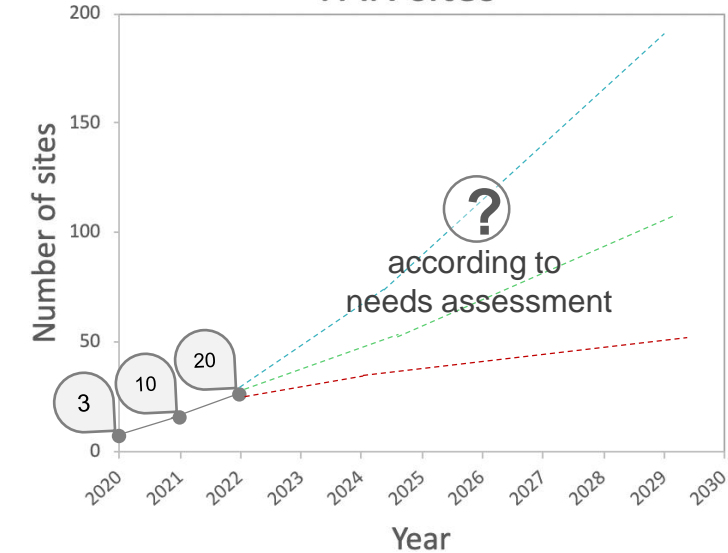
- Goal
Install at least 1 Pandora set at the polluted area in each Asian country
→ Total 20 Pandora sets
- Period : 2020-2022
- Requirements for Pandora site
 1. Highly polluted area : Capital city or area vulnerable to wildfire and biomass burning
 2. Regional background area : Jeju, Korea / Phimai, 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

PAN site map (project + China, Japan, Korea, Singapore)



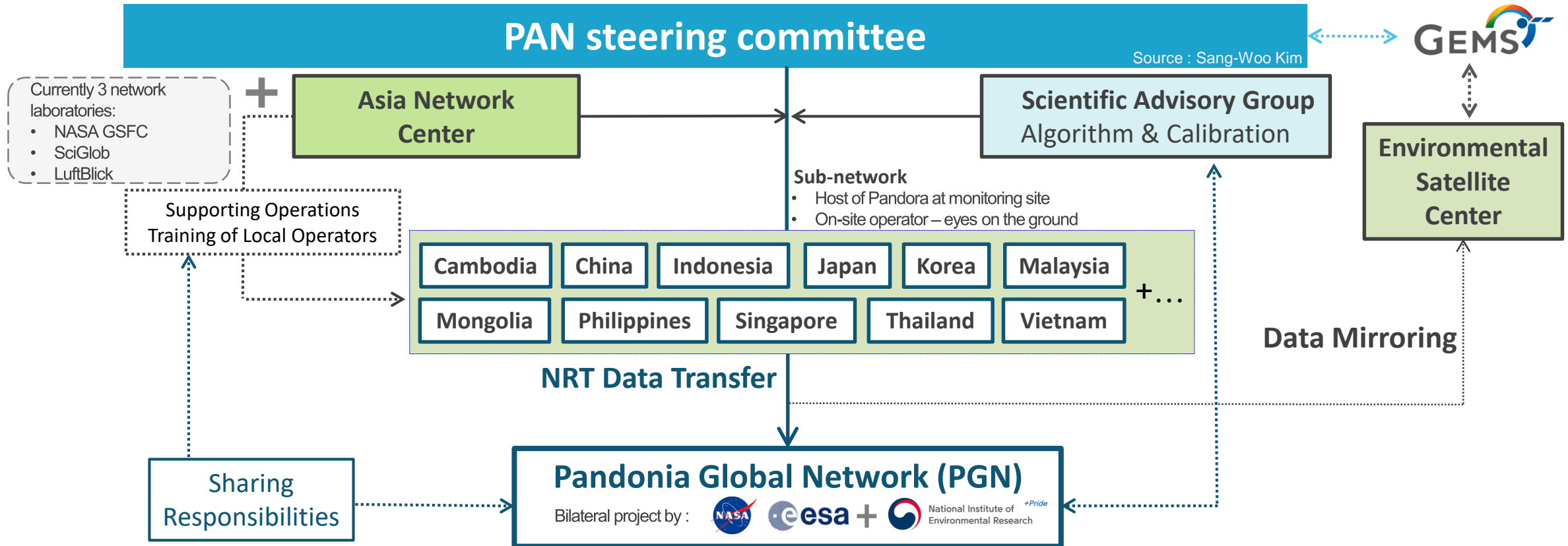
PAN will start with a few stations and could be substantially scaled up in the future

PAN sites



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



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

Pandora Asia Network (PAN) Online Conference

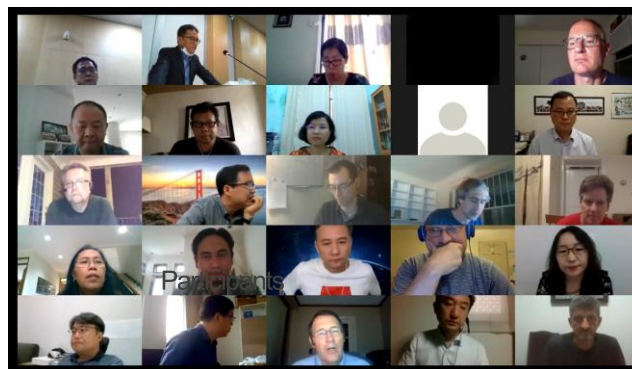
(28 May 2020, 10:00-14:00 Seoul, UTC+9)

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	Kyungwha Lee (NIER)	GEMS current status and application
11:00~11:20	Alexander Cede(Luftblick) Tom Hamisco (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 Odooy	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

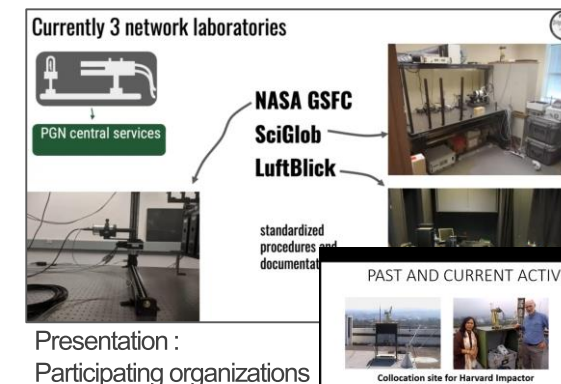
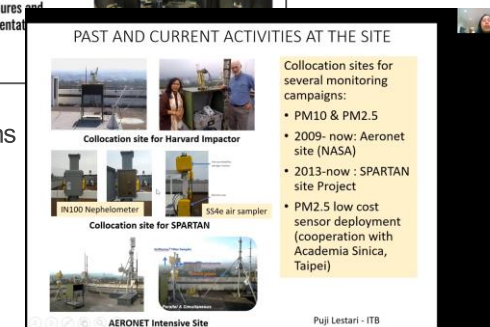
- May 28, 2020 10:00-14:00 (Seoul time)
- Meeting registrants : 67
- Participating Asian Countries : 13 (Bangladeshi, Cambodia, China, etc)
- Participating organizations :
NASA, UN ESCAP, Sciglob, Luftblick, EPA, KOICA, KECO, NIER etc.









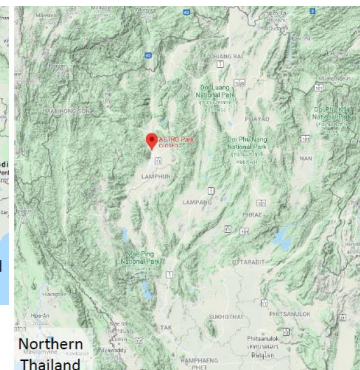
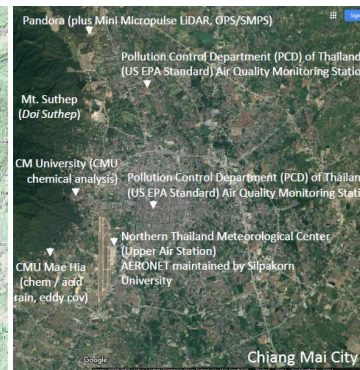
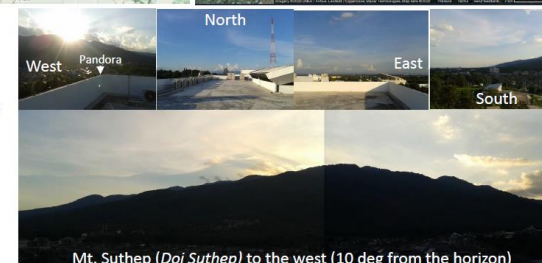
President of NIER

Deputy Executive
Secretary of ESCAP

President of KOICA

Presentation :
Participating organizations

Presentation : Asian countries

Thailand (Bangkok)	Thailand (Chiang Mai)
<p>Nguyen Thi Kim Oanh (Asian Institute of Technology, AIT)</p>	
<p>AIT</p> <ul style="list-style-type: none"> Monitoring items: real time PMx counters\ Rooftop ~4m height <p>Government Public Relations Department (PCD)</p> <ul style="list-style-type: none"> Monitoring items : hourly PM2.5, PM10, SO2, Nox, CO, O3 Rooftop at ~3m height 	<ul style="list-style-type: none"> Biogenic VOC Lidar PCD monitoring station <ul style="list-style-type: none"> Items : hourly hourly PM2.5, PM10, SO2, Nox, CO, O3 Rooftop at ~3m height
<div data-bbox="300 711 805 986">  </div> <div data-bbox="817 739 1230 896"> <p>Alternative sites surveyed:</p> <ul style="list-style-type: none"> 20T (ambient PCD stations) 59T (ambient PCD stations) AIT ambient lab </div> <div data-bbox="272 1006 491 1268">  </div> <div data-bbox="262 1273 430 1300" data-label="Caption"> <p>AIT: Ambient lab</p> </div> <div data-bbox="501 1118 573 1256">  </div> <div data-bbox="721 995 924 1249">  </div> <div data-bbox="718 1258 942 1285" data-label="Caption"> <p>20T: Bangkok University</p> </div> <div data-bbox="1021 995 1223 1256">  </div> <div data-bbox="1009 1268 1205 1292" data-label="Caption"> <p>59T: Government Public</p> </div>	<div data-bbox="1409 692 1574 991">  </div> <div data-bbox="1574 692 1931 1058">  </div> <div data-bbox="1931 692 2288 1058">  </div> <div data-bbox="1409 1068 1750 1318"> <p>Location: NARIT AstroPark, Chiang Mai, Thailand Latitude: 18.852570 N Longitude: 98.958087 E Altitude: 350.6 mASL Power: 220 V, 50 Hz, backup generator available, but UPS is recommended Internet: Available Shelter: Available Horizon Viewing Conditions: only obstruction is Mt. Suthep to the west. Approximately 1.6 km high and 10 km from the site (around 10 deg from the horizon)</p> </div> <div data-bbox="1750 1058 2288 1318">  </div>

- PAPGAPI prompts GEMS data utilization and PAN establishment for use on air quality research and management by Asian countries
- PAPGAPI project is currently under budget review of Ministry of Strategy and Finance and will be launched later this year
- NIER will share GEMS and PAN data with Asian countries in collaboration with NASA, ESA and PGN

நன்றி

ขอบคุณ

谢谢

Thank you

cảm ơn bạn

ありがとうございました

감사합니다

Salamat

баярлалаа

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GEMS validation team

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Donghee Kim (dhk53@korea.kr)

Reference

Choi, W. J. et al., Introducing the Geostationary Environment Monitoring Spectrometer (2018), JARS

Duncan, B. N. et al., A space-based, high-resolution view of notable changes in urban NO_x pollution around the world (2005-2014) (2015), J. Geophys. Res. Atmos.