Status of GEMS - Validation Plan:

Networking *in-situ* ground measurements

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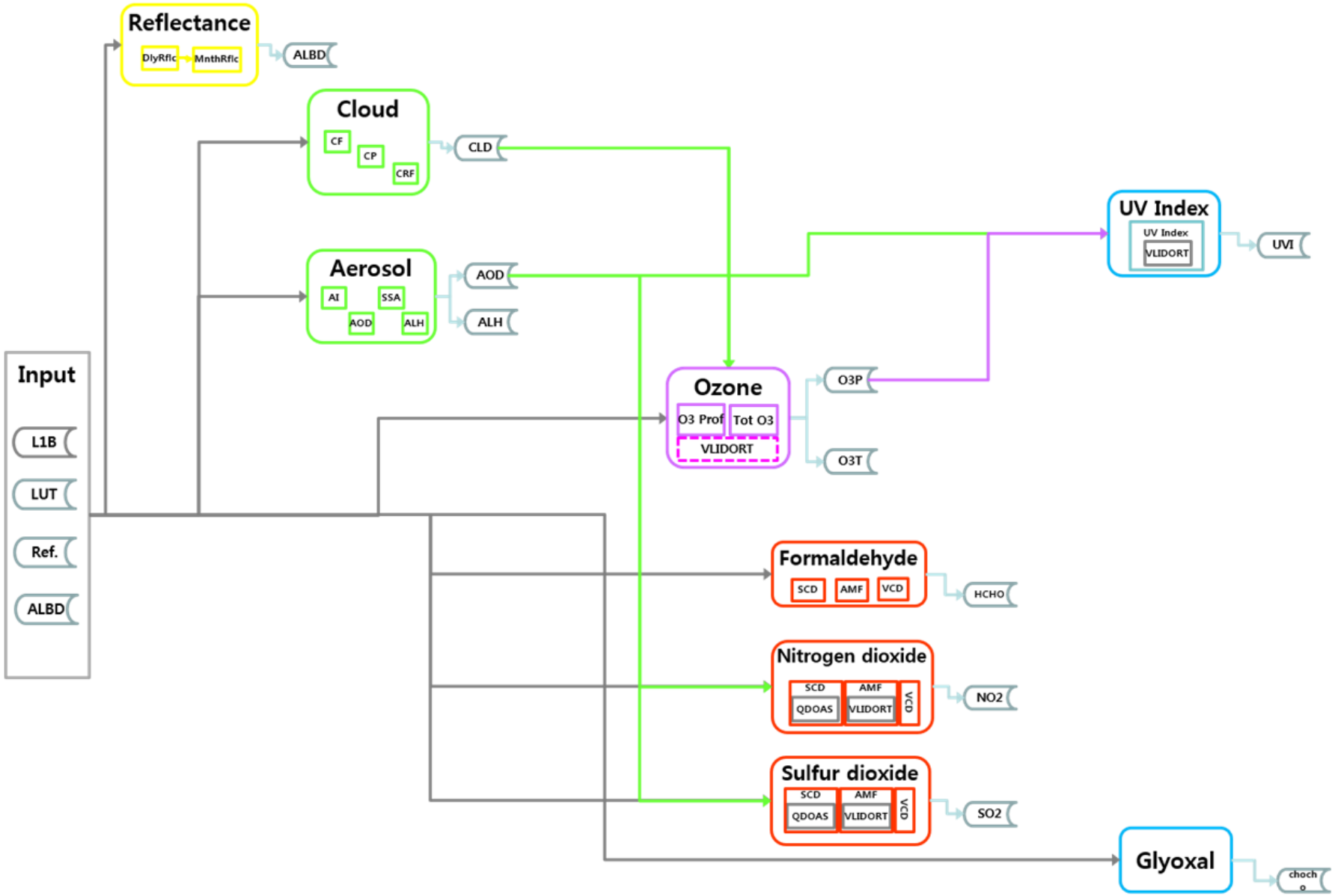
GEMS products and target accuracy for validation

GEMS L2 Products for Validation



Define GEMS main products for validation

Priority	Aerosol (Main)	Aerosol (Sub)	NO_2	SO_2	O_3 (Total)	O_3 (Profile)	HCHO	Cloud	UV Index
1	**AOD**	**AEH**	**VCD**	**VCD**	**Total Column Ozone**	**Profile**	**VCD**	**Effective Cloud Fraction**	**UV-Index (Erythema Dose)**
2	SSA	(Type)	**Trop. VCD**	**Trop. VCD**		Trop. Ozone		Cloud Centroid Pressure	DNA Dose Rate
3	ALH	(AOD)	SCD	SCD		Stratos. Ozone		Cloud Radiance Fraction	Plant Dose Rate
4	UVAI		AMF	AMF		Total Column Ozone			Vit. D Dose Rate
5	Type								

*VCD : Vertical Column Density
*SCD : Slant Column Density
*AMF : Air Mass Factor
*Gas Column Density Unit : Dobson Unit (for Ozone), molecule cm^{-2} (for others)

Suggested target accuracy for validation by GEMS algorithm team

L2 Products	Correlation coefficient (R)	a, Slope	*b, Intercept*	RMSE	Error (%)	Reference
O3 (Total)	0.82–0.97	0.83–0.97	35.5 DU	*7%*	N/A	M. Anton et al.(2010), Park et al.(2012)
O3 (Trop)	0.5–0.8	0.5–0.9	0–15 DU	*5–10 DU (10–20%)*	3–6 DU *(10–20%) [f(SZA)]*	J.R. Zimke et al. (2005, 2006)
HCHO	0.57–0.77	0.75–0.88	-2.3–1.8×10^{15}	*N/A*	*N/A*	Wittrock et al.(2006)
AOD	0.7	N/A	N/A	T/V	30% at AOD > 0.1	Ahn et al.(2008), Torres et al.(2007)
NO2	0.8	0.5	$3.0 \times 10^{15} cm^{-2}$	*N/A*	20%	Irie et al.(2008, 2009)
SO2	0.7	1.0 ± 0.6	0.5 DU	*N/A*	*50–100%*	Lee et al.(2009)
CF	0.90	0.9~1.1	N/A	N/A	2% ~ 5%	Wager et al. (2008)
CP	0.80	0.9~1.1	N/A	N/A	5% ~ 20%	Wager et al. (2008)
UV Index	0.86–0.96	0.8–1.3	1–20 mW/m^2	14–17 mW/m^2 (20–58%)	20~50% at high AAOD	I. Ialongo et al. (2008) V. Buchard et al. (2009)
Surface Reflectance	0.70~0.91	N/A	N/A	0.03	5~40%	Kleipool et al.. (2008), Vermote et al.(2002)

Independent ground measurements for GEMS validation

Validation datasets using by GEMS algorithm team

*Ground-Based Measurement
*Satellite Measurement
***Bold: for representative product**

Priority (VAL. Dataset)	Aerosol (Main)	Aerosol (Sub)	NO_2	SO_2	O_3 (Total)	O_3 (Profile)	HCHO	Cloud	UV Index
1	**AERONET**	**Ground-Lidar &** CALIPSO	**Pandora**	**Pandora**	**Brewer**	**Ozonesonde (WOUDC,** SHADOZ)	**OMI-NASA**	**OMI (O2-O2)**	**Brewer (WOUDC)**
2	MFRSR		**MAX-DOAS**	**MAX-DOAS**	Pandora	OMI	(Pandora)		OMI L2 OPUVI
3	SKYNET				Dobson	(OMPS, TropOMI)	OMI-BIRA		JAXA AHI
4	OMI				OMI		MAX-DOAS		
5	(TropOMI)				(OMPS, TropOMI)				

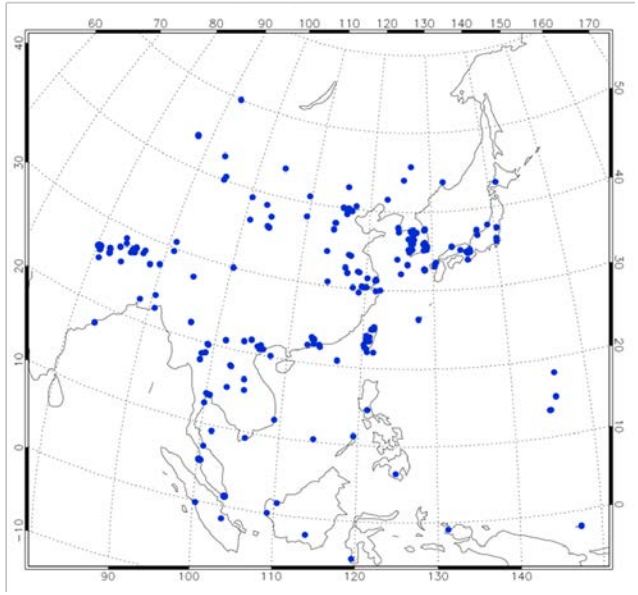
Priority	Aerosol (Main)	Aerosol (Sub)	NO_2	SO_2	O_3 (Total)	O_3 (Profile)	HCHO	Cloud	UV Index
1	**AOD**	**AEH**	**VCD**	**VCD**	**Total Column Ozone**	**Profile**	**VCD**	**Effective Cloud Fraction**	**UV-Index (Erythema Dose)**
2	SSA	(Type)	**Trop. VCD**	**Trop. VCD**		Trop. Ozone		Cloud Centroid Pressure	DNA Dose Rate
3	ALH	(AOD)	SCD	SCD		Stratos. Ozone		Cloud Radiance Fraction	Plant Dose Rate
4	UVAI		AMF	AMF		Total Column Ozone			Vit. D Dose Rate
5	Type								

GEMS main products

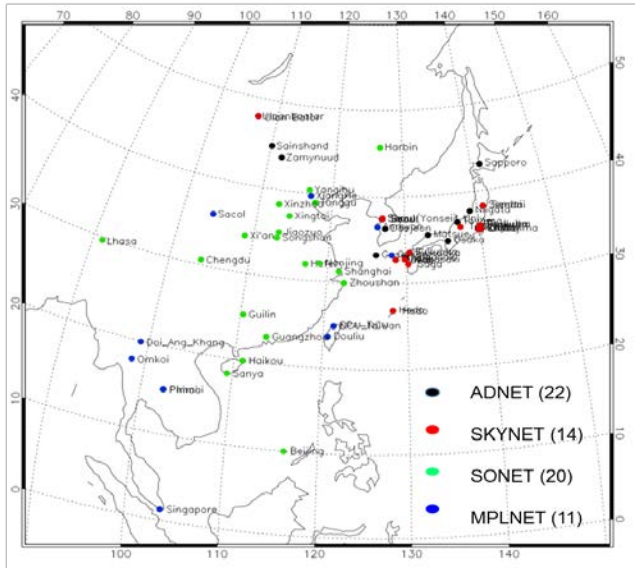
Aerosol

Aerosol (Main)	Aerosol (Sub)
AERONET	**Ground-Lidar &** CALIPSO
MFRSR	
SKYNET	
OMI	
(TropOMI)	

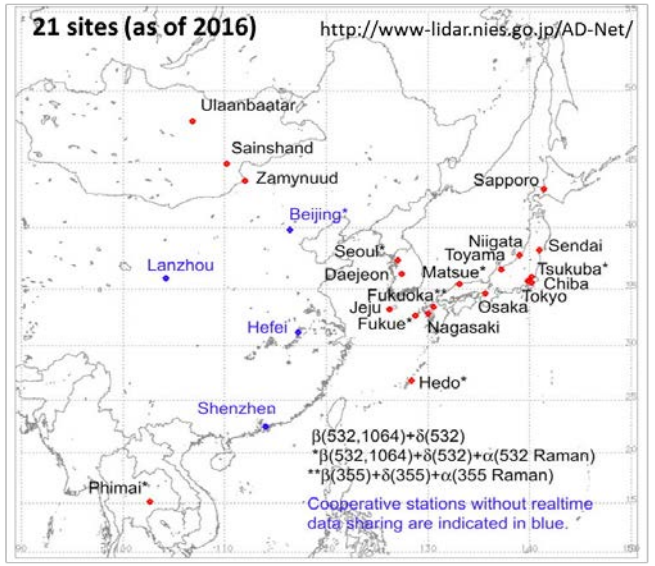
AERONET sites (190)



ADNET / MPLNET/ SKYNET / SONET



AD-Net Asian dust and aerosol lidar observation network

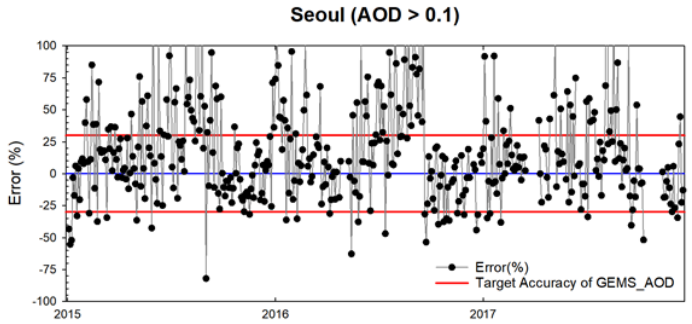


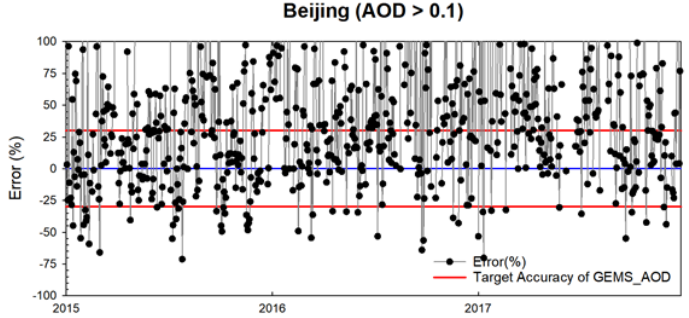
*WMO/GAW GALION (MPLNET, EARLINET, AD-NET, ...)

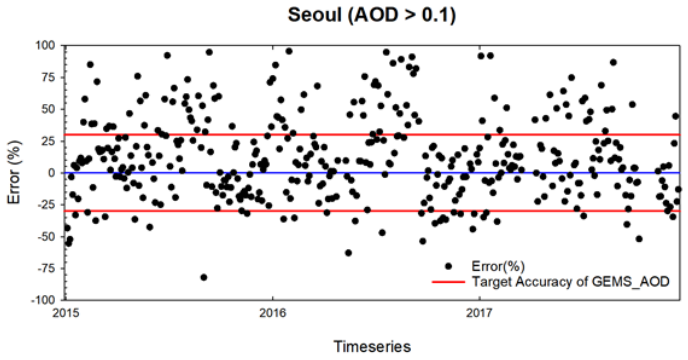
Aerosol (Main)	Aerosol (Sub)
AOD	**AEH**
SSA	(Type)
ALH	(AOD)
UVAI	
Type	

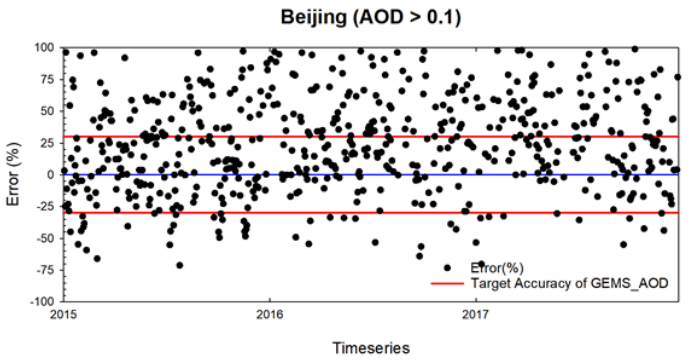
Example: GOCI AOD relative error to AERONET

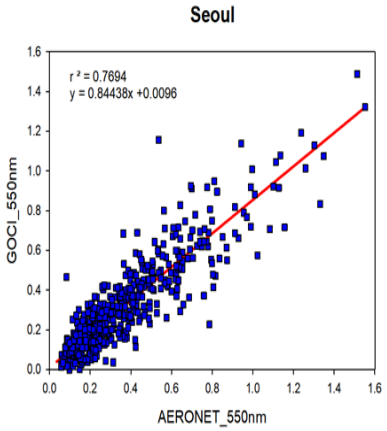
2015.1.1.~2017.12.31.

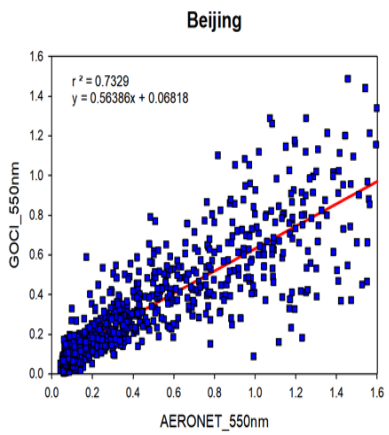


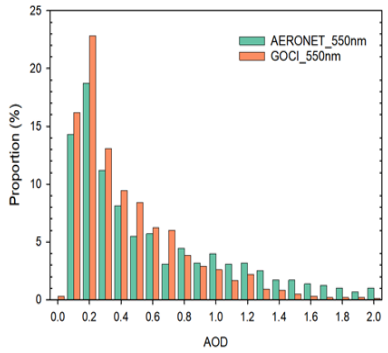


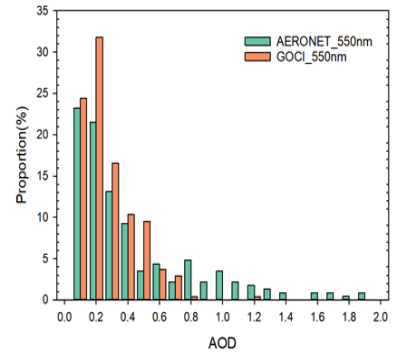








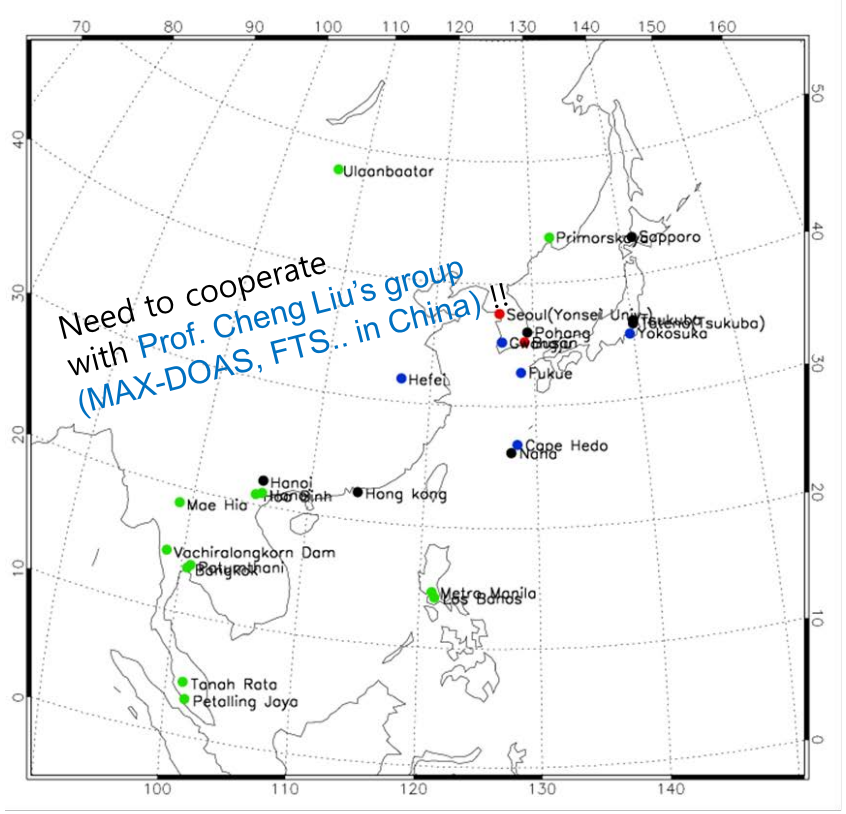




L2 Products	Correlation coefficient (R)	a, Slope	*b, Intercept*	RMSE	Error (%)	Reference
AOD	0.7	N/A	N/A	T/V	30% at AOD > 0.1	Ahn et al.(2008), Torres et al.(2007)

NO2 & SO2

NO_2	SO_2
Pandora	**Pandora**
MAX-DOAS	**MAX-DOAS**

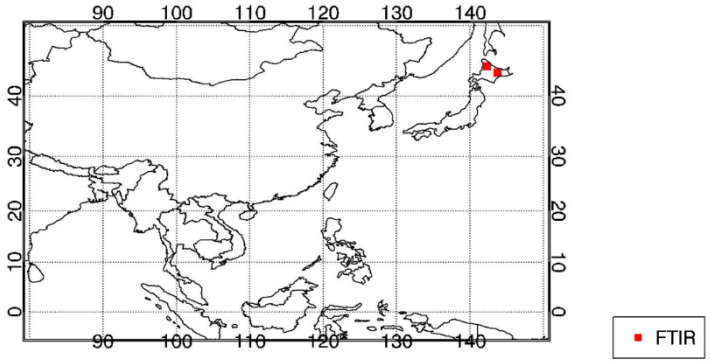


- Pandora (2)
- MAX-DOAS (5)
- EANET (12)
- Ozone sondes (7)

NO_2	SO_2
VCD	**VCD**
Trop. VCD	**Trop. VCD**
SCD	SCD
AMF	AMF

HCHO

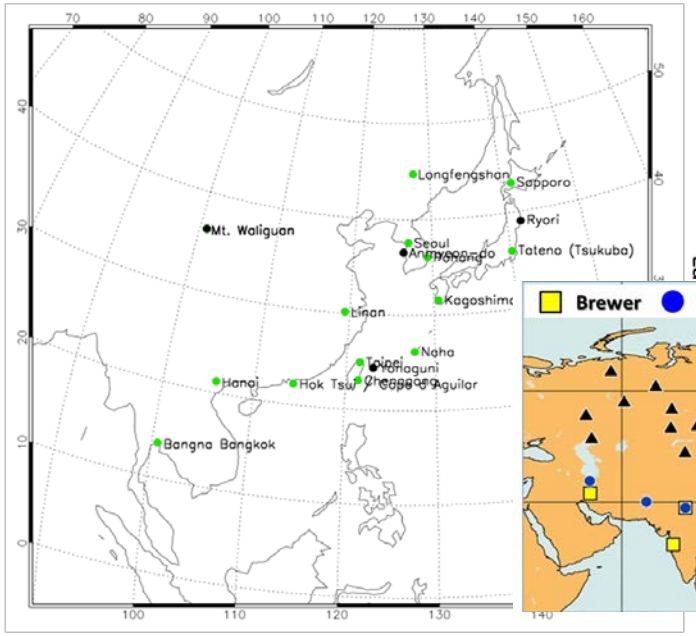
HCHO
OMI-NASA
(Pandora)
OMI-BIRA
MAX-DOAS



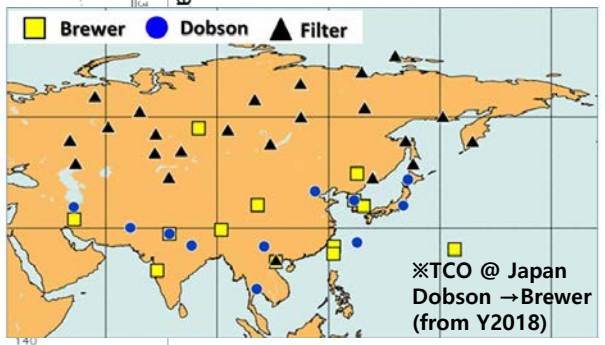
HCHO
VCD

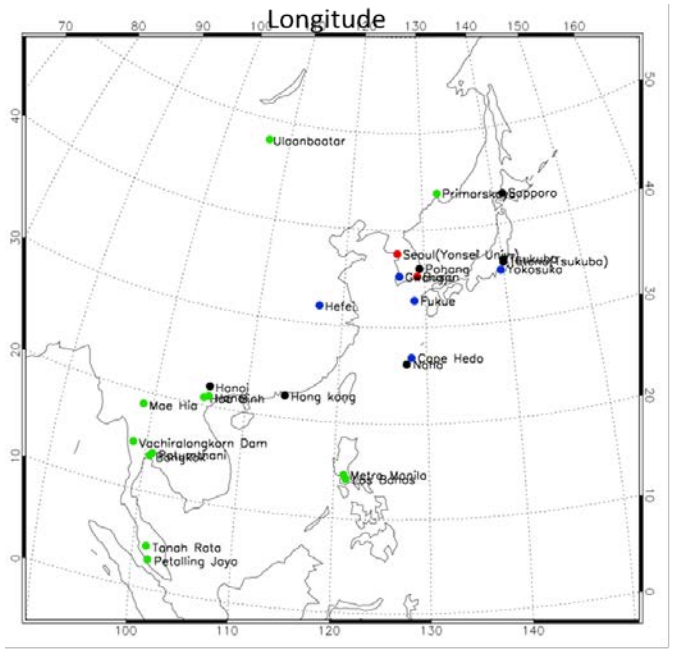
O3

O_3 (Total)	O_3 (Profile)
Brewer	**Ozonesonde (WOUDC,** SHADOZ)
Pandora	OMI
Dobson	(OMPS, TropOMI)
OMI	
(OMPS, TropOMI)	



- Brewer (14)
- GAW-WDCA (4)





- Pandora (2)
- MAX-DOAS (5)
- EANET (12)
- Ozone sondes (7)

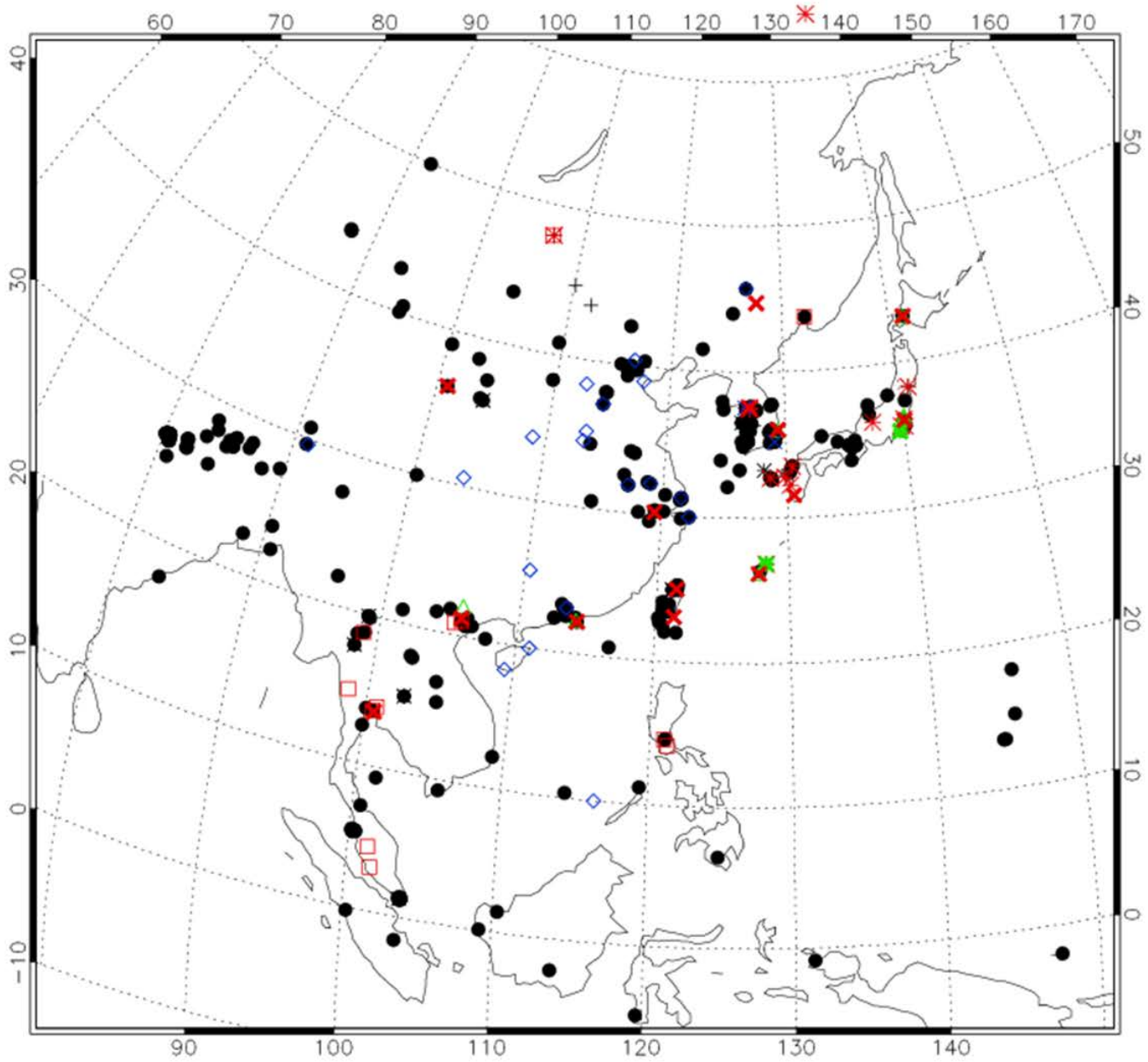
O_3 (Total)	O_3 (Profile)
Total Column Ozone	**Profile**
	Trop. Ozone
	Stratos. Ozone
	Total Column Ozone

UV

UV Index
Brewer (WOUDC)
OMI L2 OPUVI
JAXA AHI

UV Index
UV-Index (Erythema Dose)
DNA Dose Rate
Plant Dose Rate
Vit. D Dose Rate

In-situ remote sensing observation network



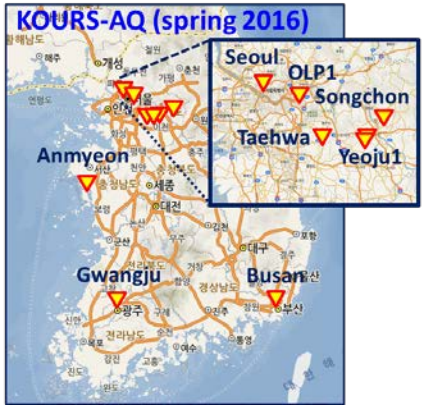
- AERONET (190)
- ADNET (22)
- SKYNET (14)
- SONET (20)
- MPLNET (11)
- Brewer (14)
- GAW-WDCA (4)
- Pandora (2)
- MAX-DOAS (5)
- EANET (12)
- Ozone sondes (7)

Pandora measurements in Korea

FOV	1.6°
FWHM	0.6nm
Wavelength range	280-525nm
Correction of Stray light	BP300 Filter (280-320nm) U340 Filter (280-380nm)
Products	Total column of O_3, NO_2, and HCHO

MAPS-Seoul campaign (spring 2015)

KOURS-AQ (spring 2016)



New developing network

For GEMS validation and Air Quality Forecasting,

Korea will newly install 6~8 PANDORAs by 2019 as the pair to aerosol LIDAR network

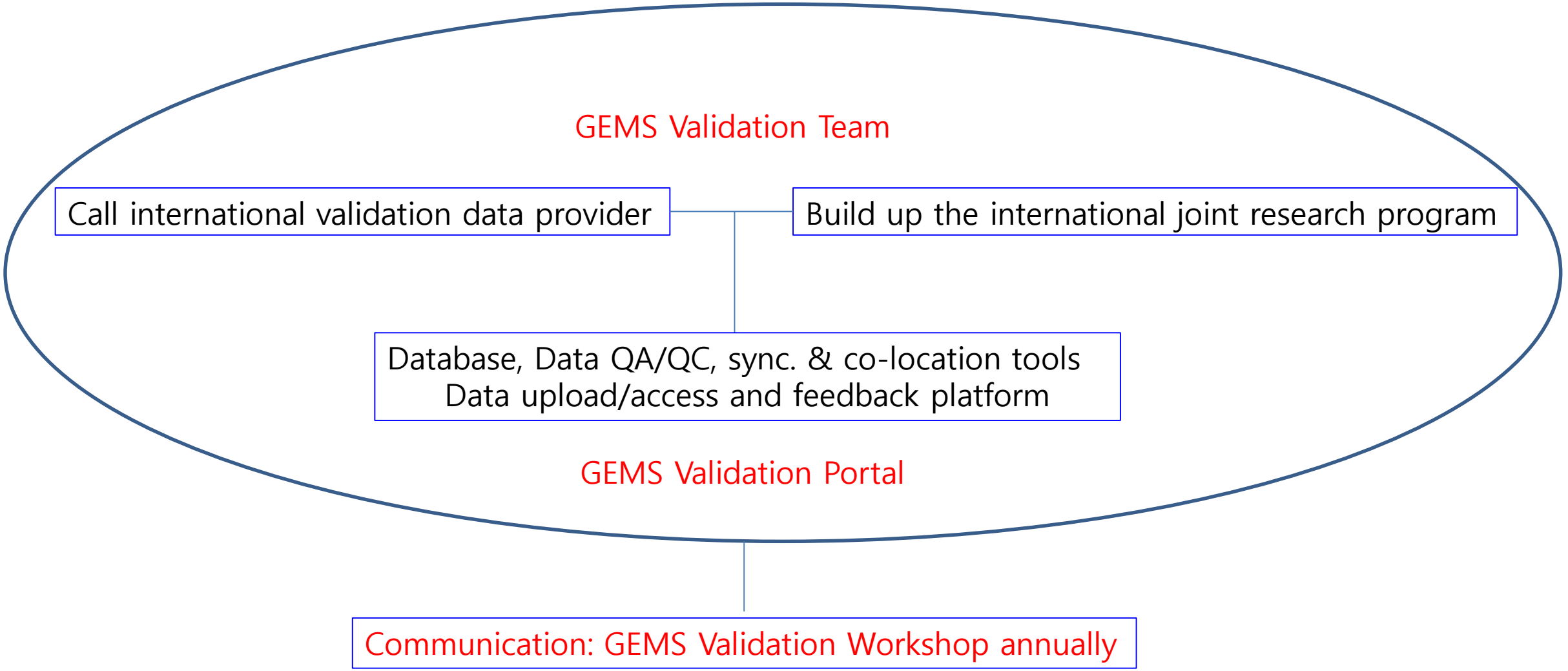
Current (2)	: YSU and PNU
2018 (2)	: SNU and UNIST
2018~2019 (6)	: TBD (by NIER)

GEMS to other satellite

Satellite	Aerosol			NO_2	SO_2	O_3		HCHO	Cloud		UV Index
	AOD	SSA	AEH			Total	Trop.		CF	Pressure	
OMI	O	O		O	O	O	O	O	O	O	O
MODIS /VIIRS	O	O			O (Volcano)				O		
GOME-2	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**
FY-3C	O					O			O		
AIRS							O				
IASI							O				
TES							O				
CALIPSO			O								
TROPOMI	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	**O**

Next step for GEMS validation

GEMS VAL dataset acquisition and communication strategy (by benchmarking S5p validation framework)



GEMS VAL international collaboration

NASA MOU with Korea (by Dr. James H. Crawford)

Strong commitments to collaboration that are in alignment with HAMAQ goals
HAMAQ science plan through tropospheric Composition Program at NASA
Pandora sites proposed in HAMAQ, which are the most urgent items before the launch of GEMS

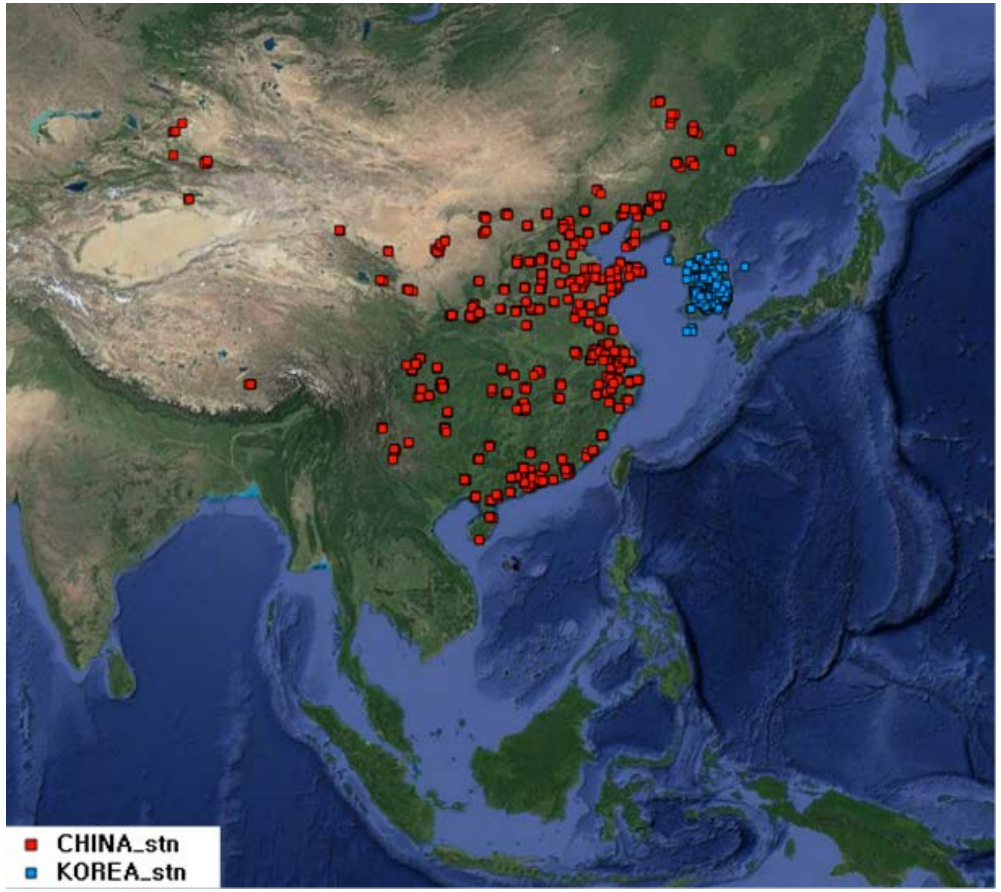
GEO AQ Constellation Geophysical Validation Needs draft (AC-VC / CEOS)

In order to enhance the relevance of the Geo-AQ constellation missions
for associated science and policy, AC-VC pursues coordination
of algorithm development, harmonization of content and format of the mission products,
as well as coordination of calibration and validation activities

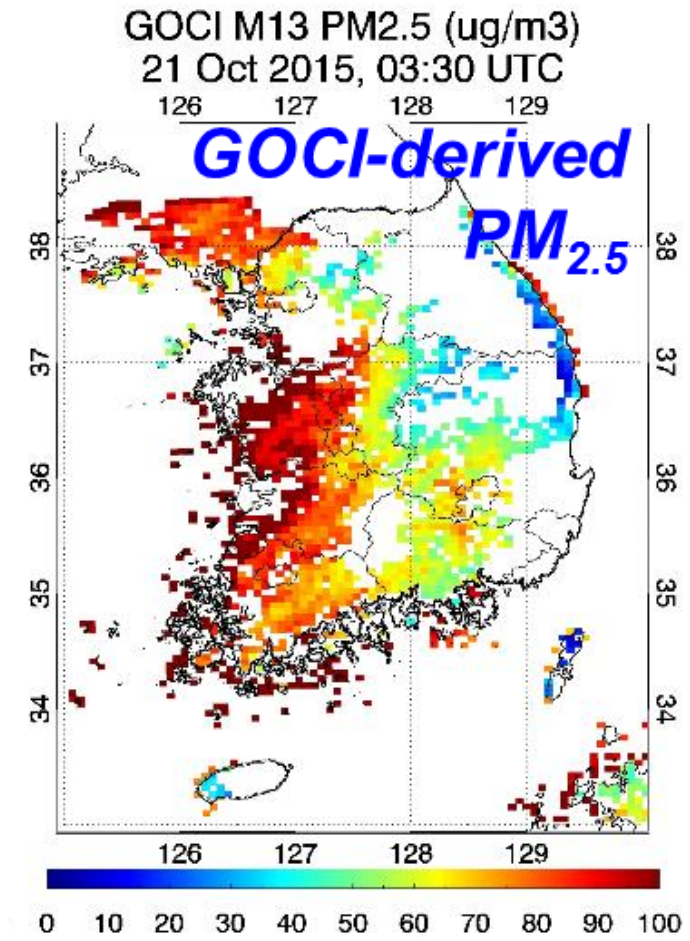
Beyond L2 products validation, extend to value-added products

i.e., SFC air concentrations

Observed Ambient air concentrations: Korea & China

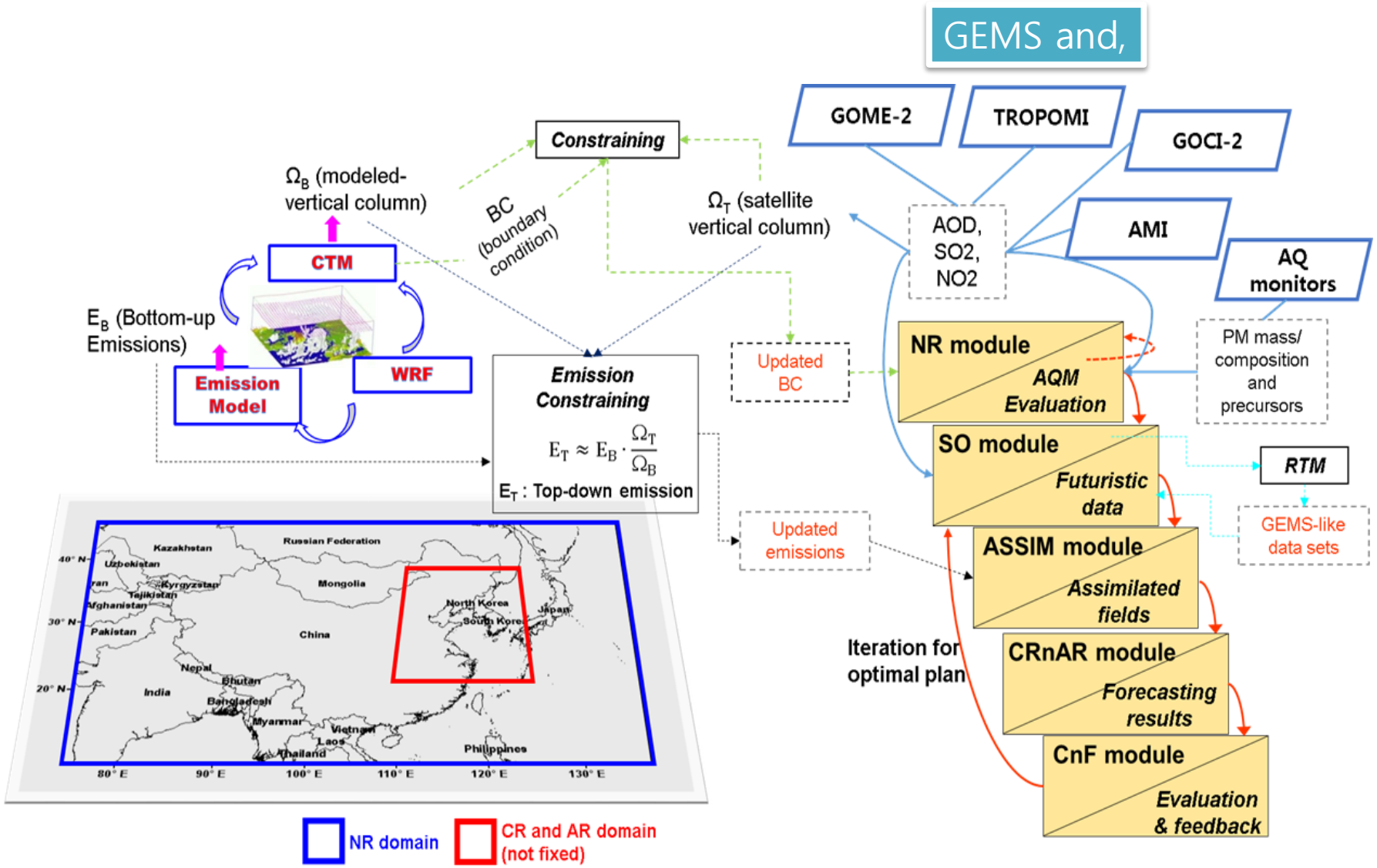


Estimated Ambient air concentrations: by GOCI

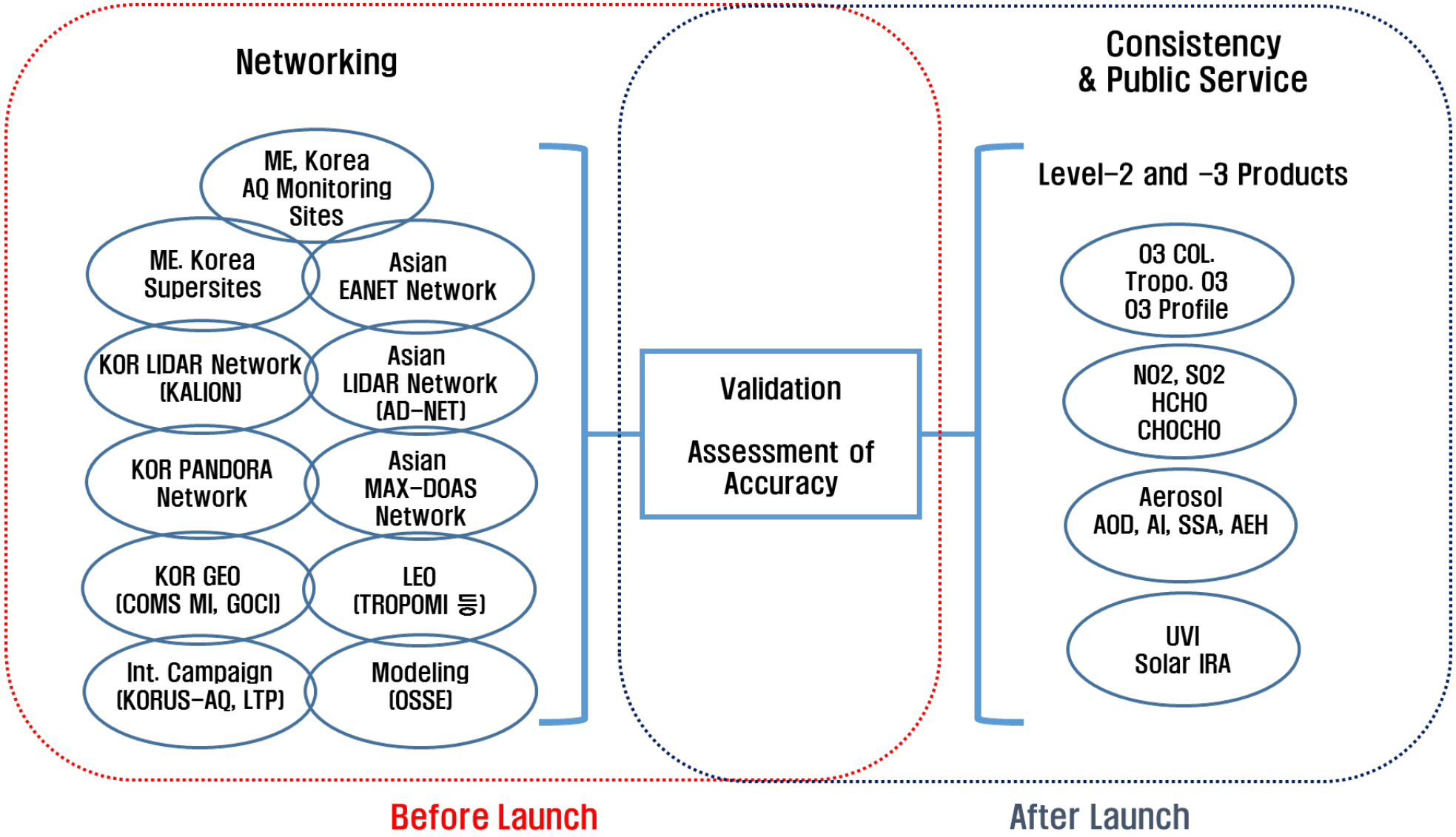


Beyond L2 products validation, extend to value-added products

i.e., OSSE by using GEMS and CTM



Summary


Networking
ME, Korea AQ Monitoring Sites
ME. Korea Supersites
Asian EANET Network
KOR LIDAR Network (KALION)
Asian LIDAR Network (AD-NET)
KOR PANDORA Network
Asian MAX-DOAS Network
KOR GEO (COMS MI, GOCI)
LEO (TROPOMI 외)
Int. Campaign (KORUS-AQ, LTP)
Modeling (OSSE)
Validation
Assessment of Accuracy
Consistency & Public Service
Level-2 and -3 Products
O3 COL. Tropo. O3 O3 Profile
NO2, SO2 HCHO CHOCHO
Aerosol AOD, AI, SSA, AEH
UVI Solar IRA
Before Launch
After Launch

Thank you for attention !!

Collaboration opportunity with you is always open..

Please contact to;

Prof. C. K. Song <cksong@unist.ac.kr>