Sentinel-5P Mission: 5 years anniversary

The Status of GEMS Products

11st Oct. 2022

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National Institute of Environmental Research

Contents

1. Overview of GEMS

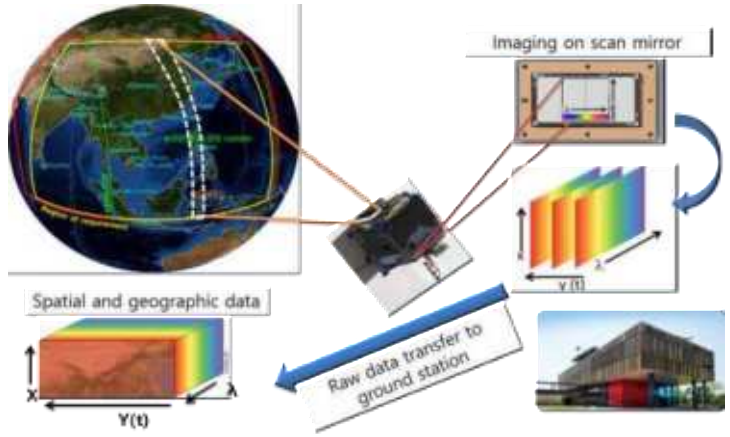
Geostationary Environment Monitoring Spectrometer (GEMS)

- Launched world's first geostationary environmental satellite (**Feb. 19, 2020**), onboard GK2B
- **Planning to observe air pollutants in East Asia** ('2021~, 8 times or more per day)

Cheollian-2B Satellite (GK-2B)

GK-2B and GEMS

- Major observation items : aerosols, nitrogen dioxide, ozone, formaldehyde, sulfur dioxide, etc.
- Wavelength range and spectral resolution: 300 nm - 500 nm (FWHM 0.6 nm)
- Spatial resolution: 35 km × 8 km (aerosol), 7 km × 8 km (gaseous species) ⇒ 35 km x 8 km (except so2, o3p)
- Observation coverage: 5,000 km × 5,000 km (5°S - 45°N, 75°E - 145°E)

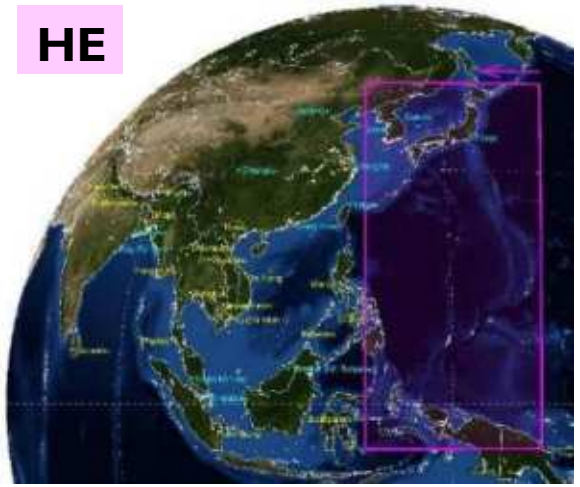


Specification of GEMS

1 Overview of GEMS

No.	1	2	3	4	5	6	7	8	9	10	11	Total Observation Time
UTC	23:00	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	
KST	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	
Jan	X	X	HE	HK	FC	FW	FW	FW	X	X	X	6
Feb	X	X	HE	HK	FC	FW	FW	FW	FW	X	X	7
Mar	X	HE	HK	FC	FC	FW	FW	FW	FW	X	X	8
Apr	HE	HK	FC	FC	FC	FW	FW	FW	FW	FW	X	10
May	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	X	10
Jun	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	X	10
Jul	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	X	10
Aug	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	X	10
Sep	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	X	10
Oct	X	HE	HK	FC	FC	FW	FW	FW	FW	X	X	8
Nov	X	X	HE	HK	FC	FW	FW	FW	X	X	X	6
Dec	X	X	HE	HK	FC	FW	FW	FW	X	X	X	6

Spring or Autumn: 8 / day
Summer : 10 / day
Winter : 6 / day



2. Status of GEMS L2

2 GEMS Products

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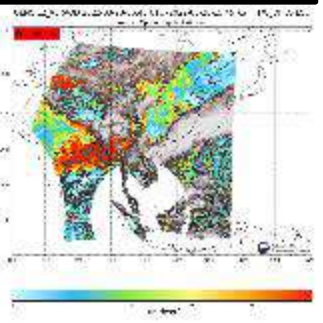
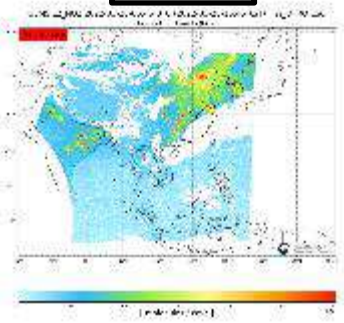
Normal Products(Lv.2)

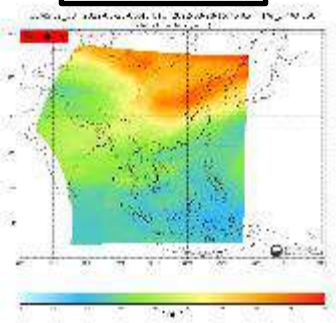
Aerosol optical depth



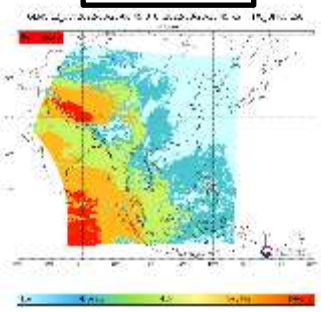
NO_2



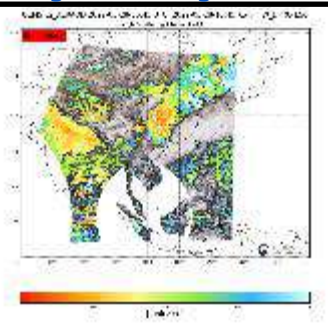
Total ozone



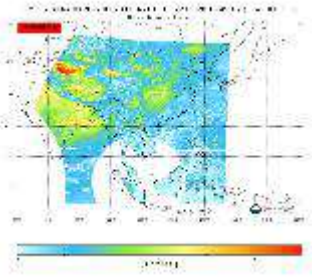
UV index



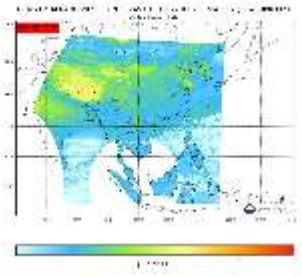
Single scattering albedo



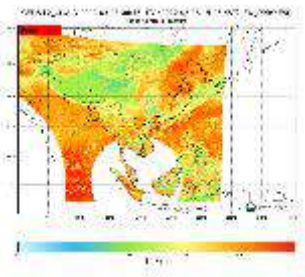
UV aerosol index



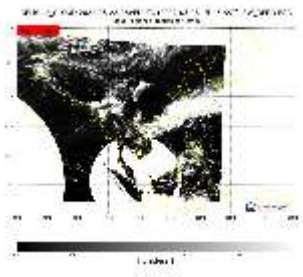
Visible aerosol index



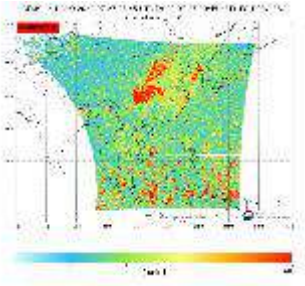
Cloud pressure



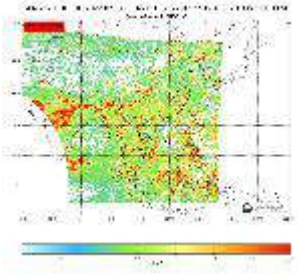
Cloud radiance fraction



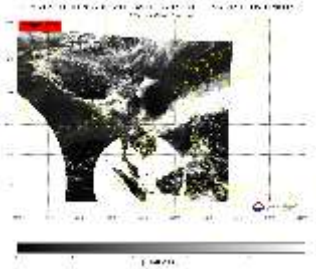
Formaldehyde



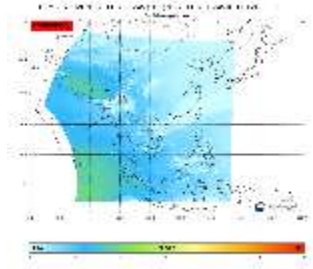
Glyoxal



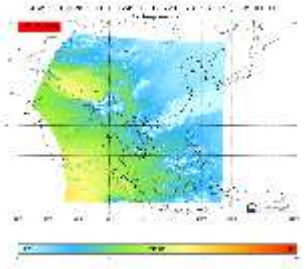
Effective cloud fraction



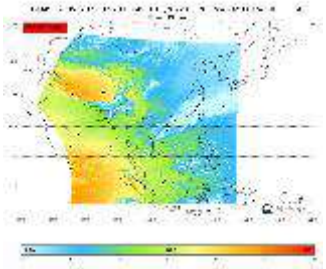
DNA damage index



Plant response index

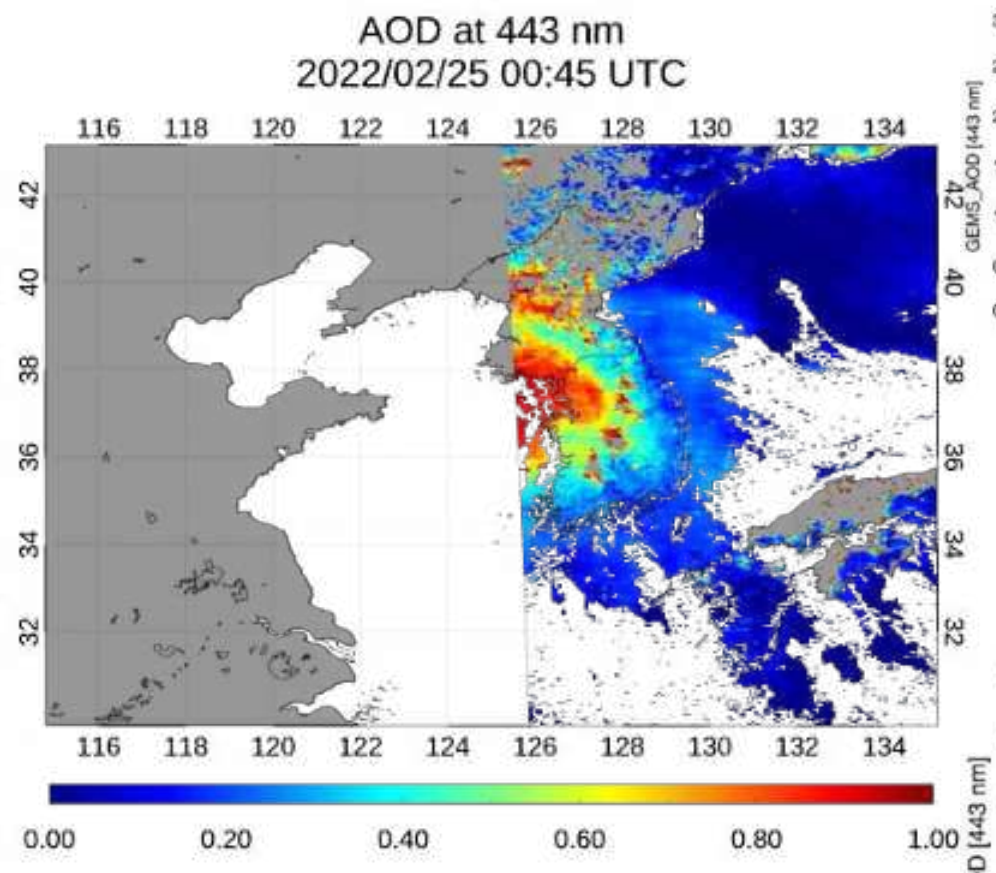


Vitamin D index



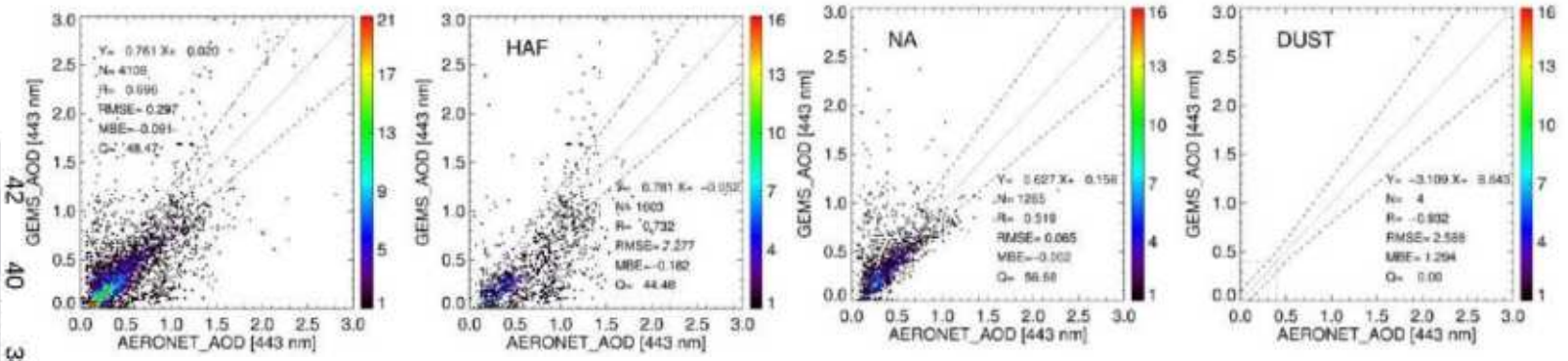
Category	Product
Aerosol	Aerosol Optical Depth
	Single Scattering Albedo
	Ultraviolet·Visible aerosol index
	Aerosol Effective Height
O_3	Total amount of ozone
	Ozone profile – stratosphere
	Ozone profile - troposphere
SFC	Surface Reflectance
Cloud	Cloud Centroid Pressure
	Effective Cloud Fraction
	Cloud Radiance Fraction
VOCs	Formaldehyde
	Glyoxal
NO_2	Nitrogen dioxide – troposphere
	Total nitrogen dioxide
SO_2	Sulfur dioxide
UVI	UV Index
	Plant Response Index
	DNA Damage Index
	Vitamin D Synthesis Index

2 GEMS Products - AOD

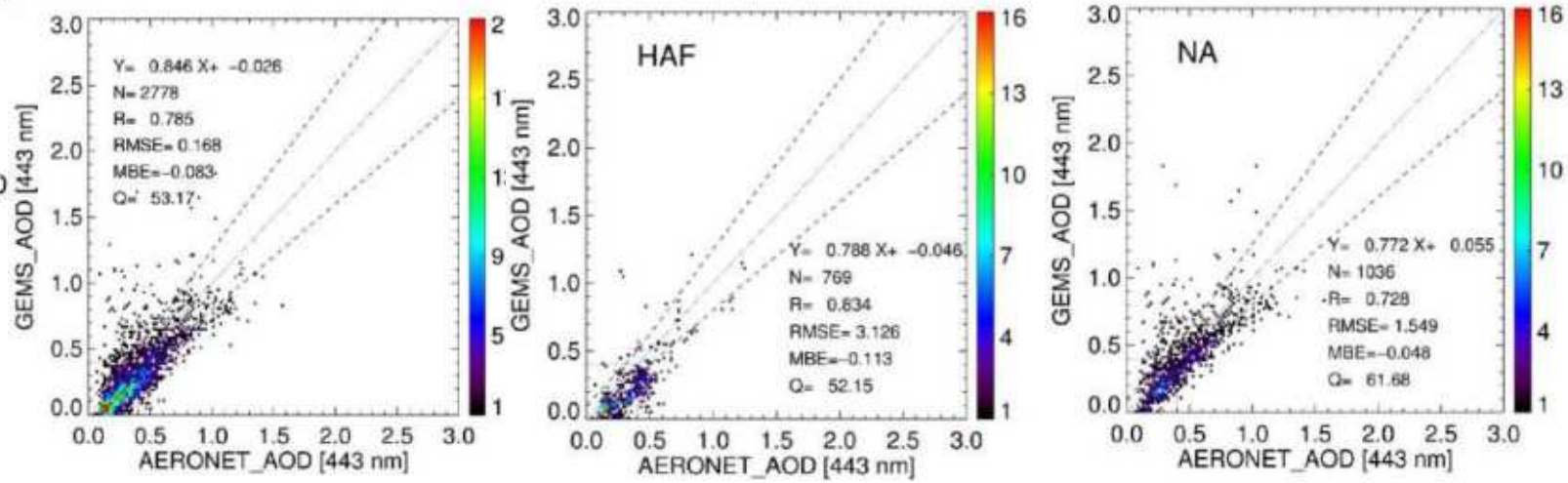


See poster by Yeseul Cho for details.
#46

[GEMS vs AERONET: GEMS All Area, 22.1.]

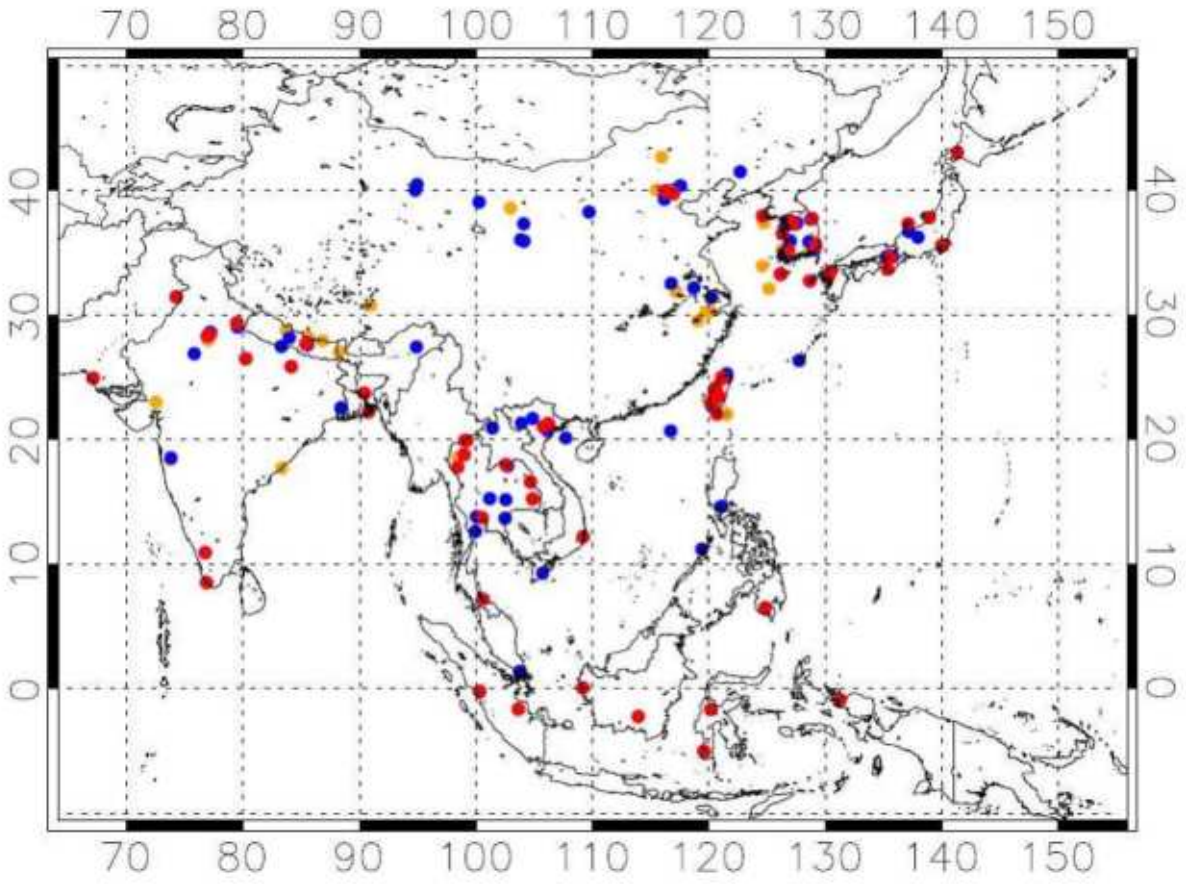


[GEMS vs AERONET: East Asia Area, 22.1.]



GEMS Products - AOD

Geostationary Environmental Monitoring Spectrometer (GEMS)



[AERONET level 2.0 version 3]

Current Operating AERONET site: 66 sites

SONET site: 17 sites

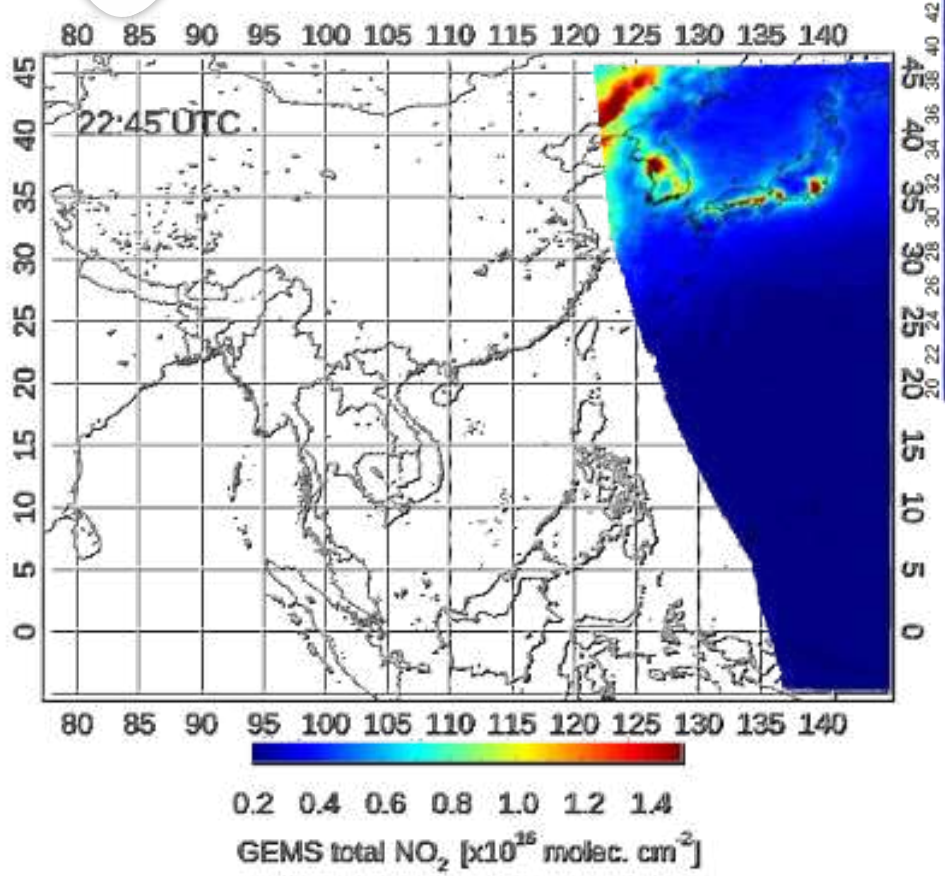
GEMS (Kim et al., 2018), AERONET Dataset

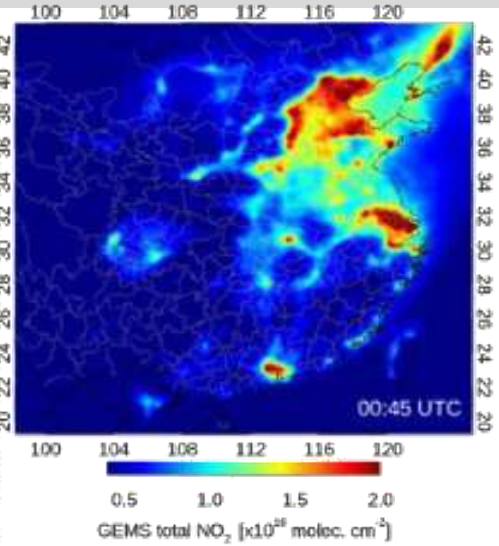
Type	Fraction of MI	Re[RI] [440 nm]	Im[RI} [440 nm]	AAE 440-675 nm	AE 440-675 nm
HAF	0.99994	1.46	0.02044	1.34	1.49
Dust	0.99823	1.48	0.00414	2.11	0.25
NA	0.99980	1.41	0.00401	1.17	1.53

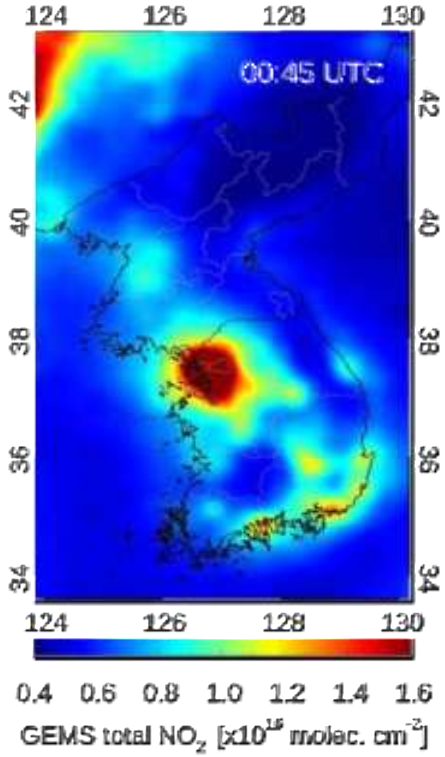
AERONET (1998-2022) + SONET (2018.06-2020.07)

Type	Fraction of MI	Re[RI] [440 nm]	Im[RI] [440 nm]	AAE 440-675 nm	AE 440-675 nm
HAF	0.999047 ± 0.010846	1.49 ± 0.076	0.02927 ± 0.01010	1.44 ± 0.43	1.35 ± 0.22
Dust	0.996803 ± 0.002696	1.50 ± 0.049	0.00493 ± 0.00218	2.34 ± 0.85	0.41 ± 0.17
NA	0.999363 ± 0.000750	1.43 ± 0.054	0.00359 ± 0.00174	1.27 ± 0.61	1.26 ± 0.23

2 GEMS Products – NO2

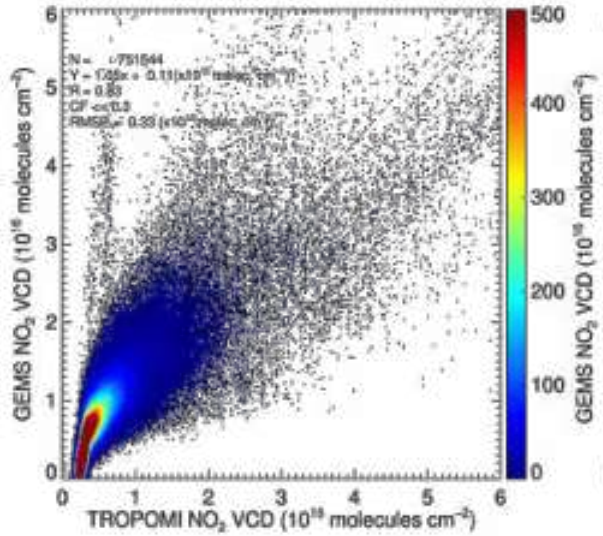






✓ **NO_2 diurnal cycle observed from space.**

< '22.1. >



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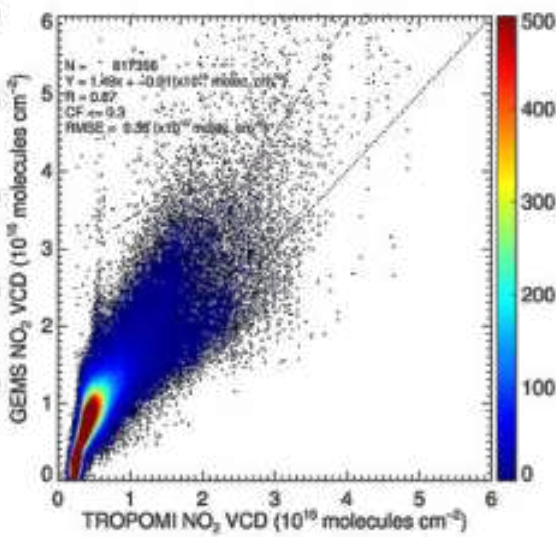

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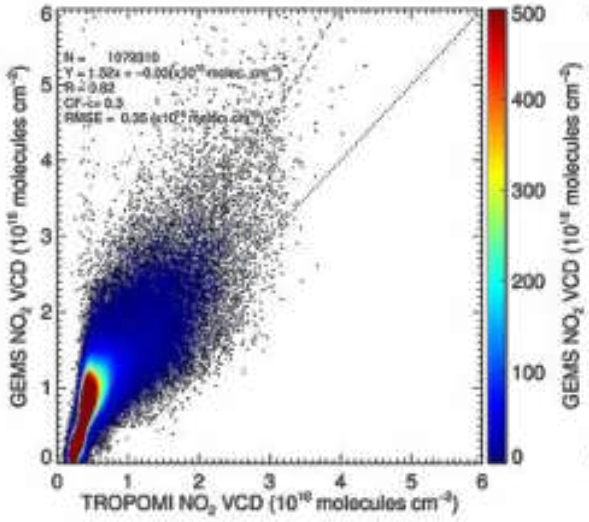

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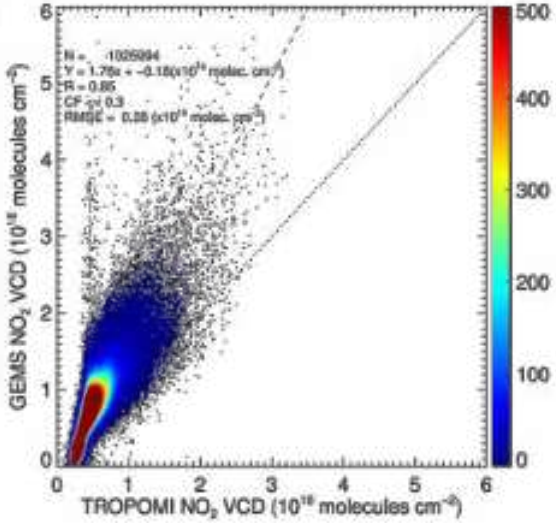
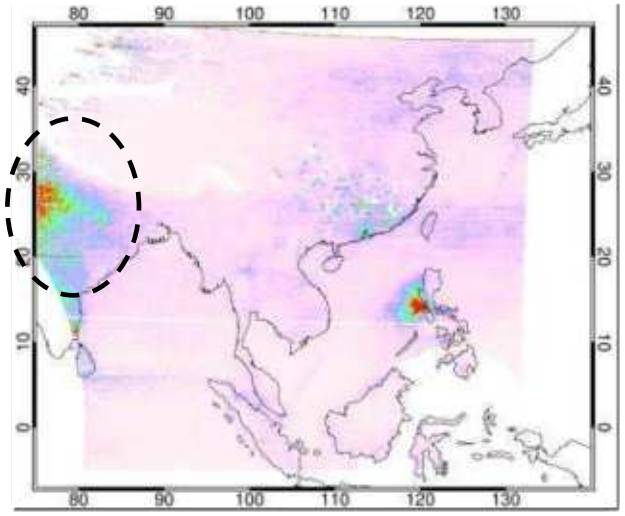


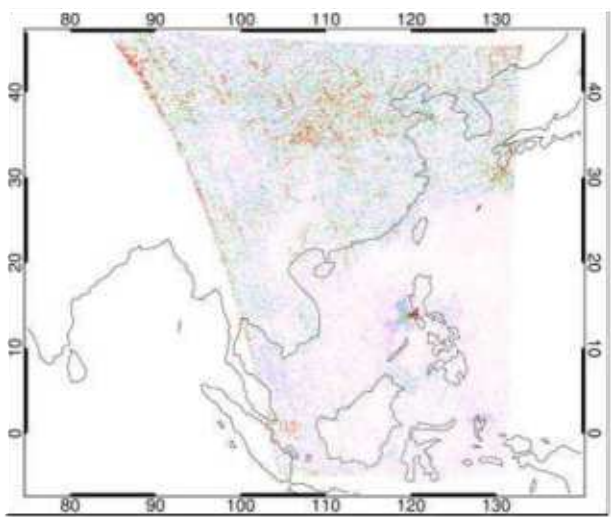
2 GEMS Products – SO2

‘22.4.

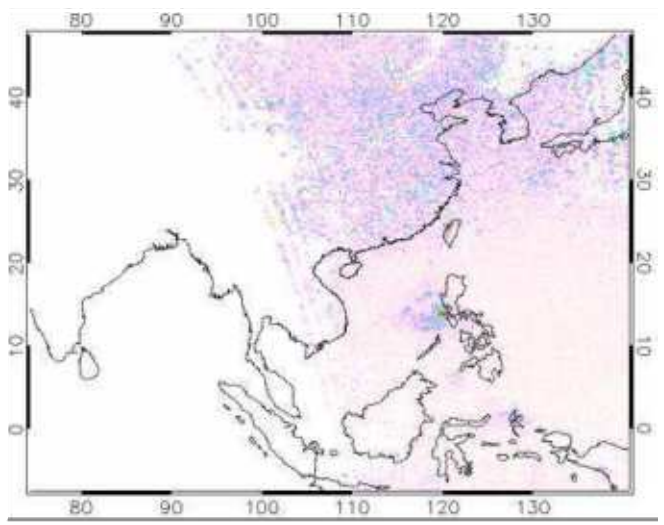
GEMS average SO_2 *(03-04 UTC)*

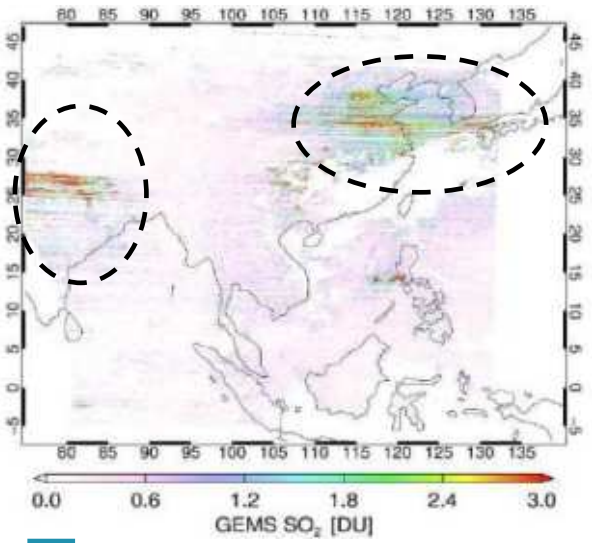


TROPOMI average SO_2 *(03-04 UTC)*



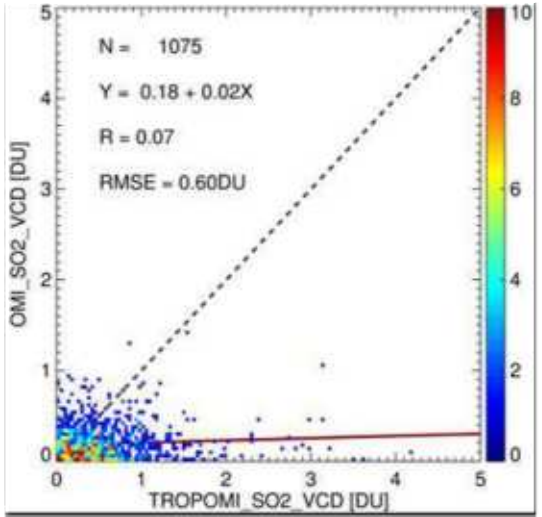
OMI average SO_2 *(03-04 UTC)*



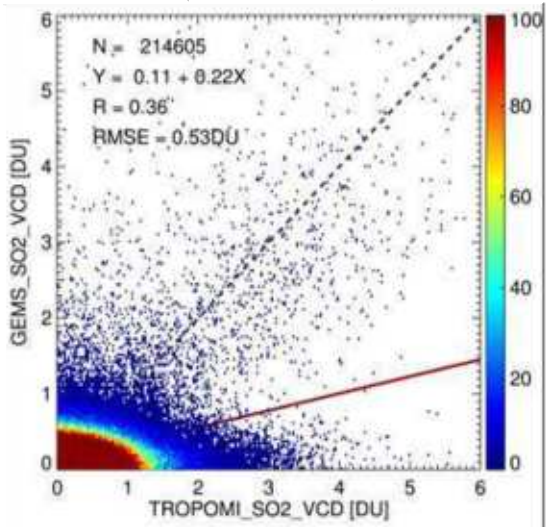


Stripe removal updated

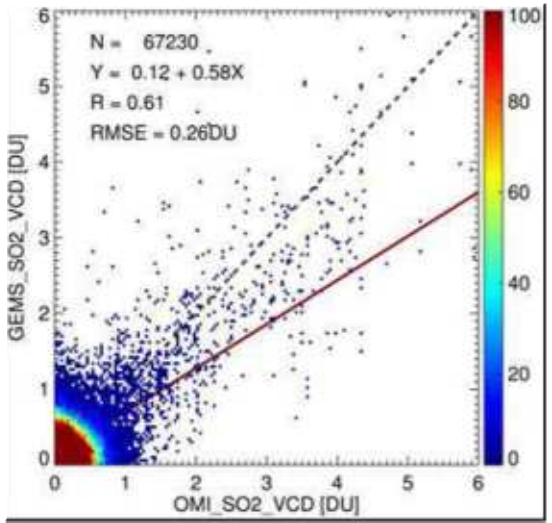
TROPOMI – OMI *(03-04 UTC)*

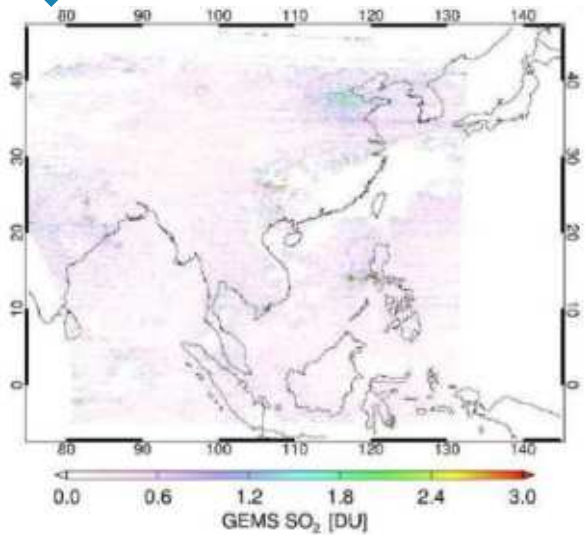


GEMS – OMI *(03-04 UTC)*

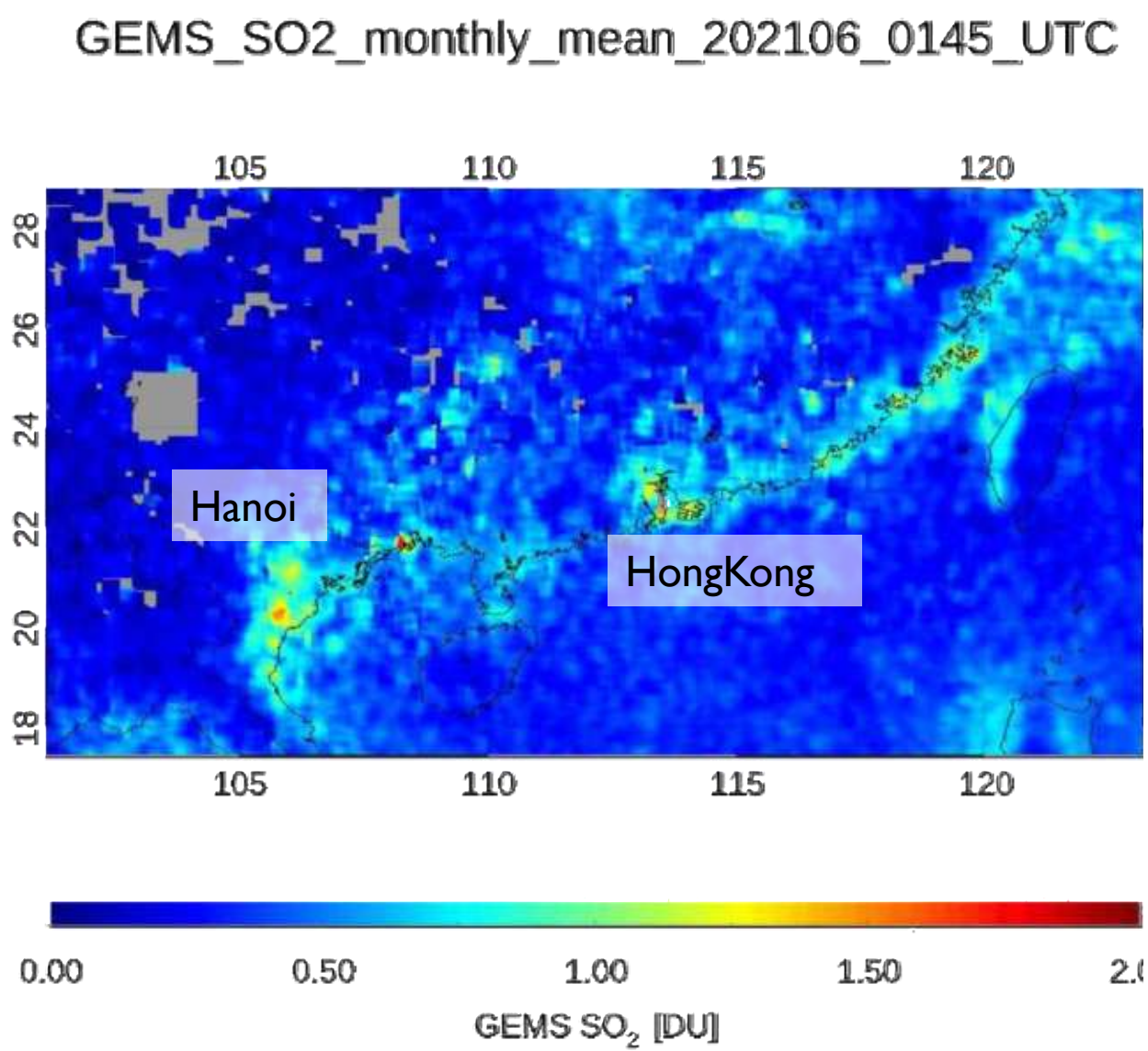


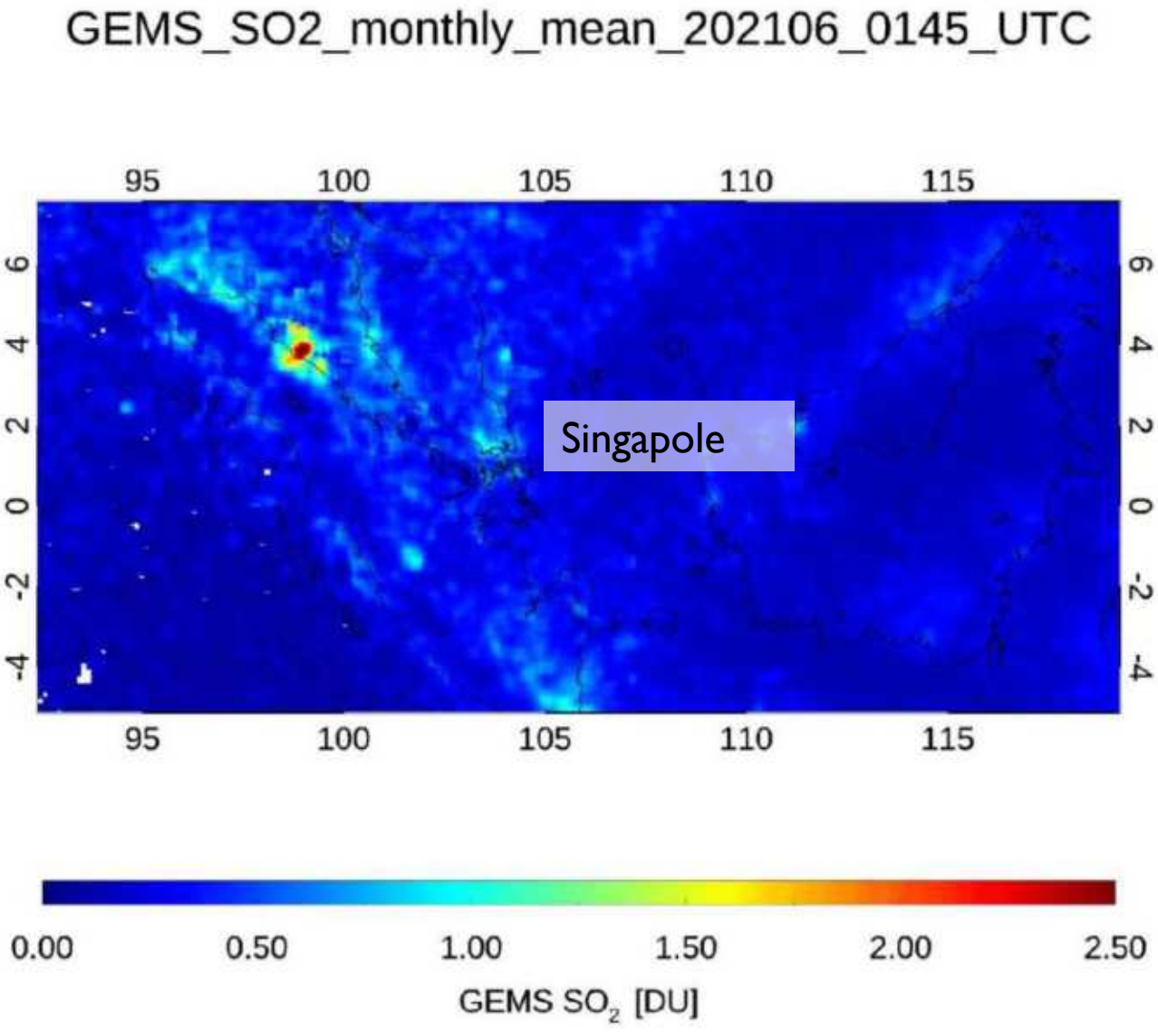
GEMS – TROPOMI *(03-04 UTC)*



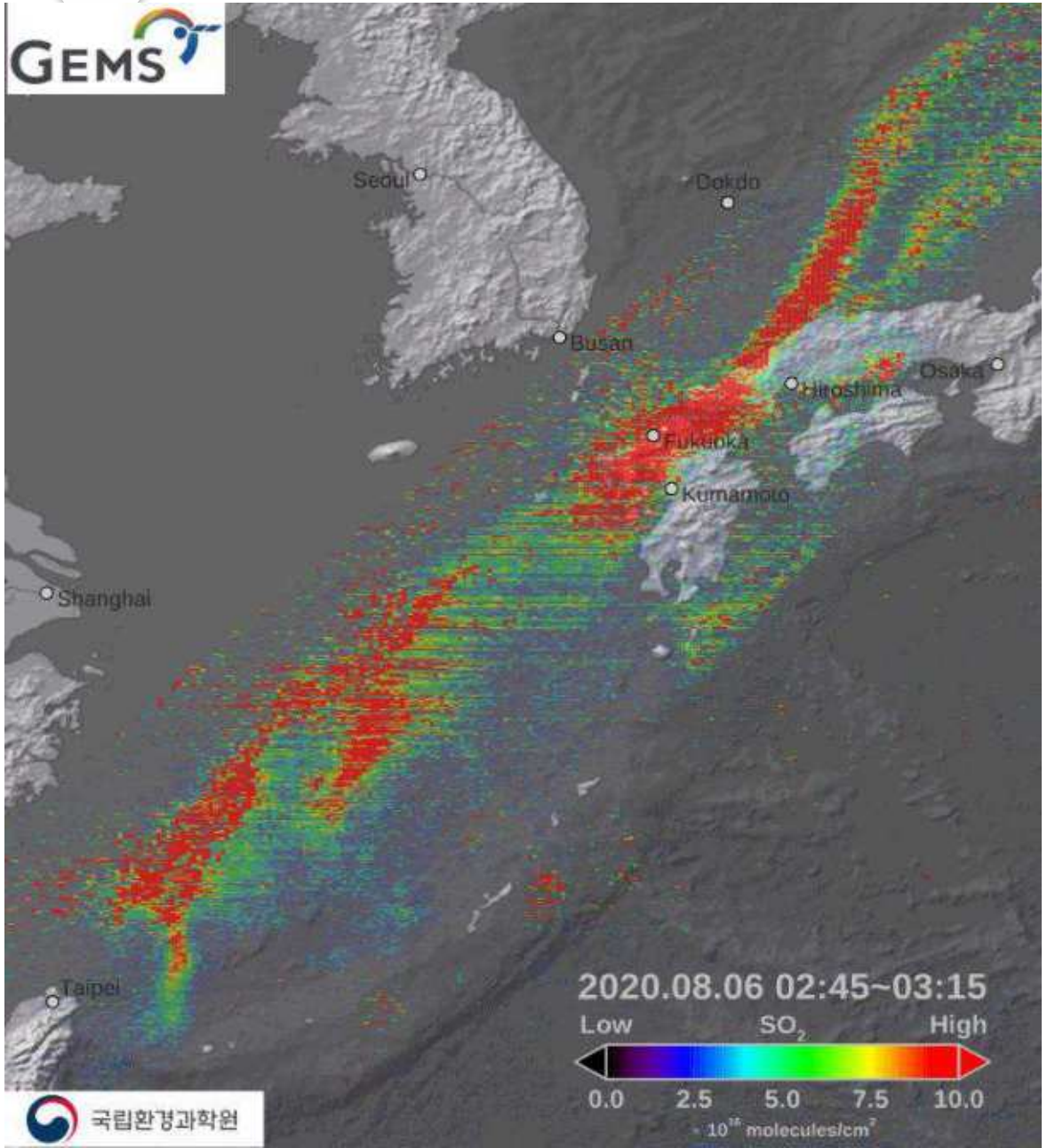


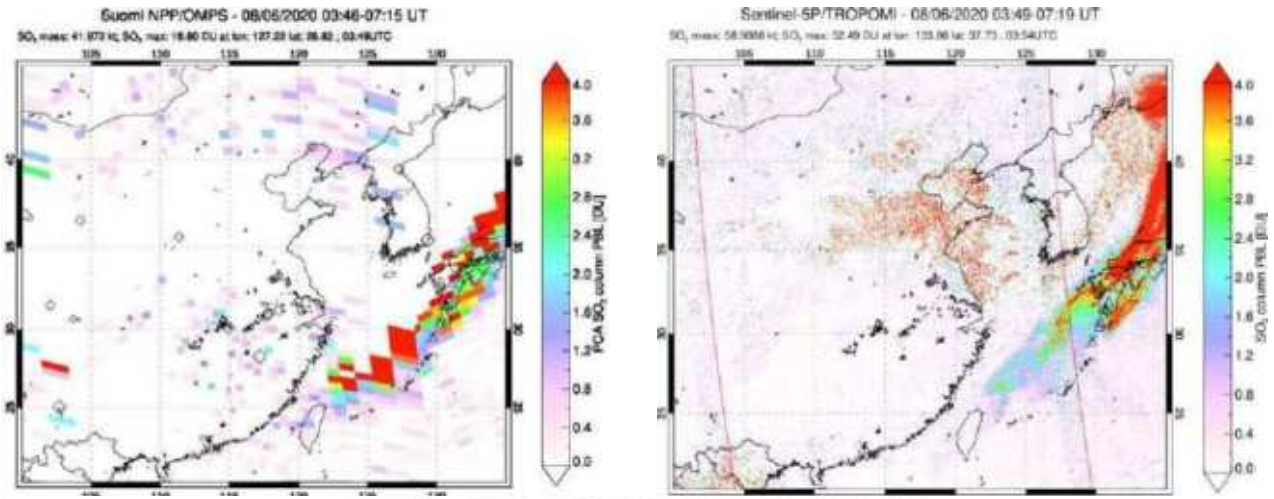
GEMS Products – SO2



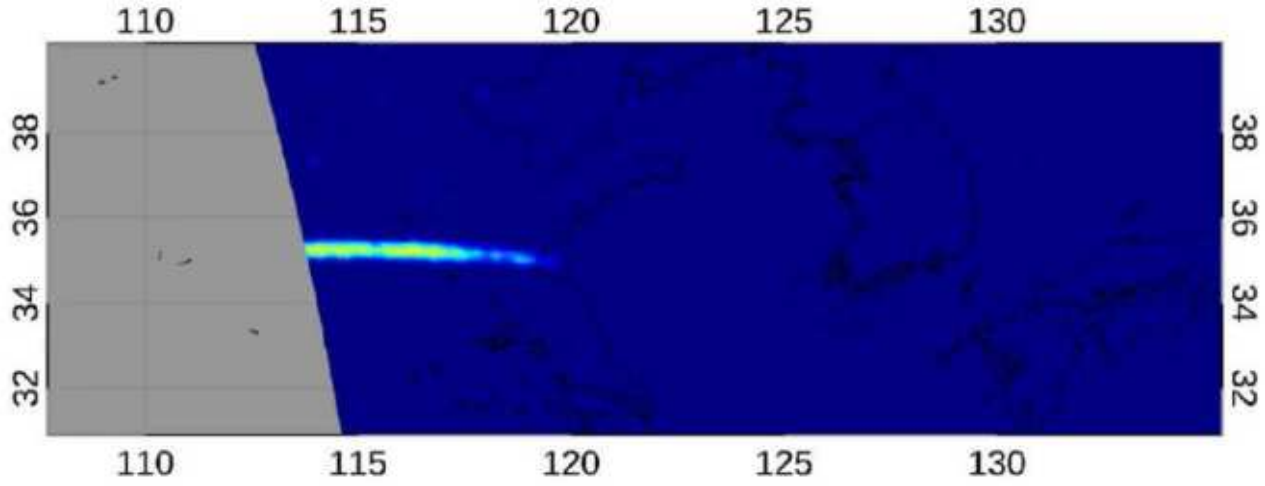


2 GEMS Products – SO2 plume by Volcano

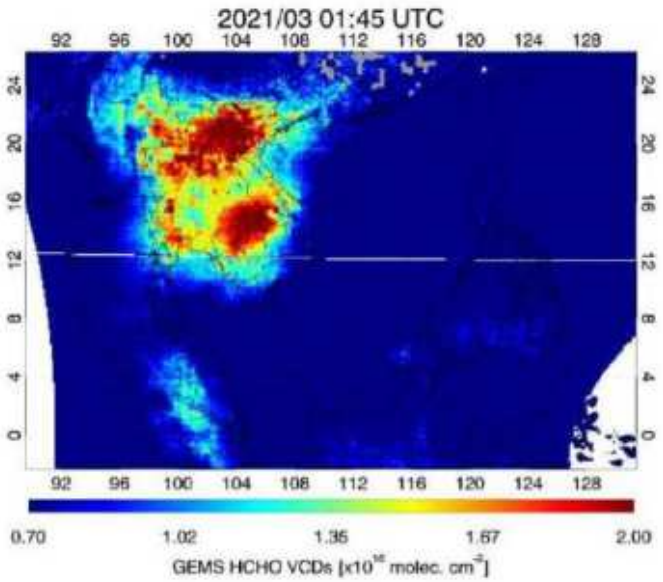


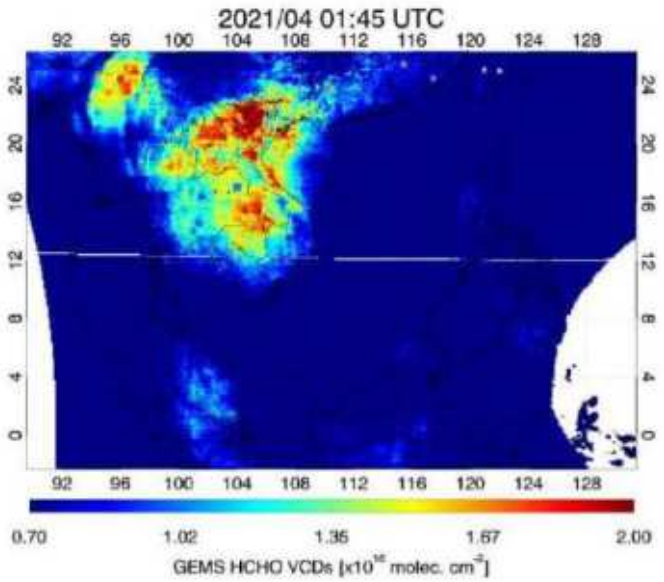


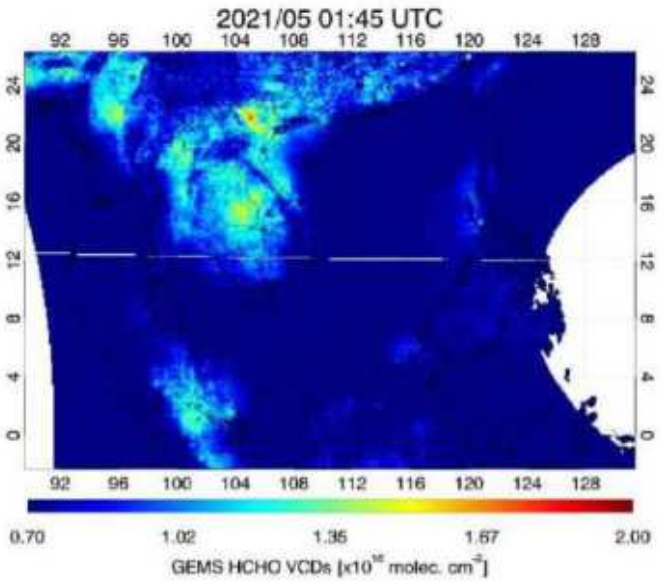
Feb. 25, 2022 01:45 UTC

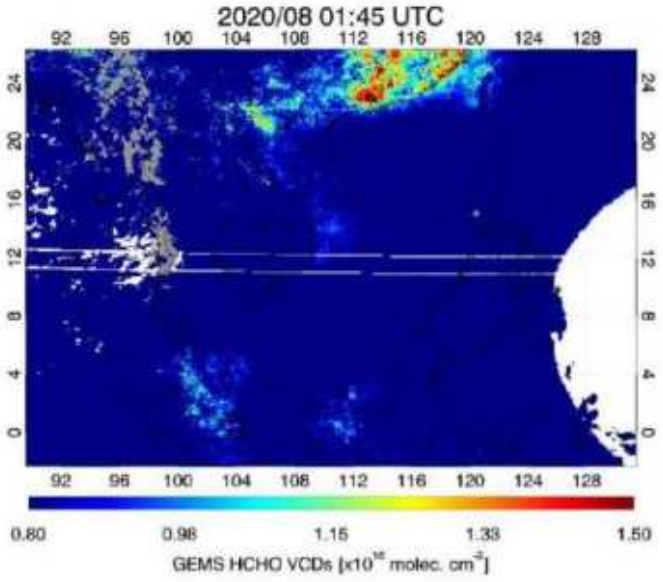


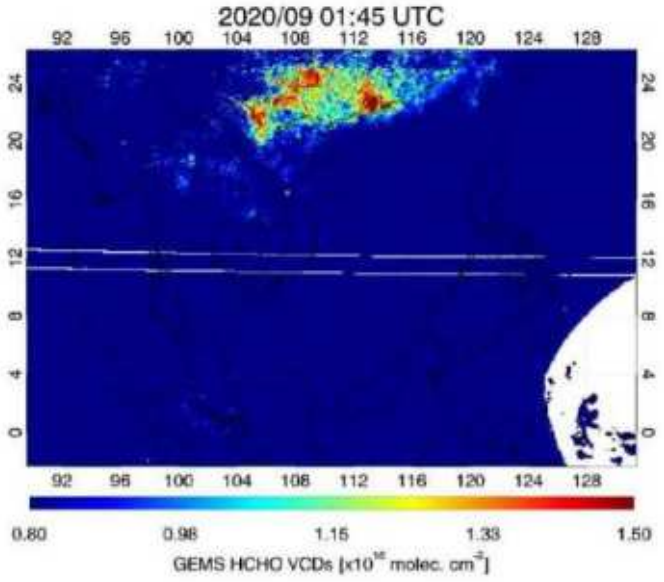
2 GEMS Products – HCHO, SouthEast Asia

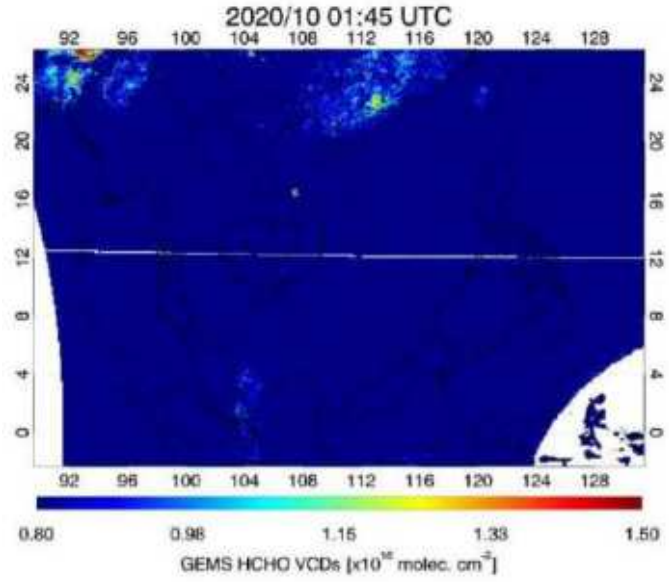






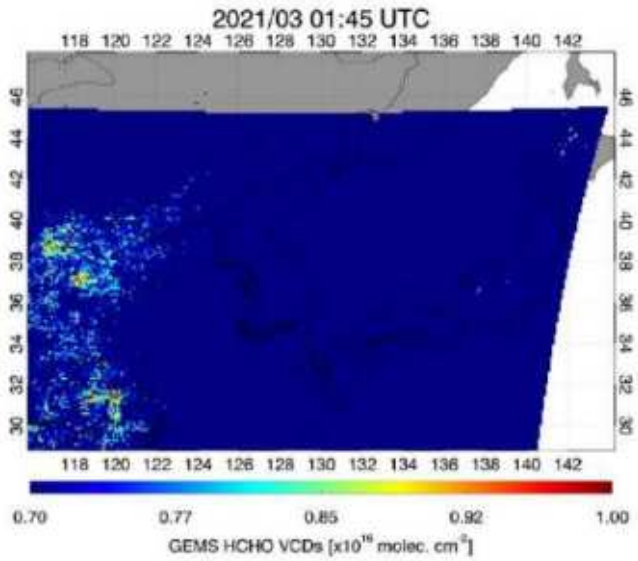


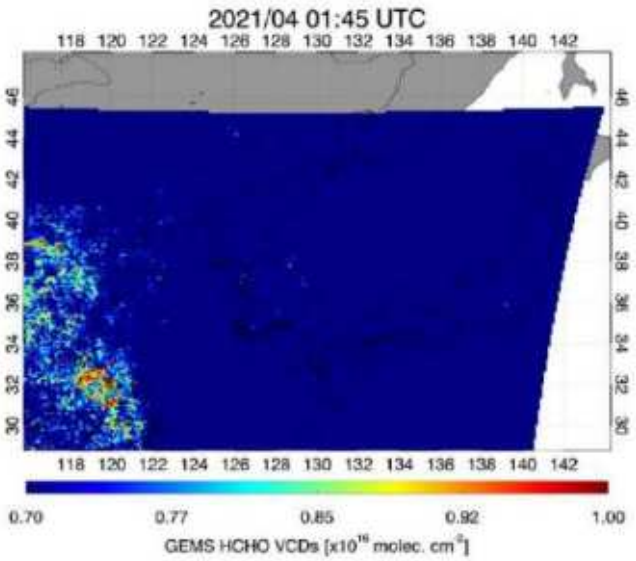


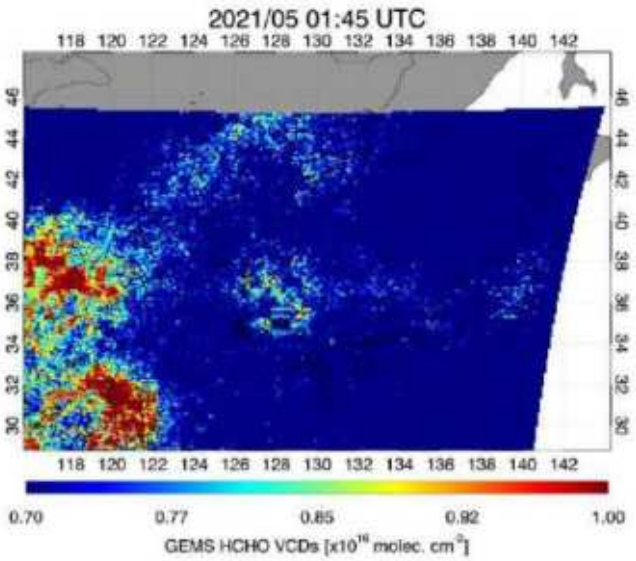


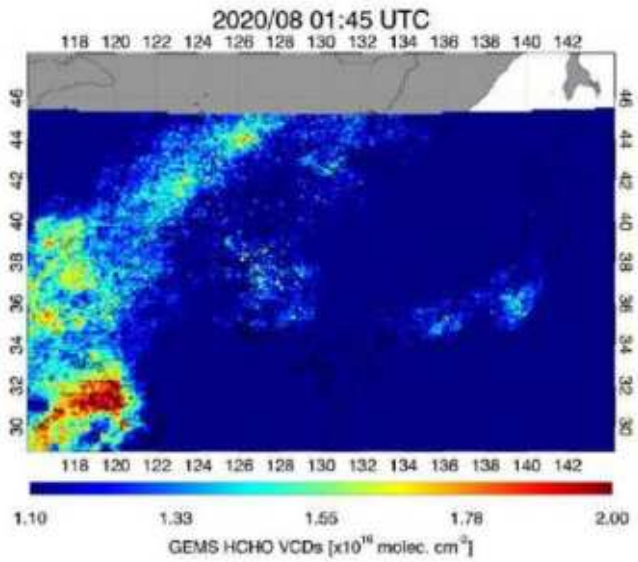
See poster by Gitaek Lee for details. #6

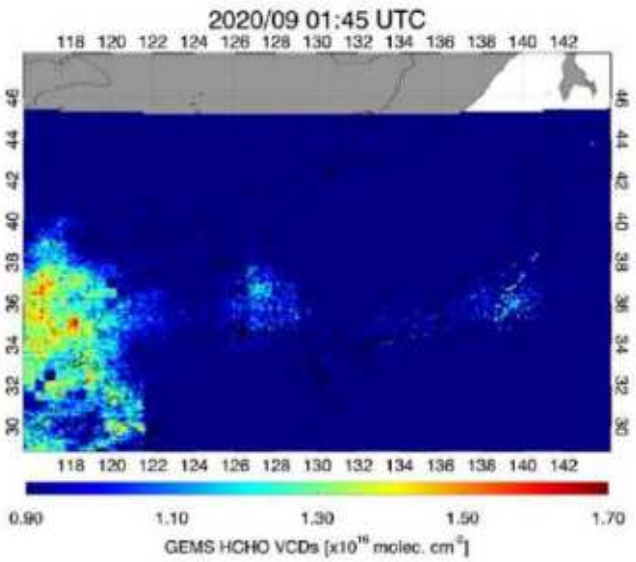
2 GEMS Products – HCHO, East Asia

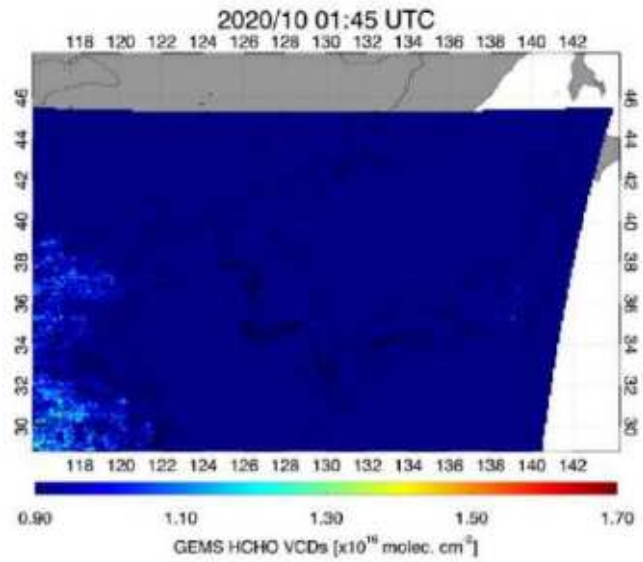






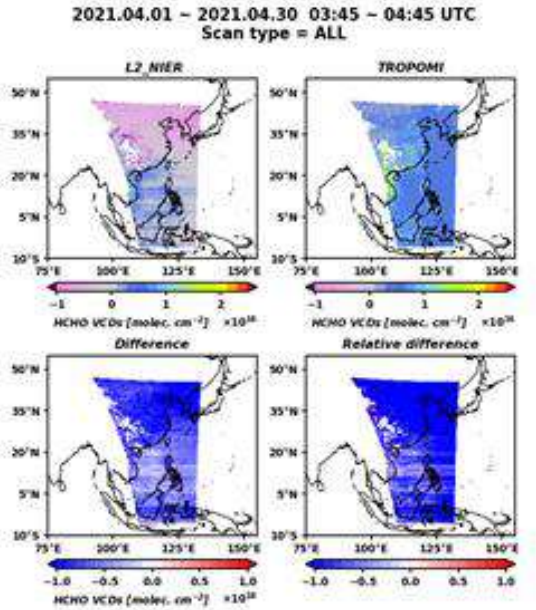


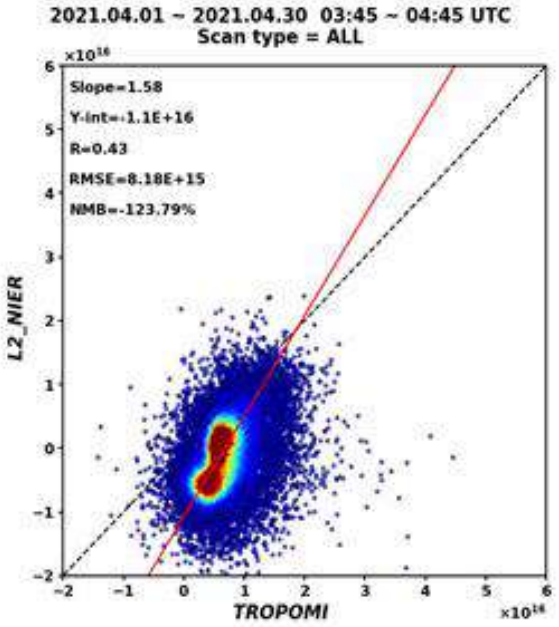


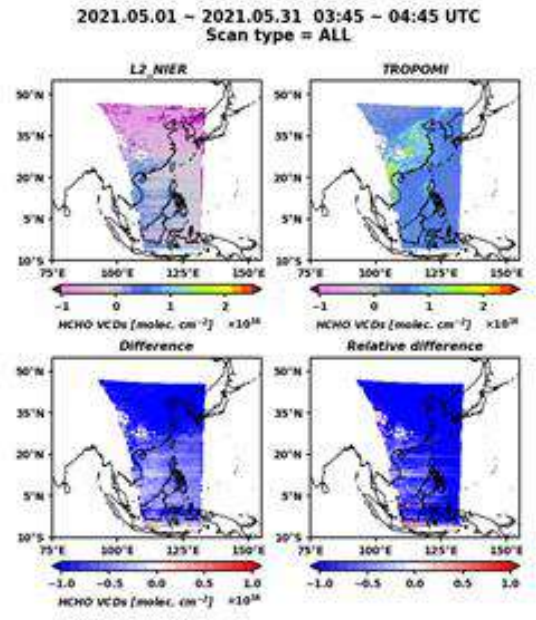


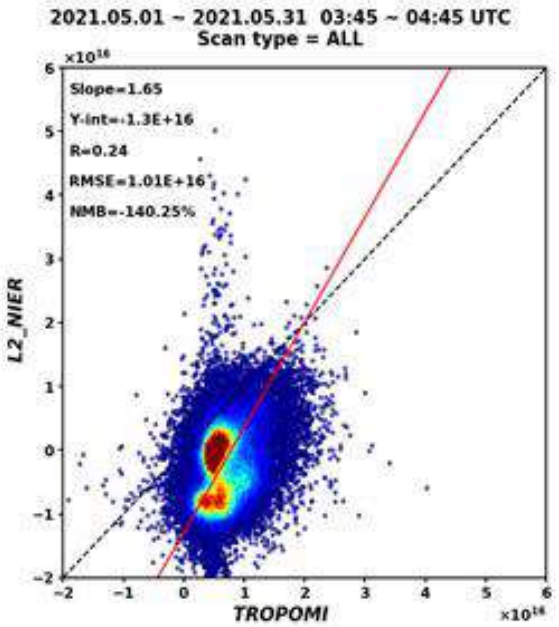
See poster by Gitaek Lee for details. #6

2 GEMS Products – HCHO

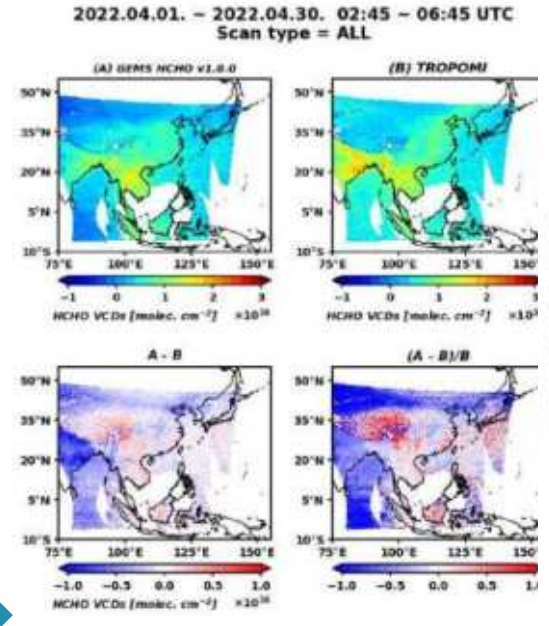


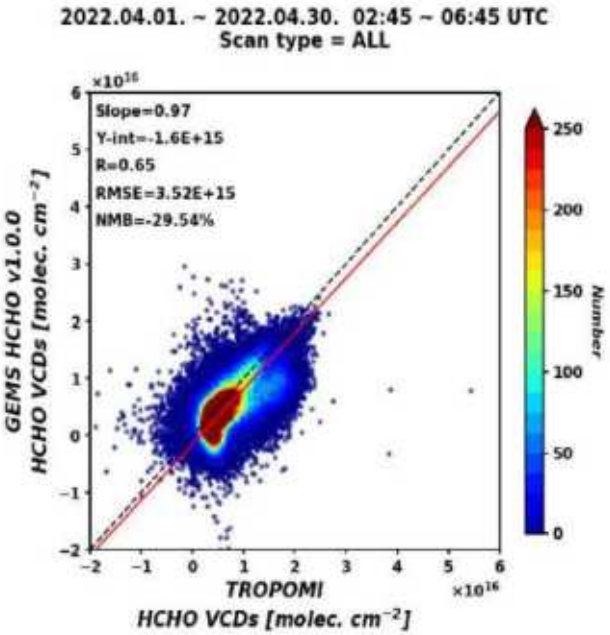


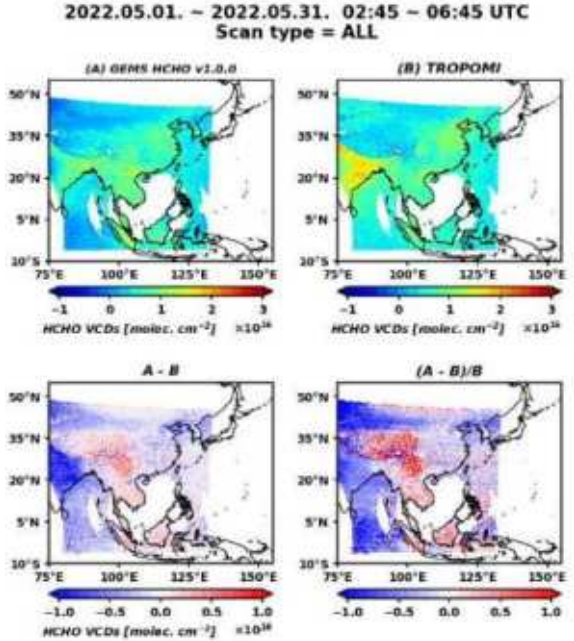


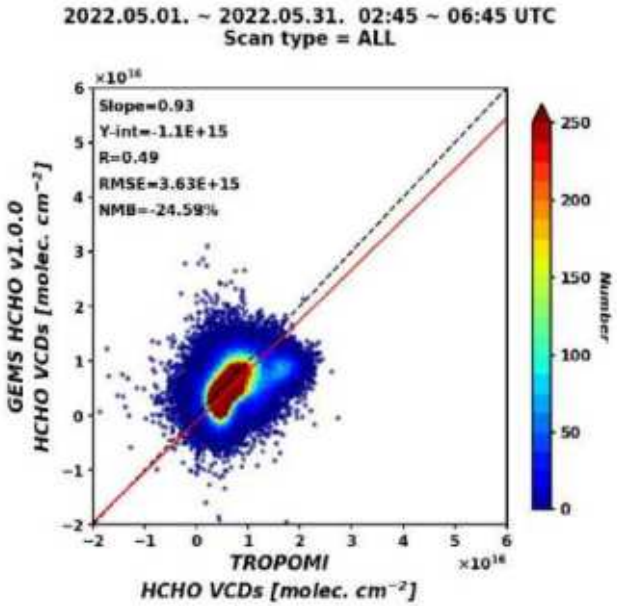


Fitting Window, Model, Reference etc. Updated



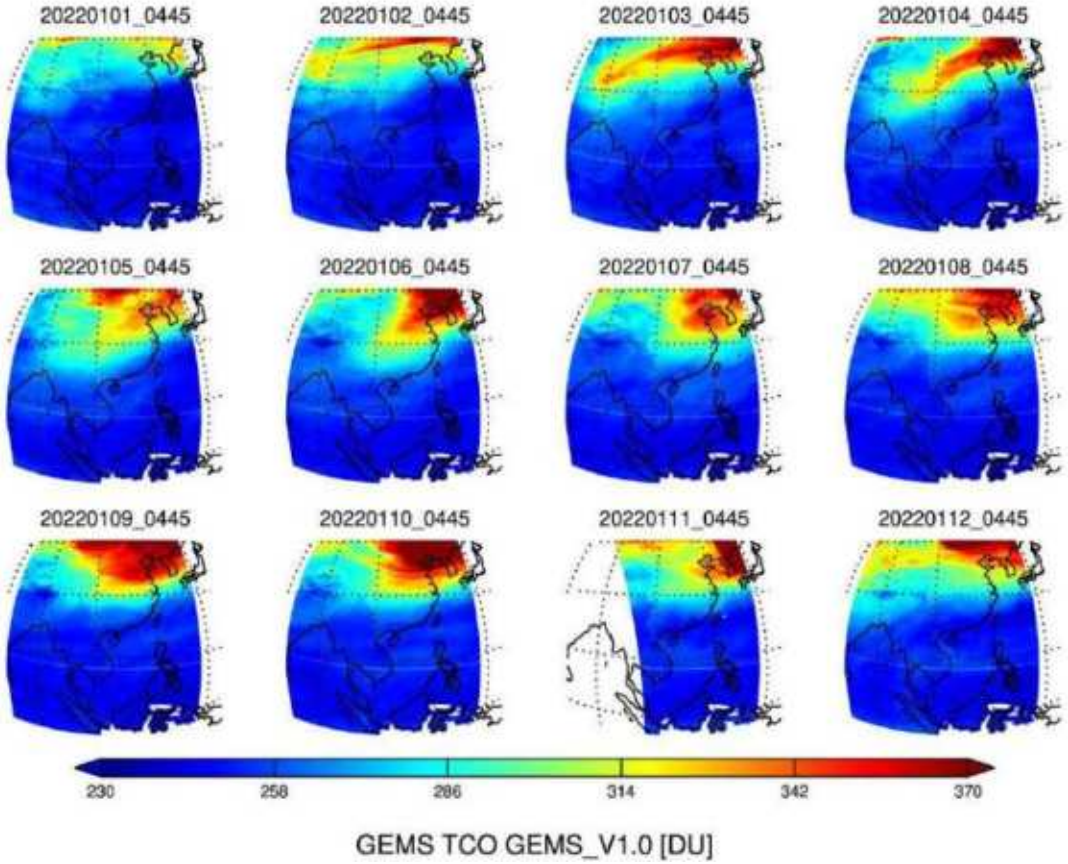




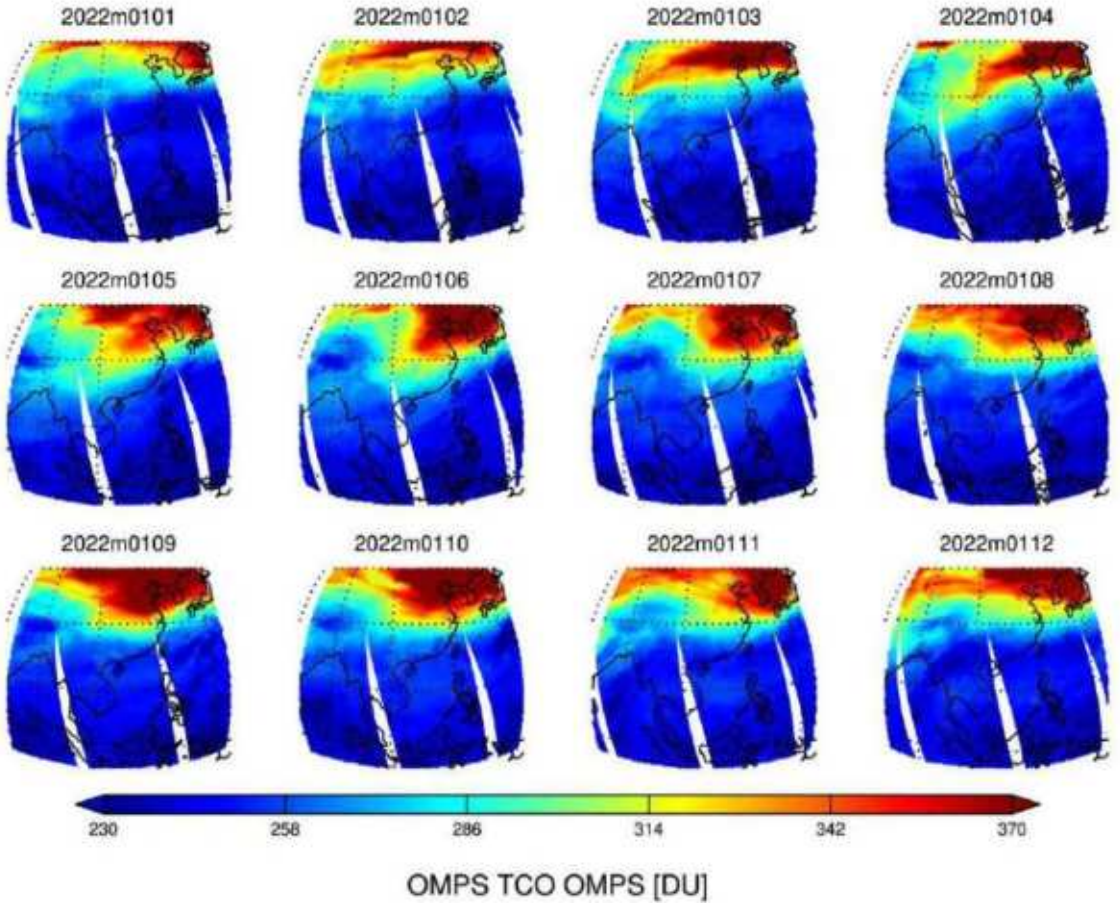


GEMS Products – Total O3

GEMS

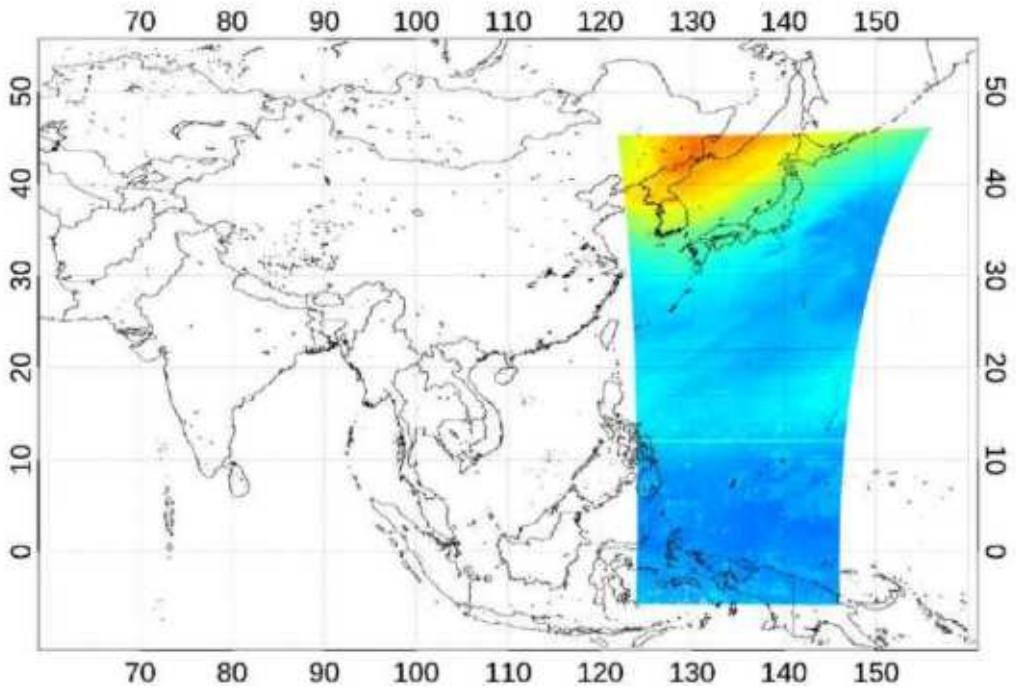


OMPS

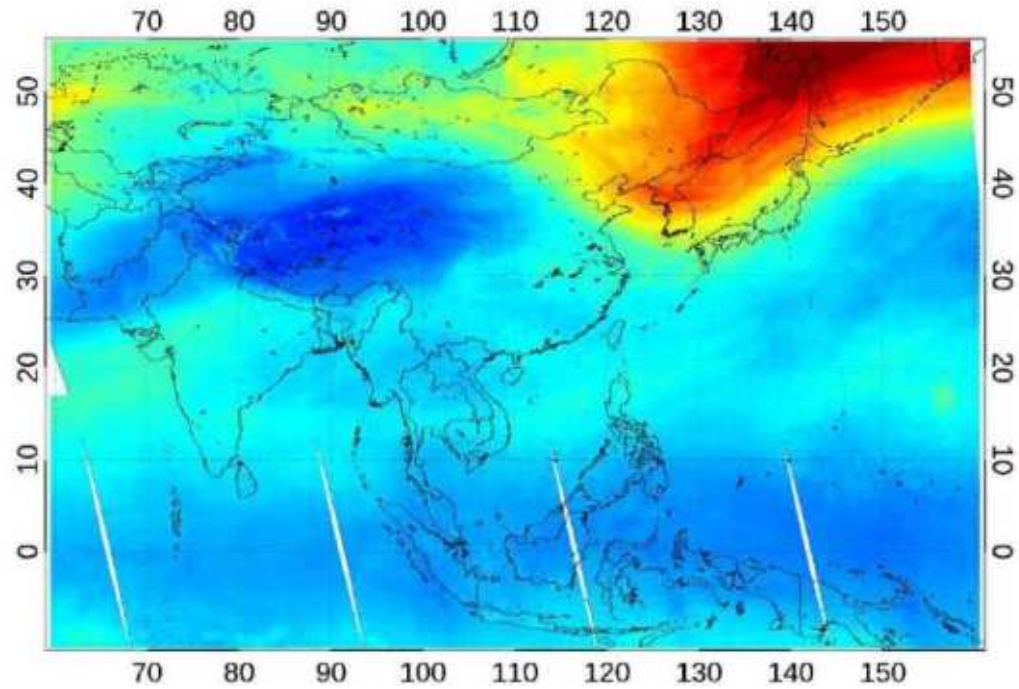


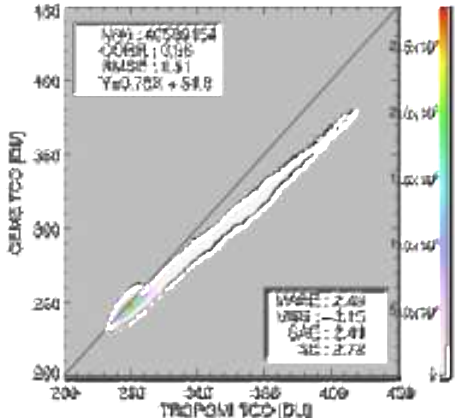
GEMS Products – Total O3

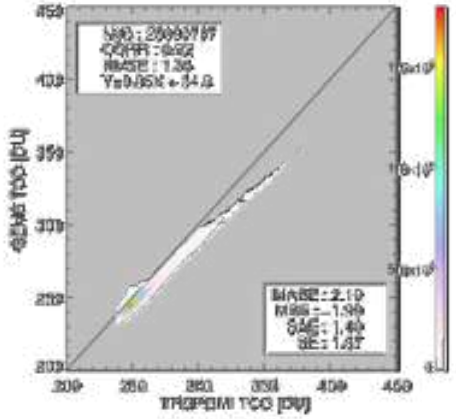
GEMS

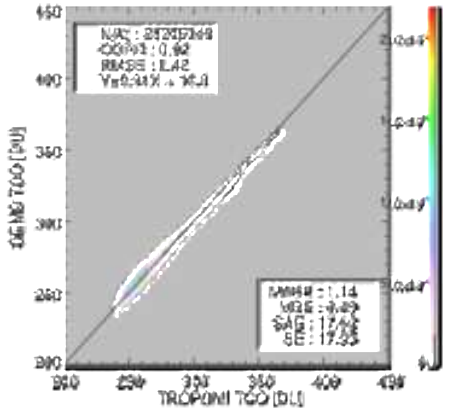


TROPOMI



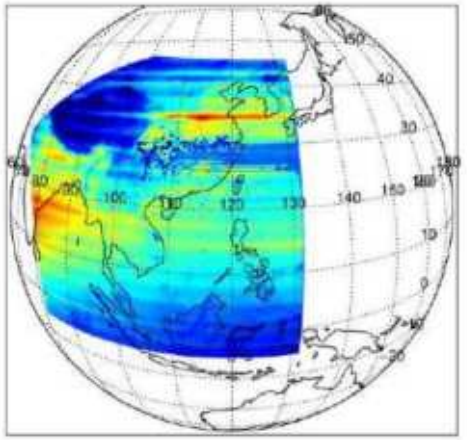


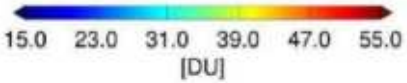




GEMS Products – Troposphere O3

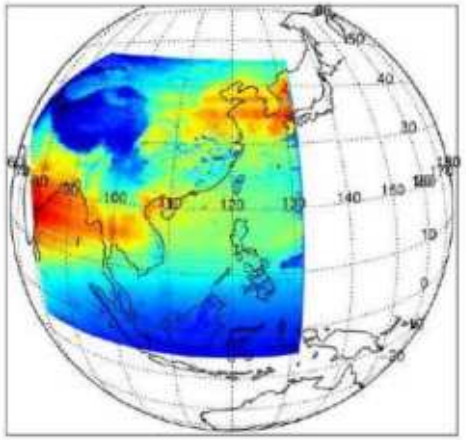
GEMS O3P Tropospheric ozone 20220117_0345



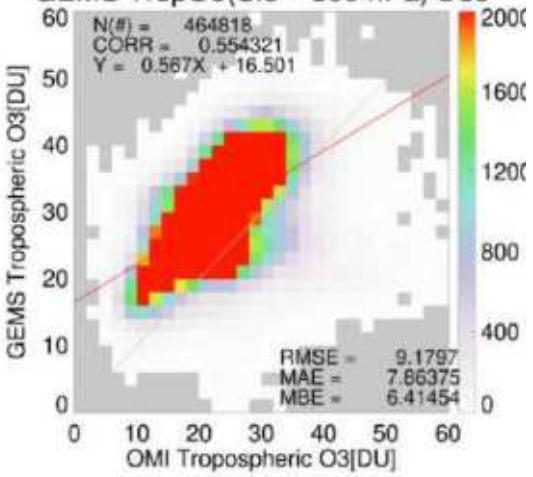


UM Model Update

GEMS O3P Under 300 hPa 20220210_0345



GEMS TropO3(Sfc – 300 hPa) Dec



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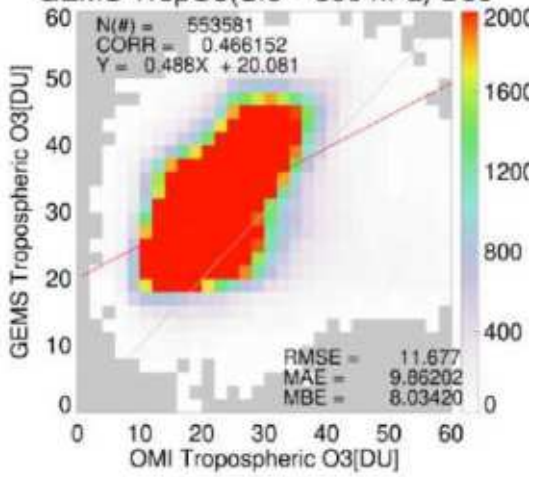

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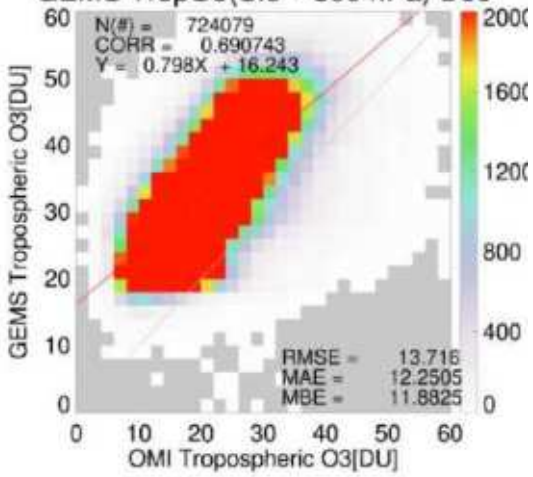

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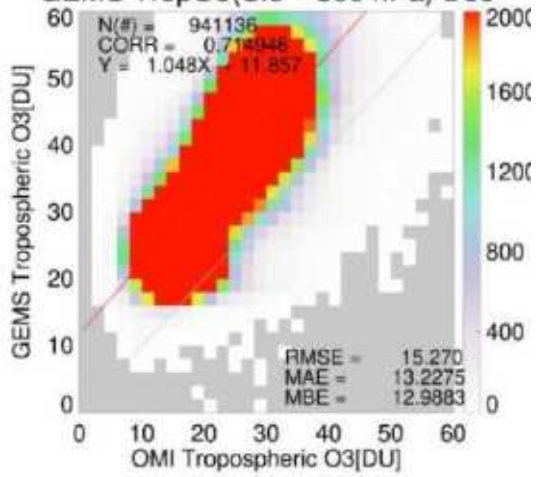

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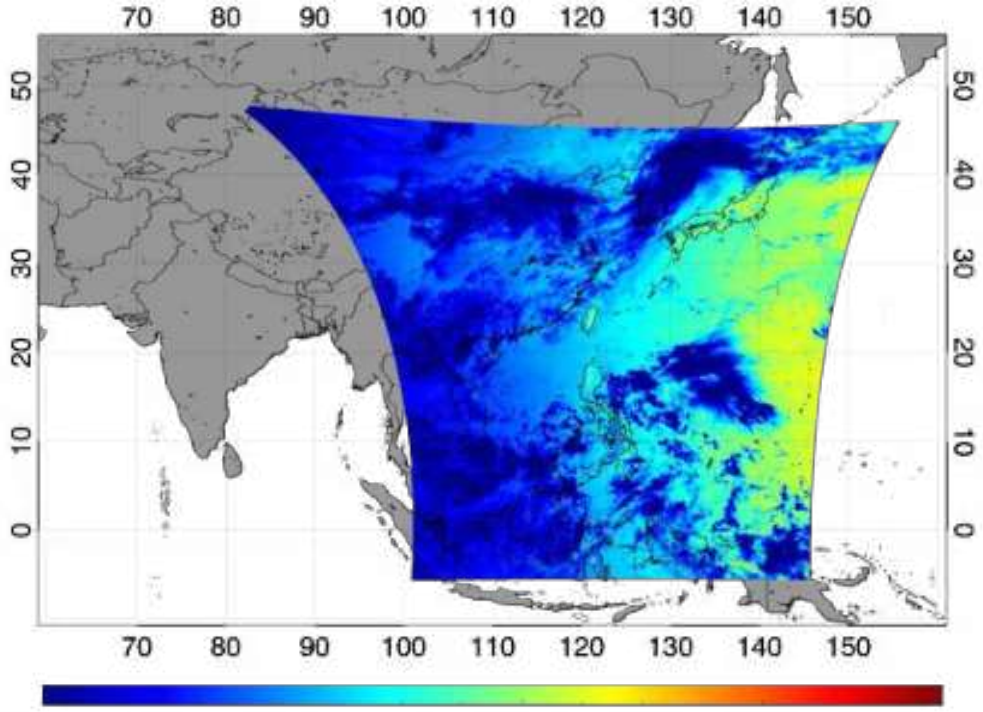
GEMS Products – UVI

UV index

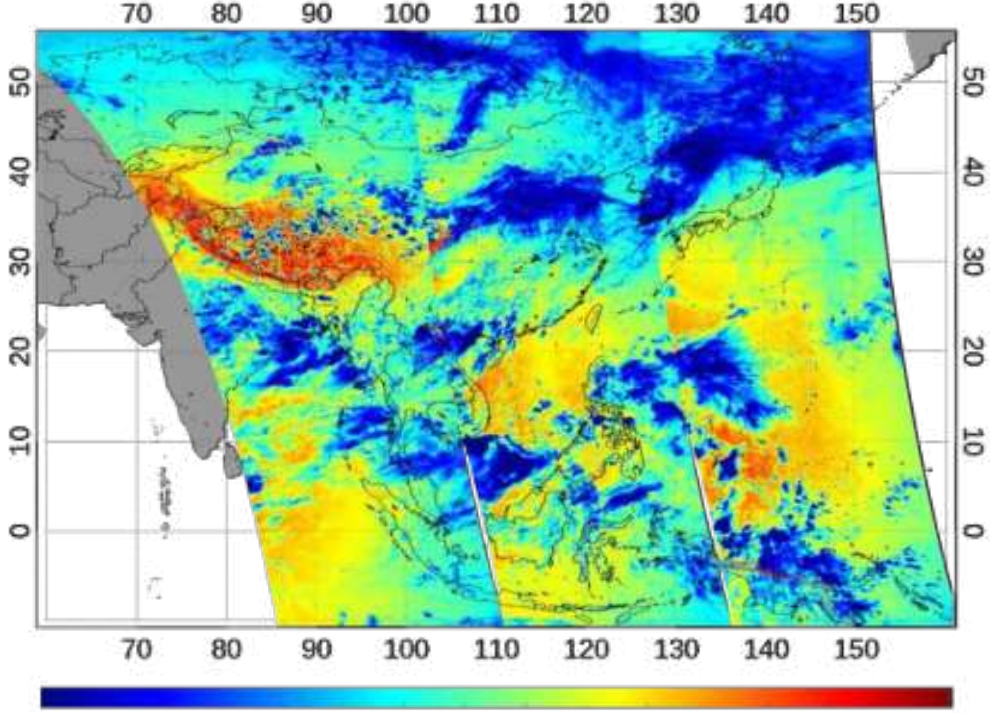
GEMS

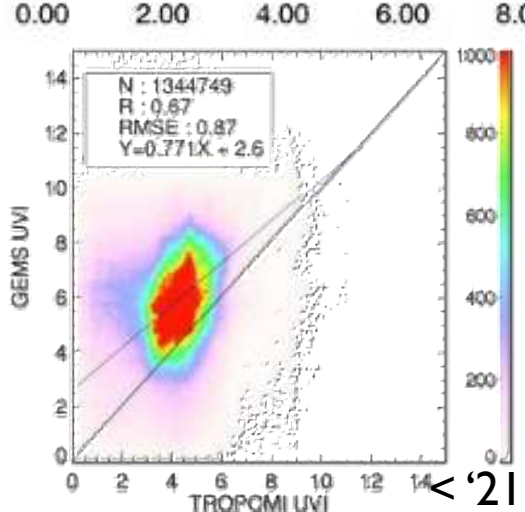
2020/08/06 00:45 UTC



TROPOMI

2020/08/06





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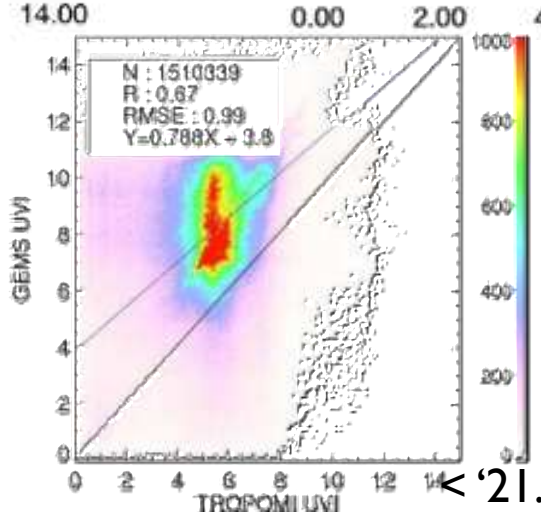

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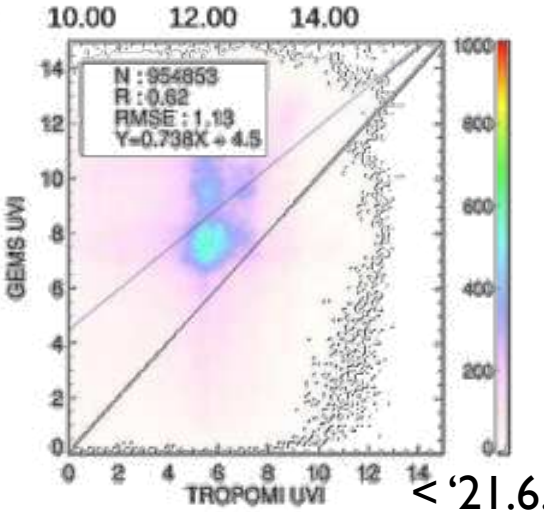


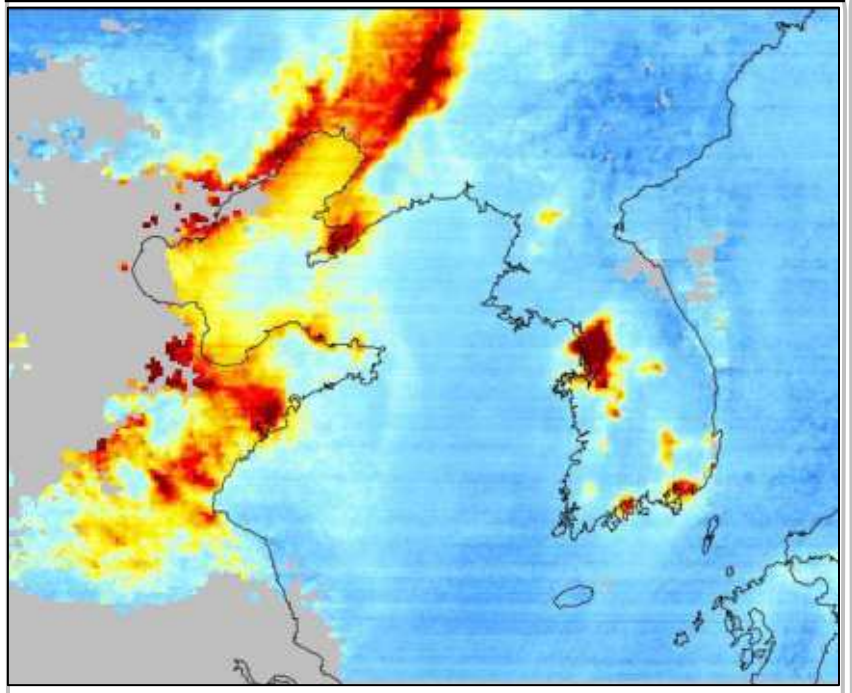
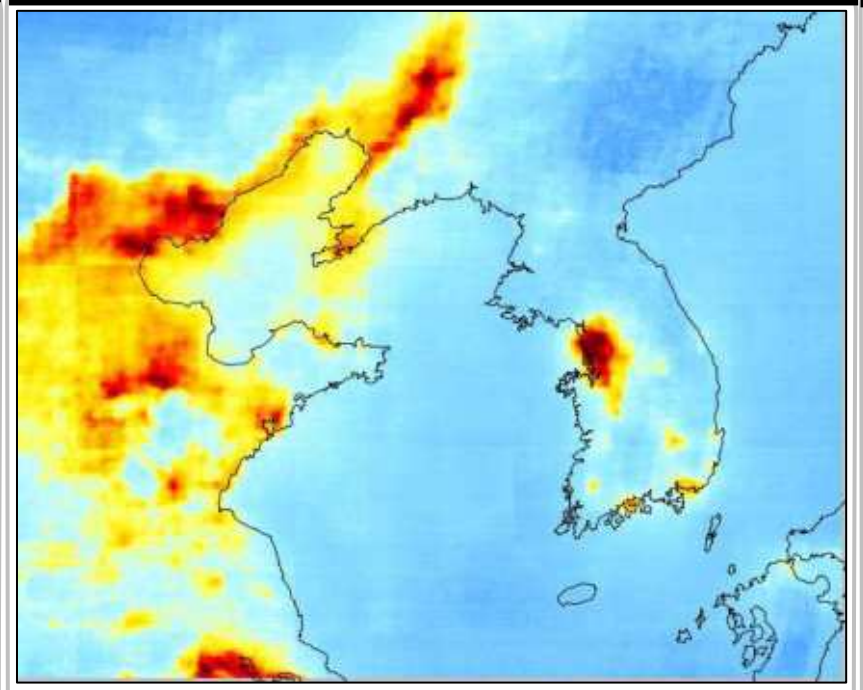
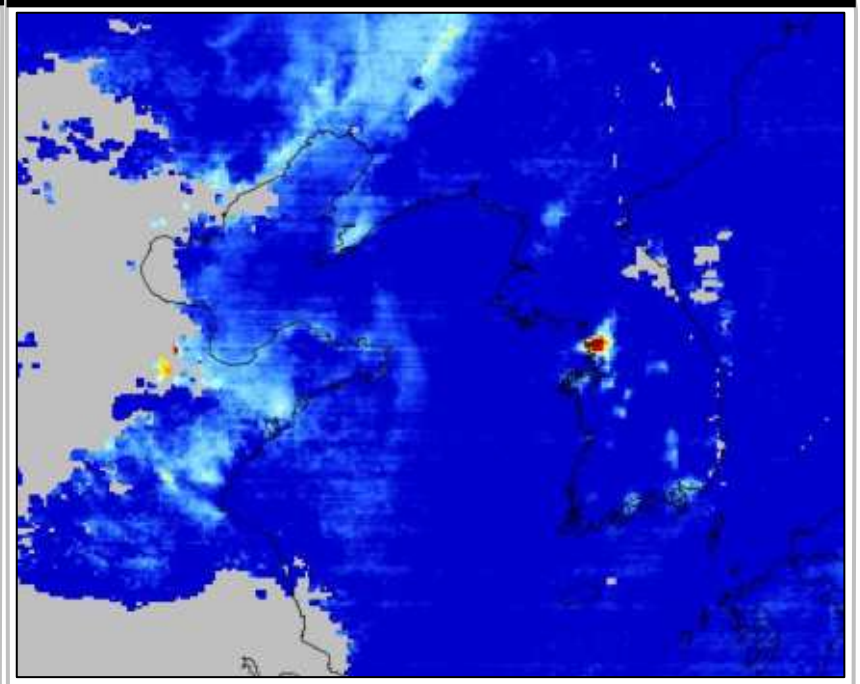
< '21.6. >

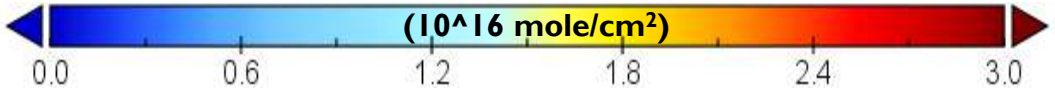
3. Status of GEMS L3

Definition of Lv.3: Consists of level 2 datasets with gridding scale

Data specification of GEMS Lv.3 products	
Target Product	NO2, AOD, SO2, HCHO, O3T (TBD)
Gridding Algorithm	Tessellation (area based) vs IDW (distance based)
Gridding Resolution	0.05 degree (≈5km, Korea Peninsula), 0.1 degree (≈10km, GEMS domain)
Time Resolution	Monthly mean, Daily mean, Hourly mean (TBD)
Attribute	Mean, Median, Max, Min, Quality Flag (TBD), Latitude, Longitude
Data Format	NetCDF

GEMS Lv.3 Time Resolution – Daily vs Monthly

21.3.8. Daily Mean (Clear Day)	21. 3. Monthly Mean	Daily – Monthly
		



3 GEMS L3: GEMS vs TROPOMI

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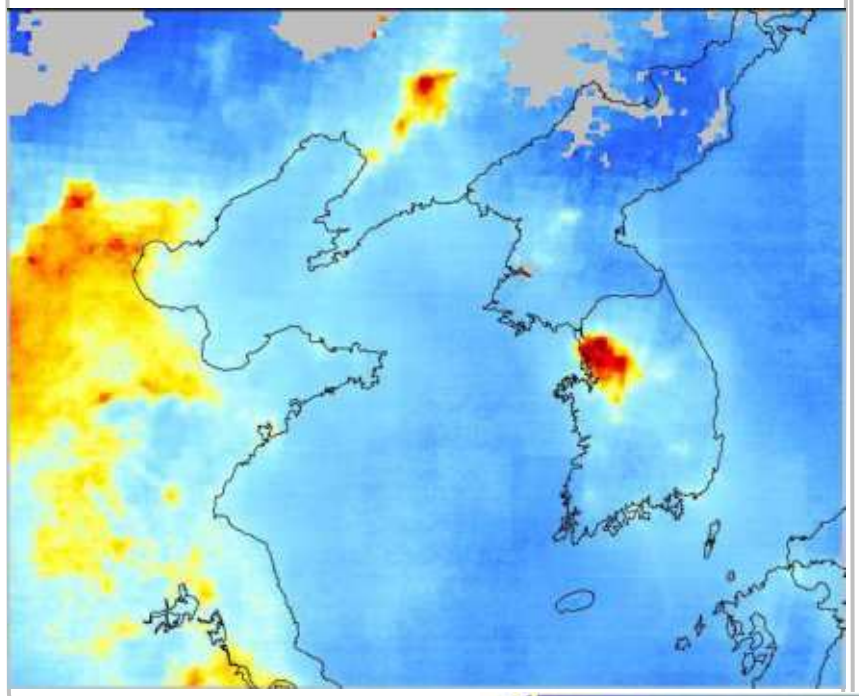
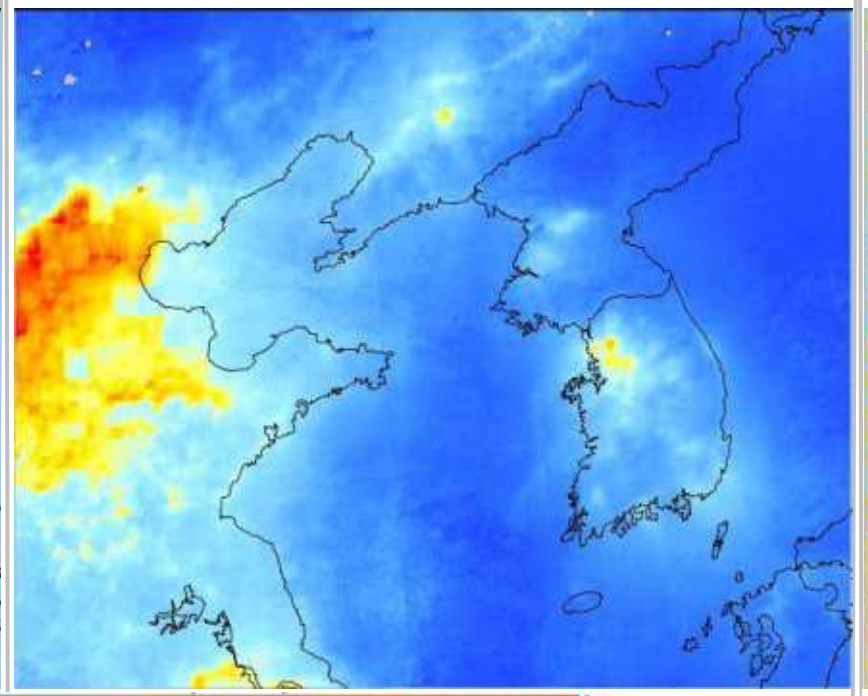
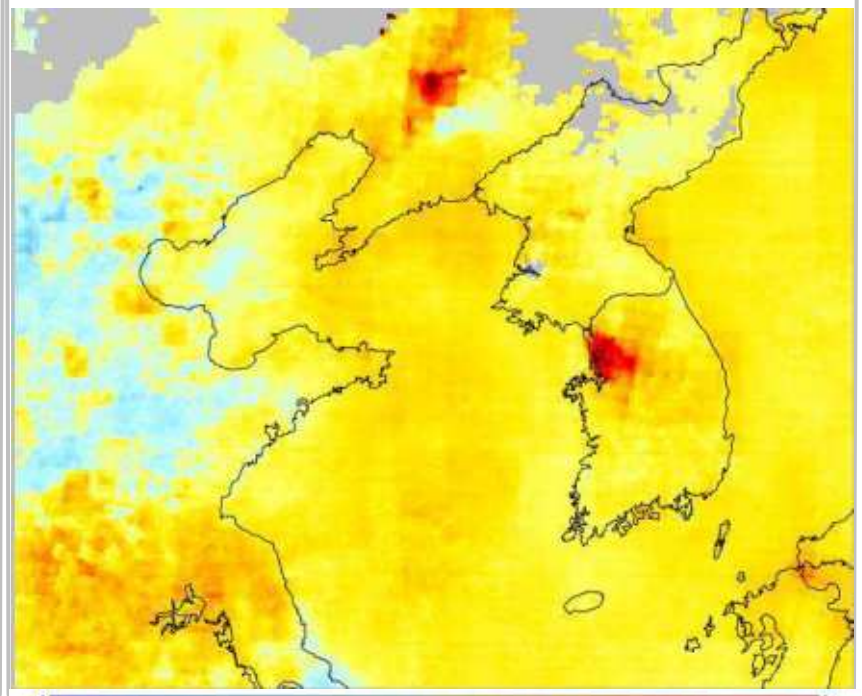
GEMS: 22.1.



TROPOMI: 22.1.



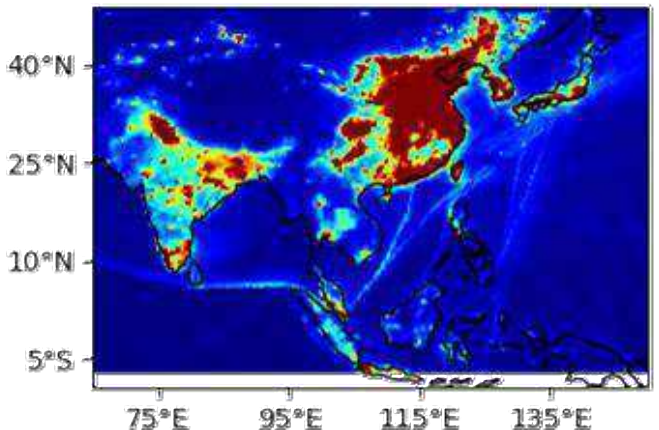
GEMS - TROPOMI: 22.1.



(10^16 mole/cm²)
0.0 0.8 1.6 2.4 3.2 4.0

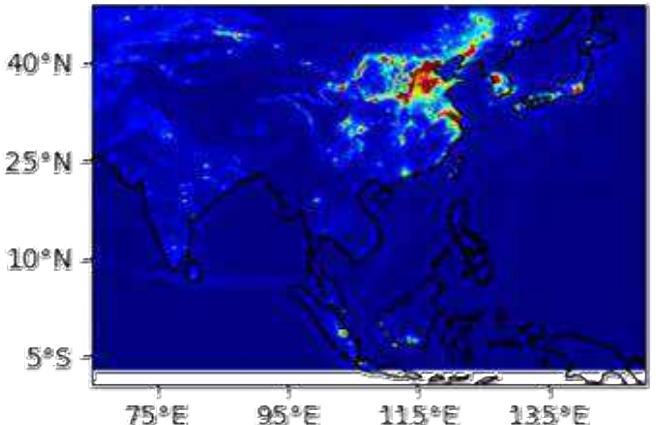
(10^16 mole/cm²)
-2.0 -1.2 -0.4 0.4 1.2 2.0

(1)WRFChem+CAMChem



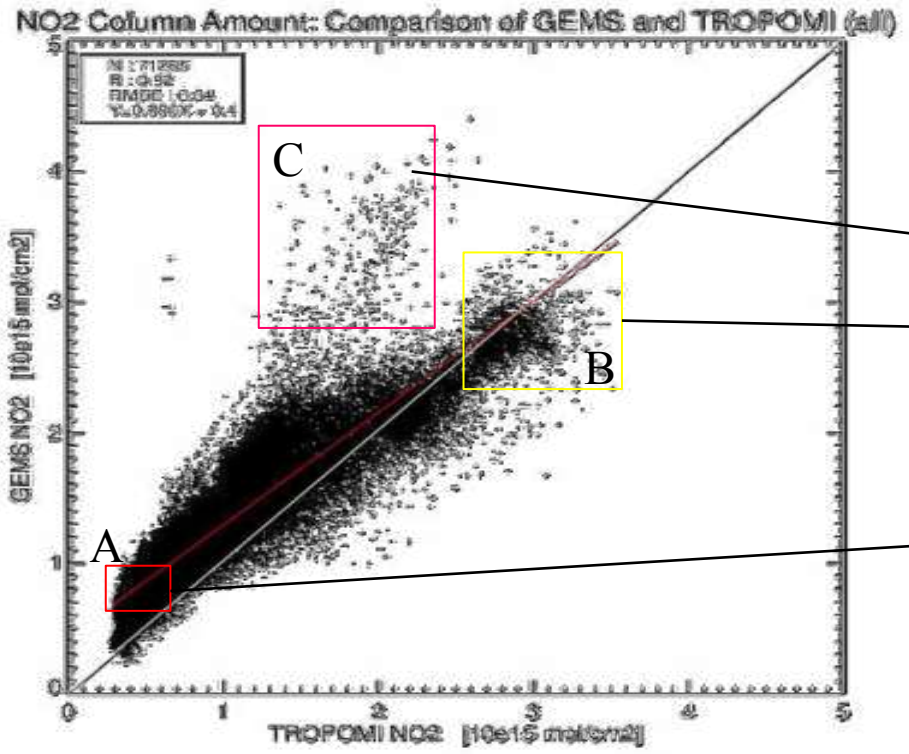
CTM Updated

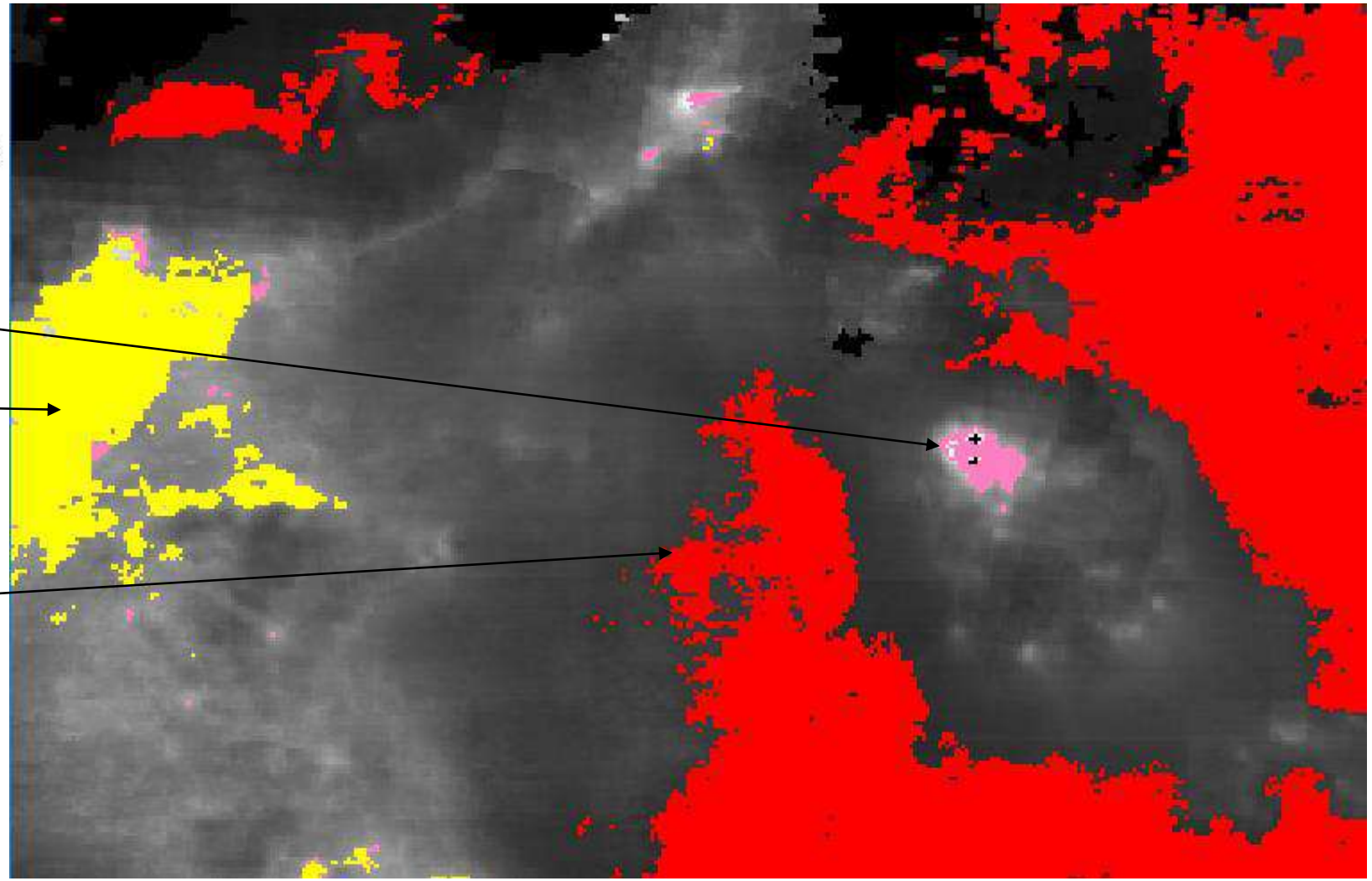
(2)GEOS-Chem



See presentation by Junsung Park for details. (THURSDAY, Synergies Sessions)

Comparison Lv.3: GEMS Lv.3 (Total, ESC) vs Tropomi Lv.3 (Total)





3 GEMS L3: GEMS vs TROPOMI

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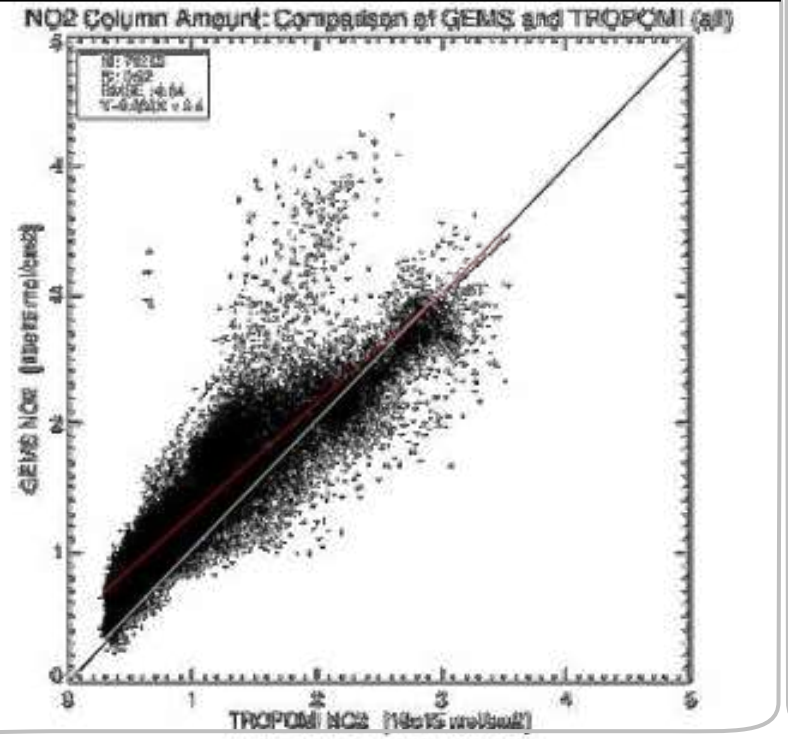
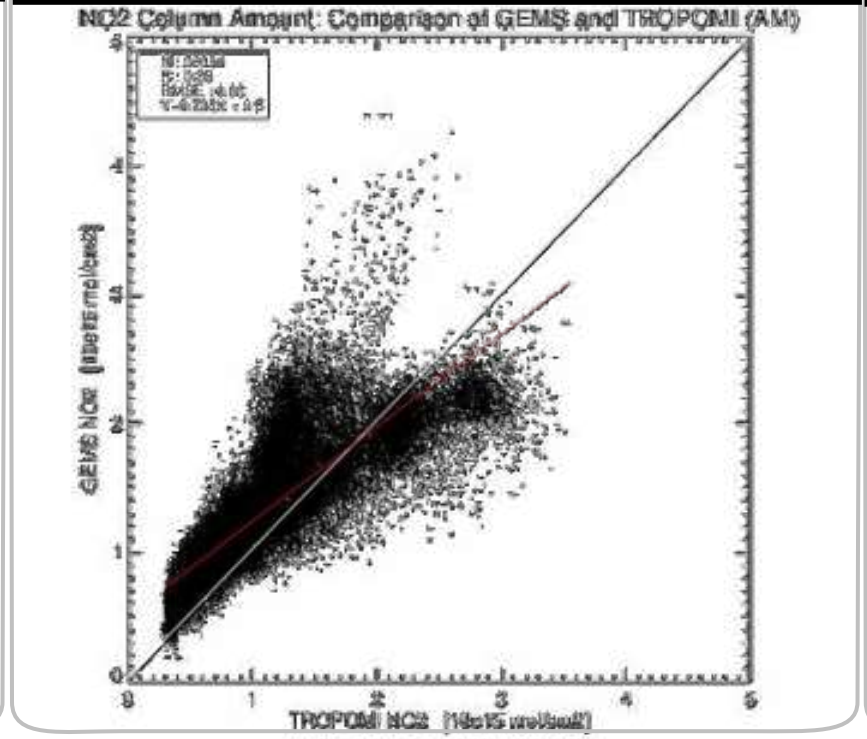
L3 Comparison w.r.t Time

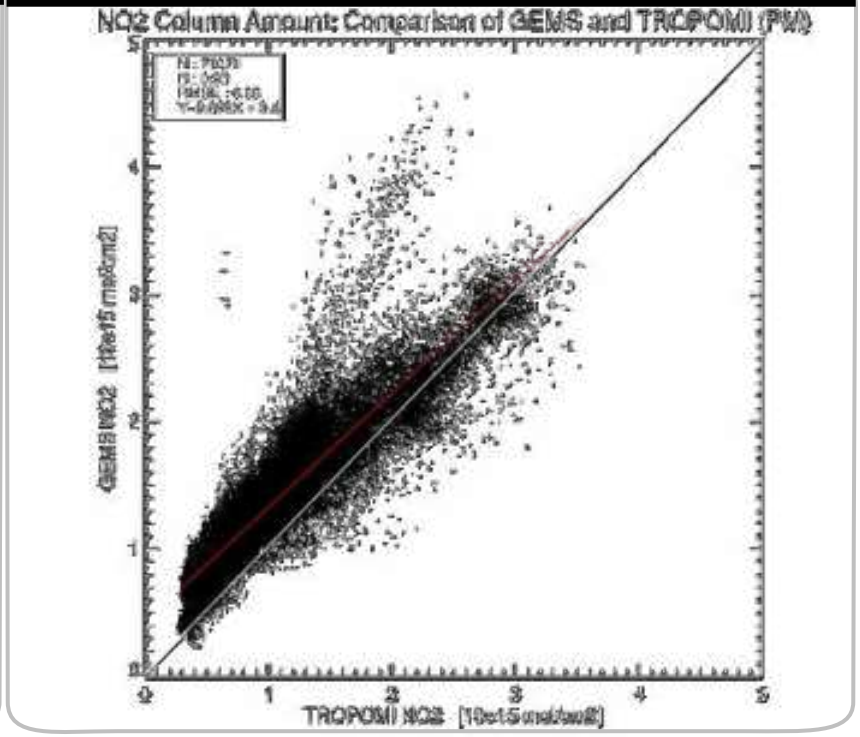
GEMS (All Time) vs TROPOMI



GEMS (morning) vs TROPOMI



GEMS (afternoon) vs TROPOMI



ALL : 00~05 UTC, 09~14 KST,

Morning : 00~02 UTC, 09~11 KST ,

Afternoon : 03~05 UTC, 12~14 KST

TROPOMI : 03~04 UTC, 12~13 KST

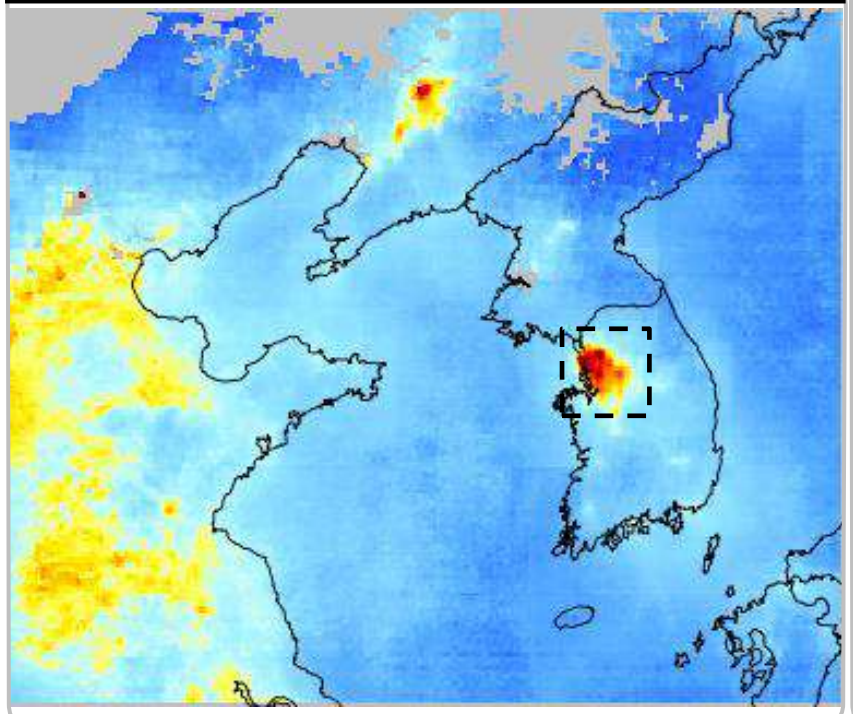
The Afternoon mean L3 are closer to the TROPOMI L3 than the morning mean L3.
More analyzes will be possible using GEMS for time variation

GEMS L3 Time variation

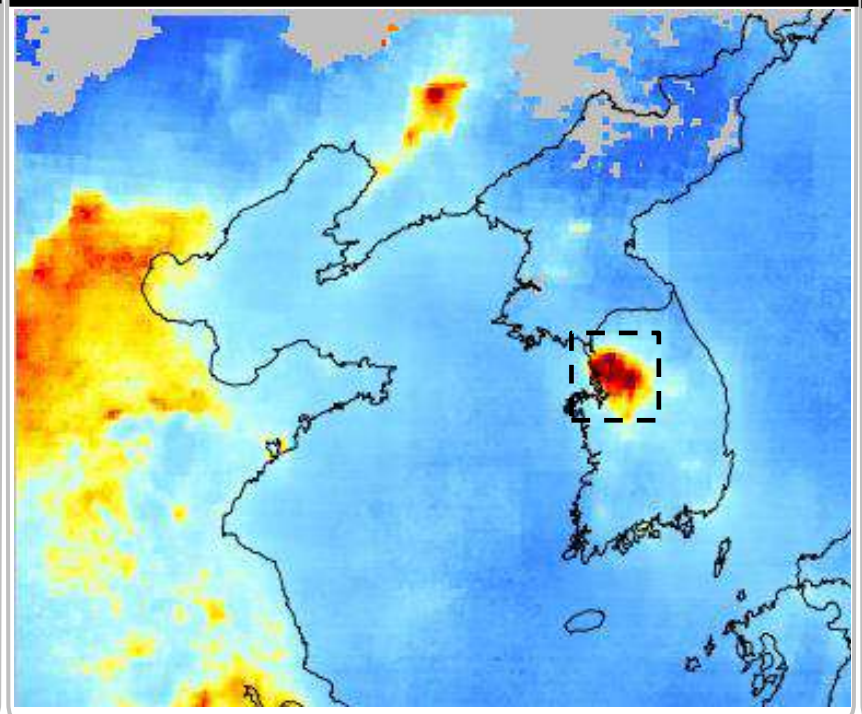
GEMS Lv.3 Morning and Afternoon

< Black rectangle, Metropolitan Area including Seoul, Incheon, Gyeonggi-do Province >

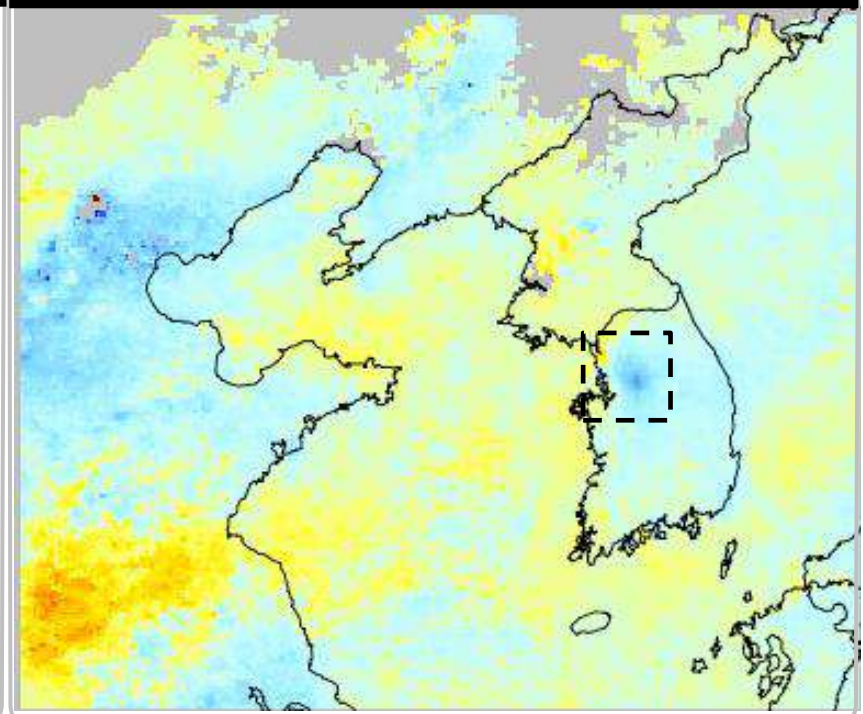
GEMS (Morning)

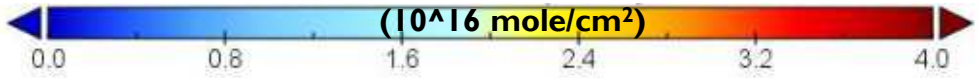


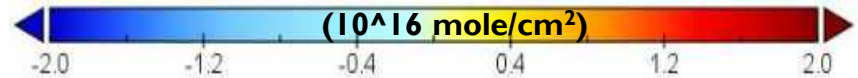
GEMS (Afternoon)



GEMS Morning - Afternoon







(in GEMS, NO2 concentration, Morning (9~11 KST) < Afternoon (12~14 KST))

3 GEMS L3 Time variation

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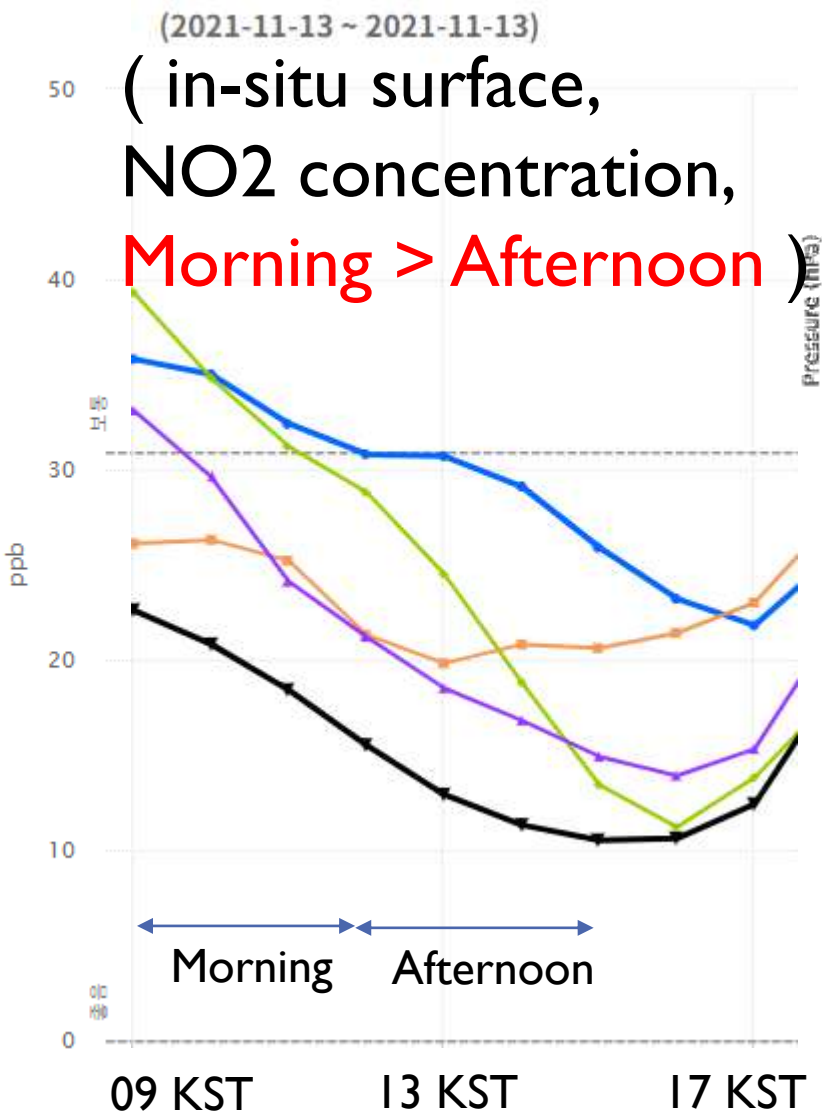
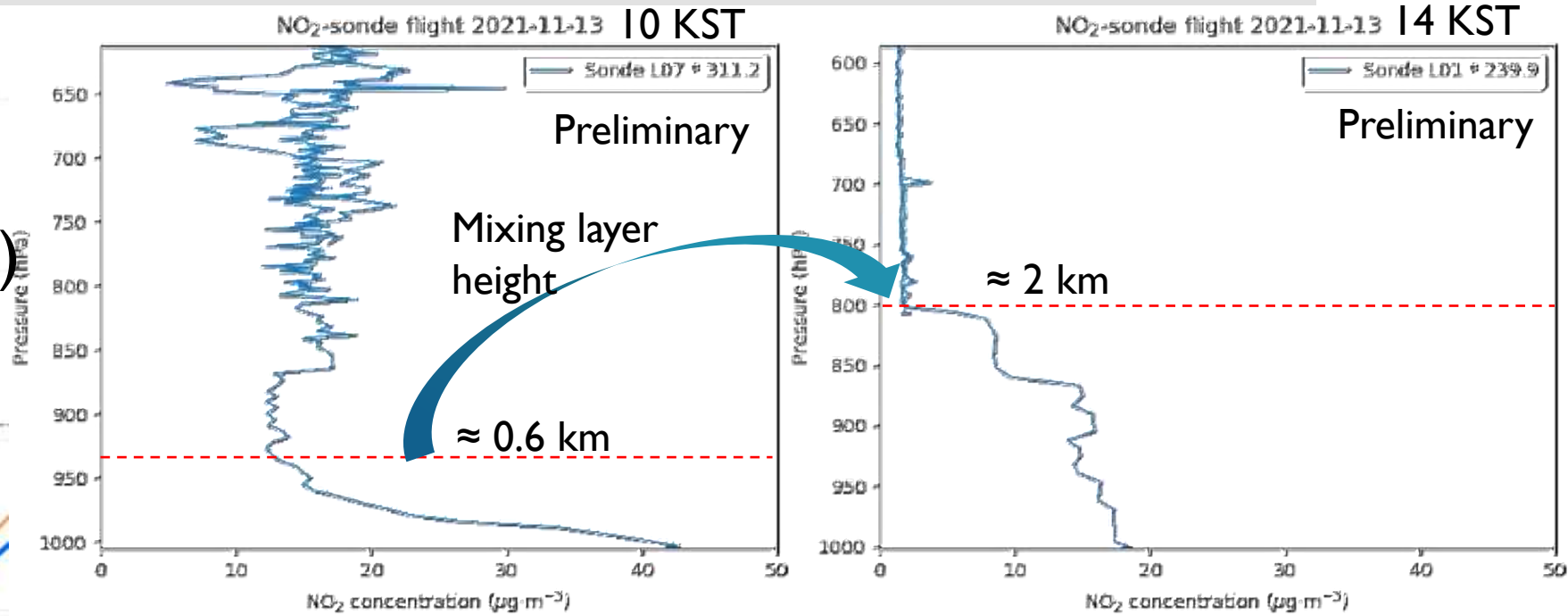
In-situ surface no2 vs no2-sonde profile



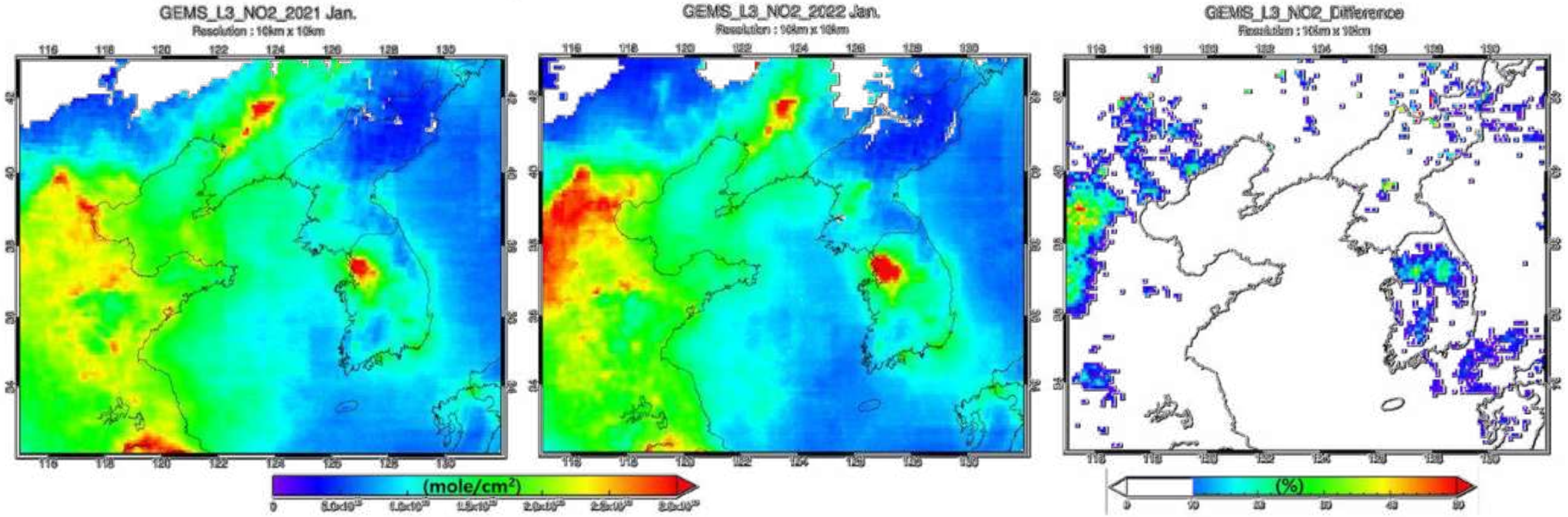
(in-situ surface,
NO2 concentration,
Morning > Afternoon)

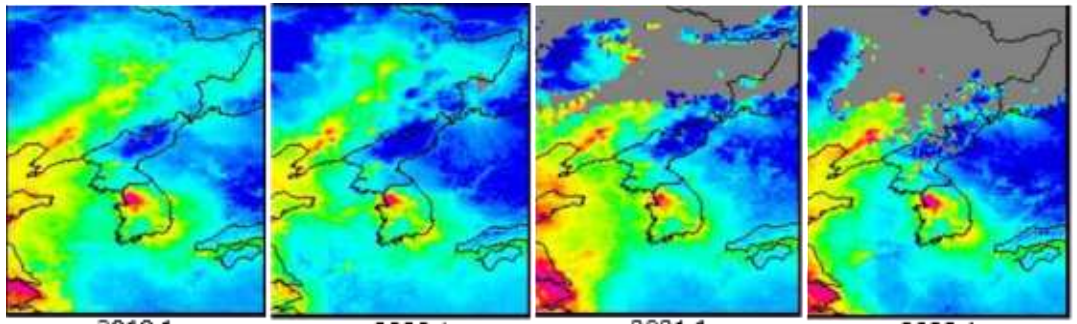


< NO2 sonde results in Yong-in, Gyeonggi-do Province,
Cooperate with KNMI (Pepijn, Mirjam) and KNU (Prof.Kim)

☞ One of reason, the total amount of NO2 increased in the afternoon.
Therefore, it appears to increase in the GEMS images
(Morning < Afternoon).
But the in-situ value appears to be lower in afternoon as the altitude of the mixing layer height increases. (Morning > Afternoon).

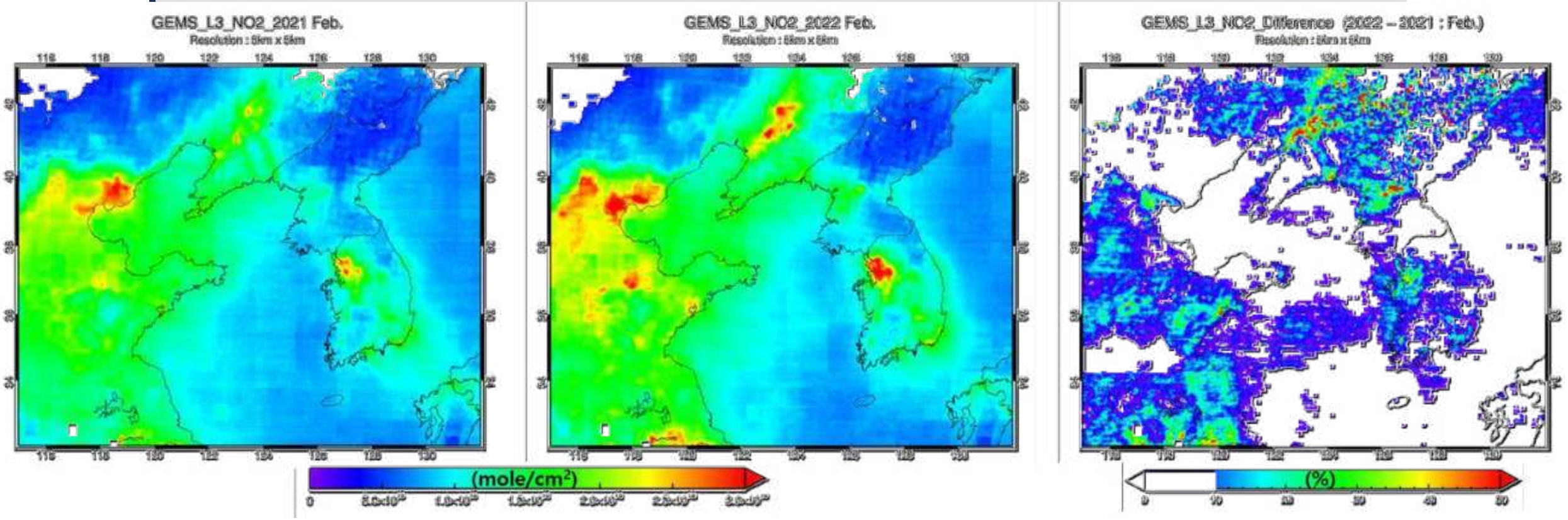
Comparing prior year data by month: ‘21.1. vs ‘22.1

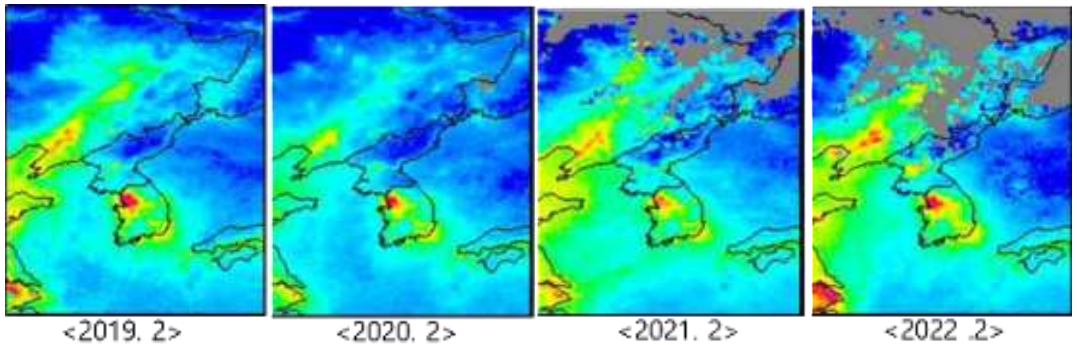




<Tropomi ‘19.1.~’22.1.>

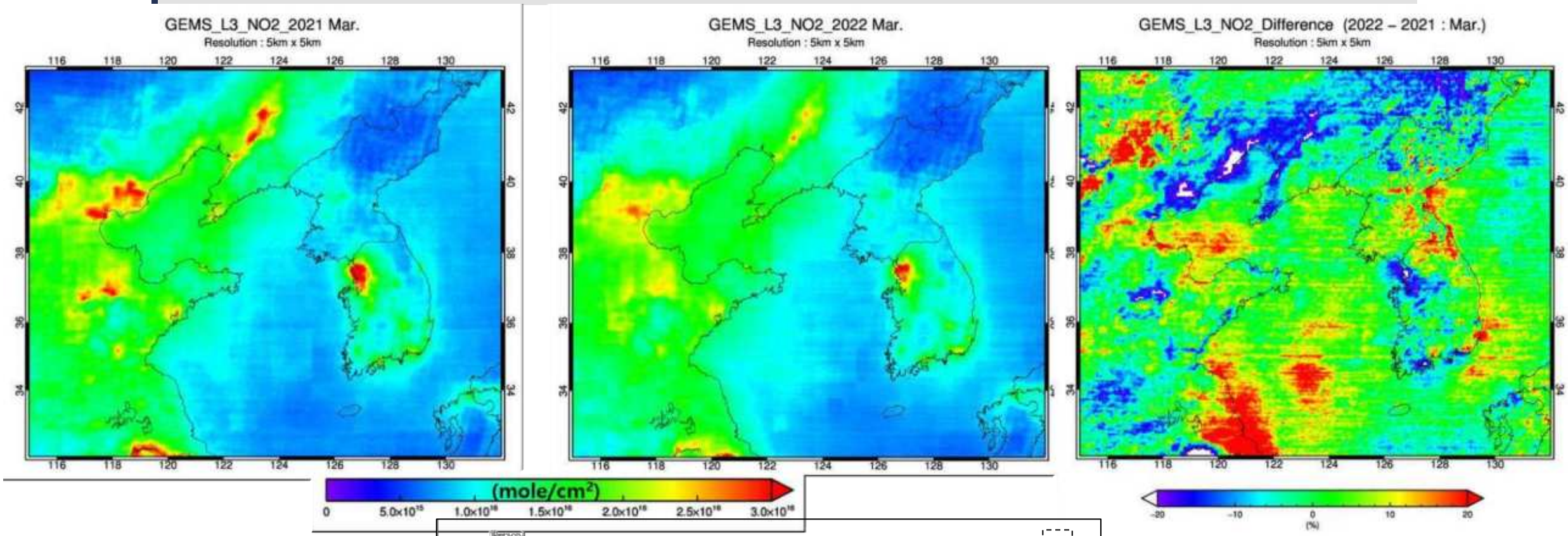
Comparing prior year data by month: ‘21.2. vs ‘22.2.

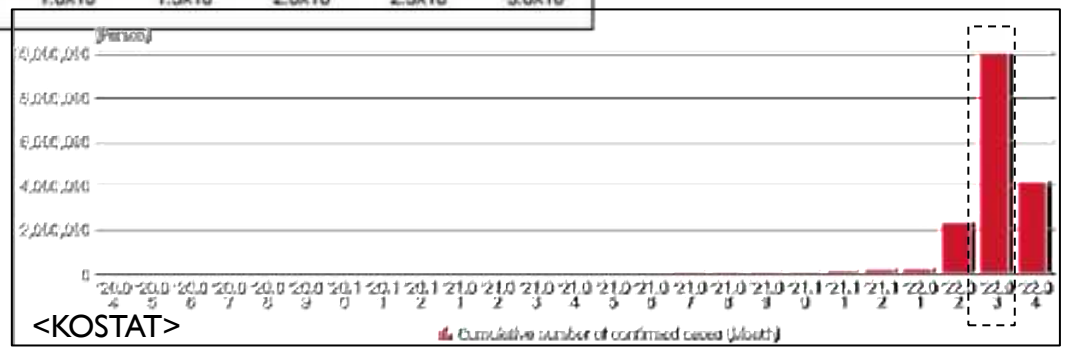




<Tropomi ‘19.2.~’22.2.>

Comparing prior year data by month: ‘21.3. vs ‘22.3

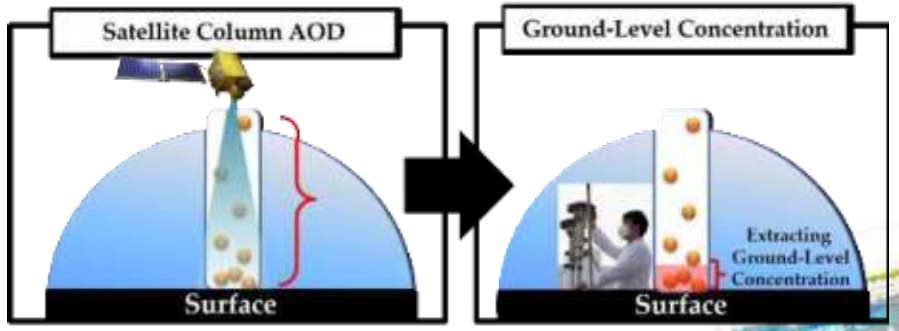


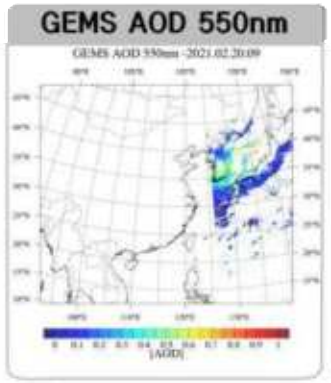


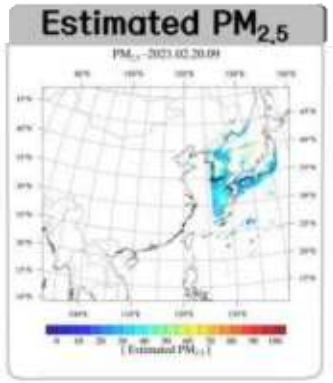
4. GEMS for Air Quality (L4) - Surface PM, LRT

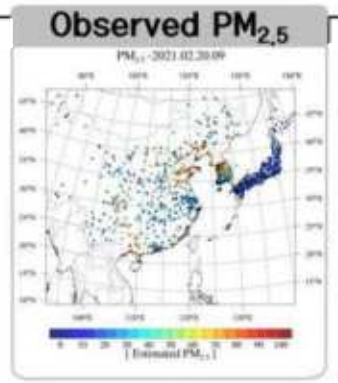
GEMS for Air Quality - L4

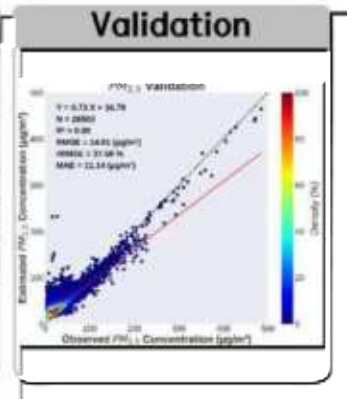
GEMS Surface Concentration of PM

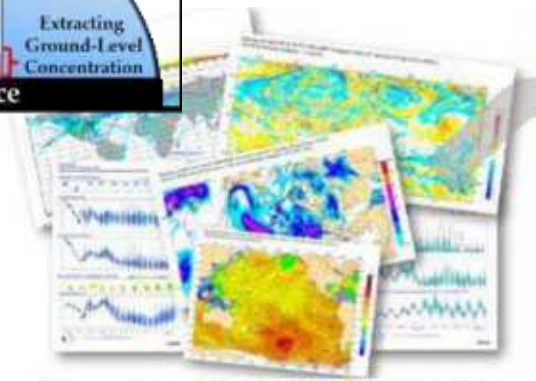










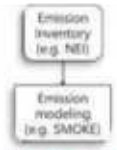


OMI
O_3, NO_2, SO_2 VCD

GOCI
AOD, AE, FMF, SSA

MODIS
NDVI, RSDN

SRTM
DEM

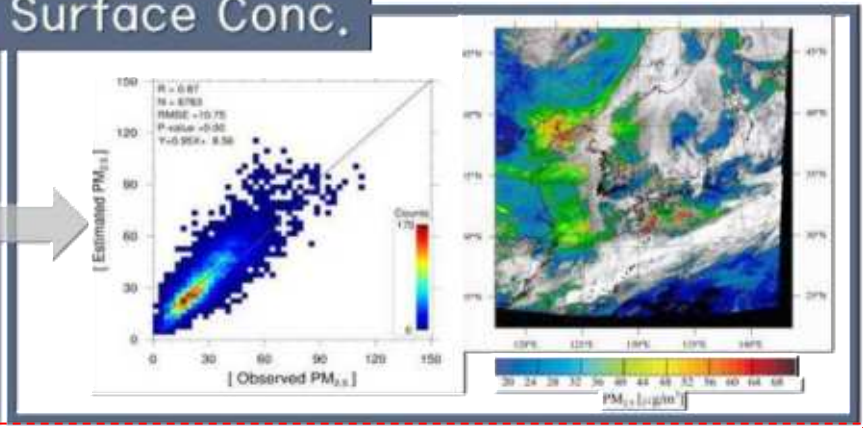


배출량 모델
대기배출량 자료

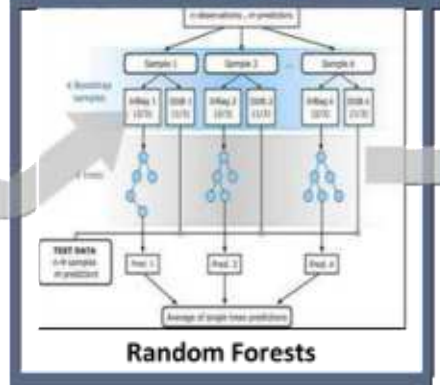
UM RDAPS
수치모델 자료

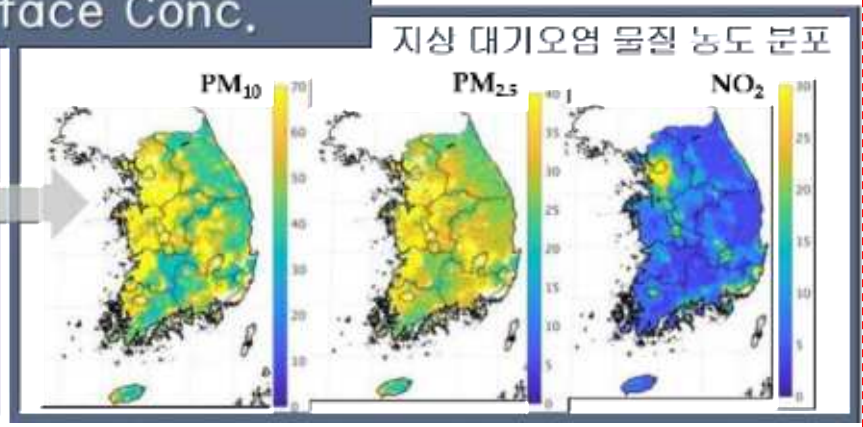
Statistics based Surface Conc.

$$PM_{2.5} = \beta_0 + \alpha_0 \times \tau + \sum_{n=1}^{m} (\beta_n \times Mn)$$



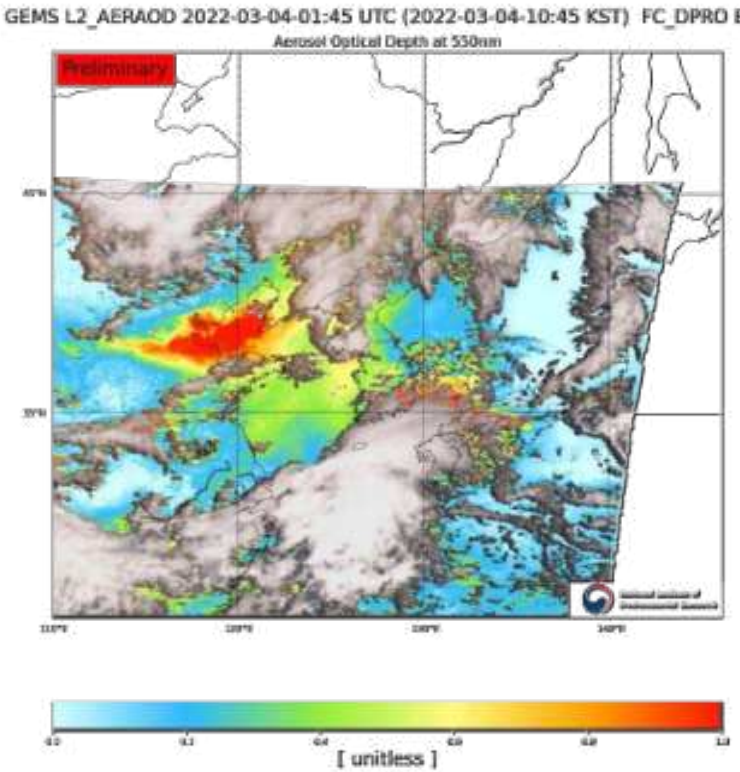
AI based Surface Conc.



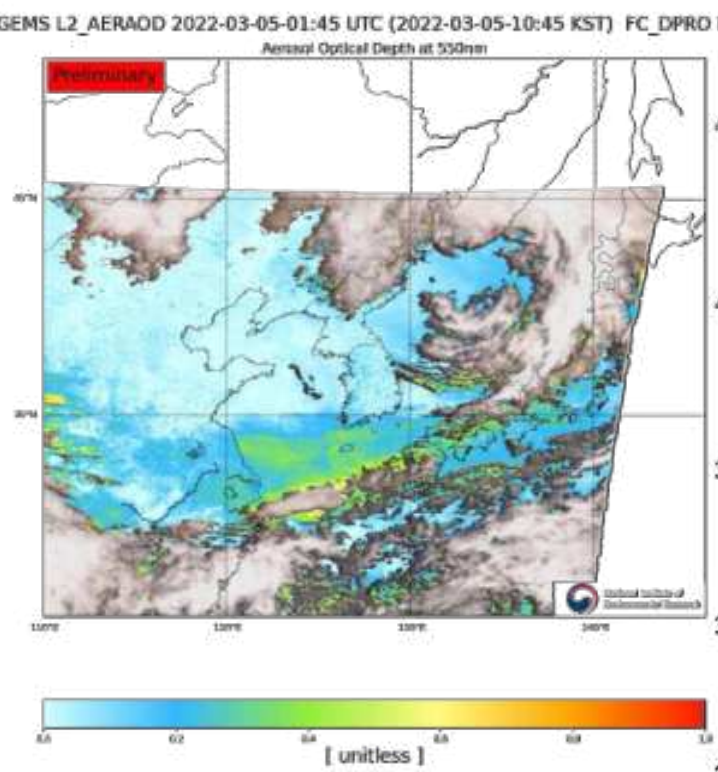


GEMS for Air Quality - L4

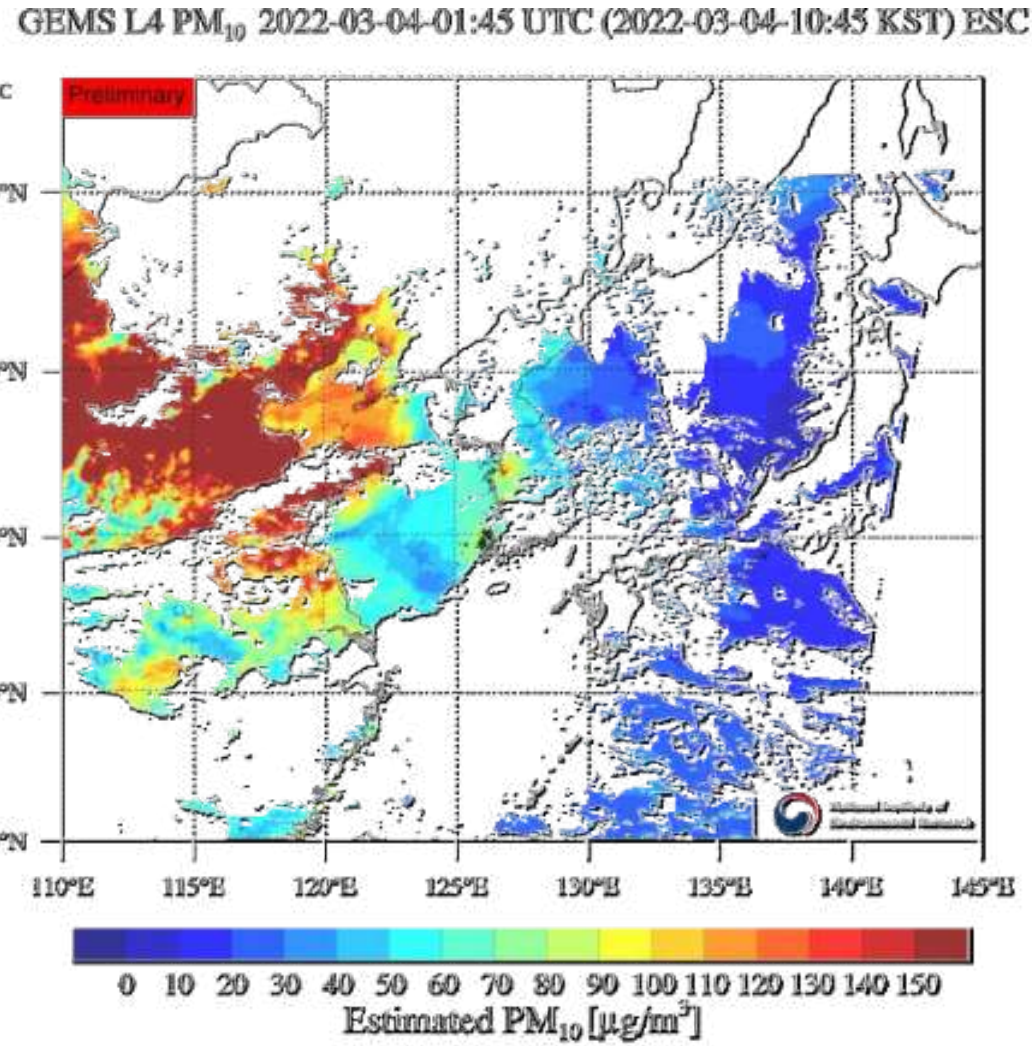
GEMS Surface Concentration of PM



< AOD, 22. 3.4.Yellow Dust >



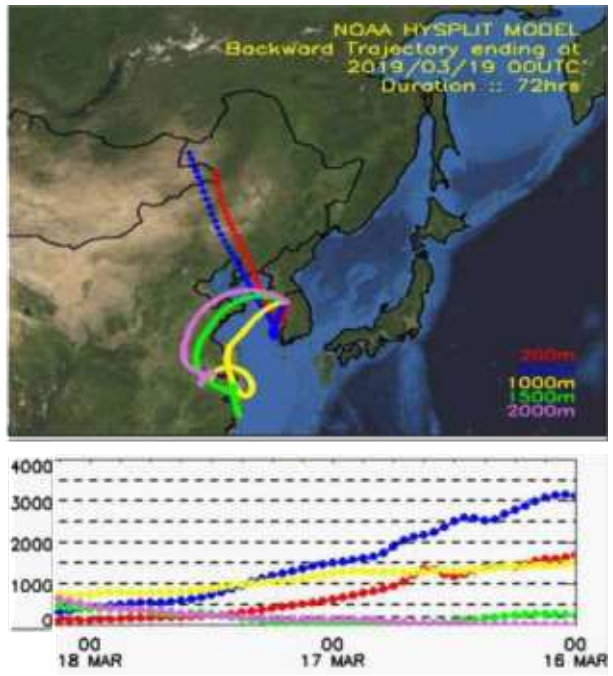
< AOD, 22. 3.5. >



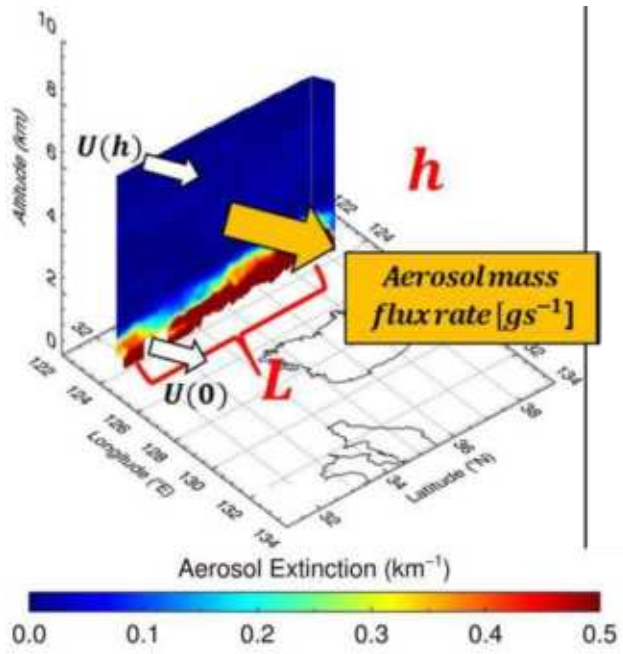
Calculation air-mass flow rate

- Evaluation of air pollutants moving across countries

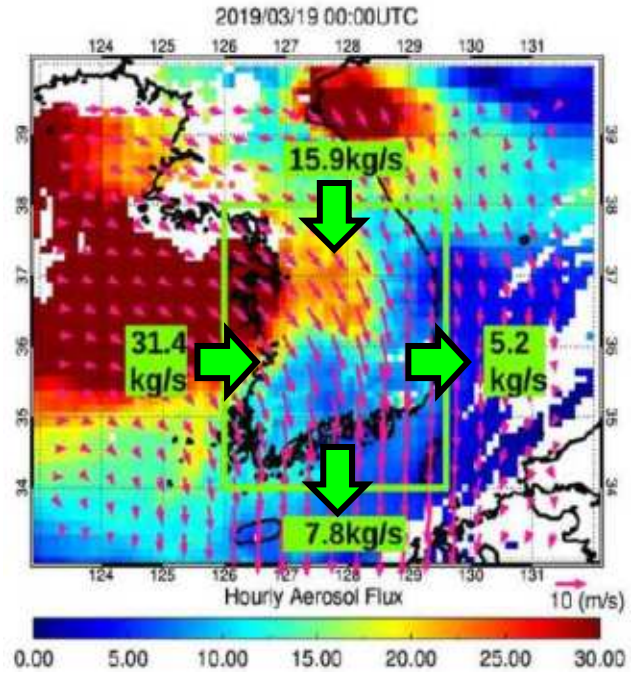
Identification of inflow



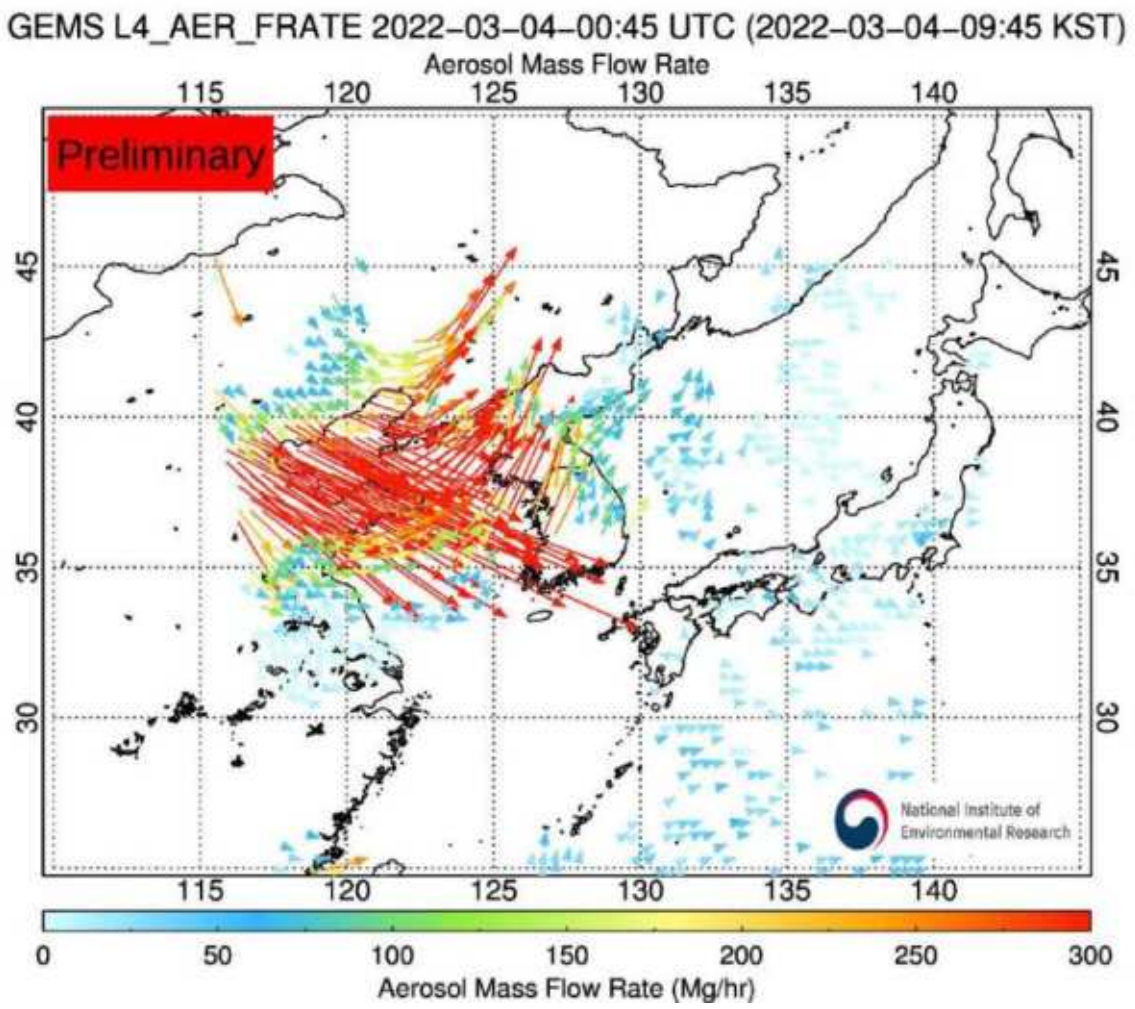
Calculation of inflow/outflow

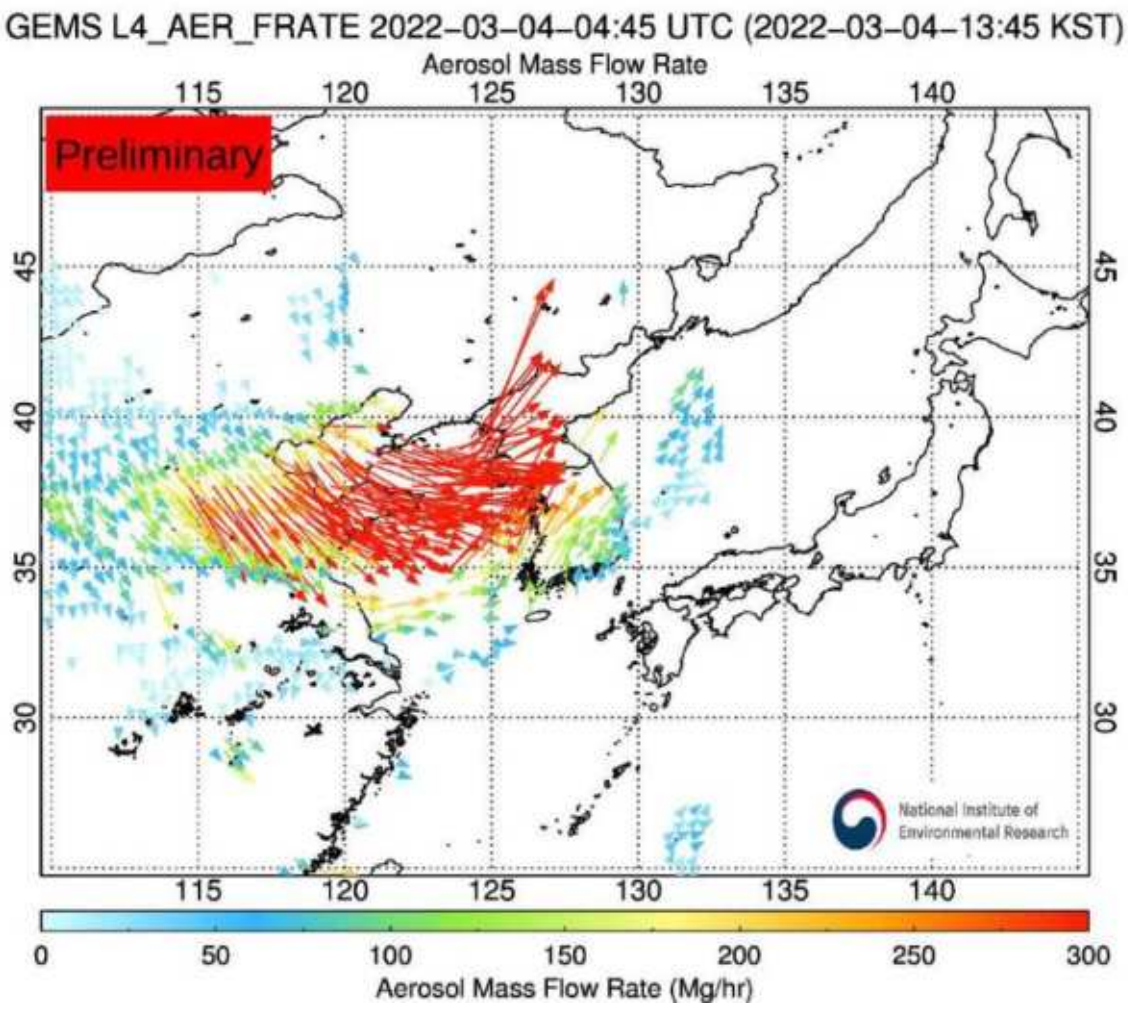


Visualization of inflow/outflow



Calculation air-mass flow rate

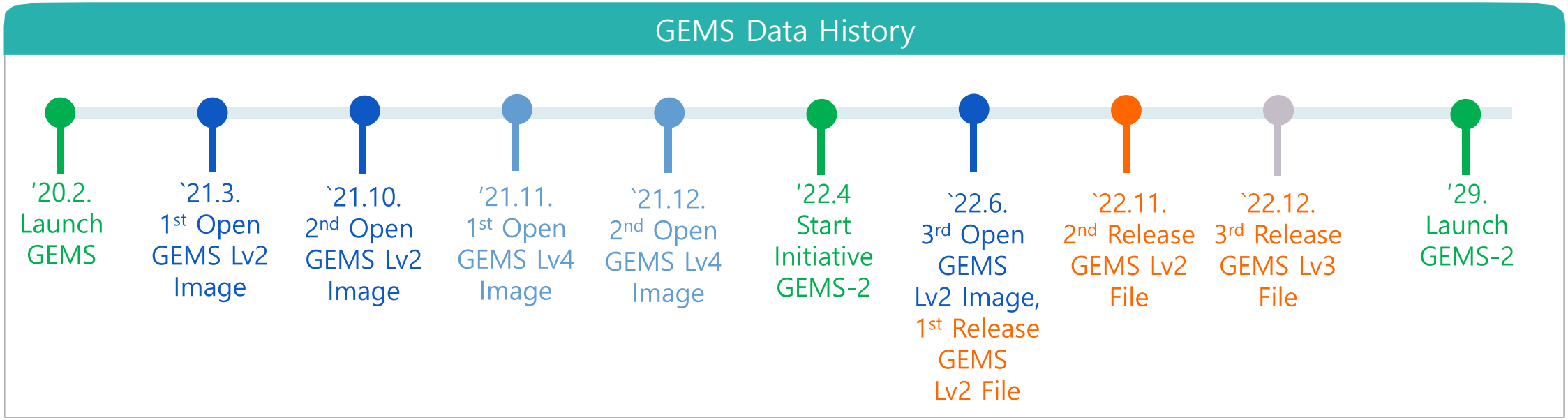




5. GEMS Data Release

GEMS Data Release

Data release plan for this year



1st Release (‘22.6.) Lv2 file product : Cloud, AOD, O3T, UVI, SO2

2nd Release (‘22.11.) Lv2 file product: AEH, O3P, SFC, HCHO, Glyoxal, NO2(troposphere, total)

3rd Release (‘22.12.) Lv3 file product: NO2 (Korea peninsula area)

※ Download data from ESC Hompage: https://nesc.nier.go.kr

☞ L1C: Only offline (HDD) distribution (because of file size, about 8G for 1 scene)

Thank you!