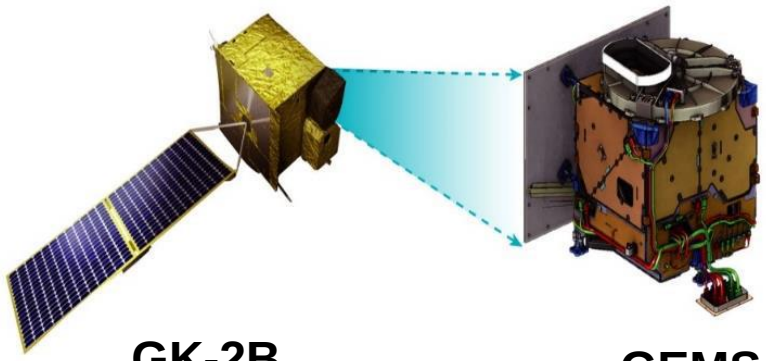
GEMS(Geostationary Environment Monitoring Spectrometer)
Current Status

Jeong-Ah Yu and ESC Members

Environmental Satellite Center (ESC)
National Institute of Environmental Research

1 GEMS Overview



GK-2B **GEMS**

(Geostationary Environment Monitoring Spectrometer)

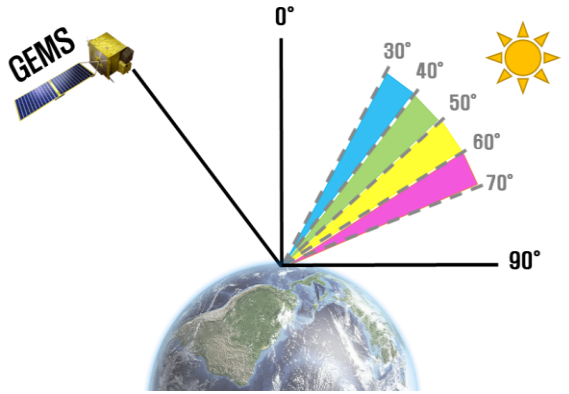
	Specifications of GEMS
Monitoring Items	Ozone(O_3), sulfur dioxide(SO_2), nitrogen dioxide(NO_2), formaldehyde(HCHO), aerosols, etc.
Mission Duration	10 years
Field of Regard	5,000 km x 5,000 km (5S to 45N / 75E to 145E)
Spatial Resolution	7 km (N/S) x 8 km (E/W) (Aerosols: 3.5 km x 8 km)
Observation Cycle	8 Observations per day
Spectral Range/Resolution	300-500nm (UV-VIS) / 0.6nm
Orbit/Altitude/Longitude	Geostationary orbit / 35,786km / 128

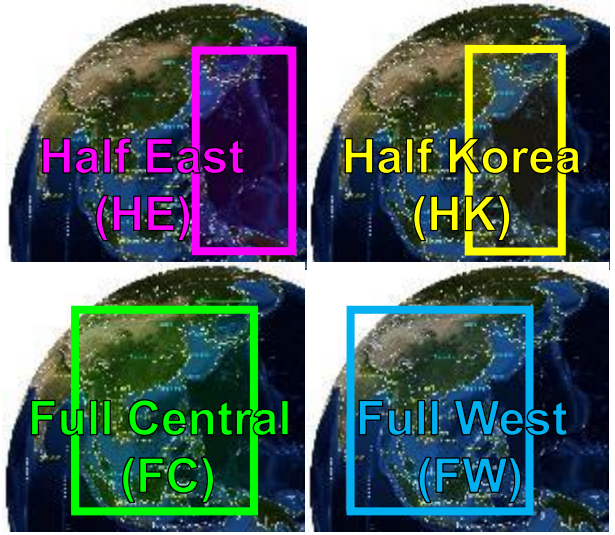
- 2008 GEMS Project start
- 2010 Pre-Feasibility study
- 2012 GEMS Development start
- 2018 ESC established
- Feb.19th 2020 Launch GK-2B
- Mar. 7th 2020 Reached Geostationary Orbit
- In-Orbit Test (IOT, ~Oct.,2020)
- Nov., 2020 Handover of GEMS operations (KARI→ESC)
- Test Operation (Nov.,2020~Mar.,2021)
- Mar., 2021~ Start Web Service
- 2021 Post-GEMS Project start
- Nov., 2022 All 21 L2 products fully released (Nov.)
- 2023 GHG satellite Project start
- Feb., 2024 Change of GEMS scan scenario
- 2024 L4 data released (Surface PM) (Oct.)
- L2 Version 3 data released (Dec.)
- Launch of GIS viewer service (Dec.)
- Apr., 2025 Official release of GEMSAT

2 Change of GEMS Scan Scenario (since 1 Feb 2024)

Scan Area by solar zenith angle

* Solar Zenith Angle : angle between the sun and the vertical





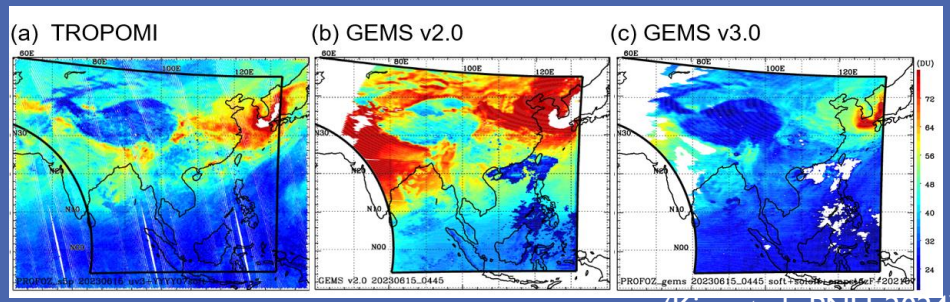
Month	07:45	08:45	09:45	10:45	11:45	12:45	13:45	14:45	15:45	16:45	#
1	-	-	HE	HK	FC	FW	FW	FW	-	-	6
2	-	-	HE	HK	FC	FW	FW	FW	FW	-	7
3	-	HE	HK	FC	FC	FW	FW	FW	FW	-	8
4	HE	HK	FC	FC	FC	FW	FW	FW	FW	FW	10
5	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	10
6	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	10
7	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	10
8	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	10
9	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW	10
10	-	HE	HK	FC	FC	FW	FW	FW	FW	-	8
11	-	-	HE	HK	FC	FW	FW	FW	-	-	6
12	-	-	HE	HK	FC	FW	FW	FW	-	-	6

	Before	After
Obs. Frequency	Winter : 6 / day (Jan, Feb, Nov, Dec) Summer : 10 / day (Jun ~ Sep)	Winter : 7 / day (Jan, Feb, Nov) Summer : 9 / day (Jun ~ Sep)
Obs. Mode	09:45 – 12:45 KST : HE, HK, FC modes depending on season	09:45 – 12:45 KST : All in FC mode

Month	07:45	08:45	09:45	10:45	11:45	12:45	13:45	14:45	15:45	16:45	#
1	-	-	FC	FC	FC	FC	FW	FW	FW	-	7
2	-	HE	FC	FC	FC	FC	FW	FW	FW	-	8
3	-	HE	FC	FC	FC	FC	FW	FW	FW	-	8
4	HE	HK	FC	FC	FC	FC	FW	FW	FW	FW	10
5	HE	HK	FC	FC	FC	FC	FW	FW	FW	FW	10
6	-	HK	FC	FC	FC	FC	FW	FW	FW	FW	9
7	-	HK	FC	FC	FC	FC	FW	FW	FW	FW	9
8	-	HK	FC	FC	FC	FC	FW	FW	FW	FW	9
9	-	HK	FC	FC	FC	FC	FW	FW	FW	FW	9
10	-	HE	FC	FC	FC	FC	FW	FW	FW	-	8
11	-	HE	FC	FC	FC	FC	FW	FW	FW	-	8
12	-	-	FC	FC	FC	FC	FW	FW	-	-	6

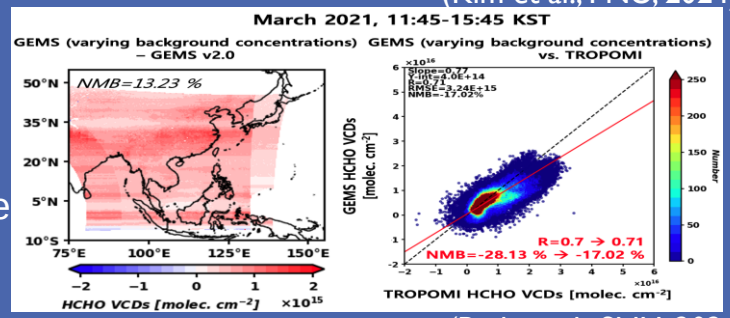
3 GEMS L2 Algorithm Updates (Dec 2024, v2.0→3.0)

O3P
Optimized Pre-processing of GEMS L1
(Update: Slit function, Radiation Offset, Soft Calibration)



(Kim et al., PNU, 2024)

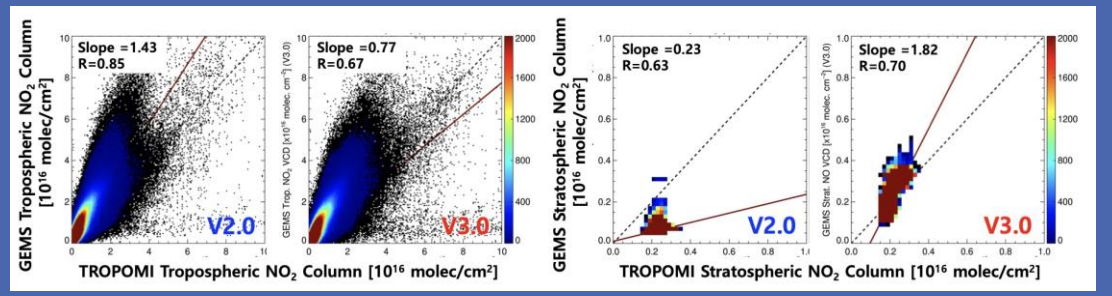
HCHO
Background Concentration correction and Surface Reflectance Input Updated
(OMI LER→GEMS BSR)

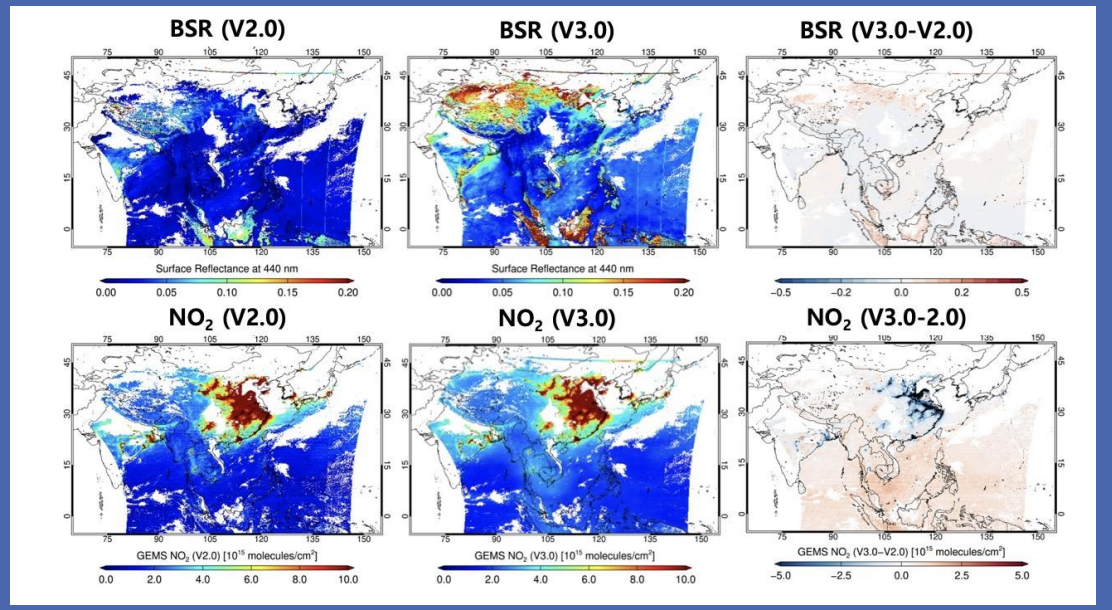


(Park et al., SNU, 2024)

GEMS L2 Product	version	GEMS L2 Product	version
AOD	2.0 → 2.1	O3P	2.0 → 3.0
AEH	2.0 → 2.1	HCHO	2.0 → 3.0
CLD	2.0 → 3.0	CHOCHO	2.0 → 2.1
NO_2	2.0 → 3.0	BSR	1.3(2.0) → 3.0
SO2	2.0 → 2.1	UVI	2.0 → 2.1
O3T	2.0 → 2.1		(Update : Dec 2024)

NO_2
Partially Resolved Issues of Tropospheric NO_2 Overestimation and Stratospheric NO_2 Underestimation
(Update: Shape Factor, Tropopause, Input surface)



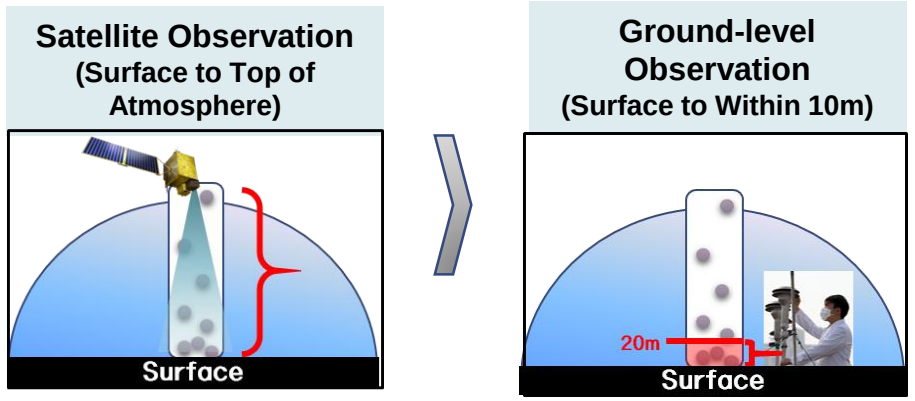


(Lee et al., PKNU, 2024)

4 GEMS L4 Data Release (Surface PM)

GEMS L4 - Estimated surface PM concentration

< Conceptual Diagram of Satellite and Ground Observations >



< GEMS L4 Products >

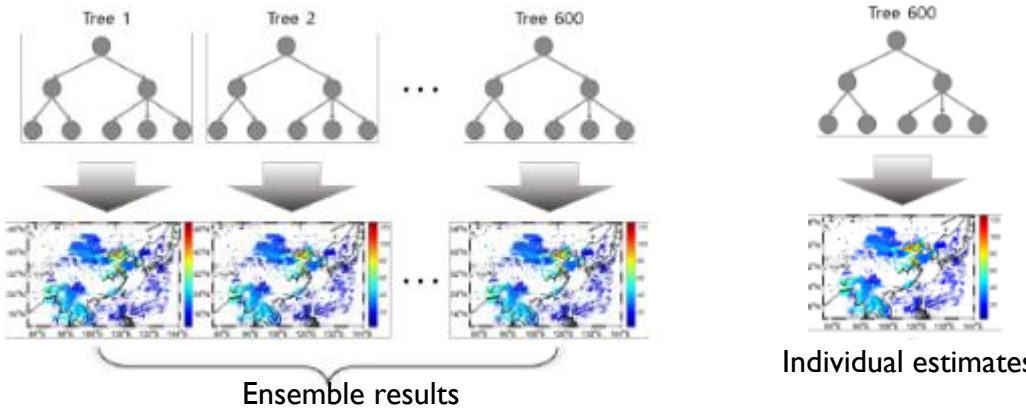
Product		Image release date	Data release date
Flow rate	Aerosol	Nov 5, 2021	
	SO_2	Dec 8, 2022	
Estimated Surface Concentration	PM_{10}	Dec 30, 2021	**Oct 30, 2024**
	$PM_{2.5}$	Dec 30, 2021	**Oct 30, 2024**
	NO_2	Dec 20, 2022	
Ratio	NO_2/CO_2(yearly)	Nov 29, 2023	
	NO_2/CO_2(seasonal)	Nov 29, 2023	

Surface PM data in NetCDF format (GEMS L4)

Datasets | Catalogs | Bookmarks

Name	Long Name	Type
GK2_GEMS_L4_20250528_0445_PM25-S...	GK2_GEMS_L4_20250528_0445_PM25-SURFAC...	Local File
Data_Fields	Data_Fields	—
CloudFraction	CloudFraction	Geo2D
Importance	Importance	1D
PM25	Surface PM2.5 Concentrations	Geo2D
SMAPE	Symmetric Mean Absolute Percentage Error	Geo2D
Geolocation_Fields	Geolocation_Fields	—
Latitude	Latitude	Geo2D
Longitude	Longitude	Geo2D

< Pixel-level uncertainty estimation using AI(Random Forest) >



$$SMAPE = \frac{100}{n}\sum_{t=1}^{n}\frac{|F_t - A_t|}{(|A_t| + |F_t|)}$$

Symmetric Mean Absolute Percentage Error

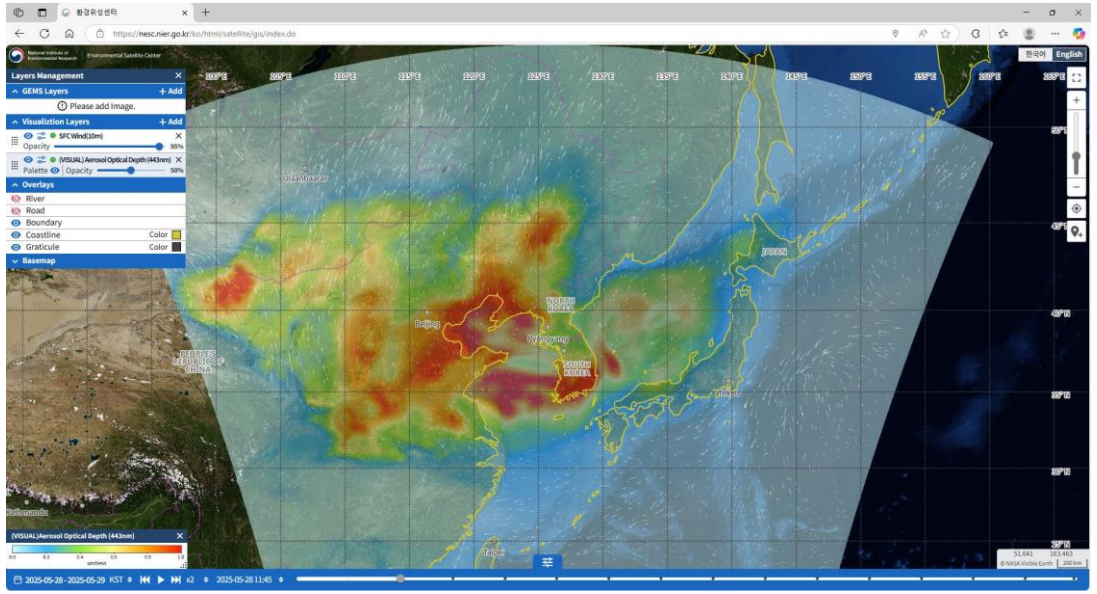
F_t : RF tree-level estimates
A_t: RF ensemble output
n: Number of trees in the model

5 GIS Viewer & GEMSAT

GIS Viewer (nesc.nier.go.kr/en/html/satellite/gis/imdex.do)

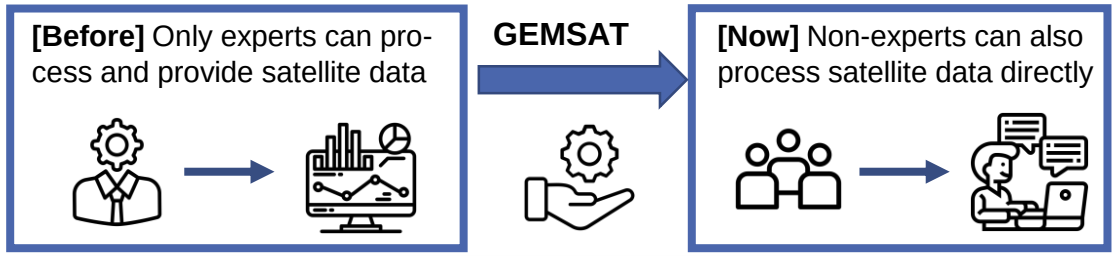
- Environmental Satellite Center is launching a map-based satellite imagery service to enhance user convenience.

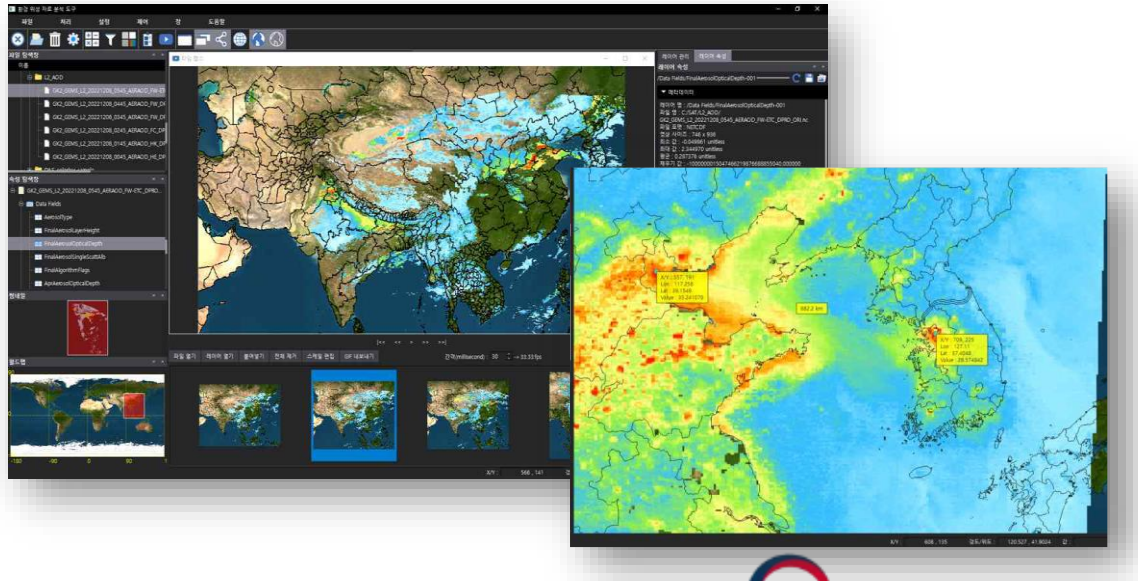
- Launch data : 30 Dec 2024
- Available data : GEMS L2, L3 and L4 images (gap-filled)



GEMSAT (GEMS Application Tool)

- GEMSAT is a multifunctional software platform designed to make it easy for anyone to view and analyze GEMS imagery.
  - Beta service : Jun 28, 2023 – Apr 29, 2025, Official release date : Apr 30, 2025





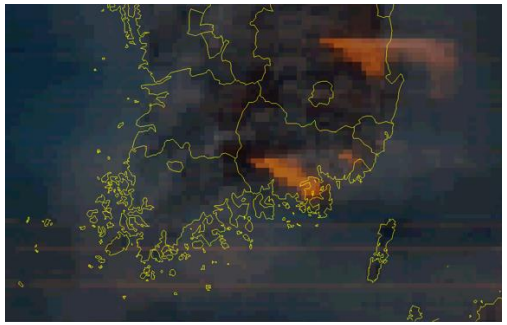
6 GEMS in Action: Detecting Wildfires in 2025

A series of wildfires in Gyeongsang area, Korea

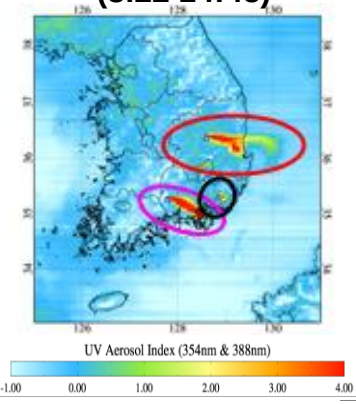
- Satellite analysis of simultaneous wildfile across the southeastern part of S. Korea (Sancheong on Mar 21, Uiseong and Gimhae on Mar 22)

< wildfire location >

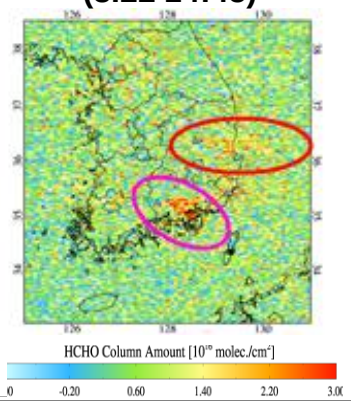
< False Color Composite >



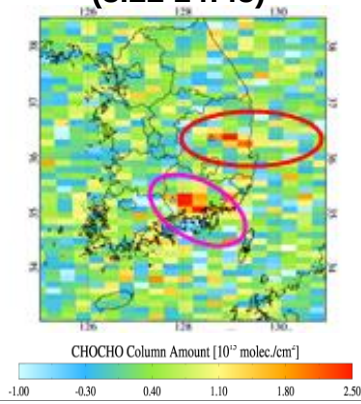
< UV Aerosol Index> (3.22 14:45)



< HCHO > (3.22 14:45)

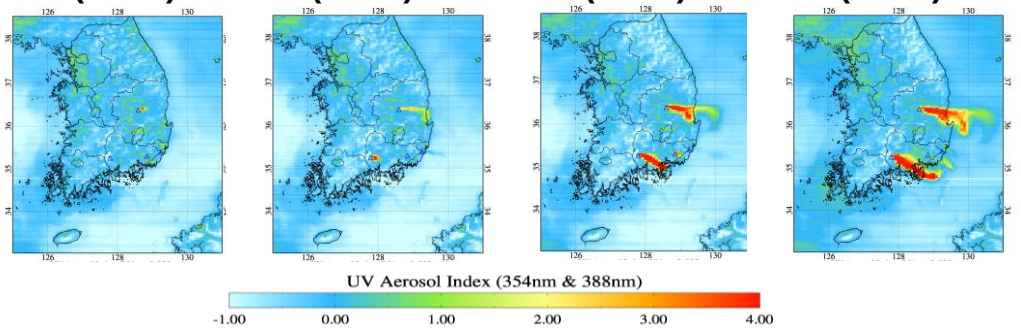


< CHOCHO > (3.22 14:45)



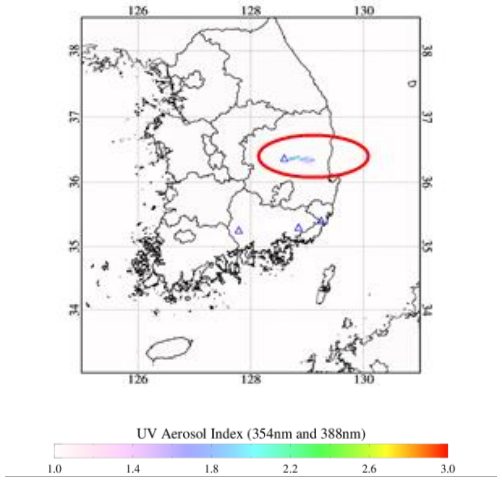
< Hourly Spatial Variation of UV Aerosol Index (Mar 22) >

(12:45) **(13:45)** **(14:45)** **(15:45)**

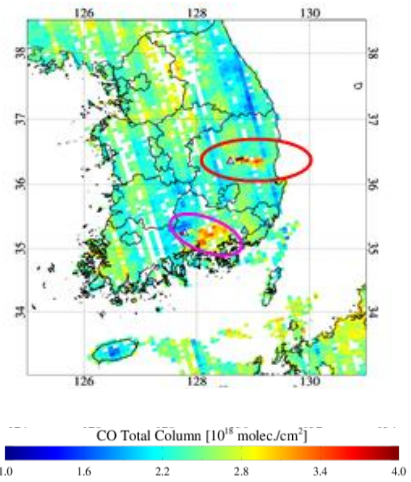


※ TROPOMI (3.22)

< Absorbing Aerosol Index >



< CO >



7 Summary

- GEMS observes UV-visible range (300–500 nm) and scans Asia ~8 times/day.
- In Feb 2024, the scan scenario was changed to continuously observe the same FC region including the Pacific area and to support aircraft campaigns.
- On Dec 10, 2024, L2 Algorithm v3.0 was released. It improved NO_2, O_3P, and HCHO accuracy significantly.
- As of Oct 30, 2024, estimated surface PM data are available in NetCDF format with SMAPE uncertainty.
- GIS Viewer launched on Dec 30, 2024. GEMSAT v1.2 officially released on Apr 30, 2025, for data display and analysis.
- GEMS successfully detected wildfire smoke events in southern Korea in 2025 and tracked their movement over time.

Thank you