AOMSUC-15 2025 FYSUC

THE 15TH ASIA-OCEANIA METEOROLOGICAL SATELLITE USERS' CONFERENCE (AOMSUC-15)
2025 FENGYUN SATELLITE USER CONFERENCE (2025 FYSUC)

A Review of the Fengyun Satellites for Atmospheric Environment Monitoring

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National Satellite Meteorological Center (National Center for Space Weather)

China Meteorological Administration

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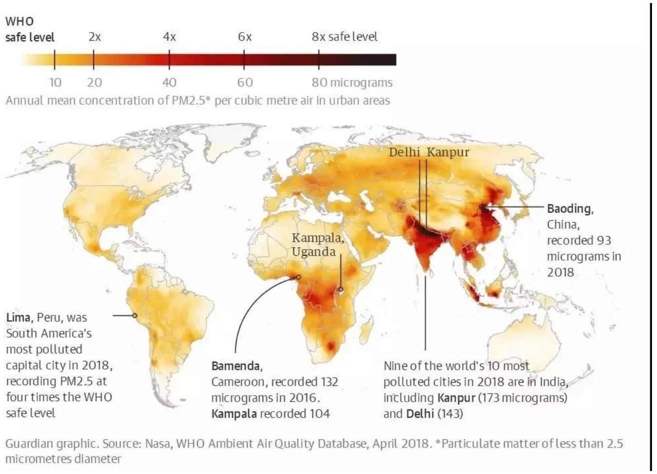
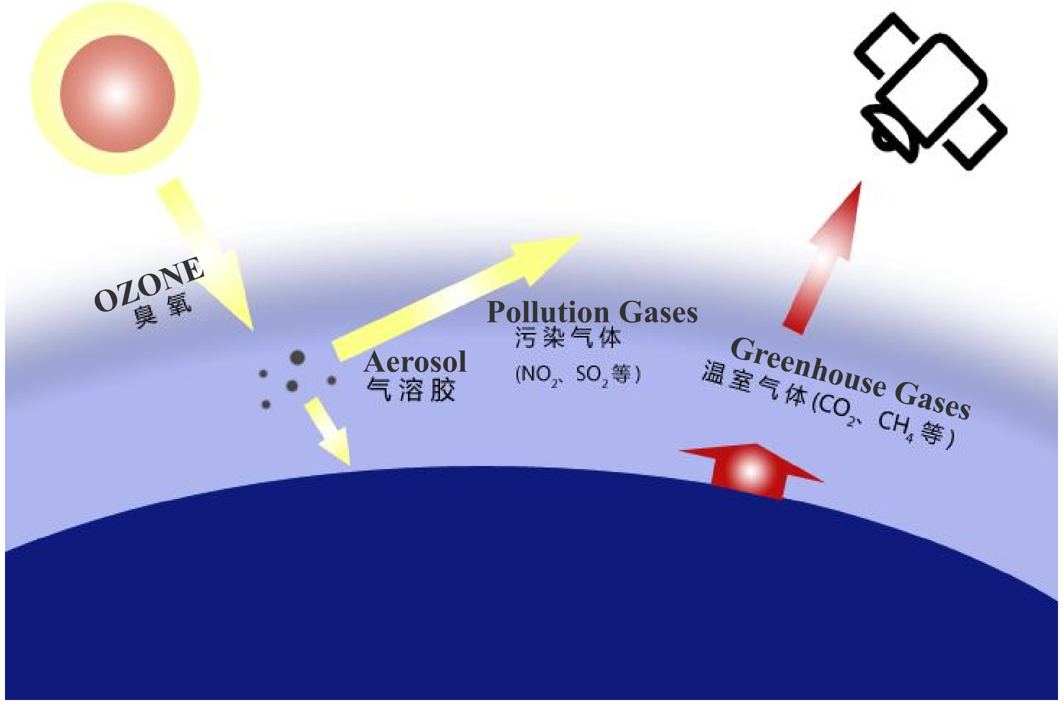
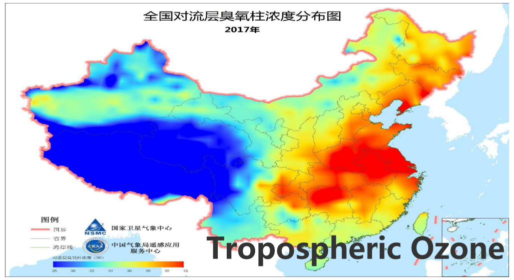
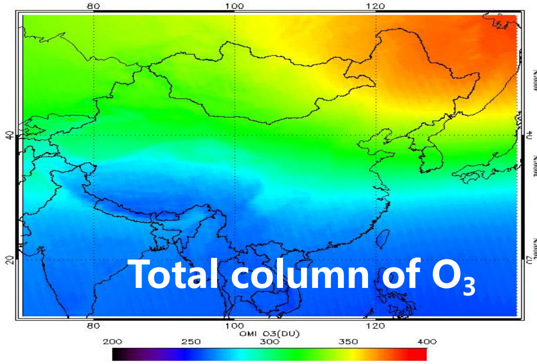
What can satellites do?

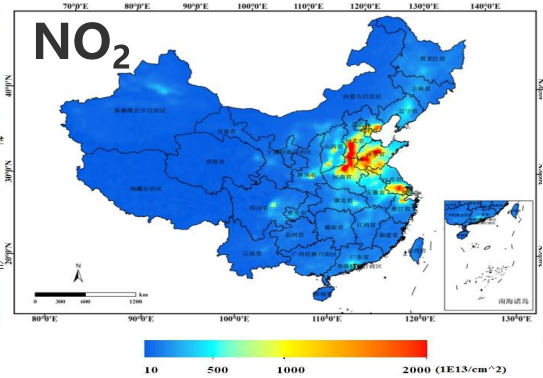


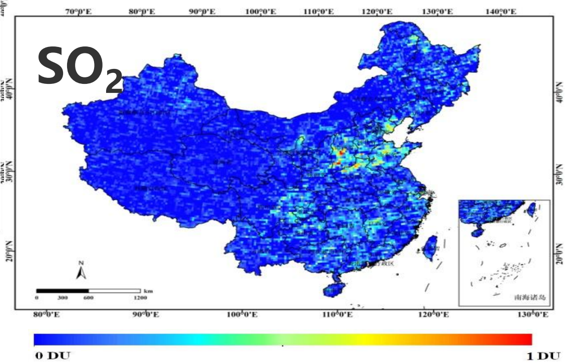


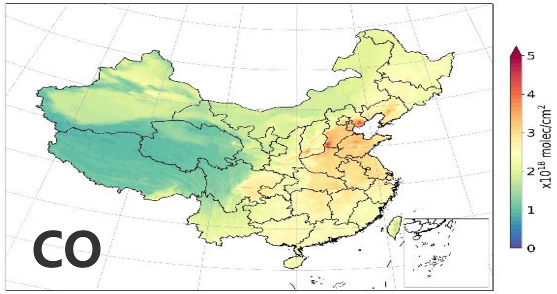
What do they already do?

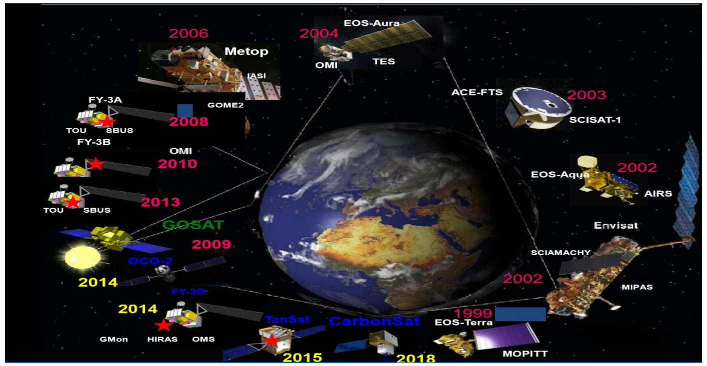


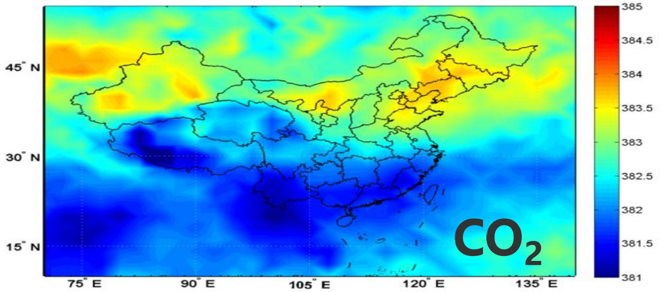


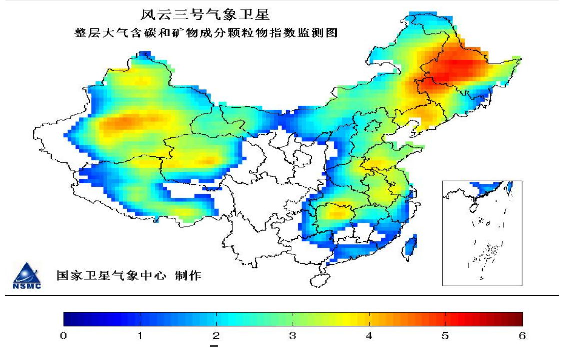


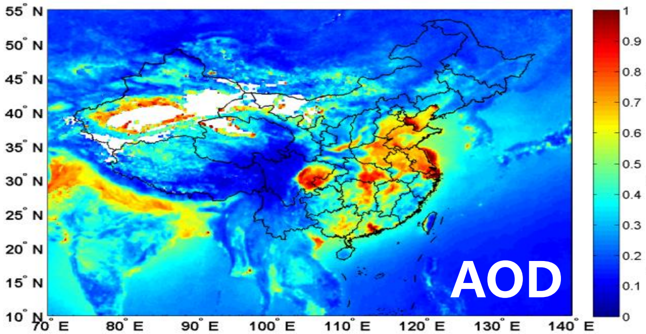


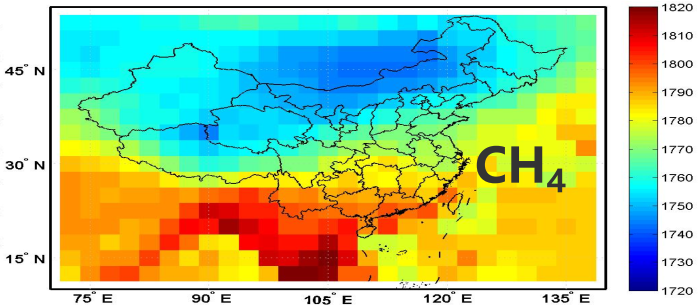












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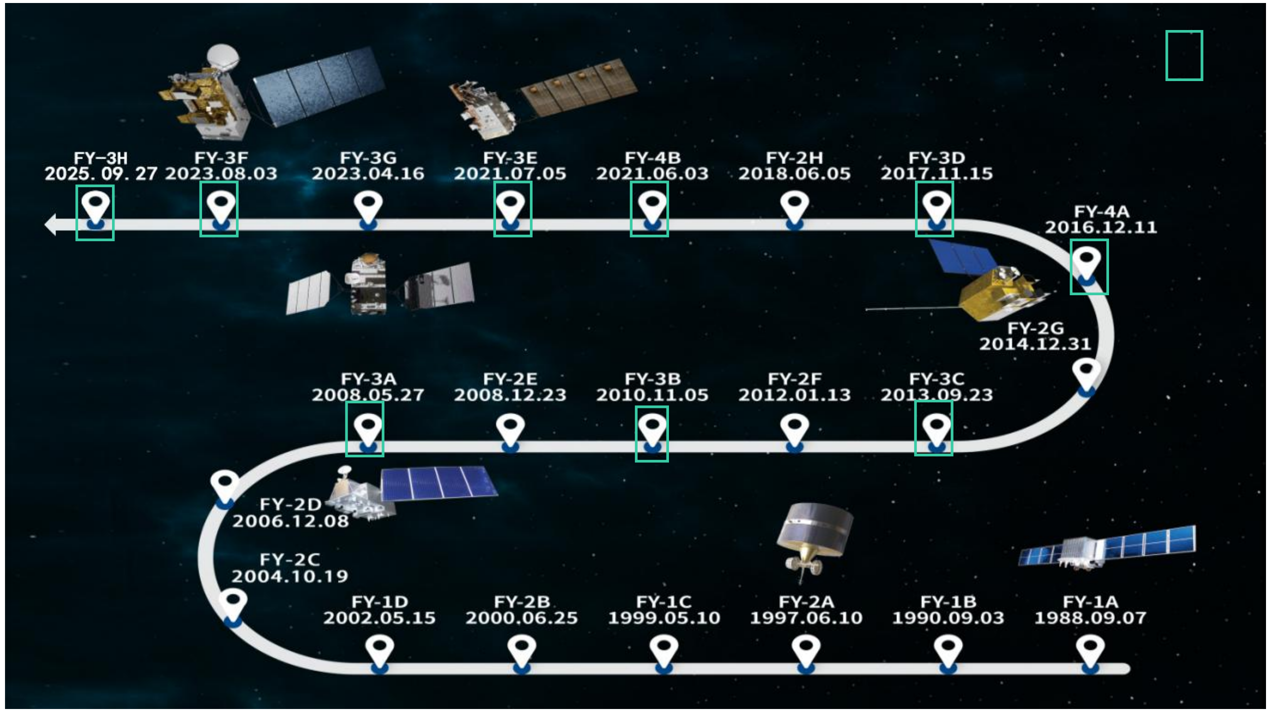
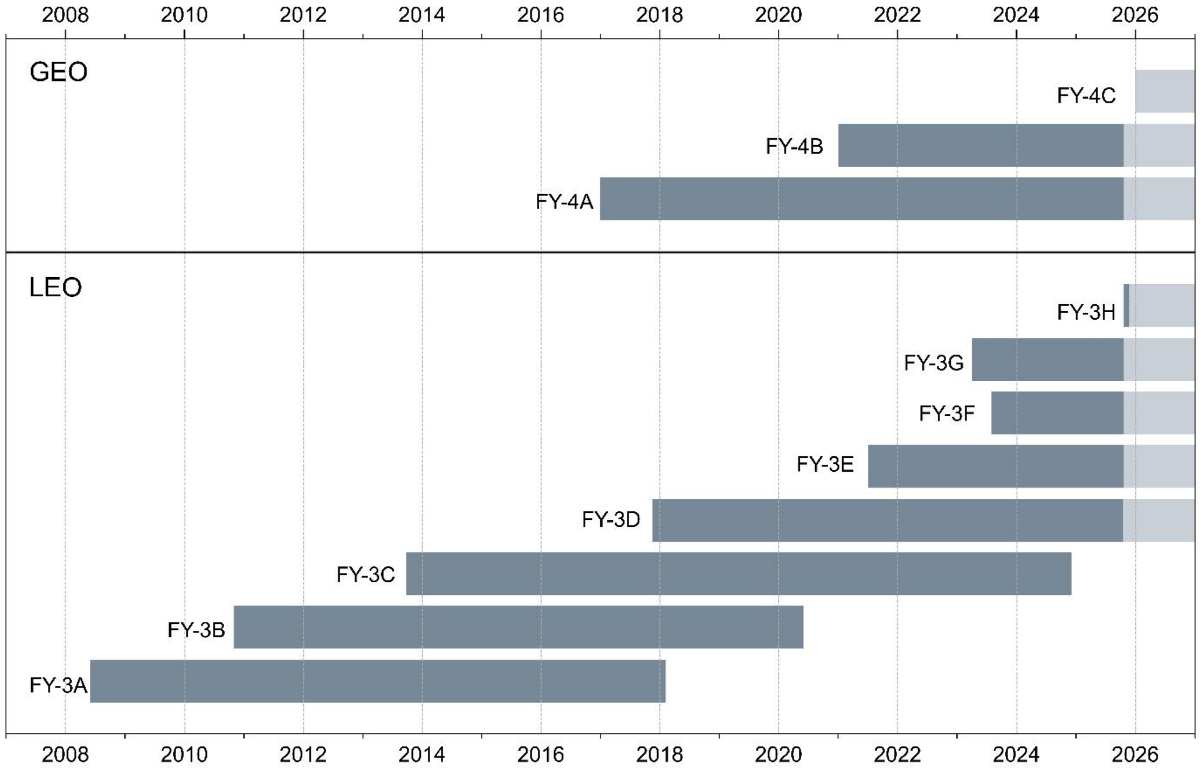
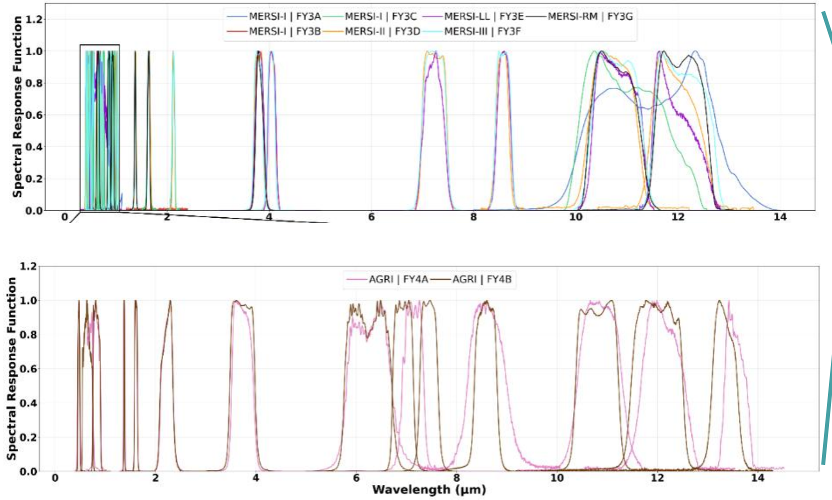
Fengyun satellites related to atmospheric composition monitoring

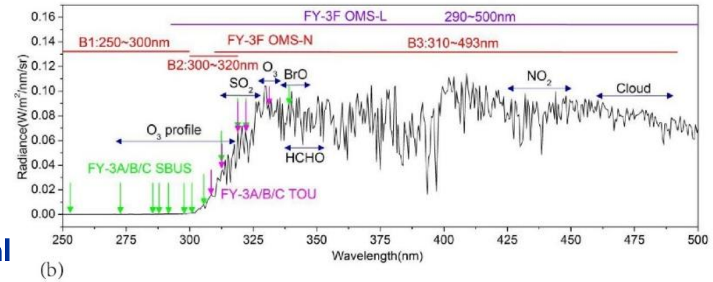




Images

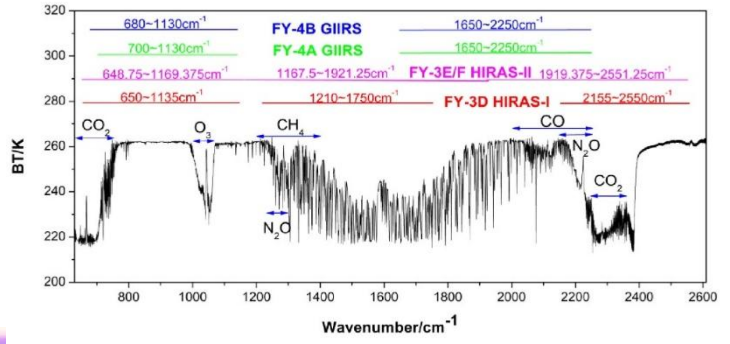


(a)



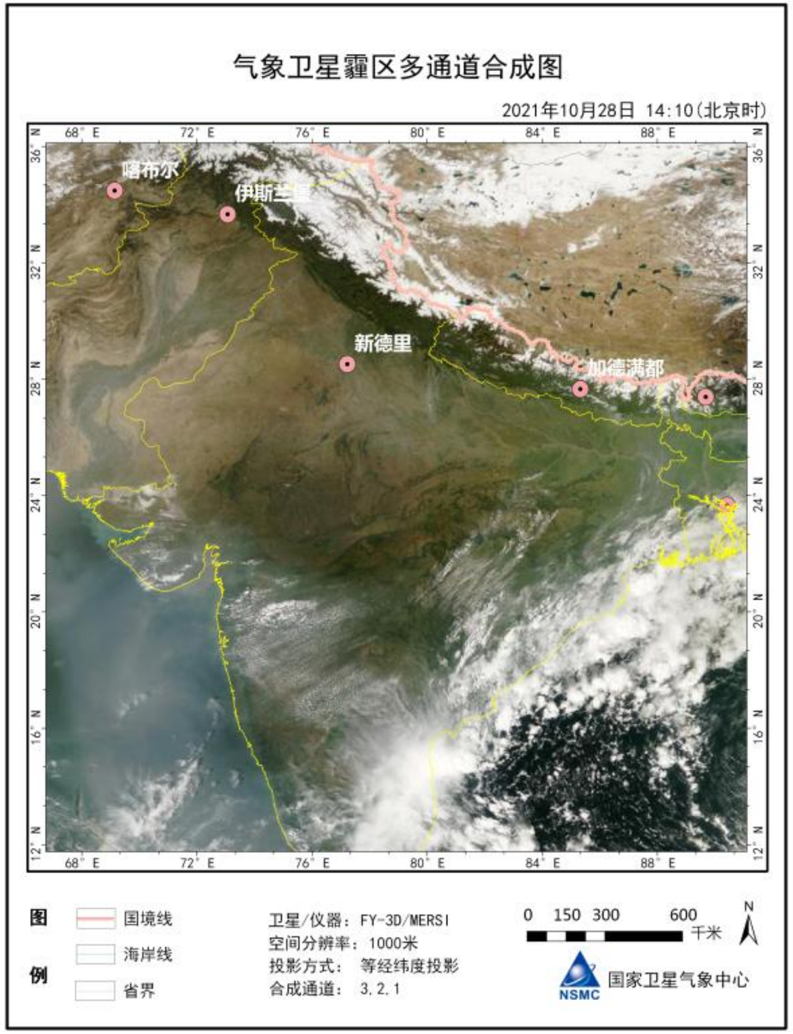
hyperspectral

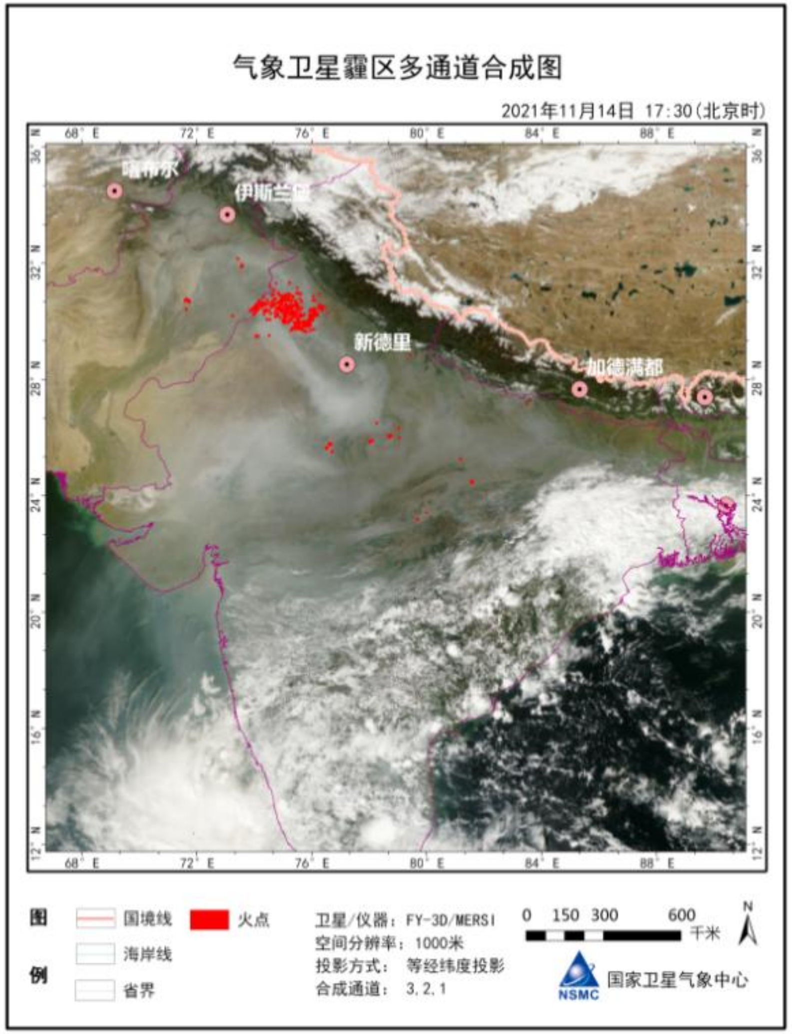
(b)



Species	Sensor	Satellite
Aerosol Optical Depth	MERSI-I/II/III AGRI	FY-3A, FY-3B, FY-3C, FY-3D, FY-3F FY-4A, FY-4B
Absorbing Aerosol Index	TOU	FY-3A, FY-3B, FY-3C
Total colomn of O_3	TOU OMS	FY-3A, FY-3B, FY-3C FY-3F
Profile of O_3	SBUS OMS HIRAS GIIRS	FY-3A, FY-3B, FY-3C FY-3F FY-3D, FY-3E, FY-3F
SO_2	OMS	FY-3F
NO_2	OMS	FY-3F
CO	GIIRS HIRAS	FY-4A, FY-4B FY-3D, FY-3E, FY-3F
NH_3	GIIRS HIRAS	FY-4A, FY-4B FY-3D, FY-3E, FY-3F
HCOOH	GIIRS	FY-4A, FY-4B
CO_2	GAS	FY-3D, FY-3H
CH_4	GAS	FY-3D, FY-3H

Clean Day .VS. Polluted Day





(1) Haze area identification

True color image **Haze Detect**

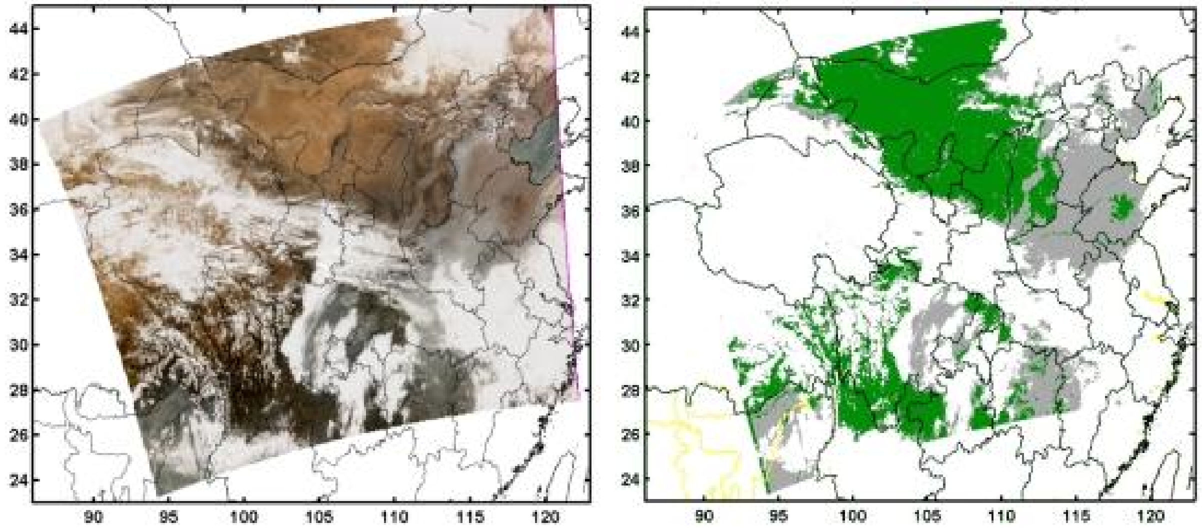


Fig. True color image (left) and haze identification map (right) of FY-3D at 06:05 UTC 23 January 2021

The cloud and snow cover pixels are filtered before the identification of haze pixels. Then, **the air molecular scattering correction** is introduced to avoid the misdetection of haze pixels under large view angle.

85. 6% **Validation** 91. 1%

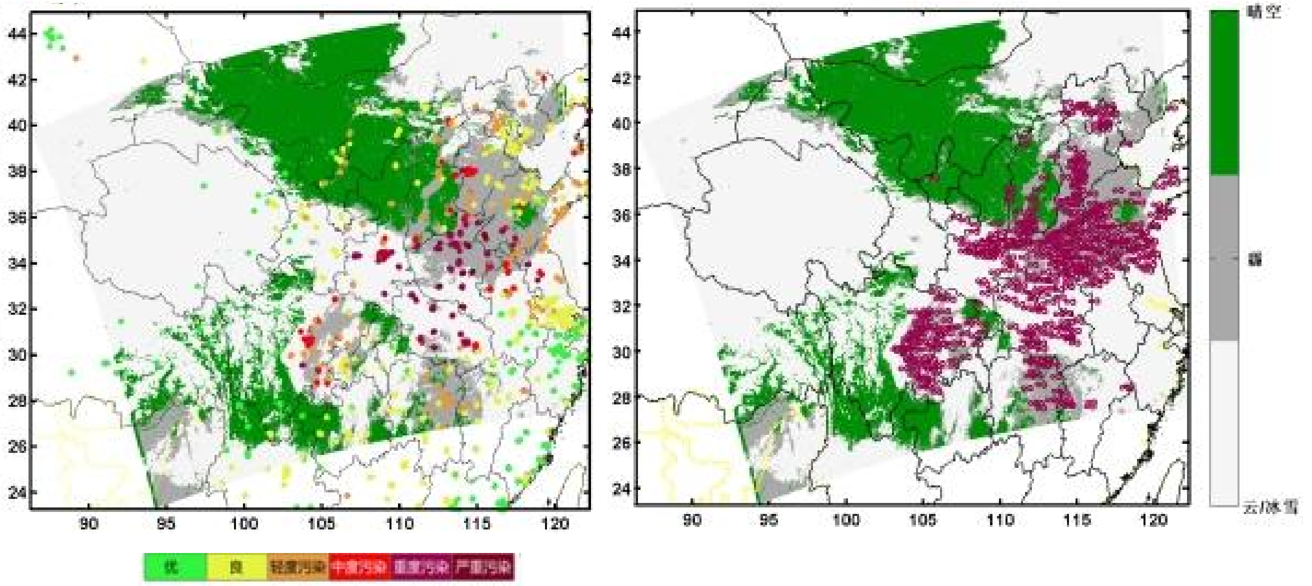


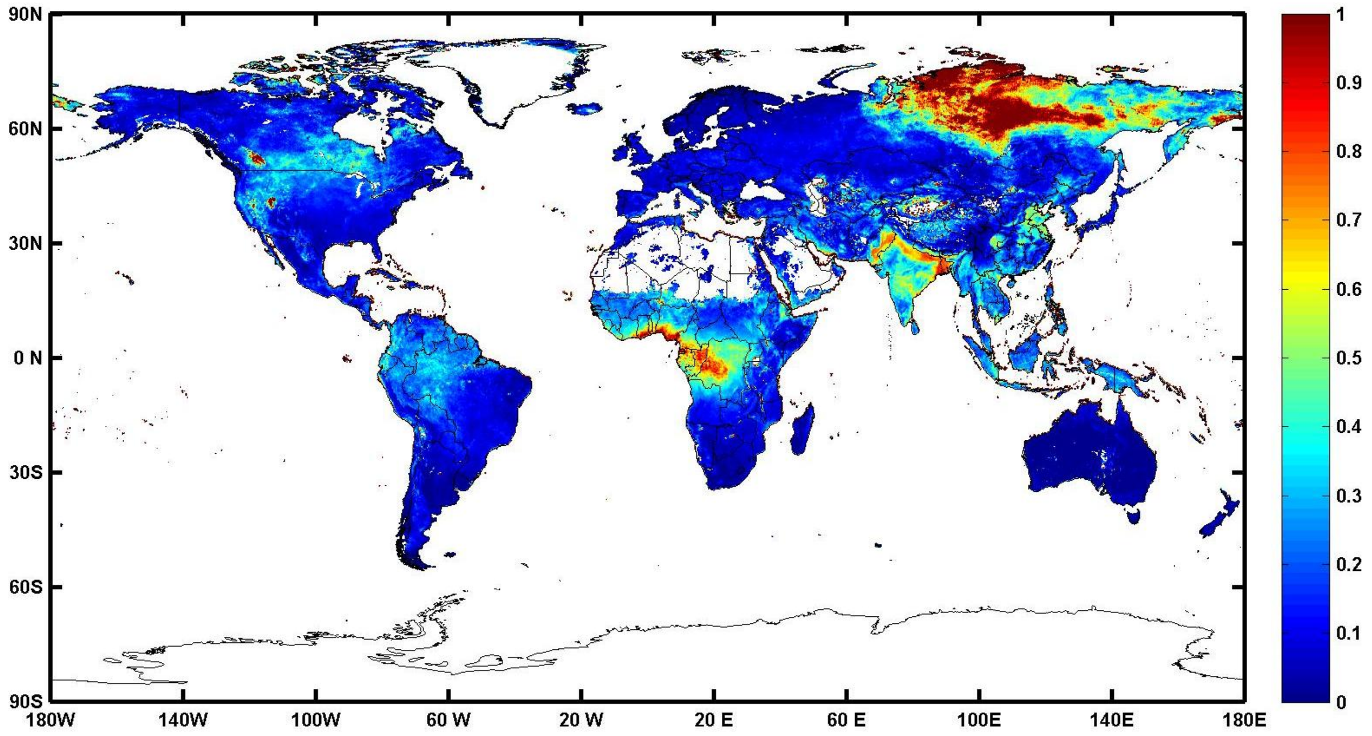
Fig. Haze identification map of FY-3D with ground-based observations at 06:05 UTC 23 January 2021 (left. PM2.5 at environmental monitoring stations, right. haze records at meteorological stations marked by∞ symbol)

(2) Aerosol Optical Depth

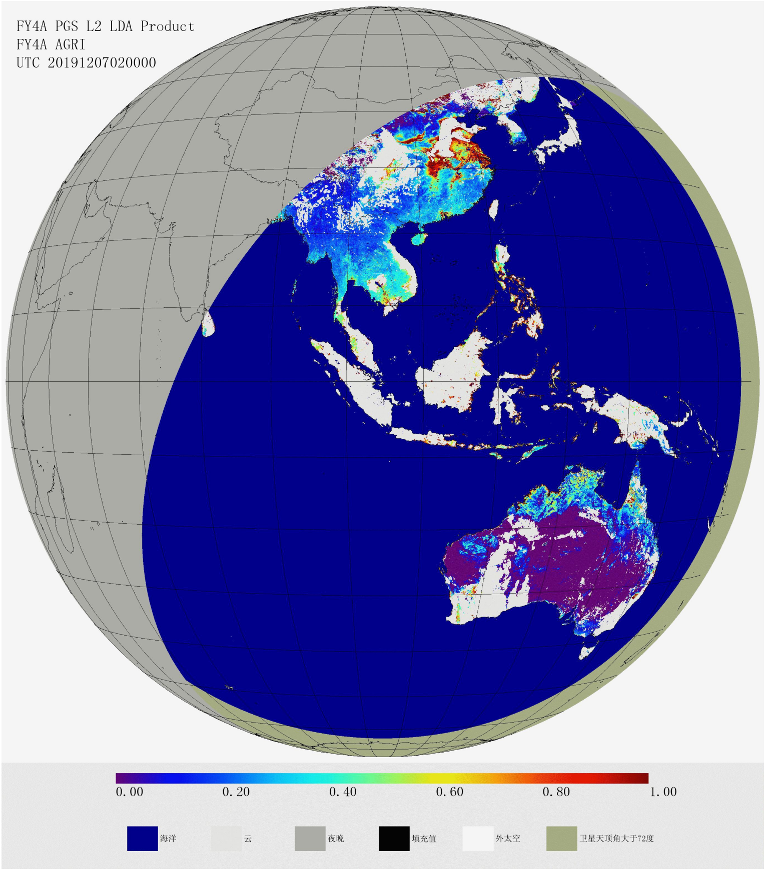
Adopted DT retrieval algorithm

FY-3

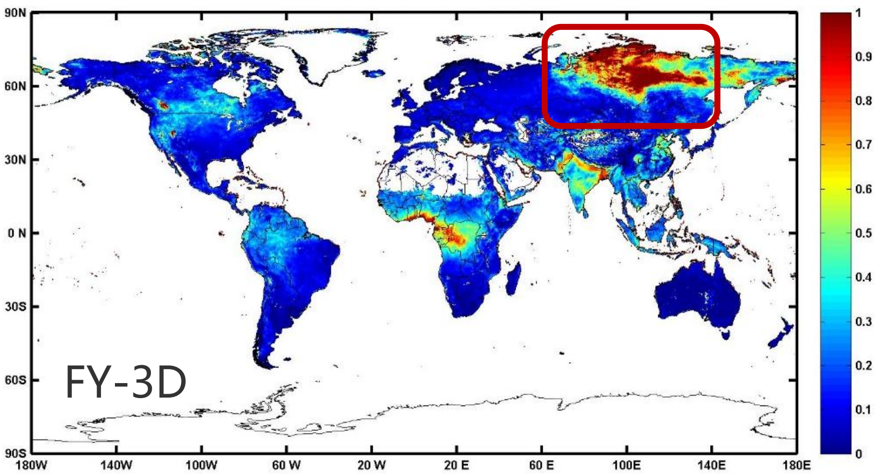
Annual mean in 2021 derived from FY-3D/MERSI

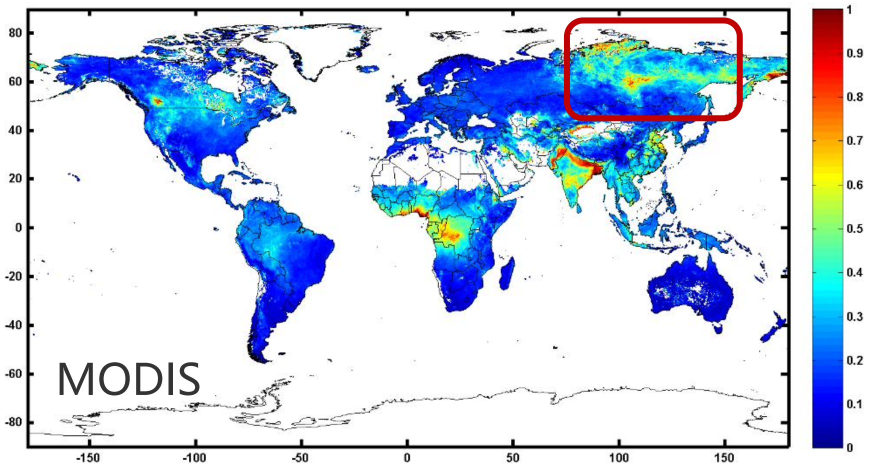


FY-4

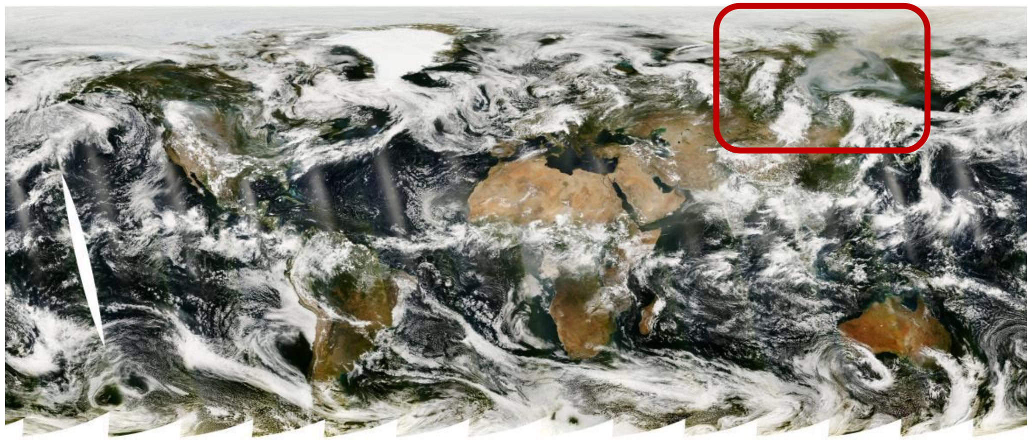


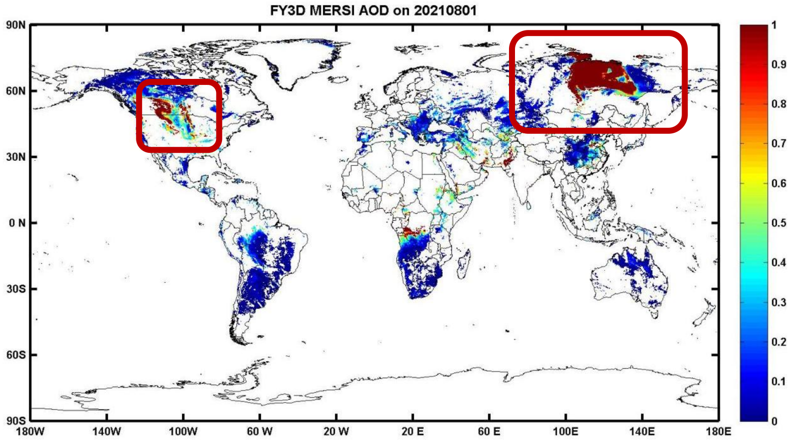
Annual mean in 2021

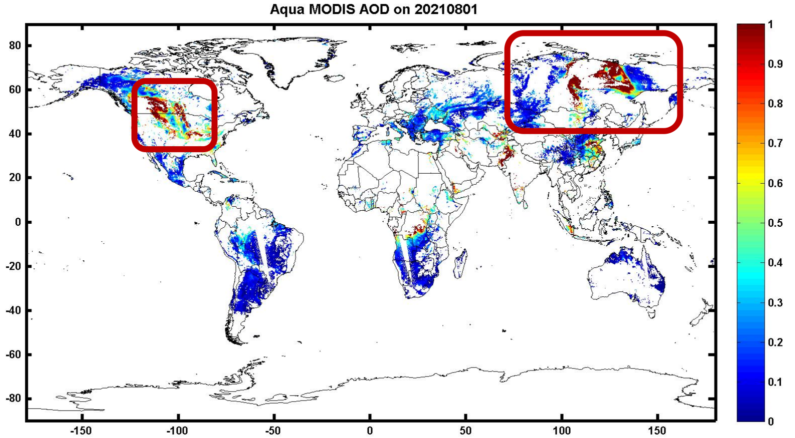




Daily on 1 Aug, 2021





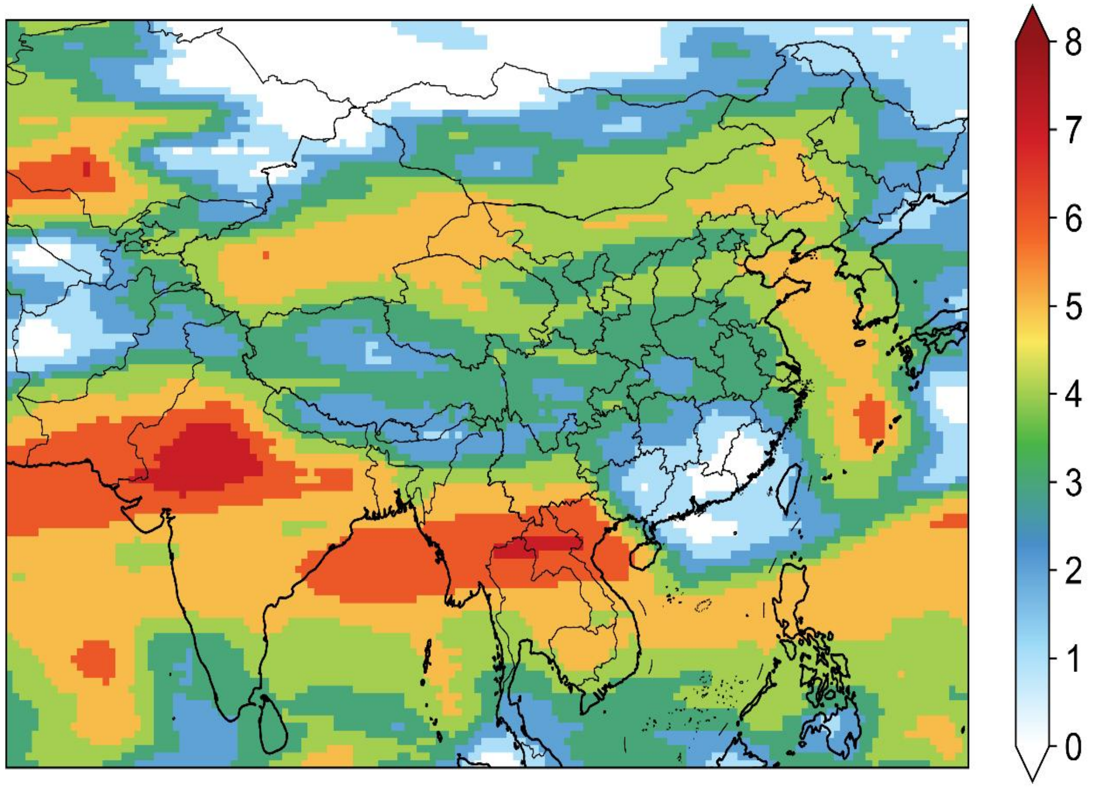


(3) Absorbing Aerosol Index

The absorbing aerosol index (AAI) is a type of satellite product that indicates the existing and elevation of **absorbing aerosols (dust storm, haze events and biomass burning monitoring)** in the atmosphere. Calculation of AAI is based on spectral contrast in the ultraviolet spectral range for a given wavelength pair :

$$AI = -100\log_{10}[(R_{360}/R_{331})_{meas} - (R_{360}/R_{331})_{cal}]$$

$R_{331,\ meas}$ and $R_{360,\ meas}$ represent the apparent reflectance measured by the satellite at 331nm and 360nm, respectively, and the $R_{331,\ cal}$ and $R_{360,\ cal}$ denote the calculated apparent reflectance at top of the atmosphere at the corresponding wavelength.



AAI observed by FY-3B/TOU on 11 April 2016

Ozone in the stratosphere protects life on earth from the harmful ultraviolet radiation, but at ground level, it is an air pollutant that threatens the respiratory health and damages crops and ecosystems.

(4) Total column of Ozone

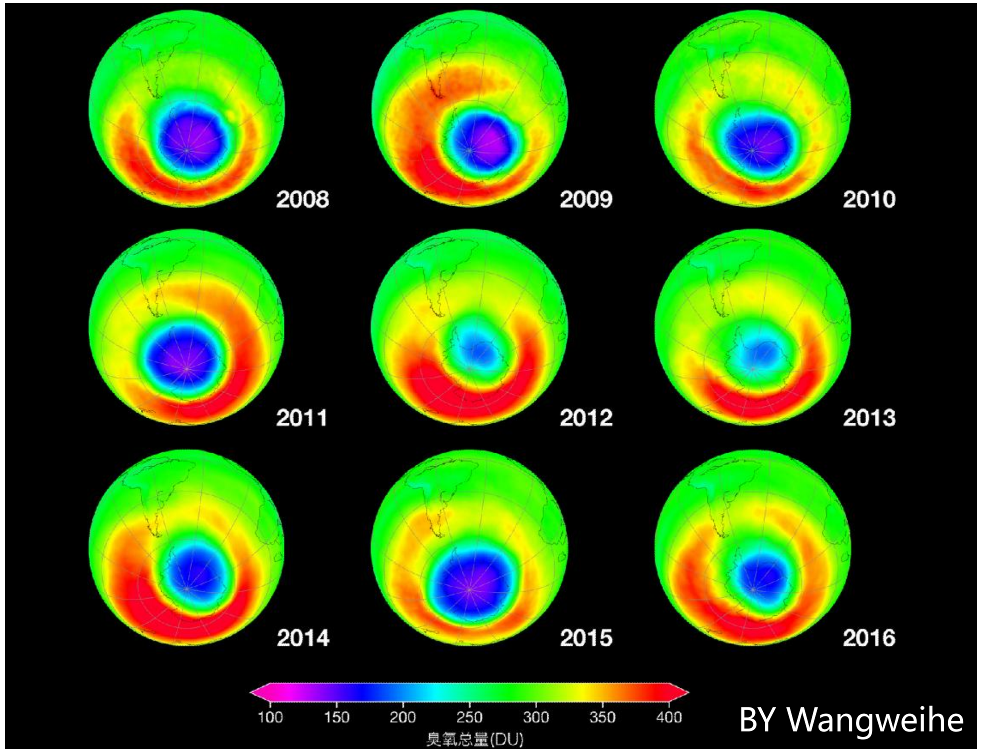
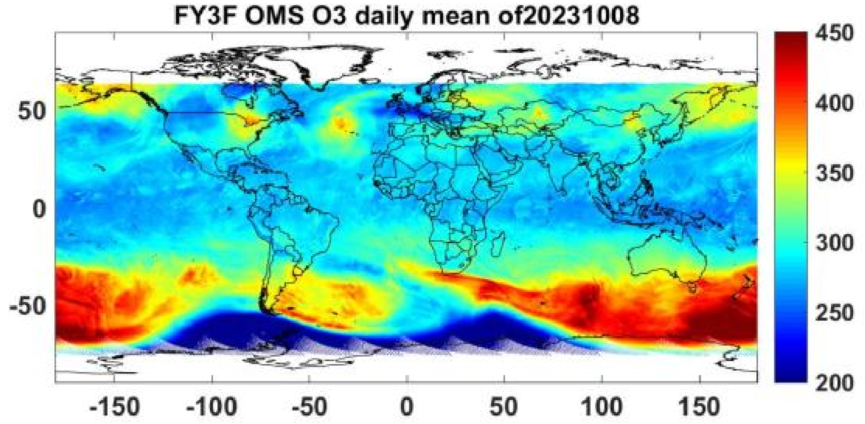
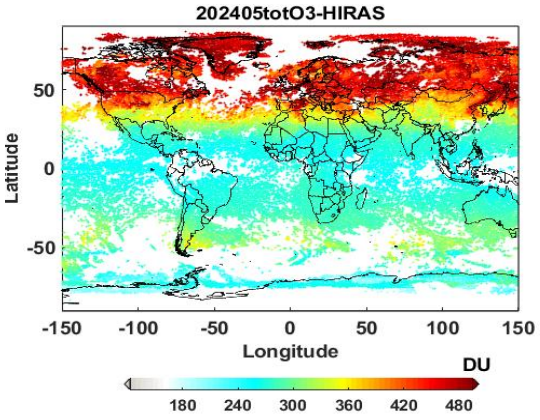
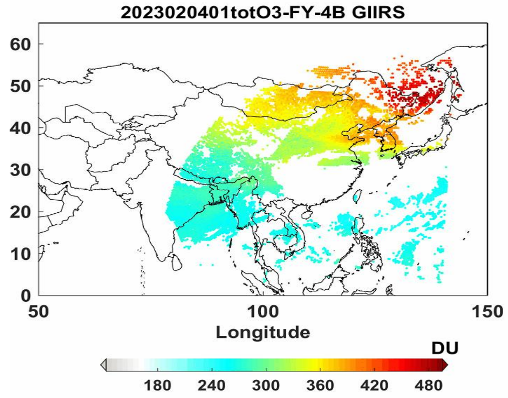


Fig. FY-3/TOU retrieved total ozone column over the South Pole in October from 2008 to 2016.

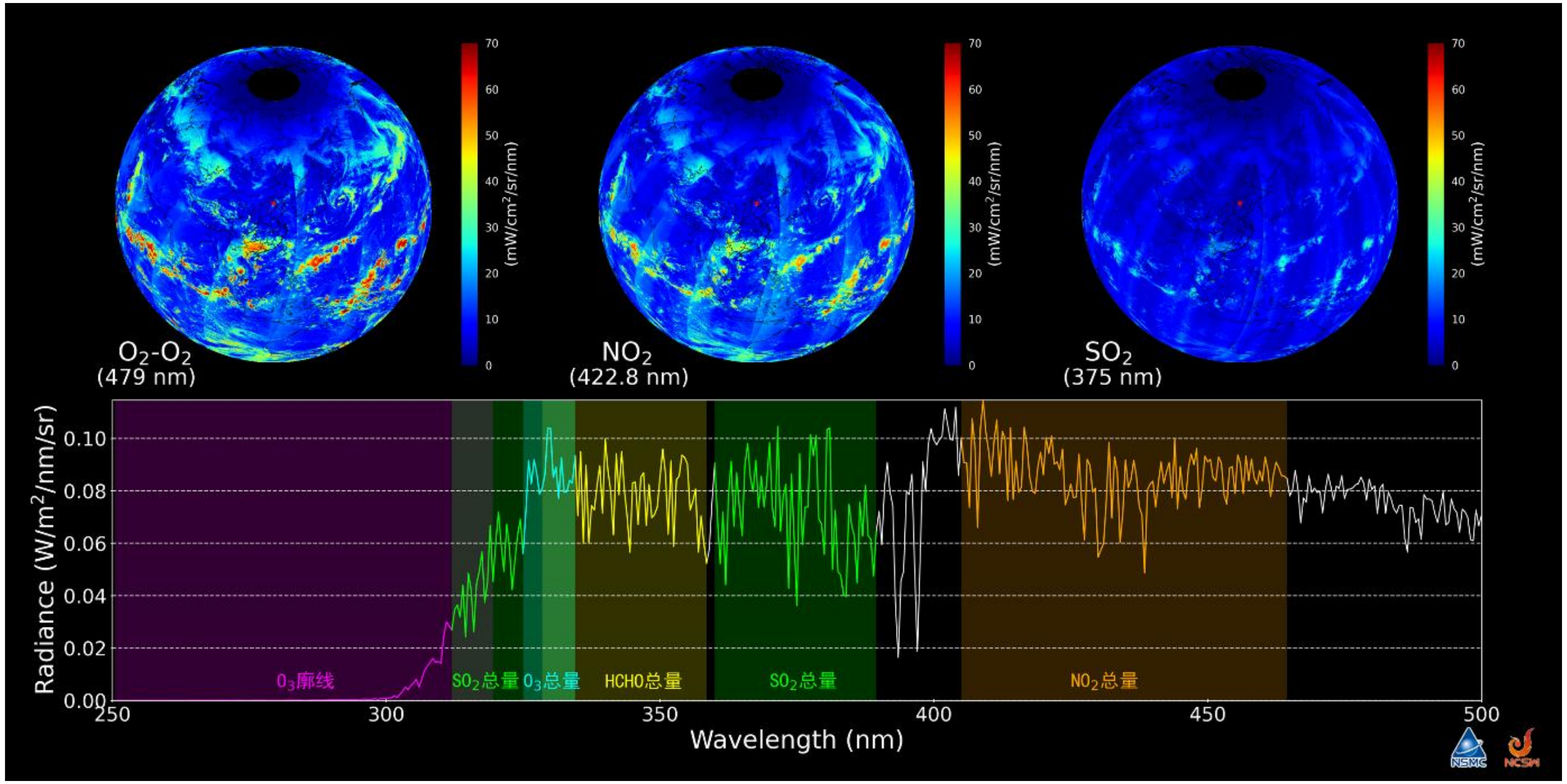


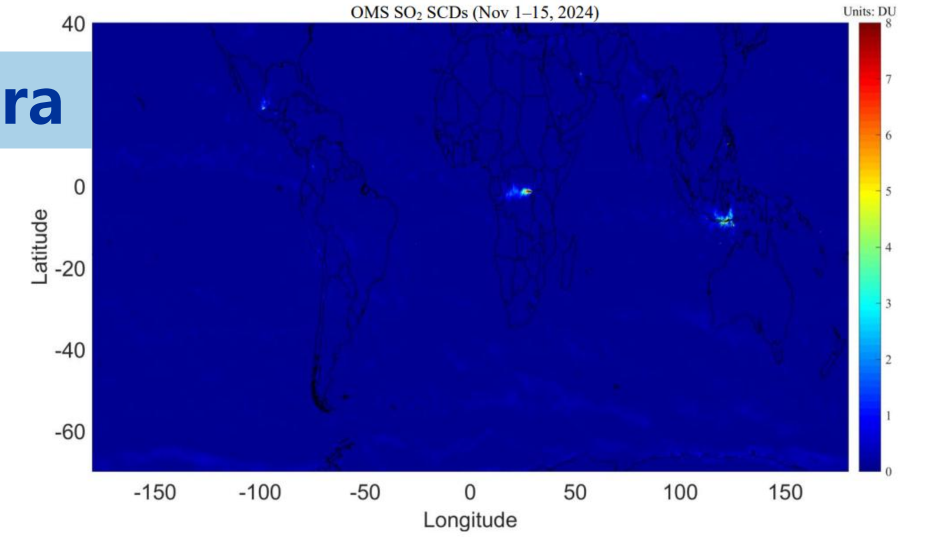


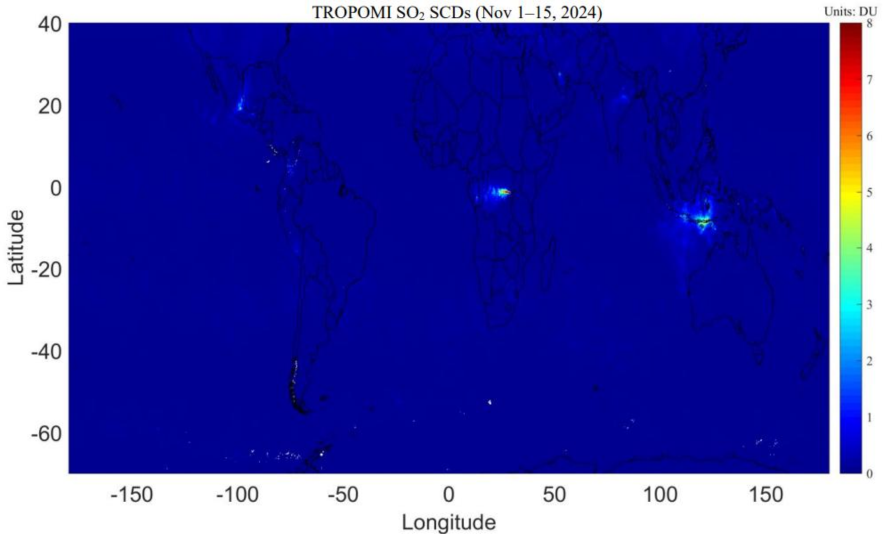


(Provided by Wang yapeng)

(5) Polluted gases retrieval from ultraviolet spectra



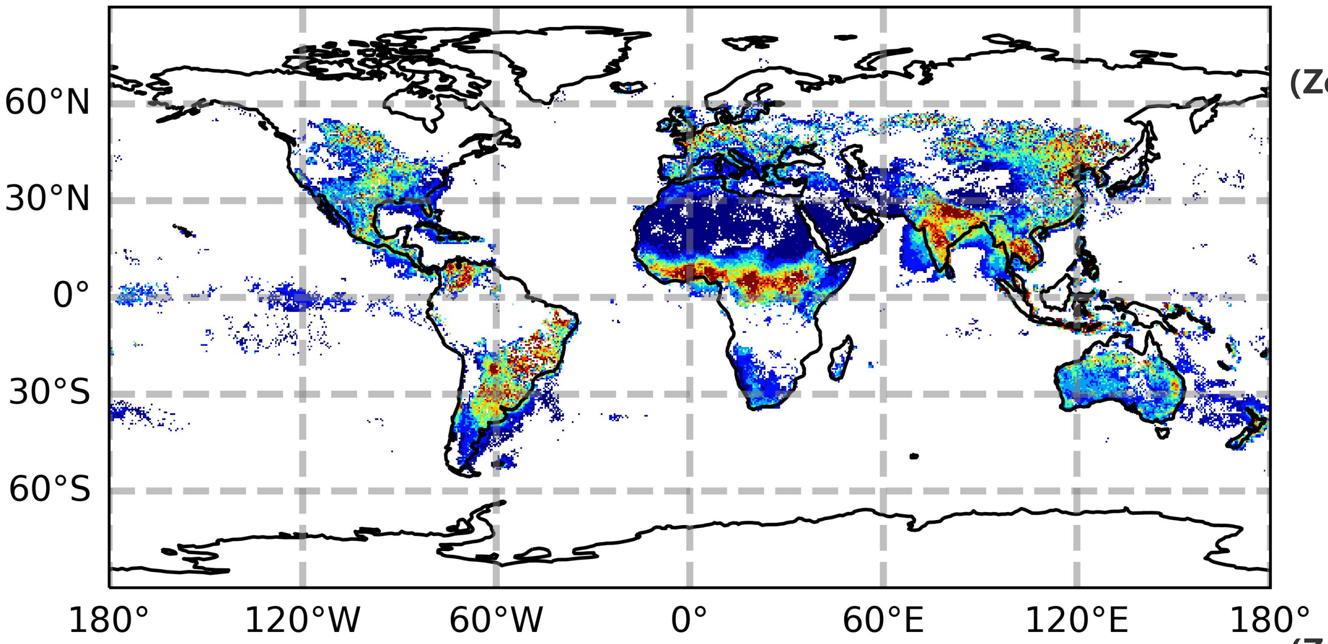




(Yan et al，EGUsphere [preprint]，2025)

(6) Pollution gases retrieval from infrared spectra

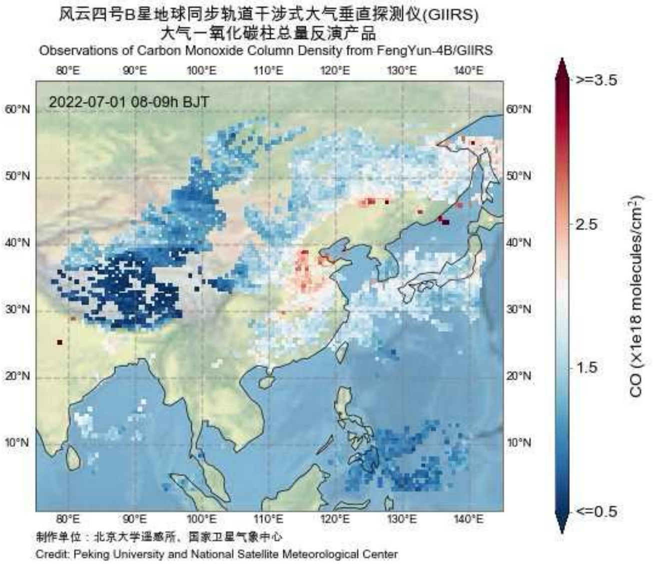
FY-3D HIRAS NH3



(Zhou et al, AAS, 2024)

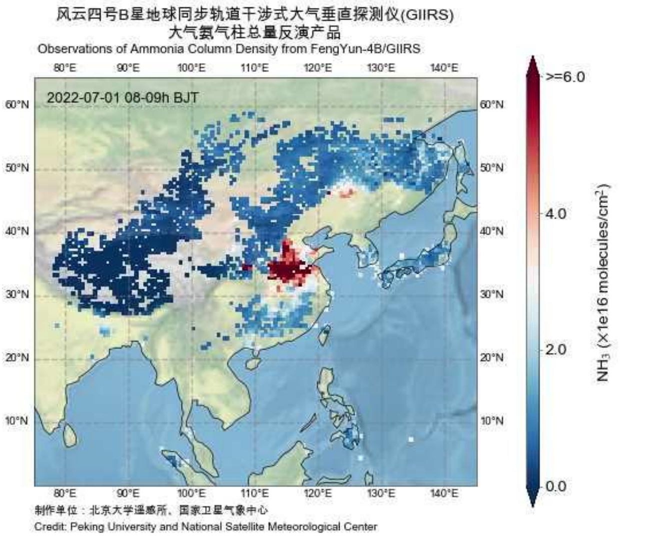
FY-4B/GIIRS CO

(Zeng et al., AMT, 2023a)



FY-4B/GIIRS NH3

(Zeng et al, AMT, 2023b)



(7) Greenhouse gases

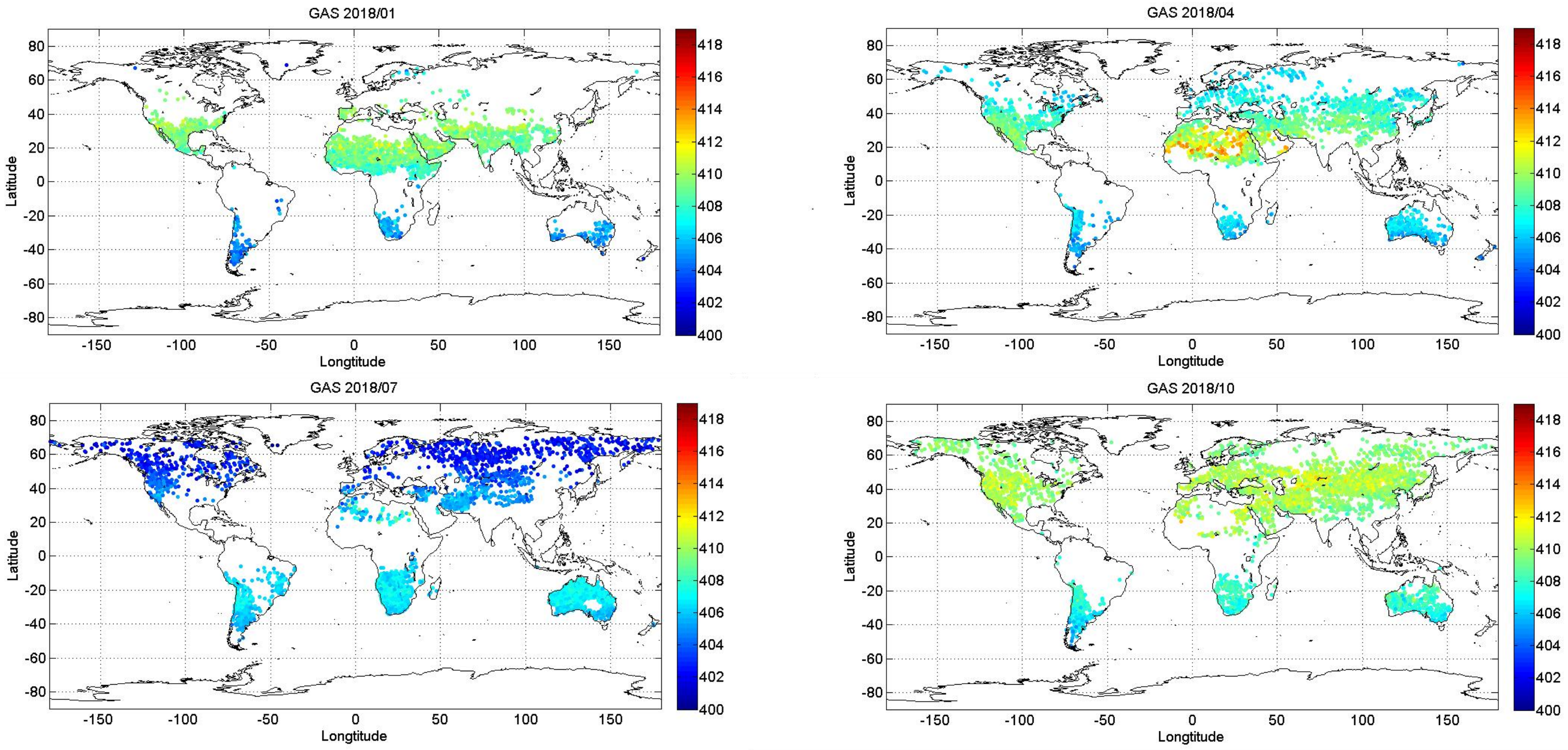
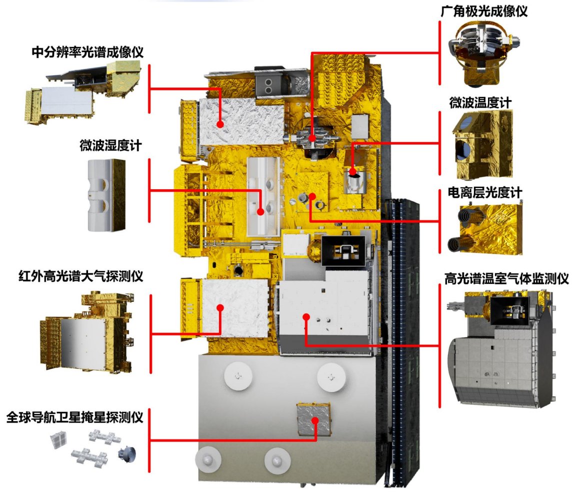


Fig. FY-3D/GAS retrieved monthly CO_2 distribution in (a) Jan, (b) Apr, (c) July, and (d) Oct in 2018.

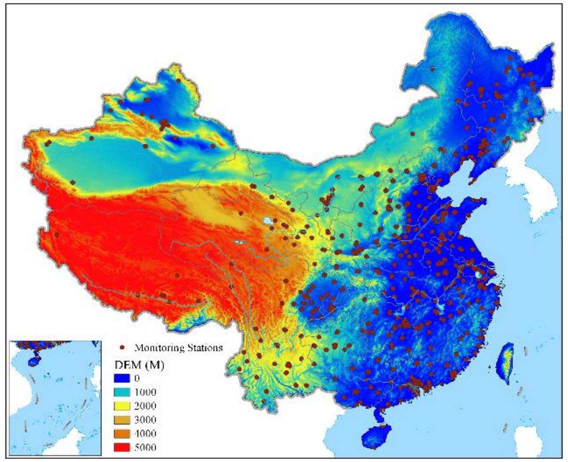
(Bi et al, JMR, 2022)



There is a significant improvement in the capabilities of FY-3H/GAS-II compared to FY-3D/GAS. The GAS employs a Fourier Transform Spectrometer, while the upgraded GAS-II is a grating spectrometer. GAS performs point observations with a wide swath but coarse spatial resolution. In contrast, GAS-II employs array observations with a 100 km swath width and 3 km spatial resolution.

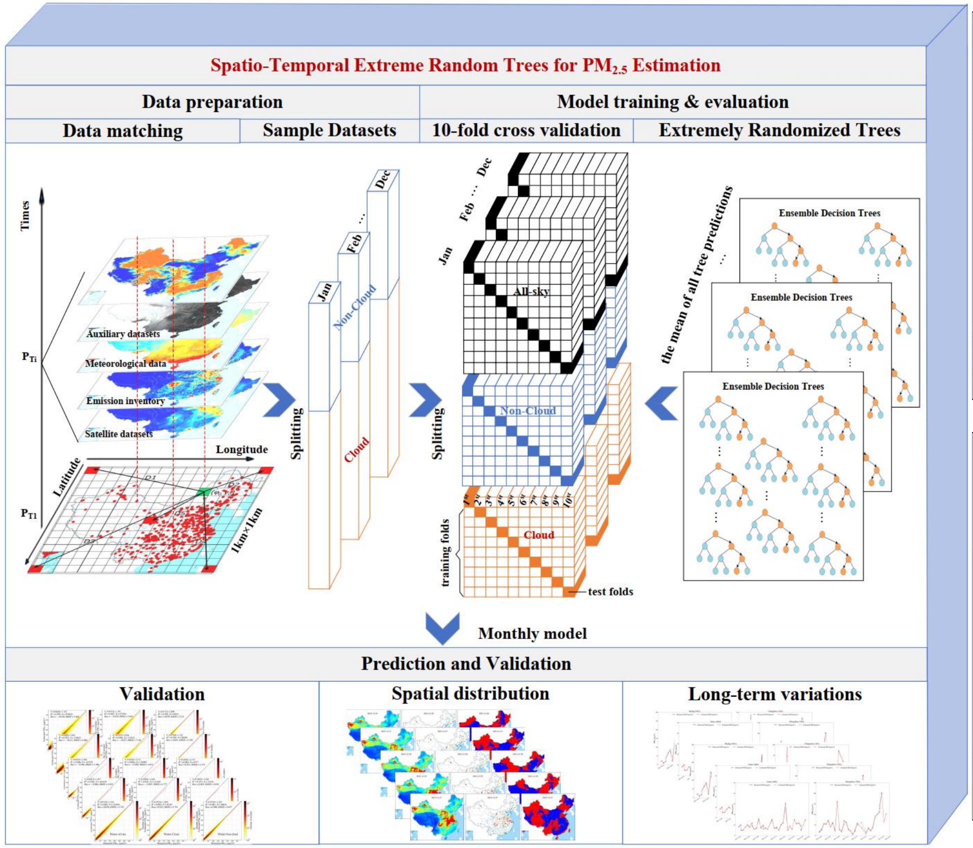
(Provided by Zhanglu)

(8) Surface PM2.5 estimation from satellites by using **Machine Learning**

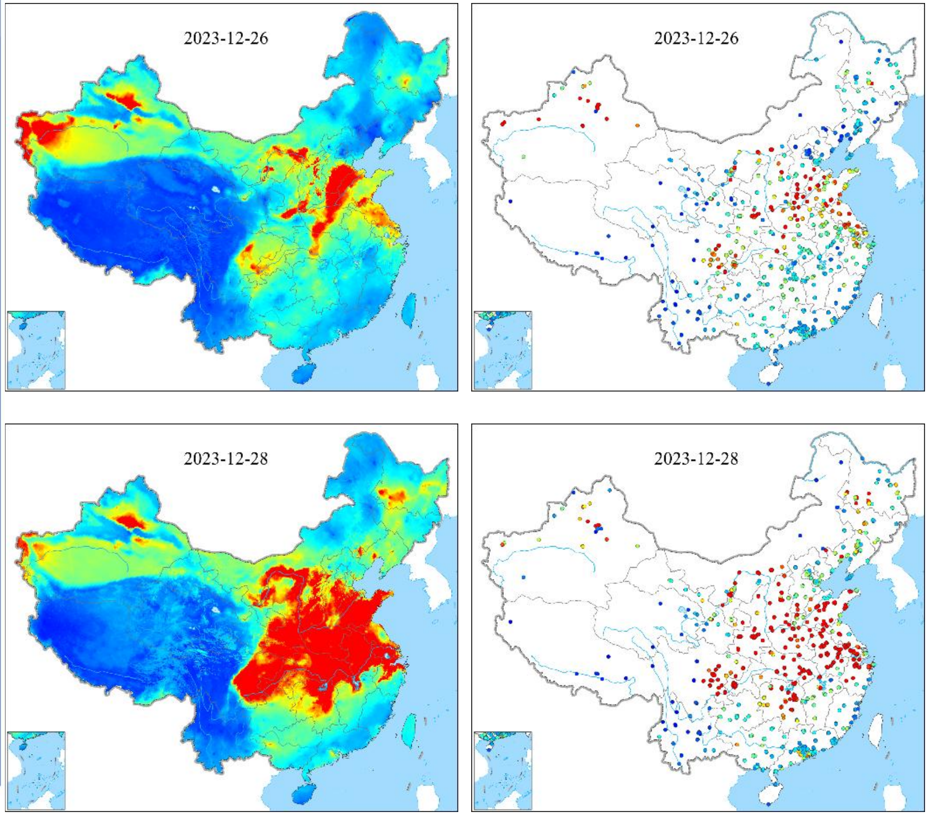


- ✓ Ground-based observation
- ✓ Satellites Datasets
- ✓ Meteorological data from NWP
- ✓ Emission inventory
- ✓ Auxiliary datasets (DEM,pop)

Method



Results



(Ling Gao， prepared)

(9)Surface Ozone estimation from satellites by using Machine Learning

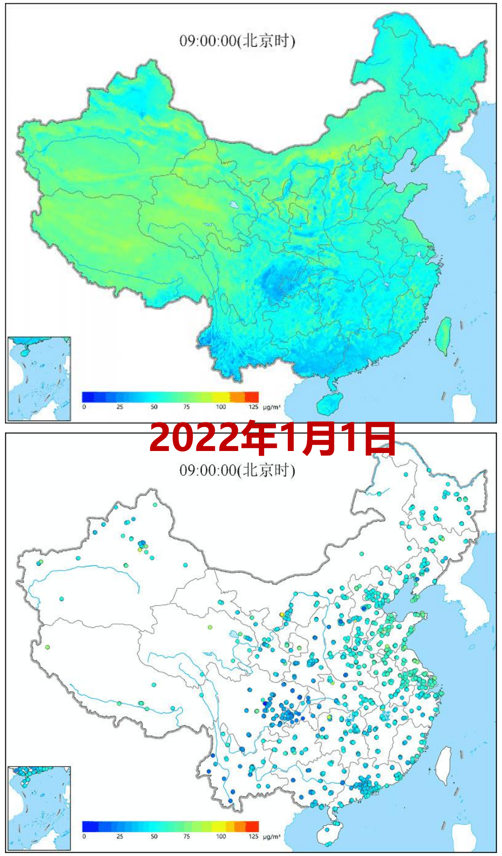
Ozone in the near-surface atmosphere is formed from its precursors and influenced by the meteorological parameters.

Using FY-4A brightness temperature data in the infrared radiation band in combination with OMI total ozone column, tropospheric NO_2 column, meteorological parameters, and other data, hourly full-coverage ground-level O_3 estimation through a machine learning method has been retrieved. To mitigate the cloud coverage limitations, the average of the total column O_3 and tropospheric NO_2 data obtained on the same day of the year from 2005 to 2021 were used.

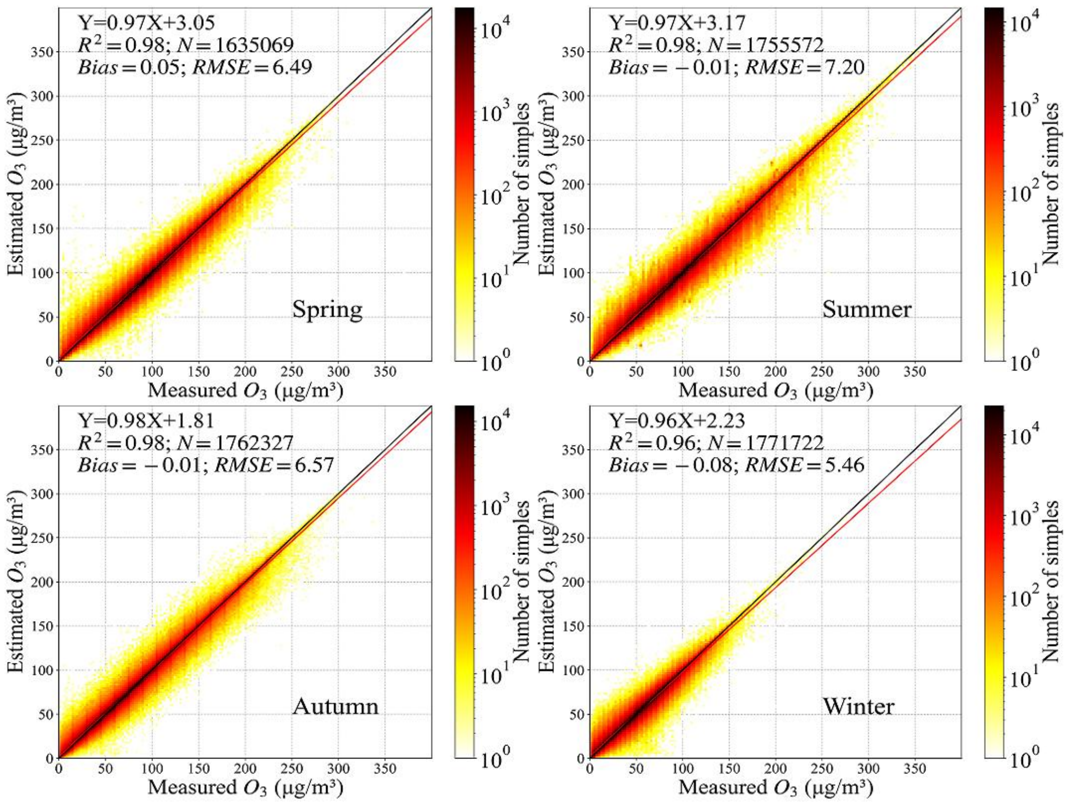
Notably, meteorological data from NECP GFS were selected instead of reanalysis data (e.g., ERA5) for operational application purposes due to data latency.

(**Ling Gao**, ***ERL***, **2024**)

Results



Validation



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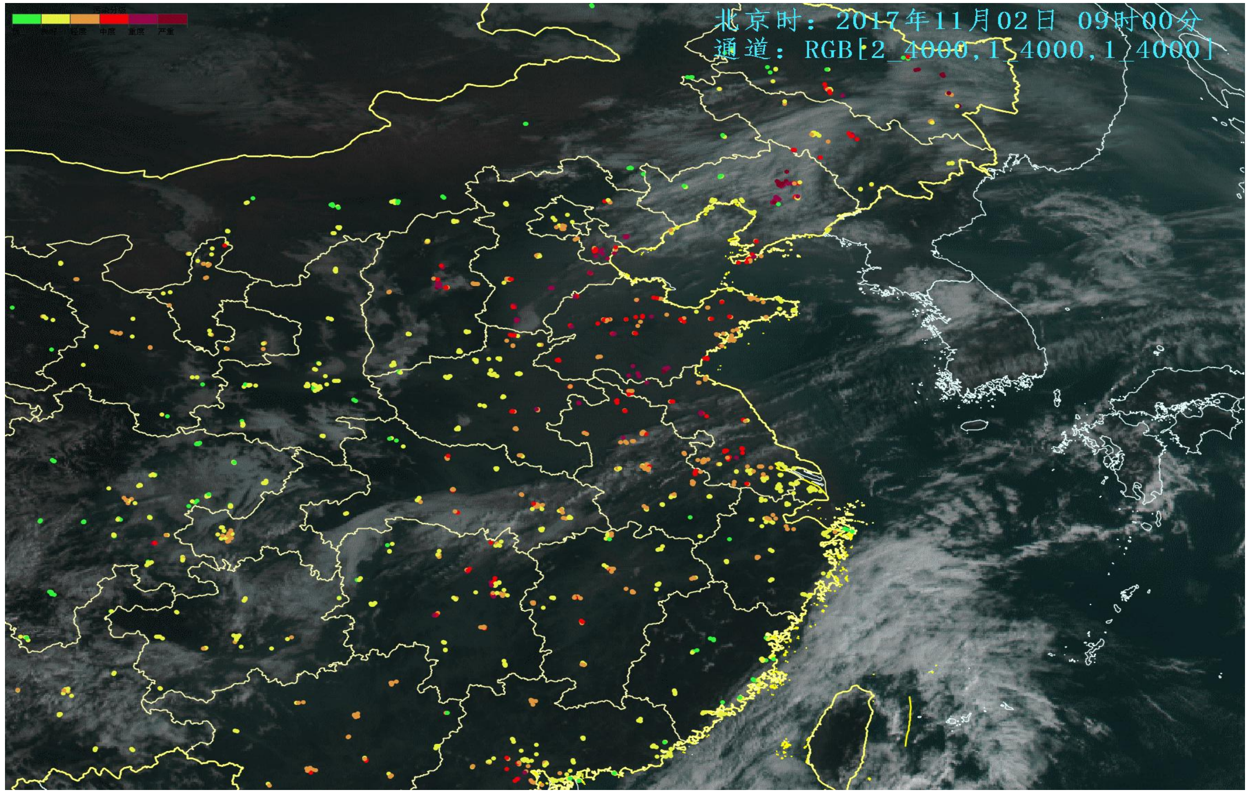
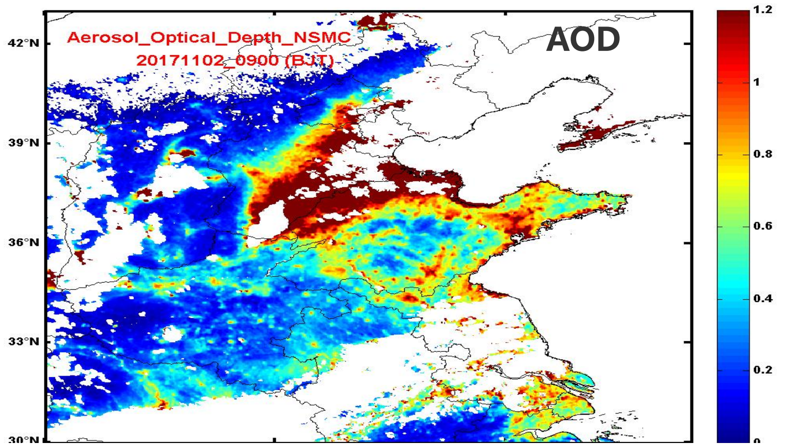
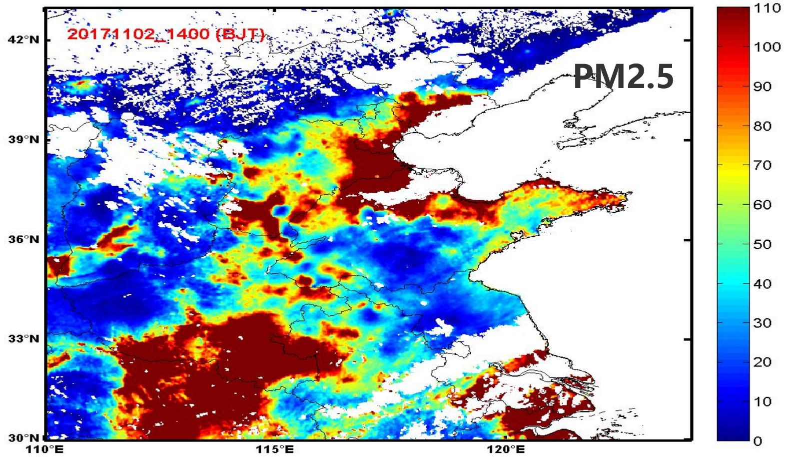
(1) Particulate pollution Monitoring in the past

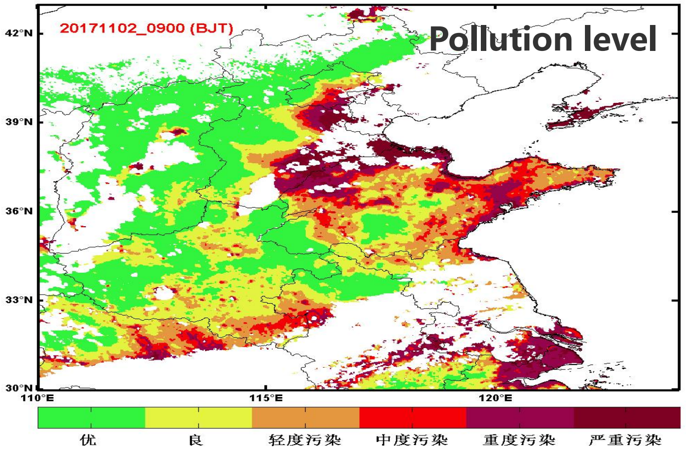


AOD

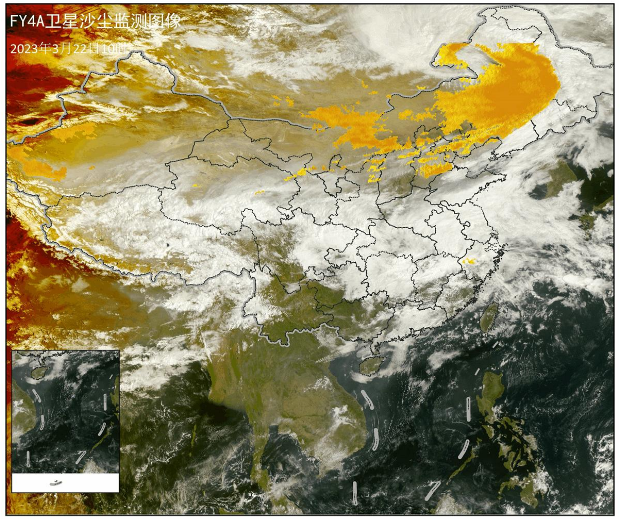
PM2.5



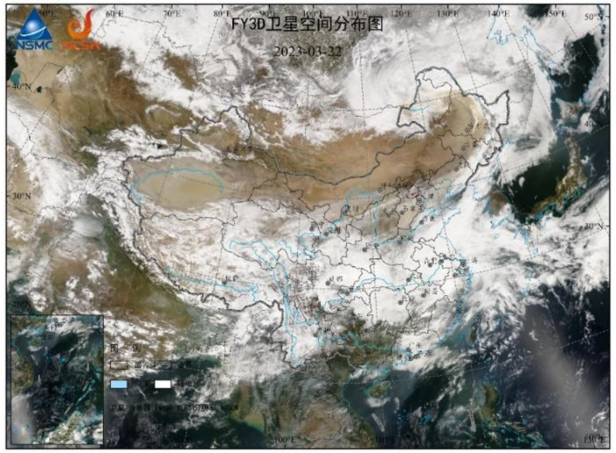




(2) Dust storm Monitoring

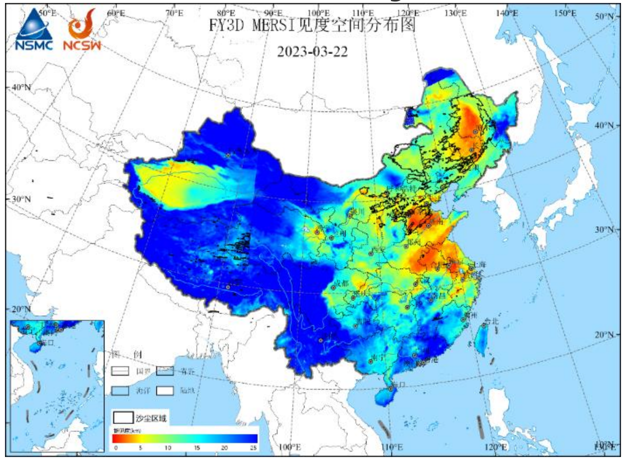


True color

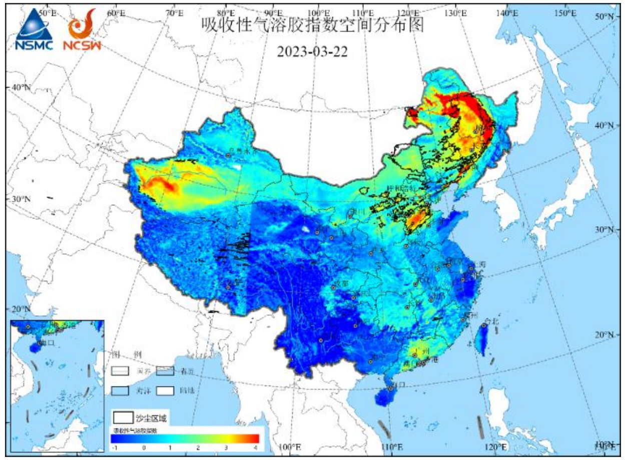


DDI

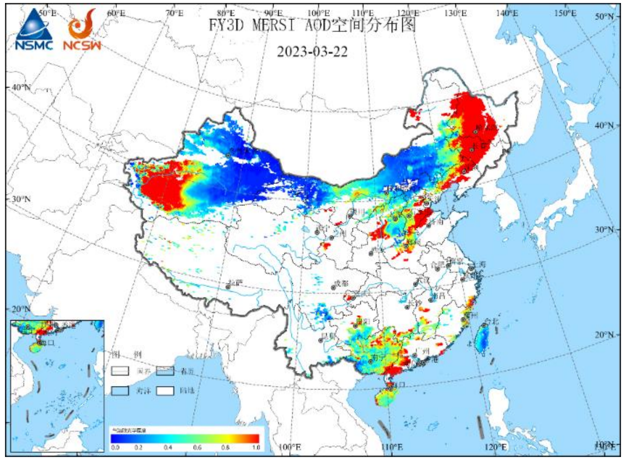
Visibility



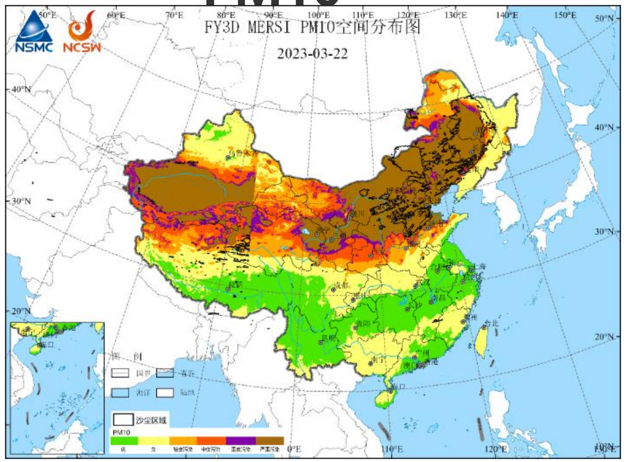
AAI



AOD

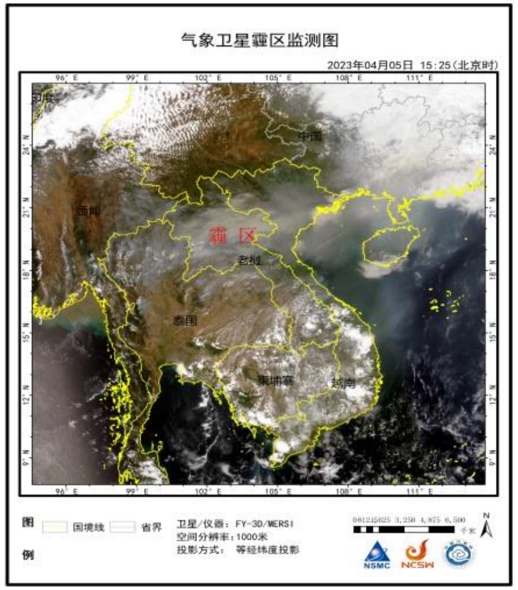


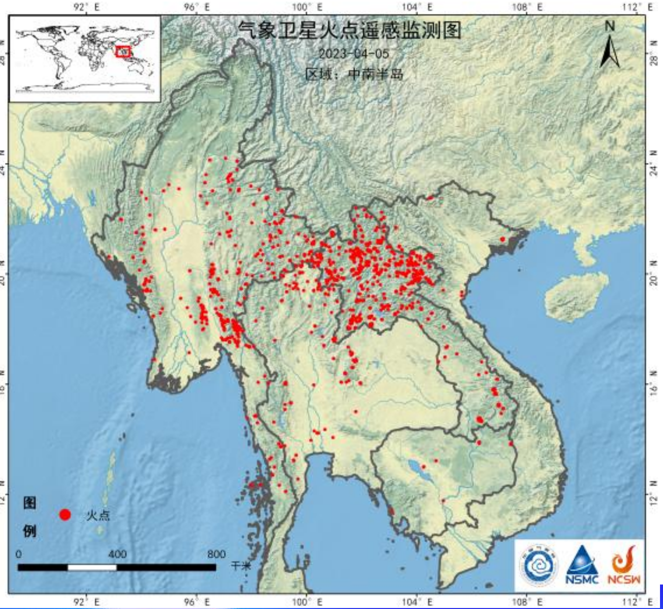
PM10

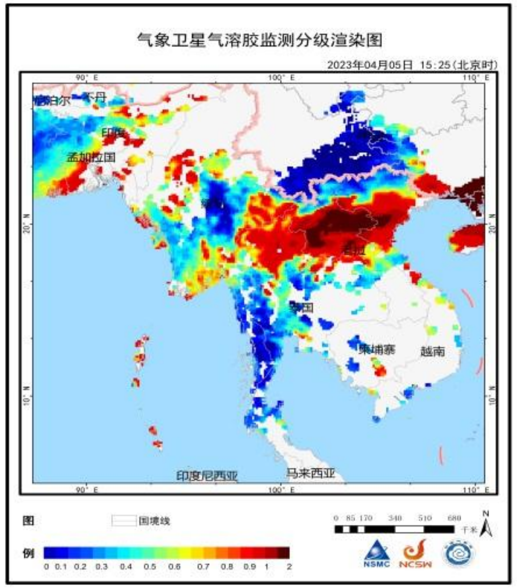


(3) The Haze Monitoring in Southeast Asia

- The Asian monsoon dominates the climate of Southeast Asia, late in the dry season (March to April), fires both intentional and accidental become widespread as people use burning to clear and maintain agricultural and residential landscapes, forest fires and burning of wasteland lead to continuous and serious air pollution problems in the Mainland Southeast Asia and spread to the surrounding regions;
- FY-3D satellite monitored the serious haze caused by the continuous biomass burning, the haze smoke were mainly appeared in northern Laos, in early April, 2023.





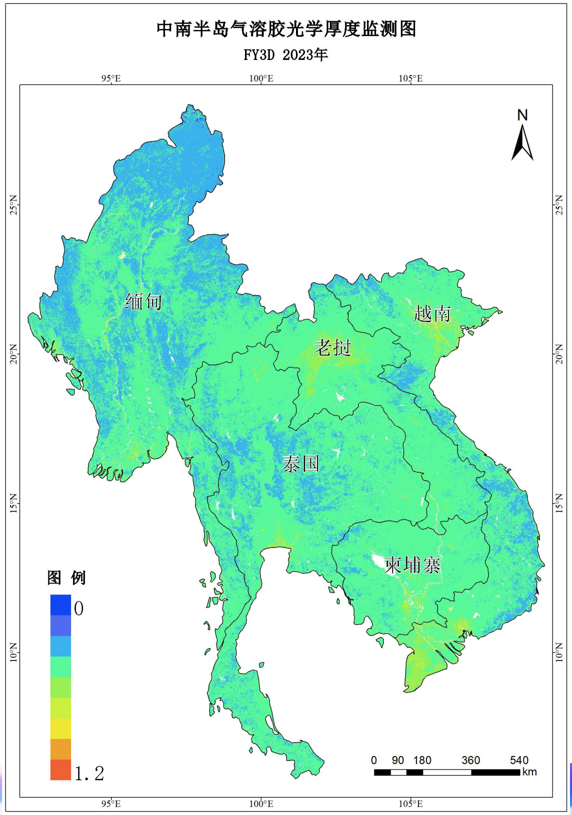


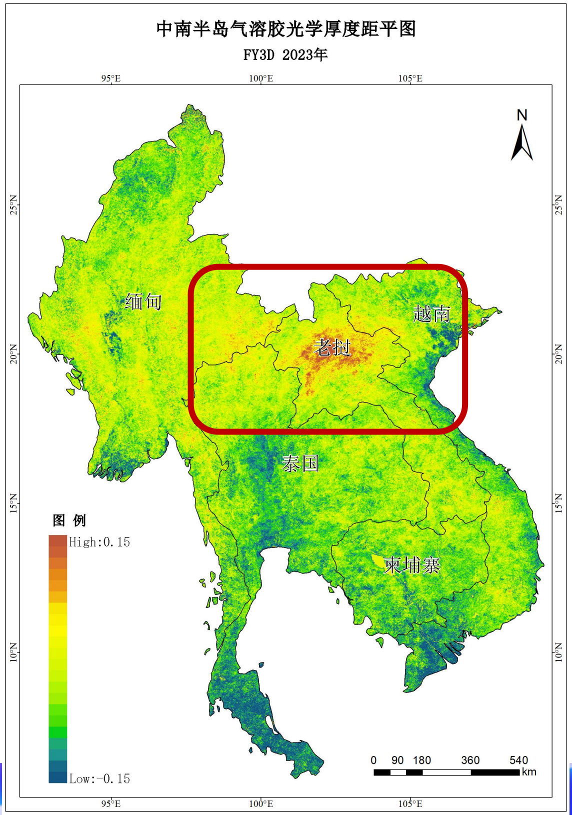
The high-value areas of AOD in the Indochina Peninsula region in 2023 are mainly distributed in northern Laos, the Red River Delta, the Mekong Delta, and the surrounding areas of Bangkok.

Northern Laos, eastern Myanmar, northern Thailand, and northern Vietnam are significantly higher than the average since 2019, while southern Thailand and the Mekong Delta region are lower than the average since 2019.

In April 2023, the Indochinese Peninsula region was affected by biomass burning, with a significant increase compared to the same period in the past four years.

Annual Mean of AOD





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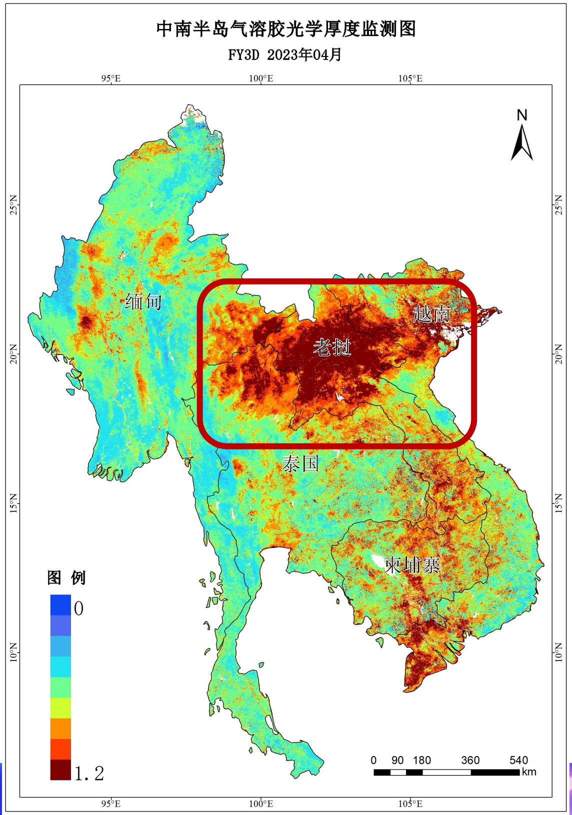
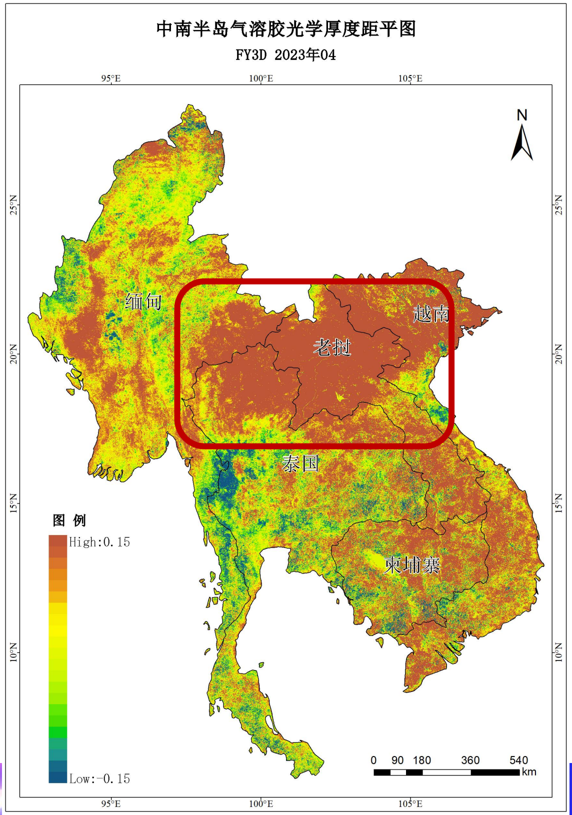
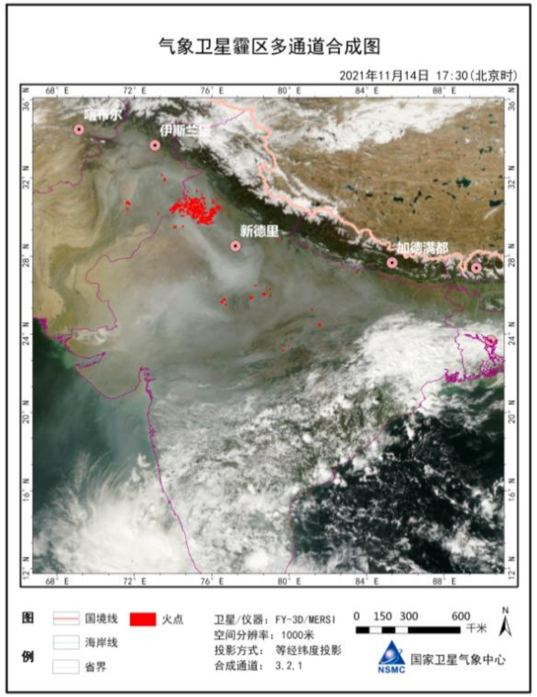


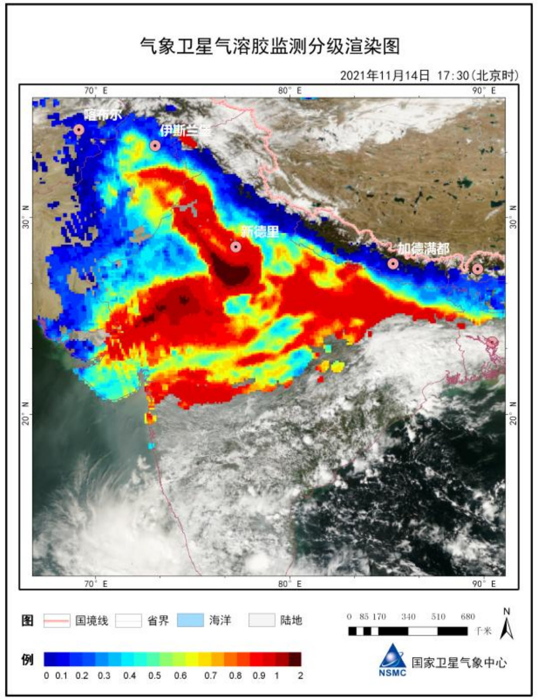


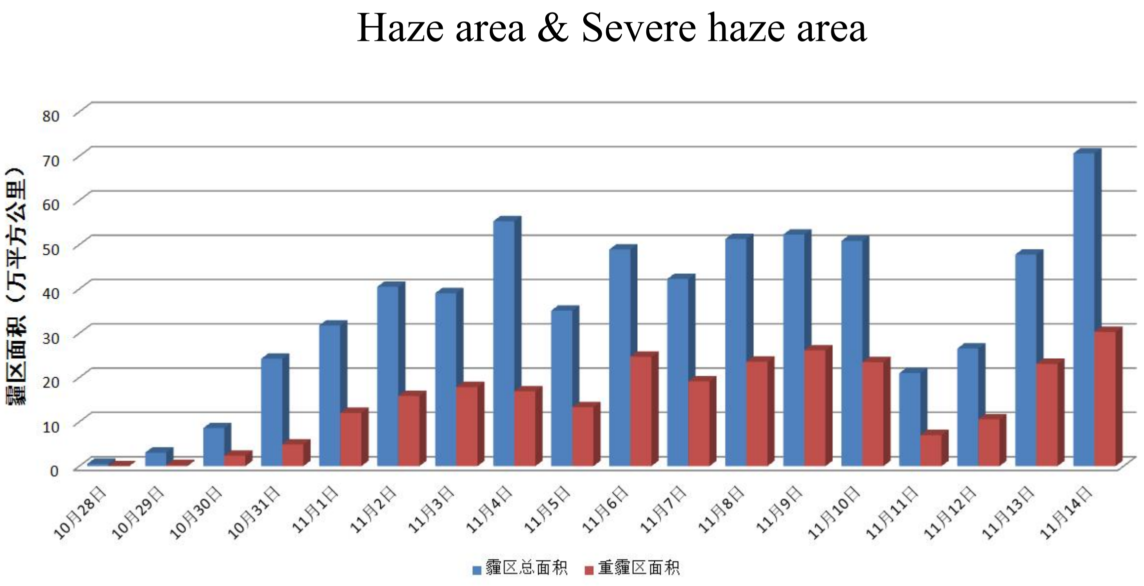
(4) Haze in India

On November 14th in 2021, haze appeared in most parts of central and northern India, with the most severe pollution occurring in the area south of New Delhi. The satellite visible haze affected an area of about 700000 square kilometers, including a severe haze area of about 300000 square kilometers.

Continuous monitoring of the total area of haze zones and the area of severe haze zones has shown an upward trend in the area affected by haze in northern South Asia. On November 14th, the range of haze impact reached its maximum during this pollution process, and the degree of air pollution is severe.





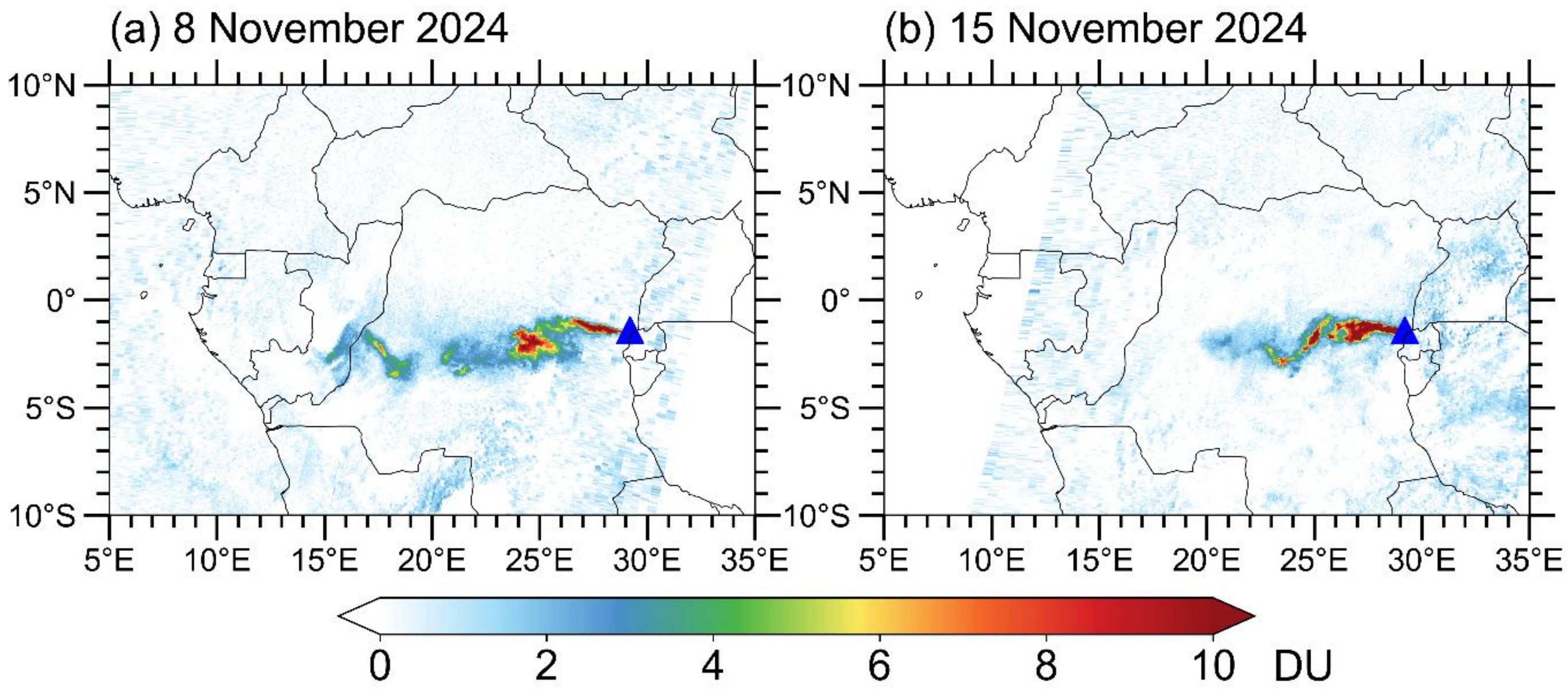


(5) The Volcano Eruption Monitoring

Nyamuragira is Africa's most active volcano and located in the eastern part of the Democratic Republic of the Congo, approximately 25 km north of Lake Kivu and 13 km north-northwest of the Nyiragongo volcano.

According to the Global Volcanism Program (GVP) weekly reports, Nyamuragira had continuing eruptive activities in November 2024.

The spatial distribution maps show that FY-3F/OMS results clearly detected the high-concentration SO2 plume from the Nyamuragira eruption.



(Data from Yan huanhuan)

CONTENTS

Future Plan

- ✓ More atmospheric chemical parameters need to be retrieved.
- ✓ To reprocess the historical data for higher-precision and more consistent Fengyun satellite atmospheric composition products.
- ✓ To obtain more precise information of the vertical structure of atmospheric chemical species.
- ✓ AI-driven high-resolution ground-level air pollution monitoring with multi-species.
- ✓ Expanding from China to other pollution-affected areas globally.

Thank you for you attention!
Welcome to international cooperation on Fengyun satellites!

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