Observing atmospheric composition from LEO and GEO hyperspectral infrared sounders onboard FengYun satellites

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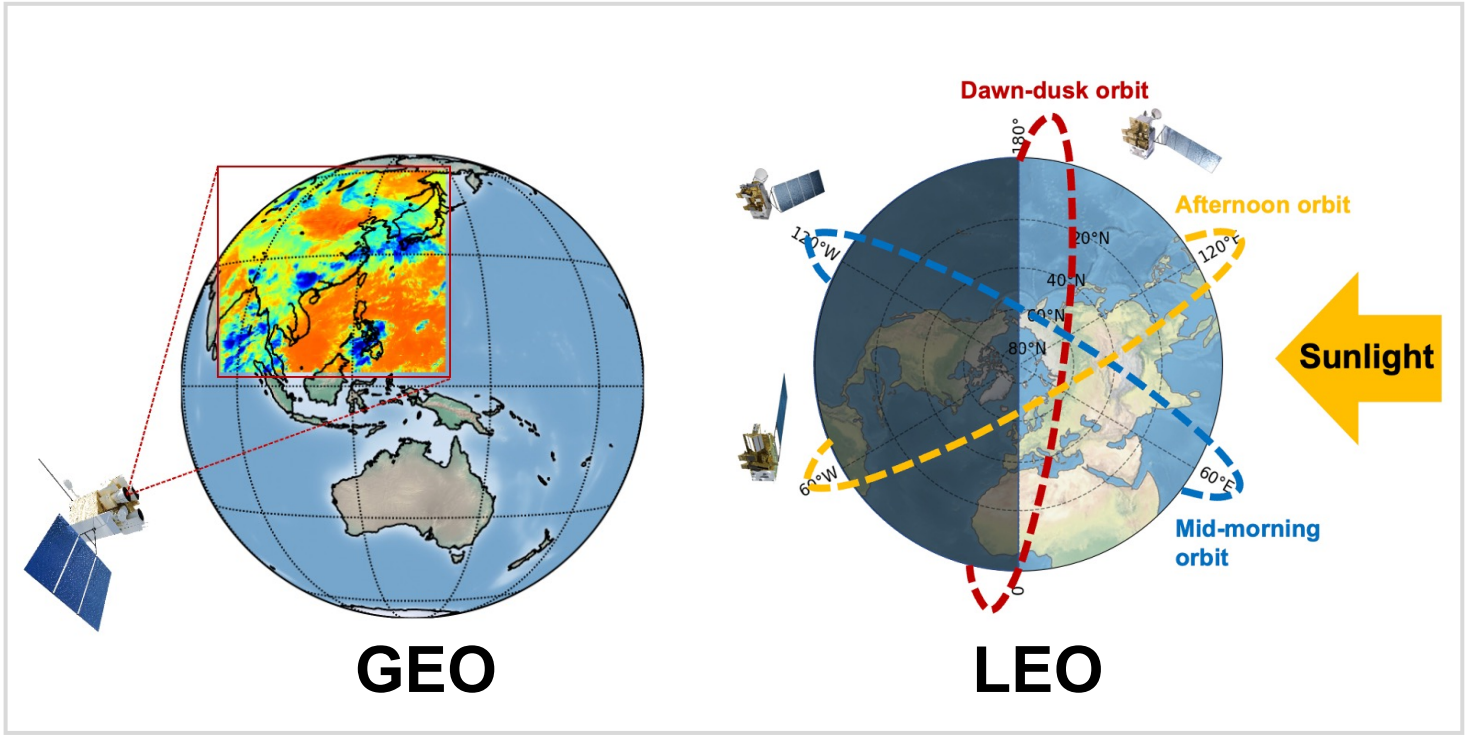
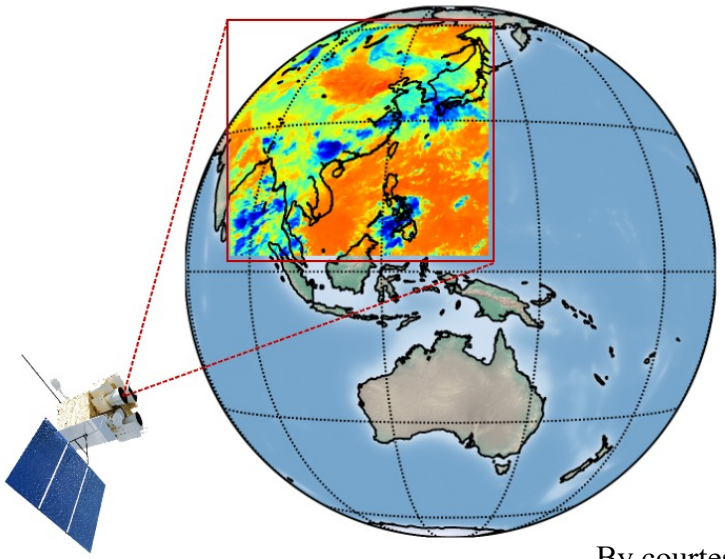


FengYun GEO and LEO hyperspectral infrared sounders

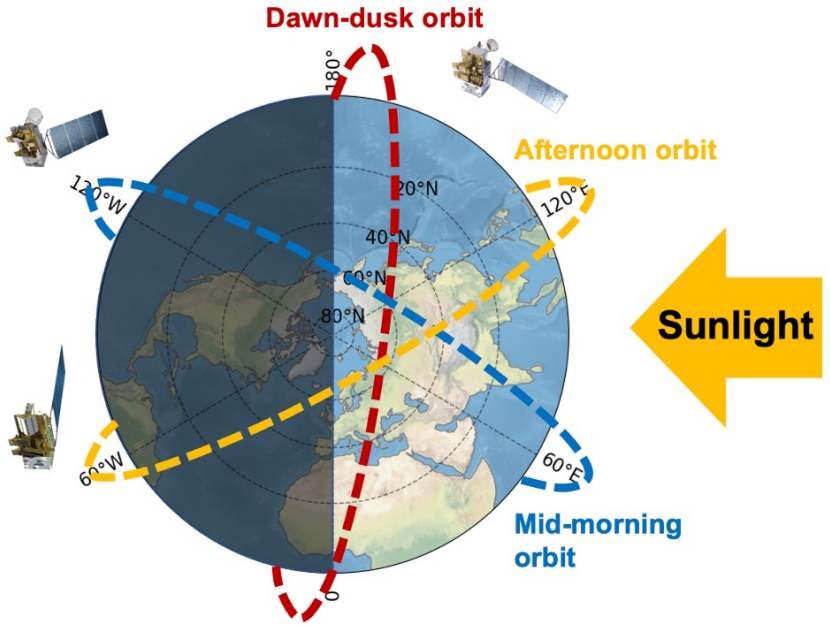
Geostationary Interferometric Infrared Sounder (GIIRS)



By courtesy of Dr. Lee Lu (NSMC)

- FY-4B/GIIRS was launched in June 2021, overlooking East Asia;
- One coverage 2 hours. 12 maps in a day covers day and night. Footprint size at Nadir: about 12 by 12 km.

Hyperspectral Infrared Atmospheric Sounder (HIRAS)

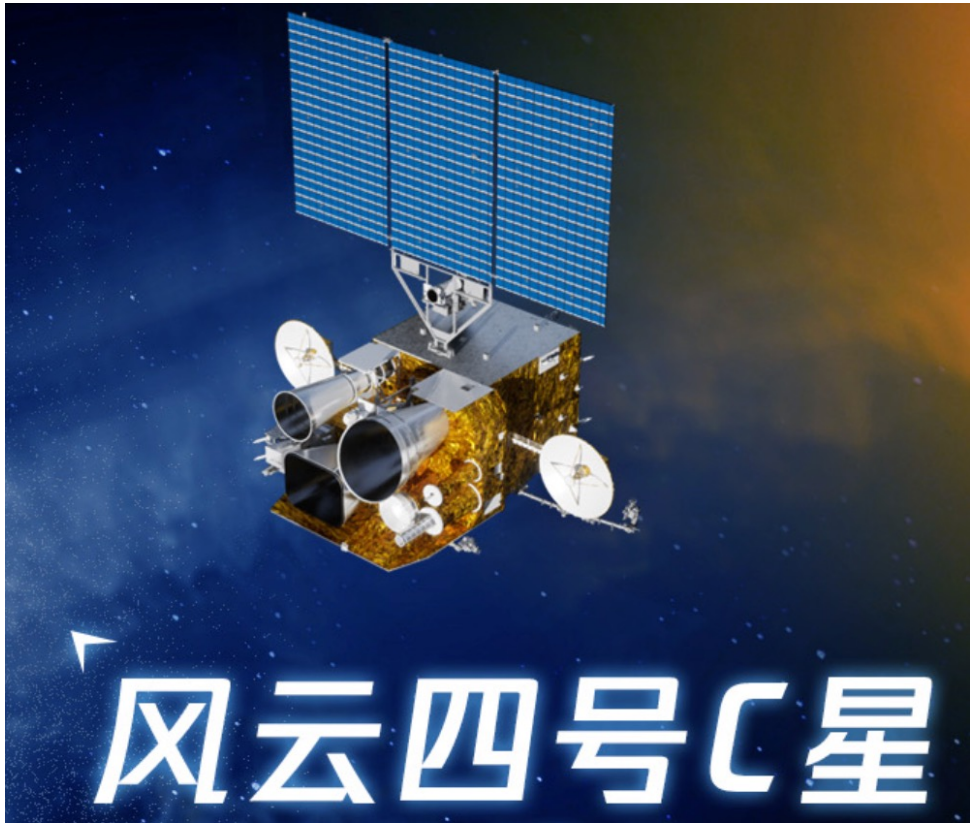


Low Earth Orbit constellation

- FY-3D/HIRAS and FY-3H/HIRAS-II: afternoon orbit (2am/pm)
- FY-3E/HIRAS-II: dawn-dusk orbit (5:30am/pm): 1st for civil use.
- FY-3F/HIRAS-II: mid-morning orbit (10am/pm), close to IASI

Updates on FY-4C/GIIRS

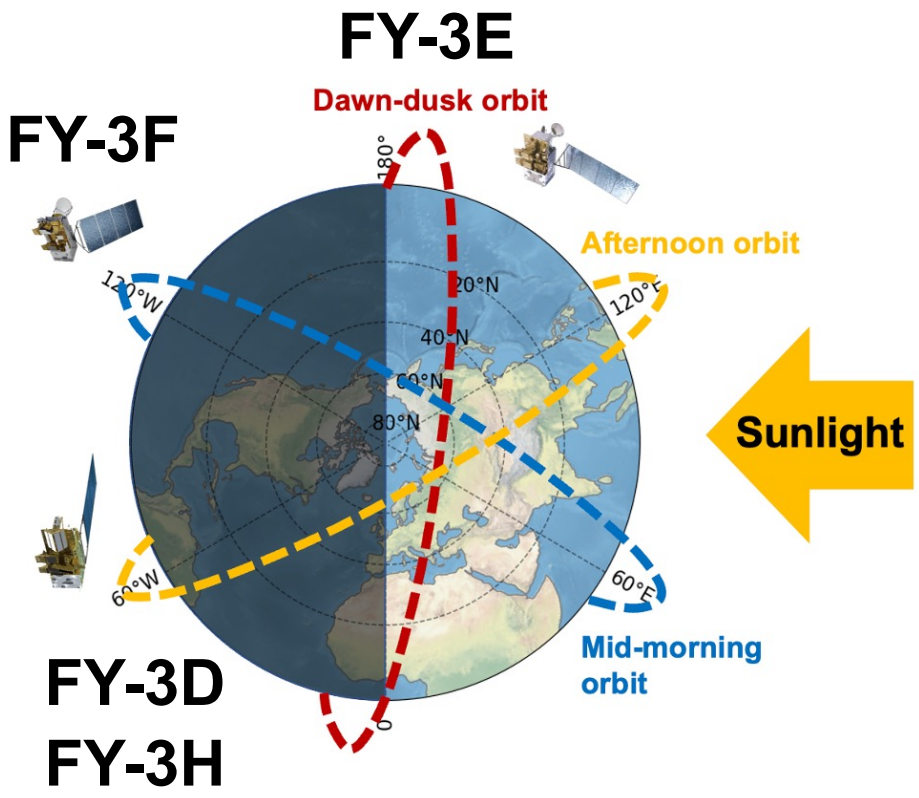
- Launched in December 2025. Currently in commissioning phase.
- Located at 133° E overlooking East Asia, with GIIRS onboard.
- Similar spectral range and spectral resolution as FY-4B/GIIRS, but with shorter revisit time (1 hour vs 2 hours) and improve spectra noise level.
- Will provide observations of NH3, CO, O3, and VOCs that have absorption features in the infrared region.



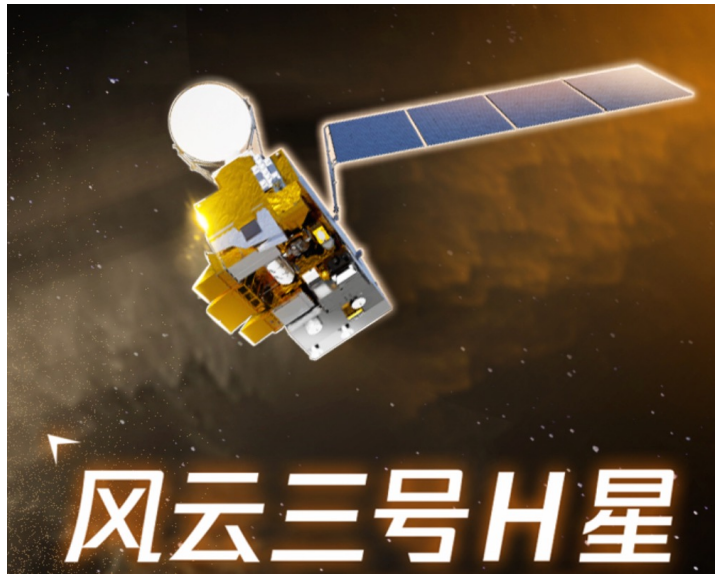
https://data.nsmc.org.cn/FY4C/html/index.html

Updates on FY-3H/HIRAS-II

- Launched in Sept 2025. Currently in commissioning phase. Spectra data to be released around this summer.
- Equatorial overpass time at 2am/pm local time;
- With HIRAS-II instrument onboard, and it will provide observations of NH3, CO, O3, and VOCs that have absorption features in the infrared region.



FengYun LEO satellite constellation



https://data.nsmc.org.cn/FY3H/html/index.html

- Global “quasi-geostationary” NH_3 observations from a LEO satellite constellaion

- Geostationary observations of air pollutants from biomass burning: a synergy of GIIRS and GEMS over Southeast Asia

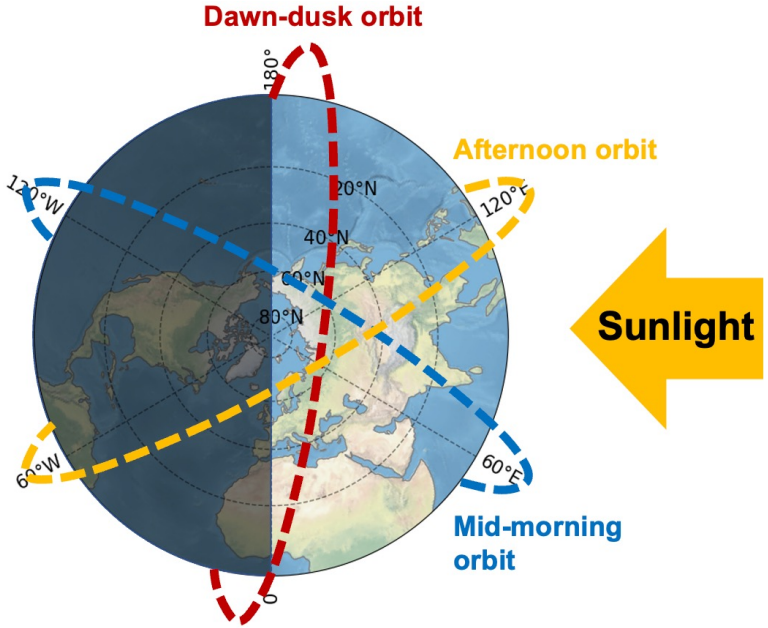
A lack of geostationary NH_3 at global scale

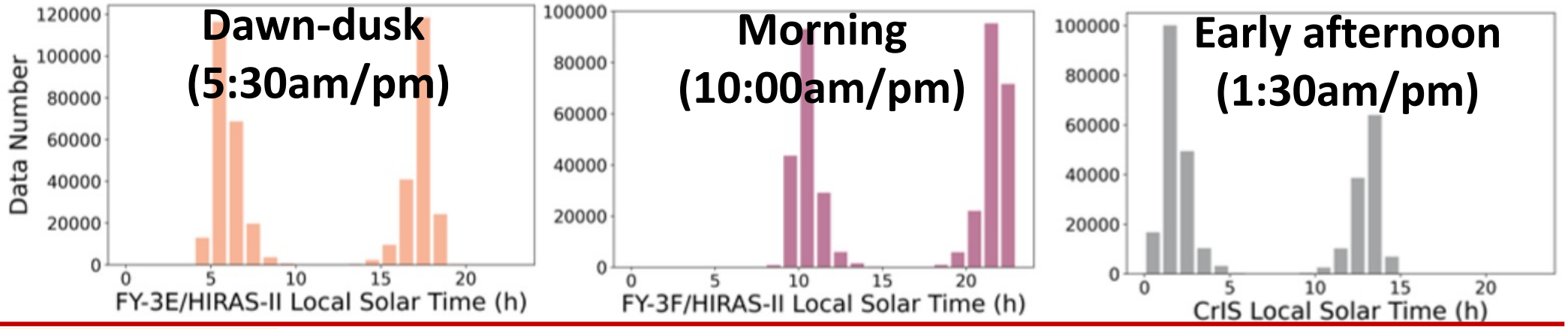
- **FY-4/GIIRS** provides diurnal NH_3 observations over East Asia
- **IRS/MTG** over Europe and Africa.
- However, in regions lacking geostationary satellite observations, such as **North America, and most regions in the Southern Hemisphere**, the diurnal cycle of NH_3 remains under-constrained

Hua et al. 2026, AMT, accepted.

Global “quasi-geostationary” NH_3 from a LEO constellaion

- An integrated constellation to achieve quasi-geostationary-like global monitoring coverage
- The constellation includes 3 LEO infrared sounder at 3 different orbits (two HIRAS-II sensors and the CrIS)
- CrIS is used to substitute FY-3H/HIRAS-II (afternoon orbit) which was launched last year, data are not publicly available yet.
- The constellation overpass times are separated by every 4 hours; 6 global coverages in a day.





Hua et al. 2026, AMT, accepted.

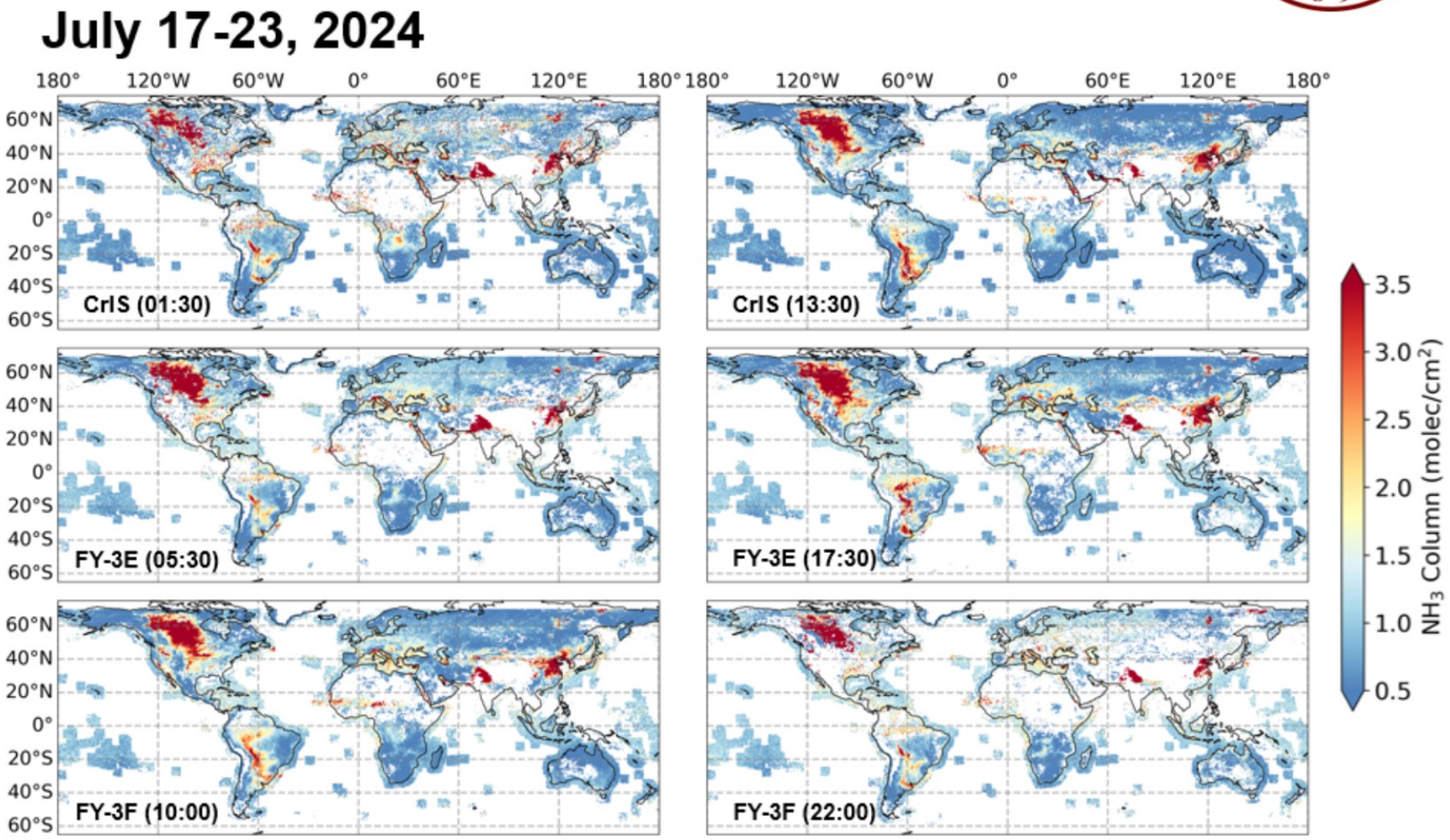
Global "quasi-geostationary" NH_3 from a LEO constellaion

FY-AIR retrieval algorithm:

- Optimal estimation based physics retrieval method
- A fixed a priori NH_3 profile
- Scale the profile to retrieve the total column and the uncertainty
- Column averaging kernel

- Example (1 week in July, 2024) CrIS, FY-3E, and FY-3F
- Consistent spatial distributions
- High NH_3 columns concentrated in North India, North China (agriculture), North and South America (biomass burning).

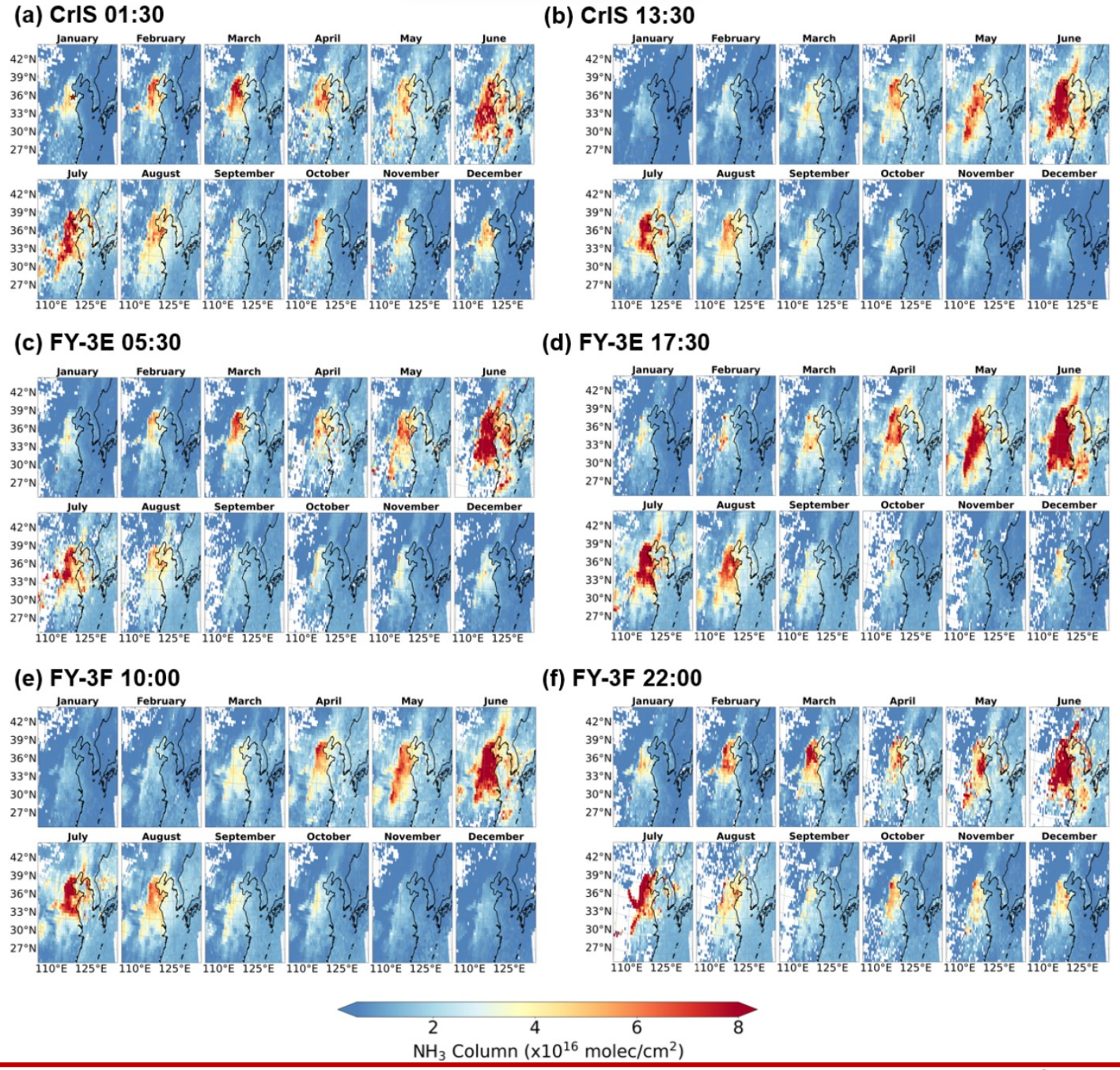
Hua et al. 2026, AMT, accepted.



Global “quasi-geostationary” NH_3 from a LEO constellaion

- Diurnal and seasonal cycles from monthly mean NH_3 total column over the North China Plain
- All retrievals at six distinct times show that NH_3 columns peak in June and low in winter months.
- The constellation provides a comprehensive observations for global NH_3 research.

Hua et al. 2026, AMT, accepted.

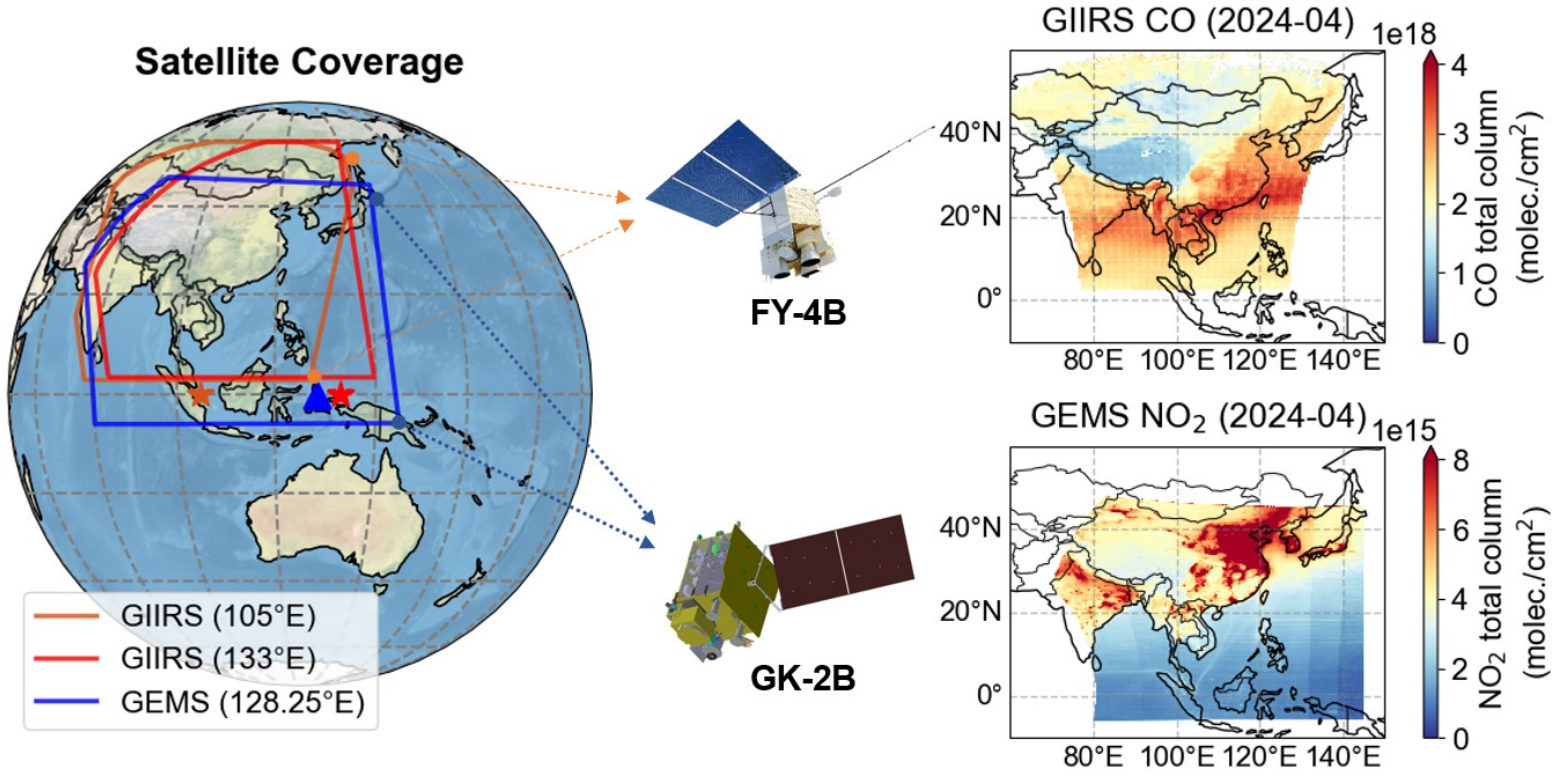


- Global “quasi-geostationary” NH_3 observations from a LEO satellite constellaion

- Geostationary observations of air pollutants from biomass burning: a synergy of GIIRS and GEMS over Southeast Asia

A synergy of GIIRS and GEMS over Southeast Asia

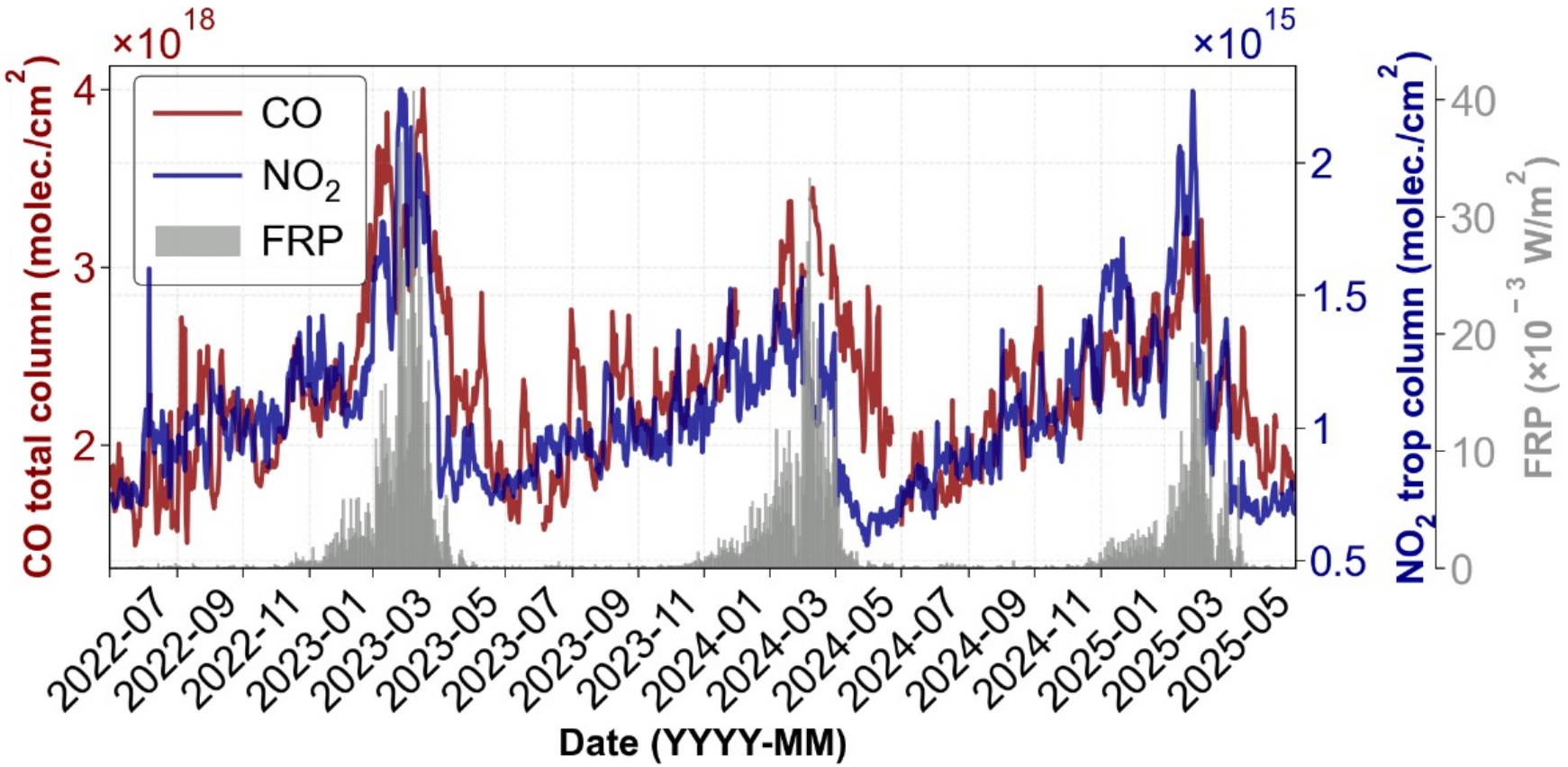
- Biomass burning (BB) emits massive CO and NO2, disturbing regional air quality and climate.
- LEO satellites provide only single daily snapshots, failing to capture rapid diurnal emission evolution.
- Integrate FY-4B/GIIRS (2-hourly) and GK-2B/GEMS (hourly) to establish the first geostationary (GEO) synergistic observation framework for monitoring the diurnal dynamics of fire emissions and combustion efficiency over the Indochina Peninsula.



Han et al. (2026), in review after revision, RSE

A synergy of GIIRS and GEMS over Southeast Asia

CO, NO2, and FRP are highly synchronized; fire peaks in March–April; seasonal diurnal cycles are interannually stable.



Han et al. (2026), in review after revision, RSE

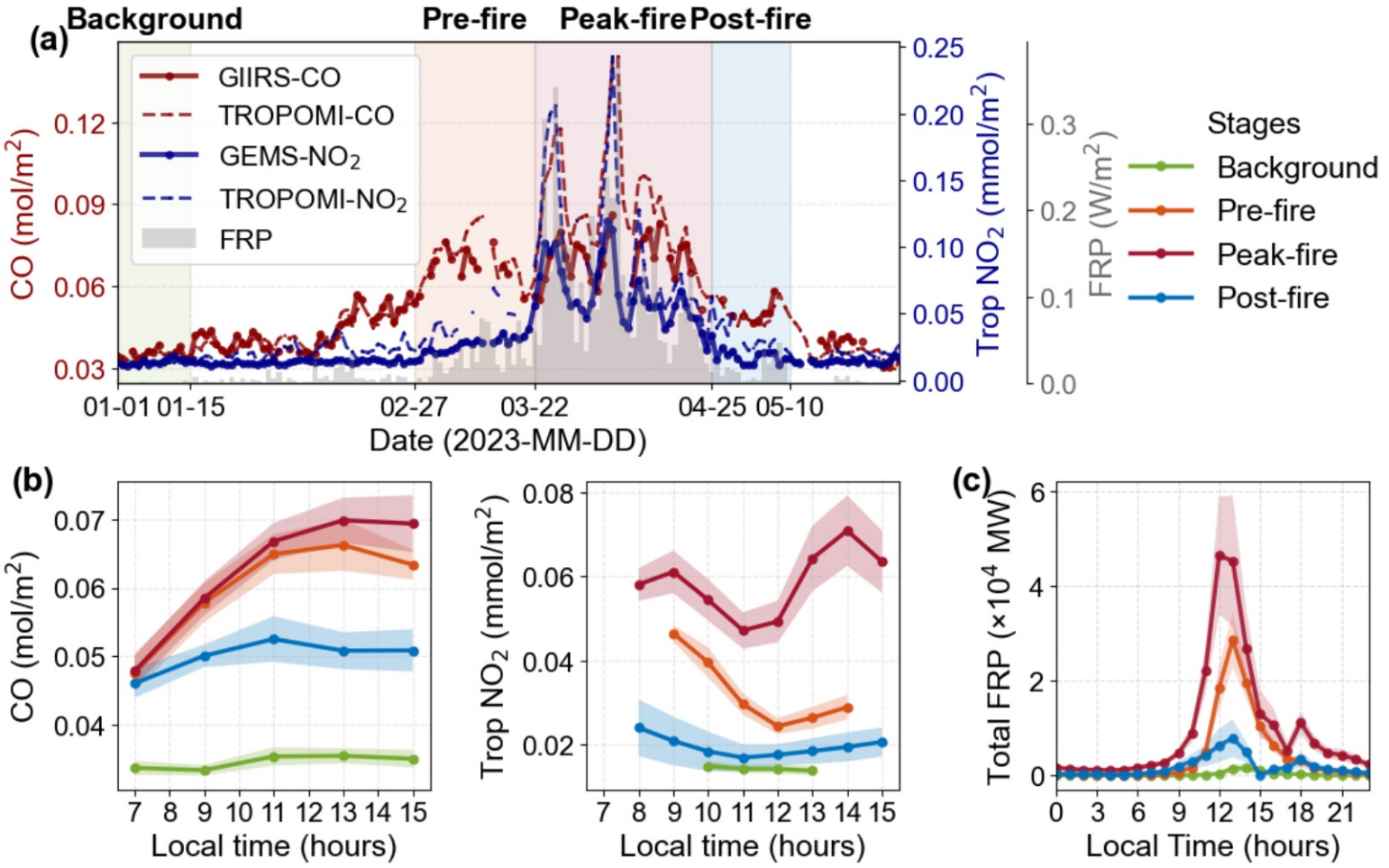
A synergy of GIIRS and GEMS over Southeast Asia

Case Study: Regional Dynamics (Northern Laos)

Diurnal evolution of trace gases:

CO accumulation: Rises continuously (07:00–13:00 LT) as intense fire emissions outpace regional dispersion.

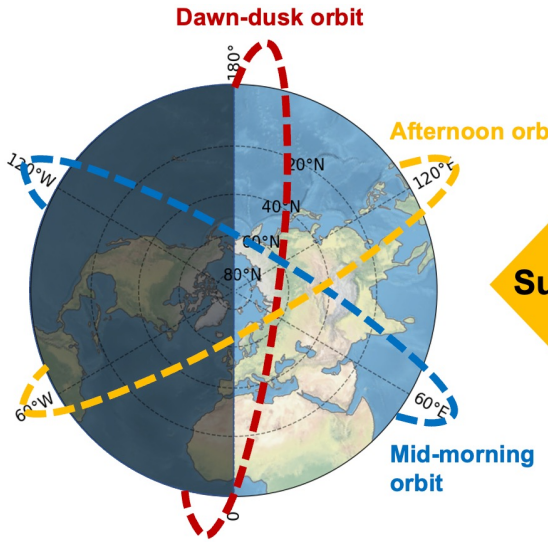
NO2 bimodal pattern (Peak-fire): ~09:00 LT (Minor Peak): Early fire onset under low winds; ~11:00 LT (Trough): Strong photolytic & OH radical sinks; ~14:00 LT (Major Peak): Midday emission climax & intense secondary production.



Han et al. (2026), in review after revision, RSE

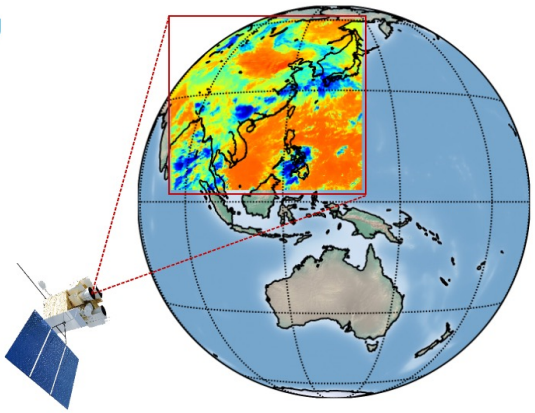
Summary

- **An LEO constellation** that achieves **quasi-geostationary-like coverage**, enabling six global NH_3 column retrievals based on the optimal estimation method, for every 4-hour per day.
- We present geostationary observations of CO and NO2 from biomass burning using **a synergy of GIIRS and GEMS** over Southeast Asia and study the impacts of biomass burning emissions;
- Observations acquired by FengYun meteorological satellites not only improves **numerical weather prediction**, but also offers key insights into **atmospheric composition** across regional and global scales.



HIRAS:
Hyperspectral InfraRed Atmospheric Sounder

GIIRS:
Geostationary Interferometric Infrared Sounder



Data availability: The GIIRS and HIRAS L1 spectra are publicly available from the National Satellite Meteorological Center: http://satellite.nsmc.org.cn/portalsite/; CO and NH_3 data from GIIRS and HIRAS have been uploaded to **Zenodo**, please check our project website (https://fengyunair.github.io/).

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Global "quasi-geostationary" NH_3 from a LEO constellaion

Important issues and possible solutions:

(1) There is a strong diurnal change in detecting sensitivity
The thermal contrast (TC) is the primary driver (we use a stringent threshold of 5K) to ensure high sensitivity;

(2) The use of a fixed a priori NH_3 profile may not be optimal
We test using a varying profile from GEOS-CF model simulations, the differences are not large (since we only use quality-controled observations with TC>5K)

More details in Hua et al. 2026, AMT EGUSphere
https://doi.org/10.5194/egusphere-2026-746