Development and Early Results from the NASA GSFC EM27/SUN Observation Network

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Introduction

Ground-based remote sensing plays a vital role in atmospheric carbon monitoring by providing independent, high-accuracy observations that improve our understanding of greenhouse gas sources, sinks, and atmospheric transport. Established networks such as the Total Column Carbon Observing Network (TCCON) have been fundamental in delivering high-precision measurements for satellite validation, atmospheric models, and carbon cycle research. However, the high cost, operational complexity, and maintenance requirements of TCCON instruments have limited the global spatial coverage of the network.

The emergence of the EM27/SUN spectrometer – a compact, portable Fourier transform infrared (FTIR) instrument – along with the development of the Collaborative Carbon Column Observing Network (COCCON), have enabled a substantial expansion of ground-based observations of column-averaged concentrations of CO_2, CH_4, and CO. This growing network offers great potential to enhance atmospheric monitoring, strengthen satellite validation efforts, and improve constraints on models and regional carbon flux estimates.

Here, we present initial results from a newly established U.S. network of ground-based EM27/SUN instruments. Measurements collected from summer 2025 through early 2026 across the DC/Maryland region demonstrate the capability of this emerging network to characterize regional greenhouse gas variability and support the validation of satellite observations and atmospheric models. These early observations highlight the value of a network of EM27/SUN measurements for advancing greenhouse gas monitoring, improving the spatiotemporal characterization of atmospheric greenhouse gas variability, and reducing uncertainties in regional carbon flux estimates.

Instrumentation

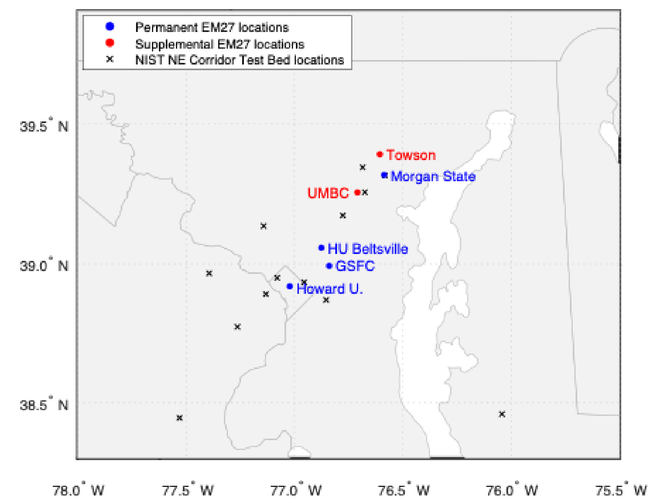
Instrument	EM27/SUN - Fourier Transform Infrared Spectrometer *Made in collaboration with Karlsruhe Institute of Technology (KIT) and Bruker
Measurement band	4000-11000 cm^{-1} (0.9 ~ 2.5 μm) *Covers same spectral region as TCCON and encompasses same spectral region as TROPOMI
Measured gas	CO_2, CH_4, CO, H_2O, O_2
Spectral resolution	0.5 cm^{-1}
Temporal resolution	~1 min (10 scans in about 58s)



- The EM27/SUN is a portable FTIR spectrometer which records direct solar spectra in the near-infrared window to measure total column concentrations of CO_2, CH_4, and CO (XCO_2, XCH_4, XCO).
- Having the advantage of being portable and easy to operate, the EM27/SUN can be a practical, lower-resolution alternative to the TCCON.
- When properly calibrated against TCCON sites or other trusted references, EM27/SUNs can provide stable and useful column measurements, enabling a broader and more flexible deployment of ground-based remote sensing capabilities.

Initial deployment of the NASA GSFC network in the DC/Maryland region

- NASA GSFC plans to deploy 10 EM27/SUN spectrometers across the U.S. to create a ground-based network.
- The initial deployment sites of the NASA GSFC network will be concentrated in the DC/Maryland region and contribute to ongoing atmospheric observation efforts around the area.
- These EM27/SUN sites have participated in several NASA airborne atmospheric observation campaigns from June – August 2025, including MAGEQ and SARP 2025.
- Combined with satellite observations and aircraft measurements, the ground-based EM27/SUN measurement efforts will yield a unique observational dataset for the urban and suburban areas of the DC/Maryland metropolitan region.
- The dense cluster of EM27/SUN sites in the DC/Maryland region, together with a newly established TCCON site at GSFC, provides a valuable testbed for a targeted satellite observations and the validation of current and future greenhouse gas missions.









Preliminary results from the NASA GSFC EM27/SUN network

- The measurement data of the initial deployment EM27/SUN sites are processed using the PROFFAST retrieval code developed by KIT, which is a least-squares fitting algorithm that adjusts measured atmospheric spectra using TCCON GGG2020 a priori profiles.
- Preliminary data from two EM27/SUNs at GSFC, and one each at the Beltsville and Towson sites compared together show that the EM27/SUN well captures the temporal variability of XCO_2, XCH_4, and XCO at each of the sites.
- The NASA GSFC EM27/SUN network will implement centralized processing of EM27/SUN data, using both PROFFAST and the EM27/SUN GGG Interferogram processing suite, providing a diverse dataset and enabling systematic evaluation of retrieval differences.

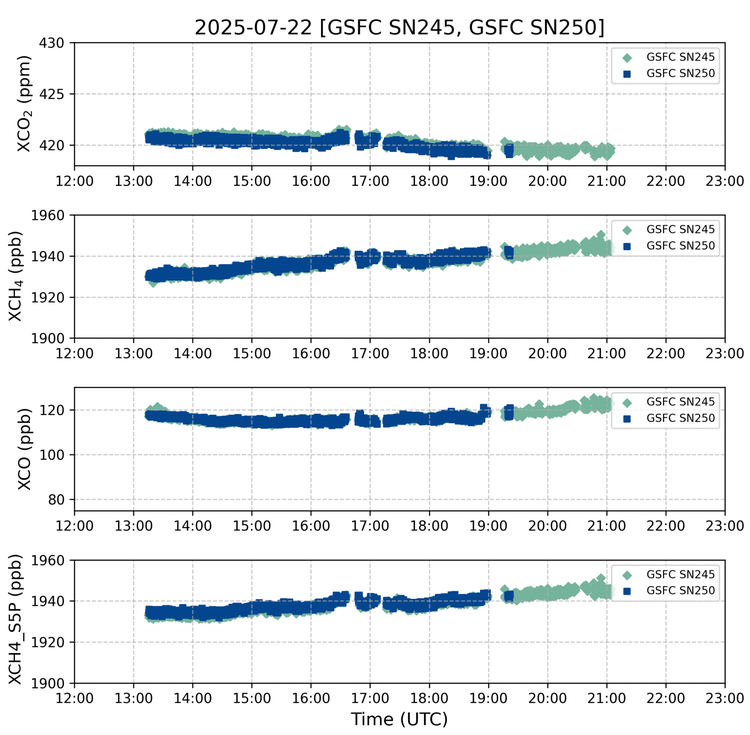


Figure 1: Side-by-side measurements from the co-located EM27/SUN instruments SN245 (green) and SN250 (blue) at GSFC show strong agreement in their observations.

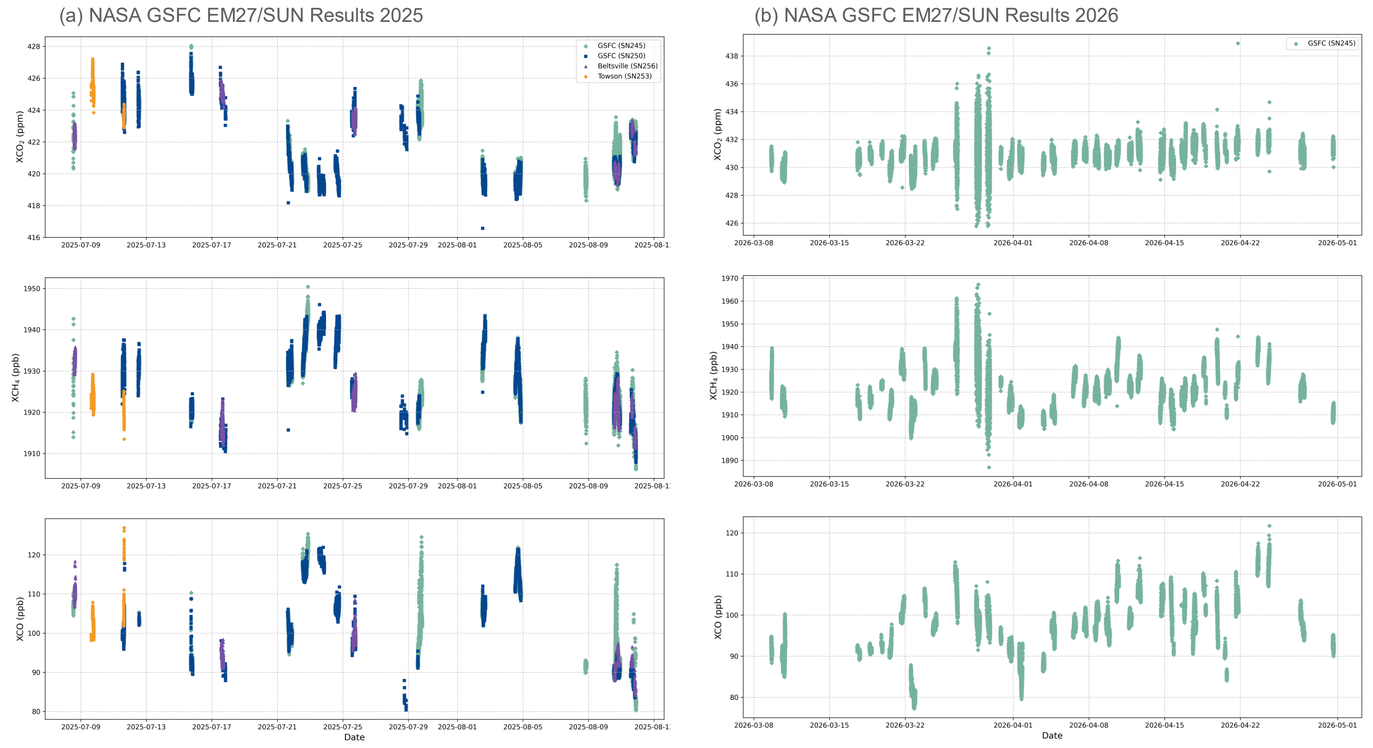


Figure 2: EM27/SUN observations from different network sites during (a) summer 2025 and (b) early 2026 reveal distinct daily variations in XCO_2, XCH_4, and XCO, highlighting spatial differences in greenhouse gas concentrations within the region.

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