

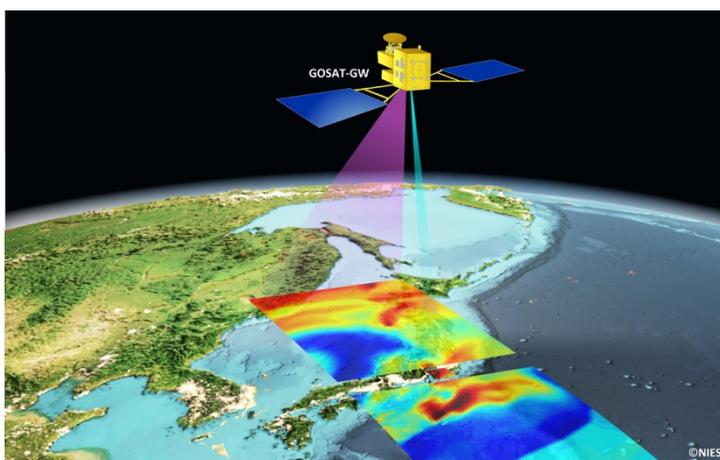


TOKYO-FIELD CAMPAIGN (TOKYO-FC)

PROJECT PLAN – FEBRUARY 2026

The Tokyo Field Campaign (Tokyo-FC) is a collaborative airborne field campaign between the National Aeronautics and Space Administration (NASA) and Japan's National Institute for Environmental Studies (NIES) and Japan Aerospace Exploration Agency (JAXA) with the overarching goal to validate products retrieved by Japan's latest satellite instrument launched in June 2025.

The Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW) satellite launched on June 29th, 2025 from JAXA Tanegashima Space Center on the final H-IIA rocket. GOSAT-GW will continue the legacy of the GOSAT missions in providing global measurements of column averaged dry-air mole fractions of carbon dioxide (CO₂) and methane (CH₄) with the added capability of mapping the nitrogen dioxide (NO₂) vertical columns. Many details about the satellite mission can be found in (Tanimoto et al., 2025). Briefly, GOSAT-GW measures CO₂, CH₄, and NO₂ with the Total Anthropogenic and Natural emissions mapping Spectrometer-3 (TANSO-3) measuring in the visible to shortwave infrared spectral ranges. GOSAT-GW is a low-Earth orbiting satellite with an equator crossing time of 13:30 LT with a 3-day repeat cycle. The spatial resolution of the data products ranges from 10 km in 'Wide Mode' down to 1-3 km for the 'Focus Mode'. The science goals of the mission include monitoring global mean concentrations often trace gases observed as well as verification of emission inventories over its seven-year lifetime.



With any new satellite products coming out, validation is required to ensure the uncertainty is well characterized before enabling their use for science or applications. The target precision to be achieved by validations with ground-based TCCON and Pandora observations is < 0.25% (~1 ppm), < 0.5% (~5 ppb), and 3.80×10^{15} molec.cm⁻² for XCO₂, XCH₄ and NO₂ VCD, respectively.

The GOSAT-GW trace gas products will primarily rely on ground-based networks like the Total Carbon Column Observing Network (TCCON; <https://www.tcon.caltech.edu/>) and Pandonia Global Network (PGN; <https://pandonia-global-network.org/>), which have instrument distributed around Japan as well as the rest of the world. Airborne measurements, though, provide a unique

perspective in being able to distinguish spatial gradients (e.g., Judd et al., 2019) as well as quantifying emission rates around sources (e.g., Cusworth et al., 2020)

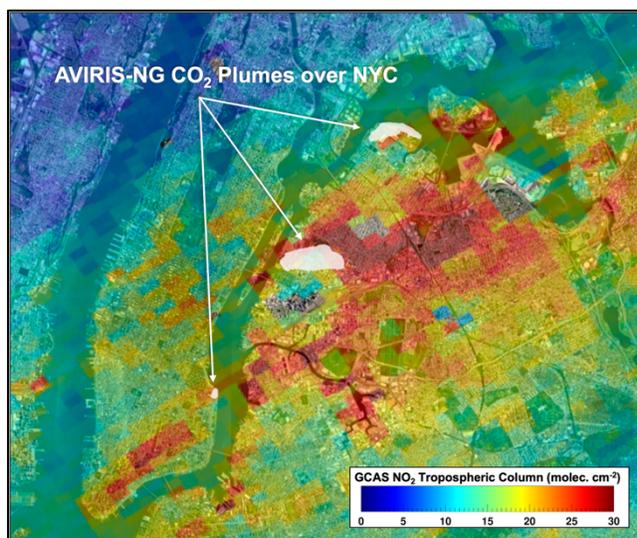
For Tokyo-FC, NASA will deploy their Langley Research Center G-III with a payload of two passive remote sensing instruments: the GEOstationary Coastal and Air Pollution Events (GEO-CAPE) Airborne Simulator (GCAS) and Airborne Visible/Infrared Imaging Spectrometer-5. These measurements will be complemented by a Diamond Air Service King Air contracted by Japan's NIES to measure in situ observations of CO₂, CH₄, and NO₂, as well as for testing a new NO₂ remote sensor developed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The scientific objectives of these flights are to validate/evaluate satellite products from GOSAT-GW to ensure that they are meeting the required accuracy and precision for their use in monitoring global atmospheric composition and constraining emissions inventories.

This project plan describes background of the instruments collecting data during this mission as well as a brief summary of flight plan strategies to accomplish the collection of a sufficient validation dataset.

Airborne measurement summary:

NASA is deploying its Langley Research Center Gulfstream-III (N520NA) which has flight duration up to six hours and flight ceiling of FL450. The aircraft has been modified with two remote-sensing portals with a view nadir of the plane while in flight, which will have the GCAS and AVIRIS-5 instruments installed.

- ⇒ GCAS has a legacy of measurements on NASA aircraft, including N520NA for the Airborne-Satellite Investigation of Asian Air Quality (ASIA-AQ: <https://www-air.larc.nasa.gov/missions/asia-aq/index.html>) mission in 2024. It is an ultraviolet-visible airborne spectrometer (300-490 nm) with a spectral resolution of 0.6 nm and a spatial field of view of 45 degrees nadir of the aircraft. At FL410, this gives a swath width of ~10 km resulting in pixels approximately 350 m across track and 550 m along track at the nominal ground speed of 400 knots. NO₂ is retrieved using differential optical absorption spectroscopy (DOAS) from the 420-465 nm spectral window with a differential slant to vertical column conversion described in Judd et al. (2019) and Judd et al. (2020). The retrieval has been validated with PGN with no known systematic biases and uncertainty within +/- 25% (Judd et al., 2020).
- ⇒ AVIRIS-5 is an imaging spectrometer measuring reflected sunlight from 380 nm to 2500 nm with a spectral sampling of 5 nm (https://airbornescience.nasa.gov/instrument/Airborne_Visible_Infrared_Imaging_Spectrometer_5). This instrument is considered the airborne version of NASA's Earth Surface Mineral Dust Source Investigation (EMIT) which has been on board the ISS since 2022 (Thorpe et al., 2023). It has a field of view nadir of aircraft of 40 degrees resulting in a swath width at FL410 of ~9 km split into 1240 spatial pixels. Its first deployment was in 2025 on the NASA ER-2. Data from AVIRIS-5 is used to retrieve estimated emissions of CO₂ and CH₄ by using an integrated mass enhancement technique to retrieve the enhancement from the background as well as wind estimation, such as those provided by meteorological models (Thorpe et al., 2014, 2017). These flights will also enable the opportunity for AVIRIS-5 to detect plumes of NO₂ (Varon et al., 2024; Borger et al., 2025).



Below is an example map of from the July 28th, 2023 Synergistic TEMPO Air Quality Science study flight in 2023 from GCAS NO₂ over New York City and plumes (white outline) observed from major CO₂ sources from AVIRIS-NG, a predecessor of AVIRIS-5. These observations were collected from two separate aircraft during STAQS but were observed approximately an hour apart. NO₂ is given in molecules cm⁻² as will be a level two product from GOSAT-GW and AVIRIS data is provided an enhanced column-integrated concentration (concentration lengths) which can be used in combination with wind data to estimate emission rates, which is an intended use of GOSAT-GW data.

Additionally, NIES for this mission is working with Diamond Air Service in Japan to outfit a King Air with complementary measurements to the NASA G-III. This aircraft will be used to map similarly to the NASA G-III as well as profile the atmosphere to connect what is measured at the surface with the column-based perspective provided by remote sensing measurements. This aircraft will include one remote sensing instrument as well as a suite of in situ measurements:

- ⇒ JAMSTEC is developing a NO₂ remote sensing instrument similar to GCAS which will be tested during this deployment. This instrument has a wider field of view than GCAS (56.2°) measuring in the 429-491 nm wavelength range with a FWHM spectral resolution of 1 nm. A temperature stabilized spectrometer (IsoPlane160) coupled with a cooled EMCCD (ProEM-HS:512BX3) is under preparation.
- ⇒ In situ trace gas measurements will be provided by a Picarro G2410-m for CO₂, CH₄, and CO. NO, NO₂, and NO_y measurements will be provided by an Eco Physics CLD780/PLC762/CON765.

Deployment Plan:

Science Flight Window: 7 March - 2 April 2026

Over this four-week window, NASA will target ten 5-hour flights for a total of 50 hours. Taking into account of ascents/descents of approximately 30 minutes each, this leaves 4 hours for science data collection each flight. This time window was chosen for several reason:

1. To observe emissions from altitude, skies must be cloud free over the area of interest. Climatologically, Japan is most cloud free in the year during the winter months. Therefore, this season was chosen to optimize flight opportunities during the first winter season of GOSAT-GW.
2. Both remote sensing instruments measure backscattered sunlight and require a large enough signal to produce high quality retrievals. The limitation for this is typically limited to solar zenith angles (SZAs) less than 70 degrees for GCAS and 60 degrees for AVIRIS-5. Tokyo does not approach more than 4 hours a day under this SZA constraint until February 2nd. By February 23, the number of hours with SZA less than 60 degrees is 5.5 increasing to over 7 hours by the end of the deployment.

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