EGU21-13404, updated on 03 Dec 2022
https://doi.org/10.5194/egusphere-egu21-13404
EGU General Assembly 2021

Monitoring the nations' climate mitigation progress using multi-species observations from Japanese passenger aircrafts

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The greenhouse gas (GHG) emissions from cities account for more than 70% of the global emissions. Over the past decades, GHG-dedicated space-based instruments, such as Japan's Greenhouse gases Observing SATellite (GOSAT) (2009-), GOSAT-2 (2018-), NASA's Orbiting Carbon Observatory-2 (OCO-2) (2014-), and OCO-3 (2019-), have collected the increased amount of the GHG data on the global scale, especially over urban areas. Such data have provided new opportunities to explore ways to study urban emissions, and they will also play a key role in monitoring the progress of subnational climate mitigation efforts towards the Paris Climate Agreement goal.

Here we present the first high-resolution multi-species (CO_2 and NO_2) observations from Japanese passenger aircrafts, which should further enhance our ability to quantify GHG emissions in combination with data collected from existing ground-based stations and satellites. Our multi-species observations should also provide direct technical and scientific implications to the planned future space missions, such as Japan's Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW) and ESA's CO_2 Monitoring Mission (CO2M), which also plan to measure CO_2 and NO_2 with a special focus on monitoring GHG emissions.

We designed and developed a carry-on luggage sized imaging spectrometer to collect high-resolution (a few handed m to a few thousand m) CO_2 and NO_2 concentration data during domestic passenger flights. We conducted our first observation during the flight between Tokyo and Fukuoka in October 2020. The two-hour flight allowed us to collect sounding data ranging from 130°E to 140°E in longitude and 33.5°N to 36°N in latitude. The data were being collected every 0.5 sec in nominal and were created up to 5M soundings during the single flight. The

obtained data depicted spatial patterns of $CO^2$and NO_2 concentrations over the cities and industrial areas, with some notable differences from ones seen from existing satellite observations. We compared our data to other data, such as emission inventories, and satellite observations of CO_2, NO_2, and nighttime lights, in order to further characterize the observed spatial gradient and patterns.

In our presentation, we will also discuss the unique utility of our new aircraft observation and its potential contribution to GHG emission monitoring and the upcoming Global Stocktakes (GST) with an expanded observation coverage and frequency.