

Commercial airliners monitoring carbon emissions from cities worldwide

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(left) Japan Airlines aircraft with a special project logo (CONTRAIL) taking off at Tokyo International Airport and (right) Continuous CO₂ Measuring Equipment onboard the aircraft Credit: CONTRAIL Team (Japan Airlines)

Cities are responsible for more than 70% of total global greenhouse gas (GHG) emissions. Ability to monitor GHG emissions from cities is an important capability in order to support climate mitigation activities in response to the Paris Agreement. Researchers use data collected from multiple platforms, such as ground-based systems, aircraft and satellites

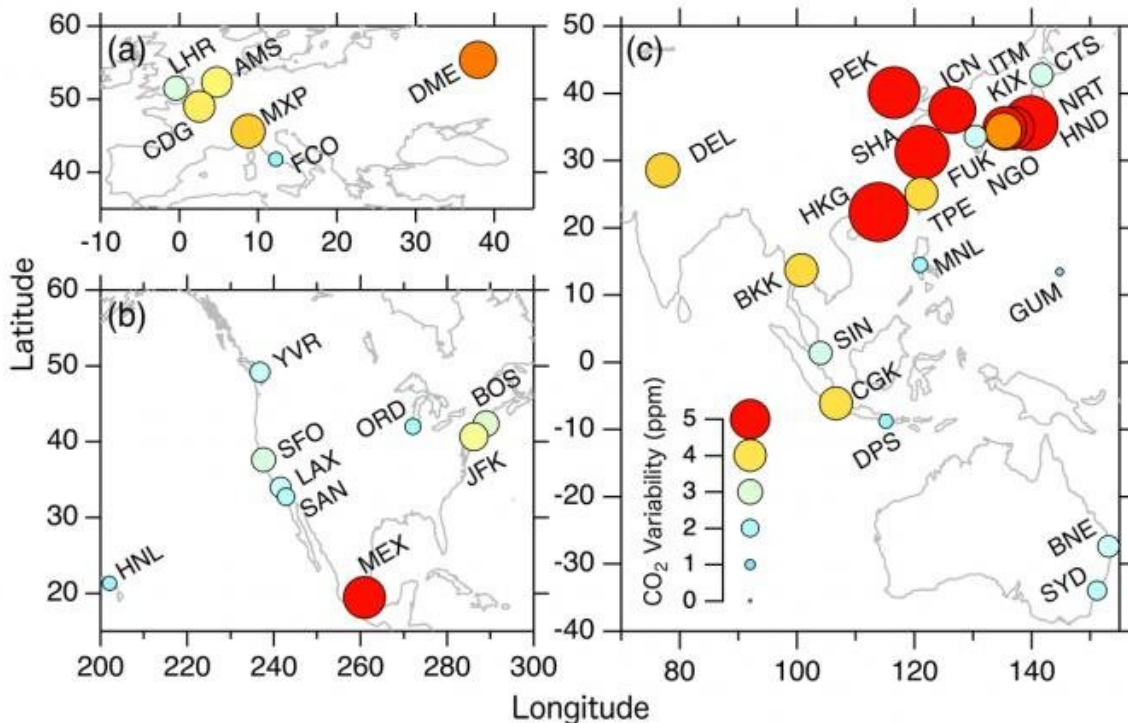
to establish a science-based monitoring capability. A study by an international team, now published in *Scientific Reports*, examined the data collected by commercial airliners and showed the potential of the aircraft data to contribute to the global GHG emission monitoring.

The CONTRAIL (Comprehensive Observation Network for TRace gases by [AirLiners](#)) program is Japan's unique aircraft observation project. Since 2005, the CONTRAIL team has achieved high-precision atmospheric CO₂ measurements using instruments onboard Japan Airlines (JAL) [commercial airliners](#). "Following the aircraft measurements conducted between Tokyo and Australia that I initiated in 1993, and had maintained during my entire career, the CONTRAIL program continuously expanded its global network and has provided data to understand the carbon budget of this planet," said Hidekazu Matsueda, co-author of the study and researcher at the Meteorological Research Institute, Japan.

Recently, the team analyzed thousands of vertical ascending and descending measurements over airports and characterized CO₂ variations over 34 [major cities](#) worldwide for the first time. Airports are often located in the proximity of large cities to ensure convenient access. The CONTRAIL aircraft fly up and down over Narita International Airport many times on a near-daily basis (7,692 times in total during 2005-2016) and are able to obtain the atmospheric chemical signature of the Greater Tokyo Area. The research team examined data collected around similar geographical locations of major airports relative to large urban centers globally in order to retrieve urban CO₂ emission signatures from the data.

"We analyzed millions of observational data collected at and around the Tokyo Narita Airport and found clear CO₂ enhancements when the wind comes from the Greater Tokyo Area," Taku Umezawa, leading author of the study and researcher at the National Institute for Environmental

Studies, Japan, said. "That was also the case globally for other airports, such as Moscow, Paris, Beijing, Osaka, Shanghai, Mexico City, Sydney and others."



Maps of magnitude of CO₂ variability over airports worldwide. Large and red circles indicate large variability. Cities are denoted by nearby airport codes. It was found that the CO₂ variability was large over airports where a nearby city has large CO₂ emissions. Credit: CONTRAIL Team (Japan Airlines)

The team also examined the magnitude of CO₂ variability in the lowermost atmosphere over these airports. "Short-term changes in the CO₂ concentration in the lower atmosphere are associated with various factors such as the upwind pattern of CO₂ emissions and uptakes, the [flight path](#) and its geographical position relative to the locations of

emissions and uptakes, and meteorological conditions during each landing and takeoff," said Kaz Higuchi, co-author of the study and adjunct professor of Environmental Studies, York University, Canada. "Despite these complex conditions under which the measurements are made, it was very interesting that we found a relationship between the magnitude of CO₂ variability and CO₂ emissions from a nearby city." The results show that the commercial airliner-based CO₂ dataset can consistently provide urban emission estimates when combined with atmospheric modeling framework.

"But still, there are missing pieces to examine the physical link to [city](#) emissions to establish urban monitoring," said Tomohiro Oda, scientist of the Universities Space Research Association, Maryland, U.S., who collaborated with the team as a PI of a NASA-funded emission modeling project. "Cities are considered to be responsible for more than 70% of the global manmade greenhouse gas emissions. Accurate estimation of CO₂ emissions from urban areas is thus important for effective emission reduction strategies."

This study suggests that commercial airliner measurements can collect useful urban CO₂ data that are complementary to the data collected from other observational platforms, such as ground stations and satellites, in order to monitor CO₂ emissions from cities. The advantage of commercial airliners is the great global spatial coverage of the measurements, even in regions where there are only sparse greenhouse gas measurement networks and areas where securing ground-site measurements is challenging, such as in developing countries.

"A further implementation of similar CO₂ instruments into other domestic and international flights will significantly extend our global monitoring capability of cities," said Toshinobu Machida, project leader of the CONTRAIL program and head of the Office for Atmospheric and Oceanic Monitoring at the National Institute for Environmental

Studies.

More information: Taku Umezawa et al, Statistical characterization of urban CO₂ emission signals observed by commercial airliner measurements, *Scientific Reports* (2020). [DOI: 10.1038/s41598-020-64769-9](https://doi.org/10.1038/s41598-020-64769-9)

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