EGU25-17804, updated on 10 Dec 2025
https://doi.org/10.5194/egusphere-egu25-17804
EGU General Assembly 2025

Towards Shipborne Emission Monitoring and Satellite Validation of CO_2, CH_4, CO, and NO_2 Through Simultaneous Columnar and In Situ Observations

Astrid Müller[1], Hiroshi Tanimoto[1], Matthias Max Frey[2], **Vincent Enders**[3], Prabir K. Patra[4,5], Takafumi Sugita[1], Ralph Kleinschek[6], Karolin Voss[6], André Butz[6,7], Isamu Morino[1], Shin-ichiro Nakaoka[1], Hideki Nara[1], and Toshinobu Machida[1]

[1]National Institute for Environmental Studies, Tsukuba, Japan
[2]Karlsruhe Institute of Technology, Karlsruhe, Germany
[3]Institute for Materials Chemistry, TU Wien, Vienna, Austria
[4]Japan Agency for Marine–Earth Science and Technology, Yokohama, Japan
[5]Research Institute for Humanity and Nature, Kyoto, Japan
[6]Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany
[7]Heidelberg Center for the Environment, Heidelberg University, Heidelberg, Germany

Precise observations of anthropogenic greenhouse gas (GHG) and air pollutant emissions are essential for improving emission inventories and evaluating the potential of their reduction, supporting the global stocktake. The global coverage of ship-, aircraft-, and ground-based observations by public and private networks, together with satellite observations of GHGs and other trace gases, is expanding. However, observations and reference data over ocean and coastal regions remain scarce.

We conduct continuous cargo ship-based observations with a novel semi-automatic Fourier transform infrared (FTIR) spectrometer combined with a VIS (visible spectral range) grating spectrometer to measure the column-averaged dry-air mole fractions of carbon dioxide (XCO_2), methane (XCH_4), carbon monoxide (XCO) and the vertical column densities of nitrogen dioxide (VCD_{NO2}). Combined with simultaneous in situ observations (CO_2, CH_4, CO, NO_2), we aim to constrain anthropogenic emissions and contribute to a satellite validation framework for upcoming satellite missions like the Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW) or the Copernicus Anthropogenic Carbon Dioxide Monitoring (CO2M) mission. These missions are designed to identify and monitor anthropogenic emissions by observing the GHG CO_2 and the short-lived combustion tracer NO_2 simultaneously. With our novel setup, we have the capability to validate these concurrent observations.

The cargo ship operates along major anthropogenic emission sources on Japan's coast between the Tokyo metropolitan area and the island of Kyushu in the southwest with a weekly round-trip schedule. We present the initial analysis results of the combined columnar and in situ observations for emission plume detection and inventory validation, and provide perspectives of

the setup for satellite validation and anthropogenic emission monitoring.