

New Tools for Greenhouse Gas Monitoring and Satellite Validation over Oceans: Utilizing Commercial Ship and Aircraft Observations and a Novel Semi-Automatic FTIR - VIS Spectrometer

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Abstract

Precise observations with high spatial and temporal coverage of anthropogenic greenhouse gas (GHG) emissions are crucial for improving emission inventories and for assessing the reduction potential of emission sources, contributing to the global stocktake. Therefore, 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. Over oceans and coastal regions, reference datasets for carbon cycle studies and satellite validation remain scarce. We integrate in situ observations by commercial ship (Ship-of-Opportunity - SOOP) and aircraft (Comprehensive Observation Network for Trace gases by Airliner - CONTRAIL) to obtain observation-based profiles, assisted by results from the MIROC4-based atmospheric chemistry transport model (ACTM). From these profiles, we obtain datasets of the column-averaged dry-air mole fractions of carbon dioxide (XCO_2) and methane (XCH_4) over the Pacific Ocean. The uncertainties of the new datasets are 0.63 ppm for XCO_2 and 16 ppb for XCH_4 . Seasonal variations of CO_2 and CH_4 are captured accurately by our datasets, and we demonstrate their applicability for satellite validation through comparison with different retrievals of the Greenhouse Gases Observing SATellite (GOSAT). Complementary, we conduct continuous cargo-ship-based observations of XCO_2 , XCH_4 , and XCO (X carbon monoxide) using a semi-automatic Fourier transform infrared (FTIR) spectrometer combined with a VIS (visible spectral range) spectrometer to measure the vertical column densities of nitrogen dioxide (VCD_{NO_2}). The aim is to constrain anthropogenic CO_2 emissions and to validate XCO_2 and VCD_{NO_2} data of the upcoming Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW). The setup, developed by Heidelberg University, was deployed on a cargo ship in September 2023, operating along major anthropogenic emission sources on Japan's coast between Kanto and Kyushu. We present initial retrieval results and provide perspectives of the setup for satellite validation and monitoring of anthropogenic emissions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions usinG Observations, GEIA: Global Emissions Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group, Japan National Committee