Unveiling Multi-Scale Emissions and their sources in Japan: Results from First Continuous Cargo Ship observations of Greenhouse Gases and Air Pollutants

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Abstract

Continuous shipborne observations offer a unique platform for studying city emission outflows over vast ocean regions and near coastlines yet such observations are either only in campaign mode or are extremely limited. This study fills in this crucial gap by making the first continuous cargo ship-based measurements (Jan 2022-Mar 2023, presented here) of trace gases (CO, CO_2, CH_4, NO, NO_2, NO_y, O_3 and SO_2) and aerosols (PM, BC, EC, OC) along the Japanese Coast, a key shipping route near major industrial areas. The results reveal significant spatial and temporal variations of these species across the Japanese Coast with a spring maximum and particularly high emissions in the Tokyo Bay region. We also demonstrate the capability of these multi-species measurements in deriving CO emissions for major city bays like Tokyo, Nagoya, Kobe, and Hiroshima and compare them against bottom-up inventories. Further, we isolate the impact of anthropogenic activities by separating background concentrations from excess ones showing that the CO_2 excess levels could be as high as 35 ppm in the four regions. It is shown that multi-species enhancement ratios derived from these observations hold promise for constraining emissions from large point sources like power plants concentrated in bay regions. This approach is also shown to identify events of particularly high emissions. Additionally, FLEXPART and ODIAC emissions alongside ship data are utilised to estimate emissions. The capability of the atmospheric transport model NICAM-TM in simulating CO_2 and CH_4 is also evaluated. The study thus highlights the immense potential of these new measurements not only to offer insights into regional air quality but also to act as a baseline for validating data of GOSAT-GW to be launched in 2024, empowering the development of robust top-down emissions estimates, to support the Global Stocktake and monitoring emissions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, AMIGO: Analysis of eMIssions usinG Observations, GEIA: Global Emissions Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups

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