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Towards An Automated Ship-Borne Fourier-Transform Spectrometer As a Validation Opportunity For Atmospheric CO2, CH4, And CO Column Densities

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Validation opportunities for model data and satellite observations in the short-wave infra-red spectral range for climate monitoring are still sparse above the oceans. Klappenbach et al. (2015) and Knapp et al. (2020) developed a ship-borne setup of a Fourier-transform spectrometer (EM27/SUN FTS) for direct sunlight observations on mobile platforms such as ships or pick-ups. The housing withstands oceanic on-deck-conditions and is equipped with a custom-built fast solar tracker. Knapp et al. (2020) tested the system on a ship cruise from Vancouver, Canada to Singapore for a five-week period in 2019, during which the instrument performed reliably. The tracker provided a pointing precision of better than 0.05° for 79% of the time. The precision of atmospheric total column densities retrieved from the FTS direct sunlight spectra was found to be 0.24ppm for carbon dioxide (CO_2), 1.1ppb for methane (CH_4), and 0.75ppb for carbon monoxide (CO).

Our ultimate goal is to develop the setup towards autonomous operations on ships to routinely collect validation data for CO_2, CH_4, and CO column densities above the world's oceans. Therefore, we further improved on the FTS box. Most prominent is a simplification of the tracking algorithm from two-dimensional mapping to two one-dimensional functions, moving a 185° fisheye camera onto the tracking rotation stage, and a change to more reliable embedded computers. Those modifications allow for sun tracking down to a solar zenith angle of 75° and increase robustness against mechanical misalignments between tracker and camera. A test campaign was conducted in the vicinity of a local coal power plant in Mannheim, Germany by mounting the FTS box on a pick-up and driving a stop-and-go pattern perpendicular to the plume direction. To this purpose, a 24 V battery powering mode was implemented.

We plan another deployment of the instrument on the Japanese research vessel Mirai in February 2021. The campaign is conducted in cooperation with the Japanese National Institute for Environmental Studies (NIES) in the western North Pacific. Such routine validation opportunities of atmospheric CO_2, CH_4, and CO column densities would be a valuable asset for global climate monitoring.

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