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Quantifying the Greenhouse Gas Emissions from the Steel Plant Bremen

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Power plants and large industrial facilities are responsible for over half of global anthropogenic CO2 emissions. As a result, accurate and independent monitoring of these sources is essential to refine global carbon estimates and support international climate commitments. The limited temporal and spatial resolution of satellite-based greenhouse gas concentration measurements necessitates the use of ground-based measurement techniques to support emission quantification at the facility level.

This work presents a unique set of various ground-based in-situ and remote sensing measurements. In conjunction with high-resolution atmospheric simulations the capability and uncertainties in quantifying greenhouse gas emissions from large point sources is accessed. The facility under study is the steel factory complex of Bremen. It consists of two blast furnaces and an associated blast furnace gas-fired power plant and contributes approximately 5 Mt/yr to the CO2 emissions of the city of Bremen, representing nearly half of the total emissions.

The campaign measurements conducted between April and June 2025 target the plumes of the steel works and surrounding industry and comprises the following instruments: Two portable Bruker EM27/SUN FTIR spectrometers provide accurate observations of the column-averaged abundances of CO2, CO and CH4 in the framework of Integrated Greenhouse Gas Monitoring System (ITMS) project. Mobile zenith-sky measurements with a differential optical absorption spectroscopy (DOAS) instrument retrieve vertical column densities of emitted NO2, allowing monitoring of the plume width and trajectory. A high-precision in-situ analyser provides surface concentrations of CO2. Information on the wind profile between 10 and 300 m above ground in the region of interest is collected using a Wind-Lidar. The field measurements are supported by the Bruker 125HR FTIR spectrometer at the University of Bremen, which provides background values of the atmospheric GHG concentrations.

Additionally, the plume trajectories are simulated with atmospheric models. One model that is employed is a simple Gaussian plume model. In the future, the Langrangian trajectory model FLEXPART will be utilised with a desired spatial

resolution of less than 100 metres. Therefore, the meteorological fields are modelled using WRF-LES. The objective is to integrate the simulation outcomes with the excess value measurements of the CO2 concentrations, with a view to deriving emission estimates for the steelworks.