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Linking airborne in-situ and column GHG measurements using an atmospheric transport model

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Atmospheric greenhouse gases (GHGs) measurements are crucial in atmospheric and climate research, as our knowledge of GHG budgets is still somewhat limited. Research flight campaigns can be a powerful extension to other observations when investigating specific point sources or regions that are not covered by existing networks. Such campaigns can make in-situ and remote sensing measurements simultaneously, but the inter-comparison of these data streams can pose a challenge. In the research campaign CoMet (Carbon dioxide and Methane Mission) which took place in 2018, both in situ measurements from the Jena Instrument for Greenhouse gas measurements (JIG) and remote sensing measurements from the Integrated Path Differential Absorption (IPDA) Lidar CHARM-F were conducted from the German research aircraft HALO.

This study aims to link these two measurements by using the regional Lagrangian transport model (STILT), and to establish the traceability of the measurements from the newly developed instrument CHARM-F to WMO standards. The STILT model uses meteorological fields from the ECMWF IFS model to derive footprints from a measurement receptor point, defining the area whose fluxes influence the atmospheric mixing ratio signal. The model then calculates the mixing ratio of the trace gases carbon dioxide (CO_2) and methane (CH_4) by multiplying the footprint with the anthropogenic emissions inventory from EDGAR and biospheric CO_2 fluxes from the diagnostic Vegetation Photosynthesis and Respiration Model. A simple bias correction for the STILT model based on in-situ measurements is first calculated and applied in order to reduce its representation error. This corrected and characterized model is then used to calculate vertical partial column (VPC) CO_2 and CH_4 mixing ratios along the flight track. By comparing the modeled VPC mixing ratios to the CHARM-F observations, the consistency of the CHARM-F measurement with the highly precise and accurate in situ measurements can be established, while taking into account the uncertainty of the model bridging the two data streams.