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Comparison of glyoxal, BrO, and IO vertical profiles derived from both ground-based and airborne MAX-DOAS measurements

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The information content of ground-based MAX-DOAS retrievals is assessed by collocated aircraft measurements for a ship MAX-DOAS setup over the Eastern tropical Pacific Ocean (TORERO RF17), and a mountain-top MAX-DOAS setup at Mauna Loa Observatory, Hawaii (CONTRAST RF17). During both case studies the CU airborne MAX-DOAS (AMAX-DOAS) instrument aboard the NSF/NCAR GV aircraft measured profiles of glyoxal, BrO, and IO with 12-20 degrees of freedom and up to 500 m vertical resolution. The TORERO field campaign took place in 2012, while CONTRAST in 2014; both campaigns covered the months of January and February. Additional measurements aboard the aircraft helped to provide information/validation of the AMAX-DOAS derived profiles, such as in-situ water vapor from the Vertical-Cavity Surface-Emitting Laser hygrometer (VCSEL), in-situ hydrocarbon measurements from the Trace Organic Gas Analyzer (TOGA), and aerosol information constrained by the Ultra High Sensitivity Aerosol Spectrometer (UHSAS).

The AMAX-DOAS profiles are compared with ground-based MAX-DOAS inversions. The latter explores the effect of using either the measured differential slant column density (dSCD) or SCD as input to the optimal estimation inversion, where SCD = dSCD + SCD_ref. SCD_ref is the residual column amount of the trace gas contained within the reference spectrum. For the AMAX-DOAS data, the values of SCD_ref were actively minimized, while SCD_ref is usually unknown for ground-based MAX-DOAS retrievals. In absence of independent measurements to constrain SCD_ref, the current state-of-the-art with ground-based MAX-DOAS applications is to use dSCDs as input to the inversion. Here we assess the effect of uncertain SCD_ref for ground-based MAX-DOAS profiles in form of a sensitivity study.

Additionally for the ground-based data, different methods are compared for the determination of SCD_ref: 1) the collocated aircraft profiles described above present the opportunity to forward calculate the SCD_ref based on the true atmospheric state; 2) through an iterative determination of SCD_ref based on the ground-based MAX-DOAS measurements and informed by an atmospheric model for consistency (in this case ground-based data is used from a deployment in Gulf Breeze, Florida, USA in conjunction with the Whole Atmosphere Community Climate Model – WACCM); and 3) through the fitting of the SCD_ref as an additional parameter in the determination of vertical column densities (VCD) as described in Theys et al., 2007.