Geophysical Research Abstracts
Vol. 19, EGU2017-15411, 2017
EGU General Assembly 2017

Test Flight Results of the New Airborne CH4 and CO_2 Lidar CHARM-F

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Installed onboard the German research aircraft HALO the integrated-path differential-absorption (IPDA) lidar CHARM-F measures weighted vertical columns of the greenhouse gases CO_2 and CH4 below the aircraft and along its flight track aiming at high accuracy and precision. CHARM-F was designed and built as an airborne demonstrator for the space lidar MERLIN, the "Methane Remote Lidar Mission", conducted by the German and French space agencies DLR and CNES with launch foreseen in 2021. It provides excellent opportunities for targeted measurements of regional fluxes and hot spots. We present exemplary measurements from several flights performed in spring 2015 over Central Europe. Our analyses reveal a measurement precision of below 0.5% for 20-km averages. A methane plume from a coal mine ventilation shaft was overflown, as well as a carbon dioxide plume from a large coal-fired power plant. The method to estimate fluxes from the lidar signals will be explained. The results show good agreement with reported emission rates.
The airborne measurements are expected to improve the retrieval of future space-borne IPDA lidar systems such as MERLIN. CHARM-F measurements over mountains, water and clouds help assess the strength and variability of backscatter from such challenging surfaces. The IPDA weighting function, or measurement sensitivity, is dependent on atmospheric pressure and temperature. We use ECMWF analyses interpolated in space and time to the aircraft track that provide these auxiliary data. The relatively coarse model representation of orography, with respect to the lidar, causes uncertainties that we assess. CHARM-F will be a key instrument in the upcoming CoMet field experiment, where active and passive remote sensing, as well as in-situ instruments will be installed onboard HALO. The flights are scheduled in April and May 2017 over Central Europe and will focus on point sources such as power plants, coal mines, and landfills, as well as on urban gradients and more extended sources such as agriculture and wetlands.