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Quantification of CO_2 Emission Rates from Large Coal-Fired Power Plants Using Airborne Lidar during CoMet

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A large fraction of global anthropogenic greenhouse gas emissions originates from localized point sources. International climate treaties foresee their independent monitoring. Given the high number of point sources and their global spatial distribution, local monitoring is challenging, whereas a global satellite-based observing system is advantageous. In this perspective, a promising measurement approach is active remote sensing by airborne lidar, such as provided by the integrated-path differential-absorption lidar CHARM-F. Installed onboard the German research aircraft HALO, CHARM-F serves as a demonstrator for future satellite missions, e.g. MERLIN. CHARM-F simultaneously measures weighted vertical column mixing ratios of CO_2 and CH_4 below the aircraft. In spring 2018, during the CoMet field campaign, measurements were taken at the largest European point sources of anthropogenic CO_2 and CH_4 emissions, i.e. coal-fired power plants and ventilation shafts of coal mines. The measurement flights aimed to transect isolated exhaust plumes, in order to derive the corresponding emission rates from the resulting enhancement in concentration, along the plume crossing. For the first time, multiple measurements of power plant emissions were made using airborne lidar. On average, we find that our measurements are consistent with reported numbers, but observe high discrepancies between successive plume crossings of up to 50 %. As an explanation for these high discrepancies, we assess the influence of inhomogeneity in the exhaust plume, caused by atmospheric turbulence. This assessment is based on the Weather Research and Forecasting Model (WRF). We find a pronounced diurnal cycle of plume inhomogeneity associated with local turbulence, predominately driven by midday solar irradiance. Our results reveal that periods of high turbulence, specifically during midday and afternoon, should be avoided whenever possible. Since lidar is intrinsically independent of sun light, measurements can be performed under conditions of weak turbulence, such as at night or in the early morning.