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Potential of Satellite Lidar Measurements of CO_2 and CH4 Emissions from Strong Point Sources

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Emissions from strong point sources, primarily large power plants, are a significant part of the total anthropogenic CO_2 emissions. International climate agreements will more and more require their independent monitoring. Plume measurements from space are challenging because the total column CO_2 or CH4 is measurably enhanced only in the core of the plume, on scales of at most a few kilometers. First emission rate estimations could be obtained from integrated-path differential-absorption (IPDA) lidar measurements of individual CO_2 and CH4 plumes from power plants and coalmines with the airborne DLR CHARM-F lidar, a demonstrator for future space missions such as MERLIN. It is appropriate now to assess the feasibility of global lidar observations of point sources that could complement the current and future observation systems, and to define the basic characteristics of a novel space-borne IPDA-lidar which goes beyond the systems currently being designed and developed. Lidar uses laser signals scattered back from Earth's surface to measure the weighted vertical column concentrations (XCO_2, XCH4) with a small and well-defined field-of-view. A cross section in the lee of the point source, perpendicular to the mean wind, within distances between a few hundred meters and a few km away from the source, yields measurements of the XCO_2 or XCH4 plume enhancement which is directly proportional to the emission rate. Leaving the details of the lidar and its pointing for future more technology-oriented studies, we use here an instrument model with an ideal detector to assess the rough size of such a space lidar, in combination with a Gaussian plume model. We find that an instrument with feasible size will be able to measure emission rates from strong CO_2 point sources with about 5 % accuracy. For CH4, a stronger absorption line or a larger system would be needed to fulfill the more demanding observational constraints. Major lidar advantages are the insensitivity to aerosol, temperature, humidity, and CO_2 or CH4 density heterogeneity in the plumes. In May and June 2018, the flight campaign CoMet (Carbon dioxide and Methane mission) will combine several active, passive and in-situ instruments on board of three different air-borne platforms, including CHARM-F on board the German HALO research aircraft. Testing the above mentioned technique on known emission sources and validating its results using supplementary measurements will be one of the main objectives of CoMet.