Progress with LEO-LEO Microwave and Infrared-laser Occultation: Performance Results and Canary Islands Greenhouse Gases Experiment

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Low Earth Orbit (LEO) transmitter and receiver satellites provide the basis for LEO-LEO microwave and infrared-laser occultation (LMIO), a new active limb sounding method for climate benchmark profiling of greenhouse gases (GHGs), thermodynamic variables and wind in the free atmosphere (Kirchengast and Schweitzer, GRL, 38, L13701, 2011; www.agu.org/pubs/crossref/2011/2011GL047617.shtml). The LEO-LEO infrared-laser occultation (LIO) part of LMIO can provide accurate profiles of all main GHGs, including CO2, CH4, N2O, H2O, O3, and isotopes 13CO2 and 18OCO, by exploiting differential absorption between carefully selected absorption ("on-line") and reference ("off-line") laser signals targeting suitable GHG absorption lines within 2 to 2.5 µm. This spectral range resides in the "hole" between the shortwave-solar and longwave-terrestrial Planck spectra so that natural background radiation is minimal to negligible. We present the fundamentals and discuss the estimated performance of LMIO-based GHG profiling, including from quasi-realistic end-to-end performance simulations considering also aerosols and clouds. We found monthly-mean GHG profiles, assuming 30 to 40 native profiles averaged per climatological "grid cell" per month, accurate to <0.15 to 0.5% r.m.s. error over the upper troposphere and lower stratosphere at ~1 km vertical resolution (e.g., CO2 <1 ppm, CH4 <7 ppb; residual biases estimated less than half these r.m.s. values). Encouraged by the potential of LMIO for GHG profiling in the free atmosphere indicated by these results we undertook in July 2011 a first ground-based demonstration experiment of LIO sounding along a ~144 km link at ~2.4 km altitude between observatories at the islands of La Palma and Tenerife being part of the Canary Islands (ESA-funded experiment project by Bernath et al.; Univ. York, Univ. Graz, Univ. Manchester, MPI Jena). With transmitter and receiver breadboard equipment built for four infrared-laser signals we targeted to measure CO2, CH4, and H2O under field conditions somewhat akin to a LIO space-based link. Despite of the practical challenges of such long-range observations, especially related to the needed fine adjustments of laser beam pointing under windy high-altitude conditions, we achieved first good data for retrieving these GHGs so that the demonstration of the experimental feasibility of LIO was successful. We will discuss these new infrared-laser occultation results in comparison to *in situ* GHG measurements (based on cavity ring-down spectrometers) taken at both the transmitter and receiver sites for validation purposes.