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# A Next-Generation Space Geodetic Technique: Profiling of Greenhouse Gases and Climate by Microwave and Infrared-Laser Occultation

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Since the pioneering GNSS radio occultation (GRO) mission GPS/Met in the mid-1990ties, and fostered by many missions since then such as CHAMP, Formosat-3/COSMIC and others, the GRO method was firmly established as a leading space geodetic technique. GRO provides vital contributions to meteorology and climate applications, like numerical weather prediction and climate change monitoring, and a range of those are covered in this session. Building on this success, further advanced techniques for future missions and science applications emerge beyond GRO. In particular, next-generation occultation between Low Earth Orbit satellites (LEO-LEO) uses GNSS-type coherent signals beyond the GRO decimeter waves at centimeter, millimeter, and micrometer wavelengths. This new technique, termed LEO-LEO microwave and infrared-laser occultation (LMIO), enables to vastly expand from the GRO refractivity-based sounding of the thermodynamic structure to a complete set of weather and climate variables, including thermodynamic ones (pressure, temperature, water vapor), greenhouse gases, wind speed, and others (Kirchengast and Schweitzer, GRL, 38, L13701, 2011; www.agu.org/pubs/crossref/2011/2011GL047617.shtml).

LMIO combines microwave occultation signals at cm and mm wavelengths (within 8-25 GHz and 175-200 GHz) for thermodynamic state profiling with infrared-laser occultation signals within 2 to 2.5 $\mu$m for greenhouse gas and line-of-sight wind profiling; greenhouse gases include water vapor ($H_2O$), the three key long-lived ones ($CO_2$, $CH_4$, $N_2O$) and others. We present the fundamentals and discuss the estimated performance of LMIO-based thermodynamic state and greenhouse gas profiling, including from quasi-realistic end-to-end performance simulations considering also clouds and aerosols. To indicate the performance, we found monthly-mean temperature and greenhouse gas profiles, assuming 30 to 40 native profiles averaged per climatological "grid cell" per month, accurate to <0.1 to 0.2 K (temperature) and <0.15 to 0.5 % (greenhouse gases, e.g., $CO_2$ <1 ppm), over the upper troposphere and lower stratosphere at $\sim$1 km vertical resolution. We will discuss these results in light of the key promise of LMIO to become an authoritative reference standard for global monitoring of greenhouse gases and climate change in Earth's free atmosphere over the 21st century.

Encouraged by such results also a first ground-based demonstration experiment of infrared-laser sounding of greenhouse gases ($CO_2$, $CH_4$, $H_2O$) was recently conducted along a $\sim$144 km link at $\sim$2.4 km altitude between the islands of La Palma and Tenerife at the Canary Islands (ESA-funded experiment project by Bernath et al.; Univ. York, Univ. Graz, Univ. Manchester, MPI Jena). First results show that this basic demonstration was successful, which was another milestone underlining the promise of LMIO as next-generation technique.