EARTH OBSERVATION SYMPOSIUM (B1)
Interactive Presentations (IP)

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# PROGRESS IN SPECTROSCOPIC LIDAR FOR FUTURE LASER REMOTE SENSING OF ATMOSPHERIC COMPOSITION

**Abstract**

Great advances in passive remote sensing have given us a whole new perspective on our planet, however, active laser remote sensing provides a much higher degree of sensitivity, accuracy and range resolution. In this paper, we review the state of the art in active sensing and show how the needs of the meteorological and scientific user base can be met with a proposed space-based observatory. We review recent technological advances, and present our proven Differential Absorption Lidar (DIAL) master laser system with a number of novel elements towards a robust, low-cost autonomous DIAL observatory, built with fiber optics and solid-state components. Despite advances in hyperspectral satellite observations, meteorologists still rely on weather balloons (radiosondes), while climate scientists are looking for new understanding of aerosols and physical processes that trigger water phase changes in the atmosphere. The assimilation of atmospheric refraction measurements by GNSS occultation into Numerical Weather Prediction (NWP) models, demonstrate the great need for new atmospheric measurements with global coverage. Furthermore, the first fixed, ground-based spectroscopic laser observatory is already providing important aerosol and water vapor data, to improve forecasts and better predict severe weather events. However, only a space-based spectroscopic laser observatory will combine global coverage with the needed accuracy, resolution and sensitivity. The DIAL technique utilizes accurate and precisely controlled laser wavelengths, which requires much lower power and smaller optics than the competing Raman technique. Furthermore, DIAL can be highly sensitive, and target any trace gas species. The elastic scattering employed by DIAL is also employed by the current Caliop and Phoenix Lidar space missions, which makes DIAL the most promising technology for future space deployment. Indeed, DIAL has been touted for future earth observation in the past, however, recent advances in laser technology and system design, finally makes this prospective for future deployment. We present our new design for a multiple-wavelength DIAL master system, and explain how we achieved the highest wavelength fractional stability of any published DIAL system to date. We present the first DIAL measurements from Australia, and compare our calibrated results against radiosonde humidity measurements. We also present modelling illustrating how DIAL is even better suited for space-based, nadir-viewing platforms. Finally, we expand on our DIAL seed and formulate a complete system design with a powerful E$r$:YAG amplifier. The proposed space-based DIAL will simultaneously measure water vapor and methane gasses, with an absolute accuracy and range resolution better than 1% and 50 meters.