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Laser Sounder for Global Measurement of CO2 Concentrations in the Troposphere from Space

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We are developing a laser technique for the remote measurement of the tropospheric CO2 concentrations from orbit. Our goal is to demonstrate a lidar technique and instrument technology that will permit measurements of the CO2 column abundance in the lower troposphere from aircraft at the few ppm level, with a capability of scaling to permit global CO2 measurements from orbit.

Measuring the tropospheric CO2 mixing ratio from space has many potential error sources. These including possible interference from other trace gas species, the effects of temperature, clouds, aerosols & turbulence in the path, changes in surface reflectivity, and variability in dry air density caused by changes in atmospheric pressure, water vapor and topographic height. Some potential instrumental errors include frequency drifts in the transmitter, small transmission and sensitivity drifts in the instrument. High signal-to-noise ratios and measurement stability are needed for mixing ratio estimates at the few ppm level.

Our approach for space uses a lidar which continuously measures at nadir from a near polar circular. Using measurements made over the same region at different times of day will make it possible to sample the diurnal variations in CO2 mixing ratios. Our calculations show global coverage with an accuracy of a few ppm with a spatial resolution of ~ 50,000 sq. km are achievable each month.

Our laser sounder instrument utilizes several tunable laser transmitters to permit simultaneous measurement of CO2 and O2 extinction, and aerosol backscatter in the same measurement path. It directs the narrow co-aligned laser beams from the instrument's fiber lasers toward nadir, and measures the energy of the strong laser echoes

reflected from land and water surfaces. During the measurement its lasers are rapidly tuned on- and off- selected CO_2 line near 1572 nm and an O_2 line in the Oxygen A band.. The receiver measures the energies of the laser echoes from the surface along with scattering from any clouds and aerosols in the path. Ratioing the on- to off-line echo pulse energies for each gas permits the column extinction and column densities of CO_2 and O_2 to be estimated via the differential optical absorption technique.

For the on-line wavelengths, we use the side of the absorption line, which weights the measurements to the lower troposphere, where CO_2 variations caused by surface sources and sinks are largest. Simultaneous measurements of O_2 column abundance are made using an identical approach with an O_2 line. The laser backscatter profiles from clouds and aerosols are measured with a lidar channel, which permits identifying measurements influenced by them. We have demonstrated some key elements of the laser, detector and receiver approaches in the laboratory and with measurements over a 206 m long horizontal path.