Geophysical Research Abstracts
Vol. 13, EGU2011-11132, 2011
EGU General Assembly 2011

Analysis of Pulsed Airborne Lidar measurements of Atmospheric CO2 Column Absorption from 3-13 km altitudes

James Abshire (1), Clark Weaver (2), Haris Riris (1), Jianping Mao (2), Xiaoli Sun (1), Graham Allan (3), William Hasselbrack (3), and Edward Browell (4)

(1) NASA - Goddard, Solar System Exploration Division, Greenbelt, Maryland, United States (james.abshire@gsfc.nasa.gov), (2) GEST/UMBC, NASA Goddard Code 613.3, Greenbelt MD 20771 USA, (3) Sigma Space Ince, NASA Goddard Code 694, Greenbelt MD 20771 USA, (4) NASA - Langley Research Center, Hampton VA 23681 USA

We have developed a pulsed lidar technique for measuring the tropospheric CO2 concentrations as a candidate for NASA's ASCENDS space mission [1]. Our technique uses two pulsed laser transmitters allowing simultaneous measurement of a CO2 absorption line in the 1575 nm band, O2 extinction in the Oxygen A-band, surface height and backscatter profile. The lasers are precisely stepped in wavelength across the CO2 line and an O2 line region during the measurement. The direct detection receiver measures the energies of the laser echoes from the surface along with the range profile of scattering in the path. The column densities for the CO2 and O2 gases are estimated via the integrated path differential absorption (IPDA) technique. Time gating is used to isolate the laser echo signals from the surface, to determine its range, and to reject laser photons scattered in the atmosphere. We developed an airborne lidar to demonstrate an early version of the CO2 measurement from the NASA Glenn Lear-25 aircraft. The airborne lidar stepped the pulsed laser's wavelength across the selected CO2 line with 20 wavelength steps per scan. The line scan rate is 450 Hz, the laser pulse widths are 1 usec, and laser pulse energy is 24 uJ. The time resolved laser backscatter is collected by a 20 cm telescope, detected by a NIR photomultiplier and is recorded by a photon counting system [2].

During July and August 2009 we made a series of 2 hour long flights and measured the atmospheric CO2 absorption and line shapes using the 1572.33 nm CO2 line. Measurements were made at stepped altitudes from 3-13 km over several locations in the US, including central Illinois, the SGP ARM site in Oklahoma, north-eastern North Carolina, and over the Chesapeake Bay and the eastern shore of Virginia. Although the received signal energies were weaker than expected for ASCENDS, clear CO2 line shapes were observed at all altitudes, and some measurements were made through thin clouds. The flights over the ARM site were under-flown with in-situ measurements made from the DOE Cessna. The Oklahoma and east coast flights were coordinated with a LaRC/ITT CO2 lidar on the LaRC UC-12 aircraft, and a LaRC in-situ CO2 sensor.

We have conducted an analysis of the ranging and IPDA lidar measurements from four flights. Most flights had 5-6 altitude steps with 200-300 seconds of recorded measurements per step. We averaged every 10 seconds of lidar measurements and used a cross-correlation approach to process the laser echo records. This was used to estimate the range to the scattering surface, to define the edges of the laser pulses and to determine echo pulse energy at each wavelength. We used an optimal estimation approach to fit an instrument response function and to solve for the best-fit CO2 absorption line shape. We then calculated the mean optical depth of the fitted CO2 line. We compute its statistics at the various altitude steps. We compare them to CO2 optical depths calculated from spectroscopy based on HITRAN 2008 and the column number densities calculated from the airborne in-situ readings. We also will present a brief overview of subsequent CO2 column absorption measurements made with stronger signals during flights over the southwestern US in during July and August 2010.

References:

1. Abshire, J.B., Riris, H., Allan, G.R., Weaver, C.J., Mao, J., Sun, X., Hasselbrack, W.E., Yu, A., Amediek, A., Choi, Y., Browell, E.V. (2010), "A lidar approach to measure CO2 concentrations from space for the ASCENDS Mission," SPIE Proceedings Vol. 7832, DOI: 10.1117/12.868567

2. Abshire, J.B., Riris, H., Allan, G.R., Weaver, C.J., Mao, J., Sun, X., Hasselbrack, W.E., Kawa. S.R. and Biraud, S. (2010), "Pulsed airborne lidar measurements of atmospheric CO2 column absorption," Tellus B, 62: 770–783. doi: 10.1111/j.1600-0889.2010.00502.x