CONTINUOUS AIRBORNE MEASUREMENTS OF CARBON DIOXIDE FLUXES AND MIXING RATIOS AND CARBON MONOXIDE MIXING RATIOS ON THE NSF/NCAR C-130 PLATFORM: PRELIMINARY RESULTS FROM GOTEX AND ACME

Campos, T., S. Shertz[1], S. Hall[1], B. Stephens[1], and L. Husted[1]

[1] *National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307; campos@ucar.edu*

ABSTRACT

Results of airborne CO_2 and CO observations from the NSF/NCAR C-130 platform during the Gulf of Tehuantepec Experiment (GOTEX 2004) and the Airborne component of the Carbon in the Mountains Experiment (ACME 2004) will be presented. A modified commercial vacuum ultraviolet fluorescence instrument monitored CO mixing ratios. CO measurements were used to help identify air masses recently influenced by combustion emissions. CO_2 mixing ratios were measured using a pressure- and temperature-controlled LI-COR 6252 analyzer. Control of time response allowed operation of the CO_2 instrument in two modes for application to either low altitude eddy covariance or higher altitude mixing ratio measurements. Performance will be assessed, including accuracy estimates derived from intercomparison activities.

Observations of Pacific marine boundary layer fluxes, obtained in February and March of 2004, during the Gulf of Tehuantepec Experiment (GOTEX) will be presented, including quantification of instrumental air motion sensitivity. Preliminary spectral analysis of flight data indicates a 5-Hz frequency response. The CO_2 instrument was tuned for slower time response to accommodate higher altitude observations during the Airborne component of the Carbon in the Mountains Experiment (CME 2004). The instrument performed with a typical precision of 0.25 ppmv and a 1- to 3-Hz frequency response when operated in this mode.

CO_2 INSTRUMENT MODIFICATIONS

The commercial non-dispersive IR CO_2 sensor was modified for application to airborne measurements. Pressure and temperature control were implemented after the manner of Daube, et al. [2002]. The flow rate and drying capacity were increased to allow tuning of the gas handling components for increased time response. For operation with a 5-Hz time response, a flow rate of 2 SLPM and a cell pressure of 400 mB allowed optimum measurements for characterizing boundary layer processes. The optical cell and transducers were isolated in a sealed, pressure-controlled housing. The sample stream was dried to a dew point lower than -30 ºC using a Nafion dryer in series with a cryogenicically-cooled trap. A 2-um stainless steel filter was inserted downstream of the trap to retain ice particles within the cooled volume. To monitor CO_2 mixing ratios with greatest precision over a larger altitude envelope of the NCAR/NSF C-130 for the Airborne component of the CME campaign, the instrument was tuned for a slower, 1-Hz, time response, requiring tuning to accommodate a 0.5 SLPM flow rate and a cell pressure as low as 350 mB.

CALIBRATION PROTOCOLS AND PERFORMANCE ASSESSMENT

In-flight calibrations were conducted using a series of three working standards tied to the WMO scale via comparison against a series of NOAA CMDL primary standards. Working standard gas concentrations were approximately 360, 370, and 395 ppmv. A 3- to 4-minute calibration sequence was conducted at 20-60 minute intervals, timed to minimize the impact on the scientific objectives of each flight pattern. Several times during each flight a fourth working standard was also analyzed as an accuracy check and to provide longer term drift characterization. Due to suspected contamination during the final flights of GOTEX, an additional procedure was implemented during ACME. The slowly changing instrumental drift was characterized by 30-second samples of the 370 ppmv standard every 5-10 minutes.

For GOTEX, data were acquired in continuous 2-minute segments at a 1-kHz rate, with a several second data gap. Continuous sampling was implemented for ACME, albeit at a reduced data rate of 25 Hz. A 0.3-s median filter was applied to GOTEX data for noise reduction, while ACME data are smoothed using a 1-s window. Data from all missions were then downsampled to 5-Hz.

Validation exercises were undertaken as part of the ACME project. Working standards for all airborne and ground based CO_2 sensors were compared against standards generated at the newly operational NCAR calibration facility developed by Britt Stephens and colleagues. Comparison will be made to Scripps flask samples of Heather Graven and Ralph Keeling. Preliminary results indicate a mean systematic difference of 0.2 ppmv with somewhat larger standard deviation.

During the fifth GOTEX research flight, a marine boundary layer transect at 380 msl was selected for comparison of the power spectral distribution of the CO_2 instrument response under ambient and calibration sampling conditions. Figures 1 and 2 are the power spectral distributions of one-minute segments of ambient and calibration sampling during this transect, representing an indication of the aircraft motion artifact of this instrument under the GOTEX measurement conditions. It is inferred from these figures that a small artifact is observed for frequencies less than 2-3 Hz, about a factor of 10-50 smaller than the power in equivalent frequencies when compared to the ambient spectrum. This test was also conducted during ACME research flight 14 on 29 July, 2004, with similarly encouraging results. Calibration gas was measured during an entire transect through boundary layer air in the racetrack flight pattern centered over the Niwot Ridge ground observation site.

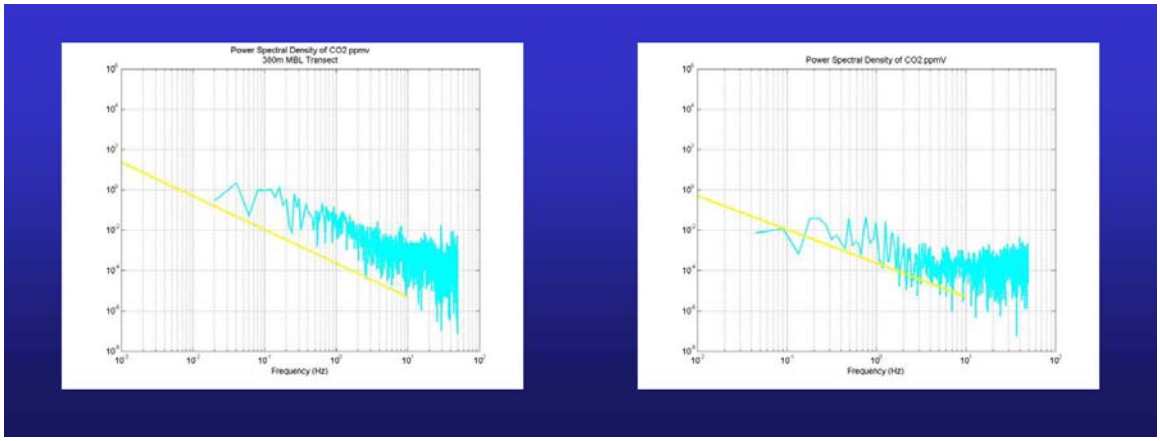

Fig. 1 Fig. 2

REFERENCES

Daube, Jr., B.C., K.A. Boering, A.E. Andrews, and S.C. Wofsy (2002), A High-Precision Fast-Response Airborne CO_2 Analyzer for In Situ Sampling from the Surface to the Middle Stratosphere, *J. Atmos. Oceanic Tech.*, *19*(10), 1532-43, doi: 10.1175/1520-0426(2002)019.