Measurements of Atmospheric CO_2 from the NASA DC-8 during the MILAGRO/INTEX-B Campaigns

Principal Investigator: Stephanie A. Vay
NASA Langley Research Center
Chemistry and Dynamics Branch
MS 483
Hampton, VA 23681
stephanie.a.vay@nasa.gov
Phone: 757-864-1574
Fax: 757-864-7790

Team Members:
Yonghoon Choi – NIA, ychoi@nianet.org
Jung-Hun Woo – NESCAUM, jwoo@nescaum.org
Krishna Vadrevu – OSU, krisvkp@yahoo.com

Summary of Proposed Work
We propose to provide highly precise, rapid in-situ CO_2 measurements aboard the NASA DC-8 during the MILAGRO/INTEX-B spring 2006 campaigns and the subsequent analyses of collected data sets. The proposed research fits well with the North American Carbon Program envisaged role for aircraft to study atmospheric CO_2 distributions in the boundary layer and free troposphere over regional and continental scales to elucidate the sampling density needed to resolve seasonal and annual CO_2 budgets. In collaboration with other MILAGRO/INTEX-B Science Team members, the enriched data sets will be examined to (1) characterize the large-scale spatio-temporal variance of CO_2 concentrations over North America (2) quantify North American CO_2 sources/sinks and the export of CO_2 emissions from Asia and the Mexico City Megaplex (3) evaluate inverse techniques that assimilate observations to derive regional to continental scale CO_2 flux estimates (4) provide integrated measures of atmospheric column amounts from vertical soundings for retrieval algorithm development and validation of remotely-sensed data products and (5) offer an independent assessment of anthropogenic emission inventories (bottom-up approaches).

Instrument Description
A modified LI-COR model 6252 infrared gas analyzer forms the basis of the CO_2 sampling system that has been successfully deployed aboard aircraft during the PEM-West [Anderson et al., 1996; Gregory et al., 1997], PEM-Tropics [Vay et al., 1999], TRACE [Vay et al., 2003] and INTEX-NA [Vay et al., 2005] mission series. The LI-COR is small (13 x 24 x 34 cm) and composed of dual 12 cm^3 volume sample/reference cells; a feedback stabilized infrared source; 500 Hz chopper; thermoelectrically-cooled solid state PbSe detector; and a narrow band (150 nm) interference filter centered on the 4.26 μm CO_2 absorption band. Using synchronous signal detection techniques, it operates by sensing the difference in light absorption between the continuously flowing sample and reference gases occupying each side of the dual absorption cell. Thus, by selecting a reference gas of approximately the same concentration as background air (~ 378 ppmv), very minute

fluctuations in atmospheric concentration can be quantified with high precision (≤ 0.07 ppmv). The system is operated at constant pressure (250 torr) and has a 0.1 second electronic time response.

During ambient sampling, air is continuously drawn through a Rosemount inlet probe, a permeable membrane dryer to remove $H_2O_{(v)}$, the LI-COR, and then exchanged through a diaphragm pump that vents overboard. In-flight calibrations are performed every 15 minutes using standards traceable to the primary standards maintained by the WMO Central CO_2 Laboratory. By interpolating between these calibrations, slow drifts in instrument response are effectively suppressed, yielding high precision values. Temperature control of the instrument minimizes thermal drift thus maximizing ambient sampling time by decreasing calibration frequency. The CO_2 measurement accuracy is closely tied to the accuracy of the standards obtained from NOAA/CMDL, Boulder, CO prior to the mission.

References

Vay, S.A., Y. Choi, J.-H. Woo, K. Vadrevu, G. Sachse, L. Pfister, G. Diskin, J. Crawford, R. Cohen, D. Blake, and M. Avery, Regional-scale Characterization of Summertime CO_2 Sources and Sinks over the Conterminous United States, presented at the *Seventh International Carbon Dioxide Conference*, Boulder, CO, September 2005.

Vay, S. A., J.-H. Woo, B. E. Anderson, K. L. Thornhill, D. R. Blake, D. J. Westberg, C. M. Kiley, M. A. Avery, G. W. Sachse, D. G. Streets, Y. Tsutsumi, and S. R. Nolf, Influence of regional-scale anthropogenic emissions on CO_2 distributions over the western North Pacific, *J. Geophys. Res.*, 108(D20), 8801, doi:10.1029/2002JD003094, 2003.

Vay, S. A., B. E. Anderson, T. J. Conway, G. W. Sachse, J. E. Collins, Jr., D. R. Blake, and D. J. Westberg, Airborne observations of the tropospheric CO_2 distribution and its controlling factors over the South Pacific Basin, J. Geophys. Res., 104(D5), 5663-5676, 1999.

Gregory, G. L., J. T. Merrill, M. C. Shipham, D. R. Blake, G. W. Sachse, and H. B. Singh, Chemical characteristics of tropospheric air over the Pacific Ocean as measured during PEM-West B: Relationship to Asian outflow and trajectory history, J. Geophys. Res., 102 (D23), 28,275-28,285, 1997.

Anderson, B. E., G. L. Gregory, J. E. Collins, Jr., G. W. Sachse, T. J. Conway, and G. P. Whiting, Airborne Observations of the Spatial and Temporal Variability of Tropospheric Carbon Dioxide, J. Geophys. Res., 101(D1), 1985-1997, 1996.