High-Precision Monitoring Instrumentation for Background Levels of the Carbon Cycle Gases

J. Smith[1], P.P Tans[2], M. Hahn[2,3], D. Guenther[2,3], M. Warshawsky[4], and P. Lang[2]

[1]Atmospheric Observing Systems, Inc., 1668 Valtec Lane, Suite A, Boulder, CO 80301;
303-652-4150 (office), 303-440-4533 (lab), Fax: 303-440-4533, E-mail: aosinc@attbi.com
[2]NOAA Climate Monitoring and Diagnostics Laboratory, Boulder, CO 80305
[3]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder 80309
[4]Azeotech, Inc., 123 High Street, Ashland, OR 97520

Atmospheric Observing Systems, Inc. (AOS) is collaborating with scientists from CMDL and CIRES to build high-precision, in situ detection systems to measure background levels of the major carbon cycle gases, CO_2, CH_4, and CO. Deployments will be on remote platforms including buoys, ships, towers, aircraft, and ground-based observatories. The CO_2 systems are being assembled after a rigorous period of research and development that has proved their capabilities on real platforms. An analyzer is being developed for methane.

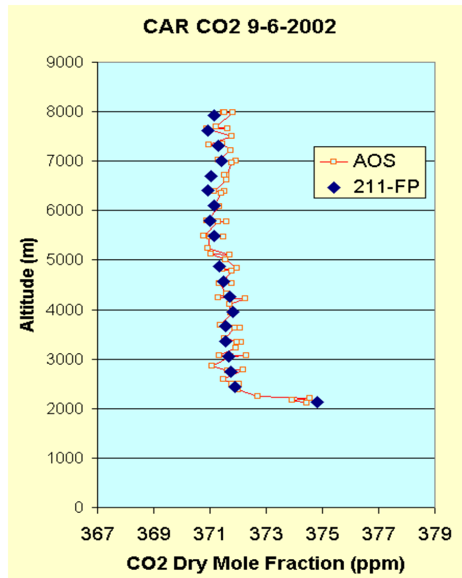

Figure 1. CO_2 measurements above Carr, Colorado, September 6, 2002.

We present the first results obtained for CO_2 from the airborne platform on five flights during September and October 2002 (e.g., Figure 1). In all cases, the results were verified by flask samples (211-FP) acquired during the same flight. The vertical profiles were flown above Carr, Colorado.

- Resolution was 1 minute uninterrupted for the AOS system and about 300 m for the flask samples.
- Deployments were autonomous for both techniques. Results of the AOS system were communicated by satellite phone in real time to CMDL. Flask samples were analyzed by CMDL using its normal procedures.
- Biases were small and have been quantified for both techniques. The flask samples have a deficit of 0.10 to 0.15 ppm; it comes from the analysis stage of processing in CMDL. Bias of the AOS system comes from the drying stage of its gas processor and depends on the method. Laboratory tests give an enrichment of 0.06 ppm for the chemical drier (magnesium perchlorate) and a deficit of 0.11 ppm for the membrane drier (Nafion). The AOS analyzer itself has zero bias.
- Three profiles were observed with the chemical drier. The mean difference, AOS – CMDL, is +0.21 ppm, in good agreement with the laboratory measures of bias. The difference does not depend on flight or altitude.
- Two profiles were observed with the membrane drier. The mean difference, AOS – CMDL, is –0.12 ppm, whereas the laboratory tests would predict almost zero. The difference does not depend on flight or altitude.
- For each flight, the techniques gave comparable relative distributions of CO_2 from 8000 m down to the boundary layer near 2000 m.
- More work is under way to reconcile any difference between laboratory and in-flight biases of the two techniques. An improved AOS system was deployed on March 14, 2003. It has negligible sensitivity to motion and no interference from radio communications associated with the platform. And its background resolution is almost one part in 15,000 or four times better than the prototype used to measure the five vertical profiles presented here.

The ultimate objective is a global network of detection systems capable of monitoring our planet's trace gases to high precision. Success is in sight for CO_2 from aircraft, arguably the most difficult of platforms.