WHAT CAN WE LEARN FROM INTENSIVE ATMOSPHERIC SAMPLING FIELD PROGRAMS?

J.C. Lin[1], C. Gerbig[2], S.C. Wofsy[3], B.C. Daube[3], D.M. Matross[3], M. Pathmathevan[3], V.Y. Chow[3], E. Gottlieb[3], A.E. Andrews[4], and J.W. Munger[3]

[1] *Department of Atmospheric Science, Colorado State University, 1371 Campus Delivery, Fort Collins, CO 80523-1371; jcl@atmos.colostate.edu*

[2] *Max-Planck-Institut für Biogeochemie, Hans-Knoell-Str. 10, D-07745 JENA (Germany)*

[3] *Department of Earth & Planetary Science and, Division of Engineering & Applied Sciences, Harvard University, 20 Oxford St, Cambridge, MA 02138*

[4] *Climate Monitoring and Diagnostics Laboratory, National Oceanographic and Atmospheric Administration, 325 Broadway, Boulder, CO 80305-3328*

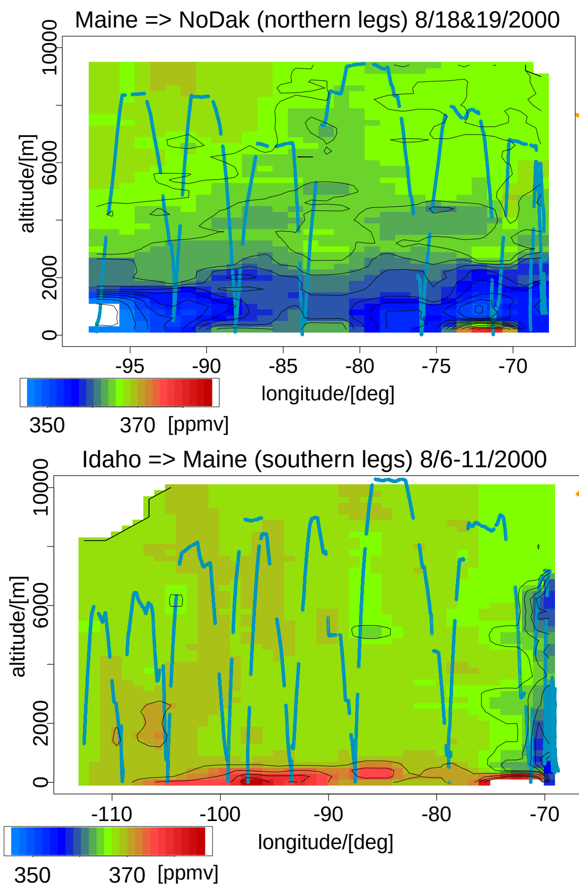
ABSTRACT
Intensive atmospheric sampling field programs are envisioned as a key component of integrated research programs such as the North American Carbon Program (NACP) [*Sarmiento and Wofsy*, 1999; *Wofsy and Harriss*, 2002]. The intensive sampling provides unique information about the spatial distribution of CO_2 as well as imposes tight constraints on regional budgets that are difficult to obtain from other means. We summarize what we have learned from the numerous COBRA (CO_2 Budget and Rectification Airborne study) experiments [*Gerbig et al.*, 2003a] that have taken place in 2000, 2003, and 2004. We present the observed spatial variability of CO_2 [*Gerbig et al.*, 2003a; *Lin et al.*, 2004a] and regional budgets derived from regional air parcel-following experiments [*Lin et al.*, 2004b]. These observations are also used as a critical testbed for modeling frameworks [*Gerbig et al.*, 2003b]. We draw conclusions about ways to maximize the value of intensive atmospheric sampling experiments and the role that such experiments should play within programs like the NACP.

COBRA: PILOT EXPERIMENT FOR GATHERING AND INTERPRETING CO_2 OBSERVATIONS OVER THE CONTINENT

The CO_2 Budget and Rectification Airborne study was conceived as a pilot experiment to conduct intensive atmospheric sampling over the continent. The objectives were to *a*) observe the distribution of CO_2 with sufficient resolution in both the horizontal and vertical dimensions over the continent that had formerly been lacking in the CO_2 measurement record; *b*) test how to extract information from such highly variable CO_2 observations over the continent. The high spatio-temporal density of such observations is of central importance for both evaluation/falsification as well as stimulating development of modeling frameworks. Thus COBRA and similar intensive experiments serve as an integral part of a coordinated research effort like the North American Carbon Program.

COBRA flights took place during August of 2000 (http://www-as.harvard.edu/chemistry/cobra/) in the U.S., May~June of 2003 (http://www.fas.harvard.edu/~cobra/) over U.S. and Canada, and May~August of 2004 (http://www.deas.harvard.edu/cobra/) over U.S. and Canada, with particular emphasis on the New England area and Québec.

Figure 1 is an example from August 2000 of the high-resolution CO_2 observations that an intensive experiment like COBRA can provide. The sampling resolves important features in CO_2 gradients—e.g., the northern legs exhibit pronounced depletions of ~20 ppmv in the lower 2 km of the atmosphere, representing the signature of photosynthetic uptake in the mixed-layer and the relic boundary layer. Marked horizontal contrasts were observed as well—the southern legs showed enhancements in the lower atmosphere rather than depletions.



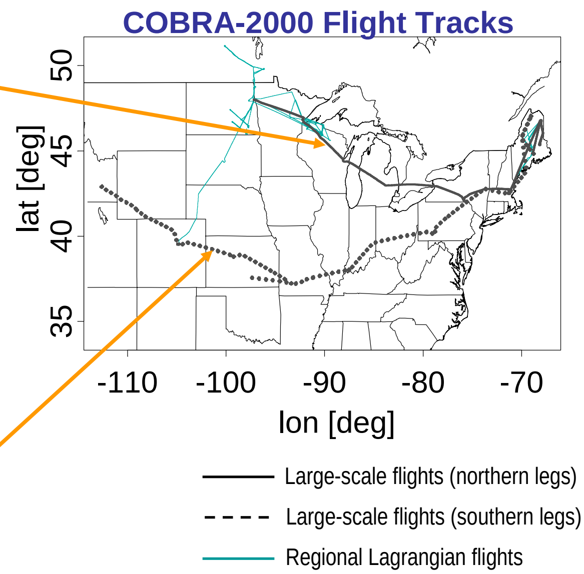


Figure 1. The flight pattern from the COBRA experiment in 2000 and the large-scale distribution of observed CO_2 (altitude vs. longitude cross-sections).The blue lines in the cross-sections represent the aircraft profile locations, which were interpolated to create the cross-sections.

REFERENCES

Gerbig, C., J.C. Lin, S.C. Wofsy, B.C. Daube, A.E. Andrews, B.B. Stephens, P.S. Bakwin, and C.A. Grainger (2003a), Toward constraining regional-scale fluxes of CO_2 with atmospheric observations over a continent: 1. Observed spatial variability from airborne platforms, *J. Geophys. Res.*, *108*(D24), 4756, doi:10.1029/2002JD003018.

Gerbig, C., J.C. Lin, S.C. Wofsy, B.C. Daube, A.E. Andrews, B.B. Stephens, P.S. Bakwin, and C.A. Grainger, (2003b)Toward constraining regional-scale fluxes of CO_2 with atmospheric observations over a continent: 2. Analysis of COBRA data using a receptor-oriented framework, *J. Geophys. Res.*, *108*(D24), 4757, doi:10.1029/2003JD003770.

Lin, J.C., C. Gerbig, B.C. Daube, S.C. Wofsy, A.E. Andrews, S.A. Vay, and B.E. Anderson (2004a), An empirical analysis of the spatial variability of atmospheric CO_2: implications for inverse analyses and space-borne sensors, *Geophys. Res. Lett.*, *31* (L23104), doi:10.1029/2004GL020957.

Lin, J.C., C. Gerbig, S.C. Wofsy, A.E. Andrews, B.C. Daube, C.A. Grainger, S. B.B., P.S. Bakwin, and D.Y. Hollinger (2004b), Measuring fluxes of trace gases at regional scales by Lagrangian observations: application to the CO_2 Budget and Rectification Airborne (COBRA) study, *J. Geophys. Res.*, *109*(D15304, doi:10.1029/2004JD004754).

Sarmiento, J.L., and S.C. Wofsy (1999), A U.S. carbon cycle science plan, Carbon and Climate Working Group, U.S. Global Change Research Program, Washington, D.C.

Wofsy, S.C., and R.C. Harriss (2002), The North American Carbon Program (NACP), NACP Committee of the U.S. Interagency Carbon Cycle Science Program, U.S. Global Change Research Program, Washington, DC.