CO_2 Budget and Rectification Study – North America (COBRA)

Statement of Work (CSU Subcontract)

We will provide modeling support and data analysis for the proposed aircraft sampling campaigns. This will include continental scale simulations of atmospheric CO_2, $13CO_2$, and SF_6 over the entire annual cycle. Simulations will be made using the Colorado State University (CSU) General Circulation Model (GCM) and the CSU Regional Atmospheric Modeling System (RAMS). In addition, high-resolution simulations of specific cases will be made in the vicinity of the ground stations and vertical profile campaigns. Analysis will focus on optimizing the observing system for quantitative determination of regional-scale trace gas budgets and on the calculation of these budgets by inverse methods.

Initial work will focus on the continental-scale distribution of CO_2 in three dimensions through the seasonal cycle as simulated by the Colorado State University (CSU) General Circulation Model (GCM). Surface emissions will be prescribed according to published maps of fossil fuel combustion, land-use conversion, and air-sea exchange. Land-surface exchange due to annually balanced photosynthesis and respiration will be calculated interactively with the Simple Biosphere model (SiB2). In the first three months of the study, we will produce an analysis of these global results intended to select and optimize flight plans for evaluation of the seasonal CO_2 rectifier effect over North America. These initial simulations will be performed at the global scale using a coarse grid (4 x 5 degrees, latitude by longitude), but will lead to timely results that are necessary to contribute to the planning of the field phase of the program.

Following the initial evaluation at the continental scale, we will develop the ability to perform continental-scale simulations of CO_2 and its stable isotopes with CSU-RAMS coupled to SiB2. These experiments will use a finer grid (probably 50 km) over North America, and will be driven by analyzed meteorology and the GCM simulations at lateral boundaries. Surface parameters will be specified from remotely sensed imagery (8 km AVHRR). Higher resolution simulations will be performed over intensive campaign areas (La Jolla, Harvard Forest, WLEF, WITN) using a nested grid within RAMS. Significant model development will be required to adapt the models to this configuration; some of this work is already supported under the DOE-NIGEC program. We anticipate completion of full annual cycle simulations over North America midway through year 2 of this project. These results will be used to optimize field campaigns, and will also be crucial for the development of inversion calculations.

Detailed simulations will also be performed at the intensive field sites (e.g., WLEF), using the coupled SiB2-RAMS system in large-eddy simulation mode. This will alllow mechanistic interpretation of the vertical profiles over the observing stations for specific cases, and may involve grids as fine as 50 m. These simulations can be compared to local tower data and to the aircraft samples, and will be invaluable for further development of models which correctly capture the rectifier effect at larger scales.