AVOCET: CO_2 Measurements

AVOCET: Atmospheric Vertical Observation of CO2 in the Earth's Troposphere

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Instrument: non-dispersive infrared spectrometer (4.26 μm)
Measurement: CO_2 mixing ratio
Dynamic Range: 0 to 3000 ppm
Accuracy: 0.25 ppm (relative to WMO standards)
Precision: less than 0.1 ppm
Data Reporting Interval: 1 sec
Representative Reference: Vay, et al., 2011. Patterns of CO_2 and radiocarbon across high northern latitudes during IPY 2008, J. Geophys. Res. 116, doi:10.1029/2011JD015643.

Goal:
AVOCET will provide high precision, fast-response measurements of carbon dioxide (CO_2) aboard the NASA DC-8 during the Southeast Asia Composition, Cloud, Climate Coupling Regional Study (**SEAC^{4}RS**) and the Deep Convective Clouds and Chemistry (**DC3**) study. In-situ CO_2 measurements will be conducted with an instrument having a proven performance heritage, flown most recently aboard the DC-8 during the 2008 ARCTAS, 2009 ICE Bridge, and 2010 ASCENDS missions. The high temporal response measurements that we offer will be quite useful for examining large-scale distributions of a radiative tracer inextricably connected to climate change, and for investigating the influence of Southeast Asian anthropogenic, biomass burning, and biogenic emissions on atmospheric composition.

As a passive tracer having a well-defined seasonal cycle, CO_2 measurements also afford a distinct label for air entering the upper atmosphere for investigative studies of troposphere-stratosphere exchange, convective redistribution of pollutants, and pyro-convection fueled by fires within tropical ecosystems. These high resolution observations of atmospheric CO_2 will be invaluable for validation of AIRS, TES, and GOSAT CO_2 column retrievals; advancing readiness for space-based CO_2 data (OCO-2, ASCENDS); and benefit temperature retrievals from space-borne sensors (e.g. MLS on Aura) and meteorological forecasts. They additionally have intrinsic merit for carbon cycle studies, enabling exploration of the connection between the distribution of CO_2 concentrations and the terrestrial biosphere via MODIS, LANDSAT, MERIS, and ASTER remote sensing data products.

Instrument Overview:
The NASA Langley CO_2 sampling system (AVOCET) has an extensive measurement heritage in tropospheric field campaigns, delivering high reliability over 3400 flight hours (452 science flights) and is recognized within the CO_2 community as a benchmark for evaluating newly evolving remote CO_2. Carbon dioxide measurements will be provided by a modified LI-COR

model 6252 non-dispersive infrared spectrometer (NDIR). This instrument was adapted by the investigators for airborne sampling and has been successfully deployed aboard NASA research aircraft beginning with the PEM-West A mission in 1992, and more recently during the 2008 ARCTAS, 2009 ICE Bridge, and 2010 ASCENDS missions. The basic instrument is small (13 x 24 x 34 cm) and composed of dual 11.9 cm^3 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 (~390 ppm), minute fluctuations in atmospheric concentration can be quantified with high precision. Precisions of ≤ 0.1 ppm ($\pm 1\sigma$) for 1 Hz sampling rates are typical for our present airborne CO_2 system when operated at 250 torr sample pressure.

Collaboration:
Dr. Vadrevu is involved in developing a robust bottom-up CO_2 emissions inventory (EI) (industrial, transportation, raw materials processing and energy sectors) that includes Southeast Asia by integrating several global and national level emission inventories: 1) the Global Emissions Inventory Activity (GEIA); 2) the Emission Database for Global Atmospheric Research (EDGAR); 3) the Streets et al., [2003] EI; 4) the International Institute for Applied Systems Analysis (IIASA) database; 5) the Garg and Shukla [2002] EI; 6) the Reddy and Venkataraman [2002] aerosol and SO_2 EI; 7) the Regional Emission inventory in Asia (REAS); 8) the Global Fire Emissions Data (GFED v2); and 9) 2006-emissions for Asia. Of particular importance for the Southeast Asian region is the inclusion of biofuels in the IIASA, REAS, and Reddy/Venkataraman databases. We will leverage the data collected from this project with the airborne data for inferring CO_2 source-sinks relationships in the Southeast Asian region.

Collaboration with the University of California, Irvine (D. Blake, PI) has afforded valuable information on the source contributions to the total measured CO_2 signal through the simultaneous collection of whole air samples assayed post-mission for $^{14}CO_2$ content. These measurements will help determine whether fossil fuel enriched CO_2 plumes from the largest cities can be resolved amidst the variability of the natural CO_2 field. For example, the MILAGRO field campaign (March 2006) focused on pollution outflow from the Mexico City Mega-plex and its influence on regional atmospheric composition. Analysis of $^{14}CO_2$ data acquired during MILAGRO revealed obscuration of the fossil fuel CO_2 signal due to enrichment of $^{14}CO_2$ values from the combustion of aged biomass, thus leading to an underestimation of the fossil fuel source. More recently, anomalously enriched $^{14}CO_2$ values measured in emissions from Lake Athabasca and Eurasian fires during the ARCTAS mission speak to biomass burning as an increasingly important contributor to the mass excess in ^{14}C observations in a warming Arctic [Vay et al., 2011]. Similar observations over Southeast Asia will provide insight into regional processes influencing CO_2 distributions, and the potential and effectiveness of radiocarbon measurements for accurate quantification of fossil fuel CO_2 emissions in other than clean, maritime atmospheric sampling environments, essential information for anticipated future treaty verification