Regional Carbon Fluxes in the Southern Great Plains during the 2007 CLASIC

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INTRODUCTION

In June 2007, a regional campaign took place in the Southern Great Plains (SGP) of the United States to estimate land-atmosphere exchanges of CO_2, water, and energy at 1 to 100 km scales. The primary goals of this campaign were to evaluate top-down and bottom-up regional fluxes and to understand the influence of moisture gradients, surface heterogeneity, and atmospheric transport on these fluxes estimates. The work was integrated with the Cloud and Land Surface Interaction Campaign (CLASIC), centered on the US Department Of Energy (DOE) Atmospheric Radiation Measurement (ARM) Program SGP region.

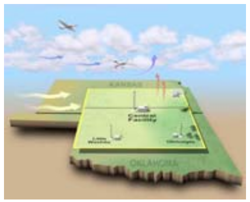


Figure 1. During CLASIC, a fleet of seven aircraft and enhanced surface instrumentation measured cloud and atmospheric properties throughout the SGP site, which covers 55,000 square miles in Oklahoma and Kansas.

CO_2 concentration data were collected from tower and airborne platforms. Eddy flux towers were deployed in the four major land cover types, distri-buted over the region's SE to NW precipitation gradient.

In addition, CO_2, water, and energy fluxes were observed with the Duke Helicopter Observation Platform (HOP) at various heights in the boundary layer, including in the surface layer (the few meters near the surface). One aircraft carried precise CO_2, CO, and CH_4 continuous measurement systems, and ^{14}C, radon, and NOAA 12-flask (carbon cycle gases and isotopes) packages. Continuous CO_2, CO, and radon concentrations, NOAA 2-flask package, and isotope diel flasks were also collected from a centrally located 60 m tower. Flights were planned to constrain simple boundary layer budget models and to conduct Lagrangian air mass following experiments.

CARBON RELATED AIRBORNE INSTRUMENTS:

During CLASIC, three airborne platforms were dedicated to carbon-related measurements, the CIRPAS Twin Otter (CTO) and the DOE Cessna 206 (C206), and the Duke Helicopter (206B Bell).

CIRPAS Twin Otter:

- •ARGUS Diode Laser Spectrometer for continuous CO/CH_4 concentrations
- •AOS system for continuous CO_2 concentrations
- •Carbon cycle gases and isotopes sampler (CO_2, CO, CH_4, N_2O, H_2, SF_6, $^{13}CO_2$, and $C^{18}OO$).
- •Radiocarbon sampler (^{14}C)
- •Radon sampler

Figure 2. CTO waiting for take-off clearance prior flying pollution pattern.

Figure 3. Cessna 206 at takeoff from Ponca City airport on June 22, 2007 (Lagrangian pattern)

Cessna 206:

- •AOS system for continuous CO_2 concentrations
- •Carbon cycle gases and isotopes sampler (CO_2, CO, CH_4, N_2O, H_2, SF_6, $^{13}CO_2$, and $C^{18}OO$).
- •Radiocarbon sampler (^{14}C)

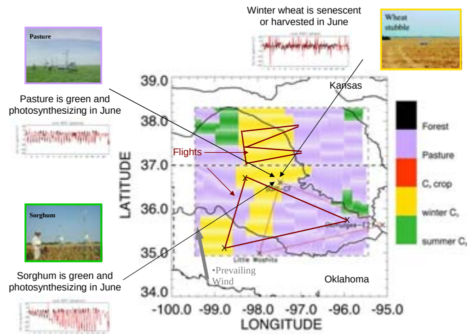
206B Bell:

- • Sonic anemometer (from the Japanese Aerospace Exploration Agency)
- • LI-7500 system for water and CO_2 concentrations
- • Aventech AIMMS-20 three-dimensional turbulence sensor

Figure 4. Duke University Bell 206 Helicopter returning to Base after a flight mission.

DATA COLLECTED

Over the duration of the CLASIC campaign we flew 17 missions, 11 on the CTO (35 flight hours) and 7 on the C206 (30 flight hours). These missions include plume pollution, air-mass following, and development of the boundary layer patterns.



ANTHROPOGENIC INFLUENCE ON THE SUB-CONTINENTAL ATMOSPHERE

On June 22, 2007 the CTO flew from Ponca City (N) to circumnavigate Oklahoma City (OKC) counter-clockwise. The plane flew at 4000 feet above sea level, or 900 m above ground level (i.e., within the boundary layer).

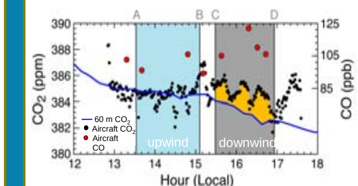


Figure 5. The black circles show CO_2 concentrations around Oklahoma City. The data on the northern leg show spikes in CO_2 concentration as well as anthropogenically released species like CO and CH_4.

The Wind was coming from the south, so the southern leg (A - B) was upwind of OKC, representing background air albeit with influence from Dallas. The Northern leg (C-D) was downwind of (influenced by) OKC.

TOP DOWN REGIONAL FLUX ESTIMATE USING LAGRANGIAN FLIGHTS

The goal of this mission was to characterize changes in an air mass as it flows northward over the land. On the afternoon of June 22, 2007 the C206 flew over a forest-prairie landscape in the North-East of Ponca City at a constant altitude of 1000 m above ground level (within the well-mixed planetary boundary layer). A steady wind was dominantly blowing from the south.

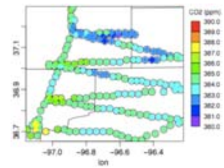


Figure 6. Top view of aircraft trajectory showing CO2 mixing ratio measured during an air-mass following experiment on June 22, 2007. Following climb from Ponca City (lower right), the plane flew a series of level legs in the boundary layer (~1km agl) from south to north.

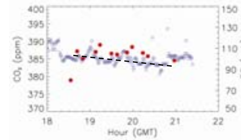


Figure 7. The black open circles and the red filled circles show CO_2 and CO concentrations, respectively. CO was measured with flask sampling.

After observing higher CO_2 mix ratios in the Ponca City Airspace (yellow), CO_2 decreased by ~ 2 ppm during the Lagrangian portion of flight. This drawn-down reflects the regional photosynthetic activity of the vegetation. As shown in Fig. 7., CO mixing ratios, which serve as a tracer of combustion, did not show a significant trend during the flight duration.

CONCLUSION

In future work, we will describe results from forward (using MM5-LSM) and inverse (using STILT) modeling to estimate regional surface carbon and energy fluxes. In addition to characterizing the influence of the land surface on the atmosphere, the aircraft data (in combination with observations of atmospheric dynamics) will allow us to characterize southern boundary condition to the NACP Mid-Continent Intensive.

ACKNOWLEDGEMENTS

This work was supported primarily by the Atmospheric Radiation Measurement program, Office of Science, U.S. Department of Energy under contract no. DE-AC02-05CH11231., with additional support and collaboration from USDA, NASA, and NOAA.