Potential of Geospatial Technologies in Linking Airborne Measurements of CO2 with Terrestrial Sources of Carbon Over a Heterogenous Landscape

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Abstract

Terrestrial ecosystems are major sources and sinks of carbon. Quantifying their role in the continental carbon budget requires an understanding of both fast fluxes (hours to days) and longer term fluxes (years to decades). The Intercontinental Chemical Transport Experiment (INTEX-NA) is a major NASA science campaign to understand the transport and transformation of gases and aerosols on transcontinental and intercontinental scales and their impact on air quality and climate. As a part of this project, extensive CO2 measurements were made from NASA DC-8 aircraft, utilizing an infrared-gas analyzer based sampling system. Important objectives of this experiment are to 1. characterize the spatio-temporal variations of CO2 concentrations over different altitudes and a variety of land surfaces 2. Evaluate and link the aircraft based CO2 mixing ratios to ground based carbon flows and fluxes and 3. Test models that assimilate surface observations to derive regional to continental scale CO2 fluxes. In this study, we discuss some of the preliminary results as well as the potential of Remote sensing and Geographic Information Systems (GIS) useful for carbon cycling studies.

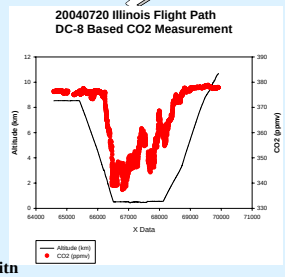
Airborne CO2 measurements – INTEX Experiment

Objectives : 1. To quantify and understand the variations in CO2 behavior between the planetary boundary layer and the free troposphere. 2. To link the aircraft measured CO2 variations in the troposphere to terrestrial landscape sources of carbon flows and fluxes for major landcover types.

Carbon dioxide and Ancilliary Data

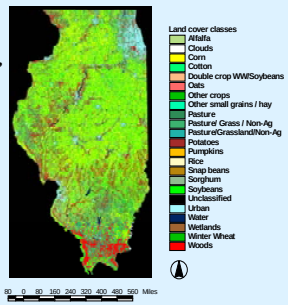
➢Project spatial scale and extent

The lowest CO2 concentrations during INTEX were observed over IL between 64581 – 69913 UTC on July 20, 2004



➢Activities:

- **CO2 measurements using Infrared gas analyzer system with a precision of less than 0.07 ppmv and accuracy of 0.25 ppmv.**
- **Data has been collected on a range of vegetation and land cover parameters such as net primary productivity carbon, plant phenology, growing season dynamics for forests and agriculture (planting, harvesting as well as peak growth depicting crop cycles and calender), hydrological regimes, soil characteristics, and land use / cover (LANDSAT and MODIS products) etc., through book keeping approaches and online web resources.**
- **Explore and use different remote sensing satellite data of land surface heterogeneity at a variety of scales relate to CO2 mixing ratios.**
- **Design and implement assimilation that explicitly incorporates information on the multiple timescales of the carbon cycle, and that combines in situ and satellite information.**



Remote Sensing Products

- **Several derived products from the LANDSAT, NOAA AVHRR and MODIS sensor will be used to specify spatial and temporal patterns of land use cover and vegetation characteristics for linking aircraft based CO2 data with terrestrial sources of carbon.**
- **In particular, MODIS products available from daily (e.g., surface reflectance) to 8-day (e.g., GPP) to monthly (e.g., LAI) to annual (e.g., NPP) temporal resolutions will be effectively utilized for characterizing the carbon flows and fluxes over heterogenous landscapes.**
- **To test different methodologies, we will use high spatial resolution datasets from LANDSAT imagery and related products.**

7.5 Minute Quadrangle for Illinois (USGS)

Addressing the landscape complexity

- **Ideally, aircraft measurements of CO2 can be separated into portions of flux records representing the land cover types through just AVERAGING the CO2 values for all cover types involved. However, such spatial separation may be a mis-representation, as**

A. *Different land cover types are often spatially mixed and heterogenous in an given area and*

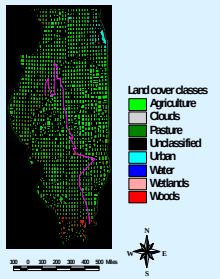
B. *Wind further mixes the CO2 fluxes to and from adjacent land cover types (Ex: Forest vs.Crops).*

C. *Land cover areas of the same cover type at different distances from the aircraft in the wind direction may contribute differently to the flux.*

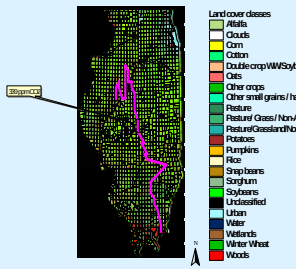
- **To address these issues :**

1. Land cover data for Illinois derived from LANDSAT in conjunction with CO2 measurements from aircraft have been averaged at 7.5 minute quadrangles. We spatially geo-referenced the flight path CO2 mixing ratios data with land cover data using GIS.
2. Distance weighted cover type fraction for each flux segment according to the wind speed and direction.
3. Use spatial 'unmixing algorithm' to separate aircraft flux measurements relating to different cover types using the weighted area fractions.

CO2 ANALYSIS AT LEVEL 1 CLASSES (AG. vs NON-AG)

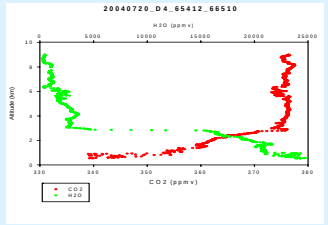


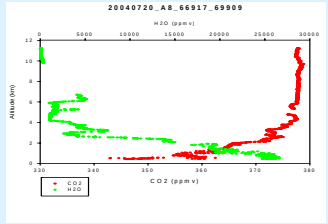
CO2 ANALYSIS AT LEVEL II CLASSES



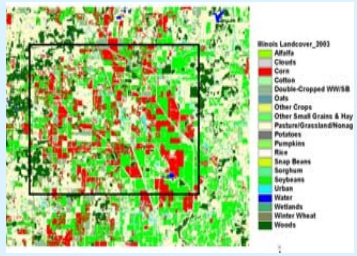
Preliminary Findings

The results suggest that :Variations in CO2 mixing ratios at lower altitudes were attributed to terrestrial sources of vegetation cover, that is highly heterogeneous occupying the landscape.



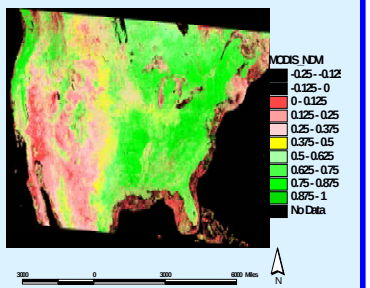


Interclass variations in CO2 mixing ratios between different vegetation types suggested averaged low CO2 mixing ratios for Corn crop compared to others. This is mainly attributed to the C4-dicarboxylic acid pathway of carbon fixation in Corn, having higher rate of photosynthesis than other C3 plants such as soybeans.



LANDSCAPE HETEROGENITY

In addition to LANDSAT derived biophysical products, MODIS products were utilized in the study: NDVI is a function of the fraction of photosynthetically active radiation (fPAR) absorbed by green vegetation (or fAPAR). High CO2 mixing ratios have been found to relate negatively with vegetation density (NDVI) derived from MODIS data. This is attributed to the photosynthesis uptake of CO2 by plants and convective mixing of the atmosphere



Acknowledgements

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