POTENTIAL OF GEOSPATIAL TECHNOLOGIES IN LINKING AIRBORNE MEASUREMENTS OF CO_2 WIH 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 (hours to days) and longer-term fluxes (years to decades). The Intercontinental Chemical Transport Experiment-North America (INTEX-NA) is a major NASA science campaign designed to understand the transport and transformation of gases and aerosols on transcontinental and intercontinental scales and their impact on air quality and climate. During the INTEX-NA summer 2004 phase, regional-scale in-situ measurements of atmospheric CO_2 were made from the NASA DC-8 over the conterminous U.S. affording the opportunity to explore how land surface heterogeneity relates to the airborne observations utilizing remote-sensing data products and GIS-based methods. In this presentation, several derived products from the LANDSAT, NOAA AVHRR, and MODIS sensors are invoked to specify spatiotemporal patterns of land use cover and vegetation characteristics for linking the aircraft-based CO_2 data with terrestrial sources of carbon. In examining the landscape mosaic utilizing these available tools, preliminary results suggest that the lowest CO_2 mixing ratios observed during the mission were over agricultural fields in IL dominated by corn then secondarily soybean crops. Low CO_2 concentrations are attributable to sampling during the peak growing season over such C4 plants as corn having a higher photosynthetic rate via the C4-dicarboxylic acid pathway of carbon fixation compared to C3 plants such as soybeans. In addition to LANDSAT derived biophysical products, results from comparisons of the CO_2 observations with NDVI values derived from MODIS data will be presented.

INTEX AIRBORNE CO_2 MEASUREMENTS AND ANCILLIARY DATA

To quantify and understand the variations in CO_2 behavior between the planetary boundary layer and the free troposphere, and to link the aircraft measured CO_2 variations in the troposphere to terrestrial landscape sources of carbon flows and fluxes for major land cover types, CO_2 measurements using a modified non-dispersive infrared (NDIR) gas analyzer with a precision of better than 0.7 ppmv and accuracy of 0.25 ppmv were made aboard the NASA DC-8 aircraft during the INTEX-A mission (June to August, 2004). Vertical profiles of CO_2 typically exhibit an increasing trend with height due to the photosynthetic uptake at the earth's surface during the summer season. Minimum CO_2

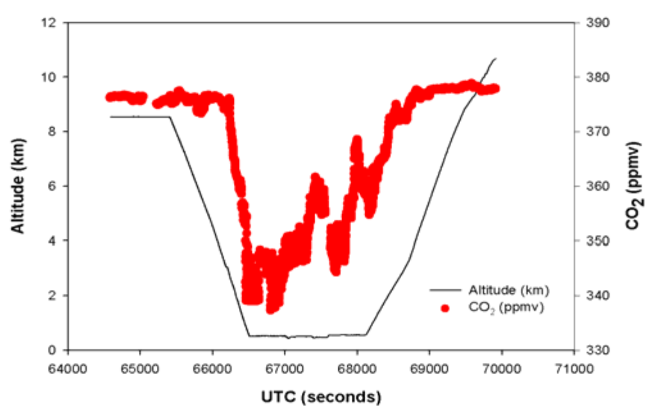

Fig. 1. DC-8 based observations showing low CO_2 mixing ratios measured over IL, July 20, 2004

mixing ratios were observed during INTEX-A over Illinois between 64581 – 69913 UTC on July 20, 2004 (Fig. 1).

Data have 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 calendar), hydrological regimes, soil characteristics, and land use/cover (e.g. LANDSAT and MODIS products). These data have been used to design and implement an assimilation scheme 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 sensors were used to specify spatial and temporal patterns of land use cover and vegetation characteristics for linking aircraft based CO_2 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 were effectively utilized for characterizing the carbon flows and fluxes over heterogeneous landscapes. To test different methodologies, we used high spatial resolution datasets from LANDSAT imagery and related products.

LANDSCAPE COMPLEXITY

Ideally, aircraft measurements of CO_2 can be separated into portions of flux records representing the land cover types through just averaging the CO_2 values for all cover types involved. However, such separation may be misrepresentative, as A) different land cover types are often spatially mixed and heterogeneous in a given area, B) wind further mixes the CO_2 fluxes to and from adjacent land cover types (e.g. forest vs. crops), and 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, land cover data for Illinois derived from LANDSAT in conjunction with CO_2 measurements from aircraft have been averaged at 7.5 minute quadrangles. We spatially geo-referenced the flight path CO_2 mixing ratio data with land cover data using GIS and distance-weighted the cover type fraction for each flux segment according to the wind speed and direction. Also, we used a spatial ‘unmixing algorithm’ to separate aircraft flux measurements relating to different cover types using the weighted area fractions.

PRELIMINARY RESULTS

The results suggest that variations in CO_2 mixing ratios at lower altitudes were attributed to terrestrial sources of vegetation cover that is highly heterogeneously occupying the landscape. Interclass variations in CO_2 mixing ratios between different vegetation types suggested averaged low CO_2 mixing ratios for corn crop compared to others. This is mainly attributed to the C4-dicarboxylic acid pathway of carbon fixation in corn, having a higher rate of photosynthesis than other C3 plants such as soybeans.

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 CO_2 mixing ratios have been found to relate negatively with vegetation density (NDVI) derived from MODIS data. This is attributed to the photosynthesis uptake of CO_2 by plants and convective mixing of the atmosphere.

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