Improving "bottom up" modeling for the Mid Continent NACP Intensive Campaign for 2006

Preliminary Discussion Document, May 2004

Background

Goals 1, 2, and 3 of Mid Continent NACP Intensive Campaign document, authored by Pieter Tans include 1) The gathering of enough atmospheric data to provide a mass balance for net carbon fluxes to an accuracy of 10% for the Mid West Agricultural belt. 2) The use of atmospheric data for improvement in the parameterization of transport /mixing processes in the lower atmosphere and 3) use of the same data to enable the measurement of future regional fluxes.

This document addresses possible complementary studies for Goal 4. Use of a variety of "bottom-up" techniques that include ecosystem and crop growth models as well as process models using eddy-covariance flux and satellite data of variables to estimate the net carbon flux over the same region. Goal 5 relates to the construction of "carbon flux maps" at various levels of temporal and spatial detail.

The Mid Continent Intensive document includes requirements for:

Long-term soil measurements for benchmark soil-monitoring sites with sufficient accuracy and detail to detect trends in soil organic carbon arising from present and future changes in management practices.

Crop growth and soil models that include remote sensing data. Examples listed include: a) the SMEX02 soil moisture model with inputs from LANDSAT, soil physical and chemical properties available from STATSGO and weather and climate data, b) Century which is a soil organic matter model with databases for climate, soil properties, topograghy, land use and weather data that can predict yields to estimate residue inputs and soil C pools and fluxes, c) ALEXI the Atmosphere-Land Exchange Inverse model, d) BIOME-BGC to estimate daily GPP, NPP and evapotranspiration and e) SiB-2 to simulate stomatal conductance and thus latent heat flux, sensible heat fluxes and GPP.

Land use and history. These will be based on the Thematic Mapper, county level data, NRI and FIA data as well as MODIS data.

Complementary Studies (preliminary thoughts)

To satisfy the above and provide complementary measurements will require the mobilization and organization of available measurements and data on soil carbon pools and fluxes as well as ecosystem exchange rates. A question that arises is the inclusion of other trace gases such as N_2O and CH_4 that greatly affect the greenhouse gas calculations and can negate C balance equations used in isolation. Available possible resources include experiment station data and personnel in the study area as well as in adjacent

areas. The extent that these measurements can be used as models for other studies as well as the influence of associated forested and grassland sites will also have to be discussed.

It is possible to establish farmer-field based soil benchmark sites relative to specific atmospheric measurements such as tall towers. These will have to be based on different management-land use, topography and soil types. The most useful information comes from long-term studies that help overcome the inherent soil heterogeneity and the slow changes in soil carbon relative to the large amounts present. Data from available long-term agricultural sites such as the ones in Iowa, Minnesota, Illinois, Michigan, Indiana, Wisconsin and Ohio provide the background for much of our present knowledge. How well their data can be used in the models and interpretation of the results of the Midwest study will have to be discussed. Newly established sites that include a greater range of vegetation types and topography than found on presently available long-term sites would be most worthwhile. Their continued support in the future however would have to be considered. Modeling and estimations of future soil carbon and greenhouse gas emmissions will be an integral part of the soil benchmark studies to allow predictions for the future, and extrapolation to other landscapes.

The NRI database contains a wealth of information. This needs to be correlated with that available in the FIA and the output placed into a format utilizable by the range of scientists and modelers who will be relating the bottom up approach to the top down measurements. The proposals for recent NASA-DOE-USDA RFP probably did not contain specific proposals for the Mid Continent Agricultural Region due to the overlap in timing. They however probably contain regional and national approaches that if modified could be most useful for this region.

The data from Eddy Covariance and Bowen Ratio towers now in operation will need to be included. The one in Mead, Nebraska includes detailed soil and plant studies. Others occur in Missouri, Indiana, Michigan and possibly Minnesota. There is ongoing discussion re the need for separation of beneath ground and soil respiration at these sites. Tracer techniques for this separation have been available for some time but it does take effort. A great deal of soil, plant and ecosystem background information is being obtained at enhanced CO_2 studies whether FACE or chambers at sites such as Wisconsin, Michigan, Illinois and Kansas. Chamber studies on greenhouse gas emmissions are being conducted relative to management -soil organic matter changes at the KBS-LTER in Michigan. The Short Grass Prairie and associated agricultural landscape sites in Colorado contain a number of flux towers as well as chamber measurements. The CASMGS project on carbon sequestration on agricultural lands is operative in Kansas, Iowa Indiana, Michigan, Ohio and Colorado. It is developing projects that concentrate on management and outreach to growers and industry as well as data management, modeling and basic studies. Iowa has faculty and field plots both at the university and associated with the Soil Tilth Laboratory.

Soil organic matter changes with management are being collected on a number of sites. These often need to be obtained on the same site over an extended period to overcome the inherent heterogeneity of soils and the small signal that management changes produce

relative to the large amount of carbon already in soils. The use of ^{13}C tracers and the sampling of fields under different management together with modeling provide most of the useful data. This will have to be coordinated with the land-use mapping and available records to ensure that representative soil type, management; land use and topographic areas are included. Agricultural, long-term plots often are restricted in the soil type and cover they study. Farmer's fields, the Conservation Reserve Program and measurements for the Wetland Reserve Program as well as aforrestation studies cover some of the other areas. The acreages involved together and the range in C sequestration estimates in the USA shows a potential for carbon sequestration. These show sequestration ranging from 0 to 1.2 ton ha^{-1} $year^{-1}$ with the greatest amounts being found in conversions to pasture, afforestation and zero till under irrigation. The highest numbers for CRP are found in the grasslands of the Iowa-Missouri border.

The development of a CO_2 monitoring and tracer collection system that could be used on benchmark sites as well as in association with the ongoing measurements at the other sites mentioned above would be most useful. Data synthesis and modeling must be an integral part of the comparison of the top-down and bottom-up approach. It is central to optimizing vegetation, present land use and land use history over the area involved. The data base expertise and personnel at Oak Ridge, Colorado State University, USDA Forest Service, USDA NRCS, Marine Biological Laboratory, the Argonne Lab and the University of Wisconsin are other resources that would need to be considered.

Summary

The techniques for measurement of soil C changes and plant responses with land-use changes are available, as are models and remote sensing land-use applications. The personnel are also available and fairly well organized in a number of joint studies. It should not be too difficult to mobilize these resources to adequately complement the studies proposed in the Midwest Intensive Initiative. The possibility of portable flux towers, more simplified soil respiration analysis and automated non-destructive soil sampling should also be discussed in such a mobilization.

The above, for discussion purposes, is extensive in both area and approaches and would address more question than just the comparison of the top down and bottom up question. It may be desirable to limit both people involved and types of study for both funding and logistic reasons. An on site-planning meeting could be worthwhile.

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