Impacts of Historical and Future Changes in Climate and Atmospheric CO_2 on Terrestrial Ecosystem Structure and Functioning in the Midwestern U.S.

Principal Investigator: Christopher J. Kucharik, Center for Sustainability and the Global Environment (SAGE), The Nelson Institute for Environmental Studies, University of Wisconsin-Madison, kucharik@wisc.edu

Co-Investigator: John D. Lenters, School of Natural Resources & Department of Geosciences, University of Nebraska-Lincoln, jlenters2@unl.edu

ABSTRACT

Objectives

The overall objective is to use a Dynamic Global Vegetation Model (DGVM; Agro-IBIS), which includes detailed representation of agro-ecosystems, to understand how past and anticipated (1948-2100) changes in agricultural land management, climate, and atmospheric CO_2 have affected and will affect ecosystem structure and functioning in the Midwest NICCR region. The goals are to quantify changes in regional-scale carbon, water, and energy cycling, highlighting shifts in potential vegetation distribution and the availability of ecosystem goods and services (e.g., crop yields, forest/grassland productivity, and freshwater availability).

Scientific Questions

We are asking these scientific questions: How has changing atmospheric CO_2 and climate previously affected the structure (e.g., biome distribution, phenology) and functioning of natural ecosystems, particularly in terms of carbon, water, and energy exchange? How has agricultural management (e.g., residue and tillage, fertilizer, crop type and hybrid, irrigation, and planting dates), decadal-scale climate change and variability, and increasing atmospheric CO_2 contributed to changes in biogeochemical cycles since ~1950? Will linkages between global change drivers (climate and atmospheric CO_2) and land management create unanticipated outcomes in freshwater availability, crop yields, and potential vegetation distribution and productivity over the next 100 years?

Location

The regional modeling domain will encompass most of the Midwest NICCR region, including the Missouri, Upper Mississippi, and Great Lakes drainage basins.

Methods

This project will integrate the Agro-IBIS DGVM, a well-tested process-based biosphere model of natural and managed ecosystems of North America, and the following drivers: (a) 10-km fractional crop cover (corn, soybeans, and wheat), soil texture, and nitrogen fertilizer data; (b) 10-km gridded historical daily climate data; (c) transient changes in atmospheric CO_2; (d) future climate scenarios using a combination of VEMAP, IPCC AR4 general circulation model (GCM) output, and newly anticipated results from the North American Regional Climate Change Assessment Program (NARCCAP). Canopy and land surface processes in Agro-IBIS are based on differences in vegetation class, C_3 and C_4 physiology, daily leaf area, and carbon allocation so coupled carbon-water exchange is responsive to land management and environmental stresses. Vegetation dynamics are based on the annual carbon balance of plant functional types (PFTs) and their competition for light and water. Model simulations will be performed for the years 1948 through 2100 across a 10-km x 10-km terrestrial grid. Historical model output will be validated using a wide range of data sources including AmeriFlux, SoyFACE, and FACE data, USDA crop yield data, MODIS land cover products, and regional water and energy balance measurements.

Deliverables and outcomes

The expected key deliverable is an improved understanding – useful to future policy decision-making – of how managed and natural ecosystems in the Midwest U.S. act in *unison* to control regional scale carbon, water, and energy exchange, and how the availability of key ecosystem goods and services, and vegetation distribution have been affected and will be affected by global change drivers. These will be communicated through conference proceedings, meetings, and the peer-reviewed literature.