Modeling CO_2 emissions in Prairie Pothole Region using DNDC model and remotely sensed data

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Introduction

The USGS Northern Prairie Wildlife Research Center (NPWRC) has conducted a series of investigations to quantify the effects of land use on changes in soil carbon sequestration and Greenhouse Gas (GHG) emissions (i.e., carbon dioxide [CO_2], nitrous oxide [N_2O], methane [CH_4]) in the Prairie Pothole Region (PPR). The USGS EROS Center is working with the NPWRC to evaluate regional GHG emissions using remotely sensed data and biogeochemical modeling. This poster describes the work on soil CO_2 emissions at the local site level.

Site Description

Total growing season precipitation at research sites during 2005 was 766 mm and 421 mm in 2006. The growing season starts in April and ends in October. Average yearly temperature is 15°C.

Figure 1. Prairie Pothole Region map

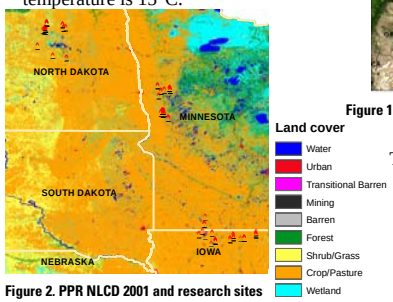

Figure 2. PPR NLCD 2001 and research sites

The PPR includes parts of North Dakota, South Dakota, Minnesota, Iowa, and Montana.

Methods

~ Site MODIS GPP 2005 and 2006 [1]

~ Revised general ensemble biogeochemical modeling system (GEMS) and DeNitrification-DeComposition (DNDC) model [2][3]

~ Local observation data[4]

~ Daily climate data from NOAA ground climate station[5]

~ Model runs for growing season 2005 and 2006 at 8 chambers in 5 different land cover sites. Parameters are adjusted manually with field observations

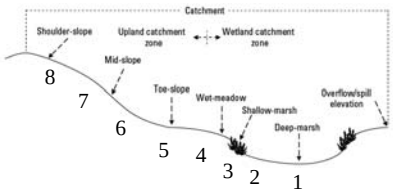

Figure 3. Wetland catchment and chamber locations in field measurement

Model Simulation and Results

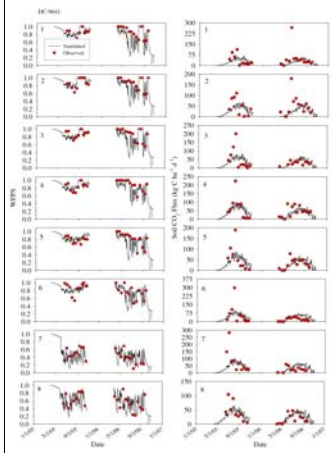

Figure 4. Daily simulation on soil moisture (WFPS) and CO_2 emission at chamber from 1 to 8 in drained cropland site (DC)

The soil water filled pore space (WFPS) simulation showed a good agreement with observations at each chamber.

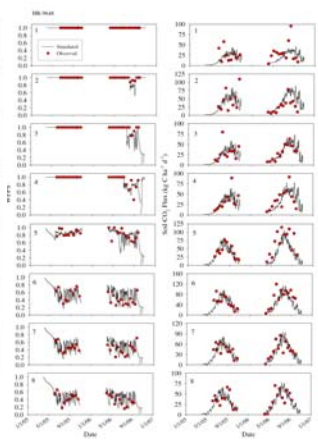

Figure 5. Daily simulation on soil moisture (WFPS) and soil CO_2 emission at chambers from 1 to 8 in hydrologically restored site (HR)

Seasonal pattern of soil CO_2 emission showed low emission rates before June, a high peak in July and August, and lower rates again in September and October.

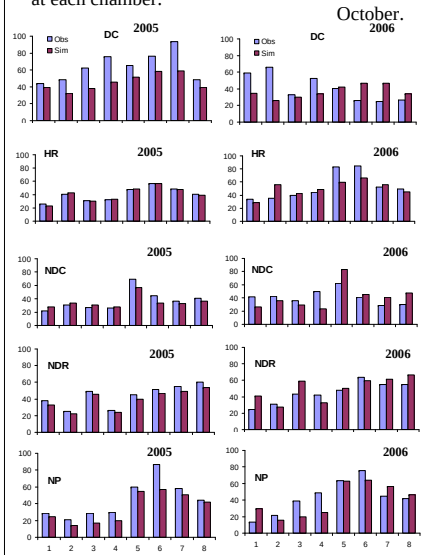

Figure 6. Simulated CO_2 in chambers 1 to 8 on 5 sites from June to September

Cropland vegetation was corn during both years. The restored and native prairie lands have emergent vegetation in wetland zones (chambers 1-4) and perennial grass in upland zones (chambers 5-8). Soil CO_2 emissions increased from the lower chambers (wetland) to higher chambers (upland). This change is likely caused by differences in soil moisture and vegetation.

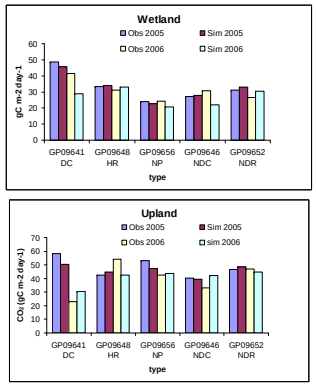

Figure 7. Comparison of wetland and upland chambers observed and simulated soil CO_2

Wetland chambers had less CO_2 emission than upland in both years. Simulated CO_2 emission showed similar results as observed results.

Table 1. Description of land cover types

Land cover	Description
DC	Drained cropland
HR	Hydrologically restored drained cropland
NDC	Nondrained cropland
NDR	Nondrained restored wetlands
NP	Native prairie wetlands

The CO_2 emissions didn't show big difference between land covers. The drained wetlands (DC, HR) had higher CO_2 emissions in wetland chambers.

Conclusions and Discussion

~ Seasonal dynamics of predicted soil respiration agreed well with observed soil WFPS and CO_2.

~ Temporal change of soil CO_2 emission during the growing season is mainly controlled by the soil temperature and vegetation growth.

~ Spatial difference of soil CO_2 emission is dominated by the soil water and vegetation condition.

~ Other factors like soil bulk density, carbon and nitrogen content, and pH did not appear to significantly influence CO_2 emissions

~ Future work should include using higher resolution remotely sensed data and more field sites to develop the regional simulation strategy

Reference:

[1] Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC), 2008, MODIS subsetted land products, Collection 5, available online at http://daac.ornl.gov/MODIS/modis.html. (Accessed February 11, 2009.)
[2] Liu, S., Loveland, T.R., and Kurtz, R.M., 2004, Contemporary carbon dynamics in terrestrial ecosystems in the southeastern plains of the United States: Environmental Management, v. 33, p. S442–S456.
[3] DNDC Model Technical Documentation,
[4] Gleason, R. A. Tangen, B. A., and Laubhan, M. K., 2008, Carbon sequestration, in R. A. Gleason, M. K. Laubhan, N. H. Euliss Jr., editors. Ecosystem services derived from wetland conservation practices in the United States prairie pothole region with an emphasis on the U.S. Department of Agriculture Conser¬vation Reserve and Wetlands Reserve Programs: U.S. Geological Survey Professional Paper 1745, p. 23–30.
[5] NNDC Climate Data, [2005-2006], National Climatic Data Center, NOAA, 2008, available online at http://cdo.ncdc.noaa.gov/CDO/cdo. (Accessed February 11, 2009.)