Simulating Net Greenhouse Gas Emissions from Major Crops in Texas through DAYCENT

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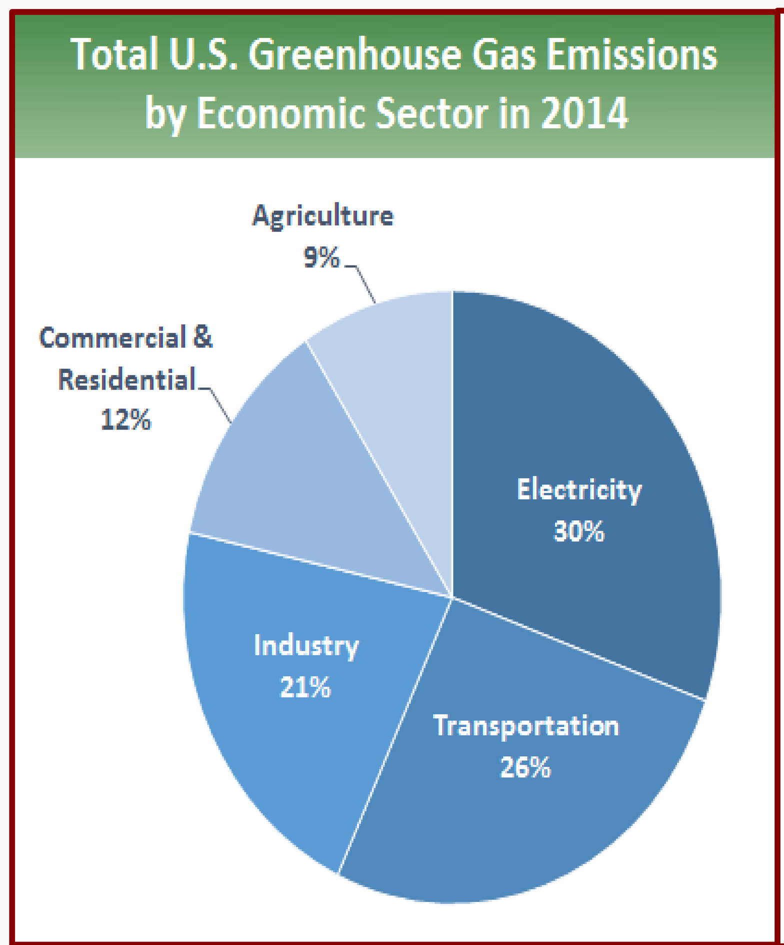
Introduction

Anthropogenic greenhouse gas (GHG) emissions have increased rapidly since pre-industrial times, which is a major factor contributing to climate change. As a primary source of anthropogenic GHG emissions, agriculture is estimated to emit about 10% of total global GHG emissions. In the last few decades, there have been increasing demands for GHG emissions inventories to quantify national and regional contributions to the increasing atmospheric concentrations of GHGs. Moreover, these inventories provide baseline information on levels and trends in emissions and are essential for evaluating the potential to reduce GHG emissions with best management practices in agricultural lands. However, accurately estimating GHG emissions with simple emission factors is a great challenge due to high variability both in space and time that is caused by various environmental and management factors. Meanwhile, it is not cost effective to continuously monitor GHG emissions and changes in soil organic carbon (SOC) stocks across vast agricultural lands with high spatial variations. Consequently, process-based models have been developed to predict emissions from field scales to national and even global scales. The objective of this study was to test the performance of the biogeochemical model DAYCENT in simulating major crop yields, SOC sequestration, and GHG emissions at a county level for Texas.



Ranking Of States With The Most Farms

Rank	State	2015	% Of U.S.
	United States	2,067,000	
1	Texas	242,000	11.71%
2	Missouri	97,100	4.70%
3	Iowa	87,500	4.23%
4	Oklahoma	78,000	3.77%
5	California	77,500	3.75%
6	Kentucky	76,400	3.70%
7	Ohio	74,400	3.60%
8	Illinois	73,600	3.56%
9	Minnesota	73,600	3.56%
10	Wisconsin	68,900	3.33%
11	Tennessee	67,300	3.26%
12	Kansas	60,400	2.92%
13	Pennsylvania	57,900	2.80%
14	Indiana	57,700	2.79%
15	Michigan	51,500	2.49%
16	North Carolina	48,800	2.36%
17	Nebraska	48,700	2.36%
18	Florida	47,300	2.29%
19	Virginia	44,700	2.16%
20	Arkansas	43,500	2.10%
21	Alabama	42,700	2.07%
22	Georgia	40,500	1.96%
23	Mississippi	36,700	1.78%
24	Washington	36,000	1.74%
25	New York	35,500	1.72%
26	Oregon	34,600	1.67%
27	Colorado	34,200	1.65%
28	South Dakota	31,300	1.51%
29	North Dakota	30,000	1.45%
30	Montana	27,500	1.33%

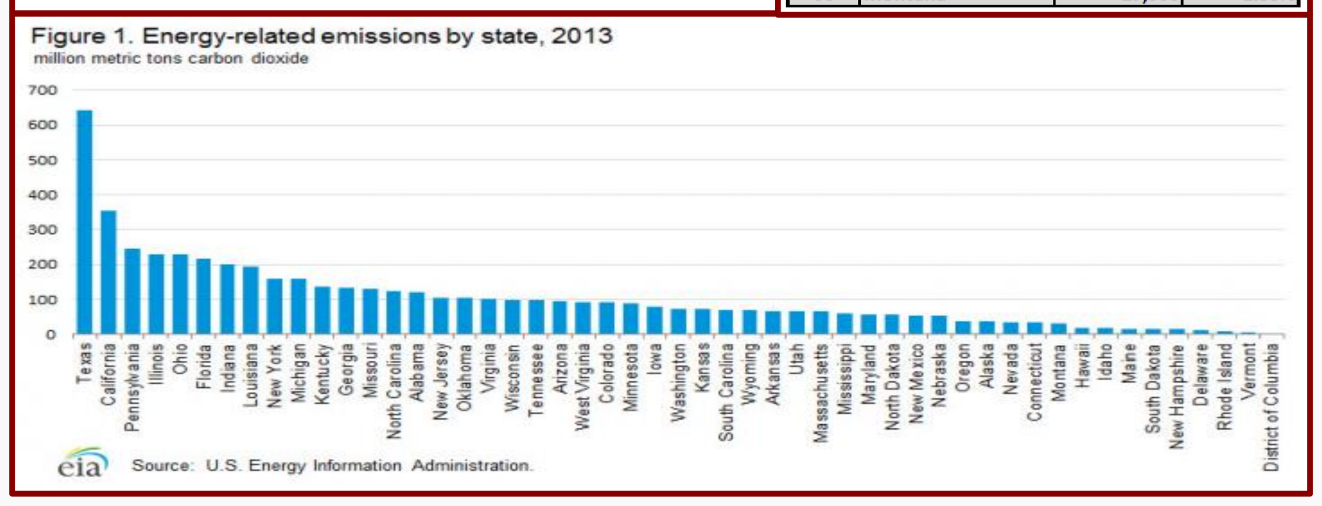


Fig. 1. Agricultural Role in GHG Emissions (top left, credit: EPA), Texas Agricultural Status (top right, credit: USDA) and GHG Emission (bottom, credit: EIA)

Material and Methods

County level simulations were carried out using DAYCENT for the state of Texas to examine carbon (C) dynamics and GHG emissions in selected conventional crops in the period of 1982-2012. The focus of regional simulations for all Texas counties and the state as a whole during this period included: (1) yields of major crops (grain corn, upland cotton, winter wheat, grain sorghum, and hay) under conventional field management practices, and (2) net GHG budget for each cropping system, including crop/soil system CO_2 flux (e.g. net SOC change), direct and indirect nitrous oxide (N_2O) emissions, and methane (CH_4) uptake.

Results

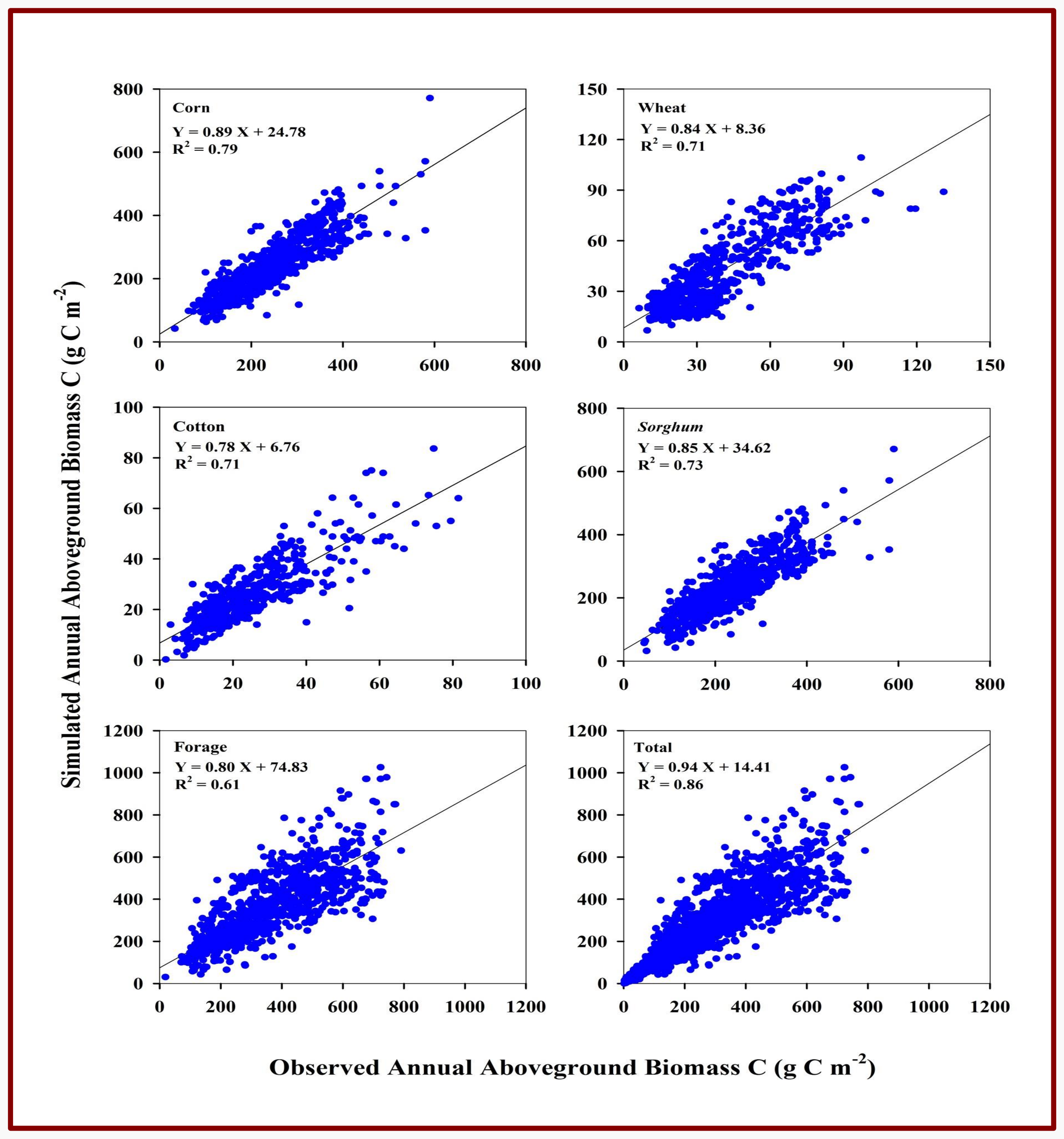


Fig. 2. Observed and Simulated Annual Aboveground Biomass C for major crops in Texas Counties in 1982-2012

Table 1. Statistics During County Level Biomass Carbon Simulations

Crop Name	Corn	Wheat	Cotton	Sorghum	Forage
Counties Simulated and Regressed *	127	170	123	174	248
Counties Simulated but not Reregressed **	62	41	52	38	4
Counties not Simulated***	65	43	79	42	2
County Level R^2 Range	0.36 - 0.98	0.31 - 0.99	0.34 - 0.98	0.34 - 0.98	0.23 - 0.90
State Level Average Harvest Aera (acre yr^{-1})	1329964	3685870	4405381	3018233	4186329

* At least 4 out of 7 investigations during 1982–2012 had yield data for the crop.

**1 ≤ investigations with yield data < 4.

*** None of 7 investigations had yield data for the crop.

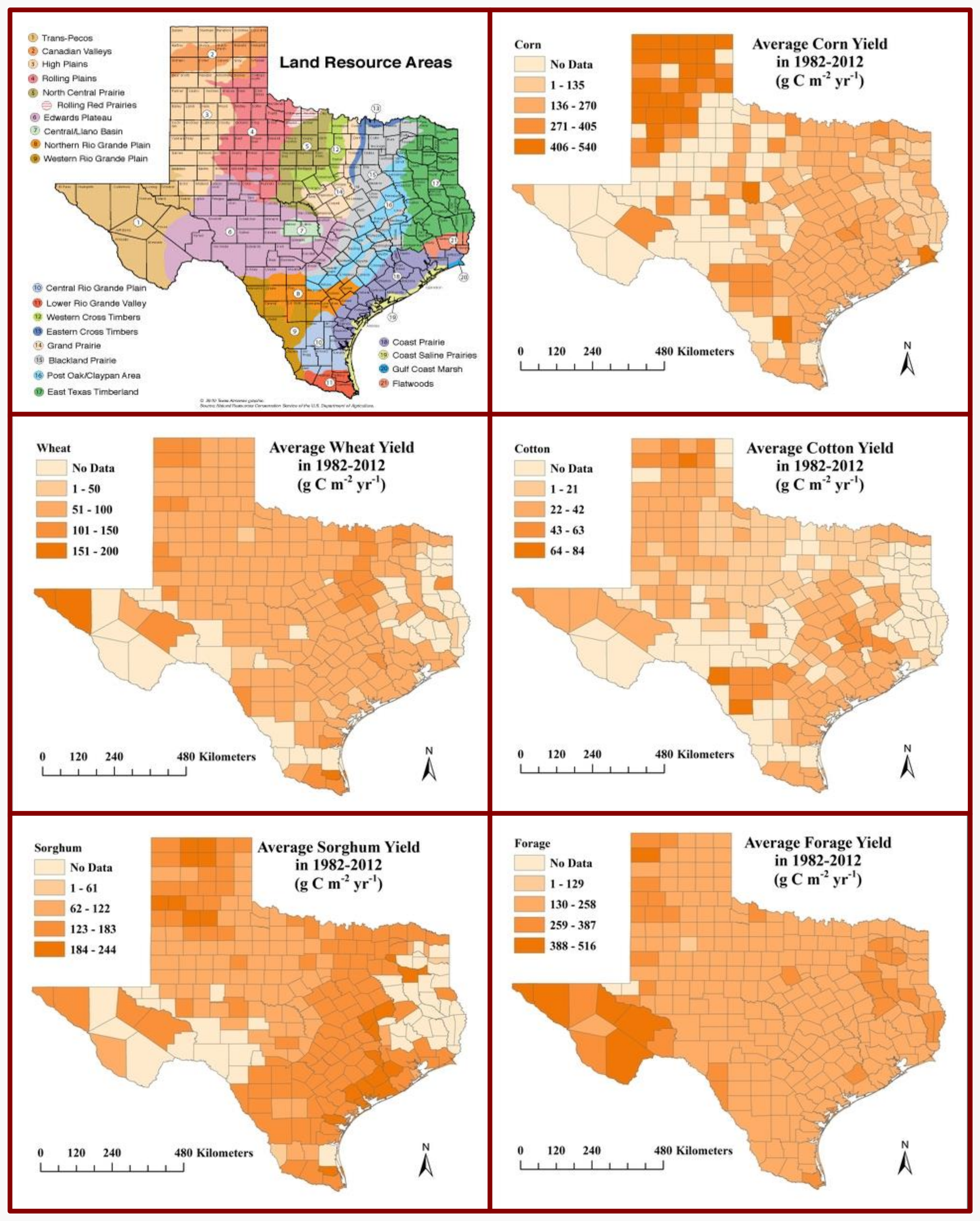


Fig. 3. Land Resource Areas Map (top left, credit: USDA/NRCS) and Average Simulated Aboveground Biomass C of Major Crops in Texas Counties in 1982-2012

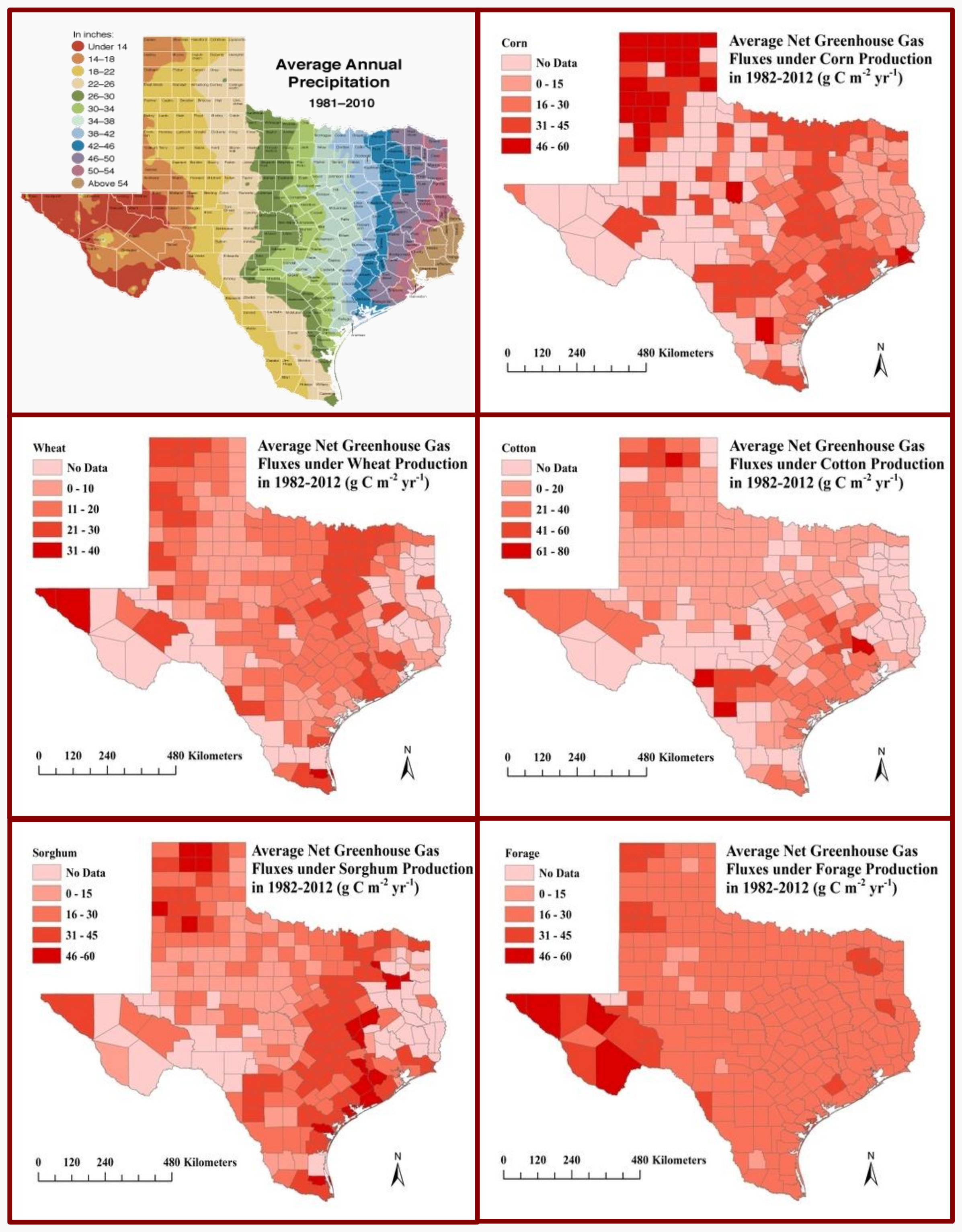


Fig. 4. Average Annual Precipitation (top left, credit: Texas Almanac) and Average Net GHG Emissions from Major Crops in Texas Counties in 1982-2012

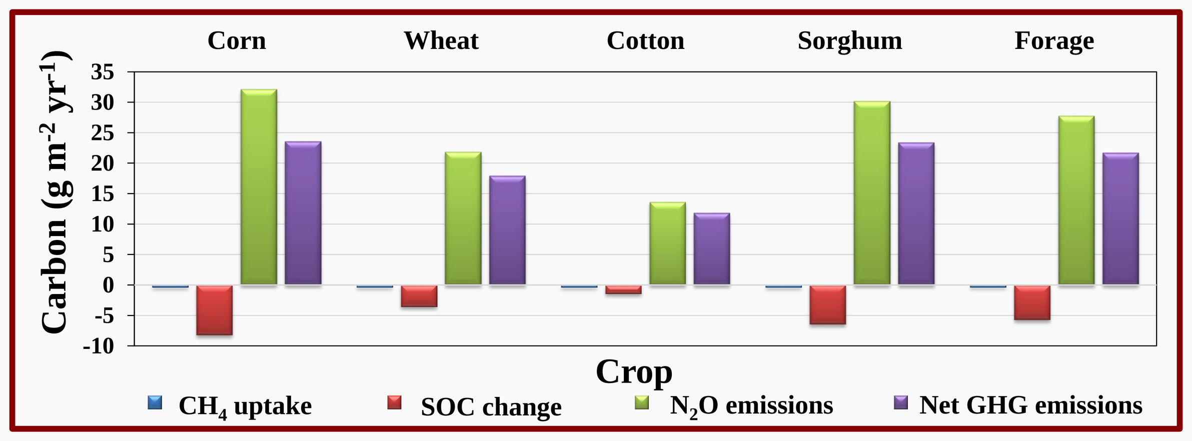


Fig. 5. State Level Carbon Sinks and Sources and Average Net GHG Emissions from Major Crops in 1982-2012

Conclusions

DAYCENT model reasonably simulated the major crop yield data in Texas counties, reflecting the crop production variation caused by annual weather change and soil property difference across the state, as well as field management practices such as N fertilization, irrigation, tillage, and residue return.

High intensity agricultural activities increased crop productivity, while at the same time resulting in higher GHG emissions as demonstrated by comparing crop yields with net GHG emission distribution throughout the state.

At the state level, higher yielding crops indicated higher SOC sequestration, possibly due to greater fertilization and larger amounts of residue and root return after harvesting. However, higher GHG emissions may offset the C sequestered in soil and increase agricultural net GHG emissions. Thus, better management practices or alternative cropping systems are needed.

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