# Noah-MP Crop Model – Developments and Applications for Food-Water Nexus Study

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# Outline

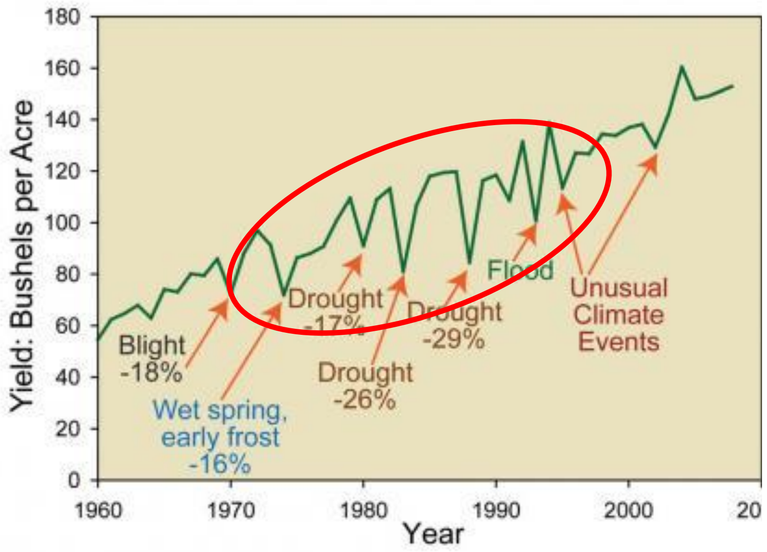
- Motivation and Introduction
- Crop model developments in Noah-MP
- New developments:

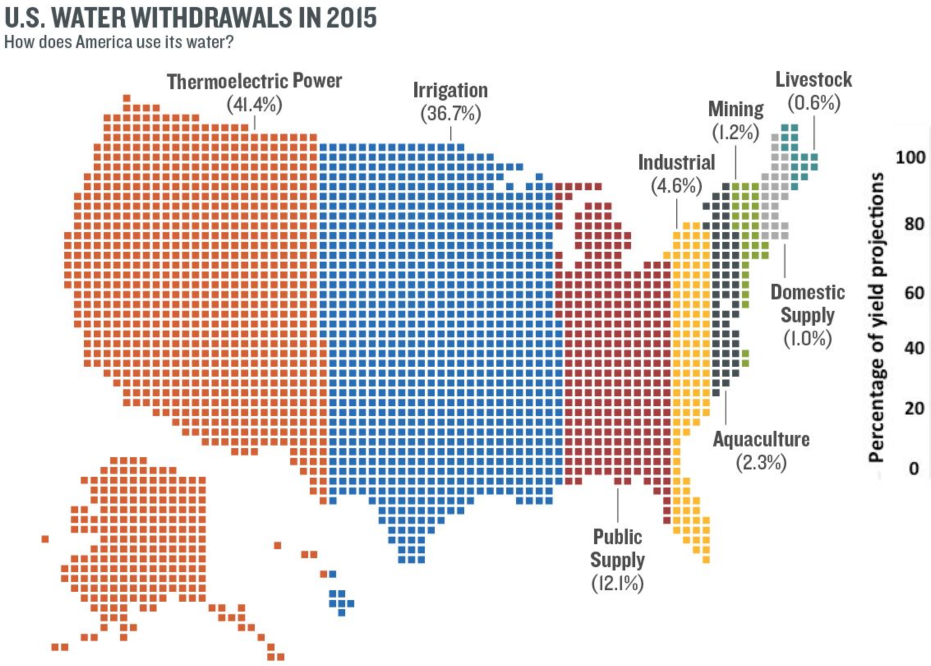
(1) Spring wheat in Canadian Prairies
(2) Dynamic planting/harvest scheme

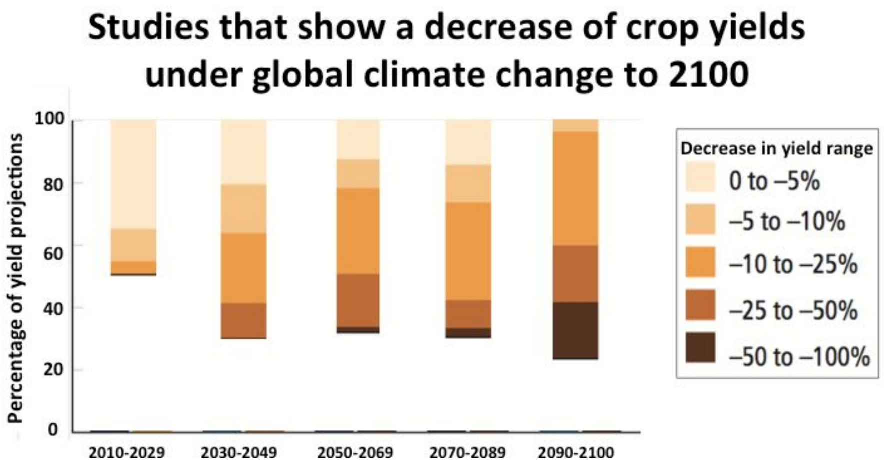
- Applications:
- Jointly model of crop and irrigation
- Assessing climate impacts on crop production

- Future Research

# Motivation and Introduction



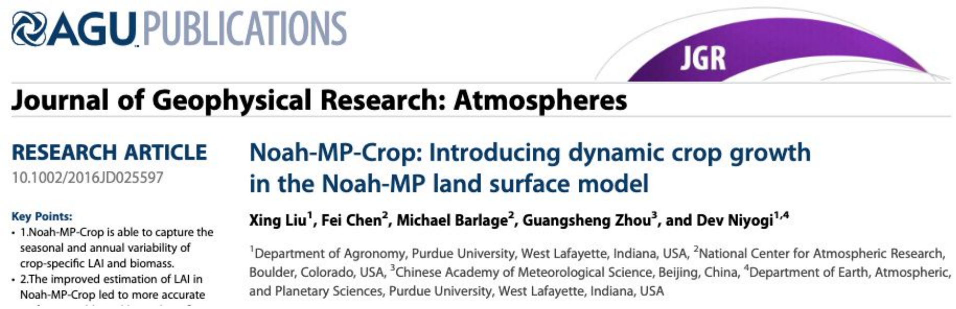




IPCC AR5, 2014

Motivation:

- Agricultural production and water consumption are closely tied together
- These food-water nexus issues become challenging and uncertain under climate change
- Better understanding of the food and water security, climate change impacts, human managements

# Development of the Noah-MP Crop model



AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2016JD025597

**Key Points:**
- 1.Noah-MP-Crop is able to capture the seasonal and annual variability of crop-specific LAI and biomass.
- 2.The improved estimation of LAI in Noah-MP-Crop led to more accurate

## Noah-MP-Crop: Introducing dynamic crop growth in the Noah-MP land surface model

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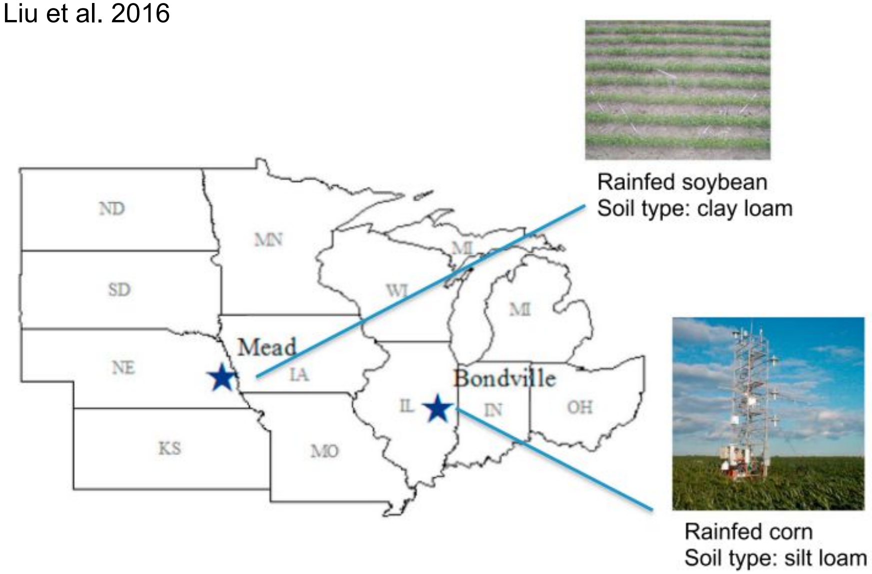
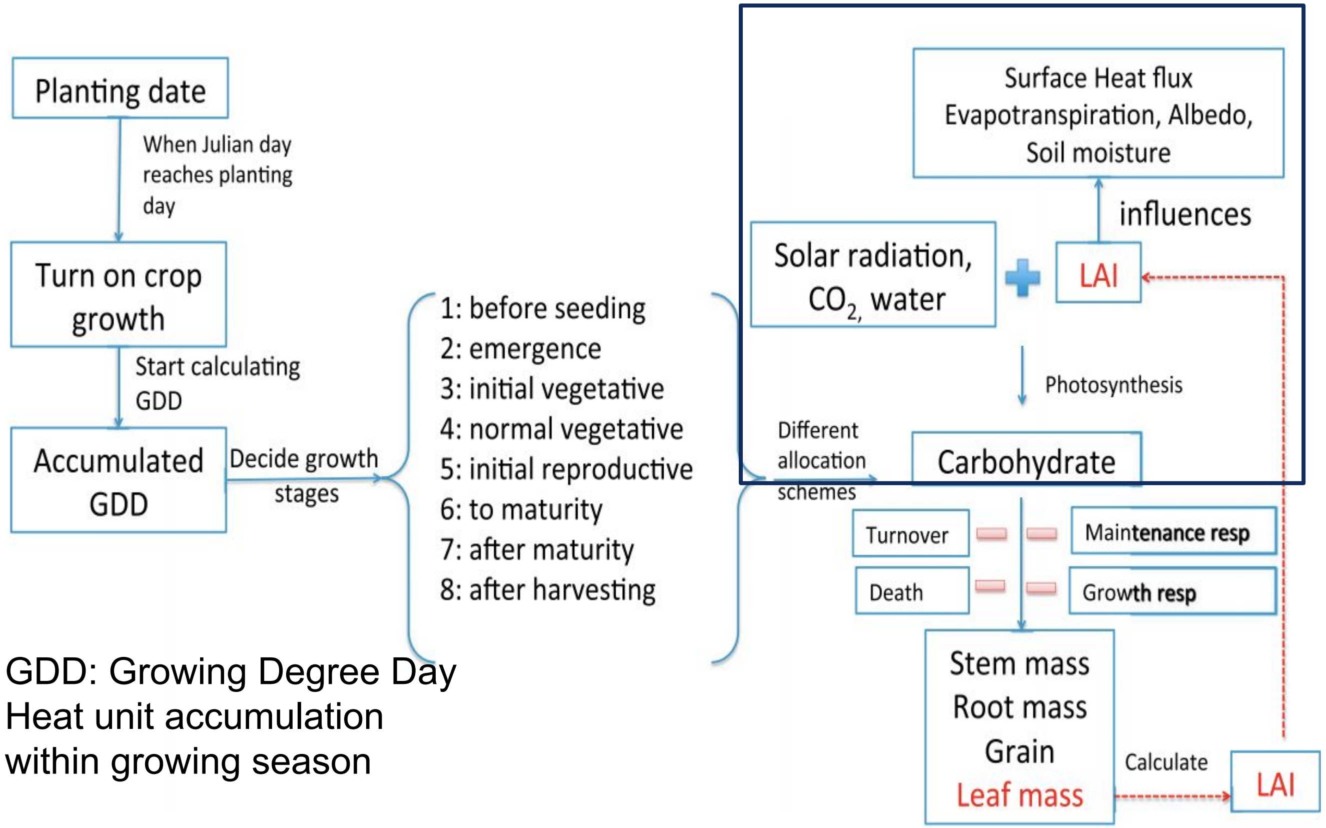
Single-point corn and soybean
Liu et al. 2016



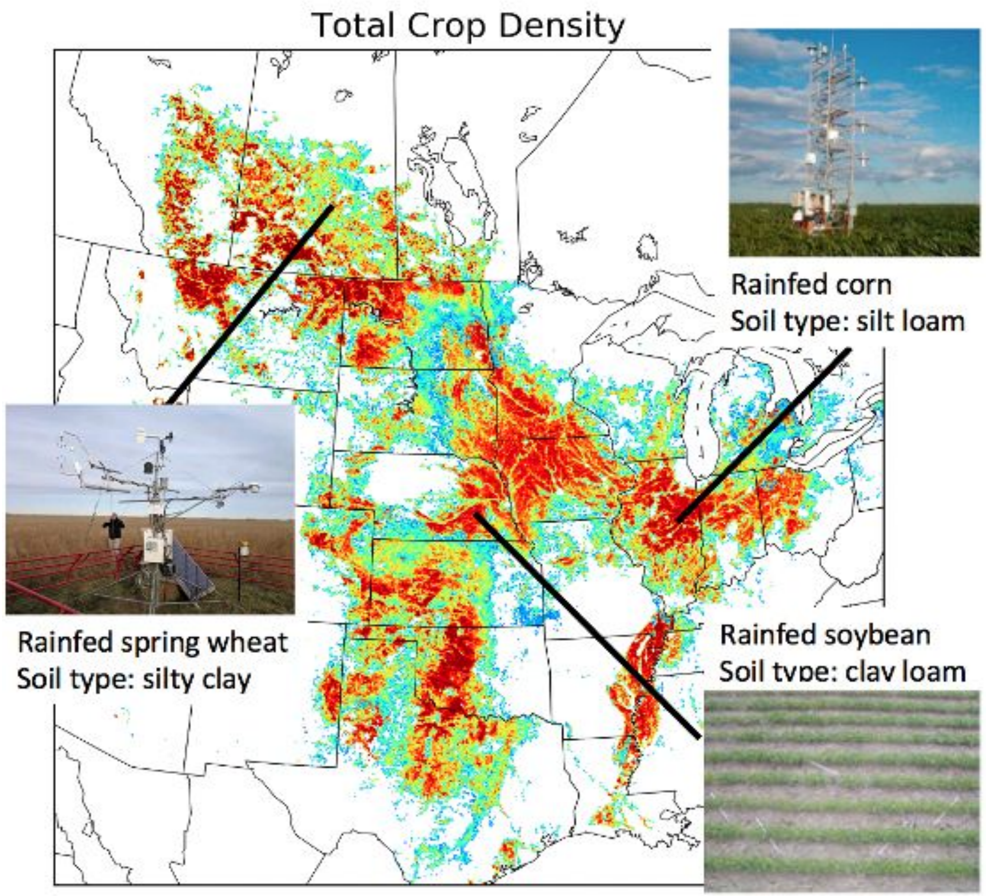

Key coupling of energy, water & carbon through transpiration and photosynthesis




GDD: Growing Degree Day
Heat unit accumulation within growing season

# Major crop species in North American

Corn in Bondville, IL
Soybean in Mead, NE
Spring Wheat in Kenaston, SK

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Geoscientific Model Development
Discussions
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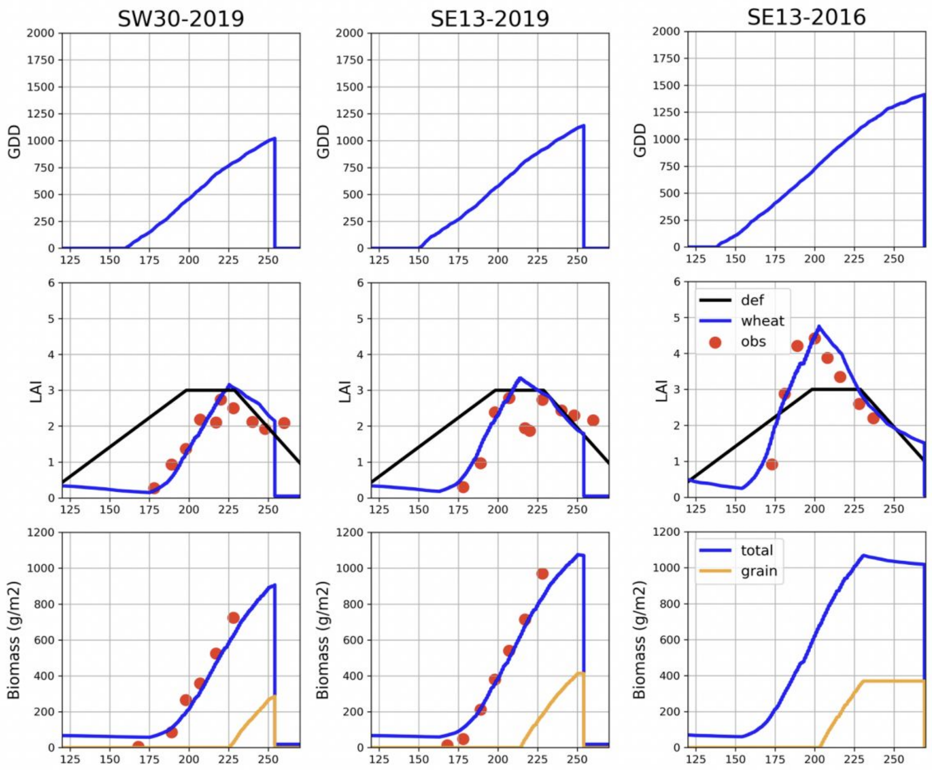
**Developing Spring Wheat in the Noah-MP LSM (v4.4) for Growing Season Dynamics and Responses to Temperature Stress**




Reasonably simulate LAI timeseries and aboveground biomass

In addition to flux tower measurement:

1. LAI timeseries
2. Biomass timeseries
3. Planting/harvest date

# Planting/Harvest in Noah-MP crop model

1. At single-point: Prescribed date

2. At state-level: USDA state level data

3. Dynamic planting: driven by temperature

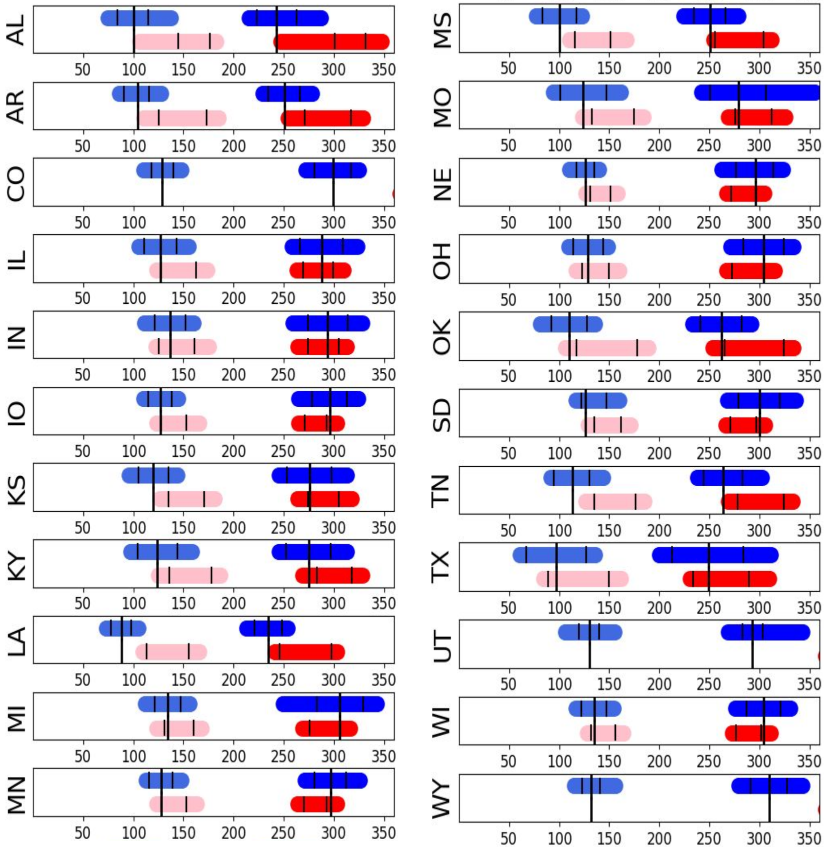
**2. USDA NASS 2010**

Field Crops Usual Planting and Harvest Dates

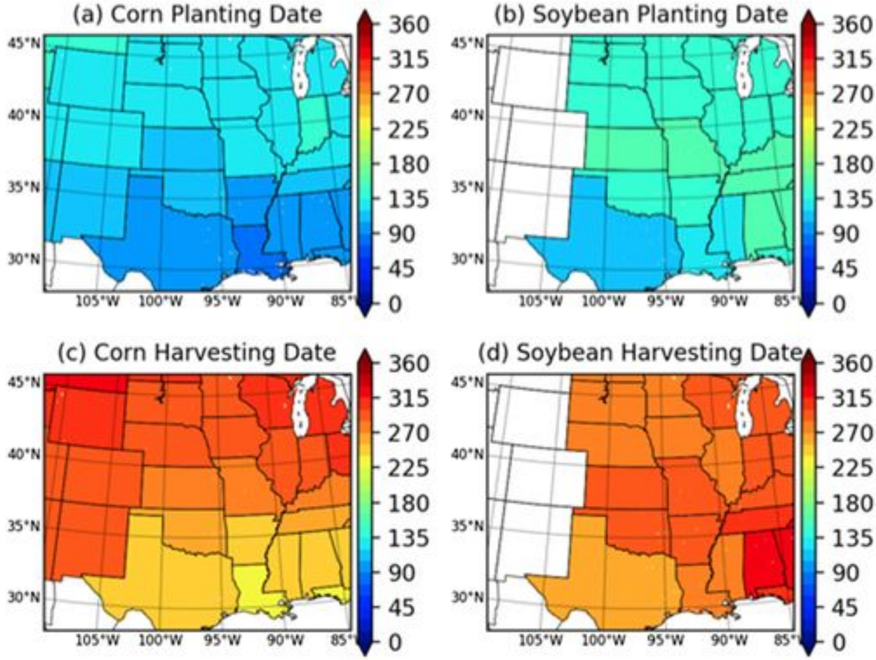
https://usda.library.cornell.edu/concern/publications/vm40xr56k

Blue – corn

Red – soybean



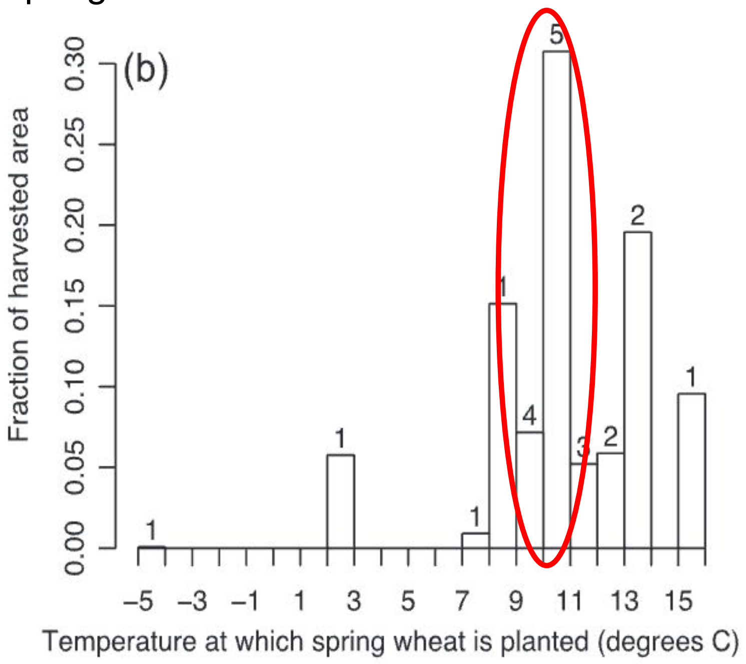

**Planting/harvest date by corn and soybean**



# Temperature-driven dynamic planting/harvest

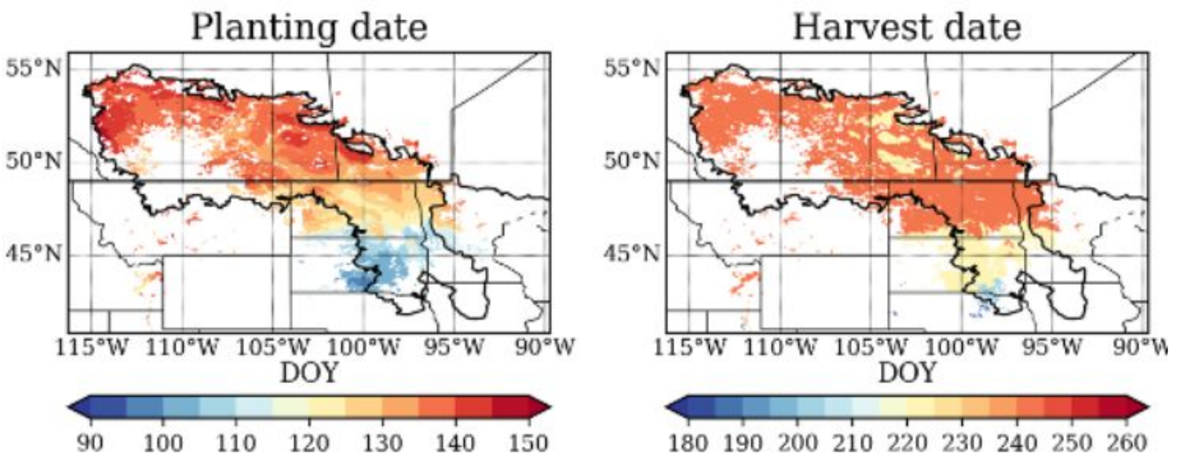
- Propose a dynamic running average temperature threshold (TAVE) for planting, and accumulated GDD threshold for harvest
- For wheat: TAVE_5 > 10C & HARVEST: GDD > 1500

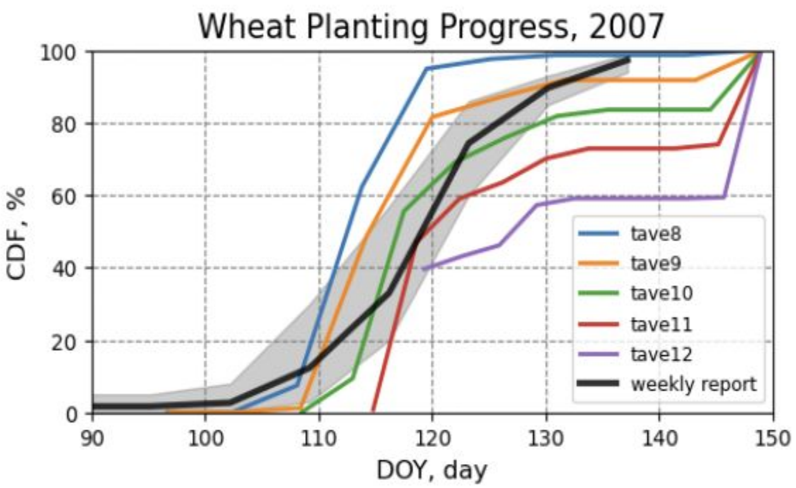
Spring Wheat

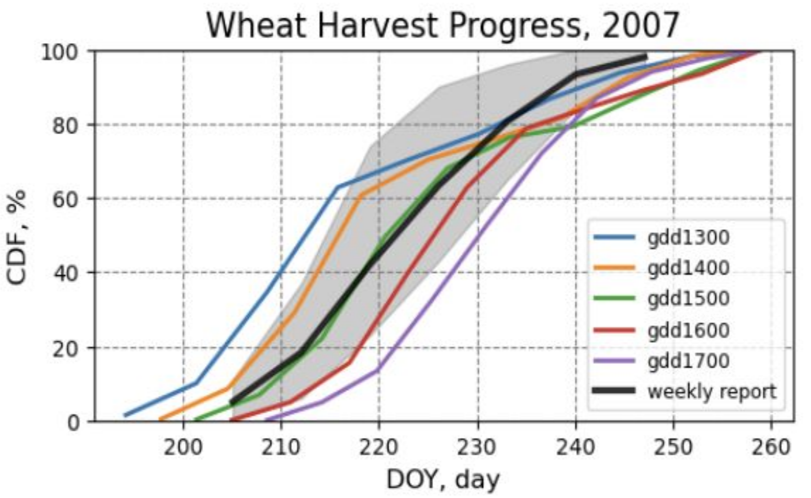



Crop planting dates: global synthesis
Sacks et al. (2010)

**Temperature-driven dynamic date**



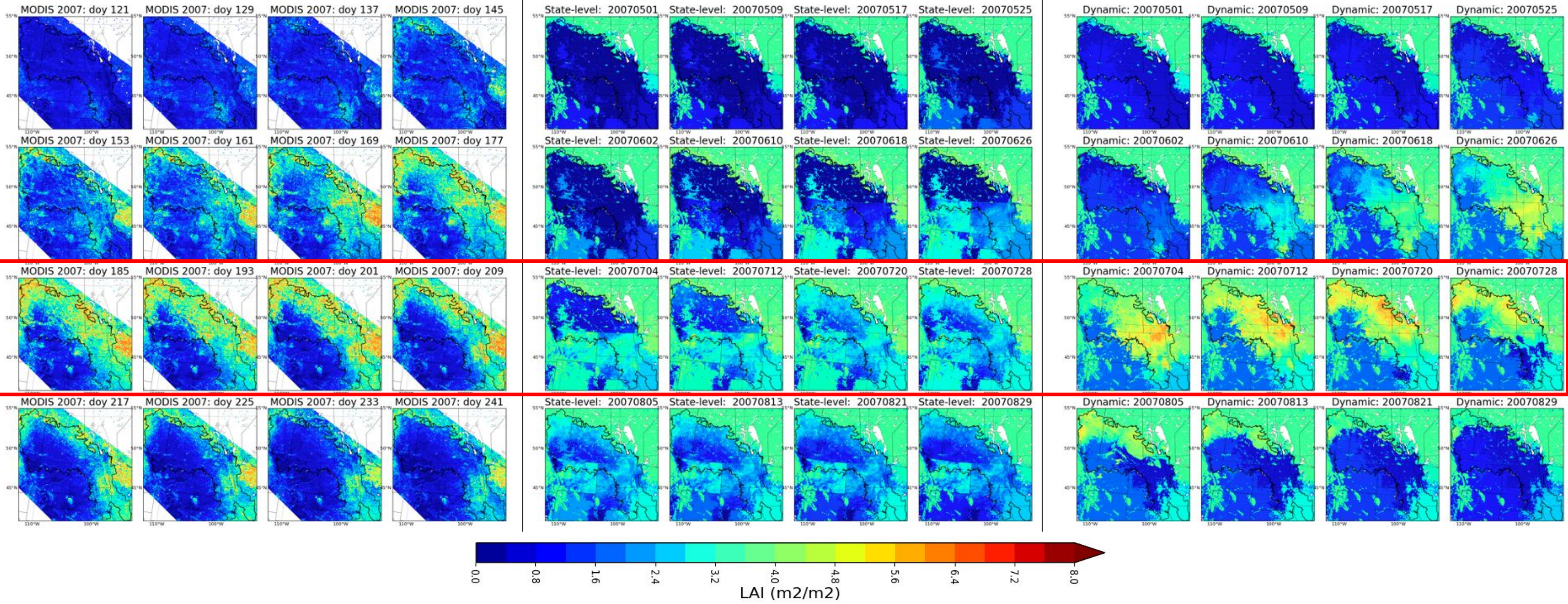

Sensitivity of threshold parameters and evaluation against USDA weekly crop progress data

# Dynamic planting & LAI

MODIS LAI

State-Level planting
State-level harvest

Dynamic Planting
& harvest



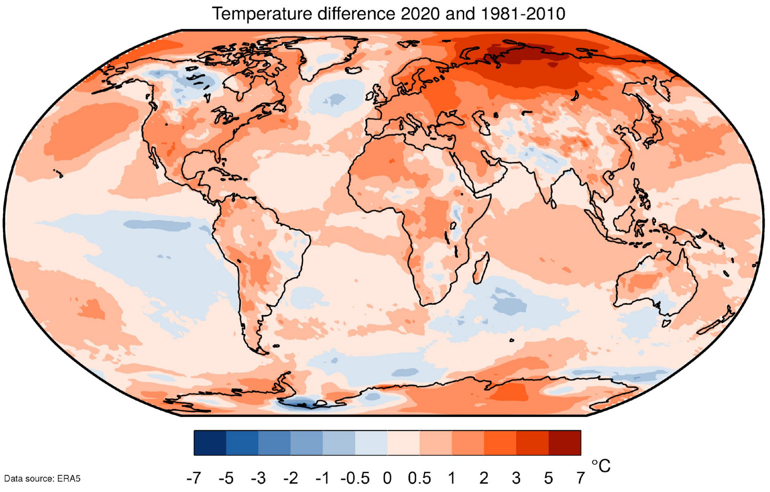

Dynamic planting improves the LAI spatially and temporally, especially peak LAI in July

# Application: Assessing climate impacts on agriculture

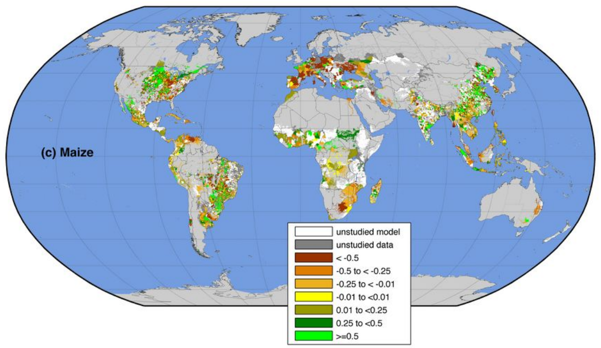
Previous approach

New approach

Ensemble GCMs + RCP scenarios + Crop models

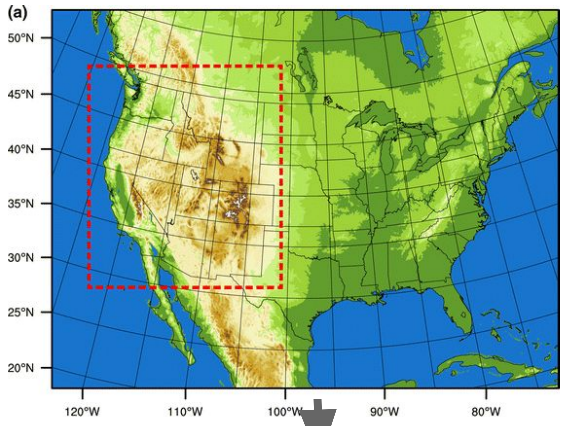



Multiple simulations allows model inter-comparison




- Do not resolve short term extremes
- Coarse resolution (~50km)
- Simple management parameterizations

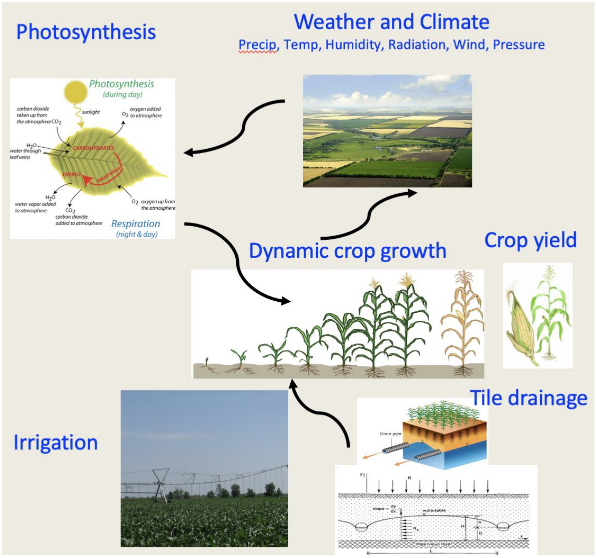
Convection-Permitting Model (CPM)




Better climate forcing
High-res, Hourly outputs
More reliable precipitation

CONUS404: reliable forcing
CONUS1: PGW scenario

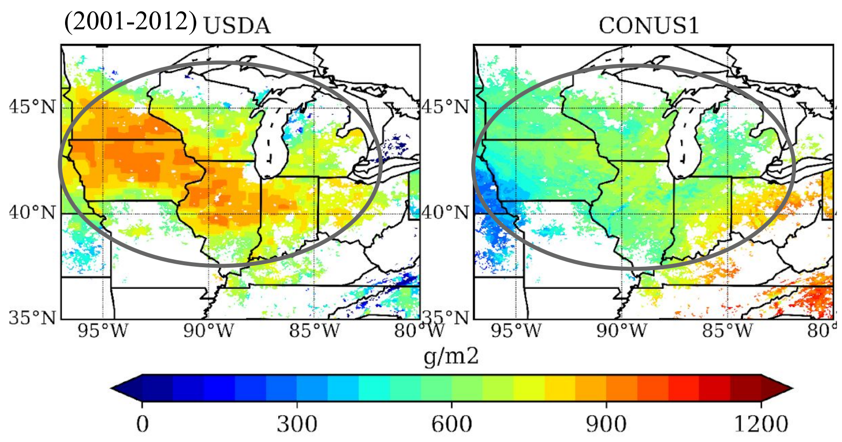
Integrated Noah-MP-crop model

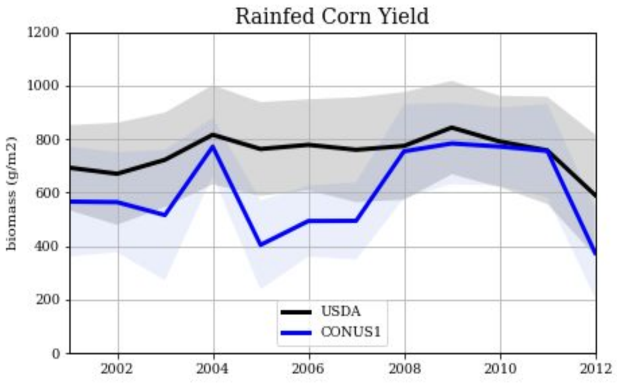


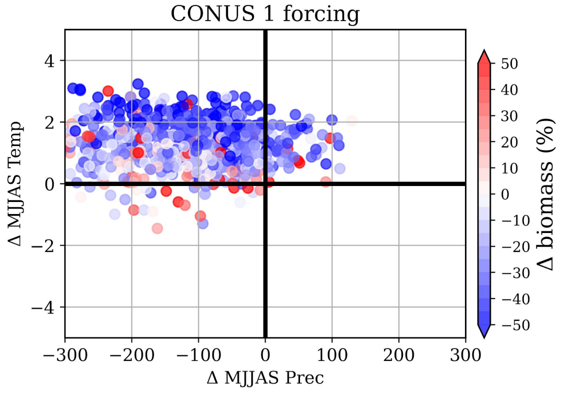

Better physics in crop growth and agriculture management models

# 1. Climate forcing has critical impacts

substantially underestimate yield and exaggerate interannual variability

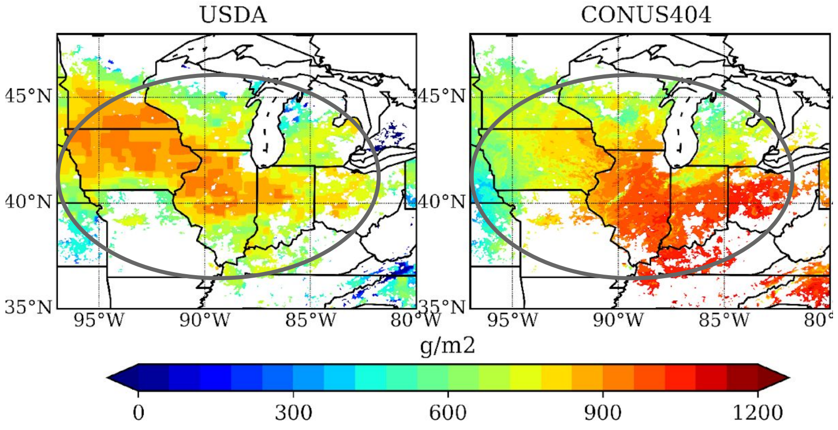


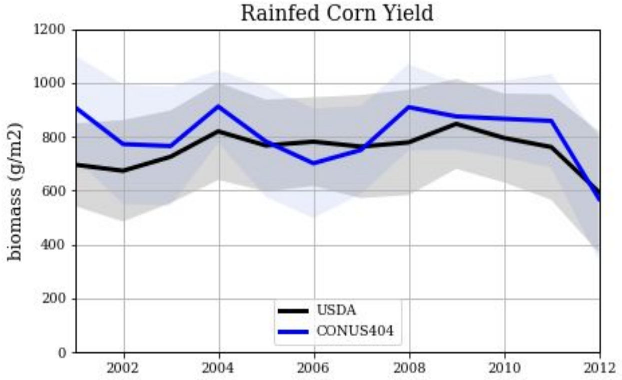



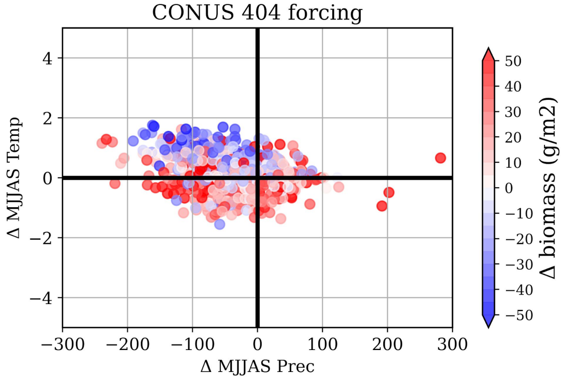




Low crop yield bias is largely associated with warm temp bias and dry prec bias

improve crop yield in both spatial distribution and more stable timeseries

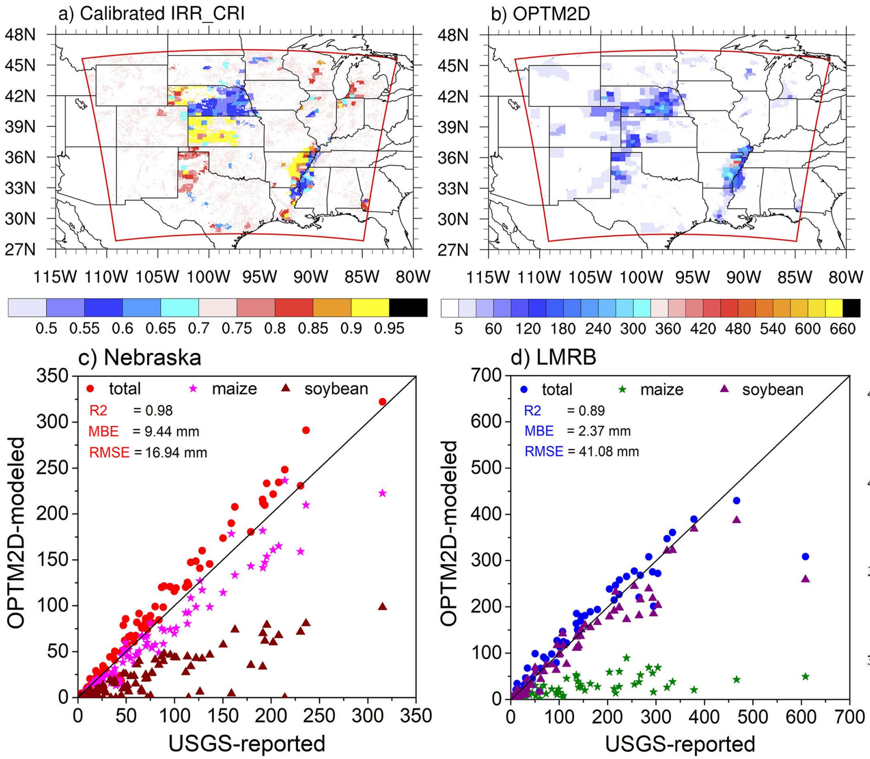


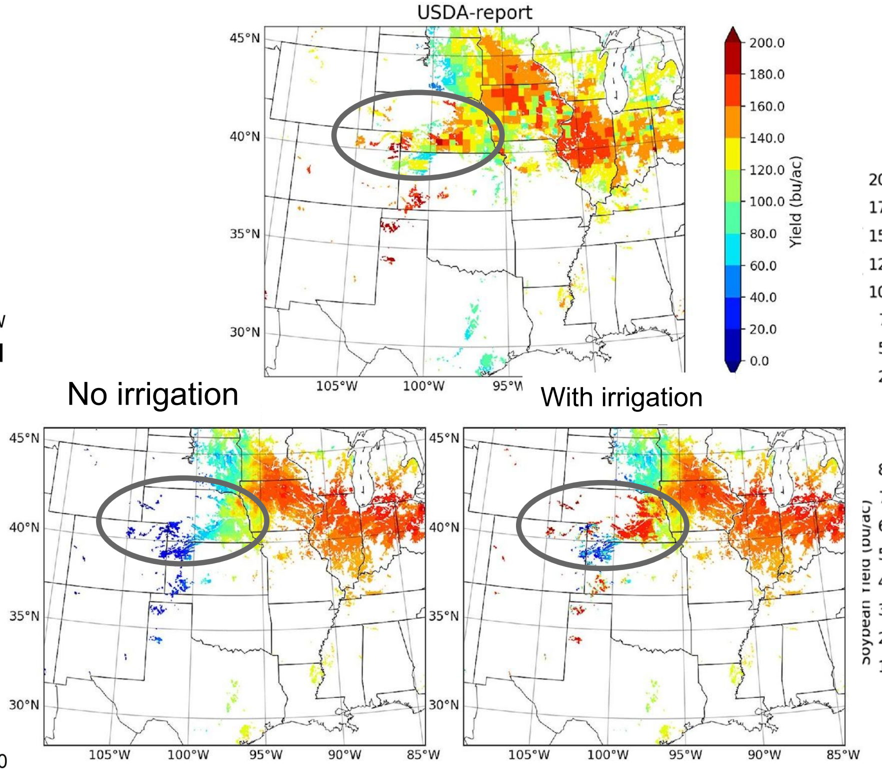



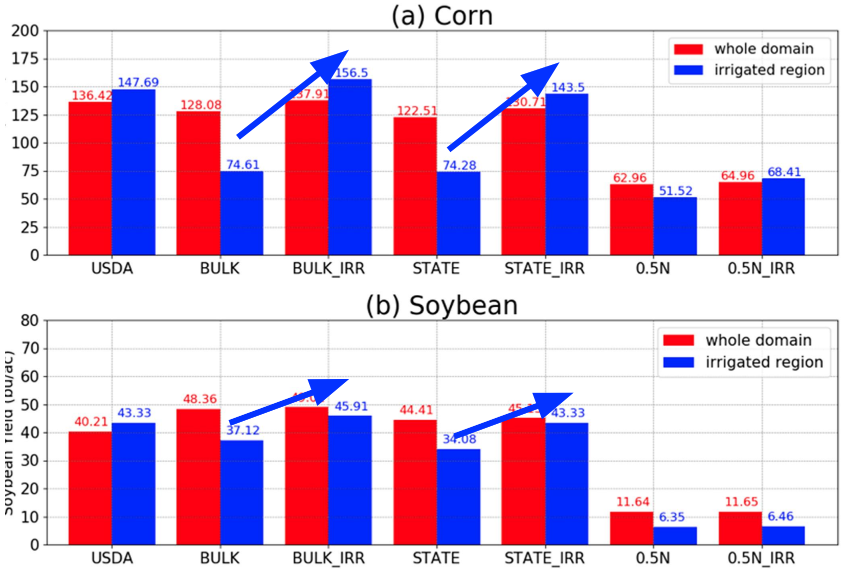



# 2. Joint modeling of crop and irrigation is critical

**After Calibration**




- Calibrated irrigation results show crop-specific irrigation amount, reasonably capturing the cropland distribution and irrigation consumption
- Irrigation can significantly improve crop yields, almost doubling the corn yields and about 1/3 of soybean.
- Joint crop-irrigation modeling is critical for food and water security

# Summary and Next Step

- Developing new crop species requires single-point data in good quality (*winter wheat*)
- Critical to propagate from point to regional scale:

  (1) model forcing

  (2) parameter calibration (*crop & irrigation*)

  (3) spatially dynamic planting/harvest (*temp- & moisture- constrained*)

  (4) regional crop growth data, (LAI, yield, growth stage, etc.)

Applications:

- Assessing climate change impacts on food and water security
- Important for human management and decision-making