Analysis of Crop Phenology Using Time-Series MODIS Data and Climate Data

Jie Ren[1], Dr. James B. Campbell[2], Dr. Yang Shao[2], and Dr. R. Quinn Thomas[3]
[1]Ph.D. Student, Geospatial and Environmental Analysis, IGEP Remote Sensing
[2]Department of Geography
[3]Department of Forest Resources and Environmental Conservation

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Abstract

Understanding crop phenology is fundamental to agricultural production, management, planning and decision-making. In the continental United States, key phenological stages are strongly influenced by meteorological and climatological conditions. This study used remote sensing satellite data and climate data to determine key phenological states of corn and soybean and evaluated estimates of these phenological parameters. A time series of Moderate Resolution Imaging Spectrometer (MODIS) Normalized Difference Vegetation Index (NDVI) 16-day composites from 2001 to 2010 was analyzed with the TIMESAT program to automatically retrieve key phenological stages such as the start of season (emergence), peak (heading) and end of season (maturity). These stages were simulated with 6 hourly temperature data from 1980 to 2010 on the basis of crop model under the Community Land Model (CLM) (version 4.5). With these two methods, planting date, and length of growing season from 2001 to 2010 were determined and compared. There should be a good correlation between estimates derived from satellites and estimates produced with the climate data based on the crop model.

Introduction

Phenology is highly variable and responsive to long-term variation in climate (White et al. 1997). Information on phenological development is a fundamental key to crop monitoring because it has been used in the planning of agricultural practices, the choice of optimum species for given bio-climatic conditions, the selection of optimum seeding dates and the prediction of harvest dates (Justice et al. 1985). The objective of this study is to evaluate the capability of detecting key phenological parameters by remotely sensed data and climate data and examine crop phenologcial variation at a regional level in the Midwestern United States.

Study Area

The Midwestern U.S., defined here by the 12 states shown in Figure 1, were analyzed in this study.

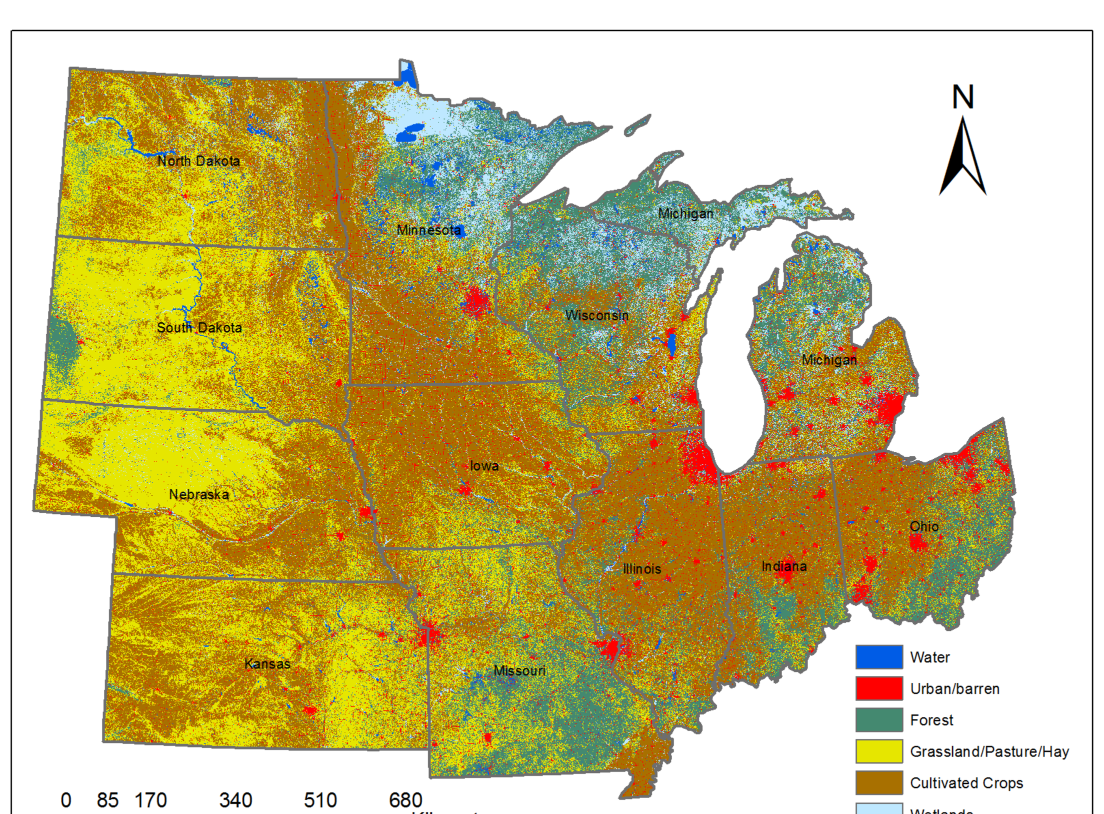
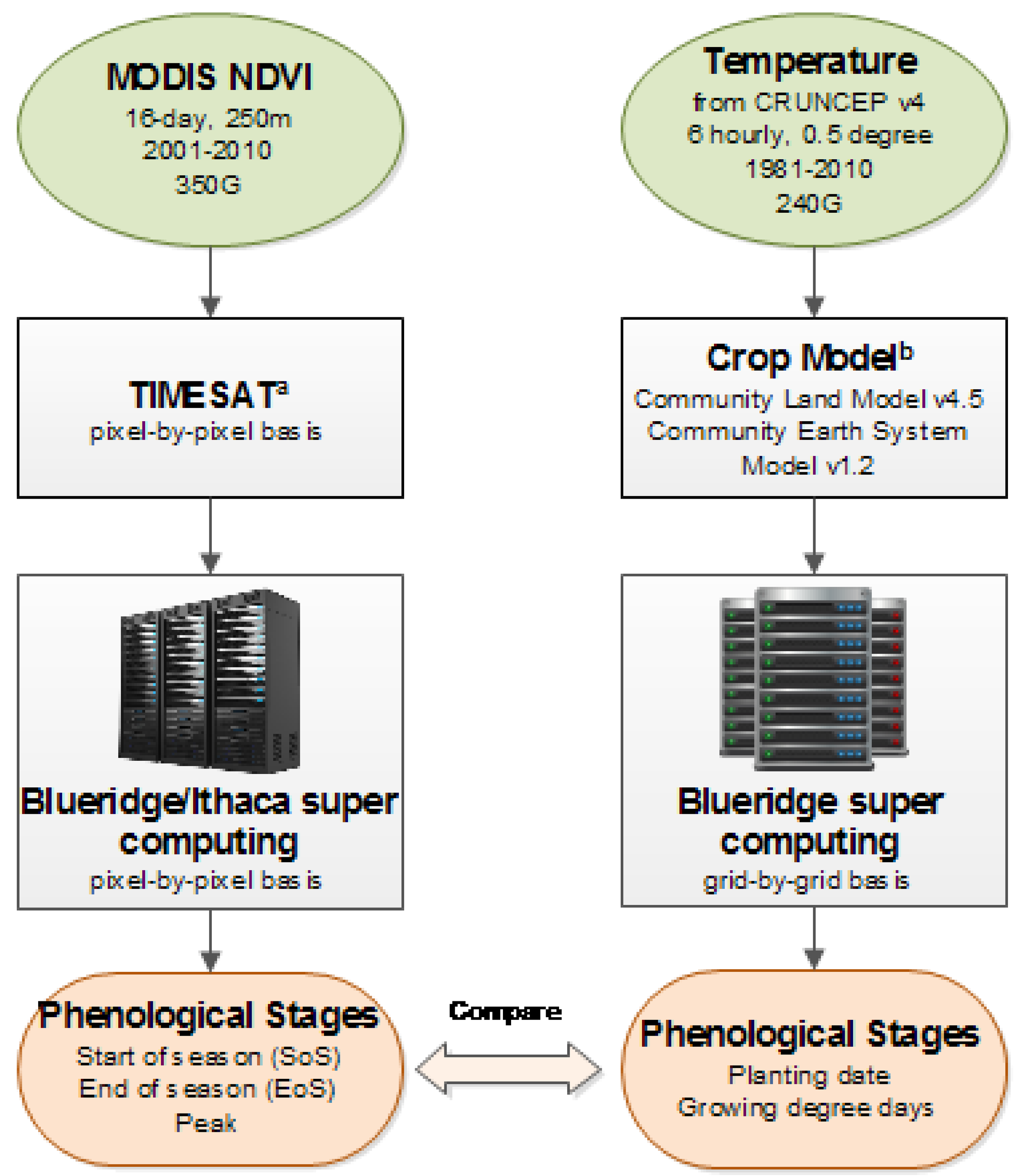


Figure 1. Study area with land use type.

Methods



a

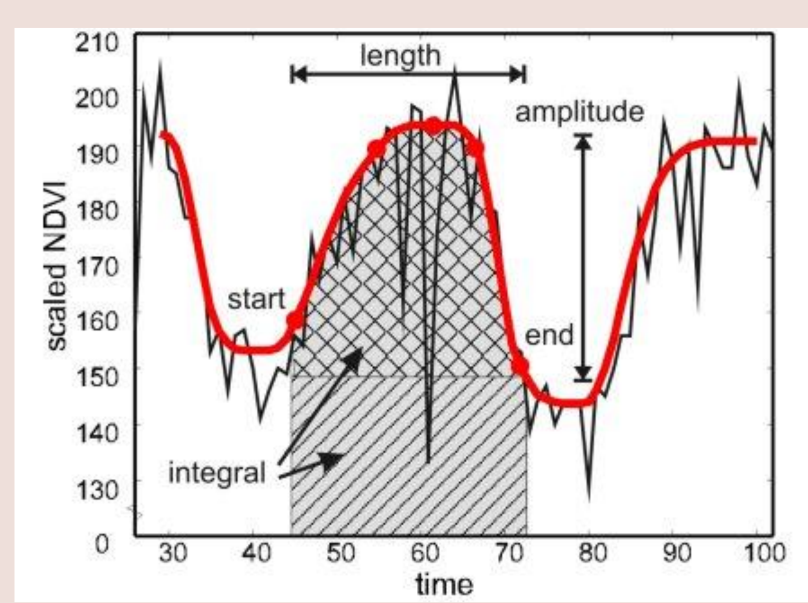


Figure 2. Key phenological parameters (SoS, EoS, length of growing seanson) from TIMESAT.

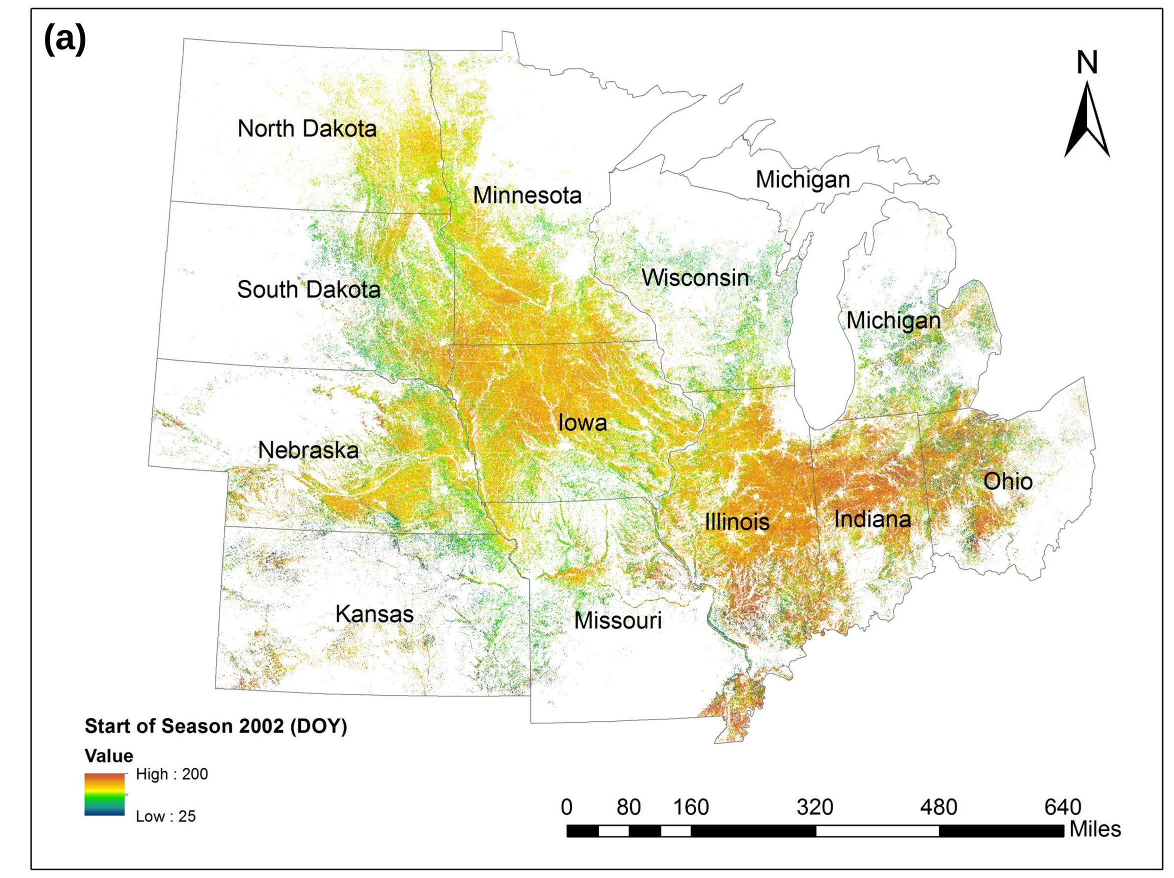
b

$$T_{10d} > T_p$$
$$T_{10d}^{min} > T_p^{min}$$
$$GDD_8 > GDD_{min}$$
$$GDD_8 = GDD_8 + T_{2m} - T_f - 8$$

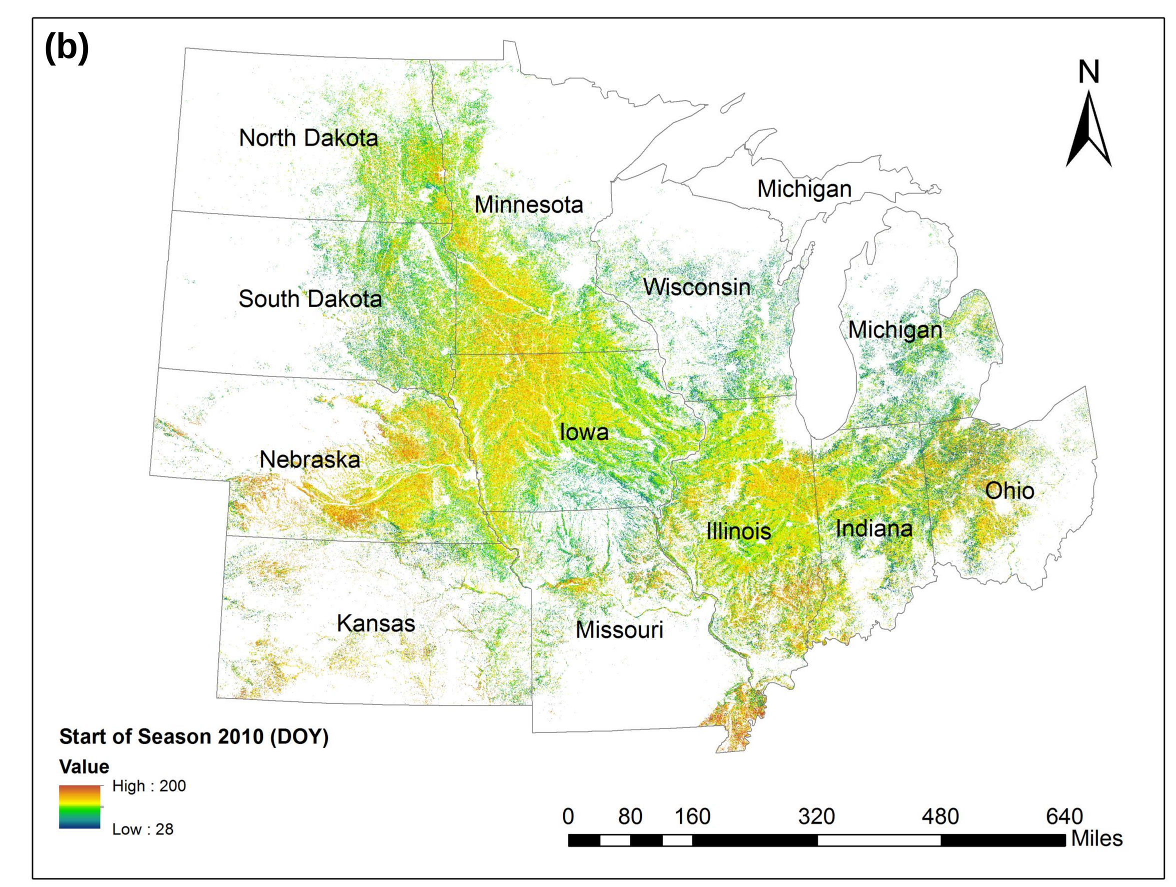
where $T_{10d}$is the 10-day running mean of T_{2m}(the simulated 2-m air temperature at every model time step) and T_{10d}^{min} is the 10-day running mean of T_{2m}^{min} (the daily minimum of T_{2m}). T_p and T_p^{min} are crop-specific coldest planting temperatures (283.15K and 279.15K for corn , and 286.15K and 279.15K for soybean), $GDD_8$is the 20-year running mean growing degree-days tracked from April through September in the northern hemisphere base 8°C with maximum daily increments of 30°days, and GDD_{min} is the minimum growing degree day requirement (50°days for both corn and soybean) (Oleson, et al, 2013).

Results and Discussions

(a)



(b)



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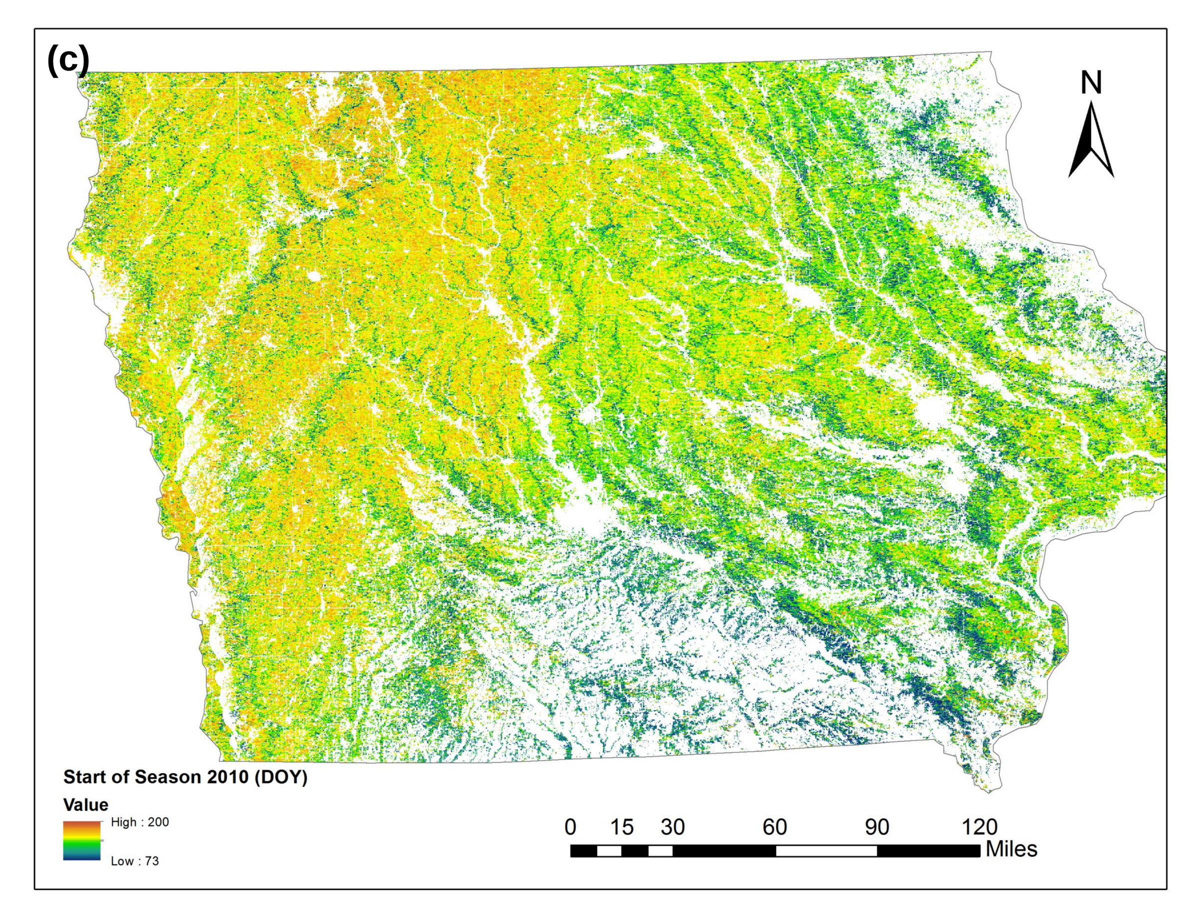
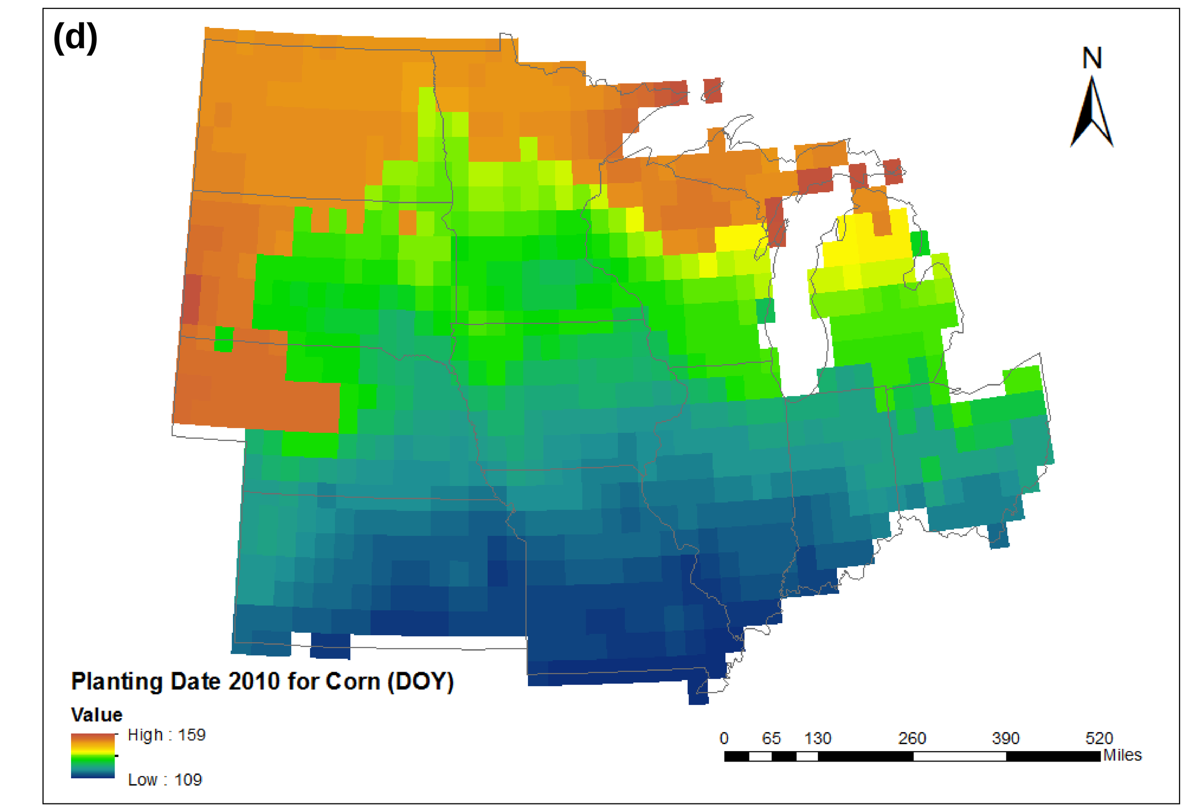


(d)



(e)

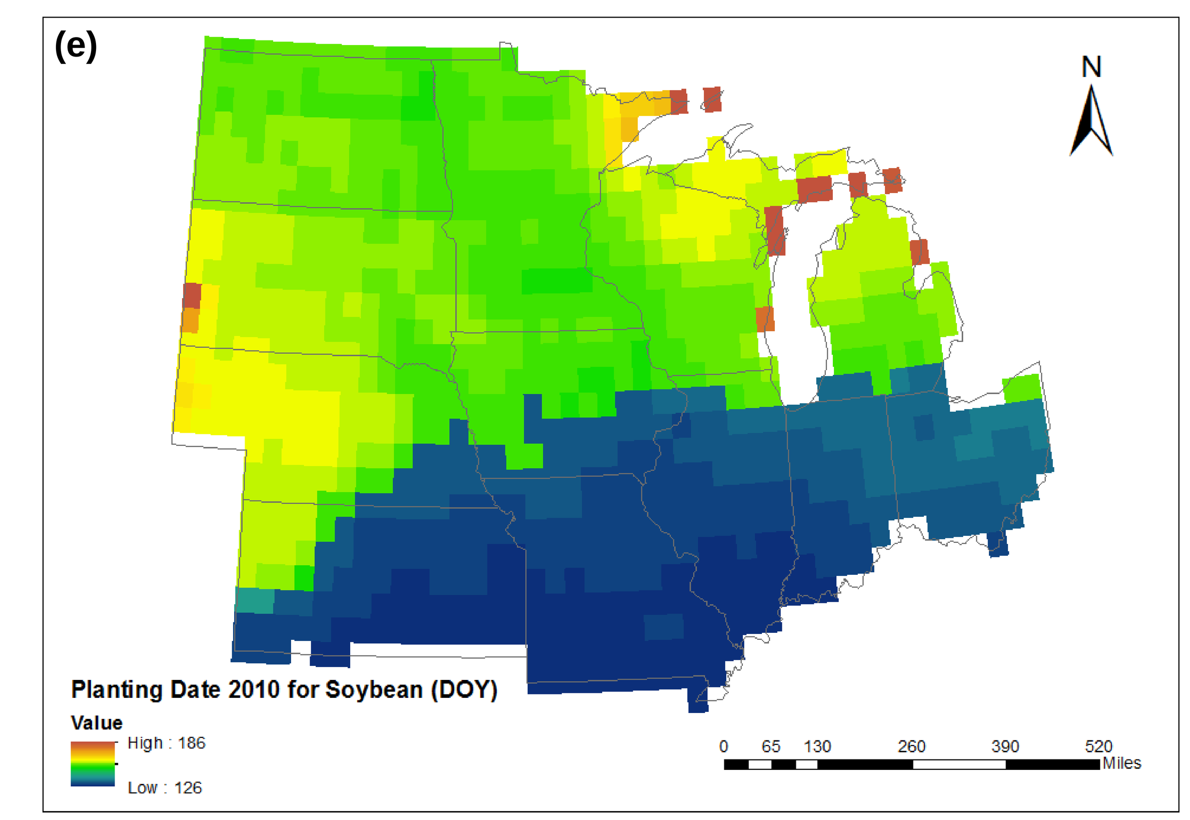


Figure 3. (a) 2002 Start of season (SoS) from MODIS in the study area; (b) 2010 SoS from MODIS in the study area; (c) 2010 SoS from MODIS in Iowa; (d) Potential Planting Date for corn from crop model in the study area; (e) Potential Planting Date for soybean from crop model in the study area.

Start of Season (SoS) shows more variations than Planting Date (Figure 3). The start of the season occurs at the beginning of the crop cycle with some green up when the planting date is the date that crop could grow under proper temperatures. Thus, SoS is later than Planting Date in general. Both SoS and Planting Date are later with higher latitude. Soybeans need warmer temperature to plant.

Conclusion

- Analysis of MODIS NDVI temporal files did well in deriving key phenological stages like SoS, EoS and Peak.
- Analysis based on climate data is not proper for studying crop phenology at regional scale.
- In the future, we will analyze other phenological parameters like length of growing season and compare the predictions.

Selected References

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