



# Estimating Maize Grain Yield From Crop Biophysical Parameters Using Remote Sensing

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November 4, 2013

# Previous studies using vegetation indices with final maize grain yield

- **Remote Sensing**

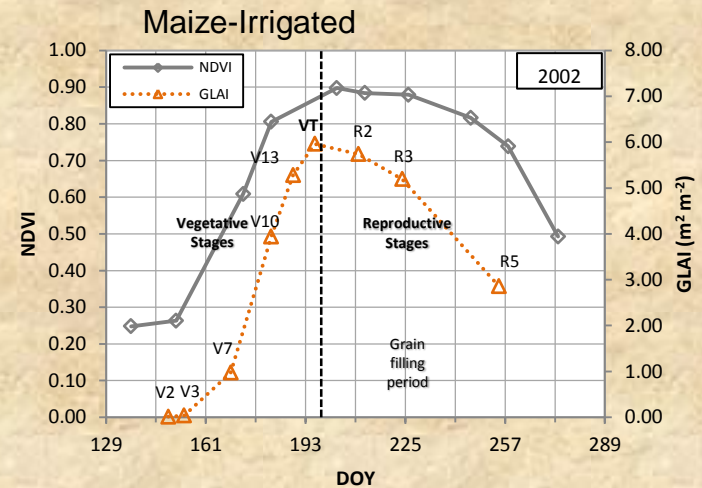
- Integration of vegetation indices over a period during the growing season (e.g. vegetative and/or reproductive stages)
- Relating vegetation index with crop yield at specific growing stages
- Complex Methods
  - Neural Network Models
  - Hidden Markov Model

Author	Growth Stage	Vegetation Index *
Zhang et al., 1998	VT	NDVI
Shanahan et al., 2001	mid-grain filling	GNDVI
Baéz et al., 2005	LAI maximum	NDVI
Elwadie et al., 2005	R5	GSRI,GNDVI
Teal et al., 2006	V8	NDVI
Martin et al., 2007	V7-V9	NDVI
Solari et al., 2008	V8, V10, and/or V12	NDVI <sub>590</sub> (Sensor Index)

# Previous studies using vegetation indices with final maize grain yield

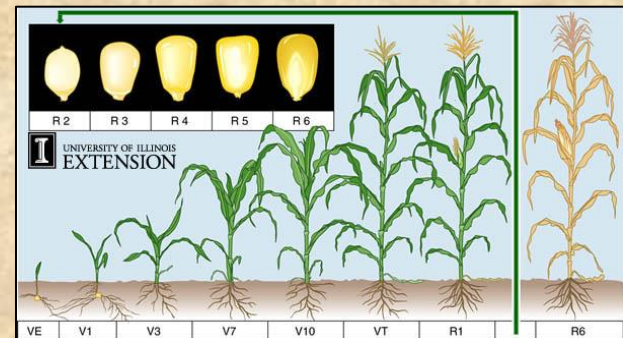
- Rationale

- A good understanding of how crop changes according to the developmental stage or “crop dynamics”.
  - How maize yield is formed?
  - Which crop biophysical parameter(s) is most involved in determining yield?
  - Which crop developmental stage is critical for yield formation?
  - Others
    - Adequate soil moisture
    - Extreme events, such as hail
    - Planting date
- Capabilities and limitations of the remote sensor in terms of spatial, spectral, and temporal resolution.



Data Source:

- NDVI: Moderate Resolution Imaging Spectroradiometer (MODIS) Vegetation Index (MOD13Q1)
- Green Leaf Area Index and Phenology data from the Carbon Sequestration Project at University of Nebraska-Lincoln.



Source: University of Illinois

# Objectives

- The primary goal of this investigation was to develop a robust technique to predict maize grain yield using remote sensing data.
  - Specifically, to identify a key crop biophysical parameter closely related with final yield that can be estimated at an optimum development stage using MODIS data.

# Materials and Methods

- This research used field data from the Carbon Sequestration Project (CSP) at University of Nebraska-Lincoln.
  - Site 1: Irrigated continuous maize (2001-2009)
  - Site 2: Irrigated maize-soybean rotation (2001, 2003, 2005, 2007, and 2009)
  - Site 3: Rainfed maize-soybean rotation (2001, 2003, 2005, 2007, and 2009)
    - Field measurements of green leaf area index (GLAI), above ground biomass (AGB), reproductive biomass (RB), green leaf biomass (GLB), and stem biomass (SB) were related with final yield at different stages under rainfed and irrigated conditions.
- MODIS Products
  - **MODIS Vegetation Index 16 day composite period 250-m (MOD13Q1)**
    - The Normalized Difference Vegetation Index (NDVI) and Enhance Vegetation Index (EVI), and day of pixel composite (DOYCMP).



**RELATING CROP BIOPHYSICAL PARAMETERS WITH MAIZE GRAIN YIELD**

# Results

- Identification of a key crop biophysical parameter and the optimum development stage that can be retrieved using remote sensing and used to estimate yield at regional level

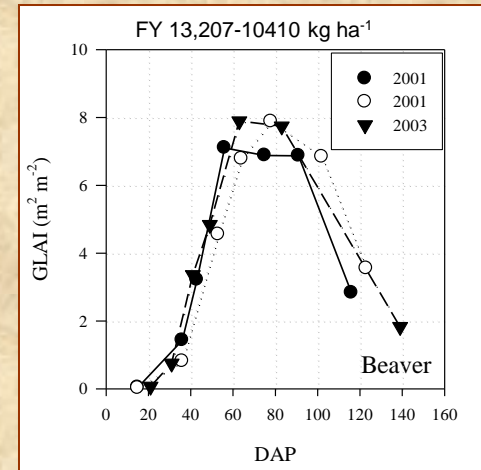
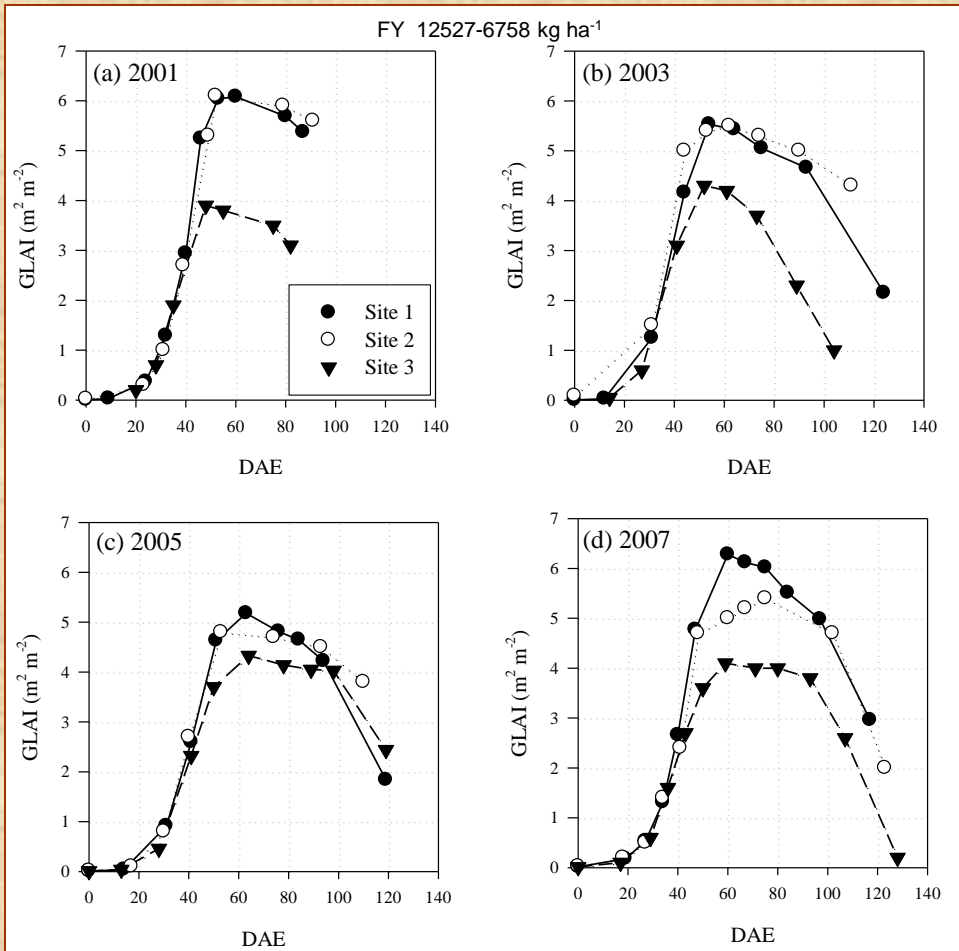
Crop Biophysical Parameter	Correlation coefficient values (R)				
	Development stage				
	V7-V9	V10-V12	VT-R1	<b>R3-R4</b>	R5
<b>GLAI</b>	0.27	0.61	0.84	<b>0.94</b>	0.61
GLB	0.20	0.60	0.76	0.90	0.65
SB	0.12	0.39	0.83	0.86	0.75
TDM	0.17	0.49	0.82	0.92	0.95
RB	-	-	0.16	0.59	0.45

Data Source:

- Crop biophysical parameters and phenology data from the Carbon Sequestration Project at University of Nebraska-Lincoln.
- GLAI =green leaf area; GLAB=green leaf biomass; SB=Stem biomass; TDM= total dry matter; RB= reproductive biomass

# Results

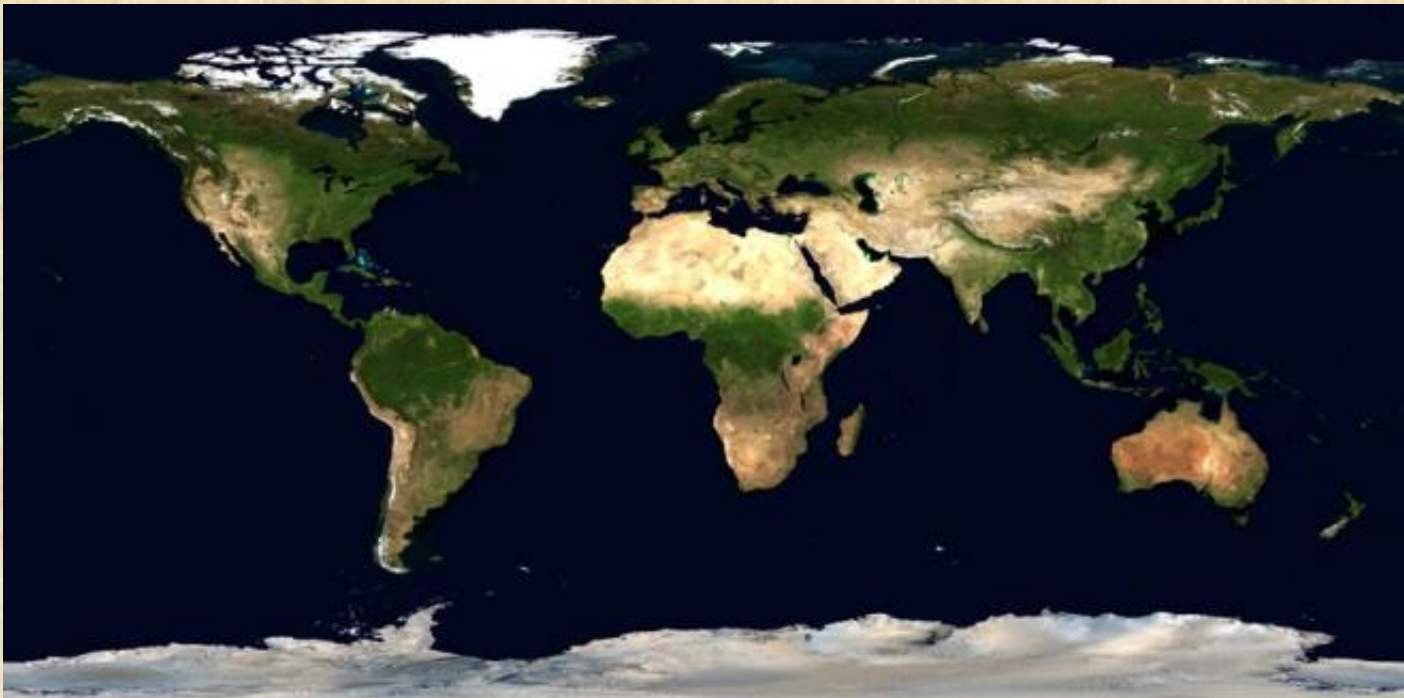
- Field measurements



(Data from Linquist et al., 2005)

GLAI=green leaf area index  
DAE= days after emergence



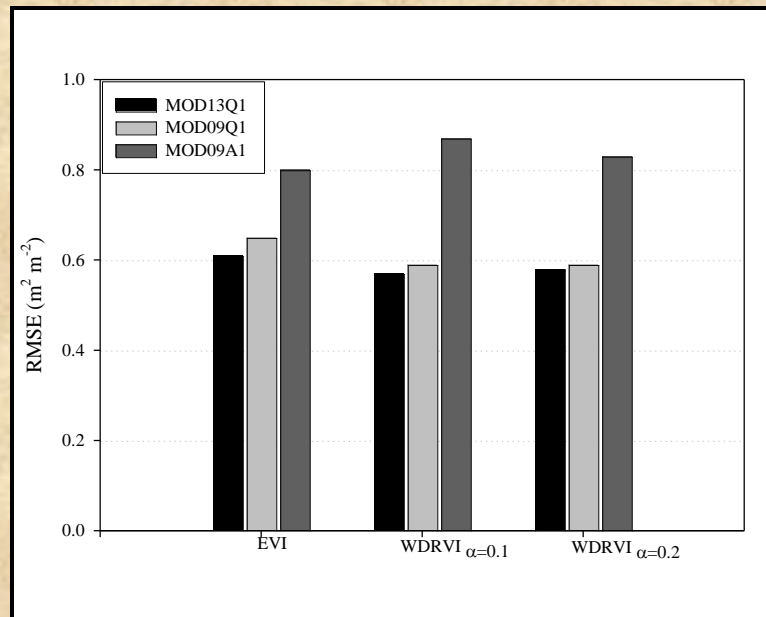


## **AN EVALUATION OF MODIS 8 AND 16 DAY COMPOSITE PRODUCTS**

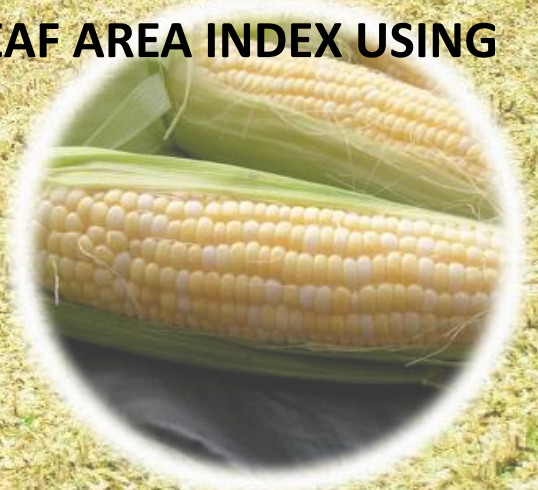
Guindin-Garcia, N., Gitelson, A. A., Arkebauer, T. J., Shanahan, J., & Weiss, A. (2012). An evaluation of MODIS 8- and 16-day composite products for monitoring maize green leaf area index. *Agricultural and Forest Meteorology*, 161, 15-25.

# Results

- A wide variability of temporal resolution obtain from MODIS 8 and 16 composite periods and highlighted the importance of information about day of MODIS product pixel composite for monitoring agricultural crops.
- Due to the high maize GLAI temporal variability, the inclusion of day of pixel composite is necessary to decrease substantial uncertainties in estimating GLAI.
- Results indicated that maize GLAI can be accurately retrieve from 250-m resolution MODIS products (MOD13Q1 and MOD09Q1) with a root mean square error (RMSE) below  $0.60 \text{ m}^2 \text{ m}^{-2}$ .



Root mean square error (RMSE) of green leaf area index estimation by vegetation indices retrieved from MODIS 250-m 16 d (MOD13Q1), 250-m 8 d (MOD09Q1), and 500-m 8 d (MOD09A1) composite period.

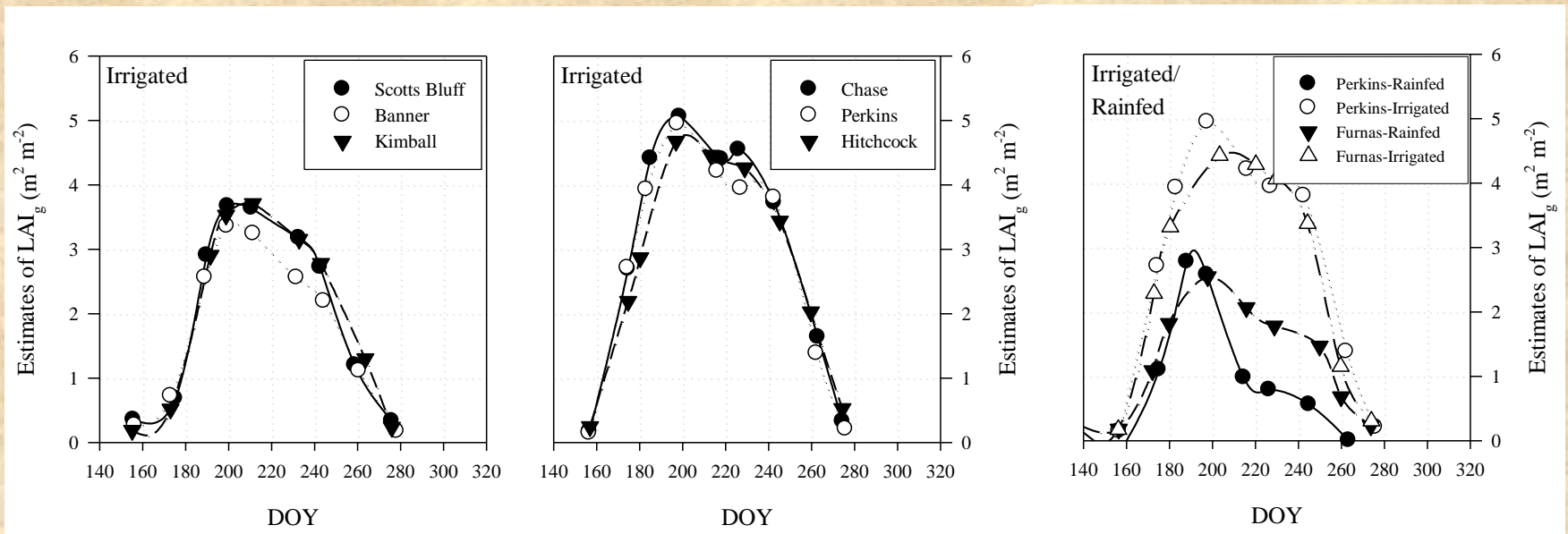


**ESTIMATING MAIZE GRAIN YIELD FROM GREEN LEAF AREA INDEX USING WDRVI AND MODIS DATA**



# Results

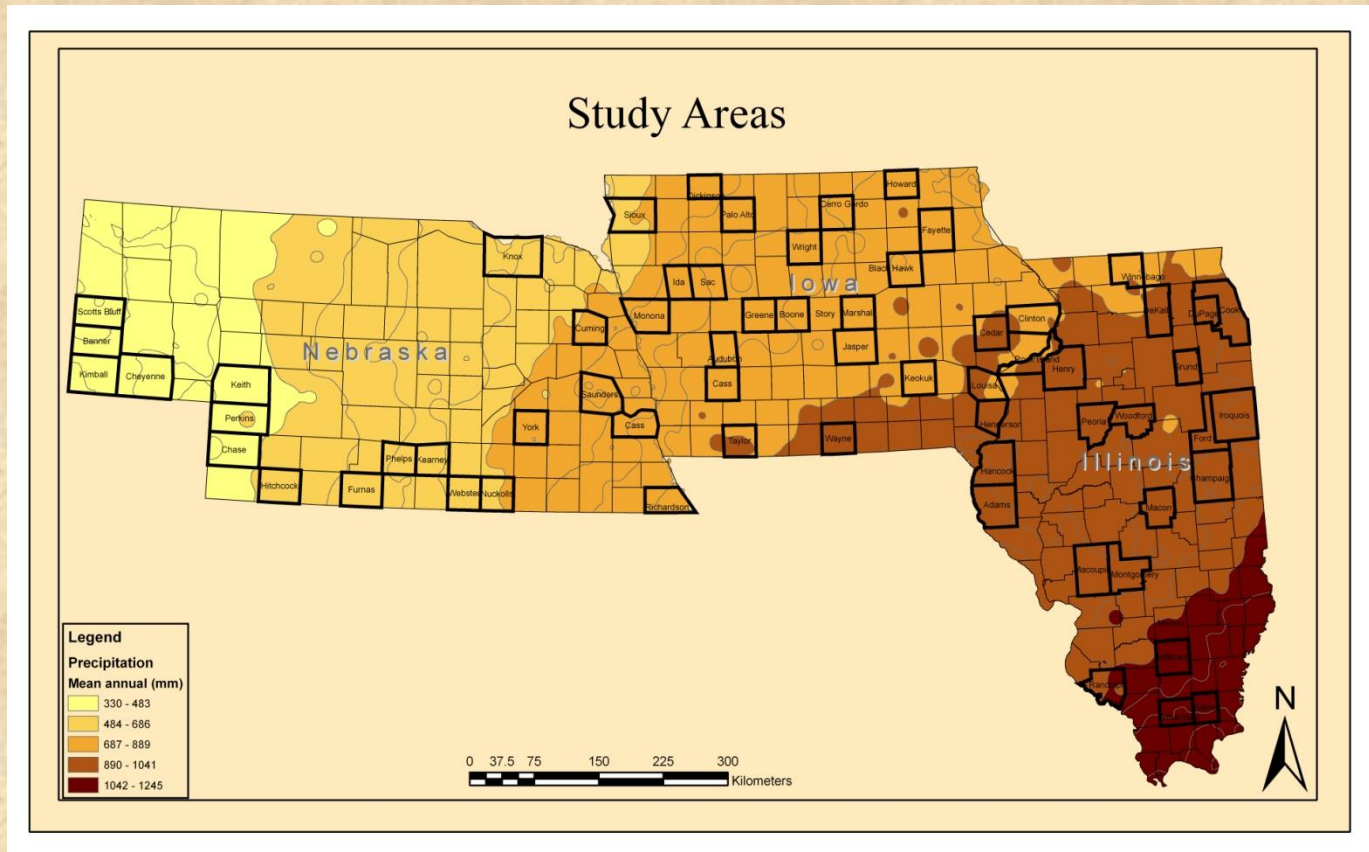
- Estimating maize green leaf area index using WDRVI and MODIS data
  - 2006



$$LAI_g = 3.96 + 5.69 * WDRVI_{\alpha=0.1}$$

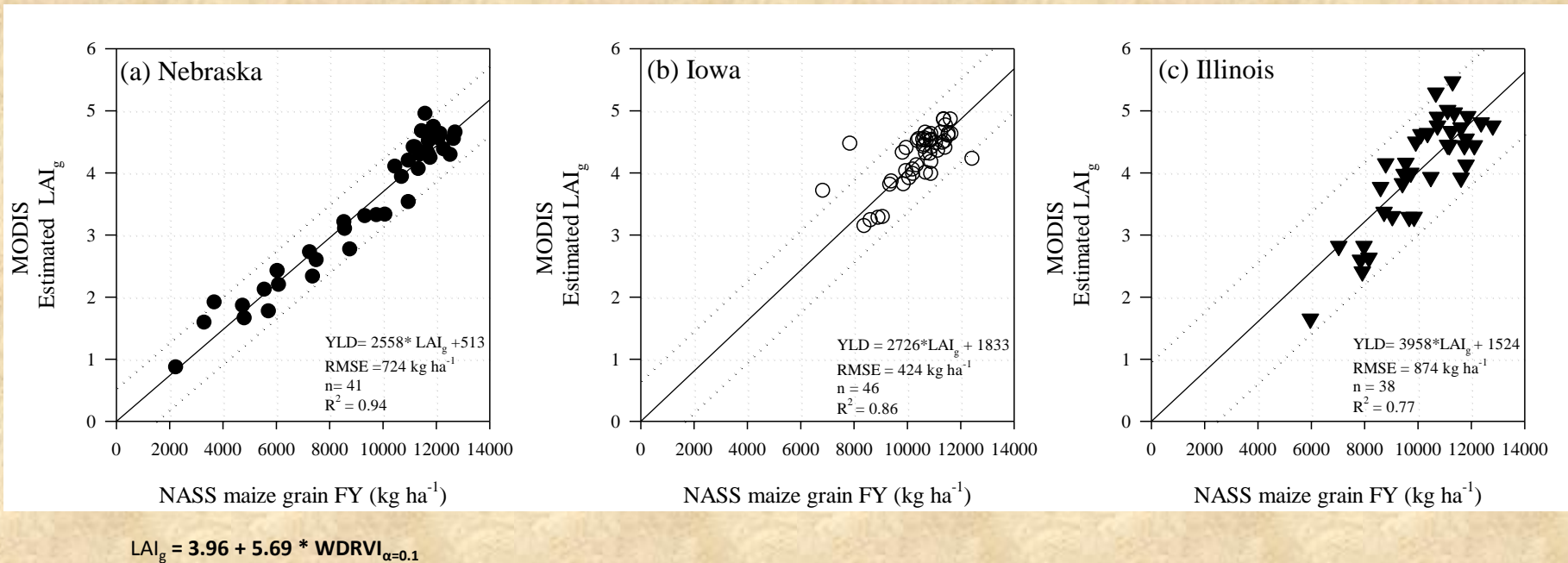
Guindin-Garcia, et al., 2012

# Results

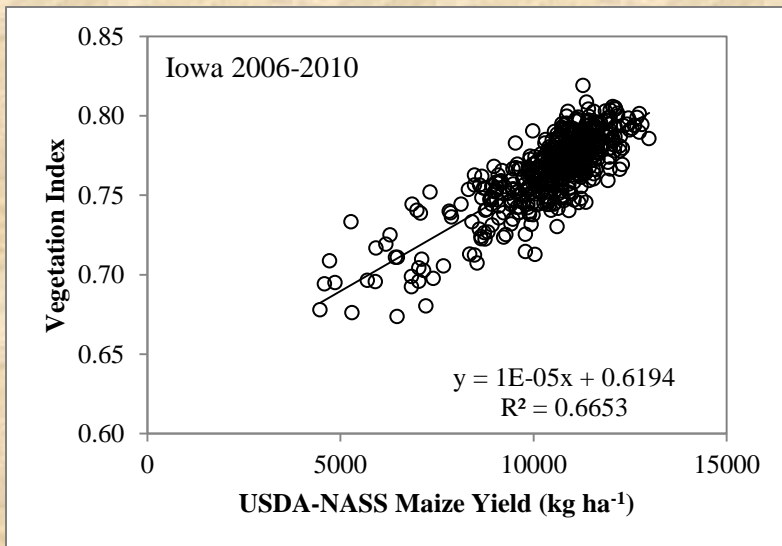
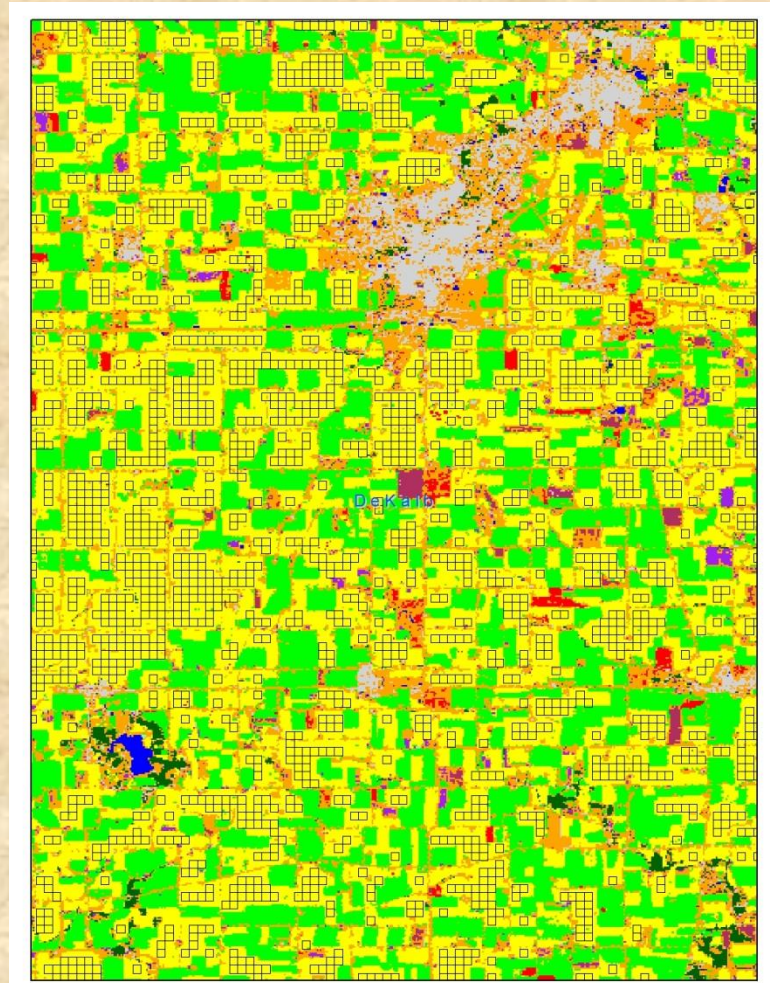
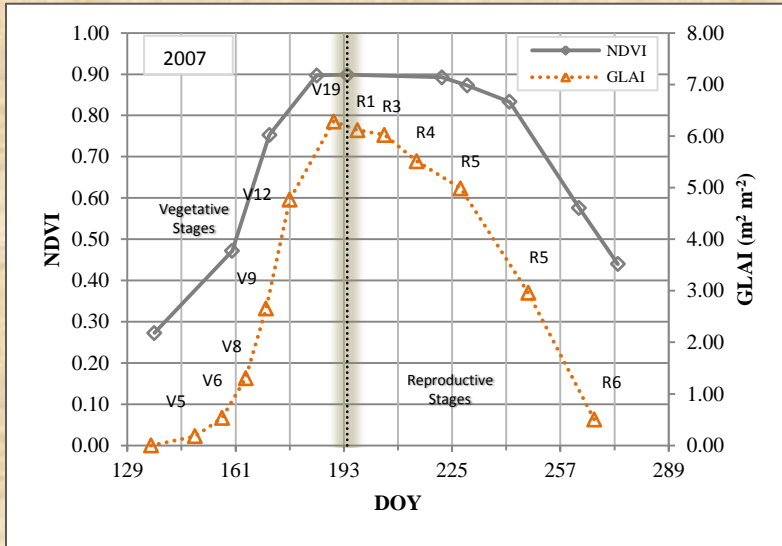


# Results

- Estimating maize grain yield from green leaf area index using WDRVI and MODIS data
  - Estimates of GLAI during the mid grain filling period using WDRVI linear model (2006-2007)



# Results

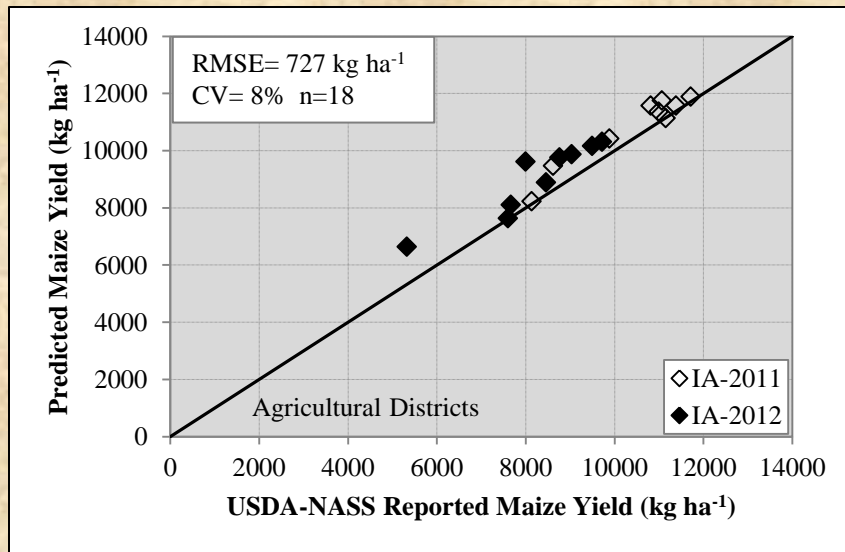




# Results

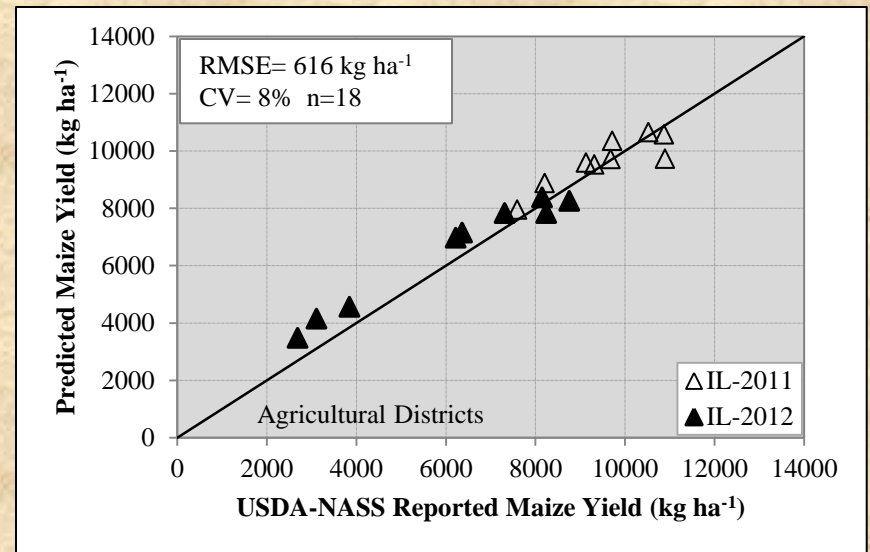
- Validation 2011-12

### Iowa Model



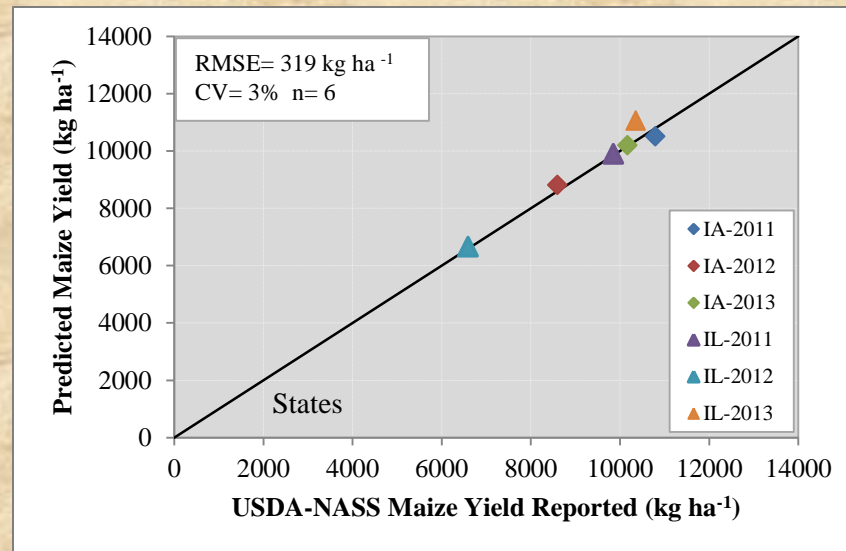
$$YLD = 47369 * VI - 25846$$

### Illinois Model



$$YLD = 43125 * VI - 23110$$

# Results



$$YLD = 43691 * VI - 23285$$

# Summary and Conclusions

- The feasibility of using remote sensing data from MODIS products to measure crop biophysical parameters such as maize GLAI requires
  - a good understanding of techniques used to assemble the satellite data in terms of temporal resolution.
  - an understanding of how crops change according to developmental stage or crop dynamics.
- Estimating maize grain yield
  - Estimates of GLAI obtained during the mid grain filling period showed a strong correlation with maize grain FY reported by USDA-NASS over selected counties in Nebraska, Iowa, and Illinois.
  - The approach presented in this study provides a robust technique to early FY estimation based on a key crop biophysical parameter estimated at the optimum development stage closely related with maize FY.
  - The technique to relate GLAI with maize grain FY can be improved by developing critical values of GLAI during the mid grain filling period for specific regions that can be used to detect the possibility of high or low yields.