INTEGRATING REMOTE SENSING CAPABILITIES INTO THE DOMESTIC CROP PRODUCTION AND YIELD FORECASTING MANDATES OF USDA

Operational Prediction of Crop Yields using MODIS Data and Products

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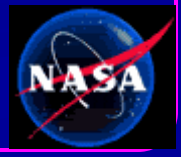


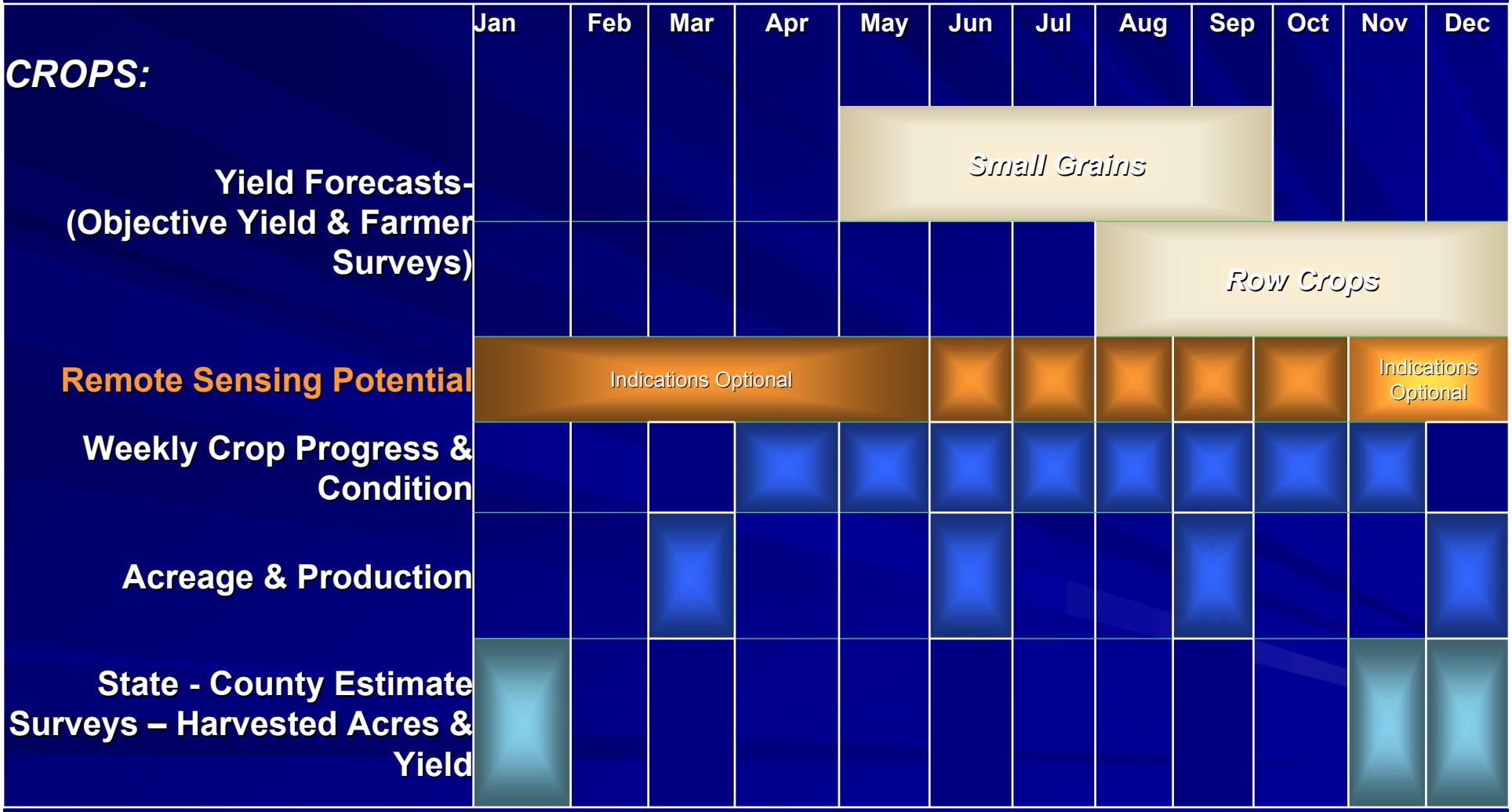
Objectives

- ✓ Develop an algorithm for operational classifications of corn and soybean fields in the U.S. Corn Belt.
- ✓ Develop 1) hydrological (only); 2) hydrological with remote sensing parameters; and 3) a simplified process model and algorithms for large areas to supplement NASS farm & field data collections for operational assessment of crop condition and yields at county level.
- ✓ Provide timely and accurate information for potential use in NASS's operational program.

NASS Operational Needs

- Timeliness
  - Must meet NASS report deadlines
  - Processing capabilities must match crop phenology
- Accuracy
  - What is the Truth?
  - 10% rule
  - Trends/History
- Reliability
  - Satellite/sensor, or climatic disturbances must not delay delivery of estimates
  - Contingency plans essential - must have alternative, nonsurvey-based indicators available
- Consistency
  - Transition to new sensors
  - Standard methodology across States, crops
  - Standard processing platform

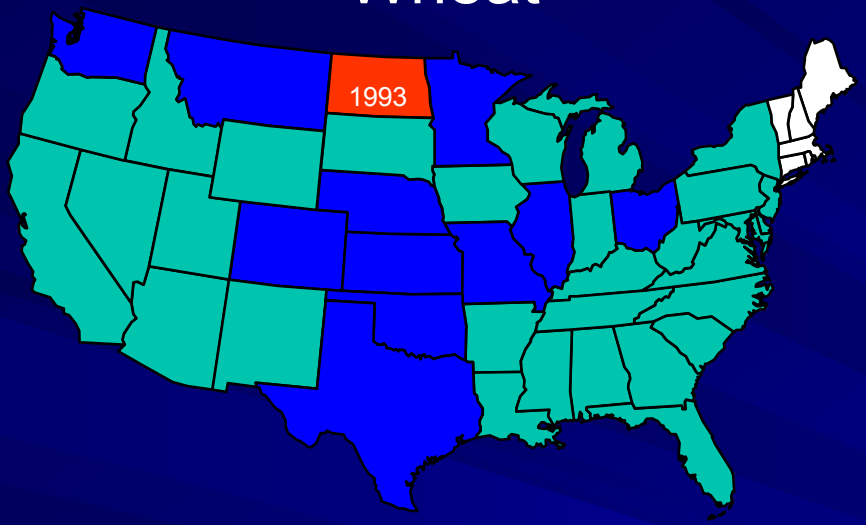
Estimating Programs for Major Data Series
National & State



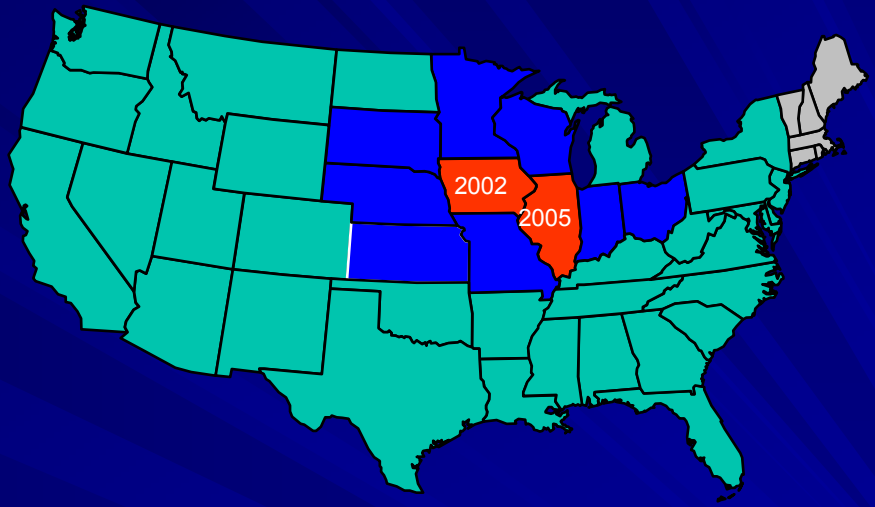
NASS Crop Production reports based on 1st of month, published by the12th.

Estimating States

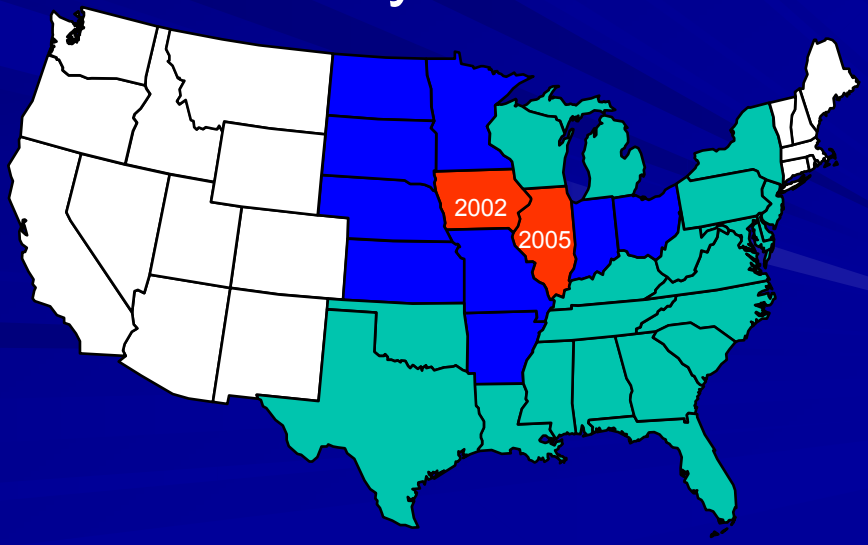
Wheat



Corn

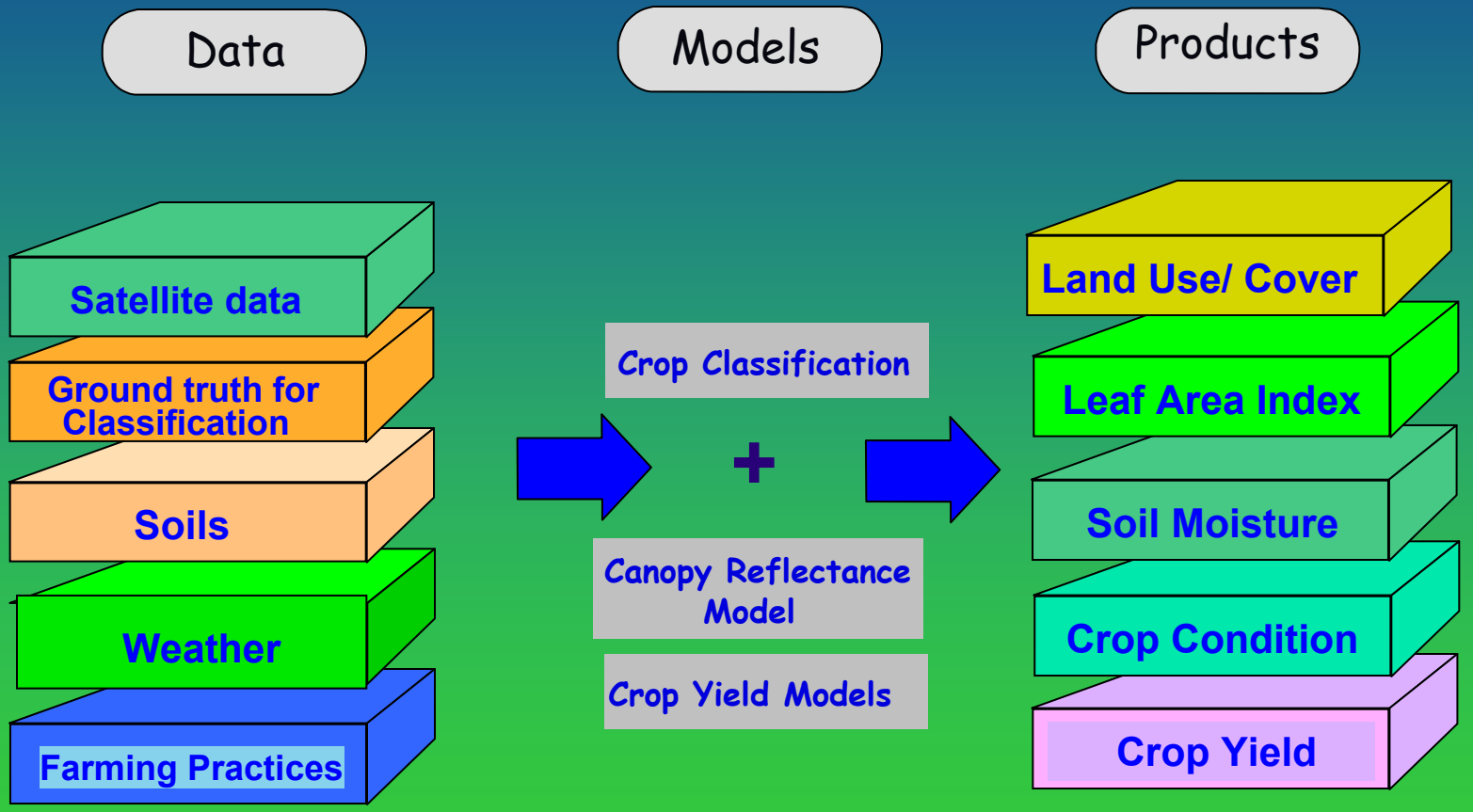


Soybeans



- Speculative State
- Non-speculative State
- Corn Silage State
- Non-estimating State
- Yield Model Research

Data Integration to Monitor and Assess Agricultural Crop Production



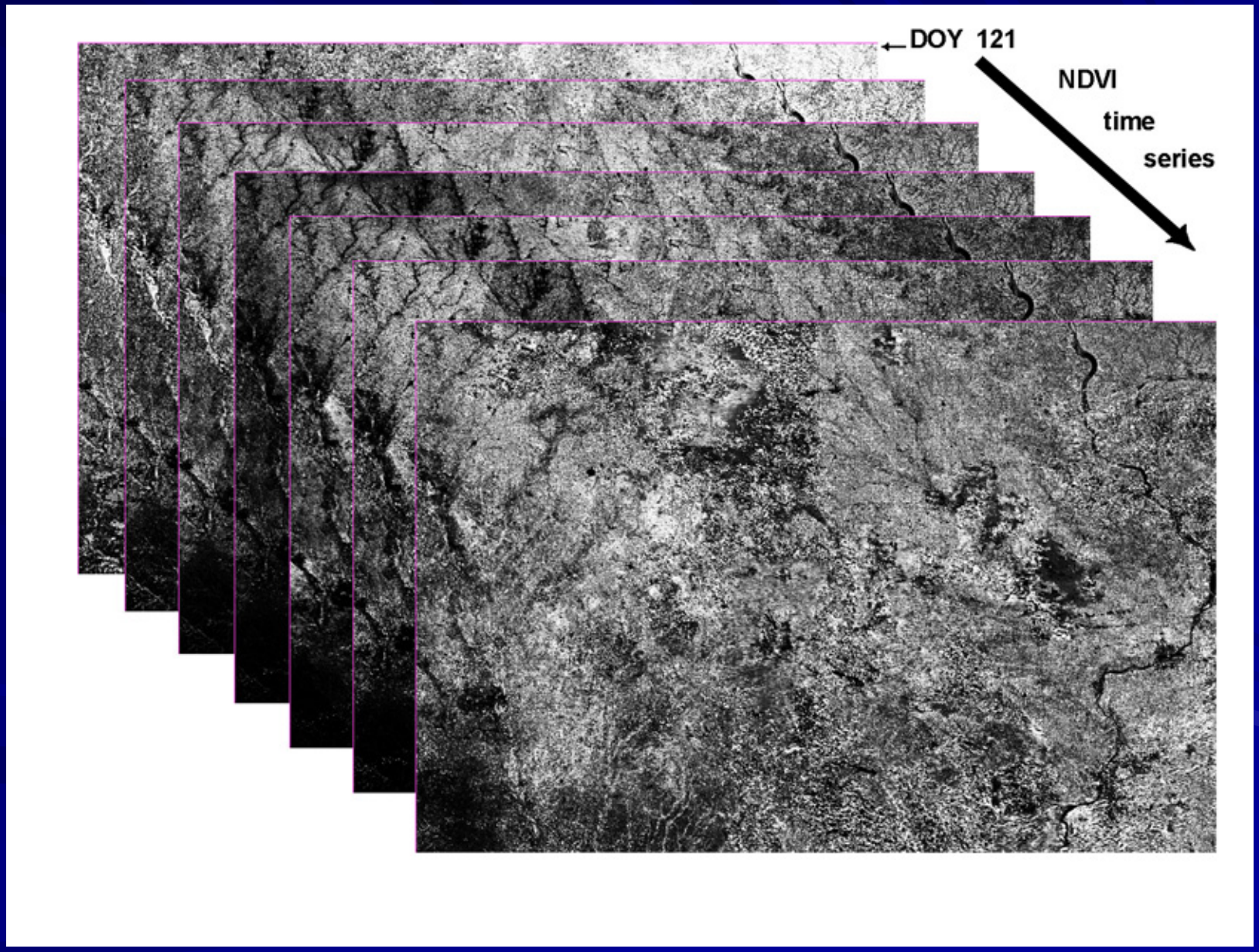
Terra - MODIS (Moderate Resolution Imaging Spectroradiometer) Satellite Band Characteristics - NASA

Coverage:	2330 km, (cross to flight direction)
Spectral range:	405nm-14,385nm (36 channels)
Space resolution:	250 m (channels 1-2), 500 m (channels 3-7), 1000 m (channels 8-36)
Periodicity:	Two flights a day - 16 days of trajectory repetition

Primary MODIS bands and products currently used in these studies:

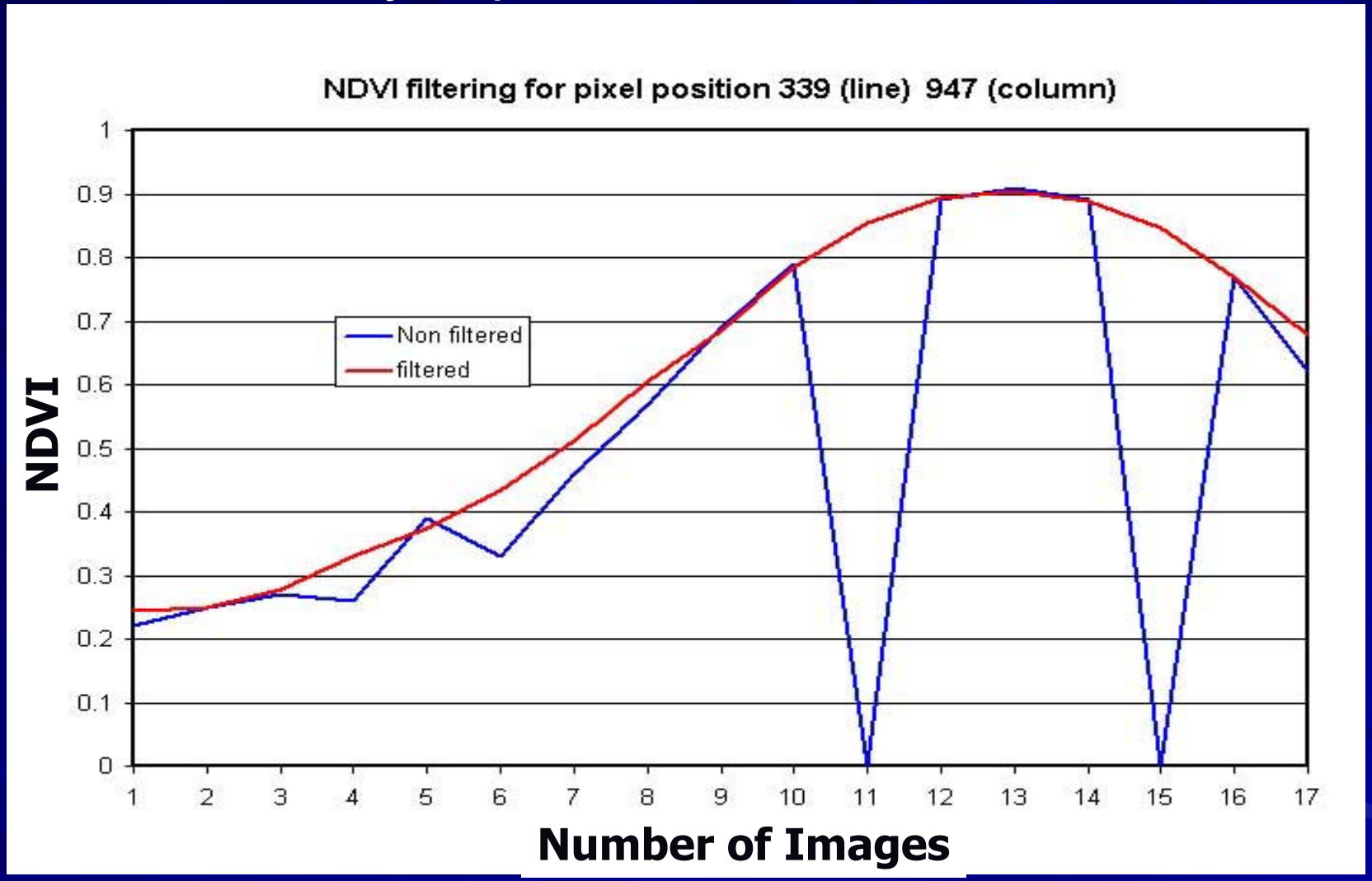
Surface Reflectance	**Land/Vegetation**
250 m Resolution	**Landcover Product at 1 km resolution**
1- 620 - 670 nm	**Leaf Area Index Product at 1 km resolution**
2- 841 - 876 nm	**8-day composite Surface Reflectance with atmospheric correction at 250m resolution**

NDVI Time Series from the MODIS-Terra 8-day Composite Product



Data Filtering

8-day Composite Data at 250 m Resolution



The Savitzky-Golay Filter is used to account for negatively biased noise. The result produces a smoothed curve adapted to the upper NDVI value in a time series.

Per Jonsson and Lars Eklundh, 2004. TIMESAT – A program for analyzing time-series of satellite sensor data. Computers and Geosciences 30, 833-845.

Crop Classification - MODIS 8-day composite images

Method: A Decision Tree Algorithm

- Operational evaluation conducted for 4 crop seasons (2002-2005)
- Accuracy compared with the USDA/NASS Landsat classification

Results: For Iowa 2005 crop season

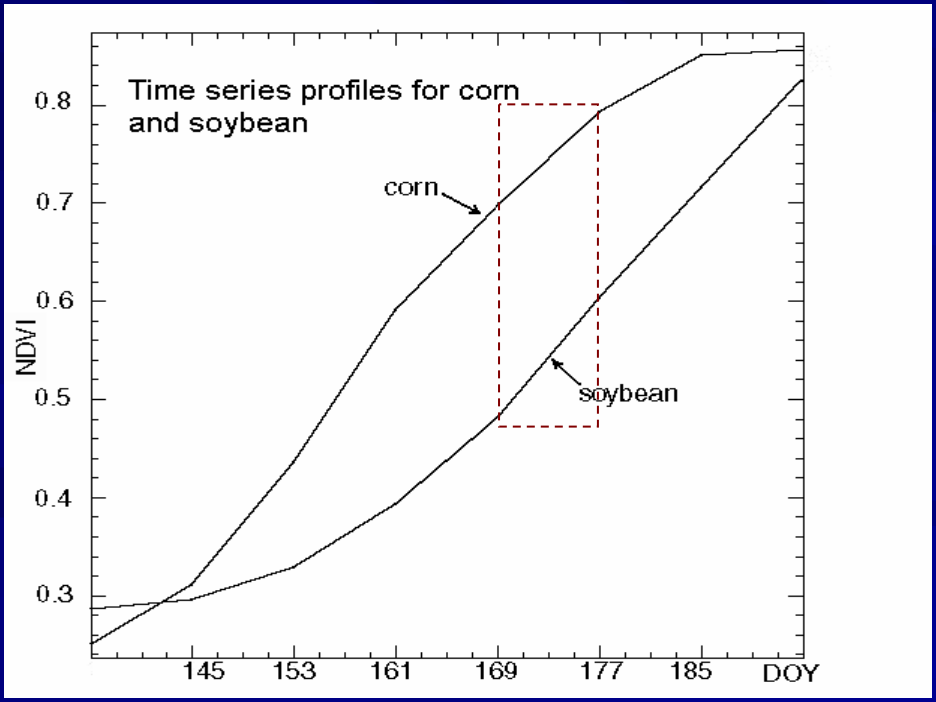
- Overall accuracy for Corn Crop Classification was 82.7% and kappa coefficient of 0.65.
- Soybean Classification accuracy was 84.7% , kappa coefficient of 0.69.

Separation of Corn and Soybean Crops

- The first step is distinguishing the "crop pixels" from others.
  - Condition used is that NDVI value in day of year (DOY) 129 must be less than 0.40 and in DOY 209 must be higher than 0.78.

- The second step of the classification is separation of corn and soybean pixels.

  - Profile fit to a third degree polynomial



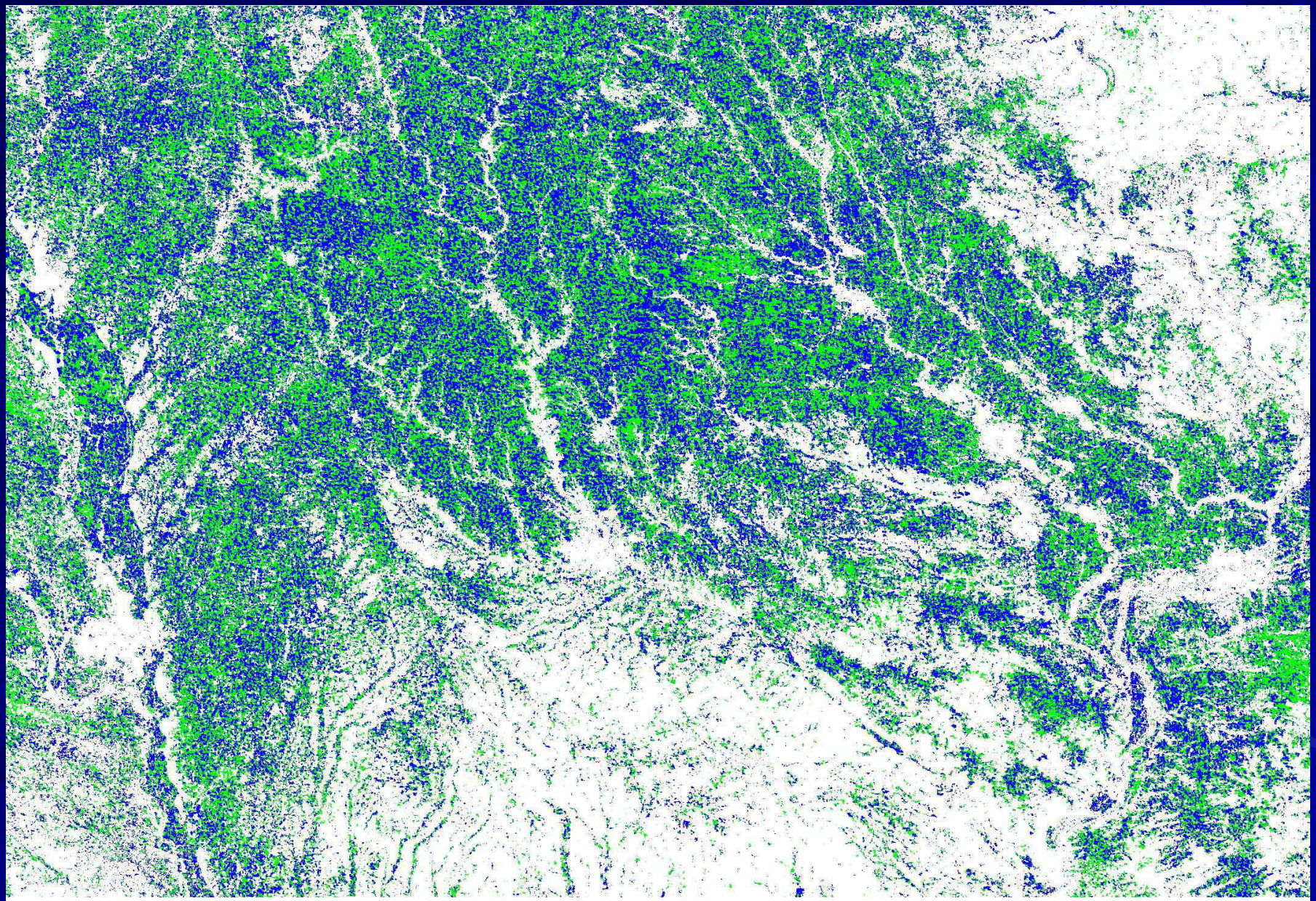
- The mean value of the second derivatives of the polynomial between DOY 169 and 177 are used.

- Green up rate for corn pixels on that DOY begins to decrease and NDVI profile is **convex.**

- For soybean pixels, green up rate is increasing and NDVI profile is **concave**

DOY 169 - 177 = June 18 - 26

Classification of Corn and Soybean Crops - Iowa, 2005



Operational Algorithm

MODIS –VIR/NIR 8-Day Composite 250 m

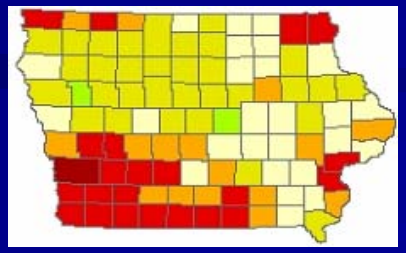
MODIS-Thermal 8-Day Composite I Km

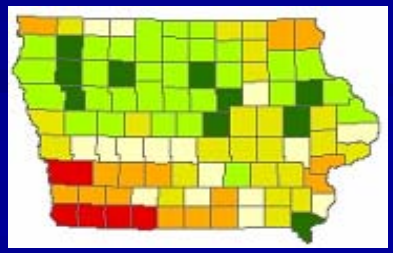
MODIS –VIS-NIR Corn and Soybean Classification Mask

Data Masked And County Averaged

County Yield Algorithm
Yield = f (NDVI, Ts)

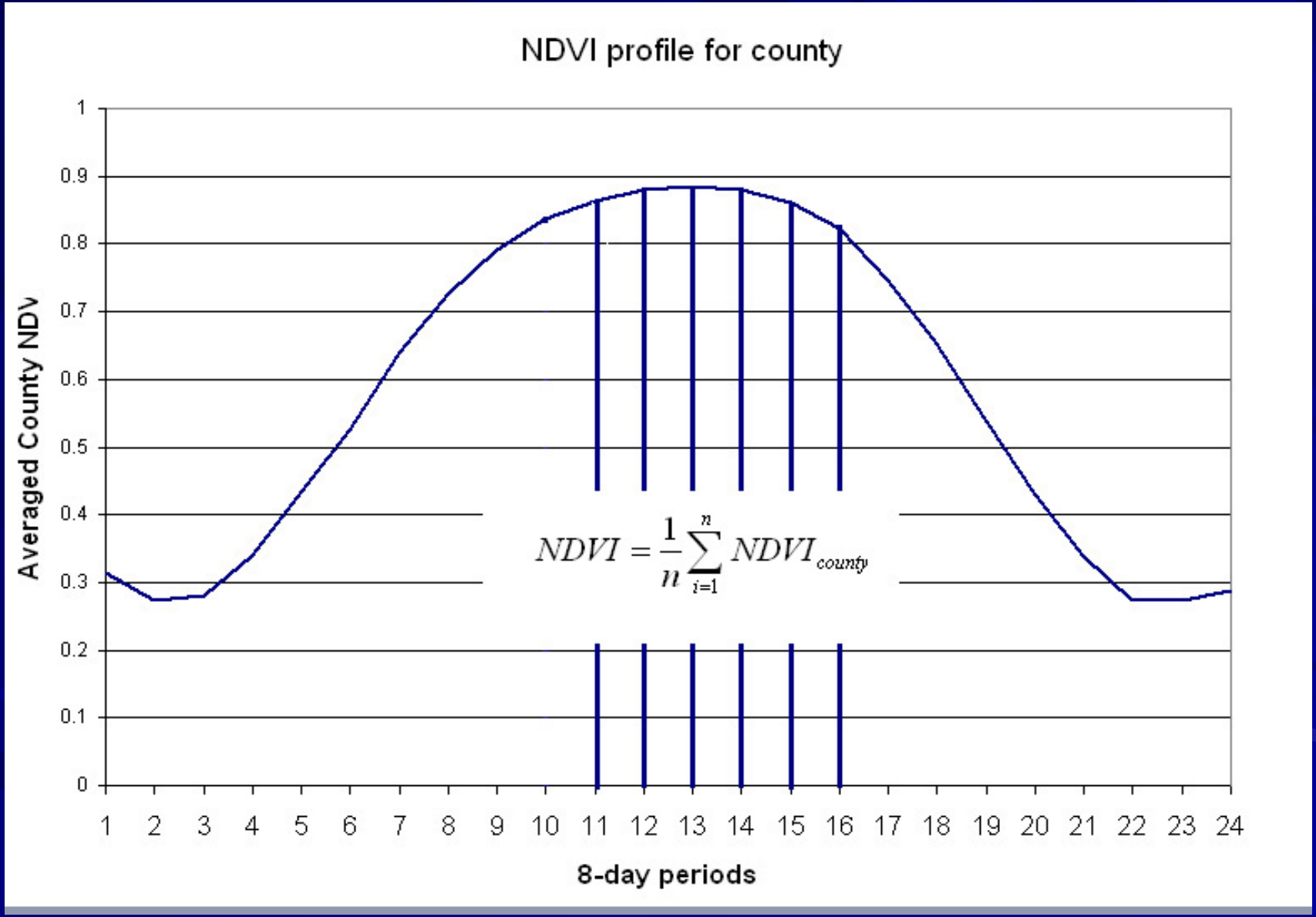
Yield Index

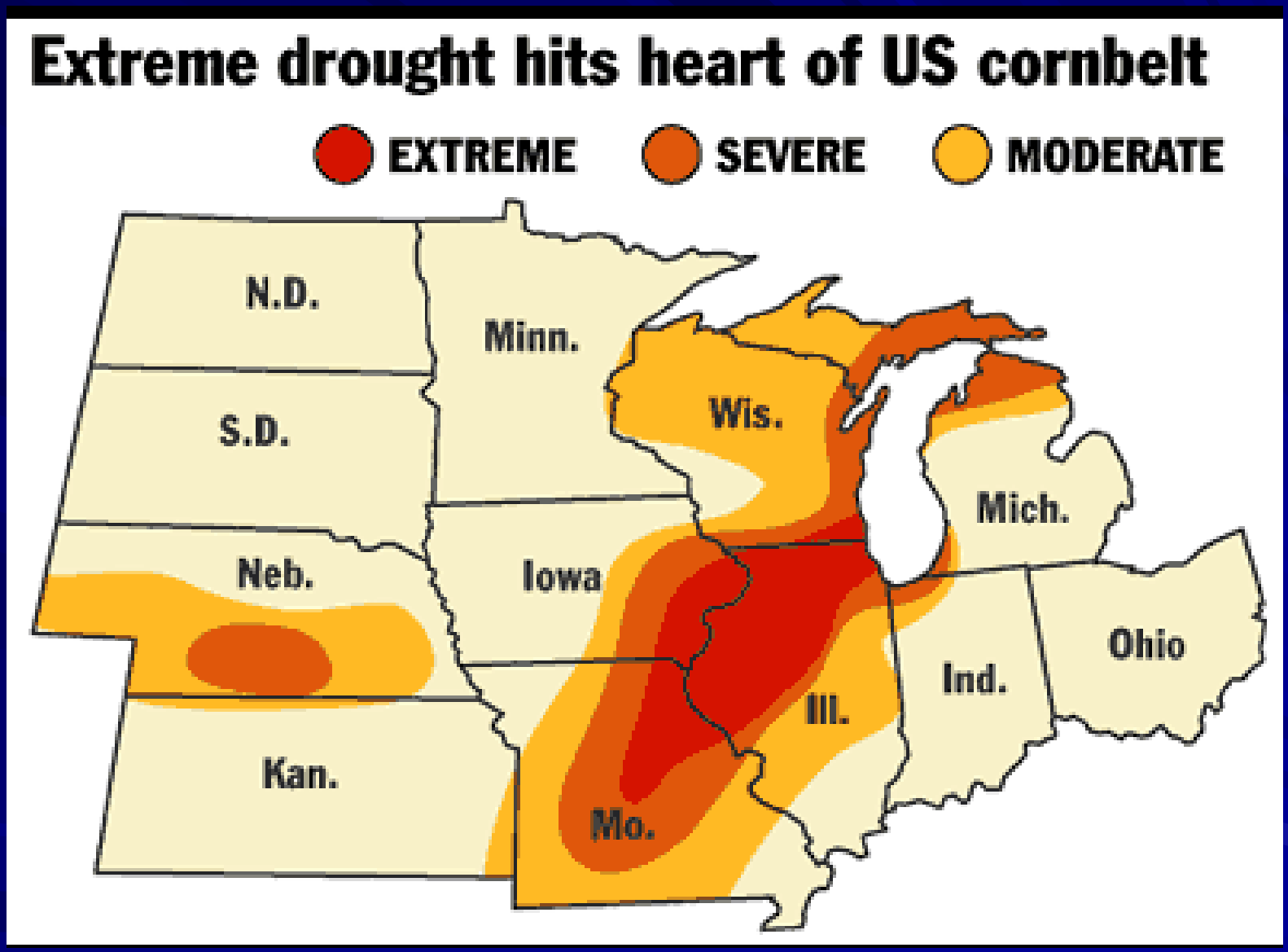




Corn ***Soybean***

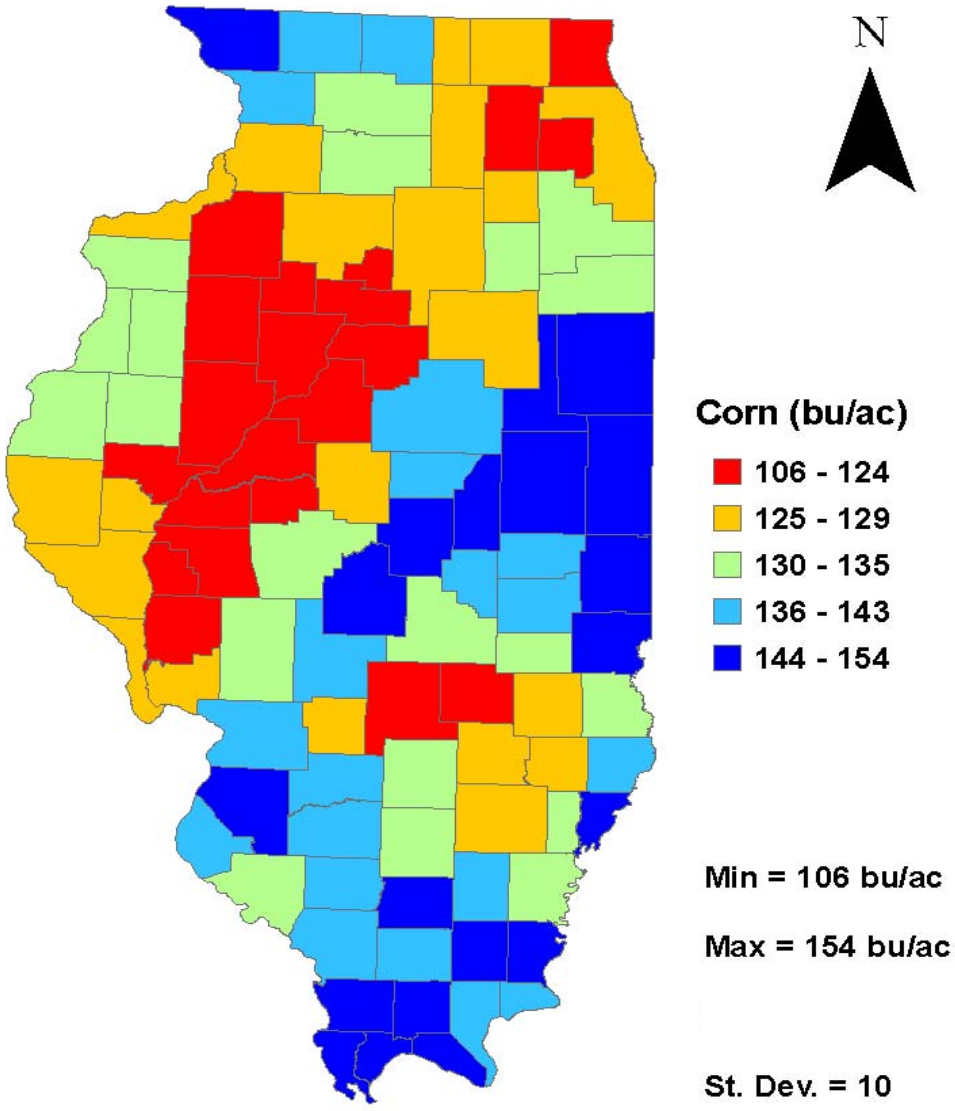
Crop Yield Assessment using MODIS NDVI and Thermal Parameters





SOURCE: NATIONAL DROUGHT MITIGATION CENTER, DATA AS OF AUG. 9, 2005; SCOTT WALLACE - STAFF

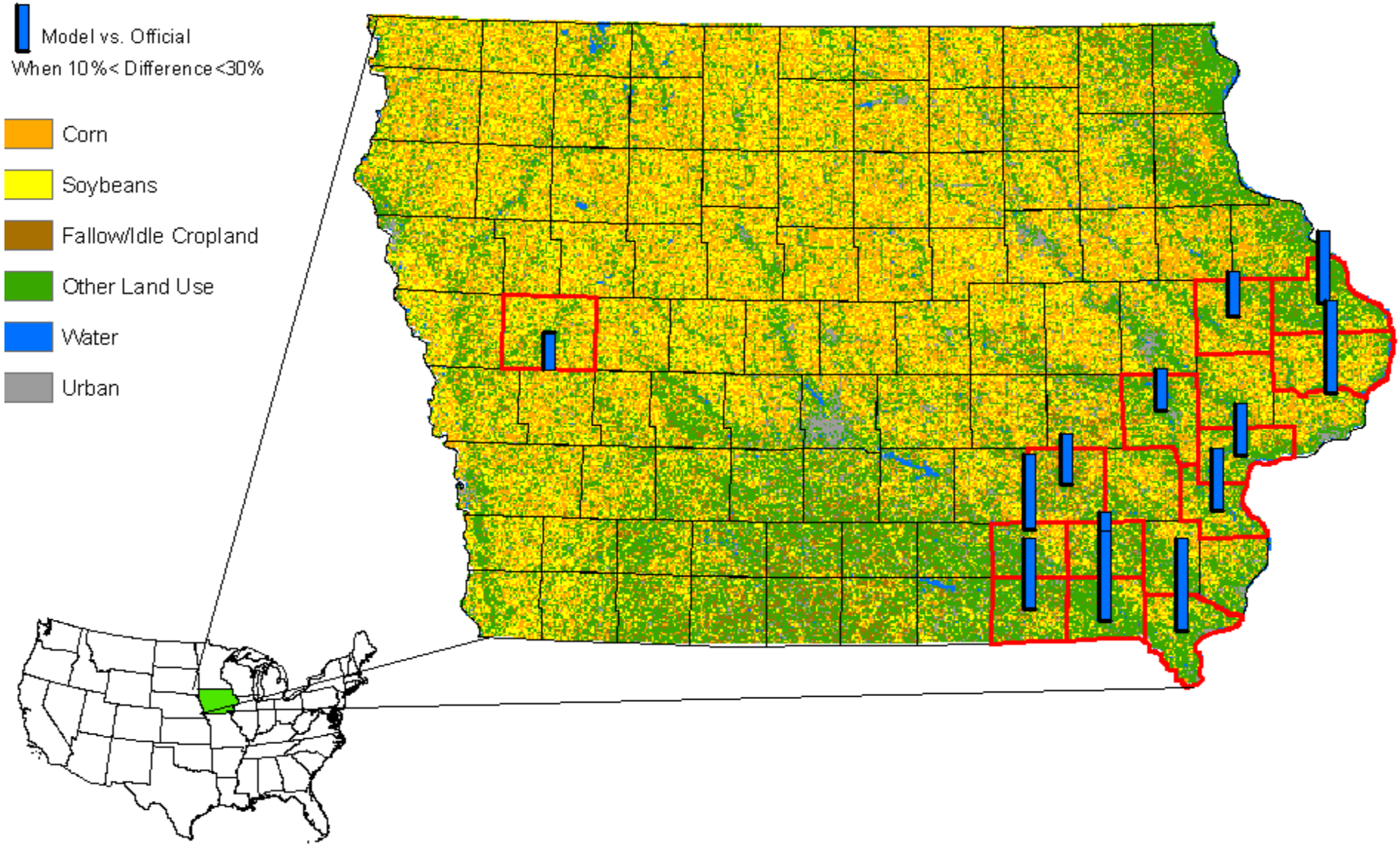
Corn Yield, IL-2005



Crop Model vs. Official Yield Estimates

On Cropland Data Layer

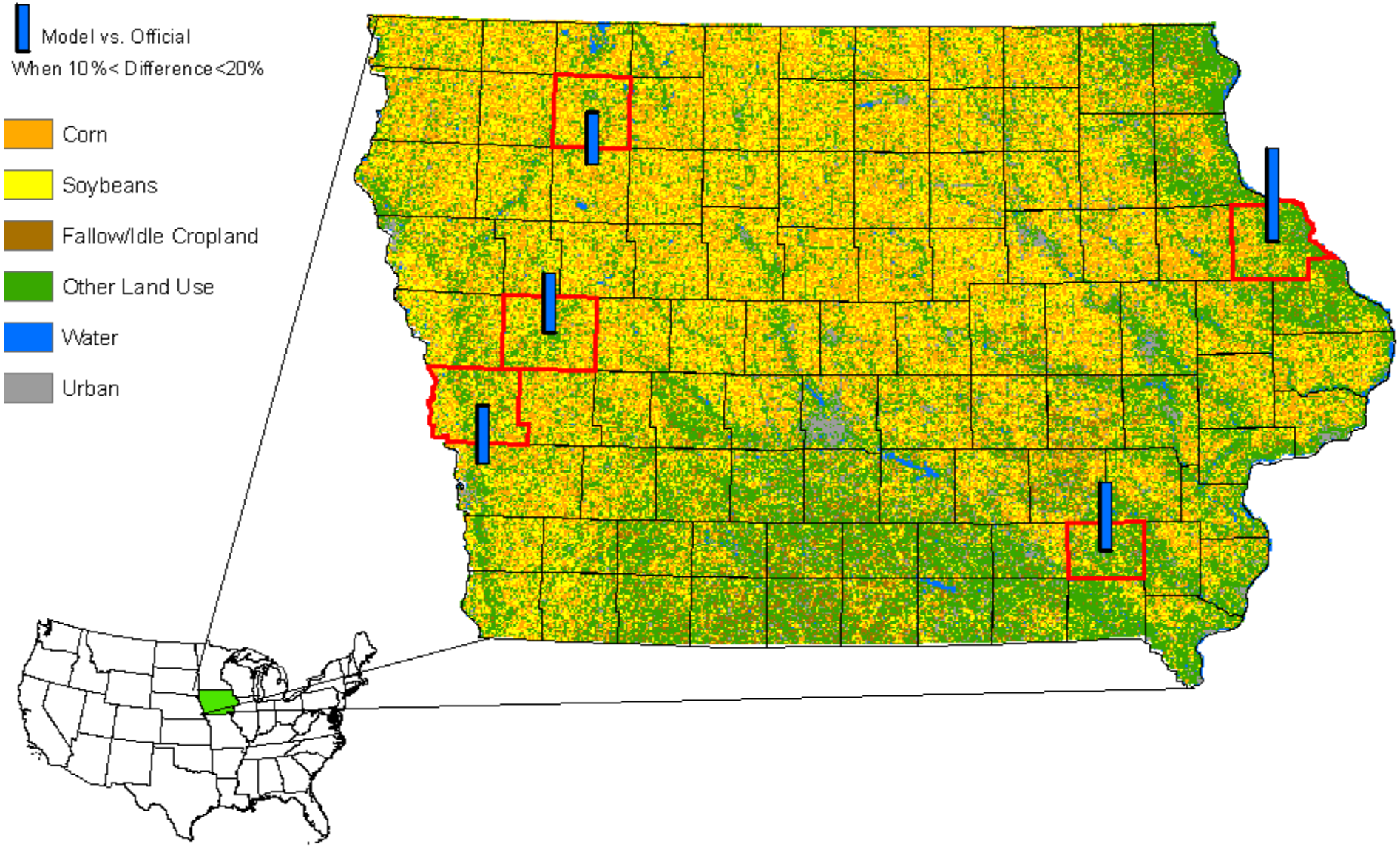
2005 Iowa Corn - County Level



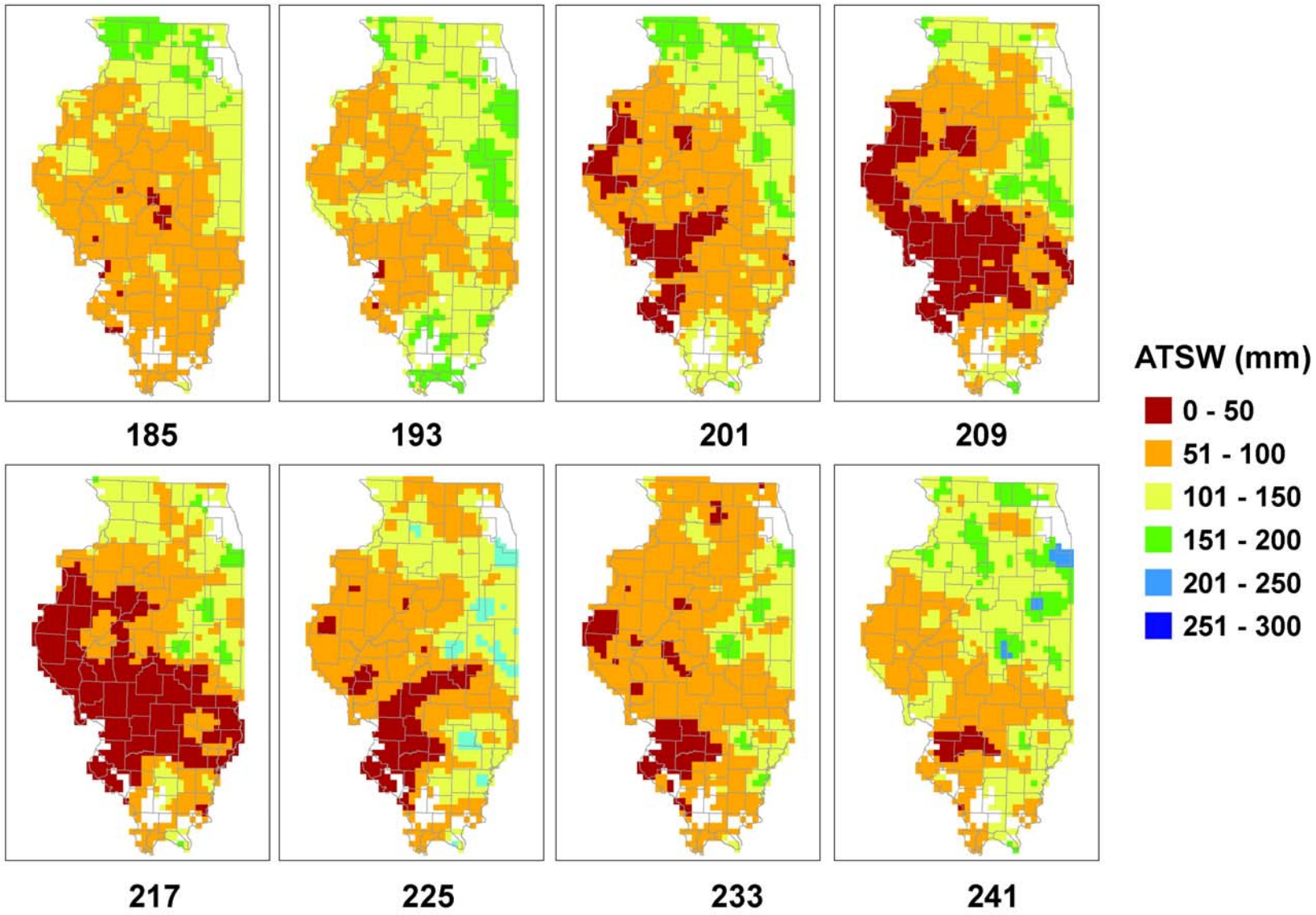
Crop Model vs. Official Yield Estimates

On Cropland Data Layer

2005 Iowa Soybeans - County Level

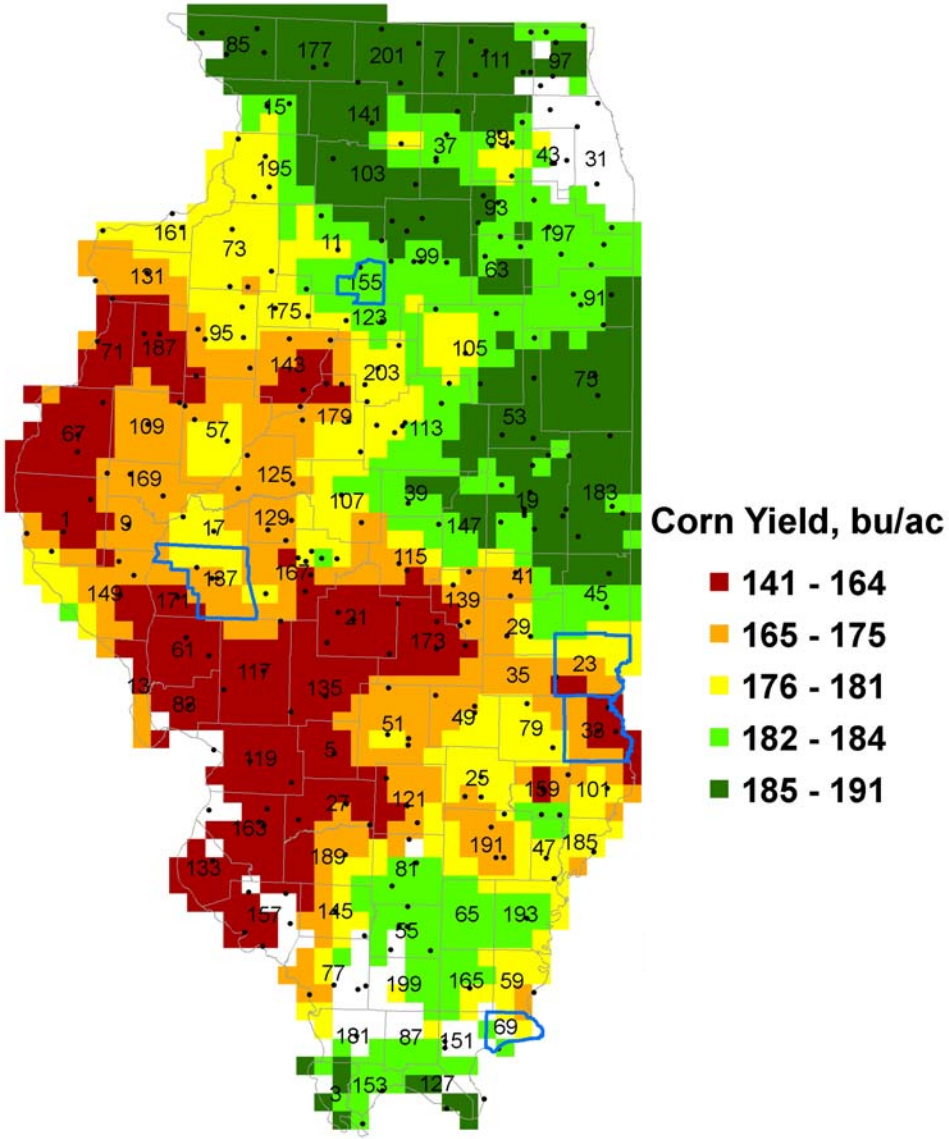


Corn 8-Day Available Transpirable Soil Water (ATSW), IL-2006



Corn Yield at 10 km, 2006, IL

No Remote Sensing. Sowing Doy= 120. Density= 8 plants/m2



Summary

1. Time series data are critical for monitoring and assessment of crop condition and potential yields at U.S. regional scales.

2. The 8-day temporal and spatial resolution is practical and suitable for operational monitoring of crop condition and yields at U.S. regional scales.

3. The BRDF and cloud contamination problems in the 8-day composite images cause significant errors in the data application at local scales.

4. Using NDVI is preferred because it reduces BRDF influence. SG-Filtering is helpful for correction of NDVI profiles.

5. The 16-day composite is a marginal improvement over the 8-day composite image, but does not provide the necessary temporal resolution.

Summary (cont'd)

6. MODIS surface reflectance product at 250m (MOD09) was found to be adequate for categorizing the major corn and soybean crop areas in Iowa and Illinois.

7. The categorization was useful to monitor crop condition at county level but is not recommended for acreage estimation.

8. The NDVI and surface temperature parameters derived from MODIS 8-day composite products are used to develop crop yield spatial variability.

9. The availability of MODIS data within two weeks of acquisition is adequate for current applications.

10. Accuracy of the crop yield is dependent on image and processing quality.

THANK YOU!

GRAZIE!