Agricultural Statistics and Remote Sensing

Remote Sensing for Agricultural Statistics in the USA

Rick Mueller
USDA/National Agricultural Statistics Service

Program Agenda

- Acreage
- Operational Cropland Data Layer Program
- Scope & method
- Assessment and accuracy of indications
- Yield
- Operational crop monitoring & production assessment
- Method overview
- Evaluation of crop model yield indications

USDA

Corn Growers Responding to Market, NCGA Sa

The National Corn Growers Association (NCGA) says the pr
plantings report released by USDA March 30 indicates corn
responding to market demands by intending to plant 90.5 m
2007. Last year, corn growers planted 78.6 million acres.

"Strong demand for corn in all market sectors – exports, livestock and ethanol – has put corn in the spotlight as producers get planting under way," says Ken McCauley, NCGA president. "We're confident corn farmers will produce another big crop given good weather."

Million Acres

95
90
85
80
75
70
65

The great corn gold rush

The price of America's most important crop has just doubled, and farmers have ethanol to thank for the jackpot, reports Fortune's Jon Birger. But are they now sitting on a 'dot-corn' bubble?

By Jon Birger, Fortune Magazine senior writer
March 30 2007: 10:37 AM EDT

FORTUNE

OAR IN 2
gest Plant

March 31, 2007, Saturday
By ANDREW MARTIN (NYT); Business/Financial Desk
Late Edition - Final, Section C, Page 1, Column 2, 1020 words

demand, U

more corn acres in 2007, according to the *Prospective Plantings* report released today by the U.S. Department of

Prospective Plantings Recap

Categories: Farm Bill

A U.S. Department of Agriculture news release from yesterday stated that, "Driven by growing ethanol demand, U.S. farmers intend to plant 15 percent more corn acres in 2007, according to the Prospective Plantings report released today by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS). Producers plan to plant 90.5 million acres of corn, the largest area since 1944 and 12.1 million acres more than in 2006.

million acres, up 1.3 million acres – or 10.3 percent – from 20

DISPLAYING ABSTRACT - With demand for ethanol pushing corn prices to $4 a bushel or higher, it was not a surprise that farmers intended to plant a lot more corn this season. What was surprising about the Agriculture Department report released yesterday was just how much they intended to plant -- a ...

ces fueled by increased demand from

90.5

USDA Prospective Plantings: Corn 90.5M 88Me (2007 intended plantings up 15%)

- Corn intended plantings at highest level since 1944
- Soybeans 67.1M, lowest since 1996
- Wheat 60.3M

Corn: The inflation crop

The U.S. is set to report a jump in acreage planted as farmers feed the ethanol machine. One byproduct: rising food prices.

By Jeff Cox, CNNMoney.com contributing writer
March 28 2007: 7:20 AM EDT

NEW YORK (CNNMoney.com) -- It's no secret that the rush to ethanol and other alternative fuels has made corn the rock star of the Farm Belt.

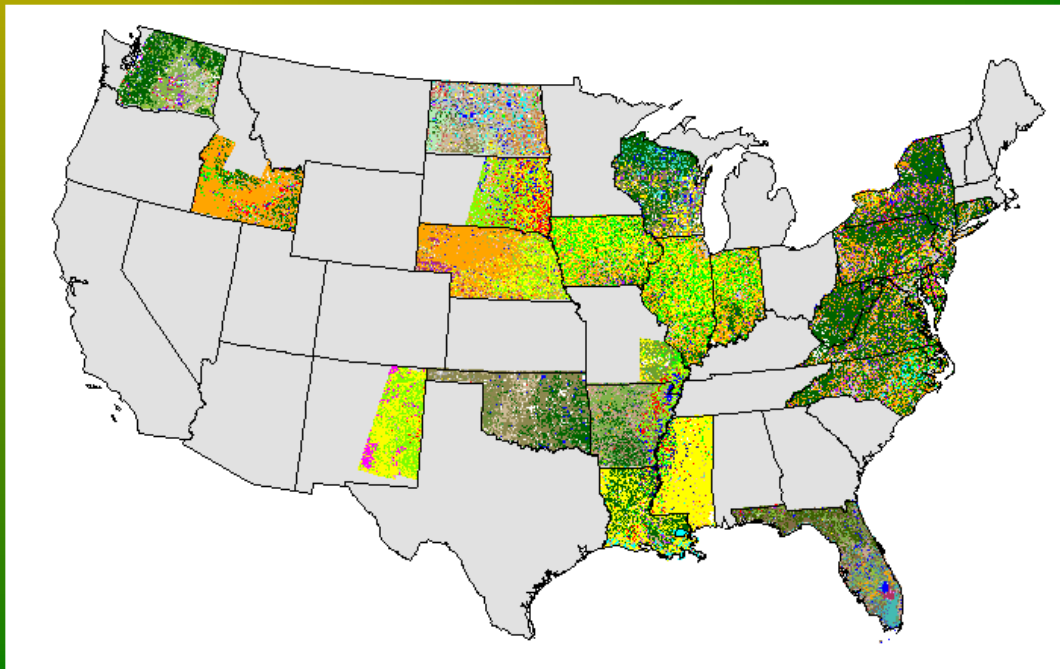
That newfound prominence has big implications for the nation's economy, experts say. Soaring corn prices are pushing up the tab for everything from candy to corn flakes, moribund land values have jumped in many Midwestern farming communities and the crop has become the lynchpin for the budding $40 billion ethanol industry.

001

Prices for corn have doubled during the last two years, a trend that's pushing food prices higher.

Remote Sensing Program Objectives

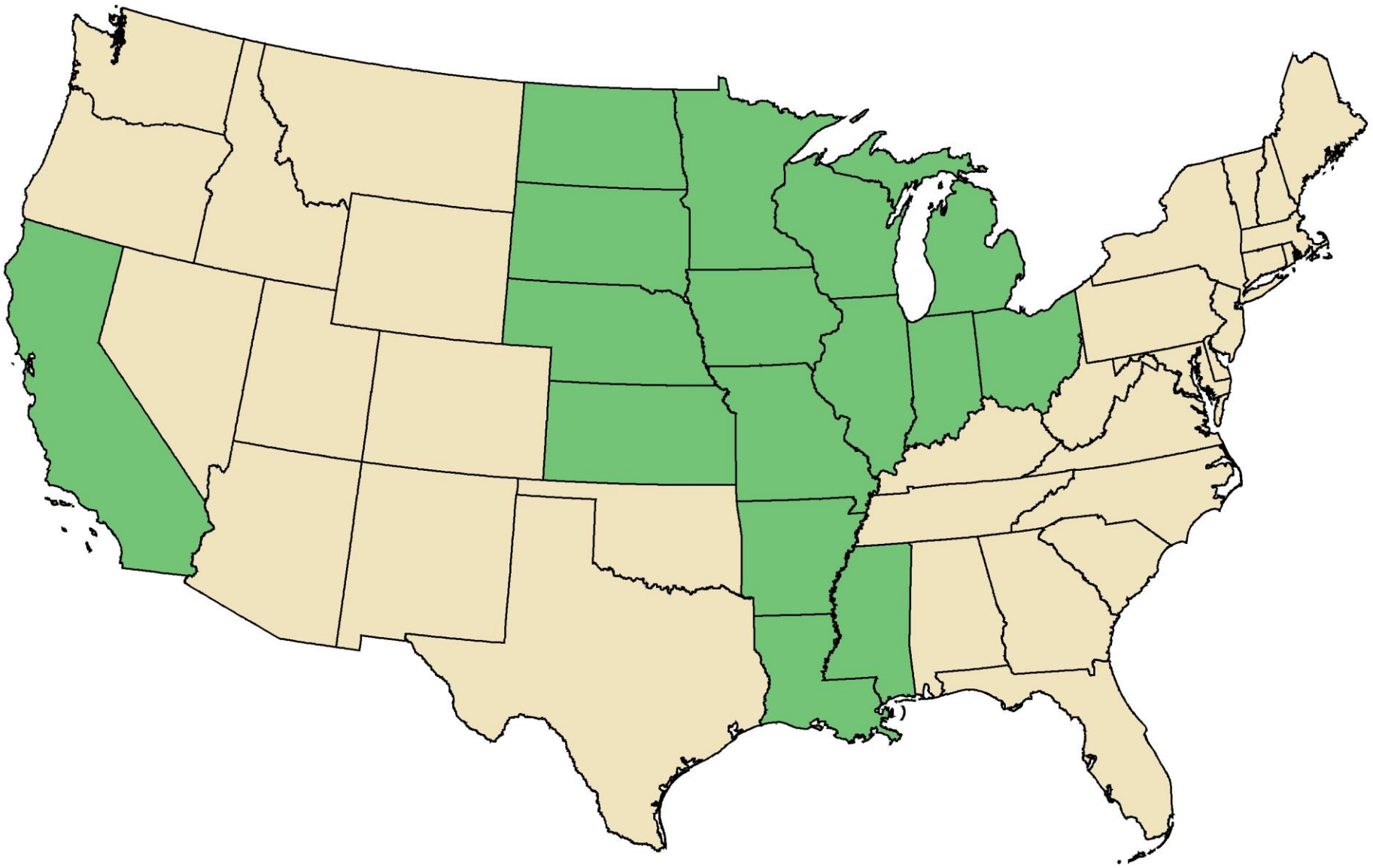
- Census by satellite
- Provide timely, accurate, useful indications
  - Measurable error
  - Unbiased estimator



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 cannot delay estimate delivery
  - Contingency plans essential - must have alternative indicators available
- Consistency
  - Standard methodology across States/crops
  - Quality assurance
  - Adopt a standard processing platform
  - Transition to new sensors

2007 Cropland Data Layer Coverage



Cropland Data Layer Components

- AWiFS sensor

The Landsat Data Gap

Landsat 7 ETM+

Landsat 5 TM

USGS
science for a changing world

News Release

November 30, 2005 Ron Beck

Landsat 5 Experiencing Technical Difficulties

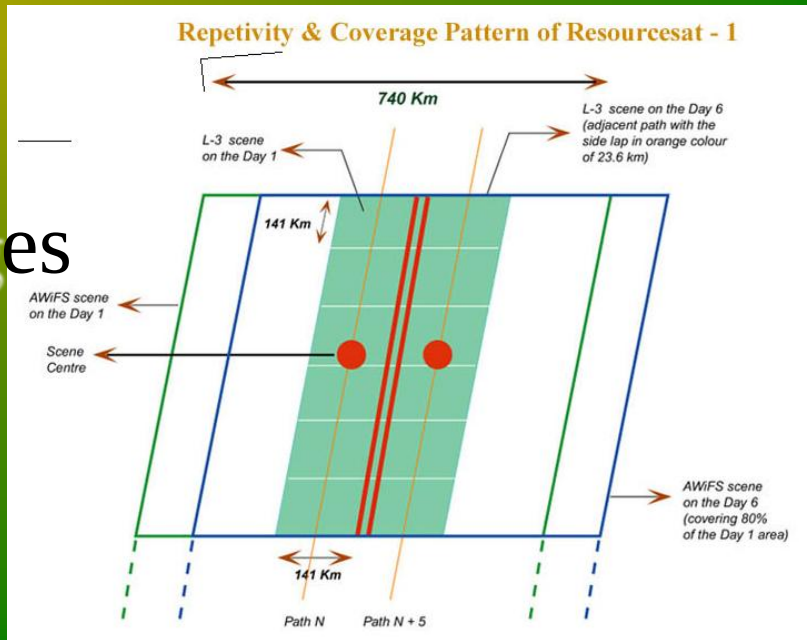
On November 26, 2005, the back-up solar array drive on Landsat 5 began exhibiting unusual behavior. The solar array drive maintains the proper pointing angle between the solar array and the sun. The rotation of the solar array drive became sporadic and the solar array was not able to provide the power needed to charge the batteries. Maintaining power to the batteries is critical to sustain proper operation of the spacecraft. The primary solar array drive failed under similar circumstances last January. As a result of this current situation, imaging operations will be suspended for at least the next two weeks or until attempts to solve the problem have been resolved.

Source: USGS, Landsat Project:
http://landsat.usgs.gov/slc_enhancements/slc_off_level1_standard.php

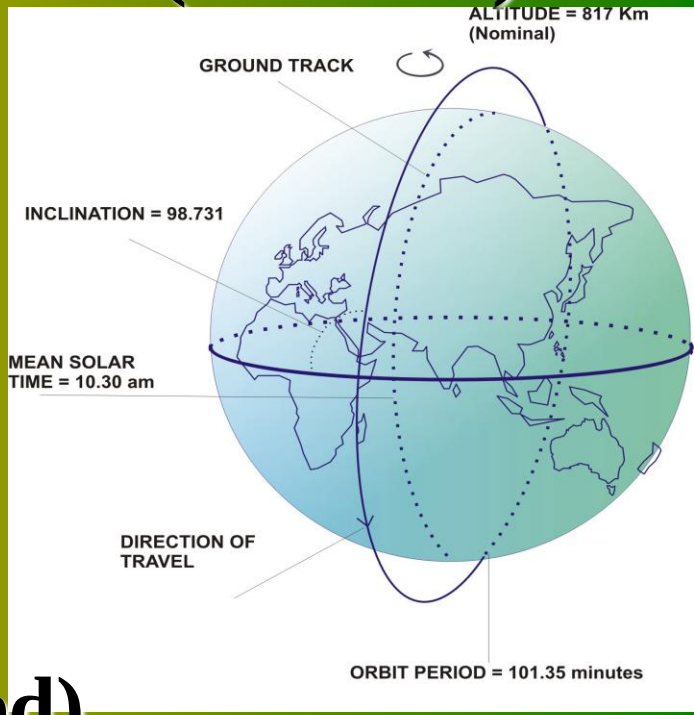
Resourcesat-1 AWiFS Sensor

Department of Space
Indian Space Research Organisation

- Launched 2003
- 370 km swath per quad
- 740 km combined
- 56 m resolution at nadir
- 70 m resolution at scene edges



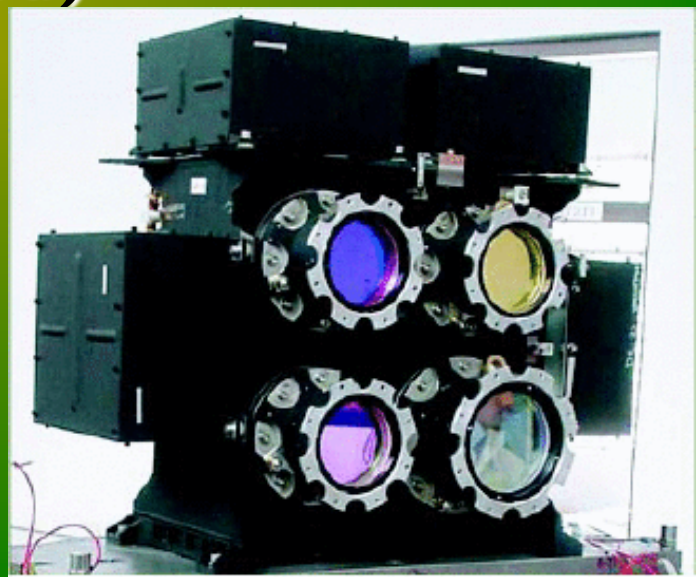
Advanced Wide Field Sensor (AWiFS)



Spectral Bands:

- B2: 0.52-0.59 (Visible Green)
- B3: 0.62-0.68 (Visible Red)
- B4: 0.77-0.86 (Near Infrared)
- B5: 1.55-1.70 (Middle Infrared)

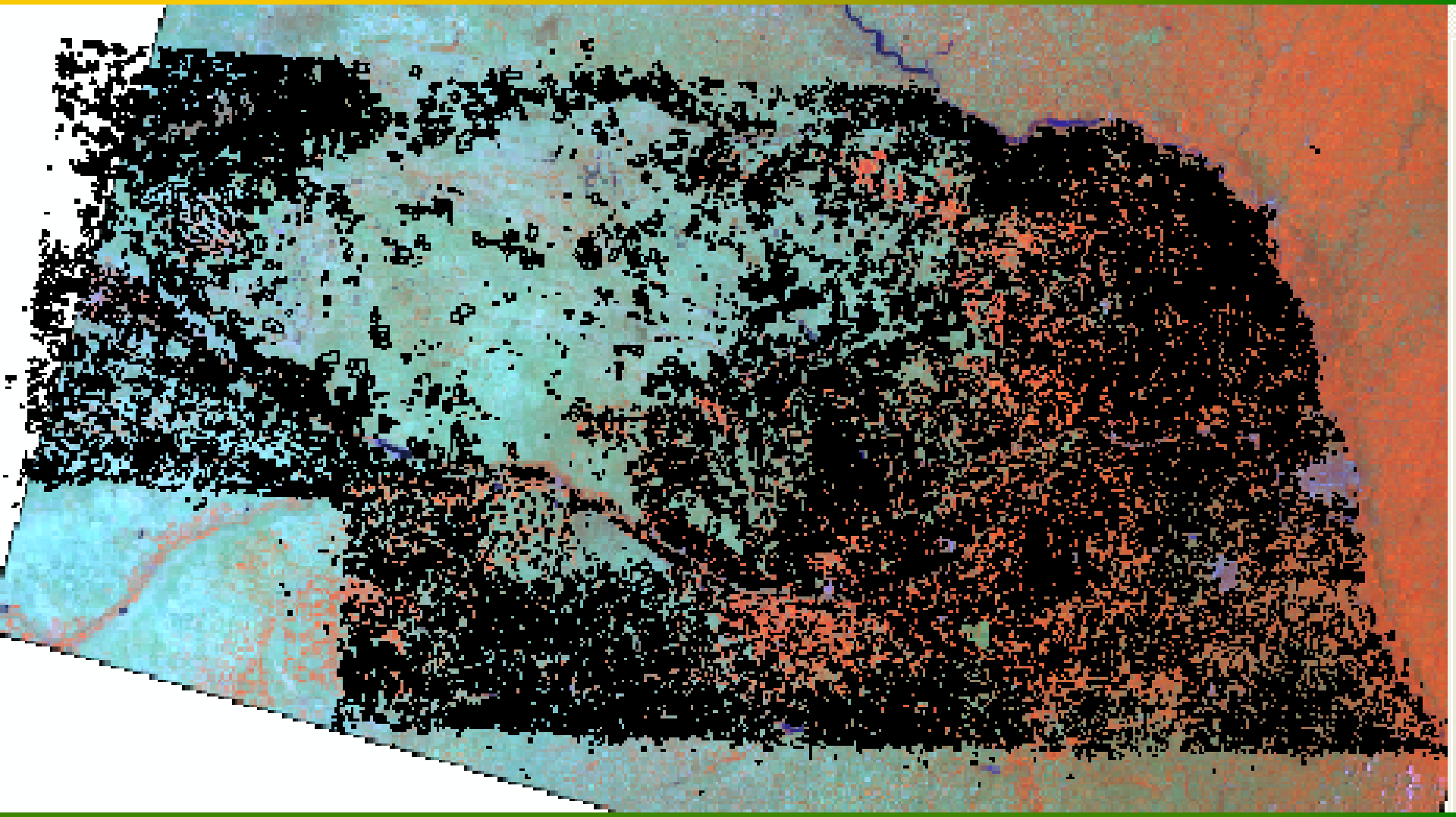
5 day repeat cycle



Cropland Data Layer Components

- AWiFS sensor
- Common Land Unit/578 Admin Data
  - USDA/Farm Service Agency
    - Training/testing datasets

Common Land Unit/578 Admin Data



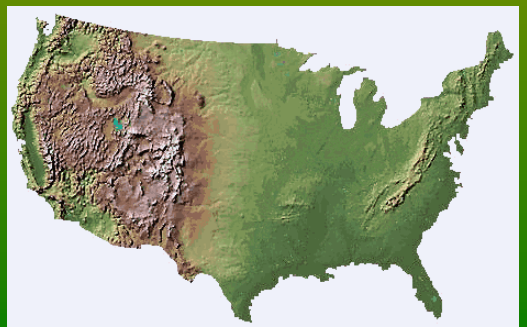
USDA United States Department of Agriculture
Farm Service Agency

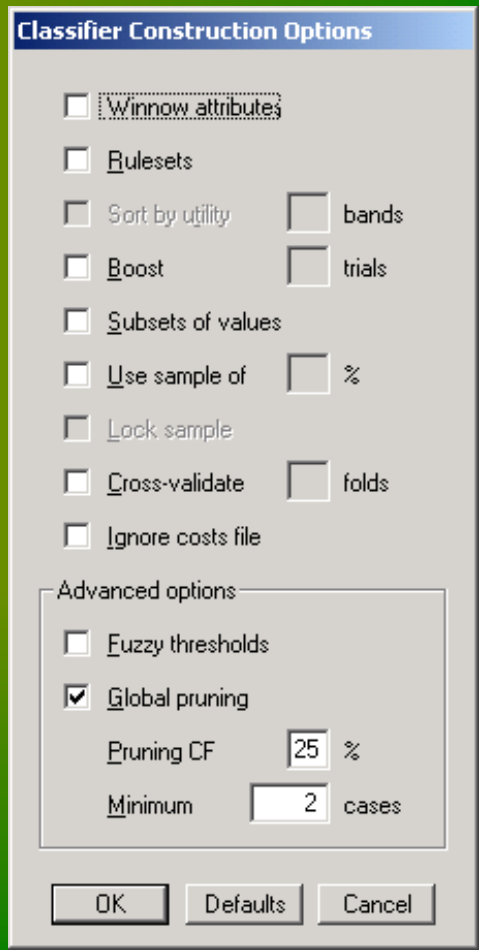
Cropland Data Layer Components

- AWiFS sensor
- Common Land Unit/578 Admin Data
  - USDA/Farm Service Agency
- ERDAS Imagine/See5
  - Image Processing/Classification

ERDAS Imagine & See5

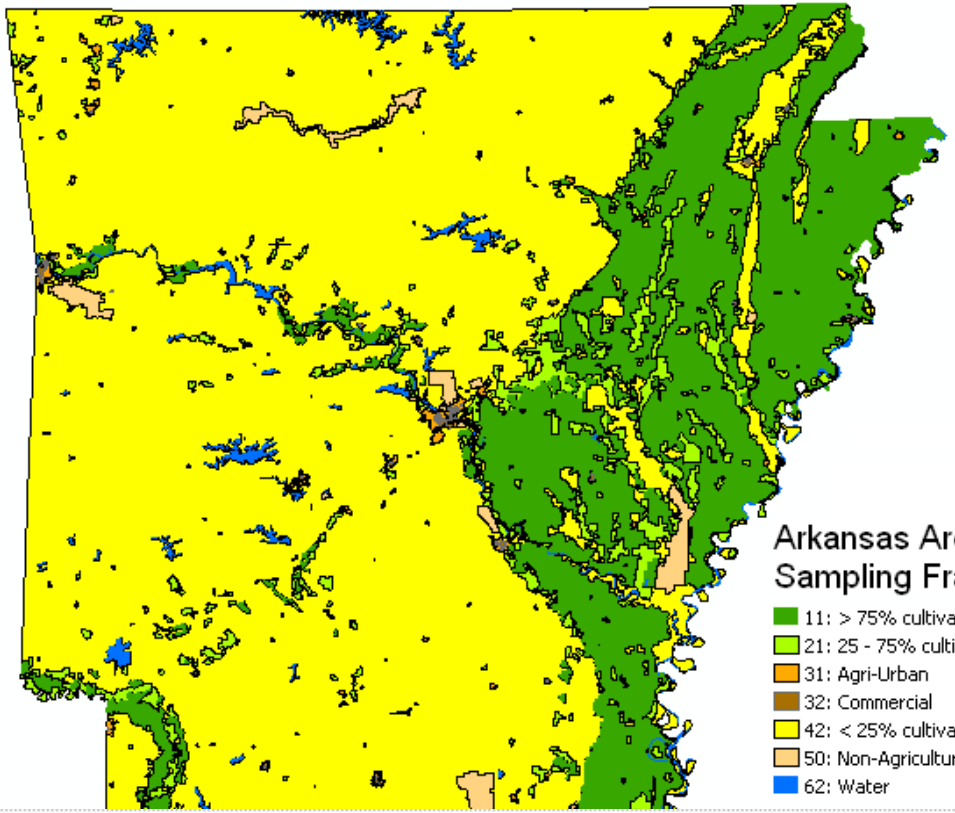
- Derivation of decision tree classification rules
  - Boosting & smart eliminate
    - www.rulequest.com
- Sample non-ag areas
  - National Land Cover Dataset (USGS)
- Ancillary datasets
  - DEM & prior CDL
- Phenological profiles with AWiFS





Cropland Data Layer Components

- AWiFS sensor
- Common Land Unit/578 Admin Data
  - USDA/Farm Service Agency
- ERDAS Imagine/See5
  - Image Processing/Classification
- Acreage Estimator
  - June Agricultural Survey



PAGE 2

SECTION D - CROPS AND LAND USE ON TRACT

17

How many acres are inside this blue tract boundary drawn on the photo (map)? . . . . . .

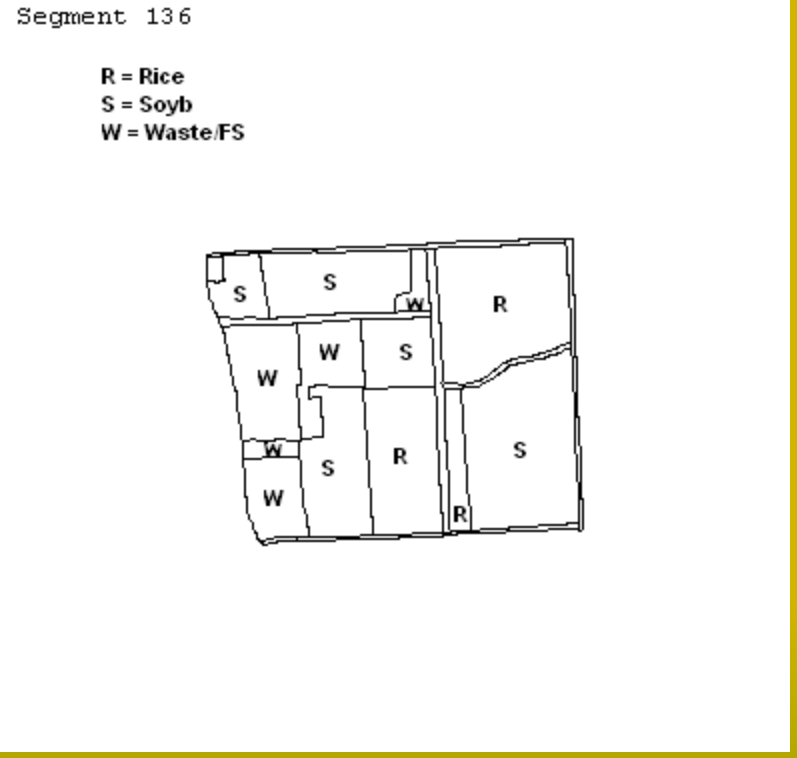
Now I would like to ask about each field inside this blue tract boundary and its use during 2000

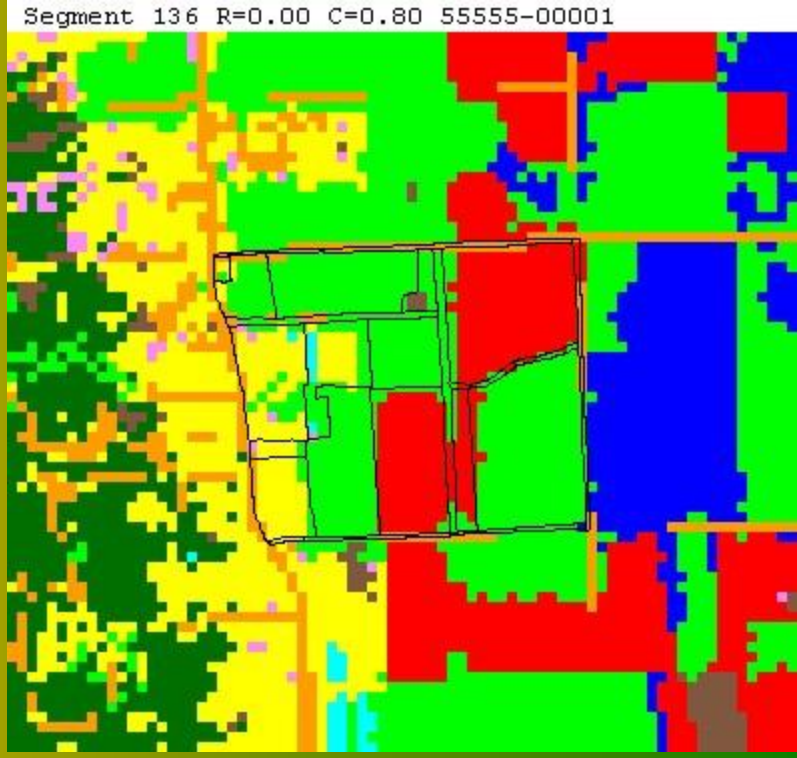
FIELD NUMBER		01	02	
1. Total acres in field		828 .	828 .	828
2. Crop or land use. [*Specify*]				
3. Occupied farmstead or dwelling		843 .		
4. Waste, unoccupied dwellings, buildings and structures, roads, ditches, etc.		--- .	--- .	--
5. Woodland		831 .	831 .	831
6. Pasture	Permanent (not in crop rotation)	842 .	842 .	842
		856	856	856

Estimation Components: Area Sampling Frame+ June Ag Survey+ Questionnaire

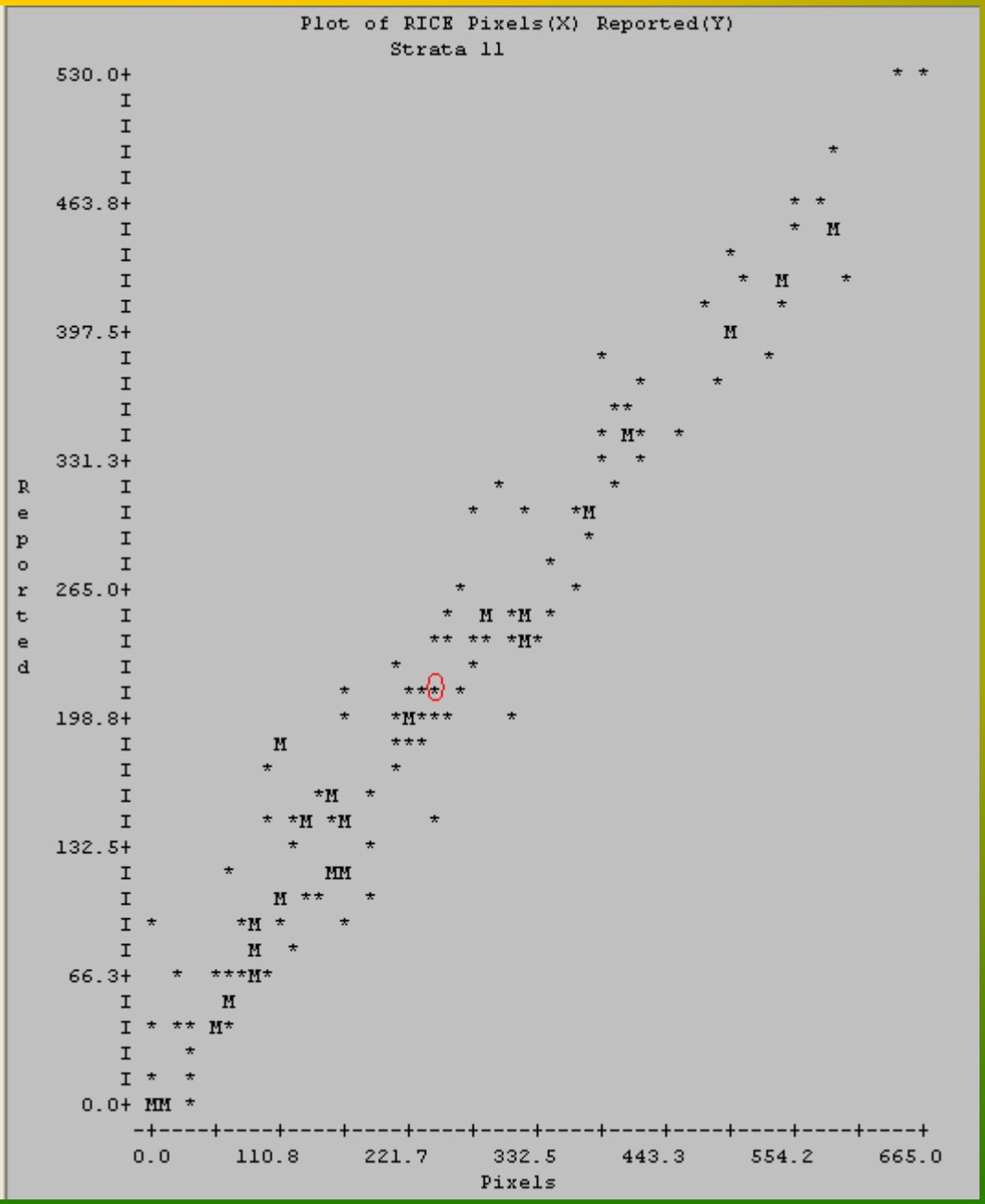
Regression Estimator

- Relate categorized pixel counts to the ground reference data
  - Independent variable - satellite data - pixels
  - Dependent variable - JAS acreage estimate
- Satellite data - lower variance than with only JAS
- Outlier segment detection
  - Correction or removal from regression analysis





Crop Type	Y	X
	Enumerated JAS Acres	Classified Pixel Acres
Rice	**227**	**273**
Soybean	**337**	**541**



$R^2 = 0.971$

a = intercept = 7.11

b = slope = 0.802

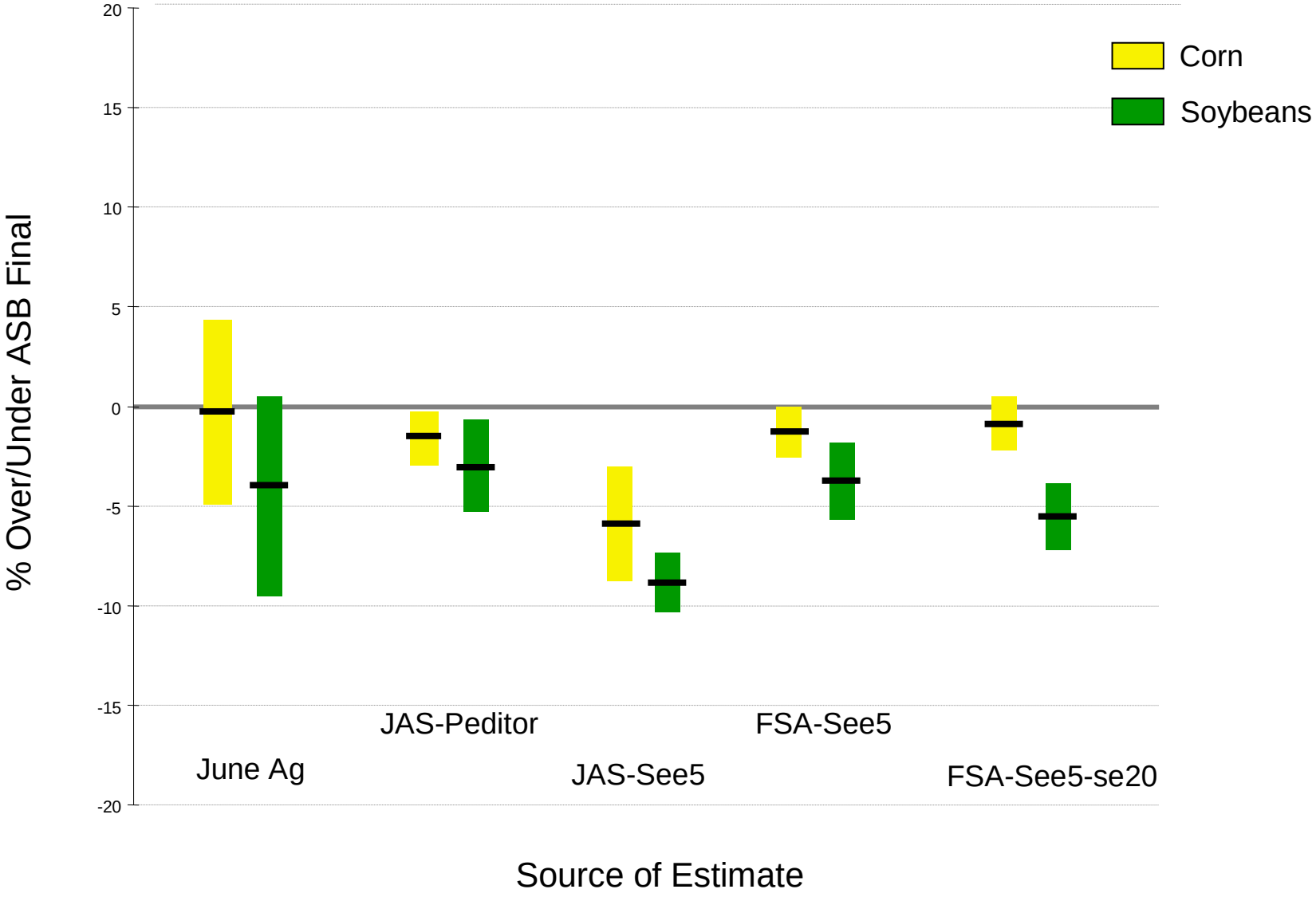
Linear Regression

$y = a + bx$

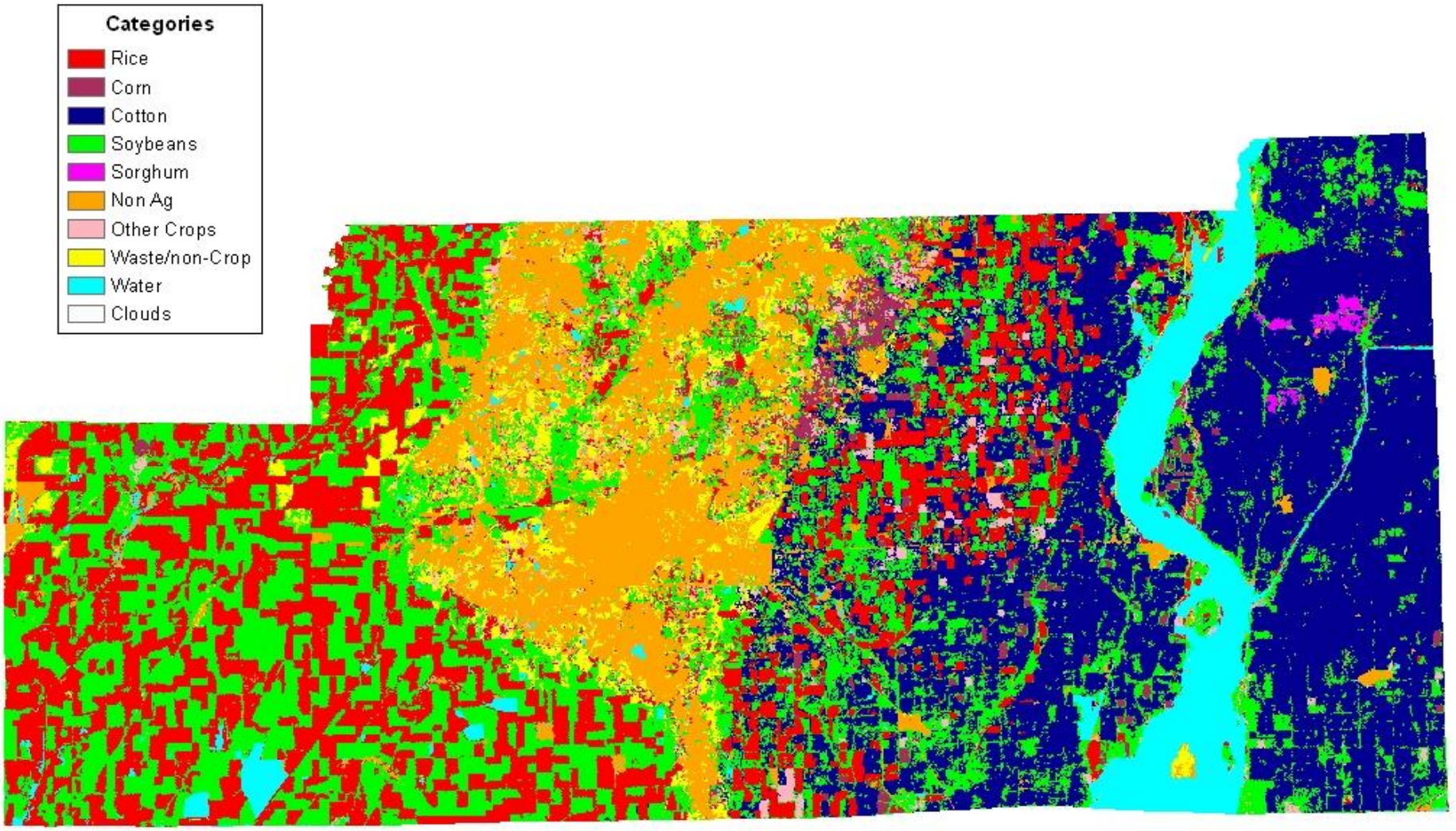
Seg 136 (x=273, y=227)

$y = 226.11$

IA 2006 State Level Estimates +/- 2% CVs
(Coefficient of Variation)



Craighead County, Arkansas 2005



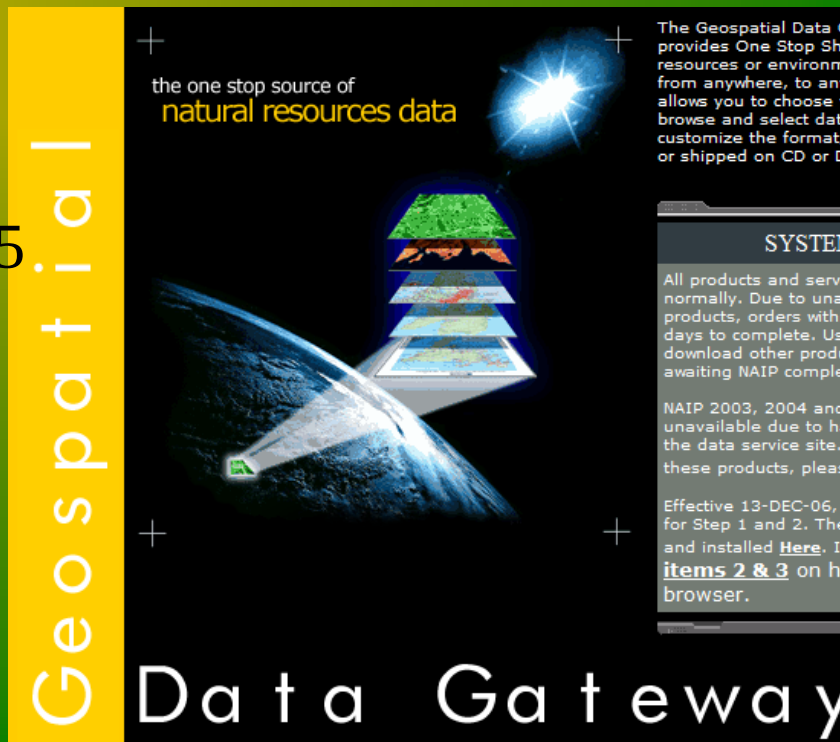
Cropland Data Layer

Cropland Data Layer Summary

- Operational estimates in corn/soybean region 2007
  - Provides measureable statistical error
  - Indication considered for national acreage estimate

- Components
  - AWiFS
  - Farm Service Agency
    - Common Land Unit (training/testing)
  - Commercial Software ERDAS/See5
  - June Agricultural Survey
    - Regression estimator

- Distribution
  - datagateway.nrcs.usda.gov



Remote Sensing Support for Crop Monitoring and Assessment

The Next Generation of Yield Estimates

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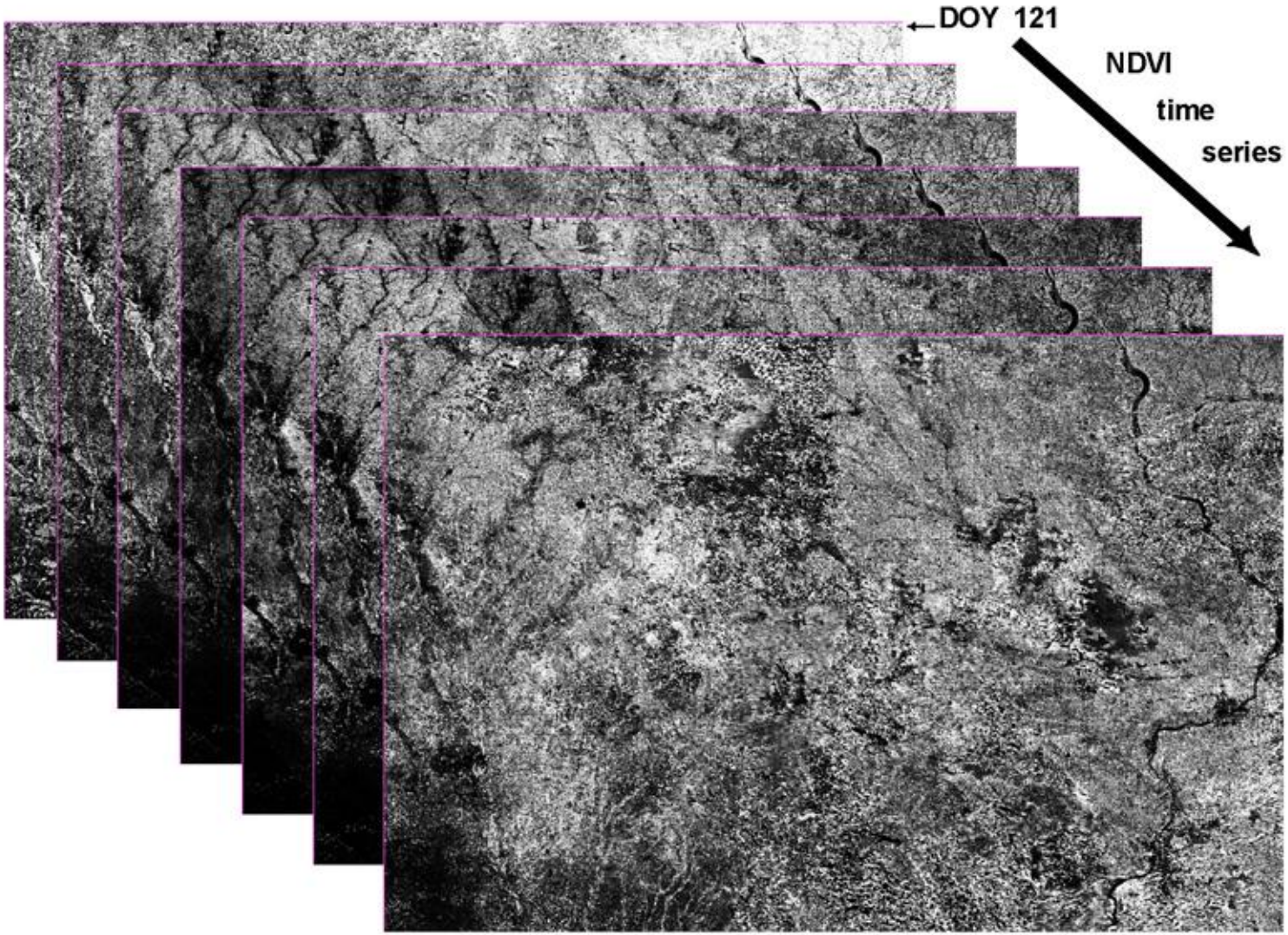
Objectives

Develop an algorithm for operational classifications of corn and soybean fields in the U.S. Corn Belt

1) Agrometerological crop model with remote sensing
2) Simplified remote sensing algorithm
3) Agrometerological (only) crop yield model

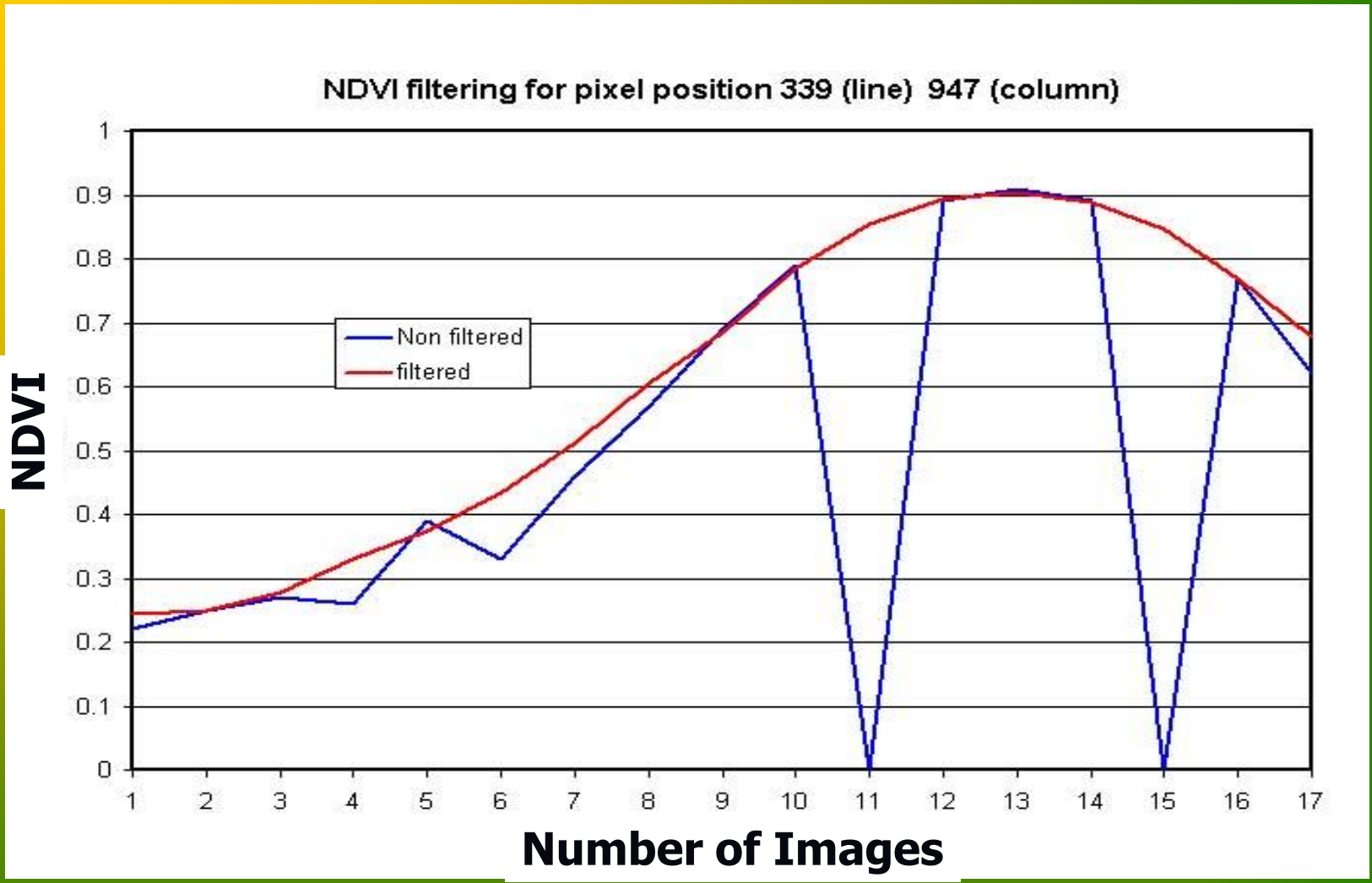
Provide timely and accurate information
-> NASS's operational program

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

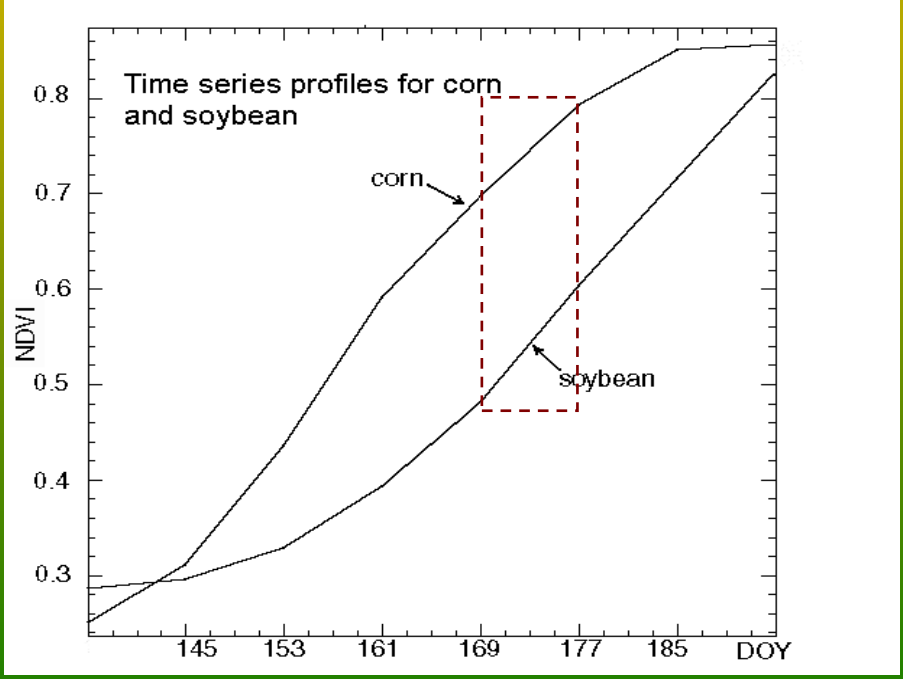
Per Jonsson and Lars Eklundh, 2004. TIMESAT – A program for analyzing time-series of satellite sensor data. Computers and Geosciences 30, 833-845

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 (May 9) must be less than 0.40 and in DOY 209 (July 28) 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



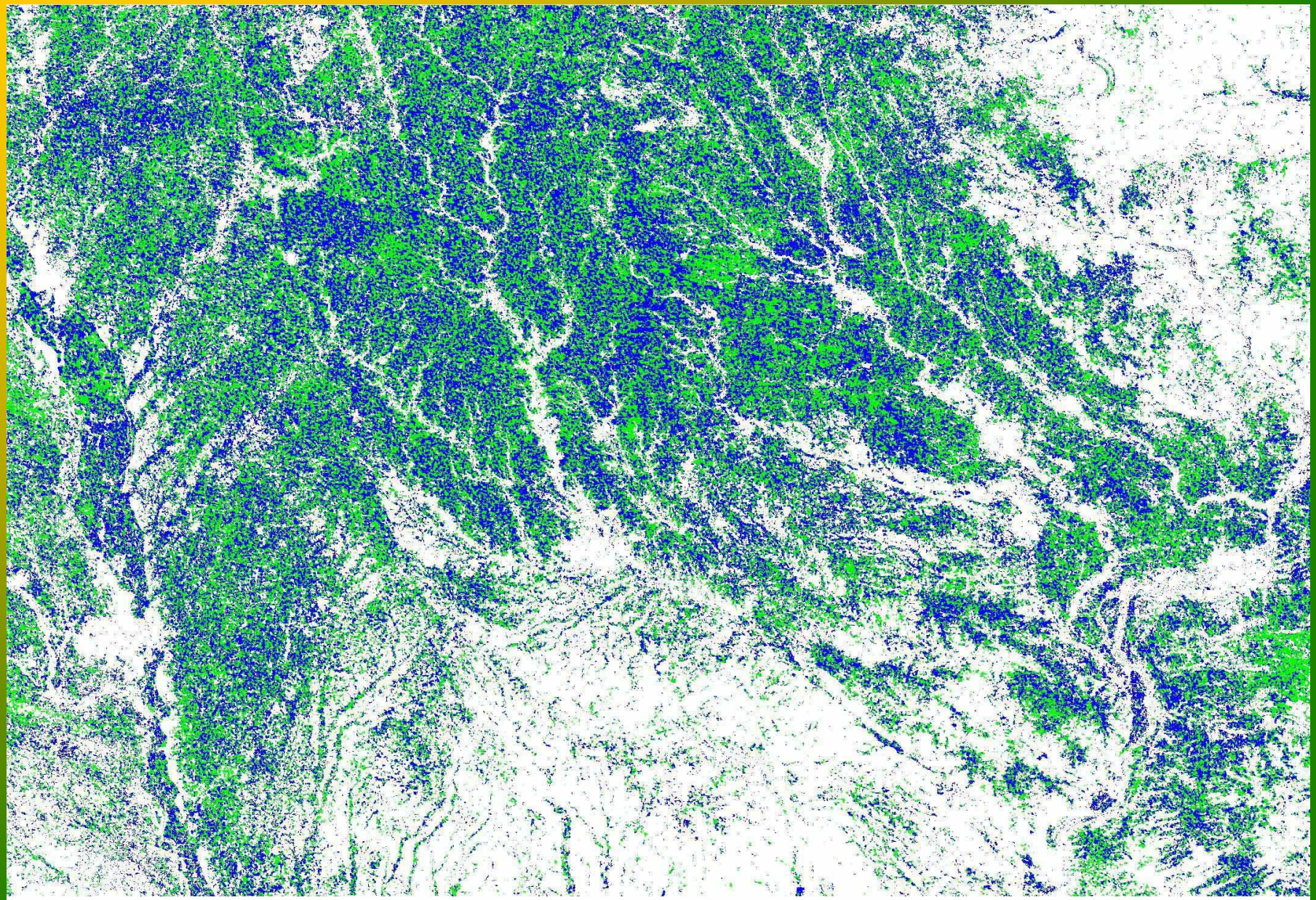
- The mean value of the second derivatives of the polynomial between DOY 169 and 177 are used.

- 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

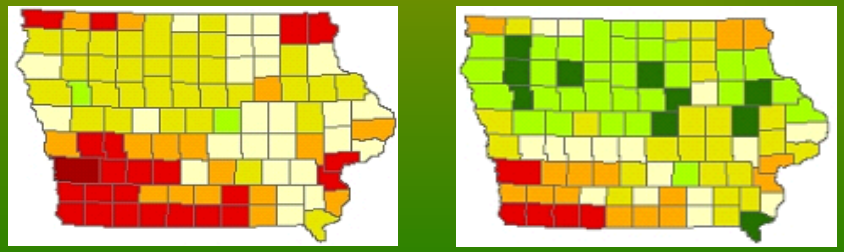
MODIS-Thermal 8-Day Composite 1 Km

MODIS –VIS-NIR Corn and Soybean Classification Mask

Data Masked and County Averaged

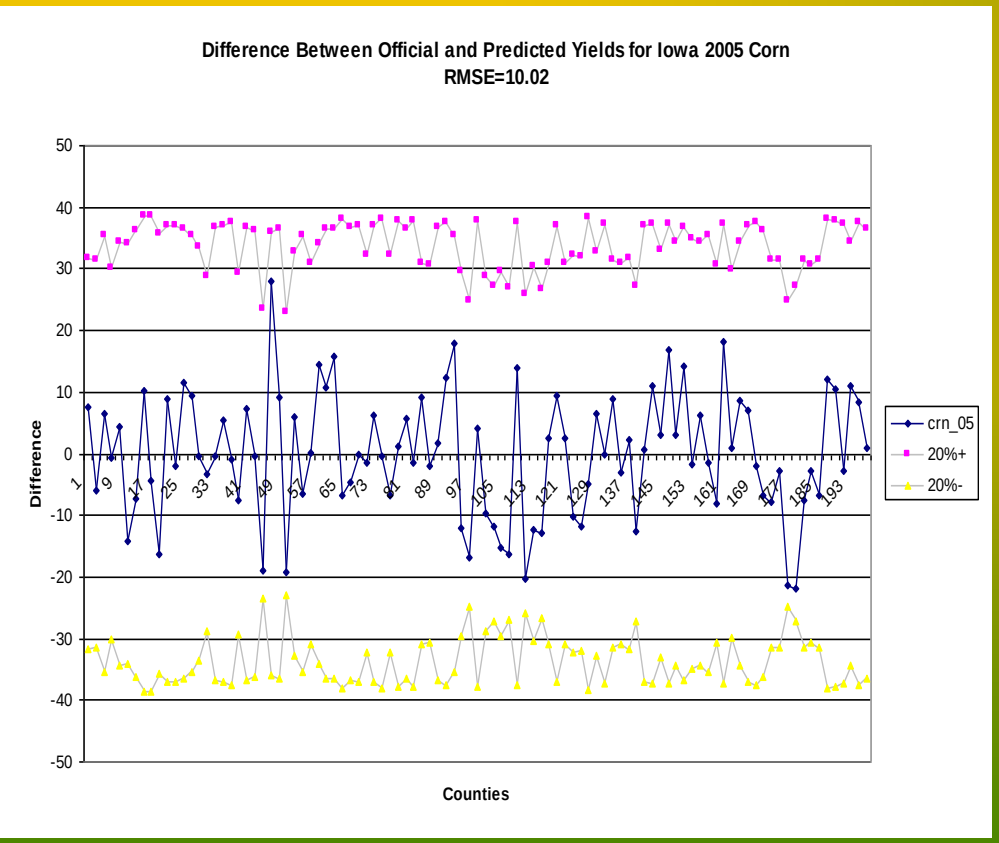
County Yield Algorithm
Yield = f (NDVI, Ts)

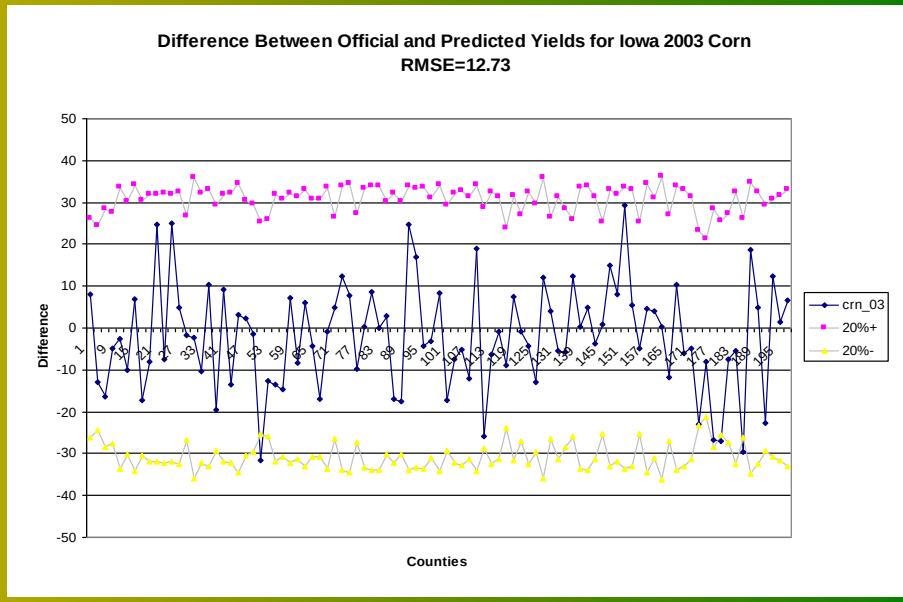
Yield Index

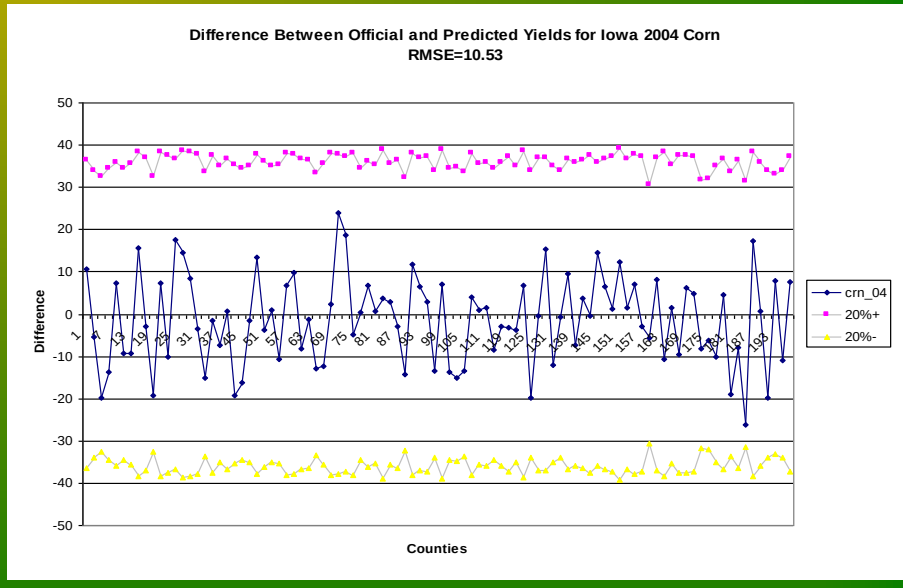


Corn ***Soybean***

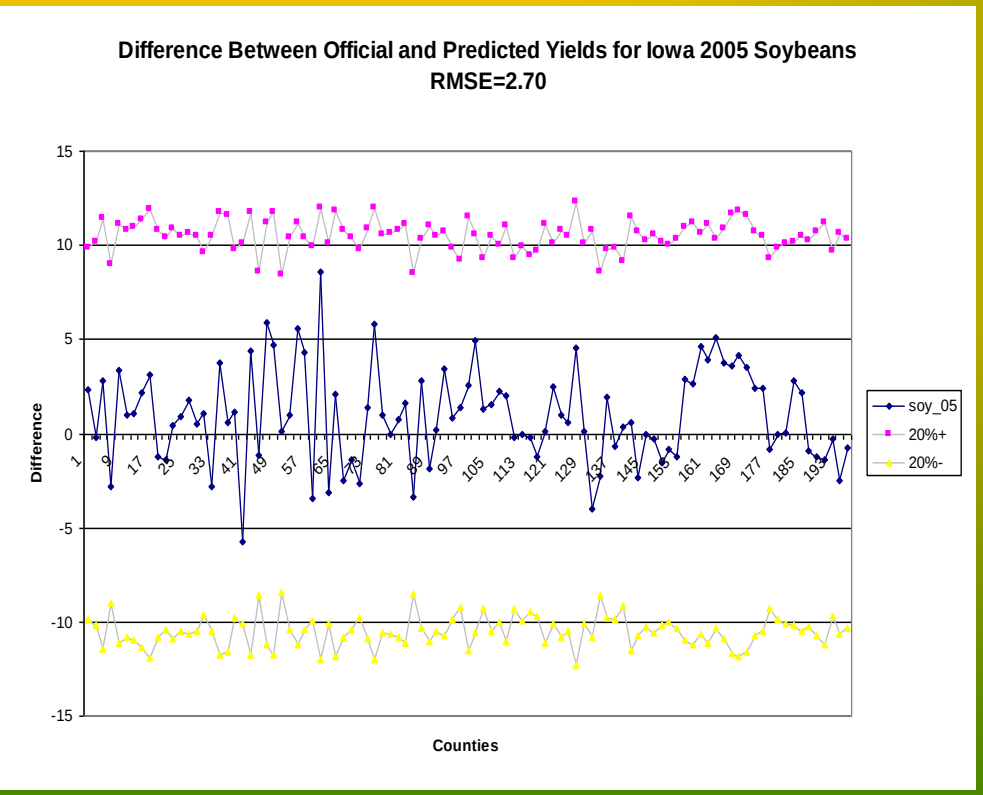
2003-05 Iowa Corn County Yield Comparisons

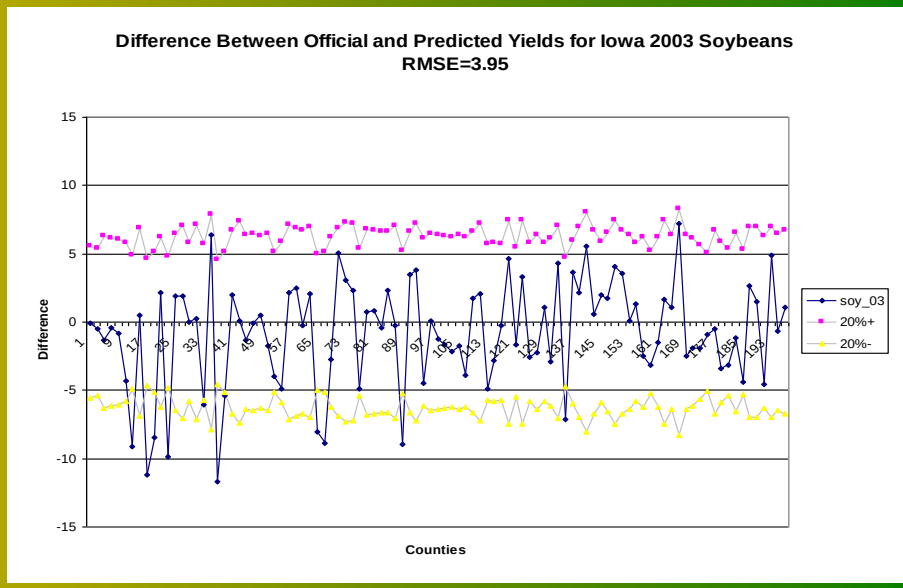


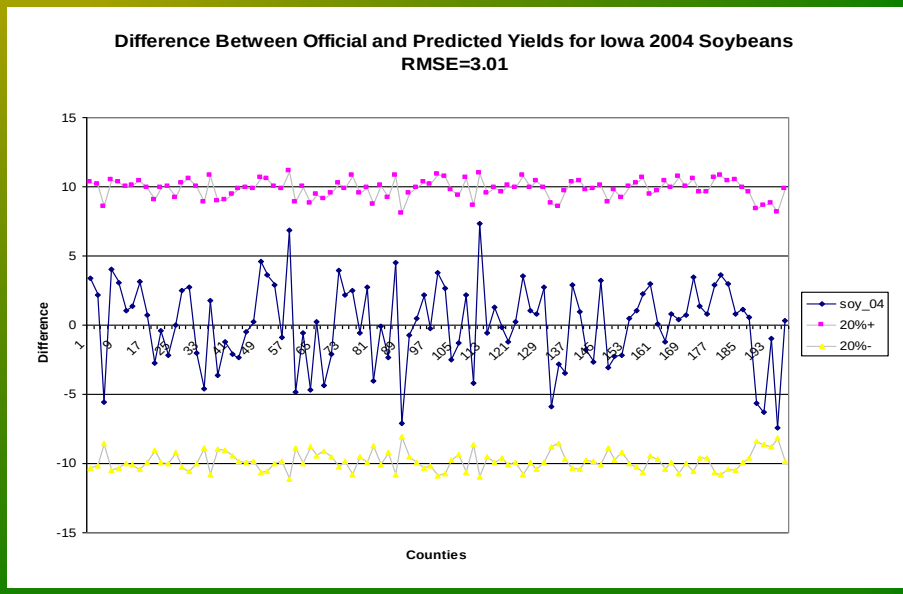




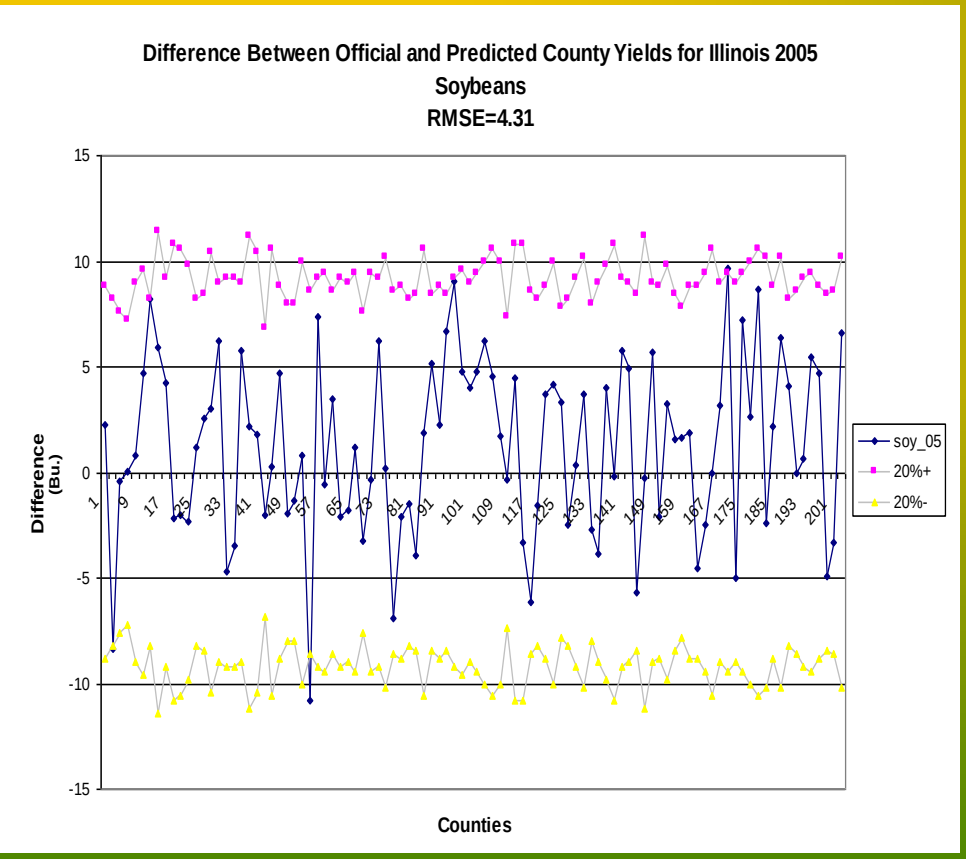
2003-05 Iowa Soybean County Yield Comparisons

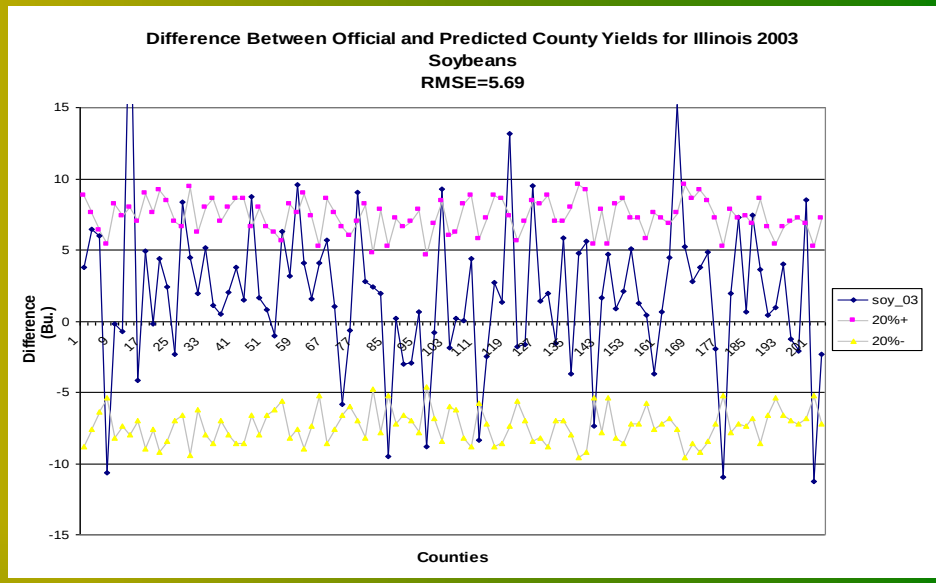


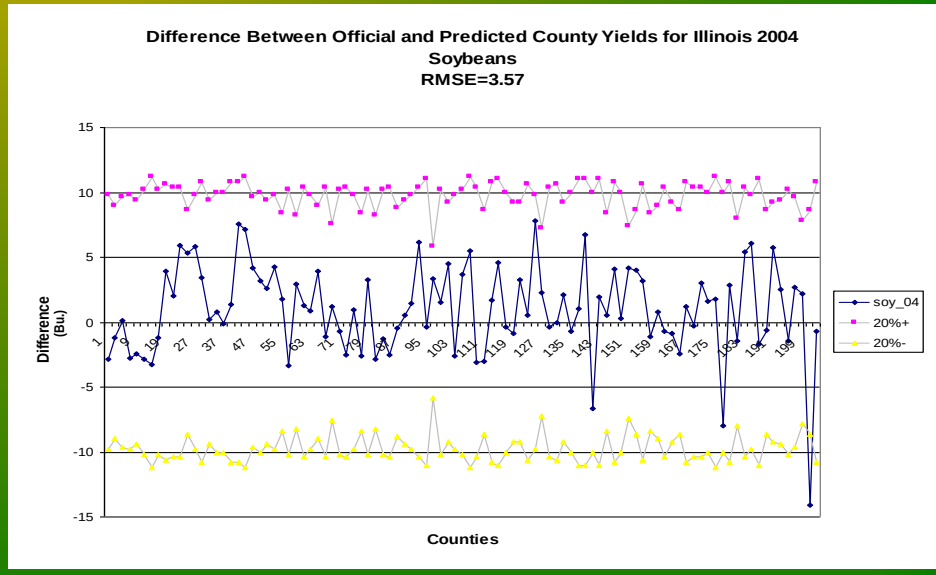




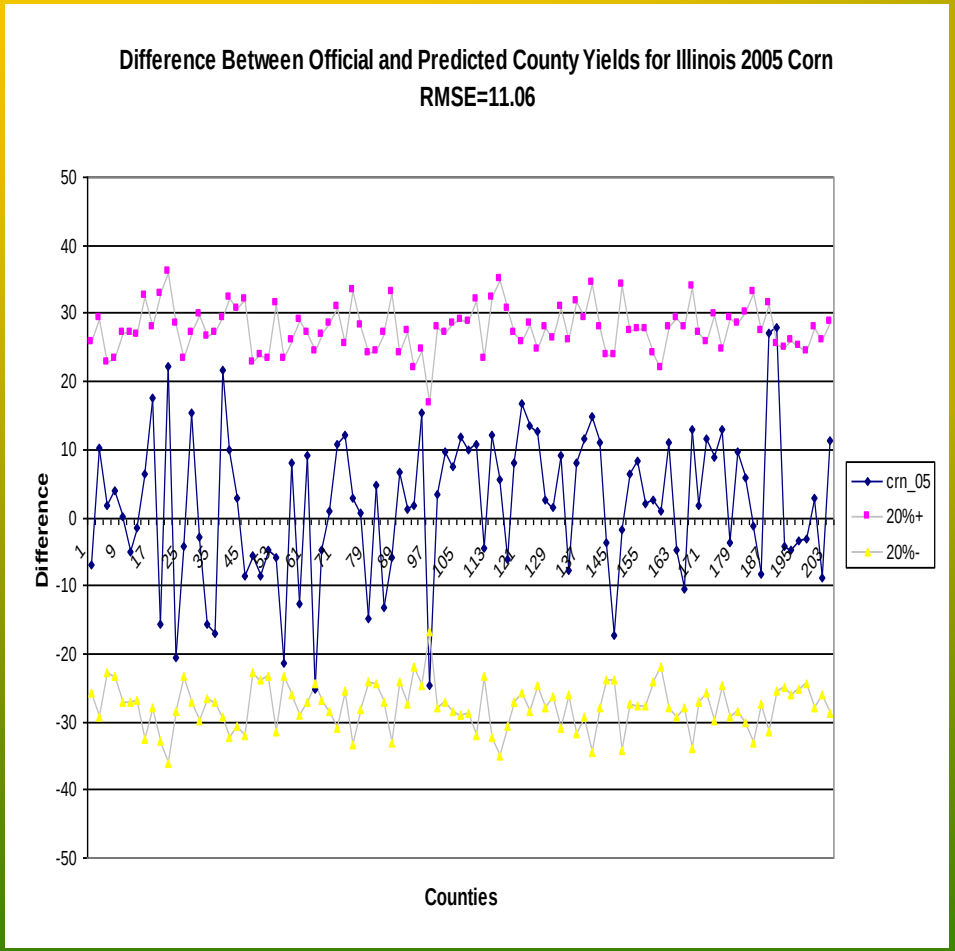
2003-05 Illinois Soybean County Yield Comparisons

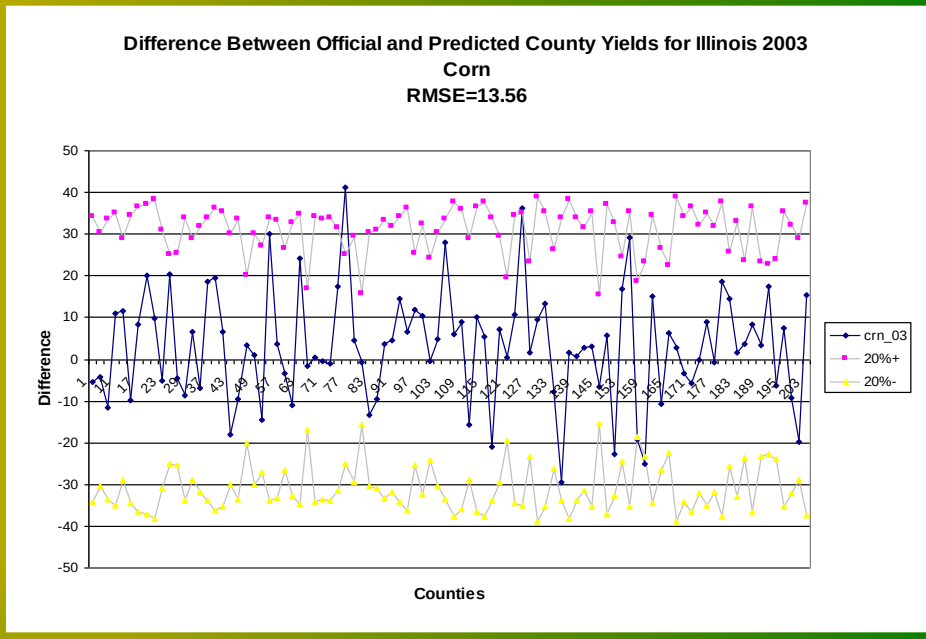


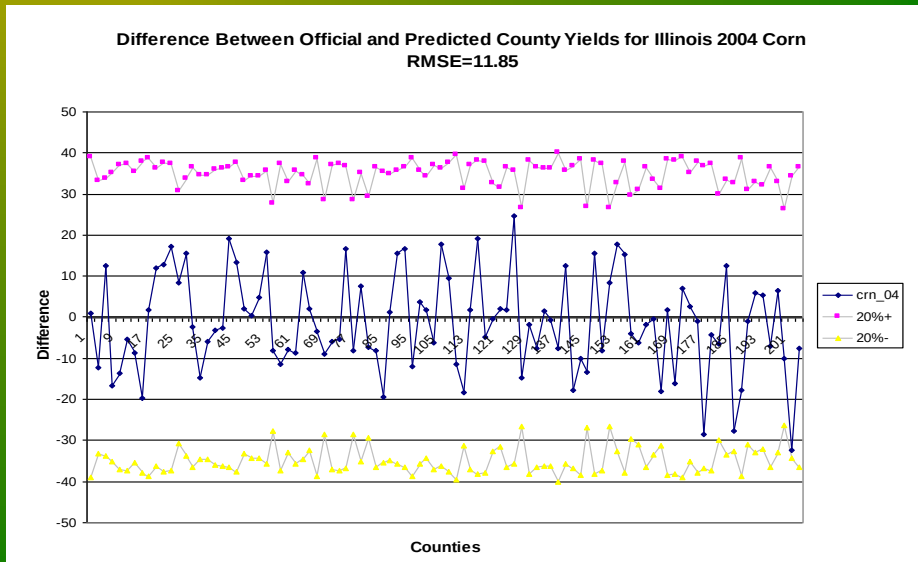




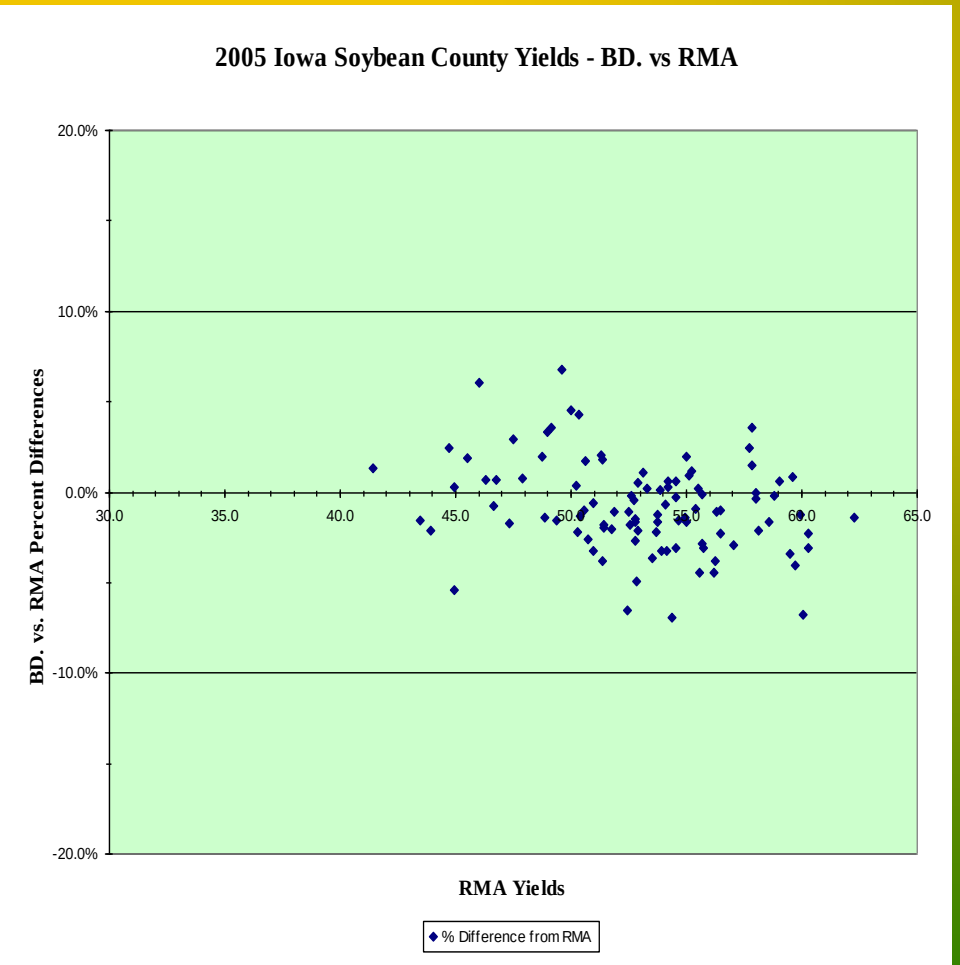
2003-05 Illinois Corn County Yield Comparison

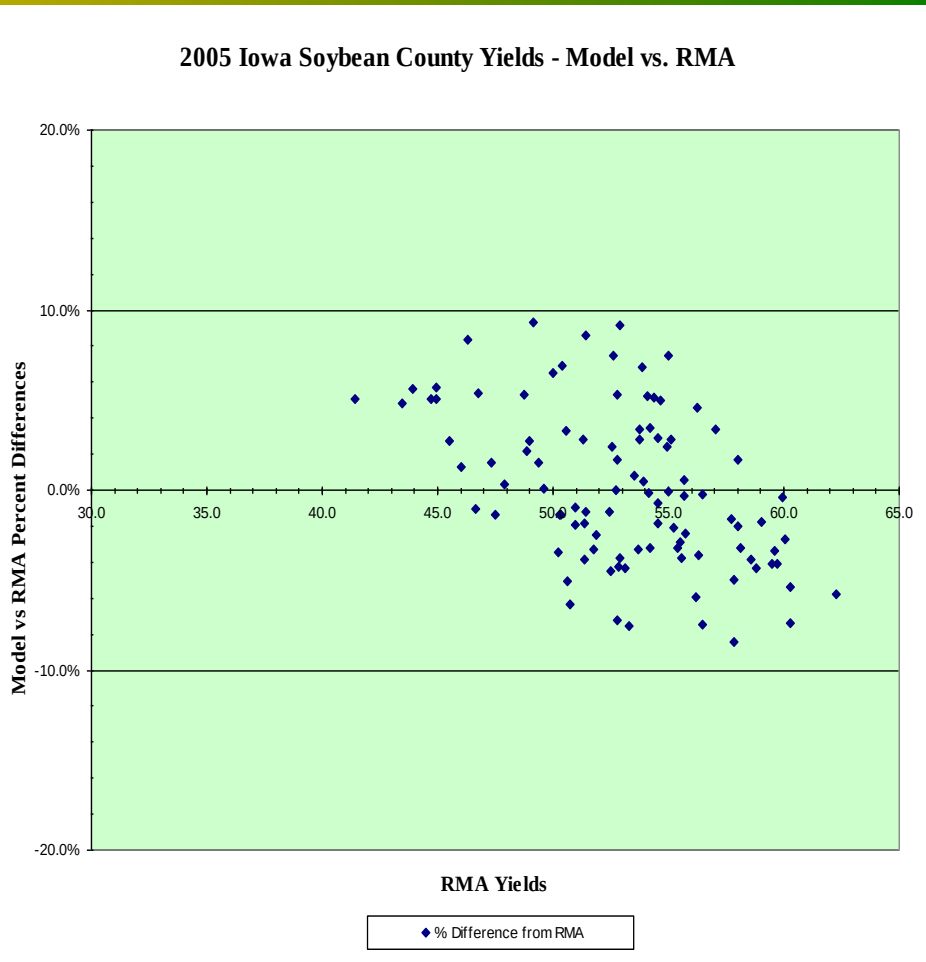




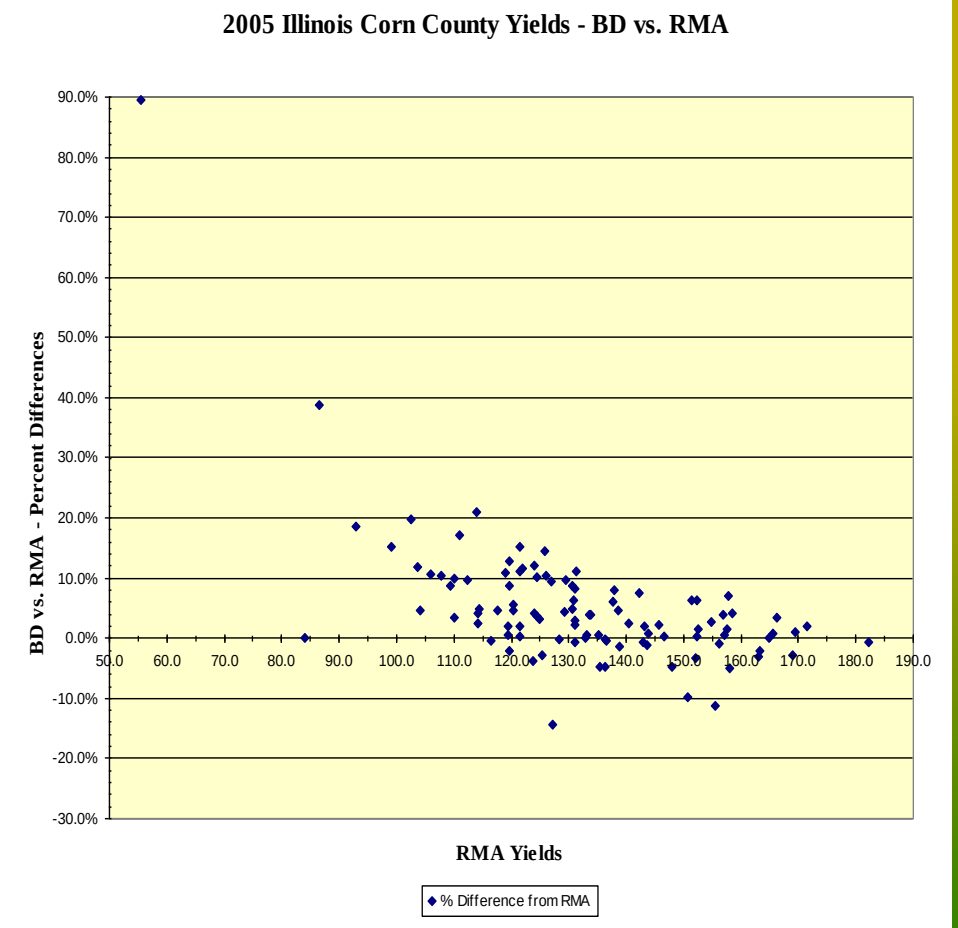


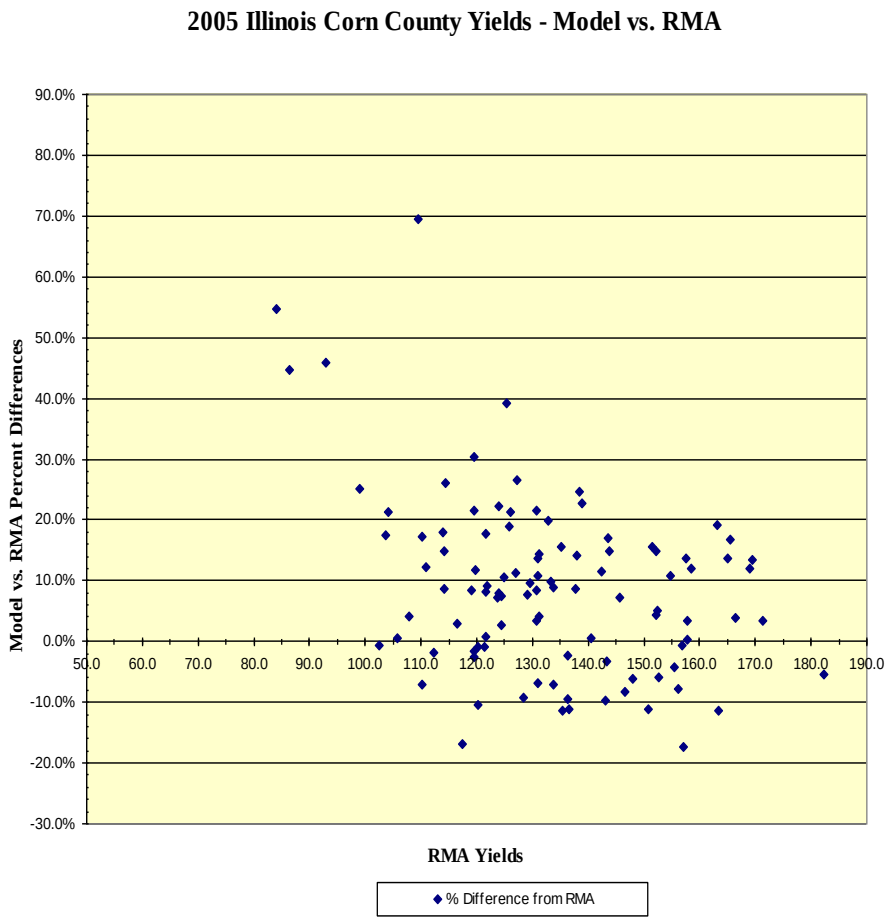
Model vs. USDA/Risk Management Agency vs. Official County Yield Estimates



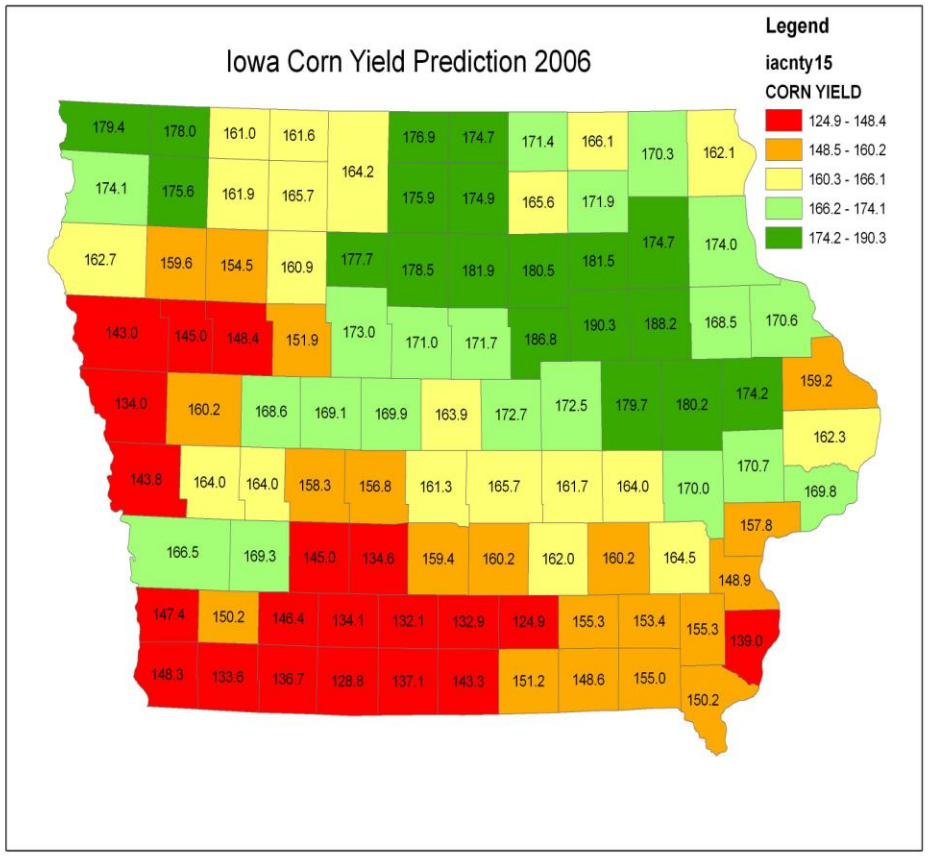


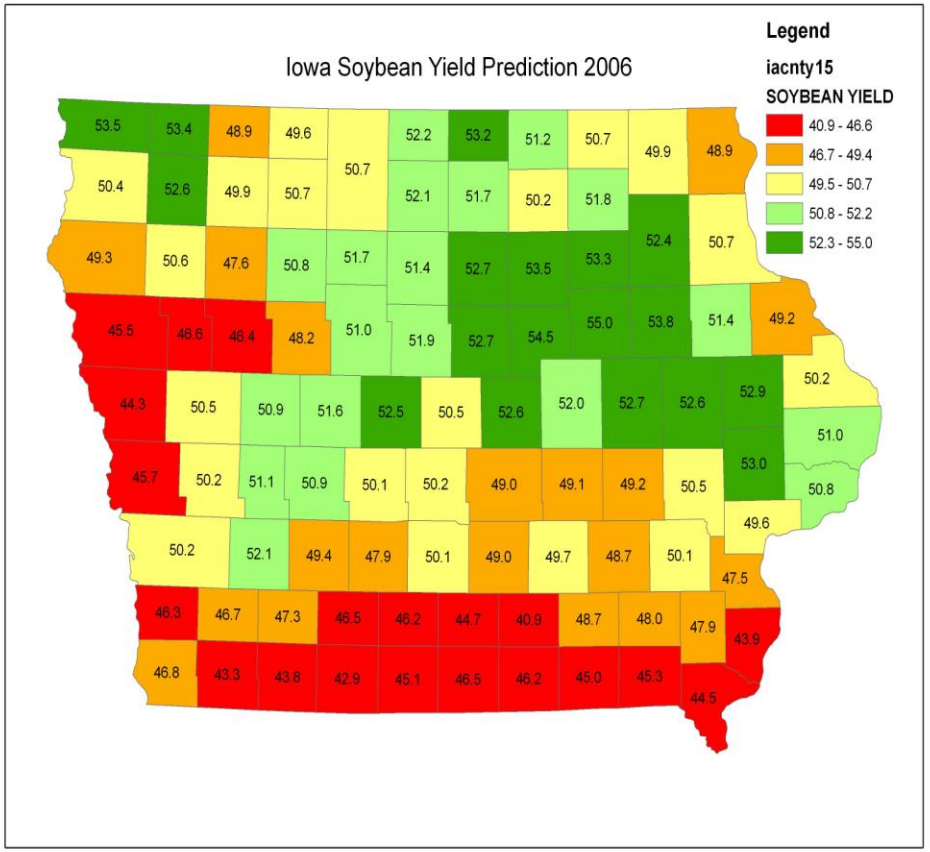
Model vs. Risk Management Agency vs. Official County Yield Estimates



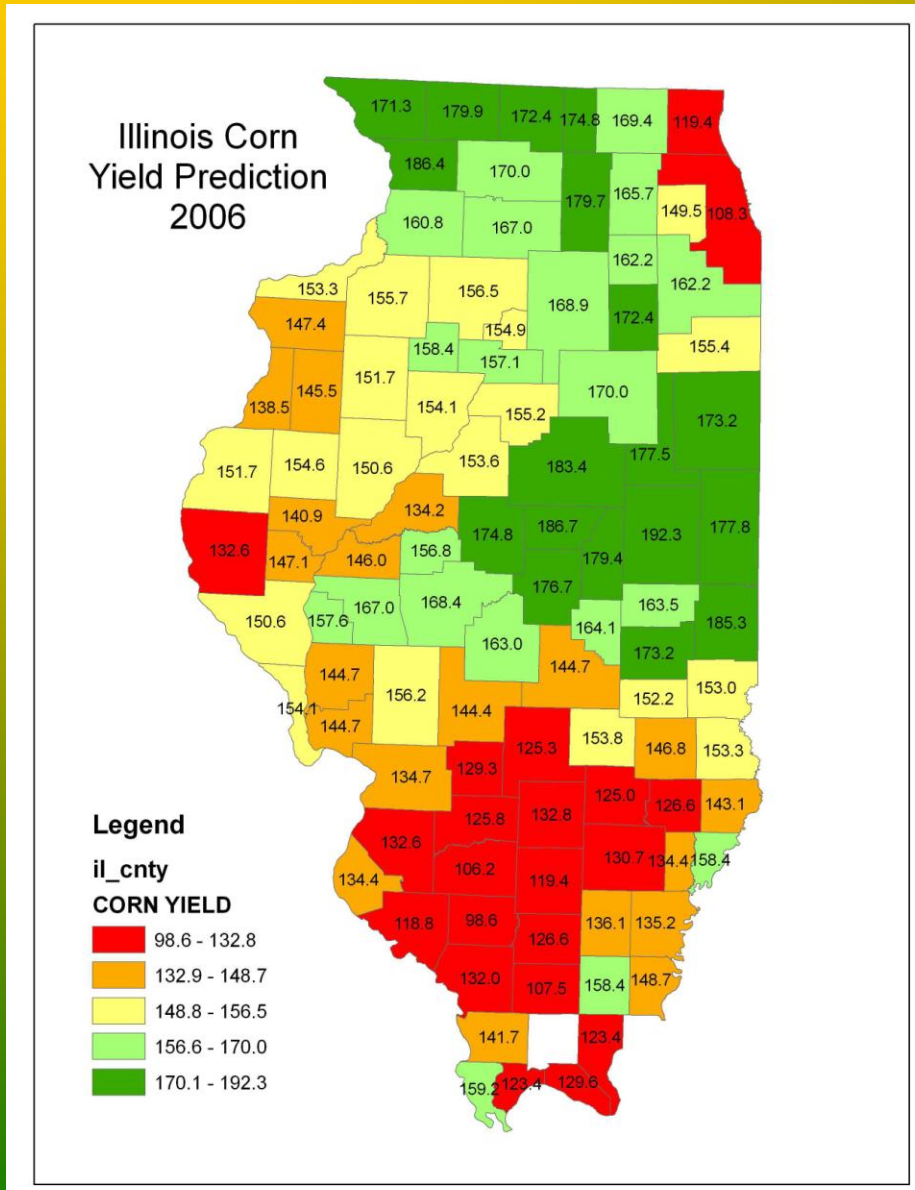


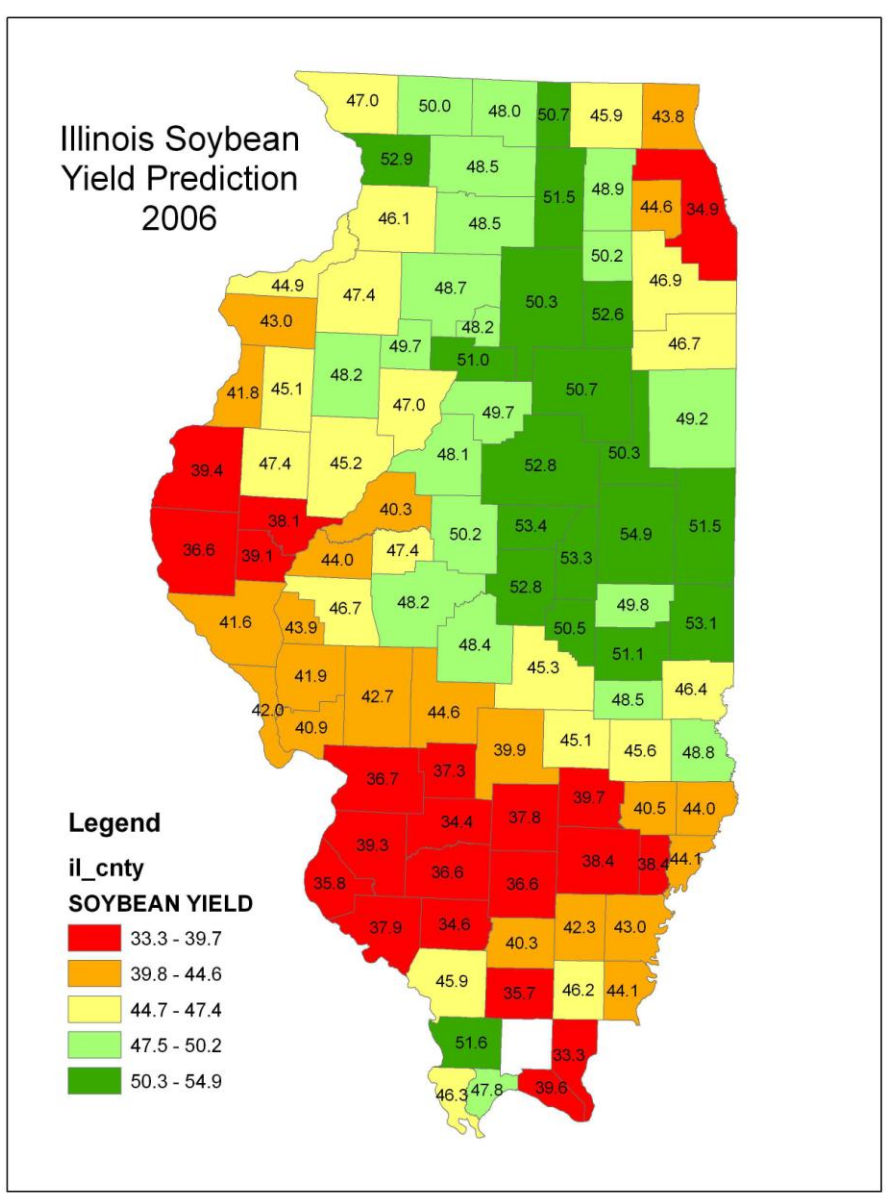
2006 Iowa Remote Sensing County Yields



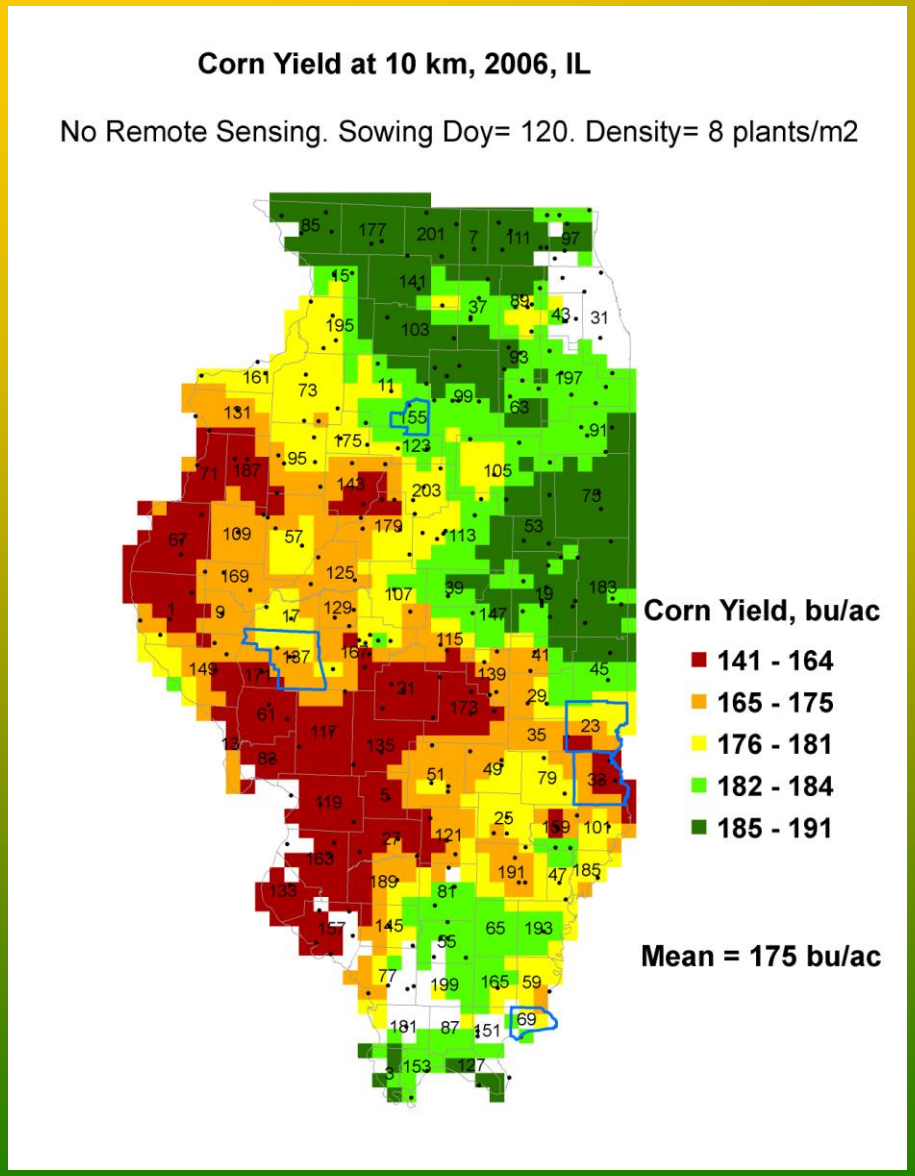


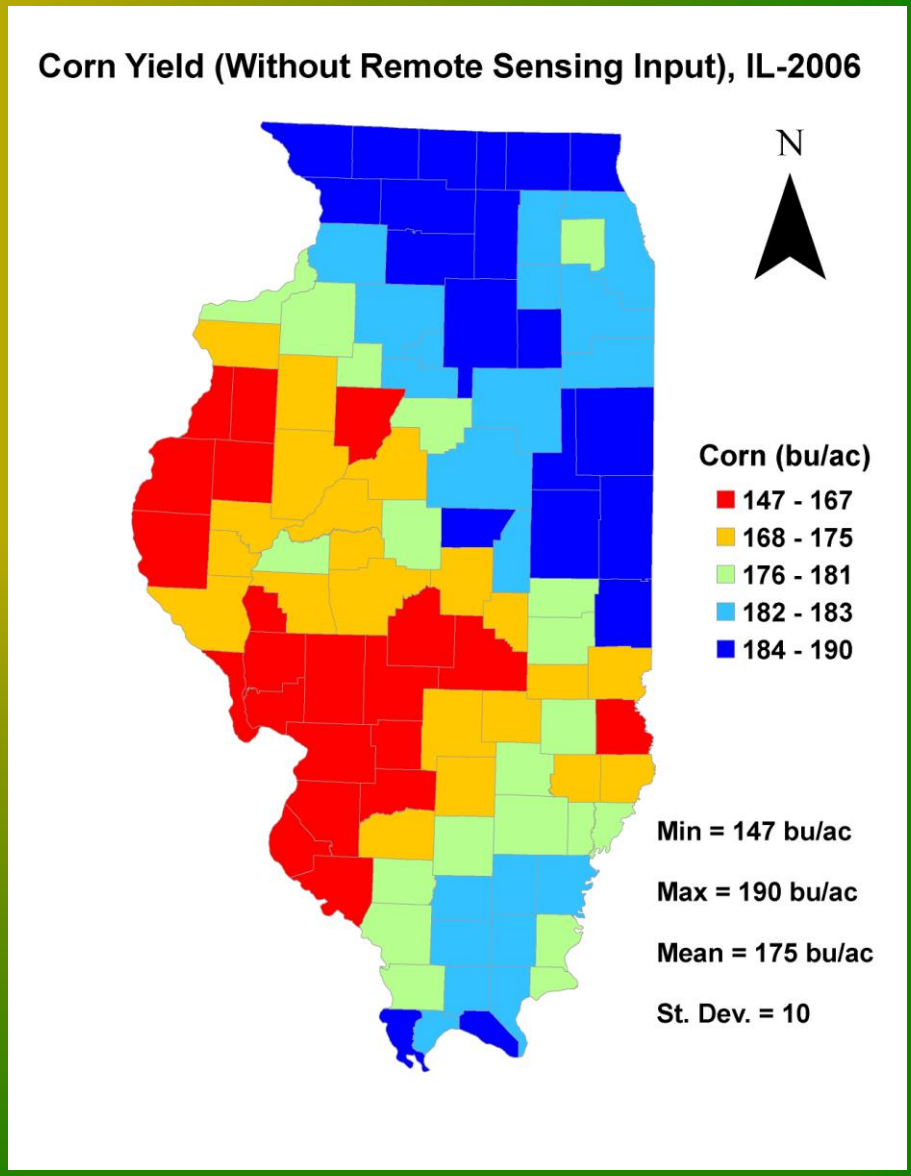
2006 Illinois Remote Sensing County Yields





Remote Sensing Support





Operational Considerations Advantages

- Statistical quality defined for both State & County
- Standardized methodology, being automated
- Staffing requirements are minimal
- Potential for reduced respondent burden
- Potential for reduced data collection costs

- Geo-referenced, digital data format
  - Estimates or GIS applications for other than political boundaries
- Farmer and courtroom defensible
- Potential for large area assessments
- Has significant international potential

Operational Considerations Disadvantages

- Technology dependent
- Climate dependent
- Represents significant change
- Requires new staff knowledge, skills & abilities
- Farming practices

Yield Summary

State-Level

- Remote sensing yields have been timely, mid-August, mid-September
- Program history is limited (03-06), so trends remain to be seen
  - Indications come with variance statistics
- Remote Sensing yield indications look as good or better than most other early season survey-based indicators
- RS yields are “bottom up”, derived from every square mile of crop in a state/county

County-Level

- Great majority (>85%) of county indications are within 10% of Official Estimates
- Majority of counties with >10% difference are those with small # of fields, i.e.,few reports
- Remote sensing county yields are available with the State yields…..mid-August, early September
- Definitional differences exist. Remote Sensing indications offer the most precise placement of yield within a county

Obrigado