Estimating US Crop Yields

From both the NASS survey and remote sensing perspectives

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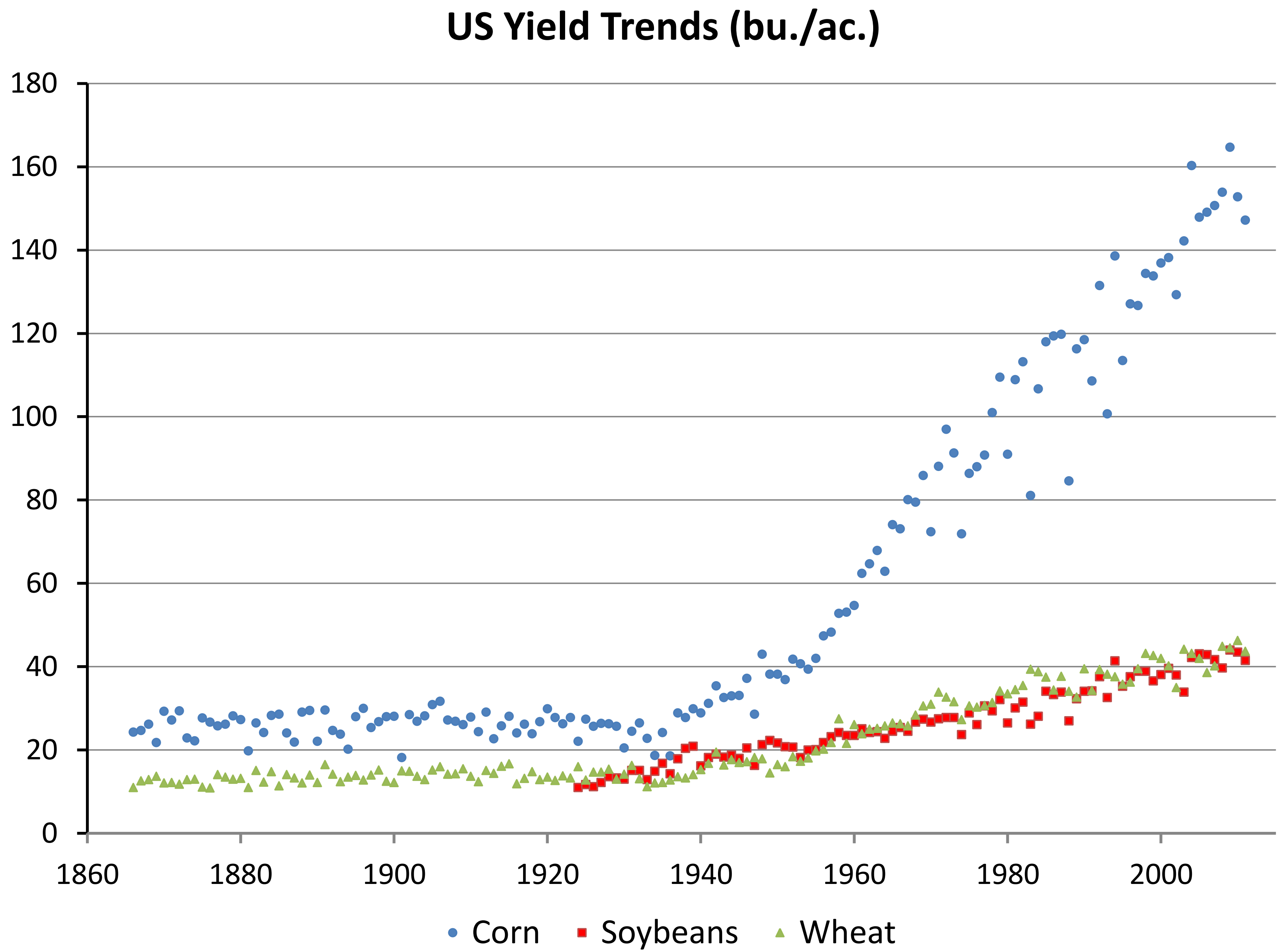

US Yield Trends (bu./ac.)
0
20
40
60
80
100
120
140
160
180
1860
1880
1900
1920
1940
1960
1980
2000
Corn
Soybeans
Wheat

Crop Production reports

Corn Area Planted for All Purposes and Harvested for Grain, Yield, and Production – States and United States: 2009-2011 (continued)

State	Yield per acre			Production		
	2009	2010	2011	2009	2010	2011
	(bushels)	(bushels)	(bushels)	(1,000 bushels)	(1,000 bushels)	(1,000 bushels)
Alabama	108.0	116.0	114.0	27,000	29,000	28,500
Arizona	175.0	210.0	180.0	3,500	4,620	5,760
Arkansas	148.0	150.0				
California	180.0	195.0				
Colorado	153.0	151.0				
Connecticut [1]	(NA)	(NA)				
Delaware	145.0	115.0				
Florida	100.0	105.0				
Georgia	140.0	145.0				
Idaho	180.0	180.0				
Illinois	174.0	157.0				
Indiana	171.0	157.0				
Iowa	182.0	165.0				
Kansas	155.0	125.0				
Kentucky	165.0	124.0				
Louisiana	132.0	140.0				
Maine [1]	(NA)	(NA)				
Maryland	145.0	106.0				
Massachusetts [1]	(NA)	(NA)				
Michigan	148.0	150.0				
Minnesota	174.0	177.0				
Mississippi	126.0	136.0				
Missouri	153.0	123.0				
Montana	152.0	135.0				
Nebraska	178.0	166.0				
Nevada [1]	(NA)	(NA)				
New Hampshire [1]	(NA)	(NA)				
New Jersey	143.0	114.0				
New Mexico	185.0	180.0				
New York	134.0	150.0				
North Carolina	117.0	91.0				
North Dakota	115.0	132.0				
Ohio	174.0	163.0				
Oklahoma	105.0	130.0				
Oregon	215.0	200.0				
Pennsylvania	143.0	128.0				
Rhode Island [1]	(NA)	(NA)				
South Carolina	111.0	91.0				
South Dakota	151.0	135.0				
Tennessee	148.0	117.0				
Texas	130.0	145.0				
Utah	155.0	172.0				
Vermont [1]	(NA)	(NA)				
Virginia	131.0	67.0				
Washington	215.0	205.0				
West Virginia	126.0	90.0				
Wisconsin	153.0	162.0				
Wyoming	140.0	121.0				
United States	164.7	152.8				

(NA) Not available.
[1] Area harvested for grain not estimated.

USDA

Crop Production

ISSN: 1936-3737

Released August 11, 2011, by the National Agricultural Statistics Service (NASS), Agricultural Statistics Board, United States Department of Agriculture (USDA).

Planted Acreage Update

Survey respondents who reported acreage as not yet planted in Minnesota, Montana, North Dakota, and South Dakota during the survey conducted in preparation for the *Acreage* report, released June 30, 2011 were re-contacted in July to determine how many of those acres were planted or still intended to be planted. Acreage estimates in this report reflect this updated information.

Corn Production Up 4 Percent from 2010
Soybean Production Down 8 Percent from 2010
Cotton Production Down 9 Percent from 2010
All Wheat Production Down 1 Percent from July Forecast

Corn production is forecast at 12.9 billion bushels, up 4 percent from 2010. If realized, this will be the third largest production total on record for the United States. Based on conditions as of August 1, yields are expected to average 153.0 bushels per acre, up 0.2 bushel from 2010, and the fourth highest yield on record. Acreage planted for all purposes is estimated at 92.3 million acres, unchanged from the June estimate. Area harvested for grain is forecast at 84.4 million acres, down less than 1 percent from June but up 4 percent from 2010.

Soybean production is forecast at 3.06 billion bushels, down 8 percent from last year. Based on August 1 conditions, yields are expected to average 41.4 bushels per acre, down 2.1 bushels from last year. Area for harvest in the United States is forecast at 73.8 million acres, down less than 1 percent from June and down 4 percent from 2010. Planted area for the Nation is estimated at 75.0 million acres, down fractionally from June.

All cotton production is forecast at 16.6 million 480-pound bales, down 9 percent from last year's 18.1 million bales. Yield is expected to average 822 pounds per harvested acre, up 10 pounds from last year. Upland cotton production is forecast at 15.8 million 480-pound bales, down 10 percent from 2010. American Pima production is forecast at 737,200 bales, up 46 percent from last year. Producers expect to harvest 9.67 million acres of all cotton, down 10 percent from 2010. This harvested total includes 9.38 million acres of Upland cotton and 287,500 acres of Pima cotton.

All wheat production, at 2.08 billion bushels, is down 1 percent from the July forecast and down 6 percent from 2010. Based on August 1 conditions, the United States yield is forecast at 45.2 bushels per acre, up 0.6 bushel from last month but down 1.2 bushels from last year.

USDA

United States Department of Agriculture
National Agricultural Statistics Service

Crop Production
2011 Summary

January 2012

ISSN: 1057-7823

USDA

Agricultural Yield Survey

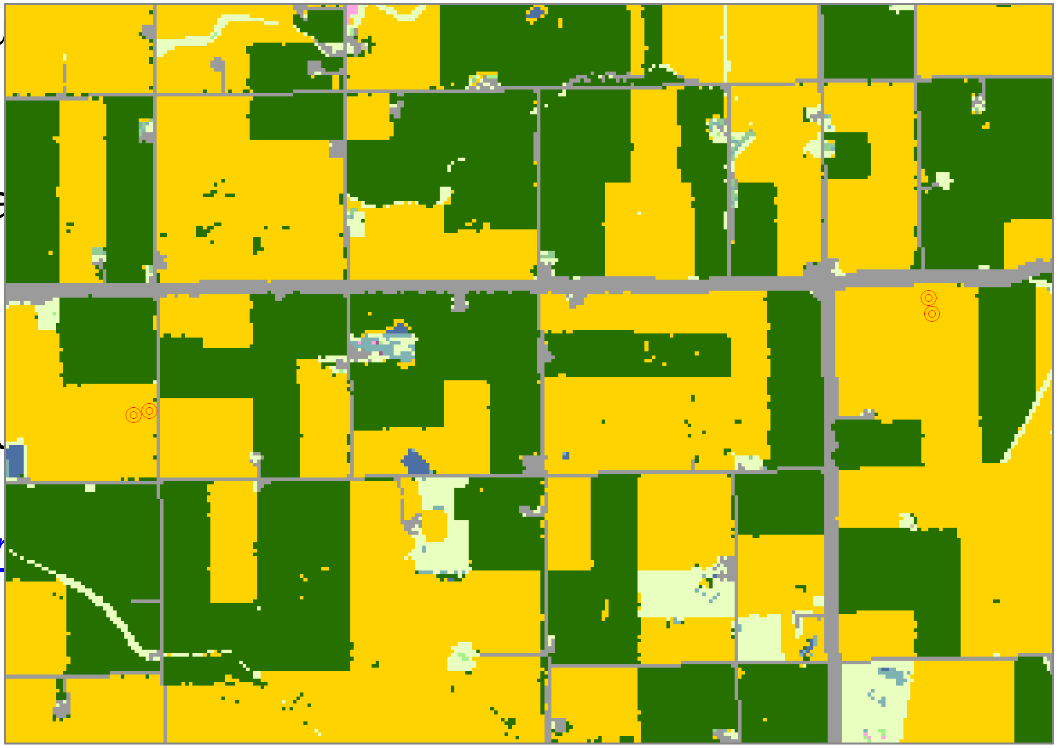
Agricultural Yield
The Agricultural Yield survey provides farmer reported survey data of expected crop yields used to forecast and estimate crop production levels throughout the growing season.
The Agricultural Yield survey is conducted in all states except Alaska and Hawaii. Samples of farm operators are selected from the March Crops/Stocks survey (small grains) and the June Crops/Stocks survey (late season crops and tobacco). Farmers reporting acreage of at least one commodity of interest are included in the monthly data collection to forecast crop yields.

Publications
The *Crop Production* report is published no later than the 12th of each month. Acreage, yield, and production forecasts and estimates are prepared for the crops in season.

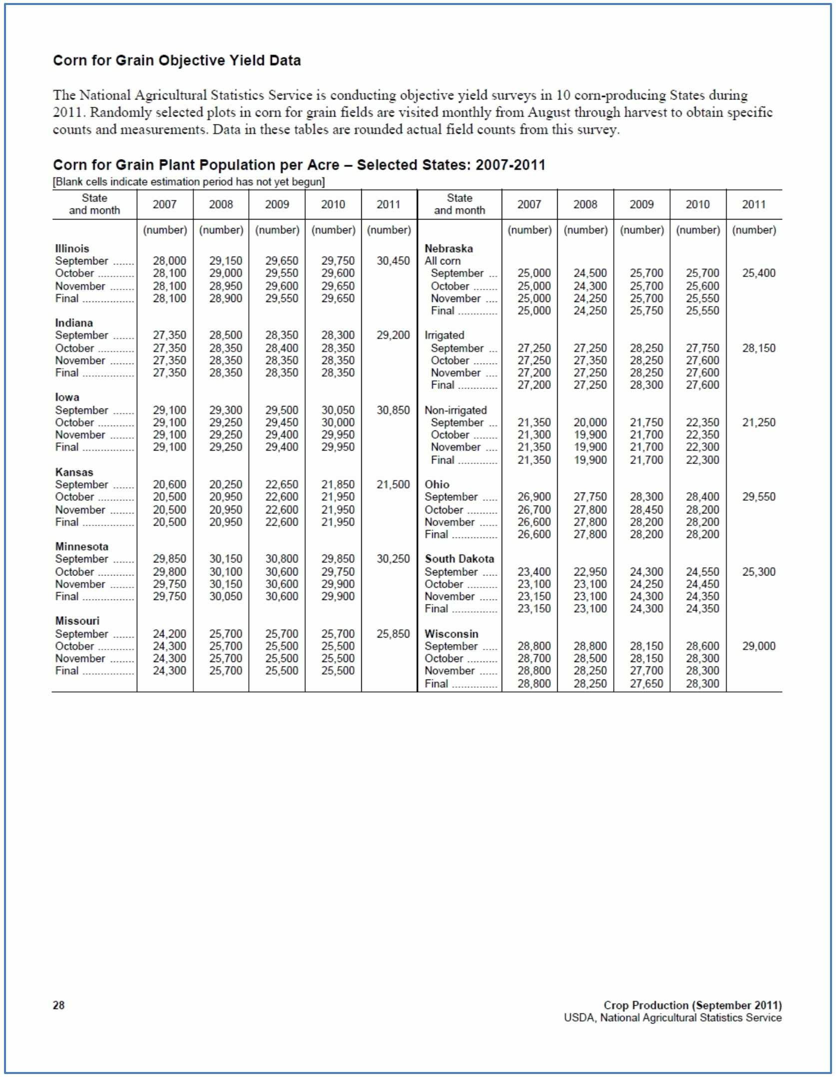
Objective yield

Corn - Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, South Dakota, Wisconsin
Cotton - Arkansas, California, Georgia, Louisiana, Mississippi, North Carolina, Texas
Soybeans - Arkansas, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Sou
Wheat - Colorado, Illinois, Kansas,
Oklahoma, Texas, Washington
Potatoes - Idaho, Maine, Minnesota
Wisconsin

Publications
Monthly production forecasts are pu
season estimates are issued in the
mid-January *Crop Production Sumr*



Plant counts vs yield



Corn for Grain Objective Yield Data

The National Agricultural Statistics Service is conducting objective yield surveys in 10 corn-producing States during 2011. Randomly selected plots in corn for grain fields are visited monthly from August through harvest to obtain specific counts and measurements. Data in these tables are rounded actual field counts from this survey.

Corn for Grain Plant Population per Acre – Selected States: 2007-2011

[Blank cells indicate estimation period has not yet begun]

State and month	2007	2008	2009	2010	2011
	(number)	(number)	(number)	(number)	(number)
Illinois					
September	28,000	29,150	29,650	29,750	30,450
October	28,100	29,000	29,550	29,600	
November	28,100	28,950	29,600	29,650	
Final	28,100	28,900	29,550	29,650	
Indiana					
September	27,350	28,500	28,350	28,300	29,200
October	27,350	28,350	28,400	28,350	
November	27,350	28,350	28,350	28,350	
Final	27,350	28,350	28,350	28,350	
Iowa					
September	29,100	29,300	29,500	30,050	30,850
October	29,100	29,250	29,450	30,000	
November	29,100	29,250	29,400	29,950	
Final	29,100	29,250	29,400	29,950	
Kansas					
September	20,600	20,250	22,650	21,850	21,500
October	20,500	20,950	22,600	21,950	
November	20,500	20,950	22,600	21,950	
Final	20,500	20,950	22,600	21,950	
Minnesota					
September	29,850	30,150	30,800	29,850	30,250
October	29,800	30,100	30,600	29,750	
November	29,750	30,150	30,600	29,900	
Final	29,750	30,050	30,600	29,900	
Missouri					
September	24,200	25,700	25,700	25,700	25,850
October	24,300	25,700	25,500	25,500	
November	24,300	25,700	25,500	25,500	
Final	24,300	25,700	25,500	25,500	

State and month	2007	2008	2009	2010	2011
	(number)	(number)	(number)	(number)	(number)
Nebraska					
All corn					
September	25,000	24,500	25,700	25,700	25,400
October	25,000	24,300	25,700	25,600	
November	25,000	24,250	25,700	25,550	
Final	25,000	24,250	25,750	25,550	
Irrigated					
September	27,250	27,250	28,250	27,750	28,150
October	27,250	27,350	28,250	27,600	
November	27,200	27,250	28,250	27,600	
Final	27,200	27,250	28,300	27,600	
Non-irrigated					
September	21,350	20,000	21,750	22,350	21,250
October	21,300	19,900	21,700	22,350	
November	21,350	19,900	21,700	22,300	
Final	21,350	19,900	21,700	22,300	
Ohio					
September	26,900	27,750	28,300	28,400	29,550
October	26,700	27,800	28,450	28,200	
November	26,600	27,800	28,200	28,200	
Final	26,600	27,800	28,200	28,200	
South Dakota					
September	23,400	22,950	24,300	24,550	25,300
October	23,100	23,100	24,250	24,450	
November	23,150	23,100	24,300	24,350	
Final	23,150	23,100	24,300	24,350	
Wisconsin					
September	28,800	28,800	28,150	28,600	29,000
October	28,700	28,500	28,150	28,300	
November	28,800	28,250	27,700	28,300	
Final	28,800	28,250	27,650	28,300	

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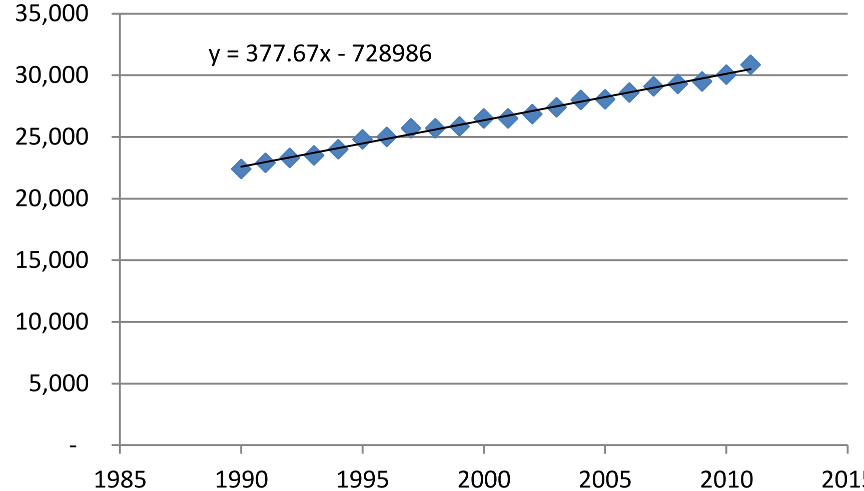
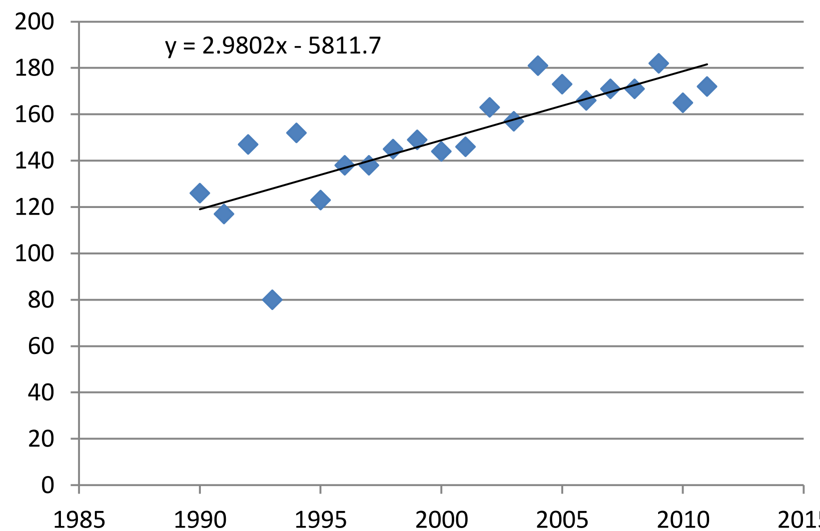
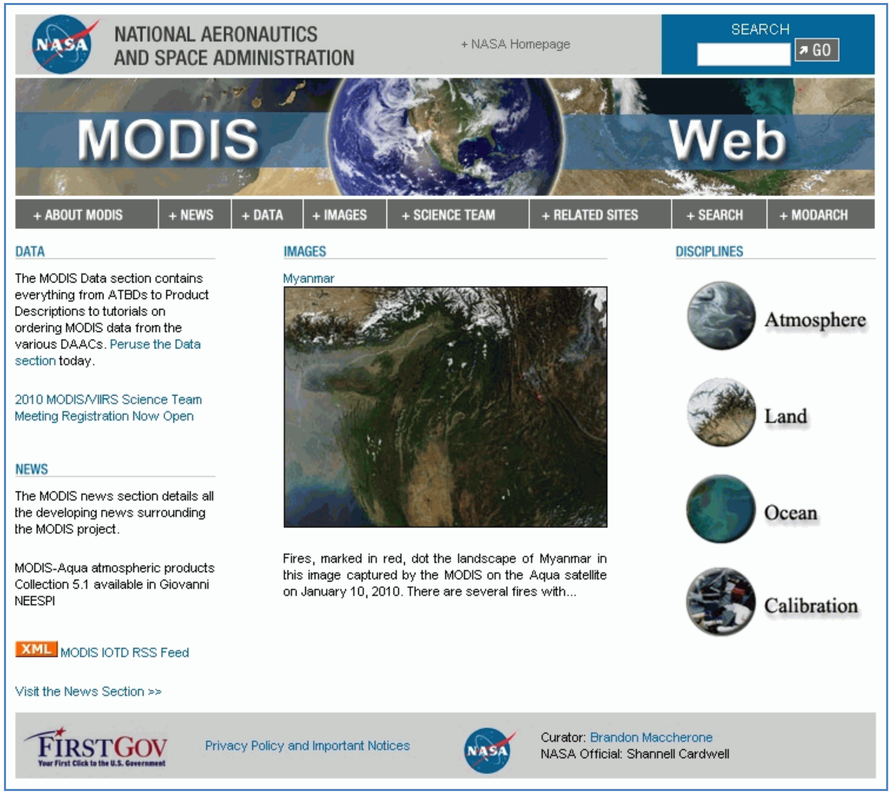
Crop Production (September 2011)
USDA, National Agricultural Statistics Service





Yield from remote sensing: MODIS-based

- Global coverage
- Daily revisit rate
- 15 acre ground sample resolution
  - from red and near-infrared bands
- "Best of" image mosaics automatically generated
  - 8 and 16-day temporal windows
- Timely
  - data usually available within a few days
- Free distribution
  - downloaded via ftp
- Robust user group
  - nearly 20,000 citations so far
- Launched in 1999 and 2002
  - 10-year plus history
- 6 year design life but still functioning fine
- Similar follow-on mission in near future
  - VIIRS



modis.gsfc.nasa.gov

Data distribution of MODIS "standard products"

Data Set Name:

Surface Reflectance 8-Day L3 Global 250m

Print Product Page

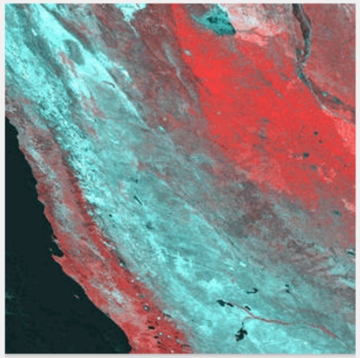
Short Name:
MOD09Q1

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmospheric scattering or absorption. Low-level data are corrected for atmospheric gases and aerosols, yielding a level-2 basis for several higher-order gridded level-2 (L2G) and level-3 products.

MOD09Q1 provides Bands 1 and 2 at 250-meter resolution in an 8-day gridded level-3 product in the Sinusoidal projection. Each MOD09Q1 pixel contains the best possible L2G observation during an 8-day period as selected on the basis of high observation coverage, low view angle, the absence of clouds or cloud shadow, and aerosol loading. Science Data Sets provided for this product include reflectance values for Bands 1 and 2, and a quality rating.

Version-5 MODIS/Terra Surface Reflectance products are Validated Stage 2, meaning that accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts. Although there may be later improved versions, these data are ready for use in scientific publications.

Short Name: MOD09Q1



A combination of Bands 2, 2, 1 displays a false-color Surface Reflectance image using 250-m data acquired between February 10–17, 2007 over parts of Chile and Argentina (h12v12). The fertile Central Valley of Chile appears to the southwest in red, as do the agricultural lowlands of Argentina's Las Pampas in the northeast corner of the image.

Change Points of Interest

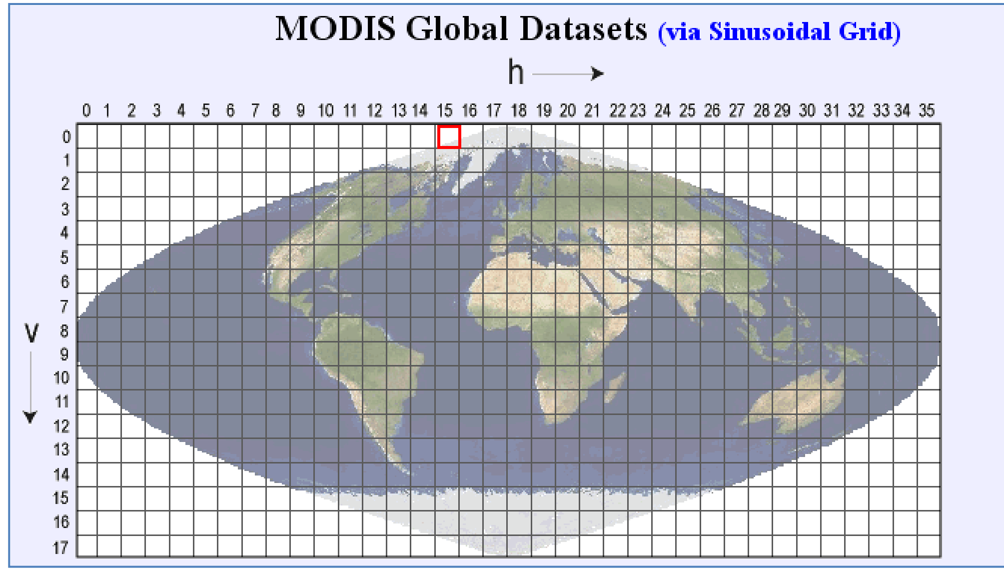
- Reduced file volume: internal compression
- Improved aerosol retrieval

Overview | Links | Layers | Policies | Get Data | Help

Overview

Data Set Characteristics

Temporal Coverage	February 24, 2000 -
Area	~10 x 10 lat/long
File Size	~72 MB
Projection	Sinusoidal
Data Format	HDF-EOS
Dimensions	4800 x 4800 rows/columns
Resolution	250 meters
Science Data Sets (SDS HDF Layers)	3



- Distributed in 10 x 10 tiles
  - lower 48 states =14 tiles
  - Corn Belt = 4 tiles
- Sinusoidal projection
  - unusual but not a problem
- NASA HDF file format
  - some somewhere can ingest
- 2-3 Data latency
  - Improves a bit every year

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Normalized Difference Vegetation Index

From Wikipedia, the free encyclopedia

This article **reads more like a story than an encyclopedia entry**. To meet Wikipedia's quality standards and conform to the neutral point of view policy, please help to introduce a more formal style and remove any personally invested tone. *(July 2011)*

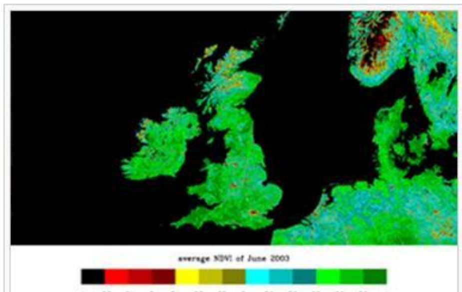
The **Normalized Difference Vegetation Index** (**NDVI**) is a simple graphical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not.

Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Lastly, low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).[1]

Contents

Brief history [edit]

The exploration of outer space started in earnest with the launch of Sputnik 1 by the Soviet Union on 4 October 1957. This was the first man-made satellite orbiting the Earth. Subsequent successful launches, both in the Soviet Union (e.g., the Sputnik and Cosmos programs), and in the U.S. (e.g., the Explorer program), quickly led to the design and operation of dedicated meteorological satellites. These are orbiting platforms embarking instruments specially designed to observe the Earth's atmosphere and surface with a view to improve weather forecasting. Starting in 1960, the TIROS series of satellites embarked television cameras and radiometers. This was later (from 1964 onwards) followed by the Nimbus satellites and the family of Advanced Very High Resolution Radiometer instruments on-board the National Oceanic and Atmospheric Administration (NOAA) platforms. The latter measures the reflectance of the planet in red and near-infrared bands, as well as in the thermal infrared. In parallel, NASA developed the Earth Resources Technology Satellite (ERTS), which became the precursor to the Landsat program. These early sensors had minimal spectral resolution, but tended to include bands



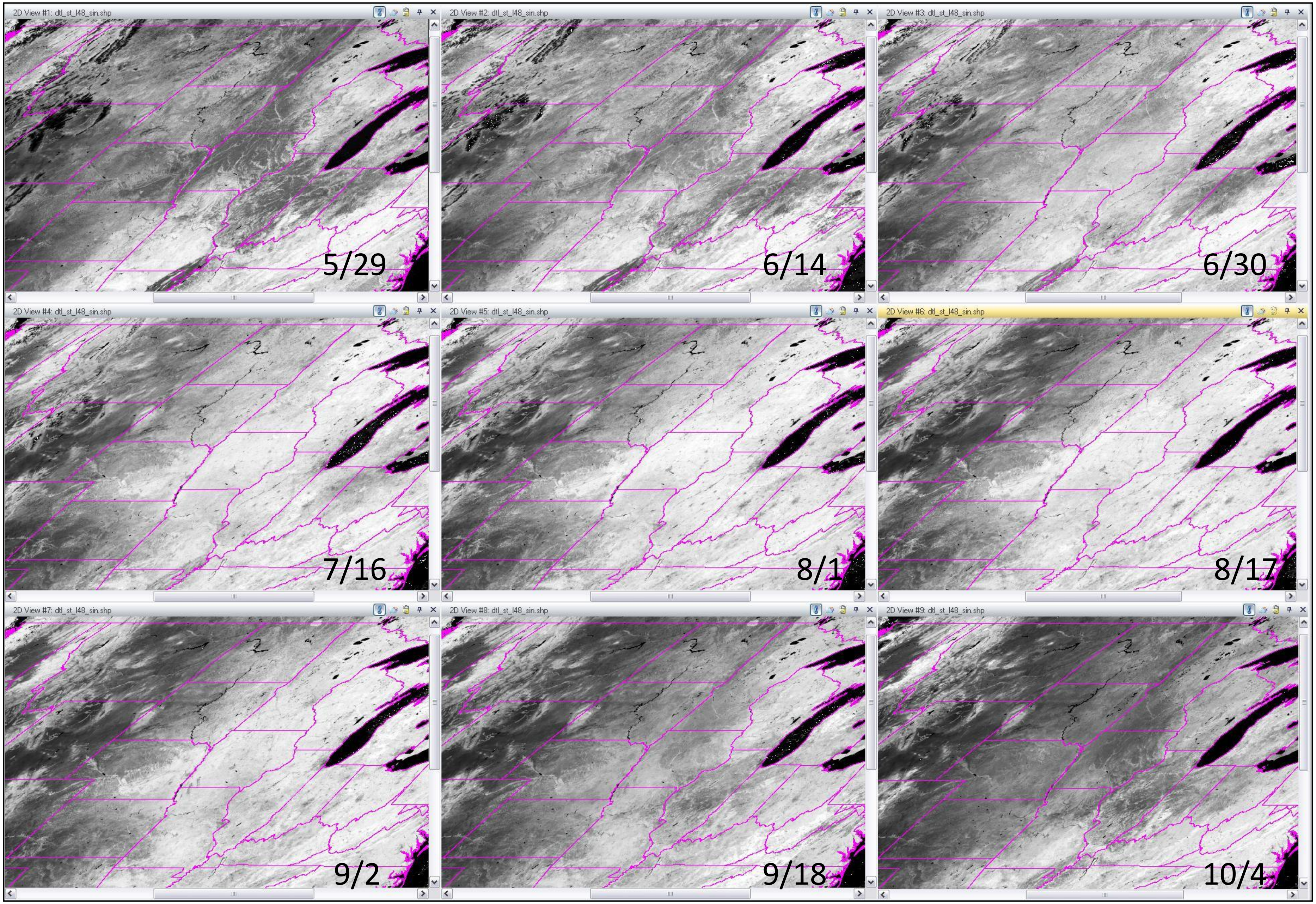
NDVI in June over the British Isles (NOAA AVHRR)

$$\text{NDVI} = \frac{(\text{NIR} - \text{VIS})}{(\text{NIR} + \text{VIS})}$$

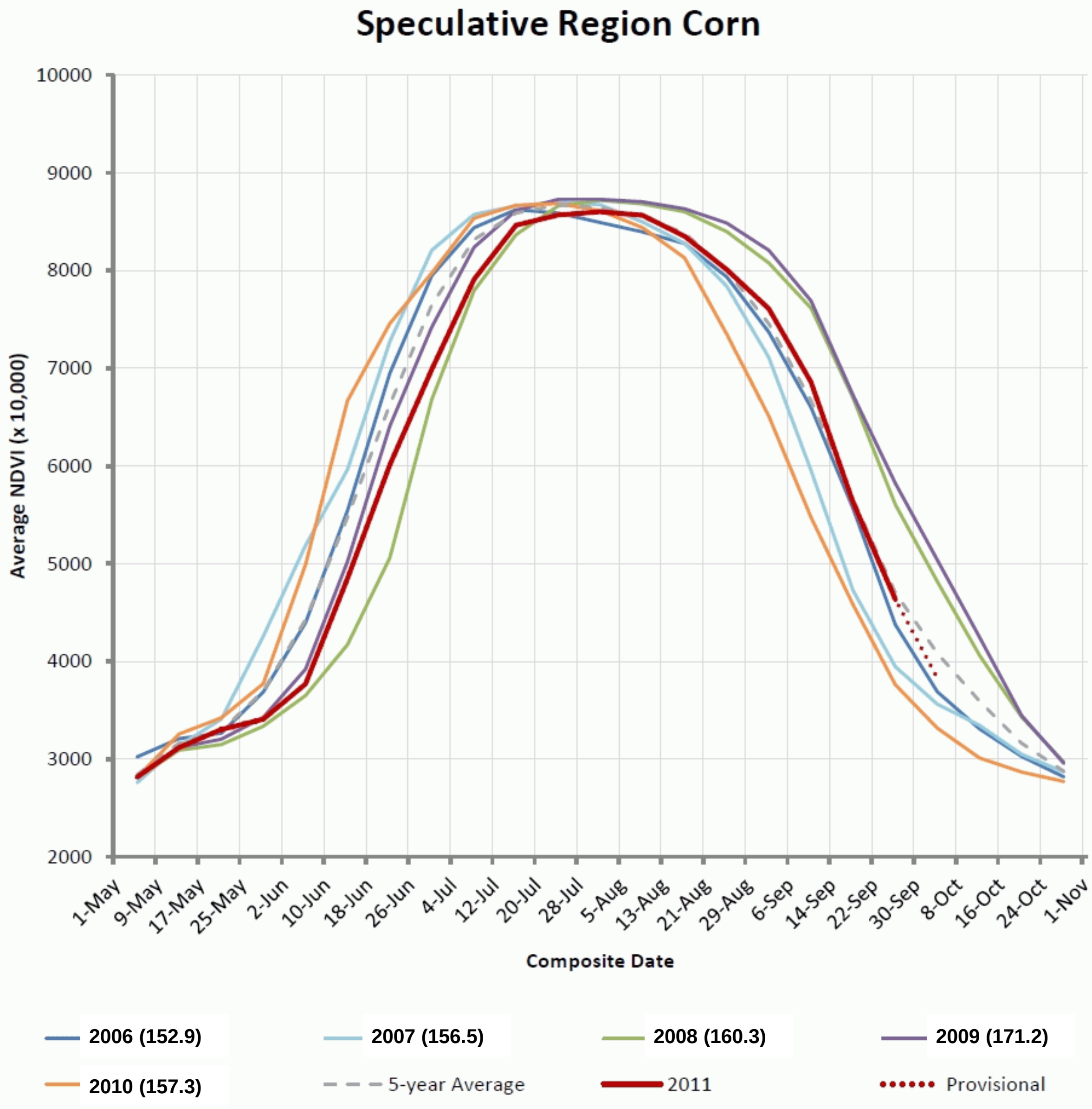
NIR = near-infrared

VIS = visible

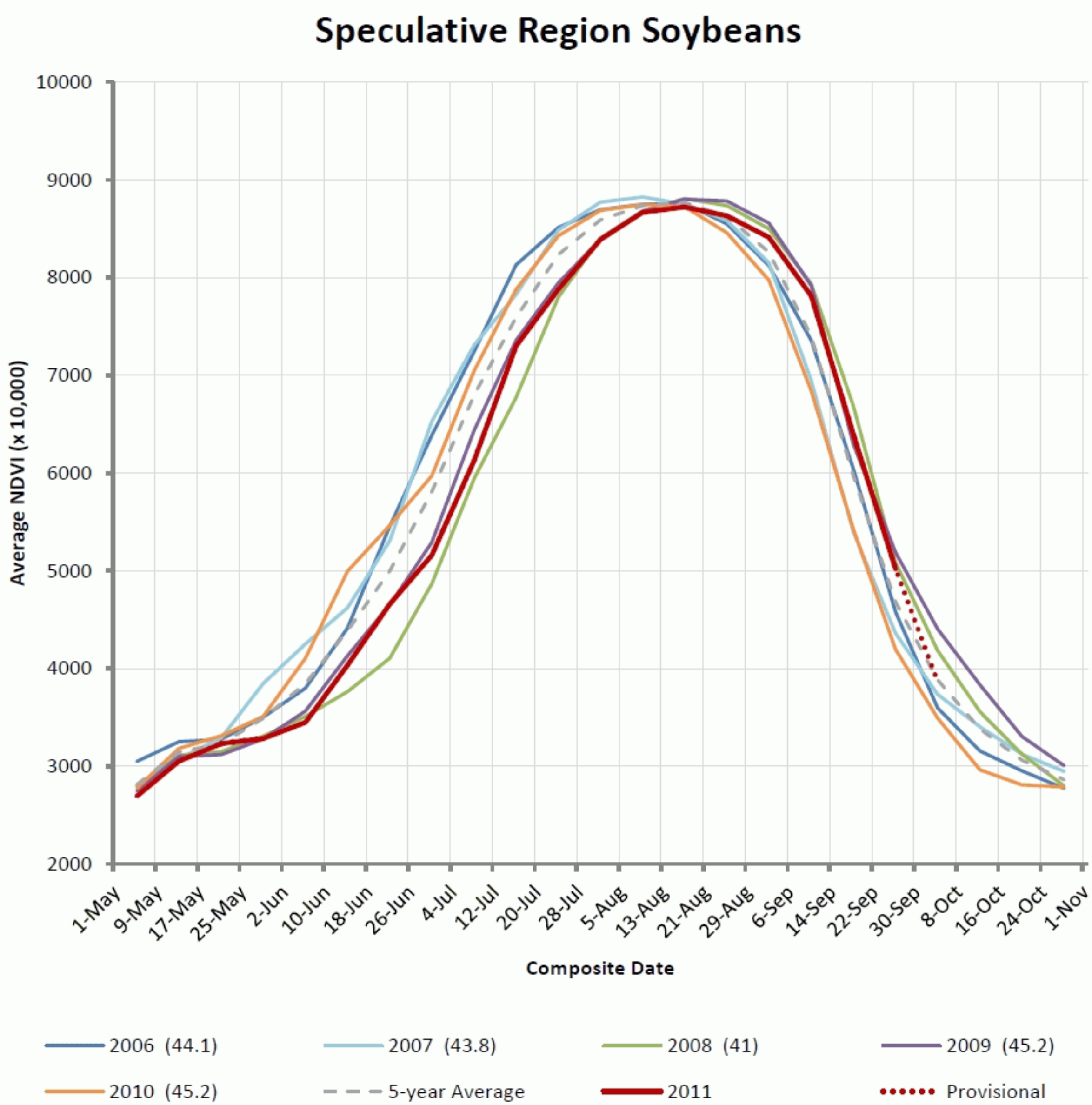
Synoptic look at NDVI over 2011 growing season



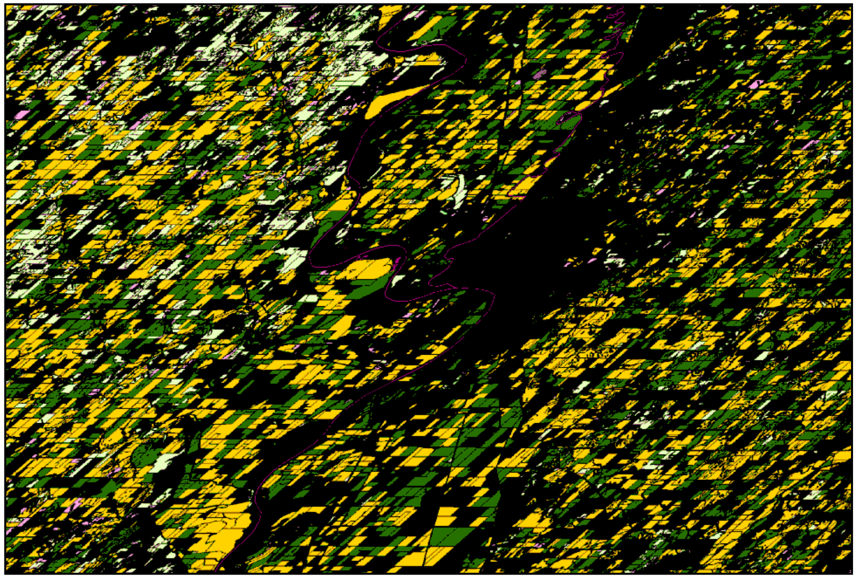
The NDVI time series viewed only with those pixels containing corn



2011 official Speculative Region (“Cornbelt”) yield = 152.5

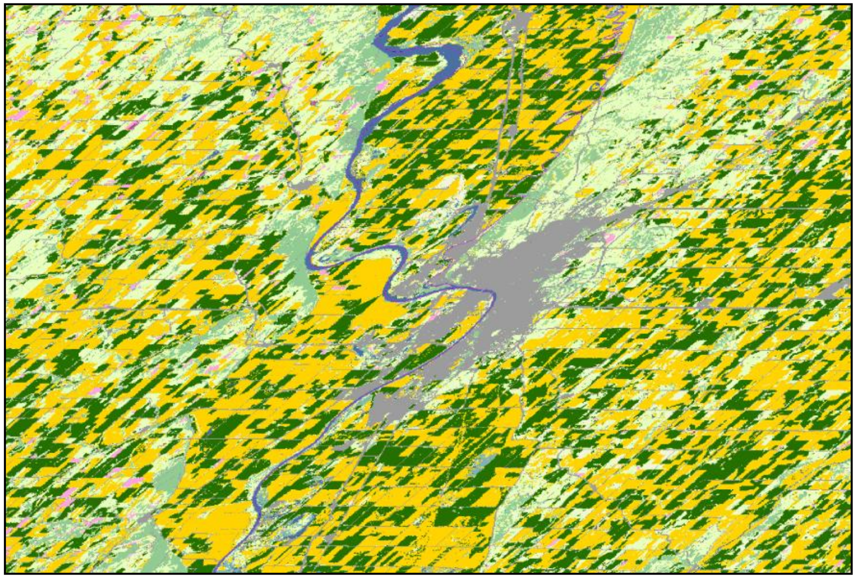

Speculative Region Soybeans
Average NDVI (x 10,000)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1-May
9-May
17-May
25-May
2-Jun
10-Jun
18-Jun
26-Jun
4-Jul
12-Jul
20-Jul
28-Jul
5-Aug
13-Aug
21-Aug
29-Aug
6-Sep
14-Sep
22-Sep
30-Sep
8-Oct
16-Oct
24-Oct
1-Nov
Composite Date
2006 (44.1)
2007 (43.8)
2008 (41)
2009 (45.2)
2010 (45.2)
5-year Average
2011
Provisional

How to establish the pixels that are only corn

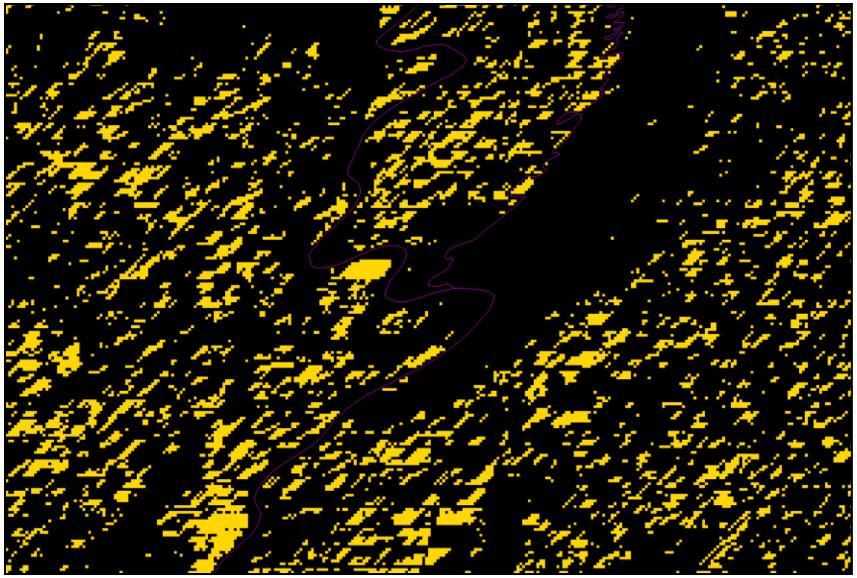


FSA CLU/578
(early season)

- or -

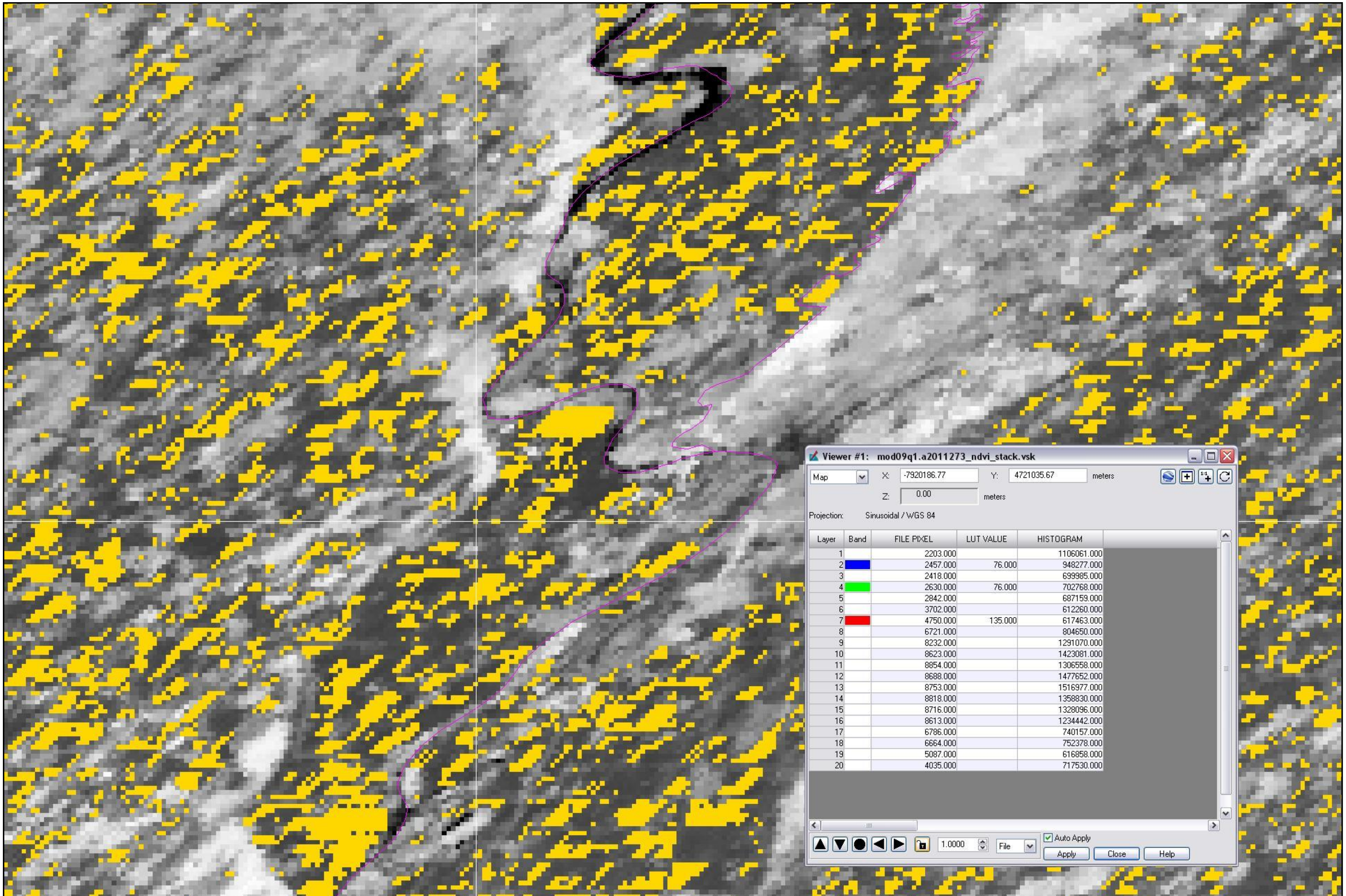


NASS CDL
(late season)

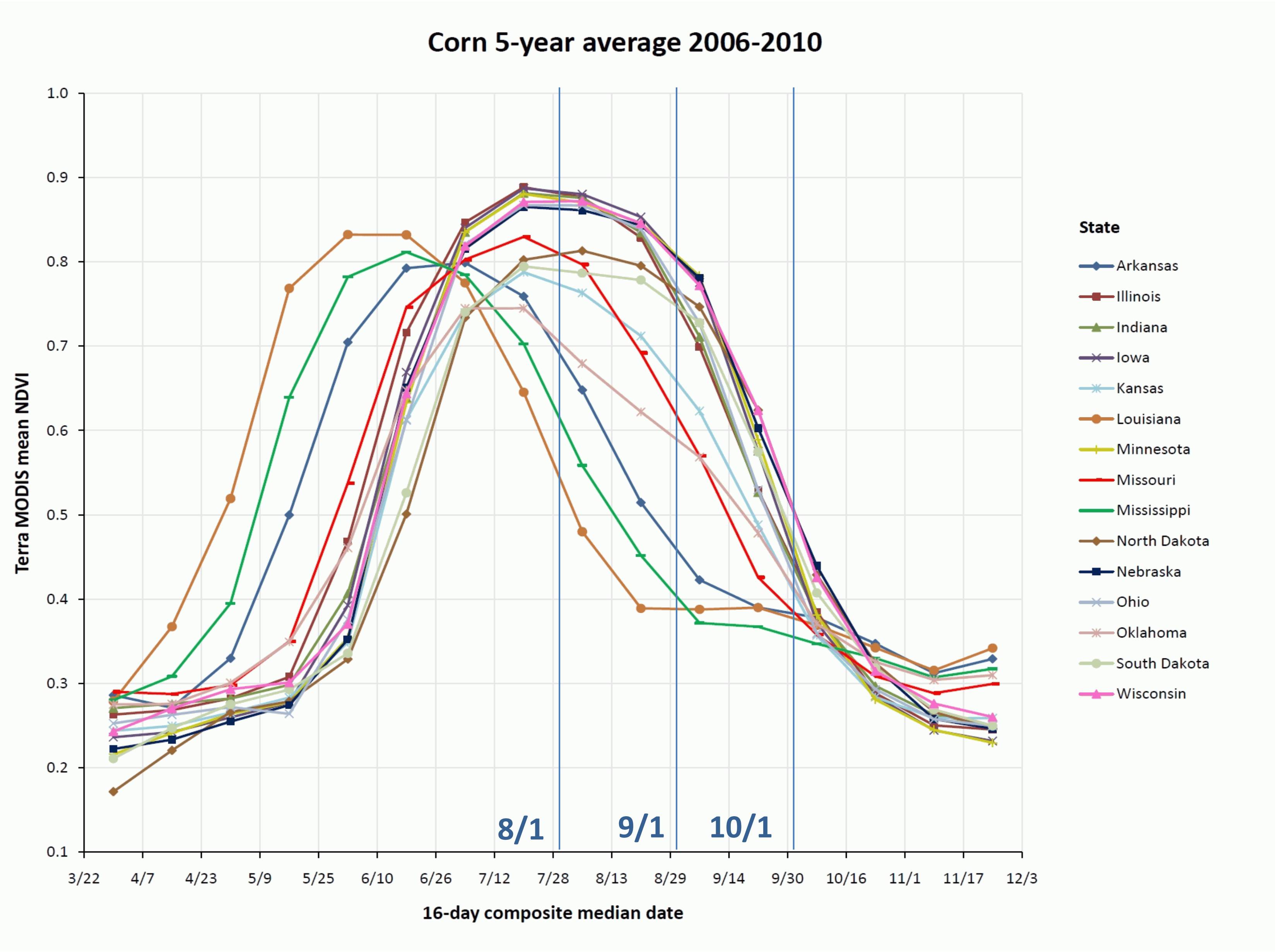


MODIS-scaled
High probability sample
of corn areas

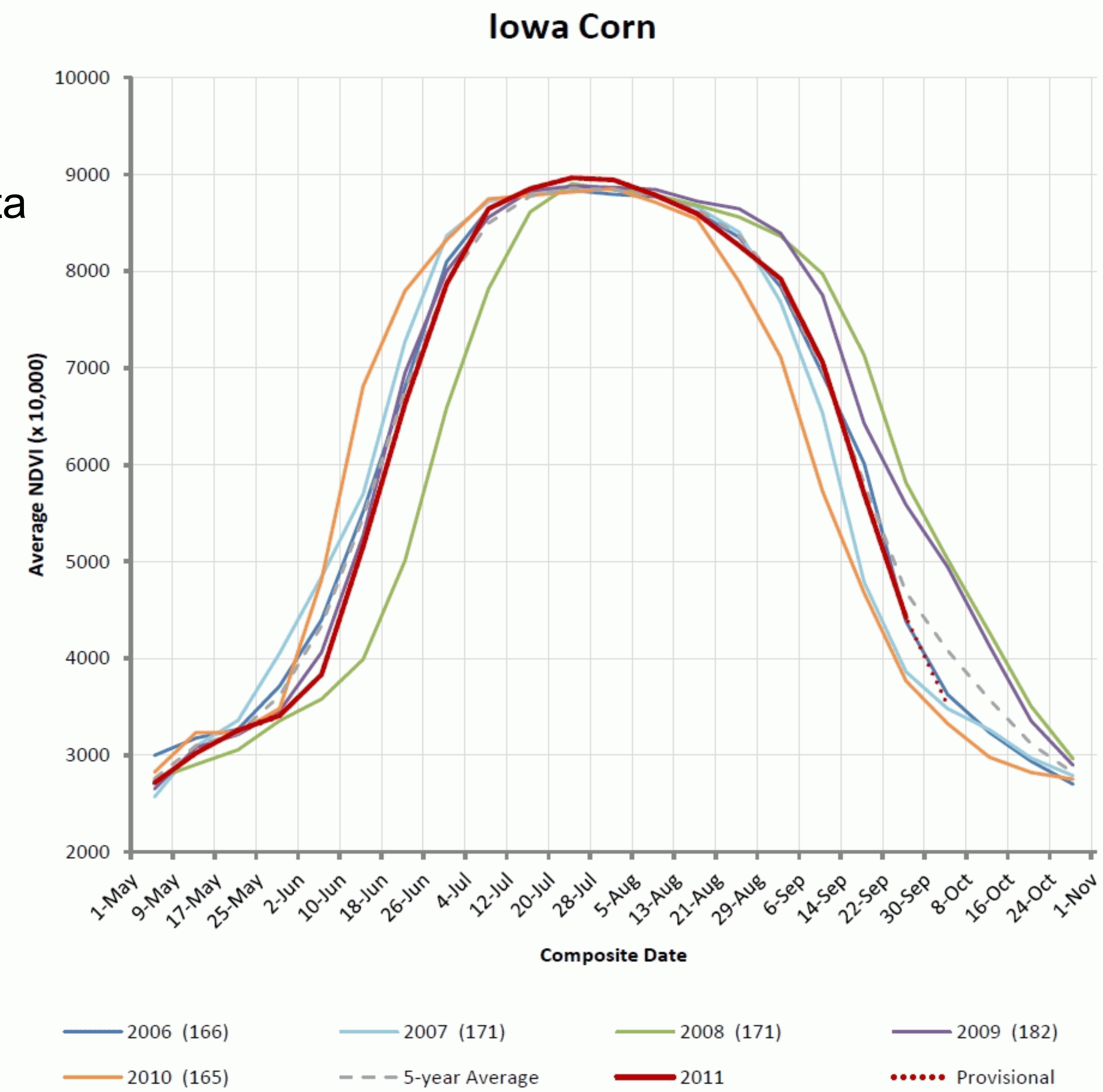
Intersecting corn "mask" with MODIS data



Corn timing importance

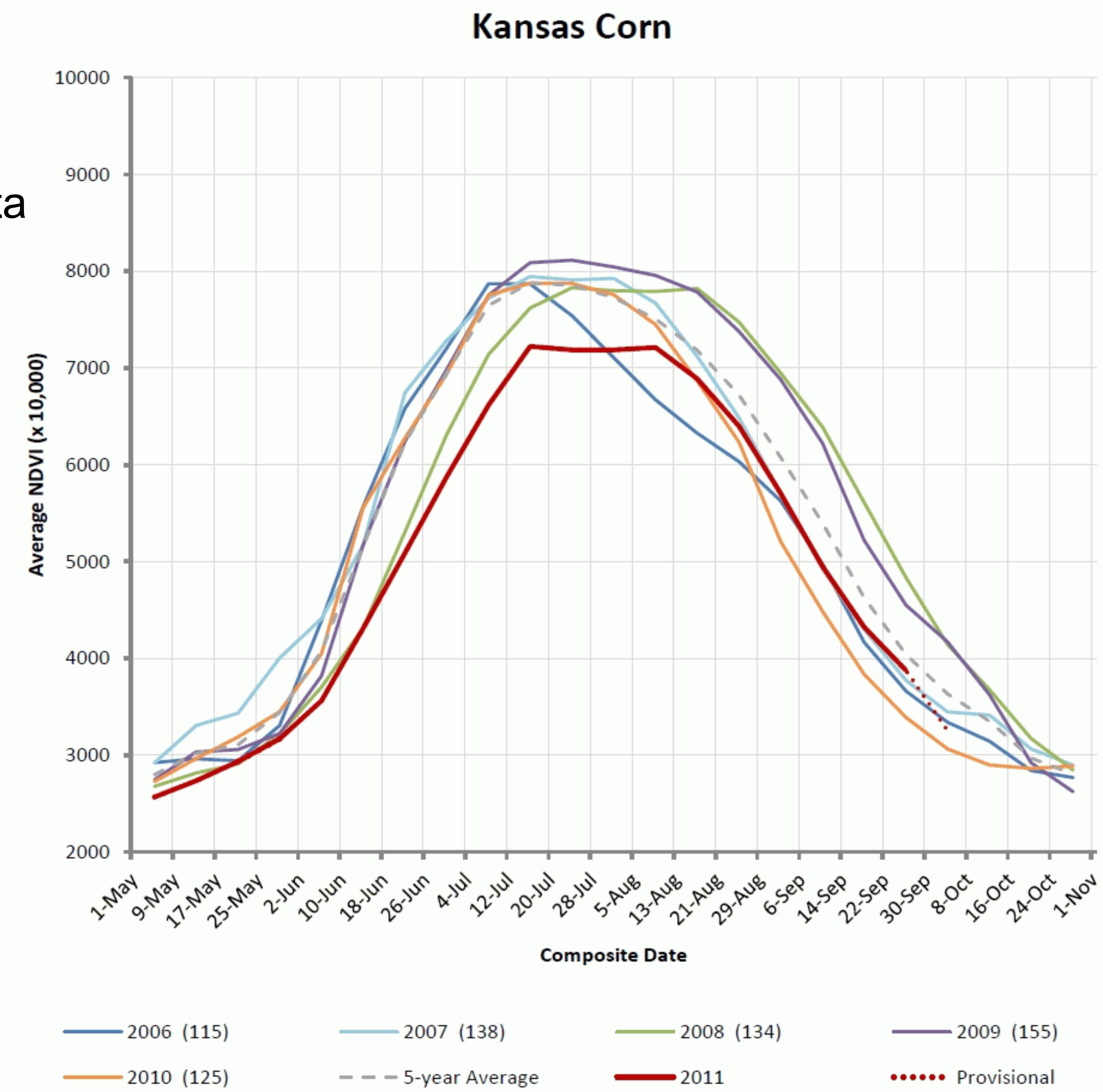


This year's data example #2



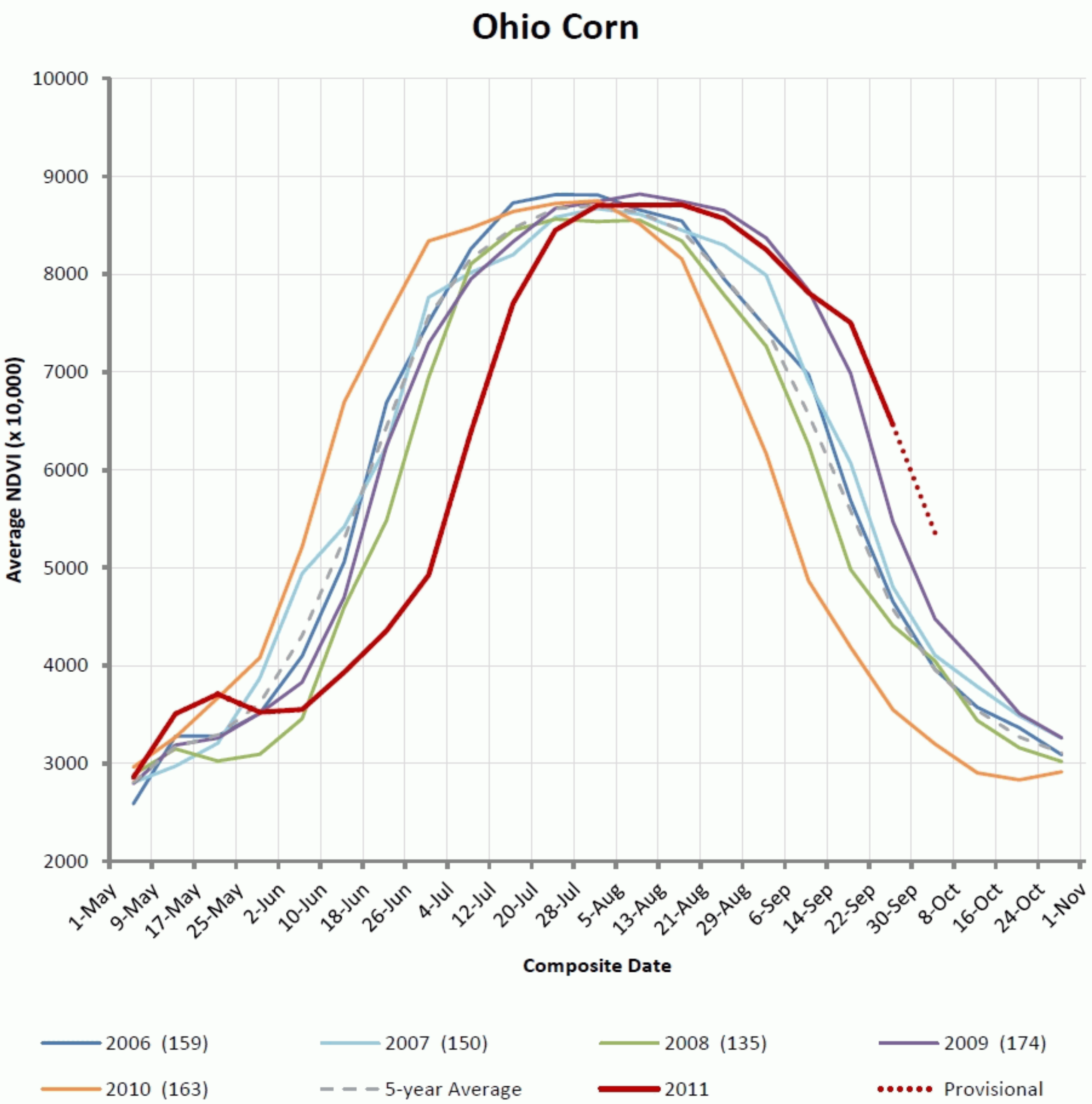
2011 official yield = 169 (October)

This year's data example #3



2011 official yield = 105 (October)

This year's data example #4



2011 official yield = 154 (October)

Modeling premise

The “bigger” the NDVI curve the bigger the yield

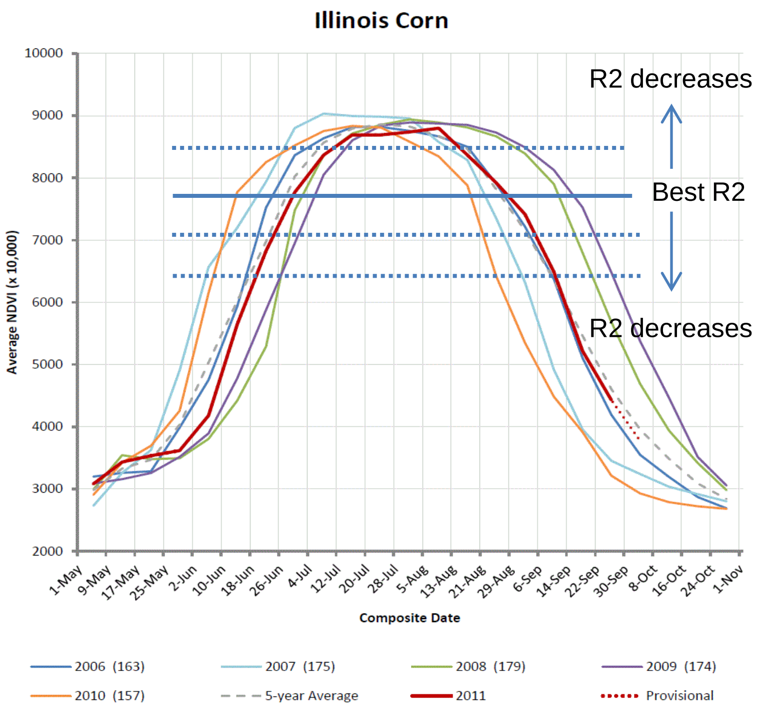
- NDVI peak
  - Mild relationship between the peak of the NDVI vs. yield
- NDVI accumulated area
  - Good relationship between area under the curve (and over some threshold) vs. yield

Both improved by also incorporating a trend component

Yield = (f(NDVI) * m1) + (year * m2) + b

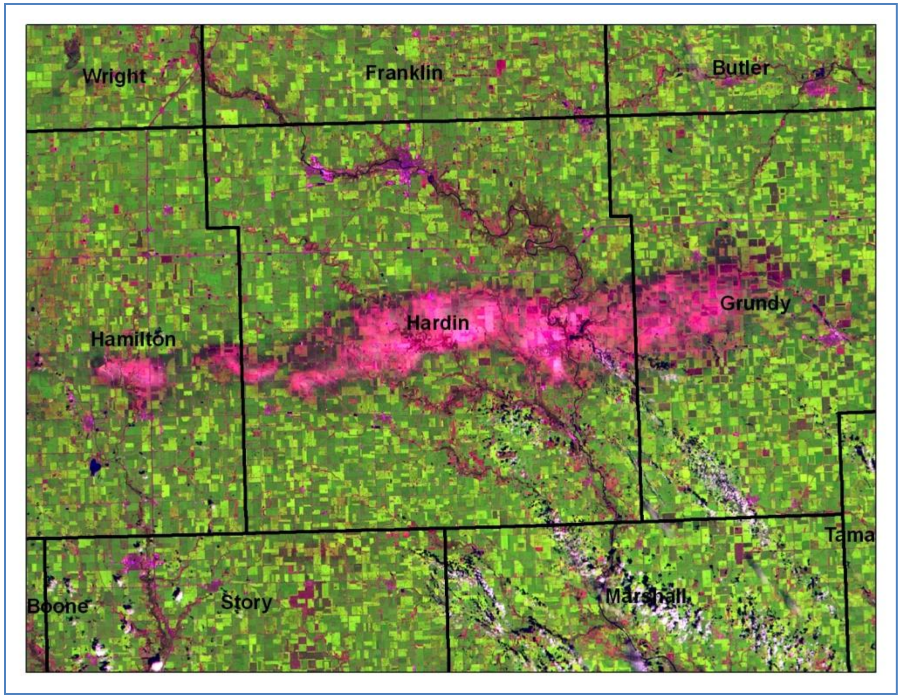
Thresholding research

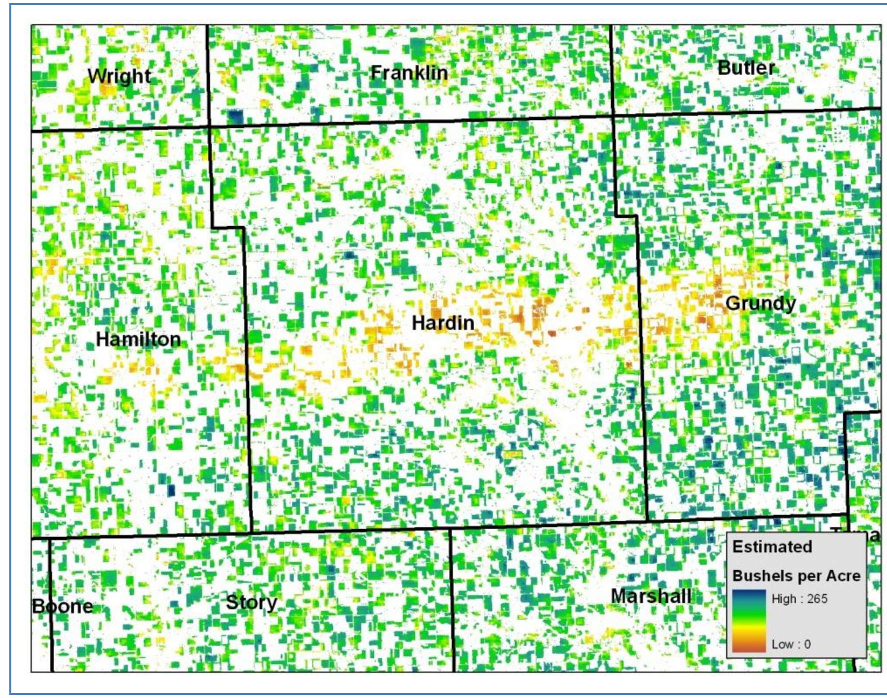
- Trying to understand what the best threshold is in which to integrate over
- Analogous to corn growing degree days
  - Say, where 10 degrees C is the threshold of importance for crop maturity.
- Through trial and error usually found
  - Too high, resulting model not as good
  - Too low, resulting model not as good
- Currently have been optimizing each model to maximize r-squared (and have a significant p-value)
  - Most cases are fairly similar
  - Would prefer something universal and tangible to biophysical processes
    - e.g. silking, denting, period of grain fill *etc.*



7000 (or 0.7 NDVI) seems like a reasonable round universal number (all things considered)

Reality check





Scene of a large hailstorm

Some conclusions

- Yield estimates should be viewed in context with phenology charts
  - A number doesn't tell the whole story
- Models seem to amplify results on extremes
  - KS and IA as examples
- About 2/3rd of model is NDVI driven, the rest trend
  - trend is flattening now though
- 0.7 NDVI seems a good all around threshold
  - Makes sense from both a modeling and biophysical standpoint
- Remote sensing forecasting a blend of planted versus harvested yield
  - satellite "sees" the corn plants but has no inclination if it is indeed harvested for grain, silage, or abandoned
- Early season forecasts are weak but probably better than educated guess
  - Trying to ascertain if the peak has indeed been reached early on is subjective

Tangential yield research with NDVI

- Soybeans run in a similar fashion as corn
  - It’s been a struggle
  - Hard to beat an educated guess
- Wheat run in a similar fashion as corn
  - Even more of a struggle
- RMA farm level yields
  - Massive and compelling 2005-2009 data set available
  - Intersectable with CLU polygons
- NASS OY plots with GPS coordinates for 2011
  - Iowa
  - Wisconsin

Or, looking for other suggestions and priorities

Moving forward

- Establish key dates in which remote sensing estimates are useful to others in NASS
- Model with fixed threshold at 0.7 NDVI
- Emphasize Speculative region work
- Think about harmonizing state level yields to nest into Speculative region
- Only use a decades worth of historical data in current year’s forecasting model (“rolling decade”)
- See what can be learned from RMA and OY GIS data
- (Hopefully) begin looking at VIIRS NDVI data next growing season

How’s the corn looking?

The ability to assess yields with good results in near-real time *via* remote sensing may have finally been reached!