Satellite Remote Sensing Imagery Quality and Timeliness: Considerations for Use in Regional Estimation of Crop Production

United States Department of Agriculture
National Agricultural Statistics Service

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BLS Data Quality Workshop, December 1, 2017
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Most popular crop reports from NASS

Acreage

ISSN: 1949-1522

**Released June 28, 2013, by the National Agricultural Statistics Service (NASS), Agricultural Statistics Board,
Agriculture (USDA).**

Corn Planted Acreage Up Slightly from 2012
Soybean Acreage Up 1 Percent
All Wheat Acreage Up 1 Percent
All Cotton Acreage Down 17 Percent

Corn planted area for all purposes in 2013 is estimated at 97.4 million acres, up slightly from l
the highest planted acreage in the United States since 1936 when an estimated 102 million acre
expect to harvest 89.1 million acres for grain, up 2 percent from last year.

Soybean planted area for 2013 is estimated at a record high 77.7 million acres, up 1 percent fr
harvest, at 76.9 million acres, is up 1 percent from 2012 and will be a record high, if realized. I
is estimated in New York, Pennsylvania, and South Dakota.

All wheat planted area for 2013 is estimated at 56.5 million acres, up 1 percent from 2012. Th
planted area, at 42.7 million acres, is 3 percent above last year and up 2 percent from the previ
about 29.4 million acres are Hard Red Winter, 9.96 million acres are Soft Red Winter, and 3.3
Winter. Area planted to other spring wheat for 2013 is estimated at 12.3 million acres, up sligh
about 11.7 million acres are Hard Red Spring wheat. The estimated Durum wheat planted area
1.54 million acres, down 28 percent from the previous year.

All cotton planted area for 2013 is estimated at 10.3 million acres, 17 percent below last year.
10.0 million acres, down 17 percent from 2012. American Pima area is estimated at 226,000 a
2012.

Annually

Crop Production

ISSN: 1936-3737

Released May 9, 2014, by the National Agricultural Statistics Service (NASS), Agricultural Statistics Board, United States Department of Agriculture (USDA).

Winter Wheat Production Down 9 Percent from 2013
Orange Production Up Slightly from April Forecast

Winter wheat production is forecast at 1.40 billion bushels, down 9 percent from 2013. As o
yield is forecast at 43.1 bushels per acre, down 4.3 bushels from last year.

Hard Red Winter production, at 746 million bushels, is up slightly from a year ago. Soft Red
bushels, is down 21 percent from 2013. White Winter, at 209 million bushels, is down 7 perce
White Winter production, 10.9 million bushels are Hard White and 198 million bushels are S

The United States all orange forecast for the 2013-2014 season is 7.21 million tons, up sligh
forecast but down 13 percent from the 2012-2013 final utilization. The Florida all orange fore
(4.96 million tons), is up slightly from the previous forecast but down 17 percent from last se
Early, midseason, and Navel varieties in Florida are forecast at 53.3 million boxes (2.40 milli
the previous forecast but down 21 percent from last season. The Florida Valencia orange fore
(2.57 million tons), is unchanged from the previous forecast but down 14 percent from last se
California and Texas production forecasts are carried forward from April.

Florida frozen concentrated orange juice (FCOJ) yield forecast for the 2013-2014 season i
42.0 degrees Brix, down 1 percent from the April forecast and down 1 percent from last seaso
1.59 gallons per box. The early-midseason portion is projected at 1.52 gallons per box, up 1 p
yield of 1.51 gallons per box. The Valencia portion is projected at 1.64 gallons per box, down
final yield. All projections of yield assume the processing relationships this season will be sin
several seasons.

Monthly

Crop Progress

ISSN: 1948-3007

Released May 12, 2014, by the National Agricultural Statistics Service (NASS), Agricultural Statistics Board, United States Department of Agriculture (USDA).

Corn Planted - Selected States

[These 18 States planted 91% of the 2013 corn acreage]

State	Week ending			2009-2013 Average
	May 11, 2013	May 4, 2014	May 11, 2014	
	(percent)	(percent)	(percent)	(percent)
Colorado	29	35	64	56
Illinois	16	43	78	53
Indiana	27	20	61	45
Iowa	14	23	70	70
Kansas	29	52	72	63
Kentucky	38	39	64	59
Michigan	28	3	20	41
Minnesota	16	8	31	62
Missouri	27	63	86	62
Nebraska	39	44	77	71
North Carolina	92	75	90	96
North Dakota	16	-	3	33
Ohio	40	9	40	46
Pennsylvania	45	8	27	41
South Dakota	33	25	52	43
Tennessee	62	68	87	76
Texas	77	73	80	65
Wisconsin	13	2	20	41
18 States	26	29	59	58

- Represents zero.

Corn Emerged - Selected States

[These 18 States planted 91% of the 2013 corn acreage]

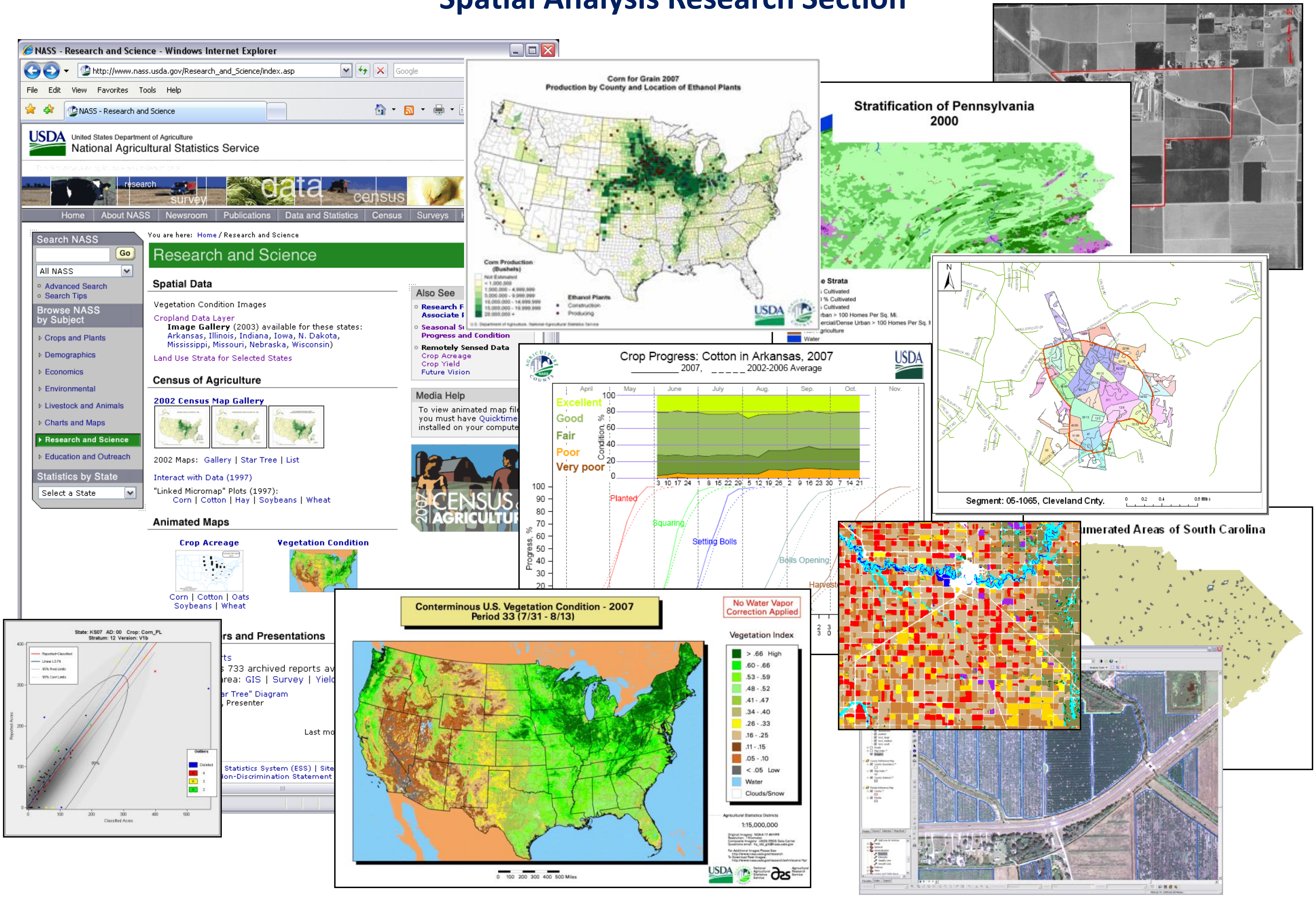
State	Week ending			2009-2013 Average
	May 11, 2013	May 4, 2014	May 11, 2014	
	(percent)	(percent)	(percent)	(percent)
Colorado	1	1	4	9
Illinois	2	8	36	32
Indiana	3	2	14	26
Iowa	1	1	9	29
Kansas	5	19	35	30
Kentucky	21	15	32	45
Michigan	1	-	1	10
Minnesota	-	-	-	18
Missouri	14	29	53	40
Nebraska	2	7	18	21
North Carolina	63	56	70	64
North Dakota	-	-	-	6
Ohio	2	-	3	21
Pennsylvania	8	-	7	12
South Dakota	1	1	4	9
Tennessee	43	35	53	62
Texas	66	58	65	69
Wisconsin	-	-	-	6
18 States	5	7	18	25

- Represents zero.

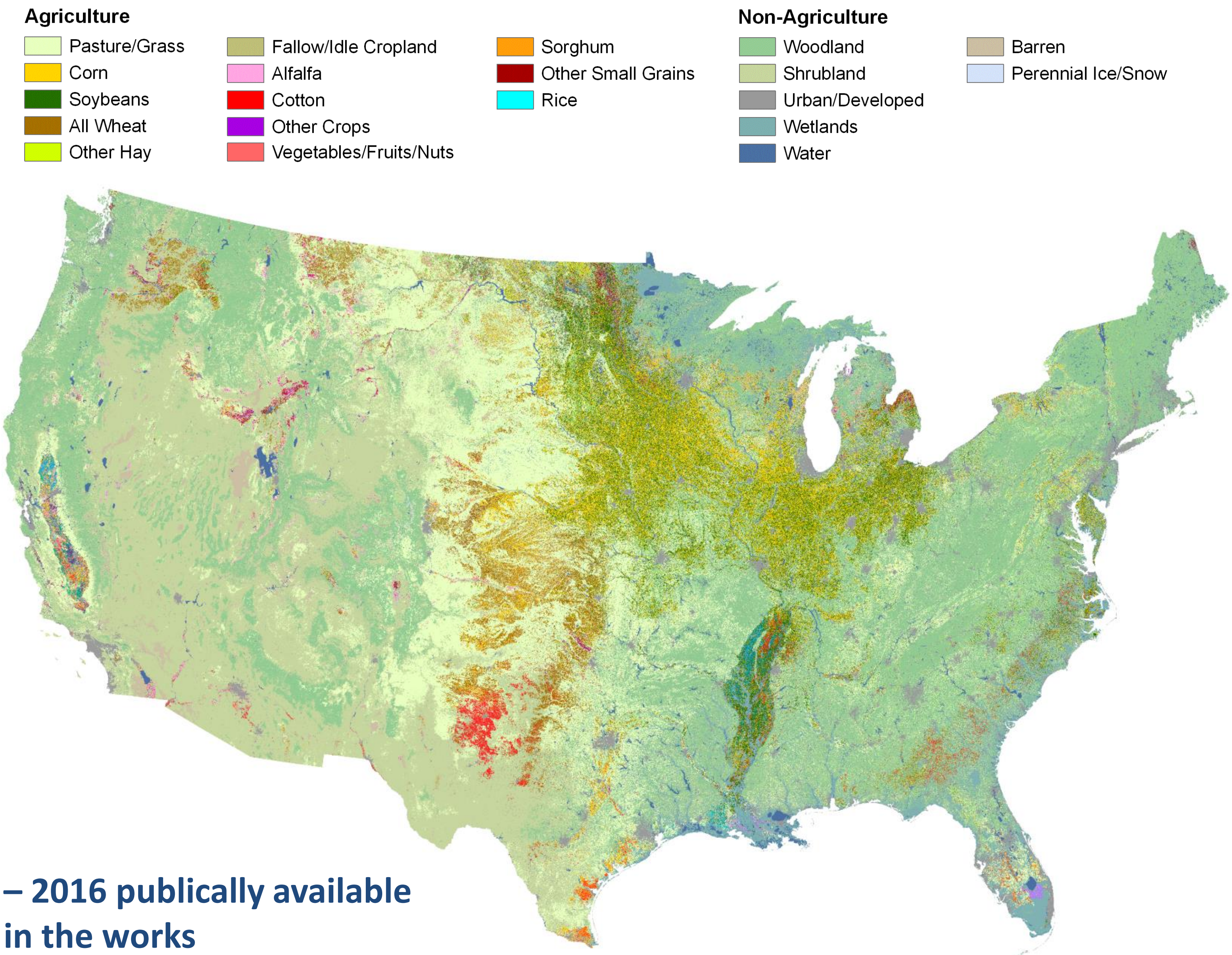
Weekly

NASS Research and Development Division

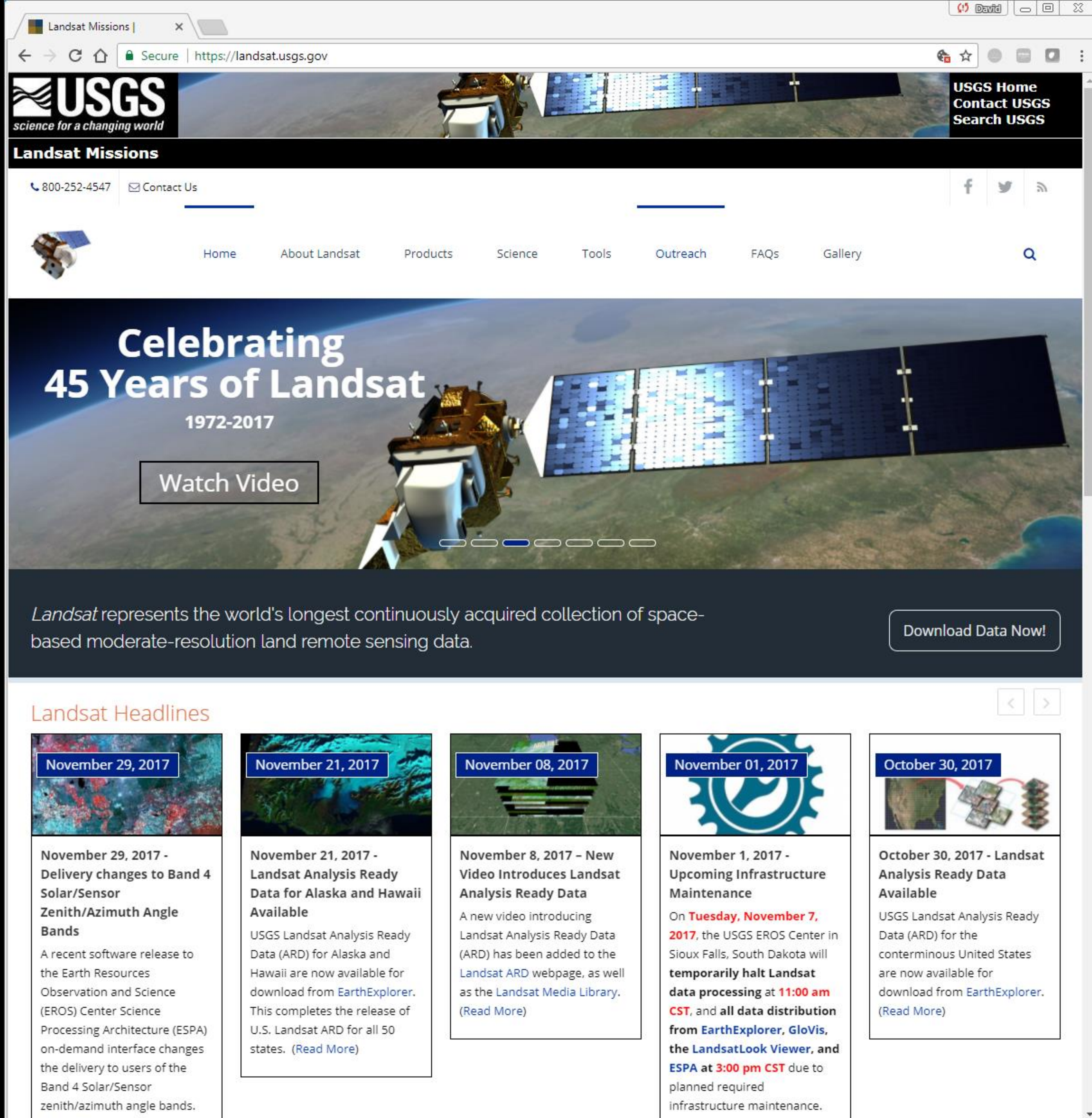
Spatial Analysis Research Section



Land cover mapping - Cropland Data Layer (CDL)



* 2008 – 2016 publically available
* 2017 in the works
* 2008 and 2009 being reprocessed from 56m to 30m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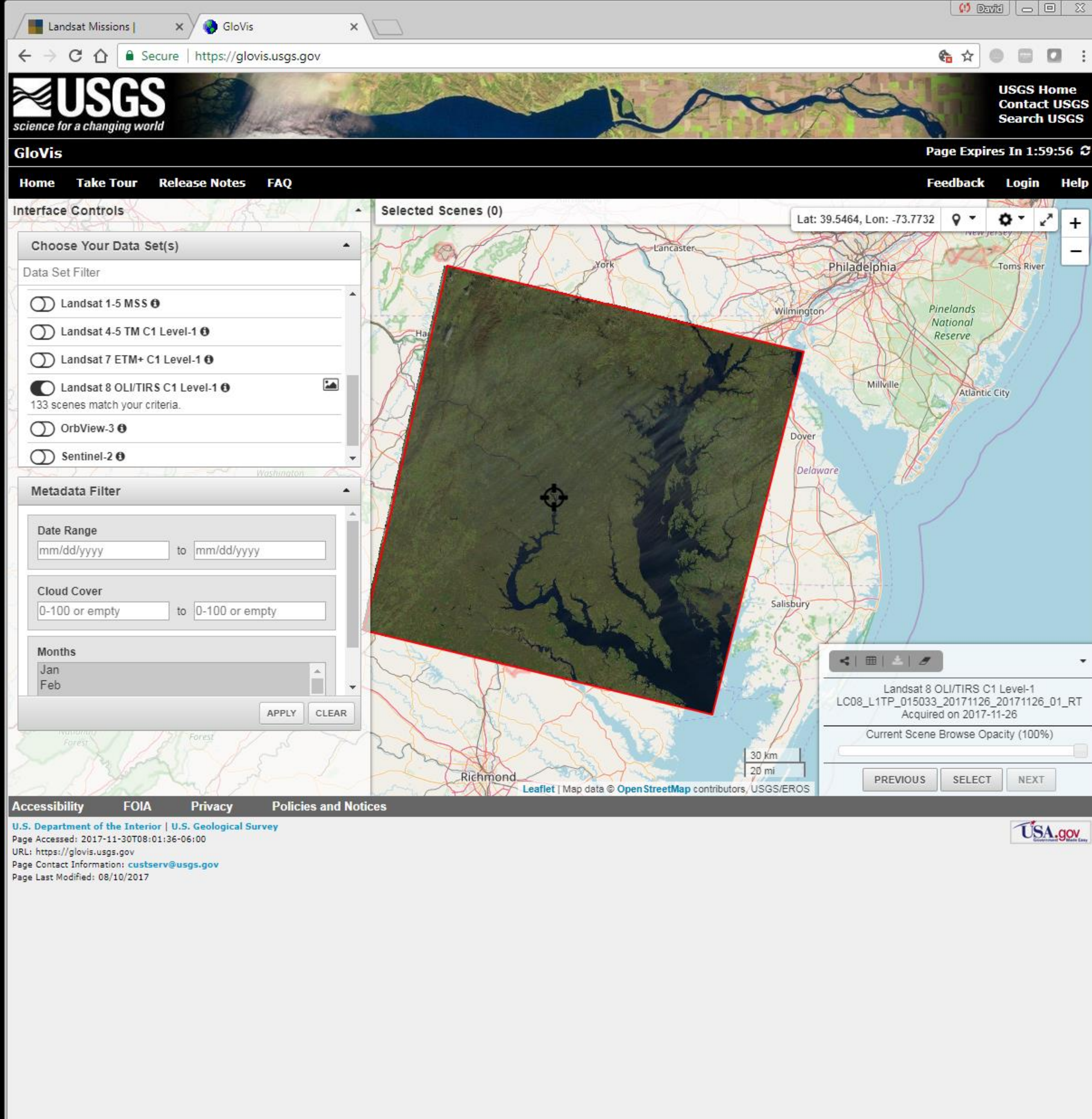
Landsat Headlines
November 29, 2017
November 29, 2017 - Delivery changes to Band 4 Solar/Sensor Zenith/Azimuth Angle Bands
A recent software release to the Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA) on-demand interface changes the delivery to users of the Band 4 Solar/Sensor zenith/azimuth angle bands.
November 21, 2017
November 21, 2017 - Landsat Analysis Ready Data for Alaska and Hawaii Available
USGS Landsat Analysis Ready Data (ARD) for Alaska and Hawaii are now available for download from EarthExplorer. This completes the release of U.S. Landsat ARD for all 50 states. (Read More)
November 08, 2017
November 8, 2017 – New Video Introduces Landsat Analysis Ready Data
A new video introducing Landsat Analysis Ready Data (ARD) has been added to the Landsat ARD webpage, as well as the Landsat Media Library. (Read More)
November 01, 2017
November 1, 2017 - Upcoming Infrastructure Maintenance
On Tuesday, November 7, 2017, the USGS EROS Center in Sioux Falls, South Dakota will temporarily halt Landsat data processing at 11:00 am CST, and all data distribution from EarthExplorer, GloVis, the LandsatLook Viewer, and ESPA at 3:00 pm CST due to planned required infrastructure maintenance.
October 30, 2017
October 30, 2017 - Landsat Analysis Ready Data Available
USGS Landsat Analysis Ready Data (ARD) for the conterminous United States are now available for download from EarthExplorer. (Read More)



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Landsat 4-5 TM C1 Level-1
Landsat 7 ETM+ C1 Level-1
Landsat 8 OLI/TIRS C1 Level-1
133 scenes match your criteria.
OrbView-3
Sentinel-2
Metadata Filter
Date Range
mm/dd/yyyy
to
mm/dd/yyyy
Cloud Cover
0-100 or empty
to
0-100 or empty
Months
Jan
Feb
APPLY
CLEAR
Selected Scenes (0)
Lat: 39.5464, Lon: -73.7732
Lancaster
York
Philadelphia
Toms River
Wilmington
Pinelands National Reserve
Millville
Atlantic City
Dover
Delaware
Salisbury
Richmond
30 km
20 mi
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Landsat 8 OLI/TIRS C1 Level-1
LC08_L1TP_015033_20171126_20171126_01_RT
Acquired on 2017-11-26
Current Scene Browse Opacity (100%)
PREVIOUS
SELECT
NEXT
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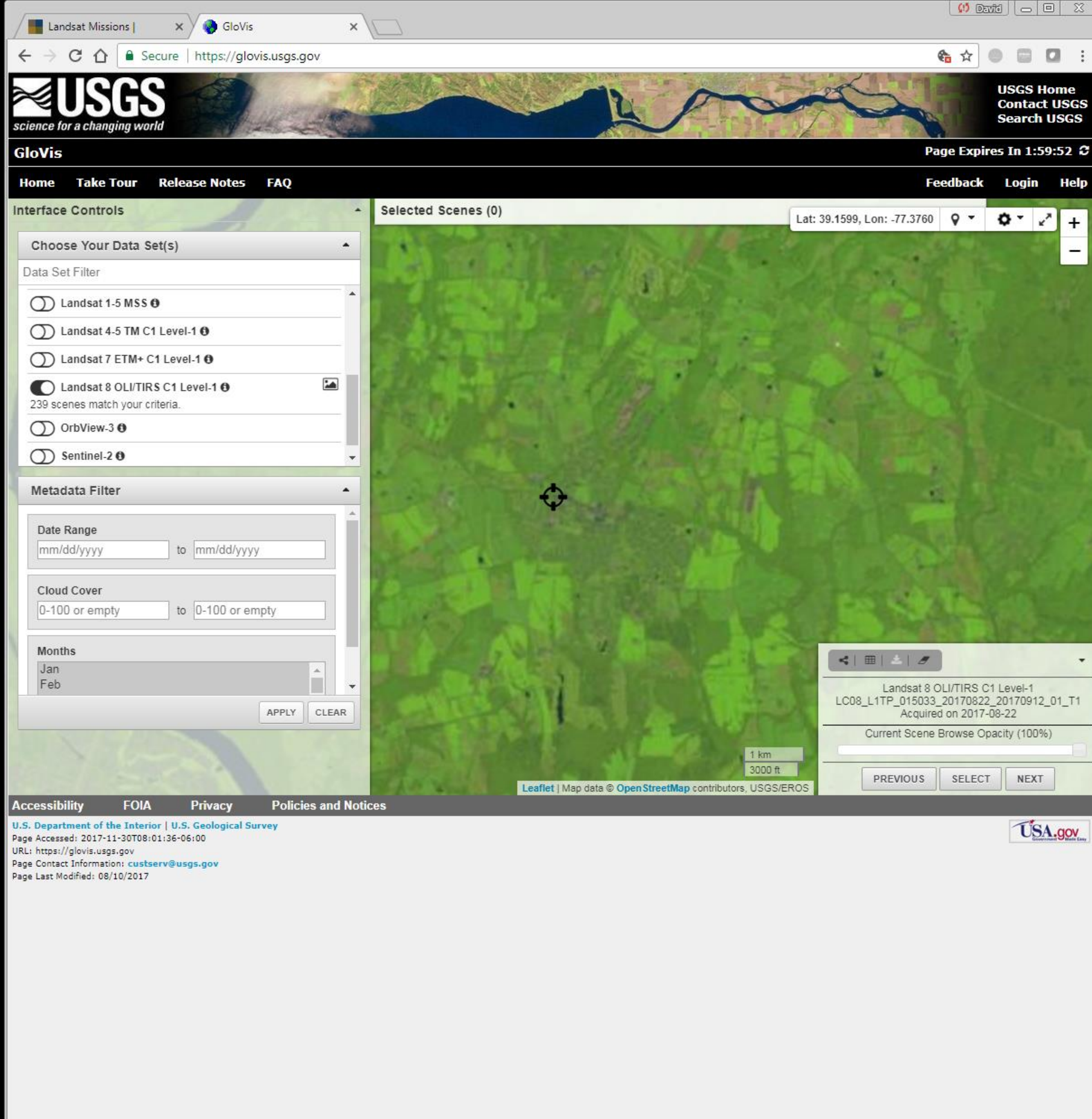
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Sentinel-2
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Date Range
mm/dd/yyyy to mm/dd/yyyy
Cloud Cover
0-100 or empty to 0-100 or empty
Months
Jan
Feb
APPLY CLEAR
Selected Scenes (0)
Lat: 39.1599, Lon: -77.3760
Landsat 8 OLI/TIRS C1 Level-1
LC08_L1TP_015033_20170822_20170912_01_T1
Acquired on 2017-08-22
Current Scene Browse Opacity (100%)
PREVIOUS SELECT NEXT
1 km
3000 ft
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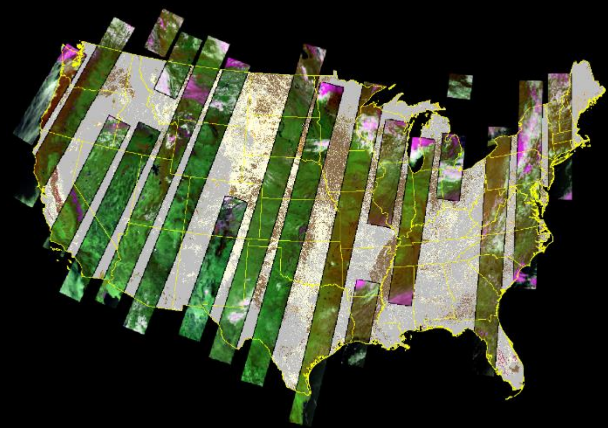
2017: June 16 – 22

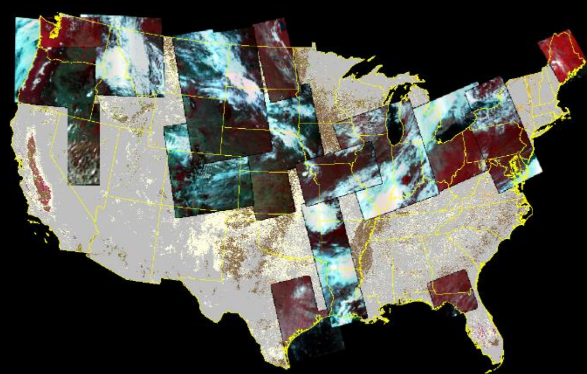
Agricultural areas

Landsat 8



Sentinel 2a

DMC Deimos

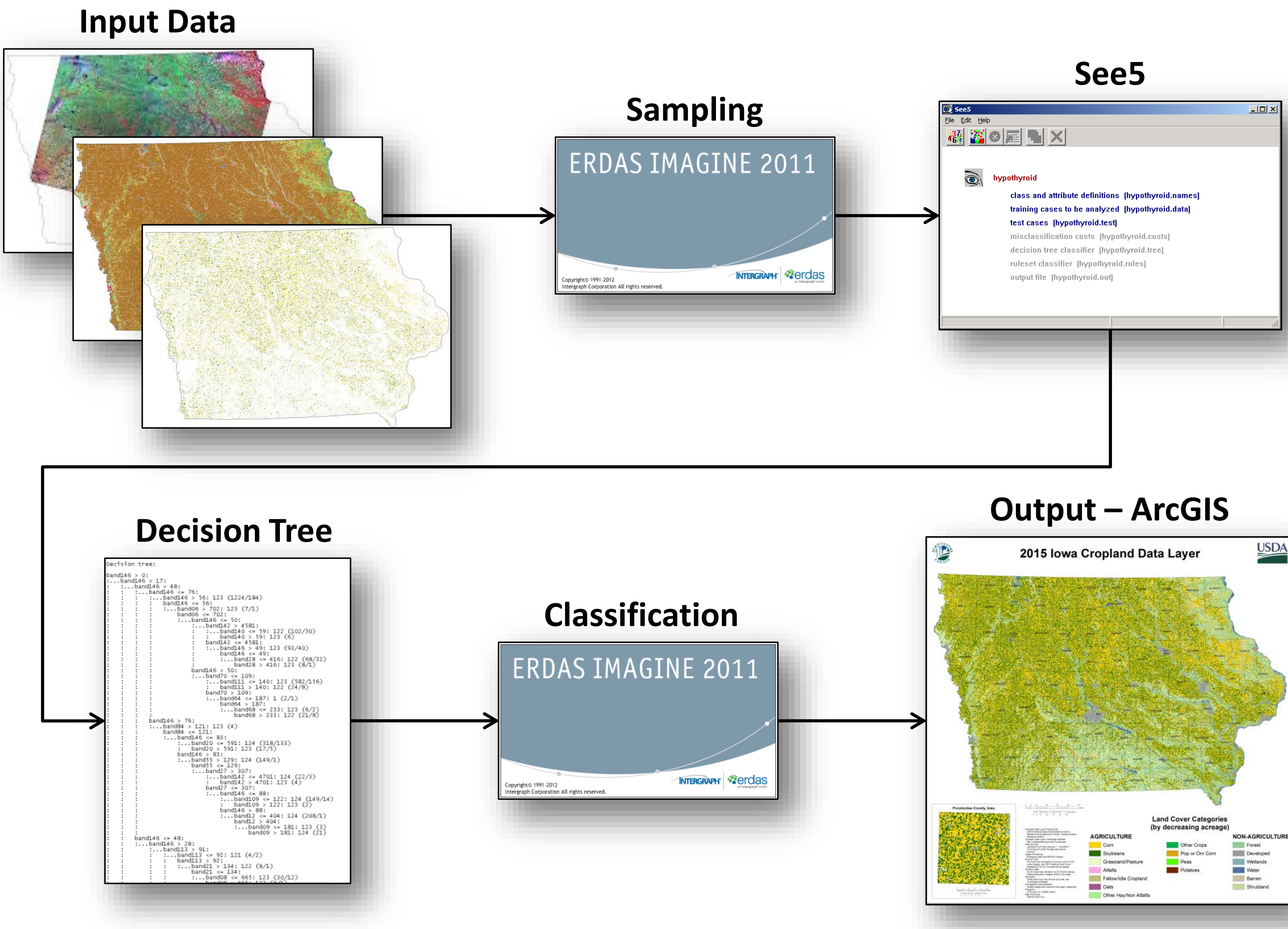


DMC UK2

Resourcesat-2 LISS3

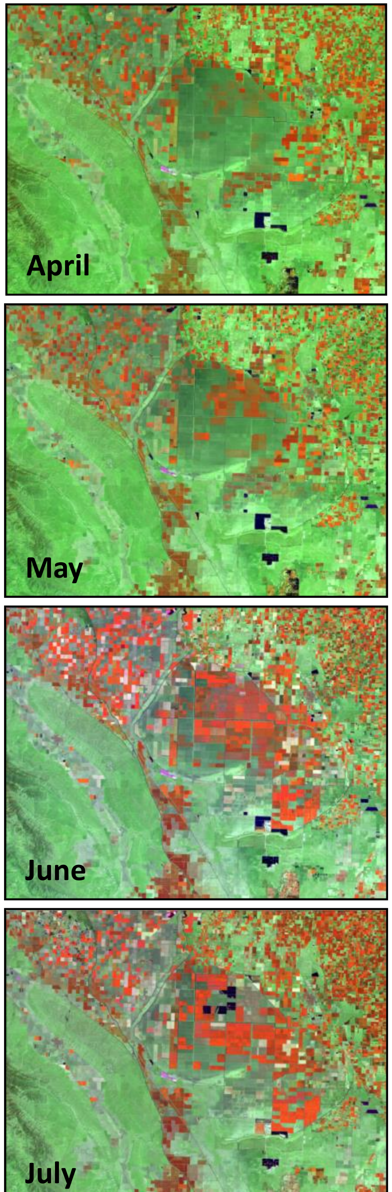
Available satellite imagery 2017: June 16 – 22

CDL Processing Flow

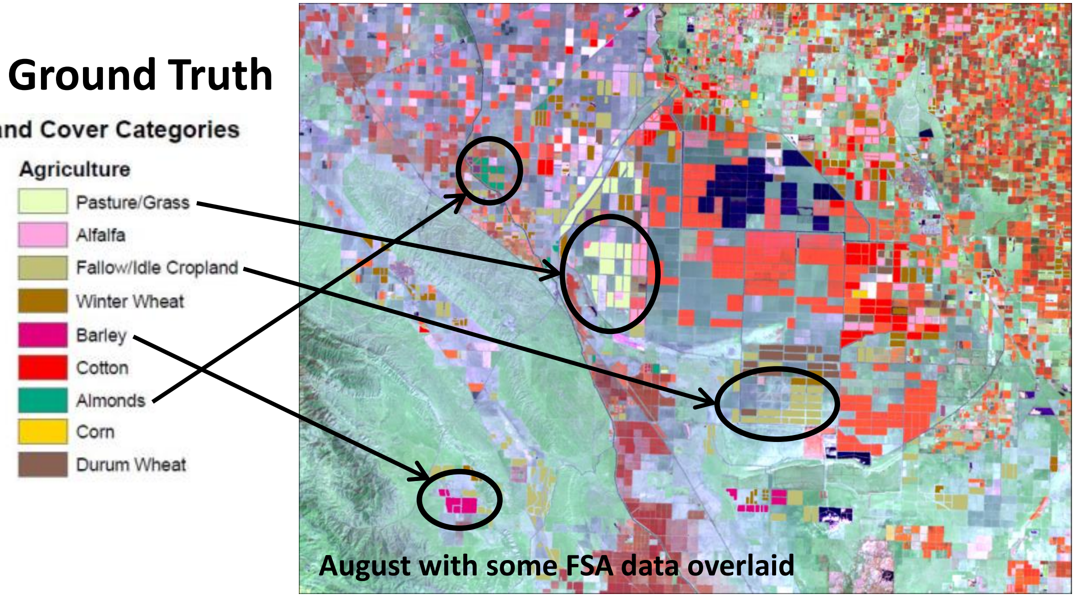


Classification

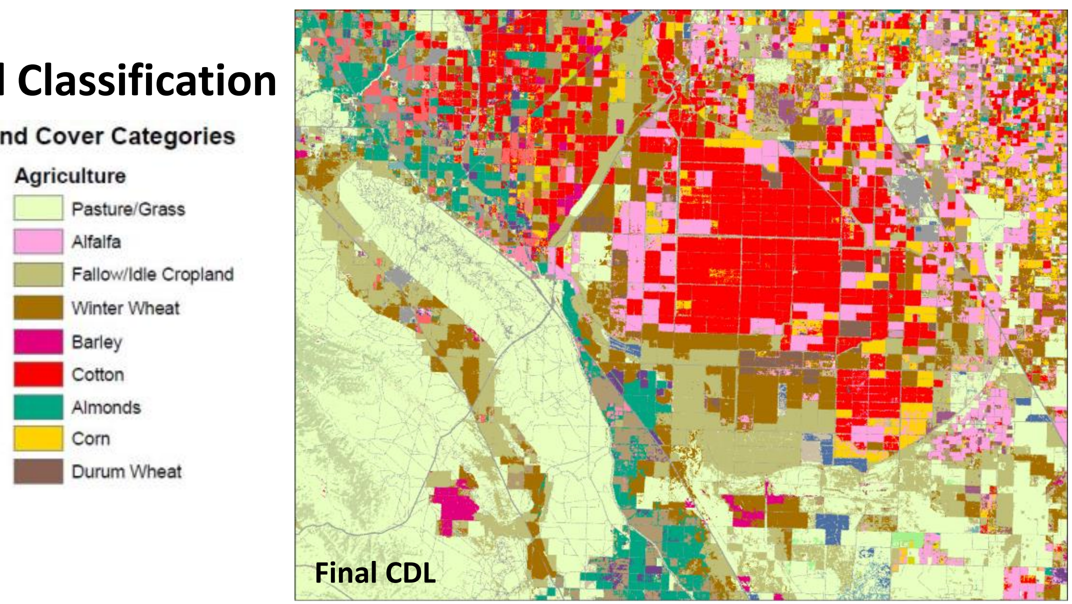
False Color IR Imagery



FSA Ground Truth



Final Classification



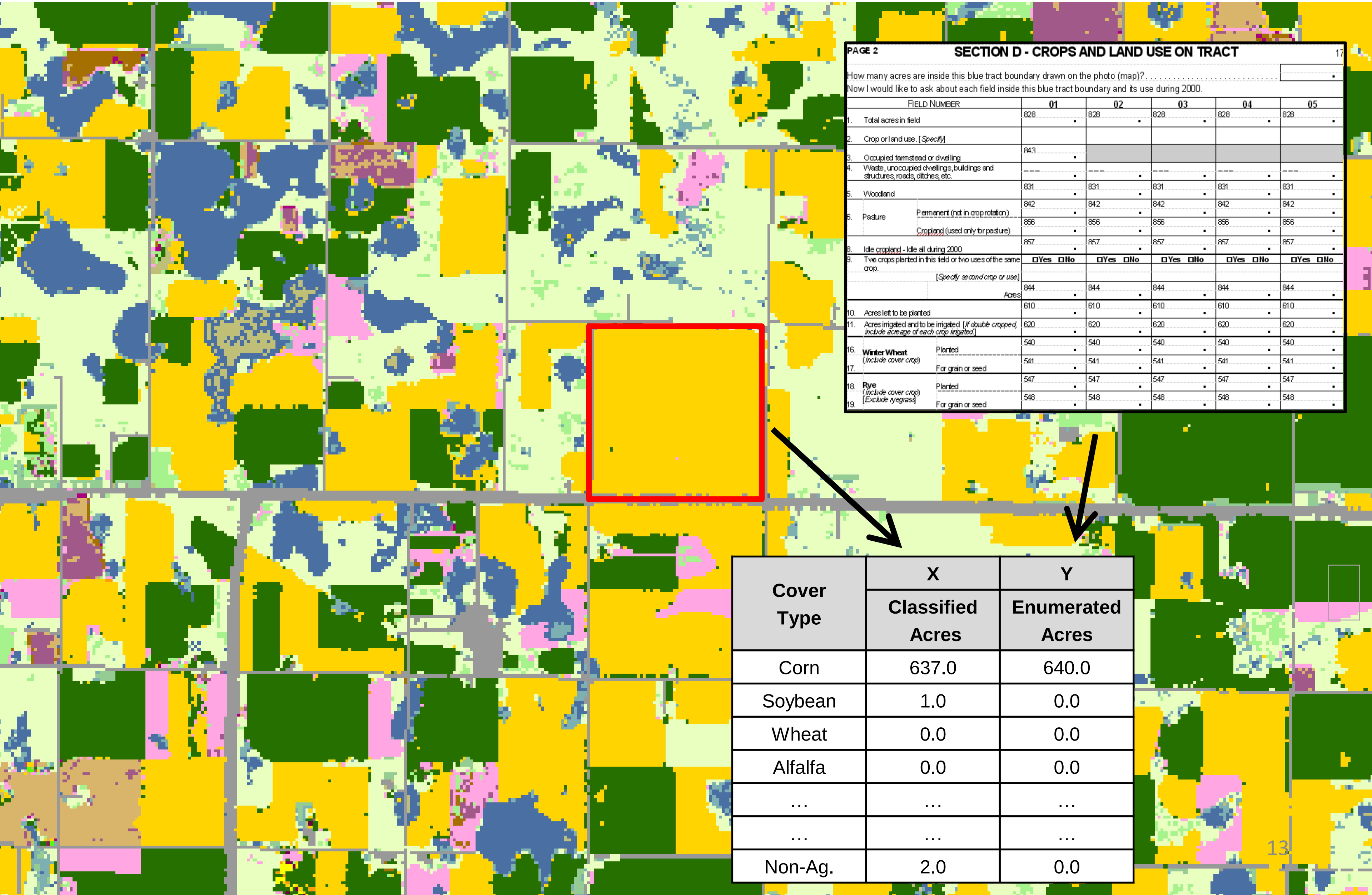
Accuracy Assessments

USDA, National Agricultural Statistics Service, 2014 Colorado Cropland Data Layer
STATEWIDE AGRICULTURAL ACCURACY REPORT

Crop-specific covers only	*Correct	Accuracy	Error	Kappa
OVERALL ACCURACY**	2,630,488	85.5%	14.5%	0.812

Cover Type	Attribute Code	*Correct Pixels	Producer's Accuracy	Omission Error	Kappa	User's Accuracy	Commission Error	Cond'l Kappa
Corn	1	419737	90.76%	9.24%	0.895	90.22%	9.78%	0.889
Sorghum	4	83214	62.32%	37.68%	0.611	64.72%	35.28%	0.635
Soybeans	5	1058	43.25%	56.75%	0.432	72.47%	27.53%	0.724
Sunflower	6	5760	39.64%	60.36%	0.395	70.61%	29.39%	0.705
Barley	21	7176	71.52%	28.48%	0.715	81.00%	19.00%	0.810
Winter Wheat	24	1100020	93.26%	6.74%	0.905	94.21%	5.79%	0.918
Millet	29	75109	67.86%	32.14%	0.671	76.85%	23.15%	0.762
Alfalfa	36	196153	89.75%	10.25%	0.891	85.60%	14.40%	0.848
Other Hay/Non Alfalfa	37	84626	63.33%	36.67%	0.624	85.92%	14.08%	0.854
Sugarbeets	41	4679	63.13%	36.87%	0.631	90.28%	9.72%	0.903
Dry Beans	42	9406	62.72%	37.28%	0.626	69.54%	30.46%	0.694
Potatoes	43	6104	89.74%	10.26%	0.897	93.79%	6.21%	0.938
Fallow/Idle Cropland	61	625989	88.08%	11.92%	0.855	89.23%	10.77%	0.869

Classified area vs June enumerated



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	03	04	05
1. Total acres in field	828	828	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	831	831
6. Pasture — Permanent (not in crop rotation)	842	842	842	842	842
Pasture — Cropland (used only for pasture)	856	856	856	856	856
8. Idle cropland - Idle all during 2000	857	857	857	857	857
9. Two crops planted in this field or two uses of the same crop.	☐Yes ☐No	☐Yes ☐No	☐Yes ☐No	☐Yes ☐No	☐Yes ☐No
[*Specify second crop or use.*]					
Acres	844	844	844	844	844
10. Acres left to be planted	610	610	610	610	610
11. Acres irrigated and to be irrigated [*If double cropped, include acreage of each crop irrigated.*]	620	620	620	620	620
16. **Winter Wheat** (*include cover crop*) — Planted	540	540	540	540	540
17. For grain or seed	541	541	541	541	541
18. **Rye** (*include cover crop*) [*Exclude ryegrass*] — Planted	547	547	547	547	547
19. For grain or seed	548	548	548	548	548

Cover Type	X	Y
	Classified Acres	Enumerated Acres
Corn	637.0	640.0
Soybean	1.0	0.0
Wheat	0.0	0.0
Alfalfa	0.0	0.0
…	…	…
…	…	…
Non-Ag.	2.0	0.0

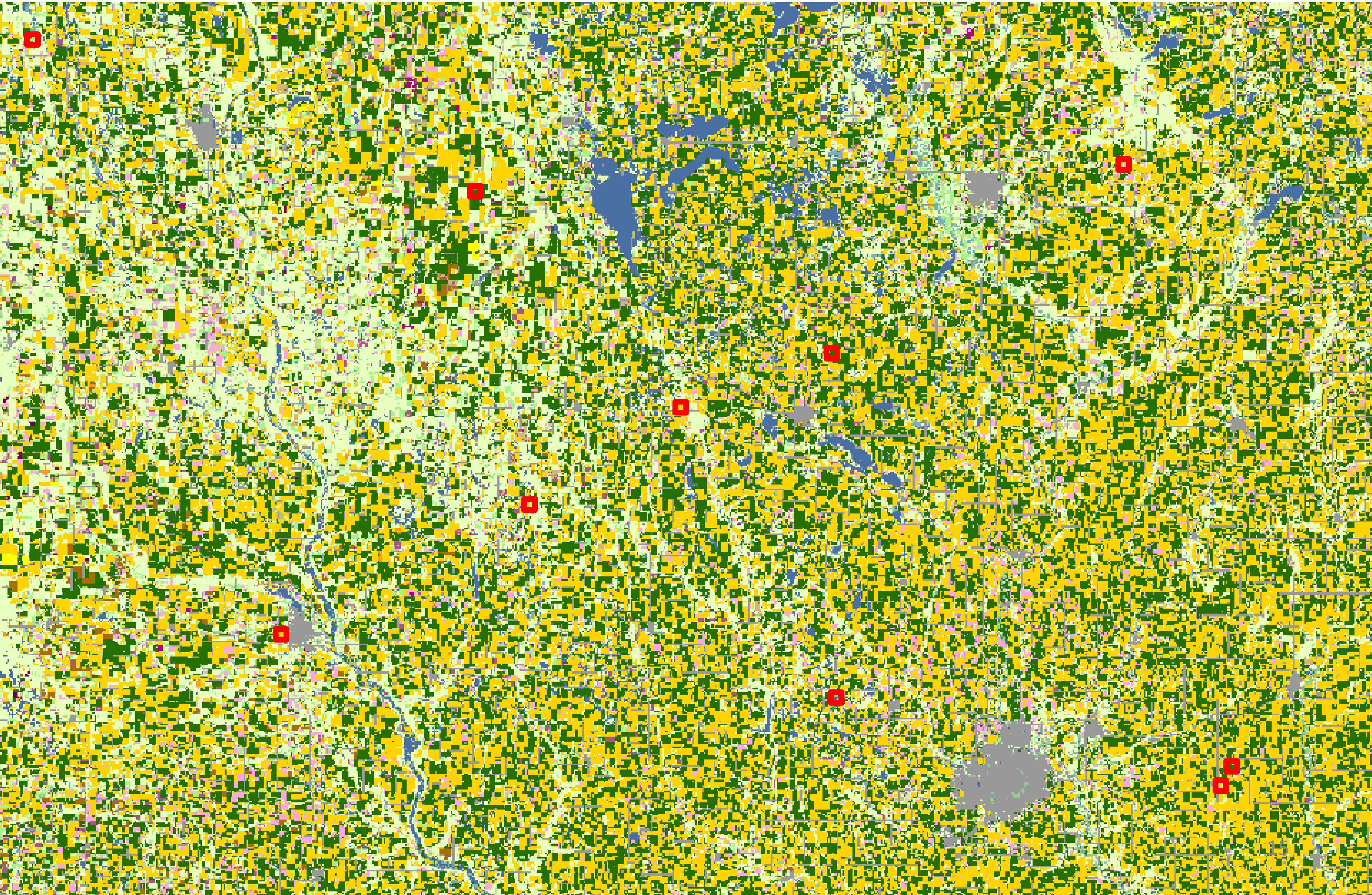
At three sites

Cover Type	X	Y
	Classified Acres	Enumerated Acres
Corn	176.0	190.0
Soybean	302.0	290.0
Wheat	0.0	0.0
Alfalfa	3.5	0.0
…	…	…
…	…	…
Non-Ag.	158.5	160.0

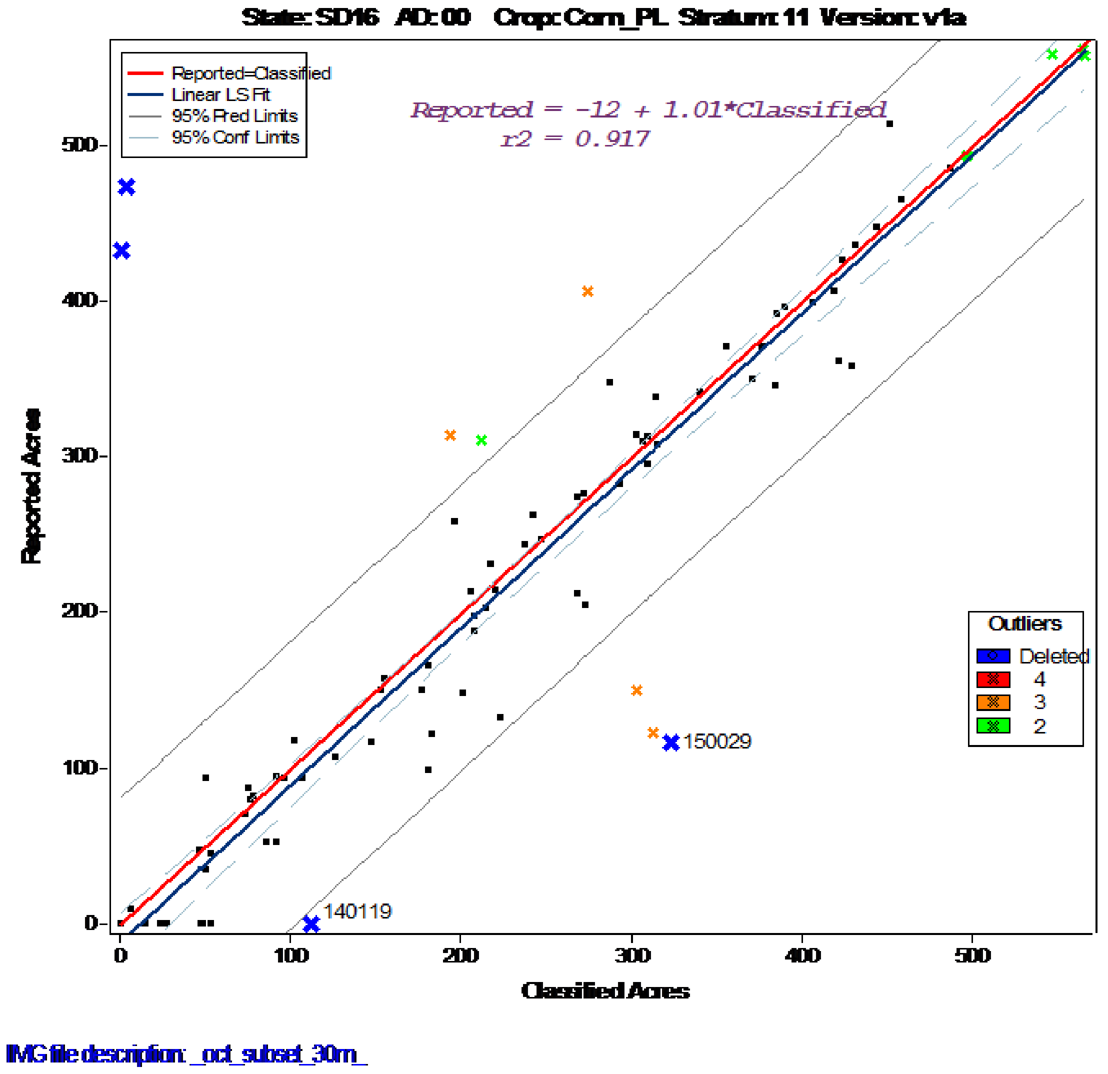
Cover Type	X	Y
	Classified Acres	Enumerated Acres
Corn	34.0	21.0
Soybean	177.0	155.0
Wheat	4.5	0.0
Alfalfa	2.5	0.0
…	…	…
…	…	…
Non-Ag.	422.0	464.0

Cover Type	X	Y
	Classified Acres	Enumerated Acres
Corn	637.0	640.0
Soybean	1.0	0.0
Wheat	0.0	0.0
Alfalfa	0.0	0.0
…	…	…
…	…	…
Non-Ag.	2.0	0.0

10 sites and so forth….

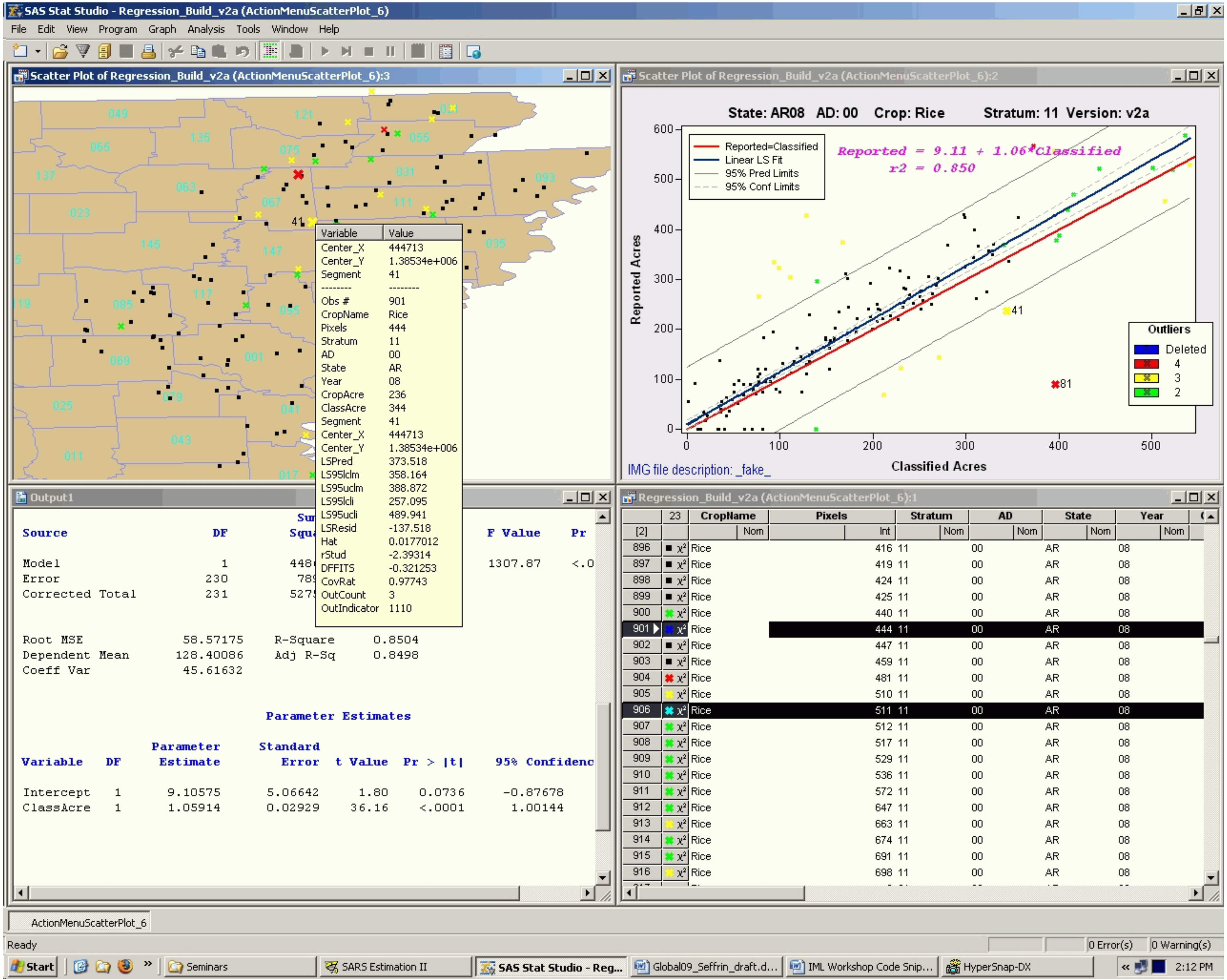


Acreage Regression Estimation

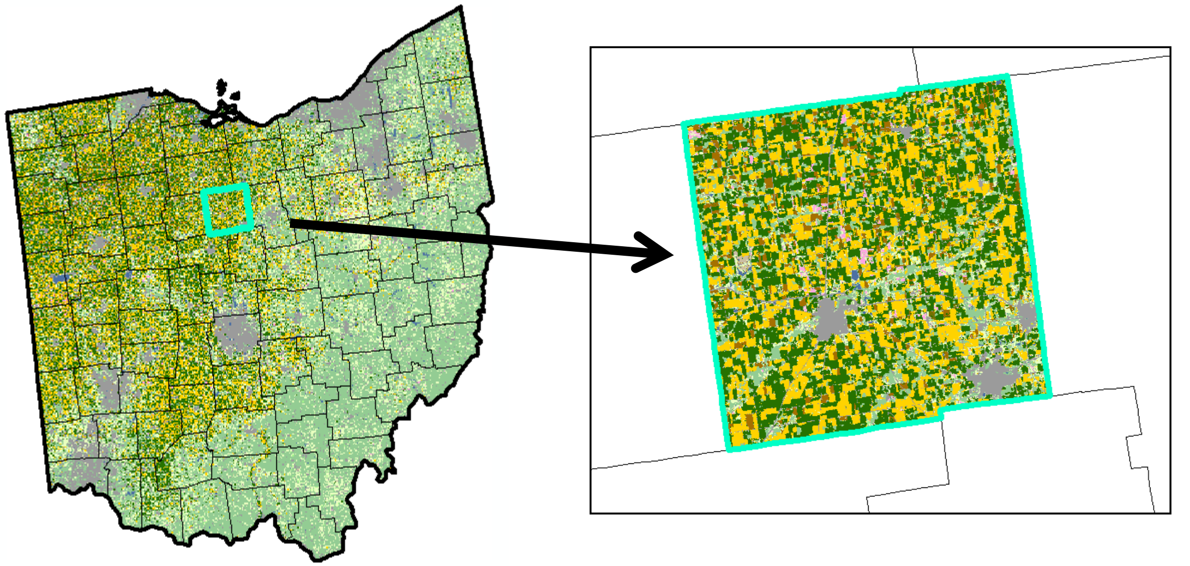


We don't just "pixel count" from CDL to estimate acreage

SAS-based Regression Estimate system



à la Bob Seffrin



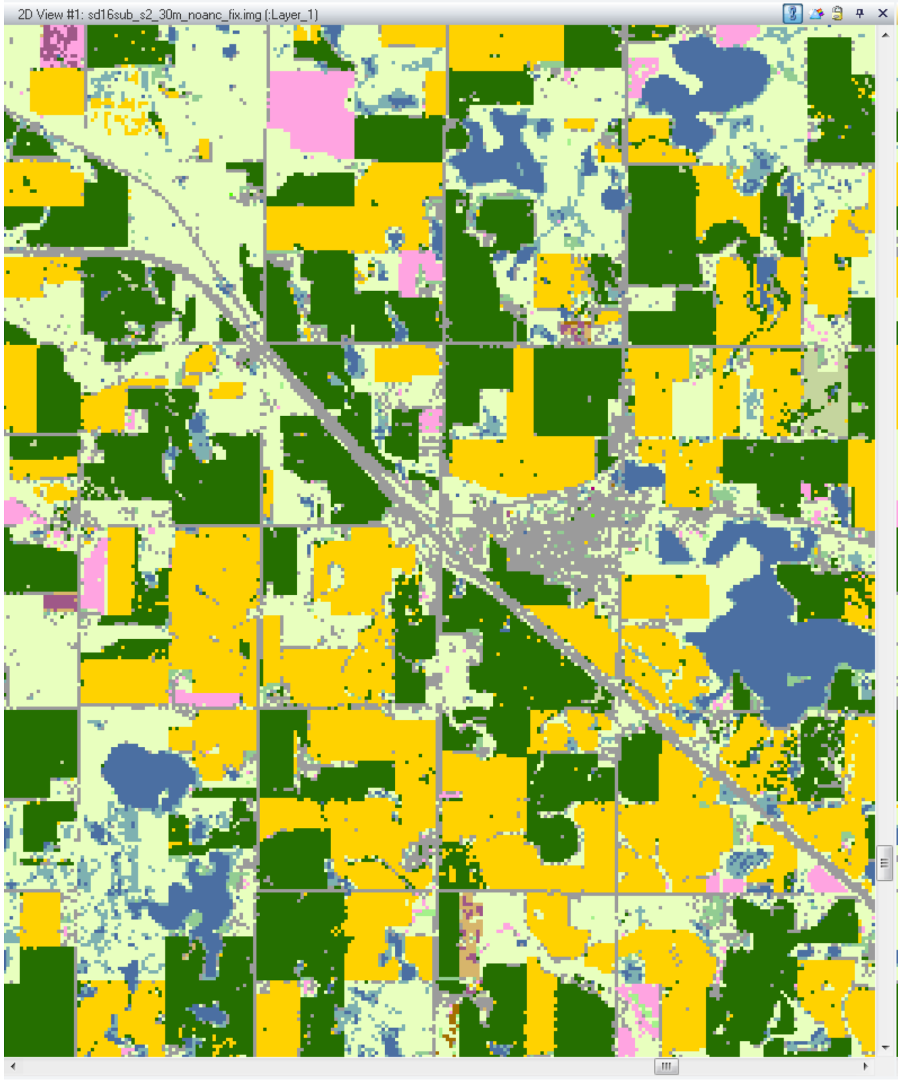
County Estimates

- Use Battese-Fuller estimator with nested design
- Apply state-strata level regression parameters
- Adjust intercept based on segments in county
- Ag Statistics Districts Est = Sum of County Estimates

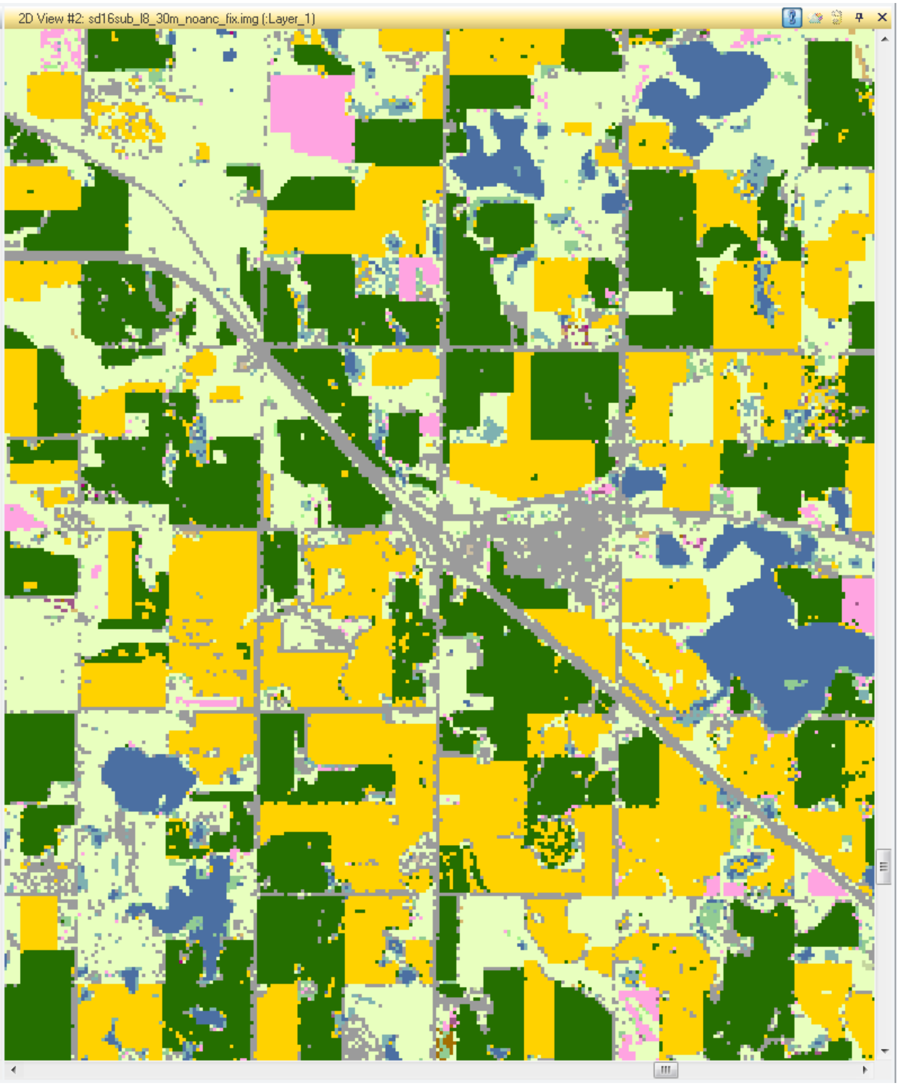
Classification comparison #1

30m Sentinel-2a

93.9



30m Landsat 8

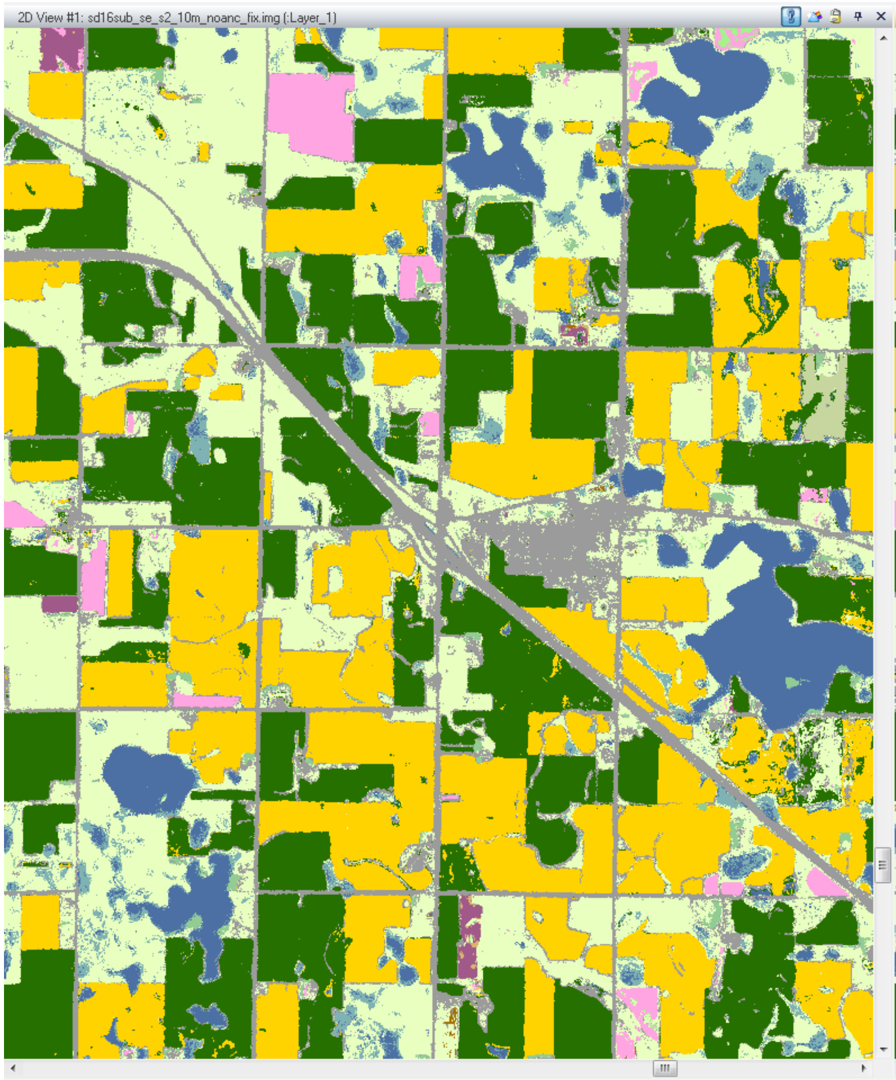


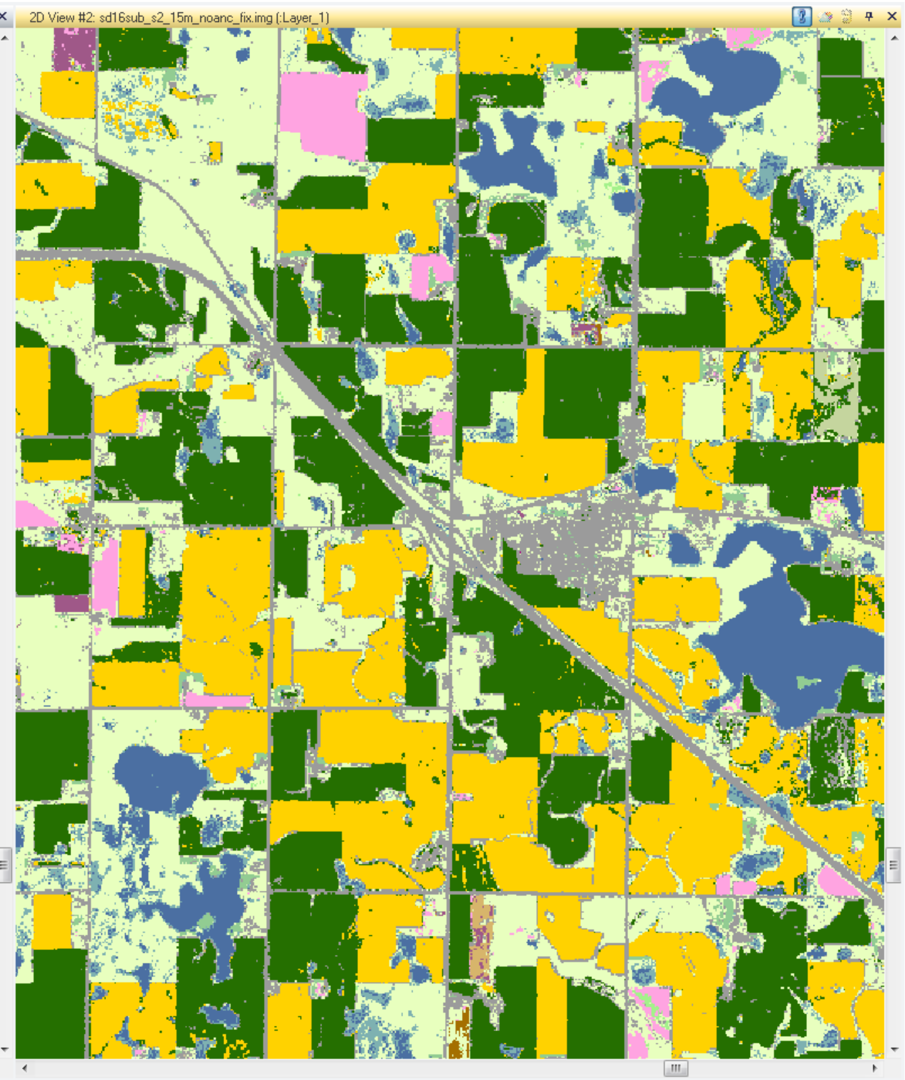
93.8

Classification comparison #2

10m Sentinel-2a | **15m Sentinel-2a**

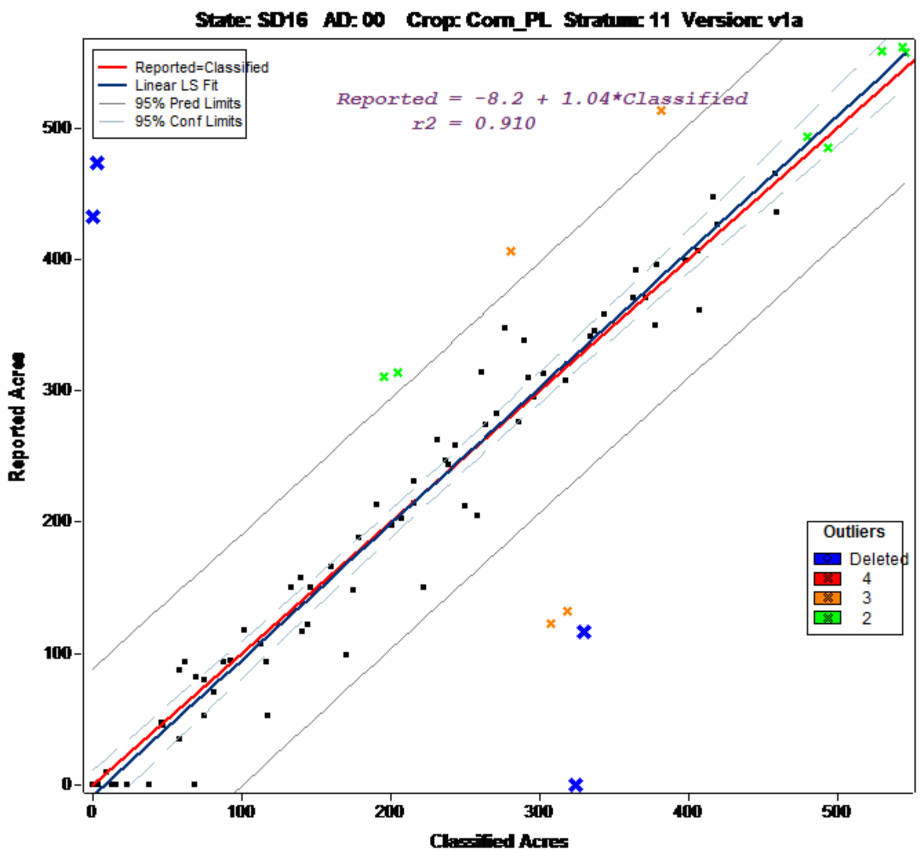
94.2





94.0

60m vs 15m regression analysis - corn



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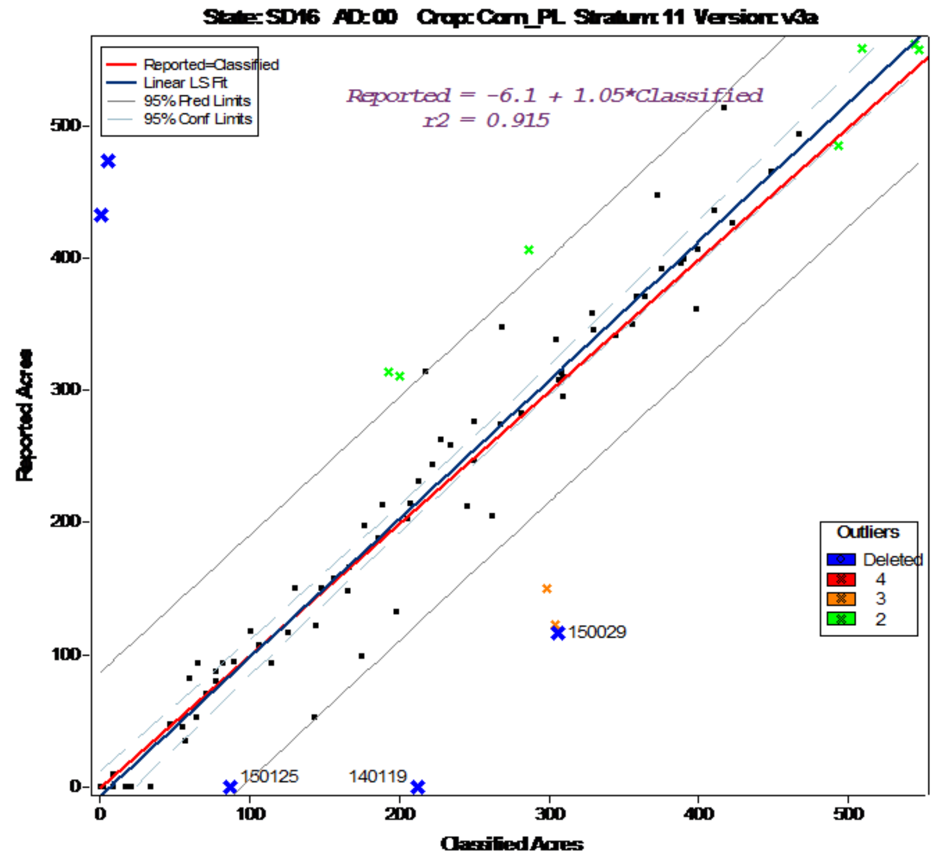

VIG file description: _sub_s2_15m_noan

CDL Applications

Climate
Acreage Estimates
Modeling
Irrigation
Epidemiology
Land Cover
Soil Utilization
Research
Pest Control
Agribusiness
Ethanol
Carbon
Forest
Erosion
Pesticides
Biodiesel
Ecology
Fertilizer
Yield
Biofuel
CRP
Land Use
Ecosystem
Commodity
Planning
Urban Growth
Water Use
Soil and Water
Fertilizer Usage
Crop Rotation
Crop Intensity
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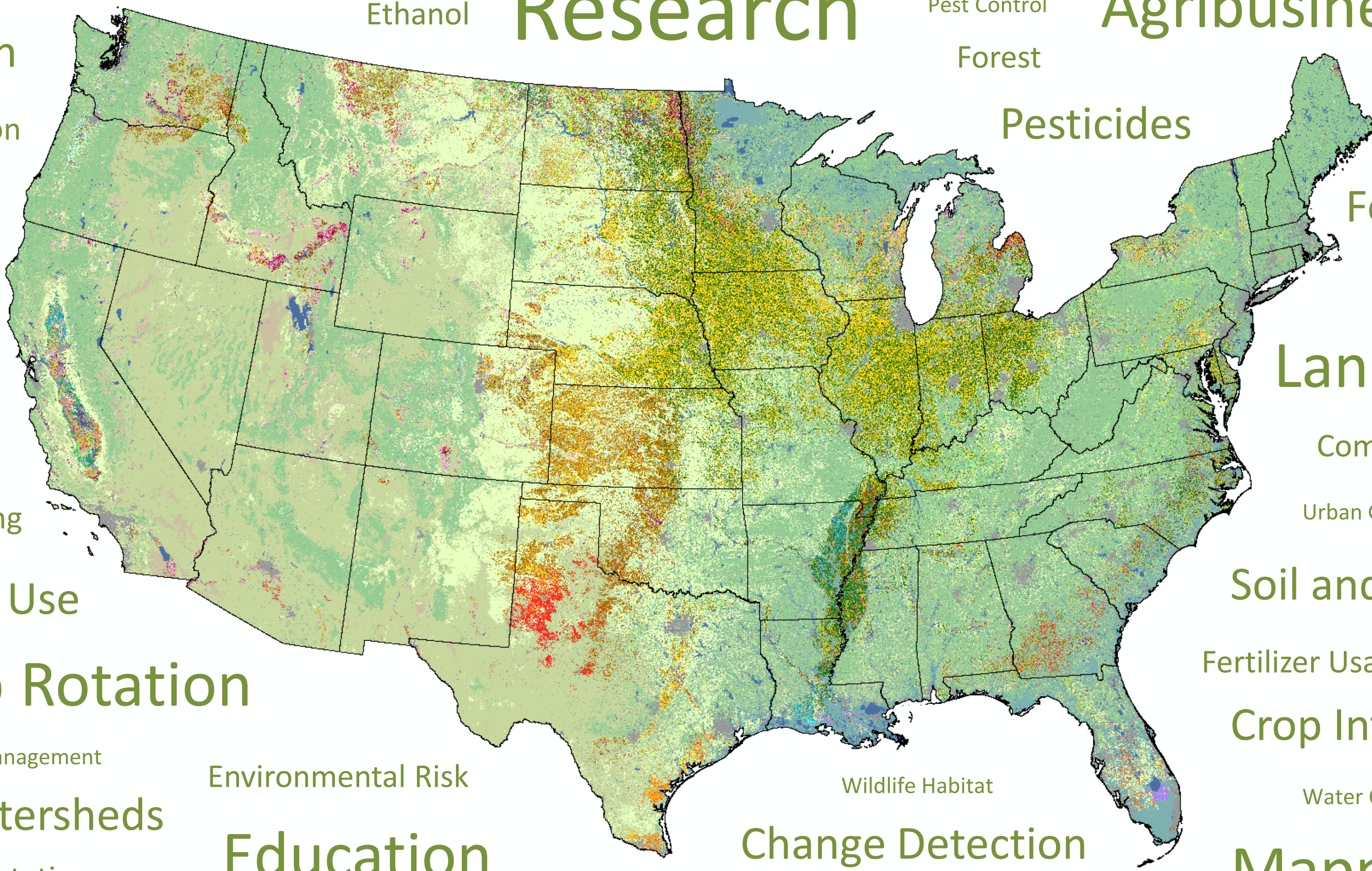
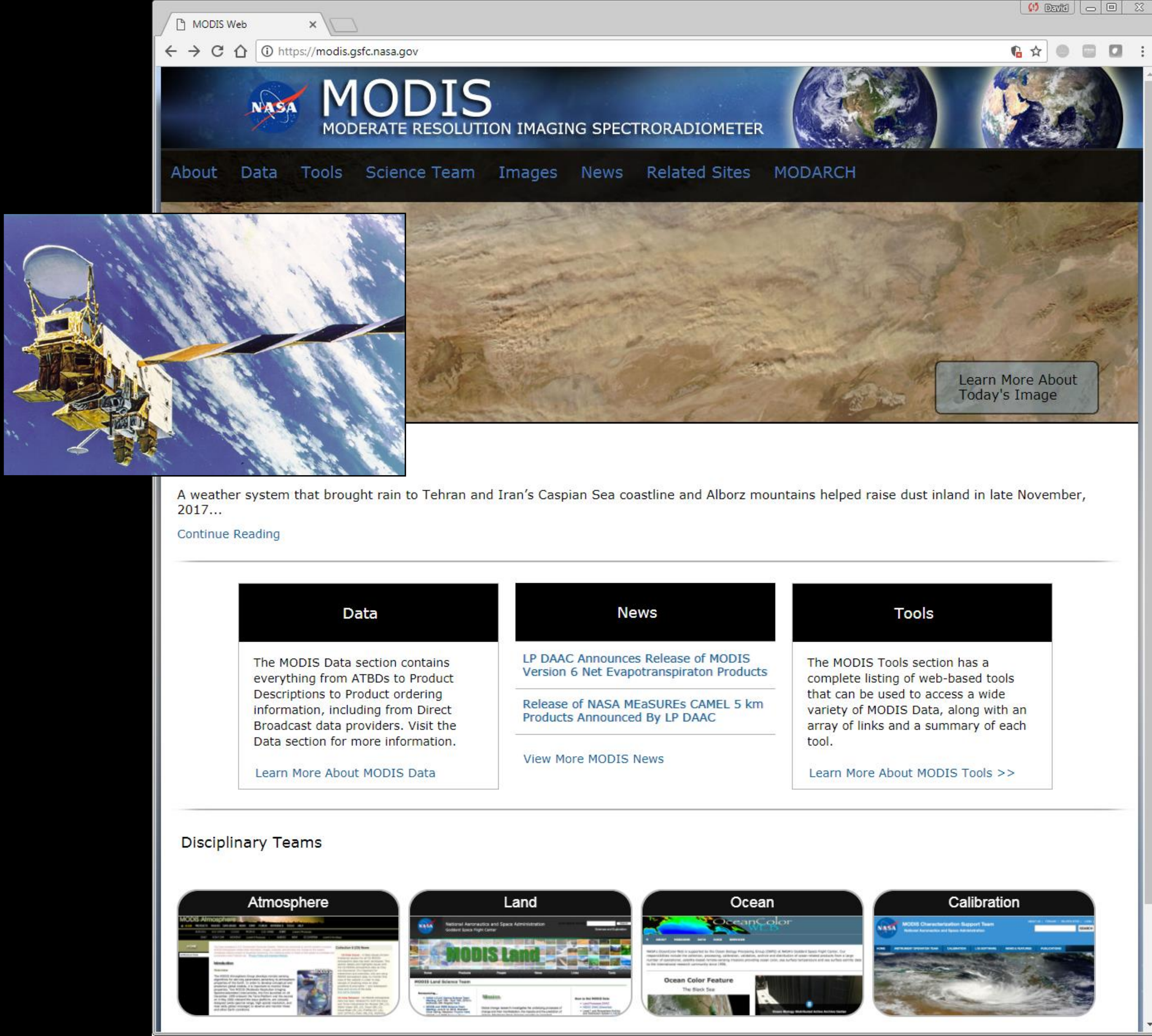
Condition Assessment
Disaster Assessment
Crop Production
Crop Protection




YIELD
BIG STONE
21
COUNTY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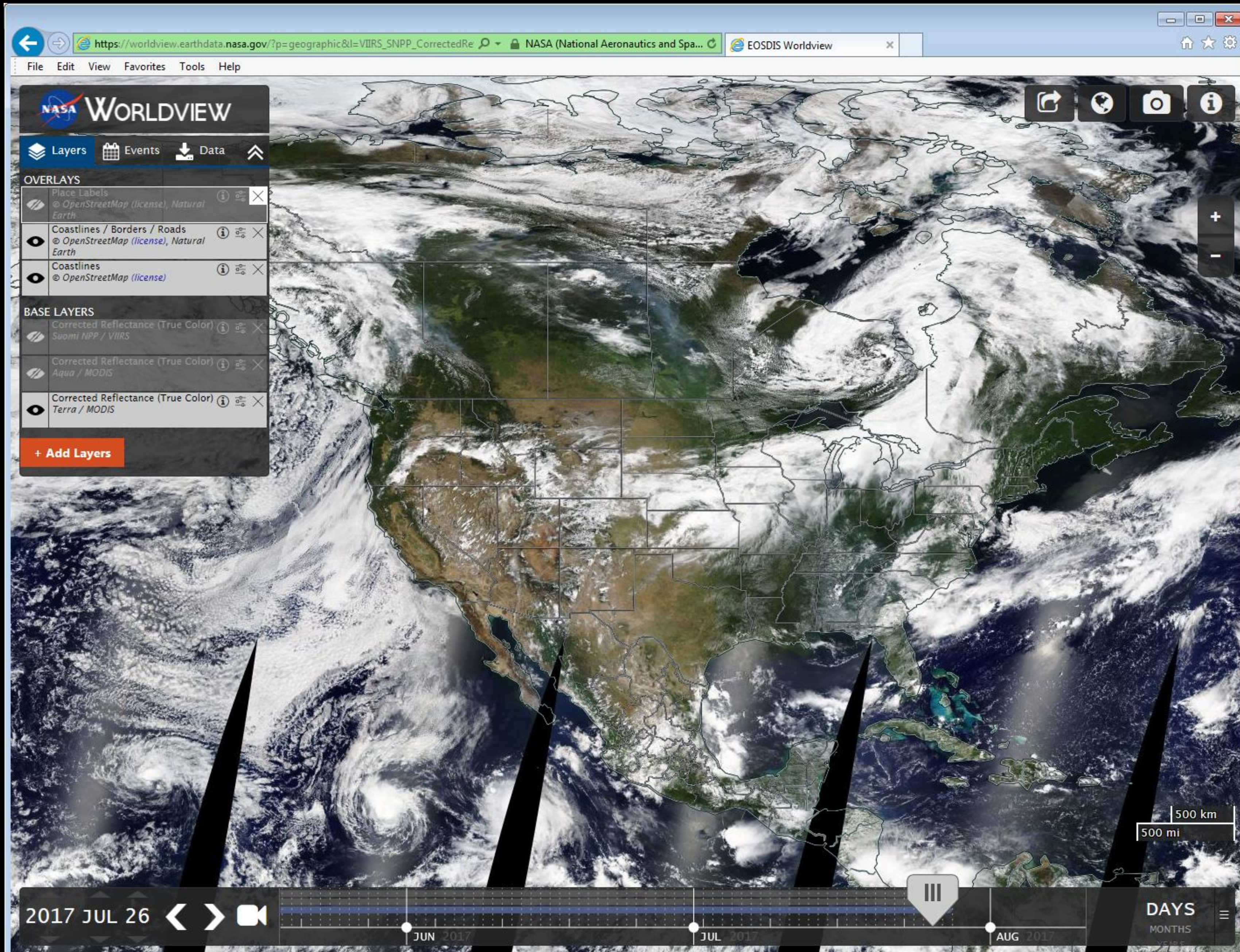
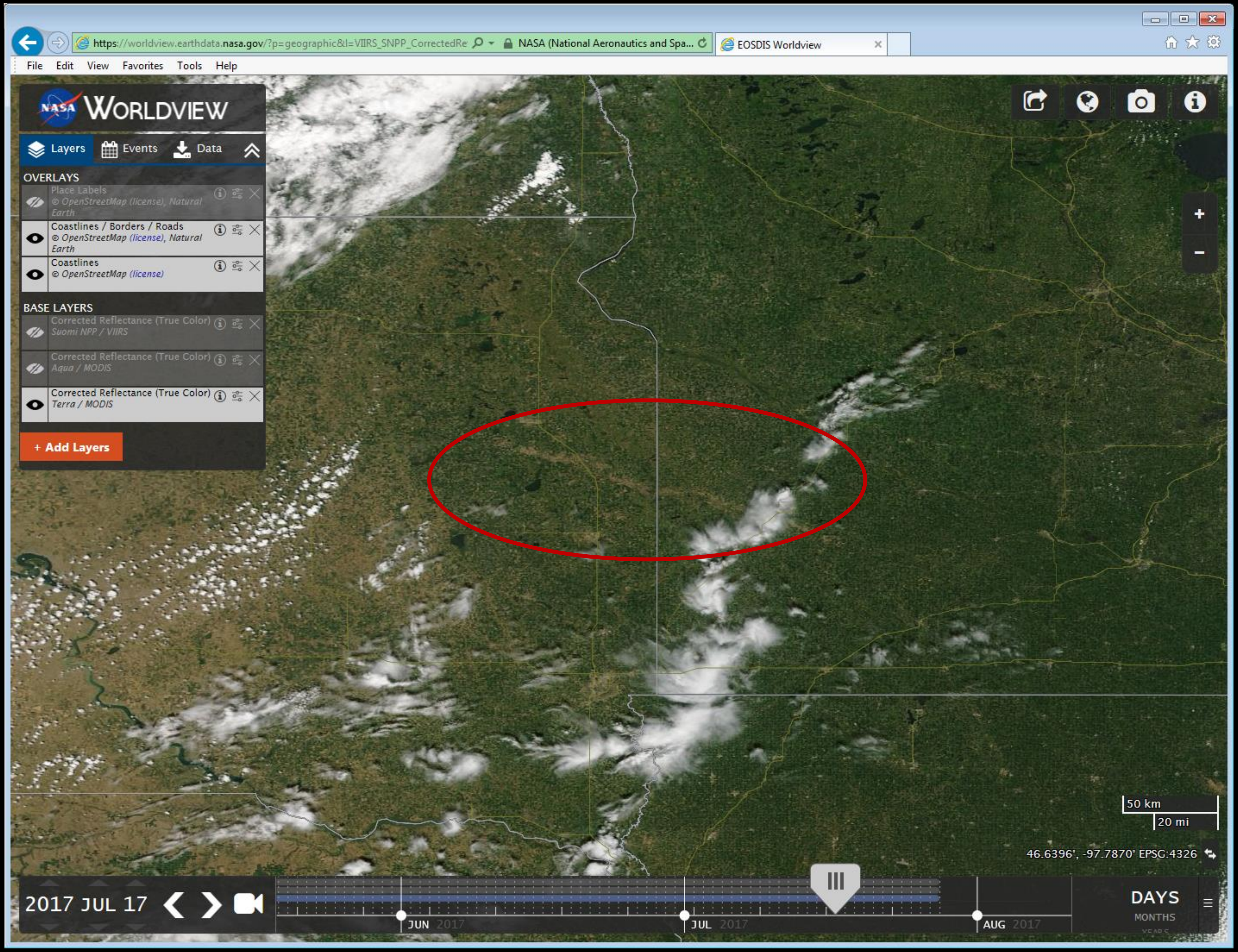
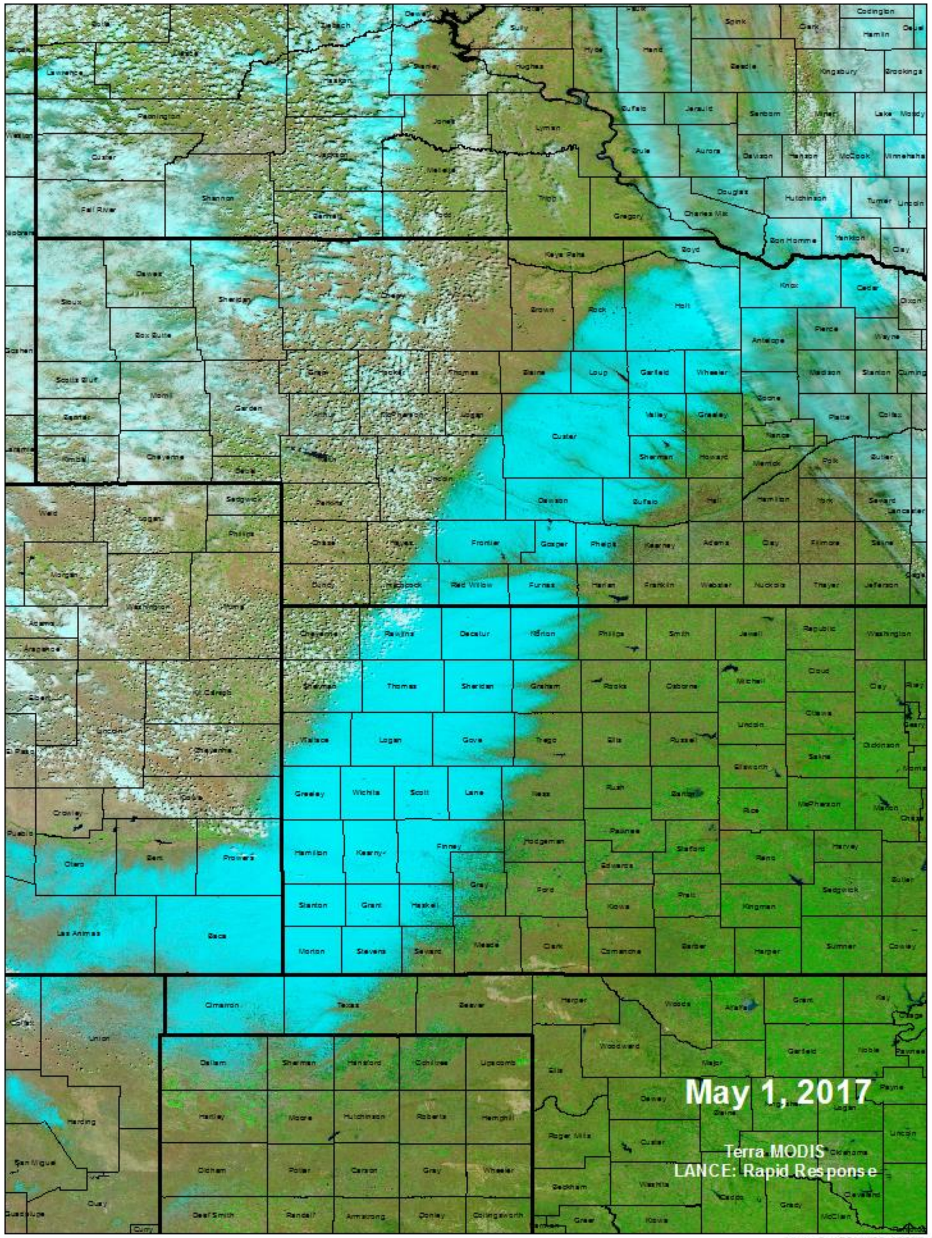
https://worldview.earthdata.nasa.gov/



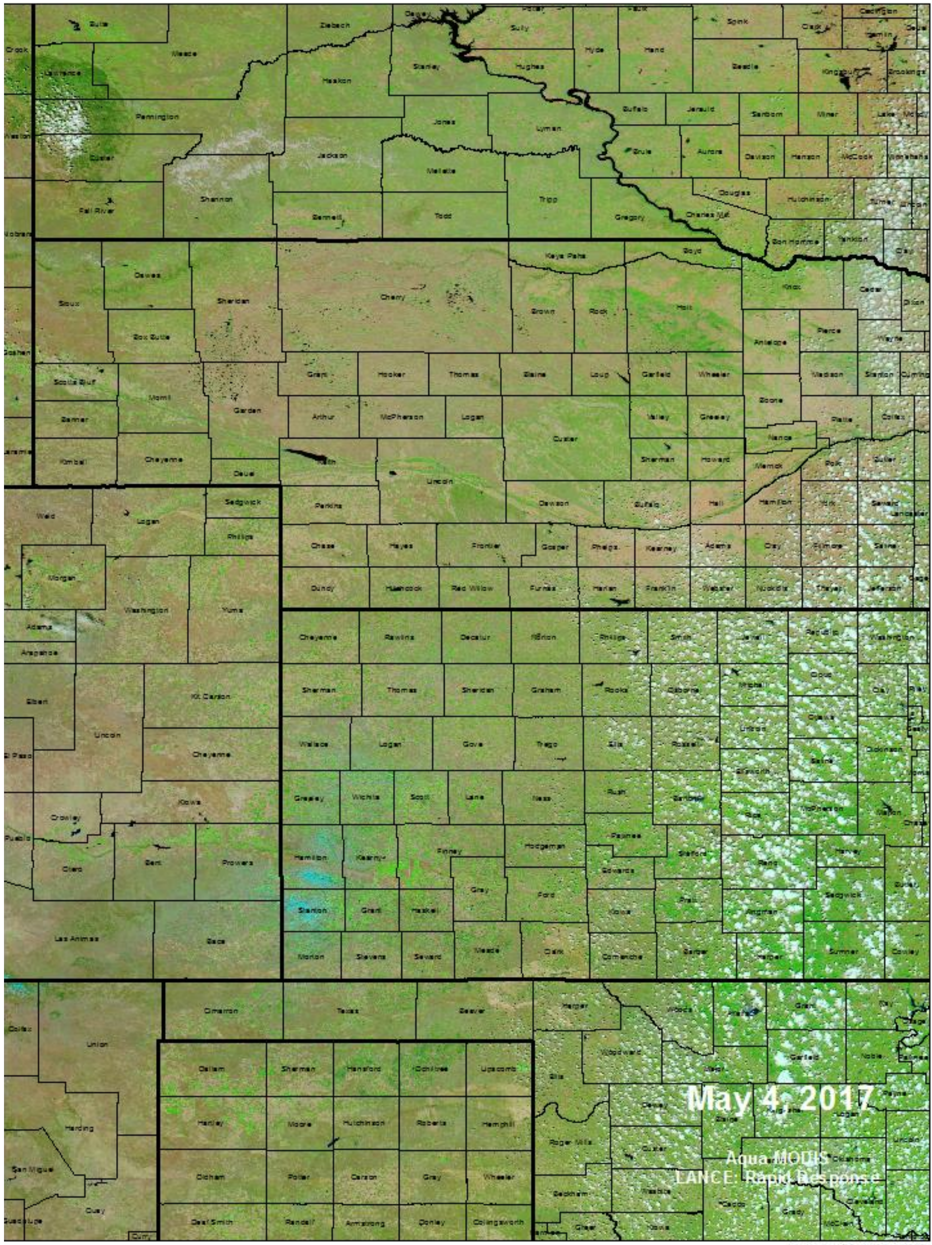
Hail example



MODIS Imagery - Snow event

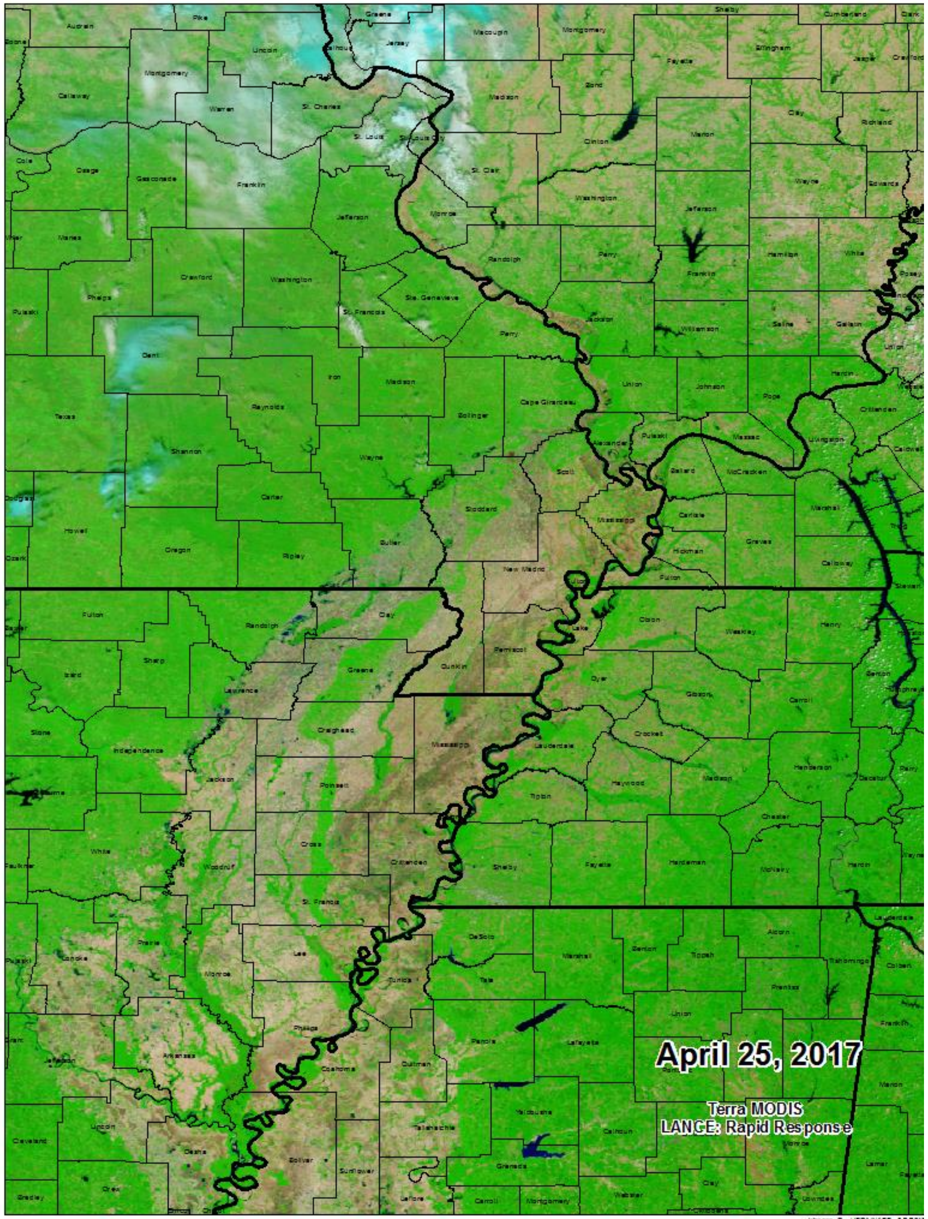


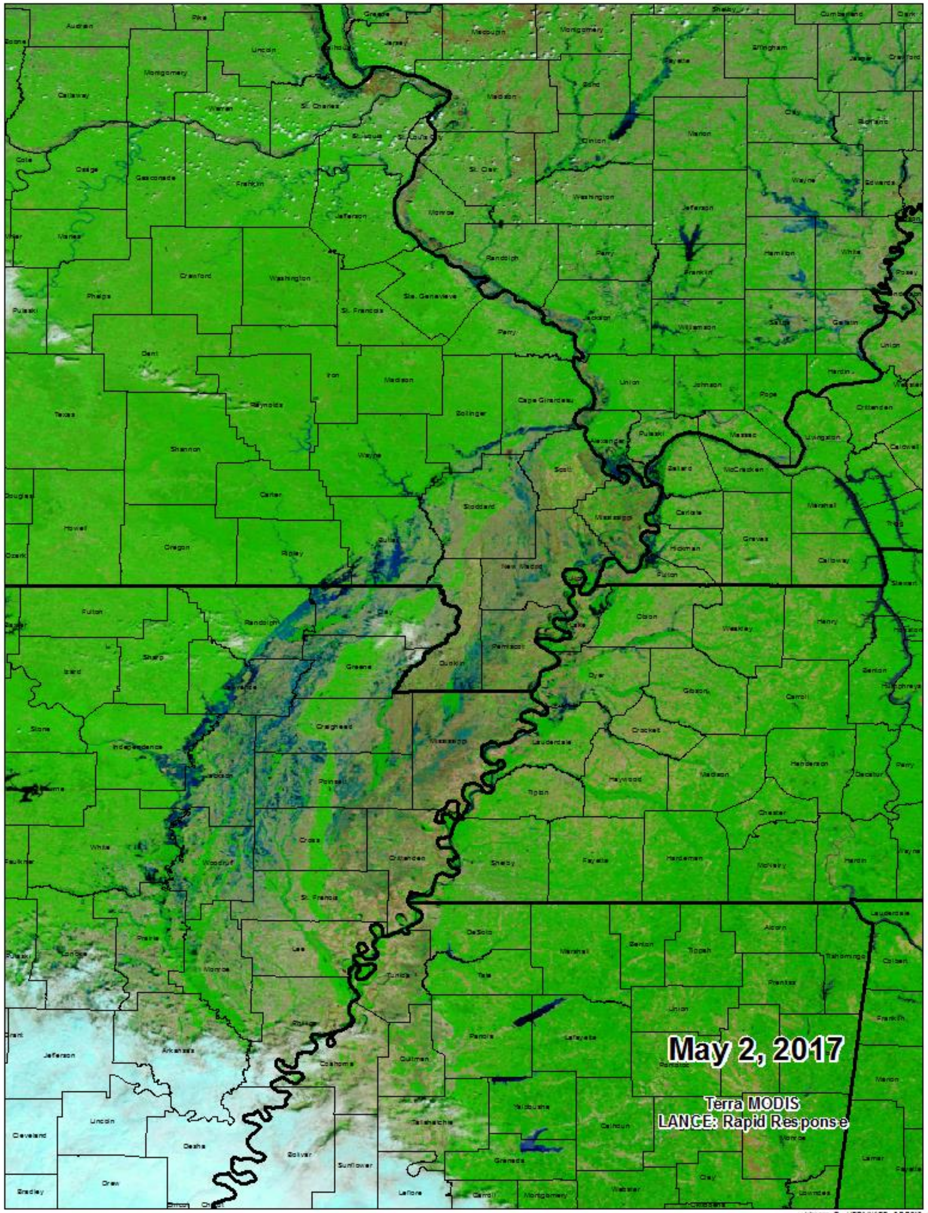
Johnson, D. USDA/NASS 5/2/2017



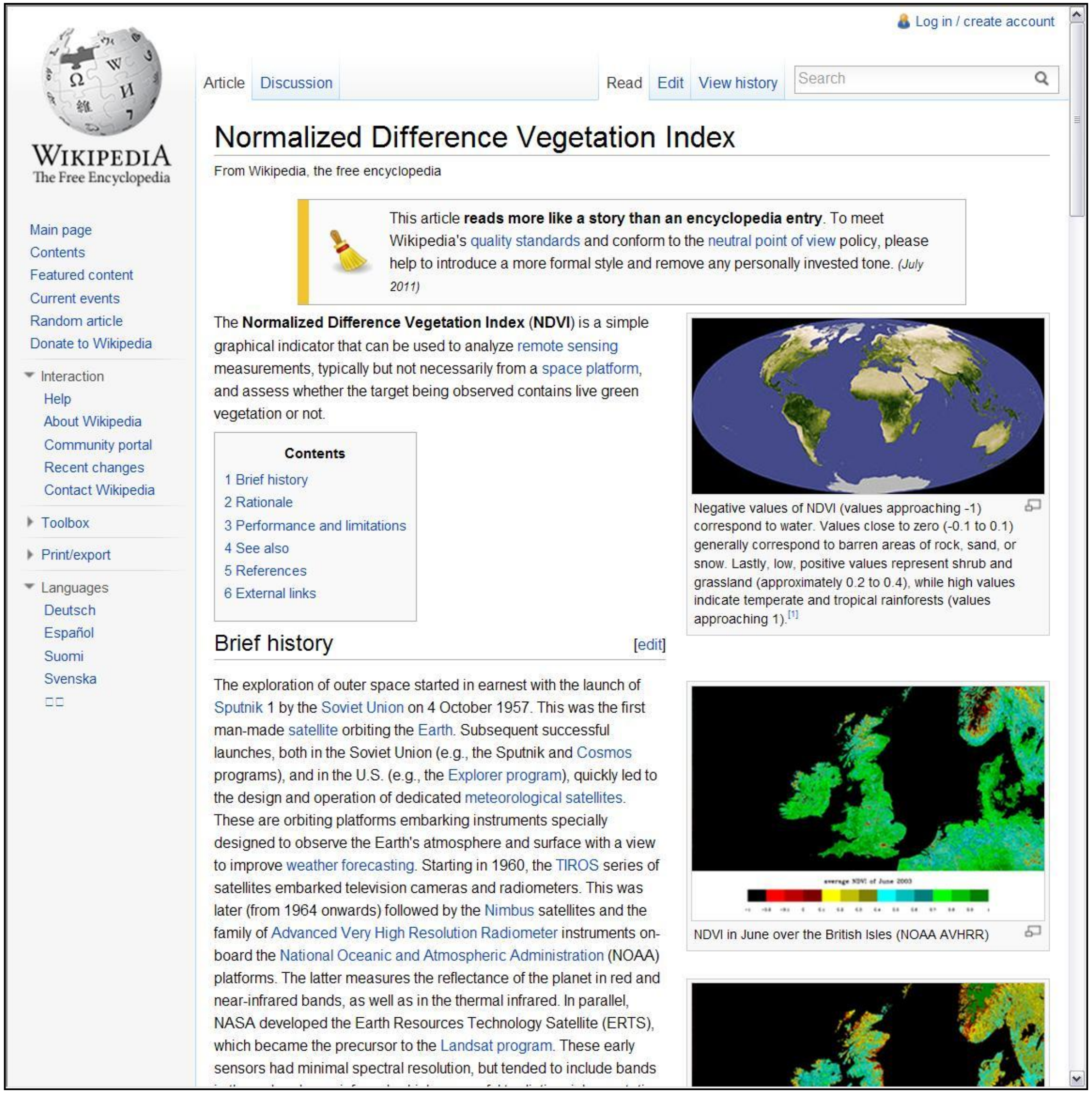
Johnson, D. USDA/NASS 5/2/2017

MODIS Imagery - Flood event





Calculation and use of NDVI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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.

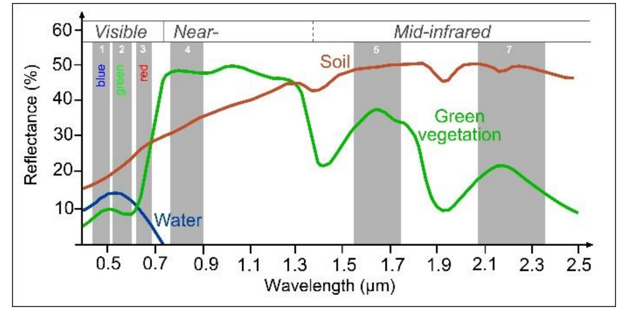
Contents

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]

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 band

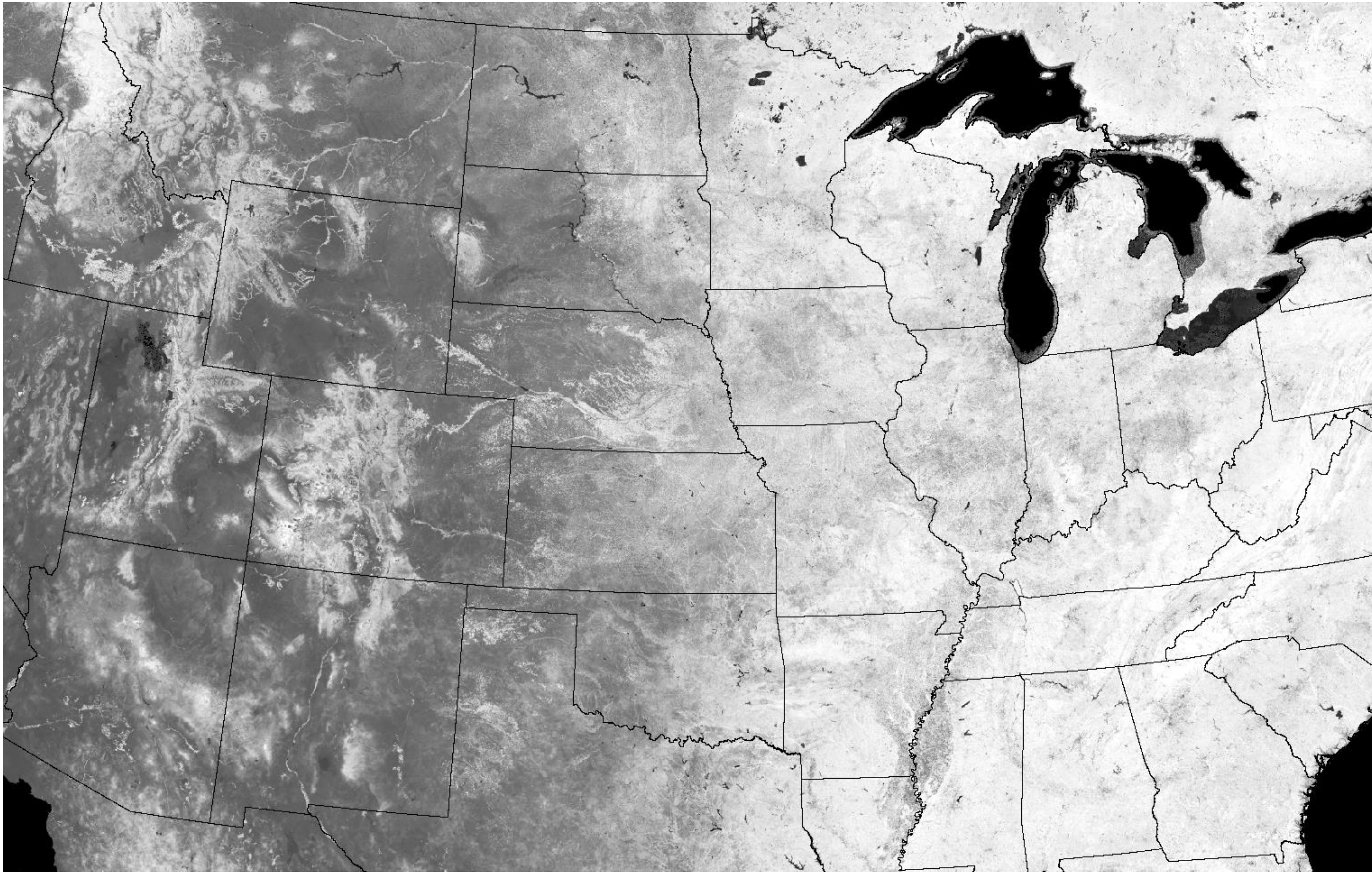
VIS = visible band

Ranges from -1.0 to 1.0

NDVI is a related to:

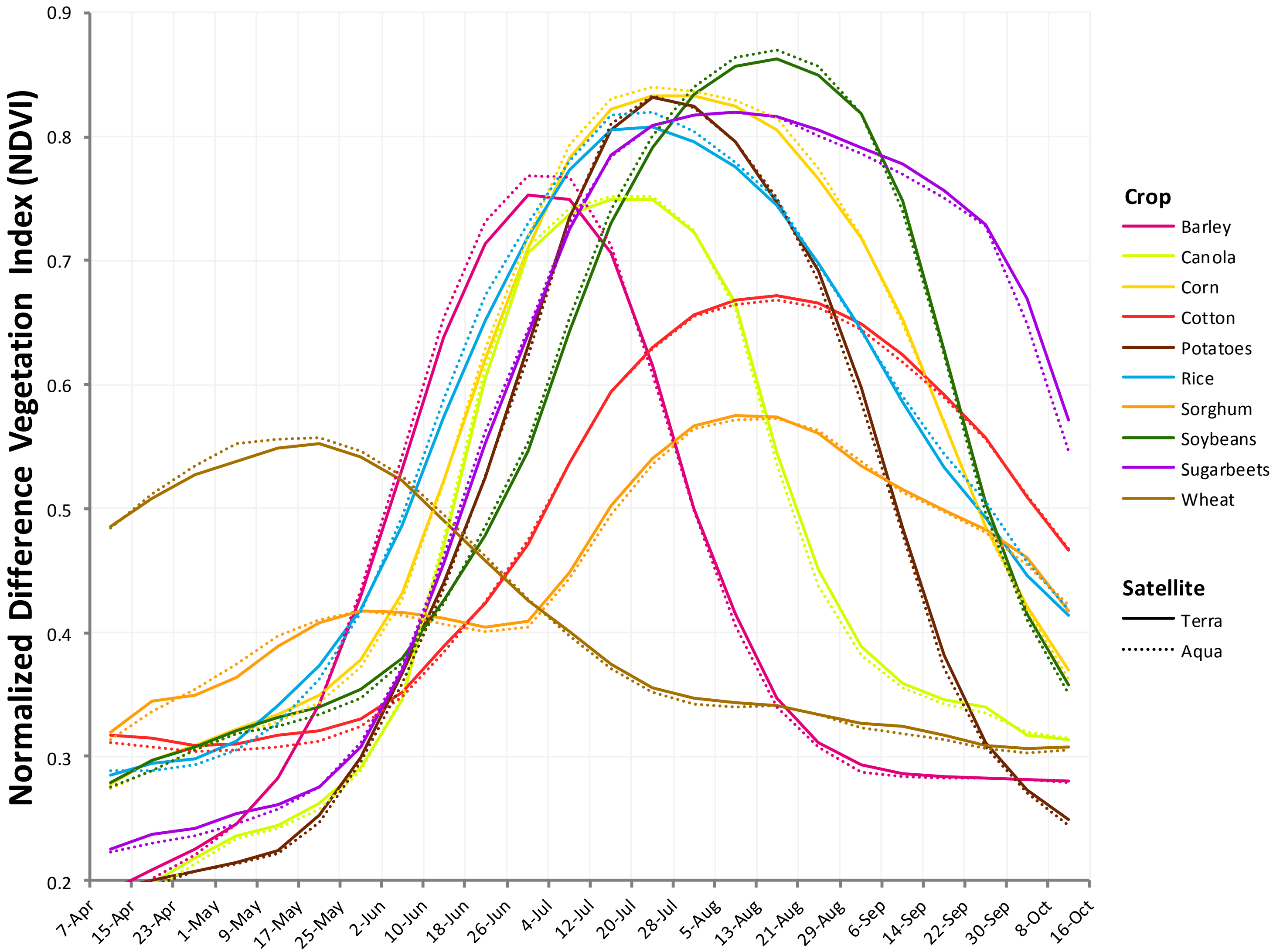
- Plant health
- Chlorophyll content
- “Greenness”
- Amount of Biomass
- Vegetation vigor
- **Yield!**

MODIS NDVI 8-day composite imagery example



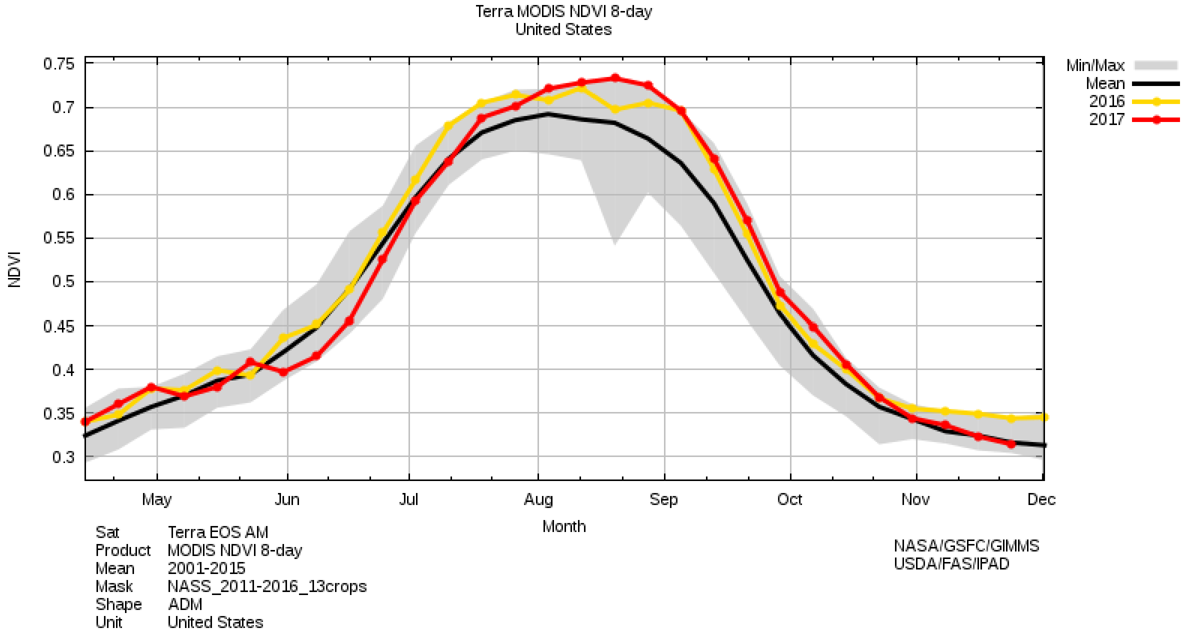
Lighter shades, greater NDVI

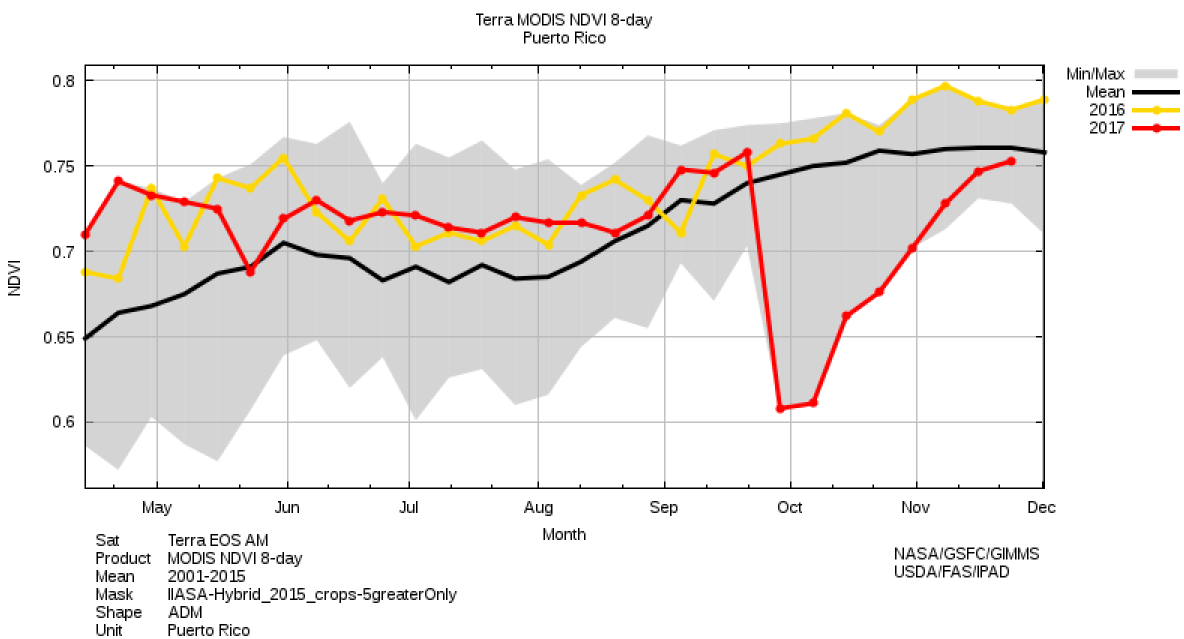
Average NDVI phenologies over United States



Signals isolated using crop specific masks

Real-time tracking of NDVI





NASS recent efforts on remote sensing of crop yields

Premise

- Positive relationship between crop yield and biomass – plant vigor - "greenness" - NDVI
- Negative relationship between crop yield and land surface temperature

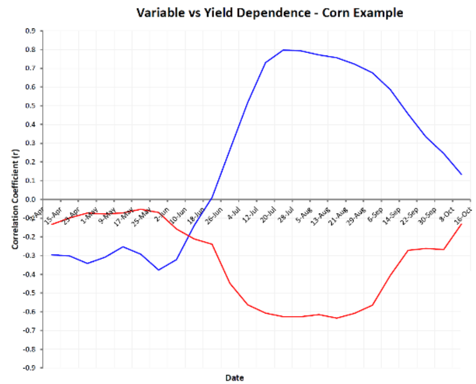
Utilize time-series MODIS satellite data to obtain biomass and temperature estimates throughout the growing season

- Use Cropland Data Layer to isolate known crop areas
- Then use them in an empirically-based prediction model based on historical imagery and NASS county-level yield statistics

Run model at National, State, and County levels

- Integrating over season approach
- Using decision trees (Rulequest Cubist)
- Corn and Soybeans operational currently

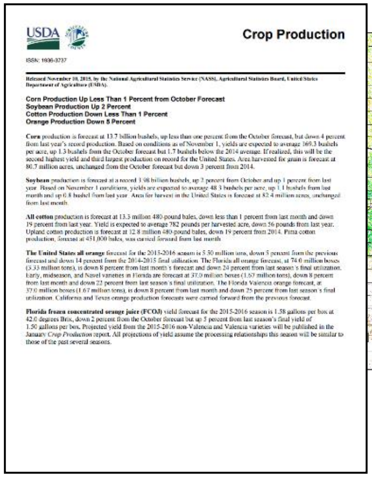
Perform within crop season at monthly intervals



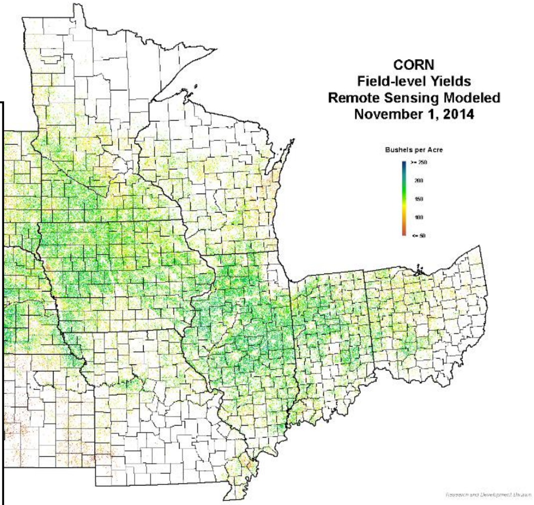

Remote Sensing of Environment

An assessment of pre- and within-season remotely sensed variables for forecasting corn and soybean yields in the United States

David M. Johnson

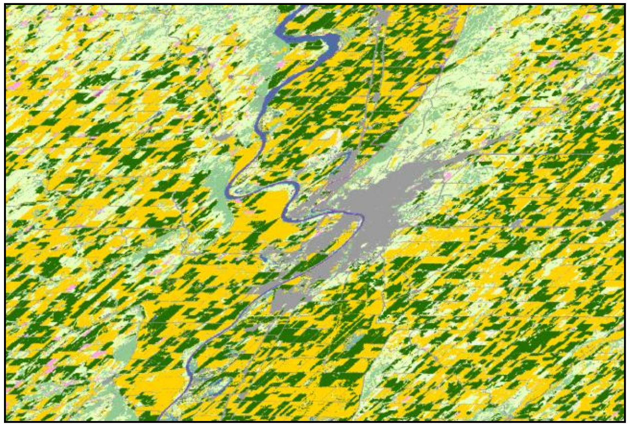

USDA

Crop Production

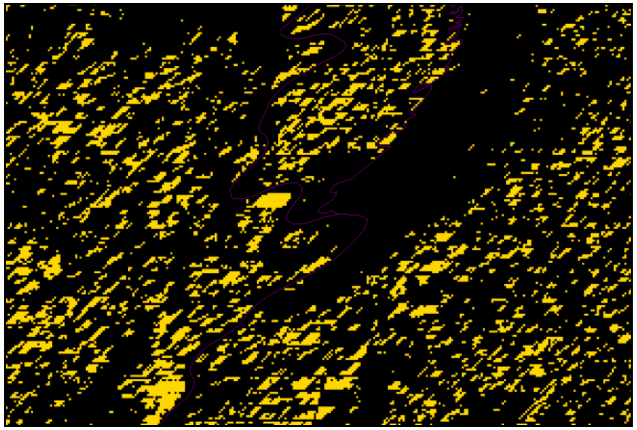


Must be timely, accurate, and useful

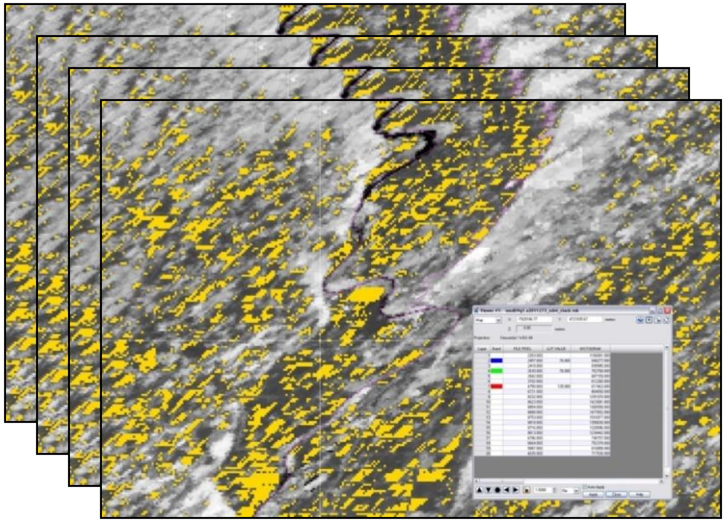
Intersecting of crop "mask" with time-series of MODIS data

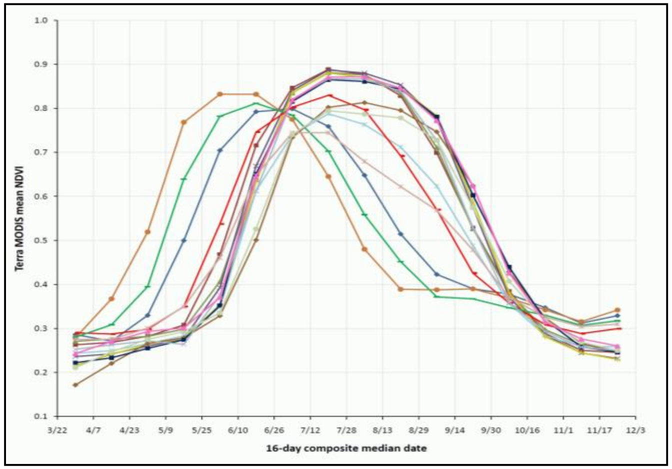


CDL



Isolate crop of interest





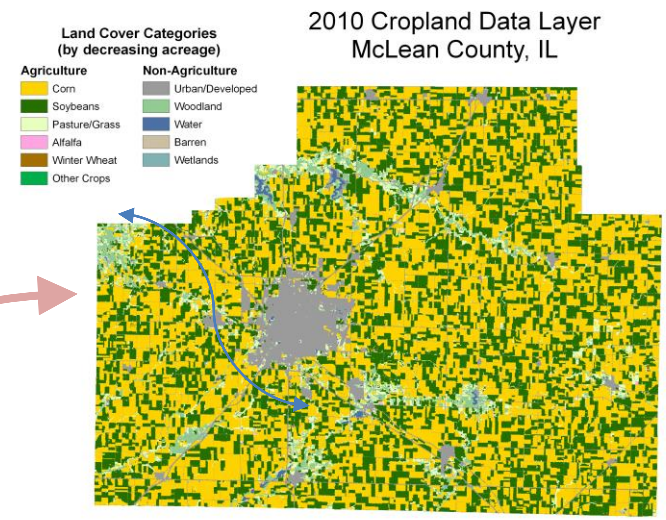
Intersect crop mask with MODIS time series and then spatially average those pixels

County-level time-series database has been built

2006 -> present

Every eight day “window” through the growing season

- Observed average value of NDVI
- Observed average value of LST

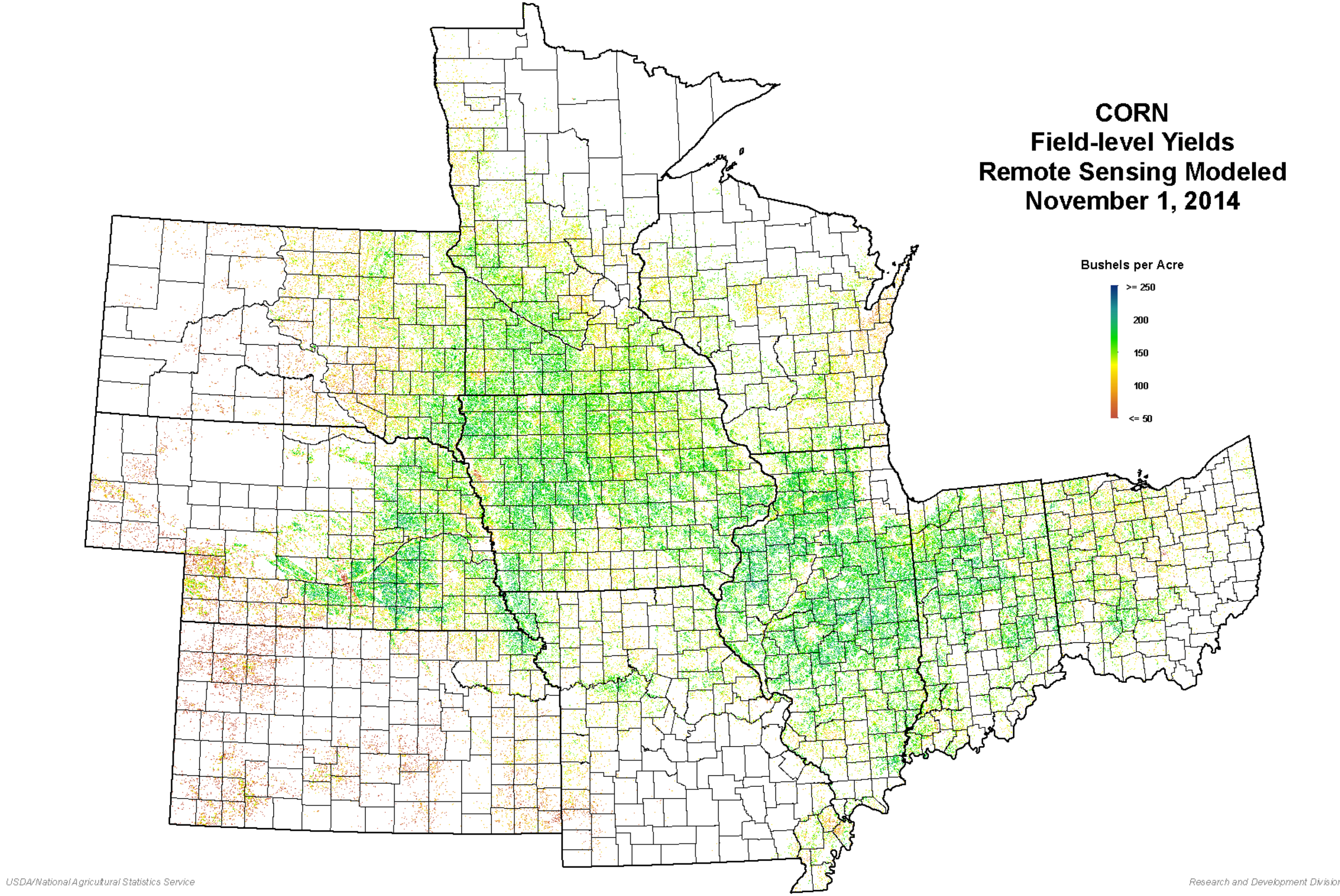


For every county we also know

- NASS published yield

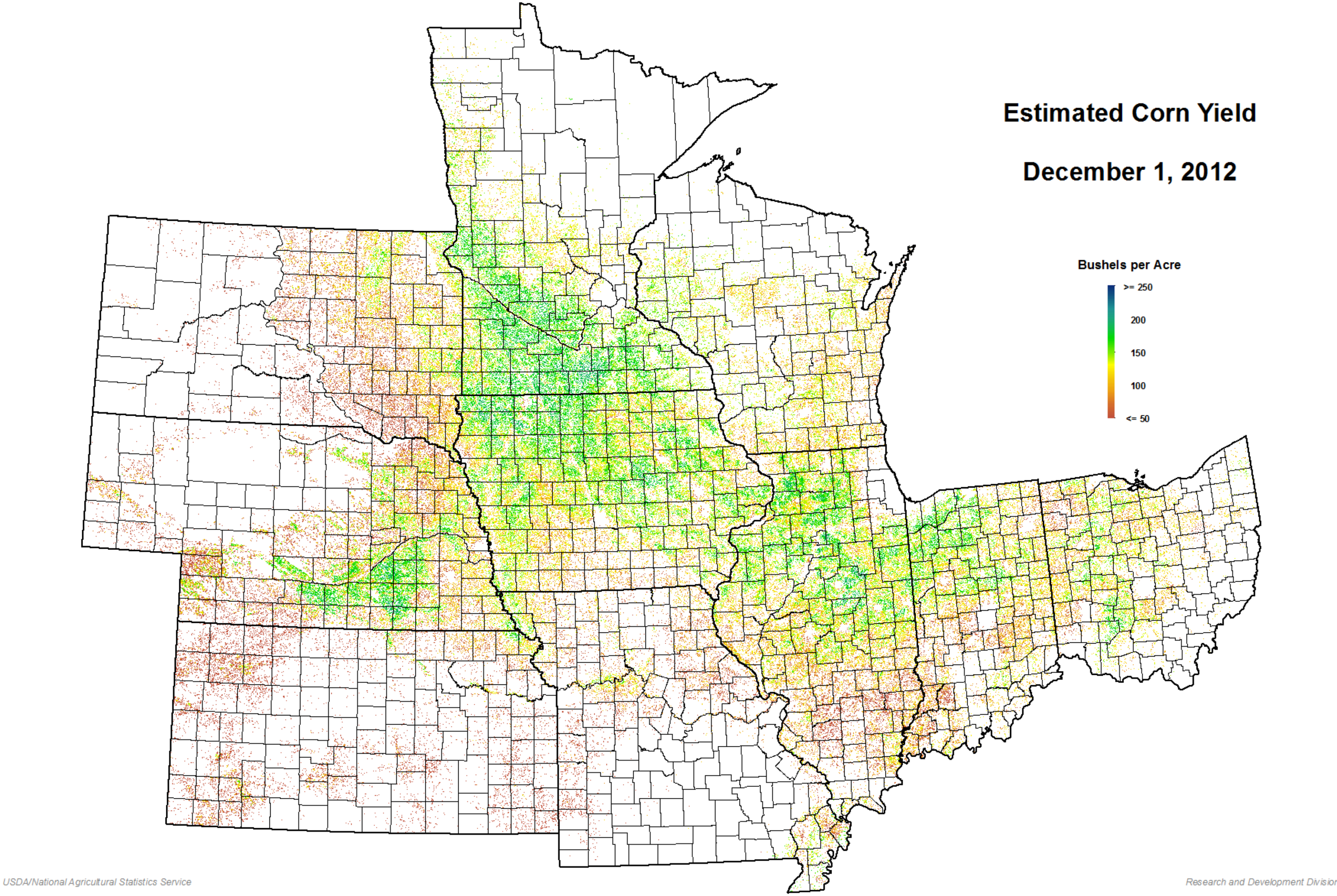
state	county	year	yield	NDVI	DLST	23-Apr	1-May	9-May	17-May	25-May	2-Jun	10-Jun	18-Jun	26-Jun	4-Jul	12-Jul	20-Ju
17	93	2010	168.6			2980.673	3264.547	3862.318	3866.409	3990.153	5893.765	7558.422	8108.906	8559.559	8826.817	8930.85	8935.61
17	95	2010	159.9			2992.195	2977.046	3203.401	3377.778	3848.078	5771.909	7450.655	8012.679	8310.476	8537.081	8645.006	8702.09
17	97	2010	?			3337.864	3836.186	5403.508	4459.949	4311.525	5635.508	7575.966	7776.288	8082.441	8575.966	8689.22	8524.83
17	99	2010	162.9			2844.2	2971.099	3332.757	3486.144	3937.887	6032.626	8059.657	8344.285	8565.456	8784.721	8903.283	8939.18
17	101	2010	156.9			3874.741	3988.952	4349.537	4930.498	5452.197	6205.825	7687.592	8022.794	8396.337	8589.467	8770.097	8827.56
17	103	2010	173.6			2782.144	2805.154	3018.966	3094.823	3512.443	5563.73	7306.284	8102.134	8554.694	8918.413	8949.941	8862.48
17	105	2010	166.6			2816.087	3007.861	3371.65	3608.025	3988.44	6100.426	8236.687	8503.526	8751.071	8872.207	8945.958	8805.10
17	107	2010	155.7			2706.578	2846.325	3249.914	3622.797	4402.778	6661.937	8254.186	8426.524	8515.872	8656.284	8755.741	8782.62
17	109	2010	141.8			3104.659	3240.878	3479.558	3558.215	4056.188	6151.458	7440.174	7913.743	8068.891	8437.704	8697.558	8783.25
17	111	2010	171.4			3079.982	3283.63	3659.725	3626.941	3909.787	5483.311	7163.395	8116.372	8578.756	8844.542	8908.066	8886.72
17	113	2010	169.5			2727.7	2899.42	3316.302	3573.485	4053.523	6484.888	8304.741	8585.89	8846.408	8960.349	8953.985	8860.08
17	115	2010	[illegible]			2791.229	2943.968	3442.016	3862.389	4880.537	7264.473	8749.776	8793.049	8769.201	8787.036	8828.984	8797.02
17	117	2010	146.9			3213.265	3342.063	3617.414	4030.15	4799.472	6474.308	8021.675	8511.256	8646.314	8885.395	8920.521	9010.37
17	119	2010	166.3			3282.816	3405.388	3712.914	4087.371	4860.512	6581.844	8129.837	8410.098	8587.161	8826.583	8879.477	8854.28
17	121	2010	149.7			3524.353	3534.901	3931.625	4260.018	4856.34	6251.207	7828.069	8242.445	8450.967	8601.465	8853.656	8952.45
17	123	2010	163.3			2748.186	2881.69	3261.708	3448.857	3851.546	5647.397	7541.326	8205.306	8567.037	8799.09	8891.405	8904.80

Map Output



Normal year

Map Output

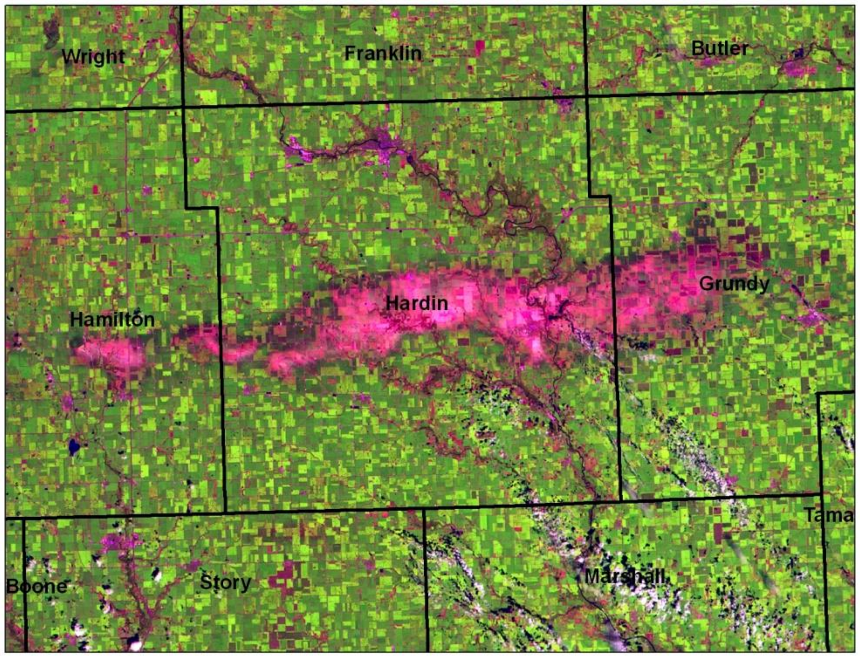


Drought year

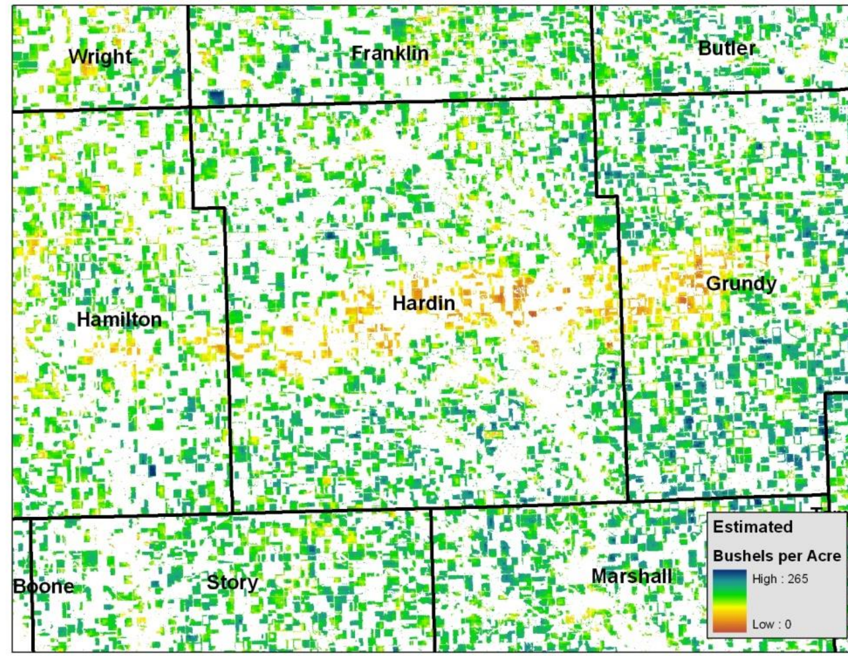
Johnson, 2014

Localized example of yield map variability

Scene of a large hailstorm



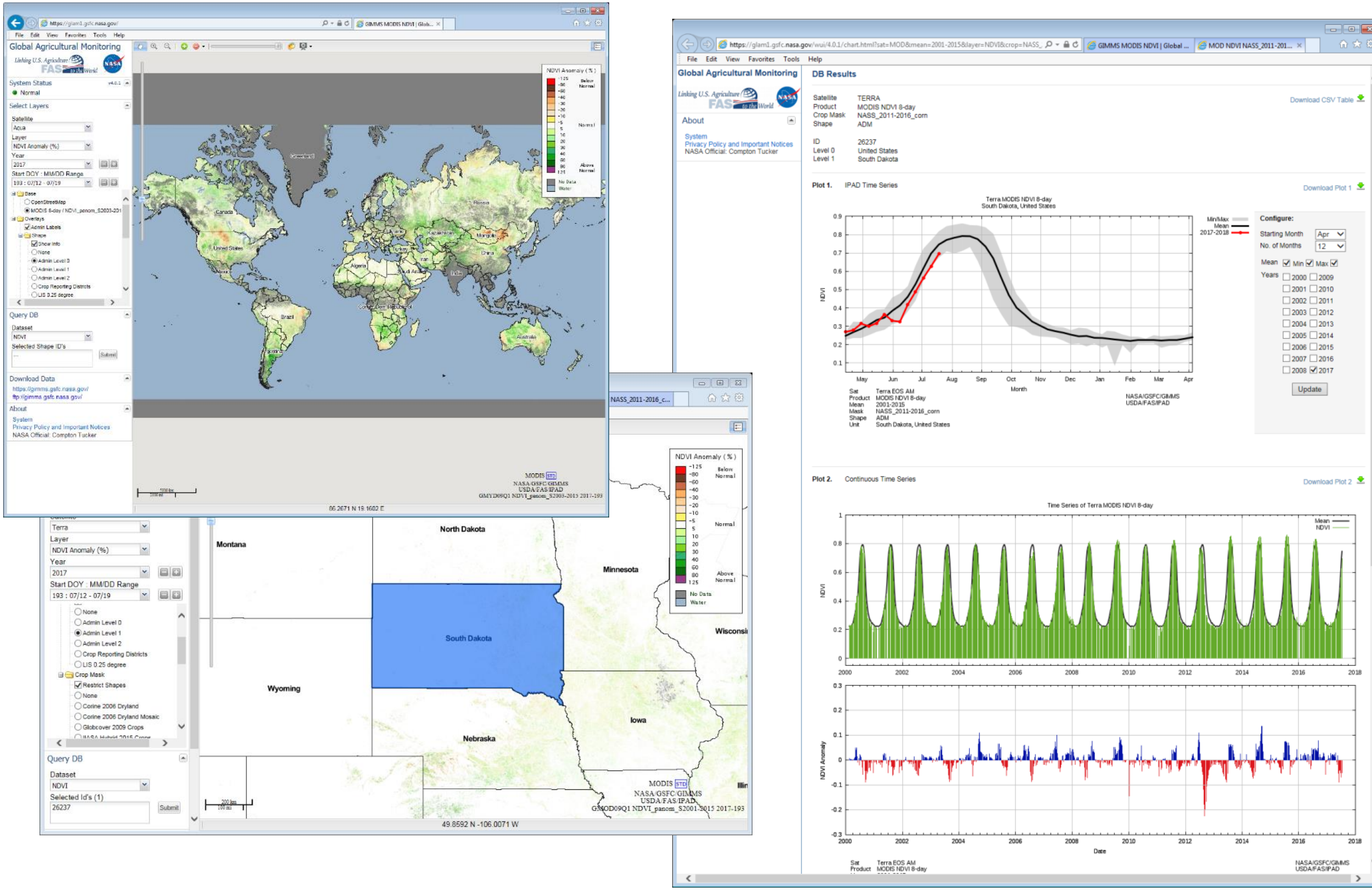
Landsat image



Modeled yields from MODIS

USDA Foreign Agricultural Service/NASA GLAM

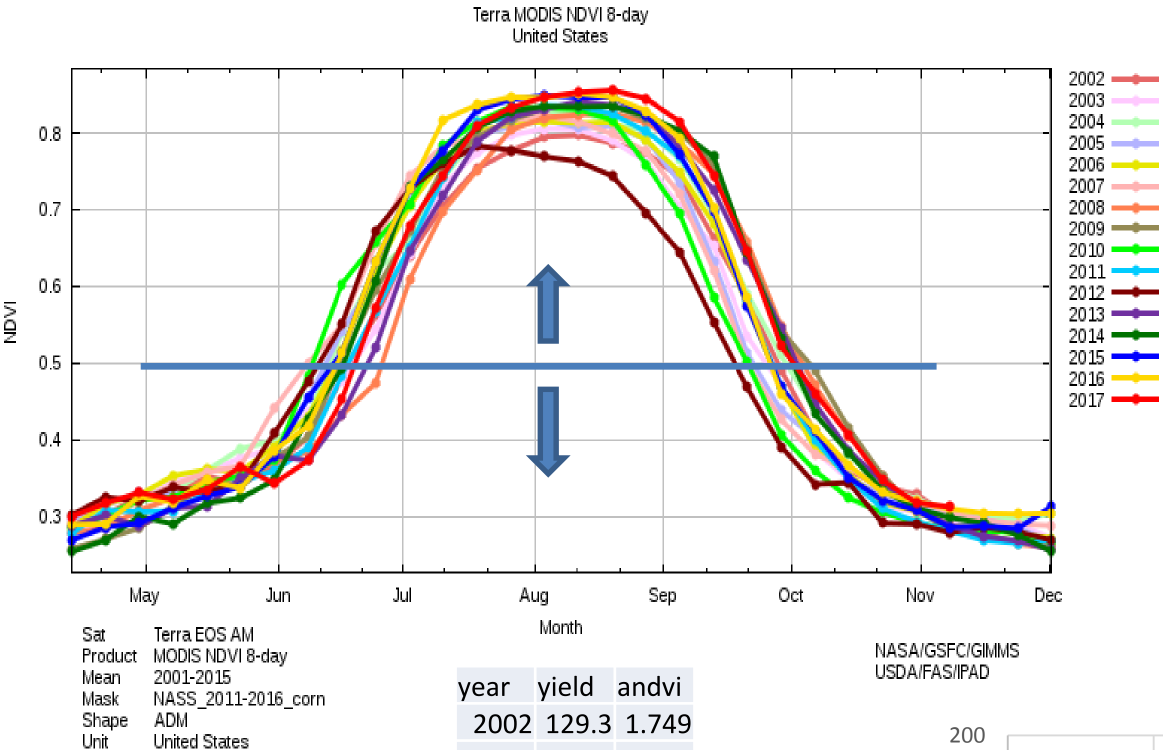
https://glam1.gsfc.nasa.gov/



Highly already customized tool for time series analysis and display

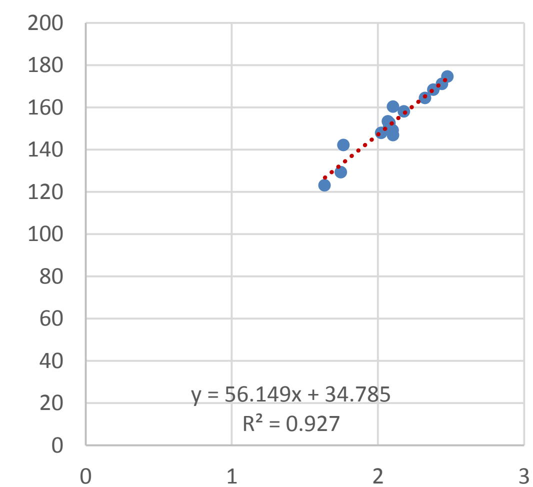
Also, shifting to a simpler model construction

Find Optimal Threshold Value

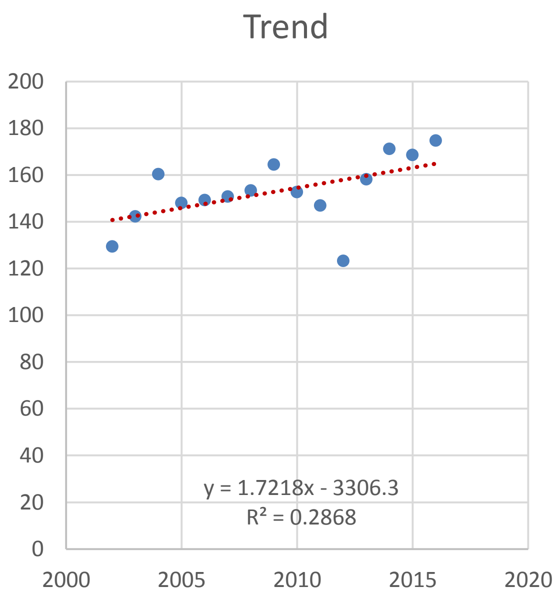


Calculate area under the curve, over a threshold and relate to past years.

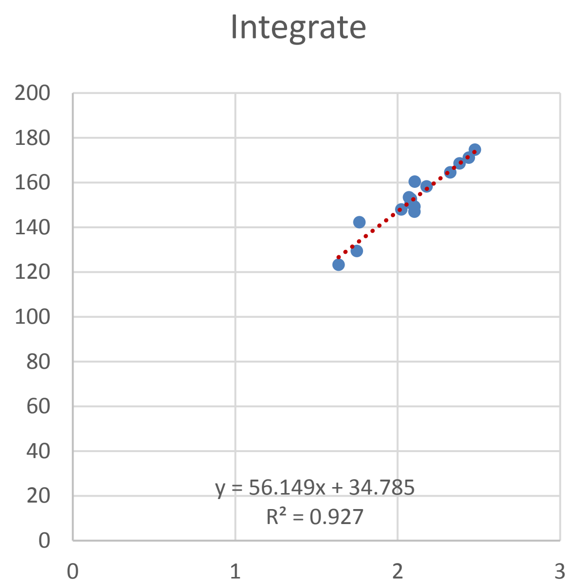
year	yield	andvi
2002	129.3	1.749
2003	142.2	1.765
2004	160.3	2.106
2005	147.9	2.024
2006	149.1	2.104
2007	150.7	2.08
2008	153.3	2.07
2009	164.4	2.324
2010	152.6	2.082
2011	146.8	2.105
2012	123.1	1.637
2013	158.1	2.179
2014	171	2.44
2015	168.4	2.382
2016	174.6	2.477



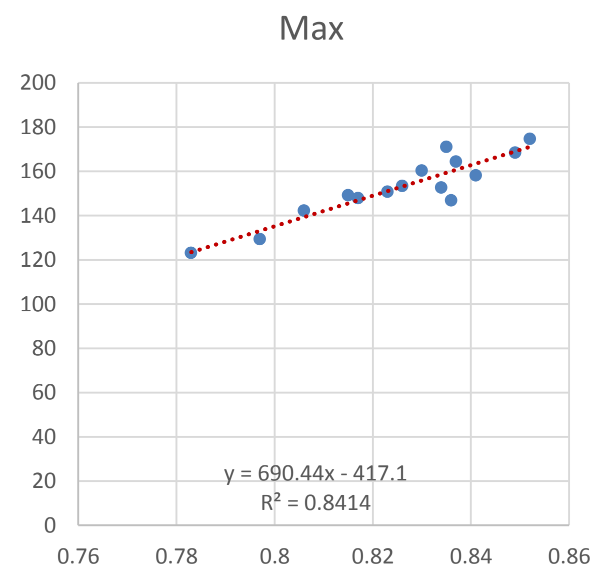
USA national-level simplistic corn yield model



Standard Error	12.5996

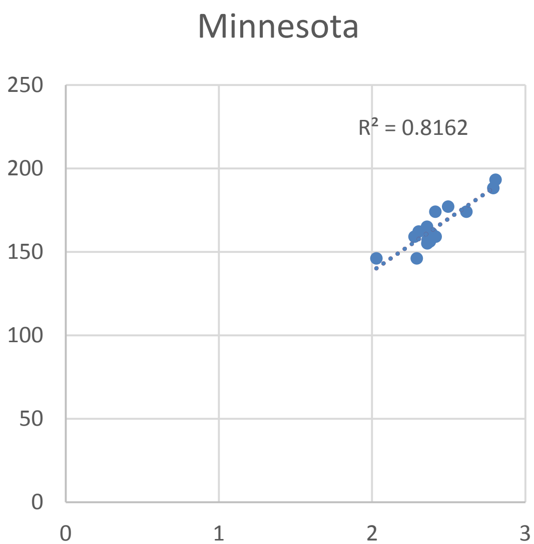


Standard Error	4.0309

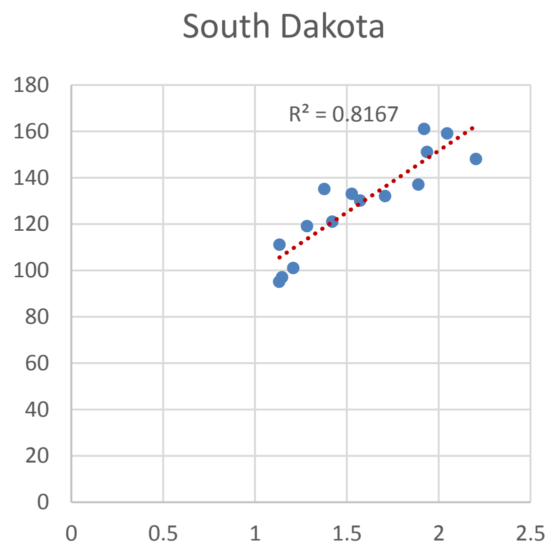


Standard Error	5.9422

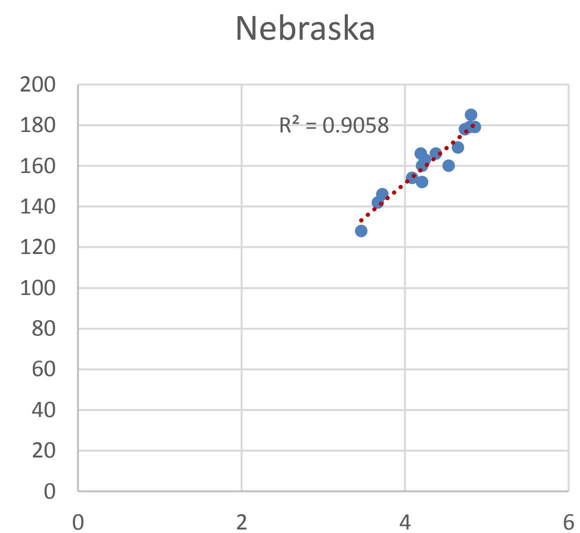
State-level simplistic yield modeling



Standard Error	6.1590

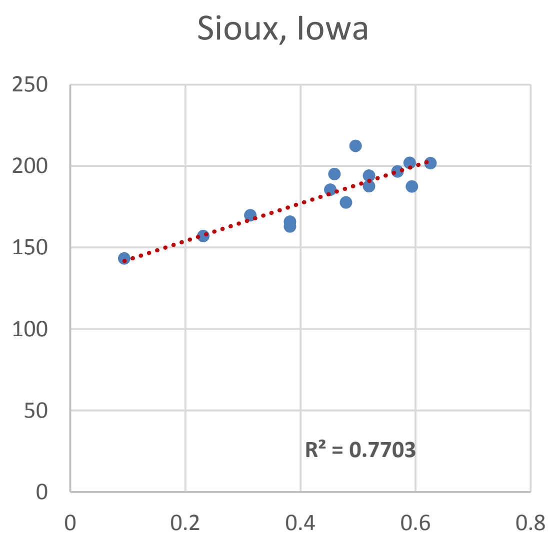


Standard Error	9.4601

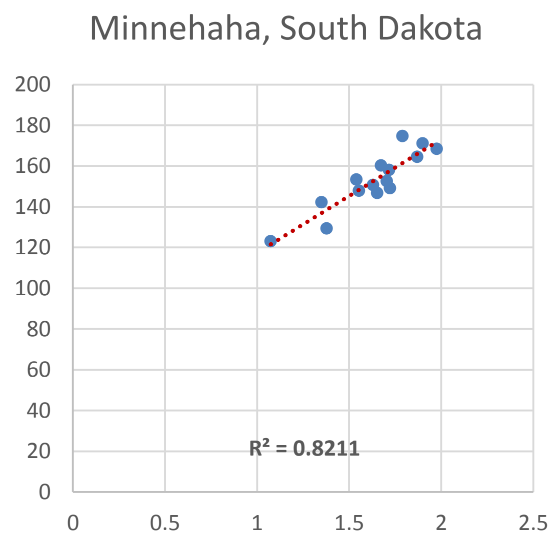


Standard Error	4.9836

County-level simplistic yield modeling



Standard Error	10.41041



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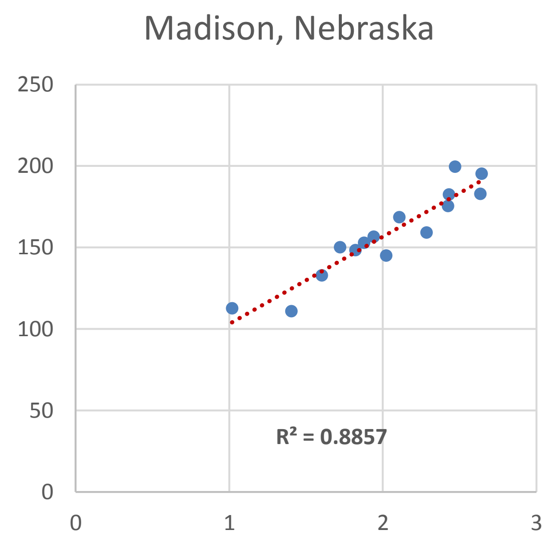
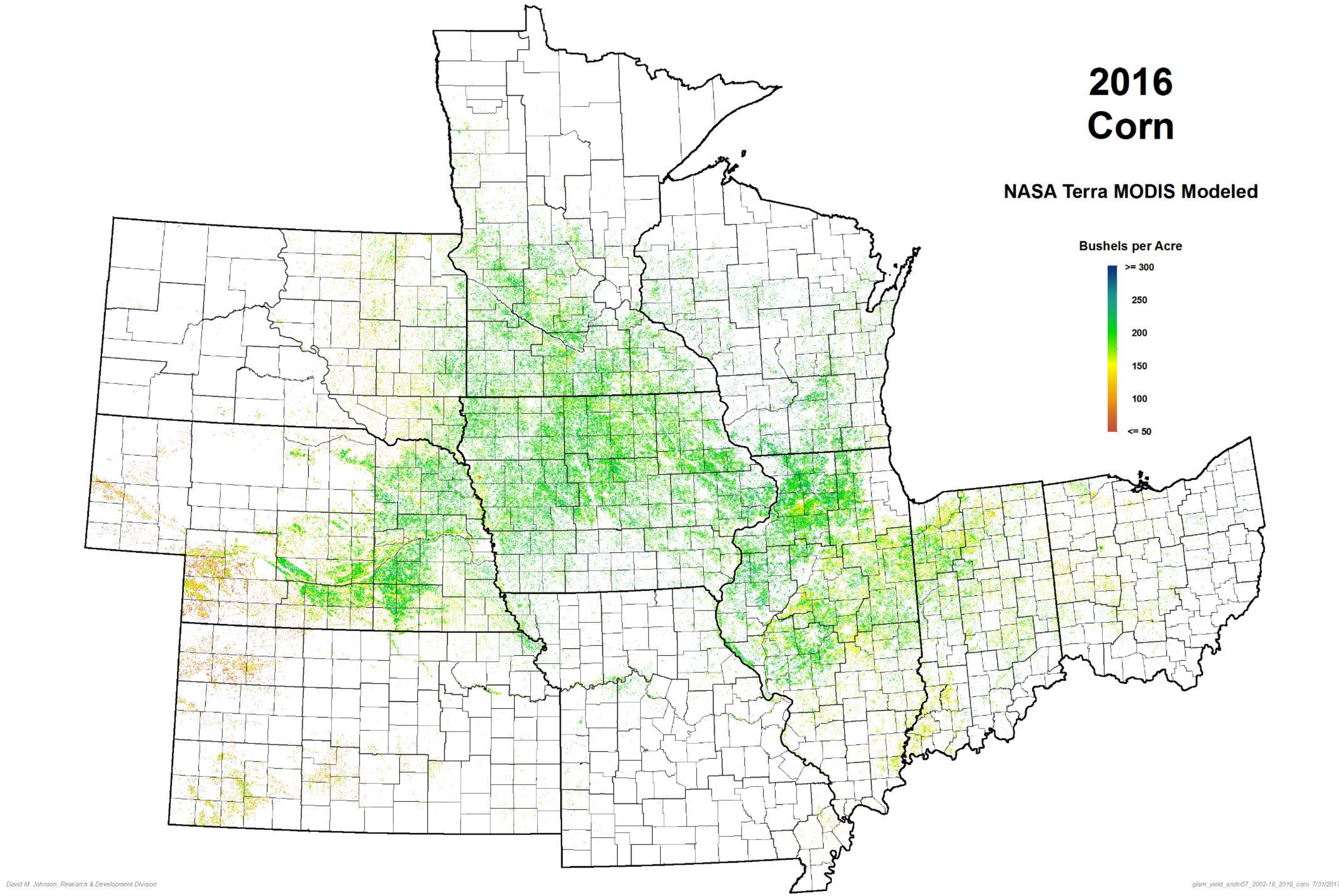
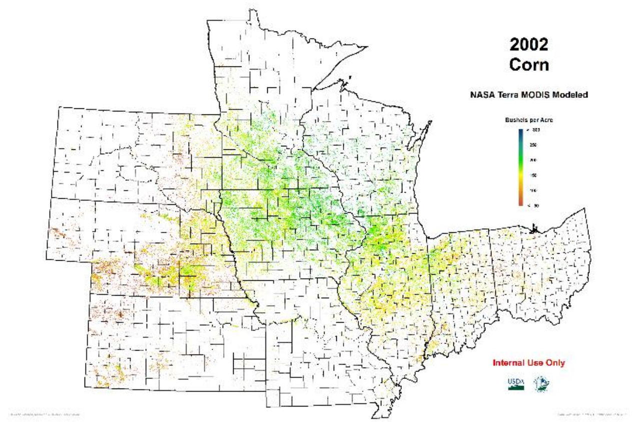


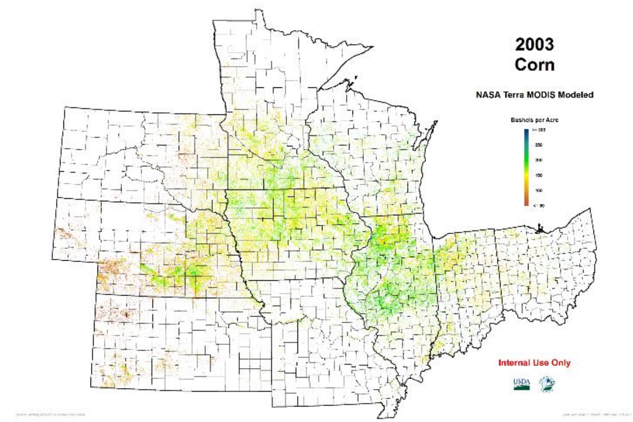
Standard Error	9.377654

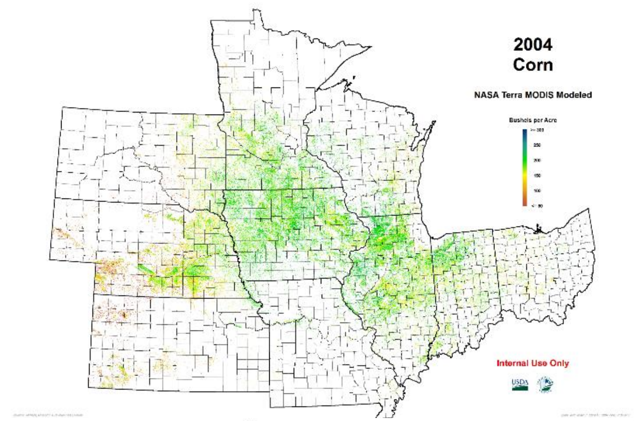
Map output still possible

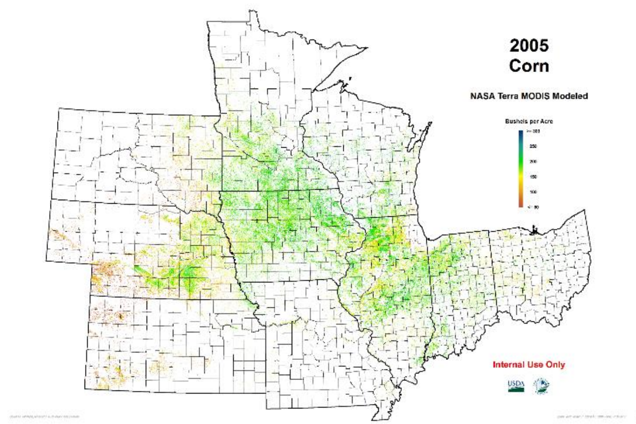


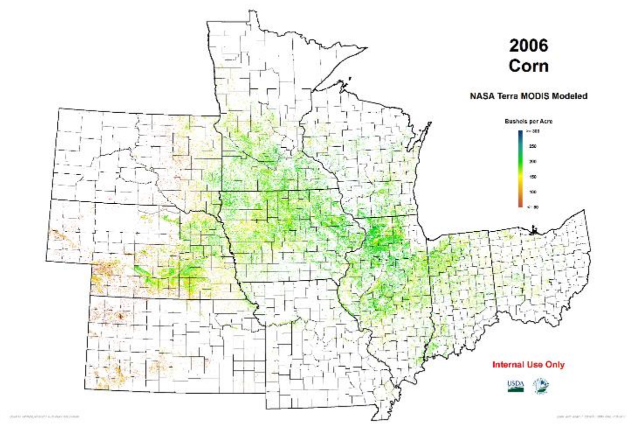
And easy to create time series…

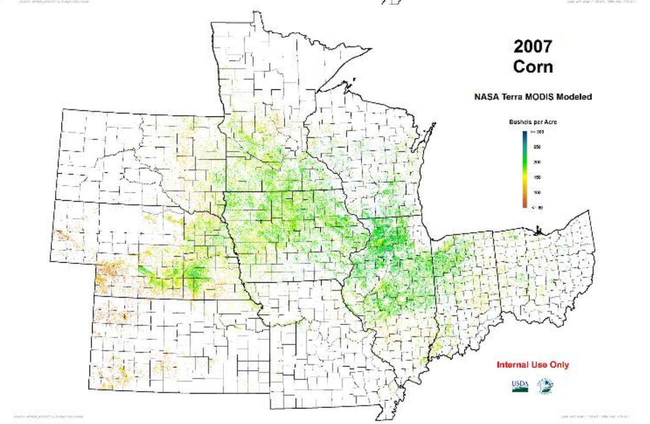


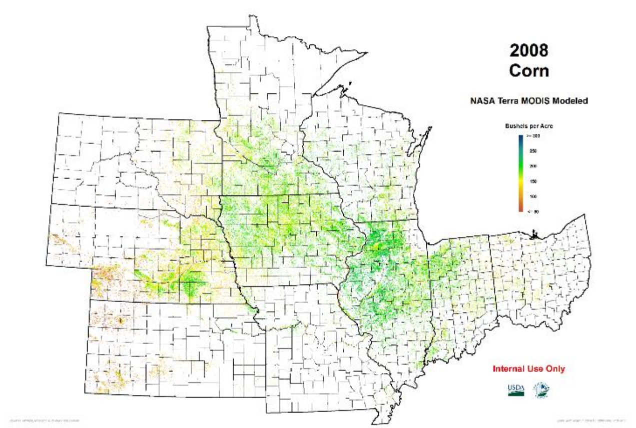


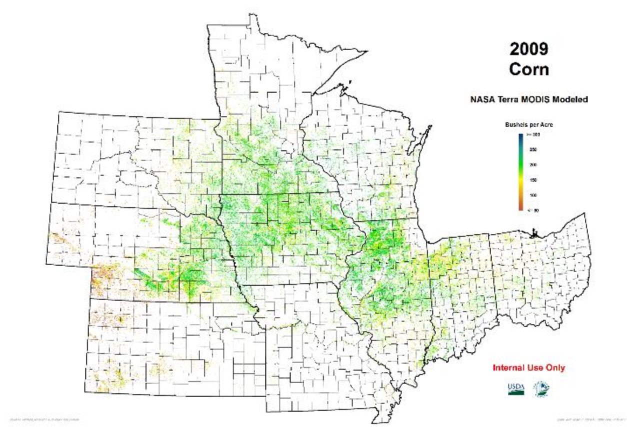


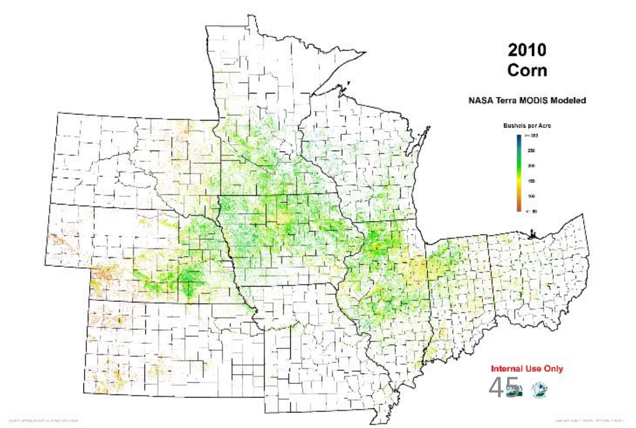










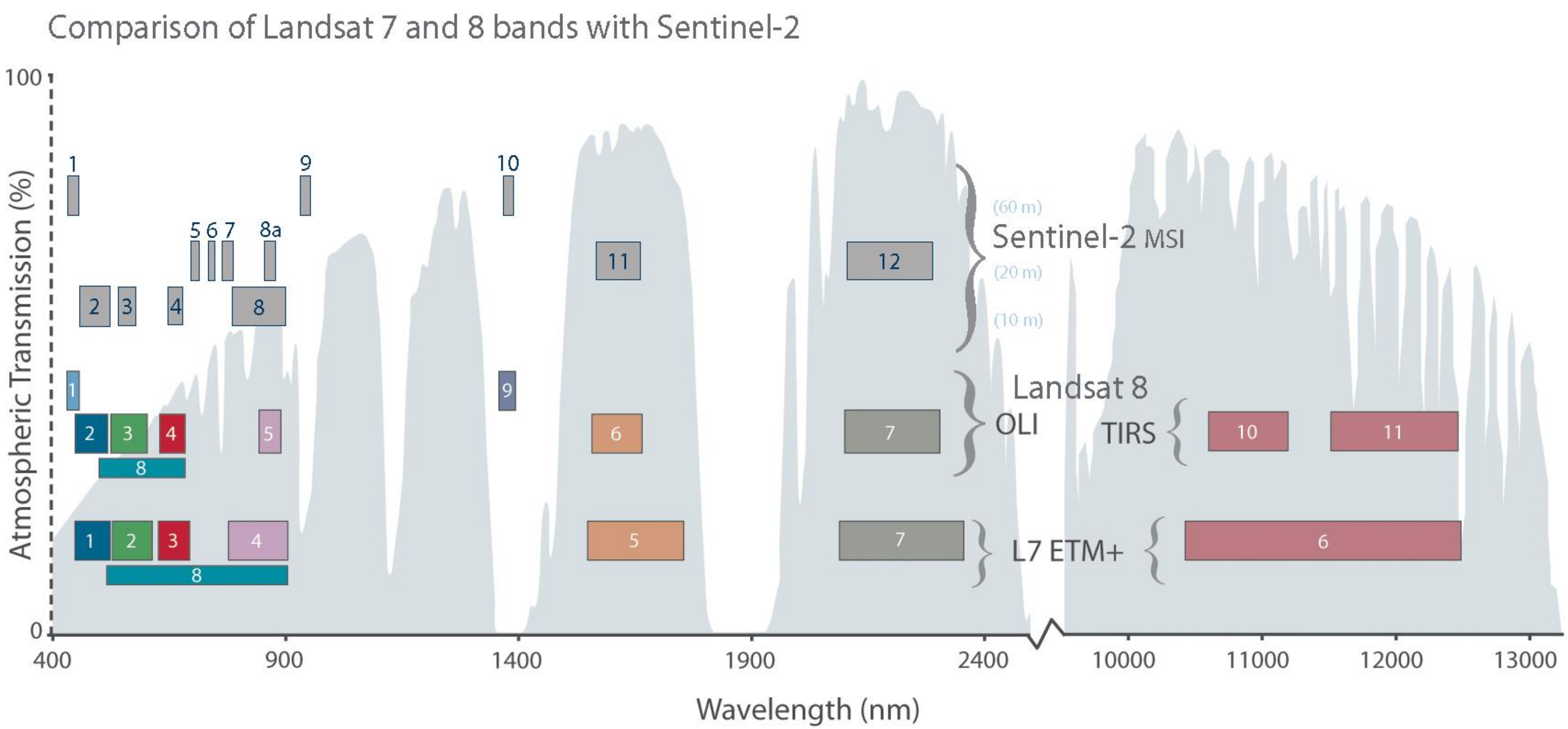


Summary of Remote Sensing for Crop Production Estimation

- **Strengths**
  - Good areal coverage
  - Solid temporal coverage
  - Many free data sources
  - Better sensors on the way
  - Little data latency
  - Fine spatial detail
  - Simple statistical models seem to be as good as complicated ones
  - Cheap computing and analytics has been a boon
- **Weaknesses**
  - Computationally intensive
  - Integrative skill set required
  - Calibration of datasets always ongoing
  - Measurement uncertainties difficult to quantify
  - A variety of noise sources are present
  - No long-term history
  - *In situ* validation lacking
  - Past utility was oversold

David M. Johnson, Geographer
BLS Data Quality Workshop, December 1, 2017
dave.johnson@nass.usda.gov

Sentinel-2 vs Landsat 7 & 8 spectral bands



Acreage estimate for a crop in stratum *h*

$$\hat{y}_h = N_h[\bar{y}_h + b_h(\bar{X}_h - \bar{x}_h)]$$

$N_h = Number\ of\ frame\ units(segments\ in\ frame)$

$\bar{y}_h = \boldsymbol{sample}\ mean\ per\ segment\ of\ reported\ acres\ of\ crop\ cover$

$b_h = Slope\ of\ the\ regression\ of\ acres\ in\ segment\ on\ pixel(acres)$

$\bar{X}_h = \boldsymbol{population}\ mean\ pixels(acres)in\ segment$

$\bar{x}_h = \boldsymbol{sample}\ mean\ pixels(acres)in\ segment$

Estimate of county total for a crop, stratum

$$\hat{T}_{(BF)hc.} = N_{hc}\left[\hat{\beta}_{0h} + \hat{\beta}_{1h}\bar{x}_{hc} + \delta_{hc}\bar{u}_{hc.}\right]$$

$$\bar{u}_{hc.} = \bar{y}_{hc.} - \hat{\beta}_{0h} - \hat{\beta}_{1h}\bar{x}_{hc.}$$ (residual)

1) if $\sigma^2_{\text{within}} = 0$, use $\delta = 1$,
2) if $\sigma^2_{\text{between}} = 0$, use $\delta = 0$,
3) if < 2 segments use $\delta = 0$,
4) if $\sigma^2_{\text{within}} = 1.0$, use $\delta = 0$,
5) otherwise use $\delta = \gamma$