A Kriging Approach for Representing Crop Progress and Condition at Small Domains

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Disclaimer

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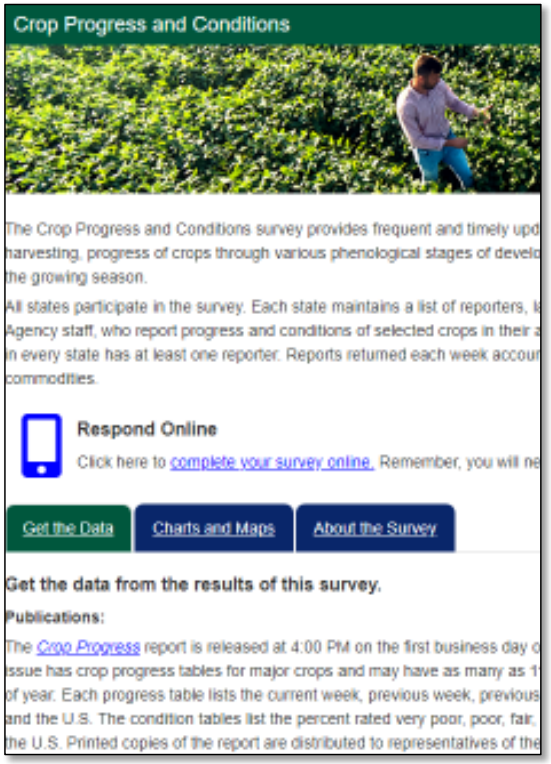
Outline

- Overview of NASS Crop Progress and Condition
- Description of issues faced by users
- Introduction of new small domain product
- Data access details

NASS Crop Progress and Condition Survey

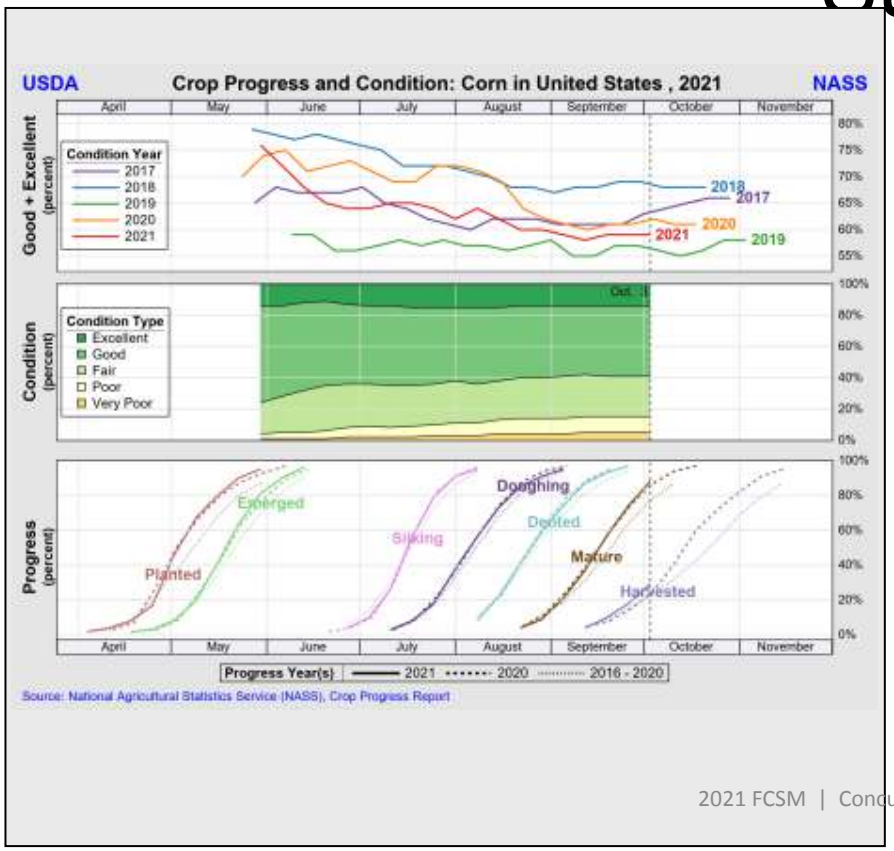


- The USDA National Agricultural Statistics Service (NASS) provides crop progress and condition estimates for selected crops on a weekly basis during crop specific growing seasons

- Crop progress and condition estimates are obtained from data provided by the **non-probability** crop progress and condition survey of crop experts (not farmers)

- Approximately 3600 experts participate in the survey annually, representing the 3108 agricultural counties in the lower 48 United States

NASS Crop Progress and Condition Survey



- Based on standard definitions, the expert respondents subjectively estimate:
  - **Progress** of crops through various stages of observed development as well as by producer activities
  - **Condition** of crops through visual evaluation and interaction with crop producers.

- Weekly reports are reviewed for reasonableness and consistency, and data is **aggregated to state and national levels** using weights derived from historical NASS acreage estimates

Current Data Format

Crop Condition:

- Condition for any given crop is reported as a breakdown of:
  - **Very Poor**
  - **Poor**
  - **Fair**
  - **Good**
  - **Excellent**
- Condition for a crop is expressed in terms of percentages within each category, always adding up to 100%
- **Ranges from 100% very poor to 100% excellent**

Iowa

Crop Condition as of September 29, 2019

Item	Very poor	Poor	Fair	Good	Excellent
	(percent)	(percent)	(percent)	(percent)	(percent)
Corn	2	7	26	54	11
Soybeans	2	7	28	52	11
Pasture and range	4	11	40	38	7

Current Data Format

Crop Progress:

- Progress also uses a percentage-in-category system like crop condition, but the categories vary by crop. The corn crop within a county can be some percent of each category, **ranging from 0% planted to 100% harvested:**

Corn Progress Categories

- **Planted**
- **Emerged**
- **Silked**
- **Doughed**
- **Dented**
- **Matured**
- **Harvested**

Iowa

Crop Progress as of September 29, 2019

Item	Districts									State			
	NW	NC	NE	WC	C	EC	SW	SC	SE	This week	Last week	Last year	5-yr average
	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)	(percent)
Corn dented	88	93	95	85	93	95	90	85	81	90	82	99	98
Corn mature	30	16	42	34	58	27	36	43	42	36	18	86	74
Hay, alfalfa, third cutting	97	97	96	96	99	92	90	76	83	89	87	98	96
Soybeans coloring	80	98	94	83	94	78	72	62	66	83	65	96	95
Soybeans dropping leaves	44	72	63	53	64	41	31	25	30	49	22	86	77

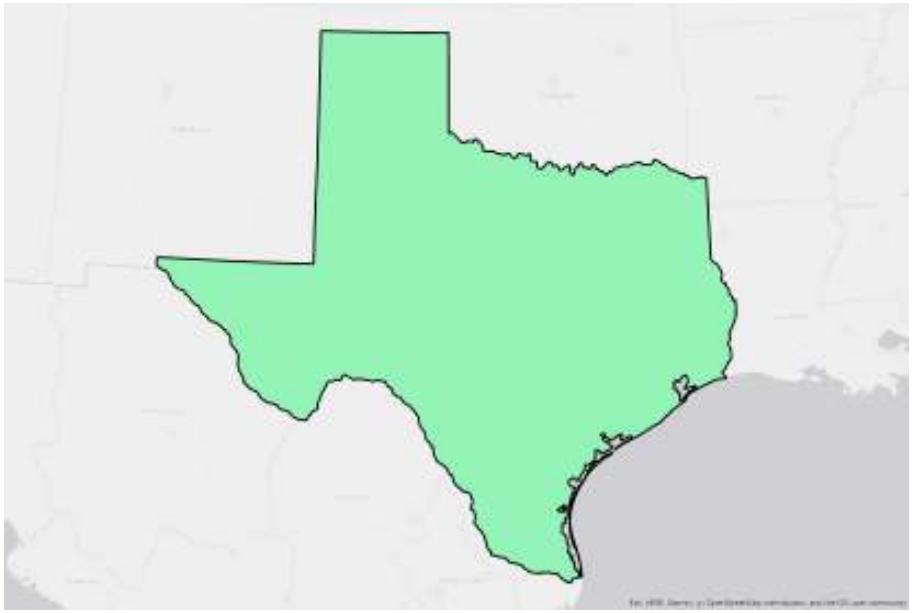
Current Data Format: Issues

Progress and Condition is **aggregated at the state and national levels for public use**. This is done to protect the confidentiality of producers, and to enhance stability of estimates. However, this presents issues for data users:

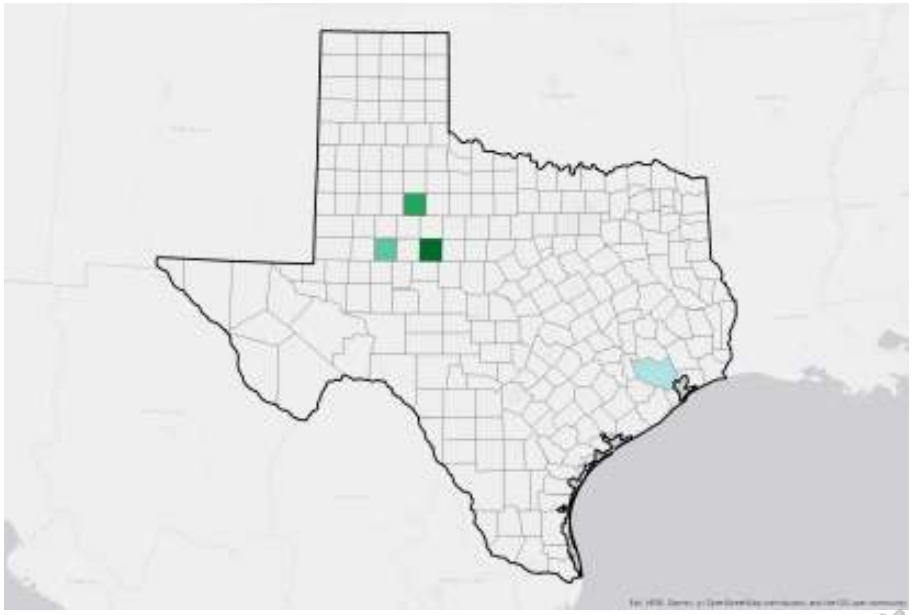
- State summaries do not represent within-state trends and variability
- There is no indication which counties or regions within the state actually contribute to reports

Exaggerated Example

One estimate for the state…



…from sparse and geographically biased inputs



New Product for Smaller Domains

The new **Crop Progress and Condition Gridded Layer**s addresses these issues by representing trends in condition and progress of major commodity crops throughout the growing season, while obscuring the actual county-level data.

This is achieved in two main steps:

1. Represent county progress and condition as simplified numeric indices or percentages based on the original percent-in-category data.
2. Interpolate these values across the lower 48 states as a continuous raster surface, independent of county boundaries.

Step 1: Reduce Original Data Into Numeric Indices

Condition Index

- Crop Condition Index combines all categorical condition percentages into single number:

Corn Condition Index =

*Corn Condition Index = (5*excellent + 4*good + 3*fair + 2*poor + very poor)/100*

- Values **range from 1 to 5**, where 1 is 100% “Very Poor”, and 5 is 100% “Excellent”

Condition Index

County	Excellent	Good	Fair	Poor	Very Poor	Con. Index
05029	100%	0%	0%	0%	0%	5
05031	80%	20%	0%	0%	0%	4.8
05033	25%	20%	50%	5%	0%	3.65
05035	0%	50%	50%	0%	0%	3.5
05037	20%	20%	30%	20%	10%	3.2
05039	0%	60%	25%	15%	0%	3.45
05041	20%	75%	5%	0%	0%	4.15
05043	40%	50%	10%	0%	0%	4.3
05045	10%	40%	50%	0%	0%	3.6
05047	30%	32%	17%	21%	0%	3.71
05049	28%	41%	20%	10%	1%	3.85
05051	36%	36%	28%	0%	0%	4.08
05053	36%	36%	28%	0%	0%	4.08
05055	30%	50%	20%	0%	0%	4.1
05057	10%	10%	40%	30%	10%	2.8
05059	36%	36%	28%	0%	0%	4.08
05061	10%	10%	40%	30%	10%	2.8
05063	44%	39%	16%	1%	0%	4.26
05065	28%	41%	20%	10%	1%	3.85
05067	0%	75%	25%	0%	0%	3.75
05069	10%	50%	30%	10%	0%	3.6
05071	0%	0%	0%	100%	0%	2

Progress Index

- Proposed crop progress index combines all categorical progress percentages into a single number. This would be based on different categories depending on the crop.

Winter Wheat Progress Index =

Wheat Progress Index = (harvested + heading + emerging + planting)/400

- Values **range from 0 to 1**, where 0 represents 0% planted and 1 represents 100% harvested

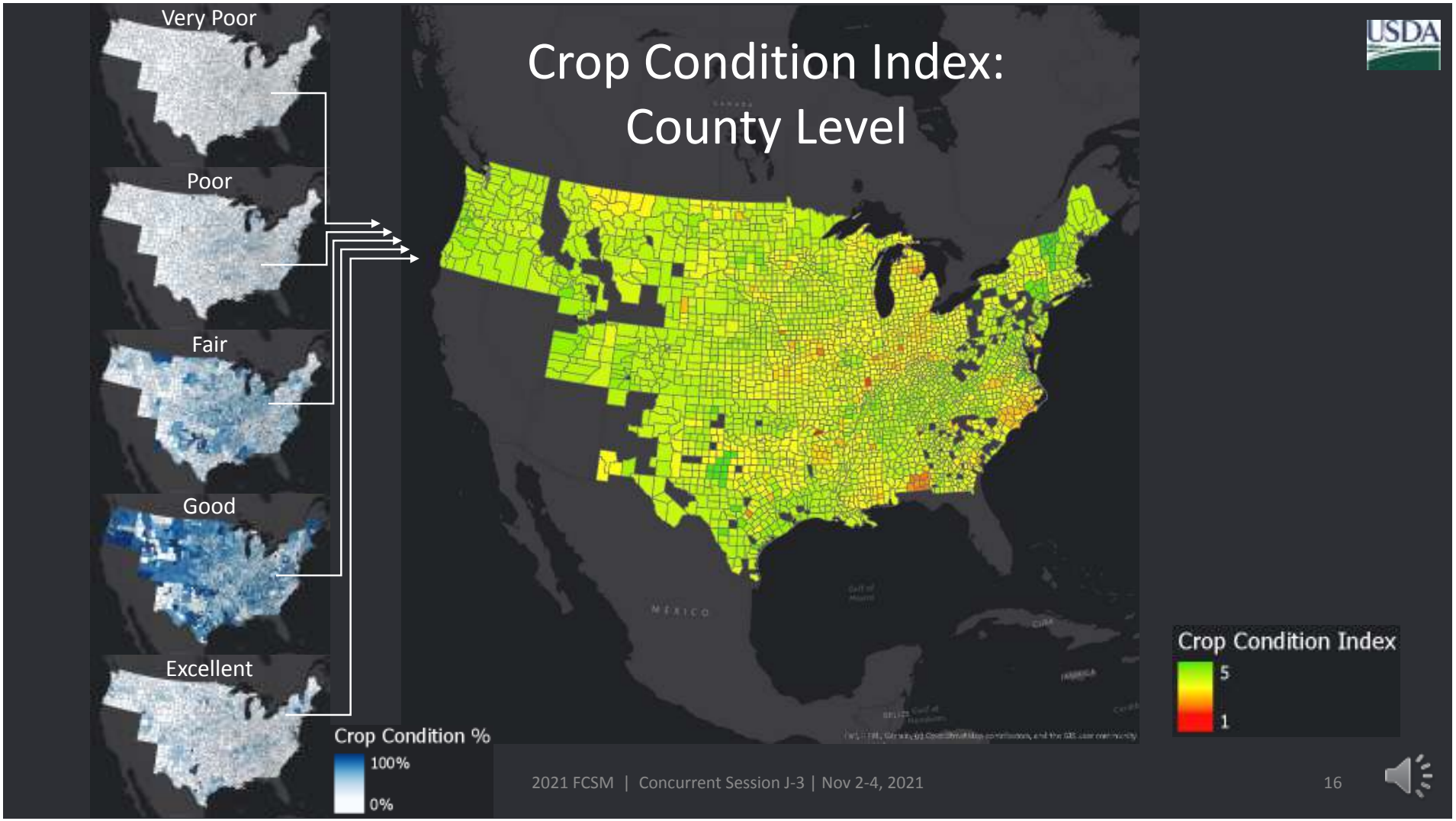
Progress Index

Growing Season

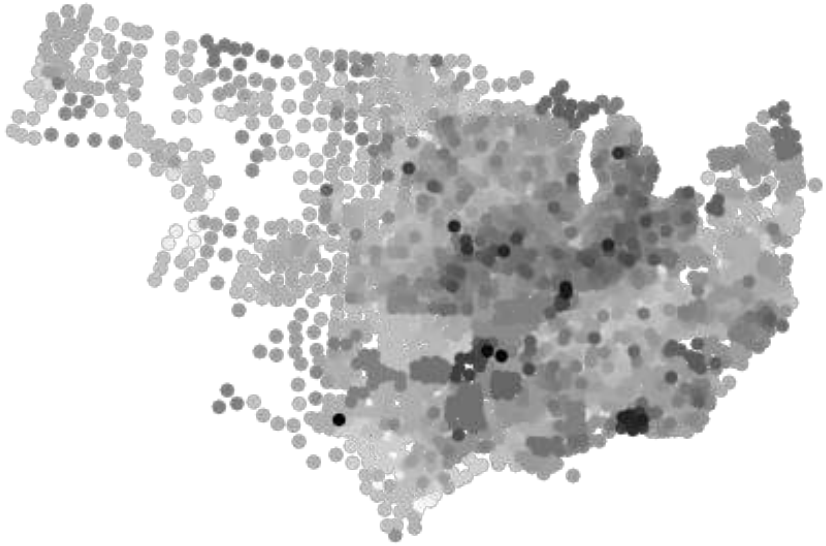
Counties

28001	0.00	0.08	0.12	0.13	0.20	0.25	0.26	0.27	0.27	0.27	0.37	0.40	0.40	0.41	0.45	0.57	0.63	0.67	0.73	0.81	0.85	0.92	0.94	0.96	0.98	0.99
28003	0.00	0.01	0.01	0.02	0.06	0.08	0.20	0.21	0.26	0.29	0.29	0.38	0.38	0.39	0.44	0.68	0.71	0.73	0.77	0.81	0.82	0.85	0.89	0.94	0.99	1.00
28005	0.00	0.08	0.12	0.13	0.20	0.25	0.26	0.27	0.27	0.27	0.37	0.40	0.40	0.41	0.45	0.57	0.63	0.67	0.73	0.81	0.85	0.92	0.94	0.96	0.98	0.99
28007	0.02	0.05	0.09	0.11	0.11	0.14	0.14	0.14	0.29	0.29	0.29	0.32	0.34	0.39	0.41	0.50	0.55	0.60	0.66	0.72	0.74	0.84	0.91	0.93	0.98	1.00
28009	0.01	0.01	0.02	0.05	0.11	0.21	0.29	0.29	0.29	0.29	0.29	0.30	0.34	0.38	0.46	0.71	0.79	0.86	0.86	0.88	0.93	0.97	1.00	1.00	1.00	1.00
28011	0.04	0.05	0.06	0.07	0.15	0.24	0.26	0.26	0.28	0.28	0.29	0.34	0.36	0.43	0.59	0.73	0.80	0.86	0.88	0.90	0.92	0.99	0.99	1.00	1.00	1.00
28013	0.01	0.04	0.09	0.13	0.15	0.18	0.24	0.26	0.28	0.29	0.29	0.29	0.34	0.37	0.39	0.58	0.62	0.66	0.78	0.82	0.86	0.94	0.98	0.99	1.00	1.00
28015	0.02	0.02	0.02	0.05	0.05	0.09	0.10	0.17	0.27	0.27	0.29	0.34	0.36	0.42	0.43	0.53	0.75	0.81	0.87	0.88	0.89	0.93	1.00	1.00	1.00	1.00
28017	0.10	0.15	0.26	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.31	0.32	0.38	0.40	0.52	0.62	0.69	0.71	0.74	0.77	0.84	0.90	0.92	0.96	0.96
28019	0.02	0.05	0.09	0.10	0.10	0.10	0.12	0.12	0.29	0.29	0.29	0.32	0.32	0.37	0.43	0.66	0.69	0.69	0.71	0.74	0.76	0.81	0.86	0.88	0.98	0.99
28021	0.00	0.08	0.12	0.13	0.20	0.25	0.26	0.27	0.27	0.27	0.37	0.40	0.40	0.41	0.45	0.57	0.63	0.67	0.73	0.81	0.85	0.92	0.94	0.96	0.98	0.99
28023	0.07	0.11	0.11	0.14	0.16	0.19	0.19	0.20	0.20	0.20	0.27	0.28	0.33	0.39	0.41	0.69	0.71	0.77	0.82	0.92	0.94	0.96	0.98	0.99	1.00	1.00
28025	0.10	0.10	0.11	0.16	0.16	0.26	0.27	0.27	0.28	0.29	0.31	0.33	0.33	0.38	0.43	0.59	0.68	0.74	0.81	0.83	0.90	0.95	0.99	1.00	1.00	1.00
28027	0.02	0.04	0.04	0.06	0.18	0.27	0.29	0.29	0.29	0.29	0.29	0.30	0.33	0.39	0.41	0.63	0.74	0.80	0.82	0.87	0.93	0.98	0.98	0.99	1.00	1.00
28029	0.09	0.09	0.14	0.20	0.26	0.27	0.29	0.29	0.29	0.29	0.37	0.37	0.37	0.40	0.49	0.66	0.71	0.76	0.82	0.88	0.91	0.99	1.00	1.00	1.00	1.00
28031	0.01	0.03	0.05	0.09	0.14	0.17	0.21	0.21	0.31	0.32	0.33	0.38	0.52	0.54	0.59	0.66	0.75	0.84	0.85	0.85	0.92	0.94	0.98	0.98	0.98	0.99
28033	0.01	0.07	0.16	0.19	0.24	0.26	0.28	0.29	0.29	0.29	0.29	0.31	0.33	0.37	0.39	0.61	0.64	0.71	0.76	0.81	0.86	0.89	0.97	0.99	1.00	1.00
28035	0.06	0.10	0.12	0.18	0.18	0.18	0.18	0.18	0.19	0.26	0.28	0.32	0.40	0.47	0.49	0.73	0.76	0.84	0.90	0.96	0.98	0.99	1.00	1.00	1.00	1.00
28037	0.05	0.09	0.16	0.17	0.26	0.27	0.29	0.29	0.29	0.29	0.37	0.40	0.43	0.49	0.57	0.74	0.86	0.86	0.91	0.93	1.00	1.00	1.00	1.00	1.00	1.00
28039	0.07	0.11	0.14	0.20	0.25	0.27	0.29	0.29	0.29	0.31	0.36	0.40	0.47	0.51	0.54	0.77	0.80	0.84	0.89	0.93	0.94	0.99	0.99	1.00	1.00	1.00
28041	0.11	0.15	0.17	0.22	0.22	0.22	0.22	0.23	0.23	0.30	0.32	0.32	0.40	0.47	0.49	0.73	0.76	0.84	0.90	0.96	0.98	0.99	1.00	1.00	1.00	1.00
28043	0.03	0.04	0.05	0.06	0.08	0.09	0.09	0.09	0.10	0.11	0.11	0.22	0.22	0.33	0.39	0.63	0.69	0.73	0.80	0.85	0.86	0.91	0.95	0.99	1.00	1.00
28045	0.11	0.15	0.17	0.22	0.24	0.24	0.24	0.25	0.25	0.31	0.41	0.43	0.50	0.51	0.54	0.63	0.65	0.68	0.73	0.80	0.81	0.83	0.83	0.88	0.92	0.93
28047	0.11	0.15	0.17	0.22	0.24	0.24	0.24	0.25	0.25	0.31	0.38	0.40	0.48	0.51	0.51	0.81	0.82	0.89	0.92	0.96	0.98	0.99	1.00	1.00	1.00	1.00
28049	0.00	0.06	0.09	0.10	0.14	0.22	0.23	0.25	0.26	0.26	0.35	0.37	0.37	0.39	0.44	0.63	0.66	0.70	0.78	0.86	0.96	0.99	1.00	1.00	1.00	1.00
28051	0.02	0.03	0.08	0.10	0.10	0.13	0.13	0.13	0.24	0.27	0.27	0.32	0.34	0.39	0.41	0.51	0.57	0.58	0.70	0.81	0.88	0.96	0.99	0.99	1.00	1.00
28053	0.11	0.14	0.20	0.20	0.21	0.26	0.27	0.28	0.29	0.29	0.32	0.36	0.41	0.45	0.47	0.70	0.75	0.78	0.85	0.91	0.96	0.98	0.99	1.00	1.00	1.00
28055	0.12	0.16	0.23	0.23	0.23	0.26	0.26	0.28	0.29	0.29	0.31	0.36	0.39	0.41	0.41	0.60	0.84	0.87	0.93	0.96	0.99	0.99	1.00	1.00	1.00	1.00
28057	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.07	0.07	0.12	0.21	0.27	0.30	0.31	0.34	0.64	0.65	0.67	0.70	0.74	0.80	0.86	0.92	0.96	1.00	1.00
28059	0.11	0.15	0.17	0.22	0.24	0.24	0.24	0.25	0.25	0.31	0.33	0.37	0.46	0.51	0.51	0.73	0.76	0.84	0.90	0.96	0.98	0.99	1.00	1.00	1.00	1.00

Crop Condition Index: County Level



Step 2:
Interpolating County-Level Numeric Data



Corn Progress, Week 27, 2019

Geostatistical Approach

Kriging Model

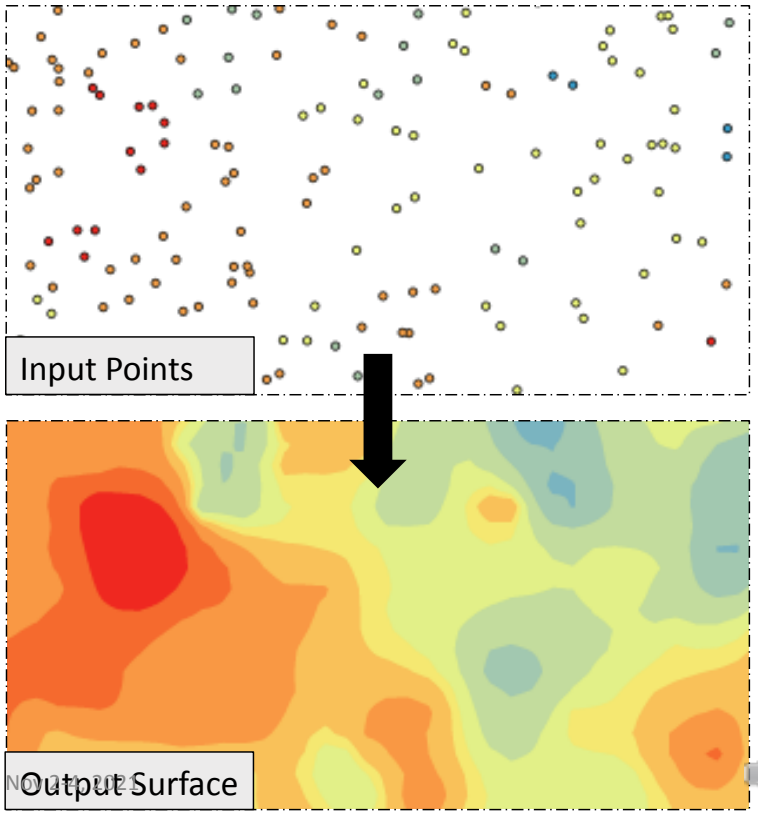
General formula for prediction surface is:

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

Where:

- $Z(s_i)$ = the measured value at the ith location
- λ_i = model weight for the measured value at the ith location
- s_0 = the prediction location
- N = the number of measured values

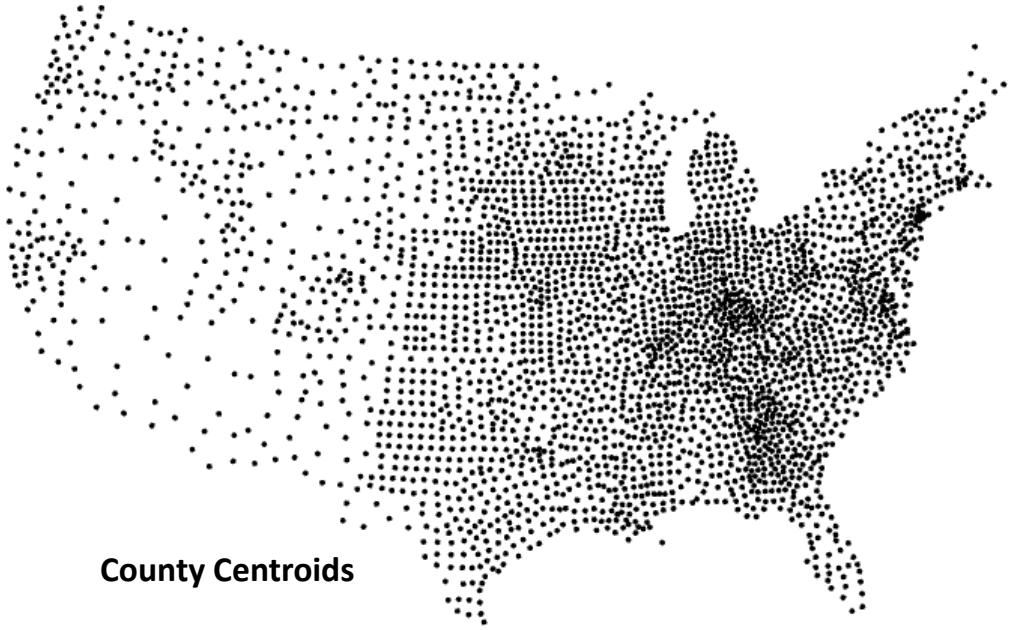
A covariance model is used to derive final model weights



Geostatistical Approach

Kriging Input

- Need a set of input points to run kriging algorithm
- Could use county centroids, but they do not represent crop acreage or location across the US
- Therefore, an input point schema representing crop acreage was devised



County Centroids

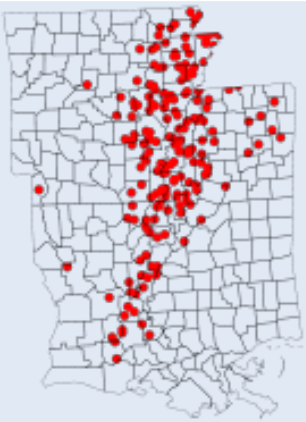
Derive Crop Area/Location Based Sampled Points

Determine known areas from Cropland Data Layer (CDL)

Create "zones" of crop area within counties, based on CDL information

Zone creation Illustration

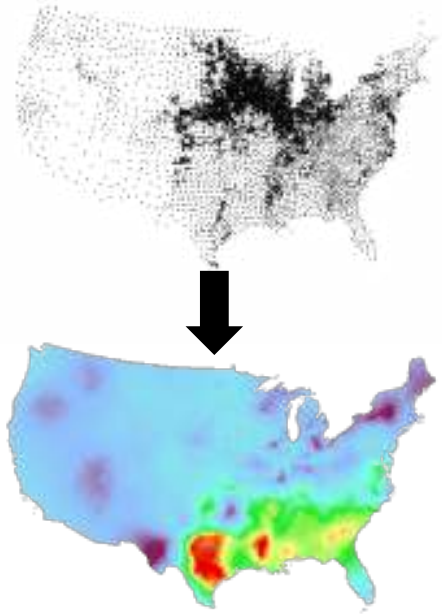
Create sample of random lat/long points within each county zone, proportional to planted acres



Density and location of points corresponds with cropland of interest

Kriging Input Point Schema

Acreage/Location Based Points Merged with County Centers

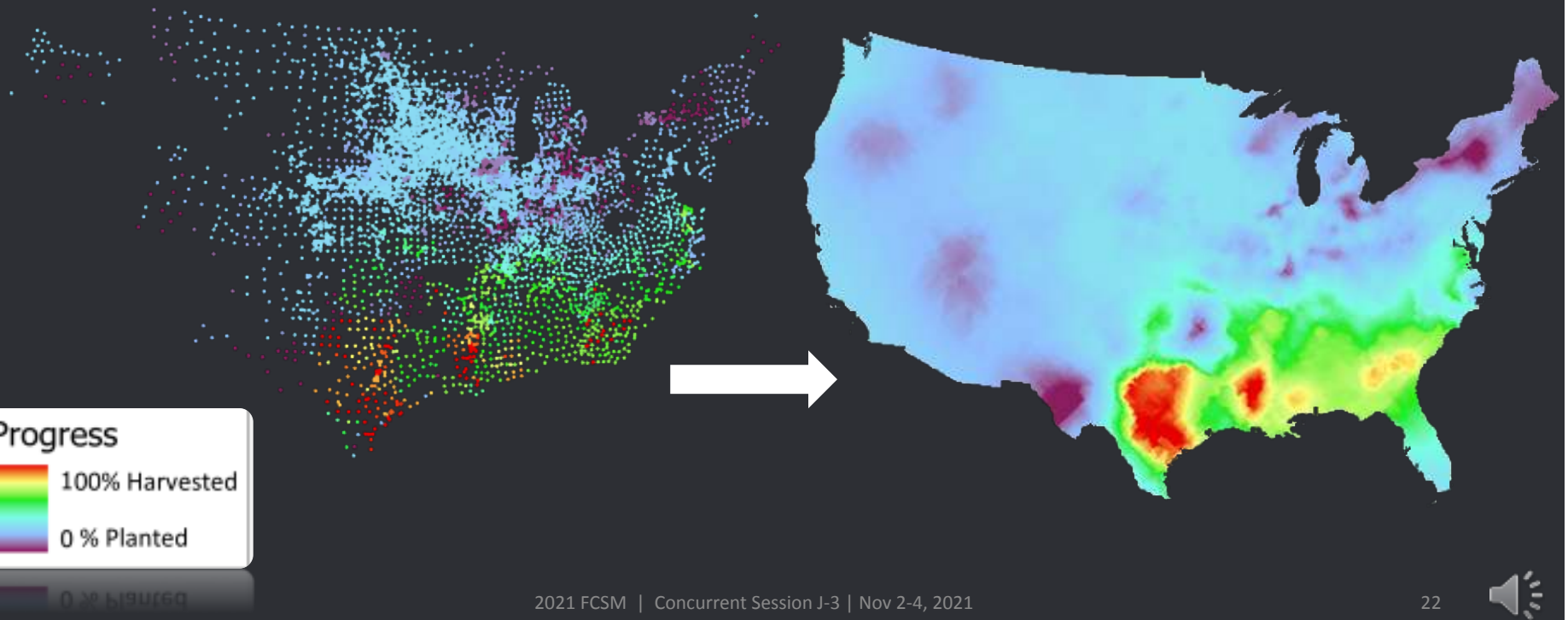


Univariate Kriging

- Using this point dataset as input for kriging allows us to:
  - Weigh the county contribution by planted acres
  - Use points which represent the probable location of planted crops
  - Perform univariate kriging, where all input points are based on the original reported data

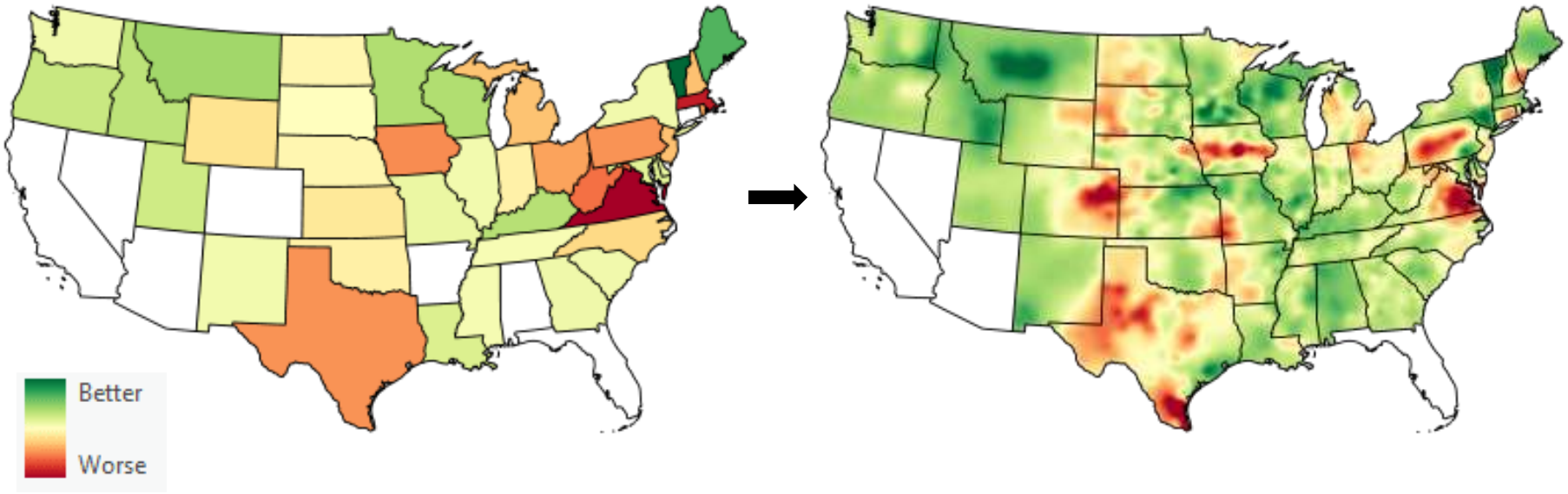
Kriged Surface

US corn progress, week 27 of 2019



Resolution of New Data

US corn condition, week 34 of 2020

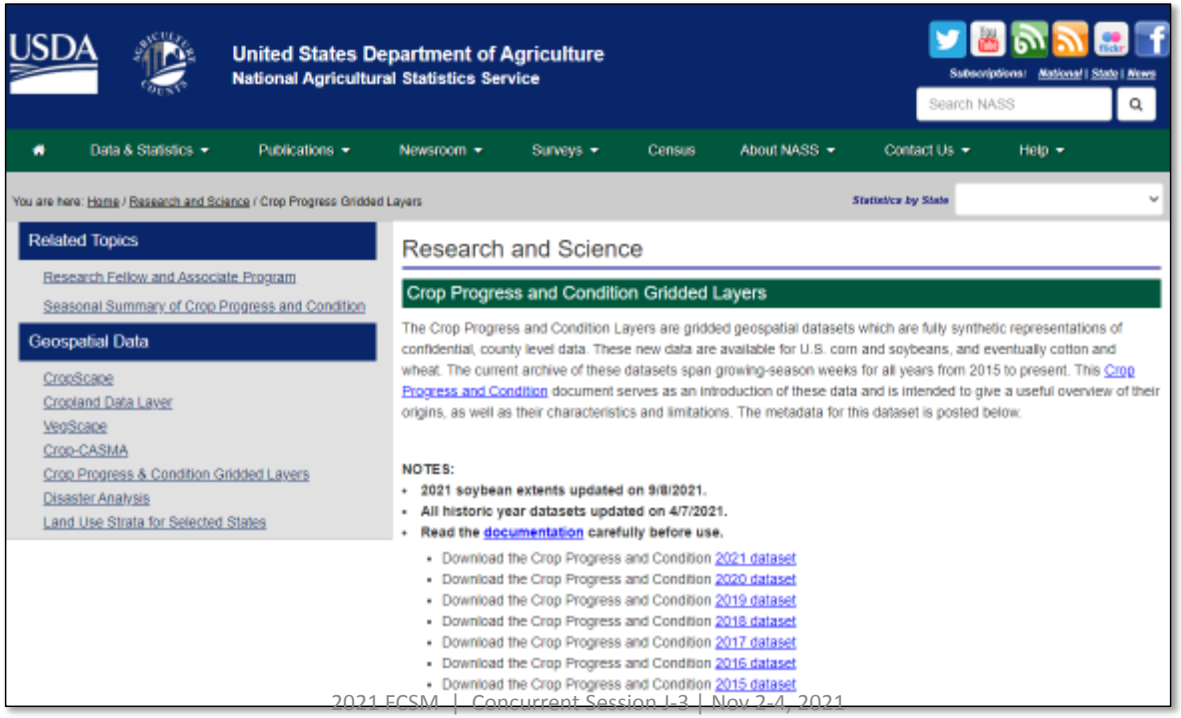


Data Availability

- Raster datasets representing both progress and condition for each:
  - Corn
  - Soy
  - Winter Wheat
  - Cotton (2022)
- Data format is **9km raster geoTIFF files** covering the contiguous United States
- Each new dataset is released within a day of NASS progress and condition data becoming available
- Data archive to be created for Crop Progress and Condition data, 2015-Present

Data Availability

https://www.nass.usda.gov/Research_and_Science/Crop_Progress_Gridded_Layers/index.php



Thank You

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https://www.nass.usda.gov/Research_and_Science/Crop_Progress_Gridded_Layers/index.php