Where Do the Crop Statistics Come From? It’s More Than You Think

Integrating Remote Sensing-based Products Into the USDA/NASS Operational Estimating Programs

Larry W. Beard
Senior Agricultural Statistician
NASS/RDD/Geospatial Information Branch; Fairfax, VA
For the 2011 Indiana Certified Crop Advisor Conference
Presentation Overview

• Intro & Background
• Overview of NASS Surveys
• Review NASS Remote Sensing Programs
• Focus on Crop Progress & the Future
• Questions
Locked Up!!
History

George Washington
How’s the corn lookin’?
5 area counties ‘pose’ for Landsat

By TOM CAMPBELL
Staff Farm Writer

Ever wonder what the town of Otterbein looks like from space? Or U.S. 52? Or a 200-acre field of corn?

Photographic printouts from two Landsat satellites now circling the Earth can show you that from a height of 567 statute miles Otterbein is about one inch across. The houses look like freckles on a child standing about a foot away. Just to the left of Otterbein is U.S. 52, which looks like a long slash from a Flair pen. And a 200-acre corn field looks like a piece of Corn Chex cereal that has fallen to the kitchen floor.

Might sound like pretty trivial information at first, but that information, it is hoped, will enable agricultural experts to predict annual crop production figures in the United States to within a percentage point of accuracy.

“We’re still in the experimental stages with this project,” said Larry Beard of the United States Department of Agriculture, who is stationed at Purdue University. Beard works for the statistics branch of the Economics, Statistics and Cooperatives Service.

“We’re about six years away from reaching our potential. First of all, we have to prove if it is effective and accurate.”

Although the Landsat satellite has been orbiting the Earth every 18 days since 1972, only now are experts learning how to fully apply the information sent back to the National Aeronautics and Space Administration in Houston, Texas.

Once every 18 days, as Landsat passes over the United States, it records information from 202 segments of land in 29 states, including nine segments in Indiana, and five in the Journal and Courier circulation area — in Tippecanoe, Montgomery, Warren, Benton and Newton counties.

All of the Indiana segments are in the upper half of the state, in the prime corn and bean growing areas.

“We hope to have the technology in a few years to be able to get readouts on fields as small as five acres,” said Beard, “but right now we are limited to 40-acre fields as a minimum, because we just don’t have the technology. Only the CIA has that kind of technology available right now,” Beard added.

By using infra-red photography, the Landsat will try to determine crop yields for the first time this fall. It has been programmed to “read” barley, rice, cotton, sorghum, wheat, beans and corn crops.

The satellite picks up different amounts of electromagnetic energy which is reflected, scattered or emitted by not only the crops, but by varying soil contents, trees, water or whatever other object might be occupying ground space.

Then when a computer takes information relayed from Landsat, it can translate the information into recognizable printouts that will tell experts like Beard what each plot of land contains.

Similar aerial surveys have been taken with a helicopter and airplanes, but Beard says those surveys are not as economically feasible as from the satellite, which can take a photograph of a 30-square-mile area.

“Planes don’t give a large enough estimate,” Beard said. “You can’t make a survey in every county in the country — it would be too expensive. We’re talking about a national estimate.”

Outside of the original expense of building, launching and monitoring the satellite, the
# NASS Surveys!!!

## And Data

<table>
<thead>
<tr>
<th>ACREAGE</th>
<th>YIELD</th>
<th>PROGRESS &amp; CONDITION</th>
<th>BALANCE SHEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>QRTRLY AG SURVEYS</td>
<td>AG YIELD SURVEYS</td>
<td>CROP WEATHER</td>
<td>SUPPLY (-) DEMAND</td>
</tr>
<tr>
<td>• Farm Operators</td>
<td>• Farm Operator Survey</td>
<td>• Ext. Agents, FSA</td>
<td>• Exports (FAS)</td>
</tr>
<tr>
<td>• March – Intentions</td>
<td>• Sample ~ 29,000 U.S.</td>
<td>• Weekly</td>
<td>• Processed (Commerce, Factory)</td>
</tr>
<tr>
<td>• June – All Crops</td>
<td>• Sample ~ 670 Indiana</td>
<td>• May – November</td>
<td>• Farm Use (seed, feed, etc.)</td>
</tr>
<tr>
<td>• Sept.– Small Grains</td>
<td>• Monthly Aug-Nov.</td>
<td>• Subjective, opinion survey</td>
<td>• Imports (Customs, AMS)</td>
</tr>
<tr>
<td>• Dec.- Row Crops, WW</td>
<td>• First of Month</td>
<td>• ~ One report per county</td>
<td>• Ending Stocks (NASS)</td>
</tr>
<tr>
<td>• 75-84,000 US Samples</td>
<td>• Data Improves Monthly</td>
<td>• State Averages weighted by County</td>
<td>• Residual</td>
</tr>
<tr>
<td>• ~2600 Indiana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JUNE AREA SURVEY</td>
<td>OBJECTIVE YIELD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 11,000 “Segments”</td>
<td>• Field Plots, plant counts &amp; measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ~640 Acres in Size</td>
<td>• Corn 1,920 US Samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Personal Enumeration of</td>
<td>• 170 for Indiana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>~ 35,000 Tract Operators</td>
<td>• Soybeans 1,835 US</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Early June</td>
<td>• 180 in Indiana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSA</td>
<td>DEC. AG SURVEY</td>
<td></td>
<td>(**) Also Industry &amp; Factory data, 5 year Ag Census, and County Estimates</td>
</tr>
<tr>
<td>• Program Acres Planted</td>
<td>• Large Producer Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Database almost</td>
<td>• Sample ~83,000 U.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>complete by October</td>
<td>• Sample ~ 2,600 for IN.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Primary survey for Late Season Crop Yields</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
We ♥ satellites!!!

Landsat 5
Landsat 7
ResourceSat 1
Terra
Aqua
Deimos
UK-DMC-2

Approx. 3,000 satellites orbiting the earth at any given time.
Satellite sensors see things differently

The Electromagnetic Spectrum

*Figure 1.19* Visible photographs (bottom) of wooded terrain. Flagged soldiers stand out only in Color Infrared Photograph (Courtesy Lonnie Schuepbach Systems, Inc.)
NASS Uses Geospatial Decision Support Systems to provide updated information to the Ag Statistics Board and data users.
2011 Production Plans

Acreage Report – Winter Wheat

Crop Production Report – Corn & Soybeans

Crop Production Report – CDL Cotton, Rice, & Peanuts

County Estimates - All Crops

Small Grains Summary

Crop Production Report – All Crops
June Acreage

15 States – winter wheat

August Production

17 – Corn & soybeans +

September Production

18 – Rice, cotton & peanuts +

September Sm. Grains

17 – Final Small grains

October Production

25 – Final Late-season crops

Production Total

28 – Total In-season operational

CDL 2011

in-season production

@ 30m

December Annual & County Estimates
2011 Cropland Data Layer Inputs

Satellite Imagery – DMC & Landsat

2006 NLCD & Derivative products

Farm Service Agency: Common Land Unit

June Agricultural Survey
## Side-by-Side Comparison

<table>
<thead>
<tr>
<th></th>
<th>Deimos/UK2</th>
<th>Landsat 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launch Date</strong></td>
<td>2009</td>
<td>1984</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>22 meters</td>
<td>30 meters</td>
</tr>
<tr>
<td><strong>Spectral Bands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2: 0.52 – 0.60</td>
<td>B2: 0.52 – 0.60</td>
<td></td>
</tr>
<tr>
<td>B3: 0.63 – 0.69</td>
<td>B3: 0.63 – 0.69</td>
<td></td>
</tr>
<tr>
<td>B4: 0.77 – 0.90</td>
<td>B4: 0.75 – 0.90</td>
<td></td>
</tr>
<tr>
<td>(Green, Red, NIR)</td>
<td>B5: 1.55 – 1.75</td>
<td></td>
</tr>
<tr>
<td>(Green, Red, NIR, SWIR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Swath Width</strong></td>
<td>600 kilometers</td>
<td>185 kilometers</td>
</tr>
<tr>
<td><strong>Revisit Rate</strong></td>
<td>4 Days</td>
<td>16 Days</td>
</tr>
</tbody>
</table>
Deimos-1/UK2 Collections

June 27 – July 2, 2011
Agricultural Ground Truth

Farm Service Agency (FSA)
Common Land Unit (CLU)
Form 578  reported data (current year)

NASS
June Agricultural Survey
Ground Truth – Land Cover

Agriculture Ground Truth

Provided by Farm Service Agency
Identifies known fields and crops

Divide known fields into 2 sets
½ used for training software
½ used for validating results

Non-Agriculture Ground Truth

USGS National Land Cover Dataset
Identifies urban infrastructure and non-agriculture land cover
Forest, grass, water, cities
Software Suite

Ground Truth Preparation
• ESRI ArcMap

Image Preparation
• Leica Geosystems ERDAS Imagine 9.1

Image Classification
• See 5

Acreage Estimates
• SAS/IML Workshop
Processing a CDL

Satellite Imagery
Ancillary Data
MODIS Data
Ground Truth

Sampling

See5

Decision Tree
Classification

ERDAS IMAGINE 9.1

2009 Washington Cropland Data Layer
Land Cover Categories
By decreasing acreage
AGRICULTURE
PeanutCrops
WinterWheat
Fall/Early Spring
Spring Wheat
 Alfalfa
Corn
Soybeans
Other Hay
Apples/Cherry/Orchard
Sweet Corn
Beans
Onions/Carrots/Sweet
Pet/Other Tree/Tree & Fruits
Other Small Trees
Canola
NON-AGRICULTURE
Wheat
Shrubs
Urban/Developed
Water
Wetlands
Barren
Permafrost/ice/Snow
Validating CDLs

We measure the accuracy of each CDL

Compare:
- Classified pixels from CDL
- Known pixels, not used for classifying imagery, from FSA

Track:
- Producer Accuracy - Errors of Omission - % of pixels from category missing
- User Accuracy - Errors of Commission - % of pixels from category that are over classified
## Accuracy Assessments

### Producer’s Accuracy:
relates to the probability that a ground truth pixel will be correctly mapped and measures errors of omission.

### Errors of Omission:
occur when a pixel is excluded from the correct category.

### User’s Accuracy:
indicates the probability that a pixel from the classification actually matches the ground truth data and measures errors of commission.

### Errors of Commission:
occur when a pixel is included in an incorrect category.

### Kappa Coefficient:
a statistics measure of agreement, beyond chance, between two maps.

### State level accuracies are very high

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>Attribute Code</th>
<th>*Correct Pixels</th>
<th>Producer's Accuracy</th>
<th>Omission Error</th>
<th>Kappa</th>
<th>User's Accuracy</th>
<th>Commission Error</th>
<th>Cond'l Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>1</td>
<td>2197719</td>
<td>96.58%</td>
<td>3.42%</td>
<td>0.9226</td>
<td>97.86%</td>
<td>2.14%</td>
<td>0.9509</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>1471094</td>
<td>96.24%</td>
<td>3.76%</td>
<td>0.9392</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9320</td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>2258219</td>
<td>98.06%</td>
<td>1.94%</td>
<td>0.9527</td>
<td>98.58%</td>
<td>1.42%</td>
<td>0.9650</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>1339089</td>
<td>96.36%</td>
<td>3.64%</td>
<td>0.9438</td>
<td>97.96%</td>
<td>2.04%</td>
<td>0.9681</td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>1856422</td>
<td>97.29%</td>
<td>2.71%</td>
<td>0.9605</td>
<td>97.32%</td>
<td>2.68%</td>
<td>0.9608</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>849249</td>
<td>95.83%</td>
<td>4.17%</td>
<td>0.9513</td>
<td>96.95%</td>
<td>3.05%</td>
<td>0.9643</td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>803251</td>
<td>94.29%</td>
<td>5.71%</td>
<td>0.9342</td>
<td>95.78%</td>
<td>4.22%</td>
<td>0.9513</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5</td>
<td>707383</td>
<td>95.03%</td>
<td>4.97%</td>
<td>0.9439</td>
<td>97.72%</td>
<td>2.28%</td>
<td>0.9741</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cover Type</th>
<th>*Correct</th>
<th>Accuracy</th>
<th>Error</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL ACCURACY</td>
<td>3688803</td>
<td>95.74%</td>
<td>4.26%</td>
<td>0.9145</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>3730093</td>
<td>97.05%</td>
<td>2.95%</td>
<td>0.9426</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>3071960</td>
<td>94.05%</td>
<td>5.95%</td>
<td>0.8981</td>
</tr>
<tr>
<td>OVERALL ACCURACY</td>
<td>2306428</td>
<td>87.51%</td>
<td>12.49%</td>
<td>0.8416</td>
</tr>
</tbody>
</table>

**Note:**
- **IA** represents Iowa, **IL** represents Illinois, **NE** represents Nebraska, and **SD** represents South Dakota.
- The table shows the accuracy assessments for corn and soybeans in each state, with columns for correct pixels, producer's accuracy, omission error, kappa, user's accuracy, commission error, and conditional kappa.
- The accuracy for each state is very high, indicating a strong agreement between the classification and ground truth data.
2010 Cropland Data Layers

Inputs: Landsat (8601 scenes) AWiFS (1194 scenes)

Released Jan. 10, 2011
National 30m Product

~ 9 billion pixels!
How Competitive Are the Remote Sensing Indications for Planted Acres?

<table>
<thead>
<tr>
<th>Highly Competitive</th>
<th>Moderately Competitive</th>
<th>Not in the Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Alfalfa</td>
<td>Other Hay</td>
</tr>
<tr>
<td>Soybeans</td>
<td>Sorghum</td>
<td>Fruits</td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>Sugarcane</td>
<td>Vegetables</td>
</tr>
<tr>
<td>All Cotton</td>
<td>Barley</td>
<td>Small Area Crops</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>Oats</td>
<td></td>
</tr>
<tr>
<td>Fall Potatoes</td>
<td>Tobacco</td>
<td></td>
</tr>
<tr>
<td>All Rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugarbeets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durum Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Dry Beans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canola</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CropScape Portal

Upcoming Release:
2008 & 2011 national coverage

Future Portal Upgrade:
Map printing
Change detection
Cultivated masks/crop intensity

nassgeodata.gmu.edu/CropScape
Corn and Soybean Yields via Remote Sensing
Sensor: MODerate resolution Imaging Spectroradiometer (MODIS)

Onboard the NASA Terra and Aqua satellites
MODIS key facts

- Global coverage
- Daily revisit rate
- 15 acre (250m) ground level pixel resolution
  - from red and near-infrared bands
- Composite “best of” image mosaics automatically generated
  - 8 and 16-day temporal windows
- Timely
  - most data usually available within 24 hours
- It’s Free!
  - downloaded via ftp
- Launched in 1999 and 2002
  - Reliable history
- 6 year design life but still functioning fine

modis.gsfc.nasa.gov
Sample Terra MODIS Normalized Difference Vegetation Index (NDVI) “greenness” composite

In terms of surface reflectance spectra:

\[ NDVI = \frac{\text{near infrared} - \text{visible red}}{\text{near infrared} + \text{visible red}} \]
Extract Crop Specific Pixels

Example MODIS NDVI from Sept. 2009

2009 Cropland Data Layer
Determining Phenological Metrics

NDVI “Curves” for Each Corn Pixel
Natural Disaster Assessments – Visual Reference

Resourcesat-1 AWIFS, August 12, 2009

[Map showing Iowa with annotations for damaged crops, haze, clouds, and urban areas]
“Largest Hailstorm Ever”- Mapping the Disaster with the Yield Model
Main concepts:
• Provide yield intel between Crop Reports
• Test feasibility
• Promote the idea that remote sensing estimates could be produced in a relatively easy fashion

## Corn Phenology and Yield Report
### August 1, 2011

### PHENOLOGY
### YIELD

<table>
<thead>
<tr>
<th>Spec Region</th>
<th>%Δ</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indiana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kansas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minnesota</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missouri</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nebraska</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Dakota</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td></td>
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</tr>
</tbody>
</table>
Disaster Assessment Products
Operational Summary

• SARS Remote Sensing Acreage Program continues to evolve and improve despite multiple challenges. Staff and flexible processing capabilities are keys to success.

• SARS Remote Sensing Yield Program shows excellent results for corn yields, only good results for soybeans. Weekly reports a big plus for NASS intelligence. Program needs more research & maturity.

• Ad Hoc Disaster Monitoring/Assessments have been needed in each of last 5 years, but needs to be more mature & systematic.

• Dissemination products, CropScape and Yield Maps (internal only), are unique and ahead of their time.

• SARS products are the most operationally advanced in the world. We’re not just about producing “pretty pictures.”
Crop Progress and Condition

Cotton Squaring – Selected States
[These 15 States planted 99% of the 2010 cotton acreage]

<table>
<thead>
<tr>
<th>State</th>
<th>July 24, 2010 (percent)</th>
<th>July 17, 2011 (percent)</th>
<th>July 24, 2011 (percent)</th>
<th>2006-2010 Average (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>85</td>
<td>50</td>
<td>64</td>
<td>85</td>
</tr>
<tr>
<td>Arizona</td>
<td>93</td>
<td>85</td>
<td>90</td>
<td>95</td>
</tr>
<tr>
<td>Arkansas</td>
<td>100</td>
<td>97</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>California</td>
<td>90</td>
<td>75</td>
<td>86</td>
<td>92</td>
</tr>
<tr>
<td>Georgia</td>
<td>96</td>
<td>70</td>
<td>80</td>
<td>91</td>
</tr>
<tr>
<td>Kansas</td>
<td>83</td>
<td>60</td>
<td>70</td>
<td>84</td>
</tr>
</tbody>
</table>
Monthly *Crop Production* Reports

- Released monthly
  - But crop progress and condition can change significantly in days!
- Not enough time or resources to conduct nationwide farmer surveys each week

*Crop Progress*

- Released each week
- Crop items change as the crop develops
- *Subjective* estimates based on standard definitions

- Key Word - *SUBJECTIVE*
Background:

- Data collected weekly from April through November
- Approximately 5,000 reporters Nationally
- Attempt to have at least one in each county
- Goal is 80% response
- Usually FSA/Extension agents
It is antiquated, but is also:

- Cheap
- Fast
- Decades (centuries?) of history
- Relatively accurate
- Remote sensing NOT READY YET
On The Horizon
Remote Sensing-Based U.S. National Crop Progress Monitoring System (NCPMS)

Zhengwei Yang$^{1,2}$, Liping Di$^2$, Genong Yu$^2$, Rick Mueller$^1$
$^1$Research and Development Division, USDA NASS
$^2$Center for Spatial Information System Science
George Mason University
Zhengwei_yang@nass.usda.gov
Project Goals

- To support and enhance the monitoring of nationwide crop progress and conditions at NASS
  - Develop science-based crop progress metrics
  - Develop and prototype an operational National Crop Progress Monitoring System (NCPMS)

- To enhance the NASS crop progress and condition data accessibility, interoperability and dissemination
New “Geospatial” Science and Research Needed

- **Crop Progress** – Provide quantitative assessments by stage of development for each specific crop.

- **Crop Conditions** – Quantitatively assess the amount of a specific crop in very poor, poor, fair, good, and excellent condition.

- **Soil Moisture** - Monitoring and assessing Topsoil (surface to 6" depth) and Subsoil (>6"--3-4") moisture in categories similar to the following - Very short, Short, Adequate, Surplus.

- **Natural Disaster Monitoring & Assessment** - timely monitoring & assessing significant events affecting crop area, conditions and yield
Test Sites

Distribution of test sites in Iowa
Crop development can be observed and change can be measured by analyzing satellite imagery throughout the growing season.
Inferences can also be made on crop condition

Very Poor

Good

Estimate this Unknown Pixel as Poor? Fair?

The more data we have, the more confident we can be in our estimations
Hopefully, someday . . . .

Estimates like these:

<table>
<thead>
<tr>
<th>Statewide Crop Conditions as of August 8, 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Corn</td>
</tr>
<tr>
<td>Soybeans</td>
</tr>
</tbody>
</table>

Will be developed **objectively** using satellite imagery, and displayed like this:
New VegScape Prototype
The NASA Soil Moisture Active Passive (SMAP) Mission: Drought Monitoring

Molly E. Brown, NASA GSFC
Peggy O’Neill, NASA GSFC
Dara Entekhabi, MIT
Eni Njoku, JPL
Kent Kellogg, JPL
Vanessa Escobar, Sigma Space and the SMAP SDT
SMAP’s 1000 km wide swath maps global surface soil moisture with high revisit (2-3 days)

Current limitations:
- Installed in situ network has inadequate coverage
- Existing space-borne sensors have inadequate sensitivity & resolution

SMAP radar and radiometer allow direct estimates of surface soil moisture at an order of magnitude higher resolution resulting in enhanced predictability

Current operational flood-guidance and drought-monitoring products use model estimates of soil moisture

Soil Moisture Links the Global Land, Water, Energy, and Carbon Cycles
Mapping Evapotranspiration and Drought Using Multi-Scale Thermal Remote Sensing Data

M.C. Anderson, W.P. Kustas
USDA-ARS, Hydrology and Remote Sensing Laboratory

C. Hain, J.R. Mecikalski
U Alabama-Huntsville, Atmospheric Science
Multi-scale Drought Monitoring

GOES Evaporative Stress Index

JUNE 2002

MODIS (1 km)

Landsat (60 m)
How’s the corn looking?

The ability to monitor and assess crops with good results, in near-real time via remote sensing, may have finally been reached!
Thank you!

Spatial Analysis Research Section
USDA/NASS R&D Division

http://www.nass.usda.gov/research/Cropland/SARS1a.htm
Questions?