Piloting A New Approach to Surveying Tillage Practices and Cover Crops

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and

Chad Watts, Executive Director - CTIC
CTIC champions, promotes and provides information on technologies and sustainable agricultural systems that conserve and enhance soil, water, air and wildlife resources and are productive and profitable.
A Public/Private Partnership

Members

• **Corporations, Institutions** (media, commodity groups, conservation organizations, associations), **Individuals**

Advisors & Partners

• Federal agencies, universities, extension, research institutions

![Logos of various organizations]
A History of Collecting Tillage Data

• 1989 - 2004 CTIC facilitated the collection of on-the-ground tillage data at a national level - Crop Residue Management (CRM) Survey
  • Windshield surveys were done by local NRCS, Conservation Districts, University Extension and other partners
  • Surveys were conducted in over 3,000 agricultural counties
Collecting Data - Windshield Surveys

• Teams of local experts traversed a prescribed route in each County
  • The same route and same data collection points were used each year
• Routes were designed to traverse the county and represent all parts of the county
  • Data points developed to constitute a statistically valid survey at the county level
Data Collected

• Present Crop
• Previous Crop
• Estimated residue amount left on the soil surface at planting
  • Bracketed residue percentages
• Tillage system used
  • Conventional Tillage (<15%)
  • Reduced Tillage (15%-30%)
  • Mulch Tillage (30%-50%)
  • No-Till (>50%)
Tillage Survey Products

- Evaluation of national tillage trends
- Characterization of tillage types, by crop type and for various geographies
  - Nation
  - Region
  - State
  - County
- 22 crops in all were evaluated
Uses of Tillage Information from the Survey

- Models
- Industry product research
- Environmental and agricultural research
- News articles
- Education
- National trends
- Program development and evaluation
Issues with the Tillage Survey

• **Manpower** - The survey took a tremendous amount of manpower to complete each year

• **Consistency** - With over 3,000 different survey teams, it is difficult to maintain consistency between teams, counties, states and regions
  
  • Timing - various survey teams conducting the survey at different times
  
  • Reporting
  
  • Data Collection
  
  • Validation
  
  • QA / QC
The Survey Post-2004

• In 2004, reallocation of partners’ workforce during the spring
  • Lack of manpower
  • Severe blow to the survey

• Since 2004,
  • Sporadic spatial and temporal reports
  • Periodic priority watershed data collection continues
What’s Next???

• CTIC began looking to continue the survey in a way that is:
  • Cost-effective
    • Manpower
  • Repeatable
  • Consistent
  • Able to provide reliable, usable information
  • Updated to use existing data and information
  • Able to capture other information...
    • Cover crops and use of other conservation practices
What is OpTIS?

• OpTIS - Operational Tillage Information System

• A remote sensing-based survey system that can automate the estimation of fractional crop residue cover on US Cropland
  • Estimates tillage types and amount of tillage taking place
  • Also highlights the timing of tillage based on multiple aerial photographs

• Also can detect the presence / absence of cover crops
  • Uses aerial photography to separate cover crops from winter grains

• CTIC and AGS are looking to refine the technology and determine the feasibility of using it on a larger scale
Currently

• Piloting the OpTIS technology in Indiana
  • Evaluating accuracy, repeatability and cost

• CTIC and AGS are looking to refine the technology so that it can be used on a larger scale across the agricultural US

• Using data collected by Indiana partners
  • Verifying OpTIS measurements
  • Assessing accuracy
    • Using on-the-ground, verified measurements

• First test of OpTIS at this scale
Project Sponsors and Partners
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Operational Tillage Information System: Tracking Conservation Practices at Field to Watershed Scales

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Background

➢ Numerous peer reviewed publications on the use of remote sensing for mapping conservation practices, like tillage, cover cropping and artificial field drainage (tile drains)

➢ Most have been successful for small area mapping through detailed calibration for the single locale, image set and time period.

➢ Challenge: how do we operationalize the system for consistent wide area mapping of crop residue dynamics, tillage systems and cover cropping over many years with well defined uncertainties?
Limitations of existing conservation data

➢ Traditional “wind-shield” survey method conducted by NRCS is expensive and prone to inconsistencies and inaccuracies.

➢ Systematic surveys of tillage practices stopped in 2004. CEAP/NASS surveys provide some information but no way to track practices in space and time.

➢ No consistent, systematic system in place for tracking residue management, tillage systems and cover crop systems.

➢ Need better data to define baseline use of conservation practices for tracking targets

➢ Existing satellite-based approaches are promising, but are limited in the way they have been implemented:
  ➢ typically single area for a single time period
  ➢ often reliant on information from a single satellite
OpTIS Approach

Overview

➢ Algorithms are applicable across a large set of sensors (optical and SAR), platforms (spaceborne, aerial and UAVs), spatial (meter to 250 meters) and temporal (daily to 16 day repeats)
➢ Data from multiple satellites*: Landsat, MODIS, AWIFS, Sentinel-1, -2, RapidEye (evaluating Skybox, Pleiades, etc)
➢ AGS is funded by NASA under Multi Sensor Land Imaging program -integration of Landsat and Sentinel-1 and Sentinel-2 for agricultural monitoring
➢ Goal for large area, operational simulations without requiring recalibration
➢ Developed algorithms for “self-calibration” for new geographies and watersheds
➢ Tradeoffs between large area and watershed and site specific implementations
➢ Client driven choices based on requirements and costs

* Most of these data sets are freely available, keeping costs lower.
OpTIS Big Picture

➢ **OpTIS**: With NASA and USDA-SBIR funding Applied GeoSolutions has developed technology that combines data from satellites with other geospatial data sets to map *crop residue* and *cover crops* over wide areas, going back through time.

➢ **OpTIS** proprietary algorithms are designed for multi-scale, operational and wide area applications.

➢ **Indiana Pilot**: We’ve applied the system in individual watersheds, but have not tested the system at the state level. This pilot project is designed to test the performance of the system when applied across the state of Indiana.

➢ **Future**: If the system works well in Indiana, we envision demand for a US-wide application.
Our approach
Products

➢ Our operational system provides detailed maps of crop residue cover and cover crops:
✓ Temporal changes in crop residue fractions
✓ Tillage in Fall & Spring
✓ Annually, with date information.
✓ Farm-field, county, & watershed level
✓ Uncertainty maps
✓ Trends
✓ Continuous no-till
Review of the Goals and Objectives

➢ **Goal:** Understand and rigorously evaluate how the OpTIS system performs when applied across a wide region (Indiana) over many years (2006-2015).

➢ **Objectives:**
  ➢ Produce annual maps and tables at the county and watershed level of tillage practice category (% no till, % reduced till, % conventional till, % cover crop) with uncertainty quantified.
  ➢ Compare OpTIS estimates to **field level** estimates from the transect surveys in the pilot counties
  ➢ Compare OpTIS estimates to windshield transect survey results at the **county scale** across Indiana
  ➢ Produce a report summarizing the application of OpTIS across Indiana: accuracy, problems encountered, recommendations on next steps for scaling the application to national scale.
Our approach
Time series of observations

➢ High temporal frequency data can be critical....
Compiled Field Data

➢ Field-based information:
➢ Historical transect information from 2009, 2011, 2013, and 2015 in the 7 pilot counties (IN Dept. Ag)

Dekalb County
Landsat Processing - ~2000 images

➢ Geospatial data - Landsat (5, 7, and 8)

Atmospheric correction & Cloud mask

Generate Indices

NDVI  NDTI  STI  CRC
MODIS Processing

➢ Geospatial data - MODIS
  ➢ MODIS MOD43A4 BRDF surface reflectance
  ➢ 463 m spatial resolution
  ➢ Rolling 16-day composite every 8 days

NDVI  NDTI  STI  CRC
Compile Ancillary Geospatial Data

➢ Geospatial data - Algorithm uses soils, weather, crop type, topography, etc for operational algorithm.
➢ PRISM precipitation associated with each Landsat image (3 day window prior to acquisition) and MODIS composite (16 day window associated with composite period)
➢ NASA CDL for crop information: used as priors in decision tree/classification algorithms
➢ County and HUC8 boundaries
➢ NRCS Soils data (SSURGO and STATSGO)
Our approach
Convert satellite data to crop residue cover estimates

April 19, 2012 Landsat 7 image (R-SWIR1, G-NIR, B-Red)
Livingston County example (Streator, IL)

Estimate of crop residue cover (Brown: 0%; Yellow: 40%; Green: 80%)
Our approach
Estimate tillage practice from residue cover over large areas

Estimate of crop residue cover (Brown: 0%; Yellow: 40%; Green: 80%)
Livingston County example (Streator, IL)

Field-level Tillage Practice (Brown: CT; Yellow: RT; Green: NT)
Classification of tillage systems

% Residue Cover

- 0-10
- 11-20
- 21-30
- 31-40
- 41-50
- > 50

0-15 CT
15-40 RT
> 40 NT
Monitors Temporal Changes in Residue

Temporal False Color Composite of RC estimate:
Red - 7 May 2015; Green - 23 May 2015; Blue - NA
Black - low RC; Yellow - high RC; Red - high to low

0-15 CT
15-40 RT
> 40 NT
Maps are created at 30m pixel resolution
Statewide Crop Residue Maps
Results will be distributed at HUC8/10 and County Scales
Challenges: Gaps in Landsat Timeseries

2009 Residue (Landsat) NO GAPS

2008 Residue (Landsat & MODIS) FILLED

2008 Residue (Landsat) GAPS
User defined “Allowable” Confidence

Option 1: unweighted average of all high confidence observations

<table>
<thead>
<tr>
<th>County</th>
<th>Ag. Acres in County</th>
<th>% covered by high confidence observations</th>
<th>% covered by low confidence observations</th>
<th>% no till corn in high confidence obs.</th>
<th>% corn in high confidence obs.</th>
<th>% bean in high confidence obs.</th>
<th>% corn in county</th>
<th>% bean in county</th>
<th>% no till in county</th>
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<td>Allen</td>
<td>210</td>
<td>74</td>
<td>16</td>
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<td>68</td>
<td>60</td>
<td>40</td>
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<td>51.8</td>
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Option 2: weighted average of high confidence observations by % crop in county (CDL)

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OpTIS Cover Crop Mapping

➢ Mapping presence and absence of cover crops.

➢ Categorize types of cover cropping:
  ➢ Winter-kill
  ➢ Spring-kill
  ➢ Commodity

➢ System separates volunteer regrowth from intended cover crops using spatial-temporal filters

Winter-killed cover crops (yellow) cover crops that survive into the spring (green), and commodity cover crops that are harvested the following summer (brown). Grey areas do not have cover crops and black areas are non-agriculture or missing data. Landsat imagery from three time periods (26 December 2013, 11 April 2014, and 17 June 2014)
Next Steps – Field Level Validation

➢ Validate Crop Residue Cover estimates and the Winter Cover Crop maps on the field level
Field Level Residue Validation – Results

✓ N = 309
✓ R^2 = 0.78
✓ RMSE = 21.7

NB: Due to errors in ocular estimates and binning of residue classes, we estimate a perfect model would have an R^2 = 0.9.

Our model is explains ~87% of the variance that could be explained.
Next Steps – County Scale Validation

➢ Validate Crop Residue Cover estimates and the Winter Cover Crop maps on the county level

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<th>% of County in No Till</th>
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<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
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<td>% Residue Cover</td>
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CTIC

Applied Geosolutions
Indiana Pilot Results:

- We have completed the validation, need to provide results to USDA and Funders before releasing the results, performance and products.

- County and HUC scale results will be publicly available and distributed by AGS and CTIC.

On-going OpTIS Improvements

- Improve temporal resolution
- Improves accuracy of OpTIS
- Enhances specificity of timing of management events: dates of tillage, estimates of cover crop emergence, fractional cover and biomass modeling

- Integration of Sentinel data
  - Sentinel-1: C-band SAR imagery, use IW mode (VV and VH; 10 meter), 6-12 day repeat, no cloud problems, sensitive to soil moisture, roughness and plant biomass.
  - Sentinel-2: Optical, VIS-SWIR, 10-20 meter with 5-10 day repeat

- Integration with crop models, soils and weather data to improve cover crop development, biomass, N uptake and reductions in soil loss
Use of OpTIS Products – USDA Building Blocks for Climate Smart Ag

➢ Need good baseline activity data on existing conservation practices
➢ Products will improve USDA baseline quantification
➢ Products can improve quantification of progress toward Soil Health Building Block goal
➢ Products can provide transparent verification of changes in activities, coupled with validated models, will provide more rigorous verification
Thank you.

Questions?

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