Crop change assessment using polarimetric RADARSAT-2 data

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Outline

• Objective
• Approach
• Data collection and preparation
• Results
• Conclusions
Objectives

• To assess crop growing cycle monitoring using multi-temporal RADARSAT-2 Fine Quad Mode data

• To develop algorithms to monitor crop growth cycle and to estimate the harvest date
Approach

• Polarimetric temporal change detection
  – Track change in basic scattering mechanisms of target over time
    
    *Series of RADARSAT-2 repeat-pass images*
  – Monitor crops by correlating the scattering mechanisms with the growth and harvest cycle
  – Combine Pauli decomposition and statistical analysis

• Supervised classification
  – Use Maximum Likelihood Classifier
  – Training and test data are from field surveys

• Assumptions:
  – data are well calibrated geometrically and spatially
  – Images are well co-registered
Data collection

• RADARSAT-2 FQ5
  – Eastern Ontario, Canada
  – 21 May to 18 September 2009
  – $\theta_{\text{inc}}$: 23.4° – 25.3°
  – Ascending passes

<table>
<thead>
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<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
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<tr>
<td>Days</td>
<td>24</td>
<td>14</td>
<td>8</td>
<td>1</td>
<td>25</td>
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<tr>
<td>0</td>
<td>24</td>
<td>48</td>
<td>72</td>
<td>96</td>
<td>120</td>
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</table>

• Ground truth data
  – Field surveys collected on a field-by-field basis
  – Three crops: corn, cereals (wheat, barley) and soybeans
Data Preparation

• Pauli-basis decomposition
• Enhanced Lee speckle filtering  
  – window size: 7 pixels by 7 pixels
• Orthorectification

• Supervised classification
• post-classification filtering  
  – mode filter  
  – window size: 7 pixels by 7 pixels
Results

Temporal change monitoring

- Pauli-basis RGB images
  - Consistent scaling of the time sequence of images
    - normalized using the max. of all images
    - permits visual qualitative assessment of changes

- Statistical analysis
  - Mean intensities of each scattering component
Results

Multi-temporal change monitoring

21 May 2009

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Results

Multi- temporal change monitoring

1 August 2009

25 August 2009

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Field surveys – crop photos

Corn

Cereal (wheat)

Soybeans

6 August 2009
Results

• Pauli-basis RGB images provide visual information
  – Strong surface scattering for 21 May
    ⇒ *Crop seeding and early emergence*
  – Dominant volume scattering and double bounce scattering for 1 August
    ⇒ *Crops in these fields in various growing stages*
  – Important surface scattering for 25 August
    ⇒ *Crops are either senescing or have been harvested*
Results

Test site statistics

- Performed statistical analysis on the training sites
  - Indicate the crop emergence to harvest cycle
  - Estimate the harvest date
- Samples
  - Corn: 59 fields, $2.5 \times 10^5$ pixels
  - Cereals: 26 fields, $6.1 \times 10^4$
  - Soybeans: 62 fields, $2.6 \times 10^5$ pixels
Results

Mean intensities of three scattering mechanisms

For all three crops, double bounce & volume scattering
- much smaller than surface
- increase rapidly during the crop growth phase
- have similar trends
Results

- Reaches max. intensity from July, then stabilized
- No harvest by 18 Sept
- Reaches peak biomass between mid August and mid Sept.

Corn Phenological Calendar

Follow
Results

Cereals

• Reaches max intensity around 1 Aug.

• Harvest starts around mid August

Phenological Calendar

• Harvest around mid August
Results

**Soybeans**

- Reaches max. intensity in July, then stabilized
- No harvest by 18 Sept
- Reaches peak biomass in mid Sept

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Phenological Calendar
Results

Statistics of scattering mechanisms
- Indicates the different growth cycles of these crops
- Can be used to estimate the harvest time
- In general, follows the phenological calendars of these crops
Results

Supervised classification

– Four classes: corn, cereals, soybeans and others
  \textit{others consist of minor crops and non-agricultural land cover}
– Training data were obtained from field surveys
– Pauli components of 5 data sets were stacked as input
– Test data used for classification accuracy assessment were obtained from field surveys
Classification Map

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## Confusion matrix (%)

<table>
<thead>
<tr>
<th></th>
<th>Others</th>
<th>Soybean</th>
<th>Corn</th>
<th>Cereal</th>
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<tbody>
<tr>
<td>Others</td>
<td>84.0</td>
<td>3.3</td>
<td>5.3</td>
<td>7.4</td>
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<tr>
<td>Soybean</td>
<td>2.3</td>
<td>88.2</td>
<td>9.2</td>
<td>0.3</td>
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<tr>
<td>Corn</td>
<td>2.3</td>
<td>10.4</td>
<td>87.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Cereal</td>
<td>24.8</td>
<td>2.1</td>
<td>2.5</td>
<td>70.6</td>
</tr>
</tbody>
</table>

**Classification accuracy:**

- Overall: 85.1%
- Corn: 87.0%
- Cereals: 70.6%
- Soybeans: 88.2%
Conclusions

• Developed an approach to monitor crop development from emergence to harvest using RADARSAT-2 FQ data
  
  – *combine Pauli decomposition and statistical analysis*
  
  – *monitor when the significant change of volume/double bounce scattering occurs*
  
  • *to determine the harvest status*

• Double bounce and volume are strong indicators of crop growth development

• Results follow crop phenological calendar

• Overall classification accuracy of 85% can be achieved using RADARSAT-2 FQ5 data
Acknowledgements

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