Screening of Earthen Levees Using Synthetic Aperture Radar

James V. Aanstoos, Charles G. O’Hara, Saurabh Prasad, Lalitha Dabbiru, Rodrigo Nobrega, Matthew Lee
Mississippi State University

The Problem:
• 100,000 miles of dams and levees nationwide
• National Committee on Levee Safety * recommends
  “expand the existing federal National Levee Database (NLD) to include inventory and inspection... of all levees”
• No funds have been allocated for extending the inspection portion of this work beyond the small subset of these levees which are managed by the Corps of Engineers.

Project Purpose: Develop new methods and software for efficiently improving knowledge of the condition of levees, based on remotely sensed data: airborne multi-polarized imaging synthetic aperture radar.

Expected Outcome: Improved knowledge of the status of levees will significantly enhance the allocation of precious resources to inspect, test, and repair the ones in most need.

Technical Approach

1. Remotely Sensed Data collection
   1.1 Develop collection plan: choose sites / dates, ancillary data
   1.2 UAVSAR Flight 1 collection; Flight 2 collection
   1.3 Ancillary descriptive and image data
2. Data exploration: compute statistics, visualize. Identify anomalies
3. Ground site visits (guided by data anomalies) and soil tests
4. Classification algorithm development
   4.1 polarimetric SAR data relation with soil moisture variability
   4.1.1 Texture-based features
   4.1.2 H-A-alpha based features (PolSARpro)
   4.2 Interferometric algorithms to map subsidence
   4.3 Refine and test algorithms

UAVSAR is a high-resolution, multi-polarization, L-band SAR, currently flown on a NASA research aircraft (Gulfstream-3). L-band signal penetrates vegetation and up to 1 m of dry soil; Backscatter carries information related to soil moisture variation.

Preliminary Results from Exploration of Flight 1 Radar Data

Ground “Truth” Data: Buck Chute Levee at Eagle Lake, MS

Soil conductivity monitoring station

Sand boil at Buck Chute

Statistical distance image between sand boil pixels and others in AOI for Gray Level Co-occurrence Matrix features:
(L) homogeneity in HV;
(R) Window mean in HH

UAVSAR Parameter Value

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Frequency</td>
<td>L-band</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>80 MHz</td>
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<tr>
<td>Range Resolution</td>
<td>1.8 m</td>
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<tr>
<td>Polarization</td>
<td>Full Quad-Polarization</td>
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<tr>
<td>Raw ADC Bits</td>
<td>12 baseline</td>
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<tr>
<td>Waveform</td>
<td>Nominal Chirp/Arbitrary Waveform</td>
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<tr>
<td>Antenna Dimensions</td>
<td>0.5 m range/1.5 m</td>
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<tr>
<td>Azimuth Steering</td>
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<tr>
<td>Power</td>
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<tr>
<td>Polarization Isolation</td>
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</tbody>
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Test area: 240 km of Mississippi River levees
UAVSAR flight 1: June 1, 2009

Under-seepage and erosion can lead to levee failure. Can we detect potential weakness via airborne radar?

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* 2009 report to Congress

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H-A-alpha Classification from PolSARpro of Grand Lake, AR seepage area

Multiple-polarization radar data color composite image of Buck Chute levee vicinity, Eagle Lake, MS.