2012 Dams Sector Research and Development Workshop

Levee Assessment via Remote Sensing

Dr. Charles 'Chuck' O'Hara
Dr. Jim Aanstoos, PI

Geosystems Research Institute
Mississippi State University

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Summary

- **Purpose of this research:**
  - Develop methods and software for improving knowledge of levee condition, giving levee managers new tools to prioritize their efforts.
  - Deliver software for levee segmentation, SAR classification algorithms, and integrated geospatial framework for rapid assessment including surface and subsurface conditions of levees using all available data.
  - Disseminate this technology to key stakeholders, involving them in the testing and evaluation of the tools.
- **Payoff:**
  - Improved knowledge of the status of levees.
  - Enhanced decisions and management of precious resources to inspect, test, and repair damaged levees in highest need priority.
  - Streamlined processing to classify SAR data for levee 'alarm' features.
  - Custom software prototype for LARS mapping and analysis.
  - Validated methods of use for UAVSAR and other SAR data streams for rapid remote sensing and actionable data products.

Summary

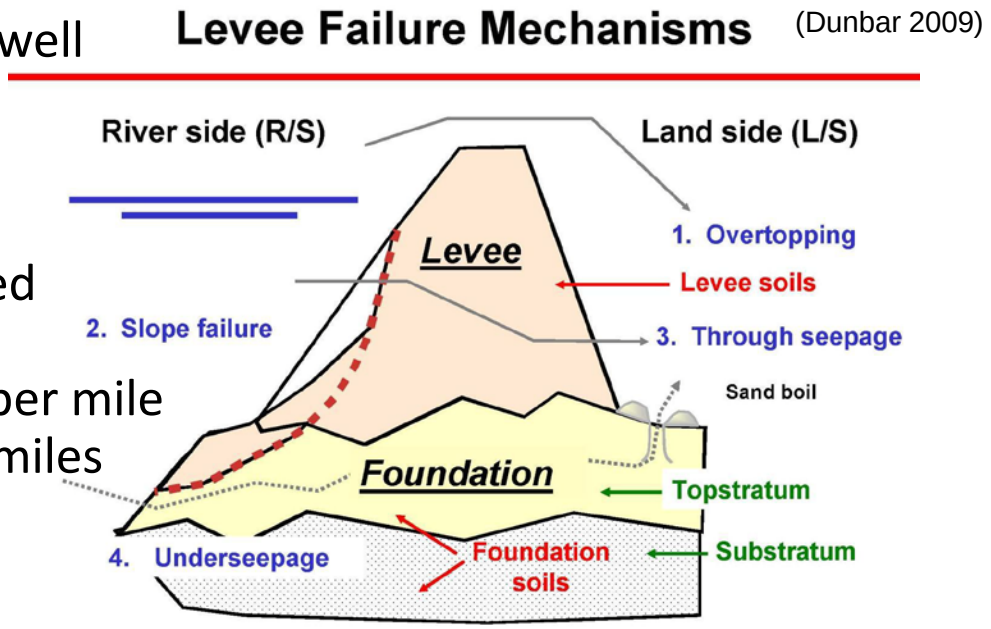
- **Timeline:**
  - Start Date: January 2009
  - End Date: August 2012
- **Sponsoring entities:**
  - Department of Homeland Security
    Southeast Region Research Initiative (SERRI)
- **Collaboration with others:**
  - U.S. Army Corps of Engineers, ERDC (Project Partners)
  - Department of Homeland Security, Additional Related Project,
    Screening of Levees via Synthetic Aperture Radar
  - NASA – ROSES: Improved Levee Management via Remote Sensing

Problem Description

- **What is the problem?**
  - Can not inspect levees on-site frequently enough to detect failures or potential problems.
  - In situ testing and on-site inspections are expensive and time consuming.
  - Over 100,000 miles of levees and dams nationwide require monitoring, condition assurance, and efficient methods to detect priority problems.
  - Existing levee assessment systems require manual inspections as well as testing such as bore-holes:

Cost / Benefits of remote methods must be demonstrated and validated

Cost of bore-hole analysis: $0.5M per mile
Cost of radar data: < $10K per 100 miles

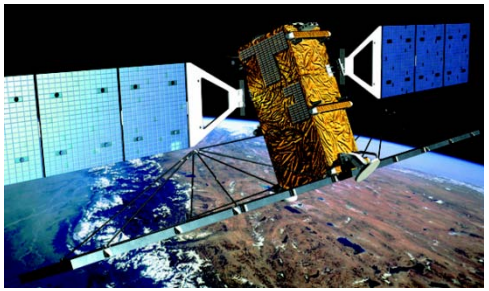


Outcomes

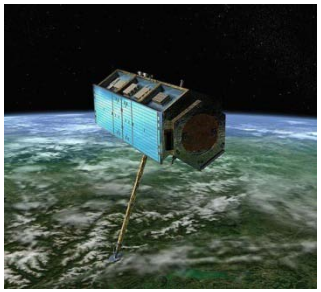
- **What are the specific products?**
  - Procedures and techniques to rapidly ***identify*** potential problem areas along levees and strengthen the existing levees will mitigate the damages caused by levee breaches and add system resilience.
  - Enhanced ***identification*** tools within a geospatial framework will add efficiency and decision support for levee strengthening efforts.
  - Algorithms for utilizing synthetic aperture radar (SAR) data will identify and classify key levee features indicating levee failures or problems.
  - A custom levee mapping tool built on open-source Mapwindow GIS will enable classification and levee segment condition assessment.
  - Validated SAR from multiple sources (aerial and satellite) will provide input for condition assessment, classification, and feature assessment.

UAVSAR

RADARSAT-2



TerraSAR-X

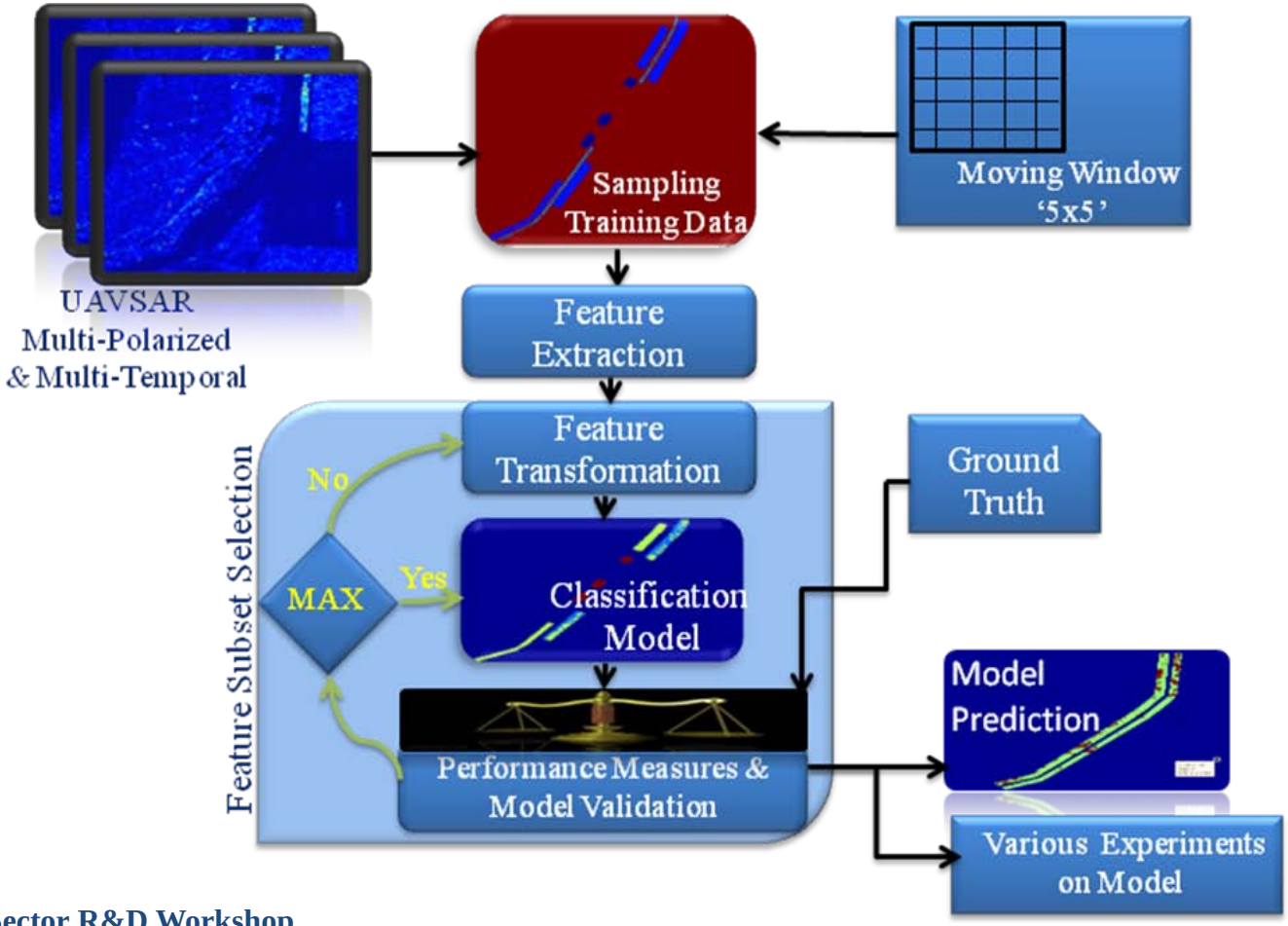


Accomplishments/Status

- Field data, coordinated exchanges of information regarding slide events, base mapping, and validation information acquisition and usage.
- Integration of slide site information, multi-source basemap image data and soil sampling

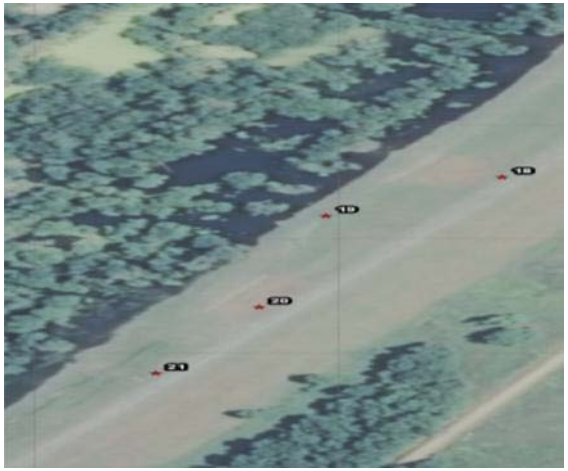
Accomplishments/Status

Classification Framework & Algorithm Development: Multiple Algorithms Developed and Tested

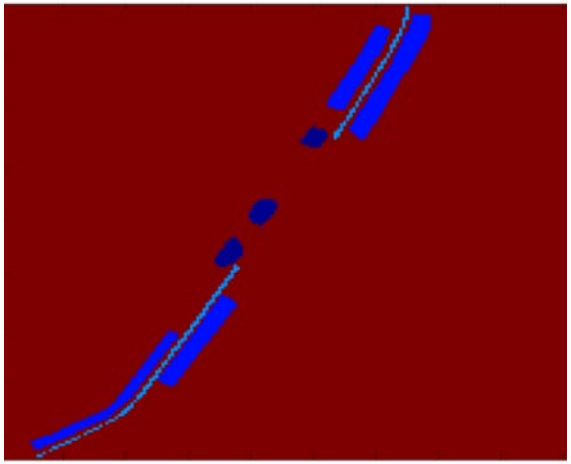


Accomplishments/Status

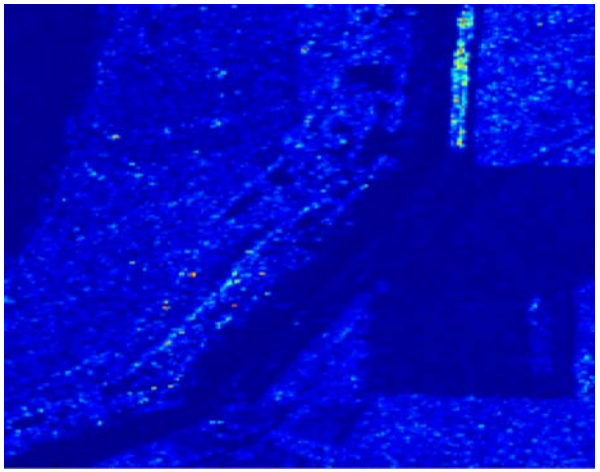
Basemap Data, Slide 'Training' Data, Multi-Temporal & Multi-Source SAR: Demonstrating Positive Results Using Multiple Classification Methods



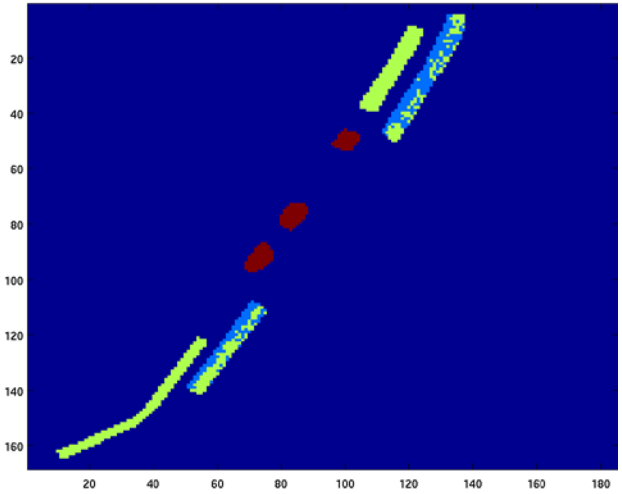
NAIP - 07, 09, 10



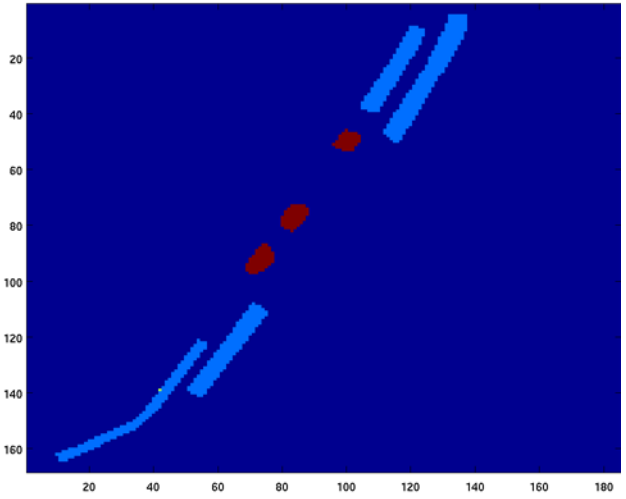
Training Masks, 17 Slides



UAVSAR Subset- '09, '10



Maximum Likelihood



Artificial Neural Network
Error Back Propagation

Accomplishments/Status

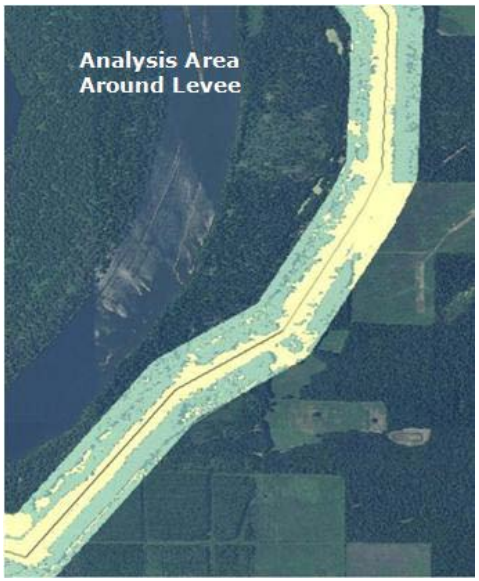
Classification / Status Mapping Software

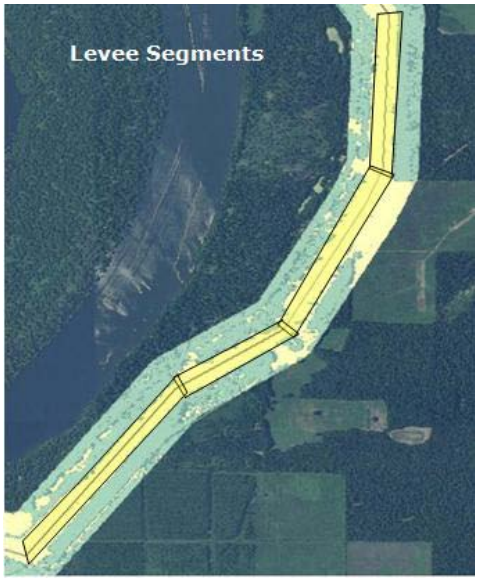
Data Input, Preprocess, And Buffer

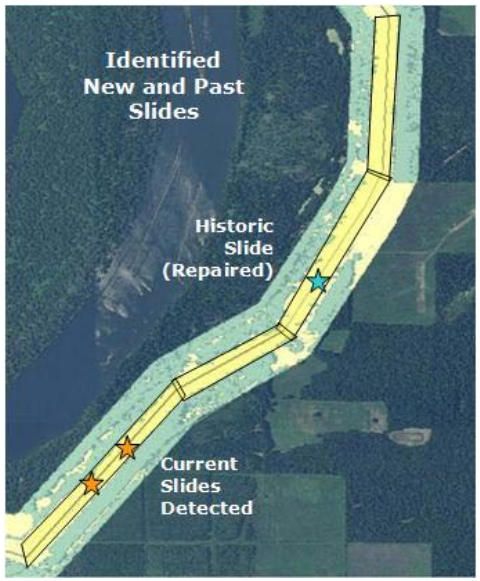
Apply Physical Segments

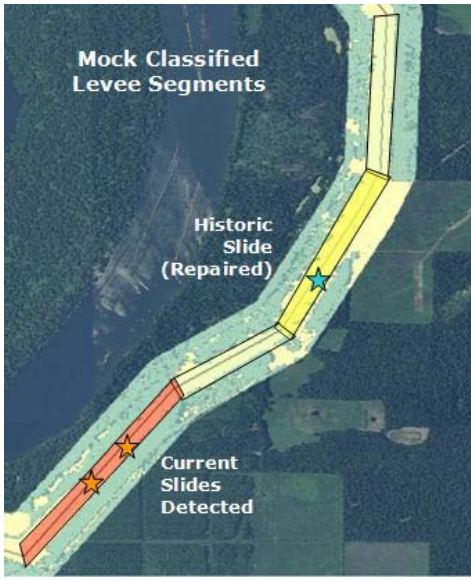
Fuse Old And New Slide Data

Apply Rule Base to Segments



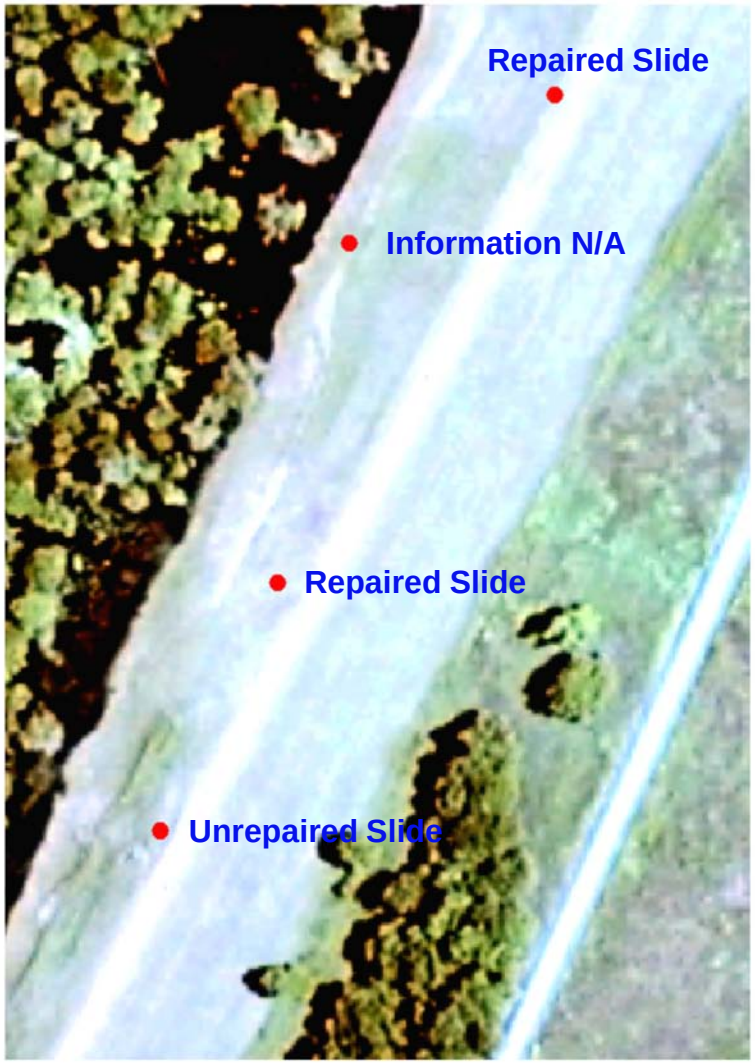


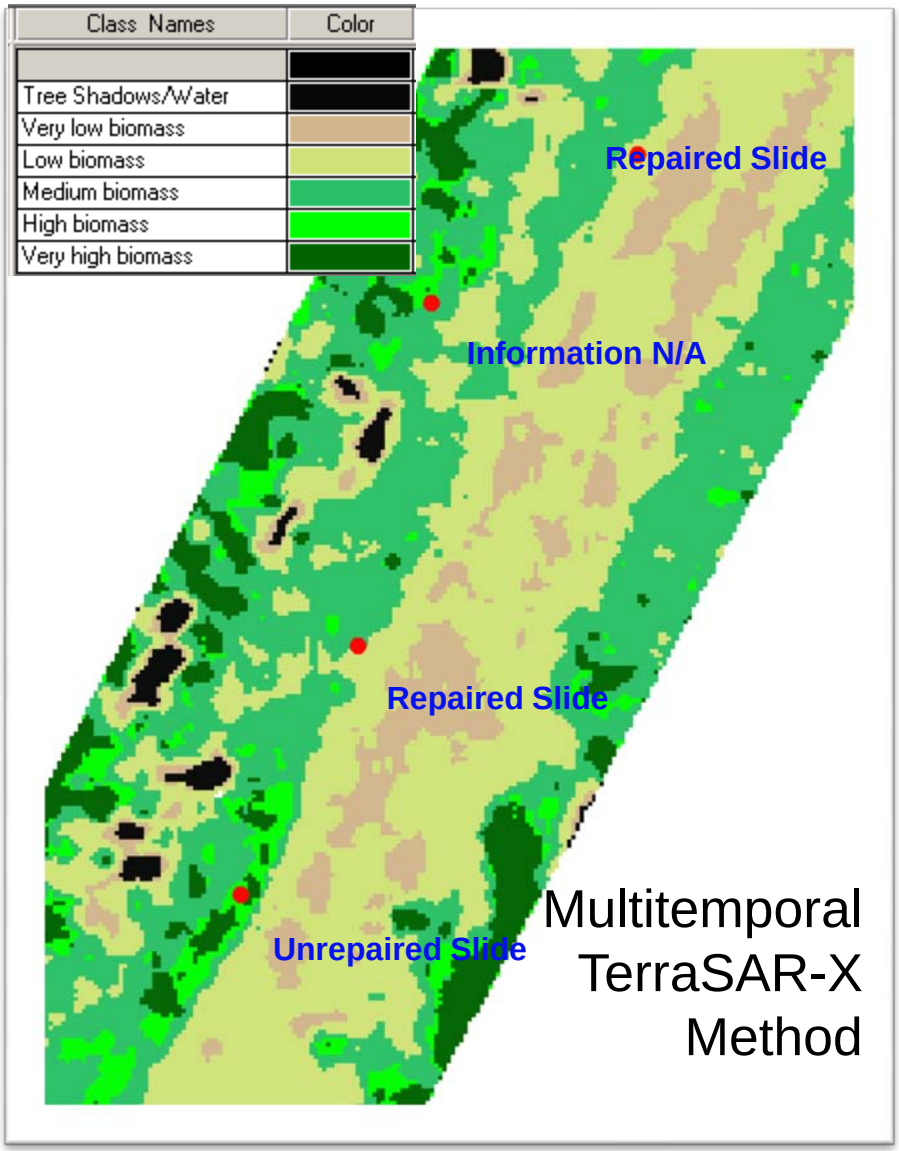




Green – Good Geology | Clay Soils | No History of Slides
Tan – Moderate Geology | Moderate Soils | No History of Slides
Yellow – Good to Mod Geology | Good to Mod Soils | History of Slide(s)
Orange – Moderate Geology | Sandy Soils | Possible Slide(s)
Red – Any Geology | Any Soils | Current Slide(s)

Accomplishments/Status

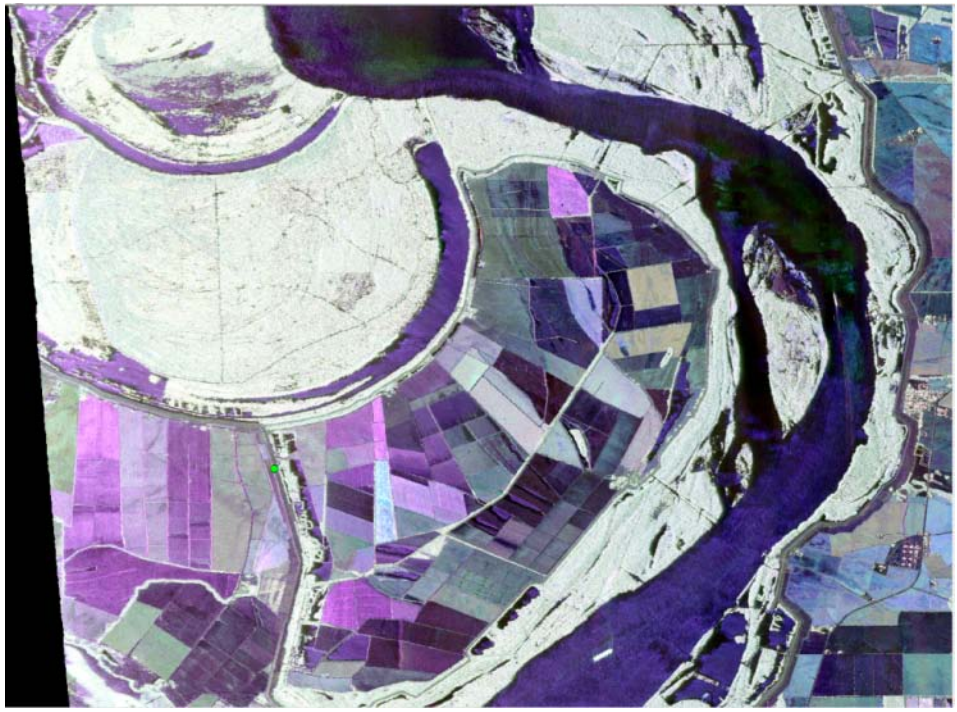




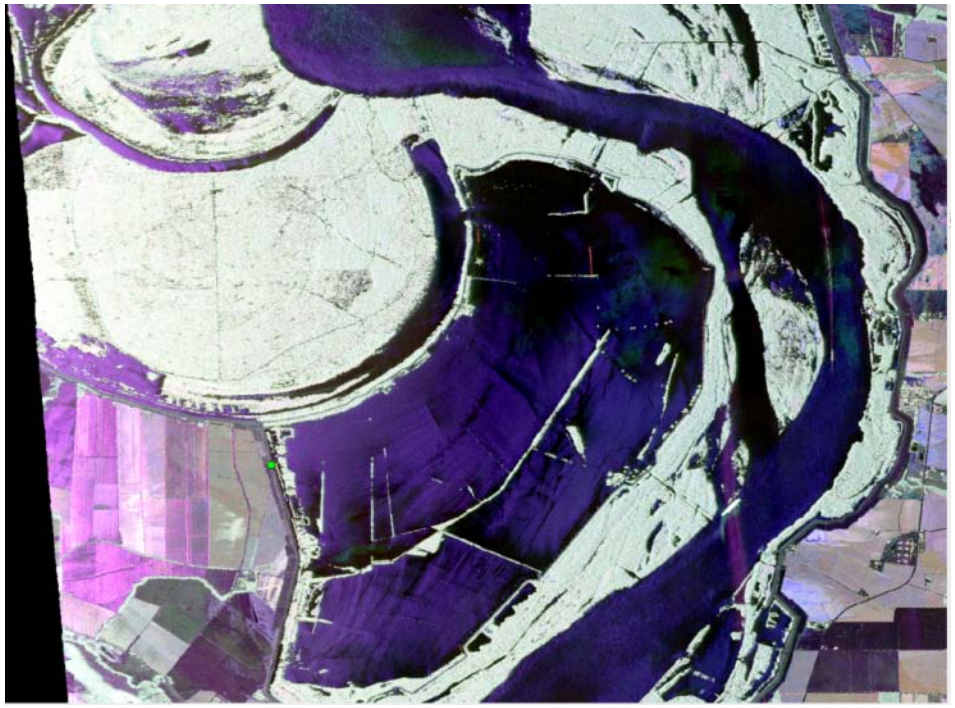
Accomplishments/Status

Unplanned Benefit of Multi-Temporal UAVSAR: Rapid Classification of Flooded Areas

28 April 2011 UAVSAR Image



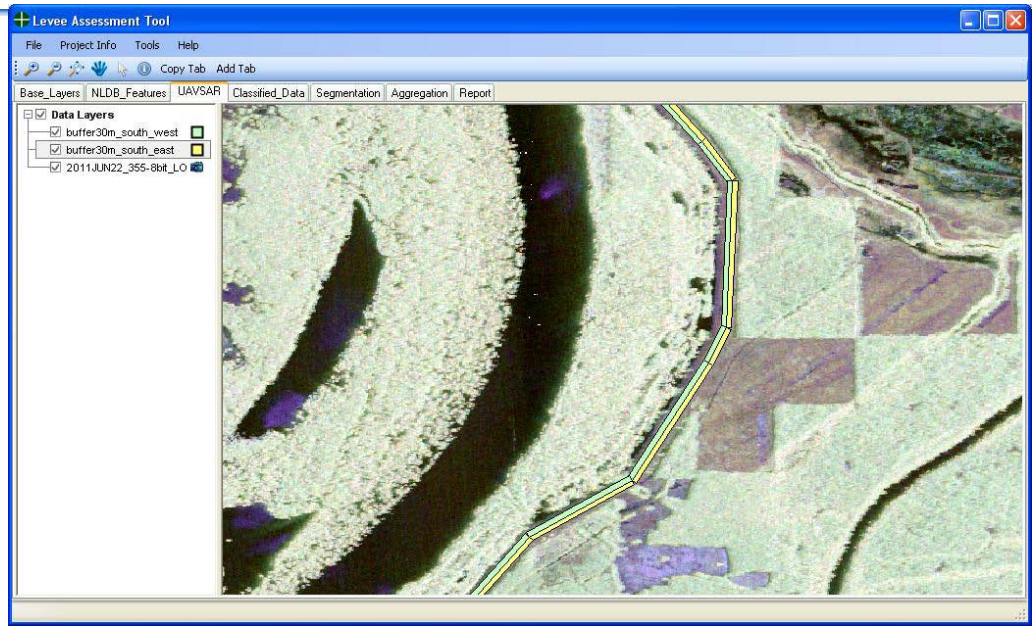
07 June 2011UAVSAR Image



Bunches Bend Area: The June 2011 image shows the agricultural fields are completely flooded

Next Steps

- Refinement and validation of classification methods.
- Mock classification results in mapping tools substituted with actual classifier outputs.
- Refinement of data processing, classification, and aggregate assignment of condition and priority alert status.
- Feedback from partners and stakeholder for final tuning and inclusion of features and benefits most needed by user community.
- Delivering products, preparing materials, and conducting outreach.



Issues and Challenges

- **Correct and Comprehensive Detection:** Optimize classification methods to capture current slides, their location, shape, size, and general characteristics as well as locations of potential and past slides while minimizing 'false positives.'
- **Temporality:** Identifying 'active slides' by remote sensing means acquiring remote sensing data after the slide and between the time when the Corps knows the slide is there and when the slide is repaired.
  - Collecting ground-truth data when the slide is active.
  - Tasking and data acquisition when the slide is active.
- **Tasking:** With UAVSAR, the team does not have flexible tasking for acquisition by the NASA platform which is scheduled and managed by NASA scientists.
- **Flexibility:** Pending availability of platform resources, flexible and timely data acquisition tasking may require further utility of satellite data resources.
- **Simplification:** Data size and complexity means that data processing and classification must be refined to the point wherein the complexity is removed and the user has a simple and easily used and understood set of tools and results.