Image Registration and Fusion for Future Formation Flying Systems

PI: Jacqueline Le Moigne

NASA GSFC

Applied Information Sciences Branch (Code 935)

Co-Investigators:

Arlene Cole-Rhodes (Morgan State University)

Roger Eastman (Loyola College)

Tarek El-Ghazawi (George Washington University)

Nathan Netanyahu (UMCP/UMIACS)

Harold Stone (GEST Center)

James Tilton (GSFC/Code 935)

Ilya Zavorin (GEST Center)

(Other Collaborators: N. Laporte (UMCP), J. Morisette (GSFC), J. Masek (GSFC))

Technical Significance of Progress Expected Impact on NASA

- Cross-Cutting Technologies:
  - Earth Science Enterprise
    - Integrate Data from Multiple Earth Science Sensors, e.g. Landsat-7/TM, EO-1/ALI and MODIS
    - Integrate Data from Multiple Missions such as TERRA and AQUA
  - Space Science Enterprise
    - New Millennium Program, constellation flying on-board processing (e.g., dimension reduction)
    - Exploration Technology Program, in-situ automatic registration and fusion for robot navigation

Technical Challenges

- Automatic Image Registration:
  - Obtain Sub-Pixel Accuracy
  - Multi-Sensor Registration of Multiple Spatial and Spectral Resolutions
- Image Fusion (with Land Cover/Land Use Program)
  - Improve Classification Accuracy
  - Integrate Disparate Data Sets for Global Land Cover Mapping
- Dimension Reduction (with ESTO/CT-HPCC Pgrm)
  - Preserve Classification Accuracy
  - High-Performance Implementation

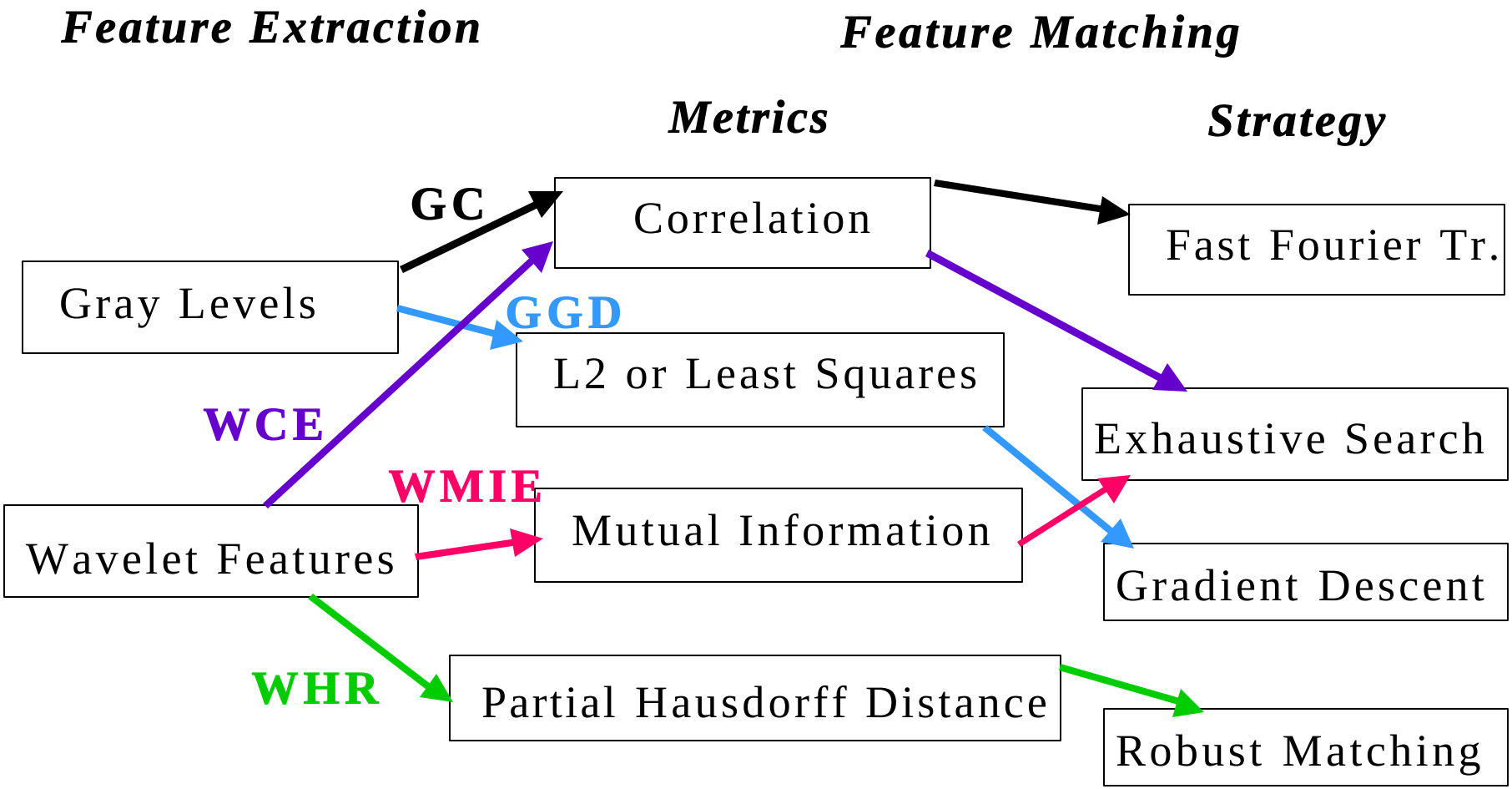
Technical Approach
Automatic Image Registration

- Image Registration Components:
  - 0 **Pre-Processing:** Cloud detection, Region of interest masking, ...
  - 1 **Feature Extraction** (“Control Points”):

    Edges, Regions, Contours, Wavelet Coefficients, ...
  - 2 **Feature Matching**
    - Spatial Transformation (a-priori knowledge)
    - Search Strategy (Global vs Local, Multi-Resolution, ...)
    - Choice of Similarity Metrics (Correlation, Optimization Method, Hausdorff Distance, ...)
  - 3 **Resampling, Indexing or Fusion**

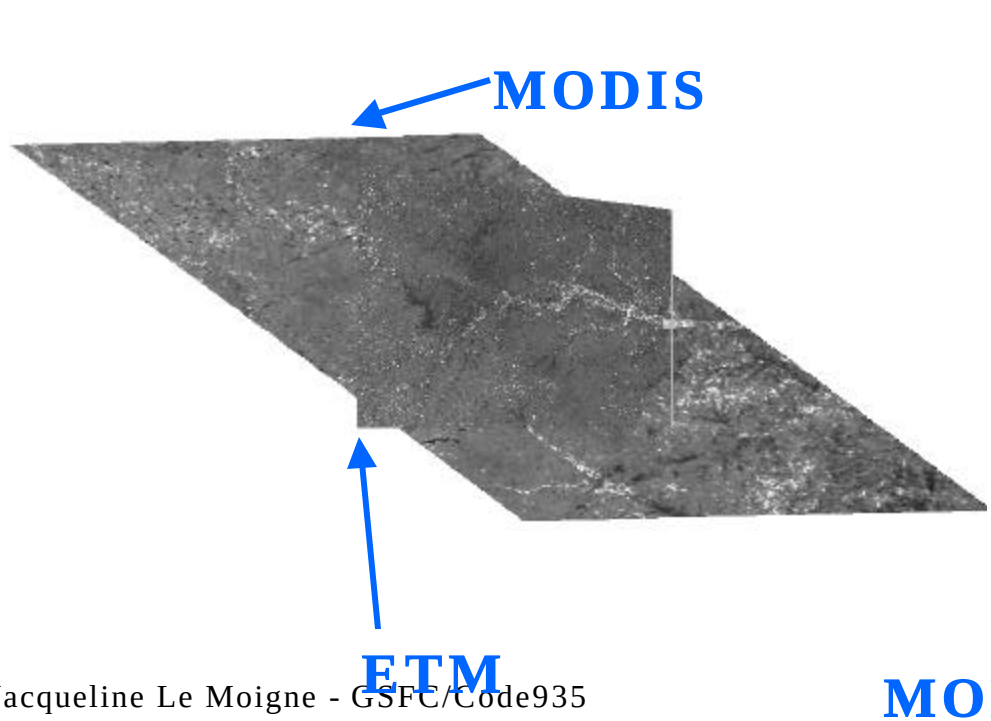
- Our work: (1), (2) and (3)

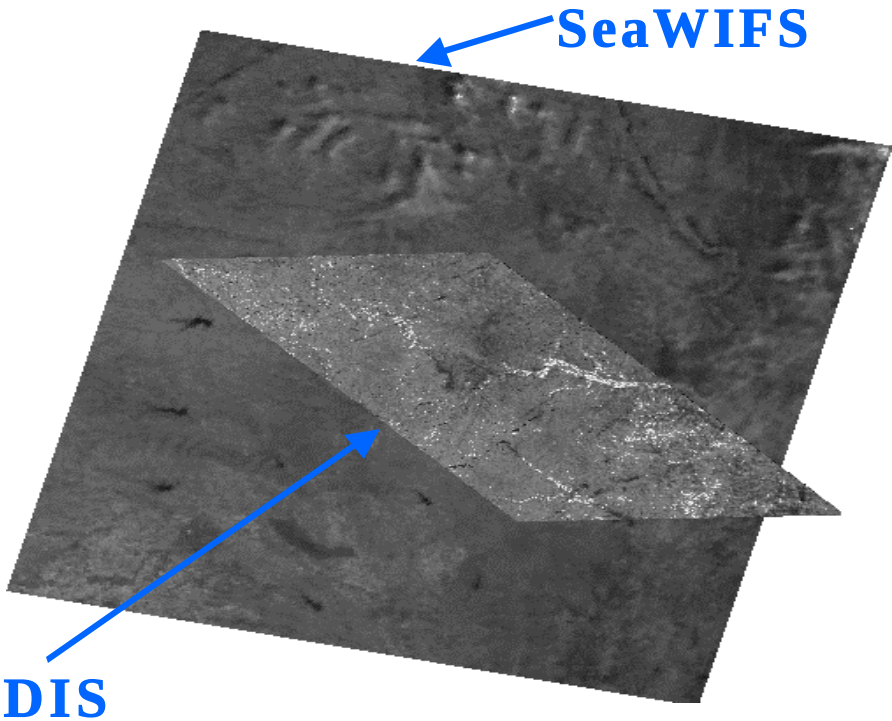
Technical Approach
Automatic Image Registration (2)



Data and NASA Relevance Image Registration

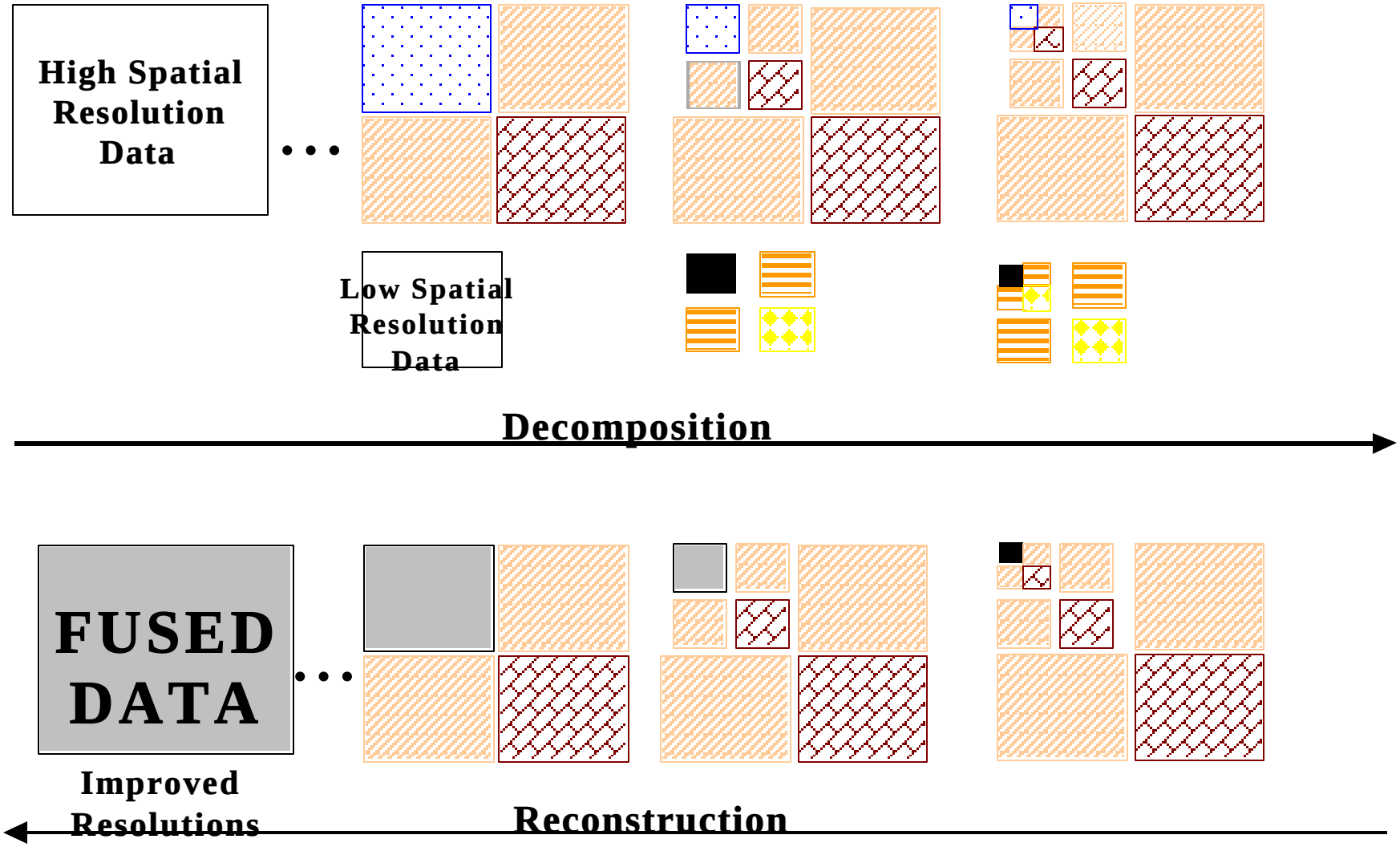
- Objective: Register Representative Formation Flying Systems Datasets
- First Milestone: EOS Validation Core Site Data (Konza Prairie), Landsat-7/IKONOS/MODIS/SeaWiFS





Technical Approach - Image Fusion

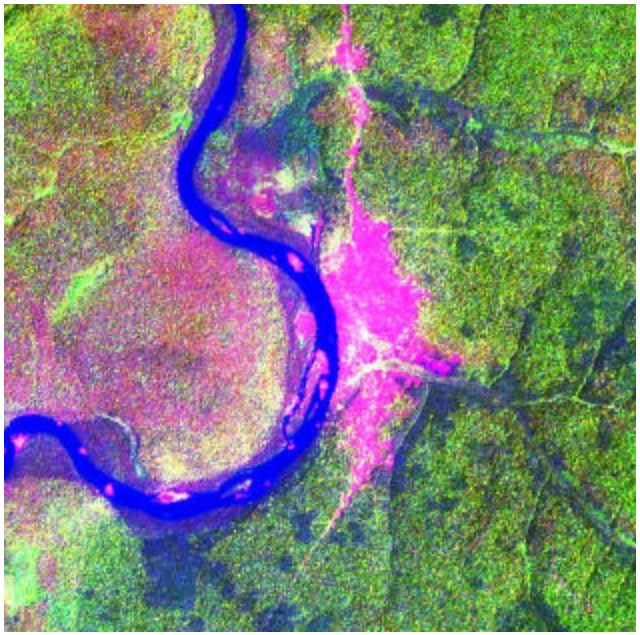
Wavelet-Based Fusion



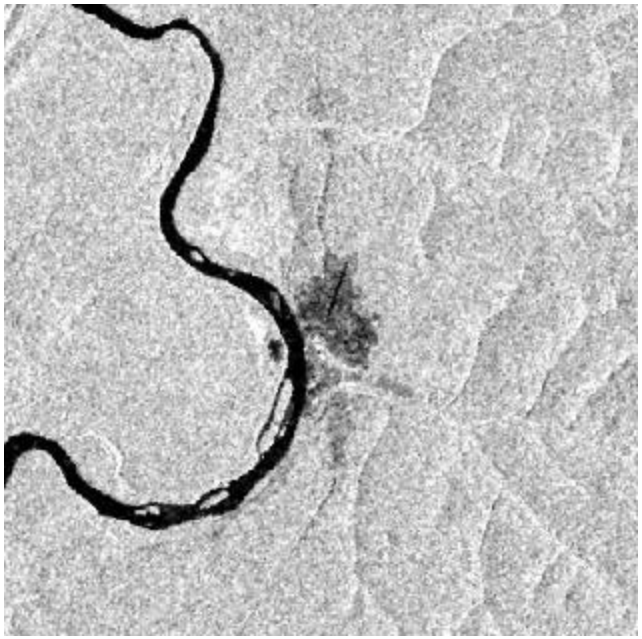
Data & NASA Relevance - Image Fusion

- Land Cover/Land Use (LCLU) Research: Build Central Africa Global Forest Monitoring System
  - Test Area: Lopé Reserve, Gabon, Central Africa
  - Fusion: MODIS(250m) with JERS Data (31.5 m) (earlier work: TM with SAR)
- Objective: Compare Classification of Landsat/TM Data with Classification of Fused JERS/MODIS Data **(in progress)**

Landsat Data



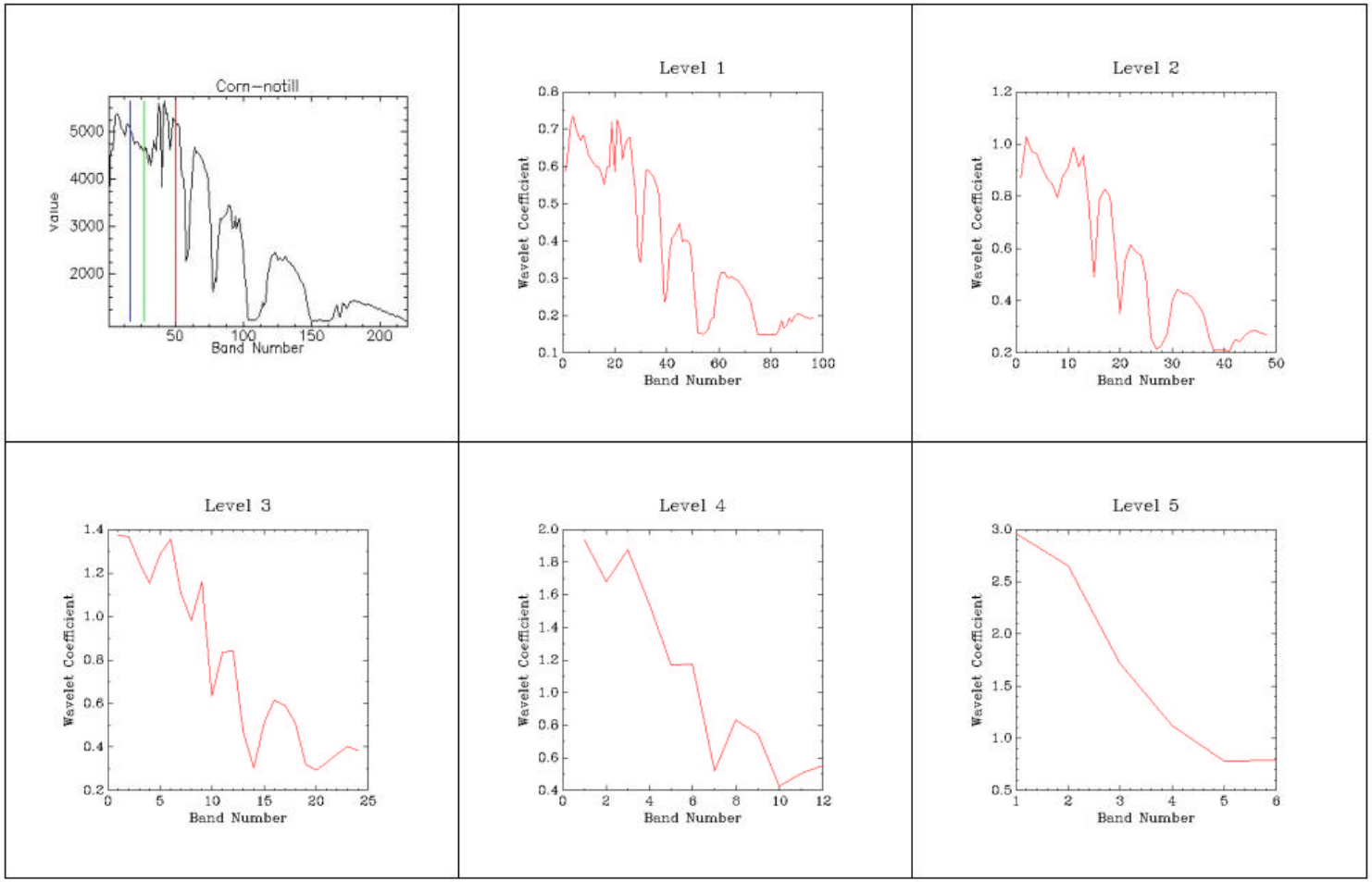
JERS data



MODIS data

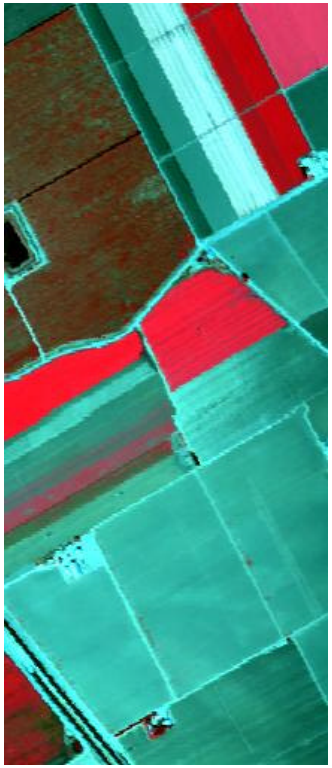
Technical Approach
Hyperspectral Dimension Reduction

Multi-Resolution Wavelet Decomposition of Each Pixel 1-D Spectral Signature

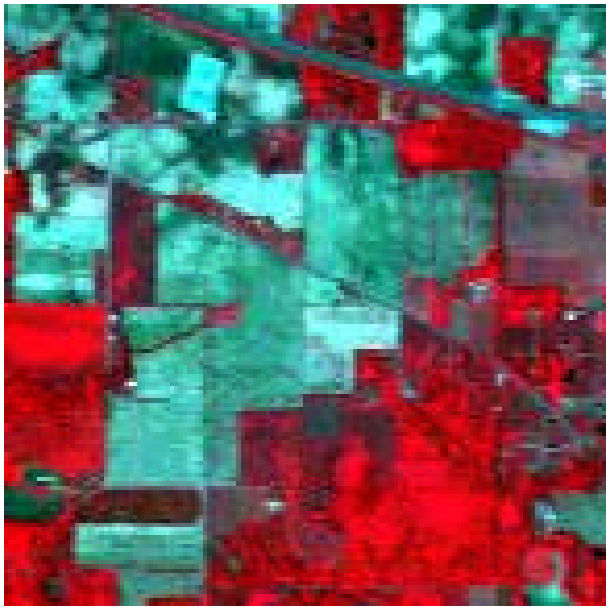


Data and NASA Relevance
Hyperspectral Dimension Reduction

"High" dimensional data → ***DIMENSION REDUCTION*** → "Low" dimensional data → **TRADITIONAL** Classification Process



AVIRIS: SALINAS'98



AVIRIS: INDIAN PINES'92

Accomplishments & Preliminary Findings - Summary

- Automatic Image Registration:
  - Experiments on EOS Core Site Multi-Sensor Dataset
  - Registration Accuracy up to 1/2 pixel
  - Registration Consistency up to 1/8 pixel
- Image Fusion
  - Qualitative Improvement of Classification by Fusion of Landsat and SAR
  - In progress: Similar Classification after Fusion of JERS and MODIS data Compared to Classification of Landsat data alone
- Dimension Reduction
  - Developed New Wavelet-Based Dimension Reduction (WDR)
  - Classification Accuracy of WDR PCA;
  - WDR Faster than PCA
  - On Beowulfs/HIVE, better scalability of WDR than PCA