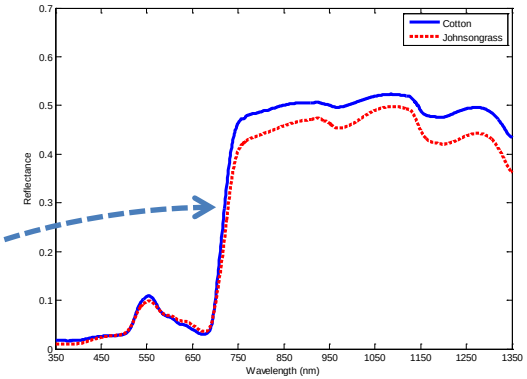
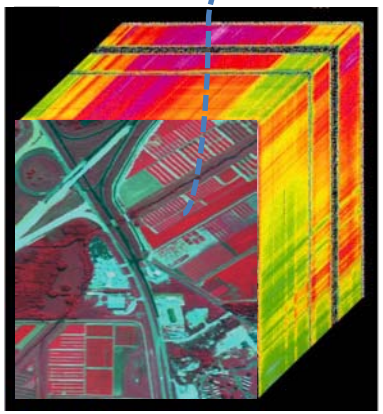
DATA EXPLOITATION OF HYSPIRI OBSERVATIONS FOR PRECISION VEGETATION MAPPING



Hyperspectral Imagery



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GRI

Background and Project Team

- Project Title: "***Applying NASA HyspIRI satellite observations to precision vegetation mapping for ecological forecasting applications***," NASA, 2009-2011.

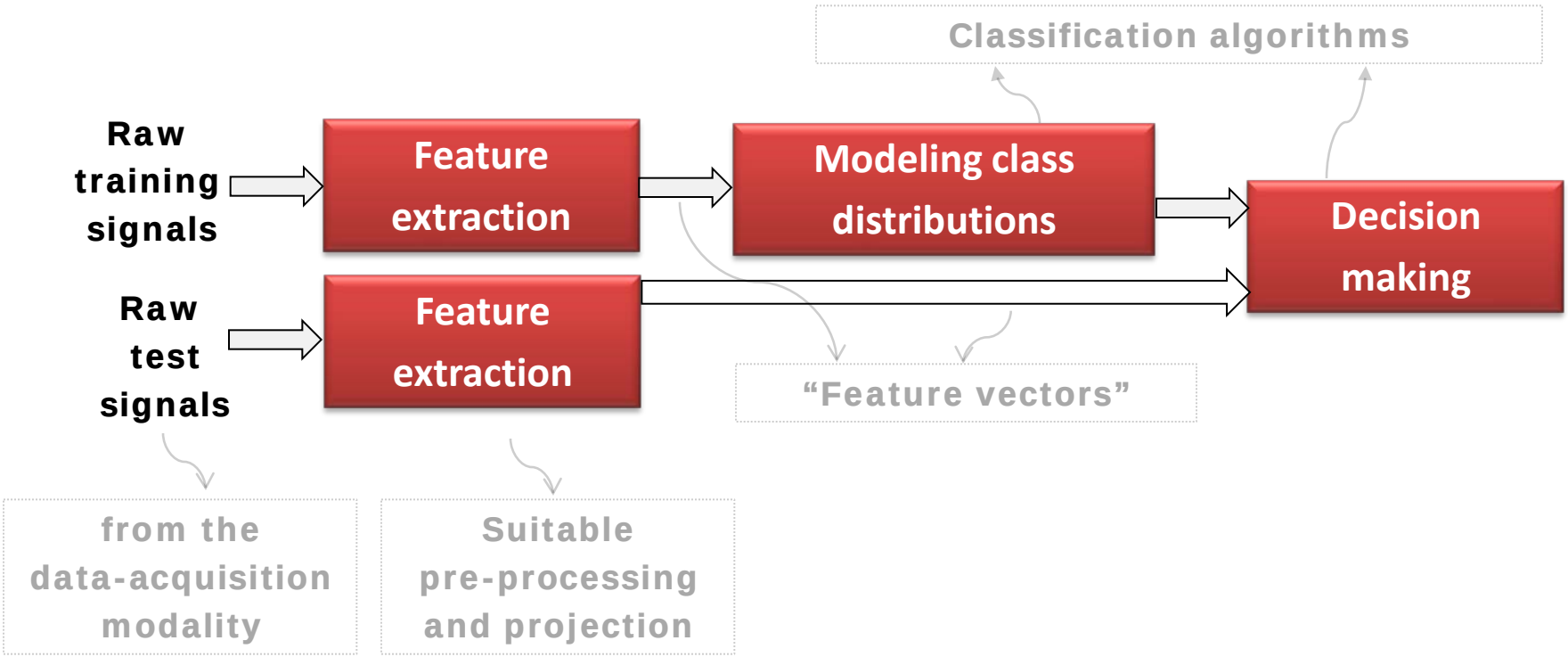
- PIs:
  - Dr. Lori M. Bruce (Electrical Engineering, Mississippi State University)
  - Dr. Saurabh Prasad (Electrical Engineering, Mississippi State University) (***Technical Lead-Statistical Pattern Recognition***)

- Collaborator:
  - Dr. Wilfredo Robles (Department of Plant and Soil Sciences , University of Puerto Rico) (Dataset provider – providing us with a library of hyperspectral samples from a variety of aquatic plant species).

Outline of this presentation

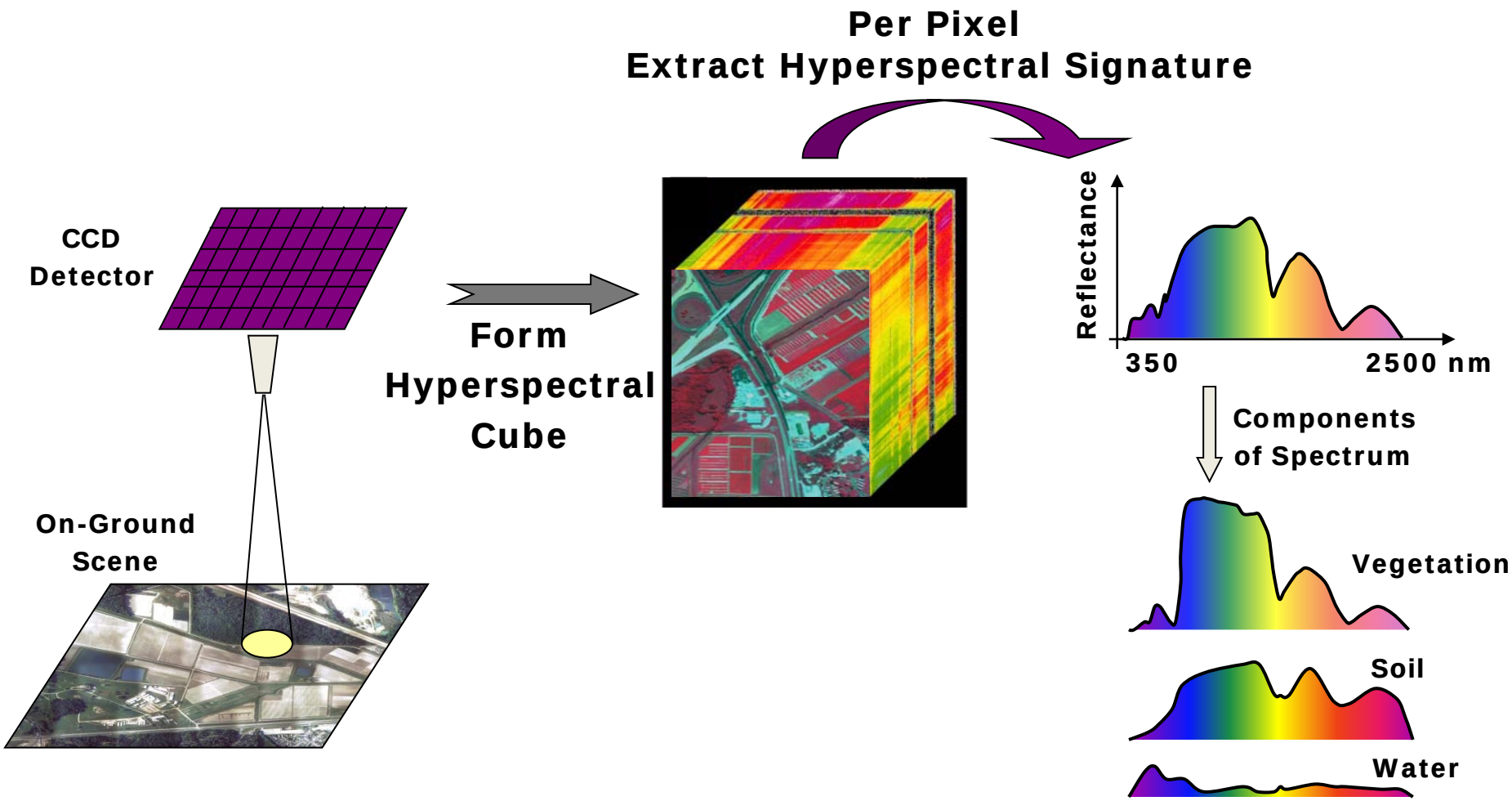
- Background – Pattern classification in the context of high-dimensional feature spaces (Direct relevance to Hyperspectral image analysis)
- Review of conventional methods
- The divide-and-conquer paradigm – a Multi-Classifier, Decision Fusion (MCDF) Framework
- Experimental analysis with:
  - Simulated/Proxy-HyspIRI data
- Conclusions and ongoing work

Statistical Pattern Classification Systems

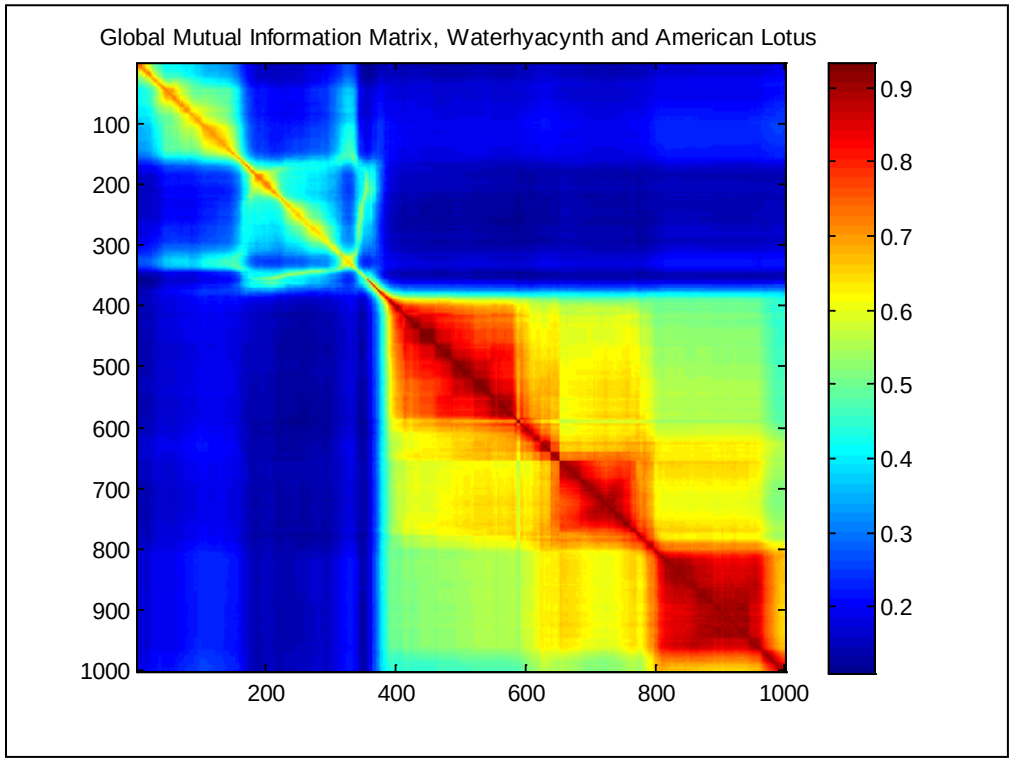


Some examples: Face recognition, target recognition and land cover classification in remote sensing applications, CAD medical applications, speech and speaker recognition …

Hyperspectral Remote Sensing Systems



The Proposed Framework – Multi-classifiers and Decision Fusion (*MCDF*)

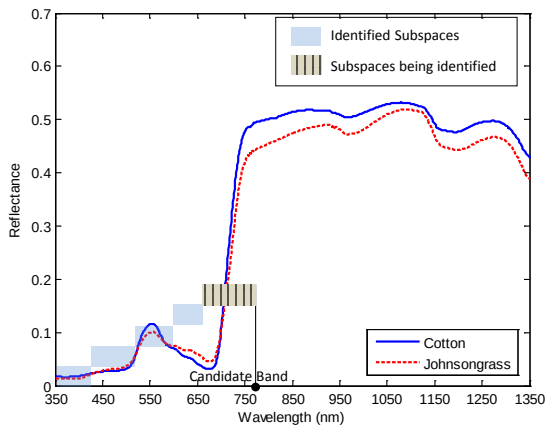


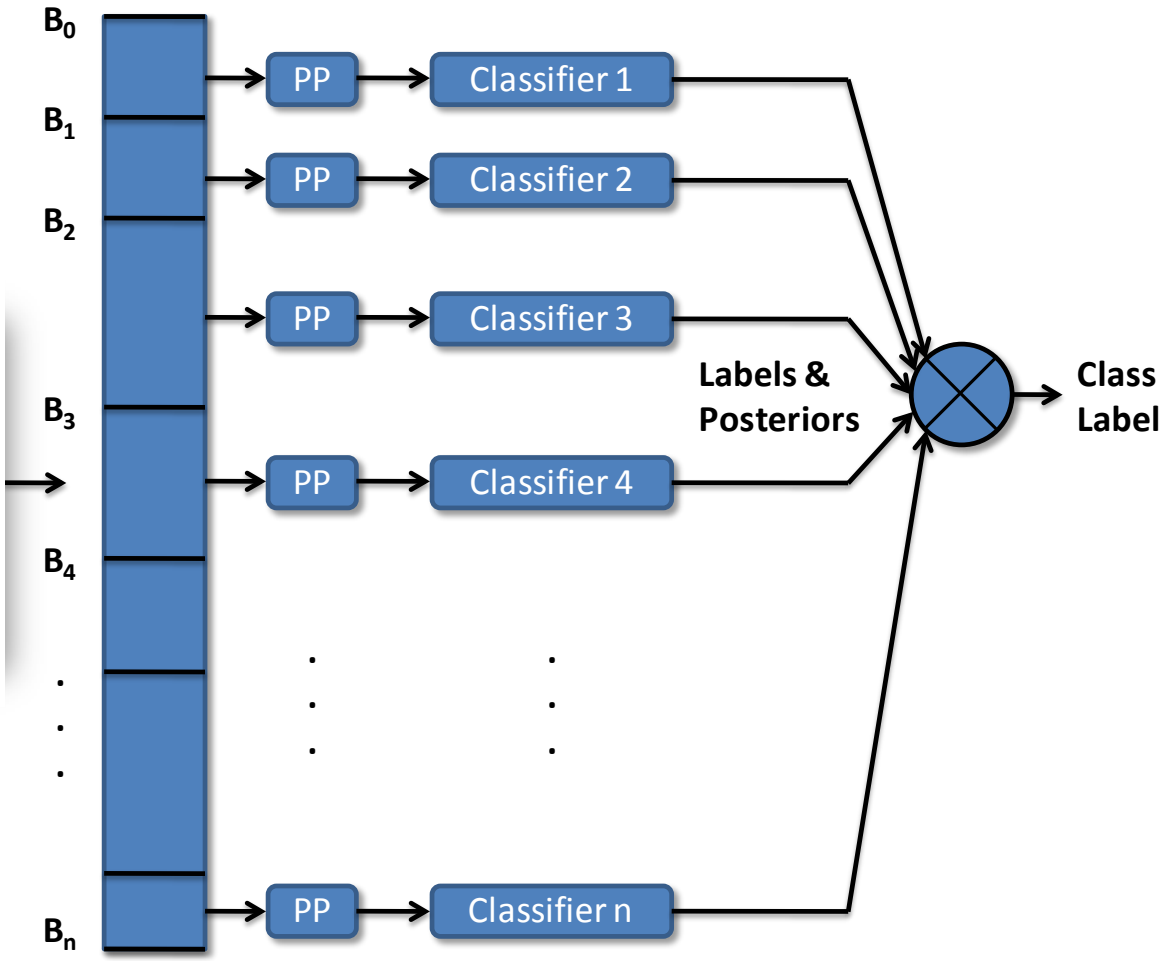
Mutual Information

Approximately independent subspaces ←→ diverse classifiers

Diverse classifiers ←→ Better decision fusion

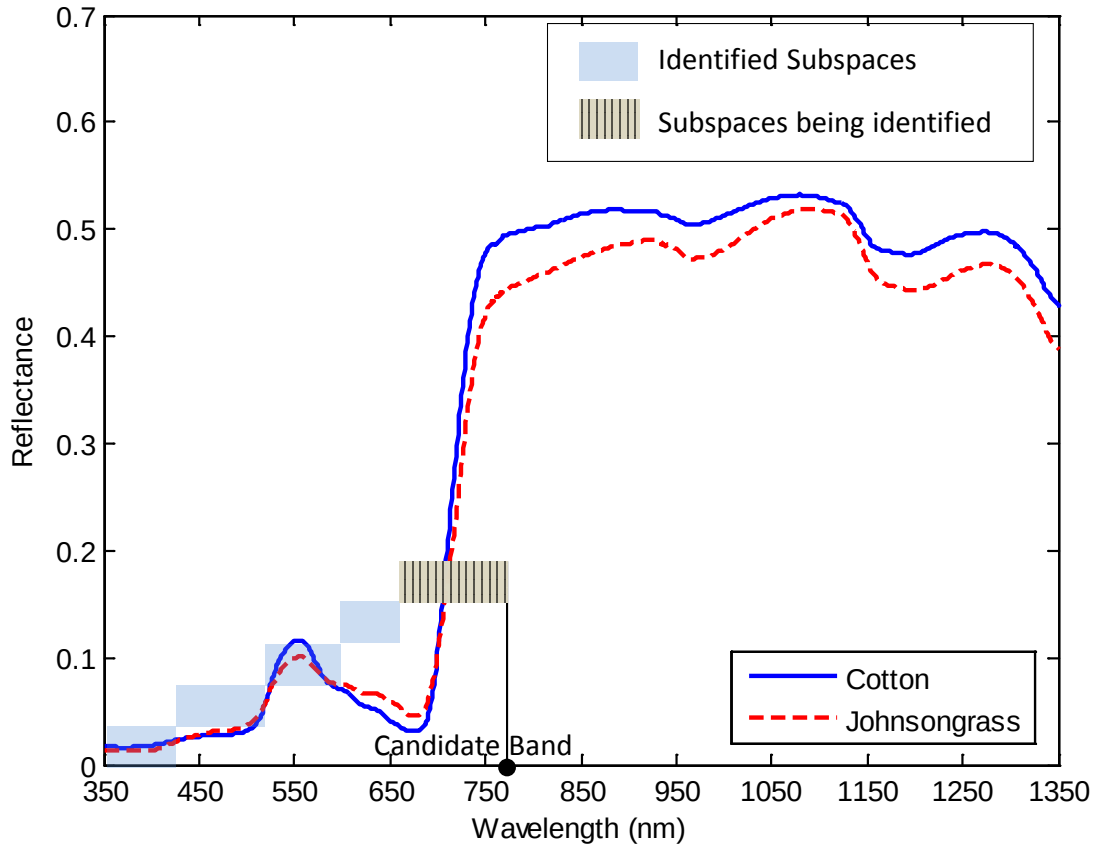
The Proposed Framework – Multi-classifiers and Decision Fusion (*MCDF*)





PP: An appropriate pre-processing

Multi-Classifiers and Decision Fusion: Subspace Identification



- Use training data for Band-Grouping
- Identify subspaces by maximizing some performance metric

Multi-Classifiers and Decision Fusion: Decision Fusion Strategies

- Hard Decision Fusion
  - Majority Vote:

$$N(i) = \sum_{j=1}^{n} I(w_j = i)$$

$$w = \arg\max_{i \in \{1,2...C\}} N(i)$$

  - Weighted Majority Vote:

$$N(i) = \sum_{j=1}^{n} \alpha_j I(w_j = i)$$

$$w = \arg\max_{i \in \{1,2...C\}} N(i)$$

Confidence score in the *j*'th subspace

Multi-Classifiers and Decision Fusion: Decision Fusion Strategies

- Soft Decision Fusion
  - Linear Opinion Pool

$$C(w_i \mid x) = \sum_{j=1}^{n} \alpha_j p_j(w_i \mid x)$$

$$w = \underset{i \in \{1,2 \ldots C\}}{\arg\max}\, C(w_i \mid x)$$

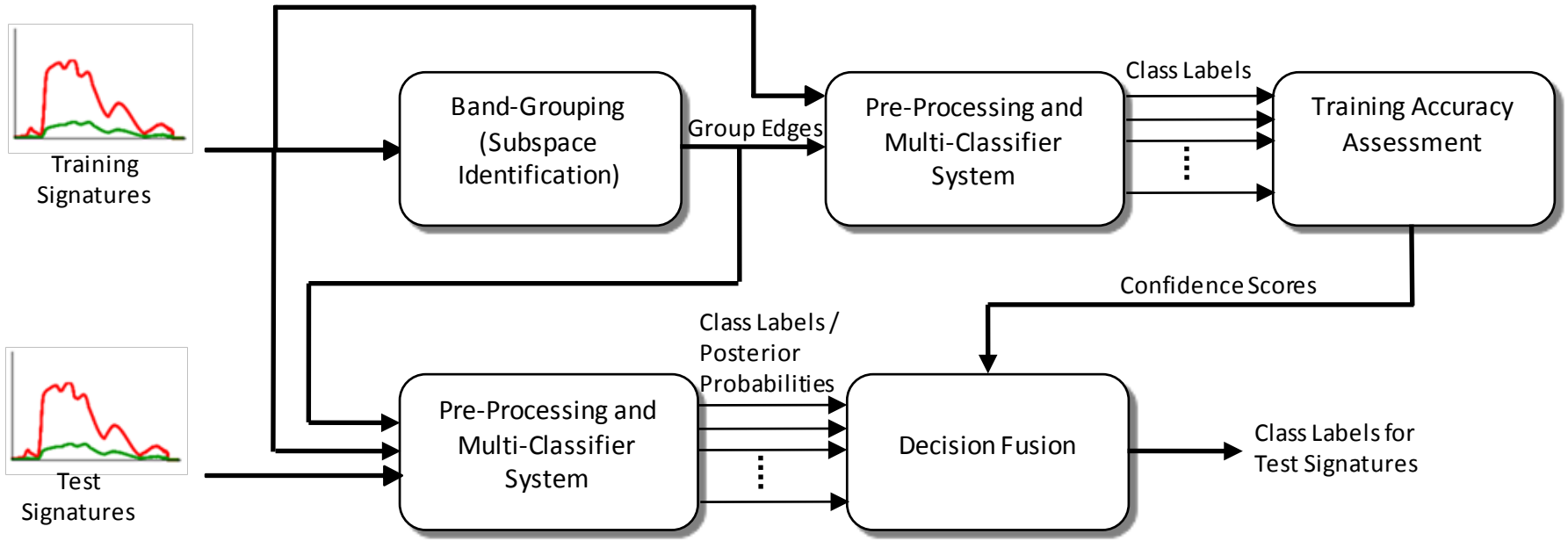
Confidence score in the *j*'th subspace

  - Logarithmic Opinion Pool

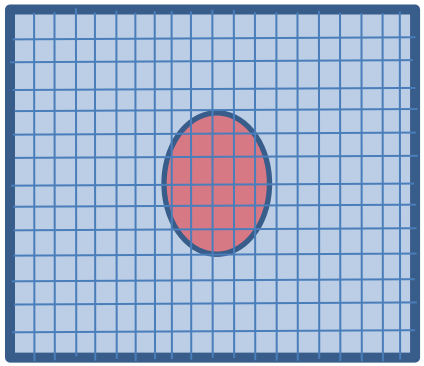
$$C(w_i \mid x) = \prod_{j=1}^{n} p_j(w_i \mid x)^{\alpha_j}$$

$$\Rightarrow \log C(w_i \mid x) = \sum_{j=1}^{n} \alpha_j \log p_j(w_i \mid x)$$

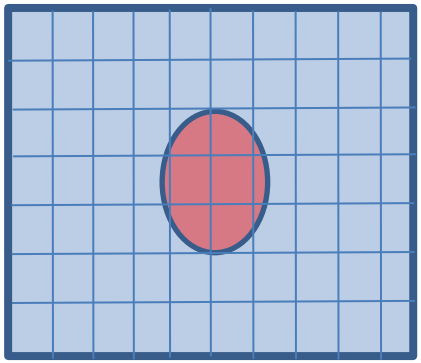
Multi-Classifiers and Decision Fusion: Adaptive Weight Assignment



Experimental hyperspectral dataset



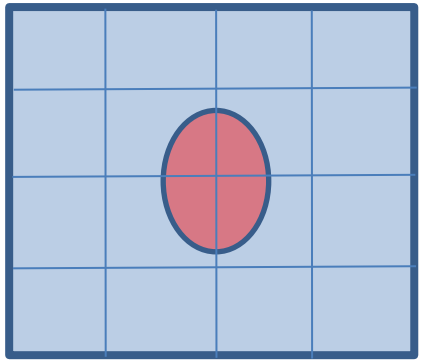
Mild pixel mixing



Moderate pixel mixing

Target

Background

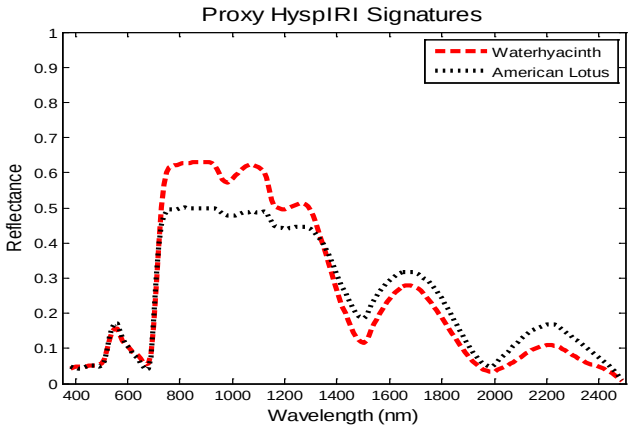


Severe pixel mixing

Practical Classification Tasks

Invasive Species Classification

Precision mapping of aquatic vegetation

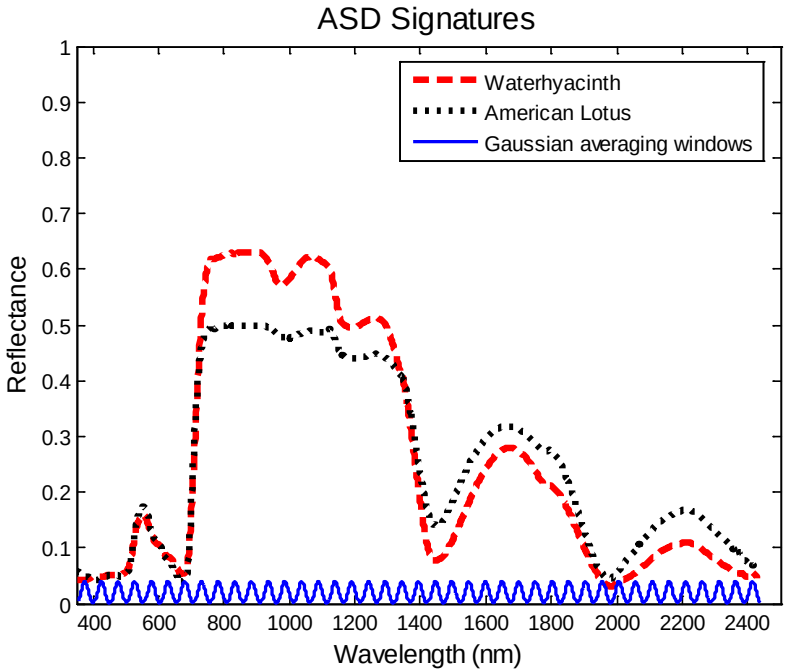


HyspIRI VSWIR Specifications:

- **Spectral range: 380 to 2500 nm, Uniformly sampled @ 10nm**
- **A spatial resolution of 60 m.**
- **Temporal revisit: 19 days (Global land coast), 3 days (Rapid response)**

Practical Classification Task 1

Invasive Species Classification – Waterhyacynth vs. American Lotus



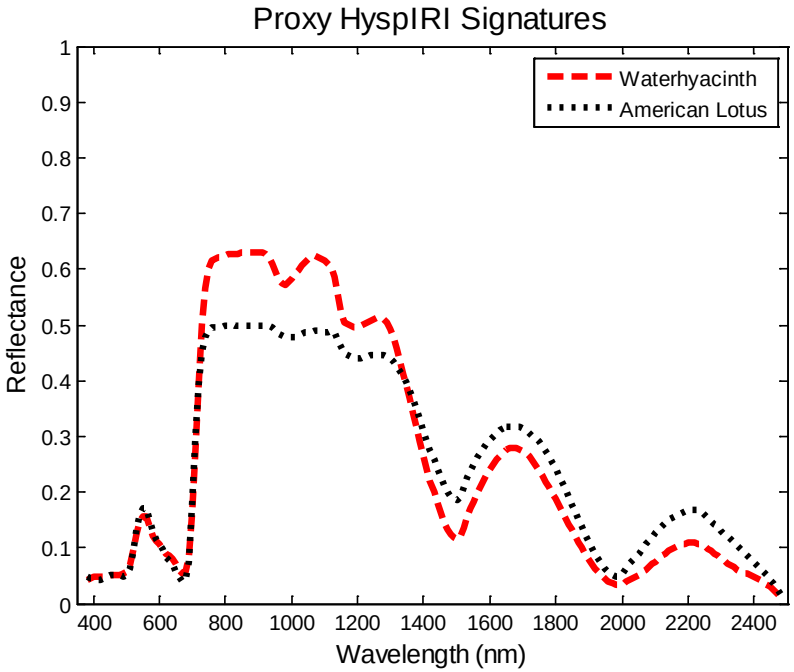
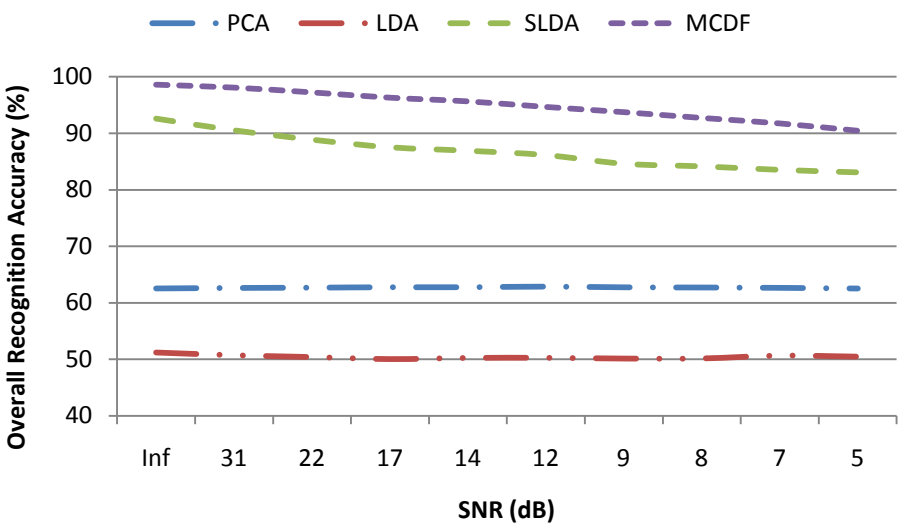


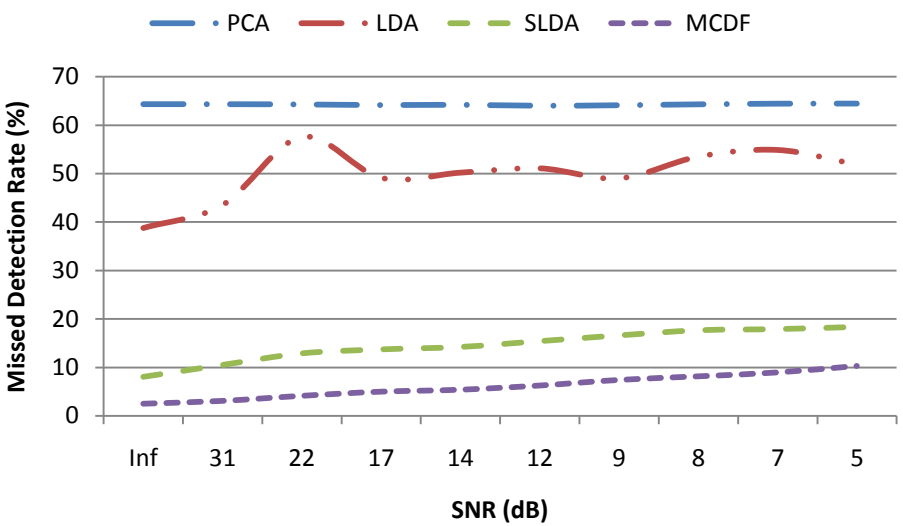
Figure: 2151 band ASD data and sample Gaussian averaging window locations (*left*), 212 band Proxy HyspIRI data generated from the ASD data (*right*) using the bank of averaging windows spaced 10nm apart, with a Full-Width Half Maximum (FWHM) bandwidth of 10nm.

A possible remote sensing application for such species may involve detecting and mapping Waterhyacinth in aquatic environments for appropriate chemical treatment and removal. The two aquatic species were grown under well-regulated environmental conditions at the R. R. Foil Plant Research Center at Mississippi State University. Data was collected in the range of ±2 hours of solar noon, every week from 24th June 2005 to 26th October 2005, for a total of twenty signatures per class per date.

Practical Classification Task 1

Invasive Species Classification – Waterhyacynth vs. American Lotus

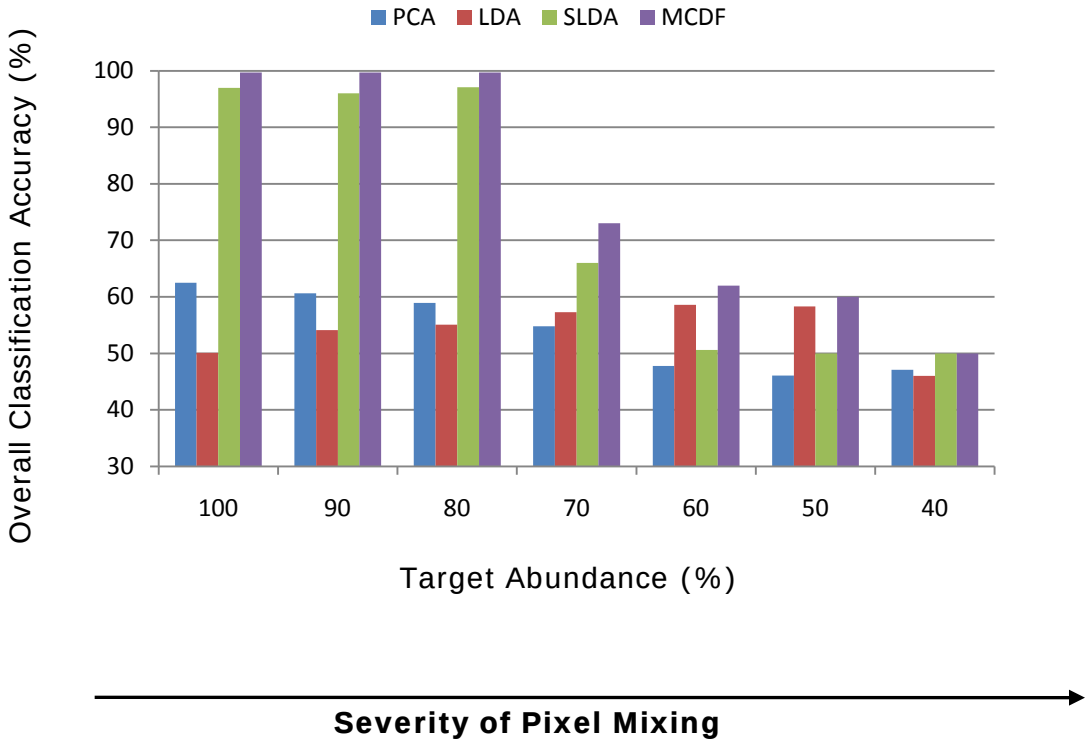




Performance of classification algorithms as a function of SNR using proxy-HyspIRI data

Practical Classification Task 1

Invasive Species Classification – Waterhyacynth vs. American Lotus



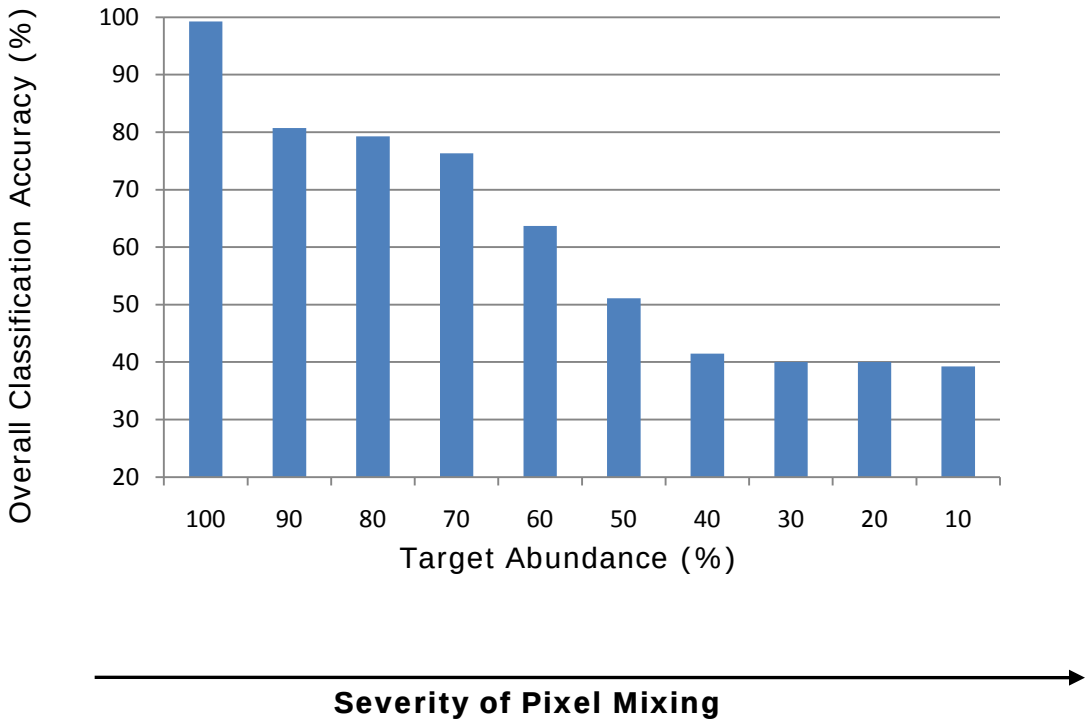
Performance of classification algorithms as a function of target abundance using proxy-HyspIRI data

Practical Classification Task 2

<u>Another aquatic species classification task</u>: Duckweed; Hydrilla; American Lotus; Eurasian watermilfoil; Salvinia; Waterhyacinth Water

Practical Classification Task 2

***Another aquatic species classification task*: Duckweed; Hydrilla; American Lotus; Eurasian watermilfoil; Salvinia; Waterhyacinth; Water**



Performance of FLDA+ML as a function of target abundance using proxy-HyspIRI data

Practical Classification Task 3

Detection and Classification of Chemical Induced Crop Stress

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Ground-Truthing with Handheld (ASD) Spectroradiometers and GPS units

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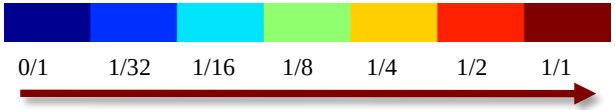
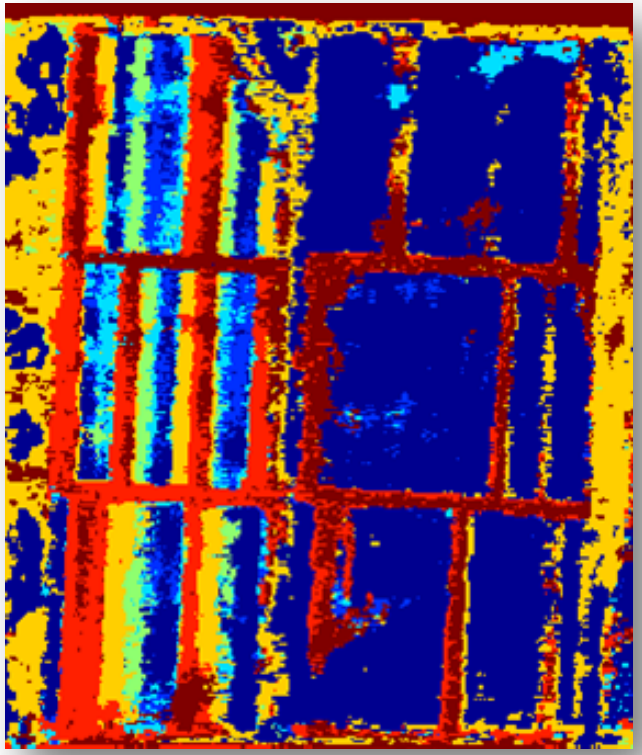
Practical Classification Task 3

Detection and Classification of Chemical Induced Crop Stress

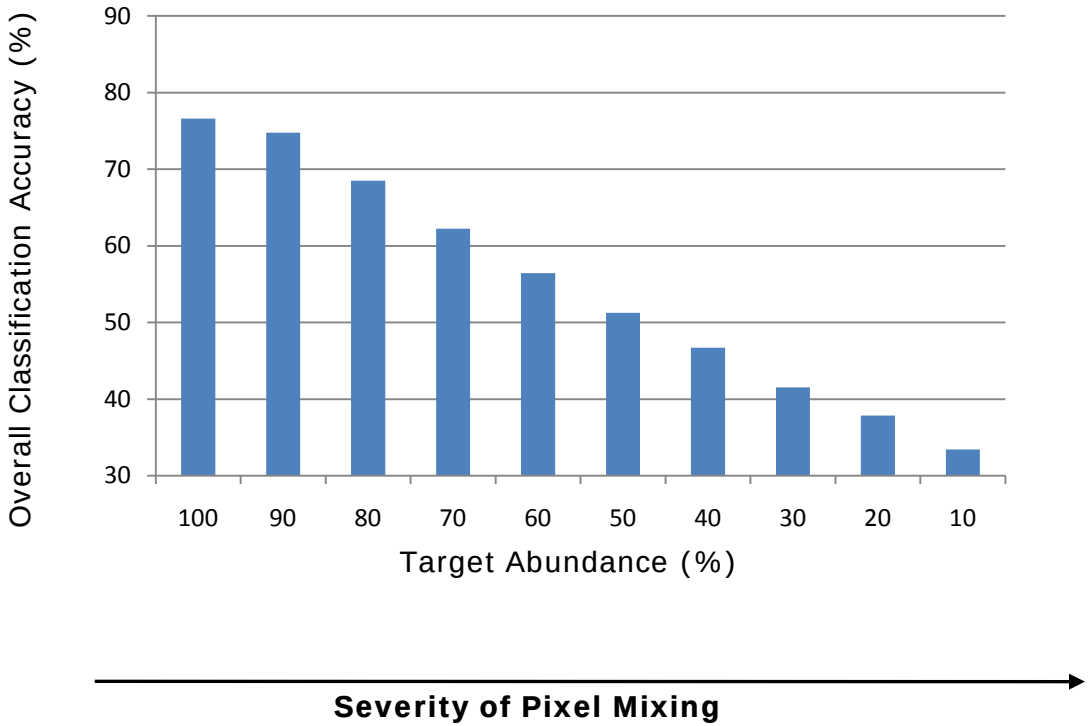


Increasing chemical stress (~dosage) on the crop



Practical Classification Task 3

Detection and Classification of Chemical Induced Crop Stress



Performance of classification algorithms as a function of target abundance using proxy-HyspIRI data

Practical Classification Task 3

Detection and Classification of Chemical Induced Crop Stress

	Overall Classification Accuracy (%)			
Temporal Misalignment	**PCA**	**LDA**	**SLDA**	**MCDF**
±1 week	60.5 (1.6)	50.1 (1.7)	97.7 (0.4)	99.7 (0.2)
±2 week	58.6 (1.6)	54.1 (1.7)	97.1 (0.5)	97.7 (0.5)
±4 week	56.7 (1.7)	53.2 (1.7)	73.1 (1.0)	92.6 (0.5)
±6 week	52.8 (1.7)	52.3 (1.7)	72.2 (1.3)	74.5 (1.0)
±8 week	46.6 (1.7)	53.2 (1.7)	58.6 (1.6)	62.0 (1.5)

Performance of classification algorithms with temporal misalignments between training and testing using proxy-HyspIRI data

Question / Comments

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