Fusion Processing for Puerto Rico Regional Sediment Management

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US Army Corps of Engineers

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Talking Points

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- Project Purpose and Overview
- Operational Resources
- Project Execution
- Results
- Acknowledgements

Project Purpose

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- Provide NCMP product suite of Puerto Rico North Shore…Eastern side priority
  - Geoclassified LAS
  - 1m/5m Grids (DSM/DTM)
  - RGBN Imagery, Shoreline
  - Fusion Products
    - HSI Reflectance (water leaving)
    - Lidar Reflectance (pseudo)
    - General Land Classification
    - General Benthic Classification Map

Overview

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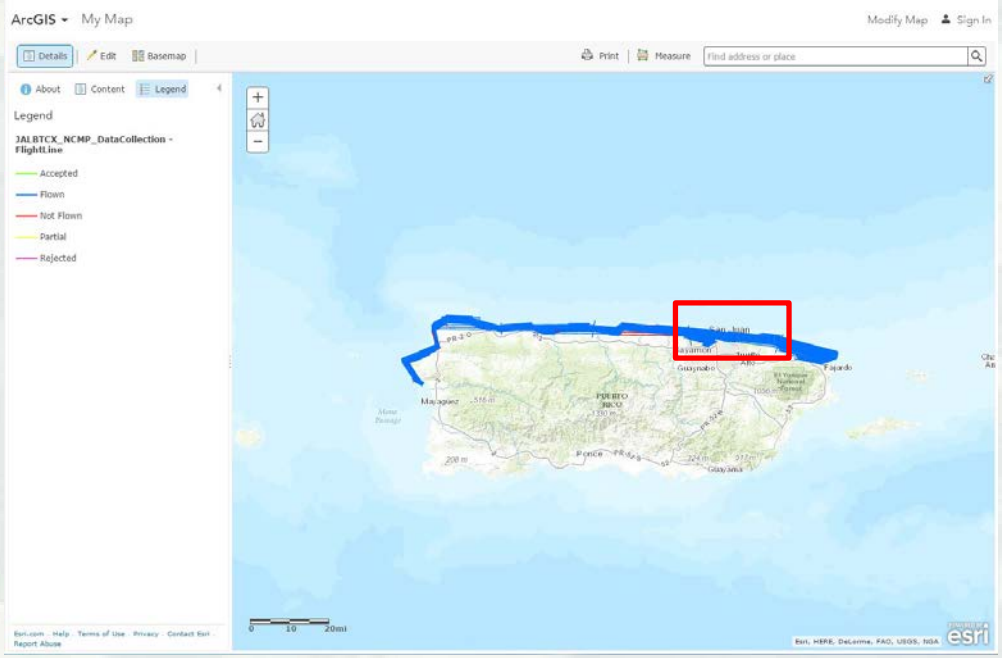
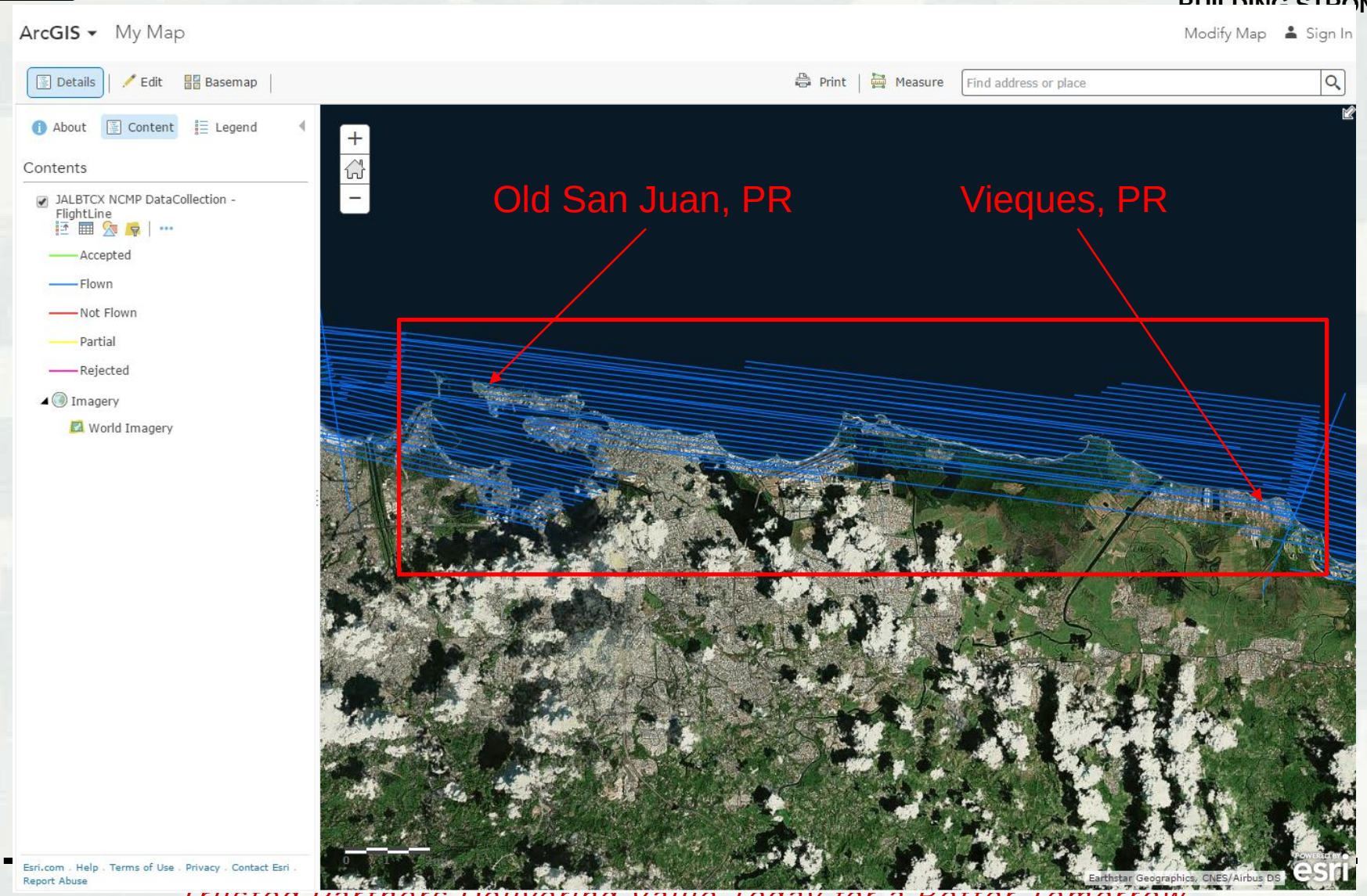
- Acquisition occurred in two phases
  - Jan 22nd – Feb 8th; West side of Island to San Juan
  - May 12th – May 16th; San Juan - Eastward



Project Location



Why Two Phases?

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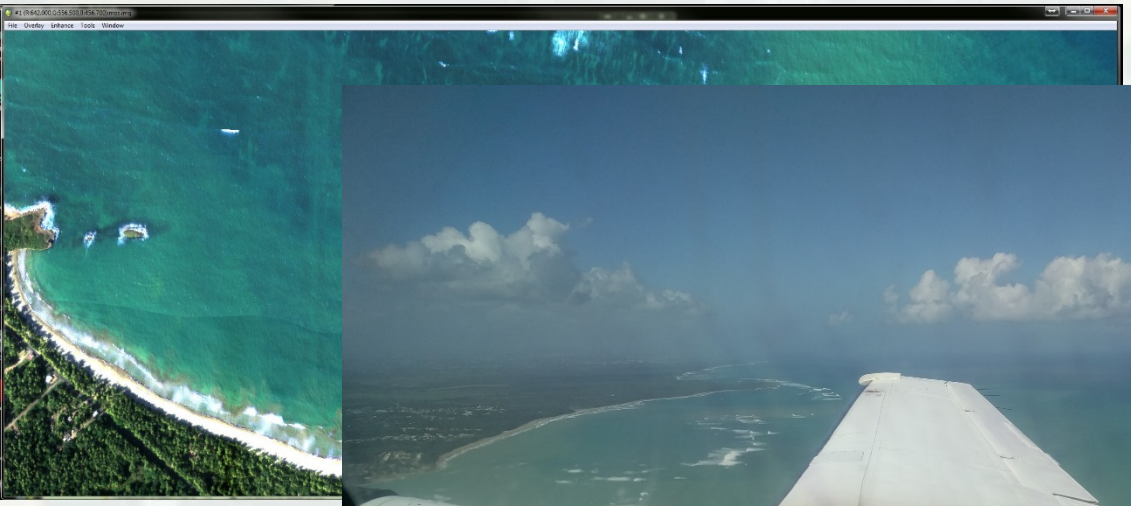

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May 12th 20

Operational Resources:

CASI 1500 Spectrometer:

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- 400m AGL (commensurate with CZMIL lidar)
- Spatial Mode (360.1 – 1051.7nm), 48 bands; No band at 532nm only 526 and 540nm
- 0.7m AlongTrack

  1.0m AcrossTrack
- Aperture 4
- Integration Time 10ms
- Collection 1.0m GSD
- Generated Products 1.0m GSD

- Optimal Conditions
  - Less than %5 cloud cover
  - No shadows
  - Solar angle must be between 20-50°
  - Flown away from the sun
  - Average solar azimuth for the flight window

Field Sampling:

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- Occurred during both phases of collection
- Sand, vegetation, asphalt, exposed bedrock, shallow water, etc…
- ASD Handheld 2 Spectrometer

HydroFusion

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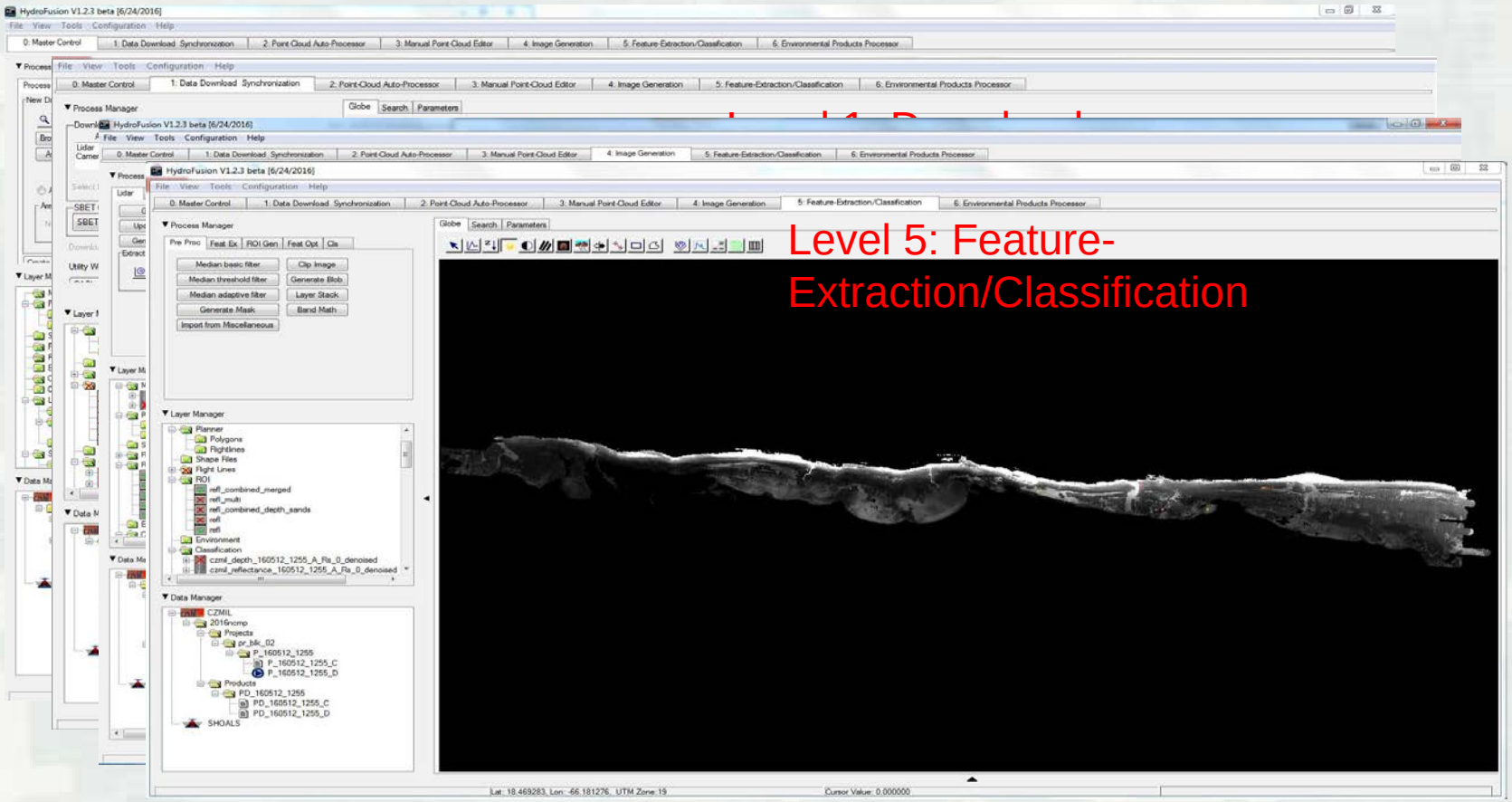

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HydroFusion L4

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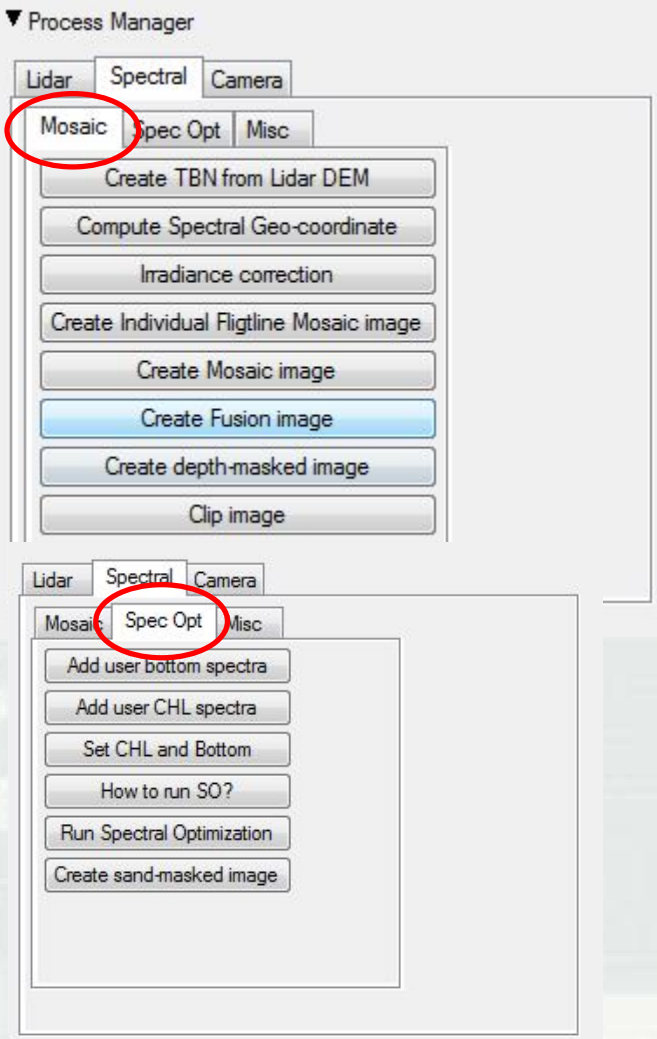
- Level 4 Processing
  - Mosaic (at sensor refl.)
    - Geometric Correction
    - Atmospheric Correction
      - Column Water Vapor Index at 940nm
      - Radiative Transfer
      - Down Scattering Angle (pub)
        - Minsu Kim
        - Glint/Ripple Correction
        - *Sprinkles of Magic*
    - Spectral Polishing
  - Spectral Optimization (water-leaving refl. or remote sensing refl.)



Spectral Optimization (SO) L4

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- Nonlinear optimization inversion method using Levenberg-Marquardt numerical scheme…so uhmm, math…to solve for remote sensing reflectance
- $R_{rs} = F(a^o_y, S, C, b^o_{bp}, n, \nu, \gamma, H, W_{1...}W_n)$
  - Ideally, use known parameters:
    - High resolution depth typically acquired with HSI (*H*)
    - Attenuation coefficient at the green channel ($a+b_b$@532) estimated from the backscattering region of the waveform
    - Bottom reflectance at 532nm can be calculated from the lidar data as well.
  - To determine bottom type and Inherent Optical properties (CHL, CDOM)

Spectral Optimization L4

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- Differences in bottom type, depth, IOPs, a
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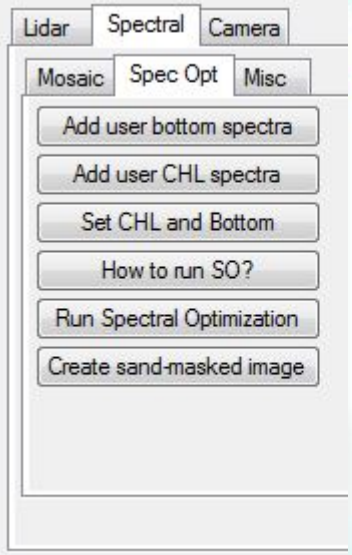

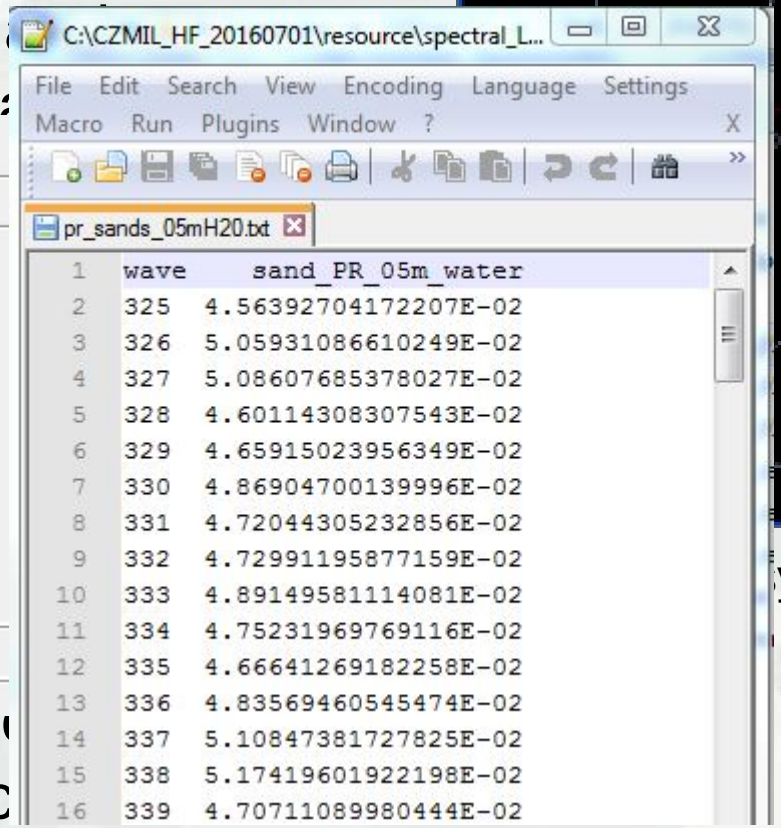

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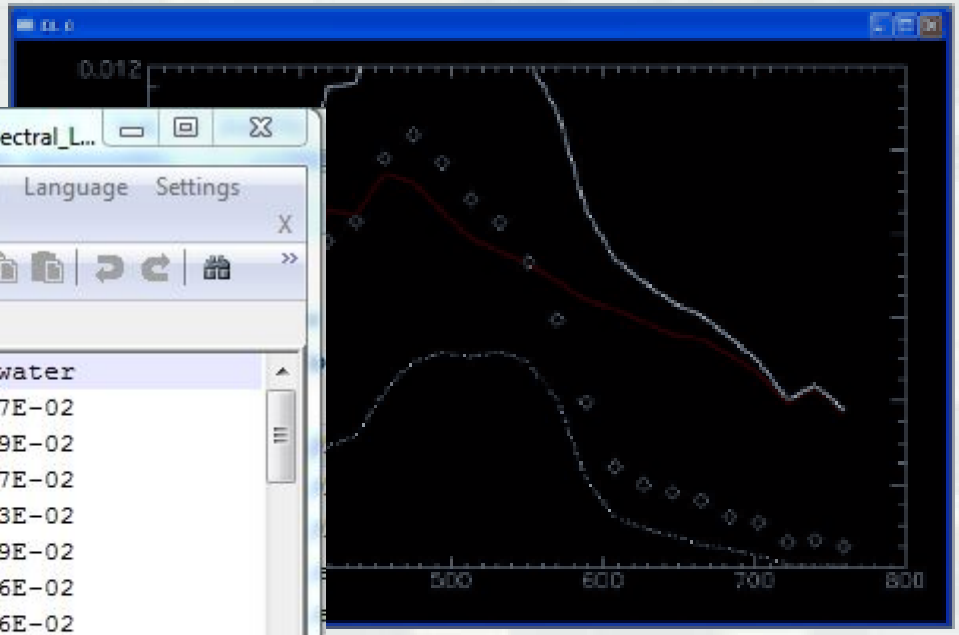

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By iteratively adjusting parameter sets, math model (white solid) fits to measured data (diamond)
Also shown are pure water signal (dotted) atm+surface (red)

Results of SO L4

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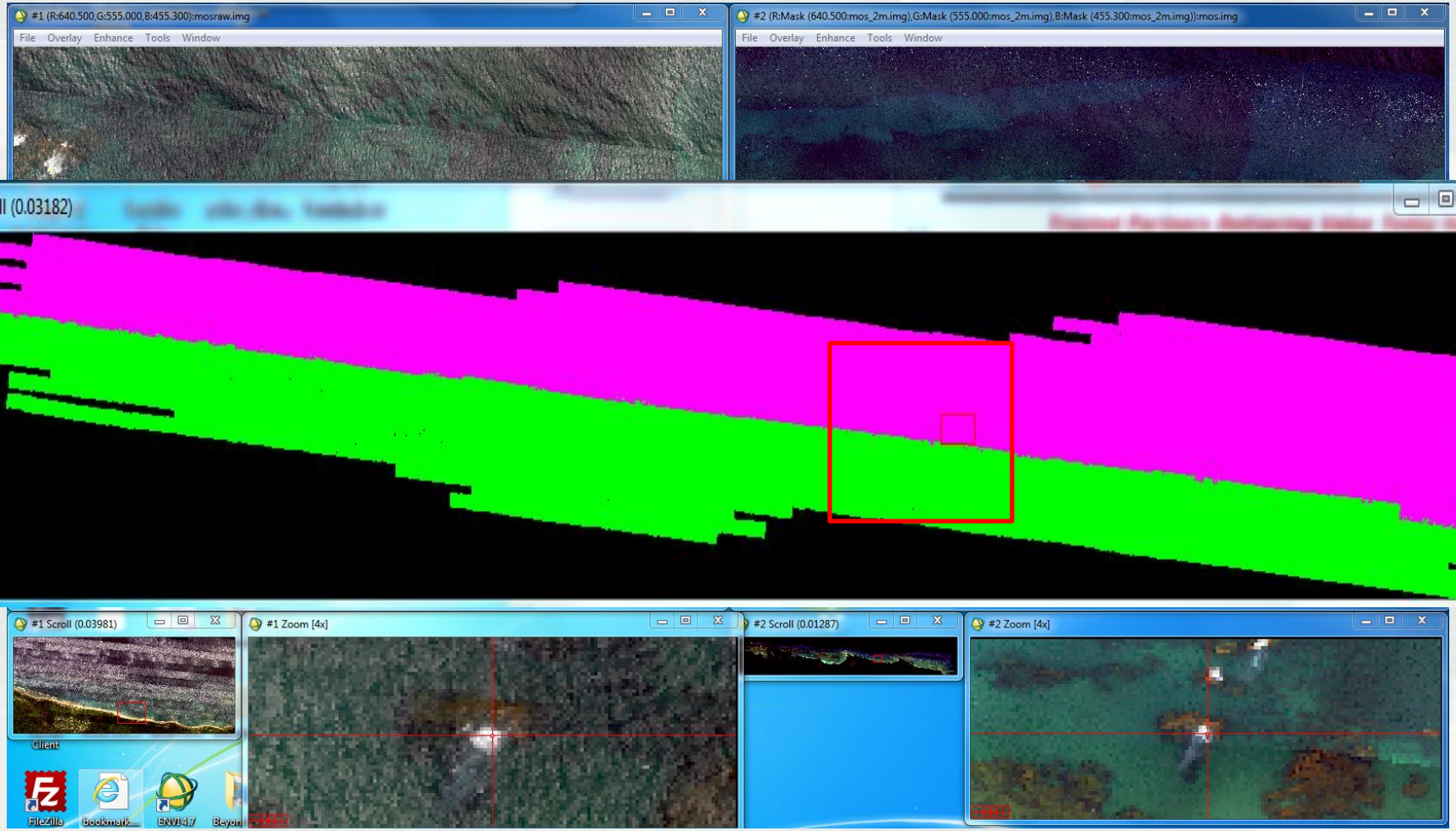
Radiance Mosaic, no actor (1mx1m)

Refl Mosaic, masked land, SO 2mx2m



Results of SO L4

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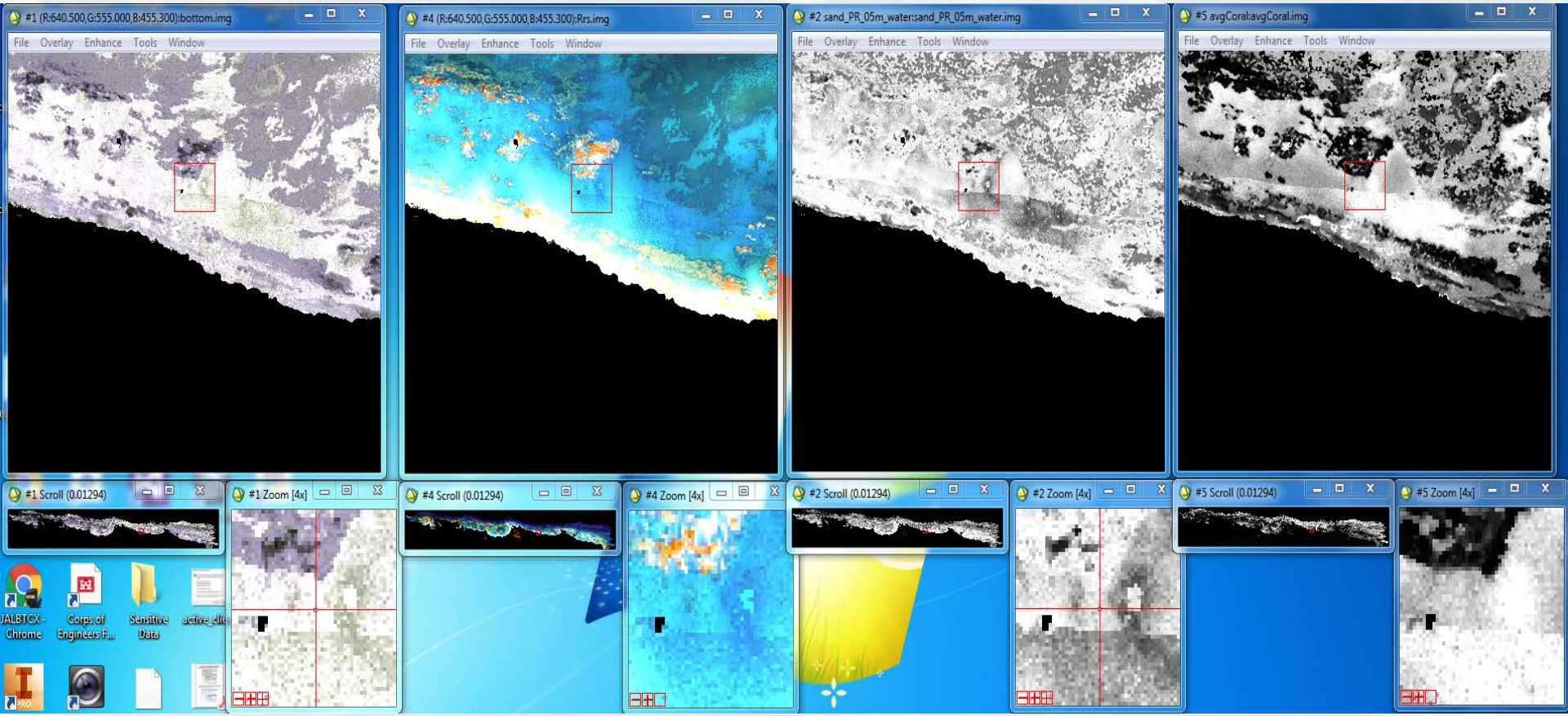
Bottom Refl. | RS Refl | Sand bottom | Coral bottom



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HydroFusion L5

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- Level 5 Processing
  - Pre-Processing
    - Filters (Median/Adaptive) – Reduces salt and pepper noise
      - A 5x5m median filters were used to denoise the reflectance and depth
    - Mask – land was masked out as a preprocessing step to Spectral Optimization
    - Layer Stacks – denoised reflectance and depth with the remote sensing reflectance from Spectral Optimization
    - Blob
    - Band Math – used to trim the max depth input from ~40m to 28m; Mostly noise in the data beyond 28m

Feature Extraction L5

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- Rugosity – Extracted from the depth; quantitative understanding of the undulations on the sea floor
- Wavelets - 1) the mother wavelet (Haar), which defines the base function used for decomposition, 2) the order of the
- base function used for decomposition and 3) the level of the decomposition.

ROI Generation L5

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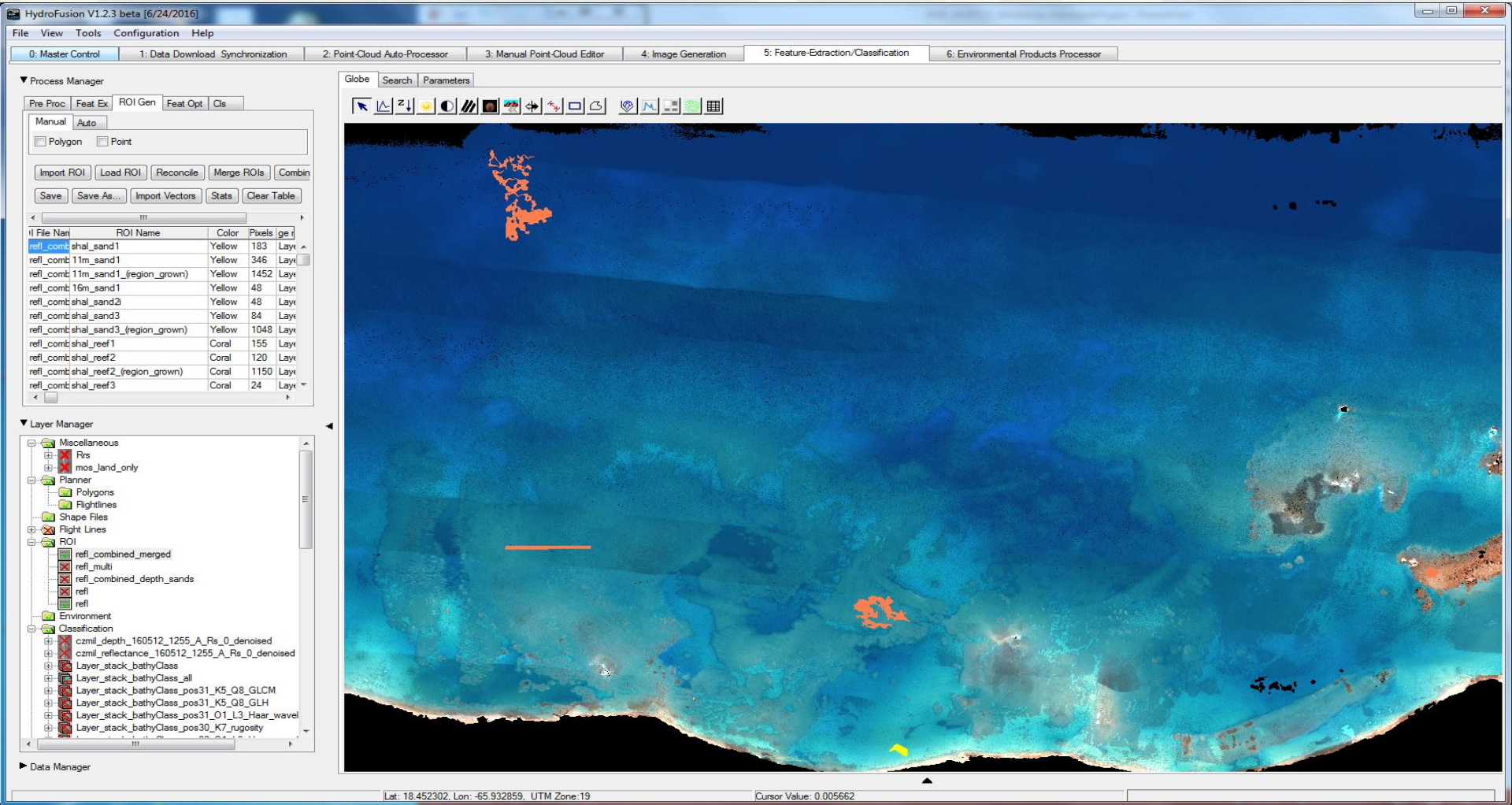
- Ability to draw ROIs easily within HF



Feature Optimization L5

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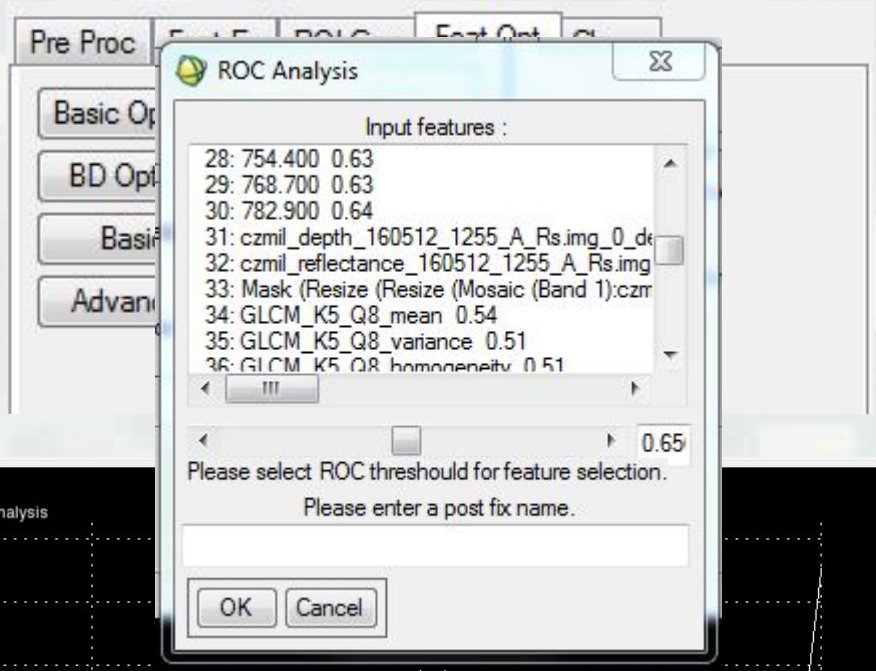
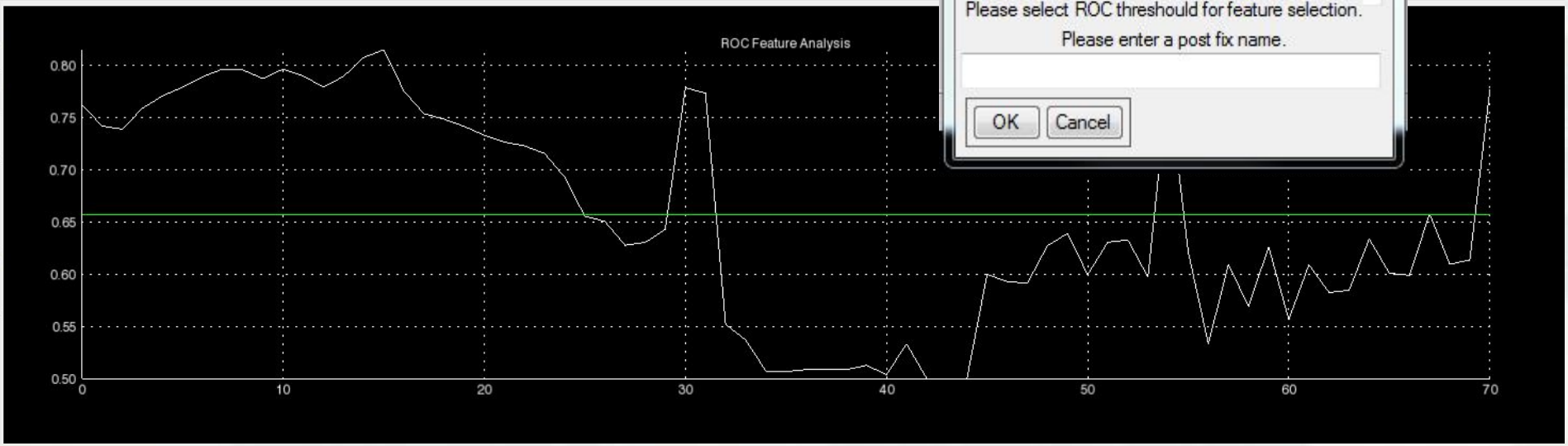
- Basic Optimization – GLCM and GLH images and the associated ROIs are used as input to provide Receiver Operating Characteristics (ROC);
  - ROC Curves allow the user to





Classification L5

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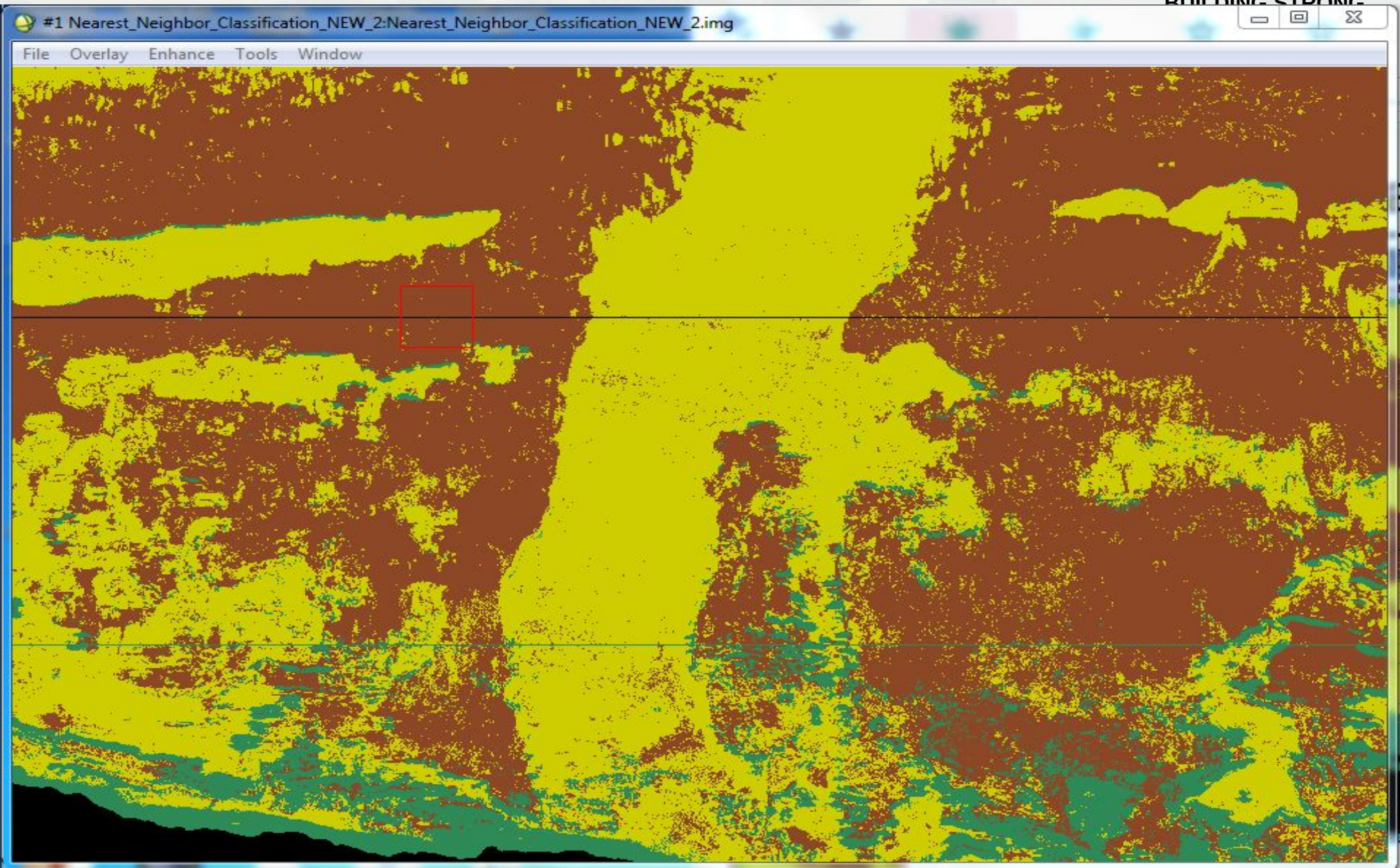
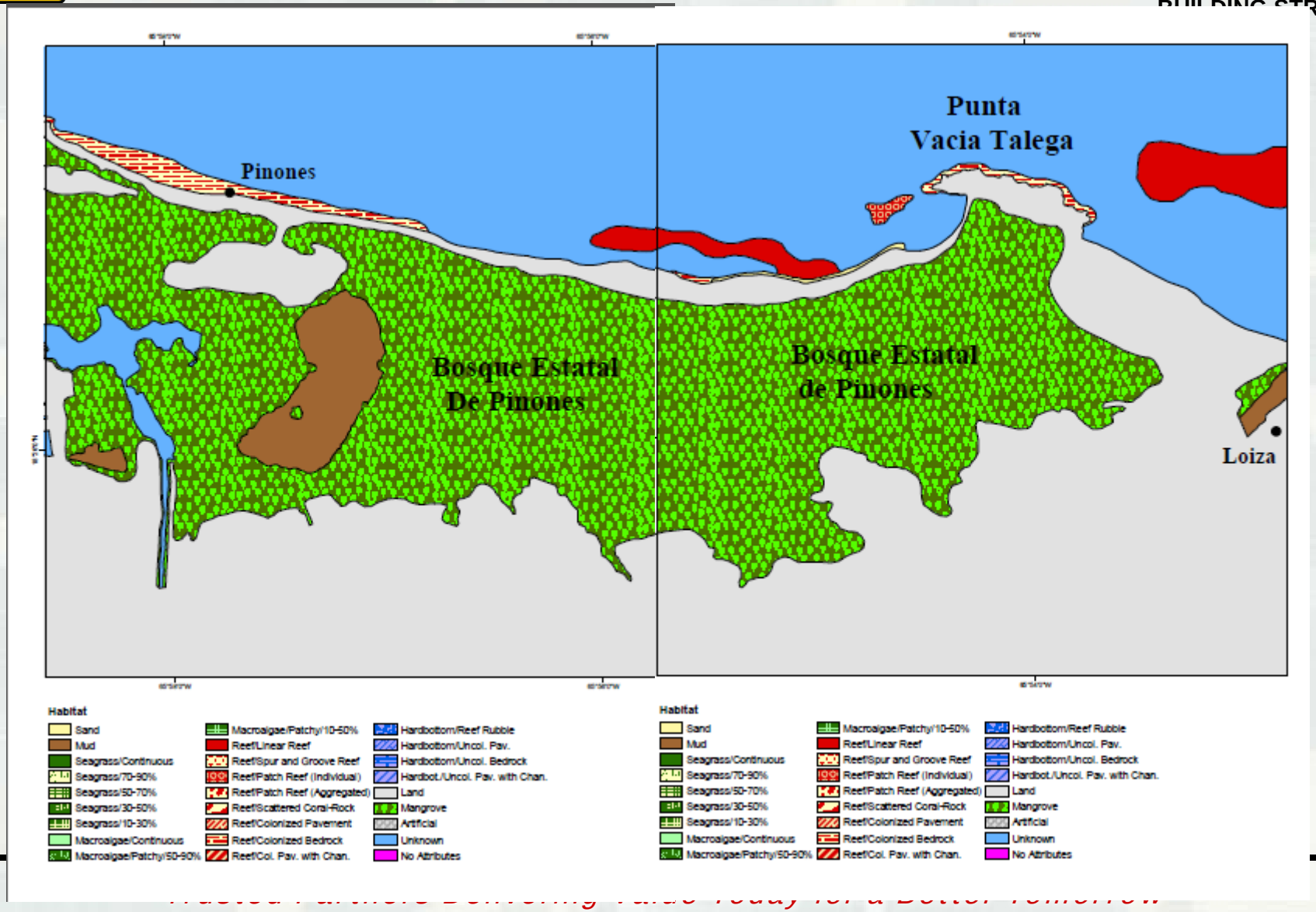
- A couple of simple machine learning algorithms
  - Nearest Neighbor – majority voting within N nearest neighbors; set at a kernel size of 5
  - Maximum Likelihood Classifier - calculates the probability that a given pixel belongs to a specific class
  - Rule Based See 5 - learns from the data under the ROI locations and generates a decision tree by splitting the feature space at nodes that maximize the net entropy change.

Classification Results L5



Classification Results L5



Future?...Present Work

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- Still working out ideal inputs for the Classification
  - Definitely leaning towards reflectance and depth based classification with help from remote sensing reflectance
- Looking to establish a Standard path from mosaic to classification map
  - Dependent on numerous conditions but achievable

Questions???

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