

# Inter-Satellite Comparison, Methods and Results

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**Presented By:**

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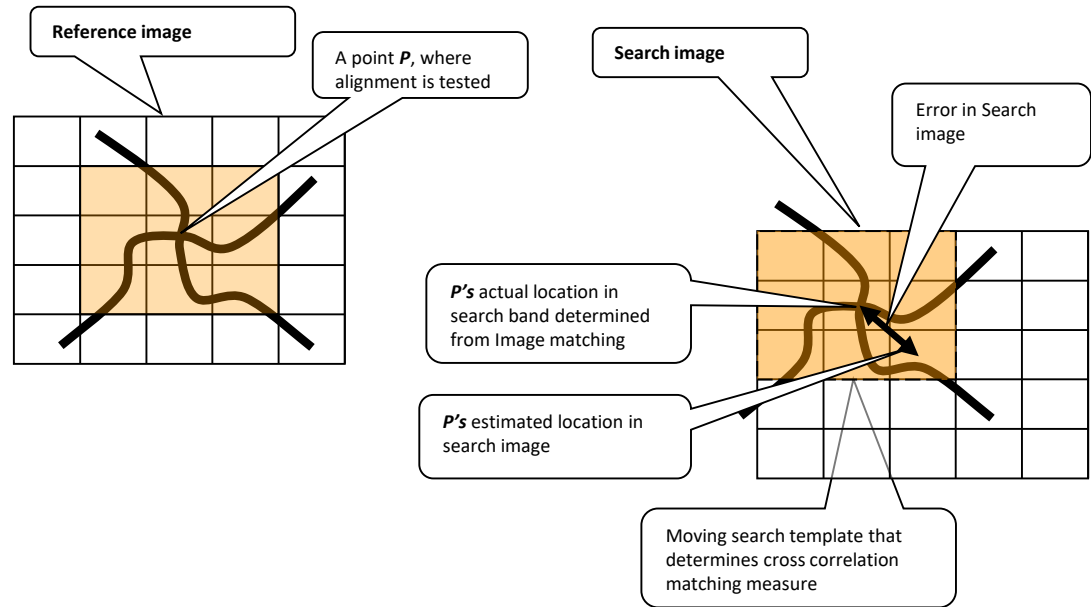
# Geometric Assessment

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- **For a multi-spectral remote sensing product, this involves the assessment of the external geodetic accuracy of the product**
  - The external geodetic accuracy assessment can be performed using three methods: manual, automated, and semi-automated.
- **The internal relative registration of the bands to each other.**

# Accuracy: Image Registration

- **Image to Image (I2I)**
  - External Geometry
  - Must have control
    - Chips or full image
- **Band-to-Band (B2B)**
  - Internal geometry
  - No external control



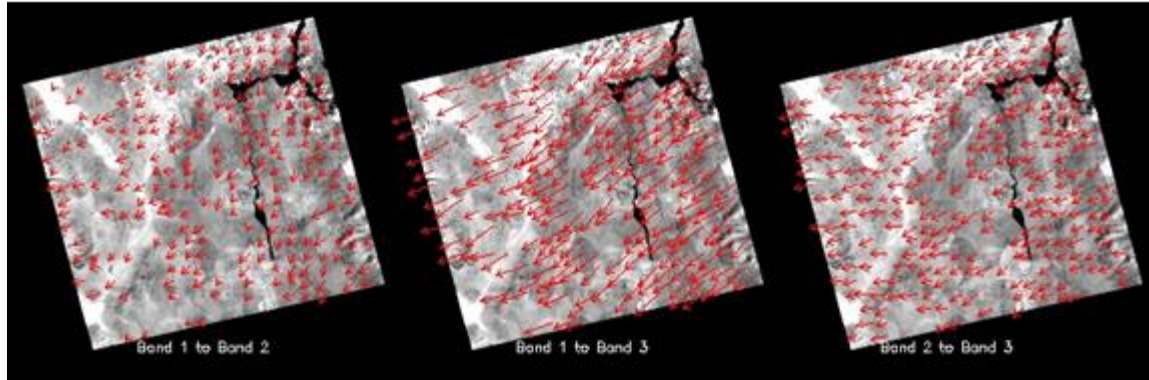
# External Geometry

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- **Manual methods:**
  - Used when high-resolution reference and search images are available or when ground control points (GCPs) are available within the image.
  - Conjugate points are manually located and their coordinates are then compared and summarized.
- **Automated geometric assessment methods**
  - Implemented in tools from the Landsat's Image Assessment System (IAS) .
  - Uses methods based on cross-correlation for the image data analysis.

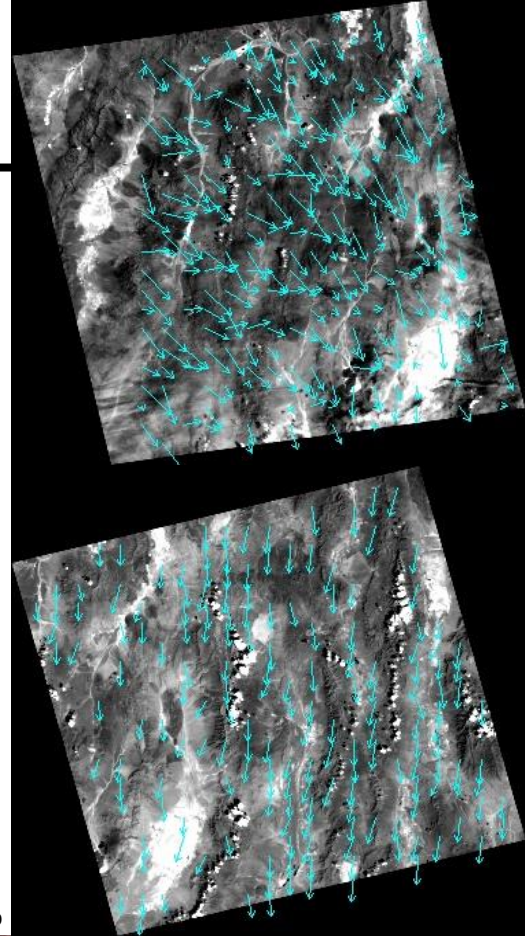
# Example Results

- **Both can provide hundreds of tie points**
  - Statistics compiled after outlier rejection
- **Trends easily visualized**
  - These examples use 3000x & 4000x magnification



DU00018fs

DU0005ddp



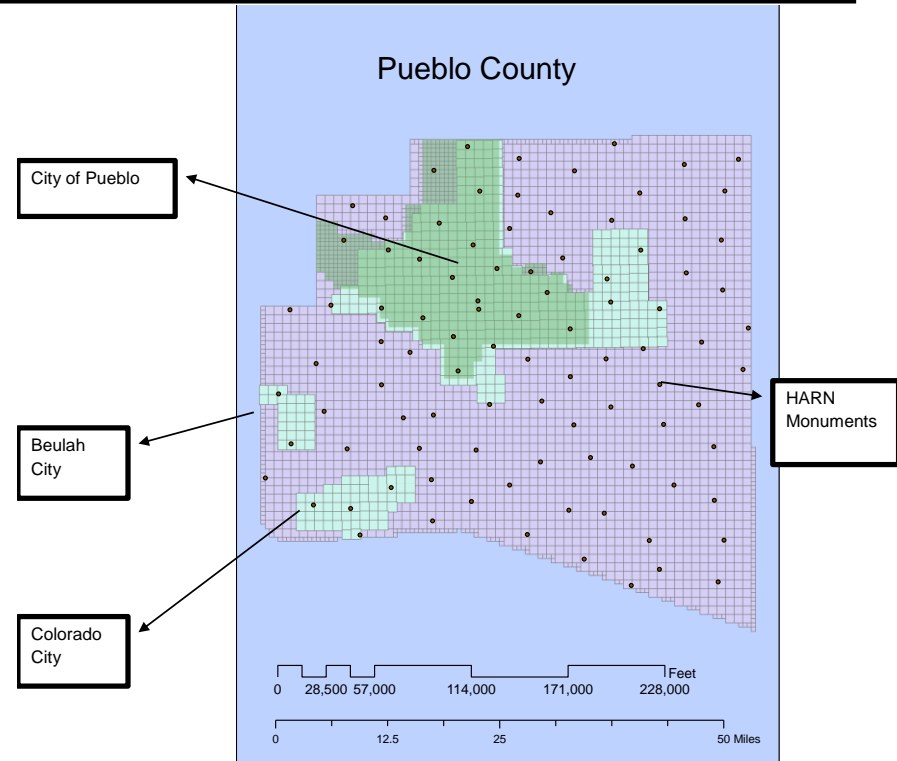
# Semi-Automated Methods

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- **Used when dealing with reasonably high-resolution images, particularly over urban areas.**
- **Automated methods can choose points that may lie on roof tops, which are not acceptable locations (due to building lean, etc.).**
- **User manually chooses locations for comparisons between reference and search images**
- **Small sub-images are cut around these locations, and image-based correlation methods described earlier are used for comparisons.**

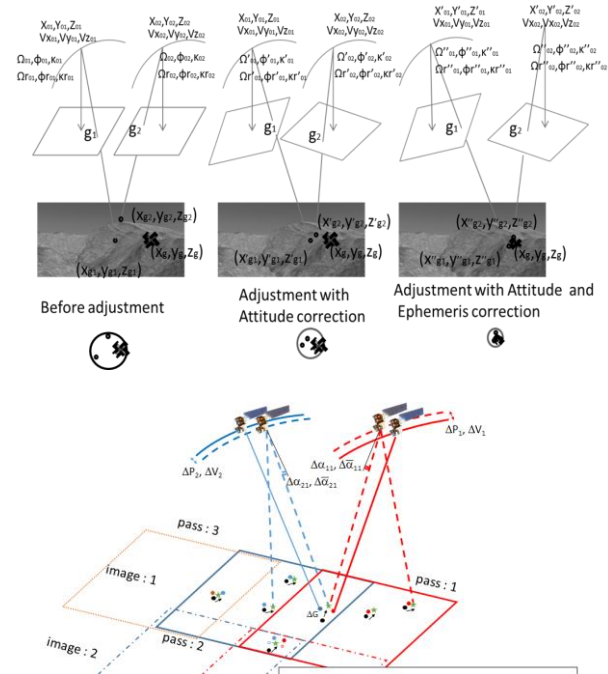
# Hi-Res Geometric Test Ranges

- Three test ranges in the US
- Mostly suitable for data with 1-5 m Ground Sample Distance(GSD)
- Established using GPS based measurements over visually identifiable targets



# Hi-Res Geometric Test Ranges

- **Outside USA**
  - Assess data with GSD in 1-6 m range (initially)
- **Use block adjustment to generate higher accuracy reference data**
  - WV-3, others etc.
- **Mostly Flat regions**





# Band Registration

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- **Assessment is typically accomplished by registering each band against the other bands.**
  - Provides a numerical evaluation of the accuracy of the band registration within an image.
  - Carried out by using automated cross-correlation techniques between the bands to be assessed.
- **Reference image is taken to be the image data from one of the bands in the multi-spectral image product and the rest of the bands are considered search images.**
  - Process is repeated cyclically by considering image data from a different band to be the reference image.
- **The analysis measures the relative alignment of the bands to each other.**

# Spatial Analysis

- **Measures the ability of the system to resolve objects spatially.**
  - There is no “one method to rule them all”
  - We use specially designed “Edge targets”
  - Landsat uses pulse targets e.g. bridges etc.
  - Target should 7-10 IFOV’s beyond the edge.
  - [https://calval.cr.usgs.gov/rst-resources/sites\\_catalog/spatial-sites/](https://calval.cr.usgs.gov/rst-resources/sites_catalog/spatial-sites/)

Home Satellite & Sensor Characterization JACIE USGS Optical Science Lab RST Resources

You are here: Home » RST Resources » Test Sites Catalog » Spatial Sites » Stennis, Mississippi, USA

## Test Site Catalog

### Site Location: Stennis, Mississippi, USA Spatial

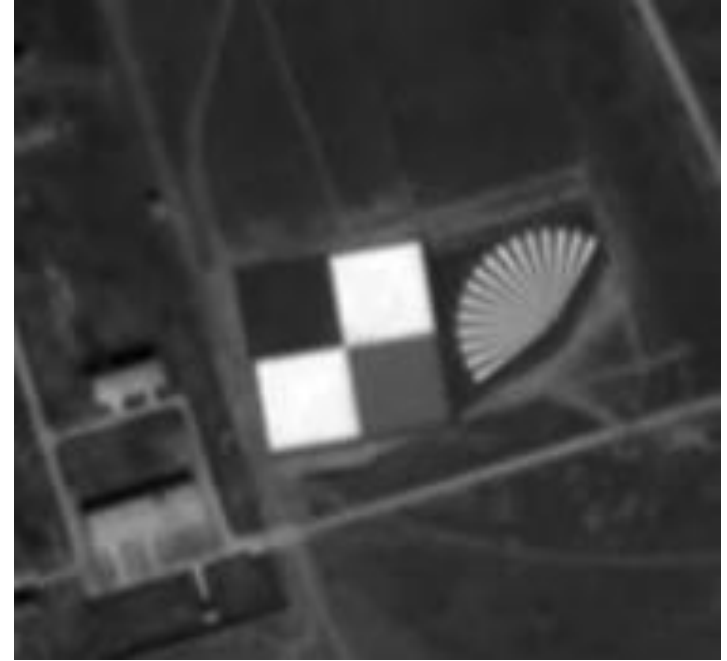


30.386151° -89.628116°



# Baotou Spatial Characterization Site

- **Baotou range selected from USGS test site catalog**
  - Only one (in test site catalog) whose dimensions seem to be practical for spatial testing (among the test sites)
  - Edge semi automatically identified
  - Multiple profiles across the edge used to perform analysis



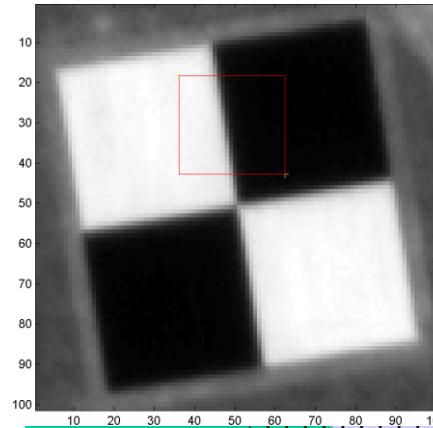
# Shadnagar Spatial Characterization Site

- ISRO Shadnagar test range
- Each square ~ 70 m in dimensions

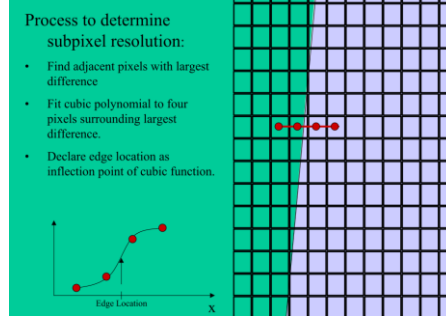
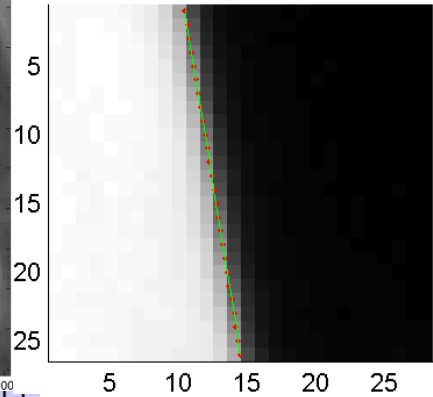


# Spatial Analysis

- Select ROI of Edge within image data
- Detect the edge line within ROI
- Get & plot Edge Spread Function (ESF)
- Determine extent of Bright & Dark areas
- Calculate and plot ESF by fitting from the trimmed ESF pixel data
- Calculate Relative Edge Response (RER)
- Calculate and plot Line Spread Function (LSF)
- Calculate Full Width at Half Maximum (FWHM)
- Calculate and Plot MTF (Modulation Transfer Function)



Edge Detection (Across, 9.19 deg)



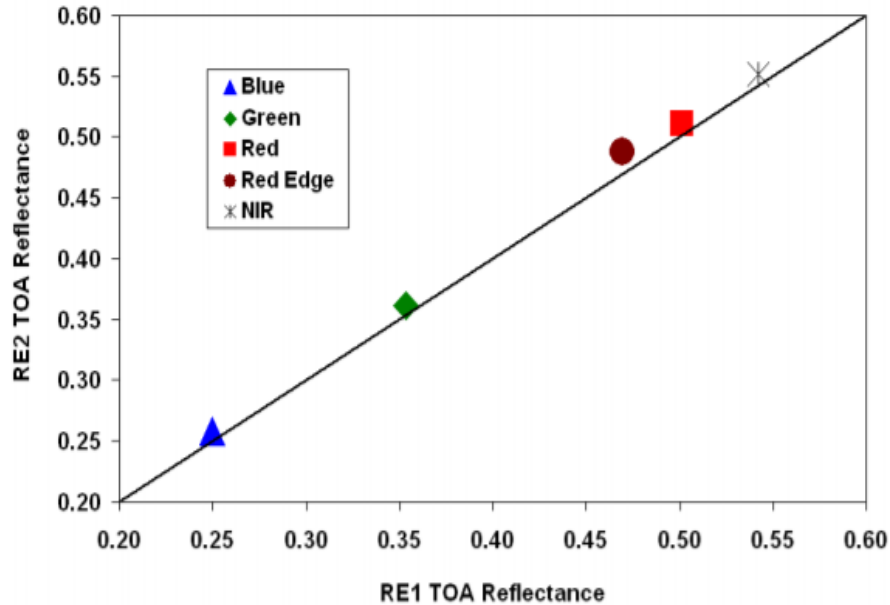
# Radiometric Analysis

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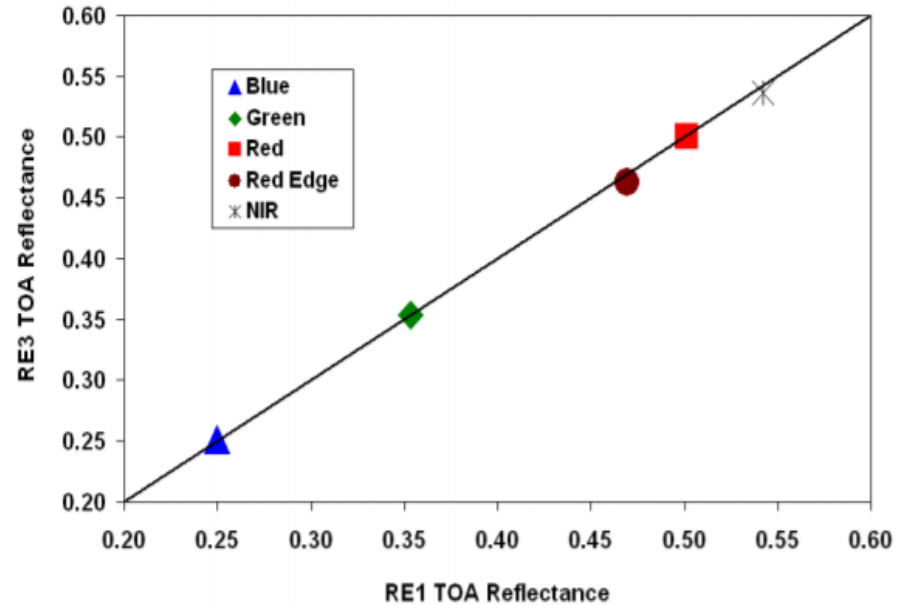
- **Select near-coincident scenes (Reference usually L8) over pseudo invariant test sites**
  - The Libyan Desert site is made up of sand dunes with no vegetation —
  - Presence of sand dunes at the test site does not satisfy the criterion of flat terrain, but site exhibits reasonable spatial, spectral, & temporal uniformity for medium resolution sensors & has minimal cloud cover
- **Determine at sensor scene radiance**
- **Convert to Top of Atmosphere reflectance**
  - TOA reflectance compared

# Radiometric Assessment Reporting

TOA Reflectance comparison of RE1 versus RE2



TOA Reflectance comparison of RE1 versus RE3



# Results



# External Geometry

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- **WV- 3**
  - 2.2 m and 2.3 m RMSE (Line, Sample) observed in Sioux Falls
  - GPS based measurements as reference
- **Planet**
  - Sioux Falls: Mean Error(x, y): (0.6 m, 4.7 m) and RMSE (x, y): (0.7 m, 4.9 m)
  - Shadnagar: Mean Error(x, y): (6.6 m, 0.7 m) and RMSE (x, y): (2.4 m, .5 m)
  - Baotuo: Mean Error(x, y): (2.4 m, 0.5 m) and RMSE (x, y): (2.6 m, .7 m)
  - Argentina: observed to 2-pixel errors, but more testing required

# Band Registration Analysis

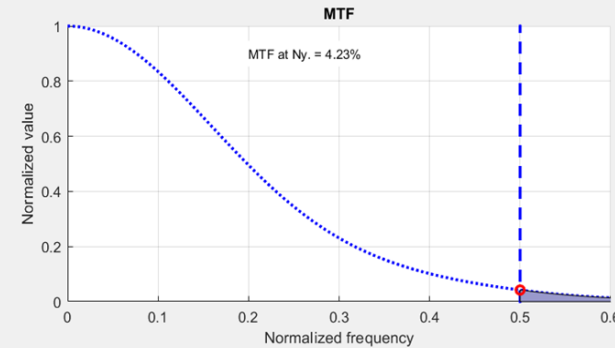
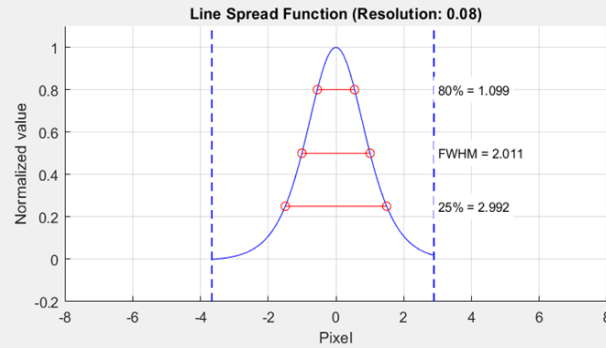
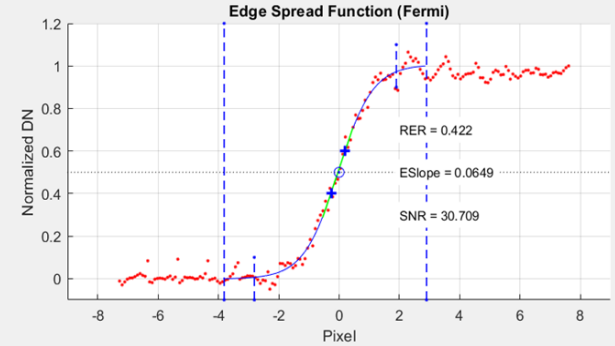
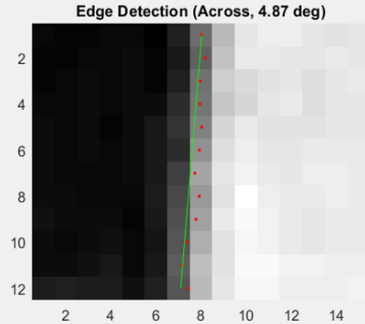
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- **WorldView 3 appears well registered**
  - ~ 0.1 pixels
  - We have access to SWR (3.7 m), will be testing band alignment going forward
- **Planet Bands are also sub pixel registered**
  - 1,2,3 appear well registered (~.15 pixels)
  - Band 4 measured to have higher mis registration
    - This measurement could be due to reduced spatial resolution

# Planet Dove Results, Bands 1-3

FWHM ~ 2

RER ~ 0.4

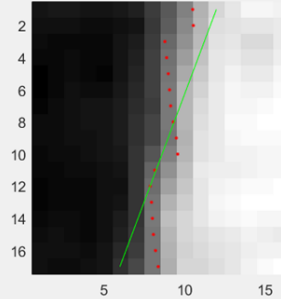


# Planet Dove Results, Band 4

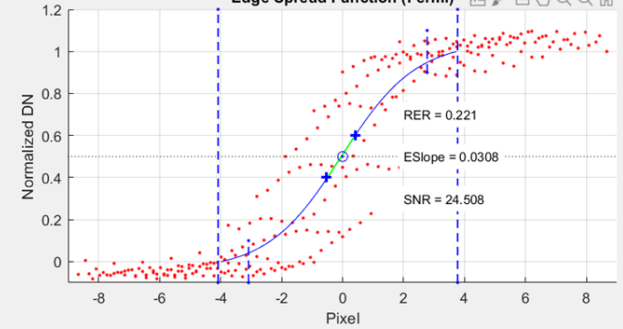
FWHM ~ 3.7

RER ~.2

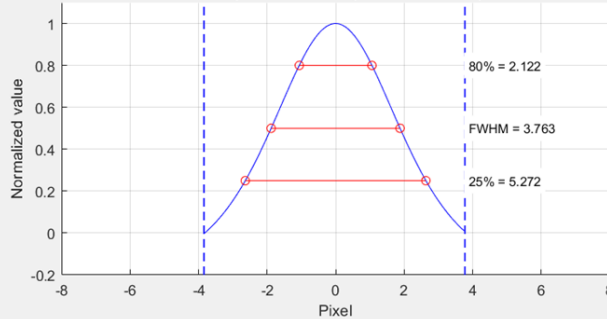
Edge Detection (Across, 20.56 deg)



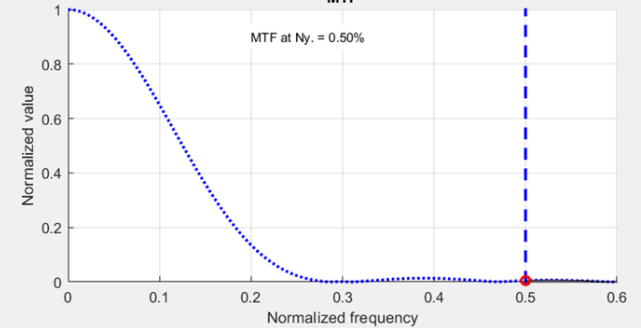
Edge Spread Function (Fermi)



Line Spread Function (Resolution: 0.05)



MTF

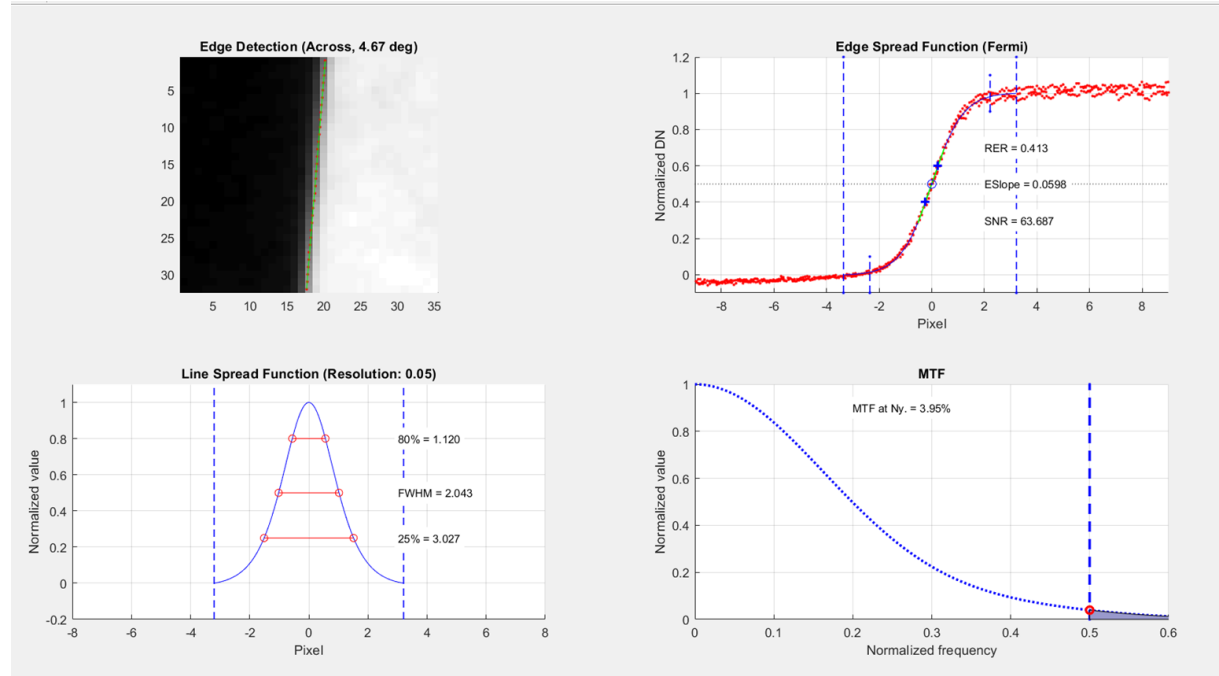


# Example: Skysat

FWHM 1.9-2.1

RER~0.4

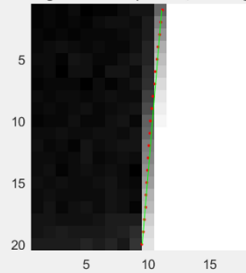
Analysis with IQE tool provided similar RER and MTF values using non-target



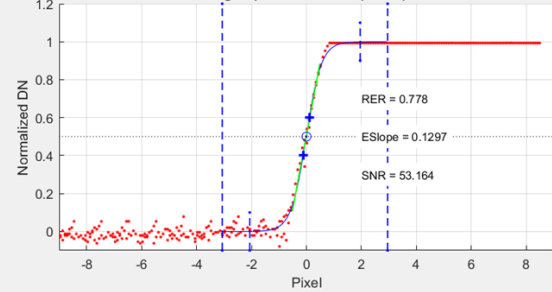
# Examples: WV-3 VNIR Bands

- FWHM-0.9-1 range
- RER Mean: 0.7

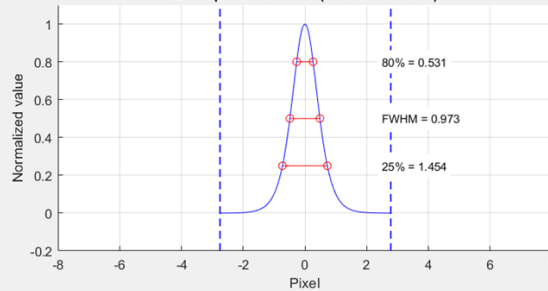
Edge Detection (Across, 4.76 deg)



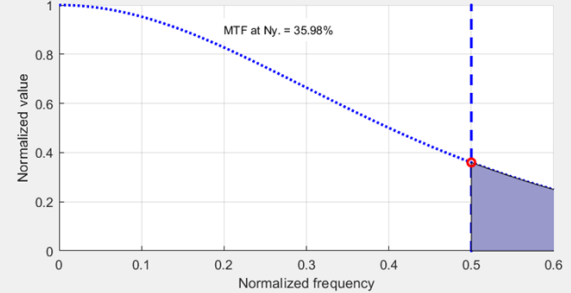
Edge Spread Function (Fermi)



Line Spread Function (Resolution: 0.05)

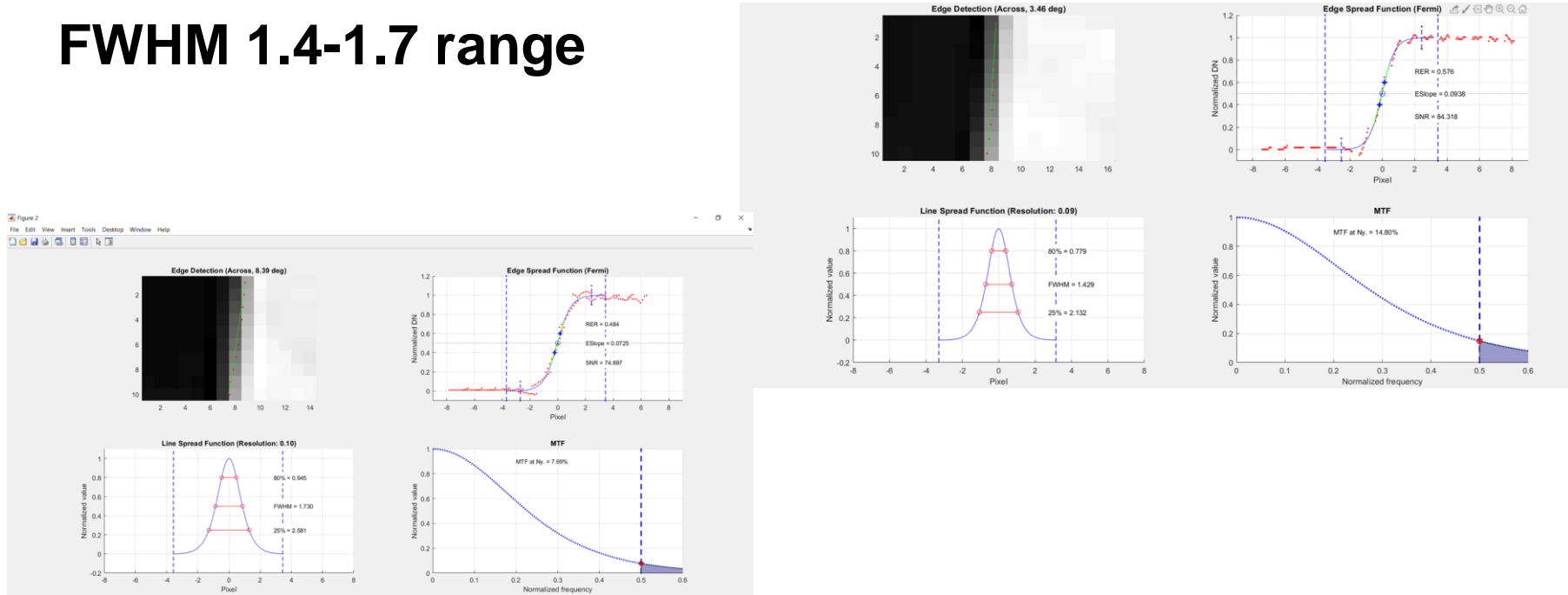


MTF



# Examaples: WV-3 SWIR bands

- FWHM 1.4-1.7 range



# Dove-L vs L8 OLI

