Atmospheric Correction using Cloud & Shadow

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Hyperspectral Imager of the Coastal Ocean (HICO) First Users Meeting, Alexandria, VA, USA

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Outline

- Cloud & Shadow atmospheric corrections
- Example of cloud shadow impact on ocean color products
- Our cloud shadow detection algorithm
- Automated Cloud & Shadow atmospheric correction
- Cloud & Shadow atmospherically corrected data vs. NIR atmospherically corrected data

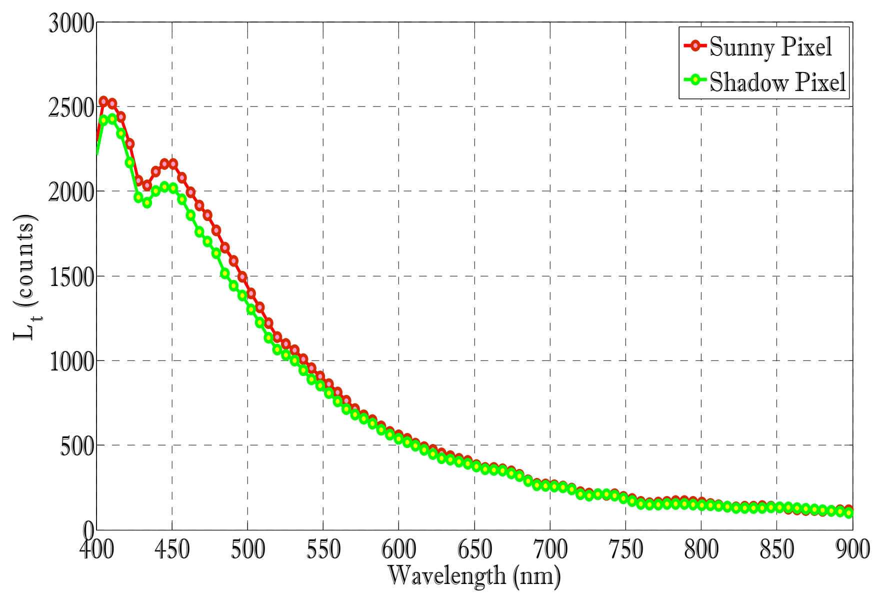
Cloud & Shadow Atmospheric Corrections

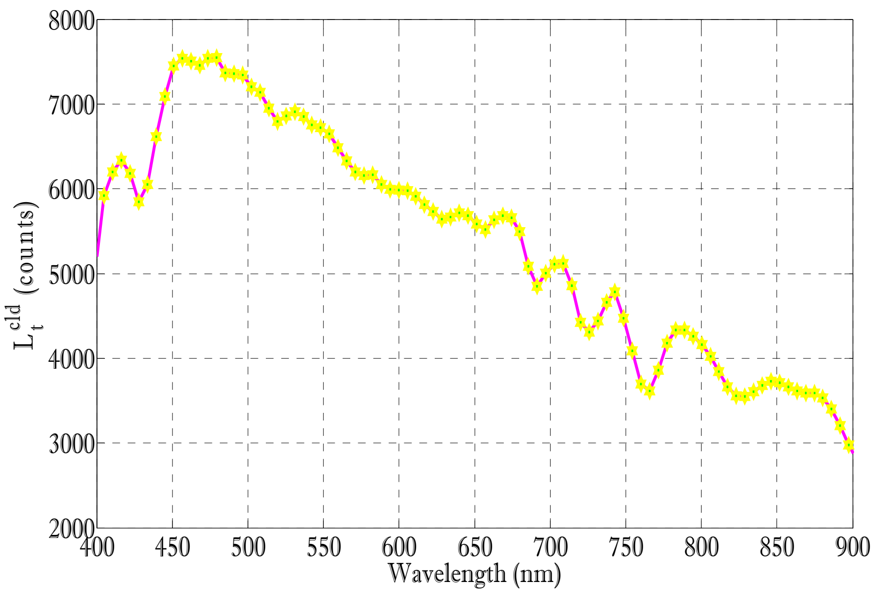
$$L_a(\lambda) = L_t^{sun}(\lambda) - \frac{L_t^{sun}(\lambda) - L_t^{sdw}(\lambda)}{1 - E_d^{sky}(\lambda) / E_d(\lambda)}$$

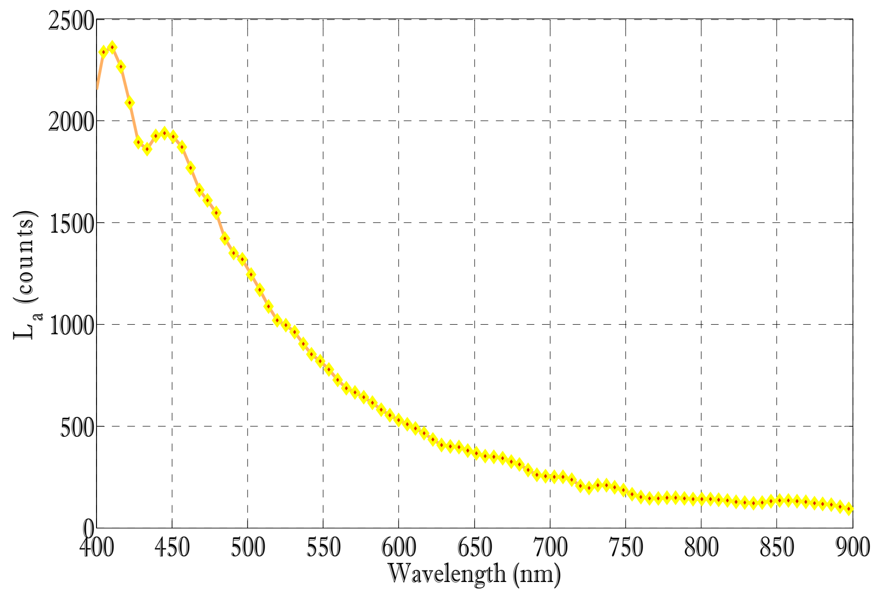
$L_a(\lambda)$ Contributions from the atmosphere and sea-surface

$$R_{rs}(\lambda) = \rho \frac{L_t(\lambda) - L_a(\lambda)}{L_t^{cld}(\lambda) - L_a(\lambda)}$$

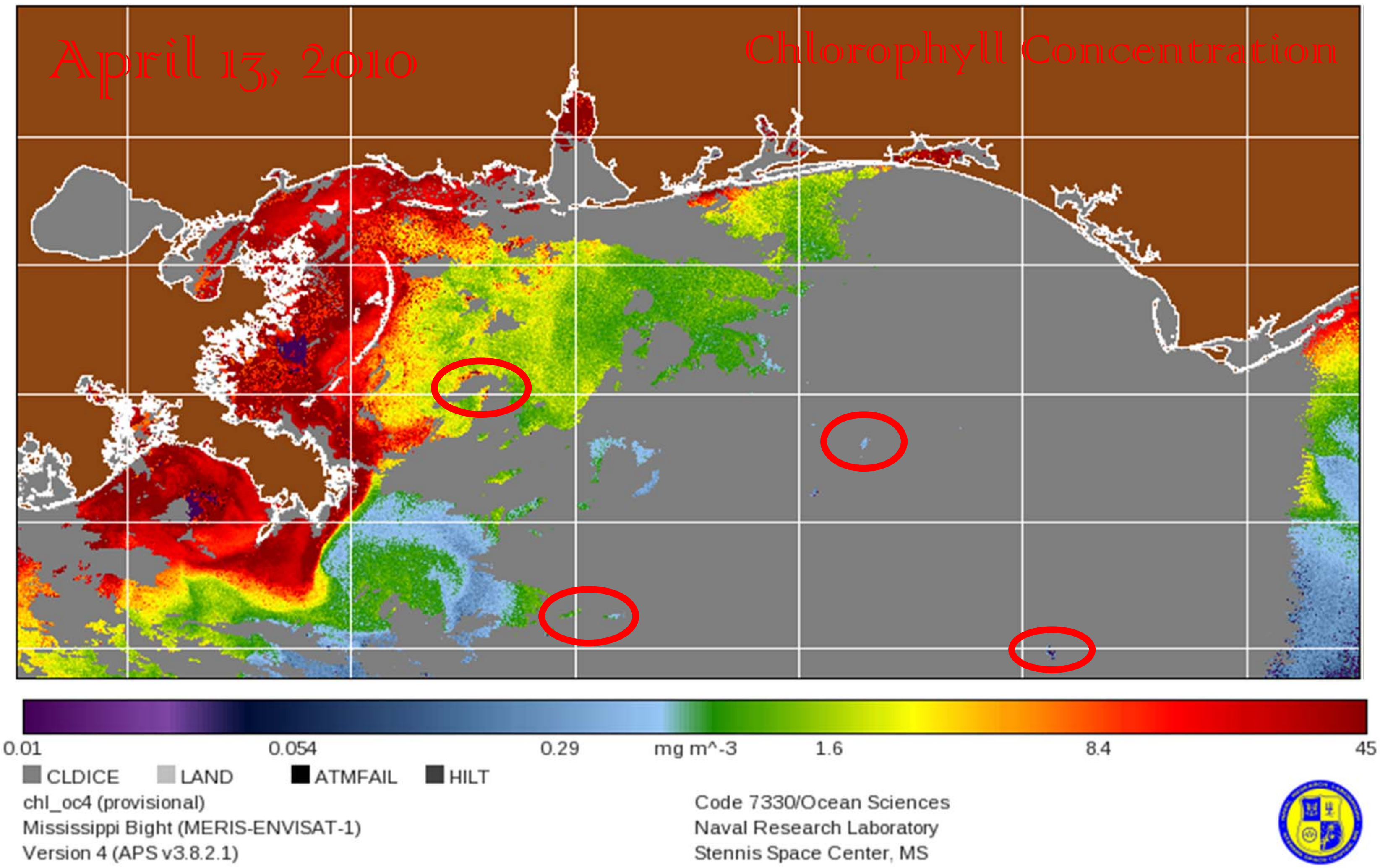
ρ Remote-sensing reflectance of the observed clouds



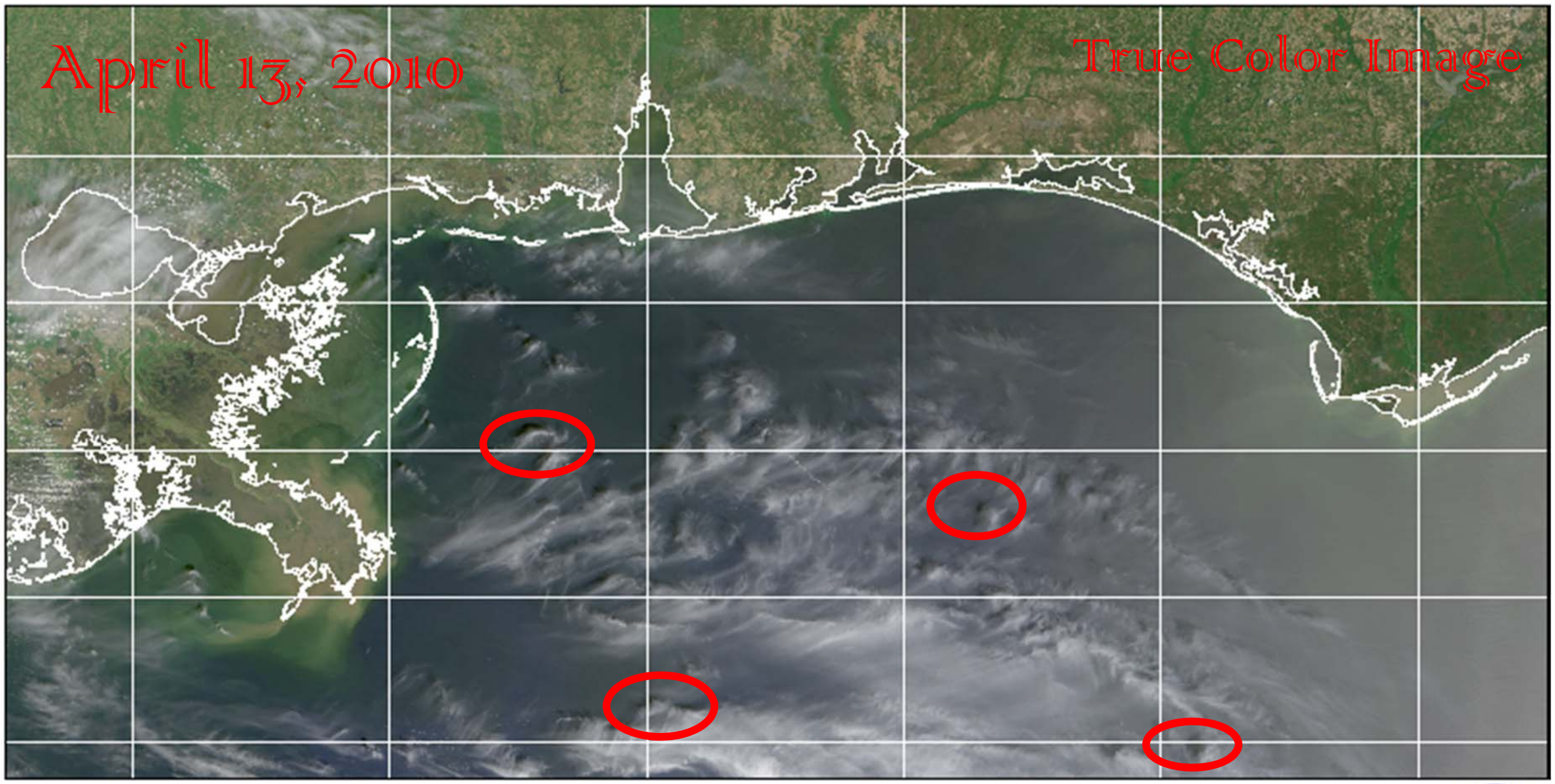




Impacts of Cloud Shadows on Ocean Color Products



Impacts of Cloud Shadows on Ocean Color Products

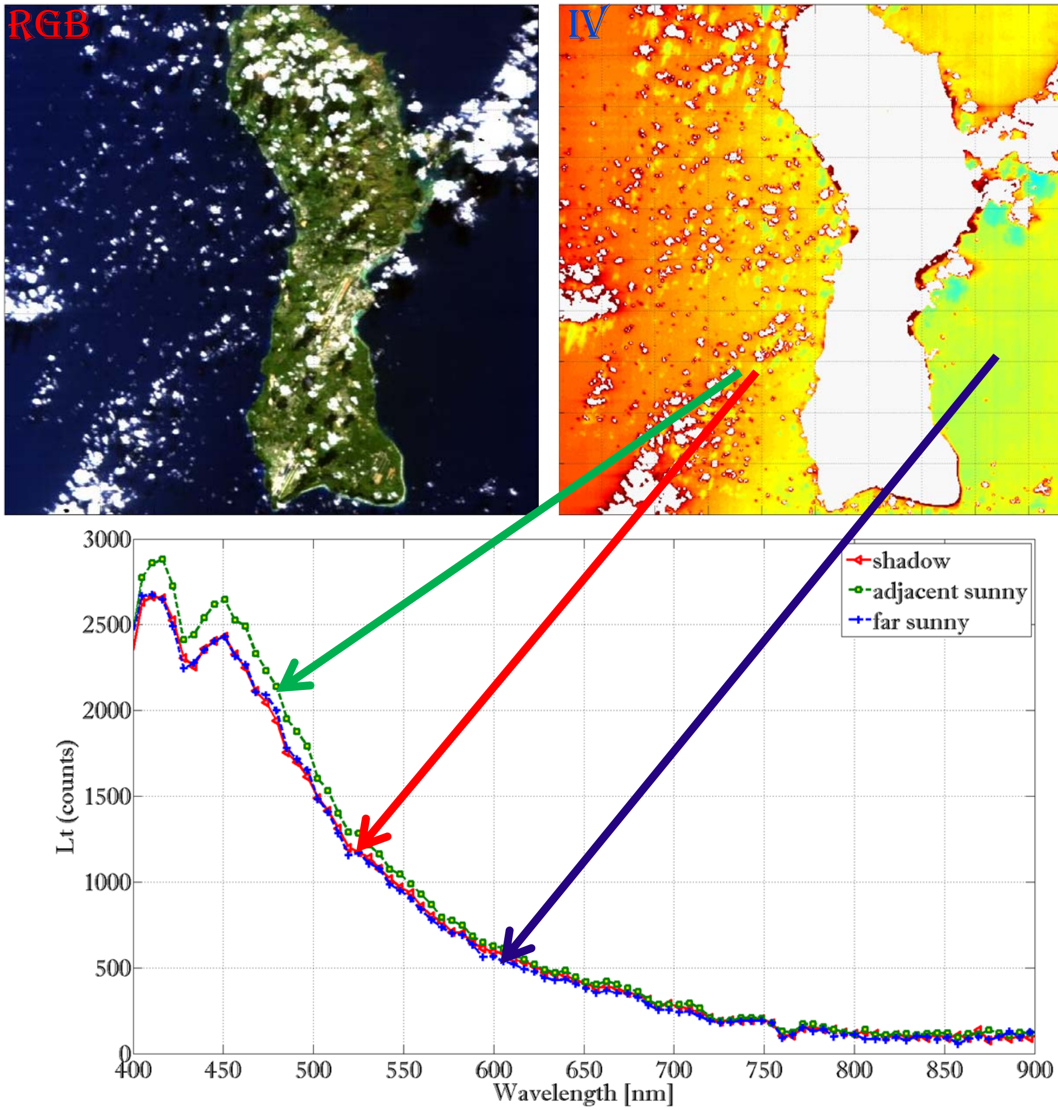


true_color
Mississippi Bight (MERIS-ENVISAT-1)
Version 4 (APS v3.8.2.1)

Code 7330/Ocean Sciences
Naval Research Laboratory
Stennis Space Center, MS

Shadow Detection Algorithm

HICO image (Nov 11,2009) over Guam



The Integrated Value (IV) index:

$$IV = \int_{400\,nm}^{600\,nm} Lt(\lambda)\,d\lambda$$

HICO has 35 channels between 400nm and 600nm range

The spatial Adaptive Sliding Box (ASB) and the Cloud Shadow Algorithm (CSA)

$$CSA = \frac{IV_c}{\langle IV_{ASB} \rangle}$$

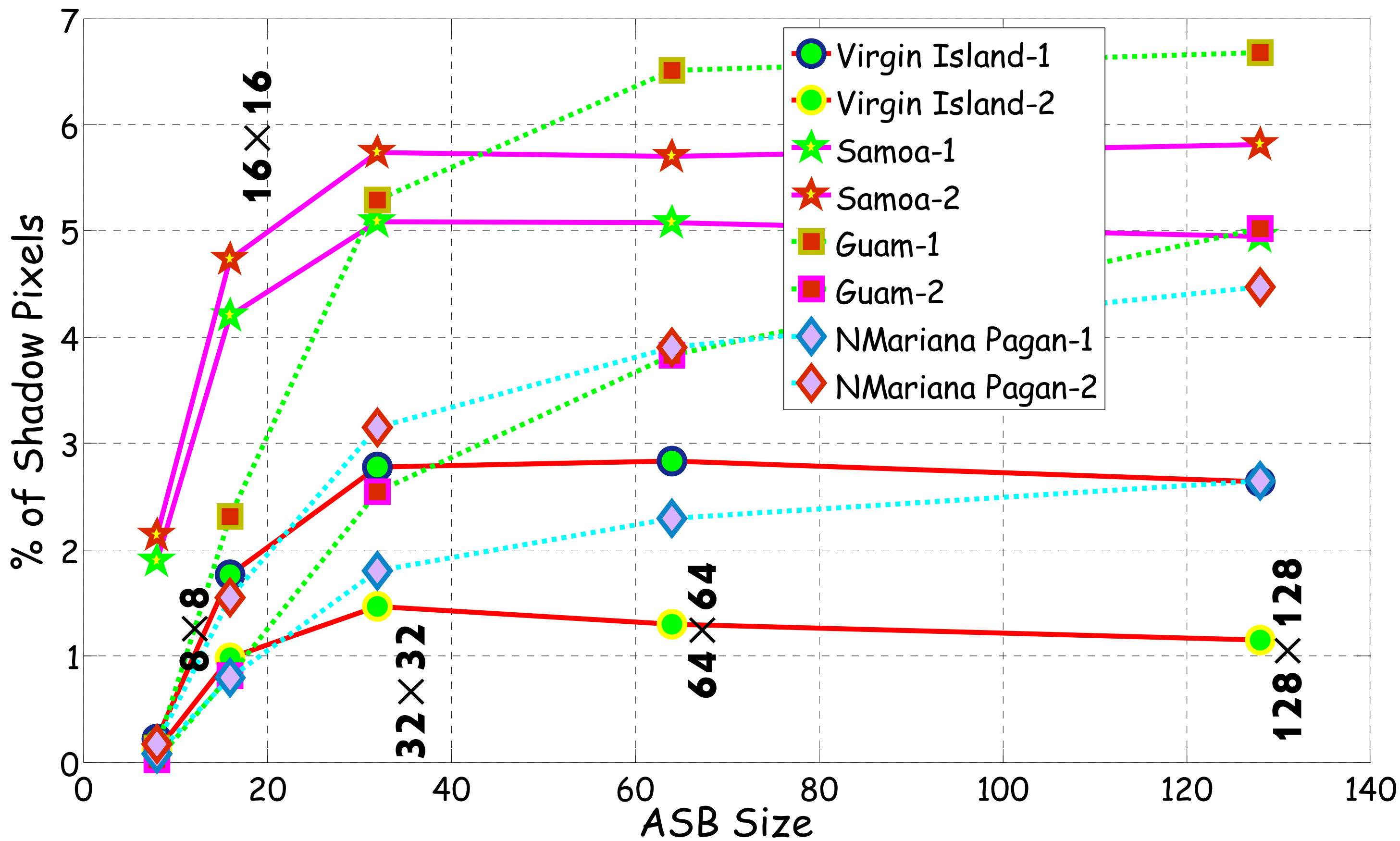
where IV_c represents the IV index of the pixel which needs to be classified as a shadow or sunny pixel. The $\langle IV_{ASB} \rangle$ represents the spatial mean of IV indices within the selected ASB of this pixel.

Challenge

Spectral profile cannot be used to separate shadow pixels

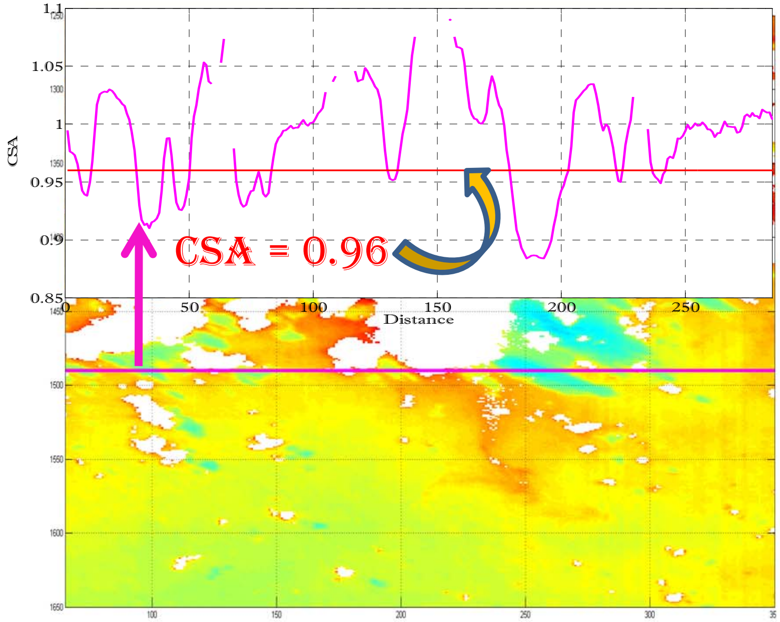
ASB size vs. Percentage of Shadow Pixels

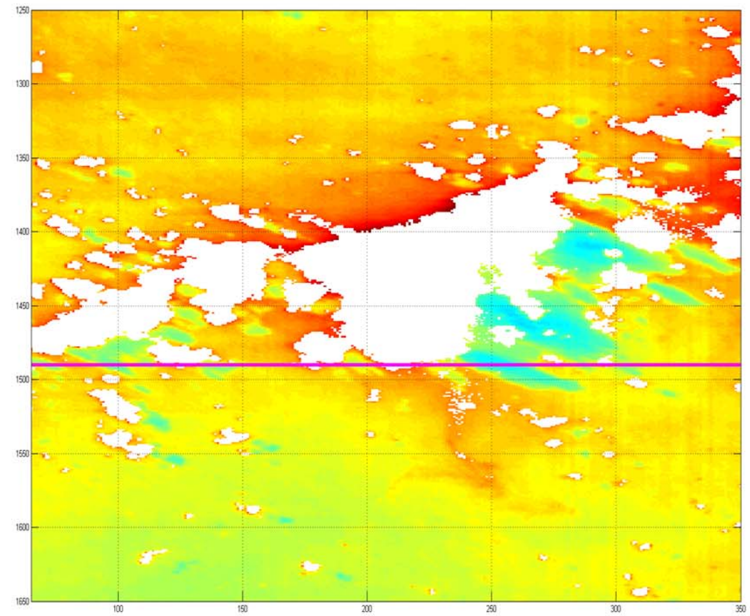
Smaller shadows (solid lines); Larger shadows (doted lines)



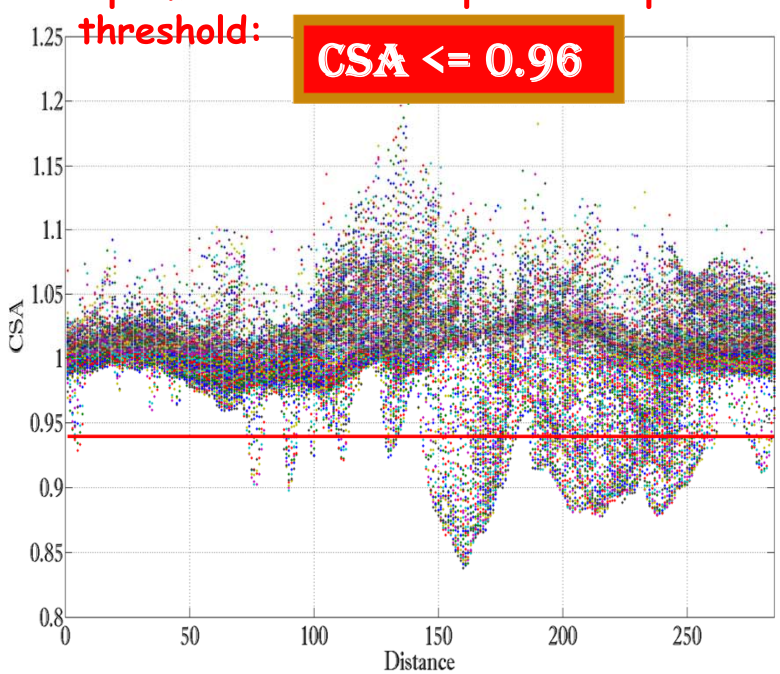
Analyses of CSA Threshold using 128 × 128 ASB

HICO image acquired over Pagan on September 26, 2010

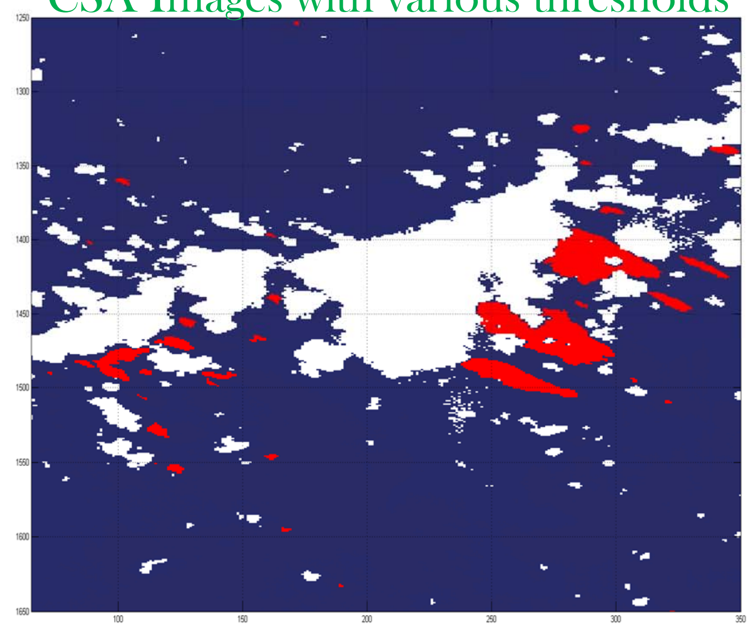


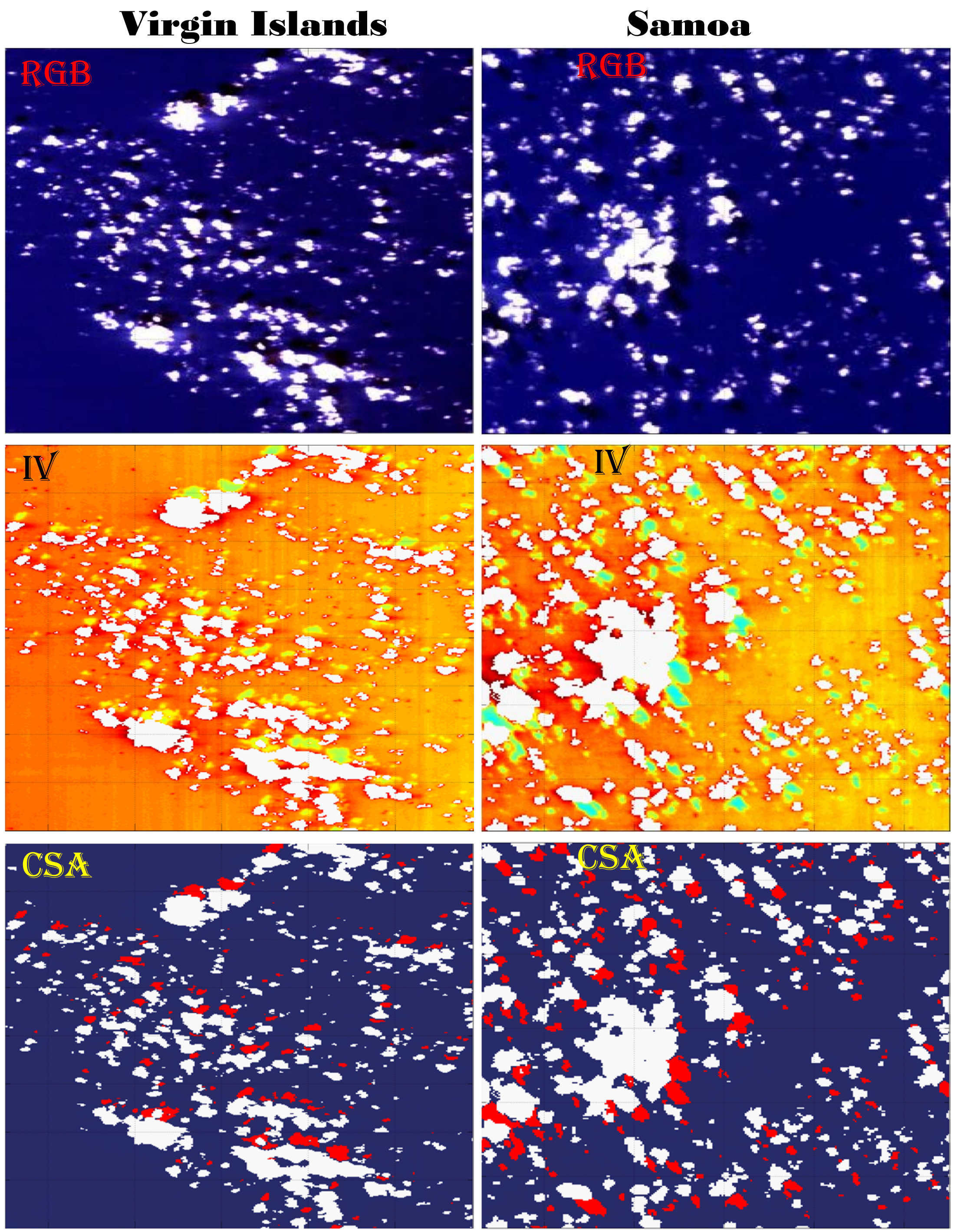


Optimal shadow pixel separation threshold:



CSA Images with various thresholds

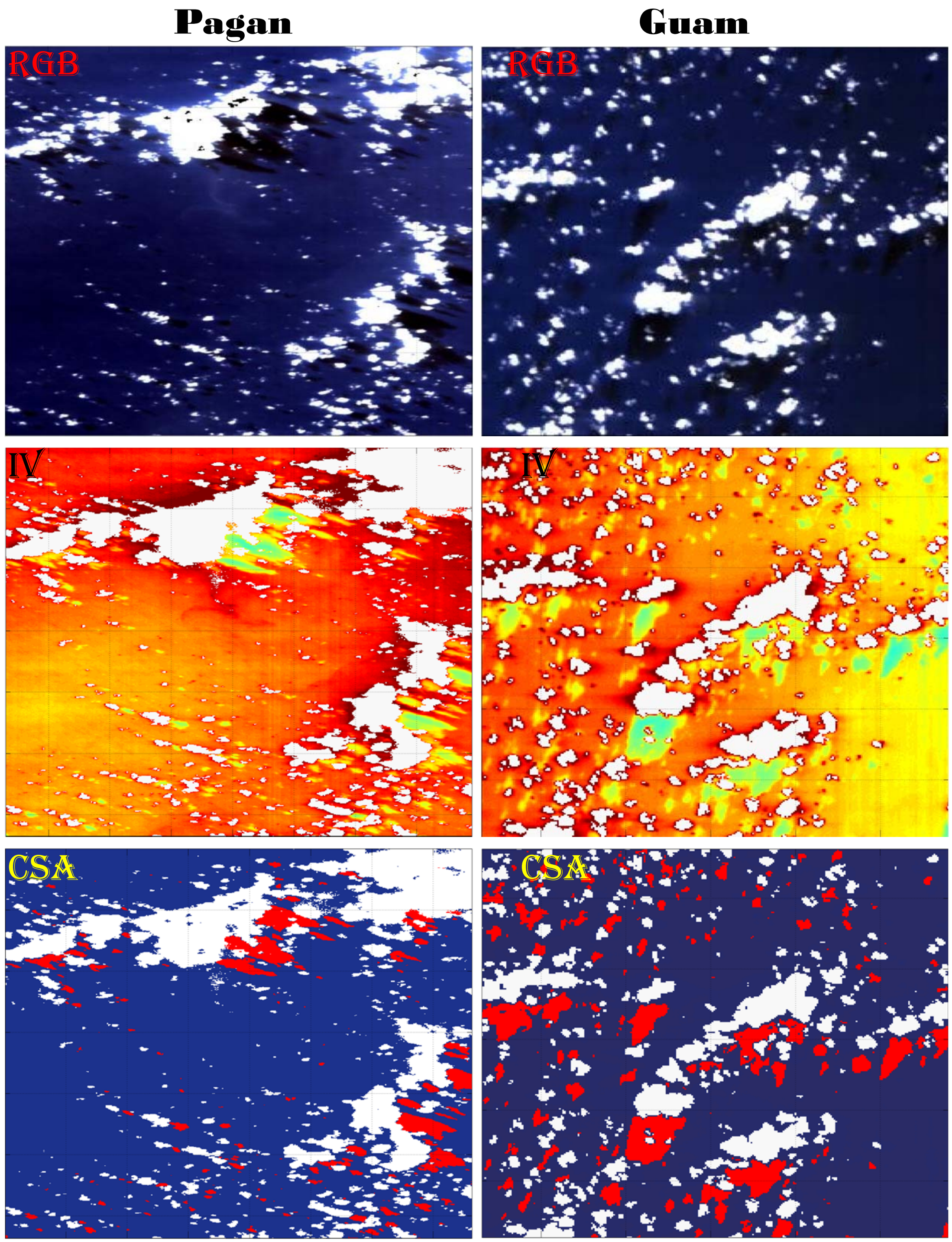




Left Panel: HICO image acquired over Virgin Islands on December 20, 2009 (image size: 270 × 400 pixels)

Right panel: HICO image acquired over Samoa on October 2, 2010 (image size: 260 × 260 pixels)

128×128 ASB is selected for the CSA Images



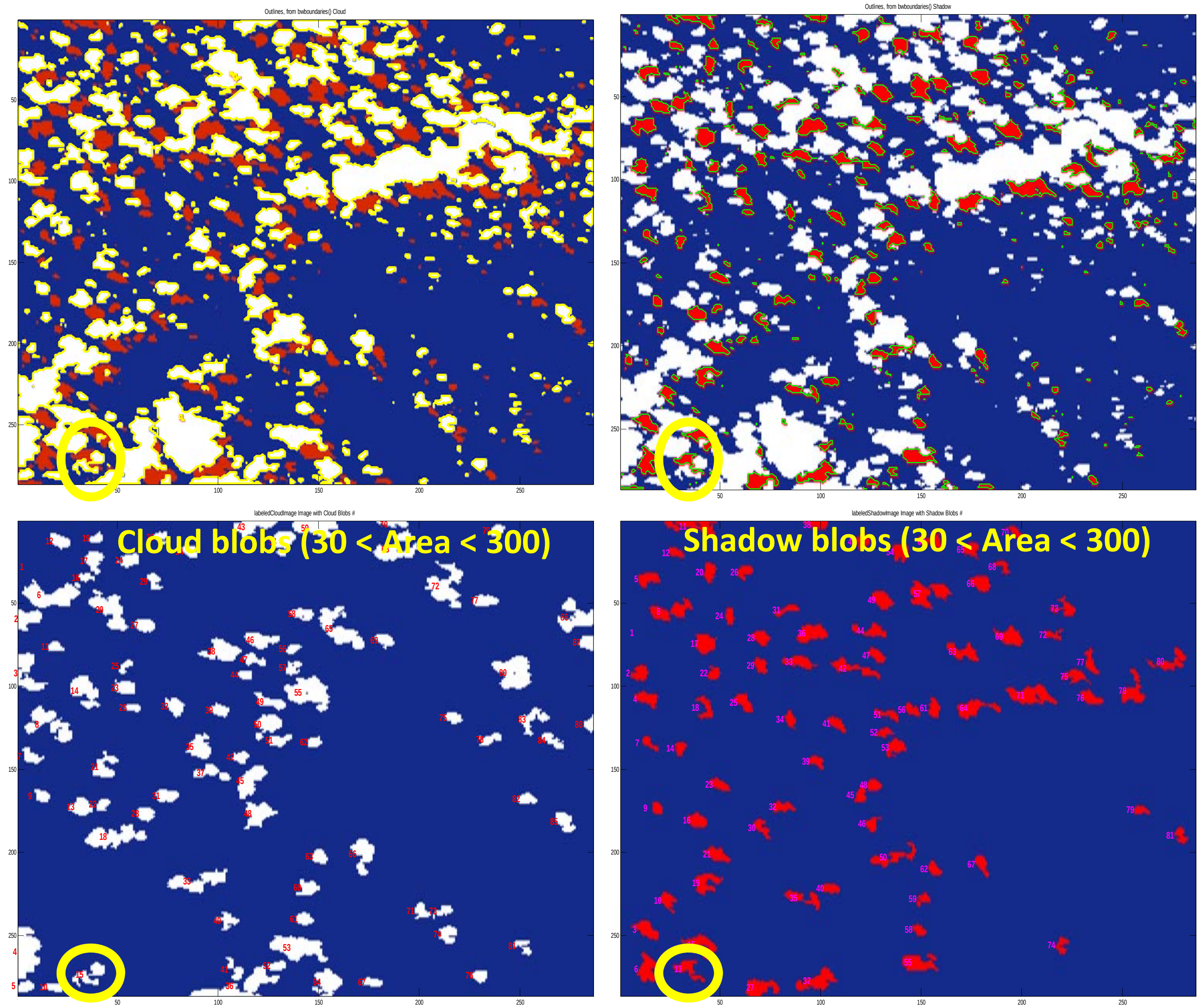
Left panel: HICO image acquired over Pagan on September 26, 2010 (image size: 380 × 635 pixels)

Right panel: HICO image acquired over Guam November 11, 2009 (image size: 275 × 275 pixels)

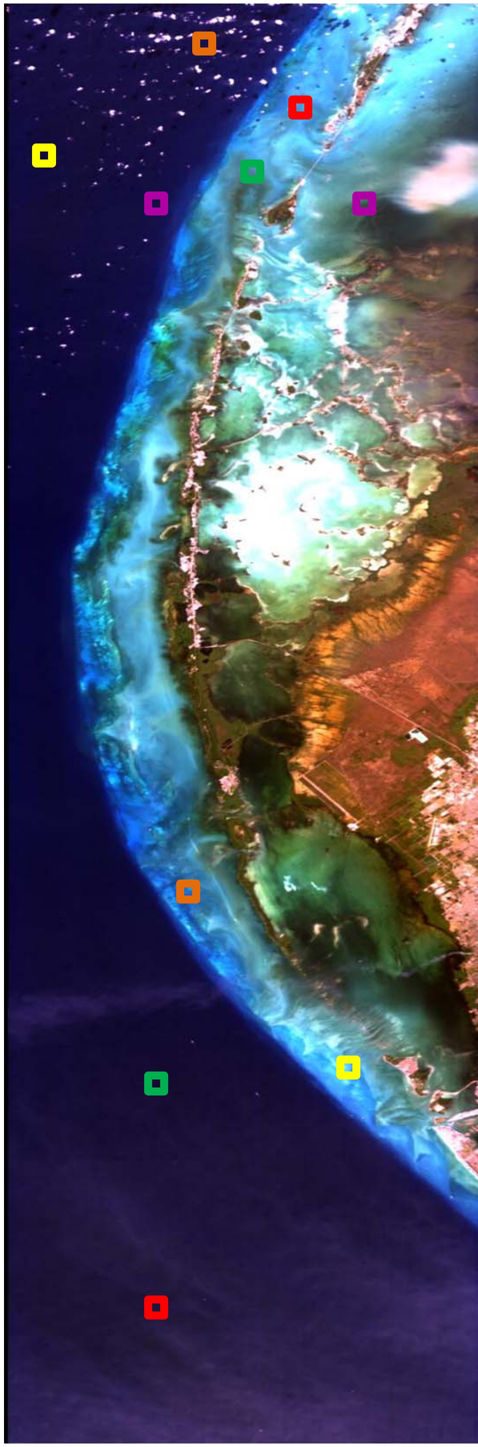
128×128 ASB is selected for the CSA Images

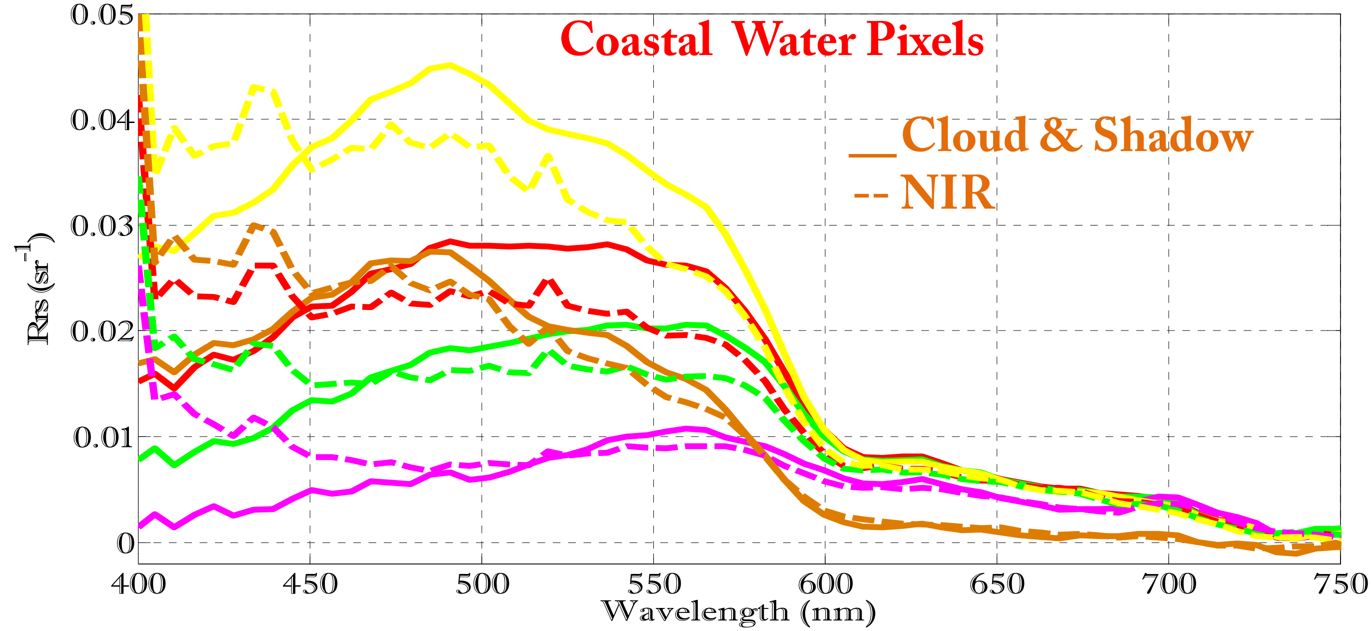
Automated Cloud, Cloud Shadow, and Sunny Pixels Selection for C&S Atmospheric Corrections using Blob Detection

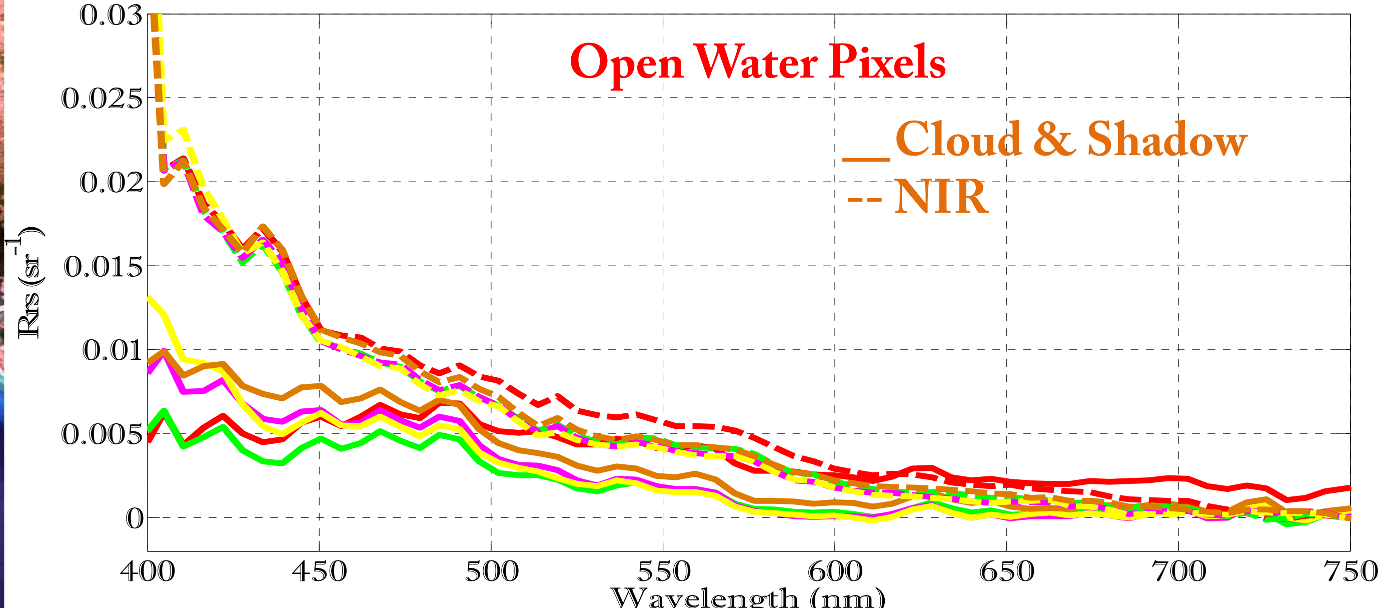
1. Identify cloud, shadow, and sunny pixels
2. Use Blob detection to get cloud, shadow and sunny blobs
3. Narrow down the cloud and cloud shadow blobs based on the blob size
4. Find the closest cloud and shadow blob using and then find the closest sunny pixel



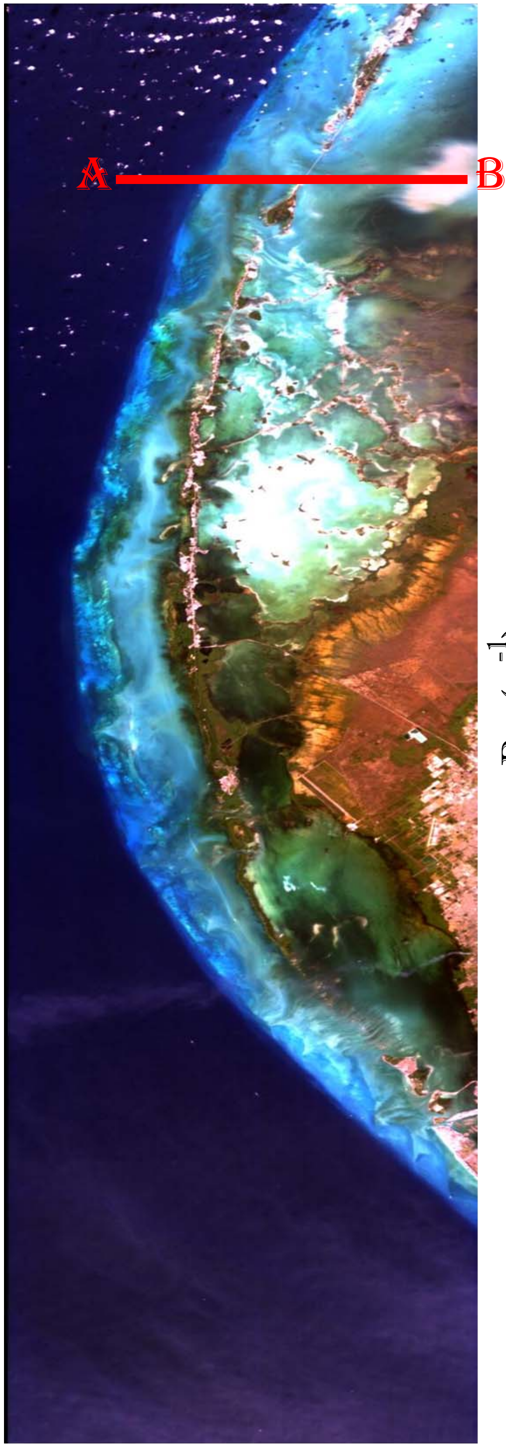
Cloud & Shadow Reflectance vs. NIR Reflectance

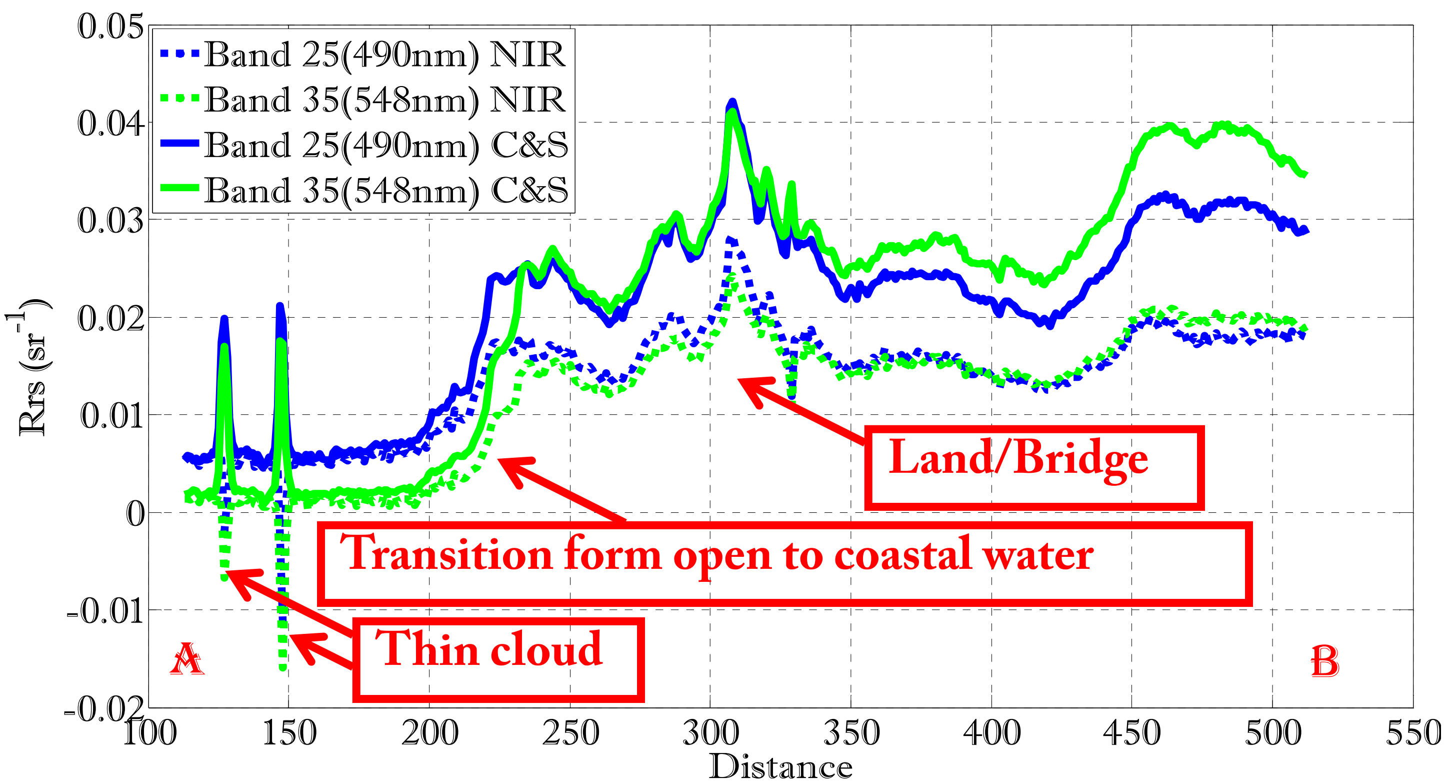






Cloud & Shadow Reflectance vs. NIR Reflectance





Conclusion

- The Cloud & Shadow atmospheric correction yields typically expected reflectance values in both coastal and open waters. However, the results from HICO data needs to be validated using in situ data.
- The NIR atmospheric correction applied to hyperspectral HICO bands also yields reasonably comparable results to that of the Cloud & Shadow except in the blue region of the spectrum . NIR gives higher reflectances in the blue region for both coastal and open water. The issue is under investigation.
- The biggest advantage of Cloud & Shadow atmospheric correction and the CSA cloud shadow detection methods is that they both do not require the knowledge of the calibration scale constant for conversion from digital numbers to radiance
- The limitation of the Cloud & Shadow atmospheric correction method is that it requires distinctive cloud shadow in a near uniform water area.