# 2012 HICO Annual Report: Characterization of Chlorophyll a and Analysis of pigment assemblages in Case II waters from Lake Erie using Derivative Hyperspectral data

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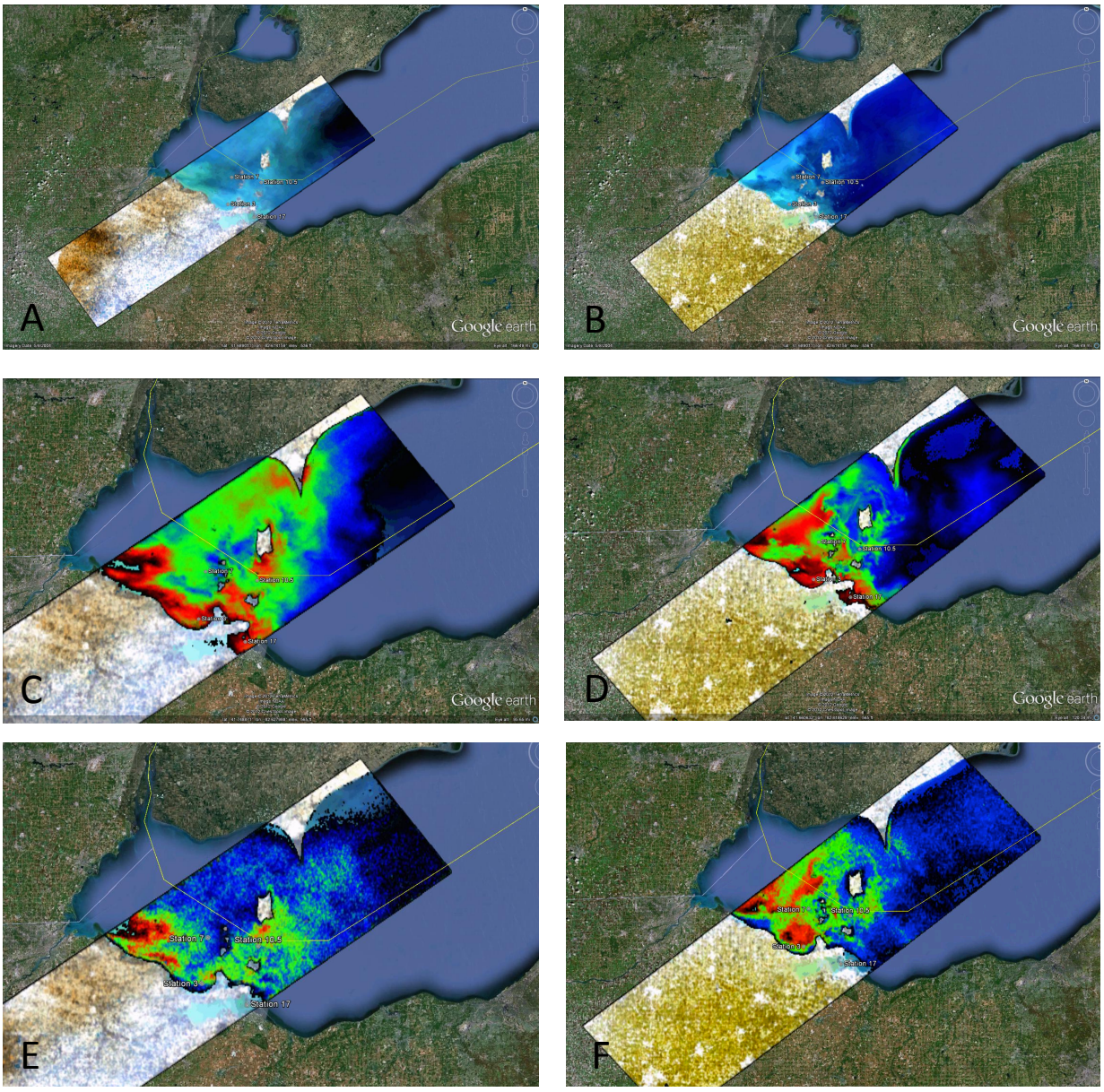
# Objectives of this work

- The aim of this work is to further improve remote sensing algorithms to better estimate the color producing agents (CPAs) from hyperspectral satellite data in an optically complex aquatic environment. The Western Basin of Lake Erie (WBLE) has high concentrations of suspended sediment due to high loading of sediment from major rivers, which respond to weather conditions. The WBLE also has several distinct phytoplankton communities (Makarewicz, 1993). Lake Erie can thus serve as a physically compact, natural laboratory for improving satellite-based retrievals of CPAs in optically complex aquatic environments.

Specific objectives of the proposed study are:

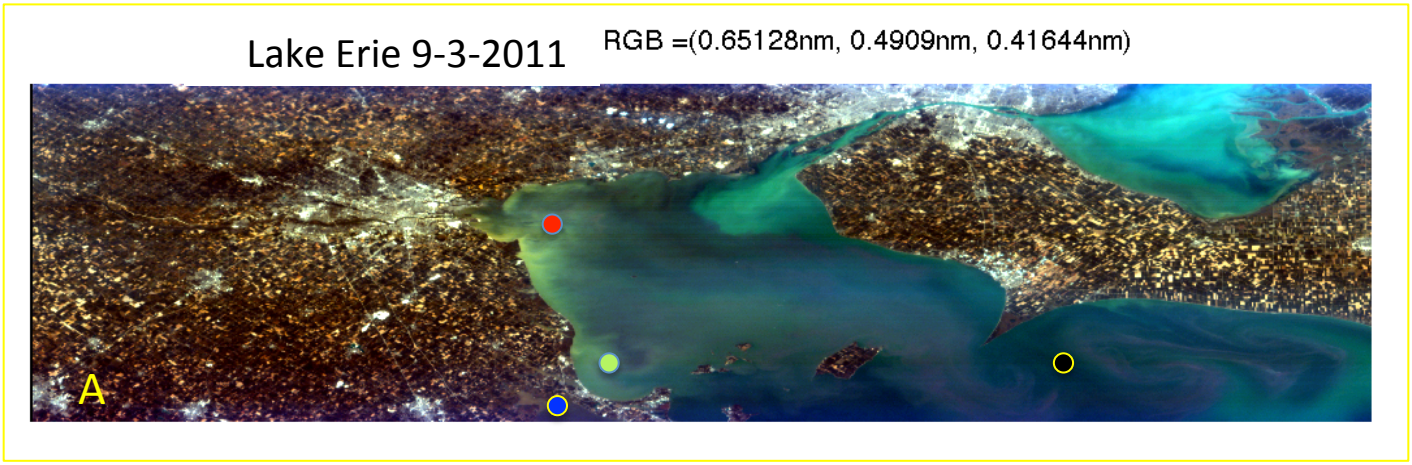
- To evaluate the concentrations and the compositions of the CPAs in the WBLE.
- To measure and characterize the optical properties of the WBLE using field and lab-based optical instruments.
- To identify the primary Case-2 water constituents in the WBLE using various analytical approaches applied to hyperspectral data.
- To parameterize the spectral windows which can be used to distinguish among selected CPAs by analyzing the optical properties of field-collected water samples.
- To evaluate correlations between HICO derived data with field and lab measured diffuse spectral reflectance (DSR) of Lake Erie water samples.
- To perform multivariate calibration of spectrally derived components using in-situ data.
- To develop more robust regional algorithms to estimate in-water constituents over the WBLE from the sensors aboard space platforms.

- Data
  - Field based physical measurements (Secchi depth, pH, dissolved oxygen, electrical conductivity, total dissolved solids, turbidity, temperature)
  - Field based optical measurements (Chlorophyll a, Phycocyanin, CDOM, Radiance, Irradiance)
  - Lab based measurements (pigment concentrations, particle composition, CDOM using fluorometer, SEM and spectrophotometer, respectively
  - Lab based reflectance measurement using ASD spectroradiometer
  - HICO hyperspectral sensor observations Acquired for dates
    - 9-3-2011 (no direct shipboard data)
    - 6-15-2012 and 7-11-2012 (shipboard data for direct comparison)
    - Additional target dates acquired but not yet processed
- Preliminary analysis
  - Application of Blue/green and Red/NIR ratio models to estimate Chlorophyll a as a proxy for phytoplankton
  - Application of multivariate techniques to derivative hyperspectral data from HICO and the Lab based ASD to characterize the various CPAs defining the water quality of the WBLE
- Reference
  - Makarewicz, J.C. (1993): Phytoplankton Biomass and Species composition In Lake Erie,. *J. Great Lakes Res*. **19 (12)**, 258-274
- Figures 1-7 – See below




# 6-15-2012 and 7-11-2012

Figure 1. Atmospherically corrected and geo-rectified, ascending track HICO images of the Western Basin of Lake Erie and Sandusky Bay showing true color images for (A) 6-15-2012, and (B) 7-11-2012 in comparison with chlorophyll a estimates obtained using the OC4 algorithm for (C) 6-15-2012, and (D) 7-11-2012, and a red/Nir algorithm for (E) 6-15-2012, and (F) 7-11-2012 .



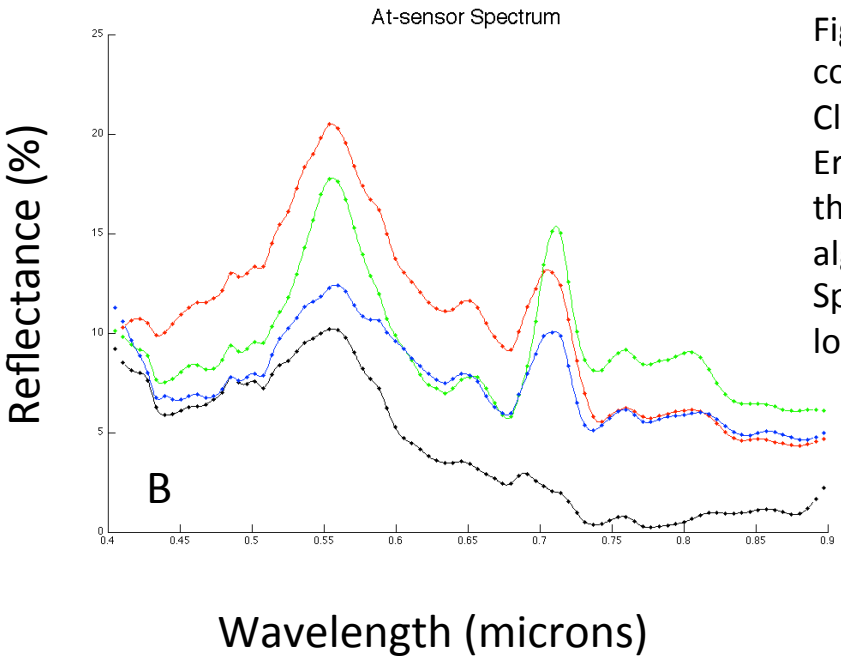




Figure 2. (A) Atmospherically corrected HICO image of Lake St. Claire, the Western Basin of Lake Erie, and Sandusky Bay showing the development of a blue-green algae bloom on 9-3-2011. (B) Spectra extracted from selected locations.

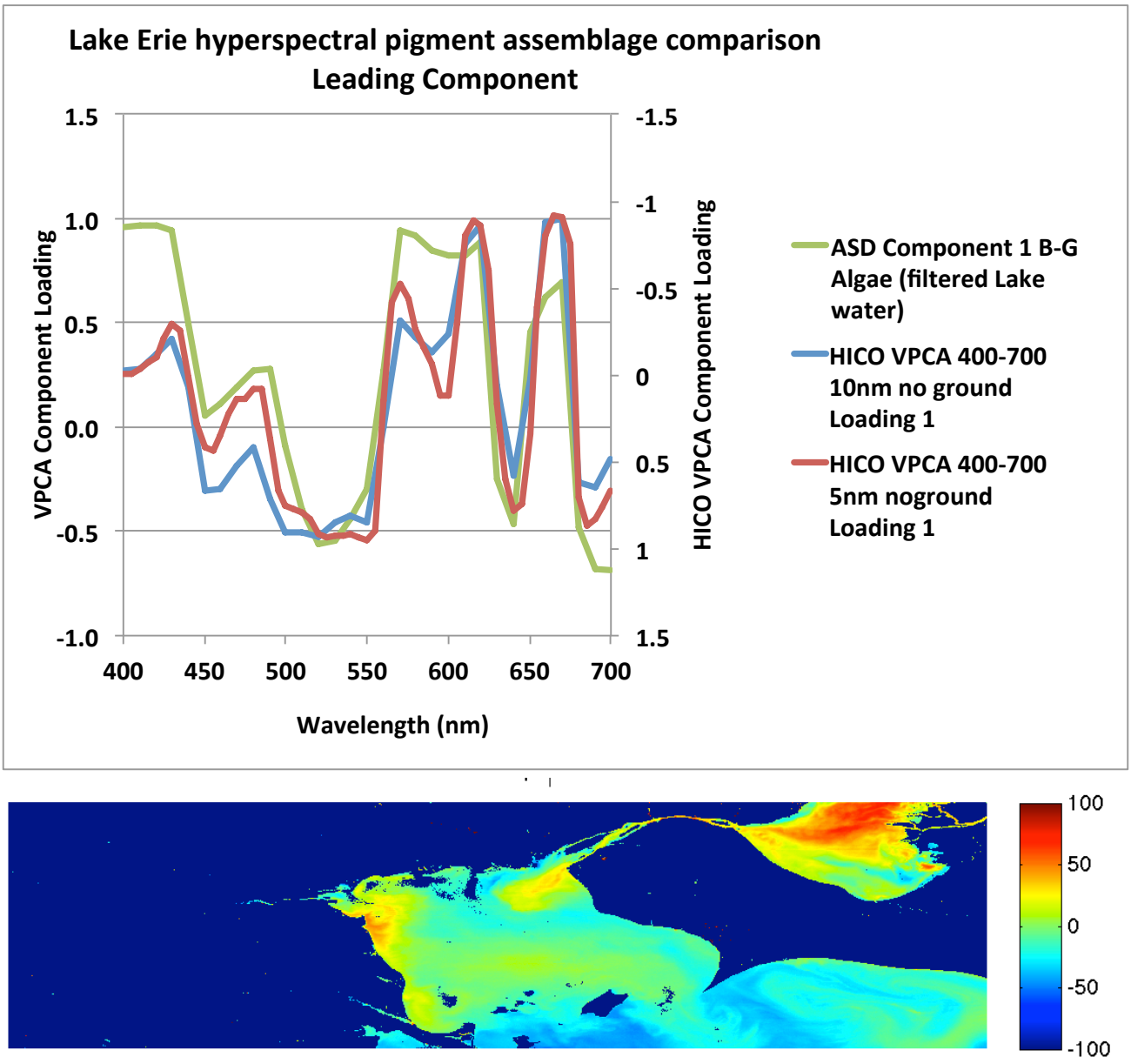



Figure 3. (A) Comparison of the leading varimax-rotated, principal component loading pattern for the Western Basin of Lake Erie based on filtered water samples collected in 2007 (green line), HICO data (9-3-11) averaged to 10 nm resolution (blue line), and HICO data averaged to 5 nm resolution (red line). (B) Spatial pattern for HICO component 1 (10 nm sampling). The spectral pattern for the filtered water sample is identified as a blue-green algae related pigment assemblage. The leading component accounts for 39.9% of the variance in the filtered data, 35.7% in the 10 nm data, and 35.8% in the 5 nm data.

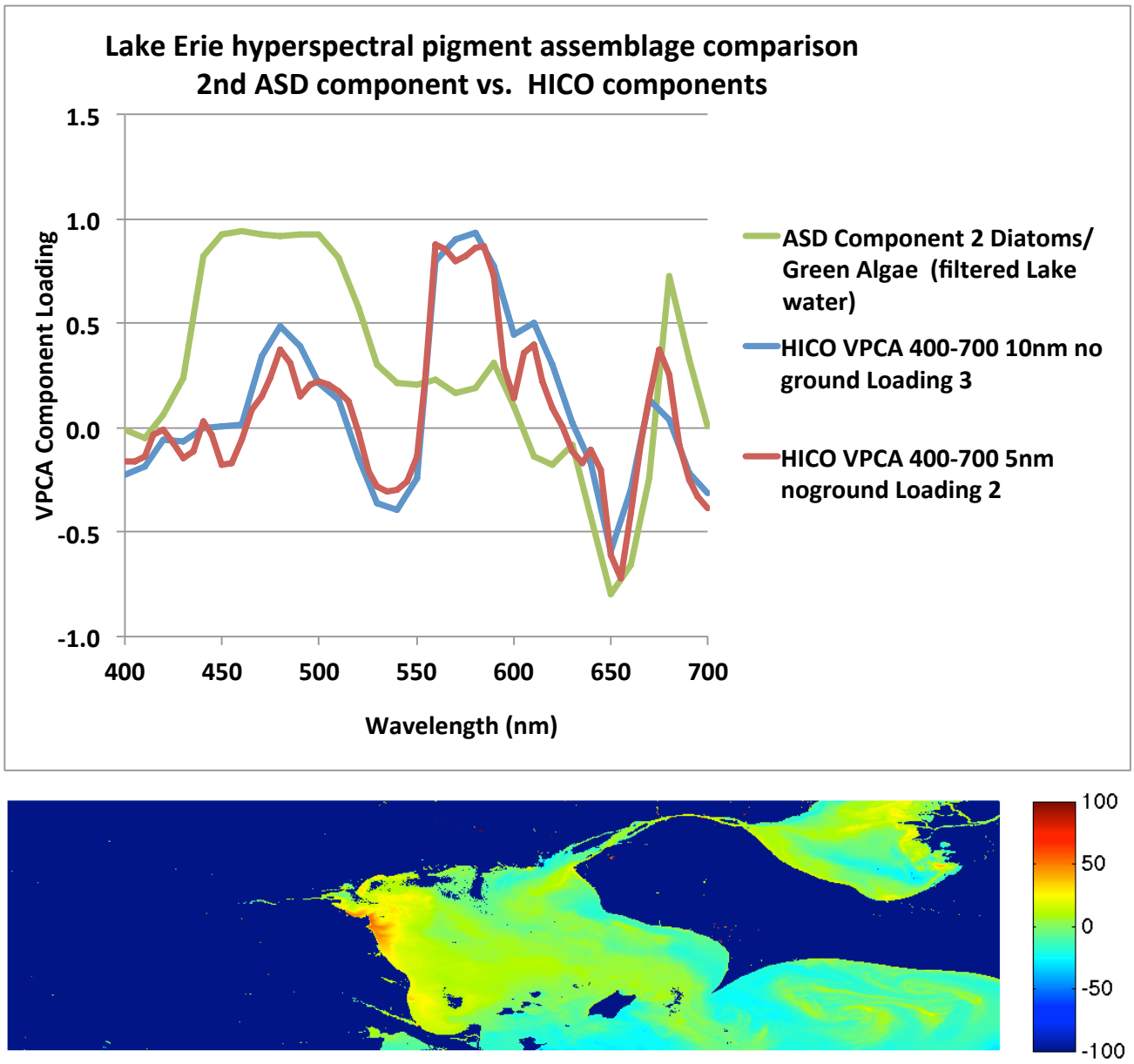
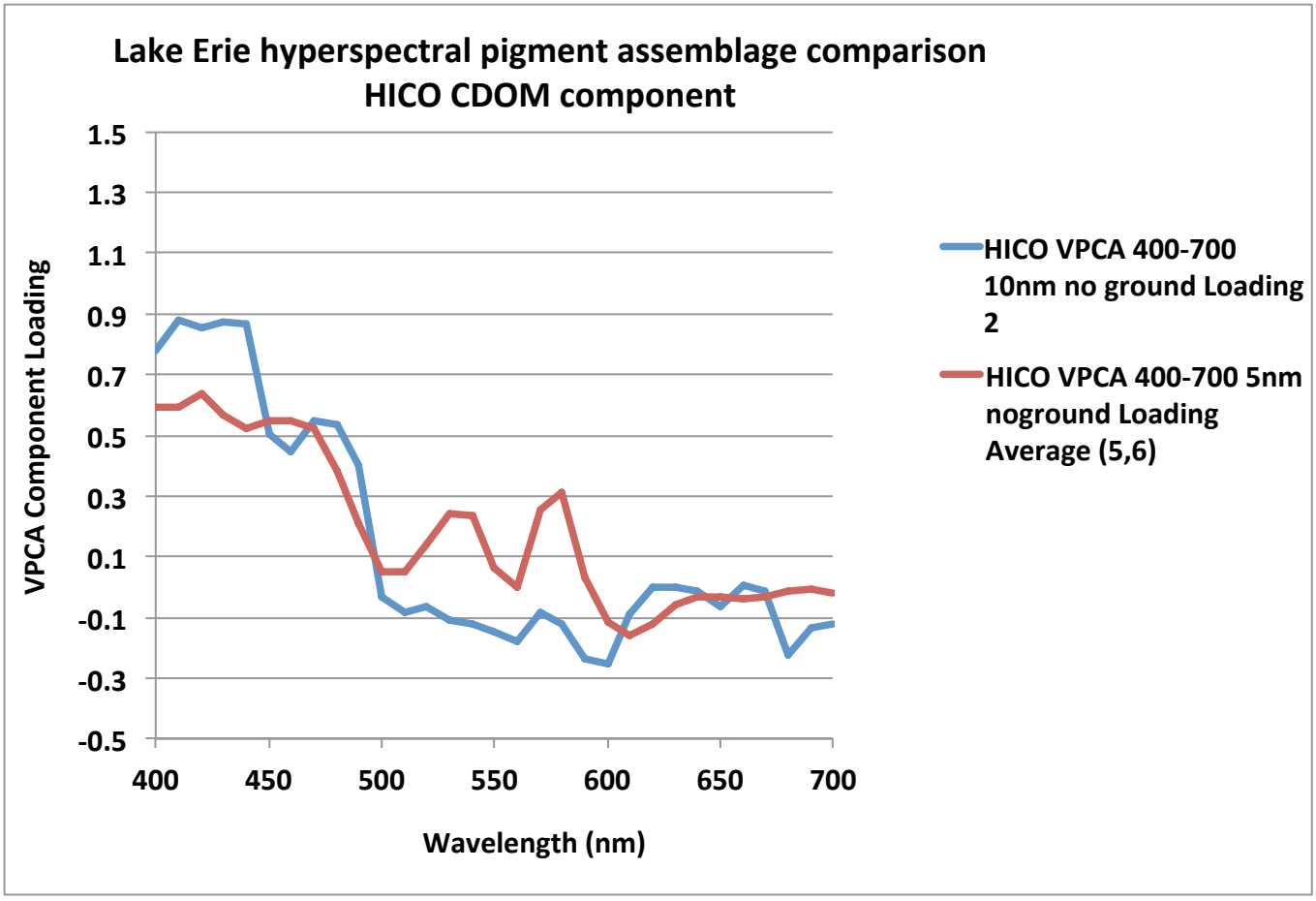






Figure 4. (A) Comparison of the second and third varimax-rotated, principal component loading pattern for the Western Basin of Lake Erie based on filtered water samples collected in 2007 (green line), HICO data (9-3-11) averaged to 10 nm resolution (blue line), and HICO data averaged to 5 nm resolution (red line). (B) Spatial pattern for HICO component 3 (10 nm sampling). The spectral pattern for the filtered water sample is identified as a diatom and/or green algae related pigment assemblage. This component accounts for 30.0% of the variance in the filtered data, 16.5% in the 10 nm data, and 13.4% in the 5 nm data. Differences in the spectral pattern for the two data types may represent differences in the concentration of accessory pigments or differences in the species composition between the two time periods.



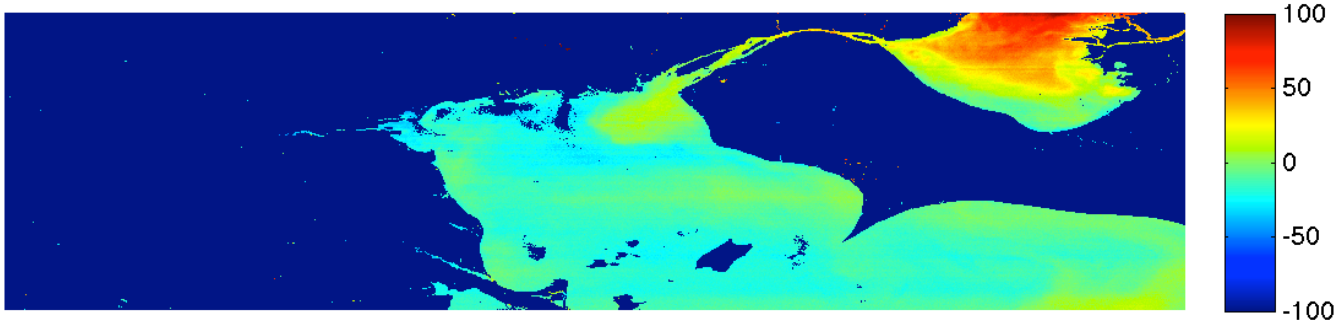




Figure 5. Comparison of the second and the average of the 5 and 6 varimax-rotated, principal component loading pattern for the Western Basin of Lake Erie based on HICO data (9-3-11) averaged to 10 nm resolution (blue line), and HICO data averaged to 5 nm resolution (red line). (B) Spatial pattern for HICO component 2 (10 nm sampling). The spectral shape, which exhibits high loadings between 400-500 nm, and the fact that there is no analog to this HICO component in the filtered data suggests that this component represents some fraction of the CDOM present in the lake. This component accounts for 16.6% of the variance in the 10 nm data, and 14.7% in the 5 nm data. Differences in the spectral pattern likely results from the finer decomposition of the 5 nm data.

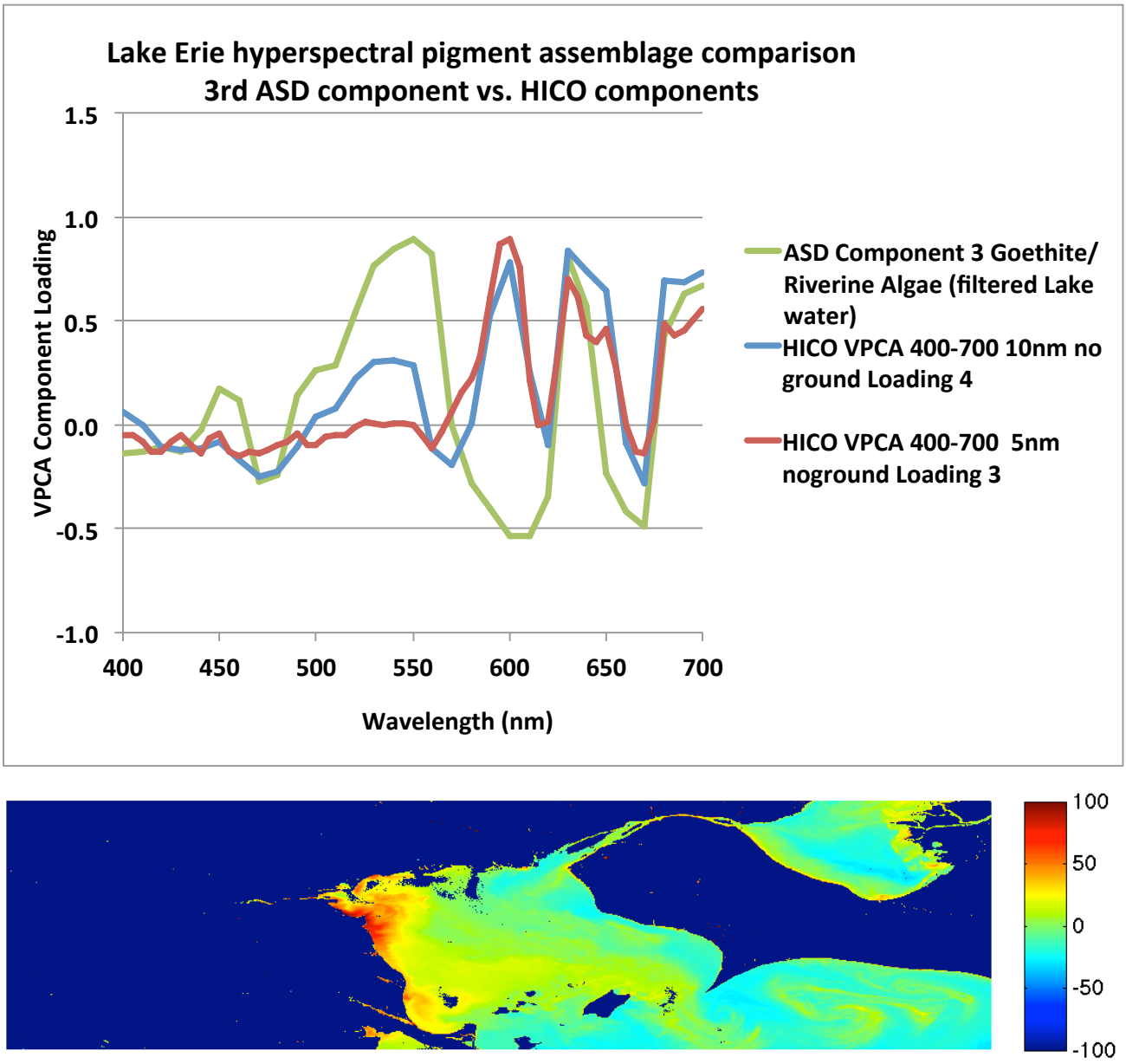



Figure 6. Comparison of the third and fourth varimax-rotated, principal component loading patterns for the Western Basin of Lake Erie based on filtered water samples collected in 2007 (green line), HICO data (9-3-11) averaged to 10 nm resolution (blue line), and HICO data averaged to 5 nm resolution (red line). (B) Spatial pattern for HICO component 4 (10 nm sampling). The spectral pattern for the filtered water sample is identified as a mixture of goethite, an iron oxyhydroxide and a blue-green algae related pigment assemblage. The spectral peak at 600 nm in the HICO data could indicate the addition of hematite an iron oxide, or a blue-green accessory pigment. This component accounts for 22.3% of the variance in the filtered data, 15.5% in the 10 nm data, and 9.6% in the 5 nm data.

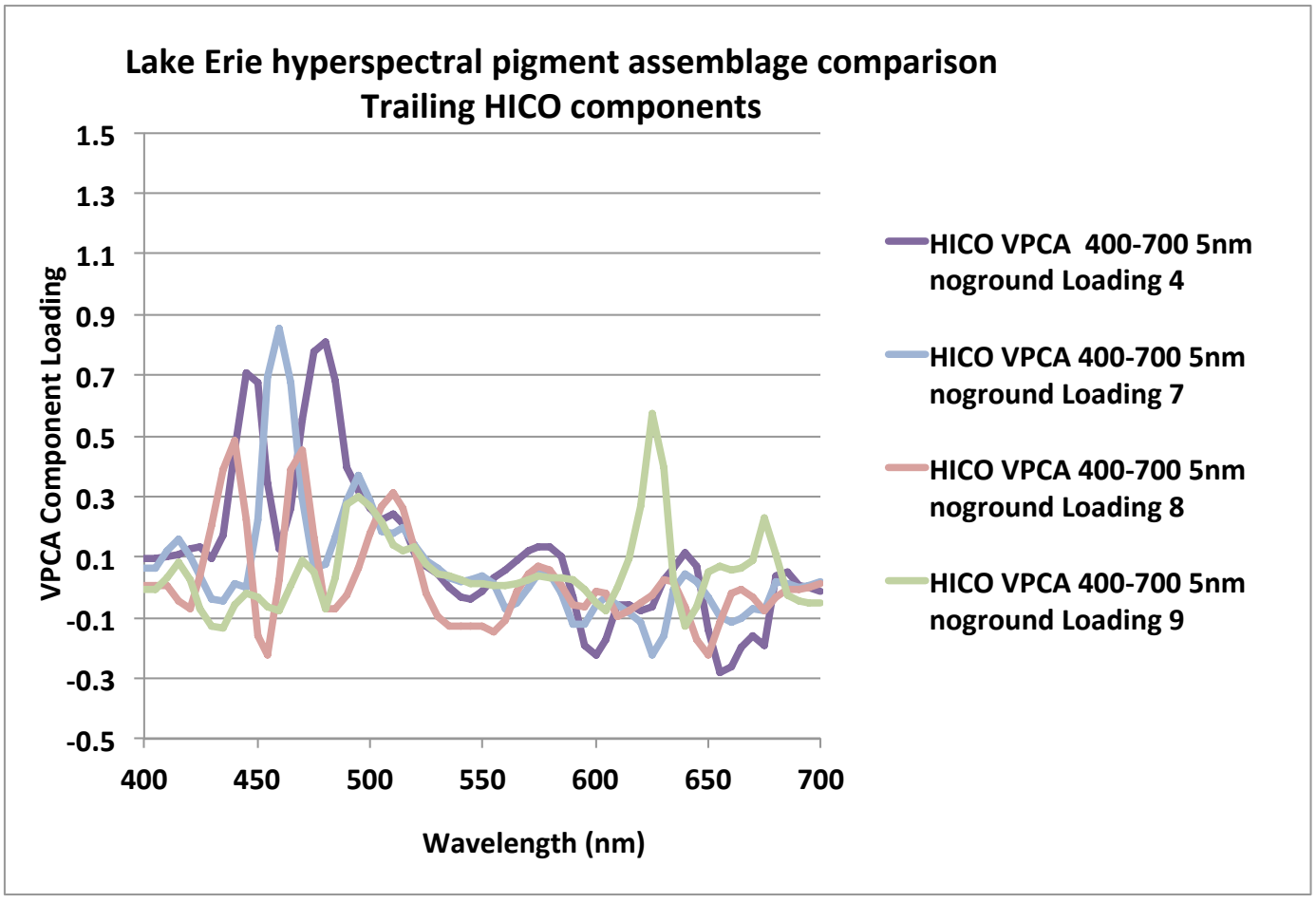



Figure 7. Comparison of the fourth, seventh, eight and ninth varimax-rotated, principal component loading patterns for the Western Basin of Lake Erie based on 5 nm resolution HICO data (9-3-11). These components have no analog in either of the 10 nm resolution data sets and likely represent minor components of the CDOM due to dissolved accessory pigments or their degradation products. (Spatial patterns for these HICO) components are not shown).