Comparing Image Enhancement Methods For Observing Suspended Sediment In Lake Erie

Aila Jalo

Centre Of Geographic Sciences

Introduction

Image enhancements have multiple purposes in the field of remote sensing. Enhancements are applied to imagery using various algorithms with the goal of improving the visual appearance of the image for human or machine analysis (Jensen, 2016, p. 273). Raw remotely sensed imagery will appear dull without any enhancements. Many materials will have similar brightness values across the electromagnetic spectrum, resulting in low-contrast images as the full sensitivity range of most satellites sensors are not being utilized (Jensen, 2016, p. 282).

An increased amount of minerals and fertilizer in water bodies provides food for algae to grow (Alliance for the Great Lakes, 2021). Algae blooms are a frequent occurrence in Lake Erie due to limited regulations regarding runoff pollution from farms in Ontario, Michigan and Ohio (Alliance for the Great Lakes, 2021).

The purpose of this analysis is to compare two enhancements techniques using PCI Geomatics Catalyst. The first enhancement is one of the default functions in the Focus software. The second is a custom enhancement to further emphasize a specific land cover feature. This comparison will focus on suspended sediment and sediment run-off in the Western Basin of Lake Erie, in between the southern shore of Essex County and Pelee Island in southern Ontario, Canada (Figure 1).

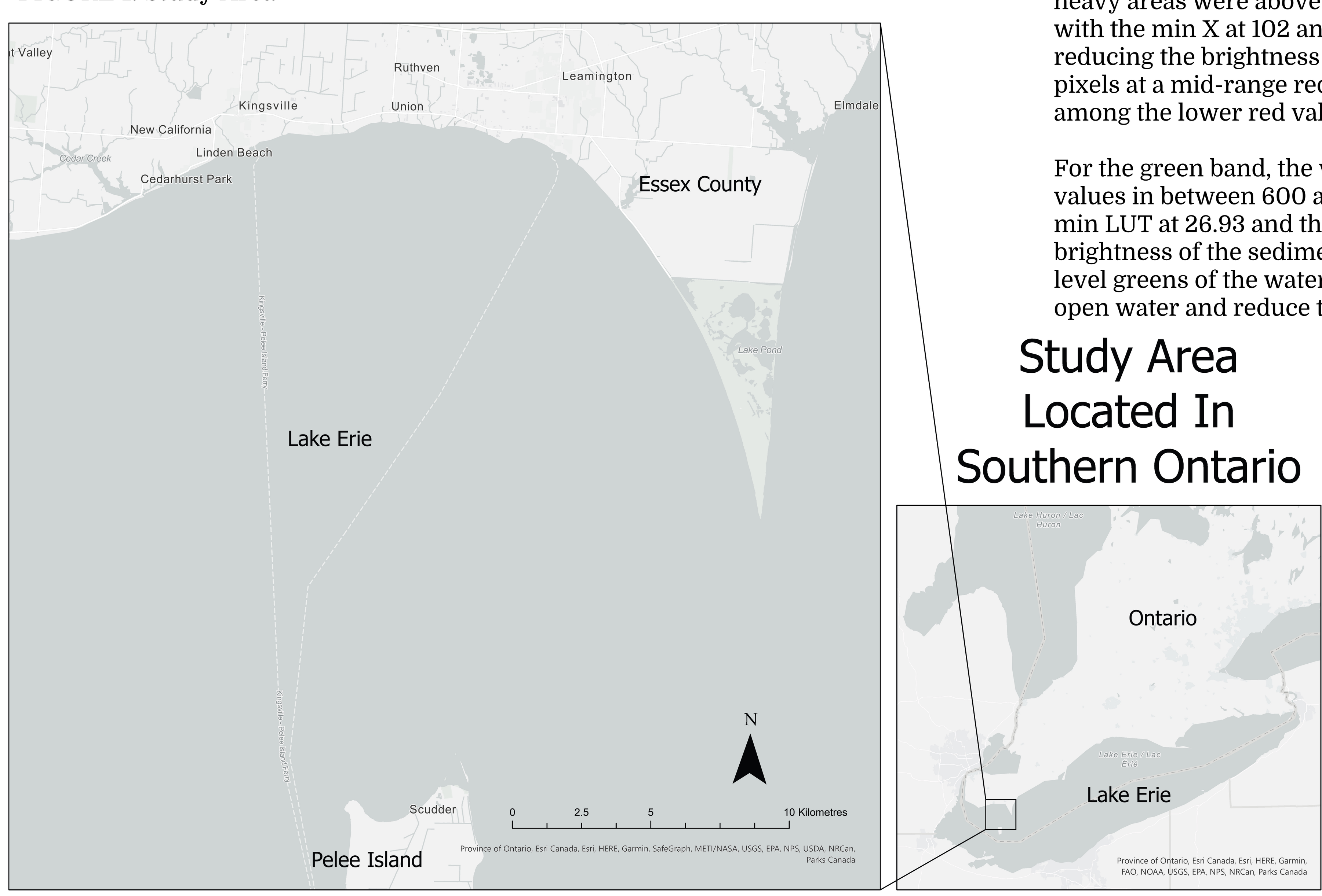
Data Preparation

To locate imagery for the project, the USGS Earth Explorer website was used. The map was moved to cover the southern part of Ontario and Lake Erie, and the coordinates for the map extent was used to search for imagery that was taken within the area. The search results were also limited to the months of June, Jul and August and to images where there was less than 20% cloud cover. The search results were from LANDSAT Collection 1 > Level 1 Data > LANDSAT 8 OLI/TIRS C1 Level 1. When an image with suitable coverage was found, the image was downloaded as a GeoTIFF Data Product.

The downloaded images were of a scene much larger than what was needed for the project. All the rasters in the image were clipped to a region of 30km by 30km. The clipped image was then put through the atmospheric correction tool to reduce the haze and create a mask of the water in the scene.

The bands chosen for this project were the Red, Green and Coastal Aerosol Blue bands. These bands in the visible spectrum were chosen as they would all show an increased reflectance in the water due to any suspended sediment, as soil and minerals will have higher reflectance than the water.

FIGURE 1: Study Area



Data Preparation (continued)

Water also absorbs red light, allowing the red band to be used to darken areas of the water where there is limited amounts of suspended sediment. The green band was chosen to show the increased reflectance of suspended sediment. The coastal aerosol band was chosen to penetrate more of the surface water to better show the sediment.

The choice of bands was also supported by looking at the spectral plots of areas of open water and areas where there was sediment. The spectral plot for the sediment showed higher reflectance values in all the visible bands.

Standard Enhancement

The first enhancement was done using the default linear contrast stretching tool on each of the bands individually. The linear contrast enhancement stretches the original brightness values of the pixels to evenly distribute them across the full range of brightness. The min and max brightness values are chosen and then the algorithm re-distributes any values in between along a straight line between the min and max. The general shape of the histogram remained the same, although it became wider as the pixels were more spread out along the x-axis.

The linear enhancement was chosen as it provided the best contrast between the open water and the sediment. In Figure 2 there are areas of visible sediment run-off where there are some lighter blues and greens along the shoreline. The sediment can also be seen being carried away by the water current.

Custom Enhancement

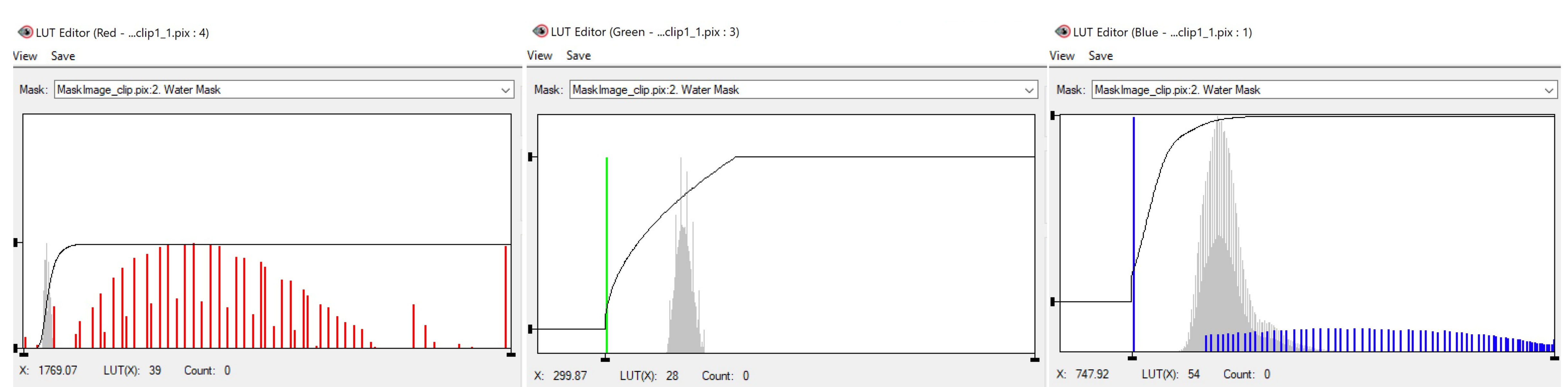
The second enhancement was done using the water mask created from the ATCOR tool, so that the contrast stretching was focused on the pixels in the water. To determine any min and max brightness values, the original DN values were observed by looking at multiple sample locations and reading the DN values for each of the Red, Green and Blue channels at the bottom of the window in Focus. The goal was to increase the contrast between the water and the suspended sediment, while reducing the 'cloudiness' of the water.

For the final map of the custom enhancement, the water was clipped and overlayed onto a greyscale copy of the standard enhancement image to better visualize the separation between the water and the shoreline.

Areas of open water had red brightness values in the 200's with few being above 280, and some areas where there was sun glint was a bit higher, while sediment heavy areas were above 330. An equalization function was applied to the red band, with the min X at 102 and the max LUT at 115. This kept the water dark while also reducing the brightness of the bright greens and blues. This function put most of the pixels at a mid-range red, while the values in between 102 and 280 were distributed among the lower red values (Figure 4).

For the green band, the water had values across the 300's, while the sediment had values in between 600 and 700. A root function was used with the min X at 300, the min LUT at 26.93 and the max LUT at 210.70. These values were chosen to limit the brightness of the sediment heavy areas, and to increase the brightness of the lower-level greens of the water. The minimum of 300 was chosen to flatten the areas of open water and reduce the sun-glint as much as possible.

FIGURE 4: Custom Enhancement Histograms



Suspended Sediment in Western Basin of Lake Erie, Using Linear Enhancement

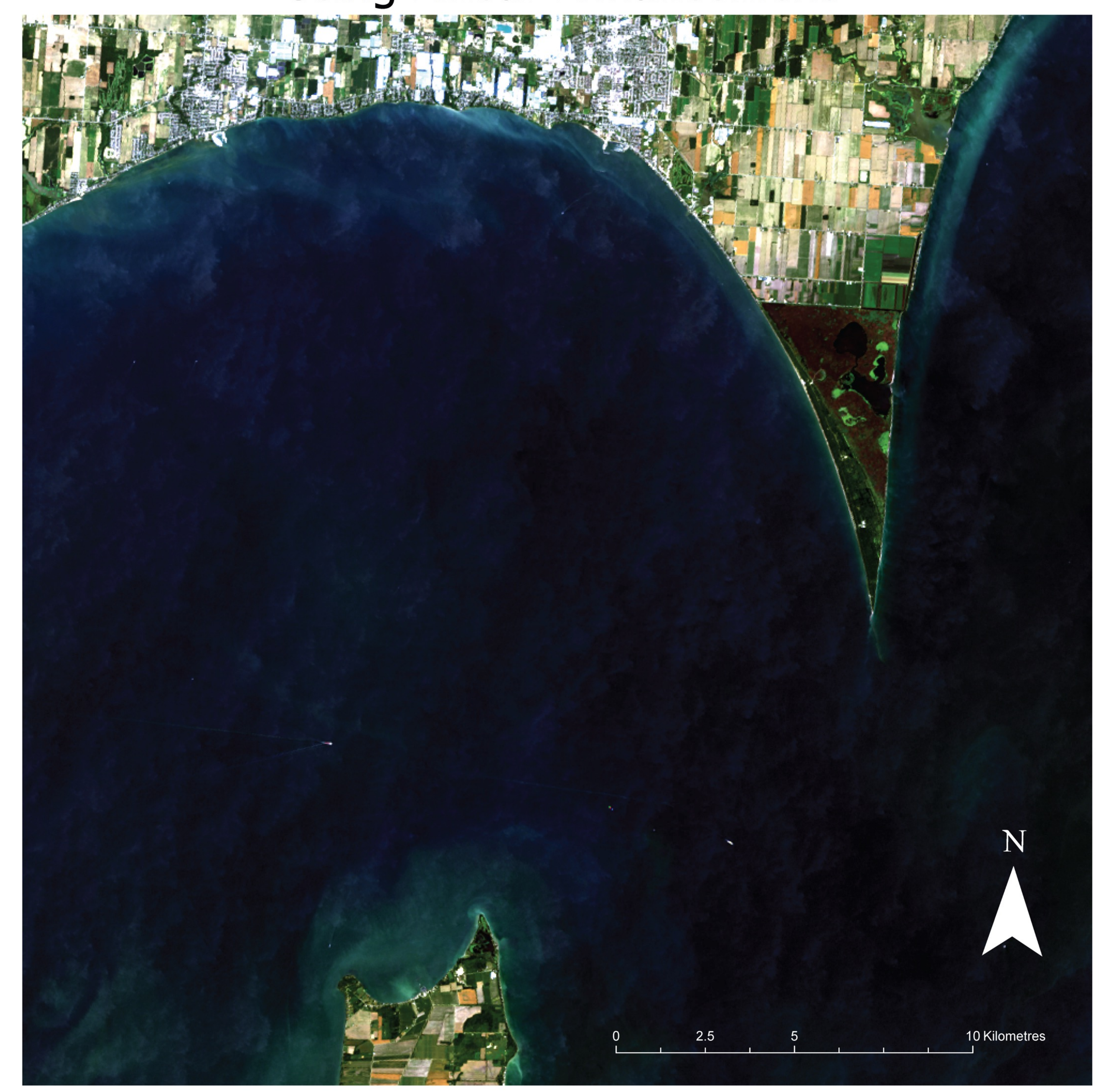


FIGURE 2: Linear Enhancement

Suspended Sediment in Western Basin of Lake Erie, Using A Custom Enhancement

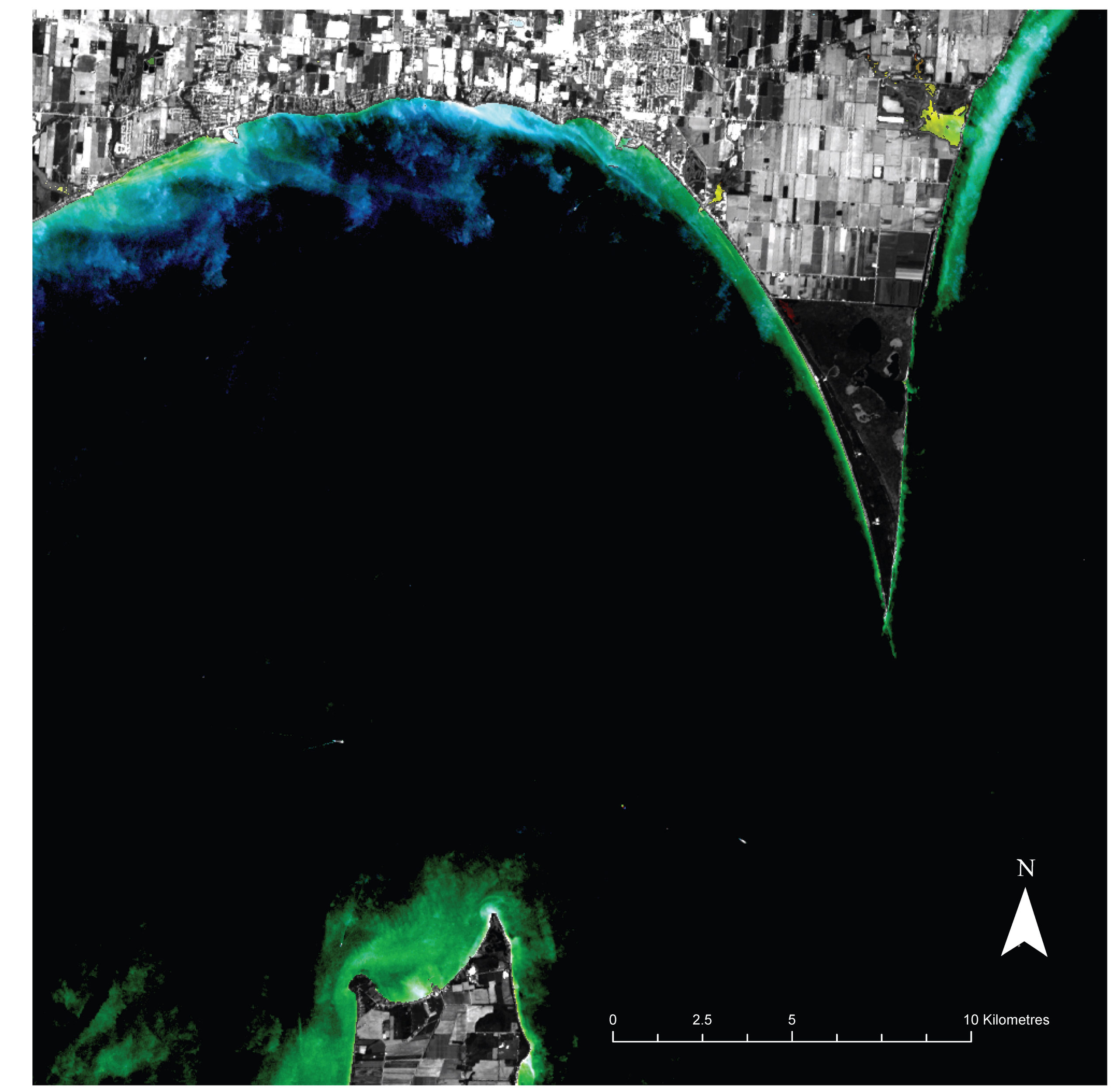


FIGURE 3: Custom Enhancement

Custom Enhancement (continued)

Open water had values ranging from the low 400's to the mid 500's in the coastal blue band. The sediment areas had values from the mid 500's to the mid 700's. An equalization function was applied to the coastal band with a min X of 408.55, and a min LUT of 54.03. Raising the min LUT brightened the blues and raising the min X flattened the water to make it darker.

The sediment in the standard enhancement could be confused for shallow water due to the more subdued blues and greens. The custom enhancement improves the interpretability of the image as there is increased contrast between the suspended sediment and the water. The areas where the sediment is running into the water are more visible as they are reflecting more light in the visible spectrum due to a heavier concentration of suspended sediment.

Conclusions

A better approach to looking at the sediment concentrations in the water would be to have field samples of the water quality to be able to compare them to an image taken the same day. This would lead to a more detailed map where a legend could be produced showing actual sediment or mineral concentrations in the water.

References and Citations

Jensen, J. R. (2016). *Introductory digital image processing: A remote sensing perspective* (4th ed.). Pearson.

Lake Erie algae blooms: Polluting our drinking water. Alliance for the Great Lakes.
(2021, July 13). Retrieved November 17th, 2021, from https://greatlakes.org/campaigns/lake-erie-algae-blooms/.

United States Geological Survey, Department of the Interior. LANDSAT-8, OLI TIRS.
Scene ID: LC80190312019204LGN00. (June 23rd, 2019). USGS Explorer http://earthexplorer.usgs.gov (November 14th, 2021).

Composite images produced with PCI Geomatics Catalyst. Maps produced with ESRI ArcGIS Pro.

Base Map Source: ESRI Light Grey Canvas, Light Grey Community Map

Projection Source: United States Geological Survey, Department if the Interior.

Projection: Universal Transverse Mercator, Zone 17 North.

Datum: World Geodetic System 1984 (WGS84).

This poster is produced by Aila Jalo as a portion of the requirements for the Remote Sensing program at the Centre of Geographic Sciences, NSCC, Lawrencetown, Nova Scotia.

This project is unedited, unverified and intended for education purposes only.

Centre of Geographic Sciences

COGS | nscc