The Use of Landsat 8 for Monitoring of Fresh and Coastal Water

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By Javier A. Concha

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Hypothesis

• “The L8 sensor can be utilized to simultaneously quantify the concentration of water constituents (specifically chlorophyll, suspended solids, and colored dissolved organic matter) in fresh and coastal waters.”
CDOM fixed = 0.0954 1/m

<table>
<thead>
<tr>
<th>CHL=0.01</th>
<th>TSS=0.01</th>
<th>TSS=9.11</th>
<th>TSS=30.7</th>
<th>TSS=50.0</th>
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</table>
TSS fixed = 1.4 g/m$^3$
Differences in Rrs with low and high Chl-a concentrations

![Graph showing differences in Rrs with varying Chl-a concentrations.]

- Chl-a = 5.0 ug/L
- Chl-a = 10.0 ug/L
- Chl-a = 60.0 ug/L
- Chl-a = 65.0 ug/L

TSS = 5.0 mg/L

$a_{CDOM}(440) = 0.9819 \, 1/m$
NASA’s OCx Models* vs Hydrolight
everything fixed but chl-a

\[ a_{\text{CDOM}}(440) = 0.0954 \, 1/m \]

TSS = 0.01 mg/L

*O’Reilly at al. (2000)
NASA’s OCx Models* vs Hydrolight nothing fixed

\[ C_a \text{ [mg/m}^3\text{]} \]

\[ R_{\text{blue}}/R_{\text{green}} \]

*O’Reilly at al. (2000)
Area of Study
Retrieval

Radiance

Atmospheric Correction

Water Pixels

Chl-a=?
TSS=7
CDOM=?

$R_{rs}^{\text{Chl-a=3}}$
TSS=4
CDOM=7

CPAs
Concentration
Map

RMSE

LUT
Empirical Line Method (ELM)

\[ L(\lambda) = \frac{E'_S(\lambda)\cos(\sigma')r(\lambda)\tau_1(\lambda)\tau_2(\lambda)}{\pi} + \frac{E_{ds}(\lambda)r(\lambda)\tau_2(\lambda)}{\pi} + L_{us}(\lambda) \]

\[ L = m \times r_d + b \]
Model-based ELM Method
Bright Pixel

False color image (red = vegetation)  City Pixels (Bright px)
Model-based ELM Method

Dark Pixel

ROI water

Reflectance
HydroLight
For low concentrations

Radiance
Landsat 8 image
## LUT: HydroLight (con’t)

### Known Concentrations

<table>
<thead>
<tr>
<th>IOPs Input</th>
<th>$C_a$ [mg m$^{-3}$]</th>
<th>$TSS$ [g m$^{-3}$]</th>
<th>$a_{CDOM}(440nm)$ [1/m]</th>
<th>$b_b/b$ [%]</th>
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Retrieval: RMSE

Water Pixels

LUT
09-29-2014: Chl-a
09-29-2014: CDOM

$L_8$ retrieved $a_{\text{CDOM}}(440\text{nm})$ [1/m]
Ground Truth Collect

Water Samples

Water Leaving Reflectance

Spectroradiometer

Backscattering

Lab Analysis
Lab Measurements

Spectrophotometer

Filtration and Spectrophotometric Analysis

IOPs

HydroLight

Concentrations
# RIT Ground Truth Collection Summary

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<tr>
<th>Date</th>
<th>Ponds</th>
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</table>
Retrieved vs Measured

- $y: 1.02x - 1.65$
  - $R^2: 0.90$; $N: 9$
  - RMSE: 11.86

- $y: 1.06x + 0.03$
  - $R^2: 0.98$; $N: 9$
  - RMSE: 0.07

- $y: 0.92x + 1.73$
  - $R^2: 0.89$; $N: 9$
  - RMSE: 4.98
Error: $\text{RMSE}/C_{\text{max}}$
Future Work

• Include a glint correction

• Try in a different water body

• Validation by comparing with products from ocean color satellites

• Integration with Hydrodynamics models
Thanks for listening!

Question?

Javier Concha: jxc4005@rit.edu
Motivation

- Product not available for medium spatial resolution satellites

- Monitoring the Earth’s fresh water supply: Create a water components product for fresh and coastal water
Empirical Line Method (ELM)

- Two pixels in the scenes with known reflectance
- Linear relationship between radiance $L$ and reflectance $R$
- Conversion pixel by pixel

\[ R_{rs} = \frac{(L - b)}{m} \]
Atmospheric Correction

- A Model-Based Empirical Line Method (ELM)

Atmospheric Correction Method

- Bright pixel:
  - Radiance (Data Spectra): Pseudo Invariant Features (PIF) from L8 image
  - Reflectance (Field Spectra): PIF from Landsat reflectance product (CDR)

- Dark pixel:
  - Radiance (Data Spectra): water ROI from L8 image
  - Reflectance (Field Spectra): HydroLight (estimated concentration)
Fixed Chl-a
different CDOM and TSS
HydroLight

• Case 2: 4-component IOP model
  1. Pure Water
  2. Chlorophyll-bearing particles
  3. CDOM
  4. Mineral Particles

• Output: Water Leaving Reflectance Curves
Model-based ELM Method
Bright and Dark Pixels

Radiance values for ELM-based method

Reflectance values for ELM-based method
Model-based ELM Method

![Graph showing model-based ELM results](image-url)