Predicting Water Quality In Kentucky Lakes Using Landsat Satellite Imagery

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Limitations of Lake Sampling

- Over 600 lakes in Kentucky (17 lakes over 1,000 acres)
  - Staffing limitations and logistical concerns
- High cost – Travel and analysis of samples
- Identify harmful algal blooms (HAB's)
  - No time to explore a whole lake looking for blooms
- Sample size not representative of entire waterbody (next)

Objective: Develop the ability to frequently and effectively monitor water quality in lakes using remote sensing and Landsat satellite imagery.
Remote Sensing using Landsat Imagery

• Acquiring information without the field work.
• Provides aerial data using different wavelengths of light.
• Used for monitoring in many disciplines (glacier and rain forest loss, population change and climate change).

1972-Present

Landsat 7- Still functioning, but with faulty scan line corrector (2003).
Landsat 8- Launched Feb 2013.

http://www.crisp.nus.edu.sg/~research/tutorial/intro.htm
Landsat Imagery

1.) Landsat imagery provides well calibrated data collected every 16 days.

-Aug 30, 2013
-June 11, 2013
-May 26, 2013

-Atmosphere has to be clear to obtain good data (~10% Cloud Cover).

-New QA Band.
2.) One Landsat 8 image covers \( \sim 12,000 \text{ mi}^2 \) (115 mi x 105 mi).
• 9 major reservoirs
• 24 personnel hours
Landsat Imagery

3.) Landsat imagery provides digital numbers in a 30 m x 30 m pixel size.

- Thousands of sample locations.
- Identify problem areas easily at fine scales.

Digital Numbers
Band 1=10779
Band 2=9726
Band 3=8728
Band 4=7395
Band 5=7341
Band 6=5564
Band 7=5333
Landsat Imagery

4.) Able to analyze many water quality variables using different band wavelengths.

-Each band explains a different story
-Helps in differentiating HABs and Chlorophyll (next.)
Identify Harmful Algal Blooms

These are obvious
It might look like this
Landsat Imagery

5.) It’s Free!

www.earthexplorer.usgs.gov

www.glovis.usgs.gov
Field Methods

• Taylorsville Lake was sampled from georeferenced locations.

• *In situ* chlorophyll *a* and *secchi depth* samples were collected on the same day as the satellite fly over (± 3 days).

• 2014 – Phycocyanin samples to model cyanobacteria density
Remote Sensing

• Digital numbers were extracted at georeferenced sites using seven bands of Landsat 8 imagery data.

Digital Numbers

- Band 1=10779
- Band 2=9726
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MLR Models

• Employed Stepwise Multiple Linear Regression
  – Water quality variables as the dependent variable (chl $\alpha$ and total P)
  – Bands 1-7 as the independent variables.

• Used stepwise comparison of single bands and ratio of bands to find model with the best fit
  – Chl $\alpha = 46.399 - (0.068*B3) + (0.108*B4) - (0.042*B6)$
    • (Adj $R^2 = 0.60$  $p < 0.001$  $n = 27$)
  – Secchi Depth = -3.4815 + (0.0021*B2) – (0.00157*B3) – (0.0004*B7)
    • (Adj $R^2 = 0.66$  $p < 0.001$  $n = 17$)
Taylorsville Lake

**Chlorophyll a (µg/l)**
- 0 - 5
- 5-10
- 10-15
- 15-20
- 20-25
- 25-30
- 30-40
- 40-50
- 50-60
- > 70

Actual
- 16-32 µg/l
- 42-60 µg/l

Predicted
- 15-40 µg/l
- 40-70 µg/l
Barren River Lake

Chlorophyll a (µg/l)
- 0 - 5
- 5-10
- 10-15
- 15-20
- 20-25
- 25-30
- 30-40
- 40-50
- 50-60
- > 70

-Geographic Differences
-Identifying Sources
Secchi Depth Model

### Secchi Depth (meters)
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1.0 - 1.2
- 1.2 - 1.4
- 1.4 - 1.6
- 1.6 - 1.8

Laurel River Lake

Taylorsville Lake
Cumberland River

-More dynamic than lakes (flow and seasonal characteristics play a factor)
• Able to monitor many environmental variables.
• Time and cost efficient.
• A useful tool to identify geographic and temporal water quality trends in lakes and some rivers.
  — Regular observation.
Advances

Un-manned Aerial Vehicles
Advances
ESA Sentinel 2

*Launches in 2015

Every 2-3 days
Thank You.

Questions?