Utilizing Moderate Resolution Satellite Observations to Map Algae in the Grand Lake Watershed

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Why water quality monitoring?

Water quality status

Point and nonpoint source pollution

Enforce laws and regulations

Water quality impairment

Enforce laws and regulations
Problems with conventional monitoring routines

- Limited resources
- Spatial limitations
- Temporal limitations
- *Accessibility issues
- *Unsafe areas

*Not observed in Grand Lake

Studies have used Earth Observation satellites to overcome these challenges
Why use satellites for monitoring algae?
About blue-green algae (BGA)

- Also known as cyanobacteria
- Microscopic organisms that live in water
- Too small to be seen, but can form visible algal blooms
- Blooms form in warm, slow-moving waters rich in nutrients
- Blooms usually occur in late summer or early fall
- The blooms can be blue, bright green, brown, or red
- Some blooms may not affect the appearance of the water
- As algae in the blooms die, water may have unpleasant odor

For more information: Oklahoma State Department of Health (OSDH) website
Exposure to BGA

- Skin Exposure: rash, hives, or skin blisters.
- Inhalation: runny eyes, runny nose, sore throat, asthma like symptoms, allergic reactions
- Ingestion: Acute, severe gastroenteritis (stomach cramps, nausea, diarrhea or vomiting)
- It may take hours or days for liver toxicity to show up in humans or animals
- Neurotoxicity symptoms may appear within 15 to 20 minutes of exposure.
- Medical care is supportive
- The Oklahoma State Department of Health (OSDH) recommends: avoid water when you see symptoms of BGA, look for and obey alerts
BGA in the Grand Lake Watershed!

Grand Lake, Oklahoma. June-July 2011

Grand Lake, Oklahoma. June-July 2011

Marion Lake, Kansas. May 2004
Lake was shut down on July 4th!
The need for a tool to guide monitoring priorities
Objective

In-situ Chl-a & BGA data + Landsat & Sentinel-2 data

Temporally & Spatially coincident

Algorithm

Mapping tool for Grand River Dam Authority

Chl-a: Chlorophyll a
Area of interest: The Grand Lake Watershed
Monitoring Reservoirs
Area of interest: Landsat scenes (WRS)

Oklahoma and Kansas share some path/row combinations

WRS: World Reference System
Water Quality Sampling: 2015, 2016, 2017

1. Sample dates
   - Temporally coincident satellite overpass
   - Sampling begins just prior to satellite overpass and continues for a short period after

2. Alternative
   - +/- 2 days individual satellite overpasses (acceptable)
   - Assumes no rainfall/runoff event
Water quality sampling
Image Acquisition and Processing

- **EROS Center**
  - Retrieves and processes images

- **USGS: Landsat**
  - Provide images via website
  - Free of cost

EROS: Earth Resources and Observation Science
USGS: United States Geological Surveys
Building the mapping tool

- Download from USGS website
- Image processing
- Extract information from image
- Build relationships between spectral and in-situ data
- Validate the relationships
- Develop computer algorithms for the relationships
- Integrate into mapping software for developing algae maps
Data validation – Lab & Probe Comparisons

- All measures of algal biomass were correlated
- Extracted chlorophyll, laboratory fluorescence, probe fluorescence
Data validation – Probe Comparisons

Correlations between OSU and GRDA probes were also good
Data validation – Band Comparisons (Landsat 7: 7/26/11)

Turbidity reflects these types of relationships
How best is this pattern reflected in spectral terms?

Data validation (Grand Lake OK, Landsat 8: 7/15)
Whole Lake (7/2015 image)

Riverine Zone (7/2015 image)

Expected band relationships for Turbidity

$R^2 = 0.5908$
The observed conditions show valid relationships for turbidity. The graph shows the correlation between Band 3 (Green) and Turbidity (Landsat 8), with an $R^2$ value of 0.7365.
What about Algae?

http://biologicalexceptions.blogspot.com/2013/06/the-colors-of-alien-plants.html

http://www.seos-project.eu/modules/marinepollution/marinepollution-c03-p05.html
Using percent BV

No. of brightness values (BV) = \(2^\text{bits}\)

- Landsat 8 = 16 bits (65,536 BVs)
- Highest BV = 8,734.373 (13.3% compared to ~3%)
- Reliable predictor of algae?
- Note: BV \neq \text{Reflectance}
Some in-situ Data

Landsat Overpass Date: Grand Lake

No sampling during winter

Ch-a - μg/L

DREAM
DRIP
DROWN
ELK
GRAND
HONEY
HORSE
P DAM
SAIL
SHANG
TREE
WOOD

No sampling during winter
Some in-situ Data

No sampling during winter

Satellite overpass dates

Secchi Disk (m)

Site
- DREAM
- DRIP
- DROWN
- DUCK
- ELK
- GRAND
- HONEY
- HORSE
- P DAM
- SAIL
- SHANG
- TREE
- WOOD

Site No sampling during winter
Moving forward

National level: Collaborate with Federal Agencies (NASA, USGS, EPA)

State/Regional level:
- Build product for GRDA
- Customize product to support monitoring priorities in OK and the region
Research team
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Dr. Nathhan Torbick, Applied Geosolutions

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References


Thank you!