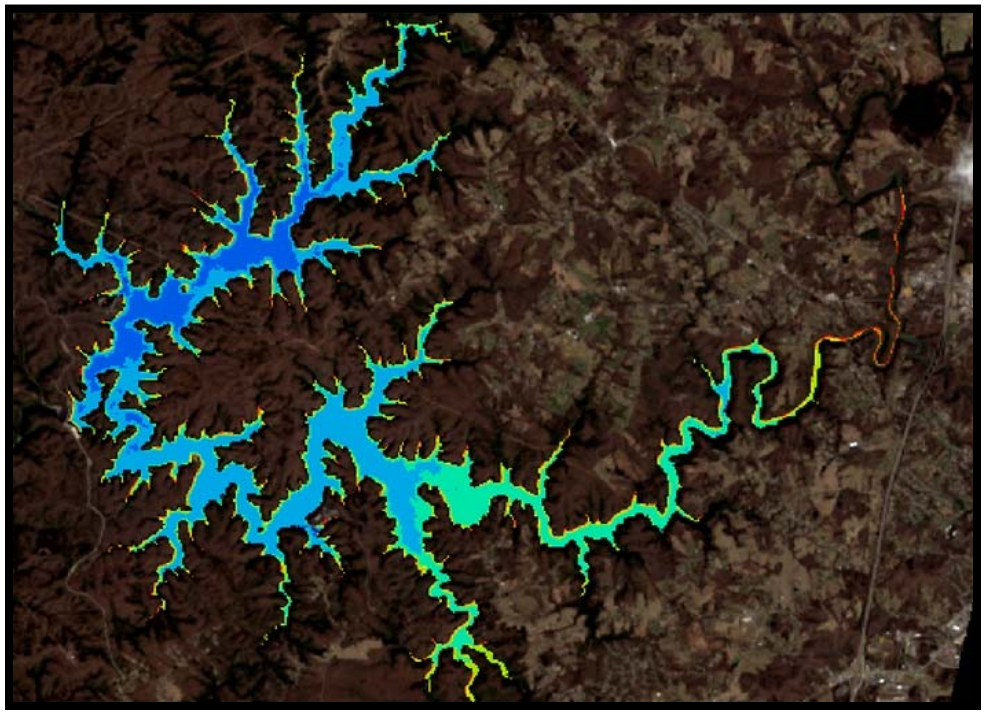
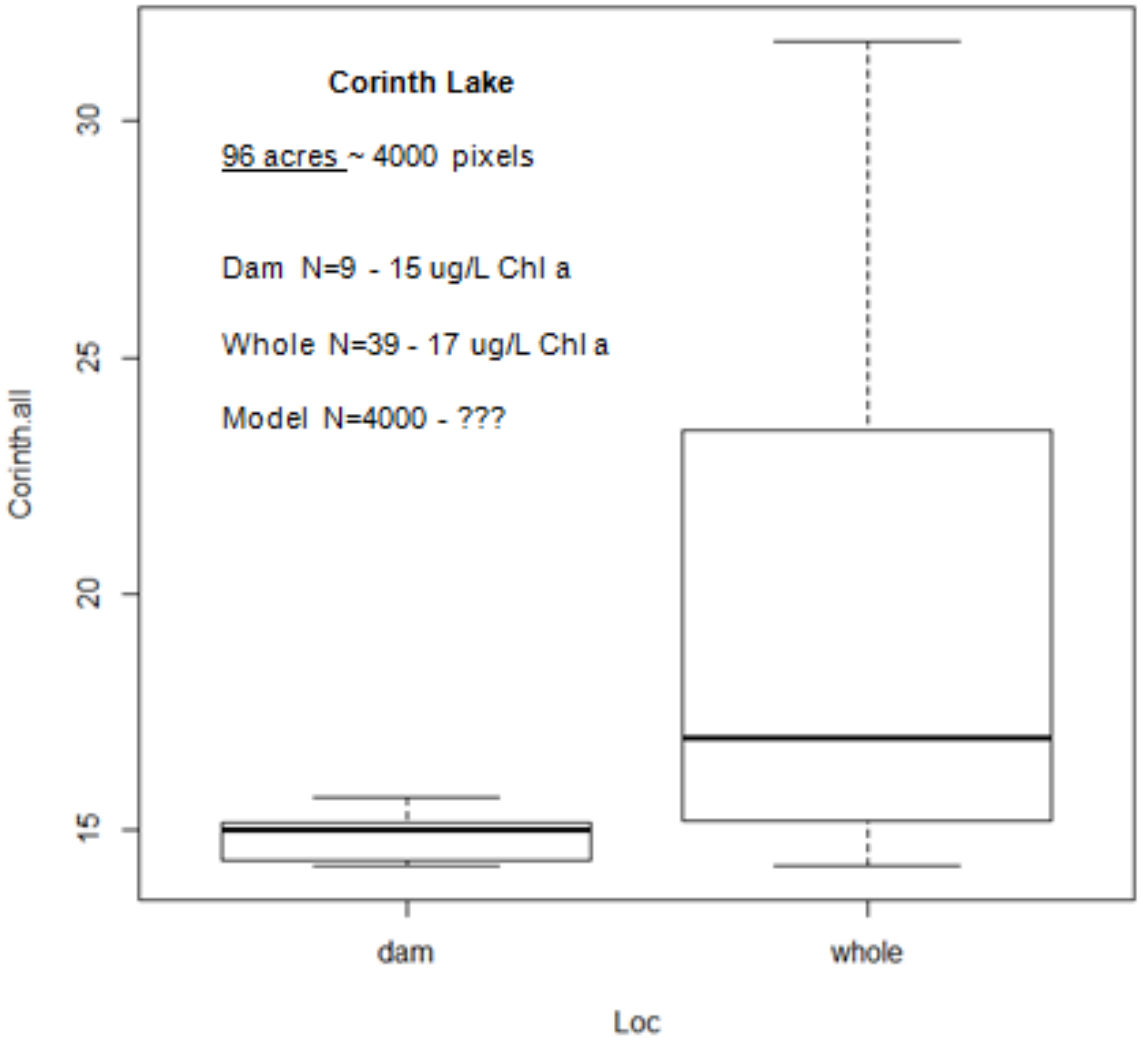
Predicting Water Quality In Kentucky Lakes Using Landsat Satellite Imagery



Garrett Stillings and Mark Martin
Kentucky Division of Water
Water Quality Branch

Limitations of Lake Sampling

- Over
  - St
- High
  - Tr
- Iden
  - N
- Sam
  (nex



)00 acres)

ns

erbody

to
itor
mote

imagery.

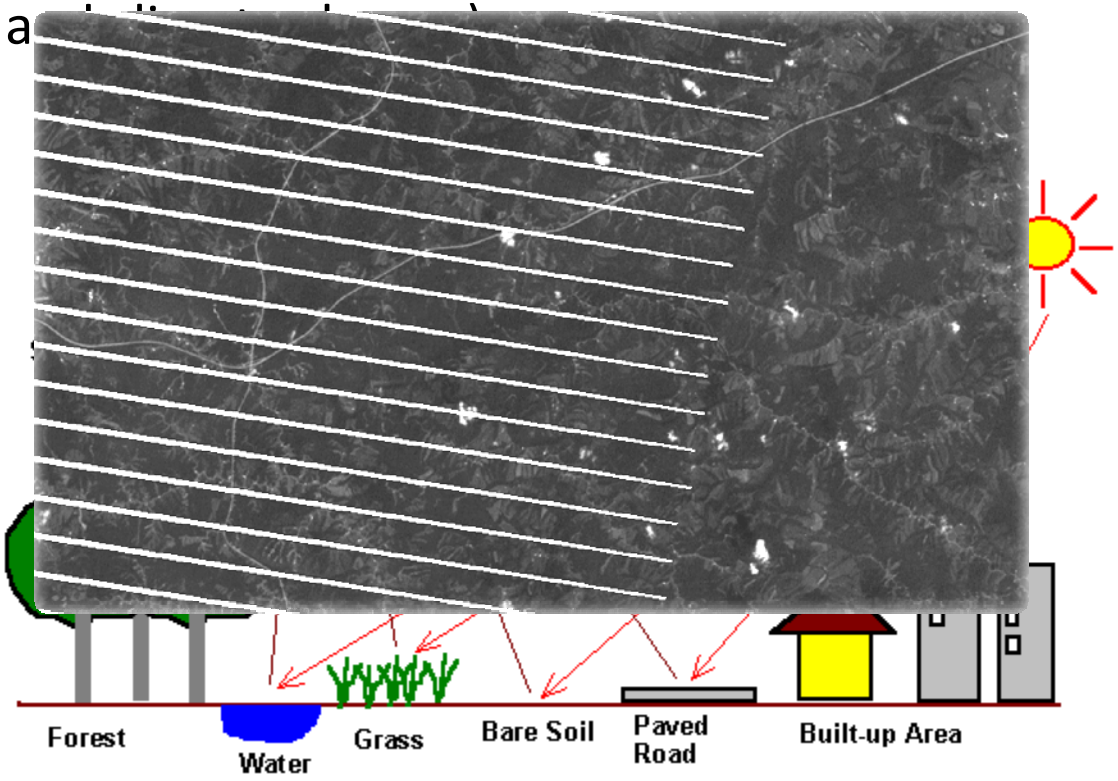
Remote Sensing using Landsat Imagery

- 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 a

1972-Present

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

Landsat 8- Launched Feb 2013.



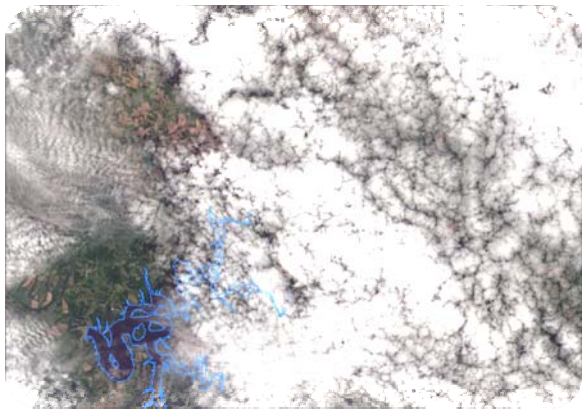
http://www.crisp.nus.edu.sg/~research/tutorial/intro.htm

Landsat Imagery

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

Aug 30, 2013

June 11, 2013



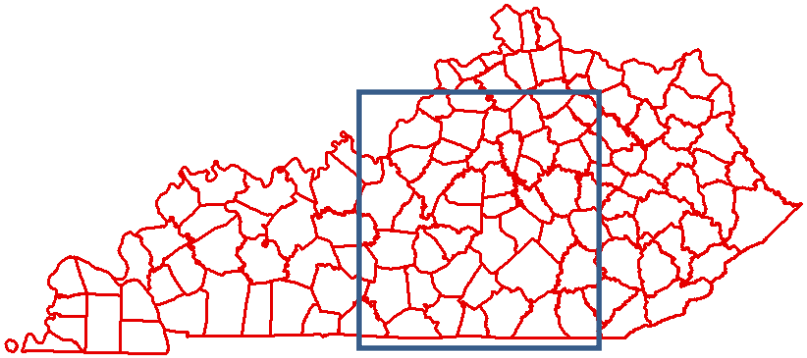
May 26, 2013

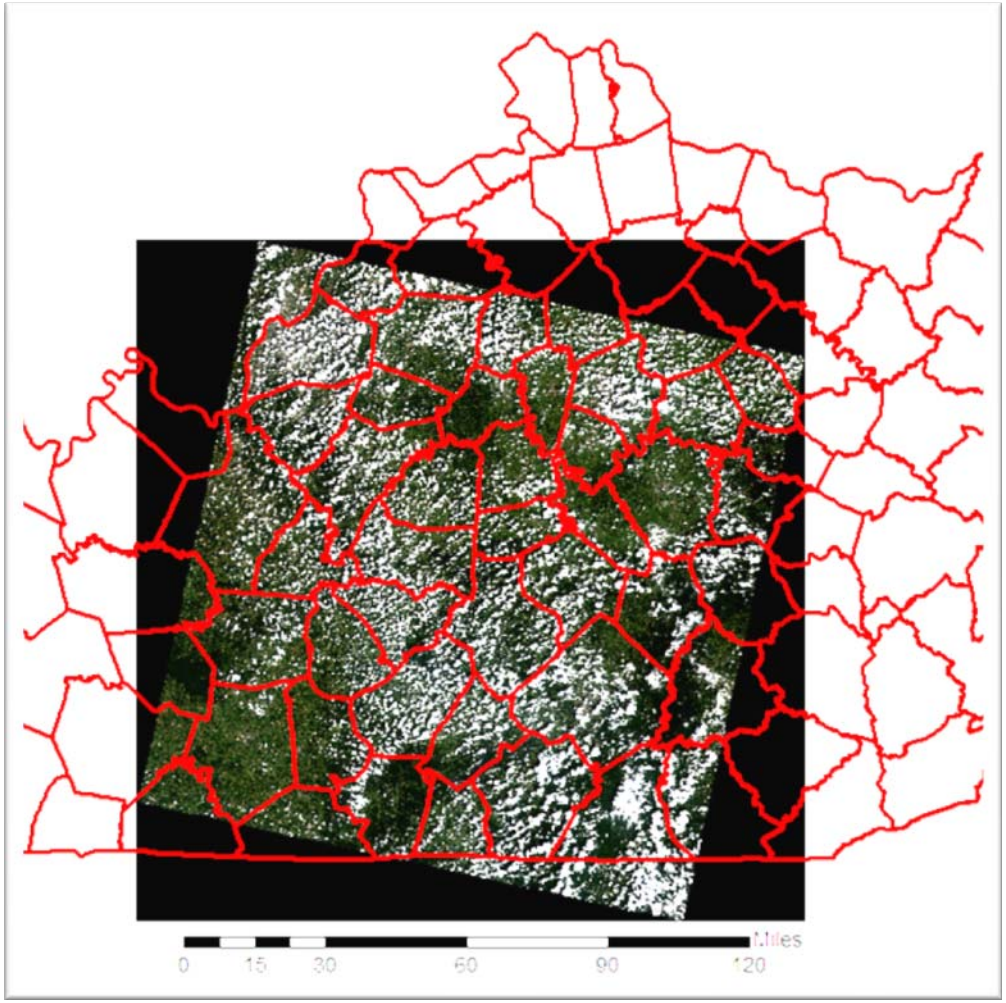
-Atmosphere has to be clear to obtain good data (~10% Cloud Cover).

-New QA Band.

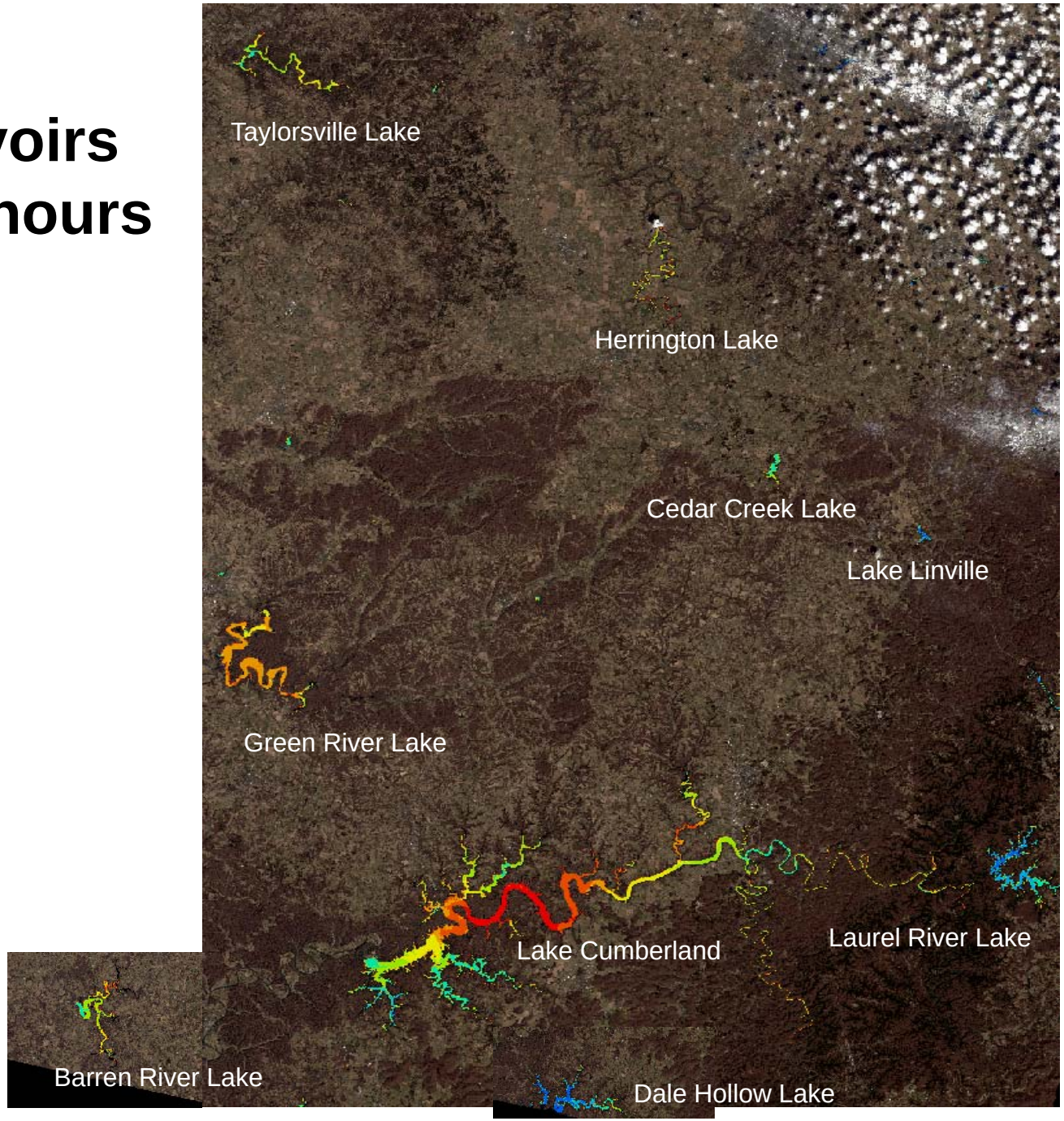
Landsat Imagery

2.) One Landsat 8 image covers ~12,000 mi^2 (115 mi x 105 mi).





- **9 major reservoirs**
- **24 personnel hours**

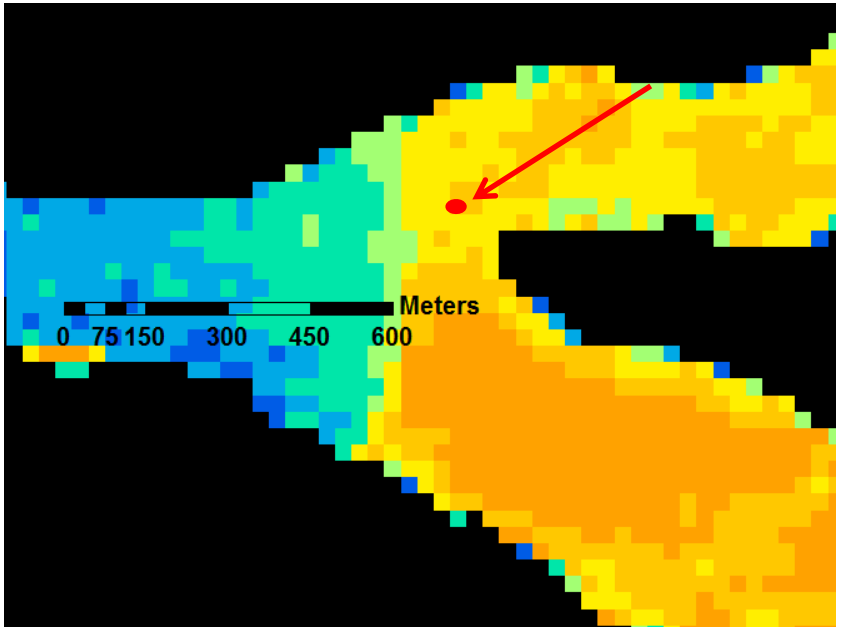


Landsat Imagery

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

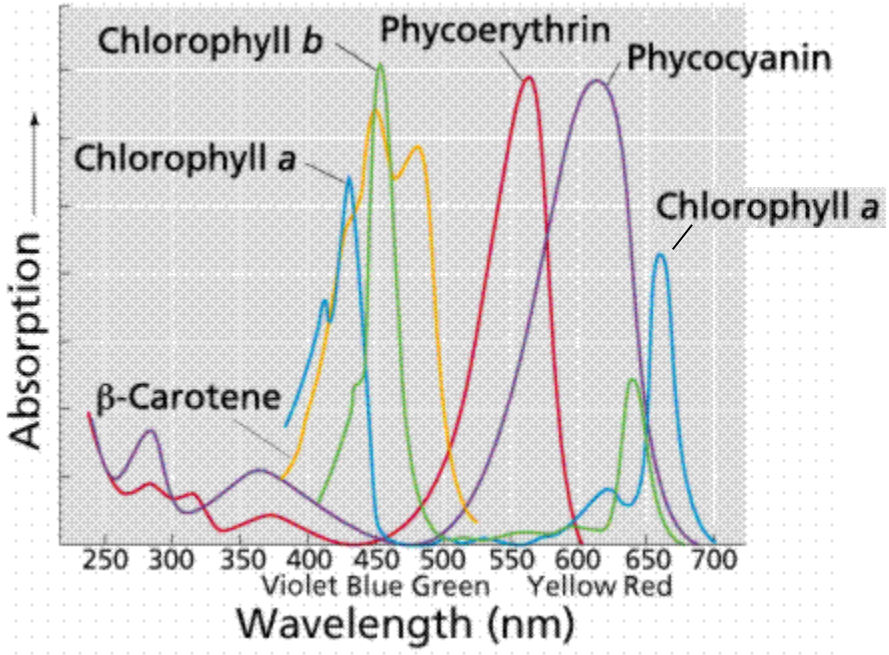
Band 1=10779
Band 2=9726
Band 3=8728
Band 4=7395
Band 5=7341
Band 6=5564
Band7=5333

Landsat Imagery

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

Spectral Band	Wavelength
Band 1 - Coastal / Aerosol	0.433 - 0.453 µr
Band 2 - Blue	0.450 - 0.515 µr
Band 3 - Green	0.525 - 0.600 µr
Band 4 - Red	0.630 - 0.680 µr
Band 5 - Near Infrared	0.845 - 0.885 µr

www.landsat.usgs.gov



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

Identify Harmful Algal Blooms

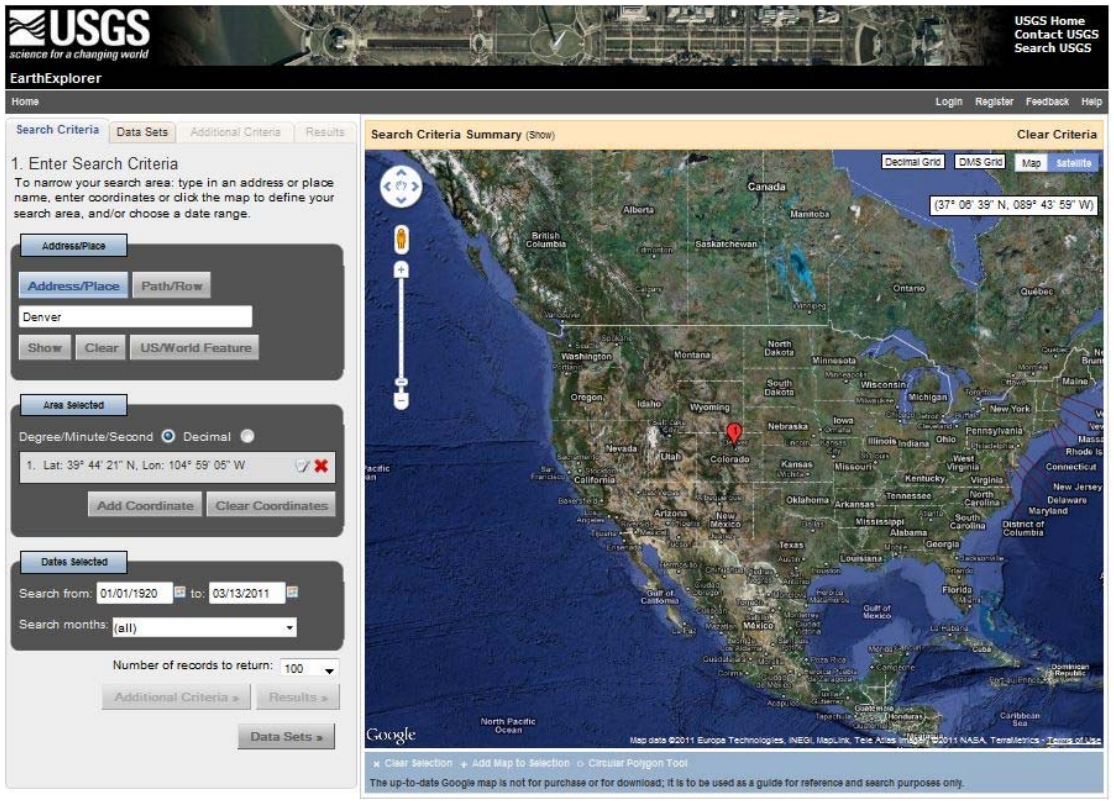
These are obvious

It might look like this

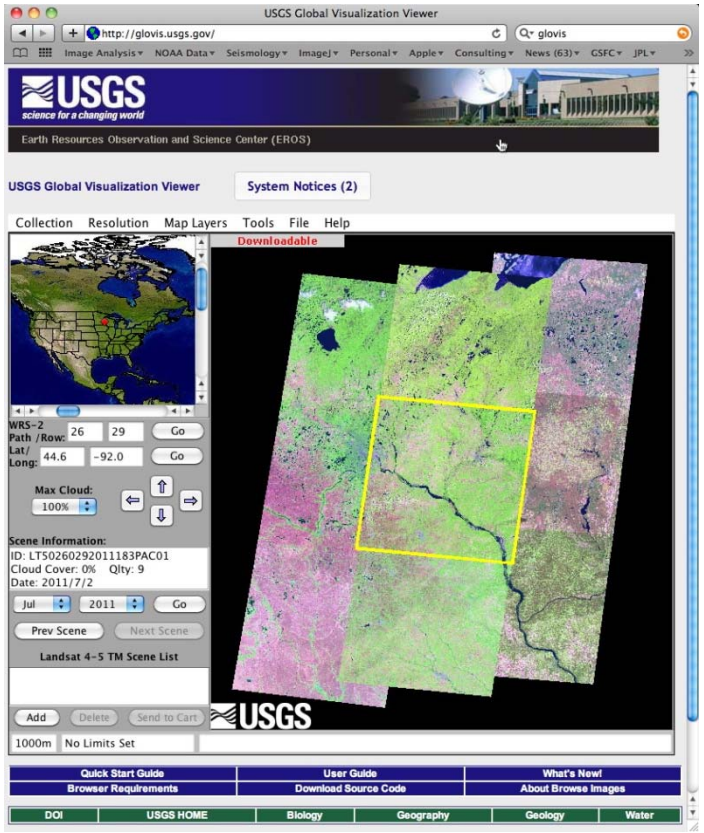
Landsat Imagery

5.) **It's Free!**

www.earthexplorer.usgs.gov



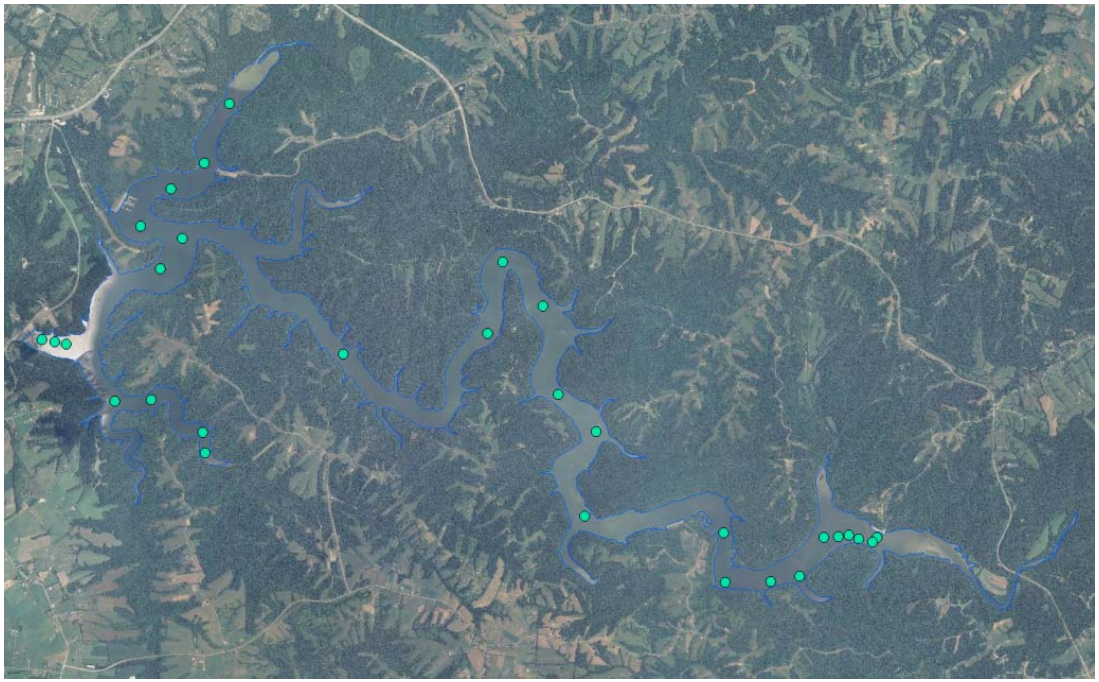
www.glovis.usgs.gov



Field Methods

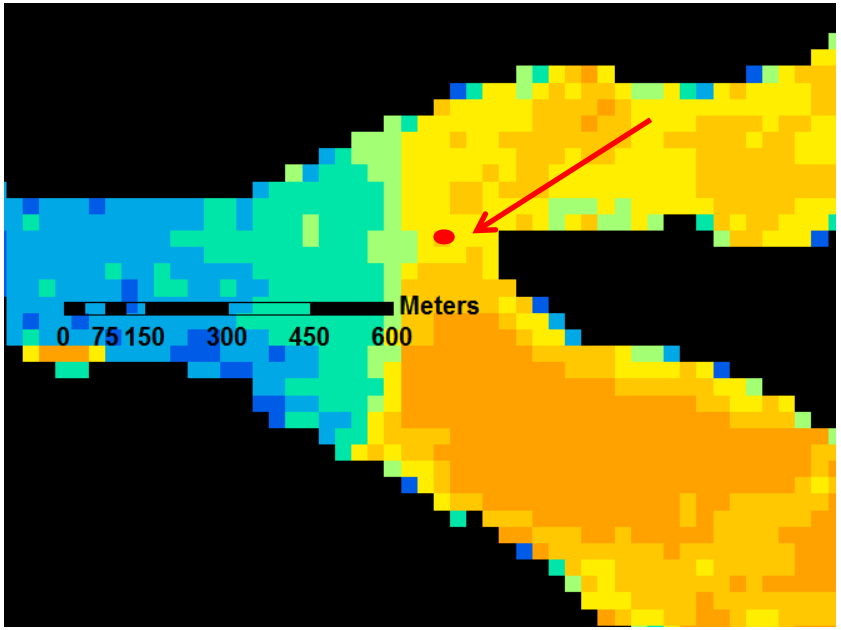
- Taylorsville Lake was sampled from georeferenced locations.
- *In situ* **chlorophyll *a*** and **secchi depth** samples were collected on the same day as the satellite fly over (± 3 days).

- 2014 – Phycocyanin samples to model cyanobacteria density



Remote Sensing

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

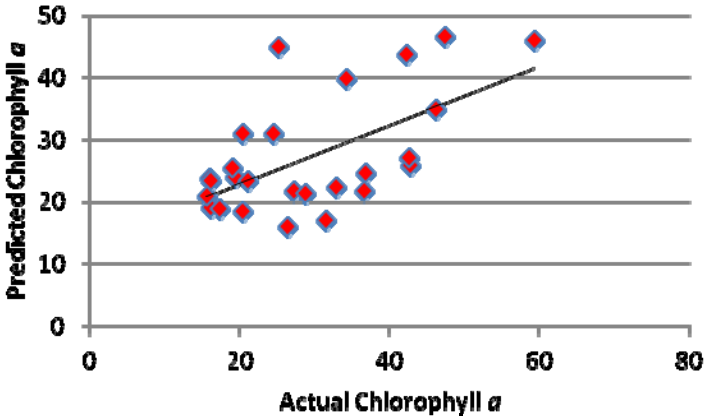


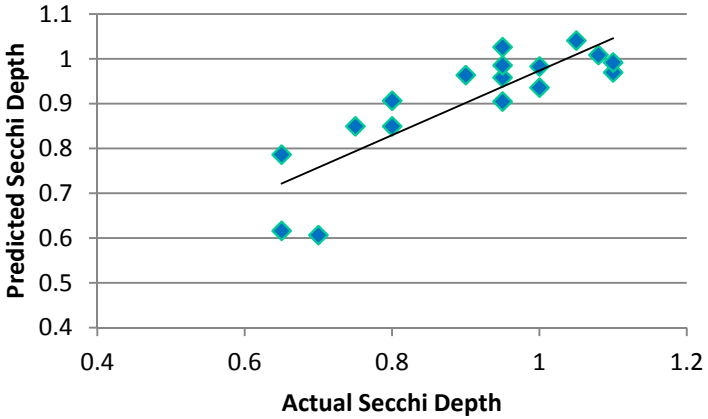
Digital Numbers

Band 1=10779
Band 2=9726
Band 3=8728
Band 4=7395
Band 5=7341
Band 6=5564
Band7=5333

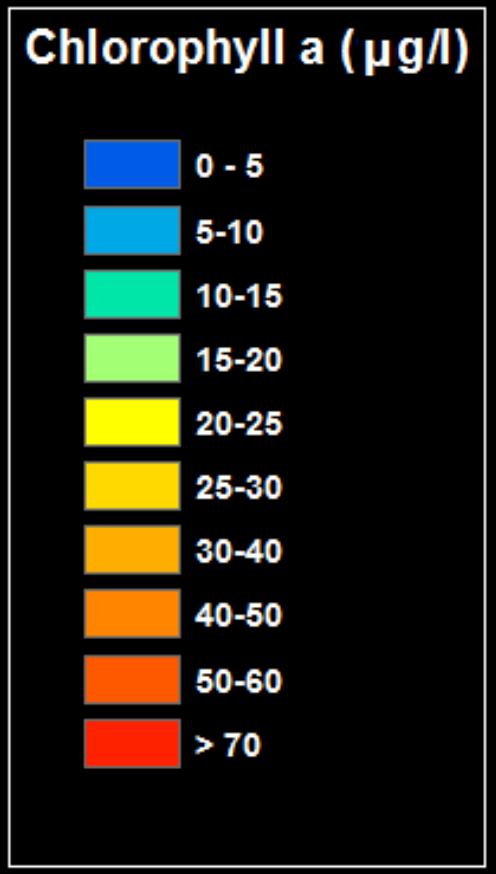
MLR Models

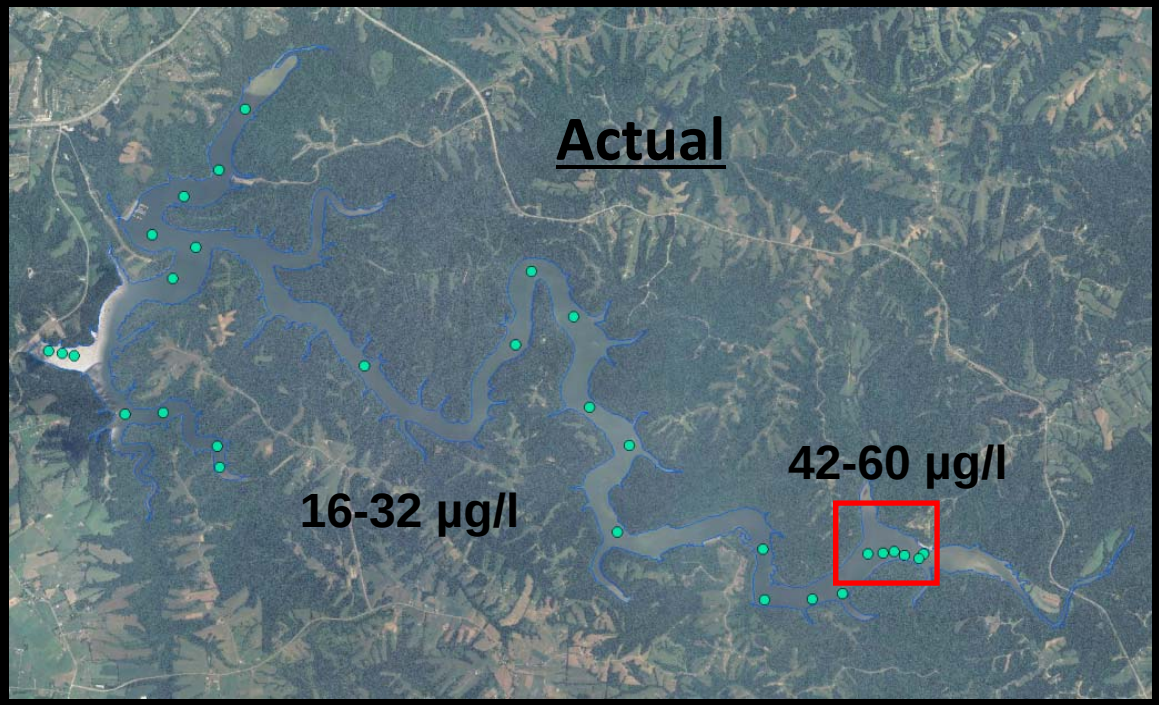
- **Employed Stepwise Multiple Linear Regression**
  - Water quality variables as the dependent variable (chl *a* and total P)
  - Bands 1-7 as the independent variables.
- **Used stepwise comparison of single bands and ratio of bands to find model with the best fit**
  - Chl *a* = 46.399 - (0.068*<u>**B3**</u>) + (0.108*<u>**B4**</u>) – (0.042*<u>**B6**</u>)
    - **(<u>Adj R^2 = 0.60</u> p < 0.001 n = 27)**
  - Secchi Depth = -3.4815 + (0.0021*<u>**B2**</u>) – (0.00157*<u>**B3**</u>) – (0.0004*<u>**B7**</u>)
    - **(<u>Adj R^2 = 0.66</u> p < 0.001 n = 17)**

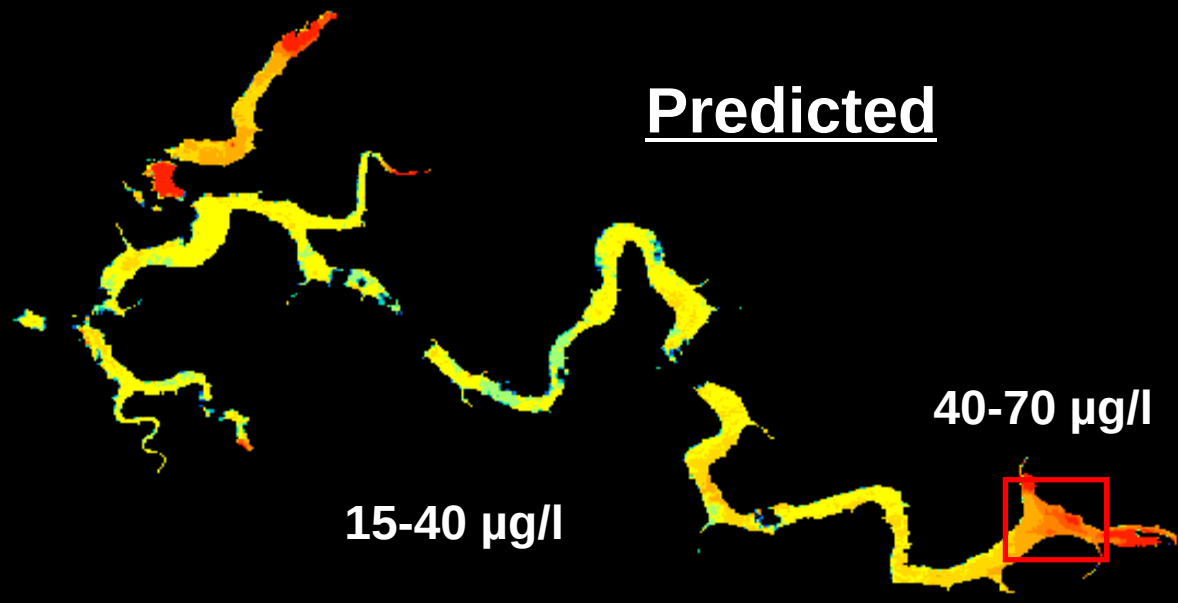




Taylorsville Lake

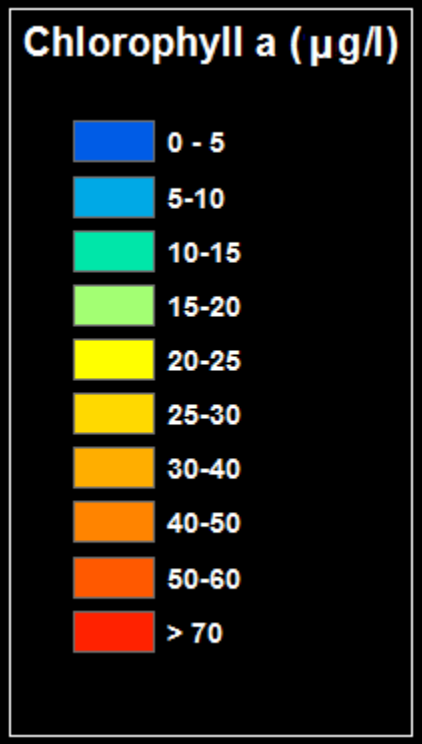


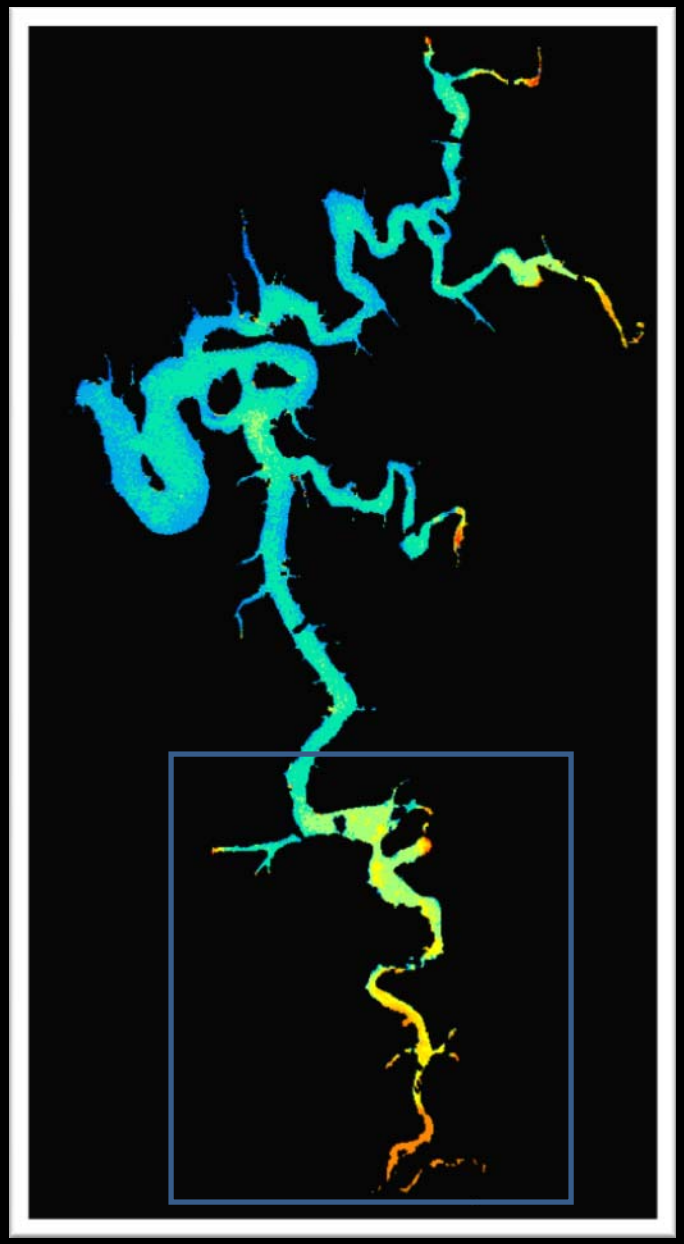




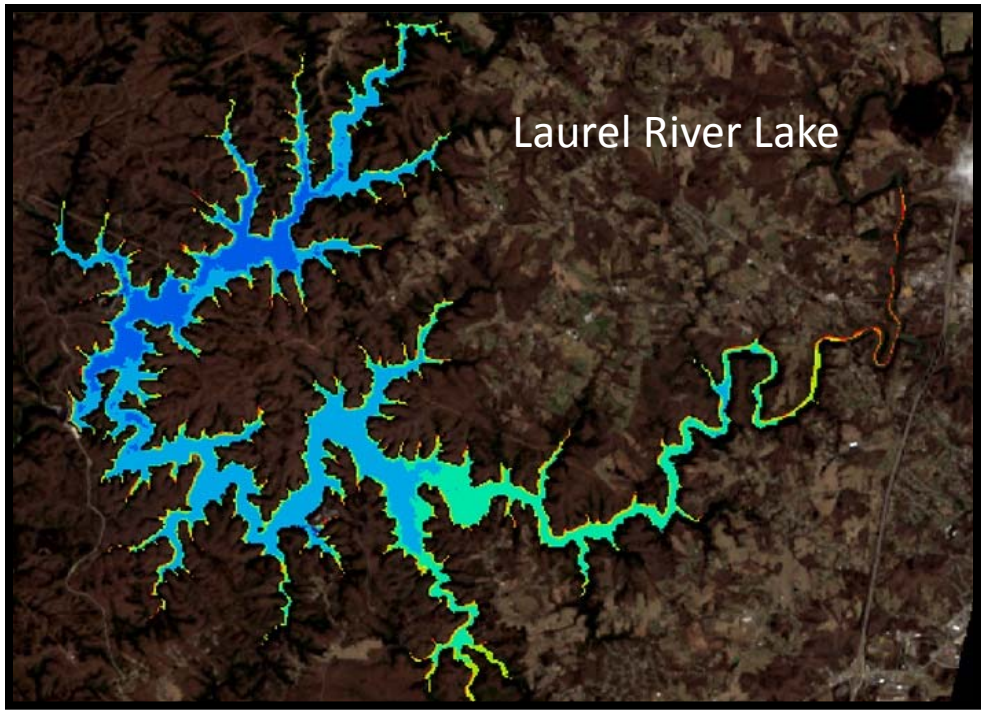
Barren River Lake

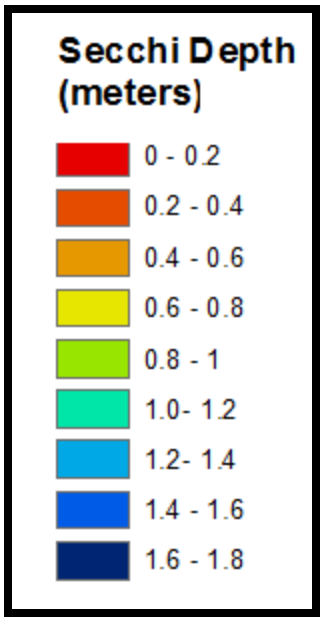
-Geographic Differences
-Identifying Sources

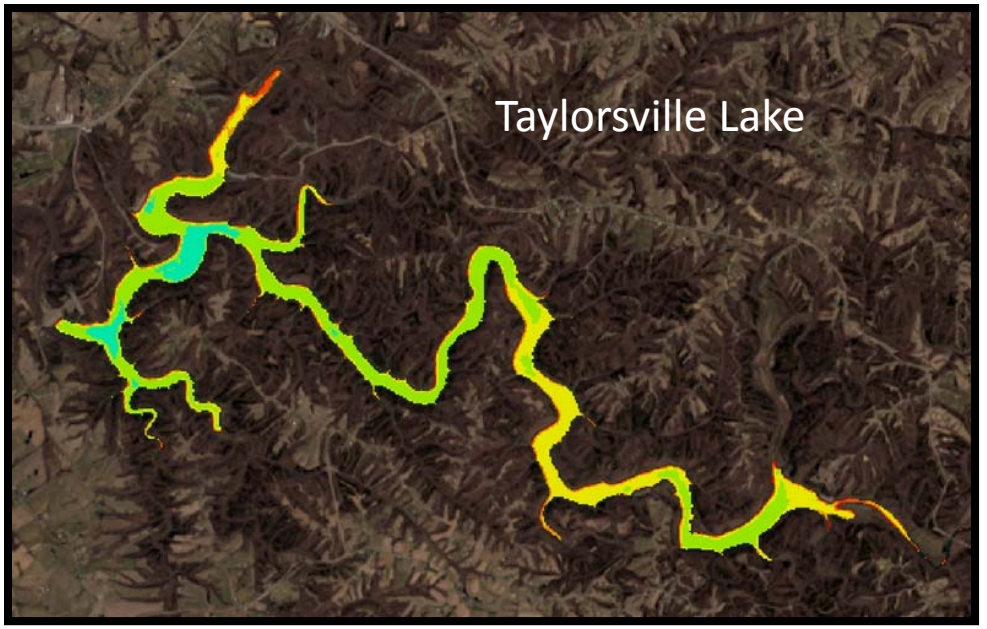




Secchi Depth Model



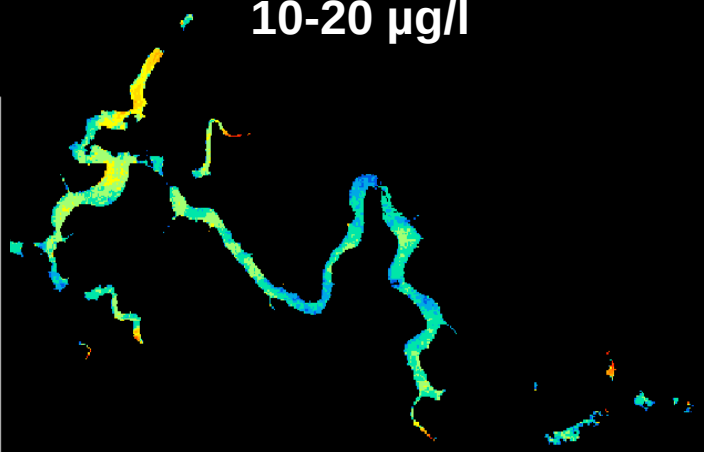




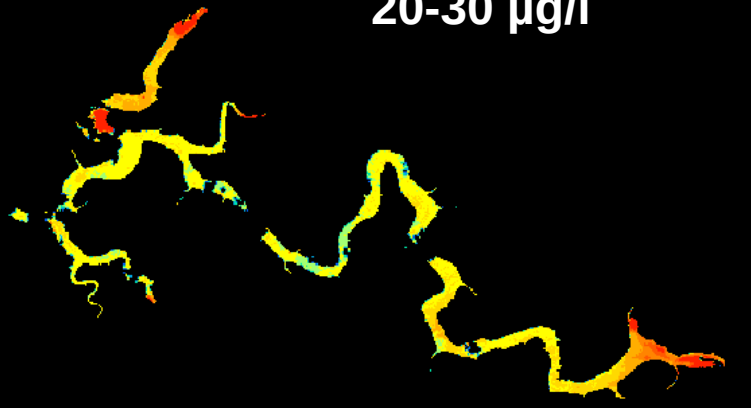
-Temporal Change
-Different Models

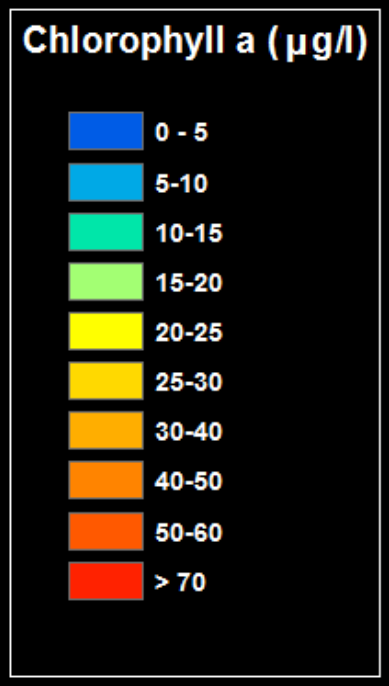
Taylorsville Lake

10-20 µg/l



20-30 µg/l

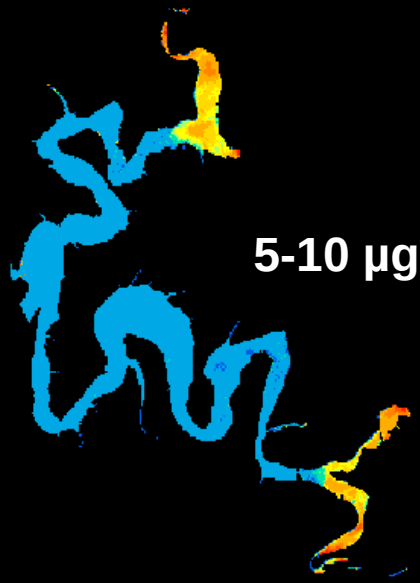




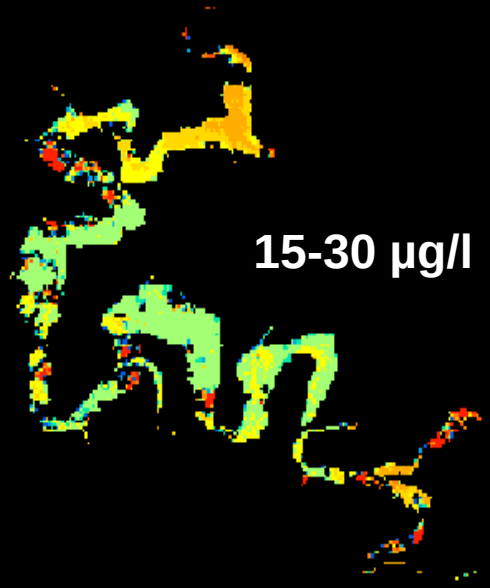
July 29, 2013

Green River Lake

Aug 30, 2013

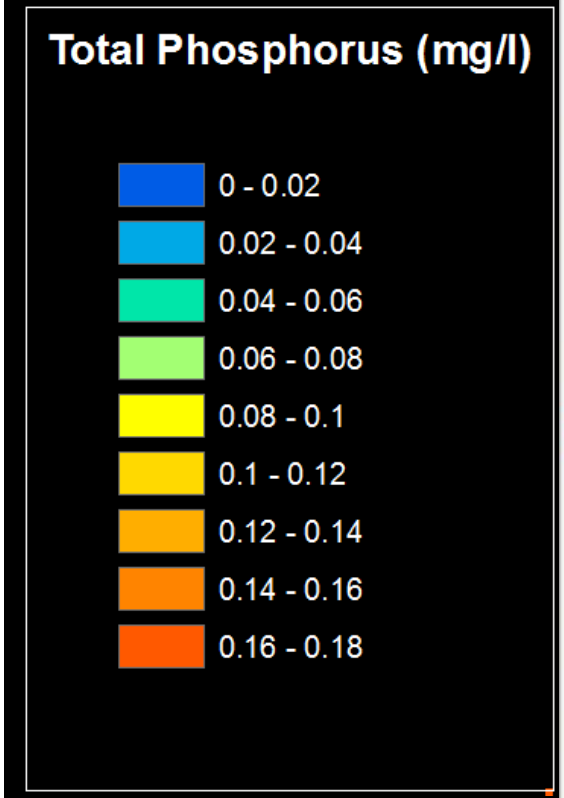


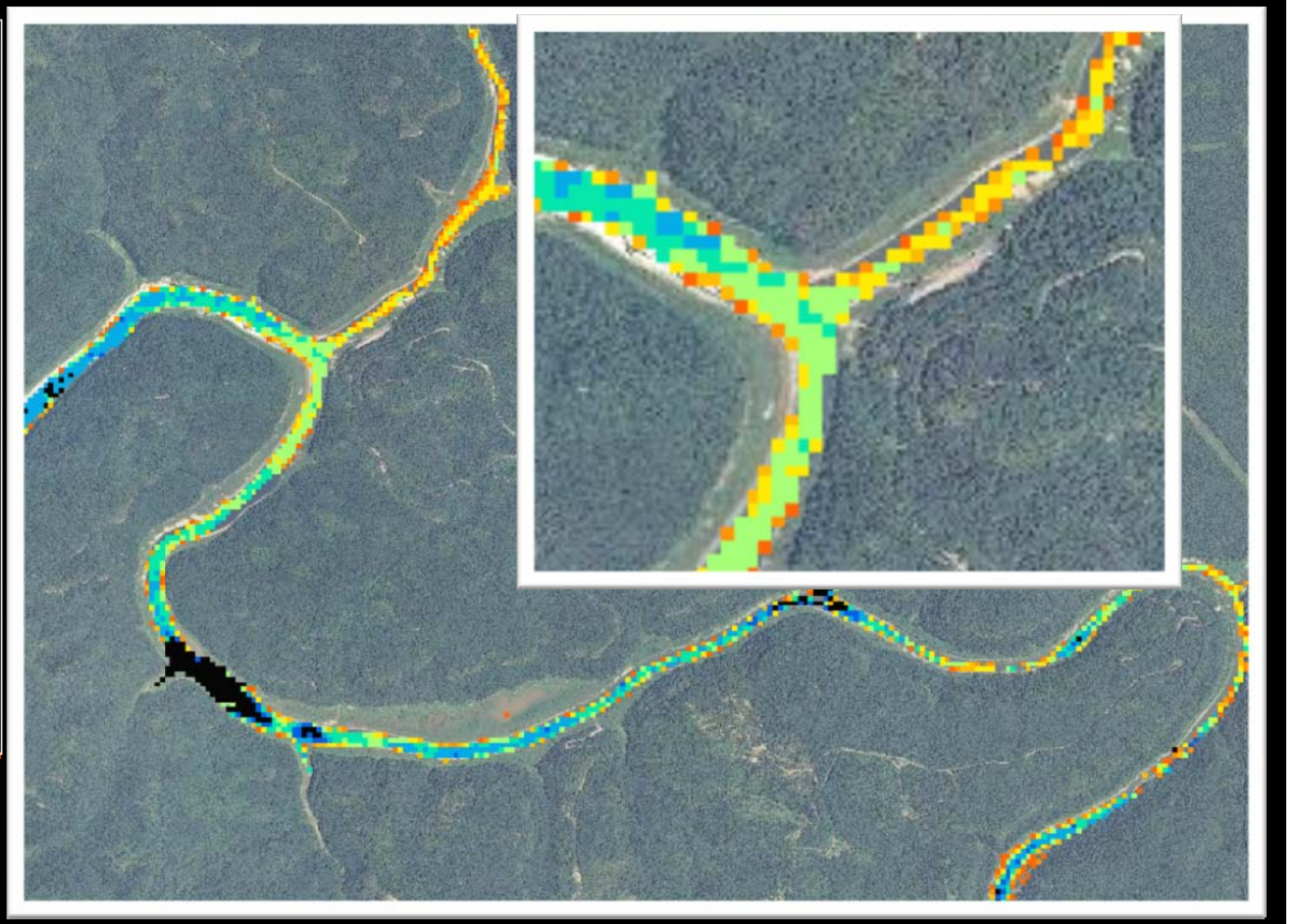
5-10 µg/l



15-30 µg/l

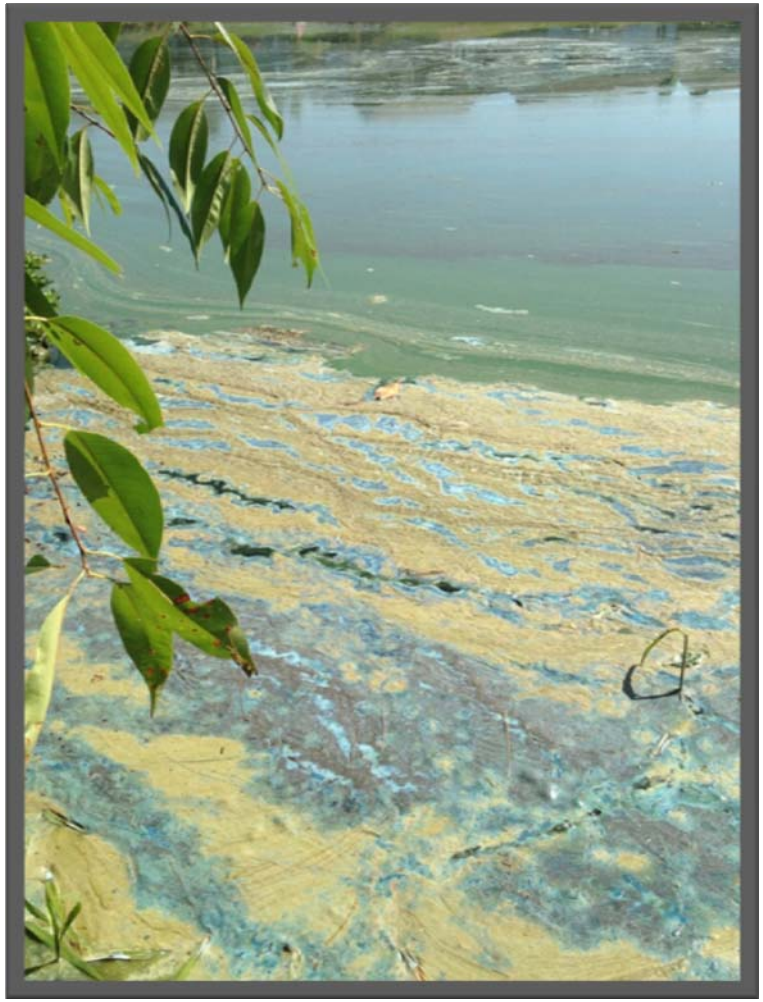
Cumberland River





-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.



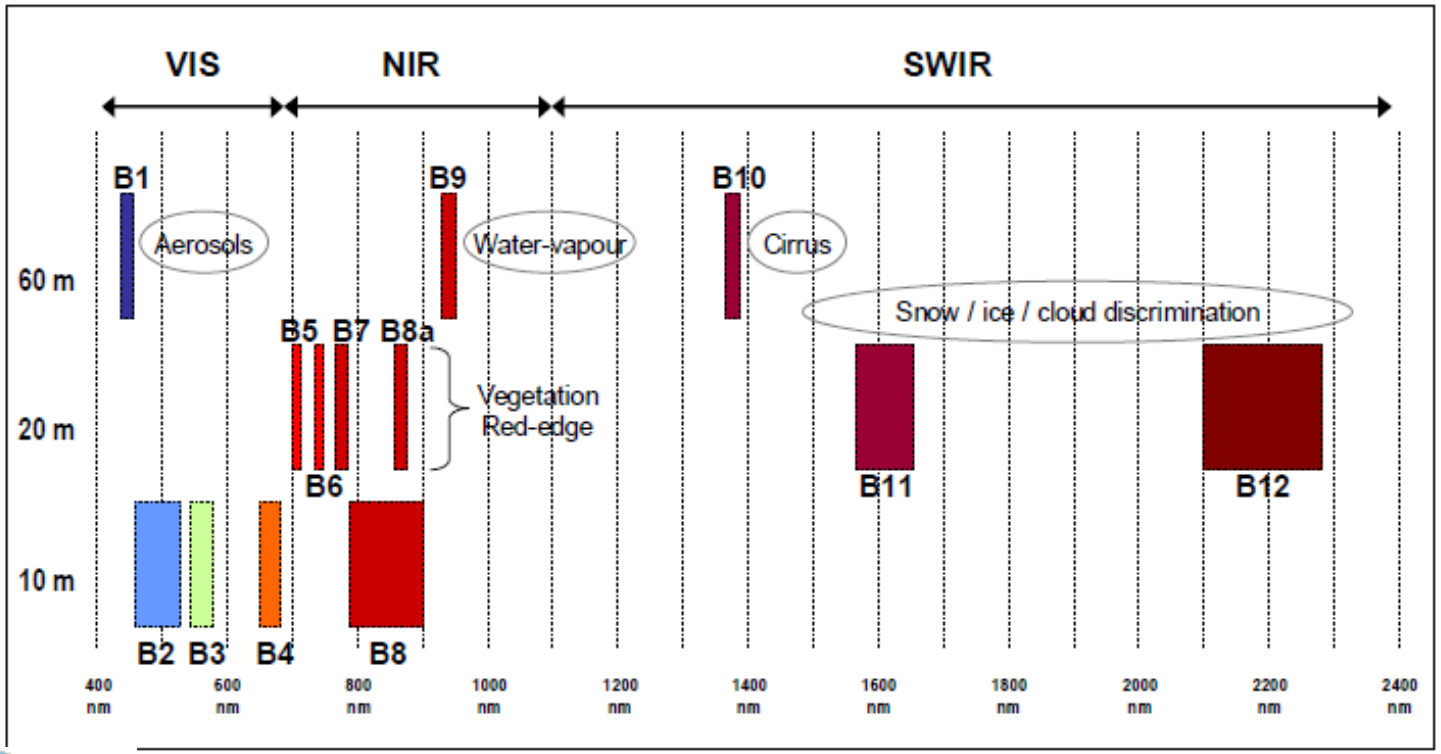
Advances

Un-manned Aerial Vehicles

Advances

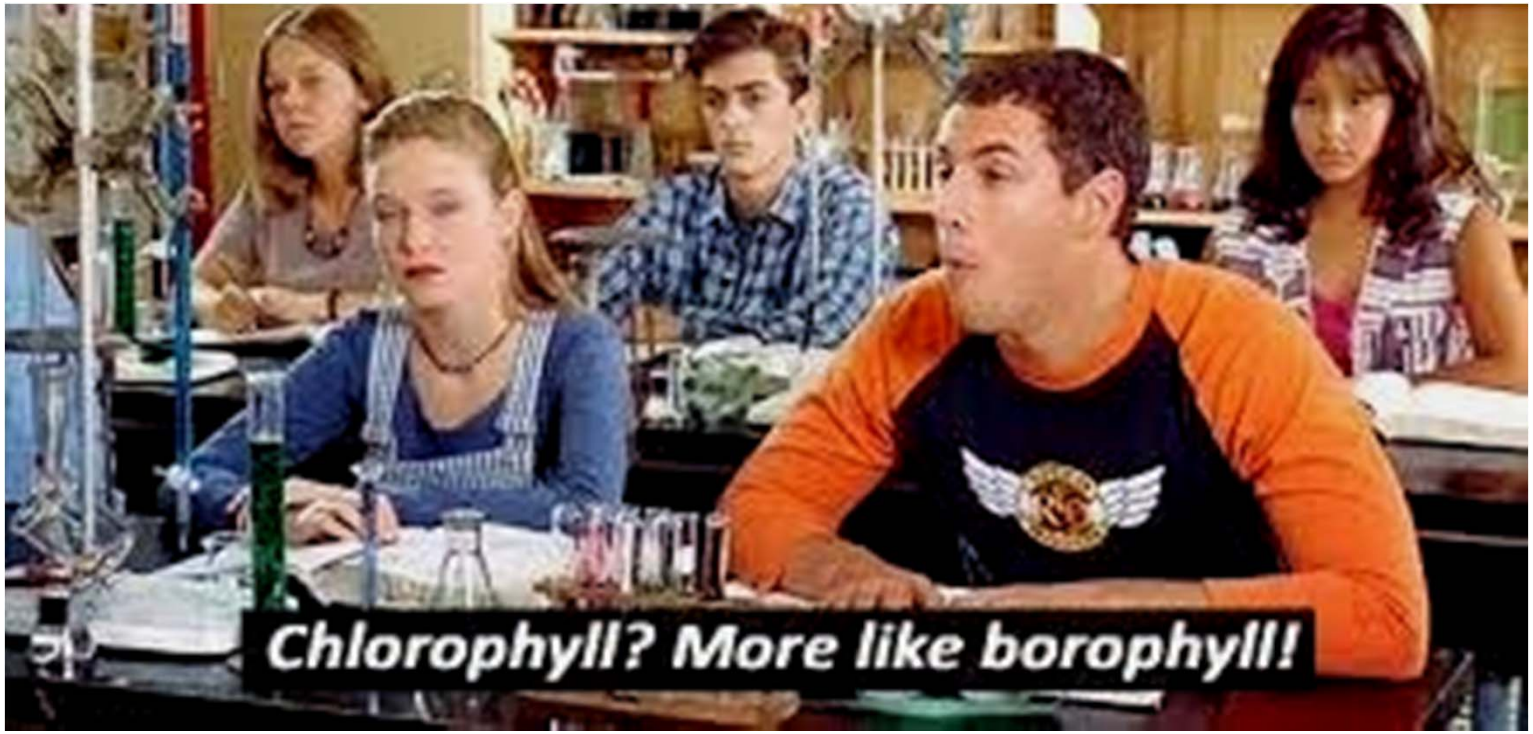
ESA Sentinel 2

*Launches in 2015



Every 2-3 days

Thank You.



Questions?