PILOTING A DECISION SUPPORT TOOL (DST) FOR MAPPING CYANOBACTERIAL HARMFUL ALGAL BLOOMS (CHABS) TO SUPPORT PUBLIC HEALTH AND RESOURCE MANAGEMENT.

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Issue

- Water quality under pressure from multiple stressors
  - Land use, climate change, point and non-point source pollution, population
- Traditional techniques to assess inland lakes are costly, time consuming, spatiotemporally limited, many agency budgets small or shrinking
- Rising concerns regarding human health and water quality as pressures continue to grow
- Recent efforts finding water quality, cyanobacteria toxicity, and human health linkages (ALS Disease)

Problem Statement

- A primary obstacle in advancing our understanding of linkages between cyanobacteria blooms, toxicity, and human health is lack of water quality information

Overarching Goal

- Operationalize a strategic suite of water quality metrics derived from satellite remote sensing

- Develop tools and modeling framework to support public health decision making

HABs Snapshot

- NASA EOS Terra MODIS image -Lake Erie
- western basin, Microcystis aeruginosa blooms

Sensors?

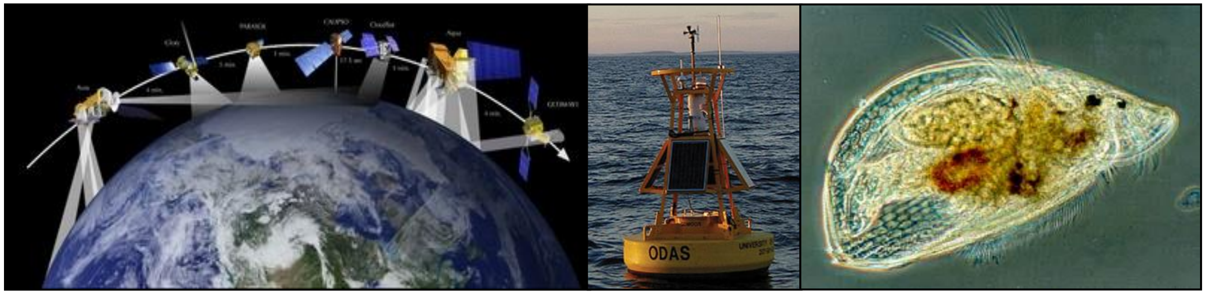
- Choosing sensors requires consideration of several factors

	Operational	Spatial	Temporal	Spectral	Small lakes	Bio-optical	Archive	Cost
Landsat	Well suited	Good	Good	Good	Good	Fair	Well suited	Well suited
MERIS	Good	Fair	Well suited	Well suited	Poor	Well suited	Good	Well suited
MODIS	Well suited	Poor	Well suited	Fair	Poor	Well suited	Well suited	Well suited
HICO	Poor	Good	Fair	Well suited	Fair	Good	Poor	Good
Proba CHRIS	Poor	Well suited	Fair	Well suited	Well suited	Good	Poor	Good
EO-1	Poor	Good	Fair	Well suited	Good	Good	Poor	Good
RapidEye	Fair	Well suited	Well suited	Fair	Well suited	Fair	Fair	Fair
WorldView	Poor	Well suited	Poor	Good	Well suited	Fair	Poor	Poor

Well suited | Good | Fair | Poor

Satellite Remote Sensing Platforms

- Scales are key: spatial resolution, temporal frequency, spectral bands



- System relies on multiple satellites:
  - Landsat 5 TM, 7ETM+, and 8OLI scale imagery
    - 8-day intervals, 30m spatial, 180km swath, broad vis-nir channels
    - 1972 – present with Landsat MSS
  - MERIS
    - ESA platform, ~weekly FR, ~280m spatial, 15 narrow bands across vis-nir, 2012
  - MODIS
    - high temporal frequency, 250m+ spatial, large area, 2001- present
  - “Research & high resolution” platforms
    - HICO, Proba CHRIS, EO-1, Rapid Eye, World View-x
    - Useful for case studies and algorithm / product development, but not operational, cost efficient, or wall-to-wall products
    - Integrating in hierarchical, nested grid framework

Sensor Comparison Chart

Satellite Name Launched	Landsat 7 ETM+ July 1999 – May 2003 USGS	Res	IKONOS Sep 24, 1999 GeoEye	Res	QuickBird Oct 18, 2001 DIGITALGLOBE	Res	SPOT 5 May 3, 2002 SPOT IMAGE	Res
Band 1	.45 - .52 µm	30 m	.45 - .52 µm	4 m	.45-.52 µm	2.4 m		
Band 2	.53 - .61 µm	30 m	.51 - .60 µm	4 m	.52-.60 µm	2.4 m	.50-.59 µm	10 m
Band 3	.63 - .69 µm	30 m	.63 - .70 µm	4 m	.63-.69 µm	2.4 m	.61-.68 µm	10 m
Band 4	.78 - .90 µm	30 m	.76 - .85 µm	4 m	.76-.90 µm	2.4 m	.78-.89 µm	10 m
Band 5	1.55 – 1.75 µm	30 m					1.58-1.75 µm	20 m
Band 6	10.40 – 12.50 µm	60 m						
Band 7	2.09 – 2.35 µm	30 m						
PAN	.52 - .90 µm	15 m	.53 - .93 µm	1 m	.45-.90 µm	60 cm	.48-.71 µm	5 m
Range	.45 – 12.5 µm		.45 – .93 µm		.45 - .90 µm		.48 - 1.75 µm	
Image Size (Standard)	170 x 183 km		13.8 x 13.8 km		16.5 x 16.5 km		60 x 60 km	
Collection Bit Depth	8 bits		11 bits		11 bits		8 bits	
Product Bit Depth	8 bits		8 or 11 bits		8 or 16 bits		8 bits	

Sensor Footprint Comparison

= **Landsat Image**

170 km x 183 km
(Path orientation)

= **IKONOS Image**

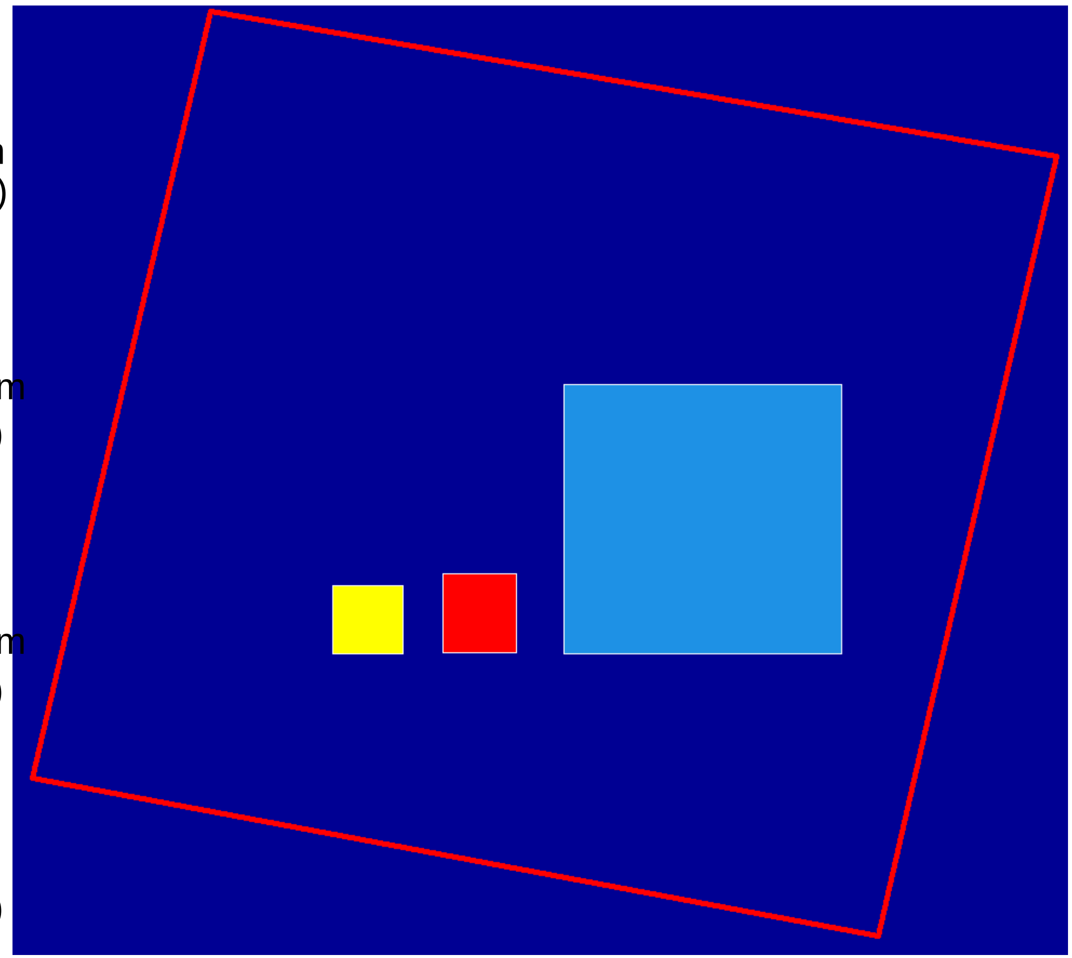
13.8 km x 13.8 km
(Map orientation)

= **QuickBird Image**

16.5 km x 16.5 km
(Map orientation)

= **SPOT 5 Image**

60 km x 60 km
(Map orientation)



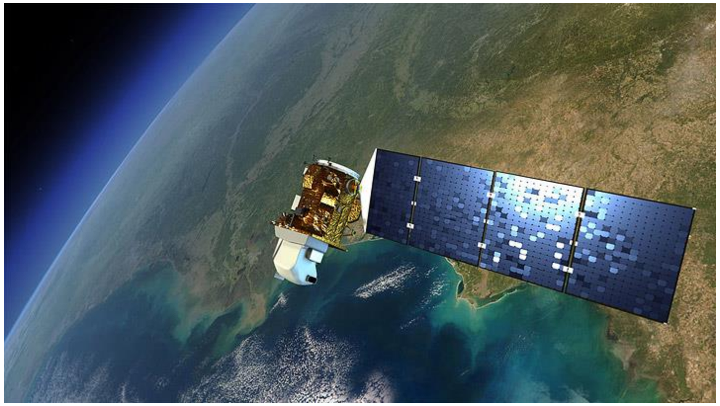
Newer Sources of Data

- WorldView I
  - Panchromatic (0.45 meter)

- GeoEye-1
  - Panchromatic (0.41 meter)
  - 4-band multispectral (1.64 meter)
  - 3 day revisit time

Newer Sources of Data

- Worldview – 2
  - 1 day revisit time
  - 8 multispectral bands
  - 1.8 m resolution
  - 1-2 million km per day when combined with 1.
- Landsat 8
  - 15-100m resolution
  - 11 ms bands (including LW IR)
  - 16 day revisit
  - Free data!



Advantages

- Remotely sensed satellite data and airborne images of the Earth have several important advantages compared to ground observations.
  - **Synoptic view**
    - Allows for simultaneous regional-scale assessments
  - **Frequent and repetitive coverage**
    - Allows for easy updating
  - **Available archived imagery**
    - Allows for examination of historic conditions
  - **Worldwide coverage**
    - Allows for access to remote locations
  - **Low-cost data**

Decision Support Tool Concept

- Driven by satellite remote sensing mapping of lake conditions and water quality metrics
- Develop Apps
- Mobile Devices
- Citizen Scientists
  - Collect data through Apps and upload to cloud
  - Used to collect calibration and validation data such as surface scums, cloudy water, or blooms
- End Users

Cloud and Mobile Apps

- NIH Grant – Link CHABS to ALS Disease
- Applied Geosolutions
  - Develop automated algorithms stored in the cloud
  - Process remotely sensed satellite images on varying scales for various water quality parameters
  - Develop Mobile Apps
    - Integrated with Cloud for direct upload through Apps
    - Data Used to Validate/Calibrate Models

Citizen Scientists

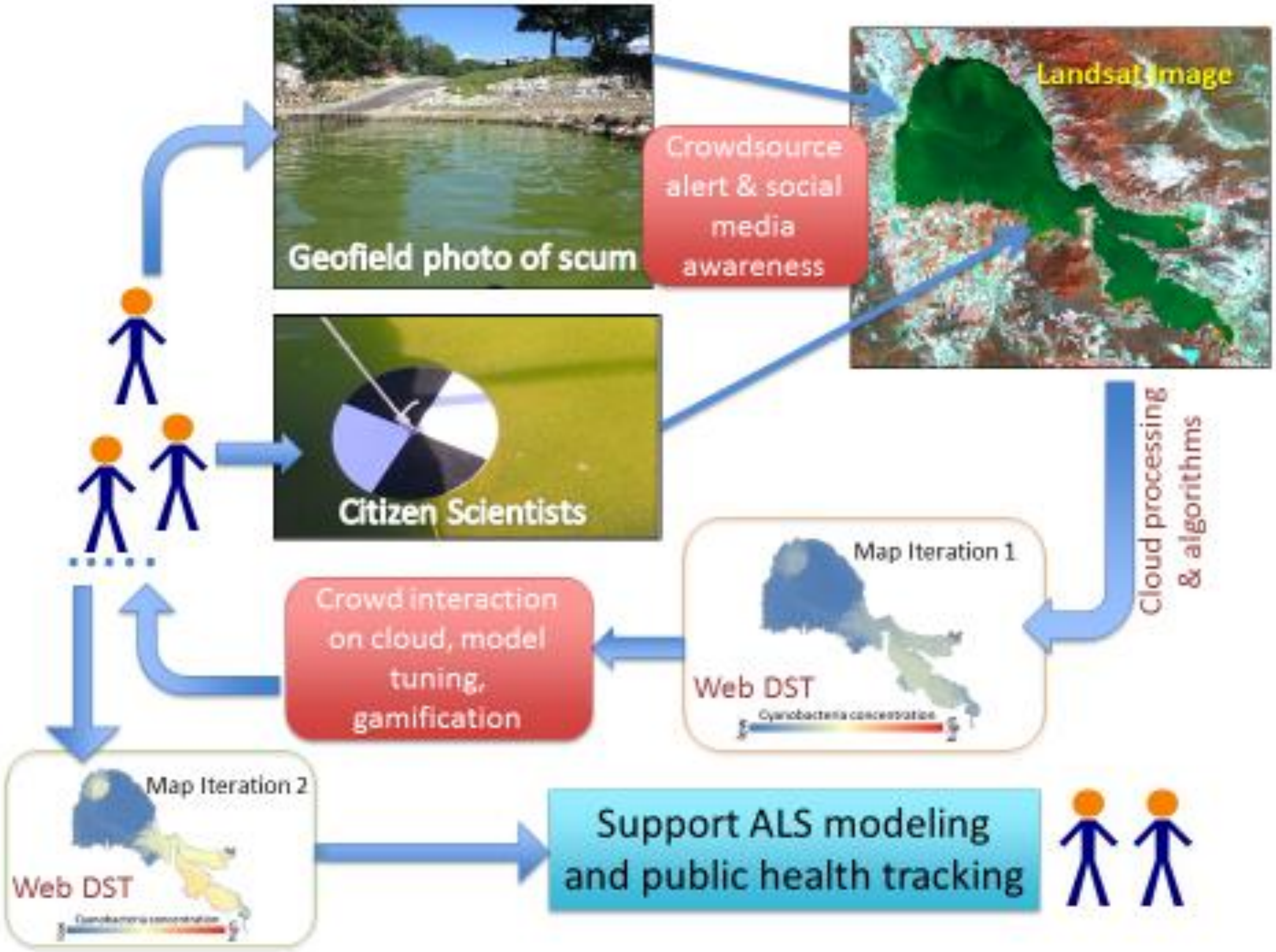
- OSU ESGP Director and Graduate Research Assistant (GRA)
  - Recruit Citizen Scientists (30-50)
    - Lake McMurtry Friends
    - Society of Environmental Scientists
    - Environmental Science Club
    - Zoology Graduate Student Society
    - Oklahoma Clean Lakes and Watershed Association
  - Train Volunteers
    - Multiple Training Sessions at OSU

Citizen Scientists

- Monitor water bodies on a weekly basis based on cloud cover conditions
    - Upload data to the cloud
- Inform volunteers of satellite platform passover times
- Collect Data – temporally coincident with satellite overpass
- Data uploaded immediately
- Models updated to reflect ground truth data

Citizen Scientists

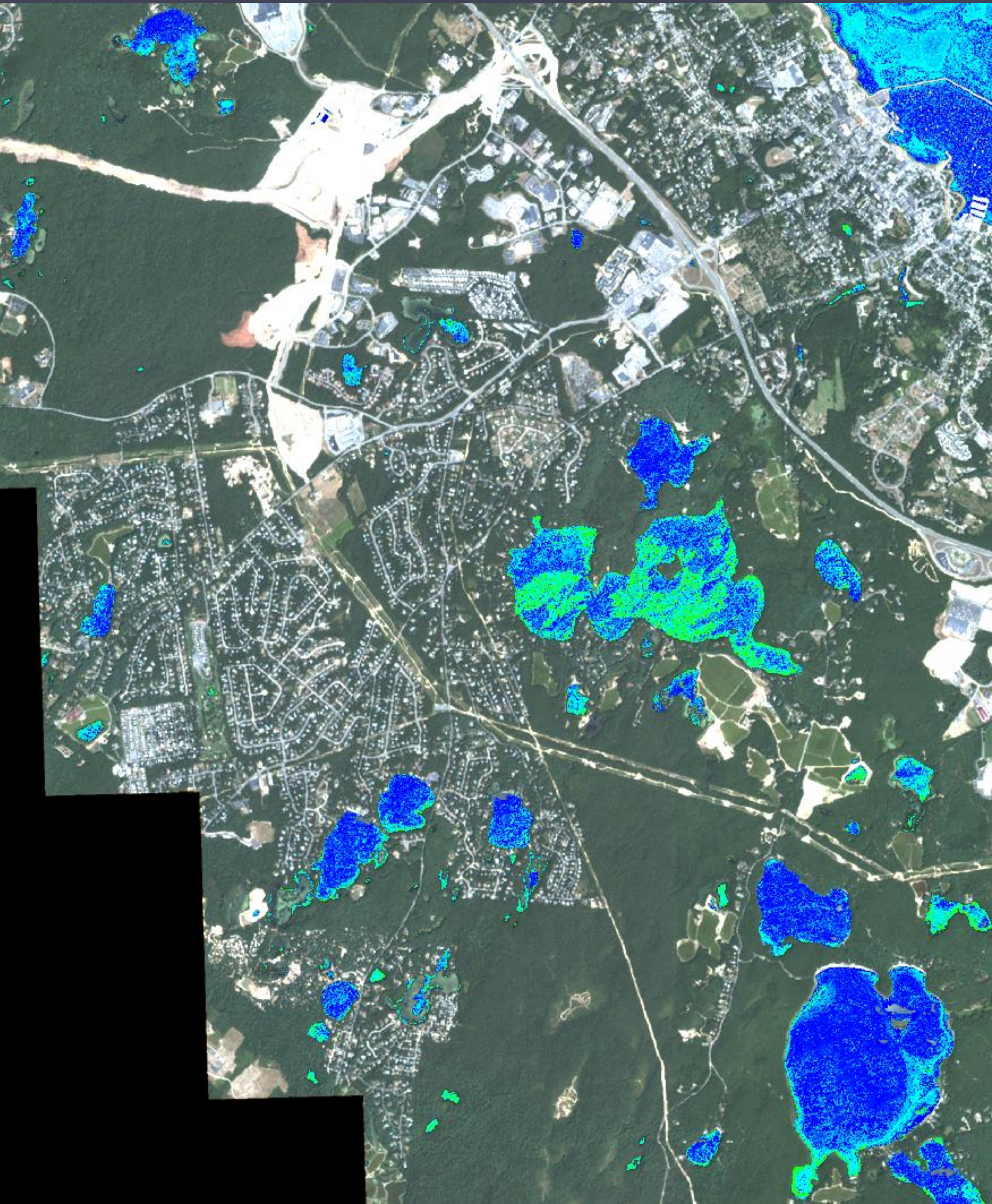
- Phones don't currently have the ability to collect spectral data
- Have to rely on visual interpretation
- Data will be collected from May through October to coincide with like bloom periods
- Processed data used to alert end users



Crowdsourcing citizen scientists

End Users

- Oklahoma Department of Environmental Quality
- Oklahoma Water Resources Board
- Oklahoma Conservation Commission
- Oklahoma State Department of Health
- Lake McMurtry Friends
- Environmental Protection Agency (EPA)



Water Quality Parameters – Plymouth Harbor, MA

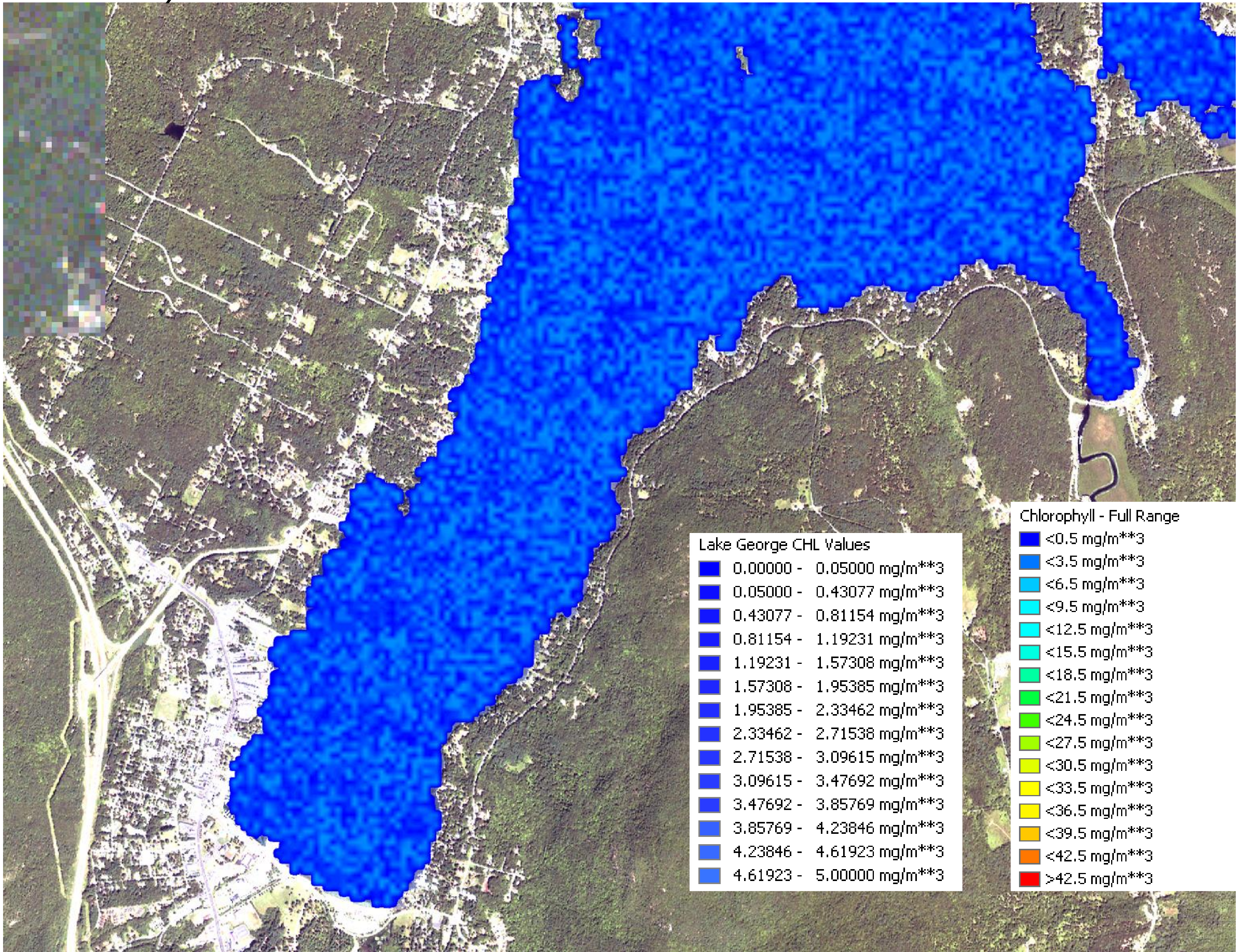
(zoomed view)

Chlorophyll

0.00000 - 0.05000 mg/m**3
0.05000 - 0.07927 mg/m**3
0.07927 - 0.12569 mg/m**3
0.12569 - 0.19927 mg/m**3
0.19927 - 0.31594 mg/m**3
0.31594 - 0.50091 mg/m**3
0.50091 - 0.79418 mg/m**3
0.79418 - 1.25916 mg/m**3
1.25916 - 1.99636 mg/m**3
1.99636 - 3.16516 mg/m**3
3.16516 - 5.01828 mg/m**3
5.01828 - 7.95634 mg/m**3
7.95634 - 12.61455 mg/m**3
12.61455 - 20.00001 mg/m**3
Over 20.00001 mg/m**3

Courtesy of: Applied Analysis Inc.

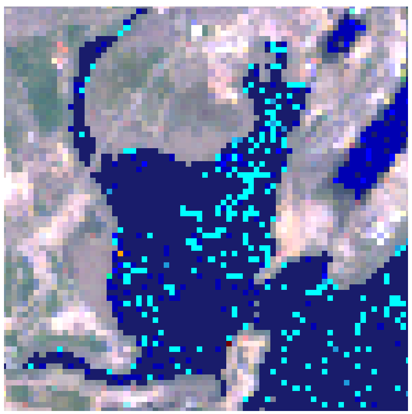
Lake George 2002 CHL - IKONOS (South end)



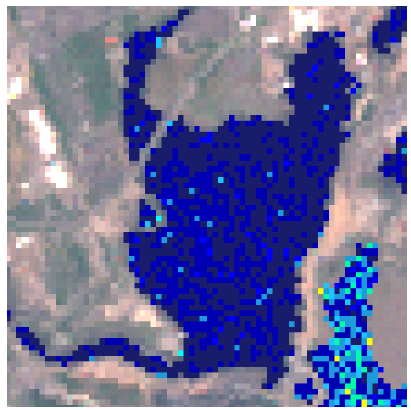
Courtesy of: Applied Analysis Inc.

Cardiff Bay, Wales Results: Chlorophyll

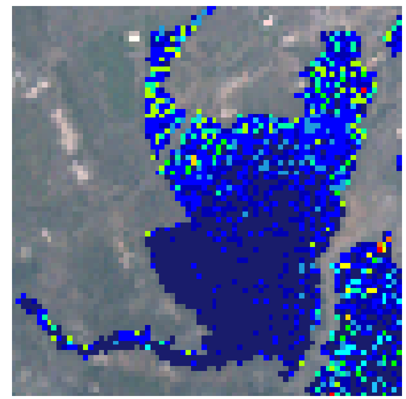
1998

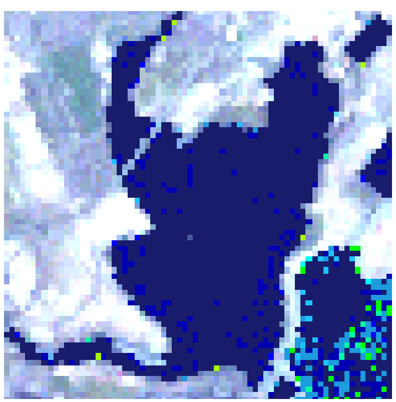


2000

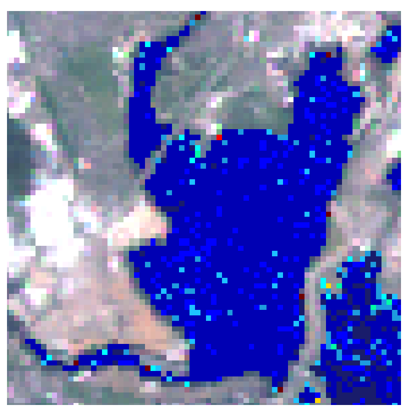


2002





2004



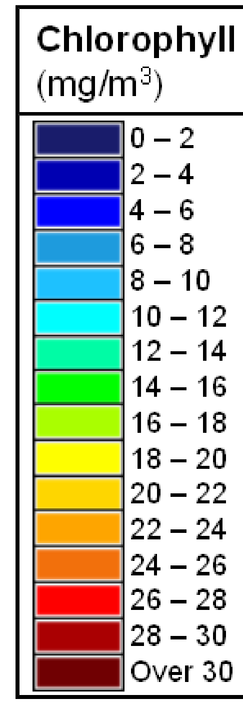
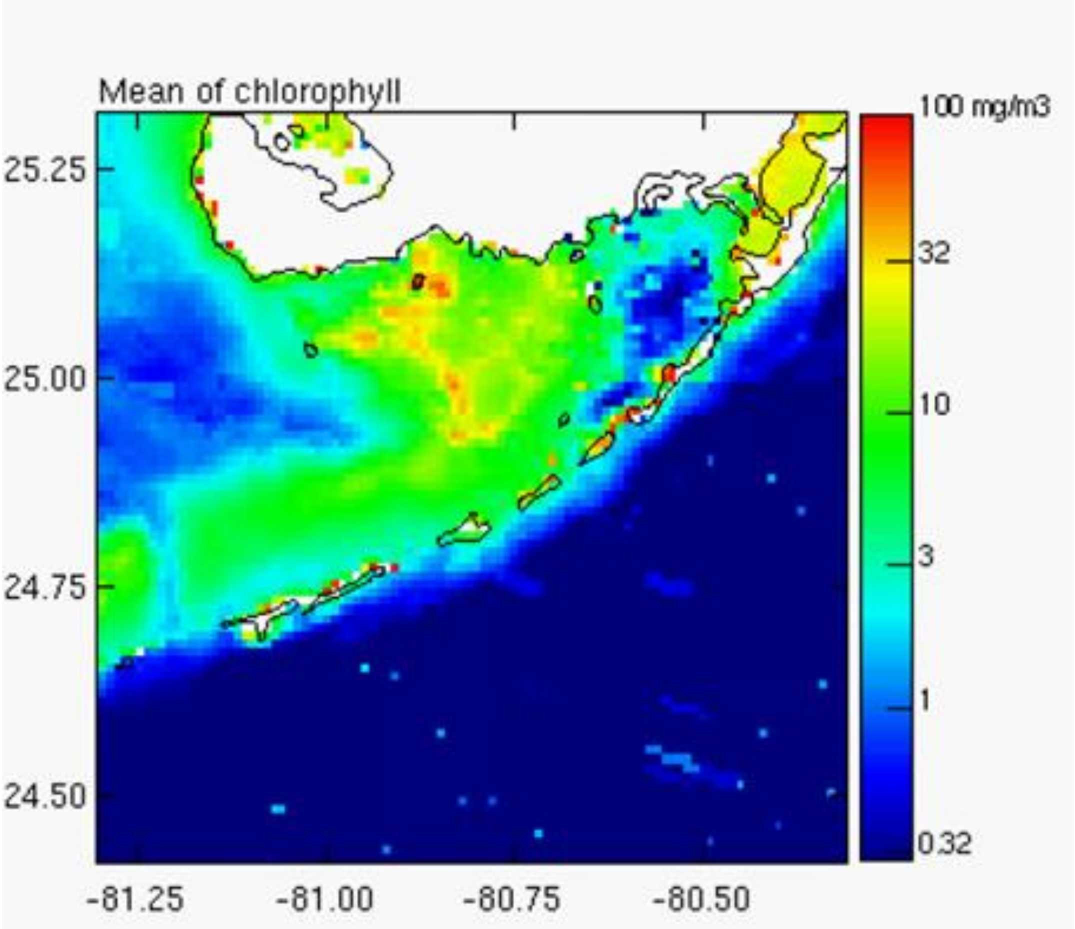


Image-derived concentration of suspended chlorophyll

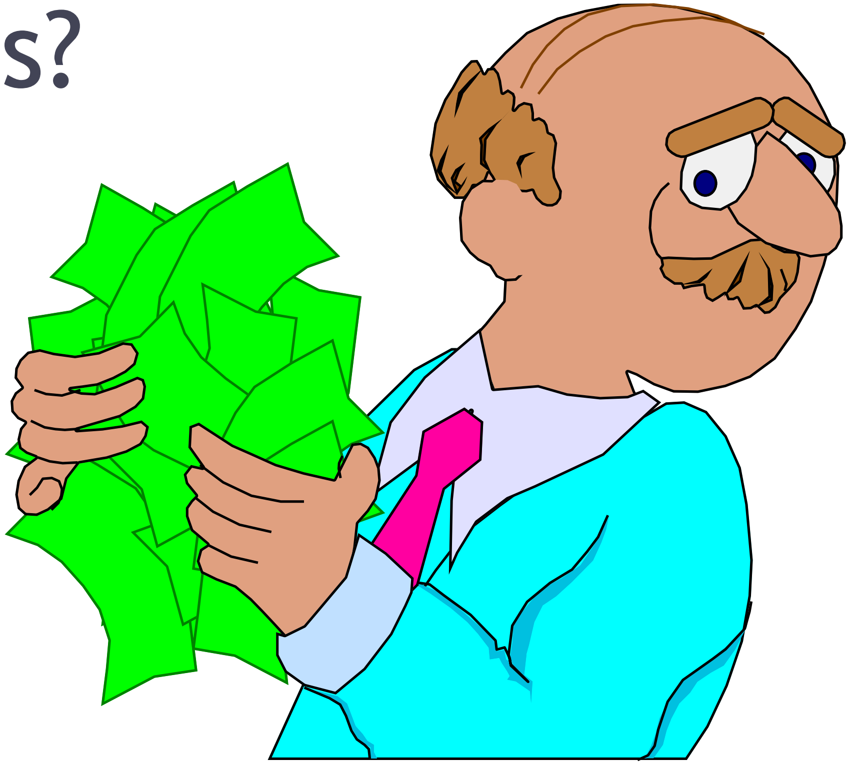
Courtesy of: AMEC Earth and Environmental

Modis/Seawifs Average CH 2003-2005



Courtesy of:
Starlab

Questions?



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