GEO Global Water Quality Monitoring Activities

Steven R. Greb
Wisconsin Department of Natural Resources
Arnold Dekker
CSIRO
Tiit Kutser
Estonian Marine Institute, University of Tartu

GloboLakes Scientific Workshop
University of Stirling
10-12th December 2012

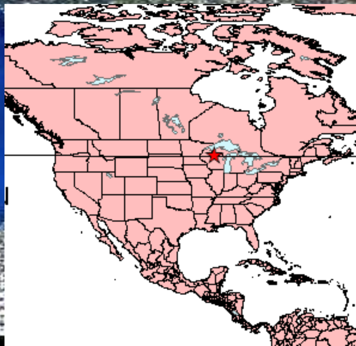
GROUP ON EARTH OBSERVATIONS

Image Source: WisconsinView.org, SSEC, University of Wisconsin-Madison


GEO
GLOBOLAKES
GEOSS
CEOS
IGWCO
WDNR
NERC
NASA
ChloroGIN
UNEP
MERIS
UNESCO
Lakes
WMO
JRC
JamesBond
SeaBASS
MOBY
ESA
IOPs

<u>Wisconsin Water Resources facts</u>

- Owned by the citizens under Public Trust Doctrine
- Over 15,000 lakes, 1 million acres (3%)
- Most Common Name- **Mud Lake (n>150)**
- 44,000 miles of river and streams,
- 4700 dams, lead country in dam busting
- Over ½ million registered boats
- Recreation is $11 billion industry



Satellite Lakes Observatory Initiative

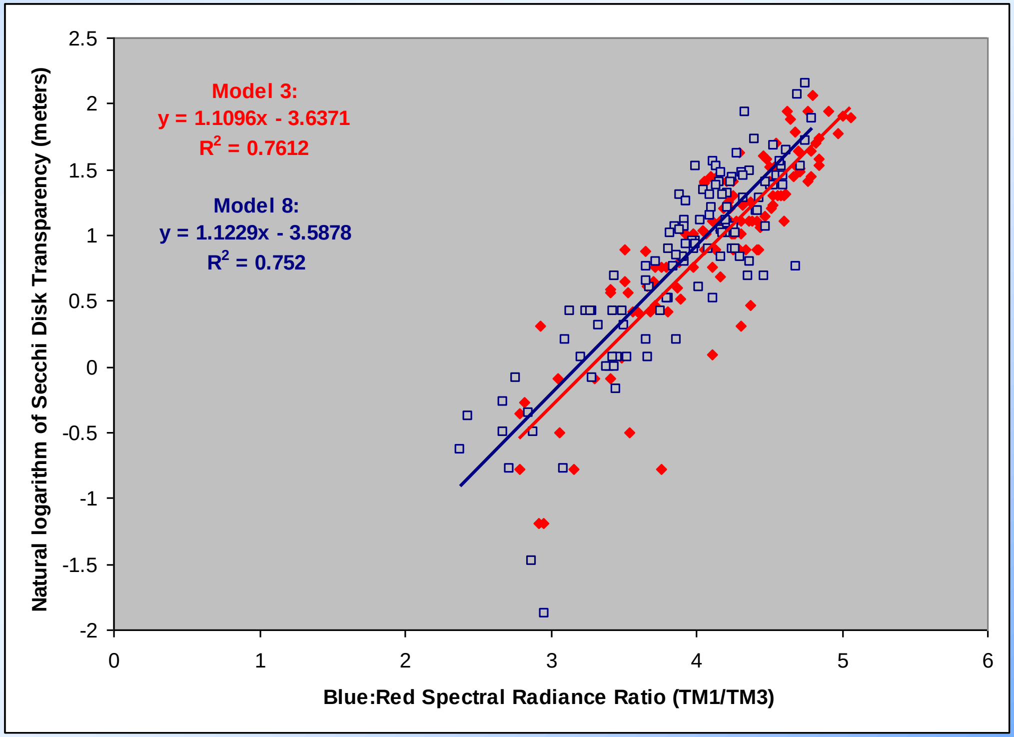
A partnership between universities, state agencies and local citizens

SLOI is a project of the Upper Midwest Regional Earth Science Applications Center (RESAC) and it is supported by the NASA Affiliated Research Center (ARC) Program

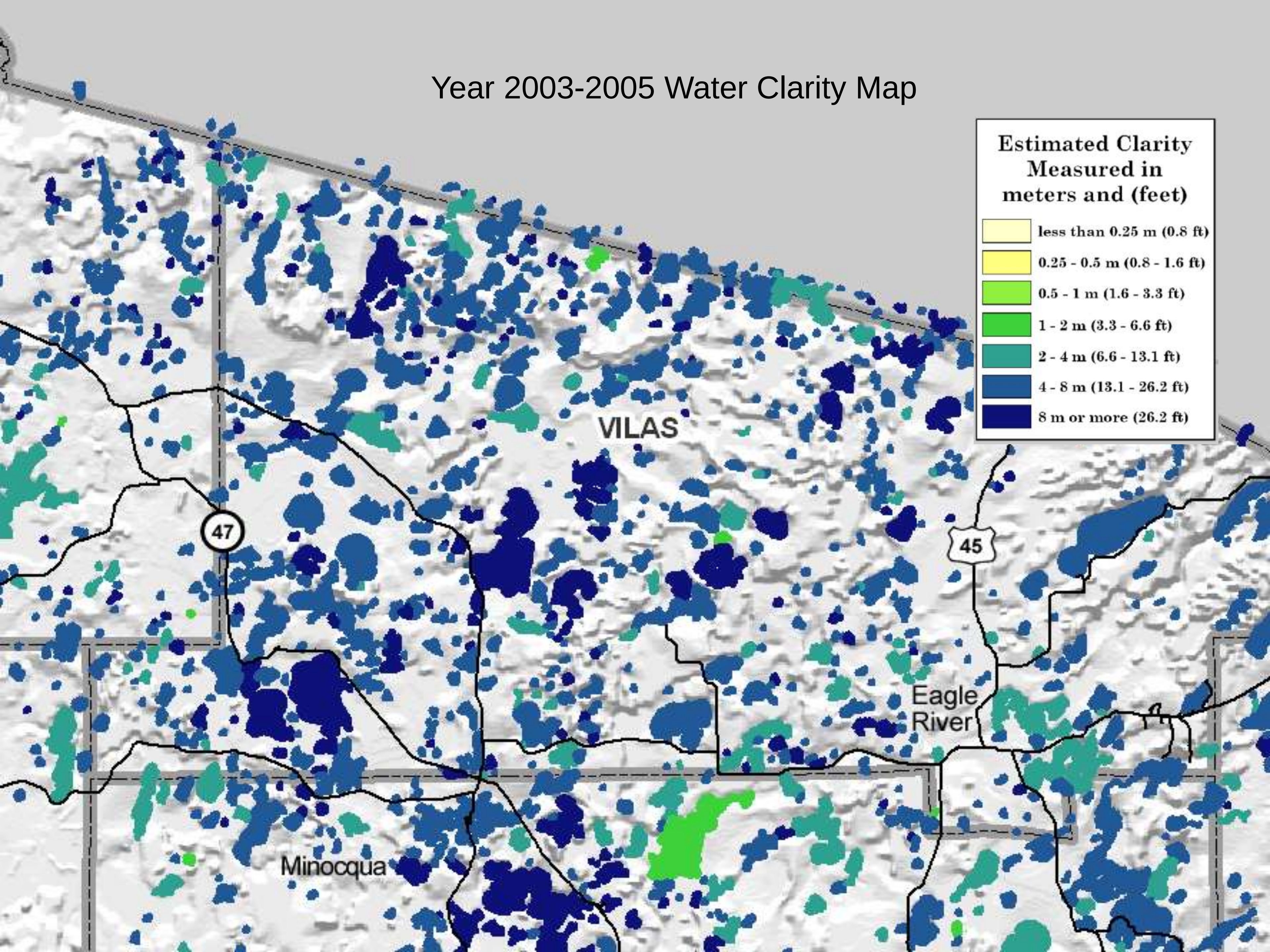
Multiple regression is used to relate the field observations and the image data:

$$\ln(\text{Secchi}) = b_0 + b_1\left(\frac{TM1}{TM3}\right) + b_2(TM1)$$

with the most important parameter being the TM1/TM3 ratio (blue/red ratio):

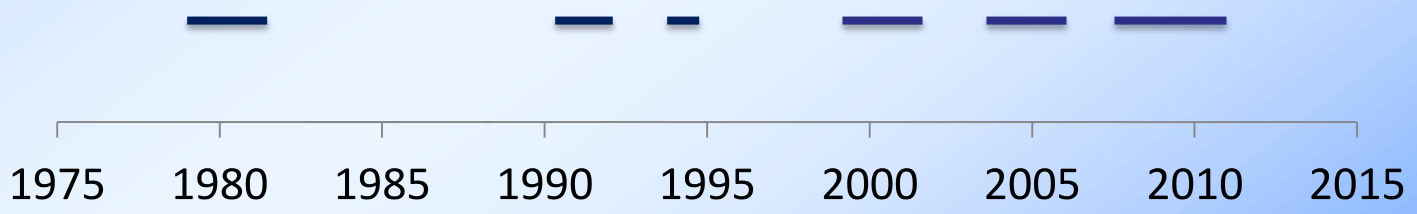


Year 2003-2005 Water Clarity Map

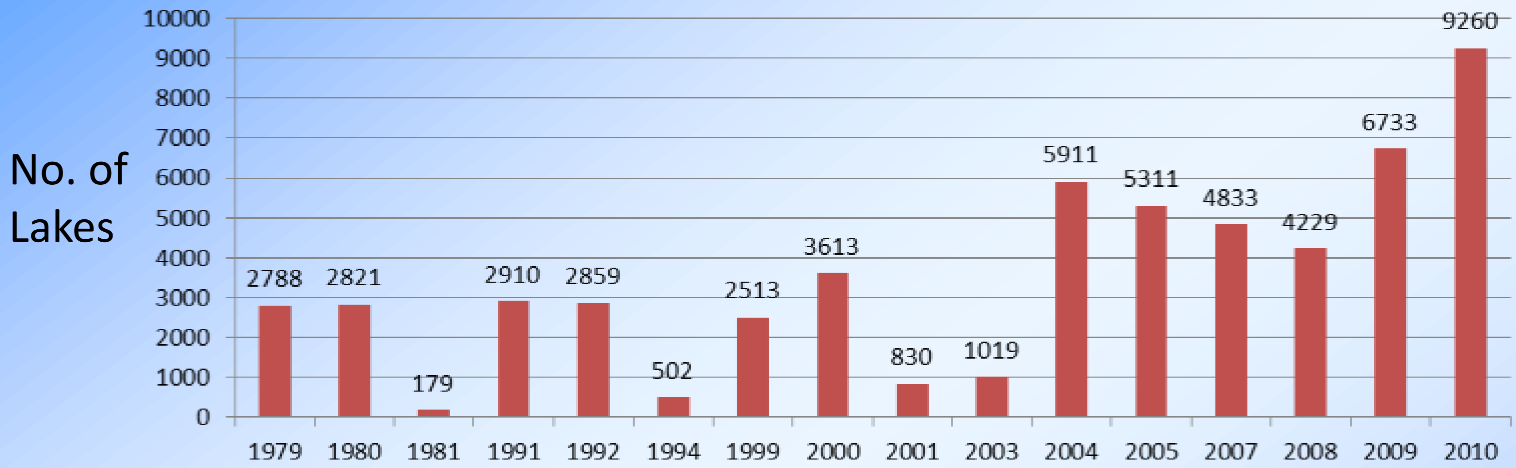


Years when satellite data was collected/processed

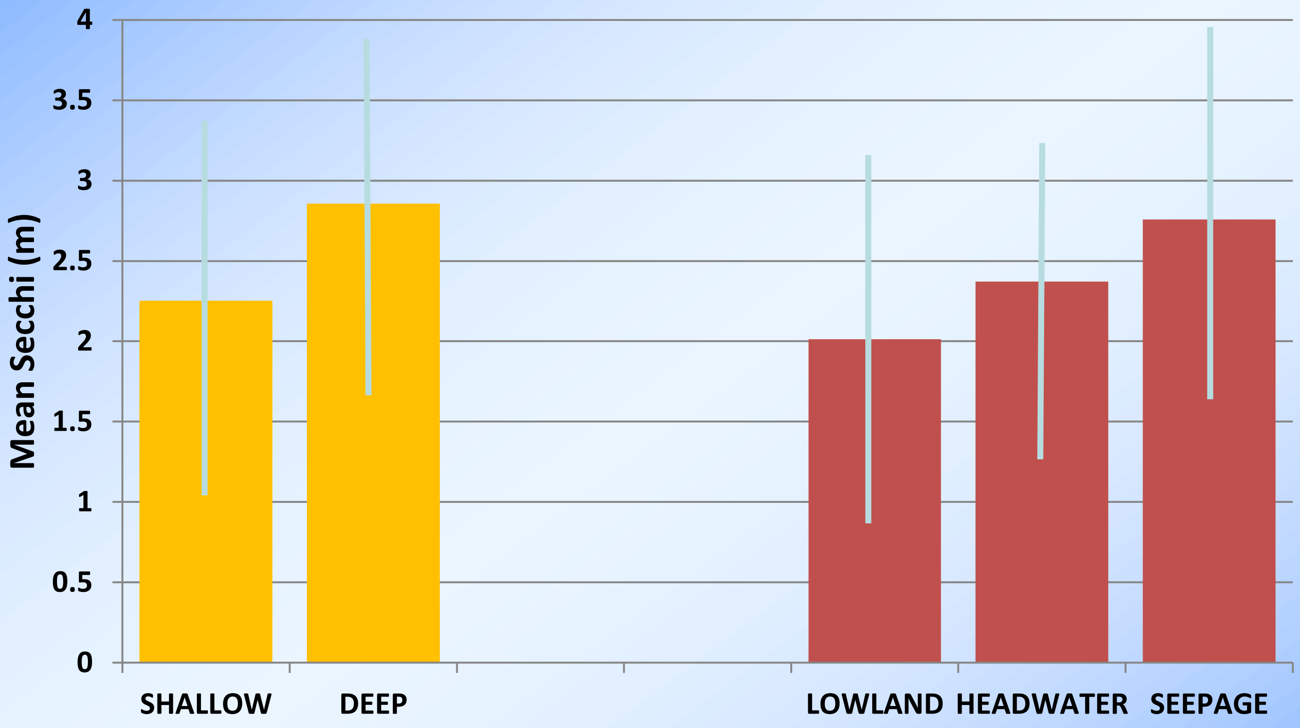
1979	2001
1980	2003
1981	2004
1991	2005
1992	2007
1994	2008
1999	2009
2000	2010



Number of Lakes with Water Clarity Measurements Estimated by Satellite Satellite



Wisconsin Lakes Secchi (m)
(all years)

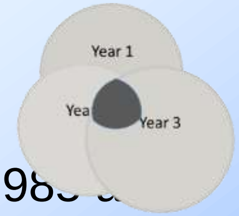


Data Analysis Approach

Annual (summer) mean for each lake (One value for each year for each lake)

Three data sets

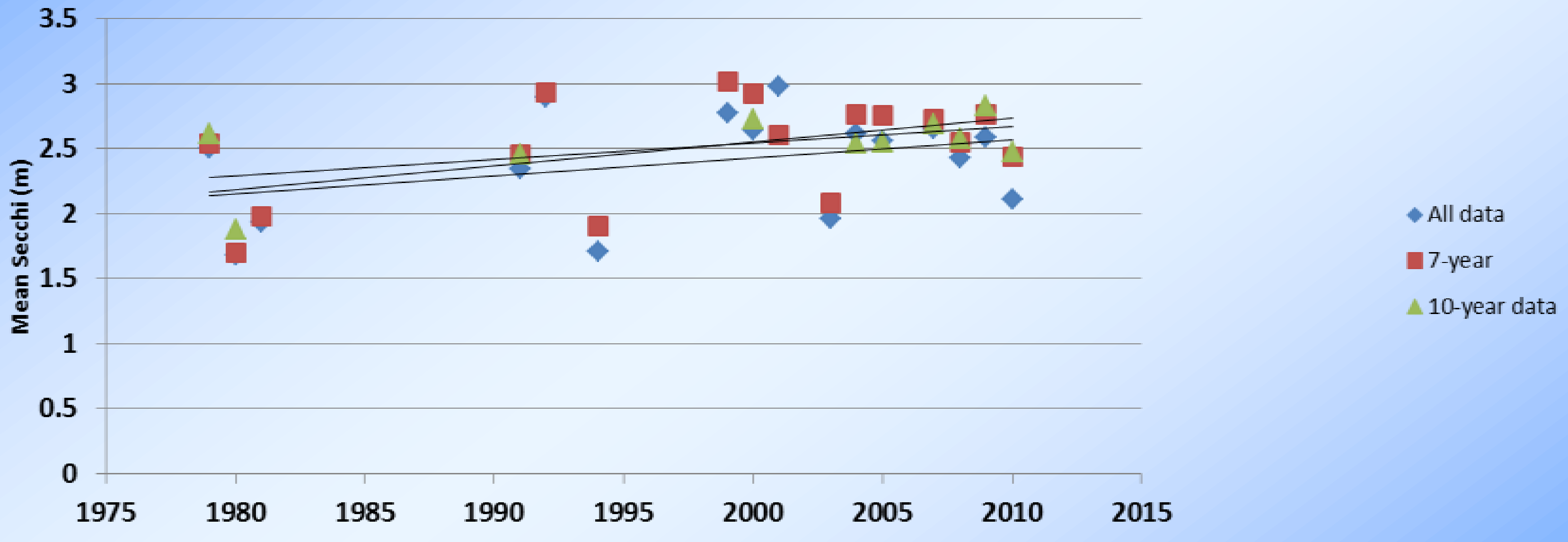
- All data, all years (n= 179 to 9200)
- Only lakes with 7 yr. record (any 7+ of 16 yrs, w/ one before 198
one after 2005. n≈3483)
- Only lakes with data for each of 10 specified yrs. (n=430)
- Additional subcategories i.e. Depth, Lake class, position



Statistical Analysis

- Regression
- Mixed effects model

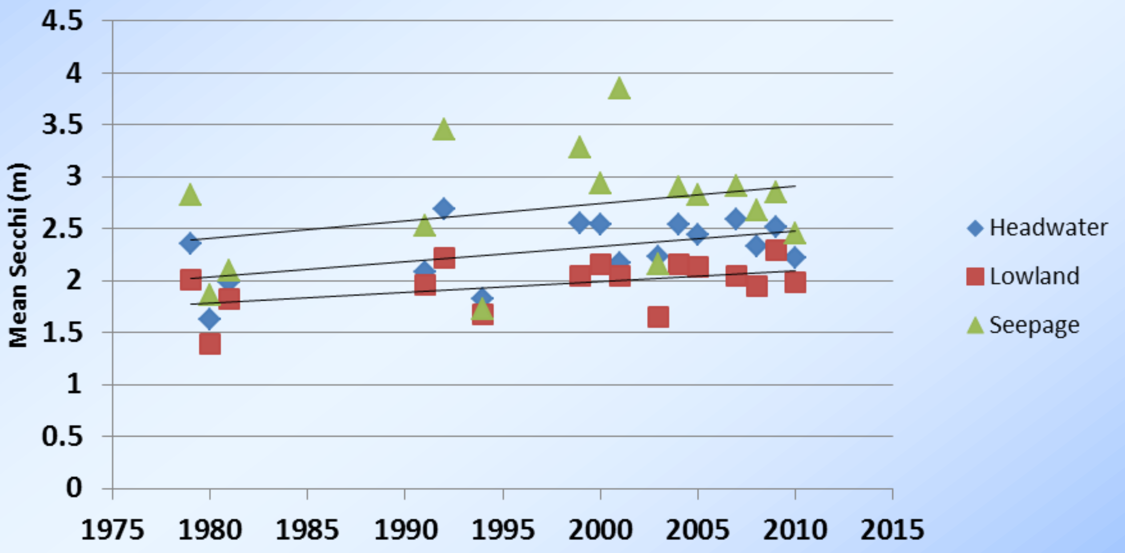
Trends in Estimated Water Clarity



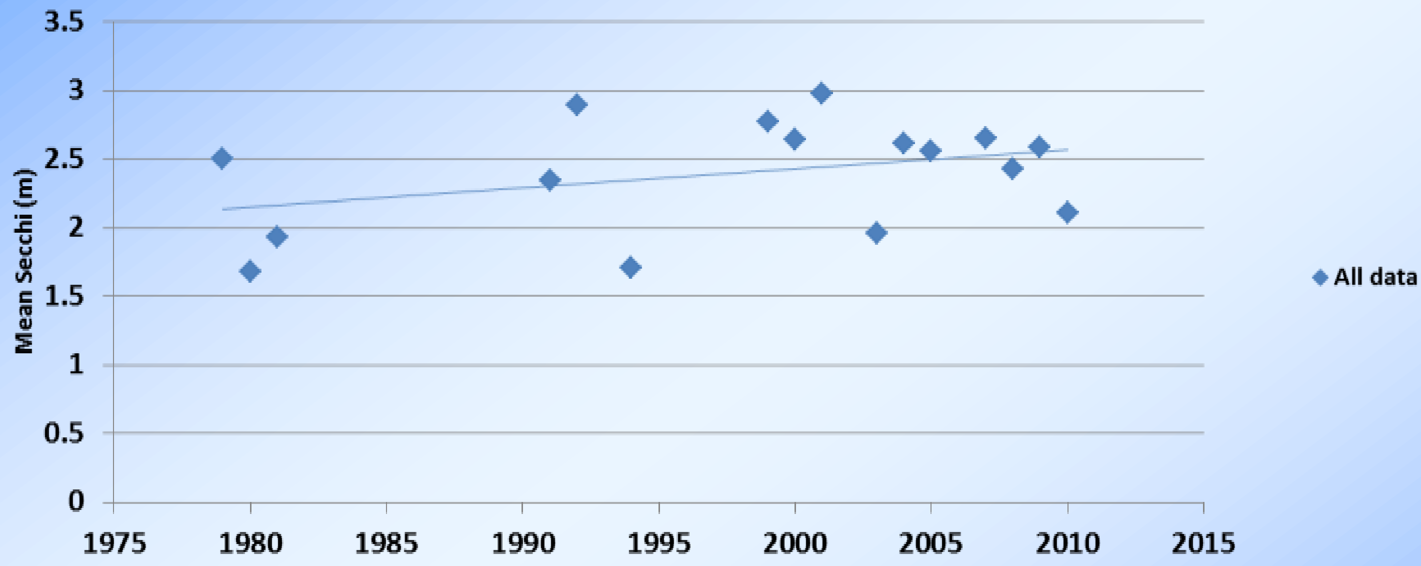
Mixed Effect Model Results

All data	Secchi= 2.14 + (0.007 * year)
7+ years	Secchi = 2.24 + (0.017 * year)
10 year complete	Secchi = 2.28 + (0.013 * year)

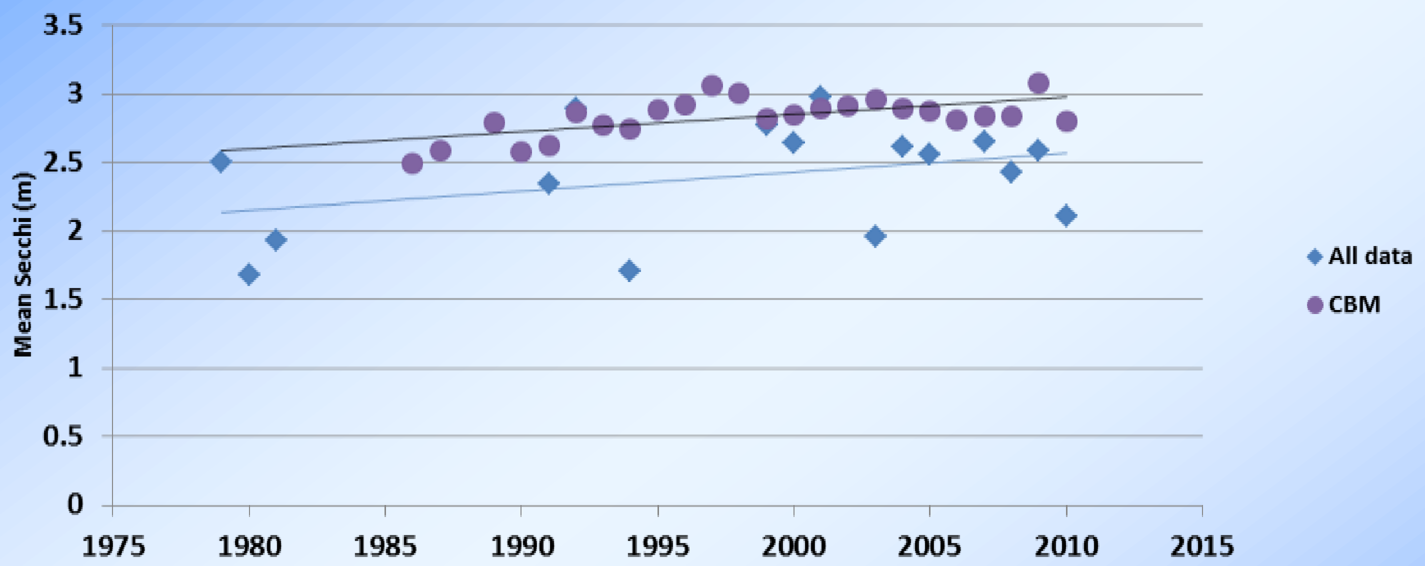
Trends in Estimated Water Clarity
Categories = Lake Position



Trends in Estimated Water Clarity
Collaborating data?



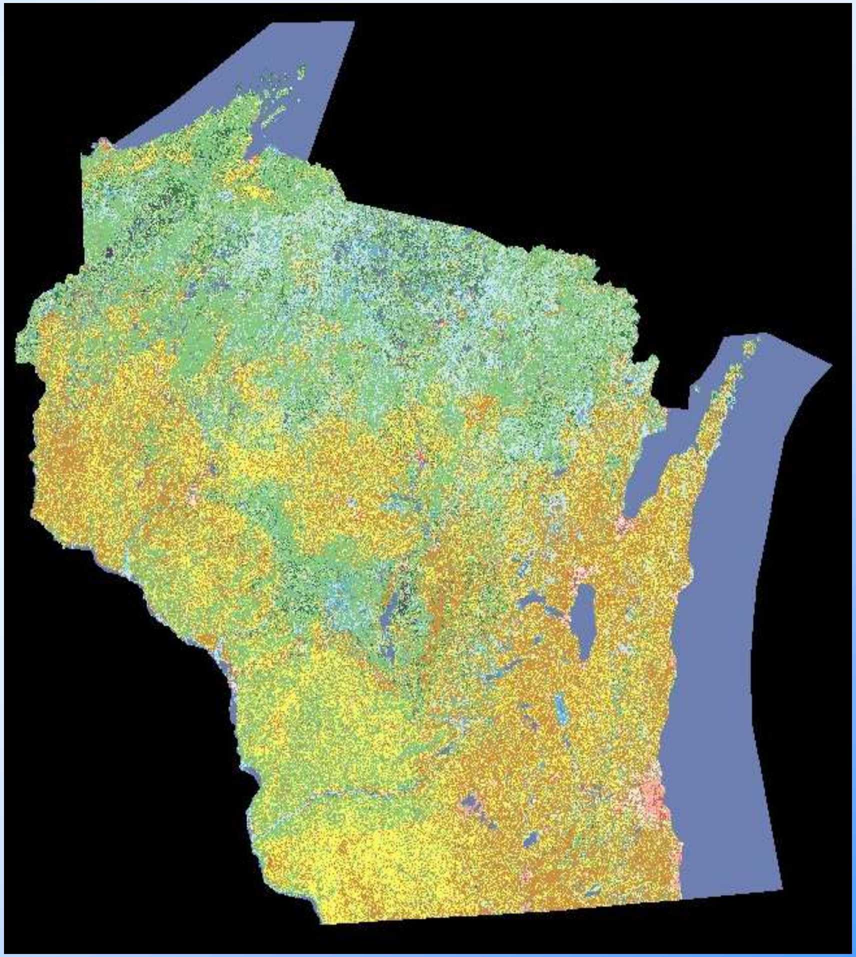
Trends in Estimated Water Clarity
Comparison with Citizen-based Monitoring In-Situ Data
(23 lakes with 24 years of data)



Satellite Remote Sensing of Lake Water Clarity: Moving Beyond Monitoring – Modeling the Future

- New Collaborative Research Effort between WDNR and UW-Madison
  - PhD project investigating mechanisms behind the major drivers of lake water clarity, their interactions, and potential impacts of land use and climate change on clarity.
  - Develop predictive models for lakes in WI using various land use and climate change scenarios.

WI Land Use/Cover



USGS NLCD 1992; http://www.mrlc.gov/

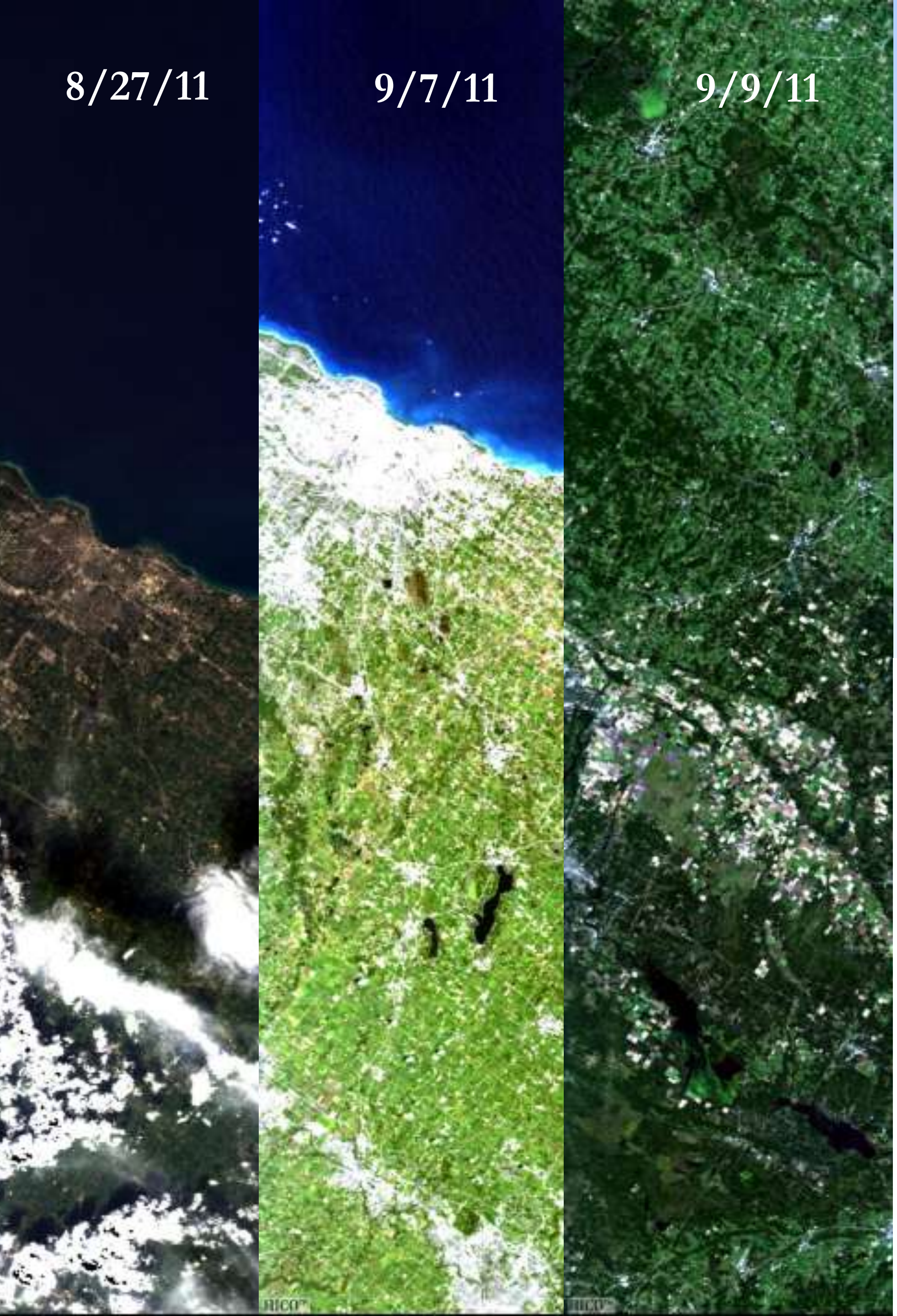
Optical Variability and Remote Sensing of Wisconsin Inland Lakes

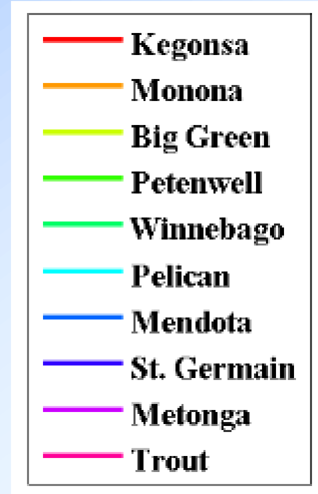
WDNR, UW-Madison, Upstate Freshwater Institute

Objective:

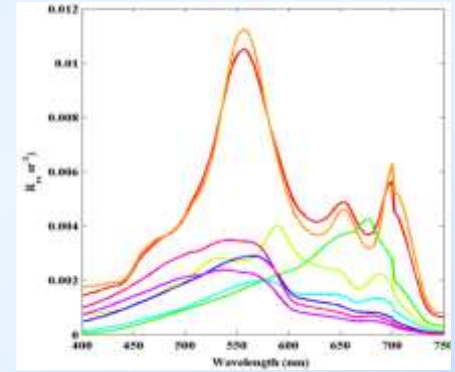
Optical and biogeochemcal characterization to support algorithm development, refinement, and validation in inland lakes with MERIS and HICO imagery. To increase our monitoring capabilities, e.g., DOC, suspended solids, Chl-a, HABs

MERIS imagery; http://miravi.eo.esa.int/en/

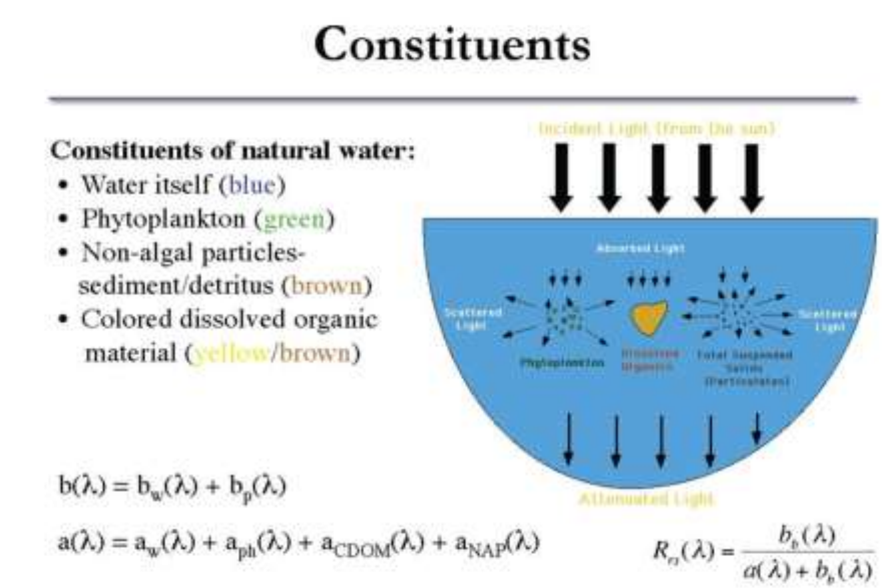




Optical Variability



Semi-Analytical Models/Radiative Transfer Theory



Constituents

Constituents of natural water:

- Water itself (blue)
- Phytoplankton (green)
- Non-algal particles-sediment/detritus (brown)
- Colored dissolved organic material (yellow/brown)

$$b(\lambda) = b_w(\lambda) + b_p(\lambda)$$

$$a(\lambda) = a_w(\lambda) + a_{ph}(\lambda) + a_{CDOM}(\lambda) + a_{NAP}(\lambda)$$

$$R_{rs}(\lambda) = \frac{b_b(\lambda)}{a(\lambda) + b_b(\lambda)}$$

Remote Sensing of Near Coastal and Inland Water Workshop

NASA ROSES 2011 E.2 Topical Workshops, Symposia, and Conferences

Colleen Mouw (University of Wisconsin) co-chair
Steven Greb (Wisconsin Dept. Natural Resources) co-chair
Paul DiGiacomo (NOAA NESDIS)
Simon Hook (NASA JPL)
Chuanmin Hu (University of South Florida),
ZhongPing Lee (University of Massachusetts-Boston)
Ru Morrison (University of New Hampshire)

Location: University of Wisconsin, Madison, WI
Date: June 20-22, 2012
Participants: 55 scientists/managers

Workshop Goals

- Provide an overview of the state of the science

- Identify pressing needs for the advancement of remote sensing in optically complex waters

- Establish an inventory of unresolved issues

- Provide a scientific basis for the next generation of remote sensing of near coastal and inland water including a framework and recommendations for future research directions

- Foster the development of new collaborations

Photo by Stephanie Caine

Inland and Coastal Waters

Workshop for Remote Sensing of Coastal and Inland Waters; Madison, Wisconsin, 20–22 June 2012

Coastal and inland water bodies, which have great value for recreation, food supply, commerce, transportation, and human health, have been experiencing external pressure from direct human activities and climate change. Given their societal and economic value, understanding issues of water quality, water quantity, and the impact of environmental change on the ecological and biogeochemical functioning of these water bodies is of interest to a broad range of communities.

Remote sensing offers one of the most spatially and temporally comprehensive tools for observing these waters. While there has been some success with remotely observing these water bodies, many challenges still remain, including algorithm performance, atmospheric correction, the relationships between optical properties and biogeochemical parameters, sufficient spatial and spectral resolution, and a lack of uncertainty estimates over the wide range of environmental conditions encountered across these coastal and inland water bodies.

A NASA-sponsored workshop took place at the University of Wisconsin-Madison in June 2012 to address these challenges. The 53 participants included researchers from Australia, Canada, China, Estonia, Germany, and the United States. The workshop focused on parameters that can be remotely sensed that lend insight into how coastal limited to products that can be derived from visible spectral reflectance (aquatic color) and infrared emissivity (surface temperature) and the science considerations surrounding these products.

The workshop summarized the current state of remote sensing in these complex waters, identifying gaps in knowledge and data needs and priorities, providing a framework for near- and long-term science goals. The workshop covered topics including products that are currently able to be retrieved; algorithm refinement and development for improved and desired products; spectral, spatial, and temporal limitations and needs; relationships between optical and biogeochemical properties; atmospheric correction; uncertainty considerations; in situ data availability and needs; planning for full utilization of forthcoming sensors with improved spatial, spectral, and temporal resolution; and priorities for the future.

Several issues were identified as being able to be resolved in the near term. Interest in inland and coastal waters across numerous scientific, management, and societal realms has led to a variety of data policies and protocols. It was recommended that a professional identity be developed that encompasses the intersection of communities, to be led by a dedicated staff person to spearhead unifying observations. The immediate data needs identified include (1) getting existing optical and the high dynamic range of parameters encountered in these waters, and (3) developing a standard set of recommended observations across investigators and nations.

The planned outcome of the workshop is a published review of the state of remote sensing of coastal and inland waters with prioritized recommendations for future research and enabling activities. Further

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Draft science recommendations from a recent NASA sponsored remote sensing of inland and coastal water workshop included:

1.)Establishment of a unified optical data repository

2.) Establish standard measurements for any in situ campaign supporting remote sensing. Update NASA protocols to include consideration of the high dynamic range of properties encountered in these systems and extends to include biogeochemical properties,

3.) Establishment of a professional identity to cross freshwater with coastal, small scales with larger, science and societal considerations. Promote these ideas to IOCCG and other national space agencies for better cross project and cross-national harmony.

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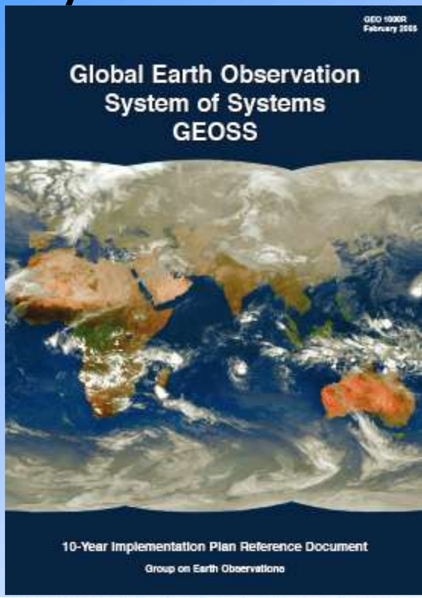
Physics-Based Ocean-Color Algorithms for Water-Quality Products of Coastal and Inland Waters

A new framework for Earth Observations: GEOSS: A Global, Coordinated, Comprehensive and Sustained System of Observing Systems



Relevant Facts:

- Launch in response to 2002 World Summit on Sustainable Development
- Voluntary partnership: ~86 nations and ~61 international organizations who have agreed to work together to build the GEOSS.
- Coordinated by the Group on Earth Observations (GEO) which implements the GEOSS work plan through the best efforts of its community
- Provide framework to develop new projects and coordinate strategies

Targets → Tasks → Sub Tasks

The Water Target

By 2015, produce comprehensive sets of data, information products and services to support decision-making for efficient management of the world's water resources, based on coordinated, sustained observations of the water cycle on multiple scales.

GEO Inland and Near-Coastal
Water Quality Remote Sensing Workshop

55 participants
26 countries
Diverse group-geographically and in expertise
Extremely dedicated group of people

Writing Teams

1. Remote Sensors
   Paul DiGiacomo/Simon Hook/Andreas Neumann

2. Data Acquisition and Distribution
   Steve Groom/Nicolas Hoepffner

3. Data Processing and Product Development
   Mark Dowell/Burt Jones/Soo Chin Liew

4. What can be delivered *vs*. What should be delivered?
   Arnold Dekker/Herman Gons/Maycira Costa

5. Calibration/Validation
   Menghua Wang/Jean-Francois Berthon/Ru Morrison

6. Special Needs and Requirements of Developing Countries
   Chris Mannaerts/Maycira Costa/Val Byfield/Wahid Moufaddal/Bilqis Amin Hoque

Editing Team – Steven Greb, John Lyon, Maycira Costa, Samantha Lavender

http://www.earthobservations.org/meetings/20070327_29_water_quality_workshop_report.pdf

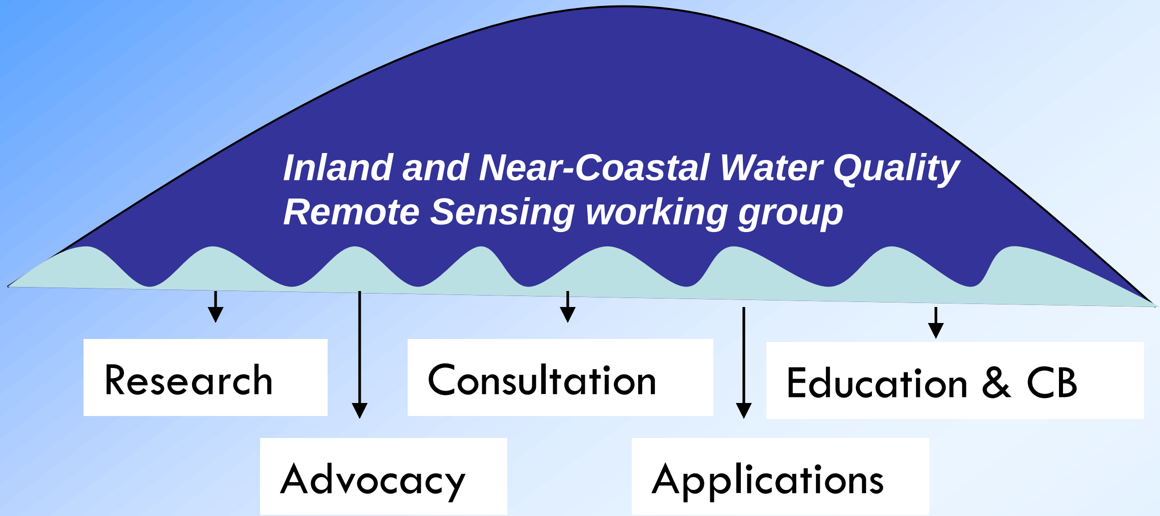
Drafting of the Water Quality ToR document

Scope of the Working Group

- **The group shall represent the interests of all professionals working in coastal and inland water quality remote sensing**. This shall include research institutions, collaborative research programmes, government agencies (local, national and international), private sector commercial operators, NGOs, and consultants.

- **It shall encompass all measurement technologies** (including satellite remote sensing, airborne data, modelling and in-situ measurements), be recognisably distinct from coastal zone management, open ocean remote sensing and climate change assessment but keep close link to those.

- **It shall consider all aspects of integrated water management and the water cycle** which are applications of coastal and inland water quality remote sensing including pollution, contamination, eutrophication, sediment transport, habitat changes, local and regional ecosystem responses, coastal and riverine engineering impacts, human health related issues and coastal planning.


Inland and Near-Coastal Water Quality
Remote Sensing working group
Research
Consultation
Education & CB
Advocacy
Applications

GROUP ON EARTH OBSERVATIONS

Work Plan Information Management System

GEO WORK PLAN 2012-2015

The GEO Work Plan provides the agreed framework for implementing the GEOSS 10-Year Implementation Plan (2005-2015). It is a living document that is updated annually.

http://www.earthobservations.org/geoss_imp.php

New

WA-01: WATER TASK Work Plan

- **C1 Integrated Water-cycle Products and Services**
- **C2 Information Systems for Hydro-meteorological Extremes (incl. Floods and Droughts)**
- **C3 Information Service for Cold Regions**
- **C4 Global Water Quality Products and Services**
- **C5 Information System Development and Capacity Building**

C4 Global Water Quality Products and Services

This component aims to develop international operational water quality information systems based on Earth observation.

This component encompasses both the collation and development of in-situ water quality databases and remote-sensed data, particularly space-borne data.

The component addresses both flowing and static water bodies, recognizes differing approaches to assessing their water quality and the linkages/interface betweeen them

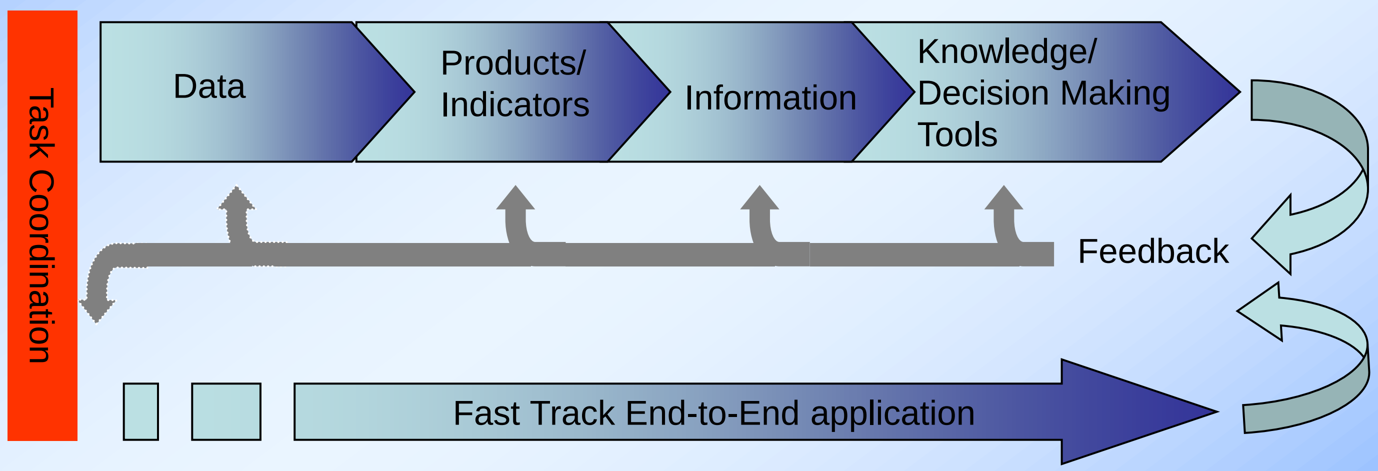
The goal of this component is to integate water quality data from multiple sources in a timely manner and through data assimilatation of Earth observation with other sources of data such as water quantity, hydrodynamics, biogeochemical modelling, generate higher level information products such as trends and anomalies in nutrient, carbon or primary productivity and additional “value-added” products such as fluxes and flows (source, transport and fate) of pollutants may be estimated

C4: Global Water Quality Products and Services

Moving Forward…

C4 Global Water Quality Products and Services

Develop 2012-15 Work Plan



Component	Suggested Remote Sensing Team Leader(s)
Data	Arnold Dekker, Tiit Kutser, Menghua Wang
Products/Indicators	Paul DiGiacomo, Stewart Bernard, Mark Dowell
Information	Gordon Campbell, Hans van der Woerd
Knowledge/ Decision Making tools	Chris Mannerts, Suhyb Salama
End-to-end application	Steve Groom
Coordination	Steven Greb, Arnold Dekker

GloboLakes
Global Observatory of Lake Responses to Environmental Change

NATURAL ENVIRONMENT RESEARCH COUNCIL

GLTC
Global Lake Temperature Collaboration

diversity
inland waters

GEO
GROUP ON
EARTH OBSERVATIONS

coastcolour

SEVENTH FRAMEWORK PROGRAMME

GLaSS

GloboLakes

Global Observatory of Lake Responses to Environmental Change

NATURAL ENVIRONMENT RESEARCH COUNCIL

GLTC

Global Lake Temperature Collaboration

diversity inland waters

GEO GROUP ON EARTH OBSERVATIONS

coastcolour

SEVENTH FRAMEWORK PROGRAMME

GLaSS

Formation of a IOCCG Working Group?

Objectives and Terms of Reference- TBD

- Algorithm Activity (a focused portion)
- Water Quality
- Human health
- Inland *or* Inland and Coastal
- Developing country WQ monitoring

Need to consider and put in the context of previous and current IOCCG working groups

IOCCG Report 3 (2000): *Remote Sensing of Ocean Colour in Coastal, and Other Optically-Complex, Waters.*
IOCCG Report 5 (2006): *Remote Sensing of Inherent Optical Properties: Fundamentals, Tests of Algorithms, and Applications.*
IOCCG Report 7 (2008): *Why Ocean Colour? The Societal Benefits of Ocean- Colour Technology.*
IOCCG Report 8 (2009): *Remote Sensing in Fisheries and Aquaculture.*
IOCCG Report 10 (2010): *Atmospheric Correction for Remotely-Sensed Ocean-Colour Products.*

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Draft Strategy Report text

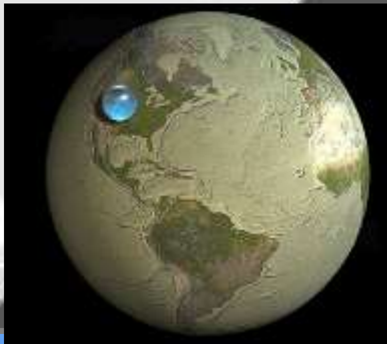
Clean water is critical for the health of the planet

Water quality can be parameterized by a host of variables with the degree of importance defined by the end use

By far the largest cause of water quality degradation and subsequent decline of aquatic systems have been from human activities and these activities threaten both human and ecosystem health

In developing countries, 80 percent of all waste is discharged untreated.
More than 80 percent of the global health burden is water related, resulting in the death of 1.8 million children under the age of 5 every year

From an ecosystem perspective, half of the world’s 500 major rivers and half the world’s lakes are classified as seriously degraded or overdepleted



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