Needs Assessment for the Use of NASA Remote Sensing Data in the Development and Implementation of Estuarine and Coastal Water Quality Standards

GOMA Implementation Workshop 2010

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Project Description

Satellite Earth Image Products Applied to the Development of Regulatory Water Quality Standards

Project Goals:

- Provide information from satellite remote sensing to support numeric nutrient criteria development
- Determine data processing methods and data quality requirements to support nutrient criteria development and implementation

Approach

- Identify water quality indicators that are used by decision makers to assess water quality (e.g., chlorophyll *a*, suspended sediment, and water clarity) and that are related to optical properties of the water, making them observable in remote sensing imagery
- Develop remotely sensed data products based on algorithms relating remote sensing imagery to field-based observations of indicator values
- Develop methods to asses estuarine water quality, including trends, spatial and temporal variability, and seasonality
- Develop tools to assist in the development and implementation of estuarine and coastal nutrient criteria

Process

- **Field Work and Data Analysis**
  - Collect and analyze the necessary field data to demonstrate the mechanistic and empirical relationships with remote sensing imagery
- **Needs Assessment**
  - Understand current criteria development process, and identify what needs could be addressed by our project
  - Evaluate attributes our products must have to be useful by analyzing responses to questions/questionnaire
  - Guide project development to address user needs and objectives
- **Validation**
  - Evaluate project developed data products and tools relative to user requirements
- **Benchmark**
  - Assess the usefulness, usability and actual use of the products
  - Evaluate perception of end-users regarding the impact of project outputs on decision making.

Criteria Development

- Criteria must have a scientific rationale.
  Have been based on:
  - WQ at unimpaired reference sites
  - historical WQ conditions, "historical reference condition"
  - regression relationships between water quality variables and biological endpoints of concern (i.e., “designated use")
  - simulation models relating causal variables and endpoints of concern.
- Criteria must consider Magnitude, Frequency, Duration
  - Criteria should address natural variability:
    - What magnitude of exceedance constitutes a violation
    - How frequently can exceedances occur
    - How do we consider the duration of the exceedance

Typical Data Sources and Analyses for Criteria Process

- Historical Status –
  - *in situ* samples – dates, locations, depth, conditions, methods
- Current Condition –
  - *in situ* samples – dates, locations, depth, conditions, methods
- Continuous Monitoring for Compliance –
  - *in situ* samples – dates, locations, depth, conditions, methods

- Data Analysis
  - Correlation between in situ samples and nutrients, rainfall/river flow
  - Individual samples vs. temporal and spatial averages
  - Comparison between spatial distributions
  - Comparison between temporal distribution (time-series analysis)

The Power of Remote Sensing Data for the Process

- **Data of interest**
  - chlorophyll *a*, suspended sediments, dissolved organic matter, light attenuation
- **Temporal availability**
  - 1 – 2 days depending on cloud cover
  - Practical expectation of 10 – 20 days/month
- **Spatial availability**
  - 250 – 1km sample distance
  - aggregate pixels near sample stations
  - geographic regions within water body (e.g. WBIDs)
  - entire water body
- **Output data format**
  - numerical values
  - map products
- **Data validation**
  - Mechanistic and empirical methods to establish relationships between in situ measurements and remotely sensed measurements
- **Uncertainty analysis**
  - How do errors propagate into estimates of parameters with remote sensing?
  - What is the natural variability of chl*a*, suspended sediments, light attenuation?

Examples from Pensacola Bay

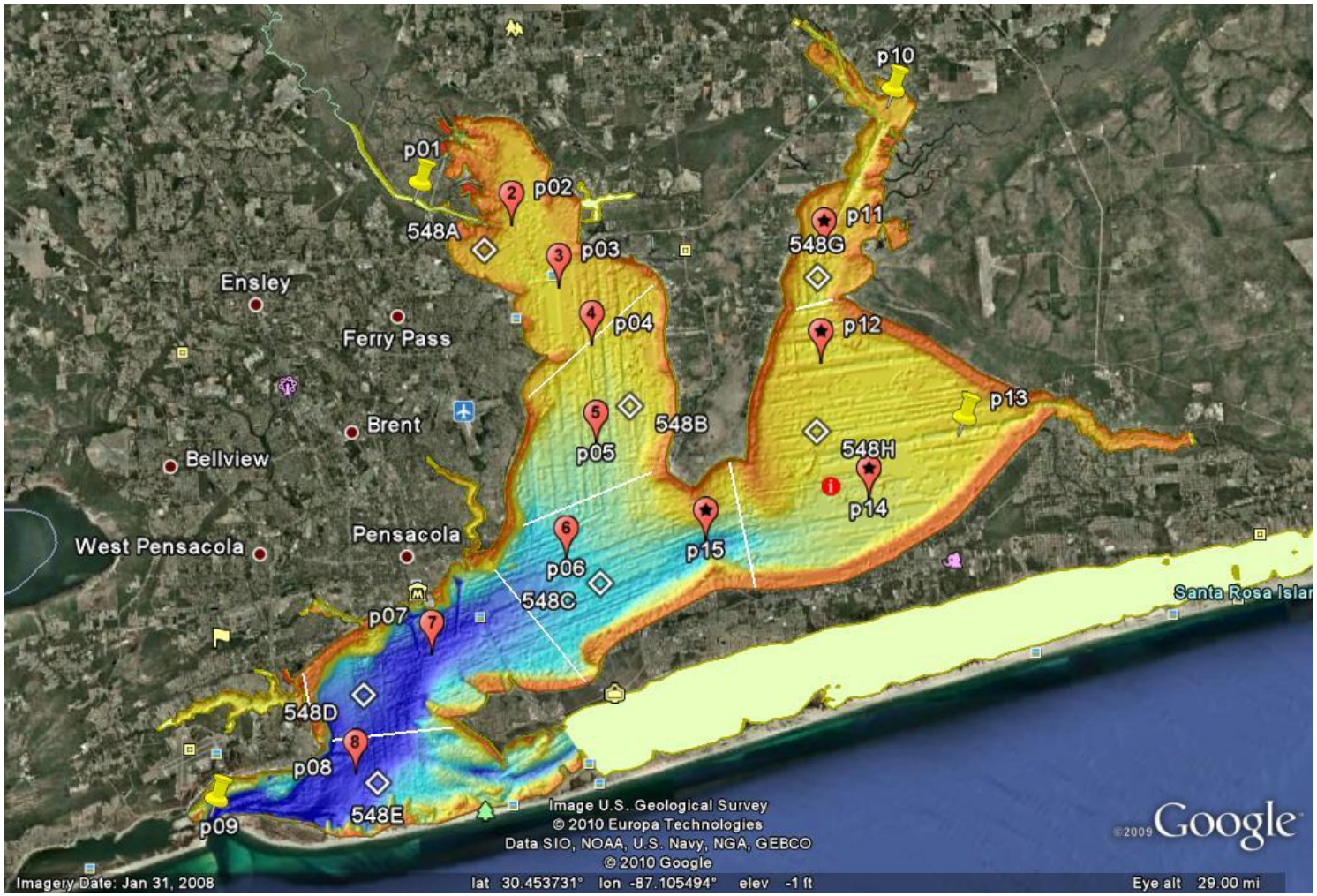
Assessment of variability and matchups using remotely sensed data:

A test case for remotely sensed reflectance at 645 nm for 2003

Examples of potentially useful data analysis techniques

- Assessment of spatial variability
- Assessment of temporal variability
- Data correlation with in situ samples
- Assessment of spatial resolution

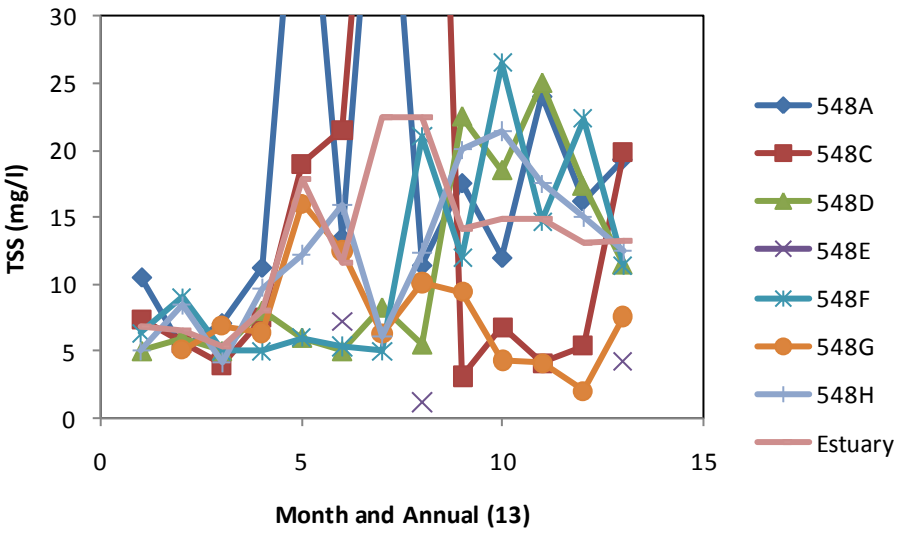
Pensacola Bay

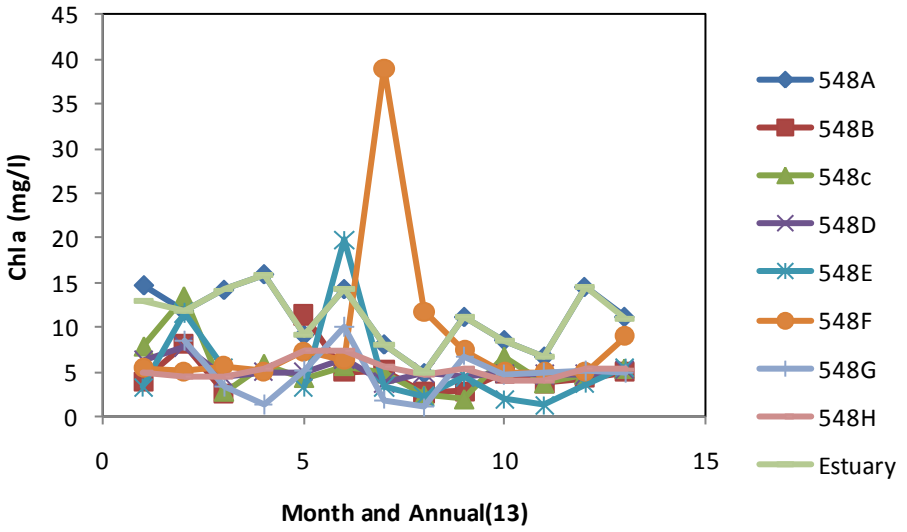


Pensacola Bay divided into WBIDs (548A-H, white line boundaries) with EPA sampling stations (marking pins). Color is bathymetry - shallow in red and deep in blue.

Spatial and Temporal Variability

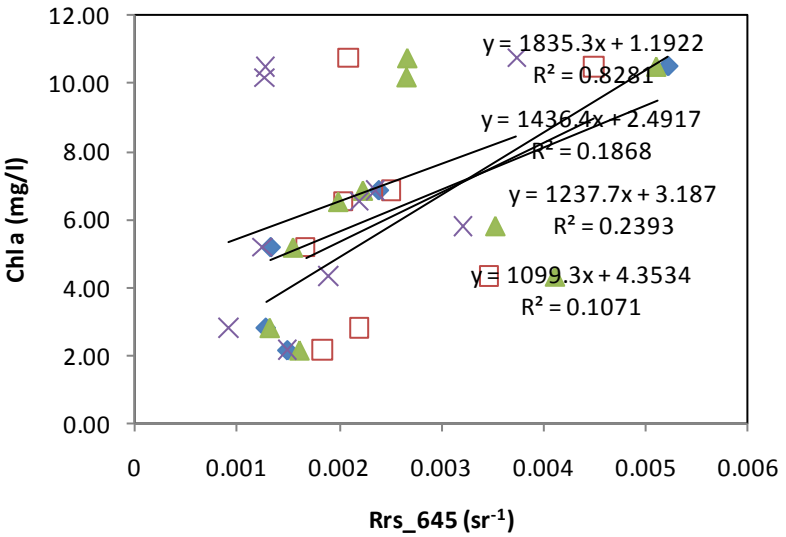
- Remote sensing products capture space and time variation

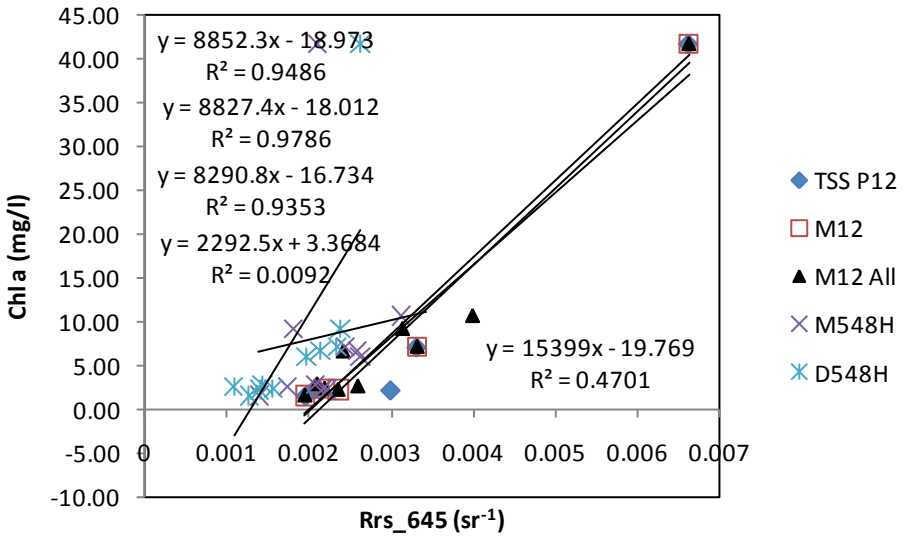




Pixel Matchups – Good and Bad

- Good
  - Demonstrate statistical parameter correlations
  - Identify differences in particle characteristics at different locations
  - Provide an indication of temporal variability
- Bad
  - Historical data sets provide few points leading to significant statistical relationships
  - Temporal and spatial averaging increases the number of matchups but doesn't necessarily improve statistical relationships
  - If pixel matchups are critical then sample plans should include validation

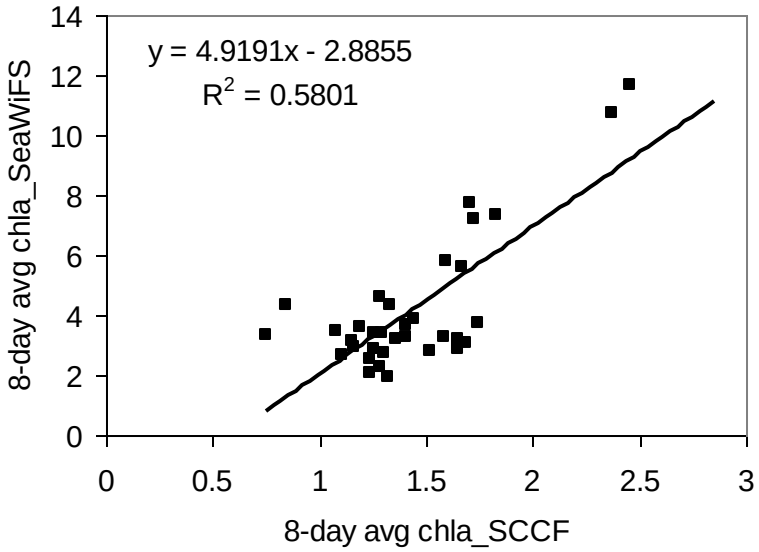




Chla vs. Rrs_645 at two different stations using small window and WBID scale averages

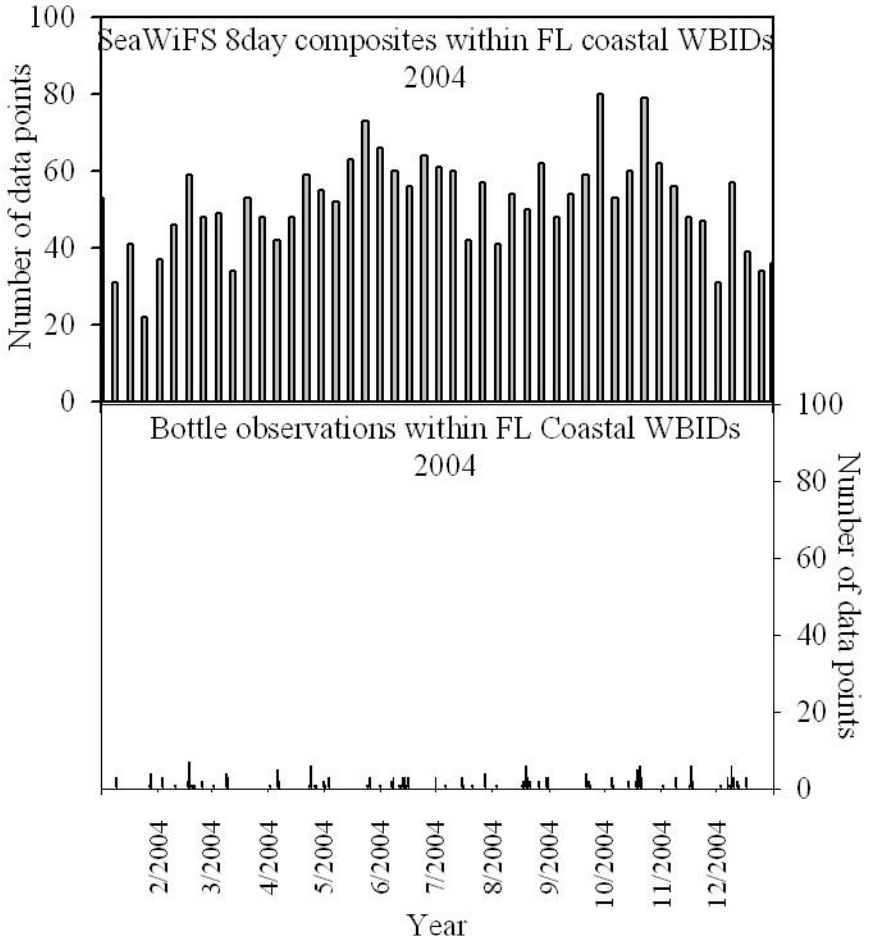
Remote Sensing Validation

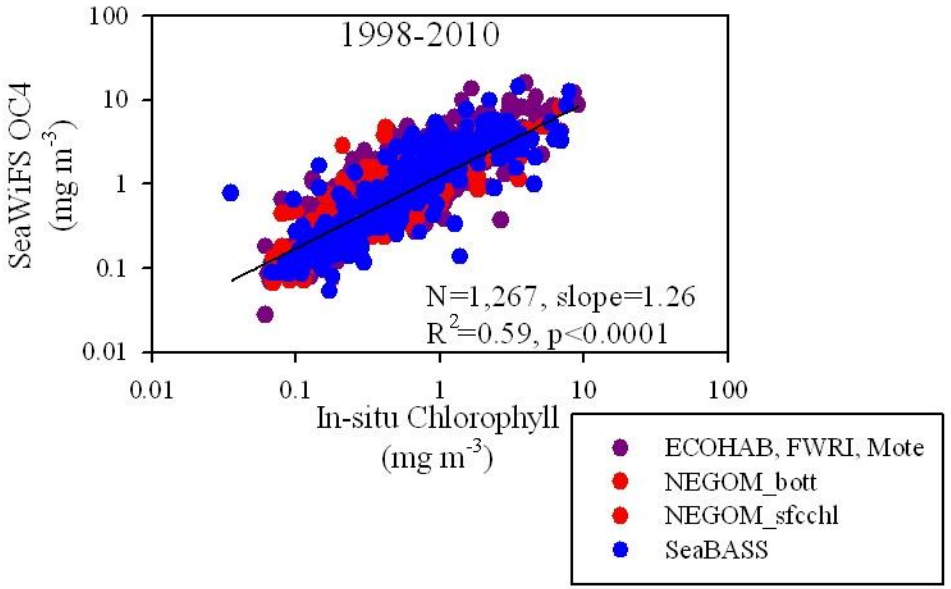
- SeaWiFS chl*a* product versus continuously monitored fluorescence (chl*a*)
- Data courtesy of the Sanibel Captiva Conservation Foundation RECON program http://recon.sccf.org/
- Hourly data from 2007 to 2009
- Water quality mooring data like these are very rare!
- Over this period, chl*a* from the two products were strongly correlated
- Calibration of both chl*a* products with discrete measurements is expected to improve the relationship
- Using 8-day averages, we were able to capture 84% of the 2-year period with SeaWiFS



Remote Sensing in Coastal Waters

- What can be done for coastal waters where there is little or no data?





Requirements for remotely sensed data products

- What remote sensing **parameters** would be of use?
  - Chl-*a*, suspended sediments, light attenuation, CDOM
- **How often** should they be measured? (frequency)
- **How up-to-date/timely** should the measurements be? (lag time)
- What **accuracy** is required for various parameters?
- What **formats** are needed?
- What are the **quantitative uncertainties** that are acceptable?
- Are **trend developments** important?

Key points of our Needs Assessment

- I**dentify** the decision makers that may benefit
- U**nderstand** how decisions related to water quality management are reached
- Determine information **requirements:**
  - Parameters, sensitivity, uncertainty
  - Temporal and spatial resolution
  - Temporal and spatial analysis methods
  - Historical reference conditions
  - Trend analysis
  - Requirements for supporting criteria implementation

- T**race** decision support requirements to NASA products
- **Result**: Decision support requirements can be correlated with appropriate NASA products

Needs Assessment for the Use of NASA Remotely Sensed Data to assess Regulatory Water Quality Standards:

Group Engagement & Information Collection

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Needs Assessment Purpose and Objectives

To identify framework for water quality decision-making

- to understand water quality decision-maker's needs
- information will be used to provide technical guidance on use of remote sensing imagery in the development of water quality standards

To identify the decision makers (audience) that may benefit

To understand how decisions related to water quality management are reached

Determine information requirements:

- Parameters, sensitivity, uncertainty
- Spatial and Temporal availability
- Historical reference conditions
- Trend analysis
- Requirements for supporting nutrient criteria implementation

Understand Water Quality Decision Making

Who are the decision makers?

Understand Water Quality Decision Making

How are water quality decisions made in your state? What are the critical decision making components in the process?

- Are there biological end-points/base resources that are of concern (i.e. seagrass, oysterbeds, etc.,)? If so, what are they?
- Are you using empirical relationships between nutrients and water quality for such biological end-points? And developing dose response relationships, and quantifying impact on end-points?

Understand Water Quality Decision Making

Are your state policy/regulatory requirements linked with Earth observation?

If so, or if there is potential, describe these links?

Determine Information Requirements

What are the current information limitations associated with your decision making processes?

- Too much data?
- Too little data?
- Spatial availability of data?
- Temporal availability of data?
- Uncertainties in data?
- others?

Next Steps

- Expand reach of contacts (to include technical experts)
- Data to be used to develop a quantitative survey to address more specific needs and specifications
- Resulting needs assessment information will be used to inform the development of relevant NASA data products and tools