Workshop Summary

Optical Remote Sensing of Coastal and Inland Waters: Challenges and Recommendations

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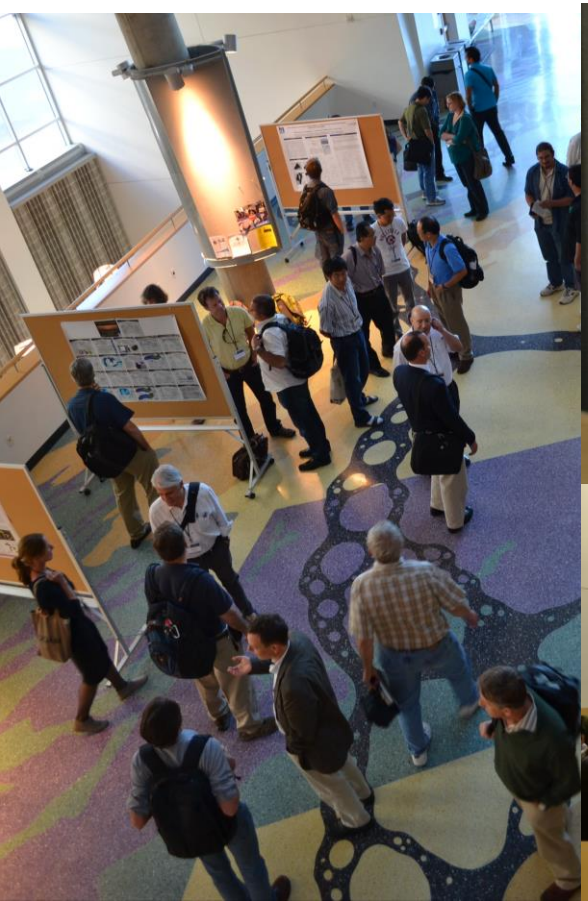
http://www.ssec.wisc.edu/meetings/ciw/



Acknowledgements

The views presented were developed from the contributions of all workshop participants.

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Publications

MEETINGS

Inland and Coastal Waters

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

Mouw, C. B., & Greb, S. (2012). *EOS Trans. AGU*, *93*(39), 375.

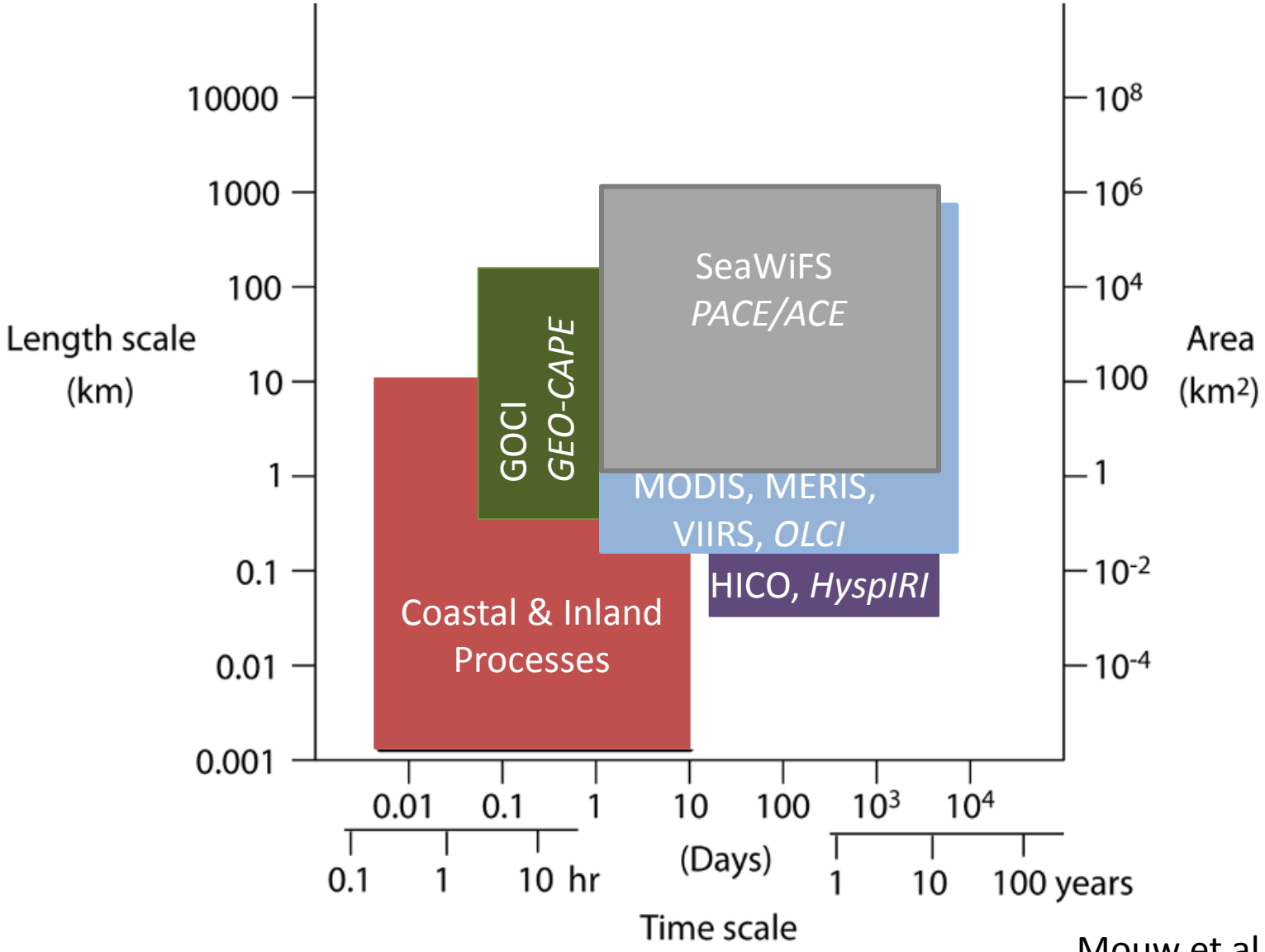
Mouw, C.B., S. Greb, D. Aurin, P. DiGiacomo, Z. Lee, M. Twardowski, C. Binding, C. Hu, R. Ma, T. Moore, W. Moses, and S. Craig, Optical remote sensing of coastal and inland waters: Challenges and recommendations for future satellite missions. *Remote Sensing of Environment, in revision.*

Motivation

- Almost all coastal and inland research and operational activities require ocean color remote sensing capabilities that are not routinely available (NRC, 2011).
- Progress has been limited by the capability of the satellite sensors in orbit. To answer questions focused on coastal and inland waters, one is left to adapt existing capability to systems in which they were not intended.
- The optical complexity requires improved spectral resolution while the physical processes acting require smaller spatial and temporal scales than are currently in orbit.

AIM: Highlight short- and long-term efforts required to ensure that coastal and inland remote sensing is enabled to their full potential.

Spatial and Temporal Resolution



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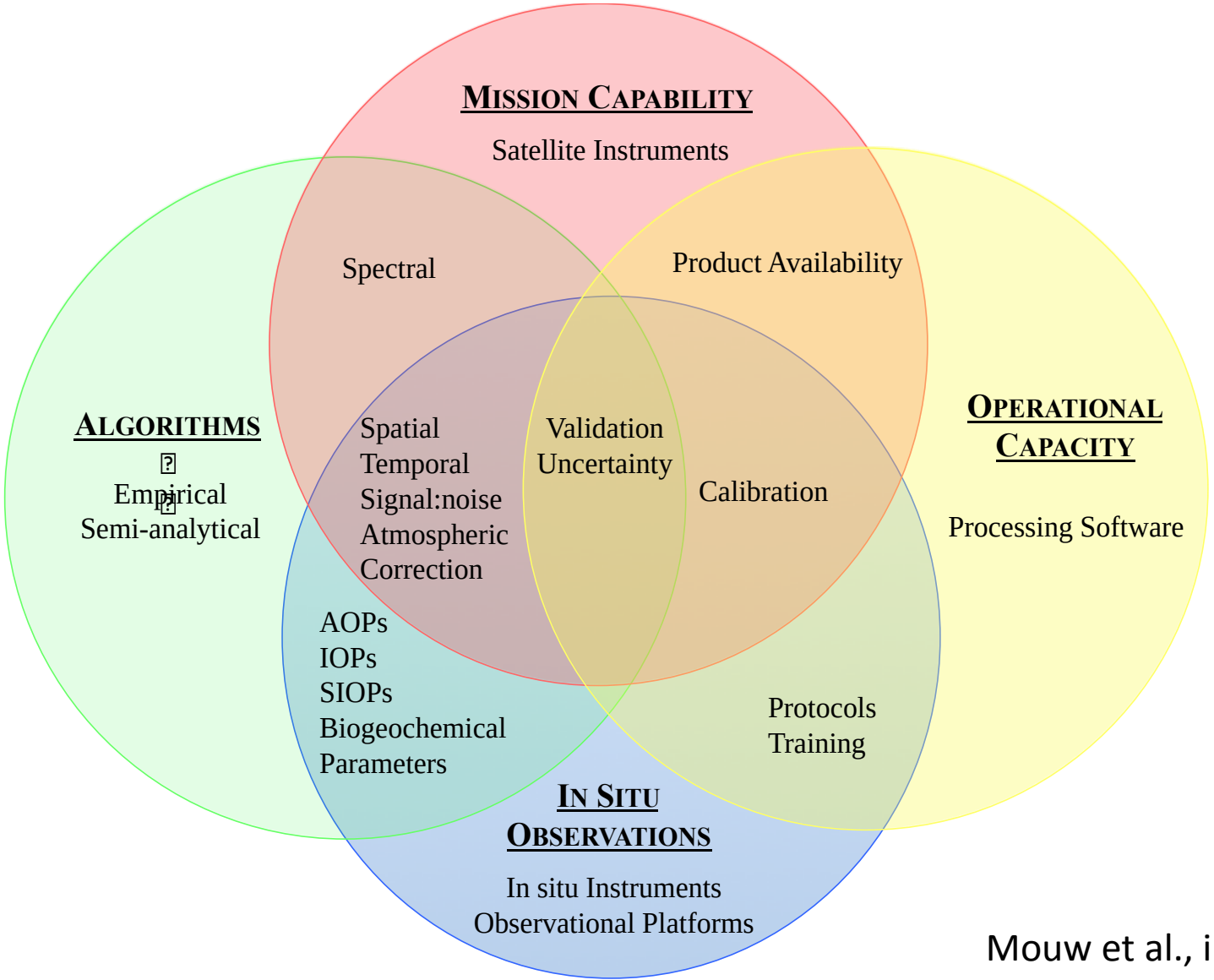
The goals of the workshop were to:

- 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 scientific basis/guidance for the next generation of remote sensing of coastal and inland water including a framework and recommendations for future research directions.
- Foster the development of new collaborations.

Integration Schematic of the Fundamental Elements of Satellite Remote Sensing



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Gap Analysis

Outline of the existing, desired and needed resources for the primary elements required for remote sensing of coastal and inland waters.

	Previous/Existing	Desired	Needed
Mission Capability	*300 m – 1 km, multispectral, polar orbiting.*	*100 – 500 m, hyperspectral, polar orbiting and geostationary with wide dynamic range and high signal to noise to allow for detection across broad parameter ranges.*	*Investment in geostationary and coastal/inland focused missions to optimize coverage, resolution and availability of new and improved measurements.*
Algorithms	*Multiple approaches optimized to different datasets for various regions.*	*A menu of algorithm choices with clear information about their respective strengths and limitations.*	• *Coordinated algorithm comparison to condense and clarify strengths and limitations and identify fit for purpose options.* • *Research into biogeochemical property variability and relationships with optical properties.*

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	Previous/Existing	Desired	Needed
***In Situ* Observation**	• *Non-coordinated, multi-agency efforts with data going to many different data repositories, if any and often with limited public data access.* • *Some coincident observations but not all minimum required observations.*	• *Limited number of centralized publically-available data repositories ensuring access to consistent high quality data.* • *Protocols that cover a dynamic range of variability.* • *At minimum, collect coincident observations of the standard suite of parameters (Table 4); if possible collect a broader suite of data products.*	• *Invest in technology development to address instrumentation gaps; such as sensors designed for high turbidity waters, and hyperspectral b_b.* • *Clear, consistent and coordinated data sharing policies across agencies.* • *Update protocols.* • *NOMAD-like dataset for coastal and inland waters.* • *Investment in sustaining and increasing observation networks.*

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	Previous/Existing	Desired	Needed
Operational Capacity	• *Global - open ocean mission /product heritage.* • *Tailored products available for some regions and applications.* • *Support and training often geared more to expert users.* • *Limited access to some satellite color data streams, especially in NRT mode.*	• *Routine and sustained delivery of high-quality operational color data in NRT and delayed modes for coastal and inland waters.* • *Development of merged remote sensing and integrated remote sensing-in situ (information) products.* • *Development of robust color-derived proxies and indicators.* • *Optimal algorithms identified for most/all coastal and inland regions with limitations and uncertainties / errors clearly indicated.*	• *Ongoing coordinated field observations for each coastal/inland region[1] to ensure continual validation.* • *Identification of best performing practices and approaches and continual evaluation as new approaches are developed.* • *Facilitate user data/product access and utilization, including development of application portals.* • *Expanded user outreach and training.* • *Free, open and timely access (NRT or other) to all satellite color data streams.* • *Implement user-driven community of practice for remote sensing of coastal and inland water to facilitate communication, best practices and harmonization efforts.*

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Standard Observations

Recommended standard *in situ* observations for algorithm development, refinement and validation.

	Minimum Parameters	Additional Parameters
AOPs	$R_{rs}(\lambda)$, $K_d(\lambda)$, Z_{eu} (or $Z_{10\%}$)	
IOPs	$a_t(\lambda)$, $a_{CDOM}(\lambda)$, $a_{NAP}(\lambda)$, $a_{ph}(\lambda)$, $b_{bp}(\lambda)$	$b_{bp,NAP}(\lambda)$, $b_{bp,ph}(\lambda)$
Biogeochemical	[Chl], TSM, OSM, ISM, DOC	HPLC pigments, primary productivity

*spectral parameters should be observed at the highest spectral resolution allowed by the instrumentation or at 2-5 nm increments.

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Prioritized Implementation

Priority	Immediate	Near-term	Long-term
1	*In Situ Observations:* *Establish limited number of centralized publically available data repositories.* *Operational Capacity:* *Provide more training opportunities for non-specialists.*	*In Situ Observations:* *Invest in data collection in complex waters and the characterization of SIOP variability.* *Operational Capacity:* *Work to ensure free, open and timely (NRT or other) access to all satellite color data streams.*	*Mission Capability:* *Ensure satellite mission capability with flexibility to handle appropriate sensitivity, spectral, spatial and temporal scales found in coastal and inland systems. Move toward sensor agnostic hyperspectral design that could be resampled for various applications.*

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Prioritized Implementation

Priority	Immediate	Near-term	Long-term
2	*In Situ Observations:* *Establish standard measurements for any in situ campaign supporting remote sensing. Update community (NASA et al.) protocols to include consideration of the dynamic range of properties encountered in these systems and extend to include biogeochemical properties.*	*Operational Capacity:* *Identify best practices and approaches for use of color remote sensing data in applications. Develop decision support information and tools for algorithm and product selection. Develop application portals to facilitate access and fit for purpose use of color remote sensing data.*	

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Prioritized Implementation

Priority	Immediate	Near-term	Long-term
3	*Operational Capacity: Establishment of a user-driven community of practice for remote sensing of coastal and inland waters to link freshwater and marine, satellite and in situ data, data providers and users, science and societal considerations, to work collaboratively with IOCCG, space agencies et al.*	*Algorithms: Perform an algorithm intercomparison for consolidation and/or simplification of algorithm choices.* *In Situ Observations: Create a 'NOMAD-like' dataset with coincident observations for the inland/coastal waters.*	

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Recommendation Summary

Interest in inland and coastal waters cross numerous scientific, management and societal realms. Recommend develop of a professional identity that encompasses the intersection of communities, lead by a dedicated staff person.

- ***Mission Capability:*** Ensure planned geostationary missions proceed.
- ***In Situ Observations:*** Data sets should be as comprehensive as possible (temporal, spatial, cover large dynamic ranges), moved toward autonomous platforms, protocol improvement, centralized database regardless of funding agency.
- ***Algorithms:*** A comparison or 'round robin' exercise is recommended to document algorithms fit for use, in addition to consolidation and simplification of the range of algorithm options.
- ***Operational Capacity:*** Educate the user community who are interested in applying satellite products to their study region or application but are not trained in optics and remote sensing techniques. Panel of experts to provide recommendations on the 'fit for purpose'.