Discussion: Validation of Aquatic Radiometry

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Aquatic Validation

Assumptions

Validation of Level 2 normalized water-leaving radiance (nLw)

- Methods - an overview of basics
- Typical Challenges
- Coastal and In-Land Water Issues

Issues of tidal wetlands

- Complex spatial mixing
- Bi-directionality and sun glint

Summary

Assumptions

- Instrument characterization and calibration done first:
  - Space instrument characterization
  - Vicarious and lunar calibration (remove bias and detrend)
  - Ground instruments characterized
  - Intercalibration of surface instruments
  - NIST traceable calibration
- Standard Cal/Val protocols
  - NASA CVO protocols (2002-2004) as a starting point
  - Further development for coastal waters underway
- Centralized data archive and quality control (e.g., SeaBASS)
- Shiptime, Buoy accessibility & maintenance budgeted (open ocean)
- Data format, distribution, and use agreements

nLw VALIDATION

Measuring At Surface nLw

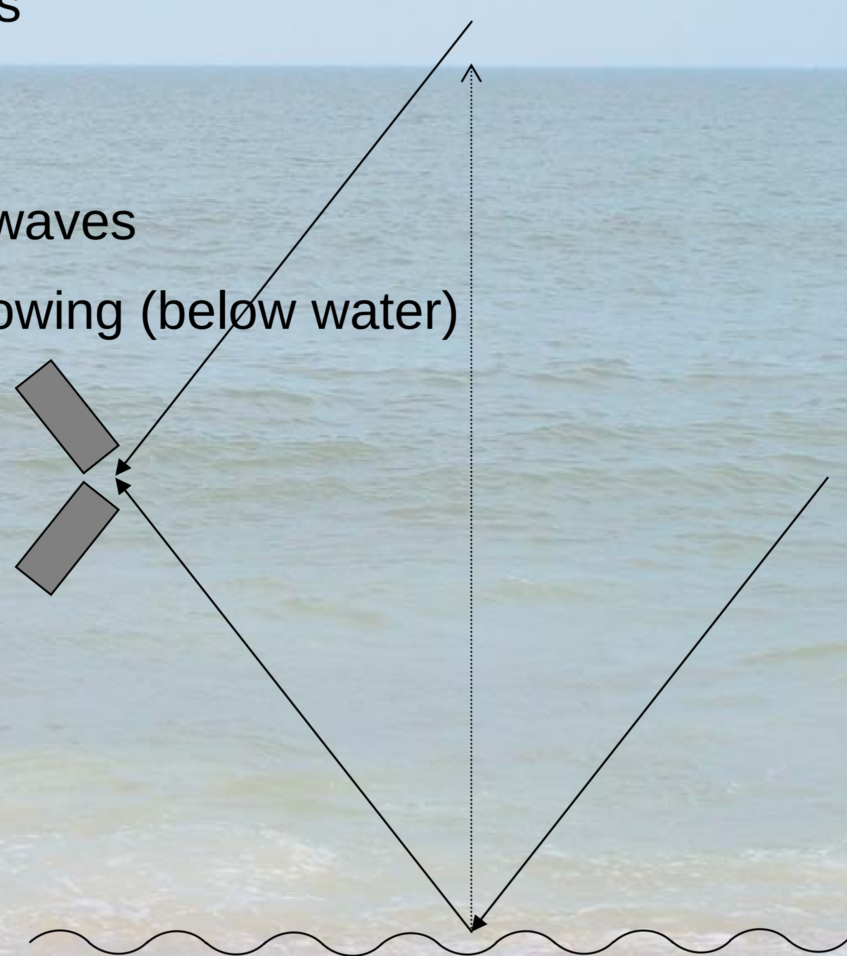
- Difficult measurement; cannot be measured directly.
- Platforms: Ships, buoys, towers
- Sun and sky photometry to get irradiance.
- Above water:
  - Measure sea surface radiance.
  - Measure sky radiance at angle of incidence.
- Below water:
  - Measure downwelling and upwelling irradiance with depth
  - Extrapolate to surface to get upwelling radiance at $z = 0^-$.

  or

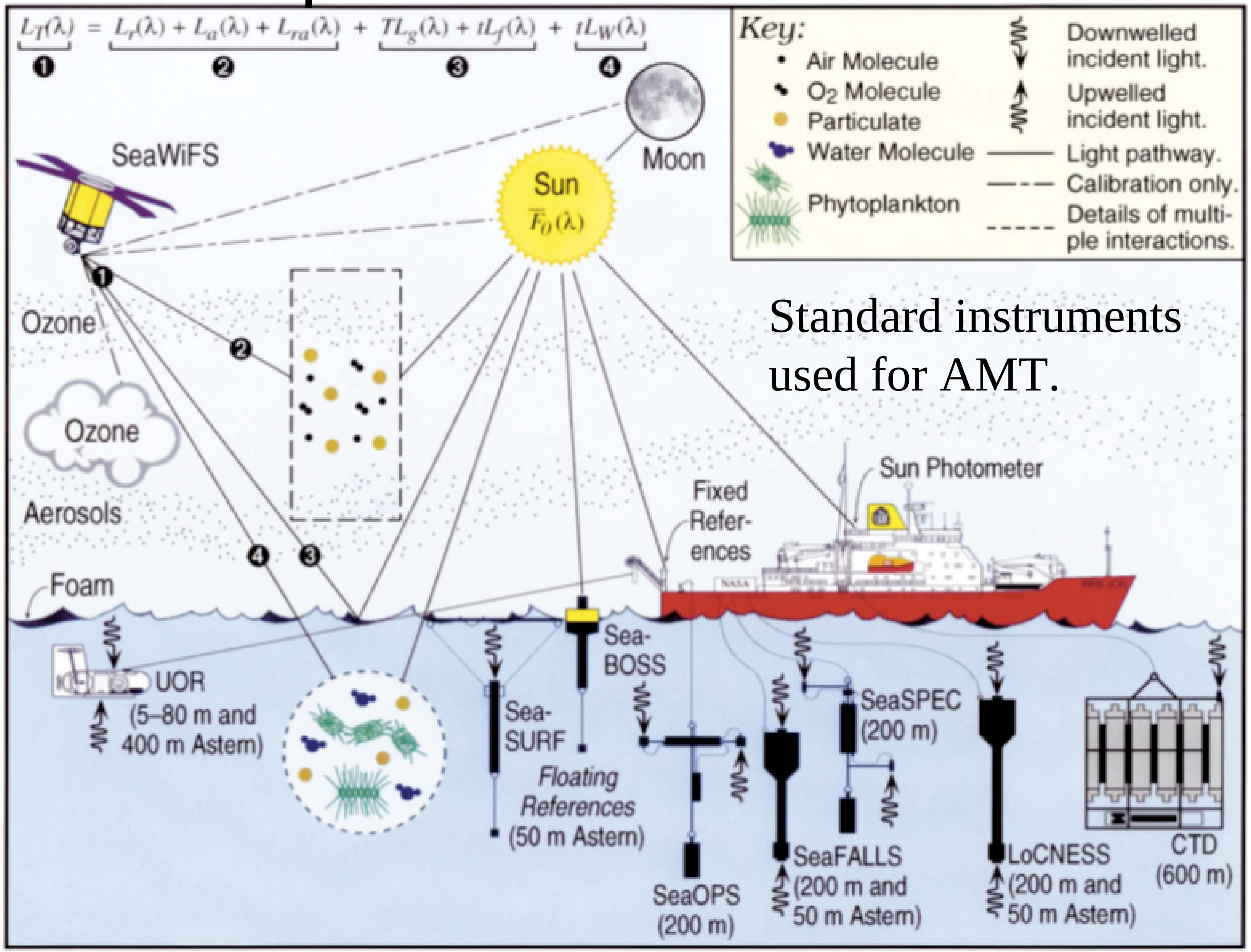
  - Measure IOPs of water samples and use radiative transfer to obtain upwelling radiance at $z = 0^-$.
- Ideally, all three are done to obtain closure.

Aquatic Validation Challenges

- Glint (above water)
  - Waves, surface conditions
  - Geometry
  - Sky conditions
- Floating platforms move with waves
- Instrument and platform shadowing (below water)
- Sea spray
- Sea foam, bubbles
- Bi-directionality
- Raman scatter (2nd order)

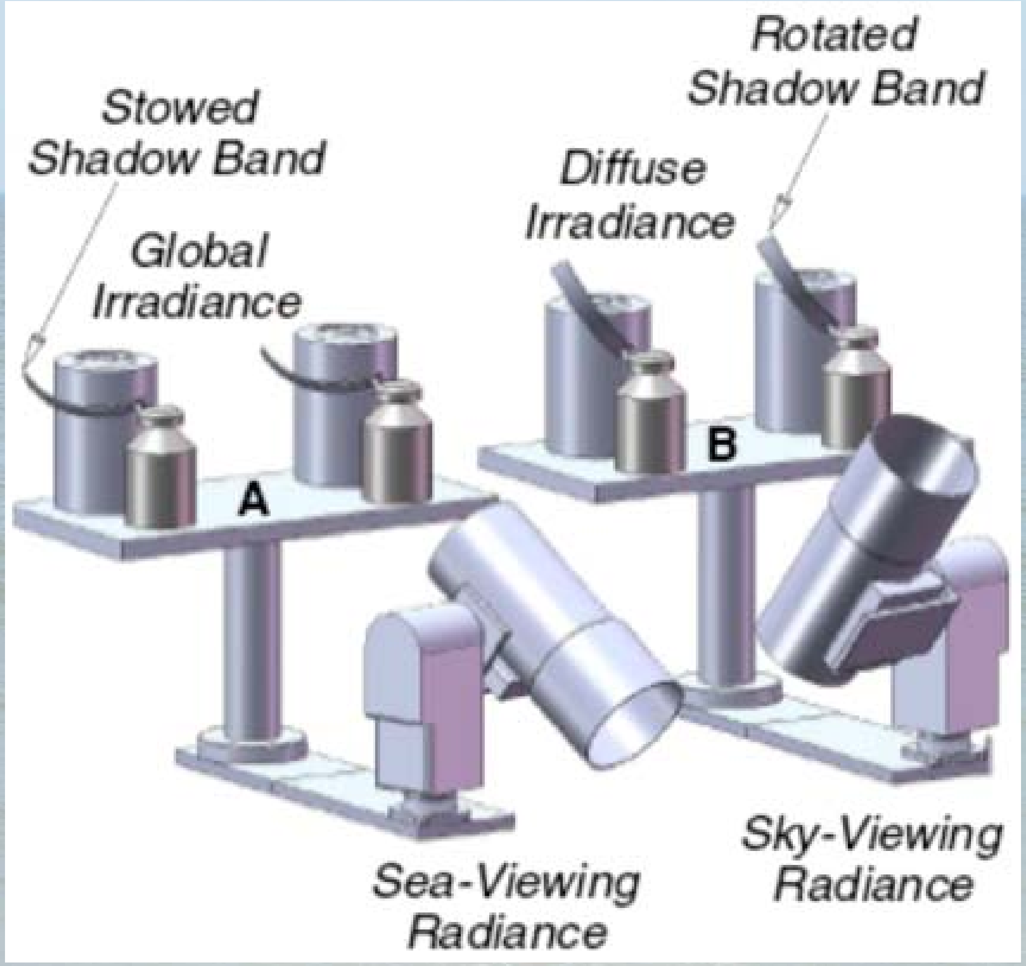


Examples of below water Instruments



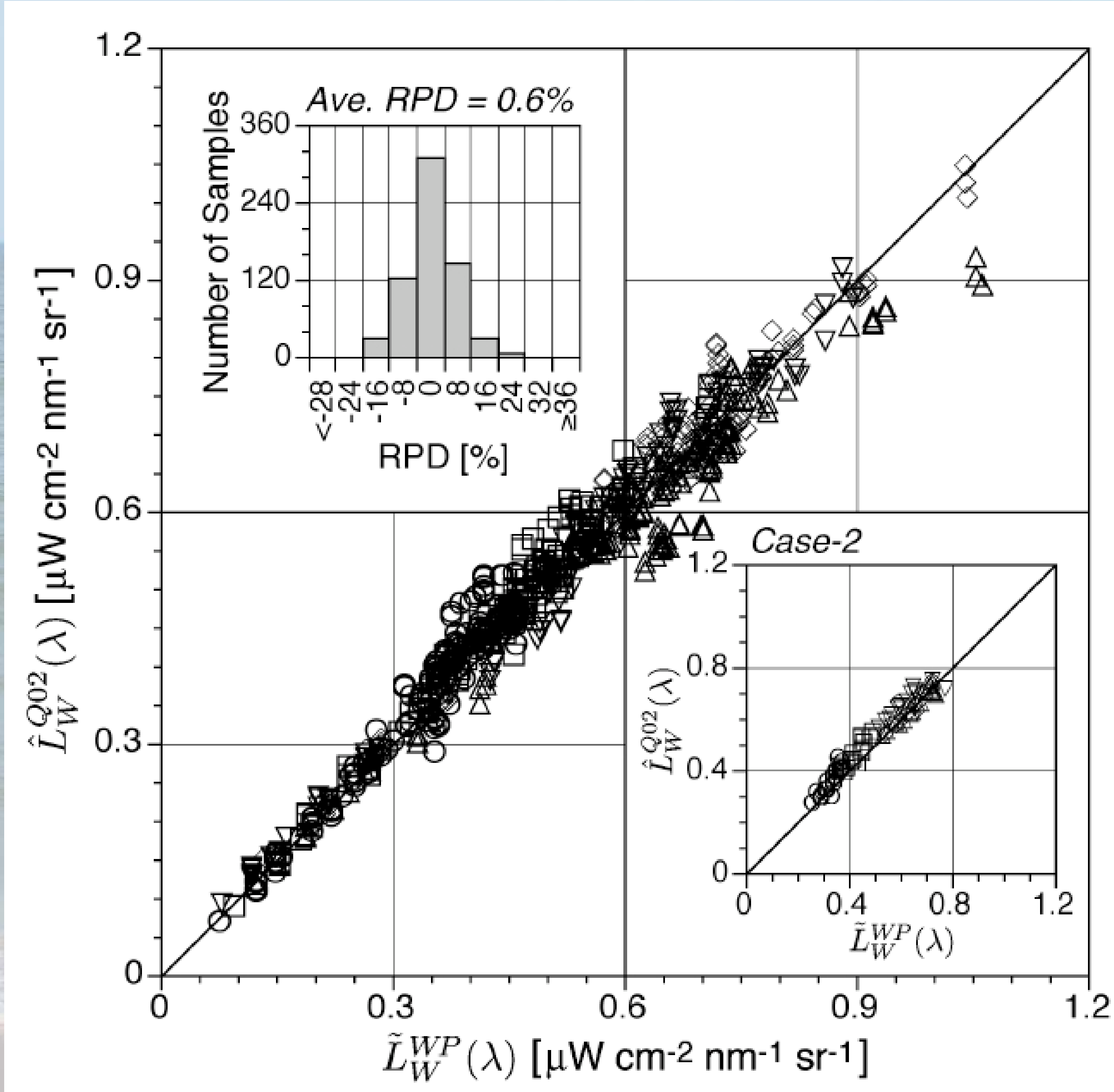
Standard instruments used for AMT.

Example above surface instruments



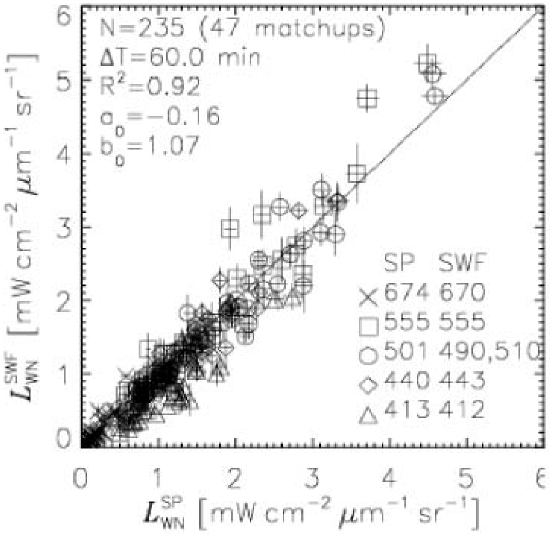
Hooker (2009)

Comparison of Above and Below Water Methods

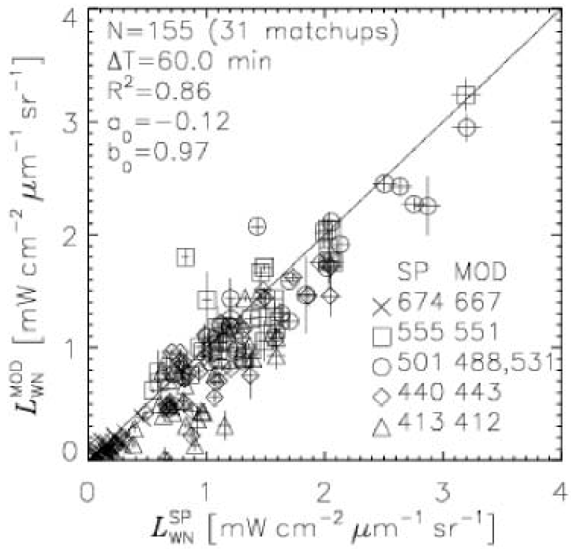


Hooker et al. 2004 OCRT Meeting

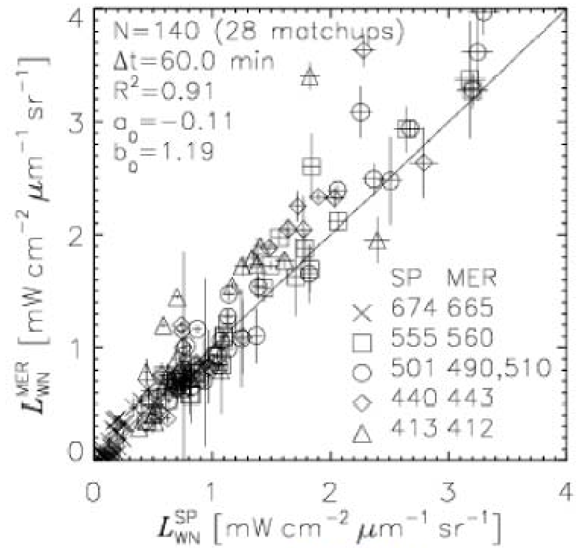
Comparison of In Situ nLw to Satellite



SeaWiFS



MODIS



MERIS

G.Zibordi, F. Mélin, S. B. Hooker, D. D'Alimonte and B. Holben. An autonomous above-water system for the validation of ocean color radiance data. *IEEE Transactions in Geoscience and Remote Sensing* , 42:401-415, 2004 .

Validation Issues for Coastal and In-land Water

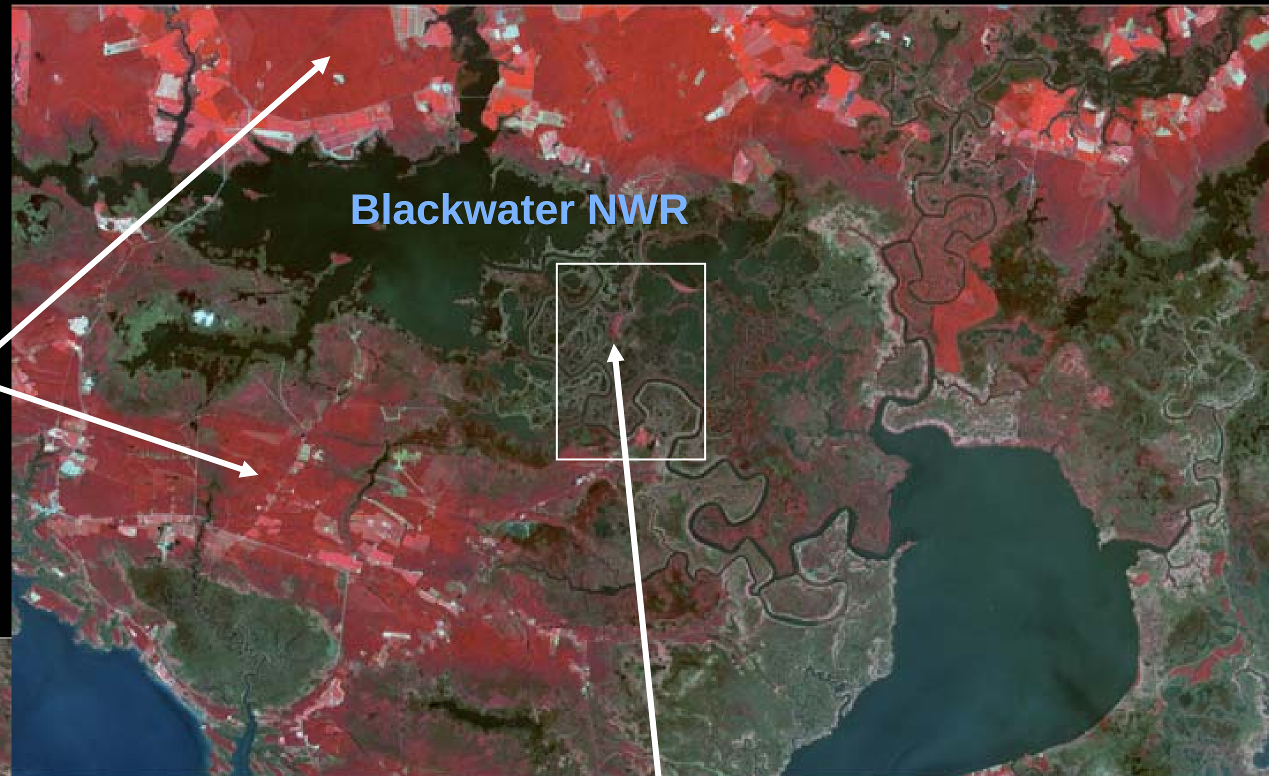
Close to land, waters can be highly variable in time and space and an improved sampling strategy may be needed:

- May need to select sites for stability (e.g.):
  - Open ocean sites
  - Lake Tahoe
  - Clear, shallow water (Bermuda, Bahamas)
- For other sites, may need tighter time constraints for match-ups requiring more planning for overpasses.
- Might use airborne instruments in combination with *in situ* to scale up variation to satellite.

TIDAL WETLANDS

ASTER Imagery over Chesapeake Bay Wetlands

Dense highland vegetation



Dense vegetation marsh; Presence of water reduces NIR reflectance of canopy

Complex Spatial Mixing

In remote sensing imagery wetlands can appear as a highly complex mix of terrestrial and aquatic components.

Validation of spectal mixing models may be necessary.

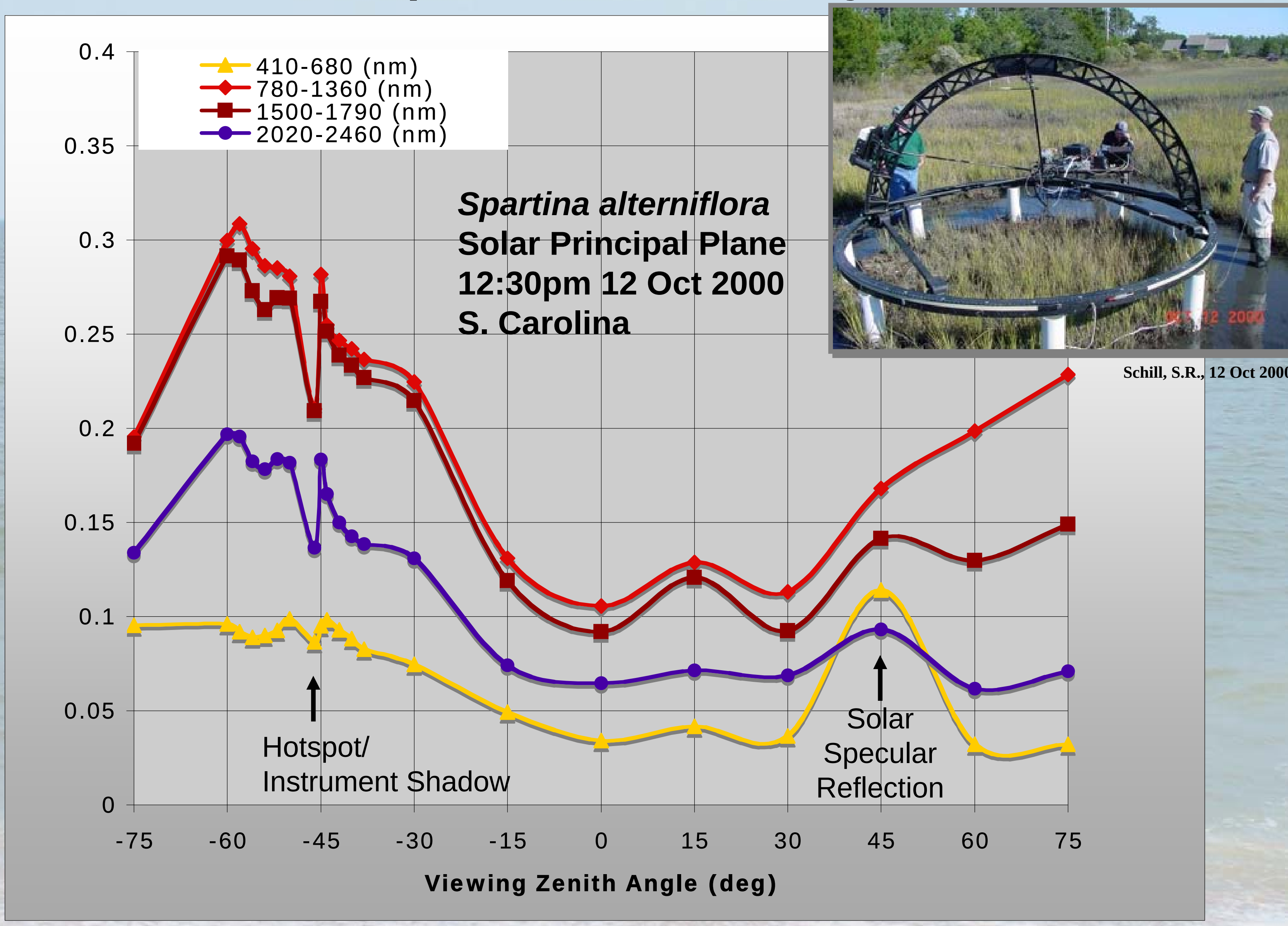
THE RAVAGES OF SUN GLINT

OFF NADIR

NADIR

CHRIS/Proba Imagery

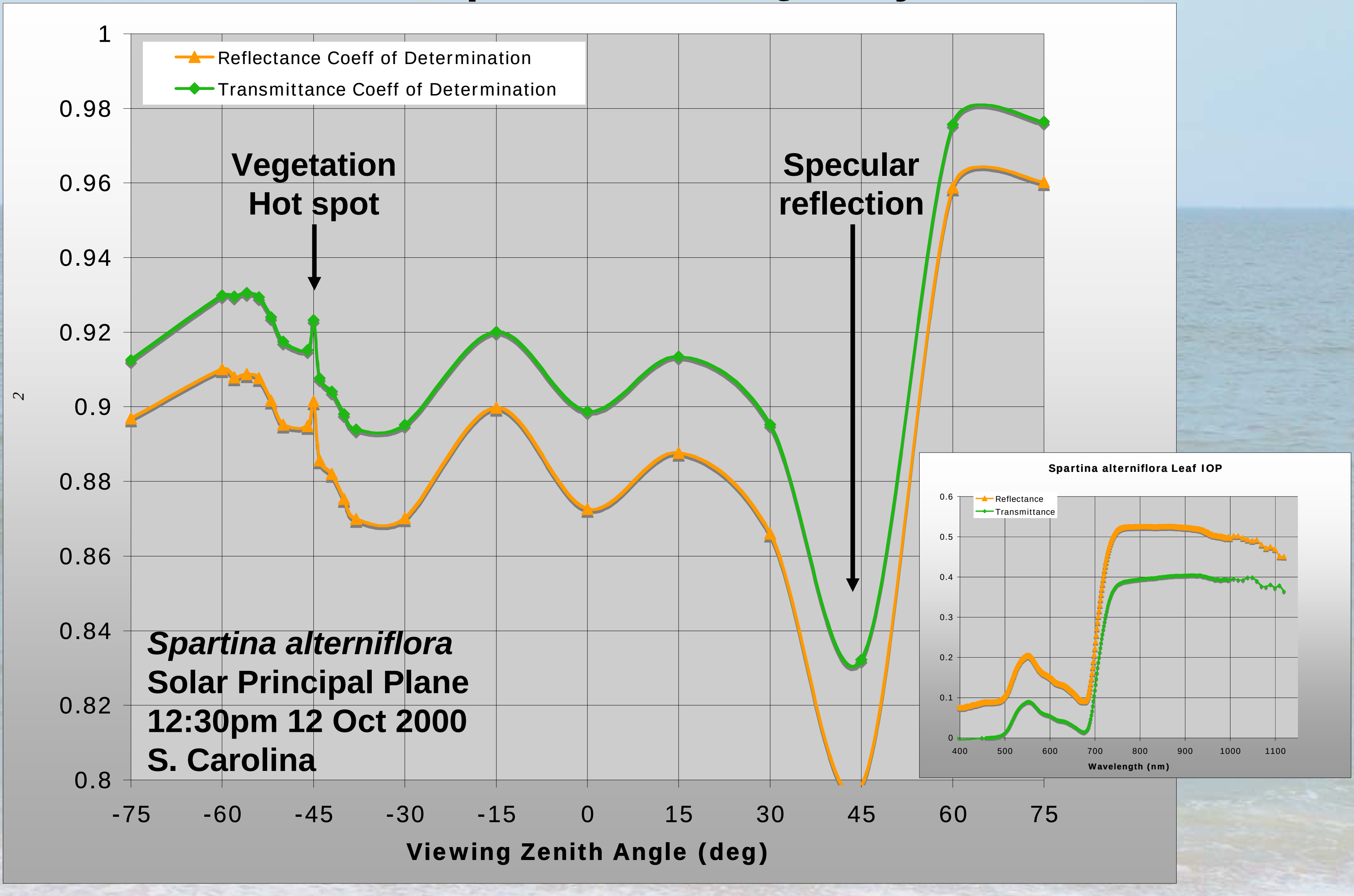
Spectral Data Quality



Schill, S.R., 12 Oct 2000

Data source: Schill, S.R., Jensen, J.R., Raber, G.T., Porter, D.E., (2004). Temporal modeling of bidirectional reflection distribution function (BRDF) in coastal vegetation. *GIScience and Remote Sensing.* 41(2), pp 116-135.

Spectral Data Quality



Data source: Ramsey, E.W., III, Rangoonwala, A., (2005). Leaf optical property changes associate with the occurrence of *Spartina alterniflora* dieback in coastal Louisiana related to remote sensing mapping. *Photogrammetric Engineering & Remote Sensing*, 71(3), pp 299-311.

Aquatic Validation Summary

- Characterization, calibration and detrending must be done first.
- Surface instruments should be intercalibrated.
- Standard protocol established.
- Programmatic infrastructure should be in place.

- Normalized water-leaving radiance cannot be measured directly.
- Different methods are employed successfully.

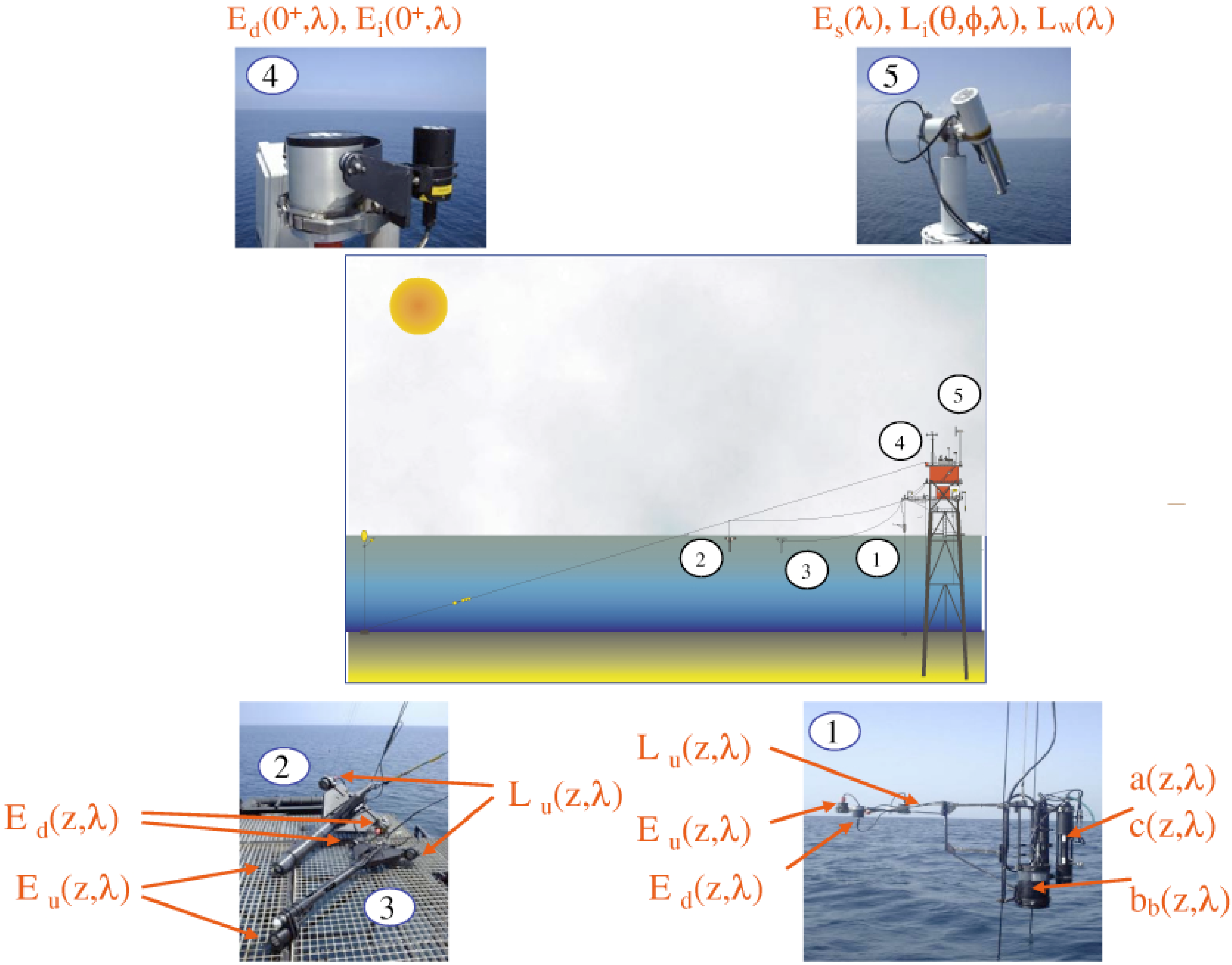
- Methods should follow common protocols.
- NASA CVO is working to improve existing protocols for coastal waters.
- More work needed for in-land waters?

- Tidal regions are subject to glint contamination and represent highly mixed terrestrial and aquatic signals.
- Validation of bi-directional spectral mixing may be useful.


DISCUSSION

AUXILLARY SLIDES

AAOT Optical Systems



Example Surface Data Sites*:

- Aeronet/SeaPRISM
- Plumes and Blooms (PnB)
- BOUSSOLE

Being intercalibrated by CVO (2009)

- BATS
- HOT
- CARIACO
- Venice Tower
- MVCO
- MOBY

*** All represent fixed assets (i.e., buoys, towers) except PnB**

Intersensor Validation:

- Covers greater area.
- Can identify large scale systematic trends.
- Differences can help identify instrument behavior.
- May helps scale up surface measurements.
- Does not help when both instruments are wrong.

Example Airborne Sensors:

- AVIRIS (NASA)
- Ocean PHILLS (NRL)
- SAMSON (FERI)
- HYDICE
- Commerical? (HyMap, CASI, AISA, etc.)

Example Spaceborne Sensors:

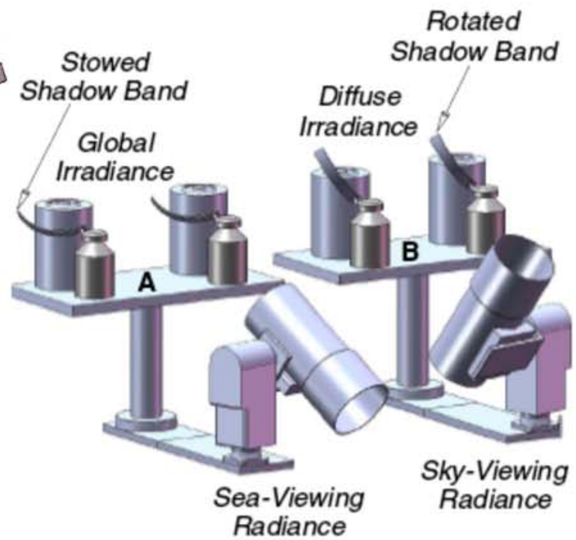
- ACE/ORCA (DS Tier 2)
- VIIRS (NPP/NPOESS 2011/2014)
- HICO (APL/NRL)
- OLCI (ESA, launch planned for end of 2012)

Future

- Future capabilities will have a much larger dynamic range in many variables (sensor response, water depth, etc.), so instrument development is needed to accommodate the new sampling requirements (AOP sensors have been miniaturized while expanding their performance, but IOP sensors have not).
- The future emphasizes shallow water, so improved sampling and data processing protocols are needed.
- The future is synergistic (ACE), so field oceanographers are going to have to be prepared to collect good atmospheric data (OSPREy).

Calibration and Validation for the Next-Generation, Coupled Ocean-Atmosphere Ocean Color Satellite

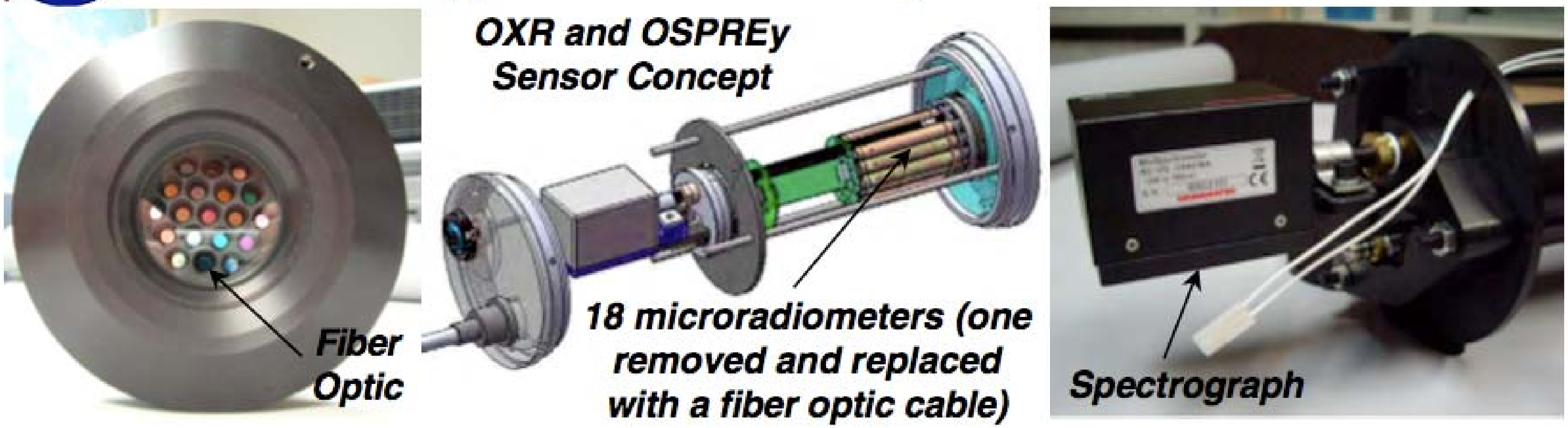
The Optical Sensors for Planetary Radiant Energy (OSPREy) concept is based on enhanced commercial off-the-shelf (COTS) sensors coupled with microradiometers for in-water validation.



The OSPREy system is comprised of the following:

- Above-water to minimize fouling and enhanced for accuracy and spectral coverage;
- Duplicate triads intercompared to improve data quality and minimize data gaps;
- Shadowbands on the irradiance sensors to support atmospheric measurements;
- NIST traceability and intercalibration with the OSPREy Transfer Radiometer (OXR);
- Sun tracking to provide the needed metrology for sea and sky measurements, as well as sun photometer data products; and
- Use of an offshore structure reduces infrastructure costs and improves survivability.

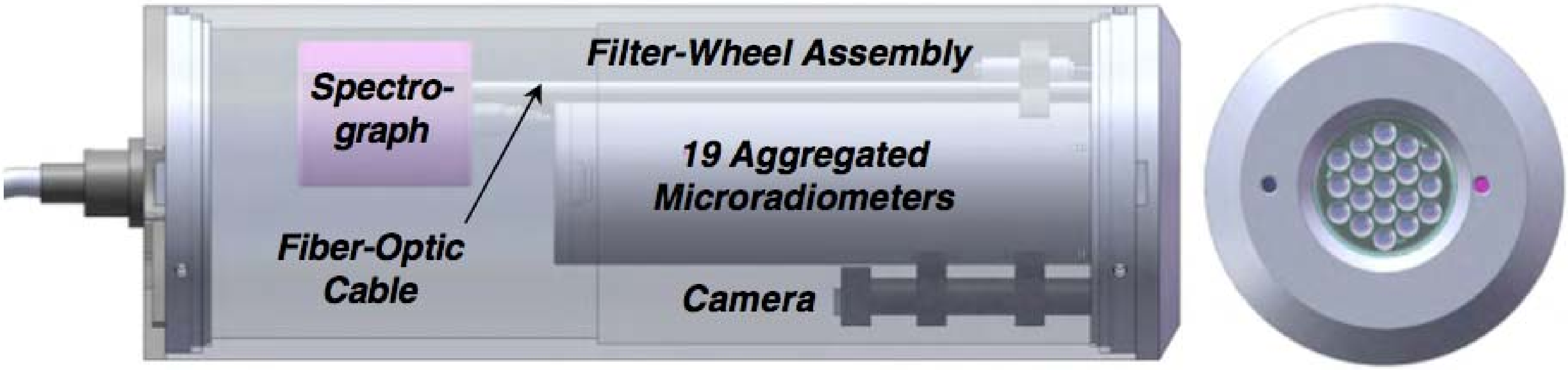
The OSPREy Transfer Radiometer (OXR): *The First Prototype of the OSPREy Field Radiometers*



OSPREy radiometers span the UV up through the SWIR and are hybrid units with 18 fixed-wavelength channels and a temperature-controlled spectrograph:

- The filter-photodetector channels will provide the absolute calibration for the hyperspectral device to permit accurate measurements at all wavelengths.
- The hyperspectral data will be used to account for spectral features in $L_W(\lambda)$ measurements caused by absorbing and scattering compounds in the water, which cannot be spectrally resolved by the regular channels.
- The irradiance sensors will be split into two units (for cosine collector optimization) and each will have a separate spectrograph (UV-VIS and VISNIR).
- The internal temperature is stable to less than ±0.1°C, which translates to variations in the responsivity of the filter channels to less than ±0.03%.

Enhancement of the OSPREy Radiometers to Improve Sea, Sky, and Sun Viewing



OSPREy radiometers span the UV up through the SWIR and are hybrid units with fixed-wavelength channels and a temperature-controlled spectrograph:

- The new design has 19 fixed-wavelength channels rather than 18.
- The addition of a filter-wheel assembly with the fiber-optic permits hyper-spectral polarimetric measurements (two polarized filters), direct sun viewing (neutral density filter), and dark current measurements (solid disk).
- The addition of a camera will improve data processing, because cloud detection is significantly improved and sea surface contamination can be verified, but it will also improve acquisition of the solar disk, so the sun photometer capabilities are enhanced. The entire sensor can be pointed, so the camera can be used to look at other targets of interest (e.g., the horizon).

Exploitation of the OSPREy Radiometers on a Very Stabile, Mobile Platform (R/V *Resolution*)

The height of the derrick on the R/V *Resolution* is about 200 ft above the water with excellent viewing opportunities of the sea, sky, and sun. The extraordinary stability of the ship during drilling operations—coupled with the fact that the ship traverses the world ocean—makes the mounting of an OSPREy system on the top of the derrick a very intriguing possibility.