IMOS Integrated Marine Observing System

Western Australian Integrated Marine Observing System (WAIMOS)

Update on the Radiometry Task Team

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and the task team members, by alphabetic order:

Elizabeth Botha (CSIRO), **Nagur Cherukuru** (CSIRO), **Arnold Dekker** (CSIRO), **Martina Doblin** (UTS), **Peter Fearns** (Curtin), **Nick Hardman-Mountford** (CSIRO), **Rob Johnson** (BoM), **Edward King** (CSIRO), **Wojciech Klonowski** (IMO), **Jenny Lovell** (CSIRO), **Tim Malthus** (CSIRO), **Ross Mitchell** (CSIRO), **Matt Slivkoff** (Curtin), **Peter Thompson** (CSIRO), **Paul Van Ruth** (SARDI)

Curtin University · CSIRO · UTS University of Technology Sydney · Australian Government Bureau of Meteorology · IMO · SARDI South Australian Research and Development Institute

Background, rationale

- Given Australia's vast ocean territory, satellites form an important means by which to establish baselines and assess spatial and temporal patterns of change. The technique here considered is **ocean colour radiometry (OCR)**, as provided now for about 18 years by dedicated NASA and ESA OCR satellite missions

- IMOS currently serve such products to the Australian research community, with an emphasis on tailored local products (Southern ocean, GBR)

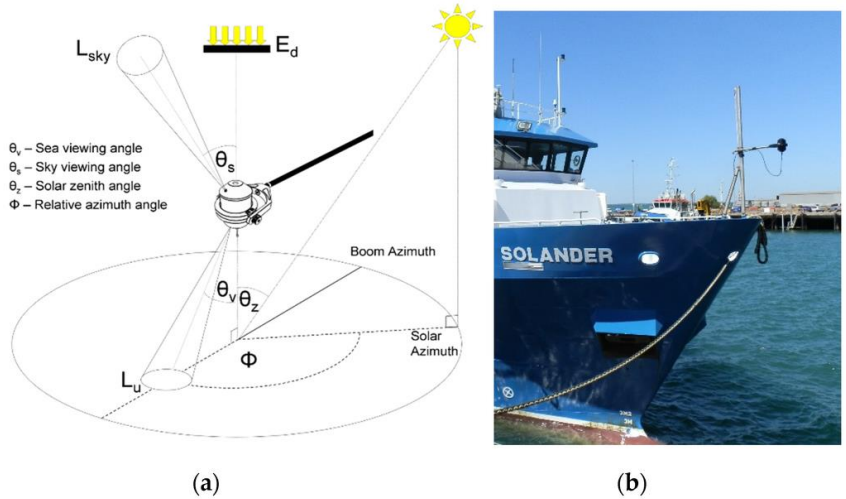
- "Local" algorithms are needed, which means measurements of IOPs and radiometry are needed

- In the coming 5 years, the IMOS remote sensing facility will also progressively incorporate data from the **VIIRS, Copernicus Sentinels and S-GLI** program missions, in order to serve the community with data for the long term (MODIS is likely close to the end of its operations). In this process, the IMOS bio-optics community should evaluate whether the data they generate for cal/val operations of ocean colour sensors remain valid or have to be adapted.

- This "**Radiometry Task Team**" (RTT) is precisely proposed to help in this process

What the Australian community does?

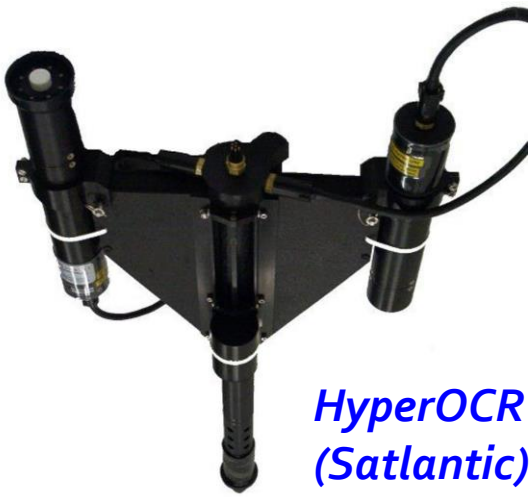
DALEC (IMO)



Brando et al., Remote Sens. **2016,** *8*(2), 150; doi:10.3390/rs8020150

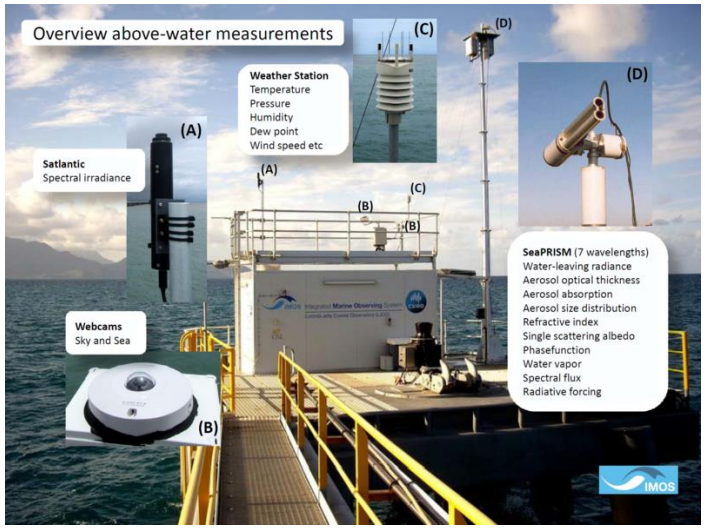
RAMSES (Trios)

http://www.iopan.gda.pl/RSL/equipment.html



HyperOCR (Satlantic)

SeaPRISM (CIMEL)



Objectives

The objective is to perform activities that can ultimately **improve usability of IMOS radiometric data sets for research purposes as well as for validation of satellite ocean colour products**.

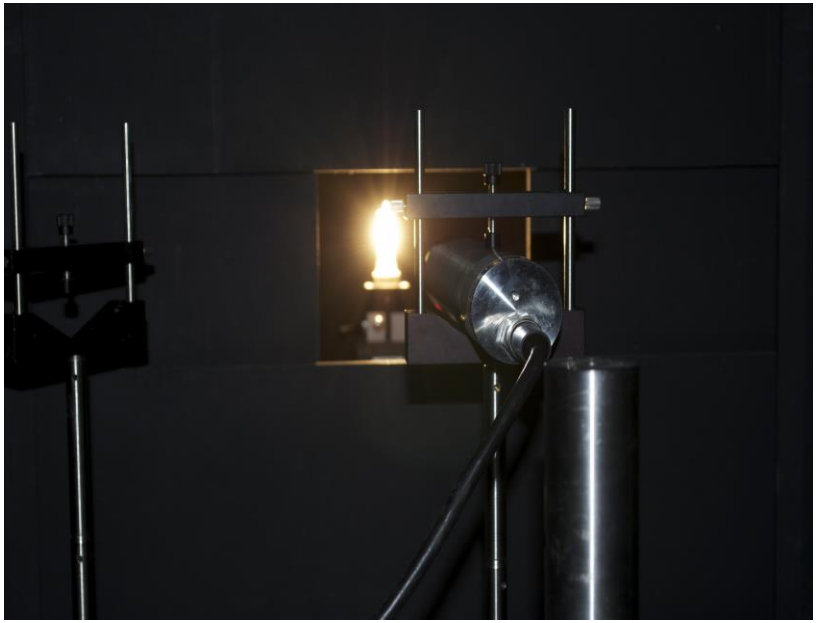
These activities are **upstream of the research** endeavour itself.

Another objective is to develop **a plan for the evolution of radiometry measurements in IMOS for the next decade**.

This can be summarized as follows:

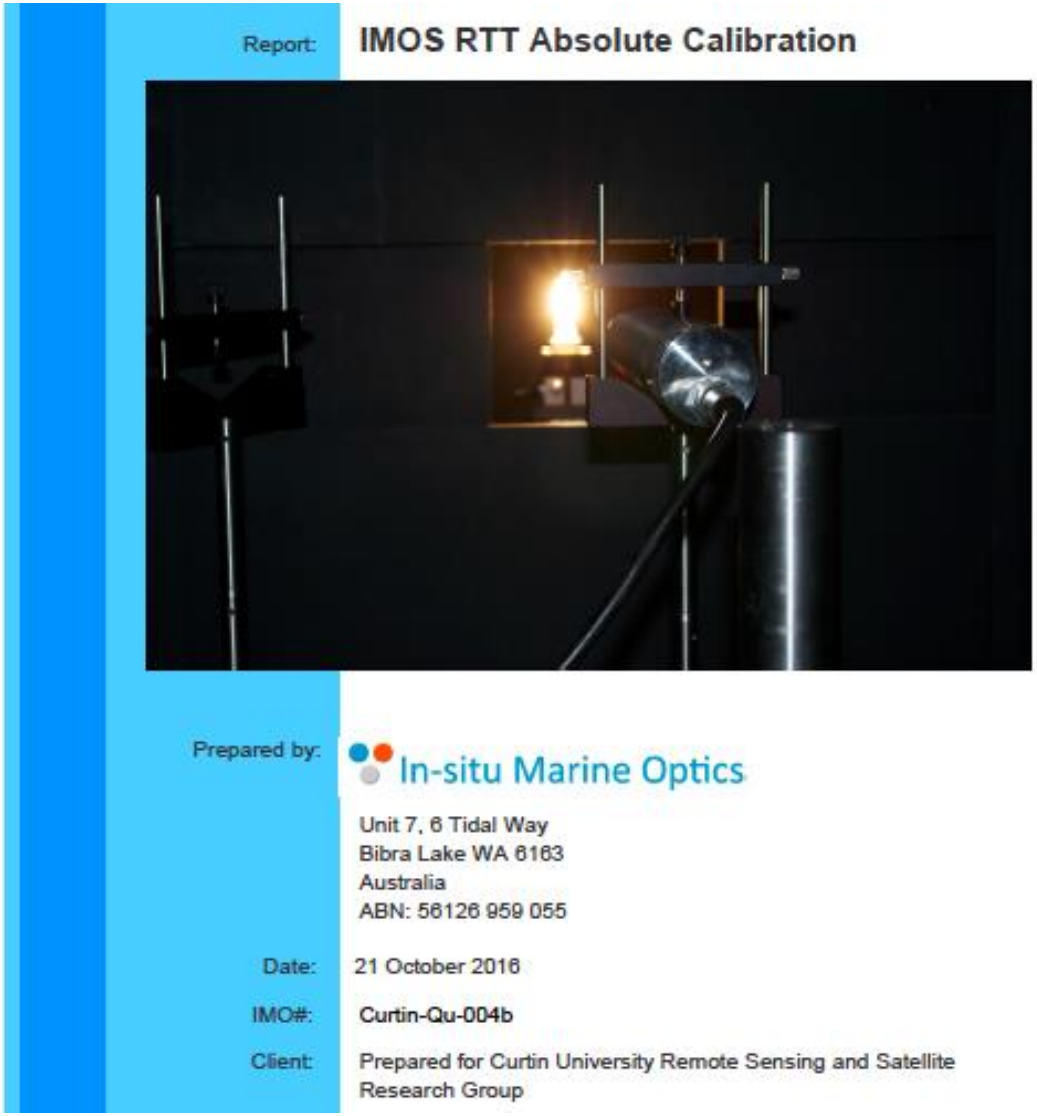
1. Evaluate the degree of consistency or inconsistency among existing sea-going radiometers used in the IMOS and the wider bio-optical community, through dedicated laboratory and field experiments
2. If needed, improve consistency among these instruments
3. Develop a plan for the evolution of radiometry measurements in IMOS for the next decade

1st activity: lab inter-comparison



- Performed at "Insitu Marine Optics" (IMO), Perth
- Instruments under test: Curtin & IMOS **DALECs**, CSIRO & UTS **Trios Ramses**, CSIRO **Satlantic HyperOCR**, CSIRO **CIMEL sun/sky photometer,** IMO **USSIMO**
- Were investigated: consistency of reference lamps, temperature effects, linearity vs. integration time
- Participants: Wojciech K. (IMO), Matt S. (IMO/Curtin), David B. (CSIRO), Kevin Davies (UTS), David A. (Curtin)
- About 5 weeks of lab work, and 4 weeks of data analysis

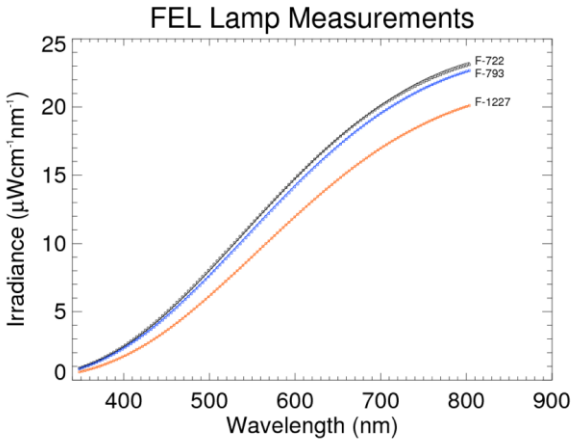
1st activity: lab calibration/characterization

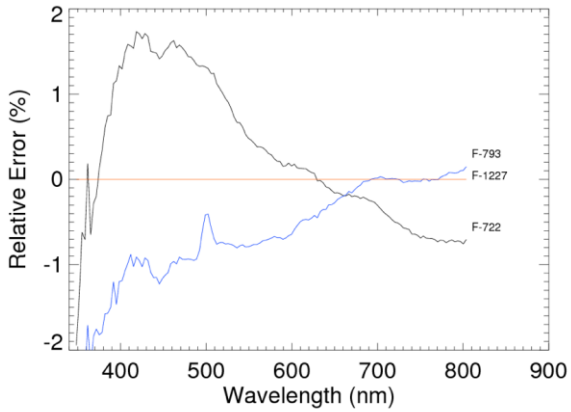


- Overall consistency of the calibration lamps
- No "out-of-range" instrument
- Temperature is to be monitored for spectrometer-based instruments
- Calibration must be done at different internal temperatures
- Manufacturer cal/charact. work insufficient
- Look at counts when using a spectrometer, and don't try to get measurements for too low/high counts
- This will be pursued with participation to the ESA's FRM4SOC "LCE1" exercise

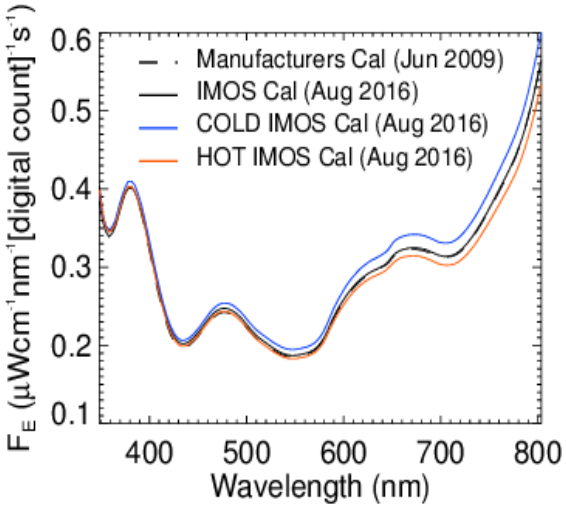
Draft report (Dec 2016); revised draft by April 2017

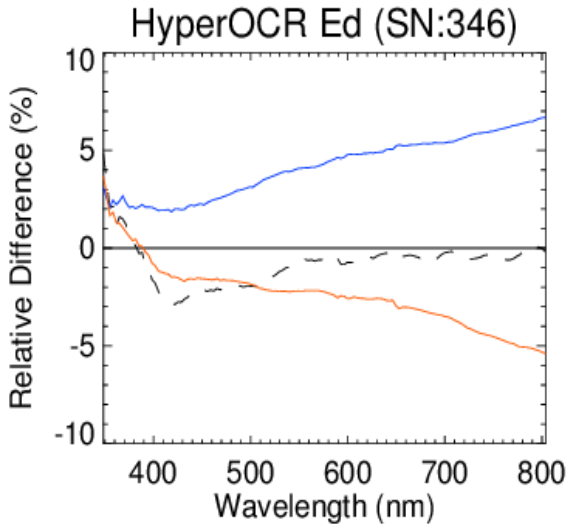
FEL Lamps (NIST certified)

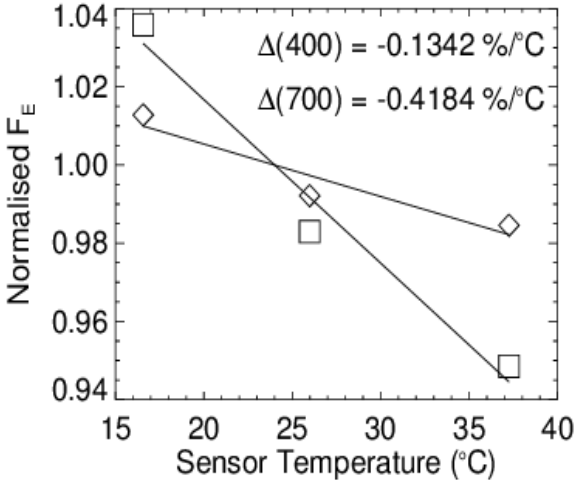




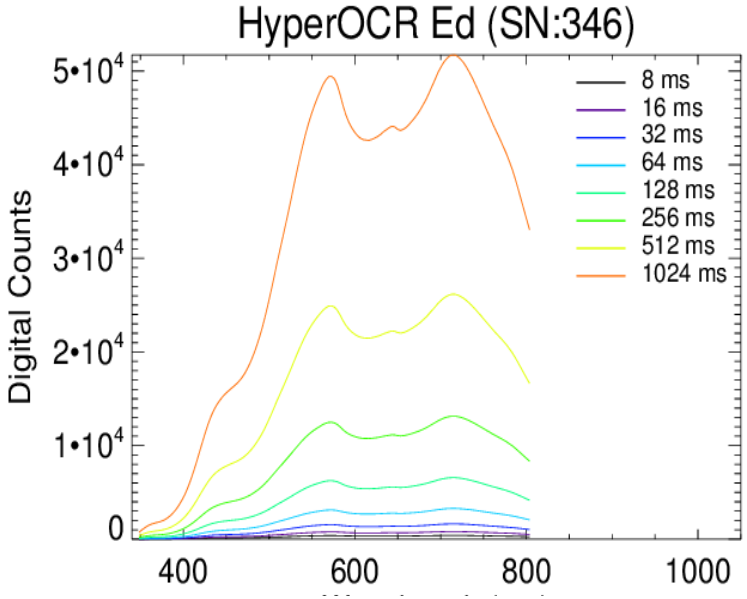
Temperature effects

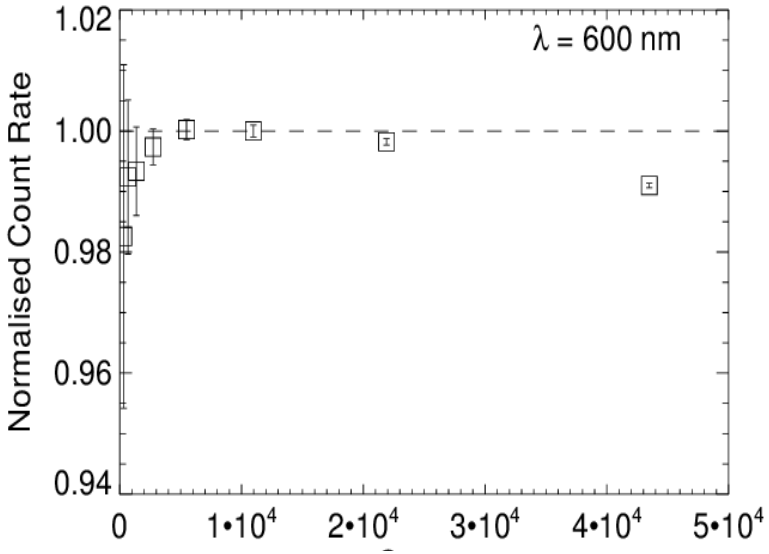


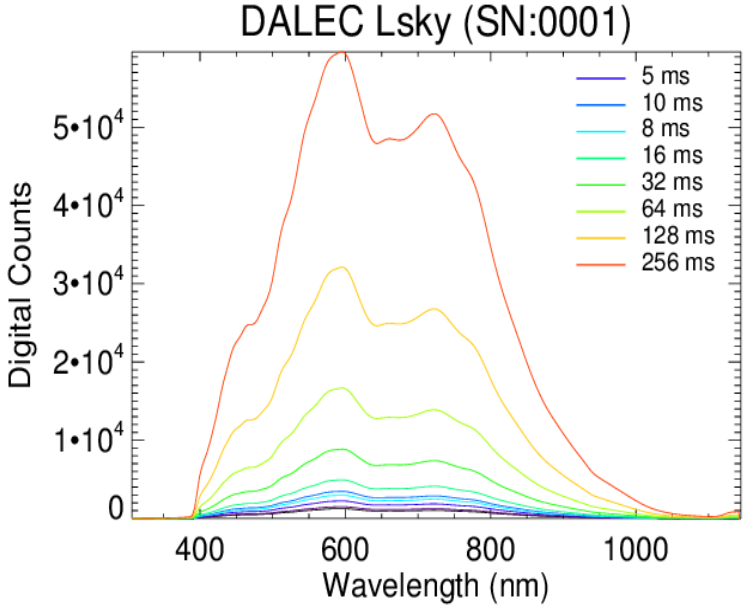


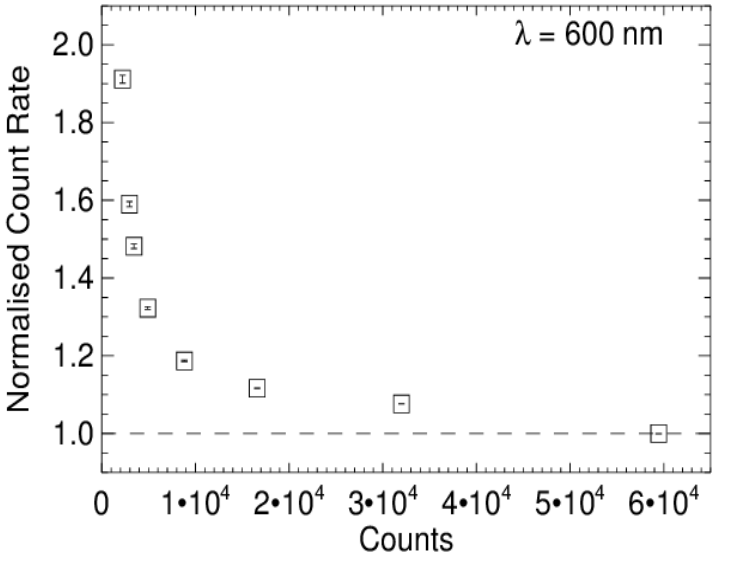


Linearity & integration time

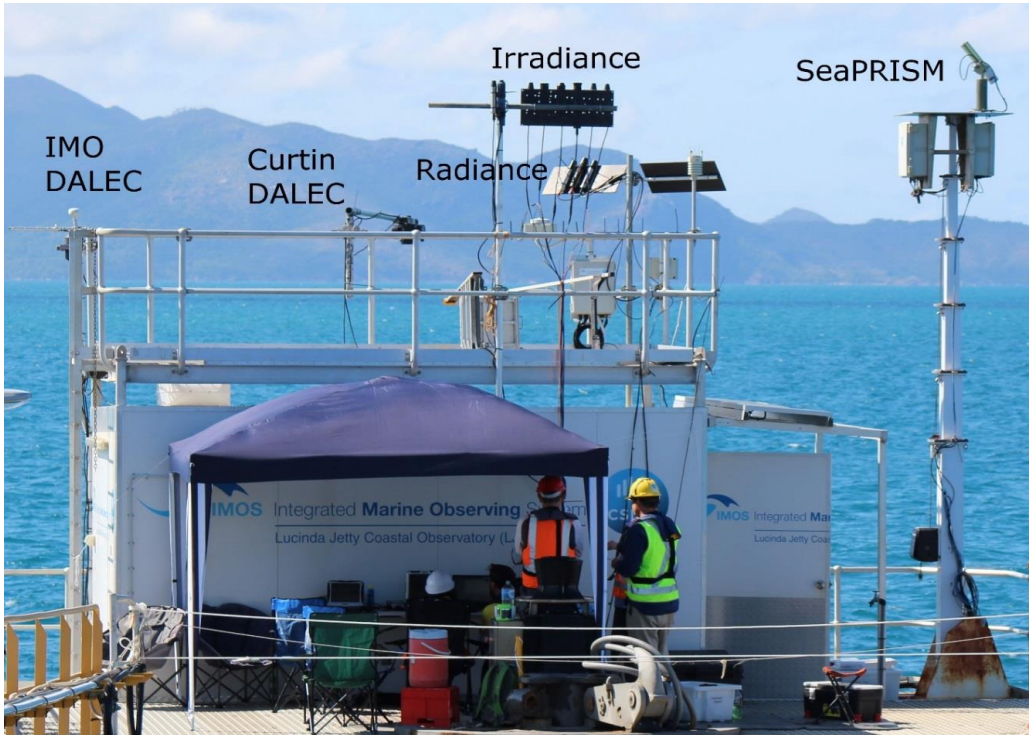




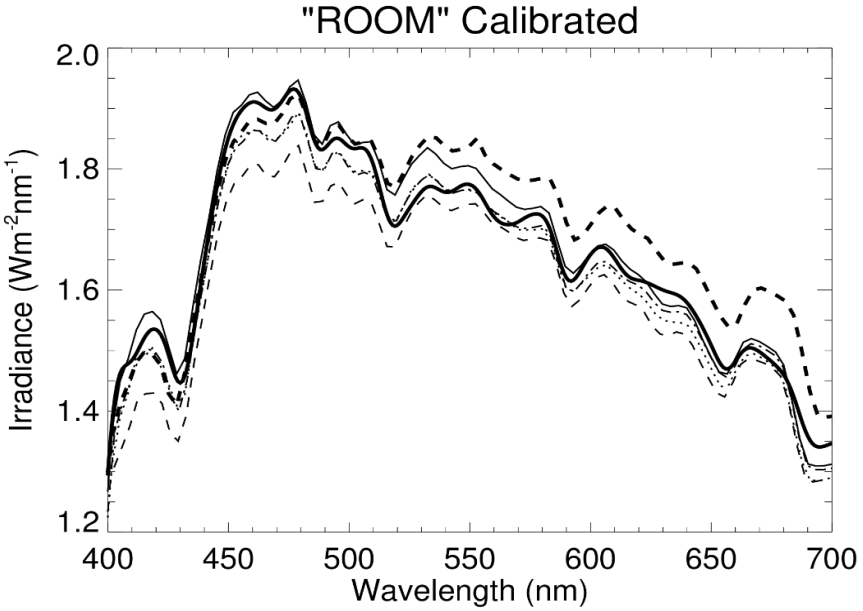


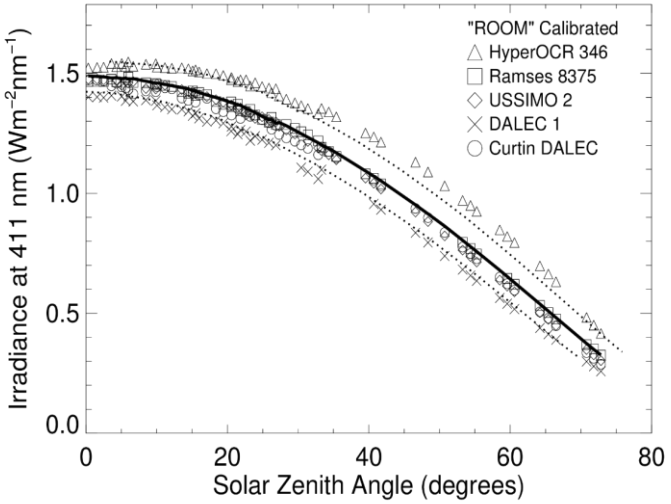


2nd activity: field inter-comparison at LJCO

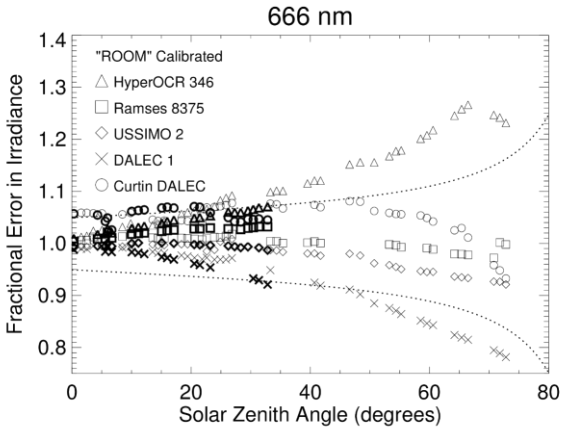


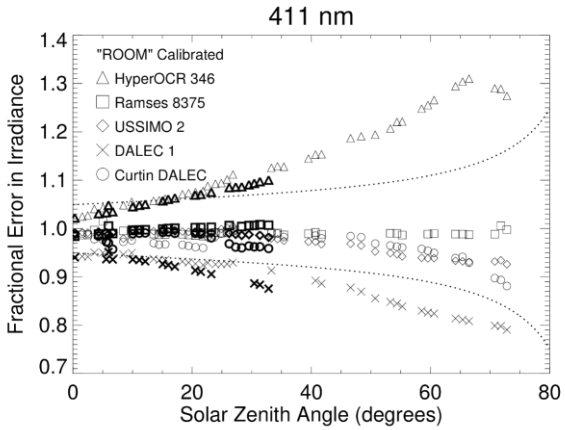
Irradiance (E_s) comparisons

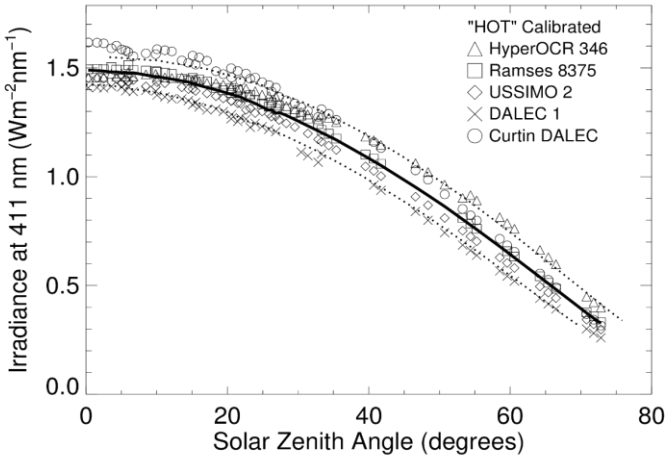




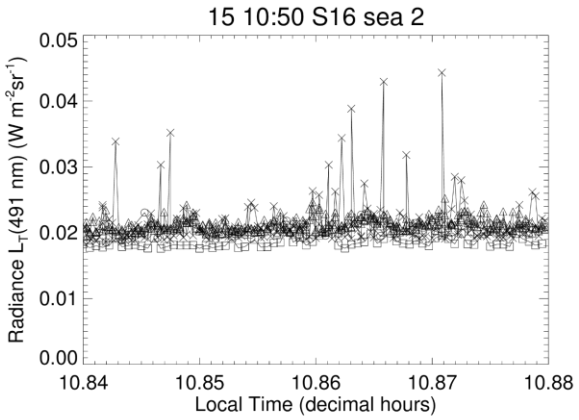
- The reference here is a theoretical clear-sky Es spectrum (modelled)

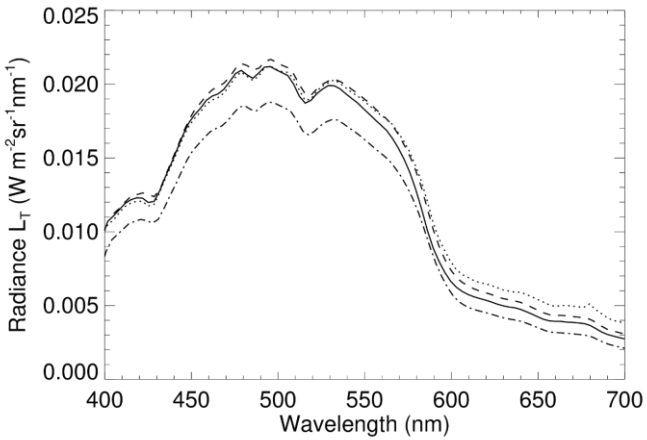


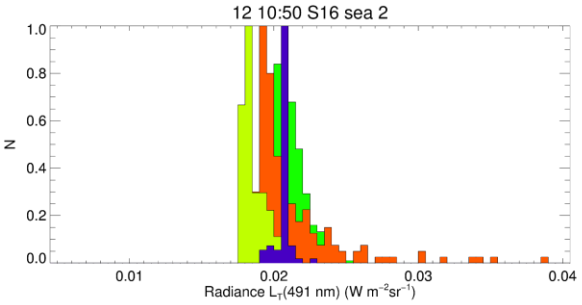


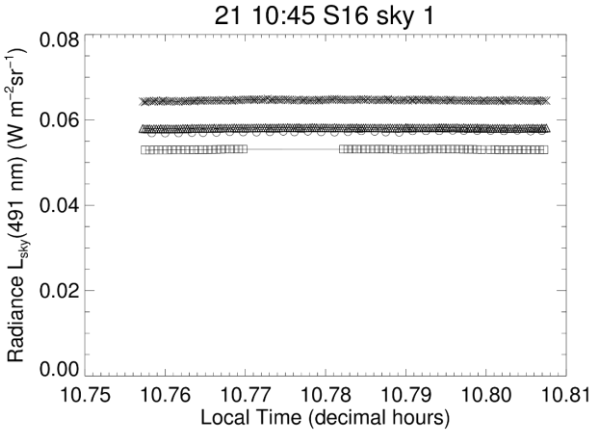


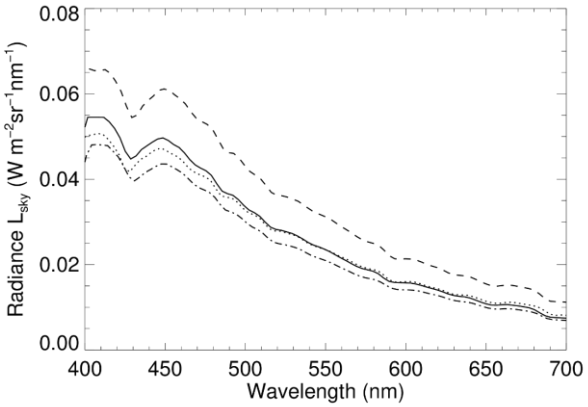
Sea/Sky radiance (L_{sea}, L_{sky}) comparisons











R_{rs} (=L_w/E_s) comparisons are underway

Draft report (Jan 2017); revised draft by April 2017

A few, preliminary, conclusions

- Was definitely useful to put that community together to start building capability (field radiometry IS a difficult endeavour)

- Non-IMOS instruments do not depart from IMOS instruments (after all instruments went through unified calibration at IMO)

- In terms of satellite OCR validation, LJCO can generate R_{rs} within the accepted uncertainties (~5%) in the international OCR community (see initial OLCI validation results)

- E_s measurements to be checked against theoretical clear-sky computations

- The DALEC cosine response could be improved

- Integration time matters a lot in L_{sea} measurements, so that direct comparison of L_{sea} from different instruments is not really possible

- Periodic radiometric calibration needed (annual at least); wavelength calibration to be monitored

- Sun zenith angle is one key parameters to be accounted for in QC

Where do we go from this?

- Finalizing reports of the lab and field (LJCO) experiments
- Presentation at the ESA's FRM4SOC workshop
- Participation to the ESA's FRM4SOC LCE1 experiment
- Collective thinking on:
  - + How we do the best with what we have until now? (QC and setting "envelopes" of confidence, reprocessing)
  - + How we do better in the future?
  - + Guidelines on best practices for different radiometer types
  - + National cal. Facility: role, where, how ??
  - + Nodes and users uptake, use ..
  - + How do we keep close links with the international OCR community?
- Ending up with clear set of recommendations by June 2017

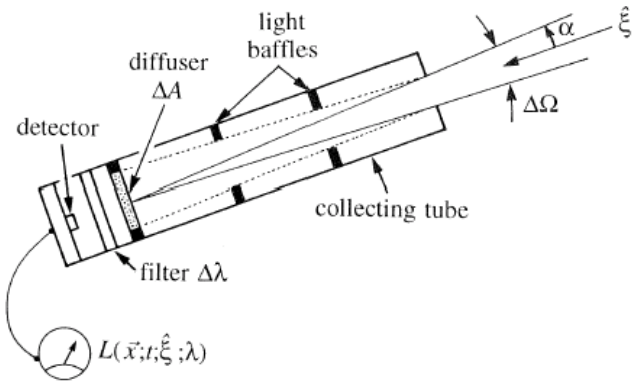
Thanks for your attention

SPARES

Radiometry ?

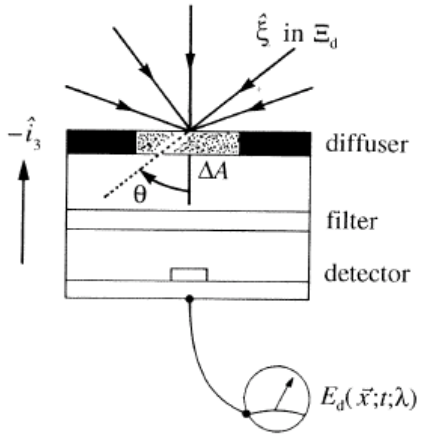
Radiometry: measuring electromagnetic radiation, including visible light, in the natural environment

$$L(\vec{x},t,\hat{\xi},\lambda) \equiv \frac{\Delta Q}{\Delta t\,\Delta A\,\Delta\Omega\,\Delta\lambda} \quad (\mathrm{J\ s^{-1}\ m^{-2}\ sr^{-1}\ nm^{-1}}).$$



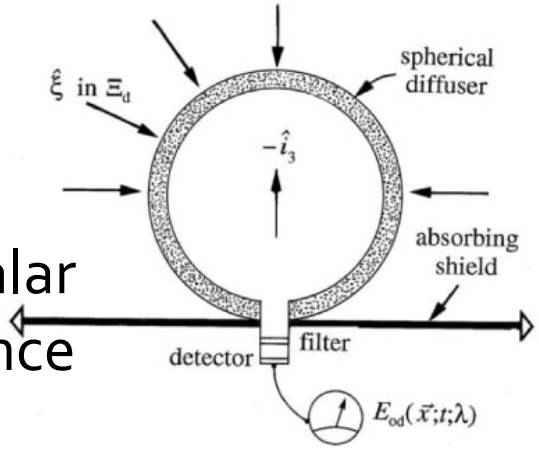
Radiance (radiant flux in a given direction per unit solid angle per unit projected area)

$$E_d(\vec{x},t,\lambda) \equiv \frac{\Delta Q}{\Delta t\,\Delta A\,\Delta\lambda} \quad (\mathrm{W\ m^{-2}\ nm^{-1}}).$$



Planar irradiance

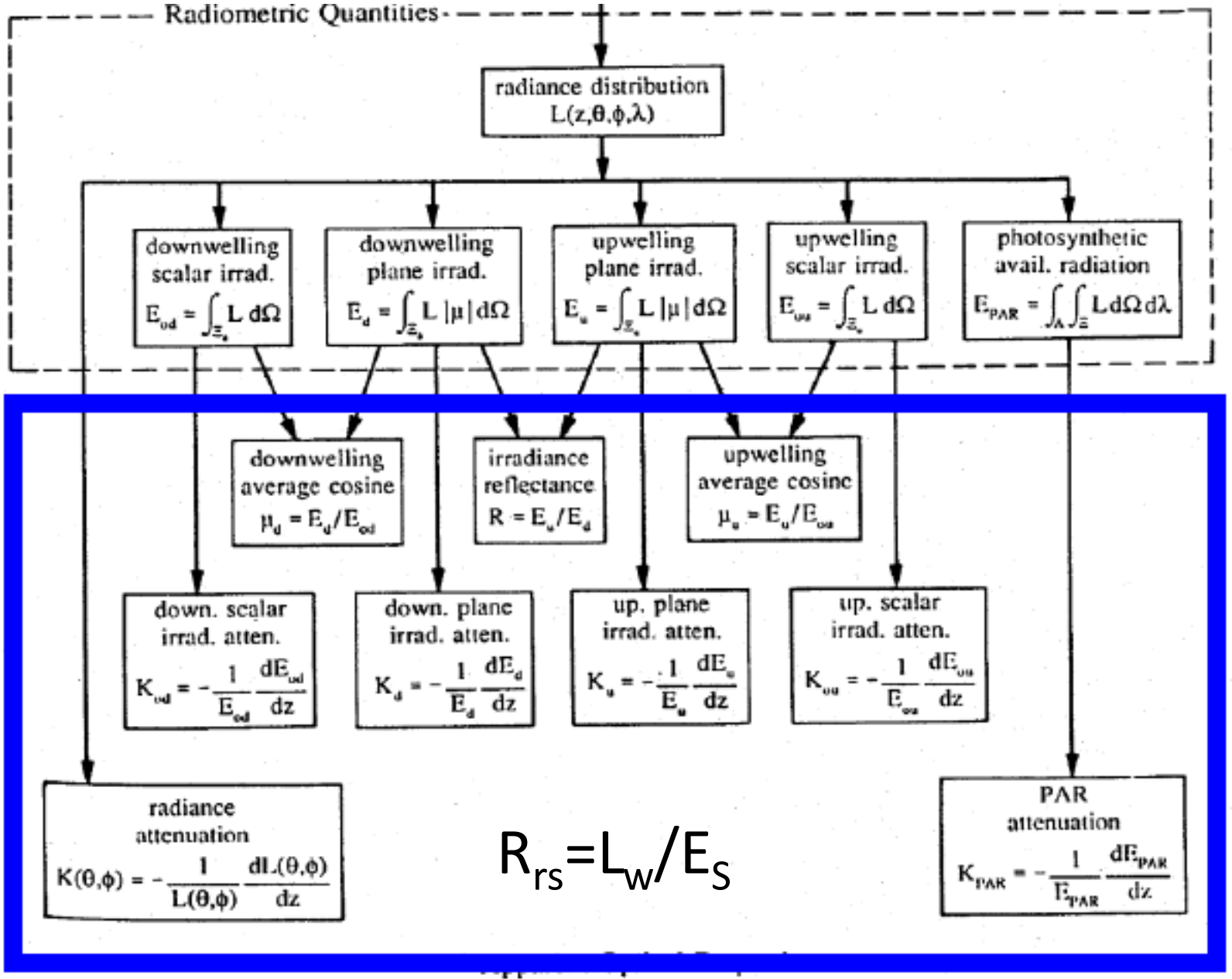
$$E_{od}(\vec{x},t,\lambda) = \int_{\hat{\xi}\in\Xi_d} L(\vec{x},t,\hat{\xi},\lambda)d\Omega(\hat{\xi}) = \int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi/2} L(\vec{x},t,\theta,\phi,\lambda)\sin\theta d\theta\, d\phi$$



Scalar irradiance

Figures from Mobley, 1994, and the ocean optics online book
http://www.oceanopticsbook.info/view/light_and_radiometry/geometrical_radiometry

Radiometry & Apparent optical properties



From Mobley, C.D., 1994

Overall schedule

	2016						2017						
	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July
Lab experiments													
Data processing													
Reporting													
Field (LJCO)													
Data processing													
Reporting													
Meetings								X	X	X	X	X	X
Other													

On tracks to deliver final report and recommendations by July 2017