



Image Credit: ESA

# Evaluation of Sentinel-3 OLCI Level 2 radiometry in Australian coastal and continental shelf waters

Jenny Lovell, on behalf of the Australian S3VT  
14 March 2018 S3VT meeting, EUMETSAT, Darmstadt, Germany

CSIRO OCEANS & ATMOSPHERE  
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# This presentation

- **Integrated Marine Observing System (IMOS) Lucinda Jetty Coastal Observatory (LJCO)**
  - Measurements, site characteristics
- **IMOS Radiometry Task**
  - Results and actions to improve data quality
- **Level 2 Radiometric Validation**
  - Lucinda Jetty Coastal Observatory, autonomous DALEC
  - Ship-based autonomous DALEC
  - Ship-based HyperOCR
- **Future Work**
  - LJCO, Bio-Argo, Southern Ocean Flux Station mooring



5 km



# It's a variable coastal site

Tidal range 0.2-4 m

Water temperature 22-31°C

Salinity 27-36.5



*(Image credit D. Boadle)*

# Overview above-water measurements

**HyperOCR**  
Spectral irradiance



**Webcams**  
Sky and Sea



**Weather Station**  
Temperature  
Pressure  
Humidity  
Dew point  
Wind speed etc



**SeaPRISM (7 wavelengths)**  
Water-leaving radiance  
Aerosol optical thickness  
Aerosol absorption  
Aerosol size distribution  
Refractive index  
Single scattering albedo  
Phasefunction  
Water vapor  
Spectral flux  
Radiative forcing

# IMO DALEC

- Dynamic above water radiance and irradiance collector
- Hyperspectral: 400-1050 nm
- Autonomous operation
- 3 compact Zeiss spectroradiometers
- GPS, pitch, roll sensors
- LJCO instalment
  - May 2016 – March 2017
  - Soon to be re-installed
- Operating at 90° relative azimuth for consistency with Aeronet SeaPrism



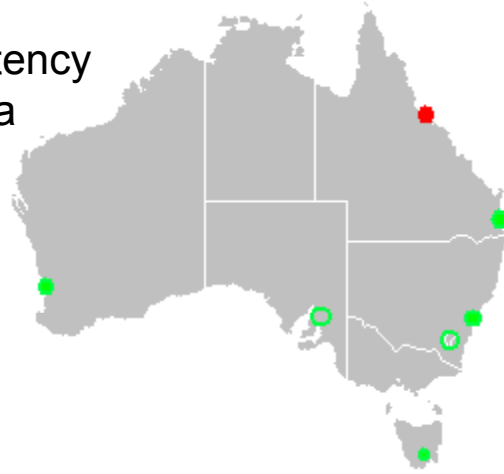
# IMOS Radiometry Task

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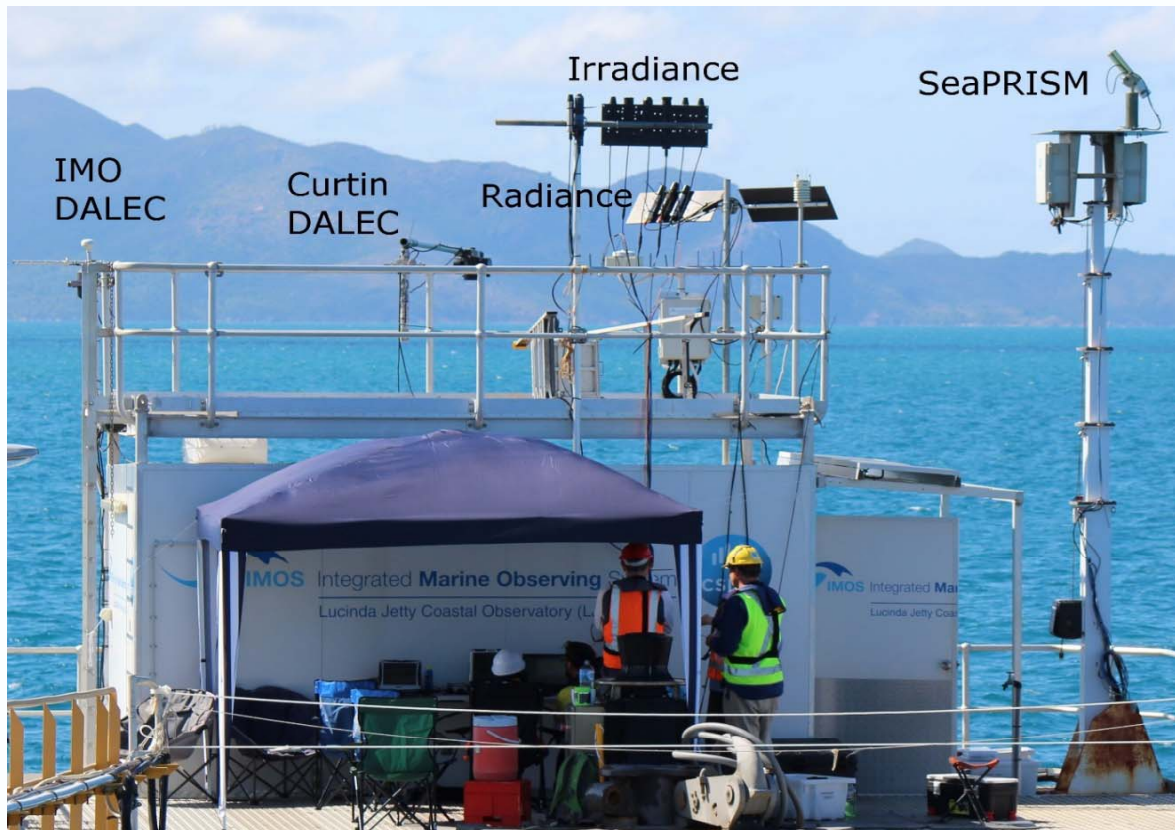
# Objectives and Activities

- Participants from all Australian agencies undertaking bio-optical measurements
- Improve usability of radiometric data sets for research purposes as well as for validation of satellite ocean colour
- Evaluate consistency among existing field-platform and sea-going radiometers used in Australian bio-optical community, through dedicated laboratory and field experiments
- Propose actions to improve consistency and the way they are deployed data processing
- Develop a plan for evolution of IMOS radiometry measurements for the next decade





# IMOS RTT Instrumentation, findings



- **Community benefit**
- **Integration time matters**  
- a lot in  $L_{sea}$  measurements
- **Calibration is temperature dependent**
- Wavelength calibration should be checked
- DALEC cosine response could be improved
- **Sun zenith angle is a key parameter in QC**
- Platform effects to be investigated



# Level 2 Radiometric Validation

## LJCO

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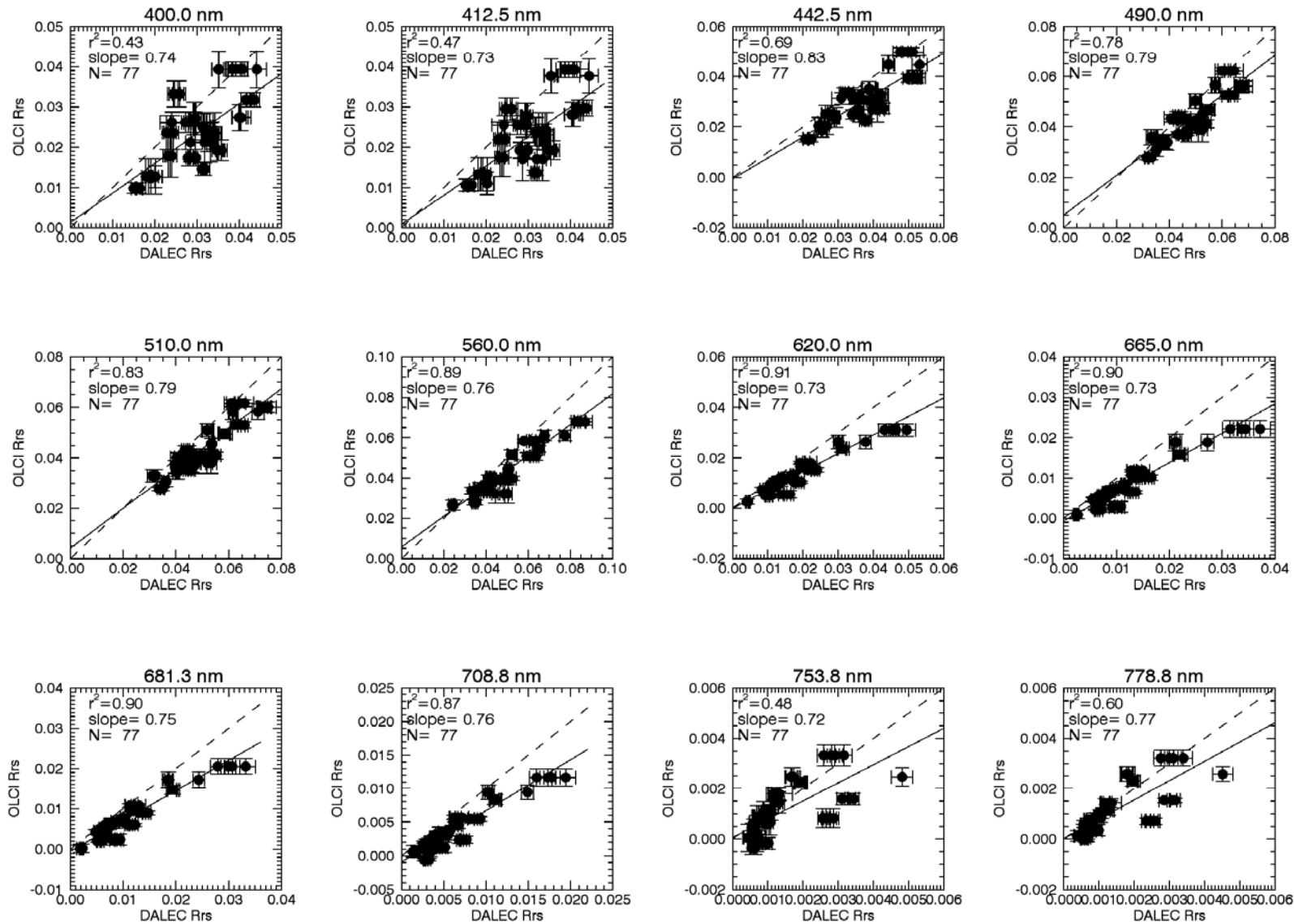


# Radiometric match-ups OLCI vs DALEC

- Date range: 4 July 2016 – 20 March 2017
- OLCI flags: CLOUD, CLOUD\_AMBIGUOUS, CLOUD\_MARGIN, INVALID, COSMETIC, SATURATED, SUSPECT, HISOLZEN, HIGHGLINT, SNOW\_ICE, LAND, INLAND\_WATER
- **20 OLCI scenes provided unflagged matchups within  $\pm 30$  min**
- DALEC spectral range 405-1000 nm
  - (405nm used for matchup with Band 01)
- DALEC Rrs uses Mobley (2015)  $\rho$  LUT
- **DALEC data averaged to 15 minute (mean, SD)**
- **OLCI median of 3x3 FR pixels, min 5 unflagged pixels**
- Comparison with original release OLCI data and latest reprocessed data (IPF 2.23)

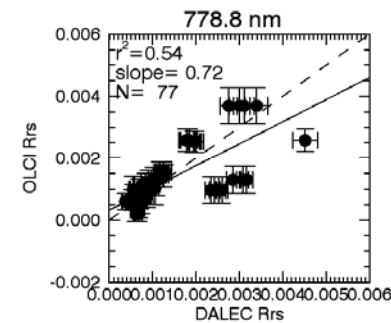
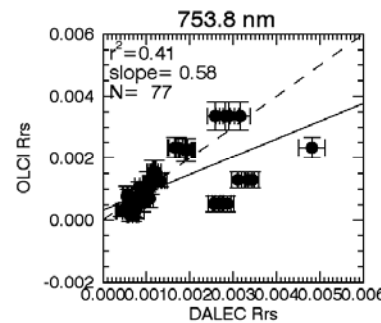
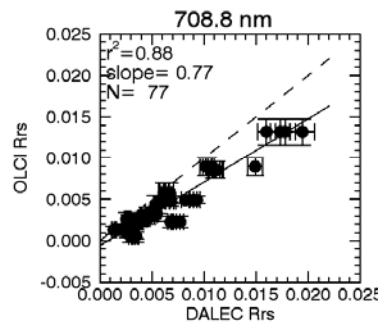
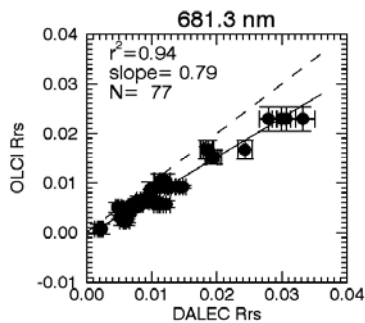
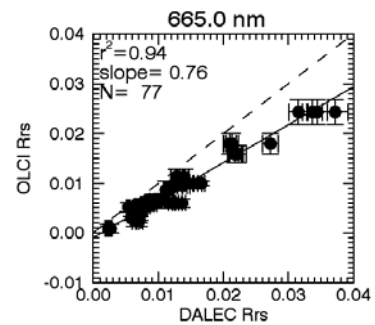
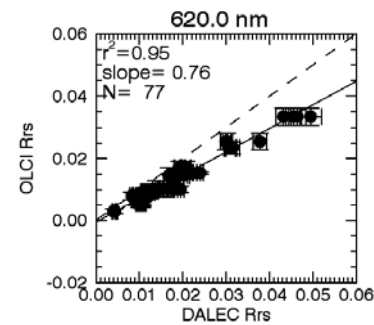
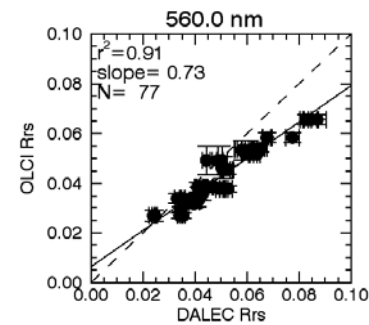
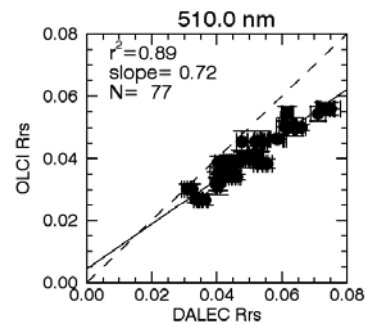
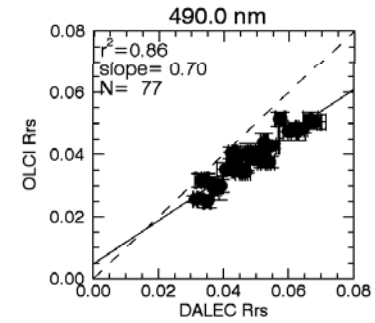
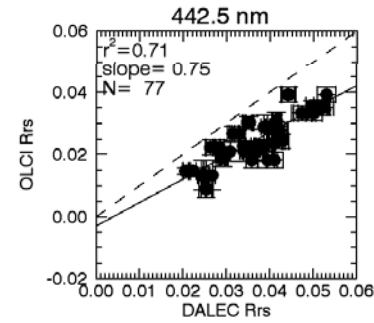
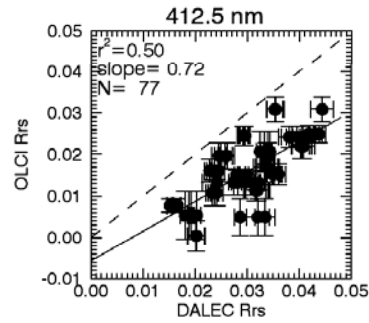
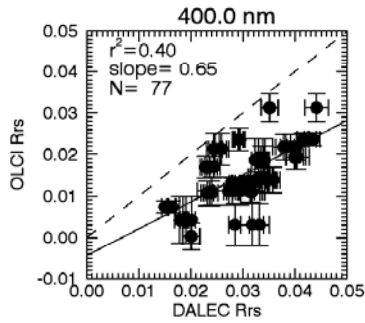
# OLCI original data release vs DALEC

## N=77, 400-778.8 nm

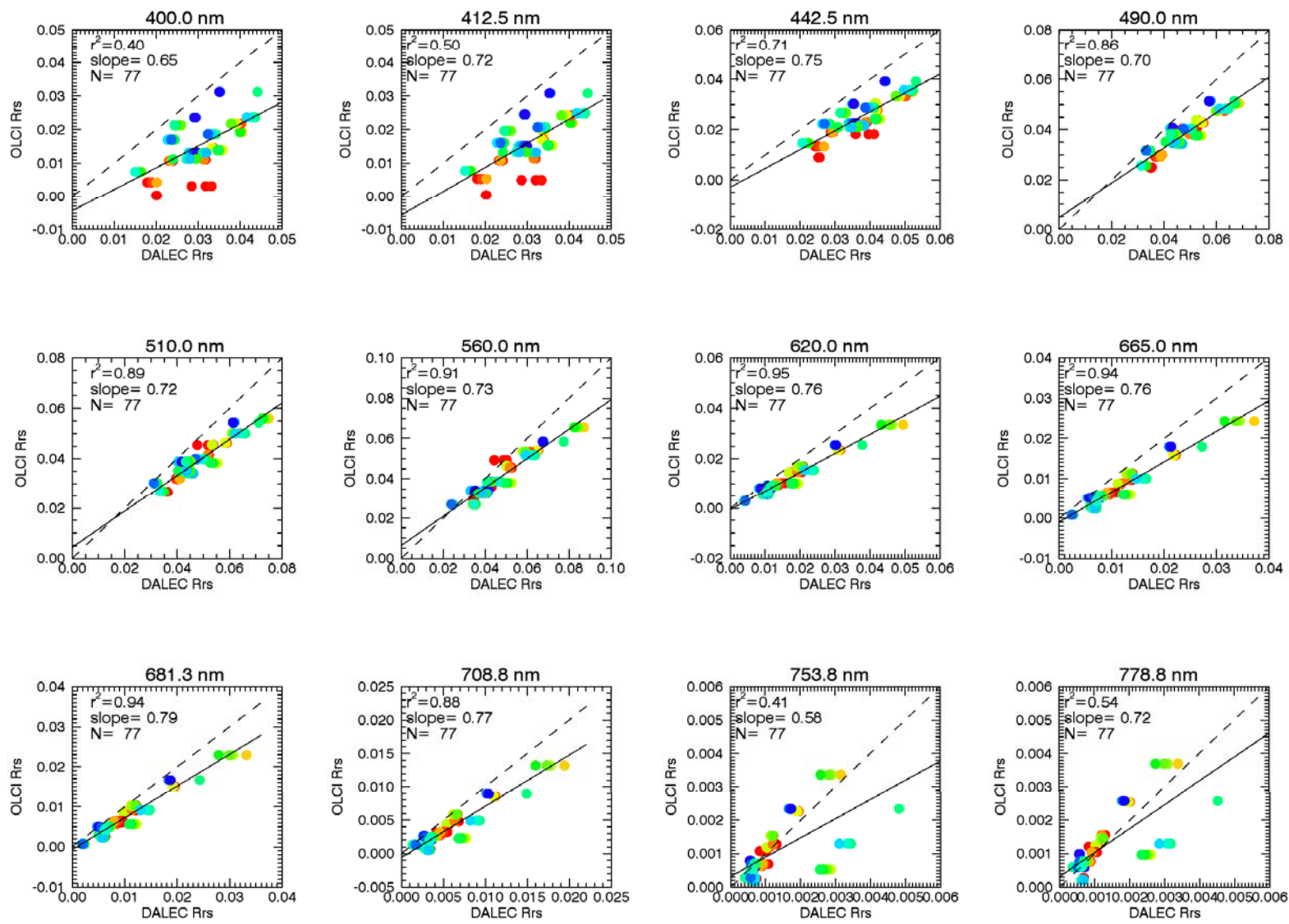
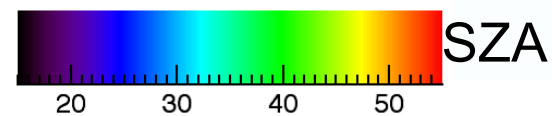


# OLCI IPF2.23 data vs DALEC

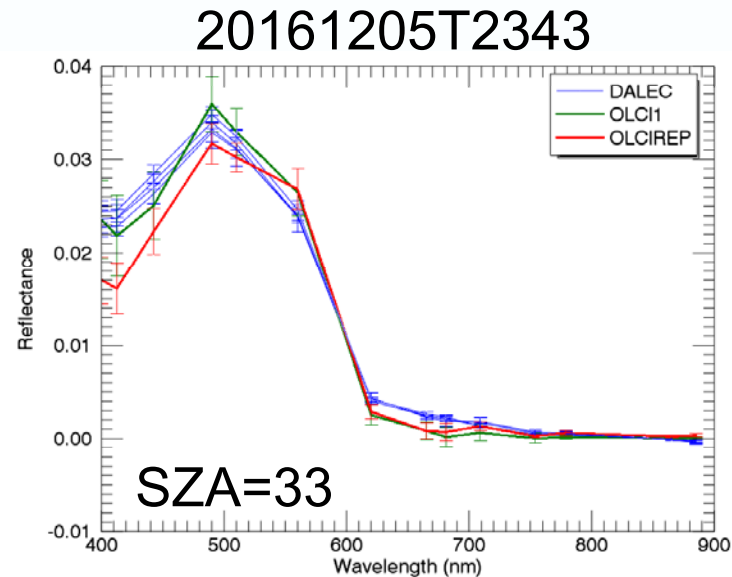
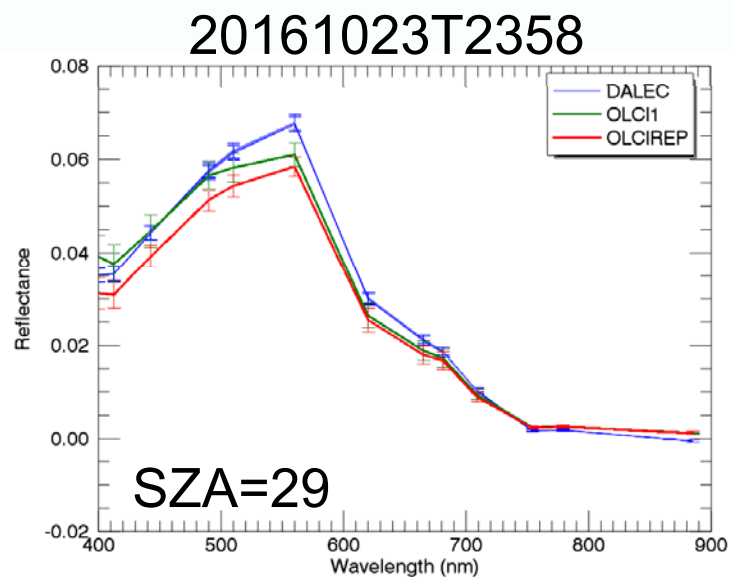
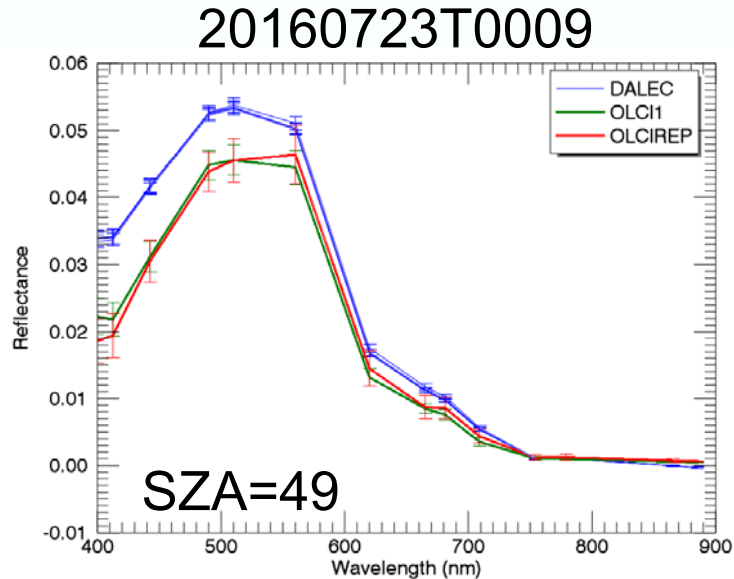
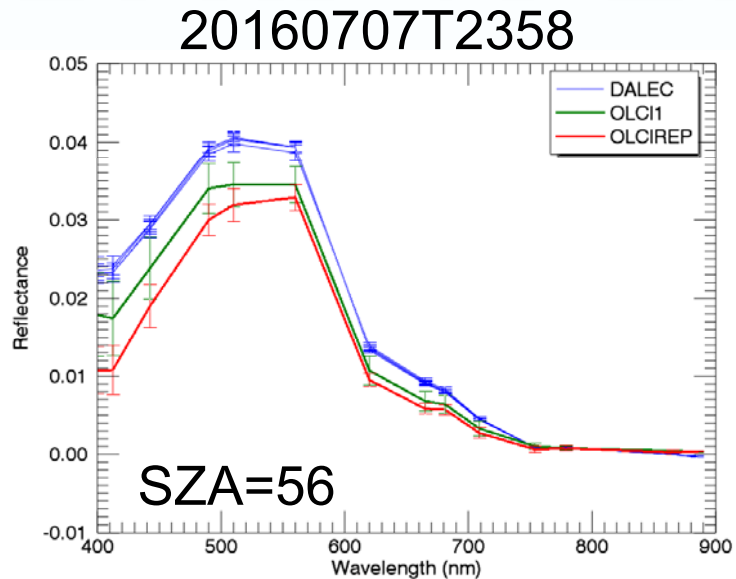
## N=77, 400-778.8 nm



# No clear Solar zenith angle dependence

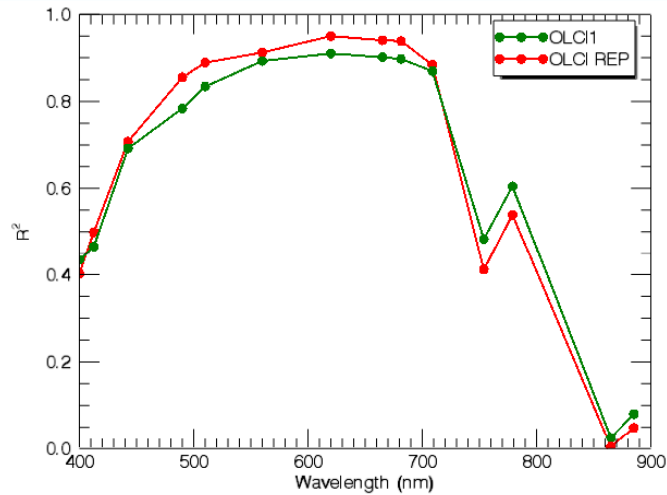


# Spectra OLCI vs DALEC

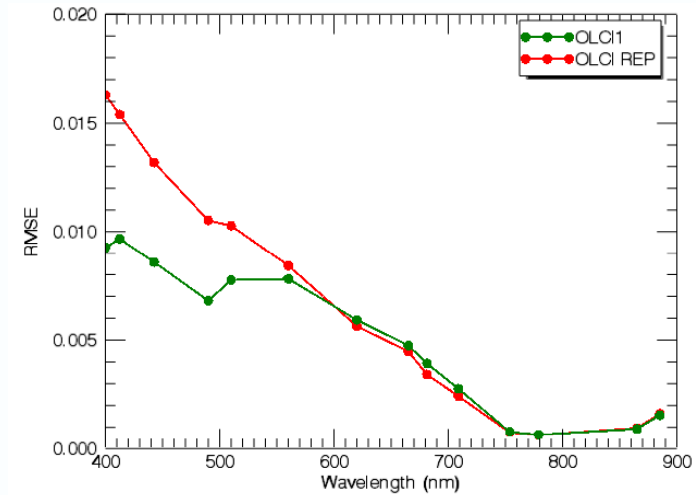


# Statistics OLCI vs DALEC

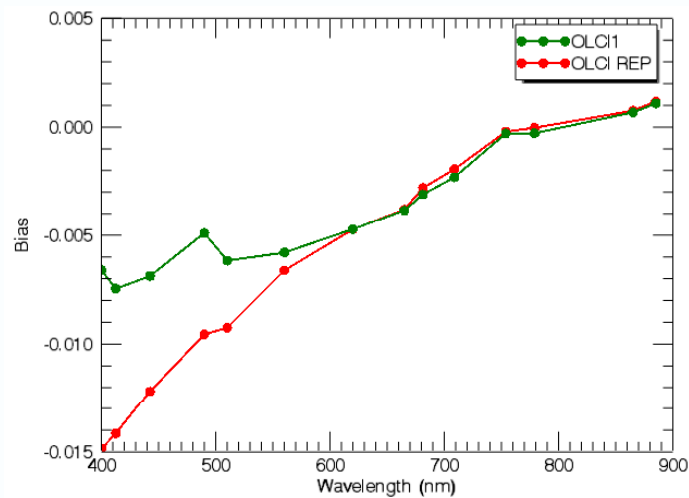
## Corr Coef



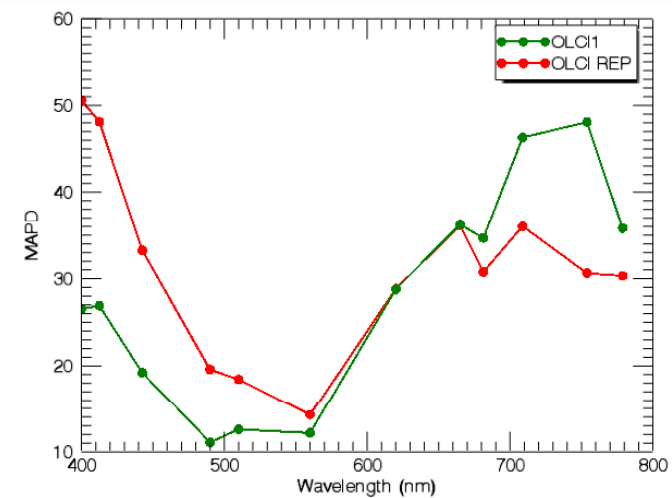
## RMSE



## Bias



## MAPD





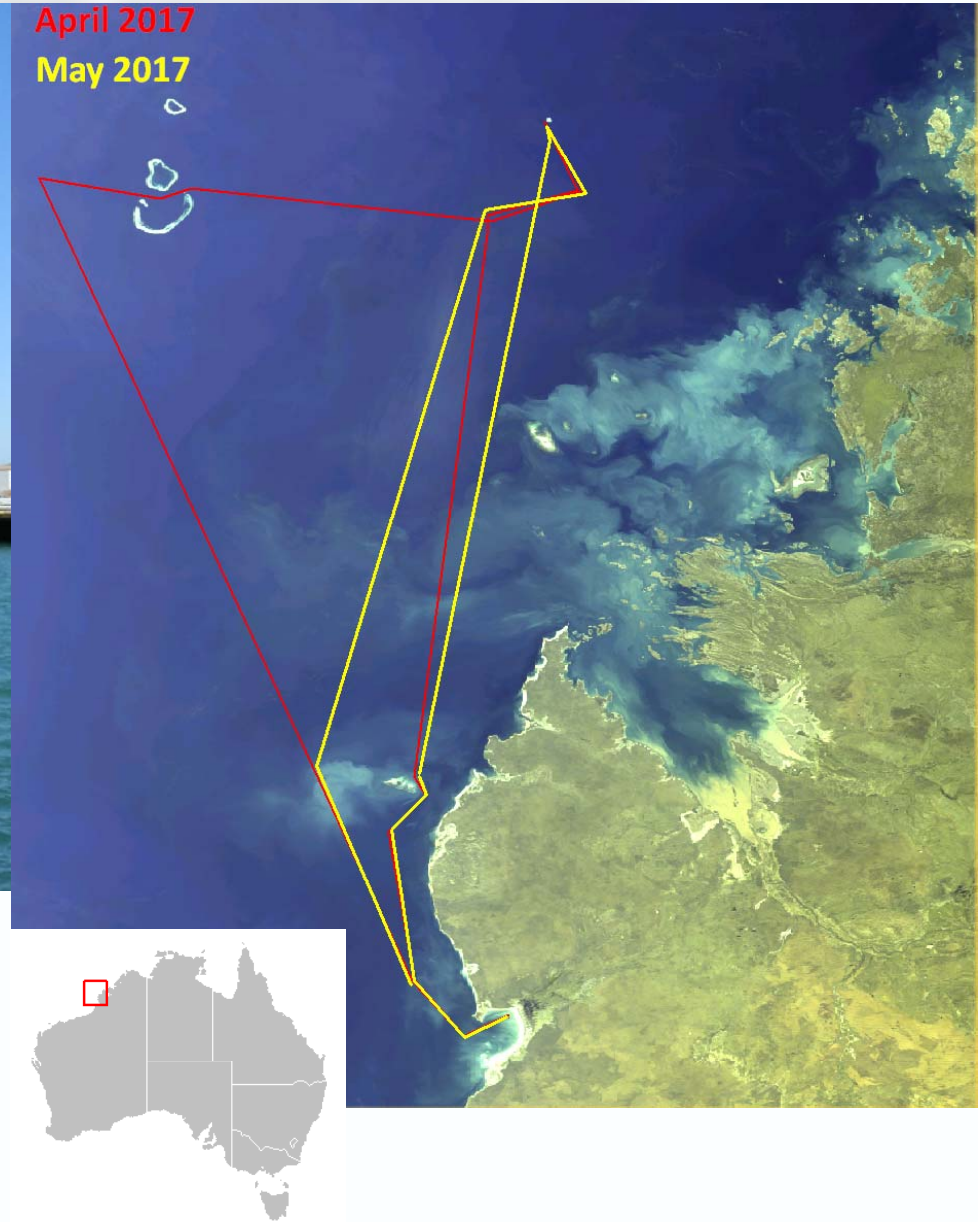
# Level 2 Radiometric Validation Ship – NW Shelf, DALEC

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# DALEC on RV Solander

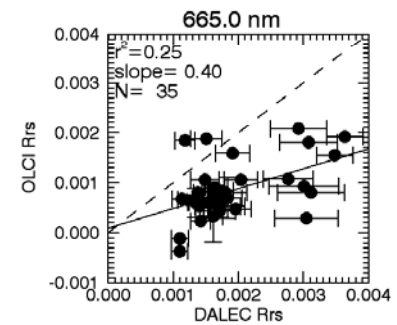
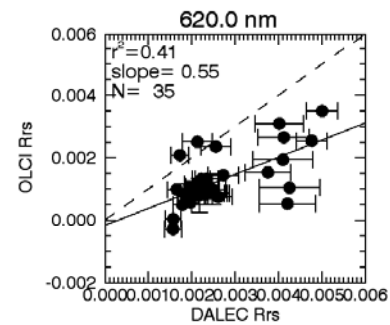
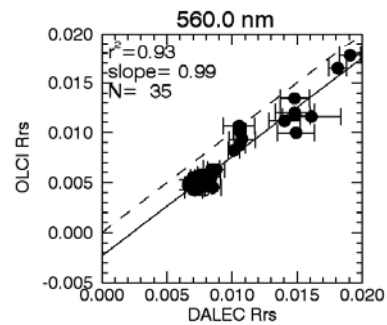
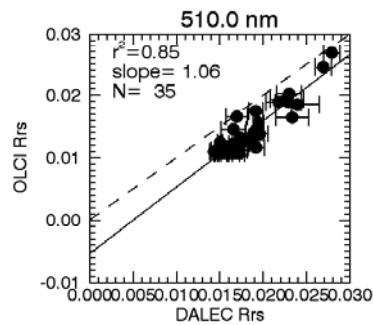
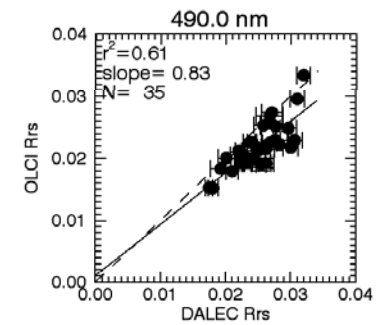
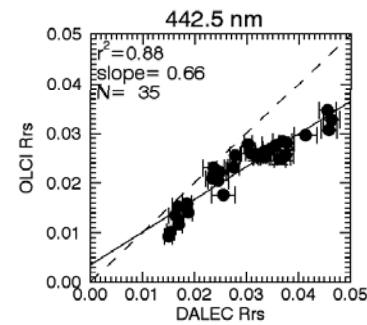
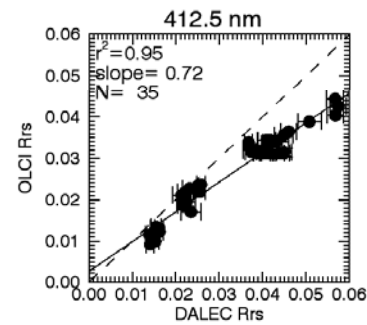
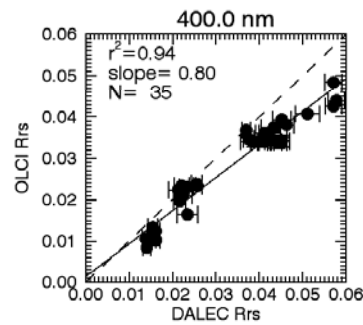
Operated by Australian Institute of Marine Science, DALEC deployed 60 days per year



- Continental shelf
- 5 OLCI scenes, 3x3 median
- DALEC  $R_{rs}$  15 min mean
- Matchups  $\pm 1$  hr

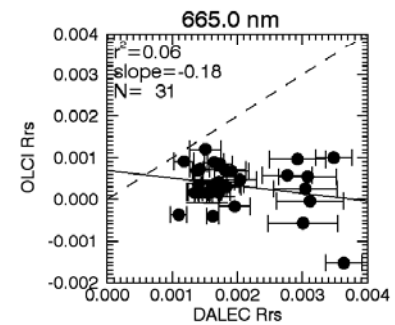
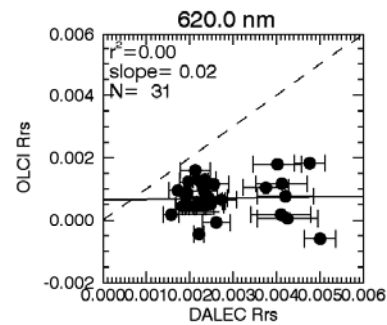
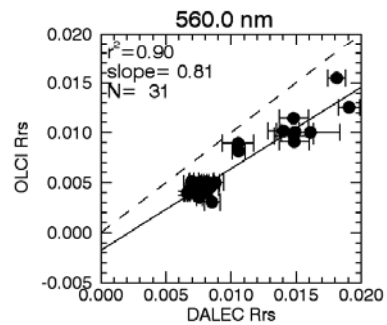
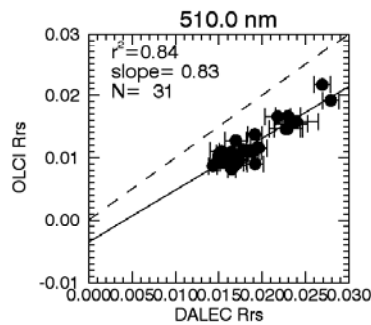
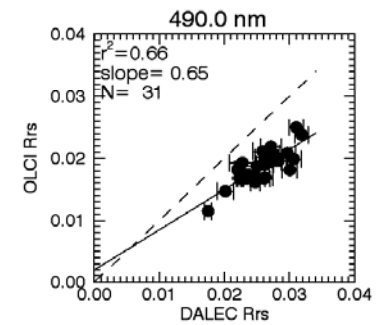
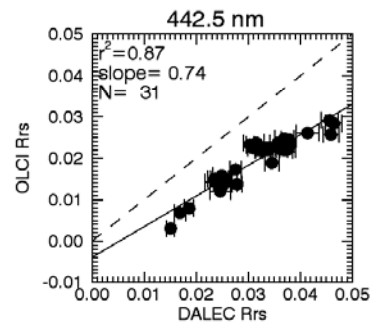
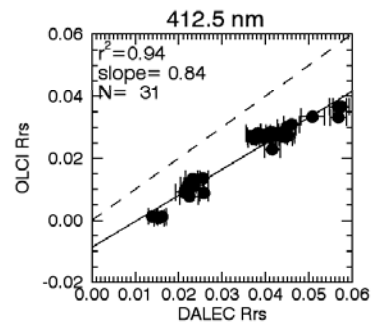
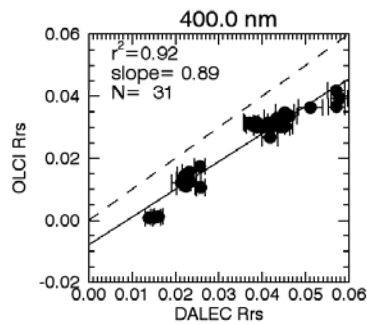
# OLCI original data release vs DALEC

## N=35, 400-665 nm

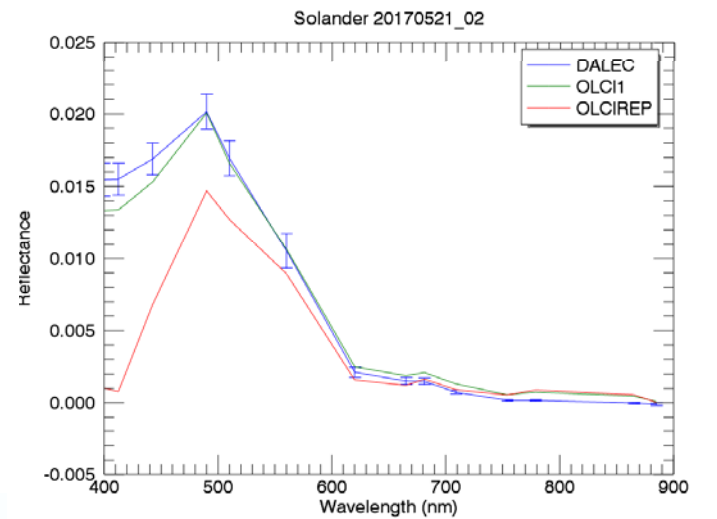
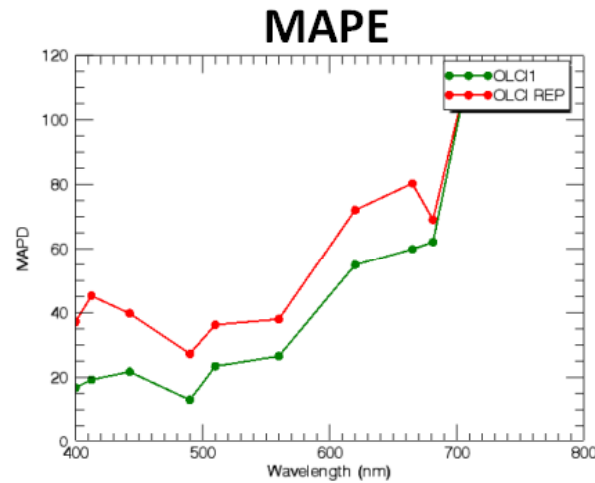
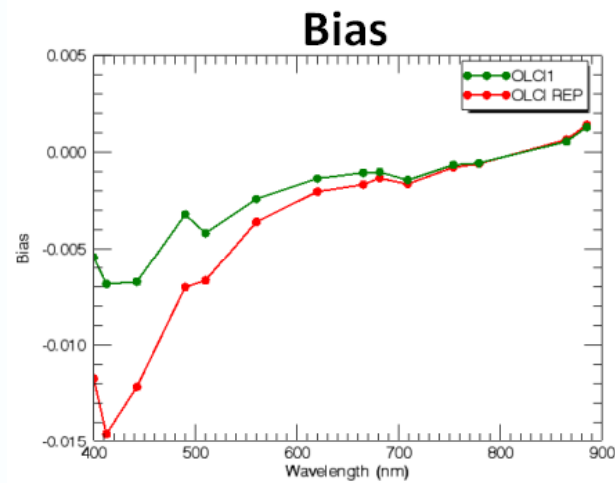
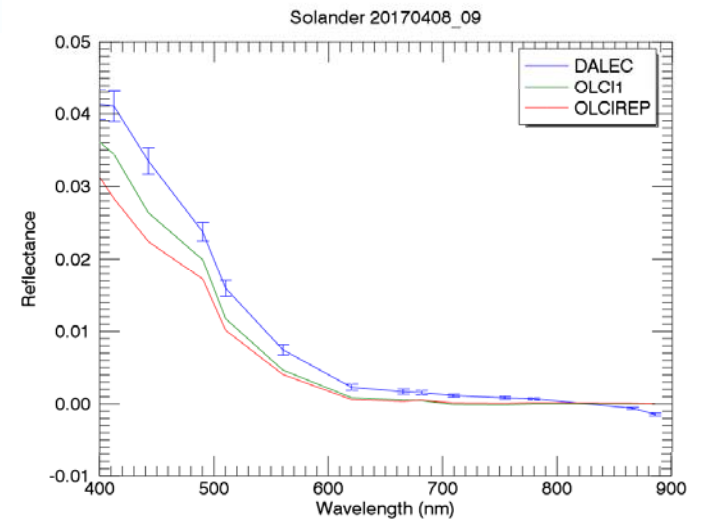
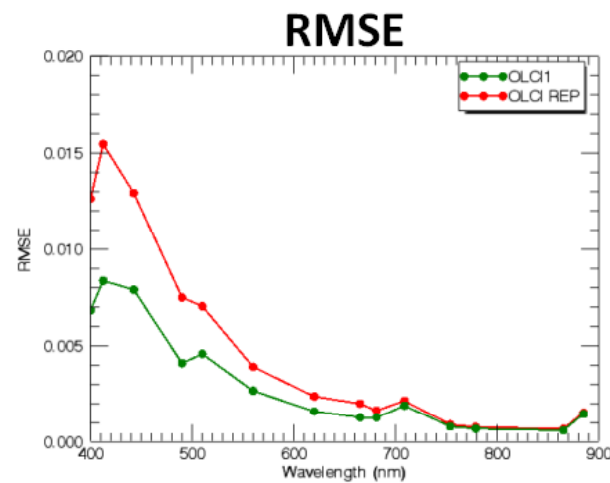
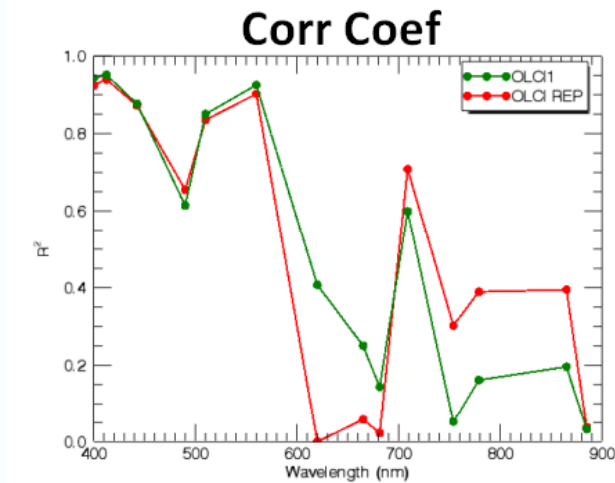


# OLCI IPF2.23 data vs DALEC

## N=31, 400-665 nm



# Spectra and Statistics OLCI vs Ship-based DALEC



# Summary table

## Level 2 Radiance Regression Slope vs DALEC

Wavelength	LJCO OLCI1	LJCO OLCIRep	Ship OLCI1	Ship OLCIRep
412.5	0.73	0.72	0.72	<b>0.84</b>
442.5	<b>0.83</b>	0.75	0.66	<b>0.74</b>
490	<b>0.79</b>	0.70	<b>0.83</b>	0.65
560	<b>0.76</b>	0.73	<b>0.99</b>	0.81
620	0.73	0.76	0.55	0.02
681.3	0.75	<b>0.79</b>	0.32	-0.10
708.8	0.76	0.77	-1.38	-1.95

# Level 2 Radiometric Validation Ship – East Australia, HyperOCR

[www.csiro.au](http://www.csiro.au)

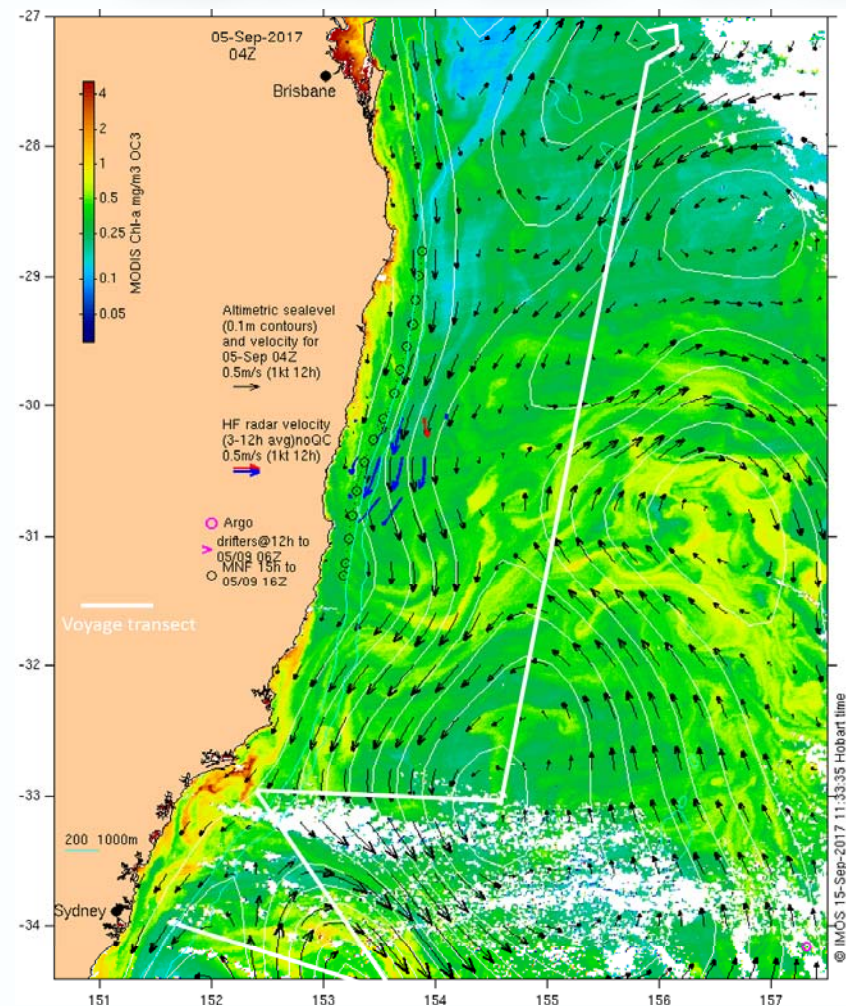


# Validation voyage off east coast of Australia

## September 2017 – RV Investigator

### Range of bio-optical data from the surface

	min	mean	std	max
Chl- <i>a</i> HPLC (mg m <sup>-3</sup> )	<b>0.19</b>	<b>0.51</b>	<b>0.46</b>	<b>1.76</b>
TSS gravimetric (g m <sup>-3</sup> )	<b>0.15</b>	<b>0.27</b> (34% inorganic, 66% organic)	<b>0.09</b>	<b>0.48</b>
$a_{\text{CDOM}}(443)$ spectroscopy (m <sup>-1</sup> )	<b>0.002</b>	<b>0.011</b>	<b>0.009</b>	<b>0.033</b>
$a_{\text{ph}}(443)$ spectroscopy (m <sup>-1</sup> )	<b>0.013</b>	<b>0.025</b>	<b>0.014</b>	<b>0.064</b>
$a_{\text{NAP}}(443)$ spectroscopy (m <sup>-1</sup> )	<b>0.003</b>	<b>0.004</b>	<b>0.002</b>	<b>0.007</b>



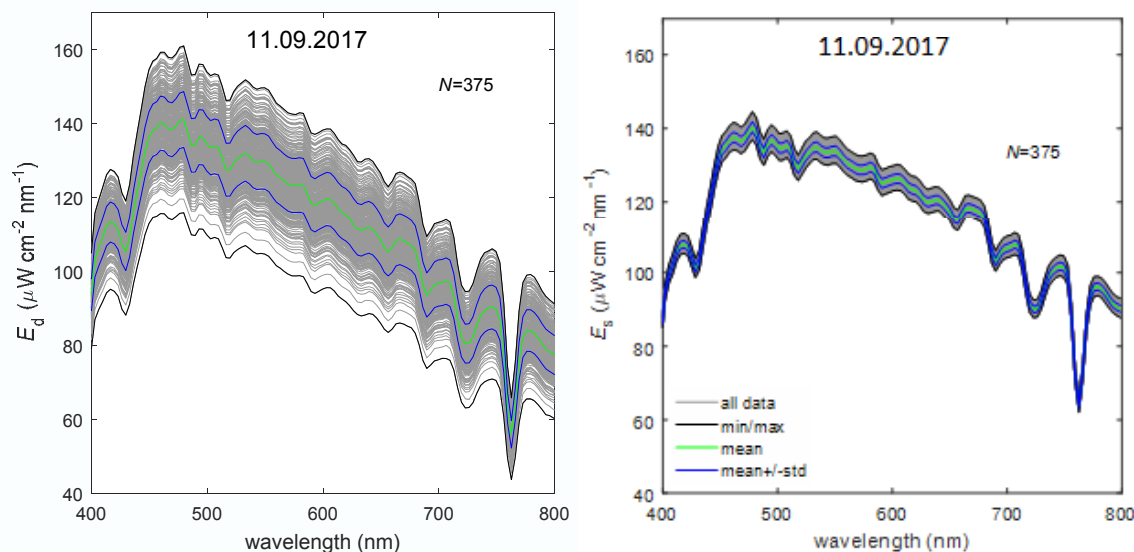
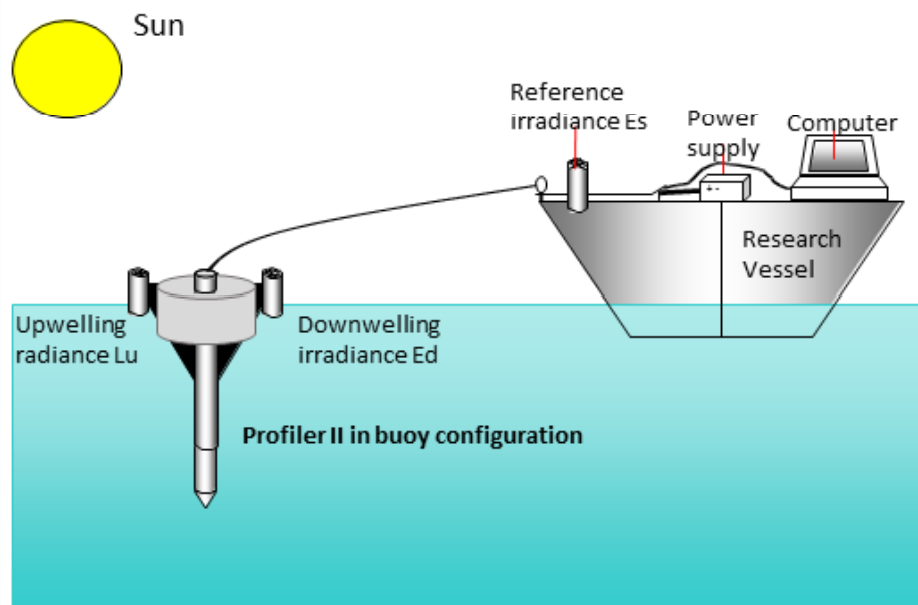
Soja-Woźniak et al., *in prep.*



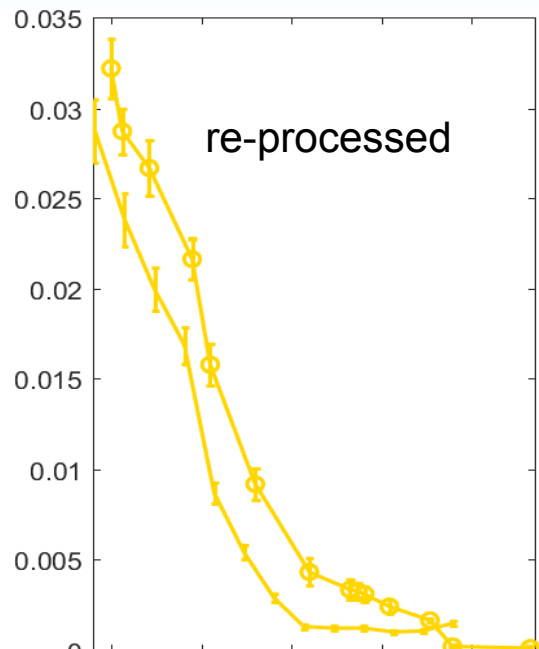
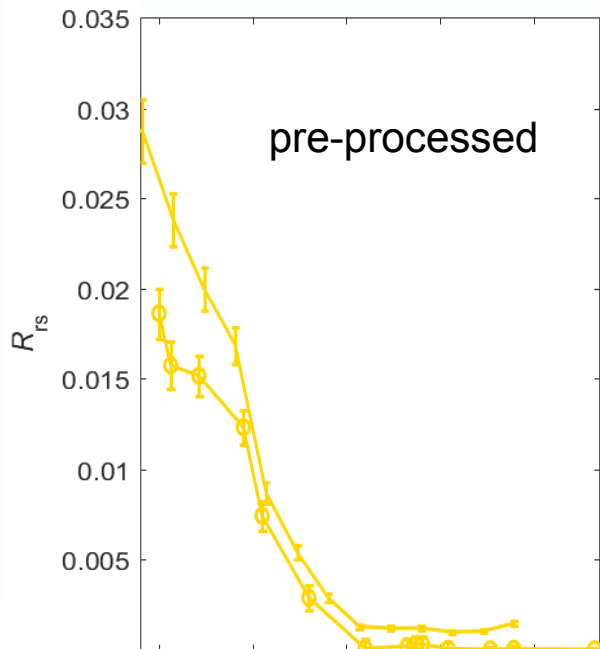


# Radiometric Measurements

## Satlantic Hyper Pro II



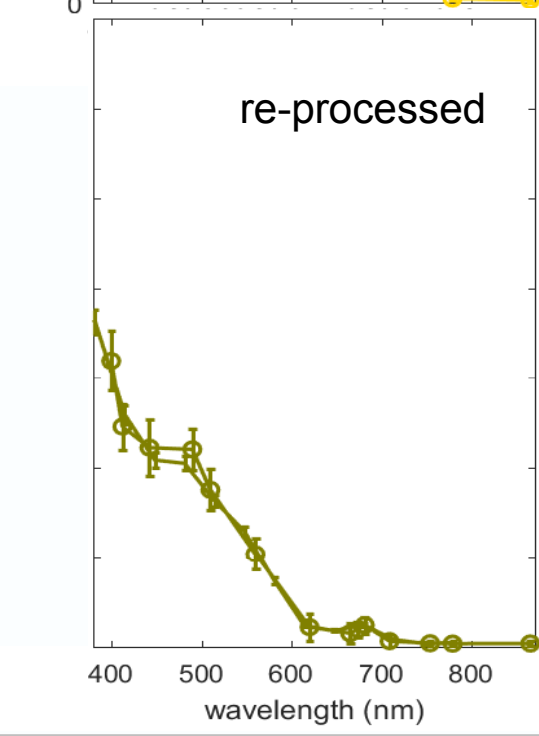
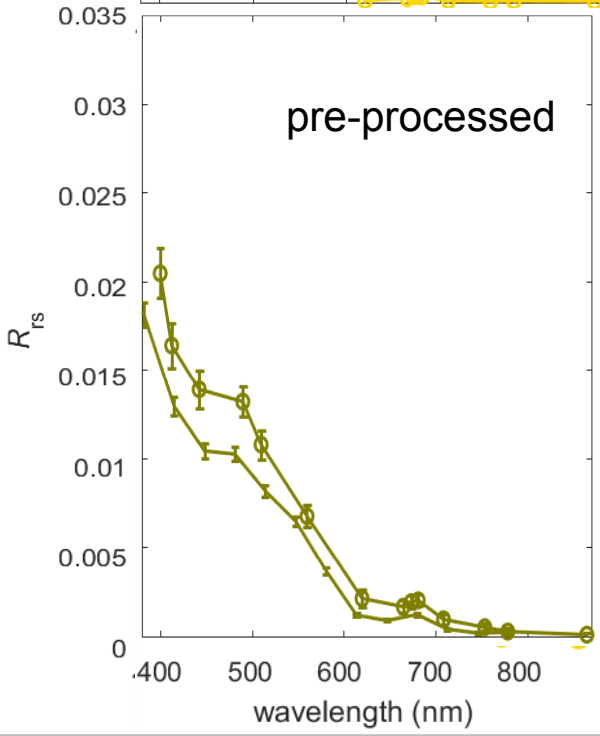
- Surface deployment :
  - for 10min
  - sunny side
  - ~25 m off the vessel
  - 'on deck' pressure tare equal to atmospheric pressure (~10.1 m)
- Reference irradiance  $E_s$  on the 2<sup>nd</sup> deck of the vessel



○ 2017 09 15 OLCI FR (mean of 3x3)  
 ▲ 2017 09 13 *in situ* CTD #29

	<i>in situ</i>	OLCI
Chl-a	= 0.22 mg m <sup>-3</sup>	0.26 mg m <sup>-3</sup>
a <sub>CDM</sub>	= 0.0031 m <sup>-1</sup>	0.017 m <sup>-1</sup>
TSS	= 0.23 g m <sup>-3</sup>	0.31 g m <sup>-3</sup>

### East coast of Australia Anticyclonic eddies



○ 2017 09 11 OLCI FR (mean of 3x3)  
 ▲ 2017 09 12 *in situ* CTD #27

	<i>in situ</i>	OLCI
Chl-a	= 1.8 mg m <sup>-3</sup>	0.44 mg m <sup>-3</sup>
a <sub>CDM</sub>	= 0.018 m <sup>-1</sup>	0.022 m <sup>-1</sup>
TSS	= 0.48 g m <sup>-3</sup>	0.44 g m <sup>-3</sup>

### East coast of Australia Cyclonic eddies

Soja-Woźniak et al., *in prep.*

# Future Work

- Continuation of Lucinda Jetty Coastal Observatory
  - Above-water and in-water measurements – <http://coast-rs-1.it.csiro.au/>
  - Water sampling approx. every 2 weeks **timed to coincide with OLCI**
- Maintenance of IMOS Bio-optical Database
- Deployment of autonomous DALEC on RV 60 days per year
- **ANN atmospheric correction applied to L1B OLCI data**
- Deployment of 3 BGC argo floats near but north of the Southern Ocean Flux Station (SOFS) moorings : 46.7° S, 141 °E
  - $E_d$  and  $L_u$  sensors (412, 443, 490, 555 nm)
  - transmissometer, chl- $a$  and CDOM fluorescence
  - backscattering (470, 532, 700 nm)

# SOFS-7 Air-Sea Flux Mooring Optics [www.imos.org.au](http://www.imos.org.au)

## On tower:

Short and long wave radiation

Licor PAR

ISMO MS9 wiped

Ed:(410,440,490,510,550,636,660,685,710)

## Just below surface:

Wetlabs FLNTUS: F-Chl, Bb(700)

ISMO MS9 wiped Lu (same bands as Ed)

## At 30 m:

Wetlabs wiped PAR

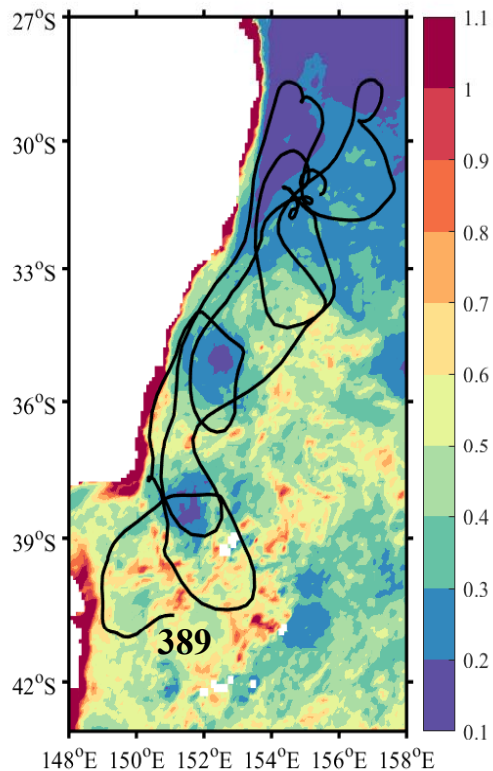
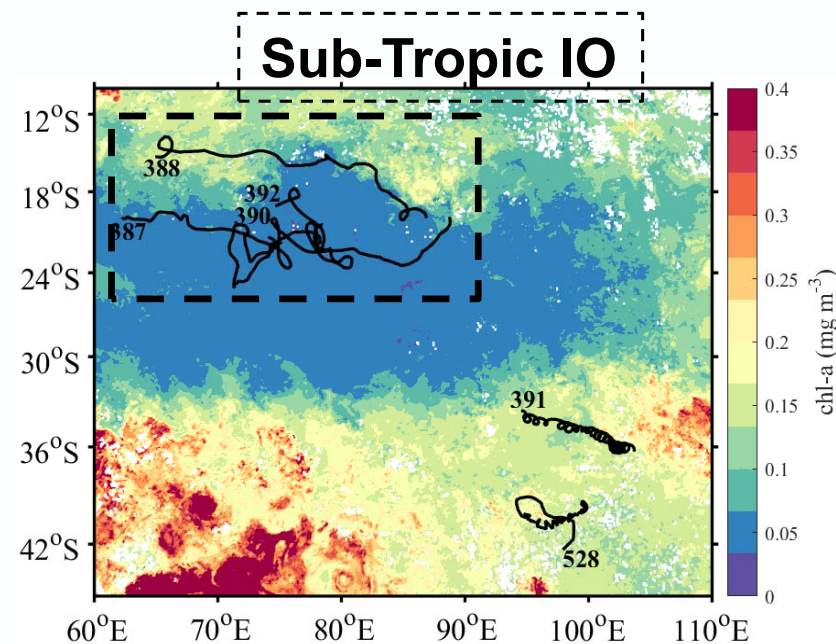
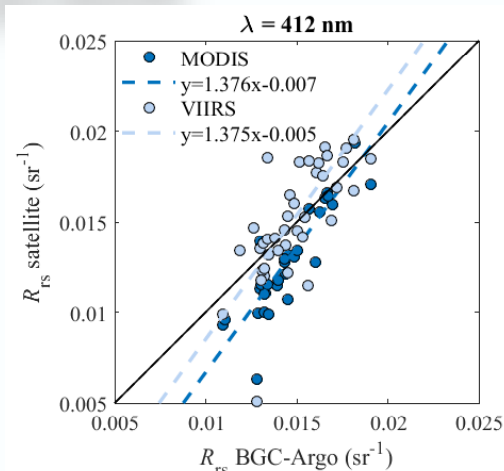
ISMO MS9 wiped Ed (as above)

Wetlabs FLNTUS (as above)

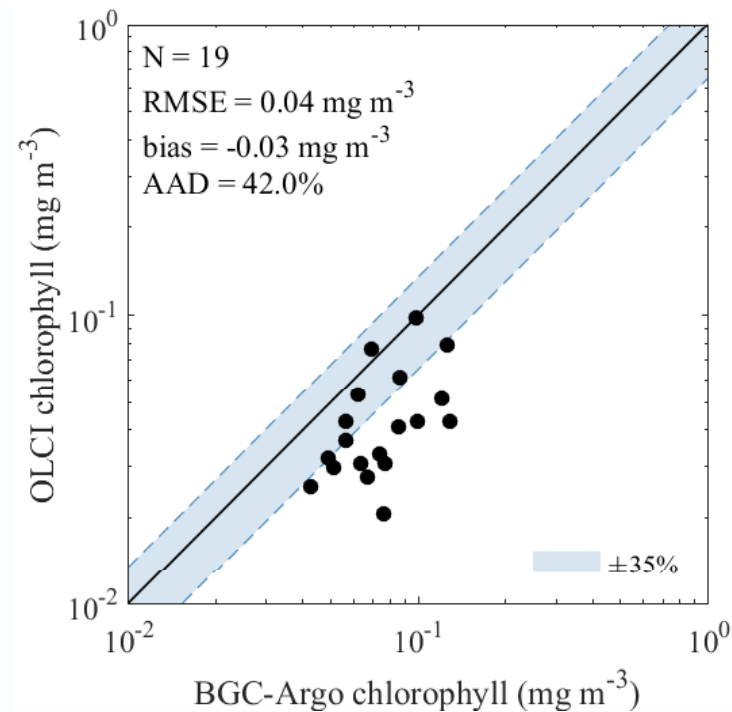
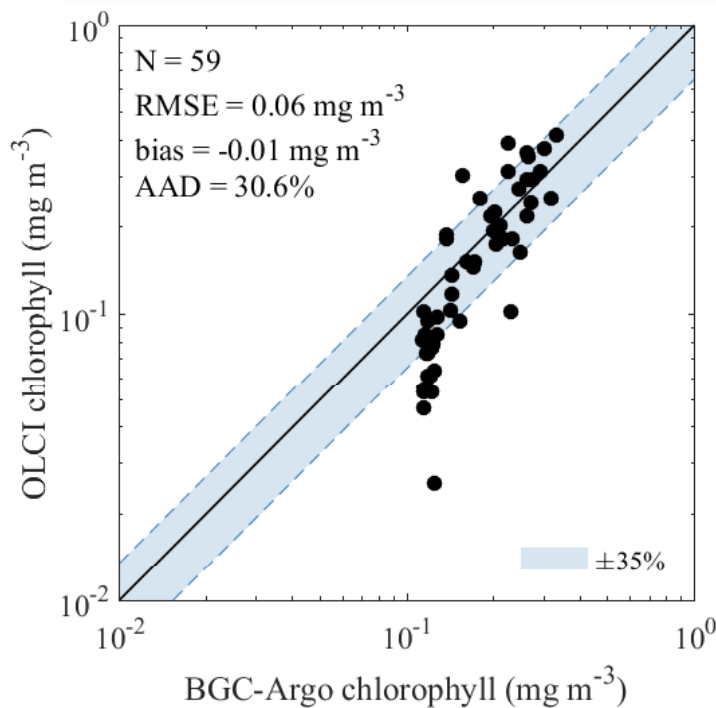


# BGC Argo Validation

- Successful use of  $R_{rs}$  derived from BGC-Argo for validation of MODIS and VIIRS products
- *No  $R_{rs}$  matchups with OLCI due to early float failure, but new deployments planned*



## Pacific



# Feedback

- **S3VT regular meetings** provide a great overview of the latest news on S-3 OLCI
  - These meetings are key for us and we thank Marc and Ewa for their organisation and delivery
  - They showcase an active community. **Thank you !!**
- **LJCO** is a challenging site for ocean colour radiometry validation but we are looking forward to showcase more research coming out of LJCO in the context of S-3 OLCI in the years to come
- **LJCO data available online** and should be contributed to ESA MERMAID DB
- At LJCO and in Northern Australian Waters the **IP2.23 data is low in the blue**
- **Change of granule size** in reprocessing complicated the matchup extraction
- The order of flags listed in SNAP and the list in attributes when exported to netCDF is different to the actual bit order of flags

# Contributors (in alphabetical order)

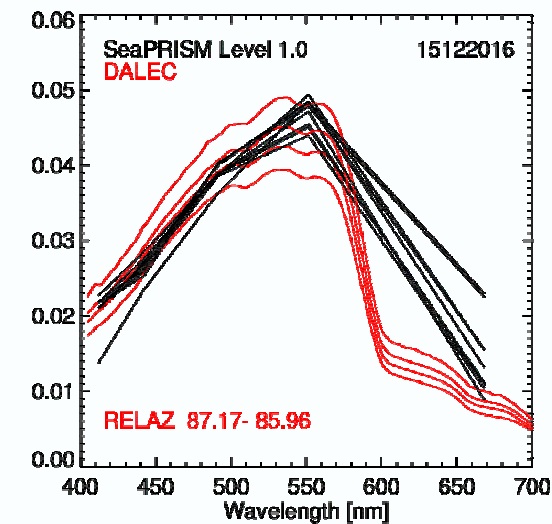
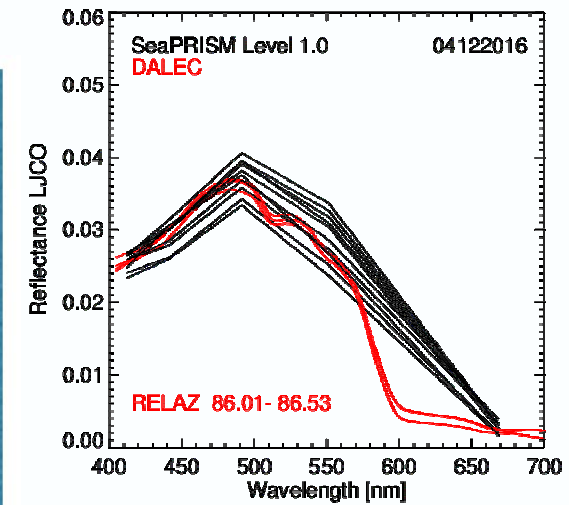
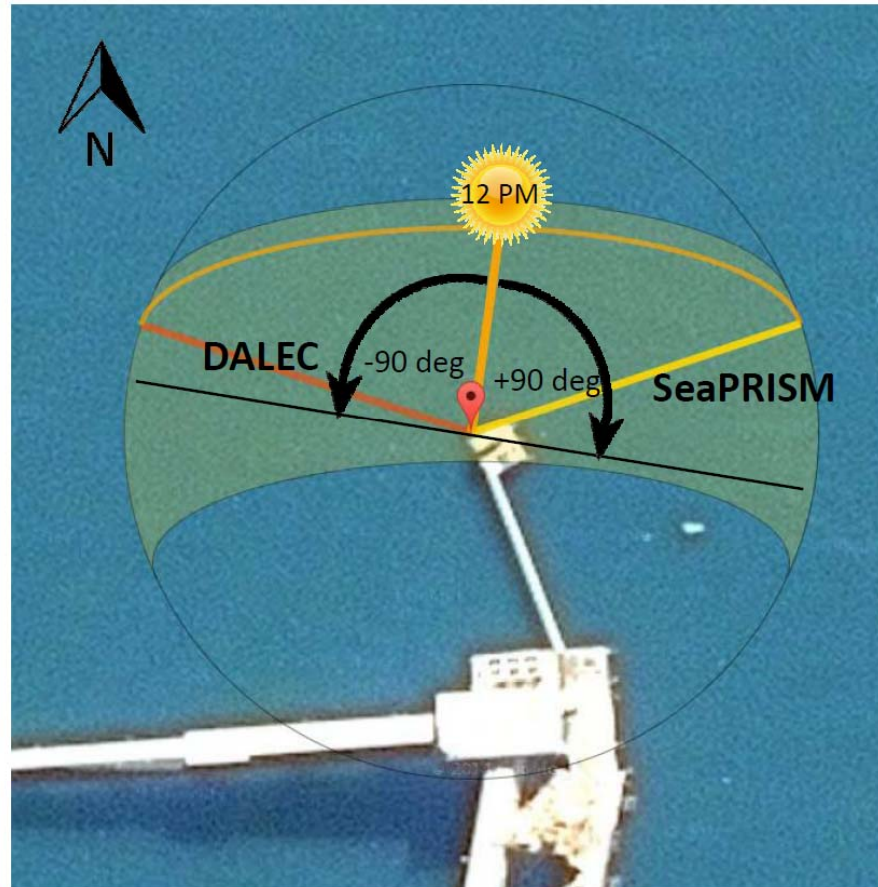
David Antoine  
Brett Baker  
David Blondeau-Patissier  
David Boadle  
Nick Hardman Mountford  
Edward King  
Wojciech Klonowski  
Jenny Lovell  
Yi Qin  
Thomas Schroeder  
Matthew Slivkoff  
Thomas Trull  
Bozena Wojtasiewicz  
Monika Wozniak

# Extras



# Level 2 Radiance Validation - LJCO

Data quality improved - DALEC and SeaPRISM now 90° with respect to the Sun



- DALEC and SeaPRISM radiometry now in good agreement
- DALEC required to capture AM satellite passes (Sentinel-3A)

# How to get the data?

<http://coast-rs-1.it.csiro.au/>

CSIRO

About Browse Order

WQM

- CHLF
- PRES\_REL
- TURB
- TEMP
- PSAL
- DOX1\_2

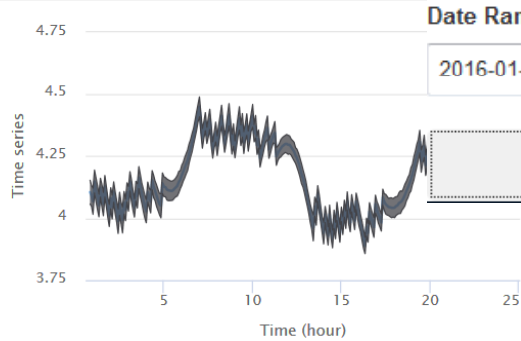
555 12

September 2016

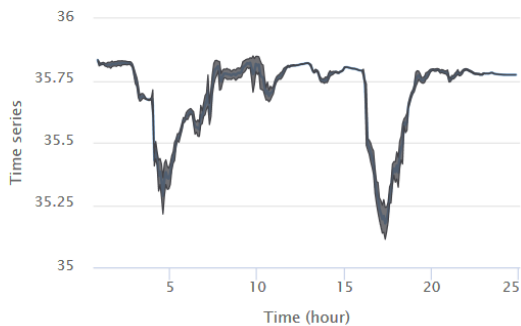
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5	6	7	8	9	10	11
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26	27	28	29	30		

Plots Selected variables

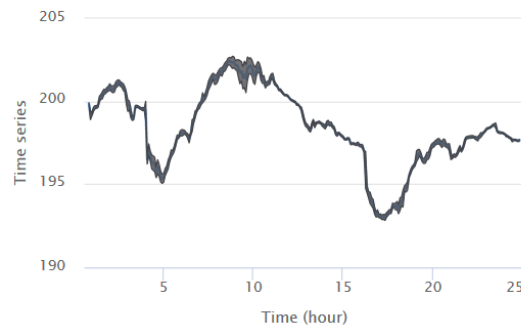
PRES\_REL: Time series



PSAL: Time series



DOX1\_2: Time series



About Browse Order

Instrument

ACS  
BB9  
WQM  
HyperOCR  
EcoTriplet

Frequency

Hourly  
Daily

Date Range

2016-01-01

2016-12-31

Select

Type	Size
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Subtotal	21994.19 Mb
Subtotal	83.96 Mb
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IMOS_SRS-OC-LICO_FTZ_201601200511262_SRC_FV91_ACS-hourly-wcc_C-20160914T075952	hourly 3.81 Mb
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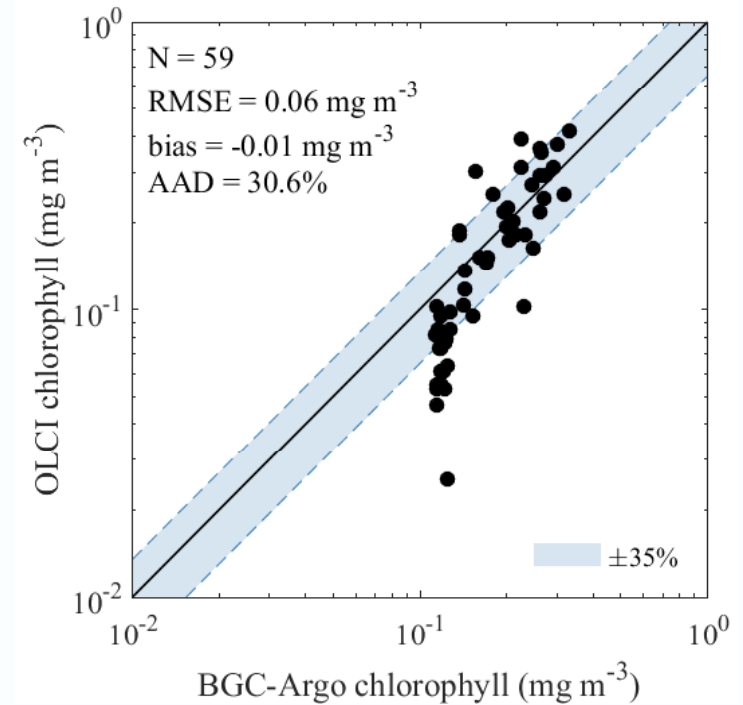
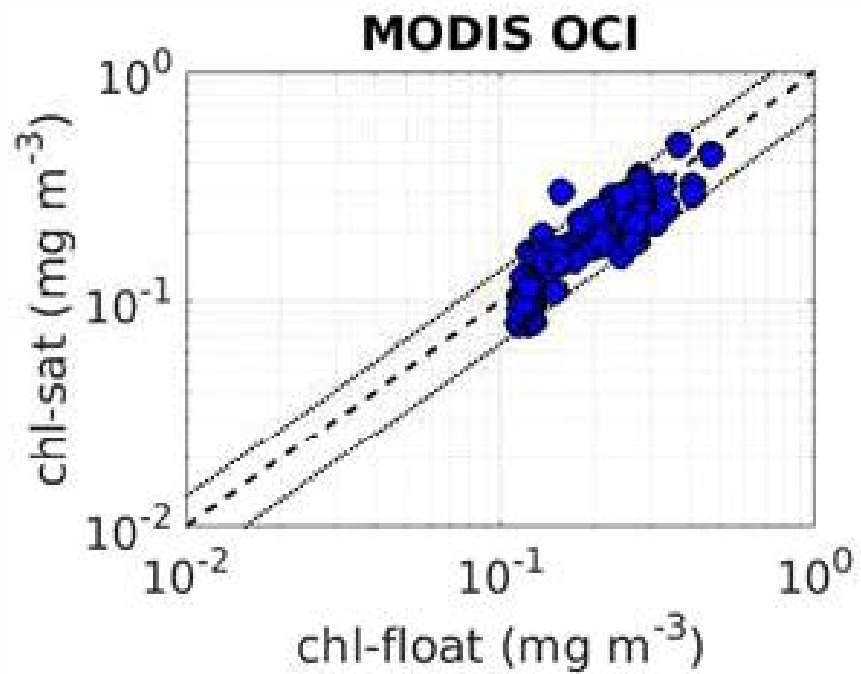


(Analysis: Qin Y.)

S3 Validation Team Meeting, 13-15 March 2018, Darmstadt, Germany



# BGC argo MODIS - Pacific



# AERONET AEROSOL ROBOTIC NETWORK

+ AEROSOL OPTICAL DEPTH + AEROSOL INVERSIONS + SOLAR FLUX + OCEAN COLOR + MARITIME AEROSOL

- Home
- Ocean Color**
- AEROSOL/FLUX NETWORKS
- CAMPAIGNS
- COLLABORATORS
- DATA
- LOGISTICS
- NASA PROJECTS
- OPERATIONS
- PUBLICATIONS
- SITE INFORMATION
- STAFF
- SYSTEM DESCRIPTION

- AERONET DATA ACCESS
- DATA SYNERGY TOOL
  - Data Display
- AEROSOL OPTICAL DEPTH
  - Data Display
  - Download Tool
  - Download All Sites
  - Climatology Tables
  - Climatology Maps
  - V2 L2 Data Availability
- AEROSOL INVERSIONS
  - Data Display
  - Download Tool
  - Download All Sites
- SOLAR FLUX
  - Data Display
- OCEAN COLOR
  - Data Display
- CLOUD MODE
  - Data Display

- AERONET Site Lists
  - Text Format
  - Google Earth Format
  - All Lists

**AERONET-Ocean Color (OC) Data Display Interface**

**DISCLAIMER**  
AERONET-OC Level 1.0. Real Time Data.  
The following AERONET data are unscreened and may not have final calibration applied

**DATA USAGE**  
Due to the research and development phase characterizing AERONET Ocean Color, use of these data requires offering co-authorship to the Principal Investigator.

Lucinda



The principal investigator(s) of the 'Lucinda' site:  
**Thomas Schroeder**  
If you intend to use the following data please contact principal investigator:  
e-mail: [Thomas.Schroeder@csiro.au](mailto:Thomas.Schroeder@csiro.au)

Return to the World Map

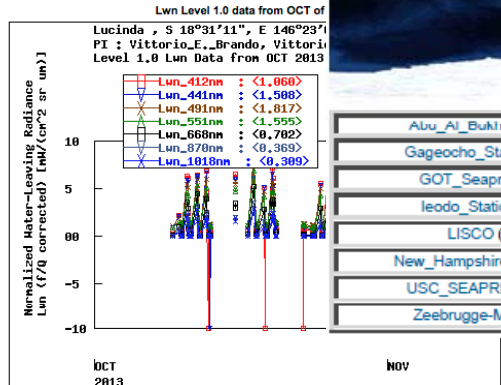
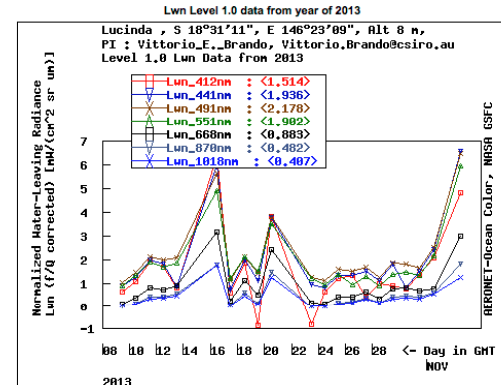
Choose Display Options:  
AERONET-OC Data Type:  Lwn (with f/Q correction)  Level 1.0  Level 1.5  
Data Format:  All points  Daily averages

SELECT CHARTS FOR LARGER IMAGES

Choose year: 2009 2010 2013  
Choose month of 2013: OCT NOV

Choose day of OCT 2013

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	



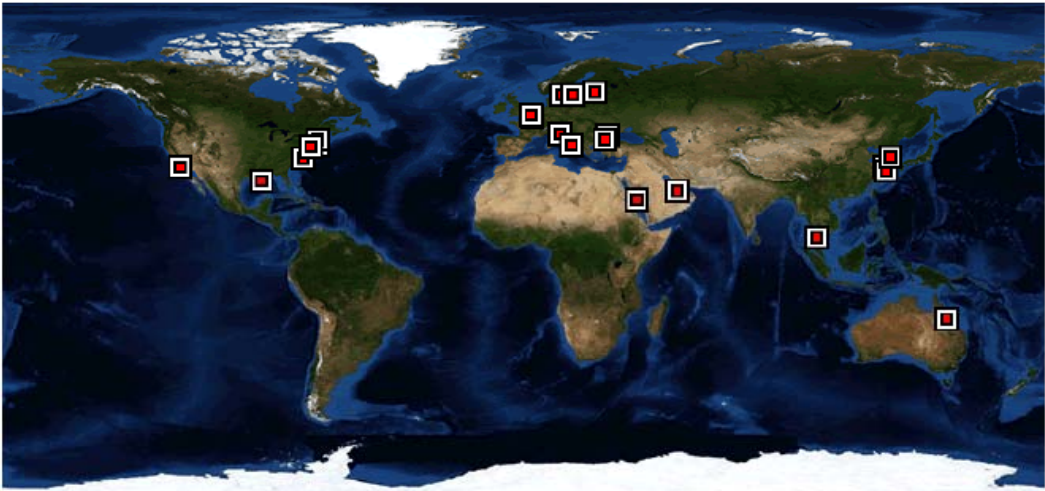
**AERONET-OC DOWNLOAD**

- Lwn Level 1.0
- Lwn Level 1.5
- Download all: Lwn Level 1.0
- Download all: Lwn Level 1.5
- Download all: Lwn Level 2.0
- More AERONET Downloadable Products...

**AERONET-OC DOWNLOAD**

- Lwn Level 1.0
- Lwn Level 1.5
- More AERONET Downloadable Products...

# SeaPRISM data Online at NASA Aeronet-OC



Abu_Ai_Bukhuushi (25N,53E)	Bari_Waterfront (41N,10E)	GOVE_SEAPRISM (30N,75W)
Gagecho_Station (33N,124E)	Galata_Platform (43N,28E)	Glonia (44N,29E)
GOT_SeaprisM (0N,101E)	Gustav_Dalen_Tower (58N,17E)	Helsinki_Lighthouse (59N,24E)
Ieodo_Station (32N,125E)	KAUST_Campus (22N,39E)	KIOST-Ansan (37N,126E)
LISCO (40N,73W)	Lucinda (18S,146E)	MVCO (41N,70W)
New_Hampshire_Univ (43N,70W)	Palgrunden (58N,13E)	Thornton_C-power (51N,2E)
USC_SEAPRISM (33N,118W)	Venise (45N,12E)	WaveCIS_Site_CSI_8 (28N,90W)
Zeebrugge-MOW1 (51N,3E)		

[http://aeronet.gsfc.nasa.gov/new\\_web/ocean\\_color.html](http://aeronet.gsfc.nasa.gov/new_web/ocean_color.html)

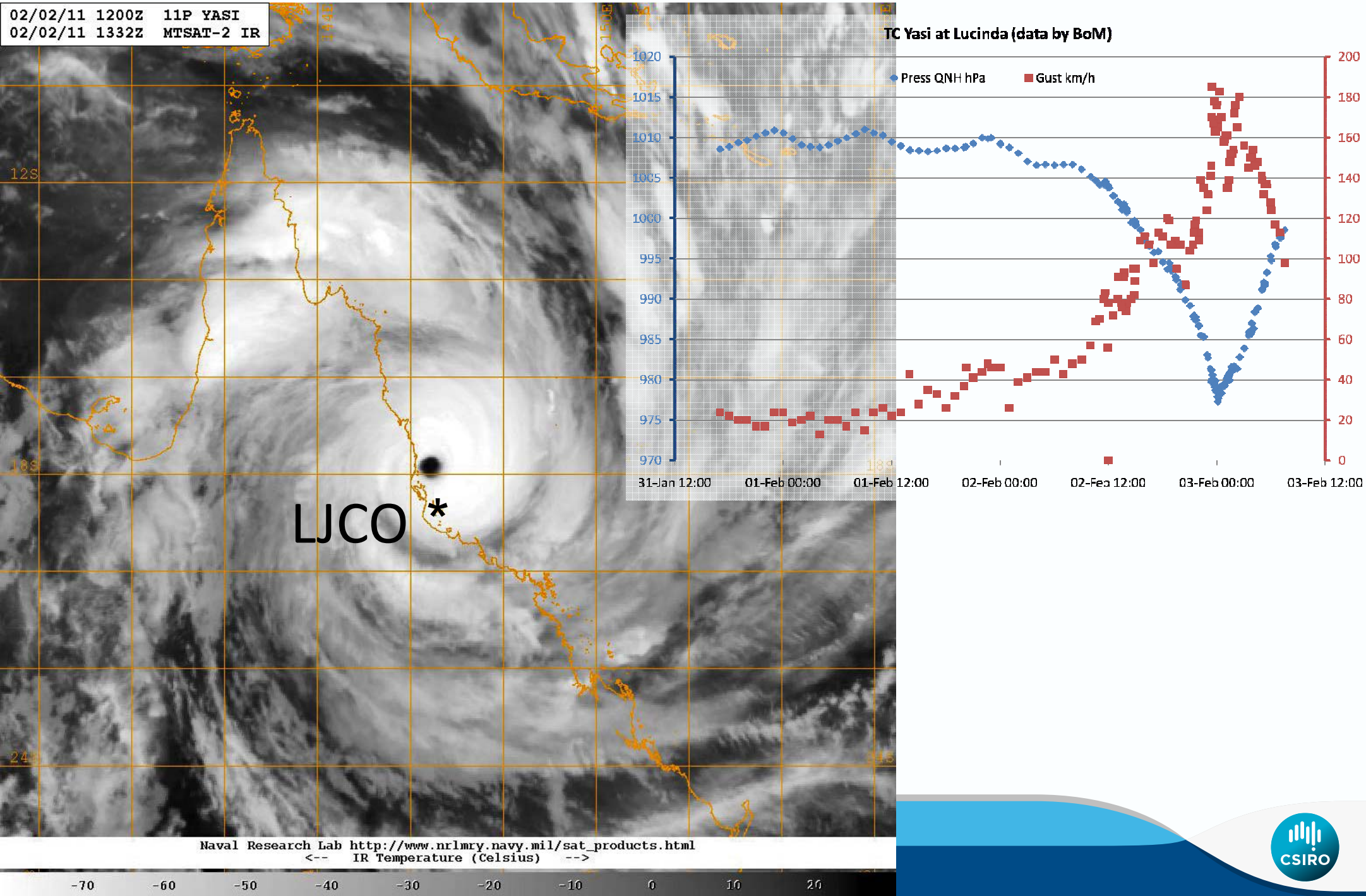




02/09/2014 10:56

# Severe Tropical Cyclone Yasi (Category 5)

## 2-3 February 2011

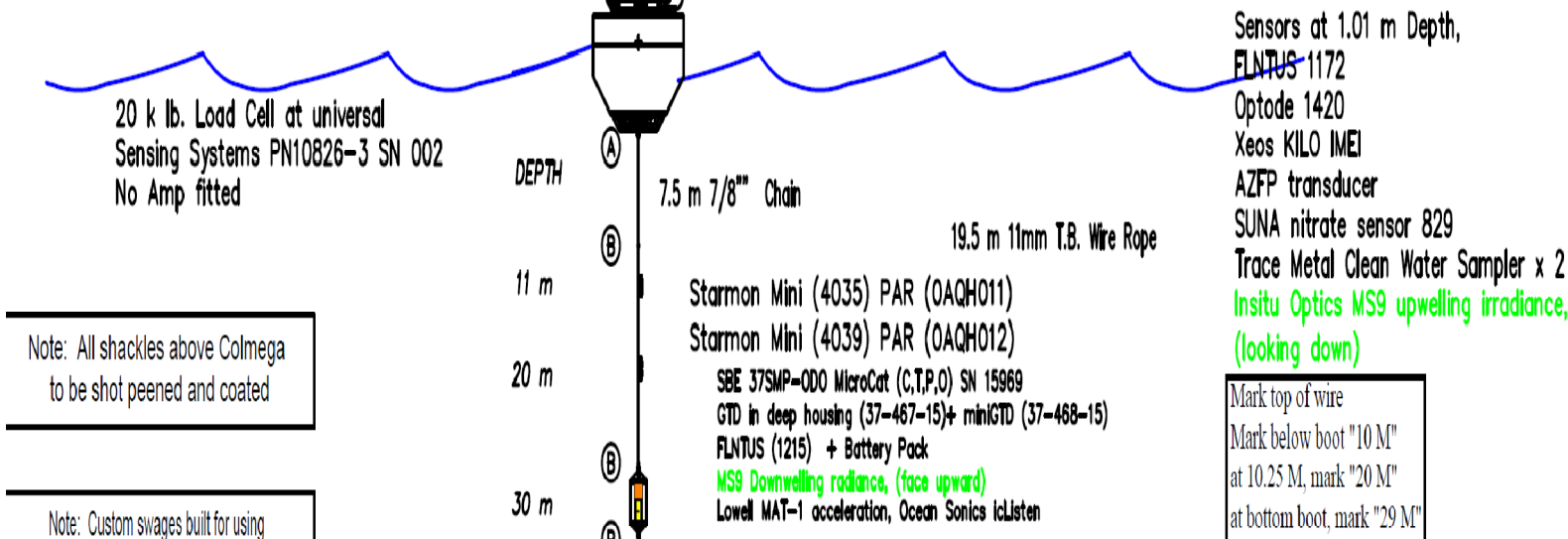


SOFS-7

L22 IMEI 300234063587940	L23 IMEI 300234010551260
HRH - 363	HRH - 255
BPR - 276	BPR - 227
PRC - 227 (CT S 9217)	PRC - 228 (CT S)
SWND -	SWND
LWR - 238	LWR - 252
SWR - 355	SWR - 241
SST - SBE37 (7409)	SST - SBE37 (7408)

2.7 m Modular Buoy with the following equipment:

- (2) ASIMET with Iridium Telemetry L22 and L23
- (1) Pickup Rope Launcher 27.195 MHz, Remote
- (1) PMEL PCO2 System, SN=
- (1) CSIRO MRU logger for (FLNTUS, Optode, LiCOR Par, loadcell, MRU ) IMEI
- (1) LICOR PAR LI-1905A-
- (1) NAL-Tracker IMEI 300234064802080
- (2) Solar lights, Flash 6 sec, 0.5 sec On
- (1) SBE39 SN 5282
- (1) Trace Metal Clean Water Sampler
- (1) TriAXYS wave sensor TAS04811
- (1) ASL AZFP acoustic profiler SN 55046
- (1) SIMRAD WBAT mini, 38 kHz sounder
- (1) MS9 - downwelling radiance (looking up)



Note: All shackles above Colmega to be shot peened and coated

Note: Custom swages built for using

Sensors at 1.01 m Depth,  
 FLNTUS-1172  
 Optode 1420  
 Xeos KILO IMEI  
 AZFP transducer  
 SUNA nitrate sensor 829  
 Trace Metal Clean Water Sampler x 2  
 Insitu Optics MS9 upwelling irradiance,  
 (looking down)

Mark top of wire  
 Mark below boot "10 M"  
 at 10.25 M, mark "20 M"  
 at bottom boot, mark "29 M"

SOTS location: west flowing closer of super-gyre, upper limb of overturning circulation

