



**SMARTSAT**  
COOPERATIVE RESEARCH CENTRE



# AquaWatch Australia

The Aim of AquaWatch Australia is to safeguard our freshwater and coastal resources

Ambitious Goal: A comprehensive national water quality monitoring & prediction system by 2026 – using integration of in-situ sensors, space technologies and innovative analysis and modelling





# Australia's Current and Near Future Satellite Calibration and Validation Capabilities- With a Focus on Marine, Coastal and Inland Waters



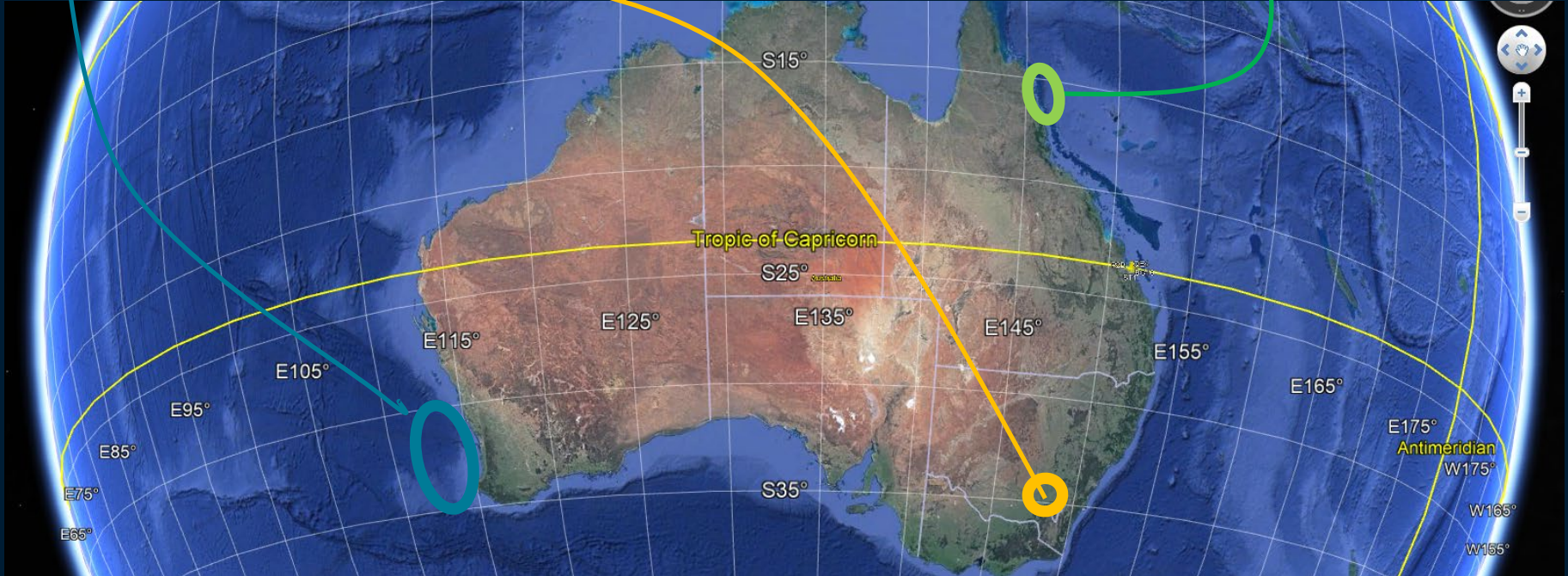


# Arnold Dekker Presenting on Behalf of Key Experts and PoC:

David Antoine- Curtin University

Thomas Schroeder – CSIRO Oceans & Atmosphere

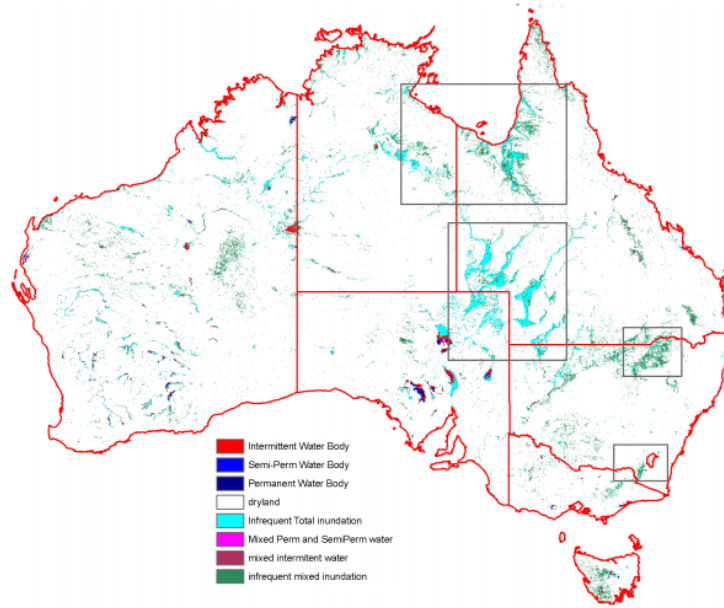
Janet Anstee - CSIRO Oceans & Atmosphere





# The challenge

- How to cost effectively roll out a calibration and validation sensor network at the scale of a continent with very remote areas from tropics to temperate ecosystems?

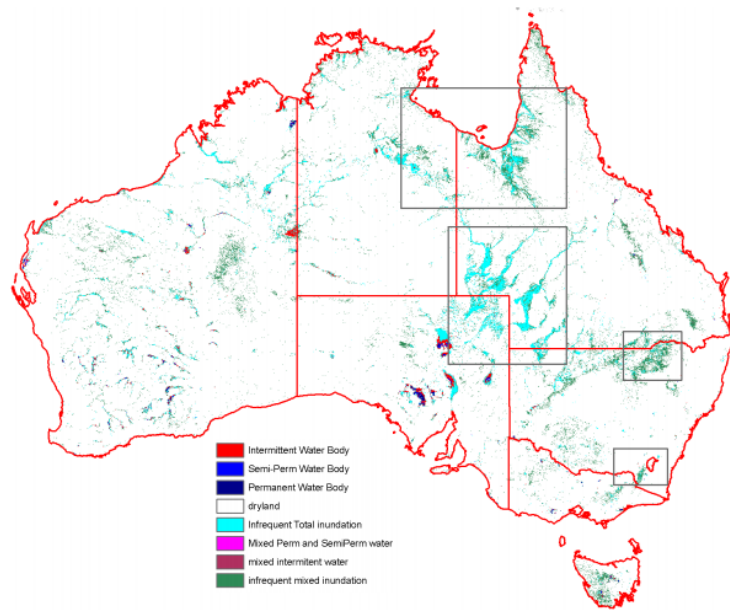


Images courtesy of Erin Hestir



# The challenge

- How to cost effectively roll out a calibration and validation sensor network at the scale of a continent with very remote areas from tropics to temperate ecosystems?



Images courtesy of Erin Hestir



# The challenge of *in situ* monitoring

- Poor data coverage
- Poor temporal continuity
- Inconsistent sampling
- Variation in data accessibility
- Limited understanding of the implications of extreme events on water quality

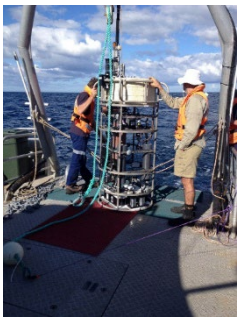




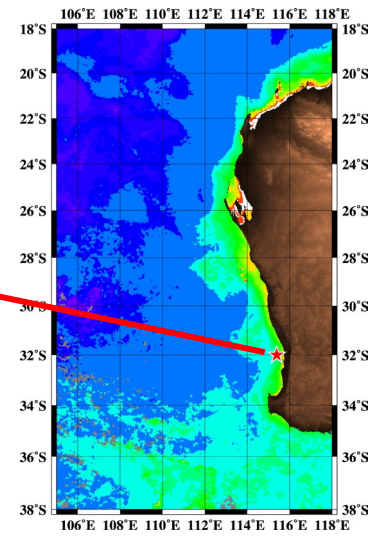
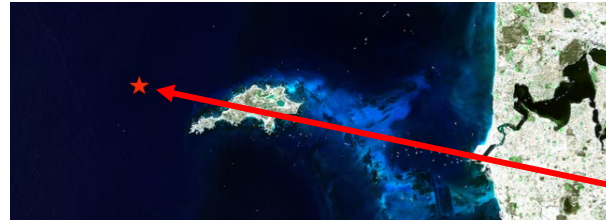
# Arnold Dekker Presenting on Behalf of Key Experts and PoC: David Antoine- Curtin University



PI: **David Antoine**  
Remote Sensing and  
Satellite research Group



# RITS (Rottnest Island Thetis Station)



❖ Regular deployments since 2017 off Rottnest Island (nearby the IMOS NRS)

❖ A positively buoyant, profiling instrument package with an on-board winch, a telemetry system, and the following sensors:

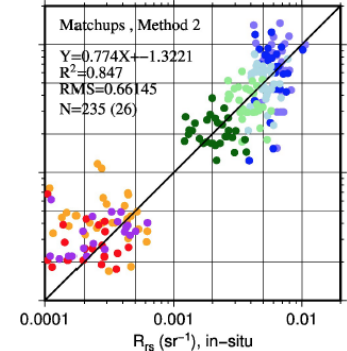
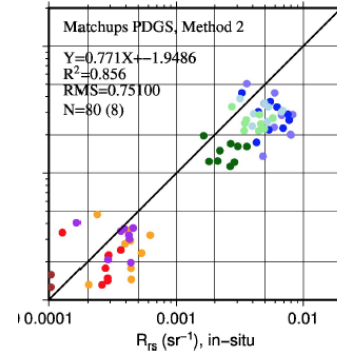
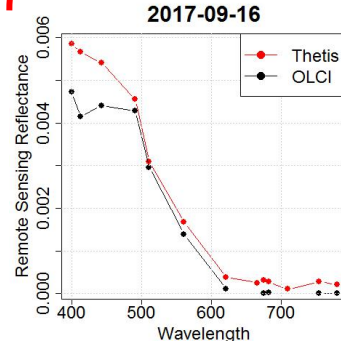
- Seabird CTD (SBE49 FastCAT) for temperature and salinity, SBE43 for Dissolved Oxygen
- Satlantic HyperOCR hyperspectral sensors (downward irradiance  $E_d$  and upwelling radiance  $L_u$ , range: 350-800 nm)
- WET Labs AC-S hyperspectral spectrophotometer (absorption and attenuation coefficients, range: 400-730nm)
- WET Labs ECO Triplet BB2FLs for particles backscattering (3 wavelengths) and chlorophyll fluorescence
- Seabird Turner  $pCO_2$  sensor

## Matchup examples (S3A-OLCI)

Initially funded through an ARC LIEF16 grant, and now through the IMOS “satellite ocean colour facility”



Activity paused in  
2020, to resume  
Q4 of 2022





## NASA / U Miami MarONet Deployment in 2023

PIs: *Kenneth J Voss and Arthur C R Gleason*, Uni Miami, *David Antoine*, RSSRG, Curtin Uni  
*Mark Yarbrough, Michael Feinholz*, SJSU, *Carol Johnson*, NIST

<https://pace.oceansciences.org>

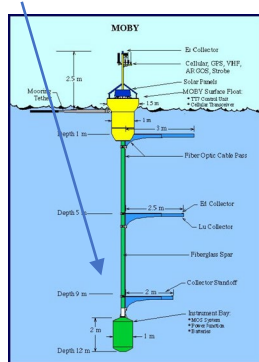
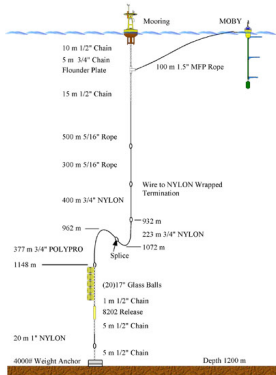


Curtin Uni will host the “Marine Optical Network” (MarONet).  
**To be deployed off Perth, in deep clear waters.**

A complimentary system is deployed in Hawaii

MOBY heritage, plus full technology refresh

MOBY & Lanai Mooring



This unique equipment is the new generation “vicarious calibration” system that NASA is going to use for the PACE mission (Plankton, Aerosols, Clouds, Ocean Ecosystem).

**PACE is the first global hyperspectral ocean colour mission**

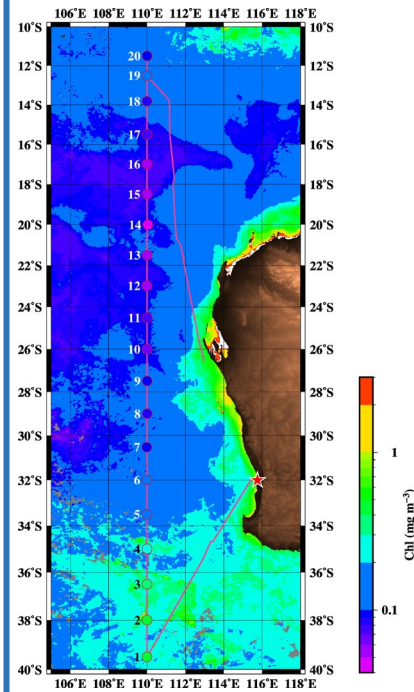
The former system (“MOBY”) has been used for 25 years, and not only serves NASA and NOAA missions but virtually all ocean colour missions (ESA, JAXA, ISRO)

# Other RSSRG field activities contributing to satellite OCR validation (essentially open ocean) – Recent past, current, future

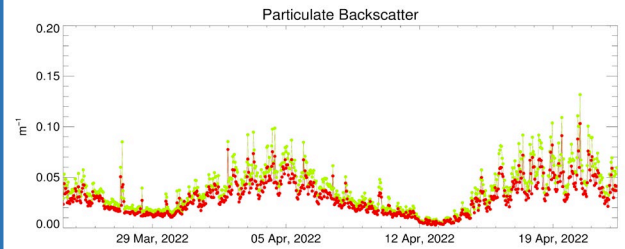
PI: *David Antoine*  
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Antarctic Circumpolar Expedition (ACE) 2016/17 (Swiss Polar Institute, Ferring Pharma)



110E-line revisit, 2019 (Australia MNF, ARC, ESA)



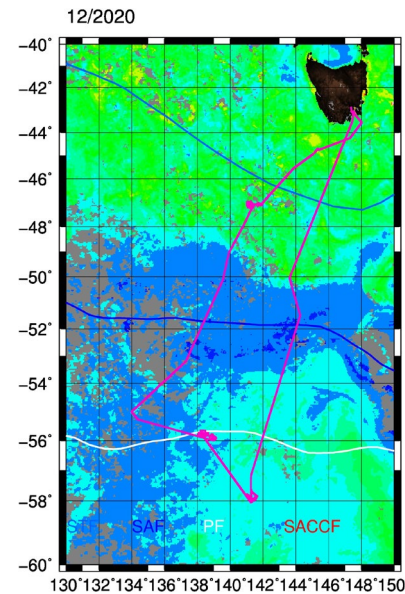
WA coastal waters (Pilbara and Kimberley areas); 2022 "SmartSAT" CRC

## SOLACE

Southern Ocean Large Area Carbon Extent



5-week research voyage in the southern ocean, south of Tasmania (PI Phil Boyd, UTAS), 2020/21





# Arnold Dekker Presenting on Behalf of Key Experts and PoC:

Thomas Schroeder – CSIRO Oceans & Atmosphere



# Lucinda Jetty Coastal Observatory

<http://lucinda.it.csiro.au/>

Objectives: *“To support validation of satellite OC observations, to provide calibration inputs to CSIRO’s Biogeochemical Models and to improve consistency of radiometric measurements”*

Observations: *“Continuous above and in-water optical measurements, Fortnightly water quality sampling”*



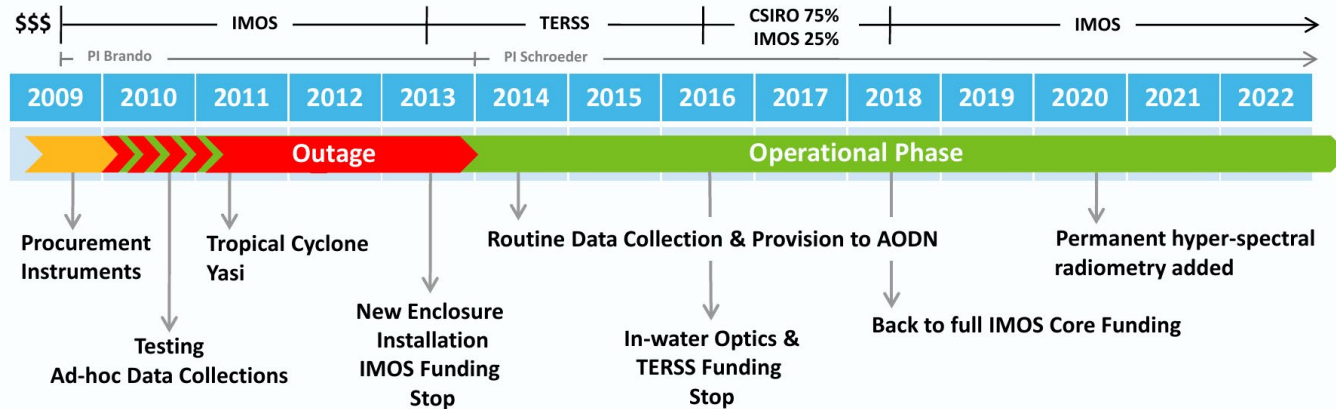


# Lucinda Jetty Coastal Observatory (LJCO)

## Timeline

IMOS funding secured until June 2023

2023-28 proposal submitted - continuation of funding likely



TERSS: Tasmanian Earth Resources Satellite Station, X-band ground station, decommissioned in 2014



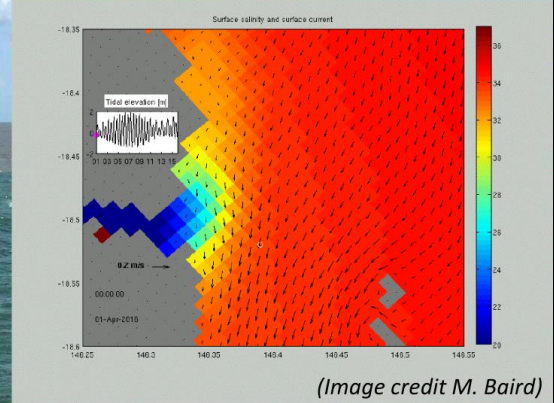
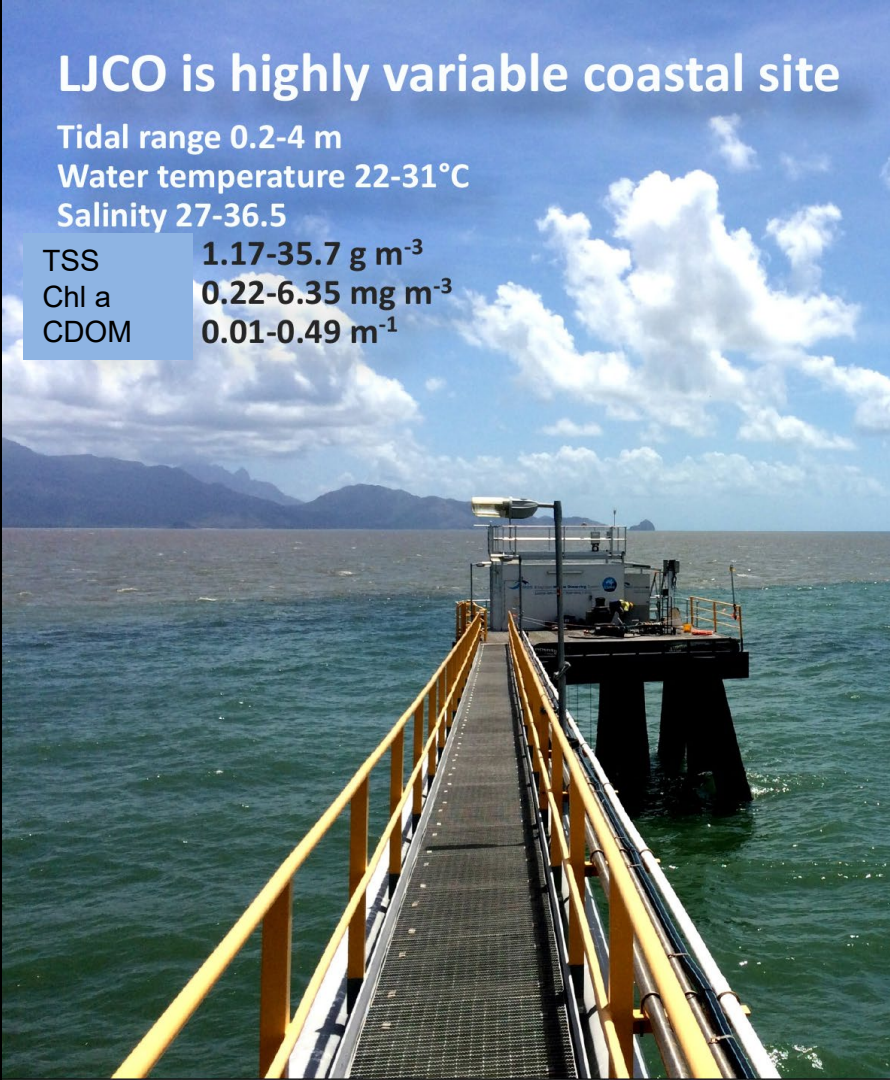
# LJCO is highly variable coastal site

Tidal range 0.2-4 m

Water temperature 22-31°C

Salinity 27-36.5

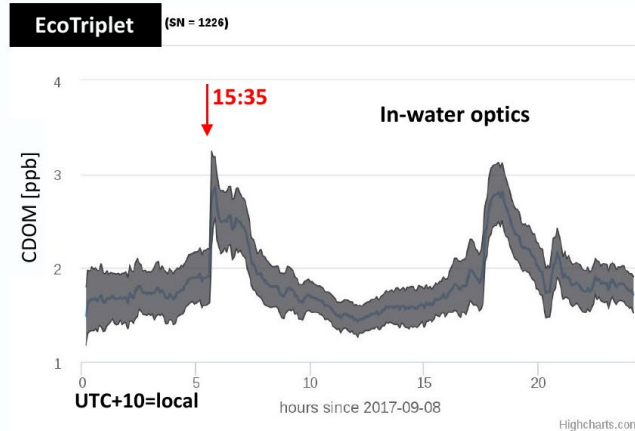
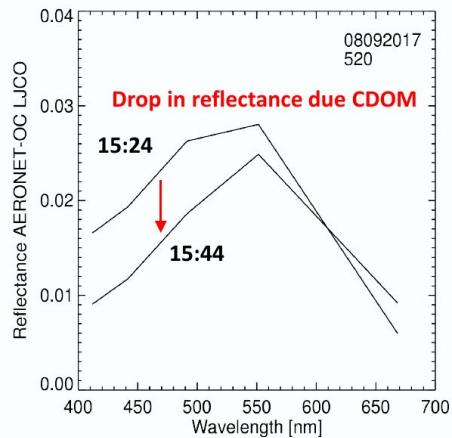
TSS	1.17-35.7 g m <sup>-3</sup>
Chl a	0.22-6.35 mg m <sup>-3</sup>
CDOM	0.01-0.49 m <sup>-1</sup>



(Image credit D. Boadle)

# Tidal fronts at LJCO

Large spectral changes within 2 subsequent SeaPRISM observations possible





# Continuous in-water measurements



**WetStar fluorometer**  
CDOM absorption  
Chlorophyll-a  
Uranine  
Phycoerythrin



**Automatic winch control using a depth transducer**  
Keeps optical cage at a constant depth  
Water temperature

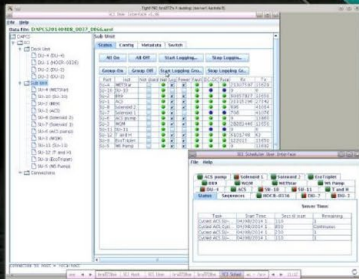


**ACs (80 wavelengths)**  
Path length 10 cm  
Total absorption  
Total attenuation

**WQM**  
Temperature  
Salinity  
Chlorophyll fluorescence  
Depth  
Dissolved oxygen  
Turbidity  
Back scattering



**DAPCS**  
Network enabled real-time data logger and scheduler



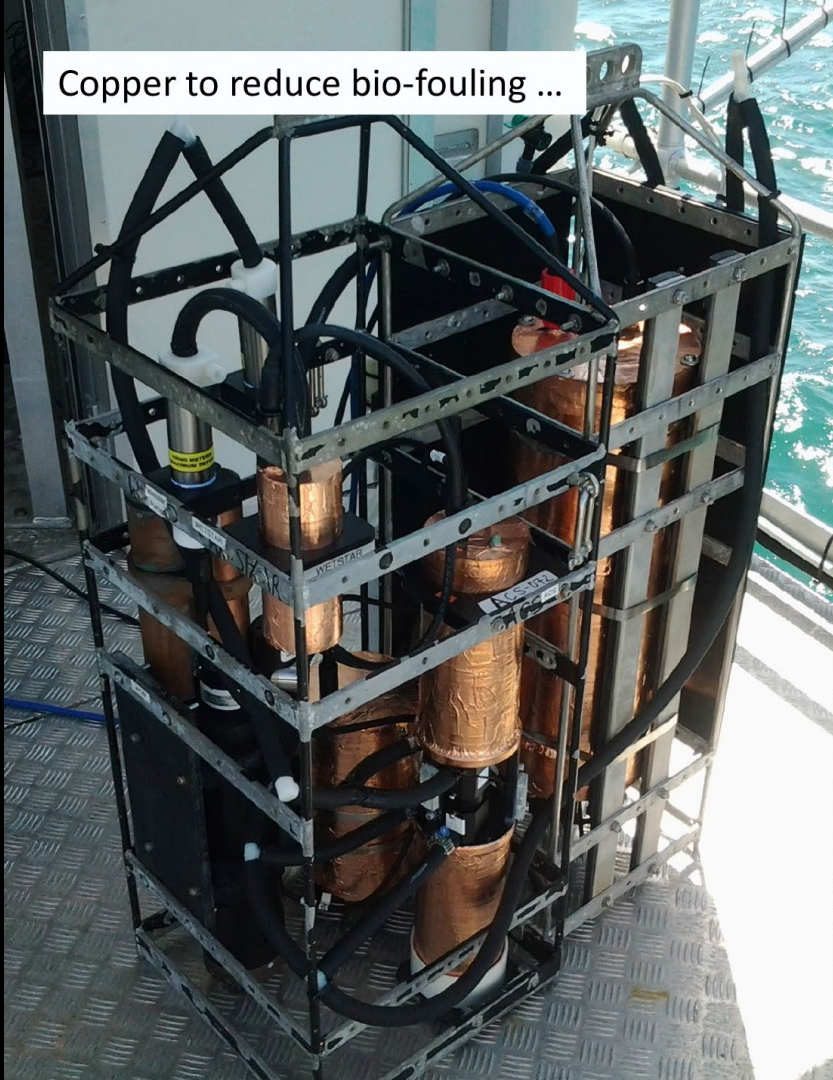
**BB9 (9 wavelengths)**  
Back-scattering



**EcoTriplet BB2FLWB**  
Back scattering  
CDOM fluorescence

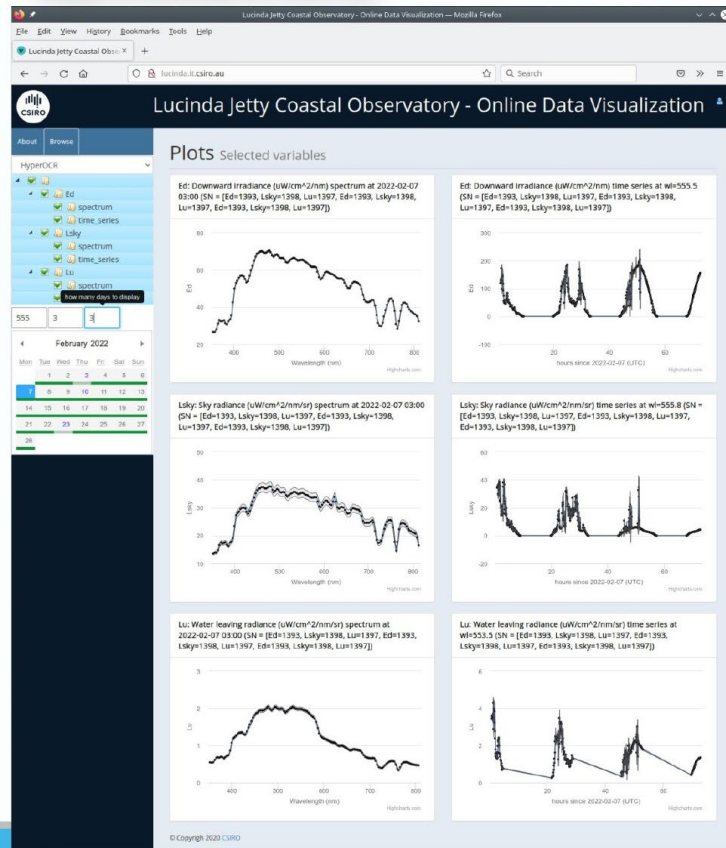


Copper to reduce bio-fouling ...



# Online Data Visualization

<https://lucinda.it.csiro.au>



# Data access via AODN

<https://portal.aodn.org.au/>

Open Access to Ocean Data

Australian Ocean Data Network

WCS Integrated Marine Observing System

# AODN Portal

"The gateway to Australian marine and climate science data"

Get Ocean Data Now

The AODN Portal provides access to all available Australian marine and climate science data and provides the primary access to IMOS data following access to the IMOS metadata.

IMOS Ocean Current

The latest ocean information around Australia

Australian Integrated Marine Observing System (AIMOS) is created by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of IMOS nodes as an unincorporated joint venture, with the University of Tasmania (UoT) as Lead Agent.

Contact Us (Acknowledgement of )  
Disclaimer (UoT, AODN, UoT, IMOS, UoT)

UNIVERSITY OF TASMANIA

NCRIS  
National Collaborative Research Infrastructure Strategy

IMOS

CSIRO

(A)



**Satlantic HyperOCR on Solar Tracker**  
Hyper-spectral  
Radiance & irradiance  
Reflectance

**Webcams**  
Sky and Sea



(B)

Continuous atmospheric measurements

(A)

**Weather Station**

Temperature  
Surface pressure  
Humidity  
Dew point  
Wind speed etc

(C)



(D)



(D)



**SeaPRISM**

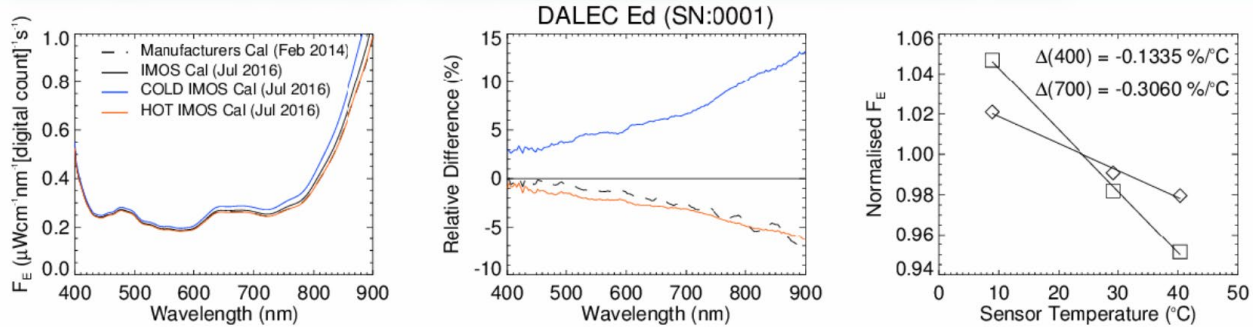
Multi-spectral  
Water-leaving radiance  
Reflectance  
Aerosol optical thickness  
Aerosol absorption  
Aerosol size distribution  
Refractive index  
Single scattering albedo  
Phasefunction  
Water vapor  
Spectral flux  
Radiative forcing

IMOS Integrated Marine Observing System  
Lucinda Jetty Coastal Observatory (LJCO)

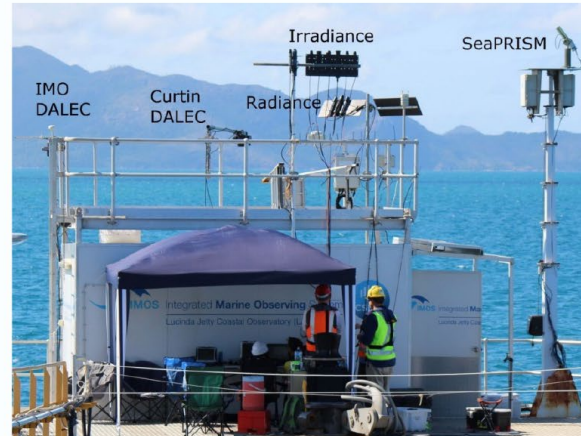
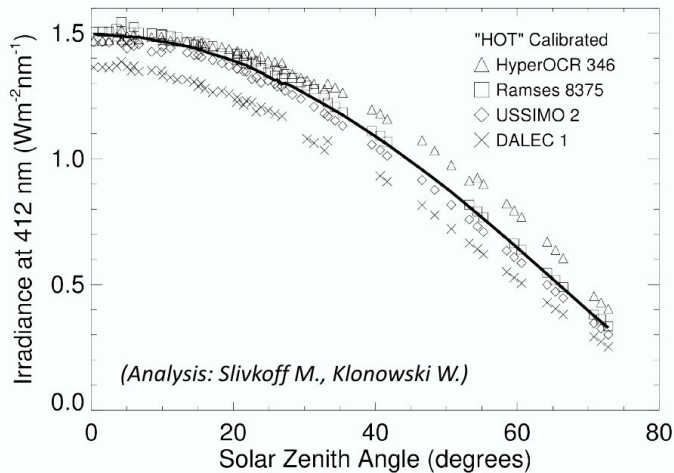


# Improving consistency of radiometric measurements

IMOS Radiometry Task Team – 1 year funded project (Antoine, Schroeder et al.)



**Recom.: Spectral approach for temperature correction of cal. coeff. should be implemented**

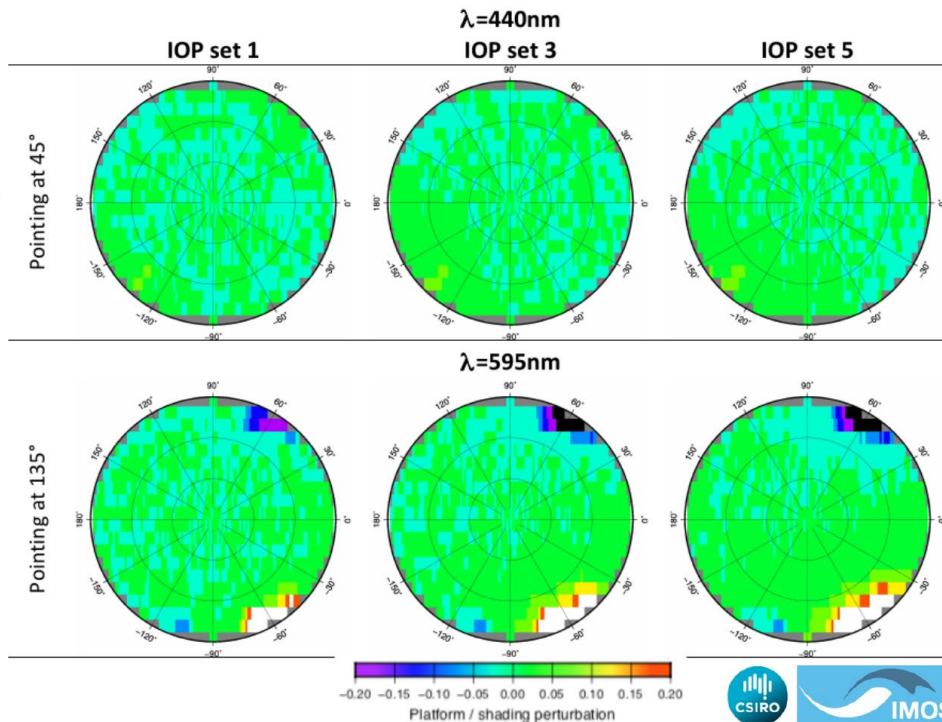
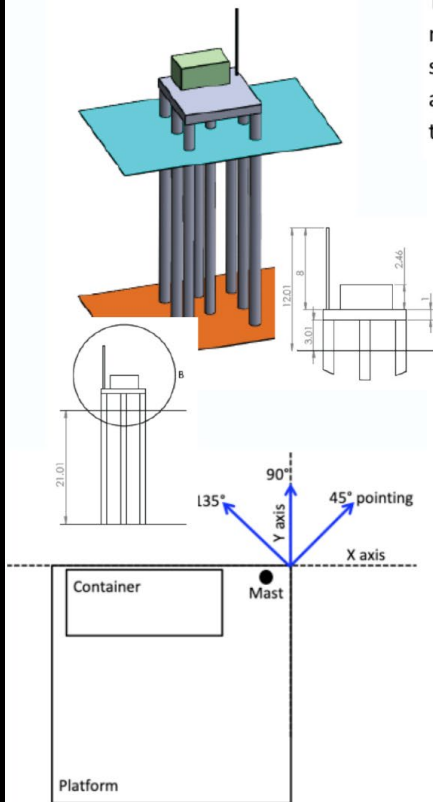


# Evaluation of platform shading effects at LJCO

## Through Monte-Carlo RT simulations

DAVID ANTOINE<sup>1,2</sup>, EDOUARD LEYMARIE<sup>2</sup>, MATTHEW SLIVKOFF<sup>1</sup>, THOMAS SCHROEDER<sup>3</sup>

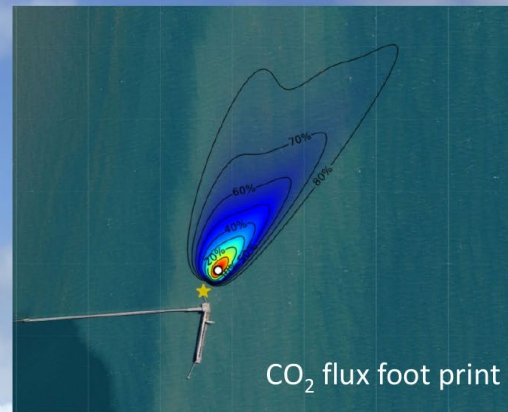
The MC simulations performed in this work clearly show that platform perturbations at LJCO are negligible (i.e., < 2%) as far as the sun zenith angle is lower than 50 degrees, and provided that some specific geometries are avoided. These geometries would be when the Sun is behind the platform at low Sun elevation opposite of the instrument viewing direction. This geometry is avoided at all times as the instrument viewing direction is fixed at 90 degrees clockwise away from the Sun.



# LI-COR Eddy Covariance System

## CO<sub>2</sub> and CH<sub>4</sub> fluxes

Added in 2021



(Analysis and PI Joey Croswell, CSIRO)

**LJCO provides continued support of national & international programs and activities:**

eReefs, Digital Earth Australia, GBRMPA, BoM, AIMS, AquaWatch Australia, QLD Gov., EnMAP, Sentinel-3 Validation Team OC, IOCCG WG on atmospheric correction, FRM4SOC, Copernicus CVS, SeaBASS (NASA), and the wider OC research community.



Contact: [Thomas.Schroeder@csiro.au](mailto:Thomas.Schroeder@csiro.au)



# IMOS Production & Validation of Ocean Colour (PVOC)

Contact: Thomas.Schroeder@csiro.au

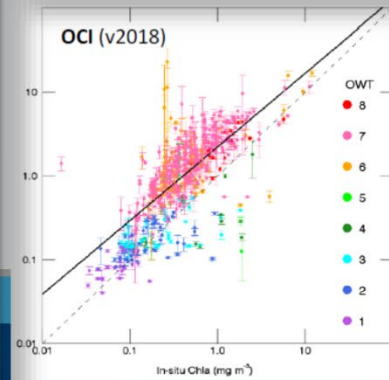
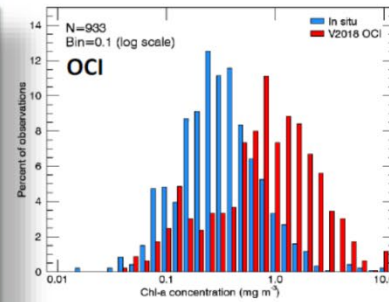
Sub-facility generates daily 1 km Level-3 (gridded) ocean colour products from MODIS-Aqua and VIIRS

Product validation using IMOS Bio-optical Database – freely available via AODN

Match-up are separated into Optical Water Types (Moore et al. 2009)

Annual validation reports

The screenshot shows the AODN Open Access to Ocean Data website. The header includes the AODN logo and navigation steps: 1. Select a Data Collection, 2. Create a Subset, 3. Download. The main content area is titled "Step 2: Create a Subset" and features a map of the Southern Ocean with various data points. On the left, there are search filters for Spatial, Temporal, and Others. The bottom of the page includes a footer with contact information for AODN and IMOS contributors.



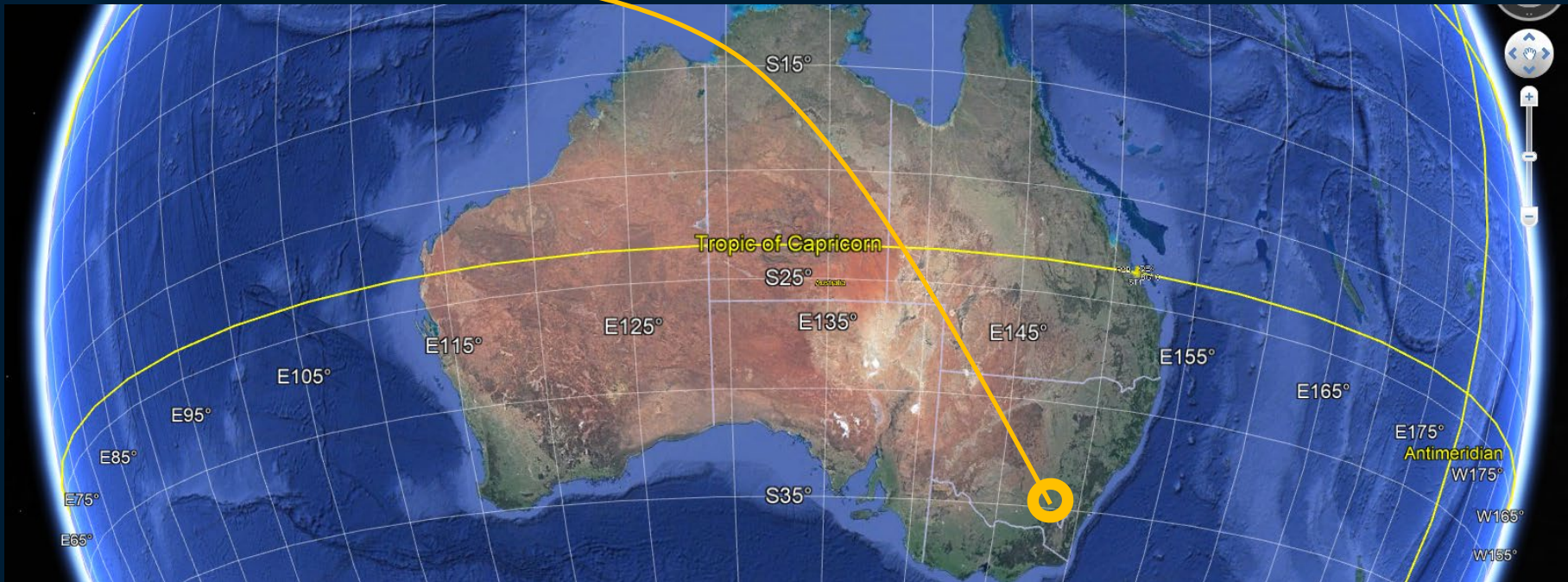
The cover of the "Ocean Colour Validation Report 2017-18" features the IMOS logo and a map of the Southern Ocean with a "AODN Portal" overlay. The report is prepared by Thomas Schroeder, Jerry Lovett, Edward King, Lindsay Clementson, Roger Scott, CSIRO Oceans and Atmosphere, and dated June 2018.

The CSIRO logo is displayed in the bottom right corner of the slide.



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Janet Anstee - CSIRO Oceans & Atmosphere

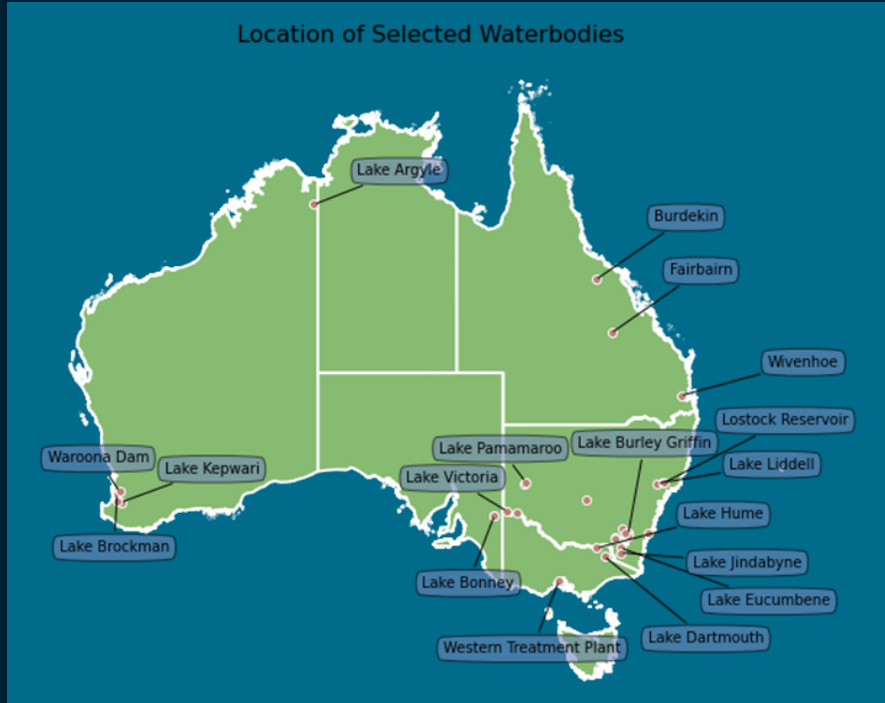




# Inland Water Quality (IWQual) Project

Co-funded CSIRO and Geoscience Australia  
PI: Janet Anstee  
2019-2022

1. Analysis of knowledge gaps in archival bio-optical database (Botha et al, 2019),
2. Database incorporating our historical and current acquisitions of *in situ* observation data,
3. Matchup data of *in situ* observations and satellite overpasses for validation,
4. Eye on Water water colour and other physio-chemical observations (Eye on Water – Australia app & db),
5. Parameterisation of a continental scale physics-based (or ML training) algorithm for satellite-derived water quality assessment.





# IWQual Bio-Optical Database

Published on CSIRO Data Access Portal

<https://doi.org/10.25919/rtd7-j815>

(In submission to) Data in Brief journal

*316 sets of observations made at 34 inland waterbodies in Australia.*

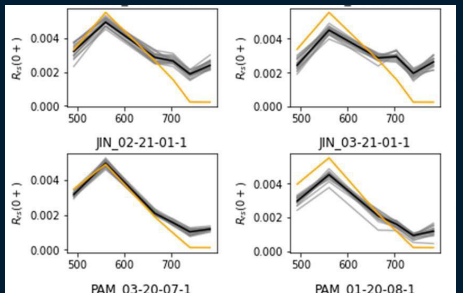
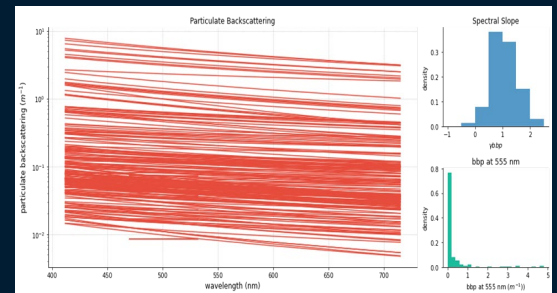
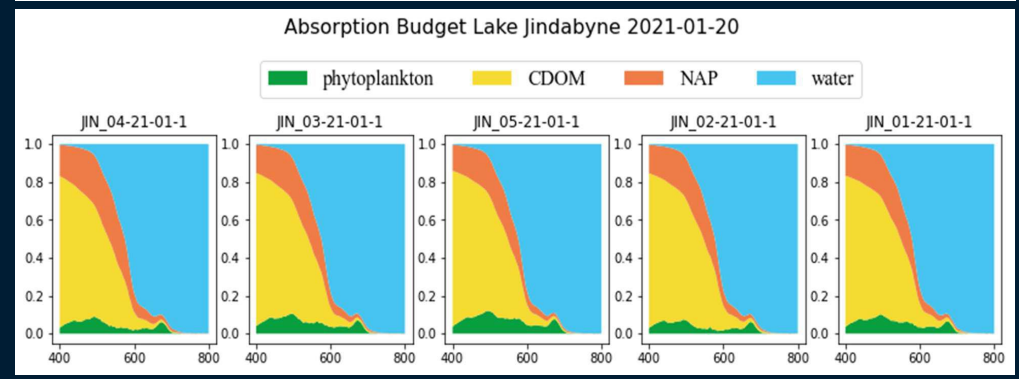
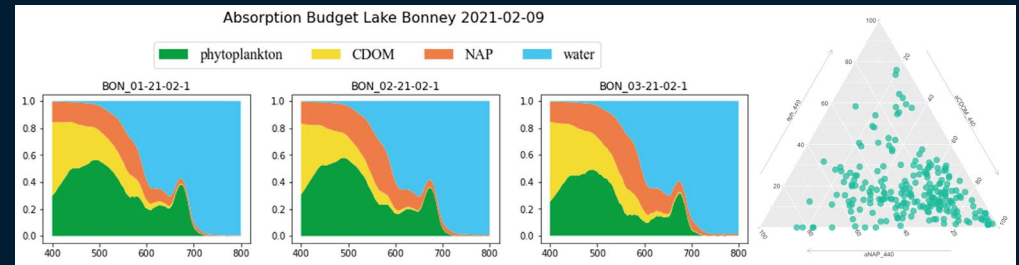
Laboratory analysis of water samples:

- Absorption coefficients
- Pigments – HPLC
- TSS

Total and dissolved organic carbon

*In situ* instruments:

- Backscattering - WetLabs BB9 or BB2
- Radiometry – RAMSES Ed, Esky & Lu

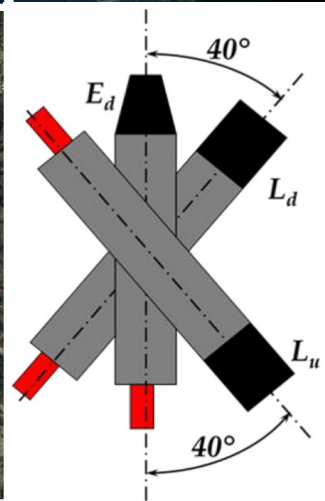




# Inland Observatory

Funded CSIRO and AquaWatch Australia  
PI: Janet Anstee

- Planned deployment for water drinking reservoir in late 2022
- Instruments include:
  - TriOS Ramses  $E_d$ ,  $L_{sky}$  and  $L_w$
  - Weather station
  - Thermistor chain
  - Planned CIMEL (CE318-T)
  - Planned in-water fluorometers (CDOM, CHL, PC)

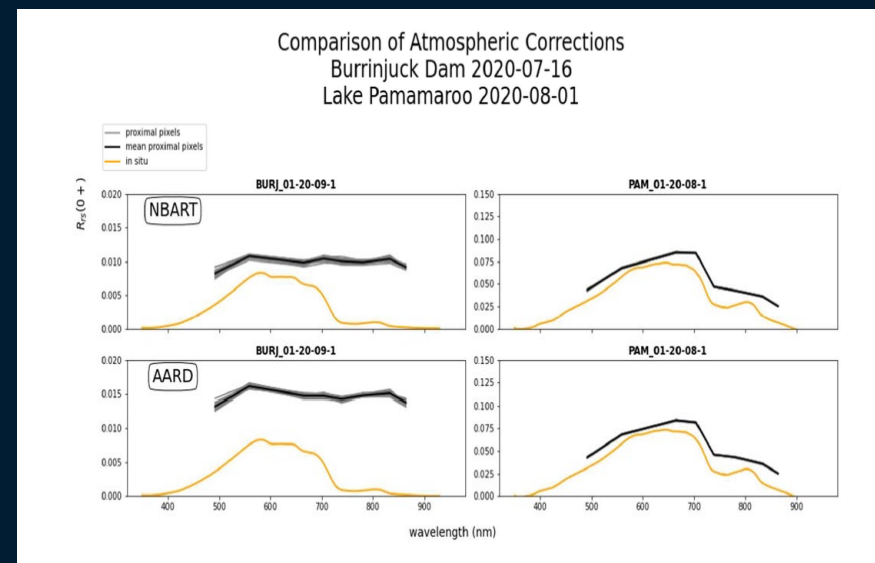
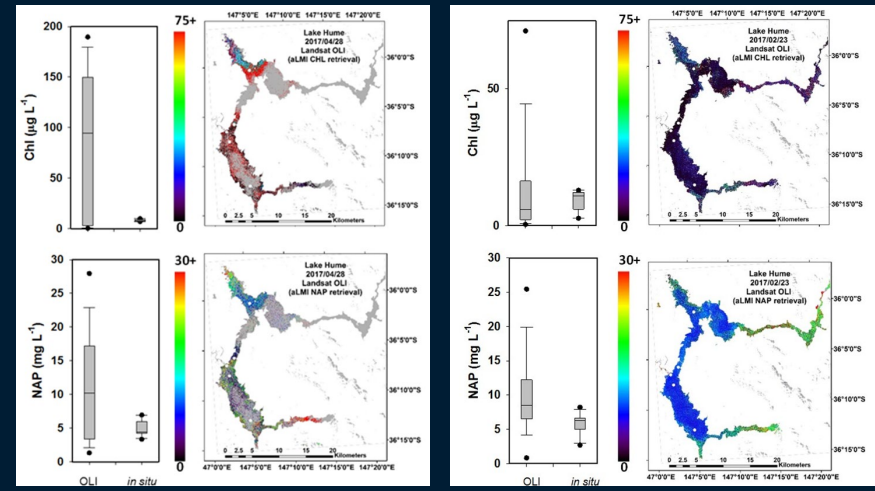




# Inland Observatory

Funded CSIRO and AquaWatch Australia  
PI: Janet Anstee

- Objective is to establish a permanent mooring at an inland drinking water reservoir. Fiducial reference measurements of water-leaving radiance to be used in the validation of EO data.
  - Proposed site (Googong Dam) is a deep clear drinking water reservoir.
  - The platform has the capacity to host other sensors (eg such as bio-optical sensors).
- Data acquired will be used to evaluate atmospheric and glint correction and water quality products of EO sensors such as Sentinel 2,3, Landsat 8 and 9, and other new sensors such as those being developed by AquaWatch Australia.





# Near Future.....

A National Space Mission for Earth Observation (NSMEO): a ~\$1.2 billion program led by the Australian Space Agency in partnership with CSIRO, Geoscience Australia, the Bureau of Meteorology and Department of Defence.



# Near Future.....

As part of NSMEO:

## **New satellite calibration and validation**

**infrastructure:** CSIRO will lead the development and maintenance of a national network of new ground-based satellite calibration and validation sites across Australia....to support domestic and international operators to calibrate their satellites and verify the data they collect to ensure its accuracy.





# Key Experts and PoC:

David Antoine-

[david.antoine@curtin.edu.au](mailto:david.antoine@curtin.edu.au)

Thomas Schroeder –

[thomas.schroeder@csiro.au](mailto:thomas.schroeder@csiro.au)

Janet Anstee -

[janet.anstee@csiro.au](mailto:janet.anstee@csiro.au)



Presented by [arnoldgdekker@gmail.com](mailto:arnoldgdekker@gmail.com)