

Overview of research activities with a specific emphasis on water quality monitoring from EO data

Aquatic Remote Sensing team and contributors
CSIRO Environment
April 2024

Dr David Blondeau-Patissier

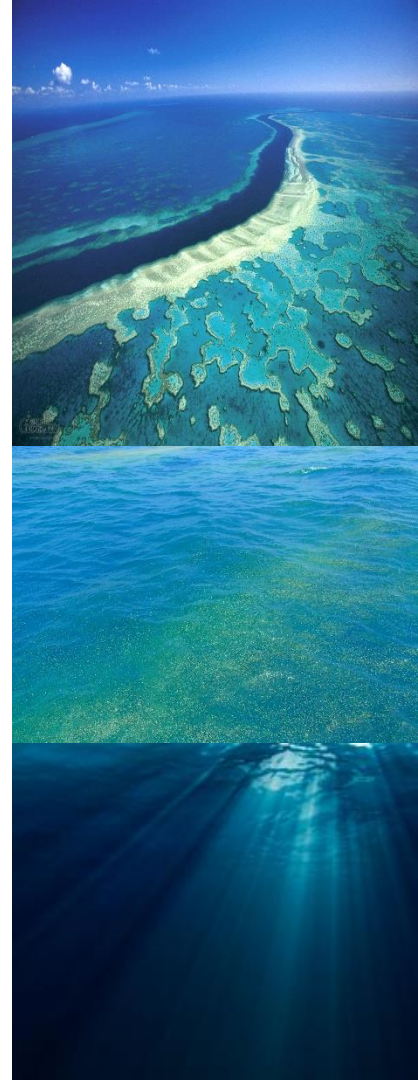
|

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with contributions from collaborators (CSIRO Environment, Data61, Space and Astronomy)

Content of this presentation

- I. CSIRO: overview
- II. Coastal and inland observatories
- III. Satellite remote sensing for coastal monitoring
- IV. EO data integration into datacubes & ML/AI applications



Our business units and focus areas



Agriculture and Food



Energy



Health and Biosecurity



Environment



Manufacturing



Mineral Resources



Space and Astronomy



Australian Centre for
Disease Preparedness



Data61



Marine National Facility



National Computing
Infrastructure



National Research
Collections of Australia

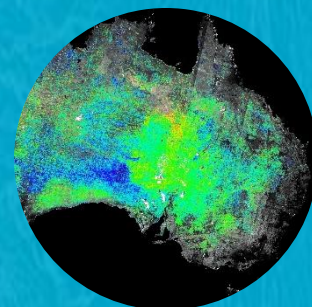
Space facilities and infrastructure



NASA's Canberra Deep
Space Communication
Complex



ESA's New Norcia
ground station



Data analytics



Satellite Optics
Laboratory



NovaSAR-1
National Facility



Satellite calibration/
validation

- CSIRO is Australia's national science organisation
 - Federal agency, ~5,000+ staff
 - Acts as a trusted advisor(nationally and internationally) and provides expert assessments
- There are 50 sites distributed nationally, and some internationally
- CSIRO is engaging with over 3,000 partners in
 - industry and
 - government agencies (at state, federal and international levels).
- CSIRO Environment Business Unit: created in December 2022
 - New BU with over 1,000 staff across 19 sites (largest of CSIRO)
 - In the context of aquatic environments:
 - Large focus on the Great Barrier Reef,
 - Land to coast interactions: coastal and inland waterways.



CSIRO CSIRO & the Aquatic Remote Sensing team

Who we are and what we do



The Aquatic Remote Sensing team : 10 team members



in-situ and satellite earth observation data across a wide range of **spatial**, **spectral** and **temporal** scales



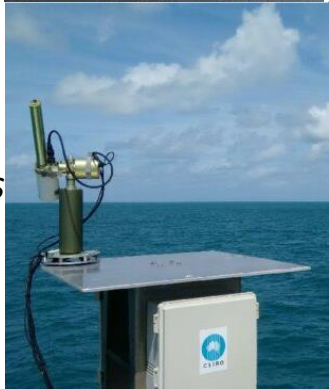
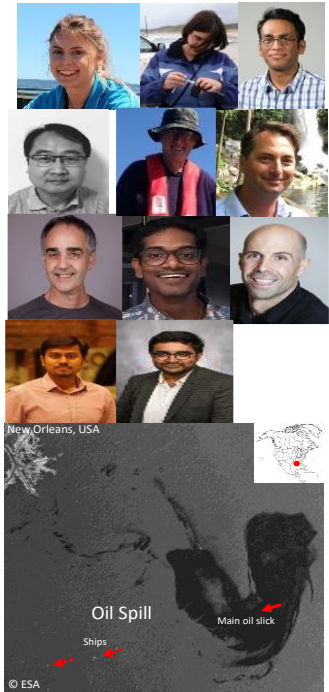
We aim to answer large and small environmental questions, such as

- *physical processes e.g. deriving sediment loads*
- *marine and atmospheric pollution, including oil spills*
- *Carbon fluxes as well as water quality and benthic habitat dynamics.*



Common theme: observations-to-models translation

- **management relevant applications**
- *calibration & validation, coupling field optical & bio-geochemical observations*
- *development of robust physics-based inversion algorithms*
- *water quality & benthic habitat mapping*
- *optically deep & shallow aquatic environments*



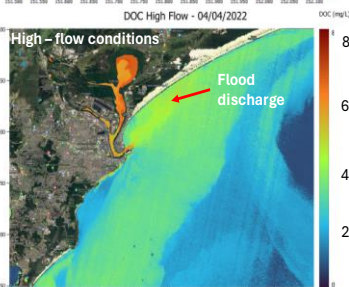
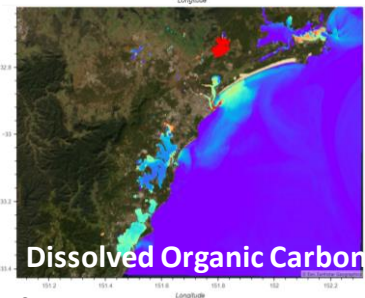
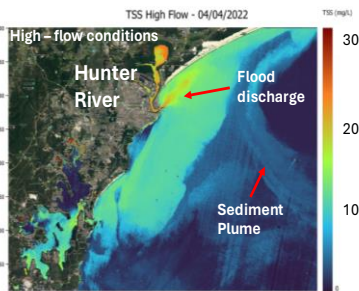
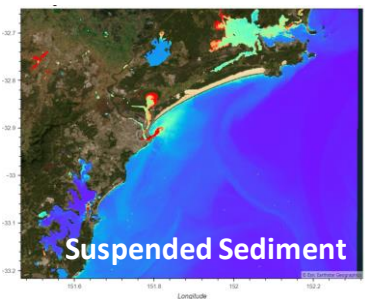
Sediment loads of river flood discharges into coastal waters (Landsat-8)

Semi-analytical approach

Deep Learning approach

NSW estuarine and coastal
water quality maps

**Different dates*



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CSIRO Environmental management-relevant applications

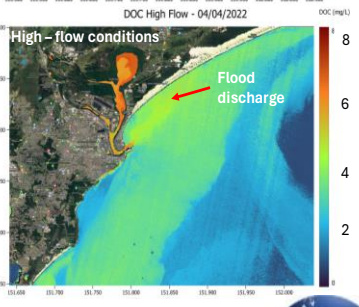
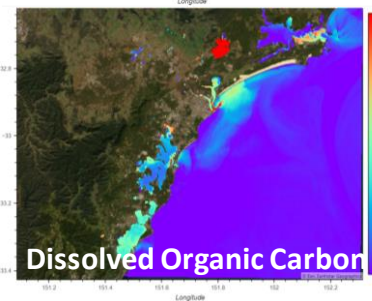
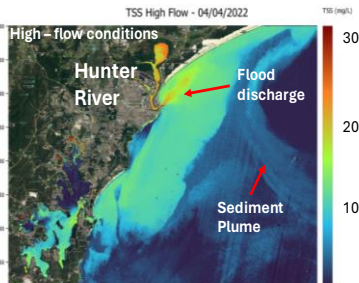
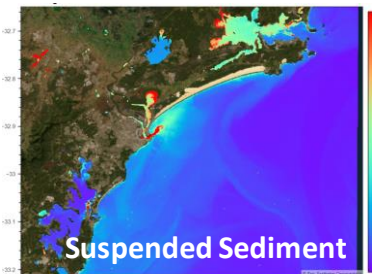
Sediment loads of river flood discharges into coastal waters (Landsat-8)

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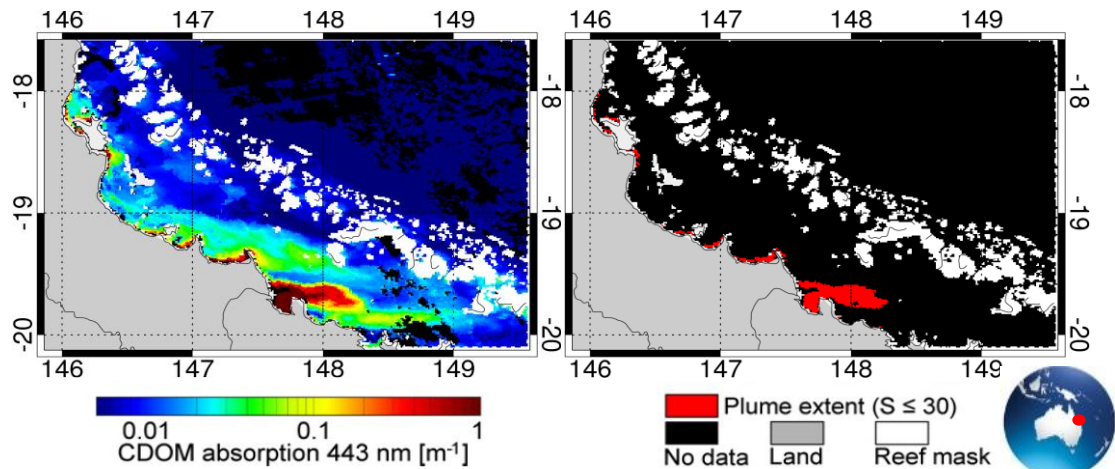
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Estimating river plumes discharging into lagoonal waters (Sentinel-3 OLCI)



CSIRO Environmental management-relevant applications

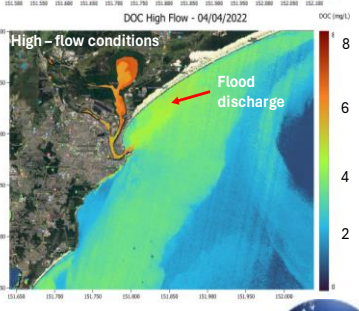
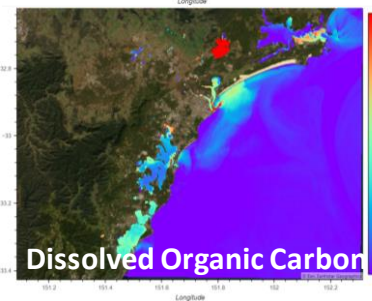
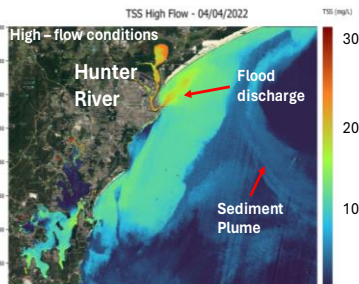
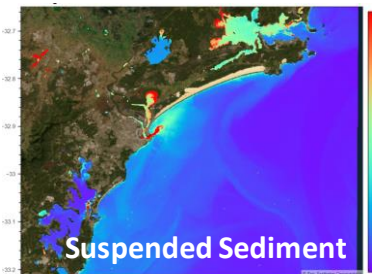
Deriving of sediment loads of river flood discharges into coastal waters

Semi-analytical approach

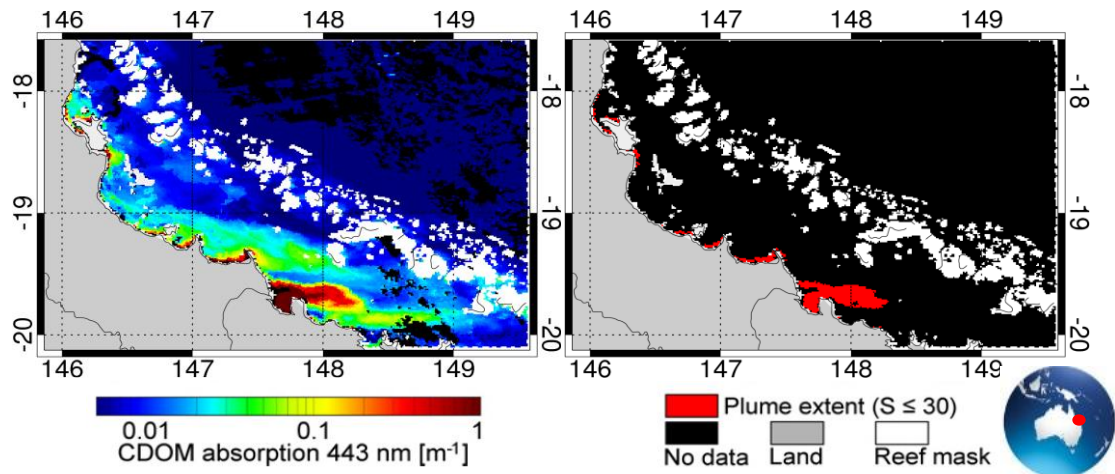
Deep Learning approach

NSW estuarine and coastal water quality maps

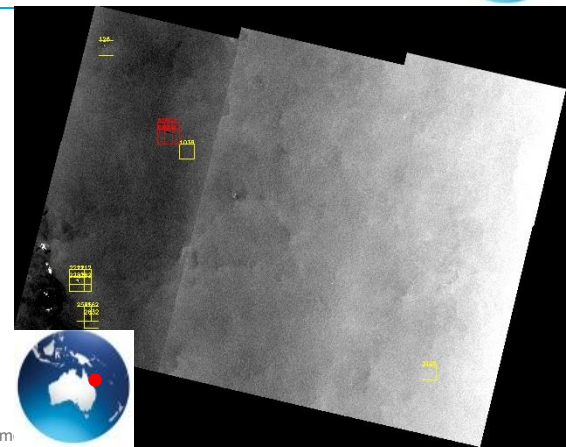
**Different dates*



Estimating river plumes discharging into lagoonal waters (Sentinel-3 OLCI)



Monitoring and detecting oil features from illegal discharges using Synthetic Aperture Radar (Sentinel-1 SAR)



- Semi-analytical models,
- Fully empirical models,
- Deep learning models,
-

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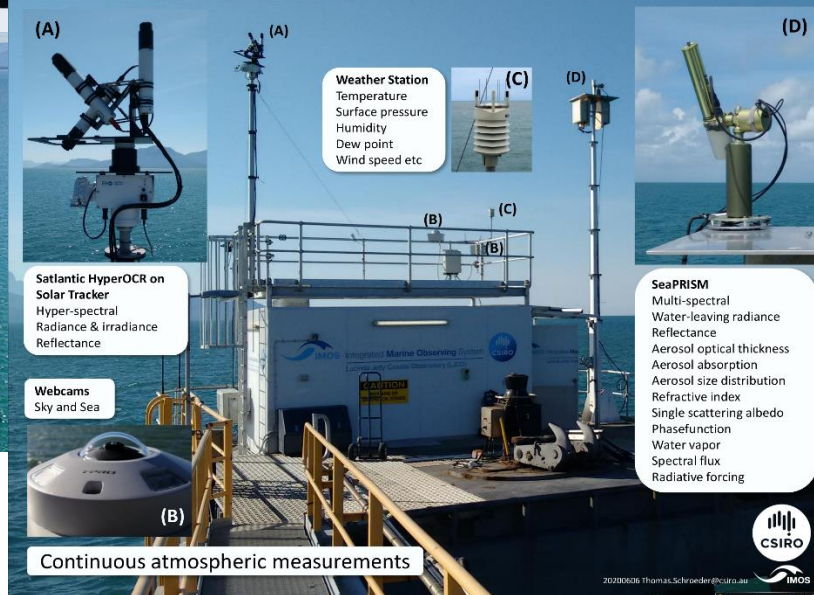
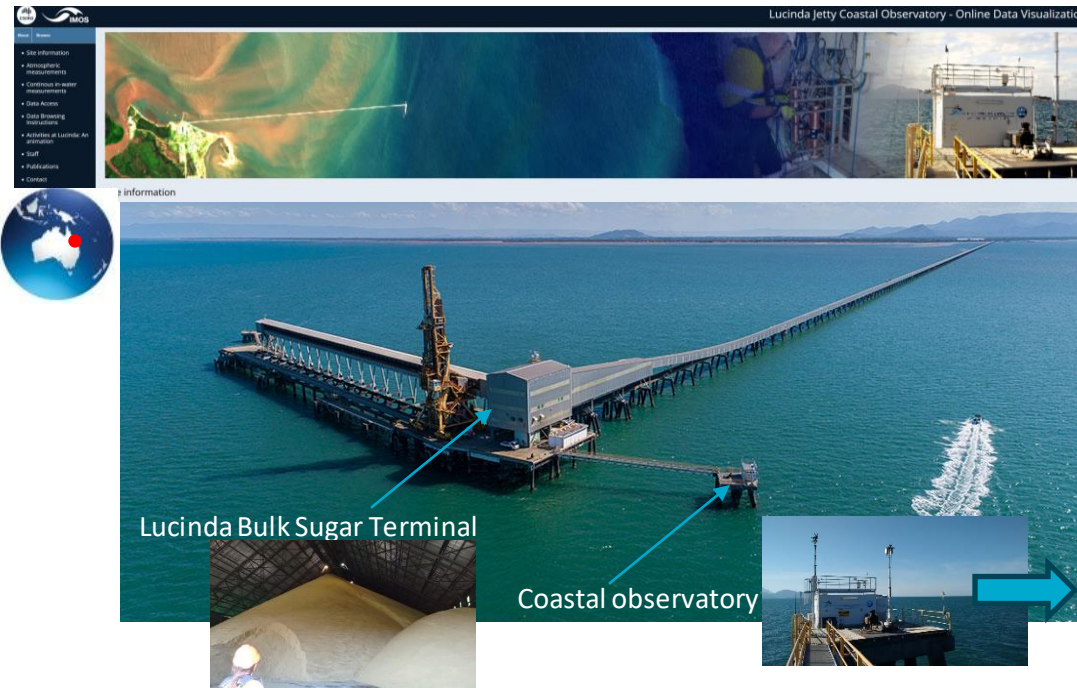
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CSIRO Coastal observatory

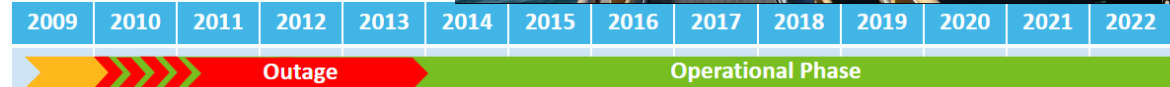
Coastal site for calibration and validation

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

- **LICO:** The Lucinda Jetty Coastal Observatory
- operational since 2014 (**10 years**).
- Continuous above-/in-water optical measurements
- Fortnightly water quality sampling to support validation of Ocean Colour observations
- provide calibration inputs to CSIRO's models
- improve consistency of radiometric measurements



Commission of
Instruments and testing



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Tropical Cyclone Yasi

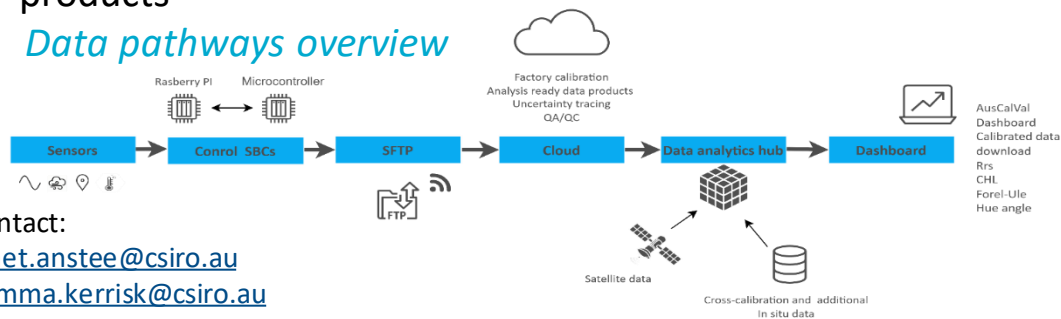
The Lucinda Jetty Coastal observatory (LICO)

CSIRO Inland observatory

Inland site for calibration and validation exercises

- **DION:** Darkwater Inland Observatory Network
- To contribute quality assurance observations to global calibration and validation efforts.
- High temporal database of paired laboratory, in situ and satellite observations for modelling and forecasting
- Operational facility, open access portal for data and products

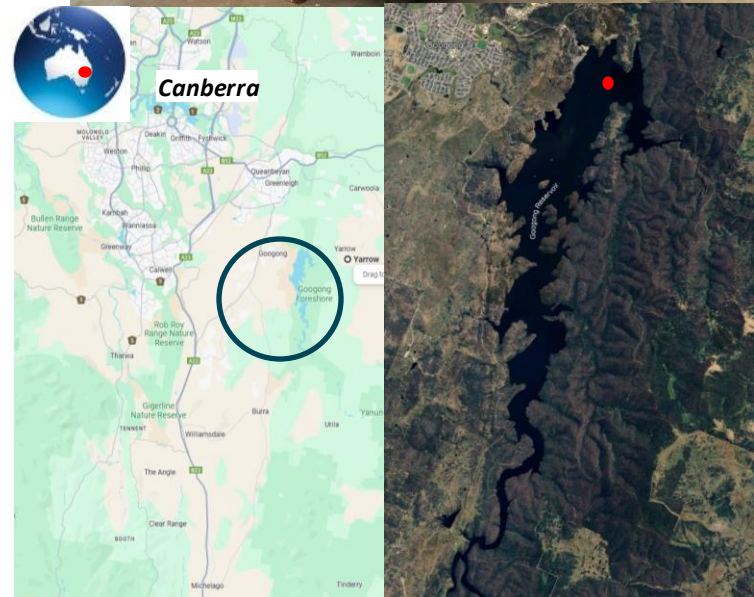
Data pathways overview



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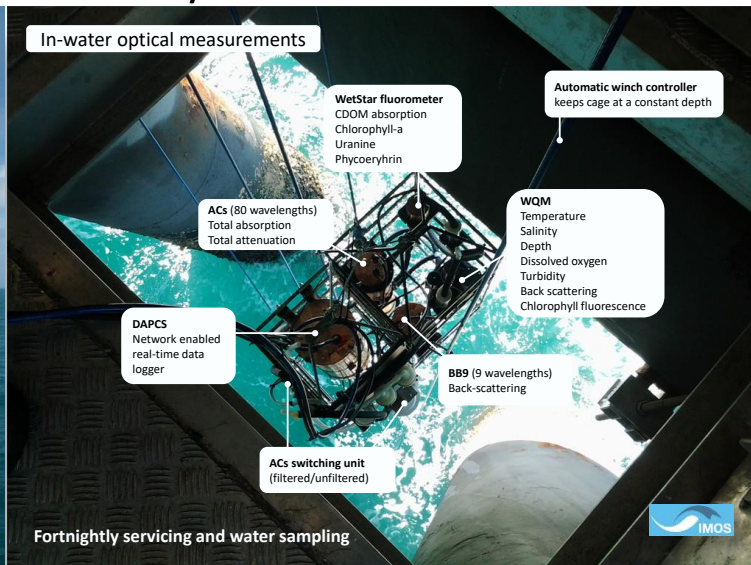
gemma.kerrisk@csiro.au



CSIRO Instrumentation and sensors

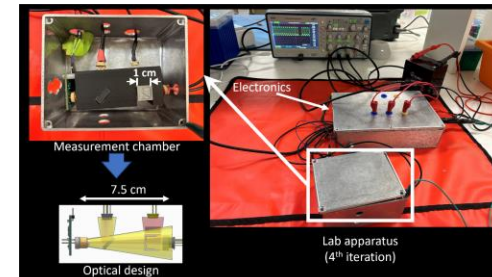
Field observations: above-/underwater sensors

Aeronet



- Water quality monitoring
 - Above-water surface reflectance,
 - Under-water bio-optics & biochemical concentrations,
 - water temperatures,
 - Satellite validation,
 - Algal bloom alerting,

In-water nitrate sensor



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CSIRO Satellite remote sensing for coastal monitoring 1/4

The eReefs multi-partner project - <https://www.ereefs.org.au/>

- eReefs was developed in 2011 and is operational, and growing, ever since

- Assess climate extremes and change on the Great Barrier Reef
- Manage coastal water quality in the Great Barrier Reef
- Be a foundation for other studies

- Multi-partner project:

- Queensland government,
- Australia's Bureau of Meteorology,
- Australian Institute of Marine Science
- CSIRO.

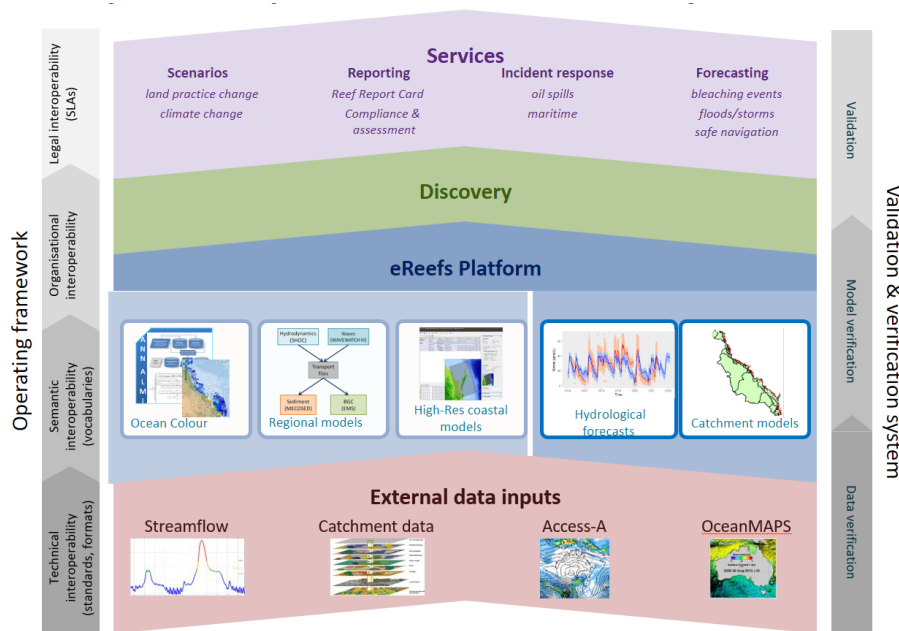
- Several component:

- in situ* observations,
- modelling and
- remote sensing (ocean colour, SAR).

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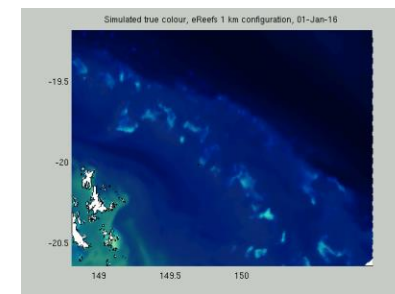
thomas.schroeder@csiro.au



Overall concept of eReefs



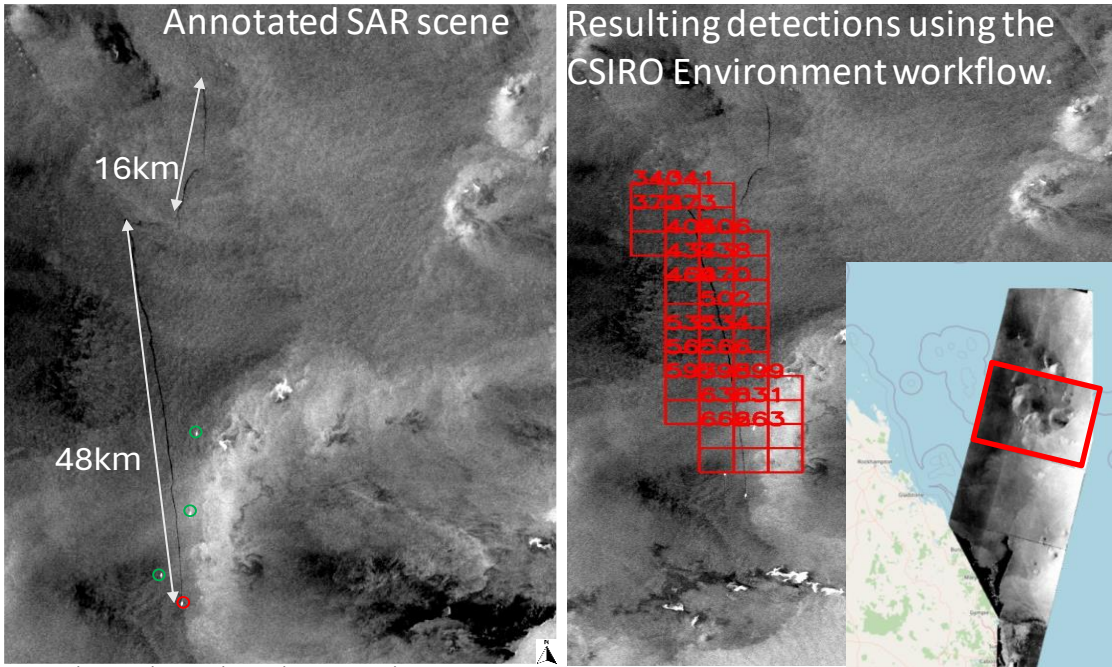
eReefs website landing page



Modelled satellite reflectance
©CSIRO modelling team

CSIRO Satellite remote sensing for coastal monitoring 2/4

Illegal oil discharges: detecting oil spilled in the Great Barrier Reef using Synthetic Aperture Radar.

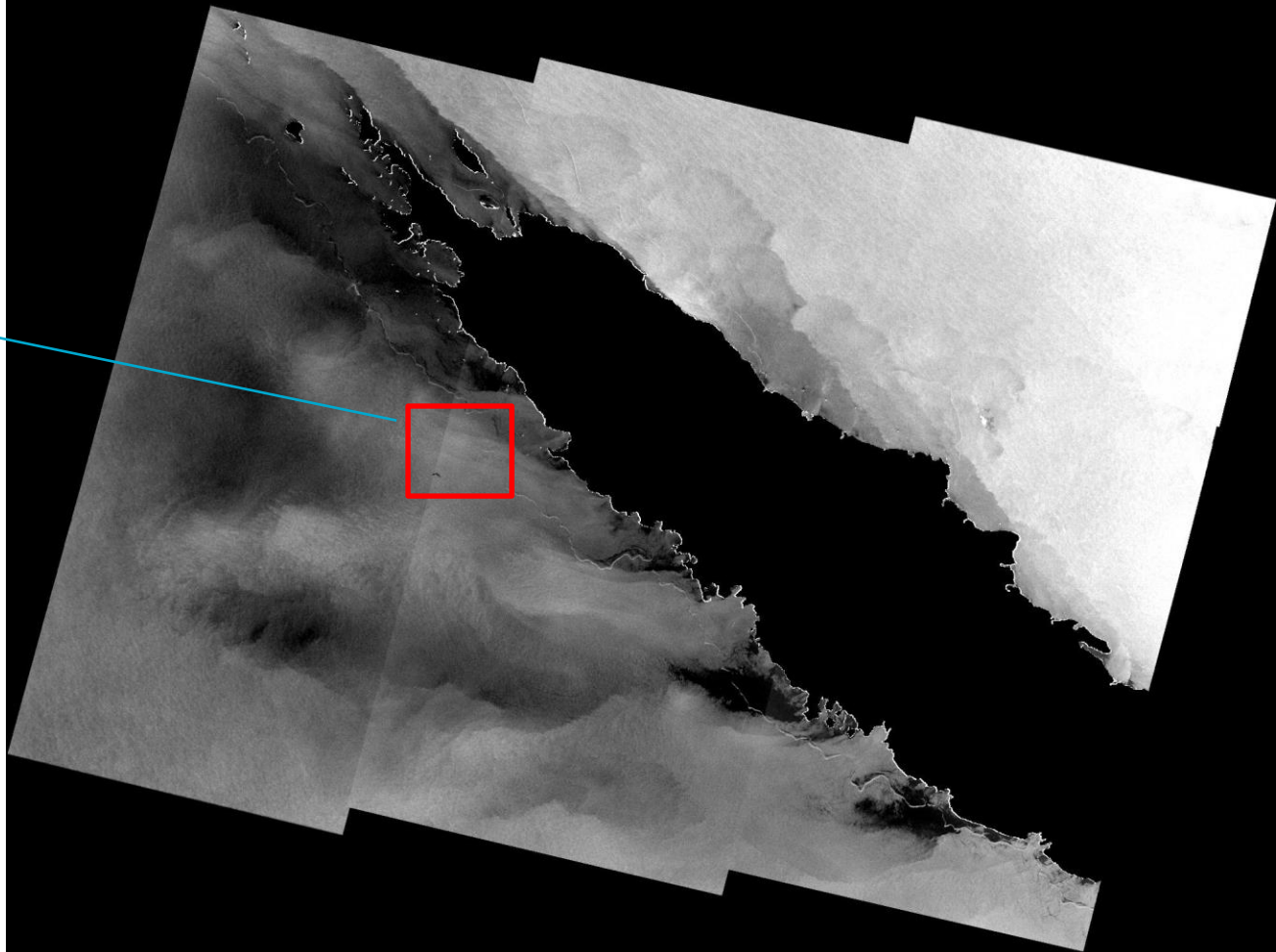
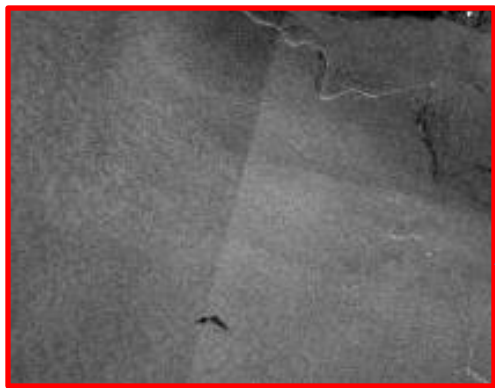


- Empirical approaches combined with machine learning are used for the monitoring and detection of illegal discharges in the Great Barrier Reef.
- This workflow is operational since December 2021 and operated by CSIRO Environment.
- Workflow can be relocated to New Caledonia.

SAR remote sensing and machine learning

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CSIRO



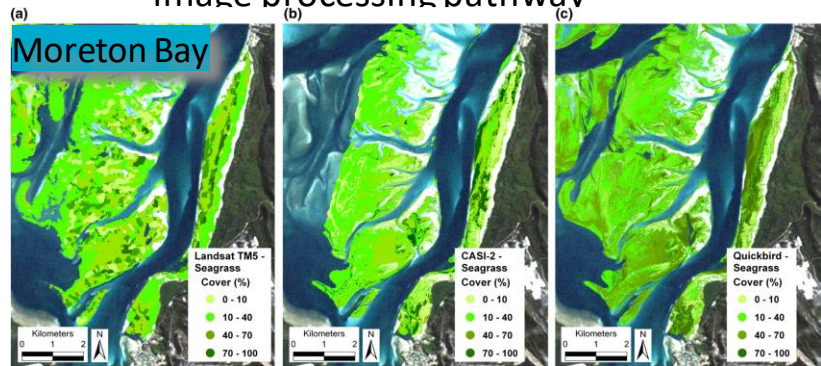
Sentinel-1 SAR

- 90 scenes / year
- every 12 days
- ~20m resolution

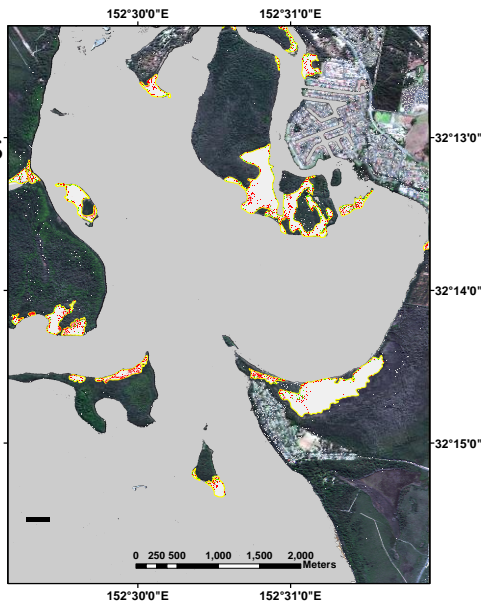
CSIRO Satellite remote sensing for coastal monitoring 3/4

vegetation and substratum mapping

- Typically involves **high-resolution satellite** imagery (\$\$\$)
- The images are used to:
 - design a more effective field survey plan
 - produce bathymetry & substratum-type maps
 - implement a quality-controlled physics-based image processing pathway



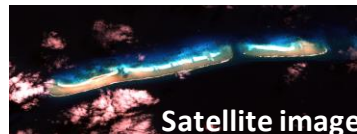
Wallis Lake (1985 – 2010)



■ No change
 ■ change
 Saltmarsh extent (API 1985)

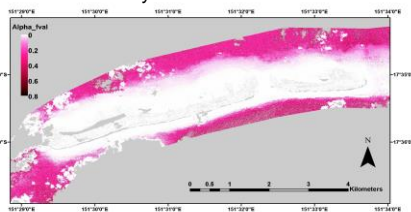
Inter-/supratidal vegetation mapping

Georgina Cay

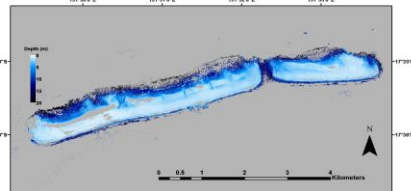


Thematic Products

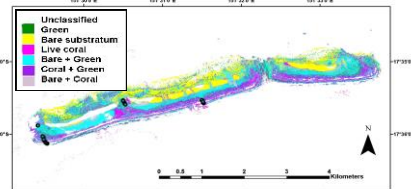
Model accuracy



Bathymetry



Substratum-type



Substratum mapping

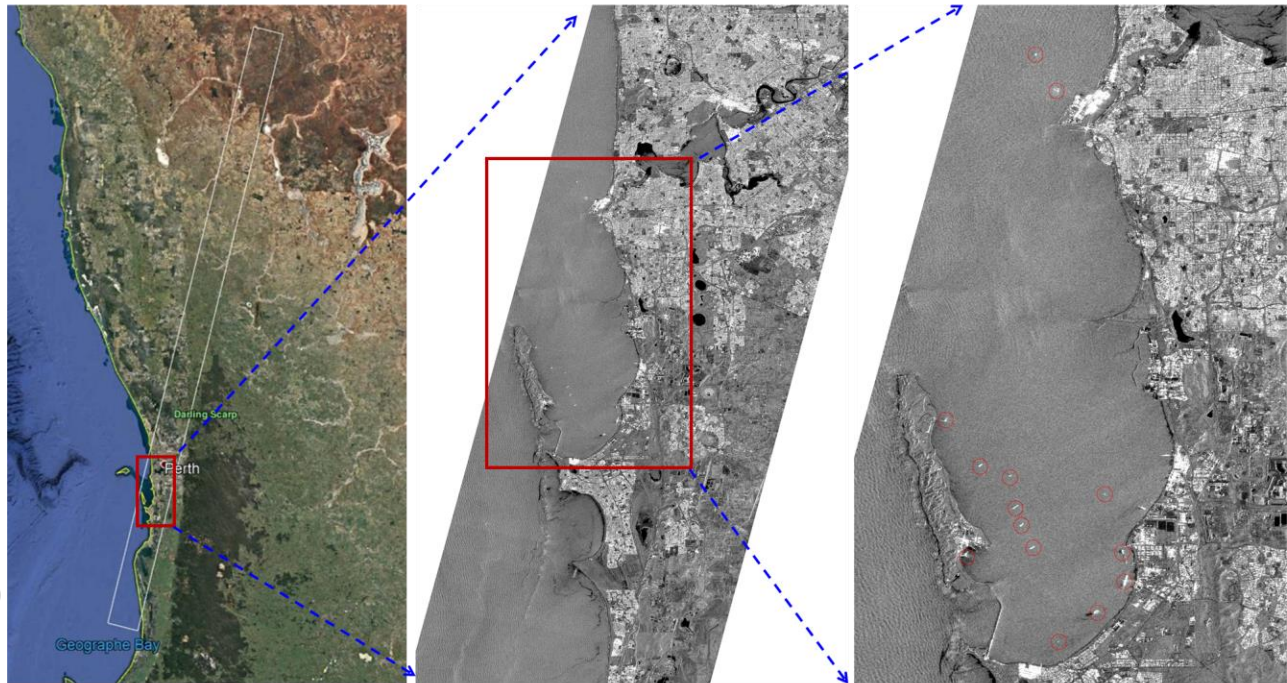
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CSIRO Satellite remote sensing for coastal monitoring 4/4

NovaSAR-1

- CSIRO: 10% share
- Launched: **October 2018**
- Resolution: 6m and 20m
- **Sensor tasking possibility**
- Applications-focused approach:
 - Ship detection (illegal fishing)
 - oil spills detection
 - Land-use mapping

Ship Detection by NovaSAR-1: Scene footprint of NovaSAR-1 SCD image acquired on 4 July 2020, HH image of Perth Coast (centre) and Detected ship candidates in red circles (right)



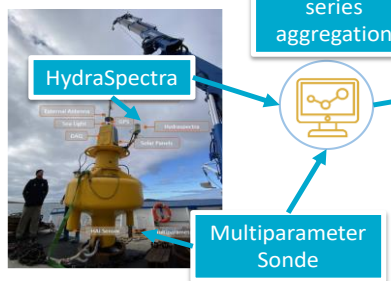
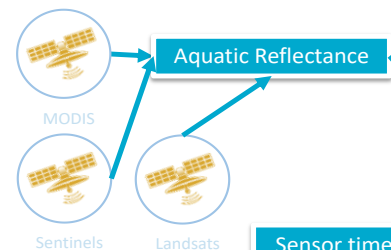
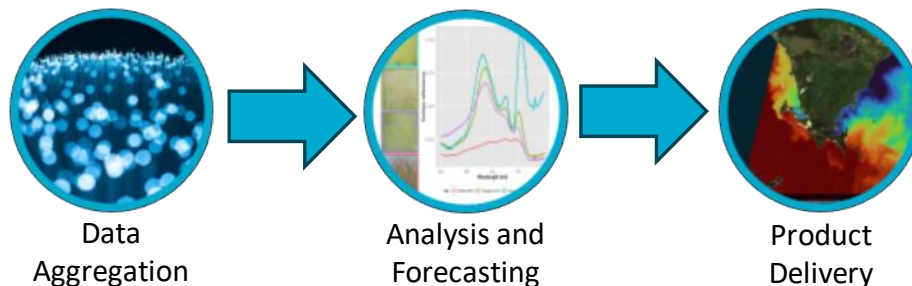
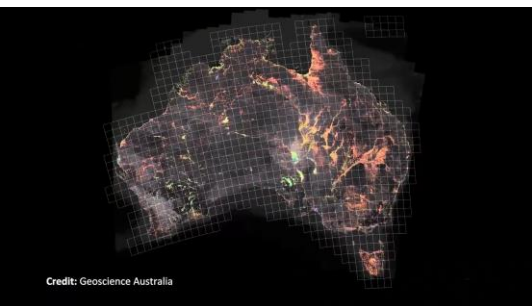
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AquaWatch

- Data acquisition, analysis, security
- Support to pilot site and end-users.
- Service and application deployment.
- Workflow automation
- Impactful research



Query EO data

```

    buff = 0.1
    latitude = lat_buff, lat_buff
    longitude = (lon_buff, lon_buff)
    out_crs = "EPSG:3587"
    time = ("2013-02", "2023-07")

    i38 = dc.load(
        project="landsat_c2_archive",
        x = longitude,
        y = latitude,
        output_crs=out_crs,
        resolution=(30, 30),
        time=time,
        desc_chunks=["time"(13),
        measurements = ["rrs_440", "rrs_480", "rrs_561", "rrs_654", "rrs_660"]
    )

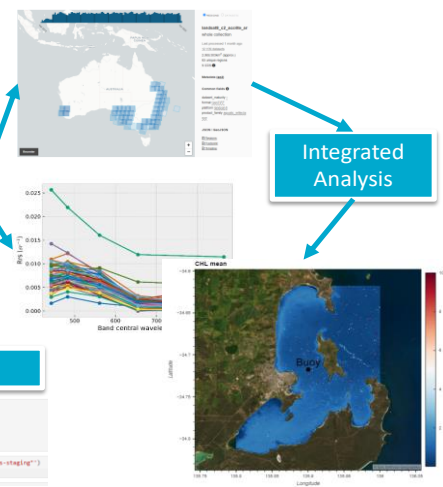
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        measurements = ["rrs_440", "rrs_480", "rrs_561", "rrs_654", "rrs_660"]
    )
  
```

Query time series

```

    cursor = connect('xtagging_db','x11/00007070301-mainprod-au-prd-athena-results',
        work_group="mainprod-au-prd-workgroup",
        region_name="us-west-2",
        result_max_age_secs=3600,
        result_max_size_in_mb=10,
        cursor_class=FetchCursor).cursor()

    names = cursor.execute("SELECT * FROM 'mainprod-au-prd-db'."mainprod-au-prd-sensor-all-sensors-staging")
    x
  
```

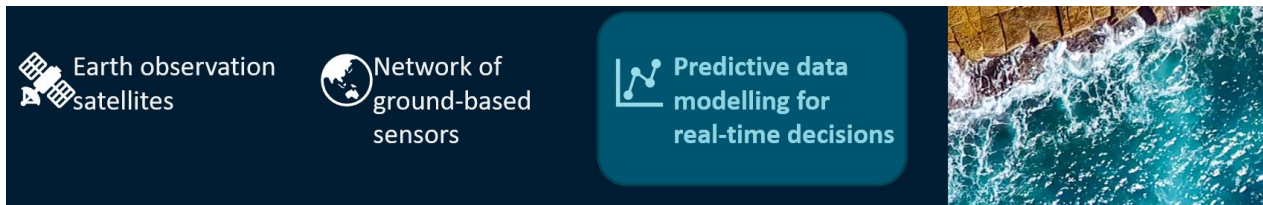


Integrated Analysis



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CSIRO ML/AI applications (CSIRO Aquatic Remote Sensing team)



AI/ML approaches are used in many aspects of our deliverables

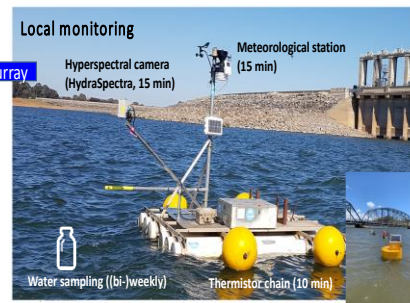
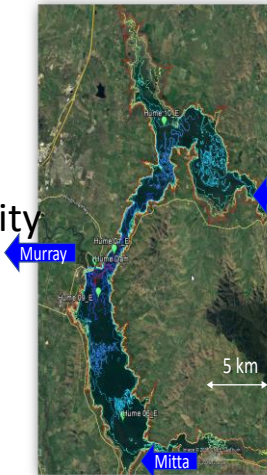
- **Ocean colour** :
 - atmospheric correction over coastal waters
 - Automated detection of surface algal blooms such as *Trichodesmium spp*
- **SAR** : feature-detection using Deep Learning
 - Illegal oil discharges
 - ships
- Data analysis and water quality forecasting
- Hybrid modelling tools for prediction of water quality
- Forecast of
 - chl-a in rivers,
 - river water temperatures...

Contact:

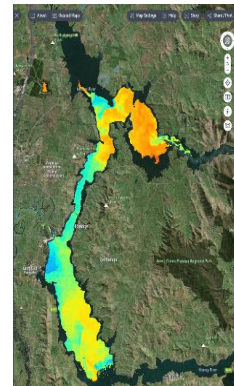
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kesav.unnithan@csiro.au

klaus.joehnk@csiro.au



klaus.joehnk@csiro.au



Inland Aquawatch pilot sites: Lake Hume, Lake Tuggeranong, Grahamstown Dam, Melbourne Water WTP

AI/ML and forecasting



Thank you

CSIRO Environment

David Blondeau-Patissier (and collaborators)
Aquatic Remote Sensing team
Brisbane.

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*This presentation was a collaboration between
CSIRO Environment, Space and Astronomy, Data61*





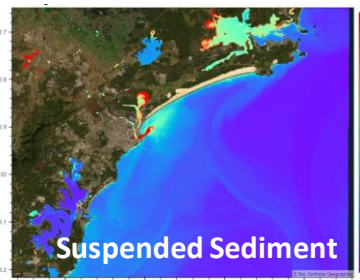
Satellite remote sensing for coastal monitoring 2/5

Deriving of sediment loads: Remote sensing of river flood discharges into coastal waters



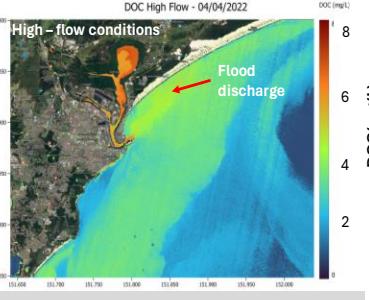
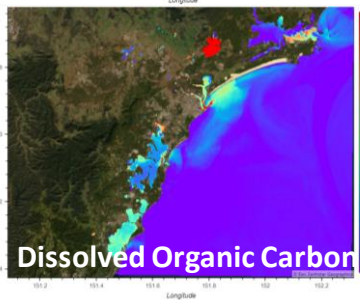
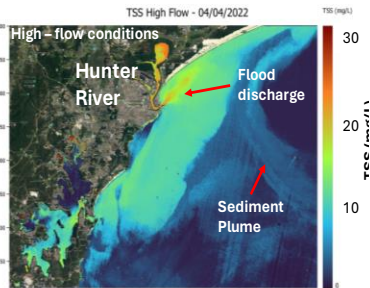
Semi-analytical approach

NSW estuarine and coastal water quality maps



Deep Learning approach

**Different dates*



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River runoff (particulate, dissolved material)

Optical remote sensing and machine learning

Ocean colour remote sensing



EO data integration into datacubes: The Living Reef

Previously: 2020-work

<https://www.thecube.gut.edu.au/whats-on/projects/the-living-reef>

