AquaWatch Australia

A 'weather service' for water quality



CSIRO Ambition: Water Quality is a Global Challenge





3 Billion people world-wide don't have access to clean water and sanitation

CSIRO AquaWatch Mission Launch March 22, 2023 (Canberra & New York)















CSIRO Scope of AquaWatch

- Technology Element for spaceto-ground water quality monitoring and forecasting, with key milestones in 2026 and 2030.
- Research program, for continuous improvement, with aligned R&D and support for growth in the user base.



Co-Design Pilots

Build new Partnerships Testing and validating system



Australia's National Science Agency

CSIRO Global Pilot Sites



Sample Pilot Site: Sacramento River Delta California

- Local collaborators: UC Davis, UC Merced, USGS
- Co-Design & Co-funding from partners
- R&D support w. students & technical experts (eg remote sensing, in-situ water quality)
- State government interest (Water Resources agency)
- Indigenous engagement
- Good prospects for sustained operation of pilot by local partners



Technical Details – Day 2



Australia's National Science Agency

AquaWatch Technical Elements





AquaWatch Data System for multi-sensor data integration and analytics



Powered by Earth Analytics and Science Innovation Platform (EASI) and Open DataCube Technology

CSIRO Potential AquaWatch Water Quality 'Measurables' Incl. R&D Needs

VIS-NIR Earth Observation:

- Chlorophyll-a
- Phycocyanin, PC *
- Phycoerythrin, PE*
- Species / genus differentiation: Blue-green algae (inland & species levels) * Dinoflagelates (coastal waters) * Phytoplankton Functional Types (PFT) * Peridinin (=dinoflagellates) *
- Total cell counts (phytoplankton abundance)
- Biovolume (may be used with species/types for a HAB index)
- Total Suspended Matter
- Secchi Disk Transparency
- Turbidity
- Coloured Dissolved Organic Matter (CDOM)
- Dissolved Organic Carbon
- Vertical attenuation, Kd
- Forel Ule scale (water colour)
- Water Column Depth (Bathymetry)
- Floating and Submerged Aquatic Vegetation Types*
- Benthic & Coral Reef Habitat*
- Water-related ecosystems & land-use

*= Hyperspectral sensors) Data Required

- Temperature
- Dissolved Oxygen
- Water Surface Height
- Water surface velocity
 - PH

Require more R&D on miniaturization & automation

- Salinity/Conductivity
- Total phosphorous
- Total inorganic Nitrogen (Nitrate-N as surrogate)
- Algal toxins
- Methylisoborneol (MIB)
- Geosmin
- MicroPLastics
- Metals (heavy and other)
- Organic micro pollutants (Pharmaceutical, antibiotics, endocrine disruptors, insecticides, herbicides)
- Pathogens (e-COLI, cholera, water borne...etc)

Composite variables

- Trophic State Index
- TRIX Trophic Index for Coastal Seas
- Trophic State using the Nutrient Colour Paradigm
- Harmful Algal Bloom Index
- CYAN Index
- ChromaticityIndex
- Floating Macro-algal Index
- Floating Algal Index
- Toxins Index

Parameters / feasibility		19-M	ar-24			20	26			20	30		Ne	eds R&	D or partne	ers
	lab	in-situ	EO	WQM	lab	in-situ	EO	WQM	lab	in-situ	EO	WQM	lab	in-situ	EO	WQM
	sampling				sampling				sampling				sampling			
Chlorophyll-a																
Phycocyanin, PC																
Phycoerythrin, PE																
Peridinin (=dinoflagellates)																
Fucoxanthin (=diatoms)																
Total cell counts (phytoplankton abundance)																
Biovolume																
Species / genus differentiation																
Algal toxins																
Secchi Disk Transparency																
Turbidity																
Total Suspended Matter																
Coloured Dissolved Organic Matter																
Dissolved Organic Carbon																
Vertical attenuation, Kd																
Forel Ule scale (water colour)																
Water Column Depth (Bathymetry)																
Submerged and Emergent Aquatic Vegetation																
Coral Reef Habitat																
Benthic Habitat (non-coral)																
Acdom (440 nm)																
S (slope)																
Inherent Optical Properties (IOP)																
Normalized water leaving radiance																
Remote sensing reflectance																
Temperature																
Water Surface Height																
Water surface velocity (flow rate, currents)																
Salinity/Conductivity																
Total phosphorus																
Total Nitrogen																
Nitrate-N																
РН																
Dissolved Oxygen																
Methylisoborneol (MIB)																
Geosmin																
MicroPlastics																
Metals (heavy and other)																
Organic micro pollutants																
Pathogens																

Not Applicable Not feasible Yes, feasible (uncertainty TBD) May be feasible with R&D or partners

Technologies



HydraSpectra Mk IV

Possible Sources of EO data for AquaWatch





Inland & Coastal Measurements (spatial resolution less than 30 m)

Extra EO Data for Water Quality Modelling: SWOT, Trishna, ...



CSIRO Pilot Site Instrumentation Stations for In-situ Water Quality Measurement and Satellite Data Validation

Instruments include:

- CSIRO Hydraspectra
- TriOS Ramses E_d, L_{sky} and L_w
- Pan/tilt unit
- Weather station
- Cameras horizontal and forward-looking
- Water temperature (below surface & 2 depths (4/8m)

HydraSpectra Mk IV







CSIRO Deployments @ national pilots







Great Barrier Reef









csiro Cyanosat-1

- Aquawatch Pathfinder
- CSIRO Satellite Optics Lab, Adelaide
- Launched June 12th on Skykraft payload
- Communication with payload, under commissioning
- Cyanosat-2 in development





CSIRO AquaSAT-1 Feasibility study, with NASA JPL

- Orbit: sun-synchronous, ~noon crossing time, ~400 km altitude (trade study: 600 km altitude)
- **GSD:** 18 m
- Imaging coverage: target sites (key lakes, rivers, estuaries, coral reefs in Australia and the US West)
- Revisit: 5 days with +/- 30 deg crosstrack slew (not accounting for cloud cover, sunglint, target site conflicts, etc.)
- Dyson imaging spectrometer (350 to 1050 nm, 9.6 nm FWHM)



CSIRO Water Quality Modelling – Remote Sensing Data Assimilation



CSIRO Coastal Dynamic Water Quality Modelling

Temp (dea C 100 200 300 400 500 Solar zenith [0 - nadir; - $\pi/2$ = horizon 15 20 25 30 -1 -0.5 0 24-Feb-2017 +00 24-Feb-2017 +00 24-Feb-2017 +00 AWST 24-Feb-2017 08:00:00 AEST 24-Feb-2017 10:00:00 DIC [mg/m3] ×104 Oxygen [mg/m3] 2.47 2.475 2.48 2.485 2.49 7 7.5 8 8.5 9 6400 6600 6800 7000 24-Feb-2017 +00 24-Feb-2017+00 24-Feb-2017 +00 liogeochemical processes: Air-sea O, & CO, exchange Steady-steady carbon chemistry 27 band spectral optics MODIS spectral response band National model v2.95 Sun & Moon light forcing EMS v1.4.0 rev(7384) 4-layer sedimen Sea-Air CO., flux [mg/m2/d] Mud [mg/m3] -0.2 -0.1 0 0.1 0.2 0.05 0.1 0.15 0.2 Simulated true colour using MODIS Bands 3, 6 & 9 sensor response 24-Feb-2017 +00 24-Feb-2017 +00 24-Feb-2017 +00 Plotted 30-Aug-2023 06:40:07

National Scale (coarse)

Regional/Local Scales of Special Interest (fine)



Information Delivery: Water Quality Products



Source: Imagery copyright 2019 Google. Map data copyright 2019 Google

Dekker, Malthus and Hestir (2013)

CSIRO Visualization – Eg. Statewide and local overviews



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Lake Hume, time series, January to March 2016

In-situ Dashboard

2.7.5 Visualisation Dashboard for Cyanobacteria (Chlorophyll-a concentration as an indicator)





Figure 1xx: Lake Tuggeranong visualisation screen shot.





CSIRO

CSIRO Key Science Challenges and Opportunities

- 1. Water Quality Forecasting Models
 - a. Linking catchment to coast ecohydrology & water quality models w. eReefs modelling capability
 - b. Testing full physics/biogeochemical- based vs. AI approaches
- 2. In-situ Sensing
 - a. Sensor Networks (existing sensors by other agencies and new deployments)
 - b. New Sensor Technologies (pesticides, toxic algae, bacteria, sewage detection, etc.)
 - c. Remote-area data relay, miniaturisation and automation
 - d. Data assimilation w. satellite data
 - e. Citizen-science applications
- 3. Petabyte-scale Multi-sensor data assimilation, cloud-computing and visualization
- 4. Integrating First Nations' cultural water indicators w. western science approached for water quality monitoring
- 5. Bespoke satellite sensors and algorithms
 - a. Distinguishing different types of algae and phytoplankton types (eg toxic algae)
 - b. Discriminate benthic cover types (algae, coral, rocks, etc.)
 - c. Atmospheric correction over water

CSIRO Opportunities for Collaboration

- 1. Establish one or more "pilot sites" with co-investment & operation by local partners
- 2. Collaborate with international space agencies (e.g. CNES) to bring relevant EO satellite data into the AquaWatch Data System (eg Trishna, SWOT, etc.)
- 3. Ground-Segment with downlink station and high-performance data analytics capacity to develop integrated AquaWatch data service

Thank you

CSIRO Space & Astronomy Dr Alex Held

Lead, AquaWatch Australia Director, Earth Observation Infrastructure

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EXTRA SLIDES



Australia's National Science Agency



Sentinel 2 based algal alerts

 The Sentinel 2 series of satellites include spectral bands that allow the calculation of an index which provides a qualitative estimate of algal concentration





CSIRO Traffic lights provide qualitative flags of extent and severity







Repeated high chlorophyll events in late spring – early summer

