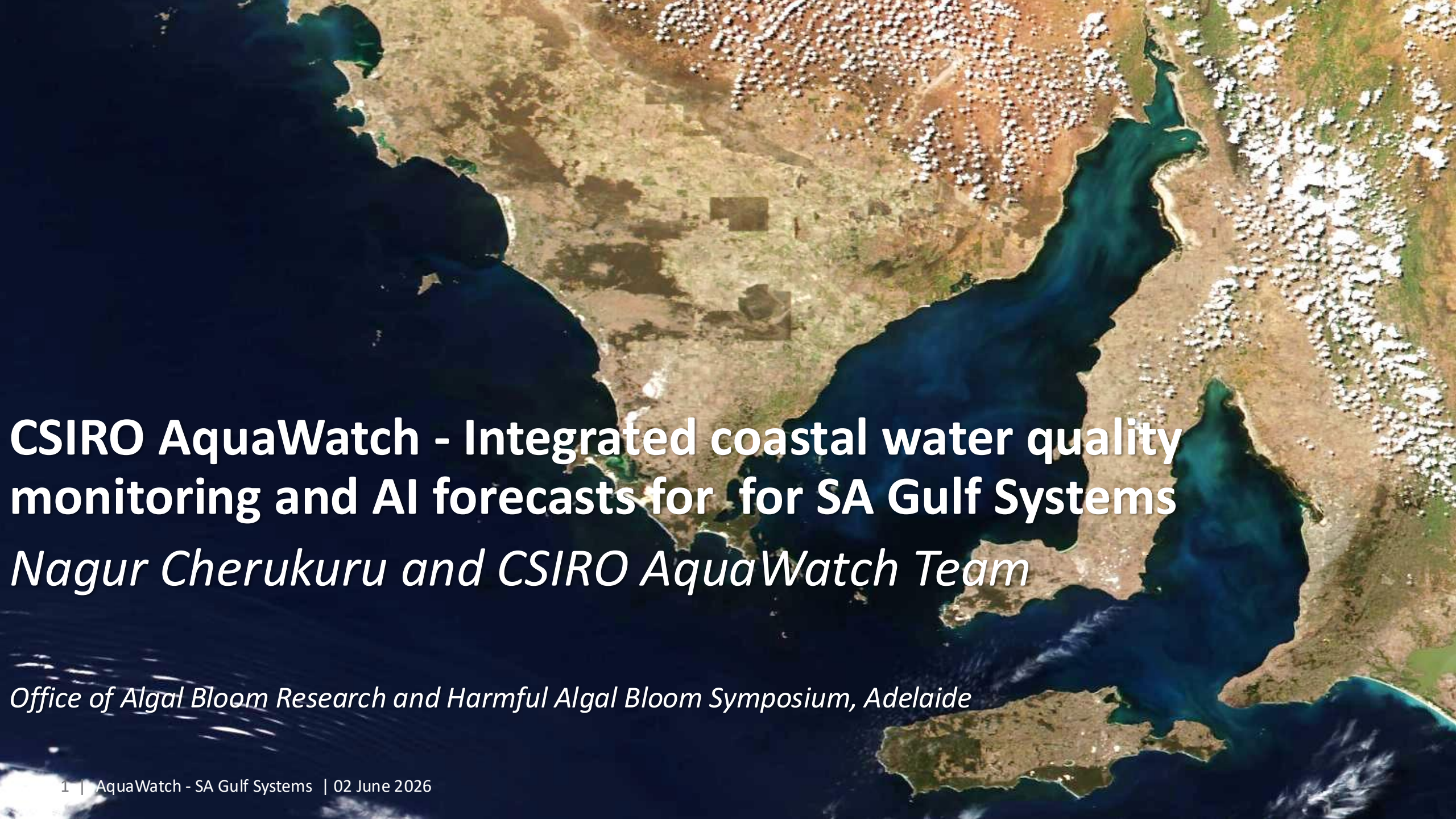


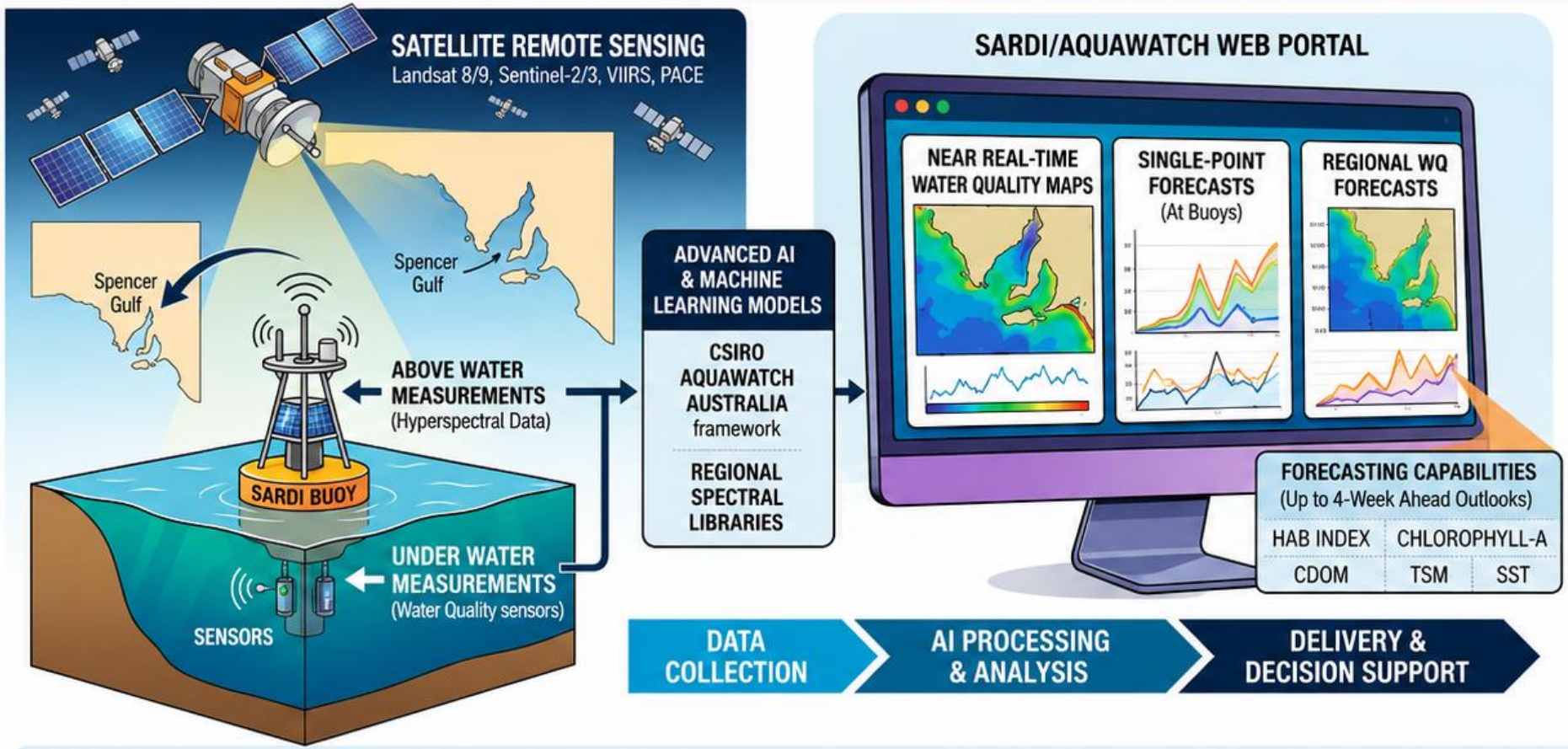
CSIRO AquaWatch - Integrated coastal water quality monitoring and AI forecasts for for SA Gulf Systems

Nagur Cherukuru and CSIRO AquaWatch Team

Office of Algal Bloom Research and Harmful Algal Bloom Symposium, Adelaide

Project objectives

INTEGRATED COASTAL MONITORING & FORECASTING SYSTEM FOR SOUTH AUSTRALIA'S SYSTEMS



PROJECT STRUCTURE:

WP1:
Insitu sensing and single-point forecasting

WP2:
Satellite remote sensing

WP3:
EO+AI-driven spatial forecasting

OUTCOMES FOR STAKEHOLDERS

- HAB EARLY WARNING
- SPATIAL ENVIRONMENTAL MONITORING
- ENVIRONMENTAL MANAGEMENT

WP1 *Insitu* sensing: HydraSpectra instruments

Five **HydraSpectra** instruments have been installed at St Kilda, Boston Bay, Kangaroo Island, Victor Harbor, and Coffin Bay.
One more **HydraSpectra** instrument to be installed at Stansbury by the end of June 2026.

Installation of HydraSpectra

Photo courtesy – Tim Bolton, CSIRO

The HydraSpectra instrument

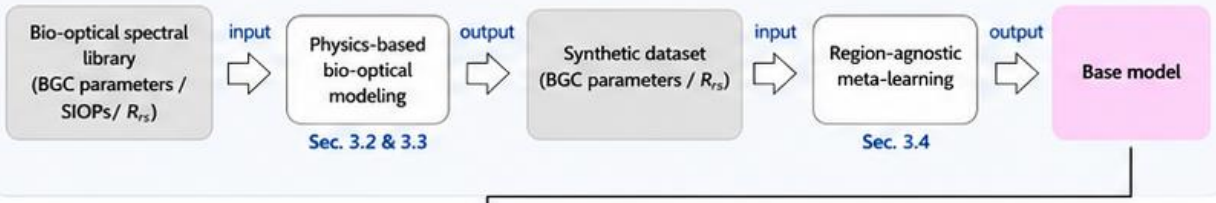
- Hemispherical Sky Camera
- Solar Irradiance Sensor $E_d(\lambda)$
- Skylight Radiance Sensors $L_{sky}(\lambda)$
- Water Horizon Camera
- Water-Leaving Radiance Sensors $L_t(\lambda)$

Tim Malthus, CSIRO

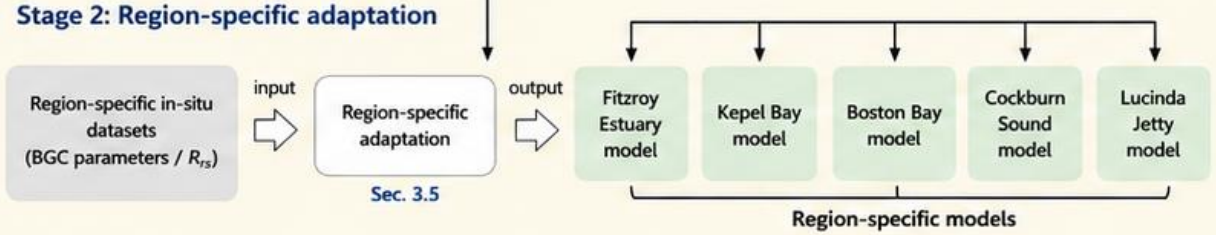
WP1: Biogeochemical retrieval from HydraSpectra sensor

A new model has been developed to retrieve biogeochemical parameters from **HydraSpectra** remote sensing reflectance.

Stage 1: Physics-aware meta-learning



Stage 2: Region-specific adaptation

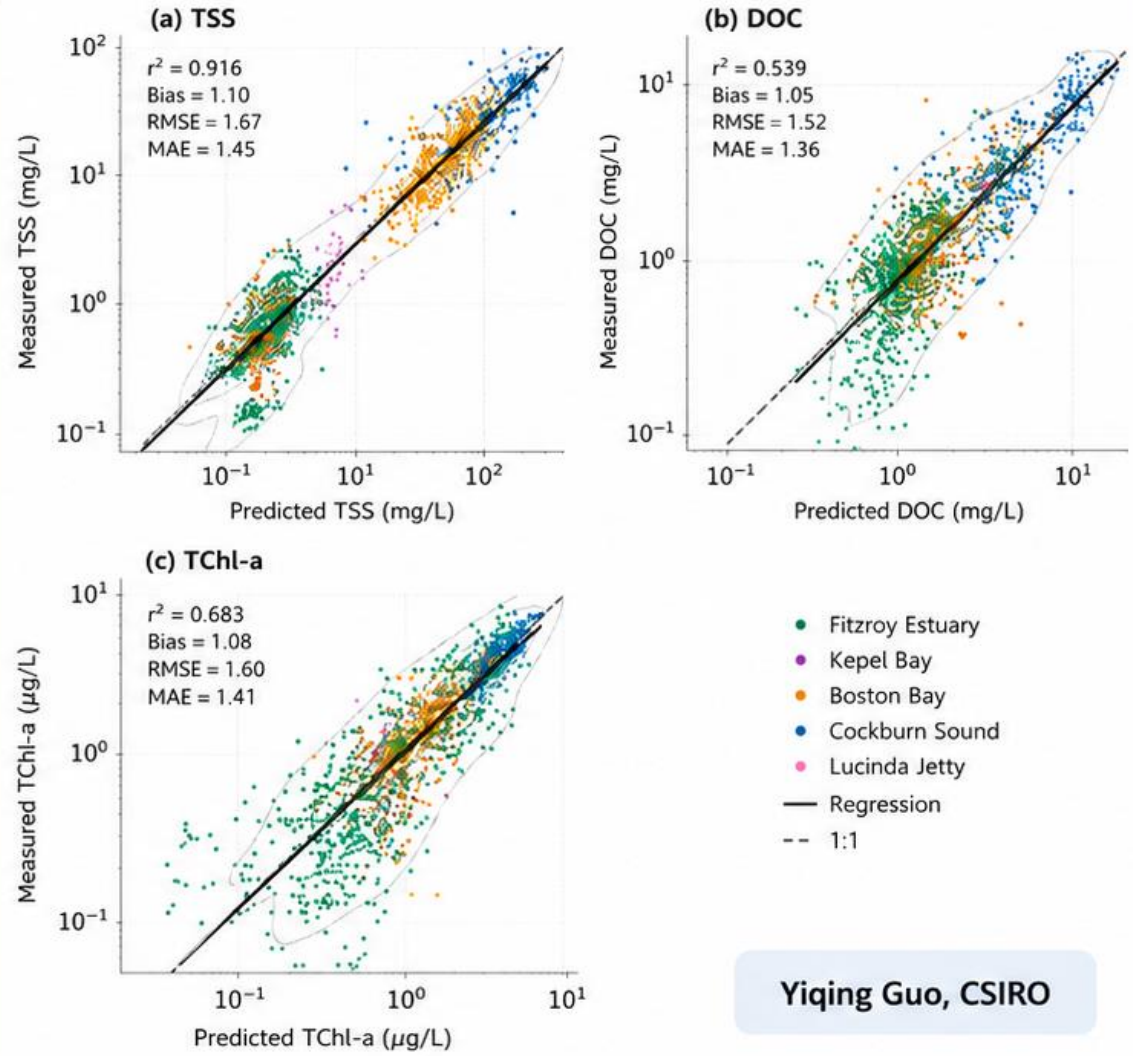


Preprint Paper

Guo, Y., Cherukuru, N.R., Lehmann, E.A., Unnithan, S.L., Malthus, T.J., Kerrisk, G., Qi, X., Islam, F., Dhar, T. and Doubell, M.J., 2026. **Region-adaptable retrieval of coastal biogeochemical parameters from near-surface hyperspectral remote sensing reflectance using physics-aware meta-learning**. *arXiv preprint arXiv:2605.05623*.

Region-adaptable retrieval of coastal biogeochemical parameters from near-surface hyperspectral remote sensing reflectance using physics-aware meta-learning

Yiqing Guo*, Ryan R. C. Cherukuru*, Eric A. Lehmann*, S. L. Kesor Unnithan*, Tim J. Malthus†, German Kerrisk†, Xuhui Qi*, Farah Islam Dhar†, Mark J. Doubell*



Yiqing Guo, CSIRO

Model (V2) will include retrieval of TSS, Tchla, CDOM, Kd and HAB index

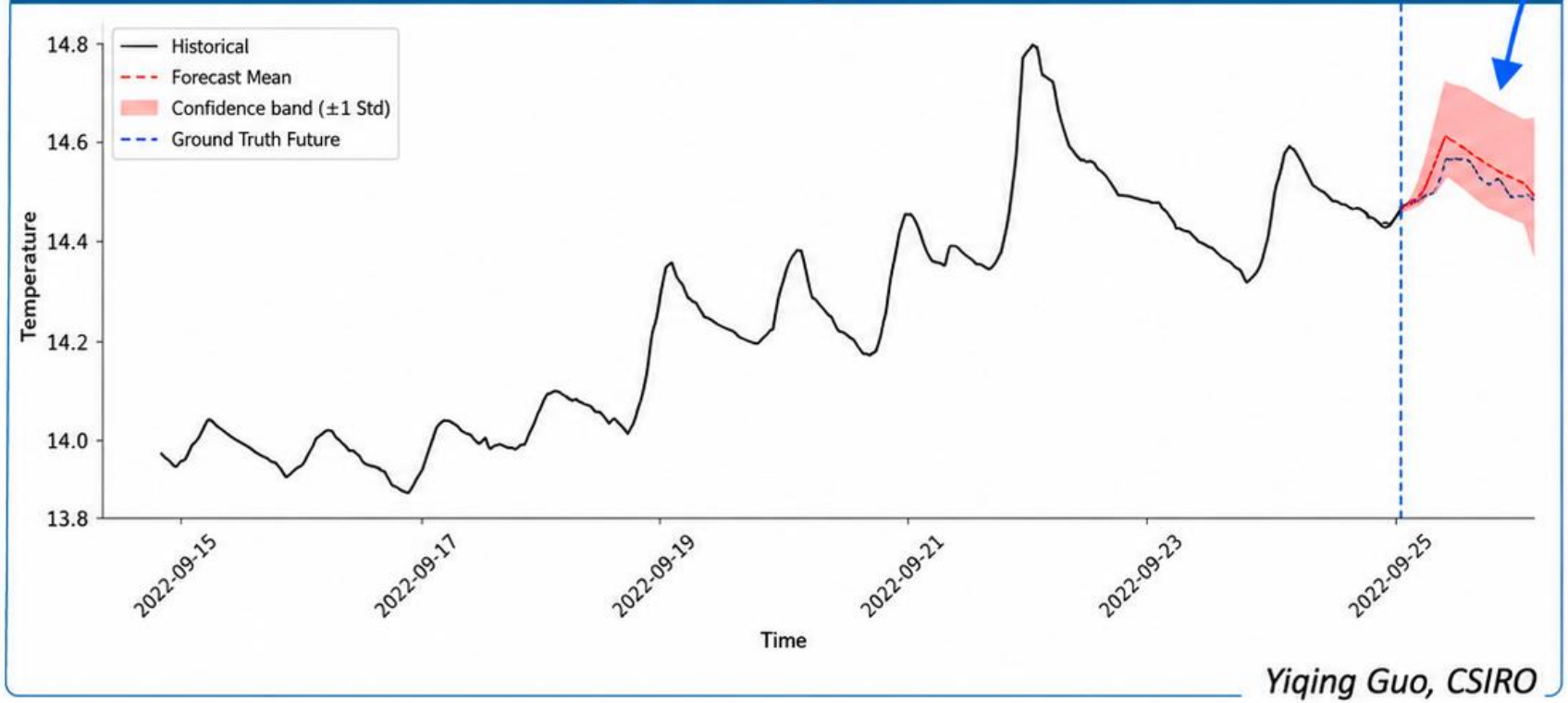
WP1: Time-series forecasting at buoy locations

A new AI model is in development for time-series forecasting of water quality.

The multimodal approach (time-series data + large language model) gives:

- ✓ The *uncertainty* of the forecasts; and
- ✓ *Why* the forecasts are given.

Sample forecasting result



Yiqing Guo, CSIRO

Deep thinking (reasoning) before forecasting

1 Step 1: Continuity from last SST

- Last observed SST: 14.453°C
- Initial forecast value: 14.475°C
- Opening delta: −0.007°C

This minimal decrease suggests we should maintain continuity with the temperate trend without any prompt for the upcoming diurnal cycle.

2 Step 2: Analysis of repeated daily cycle

- Expected trough: 14.407°C at hour 4
- Expected peak: 14.621°C at hour 10
- Forecast range (peak–trough): 0.2739°C

We will track this oscillation cycle, as it's the forecast range of 0.2739°C, and also maintains resemblance with typical diurnal variations.

3 Step 3: Analysis of long-term trend

- Recent high peak: 14.5114°C
- Preceding local peak: 14.4538°C
- Positive delta: +0.0576°C

We will incorporate this positive delta of 0.0576°C from our projections, ensuring the forecast reflects the gradual upward shift in baseline temperature.

4 Step 4: Analysis of peak/trough magnitude

- Forecasted peak: 14.621°C
- Forecasted trough: 14.407°C
- Recent maximum: 14.627°C
- Recent minimum: 14.3255°C

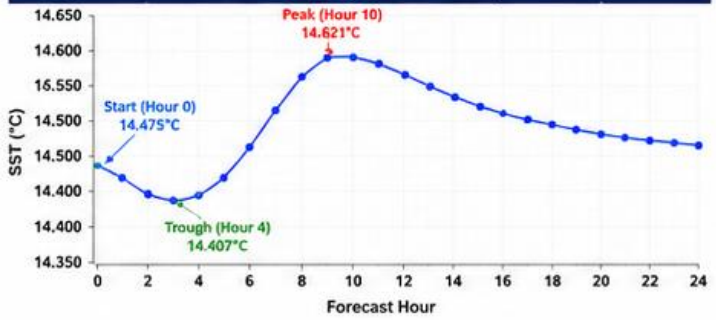
We will monitor these magnitudes to ensure they remain within the expected bounds of the recent block's range, confirming the stability of the cycle extremes.

5 Step 5: Impact of extreme events

- Significant events in historical period: None
- Scheduled events in forecast horizon: None

No external disturbances are expected. We will proceed with the standard cycle model without adjustment.

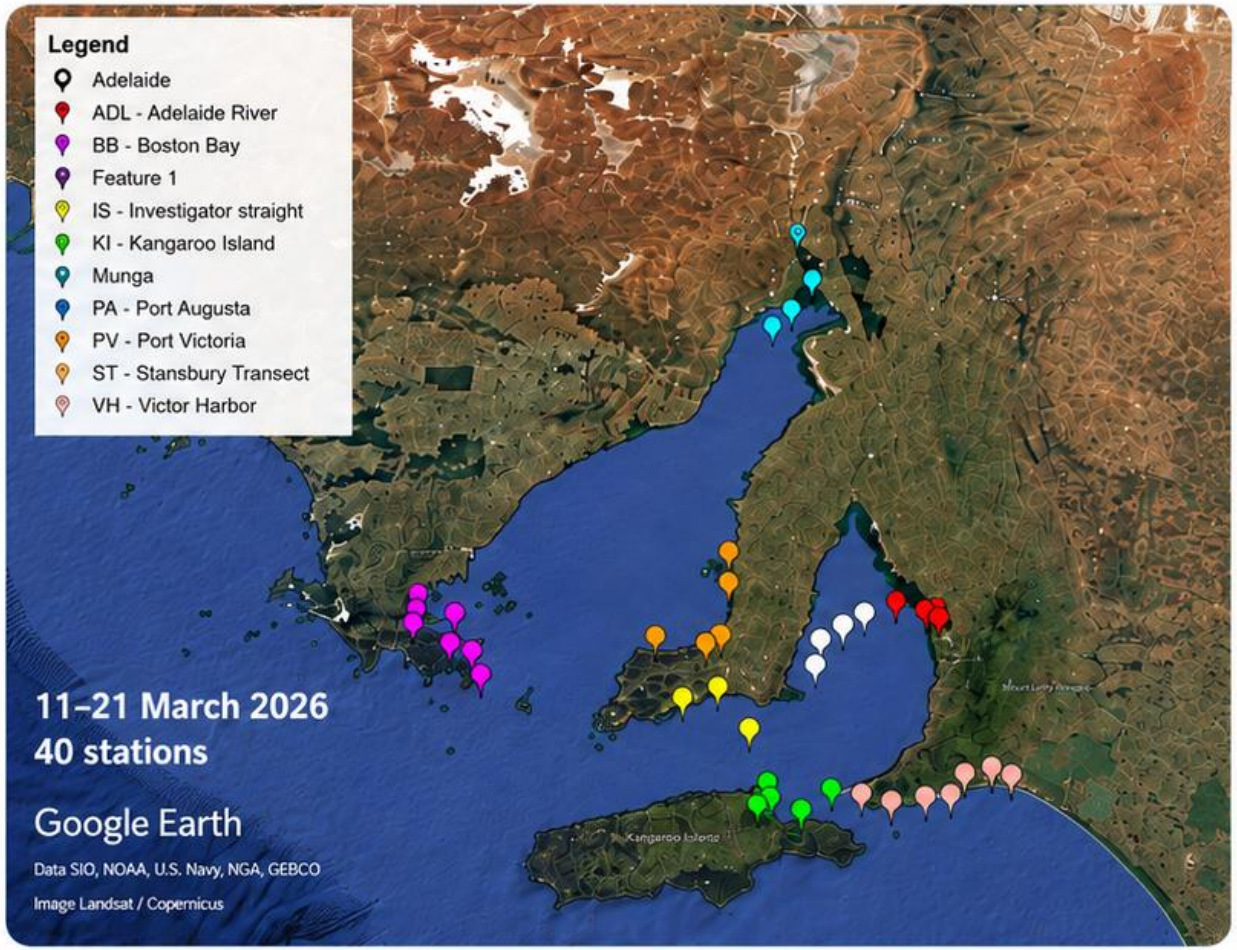
SST Forecast (Next 24 Hours)

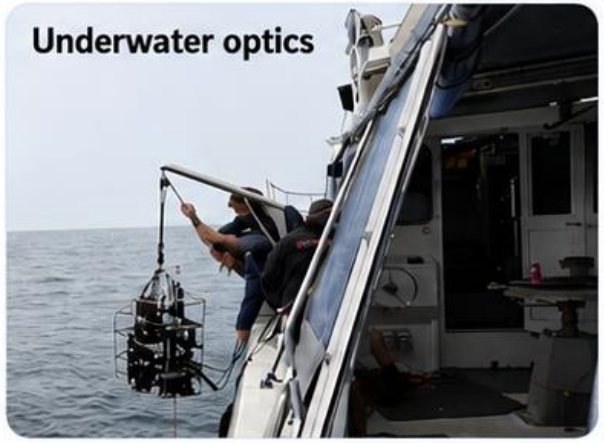


WP2: SA field work and spectral libraries

Measurements made:

- Phytoplankton Pigs. – HPLC
- Total Suspended solids (organic/inorganic)
- Total, particulate and dissolved organic Carbon
- Nutrients
- Phyto., detritus and CDOM absorption
- Particulate scattering and backscattering
- Remote sensing reflectance
- Phyto. Taxa (SARDI) eDNA samples (CSIRO)

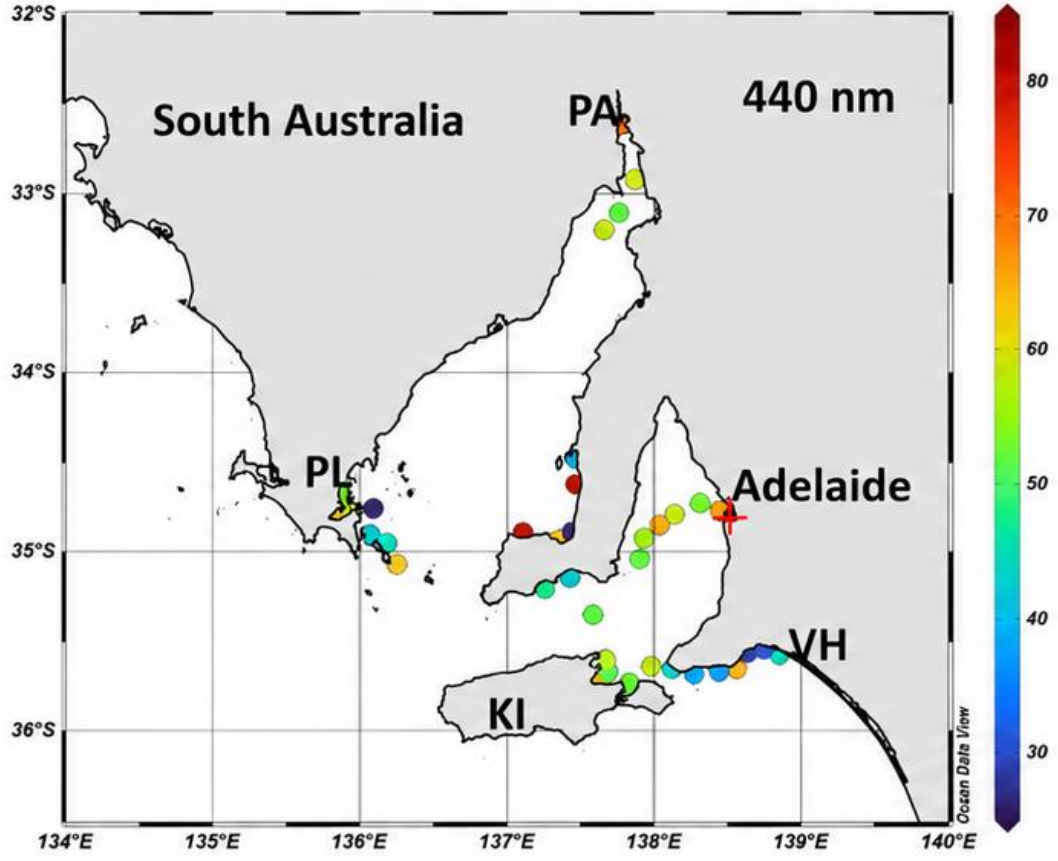




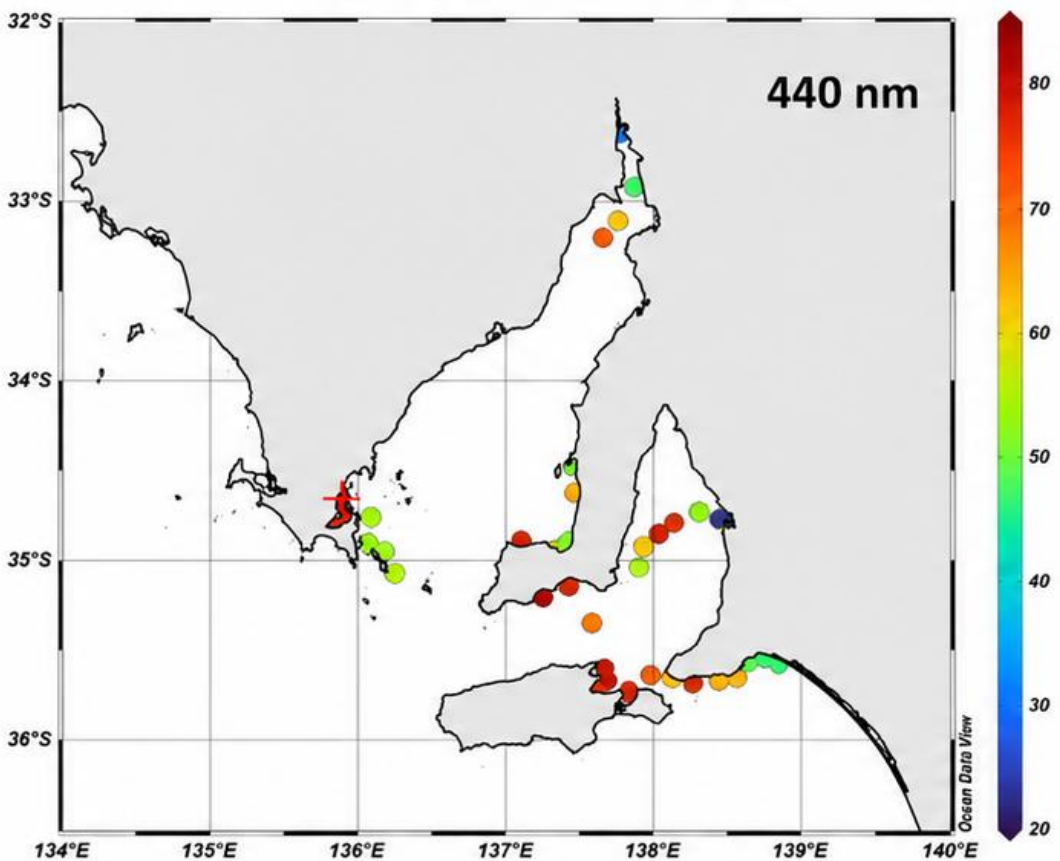
In situ measurements → Water quality & biogeochemistry → **Spectral Libraries**: Bio-optical properties & phytoplankton → Remote sensing reflectance → Tchla, TSS, CDOM HAB index, Kd

Fieldwork first results – absorption properties

aCDOM/ aPart+CDOM (%)



aPhyto / aParticulate (%)

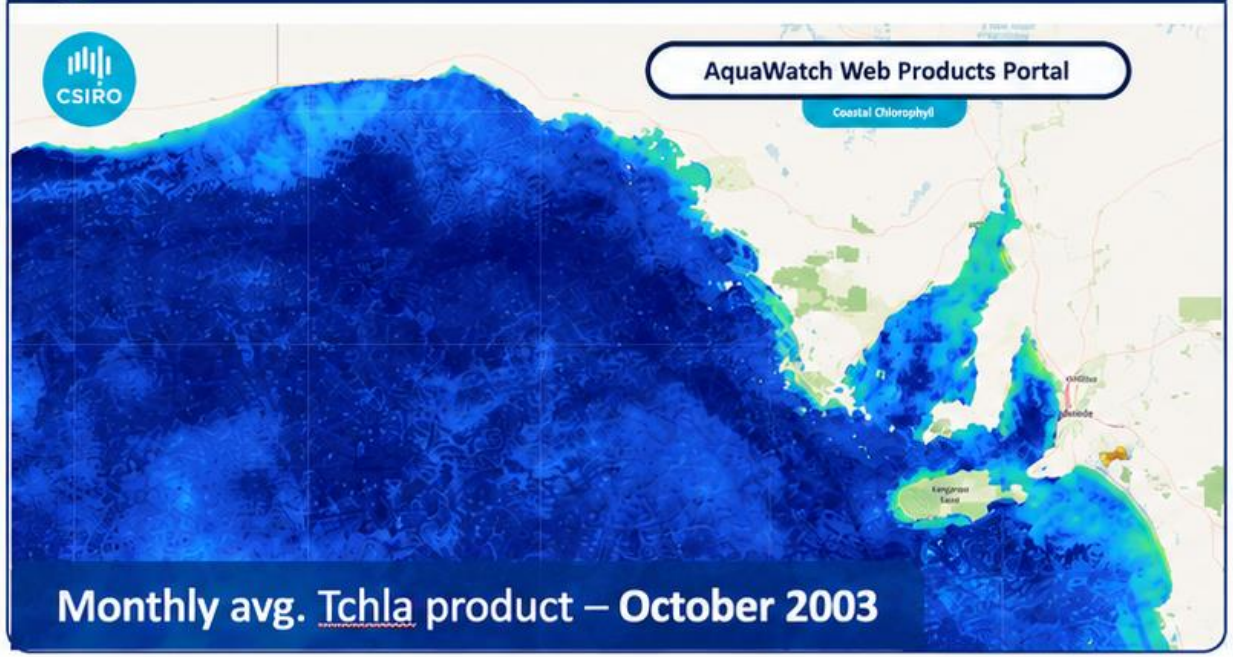


CDOM dominates the absorption budget in SA Gulf waters. Relatively less contribution near Victor Hbr and PL regions

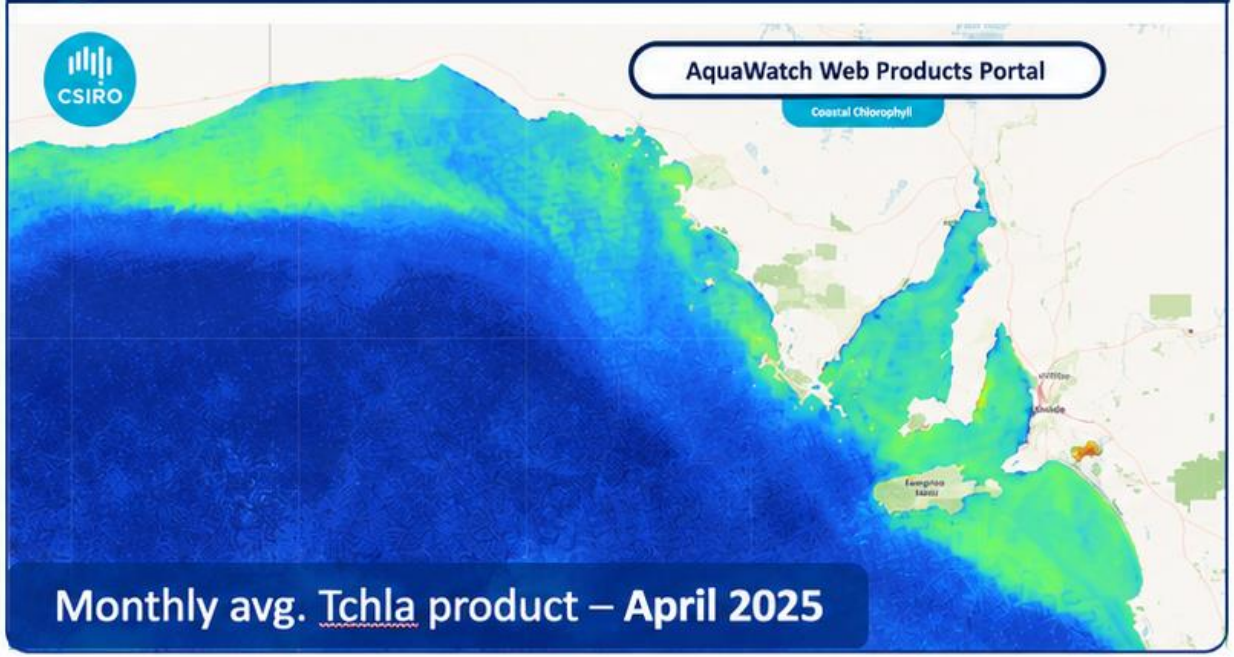
Particulate absorption is dominated by Phytoplankton contributions. Adelaide and PA stations close to coast as dominated by non-algal mater.

WP2: Remote sensing products: MODIS and VIIRS (1 km)

Historical data: NASA MODIS 1km (2002–2023)



Current: NOAA VIIRS 1km (2022 – present)



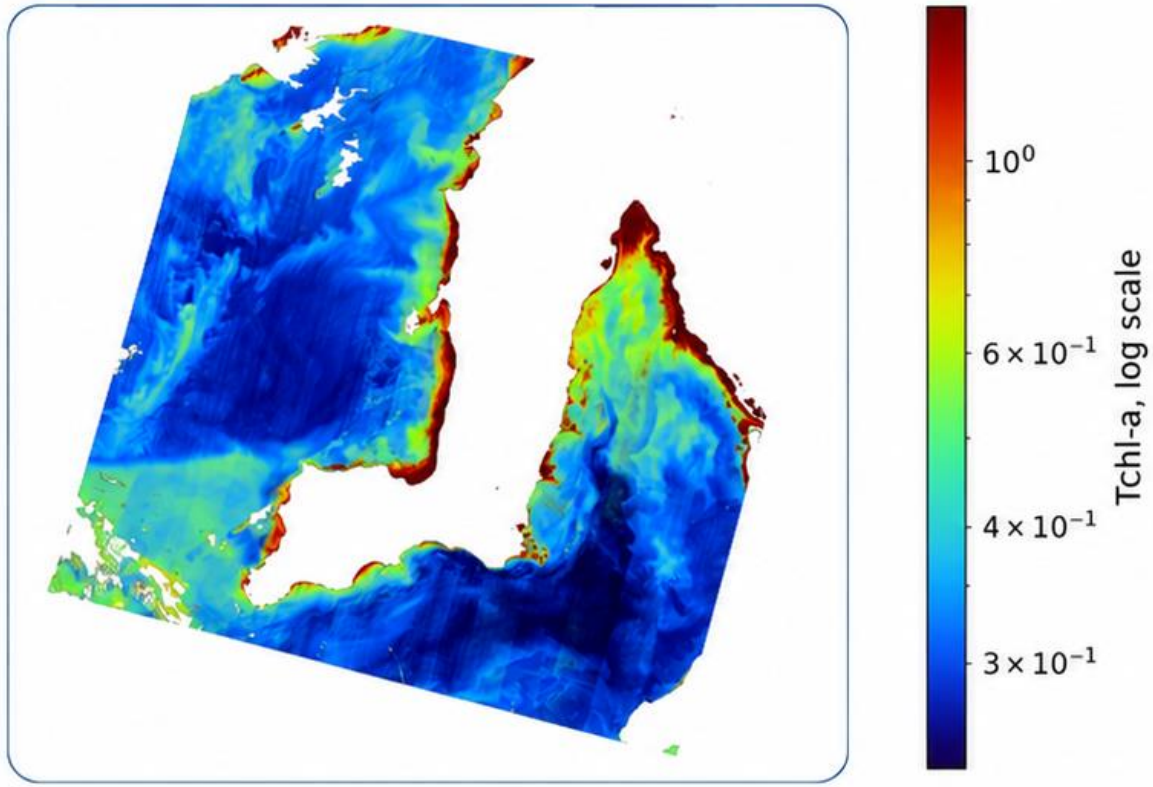
- MODIS daily and monthly averaged images are available.
- WQ products include: TSS, Tchl-a, CDOM and Kd
- ADS platform supports spatio-temporal analysis

- VIIRS daily and monthly averaged images are available.

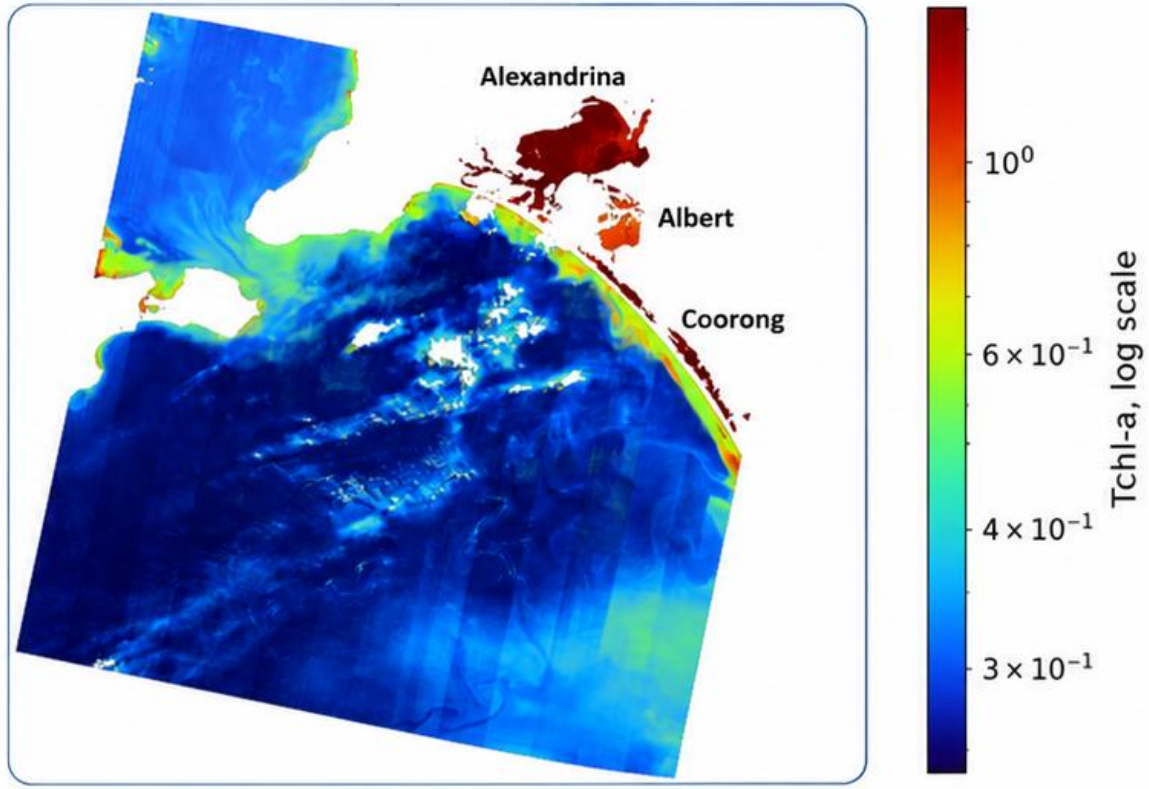
Next step: Sentinel 3A and 3B (300 m) WQ products

WP2: LandSat-8 30 m pixel Tchl-a map

14/March/2026



23/March/2026

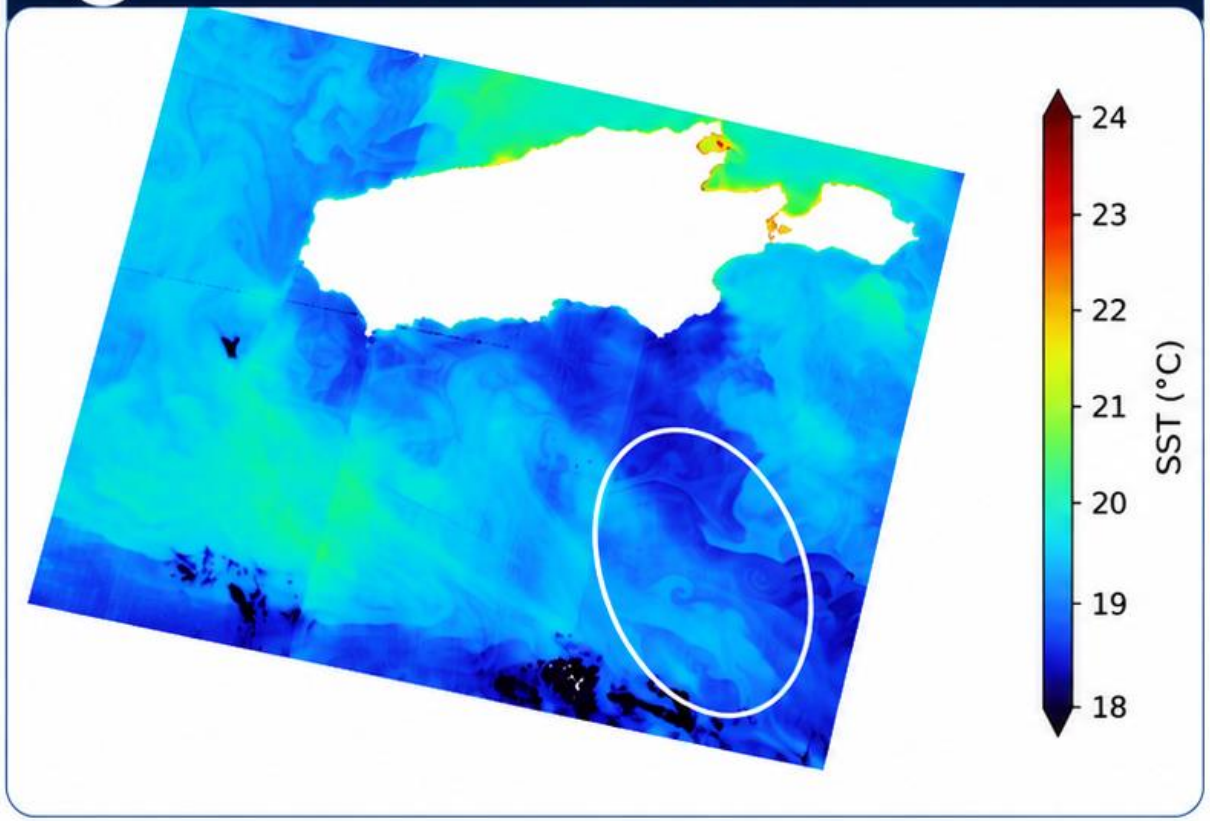


- **30 m resolution** captures coastal and estuarine features missed by 1 km products.
- **Detects fine-scale variability** in chlorophyll-a, TSS, CDOM, and Kd.
- **Improves monitoring nearshore and aquaculture zones** for local management applications.

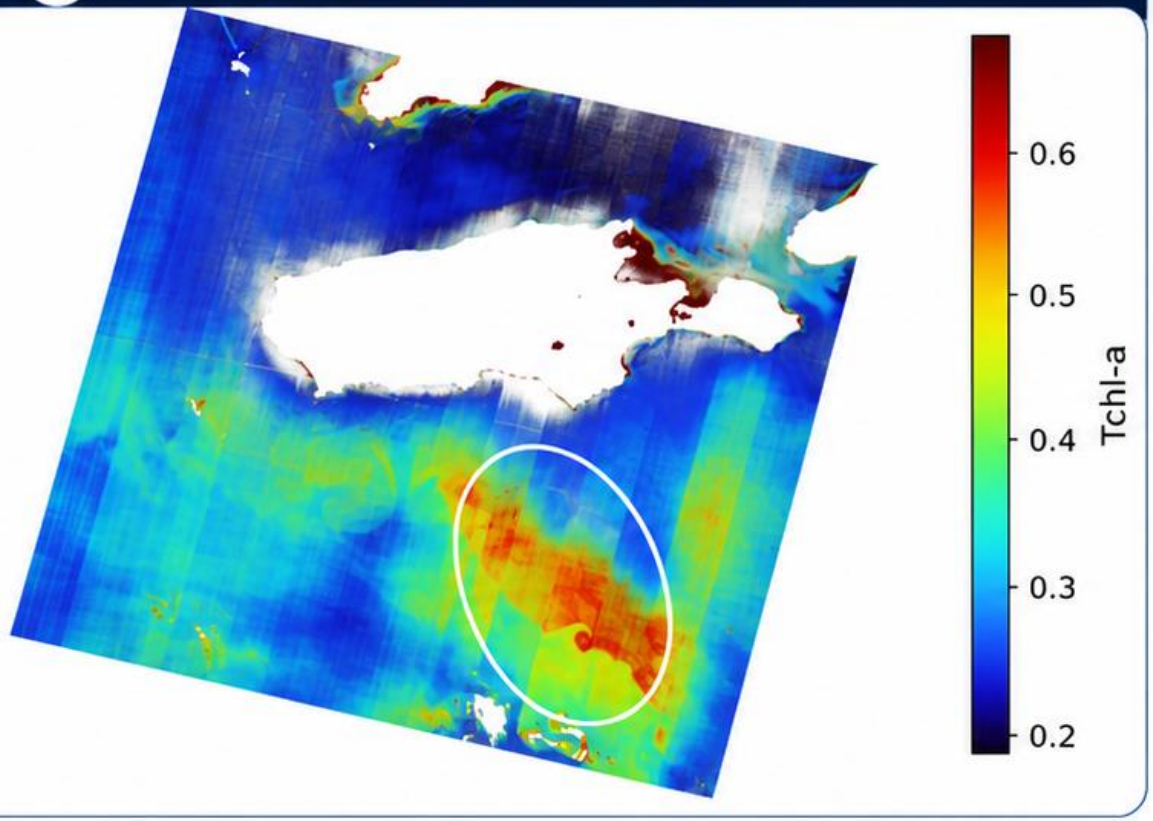
Kesav Unnithan, CSIRO

WP2: LandSat-8 SST and Tchl-a

01/April/2021 SST (100 m)



01/April/2021 Tchl-a (30 m)



- **30 m TChl-a** resolves estuaries, coastal waters, and aquaculture sites.
- **100 m SST** captures local temperature gradients and thermal hotspots.
- **Combined TChl-a + SST** enables site-scale HAB and water quality monitoring.

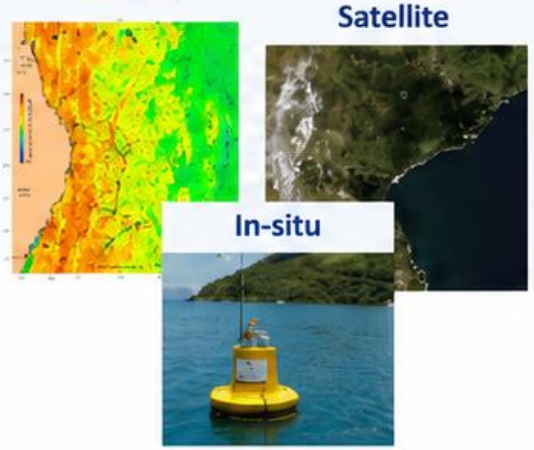
WP3: EO + AI-driven coastal water quality forecasting

1. Training data

Climate

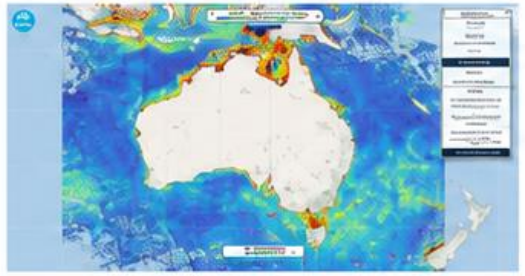
Satellite

In-situ



+

Hydrodynamic model

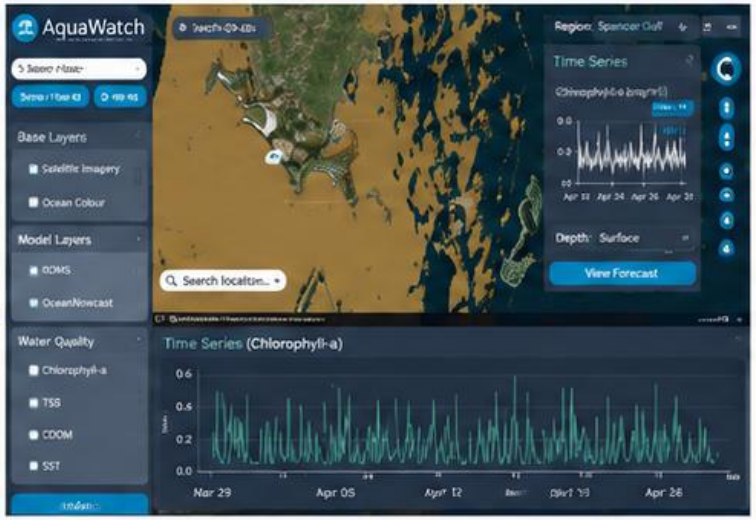


2. ML/DL and cloud computing

OPEN DATA CUBE

EASI / ADS

3. Water quality mapping and forecasting (spatial and temporal)



Water quality variables

- Sediment
- Dissolved organic carbon
- Chlorophyll
- Light availability

4. Impact areas

Aquaculture sites

- SST changes
- TChl-a and HAB index changes

Marine park management (NSW)

- Extreme event preparedness
- Risk reduction planning
- Hotspot detection

Outcome: Timely, actionable intelligence for sustainable coastal and marine management.

Eric Lehmann, Nagur Cherukuru, CSIRO

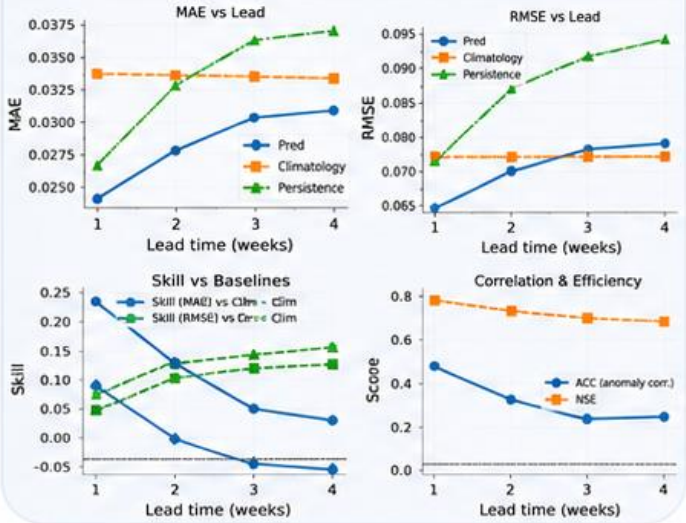
WP3: EO + AI-driven coastal water quality forecasting

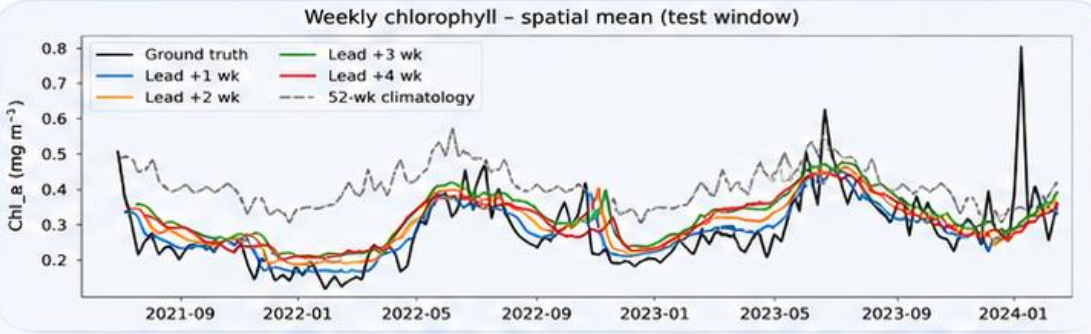
AI + EO forecasting model – Preliminary results

DL spatiotemporal model integrating:

- Physics-aware loss function & advection–diffusion loss (physics informed)
- Artificial cloud gaps to handle missing data
- Trained on eReefs (daily), fine-tuned on real RS data (weekly)

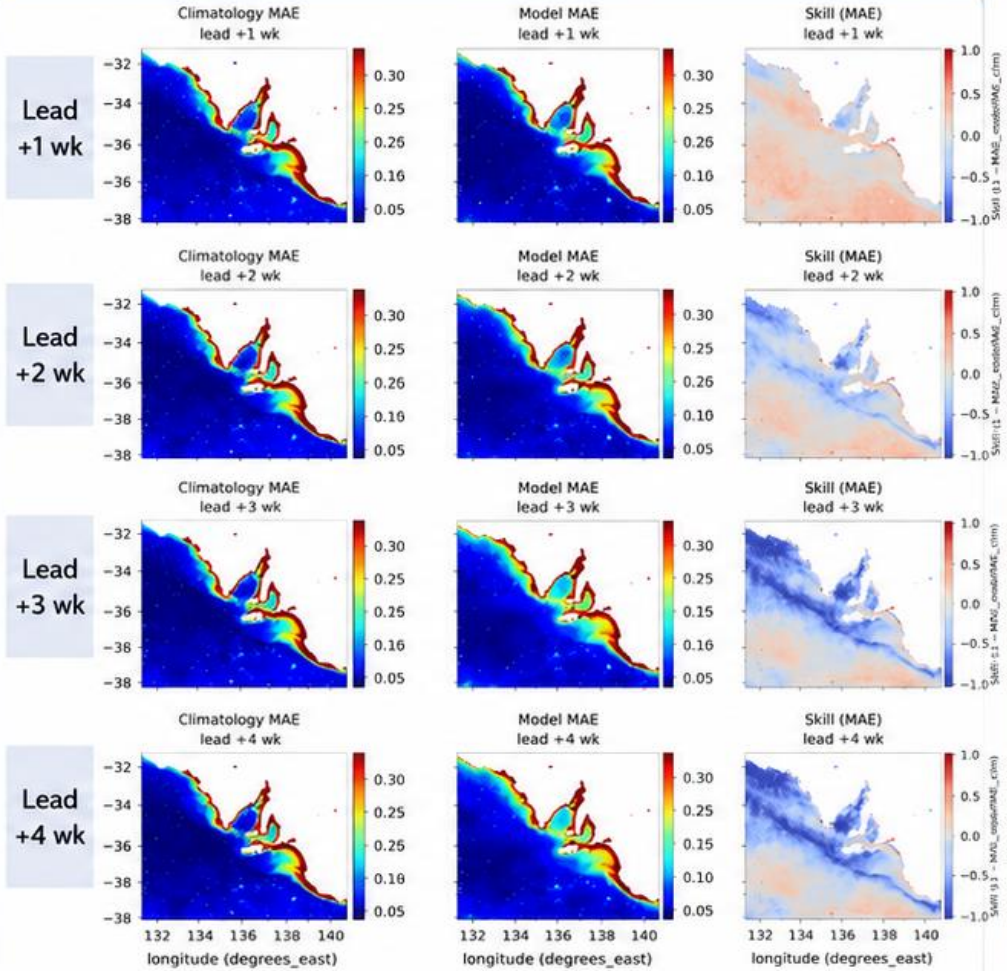
Lead-time performance using weekly eReefs test set





Spatial mean of weekly TChl-a forecasting in Spencer Gulf, 4 weeks ahead

Forecasting skills vs. lead time (averaged across test times)



Impact areas

Aquaculture sites

- SST changes
- TChl-a and HAB index changes

Marine park management (NSW)

- Extreme event preparedness
- Risk reduction planning
- Hotspot detection

Integrating EO, in-situ observations, ocean models and AI for timely coastal water quality forecasts that support aquaculture and marine park management.

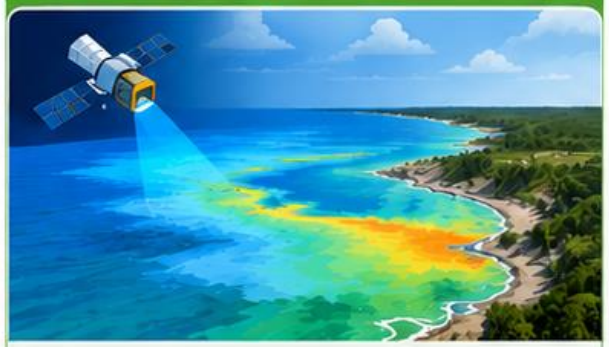
Eric Lehmann, Foivos Diakogiannis, Nagur Cherukuru, CSIRO

Project Timelines

June 2026 (6 months)

- In situ forecasting at selected locations
- LandSat (100m) SST maps (V1)
- LandSat (30 m) and S2 (10 m) WQ maps (V1)
- NRT S3 (~300 m) maps of WQ and HAB index (V1)
- RS based WQ forecasting (V1)

December 2026 (12 months)



- In situ forecasting at multiple locations
- New regional spectral libraries
- Improved RS model (V2)

June 2027 (18 months)

- Single point forecasting at six SA buoy sites
- NRT remote sensing maps of SST, WQ and HABindex
- Data visualisation
- RS based WQ forecasting (V2)

December 2027 (24 months)

- End-to-End WQ, HAB Index, SST workflows
- Next phase discussion
- Science communication

Building an integrated EO + AI forecasting system to deliver timely, accurate and actionable coastal water quality information.

Questions?

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Acknowledgements

SARDI/PIRSA
SARDI field team

CSIRO AquaWatch Australia
AquaWatch Data System Team
Coastal and Oceanic Systems Program, CSIRO
CSIRO Data61
CSIRO Space & Astronomy
CSIRO Environment

CSIRO AquaWatch Project Team

Eric Lehmann, Yiqing Guo, Kesav Unnithan, Tish Dhar, Peter Wang, Dave Cole, Ronnie Taib, Albertina Dias, James Taylor, Gemma Kerrisk, Tim Malthus, Tim Bolton, Erin Kenna, Timon Sotiropoulos, Rob Woodcock, Janet Anstee, Alex Held