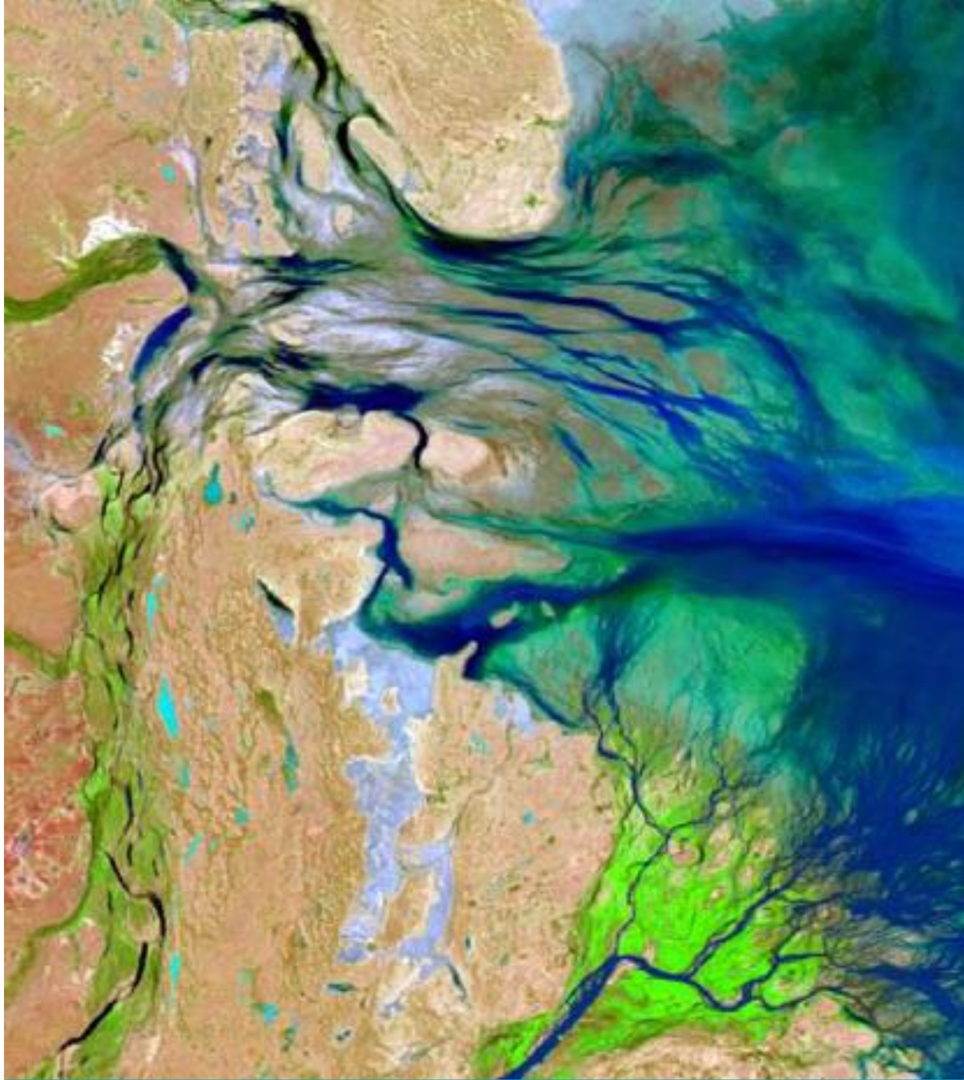
Remote sensing and water modelling

A 5 year outlook

Tim Malthus | CSIRO Oceans and Atmosphere |
2020-02-27

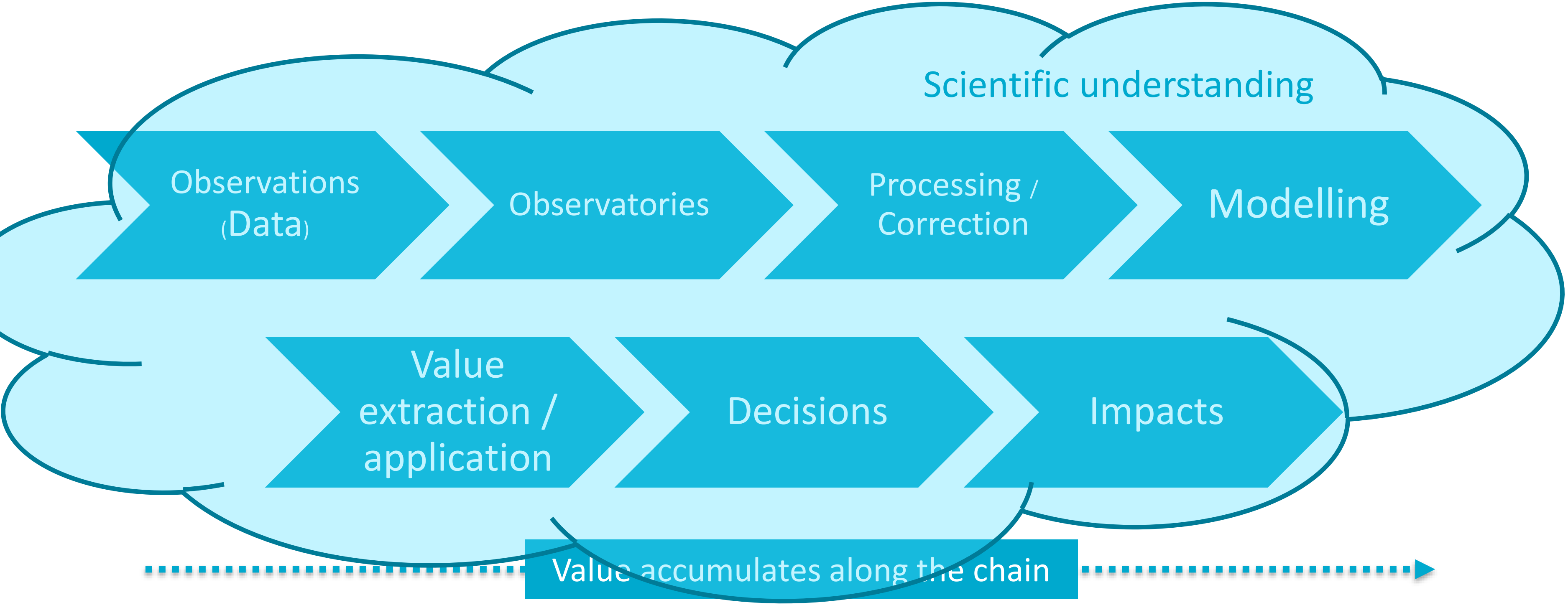
Australia's National Science Agency



Structure

- Perspectives
- Trends in remote sensing
- Remote sensing and modelling relationship
- Issues and opportunities
- Conclusion

My pipeline - observations **and** models critical to the success of decision making



Remote sensing and modelling

Remote Sensing	Models
Higher spatial and temporal coverage than in situ measurements	High spatial and temporal resolution
40+ year time series (hindcasting)	Tool for forecasting, scenario assessment
Surface view only	3D structure
Cloud interference	Cloud free, continuous
Large uncertainties	Uncertainties?
Satellite drifts, calibration for time series	Process understanding
Regional and temporal biases	

National perspectives

Australian Space Agency

SMARTSAT Cooperative Research Centre

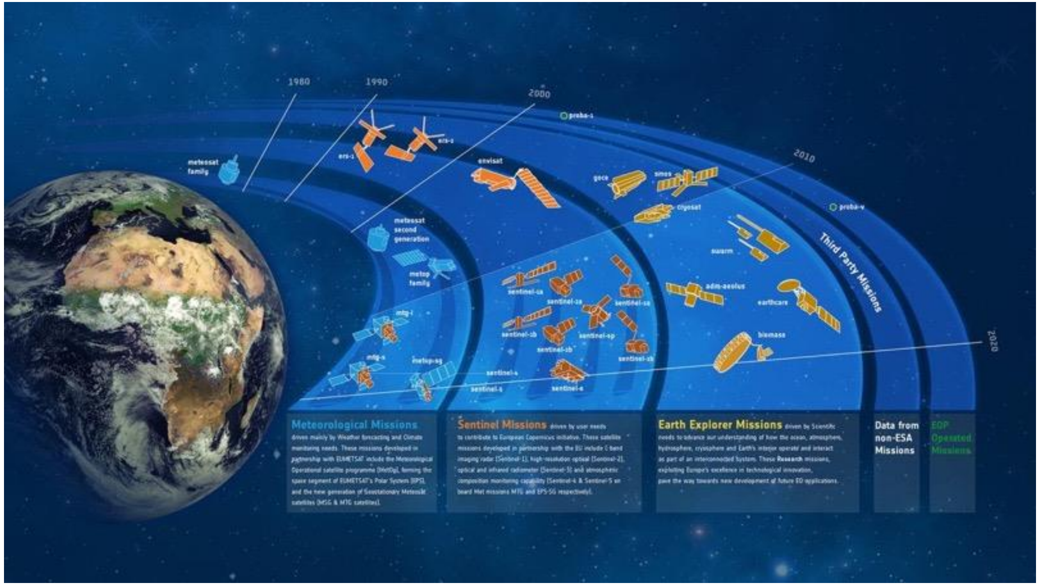
EOA Earth Observation Australia

Digital Earth AUSTRALIA

CSIRO Space Future Science Platform

Trend - Pervasiveness

- Constellations
- Commercialisation

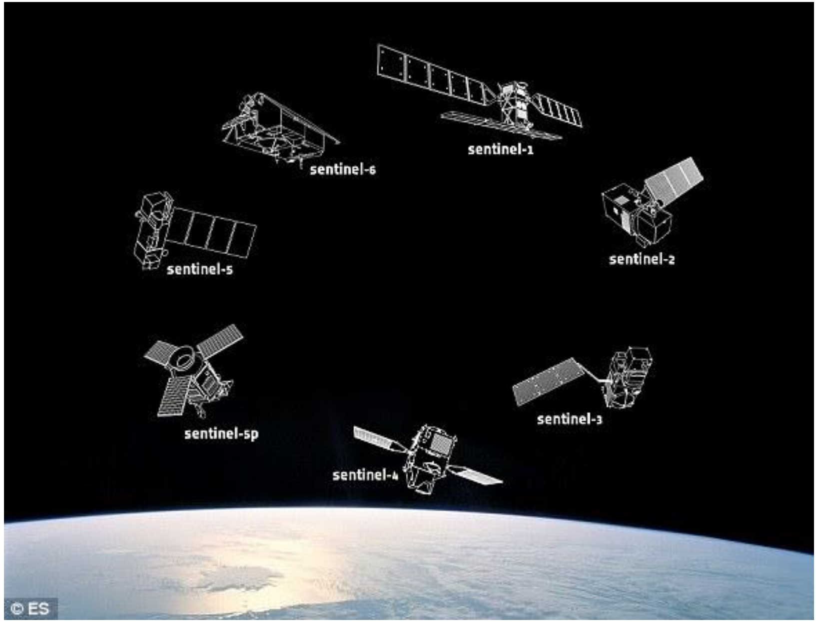


A sky full of (commercial) eyes – Up to 1,300 Earth observation satellites in next 5 years

BY DOUG MOHNEY JULY 24, 2018 ! LEAVE A COMMENT

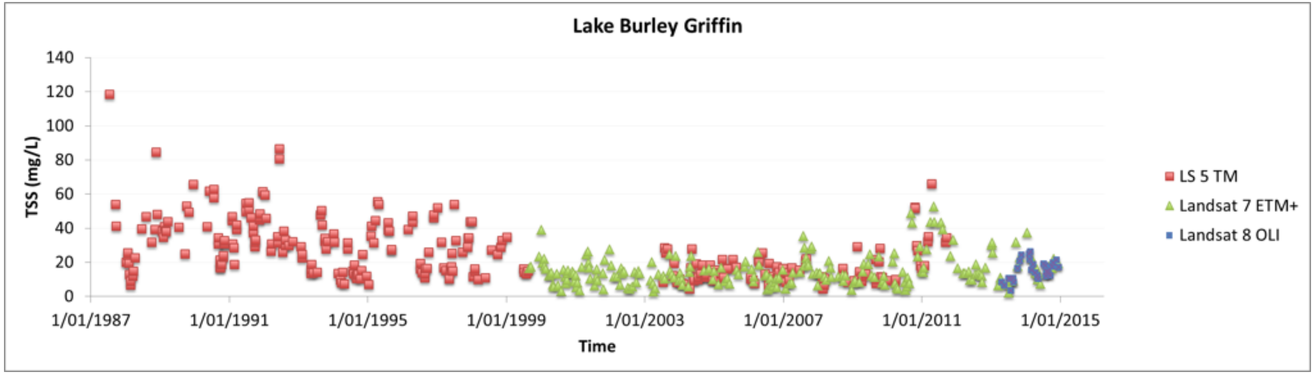
BLACKSKY EARTH NOW planet. ICEYE

Trend – Data continuity



Data supply guaranteed until 2030s

Supported by Landsat:
Landsat 9 – Dec 2020
Landsat 10 – in planning



Lymburner et al. (2016) Remote Sensing of Environment

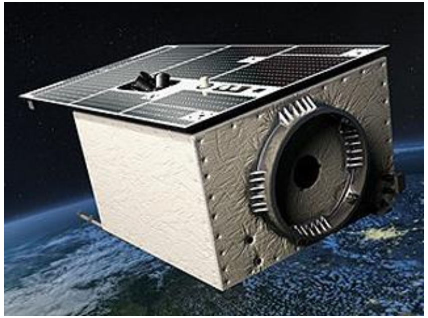
Trend – Diversity

- Platforms:
  - UAVs
  - Planes, balloons
  - Cube and micro-sats
  - Satellites
- Sensors:
  - Hyperspectral
  - Lidar
  - Radar
  - Geostationery

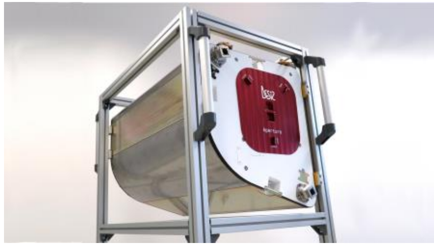
Trend - Hyperspectral satellites

Prisma (2019)

Gaofeng-5 (2018)



EnMap (2020)

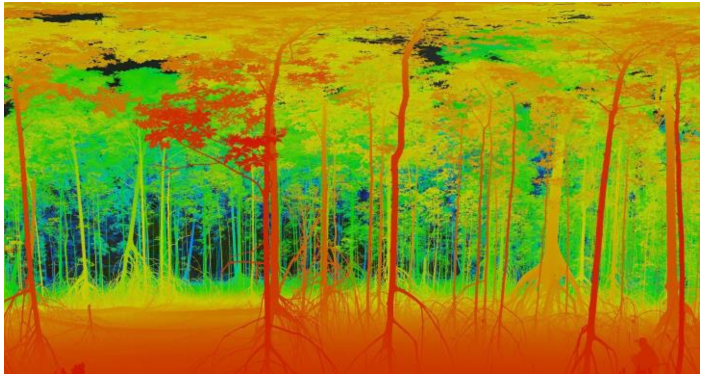


DESIS (2018)

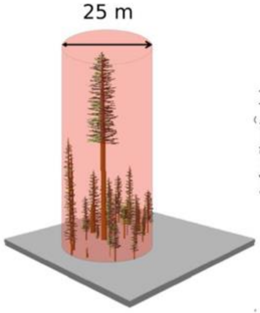
HISUI (2019)

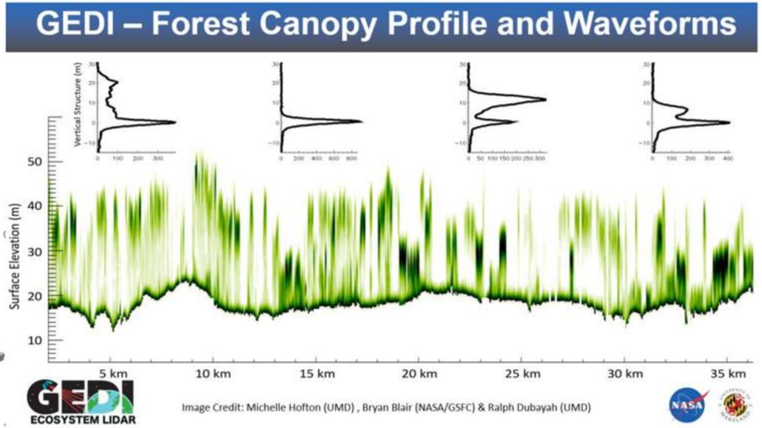
High spectral resolution promises improved parameters and reduced uncertainties

Lidar



Terrestrial Laser scanning - Mangroves



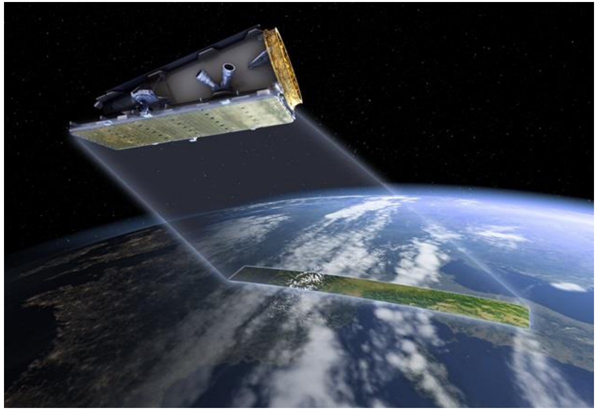


GEDI
ECOSYSTEM LIDAR

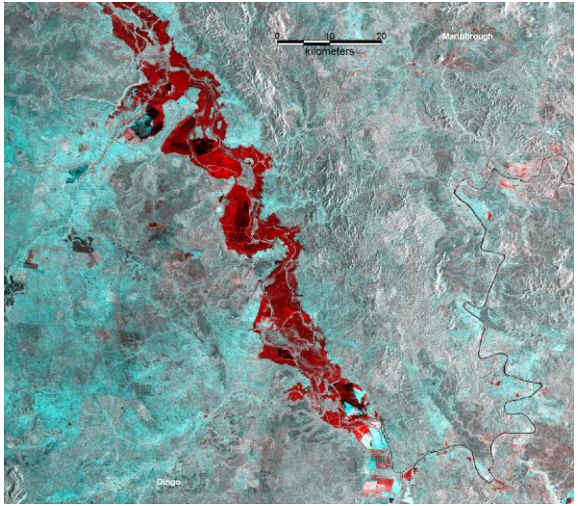
Lidar offers 3D structure, fine scale

Radar

Sentinel-1 (2015)



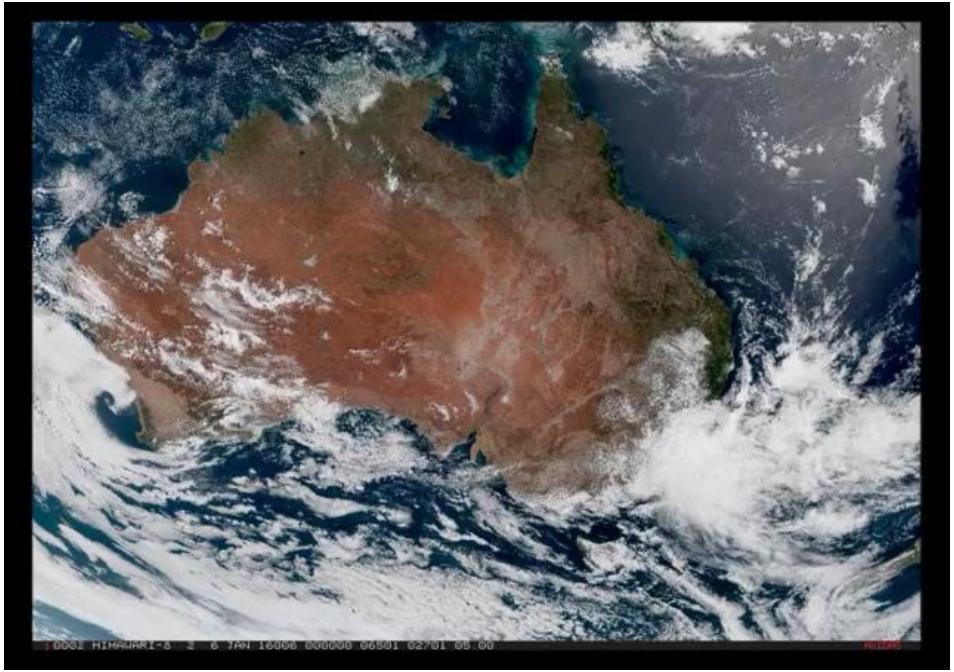
NovaSAR (2018)



SAR offers weather independence, structure, water delineation

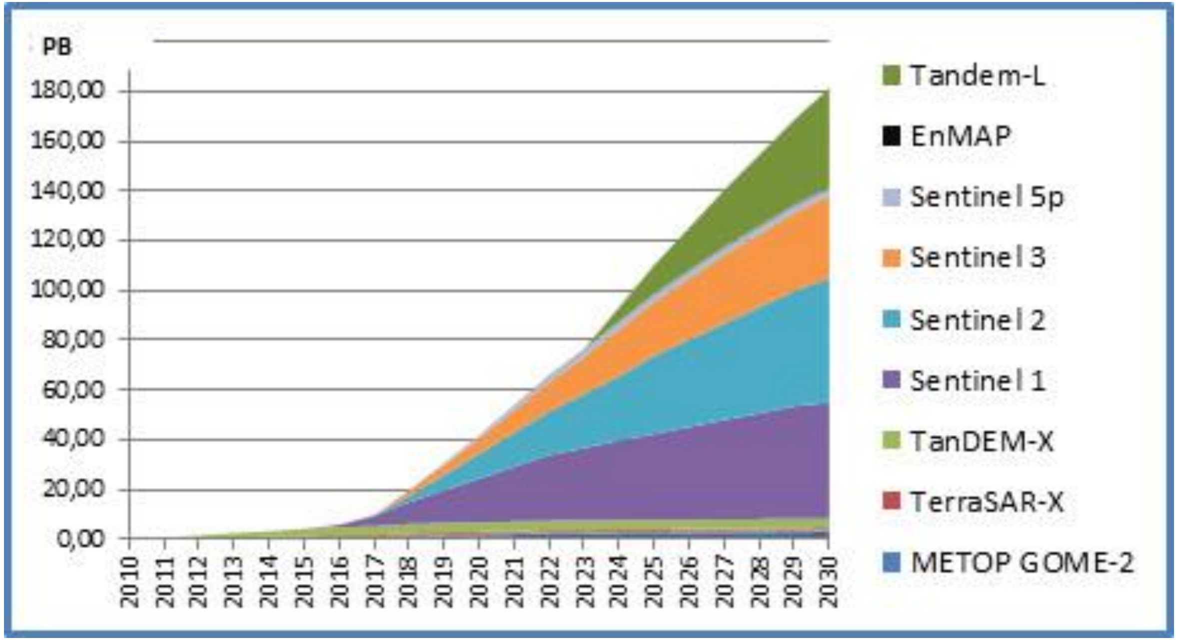
Geostationery

Himawari-8 (2014)



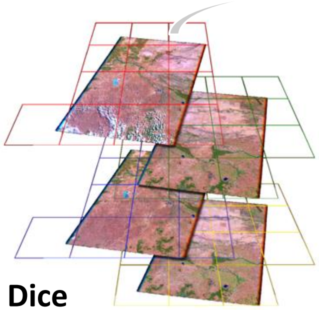
Geostationery offers high temporal resolution, dynamic processses

Challenge – Data volumes



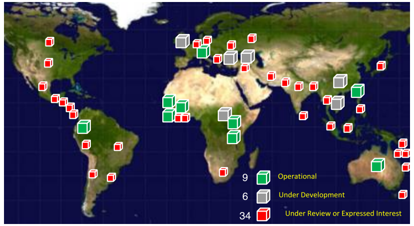
Trend – Discoverability & processing

- Analysis Ready Data
- Data cubes / Hubs (the pixel is key)
- Open data / Open source
- Off-the-shelf products
- Lowering the barrier to entry
- Operational services
- Processing in the cloud



Dice …

…and Stack



OPEN DATA CUBE

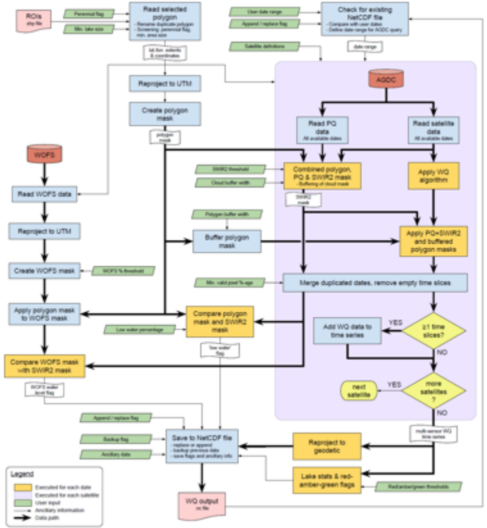
amazon web services

Google Earth Engine

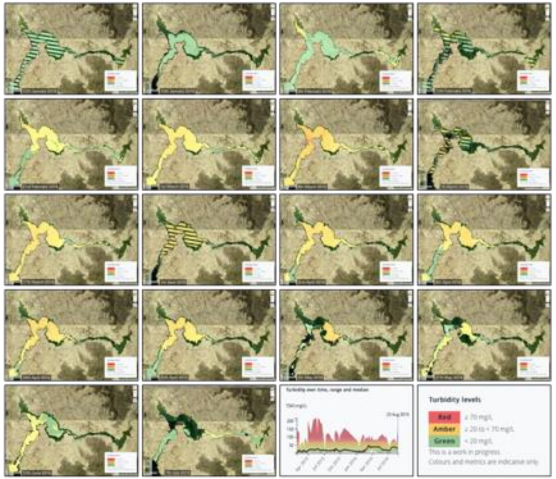
Digital Earth AUSTRALIA

CSIRO

Algal bloom detection and visualisation

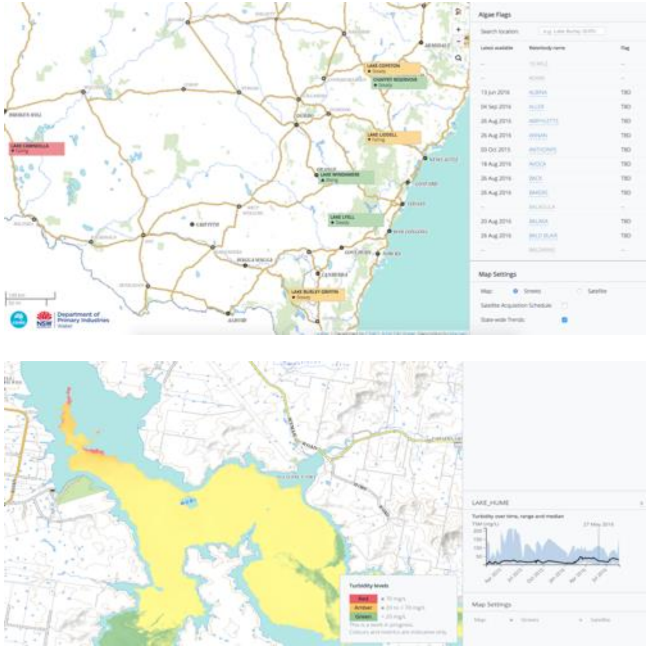


Workflow



Lake Hume, time series, January to July 2016

Processing



Visualization

Malthus et al. (2019) Remote Sensing, 11:2954

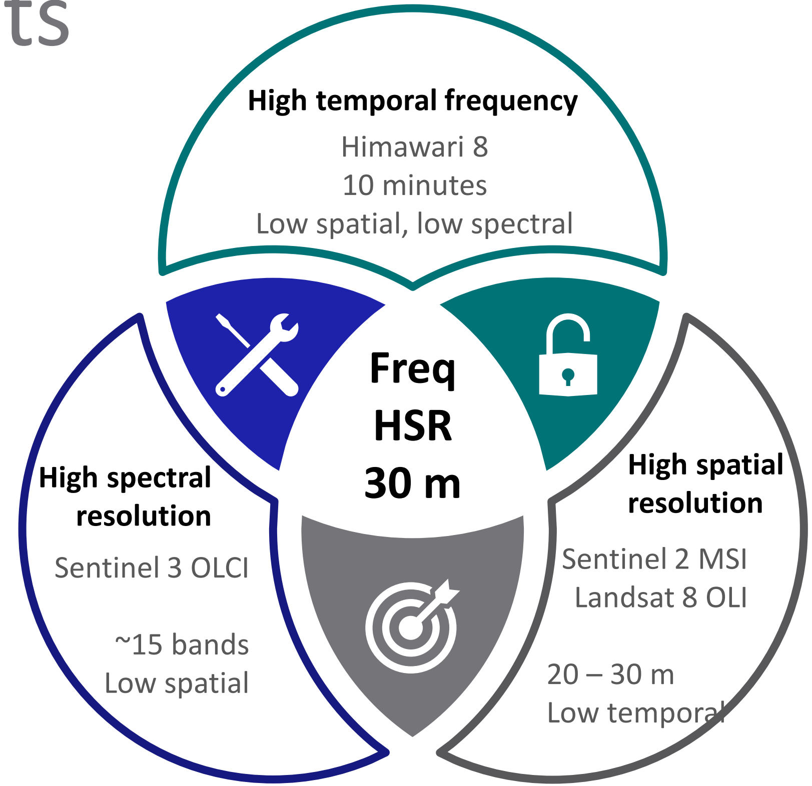
Issues and opportunities

- Access is mixed
- Continuity of the time series and products
- Duplication of effort
- Continuing calibration and validation

- From single-sensor products to the development of temporal merging, multi-sensor products, data assimilation
- Hierarchical approaches - Small scale high resolution to wider scale low resolution
- Automated recognition – structures, habitats, species

Data fusion, virtual datasets

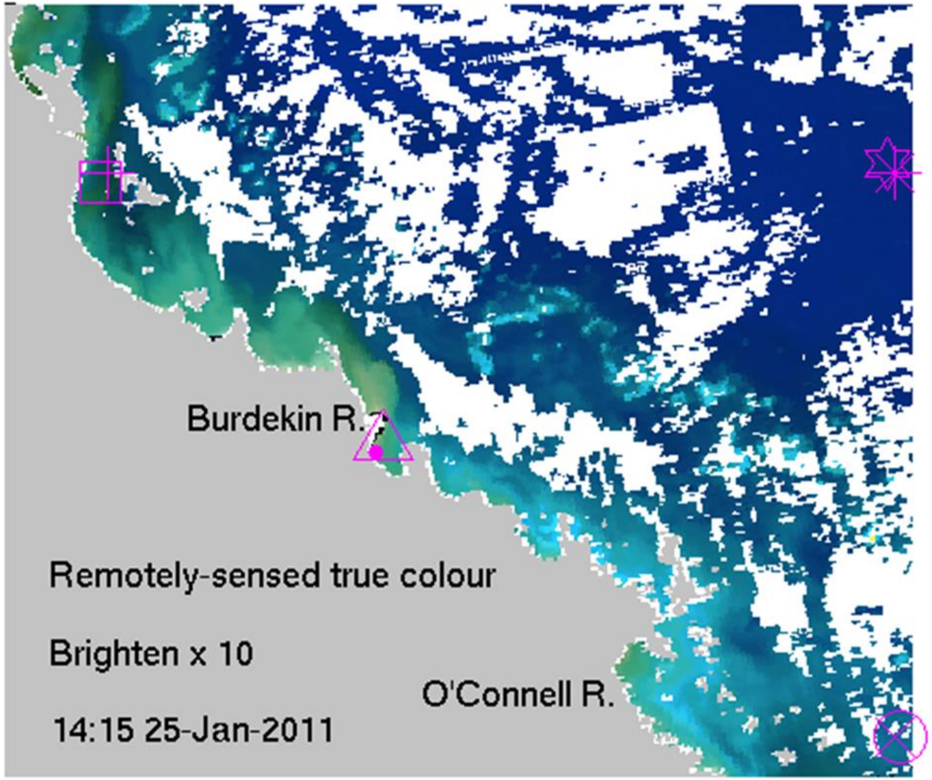
- Exploits high temporal, spatial and spectral resolution
- No single sensor achieves it, but we have sensors that satisfy each requirement
- Can we combine these to satisfy what we need?
  - Spectral-temporal / Spatial-temporal fusion
  - ML / AI



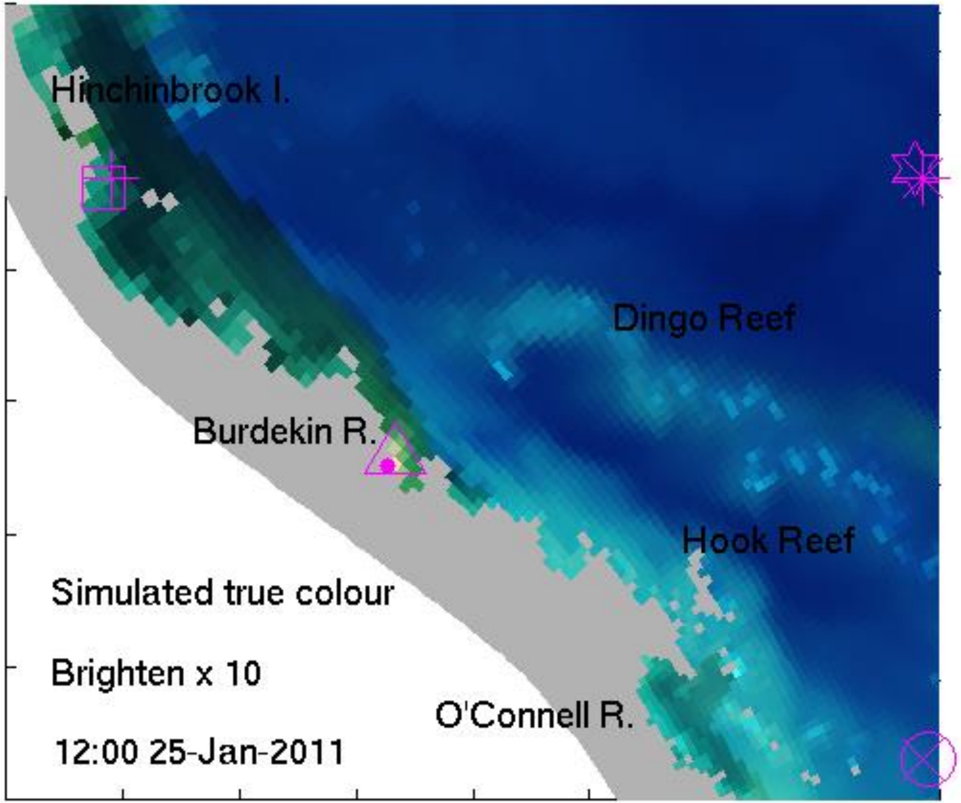
Remote sensing and modelling

- Greater synergy between RS and models
- RS informs model validation, model skill assessment
- Modelling informs RS, e.g. algorithm improvement
- Challenges:
  - Mis-match between model outputs and ocean colour products
  - Each provides a different “measurement” inhibiting straightforward intercomparisons
  - Differences in terminology/similarly names variables, uncertainties, new developments in modelling directly link to RS (example)

eReefs – Validation using true colour



True colour from orbiting satellite (MODIS)



True colour as a model output

eReefs – RS data assimilation

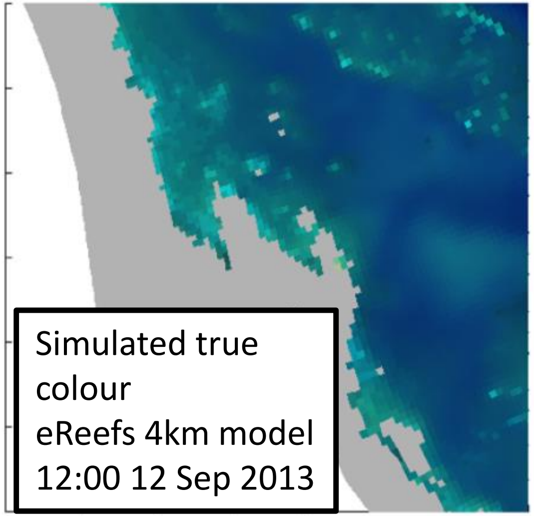
- Data assimilation system constrained using the mismatch between observed and simulated remote-sensing reflectance.
- Reanalysis (1 June 2013 – 30 October 2016) completed on 24 Feb 2017, 4 days ahead of schedule.

Biogeosciences, 13, 1–30, 2016
www.biogeosciences.net/13/1/2016/
doi:10.5194/bg-13-1-2016

Biogeosciences
Open Access
EGU

Use of remote-sensing reflectance to constrain a data assimilating marine biogeochemical model of the Great Barrier Reef

Emlyn M. Jones[1], Mark E. Baird[1], Mathieu Mongin[1], John Parslow[1], Jenny Skerratt[1], Jenny Lovell[1], Nugzar Margvelashvili[1], Richard J. Matear[1], Karen Wild-Allen[1], Barbara Robson[2], Farhan Rizwi[1], Peter Oke[1], Edward King[1], Thomas Schroeder[3], Andy Steven[3], and John Taylor[4]



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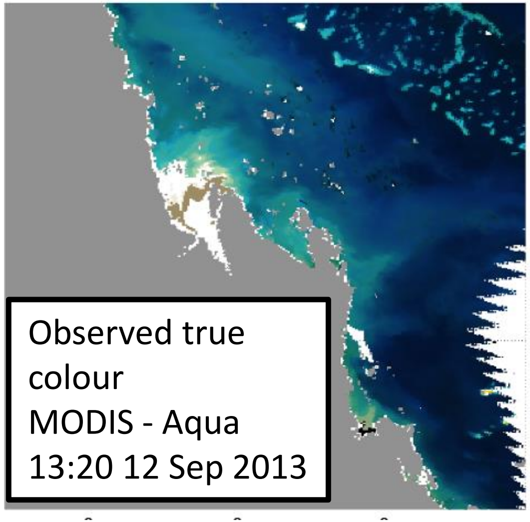

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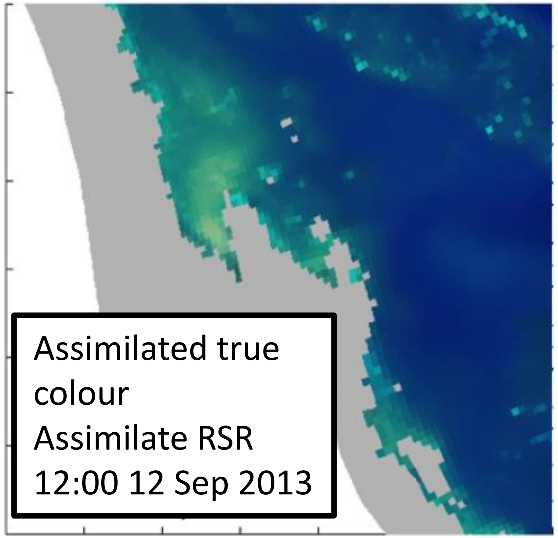

Conclusions

- A RS data explosion, more accessible, higher resolution, diversity
- Modellers need to be better informed of RS use and developments
- Greater dialogue needed between the two communities – how to interpret the comparisons
- Data assimilation needs work – formal mechanisms to synthesize observations and models
- Uncertainty in RS products requires greater understanding
- Both RS and modelling depend on in situ data

Thank you

Oceans and Atmosphere
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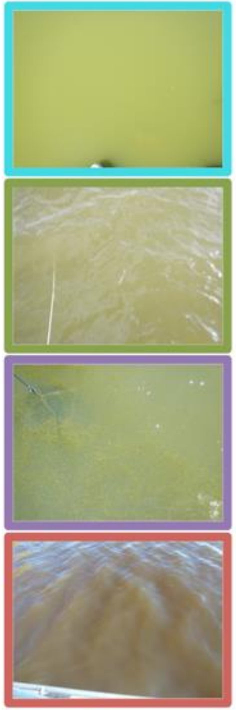
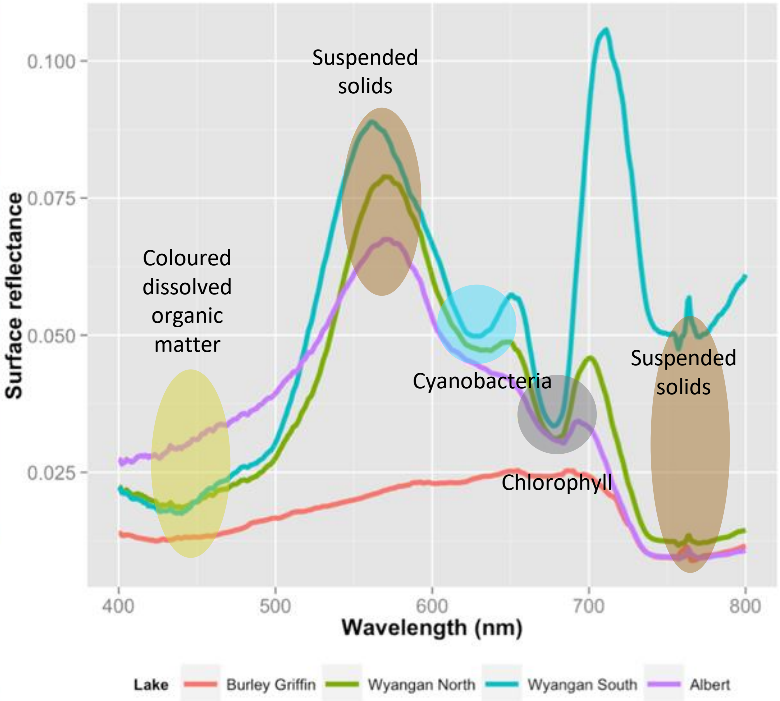
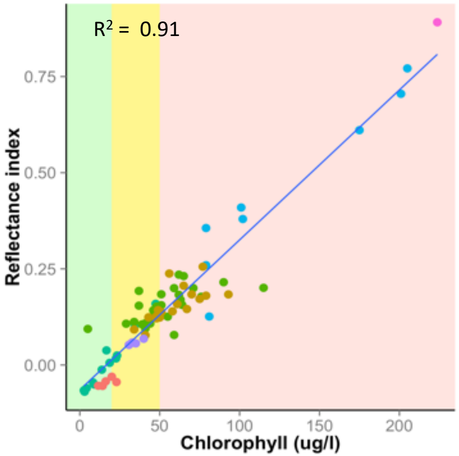
Driven by colour - information in spectral reflectance

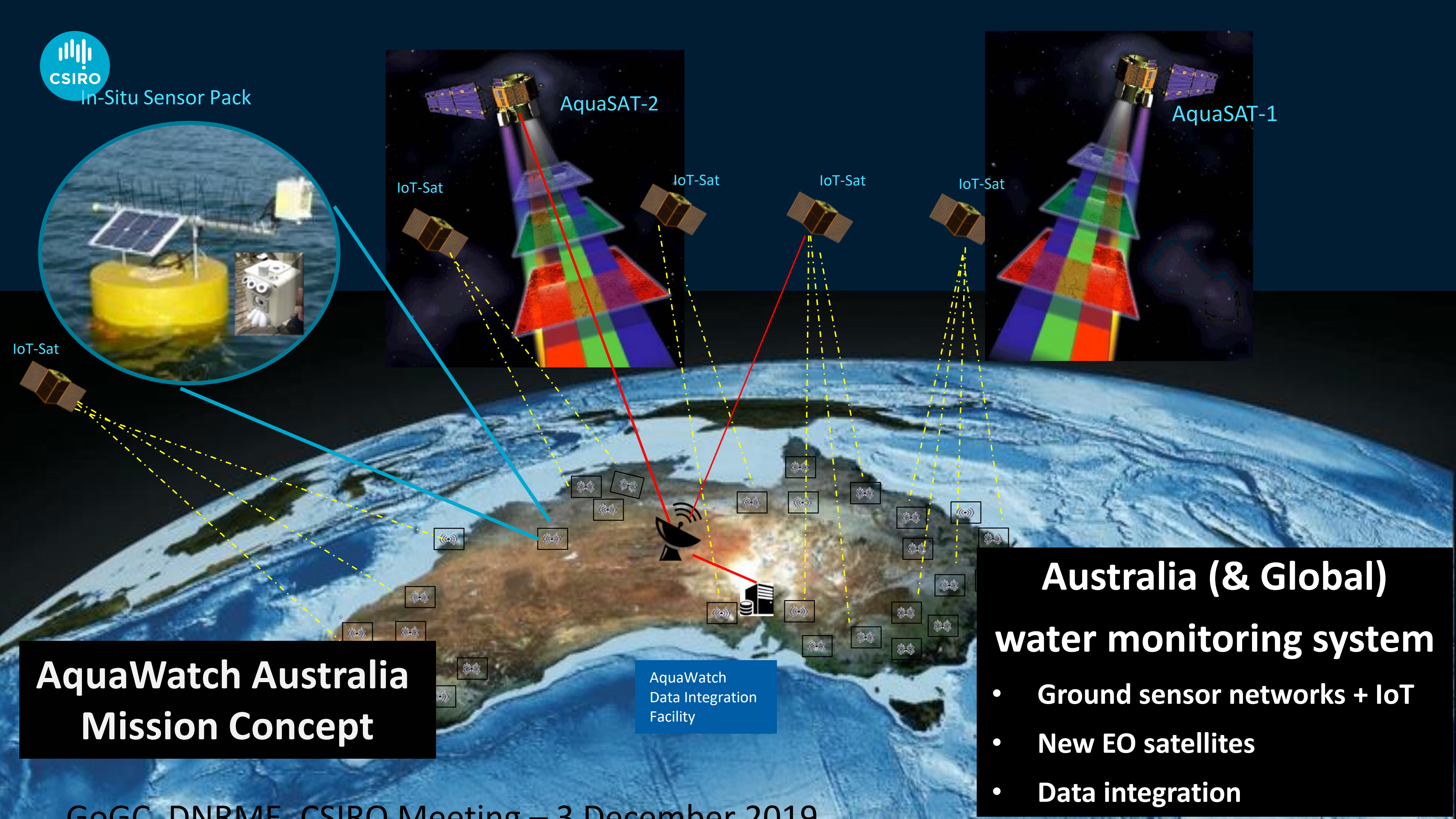




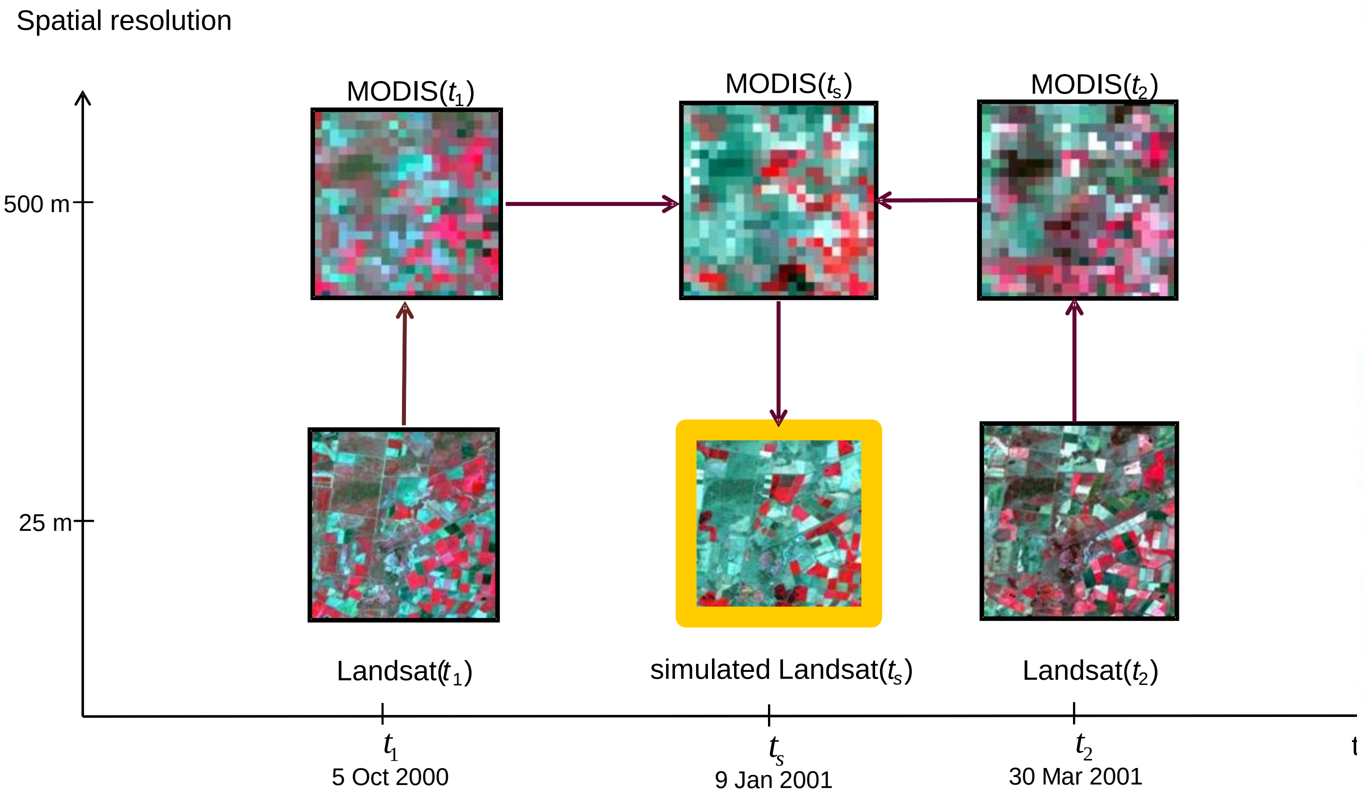


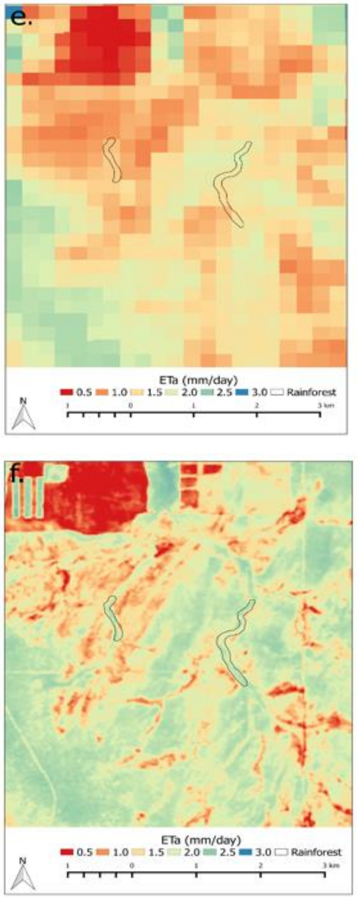
Alert level	Chlorophyll level
Green	<20 ug Chl l^{-1}
Amber	>20-50 ug Chl l^{-1}
Red	>50 ug Chl l^{-1}

NHMRC/WHO – Guidelines for recreational use


CSIRO
In-Situ Sensor Pack
AquaSAT-2
AquaSAT-1
IoT-Sat
IoT-Sat
IoT-Sat
IoT-Sat
IoT-Sat
AquaWatch Data Integration Facility
AquaWatch Australia Mission Concept
Australia (& Global) water monitoring system
• Ground sensor networks + IoT
• New EO satellites
• Data integration
GoGC, DNRME, CSIRO Meeting – 3 December 2019

Example - Landsat-MODIS blending





Waterhole persistence and quality

May

October