Australian Government
Geoscience Australia

# Earth Observations from Space and The Australian Geoscience Data Cube:

# Analysing Australia in space and time.

Dr Stuart Minchin

Geoscience Australia

# Acknowledgements

**Industry**:

- Cooperative Research Centre for Spatial Information
- Lockheed-Martin

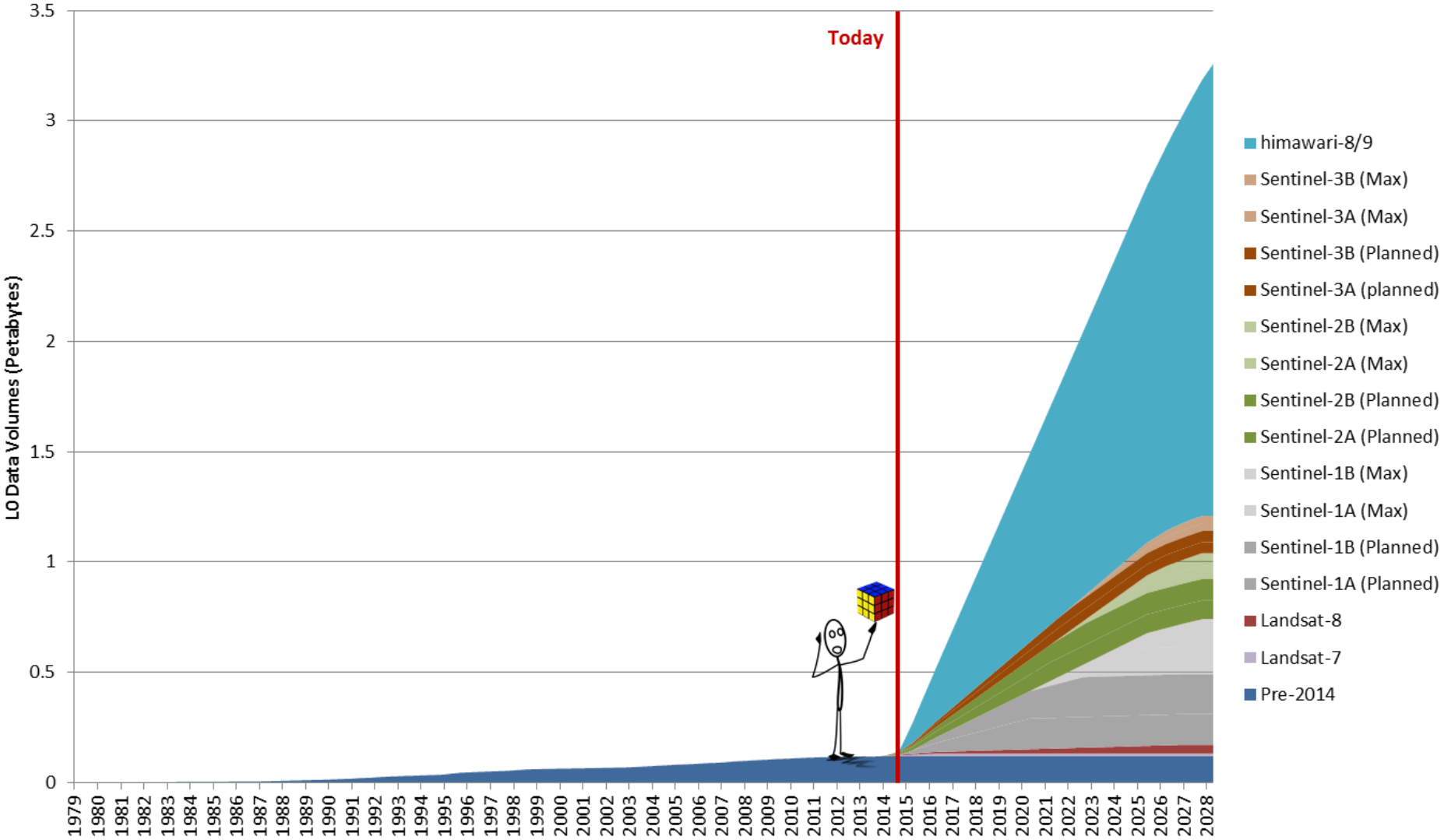
**Research**:

- CSIRO
- National Computational Infrastructure
- Victorian Partnership for Advanced Computing

**International**:

- NASA
- The United States Geological Survey

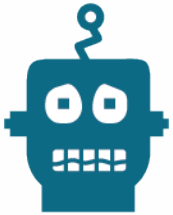
# Estimated Satellite Earth Observation Data Volumes over Australia upto 2029 - Level 0 Data



# Traditional remote sensing product process

Petabyte heirarchical archive:

Millions of individual scenes. Tape store accessed by robot.



Search catalogue order scenes.

Identify footprint of product in space or time.

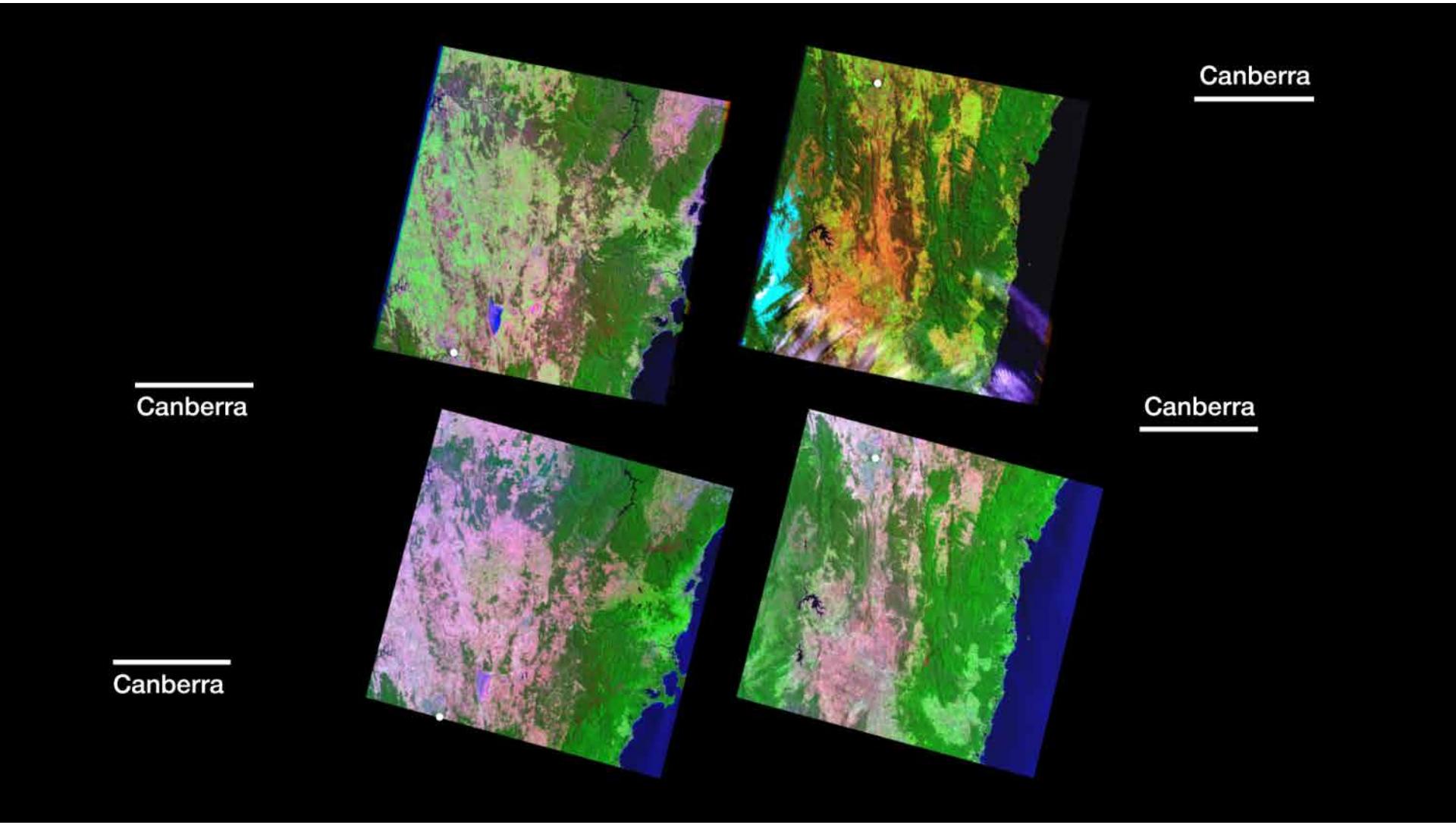
Client requests product.

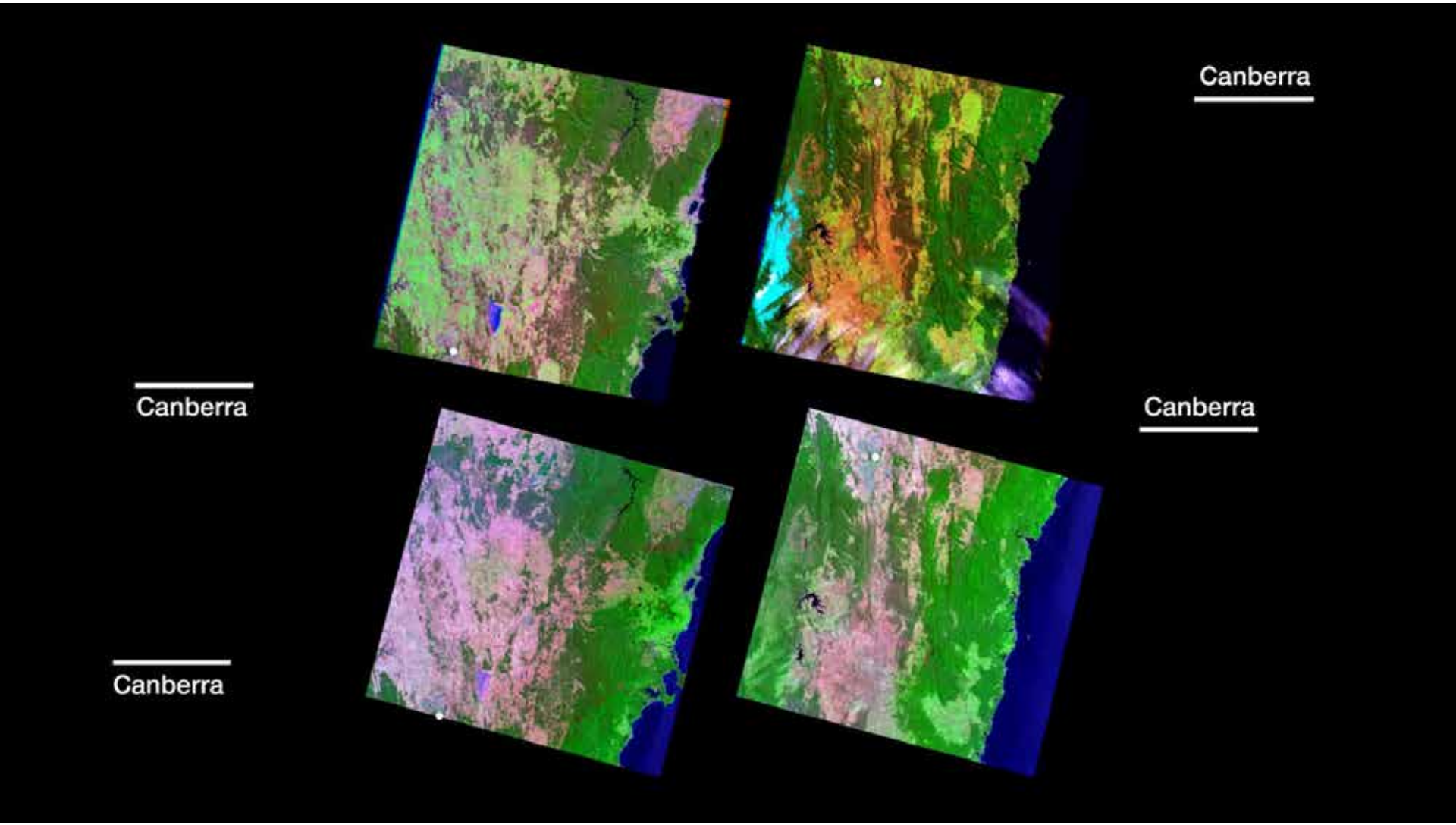
Orthorectification calibration, cloud masking, atmospheric correction, mosaicing.

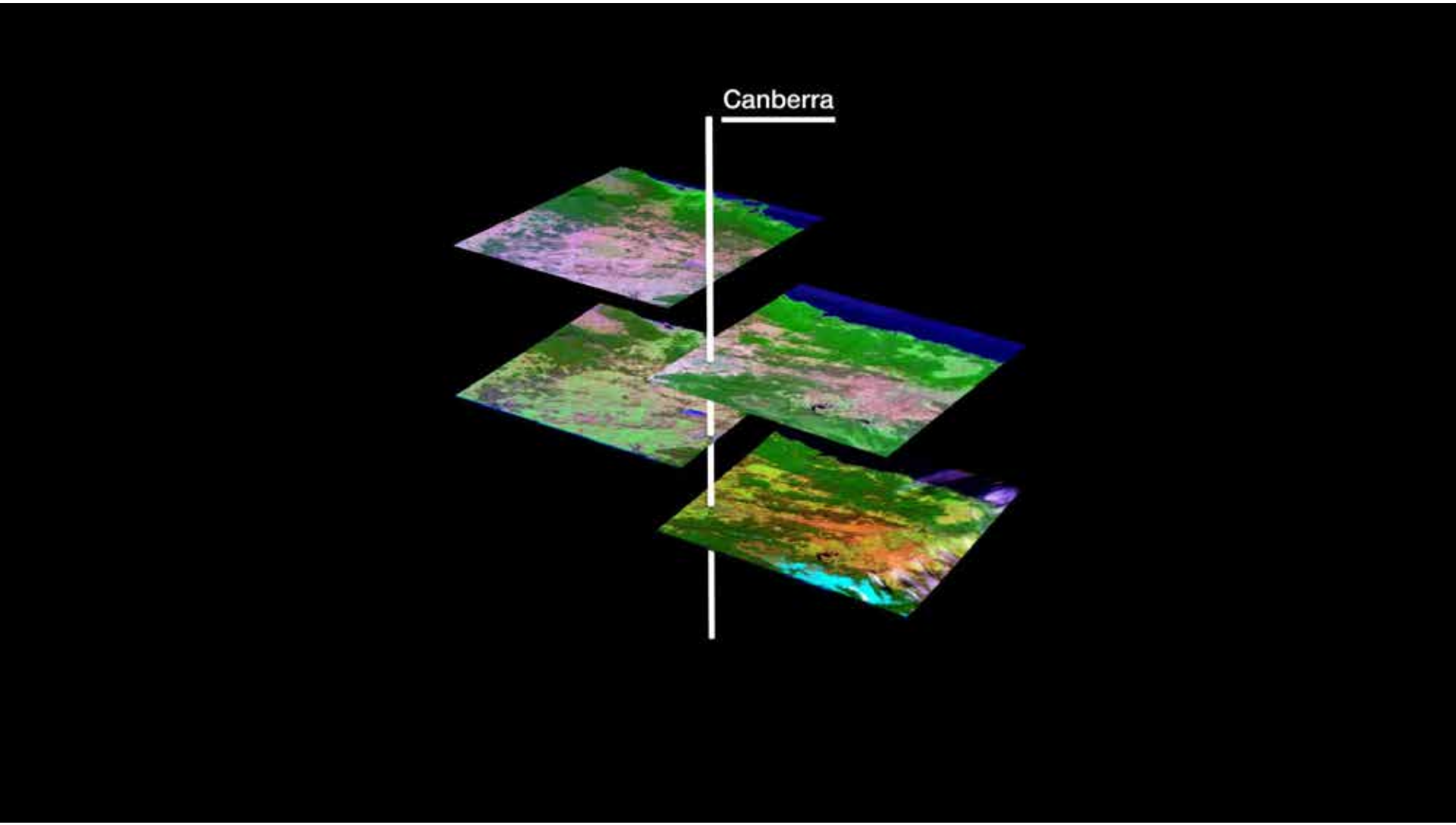
Feature extraction, algorithm application spectral unmixing.

Product packaging and delivery.

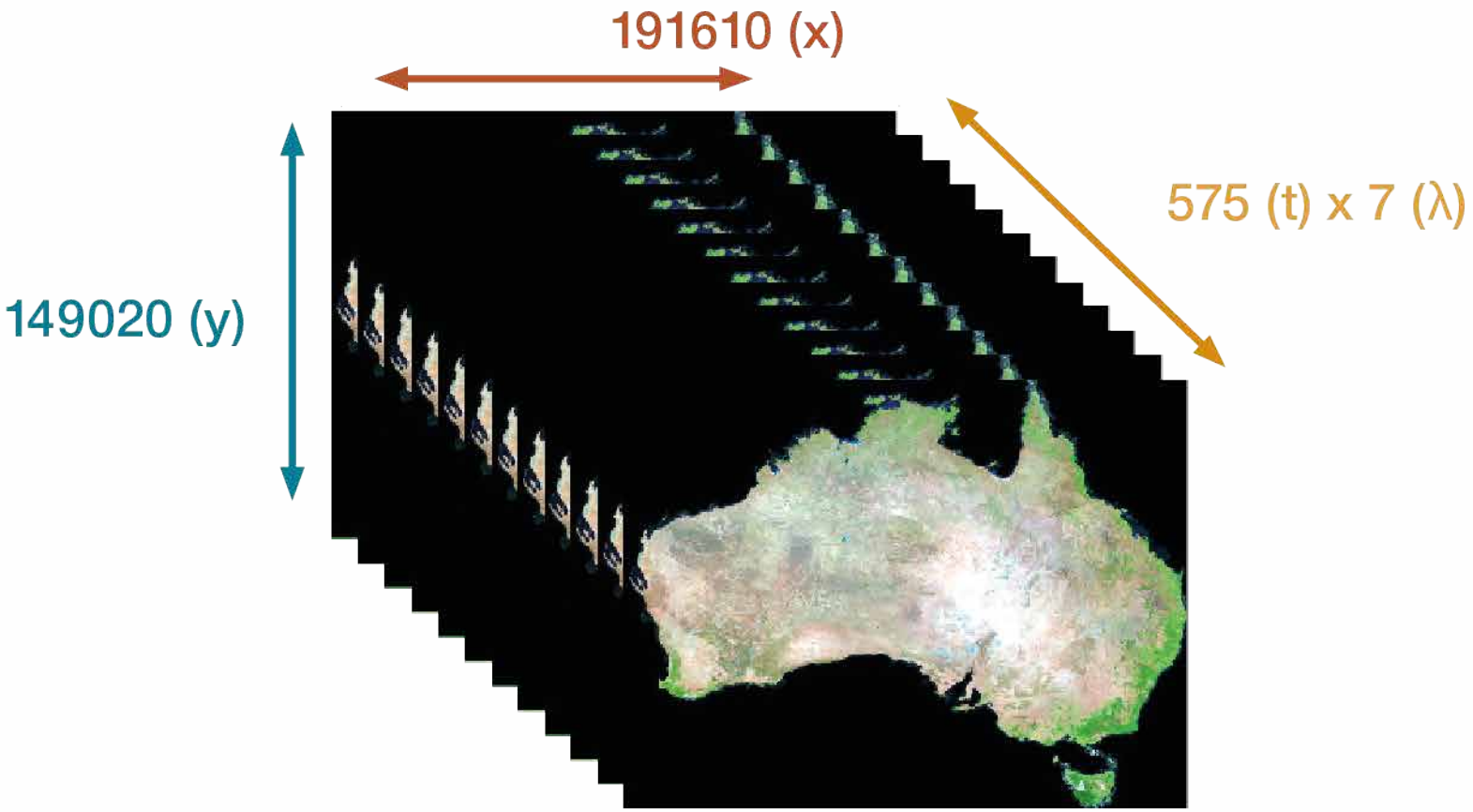
# The Data Cube Approach







# The Data Cube concept



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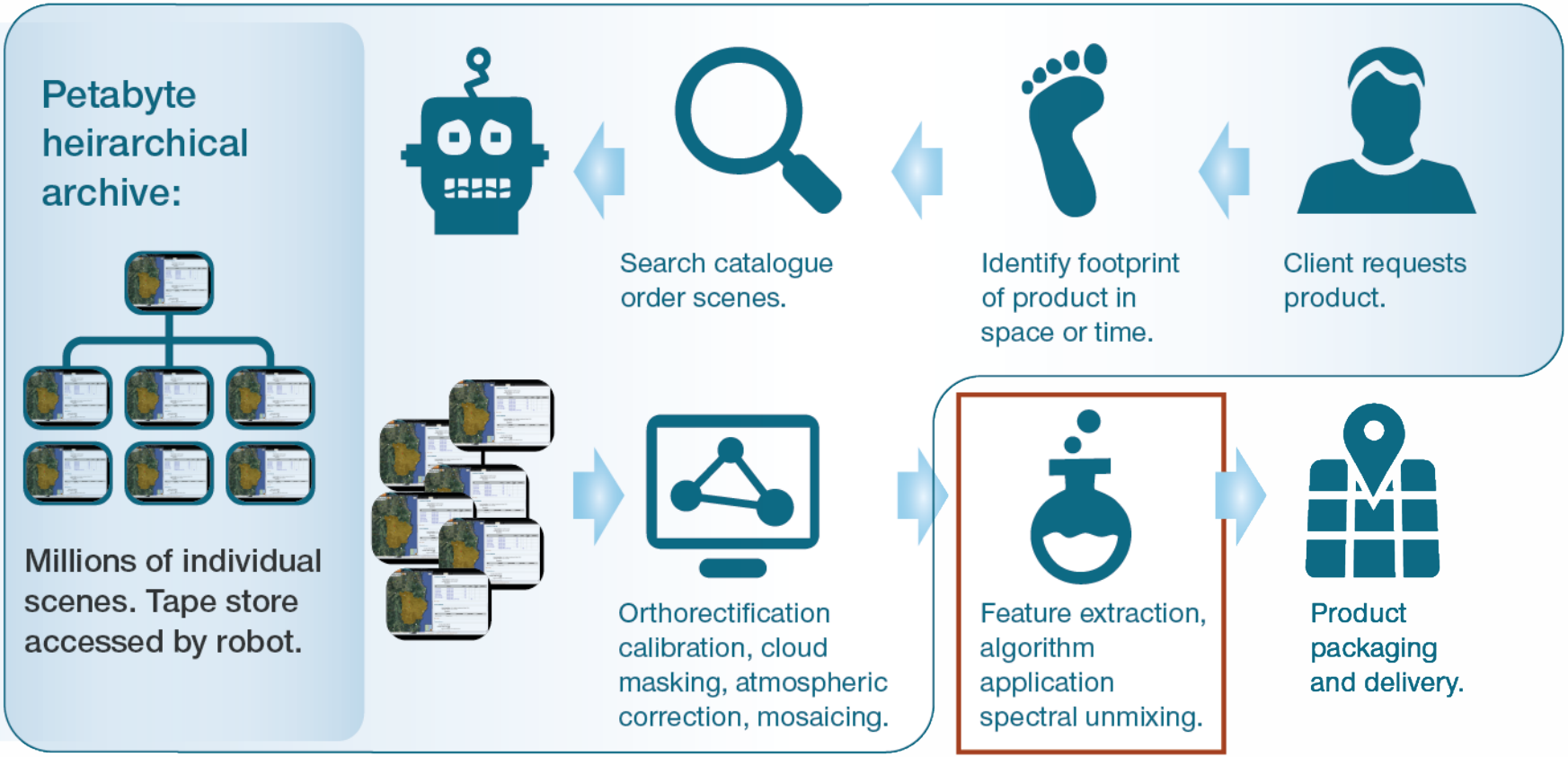


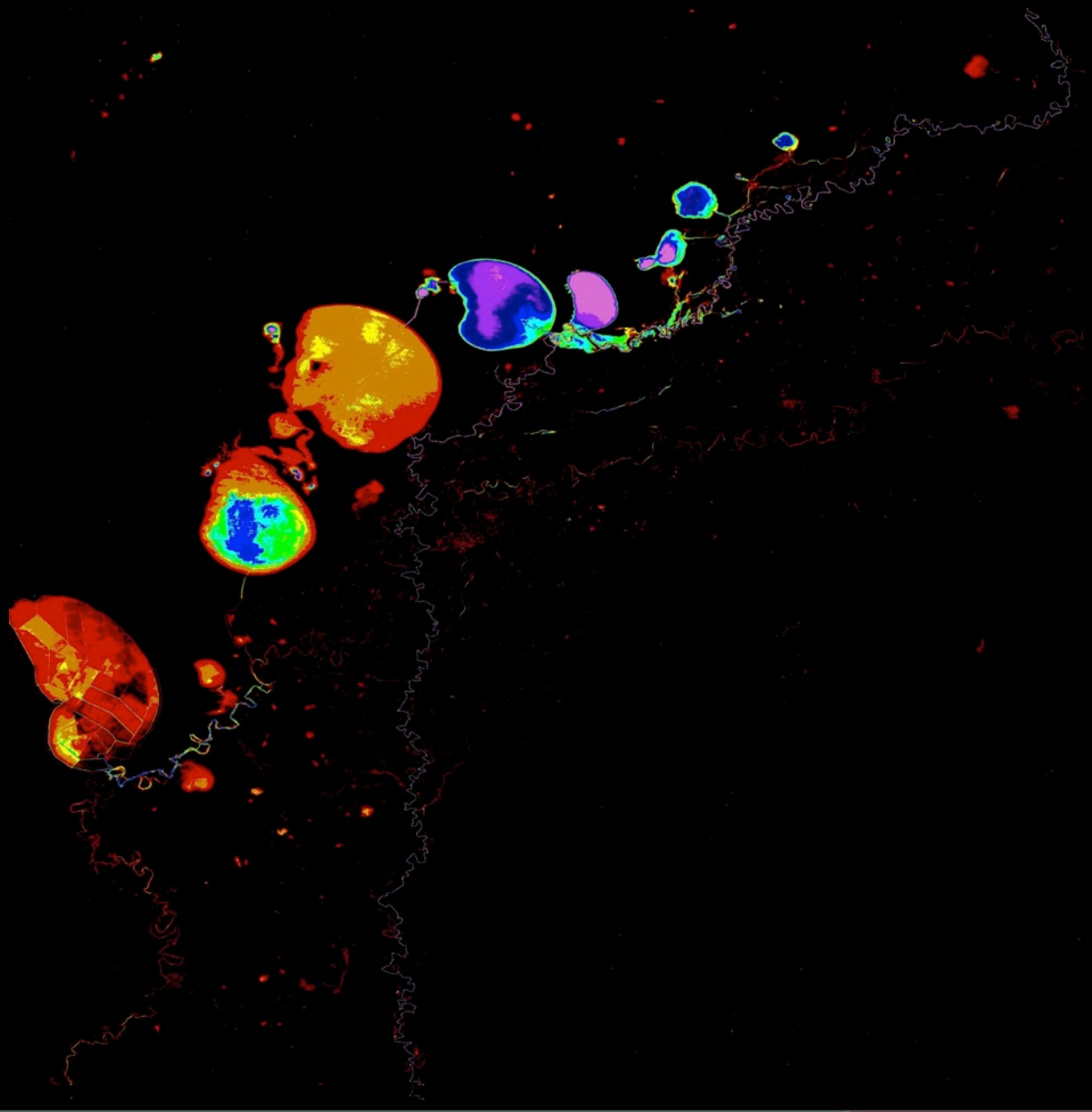
# Surface water

Menindee Lakes time series

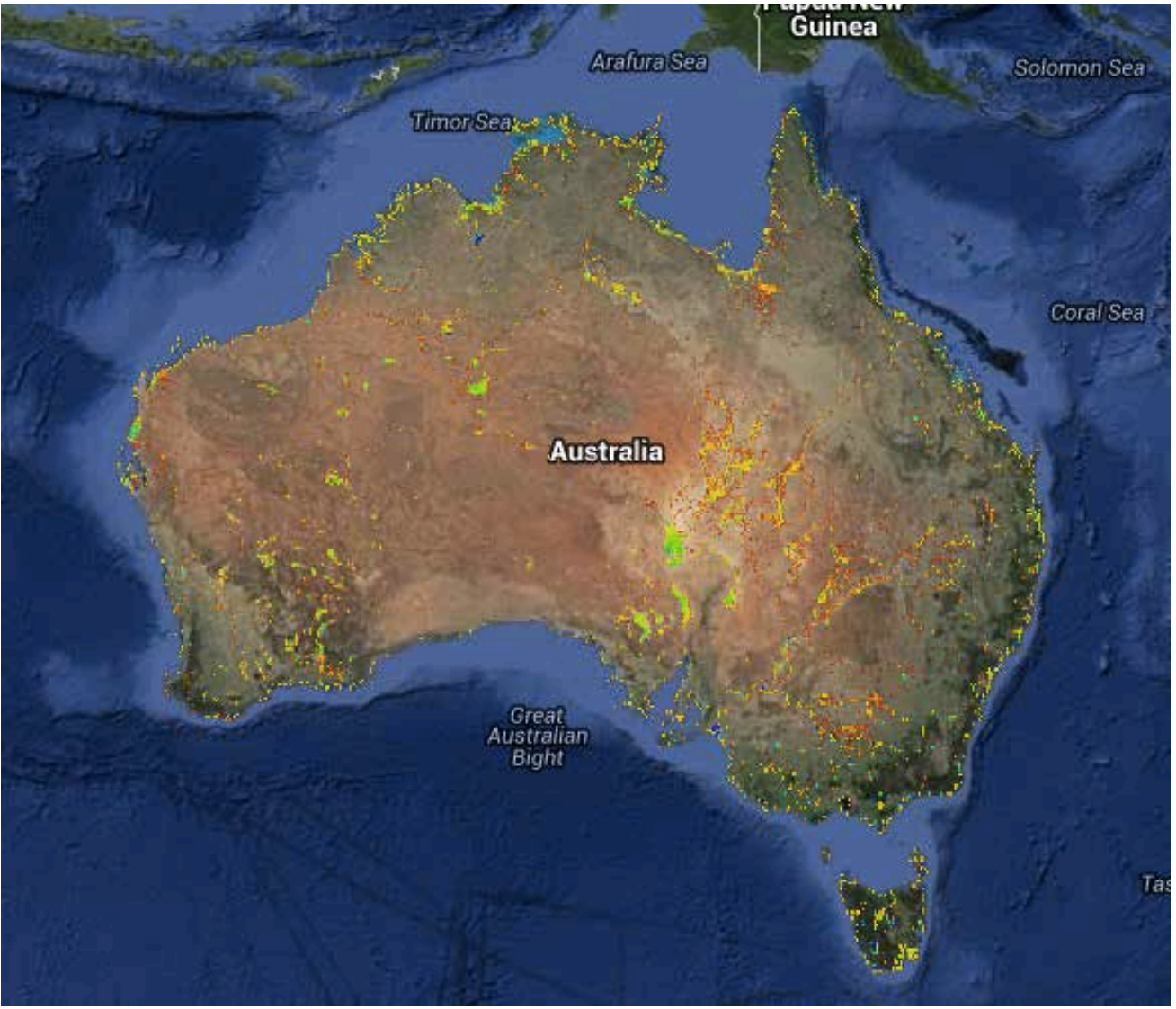
1998-2012

Total observations per grid cell ~600-1200

4000*4000 grid cells



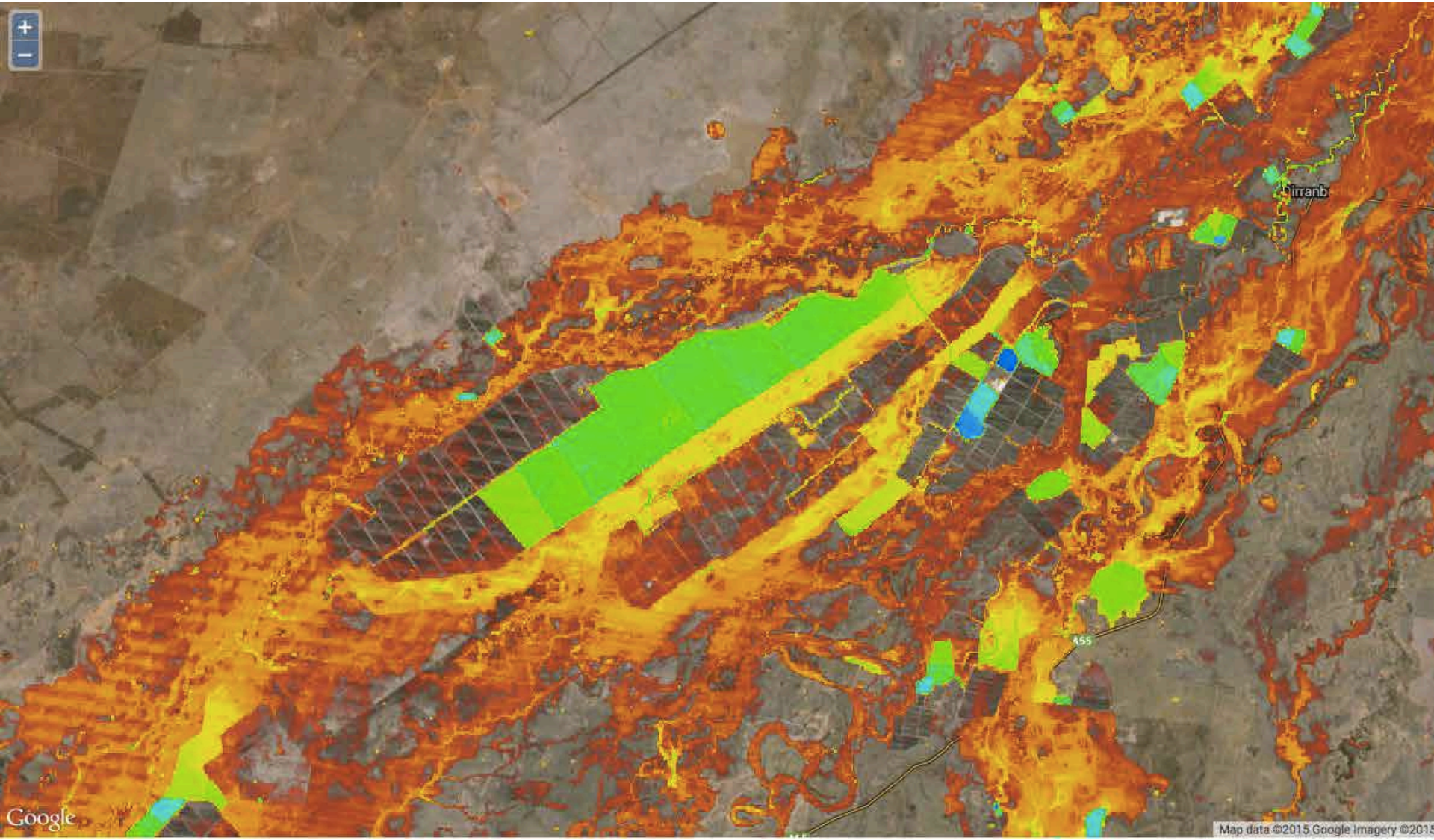
# Continental Scale Water Observations from Space




**WOFS water detection**

- **27 Years** of data from LS5 & LS7(1987-2014)
- **25m** Nominal Pixel Resolution
- Approx. 300,000 individual source ARG-25 scenes in approx. 20,000 passes
- Entire 27 years of 1,312,087 ARG25 tiles => **$93 \times 10^{12}$ pixels** visited
- **0.75 PB** of data
- **3 hrs** at NCI (elapsed time) to compute.

# Cubbie Station: floodplain water storages



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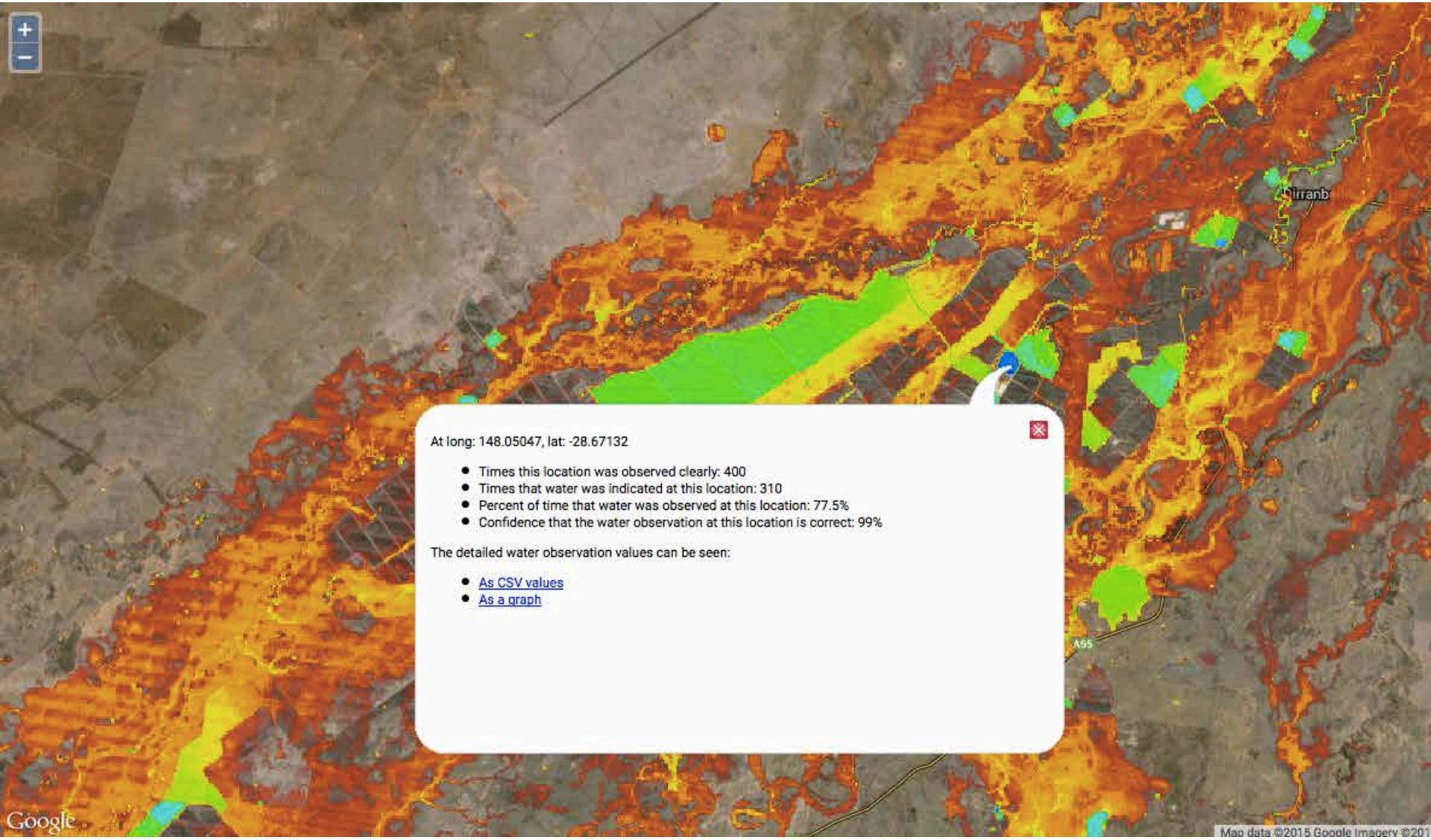

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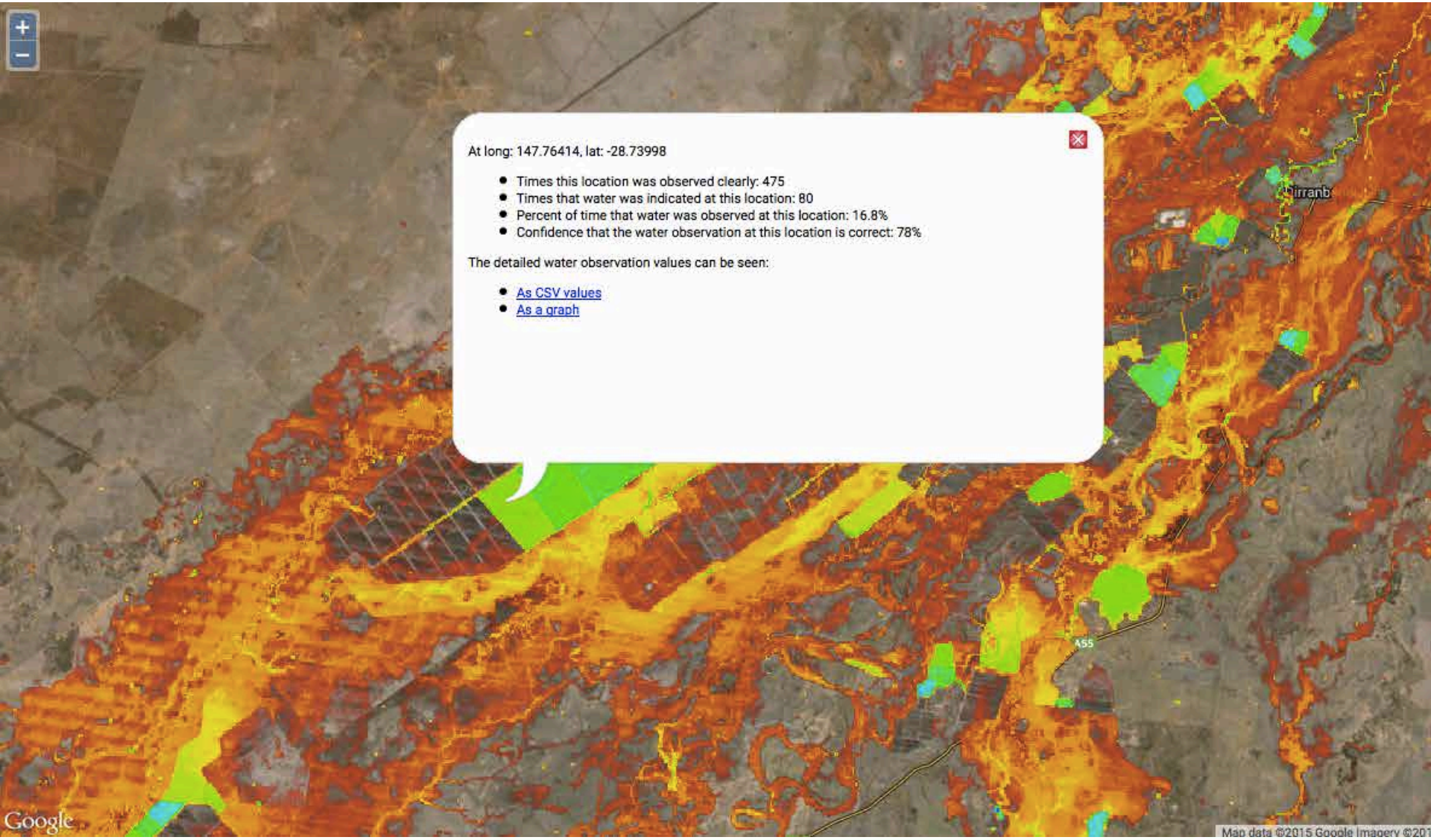
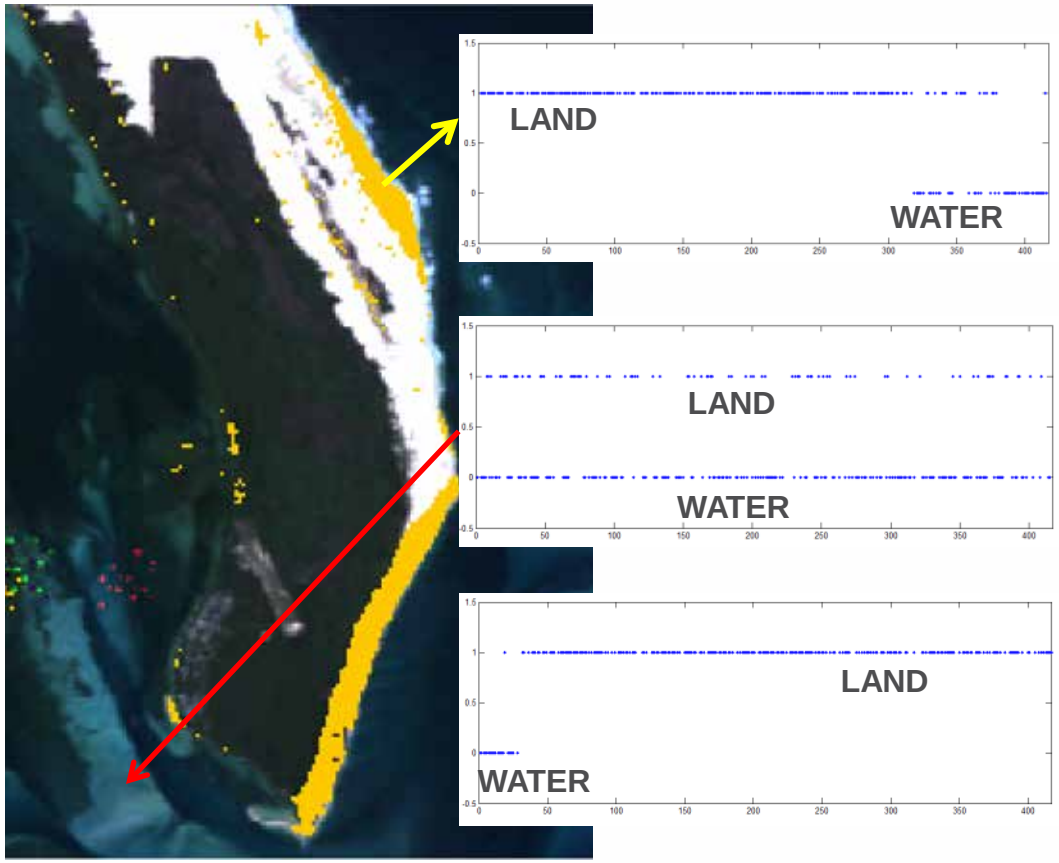
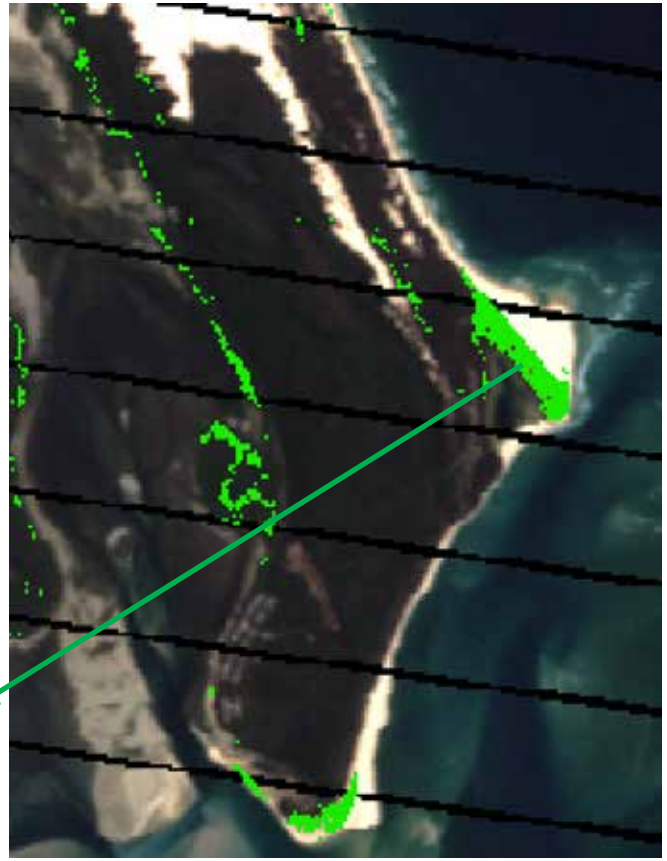


# Cubbie Station: floodplain water storages

# Coastal Change Detection



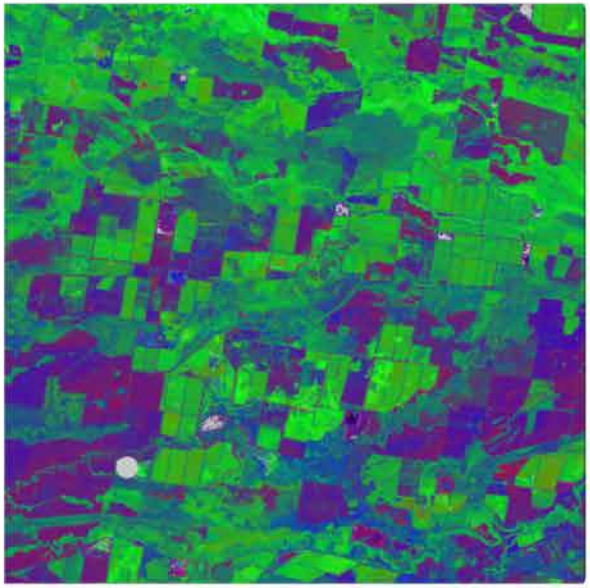



1988 Landsat 5
First Water Observation Anomaly

2013 Landsat 7
Last Water Observation Anomaly

# Land use change: Cropping patterns

Land Management – Keytah Station. ‘Fractional cover’



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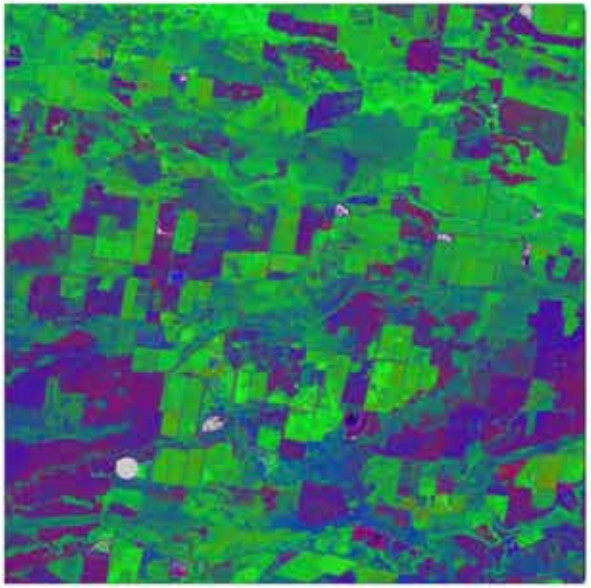

# Great Barrier Reef Water quality - history

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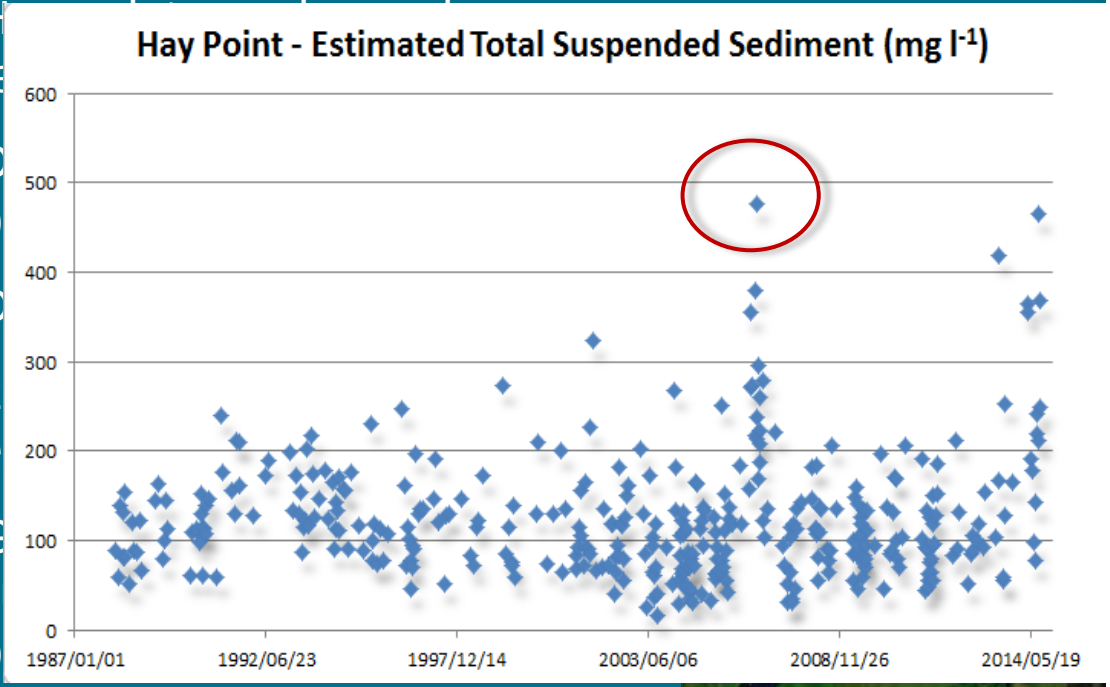
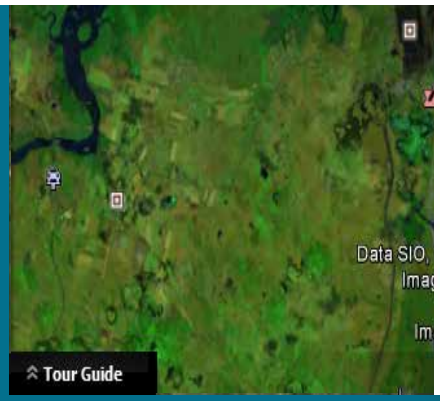
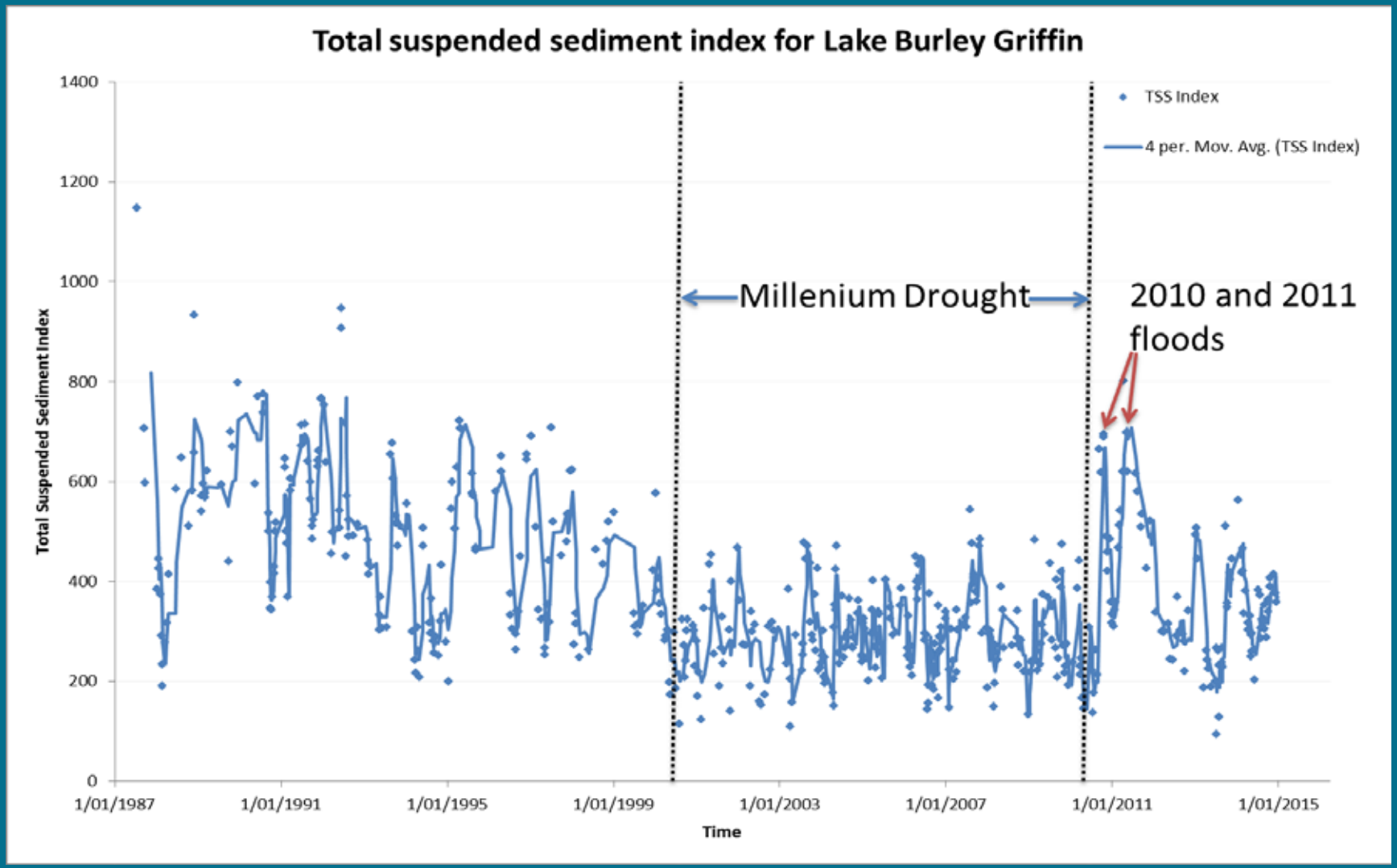




True colour image of the sediment plume produced by dredging. Image taken 27 August 2006 by Landsat Satellite.

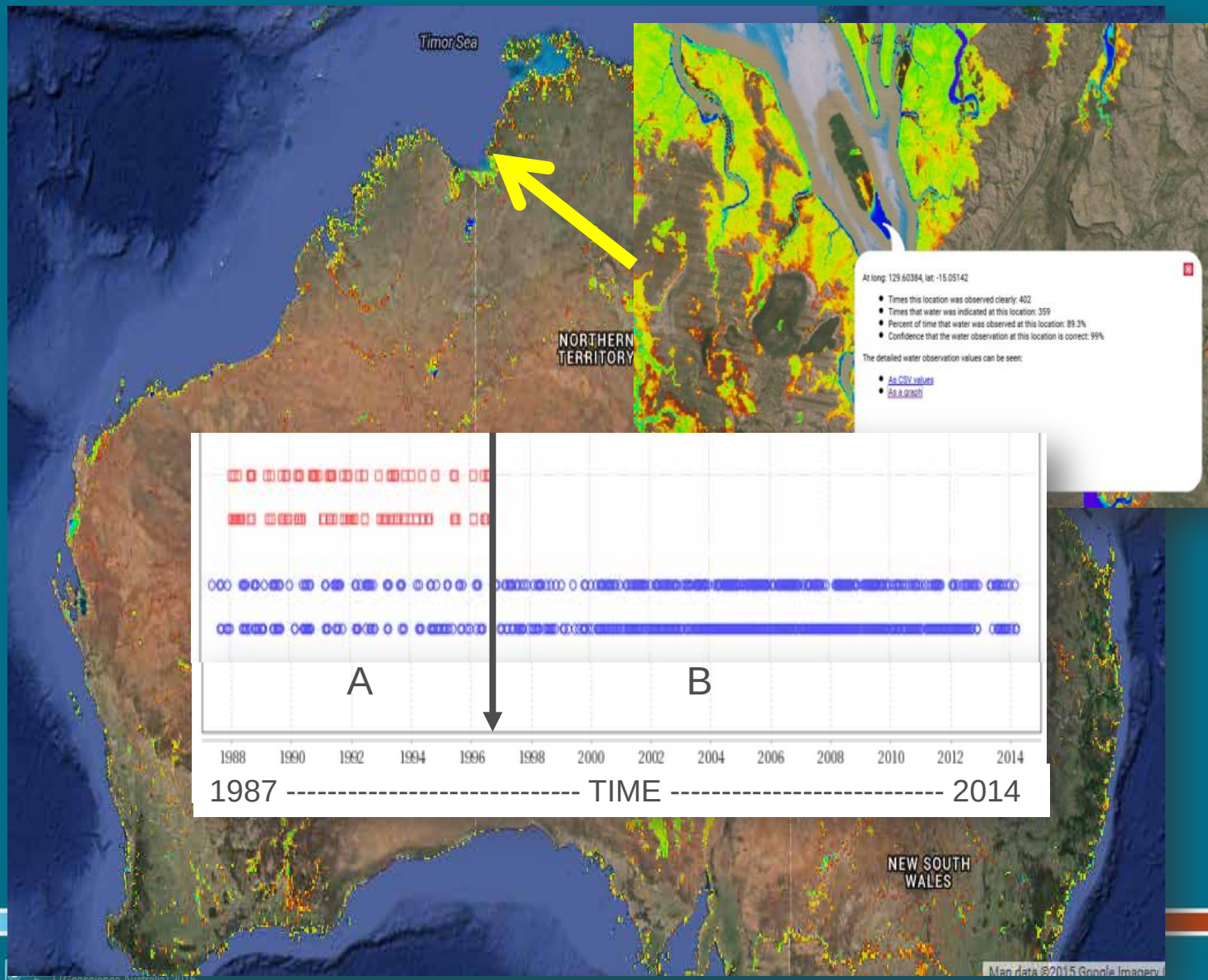
# Water quality monitoring – Lake Burley Griffin



# The potential for change detection: Mangroves

Timing and strength of change for any (data cube) variable

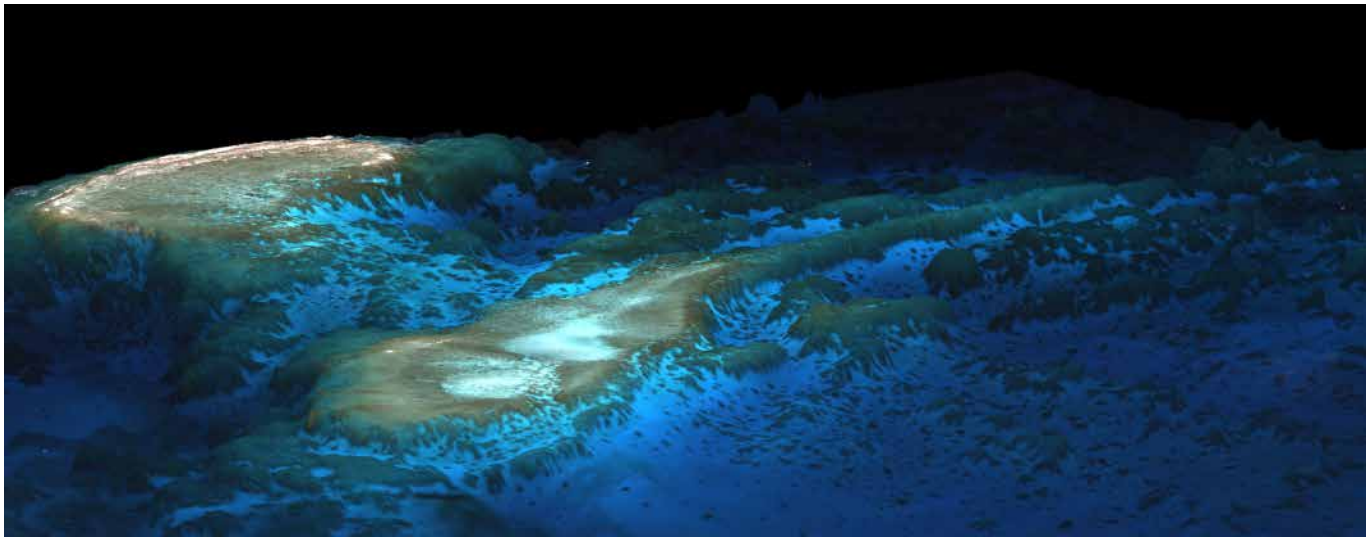
National & regional shoreline erosion studies, mangrove change mapping



# Data Cube Shallow Water Bathymetry Estimation

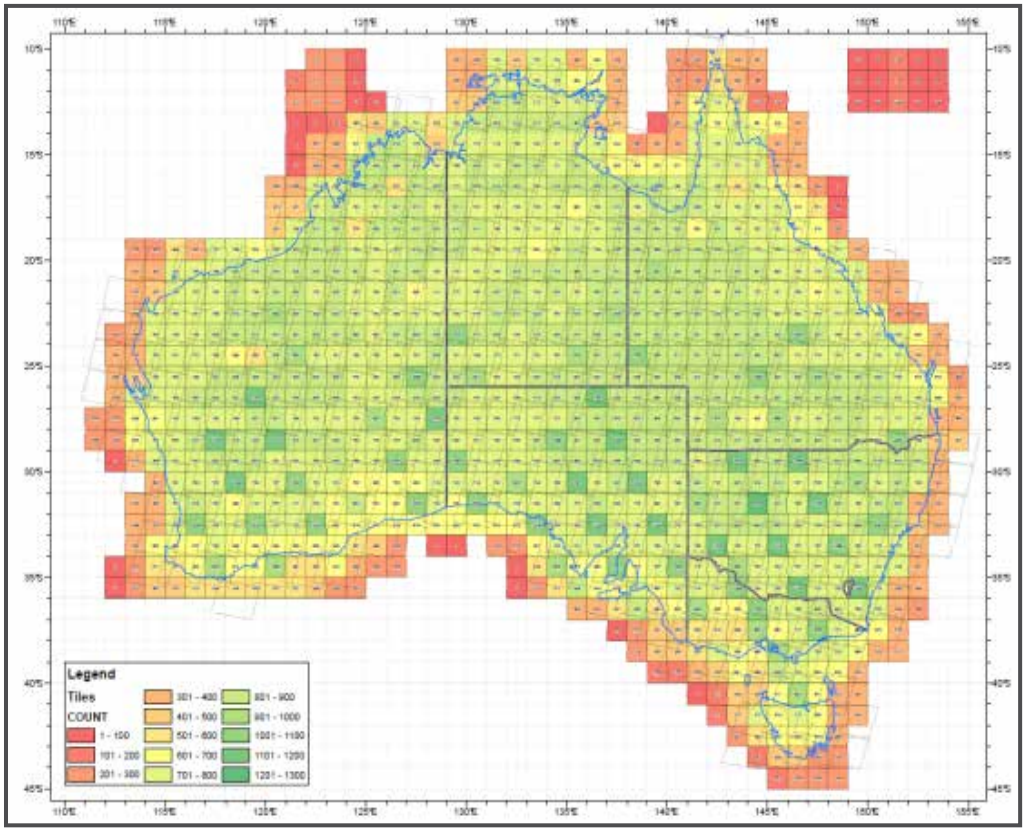
- **Adjusting Water Observations from Space to provide intertidal bathymetry**
- **Applying CSIRO's SAMBUCA algorithm to data cube**

  - This research is currently being supported through a joint CSIRO-GA project.



# Moving to a National Scale Approach

- Fundamental shift from case study projects to national scale time series approaches
- Driven by the potential of the Australian Geoscience Data Cube (AGDC)
- Landsat 5 & 7 Archive from 1987-2014
- Landsat 8 (and other) data ingestion – even more opportunities for Aquatic applications

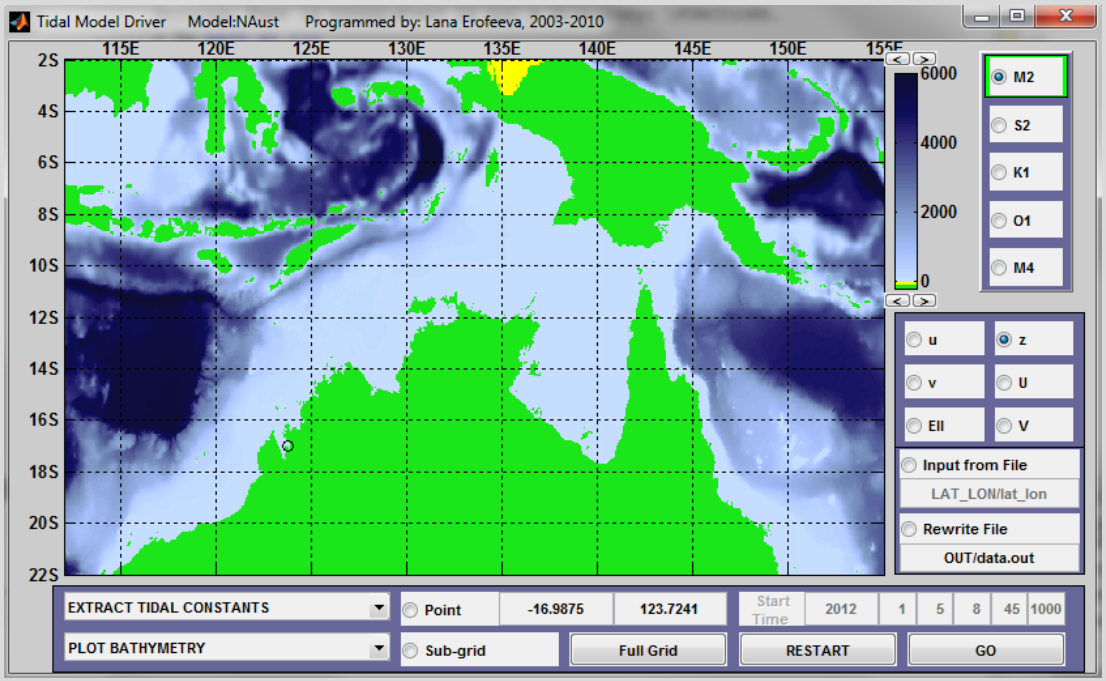


# Tidal Attribution across the Landsat Archive

## How to best model the tides for the last 27 years of observations?

- Ideally use Hydrographic Office tidal records
- Not possible for the temporal and spatial steps we need

### Oregon State University Tidal Inversion Software




- A tidal harmonics based regionally validated model with <5cm RMSE misfit
- Our testing against the Hydrographic Office Austides record show a RMSE misfit of ~12cm

Can be implemented on the AGDC for automatic tidal attribution of each scene

# Using tidal models to map tidal extents

Tidal Range of >10m

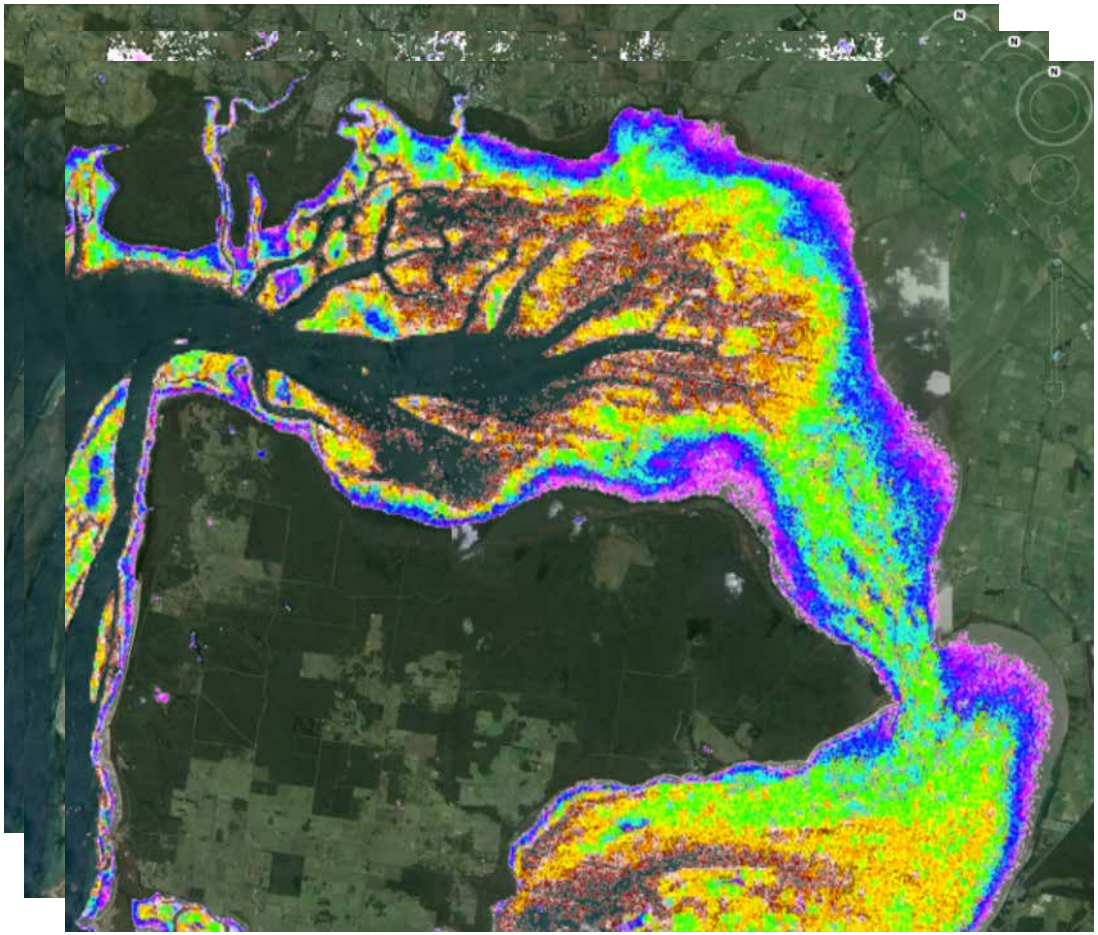
## Tidal Zone Extent

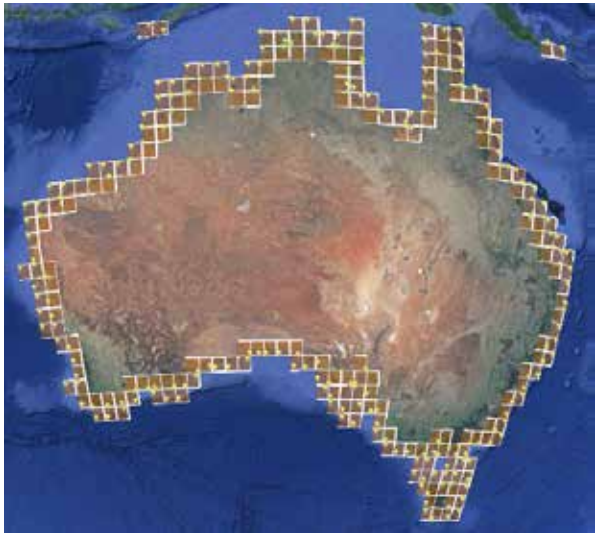
Can be attributed with offsets of LAT to lowest observed tide and HAT to highest observed

## Tidal Zone Morphology

Fraction of water observations over the time series. Can we attribute this with depths?

# Adjusting Water Observations from Space to provide intertidal bathymetry

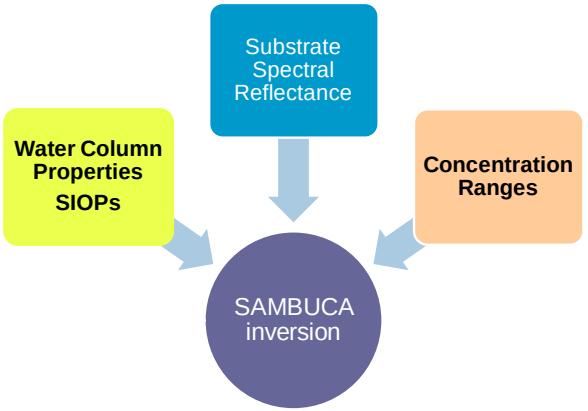




# Physics-Based Inversion for Bathymetry Estimation

A methodological approach

- *Characterization of coastal waters and substrates*
- *Model parameterization*
- *Remote sensing imagery data inversion*



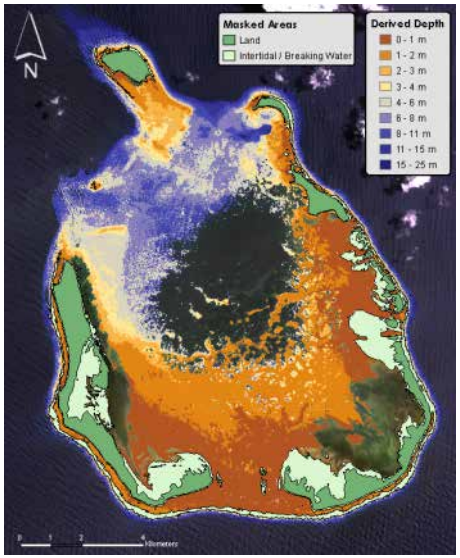

## Semi Analytical Model for Bathymetry Unmixing and Concentration Assessment

SAMBUCA is an enhancement (by Brando et al. 2009) of the inversion/optimization method by Lee *et al.* (1998; 1999; 2001) to enable:

- Retrieval of chlorophyll-a, CDOM and NAP concentrations
- Pure and mixed substratum-type compositions
- Retrieval of vertical attenuation (for optically deep water)
- Retrieval of bathymetry
- Estimating the contribution of the substratum-type to the remote sensing signal (SDI)

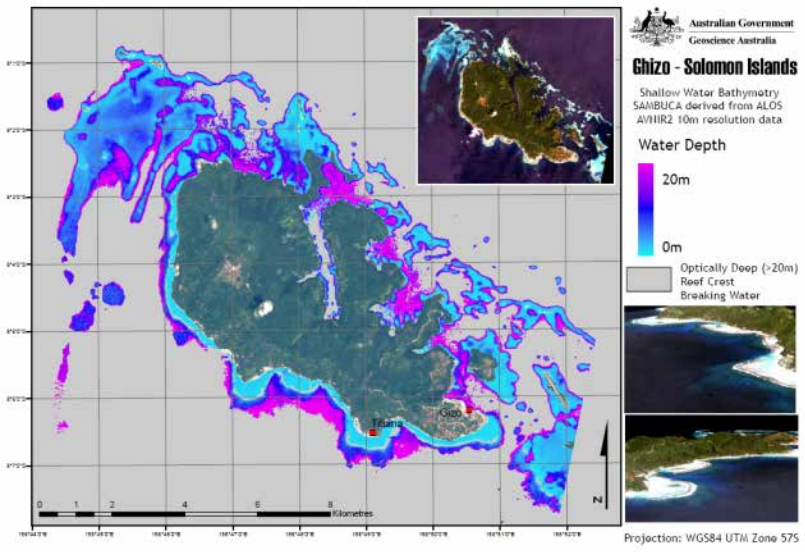
# Aquatic Remote Sensing in NEMO

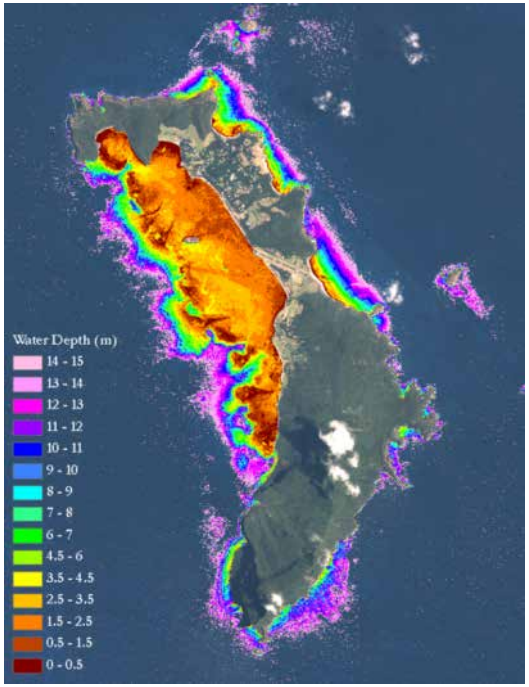
Previous work has centred around physics-based shallow water bathymetry estimation from high-resolution remote sensing data in case-study applications




Cocos (Keeling) Island
*ATWS*

Ghizo Island, Solomons
*AusAID*




Lord Howe Island
*Marine Biodiversity Hub*


# Establishing National Databases

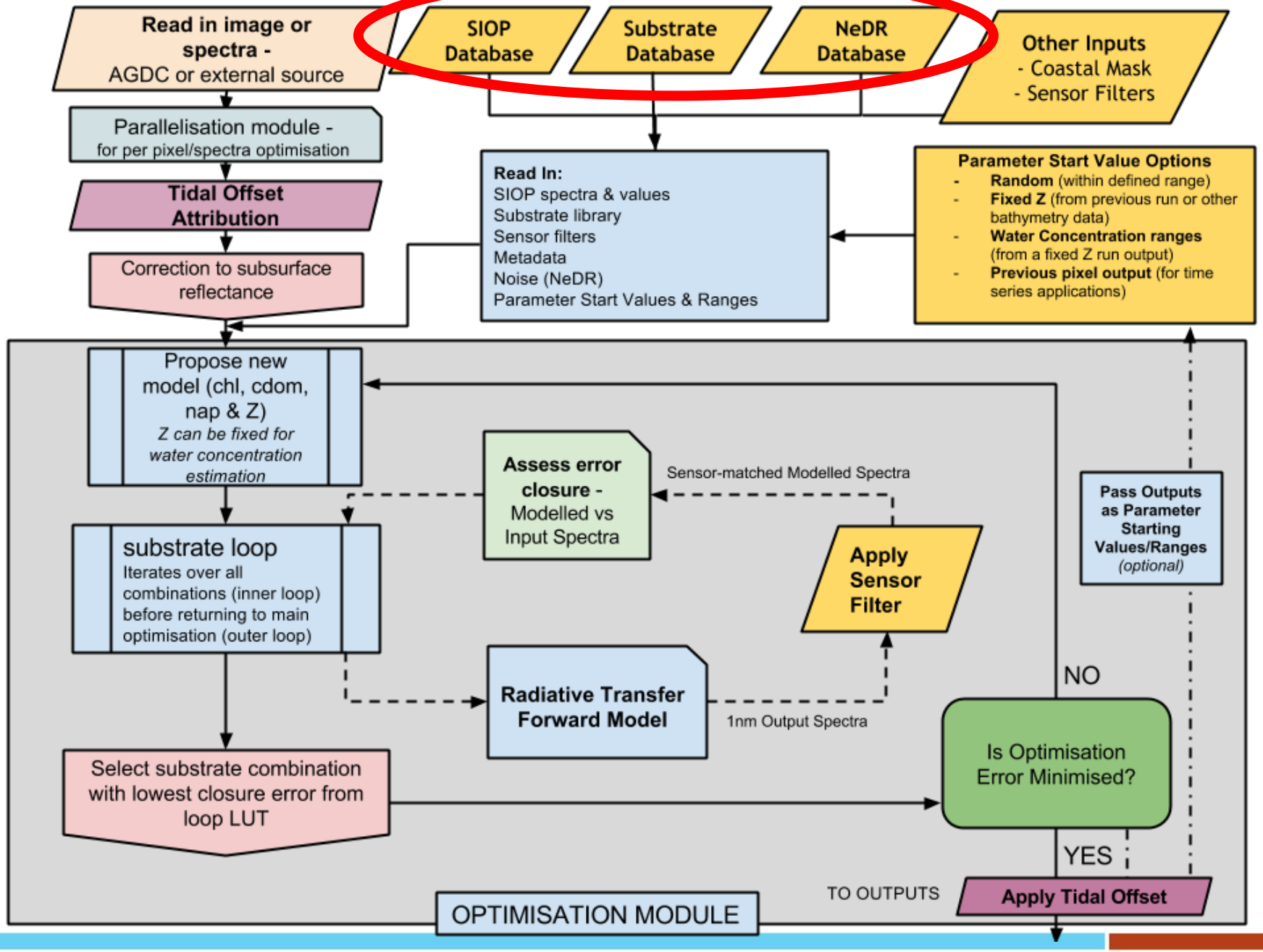
3 work packages being developed at CSIRO/GA:

Generic geographically tagged databases of SIOP (water quality), Substrate Libraries and Noise Characteristics *for* Landsat data.


Moore, T. S., J. W. Campbell & M. D. Dowell (2009) A class-based approach to characterizing and mapping the uncertainty of the MODIS ocean chlorophyll product. *Remote Sensing of Environment,* 113**,** 2424-2430.

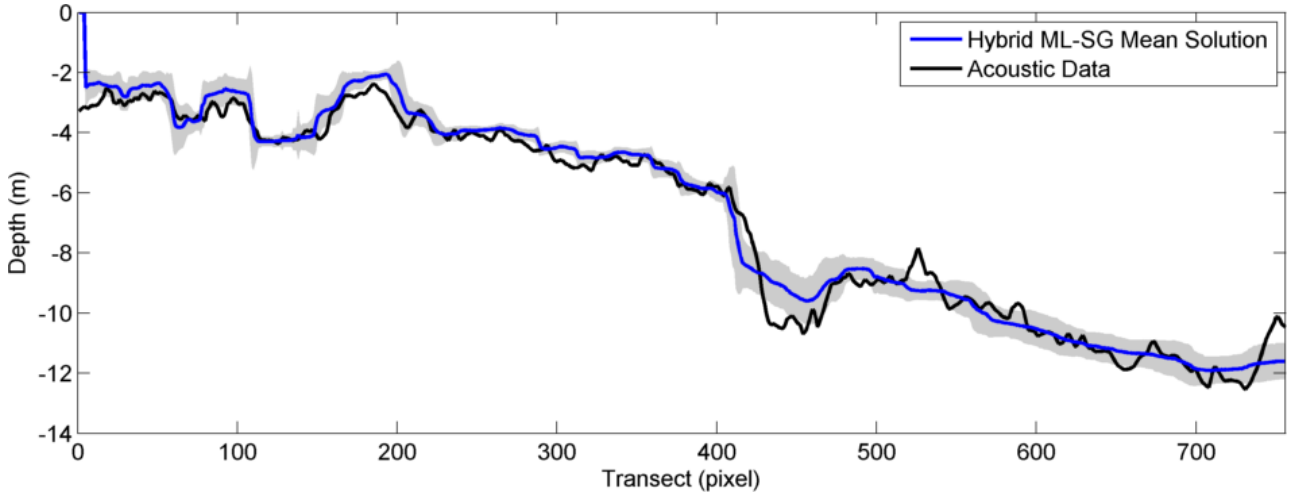
Botha, E.J., Brando, V.E., Anstee, J.M., Dekker, A.G. and Sagar, S. (2013) Increased spectral resolution enhances coral detection under varying water conditions. Remote Sensing of Environment. 2013; 131:247-261. (details of the normalised Spectral Separability Metric).

Mount R, Bricher P & Newton J. 2007. NISB Habitat Classification Scheme. Report to the National Land and Water Resources Audit. http://lwa.gov.au/products/pn21267



# Benefits of using the AGDC

- Time Series Analysis can assist to regularize the inversion solution
- Ensemble results enable analysis of uncertainty




Physics based processing is still challenging with Landsat Data, due to

Noise, Spatial Scale, Spectral and Radiometric Resolution

We are establishing a framework to enable processing on the NCI with any data that is ingested into the data cube

# Some (already identified) applications for the data cube:

- Vegetation change, agricultural production
- Flood inundation mapping, farm dam development
- Wetland management and characterisation
- Carbon accounting
- Seagrass and substrate mapping
- Coastal change and water quality
- Shallow water bathymetry
- Mining footprint and urban development
- Bushfire scar mapping and forestry inventory
- Location-specific products for mobile platforms
  - “Map my paddock”

# What questions do YOU have?..... J