Production of CEOS Analysis Ready Data for Land (CARD4L): Geoscience Australia's Experience with Optical Data from Landsat and Sentinel-2

Medhavy Thankappan, Josh Sixsmith, Guy Byrne, Fuqin Li, Lan-Wei Wang, Andrew Walsh, Mark Broomhall, Jeremy Hooke, Passang Dorji, Simon Oliver, Andreia Siqueira, Adam Lewis

CARD4L background

LSI-VC served as the forum for developing the CEOS Analysis-Ready Data definition (now known as CARD4L – CEOS Analysis-Ready Data for Land)

The CARD4L definition and the overall framework were endorsed at the CEOS Plenary in 2016

CARD4L underpins future data architectures work being progressed within CEOS, enabling many users to more rapidly use data and help space agencies to maximise the potential of their data.

Work on ARD standards across CEOS kicked-off with the development of specifications for Product Families under CARD4L

CARD4L is part of a broader CEOS ARD Strategy

CARD4L introduction

CEOS Analysis Ready Data for Land (CARD4L) are satellite data that have been processed to a minimum set of requirements and organised into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets.

CARD4L offers numerous benefits for data producers, data distributors, and data users.

Data Producers
Increase Uptake
Increase Impact
Stay Relevant
Increase Efficiency
Enable Interoperability

Data Distributors
Platform Appeal
Consistent Data Sets

Data Users
Save Time and Effort
Capitalise on Experts
Minimise Costs
Consistent Data Sets

More info: http://ceos.org/ard/
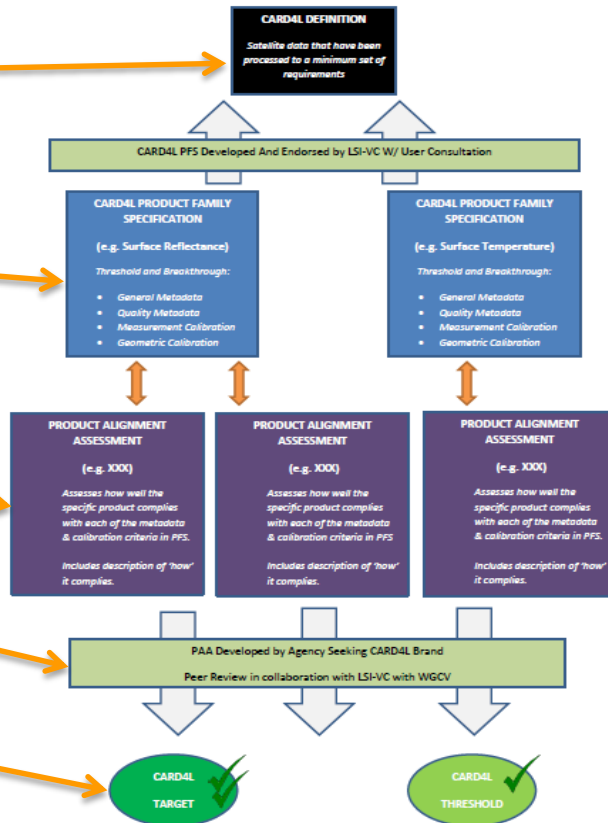
CARD4L framework

CARD4L Definition

Product Family Specifications (PFS)
- Optical Surface Reflectance (CARD4L-OSR)
- Surface Temperature (CARD4L-ST)
- Normalised Radar Backscatter (CARD4L-NRB)
* Additional SAR PFSs are under consideration

Providers self-assess how well their products meet the specifications

Providers submit self-assessment to LSI-VC and WGCV for peer review

CARD4L-compliant stamp!

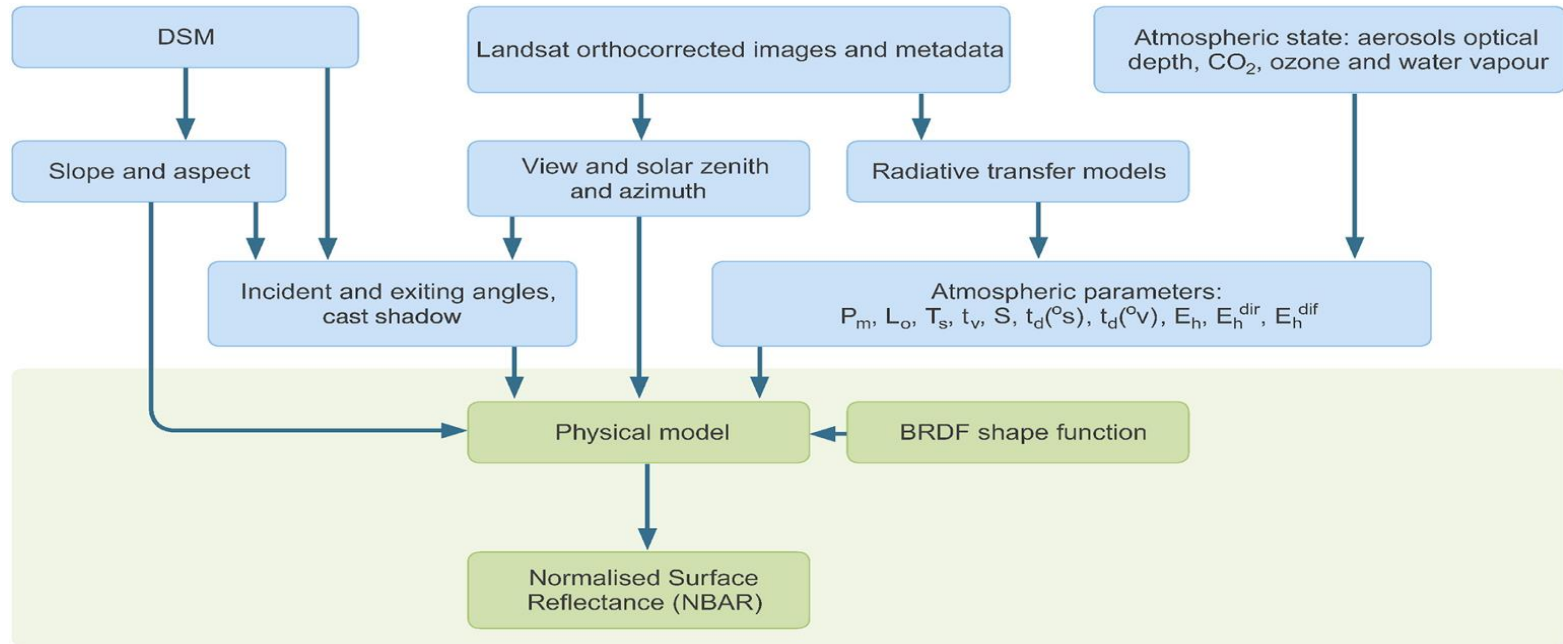**CARD4L DEFINITION**

Satellite data that have been processed to a minimum set of requirements

CARD4L PFS Developed And Endorsed by LSI-VC W/ User Consultation

CARD4L PRODUCT FAMILY SPECIFICATION

(e.g. Surface Reflectance)

Threshold and Breakthrough:
- *General Metadata*
- *Quality Metadata*
- *Measurement Calibration*
- *Geometric Calibration*

CARD4L PRODUCT FAMILY SPECIFICATION

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PRODUCT ALIGNMENT ASSESSMENT

(e.g. XXX)

Assesses how well the specific product complies with each of the metadata & calibration criteria in PFS.

Includes description of 'how' it complies.

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PAA Developed by Agency Seeking CARD4L Brand

Peer Review in collaboration with LSI-VC with WGCV

CARD4L TARGET

CARD4L THRESHOLD

Digital Earth Australia

Structured time-series

Observations

Analysis Ready Data

Products

Information for decisions

Reporting

Web services

Write code

Surface reflectance correction process
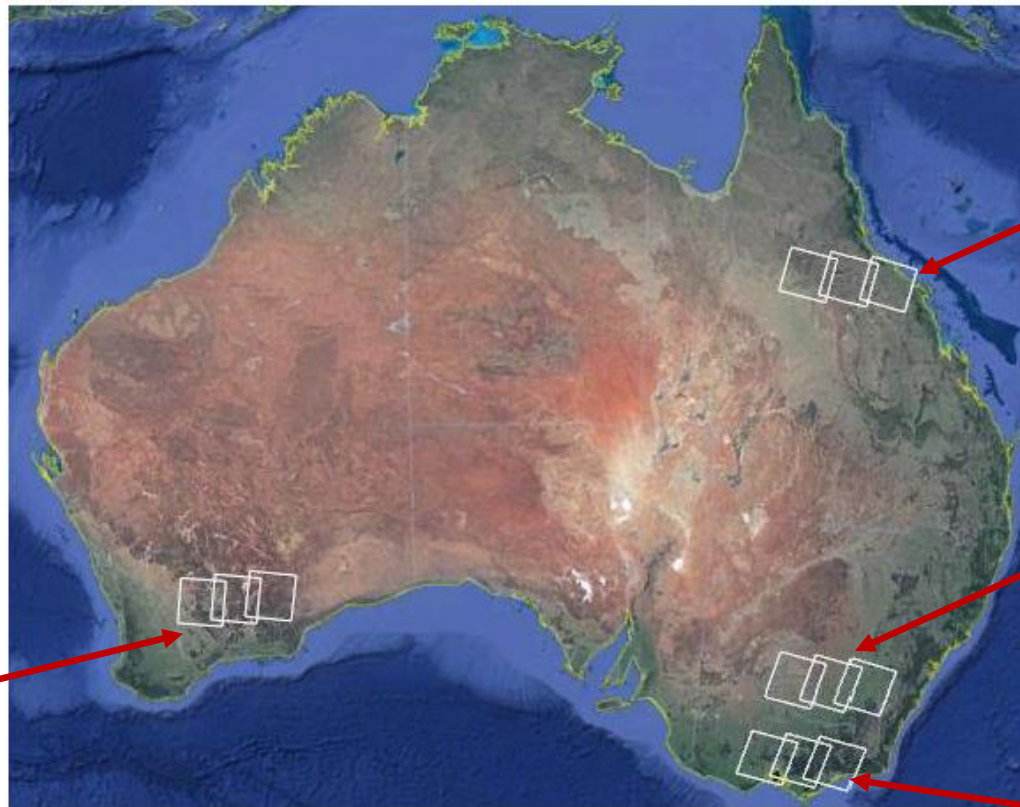

Atmospheric and BRDF correction for Landsat: Li et al., RSE 2012
https://www.sciencedirect.com/science/article/abs/pii/S0034425712002544?via%3Dihub

Improved BRDF correction: Li et al., RSE 2017
https://www.sciencedirect.com/science/article/pii/S0034425717301359?via%3Dihub

Surface reflectance sensitivity analyses

Total 10000
Landsat 5,7 &8
scenes tested

Path 094-096, Row 074
median BRDF area

Path 091-093, Row 084
median BRDF area

Path 108-110, Row 082
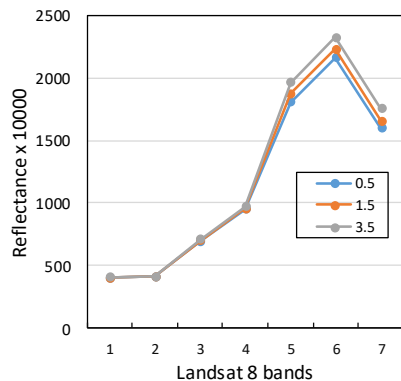Low BRDF area

Path 091-093, Row 086
high BRDF area

Surface reflectance sensitivity results

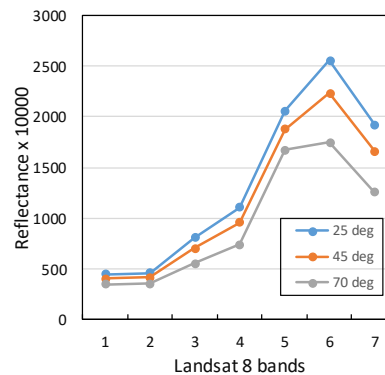| Parameters	Low	Medium	High
Aerosol optical depth	0.05	0.25	0.50
Water vapor (g/cm^2)	0.5	1.5	3.5
Solar angle	25	45	70
BRDF	low	medium	high

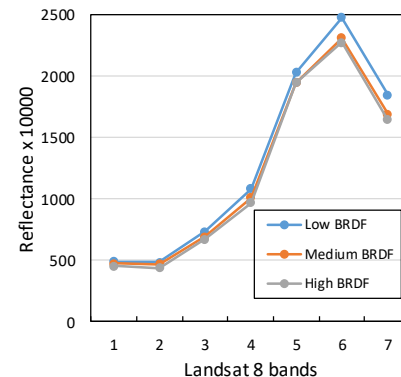**Mean surface reflectance at different aerosol values**
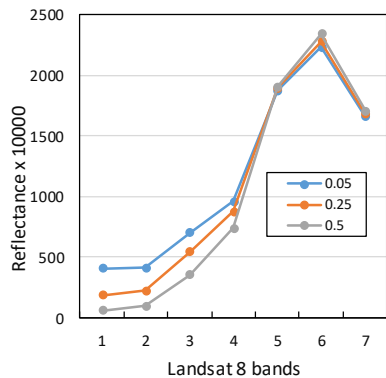
Mean surface reflectance at different water vapour values

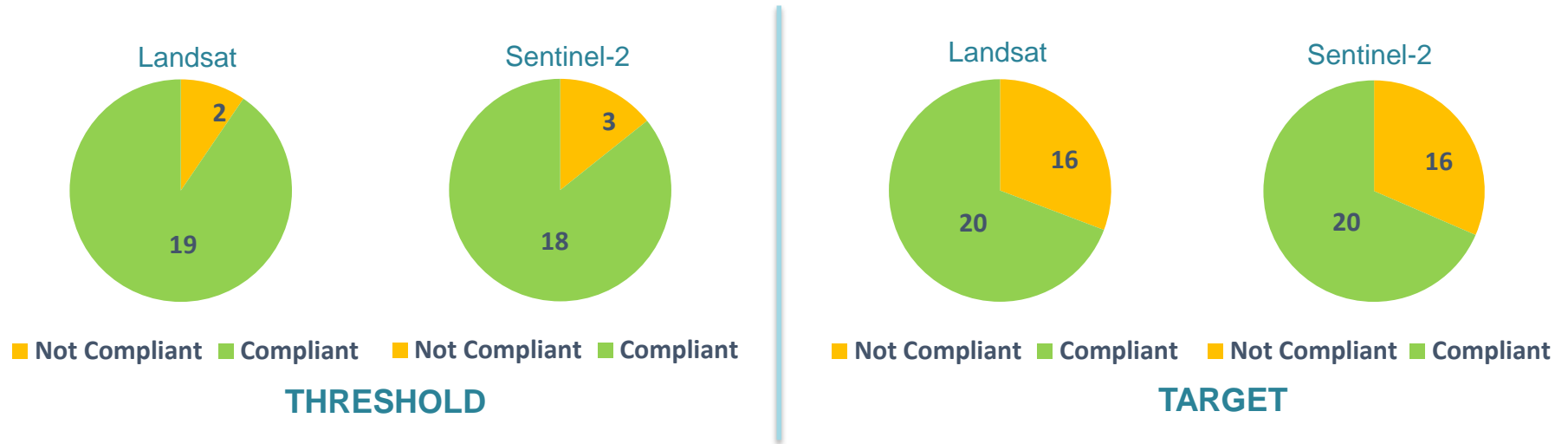**Mean surface reflectance at different values of solar angle normalisation**

Mean surface reflectance at different BRDF levels

CARD4L self-assessment

Self-assessment of GA Landsat and Sentinel-2 SR products against CARD4L specifications

Landsat

2
19

■ Not Compliant ■ Compliant

Sentinel-2

3
18

■ Not Compliant ■ Compliant

THRESHOLD

Landsat

16
20

■ Not Compliant ■ Compliant

Sentinel-2

16
20

■ Not Compliant ■ Compliant

TARGET

Working with CEOS LSI-VC & WGCV to progress work on the CARD4L peer-review process

Landsat collection upgrade

Up-to-date software / calibration, savings on resources, consistency with USGS
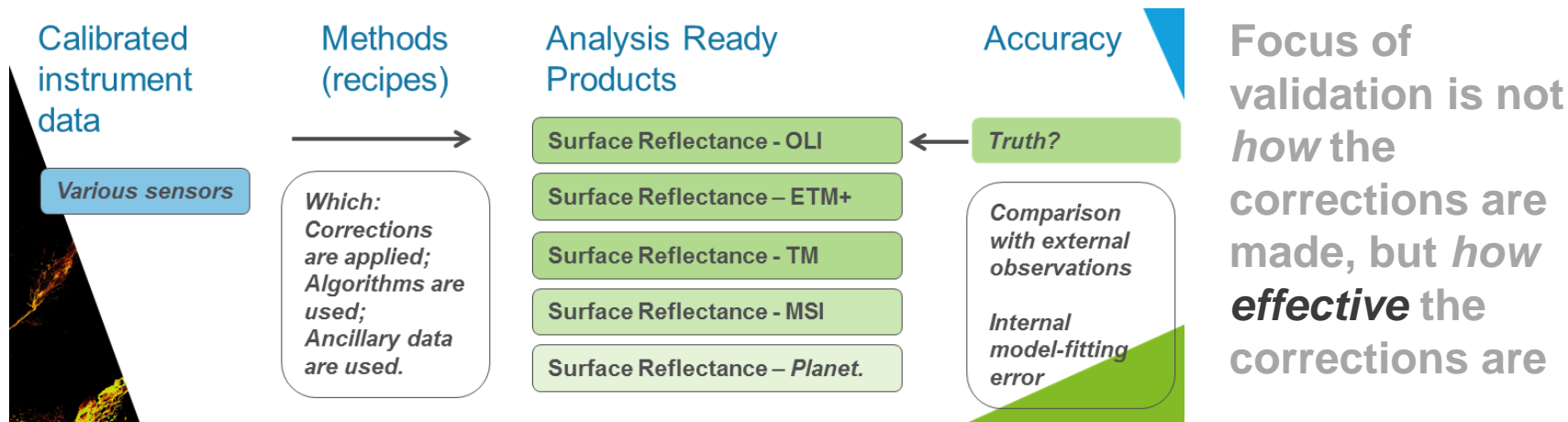
Upgraded collection will have a single product that includes:

- Two flavours of surface reflectance:
    - NBAR (Nadir BRDF Adjusted Reflectance)
    - NBART (NBAR with Terrain Illumination Correction)

- Scene geometry retained - no ingestion / tiling / reprojection

- Cloud Optimised GeoTIFF (COG)

- FMask (pixel classification - cloud, water etc.)

- Terrain shadow mask (Terrain Illumination correction)

- Metadata - YAML configuration (STAC compatible)

ARD products and field validation

Field measurements are important for the on-going development of rigorous ARD products that are validated

The DEA team includes a cal / val capability that supports the ARD agenda driven by CEOS (LSI-VC, WGCV, WGISS)

Calibrated instrument data	Methods (recipes)	Analysis Ready Products	Accuracy
Various sensors	**Which: Corrections are applied; Algorithms are used; Ancillary data are used.**	**Surface Reflectance - OLI** **Surface Reflectance – ETM+** **Surface Reflectance - TM** **Surface Reflectance - MSI** **Surface Reflectance – Planet.**	**Truth?** **Comparison with external observations** **Internal model-fitting error**

Focus of validation is not *how* the corrections are made, but *how* *effective* the corrections are

PFS Process - CARD4L

Continental scale validation of surface reflectance

Field data for Phase 1 collected from March 2018 to June 2019

Planning for Phase 2 data collection in progress

Phase 1 field validation results in next talk
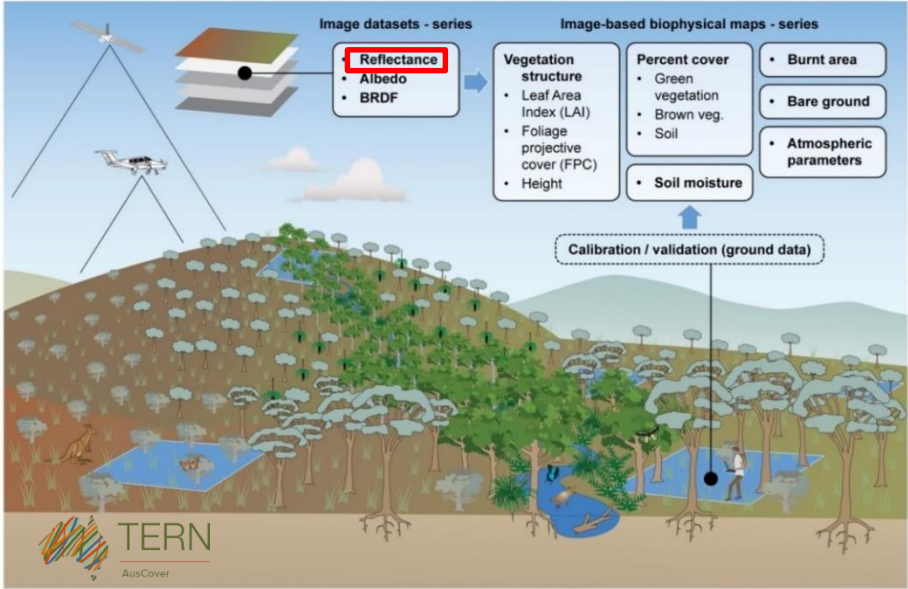
Application examples

Peer-reviewed publications

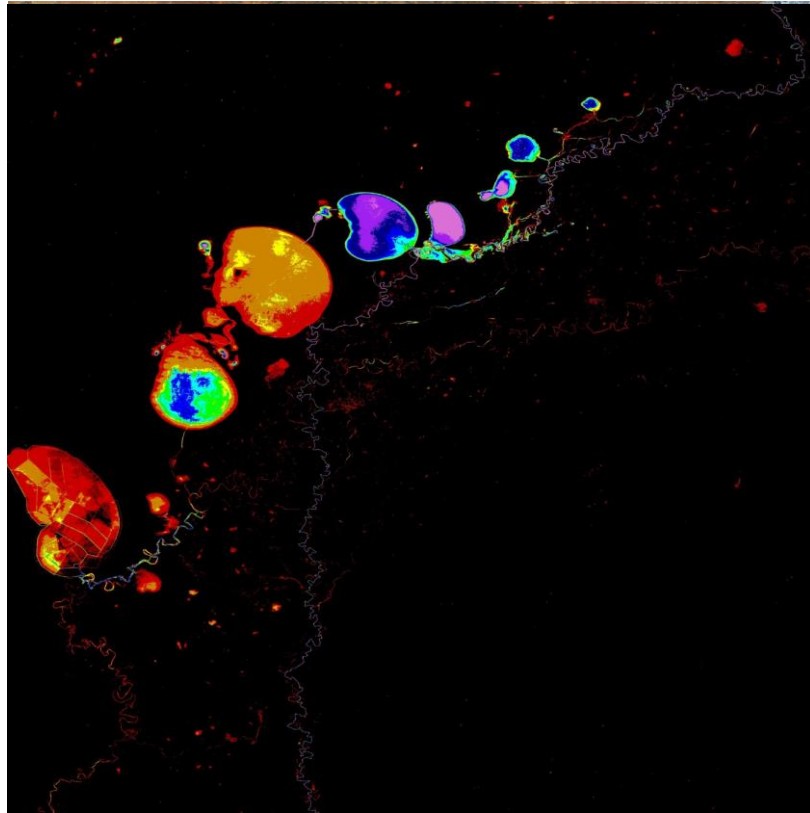Surface water dynamics (WOfS): Mueller et al. 2016 Rem Sens Env

https://www.sciencedirect.com/science/article/pii/S0034425715301929

Intertidal zone extent: Sagar et al. 2017 Rem Sens Env

https://www.sciencedirect.com/science/article/pii/S0034425717301591

Suspended sediment: Lymburner et al. 2017 Rem Sens Env

https://www.sciencedirect.com/science/article/abs/pii/S0034425716301560

Water Observations from Space (WOfS)

Water observations from space: Mapping surface water from 25 years of Landsat imagery across Australia

N. Mueller [a,*], A. Lewis [a], D. Roberts [a,b], S. Ring [a], R. Melrose [a], J. Sixsmith [a], L. Lymburner [a], A. McIntyre [a], P. Tan [a], S. Curnow [a], A. Ip [a]

[a] Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia
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ABSTRACT

Following extreme flooding in eastern Australia in 2011, the Australian Government established a programme to improve access to flood information across Australia. As part of this, a project was undertaken to map the extent of surface water across Australia using the multi-decadal archive of Landsat satellite imagery. A water detection algorithm was used based on a decision tree classifier, and a comparison methodology using a logistic regression. This approach provided an understanding of the confidence in the water observations. The results were used to map the presence of surface water across the entire continent from every observation of 27 years of satellite imagery. The Water Observation from Space (WOfS) product provides insight into the behaviour of surface water across Australia through time, demonstrating where water is persistent, such as in reservoirs, and where it is ephemeral, such as on floodplains during a flood. In addition the WOfS product is useful for studies of wetland extent, aquatic species behaviour, hydrological models, land surface process modelling and groundwater recharge. This paper describes the WOfS methodology and shows how similar time-series analyses of nationally

Satellite based water observations over 27 years, covering the Australian continent

Intertidal extents

Gridded dataset characterising the spatial extents of the exposed intertidal zone, at intervals of the observed tidal range. Utilises all Landsat observations (5,7, and 8) for Australian coastal regions (excluding off-shore Territories) between 1987 and 2015
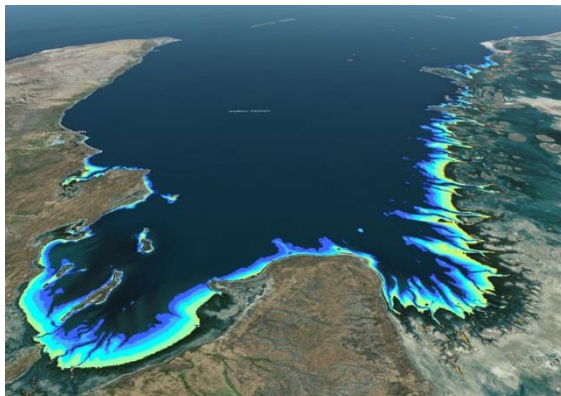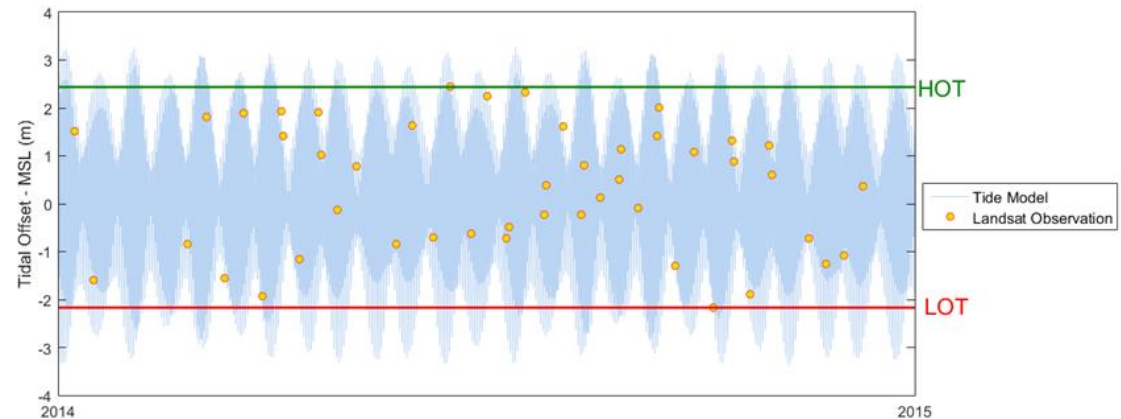
Extracting the intertidal extent and topography of the Australian coastline from a 28 year time series of Landsat observations
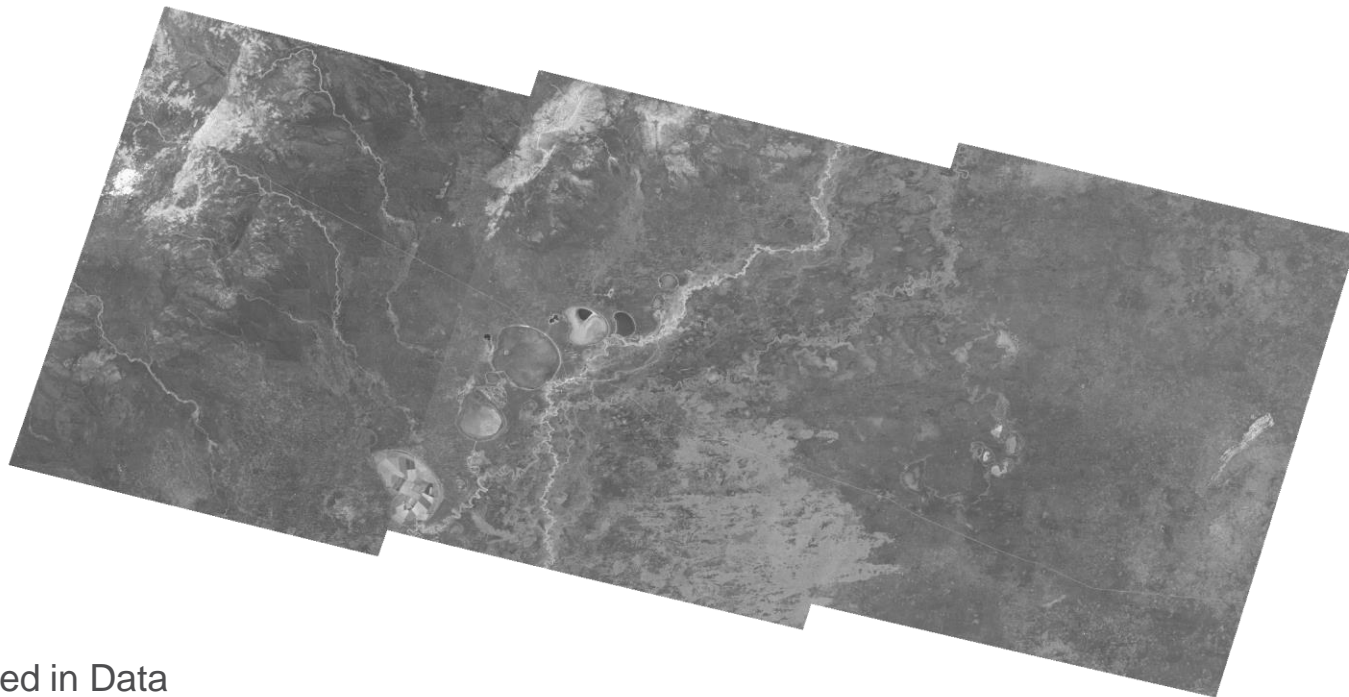
Stephen Sagar [a,*], Dale Roberts [a,b], Biswajit Bala [a], Leo Lymburner [a]

[a] National Earth and Marine Observations Branch, Geoscience Australia, Canberra, Australia
[b] Australian National University, Canberra, Australia

Example Backscatter Product - Menindee Lakes

Paper published in Data
Building a SAR-Enabled Data Cube Capability in Australia Using SAR Analysis Ready Data
Catherine Ticehurst, Zheng-Shu Zhou, Eric Lehmann, Fang Yuan, Medhavy Thankappan, Ake Rosenqvist, Ben Lewis and Matt Paget

https://www.mdpi.com/2306-5729/4/3/100?type=check_update&version=1

Monitoring Environmental Flows

Monitoring Environmental Flows

Digital Earth Africa

- US based Helmsley Charitable Trust and the Australian Government have funded the establishment of DE Africa

- Digital Earth Australia is providing technical and operational guidance

- DE Africa will eventually be a sovereign operational and analytical capability for Africa with in-country expertise in EO data analysis and management

Global impact

3 — Operational

7 — Under Development

29 — Under Review or Expressed Interest

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