CEOS Analysis Ready Data (CEOS-ARD)

Matthew Steventon

CEOS-ARD Oversight Group and Land Surface Imaging Virtual Constellation

6th Asia-Oceania Group on Earth Observations (AOGEO) Workshop

29 May 2023

CEOS
Committee on
Earth Observation Satellites

CEOS Overview

Established in 1984

Comprises the world's major civil space agencies

- 34 Members
- 29 Associate Members

63 Agencies operating 201 satellites

All of whom contribute to CEOS on a 'best efforts' and voluntary basis.

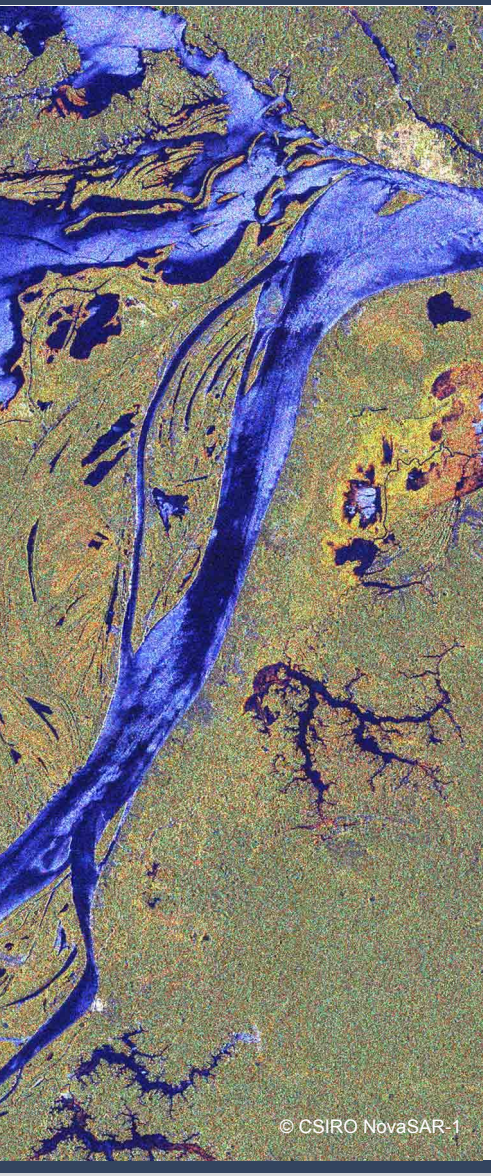
https://ceos.org/

Mission: CEOS ensures international coordination of civil space-based Earth observation programs and promotes exchange of data to optimize societal benefit and inform decision making for securing a prosperous and sustainable future for humankind.

What exactly is ‘analysis-ready’ anyway?

- Needed to define something - address the ambiguity!
- Open Data Cube – Digital Earths
- Space agency experience
- What do most ‘non-expert’ users want?
  - Sensor agnostic geophysical variables
- Define key parameters and corrections for different types of geophysical products
- Ensuring documentation, rather than prescribing methods

Motivations

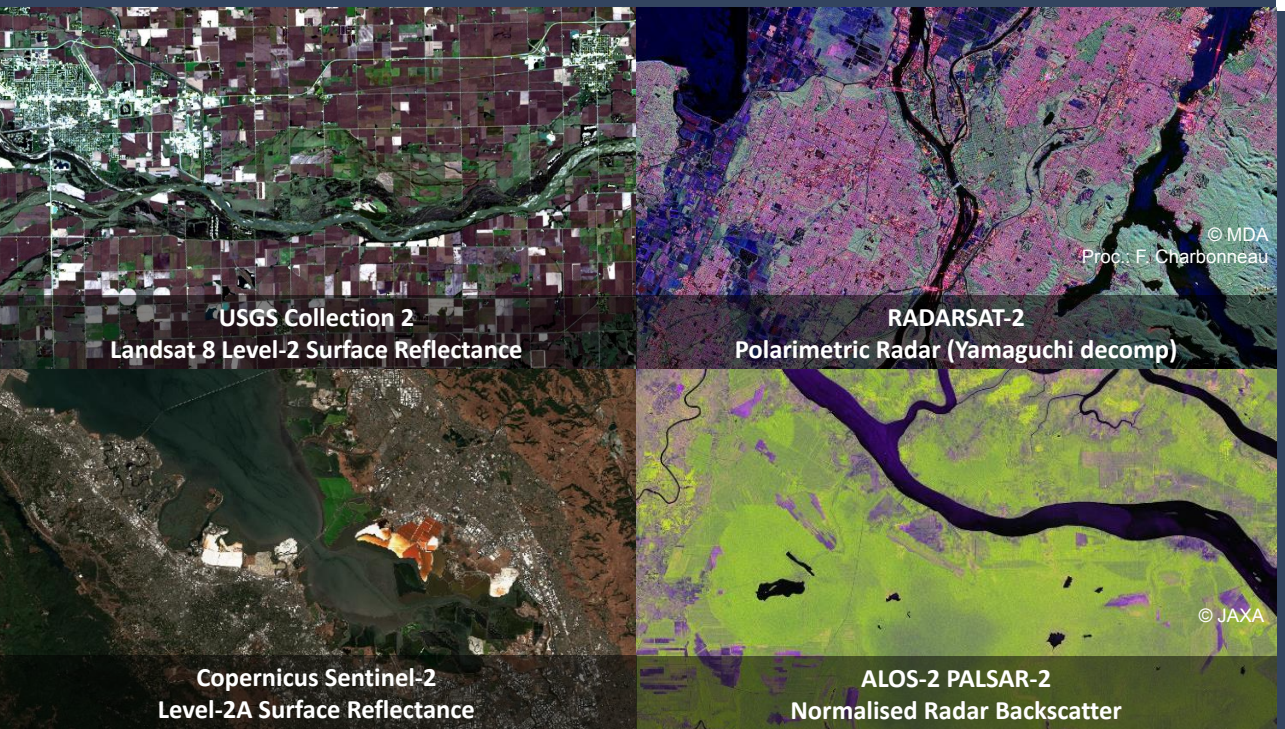


- Big Data
- Reduce pre-processing burden for users
  - Facilitate analysis in the cloud
  - Reduce egress and processing
- Provide a first step for interoperability
  - Open and transparent
  - Common starting point; consistency
- Increase data uptake and foster new user communities
- Capitalise on space agency expertise and experience
  - Best available science and high quality processes

CEOS Analysis Ready Data

CEOS Analysis Ready Data (CEOS-ARD) are satellite data that have been **processed to a minimum set of requirements** and organized into a form that allows:

- **immediate analysis** with a minimum of additional user effort
- **interoperability** both through time and with other datasets



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CEOS-ARD Product Family Specifications

Product Family Specifications (PFS)

Specifications for each geophysical measurement

Detail 'Threshold' and 'Target' / 'Goal' requirements for a variety of parameters

Started with land (CEOS-ARD 4 Land):

- **Surface Reflectance**
- **Surface Temperature**
- **Normalised Radar Backscatter**

1. General Metadata
1.1 Traceability
1.2 Metadata Machine Readability
1.3 Data Collection Time
1.4 Geographical Area
1.5 Coordinate Reference System
1.6 Map Projection
1.7 Geometric Correction Methods
1.8 Geometric Accuracy of the Data
1.9 Instrument
1.10 Spectral Bands
1.11 Sensor Calibration
1.12 Radiometric Accuracy
1.13 Algorithms
1.14 Ancillary Data
1.15 Processing Chain Provenance
1.16 Data Access
1.17 Overall Data Quality

2. Per-Pixel Metadata
2.1 Metadata Machine Readability
2.2 No Data
2.3 Incomplete Testing
2.4 Saturation
2.5 Cloud
2.6 Cloud Shadow
2.7 Land/Water Mask
2.8 Snow/Ice Mask
2.9 Terrain Shadow Mask
2.10 Terrain Occlusion
2.11 Solar and Viewing Geometry
2.12 Terrain Illumination Correction
2.13 Aerosol Optical Depth Parameters
3. Radiometric and Atmospheric Corrections
3.1 Measurement
3.2 Measurement Uncertainty
3.3 Measurement Normalisation
3.4 Directional Atmospheric Scattering
3.5 Water Vapour Corrections
3.6 Ozone Corrections
4. Geometric Corrections
4.1 Geometric Correction

Current CEOS-ARD Specifications

Land

Optical

Surface Reflectance

Surface Temperature

Nighttime Lights Surface Radiance

Radar

Normalised Radar Backscatter

Polarimetric Radar

Inland and Coastal Waters

Aquatic Reflectance

Oceans

Ocean Radar Backscatter

PFS	Type	Version	Download	Metadata Spec	Last Updated
Surface Reflectance	Optical	5.0	PDF | Word	-	8 June 2020
Surface Temperature	Optical	5.0	PDF | Word	-	8 June 2020
Normalised Radar Backscatter	Radar	5.5	PDF | Word	XLSX	13 May 2022
Polarimetric Radar	Radar	3.5	PDF | Word	XLSX	13 May 2022
Aquatic Reflectance	Optical	1.0	PDF | Word	-	23 February 2022
Ocean Radar Backscatter	Radar	1.0	PDF | Word	XLSX	21 September 2022
Nighttime Lights Surface Radiance	Optical	1.0	PDF | Word	-	2 October 2022

http://ceos.org/ard/index.html#specs

Current + In-development CEOS-ARD Specifications

Land

Optical

Surface Reflectance

Surface Temperature

Nighttime Lights Surface Radiance

LiDAR Terrain and Canopy Top Height

Radar

Normalised Radar Backscatter

Polarimetric Radar

Geocoded Single-Look Complex (GSLC)

Interferometric Radar (INSAR)

Inland and Coastal Waters

Aquatic Reflectance

Oceans

Ocean Radar Backscatter

PFS	Type	Version	Download	Metadata Spec	Last Updated
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Surface Temperature	Optical	5.0	PDF | Word	-	8 June 2020
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Ocean Radar Backscatter	Radar	1.0	PDF | Word	XLSX	21 September 2022
Nighttime Lights Surface Radiance	Optical	1.0	PDF | Word	-	2 October 2022

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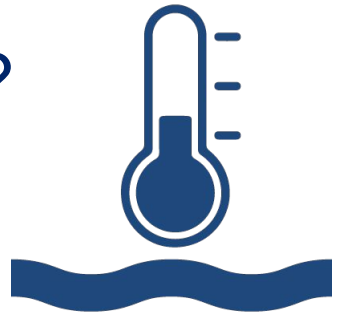
What next?

Sea Surface Temperature?



Precipitation?

Ocean Colour?

Atmospheric Composition Datasets?

Methane?

Active discussion by CEOS Virtual Constellations and CEOS-ARD Oversight Group. User demand is key.

CEOS-ARD Assessment

Completed Self-assessment Table
- Blank table in the specification
- Includes references to metadata, DOIs, methods, etc.

Sample Products
- Incl. metadata

CEOS-ARD Secretariat
- Initial checks

CEOS Working Group on Cal/Val
- Peer review
- For Threshold – simplified checks
- For Target/Goal – Review Panel
- Iterative

CEOS-ARD

More Details

- ceos.org/ard
- CEOS-ARD Framework

OGC-ISO ARD Standards Working Group

- **Significant activity and discussion in the broader EO community** around 'Analysis Ready Data'
- With its long heritage, experience, and expertise, **CEOS has a key role to play in defining ARD for the community** (Incl. 'New Space')
- **Feedback from industry** (VH-RODA, JACIE, LPS, ARD2x) that **formal standards are needed** for 'ARD'
- Government and commercial sectors may not reference documents and commit funds unless they have gone through an **open standards process** (formal peer review, etc.)
- **Standards built on the CEOS-ARD foundation** would be helpful
- **Increase reach** of the concepts of CEOS-ARD

Recent Updates

- **OGC ARD Standards Working Group was approved May 3.**
  - ISO counterpart vote closed May 23. Awaiting word.
  - Using CEOS Analysis Ready Data as the basis
  - Generalised to geospatial data
  - OGC ARD SWG will have its next hybrid meeting at the 126th OGC member meeting in Huntsville, Alabama in the first week of June.
  - Two-year development period
- **ISO has designated the ARD series of standards to be ISO 19176.**
    - ISO 19176-1 is the first Part.
    - CEOS will be represented in the ISO 19176 development team.
    - Additional representation welcome
    - Getting Part I right will be critical.

Current CEOS-ARD Products

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Threshold Specification	Target Specification	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
ALOS-2 PALSAR-2 Global Mosaics (RTC)	Normalised Radar Backscatter	v5.5	JAXA	ALOS-2 PALSAR-2	100%	Not assessed	Link	Link	DOC	DOC	Link
ALOS-2 PALSAR-2 25m ScanSAR NRB	Normalised Radar Backscatter	v5.5	JAXA	ALOS-2 PALSAR-2	100%	Not assessed	Link	Link	DOC	DOC	Link
EnMAP	Surface Reflectance	v5.0	DLR	EnMAP	100%	Not assessed	TBA	Link	PDF	PDF	Link
Landsat Collection 2	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	81%	Landsat 4-5, 7, 8-9	Link	PDF	PDF	Link
Landsat Collection 2	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	83%	Landsat 4-5, 7, 8-9	Link	PDF	PDF	Link
Landsat Collection 2 U.S. ARD	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	Not assessed	Link	Link	PDF	PDF	Link
Landsat Collection 2 U.S. ARD	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	Not assessed	Link	Link	PDF	PDF	Link
PROBA-V L3 (0.1/0.333/1 km) TOC	Surface Reflectance	v5.0	VITO / ESA	PROBA-V	100%	Not assessed	Link	Link	PDF	PDF	Link
Sentinel-1 RTC	Normalised Radar Backscatter	v5.5	Sinergise & Digital Earth Africa	Sentinel-1 (A, B)	100%	Not assessed	Link	Link	PDF	PDF	Link
Sentinel-2 Level-2A	Surface Reflectance	v5.0	ESA	Sentinel-2A, 2B	100%	Not assessed	Link	Link	PDF	PDF	Link

http://ceos.org/ard/index.html#datasets

Future CEOS-ARD Products

Under Peer Review

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
L8 SR (Aerospace Information Research Institute)	Surface Reflectance	v5.0	AIR (China)	Landsat 8	TBA	TBA	TBA	TBA	TBA
L8 ST (Aerospace Information Research Institute)	Surface Temperature	v5.0	AIR (China)	Landsat 8	TBA	TBA	TBA	TBA	TBA
NovaSAR-1 RTC	Normalised Radar Backscatter	v5.5	CSIRO	NovaSAR-1	TBA	Link	TBA	TBA	TBA

Under Development:

- **SR:** DESIS L2A, Envisat MERIS, ERS ATSR, Fused S-2 & L-8/9 (Level-2F), Gaofen-1 SR, Harmonised S-2 & L-8/9 (Level-2H), Resourcesat-2/2A, Sentinel-3 SYN SDR Product, SPOT 1-7 Surface Reflectance
- **NRB:** NovaSAR NRB, Sentinel-1 NRB, ENVISAT NRB, ERS-1/2 NRB, RISAT-1A (EOS-04) NRB
- **AR:** Landsat L2 Provisional Aquatic Reflectance, Sentinel-2 L2A/B AR Layer
- **ORB:** Sentinel-1 ORB

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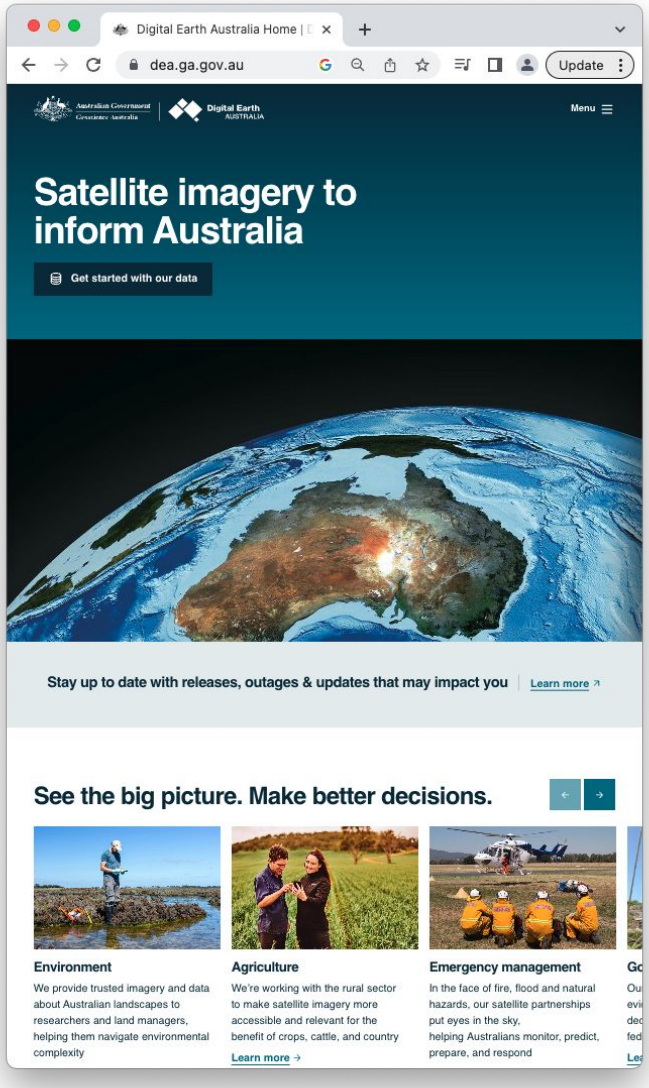
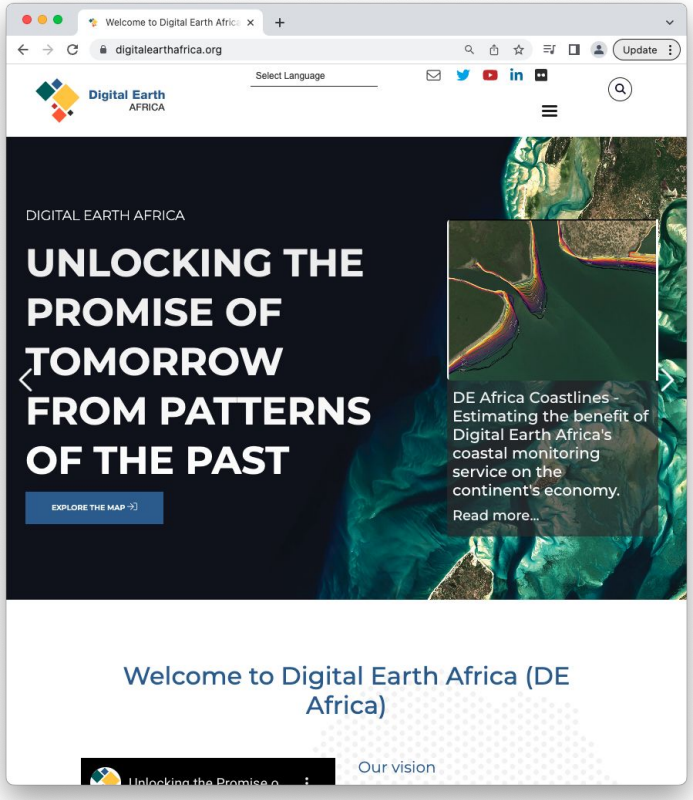
Applications

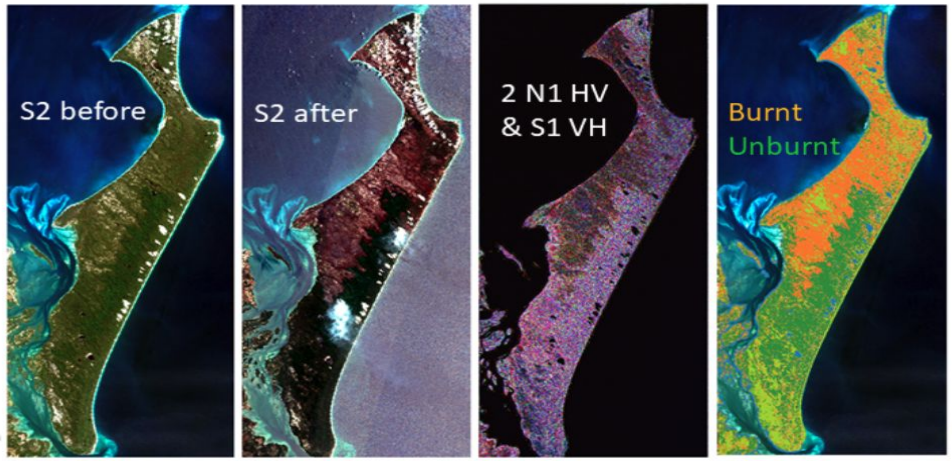




NovaSAR-1 ARD Application Examples

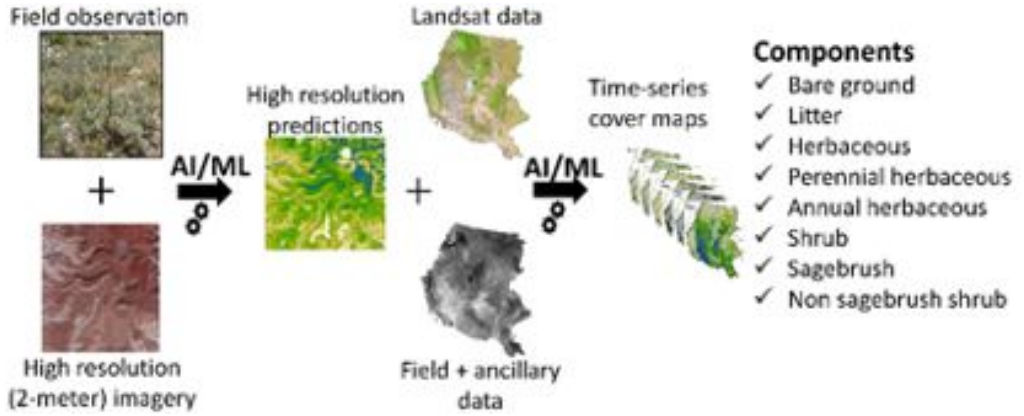
- Burn Area Mapping in Fraser Island, QLD in Oct-Dec 2020 (Ticehurst et al, 2021)

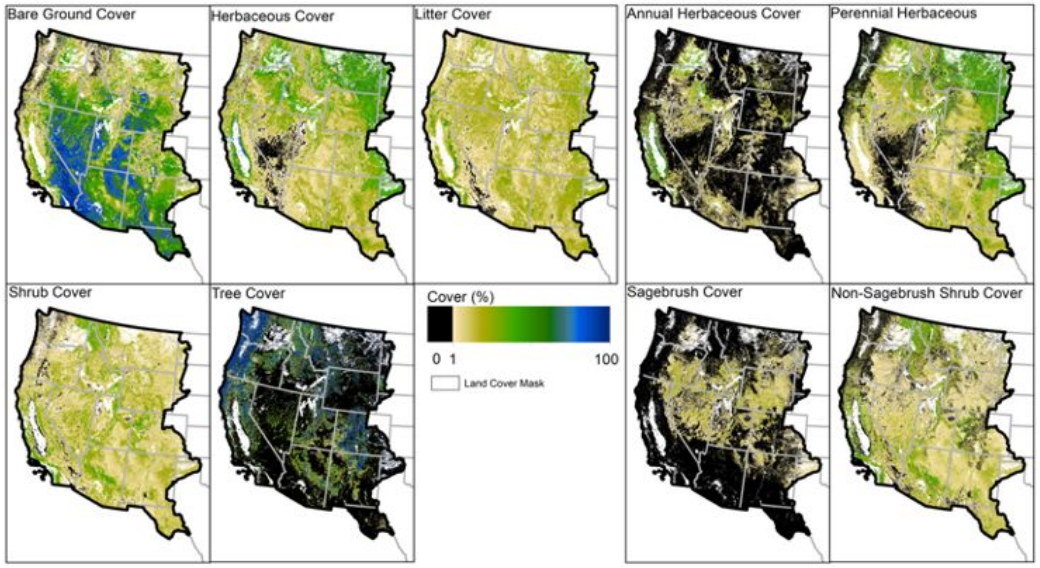
Contact: <Zheng-Shu.Zhou@data61.csiro.au>



USGS RCMAP

- **Matthew Rigge, USGS <mrigge@usgs.gov>**
- **Rangeland Condition Monitoring Assessment and Projection (RCMAP):**
  - AI/ML based project
  - Capture gradual and abrupt change in rangeland condition
  - Compliment field observations
  - Monitoring changes to vegetation composition, evaluating past management practices, targeting future improvements, and evaluation of critical wildlife habitat and landscape health
- 3 study approaches to be investigated, Optical only (Landsat 8), SAR only (Sentinel 1), and Optical + SAR
  - All 3 approaches trained using high-resolution (MAXAR: Worldview 2/3) predictions of rangeland components
- Goals:
  - Determine how the additional SAR data can contribute to mapping of shrub cover, bare ground, and herbaceous, and maybe tree cover utilizing an AI/ML approach. Specifically, investigate differences in shrubs/grass discrimination (DNN/CNN).
  - Obtain lessons learned about the data (what is missing from the current CEOS-ARD specs) to help shape what a data provider may need to incorporate to meet a real science user need.





CEOS-ARD Promotion & Communications

CEOS has been engaging with the broader community through various channels

- Workshops, webinars, conference sessions and abstracts
  - ARD23 Workshop, IGARSS 2023, CEOS-Industry ARD Workshop (TBC), Big Data from Space, VH-RODA, JACIE, etc.
- CEOS-ARD Webpage
  - https://ceos.org/ard/
- Documentation
  - CEOS-ARD Strategy
  - Framework
  - Specifications

ARD23

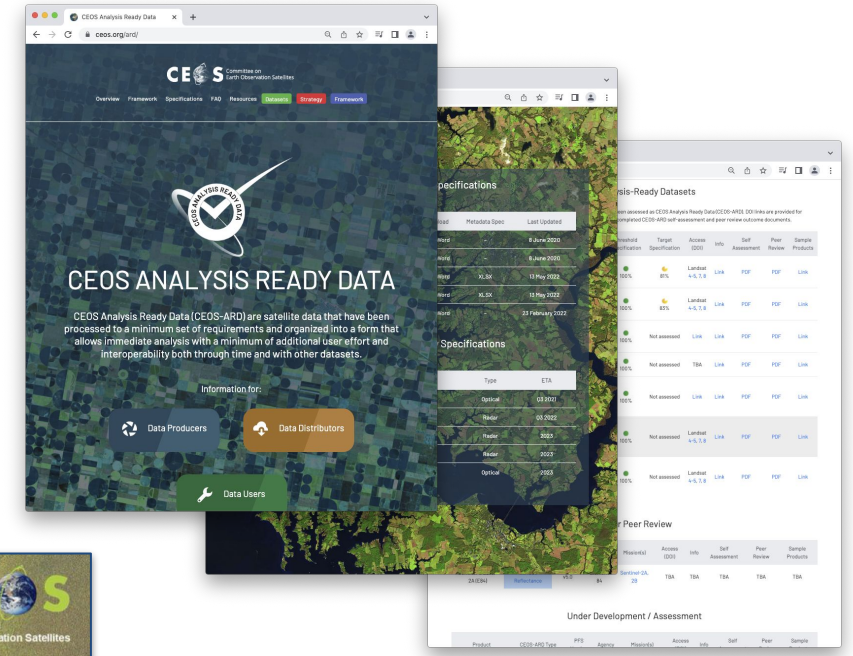
IGARSS Pasadena, California 2023

CEOS

https://2023.ieeeigarss.org/community_contributed_sessions.php **(session: Analysis Ready Data: New Opportunities)**

More Information

https://ceos.org/ard/



CEOS-ARD Newsletter Sign-up

- Past issues: https://ceos.org/ceos-ard-newsletter/

https://twitter.com/CEOSARD

CEOS-ARD Oversight Group Contacts

- Ferran.Gascon@esa.int
- matthew@symbioscomms.com

Thank you!

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