CEOS Analysis Ready Data for SAR – 2026 Update

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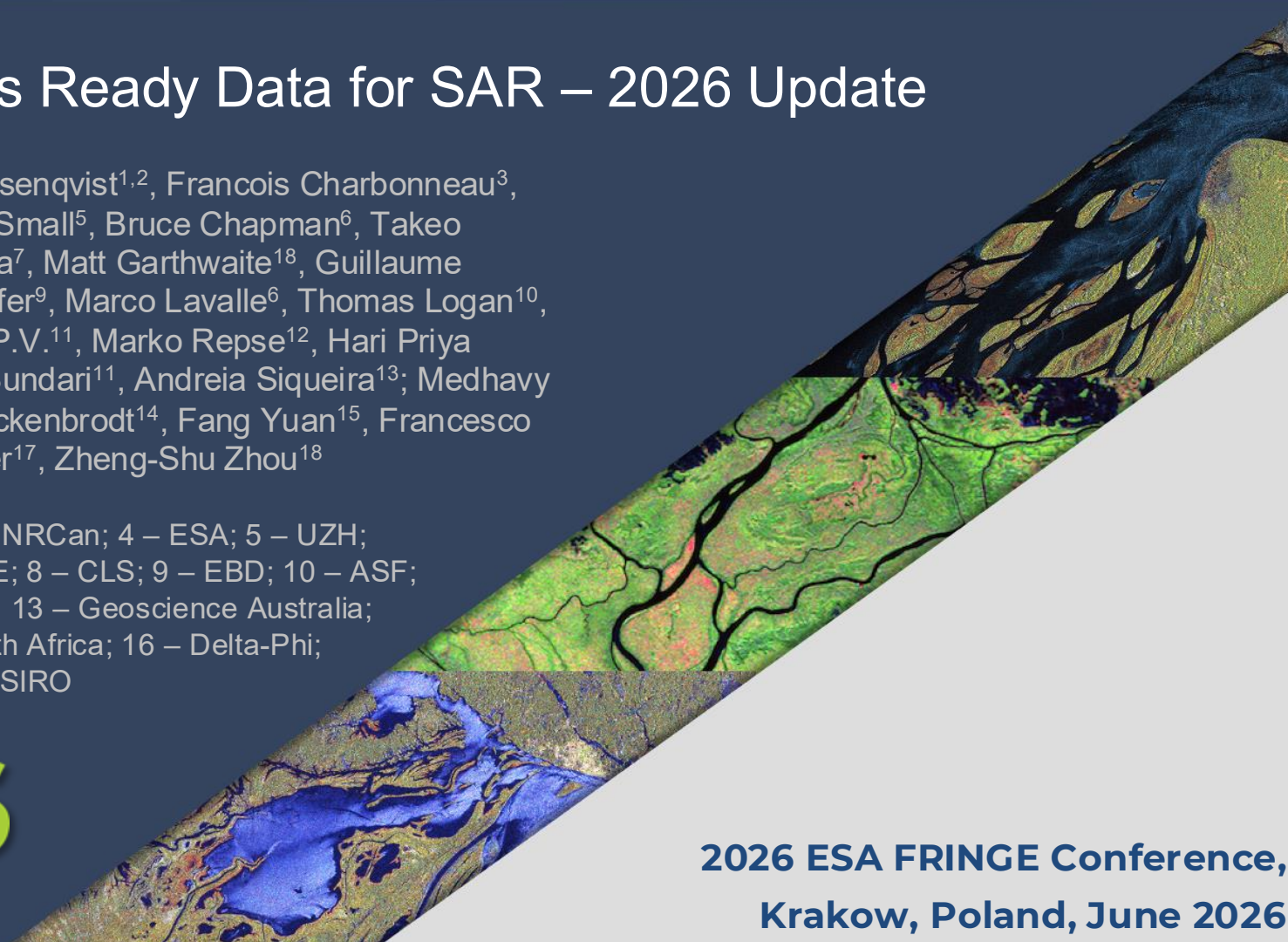
1 – JAXA; 2 – soloEO; 3 – NRCan; 4 – ESA; 5 – UZH;
6 – NASA JPL; 7 – CONAE; 8 – CLS; 9 – EBD; 10 – ASF;
11 – ISRO; 12 – Sinergise; 13 – Geoscience Australia;
14 – DLR; 15 – Digital Earth Africa; 16 – Delta-Phi;
17 – Stanford Univ; 18 – CSIRO



CEOS
Committee on
Earth Observation Satellites

2026 ESA FRINGE Conference,
Krakow, Poland, June 2026

CEOS-ARD for SAR
Current status

CEOS ARD specifications for Synthetic Aperture Radar (SAR) products:

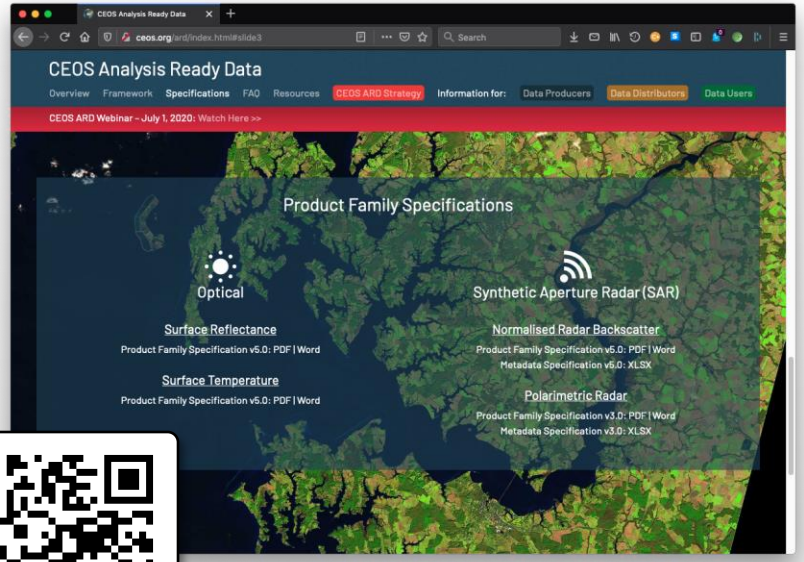
Endorsed and available at http://ceos.org/ard

CEOS-ARD for Synthetic Aperture Radar

- Normalised Radar Backscatter (NRB)
- Polarimetric Radar (POL)
- Ocean Radar Backscatter (ORB)
- Geocoded SLC (GSLC)
- Interferometric Radar (InSAR) [NEW]

In the pipeline:

- Multi-source NRB
- Others?
  - NRB for VHR data
  - CSLC: Colocated SLC
  - GMLC : Geolocated multilooked SLC



CEOS-ARD for SAR
Specifications for Data Providers

CEOS Committee on Earth Observation Satellites	Analysis Ready Data	Product Family Specification: Synthetic Aperture Radar

#	Parameter	CEOS-ARD product	Requirements
1.6.1	Source Data Access	[NRB] [POL] [ORB] [GSLC]	**Threshold (Minimum) Requirements** The metadata identifies the location from where the source data can be retrieved, expressed as a URL or DOI. **Goal (Desired) Requirements** The metadata identifies an online location from where the data can be consistently and reliably retrieved by a computer algorithm without any manual intervention being required.
1.6.2	Instrument	[NRB] [POL] [ORB] [GSLC]	**Threshold (Minimum) Requirements** The instrument used to collect the data is identified in the metadata: - Satellite name - Instrument name **Goal (Desired) Requirements** As threshold, but including a reference to the relevant CEOS Missions, Instruments and Measurements Database record.
1.6.3	Source Data Acquisition Time	[NRB] [POL] [ORB] [GSLC]	**Threshold (Minimum) Requirements** The start date and time of source data is identified in the metadata, expressed in UTC in date and time, at least to the second. **Goal (Desired) Requirements** As threshold.
1.6.4	Source Data Acquisition Parameters	[NRB] [POL] [ORB] [GSLC]	**Threshold (Minimum) Requirements** Acquisition parameters related to the SAR antenna: - Radar band - Centre frequency - Observation mode (i.e., Beam mode name) - Polarization(s) (listed as in original product) - Antenna pointing [Right/Left] - Beam ID (i.e., Beam mode Mnemonic)

Extract from CEOS-ARD NRB specification document

CEOS-ARD specs
(a.k.a. Product Family Specifications – PFS)

- "Guidance document" for data providers:
  - Geometric corrections
  - Radiometric corrections
  - General meta (ancillary) data
  - Per-pixel (image) meta data
- Two levels of requirements
  - Threshold (mandatory) requirement
  - Goal (optional) requirement

CEOS-ARD for SAR Metadata

General Metadata – Metadata Specifications

#	Item	CEOS-ARD product	Threshold Requirements <parameters>	Goal Requirements <parameters>	itemAttribute	Type [and list of values]
1.1	Traceability		(Not Applicable in metadata file)			
1.2	Metadata machine readability		(Not Applicable in metadata file)			
1.3	Product type	[ALL]	<Product>		copyright=" "	String
			<ProductList>		count={"2", "3", ... ""}	Integer
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			<ProductType>		"Polarimetric Radar"	String
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			<ProductType>		"Geocoded Single-Look Complex"	String
1.4	Document Identifier	[ALL]	<DocumentIdentifier>		name="CEOS-ARD for Synthetic Aperture Radar"	String
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					type="URL"	https://ceos.org/ard/files/PFS/SAR/v1.0/CEOS-ARD_PFS_Synthetic_Aperture_Radar_v1.0.pdf
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Metadata Specifications

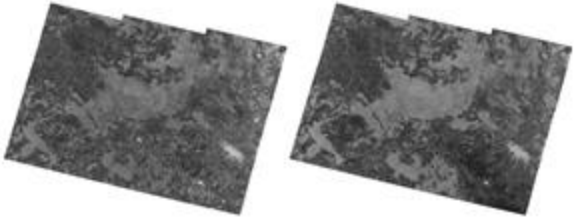
- Metadata specification developed to accompany each Radar PFS
- Consistent mapping of parameter names between PFS and metadata
- Specs for XML format but data provider may select other metadata formats (yaml, json, etc.)
- Currently non-mandatory (Goal req.), yet broad uptake by SAR agencies

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements
1.2	**Metadata Machine Readability**	Metadata is provided in a structure that enables a computer algorithm to be used to consistently and automatically identify and extract each component part for further use.	As threshold, but metadata is formatted in accordance with CARD4L NRB Metadata Specifications, v.5.5, or a community endorsed standard that facilitates machine-readability, such as ISO 19115-2

CEOS-ARD for SAR
General PFS Structure

1. Radar Measurements

Radiometric and Geometric specs



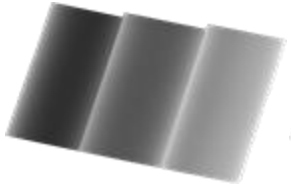
2. Per-Pixel Metadata (image data)

Local Inc Angle (Target)

Scattering Area (Goal)

Data Mask (Target)

Sigma-to-Gamma ratio (Goal)



Noise Power (Goal)

Ellipsoid Inc Angle (Goal)

3. General Metadata

s1_rtc_039039_N07E000_2021_12_02_metadata_v5.5.xml

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Sentinel-1 (Copernicus)

Processing:

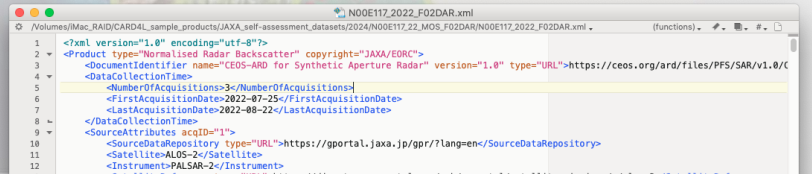
Z-S Zhou, CSIRO

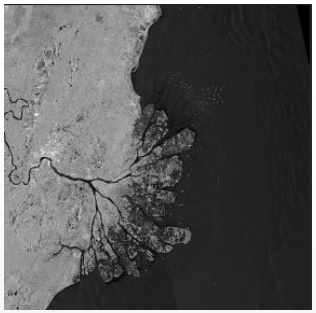
CEOS ANALYSIS READY DATA

CEOS-ARD for SAR
Normalised Radar Backscatter [NRB]

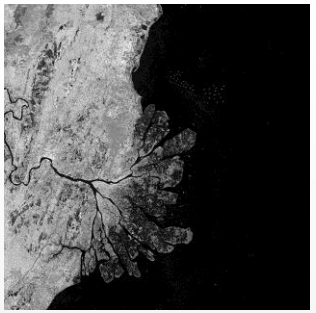
CEOS-ARD Normalised Radar Backscatter [NRB]

- Radar Measurement data:
  - Geometric Terrain Correction (ortho)
  - Radiometric Slope Correction
  - Backscatter expressed as gamma-nought, γ^0
- Per-pixel metadata:
  - Threshold (required):
    - Local Incidence Angle image
    - Mask image
    - Acquisition ID image (for composite products)
  - Goal (optional):
    - Scattering Area image
    - Gamma-to-Sigma ratio image
    - Ellipsoid Inc. Angle image
    - Noise power image (if applied)
    - Per-pixel DEM
- General metadata:
  - Detailed specs about source data and (CEOS-ARD) product
  - Metadata XML format spec provided (Target)





γ^0 *Backscatter (HH)*



γ^0 *Backscatter (HV)*

Local Inc. Angle

Acquisition ID

Data Mask

ALOS-2 PALSAR-2

(Global mosaic)

Processing: JAXA EORC

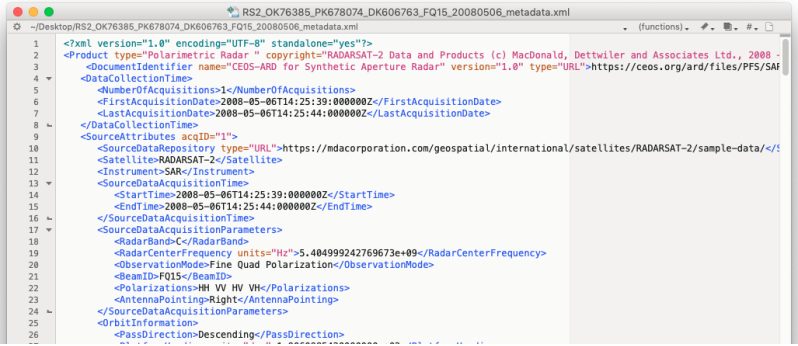
CEOS-ARD for SAR
Polarimetric Radar [POL]

CEOS-ARD Polarimetric Radar [POL]

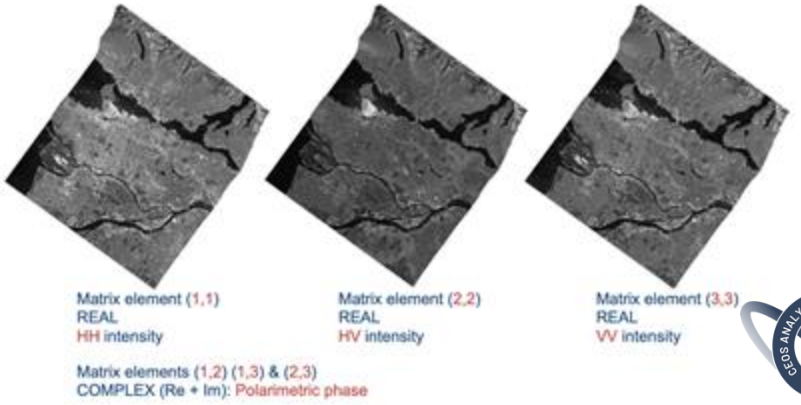
General Metadata, Per-pixel Metadata, Geometric & Radiometric corrections near-identical to NRB

POL Measurement Data covers two product types:

- Polarimetric Decomposition
  - Data Providers to decide what decompositions to offer to users (e.g. Eigen value; Pauli, Freeman-D; Yamaguchi, etc.)
- Polarimetric Covariance Matrix
  - Polarimetric phase and amplitude preserved
  - For polarimetric time-series and Pol-InSAR applications



RADARSAT-2 (MDA)
Processing: F. Charbonneau (NRCan)

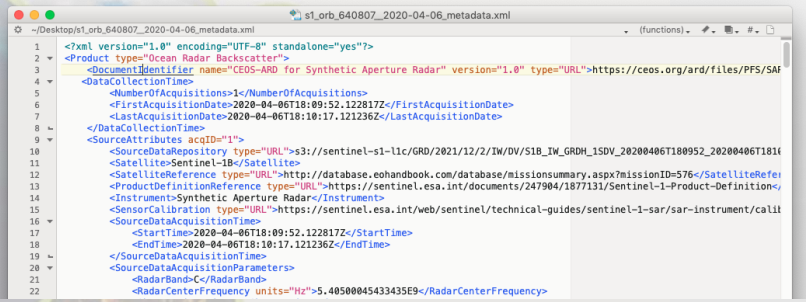


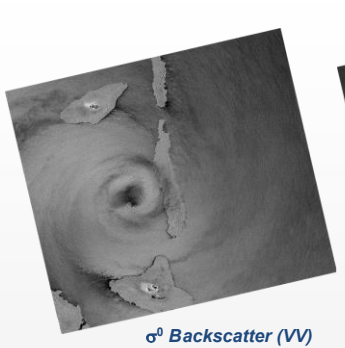
CEOS-ARD for SAR
Ocean Radar Backscatter [ORB]

CEOS-ARD Ocean Radar Backscatter [ORB]

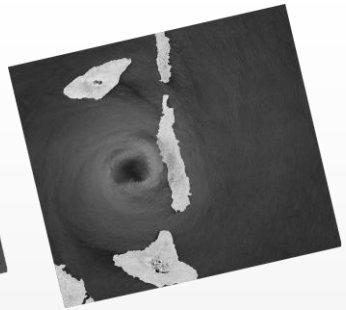
– Simplified version of the NRB product for ocean applications

- Radar Measurement data:
  - Geoid-corrected backscatter
  - Expressed as σ^0
- Per-pixel metadata:
  - Threshold (required):
    - Geoid Incidence Angle image
    - Mask image (including land mask)
    - Acquisition ID image (for composite products)
  - Goal (optional):
    - Noise power image (if applied)
    - Per-pixel Geoid
    - Look Direction image



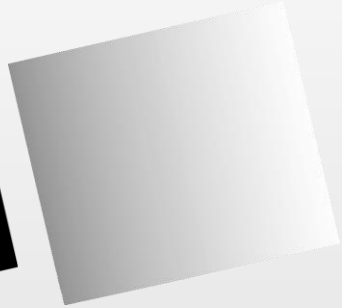


σ^0 *Backscatter (VV)*



σ^0 *Backscatter (VH)*

Data Mask image



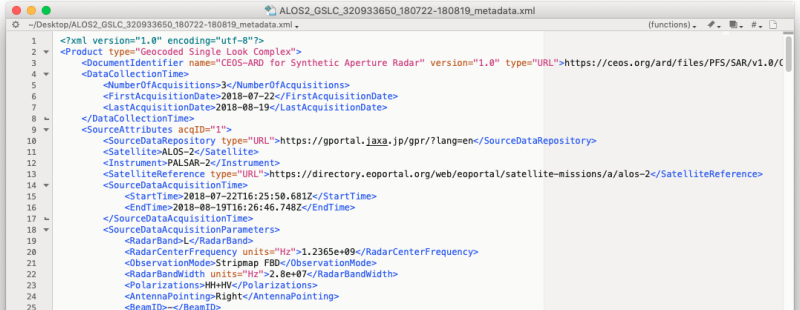
Geoid Inc. Angle image

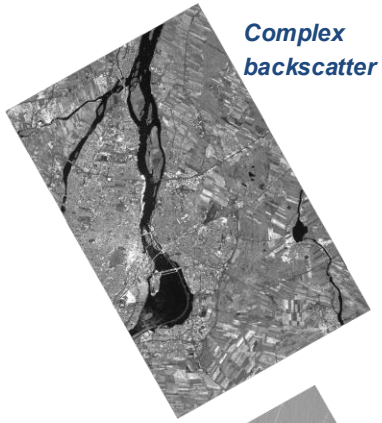
Sentinel-1 IWS
CEOS-ARD ORB (mock-up)
(Processing: soloEO)

CEOS-ARD for SAR
Geocoded SLC [GSLC]

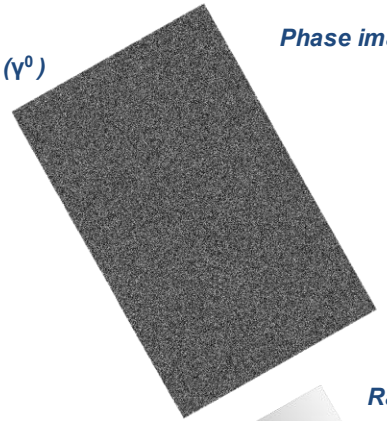
CEOS-ARD Geocoded Single-Look Complex [GSLC]

- Radar Measurement data:
  - Backscatter in complex format (I+Q) from which both **amplitude** and **phase** can be derived
  - Radiometry: Radiometric slope correction, expressed as γ^0
  - Geometry:
    - Ground-based map projection (i.e. not slant range)
    - Corrected relative to a common reference orbit → Co-registered GSLC images in a stack have same geometry → interferometric applications feasible by simple image math .
- Per-pixel metadata (Threshold):
  - Local Incidence Angle image
  - Mask image
  - Acquisition ID image (for composite products)

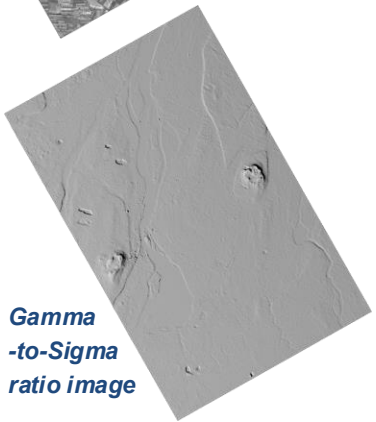




Complex backscatter (γ^0)



Phase image



Gamma -to-Sigma ratio image

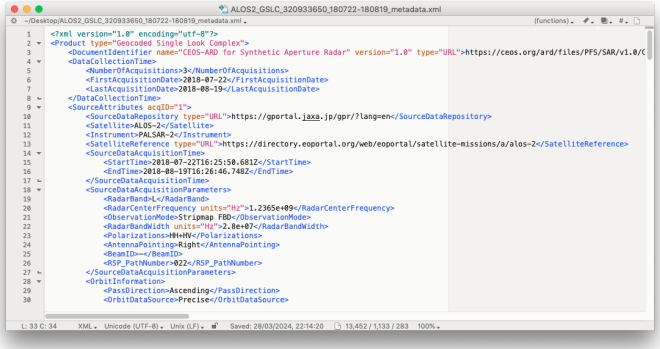
Radar Unit Look Vector Grid image

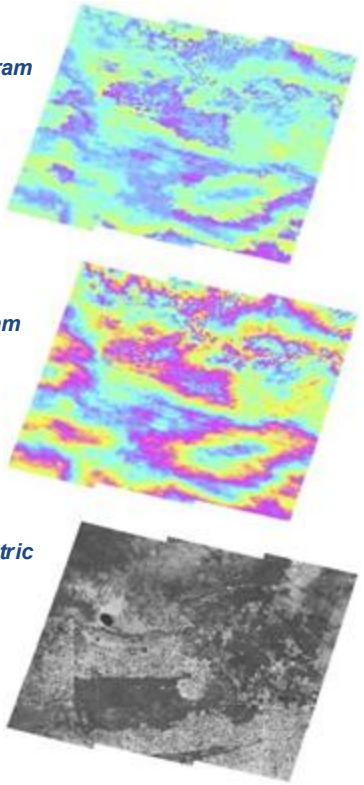
RCM1 ©CSA Proc. F. Charbonneau, NRCan

CEOS-ARD for SAR
Interferometric Radar [InSAR]

CEOS-ARD Interferometric Radar [InSAR]

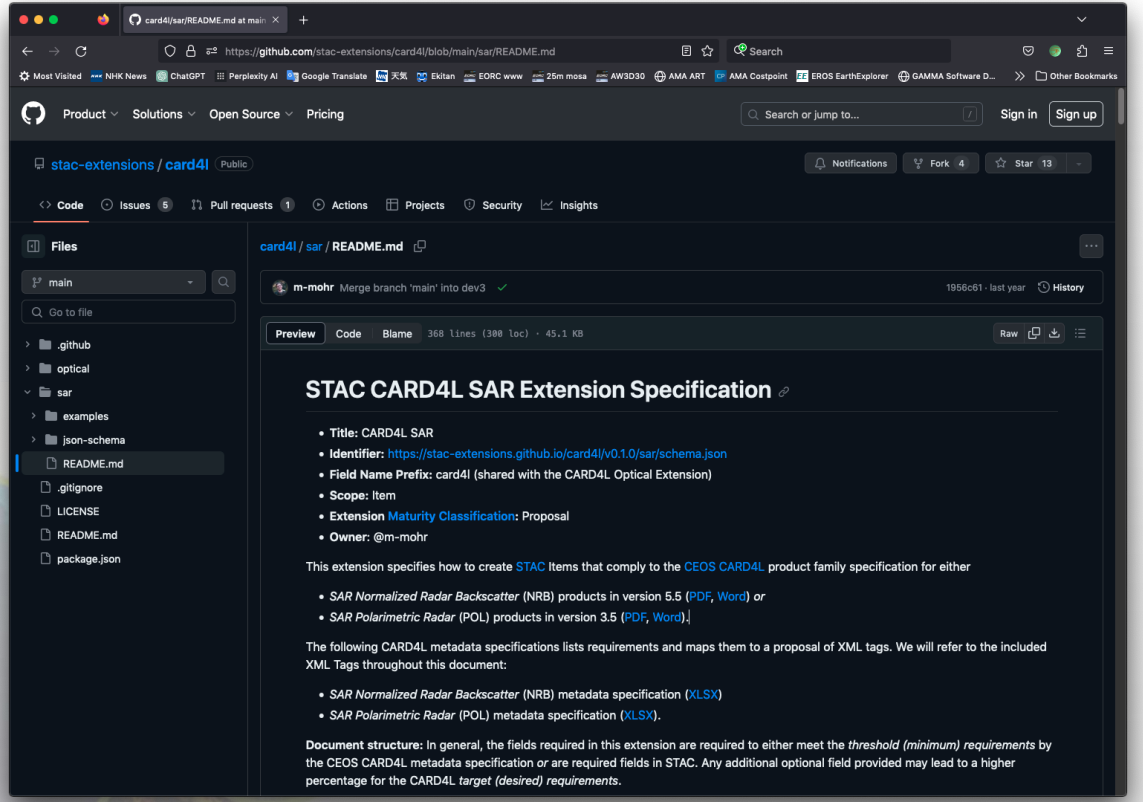
- **A suite of three products generated from an InSAR pair, or a stack**:
  - Wrapped interferogram(s): Image of differential phase signals between two images (or stacks)
  - Unwrapped interferogram(s): Image of differential phase signals where the wrapped fringes are summed (“unwrapped”) to give a continuous phase signal across the image
  - Interferometric coherence: Image of phase coherence between the two images, or stacks of images.
  - Per-pixel metadata:
    - Threshold (required):
      - Mask image
      - Ellipsoidal Incidence Angle image
    - Goal (optional)
      - Scattering Area image
      - Gamma-to-Sigma ratio image
      - Noise power image (if applied)
      - Per-pixel DEM
      - Radar Unit Look Vector Grid image
      - Slant Range Sensor to Surface image
      - InSAR Phase Uncertainty image
      - Atmospheric Phase Correction image
      - Ionospheric Phase Correction image
      - Simulated Topographic Phase image
      - InSAR Perpendicular Baseline image
      - InSAR Parallel Baseline image
      - InSAR Displacement Model Points image





Sentinel 1 interferometric products (Geoscience Australia team)

STAC CEOS-ARD SAR Extension



STAC extensions

- Developed in 2021 for optical and SAR (NRB & POL) PFSs
- Name change: CARD4L → CEOS-ARD
- Major revision in 2025/2026

CEOS-ARD for SAR Community Uptake

	Name	Status	Type	Version	Agency/Orga...	Mission / Instrument(s)
1	ALOS-2 PALSAR-2 25m ScanSAR NRB	CEOS-ARD	SAR-NRB	v1.0	JAXA	ALOS-2 PALSAR-2
2	ALOS-2 PALSAR-2 Global Mosaics (RTC)	CEOS-ARD	SAR-NRB	v1.0	JAXA	ALOS-2 PALSAR-2
3	Catalyst Sentinel-1 RTC	CEOS-ARD	SAR-NRB	v1.1	Catalyst/PCI	Sentinel-1 (A, B, C, D)
4	NovaSAR-1 RTC	CEOS-ARD	NRB	v5.5	CSIRO	NovaSAR-1
5	Opera RTC Sentinel-1	CEOS-ARD	NRB	v5.5	NASA/JPL	Sentinel-1 (A, B, C, D)
6	RISAT-1A (EOS-04) NRB	CEOS-ARD	SAR-NRB	v1.0	ISRO	RISAT-1A (EOS-04)
7	RISAT-1A (EOS-04) NRB India Mosaic	CEOS-ARD	SAR-NRB	v1.1	ISRO	RISAT-1A (EOS-04)
8	Sentinel-1 RTC (Digital Earth Africa)	CEOS-ARD	NRB	v5.5	Sinergise & Digit...	Sentinel-1 (A, B, C, D)
9	NRCan RCM NRB	CEOS-ARD	SAR-NRB	v1.1	NRCan	RCM-1/2/3
10	NRCan RCM POL	CEOS-ARD	SAR-POL	v1.1	NRCan	RCM-1/2/3
11	Sentinel-1 NRB (Geoscience Australia)	CEOS-ARD	SAR-NRB	v1.2	GA	Sentinel-1 (A, B, C, D)
12	Sentinel-1 OPERA InSAR Surface Displac...	CEOS-ARD	SAR-INSAR	v1.2	NASA/JPL	Sentinel-1 (A, B, C, D)
13	Synspective StriX Series NRB	CEOS-ARD	SAR-NRB	v1.2	Synspective	StriX Series

Approved CEOS-ARD compliant products:

- 13 data products (NRB, POL, INSAR)
- 9 data providers
- 6 missions/

CEOS-ARD for SAR Community Uptake

	Name	Status	Type	Version	Agency/Orga...	Mission / Instrument(s)
14	SAOCOM	Under Peer Review	SAR-NRB	v1.1	CONAE	SAOCOM-1A, 1B
15	ENVISAT NRB	Under Development	SAR-NRB		ESA	Envisat
16	ERS-1/2 NRB	Under Development	SAR-NRB		ESA	ERS-1, ERS-2
17	KOMPSAT-5 NRB	Under Development	SAR-NRB		KARI	KOMPSAT-5
18	NISAR (ISRO Products: GSLC, GNUW, GC...	Under Development	SAR-NRB, SAR-GSLC, SAR-POL		ISRO	NISAR
19	NovaSAR-1 NRB	Under Development	SAR-NRB		ISRO	NovaSAR-1
20	Opera GSLC S1	Under Development	SAR-GSLC		NASA/JPL	Sentinel-1 (A, B, C, D)
21	Opera NISAR RTC & GSLC	Under Development	SAR-NRB, SAR-GSLC		NASA/JPL	NISAR
22	Radarsat-1	Under Development	SAR-NRB		CSA	Radarsat-1
23	Radarsat-2	Under Development	SAR-NRB		CSA	Radarsat-2
24	Radarsat Constellation Mission	Under Development	SAR-NRB		CSA	RCM
25	Sentinel-1 NRB	Under Development	SAR-NRB		ESA	Sentinel-1 (A, B, C, D)
26	RISAT-1A/1B POL	Under Development	SAR-POL		ISRO	RISAT-1A, 1B
27	ROSE-L	Future	SAR-NRB		ESA	ROSE-L

CEOS-ARD products in preparation:

- 14 data products (NRB, POL, GLSC, InSAR)
- 6 data providers
- 12 missions/sensors

CEOS ANALYSIS READY DATA

CEOS-ARD SAR – PFS in the Pipeline

- **Multi-source NRB (MSB)**

  * Averaged composite products

    - Pixel values not unique to one source data take

    - Combination of data from ascending and descending passes → improved spatial resolution and eliminate radar shadow

    - Combination of data acquired by different sensors → improving temporal resolution

    - Certain per-pixel metadata no longer defined (e.g. data mask; local inc angle, scattering area)

CEOS-ARD SAR – Under Consideration

- **Special considerations for VHR (metre/sub-metre) SAR products:**

  * Mismatch between publicly available DEMs and VHR pixel spacing

  * Is Radiometric Terrain Correction meaningful?

  * Even with VHR DEMs, RTC designed for distributed target backscatter. May for certain targets introduce backscatter artefacts

  → Special NRB PFS required for VHR SAR?

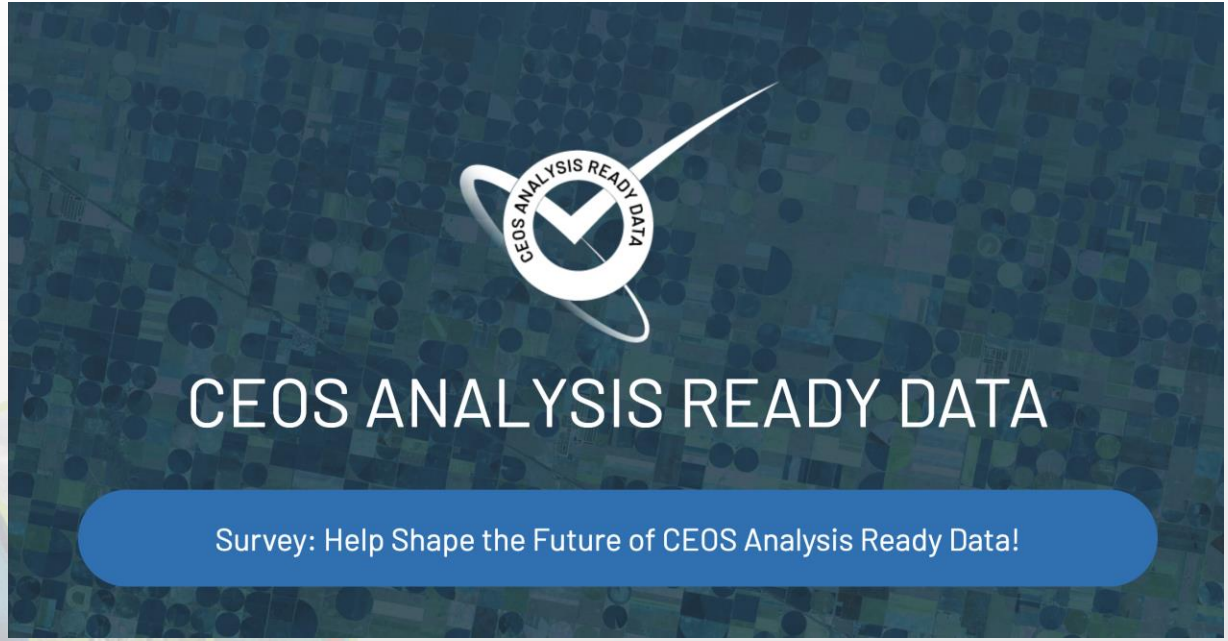
- **Co-located SLC (CSLC)**

  * Coregistered images in sensor geometry that incorporates corrections for geometric distortions (e.g. topographic effects), atmospheric delays (tropospheric and ionospheric), and other influencing factors.

- **Geolocated Multi-looked Complex (GMLC)**

  * Ground projected multi-looked complex product that will integrate all the data-driven corrections already applied CSLC. The phase can be used to generate multi-looked interferograms between any pairs of acquisitions.

CEOS-ARD
Synthetic Aperture Radar



http://ceos.org/ard