

	Analysis Ready Data For Land (CARD4L)	Product Family Specification: Normalised Radar Backscatter
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Document Status

For Adoption as: Product Family Specification, Normalised Radar Backscatter

This Specification should next be reviewed on: March 2021, or no later than 2 weeks before LSI-VC-11 meeting.

Proposed revisions may be provided to: lsi@lists.ceos.org

Document History

Version	Date	Description of Change	Author
0.0.2	23.03.2017	Zero Draft based on materials discussed in and leading up to LSI-VC-3, provided by SEO and others	Lewis
0.1.0	18.04.2017	Various revisions to structure.	Lewis
1.0.0	18.04.2017	Included material provided by Brian Killough/SEO reflecting input from a range of SAR experts/users.	Lewis
1.0.1	20.04.2017	Edits reflecting feedback from SEO, change to the figure/table in 'guidance'; removed item 4.2, which appeared redundant; moved reference to definitive ephemeris to a note under item 4.1; added reference to speckle under table 3 (radiometric corrections).	Lewis, Killough
2.0.0	30.08.2017	Feedback incorporated, circulated to LSI-VC.	Lewis
2.1.0	06.09.2017	Feedback from ESA included.	Lewis
2.1.1	06.09.2017	Edits rolled in.	Lewis
3.0	02.02.2018	Feedback from the teleconference (06/12/2018) and post teleconf (emails) Included.	Siqueira
3.1	03.04.2018	Nuno Miranda (ESA) comments addressed (uncertainty information to be required at the threshold level – 3.4 Radiometric corrections (Accuracy), split sensor acquisition mode).	Siqueira, Miranda
3.1.1	12.04.2018	Ake Rosenqvist (JAXA) comments (split sensor acquisition mode into acquisition and processing parameters, include "global incidence angle").	Siqueira
	04.06.2018	Feedback from Ben Lewis, GA (process table update)	Siqueira
3.2	07.08.2018	Feedback from the "SAR ARD definition Team" before and at IGARSS 2018. Feedback on the 2nd SAR ARD definition Team teleconference (20/08/2018):	Siqueira
	21.08.2018		Rosenqvist

Version	Date	Description of Change	Author
		add a sentence on 1.19 that the radiometric performance metadata should be provided for each of the polarisation channel when available	
3.2.1	14.12.2018	Clarification about per pixel NESZ provision for each channel when noise removal is implemented.	Chapman
3.2.2	05.02.2019	Abstract updated, metadata definition added and v3.2.2 shared with LSI-VC list and LSI-VC-7 participants.	Rosenqvist, Charbonneau & Siqueira
3.2.3	27.05.2019	Formatting and verbiage updated for consistency.	Metzger
4.0	02.03.2019	Version endorsed at LSI-VC7 meeting (14Feb 2019) with minor amendments to address feedback from the SAR Definition Team.	LSI-VC-7
4.1	26.06.2019	Added self-assessment columns	Bontje
4.2	20.12.2019	Integrated review at ESRIN CEOS WGCV SAR meeting.	Rosenqvist, Small, Chapman, Meyer, Lavallo, Miranda, Thankappan, Tadono, Zhou
4.3	11.01.2020	Integrated experiences with polarimetric document and clarified metadata descriptions for source data and products. Metadata specifications as separate document.	Small, Rosenqvist, Charbonneau & Zhou
4.4	12.01.2020	Single-source and Multi-source cases tentatively as separate documents.	Small & Rosenqvist
4.5	06.02.2020	2.3 Scattering Area Image added	Small, Rosenqvist Charbonneau, Yuan, Dadamia, Zhou & Kellndorfer
4.6	18.02.2020	Simple mosaic multi-source case tentatively added to single document. Separate multi-source case still in development and alignment with POL v.2.7	Rosenqvist
4.7	13.03.2020	Update to 4.4 Gridding Convention	Small, Kellndorfer, Rosenqvist & Charbonneau
4.8	23.04.2020 10.05.2020	<ul style="list-style-type: none"> Definitions: Revised CARD4L Acronym for Interferometric Radar from “IR” to “InSAR” Item 3.2. Name change from “Backscatter conversion” to “Scaling conversion” 	Thankappan, Rosenqvist, Small, Charbonneau
4.9	12.05.2020	<ul style="list-style-type: none"> Items 1.2 & 2.1 . Aligned Target requirements with the SR 4.2 PFS and added NRB Metadata Specification as Target Document history editorial 	Rosenqvist, Labahn Rosenqvist, Chapman, Labahn
5.0	12.05.2020	PFS endorsed at LSI-VC-9, meeting #3	LSI-VC-9

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Description

Product Family Title: **Normalised Radar Backscatter (CARD4L-NRB)**

Applies to: Data collected by Synthetic Aperture Radar sensors.

Abstract

The CARD4L Product Family Specifications for Synthetic Aperture Radar (SAR) data are specifically aimed at users interested in exploring the potential of SAR, but who may lack the expertise or facilities for SAR processing. There are currently four CARD4L SAR products:

- *Normalised Radar Backscatter*
- *Polarimetric Radar*
- *Geocoded Single-Look Complex*
- *Interferometric Radar*

The CARD4L Normalised Radar Backscatter product specification described below has been subject to Radiometric Terrain Correction (RTC) and is given in gamma-0 (γ^0) backscatter, which mitigates the variations from diverse observation geometries. It is recommended for most land applications. However, sigma-0 (σ^0) backscatter can be retrieved by using the per-pixel metadata. As the NRB product contains backscatter values only, it cannot be used for SAR polarimetry or interferometric applications that require local phase estimates.

It should be noted that while speckle is inherent in SAR acquisitions, speckle filtering has not been applied to the Normalised Radar Backscatter product in order to preserve spatial resolution and user freedom. Some applications (or processing methods) may require spatial or temporal filtering for stationary backscatter estimates.

Definitions

CARD4L	CEOS Analysis Ready Data for Land
NRB	Normalised Radar Backscatter
POL	Polarimetric Radar
GSLC	Geocoded Single-Look Complex
InSAR	Interferometric Radar
Ancillary Data	Data other than instrument measurements, originating in the instrument itself or from the satellite, required to perform processing of the data. They include orbit data, attitude data, time information, spacecraft engineering data, calibration data, data quality information, and data from other instruments.
Auxiliary Data	The data required for instrument processing, which does not originate in the instrument itself or from the satellite. Some auxiliary data will be generated in the ground segment, whilst other data will be provided from external sources.
Metadata	Structured information that describes other information or information services. With well-defined metadata, users should be able to get basic information about data, without the need to have knowledge about its entire content.
Spatial Resolution	The highest magnification of the sensor at the ground surface.
Spatial Sampling Distance	Spatial sampling distance is the barycentre-to-barycentre distance between adjacent spatial samples on the Earth's surface.

Requirements

General Metadata

These are metadata records describing a distributed collection of pixels. The collection of pixels referred to must be contiguous in space and time. General metadata should allow the user to assess the overall suitability of the dataset, and must meet the following requirements:

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
1.1	Traceability	Not required.	Data must be traceable to SI reference standard. <i>Note 1: Relationship to 3.4. Traceability requires an estimate of measurement uncertainty.</i> <i>Note 2: Information on traceability should be available in the metadata as a single DOI landing page.</i>				
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.5.0, or a community endorsed standard that facilitates machine-readability, such ISO 19115-2.				
1.3	Product Type	CARD4L product type name and (if required by the data provider) Copyright.	As threshold.				
1.4	Document Identifier	Reference to CARD4L-Normalised Radar Backscatter document as URL or DOI.	As threshold.				
1.5	Data Collection Time	Number of source data acquisitions of the data collection is identified. The start and stop time of data	As threshold.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
		collection is identified in the metadata, expressed in date/time (UTC). In case of composite products, the dates/times of the first and last datatakes.					
1.6	Source Data Attributes	Subsection describing (detailing) <u>the SAR acquisition</u> used to generate the CARD4L product. <i>Note: Source data attribute information are described for each acquisition and sequentially identified as acqID= 1, 2, 3, ...</i>					
1.6.1	Source Data Access	The metadata identifies the location from where the source data can be retrieved, expressed as a URL or DOI.	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	The instrument used to collect the data is identified in the metadata. - Satellite name - Instrument name	As threshold, but including a reference to the relevant CEOS Missions, Instruments and Measurements Database record.				
1.6.3	Source Data Acquisition Time	The start and stop date+time of source data is identified in the metadata, expressed in date/time, to the second, with the time offset from UTC unambiguously identified.	Acquisition time for each pixel is identified (or can be reliably determined) in the metadata, expressed in date/time at UTC, to the microsecond.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
1.6.4	Source Data Acquisition Parameters	Acquisition parameters related to the SAR antenna: <ul style="list-style-type: none"> - Radar band - Centre frequency - Observation mode - Polarisation(s) - Antenna pointing [Right/Left] - Beam ID 	As threshold.				
1.6.5	Source Data Orbit Information	Information related to the platform orbit used for data processing: <ul style="list-style-type: none"> - Pass direction [asc/desc] - Orbit data source [e.g., predicted/definite/precise/ downlinked etc.] 	As threshold, including also: <ul style="list-style-type: none"> - Platform heading angle - Orbit data file containing state vectors (minimum of 5 state vectors, from 10% of scene length <i>before</i> start time to 10% of scene length <i>after</i> stop time) - Platform (mean) altitude 				
1.6.6	Source Data Processing Information	Processing parameters details of the source data: <ul style="list-style-type: none"> - Processing facility - Processing date - Software version - Product level - Product ID (file name) - Azimuth number of Looks - Range number of Looks (separate values for each beam, as necessary) 	As threshold, plus additional relevant processing parameters, e.g., Range- and Azimuth Look Bandwidth and LUT applied.				
1.6.7	Source Data Image Attributes	Image attributes related to the source data: <ul style="list-style-type: none"> - Product geometry (slant range/ground range) 	As threshold.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
		<ul style="list-style-type: none"> - Azimuth pixel spacing - Range pixel spacing - Azimuth resolution - Range resolution - Near range incident angle - Far range incident angle 					
1.6.8	Sensor Calibration	Not required.	Sensor calibration parameters are identified in the metadata or can be accessed using details included in the metadata. Ideally this would support machine to machine access.				
1.6.9	Performance Indicators	Provide performance indicators on data intensity mean noise level ($NE\sigma^0$ or $NE\beta^0$ (noise equivalent beta naught)). Provided for each polarisation channel when available. Those are not to be estimated individually for each product but estimated once for each acquisition mode and annotated on all products.	Provide additional relevant performance indicators (e.g., ENL, PSLR, ISLR, etc.).				
1.6.10	Source Data Polarimetric Calibration Matrices	Not required.	The complex-valued polarimetric distortion matrices with the channel imbalance and the cross-talk applied for the polarimetric calibration.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
1.6.11	Mean Faraday Rotation Angle	Not required.	The mean Faraday rotation angle estimated from the polarimetric data and/or from models with reference to the method or paper used to derive the estimate.				
1.6.12	Ionosphere Indicator	Not required.	Flag indicating whether the backscatter imagery is “significantly impacted” by the ionosphere (0- no, 1 – yes). Significant impact would imply that the ionospheric impact on the backscatter exceeds the radiometric calibration requirement or goal for the imagery.				
1.7	Product Attributes	Subsection containing information related to the CARD4L product generation procedure and geographic parameters.					
1.7.1	Product Data Access	<p>Processing parameters details of the CARD4L product:</p> <ul style="list-style-type: none"> - Processing facility - Processing date - Software version - Product level - Product ID (file name) <p>The metadata also identifies the location from where the CARD4L product can be retrieved, expressed as a URL or DOI.</p>	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.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
1.7.2	Ancillary Data	Not required.	The metadata identifies the sources of ancillary data used in the generation process, ideally expressed as DOIs. <i>Note: Ancillary data includes DEMs, etc., and any additional data sources used in the generation of the product.</i>				
1.7.3	Product Sample Spacing	CARD4L product processing parameters details: - Pixel (column) spacing - Line (row) spacing	As threshold.				
1.7.4	Filtering	Flag if filter has been applied (Y/N) . Metadata should include: - Reference to algorithm - Input filtering parameters - Type - Window size - Other filter parameters	As threshold.				
1.7.5	Geographic Bounding Box	The four corners of the product file (bounding box) are identified, expressed in an accepted coordinate reference system.	As threshold.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
1.7.6	Geographic Image Extent	The 4 extreme points of the image expressed as 4 sets of geographic coordinates holding the points of minimum and maximum latitude, minimum and maximum longitude.	As threshold.				
1.7.7	Product Image Size	Image attributes of the CARD4L product: <ul style="list-style-type: none"> - Number of lines - Number of pixels/line - File header size (if applicable) - Number of border pixels (if applicable) 	As threshold.				
1.7.8	Pixel Coordinate Convention	Pixel coordinate convention [pixel centre, pixel ULC or pixel LLC].	As threshold.				
1.7.9	Coordinate Reference System	The metadata lists the coordinate reference system that has been used.	As threshold, but expressed as an EPSG code.				
1.7.10	Map Projection	The metadata lists the map projection (or geographical coordinates if applicable) that has been used and any relevant parameters required in relation to use of data in that map projection.	As threshold, but expressed as a human readable (gdal WKT) code.				

Per-Pixel Metadata

The following minimum metadata specifications apply to each pixel. Whether the metadata are provided in a single record relevant to all pixels, or separately for each pixel, is at the discretion of the data provider. Per-pixel metadata should allow users to discriminate between (choose) observations on the basis of their individual suitability for application.

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
2.1	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.5.0.				
2.2	Data Mask Image	Mask image indicating: <ul style="list-style-type: none"> - Valid data - Invalid data - No-data File format specifications/ contents provided in metadata: <ul style="list-style-type: none"> - Sample Type [Mask] - Data Format [Raw/GeoTif, ...] - Data Type [Byte/Int/Float, ...] - Bits per sample - Byte order - Bit value representation 	As threshold, including in addition e.g., <ul style="list-style-type: none"> - Layover (included as invalid data in Threshold) - Radar shadow (included as invalid data in Threshold) - Ocean water, etc. 				
2.3	Scattering Area Image	DEM-based local contributing area image used for normalisation is provided. File format specifications/contents provided in metadata: <ul style="list-style-type: none"> - Sample Type [square_meters] - Data Format - Data Type - Byte Order - Bits per sample 	As threshold.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
2.4	Local Incident Angle Image	<p>DEM-based Local Incident angle image is provided.</p> <p>File format specifications/contents provided in metadata:</p> <ul style="list-style-type: none"> - Sample Type [Angle] - Data Format - Data Type - Byte Order - Bits per sample <p><i>Note: Users should be made aware that estimated "local incident angle" values are incorrect in regions where the scattering normalisation areas is integrated from irregular terrain, especially foreslopes.</i></p>	As threshold.				
2.5	Ellipsoidal Incident Angle Image	Not required.	<p>Ellipsoidal incident angle is provided.</p> <p>Indicate which ellipsoidal height was used.</p> <p>File format specifications/contents provided in metadata:</p> <ul style="list-style-type: none"> - Sample Type [Angle] - Data Format - Data Type - Byte Order - Bits per sample 				
2.6	Noise Power Image	Not required.	Estimated noise equivalent σ^0 (or β^0 , as applicable) used for Noise Removal, <u>if applied</u> , for each channel.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
			File format specifications/contents provided in metadata: <ul style="list-style-type: none"> - Sample Type [NESZ or NEBZ] - Data Format - Data Type - Byte Order - Bits per sample 				
2.7	Gamma-to-Sigma Ratio Image	Not required.	Ratio of the integrated area in the Gamma projection over the integrated area in the Sigma projection (ground). Multiplying RTC γ^o by this ratio results in an estimate of RTC σ^o . File format specifications/contents provided in metadata: <ul style="list-style-type: none"> - Sample Type [Ratio] - Data Format - Data Type - Byte Order - Bits per sample 				
2.8	Acquisition Date Image	Required for multi-source product. Acquisition date for each pixel is identified. Data are day offset to reference observation date [UTC]. Date used as reference ("Day 0") is provided in the metadata. Acquisition date image data type	As threshold.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self- Assessment	Target Self- Assessment	Self-Assessment Explanation/ Justification	Recommended Requirement Modification
		<p>[Byte/INT16/Float/etc.] provided in metadata.</p> <p><i>Note: Not required for single source data.</i></p> <p>Alternatively to "image", when offsets are in integer format, a shapefile (.shp) containing polygons delimiting each "day offset class"</p> <p>In case of multi-temporal image stacks, use acquisition ID to list contributing images.</p>					

Radiometric Terrain Corrected Measurements

The following requirements must be met for all pixels in a collection. The requirements indicate the necessary outcomes and, to some degree, the minimum steps necessary to be deemed to have achieved those outcomes. Radiometric corrections must lead to normalised measurement(s) of backscatter intensity.

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
3.1	Backscatter Measurements	<p>Gamma-Nought (γ^0) backscatter coefficient is provided for each polarisation (e.g., HH, HV, VV, VH).</p> <p>File format specifications/contents provided in metadata:</p> <ul style="list-style-type: none"> - Measurement Type [Gamma-Nought] - Backscatter Expression Convention [linear amplitude or linear power*] - Polarisation [HH/HV/VV/VH] - Data Format [Raw/GeoTIFF, etc.] - Data Type [Byte/Int/Float, etc.] - Byte order - Bits per sample <p><i>*Note: transformation to the logarithm decibel scale is not required or desired as this step can be easily completed by the user if necessary.</i></p>	As threshold.				
3.2	Scaling Conversion	Indicate equation to convert from pixel linear amplitude/power to logarithmic decibel scale, including, if applicable, associated calibration (dB offset) factor.	As threshold.				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
3.3	Noise Removal	<p>Flag if noise removal* has been applied (Y/N). Metadata should include reference to algorithm as URL or DOI.</p> <p><i>*Note: Thermal noise removal and image border noise removal to remove overall scene noise and scene edge artefacts, respectively.</i></p>	As threshold.				
3.4	Radiometric Terrain Correction Algorithms	<p>Adjustments are made for terrain by modelling the local illuminated reference area using the preferred choice of a published peer-reviewed algorithm to produce a radiometrically terrain corrected (RTC) γ^0.</p> <p>Metadata references:</p> <ul style="list-style-type: none"> - a citable peer-reviewed algorithm - technical documentation regarding the implementation of that algorithm expressed as URLs or DOIs - the sources of ancillary data used to make corrections <p><i>Note: Examples of technical documentation include an Algorithm, Theoretical Basis Document, product user guide, etc.</i></p>	Require resolution of DEM better than the output product resolution when applying terrain corrections.				
3.5	Radiometric Accuracy	Not required.	Uncertainty (e.g., bounds on γ^0) information is provided as document referenced as URL or DOI. SI traceability is achieved.				

Geometric Terrain Corrections

Geometric corrections must place the measurement accurately on the surface of the Earth (that is, geolocate the measurement) allowing measurements taken through time to be compared.

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/Justification	Recommended Requirement Modification
4.1	Geometric Correction Algorithms	Not required.	<p>Metadata references:</p> <ul style="list-style-type: none"> - a Metadata citable peer-reviewed algorithm - technical documentation regarding the implementation of that algorithm expressed as URLs or DOIs - the sources of ancillary data used to make corrections <p><i>Note: Examples of technical documentation include an Algorithm, Theoretical Basis Document, product user guide.</i></p>				
4.2	Digital Elevation Model	<p>a) During ortho-rectification, the data provider shall use the same DEM that was used for the radiometric terrain flattening to ensure consistency of the data stack.</p> <p>b) Provide reference to Digital Elevation Model used for Geometric Terrain Correction.</p>	<p>a) A DEM with comparable or better resolution to the resolution of the output CARD4L product shall be used.</p> <p>b) As threshold.</p>				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self- Assessment	Target Self- Assessment	Self-Assessment Explanation/ Justification	Recommended Requirement Modification
4.3	Geometric Accuracy	<p>An estimate of the geometric accuracy (absolute localisation error) is provided (e.g., as slant range bias and standard deviation, and as azimuth bias and standard deviation).</p> <p>Output product subpixel accuracy is taken to be less than or equal to 0.2-pixel radial root mean square error (rRMSE).</p> <p><i>Note 1: Typically obtained from corner reflector measurements, and not estimated on a per-product basis.</i></p> <p><i>Note 2: Accurate geolocation is a prerequisite to radar processing to correct for terrain. To enable interoperability between radar sensors, absolute accuracy is required.</i></p>	<p>Output product subpixel accuracy is taken to be less than or equal to 0.1-pixel radial root mean square error (rRMSE).</p> <p>Provide documentation of estimate of absolute localisation error as DOI or URL.</p>				
4.4	Gridding Convention	<p>A consistent gridding/sampling frame is used. The origin is chosen to minimise any need for subsequent resampling between multiple products (be they from the same or different providers). This is typically accomplished via a “snap to grid” in relation to the most proximate grid tile in a global system.**</p> <p><i>**Note: If a product hierarchy of resolutions exists (or is planned), the multiple resolutions should nest</i></p>	<p>When multiple providers share a common map projection, providers are encouraged to standardise the origins of their products among each other.</p> <p>In the case of UTM/UPS coordinates, the upper left corner coordinates should be set to an integer multiple of sample intervals from a 100 km by 100 km grid tile of the Military Grid Reference System's 100k coordinates</p>				

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self- Assessment	Target Self- Assessment	Self-Assessment Explanation/ Justification	Recommended Requirement Modification
		<i>within each other (e.g., 12.5m, 25m, 50m, 100m, etc.), and not be disjointed.</i>	("snap to grid"). For products presented in geographic coordinates (latitude and longitude), the origin should be set to an integer multiple of samples in relation to the closest integer degree.				

Summary Self-Assessment Table

		Threshold	Target
1	General Metadata		
1.1	Traceability		
1.2	Metadata Machine Readability		
1.3	Product Type		
1.4	Document Identifier		
1.5	Data Collection Time		
1.6	Source Data Attributes		
1.6.1	Source Data Access		
1.6.2	Instrument		
1.6.3	Source Data Acquisition Time		
1.6.4	Source Data Acquisition Parameters		
1.6.5	Source Data Orbit Information		
1.6.6	Source Data Processing Information		
1.6.7	Source Data Image Attributes		
1.6.8	Sensor Calibration		
1.6.9	Performance Indicators		
1.6.10	Source Data Polarimetric Calibration Matrices		
1.6.11	Mean Faraday Rotation Angle		
1.6.12	Ionosphere Indicator		
1.7	Product Attributes		
1.7.1	Product Data Access		
1.7.2	Ancillary Data		
1.7.3	Product Sample Spacing		
1.7.4	Filtering		
1.7.5	Geographical Bounding Box		
1.7.6	Geographic Image Extent		
1.7.7	Product Image Size		
1.7.8	Pixel Coordinate Convention		
1.7.9	Coordinate Reference System		
1.7.10	Map Projection		
2	Per-Pixel Metadata		
2.1	Metadata Machine Readability		
2.2	Data Mask Image		
2.3	Scattering Area Image		
2.4	Local Incident Angle Image		
2.5	Ellipsoidal Incident Angle Image		
2.6	Noise Power Image		
2.7	Gamma-to-Sigma Ratio Image		
2.8	Acquisition Date Image		
3	Radiometric Terrain Corrected Measurements		
3.1	Backscatter Measurements		
3.2	Scaling Conversion		
3.3	Noise Removal		
3.4	Radiometric Terrain Correction Algorithms		
3.5	Radiometric Accuracy		
4	Geometric Terrain Corrections		
4.1	Geometric Correction Algorithms		
4.2	Digital Elevation Model		
4.3	Geometric Accuracy		
4.4	Gridding Convention		

Guidance

This section aims to provide background and specific information on the processing steps that can be used to achieve analysis ready data. This Guidance material does not replace or over-ride the specifications.

Introduction to CARD4L

What are CEOS Analysis Ready Data for Land (CARD4L) products?

CARD4L products 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. These products would be resampled onto a common geometric grid (for a given product) and would provide baseline data for further interoperability both through time and with other datasets.

CARD4L products are intended to be flexible and accessible products suitable for a wide range of users for a wide variety of applications, including particularly time series analysis and multi-sensor application development. They are also intended to support rapid ingestion and exploitation via high-performance computing, cloud computing, and other future data architectures. They may not be suitable for all purposes and are not intended as a 'replacement' for other types of satellite products.

When can a product be called CARD4L?

The CARD4L branding is applied to a particular product once:

- the product has been assessed as meeting CARD4L requirements by the agency responsible for production and distribution of the product, and
- the assessment has been peer reviewed by the CEOS Land Surface Imaging Virtual Constellation in consultation with the CEOS Working Group on Calibration and Validation.

Agencies or other entities considering undertaking an assessment process should contact the co-leads of the [Land Surface Imaging Virtual Constellation](#).

A product can continue to use CARD4L branding as long as its generation and distribution remain consistent with the peer-reviewed assessment.

What is the difference between Threshold and Target?

Products that meet all threshold requirements should be immediately useful for scientific analysis or decision-making.

Products that meet target requirements will reduce the overall product uncertainties and enhance broad-scale applications. For example, the products may enhance interoperability or provide increased accuracy through additional corrections that are not reasonable at the *threshold* level.

Target requirements anticipate continuous improvement of methods and evolution of community expectations, which are both normal and inevitable in a developing field. Over time, *target* specifications may (as subject to due process) become accepted as *threshold* requirements.

Reference Papers

The following papers provide scientific and technical guidance:

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Small D. Flattening Gamma: Radiometric Terrain Correction for SAR Imagery, *IEEE Transactions on Geoscience and Remote Sensing*, 2011, Vol. 49(8), pp. 3081-3093. doi: [10.1109/TGRS.2011.2120616](https://doi.org/10.1109/TGRS.2011.2120616)

Shimada, M. Ortho-Rectification and Slope Correction of SAR Data Using DEM and Its Accuracy Evaluation. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*. Dec. 2010, 3(4), pp 657-671.

Small D., Miranda N., Meier E. [2009] (presentation), Local Incidence Angle Considered Harmful, *Proc. of CEOS SAR 2009 Workshop*, Pasadena, California, USA, Nov. 17-19, 2009.

Small D., Miranda N. and Meier E., "A revised radiometric normalisation standard for SAR," 2009 *IEEE International Geoscience and Remote Sensing Symposium*, Cape Town, 2009, pp. 566-569.
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