NASA SDS Product Specification

Level-2 Geocoded Unwrapped Interferogram

L2_GUNW

Rev B

JPL D-102272

November 9, 2023

Authors: Virginia Brancato, Jungkyo Jung, and Xiaodong Huang, Heresh Fattahi

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

SIGNATURE PAGE

Prepared by:

Electronic Signature on File | *30-Nov-2023*
Virginia Brancato, NISAR ADT Level-2 Product Developer | Date

Email Approval on File | *30-Nov-2023*
Jungkyo Jung, NISAR ADT Level-2 Product Developer | Date

Email Approval on File | *30-Nov-2023*
Xiaodong Huang, NISAR ADT Level-2 Product Developer | Date

Electronic Signature on File | *01-Dec-2023*
Heresh Fattahi, NISAR ADT Lead | Date

Approved by:

Electronic Signature on File | *05-Dec-2023*
Ana Maria Guerrero, NISAR Mission System Manager | Date

Electronic Signature on File | *01-Dec-2023*
Chuck Baker, NISAR Mission System Engineer | Date

Electronic Signature on File | *03-Dec-2023*
Paul Rosen, NISAR Project Scientist | Date

Electronic Signature on File | *30-Nov-2023*
Cecilia Cheng, NISAR SDS Manager | Date

Electronic Signature on File | *04-Dec-2023*
Helen Mortensen, NISAR SDS Lead System Engineer | Date

EPDM ELECTRONIC SIGNATURES

User-Group/Role	...	Decision	Comments	Date
Cheng, Cecilia S (cecilia)-JPL Consumer/Project Co...	...	Approve		30-Nov-2023 17:13
Fattahi, Heresh (fattahi)-JPL Author/JPL Author WIP	...	Approve		01-Dec-2023 06:27
Guerrero, Ana Maria P (ana)-JPL Author/JPL Author	...	Approve		05-Dec-2023 07:33
Brancato, Virginia (vbrancat)-JPL Consumer/Project...	...	Approve		30-Nov-2023 14:24
Mortensen, Helen B (hbmorten)-JPL Consumer/Pro...	...	Approve		04-Dec-2023 13:51
Baker, Charles J (cjbaker)-Engineering/Engineer	...	Approve		01-Dec-2023 07:51
Rosen, Paul A (parosen)-JPL Consumer/Project Con...	...	Approve	I continue to believe nan is not the right choice for fill value.	03-Dec-2023 23:07

ACKNOWLEDGEMENT

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

DOCUMENT CHANGE LOG

Revision	Cover Date	Sections Changed	ECR #	Reason, ECR Title, LRS #*
DRAFT Initial Release	December 11, 2020	All	N/A	Draft for Engineering Release for R1.1 Initial Release for R1.1 delivery
Initial Release	February 2, 2021	All	N/A	For Release 1.1. LRR-04xxx
Rev A (R1.1) Working Version	February 5, 2021	All	N/A	
Rev A (R2) Working Version 2	May 13, 2021	Sec 1.2, Sec 2.1, Sec 2.2, Sec 6	N/A	Merged info from Product Description Document (PDD). Removed reference to PDD. Added Section 6 on metadata cubes. LRR056764 for ISRO LRR056771 for NISAR Science Team
Rev A (R2) Working Version 2	July 15, 2021	Sec 6.1	N/A	Updated metadata cube formula
Rev B (R2) Working Version 2	July 15, 2021	All	N/A	Removed LRR number in footer. Updated list of TBD items table.
Rev A (ER 3.0) Working Version	December 10, 2021	Sec 3.2.3	N/A	For Engineering Release ER 3.0.
Rev A (R3) Working Version	March 04, 2022	Sec. 1.3, Figure 2-1, Table 2-1, Appendix A, TBD table.	N/A	Updated Docushare link in Sec. 1.3. Added description of offset products in Table 2-1. Updated product dependency Figure 2-1. Added missing and new acronyms in Appendix A. Removed incomplete LRR number in the footer.
Rev A (R3.1) Working Version	August 05, 2022	Front page, Sec 2.1	N/A	Updated NISAR ADT Lead; updated product dependency figure
Rev A (R3.1) Working Version	August 05, 2022	Cover. TBD, TBC tables, Acronym List	N/A	Requested fixes. LRR067551
Rev A (R3.2) Working Version	January 27, 2023	All	N/A	Revised for R3.2 release
Rev A (R3.3)	June 6, 2023	All	N/A	Revised for R3.3 release URS CL# 23-3181

Rev B (R3.4)	November 9, 2023	Cover page, Sec. 1.3, Sec. 2.2, Sec. 3.2.2; Sections 5.2, 5.3, 5.4, 5.5, 5.6	N/A	Modified date on cover page; Updated reference to RSLC product specification and NISAR products filename convention documents; Removed reference and link to EPDM; Corrected formation of blended pixel offsets layers in Sec. 2.2 and added reference to NISAR SDS ATBD; Modified Table 3.4 to reflect information in product XML specifications. Updated Sections 5.2, 5.3, 5.4, 5.5, 5.6.
* *Include the JPL Limited Release System (LRS) clearance number for each revision to be shared with foreign partners.*				

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

LIST OF TBC ITEMS

These items are to be completed when document is ready to enter configuration control.

Page	Section	Date / Release

LIST OF TBD ITEMS

These items are to be completed when document is ready to enter configuration control.

Page	Section	Date / Release

1 INTRODUCTION

1.1 Purpose of Description

This document provides a specification of the NASA-ISRO Synthetic Aperture Radar (NISAR) L-SAR Level-2 Geocoded Unwrapped interferogram product to be generated by the NASA Science Data System (SDS) and provided to the Distributed Active Archive Center (DAAC). This data product is referenced by the short name L2_GUNW.

1.2 Document Organization

Section 2 provides an overview of the product, including its purpose, and latency.

Section 3 provides the structure of the product, including granule definition, file organization, spatial resolution, temporal and spatial organization of the content, the size and data volume.

Section 4 provides qualitative descriptions of the information provided in the product.

Section 5 provides a detailed identification of the individual fields within the L2_GUNW product, including for example their units, size, and coordinates.

Section 6 provides a description of the metadata cube representation.

Appendix A provides a listing of the acronyms used in this document.

Appendix B provides a description of geolocation grids and projection systems used for the product.

1.3 Applicable and Reference Documents

Applicable documents levy requirements on areas addressed in this document. Reference documents are cited to provide additional information to readers. In case of conflict between the applicable documents and this document, the Project shall review the conflict to find the most effective resolution.

Applicable Documents

[AD1] NISAR NASA SDS Level 4 Requirements, JPL D-95655, Initial, Sep. 13, 2019

[AD2] NISAR NASA SDS Algorithm Development Plan, JPL D-95678, Initial, Sep. 12, 2019

[AD3] NISAR Science Data Management and Archive Plan, JPL D-80828, June 1, 2016

[AD4] NISAR Science Management Plan, JPL D-76340, Rev A, Aug. 14, 2018

[AD5] NISAR Calibration and Validation Plan, JPL D-102256, September. 2019

[AD6] NISAR NASA SDS L4 Software Management Plan (SMP), JPL D-95656, Rev A, Sep. 19, 2022

[AD7] ISO-19115-2, https://www.iso.org/obp/ui/#iso:std:iso:19115:-2:ed-2:v1:en

Reference Documents

[RD1] NISAR NASA SDS Algorithm Theoretical Basis Document, JPL D-95677, Initial, Feb. 06, 2022.

[RD2] EOSDIS Handbook, July 2016, retrieved from https://cdn.earthdata.nasa.gov/conduit/upload/5980/EOSDISHandbookWebFinaL2.pdf

[RD3] NISAR SDS File Naming Conventions, JPL D-102255, Initial, Nov. 4, 2020

[RD4] NISAR L1_RSLC Product Specification Document, JPL D-102268, R3.3, Apr. 28, 2023.

[RD5] HDF5 documentation at https://portal.hdfgroup.org/display/HDF5/HDF5

[RD6] Eineder, M. (2003), Efficient simulation of SAR interferograms of large areas and of rugged terrain, IEEE Transactions on Geoscience and Remote Sensing, 41(6), 1415-1427.

The NISAR Level 1 science requirements are translated into requirements on the various spacecraft and instrument systems, including the requirements related to the processing system producing the L0-L2 products. These SDS requirements [AD1] fall into three general categories: resolution requirements, radiometric and spatial location accuracy requirements, and latency and throughput requirements.

2 PRODUCT OVERVIEW

2.1 Product Background

Each NASA SDS L0-L2 L-band product (Figure 2-1 and Table 2-1 Product Dependency) is distributed as a single Hierarchical Data Format version 5 (HDF5, [RD5]) granule. All the metadata and imagery data are packaged in clearly defined sub-groups within the granule in compliance with the HDF5 specification [RD5]. The NISAR product level definitions are given in **Error! Reference source not found.**.

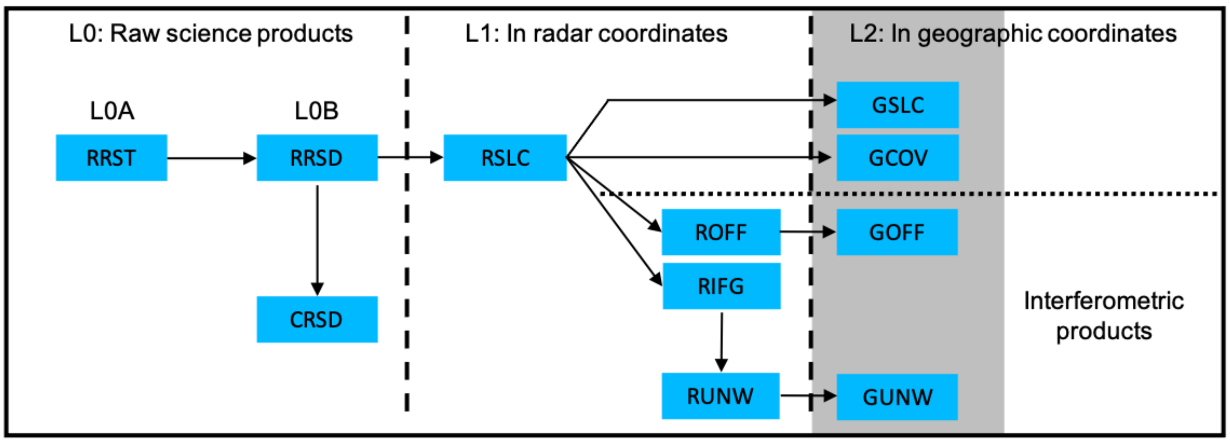

Figure 2-1 Product Dependency

Table 2-1. Key to Product Dependency Diagram

Product	Scope	Description	Granule Size
Radar Raw Science Telemetry (RRST)	Global	This L0A product is the raw downlinked data delivered to SDS	By downlinked files
Radar Raw Signal Data (RRSD)	Global	This L0B product is corrected, aligned radar pulse data derived from the RRST products and used for further processing	By radar observation, i.e., continuous data collected in a single radar mode
Calibration Raw Signal Data (CRSD)	Global	This L0B product contains instrument calibration data.	By radar datatake, i.e., a sequence of observations for one radar-on period

Product	Scope	Description	Granule Size
Range-Doppler Single Look Complex (RSLC)	Global	Used to generate all higher-level products	On pre-defined track/frame. High-resolution modes will have a high-res RSLC product and a background resolution RSLC product

Product	Scope	Description	Granule Size
Range-Doppler Nearest-Time Interferogram (RIFG)	Antarctica, Greenland, and selected mountain glaciers. Nearest pair in time and co-pol channels only.	Multi-looked interferogram in Range Doppler coordinates with geometrical phase (including topographic phase) removed and formed using high-resolution dense pixel offsets.	On pre-defined track/frame
Range-Doppler Nearest-Time Pixel Offsets (ROFF)	Antarctica, Greenland, and selected mountain glaciers. Nearest pair in time and co-pol channels only.	Unfiltered and unculled layers of pixel offsets in Range Doppler coordinates with different resolutions obtained from incoherent speckle tracking.	On pre-defined track/frame
Range-Doppler Nearest-Time Unwrapped Interferogram (RUNW)	Antarctica, Greenland, and selected mountain glaciers. Nearest pair in time and co-pol channels only.	Multi-looked, unwrapped differential interferogram in Range Doppler coordinates with geometrical phase (including topographic phase) removed.	On pre-defined track/frame

Product	Scope	Description	Granule Size
Geocoded SLC (GSLC)	Global and all channels.	Geocoded version of RSLC product using the MOE state vectors and a DEM.	On pre-defined track/frame
Geocoded Nearest-Time Pixel Offsets (GOFF)	Antarctica, Greenland, selected mountain glaciers. Nearest pair in time and co-pol channels only.	Geocoded version of ROFF product using the MOE state vectors and a DEM.	On pre-defined track/frame
Geocoded Nearest-Time Unwrapped Interferogram (GUNW)	Global. Nearest pair in time and co-pol channels only.	Geocoded, multi-looked unwrapped differential interferogram with geometrical phase (including topographic phase) removed. It contains a geocoded version of the wrapped interferogram and normalized interferometric correlation at a finer posting.	On pre-defined track/frame
Geocoded Polarimetric Covariance Matrix (GCOV)	Global and all channels. Single/Dual/Quad pol.	Geocoded, multi-looked polarimetric covariance matrix.	On pre-defined track/frame

Table 2-2 NISAR Data Level Descriptions defined by Science.

Data Level	Description
Level 0A	Unprocessed instrument data with some communications artifacts removed, but without reconstruction of missing data and reordering of samples from the instrument. May still contain bit errors and missing data that needs reconstruction.

Level 0B	Reconstructed, unprocessed instrument data at original resolution, time ordered, all communications artifacts removed.
Level 1	Processed instrument data, focused to full resolution complex images, time referenced and annotated with ancillary information, including radiometric and relevant geometric calibration coefficients and georeferencing parameters (i.e., platform ephemeris) computed and appended, in natural radar coordinates.
Level 2 Category 1	Derived radar-specific parameters at the same or reduced resolution as Level 1 imagery, but resampled and geocoded to a geographic or ellipsoidal grid.
Level 2 Category 2	Derived radar-specific parameters at reduced resolution, in original Level 1 coordinates.
Level 3	Geophysical parameters derived from Level 1 or 2 data that have been spatially and/or temporally re-sampled to a global grid.

2.2 L2_GUNW Overview

The L2_GUNW product is a Level 2 Category 1 product mainly derived from the L1_RUNW product by using a Digital Elevation Model (DEM) to project the data to a pre-defined UTM/Polar stereographic system map grid (Appendix B: Geocoded Product Grids) with 80 m spacing. Bilinear interpolation is used to interpolate floating-point data layers onto a uniformly spaced, north-south/east-west aligned geographic grid. Sinc interpolation is used to interpolate complex data. All lookup tables including the phase corrections are transformed from image coordinates to map coordinates.

The L2_GUNW product is generated between consecutive in time L1_RSLC products, i.e., the current (secondary) and the immediately preceding in time L1_RSLC product (reference). Layers available in the L2_GUNW product are only generated for the co-pol channels of the main imaging band (frequencyA).

The primary quantities contained in L2_GUNW products are the wrapped complex interferogram (20 m posting), the unwrapped interferometric phase in radians (80 m posting), the normalized interferometric correlation, connected components, geometry masks (e.g., layover/shadow mask) and sub-pixel offset layers obtained from incoherent speckle tracking. If an offset product in Range Doppler coordinates (e.g., L1_ROFF) is available for the processed frame, the sub-pixel offset layers included in L2_GUNW are obtained by optimally blending the multiresolution offset layers included in L1_ROFF. The blended offset layer is then geocoded on the same geographical grid of the unwrapped interferogram [RD1]. On the contrary, when no L1_ROFF is available for the processed frame, the sub-pixel offset layers included in L2_GUNW are obtained by running speckle tracking once with a pre-defined set of parameters [RD1].

The L2_GUNW product also contains an ionospheric phase screen layer and a layer quantifying its uncertainty. The ionospheric phase screen comes from the L1_RUNW product and is estimated from the two spectral bands (frequencyA and frequencyB) whenever possible. In the case of mode transitions where continuity of spectral bands is impacted, a split spectrum ionospheric phase estimate is derived from the main imaging band (frequencyA). Due to the variable quality of estimated phase screens in different modes, which could significantly impact mosaicking, the estimated ionospheric phase screen is included as a layer in the product but not applied by default.

The L2_GUNW product also include lookup tables for external phase corrections (e.g., solid Earth tides, ECMWF hydrostatic and wet delays). These phase corrections, when available, are not applied to the data but are available to users for application in post-processing workflows.

The groups with their basic properties are given in Section 4**Error! Reference source not found.**. The details of the data elements are given in Section 5. Metadata cubes are discussed in Section 6.

3 PRODUCT ORGANIZATION

3.1 File Format

All NISAR standard products are in the Hierarchical Data Format version 5 (HDF, [RD5]). HDF5 is a general-purpose file format and programming library for storing scientific data. The National Center for Supercomputing Applications (NCSA) at the University of Illinois developed HDF to help scientists share data more easily. Use of the HDF library enables users to read HDF files regardless of the underlying computing environments. HDF files are equally accessible in Fortran, C/C++, and other high-level computation packages such as IDL, MATLAB or Python.

The HDF Group, a spin-off organization of the NCSA, is responsible for development and maintenance of HDF. Users should reference The HDF Group website at https://portal.hdfgroup.org/display/HDF5/HDF5 [RD5] to download HDF software and documentation.

HDF5 represents a significant departure from the conventions of previous versions of HDF. The changes that appear in HDF5 provide flexibility to overcome many of the limitations of previous releases. The basic building blocks have been largely redefined and are more powerful but less numerous. The key concepts of the HDF5 Abstract Data Model are Files, Groups, Datasets, Datatypes, Attributes and Property Lists. The following sections provide a brief description of each of these key HDF5 concepts.

3.1.1 HDF5 File

A File is the abstract representation of a physical data file. Files are containers for HDF5 Objects. These Objects include Groups, Datasets, and Datatypes.

3.1.2 HDF5 Group

Groups provide a means to organize the HDF5 Objects in HDF5 Files. Groups are containers for other Objects, including Datasets, named Datatypes and other Groups. In that sense, groups are analogous to directories that are used to categorize and classify files in standard operating systems.

The notation for files is identical to the notation used for Unix directories. The root Group is “/”. A Group contained in root might be called “/myGroup.” Like Unix directories, Objects appear in Groups through “links”. Thus, the same Object can simultaneously be in multiple Groups.

3.1.3 HDF5 Dataset

The Dataset is the HDF5 component that stores user data. Each Dataset associates with a Dataspace that describes the data dimensions, as well as a Datatype that describes the basic unit of storage element. A Dataset can also have Attributes.

3.1.4 HDF5 Datatype

A Datatype describes a unit of data storage for Datasets and Attributes. Datatypes are subdivided into Atomic and Composite Types.

Atomic Datatypes are analogous to simple basic types in most programming languages. HDF5 Atomic Datatypes include Time, Bitfield, String, Reference, Opaque, Integer, and Float. Each atomic type has a specific set of properties. Examples of the properties associated with Atomic Datatypes are:

- Integers are assigned size, precision, offset, pad byte order, and are designated as signed or unsigned.
- Strings can be fixed or variable length, and may or may not be null-terminated.
- References are constructs within HDF5 Files that point to other HDF5 Objects in the same file.

HDF5 provides a large set of predefined Atomic Datatypes. Table 3-1 lists the Atomic Datatypes that are used in NISAR data products.

Table 3-1. HDF5 Atomic Datatypes

HDF5 Atomic Datatypes	Description
H5T_STD_U8LE	unsigned, 8-bit, little-endian integer
H5T_STD_U16LE	unsigned, 16-bit, little-endian integer
H5T_STD_U32LE	unsigned, 32-bit, little-endian integer
H5T_STD_U64LE	unsigned, 64-bit, little-endian integer
H5T_STD_I8LE	signed, 8-bit, little-endian integer
H5T_STD_I16LE	signed, 16-bit, little-endian integer
H5T_STD_I32LE	signed, 32-bit, little-endian integer
H5T_STD_I64LE	Signed, 64-bit, little-endian integer
H5T_IEEE_F32LE	32-bit, little-endian, IEEE floating point
H5T_IEEE_F64LE	64-bit, little-endian, IEEE floating point
H5T_C_S1	character string made up of one or more bytes

Derived Datatypes are user-defined variants of predefined Atomic Datatypes where the data organization has been modified at the bit-level. Derived data types are particularly useful for representing custom N-bit integers and floating-point numbers.

Composite Datatypes incorporate sets of Atomic Datatypes. Composite Datatypes include Array, Enumeration, Variable Length and Compound.

- The Array Datatype defines a multi-dimensional array that can be accessed atomically.

- Variable Length presents a 1-D array element of variable length. Variable Length Datatypes are useful as building blocks of ragged arrays.
- Compound Datatypes are composed of named fields, each of which may be dissimilar Datatypes. Compound Datatypes are conceptually equivalent to structures in the C programming language.

Named Datatypes are explicitly stored as Objects within an HDF5 File. Named Datatypes provide a means to share Datatypes among Objects. Datatypes that are not explicitly stored as Named Datatypes are stored implicitly. They are stored separately for each Dataset or Attribute they describe.

NISAR products employ the following Derived and Compound Datatypes.

Table 3-2 NISAR HDF5 Derived and Compound Datatypes

Description	Comments
16-bit little-endian floating point	“binary16” half precision type in IEEE 754-2008 standard. Matches numpy.float16 type in Python. We will refer to this type as H5T_IEEE_F16LE or Float16 in our documents.

H5T_COMPOUND
{
16-bit little-endian floating-point "r";
16-bit little-endian floating-point "i";
}
	Complex numbers made up of two half precision floating point numbers. We will refer to this type as H5T_CPX_F16LE or CFloat16 in our documents.

H5T_COMPOUND
{
32-bit little-endian floating-point "r";
32-bit little-endian floating-point "i";
}
	Complex numbers made of two single precision floating point numbers. We will refer to this type as H5T_CPX_F32LE or CFloat32 in our documents.

H5T_COMPOUND
{
64-bit little-endian floating-point "r";
64-bit little-endian floating-point "i";
}
	Complex numbers made of two double precision floating point numbers. We will refer to this type as H5T_CPX_F64LE or CFloat64 in our documents.

3.1.5 HDF5 Attribute

An Attribute is a small aggregate of data that describes Groups or Datasets. Like Datasets, Attributes are also associated with a particular Dataspace and Datatype. Attributes cannot be subsetted or extended. Attributes themselves cannot have Attributes.

3.2 NISAR File Organization

3.2.1 Groups

All NISAR HDF5 files are organized as groups with no actual data at the root(“/”) level. Table 3-3 shows the general layout of the HDF5 files that are generated by the NISAR Science Data System. Data from the L-SAR and S-SAR instruments are also separated out into their own groups under the “/science” group.

Table 3-3 Group organization at the top level of a NISAR HDF5 File

Group Name	Description
/science/LSAR	All science data from the L-SAR instrument is organized under this group
/science/SSAR	All science data from the S-SAR instrument is organized under this group
/science/LSAR/identification	File level metadata for cataloging, archiving the granule

In the nominal baseline, L-SAR and S-SAR data will not appear in the same granule, even if they cover the same geographic area. Data structure described below the primary groups (“/science/LSAR” for L-SAR and “/science/SSAR” for S-SAR) will be the same for L-SAR and S-SAR products. The rest of the document from this point on describes the layout of the product containing L-SAR data. The specification for equivalent S-SAR data products is expected to be the same except for the substitution of “LSAR” by “SSAR” in the dataset paths in the HDF5 granule.

3.2.2 File Level Metadata

Global metadata at the file level are currently given as Global Attributes shown in Table 3-4.

Metadata regarding the data in the particular granule are given in “/science/LSAR/identification” for L- or S-SAR. These data are described further in Sec 4.2 and Sec 5.2.

Table 3-4 Global Attributes of L2_GUNW

Attribute	Format	Description	Value
Conventions	string	NetCDF-4 conventions adopted in this product. This attribute should be set to CF-1.8 to indicate that the group is compliant with the Climate and Forecast NetCDF conventions.	CF-1.7
Title	string	Product title.	NISAR L2_GUNW Product
Institution	string	Name of producing agency.	NASA JPL
mission_name	string	Mission name.	NISAR

reference_document	string	Name and version of Product Description Document to use as reference for product.	D-102272 NISAR NASA SDS Product Specification L2 Geocoded Unwrapped Interferogram
Contact	string	Contact information for producer of product.	nisar-sds-ops@jpl.nasa.gov

3.2.3 Variable Metadata (HDF5 Attributes)

NISAR standards incorporate additional metadata that describe each HDF5 Dataset within the HDF5 file. Each of these metadata elements appear in an HDF5 Attribute that is directly associated with the HDF5 Dataset. Wherever possible, these HDF5 Attributes employ names that conform to the Climate and Forecast (CF) conventions.

Table 3-5 lists the CF names for the HDF5 Attributes that NISAR products typically employ.

Table 3-5. Common variable attributes in HDF5 file.

Attribute	**Description**
_FillValue	The value used to represent missing or undefined data. (Before applying add_offset and scale_factor).
add_offset	If present this value should be added to each data element after it is read. If both scale_factor and add_offset attributes are present, the data are first scaled before the offset is added.
scale_factor	If present, the data are to be multiplied by the value after they are read. If both scale_factor and add_offset attributes are present, the data are first scaled before the offset is added.
Comment	Miscellaneous information about the data or the methods to generate it.
Coordinates	Coordinate variables associated with the variable. The basename of the coordinate variable is used in this representation and group scoping rules for CF conventions apply.
long_name	A descriptive variable name that indicates its content.
quality_flag	Names of variable quality flag(s) that are associated with this variable to indicate its quality.
Units	Unit of data after applying offset (add_offset) and scale_factor.
valid_max	Maximum theoretical value of variable before applying scale_factor and add_offset (not necessarily the same as maximum value of actual data)
valid_min	Minimum theoretical value of variable before applying scale_factor and add_offset (not necessarily the same as minimum value of actual data)

Some HDF5 datasets are populated with statistical attributes. Table 3-5, Table 3-6 and Table 3-8 describe statistical attributes added to real- and complex-valued, and mask HDF5 datasets, respectively. The list of real- and complex-valued and mask HDF5 datasets for the standard L2_GUNW product is given in Table 3-9.

Table 3-5. Statistical attributes for real-valued HDF5 datasets.

Attribute	Description
min_value	Minimum value of a real-valued HDF5 dataset
mean_value	Mean value of a real-valued HDF5 dataset
max_value	Maximum value of a real-valued HDF5 dataset
sample_standard_deviation	Sample standard deviation of a real-valued HDF5 dataset

Table 3-6. Statistical attributes for complex-valued HDF5 datasets.

Attribute	Description
min_real_value	Minimum value of the real part of a complex-valued HDF5 dataset
mean_real_value	Mean value of the real part of a complex-valued HDF5 dataset
max_real_value	Maximum value of the real part of a complex-valued HDF5 dataset
sample_standard_deviation_real	Sample standard deviation of the real part of a complex-valued HDF5 dataset
min_imag_value	Minimum value of the imaginary part of a complex-valued HDF5 dataset
mean_imag_value	Mean value of the imaginary part of a complex-valued HDF5 dataset
max_imag_value	Maximum value of the imaginary part of a complex-valued HDF5 dataset
sample_standard_deviation_imag	Sample standard deviation of the imaginary part of a complex-valued HDF5 dataset

Table 3-8. Statistical attributes for mask HDF5 datasets.

Attribute	Description
layover_percentage	Percentage of pixels in layover
shadow_percentage	Percentage of pixels in shadow
layover_shadow_percentage	Percentage of pixels in layover and shadow
land_percentage	Percentage of pixels on land
water_percentage	Percentage of pixels on water bodies (e.g., ocean)

Table 3-9. L2_GUNW HDF5 datasets populated with statistical attributes.

HDF5 Group	HDF5 Datasets	Dataset type
/science/LSAR/GUNW/grids/frequency/interferogram	layoverShadowMask	Four-valued
/science/LSAR/GUNW/grids/frequency/interferogram	waterMask	Binary-valued
/science/LSAR/GUNW/grids/frequencyA/interferogram/HH	unwrappedPhase, coherenceMagnitude, ionospherePhaseScreen	Real-valued
/science/LSAR/GUNW/grids/frequencyA/interferogram/VV	unwrappedPhase, coherenceMagnitude, ionospherePhaseScreen	Real-valued
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH	alongTrackOffset, slantRangeOffset	Real-valued
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV	alongTrackOffset, slantRangeOffset	Real-valued
/science/LSAR/GUNW/metadata/radarGrid	parallelBaseline, perpendicularBaseline	Real-Valued

3.3 Granule Definition

NISAR L2_GUNW granules will conform to the Tiling Scheme being developed for the mission and are expected to have a ground footprint of 240 km x 240 km.

3.4 File Naming Convention

NISAR L2_GUNW Granule names will conform to the Standard Product File Naming Scheme [RD3].

3.5 Temporal Organization

Temporal organization is not specifically applicable to the L2_GUNW product, although it is generally arranged in order of increasing azimuth time.

3.6 Spatial Organization

The L2 data are arranged on a uniformly spaced, North-up and West-left grid i.e., decreasing North or Y coordinate in the row direction and increasing East or X coordinate in the column direction following the row-major order convention of representing 2D raster arrays. Pixel-is-area convention (see Appendix B: Geocoded Product Grids) is used to tag the raster layers with coordinate information.

3.7 Spatial Sampling and Resolution

Some salient features of the output grid for the L2_GUNW product are:

1. The top-left corner of the top-left pixel will correspond to the same geographic coordinate for all imagery layers in an L-SAR L2_GUNW product.
2. The main imaging band (frequencyA) is spatially averaged to the same posting, irrespective of the imaging mode **Error! Reference source not found.**. This allows for spatial mosaicking operations across instrument mode changes.

3.7.1 Mosaicking

The spatial sampling of the output grid has also been designed to facilitate along-track mosaicking of contiguous L2_GUNW product granules if the user desires. See Appendix B: Geocoded Product Grids for details on the common output grid used for all L2 products.

3.7.2 Partially compressed SLC data

Partially compressed data in L1_RSLC files will not be used to produce L2_GUNW products.

4 LEVEL 2 GEOCODED UNWRAPPED INTERFEROGRAM PRODUCT

The L2_GUNW product is the Geocoded, Multi-looked Unwrapped Interferogram product and is derived from the L1_RUNW product using a DEM and the best available orbit information. It is output in the UTM/ Polar Stereographic system (see**Error! Reference source not found.** Appendix B: Geocoded Product Grids). The L2_GUNW product can be directly overlaid on a map or combined with other similar L2_GUNW products to create change maps, for example.

In this section, we briefly describe the layout of L2_GUNW data and associated metadata within the NISAR HDF5 file. Detailed description of Group and Dataset names can be found in Section 5. In this section, we focus on the organization of L-SAR instrument data within the file under the Group name "/science/LSAR".

4.1 Dimensions and Shapes of Data

Information on the dimensions and shapes of the data items in various data tables is described as part of the metadata (Sec 5.1). This information is useful both as part of the product identification and for setting up further processing, i.e., dimensioning arrays.

4.2 Product Identification

Information needed to identify this product is given under the Group "/science/LSAR/identification" (Sec 5.2). This includes information such as orbit number, track-frame number, acquisition times, a polygon representing the bounding box of the included imagery in geographic coordinates, and product version.

4.3 Radar Imagery

The imagery layers of the L2_GUNW product are organized by center frequency under the Group "/science/LSAR/GUNW/grids/frequencyA/interferogram". Unwrapped interferogram layers are generated only from the main imaging band (frequencyA). Imagery layers are further organized as individual 2D datasets by polarization (TxRx) under "/science/LSAR/GUNW/grids/frequencyA/interferogram". For example, the dataset "/science/LSAR/GUNW/grids/frequencyA/interferogram/HH/unwrapped/unwrappedPhase" corresponds to the unwrapped phase for polarization combination HH for center frequency frequencyA. The other main datasets at the "frequencyA" level are speckle tracking sub-pixel offsets. The latter are contained in "science/LSAR/GUNW/grids/frequencyA/pixelOffsets". The "pixelOffsets" group is further organized by polarization.

The details of the data elements for the granule are given in Section **Error! Reference source not found.**.

4.4 Radar Metadata

The *metadata* group under "/science/LSAR/GUNW/metadata" includes a list of miscellaneous metadata needed to interpret the imagery (e.g., wrapped complex interferogram, unwrapped interferometric phase) included in the L2_GUNW product.

4.4.1 Processing Information

The *processingInformation* includes the processing parameters used to generate the L2_GUNW product. This group also include a list of the used algorithms, and the inputs granules and files used to produce L2_GUNW. For a complete description of this group, refer to Section 5.4.

4.4.1.1 Parameters

The *parameters* subgroup ("/science/LSAR/GUNW/metadata/processingInformation/parameters") is further organized in seven subgroups:

1. *common*: organized by frequency, and including the parameters derived by combining the information from the reference and secondary RSLC e.g., Doppler centroid and the Doppler bandwidth.
2. *reference*: including the reference terrain height of the reference RSLC and Boolean flags to indicate if the RSLC is the results of mixed mode processing and if RFI correction has been applied. This subgroup is further organized by frequency and includes some relevant parameters of the reference RSLC such as the slant range and zero Doppler time spacings, the slant range and the azimuth bandwidths, and the Doppler centroid.
3. *secondary*: this subgroup follows the same organization of *reference* but includes the corresponding metadata for the secondary RSLC.
4. *interferogram*: including the parameters used to generate the complex wrapped interferogram and the normalized interferometric correlation e.g., the common slant range and azimuth bandwidths and the number of looks in along-track and slant range directions used to generate the complex wrapped interferogram in radar coordinates.
5. *ionosphere*: including the parameters used to generate the ionosphere phase screen e.g., the bandwidth of the low and high sub-images used in the ionosphere phase estimation with the range split spectrum technique.
6. *pixelOffsets*: including the parameters (e.g., window size, search window, offset spacings) to generate the along-track and slant range layers of pixelOffsets in radar coordinates. This subgroup is further organized by frequency.
7. *geocoding*: including a set of Boolean flags indicating the corrections that have been applied while geocoding the pixel offsets layers from radar to geographical coordinates i.e., wet and dry troposphere correction, slant range and azimuth ionosphere corrections.

The *parameters* subgroup also contains a field called *runConfigurationContents* which included the content of the run configuration file with all the options and the input files used for processing.

4.4.1.2 Algorithms

The *algorithms* subgroup (“/science/LSAR/GUNW/metadata/processingInformation/algorithms”) includes the name and the version of the software used to generate the product. The subgroup is further organized by the processing step used to generate the L2_GUNW product:

1. *coregistration*: including the algorithms used to perform the coarse and fine coregistration of the reference and secondary RSLCs (e.g., geometry coregistration, cross-correlation algorithm).
2. *interferogramFormation*: including the algorithms used to form the complex wrapped interferogram and the normalized interferometric correlation (e.g., flattening method)
3. *unwrapping*: including the algorithms used to perform phase unwrapping (e.g., unwrapping algorithm, unwrapping initializer, type of performed preprocessing of the wrapped interferometric phase).
4. *ionosphereEstimation*: including the algorithm used to perform the estimation of the ionosphere phase screen (e.g., outlier estimation and filling, unwrapping error correction).
5. *geocoding*: including the algorithms to geocode the different data layers contained in the L2_GUNW product e.g., floating, integer, and complex geocoding interpolation.

4.4.1.3 Input Files

The *inputs* subgroup (“/science/LSAR/GUNW/metadata/processingInformation/inputs”) includes all the input files and granules used to generate the product i.e., L1_RSLC reference and secondary input granules, a description of the DEM used for processing, configuration files, and orbit files.

4.4.2 Other Radar Metadata

Section 5.5 includes the orbit ephemeris used for generating the L2_GUNW under a subgroup named “/science/LSAR/GUNW/metadata metadata/orbit”.

4.4.2.1Orbit

The orbit ephemeris used for generating the L2_GUNW product can be found under a subgroup named “orbit”. This group includes time-tagged antenna phase center position and velocity vectors in Earth Centered Earth Fixed (ECEF) cartesian coordinates. In nominal operations, this would be the MOE state vectors that were used by the L2 processor.

4.4.3 Radar Grid

Section 5.6 contains information describing the radar geometry of the sensor during data taking in the group "/science/LSAR/GUNW/metadata/radarGrid/”. This information is given in the form of data cubes, referred to as *radar grid cubes*, that are organized over a three-dimensional geographic grid. The representation as data cubes, rather than two-dimensional rasters, is used to reduce the amount of space required to store radar geometry values within NISAR L2 products. This is possible because each radar grid cube contains slowly varying values in space that can be described by a low-resolution three-dimensional grid with sufficient accuracy.

These values, however, are usually required at the terrain height, often characterized by a fast-varying surface representing the local topography. A higher-resolution DEM can then be used to interpolate radar grid cubes and generate high-resolution maps of the corresponding radar geometry variable.

Radar grid cubes (for geocoded products) are provided in the same coordinate system as the product imagery with similar extents (bounding box) but coarser pixel spacing. The three-dimensional geographic grid is defined by the HDF5 datasets “xCoordinates” (defining the east component), “yCoordinates” (north component), and “heightAboveEllipsoid” (height above the WGS84 ellipsoid), common to all radar grid cubes, and following the CF-1.8 convention.

Radar grid cubes provide the following list of radar geometry information in the associated HDF5 datasets:

1. The zero-Doppler radar grid is defined through the datasets “slantRange” and “zeroDopplerAzimuthTime”, which contain respectively the range position in meters and the zero-Dopper azimuth time in seconds for each point of the geographical grid.
2. The line-of-sight (LOS) unit vector, i.e., the vector from the target to the sensor, is defined by the datasets “losUnitVectorX” and “losUnitVectorY” which contain respectively the east and north components of the LOS unit vector in the east-north-up (ENU) coordinate system for each point of the geographic grid. Note that the third component of the LOS unit vector is not provided in the product as it can be simply derived from the other two components as:

$$losUnitVectorZ = \sqrt{1 - losUnitVectorX^2 - losUnitVectorY^2}$$

3. The along-track unit vector represents the projection of the along-track vector at the ground height. It is defined by the datasets “alongTrackUnitVectorX” and “alongTrackUnitVectorY” containing respectively the east and north components of the along-track unit vector in UTM coordinates.
4. The incidence angle, i.e., the angle between the LOS vector and the normal to the ellipsoid at the target height, is given by the dataset “incidenceAngle.
5. The elevation angle, defined as the angle between the LOS vector and the normal to the ellipsoid at the sensor, is provided as “elevationAngle”.
6. The ground track velocity which contains the absolute value of the platform velocity scaled at the target height is given as “groundTrackVelocity”.

7. The InSAR phase due to the Earth ground tides provided as "slantRangeSolidEarthTidesPhase" and "alongTrackSolidEarthTidesPhase".
8. The InSAR phase due to the wet and dry tropospheric delay computed using a weather model file provided as "wetTroposphericPhaseScreen", "dryTroposphericPhaseScreen".

5 PRODUCT SPECIFICATION

5.1 Dimensions and Shapes

To simplify the description of the layout of data within the HDF5 file, we will use a table of dimensions and shapes to represent the relationship between similarly sized datasets. The entries in this table do not present actual datasets in the HDF5. This table is meant to be a guide to interpreting the shapes of the datasets in subsequent subsections.

Table 5-1 Table of dimensions and shapes in L2_GUNW product

Name	Shape	Description
scalar	scalar	None
numberOfDatatakes	scalar	number of datatakes in product
numberOfObservations	scalar	number of observations in product
numberOfFrequencies	scalar	Number of L-SAR frequencies in product
numberOfFrequencyAPolarizations	scalar	Number of polarization layers associated with L-SAR frequency A
frequencyAWidth	scalar	Number of pixels in all L-SAR frequency A imagery datasets
frequencyALength	scalar	Number of lines in all L-SAR frequency A imagery datasets
complexDataFrequencyAShape	(frequencyALength, frequencyAWidth)	Shape associated with L-SAR frequency A imagery datasets
realDataFrequencyAShape	(frequencyALength, frequencyAWidth)	Shape associated with L-SAR frequency A imagery interferometric dataset
offsetDataShape	(offsetLength, offsetWidth)	Shape associated with Pixel Offset layers
offsetWidth	scalar	Number of pixels in Pixel Offset layers
offsetLength	scalar	Number of lines in all L-SAR frequency A imagery datasets
radarGridShape	(radarCubeLength, radarCubeWidth)	Shape associated with 2D rasters on same grid as metadata cubes
radarCubeShape	(radarCubeHeight, radarCubeLength, radarCubeWidth)	Shape associated with metadata cubes

twoLayersCubeShape	(radarCubeWidth, radarCubeLength, twoLayersCubeHeight)	Shape associated with baseline metadata cubes
radarCubeHeight	scalar	Height dimension of the metadata cube
radarCubeLength	scalar	Length dimension of the metadata cube
radarCubeWidth	scalar	Width dimension of the metadata cube
twoLayersCubeHeight	scalar	Height dimension of the baseline metadata cube
dopplerCentroidLength	scalar	Length dimension of Doppler centroid grid
dopplerCentroidWidth	scalar	Length dimension of Doppler centroid grid
dopplerCentroidShape	(dopplerCentroidLength, dopplerCentroidWidth)	Shape of the Doppler centroid grid
calibrationLength	scalar	Length of calibration LUTs
calibrationWidth	scalar	Width of calibration LUTs
calibrationScaleShape	(calibrationLength, calibrationWidth)	Shape of calibration LUTs
antennaPatternComplexShape	(calibrationLength, calibrationWidth)	Shape of antenna pattern datasets
orbitListLength	scalar	description="Number of orbit state vectors
orbitShape	(orbitListLength, 3)	Shape of orbit state vector triplets dataset
attitudeListLength	scalar	Number of attitude state vectors
attitudeQuaternionShape	(attitudeListLength, 4)	Shape of attitude quaternion dataset
attitudeShape	(attitudeListLength, 3)	Shape of attitude Euler angle triplets dataset
chirpWeightingFrequencyLength	scalar	Shape associated with 1D filter representations in frequency domain
numberOfInputL1Files	scalar	Number of input L1 granules
numberOfInputOrbitFiles	scalar	Number of input orbit files
numberOfInputConfigFiles	scalar	Number of input configuration files

5.2 Product Identification

Table 5-2 NISAR HDF5 variables used for product identification

Product Identification Variables		
/science/LSAR/identification/absoluteOrbitNumber		
Type: UInt32	**Shape: scalar**	
Description: Absolute orbit number		
	units	unitless
/science/LSAR/identification/trackNumber		
Type: UByte	**Shape: scalar**	
Description: Track number		
	units	unitless
/science/LSAR/identification/frameNumber		
Type: UInt16	**Shape: scalar**	
Description: Frame number		
	units	unitless
/science/LSAR/identification/missionId		
Type: string	**Shape: scalar**	
Description: Mission identifier		
/science/LSAR/identification/processingCenter		
Type: string	**Shape: scalar**	
Description: Data processing center		
/science/LSAR/identification/productType		
Type: string	**Shape: scalar**	
Description: Product type		
/science/LSAR/identification/granuleId		
Type: string	**Shape: scalar**	
Description: Unique granule identification name		
/science/LSAR/identification/productVersion		
Type: string	**Shape: scalar**	
Description: Product version which represents the structure of the product and the science content governed by the algorithm, input data, and processing parameters		
/science/LSAR/identification/productSpecificationVersion		
Type: string	**Shape: scalar**	
Description: Product specification version which represents the schema of this product		
/science/LSAR/identification/lookDirection		
Type: string	**Shape: scalar**	
Description: Look direction can be left or right		
/science/LSAR/identification/orbitPassDirection		

Type: string	**Shape: scalar**
Description: Orbit direction can be ascending or descending	
/science/LSAR/identification/referenceZeroDopplerStartTime	
Type: string	**Shape: scalar**
Description: Azimuth start time of reference RSLC product	
/science/LSAR/identification/secondaryZeroDopplerStartTime	
Type: string	**Shape: scalar**
Description: Azimuth start time of secondary RSLC product	
/science/LSAR/identification/referenceZeroDopplerEndTime	
Type: string	**Shape: scalar**
Description: Azimuth stop time of reference RSLC product	
/science/LSAR/identification/secondaryZeroDopplerEndTime	
Type: string	**Shape: scalar**
Description: Azimuth stop time of secondary RSLC product	
/science/LSAR/identification/plannedDatatakeId	
Type: string	**Shape: (numberOfDatatakes)**
Description: List of planned datatakes included in the product	
/science/LSAR/identification/plannedObservationId	
Type: string	**Shape: (numberOfObservations)**
Description: List of planned observations included in the product	
/science/LSAR/identification/isUrgentObservation	
Type: string	**Shape: scalar**
Description: Boolean indicating if observation is nominal or urgent	
/science/LSAR/identification/listOfFrequencies	
Type: string	**Shape: (numberOfFrequencies)**
Description: List of frequency layers available in the product	
/science/LSAR/identification/diagnosticModeFlag	
Type: UByte	**Shape: scalar**
Description: Indicates if the radar operation mode is a diagnostic mode (1-2) or DBFed science (0): 0, 1, or 2	
units	unitless
/science/LSAR/identification/productLevel	
Type: string	**Shape: scalar**
Description: Product level. L0A: Unprocessed instrument data; L0B: Reformatted, unprocessed instrument data; L1: Processed instrument data in radar coordinates system; and L2: Processed instrument data in geocoded coordinates system	
/science/LSAR/identification/isGeocoded	
Type: string	**Shape: scalar**
Description: Flag to indicate if the product data is in the radar geometry ("False") or in the map geometry ("True")	
/science/LSAR/identification/boundingPolygon	
Type: string	**Shape: scalar**

Description: OGR compatible WKT representation of bounding polygon of the image	
/science/LSAR/identification/processingDateTime	
Type: string	**Shape: scalar**
Description: Processing UTC date and time in the format YYYY-MM-DDTHH:MM:SS	
/science/LSAR/identification/radarBand	
Type: string	**Shape: scalar**
Description: Acquired frequency band	
/science/LSAR/identification/instrumentName	
Type: string	**Shape: scalar**
Description: Name of the instrument used to collect the remote sensing data provided in this product	
/science/LSAR/identification/processingType	
Type: string	**Shape: scalar**
Description: NOMINAL (or) URGENT (or) CUSTOM (or) UNDEFINED	
/science/LSAR/identification/isDithered	
Type: string	**Shape: scalar**
Description: "True" if the pulse timing was varied (dithered) during acquisition, "False" otherwise.	
/science/LSAR/identification/isMixedMode	
Type: string	**Shape: scalar**
Description: "True" if this product is a composite of data collected in multiple radar modes, "False" otherwise.	

5.3 Radar Imagery

Table 5-3 NISAR HDF5 variables related to SAR imagery

Product Imagery Variables		
/science/LSAR/GUNW/grids/frequencyA/listOfPolarizations		
Type: string		**Shape: (numberOfFrequencyAPolarizations)**
Description: List of processed polarization layers with frequencyA		
/science/LSAR/GUNW/grids/frequencyA/centerFrequency		
Type: Float64		**Shape: scalar**
Description: Center frequency of the processed image in Hz		
	units	Hz
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/projection		
Type: Int32		**Shape: scalar**
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code
	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.
	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/yCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive lines		
	long_name	Y coordinates spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/xCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive pixels		
	long_name	X coordinate spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/projection		
Type: Int32		**Shape: scalar**
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code

	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.
	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/yCoordinateSpacing		
Type: Float64	**Shape: scalar**	
Description: Nominal spacing in meters between consecutive lines		
	long_name	Y coordinates spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/xCoordinateSpacing		
Type: Float64	**Shape: scalar**	
Description: Nominal spacing in meters between consecutive pixels		
	long_name	X coordinate spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/projection		
Type: Int32	**Shape: scalar**	
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code
	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.
	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/yCoordinateSpacing		
Type: Float64	**Shape: scalar**	
Description: Nominal spacing in meters between consecutive lines		
	long_name	Y coordinate spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/xCoordinateSpacing		
Type: Float64	**Shape: scalar**	
Description: Nominal spacing in meters between consecutive pixels		

	long_name	X coordinate spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/projection		
Type: Int32		**Shape: scalar**
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code
	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.
	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/yCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive lines		
	long_name	Y coordinates spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/xCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive pixels		
	long_name	X coordinate spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/xCoordinates		
Type: Float64		**Shape: (frequencyAWidth)**
Description: CF compliant dimension associated with the X coordinates		
	long_name	X coordinate of projection
	standard_name	projection_x_coordinate
	units	meters
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/yCoordinates		
Type: Float64		**Shape: (frequencyALength)**
Description: CF compliant dimension associated with the Y coordinates		
	long_name	Y coordinate of projection
	standard_name	projection_y_coordinate
	units	meters
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/xCoordinates		
Type: Float64		**Shape: (frequencyAWidth)**
Description: CF compliant dimension associated with the X coordinates		
	long_name	x coordinate of projection
	standard_name	projection_x_coordinate
	units	meters

/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/yCoordinates		
Type: Float64	**Shape: (frequencyALength)**	
Description: CF compliant dimension associated with the Y coordinates		
	long_name	x coordinate of projection
	standard_name	projection_x_coordinate
	units	meters

/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/xCoordinates		
Type: Float64	**Shape: (frequencyAWidth)**	
Description: CF compliant dimension associated with the X coordinates		
	long_name	X coordinate of projection
	standard_name	projection_x_coordinate
	units	meters

/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/yCoordinates		
Type: Float64	**Shape: (frequencyALength)**	
Description: CF compliant dimension associated with the Y coordinates		
	long_name	Y coordinate of projection
	standard_name	projection_y_coordinate
	units	meters

/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/xCoordinates		
Type: Float64	**Shape: (frequencyAWidth)**	
Description: CF compliant dimension associated with the X coordinates		
	long_name	x coordinate of projection
	standard_name	projection_x_coordinate
	units	meters

/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/yCoordinates		
Type: Float64	**Shape: (frequencyALength)**	
Description: CF compliant dimension associated with the Y coordinates		
	long_name	x coordinate of projection
	standard_name	projection_x_coordinate
	units	meters

/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/unwrappedPhase		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Unwrapped interferogram between HH layers		
	units	radians

/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/connectedComponents		
Type: Int32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Connected components for HH layer		
	_FillValue	255
	grid_mapping	projection
	units	DN

/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/coherenceMagnitude		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Coherence magnitude between HH layers		
	_FillValue	nan
	grid_mapping	projection

	units	unitless
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/ionospherePhaseScreen		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Ionosphere phase screen		
	_FillValue	nan
	grid_mapping	projection
	units	radians
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/HH/ionospherePhaseScreenUncertainty		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Uncertainty of the ionosphere phase screen		
	_FillValue	nan
	grid_mapping	projection
	units	radians
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/unwrappedPhase		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Unwrapped interferogram between VV layers		
	units	radians
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/connectedComponents		
Type: Int32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Connected components for VV layer		
	_FillValue	255
	grid_mapping	projection
	units	DN
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/coherenceMagnitude		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Coherence magnitude between VV layers		
	_FillValue	nan
	grid_mapping	projection
	units	unitless
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/ionospherePhaseScreen		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Ionosphere phase screen		
	_FillValue	nan
	grid_mapping	projection
	units	radians
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/VV/ionospherePhaseScreenUncertainty		
Type: Float32	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Uncertainty of the ionosphere phase screen		
	_FillValue	nan
	grid_mapping	projection
	units	radians
/science/LSAR/GUNW/grids/frequencyA/unwrappedInterferogram/mask		
Type: Byte	**Shape: (frequencyALength, frequencyAWidth)**	
Description: Byte layer with flags for various channels (e.g. layover/shadow, data quality)		
	_FillValue	255

	grid_mapping	projection
	units	DN
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/wrappedInterferogram		
Type: Float32		**Shape: (frequencyALength, frequencyAWidth)**
Description: Complex wrapped interferogram between HH layers		
	_FillValue	(nan+nanj)
	grid_mapping	projection
	units	DN
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/HH/coherenceMagnitude		
Type: Float32		**Shape: (frequencyALength, frequencyAWidth)**
Description: Coherence magnitude between HH layers		
	_FillValue	nan
	grid_mapping	projection
	units	unitless
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/wrappedInterferogram		
Type: Float32		**Shape: (frequencyALength, frequencyAWidth)**
Description: Complex wrapped interferogram between VV layers		
	_FillValue	(nan+nanj)
	grid_mapping	projection
	units	DN
/science/LSAR/GUNW/grids/frequencyA/wrappedInterferogram/VV/coherenceMagnitude		
Type: Float32		**Shape: (frequencyALength, frequencyAWidth)**
Description: Coherence magnitude between VV layers		
	_FillValue	nan
	grid_mapping	projection
	units	unitless
/science/LSAR/GUNW/grids/frequencyA/numberOfSubSwaths		
Type: UByte		**Shape: scalar**
Description: Number of swaths of continuous imagery, due to transmit gaps		
	units	unitless
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/projection		
Type: Int32		**Shape: scalar**
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code
	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.
	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number

/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/slantRangeOffset		
Type: Float32	**Shape: (offsetLength, offsetWidth)**	
Description: Slant range offset		
	_FillValue	nan
	grid_mapping	projection
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/alongTrackOffset		
Type: Float32	**Shape: (offsetLength, offsetWidth)**	
Description: Along track offset		
	_FillValue	nan
	grid_mapping	projection
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/correlationSurfacePeak		
Type: Float32	**Shape: (offsetLength, offsetWidth)**	
Description: Normalized correlation surface peak		
	_FillValue	nan
	grid_mapping	projection
	units	unitless
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/projection		
Type: Int32	**Shape: scalar**	
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code
	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.
	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/slantRangeOffset		
Type: Float32	**Shape: (offsetLength, offsetWidth)**	
Description: Slant range offset		
	_FillValue	nan
	grid_mapping	projection
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/alongTrackOffset		
Type: Float32	**Shape: (offsetLength, offsetWidth)**	
Description: Along track offset		
	_FillValue	nan
	grid_mapping	projection
	units	meters

/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/correlationSurfacePeak		
Type: Float32		**Shape: (offsetLength, offsetWidth)**
Description: Normalized correlation surface peak		
	_FillValue	nan
	grid_mapping	projection
	units	unitless
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/xCoordinates		
Type: Float64		**Shape: (offsetWidth)**
Description: CF compliant dimension associated with the X coordinates		
	long_name	X coordinate of projection
	standard_name	projection_x_coordinate
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/yCoordinates		
Type: Float64		**Shape: (offsetLength)**
Description: CF compliant dimension associated with the Y coordinates		
	long_name	Y coordinate of projection
	standard_name	projection_y_coordinate
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/xCoordinates		
Type: Float64		**Shape: (offsetWidth)**
Description: CF compliant dimension associated with the X coordinates		
	long_name	X coordinate of projection
	standard_name	projection_x_coordinate
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/yCoordinates		
Type: Float64		**Shape: (offsetLength)**
Description: CF compliant dimension associated with the Y coordinates		
	long_name	Y coordinate of projection
	standard_name	projection_y_coordinate
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/xCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive pixels		
	long_name	X coordinate spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/HH/yCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive lines		
	long_name	Y coordinates spacing
	units	meters
/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/xCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive pixels		
	long_name	X coordinate spacing
	units	meters

/science/LSAR/GUNW/grids/frequencyA/pixelOffsets/VV/yCoordinateSpacing		
Type: Float64		**Shape: scalar**
Description: Nominal spacing in meters between consecutive lines		
	long_name	Y coordinates spacing
	units	meters

5.4 Processing Information

Table 5-4 NISAR HDF5 variables related to processing parameters

Processing-related variables		
/science/LSAR/GUNW/metadata/processingInformation/parameters/runConfigurationContents		
Type: string		**Shape: scalar**
Description: Contents of the run configuration file with parameters used for processing		
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/rfiCorrectionApplied		
Type: string		**Shape: scalar**
Description: Flag to indicate if RFI correction has been applied to reference RSLC		
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/isMixedMode		
Type: string		**Shape: scalar**
Description: "True" if reference RSLC is a composite of data collected in multiple radar modes, "False" otherwise		
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/referenceTerrainHeight		
Type: Float32		**Shape: (dopplerCentroidLength, dopplerCentroidWidth)**
Description: Reference Terrain Height as a function of map coordinates for reference RSLC		
	units	meters
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/frequencyA/slantRangeSpacing		
Type: Float64		**Shape: scalar**
Description: Slant range spacing of reference RSLC		
	units	meters
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/frequencyA/zeroDopplerTimeSpacing		
Type: Float64		**Shape: scalar**
Description: Time interval in the along-track direction for reference RSLC raster layers		
	units	seconds
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/frequencyA/rangeBandwidth		
Type: Float64		**Shape: scalar**
Description: Processed slant range bandwidth for reference RSLC		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/frequencyA/azimuthBandwidth		
Type: Float64		**Shape: scalar**
Description: Processed azimuth bandwidth for reference RSLC		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/reference/frequencyA/dopplerCentroid		
Type: Float64		**Shape: (dopplerCentroidLength, dopplerCentroidWidth)**
Description: 2D LUT of Doppler Centroid for Frequency A		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/referenceTerrainHeight		
Type: Float32		**Shape: (dopplerCentroidLength, dopplerCentroidWidth)**

Description: Reference Terrain Height as a function of map coordinates for secondary RSLC		
	units	meters
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/rfiCorrectionApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if RFI correction has been applied to secondary RSLC		
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/isMixedMode		
Type: string	**Shape: scalar**	
Description: "True" if secondary RSLC is a composite of data collected in multiple radar modes, "False" otherwise		
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/frequencyA/slantRangeSpacing		
Type: Float64	**Shape: scalar**	
Description: Slant range spacing of secondary RSLC		
	units	meters
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/frequencyA/zeroDopplerTimeSpacing		
Type: Float64	**Shape: scalar**	
Description: Time interval in the along-track direction for secondary RSLC raster layers		
	units	seconds
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/frequencyA/rangeBandwidth		
Type: Float64	**Shape: scalar**	
Description: Processed slant range bandwidth for secondary RSLC		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/frequencyA/azimuthBandwidth		
Type: Float64	**Shape: scalar**	
Description: Processed azimuth bandwidth for secondary RSLC		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/secondary/frequencyA/dopplerCentroid		
Type: Float64	**Shape: (dopplerCentroidLength, dopplerCentroidWidth)**	
Description: 2D LUT of Doppler Centroid for Frequency A		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/common/frequencyA/dopplerCentroid		
Type: Float64	**Shape: (dopplerCentroidLength, dopplerCentroidWidth)**	
Description: 2D LUT of Doppler Centroid for Frequency A		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/common/frequencyA/dopplerBandwidth		
Type: Float64	**Shape: scalar**	
Description: Common Doppler Bandwidth used for processing interferogram		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/rangeBandwidth		
Type: Float64	**Shape: scalar**	
Description: Processed slant range bandwidth for frequencyA interferometric layers		
	units	Hz

/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/azimuthBandwidth		
Type: Float64	**Shape: scalar**	
Description: Processed azimuth bandwidth for frequencyA interferometric layers		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/commonBandRangeFilterApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if common band range filter has been applied		
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/commonBandAzimuthFilterApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if common band azimuth filter has been applied		
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/numberOfRangeLooks		
Type: UInt32	**Shape: scalar**	
Description: Number of looks applied in the slant range direction to form the wrapped interferogram		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/numberOfAzimuthLooks		
Type: UInt32	**Shape: scalar**	
Description: Number of looks applied in the along-track direction to form the wrapped interferogram		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/ellipsoidalFlatteningApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if the interferometric phase has been flattened with respect to a zero height ellipsoid		
/science/LSAR/GUNW/metadata/processingInformation/parameters/wrappedInterferogram/frequencyA/topographicFlatteningApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if the interferometric phase has been flattened with respect to topographic height using a DEM		
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/rangeBandwidth		
Type: Float64	**Shape: scalar**	
Description: Processed slant range bandwidth for frequencyA interferometric layers		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/azimuthBandwidth		
Type: Float64	**Shape: scalar**	
Description: Processed azimuth bandwidth for frequencyA interferometric layers		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/commonBandRangeFilterApplied		
Type: string	**Shape: scalar**	

Description: Flag to indicate if common band range filter has been applied		
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/commonBandAzimuthFilterApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if common band azimuth filter has been applied		
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/numberOfRangeLooks		
Type: UInt32	**Shape: scalar**	
Description: Number of looks applied in the slant range direction to form the unwrapped interferogram		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/numberOfAzimuthLooks		
Type: UInt32	**Shape: scalar**	
Description: Number of looks applied in the along-track direction to form the unwrapped interferogram		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/ellipsoidalFlatteningApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if the interferometric phase has been flattened with respect to a zero height ellipsoid		
/science/LSAR/GUNW/metadata/processingInformation/parameters/unwrappedInterferogram/frequencyA/topographicFlatteningApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if the interferometric phase has been flattened with respect to topographic height using a DEM		
/science/LSAR/GUNW/metadata/processingInformation/parameters/ionosphere/lowBandBandwidth		
Type: Float64	**Shape: scalar**	
Description: Slant range bandwidth of the low sub-band image		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/ionosphere/highBandBandwidth		
Type: Float64	**Shape: scalar**	
Description: Slant range bandwidth of the high sub-band image		
	units	Hz
/science/LSAR/GUNW/metadata/processingInformation/parameters/geocoding/rangeIonosphericCorrectionApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if the range ionospheric correction is applied to improve geolocation		
/science/LSAR/GUNW/metadata/processingInformation/parameters/geocoding/azimuthIonosphericCorrectionApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if the azimuth ionospheric correction is applied to improve geolocation		
/science/LSAR/GUNW/metadata/processingInformation/parameters/geocoding/hydrostaticTroposphericCorrectionApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if hydrostatic tropospheric correction is applied to improve geolocation		
/science/LSAR/GUNW/metadata/processingInformation/parameters/geocoding/wetTroposphericCorrectionApplied		
Type: string	**Shape: scalar**	

Description: Flag to indicate if wet tropospheric correction is applied to improve geolocation		
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/alongTrackWindowSize		
Type: UInt32	**Shape: scalar**	
Description: Along track cross-correlation window size in pixels		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/slantRangeWindowSize		
Type: UInt32	**Shape: scalar**	
Description: Slant range cross-correlation window size in pixels		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/alongTrackSearchWindowSize		
Type: UInt32	**Shape: scalar**	
Description: Along track cross-correlation search window size in pixels		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/slantRangeSearchWindowSize		
Type: UInt32	**Shape: scalar**	
Description: Slant range cross-correlation search window size in pixels		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/alongTrackSkipWindowSize		
Type: UInt32	**Shape: scalar**	
Description: Along track cross-correlation skip window size in pixels		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/slantRangeSkipWindowSize		
Type: UInt32	**Shape: scalar**	
Description: Slant range cross-correlation skip window size in pixels		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/crossCorrelationSurfaceOversampling		
Type: UInt32	**Shape: scalar**	
Description: Oversampling factor of the cross-correlation surface		
	units	unitless
/science/LSAR/GUNW/metadata/processingInformation/parameters/pixelOffsets/frequencyA/isOffsetsBlendingApplied		
Type: string	**Shape: scalar**	
Description: Flag to indicate if pixel offsets are the results of blending multi-resolution layers of pixel offsets		
/science/LSAR/GUNW/metadata/processingInformation/algorithms/softwareVersion		
Type: string	**Shape: scalar**	
Description: Software version used for processing		
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/coregistrationMethod		
Type: string	**Shape: scalar**	

Description: RSLC coregistration method		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/geometryCoregistration		
Type: string	**Shape: scalar**	
Description: Geometry coregistration algorithm		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/crossCorrelation		
Type: string	**Shape: scalar**	
Description: Cross-correlation algorithm for sub-pixel offsets computation		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/resampling		
Type: string	**Shape: scalar**	
Description: Secondary RSLC resampling algorithm		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/crossCorrelationOutliers		
Type: string	**Shape: scalar**	
Description: Outliers identification algorithm		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/crossCorrelationFilling		
Type: string	**Shape: scalar**	
Description: Outliers data filling algorithm for cross-correlation offsets		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/coregistration/crossCorrelationFilterKernel		
Type: string	**Shape: scalar**	
Description: Filtering algorithm for cross-correlation offsets		
	algorithm_type	RSLC coregistration
/science/LSAR/GUNW/metadata/processingInformation/algorithms/interferogramFormation/multilooking		
Type: string	**Shape: scalar**	
Description: Multilooking algorithm		
	algorithm_type	Interferogram formation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/interferogramFormation/wrappedInterferogramFiltering		
Type: string	**Shape: scalar**	
Description: Algorithm used to filter wrapped interferogram prior to phase unwrapping		
	algorithm_type	Interferogram formation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/interferogramFormation/flatteningMethod		
Type: string	**Shape: scalar**	
Description: Algorithm used to flatten the wrapped interferogram		
	algorithm_type	Interferogram formation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/unwrapping/unwrappingAlgorithm		
Type: string	**Shape: scalar**	
Description: Algorithm used for phase unwrapping		

	algorithm_type	Unwrapping
/science/LSAR/GUNW/metadata/processingInformation/algorithms/unwrapping/unwrappingInitializer		
Type: string	**Shape: scalar**	
Description: Algorithm used to initialize phase unwrapping		
	algorithm_type	Unwrapping
/science/LSAR/GUNW/metadata/processingInformation/algorithms/unwrapping/costMode		
Type: string	**Shape: scalar**	
Description: Cost mode algorithm for phase unwrapping		
	algorithm_type	Unwrapping
/science/LSAR/GUNW/metadata/processingInformation/algorithms/unwrapping/preprocessing/wrappedPhaseOutliers		
Type: string	**Shape: scalar**	
Description: Algorithm identifying outliers in the wrapped interferogram		
	algorithm_type	Unwrapping
/science/LSAR/GUNW/metadata/processingInformation/algorithms/unwrapping/preprocessing/wrappedPhaseFilling		
Type: string	**Shape: scalar**	
Description: Outliers data filling algorithm for phase unwrapping preprocessing		
	algorithm_type	Unwrapping
/science/LSAR/GUNW/metadata/processingInformation/algorithms/ionosphereEstimation/ionosphereAlgorithm		
Type: string	**Shape: scalar**	
Description: Algorithm used to estimate ionosphere phase screen		
	algorithm_type	Ionosphere estimation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/ionosphereEstimation/ionosphereOutliers		
Type: string	**Shape: scalar**	
Description: Algorithm identifying outliers in unfiltered ionosphere phase screen		
	algorithm_type	Ionosphere estimation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/ionosphereEstimation/ionosphereFilling		
Type: string	**Shape: scalar**	
Description: Outliers data filling algorithm for ionosphere phase estimation		
	algorithm_type	Ionosphere estimation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/ionosphereEstimation/ionosphereFiltering		
Type: string	**Shape: scalar**	
Description: Filtering algorithm for ionosphere phase screen computation		
	algorithm_type	Ionosphere estimation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/ionosphereEstimation/unwrappingErrorCorrection		
Type: string	**Shape: scalar**	
Description: Algorithm correcting unwrapping errors in sub-band unwrapped interferograms		
	algorithm_type	Ionosphere estimation
/science/LSAR/GUNW/metadata/processingInformation/algorithms/geocoding/demInterpolation		
Type: string	**Shape: scalar**	
Description: DEM interpolation algorithm		
	algorithm_type	Geocoding

/science/LSAR/GUNW/metadata/processingInformation/algorithms/geocoding/floatingGeocodingInterpolation		
Type: string	**Shape: scalar**	
Description: Geocoding interpolation algorithm for floating point datasets		
	algorithm_type	Geocoding
/science/LSAR/GUNW/metadata/processingInformation/algorithms/geocoding/integerGeocodingInterpolation		
Type: string	**Shape: scalar**	
Description: Geocoding interpolation algorithm for integer datasets		
	algorithm_type	Geocoding
/science/LSAR/GUNW/metadata/processingInformation/algorithms/geocoding/complexGeocodingInterpolation		
Type: string	**Shape: scalar**	
Description: Geocoding interpolation algorithm for complex-valued datasets		
	algorithm_type	Geocoding
/science/LSAR/GUNW/metadata/processingInformation/inputs/l1ReferenceSlcGranules		
Type: string	**Shape: (numberOfInputL1Files)**	
Description: List of input reference L1 RSLC products used		
/science/LSAR/GUNW/metadata/processingInformation/inputs/l1SecondarySlcGranules		
Type: string	**Shape: (numberOfInputL1Files)**	
Description: List of input secondary L1 RSLC products used		
/science/LSAR/GUNW/metadata/processingInformation/inputs/orbitFiles		
Type: string	**Shape: (numberOfInputOrbitFiles)**	
Description: List of input orbit files used		
/science/LSAR/GUNW/metadata/processingInformation/inputs/configFiles		
Type: string	**Shape: (numberOfInputConfigFiles)**	
Description: List of input config files used		
/science/LSAR/GUNW/metadata/processingInformation/inputs/demSource		
Type: string	**Shape: scalar**	
Description: Description of the input digital elevation model (DEM)		

5.5 Other Radar Metadata

Table 5-5 NISAR HDF5 variables related to useful radar metadata

Radar metadata-related variables		
/science/LSAR/GUNW/metadata/orbit/time		
Type: Float64		**Shape: (orbitListLength)**
Description: Time vector record. This record contains the time corresponding to position, velocity, acceleration records		
	units	seconds since YYYY-MM-DD HH:MM:SS
/science/LSAR/GUNW/metadata/orbit/position		
Type: Float64		**Shape: (orbitListLength, tripletxyz)**
Description: Position vector record. This record contains the platform position data with respect to WGS84 G1762 reference frame		
	units	meters
/science/LSAR/GUNW/metadata/orbit/velocity		
Type: Float64		**Shape: (orbitListLength, tripletxyz)**
Description: Velocity vector record. This record contains the platform velocity data with respect to WGS84 G1762 reference frame		
	units	meters per second
/science/LSAR/GUNW/metadata/orbit/acceleration		
Type: Float64		**Shape: (orbitListLength, tripletxyz)**
Description: Acceleration vector record. This record contains the platform acceleration data with respect to WGS84 G1762 reference frame		
	units	meters per second squared
/science/LSAR/GUNW/metadata/orbit/orbitType		
Type: string		**Shape: scalar**
Description: PrOE (or) NOE (or) MOE (or) POE (or) Custom		
/science/LSAR/GUNW/metadata/attitude/time		
Type: Float64		**Shape: (orbitListLength)**
Description: Time vector record. This record contains the time corresponding to attitude and quaternion records		
	units	seconds since YYYY-MM-DD HH:MM:SS
/science/LSAR/GUNW/metadata/attitude/quaternions		
Type: Float64		**Shape: (attitudeListLength, quaternions)**
Description: Attitude quaternions (q0, q1, q2, q3)		
	units	unitless
/science/LSAR/GUNW/metadata/attitude/angularVelocity		
Type: Float64		**Shape: (attitudeListLength, tripletxyz)**
Description: Attitude angular velocity vectors (wx, wy, wz)		
	units	radians per second
/science/LSAR/GUNW/metadata/attitude/eulerAngles		
Type: Float64		**Shape: (attitudeListLength, tripletxyz)**

Description: Attitude Euler angles (roll, pitch, yaw)		
	units	degrees

/science/LSAR/GUNW/metadata/attitude/attitudeType	
Type: string	**Shape: scalar**
Description: PrOE (or) NOE (or) MOE (or) POE (or) Custom	

5.6 Radar Grid

Table 5-6 NISAR HDF5 variables related to metadata cube

Metadata cube-related variables		
/science/LSAR/GUNW/metadata/radarGrid/epsg		
Type: Int32	**Shape: scalar**	
Description: EPSG code corresponding to the coordinate system used for representing the geolocation grid		
	long_name	EPSG code
	units	unitless
/science/LSAR/GUNW/metadata/radarGrid/slantRange		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Slant range in meters		
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/hydrostaticTroposphericPhaseScreen		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Hydrostatic component of the troposphere phase screen		
	units	radians
/science/LSAR/GUNW/metadata/radarGrid/wetTroposphericPhaseScreen		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Wet component of the troposphere phase screen		
	units	radians
/science/LSAR/GUNW/metadata/radarGrid/slantRangeSolidEarthTidesPhase		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Solid Earth Tides phase along slant range direction		
	units	radians
/science/LSAR/GUNW/metadata/radarGrid/alongTrackSolidEarthTidesPhase		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Solid Earth Tides phase in along-track direction		
	units	radians
/science/LSAR/GUNW/metadata/radarGrid/zeroDopplerAzimuthTime		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Zero doppler azimuth time in seconds		
	units	seconds since YYYY-mm-dd HH:MM:SS
/science/LSAR/GUNW/metadata/radarGrid/incidenceAngle		
Type: Float32	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Incidence angle is defined as the angle between the LOS vector and the normal to the ellipsoid at the target height		
	max	90.0
	min	0.0
	_FillValue	nan
	grid_mapping	projection

	long_name	Incidence angle
	units	degrees
/science/LSAR/GUNW/metadata/radarGrid/losUnitVectorX		
Type: Float32	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: East component of unit vector of LOS from target to sensor		
	max	-1.0
	min	1.0
	_FillValue	nan
	grid_mapping	projection
	long_name	LOS unit vector X
	units	unitless
/science/LSAR/GUNW/metadata/radarGrid/losUnitVectorY		
Type: Float32	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: North component of unit vector of LOS from target to sensor		
	max	-1.0
	min	1.0
	_FillValue	nan
	grid_mapping	projection
	long_name	LOS unit vector Y
	units	unitless
/science/LSAR/GUNW/metadata/radarGrid/alongTrackUnitVectorX		
Type: Float32	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: East component of unit vector along ground track		
	max	-1.0
	min	1.0
	_FillValue	nan
	grid_mapping	projection
	long_name	Along-track unit vector X
	units	unitless
/science/LSAR/GUNW/metadata/radarGrid/alongTrackUnitVectorY		
Type: Float32	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: North component of unit vector along ground track		
	max	-1.0
	min	1.0
	_FillValue	nan
	grid_mapping	projection
	long_name	Along-track unit vector Y
	units	unitless
/science/LSAR/GUNW/metadata/radarGrid/elevationAngle		
Type: Float32	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Elevation angle is defined as the angle between the LOS vector and the normal to the ellipsoid at the sensor		
	max	90.0
	min	0.0
	_FillValue	nan
	grid_mapping	projection
	long_name	Elevation angle
	units	degrees
/science/LSAR/GUNW/metadata/radarGrid/groundTrackVelocity		

Type: Float64	**Shape: (radarCubeLength, radarCubeWidth)**	
Description: Absolute value of the platform velocity scaled at the target height		
	_FillValue	nan
	grid_mapping	projection
	long_name	Ground-track velocity
	units	meters per second
/science/LSAR/GUNW/metadata/radarGrid/secondaryZeroDopplerTime		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Zero Doppler azimuth time of corresponding pixel in secondary image		
	units	seconds since yyyy-mm-dd
/science/LSAR/GUNW/metadata/radarGrid/secondarySlantRange		
Type: Float64	**Shape: (radarCubeHeight, radarCubeLength, radarCubeWidth)**	
Description: Slant range of corresponding pixel in secondary image		
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/parallelBaseline		
Type: Float64	**Shape: (radarCubeWidth, radarCubeLength, twoLayersCubeHeight)**	
Description: Parallel component of the InSAR baseline		
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/perpendicularBaseline		
Type: Float64	**Shape: (radarCubeWidth, radarCubeLength, twoLayersCubeHeight)**	
Description: Perpendicular component of the InSAR baseline		
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/xCoordinates		
Type: Float64	**Shape: (radarCubeWidth)**	
Description: X coordinate values corresponding to the radar grid		
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/yCoordinates		
Type: Float64	**Shape: (radarCubeWidth)**	
Description: Y coordinate values corresponding to the radar grid		
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/heightAboveEllipsoid		
Type: Float64	**Shape: (radarCubeHeight)**	
Description: Height values above WGS84 Ellipsoid corresponding to the radar grid		
	standard_name	height_above_reference_ellipsoid
	units	meters
/science/LSAR/GUNW/metadata/radarGrid/projection		
Type: Int32	**Shape: scalar**	
Description: Product map grid projection: EPSG code, with additional projection information as HDF5 Attributes		
	ellipsoid	Projection ellipsoid
	epsg_code	Projection EPSG code
	false_easting	The value added to all abscissa values in the rectangular coordinates for a map projection.
	false_northing	The value added to all ordinate values in the rectangular coordinates for a map projection.

	grid_mapping_name	Grid mapping variable name
	inverse_flattening	Inverse flattening of the ellipsoidal figure
	latitude_of_projection_origin	The latitude chosen as the origin of rectangular coordinates for a map projection.
	longitude_of_projection_origin	The longitude, with respect to Greenwich, of the prime meridian associated with the geodetic datum.
	semi_major_axis	Semi-major axis
	spatial_ref	Spatial reference
	utm_zone_number	UTM zone number

6 METADATA CUBE

In this section, we provide an overview of the metadata cubes used to store spatially-varying ancillary data in the secondary layers of the NISAR L-SAR product HDF5 granules. Note that this sparse representation is to assist users in ingesting and analyzing NISAR products within existing GIS software and is not meant to replace traditional representations of SAR data within the product granules or traditional processing approaches with radar geometry-aware software.

Metadata cubes are represented as three-dimensional arrays in the NISAR product HDF5 modules (Figure 6-1). The axes of the array are interpreted as (height, increasing azimuth time, and increasing slant range) in case of radar geometry products and as (height, decreasing northing, and increasing easting) in case of geocoded products. The data is organized with height as the first axis, as this allows one to directly ingest data as GCPs or rasters into existing GIS software. Each height layer is the same size. Metadata cubes will have fixed grid spacing (3 km in azimuth/northing x 1 km in slant range/easting x 1.5 km in height and will allow for easy merging when multiple products along the same imaging track are to be concatenated. The metadata fields on this coarse resolution grid will be evaluated using traditional radar processing approaches without approximations. The metadata cube will also span a field slightly larger than the original image product to allow users to interpolate data without introducing edge effects. Such low-resolution representation of slowly varying parameters has been demonstrated for InSAR products and processing **Error! Reference source not found.**.

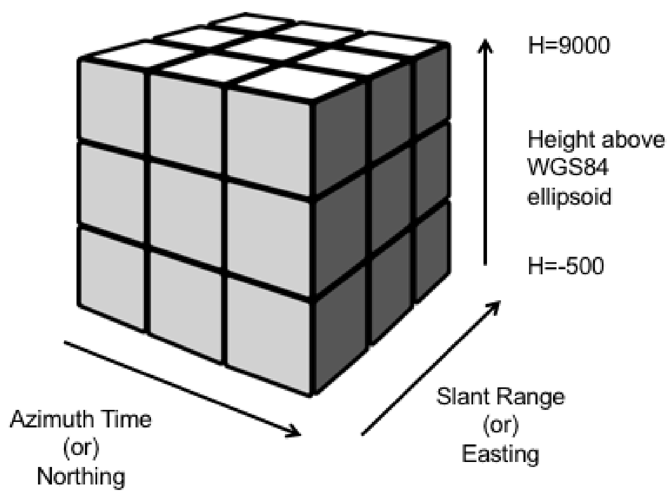

Figure 6-1. Metadata cube layer schematic

6.1 Metadata Cube Interpolation Example

We provide here a conceptual example of how these metadata cubes can be used within an existing GIS framework. Let us consider a L2_GUNW product on a UTM Zone 10 grid (Table

6-1). We use a geocoded product for the demonstration but the presented approach can be easily extended to radar coordinate products by replacing northing axis by azimuth time and easting axis by slant range.

Table 6-1. Example metadata cube properties

Name	Value	Description
Primary layer properties		
xmin	100000.0	Easting of the first column (m)
xmax	340000.0	Easting of the last column (m)
dx	30.0	Column spacing in Easting (m)
Nx	8001	Number of columns
ymax	570000.0	Northing of first row (m)
ymin	330000.0	Northing of last row (m)
dy	-30.0	Row spacing in Northing (m). Negative to emphasize North-up imagery in geocoded products
Ny	8001	Number of rows
Metadata cube properties		
Cxmin	97000.0	Easting of first column (m)
Cxmax	343000.0	Easting of last column (m)
Cdx	1000.0	Column spacing in Easting (m)
CNx	247	Number of columns
Cymax	579000.0	Northing of first row (m)
Cymin	321000.0	Northing of last row(m)
Cdy	-3000.0	Row spacing in Northing (m). Negative to emphasize North-up imagery in geocoded products
CNy	87	Number of rows
Czmin	-1500	Height of the first layer (m)
Czmax	9000	Height of the last layer (m)
Cdz	1500	Layer spacing in height (m)
CNz	8	Number of height layers

Suppose we are interested in computing the Perpendicular Baseline (Bperp) at a pixel of interest located at UTM coordinates point (Px,Py). Since these are coordinates on a map domain, we can look up a DEM to get the height at this point. The three-dimensional point of interest then becomes (Px, Py, h(Px,Py)).

The metadata cube for Perpendicular baseline can be thought of as a three-dimensional field Bperp(x,y,z) – even though it is oriented as (Nz,Ny,Nx) in the HDF5 file for ease of use with a GIS. The user can use standard built-in regular grid three-dimensional interpolation routines in languages like MATLAB (e.g, interp3), IDL or Python (e.g, RegularGridInterpolator) to interpolate the Bperp array. We recommend cubic interpolation for best results. If a three-dimensional interpolator is not available, one could use two-dimensional cubic interpolation for each height layer followed by a one-dimensional cubic interpolation in the following manner:

1. Populate f(i), i=0,…Nz-1 by two-dimensional cubic interpolation of each height layer:

$$f(i) = Bperp\left[i, \frac{Py - Cymax}{Cdy}, \frac{Px - Cxmax}{Cdx}\right]$$

   where the numbers in the square brackets indicate indices into the three-dimensional cube. For example, if we are interested in the point (107590.0 East, 555870.0 North, 300.0 Height), we would interpolate at Row 7.71 and Column 10.59 for each height layer.

2. Interpolate f(i) using one-dimensional cubic interpolation:

$$Bperp\big(Px, Py, h(Px, Py)\big) = f\left[\frac{h(Px, Py) - Czmin}{Cdz}\right]$$

   where the number in the square bracket indicates an index into a one-dimensional array. For example, for a height value of 200.0, we would interpolate at an index of 1.2.

6.2 Metadata Cube Usage Note

Note that the metadata cubes are designed to accommodate one double-precision cube within 1 MB of memory, allowing for information to be easily stored in memory for on-the-fly computation within GIS frameworks or software without much overhead. The metadata cubes are not a replacement for traditional SAR processing approaches or very high-resolution analyses. They are meant to facilitate rapid processing and analysis by non-experts and will serve the needs for most SAR applications. Analyses show that the geolocation error is on the order of 1.5 cm due to interpolation which is significantly smaller than errors from sources such as DEM, orbits, and atmospheric path delay. Interpolation errors for each of the metadata layers will be reported after additional study.

APPENDIX A: ACRONYMS

ADT	Algorithm Development Team
AT	Along Track
AWS	Amazon Web Services
BFPQ	Block adaptive Floating-Point Quantization
Cal/Val	Calibration and Validation (also sometimes cal/val)
CDR	Critical Design Review
CF	Climate and Forecast
CPU	Central Processing Unit
CRSD	Calibration Raw Signal Data
CSV	Comma-separated values
DAAC	Distributed Active Archive Center
DEM	Digital Elevation Model
DN	Digital Number
EAR	Export Administration Regulations
ECMWF	European Centre for Medium-Range Weather Forecasts
ECEF	Earth Centered Earth Fixed
EPSG	European Petroleum Survey Group
ESA	European Space Agency
FM	Frequency Modulation
FOP	Forecast Orbit Ephemeris
FOV	Field of View
GCOV	Geocoded Polarimetric Covariance (L2_GCOV)
GCP	Ground Control Point
GDAL	Geospatial Data Abstraction Library
GDS	Ground Data System
GIS	Geographic Information System
GMTED	Global Multi-resolution Terrain Elevation Data
GOFF	Geocoded Pixel Offsets (L2_GOFF)
GPU	Graphics Processing Unit
GSLC	Geocoded Single Look Complex (L2_GSLC)
GUNW	Geocoded Unwrapped Interferogram (L2_GUNW)
HDF5	Hierarchical Data Format version 5
HK, HKTM	Housekeeping Telemetry
InSAR	Interferometric Synthetic Aperture Radar
ISCE	InSAR Scientific Computing Environment
ISCE3	InSAR Scientific Computing Environment Enhanced Edition (for NISAR)
ISO	International Organization for Standardization
ISRO	Indian Space Research Organisation (British spelling)

L0B	Level-0B (data)
L1	Level-1 (data)
L2	Level-2 (data)
LOS	Line-Of-Sight
LUT	Lookup Table
Mbps	Megabits per second
MHz	Megahertz
MOE	Medium-precision Orbit Ephemeris
NCSA	National Center for Supercomputing Applications
NetCDF4	Network Common Data Form version 4
NISAR	NASA-ISRO Synthetic Aperture Radar
NOE	Near-Realtime Orbit Ephemeris
PDR	Preliminary Design Review
POD	Precision Orbit Determination
POE	Precision Orbit Ephemeris
PRF	Pulse Repetition Frequency
QA	Quality Assurance
REE	Radar Echo Emulator
RFI	Radio Frequency Interference
RIFG	Range-Doppler Interferogram (L1_RIFG)
ROFF	Range-Doppler Pixel Offsets (L1_ROFF)
RRSD	Radar Raw Signal Data
RRST	Radar Raw Science Telemetry
RSLC	Range-Doppler Single Look Complex (L1_RSLC)
RUNW	Range-Doppler UnWrapped Interferogram (L1_RUNW)
SAR	Synthetic Aperture Radar
SAS	Science Algorithm Software
SDS	Science Data System
SDT	Science Definition Team
SIS	Software Interface Specification
SLC	Single Look Complex
SNAPHU	Statistical-cost, Network-flow Algorithm for Phase Unwrapping
SRTM	Shuttle Radar Topography Mission
ST	Science Team
TAI	International Atomic Time (Temps Atomique International)
TCF	Terrain Correction Factor
TEC	Total Electron Content
TFdb	Track-frame Database
SWST	Sampling Window Start Time
UR	Urgent Response
UTC	Universal Time Coordinated

UTM	Universal Transverse Mercator
WGS84	World Geodetic System 84
XML	eXtensible Markup Language (xml in code)
YAML	YAML Ain't Markup Language

APPENDIX B: GEOCODED PRODUCT GRIDS

NISAR L2 products will be generated on a pre-defined Track/Frame system. The projection system for a particular frame will be available to the users as a predefined map and will be held constant through the life of the system. Each L2 HDF5 granule itself will include information indicating the projection used for the product.

Map Projections

NISAR's SDS is able to ingest any Digital Elevation Model whose vertical datum represents height above the WGS84 Ellipsoid and the horizontal datum can be represented by an European Petroleum Standards Group (EPSG) code for generating geocoded product. Table 7-1 lists the various projection systems used to output L2 geocoded products.

Table 7-1. Projection Systems for NISAR L2 Products

EPSG code	PROJ.4 string	Common Name	Geographical scope
3031	+proj=stere +lat_0=-90 +lat_ts=-71 +lon_0=0 +k=1 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs	Antarctic Polar Stereographic	Antarctica and Southern Hemisphere Sea Ice
3413	+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45 +k=1 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs	NSIDC Sea Ice Polar Stereographic North	Greenland and Northern Hemisphere Sea Ice
32601-32660	+proj=utm +zone=X-32600 +datum=WGS84 +units=m +no_defs	UTM Zone North	Northern Hemisphere Land except Greenland
32701-32760	+proj=utm +zone=X-32700 +south +datum=WGS84 +units=m +no_defs	UTM Zone South	Southern Hemisphere Land except Antarctica

Grid Alignment

NISAR L2 products will use a "pixel is area" convention (http://geotiff.maptools.org/spec/geotiff2.5.html , "The "PixelIsArea" raster grid space R, which is the default, uses coordinates I and J, with (0,0) denoting the upper-left corner of the image, and increasing I to the right, increasing J down. The first pixel-value fills the square grid cell with the bounds: top-left = (0,0), bottom-right = (1,1)").