CLPX-Airborne: Airborne Synthetic Aperture Radar (AIRSAR) Imagery, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

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National Snow and Ice Data Center

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1   DETAILED DATA DESCRIPTION

AIRSAR is a synthetic aperture radar polarimetric and interferometric flexibility and capability that measures the ratio of the returned backscattered power from a scene to that transmitted at three separated frequencies. The AIRSAR data for CLPX were acquired in two modes: TOPSAR mode (which uses single-pass interferometry to measure topography), and POLSAR mode (which is fully polarimetric).

In POLSAR mode, fully polarimetric data (also known as 'quad-pol') are acquired at three frequencies: 5.3 GHz center frequency (C-band), 1.2 GHz center frequency (L-band), and 430 MHz center frequency (P-band). The bandwidth dictates the resolution of the data, independent of the pixel spacing of the imagery. The bandwidth of the C-band and L-band data is 40 MHz, while P-band is only 20 MHz (due to frequency allocation issues over U.S. airspace). This means that theresolution of the P-band is coarser by a factor of two than the C-band and L-band data, even though the imagery for all three bands is sampled at the same pixel spacing. The standard compressed-format polarimetric data are left in the 'slant range' projection, which is the natural projection of SAR imagery. This projection is not standard. While the pixel spacing in the cross-track direction is constant in the slant range, on the ground it varies with the cross-track distance (depending on the topography of the surface). The elements of the Stokes Matrix are calculated from the single-look scattering matrix for each pixel, and they are compressed.

In TOPSAR mode, AIRSAR collects interferometric data using C- and L-band vertically displaced antenna pairs to produce digital elevation models (DEMs). The C-band and L-band imagery (vertically polarized on transmit and receive, also known as 'VV') and the P-band fully polarimetric imagery are overlaid onto the C-band DEM. Radiometric calibration errors resulting from the impact of terrain slope on pixel area, as well as antenna pattern errors, are corrected based on the C-band DEM. The VV imagery is saved as an amplitude image, which is the square root of the power image.

If the AIRSAR image scenes were imaged on the same date, they were mosaicked together when possible. In areas with data from two or more different scenes at the same UTM coordinates, the mosaic includes only one of the scenes (i.e. there is no averaging of data). If data are from the TOPSAR mode, then the DEM, incidence angle, and correlation files were also mosaicked. If the data are compressed Stokes matrix data, the HH, HV, VV, and HH-VV phase difference files were mosaicked. All mosaics are in UTM projection. For georeferenced data, the power is saved rather than the amplitude.

General information about the AIRSAR program is available at the NASA AIRSAR site, including a paper about the NASA/JPL Airborne Synthetic Aperture Radar System (PDF file).

1.1 Format

Different types of products are available, depending on the mode of acquisition. When in POLSAR mode, only the fully polarimetric data are available. When in TOPSAR mode, in addition to the VV imagery for C-band and L-band and the fully polarimetric P-band data, DEM files, incidence angle files, and image-pair correlation files are also available.

Data are available as binary files, in compressed Stokes matrix (10 bytes per pixel), unsigned byte, 16-bit signed integer format, or floating-point GeoTIFF.

Detailed information about data format and file headers is available in NASA's AIRSAR data format document (PDF file).

All standard AIRSAR data files, except GEOTIFF files, start with ASCII header records embedded in the data files. Except for the radiometric correction vectors, each header consists of a number of different fields 50 characters long. The field descriptor is left-justified in the 50-character string, followed by the value for that descriptor, right-justified in the same 50-character string. The headers are:

first header: general information about the data file including number of lines and samples and offset to the first data record.

parameter header: information specific to the scene

calibration header: information on data calibration

DEM header: only present for TOPSAR data; contains the elevation offset and elevation increment needed to translate the 16-bit signed integer values to elevations in meters. It also contains the 'peg point' location, heading, and image offsets needed to geolocate each pixel of the image.

1.1.1   POLSAR Data

The POLSAR operating mode of the AIRSAR instrument collects twelve channels of data, four channels each in the P-, L-, and C-bands. The four data channels are the complex single-look data, and they characterize the scattering matrix:

HH - horizontally polarized transmit wave, horizontally polarized receive wave
HV - horizontally polarized transmit wave, vertically polarized receive wave
VH - vertically polarized receive wave, horizontally polarized receive wave
VV - vertically polarized receive wave, vertically polarized receive wave

The Stokes matrix is a 4 by 4 real matrix of values that characterizes the polarization properties of the reflecting scene. Using the Stokes matrix, a user may 'synthesize' the backscattered power for any arbitrary transmit/receive polarization. The Stokes matrix is calculated from the scattering matrix, which is measured by the above four channels. During calibration processing, HV and VH are set equal to one another. A single data file is generated for each frequency band, consisting of elements of the Stokes matrix. These elements of the Stokes matrix are compressed to just 10 bytes per pixel, by taking advantage of various relationships between the elements of the Stokes matrix.

The POLSAR data stored in the compressed Stokes matrix files have a nominal pixel spacing of 9.26 m (along-track direction) and 3.3 m (cross-track direction). The data remain in the natural SAR slant-range projection. Each POLSAR scene typically contains three compressed Stokes matrix data files, one for each frequency. This is a non-standard format specific to polarimetric SAR imagery.

All POLSAR products begin with the letters 'cm'. GeoTIFF products begin with 'AIRSAR_' followed by the the scene identifier (cm####).

JPEG images at full resolution are available, that show color overlays of the 'total power' of each frequency band. The total power is the sum of the HH, HV, VH, and VV backscatter. The red intensity is P-band, the blue intensity is C-band, and the green intensity is L-band.

1.1.2   TOPSAR Data

The TOPSAR operating mode of the AIRSAR instrument also collects 12 channels of data, but some of these channels are used to store data from antennas that are vertically displaced from one another. This vertical displacement between antennas allows the AIRSAR processor to use interferometric principles to derive the topography of the surface. For CLPX, TOPSAR data were acquired for both C- and L-bands. Since AIRSAR was using data channels to store data from multiple antennas, fully polarimetric data for C- and L-bands were not acquired. Only VV backscatter data were acquired at these frequencies, but fully polarimetric data were acquired at P-band.

During processing, the two VV images from C-band were registered to one another and interfered. The AIRSAR processor measured and saved the correlation between the two images. Then, the interferogram was 'unwrapped' to yield topographic relief. This topography was then projected from the slant-range projection to the now-known surface topography. The incidence angle to each pixel was also calculated and saved. The same procedure applied for the L-band data. The VV images for C-band and L-band, and the P-band fully polarimetric data were calibrated for topography-induced radiometric errors and projected to the ground-surface topography. In areas where

AIRSAR cannot measure the topography (for instance, areas that are shadowed), the pixels were flagged. The output pixel spacing for the resulting data products was set to 5 m, but the geographic projection is specific to the imaging geometry of the airborne platform. Georeferencing of the data may not be possible with standard commercial software packages. The VV imagery is saved as an amplitude image, which is the square root of the power image. To retrieve calibrated backscattered power (versus transmitted power), each 16-bit signed integer pixel value should be squared and the result divided by 1000.0. To convert to db, multiply the log base 10 of this value by 10. Georeferenced data in GeoTIFF format already have this scale factor applied. The correlation is a raw, unsigned byte file, where the correlation is scaled from 0 to 1 (255 bytes). The incidence angle is a raw, unsigned byte file, where the incidence angle is scaled from 0 to 360 degrees (255 bytes). The DEM products are in meters. The DEM header stores the height offset and increment per digital number (DN) value.

All TOPSAR products begin with the letters 'ts'. GeoTIFF products begin with 'AIRSAR_', followed by the scene identifier (ts####).

Two types of full-resolution JPEG images are provided when the data were acquired in the TOPSAR mode. One set of color overlays consists of the C-band VV backscattered power (blue), the L-band VV backscattered power (green), and the 'total power' of the P-band (red). The total power is the sum of the HH, HV, VH, and VV backscatter. The other set of color overlays determines the brightness from the VV backscatter image, and the color corresponds to height.

1.1.3   Georeferenced Data

There are two types of georeferenced data: scenes and mosaics of scenes. These products are produced from the standard AIRSAR data products. Selected data products are saved in floating-point GeoTIFF format. Since it is not possible to save the compressed Stokes matrix as a GeoTIFF file, for fully polarimetric data (either from the POLSAR mode data, or the P-band TOPSAR mode data), HH, HV, VV, and the HH-VV phase differences were calculated and saved as individual GeoTIFF files. For data acquired in TOPSAR mode, the VV backscatter image, the DEM, the incidence angle, and the correlation were saved as individual GeoTIFF files. GeoTIFF data are projected to UTM. Unlike the non-georeferenced data, the calibrated power was saved rather than the amplitude. To convert to db, multiply 10 by the log base 10 of the floating-point pixel value. The correlation is a floating-point value between 0 and 1. The incidence angle and the HH-VV phase difference are floating-point values between 0 and 360 degrees. The DEM data are in meters.

Mosaics of AIRSAR data are restricted to data collections that were acquired on the same date and in the same mode.

1.2 File and Directory Structure

There is one directory for each product ID for both TOPSAR and POLSAR data (for example, ts1532 and cm6621).

The "ts" directories contain files such as:

image files (color overlays, uncalibrated):

`ts1555.gif`	- three frequency band overlay, annotated
`tsdem1555.gif`	- C-band DEM image, annotated
`tsdem1555l.gif`	- L-band DEM image, annotated
`ts1555_full.jpg`	- three frequency band overlay, full resolution
`tsdem1555_full.jpg`	- C-band DEM image, full resolution
`tsdem1555l_full.jpg`	- L-band DEM image, full resolution

metadata files:

`ts1555_meta.airsar`	- ASCII metadata file, easy to read
`ts1555_meta.podaac`	- ASCII metadata file, comma-separated values
`ts1555_letter.htm`	- HTML file about processing

data and imagery files:

`ts1555_c.corgr`	- C-band unsigned byte, correlation
`ts1555_c.demi2`	- C-band signed 16-bit signed integer DEM, scale factor in DEM header
`ts1555_c.incgr`	- C-band unsigned byte, incidence angle
`ts1555_c.rad_vec`	- C-band ASCII radiometric correction vector applied to imagery
`ts1555_c.vvi2`	- C-band VV signed 16-bit signed integer, backscatter image
`ts1555_l.corgr`	- L-band unsigned byte, correlation
`ts1555_l.demi2`	- L-band signed 16-bit signed integer DEM, scale factor in DEM header
`ts1555_l.incgr`	- L-band unsigned byte, incidence angle
`ts1555_l.rad_vec`	- L-band ASCII radiometric correction vector applied to imagery
`ts1555_l.vvi2`	- L-band VV signed 16-bit signed integer, backscatter image

`ts1555_p.datgr`	- P-band ground-range, projected, compressed Stokes matrix file
`ts1555_p.rad_vec`	- P-band ASCII radiometric correction vector applied to imagery
`ts1555_rad_vec.README`	- ASCII readme file about radiometric correction vectors

georeferenced files in GeoTIFF format:

`AIRSAR_ts1555_ccor_vv_30-MAR-03_mag.tif`	- C-band correlation, date of acquisition
`AIRSAR_ts1555_cinc_vv_30-MAR-03_mag.tif`	- C-band incidence angle, date of acquisition
`AIRSAR_ts1555_cvv_30-MAR-03_dem.tif`	- C-band VV polarization backscattered power image
`AIRSAR_ts1555_lvv_30-MAR-03_dem.tif`	- L-band VV polarization DEM in meters
`AIRSAR_ts1555_lvv_30-MAR-03_mag.tif`	- L-band VV polarization backscattered power image
`AIRSAR_ts1555_phhvv_30-MAR-03_mag.tif`	- P-band HH-VV phase difference
`AIRSAR_ts1555_phh_30-MAR-03_mag.tif`	- P-band HH backscattered power
`AIRSAR_ts1555_phv_30-MAR-03_mag.tif`	- P-band HV backscattered power
`AIRSAR_ts1555_pvv_30-MAR-03_mag.tif`	- P-band VV backscattered power

The "cm" directories contain files such as:

image files (color overlays, uncalibrated):

`cm6624.jpg`	- three frequency color overlay, annotated
`cm6624_full.jpg`	- three frequency color overlay, full resolution

metadata files:

`cm6624_meta.airsar`	- ASCII metadata file, easy to read
`cm6624_meta.podaac`	- ASCII metadata file, comma-separated values
`cm6624_report.log`	- processing log

data files:

`cm6624_c.dat`	- C-band slant-range, compressed Stokes matrix file
`cm6624_c.rad_vec`	- C-band ASCII radiometric correction vector applied to imagery
`cm6624_l.dat`	- L-band slant-range, compressed Stokes matrix file
`cm6624_l.rad_vec`	- L-band ASCII radiometric correction vector applied to imagery
`cm6624_p.dat`	- P-band slant-range, compressed Stokes matrix file
`cm6624_p.rad_vec`	- P-band ASCII radiometric correction vector applied to imagery
`cm6624_rad_vec.README`	- ASCII readme file about radiometric correction vectors

For information on how to read the AIRSAR files, please see the NASA/JPL Introduction to AIRSAR data.

1.3 File Naming Convention

1.3.1 POLSAR Data

POLSAR data are named:

```
cm####_c.dat
cm####_l.dat
cm####_p.dat
cm####_c.rad_vec
cm####_l.rad_vec
cm####_p.rad_vec
```

where "cm" indicates the data are in a compressed Stokes matrix form, and #### is a four-digit output product number that is unique for each scene. The next character indicates the band (c, l, or p). The "cm" data are oriented so that each pixel sample is of decreasing azimuth (along-track) and each pixel line is of increasing range (cross-track).

1.3.2 TOPSAR Data

TOPSAR data are named:

```
ts####_c.vvi2
ts####.demi2
ts####.corgr
ts####.incgr
ts####_p.datgr
```

where "ts" indicates that the data are from TOPSAR, and #### is a four-digit output product number that is unique for each scene. All TOPSAR data, including any polarimetric data collected in a TOPSAR mode, are projected in the ground range (indicated by "gr" in the file extension).

Header files:

`HD###.txt`

Quickview images are available in GIF and JPEG formats. For example, "`cm6624.jpg`," "`ts1555.gif`," and "`tsdem1555.gif`" (DEM).

1.3.3   Georeferenced Data

The file naming convention for the georeferenced imagery files is as follows:

`AIRSAR_mm####_DDMMMYYYY_ccc_bpp_ttt.tif` where:

mm = TOPSAR(ts) or POLSAR(cm)
= four-digit output number
DDMMMYYYY = acquisition date of the image (ex. 21feb2002)
ccc = correlation (cor) or incidence angle (inc)
b = frequency band (c, l, p)
pp = polarization (hh, vv, hv, hhvv)
ttt = imagery (mag) or DEM (dem)
tif = GEOTIFF file extension

The file naming convention the georeferenced mosaic files is as follows:

`AIRSAR_msa_DDMMMYYYY_bpp_ttt.tif` where:

msa = name of the MSA (northpark, rabbit, fraser)
DDMMMYYYY = acquisition date of the image (ex. 21feb2002)
b = frequency band (c, l, p)
pp = polarization (hh, vv, hv, hhvv)
ttt = imagery(mag) or DEM(dem)
tif = GEOTIFF file extension

1.4 Spatial Coverage

Data were collected over the three CLPX MSAs: Fraser, North Park, and Rabbit Ears Pass, Colorado, USA.

MSA	Upper Left	Lower Left	Upper Right	Lower Right
North Park (lat/long)	40° 48' 00" N 106° 26' 00" W	40° 34' 30" N 106° 26' 00" W	40° 48' 00" N 106° 08' 30" W	40° 34' 30" N 106° 08' 30" W
North Park (UTM)	378,978 E 4,517,548 N	378,574 E 4,492,493 N	403,683 E 4,517,170 N	403,387 E 4,492,088 N
Rabbit Ears (lat/long)	40° 34' 00" N 106° 50' 00" W	40° 20' 30" N 106° 50' 00" W	40° 34' 00" N 106° 32' 30" W	40° 20' 30" N 106° 32' 30" W
Rabbit Ears (UTM)	344,736 E 4,492,250 N	344,170 E 4,467,141 N	369,468 E 4,491,819 N	369,064 E 4,466,737 N
Fraser (lat/long)	40° 00' 30" N 106° 01' 30" W	39° 47' 00" N 106° 01' 30" W	40° 00' 30" N 105° 44' 00" W	39° 47' 00" N 105° 44' 00" W
Fraser (UTM)	412,437 E 4,429,124 N	412,215 E 4,404,072 N	437,461 E 4,428,902 N	437,184 E 4,403,878 N

1.4.1   Spatial Resolution

The POLSAR data have a nominal resolution of 9.26 m (azimuth) and 3.3 m (range), and TOPSAR data have a data resolution of 5 m in both azimuth and range.
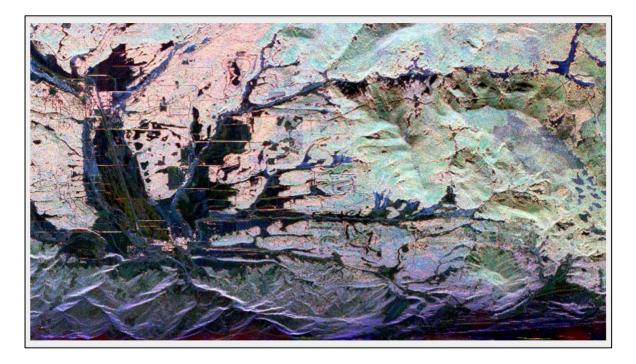
1.5 Temporal Coverage

Data in both modes were collected on 19, 21, and 22-24 February 2002, and on 25 March 2002. TOPSAR data were also collected during snow-free conditions on 17 September 2002. AIRSAR data were collected on 25, 26, 28-30 March 2003.
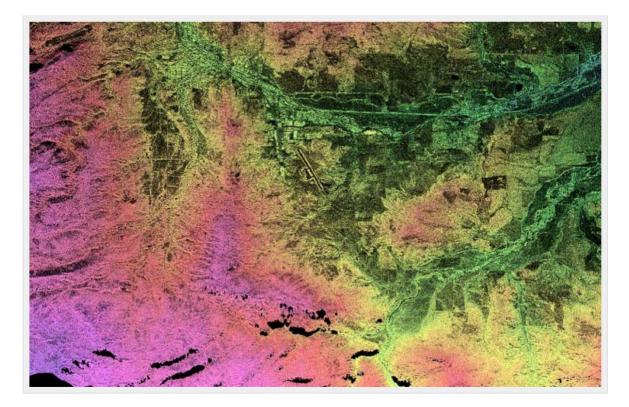
1.6 Parameter or Variable

This data set consists of Synthetic Aperture Radar (AIRSAR) imagery, DEMs, correlations, and incidence angles.

1.6.1   Sample Data Record

Sample POLSAR image over Fraser MSA, Colorado (P/L/C-band overlay of Fraser270-1, collected on 27 February 2002):

Sample C-band DEM of Rabbit Ears 270-1, collected on 13 February 2002:

2   SOFTWARE AND TOOLS

2.1 Quality Assessment

Information about the quality of these data is available in the NASA/JPL Airborne Synthetic Aperture Radar System (PDF file) document.

3   DATA ACQUISITION AND PROCESSING

Detailed information on the AIRSAR instrument and data collection are available at the NASA AIRSAR Instrumentation site and in the NASA/JPL Airborne Synthetic Aperture Radar System document (PDF file).

4   REFERENCES AND RELATED PUBLICATIONS

Lou, Y., Y. Kim, and J. van Zyl. *The NASA/JPL Airborne Synthetic Aperture Radar System*. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

NASA/JPL AIRSAR Web Site.

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6   DOCUMENT INFORMATION

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