CV-580 SIR-C Format Definition

CCRS-TN-2002-026

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Abstract

This document defines the file format of the CV-580 SIR-C image, header, and log files. The SIR-C image is a BIP 10-channel geo-coded or geo-referenced product.

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* Under contract to CCRS from Prologic Systems Ltd.

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1 Introduction

The CV-580 SIR-C file format is based on the JPL MLC quad-pol SIR-C format. This format is usually used to provide the smallest geo-referenced or geo-coded product although it can be used for full resolution imagery. It assumes that the scattering matrix is symmetric with respect to the cross polarizations, thus making one polarization redundant and reducing the data size.

Table 1 presents the files associated with the SIR-C format, their naming convention, description, and approximate data volumes. The image volume presented here is for a geo-referenced image, which contains no extra padding on its edges. The image volume of a geo-coded product would be greater and its actual size dependent on its orientation.

Table 1. Files associated with the SIR-C format

Type	Naming Convention	Description	Approximate Volume
.log	L#p#sso2SIRC.log	Text log file	6339 bytes
.hdr	L#p#SIRC.hdr	Text header file	509 bytes
.img	L#p#SIRC.img	Binary image file	6.43 MB/km

Note that this document describes the CCRS implementation of the SIR-C format. In the CCRS implementation only the binary image file follows the JPL MLC quad-pol SIR-C guidelines. The official JPL format provides a much more complicated header file format and does not include a log file. The CCRS implementation greatly reduces the number of entries in the header file and provides a record of problematic pixels in a log file.

2 Log File

The log file is generated when the image file is converted from the SSO image. The log file records errors on pixels that do not fall within the range of signed 8 bit integers. A small number of pixels may be corrupted in an image. These errors may be due to saturation or a known problem with GEOCOR, where problem pixels may be generated on the edge of a scene.

Each line of the log file contains five values pertaining to the problem pixel:

- Pixel
- Line
- Channel
- Problem value as a float
- Problem value as a signed character

The log file can be plotted using plotsso2sirc to quickly determine the locations and number of problematic pixels.

3 Header File

The header file describes the size, format, and location of the image file. The keys on the left may be up to 22 characters long and their values begin in column 24. An example is presented here.

```
sso2sirc_version       1
sso2sirc_release       1
sso2sirc_patch         0
number_lines           3037
number_samples         2779
header_offset          0
number_channels        10
datatype               1
number_format          int8
complex_flag           0
transposed             0
sample_size            4.0000000000
sample_size_az         4.0000000000
reference corner       Upper_Left
reference projection   UTM zone 18
reference north        5032958.0000000000
reference east         423210.0000000000
```

First, the sso2SIRC version, release, and patch used to create the product are recorded. Next, the image size is given in lines and samples. There is no header information in the image file so the header_offset is zero. The fact that the image is a BIP 10 channel 8-bit file is recorded in the next three fields. The data is not complex so the complex_flag is set to zero. The transpose flag is set to zero for a geocoded product as it is not applicable, but is used in its usual sense for non-geocoded imagery.

The final six fields relate to the geo-location of the image and their units depend upon the reference projection used. The reference projection may be provided as a UTM zone or as latitude and longitude. For a UTM projection, the sample sizes and the reference position (north and east) are provided in metres. If the data is recorded in latitude and longitude, the sample sizes and the reference position are provided in arc seconds. The reference corner is usually set to the upper left (North-West) corner, as seen in the example, but may be any corner. This reference corner is taken as the image origin and its location is given by the reference north and east positions. For a non-geocoded product, these values may or may not be valid.

Table 2. Explanation of the SIR-C header keys

Key	Comments
sso2sirc_version	Version, release and patch code of the sso2sirc program used to create the SIR-C image

sso2sirc_release	from the SSO image.
sso2sirc_patch	
number_lines	Number of lines in the image (rows running East-West).
number_samples	Number of samples in the image (columns running North-South).
header_offset	Always zero (0) because no header information is stored in the image.
number_channels	Always ten (10) by definition of the SIR-C format.
Datatype	Always one (1) indicating *integers*.
number_format	Always int8 indicating 8 bit integer values.
complex_flag	Always zero (0) indicating real data.
Transposed	Always zero (0) because it is irrelevant to a geocoded product.
sample_size	The pixel size is preset to four (4) metres in each direction to produce square pixels.
sample_size_az	
reference corner	Corner of image to be used as the origin. Normally set to Upper_Left.
reference projection	Map projection used to geocode the image. Set to the appropriate UTM zone to allow for the desired 4 m pixel size.
reference north	The north and east coordinates of the reference corner measured in metres consistent with the projection used.
reference east	

4 Image

The image file is a Band-Interleaved-by-Pixel (BIP) 10-channel 8-bit signed integer file. The ten channels contain combinations of information from the three independent polarizations. This information is recorded in such a way that the magnitude and relative phase of each polarization can be re-derived.

The ten channels are based on the upper-right triangle of the SSO matrix as described in CCRS-TN-2000-001A (Wind, 2000). The two cross-polarized channels are combined into one channel during the conversion to SSO format by CV2SSO. We start with the IQ PolGASP data and convert the data to SSO format. During geocoding, it is converted to SIR-C format.

CV2SSO provides the operator with several options for combining the cross-polarized channels. The operator may choose the desired method for the magnitude and phase independently. The method used is recorded in the log file for CV2SSO. The options for each parameter are presented in Table 3.

Table 3. Options in CV2SSO for Combining the Cross-Polarizations

Magnitude Combination Option	**Defining Equation**
Mean vector	$\left\|S_X\right\| = \left\|\frac{S_{HV} + S_{VH}}{2}\right\|$
Mean amplitude	$\left\|S_X\right\| = \frac{\left\|S_{HV}\right\| + \left\|S_{VH}\right\|}{2}$
Mean power	$\left\|S_X\right\|^2 = \frac{\left\|S_{HV}\right\|^2 + \left\|S_{VH}\right\|^2}{2}$
None	$\left\|S_X\right\| = 0$
Phase Combination Option	**Defining Equation**
Mean vector	$\phi_X = Phase\left(\frac{S_{HV} + S_{VH}}{2}\right)$
Mean phase	$\phi_X = \frac{Phase(S_{HV}) + Phase(S_{VH})}{2}$
HV	$\phi_X = Phase(S_{HV})$
VH	$\phi_X = Phase(S_{VH})$
None	$\phi_X = 0$

4.1 Conversion to JPL SIR-C format

The SIR-C format was introduced by JPL (Chapman and Freeman, 1995) and is defined in terms of the complex backscatter coefficients $\{S_{HH}, S_{VV}, S_{HV}, S_{VH}\}$. This format represents the polarimetric scattering of each pixel in a 10-element vector of byte data that effectively uses the

8-bit dynamic range by dynamically scaling the data on a pixel basis. The 10-element JPL vector $\{B_i\}$ is built from the symmetrized SSO matrix, *M*, in SSO2SIRC through the relation that follows (Hawkins et al, 2002).

$$\left.\begin{aligned}
B_1 &= f_{loor}\left[\ln(4M_{11})/\ln 2\right]\\
B_2 &= R_{\text{int}}\left[254\times(4M_{11}/2^{B_1}-1.5)\right]\\
B_3 &= R_{\text{int}}\left[255\times\text{Re}\sqrt{\frac{M_{33}+M_{44}}{Q}}\right]-127\\
B_4 &= R_{\text{int}}\left[255\times\text{Re}\left(\frac{2(M_{11}+M_{12})-M_{33}-M_{44}}{Q}\right)\right]-127\\
B_5 &= R_{\text{int}}\left[127\times sign\left(\frac{M_{13}-M_{23}}{Q}\right)\times\sqrt{2\left|\frac{M_{13}-M_{23}}{Q}\right|}\right]\\
B_6 &= R_{\text{int}}\left[127\times sign\left(\frac{M_{24}-M_{14}}{Q}\right)\times\sqrt{2\left|\frac{(M_{24}-M_{14})}{Q}\right|}\right]\\
B_7 &= R_{\text{int}}\left[254\times\left(\frac{M_{33}-M_{44}}{Q}\right)\right]\\
B_8 &= R_{\text{int}}\left[254\times\left(\frac{-2M_{34}}{Q}\right)\right]\\
B_9 &= R_{\text{int}}\left[127\times sign\left(\frac{M_{13}+M_{23}}{Q}\right)\times\sqrt{2\left|\frac{M_{13}+M_{23}}{Q}\right|}\right]\\
B_{10} &= R_{\text{int}}\left[127\times sign\left(\frac{-M_{24}-M_{14}}{Q}\right)\times\sqrt{2\left|\frac{-M_{24}-M_{14}}{Q}\right|}\right]
\end{aligned}\right\} \qquad (1)$$

Here $\ln(x)$ is the natural logarithm of x; $sign(x)$ is the sign of x; $f_{loor}(x)$ is the largest integer not greater than x; $R_{\text{int}}(x)$ is the nearest integer to x; and, $Q=\left(\frac{B_2}{254}+1.5\right)\times 2^{B_1}$.

The total power of a pixel is given by $0.25\left(Byte(2)/254+1.5\right)2^{Byte(1)}$.

The format and content of each byte in the SIR-C format is described thoroughly by JPL for their multi-look complex data. JPL symmetrizes their data using the mean vector approach. This is the option applied in CV2SSO by CCRS also. The definition of each channel in terms of the complex backscatter coefficients can be found at the following web page:

http://southport.jpl.nasa.gov/software/dcomp/dcomp.html#RTFToC10.

5 Process Summary

A summary of the processes required to go from the calibrated PolGASP imagery to the SIR-C format is presented in a flow diagram (Figure 1). The original PolGASP data is in complex IQ format with one band for each polarization. This format is converted to the SSO format, containing 16 real bands, by the program CV2SSO. During this process the HV and VH channels are combined so that the SSO matrix becomes symmetric and 6 bands become redundant. The SSO format enters GEOCOR where the image is either georeferenced or geocoded. GEOCOR corrects for the slant range geometry and also resamples the data to generate square pixels. The SSO format is required for the pixel resampling process but is not as useful as an end product because of its size. Thus, SSO2SIRC is used to convert the SSO image to the final SIR-C format explained in this document.

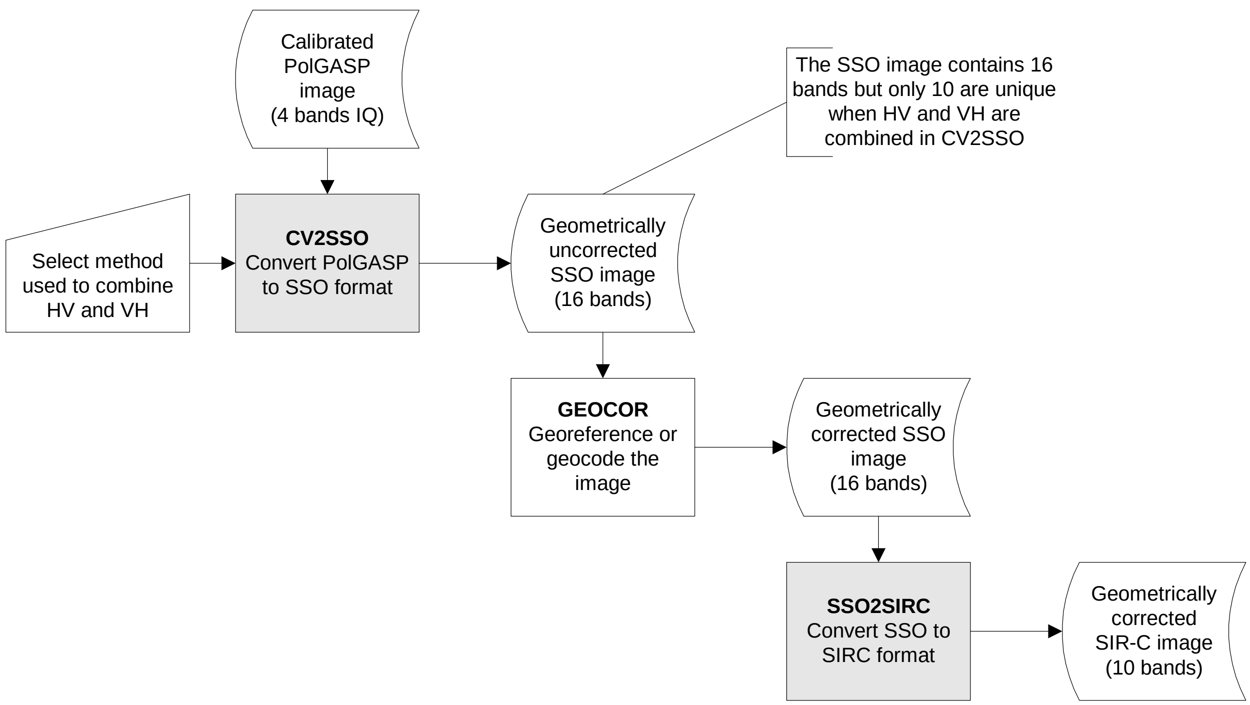

Figure 1. Flow of imagery from PolGASP to SIR-C formats.

6 References

Chapman, B., and A. Freeman, SIR-C standard data format, http://southport.jpl.nasa.gov/sampledata/Readme.dataformat.html, 1995.

Hawkins, R., Wind, A., Murnaghan, K., Gibson, J., Nedelcu, S., and Brown, C., Processing of the C-Band Polarimeter on the Environment Canada CV-580 – A Review, Presented at World Space Conference, Houston, 10p., 2002.

Wind, A., Polarimetric Resampling of the CCRS SAR Data Using the Stokes Scattering Operator, CCRS-TN-2000-001, 21p., 2000.