Vela-Carina - v1.0 Data Release

Galactic Structure and Star Formation in Vela-Carina

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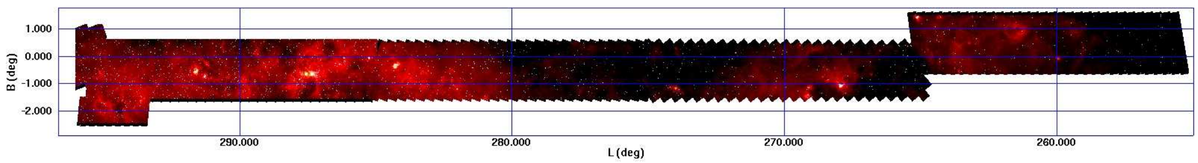

Contents

1 Quick Start

The Vela-Carina project extends the Galactic Legacy Mid-Plane Survey Extraordinaire (GLIMPSEI[1]) style coverage (two 1.2 second exposures at each position) to Galactic longitudes $255° < l < 295°$, observing the Carina and Vela regions of the Galactic plane, with a latitude width of about 2°. For $265° < l < 295°$ the latitude center is -0.5°and for $255° < l < 265°$ the latitude center is +0.5° (see Figure 1). The data have been processed by the Wisconsin GLIMPSE IRAC pipeline. Vela-Carina data products are available at the Infrared Science Archive (IRSA)

- IRSA – http://irsa.ipac.caltech.edu/data/SPITZER/GLIMPSE/

For those who are familiar with GLIMPSE data, Vela-Carina enhanced data products are very similar. There are two types of sources lists: a high reliability point source Catalog and a more complete point source Archive. The other main product is the set of mosaicked images. This Vela-Carina data release contains source lists (2,001,032 Catalog sources and 4,545,966 Archive sources) and mosaic images (with and without background matching and gradient correction) for the entire survey region. With this data delivery, all Vela-Carina enhanced data products have been delivered to IRSA.

2 Vela-Carina Survey and Data Products

2.1 Project Overview

Vela-Carina is the fourth in a series of large area projects to map selected regions of the Galactic plane using the *Spitzer* Space Telescope (SST) (Werner et al. 2004) Infrared Array Camera (IRAC) (Fazio et al. 2004). The Vela-Carina project (PID=40791) (Majewski et al. 2007, Zasowski et al. 2009) extended GLIMPSE-style coverage (two 1.2 second integrations at each position) to Galactic longitudes $255° < l < 295°$ covering 86 square degrees of the Carina and Vela regions of the Galactic plane. Figure 1 shows the area observed by the Vela-Carina survey.

IRAC has four bands, centered at approximately 3.6, 4.5, 5.8 and 8.0 μm (Table 1). The Vela-Carina survey was part of the Spitzer cryogenic mission in which all four IRAC bands were in operation. All of the Vela-Carina survey area has 2-visit single epoch coverage. The data were reduced by the Wisconsin GLIMPSE IRAC pipeline. The Vela-Carina survey produced enhanced data products in the form of a point source Catalog, a point source Archive, and mosaicked images. Table 2 gives the dates of observation and the Spitzer Science Center (SSC) pipeline processing version of the data for each 10 degree segment of the survey.

Table 3 summarizes the approximate coverages, wavelengths observed, and integration times for the larger Galactic plane projects. See Benjamin et al. (2003), Churchwell et al. (2009) and the GLIMPSE web site (www.astro.wisc.edu/glimpse/) for more description of the GLIMPSE projects and pipeline processing.

[1] Although originally known as GLIMPSE, we will use the acronym GLIMPSEI to avoid confusion between it, GLIMPSEII and GLIMPSE3D

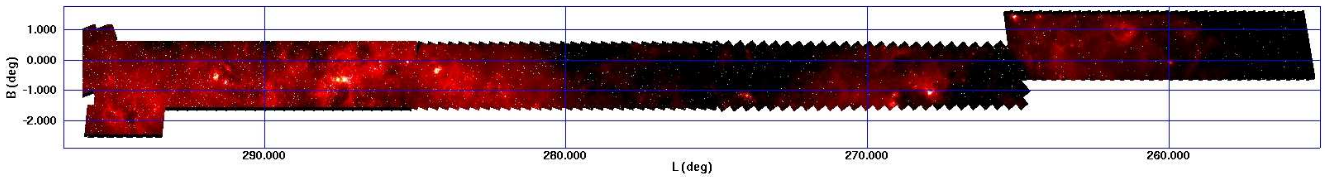

Figure 1: The area observed by the Vela-Carina survey. This is a 3-color image ([3.6], [4.5] and [8.0] in blue, green, and red respectively) of the survey region. Source lists and enhanced images for the entire survey area have been delivered to IRSA.

Table 1. Sensitivity/Saturation Limits for the Catalog

Band	λ^a	S_0^a	$\frac{A_{[\lambda]}}{A_K}^b$	m^c_{sens}	m^d_{sat}	m^e_{conf}
J	1.25	1594	2.50 ± 0.15	—	—	—
H	1.65	1024	1.56 ± 0.06	—	—	—
K_s	2.17	666.7	1.00	—	—	—
1	3.55	280.9	0.56 ± 0.06	14.2	7.0	13.3−13.6
2	4.49	179.7	0.43 ± 0.08	14.1	6.5	13.3−13.6
3	5.66	115.0	0.43 ± 0.10	11.9	4.0	11.7−12.3
4	7.84	64.13	0.43 ± 0.10	9.5	4.0	11.0−12.4

[a]Vega isophotal wavelengths (λ in μm) and IRAC zero magnitudes (S_0 in Jy) from Cohen et al. (2003) and Reach et al (2005). [b]Extinction from Indebetouw *et al.* (2005). [c]Faint limit based on GLIMPSE Science Verification Study (Addendum) http://www.astro.wisc.edu/glimpse/addendum4.pdf. [d]Saturation limit based on GLIMPSE Quality Assurance document http://www.astro.wisc.edu/glimpse/GQA-master.pdf. [e]Confusion limit from Benjamin et al. (2005).

Table 2. Observation Dates and SSC processing versions

Longitude range (deg)	date obs	SSC pipeline version
255.5 − 265	20080131 to 20080201	S17.0.1
265 − 275	20080303 to 20080305	S17.0.1
275 − 285	20080407 to 20080409	S17.2
285 − 295.7	20080719 to 20080720	S18.0

Table 3. Vela-Carina and Similar Spitzer Galactic Plane Surveys

Survey	Coverage	Approx. Area	Instrument/Bands	Exp. Time	Reference
Vela-Carina	l=255°– 295°; b ≈ -1.5°– +1.5°[a]	86 sq. deg.	IRAC [3.6],[4.5],[5.8],[8.0]	2×1.2 s	Zasowski et al. (2009)
GLIMPSE I	10°< $\|l\|$ <65°; $\|b\|$ < 1°	220 sq. deg.	IRAC [3.6],[4.5],[5.8],[8.0]	2×1.2 s	Churchwell et al. (2009)
GLIMPSE II	$\|l\|$ < 10°; $\|b\|$ <1.5° [a]	54 sq. deg.	IRAC [3.6],[4.5],[5.8],[8.0]	3×1.2 s[b]	Churchwell et al. (2009)
GLIMPSE 3D	< $\|l\|$ < 31°;$\|b\|$ > 1°[a]	120 sq. deg.	IRAC [3.6],[4.5],[5.8],[8.0]	$3(2) \times 1.2$ s[c]	Churchwell et al. (2009)
GLIMPSE 360	l=65°– 76°,82°– 102°,109°–265° $\|b\|$ < 3°[a]	511 sq. deg.	IRAC [3.6],[4.5]	3×10.4 s	Whitney et al. (2008)
Deep GLIMPSE	l = 265°–350°, b°=-2°– +0.1° l = 25°–65°, b= 0°– +2.7°	208 sq. deg.	IRAC [3.6],[4.5]	3×10.4 s	Whitney et al. (2011)
SMOG	l=102°– 109°; b= 0°– 3°	21 sq. deg.	IRAC [3.6],[4.5],[5.8],[8.0]	4×10.4 s	Carey et al. (2008)
Cygnus-X	l= 76°– 82°; b = -2.3°– +4.1°[a]	24 sq. deg.	IRAC [3.6],[4.5],[5.8],[8.0]	3×10.4 s	Hora et al. (2007)

[a]Irregular region; see survey documentation for details. [b]GLIMPSE II data products include the *Spitzer* Galactic Center survey (S. Stolovy; PID=3677) which has five visits. [c]Some portions of GLIMPSE 3D use two visits and others have three.

This document describes the data products from the Vela-Carina Survey. The organization is as follows: §2 gives an overview of the Vela-Carina survey and the data products; §3 discusses the quality checks and validation of the source lists; §4 provides an overview of the data products; and §5 provides a more detailed description of data formatting. A complete discussion of the Source Quality Flag is given in Appendix A. Since the data processing for this survey is very similar to the previous GLIMPSE programs, this description is not repeated here. Please see §3 of the GLIMPSEI v2.0 Data Release document (http://www.astro.wisc.edu/glimpse/glimpse1_dataprod_v2.0.pdf, hereafter GLI Doc) for this discussion. The differences between the GLIMPSEI v2.0 and Vela-Carina v1.0 processing are:

- The criteria for including a 2MASS source was changed. In GLIMPSEI v2.0 processing, a GLIMPSE source would match to a 2MASS source only when the 2MASS source had a good K_s band measurement (photometric quality of "A"). This potentially left out sources that were K_s band "drop-outs" but detected in J and H bands. Here, we include a 2MASS match if the source has a photometric quality flag of A, B, C or D for the K_s band, or a quality flag of A or B in the H band.
- The 2MASS photometric quality flag is now included in our Source Quality Flag (SQF) (see Table 6 and Appendix A).
- The value of the flux calculation method flag has changed. For GLIMPSEI the method flag for the 2 sec frametime was 12 and for Vela-Carina it is 48.

More details about the photometry steps can be found at
www.astro.wisc.edu/glimpse/glimpse_photometry_v1.0.pdf.

If you find yourself confused by the numerous acronyms, a glossary is provided at the end of this document.

2.2 Data Products Overview

The Vela-Carina enhanced data products consist of a highly reliable Point Source Catalog (VelaCarC), a more complete Point Source Archive (VelaCarA), and mosaic images covering the survey area.

1. The Vela-Carina Catalog (VelaCarC, or the "Catalog"), consists of the highest reliability point sources. To be in the Catalog, sources must be detected at least twice in one IRAC band and at least once in an adjacent band, which we call a "2+1" criterion, where the "1" can include the 2MASS K_s band. Based on considerations detailed in §3.2 of the GLI v2.0 Data Release Document, this yields a Vela-Carina Catalog with a reliability greater than 99.5%; that is, only five sources in a thousand are expected to be spurious. Table 1 provides estimates for the sensitivity, saturation, and confusion limits for the Vela-Carina Catalog in magnitude units, together with the isophotal wavelengths and IRAC zero magnitudes. The range of confusion limits, which are highly dependent on Galactic latitude/longitude, are based on an analysis of GLIMPSEI data. Figure 2 shows the number of Vela-Carina Catalog

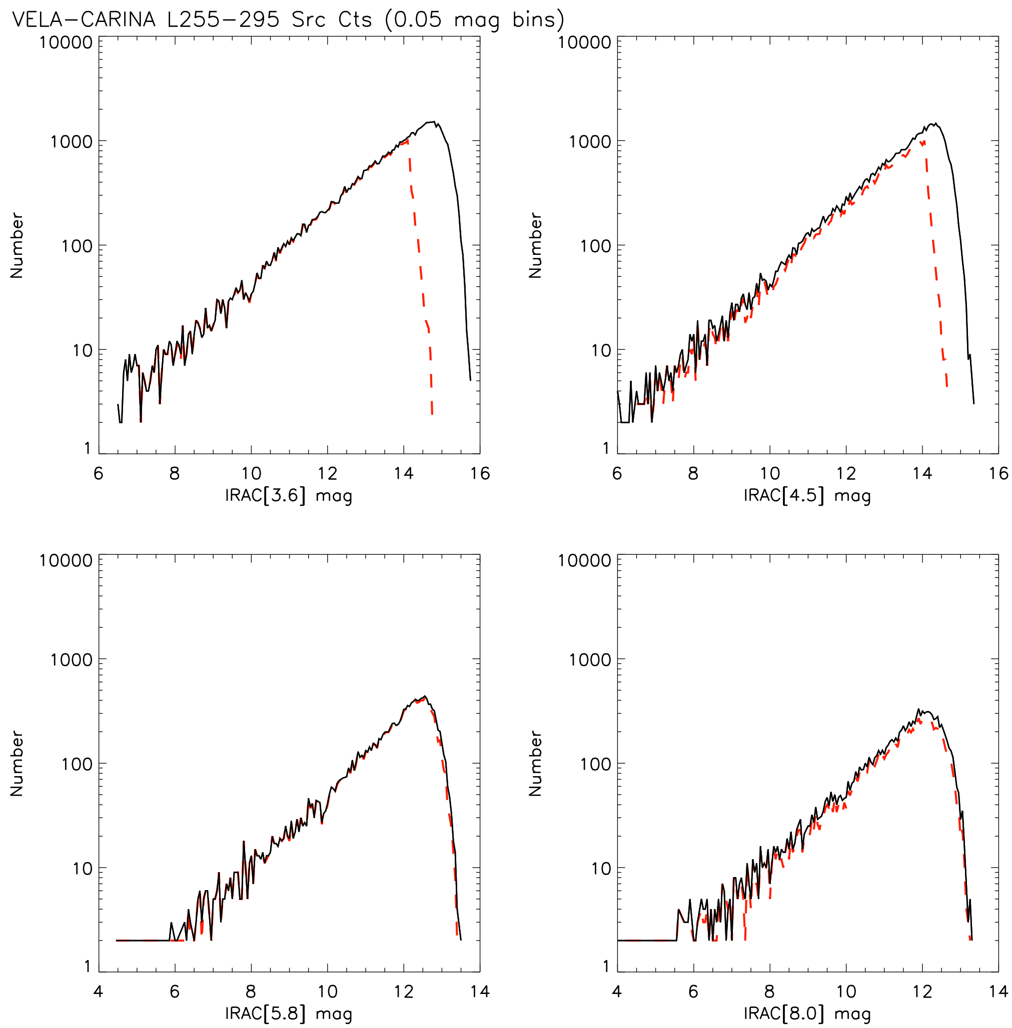

Figure 2: Plotted is the logarithm of the source counts in the Vela-Carina Catalog (dashed lines) and Archive (solid lines) binned every 0.05 magnitudes. Each of the 4 bands is plotted, showing the effective limiting magnitude for each band. Sources from all of the Vela-Carina survey were used for these plots.

sources as a function of magnitude for each IRAC band. The photometric uncertainty is typically < 0.2 mag and is discussed further in §3.2.

For each IRAC band the Catalog provides fluxes (with uncertainties), positions (with uncertainties), the areal density of local point sources, the local sky brightness, and a flag that provides information on source quality and known anomalies present in the data. Sources were bandmerged with the Two Micron All Sky Survey Point Source Catalog (2MASS; Skrutskie et al. 2006). 2MASS provides images at similar resolution to IRAC, in the J (1.25 μm), H (1.65 μm), and K_s (2.17 μm) bands. For each source with a 2MASS counterpart, the VelaCarC also includes the 2MASS designation, counter (a unique identification number), fluxes, signal-to-noise, and a modified source quality flag. For some applications, users will want to refer back to the 2MASS Point Source Catalog for a more complete listing of source information. The Vela-Carina Catalog format is ASCII, using the IPAC Tables convention (irsa.ipac.caltech.edu/applications/DDGEN/Doc/ipac_tbl.html).

2. The Vela-Carina Archive (VelaCarA or the "Archive"), consists of point sources with a signal-to-noise > 5 in at least one band and less stringent selection critera than the Catalog (see §3.2 of the GLI Doc). The photometric uncertainty is typically < 0.3 mag. The information provided is in the same format as the Catalog. The number of Archive sources as a function of magnitude for each IRAC band is shown in Figure 2. The Catalog is a subset of the Archive, but note that the entries for a particular source might not be the same due to additional nulling of magnitudes in the Catalog because of the more stringent requirements (§3.2 of the GLI Doc).

3. The delivered Vela-Carina Images are mosaicked images for each band, each covering e.g. $1.1^\circ \times 1.1^\circ$. These are 32-bit IEEE floating point single extension FITS formatted images covering the survey area. These images, in units of surface brightness MJy/sr, have a pixel size of $0.6''$. Mosaics of each band are made for larger, e.g. $3.1^\circ \times 2.4^\circ$ areas, with a pixel size of $1.2.''$ $1.2''$ pixel mosaics are provided with and without background matching and gradient correction. Also included are quicklook 3-color jpeg images of the same size as the FITS images. In the background matched and gradient corrected mosaics we match instrumental background variations between the images. Instrument artifacts (Hora et al 2004; IRAC Data Handbook[2]) such as full array pull-up, first frame effect and frame pull-down are mostly removed from the images during the background matching. The background matching introduces large-scale gradients which are removed. This processing may be removing real sky variations so we provide these images *in addition* to the images that do not have the background matching. The processing done to produce the background matched and gradient corrected images is described in §4.2.

3 Quality Checks and Source List Validation

This section describes some of the checks we have made on the quality and integrity of the Catalog and Archive point source lists. Since many of the checks for this data were also performed as part of GLIMPSE, additional information can be found in the following documents:

- *GLIMPSE Quality Assurance (GQA) document*: http://www.astro.wisc.edu/glimpse/GQA-master.pdf
- *Reliability and Completeness for GLIMPSE*: http://www.astro.wisc.edu/glimpse/cr_manuscript.pdf
- *Observation Strategy Validation Report*: http://www.astro.wisc.edu/glimpse/val.20040130.pdf
- *Addendum to the Validation Report*: http://www.astro.wisc.edu/glimpse/addendum4.pdf

These documents describe the GLIMPSEI data validation and the results of a reliability study using GLIMPSEI Observation Strategy Validation (OSV) data to develop source selection criteria. Additional details are given in §3.2 and §4.1 of the GLI Doc. A study of completeness in all the GLIMPSEs point source lists can be found in Kobulnicky et al. 2013.

[2] http://ssc.spitzer.caltech.edu/irac/dh/

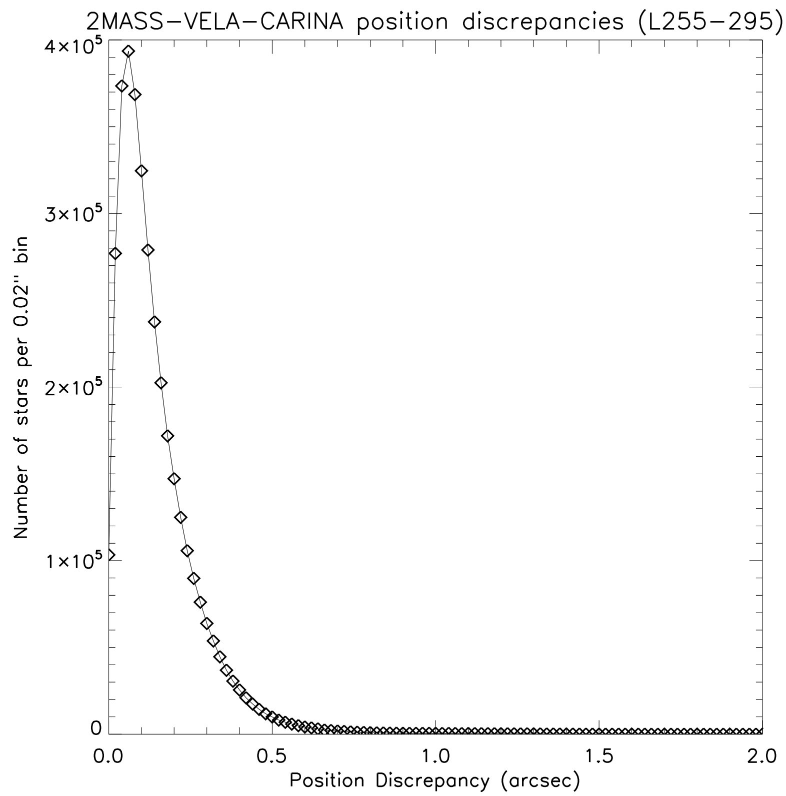

Figure 3: Comparison of Vela-Carina source positions to their corresponding 2MASS PSC positions from all sources in the survey. The astrometric discrepancy plotted is the angular separation in arcseconds between the Vela-Carina position and the 2MASS position. Note that sources with 2MASS associates have Vela-Carina positions that are in part derived from the 2MASS position. Thus this is not a comparison of a pure IRAC-only position with the 2MASS position.

3.1 Astrometric Accuracy

Sources bright enough to have 2MASS associations are typically within $0.3''$ of the corresponding 2MASS position, as discussed in §4.1. Figure 3 shows a comparison of Vela-Carina source positions to the 2MASS PSC positions, in $0.02''$ bins for all the sources in the Vela-Carina survey. The peak of the plot is about $0.1''$ and the majority of the sources have positional differences less than $0.3''$. Fainter Vela-Carina sources are likely to have larger errors due to poorer centroiding. See Section VII of the GQA for a more detailed discussion of positional accuracy.

3.2 Photometric Accuracy

Photometric accuracy for GLIMPSEI was verified with simulated images consisting of known point source fluxes placed on residual images (IRAC images with point sources removed giving realistic backgrounds). The point source accuracy depends on background level. A table of photometric accuracy as a function of background level is given in the Addendum to the GLIMPSE Validation Report (http://www.astro.wisc.edu/glimpse/addendum4.pdf). For average background levels, the photometric accuracy is $\leq 0.2^m$ at magnitudes brighter than $\sim 14, \sim 12, \sim 10.5, \sim 9.0$ for bands

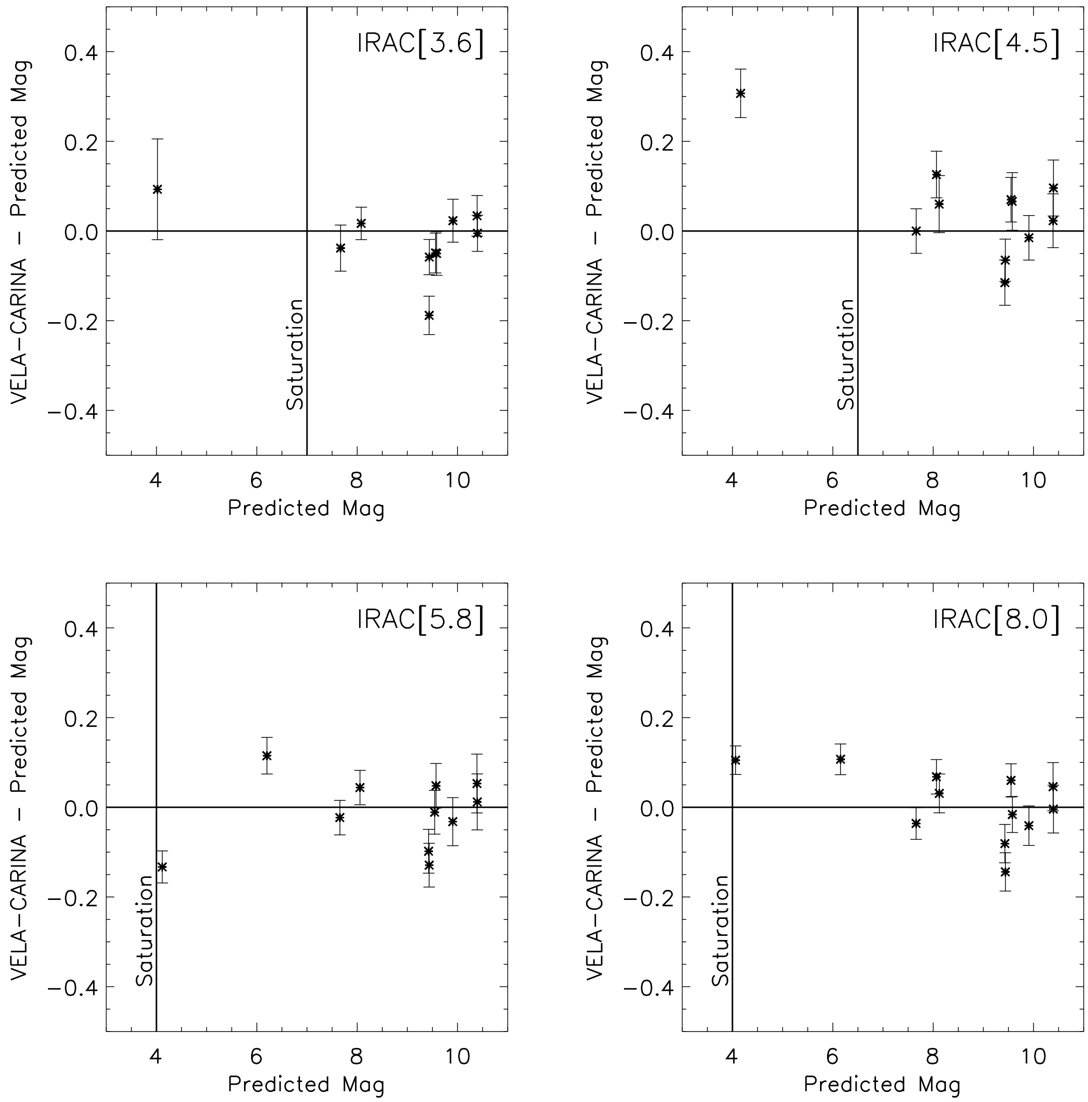

Figure 4: Vela-Carina Flux Calibrators. Comparison of eleven GLIMPSEI and Observation Strategy Validation (OSV) flux calibrators that are in the overlap areas with the Vela-Carina survey. They show good agreement between the GLIMPSEI, OSV and Vela-Carina extractions as well as agreement with Martin Cohen's predicted magnitudes for each IRAC band. Error bars are the root-sum-of-squares of the errors of both the extracted and predicted magnitudes for each source. The vertical lines are the best estimates of the saturation limits.

[3.6], [4.5], [5.8] and [8.0] respectively.

Our goal was to achieve point source photometry accuracy of $\leq$0.2 mag. Table 4 shows a summary of the fraction of sources in the Vela-Carina Catalogs and Archives that achieve this level. The results are consistent with GLIMPSEI (§4.3 of the GLI Doc). The [5.8] band shows a higher percentage of sources with photometric accuracy >0.2 mag, probably due to its lower sensitivity. The [4.5] band shows a higher percentage of sources with photometric accuracy >0.2 mag compared

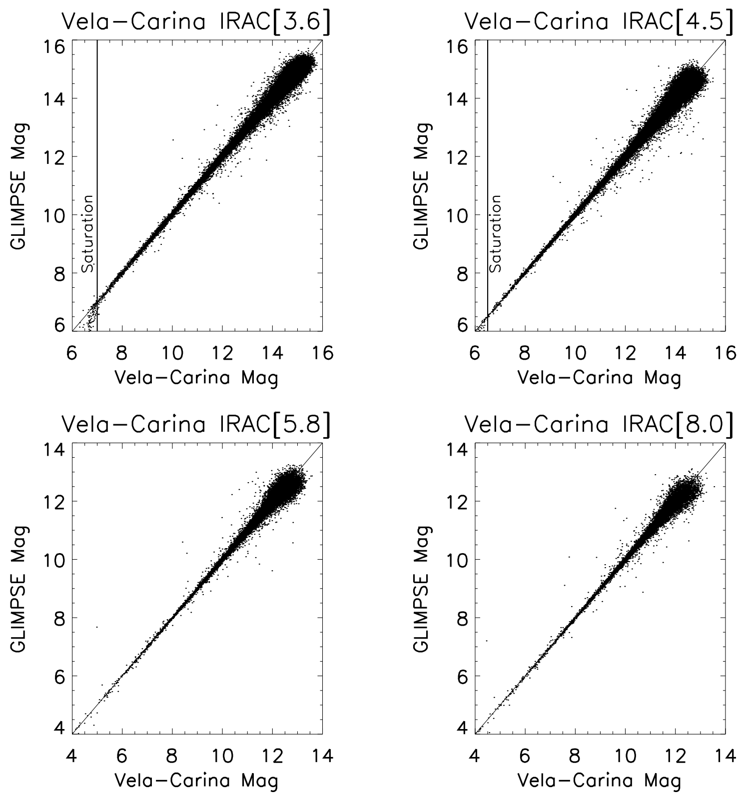

Figure 5: Comparison between overlap regions between Vela-Carina and GLIMPSEI and OSV data. There are about 47263 Vela-Carina sources that overlap the GLIMPSEI area at l= 295° and 102845 Vela-Carina sources that overlap the OSV area at l= 284.2°. This shows the good agreement between datasets.

to the [3.6] band. This is a result of our selection criteria (§3.2 in the GLI Doc). For the Catalog, the [3.6] band is almost always the band with the "2" in our "2+1" criteria. The signal-to-noise for the band with 2 detections is required to be greater than 5. Therefore a smaller percentage of the [3.6] band sources with photometric accuracy >0.2 mag will be in the Catalog. Similarly, the Archive requires two detections in any band. The two detections are often the [3.6] band detections with the signal-to-noise required to be greater than 5.

Table 4. Photometric Accuracy of Vela-Carina Sources

Band (μm)	[3.6]	[4.5]	[5.8]	[8.0]
Catalog				
No. with error >0.2 mag	3660	87171	219072	142271
Total number of entries	1992654	1950335	897081	731513
% with errors >0.2 mag	0.18	4.47	24.42	19.45
Archive				
No. with error >0.2 mag	108229	1042333	270440	187631
Total number of entries	4439308	3382154	967145	823543
% with errors >0.2 mag	2.44	30.82	27.96	22.78

Photometric accuracy for the GLIMPSEI survey was verified by comparison with more than 250 flux calibrators distributed throughout the GLIMPSEI survey region. The flux predictions were supplied by Martin Cohen. These calibrators span a wide range of fluxes in each IRAC band. The techniques used to produce the flux predictions are described in Cohen et al. (2003). There are eleven GLIMPSEI and OSV flux calibrators that overlap the Vela-Carina coverage. The Vela-Carina fluxes of these eleven flux calibrators were compared to the GLIMPSEI and OSV fluxes and to Martin Cohen's predictions. Figure 4 and Table 5 show the good agreement between the Vela-Carina fluxes, the GLIMPSEI and OSV fluxes and the predictions. We also compared the fluxes of sources in the overlap between the Vela-Carina, GLIMPSEI and OSV areas. The results are given in Figure 5 and show the good agreement between the two data sets.

Table 5. Comparison of Flux Calibrators to Predicted Magnitudes

Band (μm)	[3.6]	[4.5]	[5.8]	[8.0]
No. Flux calibrators	9	10	10	11
Ave. [Observed-Predicted] mag	-0.035	0.025	-0.002	-0.001
RMS error	0.067	0.075	0.073	0.073

The conclusion is that the average magnitude difference between our values and Cohen's predictions is typically less than 0.03 mags, with a typical scatter about that difference of about 0.07 mags. These values have been consistent from survey to survey (GLIMPSEI, GLIMPSEII, GLIMPSE3D and Vela-Carina).

3.3 Color-Color and Color-Magnitude Plots

Color-color and color-magnitude plots were made of each Catalog and Archive Table ($1^\circ \times 2^\circ$ blocks). An example set of color-color and color-magnitude plots is shown in Figures 6 and 7, respectively. The color-color plots generally show a peak near 0 color due to main sequence and giant stars, and a red tail corresponding to the large variety of stars with circumstellar dust and possibly galaxies. The color-magnitude plots can be used to show the limiting magnitudes where the flux errors become large and the colors begin to show large deviations. Postscript files of the color-color and color-magnitude plots for each of the areas in the Vela-Carina survey are available from the GLIMPSE web site (http://www.astro.wisc.edu/glimpse/velacar/ColorColor/ and http://www.astro.wisc.edu/glimpse/velacar/ColorMag/).

3.4 Other checks

Spot checks include inspection of residual images to verify proper point source extraction; over-plotting the positions of the sources in the Catalogs and Archives on mosaic images; and plotting Spectral Energy Distributions (SEDs) of several sources.

4 Description of Data Products

Here we provide information on the fields and flags recorded for each point source provided in the Catalog or Archive. More detailed information on the file formats for the Catalog and Archive, as well as mosaics, can be found in the following section.

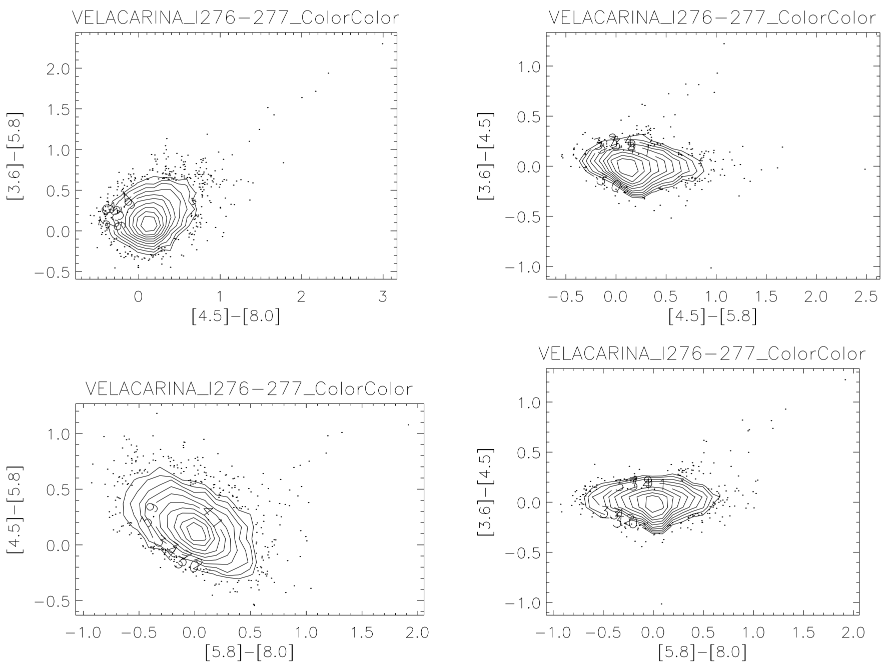

Figure 6: Color-color plots of the region $l = 276 - 277°$ and b=-1.5 to +0.5° for sources in the Catalog. 10 contours are evenly spaced between log(# sources/mag^2)=2.0 and the log of maximum number of sources per square magnitude. The contours are labeled with the log of the number of sources per square magnitude. Outside of the lowest contour, the positions of individual sources are plotted.

4.1 Catalog and Archive Fields and Flags

Each entry in the Vela-Carina Catalog and Archive has the following information:

designation	SSTVELC GLLL.llll±BB.bbbb, SSTVELA GLLL.llll±BB.bbbb
2MASS PSC names	2MASS designation, 2MASS counter
position	l, b, dl, db, ra, dec, dra, ddec
flux	mag$_i$, dmag$_i$, F$_i$, dF$_i$, F$_i$_rms (IRAC)
	mag$_t$, dmag$_t$, F$_t$, dF$_t$ (2MASS)
diagnostic	sky$_i$, SN$_i$, srcdens$_i$, # detections M$_i$ out of N$_i$ possible (IRAC)
	SN$_t$ (2MASS)
flags	Close Source Flag, Source Quality Flag (SQF$_i$), Flux Method Flag (MF$_i$) (IRAC)
	Source Quality Flag (SQF$_t$) (2MASS)

where i is the IRAC wavelength number (IRAC bands 3.6 μm, 4.5 μm, 5.8 μm and 8.0 μm) and t is the 2MASS wavelength band (J, H, K$_s$). Details of the fields are as follows:

Designation

This is the object designation or "name" as specified by the IAU recommendations on source nomenclature. It is derived from the coordinates of the source, where G denotes Galactic coordinates, LLL.llll is the Galactic longitude in degrees, and ±BB.bbbb is the Galactic latitude in degrees. The coordinates are preceded by the acronym SSTVELC (Vela-Carina Catalog) or

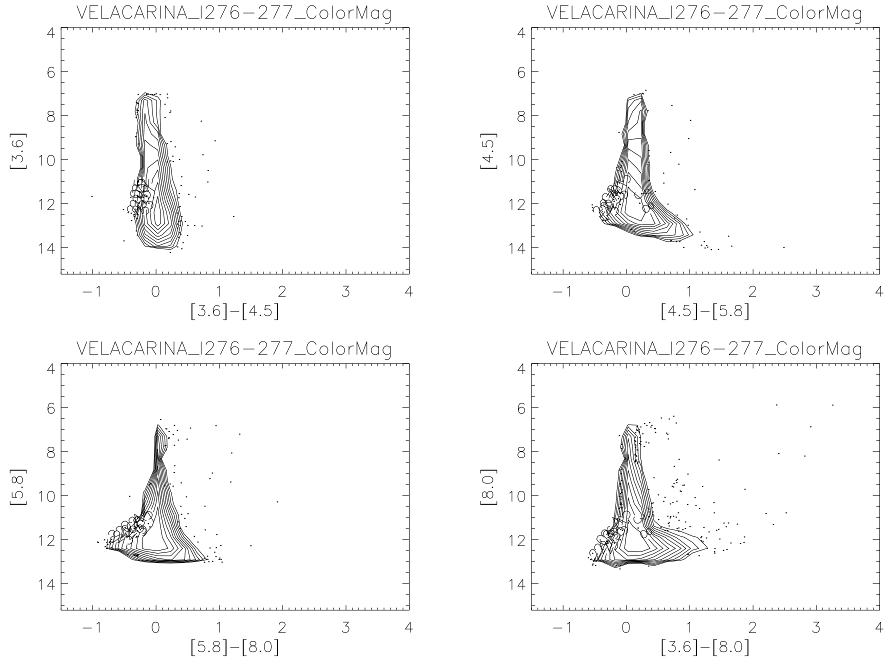

Figure 7: Color-magnitude plots of the region $l = 276 - 277°$ and b=-1.5 to +0.5° for sources in the Catalog. 10 contours are evenly spaced between log(# sources/mag^2)=2.0 and the log of the maximum number of sources per square magnitude. The contours are labeled with the log of the number of sources per square magnitude. Outside of the lowest contour, the positions of individual sources are plotted.

SSTVELA (Vela-Carina Archive).

2MASS PSC information

The 2MASS designation is the source designation for objects in the 2MASS All-Sky Release Point Source Catalog. It is a sexagesimal, equatorial position-based source name of the form hhmmssss±ddmmsss, where hhmmssss is the right ascension (J2000) coordinate of the source in hours, minutes and seconds, and ±ddmmsss is the declination (degrees, minutes, seconds). The 2MASS counter is a unique identification number for the 2MASS PSC source. See www.ipac.caltech.edu/2mass/releases/allsky/doc/sec2_2a.html for more information about these fields.

Position

The position is given in both Galactic (l, b) and equatorial (α, δ) J2000 coordinates, along with estimated uncertainties. The pointing accuracy is $1''$ (Werner et al. 2004). The SSC pipeline does pointing refinement[3] of the images based on comparison with the 2MASS Point Source Catalog, whose absolute accuracy is typically $< 0.2''$ (Cutri et al. 2005). After applying the SSC geometric distortion corrections and updating to the 2MASS positions, the Vela-Carina point source accuracy is typically $\sim 0.3''$ absolute accuracy, limited by undersampling of the point-spread function. The position uncertainties are calculated by the bandmerger based on the uncertainties of individual

[3]http://irsa.ipac.caltech.edu/data/SPITZER/docs/files/spitzer/pointingrefine.pdf

detections, propagated through the calculation of the weighted mean position. Sources with 2MASS associates have positions in part derived from the 2MASS position.

Flux

For each IRAC band i = 3.6, 4.5, 5.8, and 8.0 μm and, when available 2MASS band t = J, H, and K_s, the fluxes are expressed in magnitudes (mag_i, mag_t) and in mJy (F_i, F_t). Each IRAC flux is the error-weighted average of all independent detections of a source. The 2MASS magnitudes and uncertainties are from the 2MASS All-Sky Release Point Source Catalog. They are the j_m, j_msigcom, h_m, h_msigcom, and k_m, k_msigcom columns from the 2MASS PSC. The zeropoints for converting from flux to magnitude for the S13.2 and later SSC processing versions are from Reach et al (2005) for the IRAC bands and Cohen et al. 2003 for 2MASS and given in Table 1.

The IRAC flux/magnitude uncertainties (dF_i; $dmag_i$) are computed during the photometry stage and take into account photon noise, readnoise, goodness of flat fielding, and PSF fitting (Stetson 1987). Magnitude uncertainties are typically <0.2 mag for the Catalog and < 0.3 mag for the Archive. The uncertainties are smaller in the [3.6] and [4.5] bands than the [5.8] and [8.0] bands due to lower backgrounds in the [3.6] and [4.5] bands and the lower sensitivity of the [5.8] band detector. Table 4 shows the percentages of sources meeting the 0.2 mag accuracy criterion.

The rms deviation (F_i_rms) of the individual detections from the final flux of each source is provided. The F_rms is calculated as follows: F_rms=$\sqrt{\sum (F_j - < F >)^2/M}$ where j is an individual IRAC frame, $< F >$ is the average Flux, and M is the number of detections.

Diagnostics

The associated flux diagnostics are a local background level (sky_i) (i = 3.6, 4.5, 5.8, and 8.0 μm) in MJy/sr, a Signal/Noise (SN_i), a local source density ($srcdens_i$) (number of sources per square arcmin), and number of times (M_i) a source was detected out of a calculated possible number (N_i). The local background, an output of DAOPHOT (Stetson 1987), is provided because high backgrounds were shown to affect the reliability of IRAS sources, and for IRAC as well (especially the [5.8] and [8.0] bands) (see the GQA document). However, the effects may not be easily characterizable in the quoted error. The Signal/Noise is the flux (F_i) divided by the flux error (dF_i). The Signal/Noise for the 2MASS fluxes (SN_t) have been taken from the 2MASS PSC (the j_snr, h_snr and k_snr columns). The local source density is measured as follows: The individual IRAC frame is divided into a 3×3 grid, each of the nine cells being $1.71'$ x $1.71'$. A source density is calculated for each cell (number of sources per arcmin^2), and is assigned to each source in that cell. The local source density can be used to assess the confusion in a given region, along with the internal reliability. M_i and N_i can be used to estimate reliability. N_i is calculated based on the areal coverage of each observed frame; due to overlaps some areas are observed more than twice per band.

Flags

There are three types of flags: the Close Source Flag, the Source Quality Flag and the Flux Calculation Method Flag. The Close Source Flag is set if there are Archive sources that are within $3''$ of the source. The Source Quality Flag provides a measure of the quality of the point source extraction and bandmerging. The Flux Calculation Method Flag describes how the final Catalog/Archive flux was determined.

• The Close Source Flag is set when a source in the Archive is within $3.0''$ of the source. It was found (see Section VIII of the GQA) that the magnitudes of a source with nearby sources closer than about 2″ are not reliably extracted and bandmerged. A source that has Archive sources within 2.0″ of the source are *culled* from the Catalog. A source that has Archive sources within 0.5″ of the source are *culled* from the Archive. The flag is defined as follows:

0=no Archive source within 3.0″ of source
1=Archive sources between 2.5″ and 3.0″ of source
2=Archive sources between 2.0″ and 2.5″ of source
3=Archive sources between 1.5″ and 2.0″ of source
4=Archive sources between 1.0″ and 1.5″ of source
5=Archive sources between 0.5″ and 1.0″ of source
6=Archive sources within 0.5″ of source

• The Source Quality Flag (SQF) is generated from SSC-provided masks and the GLIMPSE pipeline, during point source extraction on individual IRAC frames and bandmerging. Each source quality flag is a binary number allowing combinations of flags (bits) in the same number. Flags are set if an artifact (e.g., a hot or dead pixel) occurs near the core of a source - i.e. within ∼3 pixels. A non-zero SQF will in most cases decrease the reliability of the source. Some of the bits, such as the DAOPHOT tweaks (see Appendix A), will not compromise the source's reliability, but has likely increased the uncertainty assigned to the source flux. If just one IRAC detection has the condition requiring a bit to be set in the SQF, then the bit is set even if the other detections did not have this condition. Sources with hot or dead pixels within 3 pixels of source center (bit 8), those in wings of saturated stars (bit 20), and those within 3 pixels of the frame edge (bit 30) were not counted during the source selection process (see §3.2 in the GLI Doc). Each of the seven bands has its own SQF. For the cross-band confusion flag and the cross-band merge lumping flag, when the condition is met for one of the bands, the bit is set for all the source's bands.

Table 6 shows the SQF sequence for the Vela-Carina v1.0 data release. We have determined that false sources from regions such as stray light do not make it into the Catalog due to our 2+1 source selection criterion (§3.2 of the GLI Doc). In addition, our photometry algorithm was modified substantially to find sources in high background regions that gives it the ability to find sources in stray light and banded regions as well, increasing the photometric uncertainties accordingly.

The value of the SQF is $\sum 2^{(bit-1)}$. For example, a source with bits 1 and 4 set will have SQF = $2^0 + 2^3 = 9$. If the SQF is 0, the source has no detected problems. More information about these flags and a bit value key can be found in Appendix A.

Table 6. Source Quality Flag (SQF) Bits

SQF bit	Description	Origin
1	poor pixels in dark current	SSC pmask
2	flat field questionable	SSC dmask
3	latent image[a]	SSC dmask
3	persistence (p)	2MASS
4	photometric confusion (c)	2MASS
7	muxbleed correction applied	GLIMPSE
8	hot, dead or otherwise unacceptable pixel	SSC pmask,dmask,GLIMPSE
9	muxbleed correction applied is $> 3\sigma$ above bkg	GLIMPSE
9	electronic stripe (s)	2MASS
10	DAOPHOT tweak positive	GLIMPSE
11	DAOPHOT tweak negative	GLIMPSE
13	confusion in in-band merge	GLIMPSE
14	confusion in cross-band merge (IRAC)	GLIMPSE
14	confusion in cross-band merge (2MASS)	GLIMPSE
15	column pulldown corrected	GLIMPSE
16	banding corrected	GLIMPSE
17	stray light	GLIMPSE
19	data predicted to saturate	GLIMPSE
20	saturated star wing region	GLIMPSE
20	diffraction spike (d)	2MASS
21	pre-lumping in in-band merge	GLIMPSE
22	post-lumping in cross-band merge (IRAC)	GLIMPSE
22	post-lumping in cross-band merge (2MASS)	GLIMPSE
23	photometric quality flag	2MASS
24	photometric quality flag	2MASS
25	photometric quality flag	2MASS
30	within three pixels of edge of frame	GLIMPSE

[a]Due to the short exposure time and high sky backgrounds in the Vela-Carina fields, we have not seen evidence for latent sources in the images, even though they are flagged via an automatic algorithm in SSC's processing.

• Flux calculation Method Flag (MF_i). The flux calculation method flag indicates by bit whether a given frametime was present, and whether that frametime was used in the final flux. This flag is more useful for High Dynamic Range (HDR) mode data which has two frame times, one of which is not necessarily used (i.e. the 12 second frametime data is not used for the very bright sources). For the 2 second frametime of the Vela-Carina survey, the method flag always equals 48 ($2^4 + 2^5$).

4.2 Vela-Carina Images

The IRAC images are mosaicked using the Montage[4] package into rectangular tiles that cover the surveyed region. The units are MJy/sr and the coordinates are Galactic. The mosaic images conserve surface brightness in the original images. We provide 1.2″ pixel mosaics as well as

[4]http://montage.ipac.caltech.edu

higher resolution 0.6″ pixel mosaics. The angular sizes of the higher resolution tiles are 1.1°×0.8°, 1.1°×1.1°, 1.1°×1.2°, and 1.1°×1.3°. Three tiles span the latitude range of the areas. The pixel size is 0.6″ , smaller than the native IRAC pixel size of 1.2″ . World Coordinate System (WCS) keywords are standard (CTYPE, CRPIX, CRVAL, CD matrix keywords) with a Galactic projection (GLON-CAR, GLAT-CAR; Calabretta and Greisen 2002). See (§5.2) for an example of a FITS header. The mosaicked images are 32-bit IEEE floating point single-extension FITS formatted images. We also provide larger (e.g. 3.1°×2.4°, 3.1°×3.4°, and 3.6°×3.8°) FITS files with a pixel size of 1.2″ , with and without background matching, for an overview look that covers the full latitude range of the Vela-Carina areas. For a quick-look of the mosaics, we provide 3-color jpeg files (the [3.6], [4.5], and [8.0] bands) for each area covered by the FITS files. These are rebinned to much lower resolution to make the files small.

The background matching and gradient removal may be removing real sky variations so we provide these images *in addition* to the 1.2″ pixel images that do not have the background matching. The background matched and gradient corrected mosaics are processed using the following procedure:

For the 1.2″ pixel mosaic images, we match instrumental background variations between the 5x5 arcmin IRAC BCD frames using Montage. Instrument artifacts (see the IRAC Data Handbook) such as full array pull-up, first frame effect and frame pull-down are mostly removed from the images. We use the "level" option in the Montage mBgModel module (http://montage.ipac.caltech.edu/docs/mBgModel.html) to produce the background matched mosaics. See http://montage.ipac.caltech.edu/docs/algorithms.html#background for a discussion of the background modeling.

In the background matching process, Montage introduces unwanted large-scale gradients. Our gradient correction algorithm finds the large-scale gradients by taking the corrections table produced by Montage and creating a smoothed version to eliminate small-scale corrections. This is done by using a Radial Basis Function interpolation with a smoothing factor of 1000. We then find the difference between the corrections and the smoothed corrections, find the standard deviation of this difference, then reject all points which deviate by more than 5 sigma. A new smoothed correction map is computed and the process is repeated until no points are rejected (typically 10 iterations). Once this is complete, a final correction map is computed and removed from the image, thus undoing the large-scale gradients introduced by Montage.

5 Product Formats

5.1 Catalog and Archive

• There is a Catalog and Archive for each of the Vela-Carina areas (1°x 2°). The Catalog and Archive files are in IPAC Table Format (http://irsa.ipac.caltech.edu/applications/DDGEN/Doc/ipac_tbl.html). Filenames are VelaCarC_l*lb*.tbl and VelaCarA_l*lb*.tbl (where *lb* is the beginning Galactic longitude of the area) for the Catalog and Archive respectively (e.g. VelaCarC_l288.tbl, VelaCarC_l288.tbl, VelaCarC_l289.tbl, VelaCarC_l289.tbl, etc.) The entries are sorted by increasing Galactic longitude within each file. An example of a VelaCarC entry is

SSTVELC G284.0002-01.3814 10175868-5829418 791309512 284.000288 -1.381481 0.3 0.3
154.494471 -58.494944 0.3 0.3 0 14.023 0.032 12.880 0.032 12.446 0.030
12.077 0.053 12.043 0.069 12.009 0.139 12.044 0.104

3.920E+00 1.155E-01 7.216E+00 2.127E-01 7.007E+00 1.936E-01
4.149E+00 2.044E-01 2.738E+00 1.745E-01 1.808E+00 2.319E-01 9.756E-01 9.372E-02
2.397E-01 1.937E-01 3.153E-01 1.953E-01 6.210E-01 3.360E-01 3.388E+00 9.545E+00
33.93 33.93 36.19 20.30 15.69 7.80 10.41 33.0 18.9 7.2 7.9
2 2 2 2 2 2 2 2 29360128 29360128 29360128 512 16896 1024 1024 48 48 48 48

Table 7 gives all of the available fields per source. Table 8 shows how to decode the above entry into these fields.

Table 7. Fields in the Catalog and Archive

Column	Name	Description	Units	Data Type	Format	Nulls OK? or Value
1	designation	Catalog (SSTVELC GLLL.llll±BB.bbbb) Archive (SSTVELA GLLL.llll±BB.bbbb)	-	ASCII	A26	No
2	tmass_desig	2MASS PSC designation	-	ASCII	A17	null
3	tmass_cntr	2MASS counter (unique identification number)	-	I*4	I10	0
4	l	Galactic longitude	deg	R*8	F11.6	No
5	b	Galactic latitude	deg	R*8	F11.6	No
6	dl	Uncertainty in Gal. longitude	arcsec	R*8	F7.1	No
7	db	Uncertainty in Gal. latitude	arcsec	R*8	F7.1	No
8	ra	Right ascension (J2000)	deg	R*8	F11.6	No
9	dec	Declination (J2000)	deg	R*8	F11.6	No
10	dra	Uncertainty in right ascension	arcsec	R*8	F7.1	No
11	ddec	Uncertainty in declination	arcsec	R*8	F7.1	No
12	csf	Close source flag	-	I*2	I4	No
13–18	mag_t,$dmag_t$	Magnitudes & 1σ error in t=J,H,K_s bands	mag	R*4	6F7.3	99.999,99.999
19–26	mag_i,$dmag_i$	Magnitudes & 1σ error in IRAC band i	mag	R*4	8F7.3	99.999,99.999
27–32	F_t,dF_t	Fluxes & 1σ error in t=J,H,K_s bands	mJy	R*4	6E11.3	-999.9,-999.9
33–40	F_i,dF_i	Fluxes & 1σ error in IRAC band i	mJy	R*4	8E11.3	-999.9,-999.9
41–44	F_i_rms	RMS dev. of individual detections from F_i	mJy	R*4	4E11.3	-999.9
45–48	sky_i	Local sky bkg. for IRAC band i flux	MJy/sr	R*4	4E11.3	-999.9
49–51	SN_t	Signal/Noise for bands t=J,H,K_s	-	R*4	3F7.2	-9.99
52–55	SN_i	Signal/Noise for IRAC band i flux	-	R*4	4F7.2	-9.99
56–59	$srcdens_i$	Local source density for IRAC band i object	no./sq ′	R*4	4F9.1	-9.9
60–63	M_i	Number of detections for IRAC band i	-	I*2	4I6	No
64–67	N_i	Number of possible detections for IRAC band i	-	I*2	4I6	No
68–70	SQF_t	Source Quality Flag for t=J,H,K_s flux	-	I*4	3I11	-9
71–74	SQF_i	Source Quality Flag for IRAC band i flux	-	I*4	4I11	-9
75–78	MF_i	Flux calc method flag for IRAC band i flux	-	I*2	4I6	-9

Table 8. Example of Catalog/Archive Entry on Previous Page

designation	SSTVELC G284.0002-01.3814	Name
tmass_desig	10175868-5829418	2MASS designation
tmass_cntr	791309512	2MASS counter
l,b	284.000288 -1.381481	Galactic Coordinates (deg)
dl,db	0.3 0.3	Uncertainty in Gal. Coordinates (arcsec)
ra,dec	154.494471 -58.494944	RA and Dec (J2000.0) (deg)
dra,ddec	0.3 0.3	Uncertainty in RA and Dec (arcsec)
csf	0	Close source flag
mag,dmag	14.023 12.880 12.446	Magnitudes (2MASS J,H,K_s) (mag)
	0.032 0.032 0.030	Uncertainties (2MASS) (mag)
mag,dmag	12.077 12.043 12.009 12.044	Magnitudes (IRAC bands 1-4) (mag)
	0.053 0.069 0.139 0.104	Uncertainties (IRAC) (mag)
F,dF	3.920E+00 7.216E+00 7.007E+00	2MASS Fluxes (mJy)
	1.155E-01 2.127E-01 1.936E-01	Uncertainties in 2MASS fluxes (mJy)
F,dF	4.149E+00 2.738E+00 1.808E+00 9.756E-01	IRAC Fluxes (mJy)
	2.044E-01 1.745E-01 2.319E-01 9.372E-02	Uncertainties in IRAC fluxes (mJy)
F_rms	2.397E-01 1.937E-01 3.153E-01 1.953E-01	RMS_flux (mJy) (IRAC)
sky	6.210E-01 3.360E-01 3.388E+00 9.545E+00	Sky Bkg (MJy/sr) (IRAC)
SN	33.93 33.93 36.19	Signal to Noise (2MASS)
SN	20.30 15.69 7.80 10.41	Signal to Noise (IRAC)
srcdens	33.0 18.9 7.2 7.9	Local Source Density (IRAC) (#/sq arcmin)
M	2 2 2 2	Number of detections (IRAC)
N	2 2 2 2	Number of possible detections (IRAC)
SQF	29360128 29360128 29360128	Source Quality Flag (2MASS)
SQF	512 16896 1024 1024	Source Quality Flag (IRAC)
MF	48 48 48 48	Flux Calculation Method Flag (IRAC)

5.2 Vela-Carina Images

The mosaicked images for each IRAC band are standard 32-bit IEEE floating point single-extension FITS files in Galactic coordinates. Pixels that have no flux estimate have the value NaN. The FITS headers contain relevant information from both the SSC pipeline processing and the GLIMPSE processing such as IRAC frames included in the mosaicked image and coordinate information.

The angular sizes of the higher resolution (0.6″ pixels) tiles are 1.1°×0.8°, 1.1°×1.1°, 1.1°×1.2°, and 1.1°×1.3°. Three tiles span the latitude range of the areas. For example, the details about the 1.1°x 0.8° mosaics are: 1.1°x 0.8°mosaics (6640 x 4840 0.6″ pixels) are about 129 Megabytes in size. There are three mosaics per 1.1 degree Galactic longitude interval with 0.05° overlap between mosaics. For example, for the l=266° region, Galactic longitudes of 265.95°to 267.05°, the centers of the three mosaics are (266.5°, +0.25°), (266.5°, -0.50°), and (266.5°, -1.25°) The latitude ranges are -0.15° to +0.65°, -0.90° to -0.10°, and -1.65° to -0.85° respectively. Filenames are VELACAR_*lcbc*_mosaic_I*ch*.fits, where *lc* and *bc* are the Galactic longitude and latitude of the center of the mosaic image, I denotes IRAC, and *ch* is the IRAC channel number. For example, VELACAR_26650+0025_mosaic_I1.fits is a 1.1°x 0.8° IRAC channel 1 mosaic centered on l=266.50°, b=+0.25°. A similar scheme is used for the 1.1°×1.1°, 1.1°×1.2°and 1.1°×1.3° mosaics. We provide low-resolution 3-color jpeg images for each area, combining the [3.6], [4.5] and [8.0] bands to be used for quick-look purposes. The filename for this jpeg file is similar to the mosaic FITS file: e.g. VELACAR_26650+0025.jpg. We also provide native resolution images (e.g. 3.1°x 2.4° mosaic FITS files (9320 x 7220 1.2″ pixels) for each band, along with low resolution 3-color jpegs. Each of the 3.1°x 2.4° mosaics is about 269 Megabytes in size. Other mosaics are 3.1°×3.4°, and 3.6°×3.8°. The filenames are similar to the other FITS and jpeg images: e.g. VELACAR_26700-0050_mosaic_I1.fits, VELACAR_26700-0050_3.1x2.4.jpg.

We also provide the background matched and gradient corrected 1.2″ pixel mosaics and 3-color jpegs. The background matched and gradient corrected image filenames have "corr_" pre-pended to the filename (e.g. corr_VELACAR_26700-0050_mosaic_I1.fits). This comment line is added to the FITS header for these images:

```
COMMENT Background Matched, Gradient Corrected
```

Here is an example of the FITS header for the 1.2" pixel VELACAR_27300-0050_mosaic_I1.fits:

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                 9320 / length of data axis 1
NAXIS2  =                 7220 / length of data axis 2
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
TELESCOP= 'SPITZER '           / Telescope
INSTRUME= 'IRAC    '           / Instrument ID
ORIGIN  = 'UW Astronomy Dept'  / Installation where FITS file written
CREATOR = 'GLIMPSE Pipeline'   / SW that created this FITS file
CREATOR1= 'S17.0.4 '           / SSC pipeline that created the BCD
PIPEVERS= '1v04    '           / GLIMPSE pipeline version
MOSAICER= 'Montage V3.0'       / SW that originally created the Mosaic Image
FILENAME= 'VELACAR_27300-0050_mosaic_I1.fits' / Name of associated fits file
PROJECT = 'VELACARINA'         / Project ID
FILETYPE= 'mosaic  '           / Calibrated image(mosaic)/residual image(resid)
CHNLNUM =                    1 / 1 digit Instrument Channel Number
DATE    = '2009-02-03T03:23:46' / file creation date (YYYY-MM-DDThh:mm:ss UTC)
COMMENT --------------------
COMMENT Proposal Information
COMMENT --------------------
OBSRVR  = 'Steven Majewski'    / Observer Name
OBSRVRID=                12843 / Observer ID of Principal Investigator
PROCYCLE=                    7 / Proposal Cycle
PROGID  =                40791 / Program ID
PROTITLE= 'Galactic Structure and Star Fo' / Program Title
PROGCAT =                   30 / Program Category
COMMENT ----------------------------
COMMENT Time and Exposure Information
COMMENT ----------------------------
SAMPTIME=                  0.2 / [sec] Sample integration time
FRAMTIME=                  2.0 / [sec] Time spent integrating each BCD frame
EXPTIME =                  1.2 / [sec] Effective integration time each BCD frame
COMMENT DN per pixel=flux(photons/sec/pixel)/gain*EXPTIME
NEXPOSUR=                    2 / Typical number of exposures
COMMENT Total integration time for the mosaic = EXPTIME * NEXPOSUR
COMMENT Total DN per pixel=flux(photons/sec/pixel)/gain*EXPTIME*NEXPOSUR
```

```
AFOWLNUM=                    4 / Fowler number
COMMENT --------------------
COMMENT Pointing Information
COMMENT --------------------
CRPIX1  =            4660.5000 / Reference pixel for x-position
CRPIX2  =            3610.5000 / Reference pixel for y-position
CTYPE1  = 'GLON-CAR'           / Projection Type
CTYPE2  = 'GLAT-CAR'           / Projection Type
CRVAL1  =         273.00000000 / [Deg] Galactic Longtitude at reference pixel
CRVAL2  =          -0.50000000 / [Deg] Galactic Latitude at reference pixel
EQUINOX =               2000.0 / Equinox for celestial coordinate system
DELTA-X =           3.10666656 / [Deg] size of image in axis 1
DELTA-Y =           2.40666676 / [Deg] size of image in axis 2
BORDER  =           0.00333333 / [Deg] mosaic grid border
CD1_1   =      -3.33333330E-04
CD1_2   =       0.00000000E+00
CD2_1   =       0.00000000E+00
CD2_2   =       3.33333330E-04
PIXSCAL1=                1.200 / [arcsec/pixel] pixel scale for axis 1
PIXSCAL2=                1.200 / [arcsec/pixel] pixel scale for axis 2
OLDPIXSC=                1.221 / [arcsec/pixel] pixel scale of single IRAC frame
RA      =         140.68499756 / [Deg] Right ascension at mosaic center
DEC     =         -50.82591629 / [Deg] Declination at mosaic center
COMMENT ----------------------
COMMENT Photometry Information
COMMENT ----------------------
BUNIT   = 'MJy/sr  '           / Units of image data
GAIN    =                  3.3 / e/DN conversion
JY2DN   =           314754.031 / Average Jy to DN Conversion
ETIMEAVE=               1.2000 / [sec] Average exposure time for the BCD frames
PA_AVE  =                -7.85 / [deg] Average position angle
ZODY_EST=              0.03837 / [Mjy/sr] Average ZODY_EST
ZODY_AVE=             -0.00468 / [Mjy/sr] Average ZODY_EST-SKYDRKZB
COMMENT Flux conversion (FLUXCONV) for this mosaic =
COMMENT Average of FLXC from each frame*(old pixel scale/new pixel scale)**2
FLUXCONV=          0.112641312 / Average MJy/sr to DN/s Conversion
COMMENT -----------------------------
COMMENT AORKEYS/ADS Ident Information
COMMENT -----------------------------
AOR001  = '0023691520'         / AORKEYS used in this mosaic
AOR002  = '0023682048'         / AORKEYS used in this mosaic
AOR003  = '0023700736'         / AORKEYS used in this mosaic
AOR004  = '0023707392'         / AORKEYS used in this mosaic
AOR005  = '0023700224'         / AORKEYS used in this mosaic
AOR006  = '0023694336'         / AORKEYS used in this mosaic
AOR007  = '0023698944'         / AORKEYS used in this mosaic
AOR008  = '0023703808'         / AORKEYS used in this mosaic
AOR009  = '0023679488'         / AORKEYS used in this mosaic
```

```
AOR010  = '0023696384'         / AORKEYS used in this mosaic
AOR011  = '0023706880'         / AORKEYS used in this mosaic
AOR012  = '0023695872'         / AORKEYS used in this mosaic
DSID001 = 'ads/sa.spitzer#0023691520' / Data Set Identification for ADS/journals
DSID002 = 'ads/sa.spitzer#0023682048' / Data Set Identification for ADS/journals
DSID003 = 'ads/sa.spitzer#0023700736' / Data Set Identification for ADS/journals
DSID004 = 'ads/sa.spitzer#0023707392' / Data Set Identification for ADS/journals
DSID005 = 'ads/sa.spitzer#0023700224' / Data Set Identification for ADS/journals
DSID006 = 'ads/sa.spitzer#0023694336' / Data Set Identification for ADS/journals
DSID007 = 'ads/sa.spitzer#0023698944' / Data Set Identification for ADS/journals
DSID008 = 'ads/sa.spitzer#0023703808' / Data Set Identification for ADS/journals
DSID009 = 'ads/sa.spitzer#0023679488' / Data Set Identification for ADS/journals
DSID010 = 'ads/sa.spitzer#0023696384' / Data Set Identification for ADS/journals
DSID011 = 'ads/sa.spitzer#0023706880' / Data Set Identification for ADS/journals
DSID012 = 'ads/sa.spitzer#0023695872' / Data Set Identification for ADS/journals
NIMAGES =                 2067 / Number of IRAC Frames in Mosaic
```

In addition to the FITS header information given above, the associated ASCII .hdr file includes information about each IRAC frame used in the mosaic image. For example, VELACAR_27300-0050_mosaic_I1.hdr includes:

```
COMMENT ----------------------------------------
COMMENT Info on Individual Frames in Mosaic
COMMENT ----------------------------------------
IRFR0001= 'SPITZER_I1_0023691520_0179_0000_01_levbflx.fits' / IRAC frame
DOBS0001= '2008-03-04T03:15:58.136' / Date & time at frame start
MOBS0001=      54529.136718750 / MJD (days) at frame start
RACE0001=           141.454163 / [Deg] Right ascension at reference pixel
DECC0001=           -50.281792 / [Deg] Declination at reference pixel
PANG0001=                -8.20 / [deg] Position angle for this image
FLXC0001=              0.10880 / Flux conversion for this image
ZODE0001=              0.03851 / [MJy/sr] ZODY_EST for this image
ZODY0001=             -0.00453 / [MJy/sr] ZODY_EST-SKYDRKZB for this image
IRFR0002= 'SPITZER_I1_0023691520_0162_0000_01_levbflx.fits' / IRAC frame
DOBS0002= '2008-03-04T03:11:51.746' / Date & time at frame start
MOBS0002=      54529.132812500 / MJD (days) at frame start
RACE0002=           140.381607 / [Deg] Right ascension at reference pixel
DECC0002=           -50.377636 / [Deg] Declination at reference pixel
PANG0002=                -7.38 / [deg] Position angle for this image
FLXC0002=              0.10880 / Flux conversion for this image
ZODE0002=              0.03834 / [MJy/sr] ZODY_EST for this image
ZODY0002=             -0.00471 / [MJy/sr] ZODY_EST-SKYDRKZB for this image
.
.       Information on the IRAC frame: filename, date of observation, central
.       position, position angle, flux convert and zodiacal light for
.       frames 3 through 2066
```

.

```
IRFR2067= 'SPITZER_I1_0023695872_0093_0000_02_levbflx.fits' / IRAC frame
DOBS2067= '2008-03-03T20:52:54.635' / Date & time at frame start
MOBS2067=      54528.871093750 / MJD (days) at frame start
RACE2067=           141.644745 / [Deg] Right ascension at reference pixel
DECC2067=           -52.084702 / [Deg] Declination at reference pixel
PANG2067=                -9.07 / [deg] Position angle for this image
FLXC2067=              0.10880 / Flux conversion for this image
ZODE2067=              0.03840 / [MJy/sr] ZODY_EST for this image
ZODY2067=             -0.00464 / [MJy/sr] ZODY_EST-SKYDRKZB for this image
END
```

6 APPENDIX A - Source Quality Flag Bit Descriptions

A.1 IRAC Source Quality Flag

Information is gathered from the SSC IRAC bad pixel mask (pmask), SSC bad data mask (dmask) and the GLIMPSE IRAC pipeline for the Source Quality Flag. Table 6 lists the bits and the origin of the flag (SSC or GLIMPSE pipeline). See http://ssc.spitzer.caltech.edu/irac/products/pmask.html and http://ssc.spitzer.caltech.edu/irac/products/bcd_dmask.html for more information about the IRAC pmask and dmask. See §3 in the GLI Doc for a description of the instrument artifacts referred to below.

bit
1 poor pixels in dark current
This bit is set when a source is within 3 pixels of a pixel identified in the SSC IRAC pmask as having poor dark current response (bits 7 and 10 in the pmask).

2 flat field questionable
If a pixel is flagged in the SSC IRAC dmask as flat field applied using questionable value (bit 7) or flat field could not be applied (bit 8), a source within 3 pixels of these pixels will have this bit set.

3 latent image
This flag comes from the latent image flag (bit 5) from the dmask. The SSC pipeline predicts the positions of possible latent images due to previously observed bright sources. Due to the short exposure times (two seconds) and high sky backgrounds in the Vela-Carina survey we have not seen latent images in the data, even though they are flagged.

7 muxbleed correction applied (the [3.6] and [4.5] bands)
This bit is set if the source was within 3 pixels of a pixel that had a muxbleed correction applied.

8 hot, dead or otherwise unacceptable pixel
Hot, dead or unacceptable pixels are identified in the IRAC pmask as having an unacceptable response to light (bits 8, 9 and 14 in the IRAC pmask). After inspecting IRAC frames, we have added bit 12 to the pmask to flag additional pixels we found to be bad. Also considered bad pixels are ones flagged as bad or missing in bit 11 and 14 in the IRAC dmask. SQF bit 8 is set if a source

is within 3 pixels of any of these bad pixels. Bands with this bit set are not counted during the source selection process (see §3.2 in the GLI Doc).

9 muxbleed correction > 3σ above the background (the [3.6] and [4.5] bands)
This bit is set if the source was within 3 pixels of a pixel where there was a muxbleed correction applied which is $> 3\sigma$ above the background.

10 DAOPHOT tweak positive
11 DAOPHOT tweak negative
Bits 10 and 11 correspond to an iterative photometric step (tweaking). Photometry is initially performed by DAOPHOT/ALLSTAR using PSF fitting. This photometric step produces a list of sources, their positions and brightnesses, as well as a residual image of those sources removed from the input image. By flattening the residual image (smoothing it and then subtracting the smoothed image from the residual image) and then performing small aperture photometry at the location of each of the extracted sources, it is possible to determine if the extracted source was over or under subtracted due to any local complex variable background or the undersampled PSF. SQF bit 10 refers to sources that were initially under-subtracted. From the aperture photometry a positive flux correction was applied to the DAOPHOT/ALLSTAR extraction value (source was brightened via aperture photometry as compared to the initial PSF fitted DAOPHOT/ALLSTAR photometry). SQF bit 11 refers to sources that were initially over-subtracted. Using aperture photometry, a negative flux correction was applied to the DAOPHOT/ALLSTAR extraction value (source was dimmed via aperture photometry as compared to the initial PSF fitted DAOPHOT/ALLSTAR photometry). Sources with both SQF bits 10 and 11 set imply 1) the source was initially under-subtracted, but the aperture photometry over- corrected and thus a second aperture correction was applied or 2) multiple observations in a band consisting of at least one observation with a positive tweak and another observation with a negative tweak.

13 confusion in in-band merge
14 confusion in cross-band merge
These bits are set during the bandmerging process. The bandmerger reports, for each source and band, the number of merge candidates it considered in each of the other bands. If the number of candidates is greater than 2, then the bandmerger had to resolve the choice based on examination of the different band-pair combinations and position (and flux in-band) χ^2 differences between candidates. If the number of candidates is greater than 1, the confusion flag is set.

15 column pulldown corrected (the [3.6] and [4.5] bands)
This bit is set if the source is within 3 pixels of a column pulldown corrected pixel.

16 banding corrected (the [5.8] and [8.0] bands)
This bit is set if the source is within 3 pixels of a banding corrected pixel.

17 stray light area
This bit is set if the source is within 3 pixels of an area of stray light as identified in the GLIMPSE smask file.

19 data predicted to saturate
This bit is set when a source is within 3 pixels of a pixel identified in the SSC IRAC dmask as being saturated (bit 10 in the dmask). GLIMPSE runs a saturated pixel predicter and sets bit 10 in the dmask. This program finds clusters of high-valued pixels. The cluster size and high pixel value are tuned so that sources above the IRAC saturation limits are flagged as saturated. Before photometry is done on an IRAC frame, these pixels are masked.

20 saturated star wing region
False sources can be extracted in the wings of saturated sources. This bit is set if the source is within a PSF-shaped region (with a 24-pixel radius) surrounding a saturated source determined from bit 10 in the dmask. See Figure 8 for an example of the shapes of the saturated star wing areas flagged by this bit. Bands with this bit set are not counted during the source selection process (see §3.2 in the GLI Doc).

21 pre-lumping in in-band merge
Sources in the same IRAC frame within a radius of 2.0″ are merged into one source (weighted mean position and flux) before bandmerging. This is potentially a case in which the source is incompletely extracted in the first IRAC frame and a second source extracted on the second IRAC frame. Or it could be a marginally resolvable double source. This bit is set for the band if sources have been lumped for that band.

22 post-lumping in cross-band merge
This bit is set if the source is a result of sources that were lumped in the cross-band merge step. Cross-band lumping is done with a 2.0″ radius. For example, say there are two sources within 2.0″ of each other. One source has data in the [3.6] and [8.0] bands and the other has data in the [4.5] and [5.8] bands. These two sources will be lumped into one source with data in all 4 bands.

30 within three pixels of edge of frame
Sources within three pixels of the edge of the IRAC frame are flagged since it is likely to be too close to the edge of the frame for accurate photometry to be done. Bands with this bit set are not counted during the source selection process (see §3.2 in the GLI Doc).

A.2 2MASS Source Quality Flag

For the 2MASS bands, the following contamination and confusion (cc) flags from the 2MASS All-Sky Point Source Catalog are mapped into bits 3, 4, 9 and 20 of the Source Quality Flag. For more information about the cc flags, see
www.ipac.caltech.edu/2mass/releases/allsky/doc/sec2_2a.html#cc_flag. Three Source Quality Flag bits (23, 24, 25) provide the 2MASS photometric quality flag information, whose possible values are (from worst to best) X, U, F, E, D, C, B, and A (see
http://www.ipac.caltech.edu/2mass/releases/allsky/doc/sec1_6b.html#phqual. Users should consult the 2MASS PSC documentation for the complete information about the source, including all of their source quality flags.

bit
3 "p" persistence
Source may be contaminated by a latent image left by a nearby bright star.

4 "c" photometric confusion
Source photometry is biased by a nearby star that has contaminated the background estimation.

9 "s" electronic stripe
Source measurement may be contaminated by a stripe from a nearby bright star.

14 confusion in cross-band merge
This bit is set during the bandmerging process. The bandmerger reports, for each source and band, the number of merge candidates it considered in each of the other bands. If the number of candidates is greater than 2, then the bandmerger had to resolve the choice based on examination of

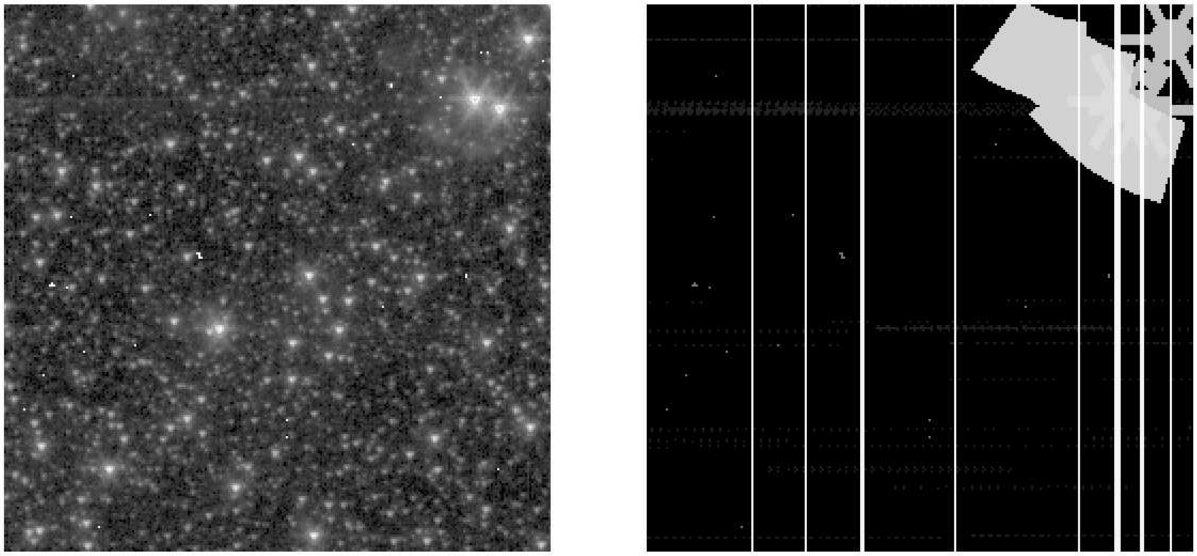

Figure 8: The [3.6] band (GLIMPSEI) IRAC frame (AOR 12110848, exposure 11) is on the left (corrections were applied for muxbleed and column pulldown); the flags for that frame are shown on the right. Stray light masks (SQF bit 17) are seen in the upper right hand corner of the frame. The PSF-shaped areas around the bright sources correspond to SQF bit 20. The vertical lines correspond to where the frame was corrected for column pulldown (SQF bit 15). The horizontal dots show which pixels were corrected for muxbleed (SQF bits 7 and/or 9). Various small dots are hot, dead or bad pixels (SQF bit 8). Bits in the SQF will have been set for sources within 3 pixels of any of these areas.

the different band-pair combinations and position χ^2 differences between candidates. If the number of candidates is greater than 1, the confusion flag is set.

20 "d" diffraction spike confusion
Source may be contaminated by a diffraction spike from a nearby star.

22 post-lumping in cross-band merge
This bit is set for all bands (IRAC and 2MASS) if the source is a result of sources that were lumped in the cross-band merge step. Cross-band lumping is done with a 2.0″ radius.

23 Photometric quality flag
24 Photometric quality flag
25 Photometric quality flag

```
  2MASS           SQF bits
"ph" Flag  =>    23, 24, 25      value
-------------  --------------- ----------
   X              0   0   0            0
   U              1   0   0      4194304
   F              0   1   0      8388608
   E              1   1   0     12582912
```

D	0	0	1	16777216
C	1	0	1	20971520
B	0	1	1	25165824
A	1	1	1	29360128

where

X - There is a detection at this location, but no valid brightness estimate can be extracted using any algorithm.

U - Upper limit on magnitude. Source is not detected in this band or it is detected, but not resolved in a consistent fashion with other bands.

F - This category includes sources where a reliable estimate of the photometric error could not be determined.

E - This category includes detections where the goodness-of-fit quality of the profile-fit photometry was very poor, or detections where psf fit photometry did not converge and an aperture magnitude is reported, or detections where the number of frames was too small in relation to the number of frames in which a detection was geometrically possible.

D - Detections in any brightness regime where valid measurements were made with no [jhk]_snr or [jhk]_cmsig requirement.

C - Detections in any brightness regime where valid measurements were made with [jhk]_snr>5 AND [jhk]_cmsig<0.21714.

B - Detections in any brightness regime where valid measurements were made with [jhk]_snr>7 AND [jhk]_cmsig<0.15510.

A - Detections in any brightness regime where valid measurements were made with [jhk]_snr>10 AND [jhk]_cmsig<0.10857.

A.3 Key to Bit Values

This section describes how to determine the bit values of a Source Quality Flag.

bt = bit in sqf
value = $2^{(bit-1)}$ i.e. bit 3 corresponds to 2^2=4

bit values: bt 1 => 1; 2 => 2; 3 => 4; 4 => 8; 5 => 16; 6 => 32; 7 => 64; 8 => 128 bt 9 => 256; 10 => 512; 11 => 1024; 12 => 2048; 13 => 4096; 14 => 8192; 15 => 16384; bt 16 => 32768; 17 => 65536; 18 => 131072; 19 => 262144; 20 => 524288; bt 21 => 1048576; 22 => 2097152; 23 => 4194304; 24 => 8388608; 25 => 16777216; 30 => 536870912

For example, the Source Quality Flags in the example in Table 8 are 29360128 for the 2MASS J, H and K_s bands. This translates to bits 23, 24 and 25 being set for J, H & K_s, which is the photometric quality A flag from the 2MASS PSC. The IRAC [3.6] band has a SQF of 512, the [4.5] band SQF is 16896, and the [5.8] and [8.0] bands have a SQF of 1024. For the [3.6] band a SQF of 512 means bit 10 has been set meaning the flux was tweaked positive in the DAOPHOT step (see Appendix A.1). For the [4.5] band a SQF of 16896 means bits 15 and 10 have been set meaning the source is within three pixels of a column pulldown corrected area and the flux was tweaked positive in the DAOPHOT step. For the [5.8] and [8.0] bands a SQF of 1024 means bit 11 has been set meaning the flux was tweaked negative in the DAOPHOT step.

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GLOSSARY

2MASS	Two Micron All Sky Survey
CYG-X	Spitzer Legacy Survey of the Cygnus-X Complex
dmask	A data quality mask supplied by the SSC for the BCD
GLIMPSE	Galactic Legacy Infrared Midplane Survey Extraordinaire
VelaCarC	Vela-Carina Point Source Catalog
VelaCarA	Vela-Carina Point Source Archive
GQA	GLIMPSE Quality Assurance
IPAC	Infrared Processing and Analysis Center
IRAC	*Spitzer* Infrared Array Camera
IRSA	InfraRed Science Archive
MF	Method Flag used to indicate exposure times included in the flux
OSV	Observation Strategy Validation
pmask	A bad pixel mask supplied by the SSC for the BCD
PSF	Point Spread Function
rmask	Outlier (radiation hit) mask
SOM	*Spitzer* Observer's Manual
SSC	*Spitzer* Science Center
SED	Spectral energy distribution
SMOG	Spitzer Mapping of the Outer Galaxy
SQF	Source Quality Flag
SST	*Spitzer* Space Telescope
smask	Stray light mask