GLIMPSE3D - v1.0 Data Release

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Contents

1 Quick Start

GLIMPSE, GLIMPSEII and GLIMPSE3D data products are available at the Spitzer Science Center (SSC) and the Infrared Science Archive (IRSA)

- SSC – http://ssc.spitzer.caltech.edu/legacy/glimpsehistory.html
- IRSA – http://irsa.ipac.caltech.edu/data/SPITZER/GLIMPSE/

Two useful websites for the analysis of these data provided by the GLIMPSE team are the Web Infrared Tool Shed (WITS) and the Young Stellar Objects (YSO) Grid and Fitter

- WITS – http://dustem.astro.umd.edu/
- YSO Model Fitter – http://caravan.astro.wisc.edu/protostars/

For those who are familiar with GLIMPSE data, GLIMPSE3D data products are very similar. There are three types of sources lists: a high reliability point source Catalog, a more complete point source Archive, and a "More Reliable" Archive for single visit data. The other main product is the set of mosaicked images. GLIMPSE3D fields provide a vertical extension of GLIMPSE or GLIMPSEII style coverage to higher Galactic latitudes in selected longitude ranges (shown in Figure 1). The GLIMPSE3D data releases through October 2011 contain all-epoch source lists for the entire survey area, single epoch source lists for the areas observed in two epochs, and mosaic images (with and without background matching) for the entire survey region. All GLIMPSE3D enhanced data products have been delivered to the Spitzer Science Center.

2 GLIMPSE3D Survey and Data Products

2.1 Project Overview

GLIMPSE3D is the third 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). GLIMPSEI[1] covered the Galactic plane from $|l| = 10°$ to $65°$ and $|b| < 1°$; GLIMPSEII filled in the inner 20 degrees of the Galactic plane, $|l| < 10°$, with vertical extensions up to $\pm1.5°$ for $|l| = 5° to\ 2°$, and up to $\pm2°$ from $|l| = 2° to\ 0°$. GLIMPSEII excluded the Galactic center region l=$\pm$1°, b=$\pm$0.75° observed by Dr. Susan Stolovy's GTO program (PID=3677), but GLIMPSE processing of these data have been included in the v2.0 GLIMPSEII data release. GLIMPSE3D adds vertical extensions, generally up to $|b| < 3°$, but up to $|b| < 4.2°$ in the center of the Galaxy. The goal of this coverage is to provide data to study the vertical stellar and interstellar

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

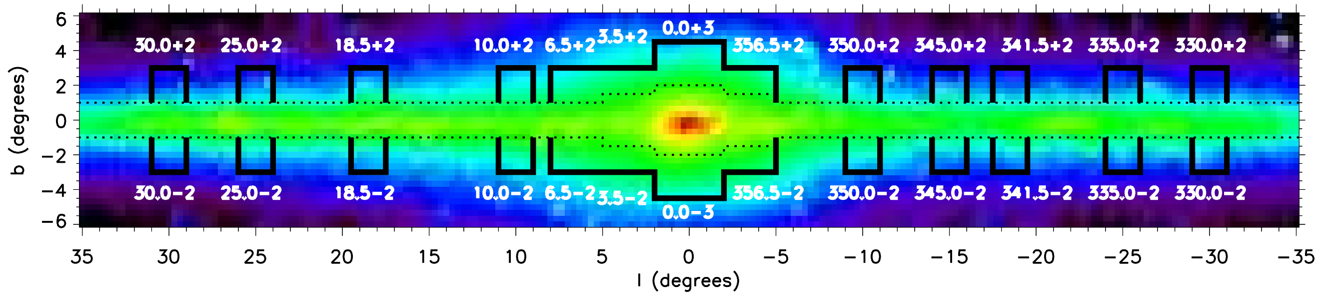

Figure 1: COBE/DIRBE 4.9 μm map of infrared intensity in the Galactic plane. Dotted lines show the area already observed by GLIMPSEI and GLIMPSEII. The vertical extensions for GLIMPSE3D are shown with solid lines. The 26 areas for which mosaics have been provided in the data releases are annotated. Source lists and enhanced images for the entire survey area have been delivered.

structure of the inner Galactic disk, bar, and spiral arms. The sky coverage of all three surveys, superposed on a COBE 4.9 μm image of the Galactic plane is shown in Figure 1.

IRAC has four bands, centered at approximately 3.6, 4.5, 5.8 and 8.0 μm respectively (Table 1). We will refer to them as bands 1 - 4 in this document. All of GLIMPSEII and some of GLIMPSE3D have 2 epoch coverage (3 visits on the sky; the first two visits taken at one epoch and the other visit days, weeks or months later) useful for variability studies. The GLIMPSE3D survey is producing enhanced data products in the form of a point source Catalog, a point source Archive, and mosaicked images. There were ten GLIMPSE3D areas where there were two epochs of coverage. For the epoch 2 single visit data, we produce a "More Reliable" Archive instead of a Catalog (since the Catalog requires two detections in one IRAC band). Table 2 shows which GLIMPSE3D areas were observed in two epochs. Table 3 gives the dates of observation for each epoch. See Benjamin et al. (2003), Churchwell et al. (2009) and the GLIMPSE web site (www.astro.wisc.edu/glimpse/) for more description of the GLIMPSE3D project.

This document describes the data products from the GLIMPSE3D Survey. The organization is as follows: §2 gives an overview of the GLIMPSE3D survey, data products, and delivery schedule; §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 GLIMSPE3D 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 GLIMPSE3D it is 48.

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

Table 1. Sensitivity/Saturation Limits for GLIMPSE3D 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] Based on GLIMPSE Science Verification Study (Addendum) http://www.astro.wisc.edu/glimpse/addendum4.pdf [d]Based on GLIMSPE Quality Assurance document http://www.astro.wisc.edu/glimpse/GQA-master.pdf [e] Benjamin et al (2005)

2.2 Data Products Overview

The GLIMPSE3D enhanced data products consist of a highly reliable Point Source Catalog (GLM3DC), a more complete Point Source Archive (GLM3DA), a More Reliable Archive (GLM3DMRA)(for the single visit data), mosaic images covering the survey area, and two useful web tools for modeling infrared data. The websites for these data products are given in §1 of this document.

1. The GLIMPSE3D Catalog (GLM3DC, or the "Catalog"), consists of the highest reliability point sources. The sources in the Catalog 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 GLIMPSE3D 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 GLIMPSE3D Catalog in magnitudes 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 GLIMPSE3D Catalog 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

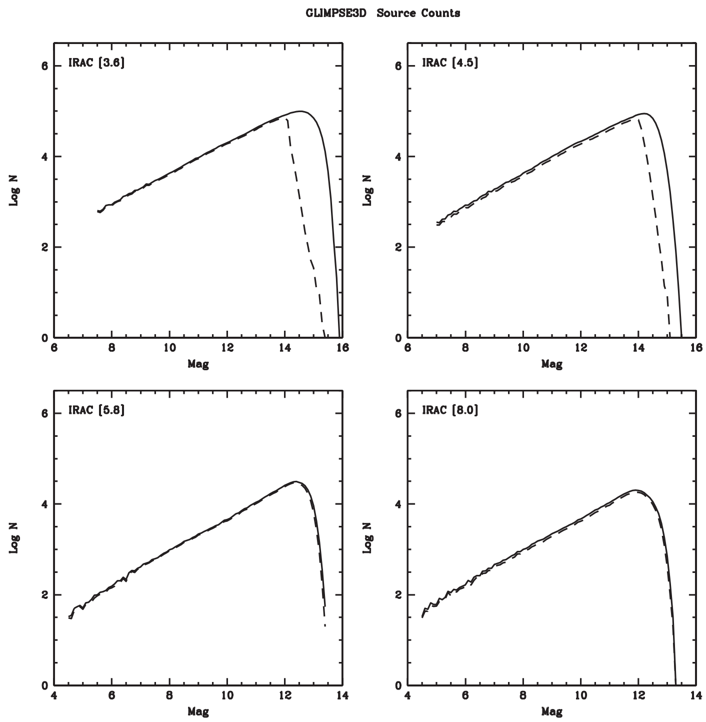

Figure 2: Plotted is the logarithm of the source counts in the GLIMPSE3D Catalog (dashed lines) and Archive (solid lines) binned every 0.1 magnitudes. Each of the 4 bands is plotted, showing the effective limiting magnitude for each band. Sources from three GLIMPSE3D regions (330+02, 330-02, 335-02) were used for these plots.

GLM3DC 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 GLIMPSE3D Catalog format is ASCII, using the IPAC Tables convention (irsa.ipac.caltech.edu/applications/DDGEN/Doc/ipac_tbl.html).

2. The GLIMPSE3D Archive (GLM3DA 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 GLIMPSE3D More Reliable Archive (GLM3DMRA) consists of the higher reliability point sources than the Archive. It was produced for the single visit epoch 2 only source lists to provide a higher reliability source list than the Archive. No highly reliable Catalog is produced for this dataset since it requires a source be detected twice in one band. The sources in the More Reliable Archive have the same stringent criteria as the Catalog except two detections are not required in a single band. Two detections in adjacent bands are required (the "1" can include the 2MASS K_s band); for example one detection in band 1 and

one detection in band 2. See §3.2 in the GLI Doc for details about the source list criteria.

4. The GLIMPSE3D Image Atlas. Mosaicked Images for each band, each covering e.g. $1.5° \times 0.9°$. 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. $2.8° \times 2.5°$ areas, with a pixel size of $1.2''$. $1.2''$ pixel mosaics are provided with and without background matching. Also included are quicklook 3-color jpeg images of the same size as the FITS images.

5. The Web Infrared Tool Shed (WITS), a web interface to a collection of models of IR spectra of dusty envelopes and photodissociation regions (PDRs), updated for IRAC and MIPS band passes. WITS is described in detail in §5.3 in the GLI Doc.

6. The YSO Model Grid and Fitter, a web-based home of a large grid of 200730 YSO model spectral energy distributions (SEDs). The 2-D YSO radiation transfer models of YSOs producing SEDs span a large range of evolutionary stages and stellar masses. The model grid browser allows users to examine SED variations as a function of a range of physical parameters. An online fitting tool fits input data using the grid of model SEDs. The Grid and Fitter is described in §5.4 in the GLI Doc.

2.3 Data Delivery Schedule

All source lists and enhanced images have been delivered to the SSC for the entire GLIMPSE3D survey region.

Background matched and gradient corrected $1.2''$ pixel mosaics are delivered in the October 2011 Data Delivery. In the background matched 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. We provide background matched and gradient corrected mosaics for the $1.2''$ pixel images. 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.

GLIMPSE3D data can be divided into three sections. One section, which we will refer to as "inner galaxy" provides vertical extension of coverage around the Galactic bulge. Together with GLIMPSEI and GLIMPSEII, this provides for a contiguous map spanning from $l = +8°$ to $l = -5°$. The vertical coverage extends to at least $b = \pm 3°$ for this entire section and to $b = \pm 4.2°$ for the innermost four degrees of longitude. This additional vertical extension includes the well known Baade's window. The GLIMPSE3D "inner galaxy" section is delivered in eight blocks, as shown in Table 2 below.

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

Table 2. GLIMPSE3D Blocks and Data Deliveries

Block Center (l, b)	$\Delta l \times \Delta b$	Epochs	Source Lists all epoch/single epoch	Mosaics	Bkg matched Gradient corrected
Southern Galactic Plane $(l < -9^\circ)$					
$330.0 - 02.0$	$2^\circ \times 2^\circ$	1	Jul 2007	Jul 2007	Oct 2011
$330.0 + 02.0$	$2^\circ \times 2^\circ$	1	Jul 2007	Jul 2007	Oct 2011
$335.0 - 02.0$	$2^\circ \times 2^\circ$	1	Jul 2007	Jul 2007	Oct 2011
$335.0 + 02.0$	$2^\circ \times 2^\circ$	1	Jan 2008	Jan 2008	Oct 2011
$341.5 - 02.0$	$2^\circ \times 2^\circ$	1	Jan 2008	Jan 2008	Oct 2011
$341.5 + 02.0$	$2^\circ \times 2^\circ$	1	Jan 2008	Jan 2008	Oct 2011
$345.0 - 02.0$	$2^\circ \times 2^\circ$	2	Jan 2008/Oct 2009	Jan 2008	Oct 2011
$345.0 + 02.0$	$2^\circ \times 2^\circ$	2	Jan 2008/Oct 2009	Jan 2008	Oct 2011
$350.0 - 02.0$	$2^\circ \times 2^\circ$	2	Jan 2008/Oct 2009	Jan 2008	Oct 2011
$350.0 + 02.0$	$2^\circ \times 2^\circ$	2	Jan 2008/Oct 2009	Jan 2008	Oct 2011
Northern Galactic Plane $(l > 9^\circ)$					
$30.0 - 02.0$	$2^\circ \times 2^\circ$	1	Jul 2008	Jul 2008	Oct 2011
$30.0 + 02.0$	$2^\circ \times 2^\circ$	1	Jul 2008	Jul 2008	Oct 2011
$25.0 - 02.0$	$2^\circ \times 2^\circ$	1	Jul 2008	Jul 2008	Oct 2011
$25.0 + 02.0$	$2^\circ \times 2^\circ$	1	Jul 2008	Jul 2008	Oct 2011
$18.5 - 02.0$	$2^\circ \times 2^\circ$	1	Jul 2008	Jul 2008	Oct 2011
$18.5 + 02.0$	$2^\circ \times 2^\circ$	1	Jul 2008	Jul 2008	Oct 2011
$10.0 - 02.0$	$2^\circ \times 2^\circ$	1	Jan 2009	Jan 2009	Oct 2011
$10.0 + 02.0$	$2^\circ \times 2^\circ$	1	Jan 2009	Jan 2009	Oct 2011
Inner Galaxy $(\lvert l \rvert < 9^\circ)$					
$356.5 - 02.15$	$3^\circ \times 1.5^\circ$	2	Jan 2009/Oct 2009	Jan 2009	Oct 2011
$0.0 - 03.10$	$4^\circ \times 2.2^\circ$	2	Jan 2009/Oct 2009	Jan 2009	Oct 2011
$3.5 - 02.15$	$3^\circ \times 1.5^\circ$	2	Jan 2009/Oct 2009	Jan 2009	Oct 2011
$6.5 - 02.00$	$3^\circ \times 2^\circ$	1	Jan 2009	Oct 2009	Oct 2011
$356.5 + 02.15$	$3^\circ \times 1.5^\circ$	2	Jan 2009/Oct 2009	Oct 2009	Oct 2011
$0.0 + 03.10$	$4^\circ \times 2.2^\circ$	2	Jan 2009/Oct 2009	Oct 2009	Oct 2011
$3.5 + 02.15$	$3^\circ \times 1.5^\circ$	2	Jan 2009/Oct 2009	Oct 2009	Oct 2011
$6.5 + 02.00$	$3^\circ \times 2^\circ$	1	Jan 2009	Oct 2009	Oct 2011

Table 3. Dates of observation for the GLIMPSE3D epoch 1 and epoch 2 data

Block Center (l, b)	date obs epoch 1	date obs epoch 2
$345.0 - 02.0$	20070403	20070404
$345.0 + 02.0$	20060921	20070403,04
$350.0 - 02.0$	20060924	20070509,10
$350.0 + 02.0$	20060924	20070404
$356.5 - 02.15$	20060925	20070509
$356.5 + 02.15$	20060925	20070508
$3.5 - 02.15$	20070510,11,12	20070515
$3.5 + 02.15$	20070511,12	20070510,11
$0.0 - 03.10$	20070510	20070512,13
$0.0 + 03.10$	20070507	20070507,08

At positive ("north Galactic plane") longitudes, there are a total of eight $2^\circ \times 2^\circ$ separate vertical blocks centered at longitudes $l = 10^\circ$, 18.5°, 25°, and 30°. At negative ("south Galactic plane") longitudes, there are ten blocks at symmetric locations on the other side of Galactic center ($l = 350^\circ, 341.5^\circ, 335^\circ, 330^\circ$, plus one additional pair of blocks located at $l = 345^\circ$). This last addition was included to cover the expected far end of the "long bar" of the Galaxy (Benjamin *et al* 2005).

Our total GLIMPSE3D data delivery consists of eight blocks from the inner galaxy, eight from the north Galactic plane, and ten from the south Galactic plane. All GLIMPSE3D regions with $l > 5^\circ$ and $l < -16^\circ$ were covered at least twice, with a single epoch of coverage. Fields with longitudes $l < 5^\circ$ and $l > -16^\circ$ were observed at least three times at two distinct epochs separated by weeks to months. The entire GLIMPSE3D survey region has been covered: ten areas mostly in the southern galaxy were observed in September 2006; six areas were observed in March/early April 2007, and the remainder of the survey was completed in May 2007.

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 initial results of a reliability study using GLIMPSEI Observation Strategy Validation (OSV) data to develop source selection criterion. Additional details are given in §3.2 and §4.1 of the GLI Doc.

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 GLIMPSE3D source positions to the 2MASS PSC positions, in $0.05''$ bins, for a two degree longitude, two degree latitude area in the GLIMPSE3D survey. The peak of the plot is about $0.1''$ and the majority of the sources have positional differences less than $0.3''$. Fainter GLIMPSE3D 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

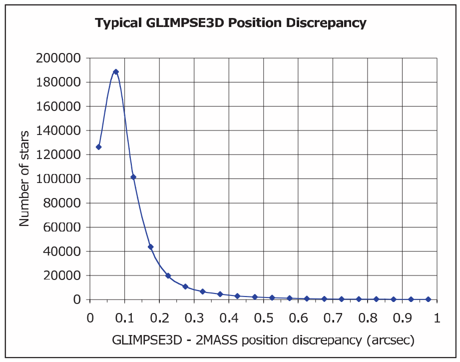

Figure 3: Comparison of GLIMPSE3D source positions to their corresponding 2MASS PSC positions from sources in the l=330 deg, b=-2 deg area. The astrometric discrepancy plotted is the angular separation in arcseconds between the GLIMPSE3D position and the 2MASS position. Note that sources with 2MASS associates have GLIMPSE3D 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.

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 1 - 4 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 GLIMPSE3D Catalogs and Archives that achieve this level. The results are consistent with GLIMPSEI (§4.3 of the GLI Doc). Band 3 shows a higher percentage of sources with photometric accuracy >0.2 mag, probably due to its lower sensitivity. Band 2 shows a higher percentage of sources with photometric accuracy >0.2 mag compared to band 1. This is a result of our selection criteria (§3.2 in the GLI Doc). For the Catalog, band 1 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 band 1 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 band 1 detections with the signal-to-noise required to be greater than 5.

Table 4. Photometric Accuracy of GLIMPSE3D Sources

Band (μm)	[3.6]	[4.5]	[5.8]	[8.0]
Catalog				
No. with error >0.2 mag	97605	1387081	2444579	1322793
Total number of entries	20288341	19792208	9783136	7033224
% with errors >0.2 mag	0.48	7.01	24.99	18.81
Archive				
No. with error >0.2 mag	529890	5206424	2809163	1531766
Total number of entries	31099459	26720472	10546743	7776984
% with errors >0.2 mag	1.70	19.48	26.64	19.70

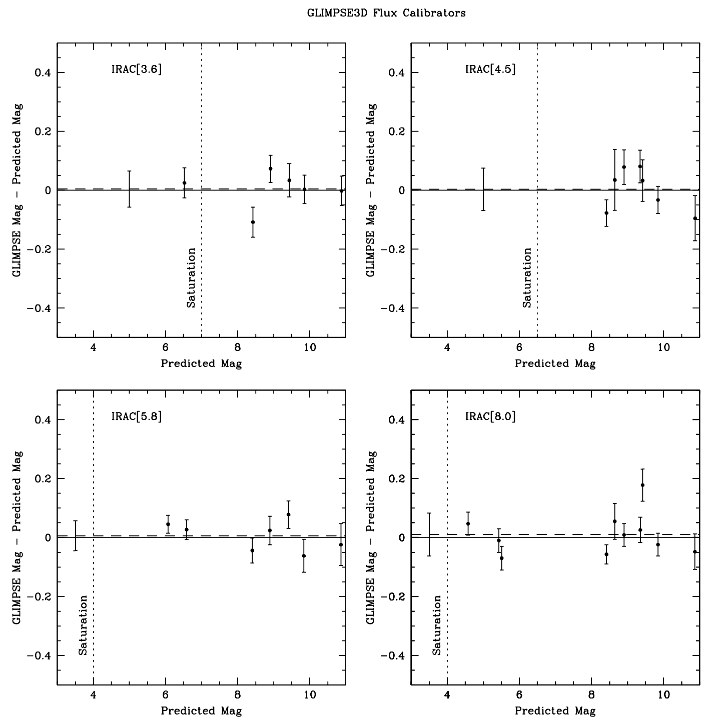

Figure 4: Comparison of twelve GLIMPSEI and GLIMPSEII flux calibrators that are in the overlap areas of the GLIMPSE3D survey. They show good agreement between the GLIMPSEI, GLIMPSEII and GLIMPSE3D extractions as well as agreement to Martin Cohen's predicted magnitudes for each IRAC band. Error bars are 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. The horizontal dashed line is the average difference between the GLIMPSE3D magnitude and the predicted magnitude. The left most error bar is the RMS of the average.

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 twelve GLIMPSEI and GLIMPSEII flux calibrators that overlap the GLIMPSE3D coverage. The GLIMPSE3D fluxes of these twelve flux calibrators were compared to the GLIMPSEI and GLIMPSEII fluxes and to Martin Cohen's predictions. Figures 4 and 5 and Table 5 show the good agreement between the GLIMPSE3D fluxes, the GLIMPSEI fluxes and the predictions. We also compared the fluxes of sources in the overlap between the GLIMPSEI and GLIMPSE3D coverage around l=330 deg, b=+1 deg. The results are given in Figure 6 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	6	7	7	10
Ave. [Observed-Predicted] mag	0.004	0.003	0.006	0.011
RMS error	0.061	0.072	0.051	0.073

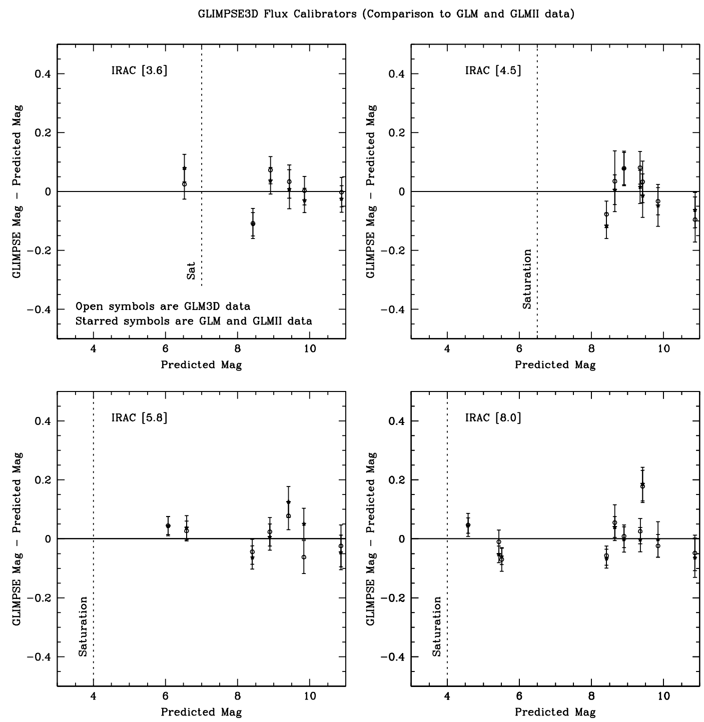

Figure 5: This figure shows the agreement between the GLIMPSE3D extracted magnitudes and the GLIMPSEI/GLIMPSEII extracted magnitudes. It confirms that multi-epoch extractions for these stars agree well from epoch to epoch and that the deviations from the predicted magnitudes may be real in some cases.

The conclusion is that the average magnitude difference between our values and Cohen's predictions is typically less than 0.01 mags, with a typical scatter about that difference of about 0.06 mags. These values have been consistent from survey to survey (GLIMPSEI, GLIMPSEII and now GLIMPSE3D).

The reliability of our uncertainties can be studied by comparing the quoted error (dF_i) with the RMS of the measurements (F_i_rms). From initial studies of GLIMPSEI data, bands 2 and 4 appear to have the largest discrepancy in these two measures of uncertainty. The formal band 2 uncertainties appear to be systematically too large by about 10%, while band 4 uncertainties may be underestimated by 20%. The true band 4 uncertainty appears to be related to the background level as well as the formal value of the uncertainty. The correction needed for band 4 uncertainties appears to be approximately 20%, (i.e. df_b4'=df_b4*1.2) but can range from about 0.8 to 2.0. There may also be small corrections for bands 1 and 3. Revisions may be made in the best values to use for source flux uncertainty following a GLIMPSE team study of these issues, but no "corrections" have been applied to the delivered source lists.

3.3 Color-Color and Color-Magnitude Plots

Color-color and color-magnitude plots were made of each Catalog and Archive Table (approximately $2^\circ \times 2^\circ$ blocks). An example set of color-color and color-magnitude plots is shown in Figures 7 and 8, respectively. The color-color plots generally show a peak near 0 color due to main sequence and

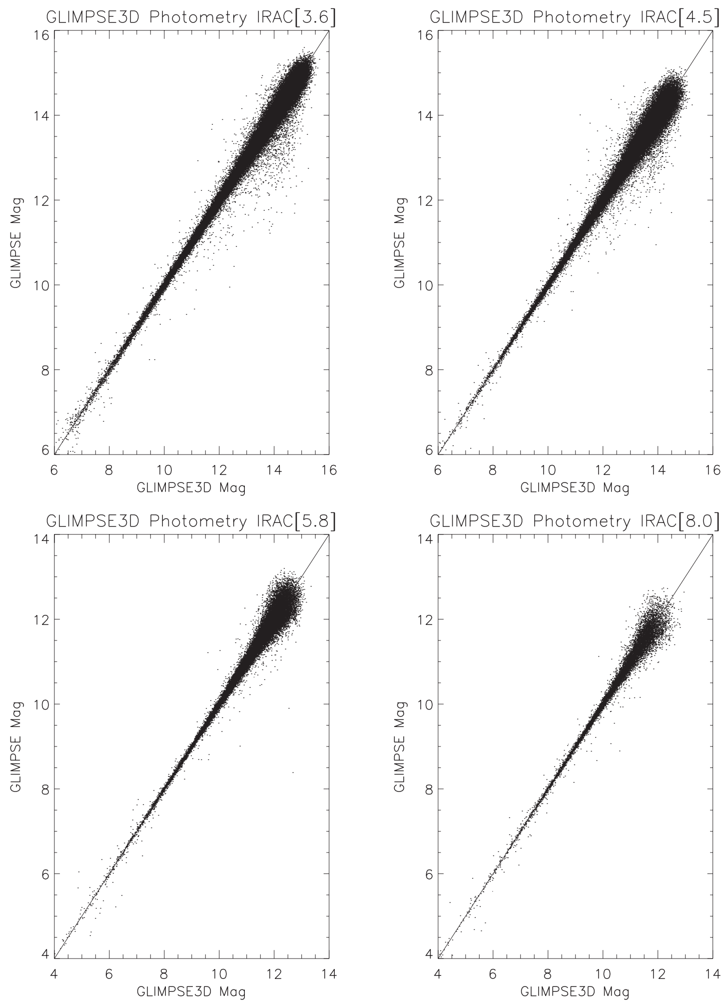

Figure 6: Comparison between overlap regions between GLIMPSEI and GLIMPSE3D data at l=330 deg and b=+1.0 deg. In this overlap area there are approximately 112000 band 1 sources that are unconfused matches at a 2″ radius, 62000 band 2 matched sources, 28000 band 3 sources and 11000 band 4 sources. This shows the good agreement between datasets.

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 GLIMPSE3D survey are available from the GLIMPSE web site (http://www.astro.wisc.edu/glimpse/glimpse3d/v1.0/ColorColor/ and http://www.astro.wisc.edu/glimpse/glimpse3d/v1.0/ColorMag/).

3.4 Other checks

Spot checks include inspection of residual images to verify proper point source extraction; overplotting the positions of the sources in the Catalogs and Archives on mosaic images; and plotting Spectral Energy Distributions (SEDs) of several sources. The l=335°, b=-2° Catalogs and Archives

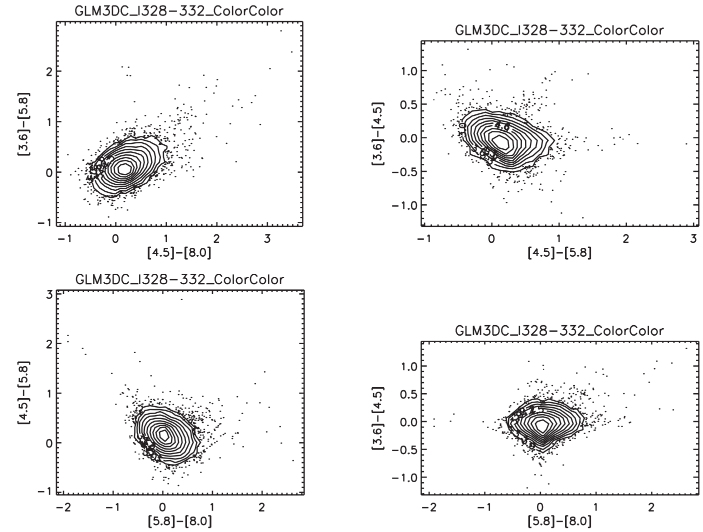

Figure 7: Color-color plots of the region $l = 329 - 331°$ and b=-1 to -3° for sources in the Catalog. 10 contours are evenly spaced between log(# sources/mag^2)=2.0 and the log of maximum number of sources per square magnitude. The contours are labeled with the log of the number of sources per square magnitude. Outside of the lowest contour, the positions of individual sources are plotted.

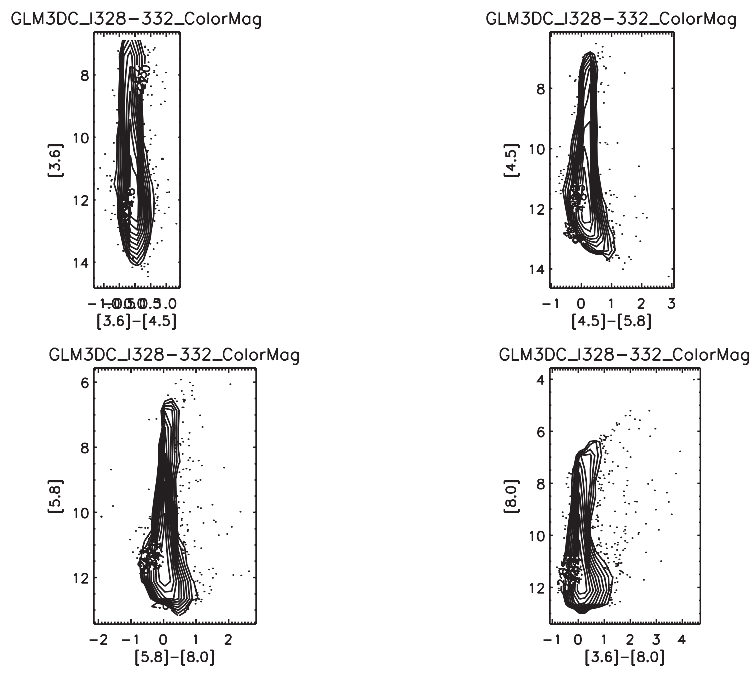

Figure 8: Color-magnitude plots of the region $l = 329 - 331°$ and b=-1 to -3° for sources in the Catalog. 10 contours are evenly spaced between log(# sources/mag^2)=2.0 and the log of the maximum number of sources per square magnitude. The contours are labeled with the log of the number of sources per square magnitude. Outside of the lowest contour, the positions of individual sources are plotted.

were run through our SED grid and fitter (Robitaille et al. 2006, 2007a). using a large grid of stellar atmosphere models. Four data points were required for the fit. About >98% (Archive) and >99% (Catalog) of the sources were well-fit within the χ^2 per datapoint < 3 and are therefore likely valid data. The remaining <1% (Catalog) and <2% (Archive) sources were examined individually and we found that about 1/2 to 2/3 of the sources have a datapoint that is questionable (due to bad or mismatched IRAC or 2MASS fluxes, or variability between IRAC and 2MASS; Robitaille et al. 2007b). The rest are real sources not well fit by stellar atmospheres, e.g. dusty Young Stellar Objects and evolved stars.

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.

4.1 Catalog and Archive Fields and Flags

Each entry in the GLIMPSE3D Catalog and Archive has the following information:

designation	SSTGLMC GLLL.llll±BB.bbbb, SSTGLMA 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 1 - 4) (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 SSTGLMC (GLIMPSE3D Catalog and More Reliable Archive) or SSTGLMA (GLIMPSE3D 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 http://pegasus.phast.umass.edu/ipac_wget/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 GLIMPSE3D 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 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 bands 1 and 2 than bands 3 and 4 due to lower backgrounds in bands 1 & 2 and the lower sensitivity of the band 3 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 bands 3 and 4) (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.

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

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 and the More Reliable Archive. 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 $\sim$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 GLIMPSE3D 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 GLIMPSE3D 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 GLIMPSE3D survey, the method flag always equals 48 ($2^4 + 2^5$).

4.2 GLIMPSE3D Image Atlas

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 $1.5°\times0.9°$, $1.6°\times0.9°$, $1.1°\times0.8°$, $1.1°\times0.9°$, $1.1°\times1.2°$, and $1.1°\times1.0°$. 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. $2.8°\times2.5°$, $3.2°\times3.1°$, $3.7°\times2.5°$, $3.8°\times2.4°$and $4.6°\times3.5°$) 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 GLIMPSE3D areas. For a quick-look of the mosaics, we provide 3-color jpeg files (bands 1, 2 and 4) 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, Archive and More Reliable Archive

• There is a Catalog and Archive for each of the GLIMPSE3D areas. The Catalog and Archive files are in IPAC Table Format (http://irsa.ipac.caltech.edu/applications/DDGEN/Doc/ipac_tbl.html). Filenames are GLM3DC_l*lcbc*.tbl and GLM3DA_l*lcbc*.tbl (where *lc* and *bc* are the Galactic longitude and latitude of the center of the area) for the Catalog and Archive respectively (e.g. GLM3DC_l330-02.tbl, GLM3DC_l330+02.tbl, GLM3DA_l330-02.tbl, GLM3DA_l330+02.tbl, etc.) For the single epoch source lists, the file names are e.g. epoch1_GLM3DC_350.0+02.tbl, epoch2_GLM3DMRA_356.0+02.tbl. The entries are sorted by increasing Galactic longitude within each file. An example of a GLM3DC entry is

SSTGLMC G329.2848+01.8695 15530382-5127437 489733518 329.284889 1.869522 0.3 0.3 238.265915 -51.462178 0.3 0.3 0 12.649 0.033 10.853 0.026 10.094 0.027

9.702 0.035 9.799 0.047 9.450 0.048 9.504 0.033
1.390E+01 4.224E-01 4.668E+01 1.118E+00 6.114E+01 1.520E+00
3.696E+01 1.196E+00 2.162E+01 9.360E-01 1.909E+01 8.435E-01 1.012E+01 3.083E-01
1.230E+00 1.727E-01 1.341E-01 1.872E-01 1.062E+00 4.260E-01 4.805E+00 2.013E+01
32.90 41.76 40.21 30.92 23.10 22.63 32.83 53.6 39.1 14.4 9.3
2 2 2 2 2 2 2 2 29360128 29360128 29360136 16384 0 0 0 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 (SSTGLMC GLLL.llll±BB.bbbb) Archive (SSTGLMA 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	$\mathrm{srcdens}_i$	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	SSTGLMC G329.2848+01.8695	Name
tmass_desig	15530382-5127437	2MASS designation
tmass_cntr	489733518	2MASS counter
l,b	329.284889 1.869522	Galactic Coordinates (deg)
dl,db	0.3 0.3	Uncertainty in Gal. Coordinates (arcsec)
ra,dec	238.265915 -51.462178	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	12.649 10.853 10.094	Magnitudes (2MASS J,H,K_s) (mag)
	0.033 0.026 0.027	Uncertainties (2MASS) (mag)
mag,dmag	9.702 9.799 9.450 9.504	Magnitudes (IRAC bands 1-4) (mag)
	0.035 0.047 0.048 0.033	Uncertainties (IRAC) (mag)
F,dF	1.390E+01 4.668E+01 6.114E+01	2MASS Fluxes (mJy)
	4.224E-01 1.118E+00 1.520E+00	Uncertainties in 2MASS fluxes (mJy)
F,dF	3.696E+01 2.162E+01 1.909E+01 1.012E+01	IRAC Fluxes (mJy)
	1.196E+00 9.360E-01 8.435E-01 3.083E-01	Uncertainties in IRAC fluxes (mJy)
F_rms	1.230E+00 1.727E-01 1.341E-01 1.872E-01	RMS_flux (mJy) (IRAC)
sky	1.062E+00 4.260E-01 4.805E+00 2.013E+01	Sky Bkg (MJy/sr) (IRAC)
SN	32.90 41.76 40.21	Signal to Noise (2MASS)
SN	30.92 23.10 22.63 32.83	Signal to Noise (IRAC)
srcdens	53.6 39.1 14.4 9.3	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 29360136	Source Quality Flag (2MASS)
SQF	16384 0 0 0	Source Quality Flag (IRAC)
MF	48 48 48 48	Flux Calculation Method Flag (IRAC)

5.2 GLIMPSE3D Image Atlas

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 tiles are 1.5°×0.9°, 1.6°×0.9°, 1.1°×0.9°, 1.1°×0.8°, 1.1°×1.2°, and 1.1°×1.0°. Three tiles span the latitude range of the areas. For example, the details about the 1.5°x 0.9°mosaics are: 1.5°x 0.9°mosaics (9040 x 5440 0.6″ pixels) are about 197 Megabytes in size. There are three mosaics per 1.5 degree Galactic longitude interval with 0.05° overlap between mosaics. For example, for the 330+02 region, Galactic longitudes of 329.45°and 330.85°, the centers of the six mosaics are (329.45°, +1.10°), (329.45°, +1.90°), (329.45°, +2.70°), and (330.85°, +1.10°), (330.85°, +1.90°), (330.85°, +2.70°). The longitude range is 328.70° to 331.60°. The latitude ranges are +0.65° to +1.55°, +1.45° to +2.35°, and +2.25° to +3.15°. Filenames are GLM_*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, GLM_32945+0190_mosaic_I1.fits is a 1.5°x 0.9° IRAC channel 1 mosaic centered on l=329.45°, b=+1.90°. A similar scheme is used for the 1.1°×0.8°, 1.1°×1.2°, 1.1°×1.0°, 1.6°×0.9°, and 1.1°×0.9° mosaics. We provide low-resolution 3-color jpeg images for each area, combining bands 1, 2, and 4 to be used for quick-look purposes. The filename for this jpeg file is similar to the mosaic FITS file: e.g. GLM_32945+0190.jpg. We also provide native resolution images (e.g. 2.8°x 2.5° mosaic FITS files (8420 x 7520 1.2″ pixels) for each band, along with low resolution 3-color jpegs. Each of the 2.8°x 2.5° mosaics is about 253 Megabytes in size. Other mosaics are 3.2°×3.1°, 3.7°×2.5°, 3.8°×2.4°and 4.6°×3.5°. The filenames are similar to the other FITS and jpeg images:

e.g. GLM_33015+0190_mosaic_I1.fits, GLM_33015+0190_2.8x2.5.jpg.

We also provide the background matched and gradient corrected 1.2″ pixel mosaics. 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 1.5°x 0.9° GLM_32945-0190_mosaic_I2.fits:

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                 9040 / length of data axis 1
NAXIS2  =                 5440 / 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= 'GLIMPSE '           / SSC pipeline that created the BCD
PIPEVERS= '1v04    '           / GLIMPSE pipeline version
MOSAICER= 'Montage V3.0'       / SW that originally created the Mosaic Image
FILENAME= 'GLM_32945-0190_mosaic_I2.fits' / Name of associated fits file
PROJECT = 'GLIMPSE3D'          / Project ID
FILETYPE= 'mosaic  '           / Calibrated image(mosaic)/residual image(resid)
CHNLNUM =                    2 / 1 digit Instrument Channel Number
DATE    = '2007-05-16T08:37:32' / file creation date (YYYY-MM-DDThh:mm:ss UTC)
COMMENT --------------------
COMMENT Proposal Information
COMMENT --------------------
OBSRVR  = 'Robert Benjamin'    / Observer Name
OBSRVRID=                31293 / Observer ID of Principal Investigator
PROCYCLE=                    6 / Proposal Cycle
PROGID  =                30570 / Program ID
PROTITLE= 'GLIMPSE 3D: The Vertical Stell' / Program Title
PROGCAT =                   27 / 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  =            4520.5000 / Reference pixel for x-position
CRPIX2  =            2720.5000 / Reference pixel for y-position
CTYPE1  = 'GLON-CAR'           / Projection Type
CTYPE2  = 'GLAT-CAR'           / Projection Type
CRVAL1  =         329.45001221 / [Deg] Galactic Longtitude at reference pixel
CRVAL2  =          -1.89999998 / [Deg] Galactic Latitude at reference pixel
EQUINOX =               2000.0 / Equinox for celestial coordinate system
DELTA-X =           1.50666666 / [Deg] size of image in axis 1
DELTA-Y =           0.90666670 / [Deg] size of image in axis 2
BORDER  =           0.00333333 / [Deg] mosaic grid border
CD1_1   =      -1.66666665E-04
CD1_2   =       0.00000000E+00
CD2_1   =       0.00000000E+00
CD2_2   =       1.66666665E-04
PIXSCAL1=                0.600 / [arcsec/pixel] pixel scale for axis 1
PIXSCAL2=                0.600 / [arcsec/pixel] pixel scale for axis 2
OLDPIXSC=                1.213 / [arcsec/pixel] pixel scale of single IRAC frame
RA      =         242.57109070 / [Deg] Right ascension at mosaic center
DEC     =         -54.19726562 / [Deg] Declination at mosaic center
COMMENT ----------------------
COMMENT Photometry Information
COMMENT ----------------------
BUNIT   = 'MJy/sr  '           / Units of image data
GAIN    =                  3.7 / e/DN conversion
JY2DN   =           249988.703 / Average Jy to DN Conversion
ETIMEAVE=               1.2000 / [sec] Average exposure time for the BCD frames
PA_AVE  =               100.96 / [deg] Average position angle
ZODY_EST=              0.30612 / [Mjy/sr] Average ZODY_EST
ZODY_AVE=              0.12649 / [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=          0.567294538 / Average MJy/sr to DN/s Conversion
COMMENT -----------------------------
COMMENT AORKEYS/ADS Ident Information
COMMENT -----------------------------
AOR001  = '0020250880'         / AORKEYS used in this mosaic
AOR002  = '0020290304'         / AORKEYS used in this mosaic
AOR003  = '0020228864'         / AORKEYS used in this mosaic
AOR004  = '0020261376'         / AORKEYS used in this mosaic
AOR005  = '0020243456'         / AORKEYS used in this mosaic
DSID001 = 'ads/sa.spitzer#0020250880' / Data Set Identification for ADS/journals
DSID002 = 'ads/sa.spitzer#0020290304' / Data Set Identification for ADS/journals
DSID003 = 'ads/sa.spitzer#0020228864' / Data Set Identification for ADS/journals
DSID004 = 'ads/sa.spitzer#0020261376' / Data Set Identification for ADS/journals
```

```
DSID005 = 'ads/sa.spitzer#0020243456' / Data Set Identification for ADS/journals
NIMAGES =                  387 / 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, GLM_32945-0190_mosaic_I2.hdr includes:

```
COMMENT ----------------------------------------
COMMENT Info on Individual Frames in Mosaic
COMMENT ----------------------------------------
IRFR0001= 'SPITZER_I2_0020250880_0083_0000_03_levbflx.fits' / IRAC frame
DOBS0001= '2006-09-20T03:54:01.123' / Date & time at frame start
MOBS0001=      53998.164062500 / MJD (days) at frame start
RACE0001=           242.883591 / [Deg] Right ascension at reference pixel
DECC0001=           -53.347584 / [Deg] Declination at reference pixel
PANG0001=               100.84 / [deg] Position angle for this image
FLXC0001=              0.13880 / Flux conversion for this image
ZODE0001=              0.30842 / [MJy/sr] ZODY_EST for this image
ZODY0001=              0.12879 / [MJy/sr] ZODY_EST-SKYDRKZB for this image
IRFR0002= 'SPITZER_I2_0020250880_0176_0000_03_levbflx.fits' / IRAC frame
DOBS0002= '2006-09-20T04:16:17.111' / Date & time at frame start
MOBS0002=      53998.179687500 / MJD (days) at frame start
RACE0002=           242.858963 / [Deg] Right ascension at reference pixel
DECC0002=           -53.427467 / [Deg] Declination at reference pixel
PANG0002=               100.87 / [deg] Position angle for this image
FLXC0002=              0.13880 / Flux conversion for this image
ZODE0002=              0.30821 / [MJy/sr] ZODY_EST for this image
ZODY0002=              0.12857 / [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 385
.
IRFR0386= 'SPITZER_I2_0020243456_0019_0000_03_levbflx.fits' / IRAC frame
DOBS0386= '2006-09-20T09:27:24.421' / Date & time at frame start
MOBS0386=      53998.394531250 / MJD (days) at frame start
RACE0386=           243.219849 / [Deg] Right ascension at reference pixel
DECC0386=           -54.297302 / [Deg] Declination at reference pixel
PANG0386=               100.64 / [deg] Position angle for this image
FLXC0386=              0.13880 / Flux conversion for this image
ZODE0386=              0.30408 / [MJy/sr] ZODY_EST for this image
ZODY0386=              0.12445 / [MJy/sr] ZODY_EST-SKYDRKZB for this image
IRFR0387= 'SPITZER_I2_0020261376_0020_0000_03_levbflx.fits' / IRAC frame
DOBS0387= '2006-09-20T10:35:36.560' / Date & time at frame start
MOBS0387=      53998.441406250 / MJD (days) at frame start
```

```
RACE0387=           242.660080 / [Deg] Right ascension at reference pixel
DECC0387=           -54.565842 / [Deg] Declination at reference pixel
PANG0387=               101.10 / [deg] Position angle for this image
FLXC0387=              0.13880 / Flux conversion for this image
ZODE0387=              0.30483 / [MJy/sr] ZODY_EST for this image
ZODY0387=              0.12519 / [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 GLIMPSE3D survey we have not seen latent images in the data, even though they are flagged.

7 muxbleed correction applied (bands 1 & 2)
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 $> 3\sigma$ above the background (bands 1 & 2)
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 (bands 1 & 2)
This bit is set if the source is within 3 pixels of a column pulldown corrected pixel.

16 banding corrected (bands 3 & 4)
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 9 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).

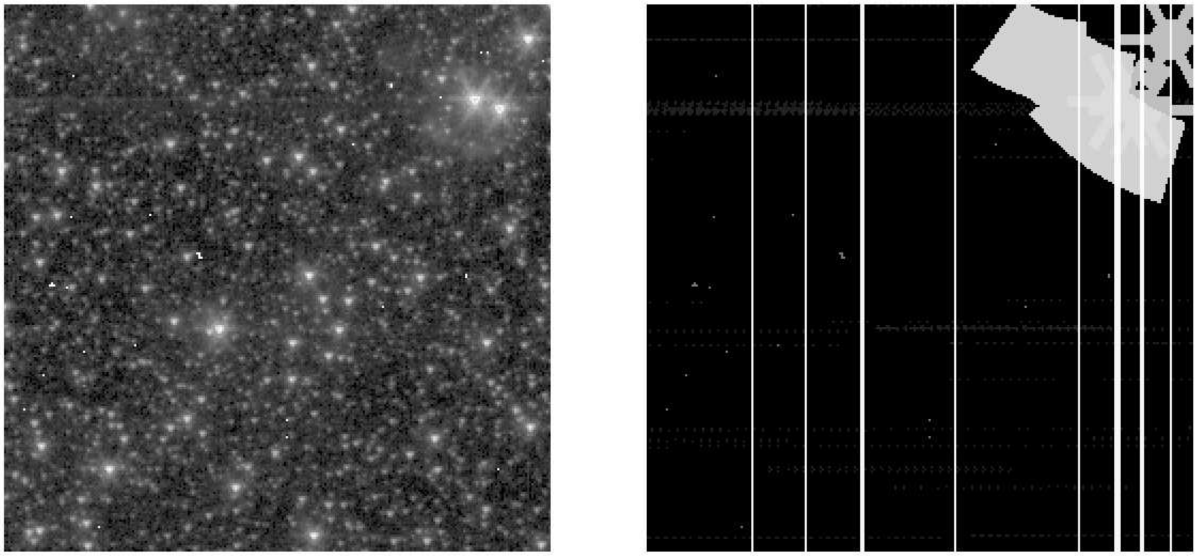

Figure 9: The band 1 (GLIMPSEI) IRAC frame (AOR 12110848, exposure 11) is on the left (corrections were applied for muxbleed and column pulldown); the flags for that frame are shown on the right. Stray light masks (SQF bit 17) are seen in the upper right hand corner of the frame. The PSF-shaped areas 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.

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 bands 1 and 4 and the other has data in bands 2 and 3. 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
http://www.ipac.caltech.edu/2mass/release/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://pegasus.phast.umass.edu/ipac_wget/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 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 and H bands and 29360136 for the K_s band. This translates to bits 23, 24 and 25 being set for J & H, which is the photometric quality A flag from the 2MASS PSC. For K_s, bits 4, 23, 24 and 25 are set, meaning the "c" photometric confusion flag was set and the photometric quality flag is A. IRAC band 1 has a SQF of 16384. This means bit 15 has been set which means the source is within three pixels of a column pulldown corrected area.

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GLOSSARY

2MASS	Two Micron All Sky Survey
dmask	A data quality mask supplied by the SSC for the BCD
GLIMPSE	Galactic Legacy Infrared Midplane Survey Extraordinaire
GLM3DC	GLIMPSE3D Point Source Catalog
GLM3DA	GLIMPSE3D Point Source Archive
GLM3DMRA	GLIMPSE3D More Reliable 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
SQF	Source Quality Flag
SST	*Spitzer* Space Telescope
smask	Stray light mask
YSO	Young Stellar Object
WITS	Web Infrared Tool Shed, for data analysis