The SAGE Data Products Description

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Contents

1. Executive Summary

This document describes the SAGE data products:

Point Source Catalogs and Archives

- **SAGELMCcatalogIRAC**, the IRAC v3.1 Single Frame + Mosaic Photometry Catalog combining Epoch 1 and Epoch 2 data bandmerged with All-Sky 2MASS and 6X2MASS. *This is the highest quality SAGE Catalog*, deeper than previously delivered single epoch catalogs that used only half of the data!
- **SAGELMCarchiveIRAC**, the IRAC v3.1 Single Frame + Mosaic Photometry Archive combining Epoch 1 and Epoch 2 data bandmerged with All-Sky 2MASS and 6X2MASS. This highest quality SAGE archive is approximately one magnitude deeper than previously delivered single epoch archives.
- **SAGELMCcatalogIRAC_EP1_EP2**, the v2.1 IRAC Catalog containing Epoch 1 only and Epoch 2 only data bandmerged with All-Sky 2MASS and 6X2MASS
- **SAGELMCarchiveIRAC_EP1_EP2**, the v2.1 IRAC Archive containing Epoch 1 only and Epoch 2 only data bandmerged with All-Sky 2MASS and 6X2MASS
- **SAGELMCcatalogOFFIRAC**, the IRAC LMC Offset Position Catalog (off-LMC position centered at RA=82.°25, Dec=–45.°95)
- **SAGELMCarchiveOFFIRAC**, the LMC IRAC Offset Position Archive (off-LMC position centered at RA=82.°25, Dec=–45.°95)
- **SAGELMCcatalogMIPS24**, the Epoch 1 only and Epoch 2 only MIPS 24 μm Catalogs
- **SAGELMCfullMIPS24**, the Epoch 1 only and Epoch 2 only MIPS 24 μm Full List
- **SAGELMCcatalogMIPS70**, the MIPS 70 μm Catalog combining Epoch 1 and Epoch 2 data
- **SAGELMCfullMIPS70**, the MIPS 70 μm Full List combining Epoch 1 and Epoch 2 data
- **SAGELMCcatalogMIPS160**, the MIPS 160 μm Catalog combining Epoch 1 and Epoch 2 data

- **SAGELMCfullMIPS160**, the MIPS 160 μm Full List combining Epoch 1 and Epoch 2 data
- **SAGELMC_IRACcatalog_E1E2Match**, the list of matched IRAC Catalog Epoch 1 and Epoch 2 sources containing variability indices
- **SAGELMC_IRACarchive_E1E2Match**, the list of matched IRAC Archive Epoch 1 and Epoch 2 sources containing variability indices
- **SAGELMC_MIPS24catalog_E1E2Match**, the list of matched MIPS 24 μm Catalog Epoch 1 and Epoch 2 sources containing variability indices
- **SAGELMC_MIPS24full_E1E2Match**, the list of matched MIPS 24 μm Full List Epoch 1 and Epoch 2 sources containing variability indices

IRAC and MIPS Images

- IRAC 3.6, 4.5, 5.8, and 8.0 μm $8^\circ \times 8^\circ$, $2''$ pixel mosaics and mosaics of residual images combining Epoch 1 and Epoch 2 12 second frametime data
- IRAC 3.6, 4.5, 5.8, and 8.0 μm $8^\circ \times 8^\circ$, $1\overset{''}{.}2$ pixel mosaics and mosaics of residual images combining Epoch 1 and Epoch 2 12 second frametime data
- IRAC 3.6, 4.5, 5.8, and 8.0 μm $1\overset{\circ}{.}2 \times 1\overset{\circ}{.}2$, $0\overset{''}{.}6$ pixel tiles combining Epoch 1 and Epoch 2 12 second frametime data
- IRAC 3.6, 4.5, 5.8, and 8.0 μm $0\overset{\circ}{.}9 \times 0\overset{\circ}{.}6$, $0\overset{''}{.}6$ pixel mosaics of the SAGE LMC offset position (centered at RA=$82\overset{\circ}{.}25$, Dec=$-45\overset{\circ}{.}95$)
- fits images containing information about the time of observation for a given SAGE IRAC source in the single epoch source lists
- MIPS 24 μm Epoch 1 only and Epoch 2 only full mosaics (not on the IRAC/MIPS common projection)
- MIPS 24 μm full mosaic combining Epoch 1 and Epoch 2 data (not on the IRAC/MIPS common projection)
- MIPS 24 μm Epoch 1 only and Epoch 2 only full mosaics
- MIPS 24 μm full mosaic combining Epoch 1 and Epoch 2 data
- MIPS 24 μm $1\overset{\circ}{.}1 \times 1\overset{\circ}{.}1$ tiles combining Epoch 1 and Epoch 2 data

- MIPS 24 μm 1$^\circ\!\!.$1 × 1$^\circ\!\!.$1 residual image tiles
- MIPS 70 μm and 160 μm full mosaics combining Epoch 1 and Epoch 2 data
- MIPS 70 μm and 160 μm residual images
- MIPS 70 μm and 160 μm weight maps (no. of measurements per pixel)

This document provides a brief overview of the project and data processing, as well as the guidance of how to use the source lists to meet the user's scientific needs. A summary of the point source lists and images listed above can be found in Tables 1 and 2, respectively. A guide to contents of the SAGE catalog and archive columns is provided.

Table 1. SAGE-LMC Point Source Lists

Source List Title	No. of Sources	Wavelengths (μm)	Content
SAGELMCcatalogIRAC	~6.4 million	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC Single Frame + Mosaic Photometry Catalog: a combination of mosaic photometry source list extracted from the combined Epoch 1 and Epoch 2 12 second frametime mosaics with all-epochs single frame source list, bandmerged with 2MASS or 6X2MASS. High reliability emphasized. Faint limits[b] are 18.1, 17.5, 15.3, and 14.2 for IRAC 3.6, 4.5, 5.8, 8.0 μm, respectively. **This is the best SAGE IRAC Catalog**; see §3 for a usage recommendation.
SAGELMCarchiveIRAC	~6.9 million	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC Single Frame + Mosaic Photometry Archive: a combination of mosaic photometry source list extracted from the combined Epoch 1 and Epoch 2 12 second frametime mosaics with all-epochs single frame source list, bandmerged with 2MASS or 6X2MASS. Includes more sources and more source fluxes (fewer nulled wavelengths), see §5.2. Faint limits[b] for both epochs are 18.3, 17.9, 15.6, and 14.9 mag for IRAC 3.6, 4.5,

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Table 1 – Continued

Source List Title	No. of Sources	Wavelengths (μm)	Content
			5.8, and 8.0 μm, respectively. **This is the best SAGE IRAC Archive**; see §3 for a usage recommendation.
SAGELMCcatalogIRAC_EP1_EP2	Epoch 1: ~4.3 million Epoch 2: ~4.2 million	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC catalog containing Epoch 1 only and Epoch 2 only sources with 0.6 and 12 second frame photometry bandmerged with 2MASS and 6X2MASS; high reliability emphasized. Faint limits[b] for Epoch 1 (Epoch 2) are 17.4, 16.9, 14.5, and 13.5 mag (17.4, 16.8, 14.5, and 13.4 mag) for IRAC 3.6, 4.5, 5.8, and 8.0 μm, respectively.
SAGELMCarchiveIRAC_EP1_EP2	Epoch 1: ~4.5 million Epoch 2: ~4.3 million	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC archive containing Epoch 1 only and Epoch 2 only sources with 0.6 and 12 second frame photometry bandmerged with 2MASS and 6X2MASS; includes more sources and more source fluxes (fewer nulled wavelengths), see §4.2. Faint limits[b] for Epoch 1 (Epoch 2) are 17.5, 17.0, 14.6, and 14.0 mag (17.4, 16.9, 14.6, and 14.0 mag) for IRAC 3.6, 4.5, 5.8, and 8.0 μm, respectively.

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Table 1 – Continued

Source List Title	No. of Sources	Wavelengths (μm)	Content
SAGELMCcatalogOFFIRAC	1612	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC offset position catalog combining Epoch 1 and Epoch 2 data for the off-LMC position centered at RA=82°.25, Dec=–45°.95. High reliability emphasized.
SAGELMCarchiveOFFIRAC	3312	1.24, 1.66, 2.16 (2MASS or 6X2MASS) 3.6, 4.5, 5.8, 8.0 (IRAC)	IRAC offset position archive combining Epoch 1 and Epoch 2 data for the off-LMC position centered at RA=82°.25, Dec=–45°.95. Includes more sources and more fluxes than SAGELMCcatalogOFFIRAC, but is less reliable.
SAGELMCcatalogMIPS24	Epoch 1: 41,346; Epoch 2: 40,173	24 (MIPS)	MIPS 24 μm catalog containing Epoch 1 only and Epoch 2 only sources; high reliability emphasized. To assure high reliability, stringent criteria were applied to the source list extracted from the 24 μm Epoch 1 and Epoch 2 image AOR mosaics. Faint limit for both epochs is 10.2 mag.
SAGELMCfullMIPS24	Epoch 1:	24	MIPS 24 μm full list containing *all*

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Table 1 – Continued

Source List Title	No. of Sources	Wavelengths (μm)	Content
	164,971 Epoch 2: 160,171	(MIPS)	Epoch 1 only and Epoch 2 only sources extracted from the 24 μm Epoch 1 and Epoch 2 image AOR mosaics. Faint limit is ∼11.3 for both epochs. This is a list of sources with lower reliability than the catalog.
SAGELMCcatalogMIPS70	Epoch C[a] 2003	70 (MIPS)	MIPS 70 μm catalog based on the combined Epoch 1 and Epoch 2 data. To assure high reliability, stringent criteria were applied to the source list extracted from the 70 μm full mosaic. The faint limit is 3.4 mag.
SAGELMCfullMIPS70	Epoch C[a] 15189	70 (MIPS)	MIPS 70 μm full list based on the combined Epoch 1 and Epoch 2 data. It contains *all* the sources extracted from the 70 μm full mosaic. The faint limit is 4.4 mag. This is a list of sources with lower reliability than the catalog.
SAGELMCcatalogMIPS160	Epoch C[a] 381	160 (MIPS)	MIPS 160 μm catalog based on the combined Epoch 1 and Epoch 2 data.

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Table 1 – Continued

Source List Title	No. of Sources	Wavelengths (μm)	Content
			To assure high reliability, stringent criteria were applied to the source list extracted from the 160 μm full mosaic. The faint limit is -0.6 mag.
SAGELMCfullMIPS160	Epoch C[a] 4154	160 (MIPS)	MIPS 160 μm full list based on the combined Epoch 1 and Epoch 2 data. It contains *all* the sources extracted from the 160 μm full mosaic. The faint limit is 0.6 mag. This is a list of sources with lower reliability than the catalog.
SAGELMC_IRACCatalog_E1E2Match ..	647865	3.6, 4.5, 5.8, 8.0 (IRAC)	Supplementary table containing multi-epoch IRAC data for all the sources detected in both epochs of the IRAC Catalog. Averaged fluxes and the variability indices are provided for each IRAC band.
SAGELMC_IRACArchive_E1E2Match ..	668718	3.6, 4.5, 5.8, 8.0 (IRAC)	Supplementary table containing multi-epoch IRAC data for all the sources detected in both epochs of the IRAC Archive. Averaged fluxes and

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Table 1 – Continued

Source List Title	No. of Sources	Wavelengths (μm)	Content
			the variability indices are provided for each IRAC band.
SAGELMC_MIPS24Catalog_E1E2Match	24810	24 (MIPS)	Supplementary table containing multi-epoch MIPS 24 μm data for all the sources detected in both epochs of the MIPS 24 μm Catalog. Averaged MIPS 24 μm fluxes and the variability indices are provided.
SAGELMC_MIPS24Full_E1E2Match ...	43838	24 (MIPS)	Supplementary table containing multi-epoch MIPS 24 μm data for all the sources detected in both epochs of the MIPS 24 μm Full List. Averaged MIPS 24 μm fluxes and the variability indices are provided.

[a] Epoch C data is the combined Epoch 1 and Epoch 2 data.

[b] The IRAC/MIPS 'faint limit' is defined as the point where 99% of IRAC/MIPS sources (with a non-NULL entry for that IRAC/MIPS band) are brighter than that quoted faint limit.

Table 2. SAGE-LMC Images

Image	Pixel Size ($''$)	Description
SAGE_LMC_IRAC*_2_mosaic.fits ……… SAGE_LMC_IRAC*_2_resid.fits ………	2	IRAC $8^\circ \times 8^\circ$, $2''$ pixel mosaic and residual images combining Epoch 1 and Epoch 2 12 second frametime data for each IRAC band (* = 3.6, 4.5, 5.8, 8.0).
SAGE_LMC_IRAC*_1.2_mosaic.fits ……… SAGE_LMC_IRAC*_1.2_resid.fits ………	1.2	IRAC $8^\circ \times 8^\circ$, $1.''2$ pixel mosaic and residual images combining Epoch 1 and Epoch 2 12 second frametime data for each IRAC band (* = 3.6, 4.5, 5.8, 8.0).
SAGE_LMC_IRAC*_tileTN.fits ………	0.6	IRAC $1.^\circ2 \times 1.^\circ2$, $0.''6$ pixel tiles combining Epoch 1 and Epoch 2 12 second frametime data for each IRAC band (* = 3.6, 4.5, 5.8, 8.0, TN is a tile number).
SAGE_LMC_OFF_IRAC*.fits ………	0.6	IRAC $0.''6$ pixel $0.^\circ9 \times 0.^\circ6$ mosaics using the 2 second frametime data of the LMC offset position centered at RA=$82.^\circ25$, Dec=–$45.^\circ95$ (* = 3.6, 4.5, 5.8, 8.0).

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Table 2 – Continued

Image	Pixel Size (″)	Description
		Epoch 1 and Epoch 2 12 second frametime data are combined.
SAGE_LMC_IRAC∗_E1.earliest_obstime.fits SAGE_LMC_IRAC∗_E1.latest_obstime.fits SAGE_LMC_IRAC∗_E2.earliest_obstime.fits SAGE_LMC_IRAC∗_E2.latest_obstime.fits	2.0	Fits images that display the earliest and latest observational times for any given area observed by SAGE for each of the 2 SAGE epochs and for each of the 4 IRAC channels (* = 1,2,3,4). Image units are minutes, corresponding to the number of minutes past Julian Date 2453500.5. See Section 4.3 for details.
SAGE_LMC_MIPS24_E1.fits	2.49	MIPS 24 μm Epoch 1 full mosaic. Not on the IRAC/MIPS common projection. Optimizes coverage versus file size
SAGE_LMC_MIPS24_E2.fits	2.49	MIPS 24 μm Epoch 2 full mosaic. Not on the IRAC/MIPS common projection. Optimizes coverage versus file size
SAGE_LMC_MIPS24_E12.fits	2.49	MIPS 24 μm full mosaic combining Epoch 1

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Table 2 – Continued

Image	Pixel Size (″)	Description
		and Epoch 2 data. Not on the IRAC/MIPS common projection. Optimizes coverage versus file size
SAGE_LMC_MIPS24_E1_rotated.fits	2.49	MIPS 24 μm Epoch 1 full mosaic The image is cropped at the edges (off-LMC area) to keep the size of the image comparable to the original MIPS 24 μm Epoch 1 mosaic (SAGE_LMC_MIPS24_E1.fits).
SAGE_LMC_MIPS24_E2_rotated.fits	2.49	MIPS 24 μm Epoch 2 full mosaic. The image is cropped at the edges (off-LMC area) to keep the size of the image comparable to the original MIPS 24 μm Epoch 2 mosaic (SAGE_LMC_MIPS24_E2.fits).
SAGE_LMC_MIPS24_E12_rotated.fits	2.49	MIPS 24 μm full mosaic combining Epoch 1 and Epoch 2 data. The image is cropped at the edges (off-LMC area) to keep the size of the image comparable to the original MIPS 24 μm mosaic (SAGE_LMC_MIPS24_E12.fits).

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Table 2 – Continued

Image	Pixel Size (″)	Description
SAGE_LMC_tile_MIPS24_TN.fits . . . . SAGE_LMC_tile_MIPS24_TN_wt.fits SAGE_LMC_tile_MIPS24_TN_residual.fits	2.49	24 μm $1^{\circ}\!.1 \times 1^{\circ}\!.1$ tiles combining Epoch 1 and Epoch 2 data (∗TN.fits, where TN is a tile number from 1 to 85); a weight map (∗TN_wt.fits, # of measurements per pixel), and a point source subtracted image (∗TN_res.fits). See Appendix F.3 for details.
SAGE_LMC_MIPS70_E12.fits . . . . SAGE_LMC_MIPS70_E12_wt.fits SAGE_LMC_MIPS70_E12_residual.fits	4.80	MIPS 70 μm full mosaic combining Epoch 1 and Epoch 2 data (∗E12.fits), a weight map (∗E12_wt.fits), and a point source subtracted image (∗E12_res.fits).
SAGE_LMC_MIPS160_E12.fits . . . . SAGE_LMC_MIPS160_E12_wt.fits SAGE_LMC_MIPS160_E12_residual.fits	15.6	MIPS 160 μm full mosaic combining Epoch 1 and Epoch 2 data (∗E12.fits), a weight map (∗E12_wt.fits), and a point source subtracted image (∗E12_res.fits).

2. Overview of the *Spitzer* SAGE Survey of the LMC

The SAGE project is a Cycle 2 legacy program on the *Spitzer* Space Telescope, entitled, "Spitzer Survey of the Large Magellanic Cloud: Surveying the Agents of a Galaxy's Evolution (SAGE)", with Margaret Meixner (STScI) as the PI. The project overview and initial results are described in a paper by Meixner et al. (2006). The main characteristics of the survey are listed in Table 3. The LMC was mapped at two different epochs dubbed Epochs 1 and 2 separated by 3 months, because it provides a 90-degree roll angle in the orientation of the detectors, which optimally removes the "striping" artifacts in MIPS and artifacts along columns and rows in the IRAC image data. In addition, these two epochs are useful constraints of source variability expected for evolved stars and some young stellar objects (YSOs). Note, the sensitivities for the complete survey are listed in Table 3 are for the whole survey, whereas the Epoch 1 and Epoch 2 catalogs use only half of the data and thus have less sensitivity (see Meixner et al. 2006 for more details). Not all sources in the SAGE catalog belong to the LMC. Meixner et al. (2006) derived preliminary estimates of 18% and 12% for Milky Way foreground and background galaxy contributions to the SAGE catalog, respectively.

The catalogs and archives in this delivery, shown in Table 1, were produced by the IRAC pipeline (Univ. of Wisconsin) and MIPS pipeline (Univ. of Arizona/STScI) and ingested into a SAGE database for review and the production of the matched catalogs and sources lists (e.g. variability index by Vijh et al. 2009), SAGE Team use and staging area for releases (STScI).

3. Brief Overview of the IRAC Source Lists and their Usage

There are several SAGE LMC IRAC source lists, detailed in Table 1:

1. Single frame + mosaic photometry (SMP), Catalog and Archive
2. Epoch 1 only (EP1) and Epoch 2 only (EP2) single frame photometry, Catalog and Archive
3. SAGE offset position (single frame photometry), Catalog and Archive

Most users will want to use the single frame + mosaic photometry (SMP) catalog or archive, described in §5. The Catalog is a more highly reliable list of 6.4 million sources, and the Archive is a more complete list both in number of sources (at 6.9 million) and flux measurements at each wavelength (less nulling of fluxes). The main differences between the Catalog and Archive are 1) fluxes brighter than a threshold that marks a nonlinear regime are nulled (removed) in the Catalog; 2) sources within $2''$ of another are culled

Table 3. Principal Characteristics for SAGE Survey: *Spitzer* program ID 20203

Characteristic	IRAC Value	MIPS Value
Nominal Center Point	RA(J2000): 5^{h} 18^{m} 48^{s}	RA(J2000): 5^{h} 18^{m} 48^{s}
	Dec(J2000): -68° 34′ 12″	Dec(J2000): -68° 34′ 12″
Survey area	7.1° × 7.1°	7.8° × 7.8°
AOR size, grid size	1.1° × 1.1°, 7 × 7	25′ × 4°, 19 × 2
Total time (hrs)	290.65	216.84
λ (μm)	3.6, 4.5, 5.8, and 8.0	24, 70, and 160
Pixel size at λ	1.″2, 1.″2, 1.″2, 1.″2	2.″5, 9.″8, 15.″9
Angular resolution at λ	1.″7, 1.″7, 1.″9, 2.″0	6″, 18″, 40″
Exposure time/pixel at λ (s) .	43, 43, 43, 43	60, 30, 6
Faint limits[a] (mJy)	SMP Catalog:	Catalog:
	0.016, 0.018, 0.087, 0.134	0.6 (E1&E2), 34.3, 281.2
	SMP Archive:	Full List:
	0.013, 0.012, 0.066, 0.070	0.2 (E1&E2) , 14, 90.5
Faint limits[a] (mag)	SMP Catalog:	Catalog:
	18.1, 17.5, 15.3, 14.2	10.2 (E1&E2) , 3.4, -0.6
	SMP Archive:	Full List:
	18.3, 17.9, 15.6, 14.9	11.3 (E1&E2) , 4.4, 0.6
Saturation limits (Jy) at λ . . .	1.1, 1.1, 7.4, 4.0	4.1, 23, 3
Saturation limits (mag) at λ .	6.0, 5.5, 3.0, 3.0	0.60, -3.7, -3.2
Epoch 1	July 15-26, 2005	July 27 - Aug. 3, 2005
Epoch 2	Oct. 26 - Nov. 2, 2005	Nov. 2-9, 2005

[a]The IRAC/MIPS 'faint limit' is defined as the point where 99% of IRAC/MIPS sources (with a non-NULL entry for that IRAC/MIPS band) are brighter than that quoted faint limit.

(removed) from the Catalog, whereas the Archive allows sources as close as 0.″5 from another; 3) sources within the PSF profile of a saturated source are culled from the Catalog but not the Archive; and 4) the Catalog has higher signal-to-noise thresholds and slightly more stringent acceptance criteria (e.g., number of detections in various bands, §5.2) . Users who want a more "bullet-proof" list and don't want to have to get as familiar with the source quality flags, or who will be doing the kind of analysis that does not allow for manual inspection of very many source Spectral Energy Distributions (SEDs), should use the Catalog. Users who want more complete SEDs and source lists, and are willing to invest time to understand the source quality flags, can make use of the Archive. This allows the use of upper limits for fluxes that are nearly saturated, more data points at lower signal-to-noise, more sources in crowded regions, and more sources in the wings of saturated sources. Using the source quality flag, these sources can be identified and should be more carefully inspected to verify their quality. Both Archive and Catalog users can improve the quality of their data by paying attention to the source quality flag, as well as other diagnostic information such as the close source flag and close fulls flag (see Appendix C).

Users interested in variability of sources will want to make use of the EP1 and EP2 source lists and the matched EP1 and EP2 lists. These contain fewer sources (4.3 million in the EP1 catalog, and 4.5 million in the EP1 Archive) than the SMP lists for 3 reasons: 1) they are based on single-frame photometry so each frame is effectively 1/4 the integration time of the mosaic image, 2) they have half as much total integration time on each sky position, and 3) photometry is done on the frames without cosmic ray removal. Therefore we had to use much more stringent source-selection criteria (§4.2) which has the side effect of removing some real sources in addition to cosmic rays. As a result, there are approximately 3 million sources that appear in both the Epoch 1 and Epoch 2 source lists. For the mosaic photometry lists, cosmic rays were removed in the mosaic-process, before photometry.

The SAGE offset position is a region of $0.^\circ9 \times 0.^\circ6$ in size located about $25.^\circ8$ from the LMC center. This is a region of "empty sky" in which source lists can be compared to estimate the number density of foreground Galactic and background extragalactic sources in the LMC fields.

4. IRAC Epoch 1 and Epoch 2 Catalog and Archive

The Epoch 1 and Epoch 2 observations are described in §2 and Table 3. The single-epoch point source lists were extracted from IRAC Epoch 1 and Epoch 2 single frame images processed with the SSC pipeline version S13.2 and later using a modified version of DAOPHOT (Stetson 1987) to perform the PSF fitting. The array-location-dependent photometric corrections[a] were applied to the source lists. The Wisconsin IRAC pipeline, which was originally developed to process the GLIMPSE data (Benjamin et al. 2003), is described by the GLIMPSE pipeline documents[b]. This pipeline was modified for the SAGE project to handle the high dynamic range (HDR) data and longer exposure times. Details for the SAGE IRAC processing can be found in Meixner et al. (2006). Here we summarize the bandmerging process and the criteria for selection of the point sources in the catalog (SAGELMCcatalo-

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[a]http://ssc.spitzer.caltech.edu/irac/locationcolor/

[b]http://www.astro.wisc.edu/glimpse/docs.html

gIRAC_EP1_EP2) and the archive (SAGELMCarchiveIRAC_EP1_EP2) after the sources are extracted from the images.

4.1. Bandmerging to Produce Epoch 1 and Epoch 2 Source Lists

The point source lists are merged at two stages using a modified version of the SSC bandmerger[c]. Before the first stage, source detections with signal-to-noise (S/N) less than 3 are culled. During the first stage, or in-band merge, all detections at a single wavelength are combined using position, S/N and flux to match the sources. The 0.6 second flux is included if the signal-to-noise is greater than (5,5,5,7) and the magnitudes are brighter than (12,11,9,9), for the four IRAC bands [3.6],[4.5],[5.8], and [8.0], respectively. This prevents Malmquist bias for the 0.6 second data from affecting the results. The 12 second flux is included if the magnitude is fainter than the saturation limit of (9.5, 9.0, 6.5, 6.5) for the four IRAC bands [3.6], [4.5], [5.8], and [8.0], respectively. When both criteria are met, the 0.6 and 12 second fluxes are combined, weighted by the propagated errors. Fluxes of sources within 1.″6 in the IRAC frame are combined together or "lumped" into one flux.

The second stage, or cross-band merge, combines all wavelengths for a given source position using only position as a criterion in order to avoid source color effects. Cross-band lumping is done with a 1.″6 radius. Position migration can still occur in the bandmerging process which results in a small number of sources that have sources within 1.″6 of it. In the cross-band merge stage we also merge with a combined All-Sky 2MASS (Skrutskie et al. 2006) and 6X2MASS point source list (Cutri et al. 2008; details on how that combined list was made can be found in Appendix B). Note that we only propagate a subset of the 2MASS quality flags and information, and users should refer to the original 2MASS and 6X2MASS catalogs available through IRSA for full information. We include the unique numeric identifier assigned by the 2MASS project "cntr" (TmassCntr in the SAGELMCcatalogIRAC_EP1_EP2 and SAGELMCarchiveIRAC_EP1_EP2) to allow this cross-referencing. All the sources with TmassCntr $<$ 1E+08 come from the 6X2MASS catalog, and the sources with TmassCntr $>$ 1E+08 are from the All-Sky 2MASS catalog.

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[c]http://ssc.spitzer.caltech.edu/postbcd/bandmerge.html

4.2. Epoch 1 and Epoch 2 Catalog and Archive Criteria

Our source list criteria have been developed to ensure that each source is a legitimate astronomical source (*culling* criteria) and that the fluxes reported for the IRAC bands are of high quality (*nulling* fluxes if they do not meet quality standards).

4.2.1. Culling Criteria - is it a real source?

The IRAC single epoch source lists were produced from photometry on individual BCD frames. The 12 second exposures suffer from cosmic rays. For this reason, stringent selection criteria were developed to limit false sources. To ensure high reliability of the final point-source Catalog (SAGELMCcatalogIRAC_EP1_EP2) by minimizing the number of false sources, we adopt the following selection criteria: Given M detections out of N possible observations (see Appendix C.5), we require that $M/N \geq 0.6$ in one band (the selection band), and $M/N \geq 0.32$ in an adjacent band (the confirming band), with a $S/N > 5$, 5, 5, 7 for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively. The 2MASS K_s band is counted as a detection. As an example, a source is typically observed twice at 0.6 second and twice at 12 seconds for a total of four possible observations in each band. Such a source detected three times in band [3.6] with $S/N > 5$, and twice in band [4.5] with $S/N > 5$ would be included in both the Catalog and Archive. For a typical source, extracted from 2×12 sec frametime images, the minimum detection criterion ($M/N \geq 0.32$) amounts to being detected twice in one band (usually band 1 or 2) and once in an adjacent band. Thus, we sometimes refer to this as the 2+1 criterion. In our source selection process, we don't allow fluxes in bands with hot or dead pixels within 3 pixels of source center, those in wings of saturated stars, and/or those within 3 pixels of the frame edge. Sources are also culled when they are too close to another source because this neighboring source could influence the flux for the source: We use the Archive list to search for near neighbors, and cull from the Catalog sources within $2''$

For the Archive (SAGELMCarchiveIRAC_EP1_EP2), the culling criteria are less stringent. The M/N and S/N criteria are the same as for the Catalog to limit false sources caused by cosmic rays. The close source criteria is relaxed: Sources are removed from the Archive if there are neighboring Archive sources within $0\farcs5$ of the source.

4.2.2. Nulling Criteria - ensuring high quality fluxes

A source may be reliably detected in two bands (usually [3.6] or [4.5]) but have questionable flux in another (usually [5.8] or [8.0]). To ensure high quality fluxes for each source, a flux/magnitude entry for a band in the *Catalog* will be nulled, i.e. removed, for any of the four following reasons: 1) the source is brighter than the 0.6 sec. saturation magnitude limits, 6.0, 5.5, 3.0, 3.0, for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively; 2) the source location is flagged as coincident with a bad pixel; 3) the S/N is less than [6, 6, 6, 10] for IRAC bands [3.6], [4.5], [5.8] and [8.0], respectively in order to mitigate Malmquist bias; 4) for 12-second only data, if M $<$ 2 or M/N is less than 0.6 in order to mitigate faint cosmic ray detections. Note that in HDR mode, data from one epoch (N=4: 2 $\times$ 12 sec observations and 2 $\times$ 0.6 sec observations) having a result with N=2 is not uncommon. Bright sources are only measurable in the 0.6 sec data and faint sources are only measurable in the 12 sec data. Only stars in the intermediate range of brightness will have useful detections in both the 0.6 and 12 sec images. If all fluxes for a source are nulled, the source is removed from the catalog.

For the *Archive*, the nulling criteria are less stringent. The magnitude is nulled if the S/N is less than 5 in that band. For photometry with 12 second only data, if M/N $<$ 0.3 the magnitude is nulled.

The actual null values for the fields in the entry for a source are given in Table 5.

Characteristics of the Epoch 1 only and Epoch 2 only source lists are summarized in Table 1. Since the selection (or culling) criteria are fairly similar between the Catalog and Archive, the total number of sources is not that different (4.3 million vs 4.5 million in Epoch 1). However, the Catalog sources have more fluxes nulled. So, for example, a given source may appear in both the Catalog and Archive but have flux at 2 wavelengths in the Catalog and 4 wavelengths in the Archive.

4.3. Time of Observation Information for each IRAC Source

The time of observation for any given SAGE IRAC source is a complex question. SAGE IRAC sources have been bandmerged from multiple imaged frames. Each area of the sky was observed at least 2 times for each epoch, and at each observing time (0.6 and 12 second in HDR mode) in the 4 IRAC bands. The [3.6] and [5.8] bands see a different area of the sky as the [4.5] and [8.0] bands during an observation. Thus a SAGE source with entries in all 4 bands will consist of measurements made from several different times. Since SAGE was observed in HDR mode, each area of the sky was observed a minimum of 4 times, and in overlap areas the number can rise to more than 10 unique observations for some limited strips of data. Because of this complication we have provided time-of-observation information in a broad sense. We provide FITS images that display the earliest and latest observational times for any given area observed by SAGE for each of the two SAGE epochs and for each of the 4 IRAC channels. The FITS files are in units of minutes and correspond to the number of minutes after Julian Date 2453500.5. In this fashion, any SAGE source with a given RA and Dec can be cross referenced with these FITS files to determine the time period within which those results were taken by epoch and by channel. We also provide an IDL program (get_sage_jd.pro) which shows how to use these timestamp FITS files.

5. IRAC Single Frame + Mosaic Photometry Catalog and Archive

The Single Frame + Mosaic Photometry (SMP) Catalog (SAGELMCcatalogIRAC) and Archive (SAGELMCarchiveIRAC) are a combination of mosaic photometry and the single frame photometry Epoch 1+2+3 source lists. Epoch 3 includes data from the re-observations of bad or missing frames. Epoch 1+2+3 source lists were derived from doing photometry on individual IRAC frames, then doing an error-weighted average of those results for each band. For each epoch there were two 12 sec frames and two 0.6 sec frames. Potentially, a result for one band could be an average of 4 (or more if in overlap areas) detections. The number of actual detections (M) and number of possible detections (N) are part of each source entry. For the all-epoch source lists (Epoch 1+2+3), all the possible frames were used in the bandmerging to produce the fluxes. The mosaic photometry was done on the 12 second frametime mosaiced images (mosaics of combined Epoch 1 and Epoch 2) which have been cleaned of most of the instrument artifacts, including cosmic rays (CRs) (which are abundant in the single frames). Stray light areas are also removed from the mosaics but are in the single IRAC frames. Then, the mosaic photometry results were merged with the epochs 1+2+3 single frame photometry results and the combined All-SKY 2MASS and 6X2MASS Point Source Catalogs (PSC; see Appendix B). A source entry can have fluxes for the IRAC bands that can come from photometry either on single IRAC frames or mosaic images. For example band 1 and 2 fluxes can come from single frame photometry and band 3 and 4 fluxes can be derived from mosaic photometry. Generally, single frame photometry was used for the brighter sources, and mosaic photometry was used at the fainter end. The Flux Calculation Method Flag (MF) for each band tells you from which data (single frame or mosaic) the flux was taken. This flag is explained in detail in Appendix C.7.

5.1. Bandmerging to Produce Single Frame + Mosaic Photometry Source Lists

Before the in-band merge stage (merging at a single wavelength), source detections with S/N less than 3 are removed, both in the single frame and mosaic photometry. For the single frame photometry (epochs 1+2+3) the 0.6 second flux is included if the signal-to-noise is greater than (5,5,5,7) and the magnitudes are brighter than (12,11,9,9), for the four IRAC bands [3.6],[4.5],[5.8], and [8.0], respectively. The 12 second flux is included if the magnitude is fainter than the saturation limit of (9.5, 9.0, 6.5, 6.5) for the four IRAC bands [3.6], [4.5], [5.8], and [8.0], respectively. When both criteria are met, the 0.6 and 12 second fluxes are combined, weighted by the propagated errors. Fluxes of sources within 1.″6 in the IRAC frame are combined together or "lumped" into one flux. For the single frame photometry data, all detections at a single wavelength are combined using position, signal-to-noise and flux to match the sources. The single frame photometry flux is compared to the mosaic photometry result for that band. The following are the criteria that were used in the in-band bandmerging of the single frame and mosaic photometry. In cases where there were both mosaic and single frame photometry results:

Band1, use mosaic data if mos_mag > 15.0, or SingleFrm_dmag > 0.1,
Band2, use mosaic data if mos_mag > 15.0, or SingleFrm_dmag > 0.1,
Band3, use mosaic data if mos_mag > 13.0, or SingleFrm_dmag > 0.1,
Band4, use mosaic data if mos_mag > 12.0, or SingleFrm_dmag > 0.1,

where mos_mag is the mosaic photometry magnitude and SingleFrm_dmag is the single frame photometry magnitude uncertainty. Effectively this means that fainter mosaic data are more reliable, and single frame data with large uncertainties (dmag > 0.1 mag corresponds roughly to S/N less than 10) are less reliable, provided the mosaic result has a better error.

Source lists from the combined mosaic and single frame photometry are hybrid lists. For bright sources, multiple single-frame extractions using PSF fitting on native images (no rotation, no translation) should provide a more reliable result. However for the fainter sources, mosaiced images will produce much more reliable and deeper results. We chose not to use mosaic results for all brightness levels for the following reason: SAGE LMC data were taken in primarily two epochs with a position angle rotation between those two epochs of roughly 90°. The mosaic image of all-epoch SAGE LMC data therefore produces an image that, when closely scrutinized, reveals bright sources with variable PSFs. The PSFs for all 4 IRAC bands are highly structured. When one looks at the coverage map for any given location in the SAGE field of view (FOV), that position may be covered by non-equal number of frames for each epoch, and thus the PSF will be highly variable across the entire

SAGE FOV. Producing a varying PSF for any given location in the SAGE FOV was not an option in our photometry pipeline processing. For this reason doing PSF fitting on the all-epoch SAGE mosaic image does not produce the best result for the bright end of the SAGE source lists. However, for the faint sources, where the flux is primarily identified in the more uniform core of the PSF, PSF fitting is reliable and well suited for extending the source lists to a fainter limit.

The cross-band merging combines all wavelengths, whether from single frame or mosaic photometry, for a given source position using only position information (not signal-to-noise or flux as in the in-band merge stage) as a criterion in order to avoid source color effects. Cross-band lumping is done with a 1.″6 radius. Position migration can occur in the bandmerging process which results in a small number of sources that are positioned just within 1.″6 of another source at the end of the process. In the cross-band merge stage we also merge with a combined All-Sky 2MASS (Skrutskie et al. 2006) and 6X2MASS point source list (Cutri et al. 2008; details on how that combined list was made can be found in Appendix B).

5.2. Single Frame + Mosaic Photometry Catalog and Archive Criteria

5.2.1. Culling Criteria - is it a real source?

The more stringent M/N criteria used in the single epoch, single frame photometry source lists (see §4.2.1) have been relaxed since we don't need to worry as much about false sources due to cosmic rays in the single frame + mosaic photometry (SMP) source lists.

For the *Catalog*, we require M/N ≥ 0.32 in adjacent bands for fluxes derived from mosaic photometry only or a mix of mosaic and single frame photometry. The 2MASS K_s band can be counted as a detection. Note that for mosaic photometry only, by definition, the possible number of observations N equals the actual detections M, which is equal to 1. A typical case would be that band 1 is derived from single-frame all-epoch photometry. N is typically 4, so we require M $\geq$ 2 in this band. If band 2 is derived from mosaic photometry, M=N=1, so M/N=1; and thus our source selection criteria is met. In addition, we require that one band (the selection band) must have S/N $\geq$ 5,5,5,7 for bands 1 through 4 respectively. The second band (the confirming band) must have S/N $>$ 5. Thus in our example, the S/N must be greater than 5 in both bands 1 and 2.

If all the fluxes are derived from single-frame photometry, then the source selection criteria from the single-epoch Catalog (§4.2.1) apply. A small percentage of sources ($< 2\%$) have only single-frame photometry in all measured bands, but an example would be a source with a magnitude of 12 at bands 1-3 and no detection in band 4. The selection criteria from

§4.2.1 applies.

To weed out some suspect data, for bands 3 and 4 only: If 0.6 sec data was used and M = 1 and N > 3, then we do not use that data as a confirming band in the culling. This case suggests that we have likely extracted a band 3/4 cosmic ray (a bright source that comes from 0.6 sec data should really be detected every time. If not, it's likely either a cosmic ray or it's saturated and highly unreliable). This occurred in only a handful of sources out of several million but is straightforward to remove with this method.

Close source flag culling is the same as for the single epoch photometry lists. For the Catalog, sources are culled if an Archive source is within 2.″0 of the source.

The culling criteria for the *Archive* is the same as for the Catalog, except the selection bands do not need to be adjacent. Close source flag culling is the same as for the single epoch photometry lists. For the Archive, sources are culled if an Archive source is within 0.″5 of the source.

5.2.2. Nulling Criteria - ensuring high quality fluxes

The nulling (removal of poor quality fluxes) of individual magnitudes is different for the Catalog and Archive. For the Catalog, we null at higher S/N threshholds and require that if mosaic photometry was used for a particular band, then the single frame photometry result (extracted flux) must be present. This is intended to weed out the lower-reliability faint end of the particular band. If all fluxes for a source are nulled, the source is removed from the source list.

Bands with S/N $<$ 6,6,6,10 for bands 1, 2, 3 and 4 respectively are nulled for the *Catalog*. The flux is nulled if the method flag indicates ($>$ 12353 but $<$ 16384) the mosaic photometry was lumped with the single frame photometry in the in-band merge, indicating severe confusion. The flux is nulled if the method flag is 12288, which means the mosaic data was present and used but there was no single frame photometry result present (no flux extracted or the flux had a S/N $<$ 3). The band 3 or 4 flux is nulled if its method flag is 3, 67 or 4099 (0.6 sec data used) and M=1, with N $>$ 3 (likely a cosmic ray). See Appendix C.7 for details about the Flux Calculation Method Flag.

If the flux in a band was derived from single-frame photometry, then the nulling criteria described in §4.2.2 also apply here.

For the *Archive*, the nulling criteria are the same as for the Catalog except that the S/N limits are 5,5,5,5 for bands 1, 2, 3 and 4 respectively; and we don't null on method flag

12288, to allow for fainter detections in the Archive.

The actual null values for the various fields in the SMP entry for a source are given in Table 6.

5.3. Adding Sources to the Single Frame + Mosaic Photometry Source Lists

One complication in the choice to produce a hybrid source list–using single frame photometry for the brighter sources and mosaic photometry for the fainter sources–was in the behavior of our pipeline bandmerging software, especially with regard to variable stars. To optimize proper source identification in the bandmerging process, flux is used as a discriminant when merging the data within any given IRAC band (the in-band merge). This is useful when source confusion is an issue, which is the case over a large area of the LMC. When combining results from multiple images into one average result, if two stars of different brightness are physically close (within the matching radius for source matching) the bandmerger will combine the brighter measurements into one source and the fainter into another. In single epoch data, when the multiple exposures are all taken at roughly the same time, this approach is an improvement over a purely positional matching routine in confused regions. However, in multiple epoch data, this method breaks down for the small percentage of sources that are variable. By comparing the Epoch 1 and Epoch 2 sourcelists we discovered these sources which were missing from the automated pipeline bandmerging process for the SMP (single frame + mosaic photometry) source lists. To correct for this, 4839 sources were manually added to the SMP Archive source list, and 4511 sources were manually added to the SMP Catalog source list. Roughly half of these are variable, and the other half are sources that were inadvertently excluded due to their positions being on the boundary of bandmerger grid cells (the bandmerging is done in 1/3 x 1/3 degree grid cells since the overall SAGE coverage is too large to bandmerge at one time). In our final SAGE SMP source lists, we identify the sources that were initially excluded by the automatic pipeline process and then manually inserted by a bit in the Flux Calculation Method Flag, bit 15 (see Appendix C.7).

6. Data Quality Checks

In this section, we describe some quality checks performed on the single-epoch and SMP source lists, including astrometry, photometric precision, photometric accuracy, and completeness.

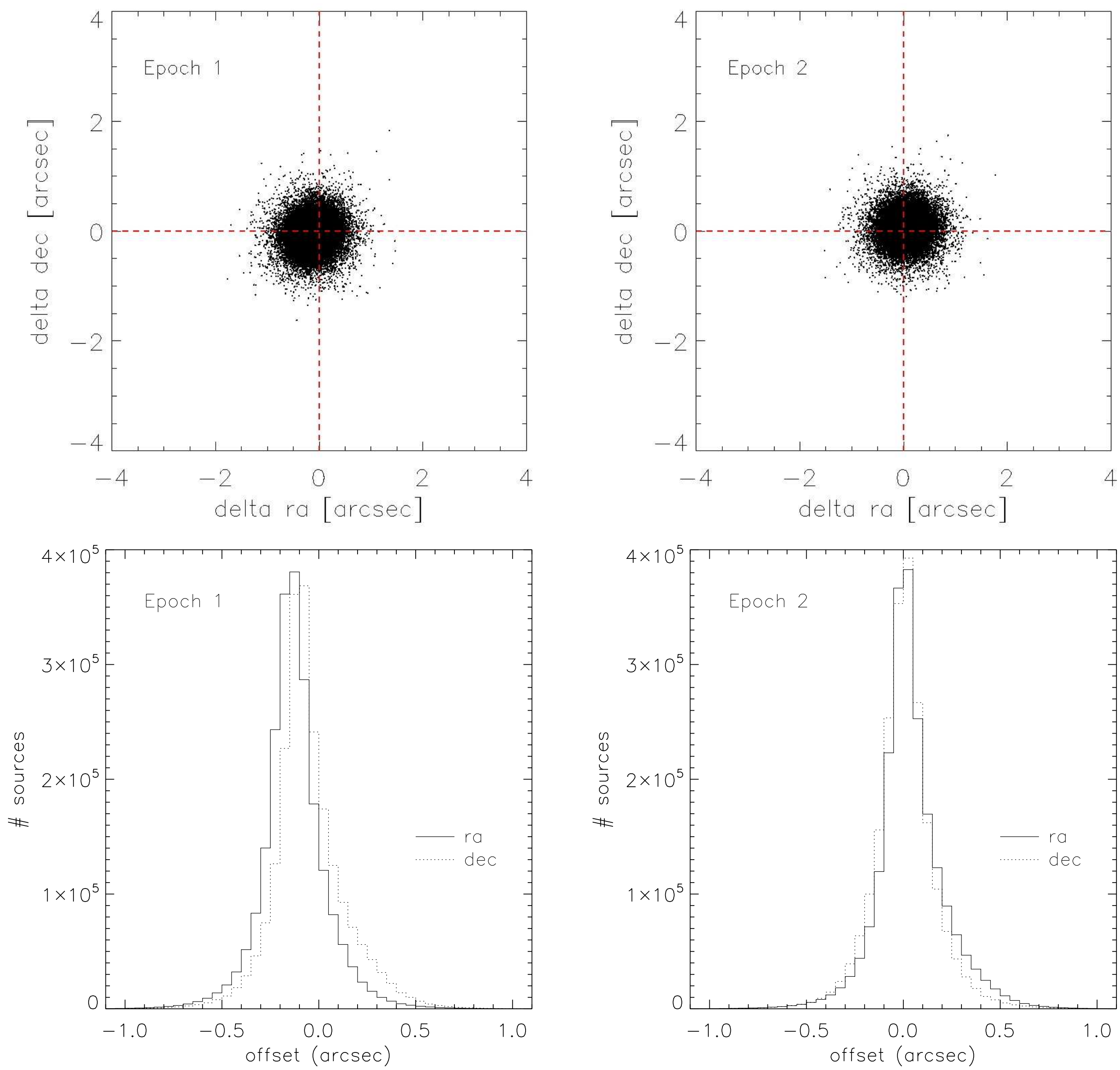

Fig. 1.— The top panels show the scatter plots of the position difference between 100,000 Epoch 1 (*left*) and Epoch 2 (*right*) sources (from SAGELMCcatalogIRAC_EP1_EP2) and their corresponding 2MASS or 6X2MASS catalog positions. The histograms at the bottom quantify the offsets between these two lists (for all ∼2.2 million sources) and show that the average is within the anticipated precision of 0.″3.

6.1. Astrometry

The IRAC catalog astrometry is referenced to the All-Sky 2MASS astrometry through cross matching of the IRAC and All-Sky 2MASS frames. The absolute uncertainty in the 2MASS astrometry is typically $0\farcs3$ (1σ). We determine the astrometric quality of the single epoch Catalogs and Archives (SAGELMCcatalogIRAC_EP1_EP2 and SAGELMCarchiveIRAC_EP1_EP2) by cross checking its positions against the All-Sky 2MASS/6X2MASS catalogs. Note that sources with 2MASS associates have SAGE positions that are in part derived from the 2MASS position.

In Figure 1, we plot the histogram showing the offsets between the Catalog Epoch 1 and Epoch 2 positions and the corresponding All-Sky 2MASS or 6X2MASS positions in 0.05 arcsecond bins. For both Epoch 1 and Epoch 2, the peak of the histogram is within the anticipated precision of $0\farcs3$. The slight difference between the Epoch 1 and Epoch 2 data may be due to the fact that the data were taken 3 months apart with a 90° difference in the spacecraft position angle, so the SSC position solution may be slightly different for each epoch. Both epochs were processed in the same way by our IRAC pipeline.

In Figure 2, we plot the histogram showing the offsets between the single frame + mosaic photometry (SAGELMCcatalogIRAC) positions and the corresponding 2MASS or 6X2MASS positions in $0\farcs05$ bins. This figure shows that the peak of the histogram is within the expected precision of $0\farcs3$.

6.2. Precision and Accuracy of the Photometry

Figures 3 and 4 show the photometric uncertainty for Epoch 1 and Epoch 2, respectively. There is a jump in uncertainties at the brighter magnitudes, e.g. 9.5 at 3.6 μm, which shows the boundary between the 0.6 and 12 second photometry (with the shorter exposure having larger errors).

Figure 5 shows the photometric uncertainty due to the extraction for the SMP (single frame + mosaic photometry) source lists.

The reliability of the flux uncertainties was studied by comparing the quoted error (dFi) with the root mean square (RMS) of the measurements (Fi_rms). For the single frame photometry single epoch source lists, Bands 2 & 4 showed the largest discrepancy. The formal band 2 uncertainties have been decreased 30%, band 3 uncertainties increased 10% and band 4 uncertainties have been increased 35%. Band 1 uncertainties were not changed. A similar analysis was done on the single frame + mosaic photometry source lists. The band

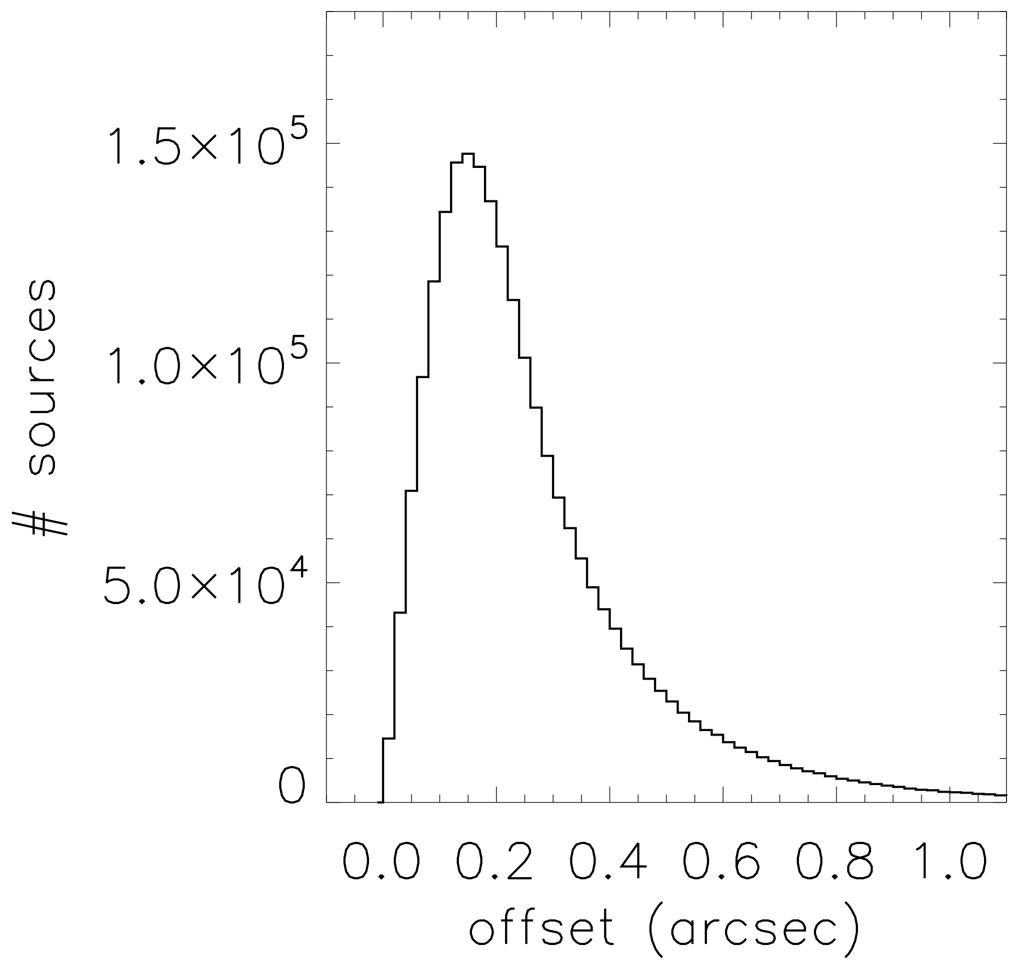

Fig. 2.— The histogram showing the position difference between the SAGELMCcatalogIRAC sources (single frame + mosaic photometry) and their corresponding All-Sky 2MASS/6X2MASS catalog positions. This plot shows that the average offset is within the anticipated precision of 0.″3.

3 uncertainties were increased 10% and the band 4 uncertainties were increased 35%.

To assure that our photometric calibration is uniform across the large area observed by SAGE, and between different AORs, epochs, and wavelengths, we compare our photometry to a network of absolute stellar calibrators custom-built for SAGE. These are 139 A0-A5V or K0-M2III stars selected from SIMBAD; their surface density within the SAGE area is approximately 3 stars per square degree. The techniques used to produce the complete UV to mid-IR absolute spectra are described by Cohen et al. (2003).

Figures 6 and 7 show the excellent agreement between the SAGE magnitudes and the

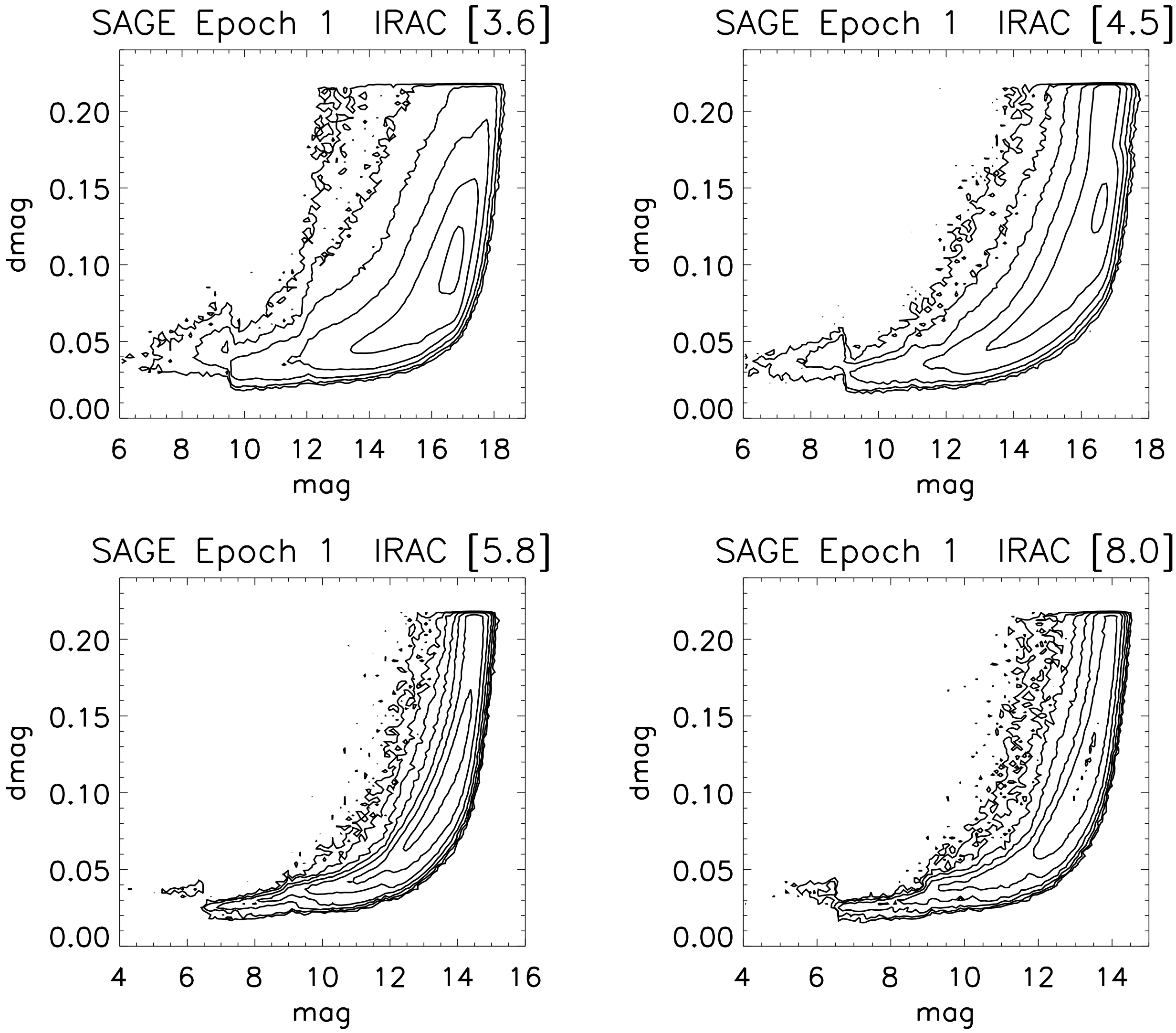

Fig. 3.— Magnitude uncertainty vs. magnitude for each IRAC band in Epoch 1 included in the SAGELMCarchiveIRAC_EP1_EP2. Contours show the density of the sources. The lack of data above dmag of .22 is caused by the criterion that archive data have signal to noise ratios of 5 or better.

predicted magnitudes of the calibration stars for the single epoch IRAC data. Uncertainties in both the extracted magnitudes and those predicted were added in quadrature to produce the plotted error bars. Magnitude differences are much smaller than the one-sigma errors of our photometry. The ensemble averaged differences and standard deviations in the four IRAC bands between SAGE and the predicted magnitudes are -0.011±0.048, 0.019±0.063, 0.008±0.051, 0.008±0.046, for bands 1 through 4, respectively for Epoch 1 and 0.003±0.072, 0.020±0.076, 0.007±0.051, 0.010±0.049, for bands 1 through 4, respectively for Epoch 2.

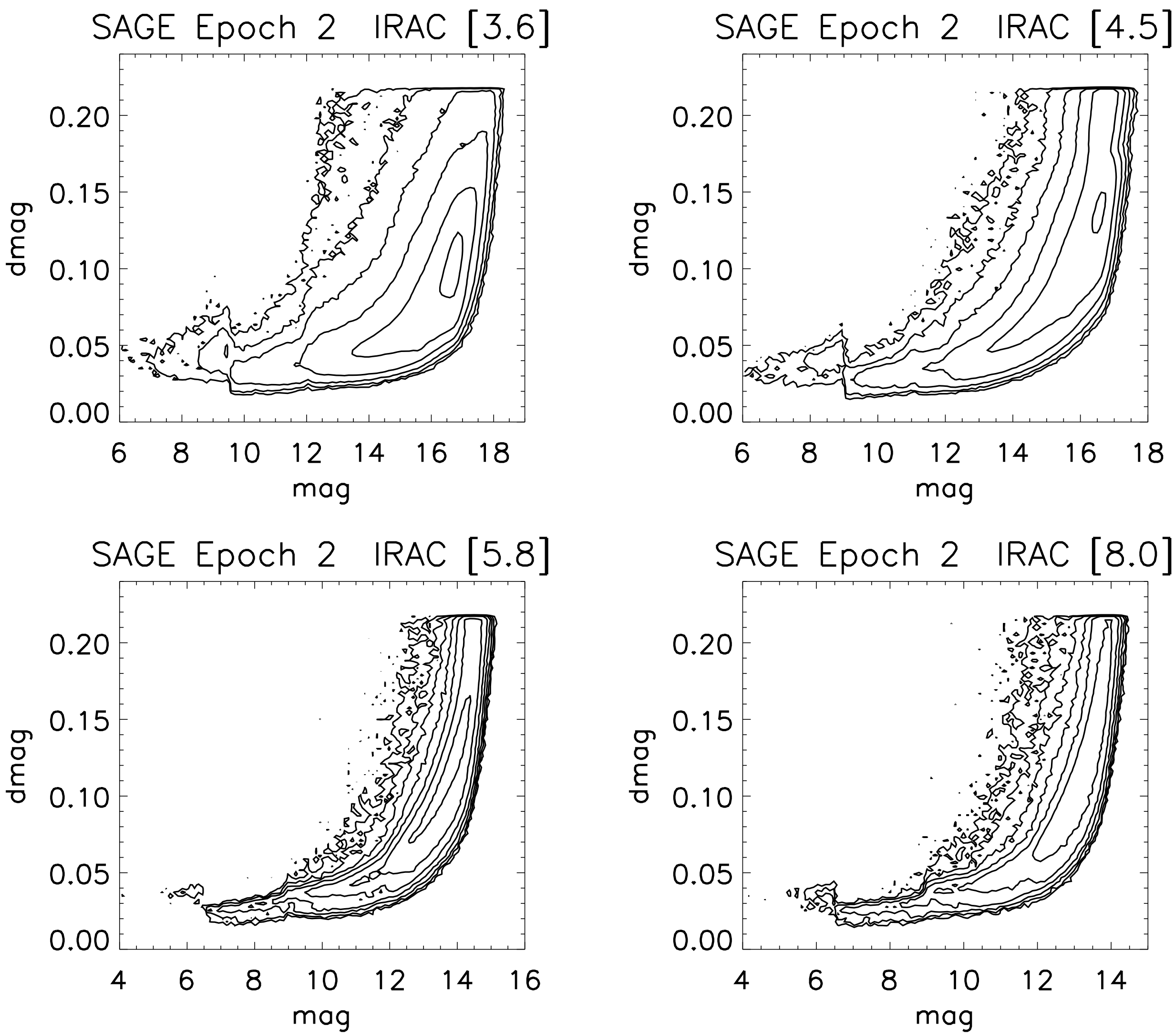

Fig. 4.— Same as Figure 3 for Epoch 2.

The number of calibrators per channel varies due to saturation and varies per epoch due to slight coverage differences. For Epoch 1 SAGE data, the numbers were 74, 105, 134 and 131 flux calibrators while Epoch 2 had 73, 101, 129, and 128 for IRAC [3.6], [4.5], [5.8], and [8.0] respectively.

The comparison of the SMP (single frame + mosaic photometry) data to the SAGE flux calibrators is shown in Figure 8. The ensemble averaged differences and standard deviations in the four IRAC bands between the SAGE SMP and the predicted magnitudes are -0.002±0.049, 0.016±0.058, 0.007±0.050, 0.010±0.046, for bands 1 through 4, respectively. The number of calibrators per channel varies due to saturation and it was 84, 108, 136, and

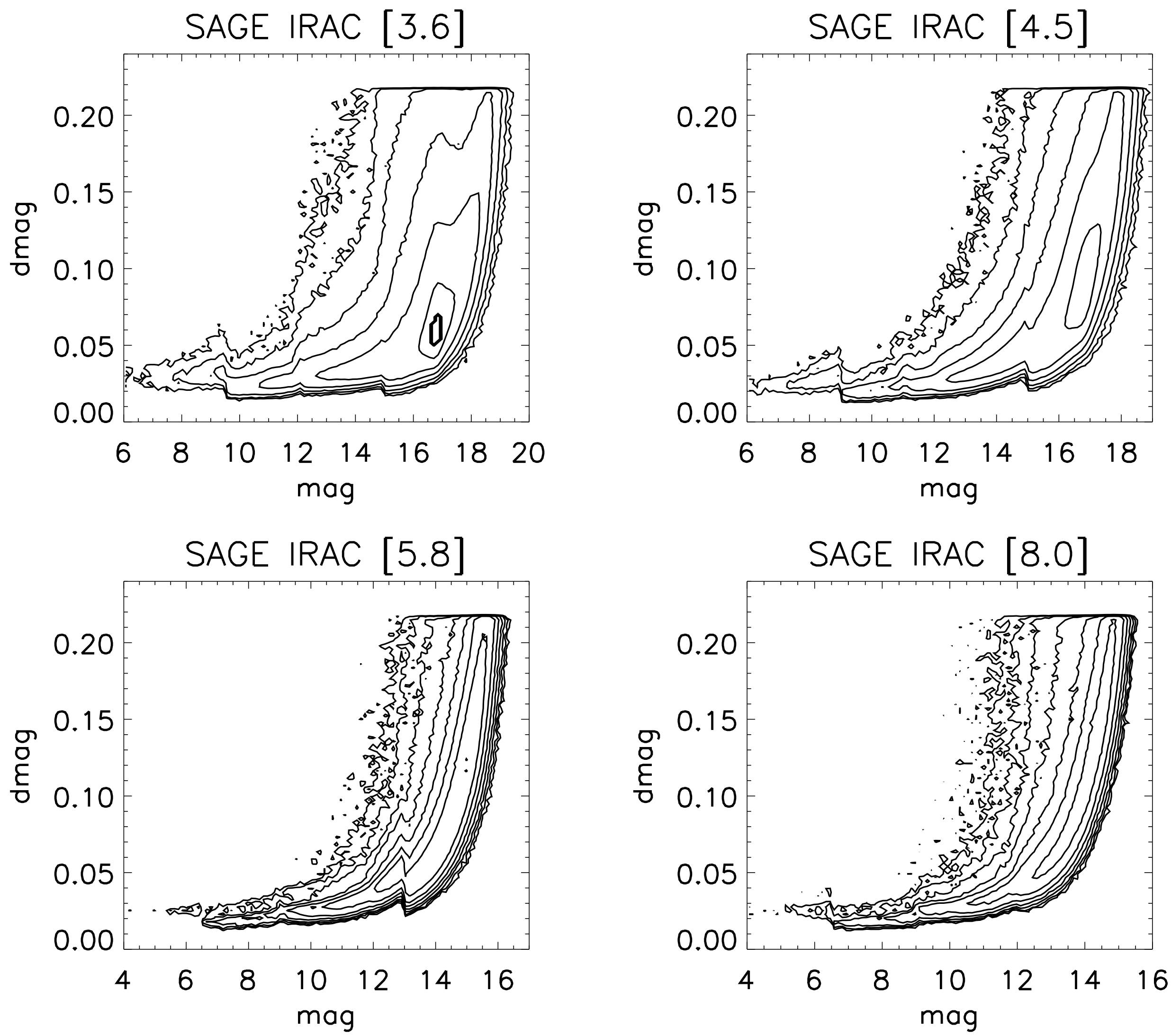

Fig. 5.— Magnitude uncertainty vs. magnitude for each IRAC band in SAGELMCarchiveIRAC (single frame + mosaic photometry). Contours are used to show the density of the sources. The lack of data above dmag of 0.22 is caused by the criterion that archive data have signal to noise ratios of 5 or better. There are two apparent 'discontinuities' in these contour plots. The discontinuity on the bright end is due to the larger uncertainties of the shorter 0.6 sec exposure times. The second discontinuity at the fainter end of each band (noticeable in bands 1 and 2 at mag=15, band 3 at mag=13, and just barely noticeable in band 4 at mag=12) is due to the fact that at these fainter magnitudes we are primarily using mosaic photometry which produces slightly smaller dmag uncertainties.

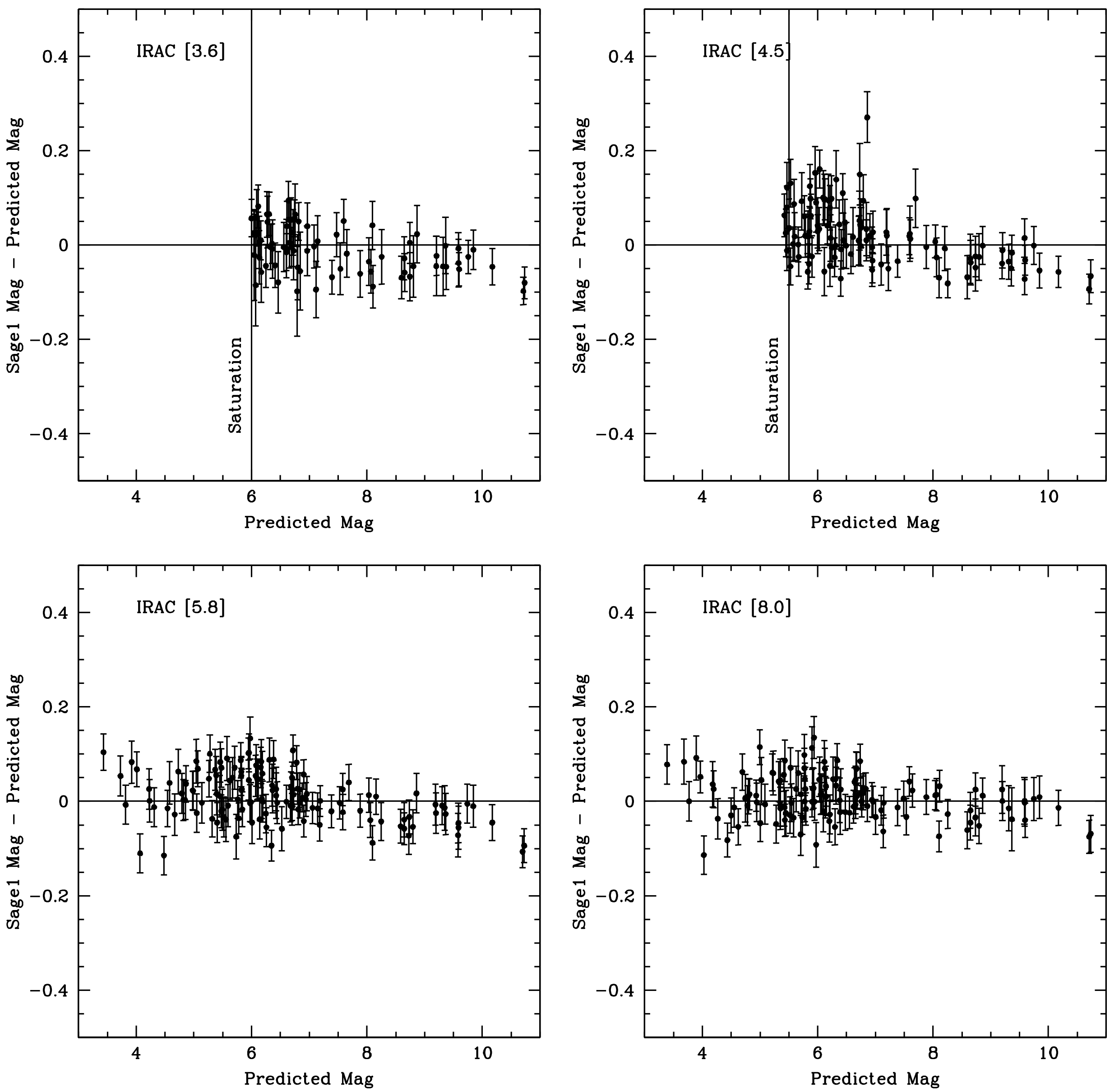

Fig. 6.— Plots demonstrating the quality of the SAGE magnitude measurements in the SAGELMCarchiveIRAC_EP1_E2 for Epoch1. SAGE magnitudes are compared to predictions for 139 calibration stars for each IRAC band. Error bars are the root sum of the squares of the errors of both extracted and predicted magnitudes for each star.

136 for IRAC [3.6], [4.5], [5.8], and [8.0], respectively.

The basis for calibration is identical for 2MASS (Cohen, Wheaton & Megeath 2003) and IRAC (Cohen et al. 2003), with absolute zero points (expressed in Jy for zero magnitude)

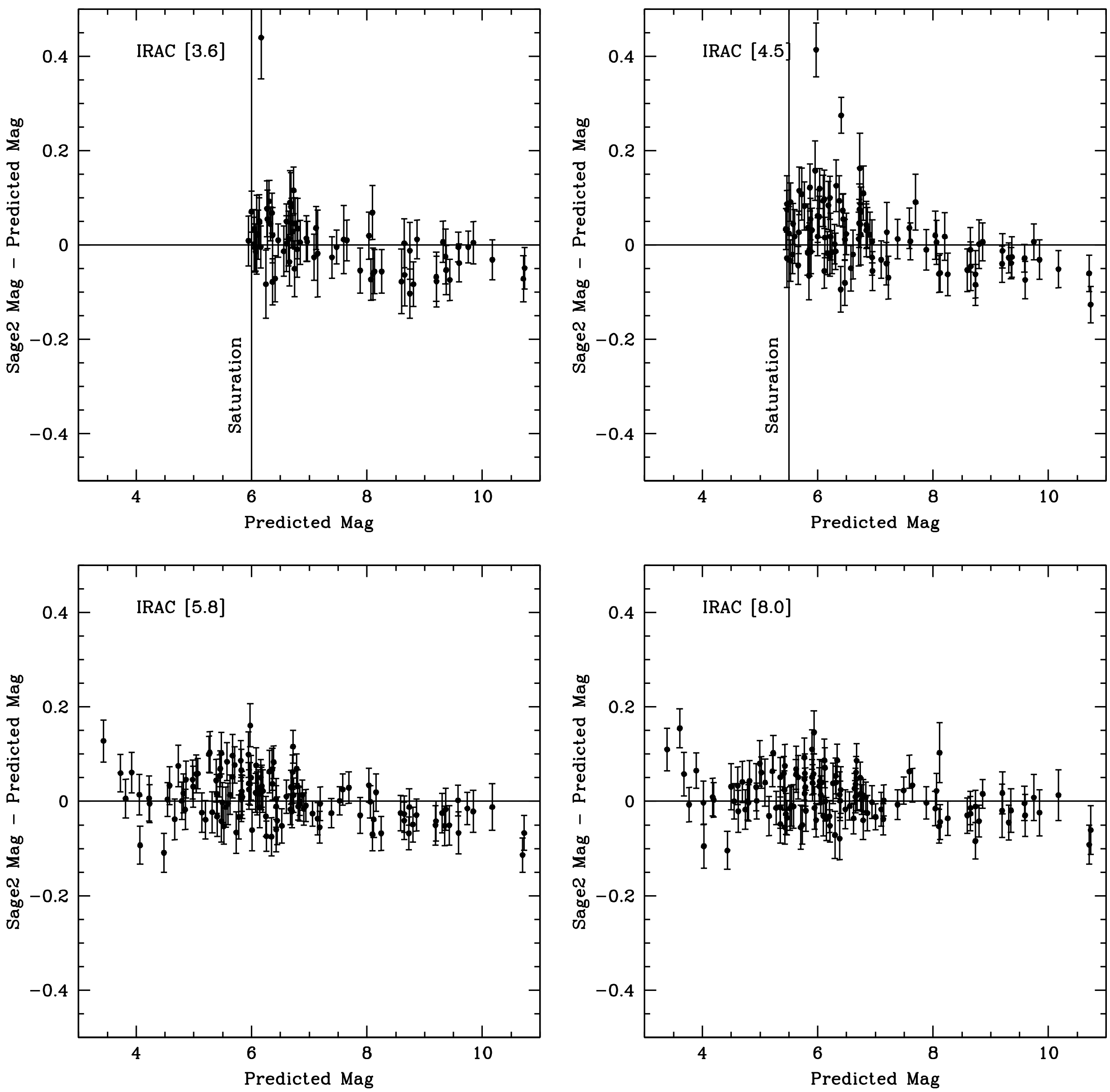

Fig. 7.— Same as Figure 6 for Epoch 2.

for 2MASS J, H, K_s and the IRAC bands (3.6, 4.5, 5.8, and 8.0 μm) of 1594.0, 1024.0, 666.7, 280.9, 179.7, 115.0, 64.13 Jy, respectively. These zero points are tied to the Midcourse Space eXperiment's (MSX) absolute calibration which has an accuracy of ±1.1% (Price et al. 2004). The method employed to produce the SAGE network of calibrators is identical to that used to create the suite of standards at the North Ecliptic Pole (Cohen et al. 2003) from which the IRAC primary calibrators were selected (Reach et al. 2005).

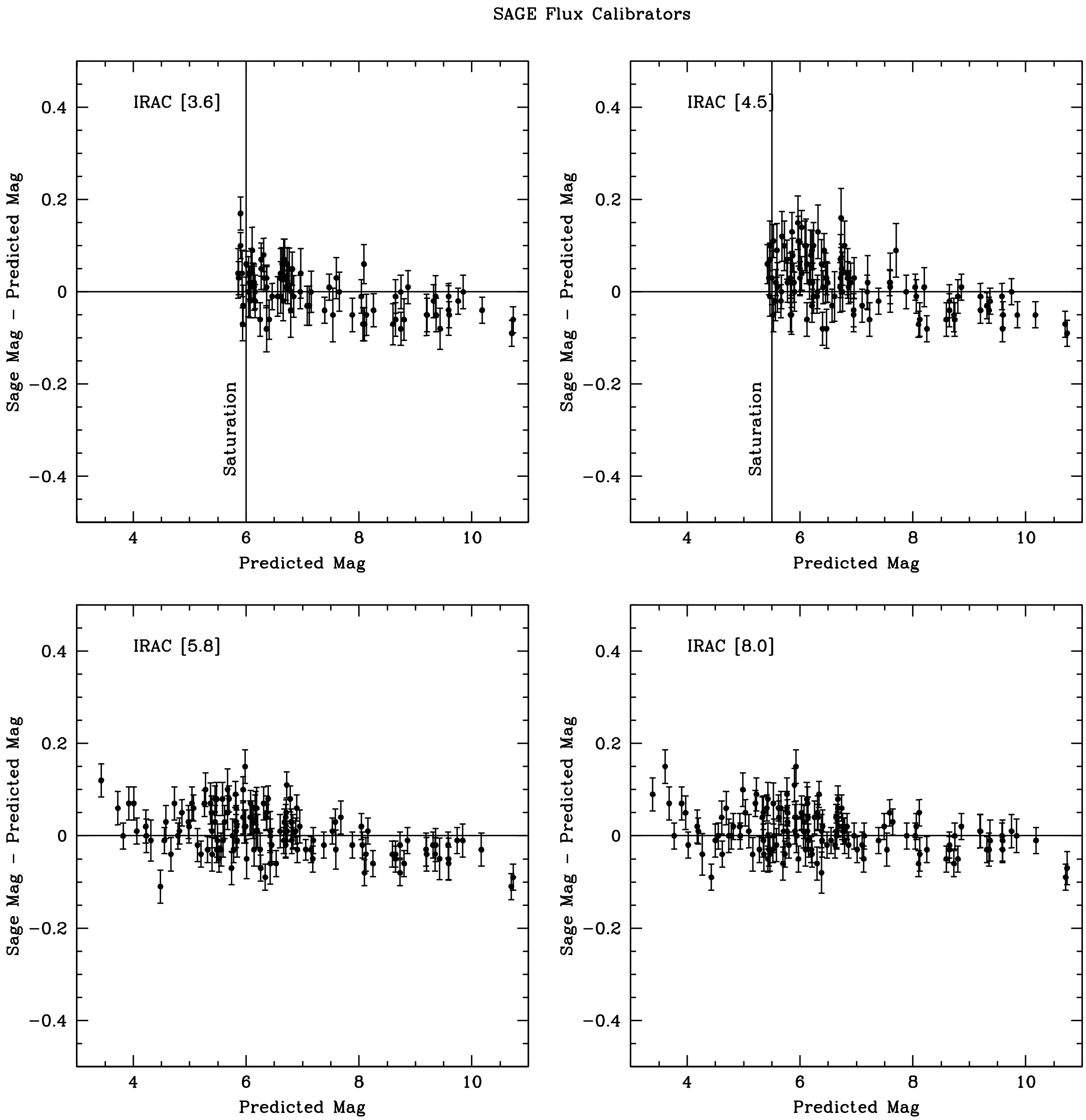

Fig. 8.— Same as Figure 6 for the single frame + mosaic photometry source list (SAGELMCarchiveIRAC).

6.3. Matching between IRAC Epoch 1 and IRAC Epoch 2 Source Lists: Comparison of Photometry and Variability Indices

Figure 9 shows a histogram comparing the fluxes of the IRAC sources detected in both epochs of the SAGE survey. The quantity on the X-axis is the error weighted absolute flux difference $\frac{f_1-f_2}{\sqrt{\sigma f_1^2+\sigma f_2^2}}$, where f_1 and f_2 are the fluxes in the two epochs and σf_1 and σf_2 are the associated errors. This quantity provides the indication of the variability of the sources (variability index V; Vijh et al. 2009). To avoid possibility of a mismatch between the epochs, only the closest matches within $0\farcs9$ (the 3σ value for IRAC photometry) were retained. The different colored lines in the histogram represent the distributions in the different bands. The percentage of matched sources is 78% of Epoch 1 and 81% of Epoch 2, i.e. ~3 million sources are detected in both epochs. More than 99% of the fluxes of the sources in each band (99.5%,99.5%,99.3%,98.8% in 3.6,.4.5, 5.8 and 8 μm bands, respectively) are within 3σ. The fact that most of the fluxes between the two epochs are in agreement confirms the flux measurements.

The SAGE survey provides four supplementary tables SAGELMC_IRACcatalog_E1E2Match, SAGELMC_IRACarchive_E1E2Match, SAGELMC_MIPS24catalog_E1E2Match, and SAGELMC_MIPS24full_E1E2Match containing multi-epoch data for sources detected in both epochs of the IRAC Catalog (SAGELMCcatalogIRAC_EP1_EP2), IRAC Archive (SAGELMCarchiveIRAC_EP1_EP2), MIPS 24 μm Catalog (SAGELMCcatalogMIPS24), and MIPS 24 μm Full List (SAGELMCfullMIPS24), respectively. These tables contain the coordinates in the individual epochs, the respective source designations, the globalsourceids, the average fluxes and the variability indicator V for each band (see Appendix G). Average fluxes are error-weighted average values for each band. Since the fainter sources may suffer from Malmquist bias making them less reliable, the following magnitude cuts were used to only include sources with highly reliable fluxes in SAGELMC_IRACcatalog_E1E2Match and SAGELMC_IRACarchive_E1E2Match tables: 15 mag, 15 mag, 13 mag, and 12 mag at 3.6 μm, 4.5 μm, 5.8 μm, and 8.0 μm, respectively. The same magnitude limits were used to construct the Single Epoch + Mosaic Photometry Catalog and Archive (SAGELMCcatalogIRAC and SAGELMCarchiveIRAC; see §5.1).

Most of the sources in the table have V ~ 0 and users should use appropriate limits on V to choose variable sources. Vijh et al. (2009) who studied the variability of the SAGE sources, required $|V_{band}| > 3$ in at least 2 consecutive bands in the same direction to classify a source as being variable. From ~ 3 million sources common in both epochs they found ~ 2000 variable sources, most of which were classified as asymptotic giant branch (AGB) stars. A large fraction (>66%) of the extreme AGB stars were found to be variable and only smaller fractions of carbon-rich (6.1%) and oxygen-rich (2.0%) stars were detected as

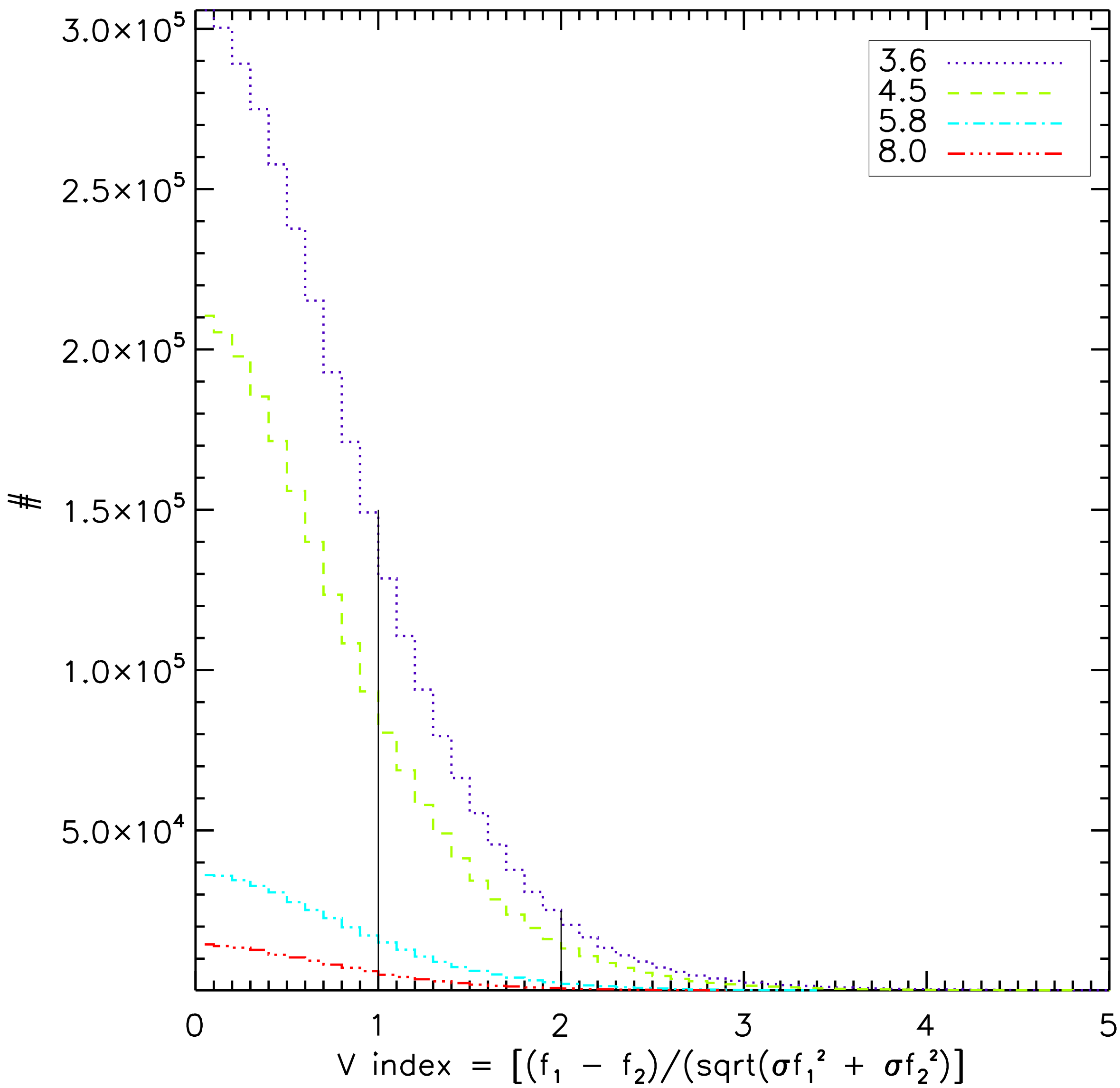

Fig. 9.— The histogram of the error weighted absolute flux difference is plotted for diffferent IRAC bands. IRAC Epoch 1 sources are matched to the closest Epoch 2 sources within 0.″9.

variable sources. They also detect a population of variable young stellar object candidates. Different limits with additional criteria for exisiting optical, near-IR variability may be used by individual users to assess the existence/extent of infrared variablity of these sources.

Users should also note that the average fluxes reported in these lists may differ from those in the mosaic photometry tables (SAGELMCcatalogIRAC and SAGELMCarchiveIRAC) as the exact method of average calculation was slightly different. For more detailed information on the single epoch values for each source like the 2MASS fluxes, flags etc, users should refer to the individual epoch sourcelists (SAGELMCcatalogIRAC_EP1_EP2 and SAGELMCarchiveIRAC_EP1_EP2 containing both Epoch 1 and Epoch 2 data) using the designations and/or globalsourceids.

6.4. Completeness

The single epoch source lists (SAGELMCcatalogIRAC_EP1_EP2 and SAGELMCarchiveIRAC_EP1_EP2) have been designed for reliability, not completeness. For this release of the data, we do not run a thorough completeness test of the catalogs. Instead, as a gauge of its completeness, we compare the number counts per magnitude bin of sources between the SAGELMCarchiveIRAC_EP1_EP2 and the SAGELMCcatalogIRAC_EP1_EP2 with source counts based on the cleaner and deeper combined SMP source lists (SAGELMCcatalogIRAC and SAGELMCarchiveIRAC) for the entire SAGE area (see Figures 10 and 11). These plots show that the Epoch 1 Archive is mostly complete down to 16.0, 16.0, 13.5 and 13.0 (16.0, 16.0, 13.0 and 12.0 in the Catalog) in IRAC bands [3.6],[4.5],[5.8],[8.0] respectively, with the big drop-offs at 16.5, 16.5, 14.0 and 13.5 for bands 1 through 4, respectively. Divergence from the 'truth' list (obtained from mosaic photometry) occurs at the fainter magnitudes, due to our stringent source-selection criteria that removes real sources in addition to cosmic rays (§4.2.1). In addition, completeness is a function of background level which is more variable for IRAC [5.8] and [8.0]. Figures 10 and 11 show that the SMP source lists extend the Archive and Catalog respectively about 1 magnitude deeper than the single-frame source lists.

Figure 12 shows that in regions of overlapping data, such as AOR boundaries, there will be an increased number of sources in the Catalogs and Archives in the single epoch source lists. The source selection criteria is based on number of detections and signal-to-noise, both of which increase in overlap regions, where multiple observations are made of given sources. This effect is not seen in the deeper SMP source lists.

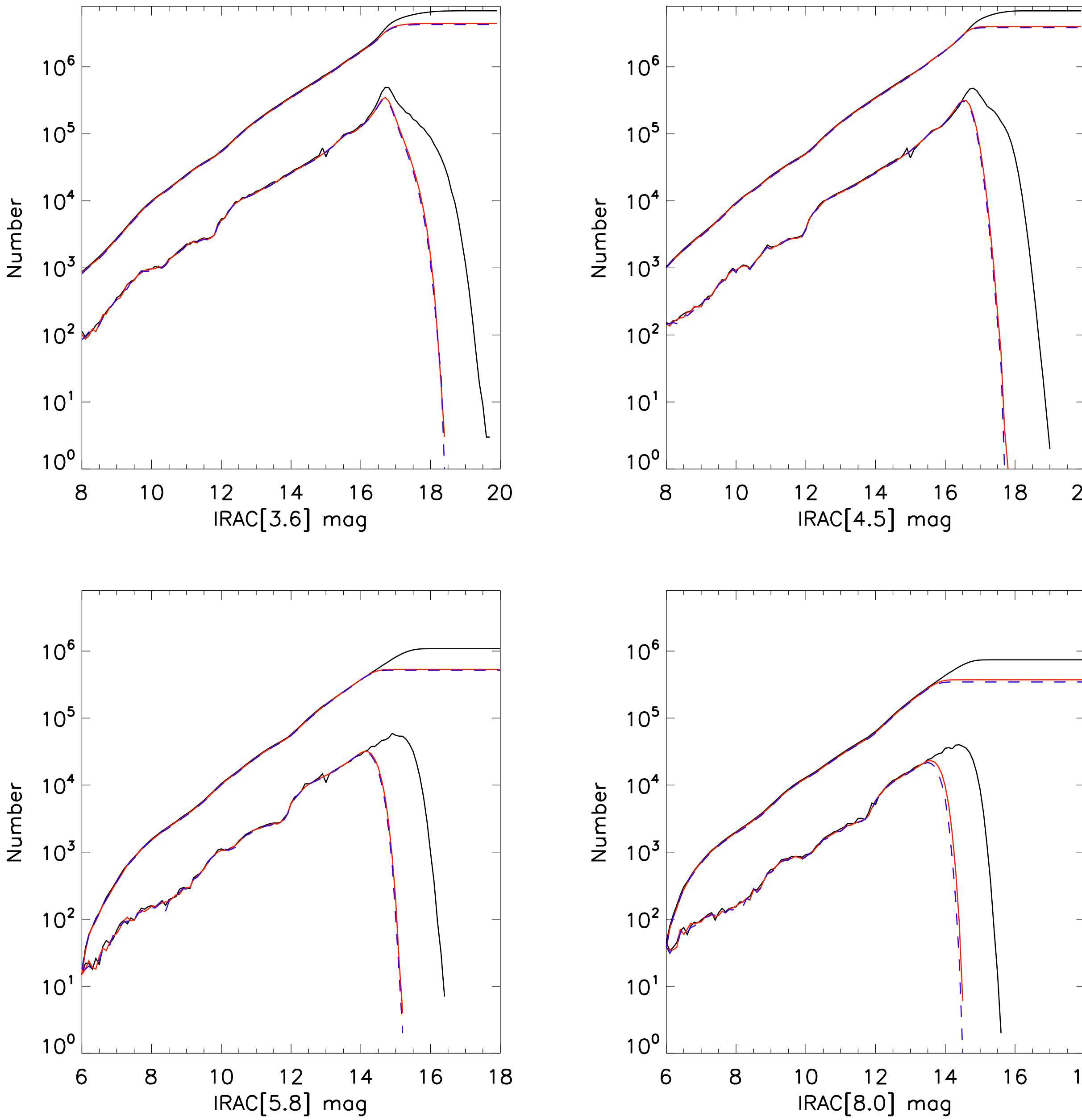

Fig. 10.— Comparison of the Epoch 1 (red lines) and 2 (blue dashed lines) Archive source counts with the SMP photometry Archive counts (black lines) for the entire SAGE survey. The upper curves in each panel are the cumulative plots while the lower curves are the differential number counts. The bright-end magnitude is cut off at the 12 sec saturation limit for the mosaic photometry. Those saturation mags are 9.5, 9.0, 6.5, 6.5 for bands 1 through 4, respectively.

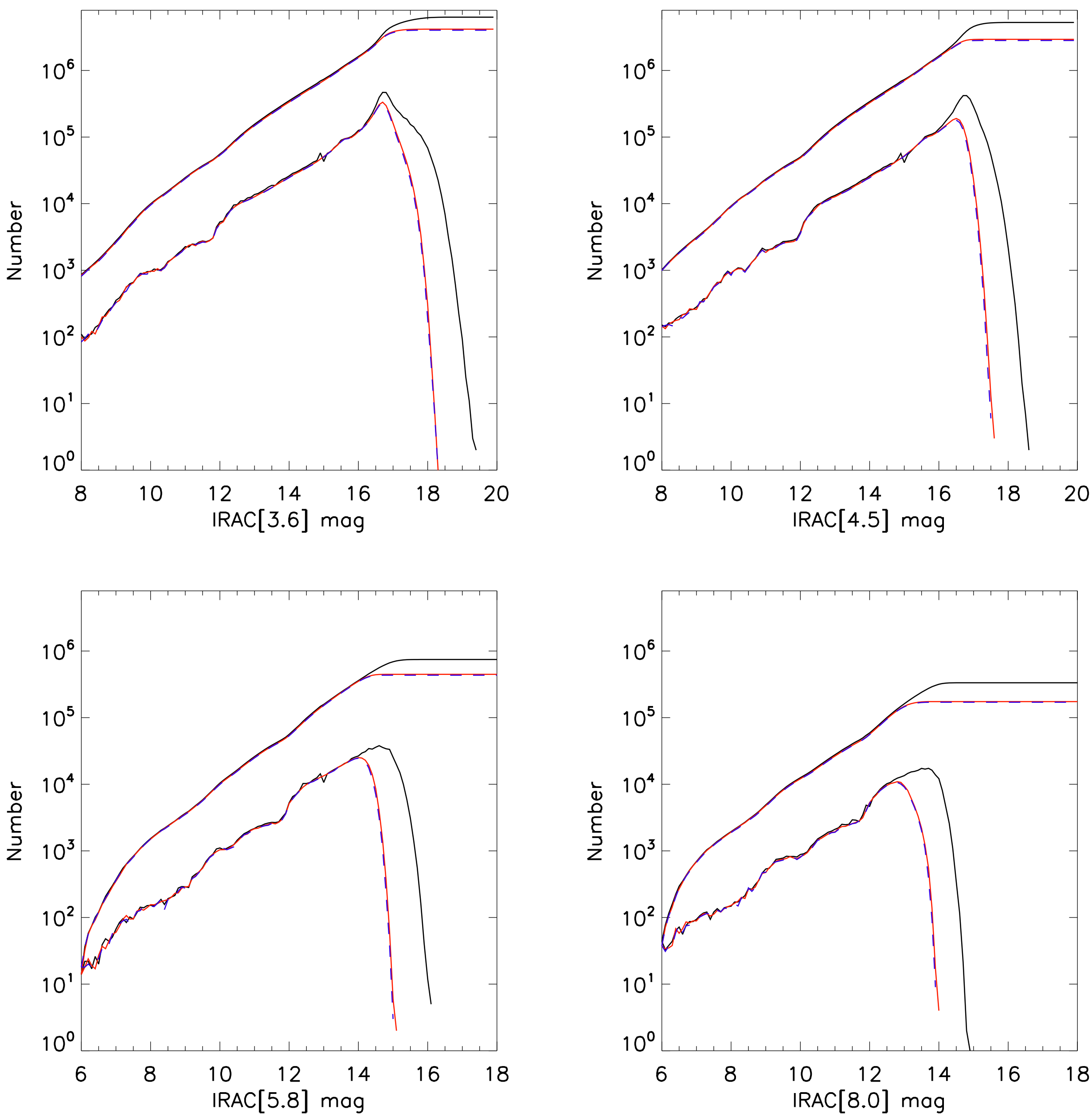

Fig. 11.— Same as Figure 10 except for the Catalog. Note the main difference seen between the Archive and the Catalog is in band 4 where our S/N threshold for the Catalog is higher.

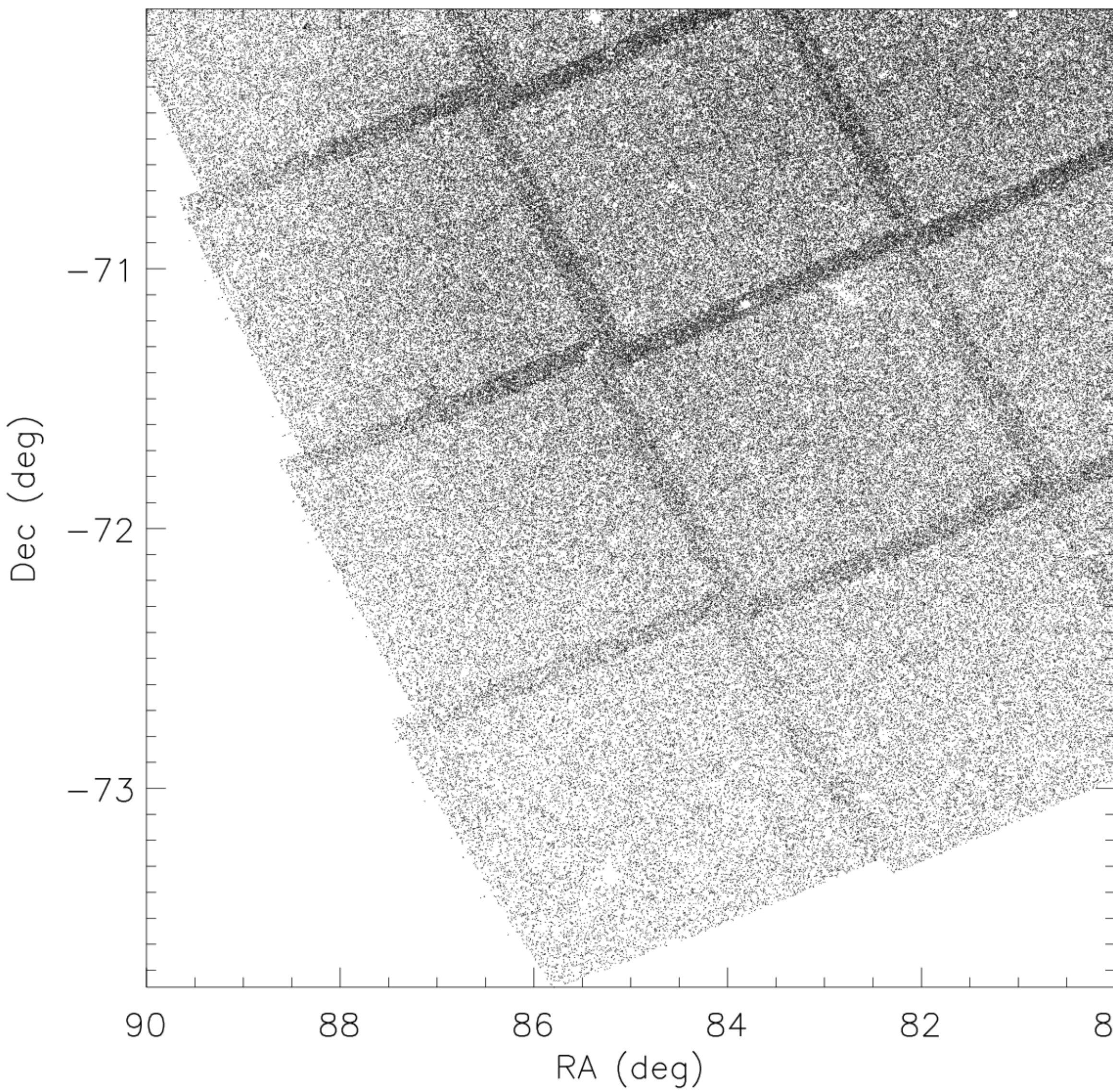

Fig. 12.— Source density image of IRAC band 2 (4.5 μm) sources with magnitudes between 16 and 17, showing some of the enhanced detections in the overlap boundary regions. This occurs in the single epoch source lists only.

7. IRAC Images

7.1. Description of IRAC Images

The SAGE Large Magellanic Cloud IRAC images have been made in two sizes (8°× 8° and 1.2°× 1.2°) and at three pixel scales: 2″ , 1.2″ (the native resolution), and 0.6″ pixels. IRAC images of the entire SAGE LMC region (8°× 8°) are provided for each of the four bands in two pixel scales: 2.0″ pixels and 1.2″ pixels. Figure 13 shows a 4-color image of the 2″ pixel 8°× 8° SAGE LMC region. Both regular image and residual image (point sources removed) mosaics are provided for the 8°× 8° images. Higher resolution 0.6″ pixel 1.2°× 1.2° mosaic tiles have also been made for the LMC region. And 0.6″ pixel mosaics have been made for the SAGE LMC offset position.

These images were made from IRAC Basic Calibrated Data (BCD) frames using SSC pipeline version S13.2 and later processing. Both SAGE LMC epochs of data were combined to produce the images. The 12 second frametime (FT) IRAC frames were mosaicked using the v3.0 Montage[d] package. The mosaic images conserve surface brightness in the original images; the units are MJy/sr. The images are 32-bit IEEE floating point single extension FITS formatted files. The images have a common projection center: RA=79.7°, Dec=-68.7°. World Coordinate System (WCS) keywords are standard (CTYPE, CRPIX, CRVAL, CD matrix keywords) with an equatorial projection (RA-TAN,DEC-TAN Calabretta and Greisen 2002). Pixels that have no flux estimate have the value NaN. The FITS headers contain relevant information from both the SSC pipeline processing and the IRAC processing. See Appendix D for an example of a FITS header.

7.2. Image Processing

The zodiacal light was subtracted from each IRAC frame. Several image artifacts (described in Hora et al. (2004) and the IRAC Data Handbook[e]) are corrected in the SAGE IRAC pipeline. We correct for column pulldown[f] in bands 1 & 2, using an algorithm written by Lexi Moustakas (GOODS team) and modified by us to handle variable backgrounds. We

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

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

[f]Column pulldown is a reduction in intensity of the columns in which bright sources are found in Bands 1 and 2. See *Spitzer* Observer's Manual (SOM) at http://ssc.spitzer.caltech.edu/documents/som/.

Fig. 13.— IRAC 4-color image of the SAGE LMC region made from the 8°× 8° 2″ pixel mosaics.

correct for muxbleed[g] in bands 1 & 2 using a modified version of the IRAC Bright Source Artifact Corrector[h]. We correct for banding[i] in band 3 by using an algorithm fitting each

[g]The multiplexer bleed effect is a series of bright pixels along the horizontal direction on both sides of a bright source in Bands 1 and 2

[h]http://spider.ipac.caltech.edu/staff/carey/irac_artifacts

[i]Banding refers to streaks that appear in the rows and columns radiating away from bright sources in Bands 3 and 4. See the SOM.

incidence of banding individually and in band 4 using an exponential function. Hot, dead, and missing pixels are masked. Outlier masking (e.g. cosmic rays, stray light from bright sources outside the field of view) was done using IRACproc (Schuster et al 2006). Visual inspection was done on the higher resolution 0.6″ pixel mosaics. The instrument artifacts found by the visual inspection (such as stray light and low or high columns and rows) were removed. Also, latent images from bright sources were removed when possible. Note that some instrument artifacts near the edge of coverage cannot be removed without causing gaps in the images, because of little or no redundancy of coverage. If there are areas of overlapping image artifacts that cause a gap in coverage, we do not mask that area. Because of the two epoch observing strategy (see section 2) the artifacts along rows and columns (e.g. banding, muxbleed, column pulldown) are mitigated. See SSC's IRAC image features web site[j] for more information about the detector artifacts.

We use the Montage[k] package v3.0 to mosaic and project to equatorial coordinates. We match instrumental background variations between the images using Montage's level background correction algorithm [l]. Instrument artifacts such as full array pull-up, first frame effect and frame pull-down are mostly removed from the images. The gradient introduced during the background matching process was removed in the 8°× 8° images using the method described in Appendix E. The 1.2°× 1.2° 0.6″ pixel mosaics have not had these gradients removed and will have different diffuse flux values than the 8°× 8° images. For the most accurate diffuse values, use the 8°× 8° images.

7.3. Residual Images

The residual images (images with point sources removed) were produced by running DAOPHOT on the 12 second FT BCD frames. We use a modified version of DAOPHOT (Stetson 1987) as our point source extractor, performing Point Spread Function (PSF) fitting on individual IRAC frames. We repeat the photometry calculations on the residual images (referred to as "tweaking"), which has been shown to substantially improve the flux estimates

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[j] http://ssc.spitzer.caltech.edu/irac/features.html

[k] http://montage.ipac.caltech.edu/;Montage is funded by the National Aeronautics and Space Administration's Earth Science Technology Office, Computation Technologies Project, under Cooperative Agreement Number NCC5-626 between NASA and the California Institute of Technology. Montage is maintained by the NASA/IPAC Infrared Science Archive.

[l] http://montage.ipac.caltech.edu/docs/algorithms.html#background

in complex background regions[m]. The 8°× 8° residual images are mosaics from individual frame residuals. Thus, if a source is extracted in some but not all frames it will show up in these images as a source (although its brightness will be reduced because it is being averaged with images where the source was extracted). Sources may not be extracted for a variety of reasons, mainly due to cosmic ray contamination, saturation/non-linearity limits and along the frame edges. Bands 1 and 2 residuals are always a bit worse than bands 3 and 4 because bands 1 and 2 have the more undersampled PSFs. Sources along ridges and on complex background regions may be slightly over-extracted. Close doubles are sometimes extracted as a single source. In these cases the residual usually looks like a dark bar between two brighter lobes. Because we use 12 second FT images, sources that saturate at this frametime will remain in the residual images even though they may have been extracted and removed for the 0.6 sec FT data.

7.4. Data Product Details: File Names, Tile Locations

The 8°× 8° image file names include the IRAC channel and pixel scale as well as whether it is a regular or a residual image (e.g. SAGE_LMC_IRAC4.5_2_mosaic.fits is the 8°× 8° 2″ pixel band 2, 4.5 μm mosaic image; SAGE_LMC_IRAC8.0_1.2_resid.fits is the 8°× 8° 1.2″ pixel band 4 8.0 μm residual image).

The 0.″6 pixel mosaic file names give the IRAC channel and tile number information, e.g. SAGE_LMC_IRAC3.6_tile45.fits is the 1.°2 × 1.°2 0.″6 pixel band 1 3.6 μm image centered at RA=79.°70, Dec=–67.°70 (see Table 4 for the tile centers).

The images delivered are:

• 8°× 8° 2.″0 pixel regular mosaics of the 12 second FT data from both SAGE LMC epochs

SAGE_LMC_IRAC3.6_2_mosaic.fits
SAGE_LMC_IRAC4.5_2_mosaic.fits
SAGE_LMC_IRAC5.8_2_mosaic.fits
SAGE_LMC_IRAC8.0_2_mosaic.fits

• 8°× 8° 2.″0 pixel mosaics of the residuals of the 12 second FT data from both epochs

SAGE_LMC_IRAC3.6_2_resid.fits

[m]see Figure 1 of Babler 2006 at http://www.astro.wisc.edu/sirtf/glimpse_photometry_v1.0.pdf

SAGE_LMC_IRAC4.5_2_resid.fits
SAGE_LMC_IRAC5.8_2_resid.fits
SAGE_LMC_IRAC8.0_2_resid.fits

• 8°× 8° 1.″2 pixel regular mosaics of the 12 second FT data from both epochs

SAGE_LMC_IRAC3.6_1.2_mosaic.fits
SAGE_LMC_IRAC4.5_1.2_mosaic.fits
SAGE_LMC_IRAC5.8_1.2_mosaic.fits
SAGE_LMC_IRAC8.0_1.2_mosaic.fits

• 8°× 8° 1.″2 pixel mosaics of the residuals of the 12 second FT data from both epochs

SAGE_LMC_IRAC3.6_1.2_resid.fits
SAGE_LMC_IRAC4.5_1.2_resid.fits
SAGE_LMC_IRAC5.8_1.2_resid.fits
SAGE_LMC_IRAC8.0_1.2_resid.fits

• 1.2°× 1.2° 0.″6 pixel regular mosaics of the 12 second FT data from both epochs

The centers of the 1.°2 × 1.°2 0.″6 pixel tiles covering the SAGE LMC survey region are listed in Table 4. The centers are offset 1°. Figure 14 is a graphical representation of the approximate tile positions. The mosaic file name SAGE_LMC_IRAC*_tileTN.fits reflects the IRAC band (* = 3.6, 4.5, 5.8, 8.0) and the tile number (TN, TN=01,02,...,85; see Figure 14). Note that tiles 9, 38 & 85 are not used in any band (they are used in the MIPS mosaics). Tiles 10, 77 & 82 are not used in bands 2 & 4. Either there was no coverage or the coverage in that tile was completely found in another tile. There are 82 bands 1 & 3 tiles and 79 bands 2 & 4 tiles. Images are projected to the common projection center: RA=79.°7, Dec=–68.°7 (J2000).

• 0.°9 × 0.°6 0.6″ pixel mosaics of the 12 second FT data from the SAGE LMC Offset position (centered at RA=82.°25, Dec=–45.°95)

SAGE_LMC_OFF_IRAC3.6.fits
SAGE_LMC_OFF_IRAC4.5.fits
SAGE_LMC_OFF_IRAC5.8.fits
SAGE_LMC_OFF_IRAC8.0.fits

Table 4. The Centers of the IRAC 1°.2 × 1°.2 Tiles.

TN	RA_{J2000} (deg)	Dec_{J2000} (deg)	TN	RA_{J2000} (deg)	Dec_{J2000} (deg)	TN	RA_{J2000} (deg)	Dec_{J2000} (deg)
1	93.21	-68.15	31	82.72	-70.67	61	73.37	-71.59
2	92.65	-67.18	32	82.58	-69.68	62	73.68	-70.60
3	92.13	-66.20	33	82.45	-68.68	63	73.96	-69.61
4	91.62	-70.31	34	82.33	-67.68	64	74.21	-68.61
5	91.08	-69.33	35	82.23	-66.68	65	74.44	-67.62
6	90.58	-68.35	36	82.13	-65.68	66	74.66	-66.62
7	90.12	-67.36	37	82.03	-64.69	67	74.86	-65.63
8	89.70	-66.38	38[a]	81.95	-63.70	68	75.04	-64.63
9[a]	89.32	-65.40	39	79.70	-73.69	69	75.21	-63.64
10[b]	89.66	-72.44	40	79.70	-72.69	70	70.25	-71.46
11	89.15	-71.46	41	79.70	-71.70	71	70.70	-70.48
12	88.70	-70.48	42	79.70	-70.70	72	71.12	-69.49
13	88.28	-69.49	43	79.70	-69.70	73	71.50	-68.50
14	87.90	-68.50	44	79.70	-68.70	74	71.84	-67.51
15	87.56	-67.51	45	79.70	-67.70	75	72.16	-66.52
16	87.24	-66.52	46	79.70	-66.70	76	72.46	-65.53
17	86.94	-65.53	47	79.70	-65.70	77[b]	72.73	-64.54
18	86.76	-73.57	48	79.70	-64.71	78	67.78	-70.31
19	86.38	-72.58	49	79.70	-63.71	79	68.32	-69.33
20	86.03	-71.59	50	76.35	-72.67	80	68.82	-68.35
21	85.72	-70.60	51	76.52	-71.67	81	69.28	-67.36
22	85.44	-69.61	52	76.68	-70.67	82[b]	69.70	-66.38
23	85.19	-68.61	53	76.82	-69.68	83	64.92	-70.09
24	84.96	-67.62	54	76.95	-68.68	84	65.58	-69.12
25	84.74	-66.62	55	77.07	-67.68	85[a]	66.19	-68.15
26	84.54	-65.63	56	77.17	-66.68	···	···	···
27	84.36	-64.63	57	77.27	-65.68	···	···	···
28	83.24	-73.66	58	77.37	-64.69	···	···	···
29	83.05	-72.67	59	77.45	-63.70	···	···	···
30	82.88	-71.67	60	73.02	-72.58	···	···	···

[a]no coverage, tile not used

[b]tile not used in bands 2 & 4

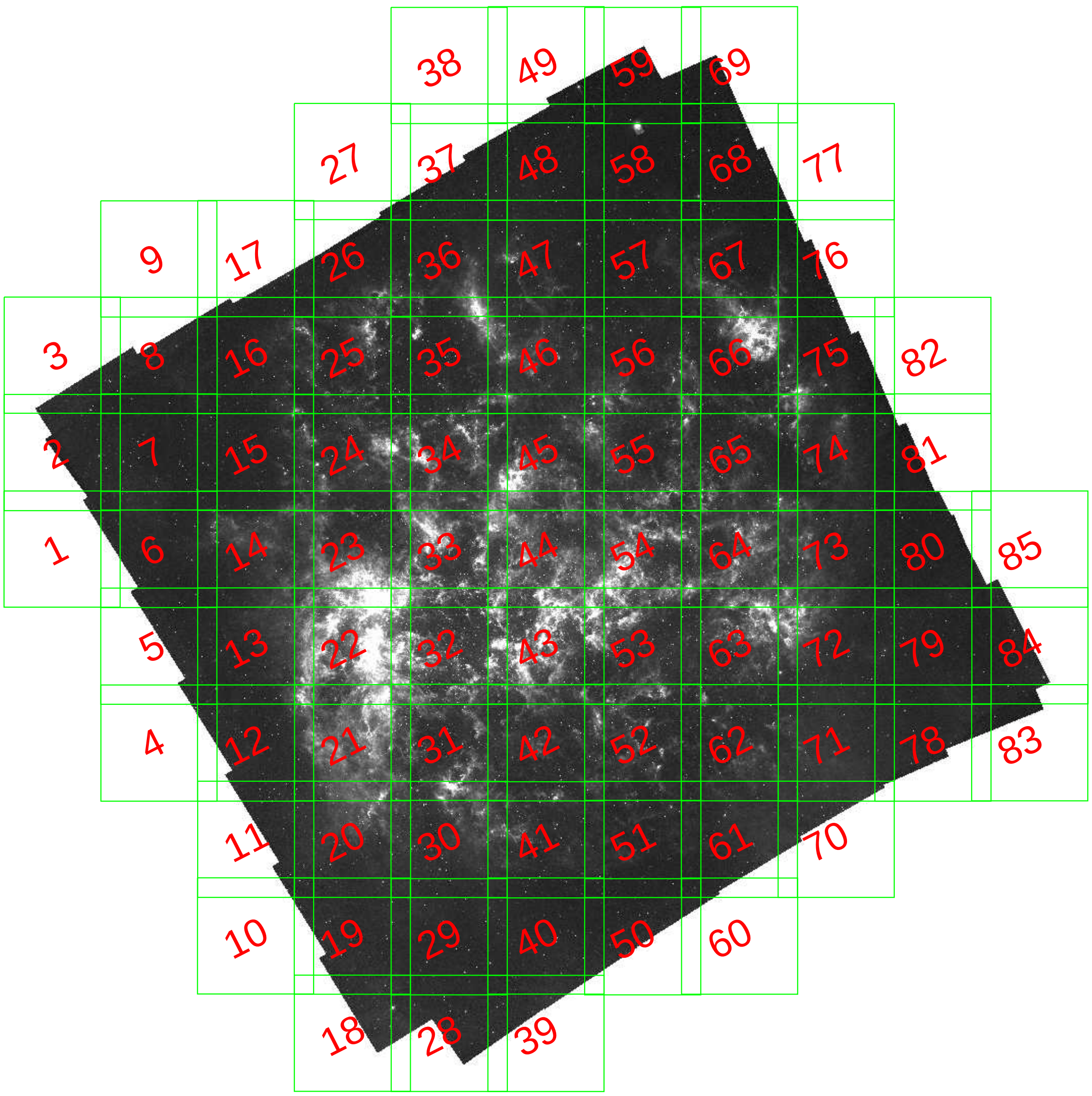

Fig. 14.— Approximate tile positions overlayed on the IRAC 8 μm mosaic. The tile size is $1\overset{\circ}{.}2 \times 1\overset{\circ}{.}2$. The tile numbers correspond to the ones listed in Table 4.

8. MIPS Full and Catalog Lists

The point source lists presented in this document were extracted from the Epoch 1 and Epoch 2 images for MIPS 24 μm and from the combined Epoch 1+2 images for MIPS 70 and 160 μm. The Arizona MIPS team pipeline, MIPS Data Analysis Tool v3.06 (DAT; Gordon et al. 2005) and customized post-processing scripts were used to do the processing and mosaicing of the individual images. The details for the SAGE MIPS Epoch 1 and Epoch 2 data processing can be found in Meixner et al. (2006). Here we summarize the criteria for selection of the point sources to be in the full and catalog list after the sources are extracted from the images. Then we describe the quality of the various lists.

8.1. 24 μm Full List and Catalog Criteria

The MIPS source lists were extracted using StarFinder (Diolaiti et al. 2000) on the Epoch 1 and Epoch 2 image AOR mosaics for MIPS 24 μm. The extraction was done using a model PSF and setting the acceptable source parameters to be $>2\sigma$ and a correlation $>$0.80. The source lists for the individual AORs were merged into single epoch source lists averaging the sources which were detected in multiple AORs. This produced two large lists of sources (called 'full lists'), one for each epoch (both in SAGELMCfullMIPS24). The reliability of sources was nonuniform over LMC and extensive tests were carried out to identify criteria which could be used to create a high reliability catalog for each epoch. To be included in each single epoch catalog, each 24 μm source has to meet a number of criteria. The source had to be nearly point like with a correlation value $>$0.89. This removed approximately 2/3 of the entries in the single epoch source lists. In regions where there is a significant structure in the surrounding region (identified as having a $\sigma > 0.25$ in a $120''$ width square box), the source had to have a correlation value $>$0.91. This requirement removed a small number of sources ($\sim$1500). There are a small number of sources with 24 μm magnitudes between 4 and 8 which have unusually low uncertainties (i.e., high S/N). The origin of these sources is under investigation and seems to be related to edge effects in the AORs. In the meantime, these sources were removed from the catalogs ($\sim$70). Finally, all sources had to have signal-to-noise (S/N) values $>$5. The S/N used was that estimated from the StarFinder code using the mosaic uncertainty image added in quadrature with an 1% error due to the background subtraction. This removed $\sim$6000 sources. The final Epoch 1 and Epoch 2 catalogs (both in SAGELMCcatalogMIPS24) likely have a few remaining unreliable sources, but we estimate this to be at the less than 1% error.

Compared to the previous delivery of the MIPS 24 μm Catalog, this new delivery is very similar. The only change is to increase the separation, from 2 to 3 arcsec, below which sources are merged into a single source (true duplicate observations) when the AORs lists are merged into the full list.

We deliver the MIPS 24 μm Full List (Epoch 1 and Epoch 2 in SAGELMCfullMIPS24) for the first time. This source list contains ALL the sources extracted from the mosaics, thus a user should be aware that it contains spurious sources. The full list may be useful to search for the potential 24 μm counterparts to known sources. Inspection of the 24 μm counterparts could be done by inspecting the 24 μm image and by analyzing the spectral energy distribution of the source.

8.2. 70 and 160 μm Full List and Catalog Criteria

The MIPS 70 and 160 μm point source lists were created using the combined Epoch 1+2 images. The combination of both epochs into a single mosaic was required due to the low redundancy of the SAGE observations at these wavelengths (especially MIPS 160 μm). The StarFinder criteria were the same as described above for the MIPS 24 μm full lists. The full 70 μm and 160 μm source lists containing all the sources extracted from the mosaics are included in SAGELMCfullMIPS70 and SAGELMCfullMIPS160, respectively. The criteria for inclusion in the catalog list (SAGELMCcatalogMIPS70 and SAGELMCcatalogMIPS160) is also the same as for the MIPS 24 μm Catalog (SAGELMCcatalogMIPS24).

The MIPS 70 and 160 μm Full Lists (delivered for the first time) should be used with caution since, similarly to the MIPS 24 μm Full List, they contain spurious sources!

8.3. Astrometry

The astrometry of the SAGELMCcatalogMIPS24 Epoch 1 and 2 are referenced to the IRAC Single Frame Epoch 1+2+3 (see §5) by using a bright 8 μm source list for the astrometric framework of the MIPS 24 μm catalog. The corrections required to register the MIPS 24 μm catalog to the bright 8 μm catalog are $\sim$1″. This is not unexpected as the nominal pointing accuracy of Spitzer is $\sim$1″. As the IRAC observations have already been registered to 2MASS sources, this results in the MIPS 24 μm sources being registered to the 2MASS coordinate system as well. The astrometry of the MIPS 70 and 160 μm lists are not corrected for this small offset as it is smaller than 1/10 of a pixel at these wavelengths.

Histograms showing the offsets between the registered MIPS 24 μm and the bright IRAC 8 μm list reveals the average offsets sharply peaked at zero as expected (Figure 15).

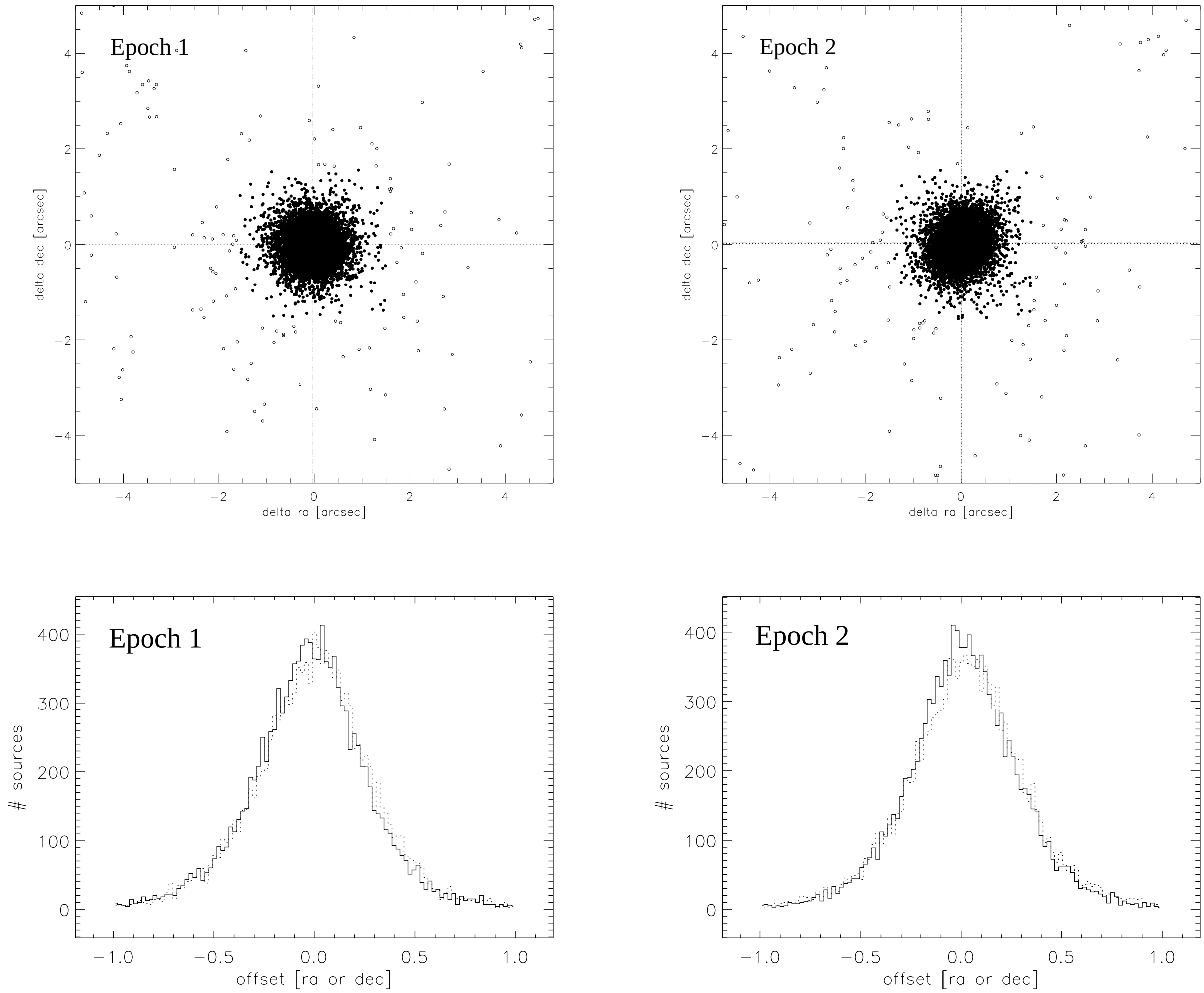

Fig. 15.— The top plots show the scatter plot of the sources matching between the bright IRAC 8 μm and the MIPS 24 μm sources within 5″. The histograms quantify the offsets between these two lists and show that the average is very near zero for both ra and dec.

8.4. Precision and Accuracy of the Photometry

Figure 16 shows the photometric uncertainties of the MIPS 24 μm Catalog (SAGELMC-catalogMIPS24) and Figure 17 shows the uncertainities for the MIPS 70 and 160 μm catalogs (SAGELMCcatalogMIPS70 and SAGELMCcatalogMIPS160, respectively). The behavior of the uncertainties as a function of magnitude is as expected. The scatter in the uncertainties at the same magnitude is due to the large variations in the background (extended) emission across the LMC.

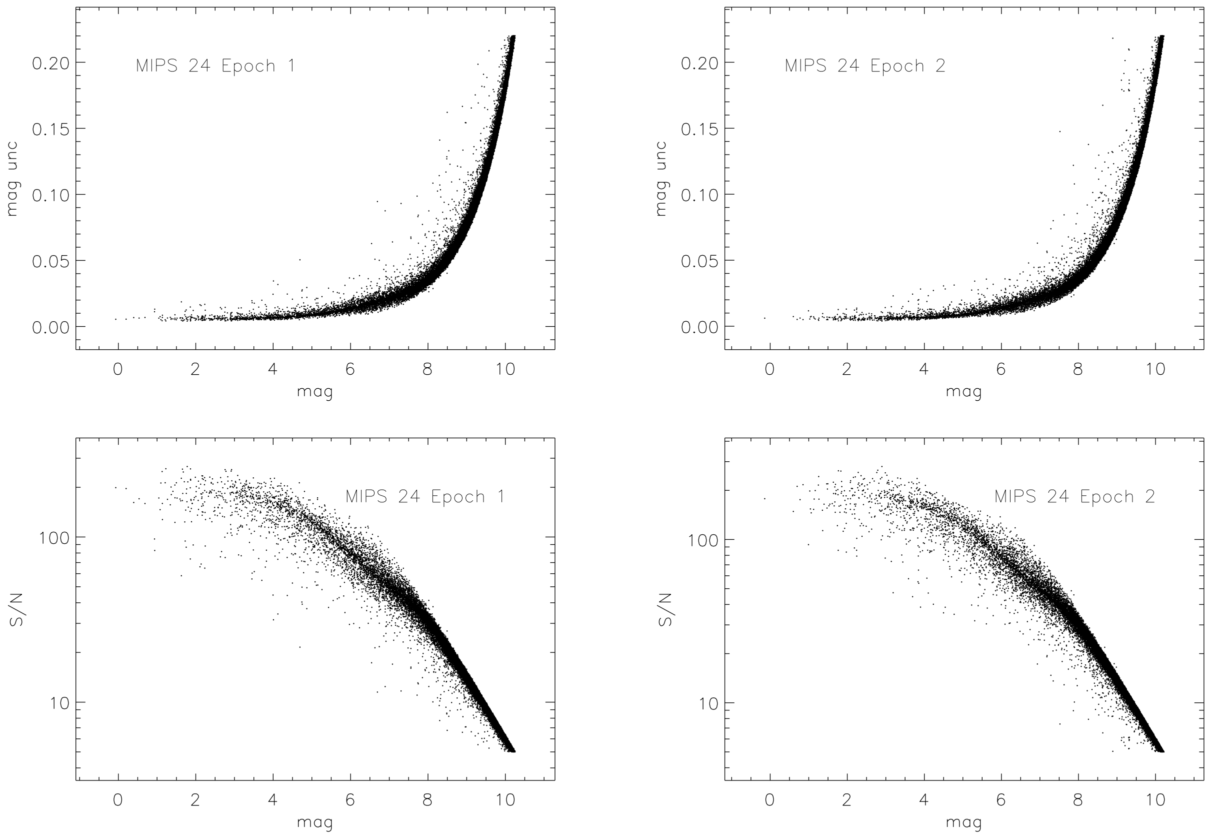

Fig. 16.— The uncertainty in magnitudes is plotted versus magnitude for the MIPS 24 μm catalogs in the upper plots. The lower plots show the S/N versus magnitude for the same catalogs.

The absolute photometry accuracy of the MIPS fluxes is 2% at 24 μm (Engelbracht et al. 2007), 5% at 70 μm (Gordon et al. 2007), and 12% at 160 μm (Stansberry et al. 2007). The zero points for the MIPS 24, 70, and 160 μm magnitudes are 7.17, 0.778, and 0.160 Jy (Rieke et al., 2008). As an independent check on the measured MIPS 24 μm magnitudes, we compared the SAGE magnitudes to the predicted MIPS 24 μm magnitudes of calibration stars in the SAGE fields (Figure 18). This checks that the extraction of point source fluxes from the images has not introduced systematic errors. The average offsets are 0.040 and 0.033 mag for Epoch 1 and Epoch 2, respectively. The expected offset is 0.029 mag due to small differences between the Cohen et al. (2003) and Rieke et al. (2008) photometric systems. The good agreement seen between the measured and expected differences provides confidence that the extraction of the MIPS 24 μm sources provides accurate photometry.

The quoted uncertainties in the fluxes were checked by comparing the flux differences

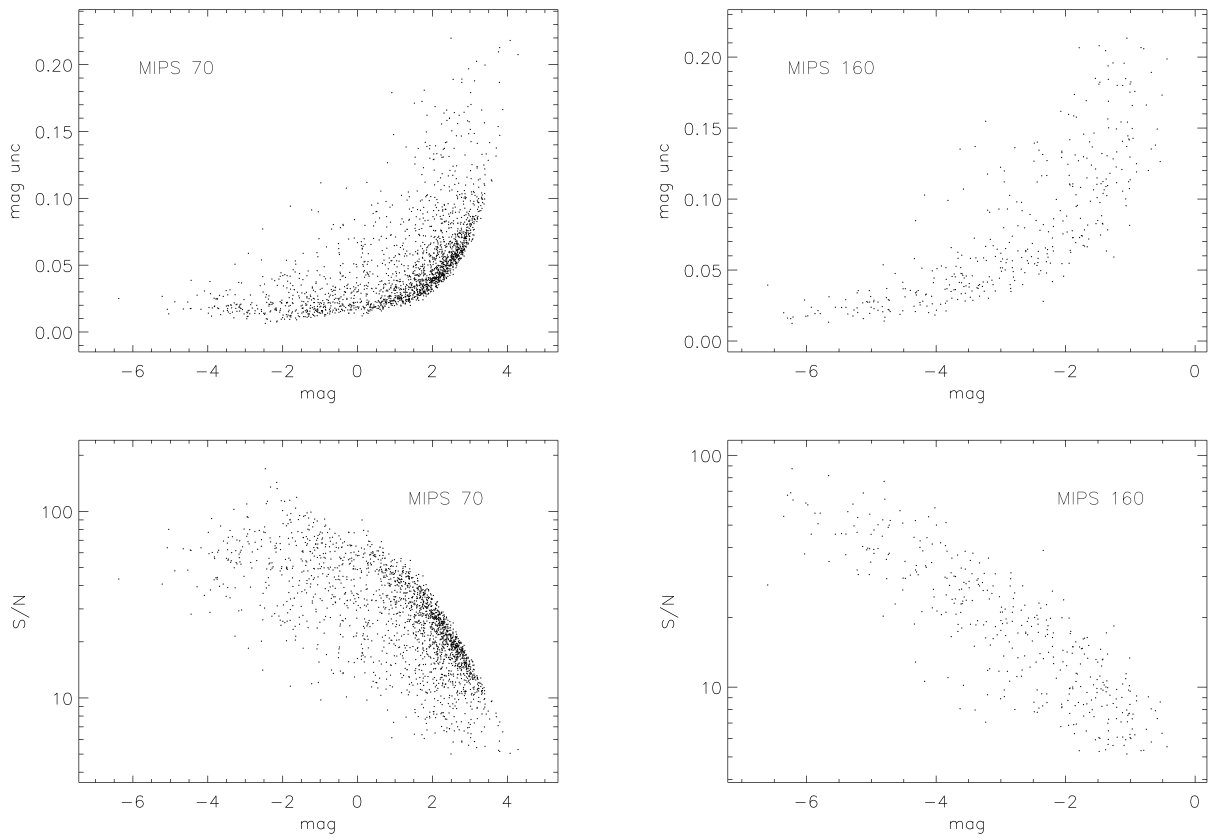

Fig. 17.— The uncertainty in magnitudes is plotted versus magnitude for the MIPS 70 and 160 μm catalogs in the upper plots. The lower plots show the S/N versus magnitude for the same catalogs.

between sources seen in both Epoch 1 and Epoch 2 catalogs with the flux differences expected given the quoted uncertainties. Figure 19 plots the histogram of this comparison along with the best fit Gaussian. The best fit Gaussian has a σ below 1 which means that the quoted uncertainties are overestimated. This overestimation is likely the result of a slightly too large uncertainty assigned to the background subtraction.

8.5. Matching between MIPS 24 μm Epoch 1 and Epoch 2 Source Lists: Comparison of Photometry and Variability Index

Figure 19 shows a histogram comparing the fluxes of the sources detected in both epochs of the MIPS 24 μm catalog. This plot is analogous to Figure 9 for IRAC (see Section 6.3 for description). The MIPS 24 μm sources were matched using a search radius of $0\farcs9$ and

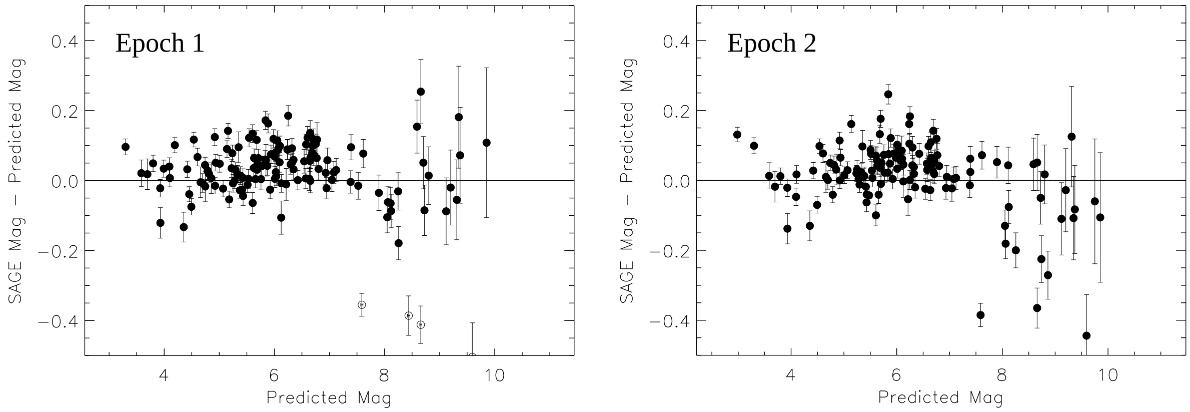

Fig. 18.— The difference between the measured SAGE magnitude and the predicted magnitude for the Cohen et al. (2003) calibration stars in the SAGE catalog is shown. The solid line is at zero. The expected offset is 0.029 mag and the observed is 0.040 and 0.033 for Epochs 1 and Epoch 2, respectively. The predicted magnitudes are based on techniques by Cohen et al. (2003).

the fluxes in the two epochs were compared. The percentage of matched sources is 65% of Epoch 1 and 68% of Epoch 2 sources. Of the $\sim 25,000$ sources detected in both epochs, 93.6% are within 3σ. A detailed analysis of both MIPS 24 μm and IRAC variable sources can be found in Vijh et al. (2009).

The SAGE survey provides two tables, SAGELMC_MIPS24catalog_E1E2Match and SAGELMC_MIPS24full_E1E2Match, containing multi-epoch data for sources detected in both epochs of the MIPS 24 μm Catalog (SAGELMCcatalogMIPS24) and Full List (SAGELMCfullMIPS24), respectively. See §6.3 and Appendix H for a detailed description of these tables. The matched Epoch 1 and Epoch 2 source lists can be used to study the variability of sources detected by SAGE.

8.6. Completeness

We have not conducted full completeness tests for the MIPS catalogs. Full completeness tests require extensive false source tests which have yet to be carried out. The overall completeness can be estimated by examining the flux histogram of the catalog sources. Figure 20 shows the histograms for all the MIPS catalogs. The full source list and the high reliability catalog histograms are shown. From the catalog histograms it can be seen that the catalogs are complete to a little above 1 mJy (24 μm), 100 mJy (70 μm), and 500 mJy

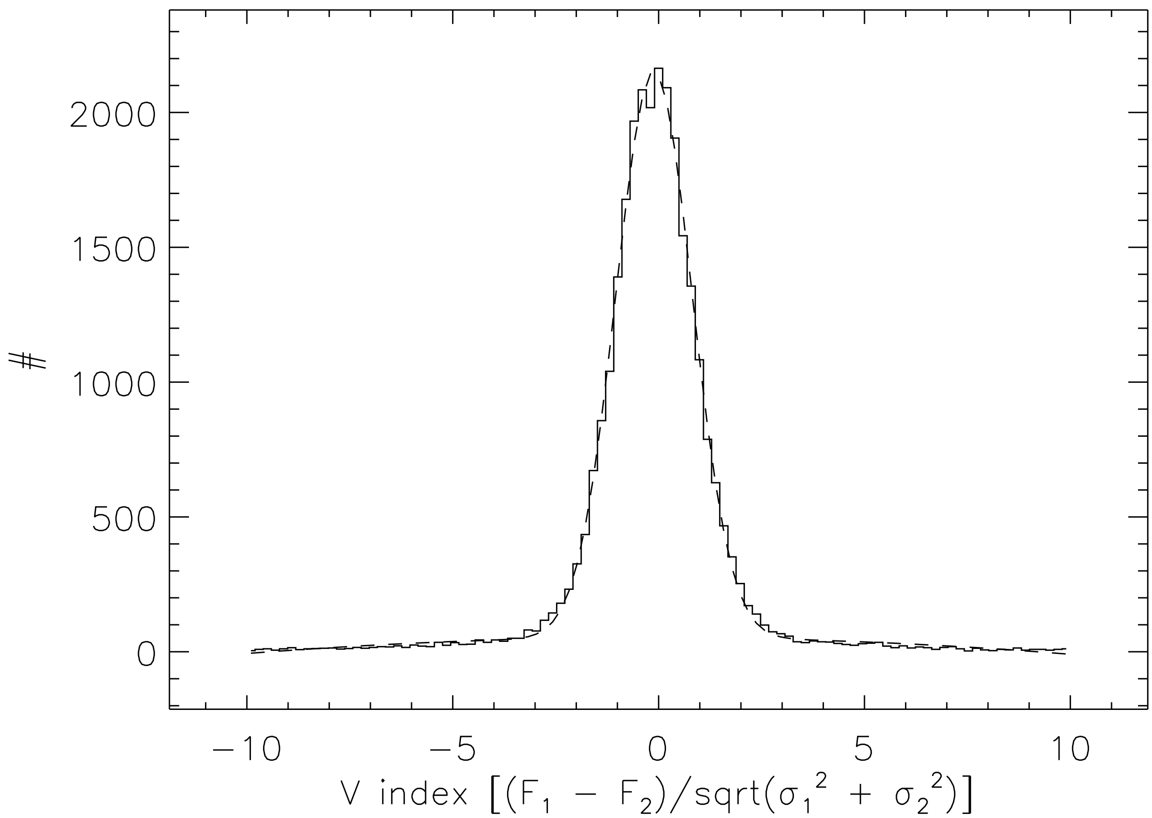

Fig. 19.— The histogram of the ratio of the flux difference to the expected flux difference is plotted for all sources in both MIPS 24 μm catalogs. In addition, the best fit Gaussian is plotted as a dashed line. The best fit Gaussian has $\sigma = 0.78$ and the expected σ is 1 indicating the flux uncertainties in the catalogs are slightly *overestimated*.

(160 μm). Given the large variations in the extended emission in the LMC, the completeness limit will vary significantly over the LMC. The number quoted above is for the faintest, least crowded regions in the LMC.

A measure of the reliability of a catalog is the histogram of the nearest neighbor distances. Figure 21 shows this histogram for the full source lists and the catalogs. The full source lists clearly include a number of spurious sources given the large peaks at close separations. These peaks are not seen in the catalog histograms confirming that they are highly reliable (at least in the context of nearest neighbors).

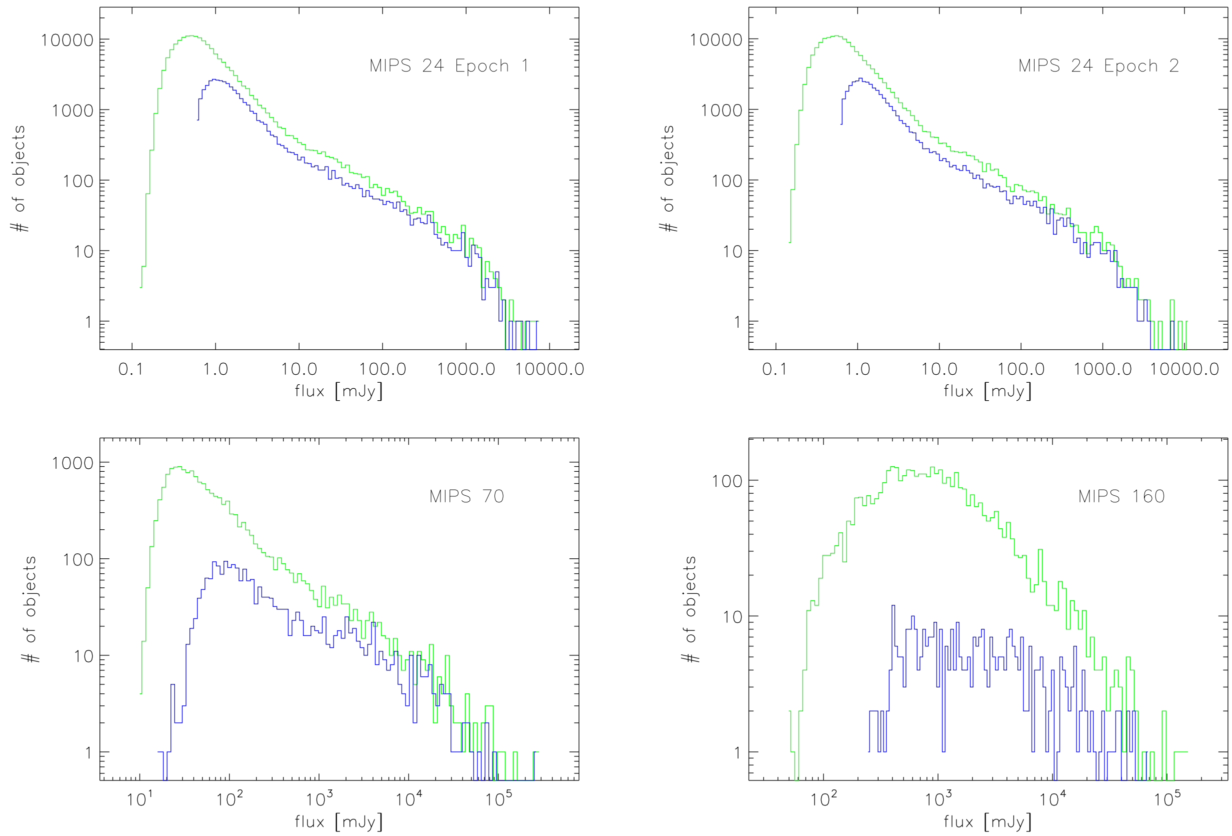

Fig. 20.— The flux histograms for the full source lists (green) as well as the high reliability catalogs (blue) is shown.

9. MIPS Images

The MIPS 24, 70, & 160 μm mosaics of the whole LMC were created by combining the $\sim$200,000 individual images per band into single mosiacs. Given the large number of images, this was especially challenging for the MIPS 24 μm data requiring different steps between the 24 μm and 70/160 μm data.

The delivered LMC images were background subtracted at 24 & 70 μm, but *not* background subtracted at 160 μm.

The processing of the individual AORs was done as described in the previous section.

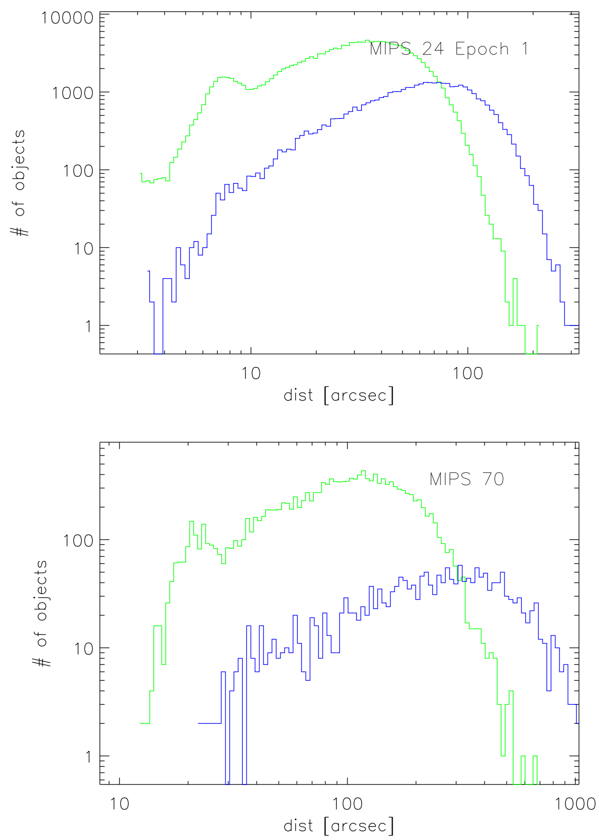

Fig. 21.— The nearest neighbor histogram of the full source lists (green) and catalogs (blue) is plotted.

9.1. MIPS 24 μm Images

The MIPS 24 μm mosaics are delivered in two different flavors. The first is single epoch and the combined Epoch 1 and Epoch 2 full mosaics of the LMC. The second is $1\overset{\circ}{.}1 \times 1\overset{\circ}{.}1$ tiles which combine the data for both epochs in a single image. The two different flavors of the mosaics were created using two different methods mainly due to the number of individual images and large size of the final MIPS 24 μm mosaics.

The single epoch and the combined Epoch 1 and Epoch 2 mosaics were created using the combination of the MIPS DAT and Montage programs. The individual AOR mosaics were created using the MIPS DAT. The zodiacal dust emission contributes significantly to the 24 μm band. The zodiacal dust emission is time variable and variations were seen during the ∼1 week it took to take a single epoch of SAGE MIPS data. The nature of the variations required them to be removed before combining the 38 AORs mosaics into a single image.

The zodiacal dust emission was modeled as two planes for each epoch where each plane was fit to the background regions outside of the LMC in each "row" of AORs. The LMC was mapped using two rows of 4° long scan legs (18 AORs per row). After subtraction of the fitted planes, the resulting single epoch mosaics were created using Montage with only mean offset corrections applied. The final mosaics displayed only small residual mismatches which can be traced to residual instrumental artifacts in the AOR mosaics themselves. Some of these will be corrected in future processing.

The $1.^{\circ}1 \times 1.^{\circ}1$ tiles were created combining both epochs of observations. These tiles were created directly from the individual images using the MIPS DAT allowing for smaller mosaic pixels and improved cosmic ray rejection. The individual images were corrected for the time variable zodiacal emission utilizing the planer fits and Montage mean offsets. These tiles overlap each other at the edges. In addition to the image tiles, point source subtracted images were also created by running StarFinder on the tiles with the same parameters used for the full source lists described previously.

In the final SAGE delivery, we provide supplemental Epoch 1 and Epoch 2 MIPS 24 μm mosaics: SAGE_LMC_MIPS24_E1_rot.fits and SAGE_LMC_MIPS24_E2_rot.fits. These mosaics were created by reprojecting the Epoch 1 and Epoch 2 MIPS 24 μm mosaics (SAGE_LMC_MIPS24_E1.fits and SAGE_LMC_MIPS24_E2.fits, respectively) to the common IRAC/MIPS projection. The images are cropped at the edges (off-LMC area) to keep their sizes comparable to the original MIPS 24 μm mosaics. The reprojected MIPS 24 μm mosaics are useful for users who are interested in comparing the MIPS 24 μm emission and IRAC (3.6, 4.5, 5.8, 8.0 μm) emission by displaying the images on top of each other.

9.2. MIPS 70 & 160 μm Images

The MIPS 70 & 160 μm mosaics were created using the MIPS DAT and represent the combination of both epochs of data. The individual epoch mosaics exhibit significant residual instrumental signatures (70 μm) or excessive cosmic rays (160 μm). This was expected as these observations have lower redundancy than the 24 μm data and suffer from larger residual instrumental signatures.

The MIPS 70 μm data were corrected for residual instrumental signatures on a pixel-by-pixel basis using a low order polynomial fit to the data outside of the LMC. This step also effectively removes the background emission measured in the regions outside of the LMC.

The MIPS 160 μm data did not require a correction for residual instrumental signatures. Thus the final full LMC 160 μm image is not background subtracted. The background subtraction at 160 μm is not simple as the dominant background source at this wavelength is the complex Milky Way cirrus which is not well approximated by a plane.

Compared to the previous delivery of the 70 μm mosaic, the new 70 μm mosaic has had the 70 μm flux nonlinearities corrected using an algorithm recently developed using the MIPS 70 μm calibration stars (Gordon et al. 2009, in prep.). This correction only affects bright surface brightnesses.

A. APPENDIX A - The Differences between the IRAC SAGE v2.1 and v1 Processing

Note that the v1 Epoch 1 only source lists (delivered in December 2006) have been superceded by the v2.1 single epoch source lists (delivered in February 2008) and are no longer available. However, users who have downloaded and made use of the v1 source lists might be interested to note the differences between these versions.

A.1. Main Improvements in the SSC Processing versions S13.2 and later

The December 2006 SAGE-LMC v1 data release (epoch 1 only source lists using single frame photometry) used SSC pipeline version S12.4.0. The v2 data products (epoch 1 only and epoch 2 only single frame photometry source lists) use SSC pipeline processing versions S13.2 and later. The S13.2 and later processings have two important improvements. First, the absolute flux calibration has been updated to reflect the results described in the IRAC calibration paper (Reach et al. 2005). Second, 'super-boresight' pointing refinement was implemented, improving the pointing accuracy for bands 3 and 4 as well as removing positional offsets between the IRAC channels. Better positions result in crisper mosaics and more accurate bandmerging of sources. Other improvements in S13.2 include new linearity corrections for band 3 and the use of a 'super-skyflat' for the flat fielding. The dark drift correction, which removes vertical striping (jailbar effect) in the data, was applied to only band 3 in the S13.2 processing but it was later found that the dark drift correction was needed for the other three bands. SSC processing version S14.0 rectified this problem. We applied a jailbar correction (http://ssc.spitzer.caltech.edu/irac/jailbar/) to bands 1, 2 and 4 frames if they were processed by the S13.2 pipeline. See the IRAC pipeline history log at http://ssc.spitzer.caltech.edu/archanaly/plhistory/irac.html for more details about the SSC processing versions.

A.2. Improved Banding Correction for Band 3

An improved banding correction for band 3 was applied using an algorithm fitting each incidence of banding individually. Previously we used an exponential function. The better banding correction for band 3 provides a more uniform background for the source extraction.

A.3. Modifications to the Flux Uncertainties

The flux uncertainties in the v1 source lists were not adjusted. The v2 flux uncertainties were adjusted as discussed in §6.2.

A.4. Bandmerging with 2MASS Point Source Catalogs

For the v2 source lists, the IRAC data were bandmerged with a combination of the 2MASS All-Sky Point Source Catalog and a pre-release version of 2MASS 6X Deep Point Source Catalog (see Appendix B). This results in more matches with 2MASS than in the v1 source lists where we used only the 2MASS All-Sky PSC.

The criteria for including a 2MASS source has changed. In the SAGE v1 processing, a source would match to a 2MASS source only when the 2MASS source had a good K_s band measurement (photometric quality of 'A'). We now 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 (see Appendix C.6.2 for the definition of the photometric quality flag).

For the v2 source lists, the 2MASS photometric quality flag is included in its Source Quality Flag (see Appendix C.6.2).

A.5. Source List Criteria

- We should no longer be losing sources when the possible number of detections, N, equals 3 (along AOR overlaps). For v1 one of the source list criteria was that $M/N >$ 0.4 which is too harsh when N=3. We changed this criteria to $M/N \geq 0.32$ (M is the actual number of detections).
- Use K_s as a possible selection band in the source list criteria.
- In the Archive, we no longer null the band's flux if M=1 and if the result is from only the 12 sec data. This allows many more sources of reasonable reliability into the Archive (especially in the [4.5] band).

A.6. Bandmerging Fix

There are no longer missing sources in the corners of the grid cells at high declinations.

NOTE: The value of the flux calculation method flag has changed. See Table 9.

B. APPENDIX B - Bandmerging with the 2MASS All Sky and 6X Point Source Catalogs

The IRAC data were bandmerged with a combination of the 2MASS All-Sky Point Source Catalog and a pre-release version of 2MASS 6X Deep Point Source Catalog.

- How the 2MASS All-Sky + 6X2MASS were combined

  The 6X2MASS catalog is deeper than the original All-Sky catalog, but contains only direct pipeline extractions from 2MASS imaging, whereas the All-Sky has been supplemented at the bright end with more sophisticated photometry. Thus, the most scientifically robust catalog should use the original All-Sky for bright sources, the 6X2MASS for faint sources, and possibly a combination at intermediate fluxes. In order to maintain maximum tracability back to the 2MASS catalog, we chose to use either the 6X or the All-Sky bandmerged source, and not to mix photometry from the different catalogs in different bands.

  Sources that lie in regions scanned more than once or in overlap regions may have multiple independent detections. One unique observation is selected for inclusion in the 6X2MASS catalog. We followed the procedure outlined in the 2MASS documentation of choosing the source furthest from its tile boundary (see www.ipac.caltech.edu/2mass/releases/allsky/doc/seca3_6d.html for more details). We first removed sources within 2″ from the pre-release 6X2MASS catalog. To the best of our knowledge this results in a catalog consistent with the 2MASS documentation.

  For each source we determined the reddest measurement (e.g. for a source with a K_s detection we use the K_s magnitude. For a source with K_s upper limit and H detection we use the H magnitude). We then constructed a list consisting of:

  – any source in the All-Sky with reddest magnitude (redband) <13
  – any source in the 6X with redband >15
  – any source in either the All-Sky or the 6X with 13 < redband < 15 and no source in the other list within 5″
  – any source with a match from the other list within 5″, choosing the source with better photometric quality flag in the reddest band.

- 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 (see Appendix C.6.2 for the definition of the photometric quality flag). The 2MASS combined catalog contains a large number of sources without K_s detections because 2MASS is more sensitive at shorter wavelengths, and the majority of sources in the Galaxy have the "blue" infrared colors of main-sequence stars. We found that in crowded regions, sources with questionable 2MASS photometry (according to their photometric quality flag) in J and/or H, and no detection in K_s, usually led to incorrect associations with IRAC. In fact, comparison of the SAGE and 2MASS sensitivity limits makes it clear that a source with reasonable astrophysical colors, good IRAC photometry, good J photometry, and only upper limits at K_s, is highly unlikely. Thus we performed a (very conservative) selection on the 2MASS catalog, removing sources with worse than A photometric quality in J, worse than C in H, AND worse than E in K_s.

C. APPENDIX C - IRAC Catalog and Archive Formats

Table 5 describes the columns in the single epoch Catalog and Archive source lists (SAGELMCcatalogIRAC_EP1_EP2 and SAGELMCarchiveIRAC_EP1_EP2) including the data format and null values. Table 6 describes the columns in the SMP (single frame + mosaic) Catalog and Archive source lists (SAGELMCcatalogIRAC and SAGELMCarchiveIRAC). There is one extra column in the SMP source lists, which is the close Fulls flag (see Appendix C.3). Note that:

- The fields in the Catalog and the fields in the Archive of each kind of list (single epoch; SMP) are the same. Data is delivered in IPAC Table format.
- Where NULL values are not legal, NO is entered in the column. Otherwise, the null value is given.

Selected columns are discussed in detail in the following subsections.

C.1. Designation

The format of the source designations is 'SSTISAGE1A JHHMMSS.SS±DDMMSS.S' and 'SSTISAGE1C JHHMMSS.SS±DDMMSS.S' for the SAGE LMC IRAC Catalogs and Archives, respectively, where

SST = Spitzer Space Telescope
I = IRAC

SAGE = LMC Survey project
1 = Epoch 1; **2** = Epoch 2, **M** = Single frame + mosaic photometry
C = highly reliable Catalog
A = more complete Archive
J = 2000.0 epoch
HHMMSS.SS = Right ascension (hr, min, sec) of source
±DDMMSS.S = Declination (deg, min, sec) of source

C.2. Close Source Flag

The Close Source Flag is set when a source in the Archive is within $3''.0$ of another Archive source. It was found that the magnitudes of sources closer than about $2''.0$ from each other are not as reliably extracted and bandmerged. Therefore, a source that is within $2''.0$ of an Archive source is culled from the Catalog. The Archive allows sources to be up to $0''.5$ from each other before culling. The Close Source Flag can have values from 0 to 6, with the following definitions:

0	no sources in the Archive within $3''.0$ of the source
1	sources in the Archive between $2''.5$ and $3''.0$ of the source
2	sources in the Archive between $2''.0$ and $2''.5$ of the source
3	sources in the Archive between $1''.5$ and $2''.0$ of the source
4	sources in the Archive between $1''.0$ and $1''.5$ of the source
5	sources in the Archive between $0''.5$ and $1''.0$ of the source
6	sources in the Archive within $0''.5$ of the source.

C.3. Close Fulls Flag

The Close Fulls Flag has been added to the entry of the SMP source lists (it is not in the single epoch, single frame photometry source lists). The "Fulls list" is a list of all the detections that come out of the bandmerger before any source list criteria are applied. "Something" was extracted at the given position, which may affect the photometry of a nearby source. Since there are many more sources at the faint end of the mosaic photometry, there are more detections that may effect the photometry at the faint flux end. We do not use this flag for any culling; it is for information only. The Close Fulls Flag is set when a source in the "Fulls List" is within $3''.0$ of the Catalog or Archive source. It has the same values as the close source flag, except it uses the Fulls list instead of the Archive as the nearest neighbor source list.

0	no sources in the Fulls list within $3\farcs0$ of the source
1	sources in the Fulls list between $2\farcs5$ and $3\farcs0$ of the source
2	sources in the Fulls list between $2\farcs0$ and $2\farcs5$ of the source
3	sources in the Fulls list between $1\farcs5$ and $2\farcs0$ of the source
4	sources in the Fulls list between $1\farcs0$ and $1\farcs5$ of the source
5	sources in the Fulls list between $0\farcs5$ and $1\farcs0$ of the source
6	sources in the Fulls list within $0\farcs5$ of the source.

Table 5. IRAC Catalog and Archive Formats-Single Epoch Source Lists

Col.	Name	Description	Data	Format	Null
1	globalSourceID	Unique identifier	I*4	i10	NO
2	sourceCatalog	Identifier for source catalog	ASCII	a8	NO
3	epoch	Identifier for the epoch of the observations of the source	ASCII	a16	NO
4	designation	Source name Archive: SSTISAGE1A JHHMMSS.SS±DDMMSS.S Catalog: SSTISAGE1C JHHMMSS.SS±DDMMSS.S	ASCII	a32	NO
5	TmassCntr	cntr from 2MASS Point Source Catalog	I*4	i10	0
6	TmassDesignation	2mass source name	ASCII	a32	null
7	ra	Right Ascension, J2000 (deg)	R*8	f11.6	NO
8	dec	Declination, J2000 (deg)	R*8	f11.6	NO
9	dra	Error in Right Ascension ($''$) dra is in units of arcseconds, so to convert to seconds of time, multiply by cos(dec)/15.	R*8	f4.1	NO
10	ddec	Error in Declination ($''$)	R*8	f4.1	NO
11	closeFlag	Close source flag	I*2	i3	NO
12-25	magi, dmagi	Magnitude from from J,H,K (i=1-3) and each IRAC band (i=4-7) and 1σ error (mag)	R*4	7(f7.3,f7.3)	99.999,99.999
26-39	fi,dfi	Fluxes and 1σ error in each band i, i=1-7 (mJy)	R*4	14(e11.3)	-999.9,-999.9
40-43	rms_fi	rms dev. of individual detections from fi (i=4-7), (mJy)	R*4	4(e11.3)	-999.9
44-47	skyi	Local sky bkg. for band i flux (i=4-7), (MJy/sr)	R*4	4(e11.3)	-999.9
48-54	sni	Signal/Noise for band i flux (i=1-7)	R*4	7(f6.2)	-9.99
55-58	srcdensi	Local source density for band i object (i=4-7), (#/sq')	R*4	4(f5.1)	-9.9
59-62	mi	Number of detections for band i (i=4-7)	I*2	4(i3)	NO
63-66	ni	Possible number of detections for band i (i=4-7)	I*2	4(i3)	NO
67-73	sqfi	Source Quality Flag for band i flux (i=1-7)	I*4	7(i10)	-9
74-77	mflagi	Flux calc method flag for band i flux (i=4-7)	I*2	4(i3)	-9
78	versionNo	Version number assigned by IRAC pipeline team	R*4	f6.2	NO
79	versionDate	Date catalog was produced in the following format, "mon dd yyyy", "Dec 5 2007"	ASCII	a12	NO
80	cx	x of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
81	cy	y of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
82	cz	z of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
83	htmID	The Hierchical Triangular Mesh partition computed at index level 20 in which this source lies	I*4	i20	NO

Table 6. IRAC Catalog and Archive Formats-Single Frame + Mosaic Photometry Source Lists

Col.	Name	Description	Data	Format	Null
1	globalSourceID	Unique identifier	I*4	i10	NO
2	sourceCatalog	Identifier for source catalog	ASCII	a8	NO
3	epoch	Identifier for the epoch of the observations of the source	ASCII	a16	NO
4	designation	Source name Archive: SSTISAGEMA JHHMMSS.SS±DDMMSS.S Catalog: SSTISAGEMC JHHMMSS.SS±DDMMSS.S	ASCII	a32	NO
5	TmassCntr	cntr from 2MASS Point Source Catalog	I*4	i10	0
6	TmassDesignation	2mass source name	ASCII	a32	null
7	ra	Right Ascension, J2000 (deg)	R*8	f11.6	NO
8	dec	Declination, J2000 (deg)	R*8	f11.6	NO
9	dra	Error in Right Ascension (″) dra is in units of arcseconds, so to convert to seconds of time, multiply by cos(dec)/15.	R*8	f4.1	NO
10	ddec	Error in Declination (″)	R*8	f4.1	NO
11	closeFlag	Close source flag	I*2	i3	NO
12	closeFullFlag	Close fulls flag	I*2	i3	NO
13-26	magi, dmagi	Magnitude from from J,H,K (i=1-3) and each IRAC band (i=4-7) and 1σ error (mag)	R*4	7(f7.3,f7.3)	99.999,99.999
27-40	fi,dfi	Fluxes and 1σ error in each band i, i=1-7 (mJy)	R*4	14(e11.3)	-999.9,-999.9
41-44	rms_fi	rms dev. of individual detections from fi (i=4-7), (mJy)	R*4	4(e11.3)	-999.9
45-48	skyi	Local sky bkg. for band i flux (i=4-7), (MJy/sr)	R*4	4(e11.3)	-999.9
49-55	sni	Signal/Noise for band i flux (i=1-7)	R*4	7(f6.2)	-9.99
56-59	srcdensi	Local source density for band i object (i=4-7), (#/sq')	R*4	4(f5.1)	-9.9
60-63	mi	Number of detections for band i (i=4-7)	I*2	4(i3)	NO
64-67	ni	Possible number of detections for band i (i=4-7)	I*2	4(i3)	NO
68-74	sqfi	Source Quality Flag for band i flux (i=1-7)	I*4	7(i10)	-9
75-78	mflagi	Flux calc method flag for band i flux (i=4-7)	I*2	4(i3)	-9
79	versionNo	Version number assigned by IRAC pipeline team	R*4	f6.2	NO
80	versionDate	Date catalog was produced in the following format, "mon dd yyyy", "Dec 5 2007"	ASCII	a12	NO
81	cx	x of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
82	cy	y of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
83	cz	z of unit vector on the unit sphere for ra,dec of this source	R*4	f30.20	NO
84	htmID	The Hierchical Triangular Mesh partition computed at index level 20 in which this source lies	I*4	i20	NO

C.4. Local Source Density

If a band's flux was derived from single frame photometry, a local source density (number of sources per square arcmin) was measured as follows: The individual IRAC frame is divided into a 3×3 grid, each of the nine cells being $1\farcm71 \times 1\farcm71$. A source density is calculated for each cell (number of sources per arcmin^2), and is assigned to each source in that cell. If a band's flux was derived from photometry on a mosaiced image, the local source density is set to zero.

C.5. M and N (number of actual detections, number of possible detections)

For fluxes derived from single frame photometry:

M = All detections used in the final flux calculation. Detections can be thrown out by exposure time (when combining 0.6 and 12 second data, for example), or because they have bad SQF flags. Detections are also thrown out at the beginning of bandmerging for sensitivity or saturation reasons. If *any* detections without bad flags went into the final flux, then only those good detections are counted. If all detections had bad flags, then all are counted, and the final source will have some bad quality flags also. Bad in this context is 8=hot/dead pixel and 30=edge (see Appendix C.6 for SQF details).

N = All frames containing the position of the combined source in this band (*not* including the edge of the frame, within 3 pixels) for which the exposure time was used in the final flux. As for M, if *any* good detections are used, we only count the good detections, but if they're all bad we count all of them and set flags in the final source. For sources not detected in a band, the position of the final cross-band merged source is used for calculating N.

For fluxes derived from mosaic photometry, M=N=1.

C.6. Source Quality Flag (SQF)

The Source Quality Flag (SQF) is generated from SSC-provided masks and the SAGE 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 C.6.1), will not compromise the source's reliability, but have 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 used in the culling to produce the Catalog. Table 7 gives the Source Quality Flag bits and the origin of the flag (SSC or SAGE pipeline). Each of the 7 bands has its own Source Quality Flag. 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.

Some SQF bits were carried over from the single frame photometry to the single frame + mosaic photometry source lists, namely bits 3 (latent), 7 (muxbleed), 9 ($>3\sigma$ muxbleed), 15 (column pulldown), 16 (banding), and 20 (saturated star wing area). Bits 10 (DAOPHOT tweak positive) and 11 (DAOPHOT tweak negative) can come from either the mosaic photometry or the single frame photometry.

There are three possible SQF styles:

1) Mosaic entry, flux calculation method flag = 12288 (mosaic only data, no single frame data). This data will only have SQF of mosaic tweaking and the bandmerging SQFs (bits 21 and higher). Mosaic photometry entries in this case should have only the following SQF bits:
10 (tweak positive) From Mosaic photometry cat file
11 (tweak negative) From Mosaic photometry cat file
21 (pre-lumping in-band merge) From bandmerging step
22 (post-lumping cross-band merge) From bandmerging step

2) Mosaic entry, flux calculation method flag of 12352 and 12353 indicates single frame photometry present. The SQF will be a mix of single frame SQF and the mosaic photometry tweak bits as well as the bandmerging SQFs (bits 21 and higher). Mosaic photometry entries should have only the following SQF bits:
3 (latent bit) From Single frame photometry database entry
7 (muxbleed) From Single frame photometry database entry
9 ($>3\sigma$ muxbleed) From Single frame photometry database entry
10 (tweak positive) From Mosaic photometry cat file
11 (tweak negative) From Mosaic photometry cat file
15 (col pulldown) From Single frame photometry database entry
16 (banding) From Single frame photometry database entry
20 (satwing) From Single frame photometry database entry
21 (pre-lumping in-band merge) From bandmerging step
22 (post-lumping cross-band merge) From bandmerging step

24 (in-band merge confusion) From bandmerging step

3) Single Frame entry - contains all Single Frame SQF values as well as the bandmerging SQFs (bits 21 and higher). The entries can have all the SQF bits listed in Table 7 except bit 24.

C.6.1. IRAC Source Quality Flag

Information is gathered from the SSC IRAC bad pixel mask (pmask), SSC bad data mask (dmask) and the SAGE IRAC pipeline for the Source Quality Flag. For more information about the IRAC pmask and dmask, see
http://ssc.spitzer.caltech.edu/irac/products/pmask.html
and
http://ssc.spitzer.caltech.edu/irac/products/bcd_dmask.html

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 issues. A detailed description of the bits is given 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.

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

Table 7. Source Quality Flag bits

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

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 Sections 4.2 and 5.2)

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 consisted 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 considers 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 for all bands.

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.

19 - data predicted to saturate

This bit is set when a source is within 3 pixels of a pixel identified in the dmask as being saturated (bit 10 in the dmask). The SAGE IRAC pipeline runs a saturated pixel estimator 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 extracted photometry above the IRAC non-linear (near-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. Bands with this bit set are not counted during the source selection process (see Sections 4.2 and 5.2)

21 - pre-lumping in in-band merge

Sources in the same IRAC frame within a radius of 1.6 arcsec 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 for all bands. Cross-band lumping is done with a 1.6 arcsec radius. For example, say there are two sources within 1.6 arcsec 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.

24 - confusion in in-band merge with mosaic photometry

This bit is set during the in-band bandmerging process. The bandmerger finds the nearest mosaic photometry source neighbor for each single frame photometry source. Then it finds the nearest single frame photometry source to each mosaic photometry source. If those two sources are pointing at each other, then it tries to merge, according to the flux criteria (see Sect 5.1). Otherwise, it decides things are confused, keeps just the single frame photometry flux, and sets this bit.

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 Sections 4.2 and 5.2)

C.6.2. 2MASS Source Quality Flag

For the 2MASS bands, the following contamination and confusion (cc) flags from the 2MASS All Sky + 6X2MASS 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/All-Sky/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/All-Sky/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 for all bands.
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 1.6 arcsec radius.
23 - Photometric quality flag
24 - Photometric quality flag
25 - Photometric quality flag

In Table 8:
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

Table 8. 2MASS Source Quality Flag

2MASS “ph” Flag =>	SQF bits 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

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.

C.6.3. Key to Bit Values

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

bt = bit in SQF
value = $\sum 2^{(bt-1)}$

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, say the Source Quality Flags 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. Say 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.

C.7. Flux Calculation Method Flag

The flux calculation method flag (MF) indicates by bit, for single frame photometry, whether a given exposure time was present, and whether that exposure time was used in the final flux. If a mosaic photometry result is present for the source's flux in a given band, bit 13 is set. If a band's flux was derived from mosaic photometry, bit 14 is set. Bit 15 is set if the source is an "addBack" source (see Sect 5.3).

Table 9.

ft	present		used	
	bit	(value)	bit	(value)
0.6	1	(1)	2	(2)
1.2	3	(4)	4	(8)
2	5	(16)	6	(32)
12	7	(64)	8	(128)
30	9	(256)	10	(512)
100	11	(1024)	12	(2048)
mosaic	13	(4096)	14	(8192)
addBack	15	(16384)		

For example, if 0.6 and 12 sec data were present, but only the 12 sec data were used, then bits 1 and 7 will be set (fluxes present) and bit 8 will be set (12 sec used) and the MF will be $2^0 + 2^6 + 2^7 = 1 + 64 + 128 = 193$ (see Table 9). Note that, in practice, MF of 193 is rarely assigned because some detections are thrown out at the beginning of bandmerging because of sensitivity or saturation issues (see Sect 4.1).

For SAGE 12/0.6 sec HDR mode and single frame + mosaic photometry, the relevant numbers work out to be

3 - short exp data used, long exp data absent
67 - short used, long present but unused
192 - long exp used, short absent
193 - long exp used, short present but unused
195 - both long and short present and used

4099 - 0.6 sec data, mosaic photometry data present
4163 - 0.6 sec data, 12 sec and mosaic present
4288 - 12 sec data, mosaic present
4291 - 12 sec and 0.6 sec data, mosaic present
12288 - mosaic photometry only, present and used
12352 - mosaic photometry present and used, 12 sec present
12353 - mosaic photometry present and used, 0.6 and 12 sec present
>16384 - an addBack source

C.8. An Example of a Line of Text for SAGELMCcatalogIRAC/SAGELMCarchiveIRAC

Here is an example of a line of text for the Single Frame + Mosaic Photometry Catalog (84 columns)

globalSourceID sourceCatalog epoch designation TmassCntr TmassDesignation ra dec dra ddec closeFlag closeFullFlag magJ dmagJ magH dmagH magK dmagK mag3_6 dmag3_6 mag4_5 dmag4_5 mag5_8 dmag5_8 mag8_0 dmag8_0 fluxJ dfluxJ fluxH dfluxH fluxK dfluxK flux3_6 dflux3_6 flux4_5 dflux4_5 flux5_8 dflux5_8 flux8_0 dflux8_0 rms_f3_6 rms_f4_5 rms_f5_8 rms_f8_0 sky3_6 sky4_5 sky5_8 sky8_0 SNJ SNH SNK SN3_6 SN4_5 SN5_8 SN8_0 srcDensity3_6 srcDensity4_5 srcDensity5_8 srcDensity8_0 m3_6 m4_5 m5_8 m8_0 n3_6 n4_5 n5_8 n8_0 sqfJ sqfH sqfK sqf3_6 sqf4_5 sqf5_8 sqf8_0 mf3_6 mf4_5 mf5_8 mf8_0 versionNo versionDate cx cy cz htmID

1529671339 iracc SMP SSTISAGEMC J041926.58-694232.0 52639282 04192661-6942318 64.860763 -69.708894 0.3 0.3 0 0 16.134 0.04 15.408 0.051 15.25 0.077 14.98 0.056 15.029 0.097 14.85 0.131 99.999 99.999 0.5609 0.02061 0.7032 0.03284 0.5296 0.0378 0.286 0.0148 0.175 0.0156 0.132 0.01595 -999.9 -999.9 0.001826 0 0 -999.9 0.009 -0.004 0.783 0.368 27.21 21.41 14.01 19.32 11.22 8.28 -9.99 22.7 0 0 0 2 1 1 1 2 1 1 1 29368320 29368320

Table 10. The Example Line from SAGELMCcatalogIRAC

Parameter	Value	Description
globalSourceID ..	1529671339	Unique identifier
sourceCatalog ...	iracc	Identifier for source catalog
epoch	smp	Identifier for epoch of source
designation	SSTISAGEMC J041926.58-694232.0	source name
TmassCntr	52639282	2MASS cntr from 2MASS PSC
TmassDesignation	04192661-6942318	2MASS designation from 2MASS PSC
ra, dec	64.860763, -69.708894	RA and Dec in degrees
dra, ddec	0.3, 0.3	Error in RA and Dec in arcsec
	...	dra is in units of arcseconds,
	...	so to convert to seconds of
	...	time, multiply by cos(dec)/15.
closeFlag	0	Close source flag
closeFullFlag	0	Close Fulls flag
mag	16.134, 15.408, 15.25, 14.98, 15.029, 14.85,99.999	Magnitudes [JHK, Bands 1-4]
dmag	0.04, 0.051, 0.077, 0.056, 0.097, 0.131, 99.999	mag uncertainties [JHK, Bands 1-4]
flux	0.5609, 0.7032, 0.5296, 0.286, 0.175, 0.132, -999.9	Fluxes (mJy) JHK and Bands 1-4
dflux	0.02061, 0.03284, 0.0378, 0.0148, 0.0156, 0.01595, -999.9	Flux uncertainties (mJy) [JHK, Bands 1-4]
rms_f	0.001826, 0, 0, -999.9	rms_flux (mJy) [Bands 1-4]
sky	0.009, -0.004, 0.783, 0.368	Sky Bkg (MJy/sr) [Bands 1-4]
S/N	27.21, 21.41, 14.01, 19.32, 11.22, 8.28, -9.99	Signal to Noise [J,H,K,Bands 1-4]
srcDensity	22.7, 0, 0, 0	Local Source Density [Bands 1-4]
m	2, 1, 1, 1	Number of detections [Bands 1-4]
n	2, 1, 1, 1	Number of poss detections [Bands 1-4]
sqf	29368320, 29368320, 29368320, 8704, 25088, 8192, 512	Source Quality Flag [J,H,K,Bands 1-4]
mf	4288, 12352, 12352, 12352	Flux Calculation Method Flag [Bands 1-4]
versionNo	3.1	Catalog version number assigned by
....	...	IRAC pipeline team
versionDate	Aug 17 2009	Date catalog was produced
	...	in the following format,
	...	"month day year"
cx	0.147323169248887	x of unit vector to this source
cy	0.313941442026067	y of unit vector to this source
cz	-0.937942777988645	z of unit vector to this source
htmID	9328355664077	20-deep HTM ID of this source

29368320 8704 25088 8192 512 4288 12352 12352 12352 3.1 Aug 17 2009 0.147323169248887 0.313941442026067 -0.937942777988645 9328355664077

Table 10 shows the same line from SAGELMCcatalogIRAC with the detailed description of the individual columns (see also Table 6 in Appendix C). SAGELMCarchiveIRAC contains the same columns with the sourceCatalog column set to 'iraca'.

The single epoch source lists (SAGELMCcatalogIRAC_EP1_EP2 and SAGELMCarchiveIRAC_EP1_EP2) contain all the columns listed in Table 10 except the 'closeFullFlag' column that is only present in the Single Frame + Mosaic Photometry Catalog and Archive. For SAGELMCcatalogIRAC_EP1_EP2/SAGELMCcatalogIRAC_EP1_EP2, the sourceCatalog column is set to 'iracc'/'iraca' and the epoch column can either be 'epoch 1' or 'epoch 2'.

D. APPENDIX D - IRAC FITS File Header

Here is an example of the IRAC FITS file header for an IRAC $8^\circ \times 8^\circ$ $2''$ pixel mosaic, SAGE_LMC_IRAC3.6_2_mosaic.fits:

```
SIMPLE  =                    T / Written by IDL:  Wed Apr 22 21:29:07 2009
BITPIX  =                  -32 / array data type
NAXIS   =                    2  / number of array dimensions
NAXIS1  =                14820
NAXIS2  =                15670
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
COMMENT --------------------
COMMENT Pointing Information
COMMENT --------------------
CD1_1   =      -4.95003625E-04
CD1_2   =       2.52216944E-04
CD2_1   =       2.52216944E-04
CD2_2   =       4.95003625E-04
CRPIX1  =              7410.50 /Reference pixel for $\times$-position
CRPIX2  =              7835.50 /Reference pixel for y-position
CRVAL1  =        79.7000000000 /[Deg] Right Ascension at reference pixel
CRVAL2  =       -68.7000000000 /[Deg] Declination at reference pixel
CTYPE1  = 'RA---TAN'           /Projection Type
CTYPE2  = 'DEC--TAN'           /Projection Type
RA      =              79.7000 /[Deg] Right ascension at mosaic center
DEC     =             -68.7000 /[Deg] Declination at mosaic center
COMMENT --------------------
TELESCOP= 'SPITZER '           /Telescope
INSTRUME= 'IRAC    '           /Instrument ID
ORIGIN  = 'UW Astronomy Dept'  /Installation where FITS file written
CREATOR = 'IRAC Pipeline'      /SW that created this FITS file
CREATOR1= 'S13.2 and later'    /SSC pipeline that created the BCD
MOSAICER= 'Montage V3.0'       /SW that originally created the Mosaic Image
FILENAME= 'SAGE_LMC_IRAC3.6_2_mosaic' /Name of this file
FILETYPE= 'mosaic  '           /Calibrated image(mosaic)/residual image(resid)
```

```
CHNLNUM =                    1 /1 digit Instrument Channel Number
DATE    = '2009-03-04T19:58:14' /file creation date (YYYY-MM-DDThh:mm:ss UTC)
COMMENT --------------------
BUNIT   = 'MJy/sr  '           /Units of image data
GAIN    =              3.30000 /e/DN conversion
PIXSCAL1=              2.00000 /[arcsec/pixel] pixel scale for axis 1
PIXSCAL2=              2.00000 /[arcsec/pixel] pixel scale for axis 2
OLDPIXSC=              1.22100 /[arcsec/pixel] pixel scale of single IRAC frame
NIMAGES =                38490 /Number of Frames in Mosaic
COMMENT --------------------
COMMENT Proposal Information
COMMENT --------------------
OBSERVR = 'Margaret Meixner'   /Observer Name
OBSRVRID=                12121 /Observer ID of Principal Investigator
PROCYCLE=                    5 /Proposal Cycle
PROGID  =                20203 /Program ID
PROTITLE= 'Spitzer Survey of the Large Magellanic Cloud' /Program Title
PROGCAT =                   30 /Program Category
COMMENT ----------------------------
COMMENT Time and Exposure Information
COMMENT ----------------------------
FRAMTIME=              12.0000 /[sec] Time spent integrating each BCD frame
EXPTIME =              10.4000 /[sec] Effective integration time each BCD frame
COMMENT DN per pixel=flux(photons/sec/pixel)/gain*EXPTIME
NEXPOSUR=                    4 /Typical number of exposures
COMMENT Total DN per pixel=flux(photons/sec/pixel)/gain*EXPTIME*NEXPOSUR
COMMENT Total integration time for the mosaic = EXPTIME * NEXPOSUR
AFOWLNUM=                    8 /Fowler number
COMMENT ----------------------------
COMMENT AORKEYS/ADS Ident Information
COMMENT ----------------------------
AOR001  = '0014353408'         /AORKEYS used in this mosaic
AOR002  = '0014349568'         /AORKEYS used in this mosaic
AOR003  = '0014349312'         /AORKEYS used in this mosaic
AOR004  = '0014349824'         /AORKEYS used in this mosaic
AOR005  = '0014350336'         /AORKEYS used in this mosaic
AOR006  = '0014350592'         /AORKEYS used in this mosaic
AOR007  = '0014350080'         /AORKEYS used in this mosaic
```

```
AOR008  = '0014351360'        /AORKEYS used in this mosaic
AOR009  = '0014351616'        /AORKEYS used in this mosaic
AOR010  = '0014350848'        /AORKEYS used in this mosaic
.
.
       AORKEY information for AORs 11 through 90
.
.
AOR091  = '0014372864'        /AORKEYS used in this mosaic
AOR092  = '0014372096'        /AORKEYS used in this mosaic
AOR093  = '0014372352'        /AORKEYS used in this mosaic
AOR094  = '0014373120'        /AORKEYS used in this mosaic
AOR095  = '0014373632'        /AORKEYS used in this mosaic
AOR096  = '0014373376'        /AORKEYS used in this mosaic
AOR097  = '0014373888'        /AORKEYS used in this mosaic
AOR098  = '0014374144'        /AORKEYS used in this mosaic
DSID001 = 'ads/sa.spitzer#0014353408' /Data Set Identification for ADS/journals
DSID002 = 'ads/sa.spitzer#0014349568' /Data Set Identification for ADS/journals
DSID003 = 'ads/sa.spitzer#0014349312' /Data Set Identification for ADS/journals
DSID004 = 'ads/sa.spitzer#0014349824' /Data Set Identification for ADS/journals
DSID005 = 'ads/sa.spitzer#0014350336' /Data Set Identification for ADS/journals
DSID006 = 'ads/sa.spitzer#0014350592' /Data Set Identification for ADS/journals
DSID007 = 'ads/sa.spitzer#0014350080' /Data Set Identification for ADS/journals
DSID008 = 'ads/sa.spitzer#0014351360' /Data Set Identification for ADS/journals
DSID009 = 'ads/sa.spitzer#0014351616' /Data Set Identification for ADS/journals
DSID010 = 'ads/sa.spitzer#0014350848' /Data Set Identification for ADS/journals
.
.
    Data Set Identification for IDs 11 through 90
.
.
DSID090 = 'ads/sa.spitzer#0014372608' /Data Set Identification for ADS/journals
DSID091 = 'ads/sa.spitzer#0014372864' /Data Set Identification for ADS/journals
DSID092 = 'ads/sa.spitzer#0014372096' /Data Set Identification for ADS/journals
DSID093 = 'ads/sa.spitzer#0014372352' /Data Set Identification for ADS/journals
DSID094 = 'ads/sa.spitzer#0014373120' /Data Set Identification for ADS/journals
DSID095 = 'ads/sa.spitzer#0014373632' /Data Set Identification for ADS/journals
DSID096 = 'ads/sa.spitzer#0014373376' /Data Set Identification for ADS/journals
```

```
DSID097 = 'ads/sa.spitzer#0014373888' /Data Set Identification for ADS/journals
DSID098 = 'ads/sa.spitzer#0014374144' /Data Set Identification for ADS/journals
END
```

E. APPENDIX E - Gradient Corrected IRAC 8°× 8° Images

The observing strategy for the SAGE project was to divide the SAGE LMC IRAC area into 7 × 7 tiles, or Astronomical Observing Requests (AORs) for each of the two epochs. One SAGE AOR was 1°.1 × 1°.1, made up of 14 × 28 IRAC frames, with half-array steps. See Meixner et al 2006 for more details of the mapping strategy. To produce the background matched and gradient corrected SAGE images, each individual AOR was mosaicked (with background matching) using Montage v3.0. For each AOR, the corrections.tbl file giving the corrections used by Montage to match the backgrounds was then converted to a table of corrections as a function of position in the AOR mosaic. This was used to find the correction at each pixel position in the AOR mosaic using a smoothing radial basis function interpolation. This 'smoothed correction map' was compared to the original corrections, and outliers were rejected from the original table. A new smoothed map was produced, and this procedure was repeated several times, to ensure that no outliers affected the smoothed map. The final background correction map obtained thus represented the incorrect fit applied by Montage, and this correction map was then subtracted from the AOR mosaic. The rejection of outliers was necessary, as these outliers correspond to desirable corrections rather than large-scale corrections. Figures 22, 23, 24 and 25 demonstrate the procedure for the mosaic of Epoch 1 AOR 14360576.

The next step was to mosaic all 49 AORs together for each epoch to produce the 8°× 8° images. Background matching was used to remove differences in the levels of different AOR frames. Once again, large-scale gradients were removed by producing smoothed correction maps and subtracting these from the mosaics. At 5.8 μm, a number of AOR mosaics were offset from the majority of AOR mosaics, and therefore had a significantly different offset correction applied. These were ignored when calculating the smoothed correction map, as these correspond to desirable corrections, rather than undesirable large-scale gradients.

For each band, the combined epoch 8°× 8° mosaic was produced by averaging the 8°× 8° mosaics for the two separate epochs. NaN pixels were ignored in the averages; so for pixels where one epoch had a NaN value, the flux for the other epoch was used. At 5.8 μm, the first 8 frames of each AOR for the first epoch, and the first 28 frames for the second epoch

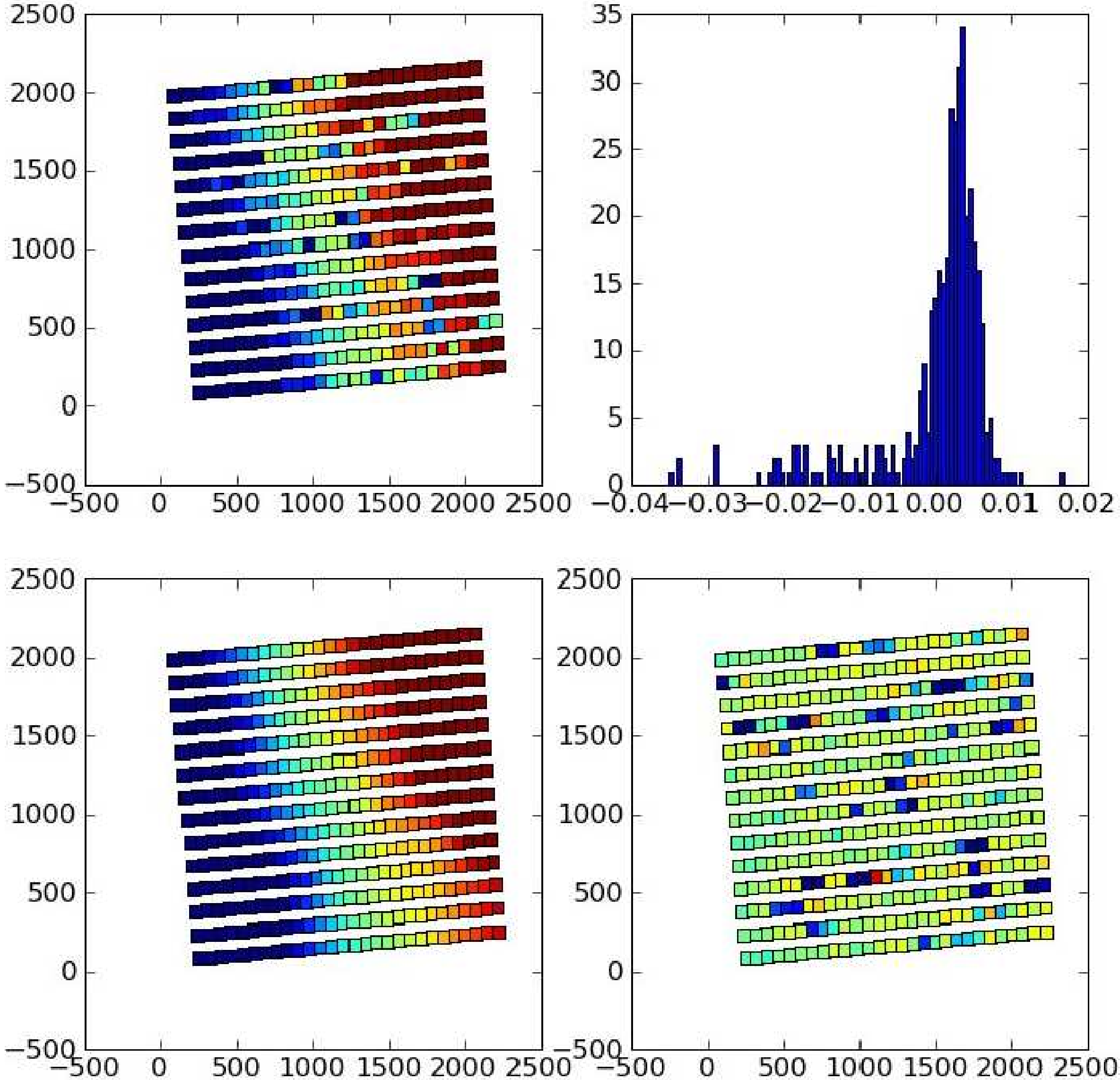

Fig. 22.— The IRAC frames of the epoch 1 AOR 14360576 (14 × 28 frames) for the 3.6 μm data. The frames are offset in height for presentation and the axis scales are arbitrary. The top left plot shows the original corrections at the pixel positions of the BCDs. The smoothed corrections at the same locations are shown in the bottom left plot. The difference between the two is shown in the bottom right, and a histogram of the differences is given in the top right plot.

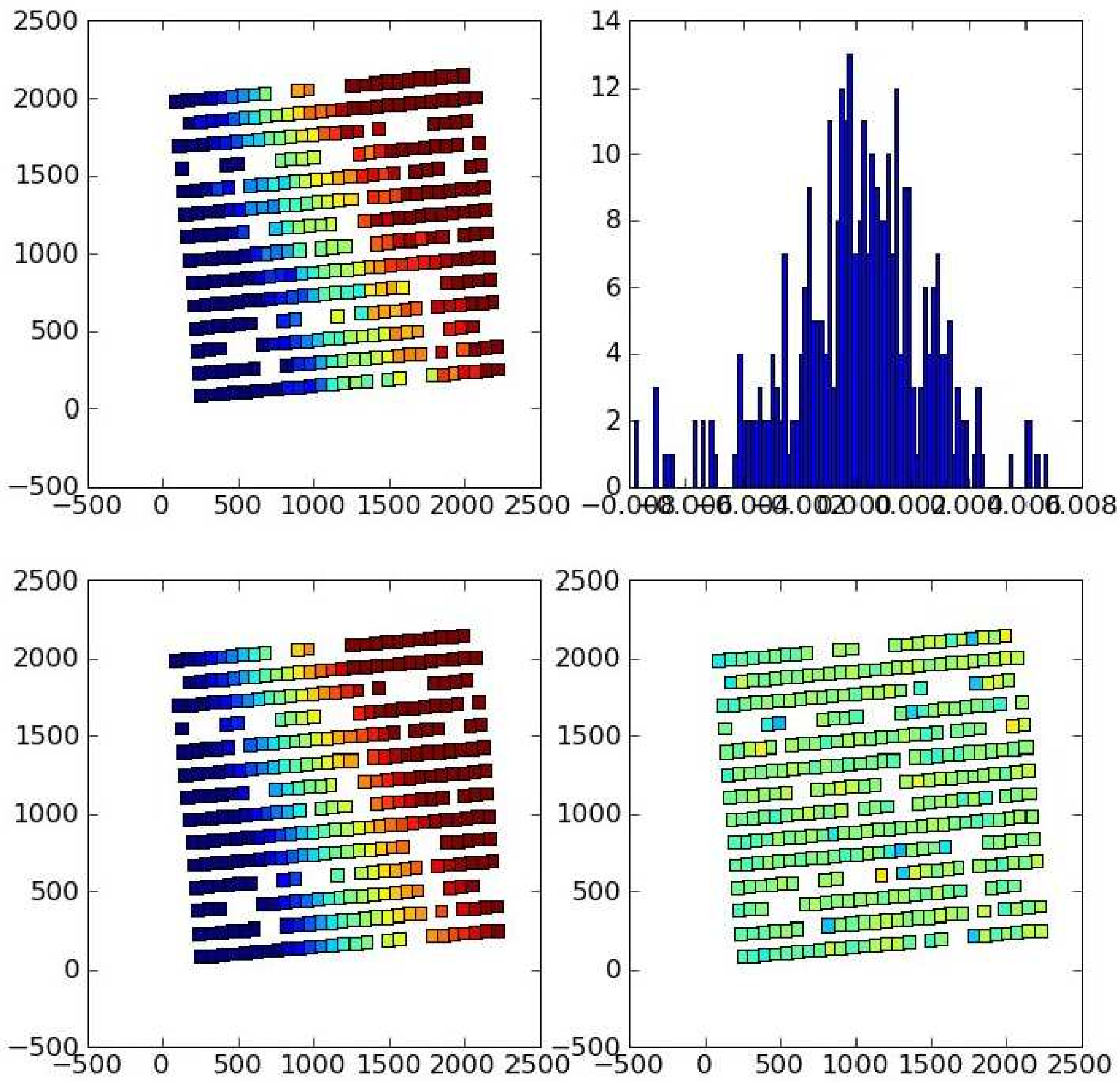

Fig. 23.— The IRAC frames of the epoch 1 AOR 14360576 (14 × 28 frames) for the 3.6 μm data with outlier frames rejected.

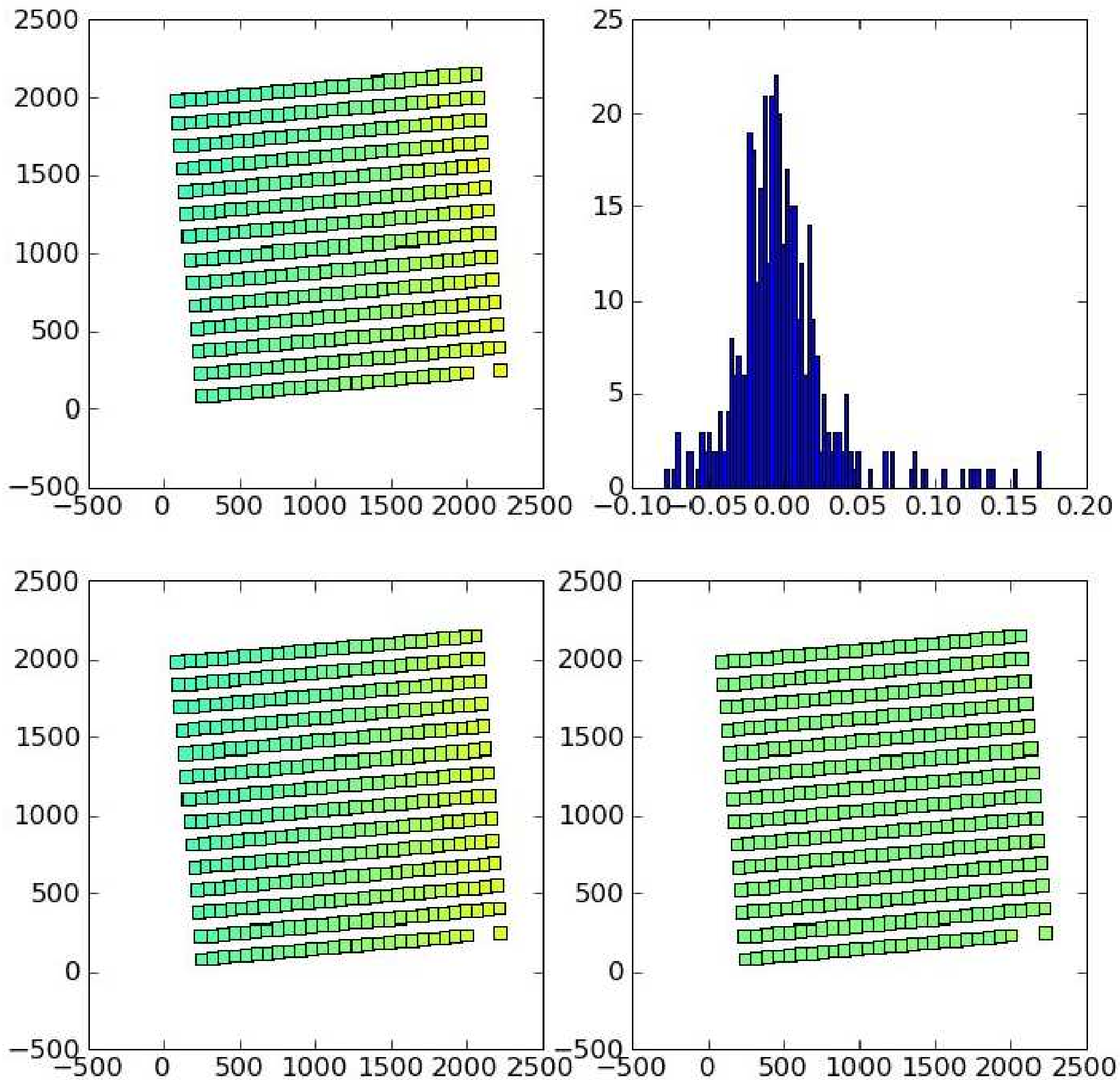

Fig. 24.— The original corrections at the positions of the IRAC 8.0 μm BCDs for AOR 14360576 with outliers rejected (top left), the smoothed corrections at the same locations (bottom left), the difference between the two (bottom right), and a histogram of the differences (top right)

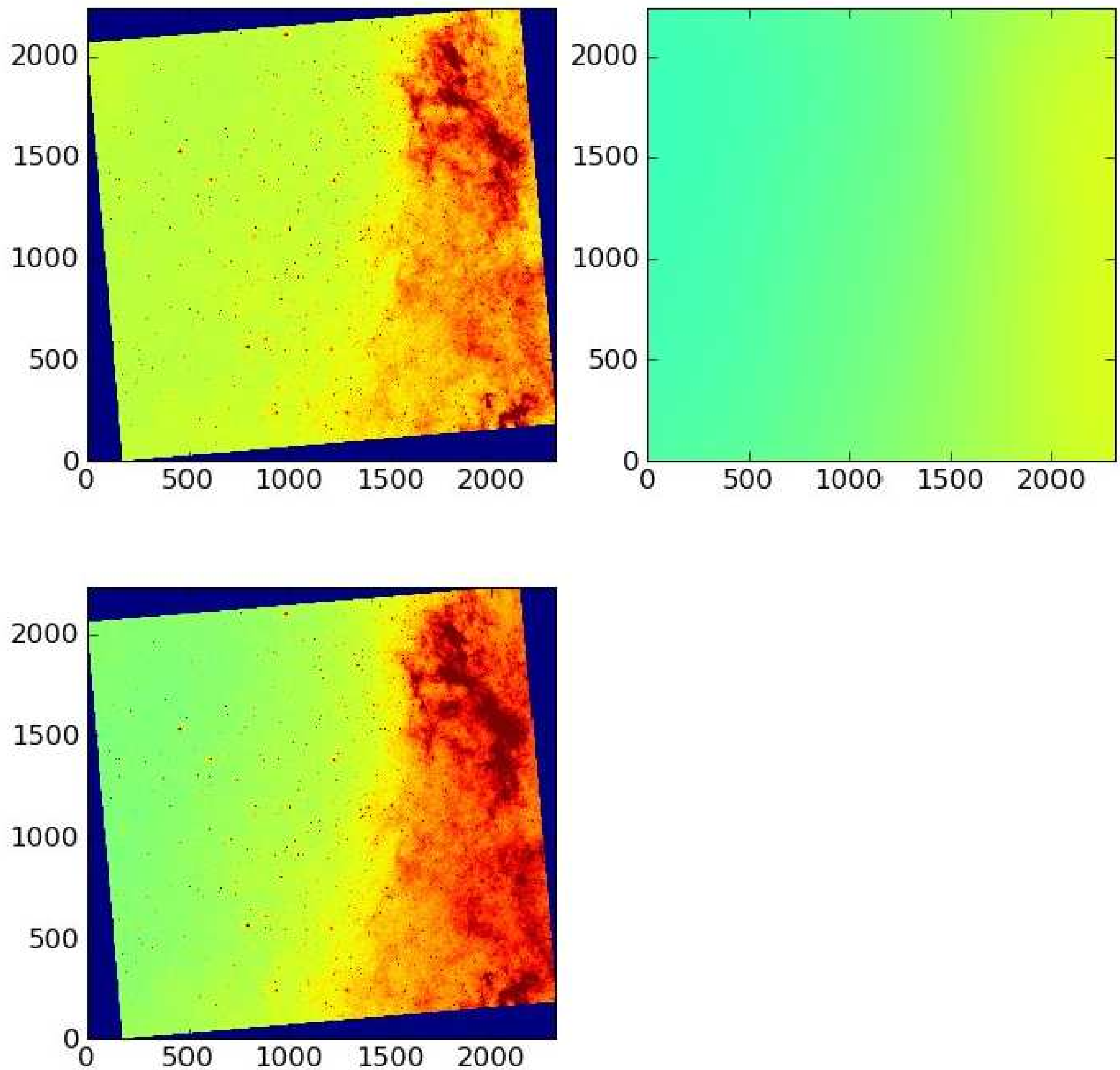

Fig. 25.— The background matched mosaic for the 8.0 μm band for AOR 14360576 (top left), the smoothed correction (top right), and the final background matched and corrected image (bottom left)

were deleted due to first frame effect.

For the 5.8 and 8.0 μm mosaics, there is a systematic difference in the absolute background flux level of about 0.2MJy/sr at 5.8 μm, and about 0.3 MJy/sr at 8.0 μm between the epochs. Therefore, when producing the combined epoch mosaics, the following offsets were applied to the single epoch mosaics:

-0.10 for 5.8 μm epoch 1
$+0.10$ for 5.8 μm epoch 2
$+0.15$ for 8.0 μm epoch 1
-0.15 for 8.0 μm epoch 2

This gives the average of the two epoch values.

F. APPENDIX F - MIPS 24 μm Catalog Formats

F.1. The Differences Between the 2nd and the 1st Delivery of the MIPS 24 μm Point Source Catalog

This second MIPS 24 μm catalog delivery has benefited from extensive reliability testing. The high reliability single epoch catalogs are the result of this testing. In addition, the processing of the individual AORs has improved by a small amount allowing for the removal of some additional 24 μm instrumental artifacts. The first MIPS 24 μm catalog delivery was based on the preliminary extractions of sources.

F.2. An Example of a Line of Text for SAGELMCcatalogMIPS24/SAGELMCfullMIPS24

Here is an example of a line of text for the Catalog (29 columns; see also Table 12)

globalSourceID sourceCatalog epoch designation ra dec dra ddec conf24 mag24 dmag24 flux24 dflux24 sky24 SN24 flag24 correlation24 mmmSkymode24 mmmSigma24 mmmSkew24 mmmNsky24 averageCoverage24 AORNumber24 versionNo versionDate cx cy cz htmID

1542970251 mips24c epoch 1 SSTM1SAGE1 J051321.75-692240.3 78.34063 -69.377871 0.02 0.02 0 -0.06707 0.005458 7627 38.34 79.68 198.93 0 0.964 37.63 33.41 0.7805 2122 11.17 14382080 2.4 Aug 31 2009 0.0711777387999096 0.344935919964786 -0.935923576269654 9315124191905

The detailed description of the individual columns and the data format can be found in Table 11. The MIPS 24 μm Full List (SAGELMCfullMIPS24) contains the same columns as the MIPS 24 μm Catalog (SAGELMCcatalogMIPS24). However, for the full list the 'sourceCatalog' column is set to 'mips24f'.

Table 11. SAGELMCcatalogMIPS24 and SAGELMC-fullMIPS24 Format

Col.	Name	Description	Data	Format	Null
1	globalSourceID . . .	Unique identification number of each source in the catalog	I*4	i10	NO

Continued on Next Page. . .

Table 11 – Continued

Col.	Name	Description	Data	Format	Null
2	sourceCatalog	Character string identifier for source catalog	ASCII	a8	NO
3	epoch	Character string identifier for the epoch of the observation of the source	ASCII	a16	NO
4	designation	SAGE source designation name	ASCII	a32	NO
5	ra	Right ascension, J2000 (deg)	R*8	f11.6	NO
6	dec	Declination, J2000 (deg)	R*8	f11.6	NO
7	dra	Error in Right Ascension (″)	R*8	f4.1	NO
8	ddec	Error in Declination (″)	R*8	f4.1	NO
9	conf24	Confusion Flag for band 24, currently unused	I*2		-9
10	flux24	24μm flux (mJy)	R*8	e11.3	-999.9
11	dflux24	24μm 1σ error (mJy)	R*8	e11.3	-999.9
12	mag24	24μm magnitude	R*8	f7.3	-999.9
13	dmag24	24μm 1σ error	R*8	f7.3	-999.9
14	sky24	Local Sky Bkg. for band 24 (MJy/sr)	R*4	e11.3	-999.9
15	SN24	Signal/Noise for band 24	R*4	f6.2	-9.99
16	flag24	The flag currently refers to how many times a source was observed by different AORs in a single epoch. Is it was observed more than once, the reported flux is the average of the multiple observations. If flag24 = 0, then it was only measured in 1 AOR. If it is > 1 (it will never be 1), then that is the number.	I*2		-9
17	correlation24	Correlation describes how like the input PSF each point source is	R*8	e11.3	-999.9
18	mmmSkymode24 ..	Scalar giving estimated mode of the sky values. Sky is	R*8	f11.6	NO

Continued on Next Page...

Table 11 – Continued

Col.	Name	Description	Data	Format	Null
		determined in a 49x49 square pixel (1 pixel = 2.″49) region surrounding the source in the residual image (all sources subtracted).			
19	mmmSigma24	Scalar giving standard deviation of the peak in the sky histogram. If for some reason it is impossible to derive skymode, then SIGMA = -1.	R*8	f11.6	NO
20	mmmSkew24	Scalar giving skewness of the peak in the sky histogram	R*8	f11.6	NO
21	mmmNsky24	number of points used to determine the sky values for mmmSkymode24, mmmSigma24 and mmmSkew24	R*8	f11.6	NO
22	averageCoverage24	The average coverage (no. of independent observations per pixel) in a 49×49 square pixel (1 pixel = 2.″49) region centered on the source.	R*8	f11.6	NO
23	AORNumber24 ...	Request key for the 1st AOR within which the source appears	I*4	i10	NO
24	versionNo	Version number assigned by MIPS pipeline team	R*4	f6.2	NO
25	versionDate	Date catalog was produced in the following format, "mon dd yyyy", "Dec 5 2007"	ASCII	a12	NO
26	cx	× of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
27	cy	y of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
28	cz	z of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO

Continued on Next Page...

Table 11 – Continued

Col.	Name	Description	Data	Format	Null
29	htmID	The Hierchical Triangular Mesh partition computed at index level 20 in which this source lies	I*4	i20	NO

Table 12. The Example Line from SAGELMCcatalogMIPS24

Parameter	Value
globalSourceID . .	1542970251
sourceCatalog	mips24c
epoch	epoch 1
designation	SSTM1SAGE1 J051321.75-692240.3
ra, dec	78.34063, -69.377871
dra, ddec	0.02, 0.02
conf24	0
mag24, dmag24 . . .	-0.06707, 0.005458
flux24, dflux24	7627, 38.34
sky24	58.98
SN24	198.92
flag24	0
correlation24	0.964
mmmSkymode24 .	37.63
mmmSigma24 . . .	33.41
mmmSkew24	0.7805
mmmNsky24	2122
averageCoverage24	11.17
AORNumber24 . . .	14382080
versionNo	2.4
versionDate	Aug 31 2009
cx	0.0711777387999096
cy	0.344935919964786
cz	-0.935923576269654
htmID	9315124191905

F.3. An Example of a Line of Text for SAGELMCcatalogMIPS70/SAGELMCfullMIPS70

Here is an example of a line of text for the Catalog (28 columns; see also Table 14)

globalSourceID sourceCatalog epoch designation ra dec dra ddec conf70 mag70 dmag70 flux70 dflux70 sky70 SN70 flag70 correlation70 mmmSkymode70 mmmSigma70 mmmSkew70 mmmNsky70 averageCoverage70 versionNo versionDate cx cy cz htmID

1529664729 mips70c epoch C SSTM2SAGECC J053945.34-693839.5 84.938941 -69.644333 0.23 0.2 0 -6.377 0.02503 276700 6379 595 43.38 0 0.912 283.6 382.7 0.7358 2274 10.05 2.1 Mar 25 2009 0.0306861043896471 0.346490548123567 -0.937551418887742 9088632062352

The detailed description of the individual columns and the data format can be found in Table 13. The MIPS 70 μm Full List (SAGELMCfullMIPS70) contains the same columns as the MIPS 70 μm Catalog (SAGELMCcatalogMIPS70). However, for the full list the 'sourceCatalog' column is set to 'mips70f'.

Table 13. SAGELMCcatalogMIPS70 and SAGELMC-fullMIPS70 Format

Col.	Name	Description	Data	Format	Null
1	globalSourceID ...	Unique identification number of each source in the catalog	I*4	i10	NO
2	sourceCatalog	Character string identifier for source catalog	ASCII	a8	NO
3	epoch	Character string identifier for the epoch of the observation of the source	ASCII	a16	NO
4	designation	SAGE source designation name	ASCII	a32	NO
5	ra	Right ascension, J2000 (deg)	R*8	f11.6	NO
6	dec	Declination, J2000 (deg)	R*8	f11.6	NO
7	dra	Error in Right Ascension ($''$)	R*8	f4.1	NO
8	ddec	Error in Declination ($''$)	R*8	f4.1	NO
9	conf70	Confusion Flag for band 70,	I*2		-9

Continued on Next Page...

Table 13 – Continued

Col.	Name	Description	Data	Format	Null
	....	currently unused			
10	flux70	70μm flux (mJy)	R*8	e11.3	-999.9
11	dflux70	70μm 1σ error (mJy)	R*8	e11.3	-999.9
12	mag70	70μm magnitude	R*8	f7.3	-999.9
13	dmag70	70μm 1σ error	R*8	f7.3	-999.9
14	sky70	Local Sky Bkg. for band 70 (MJy/sr)	R*4	e11.3	-999.9
15	SN70	Signal/Noise for band 70	R*4	f7.2	-9.99
16	flag70	The flag currently refers to how many times a source was observed by different AORs in a single epoch. Is it was observed more than once, the reported flux is the average of the multiple observations. If flag70 = 0, then it was only measured in 1 AOR. If it is > 1 (it will never be 1), then that is the number.	I*2		-9
17	correlation70	Correlation describes how like the input PSF each point source is	R*8	e11.3	-999.9
18	mmmSkymode70..	Scalar giving estimated mode of the sky values. Sky is determined in a 49x49 square pixel (1 pixel = 4$''$.80) region surrounding the source in the residual image (all sources subtracted).	R*8	f11.6	NO
19	mmmSigma70	Scalar giving standard deviation of the peak in the sky histogram. If for some reason it is impossible to derive skymode, then SIGMA = -1.	R*8	f11.6	NO
20	mmmSkew70	Scalar giving skewness of the peak	R*8	f11.6	NO

Continued on Next Page...

Table 13 – Continued

Col.	Name	Description	Data	Format	Null
		in the sky histogram			
21	mmmNsky70	number of points used to determine the sky values for mmmSkymode70, mmmSigma70 and mmmSkew70	R*8	f11.6	NO
22	averageCoverage70	The average coverage (no. of independent observations per pixel) in a 49×49 square pixel (1 pixel = 4.″80) region centered on the source.	R*8	f11.6	NO
23	versionNo	Version number assigned by MIPS pipeline team	R*4	f6.2	NO
24	versionDate	Date catalog was produced in the following format, "mon dd yyyy", "Dec 5 2007"	ASCII	a12	NO
25	cx	× of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
26	cy	y of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
27	cz	z of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
28	htmID	The Hierchical Triangular Mesh partition computed at index level 20 in which this source lies	I*4	i20	NO

Table 14. The Example Line from SAGELMCcatalogMIPS70

Parameter	Value
globalSourceID . .	1529664729
sourceCatalog	mips70c
epoch	epoch C
designation	SSTM2SAGECC J053945.34-693839.5
ra, dec	84.938941 -69.644333
dra, ddec	0.23 0.2
conf70	0
mag70, dmag70 . . .	-6.377, 0.02503
flux70, dflux70	276700 6379
sky70	595
SN70	43.38
flag70	0
correlation70	0.912
mmmSkymode70 .	283.6
mmmSigma70 . . .	382.7
mmmSkew70	0.7358
mmmNsky70	2274
averageCoverage70	10.05
versionNo	2.1
versionDate	Mar 25 2009
cx	0.0306861043896471
cy	0.346490548123567
cz	-0.937551418887742
htmID	9088632062352

F.4. An Example of a Line of Text for SAGELMCcatalogMIPS160/SAGELMCfullMIPS160

Here is an example of a line of text for SAGELMCcatalogMIPS160 (28 columns; see also Table 16)

globalSourceID sourceCatalog epoch designation ra dec dra ddec conf160 mag160 dmag160 flux160 dflux160 sky160 SN160 flag160 correlation160 mmmSkymode160 mmmSigma160 mmmSkew160 mmmNsky160 averageCoverage160 versionNo versionDate cx cy cz htmID

1529670886 mips160c epoch C SSTM3SAGECC J053829.32-690212.4 84.622197 -69.036796 0.48 0.5 0 -6.601 0.03937 69930 2535 376.2 27.59 0 0.911 216 217.5 0.6655 2242 1.975 2.1 Mar 25 2009 0.0335309824450009 0.356193548262535 -0.933810381925805 9312150701044

The detailed description of the individual columns and the data format can be found in Table 15. The MIPS 160 μm Full List (SAGELMCfullMIPS160) contains the same columns as the MIPS 160 μm Catalog (SAGELMCcatalogMIPS160). However, for the full list the 'sourceCatalog' column is set to 'mips160f'.

Table 15. SAGELMCcatalogMIPS160 and SAGELMCfullMIPS160 Format

Col.	Name	Description	Data	Format	Null
1	globalSourceID	Unique identification number of each source in the catalog	I*4	i10	NO
2	sourceCatalog	Character string identifier for source catalog	ASCII	a8	NO
3	epoch	Character string identifier for the epoch of the observation of the source	ASCII	a16	NO
4	designation	SAGE source designation name	ASCII	a32	NO
5	ra	Right ascension, J2000 (deg)	R*8	f11.6	NO
6	dec	Declination, J2000 (deg)	R*8	f11.6	NO
7	dra	Error in Right Ascension (″)	R*8	f4.1	NO
8	ddec	Error in Declination (″)	R*8	f4.1	NO

Continued on Next Page...

Table 15 – Continued

Col.	Name	Description	Data	Format	Null
9	conf160	Confusion Flag for band 160, currently unused	I*2		-9
10	flux160	160μm flux (mJy)	R*8	e11.3	-999.9
11	dflux160	160μm 1σ error (mJy)	R*8	e11.3	-999.9
12	mag160	160μm magnitude	R*8	f7.3	-999.9
13	dmag160	160μm 1σ error	R*8	f7.3	-999.9
14	sky160	Local Sky Bkg. for band 160 (MJy/sr)	R*4	e11.3	-999.9
15	SN160	Signal/Noise for band 160	R*4	f6.2	-9.99
16	flag160	The flag currently refers to how many times a source was observed by different AORs in a single epoch. Is it was observed more than once, the reported flux is the average of the multiple observations. If flag160 = 0, then it was only measured in 1 AOR. If it is > 1 (it will never be 1), then that is the number.	I*2		-9
17	correlation160	Correlation describes how like the input PSF each point source is	R*8	e11.3	-999.9
18	mmmSkymode160 . .	Scalar giving estimated mode of the sky values. Sky is determined in a 49x49 square pixel (1 pixel = 15$''$.6) region surrounding the source in the residual image (all sources subtracted).	R*8	f11.6	NO
19	mmmSigma160	Scalar giving standard deviation of the peak in the sky histogram. If for some reason it is impossible to derive skymode, then SIGMA = -1.	R*8	f11.6	NO

Continued on Next Page. . .

Table 15 – Continued

Col.	Name	Description	Data	Format	Null
20	mmmSkew160	Scalar giving skewness of the peak in the sky histogram	R*8	f11.6	NO
21	mmmNsky160	number of points used to determine the sky values for mmmSkymode160, mmmSigma160 and mmmSkew160	R*8	f11.6	NO
22	averageCoverage160	The average coverage (no. of independent observations per pixel) in a 49×49 square pixel (1 pixel = 15.″6) region centered on the source.	R*8	f11.6	NO
23	versionNo	Version number assigned by MIPS pipeline team	R*4	f6.2	NO
24	versionDate	Date catalog was produced in the following format, ”mon dd yyyy”, ”Dec 5 2007”	ASCII	a12	NO
25	cx	× of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
26	cy	y of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
27	cz	z of unit vector on the unit sphere for ra,dec of this source	R*8	f30.20	NO
28	htmID	The Hierchical Triangular Mesh partition computed at index level 20 in which this source lies	I*4	i20	NO

Table 16. The Example Line from SAGELMCcatalogMIPS160

Parameter	Value
globalSourceID	1529670886
sourceCatalog	mips160c
epoch	epoch C
designation	SSTM3SAGECC J053829.32-690212.4
ra, dec	84.622197, -69.036796
dra, ddec	0.48, 0.5
conf160	0
mag160, dmag160 . .	-6.601, 0.03937
flux160, dflux16	69930 2535
sky160	376.2
SN160	27.59
flag160	0
correlation160	0.911
mmmSkymode160 .	216
mmmSigma160 . . .	217.5
mmmSkew160	0.6655
mmmNsky160	2242
averageCoverage160	1.975
versionNo	2.1
versionDate	Mar 25 2009
cx	0.0335309824450009
cy	0.356193548262535
cz	-0.933810381925805
htmID	9312150701044

F.5. MIPS 24 μm 1$^\circ\!\!.$1 × 1$^\circ\!\!.$1 Tiles

SAGE_LMC_tile_MIPS24_TN.fits and SAGE_LMC_tile_MIPS24_TN_wt.fits images were mosaiced to match the positions of the IRAC tiles. The overlap between MIPS tiles is 0$^\circ\!\!.$1. 'TN' in the filenames is the Tile Number and ranges from 1 to 85. Table 4 lists the centers of the tiles and Figure 26 is a graphical representation of the tile positions. Each FITS file is calibrated in units of MJy/sr, and has 2$''\!\!.$49 pixels. Data from both epochs of SAGE observations are included in the tiles. SAGE_LMC_tile_MIPS24_TN.fits files give the images in MJy/sr. SAGE_LMC_tile_MIPS24_TN_wt.fits give the depth of coverage (# of measurements per pixel). A background has been subtracted from these data, using the same fit that was made to the full LMC mosaic. In addition, the small residual background (−0.03 MJy/sr, or about 0.15% of the original background level) measured in the full mosaic has also been subtracted from these tiles.

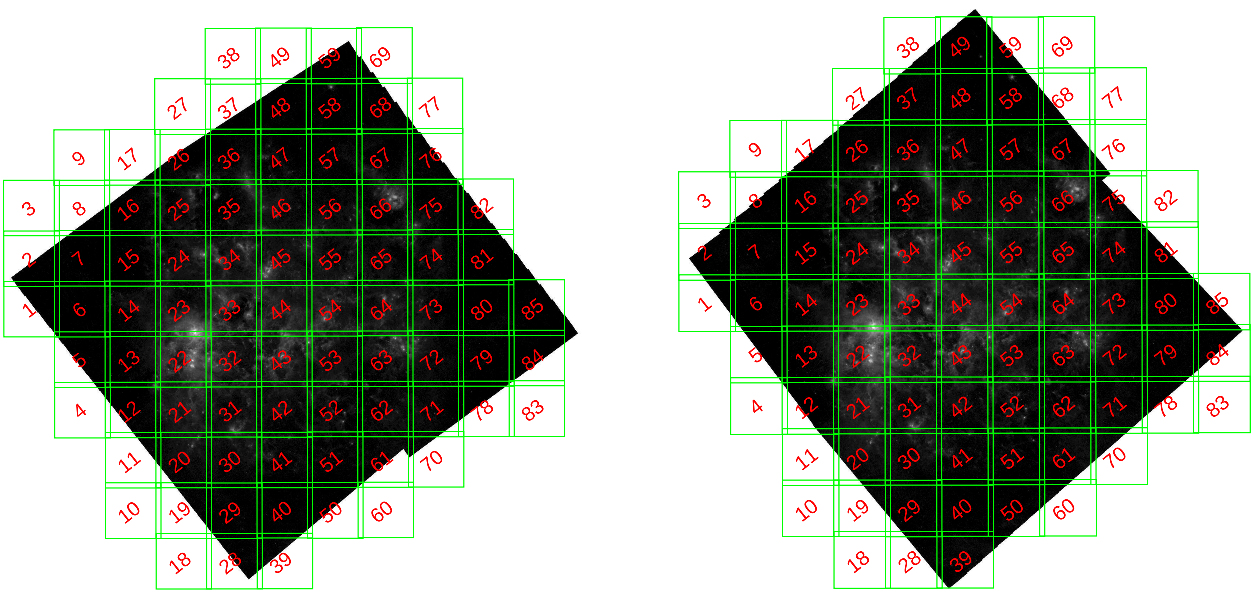

Fig. 26.— Tile positions overlayed on the MIPS 24 μm Epoch 1 (*left*) and Epoch 2 (*right*) mosaics. The tiles contain more data than the full mosaics shown here, e.g. for tile #18, no data appear in the full mosaic but do appear in the tile. The tiles were created using the software developed by the MIPS team, while the full mosaics were made with the Montage program from the AOR mosaics. More data were rejected by either Montage or during the AOR mosaic creation than when the tiles were made.

For each tile, there is also a point-source-subtracted image, found in the SAGE_LMC_tile_MIPS24_TN_res.fits files. Point sources have been subtracted using the same software (StarFinder) used to create the 24 μm catalog. The temperature of the model

PSF of 100 K and a 2σ cutoff were used for source identification. No attempt has been made to rotate the PSF to match the orientation of the images (and couldn't be on these products, anyway, since 2 epochs at different roll angles are combined), so there will be residual diffraction spikes where bright sources were present.

G. APPENDIX G - Matching Between Epoch 1 and Epoch 2 IRAC Source Lists: IRAC Variability Index

SAGELMC_IRACCatalog_E1E2Match/SAGELMC_IRACArchive_E1E2Match matches between the Epoch 1 and Epoch 2 IRAC Catalog/Archive (both epochs are listed separately in SAGELMCcatalogIRAC_EP1_EP2/SAGELMCarchiveIRAC_EP1_EP2). For a detailed description of the *_E1E2Match source lists see §6.3. Table 17 describes the columns in the *_E1E2Match source lists including the data format and null values.

Here is an example of a line of text for SAGELMC_IRACCatalog_E1E2Match (16 columns; see also Table 18):

SSTISAGE1C J050426.21-701441.1 68848881 76.109217 -70.244763 SSTISAGE2C J050426.23-701441.0 61272662 76.109324 -70.244738 1.844977 -0.152020627929403 1.07730710506439 -0.407397393974428 0.725366413593292 -1.30596318728118 0.416247934103012 1.06198634155666

SAGELMC_IRACArchive_E1E2Match contains the same columns as SAGELMC_IRACCatalog_E1E2Match. The full Epoch 1 only and Epoch 2 only IRAC Catalog/Archive data can be retrieved from the SAGELMCcatalogIRAC_EP1_EP2/ SAGELMCarchiveIRAC_EP1_EP2 using designations and globalsourceids for each epoch provided for each pair of matched sources in SAGELMC_IRACCatalog_E1E2Match/ SAGELMC_IRACArchive_E1E2Match.

H. APPENDIX H - Matching Between Epoch 1 and Epoch 2 MIPS 24 μm Source Lists: MIPS 24 μm Variability Index

SAGELMC_MIPS24Catalog_E1E2Match/SAGELMC_MIPS24Full_E1E2Match contains matches between the Epoch 1 and Epoch 2 MIPS 24 μm Catalog/Full List (both epochs are listed separately in SAGELMCcatalogMIPS24/SAGELMCfullMIPS24). For a detailed description of the *_E1E2Match source lists see §8.5. Table 19 describes the columns in the *_E1E2Match source lists including the data format and null values.

Here is an example of a line of text for SAGELMC_MIPS24Catalog_E1E2Match (10 columns; see also Table 20):

SSTM1SAGE1 J051301.82-693351.0 1542970521 78.257574 -69.564176 SSTM1SAGE2 J051301.75-693351.3 1543011850 78.257299 -69.56426 336.239540688967 -6.21315712507615

SAGELMC_MIPS24Full_E1E2Match contains the same columns as

SAGELMC_MIPS24Catalog_E1E2Match. The full Epoch 1 only and Epoch 2 only MIPS 24 μm Catalog/Full List data can be retrieved from the SAGELMCcatalogMIPS24/ SAGELMCfullMIPS24 using designations and globalsourceids for each epoch provided for each pair of matched sources in SAGELMC_MIPS24Catalog_E1E2Match/SAGELMC_MIPS24Full_E1E2Match.

Table 17. SAGELMC_IRACCatalog_E1E2Match and SAGELMC_IRACArchive_E1E2Match Format

Col.	Name	Description	Data	Format	Null
1	E1designation ..	IRAC Epoch 1 source designation	ASCII	a32	NO
2	E1globalsourceid	Globalsourceid (unique identification number) for the Epoch 1 source	I*4	i10	NO
3	E1ra	Right ascension of the Epoch 1 source, J2000 (deg)	R*8	f11.6	NO
4	E1dec	Declination of the Epoch 1 source, J2000 (deg)	R*8	f11.6	NO
5	E2designation ..	IRAC Epoch 2 source designation	ASCII	a32	NO
6	E2globalsourceid	Globalsourceid (unique identification number) for the Epoch 2 source	I*4	i10	NO
7	E2ra	Right ascension of the Epoch 2 source, J2000 (deg)	R*8	f11.6	NO
8	E2dec	Declination of the Epoch 2 source, J2000 (deg)	R*8	f11.6	NO
9	avgf36	Average of the Epoch 1 and Epoch 2 3.6 μm flux (mJy)	R*8	e11.3	-999.9
10	V36	V index for the 3.6 μm band	R*8	e11.3	-999.9
11	avgf45	Average of the Epoch 1 and Epoch 2 4.5 μm flux (mJy)	R*8	e11.3	-999.9
12	V45	V index for the 4.5 μm band	R*8	e11.3	-999.9
13	avgf58	Average of the Epoch 1 and Epoch 2 5.8 μm flux (mJy)	R*8	e11.3	-999.9
14	V58	V index for the 5.8 μm band	R*8	e11.3	-999.9
15	avgf80	Average of the Epoch 1 and Epoch 2 8.0 μm flux (mJy)	R*8	e11.3	-999.9
16	V80	V index for the 8.0 μm band	R*8	e11.3	-999.9

Table 18. The Example Line from SAGELMC_IRACCatalog_E1E2Match

Parameter	Value
E1designation ..	SSTISAGE1C J050426.21-701441.1
E1globalsourceid	68848881
E1ra	76.109217
E1dec	-70.244763
E2designation ..	SSTISAGE2C J050426.23-701441.0
E2globalsourceid	61272662
E2ra	76.109324
E2dec	-70.244738
avgf36	1.844977
V36	-0.152020627929403
avgf45	1.07730710506439
V45	-0.407397393974428
avgf58	0.725366413593292
V58	-1.30596318728118
avgf80	0.416247934103012
V80	1.06198634155666

Table 19. SAGELMC_MIPS24Catalog_E1E2Match and SAGELMC_MIPS24Full_E1E2Match Format

Col.	Name	Description	Data	Format	Null
1	E1designation . .	MIPS 24 μm Epoch 1 source designation	ASCII	a32	NO
2	E1globalsourceid	Globalsourceid (unique identification number) for the Epoch 1 source	I*4	i10	NO
3	E1ra	Right ascension of the Epoch 1 source, J2000 (deg)	R*8	f11.6	NO
4	E1dec	Declination of the Epoch 1 source, J2000 (deg)	R*8	f11.6	NO
5	E2designation . .	MIPS 24 μm Epoch 2 source designation	ASCII	a32	NO
6	E2globalsourceid	Globalsourceid (unique identification number) for the Epoch 2 source	I*4	i10	NO
7	E2ra	Right ascension of the Epoch 2 source, J2000 (deg)	R*8	f11.6	NO
8	E2dec	Declination of the Epoch 2 source, J2000 (deg)	R*8	f11.6	NO
9	avgf24	Average of the Epoch 1 and Epoch 2 24 μm flux (mJy)	R*8	e11.3	-999.9
10	V24	V index for the 24 μm band	R*8	e11.3	-999.9

Table 20. The Example Line from SAGELMC_MIPS24Catalog_E1E2Match

Parameter	Value
E1designation . .	SSTM1SAGE1 J051301.82-693351.0
E1globalsourceid	1542970521
E1ra	78.257574
E1dec	-69.564176
E2designation . .	SSTM1SAGE2 J051301.75-693351.3
E2globalsourceid	1543011850
E2ra	78.257299
E2dec	-69.56426
avgf24	336.239540688967
V24	-6.21315712507615

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- IRAC pipeline based at the University of Wisconsin: Barbara Whitney (lead/SSI), Marilyn Meade (Univ. of Wisconsin), Brian Babler (Univ. of Wisconsin), Remy Indebetouw (Univ. of Virginia), Joe Hora (Harvard/CfA), Steve Bracker (Univ. of Wisconsin), Thomas Robitaille (Harvard/CfA)
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