Reanalysis for Absolute Photometric Calibration of the Infrared Camera (IRC) aboard *AKARI*

Takuto Deyama,[1] Fumihiko Usui,[2] and Keiji Ohtsuki[1]

[1]*Department of Planetology, Graduate School of Science, Kobe University, 1-1, Rokkodai-cho, Nada-ku, Kobe, 657-8501, Japan*
[2]*Center for Planetary Science, Graduate School of Science, Kobe University, 7-1-48, Minatojima-Minamimachi, Chuo-Ku, Kobe 650-0047, Japan*

ABSTRACT

A good absolute photomertic calibration is essential to achieve science goals in astronomical observations. In the imaging observations with the Infrared Camera (hereafter IRC) aboard *AKARI*, standard stars near the North Ecliptic Pole region (NEP), the South Ecliptic Pole region (SEP), and in the Large Magellanic Cloud (LMC) are used for the calibration (Tanabé et al. 2008). The IRC imaging toolkit was updated in 2015, thus the calibration values need to be revised accordingly. In the present work, using the updated IRC imaging toolkit, we derived the conversion factors from the measured values in analog-to-digital unit (ADU) to the absolute flux densities by comparing the observed and estimated brightness of a set of standard stars. In addition, we reexamined the aperture correction factors for the point sources in the IRC imaging observations. We found that these correction factors are consistent with those derived in Tanabé et al. (2008) within 10%.

Keywords: methods: data analysis—techniques: photometric—infrared: general

1. INTRODUCTION

AKARI (Murakami et al. 2007) is an infrared satellite developed by the Japan Aerospace Exploration Agency (JAXA). It was launched on February 21, 2006 (UT) and has been operated until November 24, 2011 (UT). The operation period consisted of Performance verification (PV), Phase 1, Phase 2, second PV, and Phase 3 (Matsuhara et al. 2005). During the PV period, instrument calibrations and test operations were carried out. Then all-sky survey observations were performed for a half year in Phase 1, and many pointed observations in addition to the all-sky survey were carried out in Phase 2. Phase 2 ended when the liquid helium, the principal coolant of the instruments, was used up. After the second PV, Phase 3 started, and observations in this period were performed only in the near-infrared (NIR) wavelengths (Onaka et al. 2010).

The Infrared Camera (IRC; Onaka et al. 2007) is one of the focal plane instruments on board *AKARI* and is designed for observations at NIR and mid-infrared (MIR) wavelengths, and the other instrument is the Far-Infrared Surveyor (FIS; Kawada et al. 2007) designed for far-infrared observations. The IRC was designed for pointed observations, but was also used in the all-sky survey. The IRC carries three channels (NIR, MIR-S, and MIR-L), and each channel has three filters and two spectroscopic dispersers. Science topics studied by observations with these instruments include formation and evolution of galaxy, star formation, evolution of protoplanetary disk, characterization of interstellar medium, and origin and evolution of Solar system objects.

In the pointed observations, deep imaging and spectroscopic observations were carried out (*AKARI* IRC Data User Manual)[1]. A single pointed observation consists of a combination of operations, i.e., “exposure cycle”, “dithering” and “change of filters”; a combination of these operations are fixed at several patterns and are called the Astronomical Observation Template (AOT). The “exposure cycle” consists of short exposures and long exposures, and the number and duration of these exposures were set for each AOT and the channel.

Tanabé et al. (2008) performed absolute photometric calibration of imaging observations with the IRC in the pointing mode, by monitoring a set of standard stars. Also, aperture correction factors for IRC photometry are prepared in 2009 and are given in the website of *AKARI* User Support[2]. However, the IRC imaging toolkit was updated on March 31, 2015 (Egusa et al. 2016). Thus calibration values must be revised accordingly. Therefore, in this study, we derive new conversion factors and aperture correction factors for IRC in Phases 1 & 2 with the updated imaging toolkit.

Corresponding author: Takuto Deyama
tdeyama@stu.kobe-u.ac.jp

[1] http://www.ir.isas.jaxa.jp/AKARI/Observation/support/IRC/IDUM/IRC_DUM.pdf
[2] https://www.ir.isas.jaxa.jp/AKARI/Observation/support/IRC/ApertureCorrection.html

Table 1. Parameter for Source Extractor

Parameters	Channels	Values (pix)
diameter of aperture	NIR	40
	MIR-S/L	30
sky annulus	NIR	50
	MIR-S/L	40

Table 2. Derived conversion factors

Bands	Conversion factors [10^{-7} Jy/ADU]
$N2$	4.421 ± 0.243
$N3$	3.728 ± 0.132
$N4$	2.602 ± 0.126
$S7$	9.821 ± 0.539
$S9W$	5.641 ± 0.348
$S11$	7.698 ± 1.104
$L15$	15.36 ± 1.11
$L18W$	11.14 ± 0.70
$L24$	50.68 ± 5.83

2. METHODS

We use the IRC imaging toolkit 20150331[3] for reduction, and Source Extractor v2.19.5 for photometric analysis. Table 1 shows parameters used in Source Extractor. In this work, we chose standard stars in the North Ecliptic Pole region (21 objects), the South Ecliptic Pole region (1 object) and the Large Magellanic Cloud (26 objects), and use the data of these standard stars obtained by long exposure observations during Phases 1 and 2. Estimated flux densities of the standard stars to be used for the derivation of the conversion factors are taken from the Cohen template (Cohen et al. 1996, 1999; Cohen 2003; Cohen et al. 2003a,b).

3. ABSOLUTE CALIBRATION

We derived the conversion factors from the measured values to the absolute flux densities by comparing the observed and estimated brightness of a set of standard stars (Cohen et al. 1992). In Figure 1, we plot estimated fluxes in unit of Jansky of the standard stars for each band as a function of the observed count values, with fitting lines obtained by the least-square method. We show the list of the derived conversion factors in Table 2, and Figure 2 shows comparison between the conversion factors derived in this work (f) and those derived by Tanabé et al. (2008) ($f_{\rm T08}$).

We also derived the aperture correction factors. These factors represent the amount of energy received in an aperture with a given pixel radius for each band. The values are normalized by the values at 40 pixels for NIR and 30 pixels for MIR-S/L (Figure 3), respectively. We excluded those stars that are adjacent to bad pixel and/or pixels with negative values, because the photometric values of such stars are smaller than those obtained with a bigger aperture size.

4. CONCLUSION

We found that the conversion factors obtained in the present work agree with those derived in Tanabé et al. (2008) within 10%. Figure 2 shows comparison between the derived conversion factors and those derived in Tanabé et al. (2008). For the aperture correction factors, the derived values are consistent with the data given in the website of the *AKARI* User Support. For future works, we plan to reanalyze these factors for short exposure frames and for Phase 3 observations.

ACKNOWLEDGMENT

This research is based on observations with *AKARI*, a JAXA project with the participation of ESA. We thank F. Egusa and T. Yamashita for useful comments. This work was supported by JSPS KAKENHI (Nos. 17K05636 and 15H03716).

[3] http://www.ir.isas.jaxa.jp/AKARI/Observation/support/IRC/

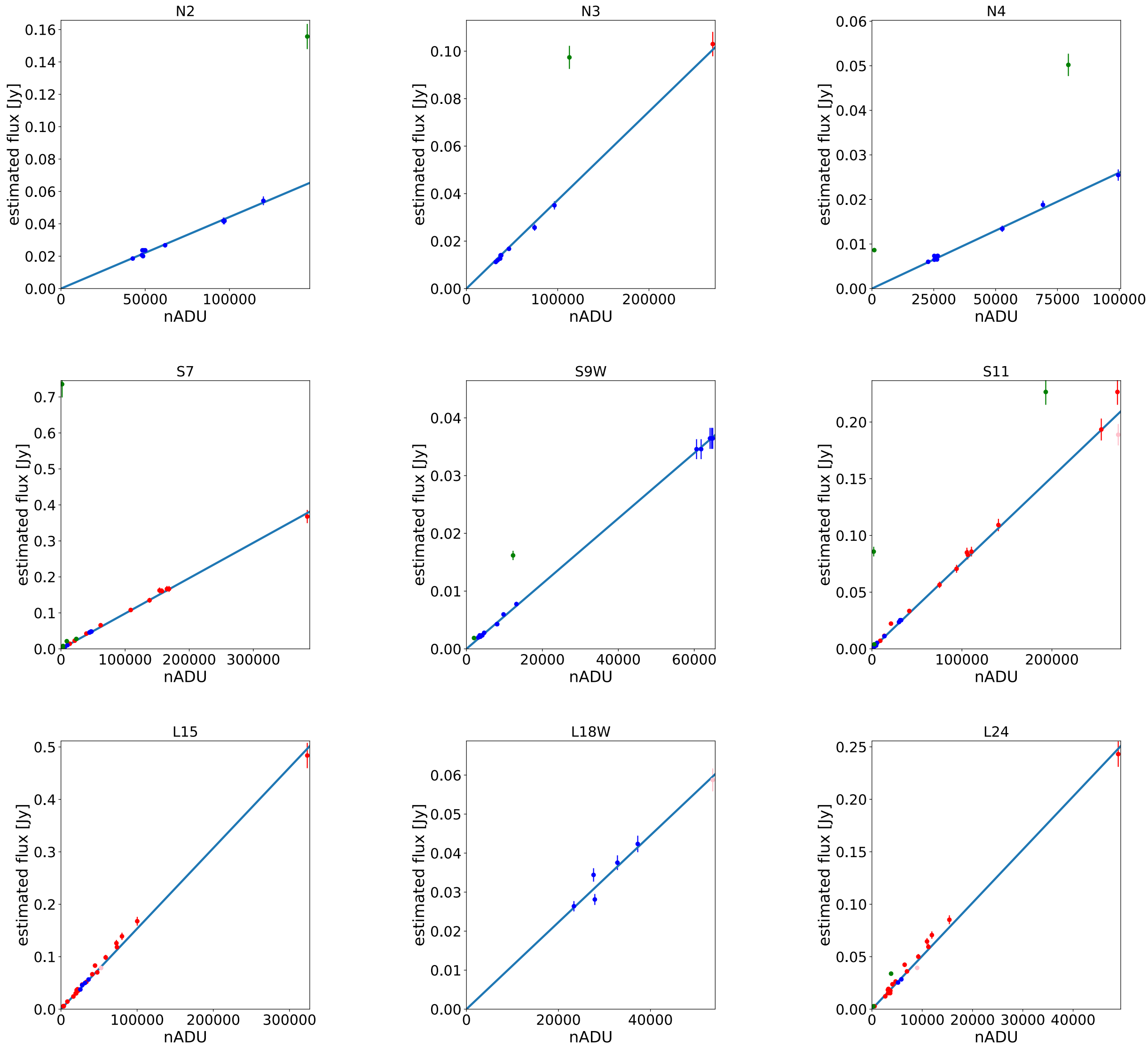

Figure 1. Relationship between the estimated flux (Jy) and the observed data values (nADU). Dots denote standard stars. (Blue, red and pink are stars in LMC, NEP and SEP, respectively.) Blue line is a least-square fit to the data (except for the green dots, which were excluded from the fitting).

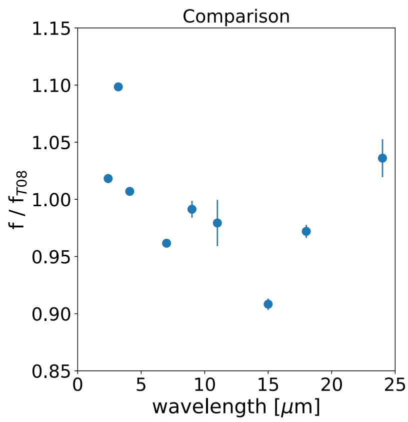

Figure 2. Comparison between the conversion factors derived in this work (f) and those derived by T08 (f_{T08} ; their Table 7).

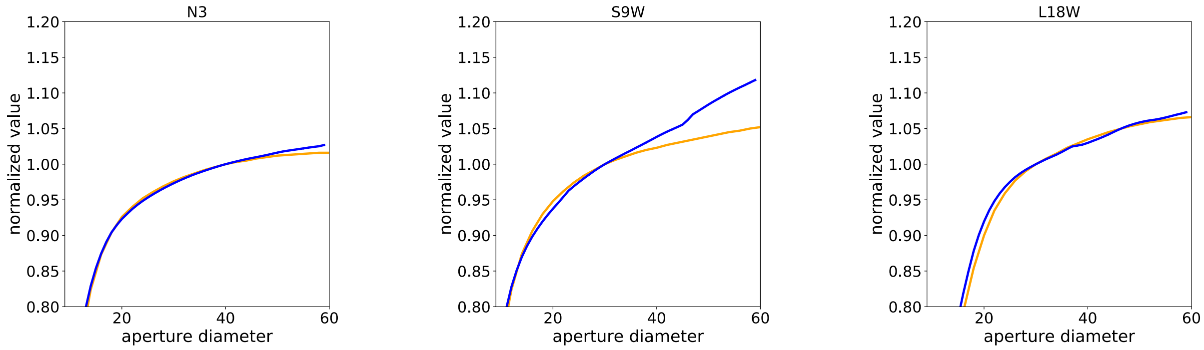

Figure 3. Aperture correction factor for $N3$, $S9W$ and $L18W$. Blue curves are derived in this work and orange curves are derived from the User Support data (https://www.ir.isas.jaxa.jp/AKARI/Observation/support/IRC/) .

REFERENCES

Cohen, M. 2003, The Calibration Legacy of the ISO Mission, 481, 135
Cohen, M., Megeath, S. T., Hammersley, P. L., Martín-Luis, F., & Stauffer, J. 2003a, AJ, 125, 2645
Cohen, M., Walker, R. G., Barlow, M. J., & Deacon, J. R. 1992, AJ, 104, 1650
Cohen, M., Walker, R. G., Carter, B., et al. 1999, AJ, 117, 1864
Cohen, M., Wheaton, W. A., & Megeath, S. T. 2003b, AJ, 126, 1090
Cohen, M., Witteborn, F. C., Carbon, D. F., et al. 1996, AJ, 112, 2274
Egusa, F., Usui, F., Murata, K., et al. 2016, PASJ, 68, 19
Kawada, M., Baba, H., Barthel, P. D., et al. 2007, PASJ, 59, S389
Matsuhara, H., et al. 2005, AdSpR, 36, 1091
Murakami, H., Baba, H., Barthel, P., et al. 2007, PASJ, 59, S369
Onaka, T., Matsuhara, H., Wada, T., et al. 2007, PASJ, 59, S401
Onaka, T., Matsuhara, H., Wada, T., et al. 2010, Proc. SPIE, 7731, 77310M
Tanabé, T., Sakon, I., Cohen, M., et al. 2008, PASJ, 60, S375