

# AKARI Data Processing and Archiving Activity

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## ABSTRACT

We overview the *AKARI* mission and current status of the data processing and archiving activity. *AKARI* was launched in February 2006, and started observation from May 2006. Operation under cryogenic temperature lasted until August 2007 (Phase 1 and 2), where the All-Sky Survey in six wavelength bands in the mid- and far-infrared as well as over 5000 pointed observations were carried out. Another 12,000 observations using the near-infrared channel of the IRC were made in the warm phase (Phase 3) from June 2008 to February 2010. The *AKARI* satellite was switched-off in November 2011. Since April 2013, *AKARI* data processing and analysis team has been working in collaboration with universities to process as much as *AKARI* data to 'science ready' state and archive them for future scientific analysis. New data products since the last *AKARI* conference are briefly explained.

**Keywords:** infrared: space mission (*AKARI*) – survey: infrared – catalogs: infrared – atlases: infrared

## 1. THE *AKARI* MISSION AND DATA PROCESSING

### 1.1. The *AKARI* Mission

The infrared astronomical satellite *AKARI* (Murakami et al. 2007) was launched in February 21, 2006 (UT). *AKARI* was equipped with a 68.8 cm telescope operated in cryogenic temperature and two scientific instruments, namely the Infrared Camera (IRC; 1.8–26.5  $\mu\text{m}$ , Onaka et al. 2007) and the Far-Infrared Surveyor (FIS; 50–180  $\mu\text{m}$ , Kawada et al. 2007). On the Sun synchronized polar orbit with the altitude of about 700 km, *AKARI* carried out an all-sky survey at four far-IR wavelengths (65, 90, 140, & 160  $\mu\text{m}$ ) and two mid-IR wavelengths (9 & 18  $\mu\text{m}$ ) as well as approximately 5,500 pointed observations by both FIS and IRC during the liquid-helium cooled phase (Phase 1 & 2) between May 2006 to August 2007. Additional 12,600 pointed observations in the near-IR wavelengths with IRC were performed between June 2008 to February 2010 (Phase 3) where instrument were cooled only by the mechanical cooler. Due to degradation of the cooling power and trouble in the satellite power-supply system, *AKARI* operation was terminated in November 24, 2011.

Table 1 summarizes *AKARI* observations. The All-Sky Survey covered more than 96 per cent of the entire sky scanned twice or more. Thanks to the *AKARI*'s polar orbit, high visibility was achieved in the high ecliptic latitude regions. In the pointed observations, 10–12 minutes observing time was acquired in 30 minutes operation time. Deep imaging observations as well as spectroscopic observations were conducted in the pointing mode.

Operation and data processing of the All-Sky Survey was led by the *AKARI* project, and the data products (catalogues and image maps) were provided to the astronomical community. Pointed observations were in principle programmed according to observing proposals. Two large area surveys near the ecliptic poles, namely the North Ecliptic Pole region survey (Wada et al. 2008; Lee et al. 2009) and the Large Magellanic Cloud region (Ita et al. 2008) were conducted by the dedicated teams in the projects. Mission programmes were considered and proposed by the teams organized mainly by project members. About 30 per cent of the pointing opportunities were utilized by the communities in Japan, Korea, and ESA related countries as Open Time programmes. In addition, calibration observations and Director's Discretionary Time observations were carried out. These data from the pointed observations were provided to the PIs of each programme with the data reduction tools and calibration information. It was data users who did data processing and analysis.

### 1.2. Data Processing and Archiving Activity

In April 2013, *AKARI data processing and analysis team* was established in ISAS as the five-year activity. The team works collaboratively with universities for *AKARI* data processing. The goal is to process as many as *AKARI* observation data and construct data archive so that the data user can immediately start scientific analysis after retrieving the data. We

**Table 1.** *AKARI* Observation Summary

All-Sky Survey		Pointed Observations		
Period	Phase 1 & 2	Number of valid observations		
Wavelength	IRC: 9, 18 $\mu\text{m}$	Mode	Phase 1 & 2	Phase 3
	FIS: 65, 90, 140, 160 $\mu\text{m}$	IRC Imaging	3000	3800
Sky Coverage	$\geq 96\%$ of the entire sky*	IRC Spectroscopy	900	8800
* Sky area scanned twice or more.		FIS Imaging	1100	N/A
		FIS Spectroscopy	550	N/A

also expect that the data archive will lead the astronomers to new ideas of data analysis, which were not intended in the original proposals.

## 2. *AKARI* DATA PROCESSING AND ARCHIVE

### 2.1. Progress on the *AKARI* Data Processing

Table 2 summarizes *AKARI* data products so far published and to be published in near future. Since the last *AKARI* conference in 2014 at Oxford (Nakagawa 2017), we have released several new data products.

From the All-Sky Survey, the Far-infrared All-Sky Maps (Doi et al. 2015; Takita et al. 2015) were officially published in December 2014. Since the release, more than ten thousand file-set have been downloaded from the *AKARI* team server. The maps are the highest-spatial resolution (1–1.5 arcmin) all-sky data in the far-IR regime, and have been used for various scientific analysis. Modeling of zodiacal emission has been attempted (Ootsubo et al. 2016, see also Ootsubo et al., this volume).

The revised version of FIS Bright Source Catalogue (FISBSCv2) has been available since April 2016 from *AKARI* team archive. The new catalogue contains more sources (about 500 thousand) in the *main* catalogue. Supplemental catalogue of approximately 400 thousand, less reliable detection is also available. The latter may be useful when one needs to check far-IR flux of known sources. The new catalogue improves position accuracy, reliability and completeness of especially bright sources. Details of the catalogue are explained in Yamamura et al. in this volume.

The FIS Faint Source Catalogue (FISFSCv1) is also constructed recently and under verification and evaluation. Although it was mentioned in the 2nd *AKARI* conference in 2012 at Jeju, the data processing was much delayed than expected due to various technical reason (mostly common with the BSC). By changing detection and confirmation policy, the catalogue contains fainter sources in the high visibility (i.e., high ecliptic latitude) region. See Yamamura et al. and Morokuma-Matsui et al. in this volume.

The Mid-Infrared All-Sky Image Maps are under processing and the initial version is expected to be available within a year.

For the pointed observation data, IRC imaging observation data are available through Phase 1 & 2 (Egusa et al. 2016, also in this volume) and Phase 3 (Yamashita et al. in prep.). The dataset includes all observations properly processed not only observing mode for imaging but also reference images for the spectroscopic observations. Point Source Catalogue is created using these reference images as a side-product of slitless spectroscopy catalogue (Mizuki et al. and Yamagishi et al., in this volume).

The near-IR spectroscopy by IRC provides a unique information. More than 5,700 near-IR spectra of about 2,200 unique targets using the point-source aperture mask of the NIR channel have been processed and archived (Usui et al., this volume). The data cover 2.5–5.0  $\mu\text{m}$  with a spectral resolution of about 120. The data is most valuable as the highest sensitivity spectroscopic data covering the wavelength range continuously before *JWST*. Spectra of diffuse sky using slits have been provided by data users as products of scientific analysis (Tsumura et al. 2013; Mori et al. 2014; Ohsawa et al. 2016). More systematic data processing of the slit data is ongoing.

As the dispersion elements (prism or grism) cover the entire field of view of IRC, objects in the imaging field were all resolved into spectra on the detectors. Extraction of spectra that are not overlapped each other on the imaging field (slitless spectroscopy) are ongoing, and the initial results are reported by Yamagishi et al. (this volume).

FIS realizes deep imaging by scanning sky areas much slower speed (8, 15, or 30 arcsec/sec) than the All-Sky Survey (3.6 arcmin/sec). More than a thousand of observations were executed in this 'slow-scan' mode. Due to technical difficulty to process data in this mode against time variation of detector characteristics caused by charged particle hits etc., data in this mode were interactively examined using *FAST* (Ikeda et al. 2012) software. About 70 per cent of SW channel (65 and 90  $\mu\text{m}$ ) and 30 per cent of LW channel (140 and 160  $\mu\text{m}$ ) of the data have been processed and will be published. Outline of the dataset is explained by Takita et al. (this volume).

The slow-scan observations were also performed using IRC. Data have been processed by a dedicated pipeline software and will soon be available in the archive. Further 'self-pointing reconstruction' procedure was applied for about 150

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**Table 2.** Major *AKARI* Data Products

Product name	Public date	Reference
Products from All-Sky Survey		
<i>AKARI</i> -FIS All-Sky Bright Source Catalogue ver.2	2016/04/25	Yamamura et al., this volume
<i>AKARI</i> -FIS All-Sky Faint Source Catalogue ver.1	in prep.	Yamamura et al., this volume
<i>AKARI</i> Far-infrared All-Sky Survey Maps	2014/12/19	Doi et al. (2015), Takita et al. (2015)
<i>AKARI</i> -IRC All-Sky Bright Source Catalogue ver.1	2010/03/30	Ishihara et al. (2010)
<i>AKARI</i> -IRC All-Sky Image Maps ver.1	in prep.	Ishihara et al., in prep.
<i>AKARI</i> Asteroid Catalogue Ver. 1	2011/10/14	Usui et al. (2011)
Products from Large Area Survey		
LMC Point Source Catalogue Ver. 1	2012/11/13	Kato et al. (2012), Ita et al. (2008)
LMC Near-IR Spectral Catalogue Ver. 1	2013/01/07	Shimonishi et al. (2013)
NEP-Wide Field Point Source Catalogue Ver. 1	2013/03/15	Kimu et al. (2012)
NEP-Deep Field Point Source Catalogue Ver. 2	2013/10/16	Murata et al. (2013)
Processed Pointed Observation Data		
Pointed Observation Images (Phase 1 & 2)	2015/03/15	Egusa et al. (2016)
Pointed Observation Images (Phase 3)	2016/04/25	Yamashita et al., in prep.
IRC Point Source Spectral Catalogue	2016/04/25	Usui et al., this volume
FIS Slow-scan Data	in prep.	Takita et al., this volume
IRC Slow-scan Data	in prep.	Takita et al. (2012)
FIS FTS Spectroscopy Data	in prep.	Murakami et al. (2010)
User's contribution data		
<i>AKARI</i> IRC NIR Low-resolution Spectral Catalogue of Diffuse Sky Patches	2013/06/27	Tsumura et al. (2013)
<i>AKARI</i> Near-infrared Spectral Atlas of Galactic HII regions	2014/03/10	Mori et al. (2014)
The Asteroid Catalog Using <i>AKARI</i> IRC Slow-Scan Observation	2014/05/20	Hasegawa et al. (2013)
<i>AKARI</i> /IRC NIR Spectral Atlas of Galactic Planetary Nebulae	2016/03/29	Ohsawa et al. (2016)
<i>AKARI</i> Asteroid Flux Catalog Ver.1	2016/10/04	Usui et al. (2011), Hasegawa et al. (2013), Mueller et al. (2014), Mueller et al. (2017)

observations of the Chamaeleon region among the total 600 observations. This corrects jitter of telescope pointing during slow-scan using point sources detected in the scan area. As a result, absolute pointing as well as relative position between the round-trip scans to be stacked are improves significantly (Takita et al. 2012).

The FIS-FTS (Fourier Transformation Spectroscopy) mode data have been processed by the expert of the FTS team. The data archive is being prepared.

## 2.2. Data Archive

The primary data archive for *AKARI* processed data is *DARTS* at ISAS/JAXA<sup>1</sup>. The Catalogue Archive Server (CAS Yamauchi et al. 2011) offers functions for various searches as well as matching with other catalogs/databases, displaying images, and SQL data mining. For the time being, however, most of the data are still distributed from the *AKARI* team server<sup>2</sup> as the temporal data archive, because data validation and construction of data service system on *DARTS* takes

<sup>1</sup> <http://darts.isas.jaxa.jp/>

<sup>2</sup> <http://www.ir.isas.jaxa.jp/AKARI/>

some time. As of writing this proceedings paper, three products, FIS All-Sky Bright Source Catalogue ver.2, IRC Pointed Observation Images in Phase 3, and IRC Point Source Spectral Catalogue are available after a simple registration. This is because that the data are still under scientific verification and documents are not ready, so the data processing team would like to contact to the users occasionally. The users are encouraged to access the data and send feedback to the team.

The public *AKARI* data are served from other archive system. The All-Sky Catalogues and far-IR All-Sky Maps are installed in the Virtual Observatory via National Astronomical Observatory, Japan<sup>3</sup>. The All-Sky Catalogues are also available from CDS Vizier<sup>4</sup>, IRSA<sup>5</sup> at IPAC, and probably other servers.

### 3. SUMMARY

*AKARI* data processing activity will officially be completed March 2018. However, efforts to produce or improve data motivated by scientific demands shall be continued in future. *AKARI* data have been used by more than 600 refereed paper and more are expected now on with the archived data. We wish *AKARI* data will be widely accepted by the astronomical community as a standard dataset.

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<sup>3</sup> <https://jvo.nao.ac.jp/>

<sup>4</sup> <http://vizier.u-strasbg.fr/viz-bin/VizieR>

<sup>5</sup> <https://irsa.ipac.caltech.edu/>