

## The NASA/IPAC Infrared Science Archive (IRSA): The Demo

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**Abstract.** This paper describes the services available at the NASA/IPAC Infrared Science Archive (IRSA).

Currently there are nearly 250,000 data requests a month, taking advantage of IRSA's data repository which includes 660 million sources (60 catalogs), 10 million images (22 image sets; 10.4 TB) and over 30,000 spectra (7 spectroscopic datasets). These data are the science products of: The Two Micron All Sky Survey (2MASS), The Infrared Astronomical Satellite (IRAS), The Mid-course Space Experiment (MSX), The Submillimeter Wave Astronomy Satellite (SWAS), The Infrared Space Observatory (ISO), The Infrared Telescope in Space (IRTS), The Spitzer First Look Survey (FLS), Spitzer Legacy & Ancillary data, Spitzer Reserved Observations (ROC) and the Spitzer Space Telescope data.

IRSA is also seamlessly interoperable with ten remote archives and services: GOODS, ISO, MAST, VizieR, DSS, NVSS, FIRST, HEASARC, NED and JPL, which help expand the available dataset wavelength range from X-ray to radio. The majority of IRSA's image collections are Simple Image Access (SIA) compliant and are available through the Virtual Observatory (VO) data mining tools.

The IRSA demo includes IRSA's five main services: inventory service RADAR, catalog query service Gator, data fusion service OASIS, general search service for complex data collections Atlas, and IRSA's 2MASS Image data access services.

IRSA's website is <http://irsa.ipac.caltech.edu>.

### 1. IRSA Overview

Over the past four years, the NASA/IPAC Infrared Science Archive (IRSA) has transformed itself from the curator of the 2MASS datasets to a multi-mission archive for NASA's infrared and sub-millimeter (IR/SM) astronomy data. Today, it serves 60 source catalogs, 22 image datasets, and 7 spectroscopic datasets from seven projects and missions, and is seamlessly interoperable with ten remote archives and services. Astronomers have taken advantage of the expansion of the archive. The average number of requests to archive services has risen nearly thirty-fold since 2000, to nearly 250,000 data requests per month, and there have been  $\sim 2000$  scientific publications based on IRSA-served datasets. The growth is due partly to an increasing number of customers accessing the data through web browsers, and partly due to remote services, such as observation planning tools for the Spitzer Space Telescope, taking advantage of seam-

less access to IRSA's data. The archive has recently released a data inventory and data mining service, called RADAR, that allows rapid access to all IRSA holdings (see section 4.1). The archive is built on the foundation of a robust architecture whose costs have been substantially reduced since 2000, allowing IRSA to serve new datasets in a highly efficient fashion.

## 2. IRSA's Scientific Data Holdings

Table 1 lists the major IRSA missions and data collections and their associated wavelength ranges; Tables 2 and 3 summarize the source catalogs, images, and spectroscopic datasets in IRSA as of March 2004. Totals for May 2000 highlight the expansion of the archive and show large increases in the number of datasets and their volume. A breakdown of the holdings is at: <http://irsa.ipac.caltech.edu/holdings.html>.

IRSA hosts data from seven missions and projects. Three of them are major infrared sky surveys. The Two Micron All Sky Survey (2MASS) is the first multi-terabyte, all-sky, fully digital image and catalog dataset to be released in astronomy. The Infrared Astronomical Satellite (IRAS) performed the first wide-area sky survey in the thermal infrared. Its successor, the Midcourse Space Experiment (MSX), provided higher spatial resolution coverage in the Galactic Plane, and surveyed those areas missed by IRAS. The Sub-millimeter Wave Astronomical Satellite (SWAS) and the Infrared Telescope in Space (IRTS) conducted new infrared spectroscopic observations, and, in the case of IRTS, far-infrared photometry. IRSA supports the Spitzer Space Telescope by serving ground-based ancillary data on behalf of the Spitzer First Look Survey and the Spitzer Legacy Science teams, consisting of source catalogs, images, and spectra covering targeted regions of the sky.

IRSA preserves the technical content of the datasets by assimilating and serving product and mission documentation at the end of the mission's lifetime. Archive staff work closely with data providers to ensure that datasets are delivered with all necessary documentation and metadata to allow proper and maximal use of the data by archive users. As part of this effort, IRSA delivered a major upgrade to the IRAS documentation in 2003, and is now serving on-line the IRAS Explanatory Supplements for the source catalogs, image atlas, small scale structure, and serendipitous catalogues.

## 3. Interoperability with Remote Datasets

Table 4 lists the remote datasets and services now accessible from IRSA; all of these program interfaces have been deployed since 2000. IRSA is interoperable with seven major astronomical datasets, including the Infrared Space Observatory (ISO), and all catalogs accessible through the VizieR interface at the Centre de Données astronomiques de Strasbourg (CDS).

Table 1. IRSA Missions Summary

Abbreviation	Dataset/Mission	Wavelength
2MASS	Two Micron All Sky Survey	J, H, K band
IRAS	Infrared Astronomical Satellite	12 $\mu\text{m}$ , 25 $\mu\text{m}$ , 60 $\mu\text{m}$ , 100 $\mu\text{m}$
MSX	Midcourse Space Experiment	8.28 $\mu\text{m}$ , 12.13 $\mu\text{m}$ , 14.65 $\mu\text{m}$ , 21.3 $\mu\text{m}$
SWAS	Submillimeter Wave Astronomy Sat.	1.4-2.8 GHz
ISO	Infrared Space Observatory	2.5 $\mu\text{m}$ - 240 $\mu\text{m}$
Spitzer	Spitzer Space Telescope	3-180 $\mu\text{m}$ ; ancillary data: X-ray to Radio
IRTS	Infrared Telescope in Space	1 - 1000 $\mu\text{m}$

Table 2. Scientific Catalog Holdings at IRSA, March 2004

Dataset/Mission	Wavelength	Num of Catalogs	Num of Sources
IRAS	12 $\mu\text{m}$ , 25 $\mu\text{m}$ , 60 $\mu\text{m}$ , 100 $\mu\text{m}$	9	1,717,014
2MASS	J, H, K band	13	656,106,982
MSX	8.28 $\mu\text{m}$ , 12.13 $\mu\text{m}$ , 14.65 $\mu\text{m}$ , 21.3 $\mu\text{m}$	1	331,117
IRTS	1 - 700 $\mu\text{m}$	1	14,294
Spitzer	3-180 $\mu\text{m}$ ; ancillary data: X-ray to Radio	36	1,270,042
Total, March 2004:		60	659,439,819
Total, May 2000:		17	185,053,997

Table 3. Scientific Image and Spectra Data Holdings at IRSA, March 2004

Dataset/Mission	Wavelength	Volume (GB)	Number
Image Data			
IRAS	12 $\mu\text{m}$ , 25 $\mu\text{m}$ , 60 $\mu\text{m}$ , 100 $\mu\text{m}$	20.91	37,460
2MASS	J, H, K band	10,358.00	9,572,125
MSX	8.28 $\mu\text{m}$ , 12.13 $\mu\text{m}$ , 14.65 $\mu\text{m}$ , 21.3 $\mu\text{m}$	38.77	7,316
IRTS	1 - 700 $\mu\text{m}$	0.18	1,067
Spitzer	3-180 $\mu\text{m}$ ; ancillary data: X-ray to Radio	14.69	155
Total, March 2004:		10,432.55	9,618,123
Total, May 2000:		77.00	807,380
Spectra			
IRTS	1 - 700 $\mu\text{m}$	0.12	536
SWAS	1.4-2.8 GHz	5.90	27,026
ISO	2.5 $\mu\text{m}$ - 240 $\mu\text{m}$	9.40	2,524
Total, March 2004:		15.42	30,086
Total, May 2000:		0.00	0

Table 4. Interoperable Datasets and Services

Dataset/Archive	Location	Wavelength	Data
Great Observatories Deep Survey (GOODS)	STScI	1150-11,200Å	280 FITS files
Infrared Space Observatory (ISO)	Vilspa	2.4-240 $\mu\text{m}$	22,966 observations
MAST Scrapbook	STScI	70-25,00Å	7,383 observations
VizieR	CDS	X-ray to Radio	4,014 catalogs
Digital Sky Survey (DSS)	STScI	0.35-1 $\mu\text{m}$	7.2 TB
New Very Large Array Sky Survey (NVSS)	NRAO	1.4 GHz	2,326 images 1,800,000 sources
Faint Images of the Radio Sky at 20 cm	LLNL	20 cm	811,117 sources
HEASARC	Goddard	X-ray to Radio	40+ sky surveys
NASA Extragalactic Database (NED)	IPAC	X-ray to Radio	7.5 million objects 1.9 million images
JPL Horizons & Small Body Ephemeris	JPL	N/A	$\geq$ 16,300 Objects

## 4. Major Archive Services

IRSA uses a component-based architecture, in which new applications are built by linking existing services through a simple executive program. In this model, the user interfaces are simply “thin” front ends that accept input from users. The following subsections describe five of the most widely used applications.

### 4.1. RADAR

<http://irsa.ipac.caltech.edu/applications/Radar>

**RADAR** is an inventory and data access service for navigating and exploring the infrared sky (Zhang et al. 2005). For a target or region, RADAR quickly generates an inventory of IRSA’s science products. RADAR supports one-click retrieval of subsets of IRSA science products and provides links to dataset-specific query and download services.

### 4.2. Gator

<http://irsa.ipac.caltech.edu/applications/Gator>

**Gator** is a completely general query building service that allows users to extract data from any of the catalogs held at IRSA. Gator supports positional queries as well as queries by parameter. It also supports upload of a table of positions for cross-comparison with catalogs.

### 4.3. OASIS

<http://irsa.ipac.caltech.edu/applications/Oasis>

**OASIS** is IRSA’s data integration tool (Good et al. 2003), which provides visualization of and access to data from many providers. OASIS has access to several image archives, IRSA’s catalogs, and all CDS Vizier catalog holdings; it can perform contour map generation and region statistics; and it has extensive overlay capabilities for image footprints and spectra/catalog source locations. Most of IRSA’s data search results will be available to the user for download as well as for viewing in OASIS, by clicking on the blue “OASIS” button.

### 4.4. Atlas

<http://irsa.ipac.caltech.edu/applications/Atlas>

Many of the datasets served by IRSA consist of images, source tables, spectra, or light curves from multiple missions, often covering a particular region of the sky. **Atlas** is a single CGI program which can be used to search any such data collection in a general and uniform manner (Alexov & Good 2004). The Atlas front page has a listing of all of the data collections currently available; the user must choose the collection they are interested in to get to its front page, which contains further information and a search form. Atlas currently serves the following datasets: Great Observatories Origins Deep Survey (**GOODS**), 2MASS 6X Lockman Hole (**LH**), IRAS Galaxy Atlas (**IGA**), Extended IRAS Galaxy Atlas (**EIGA**), Mid-Infrared Galaxy Atlas (**MIGA**), IRAS Sky Survey Atlas (**ISSA**), 2MASS Large Galaxy Atlas (**LGA**), spectra from the ISO

Short Wavelength Spectrometer (**SWS**), NASA/IPAC Extragalactic Database Image Data Atlas (**NED**), Midcourse Space Experiment (**MSX**), Spitzer Reserved Observation Catalog Atlas (**ROC**), Spitzer First Look Survey (FLS) – Ancillary VLA Data (**FLS VLA**), Spitzer First Look Survey (FLS) – NOAO Extragalactic – R (**FLS MAIN R**), Spitzer First Look Survey (FLS) – NOAO ELAIS N1 – R (**FLS ELAISN1 R**), Infrared Telescope in Space (**IRTS**), The MAST Image/Spectra Scrapbook (**MAST Scrapbook**), Spitzer Wide-area Infrared Extragalactic Survey (**SWIRE**), Cosmic Evolution Survey with HST (**COSMOS**) and Spitzer Space Telescope Data Atlas (**SPITZER**).

#### 4.5. 2MASS Image Services

<http://irsa.ipac.caltech.edu/applications/2MASS/IM>

The **2MASS Image Services** provide access to the Two Micron All Sky Survey (2MASS) Atlas and Quicklook Images.

1. **Interactive Image Service:** Enables rapid interactive viewing and retrieval of single 2MASS image sets (J, H, and K) covering a specified location or object. Indicates image artifacts. This is useful for fast examination of individual sources and/or small fields.
2. **Image Inventory Service:** Provides a listing of all 2MASS images and their metadata that cover a point or region on the sky. It is useful for determining if a position is covered by more than one image, as is the case in tile overlap regions, and for selectively finding and retrieving images that cover a broader region.
3. **Batch Image Service:** Retrieves sets of all 2MASS images that cover a specified region, sets of images that cover an input list of sky positions, or sets of images that match an input list of image descriptors. This is useful for retrieving large numbers of images to construct large area image mosaics, and for generating finding charts for large numbers of targets.

#### 4.6. Custom services

IRSA has many custom services for other datasets. These can be found on the IRSA **Home** page, or through the full list of IRSA **Services**: <http://irsa.ipac.caltech.edu/services>.

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