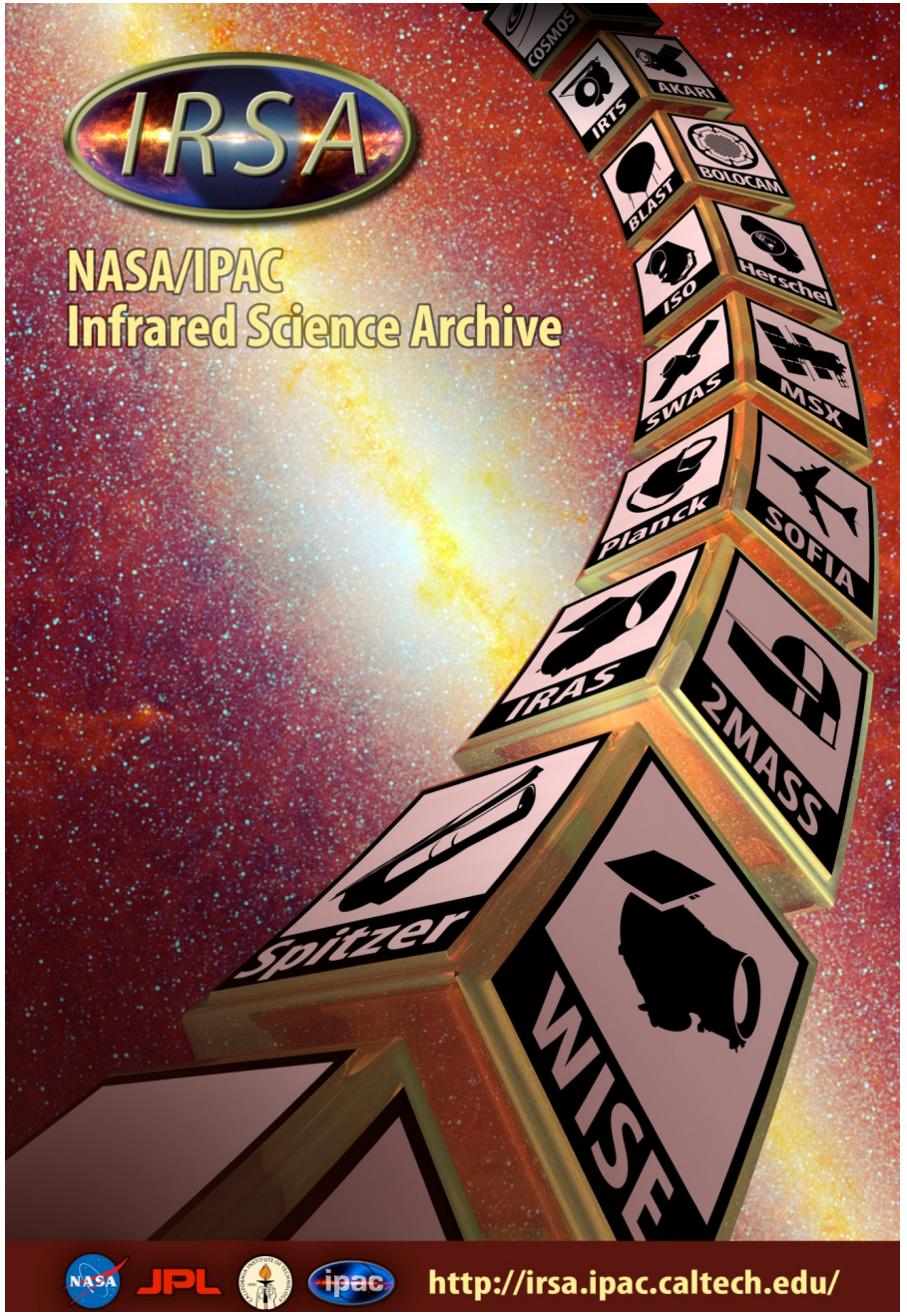
NASA / IPAC Infrared Science Archive

The IPAC Research Archives

Steve Groom
IPAC / Caltech



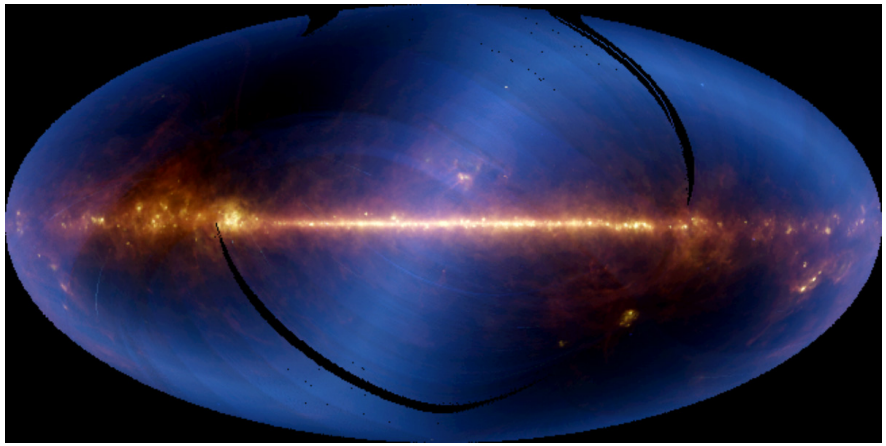
NASA / IPAC Infrared Science Archive

IRSA

IPAC overview

The Infrared Processing and Analysis Center (IPAC) at Caltech is dedicated to science **operations**, data **archives**, and community **support** for astronomy and solar system science missions, with a historical emphasis on infrared-submillimeter astronomy and exoplanet science.

IPAC is entering its **30th year** of building and operating successful data centers and research archives for space- and ground-based astronomical observatories and large-scale survey programs.



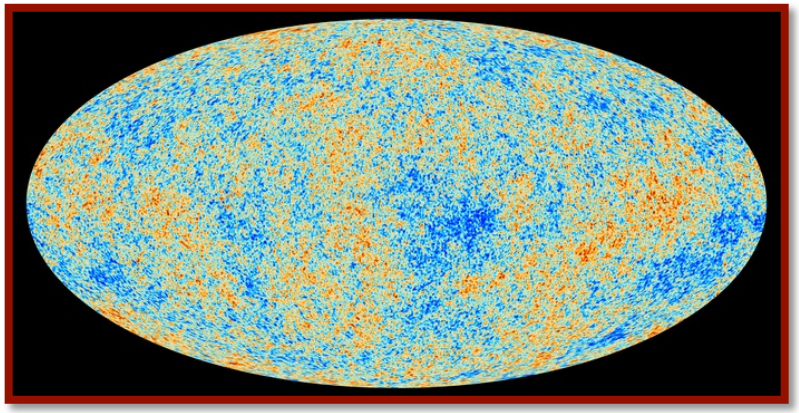
The IRAS mission surveyed the infrared sky in 1983.

IPAC Activities

- NASA/IPAC Infrared Science Archive (IRSA)
- NASA Extragalactic Database (NED)
  - NASA's *"Google for galaxies"*
- NASA Exoplanet Science Institute (NExScI)
  - Exoplanet Archive
  - Keck Observatory Archive (KOA)
- Archives Education and Public Outreach
  - NASA/IPAC Teacher Archive Research Program (NITARP)
  - Astropix archive of astrophysical images.

NASA / IPAC Infrared Science Archive

IPAC Activities (2)



2013: Planck produces most precise map of the early universe

IPAC is also home to:

- Spitzer Space Telecope Science Center
- NASA Herschel Science Center
- NASA/US Planck Data Center

- Las Cumbres Observatory Global Telescope (LCOGT) Archive
- Palomar Transient Factory (PTF) Archive

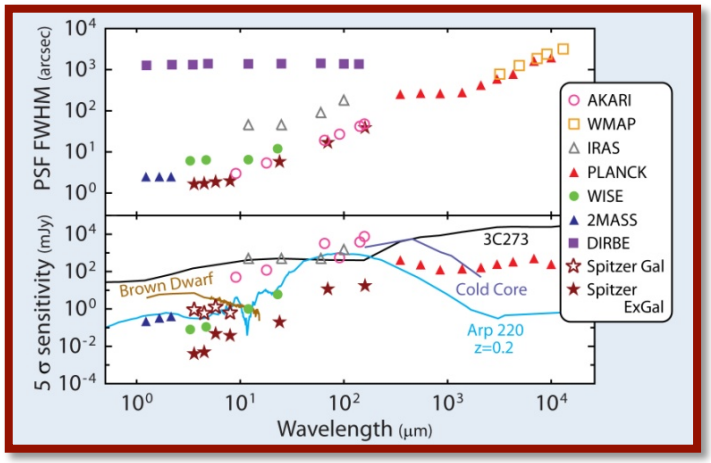
NASA / IPAC Infrared Science Archive

IRSA Overview

IRSA is NASA's IR/sub-mm archive

- Began with IRAS and 2MASS, leading into the decade of IR missions

- Spitzer Space Telescope
- Wide-Field Infrared Survey Explorer (WISE)
- NASA Planck Archive



IRSA serves an unparalleled array of all-sky IR surveys providing a total of 20 bands from 1 mm to 10 mm.

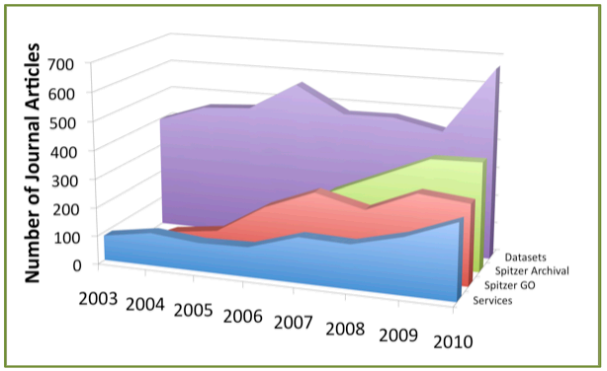
IRSA also provides access to many other mission datasets, including some hosted at other institutions, brought together for the convenience of researchers

Spitzer WISE Planck Herschel 2MASS IRAS AKARI MSX SWAS IRTS BLAST SOFIA

NASA / IPAC Infrared Science Archive

Purposes behind archiving

- Permits others to exploit data – now and into the future
  - For many mission datasets, papers produced from archival research outnumber those from original science teams



- Provides efficient access to mission data *to enable research that has not yet been envisioned*

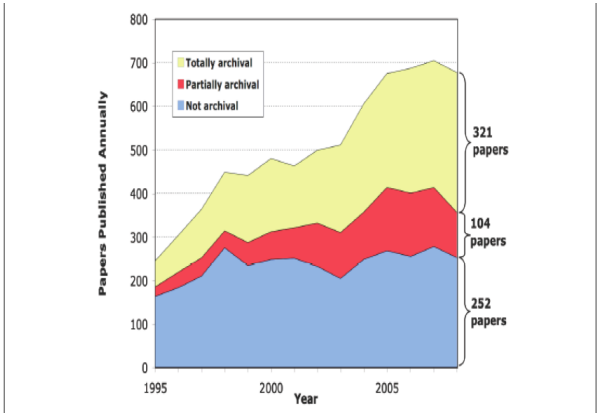


FIGURE 5-6 Number of annual publication using Hubble Telescope data. The publications have been divided into non-archival papers written by the original investigators (blue), totally archival publications not involving any of the original proposers (yellow), and papers that include data from multiple proposals with some being archival and some not (red). The number of archival papers has exceeded the number of PI-led papers since 2006. Courtesy of Richard L. White (Space Telescope Science Institute).

The most important questions our users want answered are:

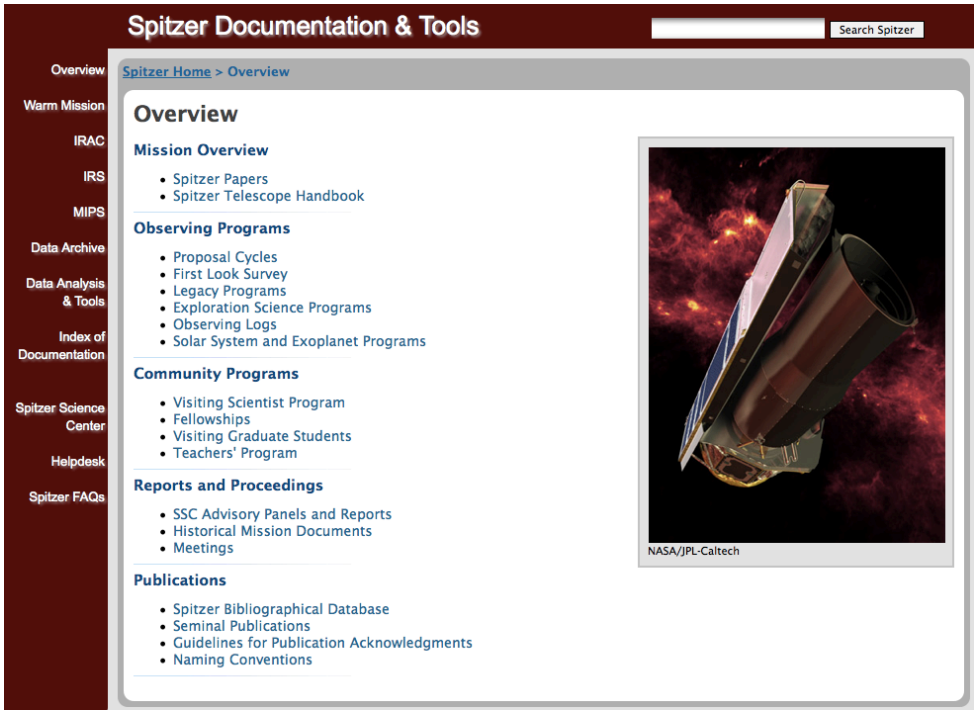
- "*How do I get (and use) my data?*"
- "*Whom do I ask if I have a problem?*"

NASA / IPAC Infrared Science Archive

IRSA

Archiving involves:

- Data curation
- Data access
- Documentation
- Tools for data reduction, analysis
- User support



All are important to ensure usefulness of the data

NASA / IPAC Infrared Science Archive

IRSA

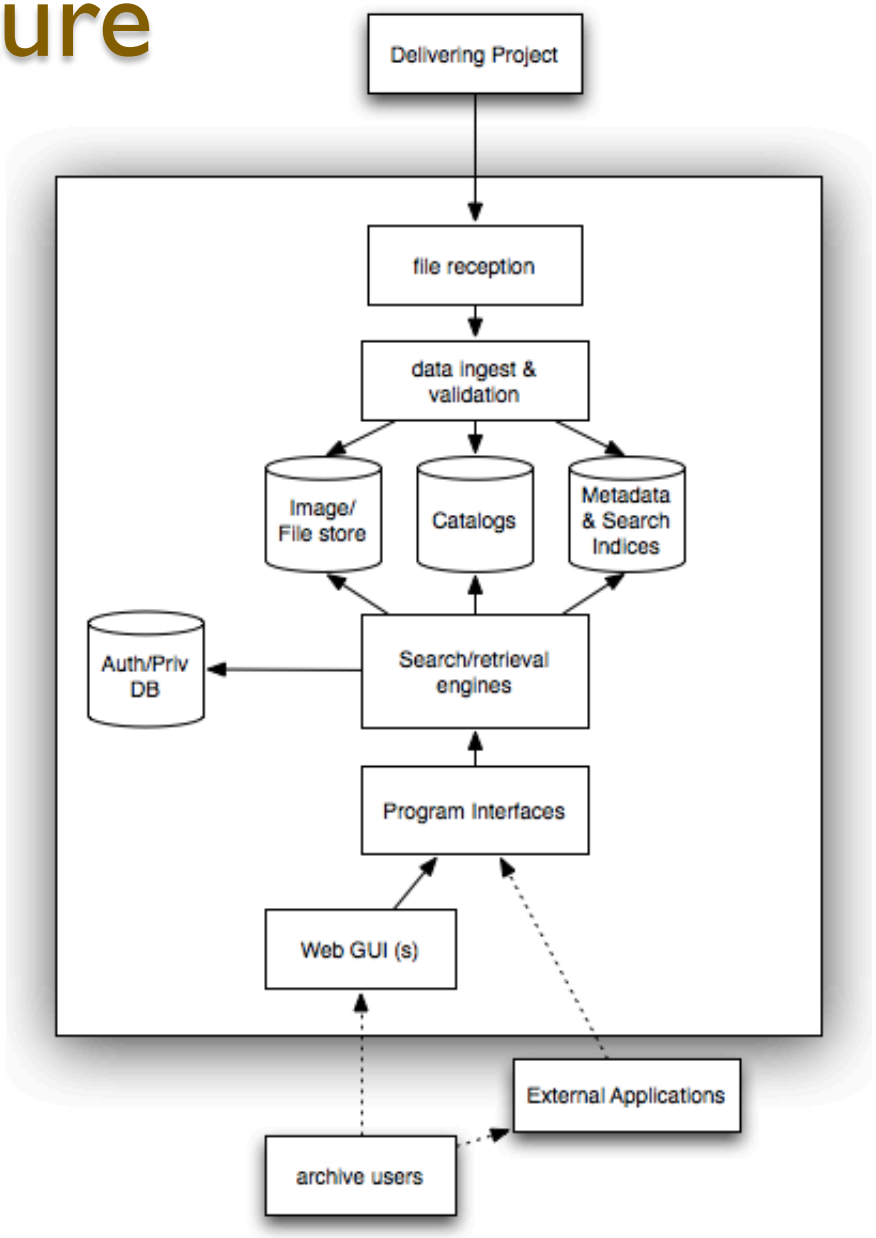
Data access models

- **Find**: Discovery/Inventory– what's available?
- **Query**: Detailed, dataset-specific query
  - Find records/images matching constraints
- **Combine**: Multi-dataset query
  - Display data from multiple datasets together
- **Mine**: Bulk query
  - Upload list of search positions or other criteria
- **Retrieve**: Bulk dataset download
  - Give me the whole thing
- **Remote Access**: Direct external access
  - "Can I just have my program connect directly to your database?"

NASA / IPAC Infrared Science Archive

Archive Architecture

- Ingestion & Validation
- Storage, Indexing
- Reusable search engines
  - Catalogs
  - Image/extended spatial
- Product retrieval
  - Also on-demand generation (e.g. image cutout, mosaic)
- Program (VO) interfaces
- Web UI's
- Support for external UI's



IRSA's common architecture supporting other activities

- NExScI – Exoplanet Archive, Kepler Science Analysis System
- Keck Observatory Archive
  - 20 years of observations
- Solar System – NEOWISE
- Non-NASA:
  - P60, PTF
  - LCOGT
  - LSST
  - TCCON (Atmospheric research)

NExScI
NASA Exoplanet Science Institute

Kepler

LCOGT

TCCON
total carbon column observing network

NASA / IPAC Infrared Science Archive

IRSA

Questions to ask in archive design

- What are the products?
  - Standard levels of processing/calibration/reduction?
- What are the use cases for search&retrieval?
- What are the units for data packaging, query, retrieval?
- What can be queried?
  - Metadata – date, instrument, position, etc
  - Pre-calculated summary metrics/statistics
  - Measurement data
  - Derived/calculated properties, combinations of data
- Any proprietary data considerations?
  - Mixing public and private data within the archive can greatly complicate handling of queries involving summary information

NASA / IPAC Infrared Science Archive

IRSA

Questions - 2

- Who needs access to the data?
- When do they need access?
  - Real or Near-real time – notification, event distribution: a topic all to itself!
  - Hours/Days/Months/Years later
- Acceptable query latency?
  - Interactive vs batch-style queries
- Anticipated usage/volume

Archive Considerations

- Consistency of formats & organization
- Completeness/Correctness of data
  - initial validation is important
- Completeness of documentation
- Examples are helpful!
  - Data reduction "cookbooks"
  - User tutorials, workshops

- Important for the long haul:
  - Consider longevity of technologies, data formats, programming languages/systems
  - Media lifetime, periodic refresh

Trends: Rapid evolution of information-handling systems

- Technology for data handling changes even more quickly than technologies for photon gathering
  - Fast Internet everywhere
  - Extremely portable disks and drives
  - Grid computing and protocols for remote analysis
  - The cloud

WISE Images
RCW86 Supernova Remnant
and
Helix Nebula

NASA / IPAC Infrared Science Archive

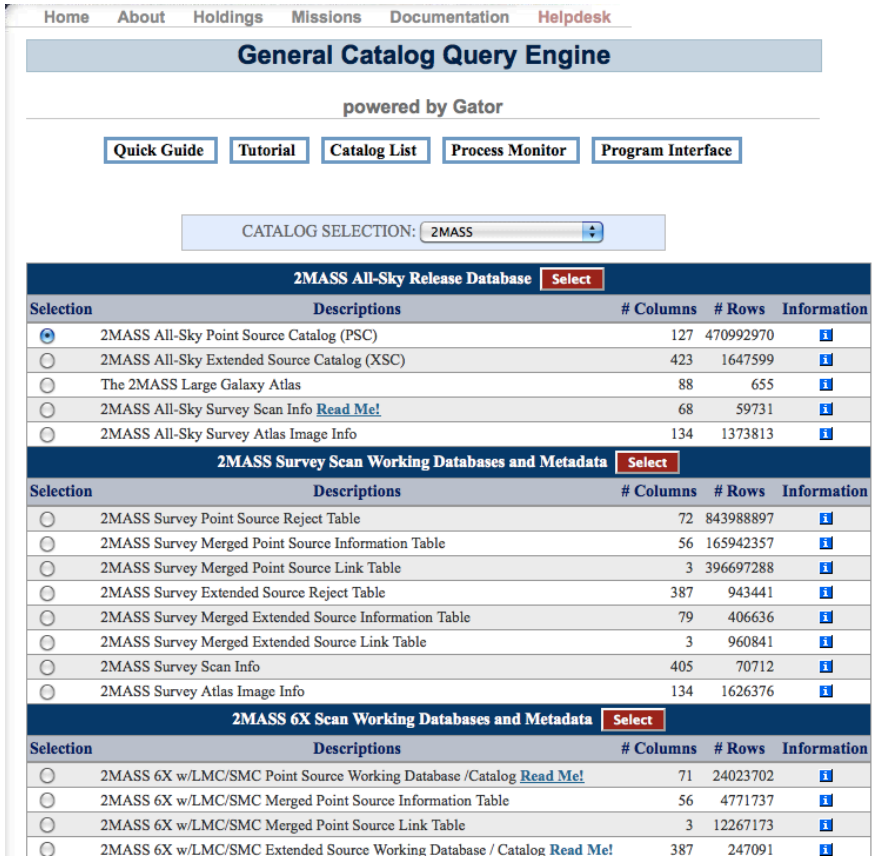
IRSA

Trends: Archives as analysis environments

- Browse-and-download
  - Identify data of interest, take it home for further study
- Complex queries
  - Finding "interesting" data within large datasets
- In-database analysis?
  - More complex queries over larger data volumes
  - Data size growing faster than communications
  - Bringing the software to the data?
  - *" 'Big Data' means you can't move it."*

Common Formats and Tools

- Catalogs – tabular data
- Images – usually as FITS files
- Spectra
- Time-series photometry - light curves



Home About Holdings Missions Documentation Helpdesk

General Catalog Query Engine

powered by Gator

Quick Guide | Tutorial | Catalog List | Process Monitor | Program Interface

CATALOG SELECTION: 2MASS

2MASS All-Sky Release Database Select

Selection	Descriptions	# Columns	# Rows	Information
◉	2MASS All-Sky Point Source Catalog (PSC)	127	470992970	i
○	2MASS All-Sky Extended Source Catalog (XSC)	423	1647599	i
○	The 2MASS Large Galaxy Atlas	88	655	i
○	2MASS All-Sky Survey Scan Info Read Me!	68	59731	i
○	2MASS All-Sky Survey Atlas Image Info	134	1373813	i

2MASS Survey Scan Working Databases and Metadata Select

Selection	Descriptions	# Columns	# Rows	Information
○	2MASS Survey Point Source Reject Table	72	843988897	i
○	2MASS Survey Merged Point Source Information Table	56	165942357	i
○	2MASS Survey Merged Point Source Link Table	3	396697288	i
○	2MASS Survey Extended Source Reject Table	387	943441	i
○	2MASS Survey Merged Extended Source Information Table	79	406636	i
○	2MASS Survey Merged Extended Source Link Table	3	960841	i
○	2MASS Survey Scan Info	405	70712	i
○	2MASS Survey Atlas Image Info	134	1626376	i

2MASS 6X Scan Working Databases and Metadata Select

Selection	Descriptions	# Columns	# Rows	Information
○	2MASS 6X w/LMC/SMC Point Source Working Database /Catalog Read Me!	71	24023702	i
○	2MASS 6X w/LMC/SMC Merged Point Source Information Table	56	4771737	i
○	2MASS 6X w/LMC/SMC Merged Point Source Link Table	3	12267173	i
○	2MASS 6X w/LMC/SMC Extended Source Working Database / Catalog Read Me!	387	247091	i

Configurable user interfaces

Decreases the costs of setting up access to new data sets and the costs of long-term maintenance. Provides unified user experience.

Summary

- Preservation of science data products as well as lower-level products enhances future research
  - Can't predict all potential use cases
- Reusable building blocks can effectively support a wide range of use cases
- Distinct perspectives for rapid vs long-term utilization
  - Fast observation followup vs future data mining
  - Discovery vs research use cases