



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

New Developments in MAST

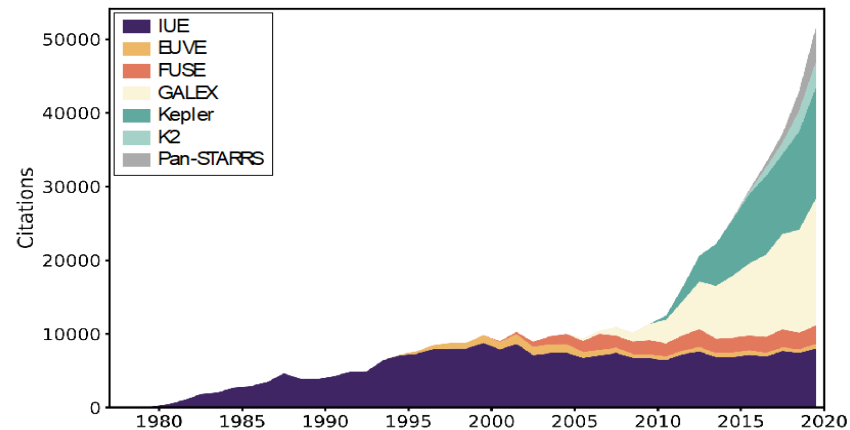
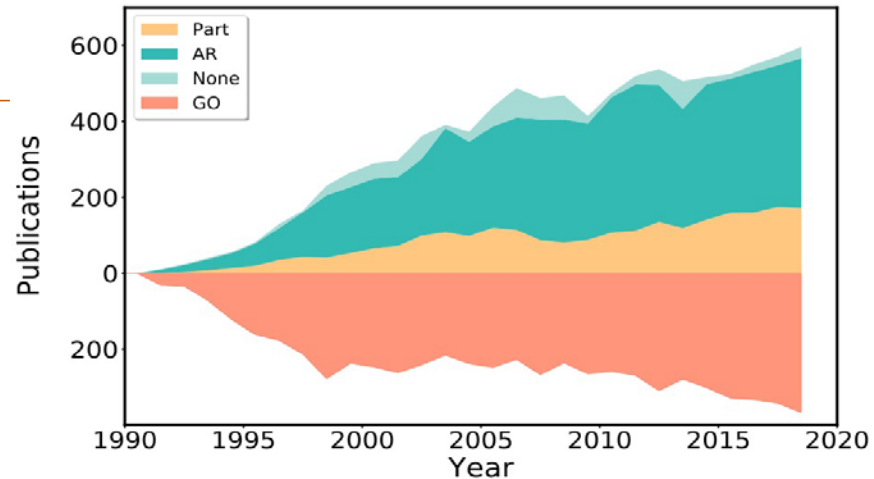
Ivelina Momcheva

Data Science Mission Office



MAST in Brief

- 2.2 PB of data from HST and 21 other missions/collections
- 165 High Level Science Product (HLSP) collections
- HST data has produced ~17,000 publications so far
- Non-HST data produces ~50,000 citations per year
- The MAST Portal is visited by ~6,000 unique users per month





What is New in MAST?

- z.MAST: a new galaxy evolution interface
- Improving access to data: APIs and Jupyter Notebooks
- HST, TESS and Kepler in the cloud

The image features the text 'zMAST' in a bold, white, sans-serif font centered against a dark blue, starry background with nebulae. A thin orange horizontal line is positioned below the text.

zMAST



z.MAST

- Enhances access, increases discoverability, and enables visualization of datasets related to galaxy evolution from the MAST missions and aid in HST and JWST observation planning.
- Current datasets: GOODS and CANDELS
- Now live at <https://z.mast.stsci.edu/>
- Get a demo at the STScI booth!

zMAST

Search for extragalactic observations and catalog data from MAST high-level science products (HLSP). Download results for further analysis or quickly view detailed information by individual galaxy—aggregated data, image cutouts, observed SEDs, and observations from **CANDELS** and **GOODS**. (More HLSP coming soon.)

Search by

Input coordinate.

RA= 53.14228820800781

dec= -27.94447135925293

radius= 1

arc seconds

max = 30 arc mins

Select an HLSP.

survey= CANDELS | GOODS

Select an observed field. [See field footprints.](#)

region= all | COSMOS | EGS | GOODS_North | GOODS_South | UDS

Pick a specific region for more catalog options.

catalog= Summary | Multiband Photometry |

Star Formation Rates

+ Add condition

Add a parameter to filter by. [See parameter descriptions.](#)

* Different catalogs have different parameters.

is greater than or equal to 1.0

SEARCH

candels_master_view.objid	candels_master_view.id	candels_master_view.lau_name	candels_master_view.ra	candels_master_view.dec	candels_master_view.field	candels_master_view.photflag	candels_master...
1000000108	108	CANDELS_GDS_F160W_J033233.81-275647.8	53.14089584350586	-27.946556091308594	GOODS-S	0	0.01
1000000118	118	CANDELS_GDS_F160W_J033232.56-275643.8	53.135684967041016	-27.945514678955078	GOODS-S	0	0.01
1000000119	119	CANDELS_GDS_F160W_J033233.45-275644.8	53.13938522338867	-27.945781707763672	GOODS-S	0	0
1000000120	120	CANDELS_GDS_F160W_J033232.60-275644.1	53.135841369628906	-27.945587158203125	GOODS-S	0	0.74
1000000121	121	CANDELS_GDS_F160W_J033233.55-275645.8	53.139793395996094	-27.946073532104492	GOODS-S	0	0.98

← Back to search CANDELS_GDS_F160W_J033222.31-275716.3

ID field 1
 RA 53.092994689941406
 DEC -27.954538345336914
 z_spec 0.5303
 z_peak 0.5303
 lmass 10.4330



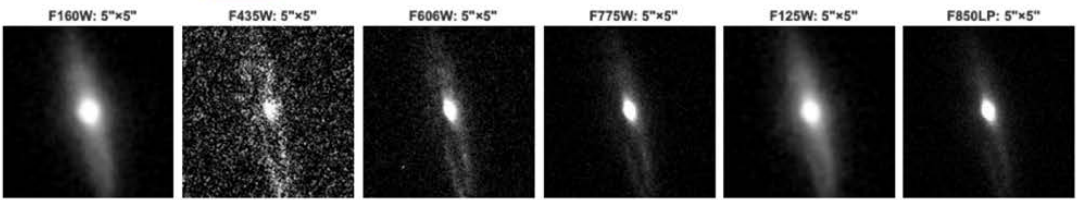
Photometry

ACS_F435W 23.4085	ACS_F606W 21.8575
ACS_F775W 20.9123	ACS_F814W 20.7820
ACS_F850LP 20.4880	WFC3_F098M
WFC3_F105M	WFC3_F125M 19.9532
WFC3_F140W	WFC3_F160M 19.5523
IRAC_CH1 19.1928	IRAC_CH2 19.1928
IRAC_CH3 19.6622	IRAC_CH4 20.0102

Morphology

a_image 18.4680	b_image 6.6980
fwhm_image 6.4600	flux_radius 9.6320
kron_radius 3.5000	

Spectral Energy Distribution Images



Q Mission - Instrument	Q Waveband	Q Product	Q Filters	Q Exposure (sec)	Q Target	Q RA	Q Dec	Q Date of Observation	Q Project	Q Observation ID
HLSP - ACS	OPTICAL	image	F814W	10316	ANY	03:32:08.422	-27:52:06.70	2011-11-26	hisp_candels	hisp_candels_hst_acs_gsd13-ect32_f814w_v0.5...
HLSP - ACS	OPTICAL	image	F814W	105907	GOODS-SD5	03:32:30.287	-27:48:13.60	2010-10-08	hisp_candels	hisp_candels_hst_acs_gs-tot-sect32_f814w_v1.0_d...
HLSP - ACS	OPTICAL	image	F814W	0	CANDELS	03:32:07.070	-27:49:39.19		hisp_candels	hisp_candels_hst_acs_gsd14_f814w_v0.5_drz
HLSP - ACS	OPTICAL	image	F814W	3672	ANY	03:32:08.398	-27:52:08.67	2010-11-28	hisp_candels	hisp_candels_hst_acs_gsd02-sect32_f814w_v0.5...
HLSP - ACS	OPTICAL	image	F606W	0	CANDELS	03:32:43.707	-27:49:39.26		hisp_candels	hisp_candels_hst_acs_gsd10_f606w_v0.5_drz
HLSP - ACS	OPTICAL	image	F814W	0	CANDELS	03:32:25.388	-27:49:39.30		hisp_candels	hisp_candels_hst_acs_gs-tot_f814w_v1.0_drz
HLSP - ACS	OPTICAL	image	F850LP	5808	GOODS-SD5	03:32:31.131	-27:48:42.60	2011-09-13	hisp_candels	hisp_candels_hst_acs_gsd11-sect32_f850lp_v0.5...
HLSP - ACS	OPTICAL	image	F850LP	11516	GOODS-SD5	03:32:31.131	-27:48:42.60	2011-11-03	hisp_candels	hisp_candels_hst_acs_gsd12-sect32_f850lp_v0.5...
HLSP - ACS	OPTICAL	image	F850LP	0	CANDELS	03:32:07.056	-27:53:42.19		hisp_candels	hisp_candels_hst_acs_gsd12_f850lp_v0.5_drz
HLSP - ACS	OPTICAL	image	F814W	0	CANDELS	03:32:25.388	-27:49:39.30		hisp_candels	hisp_candels_hst_acs_gsd13_f814w_v0.5_drz
HLSP - ACS	OPTICAL	image	F814W	0	CANDELS	03:32:43.716	-27:53:42.26		hisp_candels	hisp_candels_hst_acs_gsd11_f814w_v0.5_drz



Improving Access to Data



Improving Data Access

- `astroquery.mast` module enables programmatic search and data download

Page Contents

MAST Queries

(astroquery.mast)

- Getting Started
 - Positional Queries
 - Observation Criteria Queries
 - Getting Observation Counts
 - Metadata Queries
- Downloading Data
 - Getting Product Lists
 - Downloading Data Products
 - Filtering
 - Cloud Data Access
- Catalog Queries
 - Positional Queries
 - Catalog Criteria Queries
 - Hubble Source Catalog (HSC) specific queries
- TESSCut
 - Cutouts
 - Sector information
- Accessing Proprietary Data
- Direct Mast Queries
- Additional Resources
- Reference/API
 - astroquery.mast Package
 - MAST Query Tool
 - Classes

MAST Queries (astroquery.mast)

Getting Started

This module can be used to query the Barbara A. Mikulski Archive for Space Telescopes of the types of queries that can be used, and how to access data products.

Positional Queries

Positional queries can be based on a sky position or a target name. The observation field

```
>>> from astroquery.mast import Observations
>>> obs_table = Observations.query_region("322.49324 12.16683")
>>> print(obs_table[:10])
```

dataproduct_type	obs_collection	instrument_name	...	distance
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0
cube	SWIFT	UVOT	...	0.0



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Search by

Input coordinate.

RA= dec= radius= max = 30 arc mins

Select an HLSP. Select an observed field. [See field footprints.](#)

survey= region=

Pick a specific region for more catalog options.

catalog=

Add a parameter to filter by. [See parameter descriptions.](#)
* Different catalogs have different parameters.

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Improving Data Access

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z.mast

0.1

Search docs

- ▢ Welcome to the z.MAST API documentation!
- ▢ Getting Started
- ▢ Object API
- ▢ Survey APIs
- ▢ SED Plots
- Other Links

Object Lookup API

CANDELS API

GOODS API

Spectral Energy Distribution Plots API

[Docs](#) » Welcome to the z.MAST API documentation!



Welcome to the z.MAST API do

- [Welcome to the z.MAST API documentation!](#)
 - [Getting Started](#)
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 - [Survey APIs](#)
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 - [GOODS API](#)
 - [SED Plots](#)
 - [Spectral Energy Distribution Plots API](#)
 - [Other Links](#)

Getting Started

This is documentation for the z.MAST API, one of the *Barba* Telescopes' (MAST) web service APIs. This API allows users to access deep field surveys. It is currently in beta and allows access to but a number of other surveys are planned additions.



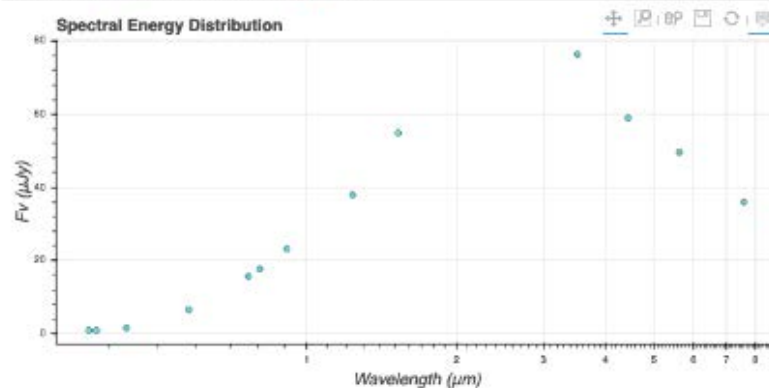
Improving Data Access

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- Application Programming Interfaces (APIs) available for most products
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```
In [1]: import requests
        from IPython.display import display, HTML
        import os,sys
        from astropy.io import fits
        import matplotlib.pyplot as plt
```

```
In [2]: r = requests.get('https://x.mast.stsci.edu/api/v0.1/sed/candels/plot/?name=CANDELS_GDS_F160W_F033222.31-275716.3')
```

```
In [3]: display(HTML(str(r.content.decode('utf-8'))))
```



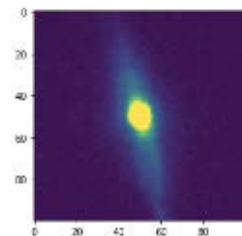
```
In [4]: url = 'https://mast.stsci.edu/xcut/api/v0.1/astrocut?ra=53.09299&dec=-27.95453&sz=100&y=100&units=ps'
        os.system('curl -o test1.zip {}'.format(url))
        os.system('unzip test1.zip')
```

```
Out[4]: 256
```

```
In [5]: foo = fits.open('candels_ga_53.092990_-27.954530_100.0pix-x-100.0pix_astrocut.fits')
```

```
In [6]: plt.imshow(foo[1].data, vmin=0.0, vmax=0.5)
```

```
Out[6]: <matplotlib.image.AxesImage at 0x11e7c9208>
```





Improving Data Access

- `astroquery.mast` module enables programmatic search and data download
- Application Programming Interfaces (APIs) available for most products
- Documentation provides use examples
- Notebook repository showcases functionality
- Browse notebooks at:

<https://spacetelescope.github.io/notebooks/>

Notebooks Index

MAST

[TESS | Intermediate: Create TESS FFI Cutout using Python Requests](#)

[TESS | Beginner: A Tour of the Contents of the TESS 2-minute Cadence Data](#)

[TESS | Beginner: Search The TESS Input Catalog Centered On HD 209458.](#)

[TESS | Beginner: Read and Plot A TESS Light Curve File](#)

[TESS | Intermediate: Search and Download GI Program Light Curves](#)

[TESS | Beginner: Read and Display A TESS Target Pixel File](#)

[TESS | Beginner: Cutout of the TESS FFIs using Astrocut and Astroquery](#)

[TESS | Exoplanet Data and TESS Light Curves Using Python Requests](#)

[TESS | Beginner: Read and Plot A TESS Data Validation Timeseries File](#)

[TESS | Beginner: Retrieve TESS Data Validation Products with Astroquery](#)

[TESS | Intermediate: Finding Flares and Variable Stars in TASC Light Curves](#)



Hubble, TESS and Kepler in the Cloud



Hubble, TESS and Kepler in the Cloud

Registry of Open Data on AWS



Space Telescope Science Institute



The Space Telescope Science Institute (STScI) is operated by the Association of Universities for Research in Astronomy (AURA) with the goal of helping humanity explore the universe with advanced space telescopes and ever-growing

Hubble Space Telescope Public Data

astronomy

The Hubble Space Telescope (HST) is one of the most productive scientific instruments ever created. This dataset contains calibrated and raw data for all of the currently active instruments on HST: ACS, COS, STIS and WFC3.

<https://registry.opendata.aws/collab/stsci/>

Internationally recognized news, education, and public outreach programs. With the datasets hosted through the AWS Public Dataset Program we aim to allow the astronomical community to carry out research to lead to new scientific discoveries.

Search datasets (currently 3 matching datasets)

Add to this registry

If you want to add a dataset or example of how to use a dataset to this registry, please follow the instructions on the [Registry of Open Data on AWS GitHub repository](#).

Unless specifically stated in the applicable dataset documentation, datasets available through the Registry of Open Data on AWS are not provided and maintained by AWS. Datasets are provided and maintained by a variety of third parties under a variety of licenses. Please check dataset licenses and

Transiting Exoplanet Survey Satellite (TESS)

astronomy

The Transiting Exoplanet Survey Satellite (TESS) is a two-year survey that will discover exoplanets in orbit around bright stars. More information about TESS is available at [MAST](#) and the [TESS Science Support Center](#).

[Details](#) →

Usage examples

- [TESS data available on AWS](#) by Arfon Smith

[See 1 usage example](#) →

Kepler Mission Data

astronomy

The Kepler mission observed the brightness of more than 180,000 stars near the Cygnus constellation at a 30 minute cadence for 4 years in order to find transiting exoplanets, and



Hubble, TESS and Kepler in the Cloud

Why use cloud computing?

- Fast data access
- Flexible computational resources
- Run tasks at scale
- Access to machine learning, databases and other services



Hubble, TESS and Kepler in the Cloud

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How do we support you?

- Cloud Exploration Archival Proposals
- Cloud computing is an allowed grant expense
- MAST-Labs Blog: mast-labs.stsci.io
- Ask us questions: STScI booth and dsmo@stsci.edu





Hubble, TESS and Kepler in the Cloud



MAST Labs

Home

Exploring AWS Lambda with cloud-hosted Hubble public data

tl;dr: In this post we are going to show you how to processing every WFC3/IR image on AWS Lambda in about 2 minutes (and for about \$2)

In [our earlier post](#), we announced the availability of HST public data for currently active instruments in the [AWS Public Dataset Program](#). In that post we described how to access ~110TB of data (raw and calibrated) from ACS, WFC3, STIS, and COS available in the `stpubdata` S3 bucket.

In this post we will show how to leverage an AWS cloud service called [Lambda](#) to process a set of WFC3/IR data. Using this approach it is possible to process every WFC3/IR image (all ~120,000 of them) on AWS Lambda in about 2 minutes (and for about \$2).



Hubble, TESS and Kepler in the Cloud



MAST Labs

Home

TESS data available on AWS

tldr - Sectors 1 & 2 from TESS are available on Amazon Web Services (AWS). In this first post, we'll introduce a basic method for accessing the data programmatically through the [astroquery.mast](#) client library.

With the release of TESS sectors 1 & 2, we're making calibrated and uncalibrated full frame images, two-minute cadence target pixel and light curve files, and co-trending basis vectors, and FFI cubes (for the Astrocut tool) available in the [s3://stpubdata/tess](#) S3 bucket on AWS.

These data are available u
compute against the data

Accessing the d



MAST Labs

Home

28 OCT, 2019

Kepler Prime Mission Data Available on AWS

tldr The first four years of data obtained by the Kepler spacecraft are available as an Amazon Web Services (AWS) Public data set. In this post we describe which data products are available and how to use [astroquery](#) to obtain a light curve file from the s3 bucket.

Kepler observed parts of a 10 by 10 degree patch of sky near the constellation of Cygnus for four years (17, 3-month quarters) starting in 2009. The mission downloaded small sections of the sky at a 30-minute (long cadence) and a 1-minute (short cadence) in order to measure the variability of stars and find planets transiting these stars. These data are now available in the public [s3://stpubdata/kepler/public](#) S3 bucket on AWS.

These data are available under the same terms as the public dataset for [Hubble](#) and [TESS](#), that is, if you compute against the data from the AWS US-East region, then data access is free.



Summary

- MAST continues to deliver incredible datasets and services to its broad user community
- z.MAST is a new galaxy evolution interface – try it out for planning HST and JWST proposals
- Improving access to data: APIs and Jupyter Notebooks allow for reproducibility and create executable documentation
- HST, TESS and Kepler are all now in the AWS cloud. K2 coming soo.
- **Stop by the STScI Booth to try out there resources and give us feedback!**