WRAP v1.0.0 User Manual

Hunter Brooks

October 1, 2023

Contents

1 What is WRAP

The Wide-field Retrival of Astrodata Program (WRAP) is an aid for Astronomers to streamline the process of gathering photometry and astrometry for low-mass stars and brown dwarfs. Gathering from the CatWISE 2020, AllWISE, Gaia, VISTA, WFCAM, 2MASS, PanSTARRS, NSC, and GALEX catalogs.

This program is supported and funded by the Backyward Worlds: Planet 9 Collaboration (logo is in Figure 1(a) and the WRAP logo is Figure 1 (b)).

1.1 Pros of WRAP

Every necessary catalog for low-mass stars and brown dwarfs is provided in one small program for quick and easy use.

Shows the catalog detections plotted on the image for each catalog to aid the user in finding their object.

Takes only a simple click to gather all photometry and astrometry for each catalog.

Allows quick stretching of the image to aid the user in finding faint objects.

WRAP works on MacOS and Windows.

1.2 Cons of WRAP

Slow loading times for CatWISE 2020, AllWISE, Gaia, VSA, and WFCAM adding time to search rates (if internet speed are slow).

Can be difficult to find object in a crowded field if search radius is too large.

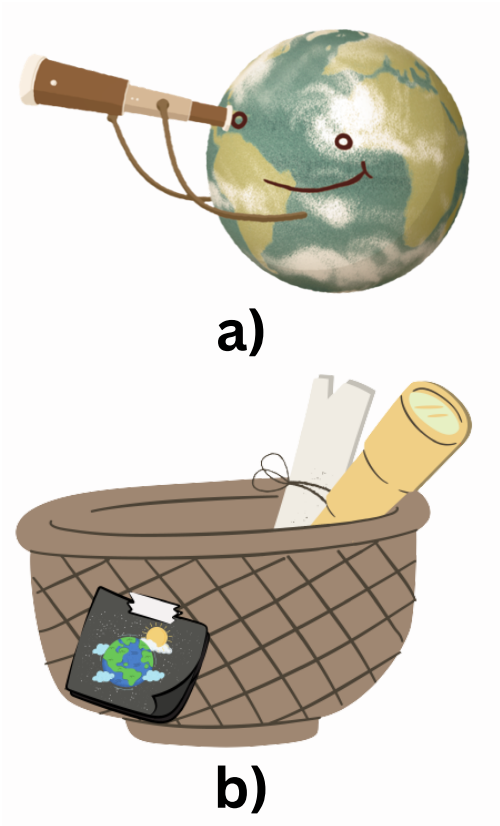


Figure 1: Subplot (a) is the logo for the Backyard Worlds: Planet 9 Collaboration. Subplot (b) is the logo for the WRAP project.

1.3 Ease of Use

1. Install: Downloading WRAP can be the hardest part if you are new to coding. However, all the documentation needed is provided in the .zip file and is explained in §2.

2. Load: Go into your terminal and load WRAP by running the "python3 WRAP" (MacOS) or "python3 .\WRAP.py" (Windows) command.

3. Input: Simply input your R.A., Decl., radius, and catalogs then click the "Run WRAP" button.

4. Click: Click your object when the catalog loads (WISEView is provided to aid in finding your desired object).

5. Output: Once finished go to the "Output" folder and all your data will be there.

1.4 Catalogs

- CatWISE2020 & AllWISE → Wide-Field Infrared Survey Explorer: `https://irsa.ipac.caltech.edu/Missions/wise.html`
- Gaia → GAIA ESA: `https://gea.esac.esa.int/archive/`
- VISTA → Visible and Infrared Survey Telescope for Astronomy: `http://horus.roe.ac.uk/vsa/index.html`
- WFCAM → Wide Field Camera: `http://wsa.roe.ac.uk/index.html`
- 2MASS → Two Micron All Sky Survey: `https://irsa.ipac.caltech.edu/Missions/2mass.html`
- PanSTARRS → Panoramic Survey Telescope and Rapid Response System: `https://outerspace.stsci.edu/display/PANSTARRS/`
- NSC → NOIRLab Source Catalog: `https://datalab.noirlab.edu/nscdr2/index.php`
- GALEX → Galaxy Evolution Explorer: `http://www.galex.caltech.edu`

2 Installation

2.1 Download

Go to `https://github.com/huntbrooks85/WRAP` and click "Releases" on the right side of the page. You will see the latest release now (v1.0.0) in which you can click "Assets" at the bottom of the release and install the .zip file.

Go to where this .zip file was downloaded and drag it to where you want your WRAP folder to reside. Double-click this file and delete the older .zip file.

NOTE: To find the directory path for where you stored WRAP right click it and select "Get Info" (MacOS) or "Properties" (Windows) which provides you with the directory. (REMEMBER THIS)

2.2 Python

Python 3.8 or greater is needed to run WRAP. During the creation of WRAP the developer used Python 3.8.8 (which is the recommended version).

To download Python 3.8.8 please follow: `https://www.python.org/downloads/release/python-388/`. If you are struggling to download Python please follow this guide to help you: `https://realpython.com/installing-python/`.

To test if Python is properly installed on your machine go to your terminal (terminal can be found by looking it up in your applications for both operating systems) and type: "python3". If it returns with ">>>" then Python is correctly installed (to exit this press "control + z").

2.2.1 Anaconda Recommendation

A recommendation for WRAP is to use virtual environments, partially Anaconda. As a result of WRAP requiring old package versions. For further instructions on Anaconda environments please go to: `https://docs.anaconda.com/free/anaconda/install/index.html`.

2.3 PIP Installations

After Python 3.8 or greater is installed, PIP v23.x or greater is required to install the needed packages. To install PIP use this guide: `https://pip.pypa.io/en/stable/installation/`. To test if PIP is correctly installed type "pip3 –version" in your terminal and it should return "pip *version directory*", see Figure 2.

```
Last login: Thu May 18 11:24:49 on ttys000
(base) hunter_brooks8@MacBook-Air ~ % pip --version
pip 23.1.2 from /Users/hunter_brooks8/opt/anaconda3/lib/
python3.8/site-packages/pip (python 3.8)
(base) hunter_brooks8@MacBook-Air ~ %
```

Figure 2: Testing if PIP is correctly installed with the "pip3 –version" command.

You can install all the necessary packages by going into the directory labeled "pip_module" and type "pip install -r requirements-mac.txt" or "pip install -r requirements-windows.txt". However, if you want to install the packages by hand please install:

- pyvo==1.4
- numpy==1.22.0
- pandas==1.5.3
- astropy==5.2.2
- truncate==0.11
- requests==2.28.1
- astroquery==0.4.6
- matplotlib==3.5.0
- PySimpleGUI==4.60.4
- OpenCV−python==4.7.0.72
- beautifulsoup4==4.11.1

If you are using Windows the Noirlab Source Catalog is not supported, therefore only MacOS users need to also install: astro−datalab==2.20.1. NOTE: All packages can be updated, however numpy and matplotlib have to be the specified version above.

```
(base) hunter_brooks8@MacBook-Air ~ % pip3 install matplotlib==3.5.0
Collecting matplotlib==3.5.0
  Downloading matplotlib-3.5.0-cp38-cp38-macosx_10_9_x86_64.whl (7.3 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7.3/7.3 MB 3.1 MB/s eta 0:00:00
```

Figure 3: An example of how to use PIP, using Matplotlib==3.5.0.

2.4 Fixing Astroquery

Astroquery needs to be updated to have the UKIDSS Hemipshere Survey, which WRAP fixes. To begin with open the "pip_module" folder in WRAP and copy the "core.py" file onto your Desktop.

Go to the directory containing Astroquery. To find this directory go into your terminal and type: "python3", "import astroquery", then "astroquery.__file__" which will return your file path for the Astroquery folder (to exit this press "control + z"), seen in Figure 4.

Once in the Astroquery directory, open the "ukidss" folder and replace the "core.py" file in that directory with the one placed on your Desktop.

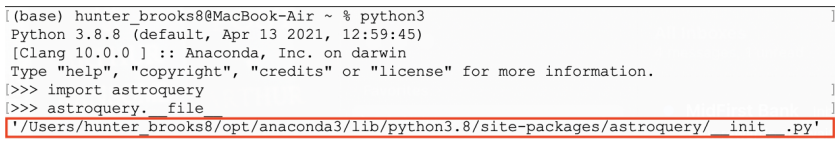


Figure 4: An example of how to find your local Astroquery directory.

3 How to Use

To run WRAP go to your directory that WRAP is stored in (by using the "cd" command in your terminal) and type "python3 WRAP.py" (MacOS) or "python .\WRAP.py" (Windows). You will know WRAP ran correctly when it pops up a window looking like Figure 5. NOTE: The window close button is disabled for WRAP, to close WRAP please select the red "Close WRAP" button at the bottom.

3.1 Single-Object Query

Once WRAP started running there are four boxes to fill, the "RA", "DEC", "RADIUS", and "Output File Name". The RA and DEC text box need be be in degrees and the RADIUS will be the search radius around this RA and DEC in arcseconds. Finally, the Output File Name needs to be only text with no file format after the name you have chosen. Note: If the "Output File Name" is left empty it will default to the name of "WRAP_Output".

Once you have put in your objects location and radius you can now select the catalog you want. Chose between CatWISE 2020, AllWISE, Gaia, VISTA, WFCAM, 2MASS, PanSTARRS, NSC (for only MacOS users), and GALEX.

Finally, after the previous two steps are complete you can now click the "Run WRAP" button and WRAP will start to search around the RA and DEC you have chosen.

You will see your default browser pop-up with WISEView to aid you

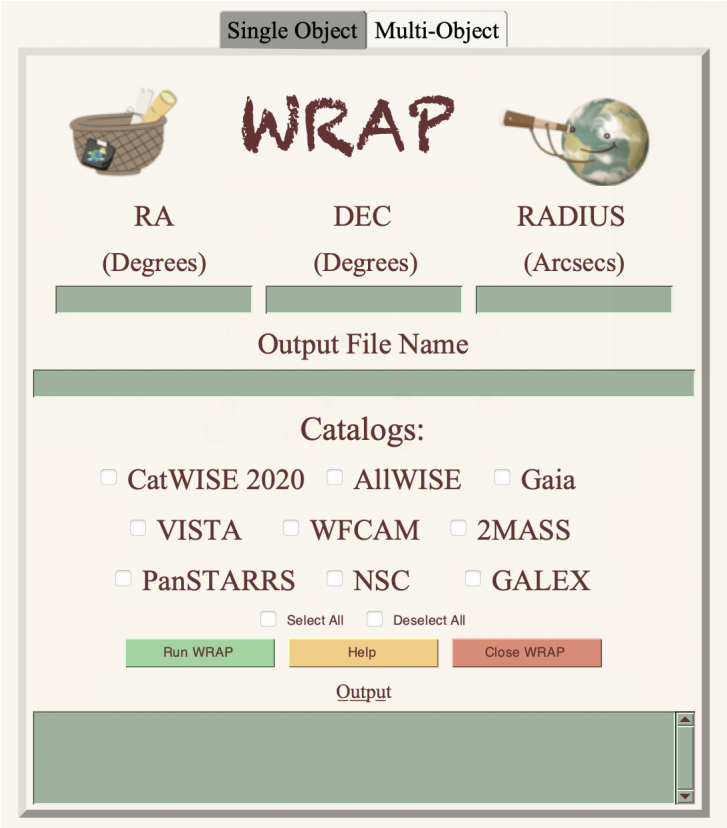
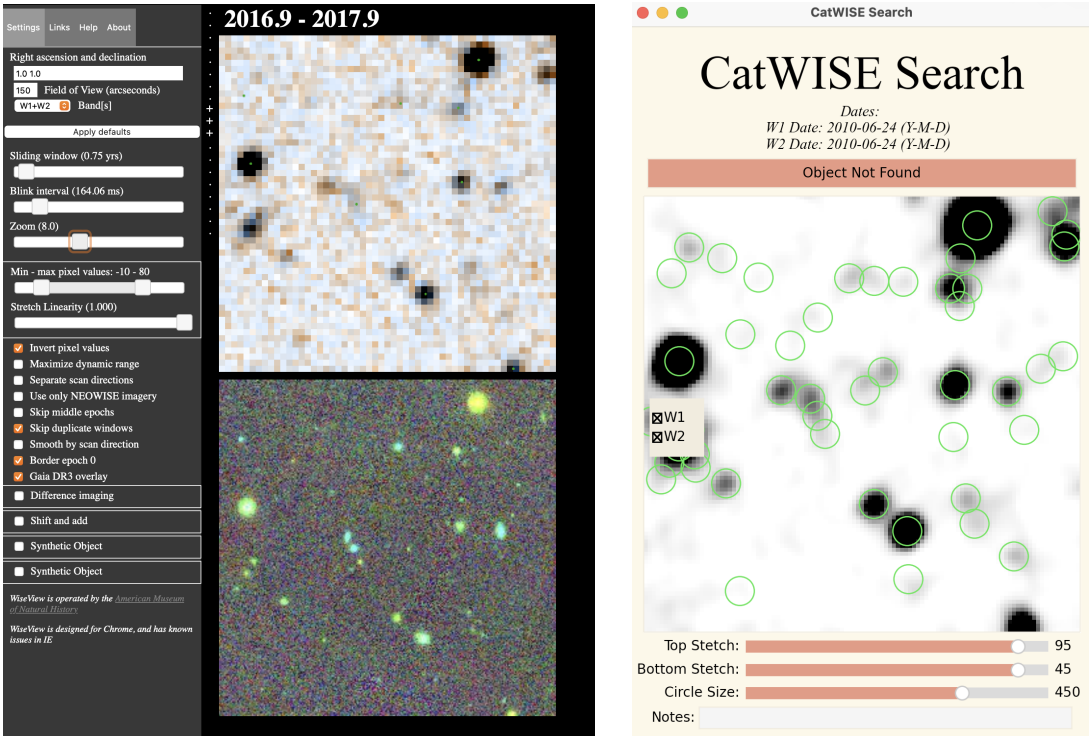


Figure 5: What the user should see if WRAP is successfully installed

in finding your object (Figure 6a). After this happens you will see another window pop-up which will be the catalog image and the corresponding object over plotted on top (seen as green circles) (Figure 6b).

If you are struggling to find your object you have a top stretch, bottom stretch, circle size, and different band options that you can change. All of these setting can aid you in finding your object. Moreover, if you have any notes you wish to put, select the "Notes" tab and record what you wish and it will be recorded in your output file.

Once you have found your object, click within in the circle and WRAP will record that object in your output file. If your object is not found in the catalog click the red "Object Note Found" button. NOTE: It might take a minute or so per each catalog to allow WRAP to download the image for each catalog.



(a) WISEView pop-up. (b) CatWISE 2020 pop-up.

Figure 6: WRAP pop-ups

After the previous step is done for every catalog, it will all be recorded in a .csv file. To find this .csv file go to your WRAP directory and open the "Output" folder and your output file will be there. Remember that if nothing was in the "Output File Name" it will default to the "WRAP_Output" file name.

3.2 Multi-Object Query

To run a multi-object search begin by selecting the "Multi-Object" tab on the top of WRAP (Figure 7). In this you will need to input a file, which can be done by selecting the "File Browser" button and then selecting the file you want. After this put in your search radius in arcseconds, the filetype of the selected file (WRAP supports CSV, FITS, ASCII, and IPAC), and an output file name. Similar to the single-object tab, if no output file name is put in it will default to "WRAP_Output". NOTE: For your file, the RA and DEC needed to be labeled as "ra" and "dec" for WRAP to read it correctly.

Once you have selected your file, radius, filetype, and output filename you can then select the catalogs you want WRAP to search through. Chose between CatWISE 2020, AllWISE, Gaia, VISTA, WFCAM, 2MASS, PanSTARRS, NSC (for MacOS users), and GALEX.

You will see your default browser pop-up with WISEView to aid you in finding your object, which will happen for every new object in your list (Figure 6a). After this happens you will see another window pop-up which will be the catalog image and the corresponding object over plotted on top (seen as green circles) (Figure 6b).

If you are struggling to find your object you have top stretch, bottom stretch, circle size, and different band options that you can change to. All of these setting can aid you in finding your object. Moreover, if you have any notes you can put it in the "Notes" tab and it will be recorded in your output file.

Figure 7: What WRAP will look like when the multi-object tab is selected.

Once you have found your object, click within in the circle and WRAP will record that object in your output file. If your object is not found in the catalog click the red "Object Note Found" button. NOTE: It might take a minute or so per each catalog to allow WRAP to download the image for each catalog.

After the previous step is done for every catalog and object all of the data will be recorded in a .csv file. To find this .csv file go to your WRAP directory and open the "Output" folder and your output file will be there. Remember that if nothing was in the "Output File Name" it will default to "WRAP_Output" file name.

3.3 Output Table

CatWISE2020:

- cw_ra & cw_ra_e: The R.A. (degrees) from CatWISE2020 and its uncertainties (arcsecs)
- cw_dec & cw_dec_e: The Decl. (degrees) from CatWISE2020 and its uncertainties (arcsecs)
- cw_w1 & cw_w1_e: The W1 band from CatWISE2020 and its uncertainties
- cw_w2 & cw_w2_e: The W2 band from CatWISE2020 and its uncertainties
- cw_pmra & cw_pmra_e: The proper motion in RA from CatWISE2020 and its uncertainties
- cw_pmdec & cw_pmdec_e: The proper motion in DEC from CatWISE2020 and its uncertainties
- cw_mjd: The modified julian date from CatWISE 2020
- cw_catalog: Provides the full name for which catalog the data is from
- cw_notes: The notes written in the CatWISE2020 by the user

AllWISE:

- aw_ra & aw_ra_e: The R.A. (degrees) from AllWISE and its uncertainties (arcsecs)
- aw_dec & aw_dec_e: The Decl. (degrees) from AllWISE and its uncertainties (arcsecs)
- aw_w1 & aw_w1_e: The W1 band from AllWISE and its uncertainties
- aw_w2 & aw_w2_e: The W2 band from AllWISE and its uncertainties
- aw_w3 & aw_w3_e: The W3 band from AllWISE and its uncertainties
- aw_w4 & aw_w4_e: The W4 band from AllWISE and its uncertainties
- aw_pmra & aw_pmra_e: The proper motion in RA from AllWISE and its uncertainties
- aw_pmdec & aw_pmdec_e: The proper motion in DEC from AllWISE and its uncertainties
- aw_catalog: Provides the full name for which catalog the data is from
- aw_notes: The notes written in the AllWISE by the user

Gaia:

- gaia_ra: The R.A. (degrees) from Gaia
- gaia_dec: The Decl. (degrees) from Gaia
- gaia_parallax & gaia_parallax_e: The parallax from Gaia and its uncertainties
- gaia_radv & gaia_radv_e: The radial velocity from Gaia and its uncertainties
- gaia_pmra & gaia_pmra_e: The proper motion in RA from Gaia and its uncertainties
- gaia_pmdec & gaia_pmdec_e: The proper motion in DEC from Gaia and its uncertainties
- gaia_g & gaia_g_e: The g band from Gaia and its uncertainties
- gaia_bp & gaia_bp_e: The bp band from Gaia and its uncertainties
- gaia_rp & gaia_rp_e: The rp band from Gaia and its uncertainties
- gaia_year: The calendar year from the Gaia archive
- gaia_catalog: Provides the full name for which catalog the data is from
- gaia_notes: The notes written in the Gaia by the user

VISTA:

- vsa_ra: The R.A. (degrees) from VISTA
- vsa_dec: The Decl. (degrees) from VISTA
- vsa_y & vsa_y_e: The Y band from VISTA and its uncertainties
- vsa_j & vsa_j_e: The J band from VISTA and its uncertainties
- vsa_h & vsa_h_e: The H band from VISTA and its uncertainties
- vsa_ks & vsa_ks_e: The Ks band from VISTA and its uncertainties
- vsa_mjd_y: The modified julian date for VISTA's Y band
- vsa_mjd_j: The modified julian date for VISTA's J band
- vsa_mjd_h: The modified julian date for VISTA's H band
- vsa_mjd_ks: The modified julian date for VISTA's Ks band
- vsa_catalog: Provides the full name for which catalog the data is from
- vsa_notes: The notes written in the VISTA by the user

WFCAM:

- wfcam_ra & wfcam_ra_e: The R.A. (degrees) from WFCAM and its uncertainties
- wfcam_dec & wfcam_dec_e: The Decl. (degrees) from WFCAM and its uncertainties
- wfcam_y & wfcam_y_e: The Y band from WFCAM and its uncertainties
- wfcam_j & wfcam_j_e: The J band from WFCAM and its uncertainties
- wfcam_h & wfcam_h_e: The H band from WFCAM and its uncertainties
- wfcam_k & wfcam_k_e: The K band from WFCAM and its uncertainties
- wfcam_pmra & wfcam_pmra_e: The proper motion in RA from WFCAM and its uncertainties
- wfcam_pmdec & wfcam_pmdec_e: The proper motion in DEC from WFCAM and its uncertainties
- wfcam_epoch: The calendar year from the WFCAM archive
- wfcam_catalog: Provides the full name for which catalog the data is from
- wfcam_notes: The notes written in the WFCAM by the user

2MASS:

- 2mass_ra: The R.A. (degrees) from 2MASS
- 2mass_dec: The Decl. (degrees) from 2MASS
- 2mass_j & 2mass_j_e: The J band from 2MASS and its uncertainties
- 2mass_h & 2mass_h_e: The J band from 2MASS and its uncertainties
- 2mass_ks & 2mass_ks_e: The Ks band from 2MASS and its uncertainties
- 2mass_catalog: Provides the full name for which catalog the data is from
- 2mass_notes: The notes written in the 2MASS by the user

PanSTARRS:

- ps_ra & ps_ra_e: The R.A. (degrees) from PanSTARRS and its uncertainties
- ps_dec & ps_dec_e: The Decl. (degrees) from PanSTARRS and its uncertainties
- ps_g & ps_g_e: The g band from PanSTARRS and its uncertainties
- ps_r & ps_r_e: The r band from PanSTARRS and its uncertainties
- ps_i & ps_i_e: The i band from PanSTARRS and its uncertainties
- ps_z & ps_z_e: The z band from PanSTARRS and its uncertainties
- ps_y & ps_y_e: The y band from PanSTARRS and its uncertainties
- ps_mjd: The modified julian date from the PanSTARRS archive
- ps_catalog: Provides the full name for which catalog the data is from
- ps_notes: The notes written in the PanSTARRS by the user

NSC:

- nsc_ra & nsc_ra_e: The R.A. (degrees) from NSC and its uncertainties
- nsc_dec & nsc_dec_e: The Decl. (degrees) from NSC and its uncertainties
- nsc_g & nsc_g_e: The g band from NSC and its uncertainties
- nsc_r & nsc_r_e: The r band from NSC and its uncertainties
- nsc_i & nsc_i_e: The i band from NSC and its uncertainties
- nsc_z & nsc_z_e: The z band from NSC and its uncertainties
- nsc_u & nsc_u_e: The u band from NSC and its uncertainties
- nsc_y & nsc_y_e: The y band from NSC and its uncertainties
- nsc_pmra & nsc_pmra_e: The proper motion in RA from NSC and its uncertainties
- nsc_pmdec & nsc_pmdec_e: The proper motion in DEC from NSC and its uncertainties
- nsc_mjd: The modified julian date from the NSC catalog
- nsc_catalog: Provides the full name for which catalog the data is from
- nsc_notes: The notes written in the NSC by the user

GALEX:

- galex_ra: The R.A. (degrees) from GALEX
- galex_dec: The Decl. (degrees) from GALEX
- galex_fuv & galex_fuv_e: The FUV band from GALEX and its uncertainties
- galex_nuv & galex_nuv_e: The NUV band from GALEX and its uncertainties
- galex_catalog: Provides the full name for which catalog the data is from
- galex_notes: The notes written in the GALEX by the user

4 Future Updates

4.1 v1.1.0

Currently the developer are adding the options of Spitzer and Skymapper as catalogs to gather more photometry. Both of these catalogs will be supported on Windows and MacOS. This will come in WRAP v1.1.0.

4.2 v1.2.0

In addition to this, a feature we are calling "Phantom Objects" will be added soon that will allow the user to see where their previously clicked objects are. This will aid the user in finding higher proper motion objects. Moreover, it will aid the user in finding their objects in a crowed field. This will come in WRAP v1.2.0.

The last big feature to be added to WRAP in the future is a pre-download setting. This will allow WRAP to download images during the first catalog search to allow the user to quickly go between catalogs. If you have used WRAP by this point it will have become obvious that there are long down times between catalogs. This will come in WRAP v1.2.0.

5 Disclaimers

Note 1: WRAP is not supported on Linux and may have problems running on older versions of MacOS (before MacOS 12 (Monterey)) and Windows (before Windows 10).

Note 2: Windows does not support the astro-datalab package, therefore Windows does not have the Noirlab Source Catalog as an option.

Note 3: The window close button has been disabled, to close WRAP please click the red "Close WRAP" button at the bottom.

Note 4: The orientation for all of the catalogs is North pointed up and East pointing left.

Note 5: 2MASS can have strange imaging cropping, this is a warning that it may happen and do not be alarmed by it.

Note 6: For any liability or copyright problems please consult the LICENSE file in WRAP.

6 Sponsor and Acknowledgements

Backyard Worlds Planet 9: Backyard Worlds research was supported by NASA grant 2017-ADAP17-0067 and by the NSF under grants AST- 2007068, AST-2009177, and AST-2009136. SLC is supported by an STFC Ernest Rutherford Research Fellowship. We want to thank the Student Astrophysics Society[1] for providing the resources that enabled the pairing of high school and undergraduate students with practicing astronomers and advanced citizen scientists.

CatWISE 2020: `https://wise2.ipac.caltech.edu/docs/release/allsky/expsup/sec1_6b.html`

AllWISE: `https://wise2.ipac.caltech.edu/docs/release/allsky/expsup/sec1_6b.html`

Gaia: `https://www.cosmos.esa.int/web/gaia-users/credits`

VISTA: `https://www.vista-vhs.org/data-access`

WFCAM: `http://wsa.roe.ac.uk/pubs.html`

2MASS: `https://irsa.ipac.caltech.edu/Missions/2mass.html`

PanSTARRS: `https://outerspace.stsci.edu/display/PANSTARRS/`

NSC: `https://noirlab.edu/science/about/scientific-acknowledgments`

GALEX: `https://galex.stsci.edu/GR6/?page=acknowledgments`

[1] `https://www.studentastrophysicssociety.com`