GOGREEN and GCLASS Data Release

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GOGREEN and GCLASS Data Release Workshop
August 2020

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WATERLOO CENTRE FOR ASTROPHYSICS

http://gogreensurvey.ca/data-releases/data-packages/gogreen-and-gclass-first-data-release/

GOGREEN and GCLASS First Data Release

Release date: Aug 11, 2020

Description and Executive Summary

This is the first Public Data Release (DR1), including all GOGREEN and GCLASS data. It is described in the accompanying paper, Balogh et al. (2020).

This release includes photometry (imaging, catalogues and derived products) and spectroscopy for all systems in GOGREEN and GCLASS, except SpARCS1033 for which most of the photometric imaging and catalogues are not available. We include the available, reduced HST images for all GOGREEN clusters. The Ultravista photometric catalogues (Muzzin et al. 2013) are also included, as these are the source of photometry for the COSMOS- systems in the sample. The SXDF catalogue of Mehta et al. (2018) must be downloaded separately, from http://homepages.spa.umn.edu/~mehta074/splash/

Finally we provide two python3 Jupyter notebooks for reading, manipulating and plotting the data.

Errata and updates

Please report problems and questions to mbalogh@uwaterloo.ca.

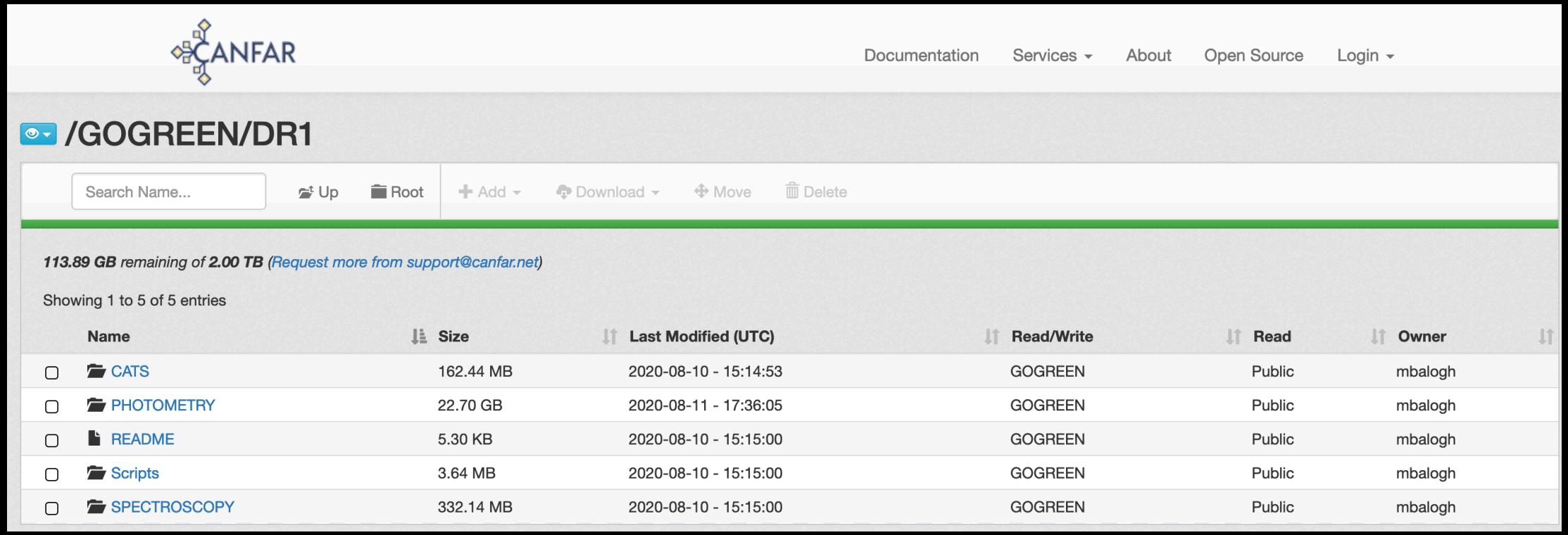
Data Access

The whole data release is ~24Gb in size. This is dominated by the images in the PHOTOMETRY/IMAGES directory. If you don't need access to those you can save a lot of download time.

1. CADC (https://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/community/gogreen)
2. NSF's NOIRLab Data Labs (coming soon, to https://datalab.noao.edu/gogreendr1/). In addition to the raw data directory, Data Labs will soon provide an integrated file service with Simple Image Access and other features being developed.

Data Access 1: CANFAR VOSpace

https://www.canfar.net/storage/list/GOGREEN/DR1



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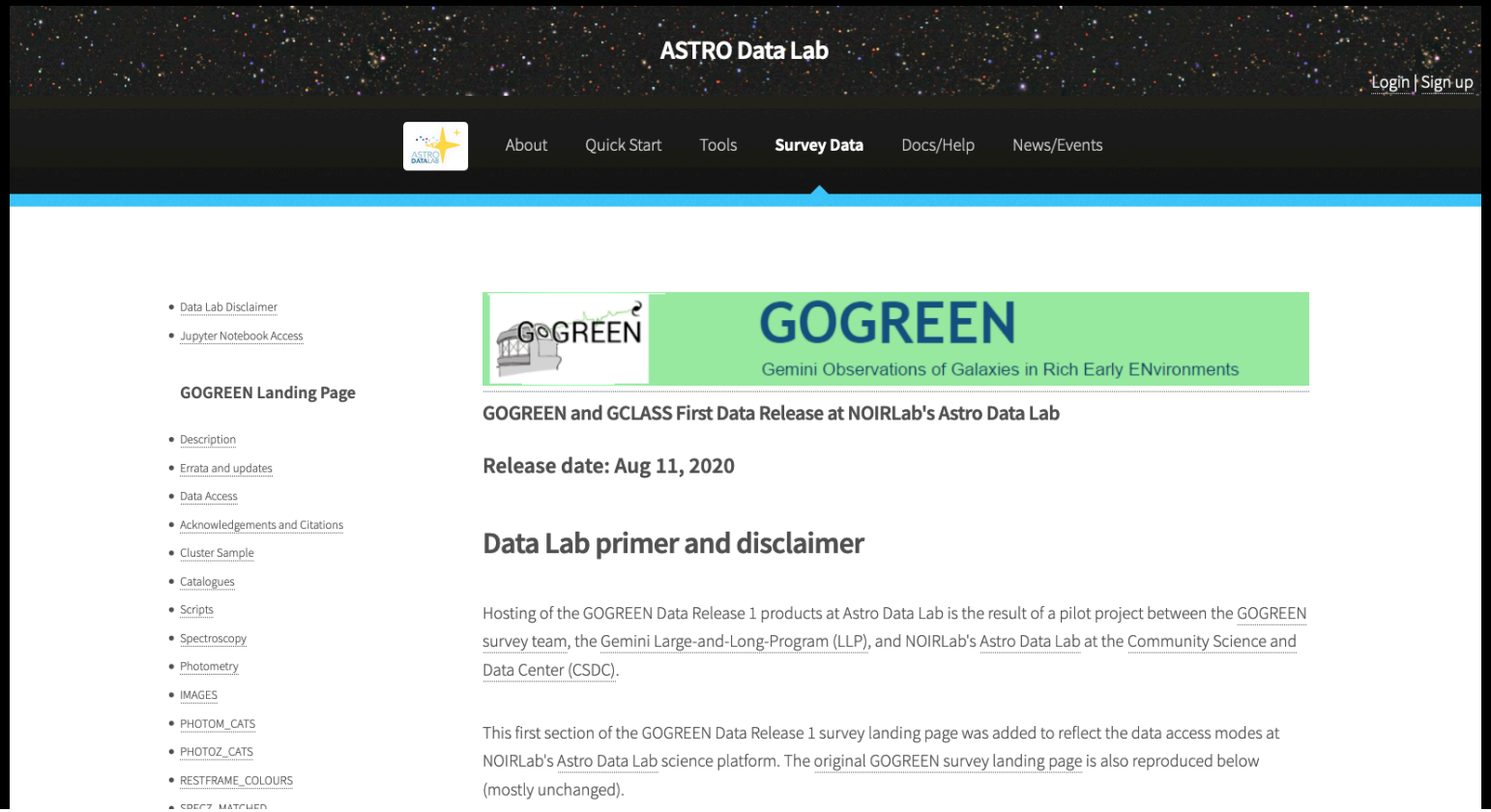
Data Access 2: NSF's NOIRLab Data Lab

https://datalab.noao.edu/gogreendr1/



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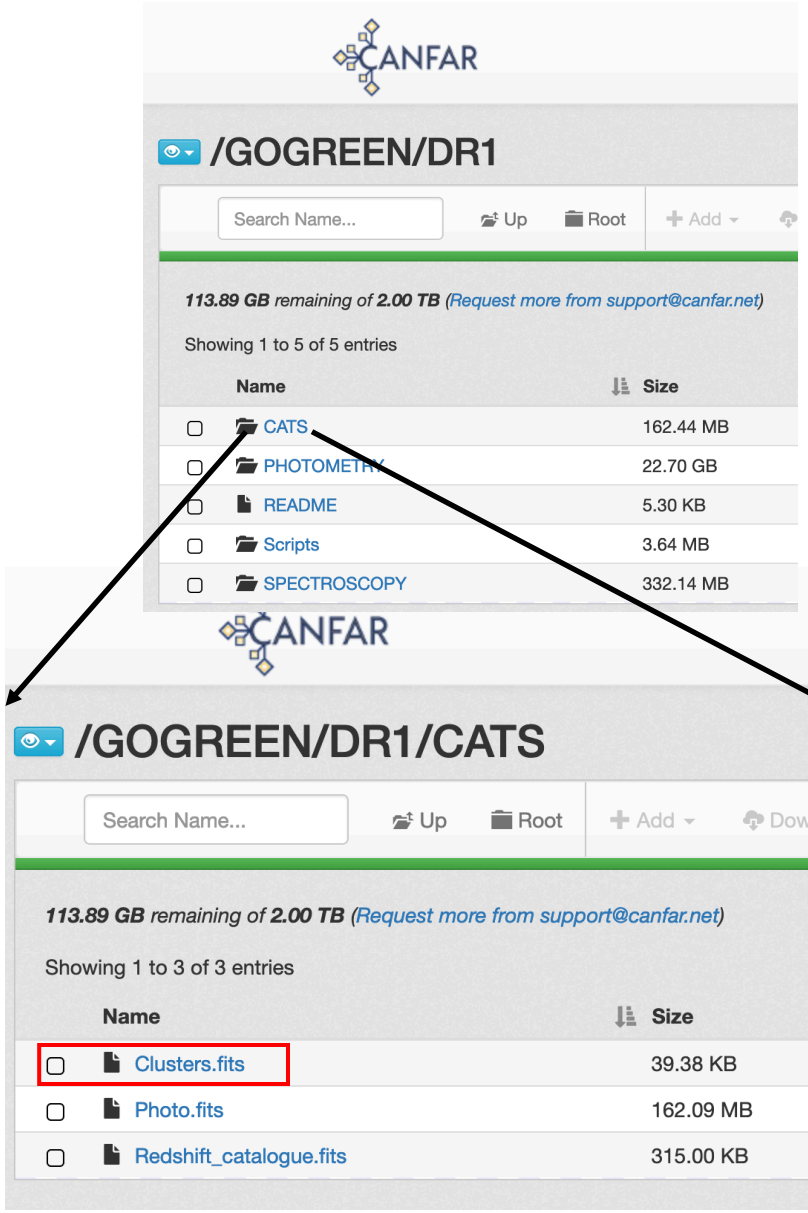
VOSpace structure: DR1/CATS

Clusters.fits
26 rows, 38 columns

column	parameter name	description
1	cluster	Short name of each cluster.
2	fullname	Longer format cluster name
3	cluster_id	An integer which is used to identify the corresponding photometry. It is a unique number for each SpARCS and SPT cluster; it is 14 for all COSMOS clusters and 13 for those in the SXDF.
4-5	RA_Best, DEC_Best	Coordinates, in J2000 degrees, for the best estimate of the cluster centre. For the SPT and SpARCS clusters, this is the location of the BCG. For the COSMOS and SXDF clusters, it is the average position of members as described in §4.2.3.
6-7	RA_GMOS, DEC_GMOS	Coordinates, in J2000 degrees, for the centre of the GMOS spectroscopic observations (GOGREEN only).
8	PA_GMOS	Position angle, in degrees, for the GMOS spectroscopic observations (GOGREEN only).
9	Redshift	Best estimate of the cluster redshift, based on available spectroscopy, including publicly available spectra from other sources not included in this release.
10-11	vdisp, vdisp_err	Velocity dispersion and its uncertainty, in km/s, computed as described in §4.2.3.
12-17	gogreen_mN	Name of each GOGREEN GMOS mask, for N from 1 to 6, used to obtain spectra for this program.
18-22	gclass_mN	Name of each GCLASS GMOS mask, for N from 1 to 5, used to obtain spectra for this program.
23	Kphot_cat	Name of K-selected photometry catalogue
24	photoz_cat	Name of photometric redshift catalogue
25	stelmass_cat	Name of catalogue with stellar mass information
26-37	IMAGE_X	Name of image for filter X for SpARCS and SPT clusters.
38	Preimage	Name of the GMOS z-band image, or Subaru pseudo-image, used for mask design. Note the preimages were used for mask design but are not optimally reduced, specifically regarding sky subtraction and astrometry.



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VOSpace structure: DR1/CATS

column	parameter name	description
1	Cluster	Short name of each cluster; matches the entry in Table 2
2	SPECID	A unique identification number. The first digit identifies the origin of the spectrum: 1 for GOGREEN and 2 for GCLASS. The next two digits correspond to the **cluster_id** identifier in the Cluster catalogue, that specify the photometric field. The remaining digits are the galaxy ID (only unique for a given field and source).
3,4	RA(J2000), DEC(J2000)	Target coordinates, in J2000 degrees. For GOGREEN, these coordinates correspond to the z' image coordinates used for mask design. These have been transformed to align with the K_s images; however positions will not match exactly with coordinates in the photometric catalogues.
5	OBJClass	This has a value of 1 for GOGREEN primary targets, i.e. those that match our photometric selection criteria. A value of 3 corresponds to a GOGREEN "mask filler" object, and 4 identifies a GCLASS spectrum. (OBJClass=2 was reserved for stellar sources used for telluric correction, and these are not included in the catalogue).
6	Redshift	The redshift measured from the spectrum
7	Redshift_Quality	The redshift quality flag. Both quality 3 and 4 are secure galaxy redshifts and can be used for scientific analysis; the difference between them is subjective and not rigorously defined. Quality 2 is a "best guess" but should be used with caution; this includes cases where there is plausible consistency with the photometric redshift, but no clearly identifiable spectral features. Quality 1 means no redshift is available.
8	EXTVER	This is the science extension number in the FITS files with the 1D and 2D spectra (see § 6.5).
9	Spec_Flag	An integer used to identify spectra that have problems that might compromise the ability to measure a redshift or line indices of a spectrum. Flags are assigned for the following: 1: Mild slit contamination or artefacts that should not strongly affect measurements 2: Non-galaxy-like spectrum and/or image 4: Significant slit contamination from neighbouring objects. Redshift and features may be compromised. 8: Poor telluric correction or sky subtraction, due for example to inadequate correction for the stray light effect described in Appendix B. 16: Major artefacts or large masked regions that render the spectrum nearly useless. Flags can be added. So, for example, a flag of 12 means there is both contamination from neighbouring objects, and poor sky subtraction.
10	SNR_8500_VAR	The signal-to-noise ratio per pixel, measured in the range $7500 < \lambda < 9500$Å. The noise estimate is taken from the VAR array associated with the spectrum.
11	SNR_8500_RMS	The signal-to-noise ratio per pixel, measured in the range $7500 < \lambda < 9500$Å. The noise estimate is taken from the *rms* in the science spectrum over the same range.
12,13	D4000, eD4000	The D_n4000 index as defined in Balogh et al. (1999), and its uncertainty. See § 4.2.2
14,15	EWOII, eEWOII	The equivalent width of the [OII] emission line and its uncertainty, in Å, using the line index definitions in Balogh et al. (1999). Positive values represent emission. See § 4.2.2
16,17	EWHdelta, eEWHdelta	The equivalent width of the Hδ absorption line and its uncertainty, in Å, using the line index definitions in Balogh et al. (1999). Positive values represent absorption. See § 4.2.2
18,19	EWOII_model, eEWOII_model	The equivalent width of the [OII] emission line and its uncertainty, in Å, calculated from the Gaussian fitting model described in Old et al. (2020).
20,21	F_OII,eF_OII	The integrated flux of the [OII] emission line and its uncertainty, in ergs/s/cm^2/Å, calculated from the Gaussian fitting model described in Old et al. (2020).
22,23	SFR,eSFR	The star formation rate in solar masses per year, estimated from the [OII] emission line flux and the stellar mass, using the calibration of Gilbank et al. (2010).
24	delta_BIC	The difference in Bayesian Information Criterion used to identify the presence of [OII] emission (ΔBIC > 10) or its absence (ΔBIC < -10). See Old et al. (2020) for more details.
25	member_Clean	Applicable only to the 11 SPT and SpARCS clusters in GOGREEN, this indicates likely cluster membership based on the CLEAN algorithm of Mamon et al. (2013). A value of 1 indicates a member, 0 is a non-member, and -1 indicates membership could not be determined.
26	member_EM	Applicable only to the 11 SPT and SpARCS clusters in GOGREEN, this indicates likely cluster membership based on the C.L.U.M.P.S. algorithm of Munari et al. (in prep). A value of 1 indicates a member, 0 is a non-member, and -1 indicates membership could not be determined.
27	member	A flag that identifies likely cluster members (1) or nonmembers (0). A value of -1 means membership could not be determined. For SpARCS and SPT clusters in GOGREEN, this is the maximum of the member_Clean and member_EM flags. For the five GCLASS clusters we use the membership given in Muzzin et al. (2012). Finally, for the systems in COSMOS and SXDF we define members as those within 1 Mpc and 2.5σ of the centre, as described in § 4.2.3.

Redshift_catalogue.fits
2771 rows, 27 columns

CANFAR

/GOGREEN/DR1/CATS

Search Name... Up Root Add Downlo

113.89 GB remaining of 2.00 TB (Request more from support@canfar.net)

Showing 1 to 3 of 3 entries

Name	Size
Clusters.fits	39.38 KB
Photo.fits	162.09 MB
Redshift_catalogue.fits	315.00 KB

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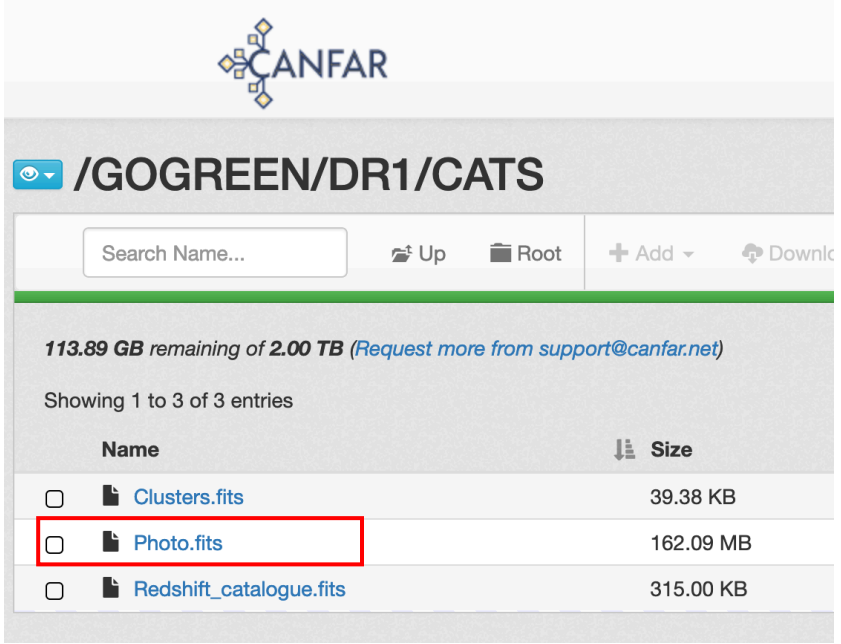
VOSpace structure: DR1/CATS

Photo.fits: 274992 rows, 78 columns
Only includes objects with data in every available filter

column	parameter name	description
1	Cluster	Name of the corresponding cluster, when there is an associated photometric catalogue. Objects in the COSMOS or SXDF photometric catalogues are identified with those labels, unless there is a GOGREEN spectroscopic redshift, in which case we use the name of the associated target. Note that SXDF49 and SXDF87 share a field, and are identified here only by SXDF49. Similarly SXDF76a and SXDF76b are identified here as SXDF76.
2	cPHOTID	This is a unique identifier for each object in this table. The first digit identifies the source of the photometry (1: GOGREEN; 2: GCLASS; 3: UltraVISTA/COSMOS; 4:SPLASH/SXDF). The next two digits are the cluster_id column from Table 2. The remaining numbers are the PHOTID identifier in the main photometric catalogues.
3	SPECID	The ID corresponding to Table 4 for objects with a corresponding GCLASS or GOGREEN spectrum.
4,5	ra,dec	J2000 positions, in degrees. Calibrated with SDSS DR7 or USNO-b whenever a cluster falls outside of the SDSS footprint.
6,7	zspec,Redshift_Quality	The spectroscopic redshift and quality flag for the associated spectrum, if any. Redshifts without a corresponding Redshift_Quality are copied from the parent (UltraVISTA or SPLASH) catalogue.
8,9,10	zphot,zphot_l68,zphot_u68	Photometric redshift, upper and lower uncertainties from the 68 per cent confidence region. Based on the *zpeak* output from EAZY (Brammer et al. 2008), where for the GOGREEN galaxies a polynomial correction is applied to improve the correspondence with spectroscopy.
11,12	$U-V, V-J$	Rest-frame colours between Johnson U, V and J, as measured with EAZY (Brammer et al. 2008). Small offsets, as described in van der Burg et al. (2020), have been applied on a cluster-by-cluster basis to improve correspondence with UltraVISTA. For the COSMOS galaxies the rest-frame colours are from the UltraVISTA catalogue.
13	Star	Star/galaxy classification based on colours, as described in van der Burg et al. (2020). Flag is 1 for a star, and 0 otherwise.
14	K_flag	SExtractor flag in the K-band.
15	totmask	Manual mask at position of detection, where objects are masked (totmask= 1) if they do not have an image in all available filters for that cluster. Only sources with totmask=0 are included in this compilation catalogue. Photometry for other sources must be obtained from the original catalogues.
16	Mstellar	Total stellar masses, measured with the FAST (Kriek et al. 2009) code and assuming the best redshift for the object (spectroscopic or *zphot*). These assume τ−model star formation histories, and are known to underestimate the stellar mass obtained with a non-parametric star formation history, by up to 0.3 dex (Leja et al. 2019). For objects in COSMOS and SXDF the stellar masses are taken from their respective catalogues.
17-46	X_i_tot	Total fluxes in each filter X_i. These are derived from the Ks_tot flux and the appropriate colour, computed in 2″ diameter circular apertures from PSF-matched images. IRAC aperture fluxes have been measured in a two-step process, similar to the description in Appendix A of van der Burg et al. (2013). The measurements within a 3″ aperture are scaled by a factor determined by comparing the 2″ aperture K_s flux with that within a 3″ aperture measured on an image convolved to match the IRAC point spread function. This is done to avoid having to convolve all the high resolution ground-based data to the IRAC psf. For objects in COSMOS and SXDF the fluxes are taken from their respective catalogues, scaled by the corresponding Ks_tot flux. Includes: $u, g, r, i, z, y, V, B, J, H, K_s$, IRAC1, IRAC2, IRAC3, IRAC4, IA484, IA527, IA624, IA679, IA738, IA767, IB427, IB464, IB505, IB574, IB709, IB827, fuv, nuv, and $mips24$.
47-77	eX_i_tot	Associated uncertainty estimates for filter X_i, assuming that the sole source of uncertainty is the background *rms*. It therefore depends on position on the stack (as the depth is not necessarily uniform), but does not depend on the source flux.



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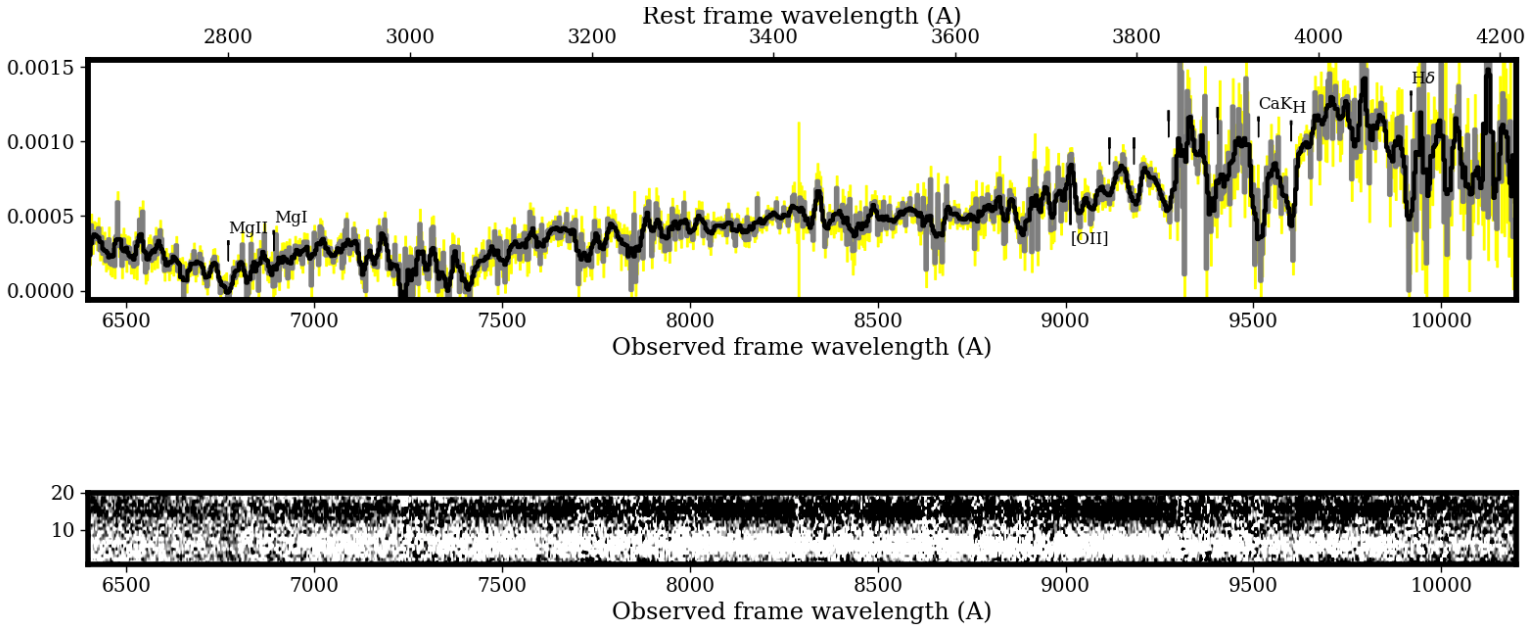
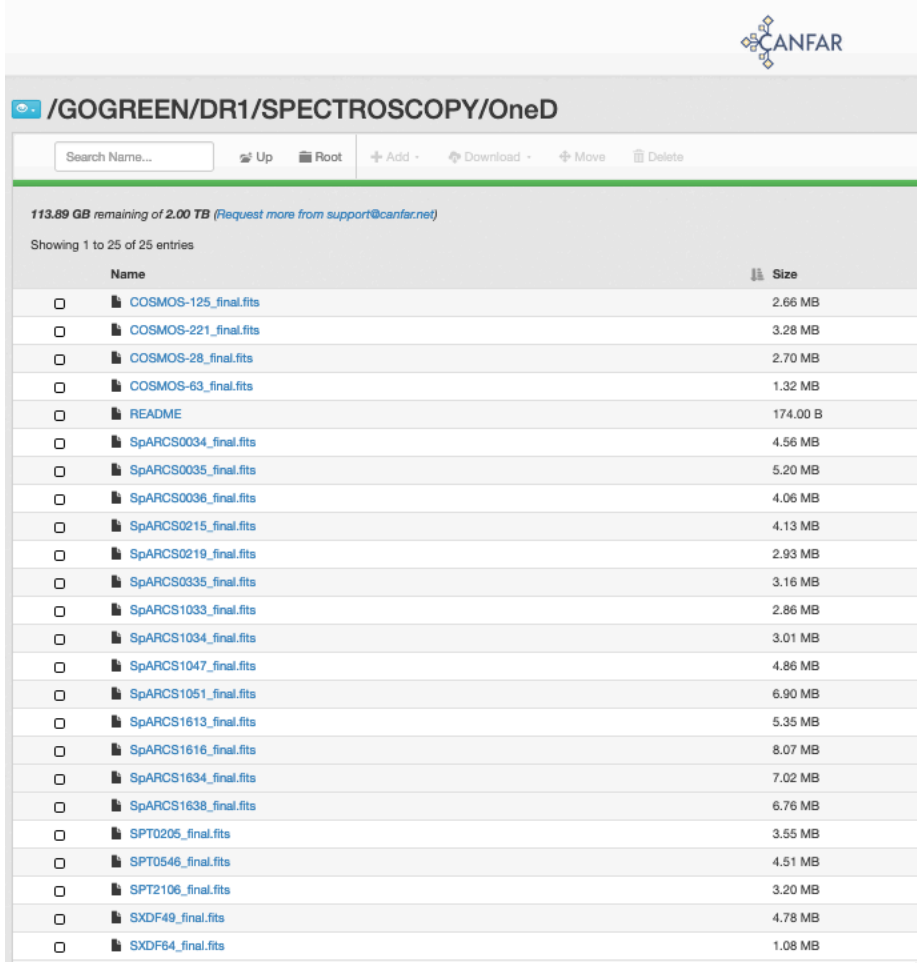
VOSpace structure: DR1/SPECTROSCOPY





1D spectra with VAR array, flux calibrated

- Absolute flux calibration where i-band imaging available. See ABS_FLUX header keyword

2D spectra available only for GOGREEN, not GCLASS

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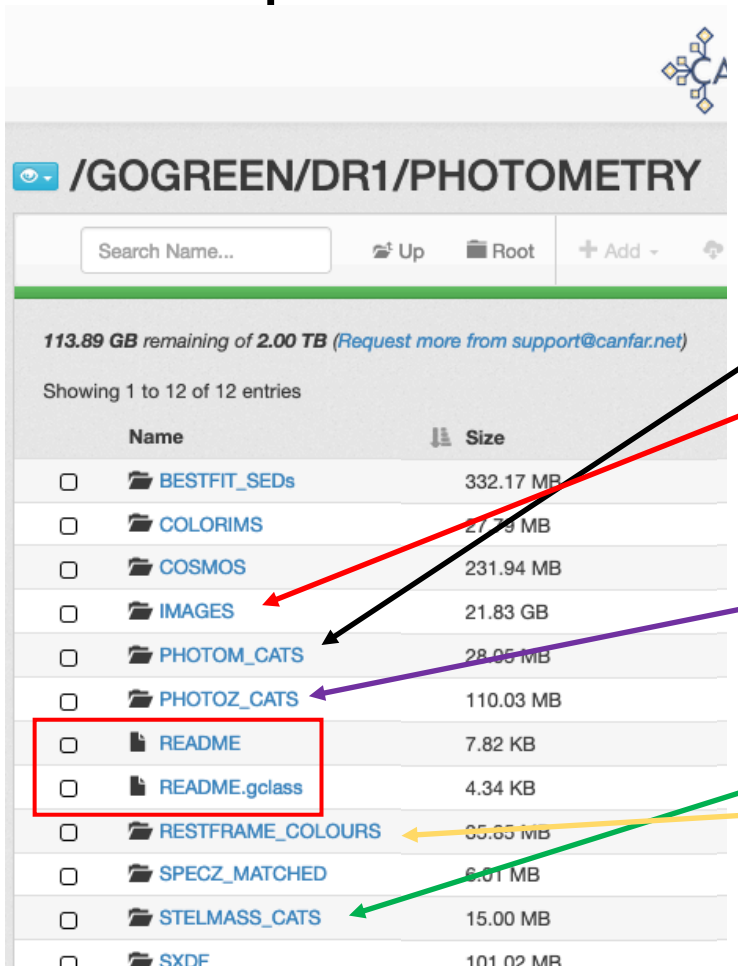
VOSpace structure: DR1/PHOTOMETRY



- Primary, Ks-selected parent catalogue; one for each cluster
- Reduced images, weight maps and masks
  - Includes a psf-matched version
  - HST F160W (GOGREEN) and F140W (GCLASS) in separate subdirectory
- Photometric redshifts, including P(z) for GOGREEN SpARCS/SPT clusters
- FAST output with template fit stellar mass and others
- Restframe colours: UVJ for GCLASS, many more for GOGREEN
  - With best z, and also with z fixed to cluster

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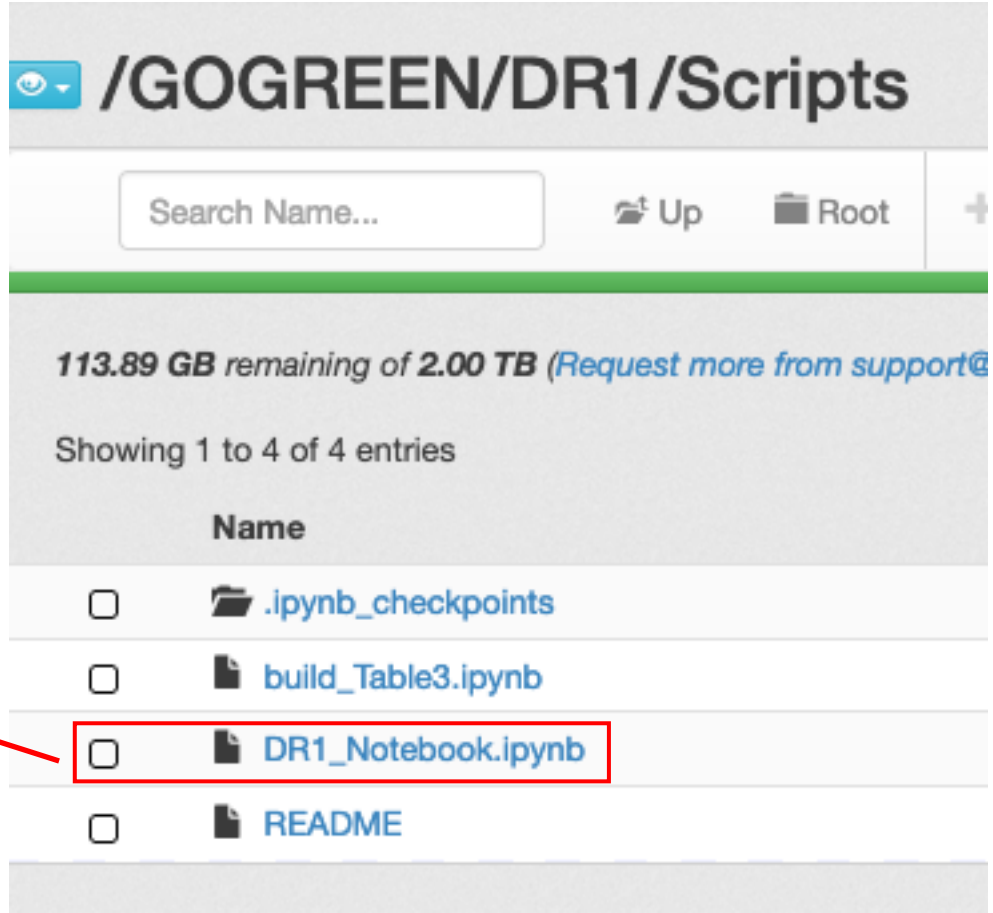
VOSpace structure: SCRIPTS

- Reads in the three main catalogues:
  - Clusters.fits
  - Redshift_catalogue.fits
  - Photo.fits
- Merges to create a single table, with one entry for every unmasked photometric point (including Ultravista and SPLASH)
- Reproduce some plots from Balogh et al. (2020)
- Access SPECTROSCOPY/ and PHOTOMETRY/ directories to make plots of spectra, image thumbnails.



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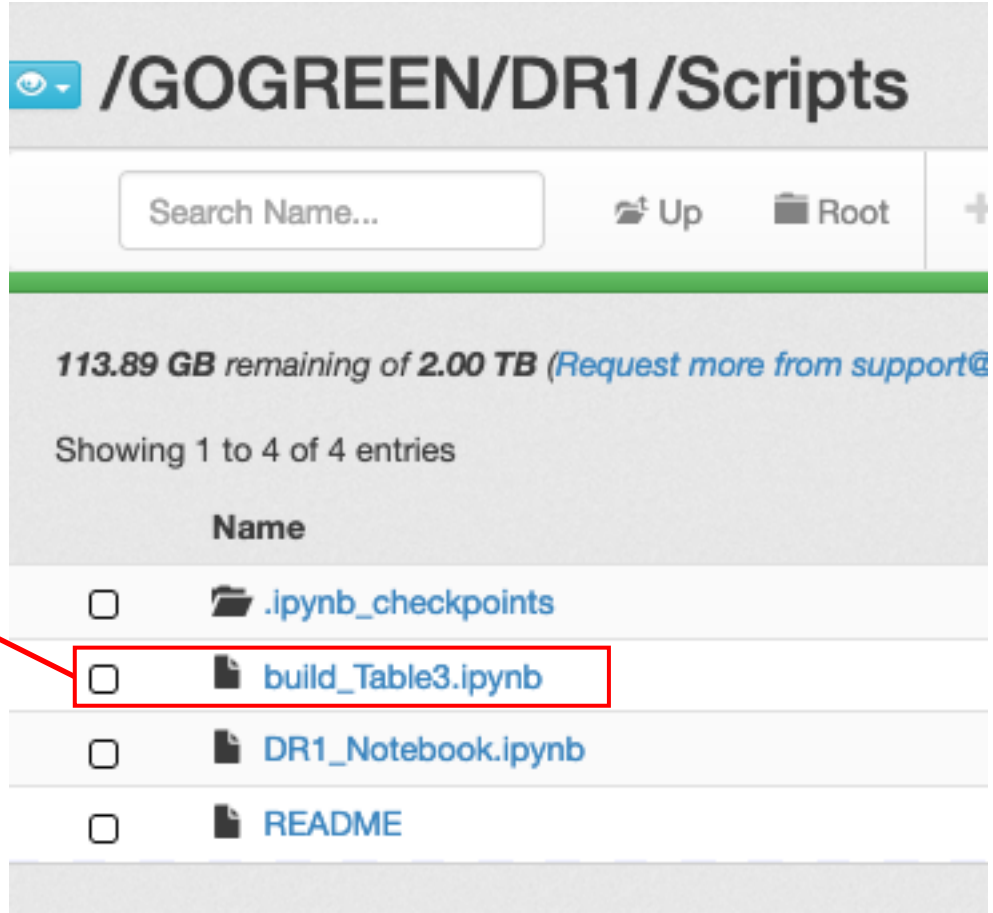
VOSpace structure: SCRIPTS

- Reads the various files in PHOTOMETRY/ directory to create the CATS/Photo.fits file. Useful for:
  - Modifying which information is included
  - Modifying which galaxies are included
  - Understanding how to find what you need



Jupyter Notebooks

jupyter DR1_Notebook Last Checkpoint: 08/06/2020 (unsaved changes) Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Run Markdown

Read in three main tables

These first scripts only need information in the catalogues. There is no need for the SPECTROSCOPY/ (about 300Mb) or PHOTOMETRY/ (about 20 Gb) directories.

1. Clusters.fits contains information about each of the 26 clusters
2. Redshift_catalogue.fits is the redshift catalogue, with one entry for each spectrum
3. Photo.fits is the merged photometric catalogue.

In [ ]:
```
clusters = catdir + 'Clusters.fits'

# read in fits data table with astropy.table.Table and immediately convert to pandas Dataframe
cluster_table = Table( fits.getdata( clusters ) ).to_pandas()
cluster_table['cluster'] = cluster_table['cluster'].str.rstrip().values # remove unnecessary spaces

print(cluster_table.columns)
cluster_table
```

In [ ]:
```
photfile = catdir+'Photo.fits'

phot_table = Table( fits.getdata(photfile) ).to_pandas()
print (phot_table.columns)
phot_table.head(5)
```

In [ ]:
```
zcatfile = catdir + 'Redshift_catalogue.fits'

# read in fits data table with astropy.table.Table and immediately convert to pandas Dataframe
redshift_table = Table( fits.getdata( zcatfile ) ).to_pandas()
redshift_table['Cluster'] = redshift_table['Cluster'].str.rstrip().values # remove unnecessary spaces

print (redshift_table.columns)
redshift_table.head(5)
```

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Balogh et al. (2020, submitted)

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Gemini Observations of Galaxies in Rich Early ENvironments

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2. NSF's NOIRLab Data Labs (coming soon, to https://datalab.noao.edu/gogreendr1/). In addition to the raw data directory, Data Labs will soon provide an integrated file service with Simple Image Access and other features being developed.

The GOGREEN and GCLASS Surveys: First Data Release

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Author affiliations are listed at the end of the paper

14 August 2020

ABSTRACT

We present the first public data release of the GOGREEN and GCLASS surveys of galaxies in dense environments, spanning a redshift range $0.8 < z < 1.5$. The surveys consist of deep, multiwavelength photometry and extensive Gemini GMOS spectroscopy of galaxies in 26 overdense systems ranging in halo mass from small groups to the most massive clusters. The objective of both projects was primarily to understand how the evolution of galaxies is affected by their environment, and to determine the physical processes that lead to the quenching of star formation. There was an emphasis on obtaining unbiased spectroscopy over a wide stellar mass range ($M \gtrsim 2 \times 10^{10}$ M$_\odot$), throughout and beyond the cluster virialized regions. The final spectroscopic sample includes 2771 unique objects, of which 2257 have reliable spectroscopic redshifts. Of these, 1704 have redshifts in the range $0.8 < z < 1.5$, and nearly 800 are confirmed cluster members. Imaging spans the full optical and near-infrared wavelength range, at depths comparable to the UltraVISTA survey, and includes *HST*/WFC3 F160W (GOGREEN) and F140W (GCLASS). This data release includes fully reduced images and spectra, with catalogues of advanced data products including redshifts, line strengths, star formation rates, stellar masses and rest-frame colours. Here we present an overview of the data, including an analysis of the spectroscopic completeness and redshift quality.

Key words: Galaxies: evolution, Galaxies: clusters

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