JWST Extragalactic Mock Catalog Documentation

Version 1.2

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1 Introduction

This document is to serve as documentation of the contents of the mock catalog built with the phenomenological model described in Williams et al. (2018) (arXiv:1802.05272). We plan to make the mock catalog source code available upon publication designed to allow users to create new mock catalogs with any area or depth, and following their chosen evolution of mass functions. Documentation to accompany the planned later release of the Python package will be supplied separately.

1.1 Mock catalog overview

As detailed in Williams et. al (2018), our approach for the creation of mock galaxy catalogs allows us to easily produce multiple, independent "realizations" of the catalog. Each realization, albeit based on the same physical model, will include different (although statistically identical) number counts, physical properties and SEDs. A realization includes both a star-forming galaxy mock and a quiescent galaxy mock, drawn from the same area on the sky (they are separated because of different column information in the catalogs that are included for the two galaxy classes). Each of these 2 files contain the galaxy physical properties (e.g. mass, redshift, luminosity, metallicity, morphologies; see Tables 2 and 3) and photometry (see also Section 5). Each mock also comes with file(s) containing the spectrum associated with each mock galaxy. Owing to the large number of star-forming galaxies, their spectra are split in multiple files. For details on the contents of the mock files containing the spectra see Section 4. Mock galaxies can be associated to their spectrum through their unique ID numbers. Quiescent galaxy IDs are also unique from star-forming galaxy IDs within each realization.

The nominal size of full realizations (i.e. $0.2 < z < 15$) are 11×11 arcmin^2. Our initial release on Feb. 15, 2018 included one fiducial mock (v1.0 r1). On Mar. 31, 2020 we now release v1.2 which includes a total of 10 full 11×11 arcmin^2 realizations.

1.2 Accessing the data

The mock catalogs are available online and can be accessed from http://fenrir.as.arizona.edu/jwstmock. This website contains general information and documentation on using the mock catalog. Clicking the "downloading the mock catalog" link will redirect to an ESA website where email registration is required (the purpose is only sending out critical information on updates and changes). After registration, an "access data" link will appear where all necessary files can be downloaded. Any issues with mock catalog realizations and their data products, or with the documentation, can be submitted through our github page. The link for the github page is https://github.com/JADES-GTO/JWST_extragalactic_mock_catalog and is available from the main website.

1.3 Version and Modification History

Catalogs are all named to indicate the version of the model which was used to generate the mock (e.g. v1.0 for the first version as submitted to AAS journals) and also the realization number (indicated as, e.g. r1 for realization 1). The table below indicates the versions and realizations available, the date when they were released, and also the updates since the previous model version. V1.0, r1 is the "fiducial mock" as decribed in Williams et al. 2018. Updates and any changes will be announced to the email address supplied during registration for data access.

Model Version	Realizations	Date Updated	Notes
v1.2	r1-r10	March 31, 2020	9 new independent realizations released. Spectra now extend to 30 micron wavelength. Spectra in the region from 1 to 1.6 microns are now uniformly sampled in wavelength. Wavelength sampling now 2.5A rather than 5A, FWHM still 5A. Spectra files for SFGs are now grouped according to redshift ranges rather than ID. Dust is now included for quiescent galaxies (an error meant v1.1 had dust-free quiescent galaxies). The V-band dust attenuation optical depth parameter for each galaxy is included in the quiescent catalog.
v1.1	r1	March 15, 2018	NIRCam fluxes re-measured using the filter profiles including detector efficiency, from https://jwst-docs.stsci.edu/display/JTI/NIRCam+Filters. RA and Decs updated to fix a bug that meant that some positions were being repeated. Fluxes without Lyα contribution are supplied in a separate file. The 5Å spectra now include the missing IDs, addressing issue https://github.com/JADES-GTO/JWST_extragalactic_mock_catalog/issues/1, and also now extend to 10μm. We also release the emission line information for mock catalog galaxies with $\xi_{\rm d} = 0.5$ and $n_{\rm H} = 1000{\rm cm}^{-3}$
v1.0	r1	February 15, 2018	version submitted to journal (fiducial mock)

2 Contents of 11x11 star-forming mock catalog files

The following table contains the column names, units and description of each column in the fits binary table file.

N	Column name	Units	Description
1	ID		Catalog ID
2	RA	degrees	Right Ascension
3	DEC	degrees	Declination
4	redshift		Redshift
5	mStar	$\log \mathrm{M}_\odot$	Stellar mass (total mass locked in stars, accounting the fraction returned by stars to the ISM. It includes the mass locked into remnants, neutron stars and black holes, as well)
6	MUV	mag	Absolute UV magnitude (averaged within a 100Å window centered at at rest-frame 1500Å)
7	beta		Rest-frame UV continuum slope (β where $f_\lambda \propto \lambda^\beta$ measured from the flux averaged over 10 absorption-free regions between 1268 and 2580 Å, as defined in Calzetti et al. 1994).
8	SFR_10	$\log \mathrm{M}_\odot \mathrm{yr}^{-1}$	Average star-formation rate over the past 10 Myr
9	SFR_100	$\log \mathrm{M}_\odot \mathrm{yr}^{-1}$	Average star-formation rate over the past 100 Myr
10	sSFR	$\log \mathrm{yr}^{-1}$	Specific SFR defined as $\log 10^{\mathtt{SFR\_100}}/10^{\mathtt{mStar}}$
11	tau	$\log \mathrm{yr}$	Star-formation timescale for the delayed star formation history ($\psi \propto \exp[t/\tau]$)
12	max_stellar_age	log yr	Maximum age of stars in a galaxy.
13	tauV_eff		V-band dust attenuation optical depth ($\hat{\tau}_\mathrm{V}$)
14	A1500	AB mag	Dust attenuation at rest-frame 1500Å (averaged within a 100Å window)
15	HST_F435W_fnu	nJy	Flux in *HST*/ACS filter F435W
16	HST_F606W_fnu	nJy	Flux in *HST*/ACS filter F606W
17	HST_F775W_fnu	nJy	Flux in *HST*/ACS filter F775W
18	HST_F814W_fnu	nJy	Flux in *HST*/ACS filter F814W
19	HST_F850LP_fnu	nJy	Flux in *HST*/ACS filter F850LP
20	HST_F105W_fnu	nJy	Flux in *HST*/WFC3 filter F105W
21	HST_F125W_fnu	nJy	Flux in *HST*/WFC3 filter F125W
22	HST_F140W_fnu	nJy	Flux in *HST*/WFC3 filter F140W
23	HST_F160W_fnu	nJy	Flux in *HST*/WFC3 filter F160W
24	IRAC_3p6_fnu	nJy	Flux in *Spitzer*/IRAC Channel 1 at 3.6μm
25	IRAC_4p5_fnu	nJy	Flux in *Spitzer*/IRAC Channel 2 at 4.5μm
26	NRC_F070W_fnu	nJy	Flux in *JWST*/NIRCam filter F070W
27	NRC_F090W_fnu	nJy	Flux in *JWST*/NIRCam filter F090W

28	NRC_F115W_fnu	nJy	Flux in *JWST*/NIRCam filter F115W
29	NRC_F150W_fnu	nJy	Flux in *JWST*/NIRCam filter F150W
30	NRC_F200W_fnu	nJy	Flux in *JWST*/NIRCam filter F200W
31	NRC_F277W_fnu	nJy	Flux in *JWST*/NIRCam filter F277W
32	NRC_F356W_fnu	nJy	Flux in *JWST*/NIRCam filter F356W
33	NRC_F444W_fnu	nJy	Flux in *JWST*/NIRCam filter F444W
34	NRC_F140M_fnu	nJy	Flux in *JWST*/NIRCam filter F140M
35	NRC_F162M_fnu	nJy	Flux in *JWST*/NIRCam filter F162M
36	NRC_F182M_fnu	nJy	Flux in *JWST*/NIRCam filter F182M
37	NRC_F210M_fnu	nJy	Flux in *JWST*/NIRCam filter F210M
38	NRC_F250M_fnu	nJy	Flux in *JWST*/NIRCam filter F250M
39	NRC_F300M_fnu	nJy	Flux in *JWST*/NIRCam filter F300M
40	NRC_F335M_fnu	nJy	Flux in *JWST*/NIRCam filter F335M
41	NRC_F360M_fnu	nJy	Flux in *JWST*/NIRCam filter F360M
42	NRC_F410M_fnu	nJy	Flux in *JWST*/NIRCam filter F410M
43	NRC_F430M_fnu	nJy	Flux in *JWST*/NIRCam filter F430M
44	NRC_F460M_fnu	nJy	Flux in *JWST*/NIRCam filter F460M
45	NRC_F480M_fnu	nJy	Flux in *JWST*/NIRCam filter F480M
46	NRC_F410M_F444W_fnu	nJy	Flux in *JWST*/NIRCam pseudofilter created from F444W - F410M
47	metallicity	$\log(Z/Z_\odot)$	Stellar and interstellar metallicity ($Z_\odot = 0.01524$)
48	log_OH	$12 + \log(O/H)$	Effective galaxy-wide gas-phase oxygen abundance, accounting for fraction of metals depleted onto dust grains
49	C4_1548_1550_EW	Å	Rest-frame equivalent width (EW) of the combined CIV $\lambda\lambda$1548,1550 doublet
50	O3_1660_EW	Å	Rest-frame EW of OIII]λ1660
51	O3_1666_EW	Å	Rest-frame EW of OIII]λ1666
52	C3_1907_1909_EW	Å	Rest-frame EW of the combined [CIII]λ1907 CIII]λ1909 doublet
53	O2_3726_3729_EW	Å	Rest-frame EW of the combined [OIII]$\lambda\lambda$3726,3729 doublet
54	HBaB_4861_EW	Å	Rest-frame EW of Hβ λ4861
55	O3_4959_EW	Å	Rest-frame EW of [OIII]λ4959
56	O3_5007_EW	Å	Rest-frame EW of [OIII]λ5007
57	HBaA_6563_EW	Å	Rest-frame EW of Hα λ6563
58	C4_1548_flux	$\log \mathrm{erg\,sec^{-1}\,cm^2}$	Flux in CIV λ1548
59	C4_1551_flux	$\log \mathrm{erg\,sec^{-1}\,cm^2}$	Flux in CIV λ1551
60	O3_1660_flux	$\log \mathrm{erg\,sec^{-1}\,cm^2}$	Flux in OIII]λ1660
61	O3_1666_flux	$\log \mathrm{erg\,sec^{-1}\,cm^2}$	Flux in OIII]λ1666

62	C3_1907_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [CIII]λ1907
63	C3_1909_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in CIII]λ1909
64	O2_3726_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [OII]λ3726
65	O2_3729_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [OII]λ3729
66	Ne3_3869_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [NeIII]λ3869
67	O3_4363_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [OIII]λ4363
68	HBaB_4861_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in Hβ λ4861
69	O3_4959_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [OIII]λ4959
70	O3_5007_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [OIII]λ5007
71	HBaA_6563_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in Hα λ6563
72	N2_6584_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [NII]λ6584
73	S2_6716_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [SII]λ6716
74	S2_6731_flux	$\log \text{erg}\,\text{sec}^{-1}\,\text{cm}^2$	Flux in [SII]λ6731
75	luminosity_distance	Mpc	Luminosity distance corresponding to the adopted redshift and cosmology.
76	Re_circ	kpc	Circularized half-light radius where Re_circ = Re_maj $\sqrt{\texttt{axis\_ratio}}$, times the appropriate conversion from arcsec to kpc at the mock galaxy redshift
77	Re_maj	arcsec	Semi-major half-light radius
78	axis_ratio		Axis ratio, defined as semi-minor half-light radius divided by semi-major half-light radius Re_maj
79	sersic_n		Sersic index
80	position_angle	degrees	Position angle on the sky

2.1 Some notes on the emission line measurements

The emission line fluxes are the fluxes of lines produced in the nebular HII regions, with the ionizing radiation coming from stars with ages < 10 Myrs. For details of the nebular models used, please see Gutkin et al. (2016). The equivalent width measurements include the stellar continuum, and as such include the effects of e.g. stellar Hβ and Hα absorption. Wherever possible, we provide equivalent width information for each line in a doublet, but when the intrinsic resolution of the models we are using are too low to cleanly separate the contribution from each line, we supply a single equivalent width for both lines.

2.2 Some notes on the treatment of Lyα

Lyα is included in the contribution to broad-band fluxes in this mock catalog. The exact Lyα line flux contamination depends on the intrinsic Lyα line strength, the attenuation by dust and absorption by the inter-galactic medium (IGM) blue-wards of 1215Å. The IGM prescription incorporated in BEAGLE is that of Inoue et al. (2014). The line profile of Lyα included in the models is symmetric, and any flux blue-wards of 1215Å may be attenuated by the IGM. Given the complex nature of this resonant line, we understand that this simple modeling procedure is likely insufficient and may affect colour-selection criteria chosen for e.g. high-redshift dropout candidates. We therefore additionally provide the same set of line fluxes without Lyα included so that the user may assess the impact of Lyα contamination. This information can be found in the file:

JADES_SF_mock_r1_v$n.n$_fluxes_noLya.fits

This file contains a subset of the columns described in Table 2.

2.3 Emission line variants for realization 1, $\xi_{\rm d} = 0.5$ and $n_{\rm h} = 1000$ cm^{-3}

As displayed in Figure 21 of Williams et al. (2018), the fiducial mock does not cover the parameter space of elevated [OIII]λ5007/Hβ line ratios seen in recent surveys at high redshifts ($z \gtrsim 2$). There are many possible explanations for the observed ratios seen in high redshift galaxies, as discussed in Section 6.5 of the paper, and we provide the emission line information for two key parameters that can produce elevated [OIII]λ5007/Hβ line ratios.

In the file:

JADES_SF_mock_r1_v$n.n$_EL_xid_0p5.fits

we supply the line luminosities and equivalent widths for each mock catalog galaxy at a dust-to metal mass ratio of $\xi_{\rm d} = 0.5$, where the fiducial mock catalog has $\xi_{\rm d} = 0.3$.

In the file:

JADES_SF_mock_r1_v$n.n$_EL_nh_1E3.fits

we supply the line luminosities and equivalent widths for each mock catalog galaxy at a hydrogen density of $n_{\rm H} = 1000$ cm^{-3}, where the fiducial mock catalog has $n_{\rm H} = 100$ cm^{-3}.

These files contains a subset of the columns described in Table 2.

3 Contents of 11x11 Quiescent mock catalog files

N	Column name	Units	Description
1	ID		Catalog ID
2	RA	degrees	Right Ascension
3	DEC	degrees	Declination
4	redshift		Redshift
5	mStar	$\log \mathrm{M}_\odot$	Stellar mass (total mass locked in stars, accounting the fraction returned by stars to the ISM but including total mass locked into remnants, i.e. neutron stars and black holes)
6	sSFR	$\log \mathrm{yr}^{-1}$	Specific SFR defined as $\log 10^{\texttt{SFR\_100}}/10^{\texttt{mStar}}$
7	tau	$\log \mathrm{yr}$	Star-formation timescale for the delayed star formation history ($\psi \propto \exp[t/\tau]$)
8	tauV_eff		V-band dust attenuation optical depth ($\hat{\tau}_{\rm V}$)
9	max_stellar_age	log yr	Maximum age of stars in a galaxy.
10	metallicity	$\log(\mathrm{Z}/\mathrm{Z}_\odot)$	Stellar metallicity
11	HST_F435W_fnu	nJy	Flux in *HST*/ACS filter F435W
12	HST_F606W_fnu	nJy	Flux in *HST*/ACS filter F606W
13	HST_F775W_fnu	nJy	Flux in *HST*/ACS filter F775W
14	HST_F814W_fnu	nJy	Flux in *HST*/ACS filter F814W

15	HST_F850LP_fnu	nJy	Flux in *HST*/ACS filter F850LP
16	HST_F105W_fnu	nJy	Flux in *HST*/WFC3 filter F105W
17	HST_F125W_fnu	nJy	Flux in *HST*/WFC3 filter F125W
18	HST_F140W_fnu	nJy	Flux in *HST*/WFC3 filter F140W
19	HST_F160W_fnu	nJy	Flux in *HST*/WFC3 filter F160W
20	IRAC_3p6_fnu	nJy	Flux in *Spitzer*/IRAC Channel 1 at 3.6μm
21	IRAC_4p5_fnu	nJy	Flux in *Spitzer*/IRAC Channel 2 at 4.5μm
22	NRC_F070W_fnu	nJy	Flux in *JWST*/NIRCam filter F070W
23	NRC_F090W_fnu	nJy	Flux in *JWST*/NIRCam filter F090W
24	NRC_F115W_fnu	nJy	Flux in *JWST*/NIRCam filter F115W
25	NRC_F150W_fnu	nJy	Flux in *JWST*/NIRCam filter F150W
26	NRC_F200W_fnu	nJy	Flux in *JWST*/NIRCam filter F200W
27	NRC_F277W_fnu	nJy	Flux in *JWST*/NIRCam filter F277W
28	NRC_F356W_fnu	nJy	Flux in *JWST*/NIRCam filter F356W
29	NRC_F444W_fnu	nJy	Flux in *JWST*/NIRCam filter F444W
30	NRC_F140M_fnu	nJy	Flux in *JWST*/NIRCam filter F140M
31	NRC_F162M_fnu	nJy	Flux in *JWST*/NIRCam filter F162M
32	NRC_F182M_fnu	nJy	Flux in *JWST*/NIRCam filter F182M
33	NRC_F210M_fnu	nJy	Flux in *JWST*/NIRCam filter F210M
34	NRC_F250M_fnu	nJy	Flux in *JWST*/NIRCam filter F250M
35	NRC_F300M_fnu	nJy	Flux in *JWST*/NIRCam filter F300M
36	NRC_F335M_fnu	nJy	Flux in *JWST*/NIRCam filter F335M
37	NRC_F360M_fnu	nJy	Flux in *JWST*/NIRCam filter F360M
38	NRC_F410M_fnu	nJy	Flux in *JWST*/NIRCam filter F410M
39	NRC_F430M_fnu	nJy	Flux in *JWST*/NIRCam filter F430M
40	NRC_F460M_fnu	nJy	Flux in *JWST*/NIRCam filter F460M
41	NRC_F480M_fnu	nJy	Flux in *JWST*/NIRCam filter F480M
42	NRC_F410M_F444W_fnu	nJy	Flux in *JWST*/NIRCam pseudofilter created from F444W - F410M
43	luminosity_distance	Mpc	Luminosity distance corresponding to the adopted redshift and cosmology.
44	Re_circ	kpc	Circularized half-light radius where $\texttt{Re\_circ} = \texttt{Re\_maj}\sqrt{\texttt{axis\_ratio}}$, times the appropriate conversion from arcsec to kpc at the mock galaxy redshift
45	Re_maj	arcsec	Semi-major half-light radius
46	axis_ratio		Axis ratio, defined as semi-minor half-light radius divided by semi-major half-light radius Re_maj
47	sersic_n		Sersic index
48	position_angle	degrees	Position angle on the sky

4 Format of star-forming and quiescent spectrum files

A spectrum is supplied for each of the objects in the mock catalog. The spectra are stored in multiple-extension fits files. The first extension contains an image extension ('FULL SED') with each row containing a single spectrum. The second extension ('FULL SED WL') contains the rest-frame wavelength array and the third extension ('OBJECT PROPERTIES') contains a table with the mock catalog IDs and redshifts corresponding to the objects stored in the file so that it is simple to identify which spectrum to select once you know which ones you want to look at in the mock catalog.

Each of the objects in the mock catalog are at a different redshift, and so to easily store them, we necessarily store them at the rest-frame wavelengths. The units of the spectra are in erg s^{-1} cm^{-2} $Å^{-1}$, so when red-shifting the wavelength array to display the spectrum at the redshift given in the mock (i.e. in the observed frame), one must also divide the f_λ values by $(1 + z)$. No further corrections for luminosity distance are required.

The spectra for the star forming catalog are supplied in 7 files, stored in .fits.gz format, each file being ~ 900 Mb. These files have the following naming convention:

JADES_SF_r[N]_v1.0_spec_5A_30um_ID_[startz]_[endz].fits

where [N] is the realization number and the [startz] and [endz] are the redshifts of the first and last spectrum included in the file respectively. The spectra for the quiescent galaxy catalog are stored in a single file.

Parameters of the spectra:

- **Resolution:** $\sigma = 5$Å for $\lambda \leq 9300$Å, variable $\lambda > 9300$Å.
- **Wavelength binning:** Binned at 5Å for $\lambda \leq 9300$Å, variable at $\lambda > 9300$Å.

As of v1.2, the spectra now extend to wavelength of 30μm, but note that JAGUAR includes only stellar emission and does not include dust emission or other mid-infrared emission sources.

5 HST and NIRCam Filters

References

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Gutkin J., Charlot S., Bruzual G., 2016, MNRAS, 462, 1757

Inoue A. K., Shimizu I., Iwata I., Tanaka M., 2014, MNRAS, 442, 1805

Williams C. C., et al., 2018, preprint, (arXiv:1802.05272)

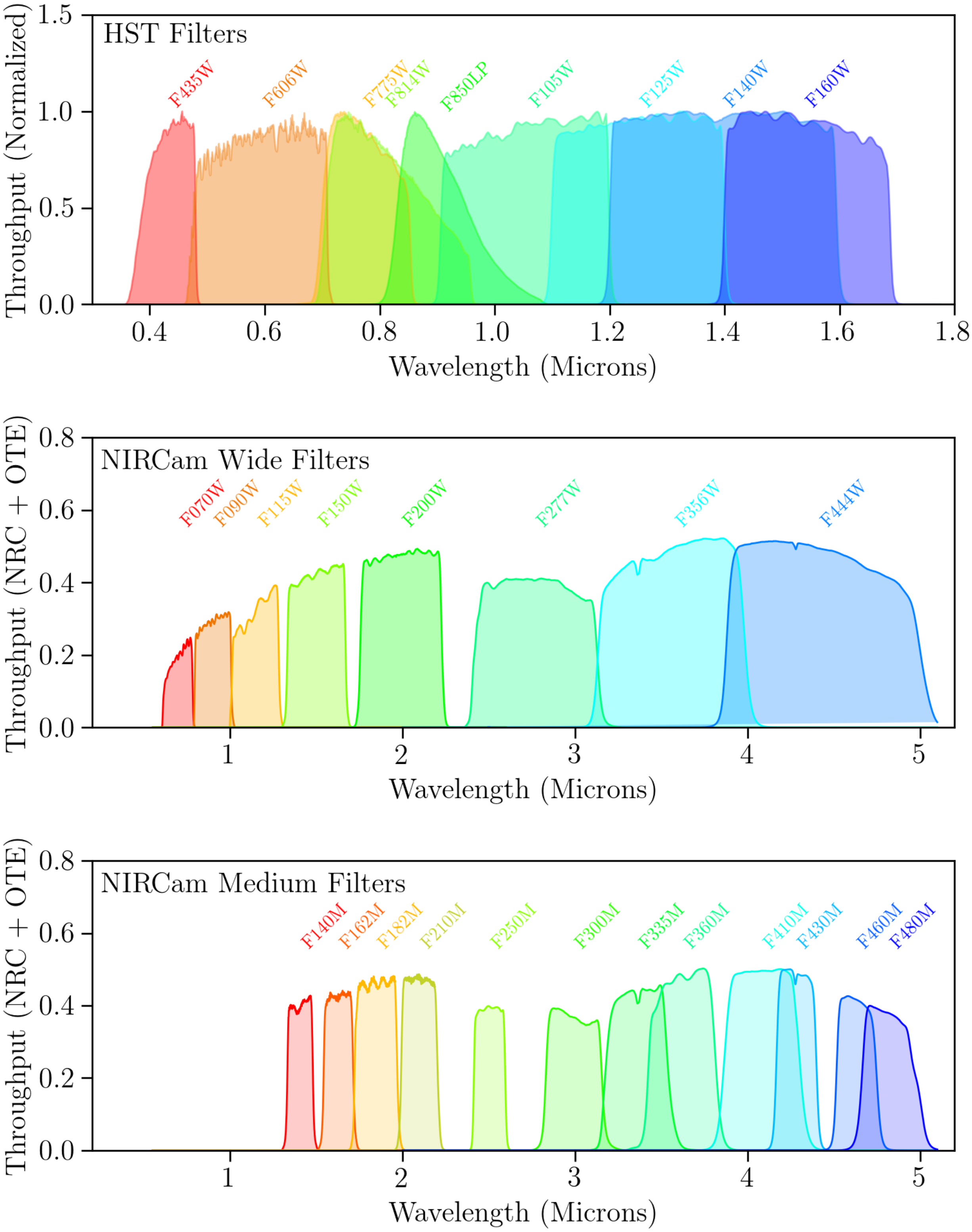

Figure 1: Transmission curves for the HST and NIRCam filters included in the star-forming and quiescent mock, as described above. The HST filters are normalized to one to aid with viewing. The NIRCam filters represent the throughput through the filter, as well as the instrument response (NRC) and the optical telescope element (OTE).