

ASTRODEEP SIMULATED IMAGES

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We produce and release a full set of simulated images resembling three real surveys datasets: CANDELS GOODS-S, CANDELS COSMOS, and a EUCLID FoV. The images are produced using the ASTROMATIC public code SkyMaker (by E. Bertin), starting from mock catalogues obtained by means of the EGG software (Schreiber 2017, in prep.). In this short document we describe the methodology adopted to produce the images.

Simulating realistic images from EGG mock catalogs

To produce images starting from EGG-generated catalogs, we use an ad-hoc Python wrapper to call SkyMaker, which creates realistic simulated images including sources and a (non-correlated) noise map. The script allows to have full control of all parameters with ease. In summary, the procedure is as follows: the EGG catalogs list positions and structural parameters of all the sources, in the chosen band(s); to produce the image based on the list, SkyMaker requiring the following additional parameters (to be given in a configuration file):

- * image size in pixels
- * gain
- * saturation level
- * exposure time
- * magnitude zero point
- * pixel size
- * seeing FWHM
- * simulated optical instrument features (mirrors diameter, etc.)
- * background magnitude per arcsec
- * limit of allowed magnitudes

Some of these parameters are generated automatically by EGG (e.g. the dimensions of the images are chosen to match the area of the field which is being simulated, with the final images being slightly larger to fully include the extended objects near the borders). Others can be considered as fixed in all the possible applications of this pipeline (the simulated CCD gain is always set equal to 1; the saturation level of the CCD is 6553500 counts/s). Finally, others depend on the images set one is willing to produce (the AB magnitude zero-points, which can be set equal to 23.9 to produce counts in μJy units, or can have arbitrary values; the pixel scale; and the exposure times).

Once all these values have been set, the only free parameter remaining to fully characterize the needed SkyMaker input is the background magnitude. However, it is easier to choose a magnitude limit at 1σ , and hence compute the background magnitude for the simulated images. To do so, we can start from the textbook formula

$$\frac{S}{N} = \frac{(F_1 t_{\text{exp}})}{\sqrt{\frac{F_1 t_{\text{exp}}}{g} + \frac{B_1 t_{\text{exp}} A}{g} + (R.O.N./g)^2}}$$

where F_1 is source flux in counts/s, B_1 is background flux in counts/s, A is pixel area of the source (defined by the number of FWHM within which the flux is measured), and g is gain, which is fixed to 1. Assuming the R.O.N. to be zero, a source of magnitude

equal to mag_{limit} has $S/N=1$ yielding $1 = \frac{F_1 t_{\text{exp}}}{\sqrt{(F_1 + B_1 A) t_{\text{exp}}}}$ and therefore $B_1 = \frac{F_1^2 t_{\text{exp}} - F_1}{A}$ where

$$F_1 = 10^{-0.4(mag_{\text{limit}} - ZP)}, \text{ and finally } mag_{\text{background}} = -2.5 \log \frac{B_1}{ps^2} + ZP.$$

To produce the images, SkyMaker needs their PSF, which can be generated internally or can be fed to the code as an external file; also, the transmission curve of the desired passbands are needed.

The simulated datasets: GOODS-South, COSMOS Wide, Euclid FOV

We produced and released sky images (i.e. including noise) normalized to counts/s and background subtracted, and noise-subtracted images (from which a RMS map can be easily obtained), plus the input EGG catalogues and the PSFs – for the following three simulated datasets of images:

- a deep field with area equal to the GOODS-South CANDELS field, including all the 19 passbands used in the CANDELS survey (all images have HST pixel-scale of $0.06''/\text{pix}$);
- a wide field of area 1 sq.deg., i.e. comparable to that of the COSMOS wide survey, including *HST* H160, ground-based and *Spitzer* passbands (all images have pixel-scale of $0.15''/\text{pix}$);

- a simulated Euclid FOV ($\sim 0.7^\circ$ per side) in the 4 satellite passbands (VIS and NIR J, H and Y) plus an EXT-Kids image (each of $\sim 28000^2$ pixels, at the VIS pixel-scale of $0.1''/\text{pix}$).

For the GOODS-South simulations, the limit magnitudes in $r_{ap} = 1$ FWHM for all bands where computed from the nominal ones given in Guo+2013 (Table 1), as $m_{limit} = m_{1\sigma} = m_{5\sigma, CANDELS} + 2.5 \log 5$ (with minor adjustments for "cosmetics"):

CTIO_U=28.4 (true: 28.38), VIMOS_U=29.5 (true: 29.72), VIMOS_B=29.5 (true: 29.6), ACS_f435=30.5 (true: 30.70), ACS_f606=30.5 (true: 31.10), ACS_f775=30.5 (true: 30.30), ACS_f814=30.5 (true: 30.60), ACS_f850=30.5 (true: 30.30), ACS_f098=30.5 (true: 30.52), WFC3_f105=29.2 (true: 29.20), WFC3_f125=29.5 (true: 29.40), WFC3_f140=29.5 (true: 29.40), WFC3_f160=29.0 (true: 29.11), ISAAC_Ks=26.85 (true: 26.83), HawkI_Ks=28.2 (true: 28.20), IRAC1=27.15 (true: 27.15), IRAC2=27.15 (true: 27.15), IRAC3=25.5 (true: 25.50), IRAC4=25.5 (true: 25.47).

From the same source, FWHM were taken as follows:

CTIO_U=1.35", VIMOS_U=0.8", VIMOS_B=0.8", ACS_f435=0.1", ACS_f606=0.1", ACS_f775=0.1", ACS_f814=0.1", ACS_f850=0.1", ACS_f098=0.13", WFC3_f105=0.15", WFC3_f125=0.16", WFC3_f140=0.17", WFC3_f160=0.17", ISAAC_Ks=0.48", HawkI_Ks=0.4", IRAC1=1.66", IRAC2=1.7", IRAC3=1.9", IRAC4=2.0".

The simulation covers an area of 0.047 sq.deg. , i.e. 172 sq.arcmin. equal to the GOODS-South field area (actually both the Deep and the Wide area of the CANDELS survey).

We proceeded in a similar way for the COSMOS simulation, taking as limiting magnitudes and FWHMs the ones given in Capak+2007, Sanders+2007 and Ilbert+2010 (again with small adjustments for cosmetics). We simulated the ground-based broad pass-bands, together with the *Spitzer* CH1 and CH2 and a detection *HST* H160 image:

WFC3_f160=29.25 (FWHM=0.2"), Subaru_B=29.0 (FWHM=0.5"), Subaru_g+=28.75 (FWHM=1.5"), Subaru_V=28.4 (FWHM=1.0"), Subaru_r+=28.5 (FWHM=0.6"), Subaru_i+=28.0 (FWHM=0.7"), Subaru_z+=27.0 (FWHM=0.8"), UKIRT_J=25.45 (FWHM=1.5"), CFHT_K=25.45 (FWHM=1.5"), IRAC1=26.65 (FWHM=1.66"), IRAC2=24.9 (FWHM=1.7"). The simulated area is 1 sq.deg. , i.e. half of the full COSMOS wide survey.

All the zero points in this datasets were fixed to 23.9, so the images are in μJy units; the exposure time is fixed to 10k sec. Since internally generated PSFs have perfect circular symmetry, we used them for all bands but for the IRAC ones in the GOODS and COSMOS simulations, because of the intrinsic strong asymmetry of the real *Spitzer* PSFs. For these images we therefore fed SkyMaker with "realistic" synthetic IRAC PSFs, generated using a Python script by the H. Ferguson and S. Lee within the CANDELS collaboration.

Finally, for the Euclid simulations all the relevant parameters were taken from the mission *Redbook*; in this case we used the passband response curves kindly provided by the Euclid community. The adopted values for limiting magnitudes (in $r_{ap} = 1.5$ FWHM) at 1σ are the following:

VIS=27.0 (FWHM=0.2"), NIR_Y=27.0 (FWHM=0.3"), NIR_J=25.75 (FWHM=0.3"), NIR_K=25.75 (FWHM=0.3").

The zero points is 25.943 for all the images and the exposure time is 1000 sec; PSFs were generated by SkyMaker.

The depth of all images were checked producing "empty" images, i.e. with identical input parameters, but without any object; then, the limiting magnitude at 1σ was computed as $mag_{limit} = -2.5 \log [STD(f) \times \sqrt{A}] + ZP$, where f are the pixel values in the image and A is the aperture area, i.e. $\pi (r_{ap} \times FWHM / ps)^2$.

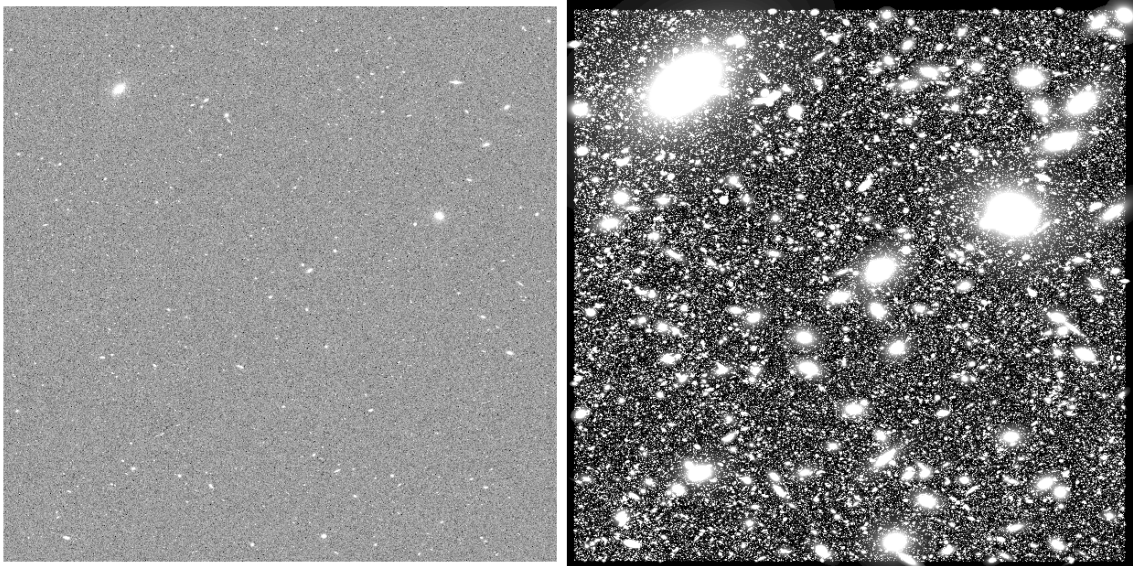


Fig. 1 – Full simulated GOODS-South WFC3_f160w field: science image (left) and noise-subtracted image (right).

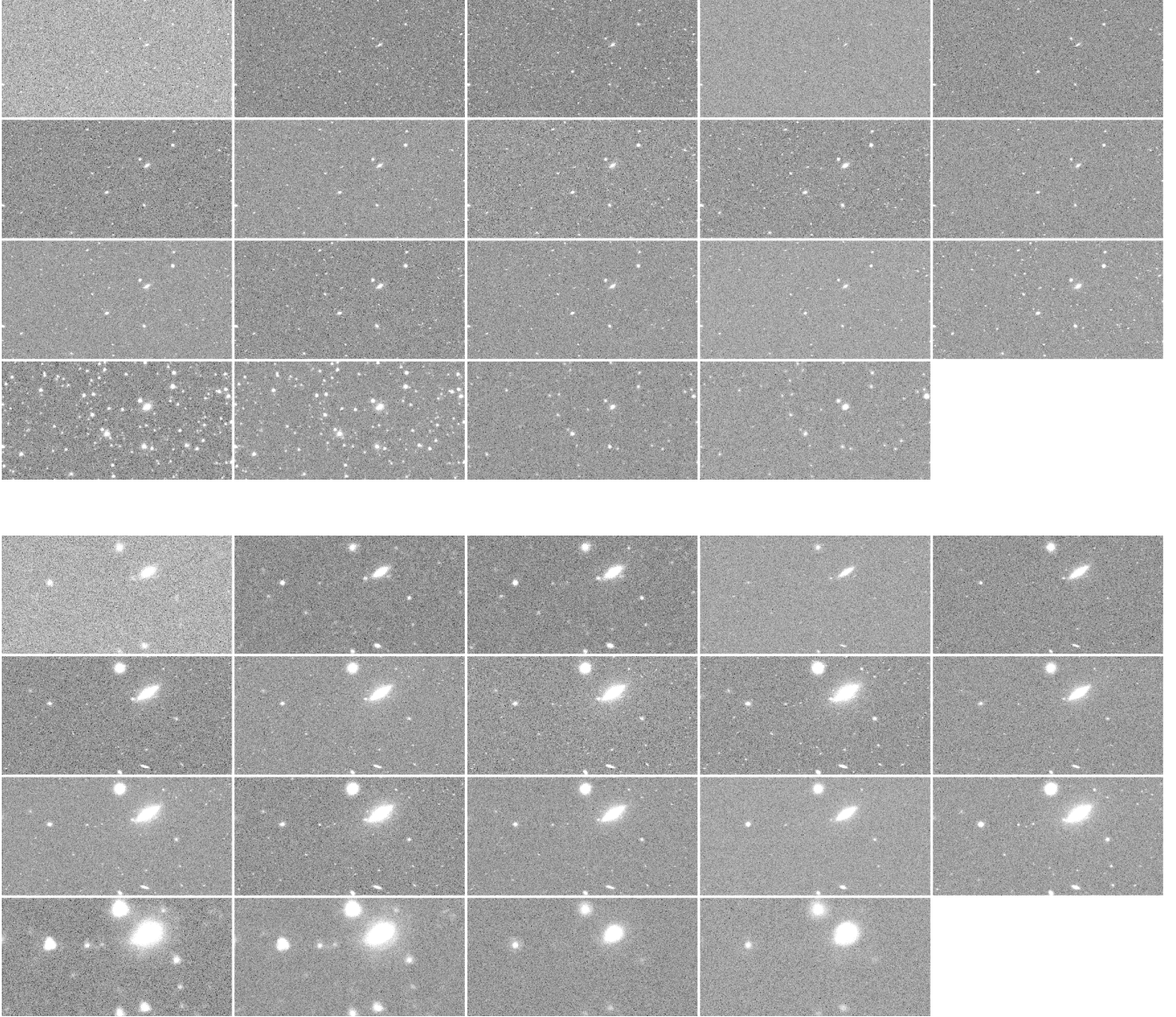


Fig. 2 – Regions within simulated GOODS-South images, at different magnifications. Both panels, left to right, top to bottom: CTIO_U, VIMOS_U, VIMOS_B, ACS_f435, ACS_f606, ACS_f775, ACS_f814, ACS_f850, ACS_f098, WFC3_f105, WFC3_f125, WFC3_f140, WFC3_f160, ISAAC_Ks, HawkI_Ks, IRAC1, IRAC2, IRAC3, IRAC4.

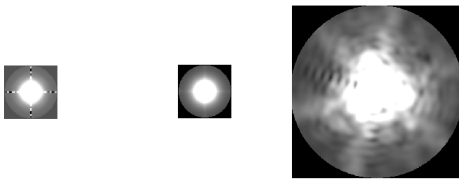


Fig. 3 – Three of the adopted PSFs. Left to right: HST WFC3_f160, HawkI_Ks, IRAC1.

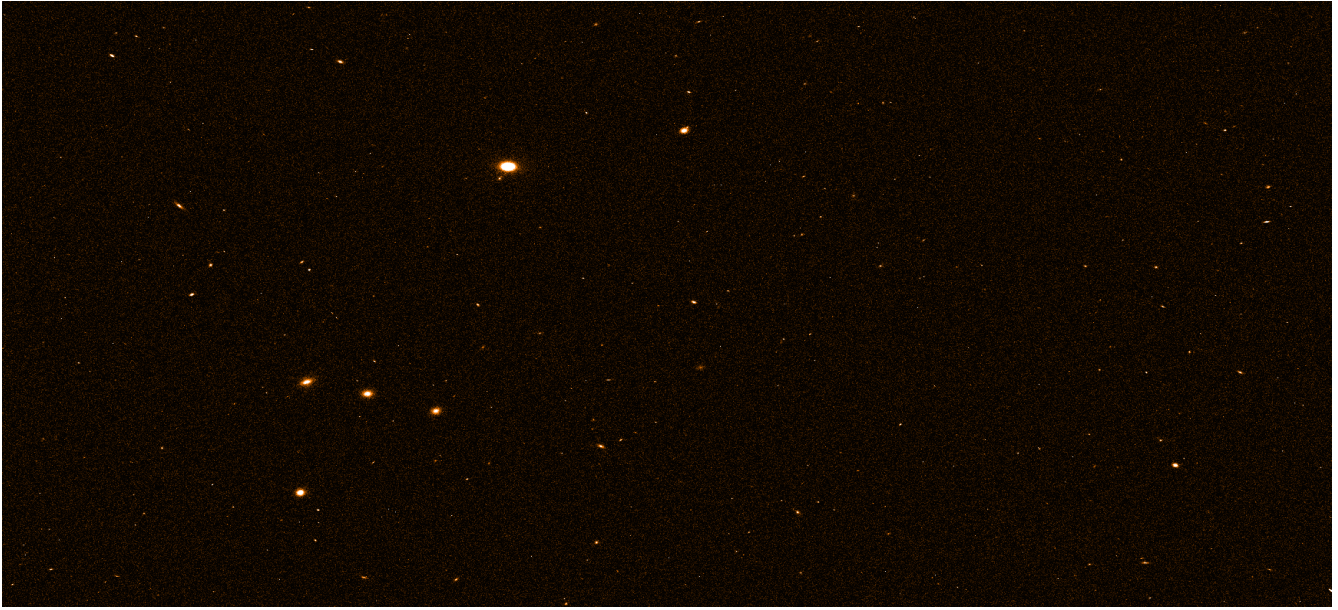


Fig. 4 – A small part of a simulated Euclid VIS image (~5% of the total area).