Guidelines for the Use of the Projected Density Map Catalogue in the HSC-SSP PDR3

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We here offer the use of the projected density map catalogue in Shimakawa et al. (2021) with incremental updates based on the Third Public Data Release of Subaru Strategic Program with the Hyper Suprime-Cam (HSC-SSP PDR3).

1 Catalogue overview

This updated catalogue based on the HSC-SSP PDR3 (Aihara et al., 2022, PASJ, tmp, 31) extends the survey area from 360 to 700 deg^2, which are split into 3 fields since 3 fields in the original PDR2 catalogue (GAMA 09H,12H,15H) are combined into 1 field (Table 1). The sample selection and methodology are nearly the same as the original paper (Shimakawa et al., 2021, MNRAS, 503, 3896, hereafter RS21) but some modifications on the sample selection as written in section 2. The catalogue contents are almost the same as in the original catalogue (figure 1), but `n*_**_r*0` (e.g. #16–24) were revised to the original numbers before the mask correction.

#	Name	Description
1	ra	R.A. (degree) of the centre of aperture
2	dec	Dec. (degree) of the centre of aperture
3	field	Field id (see Table 1)
4	ix	Pixel id in each field on the R.A. axis
5	iy	Pixel id in each field on the Dec. axis
6	skymap_id	Nearest tract and patch in HSC-SSP
7	eff_r10	Fraction of effective area in $r = 10$ arcmin
8	eff_r30	Fraction of effective area in $r = 30$ arcmin
9	nd3_r10	The number of $z = [0.3:0.4)$ sources in $r = 10$ arcmin
10	nd3_r30	The number of $z = [0.3:0.4)$ sources in $r = 30$arcmin
11	sgm3_r10	Contrast of nc3_r10 in standard deviation
12	sgm3_r30	Contrast of nc3_r30 in standard deviation
13	dlt3_r10	Contrast of nc3_r10 in variance
14	dlt3_r30	Contrast of nc3_r30 in variance
15	n3_02_r10	The number of $z = [0.30:0.32)$ sources in $r = 10$ arcmin
16	n3_02_r30	The number of $z = [0.30:0.32)$ sources in $r = 30$ arcmin
17	n3_24_r10	The number of $z = [0.32:0.34)$ sources in $r = 10$ arcmin
18	n3_24_r30	The number of $z = [0.32:0.34)$ sources in $r = 30$ arcmin
19	n3_46_r10	The number of $z = [0.34:0.36)$ sources in $r = 10$ arcmin
20	n3_46_r30	The number of $z = [0.34:0.36)$ sources in $r = 30$ arcmin
21	n3_68_r10	The number of $z = [0.36:0.38)$ sources in $r = 10$ arcmin
22	n3_68_r30	The number of $z = [0.36:0.38)$ sources in $r = 30$ arcmin
23	n3_80_r10	The number of $z = [0.38:0.40)$ sources in $r = 10$ arcmin
24	n3_80_r30	The number of $z = [0.38:0.40)$ sources in $r = 30$ arcmin
25–40		Same as #9–24 but for $z = [0.4:0.5)$
41–56		Same as #9–24 but for $z = [0.5:0.6)$
57–72		Same as #9–24 but for $z = [0.6:0.7)$
73–88		Same as #9–24 but for $z = [0.7:0.8)$
89–104		Same as #9–24 but for $z = [0.8:0.9)$
105–120		Same as #9–24 but for $z = [0.9:1.0)$
121	eff_z3	Same as #7 but for $r = 10$ cMpc at $z = [0.3:0.4)$
122	eff_z4	Same as #7 but for $r = 10$ cMpc at $z = [0.4:0.5)$
123	eff_z5	Same as #7 but for $r = 10$ cMpc at $z = [0.5:0.6)$
124	eff_z6	Same as #7 but for $r = 10$ cMpc at $z = [0.6:0.7)$
125	eff_z7	Same as #7 but for $r = 10$ cMpc at $z = [0.7:0.8)$
126	eff_z8	Same as #7 but for $r = 10$ cMpc at $z = [0.8:0.9)$
127	eff_z9	Same as #7 but for $r = 10$ cMpc at $z = [0.9:1.0)$
128	sgm3_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.3:0.4)$
129	dlt3_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.3:0.4)$
130	sgm4_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.4:0.5)$
131	dlt4_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.4:0.5)$
132	sgm5_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.5:0.6)$
133	dlt5_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.5:0.6)$
134	sgm6_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.6:0.7)$
135	dlt6_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.6:0.7)$
136	sgm7_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.7:0.8)$
137	dlt7_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.7:0.8)$
138	sgm8_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.8:0.9)$
139	dlt8_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.8:0.9)$
140	sgm9_c10	Same as #11 but for $r = 10$ cMpc at $z = [0.9:1.0)$
141	dlt9_c10	Same as #13 but for $r = 10$ cMpc at $z = [0.9:1.0)$

Figure 1: Contents of the density map catalogue.

Table 1: Survey areas.

ID	R.A. $\alpha_{\rm min}, \alpha_{\rm max}$	Dec. $\delta_{\rm min}, \delta_{\rm max}$	N grids $X \times Y$	Area deg^2 (effective)
1	212, 251	+42, +45	1132×120	85 (59)
2	128, 226	−2, +5	3920×280	686 (480)
3	330, 40	−2, +3	2800×200	350 (245)

2 How to download galaxy members through the SQL?

Basically, we adopted the same sampling selection as in the original version (RS21, section 2) as below,

- `isprimary=True`,
- `(grizy)_inputcount_count_value>0`,
- `(grizy)_pixelflags_edge=False`,
- `(grizy)_pixelflags_bad=False`,
- `(grizy)_pixelflags_interpolatedcenter=False`,
- `(grizy)_pixelflags_saturatedcenter=False`,
- `(grizy)_pixelflags_crcenter=False`,
- `(grizy)_mask_brightstar_halo=False`,
- `(grizy)_mask_brightstar_ghost=False`,
- `(grizy)_mask_brightstar_blooming=False`,

where the last three criteria are further bright-object mask flags available since PDR3. In the updated version, additionally, we excluded some point sources by comparing PSF magnitudes with CModel magnitudes (`i_psfflux_mag−i_cmodel_mag>0.2`; see also Strauss et al., 2002, AJ, 124, 1810; Baldry et al., 2010, MNRAS, 404, 86), although they have negligible impacts on our density estimation. The followings are further criteria for the magnitude cuts, detection levels (5σ), and the removal of point-sources, respectively,

- `i_cmodel_mag−a_i<23`,
- `(grizy)_cmodel_magerr<0.217`,
- `i_psfflux_mag−i_cmodel_mag>0.2`.

Additional thresholds for photometric redshifts (Tanaka et al. 2016, ApJ, 801, 20; 2018, PASJ, 70, 9) were applied as follows,

- `prob_star=0`,
- `reduced_chisq<5`,
- `photoz_best BETWEEN 0.299 AND 0.999`.

That's it! If you adopt all the above selection criteria in the SQL query, you will obtain ~ 20 million sources, and 14.4 millions out of them were used in this work (cf. we additionally restricted the survey areas as in table 1 and removed shallow areas with `imag_psf_depth<26`, see RS21 for the details of the density estimation).

3 How to reproduce the density map figures?

For example, the following sample scripts will allow you to produce the projected density map in the HectoMAP (Field ID = 1) at $z = [0.8, 0.9)$.

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

df = pd.read_csv("densitymap_pdr3.csv")
df = df[(df["field"]==1) & (df["eff_r10"]>0.5)]

xmin, xmax = 212, 251
ymin, ymax = 42, 45
nx, ny = 1132, 120

x0 = np.linspace(xmin, xmax, nx, endpoint=False)
y0 = np.linspace(ymin, ymax, ny, endpoint=False)
X, Y = np.meshgrid(x0, y0)

Z = np.zeros([ny,nx])
Z[:,:] = np.nan
for ix, iy, od in zip(
    df["ix"],df["iy"],df["sgm8_r10"]
):
    Z[iy][ix] = od
l = np.arange(-2,4,1)

plt.figure(figsize=(10,1))
plt.contourf(X, Y, Z, levels=l, cmap="viridis")
plt.xlim(xmax,xmin)
plt.ylim(ymin,ymax)
plt.tight_layout()
plt.show()
```

This is just a simple example, and thus you may want to modify the script to make it much nicer. If you want to change the field to ID = 2 or 3, please change `xmin, xmax` and `nx, ny` parameters according to table 1.

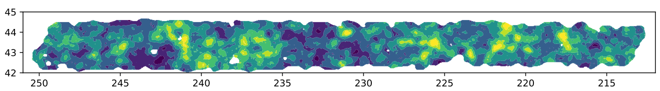

Figure 2: Output figure from the sample script.

4 How to cross-match the catalogue with your sample?

The easiest solution seems to be to use `TOPCAT` (the Tool for OPerations on Catalogues And Tables; Taylor, 2005, ASPC, 347, 29). `TOPCAT` has a useful match selection, "Best match for each Table row", which allows you to find the nearest grid points to your individual samples (figure 3). Also, the max error should be ∼64 arcsec, because the grid xy size of the density map catalogue is ∼0.025 deg.

Figure 3: Example setting in the cross-match with `TOPCAT`.