# Comparing Helmboldt selected PAPER sources with existing catalogs.

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Consider 65 sources measured in 4 10MHz channels in 16 antenna Green Bank data. The visibiliites are flux calibrated to 3c405 (cyg), phased to the source location and averaged in time to form a "beam" on the source that results in a flux measurement less contaminated by non-gaussianity than a model fit. With this large catalog one can start to ask questions like: How does the pgb catalog compare to other catalogs? or more exactly How does the difference between paper and other catalogs compare to the difference between existing catalogs. Existing catalogs at these frequencies are dominated by measurements at 151 (7c and 6c) and 178 (3c) so we will focus on the 150 and 170 MHz channels. PGB sources are selected from the Helmboldt catalog which is based on the VLSS catalog at 74 MHz. Helmboldt aggregates all available spectrum points between 10MHz and 33GHz, provides a fitted spectrum as well as a best-fit spectrum, the fit rms and number of components. Comparing hundreds of catalogs is difficult to do without error and indeed several irregularities in the Helmboldt spectrum data appear in the "anchor" nvss points included in the spectrum. By flagging and removing sources with high rms ($rms > log(1.25)$) and multiple components we can eliminate this variance and at the same time generate a source flag list to use on misbehaving sources from all other catalogs (Fig 1). In this comparison we do our comparisons with both the full catalogs and those sources that also have entries in the "well behaved" helmboldt set.

Each catalog has its own flux scale which will likely differ from the others. Thus the comparison methodology is to first solve for a linear transformation that scales the catalog in question to minimize the difference between the two (Fig 2). $F_{corr} = F_{meas}m + b$

The rms and distribution of the fractional error between the two catalogs tells us how we did (Fig 3).

The statistical standard of comparison between independent catalogs is set by the comparison between the 6th and 7th cambridge surveys at bottom of Fig 3. The effect of the Helmboldt flagging is most striking when applied to this comparison. While the error between the catalogs is over 80% even when the flux of 7c is corrected the Helmboldt flagged list of sources has a remarkably low average fractional error of 5% and requires less correction to get to the same flux scale. Against this error landscape we see that this initial paper catalog

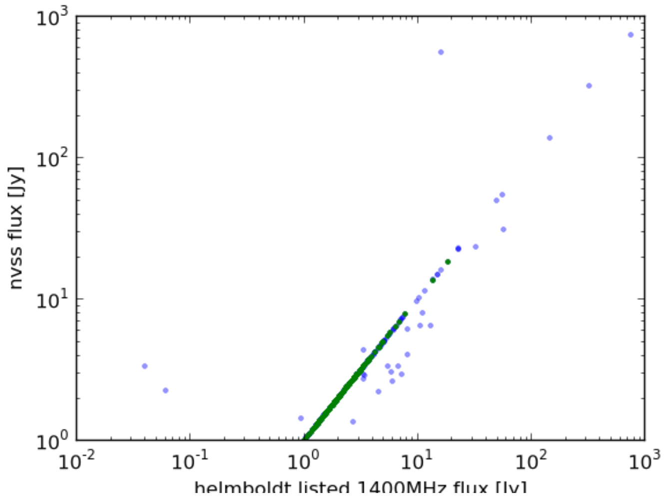



Figure 1: NVSS in Helmboldt vs NVSS from Vizier in blue. Several of these errors are related to "corrections" for the number of components listed in the NVSS data set but most are not of obvious origin. All sources with rms<log(1.25) and ncomp=1 in green agree exactly.

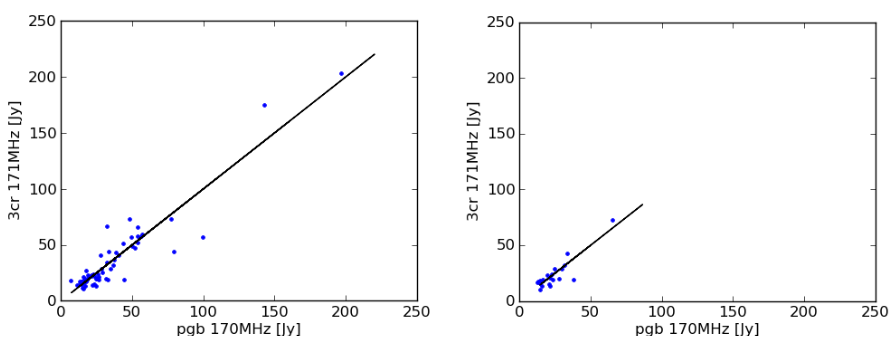
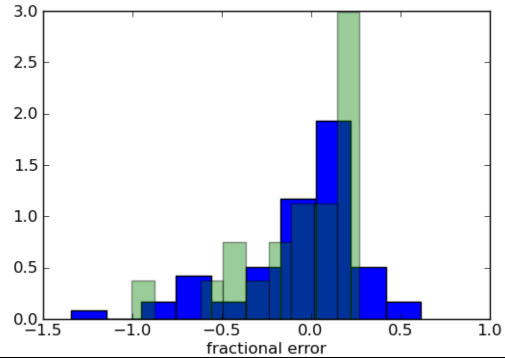
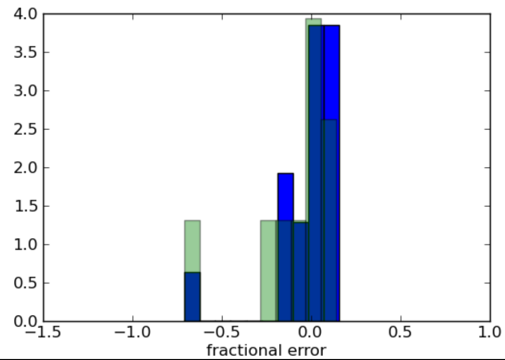



Figure 2: left: pgb16 170MHz helmboldt selected catalog compared against 3cr. Flux correction of pgb*0.89+0.55Jy has been applied to pgb to force agreement. rms fractional error: 0.57 right: pgb downselected for good fit in helmboldt. Flux correction of pgb*0.73+1.99Jy has been applied. rms fractional error: 0.37. Note that removing the high Helmboldt rms sources removes most sources above 50 Jys, significantly reducing the significance of the flux correlation.



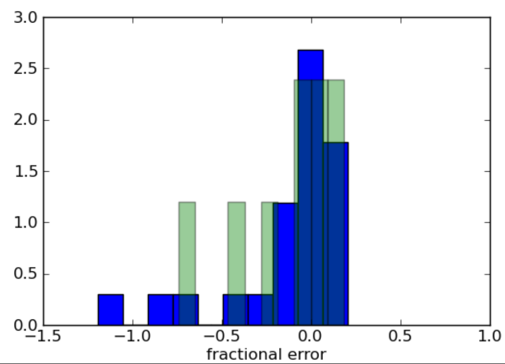

3CR-pgb*

| set | m | b | rms | N |
|---|---|---|---|---|
| all | 0.89 | 0.54 | 0.57 | 61 |
| Helm | 0.73 | 1.99 | 0.34 | 21 |



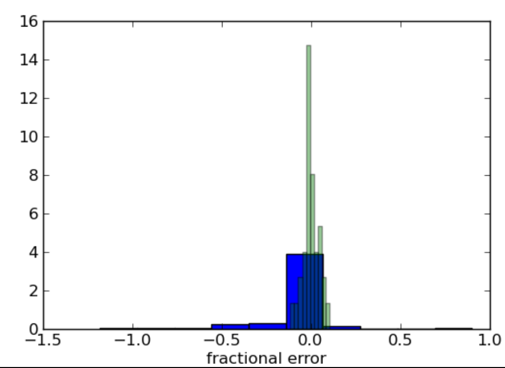

7C-pgb*

| | m | b | rms | N |
|---|---|---|---|---|
| all | 1.06 | -0.73 | 0.33 | 21 |
| helm | 1.24 | -4.69 | 0.28 | 9 |




6C-pgb*

| | m | b | rms | N |
|---|---|---|---|---|
| all | 0.80 | 5.98 | 0.41 | 24 |
| helm | 0.44 | 11.11 | 0.18 | 9 |




6C - 7C*

| | m | b | rms | N |
|---|---|---|---|---|
| all | 0.93 | 0.72 | 0.81 | 285 |
| helm | 0.98 | 0.27 | 0.05 | 34 |

Figure 3: Comparison between various reference surveys for all common sources (blue) as well as for sources having low rms and ncomp=1 as defined by helmboldt (green) starred catalog has been corrected, parameters listed in table. Left: distribution of catalog difference. right: best fit flux correction required to correct pgb (top 3) or 7c (bottom) to minimize difference with reference catalog, the average fractional error and the number of sources in the overalap. Note the significant positive effect of the helmboldt based downselection on the agreement between 6c and 7c.

fairs middlingly well, having an average fractional error somewhere between 40 and 60% before removal of helmboldt flagged sources and 20 to 35% after. Use of the Helmboldt flags is hampered here by the relatively low number of sources which are both well behaved according to Helmboldt, included in the PAPER set, and also surveyed by 6c or 7c.

Without application of the spectral fit information in Helmboldt we can only say that the pgb16 catalog has, on average half as much fractional error ~40% compared to the cambridge surveys then the cambridge surveys do between themselves. However when we exclude those sources known to have complicated spectral or morphological properties the cambridge surveys are found to agree with each other to within 5% while comparisons with the PAPER measurements enjoy only a small improvement.

## Conclusion

Using the Helmboldt et. al. spectral compilation meta-data we can select a "Class A" subset of sources which have a much better than average agreement between known catalogs. While this does not necessarily improve agreement between the current PAPER catalog and known catalogs, this is only partly because just 9 of the 35 Class A sources were measured for this catalog. Despite the low numbers the error in these 9 sources is larger than it should be by about a factor of 4.

| | |
|---|---|
| 14:47:08.5_+76:56:21 | J1447+766 |
| 10:11:45.7_+46:28:24 | J1012+463 |
| 15:41:45.8_+60:15:35 | J1542+602 |
| 13:42:13.5_+60:21:45 | J1342+602 |
| 18:07:48.3_+48:29:26 | J1808+483 |
| 15:35:01.6_+55:36:49 | J1535+554 |
| 14:21:05.6_+41:44:49 | J1421+414 |
| 15:24:05.7_+54:28:15 | J1524+543 |
| 09:39:24_+83:15.4 | J0939+832 |
| 16:04:12.8_+44:23:23 | J1604+442 |
| 11:45:43.4_+49:46:11 | J1146+495 |
| 07:09:18.1_+74:49:30 | J0709+745 |
| 08:57:39.9_+34:04:03 | J0858+340 |
| 02:38:02.2_+59:11:47 | J0238+591 |
| 16:28:53.4_+44:19:06 | J1629+442 |
| 12:20:33.3_+33:43:09 | J1221+334 |
| 15:20:47.4_+72:25:05 | J1521+723 |
| 10:14:15.1_+74:37:38 | J1014+744 |
| 14:06:43.5_+34:11:19 | J1407+341 |
| 15:49:58.5_+62:41:23 | J1550+624 |
| 11:11:31.8_+35:40:42 | J1112+354 |
| 11:14:38.4_+40:37:18 | J1115+404 |
| 18:19:04.2_+50:31:04 | J1819+503 |
| 17:10:44.9_+46:01:30 | J1711+460 |
| 11:45:29.2_+31:33:41 | J1145+313 |
| 10:58:58.6_+43:01:20 | J1059+430 |
| 12:09:13.8_+43:39:22 | J1209+434 |
| 17:04:42.2_+60:44:43 | J1705+604 |
| 08:01:35.4_+50:09:46 | J0802+501 |
| 14:49:21.6_+63:16:14 | J1449+632 |
| 09:22:50.2_+53:02:21 | J0923+530 |
| 13:45:26.7_+49:46:35 | J1345+495 |
| 12:15:29.7_+53:35:52 | J1216+534 |
| 09:12:01.9_+37:51:32 | J0912+375 |

Table 1: Class A sources in truncated position name and J2000 VLSS type name. These sources are available in Helmboldt (VLSS with decent spectra), 7c and 6c.

| | | | |
|---|---|---|---|
| J1027+063 | J0051+511 | J0713+115 | J0353-071 |
| J0728+144 | J1645+131 | J1630+232 | J2119+182 |
| J1542+602 | J0334+741 | J2014+233 | J2231+541 |
| J2147+152 | J0835+141 | J0714+144 | J0853-205 |
| J0327+552 | J2144+281 | J0036+184 | J0025-293 |
| J1347-080 | J1209+434 | J2341+043 | J0937+042 |
| J1146+495 | J0003-173 | J1115+404 | J2151+143 |
| J1604+442 | J0155+435 | J1216+534 | J1123+053 |
| J1106-211 | J1449+632 | J2321-162 | J0748-192 |
| J1808+483 | J1221+334 | J0805+102 | J0118+026 |
| J2033+535 | J0351-143 | J0645+212 | J0234+313 |
| J1342+602 | J1002+285 | J0455-203 | J0403+746 |
| J1357+010 | J0412-006 | J0334-011 | J1629+442 |
| J0614+260 | J1625+235 | J0216-126 | J2108+494 |
| J0413+745 | J1705+604 | J1145+313 | J2129+073 |
| J0853+135 | J0355+725 | J0400-161 | J0020+154 |
| J0952-000 | J1834+473 | J2118-302 | J0034+392 |
| J0434+723 | J0136+206 | J0815-031 | J0725-094 |
| J2203+624 | J1423+194 | J0912+375 | J2346+656 |
| J0809-103 | J1306+086 | J1012+463 | J1711+460 |
| J1846+095 | J2312+092 | J0520+505 | J0858+275 |
| J0907+165 | J0827-203 | J1517+070 | J0455-301 |
| J1550+624 | J2354+326 | J1014+744 | J2048+070 |
| J0447+504 | J0035-200 | J1407+341 | J2020+294 |
| J2118+605 | J1206+041 | J1524+543 | J2123+170 |
| J2131-204 | J0059-170 | J0622+143 | J0744+375 |
| J0310+171 | J2022+100 | J1121+233 | J1143+221 |
| J2359+440 | J0108-160 | J0643+232 | J0950+142 |
| J0709+745 | J1447+766 | J1112+354 | J0939+832 |
| J0944+095 | J0858+340 | J1254+154 | J1644+172 |
| J1150+125 | J0827+292 | J2104+763 | J0923+530 |
| J1338-063 | J0802+501 | J1134-195 | J1620+174 |
| J1315-186 | J1521+723 | J0446+395 | J1425-296 |
| J1730+795 | J1535+554 | J0453+313 | J1429-012 |
| J0338+505 | J0128-140 | J1059+430 | J1102-012 |
| J1819+503 | J1134-173 | J0542+473 | J0531+063 |
| J0503+252 | J1345+495 | J1355+161 | J0627-055 |
| J0527+325 | J0038+132 | J0112+144 | J0511-184 |
| J0238+591 | J2325-121 | J1605-173 | J1759+133 |
| J2206+293 | J0110+315 | J0802+141 | J1421+414 |
| J1646+021 | J0821+181 | J0041+331 | J0522-205 |

Table 2: The high quality Helmboldt sources. Those having rms<log(1.25) and ncomp=1. 164 out of 388 have passed this cut