Data quality checks in TGSS images

Compiled by NGK for TGSS team - based on several discussion in the team

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The TIFR GMRT Sky Survey (TGSS) is being conducted at 150 MHz using the Giant Metrewave Radio Telescope (GMRT) near Pune. The survey will cover the entire sky north of declination of -35d and will be the most sensitive survey at this frequency.

We have been devising and running some tests on these data as listed below. CUrrently these tests have been carried out on the 36 fields on which we have been trying to understand the various effects due to ionosphere and system.

1. Position offsets - comparing with NVSS.
2. Flux density offsets - we plot the (1) spectral index distribution (2) spectral index versus TGSS flux density (3) differential N $\rightarrow$ S plot - these could be due to a number of reasons such as (a) primary beam correction (b) calibrator flux scale problems (c) Tsys correction (d) any antenna related issues.
3. Non-isoplaniticity - plot the angular distance of TGSS coordinate from the phase centre of the same field against the difference in the TGSS and NVSS coordinates.
4. Dependence of HPBW on declination or other parameters - this will be subsequently checked for when more fields are imaged.

The list of checks that we have been conducting on the data are as follows:

1. Visual inspection of images
2. Contour maps of extended sources (sources $>$ 30 arcsec) superposed on NVSS.
3. Comparing GSB images with GHB images.
4. Positional offset (TGSS, NVSS) and distance from phase centre (non-isoplaniticty, offset in RA, dec, offset between adjoining fields which are co-added). Uses catalogues.

5. Flux density scale: differential N $\rightarrow$ S plots for each field. Uses catalogues.

6. Flux density scale: log N $\rightarrow$ log S plot (for all fields together if possible). Uses catalogues.

7. Flux density scale: Spectral index (TGSS, NVSS) distribution. Uses catalogues.

8. Tsys correction from Haslam et al. 408 MHz map, if required. This correction is applied only if the correction factor differs by $\geq 10\%$.

9. Flux density and positions of sources located in different parts of the primary beam are examined in adjoining primary beam corrected images.

10. Examining the TGSS sources that are not detected in NVSS.

The above list of checks with the results we have obtained on the 36 co-added images which were released for GTAC in July 2010 are listed below:

1. **Comparison of sources > 30" (TGSS) with NVSS for GHB, GSB and GHB+GSB:** The correlation is fairly good. And the NVSS sources are resolved by TGSS. Some images show a positional offset between GHB and GSB and with NVSS - we are looking into the reasons. (e.g. R58D17-30arcsec-src.ps)

2. **Positional offsets:** Since the TGSS images are phase self-caled, this can result in position errors in the image plane. We find that in many cases the positional error in the images made with GHB data, GSB data and when compared to NVSS appears to be about 10". The maximum errors can be larger than this, whereas the lower limit can be fairly close to 0". Some plots shown here quantify this. (e.g. R58D17.cat4.ps - the offset is fairly small), (e.g. R57D16.cat4.ps - the offset is large in the central parts of the beam and then tapers off. We have traced this to an offset in the images which are randomised when co-added with neighbouring images). (e.g. R42D18.cat4.ps - the offset is small in the central parts, but the scatter increases in the co-added parts of the beam. This could be due to a position offset in the neighbouring fields or could be due to non-isoplaniticity effects. The latter can be

ruled out if the neighbouring field does show an offset which can explain this. In some cases, we find that in the co-added regions, the sources are elongated and this has clearly been traced to an offset in the neighbouring field)

(field-offset-TGSS-NVSS.ps)

3. **Flux density scale: 1. Differential source count** (NvS-R4.ps, NvS-R5.ps) We plotted the differential source counts to check for (1) flux density upto which our catalogue is expected to be complete. As quoted by us, the value is 40 mJy. In some fields, the completeness limit might be lower but as a whole including the pointings close to the Galactic plane, the catalogue will be complete to 40 mJy. (2) This suggests that our flux scale might not have large errors. However we need to test it more quantitatively and on a larger number of fields. Moreover we have extensive data on 3C48 and 3C286 which can be used to derive any system correction which might be required.

   Spectral index distribution We estimated spectral indices of the TGSS sources which have a NVSS counterpart and plotted the distribution. e.g. (a) R41D16.cat4.ps - mean spectral index is -0.54. The distribution of several of the R4* fields seem to have a mean spectral index of -0.5 to -0.55 which is somewhat flatter than the -0.75 to -0.8 expected for extragalactic radio sources. The reasons for this could be (1) flux density scale error in TGSS which would underestimate the 150 MHz flux densities In a few cases, we do find that the flux scale obtained from 3C48 and 3C286 differ. (2) Possible Tsys correction which underestimates 150 MHz flux densities - we have extrapolated the Tsky from the Haslam et al. 408 MHz map using a temperature spectral index of -2.55 and a half power beam of 173 arcmins. (3) it appears that the lower flux density TGSS sources are biasing the spectral index to lower magnitudes - for example if we put a cutoff on the TGSS flux density at 40 mJy, then the mean appears to shift to larger magnitudes but still falls short of the expected. This could be because we are not sensitive to any diffuse emission around the weak sources. The spectral index distribution shifts to negative spectral indices for stronger sources. We are investigating the possible causes for this behaviour.

(b) R56D17.cat4.ps - mean spectral index -0.67 after Tsys correction.

(c) R56D15.cat4.ps - mean spectral index is -0.74 after Tsys correction.

(spectralindex-field.ps - shows the mean spetral index of the 36 fields.)

4. **Sources common in adjoining pointings** We compared the flux densities and positions of a few sources in primary-beam corrected images which were common to neighbouring pointings and were located in the outer parts of the beam. On the average we found that the positional offsets are present but appear to be < 10" - ie less than 0.5 seconds in RA and less than 8" in declination. The integrated flux densities match to within 10% for many sources - however for a few sources, a variation of about 30% is also noted. We also note that this exercise has not been done systematically on all the fields which we plan to do. However we have to note that the integrated flux densities in the outer parts of the beam will also depend on the local noise which will increase in the outer parts where this comparision is done. In the final co-adding of the images the position offset and the flux density scale will be examined in detail and then applied.

5. **TGSS sources not detected by NVSS** We also are trying to examine the TGSS sources that are not detected by NVSS. SOme of these are likely to be (1) sidelobes of strong sources which are wrongly being identified as TGSS. In later versions of the catalogues we aim at providing a flag for the same (2) some weak sources might be spurious artifacts (3) some of them might be steep spectrum sources. We find no correlation between a large number of sources missing a NVSS counterpart to the strongest source in the field indicating that sidelobes might not be the only reason for this. The fraction of TGSS sources which do not show a NVSS counterpart vary from about 15% of the total TGSS sources to more than 35% as shown in the figures. (missing-NVSS-counterpart-percent.ps, missing-NVSS-counterpart.ps) We are continuing our efforts to understand this.