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ASKAP Commissioning Update, July 2019

In this issue, we report early results from imaging the Rapid ASKAP Continuum Survey (RACS). We also describe the latest data release on CASDA and improvements to spectral index measurements derived from Taylor term imaging in ASKAPsoft.

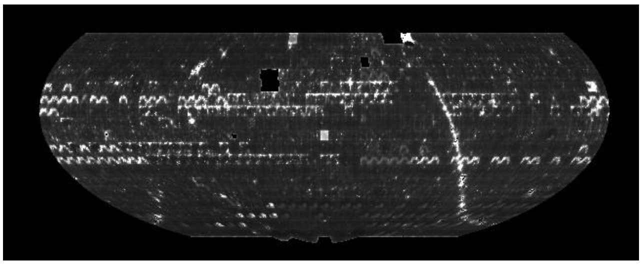
RACS data processing report

In the May issue of this newsletter, we reported that the first pass of RACS had been observed (except for the polar cap and a few fields at the position of the Sun). Over the last two months, the ASKAP team (led by Julie Banfield and David McConnell) has been running RACS visibility data through the ASKAP image processing pipeline, using a parameter set optimised for 15-minute fields.

For this first processing attempt, all fields were imaged with the same set of parameters. The goal was to obtain an initial estimate of data quality and performance. After some experimentation and optimisation, we have been able to achieve roughly real-time processing rates. This means the full survey can be calibrated and imaged in about 2 weeks from start to finish. We are now analysing the results of this first attempt.

Extended emission and improved flagging

The map of RMS noise in each observed field (below) shows that most of the data responded well to the default processing parameters, meeting our target noise level.



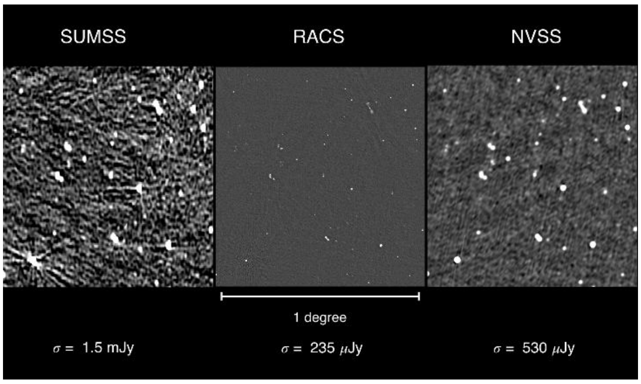
RMS map of the RACS observations, showing that we achieve the expected 250 uJy RMS across most of the sky, except for areas containing significant extended emission like the galactic plane, and some scheduling blocks that were impacted by systematic errors.

However, the RMS map also highlights two aspects of the survey that require improvement. The Galactic plane is clearly visible in the RMS map (especially the Southern portion) and this was expected due to the presence of significant extended structures containing flux on large spatial scales. Our default imaging approach did not use multi-scale CLEAN and we therefore expected increased artefact levels around bright extended sources. Tests show that the addition of larger CLEAN scales can improve the noise level in these fields significantly and we will re-process these fields accordingly.

The second issue is the presence of increased noise with structure on the scale of individual beams that repeats for multiple fields. A quick analysis shows correspondence between the grouping of these artefacts and the scheduling block in which they were observed, suggesting either a common calibration issue or poor performance due to sub-optimal beam weights (as these are currently kept fixed during any given scheduling block).

Further inspection shows that we are likely impacted by the inclusion of certain beams and channels on some antennas that should have been flagged by the control system. We will re-process all such data with improved flagging, which will hopefully reduce the noise level.

RACS was our first large-scale attempt at an all-sky survey and we are pleased that most of the data appears to be of high quality. The image below compares a typical RACS image to SUMSS and NVSS, the previous best surveys. RACS clearly has superior sensitivity and resolution, meeting our goal of making it the new benchmark in radio continuum surveys around 1 GHz.



Comparison of image quality in a typical RACS observation with previous surveys, showing that RACS has better sensitivity and resolution.

The experience gained with RACS will help improve the reliability of future survey observations and data processing. We intend to make data from the first RACS epoch available as soon as possible, likely starting with the images themselves once suitable quality control has verified the flux scale and astrometry to a quantifiable degree. The images will later be supplemented with source catalogues and eventually large mosaics across multiple tile boundaries, creating a smooth image of the whole survey area as well as a global sky model.

Spectral index calculation

As reported last month, the GAMA23 test field data release highlighted an issue with the way that ASKAPsoft was calculating spectral indices for sources obtained via multi-frequency synthesis using Taylor term imaging. The mean spectral index in the source catalogue was significantly steeper than expected for sources at this frequency. Subsequent investigation has revealed two problems that should be solved in the next release.

Correction to TT1 primary beam model

The first improvement is one that was highlighted by ACES members several years ago (see Josh Marvil's memo). The primary beam correction done to higher-order Taylor terms needs to be different to that done to the zero-order term, and this was not being accounted for.

The correction described in the memo had been implemented but needed testing before being enabled. This work has now been completed and tests show that the resulting spectral indices are much closer to expectations.

Residuals in TT1 images

Testing the improvement described above led to the discovery of another issue.

We found that residual images in TT1 had not been properly scaled for coupling between the other Taylor term images, although the cleaned components were. This means that consistent spectral indices are found if the cleaning is deep enough, but not if there is significant flux present in the residual image. This problem was more difficult to track down and fix, but the next release of the software should correctly scale the residuals.

Estimating a meaningful uncertainty for the spectral indices derived in this way remains challenging and users should be aware that values quoted for sources close to the detection threshold have low precision. Uncertainties on spectral index values are given in the Selavy source catalogue as the error arising from the fitting process, but this does not capture systematic effects.

Latest additions to CASDA

The ASKAP team continues to process test observations requested during preparations for pilot surveys. The latest release on CASDA is a 4-tile continuum image of the Large Magellanic Cloud field. We hope to release images and catalogues of the GAMA12 field very soon as well.

LMC continuum image release

The LMC is a complicated field, containing many supernova remnants as well as 30 Doradus, the most active star-forming region in the local group. We have observed this field in spectral line mode to image its neutral hydrogen emission, but we also observed in continuum mode with 1 MHz channels to assist in the calibration of the spectral line data. The continuum image is itself spectacular and has now been released on CASDA. It can be found by searching for scheduling block 8532.

Comparison of LMC optical image from DSS observations (left) and the ASKAP continuum image (right) showing remarkable correspondence, with similar structures visible in both.

Finally, a revised version of the ASKAP science observation guide is now available on the science team confluence pages. This version includes more information about ASKAP's polarisation conventions, and many other improvements requested by the science community.

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