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ASKAP Commissioning Update

In this issue, we focus on recent efforts leading up to the release of several ASKAP early science continuum observations via the science data archive. This work included tuning the imaging pipeline and developing a suite of quantitative diagnostic parameters that give the user an idea of the science readiness of commissioning data.

Intensive effort to tune default ASKAP imaging pipeline parameters

One of the major components of ASKAP is the Science Data Pipeline (SDP), an extensive suite of software and associated scripts. In its final form, this pipeline will be triggered automatically at the end of an observation and then operate autonomously to produce science-quality images, cubes and catalogues from raw visibility data.

During early science, the pipeline will be extensively tested so that we can determine the best imaging parameters to use. Processing jobs will initially be launched by an operator, and the output inspected by hand. Because we are keeping the raw visibility data from the 12-antenna early science array, there will be a chance to perform multiple passes and iteratively improve the science data output.

The continuum processing challenge

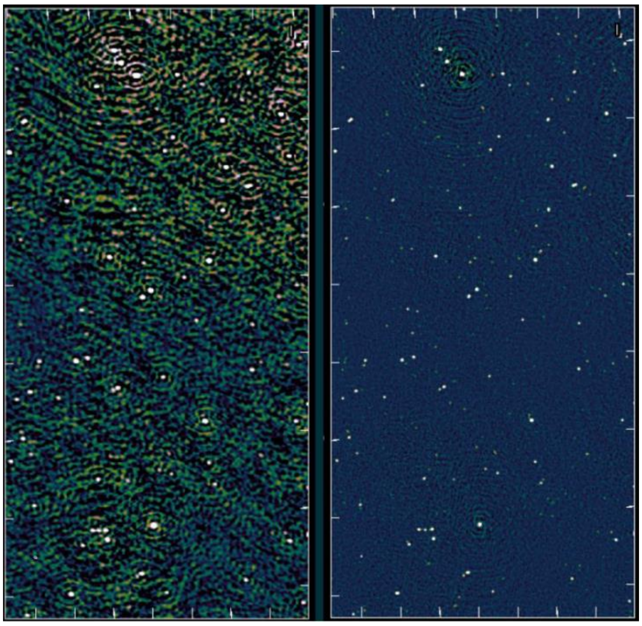
Synthesis imaging involves multiple stages – data must be flagged, gridded, calibrated, imaged and mosaiced to obtain a final map of the full field of view from multiple beams and potentially multiple interleaved fields. These steps can be carried out using a variety of different algorithms, each of which can be tuned with a suite of input parameters.

To develop a processing strategy for early science data, we first selected an example observation and issued a challenge to members of the ACES team – produce the "best" possible continuum image within the constraints of the algorithms available.

This first data challenge involved a 12-hour observation (SB2338) of a field surrounding NGC7232 using a single correlator block (48 MHz of bandwidth) and 36 beams in a 6x6 square configuration, observed on the 18th of October 2016. These files can now be downloaded from CASDA.

After much discussion and iteration, the most successful strategy involved a combination of Hogbom CLEAN and phase-only self-calibration (see the image to the right).

Subsequent use of the new pipeline parameters to process several additional observations of the same field have produced similar results and led to further slight adjustments aimed at reducing the chance of divergence in the self-calibration loop.



A section of the NGC7232 field from scheduing block 2338, before (left) and after (right) the updated pipeline parameters.

Investigating early science data

Although the default pipeline parameters now produce a reasonable continuum image over the full field of view for most of the available early science data, ongoing tests have revealed several remaining issues.

Source position offsets

The most pressing issue is a significant (and variable) offset in the mean source position as measured by ASKAP with respect to existing catalogues (NVSS and SUMMS).

The exact cause of these offsets is unknown, though many theories have been raised and several people are working to narrow down the possibilities, which include ionospheric variations, un-modelled sources in the calibrator field and differences in antenna elevation between the calibrator and science observations.

ACES members have developed a method to correct for these position offsets by referencing the ASKAP field to an existing catalogue, but it would still be worthwhile to understand their cause.

Primary beam correction

Another issue is the amount of dispersion in the observed flux ratios when comparing an ASKAP field to NVSS or SUMMS. This is likely a result of our primary beam correction, which currently assumes that each antenna and each beam has an identical Gaussian profile. Holography observations have shown that this is not the case – the current beamforming algorithm optimises for sensitivity and places no constraint on the shape of the beam, which can result in ellipticity, particularly near the edge of the field.

We are investigating two alternative beamforming methods that improve the consistency of beam shapes, though both are likely to impose a sensitivity penalty compared to the current approach.

In addition, we are investigating ways to use holography data to improve the accuracy of the models used for primary beam correction.

Supporting additional bandwidth

We have also tested the SDP on several more recent observations with 192 MHz of bandwidth. Although the initial results are promising, there are a few issues to address before the data can be released.

The main issue is that to determine the spectral indices of weak sources, we need to perform Taylor term imaging. While ASKAPsoft supports this, the current algorithms are not converging swiftly. It seems that the preconditioning step used to improve the efficiency of the pipeline leads to degeneracy between the spectral index and curvature terms. While alternative algorithms are known, it will take some time to determine the best approach. We need to consider how to support early science (with its reduced sensitivity and UV coverage) and full ASKAP without significant additional software development.

Another issue is the need to do frequency-dependent primary beam correction when making the final mosaic. While this has now been implemented, it needs to be tested (ideally after the Taylor term imaging problem has been resolved).

Imaging extended structure

In addition to the NGC7232 test field, we have been using observations of the Large Magellanic Cloud as a test case. This is a more challenging target due to the presence of significant extended structure, but the default SDP parameters still do a reasonable job. The much-improved UV coverage of ASKAP-12 makes a clear difference when compared to early BETA images of the same LMC field, but we would like to address the bandwidth-related issues described above before releasing these observations.

Validation and testing

Due to the volume of ASKAP data that will be produced (even during the early science phase), we have been developing a secondary pipeline designed to automatically assess various aspects of image quality. The idea is to run this validation pipeline on the output of the SDP to quickly determine whether the operator needs to step in or flag more serious issues.

In developing this validation pipeline, we realised that it would be useful to include several quantitative metrics (described in more detail here) in the package uploaded to the science data archive.

Updates to CASDA

On the 29th of June 2017, the CASDA development team released a new version of the archive software that supports quantitative validation metrics. The parameters included in the validation report are visible to the person responsible for approving data for public release, and are also searchable in the final database.

Feedback required

Following the CASDA update mentioned above, we uploaded and released several of the NGC7232 48 MHz observations. We encourage all SSTs to experiment with these data and bring feedback to the early science forums held on the third Tuesday of each month.

CONTACT US
t 1300 363 400
+61 3 9545 2176
e csiroenquiries@csiro.au
w www.csiro.au

FOR FURTHER INFORMATION
CSIRO Astronomy and Space Science
Aidan Hotan
t +61 8 6436 8543
e aidan.hotan@csiro.au
w www.csiro.au/askap