# Starlink Software in 2013


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### Starlink Software Collection

The Starlink Software Collection is an open-source software project hosted on github that has been in constant development since 1980 (Disney & Wallace 1982). Although the Starlink Project was closed in 2005, Starlink software continues to be developed and supported by the Joint Astronomy Centre for its and its users' data-reduction requirements.

This poster outlines the key changes relative to the previous *Kapuahi* release detailed in an ADASS paper (Berry et al. 2013).

### 64-bit Integer Support

Data sets have continued to grow in size and the need for 64-bit integers has become more important. The *Herschel t*elescope generated data products with 64-bit integers and people attempted to convert these files into Starlink NDF format (see Poster P91 for an overview of NDF), with little success. Historically we had been reticent regarding the addition of support for 64-bit integers given varied Fortran compiler support for the `INTEGER*8` data type and requiring C99 compilers for a guaranteed 64-bit data type in C (`int64_t`). With modern compilers this is no longer an issue and type `_INT64` was added to the Starlink file format (HDS) and the application code dealing with multiple types was consistently modified to use code automatically generated by the GENERIC application. This required that many generic source files were re-generated from the derived files which had been committed during the switch to a unified revision control system back in 2005 (Gray et al. 2005).

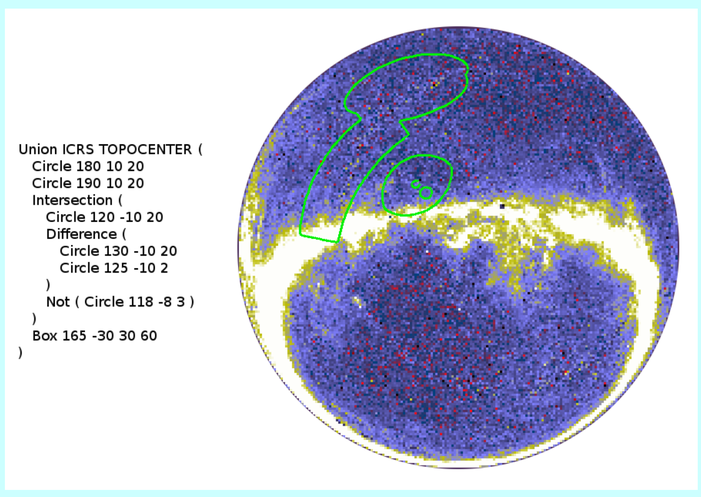
### Applications Updates

Applications such as CONVERT, CCDPACK, and KAPPA all automatically received the ability to process data with 64-bit integers.

**GAIA (data visualisation and analysis)**

A new toolbox was added for overlaying STC-S regions on an image. There is an example below.

It is now possible add local colour and intensity maps.




**KAPPA (general-purpose commands)**

Two new commands report the values of configuration parameters from a text file (using the standard configuration format supported by the GRP library) or NDF file history, and also to expand file lists.

Features were added to about twenty commands such as the following.

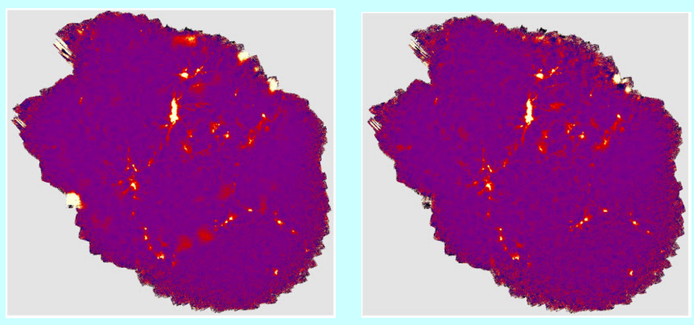
- BEAMFIT offers more control on the initial or fixed sizes and shapes of the beams.
- CHANMAP, COLLAPSE, and MSTATS have four new estimators which produce the fraction or count of good or bad array elements.
- NORMALIZE permits normalisation against a single row or column when comparing two two-dimensional NDFs.

### POLPACK (polarimetry)

A new command POLROTREF has been added to rotate the reference direction of a pair of *Q* and *U* images. POLVEC omits vectors from positions that have negative total intensity.

### SMURF (sub-millimetre data from JCMT)

The main focus of the *Hikianalia* release was to support the reduction of data from SCUBA-2 (Chapin et al. 2013; Holland et al. 2013). In particular a new approach to map-making was developed whereby all data are involved in each iteration rather than iteratively processing small chunks and co-adding them all at the end. An example of this so-called *Skyloop* or inside-out algorithm is presented below.



The left panel shows an example reduction of a SCUBA-2 continuum image without the SKYLOOP technique. The right panel shows the same data after application of SKYLOOP. Notice many diffuse false-emission blooms and bright edge features now disappear. SKYLOOP helps distinguish noise from true emission. (Images courtesy of Harriet Parsons.)

There was a rationalisation of the various standard configuration files for different classes of data, adjusting to current best practice.

Multiple masks can now be specified.

Scuffs arising from one or more sub-arrays entering into a higher noise state for a period of time can be removed with the new `NOI.BOX_SIZE` parameter to set to half a sub-scan.

**SPLAT (spectrum analysis)**

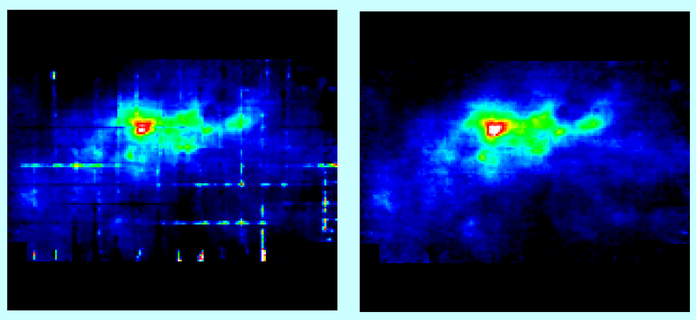
This has improved support for SSAP queries, with server grouping and new metadata parameters (see Dolensky & Tody 2004 for a protocol introduction).

### ORAC-DR (data-reduction pipeline)

*SCUBA-2 & `PICARD`*: A number of data-quality analysis recipes have been added that allow an assessment of the properties of SCUBA-2 data.

- Instrumental noise—This helps identify excessively noisy data that can be excluded from the map-maker (`ASSESS_DATA_NOISE`).
- Calibration consistency—Calculate flux-conversion factors and beam sizes of standard sources to check calibration quality (`SCUBA2_CHECK_CAL`). This includes fitting of the source peak for FCF calculations now attempts to fit two Gaussian components for high (100) signal-to-noise ratio images of calibrators.
- Output map noise—Calculate the noise and NEFD from the map, compare with those derived from noise calculations and the SCUBA-2 integration-time calculator (`SCUBA2_CHECK_RMS`). Calculate the spatial power spectrum and determine noise power on scales up to a high-pass filtering scale (`SCUBA2_MAP_PSPEC`).

*Heterodyne*: Further improvements to the detection of bad spectra (Currie 2012) include automatic emission detection or user-defined regions to excise emission from non-linear baseline detections, a filter to identify spectra with ringing (the same oscillation pattern appears in varying strength over tens of contiguous time series). Different options are now available to determine the receptor-to-receptor flat field.



Reduced HARP cubes integrated along the spectral axis over the source emission in L1448. The left panel shows the effect of ringing, which although much weaker extends over many more spectra than the common noise interference; and relative receptor sensitivities. The right panel has the affected spectra excised and a flat field applied.

The ACSIS/HARP pipeline can now process most data from the earlier DAS backend, arising in part from better merging of hybrid data, instrument-specific quality assurance criteria, and baseline correction in line forests.

Although the goal is to provide high-quality results automatically for the JCMT Science Archive, many new tailoring recipe parameters, su.ch as to control memory requirements and the creation of a longitude-velocity image, have been added.

### Libraries:

**AST (objected-oriented WCS)**

This library (see Berry & Jenness 2012 and references therein) can now read FITS headers that use the SAO convention for representing a distorted TAN projection, and can now handle missing `CNPIX1` and `CNPIX2` keywords in DSS headers. There were also modifications to flux conservation and normalisation in the rebinning routine.

**NDF (extensible hierarchical data model)**

The NDF library will now limit the maximum size of an NDF section. There have also been efficiency improvements in the way that provenance information is stored.

### References:


Berry, D.S. et al. 2013, ADASS XXII, 247
Berry, D.S. & Jenness, T. 2012 ADASS XXI, 825
Chapin, E.L. et al. 2013, MNRAS, 430, 485
Currie, M.J. 2013, ADASS XXII, 341
Disney, M.J. & Wallace, P.T. 1982, QJRAS, 23, 485
Dolensky, M. & Tody, D. 2004, Proc. SPIE, 5493, 262
Gray et al. 2005, ADASS XIV, 119
Holland W.S. et al. 2013, MNRAS, 430, 2513


### Links:

Starlink home page: **www.starlink.ac.uk**
Starlink github repository: **github.com/Starlink/starlink**
ORAC-DR: **www.oracdr.rog**
Joint Astronomy Centre: **www.jach.hawaii.edu**
AST: **www.starlink.ac.uk/ast**
GAIA: **star-www.dur.ac.uk/~pdraper/gaia/gaia.html**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