APERTIF DR1 - Data Quality

Continuum image quality

All released continuum multi-frequency synthesis images have passed validation, ensuring that they meet the resolution requirements, minimum sensitivity requirements, and have no significant image artifacts, as described in “Validation of processed data products: Continuum”.

The noise values for all released continuum images are shown in Fig. 14. The left panel shows the noise distribution on the inner part of image (inner hereafter) where many sources are detected. On the right panel the noise of the outer part (outer hereafter), which is typically source-free, is considered (see “Validation of processed data products: Continuum” for more details). The median values (41.4 and 36.1 uJy, respectively) are indicated by the solid lines. The dashed lines and numbers in parentheses indicate the noise values that bound 68% of all values around the median. The median value of the inner noise is slightly larger; this is because the inner part of the image has sources and may still have minor artifacts. The outer noise represents the theoretical best that can be achieved with perfect imaging. The median outer noise is 36.1 microJy/beam and the best achievable (5th percentile) is 29.3 microJy per beam.

The noise values skew to higher values from the median. This is likely because some images may still have minor imaging artifacts. Any issue affecting image quality will only ever increase the noise of an image.

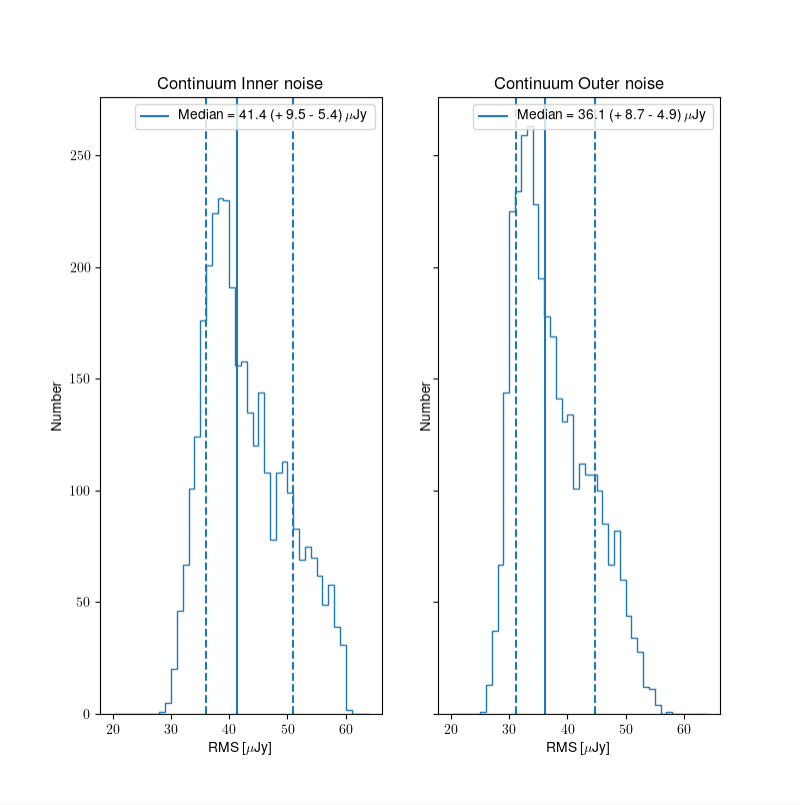

Fig. 14 Noise distribution for all relased images in the inner (left) and outer (right) part of the continuum images.

Polarization data quality

All processed data products are released based on the continuum validation (see “Released processed data products”). Thus, some polarization images and cubes may be released that do not pass their own validation. However, this is a small number of images/cubes and they may still be useful (see “Validation of processed data products: Polarization” for more details).

Fig. 15 shows the distribution of inner and outer noise for the Stokes V mfs images. Both all released images (3374) and only those that pass validation (3198) are shown. Very few polarization images fail the polarization validation after passing the continuum validation. This is to be expected as the validation criteria are very similar and the continuum and Stokes V mfs images should generally have similar quality to each other. There is no appreciable difference in the noise distribution between all released images and those that pass validation.

The same qualitative trends are present as for the continuum noise; the outer noise is lower than the inner, and the distribution of noise values is skewed to higher noise values, due to the presence of low level artifacts that increase the noise. Overall, the noise in the polarization images is lower than the continuum; this is likely because the Stokes V images are essentially empty.

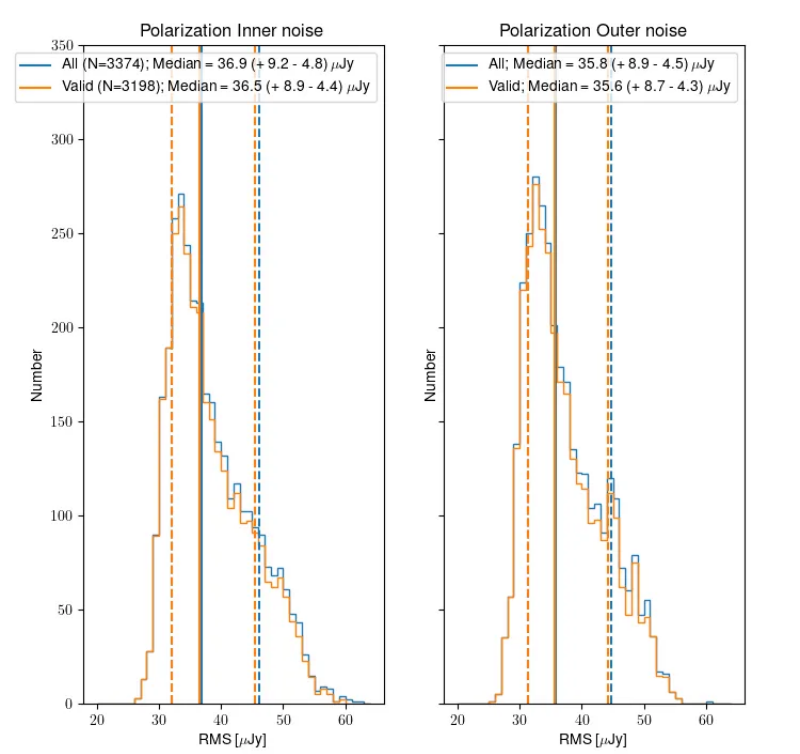

Fig. 15 Noise distribution for all relased (blue) and valid (orange) Stokes V multi frequency images, in the case of the inner (left) and outer (right) part.

Line data Quality

Line cubes are released for a beam if the continuum image passes validation; thus some of the line cubes may fail their validation. The line cubes are classified as “good”, “okay” or “bad” depending on the severity of the artefacts in the line data, as detailed in “Validation of processed data products: HI”.

Fig. 16 shows the distribution of noise for cubes 0, 1 and 2. All released cubes are shown, plus split separately into the good, okay, bad categories. The median noise over all released cubes is 1.62 mJy/bm. The median noise decreases slightly as the cubes increase in frequency; this is consistent with the RFI environment being worse at lower frequencies. As is to be expected, the median noise for good cubes is better than for the okay cubes, which are better than the bad cubes. The best achievable noise (5th percentile, cube 2, only good) is 1.32 mJy/beam.

As with the continuum and polarization noise distributions, the distribution has a longer tail to higher noise values; this is because image artifacts and bad frequency ranges will only ever increase the noise.

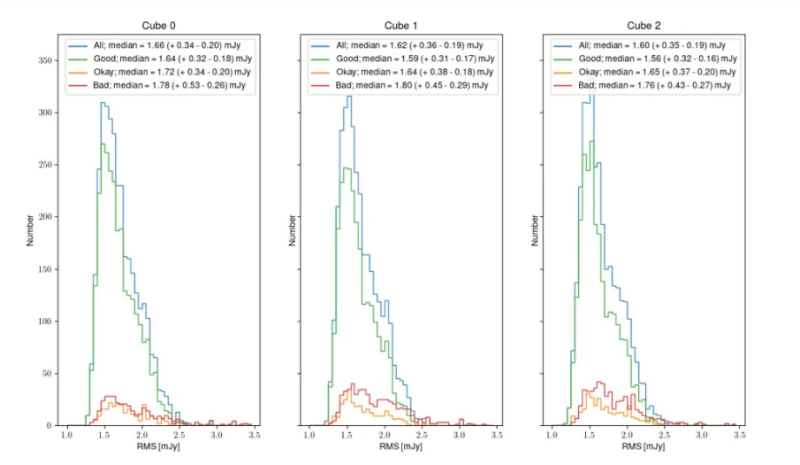

Fig. 16 Noise distribution for all relased (blue), Good (green), Okay (orange) and bad (red) HI line cubes for cube 0, 1 and 2.

Data quality per compound beam

The above views of data quality combine all released observations, across different compound beams. However, the behavior of different compound beams is not identical. Specifically, the outer compound beams illuminate the edge of the field of view and thus may be expected to have a reduced sensitivity. For reference, Fig. 17 shows the compound beam layout, with colors indicating the expected sensitivity based on the forward gain of an Apertif phased-array feed (PAF).

Fig. 18 shows the normalized average noise (over all continuum images) in the compound beam layout. The beams on the edge of layout have higher average noise values, consistent with the picture that the overall sensitivity falls off. Fig. 19 quantifies this by showing the normalized noise as a function of distance from the pointing center of the PAF; the increased noise values track with distance.

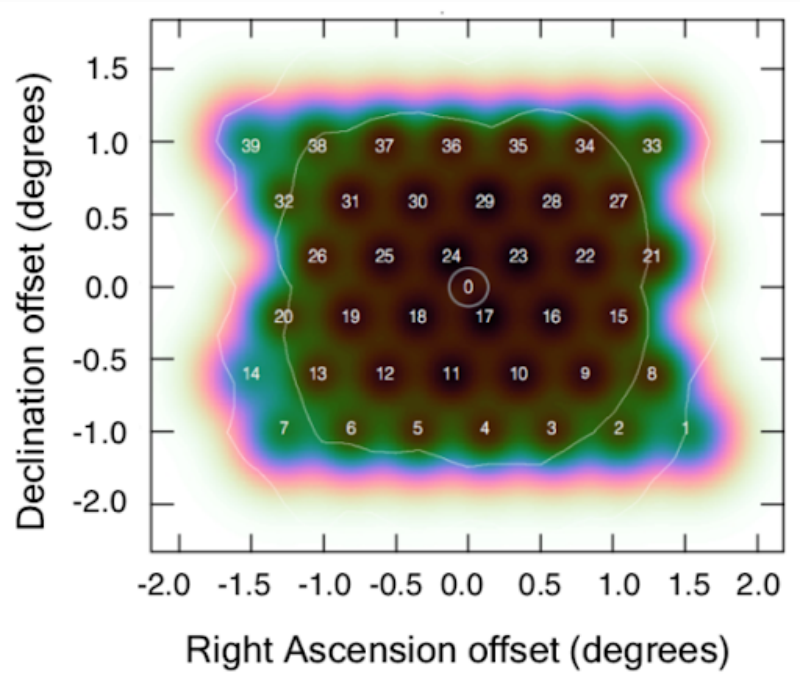

Fig. 17 The compound beam layout for Apertif. Blue is at about the 50% level; transition between black/brown to green is at about the 85% level.

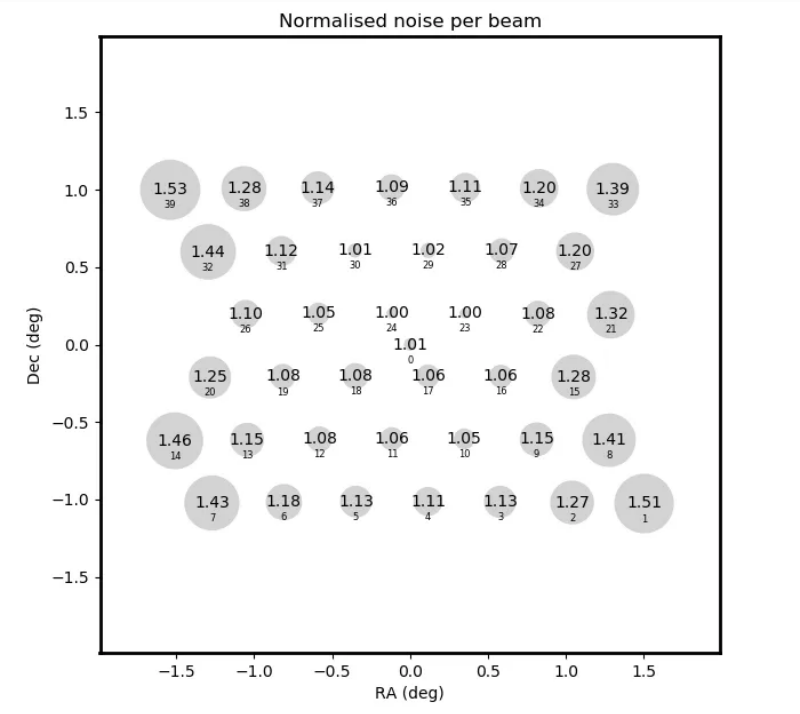

Fig. 18 The normalized average continuum noise per compound beam, shown in the compound beam layout. Compound beams closer to the edge have larger average noise values.

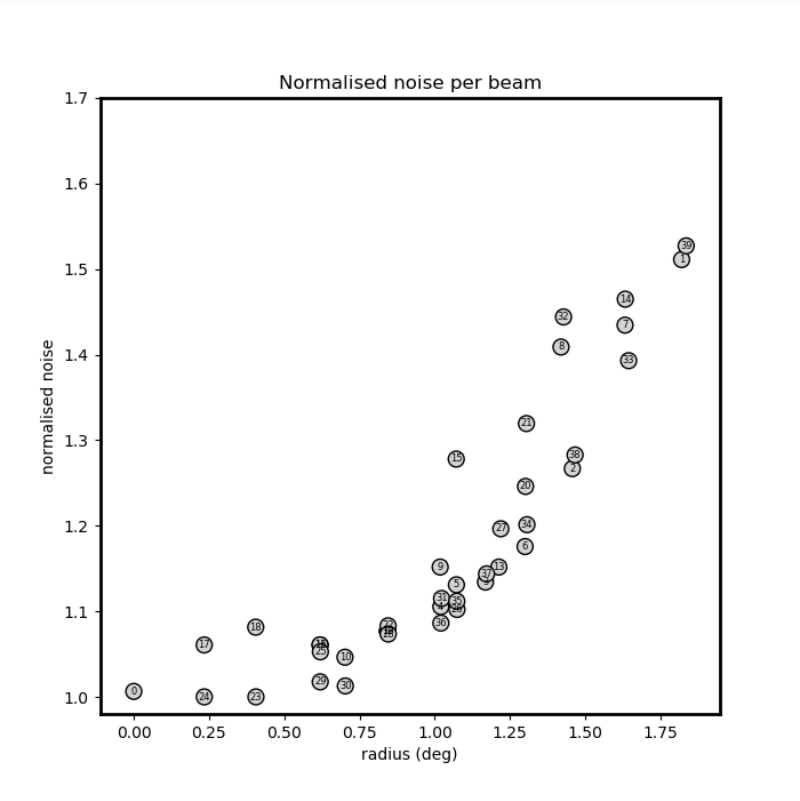

Fig. 19 The normalized continuum noise of each compound beam (labeled points) as a function of distance from pointing center of the PAF. The pattern of increased noise scales with distance from center of the PAF.

Released processed data products

The processed data products are of the most immediate scientific interest. Only processed data products which pass validation are considered for release. Specifically, we require the continuum multi-frequency synthesis (mfs) image to pass the validation outlined in “Validation of processed data products: Continuum”. In that case, all processed data products are released for that beam of a given observation. It may be the case that the polarization or line products do not pass their validation (see respective sections in “Validation of processed data products”). In this case, these data products are flagged in the quality assessment columns of the VO tables (see User Interfaces).

The sections below provide a brief look at the released data products for continuum, polarization and line. The separate section “Data quality” provides a view of the data quality of these released data products.

Released continuum data products

The main continuum data product is the multi-frequency synthesis continuum image. The resolution is better than 15×15/sin() (requirement of validation). The median noise value is ~40 uJy/beam.

The table containing all observation / beam combinations that pass continuum validation, along with all the metrics used in continuum validation (described in ”Validation of processed data products: Continuum ”) can be exported using the VO infrastructure, more details are provided in section “User Interfaces”.

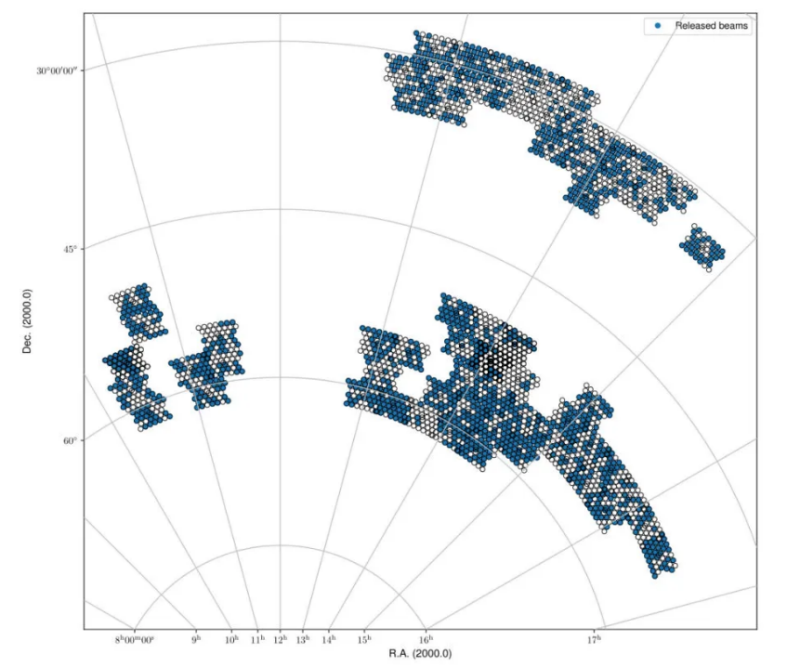

Fig. 20 The spring sky coverage of released beams based on the continuum validation.

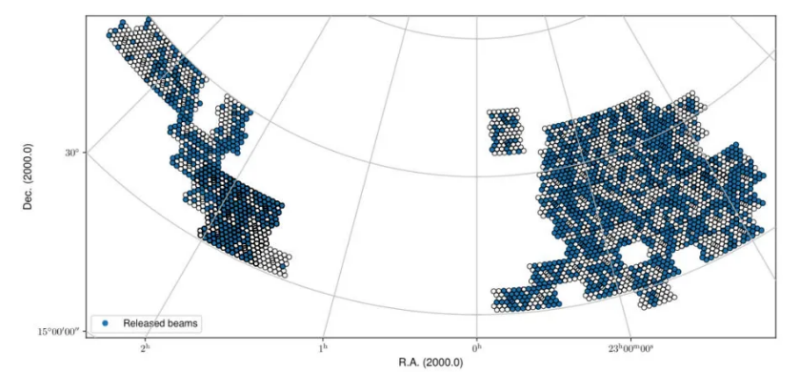

Fig. 21 The fall sky coverage of released beams based on the continuum validation.

Released polarization data products

The polarized data products include a Stokes V multi-frequency synthesis image and Stokes Q&U cubes. The polarized data products are only released if the continuum validation is passed but the polarization products may not pass their own validation (see section “Validation of processed data products: Polarization”). The Stokes V images and Q/U cubes are validated separately, and their validation state is clearly given in the User Interfaces.

A table of all released beams with the line validation status (“G”ood, “O”kay, or “B”ad) for cubes 0-2 (given by the columns “cube?_qual”), plus the metrics used for the line validation (described in HI validation) can be exported using the VO infrastructure, more details are provided in section “User Interfaces”.

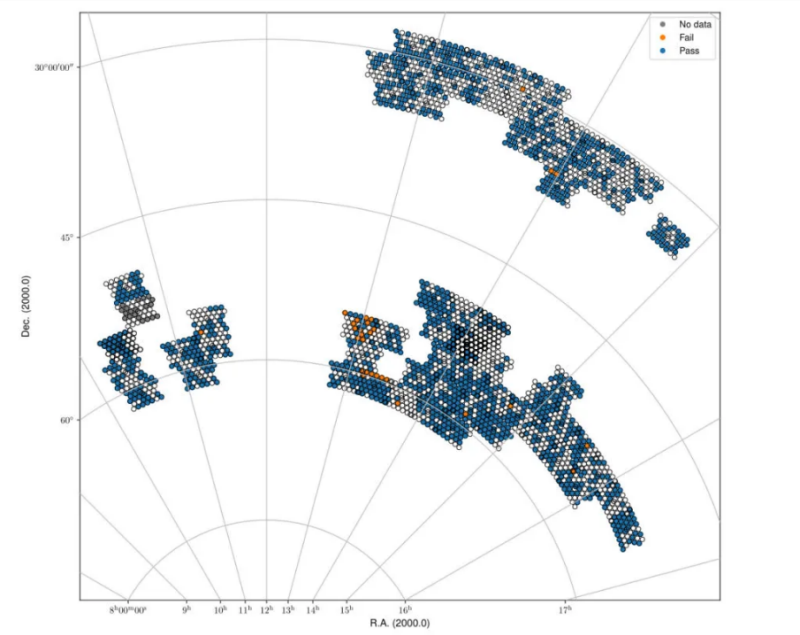

Fig. 22 Spring sky view of the released QU cubes, color-coded by whether they pass validation or not.

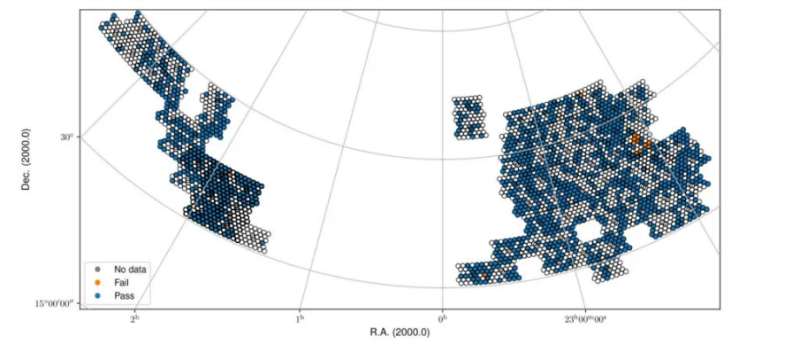

Fig. 23 Fall sky view of the released QU cubes, color-coded by whether they pass validation or not.

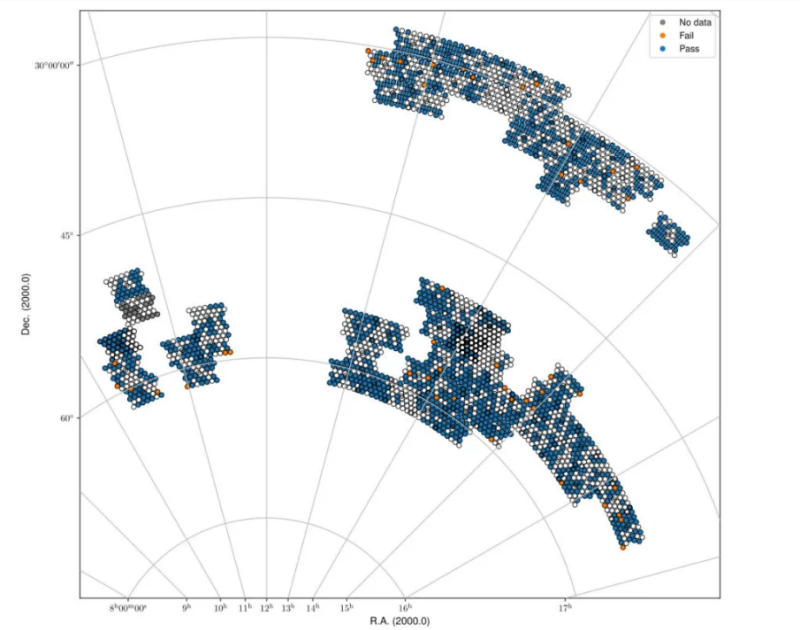

Fig. 24 Spring sky view of the released Stokes V mfs images, color-coded by whether they pass validation or not.

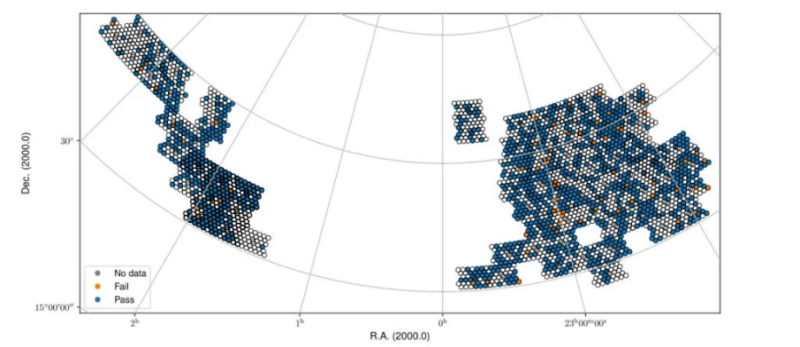

Fig. 25 Fall sky view of the released Stokes V mfs images, color-coded by whether they pass validation or not.

Released line data products

The released line data products include four dirty cubes and their associated dirty beam cubes. The three lowest frequency cubes (spectrally averaged by 3 channels) are validated independently, while the highest frequency, non-averaged cube (cube3) is not directly validated but generally follows the quality of the closest cube in frequency (cube2). The details of the validation are in “Validation of processed data products: HI”.

Table of all released beams with the line validation status (“G”ood, “O”kay, “B”ad, or “N”o cube) for cubes 0-2 (cube?_qual) plus the metrics used for the line validation (described in HI validation) can be exported using the VO infrastructure, more details are provided in section “User Interfaces”.

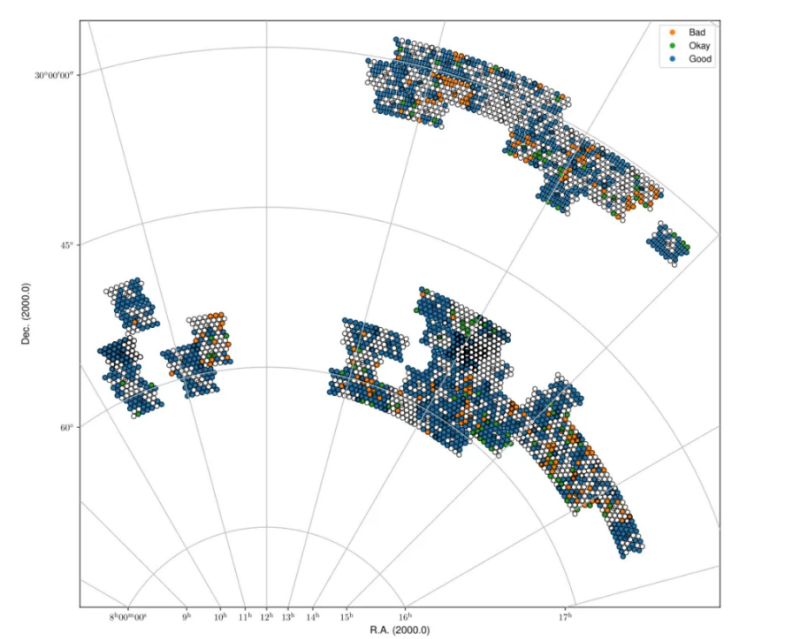

Fig. 26 Spring sky view of the released data for cube2, color-coded by status (Good, Okay, Bad).

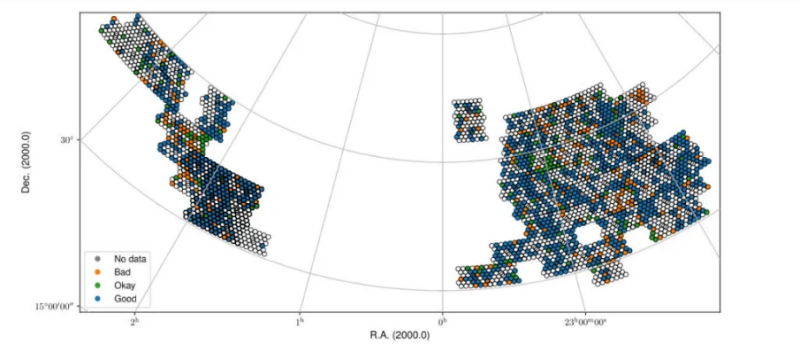

Fig. 27 Fall sky view of the released data for cube2, color-coded by status (Good, Okay, Bad).

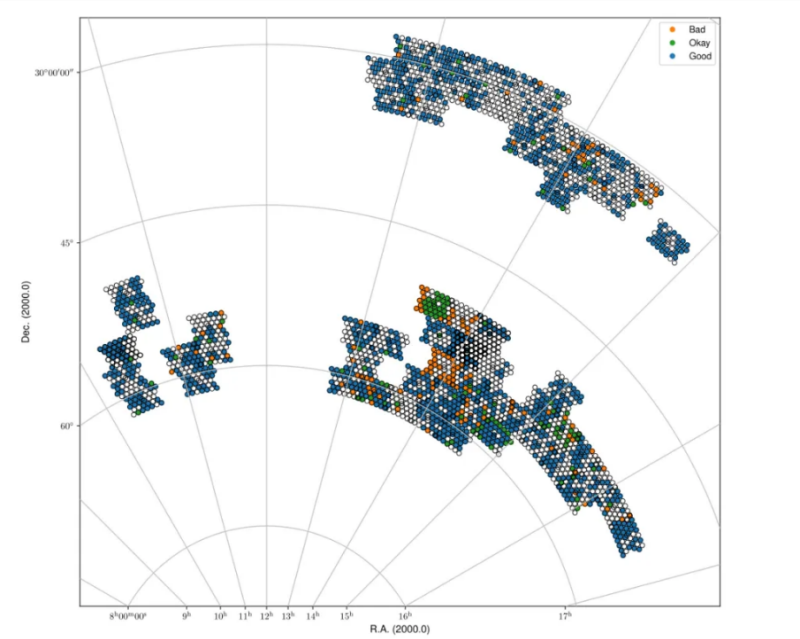

Fig. 28 Spring sky view of the released data for cube1, color-coded by status (Good, Okay, Bad).

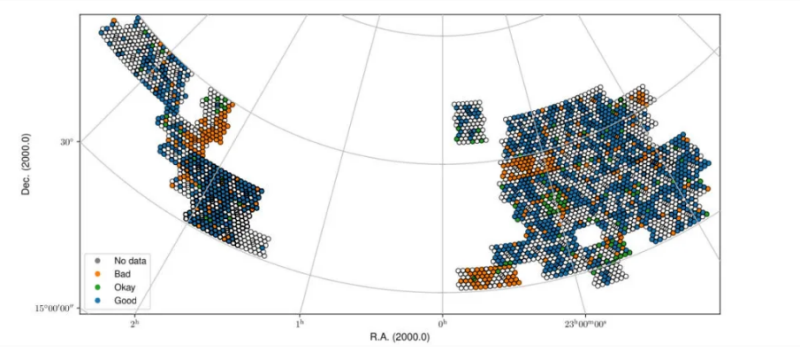

Fig. 29 Fall sky view of the released data for cube1, color-coded by status (Good, Okay, Bad).

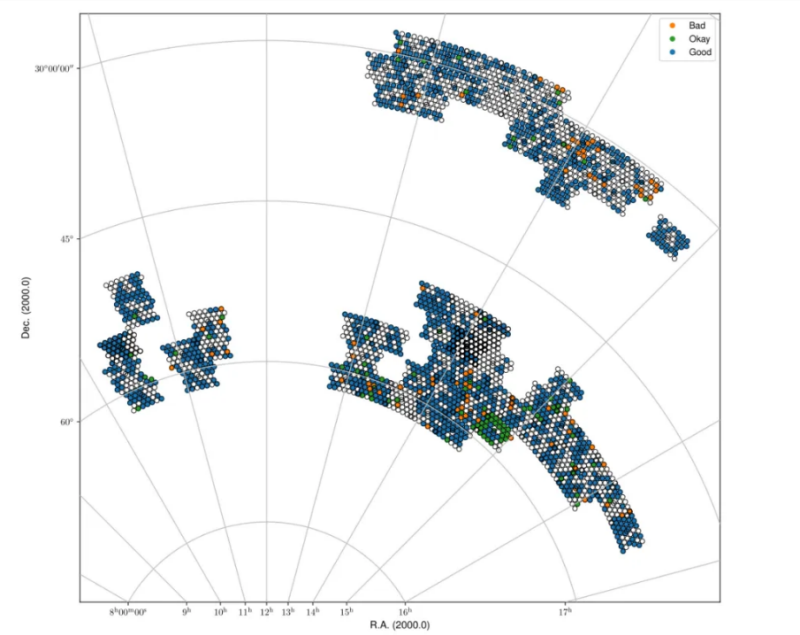

Fig. 30 Spring sky view of the released data for cube0, color-coded by status (Good, Okay, Bad).

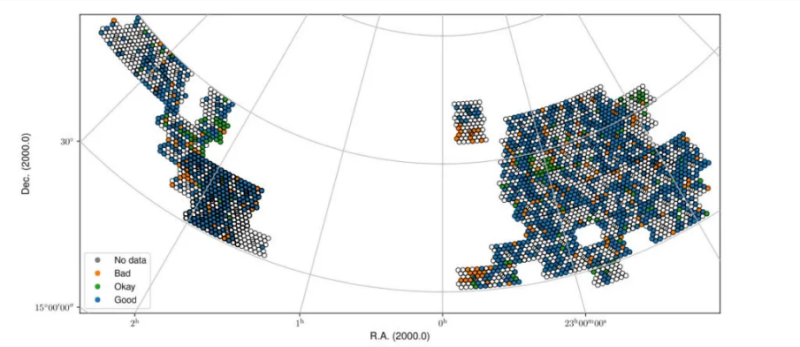

Fig. 31 Fall sky view of the released data for cube0, color-coded by status (Good, Okay, Bad).