Feathering vs. UV Data Combination

W. D. Cotton (NRAO) June 26, 2017

***Abstract*—Feathering and UV data combination are compared as means for combining data made with very different resolutions but similar sensitivities. The conclusion is that neither has the desired effect except when the extended emission is unusually strong and in most of those cases feathering may give superior results. The noise in the high resolution image usually swamps the extended emission after scaling to the higher resolution.**

***Index Terms*—Image combination**

I. Introduction

CELESTIAL sources can have spatial structure on a very wide range of scales whereas a given astronomical instrument will be limited to a finite range of scales that it samples well. Interferometers are explicitly spatial frequency filters whose range of scales sampled is defined by the shortest and longest baselines used. Instruments like the VLA have movable antennas that can be used to adjust the array to sample different ranges of spatial scales. There are several commonly used techniques to combine data from different array configurations. Two of these will be examined in the following. Examples shown here use the Obit package ([1], http://www.cv.nrao.edu/∼bcotton/Obit.html).

II. Image Combination

Two commonly used schemes for combining data from different radio interferometers or configurations are 1) combining the UV data sets and imaging them together and 2) imaging the data-sets independently and then "Feathering"[2], [3] the images together.

A. UV data combination

Combination of UV ("visibility") data is in principle straightforward, the main complication is assuring that the relative weights attached to the data are realistic. Imaging of regions with a range of spatial scales generally requires some variation on multiresolution imaging [4]; this is especially true when data sets with a range of spatial sensitivities are combined. In general, the way multiresolution schemes work is that the CLEAN components are "restored" onto the highest resolution residuals with the appropriate scaling by restoring beam areas.

If the noise in the highest resolution data exceeds the values of the scaled, lower resolution CLEAN components, the extended emission will not be visible in the final image. Thus, the higher resolution data should have much higher sensitivity (lower noise) than the lower resolution data. Ideally, the noise should scale with the inverse of the beam area ratios; or, for equally sensitive arrays the integration time needs to scale with the square of the beam area ratio. This case is seldom (if ever) achieved.

A further complication in the implementation in [4] (and possibly others) is that the limiting CLEAN flux density for lower resolution than the maximum scales with the beam area ratios. This may reduce the depth to which lower resolution data which is CLEANed and hence reduce the flux density in the restored image.

B. Feathering

Feathering[2], [3] is a technique in which images are combined in the UV (AKA Fourier) plane using a weighting that represents the relative sensitivity as a function of size scale of the images being combined. Given the input images, it is far faster than imaging the combined visibility data and works nicely on mosaics and with single dish images. It also allows CLEANing to an appropriate depth in each of the input images and will incorporate all the power represented in the input images, even that not CLEANed. Feathering still has the property that the noise in the highest resolution image can mask the emission from the lower resolution images after scaling to the highest resolution so it does not avoid the need for better sensitivity at higher resolutions.

III. Tests

A comparison of UV data combination and Feathering was done using Obit for data from a VLA Galactic plane survey using the "D" (15") and "B" (1.5") configurations. The observation were made with the same frequency setup and similar observation strategies, i.e. equivalent on source integration times. The sky is covered using a mosaic of pointings. Two test cases are examined to determine the optimum combination strategy. Imaging in these tests used Obit wide-band imager MFImage and feathering task Feather.

A. Mosaic test

The first test is the mosaic of a region of star formation and is shown in 1. This displays images of the same region in the D and B configurations as well as images derived from a combination of either the visibility data or the images.

The image derived from a combination of the visibility data set is nearly indistinguishable from the B configuration only image whereas the feathered image shows more of the extended emission. The reason that the combined visibility CLEAN recovered so little of the extended emission was that the limiting flux density level as determined from scaling the high resolution sensitivity allowed very little of the extended emission to be CLEANed, hence to be included in the combined image. The extended emission in this test case

W. Cotton is with National Radio Astronomy Observatory, 520 Edgemont Rd., Charlottesville, VA, 22903 USA email: bcotton@nrao.edu

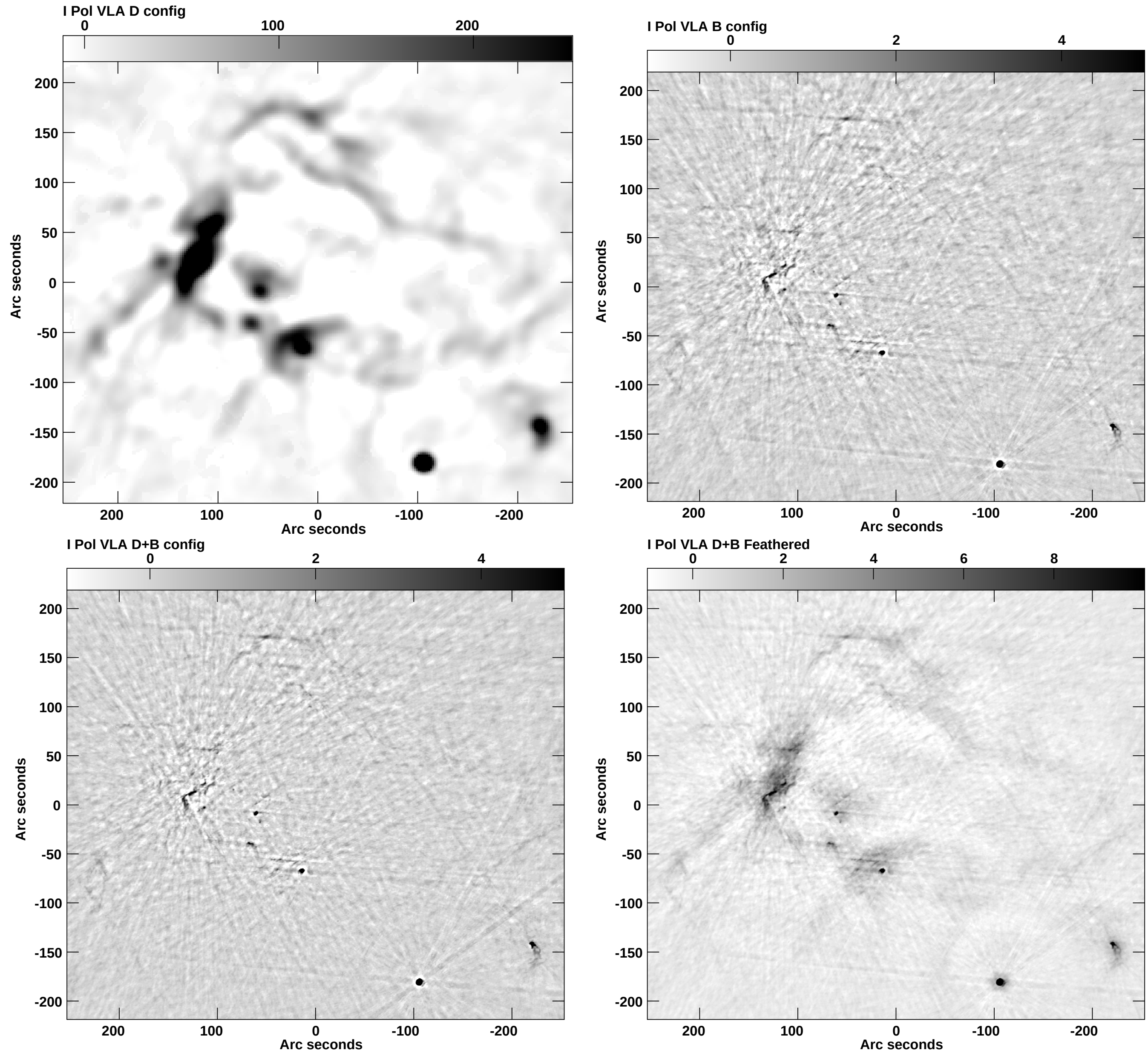

Fig. 1. Mosaic images of a star forming region as negative gray-scale with a scale bar in mJy/bm at the top. Top left is the D (15”) configuration image, top right B (1.5”) configuration image. Bottom left is the D+B UV combination image and bottom right is the feathered image.

is relatively strong. As the mosaic combines all overlapping pointing images it should have the highest sensitivity possible from this dataset.

B. Single pointing test

The second test used a single pointing on a field containing more moderate extended emission. The imaging was modified to allow CLEANing in the lower resolutions below the beam ratio scaled highest resolution limit but based on the measured RMS in the resolution in question. In principle, this allows better recovery of extended emission. The resulting results are shown in Figure 2. All of the higher resolution images show an unresolved source on the right hand side but none show more than hints of the extended emission. Neither feathering nor the modification of the CLEANing seems not to avoid the problem of noise at the higher resolution masking extended emission.

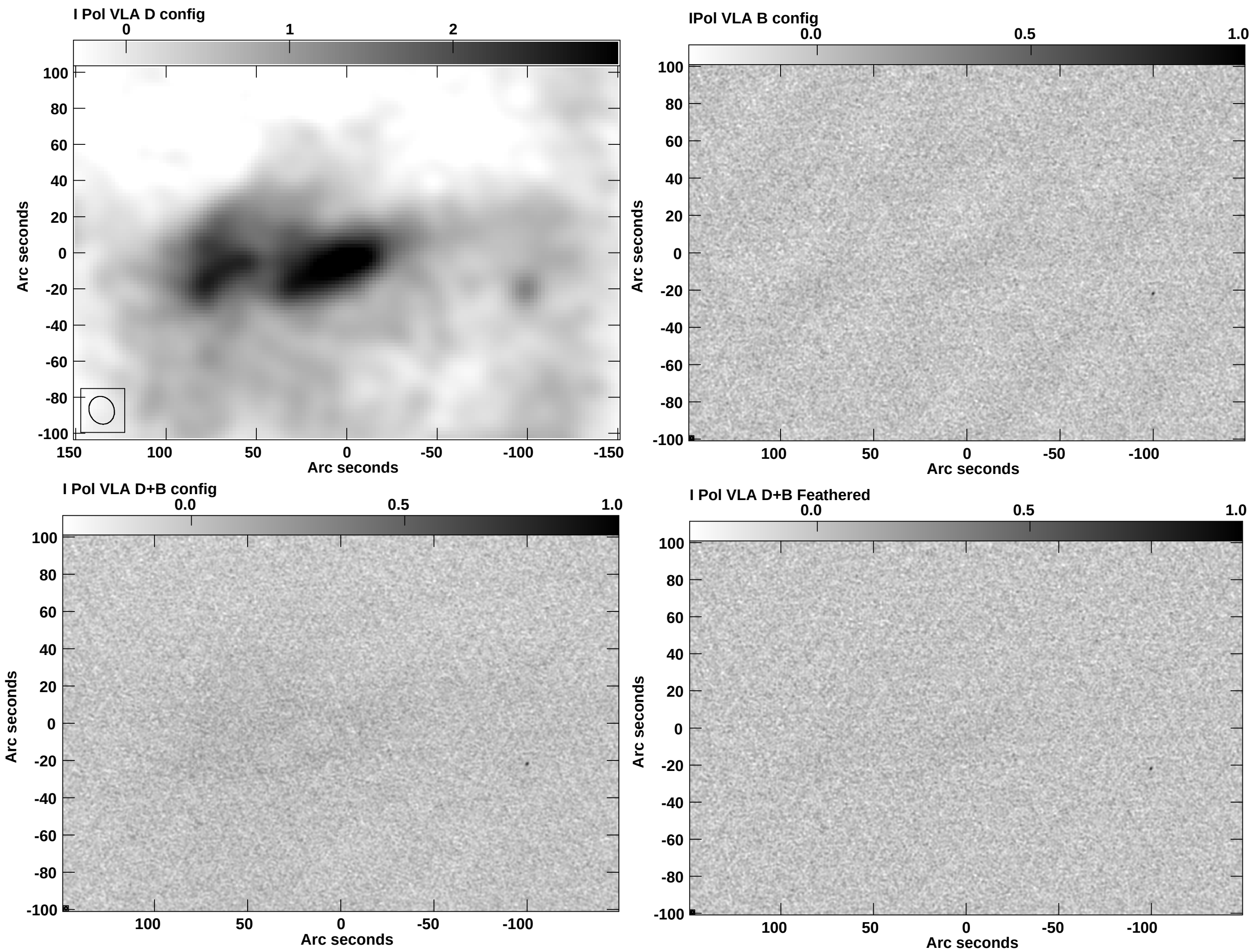

Fig. 2. Single pointing images of an extended source as negative gray-scale with a scale bar in mJy/bm at the top. Top left is the D configuration image, top right B configuration image. Bottom left is the modified D+B UV combination image and bottom right is the feathered image. Resolution is shown in the lower left corner.

IV. Discussion

Several comparisons were made of feathering vs. visibility combination for combining comparable sensitivity data-sets at very different resolutions. The conclusion about visibility combination is that it's only useful if the extended emission after scaling to the highest resolution significantly exceeds the noise in the highest resolution image. Feathering has a similar limitation but recovers weaker extended emission that visibility combination. For the survey in question, combination of the two resolution results appears to be useful in a relatively limited range of cases and in those feathering is generally more useful.

References

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