Tests of Signal/Noise Optimization on Flat-Field Images

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As part of the effort to study the misregistration noise in IUE data, a preliminary analysis for the SWP and LWP cameras has been performed. Six flat-field SWP UV-flood images were selected for the current analysis. Three of these images were taken at a 60% exposure level and three at a 120% exposure level. The SWP images chosen were acquired over the eight year period 1978-1986, in order to identify any time-dependency in the suitability of the two available Intensity Transfer Functions (ITFs) for this camera. Four LWP UV-flood images were also selected for this analysis. Two of these images were taken at a 60% exposure level and two at a 120% exposure level. The images analyzed were acquired in 1978 and 1982 for the 60% and 1980 and 1982 for the 120% analysis.

Procedure

Each test image was photometrically corrected in two ways:

1. *Explicit geometric correction with found reseau positions.* In this method the reseau marks on the flat-field test image are located and their positions used to geometrically correct the test image. The ITFs are then directly applied to the geometrically-corrected test image to produce a photometrically-corrected image.
2. *Implicit geometric correction using mean reseau positions.* This method is equivalent to the procedure used by IUESIPS in the normal processing of data images. Since the reseaux are not easily located on data images, this procedure uses a set of mean reseau positions which have been positionally extrapolated using time and temperature dependencies. Instead of geometrically correcting the data images, the ITF array is mapped into the raw data image space, using these mean reseau positions, to photometrically correct the data image.

One caveat must be noted. In the first method, both the test and the ITF images are smoothed once during the geometric correction procedure. In the second method, the ITF images are smoothed twice (once during geometric correction and once when mapping to the raw test image space) but the test image is never smoothed. These two smoothing procedures are not equivalent and the first method indeed produces more smoothing (and thus a higher signal-to-noise ratio) than the second. This smoothing accounts for 10-50 % of the improved S/N reported here, depending on the region of the image tested.

Statistics

In order to assess the quantitative impact of the two methods of photometric correction described above, each resulting test image was divided into four mutually exclusive square areas. Each area is the largest possible square lying entirely inside the target ring, with one corner at the center of the image. The areas are numbered 1,2,3 and 4 for the upper left, upper right, lower left and lower right portions of the image. Within each of these numbered areas, 12x12 pixel boxes were used to determine a mean flux, standard deviation of the flux, and resulting signal/noise (S/N) ratio for the large numbered area.

Results

Figure 1 shows plots of the S/N ratio in the SWP 60% images for each of the four large areas vs. time (year of image acquisition). Only the results for the 60% level exposures have been reproduced; the results for the 120% level are basically similar to those presented here and suffer from saturation effects, thus containing no additional information. The asterisks represent explicit geometric corrections using the found reseau positions and new ITF, the plus marks represent explicit geometric corrections using found reseau positions and the old ITF; the "x" marks represent the implicit geometric corrections using mean reseau positions and the new ITF, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the old ITF. Figure 2 presents the data for the LWP 60% images and Figure 3 presents the data for the LWP 120% images, using the same symbols to represent the various methods of photometric correction. The plots have been arranged in the same configuration as the areas on the image they represent.

It is immediately apparent from the figures that the explicit geometric correction using found reseau positions always yields a significantly higher S/N ratio (by factors of 1.4 to 2.5) than the normal production processing by IUESIPS. This result is true regardless of the year of image acquisition or ITF used. In fact, a major conclusion of this work is that the choice of which ITF to use is much less important than the proper alignment of the ITF with the raw data image pixels. Also, we note the results in Figure 1 indicate that while the new SWP ITF reduces the signal-to-noise ratio for an image taken in 1982, it offers little improvement for images taken in 1978 and 1986. While these results are preliminary and the statistics are still small, they suggest that images taken recently may not benefit from implementation of the new SWP ITF.

Most instructive are Figures 2 and 3, where the results of explicit geometric correction of images actually used in the creation of the ITF (LWP 1144 and LWP 1237) show an substantially improved S/N ratio over the current processing method for each image. LWP 1144 is one of six 60% images averaged together to produce the 60% level of the old LWP ITF. If the ITF is being properly applied to the data image, the result of applying the ITF to an image used in the creation of the ITF should be a much greater S/N ratio than when the ITF is applied to a random image. This is the case for LWP 1144 with the explicit geometric correction using found reseau positions (denoted by "plus" marks on the plots). LWP 1237 was in fact the only image used in the 120% level of the old LWP ITF. Therefore, applying the old LWP ITF to LWP 1237 should produce a completely flat image if the alignment between the data image and the ITF is perfect. When found reseau marks are used to geometrically correct LWP 1237, the determined signal-to-noise ratio values for the case of explicit geometric correction and application of the old LWP ITF are in the range of 50 to 75 for three of the four areas analyzed. Rather than plot these values exactly, we preferred to maintain the same scale between all of the figures for comparison, and indicated values larger than 30 as outside the range of the plot. The normal production processing technique, on the other hand, shows no difference between application of the old ITF and the new ITF (in which LWP 1237 was not used in the creation of the ITF). Clearly, improved alignment of the ITFs with the data images has great potential for improving the S/N ratio of IUE data, and explicit geometric correction of the data image is one way of achieving this level of improvement.

Conclusions

Based on the data presented herein, we have concluded the following:

1. Explicit geometric correction using found reseau positions increases the signal-to-noise ratio by a factor of ≈1.5-2 over the current production processing method for the SWP and LWP cameras.
    a. Up to half of this increase is due to the smoothing of portions of the data image in the geometrical correction procedure.
    b. The remainder of the increase is due to proper alignment and application of the ITFs.
2. Explicit geometric correction is a more appropriate method for applying the ITF and should be considered for use in the creation of the final archive, assuming flux is preserved.
3. For the enhancement of signal-to-noise ratio, it is far more important *how* the ITF is applied than *which* ITF is used.

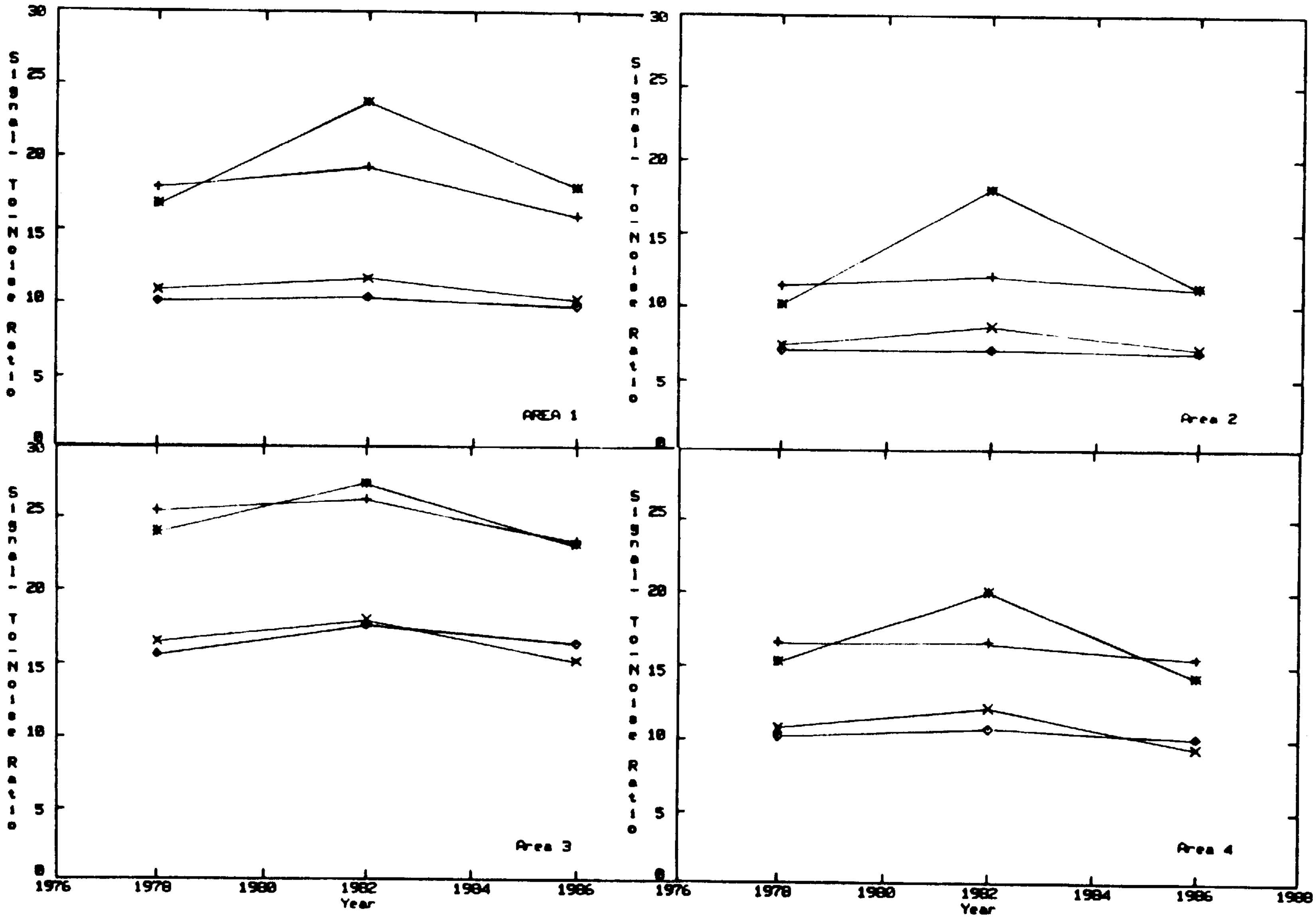

Fig. 1. Plots of S/N ratio for each of the four large areas in an SWP 60% flat-field image vs. time (year of image acquisition). The asterisks represent explicit geometric corrections using the found reseau positions and new ITFs, the plus marks represent explicit geometric corrections using found reseau positions and the old ITFs, the "x" marks represent the implicit geometric corrections using mean reseau positions and the new ITFs, and the diamonds represent the implicit geometric corrections using mean reseau positions and the old ITFs. The

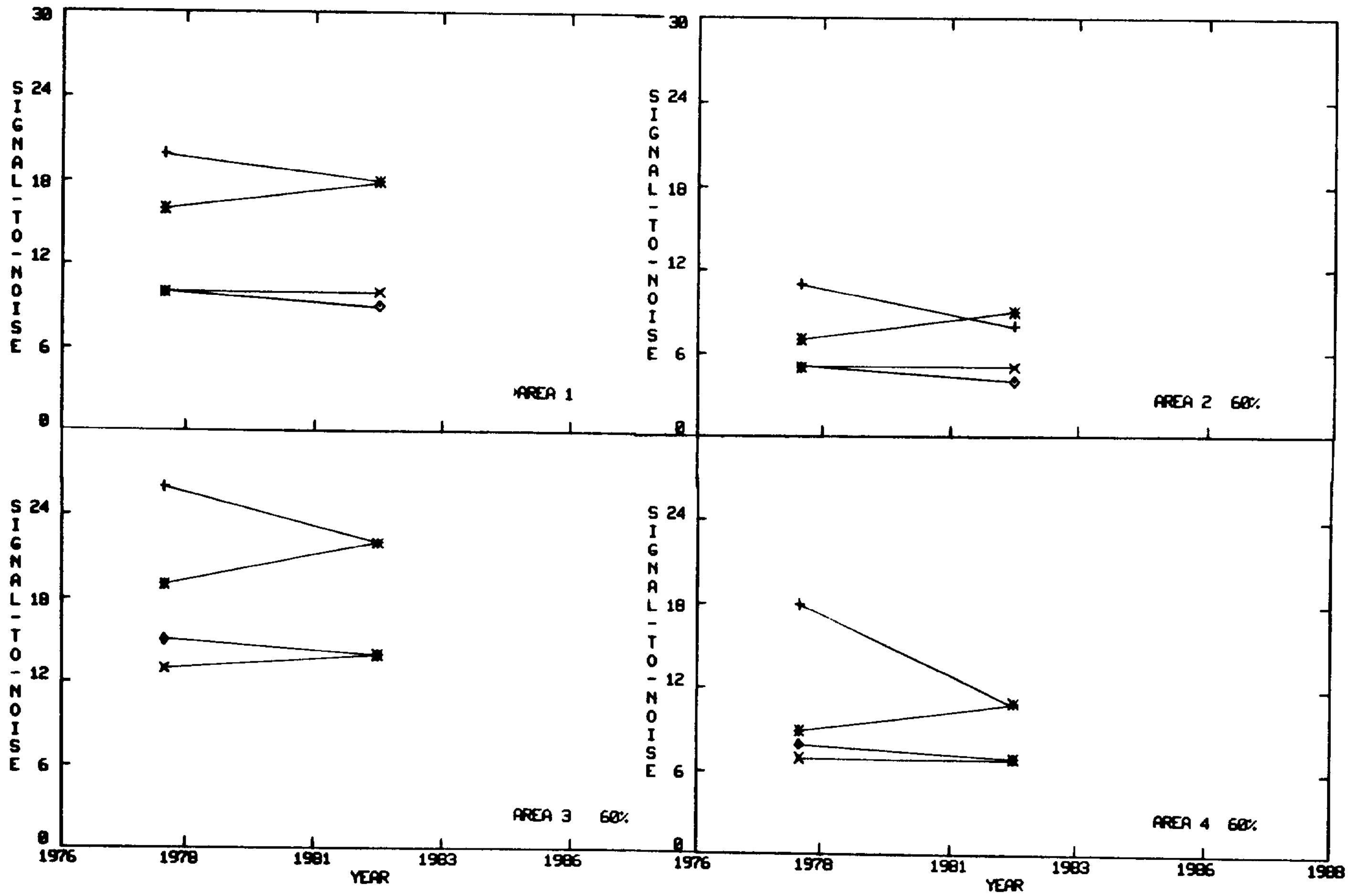

Fig. 2. Plots of S/N ratio for each of the four large areas in an LWP 60% flat-field image vs. time (year of image acquisition). The asterisks represent explicit geometric corrections using the found reseau positions and new ITFs, the plus marks represent explicit geometric corrections using found reseau positions and the old ITFs, the "x" marks represent the implicit geometric corrections using mean reseau positions and the new ITFs, and the diamonds represent the implicit geometric corrections using mean reseau positions and the old ITFs. The plots have been arranged in the same configuration as the areas on the image they represent.

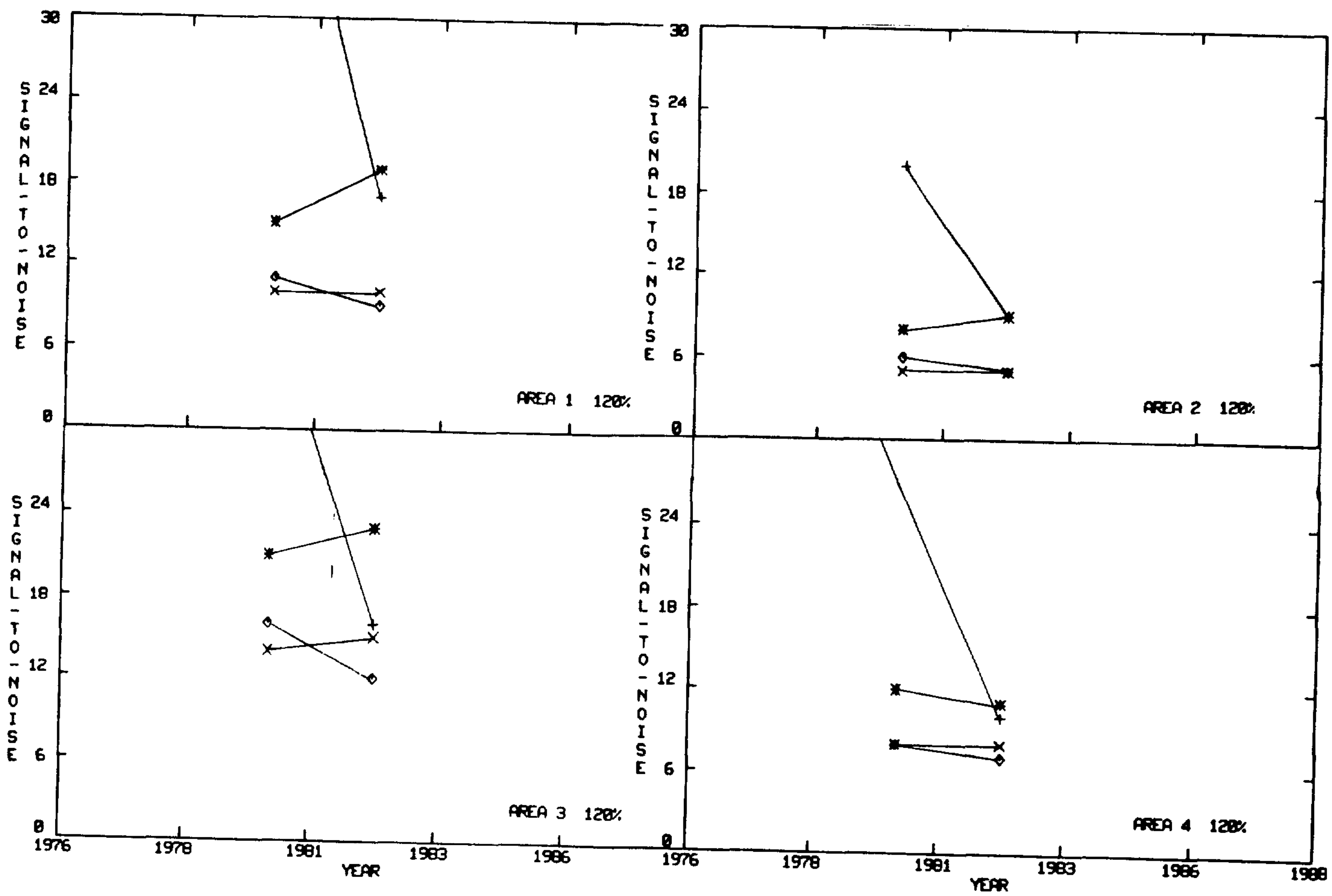

Fig. 3. Plots of S/N ratio for each of the four large areas in an LWP 120% flat-field image vs. time (year of image acquisition). The asterisks represent explicit geometric corrections using the found reseau positions and new ITFs, the plus marks represent explicit geometric corrections using found reseau positions and the old ITFs, the "x" marks represent the implicit geometric corrections using mean reseau positions and the new ITFs, and the diamonds represent the implicit geometric corrections using mean reseau positions and the old ITFs. The plots have been arranged in the same configuration as the areas on the image they represent.