ITF Registration Study
and
Time Dependency of the ITFs

Joy Nichols-Bohlin

Astronomy Programs
Computer Sciences Corporation

Introduction

Previous analysis of the misregistration noise in IUE data compared photometric correction techniques which employed explicit geometric correction and implicit geometric correction (Nichols-Bohlin 1988). However, only three images for the SWP camera and two images for the LWP camera were studied at that time. While the previous analysis showed that explicit geometric correction always yields superior S/N ratio over implicit geometric correction as used in IUESIPS production processing, the data were insufficient for determining which of the two available ITFs for each camera is more applicable to each epoch of observations. We have sought here to include data from each year of IUE operation to more accurately judge the time dependency of the applicability of each ITF. In addition, we have performed a basic self-consistency test of the registration of the ITFs with the data images. Images actually used in the construction of the old and new ITFs for each camera have been photometrically corrected with both ITFs for the respective cameras. If the ITF is accurately registered by use of the explicit geometric correction, the image used in the ITF construction should have a significantly higher signal-to-noise ratio than an image taken years earlier or later. This technique also allows us to separate the effects of data smoothing due to explicit geometric correction from the data smoothing resulting from improved flat-fielding of the data.

Procedures

Each test image was photometrically corrected 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 image, the ITF array is mapped into raw data image space, using these mean reseau positions, to photometrically correct the data image.

Signal-to-noise statistics for the test images were derived by dividing each image 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 average signal-to-noise ratio for the large numbered area.

Registration Study

Component images from four levels (40%, 60%, 80%, and 100%) of the two ITFs have been analyzed for the SWP and LWP cameras. Levels higher than 100% begin to show saturation effects which would bias the results. Figure 1 shows the signal-to-noise ratio for "Area 1" of four images used in the construction of the SWP ITF1. The asterisks represent explicit geometric corrections using found reseau positions and SWP ITF2, the plus marks represent explicit geometric corrections using found reseau positions and the SWP ITF1; the "x" marks represent the implicit geometric corrections using mean reseau positions and the SWP ITF2, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the SWP ITF1. Figure 2 presents the same information, but for four component images of the SWP ITF2. In both cases, the component images are better photometrically corrected by their "parent" ITF. It is quite clear from the plots that implicit geometric correction does not properly align the data image and the ITF, because there is virtually no difference between the S/N ratios for either ITF with implicit geometric correction, while there is a significant difference when explicit geometric correction is employed. The difference in S/N ratio between SWP ITF1 and SWP ITF2 is much larger for images acquired for SWP ITF2 than for images acquired for SWP ITF1. This can probably be attributed to some differences in the software used to create the SWP ITF1 in 1978 and that used to create SWP ITF2 in 1985. The software used to geometrically correct the ITF component images in 1978 is not readily available to us, so we may have performed the geometric correction slightly differently than was done for the construction of SWP ITF1.

Figures 3 and 4 present the same analysis for the LWP camera. Figure 3 plots the S/N ratio for component images of four levels of the ITF, processed in the four methods described above. Note the scale on the y-axis is different for this plot than for Figures 1,2 and 4. The 40% and 100% levels of LWP ITF1 were constructed using one image only. The fewer the number of images summed to create a given level of the ITF, the higher the S/N ratio of one of the component images when photometrically corrected with the ITF. If only one image is used for a given level in the ITF, the S/N ratio of that image after photometric correction with the ITF would theoretically approch infinity (i.e., the image should be perfectly flat, having been corrected with itself). The S/N ratio of these images when photometrically corrected is particularly high (90 for the 40% level and 60 for the 100% level). Note, however, that the 60% image exhibits similar S/N ratio regardless of which ITF is applied. Figure 4 shows the results for component images from LWP ITF2. A very marked improvement in S/N ratio over that achieved with the use of LWP ITF1, similar to that seen for SWP ITF2, is apparent in this figure.

Because the data were treated in exactly the same way for explicit geometric correction with both the old and the new ITFs, the difference in S/N ratio between these two methods must represent improvement due solely to improved registration of the ITF. Some smoothing occurs during explicit geometric correction which would be a part of the differences between the data using explicit and using implicit geometric correction. However, the differences between the two ITFs with explicit geometric correction reflect the improved registration and appropriate choice of ITF for the data. We conclude that explicit geometric correction allows significantly better alignment of the data image with the ITF. This conclusion does not preclude the potential of even greater improvement in the accuracy of the alignment of the ITF with the data image through techniques which are currently being explored (see related papers in this volume).

Time Dependency of the ITFs

The question of which of the available ITFs to apply to the various epochs of IUE data must be answered before the determination of the final absolute calibrations for the IUE Final Archive. The following analysis was performed in an attempt to begin to understand the degree of disparity between the photometric accuracy of data corrected with the two available ITFs over the lifetime of IUE. Camera baseline images were selected at approximately one year intervals, and processed by the two methods described above, each method using both the old and the new ITF for the relevant camera. Sixty percent images were chosen, due to their relative prevalence in the archive. However, the absence of data for the LWR camera after 1984, and the LWP camera prior to 1982, limits the temporal ranges for these cameras.

Figure 5 presents the data for the SWP camera. The plots for each of the four large areas, as described above, are arranged in the same configuration as the areas on the image they represent. Signal-to-noise ratio has been plotted against time. The symbols represent the various methods of photometric correction as in Figures 1-4. Figures 6 and 7 represent the data for the LWR and LWP cameras, respectively, with the same configuration and symbols as Figure 5. The time dependency of the ITFs is not particularly straightforward, nor is it consistent in all areas of the image. For the SWP camera, the results are least consistent. The SWP ITF2 appears to give the better results near 1985, when it was acquired (to be expected), but also gives the better results near 1981. For Area 4, ITF2 also gives better results in mid-1982, but this is not consistent with the other areas of the camera. In between these noted epochs, there is not a significant difference in the S/N ratio of the data with ITF1 or ITF2. Notably, there is no significant difference between the results from the two ITFs from 1986 to mid-1987, implying instrumental changes may have negated the benefit of the 1985 ITF and a new ITF may be needed for this camera.

From Figure 6, we conclude that LWR ITF1 is the more applicable to data acquired from launch to 1980. After that time there is a slight preference for LWR ITF2, based primarily on the results in Areas 1 and 3. Interestingly, the best S/N ratio achieved with the LWR ITF2 occurred in 1981, while the images for LWR ITF2 were acquired in late 1983. Compared to the results for the SWP camera, the differences in the S/N ratio for data processed with the two ITFs for the LWR camera are not large, and it may be reasonable to select LWR ITF1 for the entire archive of LWR data to avoid discontinuity in calibrations in the archives.

The data for the LWP camera is the most useful for determining the appropriate ITF for each epoch. LWP ITF1 gives the better S/N ratio for Areas 3 and 4 between 1982 and 1983. However, LWP ITF2 actually gives better results for Area 1 and there is no difference in Area 2 for this period. After 1983, all four areas give better results with ITF2 except for one image in mid-1983 in Areas 1 and 2, which shows a slight preference for ITF1. Because the LWP ITF1 is known to be of poorer quality than LWP ITF2, due to the limited amount of data included in the various levels of the earlier ITF, it appears the LWP ITF2 would be the better choice for the entire archive of LWP data.

Conclusions

Explicit geometric correction produces improved registration of the ITF with the data images, based on a self-consistency test of ITF component images. This improved S/N ratio cannot be primarily due to smoothing of the data introduced via the bilinear interpolation inherent in the current method of geometric correction. Instead, the majority of the improvement is due to improved flat-fielding of the data by means of more accurate registration of the ITF.

Although an initial study of the time-dependency of the ITFs has been made, conclusions must be delayed until data from smaller time intervals can be analyzed, especially in the case of the SWP camera. Also, improvements in the method of construction and application of the ITFs currently under investigation may change these results substantially. However, preliminary recommendations for use of the LWP ITF2 and LWR ITF1 exclusively can be made on the basis of this investigation.

References

Nichols-Bohlin, J. 1988, NASA IUE Newsletter #36, p. 28.

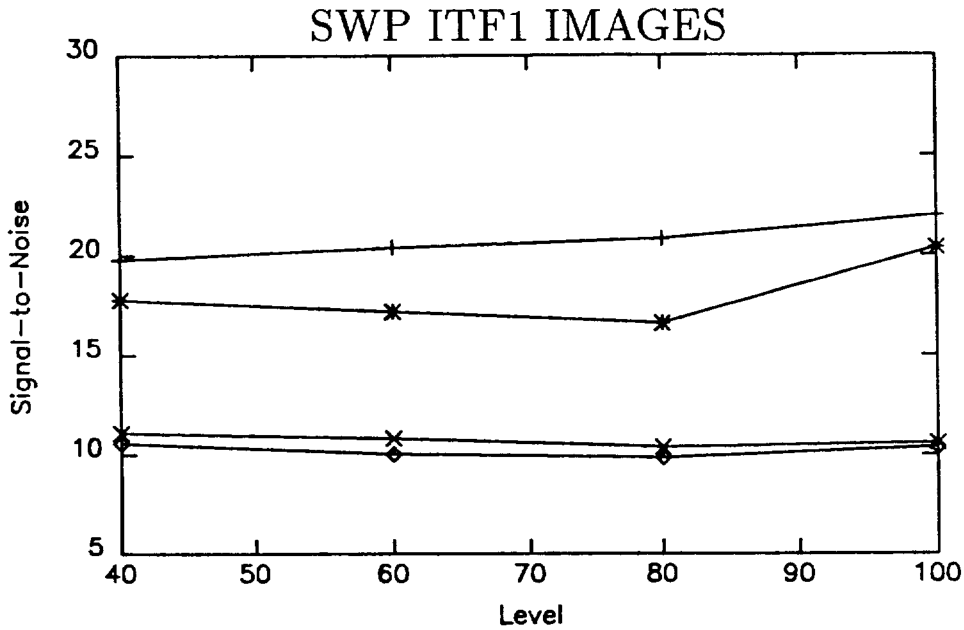

Figure 1: Plot of S/N ratio for "Area 1" in SWP ITF1 flat-field images vs. ITF level (exposure level). The asterisks represent explicit geometric corrections using found reseau positions and SWP ITF2, the plus marks represent explicit geometric corrections using found reseau positions and the SWP ITF1; the "x" marks represent the implicit geometric corrections using mean reseau positions and the SWP ITF2, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the SWP ITF1.

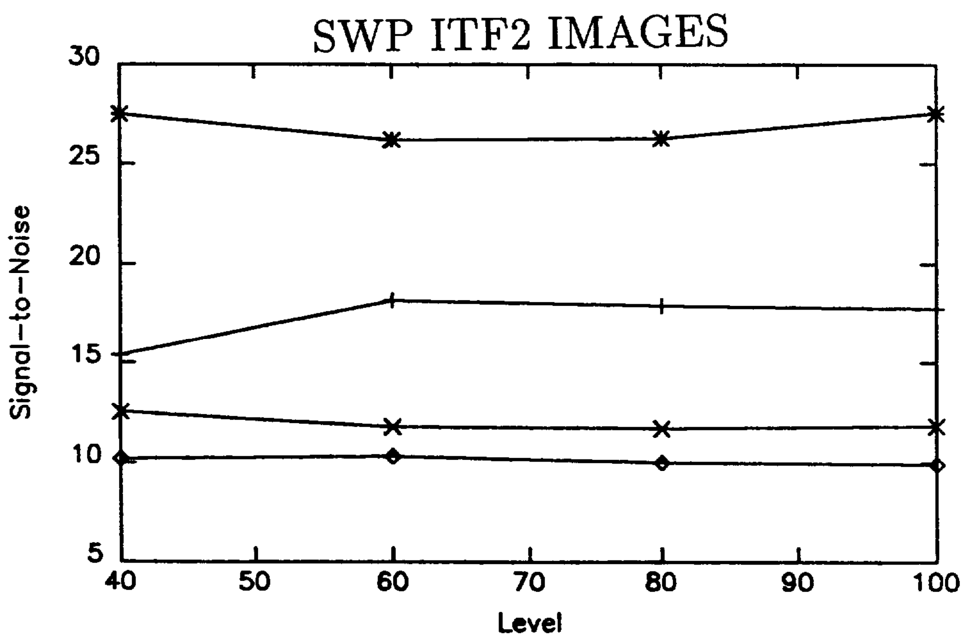

Figure 2: Plot of S/N ratio for "Area 1" in SWP ITF2 flat-field images vs. ITF level (exposure level). Symbols used as in Figure 1.

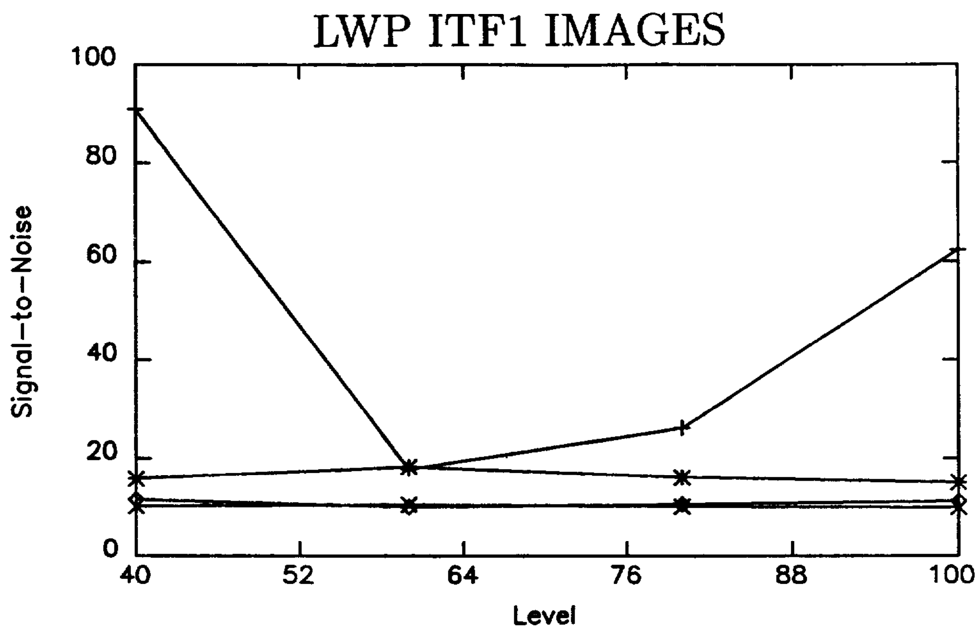

Figure 3: Plot of S/N ratio for "Area 1" in LWP ITF1 flat-field images vs. ITF level (exposure level). The asterisks represent explicit geometric corrections using found reseau positions and LWP ITF2, the plus marks represent explicit geometric corrections using found reseau positions and the LWP ITF1; the "x" marks represent the implicit geometric corrections using mean reseau positions and the LWP ITF2, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the LWP ITF1.

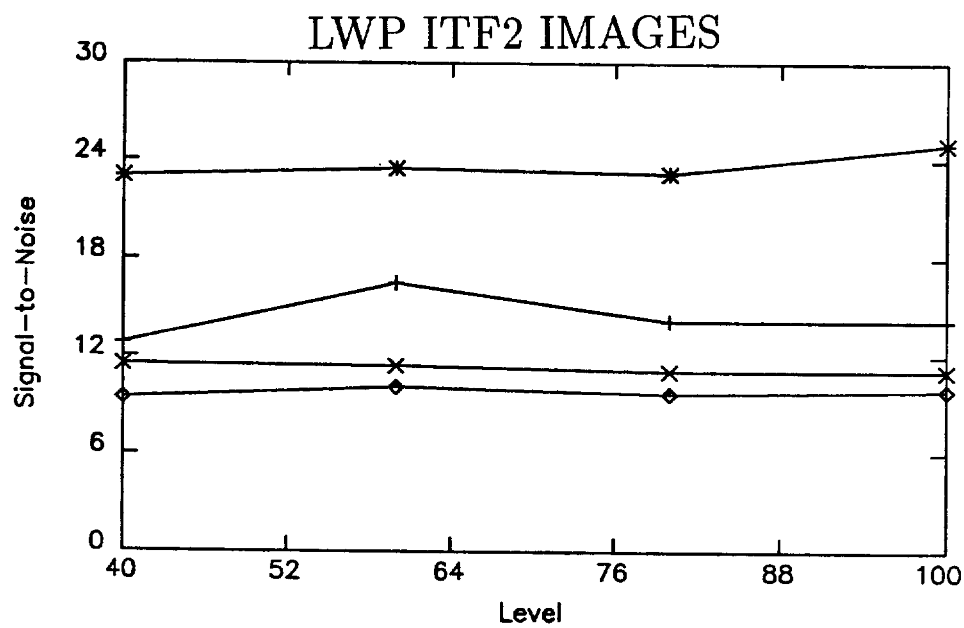

Figure 4: Plot of S/N ratio for "Area 1" in LWP ITF2 flat-field images vs. ITF level (exposure level). Symbols used as in Figure 3.

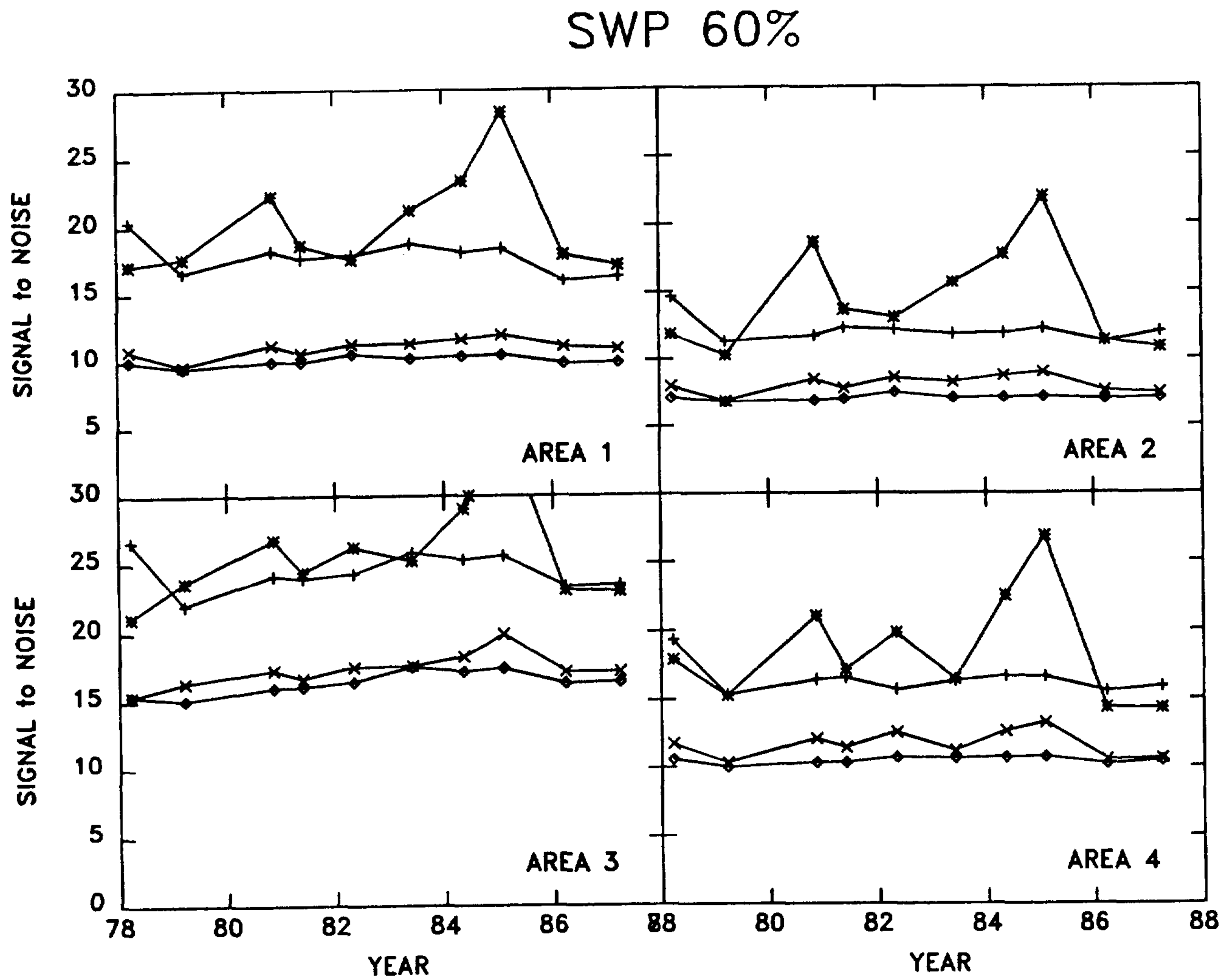

Figure 5: Plots of S/N ratio for each of the four large areas in an SWP 60% flat-field image vs. time (year of acquisition). asterisks represent explicit geometric corrections using found reseau positions and SWP ITF2, the plus marks represent explicit geometric corrections using found reseau positions and the SWP ITF1; the "x" marks represent the implicit geometric corrections using mean reseau positions and the SWP ITF2, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the SWP ITF1. The plots have been arranged in the same configuration as the areas on the image they represent.

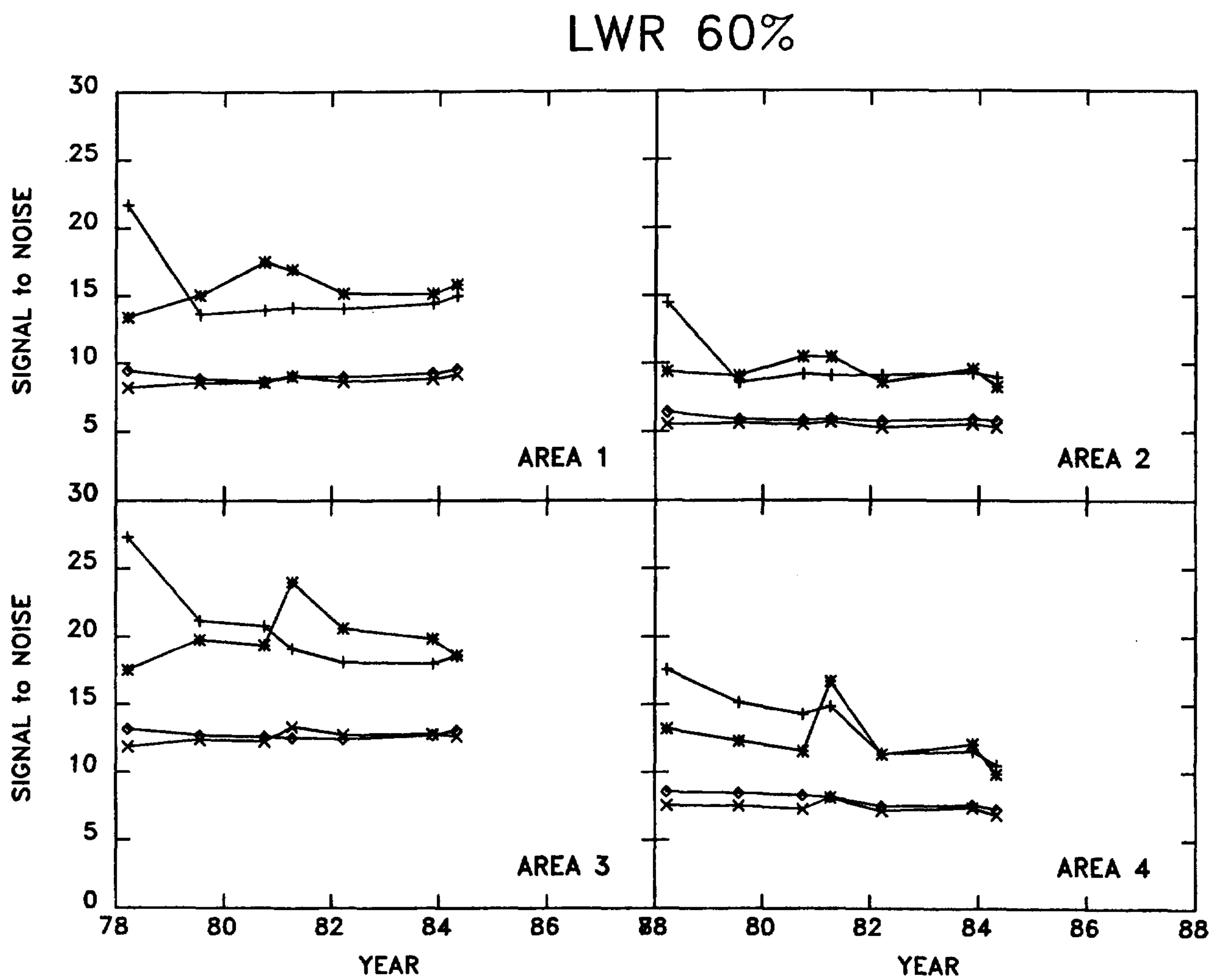

Figure 6: Plots of S/N ratio for each of the four large areas in an LWR 60% flat-field image vs. time (year of acquisition). asterisks represent explicit geometric corrections using found reseau positions and LWR ITF2, the plus marks represent explicit geometric corrections using found reseau positions and the LWR ITF1; the "x" marks represent the implicit geometric corrections using mean reseau positions and the LWR ITF2, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the LWR ITF1. The plots have been arranged in the same configuration as the areas on the image they represent.

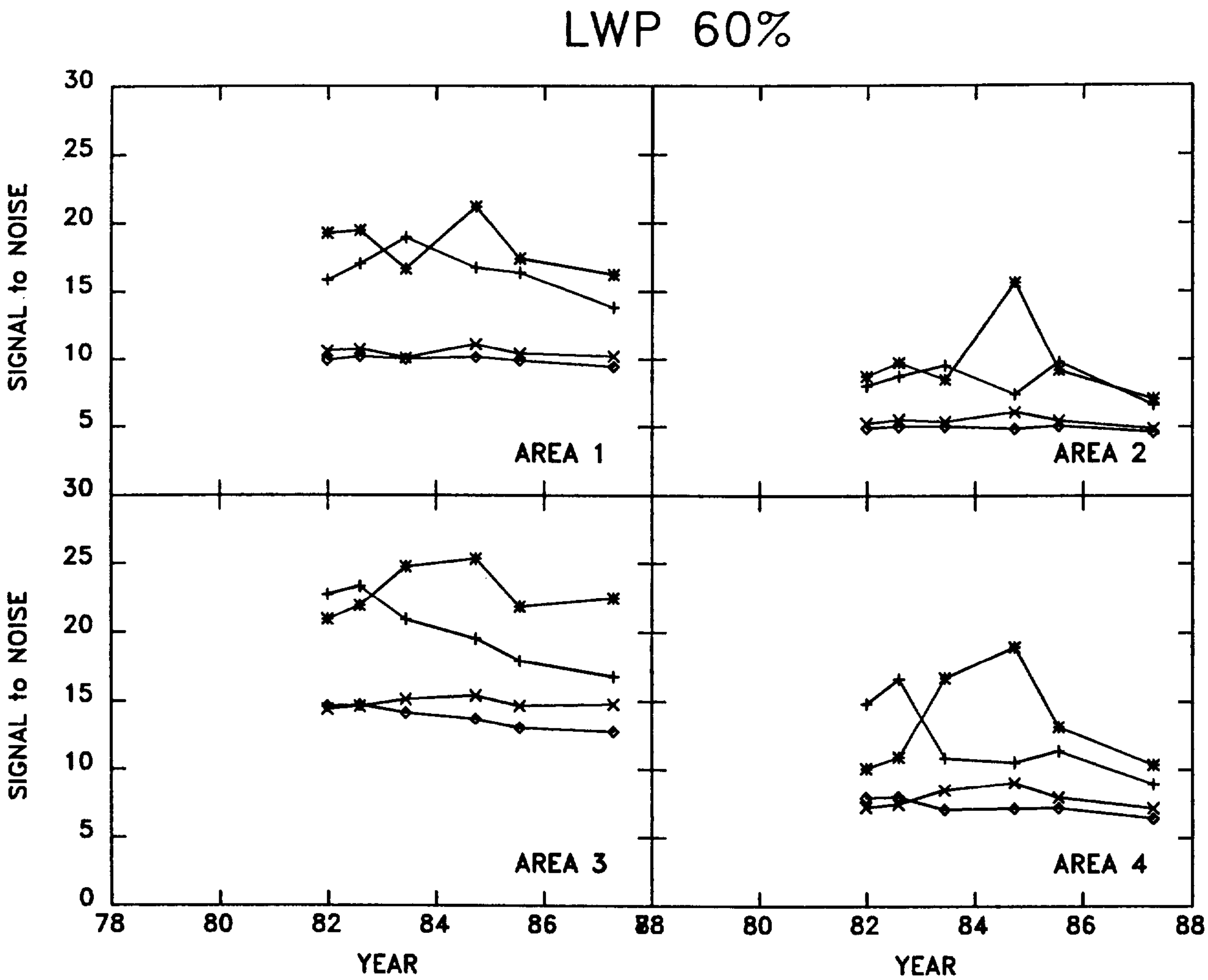

Figure 7: Plots of S/N ratio for each of the four large areas in an LWP 60% flat-field image vs. time (year of acquisition). asterisks represent explicit geometric corrections using found reseau positions and LWP ITF2, the plus marks represent explicit geometric corrections using found reseau positions and the LWP ITF1; the "x" marks represent the implicit geometric corrections using mean reseau positions and the LWP ITF2, and finally, the diamonds represent the implicit geometric corrections using mean reseau positions and the LWP ITF1. The plots have been arranged in the same configuration as the areas on the image they represent.