A PRELIMINARY INVESTIGATION OF SYSTEMATIC NOISE
IN DATA ACQUIRED WITH THE AIRBORNE IMAGING SPECTROMETER

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ABSTRACT

Systematic noise is present in airborne imaging spectrometer (AIS) data collected on October 28, 1983 and May 5, 1984 in grating position 0 (1.2-1.5 µm). In the October data set the noise occurs as 135 scan-lines of low DN's every 270 scan-lines. The noise is particularly bad in bands nine through thirty, restricting effective analysis to at best ten of the 32 bands. In the May data the regions of severe noise have been eliminated, but systematic noise is present with three frequencies (3, 106 and 200 scan-lines) in all thirty-two bands. The periodic nature of the noise in both data sets suggests that it could be removed as part of routine processing at JPL. This is necessary before classification routines or statistical analyses are used with these data.

BACKGROUND

Data were acquired on October 28, 1983 and May 5, 1984 with the airborne imaging spectrometer (AIS) over the George Washington National Forest in West Virginia in order to examine the utility of sensors with high spectral resolution for geobotanical mapping. The October AIS data covered thirty-two bands in the 1.2-1.5µm region and while the May data covered 128 spectral bands in the 1.2-2.4µm region, only the first thirty-two bands were analyzed in this study. The October overflight of the test sites produced data with considerable noise in bands nine through thirty (Figure 1). Histograms of these bands were bimodal with noise forming a significant peak at thirty or less digital counts (Figure 2). The effect of the noise on unsupervised classification was dramatic. Forest communities in areas in which noise was present were placed in separate classes from similar communities in the noise-free regions. Figure 3 illustrates the difference in classified images produced using only noise-free bands and all 32 bands. In the latter case, noise-related classes appear at regular intervals across the image. The May overflight produced data with reduced noise (Figure 4). The large regions of low digital numbers (DN's) present in the October data were gone. However, periodic noise was still present at a level unacceptable for statistical analyses which involve comparisons of reflectance between small test sites.

ANALYSIS

The noise in the October 1983 AIS data was first recognized in a principal components transformation of the 32 bands. When the first four principal components were displayed, the noise was present in components two and four as regions of lower DN's (Figure 5). An examination of all thirty-two bands revealed that there was substantial noise in bands 9-30, which fall within a region of strong water absorption. The remaining ten bands which fall outside this region were relatively noise free. In plots of columns from band fifteen, noise appeared as 130-140 lines of lower DN's which occur about every 270-300 scan-lines. Similar plots for one of the noise-free bands, band one, did not show a regular pattern of either high or low values.

The large regions of noise which characterize the October data are absent from the May 1984 AIS image (Figure 4). However, noise in the aircraft electrical system ,which affects roughly every third scan-line, is worse in the May data. Also new in the May data are spikes and dips in the signal which appear every 106 scanlines. In band 1 these appear as scan-lines with DN's 2000 to 3000 counts lower than surrounding lines. In band 15 the same scanlines are approximately 1500 counts higher than surrounding lines. The occurrence of this noise at a precise interval suggests that its source is within the AIS system. A third type of noise encountered in the May data is saturated scanlines (lines in which all the pixels have the value 4095). The interval between these spikes varies from 4 to 200 scanlines and the spikes occur at the same location in all bands. The irregular interval between spikes suggests that the source of this noise is outside the AIS system. Principal component transformations of this AIS data offer no improvement over the raw data for interpretation (Figure 6) because noise is present in all components and is enhanced in components four and five. However, the results of an unsupervised classification procedure using the data are relatively unaffected by the noise.

The cyclic nature of the electrical noise requires that special care be taken in performing statistical comparisons between test sites along a flight line. The presence of cyclic noise superimposed on the reflectance data creates a situation in which pixels are more similar along rows than down columns and pixels from rows spaced one cycle apart may be more closely related than pixels from adjacent rows. In placing test sites one should try to locate them on scanlines which are at the same place in the noise cycle and the test sites should be large enough to adequately sample

the variations in DN due to noise as well as variations due to canopy reflectance. Finally, the means from the sites should be used as observations in the analysis and not the individual pixels. This is particularly important due to the high degree of autocorrelation which stems from the electrical noise.

CONCLUSIONS

Noise is present in both the October 1983 and May 1984 AIS data sets acquired over the George Washington National Forest. The noise is for the most part periodic, occurring every three and 106 scanlines. Suitably chosen filters should be used to remove the noise prior to making statistical comparisons between test sites using these data sets.
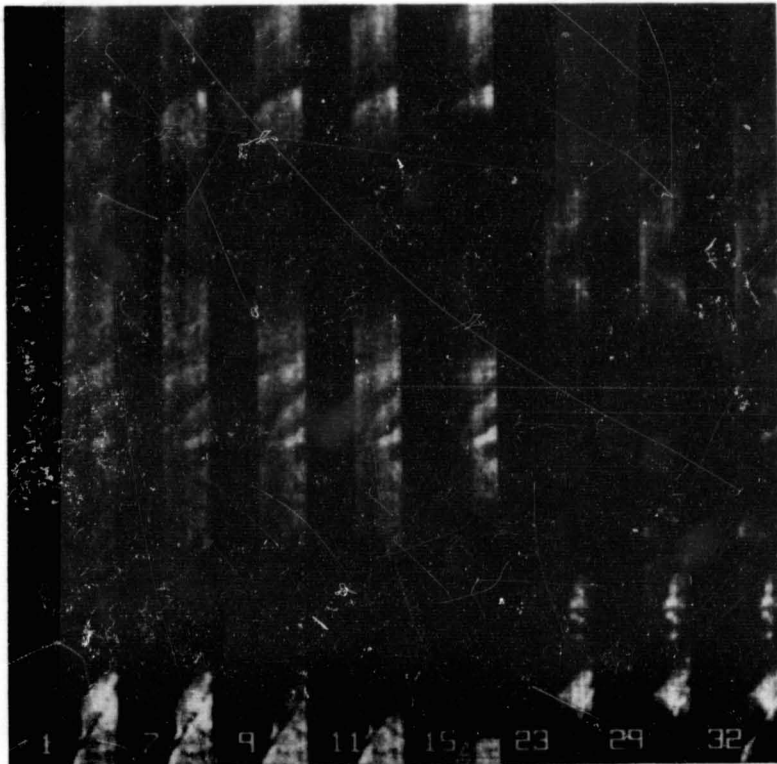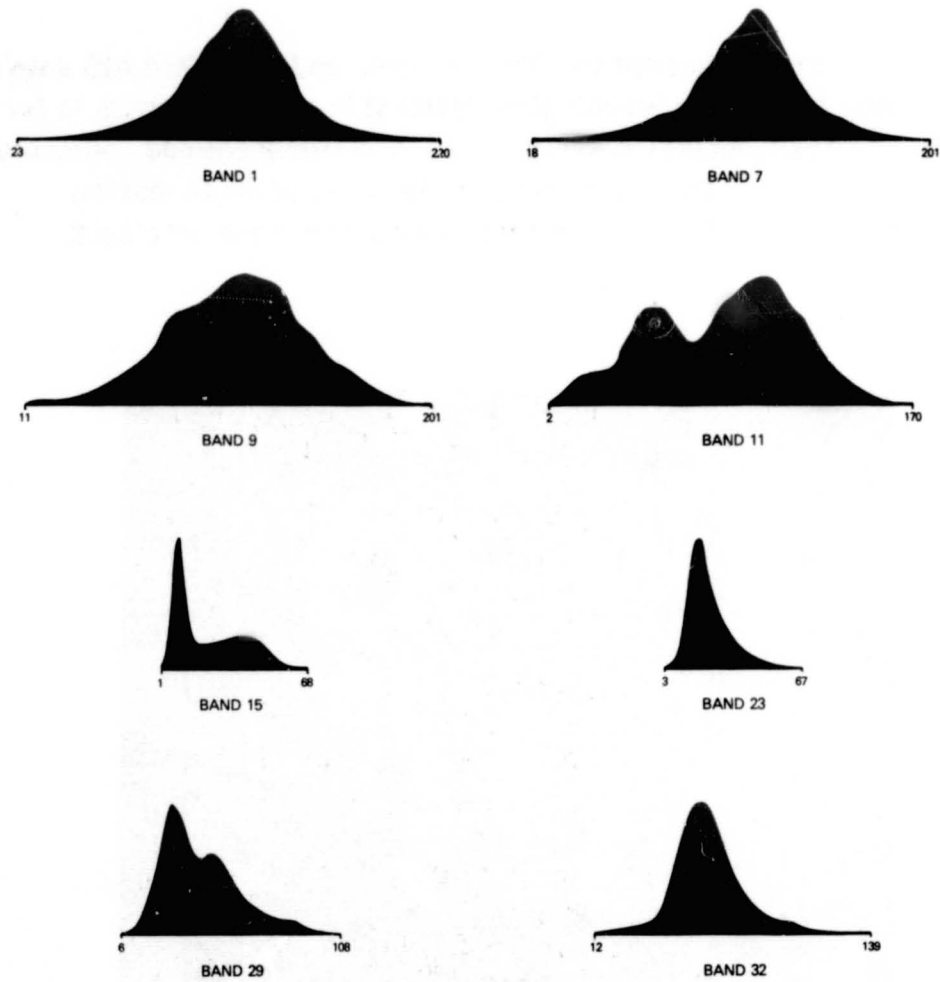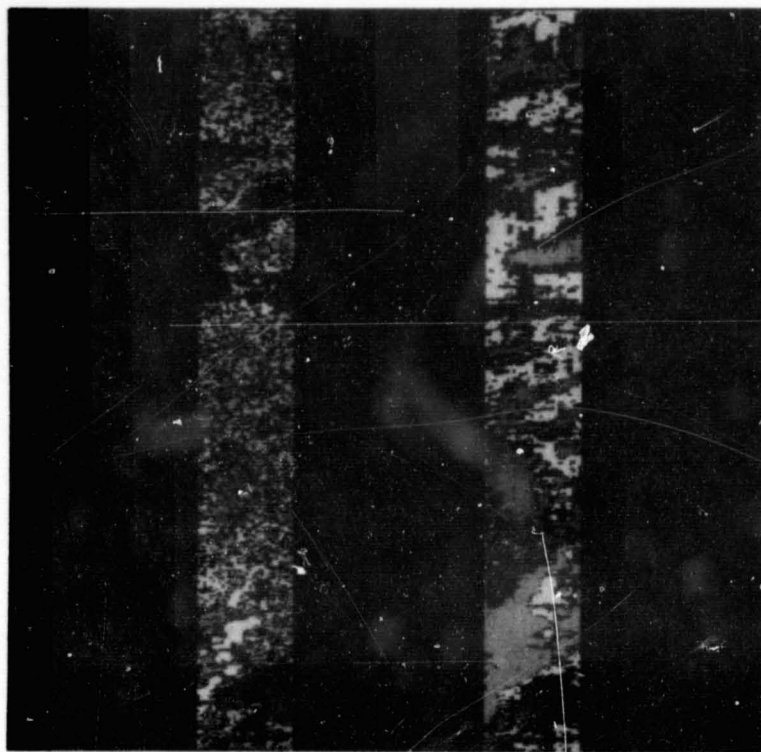

Fig. 1. Eight bands from the October 28, 1983 AIS flight (band numbers appear to the left of the each image)

Fig. 2. Histograms of DN values for the eight bands in figure 1. Noise appears as a peak in the one-to-thirty DN range.

Fig. 3. Two classifications produced by an unsupervised clustering routine, ISOCLS. The left image was produced from only the first eight bands of the October data. The right image was produced using all thirty-two bands. Homogeneous regions in the right image occur where noise is the greatest.
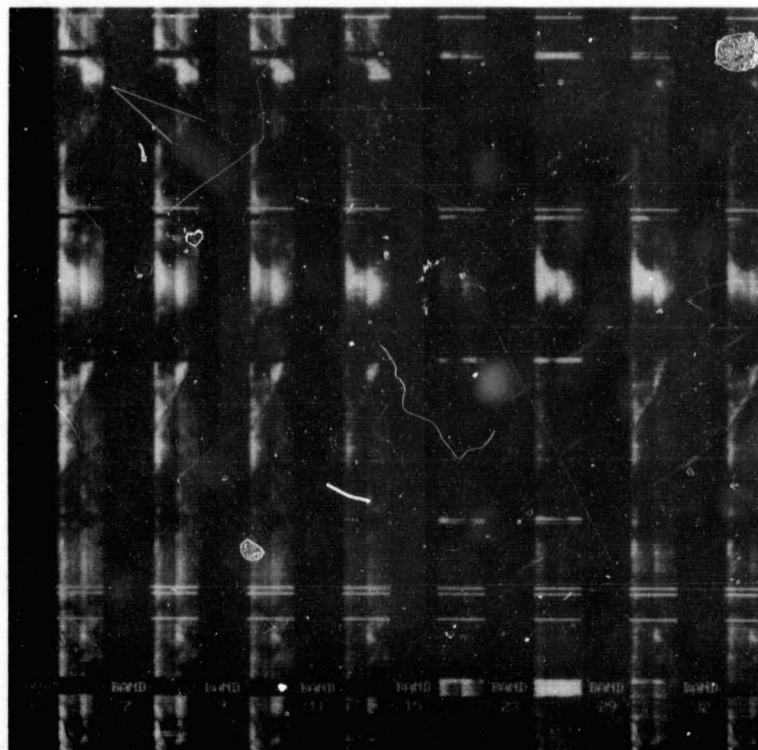
Fig. 4. Eight bands from the May 5, 1984 data.
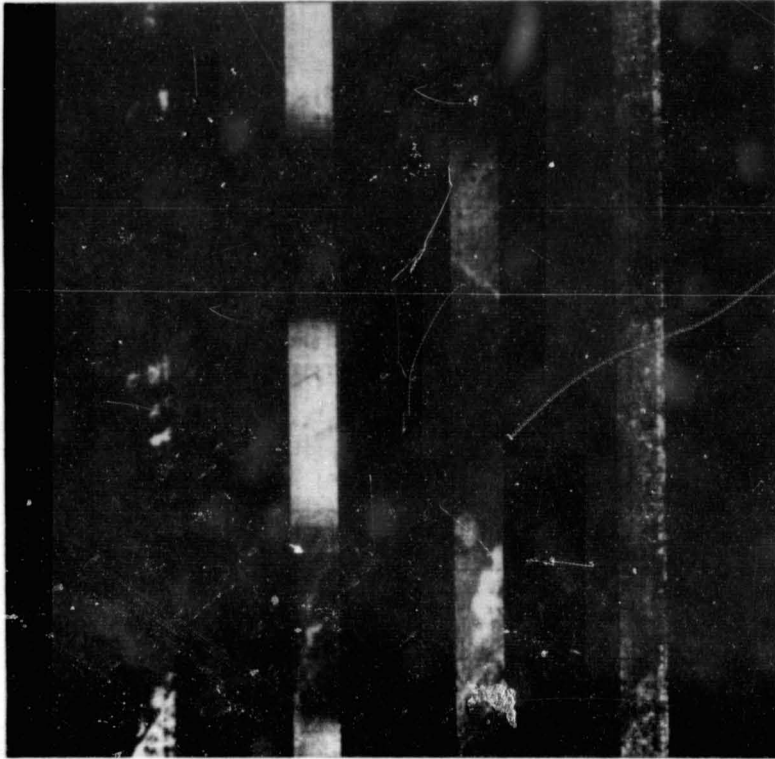
Fig. 5. Principal components analysis all thirty-two bands from the
October data. The first principal component is on the left.
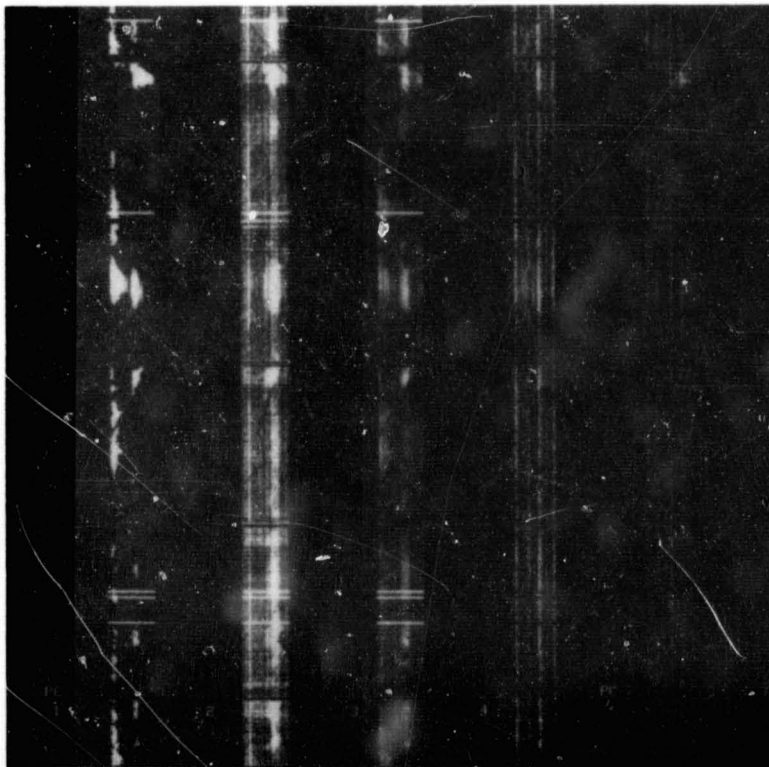
Fig. 6. Five principal components produced from the first thirty-two
bands of the May 5, 1984 data.