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EXPERIMENTAL MASKING OF RBV IMAGES TO REDUCE STATIONARY RESIDUAL INACCURACIES IN RADIOMETRIC CORRECTION

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ABSTRACT

RBV vidicon tube calibration data are used to correct spatially non-uniform radiance response in individual vidicons, during post-acquisition signal processing. However, examination of different ERTS-1 RBV-1, -2, and -3 image scenes showed stationary, repetitive residual inaccuracies in shading correction, large enough to affect qualitative and quantitative image analyses.

Photographic masks designed to reduce residual shading were prepared from RBV-1, -2, and -3 images of a relatively cloud-free ocean scene of uniform reflectance. When applied to other RBV scenes, the masks enabled more closely corrected RBV images to be printed. Illustrations are given of RBV-1 image before and after correction, compared with an equivalent MSS spectral image of the same scene.

1. INTRODUCTION

In an investigation where it was necessary to compare equivalent bulk-processed RBV and MSS spectral bands, a large number of local density variations were noted in RBV-1, -2, and -3 images vis-a-vis MSS-4, -5, and -6 records of the same scene. Analysis of a number of RBV scenes confirmed that many of the density variations in individual RBV spectral bands also had the same position, shape and density distribution from scene to scene.

It was necessary to correct the repetitive density variations in the RBV images before a useful comparison could be made with their MSS counterparts. The simplest method available was by photographic masking. Masking entails making a replica in opposite polarity of the image to be treated, in this case a negative mask, which when registered image-wise with the original positive would have densities exactly cancelling the unwanted densities in the original scene. When the combination is reproduced, a new scene would be formed, minus the unwanted density variations.

2. THE PROBLEM

Each RBV vidicon tube in ERTS-1 is mapped during calibration for radiometric response, since the photoconducting image surfaces of vidicon tubes vary in sensitivity from point to point. Response is measured on an 18X18 matrix, and data from the 364 points are used for generating a radiometric response correction program for reducing the shading errors to about 10% during post-acquisition signal processing, before imagery is produced. In the RBV images used in this investigation, it appears that the 18X18 matrix does not provide enough correction points to sufficiently smooth out some major shading errors, and local deviations much greater than 10% persist. Spot density measurements on the RBV image cannot be related with confidence to spectral reflectances of the same scene in the equivalent MSS band.

Figure 1 is of ERTS-1 RBV-1 images of different scenes, taken several days apart, printed at high contrast to emphasize and show the correlation of stationary shading errors in the RBV-1 camera. Similar errors were found in RBV-2 and -3 images. In the three RBV bands at 1:1,000,000 scale, graduated density variations occur in circular or elliptical patches varying from a few millimeters to 15 or 20 mm in size. Linear crosshatching at 45° also was found in parts of these images, appearing as lines of graduated density 1 or 2 mm wide and up to 60 mm long; this seems to be related to the 18X18 matrix but at a 36X36 frequency.

3. MASKING

A relatively cloud-free 9.5 inch, positive transparency scene was found, E-1007-15160-1, with a uniformly-reflecting ocean surface, confirmed by examination of the MSS-4 image. The RBV-1 image showed the repetitive residual errors noted above, and was used for making the correction mask as follows:

As all ERTS-1 images are reproduced at gamma 1.0* within close tolerances, the mask would also be made at gamma 1.0. A film was selected, Kodak Commercial, polyester base, and processing was established in D-19 developer for obtaining gamma 1.0 reproduction of a calibrated

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*This is not exactly correct. Reproduction of the darker areas of the bulk-processed scene (in the positive transparency) is at gamma less than 1.0, where the scene was recorded at sensor response of less than 20% full-scale. E.G., at 2% sensor output, gamma would be 0.75. In the mask, densities representing the darkest, lower gamma areas of the positive are also at a lower gamma, providing an almost perfect match for density cancellation.

step-tablet, under the contact printing exposure conditions to be used.

Bulk-processed ERTS-1 images are also controlled in density range, as well as gamma. The density range is normally adjusted to have the brightest objects in the scene such as clouds, at D 0.40±0.12 in the positive. As long as the image is on the straight line of the film reproduction material, with its density range within tolerance, and gamma 1.0 is maintained both in the mask and the image to be treated, one correction mask can be used with other images from the same spectral band.

A series of negative masks was then printed from the RBV-1 positive master, each processed to gamma 1.0. The negative mask which most completely cancelled densities in the positive master, when registered with it, was then selected for use with RBV-1 images from other scenes.

4. THE RESULT

ERTS-1 E-1002-18140, 25 Jul 72, RBV-1 was registered with the negative mask selected and reprinted through the combination. Sections of this image before and after masking are shown in Figure 2, compared with an MSS-4 image of the equivalent spectral band. The result is an obvious smoothing of residual RBV radiometric correction errors which enable the RBV-1 and MSS-4 image densities to be compared with each other for image analysis. The dark artifacts on the ocean in the lower left of the masked image are negative images of clouds, which were in the image from which the mask was made. Some scale differences exist between the reseaux of the mask and the masked image, but are not present in other RBV-1 images which have been tested. (The same procedures have been used for making radiometric correction masks of RBV-2 and -3 imagery.)

The extent to which residual shading has been reduced in the RBV-1 image is difficult to determine accurately, when comparing it with the MSS-4 image. As the RBV-1 spectral band extends further into the blue region than MSS-4, some differences might be expected from atmospheric effects, and would appear more prominently over a uniform background such as water.

However, the degree of correction exercised by the mask can be judged by measuring its density range between the lightest and darkest areas. The range is about 0.60 density units, a 4:1 difference in transmission. Density variations measured in the registered combination of the mask and the master from which it was printed do not exceed ±0.03. Maximum spatial non-uniformity of densities in the third generation 9.5 inch ERTS image is in the order of 0.10. The combined local error between the mask and the image could be in the worst case, ±0.13, or 1.35:1; a significant improvement over the original 4:1 shading error.

5. CONCLUSIONS

It is concluded that the 18X18 RBV correction matrix does not sufficiently eliminate radiance response inaccuracies in the bulk processed images, where densities in these images are to be related to scene radiances as viewed from the sensor position. This tends to vitiate the usefulness of an otherwise excellent sensor system.

Masking offers a relative simple means of correcting residual RBV radiometric errors, which could be applied during production of 9.5 inch enlarged images with appropriate masks on the exposure platen. RBV images made over a completely calm ocean area, undisturbed by waves and free of clouds and sun-glitter, would provide master images from which correction masks could be made for routine production work.

REFERENCE

Data Users Handbook
NASA/GSFC Document No. 71SD4249

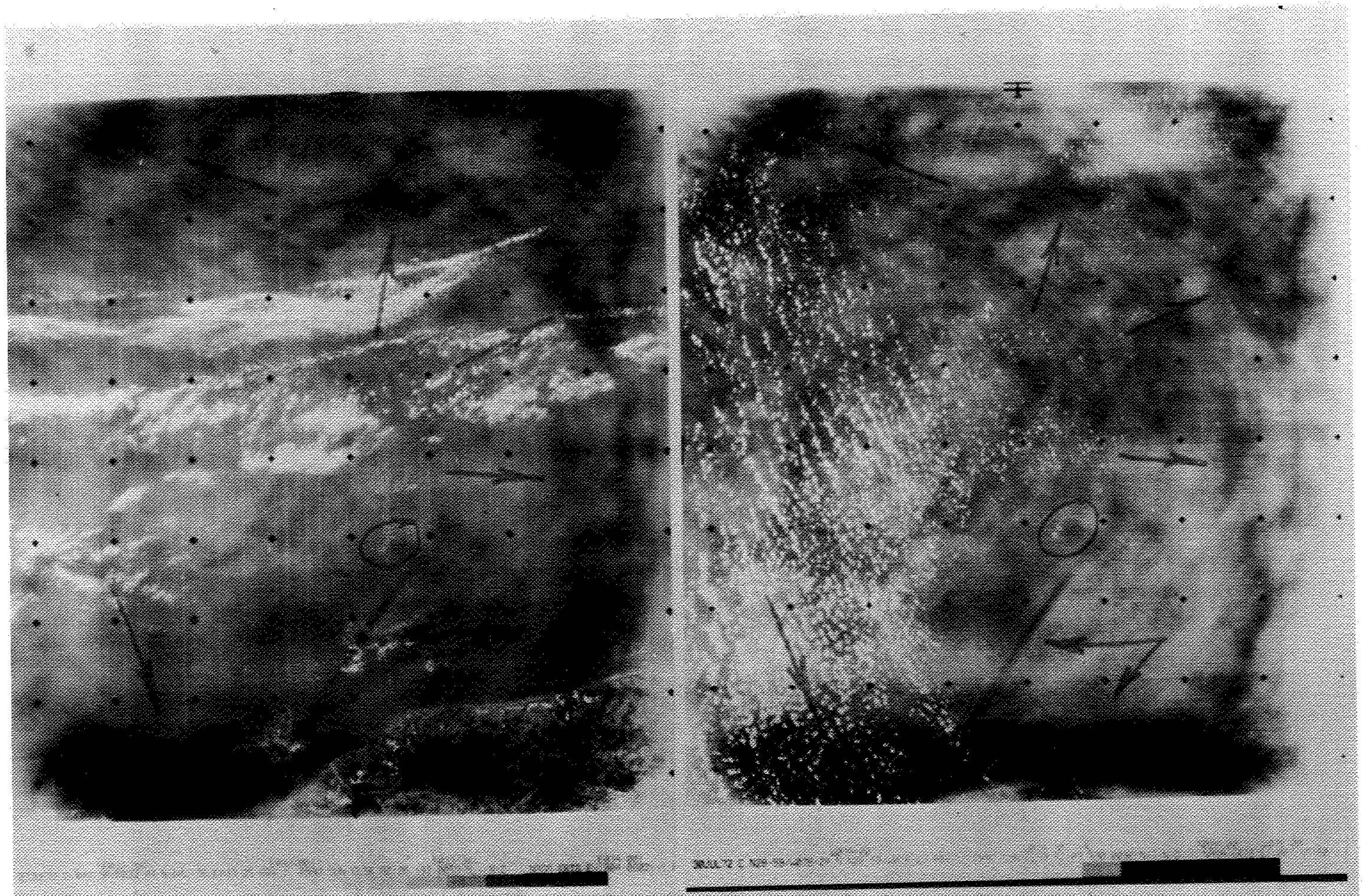

FIGURE 1. ERTS-1 RBV-1 IMAGES SHOWING STATIONARY RESIDUAL SHADING ERRORS. LEFT, E-1004-08021-1, 27 Jul 72; RIGHT, E-1007-15160-1, 30 Jul 72.

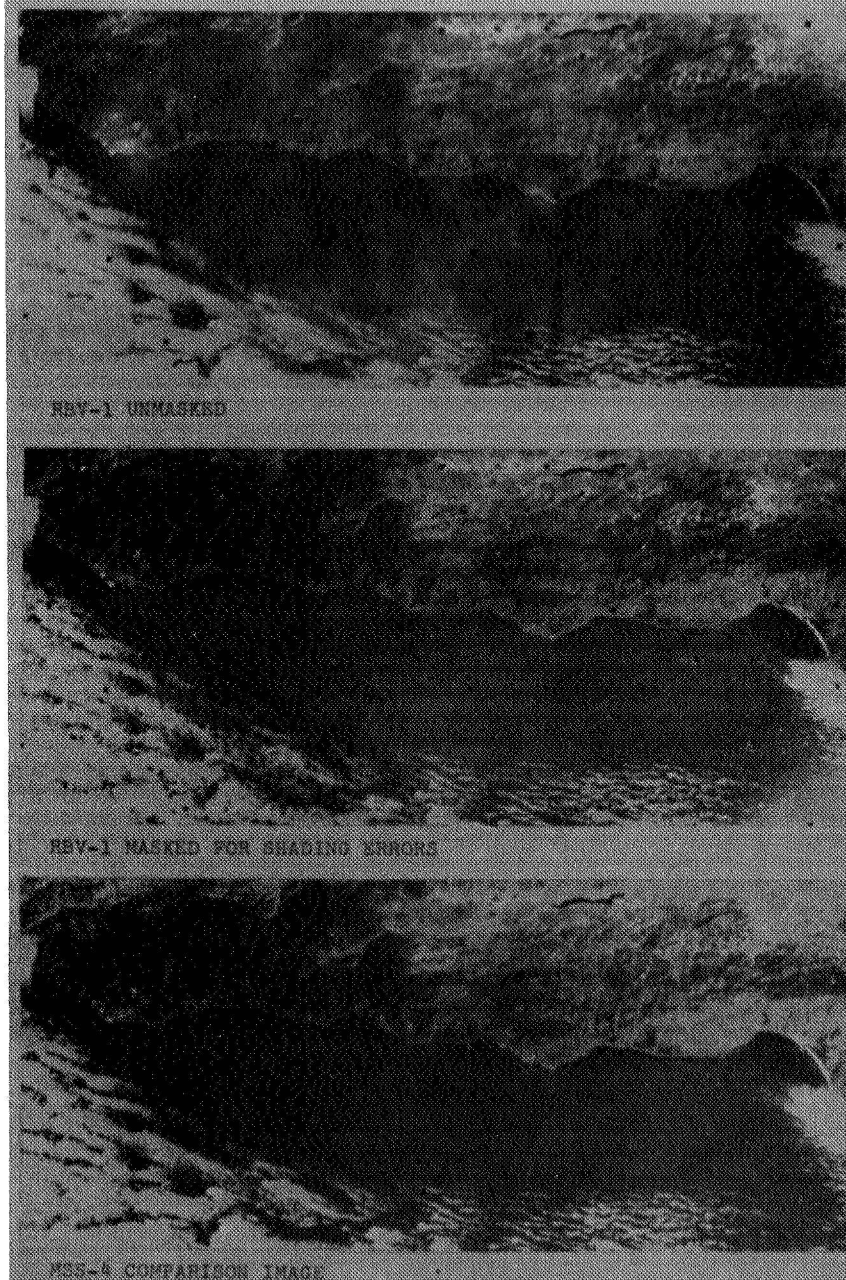

FIGURE 2. ERTS-1 E-1002-18140, 25 Jul 72 RBV-1 IMAGE UNMASKED AND MASKED TO REDUCE SHADING ERRORS, COMPARED WITH MSS-4 IMAGE IN SAME SPECTRAL BAND.