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Effects of Resolution Versus Speckle in Spaceborne Radar Image Interpretation: A Geologic-User Based Analysis

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EFFECTS OF RESOLUTION VERSUS SPECKLE IN SPACEBORNE RADAR IMAGE INTERPRETATION: A GEOLOGIC-USER BASED ANALYSIS

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Discrimination of geologic targets on synthetic-aperture radar (SAR) images is governed to a large degree by the ground resolution, the image speckle, and the range of contrast on the images. Holding the image contrast constant a survey was made of the effects of ground resolution versus speckle relative to discrimination and interpretability of Earth terrane features. Seasat SAR data of three different test sites were used to simulate thirteen combinations of range resolution, azimuth resolution and speckle (Table 1).

Table 1. Image Simulations

Range Resolution (m)	Azimuth Resolution (m)	Total Looks
50	25	1, 2, 4
50	50	1, 2, 4
50	300	1, 2, 4
300	300	1, 4, 16, 32

A relative measure of speckle is given by the number of independent estimates that are made of the power return in each pixel. Each independent estimate is termed a look.

Speckle reduction is achieved by independent averaging of the pixels. Both spectral and spatial averaging were used to obtain the simulations listed in Table 1. The simulated resolutions were obtained by selectively sampling the radar signal bandwidth in range and in azimuth. Targets consisting of geologic and geomorphic features were selected at each test site, for discrimination by a population of geologic-user analysts, and in some cases their students, who had agreed to participate in this study. The extent to which discriminability of the targets is enhanced or suppressed as a function of resolution and speckle on the images is determined here from a survey of the analyst evaluations. The overall best images of the three scenes, as determined by a 2/3 majority of all respondents, are reproduced in Figures 1, 4, 8. For comparison the best images at the lowest resolution are shown in Figures 2, 5, 9. Corresponding sketch maps that show the location of the selected targets are given in Figures 3, 6, 7.

Participant analysts were requested to separate the thirteen images of each test site into three groups of three and one group of four. This grouping served to segregate the images according to the four selected combinations of range and azimuth resolutions though this was not known to the analysts at the time they made the evaluations. For each target the analysts were requested to identify the best and worst image in each group. They also indicated the images where they considered the target or targets to be indiscriminable. Part two of the analysis was to compare the worst image of a given group with the best image of the next adjacent group. The purpose of this exercise is to identify for each target at each test site any image(s) where a combination of lower resolution and higher looks is superior to higher resolution and lower looks. Finally the analysts were requested to specify separately for each target the overall best and overall worst images. Wherever an image was designated "worst" the target is at least discriminable.

The summary of the analyst evaluations which follows is incomplete at this time of writing. However it is based on returns from about 25 professional image interpreters, with applications interests in the Earth Sciences, and an approximately equivalent number of students. This is considered sufficient to present preliminary observations.

About 75% of the professional analysts have over five years and about 95% of the students have less than one year of experience with image interpretation. Consequently the responses were tabulated separately. The separate tabulations reveal a high degree of correlation in preferences for best and worst images. Without exception each analyst indicated that the worst of the high-resolution images (50/25 or 50/50) is superior to the best of the low-resolution images (50/300 or 300/300). For every target the overall best image is one of the highest resolution and the overall worst image (target discriminable) is one of a low-resolution group.

For the majority of analysts the results to date show that at relatively high resolutions of

50 m or less the images processed at two looks are best for discriminating features of large areal extent. A higher number of looks is preferred for smaller, subkilometer-scale features. At low resolutions of 300 m or more the best images of extended targets are those processed at sixteen looks or more, and geologic features of subkilometer scale are obscure or indiscriminable. The relation between discriminability and type of target is unmistakably clear for sand dunes and sand sheets. For other types of targets this relation is less obvious and has not been determined. One-look images are uniformly unsatisfactory for most targets at all simulated resolutions. In many instances one-look images at a given resolution are inferior to corresponding multiple-look images at a slightly lower resolution. Further generalizations are not warranted for the present.

ACKNOWLEDGMENT

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VALLEY AND RIDGE , TENNESSEE

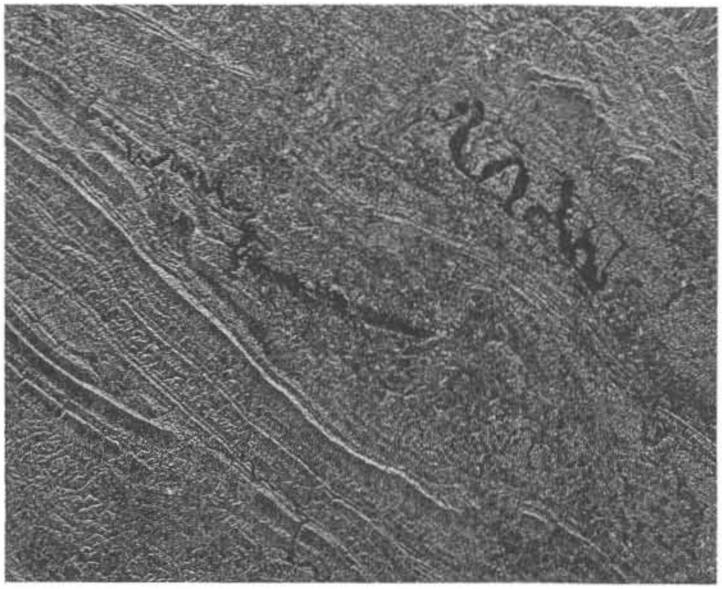

Figure 1. Seasat SAR image of Valley and Ridge area, Tennessee. Data are from Rev. 874 acquired August 27, 1978; digitally processed at two looks, 50 X 25 m resolution.

Figure 2. Seasat SAR data in Fig. 1, processed at sixteen looks, 300 X 300 m resolution.

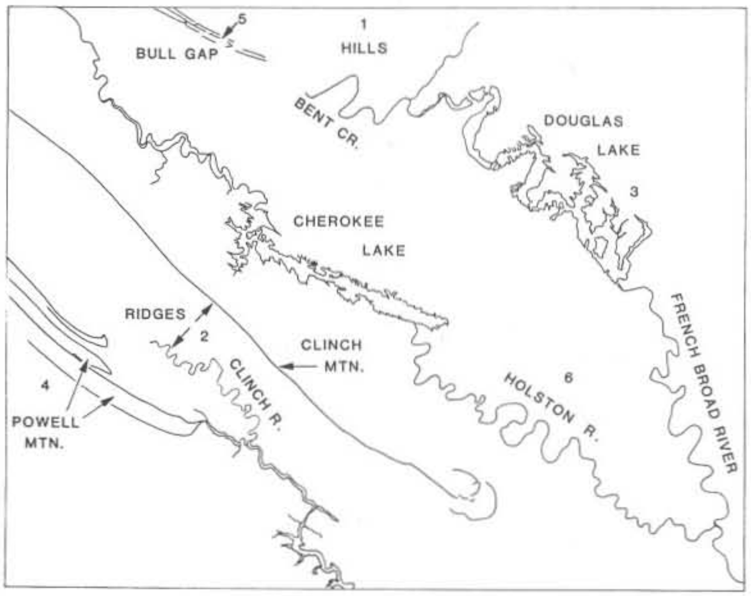

Figure 3. Location of six targets in Valley and Ridge area, Tennessee.

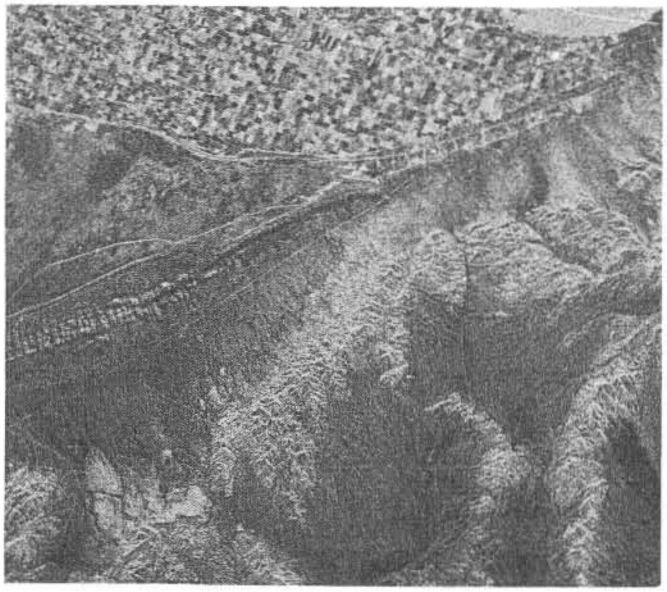

Figure 4. Seasat SAR image of Algodones Dunes/ Imperial Valley area, California. Data are from Rev. 1140 acquired September 14, 1978; digitally processed at four looks, 50 X 25 m resolution.

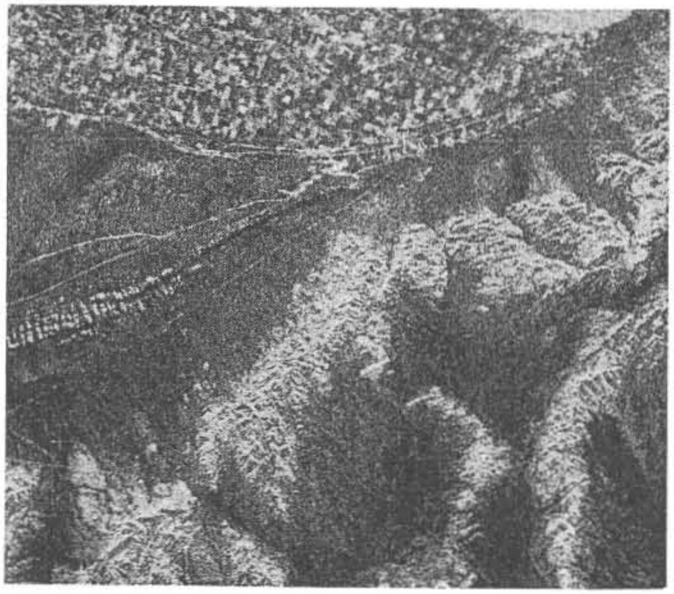

Figure 5. Seasat SAR data in Fig. 4, processed at thirty two looks, 300 X 300 m resolution.

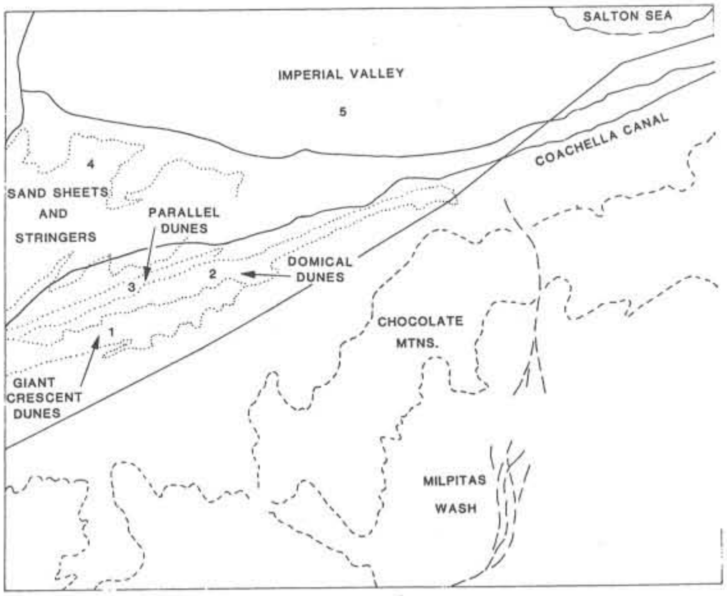

Figure 6. Location of five targets in Algodones Dunes/Imperial Valley area, California.

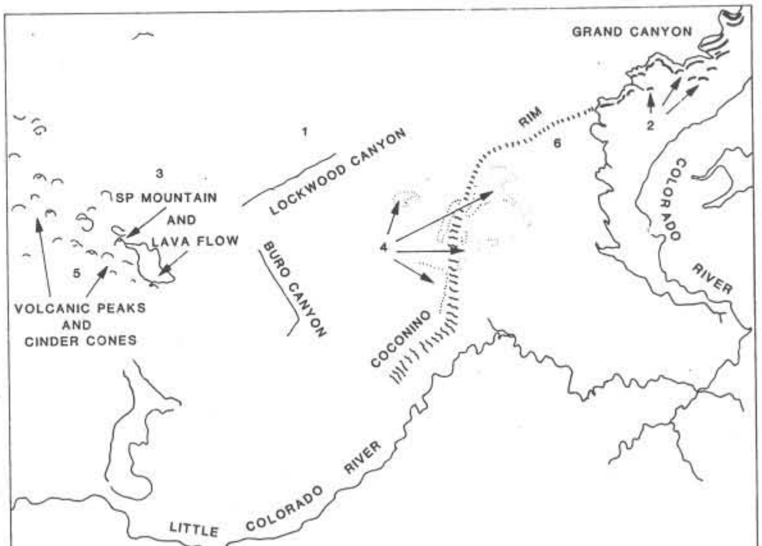

Figure 7. Location of six targets in Grand Canyon/Coconino Plateau area, Arizona.

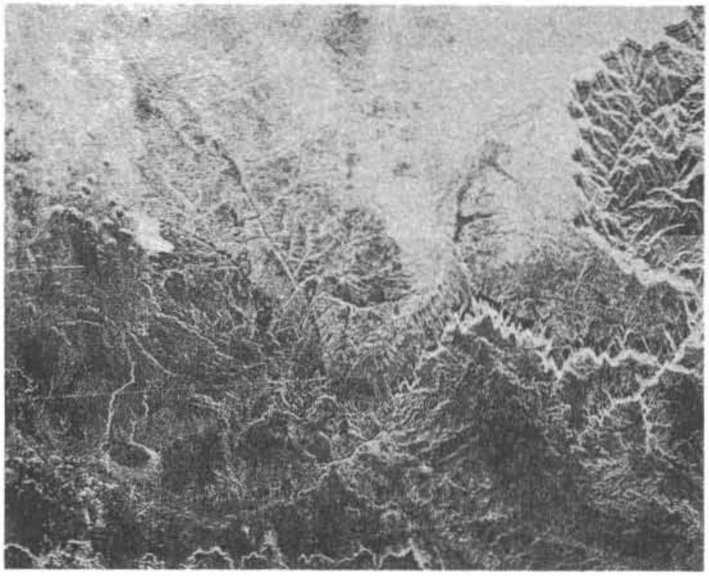

Figure 8. Seasat SAR image of Grand Canyon/ Coconino Plateau area, Arizona. Data are from Rev. 322 acquired July 19, 1978; digitally processed at two looks, 50 X 25 m resolution.

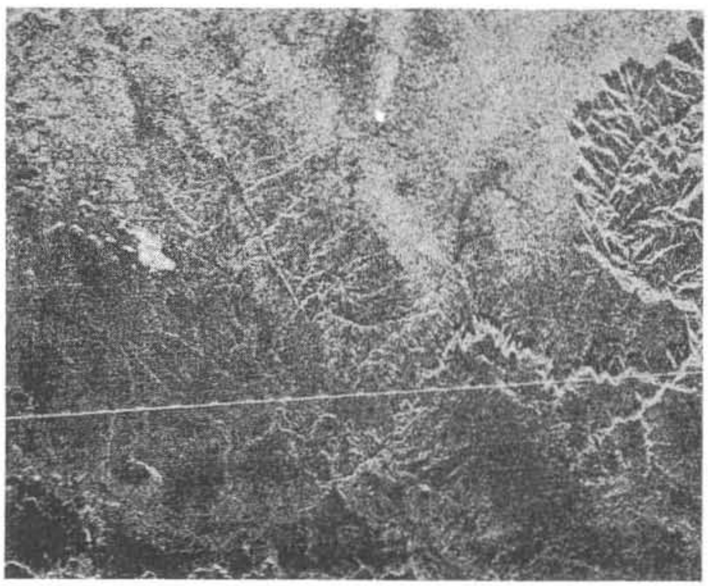

Figure 9. Seasat SAR data in Fig. 8 processed at sixteen looks, 300 X 300 m resolution.