JPL NO. 9950 – 1194

CAT. 43

IN-43732

P-10

AN EVALUATION OF A SIRA IMAGE TO DETERMINE FOREST DENSITY UNDER CONDITIONS OF MODERATE TOPOGRAPHICAL VARIATION

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Final Report
Jet Propulsion Laboratory
Contract 956431
October 1985

(NASA-CR-179956) AN EVALUATION OF A SIRA IMAGE TO DETERMINE FOREST DENSITY UNDER CONDITIONS OF MODERATE TOPOGRAPHICAL VARIATION Final Report (Washington Univ.) 10 p CSCL 02F G3/43

N87-13836

Unclas 43630

Many studies have shown that radar images have increased classification accurracy over spectral classifications using only Landsat MSS images (e.g. Ulaby et al. 1982). Our analysis of spectral mixture models to identify ultramafic rocks in the Klamath Mountains near Hayfork, California using only Landsat MSS images demonstrated an inability to accurrately separate units that were vegetated with more than 50% ground cover (Cooke et al. 1985). In addition, we had difficulty separating pasture lands from xeric sparse forests on south slopes. It was our objective to determine if a SIRA image taken over Hayfork when used alone or in conjunction with Landsat MSS data would increase separation of units not identified by Landsat spectral mixture models. Our hypothesis was that the longer wavelength of SIRA images could contain a significant and direct response to the surface roughness created by the vegetation architecture. To test this hypothesis we compared areas in the Landsat model of varying vegetation density (0-50%) that had proven to be accurrate by field surveys. These areas were primarily the less densely vegetated ultramafics characteristic of the area.

An analysis of the second order surface roughness effects (e.g. diaelectric and architecture effects) in SIRA images requires that the primary effects due to topography be removed. The SIRA image of Hayfork was initially rectified and registered to provide a projection and resolution equivalent to the digital terrain data. To remove that component of the radar return that was specifically due to topography we used a radar simulation developed by Mike Kobrick at JPL. The simulation computed the incidence angle of the transmitted signal to surface topography using digital terrain data and other parameters related to the instrumentation and space shuttle orbit. The predicted radar image (Fig. 1) illustrates the relative coarseness of the digital terrain data by some of the flat valleys and ridges. A qualitative comparison of Fig. 1 with the original SIRA image (Fig. 2) indicates that the primary feature highlighted in the image is the topography.

An empirical calibration of the SIRA image was performed to remove that component in the image due solely to the topography. The calibration consisted of determining the cosine response of the SIRA image as a function of computed incidence angle using digital terrain data. The plot of data in Fig. 3 is the average DN return for each pixel rounded to the nearest degree of incidence angle. The points in Fig. 3 have a correlation of 0.98 when the data were regressed using the following equation:

$$\text{SIRA DN} = 116.27 \cos(\text{incidence angle}) + 73.98$$

The observed cosine response exhibited by the data provides evidence of the validity of the digital terrain simulation as well as illustrating the a symmetrical distribution of surface angles in the area. Subtracting each pixel of the image using Equation (1) from the SIRA image of Fig. 2 results in a SIRA image without the primary response due to topography (Fig. 4).

Although major topographical variations have been removed (Fig. 4) topographical features still remain a dominant component of the SIRA image. The only other features apparent in the image are bodies of water (e.g. a few lakes and a resevior).

Fig. 5 is an image for comparison where density of vegetation is proportional to the image brightness (brightest areas are 100% vegetation density - dark areas are 0% vegetation density). This image was computed from Landsat MSS data by separating the spectral signature of vegetation from that of the shade and substrate. The visual lack of topographical information in Fig. 5 compared to Fig. 4 is an indication that the SIRA image is not significantly responding to changes in vegetation density or any other vegetation architectural changes. The vegetation densities illustrated by Fig. 5 closely coincide with field work and depict a wide range of density variation as shown by the spatial variation in brightness. Note that the clearcuts which appear as dark rectangular areas in Fig. 5 are not observed in the SIRA image (Fig. 2) or in the residual image (Fig. 4), indicating that SIRA is not sensitive to vegetation density in this scene.

In summary, we find in the Hayfork area that SIRA does not increase or help delineation of vegetation or ultramafic units over Landsat MSS. In general, these results suggest a need to isolate the physical causes resulting in increased classification accurracies found in other studies. Many studies in forest inventory have concluded that classification accurracy of forests using Landsat MSS can be increased significantly by adding digital terrain data alone (e.g. Sugarbaker et al. 1980). Our results suggest that SIRA images are predominately an expression of the topography and not of the small scale surface roughness associated with vegetation or diaelectic coefficients.

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Ulaby, F., R. Li, and K. Shanmugan. Crop classification using airborne radar and Landsat data. IEEE Trans. Geoscience and Remote Sensing 20:1,42-50, 1982.

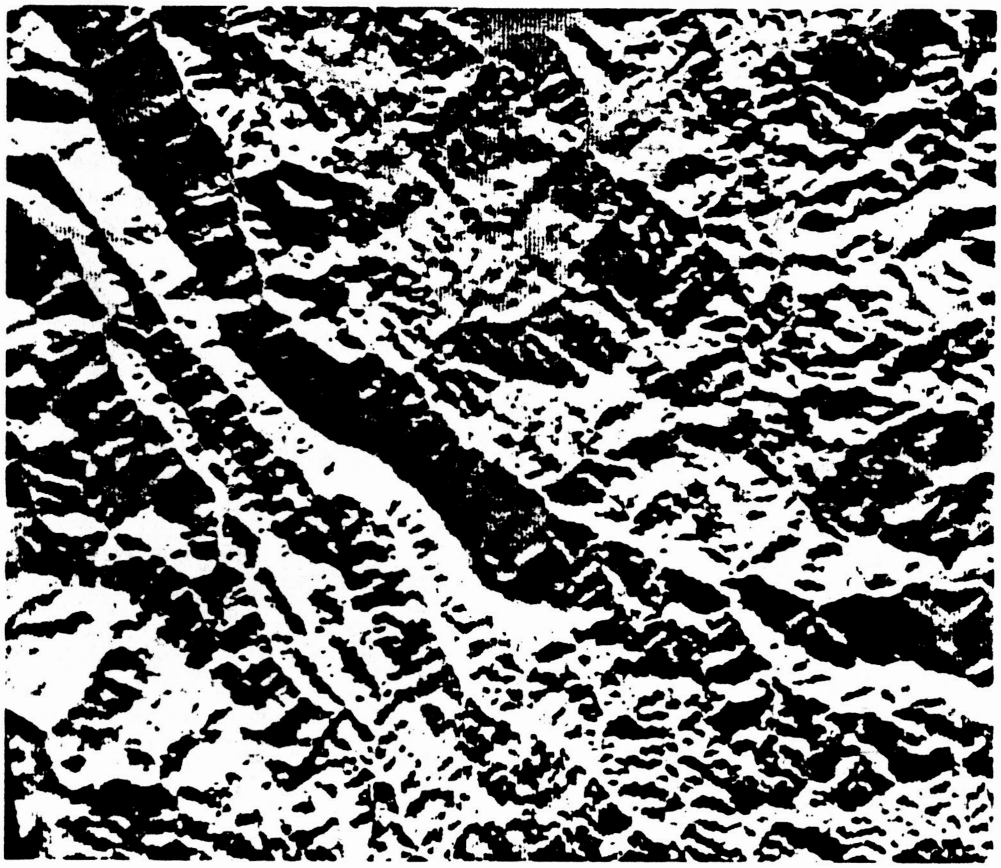

Figure 1. Simulated SIRA image using digital terrain of area south of Hayfork, California.

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Figure 2. SIRA image of area south of Hayfork, California.

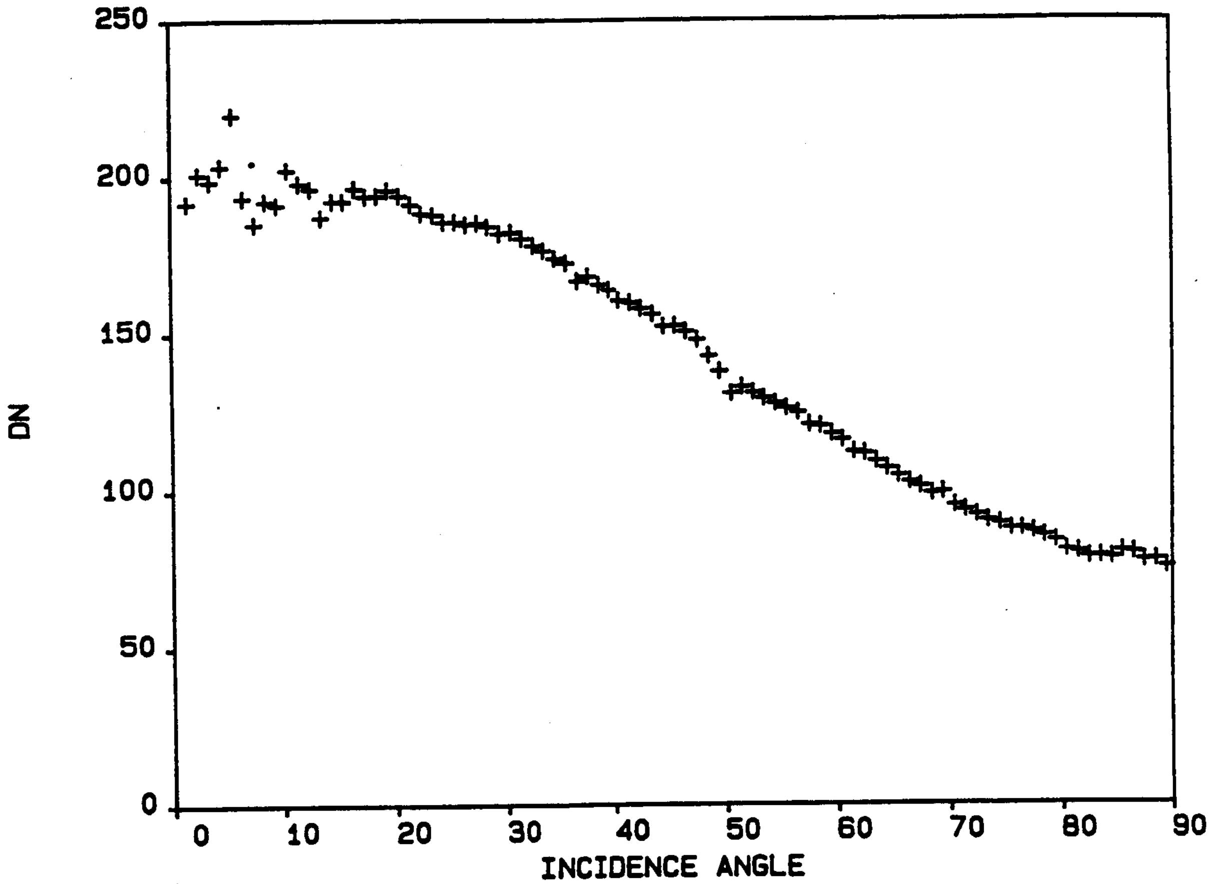

Figure 3. The cosine relation between computed incidence angle from digital terrain data to the average SIRA DN for each pixel of the scene in Fig. 2 has a correlation of 0.98.

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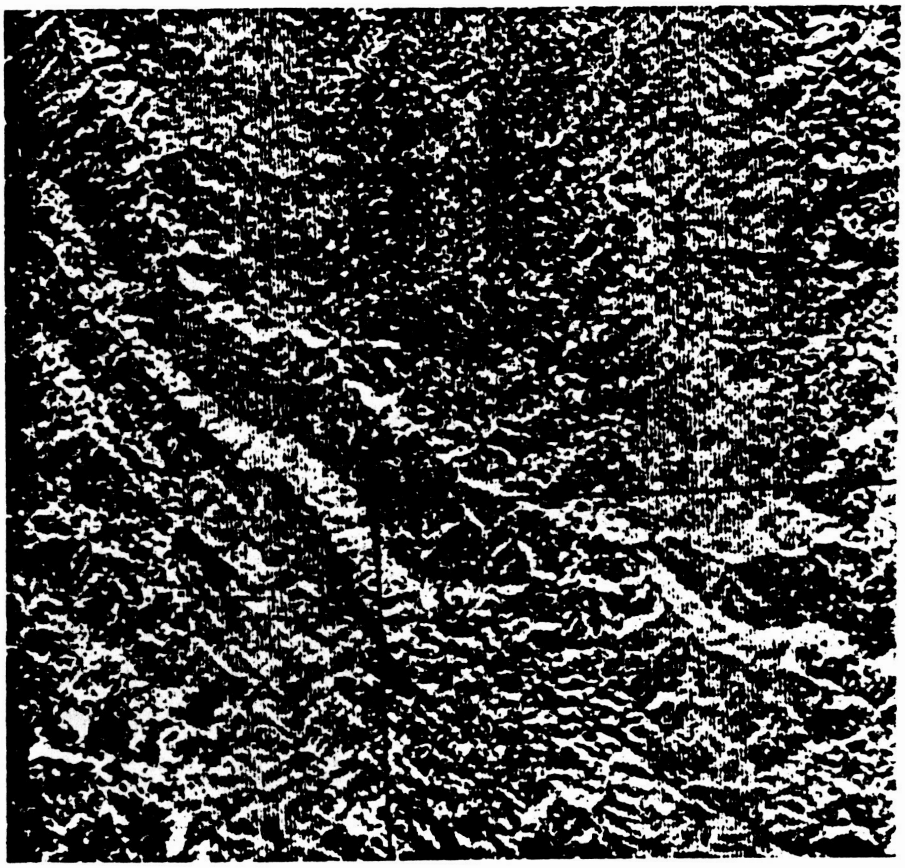

Figure 4. SIRA image with the primary expression of topography removed using the empirical cosine calibration of Equation 1.

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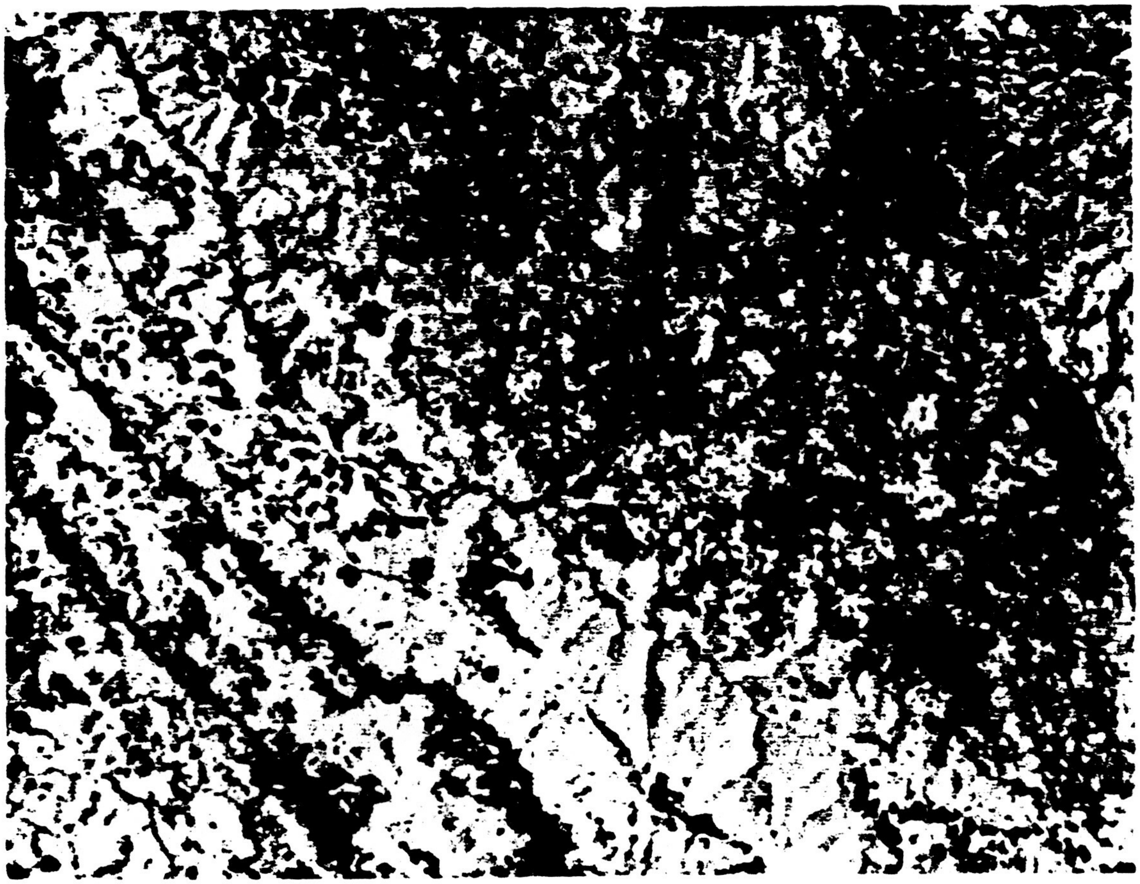

Figure 5. Vegetation density resolved from spectral mixtures using a Landsat image of Hayfork, California. Image is scaled so that white is 100% vegetation density and black is 0% vegetation density.