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PRELIMINARY ANALYSIS OF THE SENSITIVITY OF AIRSAR IMAGES TO SOIL MOISTURE VARIATIONS

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Introduction

Synthetic Aperture Radar (SAR) images acquired from various sources such as Shuttle Imaging Radar B (SIR-B) and airborne SAR (AIRSAR) have been analyzed for signatures of soil moisture (Dobson et al., 1986, Wang et al., 1986, Rao et al., 1992). The SIR-B measurements have shown a strong correlation between measurements of surface soil moisture (0-5 cm) and the radar backscattering coefficient σ^o, (Wang et al., 1986). The AIRSAR measurements, however, indicated a lower sensitivity (Rao et al., 1992). In this study, an attempt has been made to investigate the causes for this reduced sensitivity.

Measurements

Polarimetric AIRSAR data were acquired over the Little Washita watershed near Chickasha, Oklahoma during June 10-18, 1992. A total of 8 days of flights were made during this period. There was a series of heavy rainfall prior to June 10. No rainfall was reported between June 10 and 18. Soil moisture samples in the top 5 cm layer were collected at a number of fields during the time of the flights. The average soil moisture was ~0.26 gm/cm^3 on the first day of flight (June 10) and ~0.13 gm/cm^3 on the last day of flight (June 18).

Two areas covered by the AIRSAR flights were selected for the study, one southwest of the watershed (site 1), and the other northeast of the watershed (site 2). Three sets of images (C, L, and P-bands) for the two areas, acquired on three different dates, June 10, 14, and 18, were analyzed. In order to obtain a broader perspective on the sensitivity of the SAR images to soil moisture variations, a finite strip of 200 pixels in the cross track and 1024 pixels in the along track directions were chosen from each image. The strips from each scene were chosen such that they cover approximately the same area on the ground.

Results

The results from the analysis for site 1 are shown in Figures 1 and 2. Each data point in these figures represents an average of 200 pixels in the cross track and 8 pixels in the along track directions. Averaging was performed to reduce the effect of speckle and noise.

Figures 1 and 2 indicate the variations of σ_{hh}^{o}, at all three frequencies, for the June 10 and 18 images. These figures show that (1) the average value of σ_{hh}^{o} changed only by about 1 dB, 2.5 dB, and 3 dB, for C, L, and P-bands, respectively from June 10 to 18, whereas soil moisture changed by ~0.13 gm/cm^3 during the same period; and (2) amplitude variations within the strips are much higher in comparison (on the order of 5-8 dB). Since soil moisture is not expected to differ by a significant amount within a strip, the wide amplitude fluctuations indicate that the radar backscatter of the AIRSAR images is sensitive to other surface features. The general pattern of the amplitude variations of σ_{hh}^{o} is the same for both the June 10 and 18 images, which suggests that these variations are caused by surface features which did not change from June 10 to 18. However, at this point, it is not clear which surface feature/features are causing these variations. Comparison of responses of the three frequencies shows that P-band has the highest variation (standard deviation of ~ 2.2) and C-band the lowest (standard deviation of ~ 0.6).

Images of site 2 were also analyzed to determine if they indicate similar trends. However, a disturbing feature was observed in the C-band images. Figures 3 and 4 indicate the variations of σ^{o} values for C-band, for June 10 and 18, respectively. These figures show that, while σ_{hh}^{o} is higher than σ_{vv}^{o} on June 10, σ_{vv}^{o} is higher than σ_{hh}^{o} on June 18. This pattern was not noticed in the case of L and P-bands. This feature is probably caused by an error in the calibration procedure; therefore, these images were not used for the analysis.

Conclusions

An attempt was made to examine the causes for the lower sensitivity of AIRSAR images to soil moisture variations in comparison with that of SIR-B images. Based on the results obtained, it can be inferred that σ^o values are less sensitive to soil moisture than to other surface features. Further analysis of these images is required to identify those surface features which predominate the radar backscatter in the case of AIRSAR.

Some of the C-band images indicated a change in the dominant polarization with time. This change is not expected to occur over a typical agricultural area and could be due to a potential problem in the calibration.

References

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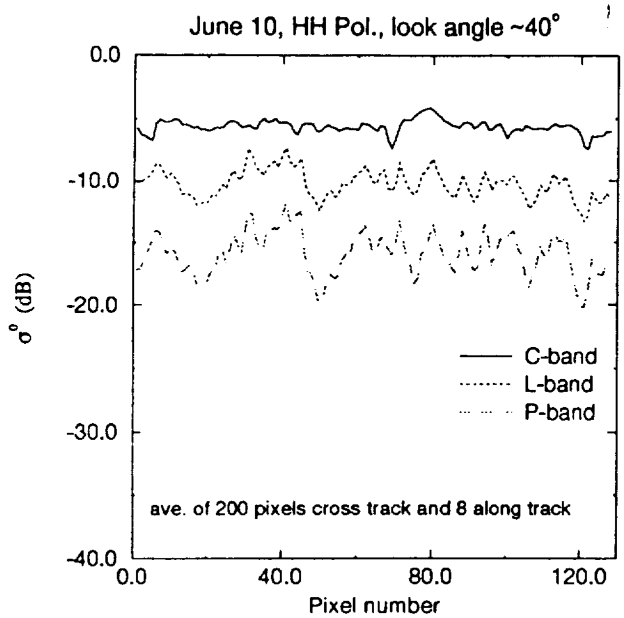

Figure 1. The along track variation of $\sigma_{HH}{}^{o}$ at the look angle of 40°, for C, L, and P-bands (June 10, 1992).

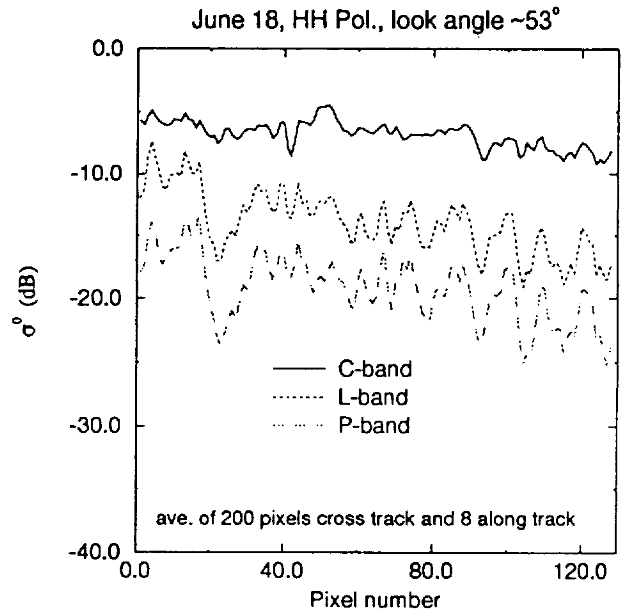

Figure 2. The along track variation of $\sigma_{HH}{}^{o}$ at the look angle of 53°, for C, L, and P-bands (June 18, 1992).

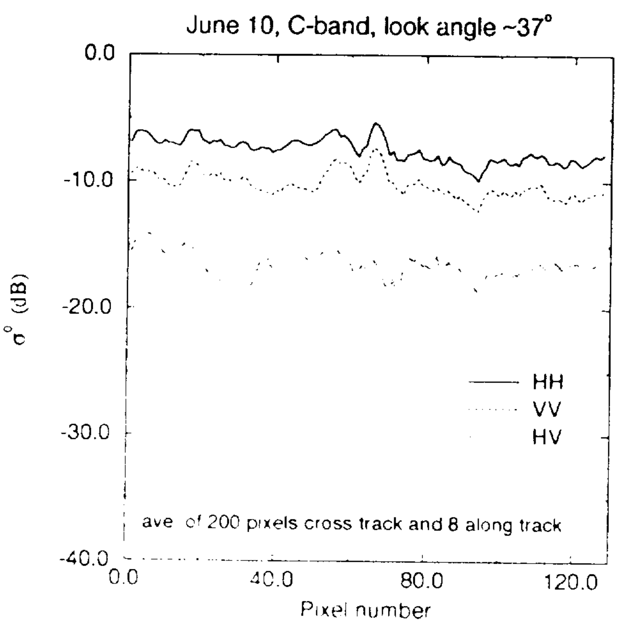

Figure 3. The along track variation of C-band σ^o values, at the look angle of 37°, for HH, VV, and HV polarizations (June 10, 1992).

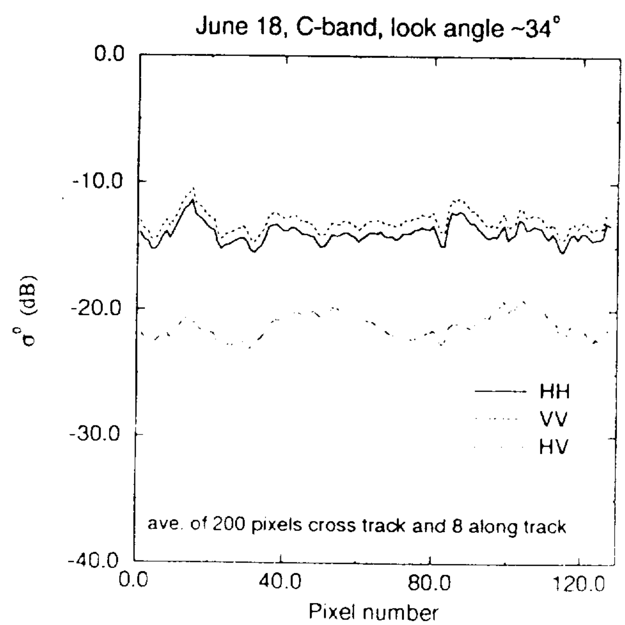

Figure 4. The along track variation of C-band σ^o values at the look angle of 34°, for HH, VV, and HV polarizations (June 18, 1992).