SEASONAL COMPARISON OF C-BAND AND Ku-BAND BACKSCATTER COEFFICIENTS OVER VEGETATION REGIONS

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Abstract– Spaceborne scatterometry, although originally used to measure winds over oceans, has been useful in the study of vegetation over different regions of the world. For example, scatterometer measurements of the normalized radar cross section, σ^o have been used for tropical vegetation classification and in studies of the freeze/thaw cycles of Boreal forests.

From September 1996 through June 1997 both the Ku-band NASA Scatterometer (NSCAT) and the C-band ERS-2 AMI scatterometer were operating. This provides a unique opportunity to simultaneously characterize large scale vegetation response at both bands. In this paper we examine the seasonal response of vegetation in North America using both sensors. Observations of the seasonal cycles are discussed.

INTRODUCTION

The primary purpose of C-band and Ku-band scatterometers are to determine wind speeds over the ocean by measuring the radar backscatter coefficient, σ^o, over ocean regions. The NASA Scatterometer (NSCAT) and the European Remote Sensing (ERS-1 and ERS-2) Active Microwave Instrument (AMI) have also proven useful in studies over the ice and land. For example, The European Remote Sensing (ERS-1 and ERS-2) AMI scatterometers, which operate at C-band and one polarization(v-pol), have been used in studies over the Boreal forests regions in Canada [2] [4], over the Siberian Forests [3]. Seasat, a Ku-band scatterometer has been used in ice studies over Greenland [5] and the Amazon [6].

While studies have taken place at both C-band and Ku-band, there has been relatively little research done in combining both bands. This paper examines σ^o measurements over the Midwest region of North America for both C-band and Ku-band. This paper uses $\mathcal{A}$ and $\mathcal{B}$ values where $\mathcal{A}$ and $\mathcal{B}$ are related to σ^o by

$$\sigma^o = \mathcal{A} + \mathcal{B}(\theta - 40^\circ) \quad (1)$$

where θ is the incidence angle of the observation. Images of $\mathcal{A}$ and $\mathcal{B}$ are made using the SIR resolution enhancement algorithm. $\mathcal{A}$ and $\mathcal{B}$ images are created for both h-pol and v-pol of NSCAT and for the v-pol of ERS-1/2.

This paper first examines ERS-1/2 $\mathcal{A}$ and $\mathcal{B}$ values over North America and then NSCAT results, finally comparing the two. Precipitation and mean temperature are ex-

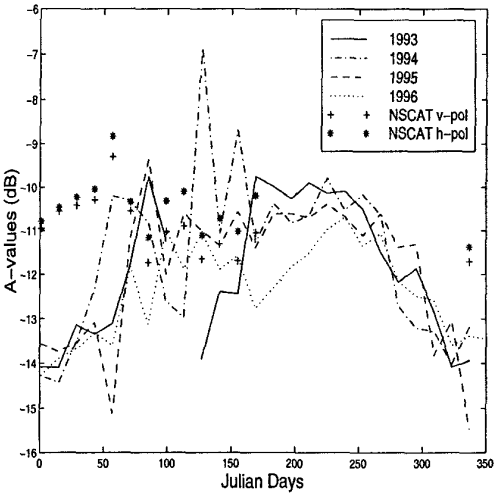

Figure 1: $\mathcal{A}$ values versus time for (a) 1993 (b) 1994 (c) 1995 and (d) 1996.

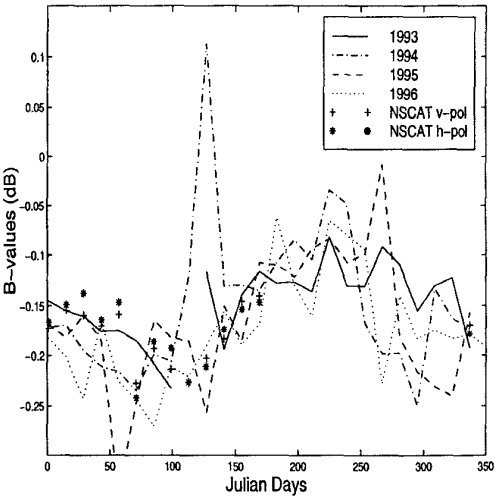

Figure 2: $\mathcal{B}$ values versus time for (a) 1993 (b) 1994 (c) 1995 and (d) 1996.

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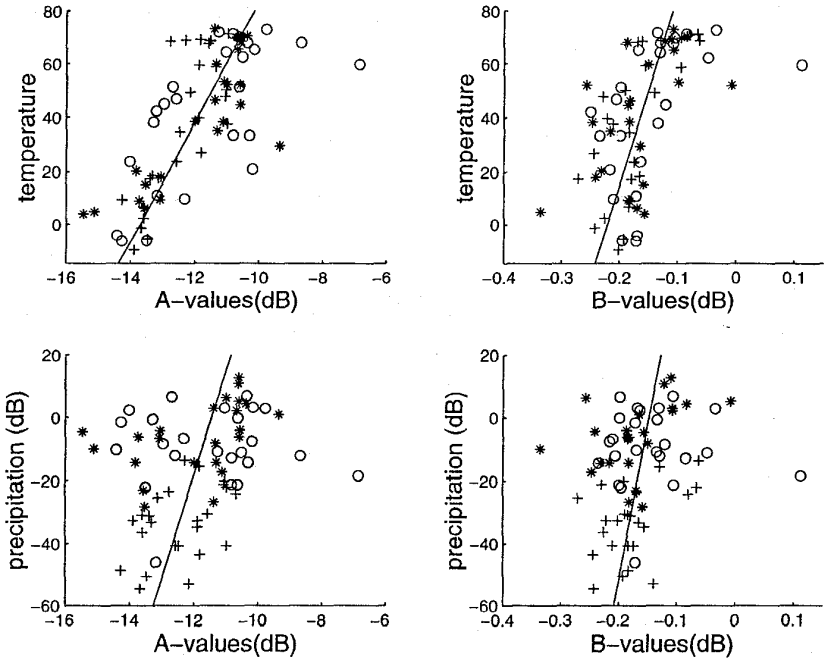

Figure 3: C-band σ^o $\mathcal{A}$ values and $\mathcal{B}$ values vs. temperature. o-1994 *-1995 +-1996.

amined. These parameters are compared to both NSCAT and ERS-1/2 data and correlations between them calculated.

ANALYSIS AND RESULTS

Annual time series of 14 day $\mathcal{A}$ and $\mathcal{B}$ images were created for North America. $\mathcal{A}$ and $\mathcal{B}$ values for a small region of the Midwest were extracted from each 14-day image and averaged. Plots of these values over several years are presented in Fig. 1 and 2. The $\mathcal{A}$ values tend to be higher during the summer months than during the winter months. The 4 dB summer/winter change is attributed to freezing and thawing of surface moisture and to vegetation growth in spring/summer. $\mathcal{B}$ values also show a similar annual cycle. NSCAT $\mathcal{A}$ values show less annual variation though the $\mathcal{B}$ value range is similar.

Figure 3 shows the correlation between temperature and precipitation and the $\mathcal{A}$ and $\mathcal{B}$ values for ERS-1/2 over the study region. The correlation coefficient, ρ, was calculated for both cases. For temperature vs. $\mathcal{A}$ values $\rho = .73$, and for $\mathcal{B}$ values $\rho = .55$, suggesting that there is a slight correlation between temperature and the $\mathcal{A}$ value. For precipitation $\rho = .316$ vs. $\mathcal{A}$ values and $\rho = .255$ vs. $\mathcal{B}$ values. This suggests that no real correlation exists between precipitation and σ^o. This may be due to the fact that precipitation is often very localized and is non-uniform over a given region. Because of this, the σ^o values would tend to be less correlated with precipitation than temperature which is more uniform over large areas.

For NSCAT both v-pol and h-pol images were used in the analysis. Figure 4 shows the correlation between temperature and $\mathcal{A}$ values for NSCAT. For vertical polarization $\rho = -.43$ and for horizontal $\rho = -.10$. This suggests that there is little relation between temperature and Ku-band σ^o values. For precipitation, vertical polarization $\rho = -.352$ while for horizontal polarization $\rho = -.126$. The correlation coefficient for $\mathcal{B}$ values in the Ku-band were for vertical polarization $\rho = -.054$ and for horizontal $\rho = -.149$.

The correlation between C-band ERS-1/2 data and Ku-band NSCAT data is plotted in Fig 5 and the correlation coefficients are $\rho = .104$ for vertical polarization and $\rho = .336$ for horizontal polarization.

The proceeding data suggests that there is a stronger correlation between temperature and precipitation for C-band σ^o than that of Ku-band. There also appears to be little correlation between the two bands. The results in the Ku-band could possibly be improved with more data points, but due to the short time that NSCAT was operational only a portion of the annual cycle could be observed.

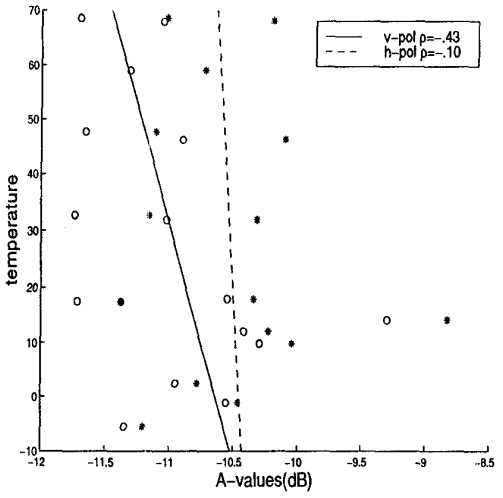

Figure 4: Ku-band σ^o $\mathcal{A}$ values for both v-pol(o) and h-pol(*) vs. temperature.

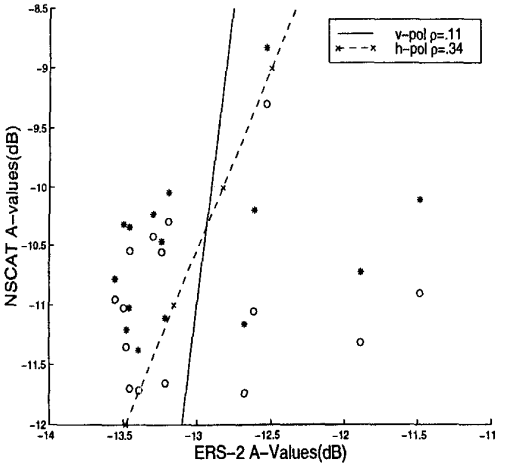

Figure 5: Ku-band v-pol(o) and h-pol(*) vs. C-band $\mathcal{A}$ during the NSCAT mission.

CONCLUSION

By studying the effects that temperature and precipitation have on σ^o over North America in both the C-band and Ku-band frequencies greater insights can be gained. Temperature tends to be correlated better with σ^o than precipitation. By combining the information from the C-band and Ku-band observations, it is hoped additional insight into the scattering mechanisms and vegetation characteristics can be obtained.

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