Vegetation Study of Amazon using QSCAT in comparison with SASS, ESCAT and NSCAT

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Abstract— The Amazon basin presents a large geographical zone that has undergone significant land cover changes during the last few decades due to accelerated logging and other anthropogenic influences. Amazon forest consists of diverse types of vegetation, which vary with various geophysical factors, like latitude, moisture, rainfall etc. In this paper, variations in the radar backscatter measurements (σ°) from various scatterometers over the Amazon basin are presented for selected study regions. C-band σ° from ERS scatterometer (ESCAT) are found to exhibit a general decrease over the period 1992-1999. ESCAT and Ku band NASA scatterometer (NSCAT) σ° measurements are compared to study the multi-spectral signatures and are, in general, found consistent. Ku band σ° measurements from SeaWinds on QuikScat (QSCAT) are used in conjunction with the NSCAT and Seasat scatterometer (SASS) data to study the change since 1978.

INTRODUCTION

Amazon basin presents a vast geographical zone constituting a large proportion of global biomass. Radar backscatter (σ°) from Amazon have been believed to be very stable over time and thus have been used for sensor calibration. Due to changes in global climate and accelerated anthropogenic influences, there is a general concern that Amazon could have undergone significant land cover changes during the last few decades.

Scatterometer data from space-borne sensors has been successfully utilized over ocean for near-surface wind field measurements. Scatterometers, coupled with day/night and all-weather capability, give precise measurements of normalized radar cross section (σ^o) of the target. Scatterometers also provide information about the physiographic parameters of tropical vegetation [1,3]. The low resolution of this data (25-50 km), though appropriate for ocean studies, is a limiting factor for detailed land studies. Enhanced images of various scatterometers have been achieved using Scatterometer Image reconstruction (SIR) algorithm [1]. The SIR algorithm exploits the high temporal resolution of scatterometer data to improve the spatial resolution to a level more suitable for large scale land studies. The SIR algorithm generates A and B images where A is the normalized radar backscatter at 40° incidence angle in (dB) and B is the incidence angle dependence of backscatter in terms of slope (dB/°). The two quantities are related to the normalized radar backscatter at angle θ according to

$$\sigma^\circ(dB) = A + B(\theta - 40^\circ).$$

Since 1978, five scatterometer space missions have flown. SASS, NSCAT and Seawinds aboard Seasat-A, ADEOS-I and QuikScat, respectively, provide Ku-band σ° measurement whereas ESCAT aboard ERS-1/2 operates at the C-band. These datasets are used collectively to investigate the temporal backscatter behavior of the Amazon basin. A summary description of the data characteristics and the temporal coverage for all sensors is shown in Table 1. C-band radar backscatter measurements from ESCAT are used to observe seasonal variations during the period 1992-1999. Ku-band σ° measurements from SASS, NSCAT and QSCAT are compared to identify potential changes since 1978.

Sensor	Platform	Years	Freq. (GHz)	Pol.	Res. (km)	SIR. (km)
SASS	Seasat-A	78	14.4	H V	50	8
ESCAT	ERS-1	91-95	5.3	V	50	25
ESCAT	ERS-2	95-	5.3	V	50	25
NSCAT	ADEOS	96-97	14.0	H V	50	4
QSCAT	SeaWinds	99-	13.4	H V	25	10

Table 1: List of available data and characteristics of the scatterometers

ESCAT TIME SERIES ANALYSIS

ESCAT aboard ERS 1/2 has been acquiring radar backscatter measurements over land since 1992. Figure 1 shows the backscatter time series of three sites at 71°W 1°S, 62°W 8°S and 59°W 14°S in the Amazon basin. The three sites are representatives of dense vegetation from central amazon rain forest, brush land and savannah, respectively. The backscatter measurements from vegetation depend upon both surface and volume scattering phenomenon [1,2]. Increase in the vegetation density increases the inhomogeneity resulting in increased contribution from volume scattering. The σ° measurements from dense forest are found to be as high as -6 dB with negligible seasonal variations since the backscatter is predominantly

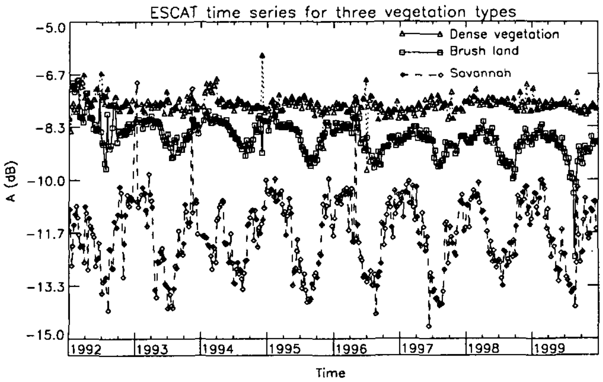

Figure 1: ESCAT σ° time series for three vegetation types

from volume scattering phenomenon. This suggests low dependence upon moisture for dense vegetation.

The brush land shows a backscatter of -10 to -8 dB with increased seasonal variations. The dependence on yearly rains is evident. Savannah grasslands present lowest backscatter of all the vegetated areas. The σ° measurements ranges from -14 to -10 dB and are highly dependent upon the time of the year. This increased dependence upon the seasonal changes results from the high contribution from the surface scattering, which is predominantly governed by soil moisture conditions.

The σ° temporal behavior of the dense forest and brush lands shows a general decrease between 1992 and 1999. Similar trend is observed for various other sites. Though this potentially indicates a reduction in the vegetation density, it could be due to long-term instrument drift. Figure 2 plots the σ° measurements for a site north of the Amazon river. Despite the seasonal fluctuations, the backscatter is decreasing over the time.

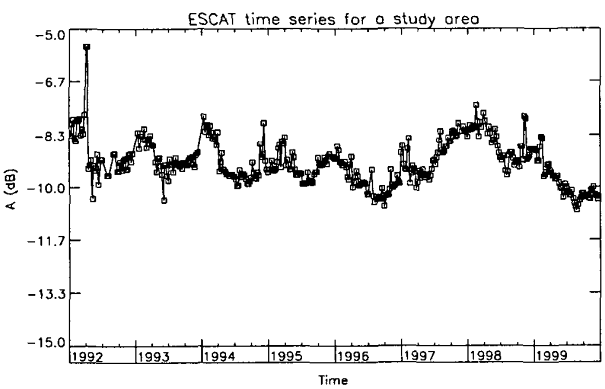

Figure 2: ESCAT σ° time series for site at 60°W 2°S

COMPARISON OF ESCAT AND NSCAT

Surface and volume scattering from different vegetation types is also dependent upon the incident frequency. Variable sensitivity of C-band and Ku-band microwaves to different vegetation type enables us to explore the multispectral signatures of Amazon rain forest. Figures 3 and 4 plot the σ° measurements from the overlap time period of ESCAT and NSCAT over the dense vegetation and savannah grasslands, respectively. C-band radar backscatter measurements are lower than the Ku-band H- and V-pol measurements. Despite the general consistency between the two data types, subtle difference are seen which are dependent upon season.

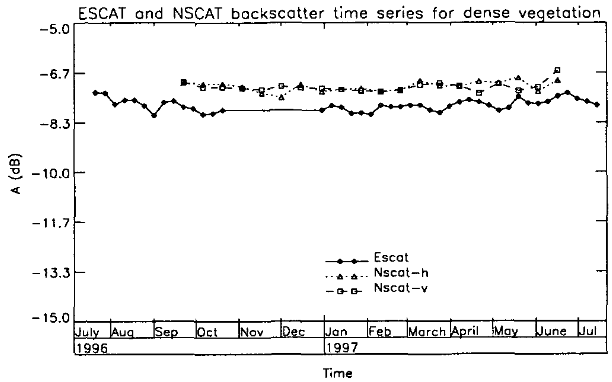

Figure 3: ESCAT and NSCAT dual-pol σ° time series at 71°W 1°S.

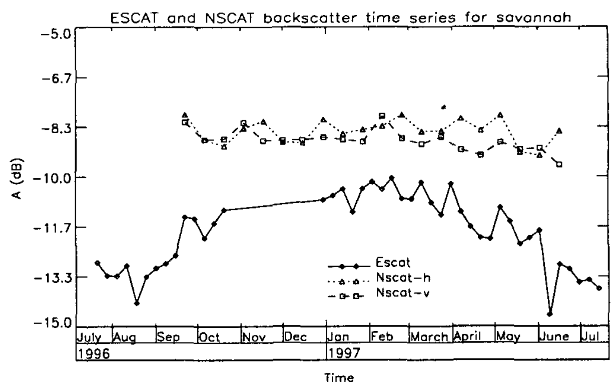

Figure 4: ESCAT and NSCAT dual-pol σ° time series at 59°W 14°S

KU-BAND TIME SERIES ANALYSIS

Data from recently launched QSCAT is compared with data from the previous Ku-band scatterometer missions. Figure 5 shows the SIR A images from three sensors. These images from SASS, NSCAT and QSCAT cover day ranges JD259-282, JD266-279 and JD266-267, respectively. The QSCAT image is for ascending passes only and is at an incidence angle of 54.1° rather than 40° as for SASS and NSCAT. Beside the general similarity in the three images, some subtle differences are evident. NSCAT and QSCAT images show a small low backscatter patch at 60°W 2°S, which is not present in the SASS image. Moreover QSCAT image presents some additional distributed low backscatter patches, which are not seen in either NSCAT or SASS images. Most of these areas are surrounded by dense vegetation areas.

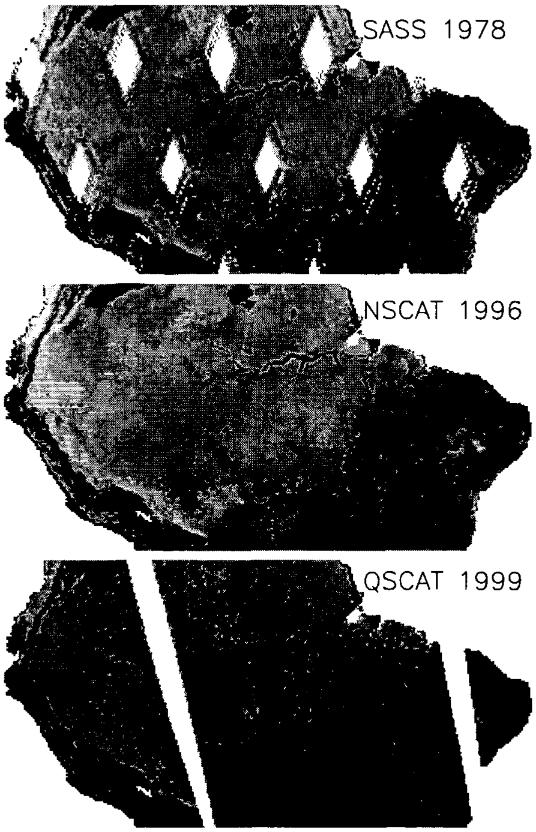

Figure 5: Comparison of σ° measurements from SASS, NSCAT and QSCAT covering day ranges JD259-282, JD266-279 and JD266-267, respectively. The SASS and NSCAT images are of σ° at 40° while QSCAT image is σ° at 54.1°. The QSCAT image is from ascending data only.

CONCLUSIONS

Results from the temporal analysis of Amazon basin are presented. C-band and Ku-band σ° measurements are found to be in general consistency. The long term time series of ESCAT σ° indicates a general decrease in backscatter for all areas studied. This may be due to a long term instrument drift or it could represent a long term change in the study areas. Data from all Ku-band sensors (SASS, NSCAT and QSCAT) is compared and found to exhibit differences at various sites distributed in the Amazon rain forest.

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