MONITORING OF LAND COVER CONDITIONS IN PADDY FIELDS USING MULTITEMPORAL SAR DATA

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ABSTRACT: The synthetic aperture radar (SAR) data by the Japanese Earth Resources Satellite 1, JERS-1, are expected to be used effectively for the purpose of monitoring of land cover conditions in tropical regions since the SAR data can be obtained repetitively in any weather condition. The authors conducted case studies for monitoring of land cover conditions in the paddy fields in Thailand using multitemporal JERS-1 SAR data. Two case studies concerning to the change of land cover by seasonal variation and flooding proved that these changes can be detected as the change of L-band SAR backscatter. The result of these case studies indicates the effectiveness of L-band SAR data by JERS-1 for the monitoring of several types of changes of land cover conditions in tropical regions, where data acquisition is necessary even in bad weather conditions of the rainy season.

KEY WORDS: SAR, Multitemporal Data, Backscatter, Soil Moisture, Vegetation Coverage, SWI, PVI, Flood.

1. INTRODUCTION

Land cover change monitoring using multitemporal data is one of the important and practical applications in remote sensing fields. However, the observations by conventional optical sensors are much affected by weather conditions. Especially in tropical regions, observation in rainy season has been almost impossible using optical sensors. On the other hand, the Synthetic Aperture Radar (SAR) can observe in any weather condition and the SAR data can be used practically to monitor land cover changes which occur in the season of bad weather conditions like the rainy season. The authors studied the applicability of the SAR data by the Japanese Earth Resources Satellite 1, JERS-1, for the monitoring of the land cover change in paddy fields at a test site of the Central Plain of Thailand.

2. RELATION BETWEEN SAR BACKSCATTER CHANGE AND LAND COVER CONDITIONS

The authors have conducted the preliminary analysis of the multitemporal JERS-1 SAR data taken in 1993 at the test site of Thailand and the result suggests that those data contain much information about the seasonal variations in SAR backscatter for various land cover types. Three images in Fig.1 show seasonal changes of L-band SAR backscatter among the middle of dry season (March 16th) , the end of dry season (April 29th) and rainy season (September 8th). The change of SAR backscatter is represented by the Normalized Radar Cross Section (NRCS) which can be derived from the SAR level 2.1 product using the calibration coefficient given by NASDA.

For the purpose to investigate the physical meanings of the SAR backscatter change, regression analysis was performed between SAR backscattering intensity and two parameters for representing land cover conditions, Soil Wetness Index (SWI) and Perpendicular Vegetation Index (PVI) using JERS-1 SAR and Landsat TM images acquired on the same day (April 29th, 1993). These parameters can be estimated in the two dimensional plane composed by the intensity of TM band 3 (visible-red) and band 4 (near infrared) as shown in Fig.2 . The SWI is defined as the regression line derived from points regression of bare soils and indicates the degree of soil moisture content. The PVI is defined as the line perpendicular to the SWI line and indicates the degree of vegetation coverage. The maximum value of PVI corresponds to the averaged value of PVI for the areas fully covered by vegetation.

The two images were co-registered each other and twenty pairs of the averaged values in 5 x 5 window areas for SAR and TM images which were sampled from the bare soil areas and the vegetated areas were used for the regression respectively. Fig.3 and 4 show the results from the regression analysis between SAR-NRCS and SWI and between SAR-NRCS and PVI respectively. The results indicate positive correlation for both of the relations between SAR backscatter and soil moisture and between that and vegetation coverage, although the correlation coefficients are moderate values. There are seen relatively large variations of NRCS for large PVI samples and for dry bare soil samples, which are the factors decreasing correlation coefficients. The variation for PVI is considered to be caused by the differences of vegetation types, that is, the SAR backscatter for grasses is lower than that for trees even the area is fully covered by vegetation. The variation for SWI is considered to be caused by the difference of surface roughness, which is one of the dominant factors affecting SAR backscatter.

3.SEASONAL CHANGES OF SAR BACKSCATTER IN PADDY FIELD

The authors studied the actual changing patterns of SAR backscatter concerning to the change of land cover conditions in the paddy field at the same test site as Fig.1. The flow of data analysis is shown in Fig.5. The three temporal SAR data in Fig.1 were co-registered each other and a MAP filter was applied in order to remove speckle noise. After principal component analysis was performed to the three SAR images, clustering was adopted as non-supervised classification method to obtain land cover classification image at the test site. As the result of clustering, total eight land cover classes were obtained. The land cover classification image is shown in Fig.6

The graph in Fig.7 shows the changing patterns of NRCS derived from the SAR standard product by NASDA for eight land cover classes obtained by above analysis. The solid lines (C2, C3, C4, and C6) in the graph correspond to the patterns of paddy fields. The change of C4 and C6 between March and September was proved to be caused by the difference between bare soil condition and the rice growth from the ground survey. The change of C2 was considered due to the planting of second rice in the dry season. The change of C3 between March and April was estimated due to the change of soil moisture according to the result of regression analysis described in the previous section. Natural levee which distributes widely in the test site was easily identified as the class C8, which always resulted in high backscatter.

As described above, in even L-band SAR images, much information about the seasonal changes of paddy and soil condition can be extracted from multitemporal data. These results seem to suggest the capability of JERS-1 SAR data for actual monitoring of land cover conditions in tropical regions.

4.CHANGES OF SAR BACKSCATTER BY FLOODING

The authors studied the change of SAR backscatter in paddy fields when they were flooded. Fig.8 shows two SAR images observed in the rainy season in 1993 and 1995. The right image shows the SAR image taken on September 26th, 1995 when a big flood occurred in the Central Plain of Thailand. This image can be compared with the left image, which was taken almost in the same rainy season but in non-flood condition.

According to a ground survey at the same time of SAR observation in 1995, the SAR data were proved to result in very low backscatter in the flooded areas as shown in Fig.9. Therefore, the flooded areas in the paddy fields were extracted by subtracting NRCS values from those of the data in non-flooded conditions, namely the data in September, 1993. According to all weather characteristics of SAR, the SAR data are considered to be effective data source for the detection of flood in the rainy season.

5.CONCLUSION

Regression analysis using JERS-1 SAR and Landsat TM data acquired on the same day suggested that the change of L-band SAR backscatter is related to the change of soil moisture and vegetation coverage conditions with positive correlation. Case studies concerning to the change of land cover in paddy fields by seasonal variation and flooding proved that these changes can be detected as the change of L-band SAR backscatter. Therefore the result of these case studies indicates the effectiveness of L-band SAR data by JERS-1 for the monitoring of several types of changes of land cover conditions in tropical regions, where data acquisition is necessary even in bad weather conditions of the rainy season.

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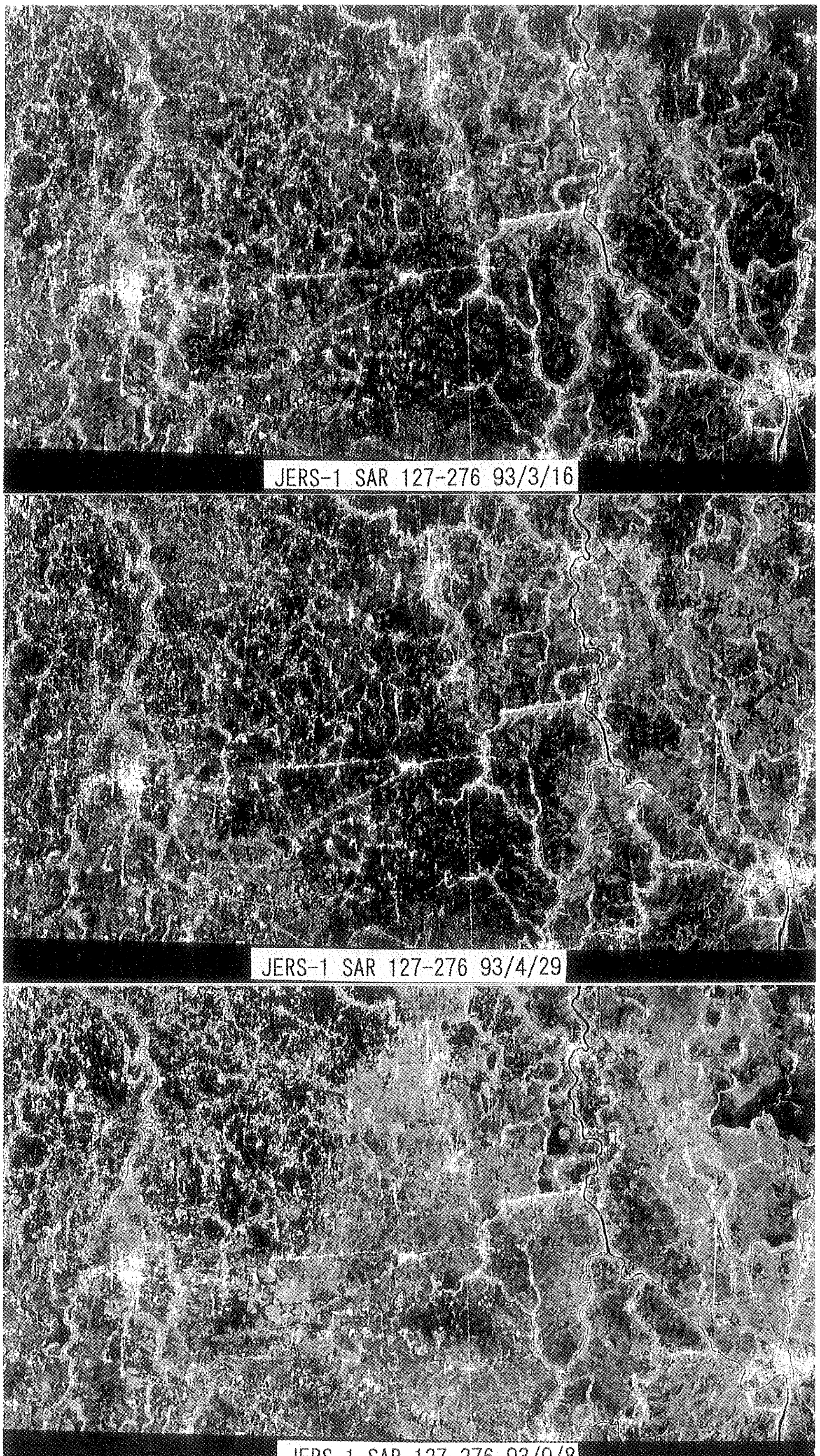


Fig.1 Three temporal JERS-1 SAR images at the Central Plain of Thailand

JERS-1 SAR: MITI/NASDA retains ownership of data.

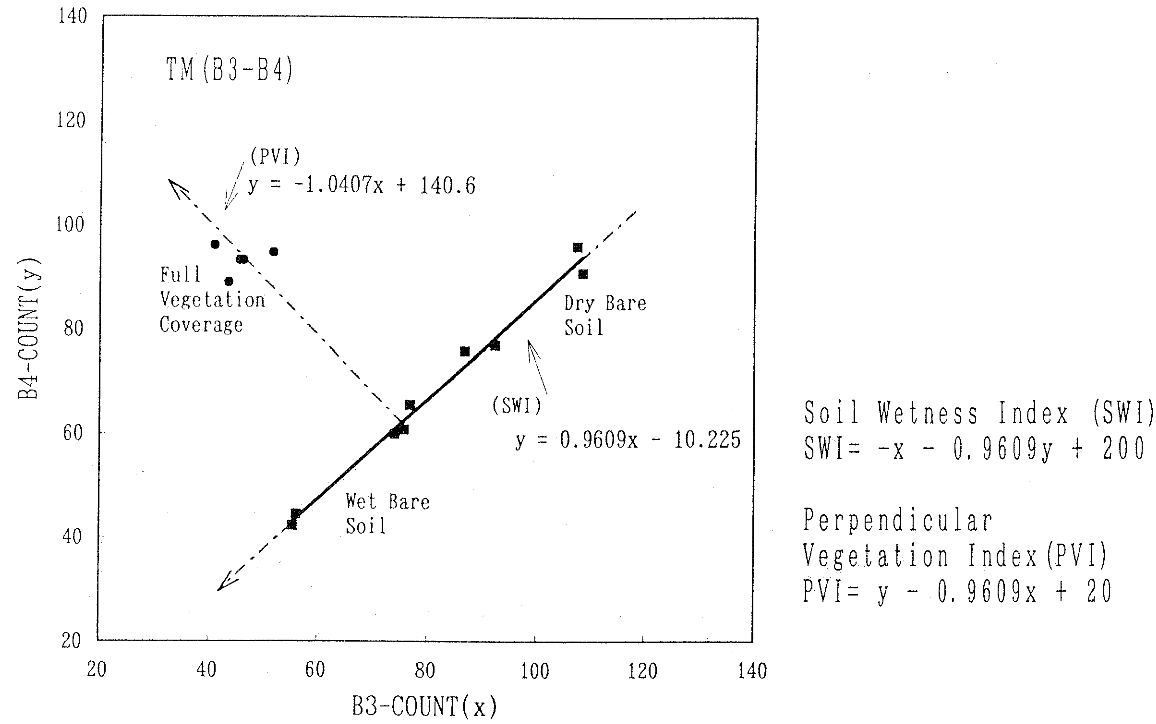


Fig.2 Soil wetness index (SWI) and perpendicular vegetation index (PVI) derived from Landsat TM data acquired on April 29th,1993.

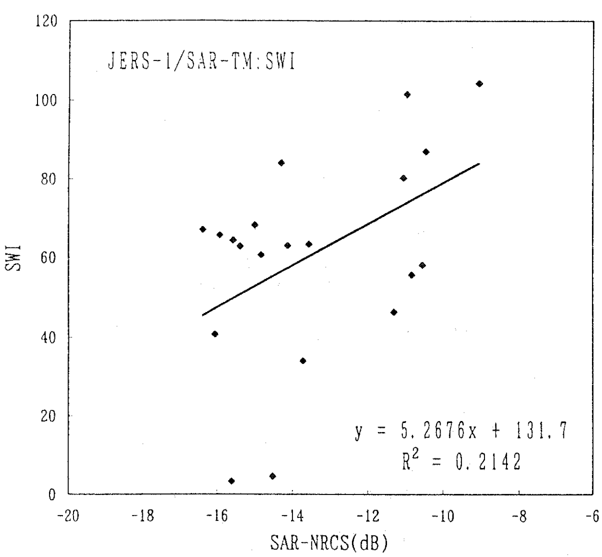


Fig.3 Result of the regression analysis between SAR backscatter (NRCS) and SWI.

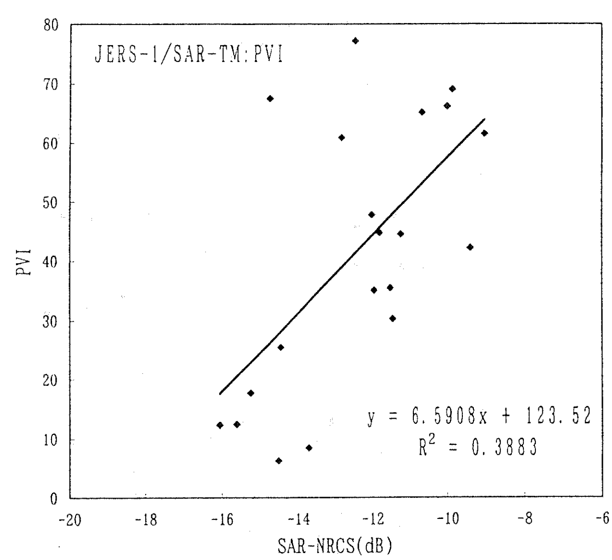


Fig.4 Result of the regression analysis between SAR backscatter (NRCS) and PVI.

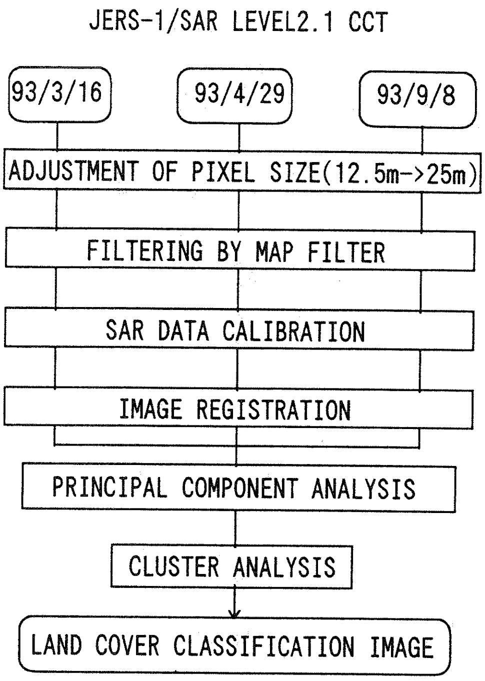


Fig.5 Flow chart of the analysis of multitemporal SAR data.

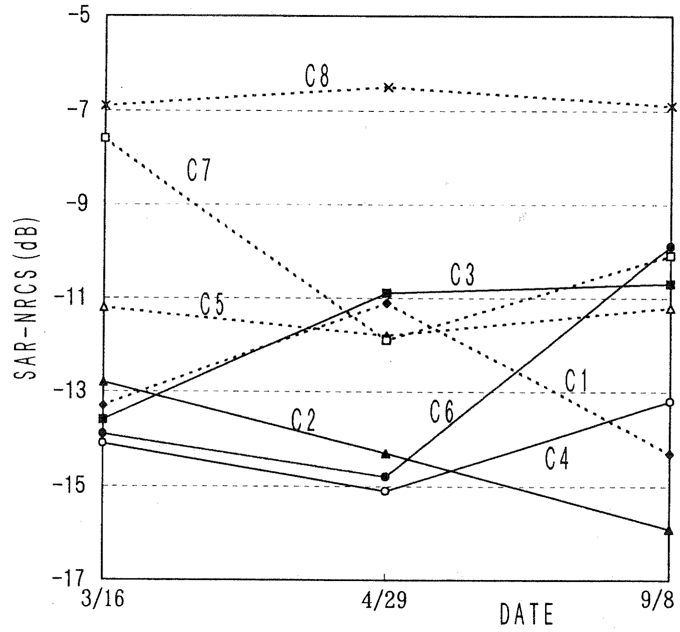


Fig.7 Seasonal changes of SAR backscatter for eight land cover types.

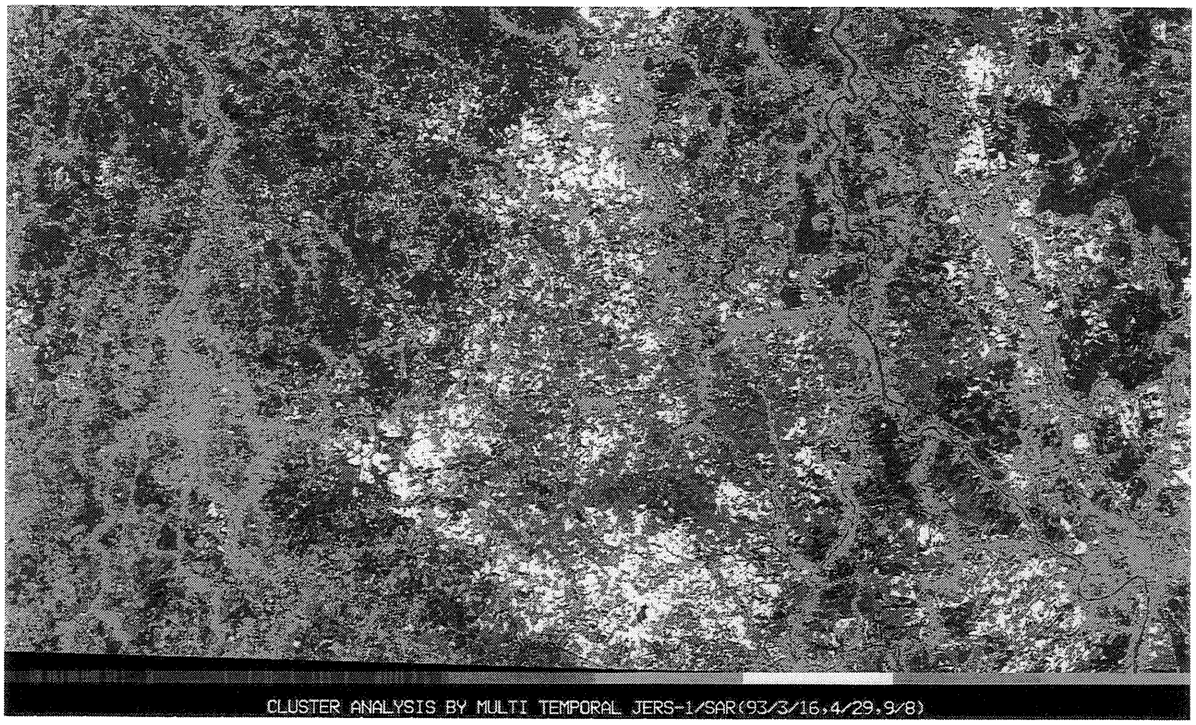
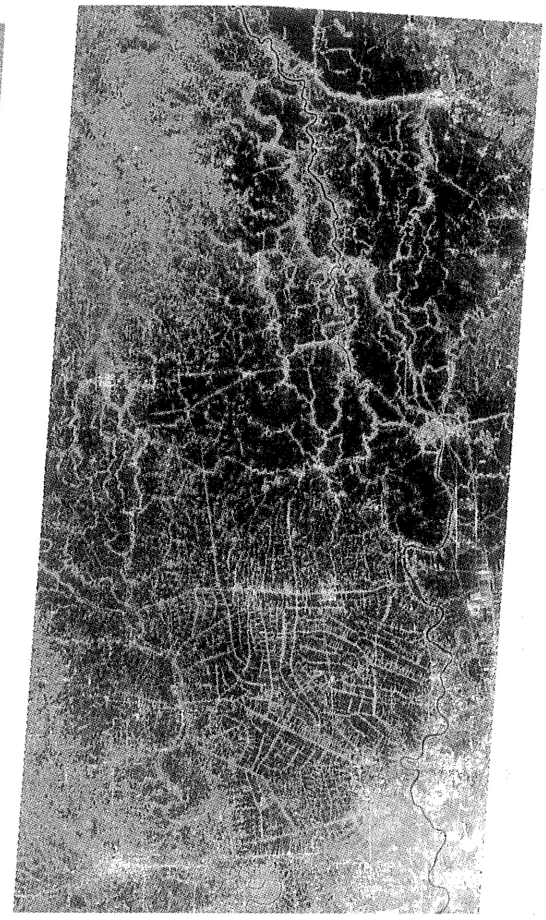


Fig.6 Result of land cover classification using multitemporal SAR images. (The under bars correspond to C1 to C8 in Fig.7 from left to right.)

1993/9/8



1995/9/26

Fig.8 JERS-1 SAR images of the Central Plain of Thainalnd acquired in non-flooded condition (left) and flooded condition (right) in the rainy season.

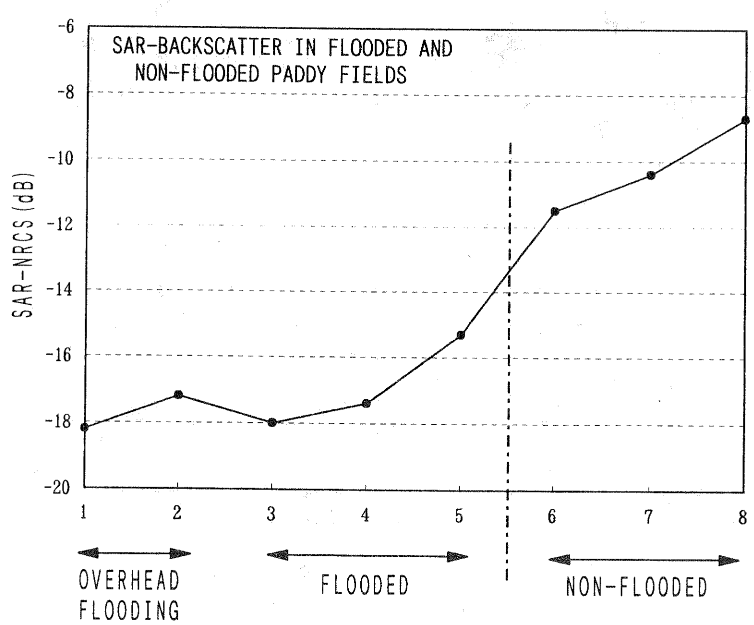


Fig.9 SAR backscatter in flooded paddy and non-flooded paddy.