ALOS PALSAR Quad-Pol Data for Soil Moisture Mapping

Y. S. Rao, T. Dyuti, G. Venkataraman

Centre of Studies in Resources Engineering, Indian Institute of Technology, Powai, Mumbai-400076, India
Email: ysrao@csre.iitb.ac.in

Abstract

ALOS PALSAR quadpol data acquired over two test sites of India were processed and analysed for soil moisture mapping and classification. Polsarpro software and some programs developed by us were used for the processing of the data. Data were classified using H/A/Alpha Wishart technique. PauliRGB and classified images give a lot of details about various land features. For soil moisture mapping, we used Dubois et al. and Oh et al models to invert backscattering coefficient values into dielectric constant. Dubois et al. model overestimates soil moisture as compared to Oh et al. model. It may be due to lower incidence angle at which the data were acquired. As we do not have groundtruth data synchronous with passes, the preliminary study is just a qualitative analysis of the data to get experience in handling the data.

Keywords: soil moisture, backscattering coefficient, inversion models, classification.

1. INTRODUCTION

Soil moisture is very important in several disciplines such as agriculture, hydrology and meteorology. It can be mapped using active and passive microwave remote sensing techniques. A special mission viz. soil moisture and ocean salinity mission (SMOS) is planned to launch in 2008 to map the soil moisture at global scale. Various investigators [1]-[4] have attempted to map soil moisture using SAR data. It has been demonstrated with SIR-C polarimetric data that quad polarized data acquired at L-band is sensitive to soil moisture and can map surface soil moisture at high spatial resolution[1][2]. ENVISAT ASAR C-band dual polarization data were also used for soil moisture mapping with various combinations of polarization[4]. It was realized using C-band ENVISAT ASAR data that C-HH polarization is sensitive to soil moisture studies and the addition of other polarizations (VV or HV) does not significantly improve soil moisture retrieval [4]

2. TEST SITES AND DATA SETS

The test sites are not exclusively selected for this study. As the archived data are available with Jaxa, we got the data and started working on it. The polarimetric data that covers over the area around N28.361/E76.674 (in Haryna state) were acquired on 19th Nov. 2006 in ascending pass. Another data set was acquired on March 7, 2007 at location N22.905/E87.540 (in West Bengal) in ascending pass. Each scene covers an area of 35km in width and 63 km in length.

Major towns covered in Haryana test scene are Jhajjar, Rewari and Dharuhera. The area is just to the west of Delhi (35 km from Delhi) and close to Gurgaon city. There are several villages in the scene. The topography is flat with alluvial plains. The rainy season is from July to Sept. by SW monsoon. The average annual rainfall is about 470 mm. Agriculture pattern in this area varies depending on the location and time. The crop seasons are divided into Kharif (July – Oct) and Rabi (Oct. to March). In Kharif, paddy, bajra, jowar for fodder, cotton, sugarcane and guar are grown around Jhajjar area and in Rabi season, wheat is the main crop. Around Rewari, most of the area is unsown during Kharif season due to less availability of water, but Bajra and Jowar are grown during this season. During Rabi season, the crops grown are wheat, mustard and barley.

The West Bengal test site covers a part of Bankura district. Small towns present in this scene are Bishnupur, Kotalpur, Indas, etc. Some part of the area covers famous Sal forest. In March, the crops grown in this area are Paddy, Potato, mustard, etc.. Some part of the area is bare and dry.

The data product obtained from Jaxa was level 1.1 in Single Look Complex (SLC) format. The product contains HH,VV,HV and VH images and leader files. The data in SLC format is more advantage than detected product because phase information is preserved in the SLC data products.

3. DATA PROCESSING

Polsarpro software was used to process the ALOS PALSAR polarimetric data. The software converts the HH, HV, VH and VV files into scattering matrix and then coherency matrix. While converting the ALOS data, it uses calibration factor which is -86dB. Before multiplying with each pixel with this calibration factor, the dB is converted into linear scale by taking CF = $(10^{-86/10})$. The scattering matrix can be written as

$$S = CF * \begin{bmatrix} S_{xx} & S_{xy} \\ S_{yx} & S_{yy} \end{bmatrix}$$

In the above matrix, elements S_{xy} and S_{yx} are symmetrised by taking average $(S_{xy}+S_{yx})/2$ though PALSAR values are different for S_{xy} and S_{yx}.

For Dubois et al. inversion model [1], backscattering coefficient values are required. The backscattering coefficient can be calculated using the following equation given by Jaxa.

$$\sigma^0 = 10*\log_{10}(I^2+Q^2) + CF - 32.0$$

Where CF (-86dB) is in dB units and I and Q are inphase and quadrature components of a pixel. As the Polsarpro requires calibration constant as an input, we did not use the Polsarpro software for the inversion of Dubois et al. model. However, it can be used for the inversion of Oh et al. model [5]. Initially, the data were multilooked two times in range and 12 times in azimuth so that the spatial resolution will be reduced to 46m x 42m (range x azimuth). Later the data were boxcar filtered with window size of 7x7.

Both the models require incidence angle map which was obtained using the coefficients given in the leader file. We have also used Polsarpro software for the classification of the data using H/A/Alpha Wishart classifier[6].

4. RESULTS AND DISCUSSION

The Pauli RGB of PALSAR Image of Haryana test image is shown in Fig. 1. Several small villages, big towns and road network are clearly scene. The centre of the scene location is N28.361, E76.674. At the top, Jhajjar and at bottom Rewari towns can be seen. Similarly, West Bengal test area

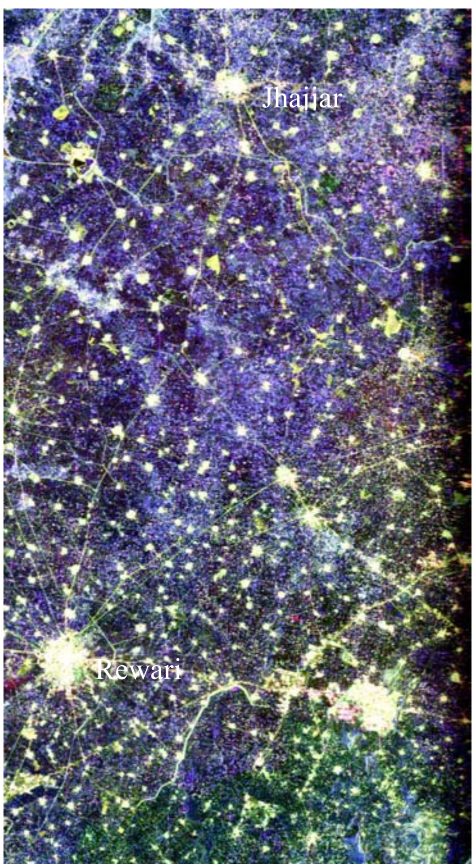


Figure 1. Pauli RGB of ALOS PALSAR Data, Haryana

Most of the upper part in Fig. 1 is in light blue colour due to single scattering in paddy (or harvested fields) which were close to harvesting stage. The lower part is in light greenish due to rain fed cultivation of the area. The field conditions will be verified by performing field work in this year at the same period.

.

The soil moisture map derived using Oh et al. model is shown in Fig. 2. Town areas and some other areas (not known) are shown with blue colour where retrieval is not possible. Most of the area show soil moisture between 2% to 12%.

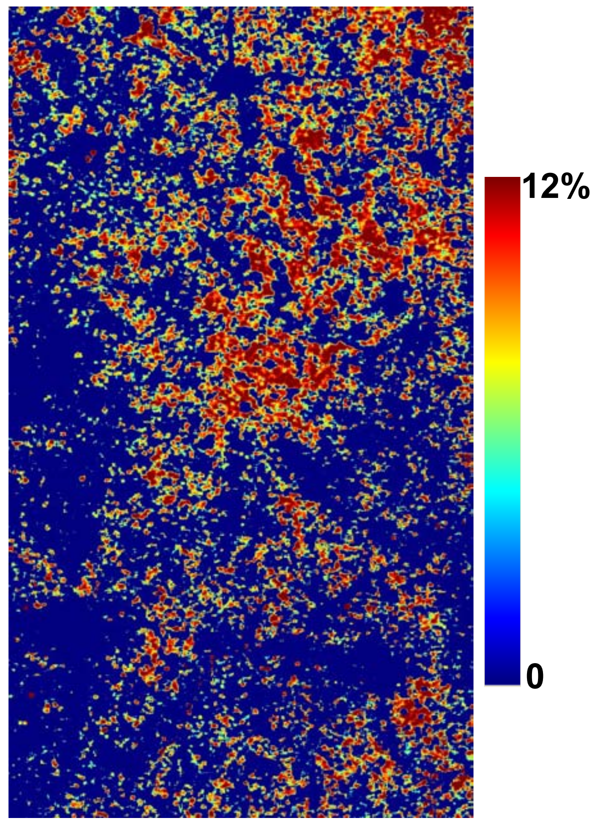


Figure 2. Soil moisture map derived using Oh et al. model. Blue (zero) shows not possible values. Light blue to Cyan to Yellow shows 0-6%, red to dark red shows 6-12%.

Inversion of Dubois et al. model for the same test area shows high soil moisture (25% to 35%) due to low incidence angle (24^0) at which PALSAR data were acquired. But the Dubois et al. model is valid above 30^0 incidence angle. Most of the soil moisture map shows not valid values due to the mask applied with vegetation and roughness conditions.

Fig. 3 shows PauligRGB for West Bengal test area. Densely grown Sal forest and fairly grown Sal forest can be seen at the left side. Reddish colour shows fairly grown Sal forest. Colour in agricultural area varies from bluish to violet and then reddish at the bottom. The crop conditions are to be verified by conducting field work. The small yellowish white patches are villages surrounded by trees.

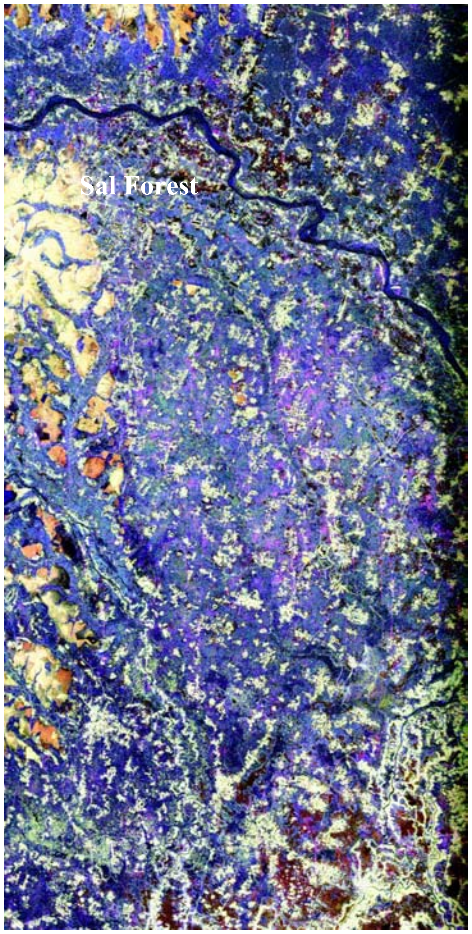


Fig. 3. Pauli RGB of ALOS PALSAR, West Bengal test area covering Sal forest at the left and agriculture areas with water ponds and villages surround by trees .

The corresponding soil moisture map is shown in Fig. 4. The soil moisture is obtained using Oh et al. model. The range of soil moisture for most of the area is from 2% to 20%. Upper part of Dwarakeswar river show highest soil moisture. Sal forest area shows blue for which soil moisture is not possible to retrieve. Similarly, settlements with trees also show the same code. Middle part and extreme lower right corner also show blue colour that indicates soil moisture is not possible to retrieve. For this test site also, we do not have groundtruth synchronous with satellite pass. So, quantitative study for soil moisture could not be done.

The images are classified using H/A/Alpha Wishart classifier. (entrophy, anisotropy and angle corresponding to scattering mechanism). The H/Alpha pixel occurrence planes are shown in Fig. 5(a)&(b) for both the test sites. Most of the pixels fall in single scattering and roughness scattering regions of the plane. For the West Bengal test area, more pixels are seen in the vegetation area because of Sal forest present in the area. As the area contains no major cities, pixels corresponding to double bounce are not seen.

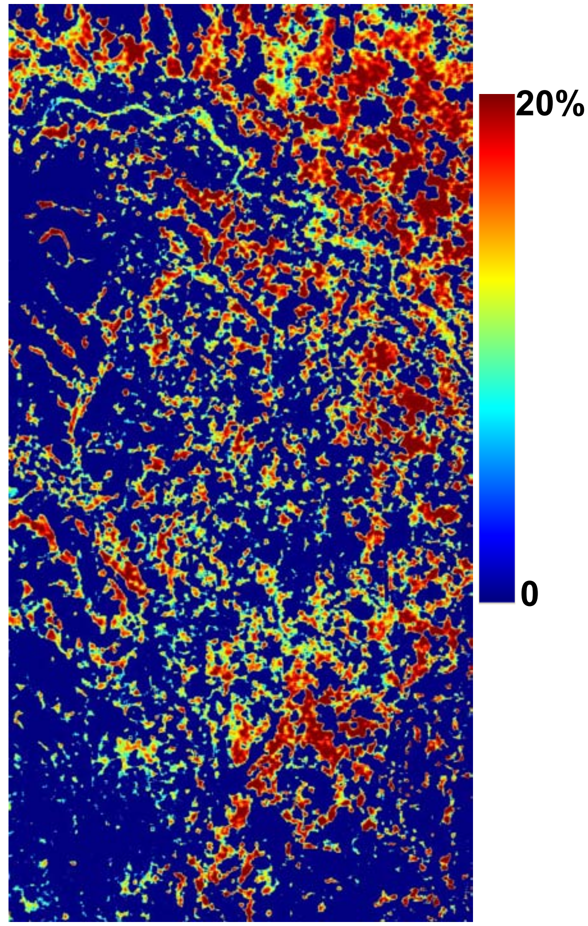
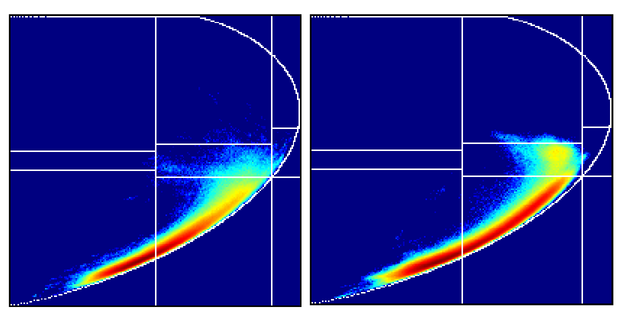


Fig. 4. Soil moisture map for West Bengal test area. It was obtained using Oh et al model. Blue colour shows soil moisture retrieval is not possible.

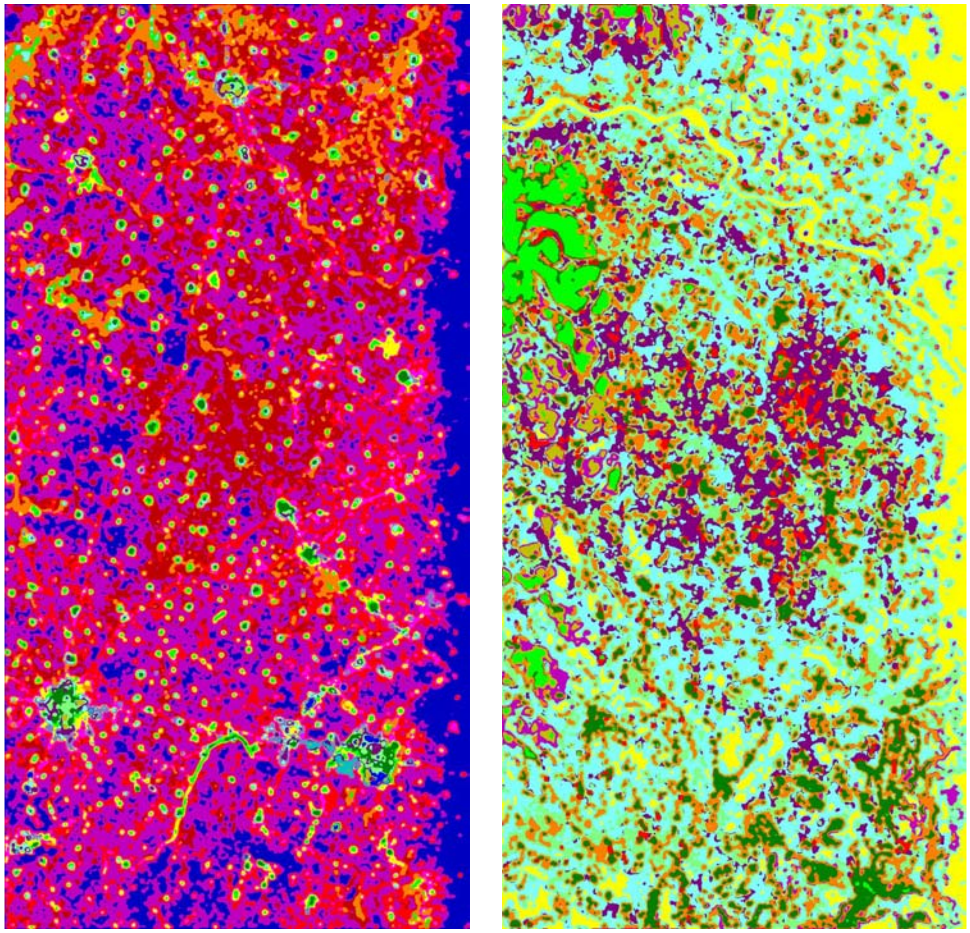


(a) (b)

Figure 5. H, Alpha occurrence plane for (a) Haryana test and (b) West Bengal test area.

The classified images show that H/A/Alpha Wishart classified images are better than that of obtained using

H/Alpha Wishart classifier. The classified images are shown in Fig. 6. It can be observed from Fig. 6(a) that the settlements including villages with road network is clearly seen. In Fig. 6(b), Sal forest and other land use/land cover areas are separated.



(a) **(b)**

Figure 6. H/A/Alpha Wishart classified images (a) Haryana test site and (b) West Bengal test site.

5. CONCLUSION

ALOS PALSAR fully polarimetric (quadpol) data acquired over two Indian test sites were processed for soil moisture and classification of the images. Oh. et al model estimates soil moisture reasonably well for the two test areas. Dubois et al. retrieval values were very high and are confined to short range. It may be due to low incidence angle data. Classified images show that villages with road network can be seen very clearly. Sal forest area is also classified very well using H/A/Alpha Wishart classified. We will extended the study by using X-Bragg [3] and Shi etl [2] for the retrieval soil moisture

Acknowledgement
This research is conducted under the agreement of JAXA Research Announcement titled '2nd RA' (JAXA-PI 381).

References

[1] P.C. Dubois et al, "Measuring soil moisture with imaging radars," IEEE Trans. Geosci. and Remote Sensing, Vol. 33, No. 4, pp.916-926, 1995.

[2] J. Shi et al, "Estimation of bare surface soil moisture and surface roughness parameters using L-band SAR Image Data," IEEE Trans. Geosci. and Remote Sensing, Vol. 35, No. 5, pp.1254-1264, 1997.

[3] I. Hajnsek et al, "Inversion of surface parameters from polarimetric SAR," IEEE Trans. Geosci. and Remote Sensing, Vol. 41, No.4, 2003.

[4] N. Baghdabi et al, "Soil Moisture estimation using multi-incident and multi-polarization *ASAR data,"* Int. Journal of Remote Sensing, Vol. 27, pp.1907-1920, 2006.

[5] Y. Oh et al, "An empirical model and an inversion technique for radar scattering from bare soil surfaces," IEEE Trans. on Geosci. and Remote Sensing, Vol. 30, 370-381, 1992.

[6] J.S. Lee et al, "Unsupervised classification using polarimetric decomposition and the complex Wishart classifier," IEEE Trans. Geosci. and Remote Sensing, Vol. 37, No.5, pp.2249-2258, 1999.