

Full and Hybrid Polarimetric SAR Data Analysis for Various Land Features

Y. S. Rao¹, Shaunak De¹, Vineet Kumar¹ and Anup Das²

¹Centre of Studies in Resources Engineering

Indian Institute of Technology Bombay, Powai, Mumbai-400 076, India

ysrao@csre.iitb.ac.in

²Space Application Centre, ISRO, Ahmedabad-380 015

Abstract

Fully polarimetric SAR data from Radarsat-2 and hybrid polarimetric SAR data from RISAT-1 were acquired over three test areas viz. Mumbai, Karjan (Vadodara district) and Vijayawada (Andhra Pradesh). Backscattering coefficient values were analyzed for the discrimination of various land features. The full pol and hybrid pol images over three test areas were classified using Wishart classifier. Radarsat-2 full pol is converted to hybrid pol and also classified for comparison. RISAT-1 hybrid pol accuracy is better than simulated Radarsat-2 hybrid pol. Some features are classified with high accuracy using RISAT-1 hybrid data.

Introduction

At present, research is focused on compact polarimetry [1] after the launch of RISAT-1 on April 26, 2012 with hybrid polarimetric mode [2] and the planned future missions such as the Canadian RADARSAT Constellation Mission, ALOS-2, and Argentina's SAOCOM. Various decomposition techniques such as $m-\delta$ [3], $m-\chi$ [4] and $m-\alpha$ [5] were developed for the analysis of hybrid polarimetric SAR data. Using simulated hybrid polarimetric data from full polarimetric SAR data, various investigators [6-7] have demonstrated the capability of hybrid polarimetric SAR data for different applications such as ship detection, soil moisture, crop classification, etc. It is important to study the capability of hybrid polarimetric SAR data for identification of various land features and their classification as compared to full pol data due to its advantages over full polarimetric SAR data in terms of large swath width and incidence angle. In order to this work, we acquired Radarsat-2 and RISAT-1 data over three test areas for classification of various land features.

Study Areas and Data Sets

Three study areas selected for this work are Mumbai city and its surroundings, Karjan agriculture areas of Vadodara district of Gujarat and Vijayawada in Andhra Pradesh state of India. Mumbai city covers various land features such as buildings, deciduous forest, mangrove forest, grass lands, lakes, wetlands and salt fans. At the time of scene acquisition, Karjan test area covers mainly cotton, sugarcane and rice crops. Vijayawada test area covers Krishna river and several agricultural crops viz. banana, rice, onion, turmeric, cotton and sugarcane. Synchronous with data acquisition, ground truth was collected in terms of soil moisture, crop height and GPS readings in point mode and polygon mode for classification of the data. The data sets acquired over the test areas are tabulated in Table 1.

Table 1: Different satellite data sets used in this study

| Test Site Name | Satellite Name | Date of data Acquisition | Satellite pass/Antenna pointing | Inc. angle | Resol. (Range x Azi.) meters | Pixel spacing (Range x Azi.) meters |
|----------------|----------------|--------------------------|---------------------------------|-------------------|------------------------------|-------------------------------------|
| Mumbai | Radarsat-2 | Feb. 16, 2011 | Ascending/right | 41 ⁰ | 5.2x7.6 | 4.73x5.50 |
| | RISAT-1 | Nov.15, 2012 | Ascending/right | 35.9 ⁰ | 2.3x3.3 | 1.80x2.50 |
| | RISAT-1 HH/HV | Nov. 14, 2014 | Ascending/right | 49.3 ⁰ | 2.3x3.3 | 1.80x2.34 |
| Karjan | Radarsat-2 | Oct. 10, 2013 | Ascending/right | 40.9 ⁰ | 5.2x7.6 | 4.73x5.13 |
| | Radarsat-2 | Nov. 3, 2013 | Ascending/right | 41.6 ⁰ | 5.2x7.6 | 4.73x5.12 |
| | RISAT-1 | Nov. 4, 2013 | Ascending/left | 35.1 ⁰ | 2.3x3.3 | 1.79x2.28 |
| | RISAT-1 | Mar. 8, 2013 | Ascending/right | 34.5 ⁰ | 2.3x3.3 | 1.80x2.43 |
| Vijayawada | Radarsat-2 | Dec. 4, 2013 | Descending/right | 40 ⁰ | 5.2x7.6 | 4.73x5.12 |
| | RISAT-1 | Nov. 21, 2013 | Ascending/left | 46 ⁰ | 2.3x3.3 | 1.79x2.28 |
| | RISAT-1 | May 4, 2013 | Ascending/left | 38.7 ⁰ | 2.3x3.3 | 1.80x2.38 |

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* In the case of RISAT-1, antenna pointing left in the table is considered as right in BAND_META.txt file and vice-versa

Data Processing

Radarsat-2 data were processed using ESA PolSARpro 5.0 and RISAT-1 data were processed using PolSDP software developed by CSRE. Mean backscattering coefficient and standard deviation of various land features and crops were calculated using ENVI software and plotted for analysis. Both data sets were multilooked to reduce the speckle noise. RISAT-1 is decomposed using m- χ decomposition [4]. Wishart supervised classification technique was used for the classification of various land features and crops using both the data sets. Classification accuracy was analysed using confusion matrix.

Results and Discussion

Mumbai Data:

Mean and standard deviation of backscattering coefficient values for urban class is the highest. Out of RH and RV sigma-0 values, RH is higher than RV. Mangrove and forest sigma-0 standard deviations values overlap with each other and discrimination may be difficult. It is observed that RH and RV of mangrove are higher than that of forest. Both Radarsat-2 and RISAT-1 classification accuracy is given in Table 2.

Table 2: Classification accuracy of Radarsat-2 and RISAT-1 data of Mumbai.

| Class | RISAT-1 Hybrid | RISAT-1 HH/HV | Radarsat-2 Simulated Hyb. |
|---------------------|----------------|---------------|---------------------------|
| Water % | 100.00 | 92.40 | 100.00 |
| Mangroves % | 88.06 | 56.79 | 66.26 |
| Urban % | 97.95 | 87.71 | 92.27 |
| Forest % | 88.33 | 77.06 | 47.92 |
| Wetland % | 96.81 | 94.76 | 79.27 |
| Overall User Acc. % | 94.04 | 78.58 | 84.38 |

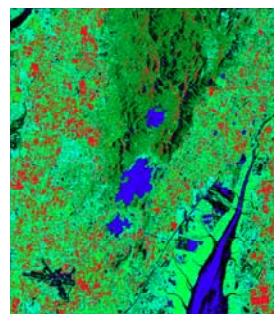


Figure 1: Classified image of RISAT-1 using Wishart.

Vijayawada Data: Results of m- χ decomposition are plotted for each feature as shown in Fig. 2 for RISAT-1 data of May 4, 2013. Volume component for Banana and rice crop is the highest. Even in bare field, volume component is observed. In urban2, most of the contribution is coming from double, while urban1 gives volume and surface in addition to double bounce. Classification accuracy for banana and bare fields are higher as compared to rice and urban class (Table 3).

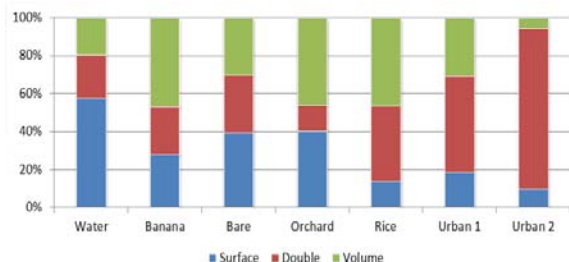


Figure 2: Components of m- χ decomposition for various features.

Table 3: Classification accuracy, Risat-1 & Radarsat-2

| Class | RISAT-1 Hybrid% | Radarsat-2 (full pol) % |
|----------------|-----------------|-------------------------|
| Settlement | 84.55 | 90.91 |
| Water | 79.09 | 85.71 |
| Bare Field | 89.61 | 83.33 |
| Cotton | 61.54 | 87.27 |
| Sugarcane | 50.89 | 51.75 |
| Scrub | 59.50 | 77.78 |
| Overall Acc. % | 69.82 | 77.61 |

Karjan in Vadodara District: M-chi decomposition for both RISAT-1 and simulated Radarsat-2 hybrid are shown in Fig. 3. Double is predominant in settlement, whereas volume is higher in Sugarcane. Classification accuracy for

RISAT-1 and Radarsat-2 is shown in Table 4. Around 7% difference is observed between RISAT-1 and Radarsat-2 in classification.

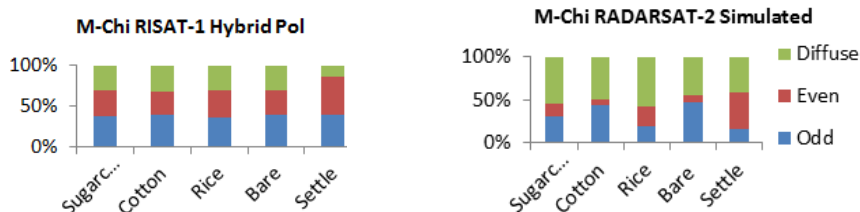


Figure 3. Scattering components of m- χ decomposition RISAT-1 and Radarsat-2.

Table 4: Wishart classified accuracy of RISAT-1 Vijayawada

| | Water | Banana | Bare | Orchard | Rice | Urban1 | Urban2 | Producer's Accuracy |
|-----------------|-------|--------|-------|---------|-------|--------|--------|---------------------|
| Water | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Banana | 0 | 92.35 | 0.02 | 1.46 | 0 | 0 | 6.17 | 92.35 |
| Bare | 0 | 0.04 | 97.21 | 2.43 | 0.04 | 0 | 0.27 | 97.22 |
| Orchard | 0 | 1.12 | 11.24 | 72.02 | 0.34 | 0.05 | 15.23 | 72.02 |
| Rice | 0 | 0 | 0.65 | 0 | 71.69 | 16.15 | 11.52 | 71.68 |
| Urban1 | 0.47 | 0.83 | 1.31 | 0.25 | 4.42 | 52.21 | 40.5 | 52.21 |
| Urban2 | 1.32 | 4.33 | 13.76 | 10.49 | 18.45 | 6.57 | 45.08 | 45.08 |
| User's Accuracy | 98.24 | 93.59 | 78.27 | 83.11 | 75.51 | 69.63 | 37.95 | 75.79 |

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