Journal of Geomatics Vol 9 No. 2 October 2015

Feature discrimination using RISAT-1 dual polarisation SAR data

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(Received: April 11, 2014; in final form: Oct 21, 2015)

Abstract: Over past few decades, radar remote sensing has proved its potential for the study of earth resources because of its capabilities of data acquisition throughout day and night as well as its surface penetration capabilities in the longer wavelength. The present study is aimed towards understanding the temporal RISAT-1 SAR data response to various features under different polarisation. In this framework main concentration for the study is given to different land use targets (forest, fallow land, sedimentary rock (sandstone), inland water bodies, urban clusters, crop lands). The study area is of Banaskatha district, Gujarat, India has been selected which comprises of agricultural fields, urban clusters, water bodies and exposed stone cover. The data used for this study is dual polarised MRS (Medium Resolution ScanSAR) mode, C-band (5.3GHz), processed (level 2) RISAT-1 data sets with its date of acquisition as August 31, 2012; December 9, 2012 and January 3, 2013. The images were processed and backscattering range was retrieved for different classes. For every feature mean and standard deviation values were marked in different polarisation channels and class separability has been generated for all the three dates. Results were analysed with reference to class separability for different dates.

Keywords: RISAT, Radar**,** Discrimination, Cross polarisation ratio, Cross polarisation index, Mean, Standard deviation

1. Introduction

In recent times, research efforts are focussed towards understanding the potential of SAR in discriminating the land covers. Before using the SAR data for operational monitoring, it is essential to understand the land cover discrimination ability of SAR using different polarisation or temporal data sets. Target recognition and discrimination is one of arduous task. On the basis of multi-temporal or multi-polarised data sets one can study the target using its backscattering information. However, certain land cover features like urban and water body are discernible even from a single data HH or VV data (Liguo et al., 2009; Zeng et al., 2015). A number of studies have shown that at all frequencies, backscatter from the cross-polarized channel consistently has a higher correlation with forest biomass, as compared to the other linear polarisations (Ranson and Sun, 1994). The cross polarisation ratio (HV/HH and HV/VV) has been found to be the best parameter for retrieval of forest vegetation parameters (Wu and Sader, 1987). In case of crop covered area or crop land the cross-polarisation data were found to be superior for crop separability (Brisco and Portz, 1980) because of high sensitivity towards the volume scattering, as it is dominant in cross polarisation signal. LULC classification of SAR data has been attempted using different global SAR sensor like ENVISAT ASAR, ALOS PALSAR and RADARSAT-2 etc (Mohan et al., 1990; Li and Yeh, 2004; Barnes and Burki, 2006; Alberga, 2007; Mohan, 2013). In general, features can be discriminated using a number of frequency or polarisation data (Turkar et al., 2012). Towards enhancing the potential application of SAR for meeting Indian requirement, first Indian radar imaging satellite, RISAT-1 was launched on 12th April, 2012. The sensor has provided large data set over Indian region for various applications. In view of this, it is required to evaluate the data set for its potential in discriminating land cover features. Thus, the present study investigates the capabilities of dual polarised C-band SAR data from RISAT-1 for discriminating various land cover features in both the polarizations and different dates.

2. Objectives

- To understand the temporal RISAT-1 SAR data response to various land cover features under different polarisation combinations.
- To discriminate different targets using various polarisation channels and indices of dual polarisation SAR data.
- To determine the separability of various features with each other.

3. Study area and data used

The study area is of Banaskatha district, Gujarat, India was taken with its geographic coordinates being (25.35° N, 72.62° E) which is majorly under the effect of desertic environment comprising of agricultural fields, urban clusters ,water bodies and stone cover. The data that has been used for this study is dual polarised MRS (Medium Resolution ScanSAR) mode,

C-band (5.3GHz), processed (level 2) RISAT-1 data set with its date of acquisition Aug 31, 2012; Dec 9, 2012 and Jan 3, 2013. The data acquired at around 36° incidence angle in descending node with 18 x 18m pixel spacing in both the directions with 120km swath. The geographical location of the study area is given in Figure 1 whereas other details of data have been given in Table 1.

Table: 1 Details of data used for the study

Date	Polarisation	Node
August 31, 2012	HH/HV	Descending
December 9, 2012	HH/HV	Descending
January 3, 2013	HH/HV	Descendings

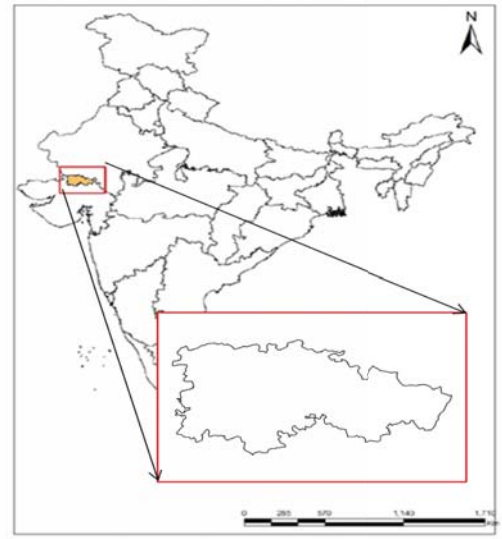

Figure 1: Study area (Banaskantha district, Gujarat, India)
(Boundry: http://bhuvan.nrsc.gov.in/gis/thematic/index.php)

4. Methodology

The L2, RISAT-1 data product contains the information regarding map projection. Thus, the next step of processing involved is speckle removal and deriving radar backscatter information. The each polarisation channel was filtered by enhanced Lee adaptive filter with kernel size 5 × 5 (Lopez et al., 1990). The extraction of backscatter information has been done using equation 1.

$$\sigma^o(dB)=20*\log_{10}(DN_p)-K_{dB}+10\log_{10}(Sin(i_p)/Sin(i_{center})) \quad (1)$$

where,

σ^o = radar backscatter coefficient in dB
DNp = digital number or the image pixel gray-level count for the pixel p
K_{dB} = calibration constant in dB
i_p = incidence angle for the pixel position p(in degree)
i_{center} =incidence angle at the scene center (can be obtained from BAND_META.txt file)

Calculation of cross polarisation ratio and cross polarisation index has been done using equations 2 and 3. The backscatter information of HH and HV is used to calculate both the indices.

Cross-Polarisation Ratio: $\sigma^o_{HV}/\sigma^o_{HH}$ **(2)**

Cross-Polarisation Index: $\sigma^o_{HH}-\sigma^o_{HV}/\sigma^o_{HH}+\sigma^o_{HV}$ **(3)**

Figure 2 shows FCC RISAT-1 image covering parts of Banaskantha district in three different dates August 31, 2012; December 9, 2012 and January 3, 2013. The four images (co-polarised HH, cross polarised HV, cross polarisation ratio, cross polarisation index) were co-registered by using image to image registration method (20 GCPs were well distributed in the image). Similar processing methodology was followed for other two date data sets.

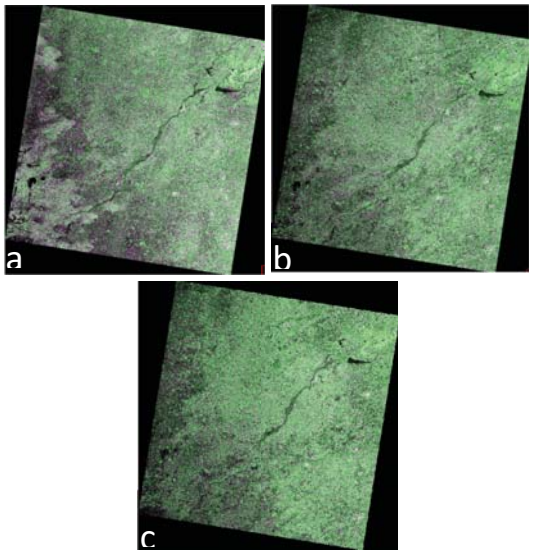

Figure 2: RISAT-1 FCC (HH, HV, HH) image covering parts of Banaskantha district in three different dates date (a)August 31, 2012; (b)December 9, 2012; and (c) January, 3, 2013

Figure 3 shows FCC of RISAT-1 image of August 31, 2012 indicating various features. To visualise each object with different polarisation at a time, all three season datasets were stacked and for each feature (urban cluster, inland water bodies, stone structure, fallow land, forested area and crop lands) three different training sites of same area within multidate image in each polarisation channels were taken. These three different training sites for a single feature were then merged and mean value of intensity and standard deviation noted. Class separability from mean and standard deviation is generated to analyse better discrimination of the features in individual polarisation. To generate class separability equation 4 was used.

Class separability: $abs(\mu_1-\mu_2)/(\sigma^o_1+\sigma^o_2)$ **(4)**

where,
μ_1, μ_2 =mean of two different classes
σ^o_1, σ^o_2 = std. deviation of two different classes.

Class separablity derived from three date was evaluated. It was observed that the best separability was for different features were found in various polarisation channel combinations. Thus, those channels which shows the best separablity is shown in the form of graph in Figure 4.

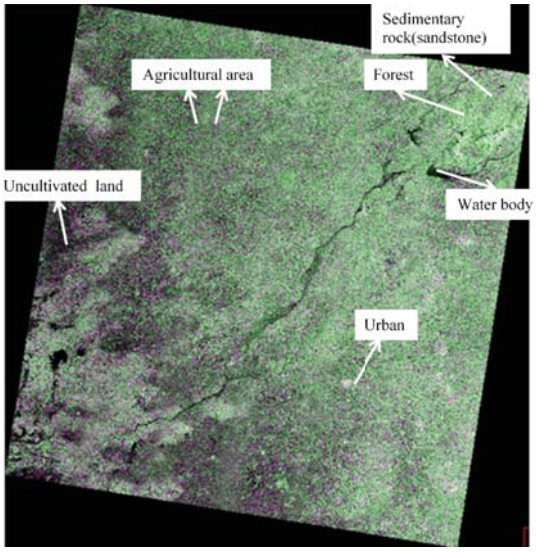

Figure 3: FCC of RISAT-1 (HH, HV, HH) of Aug 31, 2012 indicating various features

5. Results and discussions

Figure 4 shows plots of various polarisation combinations showing intensities of various features in linear or Cross polarization v/s cross polarization ratio in three dates. Separability of various features was analysed using equation 4, under different polarisation and its derivatives. It was observed that urban clusters and water bodies gives high separability almost in all polarisation but shows better visual interpretation in the combination of HH and HV polarization. Another feature which was marked using ground truth data was sedimentary rock (sandstone). It shows its best separability in the band combination of HH with HV/HH in the month of December and January. However, poor separability was observed in the month of August was due to signature mixing caused by high soil moisture conditions. Further in case of agricultural fields and forested area it is difficult to identify them using single polarization data as it show similar signature. It was observed that these objects give clear visual interpretation using data in combination with HV and cross polarization ratio. In these band combinations, it shows the best separability in HV with cross polarization ratio in the month of January. The least feature discrimination was observed in cross polarisation index.

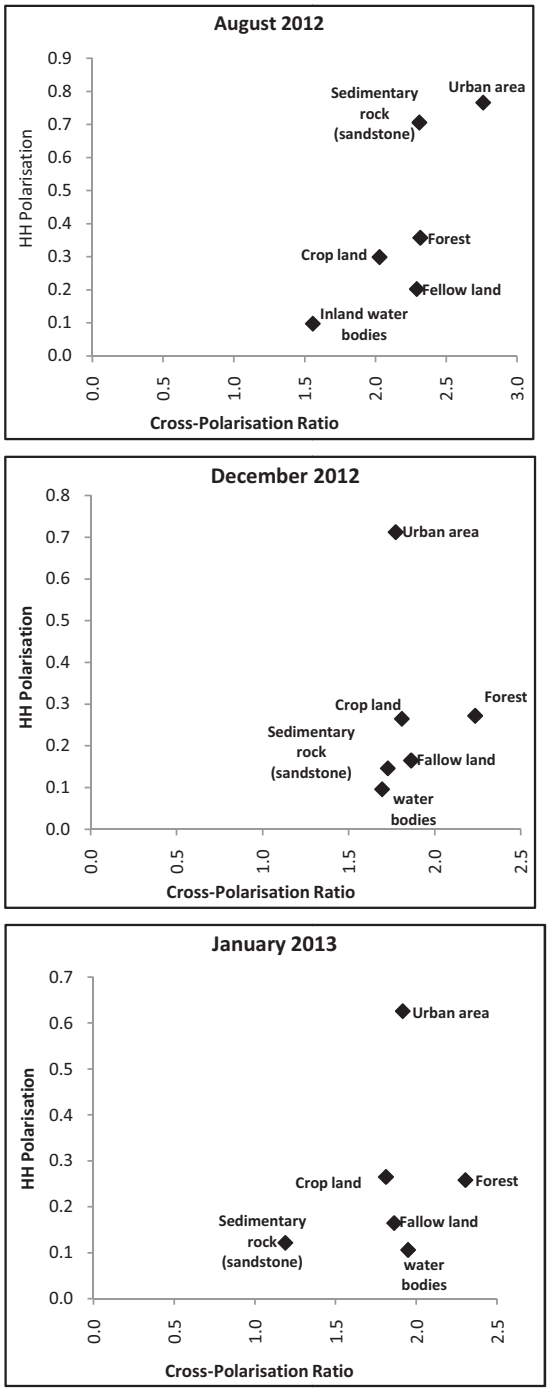

Figure 4: Scatter plot of mean intensity (HH v/s cross polarisation ratio)

6. Conclusion

The present study brings out the potential of RISAT-1 SAR in discriminating various features using various polarisation channels and polarimetric indices. It was observed that a combination of linear/cross polarization image with cross polarization ratio image consistently shows high separablity for cropland.

However, it is difficult to differentiate between crop lands and forested area using single channel data e.g linear or cross polarized data. Inland water bodies and urban clusters can be separated out in every single polarisation channels. The study concludes on the use of dual channel (linear/cross polarization and cross polarization ratio) for optimum identification of features.

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