Discrimination of Urban Targets using Sentinel-1 and Radarsat-2 C band Data

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ABSTRACT:

In the current study, an attempt has been made to identify and discriminate various urban features based on their backscatter values and scattering properties, using C band Sentinel-1 and Radarsat-2 SAR data. A part of the Vancouver city of Canada has been chosen as the study area, considering its dense urban structure, proximity to the coastal area and port activities, along with a lush green landscape. Some of the major urban features that were identified include high rise and low rise Building Clusters, roads and bridges based on difference in scattering behaviour, cultivated and non-cultivated agricultural land, forest areas on hilly terrain, ships, water body etc. Based on the difference in backscatter values (dB) and change in scattering behavior using Freeman Durden Decomposition and Volume Scattering Index, an attempt to generate a SAR polarimetric signature bank for urban features, using two time periods C-band SAR polarimetric data has been done.

1. INTRODUCTION

Identifying targets using Microwave data has always been an area of interest for those who works on surface and subsurface features. Microwave has not been much used in Urban Area. Synthetic Aperture Radar (SAR) has mostly been associated with most of the studies because of its penetration and its varied behaviour with different surface material. This study is an attempt to identify between Low rise and High rise building features. It is a case study of Vancouver city of Canada. Radarsat 2 with spatial resolution (3-100km) and imaging frequency of 5.405 Ghz has been used and Sentinel-1 C Band data (Interferometric Wide Swath Level 1 product) with 5*20 m resolution. VV and VH polarized data has been used. The wavelength of C Band is 3.8-7.5 cm Discriminating between various Urban Clusters such as High Rise building , Low Rise Building, Dense Forest, Vegetation, Different Types of Bridges, has been attempted to do.

2. STUDY AREA AND DATA USED

Vancouver is a city in Canada with latitude of 49°15'N and longitude of 123°6'W.Vancouver being one of the largest city of British Columbia and one of the largest municipality in Canada. Vancouver is bounded to the North by English Bay (City of vancouver, n.d.).On the western boundary is the Pacific Ocean's Strait of Georgia. And to the South Fraser River separates Vancouver from the smaller satellite communities. Dataset used is Radarsat2 is second in series of Canadian Spaceborne Synthetic Aperture Radar(SAR).The features of radarsat2 which makes it more significant are (a)There are three polarization modes Selective,Polarimetry,Selective-Single.(b)Resolution of radarsat2 is 3m ultra fine mode and 10m in multilook fine mode.Radarsat2 gives Polarimetry data, which includes Amplitude and Phase information. (Schwartz) .In this Study the data used is of Radarsat 2 –c band with VH and VV polarization.Other dataset used is SENTINEL1, which is a mission of ESA(European Space Agency).SENTINEL_1 mission includes C Band imaging operating in four exclusive imaging modes with different resolution (upto5m) and Swath (400m), providing dual polarization i.e. VH and VV (Agency, n.d.).Dataset Obtained for the study is of 21st July 2017, It is a Ground Range Detected , Interferometric Wide Swath data acquired with TOPSAR(Terrain Observation With Progressive Scan SAR)

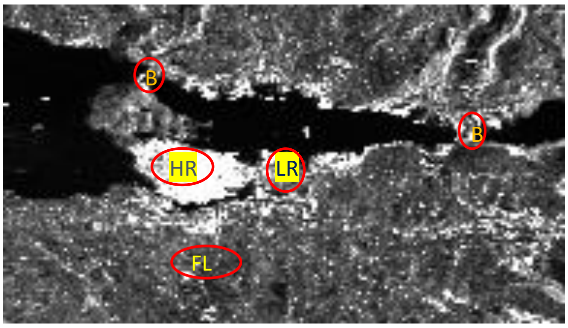


Figure 1: Radarsat2 Image of Vancouver

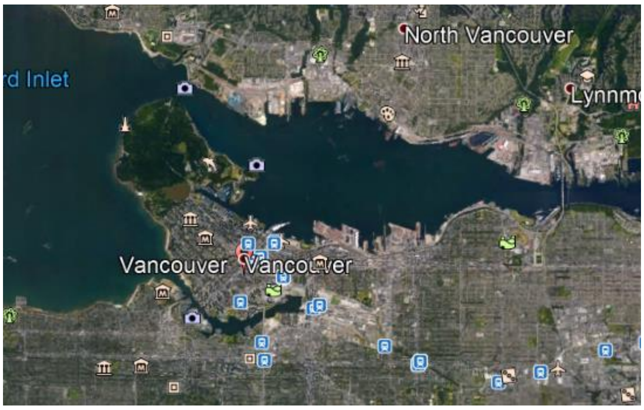


Figure 2: Google Earth Image of Vancouver

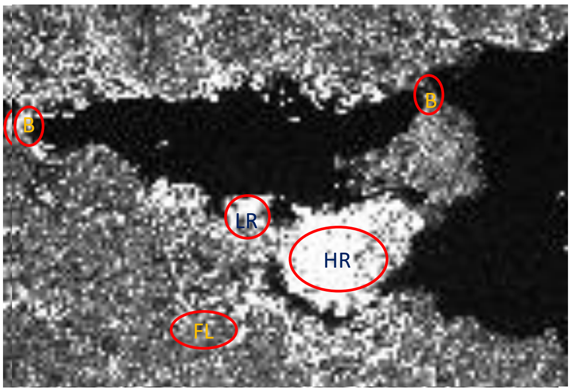


Figure 3:Sentinel1 Image of Vancouver

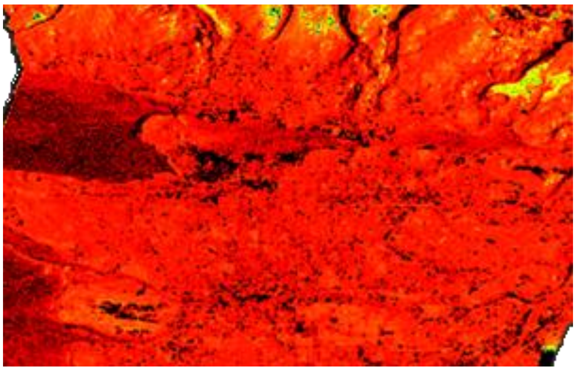
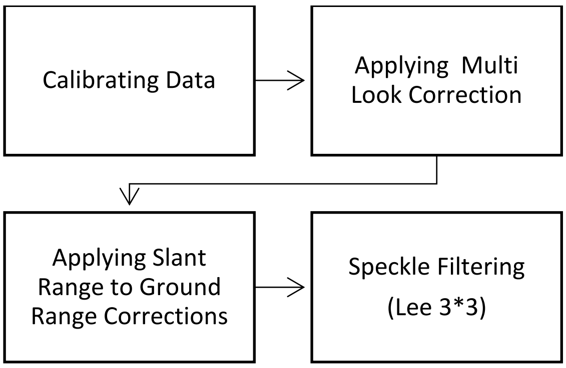


Figure4:Freeman Durden Decomposition Image

3. METHODOLOGY



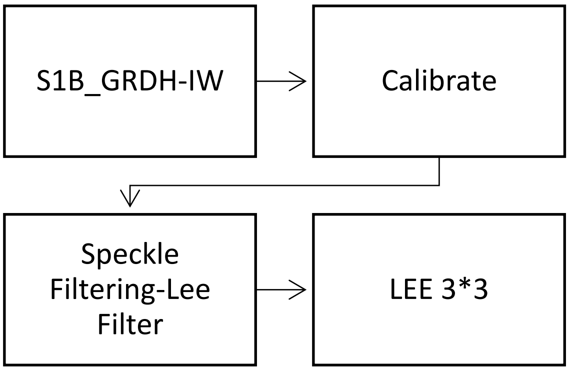


Figure 5:Methodology Adopted For Processing Radarsat2 C Band Data

Figure 6: Methodology Adopted For Processing Sentinel1 C Band Data.

The methodology adopted for processing the data is as shown above on Fig3 and Fig4 the first step is calibrating data the objective of SAR calibration is to provide imagery in which the pixel values can be directly related to the radar backscatter of the scene" (Sentinel.esa.int, n.d.) second step is multilook processing, it refers to the division of the radar beam into several narrower sub beams each sub beams provides an independent look at the illuminated scene as the name suggest each of these looks will also be the subject of speckle but by summing and averaging them together to form the final output image the amount of speckle will be reduced (Canada, n.d.).The third step is applying slant range to ground range correction it is performed because feature in near range are compressed relatively to features in the far range due to the slant range scale variability. It is desirable to have the radar image presented in a format which corrects for this distortion, to enable true distance measurements between features (Canada, n.d.).The Fourth step performed is Speckle filtering, it is a process which is done to reduce spackle noise in SAR image "Speckle noise is a coarse noise that is usually evident in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Radar waves can interfere constructively or destructively to produce light and dark pixels in radar image. Speckle noise is commonly observed in radar sensing system and images" (Klogo Griffith S.1, 2013).After the pre processing of data, areas of interest were identified using google earth imagery. The major classes which were identified were High Rise Building Clusters, Low Rise Building Clusters, Bridges, Ship, Water, Vegetation . Freeman Durden Decomposition was than performed the objective is to describe each interferometric cross correlation as the sum of the contributions corresponding to direct, double-bounce, and random volume scattering processes. This procedure enables the retrieval not only of the magnitude associated with each mechanism but also of their location along the vertical dimension of the scene. One of the most important features of this algorithm is the potential to isolate more accurately the direct and volume contributions which usually cannot be correctly separated by means of PolSAR measurements. In addition, it is also possible to distinguish between direct scattering responses originated either at ground or produced by upper layers of vegetation (J.David Ballesta Berman, 2010). Freeman Durden approach is based on the decomposition of the power reflection matrix of a scatterer. The scattering mechanism of a target or an ensembale of targets can be explained through a 3*3 scattering matrix in power domain of monostatic case. The Freeman Durden Decomposition models the covariance matrix as the contribution of three scattering mechanism (Freema, 1998) : (1)Volume Scattering where a canopy scatterer is modeled as a set of randomly oriented dipoles (2) Double Bounce Scattering modeled by a dihedral corner reflector (3) Surface or single bounce scattering

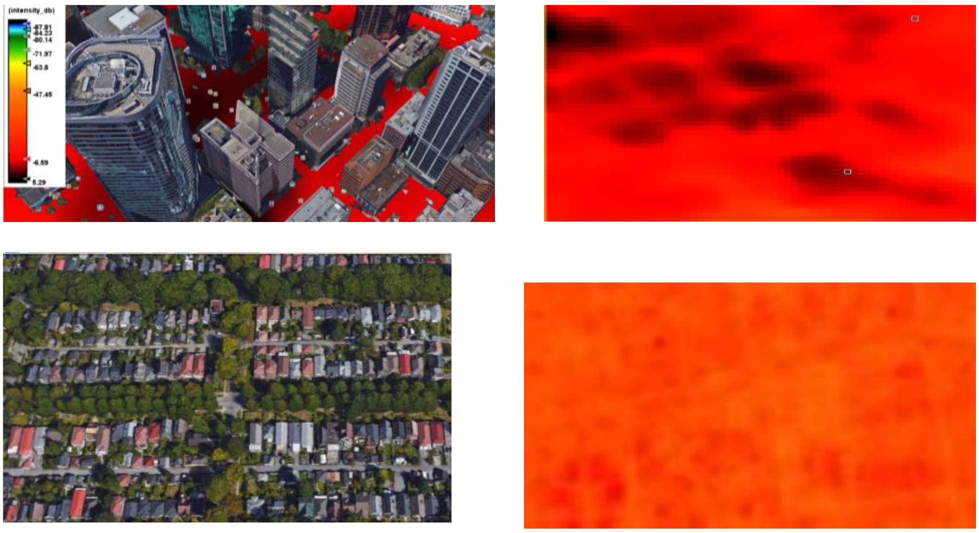
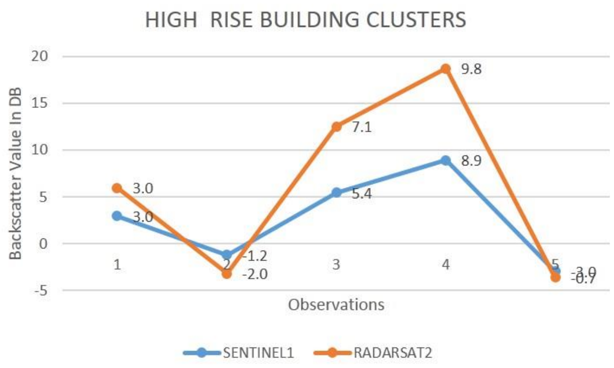


Figure 7: Visualisation of Building clusters in Google Earth and Radarsat Data in SNAP

4. OBSERVATIONS



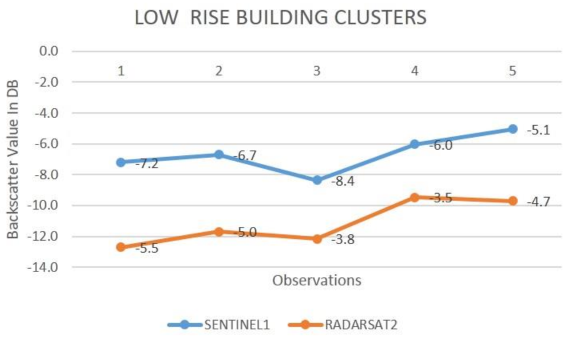


Figure 8:Backscatter Plot For High Rise Building Clusters

Figure 9:Backscatter Plot for Low Rise Building Clusters

The Range of Backscatter Value in DB for High Rise Building Clusters for VV polarization in Radarsat2 data is from -2 to 9.8 and for SENTINEL1 is from -3 to 8.9. While, the Range of Backscatter Value in DB for Low Rise Building Clusters for VV polarization in Radarsat2 data is from -5.4 to -3.4 and for SENTINEL 1 is from -8.3 to -5.05. It can be observed that the backscatter values in Db are more prominent in Co-Polarisation of High Rise Building Clusters than in Low Rise Building Clusters.The deviation in value observed is due to there more double bounce effect in High Rise Building Clusters than in Low Rise Building Clusters. It is a result of corner reflection, and even the signals in high rise building are directly sent to the reciever whereas in low rise gets scattered resulting to lower backscatter value.

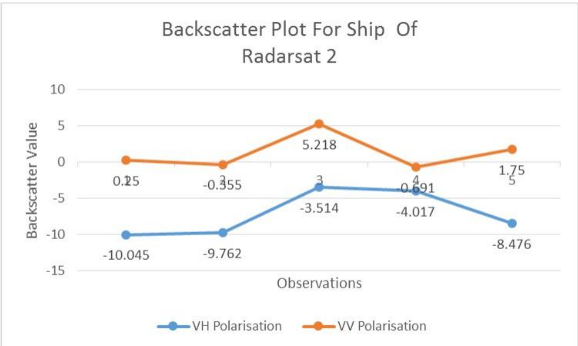
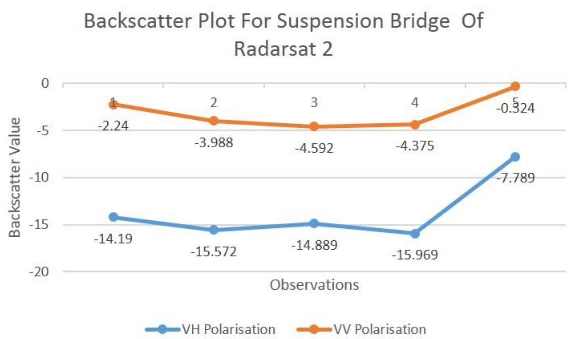


Figure 10:Backscatter Plot For Ship

The Range of Backscatter value in DB for Ship in VH Polarization is from -3.554 to -10.045 and in VV polarization is from -0.691 to 5.218. In VH polarization most of the signal gets lost due to the movement of ship and dynamic nature of ship. Even due to composite material used in building ships it has different dielectric constant.



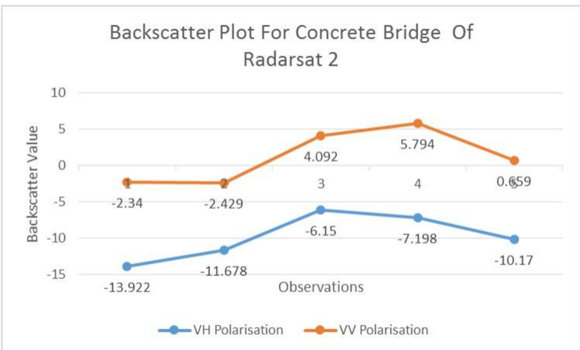
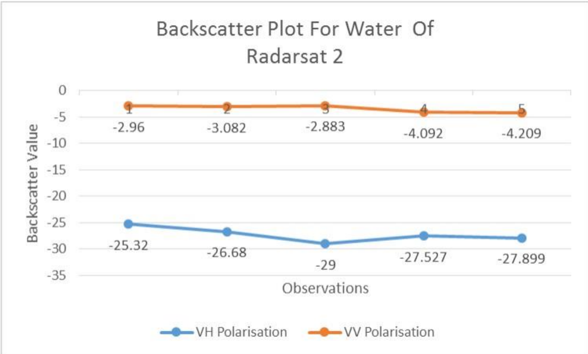


Figure 11:Backscatter Plot For Suspension Bridge

Figure12:Backscatter Value for Concrete Bridge

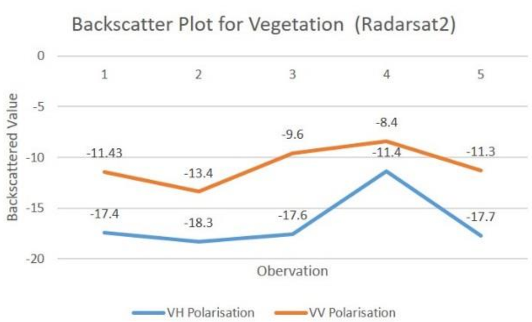
The Range of Backscatter Value in DB for Suspension Bridge in VH polarisation is from -7.789 to -15.969 and in Concrete Bridge is from -6.150 to -13.922 and in VV Polarization for Suspension Bridge is from -0.324 to -4.592 and in Concrete Bridge is from -2.340 to 5.794. In VH polarisation the backscatter value of concrete bridge is more than in suspension bridge because there are no obstruction in Concrete Bridge and realtively smooth surface than in

Suspension Bridge, there are steel wire suspended with the girder. In VV polarisation the direction of sending and receiving signal is same so in the Suspension Bridge due to the wires suspended with girder the signals are sent back directly to the reciever without any deviation.



The range observed is VV Polarization is from -2.851 to -4.209 and in VH Polarization is from -25.33 to -29.005.The dielectric constant of water is 80 and so water appears dark in image.

.Figure 13: Backscatter Plot For Water



The range observed is VV Polarization is from -8.4 to -13.4 and in VH Polarization is from -11.4to -18.3.Vegetation is observed better in VV Polarisation. The canopy of vegetation surface is rough and hence signal gets scattered in various direction instead of going back to target.

Figure 14 : Backscatter Plot For Vegetation

5.RESULTS AND FINDINGS

Figure 15: Graph of various classes and its Freeman Durden Decomposition Values

This graph indicates the different volume scattering, double bounce and surface svcaterring values of various classes.The nomenclature HRB,LRB is for High Rise Building Cluaster and Low Rise Building Clusters. Highest Voulme Scattering is observed in Ships this is because the materials used for building ships are of different dielectric propertiesand the lowest volume scattering is observed in buildings it is because the diversity in material used is less with least variability in dielectric constant..The highest double bounce effect and surface scattering is observed in Vegetation.is due to variations in height and inhomogenity in shape, size of the branches and irregular surface leads to scattering of signals and surface scattering. Amongst High Rise Buildings Clusters and Low Rise Building Clusters Surface scattering is more in High Rise Building Clusters, it is due to the corner reflection and it leads to double bounce effect.

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