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# COMPARISION OF URBAN BACKSCATTER CHARACTERISTICS OF MULTITEMPORAL ALOS PALSAR IMAGES

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**ABSTRACT:** The aim of this paper is to describe and analyze the polarimetric backscatter characteristics of different urban land surface fecatures using multitemporal L-band SAR images. For this purpose, multitemporal polarimetric ALOS PALSAR images of Ulaanbaatar, the capital city of Mongolia have been used. For the analysis, the backscatter values of a group of contextually dependent pixels selected from different parts of the images presented in digital numbers have been used. The results are discussed and some explanations on findings are given.

## 1.INTRODUCTION

The radar backscatter received from a surface is determined by incident angle, wavelength, polarization, surface roughness and dietectric properties of the surface. At radar wavelengths, three types of scattering such as surface scattering, volume scattering, and double bounce scattering can occur. If the surface is homogeneous then surface scattering will occur and it can be either specular or diffuse, or intermediate depending on the wavelength and surface roughness. If the surface is dielectrically inhomogeneous then volume scattering from the underlying materials will occur. In volume scattering when the density of scatterers is low, the dependence of the backscattering coefficient is only slight and as the average dielectric constant increases, the dependence on incident angle increases. Double bounce scattering occurs in result of right angles formed between natural and artificial objects.

Polarisation can be reflected in various ways from the natural objects. If the surface is sufficiently rough then both like and cross polarized fields can be received. HH polarized image will be dominated by reflectance coming from surface scattering mechanisms. HV and VV polarized data will display a greater component of volume scattering as a result of the signal penetrating to some depth below the surface. In general, the brighter the return on HV or VV images, the more likelihood the backscatter is coming from a three dimensional or heterogeneous layer [1,2,4]. Radar with its side viewing modes and which introduce different distortions and require various procedures for their correction. The aim of this paper is make judgment on the basis of interpretation of backscatter values and geometric problems will not be discussed.

The aim of this paper is to analyze the basic scattering characteristics of L-band SAR data for different urban features and describe how they vary with the polarization and time. For this purpose, multitemporal polarimetric ALOS PALSAR images of Ulaanbaatar, the capital city of Mongolia have been used. For the analysis, the backscatter values of a group of contextually dependent pixels selected from different parts of the images presented in digital numbers (DN) have been used and compared on the basis of the mean values and standard deviation (SD).

## 2. STUDY AREA AND DATA SOURCES

As a test site, central and western parts of Ulaanbaatar city have been selected. The area is situated in between forest-steppe and steppe zones and is characterized by such main classes as building area (1), ger (Mongolian national dwelling) area (2), forest (3), shrub (4), dry soil (5), wet soil (6) and water (7).

The used fully polarimetric ALOS PALSAR data sets were acquired on 25 May  and 25 August 2006 and were resampled to a pixel resolution of 18m. The images used in the present study are shown in Figure 1.

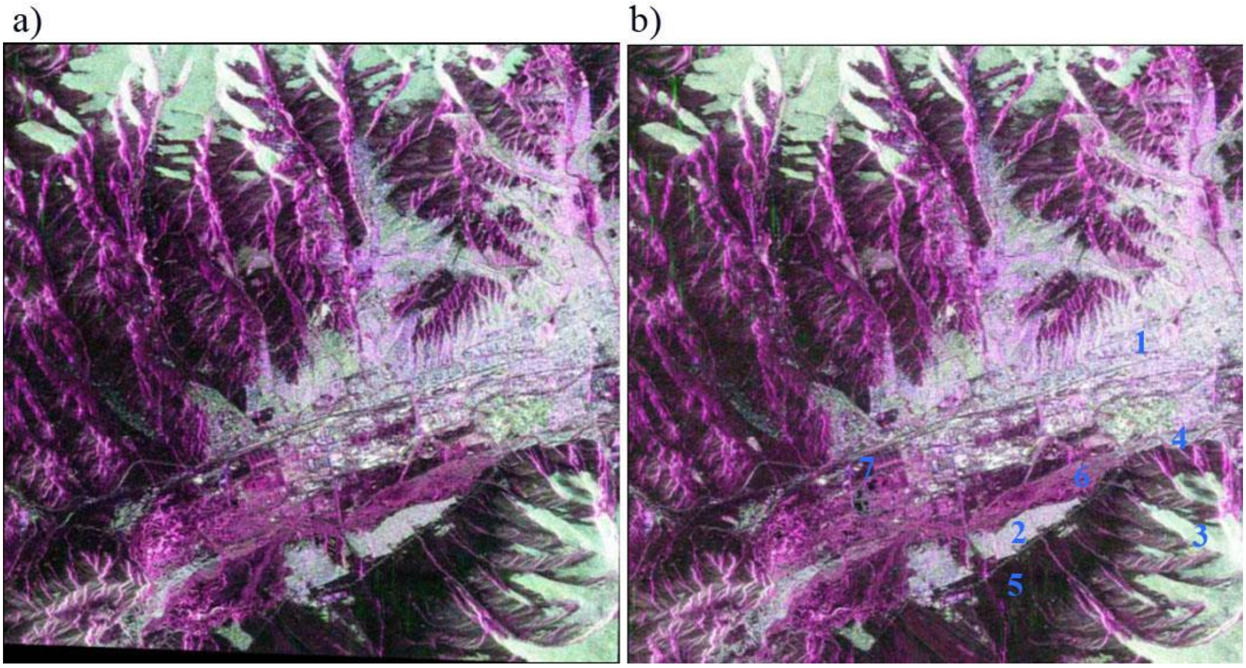


Figure 1. The polarimetric ALOS PALSAR images of Ulaanbaatar city.
a) ALOS PALSAR image of 25 May  2006,
b) ALOS PALSAR image of 25 August 2006.

Also, as additional ground truth information a topographic map of 1984, scale 1:50,000 and Landsat ETM+ image of June 2006 and soil and vegetation maps of scale 1:100,000 were available.

## 3. BACKSCATTER ANALYSIS AND SIGNATURE EVALUATION

Initially, the speckle of the PALSAR images was supressed by the use of a 3x3 size gammamap filter [3]. Then on the SAR images, polygons representing the selected land cover types have been selected. After that, the polygons were transformed into primary signatures of the representative classes. The final signatures included about 149-1382 pixels. The observed brightness values of the signatures representing the selected cover types are shown in table 1.

Table 1. The mean backscatter values of the selected land cover classes and their variations in different polarizations of the multitemporal PALSAR images.

| No | Classes | HH | | HV/VH | | VV | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD |
| 1 | Building area (May) | 201.6 | 41.2 | 187.3 | 37.5 | 223.8 | 32.0 |
| 1’ | Building area (August) | 218.5 | 36.9 | 192.7 | 38.3 | 232.2 | 25.1 |
| 2 | Ger area (May) | 247.3 | 14.4 | 212.2 | 28.0 | 251.6 | 5.9 |
| 2’ | Ger area (August) | 250.1 | 9.6 | 215.0 | 29.5 | 251.2 | 6.3 |
| 3 | Forest (May) | 168.8 | 39.9 | 211.6 | 34.3 | 188.3 | 36.0 |
| 3’ | Forest (August) | 190.5 | 35.2 | 214.1 | 30.9 | 198.8 | 31.7 |
| 4 | Shrub (May) | 151.5 | 43.5 | 162.0 | 54.0 | 167.6 | 45.5 |
| 4’ | Shrub (August) | 167.9 | 41.0 | 169.1 | 48.5 | 188.8 | 38.5 |
| 5 | Dry soil (May) | 23.5 | 22.1 | 22.5 | 17.1 | 29.7 | 23.6 |
| 5’ | Dry soil (August) | 67.7 | 32.5 | 46.4 | 19.2 | 67.1 | 30.4 |
| 6 | Wet soil (May) | 115.4 | 38.1 | 40.1 | 23.4 | 111.9 | 37.7 |
| 6’ | Wet soil (August) | 119.2 | 32.6 | 53.6 | 20.3 | 117.5 | 28.8 |
| 7 | Water (May) | 114.4 | 43.1 | 29.4 | 21.2 | 111.0 | 42.7 |
| 7’ | Water (August) | 73.7 | 48.2 | 54.1 | 24.2 | 81.2 | 46.7 |

As seen from table 1, ger area has the highest mean backscatter values and created more compact signatures, while building area has the second highest mean backscatter values (except in cross polarization), but form more scattered signatures. In urban areas, the backscatter would contain information about street alignment, building size, density, roofing material, its orientation, vegetation and soil, i.e., it would contain all kinds of scattering. Roads and buildings can reflect a larger component of radiation if they are aligned at right angles to the incident radiation. Here, the intersection of a road and a building tends to act as a corner reflector. The amount of backscatter is very sensitive to street alignment. The areas of streets and buildings aligned at right angles to the incident radiation will have a very bright appearance and non-aligned areas will have a more dark appearance in the resulting image. Volume and surface scattering will also play an important role in the response from urban areas [1,5]. To form the signatures of ger area and building classes, the polygons representing these classes were selected from more homogeneous parts of the images. Therefore, the average backscatter values for these classes are somewhat lower after averaging the selected pixels. However, if the investigation of the individual pixels could be performed then those objects aligned at right angles will give extremely high backscatter values.

As seen from table 1, forest and shrub have higher average backscatter values than some other classes and display moderate variations, however, cross polarization of the forest class has very high values compared to all other classes (except the ger area). There are clear distinctions of these classes on the cross polarization, but on the like polarized fields the two classes have the values which are not highly separable from each other. In the case of these classes, at L-band frequency the wavelength will penetrate to the forest canopy and will cause volume scattering to be derived from multiple-path reflections among twigs, branches, trunks and ground [1,5]. Comparing the backscatter values, one can observe that at L-band frequency volume scattering in forest area is stronger than in shrub, because of the increased interaction among different scattering mechanisms that contributed to the overall backscatter return.

There are two soil classes having different average backscatter values. As seen, they can be totally differentiated at like polarizations, however, the cross polarization values are not highly distinguishable. Here, dry soil forms more compact signatures but wet soil forms a scattered cluster. The backscatter of soil depends on the surface roughness, texture, existing surface patterns, moisture content, as well as wavelength and incident angle. The presence of water strongly affects the microwave emissivity and reflectivity of a soil layer. At low moisture levels there is a low increase in the dielectric constant. Above a critical amount, the dielectric constant rises rapidly. This increase occurs when moisture begins to operate in a free space and the capacity of a soil to hold and retain moisture is directly related to the texture and structure of the soil [1,5]. As it can be seen from table 1, dry soil has the lowest values in comparison with all other classes. This indicates low backscatter intensities caused by specular reflection due to lack of some surface features, low roughness properties and low dielectric constant of the soil. Wet soil gives high backscatter return compared to the dry soil and water classes because of the soil moisture content and increase of dielectric constant.

Furthermore, as seen from table 1, forest, grass and soil classes have the increased backscatter values at all polarizations in August compared to May. It might be related with their increased moisture contents as well as the increased dielectric constants.

Water has the second lowest backscatter values at all polarizations, but creates more scattered signatures. This is due to the specular reflection of water that causes less reflection towards the radar antenna, but due the contextual influence this class has more backscatter return than the dry soil.

## 4. CONCLUSIONS

The aim of this paper was to describe and analyze the polarimetric backscatter characteristics of different urban land surface features using multitemporal L-band ALOS PALSAR images. For this purpose, polarimetric ALOS PALSAR images of Ulaanbaatar, the capital city of Mongolia have been used. Overall, the research demonstrated that the ALOS PALSAR images can be successfully used for the investigation of different land surface features, however, in order to perform thorough analyses, one should have knowledge about the study area as well as sufficient ground truth data. This kind of study might be very useful for preliminary data analysis before applying different image classification and segmentation techniques.

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