POLARIZED POINT SCATTERERS: AN ALGORITHM FOR DETECTION USING ALOS-PALSAR DATA

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1. INTRODUCTION AND MOTIVATION

The ALOS-PALSAR satellite has been in orbit now since 2006. This L-band radar has an experimental Quadpol mode PLR21.5, which obtains full complex [S] matrix data for each pixel in a SAR scene, albeit for reduced swath width and relatively small angles of incidence only. In this paper we use this mode to identify an important new class of point scatterers, to complement the well-known permanent scatterers (PS) of multipass InSAR [1] and the recently developed coherent scatterer (CS) technique, [2] which requires only single pass but broad bandwidth data. We call these polarized point scatterers or PPS. Like their other point target counterparts, these scatterers are most commonly found in urban scenes. Figure 1 shows an example for the city of Edinburgh in Scotland.

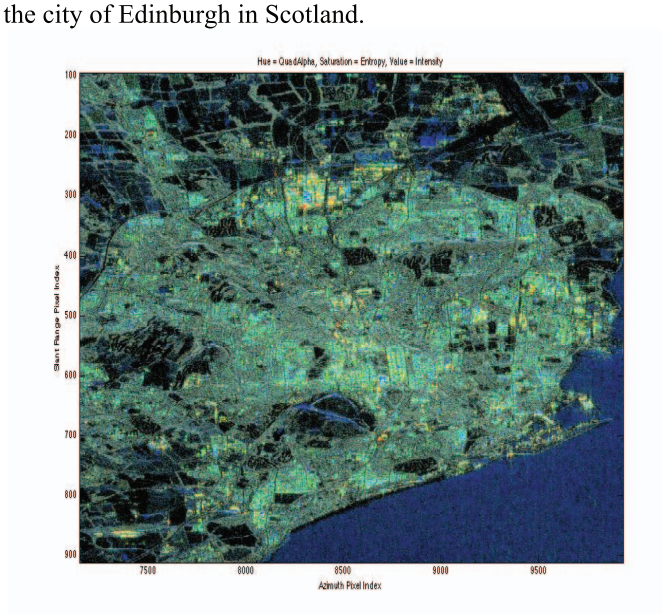

Figure 1 : L-Band Entropy/Alpha/Intensity HSV composite for the city of Edinburgh, Scotland

Here we show an entropy/alpha/intensity HSV composite image [3] and note both the intensity of color (due to the highly polarized nature of the points) and also the diversity of color (demonstrating the wide variety of polarized scattering mechanisms). In this paper we show that these responses are based on the electromagnetic boundary conditions at these scatterers and hence are robust indicators of the physical structure of the points. We also show that the ALOS geometry leads to high sensitivity to changes in these boundary conditions for dihedral scattering [4]. Hence these points provide information complementary to that of PS or CS. In this paper we first develop an algorithm for the detection of these points, taking into account the probability of false alarm due to speckle fluctuations. We then apply the technique to various data sets from the ALOS PALSAR archive to illustrate their utility.

2. METHODOLOGY

To isolate the polarized scatterers and reject depolarized targets, we begin by performing multi-look averaging of the SLC quad-pol data with a small data window. Consequently we do not obtain a direct estimate of the pixel scattering matrix [S] itself but instead its 4x4 Hermitian coherency matrix <[T]>. In order to retrieve the scattering matrix for a given pixel we therefore employ an eigenvector decomposition of <[T]> [5]. In this study we select the eigenvector $\underline{e}_1$ corresponding to the dominant eigenvalue (λ_1) as our candidate scattering matrix. Finally we obtain a 3 dimensional complex unit vector, which has multiple parameters to characterize the physical boundary conditions and symmetry of the point target. In particular we are interested in exploiting dihedral or double bounce scattering in urban environments. We plan to exploit fully polarimetric data to use this mechanism to estimate dielectric constant of building surfaces. Importantly, for the space-borne geometry of PALSAR, we can separate these dihedrals in the data as follows. Starting with the case of surface Bragg scatter, it is well known that the alpha parameter increases (negatively) with increasing e_r [5]. However it has low sensitivity for small θ, for example a change in dielectric constant from 10 to 20 causes a change of only 1 degree in alpha. Hence the polarized surface scattering response in ALOS imagery will be very limited in polarization space. This enables us to use small window sizes to reject both unpolarized returns (using entropy) [5,6] and direct surface returns (using alpha). Turning now to dihedral scattering we find we have a potential ambiguity, in that we have two dielectric constants to consider, one for each surface. However, for small angles of incidence, the primary dependence comes from the vertical and not the horizontal reflection. This can be qualitatively explained because the first surface is always illuminated at a small angle, for which the Fresnel reflection coefficients are almost equal in HH and VV, while the second surface is illuminated at a much larger angle (to make the total reflection 180 degrees or backscatter). Indeed the second angle can be so large as to approach the Brewster angle, which represents a phase transition in polarimetry terms with 180 degrees HH/VV phase before and zero phase beyond the Brewster angle. For this reason the alpha parameter for dihedral scattering (contrary to usual interpretations [3]) can lie below $\pi/4$.

3. CONCLUSIONS

The small incidence angle of ALOS-PALSAR in many ways limits the information content of its quadpol PLR21.5 mode. However, in this paper we show that for a certain class of polarized point scatterers (PPS) there remains a large sensitivity to changes in dielectric constant and structure of the targets. This can be useful for classification but also for physical parameter estimation, such a dielectric constant of natural and man-made structures. We show that false alarms can arise in two ways, either from speckle fluctuations of depolarized distributed targets or from polarized specular backscatter terms. The former we show can be controlled by appropriate choice of window size while the latter can be filtered using polarization filtering. We illustrate the detection algorithm by application to various urban scenes from the ALOS-PALSAR archive.

4. REFERENCES

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