TOPOGRAPHY POLARIZATION ORIENTATION SHIFT ANALYSIS OF VEGETATED TERRAIN USING L BAND POLSAR DATA

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1. INTRODUCTION

Polarization orientation angle (POA) is a backscattered TEM wave polarization state parameter which gives the polarization ellipse long axis orientation with respect to the horizontal. Duo to the POA of transmitted wave will be modified by the geometry and structure of scatter, POA shift value will contain the information of terrain slope variation, orientation of artificial buildings. From this view, Schuler and Lee proposed a Topography-POA shift model which contributes to measuring Digital Elevation Model (DEM) using multi-pass or single pass full polarimetry SAR (POLSAR) data, compensating the polarization state variation induced by rugged terrain for geophysical parameters estimation [1, 2]. However, as the Topography-POA shift model has rigorous applying condition to L band SAR over area covered by forest and crop, the performance of POA shift estimation algorithm is not as well as it is used over bare surface. This paper will illustrate the performance difference using L band airborne POLSAR data over sparse and thick forested area analyze the Topography-POA shift model and clarify the model’s limitation. Based on a vegetated Topography-POA shift model deduced in this paper and Cloude’s target decomposition theory, we attempt to modify the topography POA shift estimation method in [1].

2. DATA SETS

2.1. AIRSAR data

There are sparse forest in Figure 1 (c-d), river, highroad and some artificial buildings.

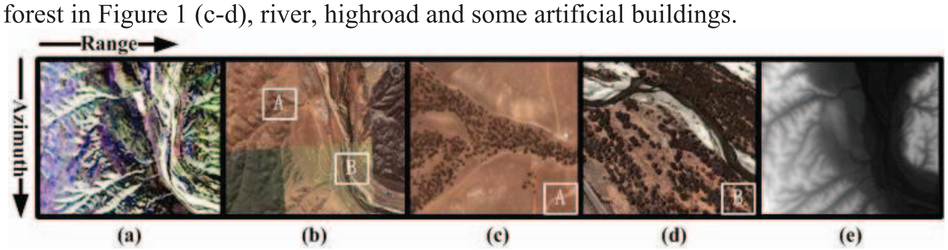


Figure 1 (a) POLSAR image (dB) of Camp Roberts, 512×512 pixel, (Red=|HH-HV|, Green=|HV|, Blue=|HH+VV|) (b) Optical image of Camp Roberts (Google Earth) (c)-(d) Areas covered by sparse forest: Data A, Data B (e) DEM image

2.2. ESAR data

The terrain of this area is composed by dense forest mostly which can be seen from Figure 2 (b-d).

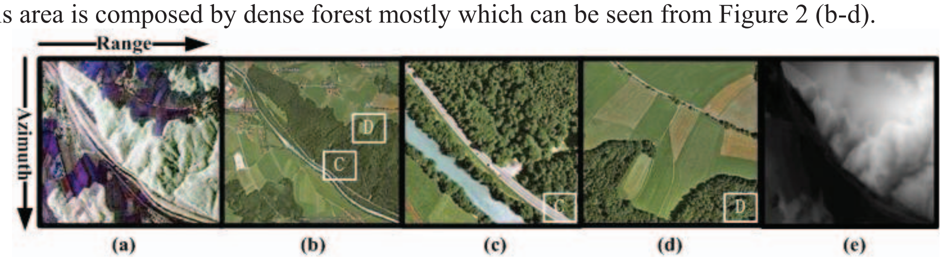
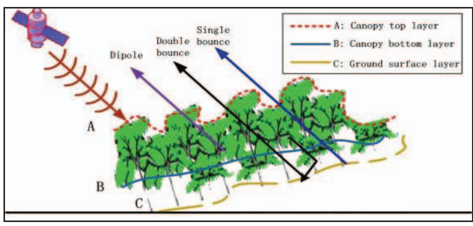


Figure 2 (a) POLSAR image (dB) of Traunstein, 1024×1024 pixel, (Red=|HH-HV|, Green=|HV|, Blue=|HH+VV|) (b) Optical image of Traunstein (Google Earth) (c)-(d) Heavily forested areas: Data C, Data D (e) DEM image

3. TOPOGRAPHY-POA SHIFT MODEL ANALYSIS

The performance of Topography-POA shift model is influenced by terrain surface cover and radar wavelength. POA shift mechanism is more complicated over forested area than bare soil surface in L band. First, POA shift effects from tilted slightly rough surface patch without vegetation cover can be characterized by $\theta = \theta_0 + \theta_T$, where θ is the POA shift in POLSAR data, θ_0 is set to zero. Vegetated Topography-POA shift model related to tree structures can be characterized by the following two layers of media with three kinds of scattering mechanisms:

1) Dipole scattering from forest canopy which is the major scattering contribution. Its propagation path is layer A→ layer B→ layer A in Fig 3. The POA shift effects of this type can be characterized by $\theta = \theta_0 + 2\theta_C + \theta_T$ where $2\theta_C$ is induced by wave propagating through canopy branches and leaves.
2) Single-bounce scattering induced by the ground below canopy. Its propagation path is layer A→ layer B→ layer C→ layer B→ layer A in Fig 3. The POA shift effects of this type can be characterized by $\theta = \theta_0 + 2\theta_C + \theta_T$ where $2\theta_C$ is induced by wave propagating through canopy branches and leaves.
3) Double-bounce scattering induced by trunk-ground. Its propagation path is layer A→ layer B→ layer C→ layer B→ layer A in Fig 3. The POA shift effects of this type can be characterized by $\theta = \theta_0 + 2\theta_C + (\theta_T + 0.5\pi)$ where 0.5π is added because of the trunk-ground double-bounce scattering effect. As the unambiguous POA shift estimation interval is between -0.25π and 0.25π, the 0.5π can be ignored.



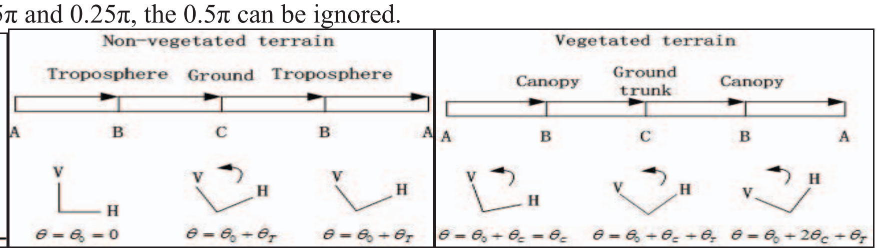


Figure 3 Scattering mechanisms in vegetated terrain. Figure 4 POA shift comparison between non-vegetated terrain and vegetated terrain. (a) Non-vegetated terrain (b) Vegetated terrain

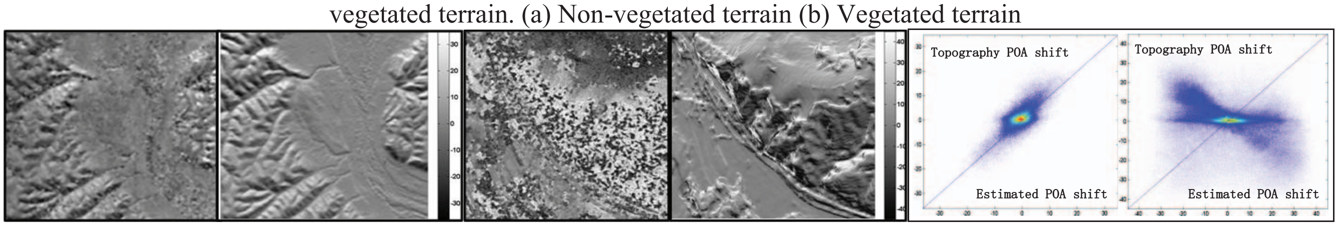


Figure 5 (a) Camp Roberts, Sparse-vegetated terrain, POA shift of POLSAR data (b) Camp Roberts, Topography POA shift (c) Traunstein, Dense-vegetated terrain, POA shift of POLSAR data (d) Traunstein, Topography POA shift (e) Scatter plot between (a) and (b) (f) Scatter plot between (c) and (d)

4. POA SHIFT ESTIMATION METHOD FOR VEHETATED TERRAIN

Cloude’s target decomposition scheme is used with the vegetated Topography-POA shift model to modify original topography POA shift estimation method.

5. CONCLUSIONS

Different polarization states construct different penetration depth; vegetated terrain is modelled as a complicated multi-layer structure to L band POLSAR data. As the POA shifts of the two layers are different, it is difficult to estimate accurate topography POA shift over vegetated terrain by the Topography-POA shift model using L band POLSAR data. Based on a vegetated Topography-POA shift model deduced in this paper and Cloude’s target decomposition theory, we will derive a topography POA shift estimation method for vegetated terrain area.

6. REFERENCES

[1] J.S. Lee, D.L. Schuler, T.L. Ainsworth. “Polarimetric SAR Data Compensation for Terrain Azimuth Slope Variation”. IEEE Transactions on Geoscience and Remote Sensing. 38(5):2153-2163.

[2] J.S. Lee, D.L. Schuler, T.L. Ainsworth, and W.-M. Boerner. “Polarization Orientation Estimation and Applications: a review”. IGRASS’2003, 7, 428-430.