ANALYZING THE "EAR" FEATURE OF A DRIED UP LAKE BASED ON VOLUME SCATTERING MODELLING

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1. INTRODUCTION

Lop Nur is a famous dried lake in Xinjiang of northwest China and finally lost its last drop of water in 1960s. It is well known for its "Human Ear Shape" feature in optical remote sensing images. Likewise, "Ear" feature is shown in Synthetic Aperture Radar (SAR) images, and even larger because of penetration effect [1, 2]. There are some explanations about external causes of the "Ear" feature according to the characteristics of the field conditions, however, the fundamental reason of the peculiar feature and the evolution process is still not revealed, and its formation is always a mystery. With the penetration capability, SAR is capable of detecting subsurface targets and materials [3, 4]. The objective of this paper is to analyze the volume scattering mechanism of subsurface and reveal the fundamental reason of "Ear" feature of Lop Nur on SAR images.

Two field investigations were conducted in 2006 and 2008 respectively, in order to validate the image interpretation and calculation results. During the first field trip conducted from October 25 to November 8, 2006, a profile along northeast direction was chosen. Every 2 kilometers a soil sample underneath the salt crust was collected. The subsurface samples were put in aluminum specimen boxes sealed with wax to keep original state. Then complex dielectric constants, moisture, soil mechanical composition and chemical composition were measured in laboratory. In 2008, the second field investigation was conducted, in order to obtain more precise soil samples and establish relationships between soil parameters and SAR signatures.

Meanwhile, ALOS PALSAR image for Lop Nur was collected, and the Cloude decomposition method was used to extract the volume scattering components, based on which the developed volume scattering model was validated.

In this study, the scattering physical mechanisms are discussed based on the results of field investigation. A suitable volume scattering model is used to simulate the contribution of volume backscattering to a certain extent. Validation of the model is also conducted based on the surveying results of field investigation and the results of Cloude decomposition using ALOS PALSAR data, and the fitting effect is relatively good. According to the analysis of the parameters of the model, it is found that salinity at subsurface is the fundamental reason of "Ear" feature, which is strongly correlated with Lop Nur evolution.

2. VOLUME SCATTERING MODELLING AND VALIDATION

2.1. Volume scattering modelling

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According to the surveying results of Ground Penetration Radar (GPR), it is noted that there are two obviously different layers underneath surface in Lop Nur, which are dry soil layer with salt crystals on top and moist soil-salt mixture at bottom. Fig. 2 is a geometrical schematic diagram of the two-layer scattering processes consisting of a rough inhomogeneous layer overlying a relatively smoother wet layer, and the scattering physical mechanisms of the upper layer is also depicted. Obviously, the total backscattering intensity is composed of the surface (top and bottom) and volume scattering, including necessary transmission and absorption attenuation effects [5]. Therefore, the clearer "Ear" feature on the SAR image is the comprehensive result of both surface and volume scattering. A two-layer surface scattering model has been developed in the previous study. Combined with the results from Cloude decomposition [6], the "Ear" feature on the volume scattering image is much clearer than the surface scattering component. That is to say, the volume scattering effect of subsurface is the primary cause of the "Ear" feature. In order to reveal the fundamental reason of the "Ear" feature and the evolution of Lop Nur, this paper focus on the study of a volume scattering model of moist saline soil.

2.2. Validation of the model

In order to validate the practicability and effectiveness of the volume scattering model, the results of the two field investigations and the results from Cloude decomposition of ALOS PALSAR data are used. Fig. 3 shows comparison between calculated and measured backscattering coefficients of volume scattering at L band (1.25 GHz), and the fitting effect is relatively good except for the 3 and 9 sample numbers. After checking the surveying record of all the sample points, it is found that there is a hole which is 30cm deep under the surface of 3 sample point, and the subsurface structure of 9 sample point is very fragmental and irregular, that is why the simulation value of these two points are not good. The average error (AE) and Root Mean Square error (RMSE) of 11 soil samples are 4.05% and 1.62% (HH), 4.22% and 1.68% (VV), respectively. In addition, from the plots in Fig. 3, it shows VV is a little bit better than HH, owing to its stronger backscattering intensity.

2.3. Extended analysis about evolution of Lop Nur

From the formulas of the model, only the volume fraction of scatterers (*f*)and the depth of the upper layer (*d*) are variables of the model. That is to say, *f* and *d* may be the fundamental reasons of the "Ear" feature. To understand the behavior of this volume scattering model, 3-D plot of volume scattering component showing its dependence on the *f* and *d*. According to the field investigation results, it is found that the depth of the upper layer is from 0.4m to 0.6m, in this interval, the volume backscattering changes along with the *f* obviously. In conclusion, it is found that *f* (salinity) is the fundamental reason of "Ear" feature.

Lop Nur is located in arid environment, which is described as "dry core" of the world, and the ground surface evaporation is very large. A lot of salinity crystals during the evaporation process, and the crystallization influence the formation of the surface structure. That is why the surface of Lop Nur is extremely rough. In a word, salinity of the soil influence not only the volume scattering intensity directly but also the roughness of the ground surface indirectly, according to rules of geomorphology.

3. CENTRAL CONCLUSIONS

Lop Nur is a famous dried lake in arid region of China, and its extinction reflects arid environment evolution. In this paper, subsurface scattering and SAR response characteristics of Lop Nur were analyzed, and explaination of the "Ear" feature was conducted based on a volume scattering model. The field investigation data and the Cloude decomposition results of the SAR image can help to validate the practicability of the volume scattering model. Parameters analysis of the model are also carried out, the experiment results show that salinity at subsurface is the fundamental reason of the "Ear" feature and evolution of Lop Nur. In future study, a detailed evolution process of Lop Nur will be obtained combining with knowledge about geomorphology and lake basin evolution in extremely arid area, and other kinds of SAR data will be used to do some more rigorous experiments.

4. REFERENCES

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Fig. 1 ALOS PALSAR (L-band, HH polarization, 34.3° incidence angle) image for Lop Nur on August 23, 2007, with clearer "Ear" feature and geological structure conditions marked. Central region is brighter than edge region. I, II and III represent three investigation routes from centre to edge in Lop Nur in 2006.

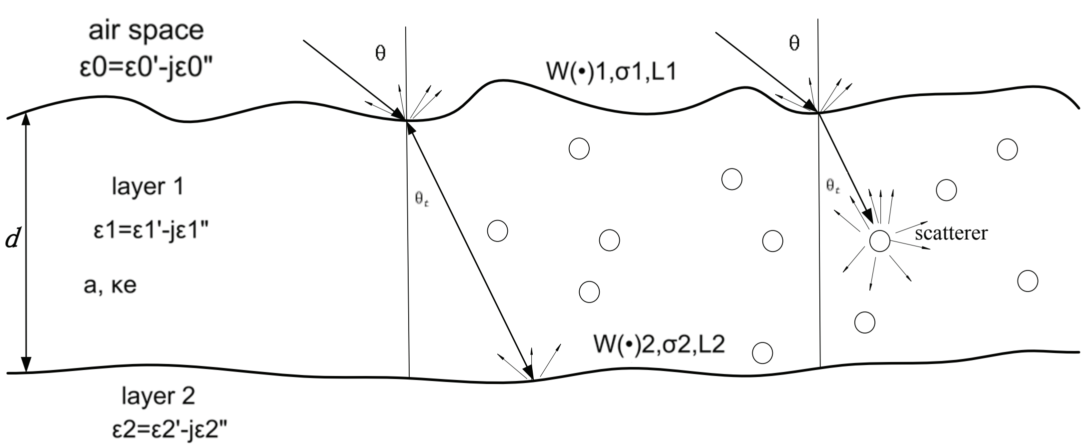

Fig. 2 Geometrical schematic diagram of the two-layer scattering processes consisting of a rough inhomogeneous layer overlying a relatively smoother wet layer, the scattering physical mechanisms of the upper layer is depicted. The complex dielectric constants (ε) and roughness of the ground surface (σ, L) were measured during the field investigations.

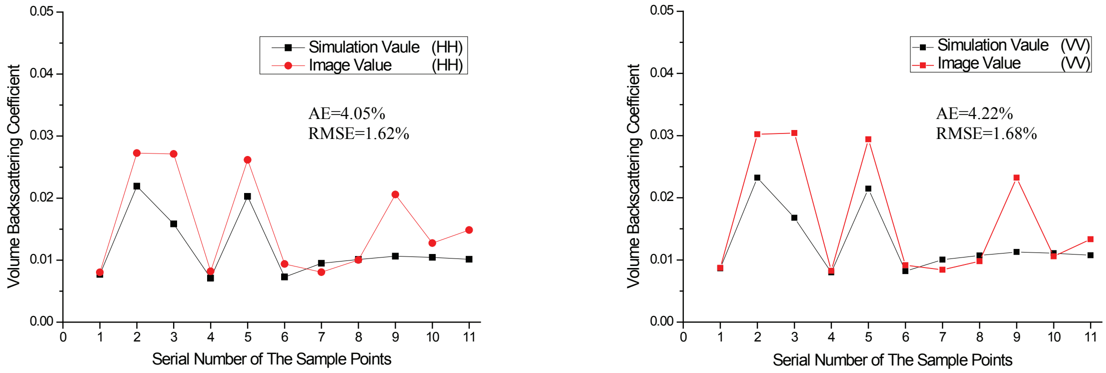

Fig. 3 Relationships between simulation and image value with AE and RMS error. The fitting effect is relatively good, and the effect of VV is a little bit better than HH, owing to its stronger backscattering intensity.

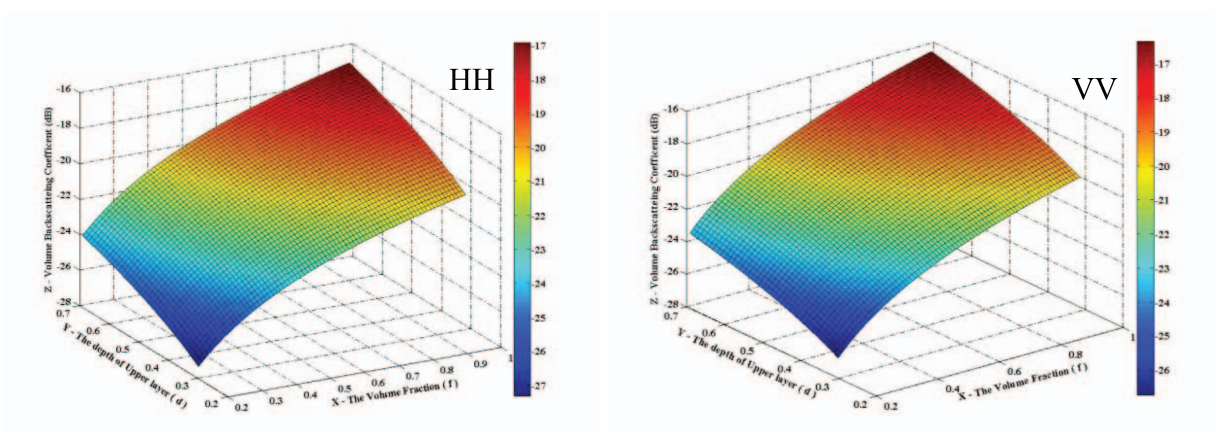

Fig.4 3-D plot of volume scattering component analysis, it can be seen clearly that the volume backscattering changes along with the *f* obviously.