SCALED MODEL FOR SAND-COVERED BEDROCK MAPPING INTERFEROMETRIC SAR

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1. INTRODUCTION

Interferometric Synthetic Aperture Radars (InSAR) have been used to measure several geophysical quantities such as topography, glacier flows and deformations [1]. To estimate the surface topography, the phase difference between two or more complex SAR images acquired using two slightly different flight paths or two physically separated antennas is used. Then through geometrical equations relating the measured phase difference to the surface height, the land topography can be estimated. Modeling of InSAR systems is very important in order to optimize the design parameters or test new processing algorithms. Efficient computational methods for conventional InSAR modeling have been proposed in the literature [2] as well as scaled models which were also used to test a new coherence optimization method [3].

In this paper, we present a scaled model for the bedrock mapping InSAR proposed in [4], where a two frequency InSAR is used to estimate the topography of sand covered bedrock in deserts. The proposed bedrock mapping system in [4] consists of two InSARs, one operating at Ka band which maps the sand surface topography and the other operates at the VHF band and uses the sand topography data to estimate the bedrock topography using an iterative algorithm.

In the scaled model, the sand height is assumed to be known and the modeling was done for the VHF InSAR. Two pyramidal horn antennas were used with a network analyzer for transmission and reception. Two antennas are more desirable than a single antenna in order to maximize the isolation and thus improve the measurement dynamic range. The two antennas were mounted on a 2.5m by 3m computer controlled XY table that allows moving the two antennas together along the X or the Y direction. A large thick flat aluminum plate was placed on the ground to reduce the clutter from tiles. A rough surface was made and placed underneath the sand in a sand box to model the bedrock. Another bare rough surface was placed on the large metal plate next to the sand box for calibration purposes. The proposed InSAR in [4] has 40% relative bandwidth and operates at 150 MHz to minimize the propagation loss and volume scattering in the sand. Common sand dielectric constant is measured to be approximately 2.8 and its loss tangent is about 0.006 (for dry sand). For the scaled model, to satisfy the area constraints, the operating frequency was chosen to be 10 GHz. Unfortunately, common sand is very lossy at this frequency and thus cannot be used in the scaled model. Instead, we used fine silica sand which has a relatively close dielectric constant at 10GHz to that of common sand at 150MHz. The scaled model operates over 8-12GHz and thus has the same 40% relative bandwidth as that of the actual system. The large bandwidth is desirable to obtain high resolution to allow for averaging in order to counteract the effect of the interferogram phase noise.

The measurement results showed the increase in the backscattering from the sand covered rough surface as compared to the bare surface as anticipated in [4]. Two SAR images were generated at two different antenna heights (1.4m and 1.55m). The two images are then coregistered and the phase interferogram is generated. The phase noise was then reduced through 5x5 resolution cells moving average filter. The phase is then unwrapped and conventional InSAR processing was applied to the interferogram. The resulting height was accurate for the bare surface, but the covered surface showed a much lower height (due to the refraction and propagation through the sand). Then, the interferogram was processed using the inversion algorithm proposed in [4] and the resulting height error was much smaller in the sand region. Due to the 5x5 averaging, the height profile was soft and the height profile resolution was significantly degraded. Better ground resolution can be achieved by applying coherence enhancement techniques such as the one described in [3]. However, even with the low resolution, we could still see significant improvement in ground height estimation achieved using the algorithm proposed in [4].

2. REFERENCES

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