BISTATIC SAR TOMOGRAPHY: PROCESSING AND EXPERIMENTAL RESULTS

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1. INTRODUCTION

During the last decades, Synthetic Aperture Radar (SAR) has become an important tool for Earth Observation. Of the many techniques that have arisen using SAR, one of the most popular is SAR interferometry (InSAR). InSAR is a well-known technique for measuring topography. It consists of using two different SAR images acquired from slightly different looking angles. For each resolution cell of the SAR image, InSAR retrieves the height of the mean or dominant scattering center. Furthermore, with only two images it is impossible to determine the heights of the different scattering centers located within a resolution cell.

Multibaseline (MB) techniques have appeared as a natural evolution of InSAR. They are based on using more than two images, acquired from slightly different positions, of the scene. Applying tomographic techniques to a MB data set, it is possible to retrieve for each resolution cell the distribution of backscattered power as function of height above ground. Scattering at different heights within the same resolution cell can be due to the penetration of the radiation through different scattering layers or because the topography is steep enough to generate foreshortening or layover. Urban areas are a clear example of the latter case. The MB technique was studied using monostatic spaceborne [1] and airborne [2] geometries. For these sensors, the MB technique requires several passes of the airborne or spaceborne platform. The resulting baselines, in these kind of configurations, depend on the transmitter's path, which is difficult to control accurately. As a result, the baseline sampling is irregular and advanced spectral estimation techniques are needed to obtain the height profile. Also, the scene might have changed between the different passes, introducing temporal decorrelation and therefore resulting in erroneous 3D MB focusing.

But, if multiple fixed-receivers were placed at different locations observing the region of interest and they were forming a set of baselines, some problems related to the classical monostatic tomography could be overcome. For example, the Born approximation in the monostatic tomography is not always a good assumption and some "ghosts" can appear in the tomographic images due to the multi-path effect, this power related to multiple reflections can be detected with a set of receivers in different locations. In addition, using a single transmitter all data could be taken in a single-pass configuration and thus eliminating the temporal decorrelation.

The Remote Sensing Laboratory (RSLab) of the Universitat Politècnica de Catalunya (UPC) is investigating bistatic configurations that use ground-based fixed receivers and orbital sensors as transmitters of opportunity. In this context, a first C-band receiver named SABRINA (SAR Bistatic Receiver for INterferometric Applications) with 4-channels [3, 4] has been implemented and successfully tested using ESA's ERS-2 and ENVISAT satellites as transmitters of opportunity. Also, a X-band

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version for TerraSAR-X is available. SABRINA is usually placed at locations with a good view of the scene, like the top of a hill or the roof of a tall building.

2. PAPER OBJECTIVE

The goal of this paper is to study tomography with a bistatic configuration using ground-fixed receivers. The paper will extend the monostatic tomography theory to the bistatic case.

A discussion about the different inversion methods for extracting the power at each height will be presented. The paper will differentiate between two types of inversion methods, parametric and non-parametric. The parametric methods need some a priori information such as the number of sources per resolution cell. This paper will discuss as parametric methods, *MUltiple SIgnal Classification* (MUSIC) [5] and *Nonlinear Least Squares* (NLS) [6]. On the other hand, the non-parametric methods do not make any assumption about the number of sources by resolution cell. The paper will focus on the classical *Beamforming* and *Capon* [7] as non-parametric methods.

These methods will be tested over real bistatic tomographic data acquired by SABRINA.

3. RESULTS

Experiments are being carried out using UPC's C-band SABRINA system. The current receiver system is battery powered, and mounted on a 19-inch rack, so that it can be easily set-up at any location and run off the power-grid.

The absence of a dedicated link between the transmitter and the receiver local oscillators results in the necessity of using a direct signal for PRF recovery and phase synchronization [8]. This direct signal is obtained using one dedicated channel, with an antenna pointing directly to the satellite. The acquisition time has to be synchronized with the satellite overpass. The acquisition window is centered in the predicted Zero Doppler Time (ZDT). The window length has to take into account the transmitter illumination time of the region of interest and some extra margin to cope with clock synchronization and predicted orbit inaccuracies, or predicted Doppler centroid error. Thus, a conservative strategy has been adopted, consisting of sampling an acquisition window continuously within the limits of the available memory, roughly 8 seconds.

For the tomographic experiments, the system will be set up at the top of 54 meter tall building at UPC's campus. Figure 1(a) shows the set-up for a previous interferometric data acquisition with only two antennas.

The tomographic experiment will use three channels, thus, two independent baselines will be available. The two baselines will allow us to distinguish between two different targets in the same resolution cell and it will be possible to retrieve their height. Two Bistatic Active Radar Calibrator (BARC) (Figure 1(b)) will be deployed in oder to simulate two strong scatters within a single resolution cell. A BARC consist in an antenna pointing to the satellite, an amplification chain and a transmitter antenna pointing to SABRINA. The two BARCs will be placed at different floors of a building with the antennas looking through an open window. They will be deployed in such a way that they will be in the same resolution cell with a controlled vertical separation.

The tomographic bistatic results with the controlled points will be shown and discussed in the full paper.

4. REFERENCES

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(a) (b)

Fig. 1. (a) Interferometric set-up with two interferometric channels. (b) Bistatic Active Radar Calibrator (BARC).

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