IDENTIFICATION OF COHERENT SCATTERERS: SPECTRAL CORRELATION VS. MULTI-CHROMATIC PHASE ANALYSIS

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1. INTRODUCTION

In recent years, attention has been devoted to the possibility of retrieving accurate phase information from stable targets in long synthetic aperture radar (SAR) data series.

Stable targets have been defined as objects on the Earth surface exhibiting high stability of their backscatter in the temporal and geometrical (baseline) dimensions [1]; they can be used as a spatial network of benchmarks to estimate and remove spurious phase contributions, such as atmospheric effects or topographic error. This allows to fully exploit decades of archive SAR acquisitions to investigate long-term surface deformation phenomena with millimetric accuracy.

Backscatter stability as defined above can only be verified a posteriori, when a co-registered stack of a sufficient number of SAR acquisitions is available.

Recently, alternate methods for detecting stable targets on single images have been investigated. In particular, the availability of new SAR sensors, such as TerraSAR-X, COSMO/SkyMed, or Radarsat 2, provided with many innovative features including a wider transmitted signal frequency bandwidth, allows to explore backscatter stability in the new dimension given by spectral diversity.

2. FREQUENCY ANALYSIS APPROACHES

An effective method to identify scatterers with stable spectral behaviour (called coherent scatterers, or CS) has been proposed in [2]. The method consists of processing single-look complex (SLC) SAR images obtained using the two halves of the available range bandwidth. Then a spatial, window-based cross-correlation is computed between these two partial-band images. Pixels exhibiting high cross-correlation values are defined as coherent scatterers. CS can be identified on each single SAR image, thus avoiding the need to wait for a sufficient number of acquisitions to accumulate before starting the investigation. Their characteristics can then be followed in time.

In [3], an alternative identification procedure for pointlike scatterers exhibiting stable spectral behaviour has been put forward. The approach relies on focusing wide-band raw data using several spectral bands within the available system bandwidth, with different central frequencies. This allows to investigate the phase trend of each single pixel as a function of the carrier frequency. Hereafter, we refer to this procedure as Multi-Chromatic Phase (MCP) Analysis. In [3], the use of different combinations of spectral separations and bandwidths is investigated through their effect on the quality of the phase samples in the spectral domain. The method has been then applied to arrays of multiple-band interferograms [4, 5], to study the inter-frequency phase behaviour, isolating coherently scattering pixels as those having a more stable phase vs. frequency dependence.

The MPC analysis can also be applied to single SAR images. By modeling the bulk of the SAR signal phase as a function of the known two-way signal path delay, through accurate knowledge of topography, the remaining phase contributions can be retrieved, for point scatterers, with sufficient accuracy to allow a multi-chromatic study. In this way, point targets can be identified searching for pixels showing a stable MCP behaviour.

3. EXPERIMENTAL COMPARISON

In the present work, the two above-mentioned point target selection techniques (CS and MCP) are compared, in terms of the statistical characteristics of the populations of targets identified with the two methods. The techniques are applied to a wide-band SAR airborne dataset acquired over a scarcely urbanized site. The dataset was acquired by a multi-channel sensor operating at X-band, with a total radar bandwidth of 400 MHz resulting from four non-overlapping channels, each 100 MHz.
wide, whose central frequencies are equally spaced in the microwave spectrum. The performances of the MCP Analysis have been evaluated for different configurations, involving different combinations of bandwidths and central band frequencies.

A substantial agreement in the location of points identified through the two techniques is noticed, taking in due account the different imaging conditions related to the approaches.

In fact, in the CS method, half-band SAR images are used, exhibiting a correspondingly halved resolution. An additional blurring effect is given by the cross-band coherence estimation window. The MCP analysis, on the other hand, can be performed over wider sub-bands, also allowing for partial band overlap, while the phase alignment is investigated on a pixel-by-pixel basis, thus involving no additional blurring effects. This translates in finer-resolution stable target maps.

In the paper, a trade-off analysis is performed on the computational burden given by the multiple-band processing required by MCP with respect to the simpler two-band processing relevant to CS, compared with the prospective advantage in resolution allowed by MCP w.r.t. CS. Other statistical investigations on the two populations of stable targets are presented, and some recommendations for use of multi-chromatic techniques on forthcoming wide-band SAR data from spaceborne sensors are proposed.

4. REFERENCES


