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ANALYSIS OF FORMATION GEOMETRIES FOR MULTISTATIC SAR INTERFEROMETRY AND TOMOGRAPHY

Abstract

Synthetic aperture radar tomography is a technique to achieve focused 3-D images SAR images (Reigber and Moreira, 2000) that relies on an aperture synthesis along the direction normal to the slant range within the slant plane, i.e. the elevation direction. That aperture is synthesized by processing properly several SAR images of the same area gathered with (slightly) different off-nadir/incidence angles. Since aperture synthesis procedures strongly rely on uniform data sampling (Richards, 2009) appropriate re-sampling techniques (Fornaro and Serafino, 2006) have to be applied to estimate a set of samples on a uniform spacing grid and their performance degrades if heavily non-uniform samples are utilized. Bistatic/multi-static SAR architectures can be properly exploited to acquire suitable tomographic data with accurate baselines and without being affected by temporal decorrelation, which severely degrades performance in repeat-pass scenarios. Moreover, these architectures can be effectively used for multi-baseline interferometry (Krieger et alii, 2003) to fulfill accuracy and ambiguity requirements. Within this framework, the proposed paper addresses formation design for multi-static SAR tomography and interferometry applications. First of all, formation requirements and basic performance parameters are derived adapting mathematical models developed in (Richards, 2009). In particular, the basic geometry parameter for SAR tomography is the effective baseline, i.e., the baseline projection onto the normal to the line of sight. The receivers have to properly sample the effective baseline along an interval that defines the tomographic aperture. In fact, the maximum effective baseline is determined by the desired height resolution and is also limited by the necessity to keep phase coherence among the signals, while the distance among the satellites is limited by the necessity to avoid ambiguities in the tomographic reconstruction. On the basis of an analytical motion model including secular J2 effects (Fasano and D'Errico, 2009), different formations, such as cartwheel (Massonnet, 2001) or helix (Krieger et alii, 2007), are optimized and compared on the basis of application performance, latitude coverage, formation stability, and collision avoidance aspects. Moreover, hybrid repeat/single pass scenarios are considered in order to reduce the number of satellite platforms, accepting the drawback of temporal decorrelation. In this case, ground track repeat cycle can be synchronized with perigee precession in order to optimize the different passages of the formation, but eventual changes in formation geometry and baseline sampling have to be properly addressed. Furthermore, performance of absolute orbit control becomes a key factor for ensuring sampling uniformity in the different formation passages.