Estimation of Vertical Structure of Forests from Multibaseline SAR data: A Performance Analysis

Relatori:
Dott. Fabrizio Lombardini (Università di Pisa)
Prof. Fabrizio Berizzi (Università di Pisa)
Dott. Matteo Pardini (German Aerospace Center, DLR)
Dott. Konstantinos Papanathanassiou (German Aerospace Center, DLR)

Candidata:
Sara Marongiu

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Abstract

The knowledge of the vertical forest structure and of its changes in space and time is fundamental e.g. for the assessment of heterogeneity, biodiversity, disturbance regime, and for the development of robust and accurate biomass estimators. Synthetic aperture radar (SAR) systems will play an essential role in establishing a continuous, systematic and global forest observation framework. Indeed, they provide the unique ability to image large areas at high spatial and temporal resolution, and at the same time they penetrate into the forest volume providing information about its vertical structure. Among the different SAR techniques that have been developed in the last decades, SAR Tomography (TomoSAR) allows the estimation of the 3-D distribution of the backscattered power from multiple SAR images, thus providing a proxy to forest vertical structure. Although TomoSAR is an established technique with several algorithmic implementations, there is still a lack of performance analyses characterizing the TomoSAR information extraction with respect to system constraints and forest structure product requirements. The aim of this thesis is to present some results of a performance analysis, considering the reconstruction of forest structure based on the Capon spectral estimator. Taking as a reference a number of meaningful backscattering profiles, the obtained Capon tomograms have been decomposed into a sum of Gaussian-shaped functions (interpreted as forest layers). In this way, each continuous power profiles could be discretized into a limited set of parameters, and the estimation performance could be evaluated in terms of the root mean squared error associated to each of them by means of Monte Carlo simulations. In a second stage, the capability to distinguish between different profiles has been evaluated. In this case, the performance has been quantified as the probability of correct detection of the changes of the layer parameters. For both TomoSAR profile estimation and profile change detection, the performance indicators have been evaluated as a function of e.g. tomographic height resolution (i.e. maximum baseline length), number of acquisitions and number of looks. Moreover a preliminary power analysis of real airborne TomoSAR data has bee carried out. In this regard the investigation and an attempt to solve some of the main issues that occur in the Tomographic data have been approached.

The results of this work are expected to contribute to spaceborne system studies (like Tandem-L) aimed at optimizing acquisition strategies for forest structure observation in order to meet product requirements.