A P-band SAR for global forest biomass measurement: the BIOMASS mission

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With the contribution of the Biomass mission Advisory Group and the ESA Biomass team.

1. INTRODUCTION

The BIOMASS mission is the Seventh ESA Earth Explorer mission, selected in May 2013, for a launch in 2020. The mission is designed to map the full range of the world's above-ground forest biomass, and to quantify biomass changes during the mission lifetime, with accuracy and spatial resolution compatible with the needs of national scale inventory and global carbon flux calculations [1]. To achieve this objective, a P-band SAR concept was proposed, based on previous works over the past two decades [2]. During the preparatory phases, six new campaigns have been conducted to address remaining questions on the biomass retrieval algorithms over tropical and boreal forests. The collected datasets comprise the accurate and complete sets of in situ data and P-band SAR data in different modes, namely Polarimetry (PolSAR), Polarimetric SAR Interferometry (PolInSAR) and Tomography (TomoSAR). It is to be noted that the mission will has an initial TomoSAR phase which will cover a part of the world' forests (10-15%), followed by a nominal phase with global PolSAR and PolInSAR acquisitions.

2. ISSUES TO BE ADDRESSED IN BIOMASS RETRIEVAL

Critical issues in biomass retrieval have been identified during the BIOMASS preparatory phases. They concern a) the retrieval of biomass in the high range of biomass, prevailing in tropical forests, b) the correction of topographic effects, since a large part of the world forest cover is on hilly and mountainous terrain and c) the mitigation of seasonal and environment effects on the SAR measurement. To address these questions, data from the P-band airborne campaigns, and also from a P-band ground-based tropical experiment have been analysed . In many cases, the airborne P-band SAR data have been subsequently processed at 6 MHz bandwidth, to provide spatial resolution compatible with the spaceborne P-band system.

These recent experiments, together with new techniques, such as tomography, have brought new understanding of the radar scattering mechanisms in boreal and tropical forests. The gained understanding was essential in developing biomass and height retrieval methods that are adapted to the conditions encountered in these major forest biomes.

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a) SAR tomography has emerged as an important tool to provide insights on the scattering mechanisms [3, 4], leading to a better understanding of the disturbing effects, to be mitigated in the biomass retrieval.

b) Analysis of PolSAR data and their temporal changes confirmed and quantified the relative importance of the disturbing effect and helped to construct the retrieval algorithms. For tropical forest, adapted topographic correction methods are required to recover the (low) sensitivity of the backscatter to biomass [5], whereas for boreal forest, the effect of changing soil moisture needs to be mitigated [6].

c) PolInSAR inversion techniques to reconstruct forest vertical structure parameters, such as forest height. However, the retrieval accuracy depends on the temporal coherence at time intervals compatible with a single satellite-borne SAR in repeat pass mode [7]. Such time intervals have not been tested in earlier experiments. The temporal coherence observed by diurnal and seasonal TropiSCAT measurements using a ground based SAR set up for one year over tropical forests [8] has been used in the PolInSAR assessment.

3. RETRIEVAL ALGORITHMS

Biomass estimation relies on statistical and physical models of the relation between the P-band PolSAR and Pol-InSAR data and forest biomass. Initially, two independent estimates of biomass are performed in parallel. The first uses the full set of PolSAR, suitably corrected for topographic and environmental effects, to give robust algorithms that can be transferred between test sites. The second derives forest height from Pol-InSAR data, then exploits the physical relation between height and biomass to derive a biomass estimate. Both estimates are then combined using a Bayesian approach to yield a final biomass estimate, together with its error, which optimally compensates for the uncertainties in the individual approaches.

The paper will give an overview of the retrieval methods, with an emphasis on the recent results obtained.

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