# GNSSBIO: FOREST BIOMASS RETRIEVAL BASED ON GNSS GROUND RECEIVER

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## 1. Extended Abstract

This paper proposes a method for the estimation of aboveground biomass (AGB) exploiting the interaction of L-band electromagnetic waves with forest vegetation. The proposed method uses the Global Navigation Satellite Systems (GNSS) direct signals in clear sky and below the vegetation to extract the attenuation (transmissivity at same polarization) and de-polarization (cross-polarization) versus satellite elevation. This activity was promoted and funded by the European Space Agency (ESA) in the framework of GNSSBio project.

The physical model was developed to characterize the attenuation and depolarization through a forest canopy composed by a crown layer (with random leaves and branches), and a trunk layer. The contributions coming from incoherent scattering and coherent propagation have been separated. The attenuation becomes important as the biomass increases and at the lowest elevation angles. The depolarization is completely due to incoherent scattering, being coherent depolarization more than 10 dB lower.

The GNSSBio experimental campaign was carried out in Tuscany (Italy) over three poplar plots with different levels of biomass ranging from 25t/ha to 250t/ha. The instrument used in the experiment was based on a GNSS-R receiver that records the two polarization components of the clear sky and biomass antennas. The data collection was complemented with extensive in-situ ground and vegetation parameter gathering: 1) Soil moisture; 2) Tree density; 3) Height of the trees; 4) Circumferences of the trees; 5) Crown insertion height; 6) Leaf Area Index (LAI). The total biomass for each poplar was derived by applying very simple allometric equations relating tree height and diameter with plant density.

Two inversion methods have been evaluated: 1) The cost function (CF) between measured and simulated transmissivity (RR) and depolarization (LR) versus the elevation; 2) Based on Artificial Neural Networks (ANN). While CF retrieval was based on the simulated data from the physical model, two different strategies have been followed for ANN, training the ANN with model simulations in the first case, and with a subset of the experimental data in the second (20% for training and the remaining 80% of data for the inversion). The ANN considered in this work are feed-forward multilayer perceptron (MLP), having two hidden layers of ten neurons each between the input and the output. The training was based on the back-propagation learning rule.

The validation was carried out by feeding the CF algorithm for the two ANN approaches with the input vectors of RR and LR measured by the GNSS-R instrument versus the elevation angles, and by comparing the biomass estimated with the in-situ measurements. Figure 1 shows the validation results, averaged on each of the five data sets available. Both ANN show some improvements of the retrieval accuracy in comparison with the corresponding CF. The ANN trained with experimental data shows the best results presenting R~1, RMSE = 5.1 t/ha, BIAS= -2.6 t/ha and p-value < 0.05.

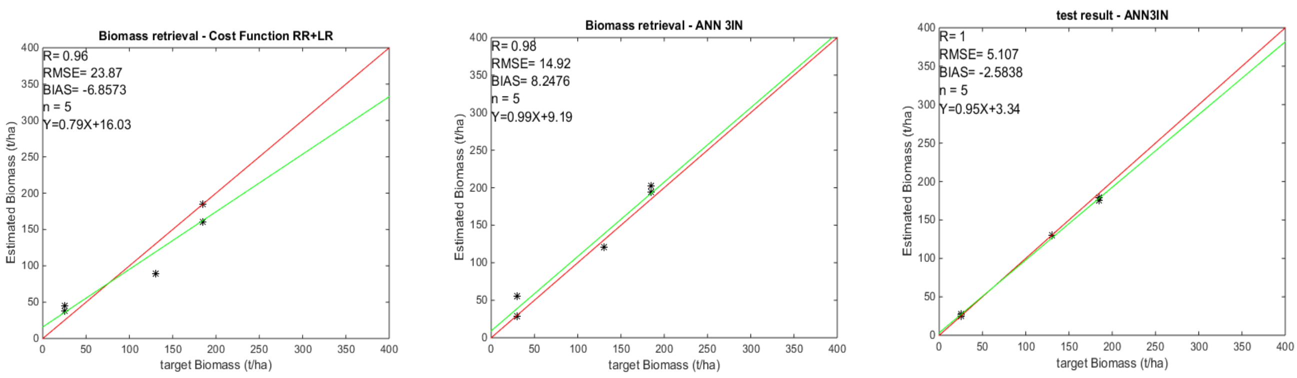


**Figure 1**. Validation results. Left) Validation of the CF algorithm versus biomass; Middle) Validation of ANN3IN algorithm versus biomass; Right Validation of ANN trained with experimental data versus biomass.