2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Forest Biomass estimation with ground based GNSS receivers

Leila Guerriero*(1), Nazzareno Pierdicca(2), Simonetta Paloscia(3), Emanuele Santi(3),
Antonio Mollfulleda(4), Francisco Martins(4)
(1) Università di Roma Tor Vergata, Italy, e-mail: leila.guerriero@uniroma2.it
(2) Università di Roma Sapienza, Italy; (3) CNR-IFAC, Firenze, Italy; (4) Starlab Limited, Harwell Oxford, UK

The interest on aboveground biomass (AGB) measurements comes from its relationship with the carbon cycle. This paper proposes a method for the estimation of AGB exploiting the interaction of L-band electromagnetic waves carried by the Global Navigation Satellite Systems (GNSS) signals with forest vegetation.

During past experiments, where the receiver was looking down from a ground based or an airborne platform (LEiMON and GRASS campaigns, respectively [1, 2]), a monotonic reduction in the land reflectivity was observed with increasing vegetation biomass, showing limited saturation for high biomass, differently to what happens with conventional L-bands radars. An alternative configuration has been proposed in the framework of the GNSSBio campaign, a project funded by ESA. It is based on the use of two identical antennas measuring the GNSS signal. The first antenna is placed in clear sky conditions, it is used to synchronize the received GNSS signals and to extract the available power used as reference. The other antenna is placed below the tree crown to measure the available power after the interaction with the forest. For the Clear Sky antenna, only the Right circular polarization is tracked, while for the second antenna both Right and Left Circular polarizations are measured. Forest Transmissivity is obtained by comparing the Right signal received in clear sky with the Right signal collected below vegetation. Depolarization is obtained by comparison of the Clear Sky signal with the Left one collected below vegetation. Transmissivity and depolarization experienced by GNSS signals when they propagate through the vegetation have been then correlated with forest biomass.

The GNSSBio experiment was carried out in April, June and September 2015, in some poplar plots close to Florence, in Italy, characterized by different biomass values, and stock volume ranging from <100m^3/ha up to >600m^3/ha. GNSS acquisitions were carried out for 3 hours continuously in different points of the canopy and in different days, in order to sample the spatial variability of the canopy. The measurements were carried out in the same time interval of the day in order to observe the same satellites. Ground-truth measurements of vegetation parameters (tree height, diameter and tree density) were collected during the GNSS data acquisitions. Measurements of LAI were also performed using fish-eye photos collected in the same points of the antenna measurements, in order to have a clear picture of the tree structure.

A theoretical model, based on radiative transfer and a discrete approach, has been also developed for the GNSSBio configuration. The electromagnetic model was then used to interpret and assess the relationships between the GNSS measurements and the tree biomass. Both direct line-of-sight propagation and volume scattering play a role in the signal magnitude and its fluctuation in time. In particular, the Transmissivity measurements are mostly dominated by the attenuation of the coherent signal, whereas Depolarization measurements are almost uniquely affected by the incoherent volume scattering.

An inversion algorithm was also proposed, based on artificial neural networks. Although the experimental dataset is limited in size and environmental conditions, the retrieval performances were encouraging and the proposed concept was reliably demonstrated.

1. A. Egido, M. Caparrini, G. Ruffini, S. Paloscia, E. Santi, L. Guerriero, N. Pierdicca, and N. Floury, "Global Navigation Satellite Systems Reflectometry as a Remote Sensing Tool for Agriculture", *Remote Sensing*, **4**, 2012, pp. 2356-2372.

2. A. Egido, S. Paloscia, L. Guerriero, N. Pierdicca, E. Motte, E. Santi, M. Caparrini, and N. Floury, "Airborne GNSS-R Soil Moisture and Above Ground Biomass Observations" *IEEE Journal Of Selected Topics In Applied Earth Observations And Remote Sensing*, **7**, 5, May 2014, pp. 1522-1532.