GNSSBio: AN EXPERIMENT FOR ASSESSING GNSS GROUND RECEIVERS POTENTIALS IN ESTIMATING FOREST BIOMASS

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An experiment was carried out in Tuscany (Italy) for investigating the potential of GNSS signal in estimating forest biomass. The importance of forest monitoring is universally recognized due to the role played by forests and other semi-natural ecosystems in regulating the carbon cycle as alternatively sources and sinks of CO₂. Spatial explicit information at different scales on forest status is therefore tremendously requested, since several applications can benefit from this information: from bioenergy production and sustainable forest management to the detection of land-use change and assessment of carbon stocks.

Forests may be characterized in terms of biophysical parameters (Leaf Area Index - LAI, Above Ground Biomass - AGB, Net Primary Productivity - NPP), which provide direct information on the productivity, structure and amount of forest resources. Usual forest biomass measurements are based on local surveys by selecting homogeneous small sample plots inside a larger area and by identifying areas representative of the entire forest. The possibility of measuring these parameters by using a receiver placed inside the forest plots is extremely appealing and therefore the use of a GNSS receiver was investigated in the framework of an ESA Project (GNSSBio AO/2-1610/14/NL/CVG-EGEP). The impact of vegetation on GNSS received signal is characterized in terms of signal attenuation and depolarization. This concept was validated in previous experimental campaigns where the receiver was looking down from a ground based or an airborne platform (LEiMON and GRASS experiments, respectively). LEiMON focused on the analysis of the scattering characteristics of GNSS signals reflected off land surfaces, whereas GRASS determined the sensitivity of GNSS-R signals to soil bio-geophysical parameters. During both projects, the reflectivity coefficients at both polarizations were found to be sensitive to soil moisture and surface roughness changes. In addition, monotonic reduction in the reflectivity was observed with AGB, showing limited saturation for high biomass, differently to what happens with conventional L-bands radars.

The Oceanpal instrument provided by Starlab allows full-polarimetric GNSS-R data acquisition and processing. This new instrument is composed of three subsystems: the Oceanpal Antenna Rig (OAR), the Oceanpal Radio-Frequency Unit (ORFU), and the Oceanpal Data Management Unit (ODMU). The new OAR features two up-looking antennas for the reception of the direct signal, that are a GPS L1 with RHC and LHC polarizations, which carried out observations of two direct received GNSS signal, one in clear sky view and one below the canopy. Both receiver antennas are identical, presenting the same orientation, and performing simultaneous power measurements. By means of this approach, the attenuation and depolarization due to the vegetation were measured. The attenuation introduced by the vegetation layer, (or one-way loss factor), can be initially defined as the ratio between the power received, i.e transmitted, below the vegetation canopy and the free-space signal received under identical conditions but without an intervening canopy between the GNSS transmitter and the receiver. Thus, the attenuation can be measured by means of the signal received at RHCP below the vegetation and the direct signal received at RHCP in free space. On its turn, depolarization can be measured by means of the LHCP signal received below the vegetation and the clear-sky signal at RHCP.

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, ranging from <100m²/ha up to >600m²/ha. According to the acquisition plan, GNSS acquisitions were carried out for 3 hours continuously in different points of the canopy. In each poplar plot, 3 GNSS measurements were carried out in order to check the
spatial variability of the canopy. The three measurements were carried out in the same time interval in order to receive the same satellites. Ground-truth measurements of soil moisture and vegetation parameters (tree height, diameter, LAI) were carried out during the GNSS data acquisitions. Measurements of LAI were carried out by using fish-eye photos collected in the same points of the antenna measurements, in order to have a clear picture of the tree structure.

The preliminary analysis of the datasets allowed confirming a marked attenuation of the signal collected under the canopy with respect to the one collected in open air. The direct overlapping of the received signal over the fish-eye pictures pointed out the different effect of the branch dimensions and positions.

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