GNSS SCATTEROMETRY OF THE EARTH SURFACE: MODEL ANALYSIS OF GEOPHYSICAL PARAMETER SENSITIVITY AND INSTRUMENT REQUIREMENTS

L. Guerriero[1], S. Landenna[3], N. Pierdicca[2], L. Pulvirenti[2], I. Ricciarelli[2], A. Zin[3]

[1]Tor Vergata University of Rome, DISP, Rome, Italy
[2] Sapienza University of Rome, Dept. Electronic Engineering, Rome, Italy
[3] Thales Alenia Space, Vimodrone (MI), Italy

Abstract

The microwave power of an electromagnetic wave scattered by the earth surface is sensitive to the moisture content of the observed soil and of the above lying vegetation cover. As far as soil moisture is concerned, its effect on the amplitude of the backscattered signal has been largely investigated and the effectiveness for this application of radars operating at lower frequency (such as L band) has been well established. The potential of SAR in both agricultural and forest applications has been also demonstrated in several studies, with the main objectives of classifying different vegetation species, and of monitoring the seasonal cycle of growth of any single crop, or the biomass increase in arboreous vegetation.

After the feasibility of scatterometric measurements over sea using the GPS constellation was proved, the exploitation of GPS transmitters to perform bistatic measurements over land has therefore appeared extremely attractive considering the well suited operating frequency (L band) for hydrological, agronomical and forestry applications. Obviously, the potential in term of geometric coverage and resolution must be confronted with several limitations concerning signal to noise ratio and orbital constraints.

In the past, an ESA study has regarded the development of electromagnetic models to simulate the response of a radar bistatic system observing bare or vegetated soil, being the specular geometry typical of GNSS scatterometry part of this modelling effort. Recently, a Phase-A study commissioned by ASI and lead by Thales AleniaSpace was focused on the development of an enhanced version of the Radio Occultation for Sounding of the Atmosphere (ROSA) instrument. In particular, the possibility to include a “module” in the receiver (and an additional antenna) for GNSS altimetry and scatterometry applications was foreseen. To this end, an analysis of the system requirements and of the feasibility to measure biomass and moisture has been carried out, in order to give reliable and realistic results, especially when considering the very low level of the transmitted signal.

With these premises, and considering the increasing interest and opportunity to flight a GNSS scatterometre on board an orbiting platform, the research has further progressed to identify potential and requirements for such type of instrumentation, with a particular focus on land applications, but without neglecting the comparably important and better consolidated oceanographic applications. The work is mainly based on simulations aiming to analyse from one side the sensitivity of the specularly reflected GNSS signal to earth surface geophysical parameters, and from the other side to identify the performances of the instrument in order to be able to appreciate the relevant characteristics of the received waveform.

At this stage the latter aspect is investigated with reference to the oceanographic reflection, whose shape as function of the sea state and wind has been reliably modelled in the literature. A set of requirements in terms of receiving antenna pattern and directivity, surface coverage, raw signal detection (quantization and sampling frequency) have been identified using a simulated return from a large number of scatterers randomly distributed over the surface and behaving as sea surface reflecting facets. The retrieval of the relevant waveform parameters generated after cross correlation between the received signal and the GPS L1 signal (the C/A coded signal) has been simulated considering different signal quantization (number of bits) and sampling frequency (from 5 MHz to 40 MHz). The study has demonstrated the effect of the receiving characteristics on the precision of the final estimates of the waveform parameters, which are basically the delay time associated to the mean sea level and the shape of the trailing edge associated to the surface slope standard deviation and thus to the sea state and surface wind speed, according to well established theoretical models.

Part of the work has been funded by the Italian Space Agency.