



F7.1 Remote Sensing of Earth Surfaces

Interferometric Radiometry and its Applications

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Introduction

The basic measurement of an interferometric radiometer is the complex cross-correlation of the random electric fields collected by a pair of antennas. When both antennas have the same polarization, but are separated forming a baseline, one talks about interferometric radiometers. In an ideal system, when a set of selected baselines are measured for the same brightness temperature scene, the whole scene or a strip of it, can be obtained by means of an inverse Fourier transform. In this case, one talks about two- or one-dimensional aperture synthesis interferometric radiometers. When both antennas have orthogonal polarizations, and are usually forming the zero baseline, one talks about polarimetric radiometers.

Applications

The spatial resolution that can be achieved by conventional total power radiometers is mainly limited by antenna size considerations, which can be very demanding in Earth observation, specially at low frequencies. To overcome the antenna size, weight, deployment and scanning problems, one- and two-dimensional L-band aperture synthesis interferometric radiometers have been studied during the last decade for the global monitoring of soil moisture and ocean salinity. Other instruments at mm-wave frequencies have also been studied for high spatial resolution monitoring of the snow and ice cover. These instruments are formed by a sparse array of antennas and inherit the techniques successfully used in radio-astronomy for decades. However, the different scenarios to be observed in both fields, together with the wide field of view, the large number of baselines to be simultaneously measured and the short integration times have required the development of new error correction, calibration and inversion methods.

When the target is formed by randomly distributed point sources, e.g. the rain, single baseline interferometric radiometers can be used to improve the spatial resolution, at the expense of a lower sensitivity. In other applications polarimetric radiometers provide an indirect measurement of the roughness state of the surface being sensed, a property that has recently raised the interest for the determination of wind speed and direction over the ocean, by passive means.

Some Experimental Activities on Interferometric Radiometry at UPC

After a review of the error correction and calibration of interferometric radiometers, and following the above classification three experimental studies carried out with an X-band interferometric radiometer prototype will be presented:

- i) two-dimensional aperture synthesis passive imaging of natural and artificial targets,
- ii) rain detection by means of a single baseline interferometric radiometer, in two configurations short- and long-baseline, and
- iii) polarimetric radiometry of artificial roughened targets and rain events.

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Microwave Radiometry of Soil Characteristics

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Soil moisture measurements are prerequisites for many research and application topics. They are of crucial importance for the derivation of fluxes at the surface atmosphere interface, for hydrologic studies and as input in Global Circulation Models (GCMs). Derivation of soil moisture has been proved to be possible through the use of passive microwave data at low frequency, but the problem lies in the difficulty to place on board a satellite a low frequency (1.4 GHz) microwave radiometer having suitable spatial and temporal resolutions. With the development of a new concept: the interferometric radiometer, spatial resolution is no more a hard difficulty, and the realisation of a space borne interferometric radiometer, is now at hand. Such systems have been proposed to space agencies and might fly in the near future. Consequently, so as to specify an L-band radiometer, it is now necessary to ascertain from models and measurements, which are the necessary requirements of such a system, and this, for all the main applications.

The results presented here are based on the research work carried out in the framework of the SMOS (Soil Moisture and Ocean Salinity) mission. The instrument is a 2-D L band radiometer allowing multi-angular and dual polarised measurements. It has been submitted to ESA in the framework of the Earth Explorer Opportunity Missions.

Surface Characteristics retrieval

Microwaves are sensitive to changes in the dielectric constant of the medium. Any changes in water content will induce changes in the dielectric properties which will affect the emissivity and thus the brightness temperature. This leads to a direct relation between soil moisture and emissivity (or brightness temperature). For a bare smooth soil the sensitivity of brightness temperature to soil moisture is quite high. However, several effects might adversely affect the signal. First, obviously, the surface temperature must be known. Then surface roughness and vegetation (through its water content) decreases sensitivity. Other parameters also have secondary order effects such as soil texture and vegetation structure, Faraday rotation etc... The SMOS concept enables thanks to the dual polarisation and multi-angle facilities to account for these factors. We will thus describe approaches to retrieve and monitor soil moisture, vegetation biomass and surface temperature. The analysis is based on model inversion. The standard error of estimate of the surface variables is computed as a function of the sensor configuration system and of the uncertainties associated with the spatial measurements. The inversion process is based on a standard minimisation routine that computes both retrieved variables and standard error associated with the retrievals. The potential for retrieval will be analysed considering view angle configuration (mono, bi or multi-angular system) and the use of the sole 1.4GHz or the combined 1.4 and 5 GHz frequency bands as well as other sensors. The analysis investigates the possibility to retrieve one, two or the three surface variables, depending on the system configuration.

In this paper we will give an overview of the problems and solution so as to give a first estimate of the requirements.