MULTIFREQUENCY THEORETICAL SIMULATIONS OF BACKSCATTERING FROM FLOODED AREAS

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1. INTRODUCTION

SAR remote sensing data stand as useful tools in early warning of flooding events. Their combined characteristics of high resolution and all-weather capability offer a unique opportunity of damage inventory and propagation forecasting. Many theoretical and experimental studies have demonstrated the sensitivity of SAR to the moisture content of soil up to its complete coverage by water. This sensitivity is driven by the dielectric constant of the observed surface which is a function of its water content and which determines its reflection property. However, both surface roughness and vegetation cover make the interaction between the electromagnetic wave and the surface a complex phenomenon. Indeed, flood may make the soil surface smoother - or rougher, if wind is present - so that the imprint of the natural disaster on the radar response changes as a function of frequency and incidence angle. On its side, vegetation attenuates scattering from underlying soil but, when stems or trunks are present, introduces a "double bounce" effect as well, which may be enhanced by a flooded water surface. Also in this case, the radar response depends on frequency but also on the vegetation biomass and on the geometry of the scattering elements. Due to the large variability of scenarios, empirical approaches are not suitable to reach a complete understanding of the scattering processes which arise in such conditions. On the contrary, models are able to single out the effects due to different variables, thus allowing a parametric analysis of the radar response of flooded land.

2. MODEL SIMULATIONS

In this paper we use a theoretical approach, i.e. the electromagnetic model developed at Tor Vergata University, to study the effects of increasing soil moisture, up to inundation, in presence of vegetation. Based on a discrete approach of the radiative transfer theory, the model is able to simulate the backscattering coefficient of bare soils and surfaces covered by vegetation with different morphological structures. In particular, a wide leaf crop, such as maize, and a thin leaf crop, such as wheat, has been considered, as well as deciduous and coniferous forests. Besides, the model developed at Tor Vergata can simulate backscattering from surfaces covered by vegetation in different growth stages, since it can take advantage from allometric equations which relate all vegetation parameters (such as leaf or branch dimensions and densities) to a driving parameter (such as plant height or trunk diameter). This allowed to study the effects of increasing biomass on the radar response of flooded pixels.

Using the most appropriate approximation to describe the electromagnetic properties of vegetation scatterers, the model is able to perform simulations in a wide range of frequencies. The backscattering coefficient at L-, C- and X-band has been modelled in order to consider frequencies used by currently operating SAR's. In this way, the optimal configuration for flood monitoring, in terms of frequencies and observation angles, can be identified. In particular, due to its penetration capabilities, L-band seems to show the most apparent effects: a decrease of backscattering coefficient when vegetation is absent or with low density, and an increase when vegetation is well developed or very dense, as in the case of forests. C-band measurements can show a significant sensitivity to flooding events when the soil is covered by tenuous vegetation, i.e. numerous thin vertical stems giving rise to an enhanced double bounce effect over standing water. Finally, experimental measurements extracted from available images, will be presented and discussed on the basis of the previously analyzed theoretical results.

The output of the model simulations constitutes a database which can be used to train classification algorithms since, based on this theoretical knowledge, flooded areas under different environmental conditions can be recognized provided some prior information on land cover and land use are made available.