FULL WAVE ANALYSIS OF VHF-UHF FOREST BISTATIC SCATTERING MECHANISMS AN INVESTIGATION ON THE INFLUENCE OF ELECTROMAGNETIC COUPLING

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1. INTRODUCTION

A 3D coherent scattering model simulating the interaction of electromagnetic waves with forests has been developed. It is obtained by means of a full wave approach, based on an integral representation of the electric field [1]. A method of moments is used to solve the integral equation and compute the scattered fields related to the various scattering mechanisms [2] as well as the contribution of tree-trunks and branches. This model is used here to evaluate the impact of electromagnetic coupling effects between a group of scatterers (which can be the branches and the trunk of a single tree, multiple tree-trunks, or multiple trees) for monostatic or/and bistatic radar configurations. To validate our model, we compare our results with anechoic chamber measurements. The forest scaled model is composed of a plate of aluminum and vertical and/or tilted dielectric parallelepipeds respectively representing the soil, the tree-trunks and the branches.

2. FOREST REPRESENTATION

At VHF-UHF frequencies, the wave is not significantly scattered by the details of the trees (smallest elements). Therefore, the complex geometry of the forest can be reduced to dielectric vertical and tilted cylinders of square cross section (in a way to discretize it by cubic cells), representing respectively trunks and main branches, above an horizontal interface separating two semi infinite homogeneous media, the air and the forest ground (Fig. 1).
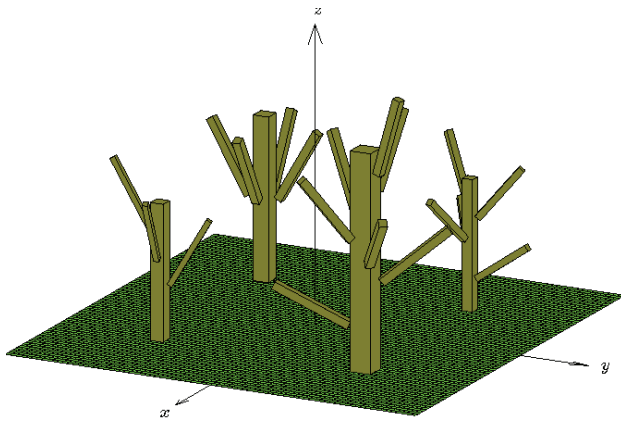

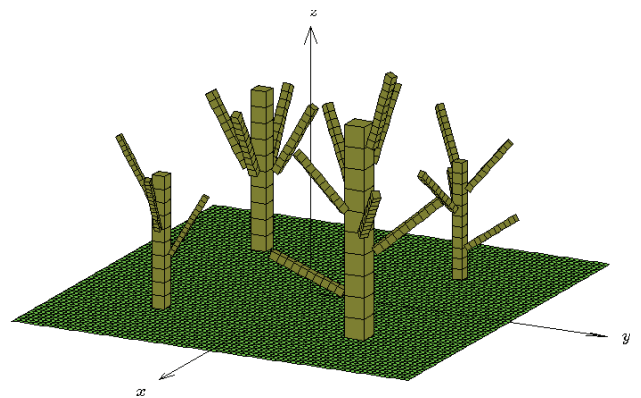**Fig. 1**. Forest Geometry.

Fig. 2. Discretized Forest.

The effects of leaves, needles and the roughness of the soil are ignored in the frequency band under consideration. The trunks and the main branches are divided into elementary cubic cells which are small enough so that the internal field is nearly uniform in each cell (Fig. 2).

3. SCATTERING MECHANISMS AND COMPUTATION PROCESS

The volume integral equation formulation and its discretization into a linear system of equations using a method of moment (MoM) [3] are employed to determine the scattered fields associated with each scattering mechanism (Fig. 3). The calculation of each scattered field, which involves the Green's function of two layered media [4], requires the knowledge of the internal field of the trees that accounts for all types of interactions. Finally, we need to sum those scattering mechanisms coherently in order to obtain the total scattered field. That way, it is possible to analyze the relative contribution of each mechanism to the scattered field for various scattering angles as in [5].
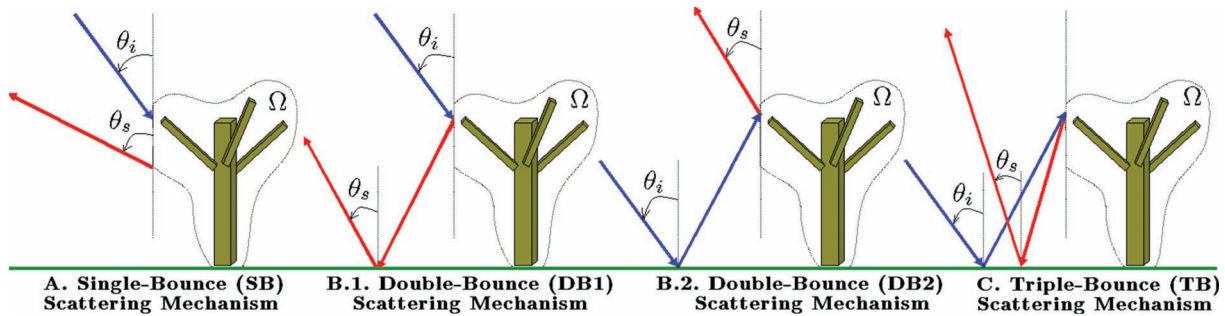

Fig. 3. Scattering Mechanisms Description. θ_i and θ_s are respectively the incidence and scattering angles. Ω is the domain occupied by the trees.

4. THE APPROXIMATE SOLUTION

Because of the limited available computer memory space and the high computational cost, which depend on the frequency under consideration and the scatterers' size, our method is not well adapted to evaluate the scattered field by a real large forest even at low frequencies. To overcome this problem, we propose a simplification by neglecting electromagnetic coupling between the trees when the gap between two adjacent trees is large enough compared to the incident wavelength. In this case, we can successively compute the scattering mechanisms for each tree rigorously and sum the contributions of every tree to obtain the total scattering response from a forest.

5. RESULTS

For bistatic radar configurations, we first compare the contributions of the different scattering mechanisms and analyze their influence on the total scattered field. Then, we study the impact of electromagnetic coupling between a group of scatterers (which can be the branches and trunk of a single tree, multiple tree-trunks, or an ensemble of trees) on both scattered and internal fields. Furthermore, experimental configurations in an anechoic chamber are used to study the effects of branches and electromagnetic coupling between two vertical parallelepipeds. Finally, we compare the simulation results with anechoic chamber measurements.

6. REFERENCES

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