

## **Electromagnetic antenna measurements and simulations for dielectric properties studies of heterogeneous soil, with different moisture and salt gradient**

Undertaking the proposed research area will require of the PhD student:

- a) studies of literature in the subject,
- b) performing FEM, FDTD or MoM electromagnetic simulations for determining the spectrum of dielectric material under given levels of stratification of material parameters,
- c) writing appropriate procedures (post-processing) for analysis and processing of the results and their visualization,
- d) preparation of work documentation and description of dependence between degree of inhomogeneity and obtained dielectric permittivity spectrum,
- e) attempts to interpret the dependence that allow the prediction of the spectrum and their models for theoretical description

Research in dielectric properties of heterogeneous porous materials is currently an important fundamental science topic. The electromagnetic wave propagating in heterogeneous materials not only undergoes attenuation, but also reflects and changes direction of propagation. These phenomena occur when the geometric dimensions of the largest non-uniformity is greater than  $1/80$  of the wavelength in the medium. The degree of interaction with the material depends also on the difference of the absolute values of dielectric permittivity of the material at the point of non-uniformity, which in turn depends on the density and porosity of the material, the amount of liquid filling the pores and the degree of salinity. Dielectric properties of the material are described by various models that take into account the particle size fractions distribution, moisture, salinity, porosity or the surface area of the solid phase. These models do not fully take into account the effect of the geometry of existing heterogeneities. A certain volume of material composed of two layers with different dielectric properties will have dielectric spectrum completely different from the same volume made up of many smaller layers. That will be so even though the average porosity or the moisture content, which are input parameters to the dielectric models, will be the same in both cases. Electromagnetic simulations will enable predictions of the geometric size and the dielectric properties of a combination of two or more layers of material with different properties. Versatile application potential of the results includes analysis of the wave phenomena affecting the correct interpretation of satellite images, technology of building materials production, as well as food products processing, protecting the environment and medical applications.

Scientific supervisor: prof. dr hab. Wojciech Skierucha, assistant supervisor: dr Andrzej Wilczek

Requirements for candidates:

- master of Physics, Chemistry, Engineering or related,
- knowledge of English enabling reading of the specialized literature,
- knowledge of MS Excel and MS Word programs,
- knowledge of at least one programming language or at least one software packages from the list: Matlab, Statistica, OriginLab,

- self-reliance and commitment,
- basic knowledge of electromagnetic simulation programs (ANSYS, Keysight, etc.)