Dielectric properties of forest understory

A. S. Shcheglova, T. D. Kochetkova[*]

National Research Tomsk State University, 36 Lenin Prospekt, Tomsk, Russia, 634050

Climate changing and the exchange of carbon in the atmosphere have been an object of interest of scientists for many years. Ecosystems of forest and marsh complexes, particularly in Western Siberia, are a natural indicator of these processes. A study of the current state, mechanisms of their functioning and dynamics is a current task. The transformation of biota and subarctic landscapes, the state of permafrost as a result of climate changing in the current conditions and are of particular interest in the investigations. When continuous observations are conducted using the remote sensing technology the issues of developing data recovery algorithms and developing dielectric models of the studied surface are the tasks of high priority [1, 2]. It is necessary to take into account the vegetation cover for a more accurate data interpretation.

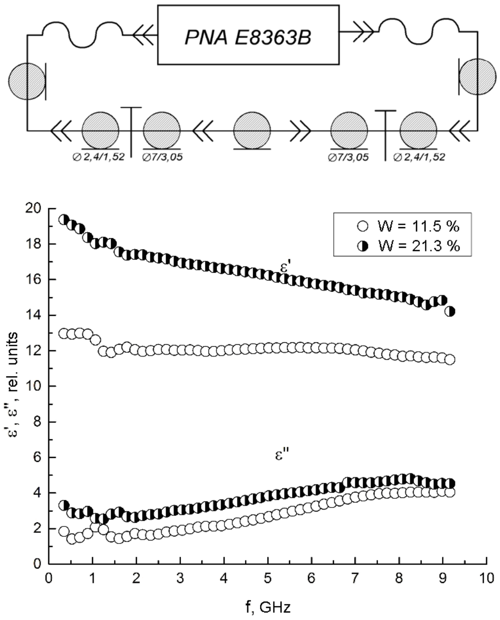
This task requires a detailed study of various types of vegetation, their dielectric properties and factors influencing the dielectric constant such as moisture, temperature and frequency of electromagnetic waves.

The present work is focused on the measurement of the dielectric properties of forest understory in the frequency range from 500 MHz to 18 GHz. The objects of this research were three species of forest understory – Pine, Cedar, Burch, Fur, Larche. The samples were collected in Tomsk region, Western Siberia, Russia. Green samples were measured at some values of moisture contents from 100% to 3–5 % during a natural drying. The measurements were performed at room temperatures within 22 ÷ 24 ° C.

We applied the measurement method based on a coaxial cell and used Agilent Technologies vector network analyzer E8363B. This method has been used successfully to measure the dielectric properties of soils [3, 4] and liquids [5]. The measurement scheme is shown in Fig. 1 (a). We used a coaxial section with different lengths (17 mm, 37 mm and 57 mm) for samples with different moisture.

The dielectric constant was calculated using the scattering matrix parameters of a four-pole network. The complex reflection coefficient (parameter S_{11} and S_{22}) and the complex transmission coefficient (parameter S_{12} and S_{21}) for a layered structure can be determined according to [6]. Dielectric constant and loss are a solution of the reverse task.

Figure 1 (b) shows the dependence of the complex dielectric constant on frequency for of pine forest understory.



(a) (b)

Fig. 1 (a) Scheme of the measurement setup. (b) The complex permittivity of the pine forest understory at the different moisture

The increase in the permittivity with increasing humidity is obvious. However, the rate of this increase is uneven. Interest is the change in the dependence of the permittivity on moisture content with the depth of the soil. The farther from the surface, the soil composition is more mineralized and contains less organic matter. This leads to the appearance of more precise boundaries for the transition of moisture in the soil to a less connected state. The results of this study will be used in the next phase – the development of a mathematical model of complex permittivity of organic soils and marsh plants in the observations of climate changing.

[1] A. Monsivais-Huertero et al., IEEE TGRS, 47(4), pp. 999-1011, 2009

[2] E. Mougin et al., J. of Hydrology, 375, pp. 14-33, 2009

[3] P. P. Bobrov et al., IEEE TGRS, 53, pp. 2366-2372, 2015

[4] M.I. Epov et al., Russian Geology and Geophysics, 50, pp. 470–474, 2009

[5] S. S. Milkin et al., The Russian journal of applied physics, 59 (1), pp. 119-123, 2014

[6] L. M. Brehovskih [Waves in Layer Media], Nauka, Moskow, pp.23-35, 1973

[*] Email: tdk_tomsk@mail2000.ru