Repeated electrical and GPR surveys for the monitoring of subsurface water content

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A subsurface hydrogeological environment can be surveyed widely by an electrical prospecting method because resistivity is a parameter sensitive to existence of water. On the other hand, the change of subsurface water content can be precisely detected by a ground penetrating radar (GPR), because subsurface electromagnetic wave velocity is governed by the dielectric constant that reflects water content. We carried out repeated electrical and GPR surveys in the KR-1 groundwater observation site, North-Kanto, Japan, where a 350 m-deep observation well and a 90-m pumping well were drilled. The purpose of these surveys is to establish the method that investigates the spatial temporal change of subsurface water content from temporal changes of resistivity structure and electromagnetic-wave velocity structure. In this site, the measurements of soil water content and temperature have been conducted every 10 minutes with the meteorological observation. The volumetric water content was measured with soil moisture meters at ten depths from 0.6 to 10 m. The temperature was measured with temperature meters at depths of 1, 3, 10 m.

In resistivity surveys, 25 electrodes were placed at 1 m intervals along a 24-m long line that crossed immediately near the soil moisture and temperature meters. Using dipole-dipole and Wenner electrode arrays, resistivity data have been collected for every month since August 2006. A 2-D resistivity section was obtained for each resistivity data set and the seasonal resistivity changes were recognized. The resistivity near the surface increased over 60 % from summer season to winter season. We compared the changes of resistivity sections with those of precipitation, volumetric water content, and soil temperature. It seems that the change of resistivity was most influenced by the change of soil temperature.

The first GPR measurement was carried out in February 2006 before the KR-1 well digging. The following surveys were conducted four times in December 2006, January 2007, February 2007 and July 2007. In these surveys, 3-D GPR data were acquired with a 350-MHz GPR system in the area of 16 m x 17 m around the soil moisture and temperature meters. 2-D GPR profile data for deep depth were collected with a continuous wave (5 to 150-MHz) GPR system along east-west 53-m long and north-south 55-m long lines. At several points, wide angle measurements were done to obtain the EM wave velocity. The changes of volumetric water content estimated from the GPR data. The values were consistent with those obtained from the moisture meters. We were able to detect the time-lapse electromagnetic-wave velocity structures which are considered to reflect the changes of water content.