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Evaluation of hydraulic and thermal properties of an Antarctic active layer: column experiments and numerical modeling

JEONGA KIM[1], SUNG-WOOK JEEN[1], HYOUN-TAE HWANG[2,3] AND JEONGHOON LEE[4]

[1]Jeonbuk National University
[2]Aquanty, Inc.
[3]University of Waterloo
[4]Ewha Womans University

Presenting Author: kja6208@naver.com

Groundwater in the polar region interacts closely with surface water and plays an important role in maintaining the surrounding ecosystems. In polar regions, groundwater flows are restricted in the active layer, a dynamic variably-saturated zone depending on temperature changes. In order to quantify the groundwater flow system in the polar region, it is important to estimate the hydraulic and thermal properties of the active layer. In this study, the hydraulic and thermal properties of the active layer in the Barton Peninsula, Antarctica were evaluated through laboratory column experiments and numerical modeling. Sediments from two lakes near King Sejong Station, which show differences in ecological and geological conditions, were collected and used for the experiments. The two soil samples were sieved to 2 mm and packed in cylindrical acrylic-columns with the same height of 52 cm. A total of five temperature and moisture sensors were installed into each column with an interval of 10 cm to measure the temperature and moisture content at each layer. Saturation-drain tests, permeameter tests, and freeze-thaw tests were performed to derive hydraulic parameters (i.e., K_s, θ_s, S_{wr}, α, β, and S_s) and thermal diffusivity (D). The parameters were estimated by inverse modeling with HydroGeoSphere (HGS), combined with Parameter ESTimation (PEST). Based on the analysis results, the saturated hydraulic conductivities (K_s) of the two Antarctic soils were dependent on the grain size distribution, and it affected the van Genutchen parameters α and β [1], which are essential parameters for quantifying the variably-saturated flow. The thermal diffusivities of the soil samples were 4.64 and 0.65 cm^2/min, and their differences were caused by differences in the lake environments such as organic matter contents and porosity. The results from this study can provide a basis for future studies regarding the surface water-groundwater interactions in Antarctica, which are affected by the freeze-thaw processes resulting from climate change.

[1] Van Genuchten (1980), *Soil Sci. Soc. Am. J.* 44, 892-898.