Numerical Assessment of Morphological and Hydraulic Properties of Moss, Lichen and Peat from a Permafrost Peatland

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Abstract

The hydraulic properties of ground vegetation cover are important for high resolution hydrological modeling of permafrost regions, due to its insulating and draining role. In this study, the morphological and effective hydraulic properties of Western Siberian Lowland ground vegetation samples (lichens, *Sphagnum* mosses, peat) are numerically assessed based on tomography scans. After numerical pre-processing, porosity is estimated through a void voxels counting algorithm, showing the existence of representative elementary volumes (REV) of porosity for most samples. Then, two methods are used to estimate hydraulic conductivity depending on the sample's homogeneity. For the most homogeneous samples, Direct Numerical Simulations (DNS) of a single-phase flow are performed, leading to a definition of hydraulic conductivity related to REV, which is larger than those obtained for porosity. For more heterogeneous samples, no adequate REV may be defined. To bypass this issue, a pore network representation of the whole sample is created from computerized scans. Morphological and hydraulic properties are then estimated through this simplified representation. Both methods converged on similar results for porosity. Some discrepancies are observed in the morphological properties (specific surface area). Hydraulic conductivity fluctuates by two orders of magnitude, depending on the method used, and yet this uncertainty is less than that found in experimental studies. Therefore, biological and sampling artifacts are predominant over numerical biases. Porosity values are in line with previous values found in the literature, showing that arctic cryptogamic cover can be considered as an open and well-connected porous medium (over 99% of overall porosity is open porosity). Meanwhile, digitally estimated hydraulic conductivity is higher compared to previously obtained results based on field and laboratory experiments. This could be related to compressibility effects, occurring during field or laboratory measurements. Thus, some supplementary studies are compulsory for assessing syn-sampling and syn-measurement perturbations in experimentally estimated, effective hydraulic properties of such a biological porous medium.

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