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Physical and Hydraulic Properties of Peat Soil Using X-ray Computed Tomography and Image Analysis

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Flow and transport within porous media are governed by their pore structure. This is true at a small scale of single pores but also at a larger scale where the structure of continuous field of hydraulic properties such as the hydraulic conductivity becomes relevant. The hydraulic conductivity is an essential parameter for understanding the behavior and future development of northern peatlands. Much of the permafrost terrain in the northern hemisphere is mantled by sphagnum-peat. Understanding the processes by which this material conducts, retains and redistributes moisture and energy is crucial to the physically-based methods of predicting the hydrological response of this vast region to continued climate warming. In this research, physical properties of the peat samples were measured from X-ray Computed Tomography (CT). Tomographic images of the samples were obtained at 5 levels between -2 cm and -40 cm soil tensions. Up to 876 2D X-ray images were taken with a diameter of 60 mm and length of 40 mm. At each of these levels, volumetric soil moisture and hydraulic conductivity were measured, and CT imagery was obtained. Combining the information generated by multiple 2D images produced a 3D image of attenuation. Properties of the pore spaces and solid elements were measured in both two and three dimensions. The 2D analysis suggests a relatively gradual transition from small to large pores; while in 3D, the distribution is dominated by a single large pore-space, whose volume and surface area is 3-orders of magnitude larger than the next largest pore, and >99% of the total inter-particle pore volume. This single, large pore space contains the Inter-particle Flowpath Network (IFN). This study elucidated the volume and configuration of the IFN for discrete ranges of soil tension that typically occur in the field.