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A coupled model for liquid water-vapor-heat migration in freezing soils

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ABSTRACT

Based on the seepage theory in unsaturated soil mechanics, a coupled model for liquid water-vapor-heat migration is established in this paper, which considers the phase changes of vapor-liquid and water-ice. The results of numerical analysis on layered unsaturated soils show that vapor migration can lead to a significant increase in the total volumetric water content. The depth of the maximum value of the total volumetric water content coincides with the depth of the freezing front (273.15K temperature line). Ground water table has a small effect on the total volumetric water content in silt. However, unfrozen water in the upper sand flows downward from the sand to the silt soil, due to gravitational and matric potentials. A lower temperature of the upper boundary can also lead to an apparent increase in the total volumetric water content. If the temperature of the upper boundary is above 273.15K, the effect of vapor migration on the soil column is small, producing only a 2% increase in the total volumetric water content.