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Physics-informed Neural Networks for Inferring Hydraulic Properties from Field Soil Water Content Measurements

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Soil hydraulic properties, including the water retention curve (WRC) and hydraulic conductivity function (HCF), are crucial for accurately simulating hydrological processes in soils. These properties are highly variable and nonlinear, making them challenging to parameterize, particularly at field scales. This study introduces a novel physics-informed neural network (PINN) approach with constraints of Richards equation to estimate these constitutive relationships, conditioned on field soil moisture measurements in a semi-arid study area. The PINN comprises three interconnected networks: soil moisture over space and time, WRC and HCF networks. Given the high non-linearity of the soil hydraulic functions, we adopted an alternating training strategy, with an outer loop to filter the observation dataset and train the networks for the observation variable and an inner loop to train the WRC and HCF networks through the constraints of Richards equation. This two-step alternating training approach (with different loss functions) obtains reasonable observation networks, and since then it strengthens the possibility and the efficiency to learn the constitutive relations.