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Infiltration experiments with ultra-high spatial and temporal resolution of saturation measurements

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Near surface hydrological processes whereby moisture exchange occurs between the vadose zone and above-ground weather systems occur on daily, seasonal, and long-term cycles. Well-controlled laboratory studies of near surface moisture migration are often limited due to number of measurement points of moisture content and pore pressure. This presentation will describe experimental and digital image analysis techniques incorporating a refractive index matched soil-pore fluid combination that increase spatial resolution of saturation measurements by over 6 orders of magnitude. The refractive index matched material changes color from black (Saturation=1) to white (Saturation=0) allowing for saturation measurements at the digital pixel scale. This visualization technique allows for direct observation of flow effects which affect boundary measurements and local flow mechanisms. The capabilities of unsaturated transparent soil are incorporated in a 2D infiltration apparatus to examine the influence of confined air on infiltration. 2D experiments agree with previous column infiltration results showing air confinement decreases infiltration rate by more than one half. The 2D apparatus allows a clear unstable wetting front to develop, visualization of dynamic moisture migration within the transmission zone. In addition, the high spatial resolution saturation measurements show detectable influence of thin heterogeneities on wetting front migration and the influence of flow direction on saturation distribution. The high-resolution saturation measurements will allow for calibration of computational models multi-phase flow and open up new insight into near surface processes to improve water balance calculations and soil-structure-climate interactions.