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Using superconducting gravimeters as an infiltrometer

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Infiltration tests provide useful information to characterize potential recharge sites, parameterize rainfall-runoff models, and to "close the water balance" in groundwater flow models by directly measuring recharge rates. Typical infiltrometers—ring infiltrometers and tension infiltrometers that sit on the land surface, borehole permeameters, and others—sample only a relatively small area, and as spatial heterogeneity increases, so too does the number of measurements required. As an alternative, precise measurements of the time-varying gravitational field provide a direct, non-invasive, spatially-averaged measurement of infiltrated water. Unlike other methods, gravimeters are sensitive both to shallow infiltration close to the instrument and large changes far from the instrument. Using field experiments, the same gravimeter is demonstrated to accurately measure (a) water content changes of a few percent in the upper centimeters of the soil profile, and (b) infiltration rates of 20,000 cubic meters per day, to depths of tens of meters, at an artificial recharge facility. In both cases, gravity data are used to identify important parameters in one- and two-dimensional unsaturated-zone flow models.