



How representative are point soil moisture measurements?

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Spatially representative soil moisture is needed to understand land-atmosphere coupling, evapotranspiration, runoff and floods, precipitation, ecosystem and nutrient dynamics, and droughts. But assessments of area-average soil moisture are fraught with difficulties that are due to the combination of limited applicability of measurement methods and the innate spatial variability, at various scales, of soil properties, land-surface characteristics and hydroclimatic factors. Because soil moisture is difficult to measure over area, point measurements have been widely used instead. A fundamental and practical question is: how representative are point measurements of soil moisture? Many previous field studies that assessed variability used indirect methods and a small number of usually depth-integrated samples. We made soil moisture measurements on thousands of samples collected from tens of sites with multiple 30-cm deep moisture profiles obtained within an area 400 m in diameter at each site. Within each area soil moisture is highly variable, with the ratio of highest to lowest value ranging between 1.8 and 12, and the ratio of profile averages ranging from 1.2 to 4.1. The shapes of the profiles are inconsistent, too: within the same site soil moisture profiles show decreasing trends with depth, or increasing, or are flat or irregular. The absence of obvious pattern, combined with the observed large spatial variability, suggests that single measurements at a point are not representative of the surrounding area. To assess the importance of the local variability, we compared the variances computed for each of the 400-m areas with the total variance for all data from all sites. The variance at the 400-m scale makes up on average 40% and as much as 85% of the variance at the continental scale. This result shows that point measurements of soil moisture are unreliable as a measure of soil moisture at any spatial scale.

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