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Analysis of water application efficiency and emission uniformity of drip irrigation systems based on space-time analysis of soil moisture patterns in soils

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In order to evaluate how efficiently and uniformly drip irrigation systems can deliver water to emitters distributed around a field, we need some methods for measuring/calculating water application efficiency (WAE) and emission uniformity (EU). In general, the calculation of the WAE and of other efficiency indices requires the measurement of the water stored in the root zone. Measuring water storage in soils allows directly saying how much water a given location of the field retains having received a given amount of irrigation water. And yet, due to the difficulties of measuring water content variability under an irrigation system at field scale, it is quite common using EU as a proxy indicator of the irrigation performance. This implicitly means assuming that the uniformity of water application is immediately reflected in an uniformity of water stored in the root zone. In other words, that if a site receive more water it will store more water.
Nevertheless, due to the heterogeneity of soil hydrological properties the same EU may correspond to very different distributions of water stored in the soil root zone.
1) In the case of isolated drippers, the storages measured in the soil root zone layer shortly after an irrigation event may be or not different from the water height applied at the surface depending on the vertical/horizontal development of the wetted bulbs. Specifically, in the case of dominant horizontal spreading the water storage is expected to reflect the distribution of water applied at the surface. To the contrary, in the case of relatively significant vertical spreading, deep percolation fluxes (fluxes leaving the root zone) may well induce water storages in the root zone significantly different from the water applied at the surface. 2) The drippers and laterals are close enough that the wetted bulbs below adjacent drippers may interact. In this case, lateral fluxes in the soil may well induce water storages in the root zone which may be significantly uncorrelated with the uniformity of the water applied at the surface.
In both the cases, the size of lateral fluxes compared to the vertical ones throughout the rooting zone depends, besides the soil hydraulic properties, on the amount of water delivered to the soil. Larger water applications produce greater spreading, but in both the horizontal and vertical directions. Increased vertical spreading may be undesirable because water moving below the active root zone can result in wasted water, loss of nutrients, and groundwater pollution.