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Using empirical orthogonal functions to interpret the spatiotemporal variability of crop yields in presence of shallow restrictive soil layer

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Shallow restrictive soil layer may enhance plant growth and development in dry years due to the creation of subsurface-minipond-like water storages in dry years and may hamper plant development in wet years due to overwetting. These effects may manifest itself differently under different nutrient management. The objective of this work was to see there exist spatial patterns that are temporally stable (do not change over several years), can explain substantial proportions of spatiotemporal variation of maize yield, and can be related to subsurface restrictive layer topography and fertilizer application. Empirical orthogonal functions (EOFs) were good candidates to express such patterns. Data were collected with yield monitors across maize fields with manure applications, uniform chemical fertilization, and precision farming-based chemical fertilizer application over the six-year period. The subsurface restrictive layer was found at depths from one to three meters using the ground penetration radar. Three EOFs explained around 60, 30 and 10 % of interannual yield variation, respectively. As evidenced by semivariograms, the spatial structure was well pronounced in EOFs at the manured field and to a lesser extent at the chemical fertilizer fields. Little difference was observed in cumulative probability distributions of the first EOF across fields with different fertilizer applications. The topography of the restrictive layer was analyzed to determine the subsurface preferential flow lateral flow pathways that could provide water accumulation in dry years and enhanced drainage in wet years. The first EOF on average increased as the distance to the subsurface flow pathways decreased both at the manure and uniform chemical fertilized field, but not at the precision fertilization field where unfavorable water availability conditions could be compensated by the improved fertilizer availability. Differences in the soil surface topography could be reflected by the second EOF. Overall, the temporal stability in crop yields reveals the topography of the shallow vadose zone boundary as the powerful control of yield variation in space and time.