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Spatiotemporal evolution of water content at the rainfall-event scale under soil surface sealing conditions

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Surface water content dynamics rules the partitioning between infiltration, runoff, and evaporation fluxes. Extending the knowledge on factors controlling top-soil water content temporal stability (TS) is needed to calibrate and validate various remote sensing technologies. Spatiotemporal evolution of water content is highly non-linear, being affected by various factors at different spatial and temporal scales. In semi-arid climates, this evolution is significantly affected by the formation of surface seals, shown in previous studies to significantly reduce both infiltration and evaporation fluxes from the soil. The drying regime in a natural sealed soil system exerts a sharp contrast in the soil profile - a very dry seal is superimposed on top of a wetter soil layer. One question is thus, whether seal layers contribute to or destroy temporal stability of top soil water content at the hillslope scale. To address this question, a typical hillslope (0.115 km^2) was chosen at the LTER Lehavim site in the south of Israel (31020' N, 34045' E) offering different aspects and a classic geomorphologic banding. The annual rainfall is 297 mm, the soils are brown lithosols and arid brown loess and the dominant rock formations are Eocenean limestone and chalk with patches of calcrete. The vegetation is characterised by scattered dwarf shrubs (dominant species Sarcopoterium spinosum) and patches of herbaceous vegetation, mostly annuals, are spread between rocks and dwarf shrubs. An extensive spatial database of soil hydraulic and environmental parameters (e.g. slope, radiation, bulk density) was measured in the field and interpolated to continuous maps using geostatistical techniques and physically based modelling. To explore the effect of soil surface sealing, Mualem and Assouline [1989] model describing the change in hydraulic parameters resulting from soil seal formation were applied. This spatio-temporal database was used to characterise 8240 spatial cells (3X3m2) serving as an input to a numeric model (Hydrus1D) solving the flow equations to predict soil water content at all temporal scales. Following intense verification and accounting for spatial autocorrelation effects, the model was used to track down explicitly the evolution of top soil TS during different climatic scenarios. The results indicate no significant difference in the first 48 hours following precipitation event as water redistribution occurs at the soil. However, once the soil enters longer drying periods, the seal layer reduces water content variability and improves its temporal stability, an effect augmented with time. Stepwise regressions found this process to be shaped by slope aspect at the first few days of drying, replaced in following days by soil depth and porosity. Prior knowledge regarding improved TS locations in a sealed soil system can be used to design more efficient remote sensing experiments in dryland areas.