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Spatial and temporal soil water variability in the plowing horizon of agriculturally used soils in two regions of Southwest Germany

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Soil water dynamics plays an important role in soil-plant-atmosphere interactions. There is a lack of long-term continuous measurements of topsoil water content at the regional scale. The objective of the present study was to quantify and elucidate the seasonal dynamics of spatial soil water content variability in the plowing horizon (Ap) of agricultural soils at the regional scale. The study was conducted in the central part of the Kraichgau and the Mid Swabian Alb in Southwest Germany. In each region a soil water network embracing 21 stations was set up. All stations were installed on cropped agricultural sites and distributed across three spatial domains: an inner domain 3 km $\times$ 3 km (5 stations), a middle 9 km $\times$ 9 km (8 stations), and an outer domain 27 km $\times$ 27 km (8 stations). Each station consists of a TDT sensor (SI.99 Aquaflex Soil Moisture Sensor, Streat Instruments Ltd, New Zealand), which senses both soil water content and soil temperature, a rain gauge, and a remote transfer unit (RTU, datalogger + GSM modem), which stores and transfers data via GPRS modem to the central data server (Adcon Telemetry GmbH, Austria) located at the University of Hohenheim. The TDT sensors were installed at 0.15 m depth. A sensor consists of a three meter long and three centimeter wide flat transmission line. The relationship between the standard deviation (σ_θ) of the soil water content (SWC) and mean spatial soil water content ($\langle\theta\rangle$) formed combinations of concave and convex hyperbolas. However, it strongly depended on SWC state and season. Generally, σ_θ was found to be changing along a convex trend during dry out and rewetting phases with a maximum in the intermediate SWC range. At the rain event scale, $\sigma_\theta(\langle\theta\rangle)$ was either ascending or converging with decreasing $\langle\theta\rangle$. A concave shape was observed when $\langle\theta\rangle$ approached to dry state. The majority of $\sigma_\theta(\langle\theta\rangle)$ hysteresis loops were observed in intermediate and intermediate/wet state of SWC. All hysteretic loops were clockwise oriented. Rainfall intensity and distribution were identified as main factors driving SWC variability at the regional scale.