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Combining a time-varying dynamic linear model (DLM) with a Kalman filter to predict pore water electrical conductivity in a sandy soil using TDR data

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Within a lab study, two lysimeter columns were packed in 11 layers with a thickness of 5cm and a density of 1.4 g/cm3. As substrate we used a sand with >80% of fine sand. The lower boundary was set under a constant pressure head of -30hPa. TDR probes, temperature probes and suction cups were installed at different depths (7, 21, 35 and 48 cm). An irrigation head was used and placed 5cm above the soil surface, water was dropping through small nozzles. In total, five irrigation events have been carried out during the study. As a result, we got time series data of soil dielectric constant (εb), bulk electrical conductivity (σb), electrical conductivity of soil pore water (σp) (obtained by suction cups), and temperature (C°). These measurements were taken each 5 minutes except for σp, which has been taken after each irrigation event.
Applying the deterministic Hilhorst (2000) model to convert σb into σp is not valid since the linear relationship between εb - σb data obtained from TDR probes resulted in strong autocorrelation between residuals of the regression. By modifying the Hilhorst model to stochastic model using time-varying dynamic linear model (DLM), and a Kalman filter, it enabled us (i) to evaluate the linear relationship between εb $\sim$ σb and (ii) to estimate precisely the electrical conductivity of soil pore water (σp), As a result, we build a valid relation between εb $\sim$ σb and could estimate precisely σp over time from the stochastic model. The means of estimated σp agree reasonably well with σp obtained from suction cups. However, even our study was done in homogenous soil, the offset values for the modified Hilhorst model varies for each depth. Changes in soil temperature along the soil column could be the reason.