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Evaluation of the capacitance-based low cost soil moisture sensor Decagon 10HS: Implications for soil moisture monitoring and related hydrological applications

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Soil moisture is an important component of the hydrological and climate system. It reflects precipitation and radiation anomalies, and directly impacts the partitioning of water and energy fluxes at the land surface. However observations of soil moisture and evapotranspiration, necessary to study land surface-atmosphere interactions, are scarce. Within the Swiss Soil Moisture EXperiment (SwissSMEX, http://www.iac.ethz.ch/url/research/SwissSMEX) an observational network of 13 stations for soil moisture measurements in Switzerland was established in 2008/09. Information about soil texture and vegetation is available at each station. Profile measurements of soil moisture down to 120 cm have been established. With a coverage down to 120 cm, not only the land surface-atmosphere interactions but also root water uptake and surface-subsurface interactions of soil moisture can be determined. Consequently, a better understanding and prediction of processes and their interactions in the land-atmosphere system is expected. To increase the on-site instrumentation and the density of the soil moisture network, a low cost sensor based on the capacitance technique was selected, beside reference measurements with the Time Domain Reflectometry (TDR) technique. These sensors are known to be less accurate but are significantly cheaper (factor 10) than the highly accurate TDR sensors. For this reason, several networks have been established using capacitance-based sensors to monitor soil moisture. For the SwissSMEX stations the low cost soil moisture sensor 10HS (Decagon Devices Inc., Pullman WA, USA) was installed at 6 levels from 5 cm down to 120 cm. The high accuracy TDR sensors TRIME-EZ and TRIME-IT (IMKO GmbH, Ettlingen, Germany) were installed in parallel to the 10HS sensor in two different depths at all sites, and over whole profiles at two sites.
We present here the evaluation of the 10HS sensor in the framework of the SwissSMEX campaign, based on laboratory measurements as well as in-situ measurements from the two sites with whole TDR profiles. These measurements are used to derive error estimates for the capacitance sensors, and illustrate possible issues with the interpretation of field measurements performed with these instruments. We find that associated errors can be significant for some soil moisture regimes (especially wet conditions) and thus need to be taken into account for the validation of hydrological, land surface and climate models, as well as for the assimilation of soil moisture observations.