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High frequency space and time temperature observations for the monitoring of soil water content in a clay-rich subsoil

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The tracing of water infiltration and the monitoring of soil water content at high spatial and temporal frequency in the vadose zone is a key element of various hydrological, agronomical, ecological and environmental studies. In this work, we evaluate the ability of soil temperature monitoring for the quantification of soil water content changes for a heterogeneous clay-rich soil. A Distributed Temperature Sensing system (AP Sensing) constituted of a datalogger, 250 m of reinforced fiber optic cable buried at 0.1, 0.2 and 0.3 m of depth and at the soil surface along a 60 m profile is used. The monitoring site is the Draix-Bleone catchment in the South French Alps, mainly composed of weathered clay-shales. The monitoring profile crosses three different soil units consisting of argillaceous weathered black marls, silty colluvium under grass and silty colluvium under forest. Soil temperature is measured every 6 minutes at a spatial resolution of 0.5 m. We show that the spatial and temporal variation, although first linked to the air temperature variations are related at the second order to the occurrence of rainfall events. The spatial and temporal evolution of the temperature in the subsoil is governed by the heat equation which involve soil thermal properties (such as thermal diffusivity). These properties are themselves affected by the soil water content. The processing of the temperature data therefore consists in inverting the soil water content that impacts the soil thermal properties such as the temperature computed from the heat equation fit the measured data. The changes of soil temperature and soil water content for the three units are compared for a period of four months. They indicate different processes of water infiltration at different velocities in relation to the presence of roots and the soil permeability. This indirect measurement technique is promising for the future; some limitations in the measurements are also discussed.