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Monitoring of water and heat transfer in the vadose zone of a carbonate reservoir formation (Upper Oligocene of Aquitaine Basin, France)

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The study of the temporal and spatial evolution of the water content and the thermal signal in porous materials as rainwater passes through the vadose zone is of scientific interest. In fact, the water flow and contaminant transport through the vadose zone show an increased attention, for instance in waste disposal in porous medium, for the retention of pollutants within the pore space of rock masses in the near surface, for the CO2 migration in the near surface. It is also important in characterizing and predicting hydrological processes in the unsaturated zone. On the other hand, many authors use temperature monitoring in order to evaluate the recharge in unsaturated soils. Vertical water seepage in the vadose zone results in a convective heat transport that modifies the temperature profile and its variations with time.

This paper studied the water and heat transfer in the vadose zone of a carbonate reservoir formation during three hydrological cycles (August 2001–May 2004). The application of the TDR method to determine the water content of the porous rock was used to monitor the water transfer. More than 285 measurements of rock water content during three hydrological cycles distributed throughout the quarry show a permanently undersaturated limestone (between 35% and 50%). Three periods of maximum water content correspond to three effective rainfall maxima but with a time-lag. The results showed that the time for water transfer was long, about 6 months. The phase lag and amplitude damping of the hydraulic and thermal signal with depth have been modelled taking into account the measured physical properties of the porous medium. The comparison between the predicted and measured hydraulic transfer time is good; however, the comparison between the predicted and measured thermal transfer time shows a discrepancy, most likely due to air circulation between the outside (atmosphere) and inside of the quarry and a rapid reequilibration of the temperature in the vadose zone with that of the air. The predicted water transfer time in the vadose zone (4.5– 7 months) is equal to the predicted thermal transfer time (4.5–4.6). This good agreement is consistent with the results of many authors.