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Use of Fiber-Optic Distributed Temperature Sensing for the characterization of groundwater flow and heat transport in fractured rocks

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Through different field applications, we show how fully distributed space - time measurements with Fiber-Optic Distributed Temperature Sensing (FO-DTS) can be used to investigate groundwater flow and heat transport in fractured media.

First of all, heat injection experiments can be combined with temperature measurements along fiber optic cables installed in boreholes. Such thermal dilution tests are shown to enable detection of cross flowing fractures and quantification of the cross flow rate. A cross borehole thermal tracer test is then analyzed to identify fracture zones that are in hydraulic connection between boreholes and to estimate spatially distributed temperature breakthrough in each fracture zone. This provides a significant improvement compared to classical tracer tests, for which concentration data are usually integrated over the whole abstraction borehole. It allows to estimate rapidly the contribution of the different fractures to heat transport. Finally, we show how a distributed borehole flowmeter can be created from Fiber Optic cables with the Active-Distributed Temperature Sensing (A-DTS) method. The principle is that the temperature of a heated cable, submerged in a flowing fluid, is a function of the fluid velocity. Compare to classical flowmeters, the great advantage of the method is to provide, for a given time, flow measurements all along the borehole depth and not at a single position. Combining these possible applications are making the FO-DTS an innovative and very useful tool for the characterization of subsurface flow and heat transport.