Continuous vertical groundwater flux profiles with aFO-DTS experiments in a heterogeneous granular aquifer

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Résumé

The development of fiber optic (FO) Distributed Temperature Sensing (DTS) as a tool for hydrogeological measurements with high spatial and temporal resolution has shown potential for characterizing aquifer heterogeneity, which remains a challenge and is needed to predict contaminant transport. Recent studies have shown that groundwater fluxes can be quantified along a vertical profile in granular aquifers by inverting the thermal responses from active heat tracer tests using FO cables. We further investigated active FO-DTS methods and the resulting high-resolution profiles for granular aquifer characterization. Fluxes from aFO-DTS experiments were compared with collocated cone penetration tests (CPT), which provide indications of hydrofacies and permeability. Tests were carried out in a well-studied heterogeneous deltaic aquifer located north of Quebec City, Canada.
Four active FO-DTS heat tracer experiments were conducted by deploying FO cables by direct push at the identical locations were a CPT profile had been previously measured. Interpretation of thermal responses from the aFO-DTS experiments was done with analytical solutions for heat transport, providing independent and accurate estimates of thermal properties and fluxes every 25 centimeters. The interpreted vertical profiles of fluxes span almost an order of magnitude and correlate well with the CPT responses.
Active FO-DTS experiments can thus provide a qualitative or quantitative proxy for hydraulic conductivity and allow the recognition of hydrofacies at a metric vertical scale. At the aquifer scale, the total flux estimated from FO-DTS measurements can also be compared and used as constraints for fluxes obtained from a numerical model. Overall, this study shows that not only does FO-DTS provide coherent results with other characterization methods, but it also adds the key measurement of groundwater flux with great accuracy that cannot be easily obtained by other means. FO-DTS has thus the potential to become a significant addition to existing characterization methods for granular aquifers.

Mots-Clés: groundwater flux, granular aquifer, fiber optics, distributed temperature sensing, direct push, cone penetration tests

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