Heat Dissipation Test with Fiber-Optic Distributed Temperature Sensing to estimate groundwater fluxes in an unconsolidated coastal aquifer

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ABSTRACT

Direct measurement of groundwater flux is desirable for the quantitative and qualitative monitoring of coastal aquifers, for understanding processes at the fresh-salt water interface and for estimating submarine groundwater discharge. Traditionally, hydraulic conductivity was measured in order to estimate flow rates. Instead, this research propose a new methodology to directly quantify groundwater flux in coastal aquifers, by using high temporal and spatial resolution Fibre-Optic Distributed Temperature sensing (FO-DTS). The method will be able to provide distributed groundwater fluxes.

A Heat Dissipation Test was conducted in the Argentona site (Spain). The system consists of a pumping well and an observation well, both located 70 meters away from the coast line. The armoured FO cable was installed in both wells outside the well casing. The pumping well was pumping for two days with a constant flow rate. The cable at the observation well, located 2 m from the pumping well, was heated for 41 hours. The obtained heating response at the observation well was used to validate the method.

In this study we show the preliminary results in which heat dissipation is governed by thermal advection and conduction. Thermal advection is driven by groundwater flow, a variable that changes in time and space. On the contrary, thermal conduction is controlled by thermal conductivity, a well-known and constant parameter. An Infinite Line Source heat transport analytical model is used to estimate saturated soil thermal conductivity and groundwater fluxes. During the first minutes of the test, temperature rises considerably due to the low thermal conductivity of the cable materials, leading to a skin effect analogous to that of well hydraulics, which needs to be acknowledged during interpretation of the heating test. The resulting groundwater fluxes are validated with velocity estimated with pumping test data.

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