Using fibre optic cable to measure groundwater temperature

National Centre for Groundwater Research and Training

This resource introduces a new method for exploring the movement of water through a river or stream bed, down into the soil below. The method uses lengths of fibre optic cable to measure the movement of water via temperature measurements beneath ground. This document is designed for a non-technical audience.

THE PROBLEM OF DATA

One of the problems in groundwater research is data collection. By its very nature, groundwater is hidden underground, and difficult to explore.

Moreover, the subsurface is extremely complicated and varied, meaning that even if you can gather information on the groundwater in one spot, things might be very different a few metres away.

Groundwater is most commonly studied either at very fine scales (for example, the data from a bore), or on really large scales (for example an entire catchment).

NCGRT researchers were interested in applying a new technique to learn about groundwater on a medium scale. Researchers used temperature to explore the soil variability below a large open irrigation channel in the South East of South Australia.

Temperature is a widely used ‘environmental tracer’. Because groundwater temperature typically remains stable, whereas surface-water temperature changes throughout the day with the heat of the sun, changes in the temperature of water just beneath a stream can be used to determine how quickly water is moving from the surface into the ground.

This particular method uses fibre optic cable as a giant thermometer to measure the temperature below ground. It takes advantage of the ability of fibre optic cable to measure lots of points, and its use below ground is a new application.

The cable used is the same fibre optic cable used for telephone lines. Once installed, a laser beam can be sent through the cable. Measuring the backscatter (the reflection of light back to its source) can tell you the temperature in the cable along every metre of the cable at up to 30 second intervals.

TRYING OUT A NEW METHOD

The experiment took place in an open channel designed to bring water back into the Coorong, a national park and lagoon ecosystem adjoining the Murray Mouth, where the Murray River flows out to sea.

The impacts of prolonged drought and water over-allocation across the Murray–Darling Basin have meant that the Coorong is close to environmental collapse, and significant restoration works are underway.

Over 1000 metres of fibre optic cable were laid beneath the dry channel. Cable was laid at three different depths, and across five different transects of the channel. This made a 20 x 20 metre plot of approximately half a metre deep.

Having completed the system installation, and after waiting for the channel to fill with water, researchers were able to download the data, and build it into a groundwater model (or simulation) of the area. Using this flow and transport model, researchers could measure temperatures in real time,

Want to know more?

This project was led by Dr Margaret Shanafield, who can be contacted via email (margaret.shanafield@flinders.edu.au) for more information. A journal paper on the project is forthcoming.

In the meantime, for more information on the NCGRT’s research, visit www.groundwater.com.au backsolving to determine water movement through any point in the model.

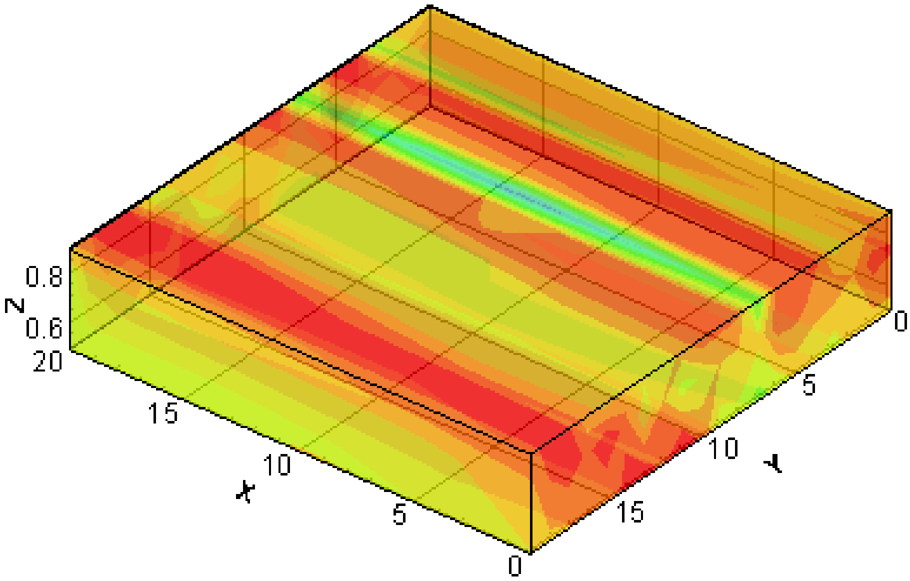
This allowed them a close look at the way in which water filters through the streambed, and at the detail of heterogeneity of the subsurface.

DATA ON A MEDIUM SCALE

With the data collected (over 300 profiles of temperature, and over 600 points of measurement over time) researchers have been modelling the research site in both 1D and 3D to explore the heterogeneity that's in the streambed, and to consider how much of that detail is needed to really understand the surface water – groundwater system.

This project has shown that using fibre optic cable in the manner described, particularly to explore the infiltration of water through the bed of a surface-water body, can be a useful technique. In particular, it may be a good choice if a medium level of detail is required.

However, the project has thrown up a series of challenges at the modelling stage – having a large amount of temperature data over a small area of land requires a detailed understanding of additional data to accurately calibrate the model.



The image above is an output from the model, showing the actual temperature beneath the channel while there was water above.

The same area was measured separately for infiltration using a different technique, and this has allowed a useful comparison of the benefits of different methods.

This method has the advantages that temperature is relatively simple to measure, that you get the data quickly, that you can take measurements quite frequently, and that once the equipment is installed, it's easy to return for more data.

In particular, this technique could be useful if you needed to find out where a particular organism could live (as the filtering of water through riverbed sediments is hugely important for fish spawning and as an environment for other organisms).

It might also be applicable if trying to work out the pathway that a contaminant might take through the streambed into an aquifer.

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