Media release

Coming to grips with uncertainty in groundwater measurement

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Swiss born Dr Gregoire Mariethoz from the University of New South Wales has recently been promoted to chief investigator in Program 1, in recognition of his contributions to aquifer characterisation using stochastic methods, that is, modelling randomness and uncertainty to improve our understanding of the real world and its complexity.

The advances of Gregoire's group provide yet another example of the fundamental research conducted at the NCGRT, and the centre's success in bolstering Australia's research capability by attracting international talent and securing highly competitive grants.

Gregoire summarises an essential problem in his field. 'When you want to study a natural process, you take measurements at different locations and depending on the spacing of your measurements you have a more or less good picture of what you are trying to study. However, you always have the problem of not knowing what's happening between the measurements. This is the case no matter how close your measurements are.'

The problem of having less data than you would like is common in groundwater studies. 'Typically, you have very few boreholes where you can measure the water table,' Gregoire says. 'They are far apart and drilling new ones is very expensive. Methods that help us understand what may happen in between are particularly important.'

'There are two aspects to this problem. The first is to come up with a prediction at a location that was not measured. For example when deciding the position of a new well, one wants to predict the amount of water that is likely to be extracted from this well', he explains. 'The second part of the problem is to understand that any prediction is to some degree uncertain, and so we want methods to quantify this uncertainty.'

Gregoire notes that the uncertainty he grapples with comes in a variety of forms. 'Predictive uncertainty depends on the nature, spacing and density of measurements, but it also depends on the complexity of the system. For example if you take temperature measurements a few kilometers apart around a city, you have a pretty good picture of the warmer and colder areas, because temperature tends to change quite smoothly. Groundwater levels and water chemistry do not vary so smoothly. Because of the heterogeneous nature of the subsurface, there are sudden changes that are difficult to capture. This can dramatically increase the uncertainty of the predictions, or in some cases make predictions impossible.'

What Gregoire wants to know, therefore, is given a reasonable set of measurements, what system complexity can be resolved, and what can never be resolved? To help answer this question, Gregoire's team has won funding to build an artificial aquifer.

Measuring heterogeneity in an artificially created aquifer can help us understand the bigger picture. 'In many groundwater studies, measurements are taken at wells or bores to understand flow and contaminant migration processes. However, it is very difficult to tell whether our predictions are correct because it would require dissecting the aquifer entirely, or putting bores everywhere, which is not possible,' Gregoire says. 'The aim of this project is to build an aquifer ourselves, such that we know exactly what happens everywhere. Then we will be able to test the added value of the information that can be gathered with usual field methods. There may be cases where accurate predictions are possible, and others there the system is just too complex. We have to be able distinguish between these possible situations.'

Combining mathematical theory and lab data has matured Gregoire's work into a set of methods for characterising subsurface groundwater systems. These make an important contribution to the understanding of uncertainty associated with predictions.

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