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Smart Aquifer Characterisation validated using Information Theory and Cost benefit analysis

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The field data acquisition required to characterise aquifer systems are time consuming and expensive. Decisions regarding field testing, the type of field measurements to make and the spatial and temporal resolution of measurements have significant cost repercussions and impact the accuracy of various predictive simulations. The Smart Aquifer Characterisation (SAC) research programme (New Zealand (NZ)) addresses this issue by assembling and validating a suite of innovative methods for characterising groundwater systems at the large, regional and national scales. The primary outcome is a suite of cost effective tools and procedures provided to resource managers to advance the understanding and management of groundwater systems and thereby assist decision makers and communities in the management of their groundwater resources, including the setting of land use limits that protect fresh water flows and quality and the ecosystems dependent on that fresh water.

The programme has focused novel investigation approaches including the use of geophysics, satellite remote sensing, temperature sensing and age dating. The SMART (Save Money And Reduce Time) aspect of the programme emphasises techniques that use these passive cost effective data sources to characterise groundwater systems at both the aquifer and the national scale by:

• Determination of aquifer hydraulic properties
• Determination of aquifer dimensions
• Quantification of fluxes between ground waters and surface water
• Groundwater age dating

These methods allow either a lower cost method for estimating these properties and fluxes, or a greater spatial and temporal coverage for the same cost. To demonstrate the cost effectiveness of the methods a ‘data worth’ analysis is undertaken. The data worth method involves quantification of the utility of observation data in terms of how much it reduces the uncertainty of model parameters and decision focussed predictions which depend on these parameters. Such decision focussed predictions can include many aspects of system behaviour which underpin management decisions e.g., drawdown of groundwater levels, salt water intrusion, stream depletion, or wetland water level.

The value of a data type or an observation location (e.g. remote sensing data (Westerhoff 2015) or a distributed temperature sensing measurement) is greater the more it enhances the certainty with which the model is able to predict such environmental behaviour. By comparing the difference in predictive uncertainty with or without such data, the value of potential observations is assessed. This can easily be achieved using rapid linear predictive uncertainty analysis methods (Moore 2005, Moore and Doherty 2006). By assessing the tension between the cost of data acquisition and the predictive accuracy achieved by gathering these observations in a pareto analysis, the relative cost effectiveness of these novel methods can be compared with more traditional measurements (e.g. bore logs, aquifer pumping tests, and simultaneous stream loss gaugings) for a suite of pertinent groundwater management decisions (Wallis et al 2014). This comparison illuminates those field data acquisition methods which offer the best value for the specific issues managers face in any region, and also indicates the diminishing returns of increasingly large and expensive data sets.

References:

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