A groundwater resources portal for New Zealand

A. Kmoch[1], S. Mannering-Tawera[2], D. Bradshaw[2], P. White[2], H. Klug[1]
[1] Z_GIS, University of Salzburg, Austria
[2] GNS Science, New Zealand

Introduction

New Zealand's freshwater resources are extremely valuable but at the same time barely understood. Most of the surface waters are already allocated and groundwater resources are more and more demanded by society. With 80% of the presently allocated groundwater resources, agricultural business is demanding a share of already allocated water (White, 2006). However, New Zealand's groundwater resource properties, like storage capacities or groundwater recharge are not well known. This might cause unsatisfactory and unsustainable developments. The regional councils in New Zealand are responsible for freshwater management, working under a common national legal framework, the management of water quality, water consents and water quantity measurement is a regional responsibility and so is data collection and storage.

Iwi/Māori have a well-recognised relationship with the natural environment which spans many centuries and is the result of interaction and adaptation with native flora and fauna of Aotearoa/New Zealand. Integral to this relationship is water which sustains life and is a taonga (treasure) with significant cultural and physical dimension. This is reflected through the on-going desire of many iwi/Māori groups to have a role in the way water is managed in New Zealand to ensure its sustainable utilisation moving forward (Kawharu, 2002). The development of scientific research tools and models that incorporate mātauranga Māori (Māori knowledge) and te reo Māori (the Māori language) are also beneficial to iwi/Māori resource policymakers, planners and decision makers.

GNS has been collecting and compiling Māori terms on hydrology, geology and geothermal phenomena to, amongst other things, explore the contribution that traditional indigenous knowledge can make to the research outcomes and model development by identifying the cultural significance of groundwater and the associated cultural links with surface water (Tipa and Tierney, 2003, Boast, 1991). The potential benefits of creating research tools that utilise te reo Maori and mātauranga Maori (within government institutional settings) includes generating increased uptake in and familiarity with te reo Māori and exposure of te reo Māori as a minority language to broader audiences. Further research could identify gaps in the dual knowledge systems (either the western scientific knowledge paradigm, or mātauranga Māori) that could be explored as an outcome of this combined research (De Bres, 2008).

Methods

Instead of a monolithic application, a service-oriented concept has been realised to be easily extensible and as interoperable as possible (Fig. 2). Multiple interfaces provide the means to deliver and consume hydro(geo)logical data. The main processing, transport and mediation happens within the "Data Interface and Services Layer". Project-related new data will be stored in the backend's project main repository, a spatially enabled database that has an appropriate data model in place to support the different needs of the project's researchers including data delivery and visualisation. Additionally, existing data providers can be registered and connected to the infrastructure, either via standardised OGC web services or via mediation interfaces. An example mediation interface has been implemented to attach the GGW to the portal. Also sensors and sensor networks can be attached.

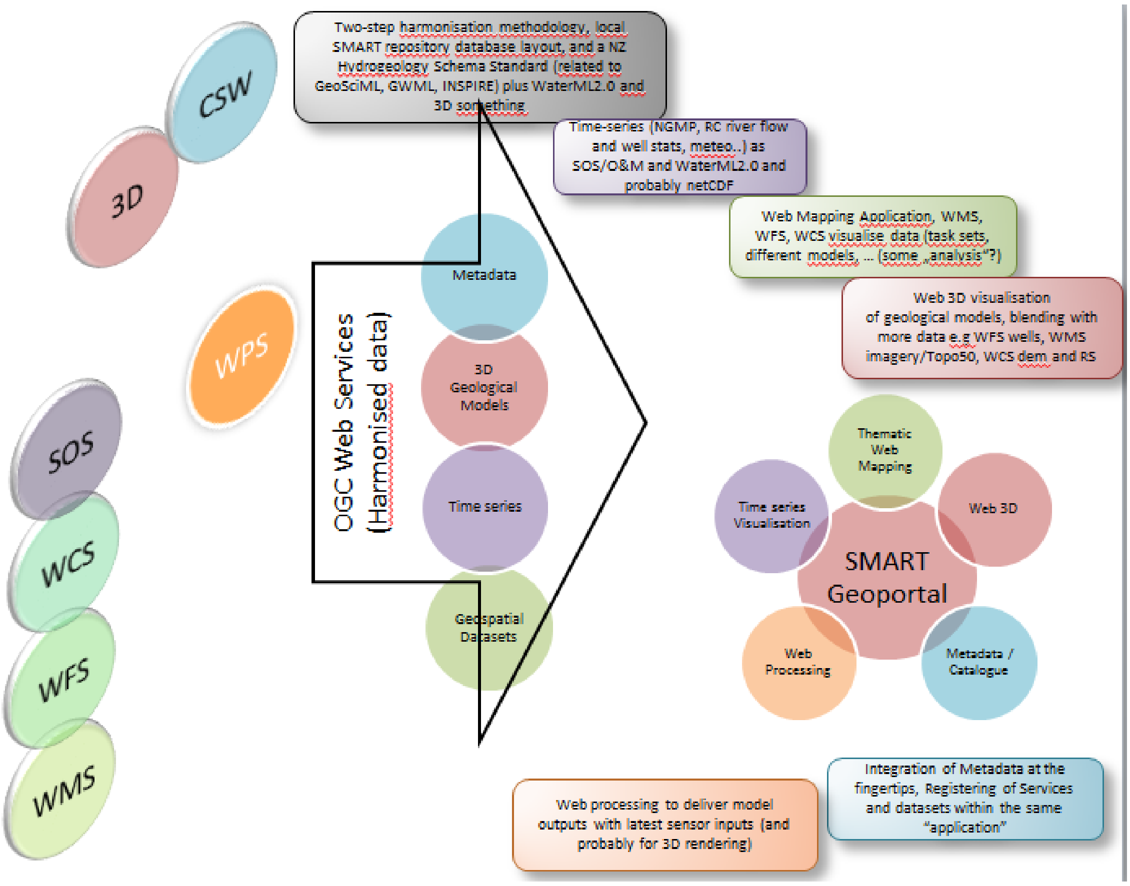

Figure 1: SMART Portal architecture overview

The web-interface, also referred as frontend or user interface, is the visible part of the WebGIS and takes the data services from the "Data Interface and Services Layer" and comprises a web application that provides the essential data viewing capabilities, like traditional 2D web maps and data graphs and attribute tables. Furthermore the frontend includes a user interface to the portal catalogue to query, search and discover registered datasets. The data is available via direct data access for sophisticated users who wish to use and analyse datasets within GIS and hydrological software applications. The connection parameters and metadata are contained in the catalogue and can be queried.

To prototype the 3D WebGIS capabilities, a 3D data set of the upper Waikato region of New Zealand (White et al., 2011) has been manually modelled and imported. This is a static sample translation from the model grid layers into the X3D scene graph description format, which then is stored in the data backend's main repository. Further development and alignment with international proceedings aim at dynamic renderings and interpolation from e.g. borehole data.

The following section is an excerpt of

Sheena Tawera-Mannering, GNS Science - "he papakupu - he rerewaingaro" (2013)

Introduction

This section will discuss the development of a GNS Science Maori groundwater lexicon. The aim of the research is to explore the possibility of delivering matauranga Maori – Maori knowledge search capabilities within a NZ groundwater web portal.

The lexicon is the result of an experimental interface between western science and matauranga Maori, As an information delivery platform, the lexicon's employment within the web portal has the potential to unlock the science and innovation potential of Maori knowledge . (MBI, 2012)

Background development and terms of reference

Initial research was undertaken to determine which groundwater terms should be selected, and how to store the lexicon's metadata. A selection of both English and Maori terms were chosen, based on their perceived usefulness to Maori end users – i.e. terms relating to geo-spatial location, identification and sustainable development of water resources, or water resource conservation/ management.

On this basis, selected terms from the New Zealand Freshwater database and freshwater feature terms such as lake, stream, river, as well as rock types associated with groundwater such as clay, gravel, sand were chosen. Maori words such as kaitiakitanga and mauri were also selected for the lexicon, along with some Maori website search tab-navigation terms.

To house the metadata, an excel spreadsheet based on GNS Science's bibliographic database fields was created.

Research methodology

Due to the timeframe and scope of the project – the following limitations applied to the research:

- No prior literature search was undertaken for the lexicon.
- The lexicon's research material was sourced from freely available information sources within the public arena (e.g websites , library collections.) No field trips were made into iwi kainga – Maori communities, or interviews conducted with kuia or kaumatua – Maori elders – to collect qualitative, primary interview data. Therefore, the lexicon's metadata reflects a western research style approach to data collection.

Discussion and results of the research

As a result of researching and translating Maori groundwater terms, the differences between matauranga Maori and the western approach to science research became apparent.

For example, the English groundwater term - "infiltration" – is there an equivalent term in Maori, and if so, can the word be translated and used within a different cultural or scientific context such as an online lexicon - without losing its mauri, -its life force – essential character, and authenticity?

In addition, the quantitative desktop approach undertaken can only provide a snapshot - what has been historically recorded within the western knowledge tradition relating to a particular subject or ethnic group – the research output of such an approach it is neither interactive nor iterative.

In contrast, a researcher contacting, engaging, gaining permission, and going out in person into iwi kainga/a Maori community to perform research amongst the people is more in keeping with the traditional matauranga Maori approach.

Conclusion

For New Zealand to develop, care for and preserve its little known but precious groundwater resources, there is a need to develop diagnostic tools that allow water management stakeholders the ability to visualise, identify, record, characterise and interpret groundwater datasets for decision making and policy planning purposes.

Developing a prototype lexicon of Maori groundwater terms for potential use in a NZ groundwater web portal is but one small stepping stone on a continuum of research that has the ability to unlock the scientific potential of matauranga Maori.

Ko te reo te mauri o te mana Maori – the language is the essence of mana Maori

(end of excerpt)

In order to provide a seamless spatial and multi-purpose view of collected groundwater related datasets, the SMART project joins forces to establish a valuable basis for groundwater analysis and decision support tools (Kmoch et al., 2012, Klug et al., 2011). One of the project's objectives is to build a web-based data and knowledge portal and attached three-dimensional web visualisation tool according to OGC and ISO compliant standards (OGC, 2012).

Therefore new interfaces and data transformations have to be implemented and OGC/ISO compliant web services (WMS - web map service, WFS - web feature service, WCS - web coverage service, SOS - sensor observation service, CSW - catalogue service for the web (OGC, 2012)) are used to publish hydro(geo)logical feature and coverage data, time series and meta data in the groundwater portal. Furthermore the open and standards-based architecture provides the necessary interoperability and contributes to the on-going efforts of the New Zealand Geospatial Office (NZGO)(4) to establish a nation-wide SDI (Spatial Data Infrastructure). To exchange hydro(geo)logical data and time series within the SMART project and with other organisations, common data exchange formats should be agreed on. Several GML-based (Geographical Markup Language) application schemas (GeoSciML, GroundwaterML) and encodings for exchange of time series and observations

(O&M, WaterML) gain outreaching attention in the international context (Bermudez and Arctur, 2011, Brodaric and Booth, 2011, Atkinson et al., 2012, Kessler et al., 2009). Finally the collected data and data sources including their respective metadata should be discoverable and therefore interoperable catalogue services (OGC CSW) provide the required capabilities.

To support te reo Māori and mātauranga Māori within the SMART portal web mapping and catalogue application, we evaluate a multi-language concept to incorporate semantic web methodologies to map and connect English and Māori terms and descriptions of presented natural phenomena as well as metadata and descriptive text within the application (Lutz et al., 2009).Beside a language template system for in-application-navigation use, a vocabulary web service based on a RDF/SKOS (Simple Knowledge Organisation System) database and an OGC CSW Catalogue server will be implemented to express structure and content of concept schemes such as thesauri, classification schemes, taxonomies, metadata and other types of controlled vocabulary. RDF/ SKOS will be used to document, link and merge concepts/terms to be with other spatial and non-spatial data (Antoine Isaac and Ed Summers, 2008). Evaluation of the lexicon's effectiveness will be measured in part by its ability to be applied successfully to the SMART portal web mapping and cataloguing application. As aquifers are inherently three dimensional in their geometry (White, 2009, White and

Reeves, 1999), properties like groundwater volume may vary with time. For all aspects of this project, databases and visualisation systems that support the storage, rendering and publishing of 3D models and time-series (4D) data are required. As the project constraints require easy and open access, proprietary software is not an option. Furthermore the national NZ open data initiative requests the free publication of governmental-funded data collection. For web-based visualisation of 3D models, several technologies are emerging to be standards candidates within OGC and ISO, like X3D, the successor of the ISO standard VRML97 or the OGC 3D web services (WPVS web perspective view service and W3DS web 3D service) (Reitz et al., 2009).

To enable analytic features within the portal, an additional web processing service (OGC WPS) is set-up. This service can be loaded with multiple algorithms and procedures and perform various calculations on the registered datasets (Smolders et al., 2011). The portal's 3D visualisation component prototype will provide pre-compiled 3D scenes from existing geological data models, e.g. created by sophisticated modelling tools. In the later course of the development, the models should be generated from the database (Reitz et al., 2009, Breunig and Zlatanova, 2011). Time series are visualised via graphs and tables in this implementation.

Finally a catalogue service web (OGC CSW) is provided. A OGC/ISO compliant CSW 2.0.2 server implementation is used to register all SMART data sources as New Zealand uses ISO 19115/19139 metadata standard as national standard. Additionally, more hydrological and geographical data publishing web services (OGC WMS/WFS) from participating regional councils can be registered and added to the interface.

The CSW provides two possibilities to contribute its stored metadata to the national SDI, either via providing a downstream search capability to the national SDI catalogue service or other cascaded catalogue services, or by getting harvested by other catalogue services on a regular basis.

Results

After the first year of the SMART project we achieved a first prototype. This needs to be discussed and tested with the involved stakeholders to tailor the tools to the needs of the groundwater industry in New Zealand. Developments will integrate in situ real-time sensor information within the database and the WebGIS.

The catalogue service for groundwater data that provides metadata according to OGC and ISO compliant standards is under development. This will enable searches for datasets via spatial and temporal extent. At that point the groundwater portal and SDI in the background will enable the visitor to discover, visualise and download published datasets, whilst data acquisition, management and legal constraints still remain with the data holders and regional councils.

Discussion

3D web-modelling capabilities in New Zealand are presently rare and most 3D models established are based on expensive proprietary (desktop) software solutions. With the 3D WebGIS component we enable stakeholders and decision makers to obtain insight into the subsurface and thus an overview of water resources available for allocation purposes.

The integrating of in situ measurements and time series will characterise the processes and function of the catchment and thus will provide insight in input and output relations in near real-time. Furthermore, the SMART project incorporates water-related methodologies and techniques from remote sensing to identify groundwater-surface water interaction, actual evapotranspiration, soil moisture and groundwater mass changes using GRACE

(Gravity Recovery And Climate Experiment). Altogether, the SMART project provides multiple synergising and partly overlapping methodologies and techniques which will be represented in the WebGIS. The dedicated tools and services that are developed and datasets that are collected within this project will be provided freely to users.

Data harmonisation is an important concern because the many data collectors (e.g. consultants, regional councils and research organisations) are independent. OGC services seem to be one of the most accepted transmission specifications and application schemes for data encoding need to be agreed. The GML application schemes GeoSciML and GroundWaterML are promising candidates, but they have to be streamlined to each other and to the latest GML specification. The European INSPIRE model is another good example. For exchange of hydrological time series WaterML2.0 is the most promising candidate. Development on these standards should be incorporated in the technological foundation of the SMART groundwater portal to enable highest interoperability as possible. With the first prototype and the stakeholder feedback we will demonstrate that data harmonisation and seamless visualisation is valuable for understanding and characterisation of New Zealand's groundwater resources.

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