The HydroGeophysics Group's (HGG's) new project HyGEM aims to develop tools to plug the gap between important geophysical findings and their application to practical, hydrological models. HGG also has plans to carry out its ground-monitoring work in more developing countries, where knowledge of fresh water resources are vital, explains group manager Esben Auken.

Tapping into the world's fresh water reserves

The HydroGeophysics Group (HGG), based at Aarhus University in Denmark, has contributed to extensive findings on the world's fresh water resources. This is achieved by advanced processing techniques and geophysical data that can produce 3-dimensional models of the subsurface.

Geophysical methods

HGG manager, Associate Professor Esben Auken says the group are doing extensive research in three 'unique' geophysical methods – one sky-based, the two other ground-based – to measure water content in the ground's sub surface, without the need to drill a hole.

The group's airborne sensor, SkyTEM, is a dual-moment Time-Domain Electromagnetic System (TDEM) designed to collect finely detailed data before only possible with ground-based geophysical techniques. Being airborne, large and even inaccessible areas can be surveyed in a very short time. It also allows for analysis of shallow and deep layers of the ground at the same time, says Auken.

The other method, Magnetic Resonance Sounding (MRS), uses similar physics to a hospital MRI scan, generating an oscillating current of protons in the earth's magnetic field through a "loop" put on the ground.

The team alter the spins of these protons and see how they react as this gives an indication of the ground's water content.

This method is much slower, Auken explains, taking around one measurement per day, compared to the airborne system where about 50 to 100

SkyTEM lands after a long day of surveying at the Mayotte Island, 2010

Below right: People on their way home from work at Petite-Terre, Mayotte Island

square kilometres of ground can be covered with more then 2500 soundings.

The last method, Induced Polarization, is also ground based. This method measures the geological layers capability to charge up when a current is applied. The method is very useful for mapping of point source contaminations like land fills, old gas stations or factory sites.

By getting a clear picture of the geological composition of the subsurface, the team can predict the location of fresh water resources.

For example, if the resistivity is 1000hm-m it means the area contains sand filled with water. If the resistivity is 10 Ohm-m or lower, this means there is clay, which means there will be no water at all in the area, says Auken.

HyGEM

Such work by HGG has been carried out, not only in Denmark, but across the world, including wider Europe, Australia and Antarctica.

Over the years the group has yielded extensive mapping of precious fresh water resources, but, missing is a way to quickly and easily turn this spatially sampled geophysical data to the framework of a hydrological model – an important tool for knowledge-based groundwater resource management.

This is why new collaborative project HyGEM is being set up, in a bid to try and develop a more automatised integration from the geophysical to the hydrological model.

"We saw it took a very long time to get the geophysical results into the modelling framework through the manual input of such measurements," Auken explains, "But we believe the transfer of data can be done much more automatically."

"Sometimes it is obvious for a human brain to make such links by itself. For example, when there are resistive areas in the subsurface of the ground this means there's got to be water there, but making the link automatically is not always easy."

With recently approved funding by Danish Council for Strategic Research, the project consists of Danish, American, Australian and Dutch research organisations, plus Danish private companies and one water management company. HyGEM will pursue three separate research approaches over a three-year period, with the aim of finding the most useful approach to minimise the very manual heavy conversion of geophysical data.

The first approach is a direct coupling of the hydrological model and the

Happy Camper survival course 2011 at the ice outside McMurdo station, Antarctica, a few days before the SkyTEM survey started in the Dry Valleys

geophysical modelling through a hydrogeophysical relationship.

The second approach attempts to create statistical links between the lithology and the resistivity, which would lead to a statistical model of the geology to go into a hydrological model.

The third approach takes takes the same paths as the second, but the statistics are formed in a different way, Auken explains.

The most successful technique will then be piloted in various geological locations around the globe.

The project members anticipate HyGEM's findings will have a significant scientific and societal impact, saying that the issues involved are of high interest to many research groups worldwide.

"The outcome will be of high value to Danish end-users as well as a valuable export article in the form of superior expertise in the industry and actual computer programs," says HGG.

The initial kick-off meeting for HyGEM took place recently in the US. Auken says it was important that the meeting was based outside of Denmark in order to enforce the international dimension of HyGEM.

Developing countries

Auken says in general the group is aiming towards more global collaborations and also greater coverage of fresh water resources in a range of different regions.

Recent research in the Galapagos Islands and a new India-focused project forms part of this new push from HGG, with an aim to carry out more mapping work in developing countries. Auken insists the group is not moving away from work in the Western world, saying there will always be further investigations to be carried out.

However, he says mapping of fresh water resources in developing countries can have a larger impact than in Western countries.

HGG's up-coming extensive Indian project, financed by the World Bank and the Indian government, aims to produce general mapping of fresh water resources in the country where there's very polluted surface waters, Auken explains. "Worldwide access to fresh water is a big problem People are getting sick because the water they have access to is so bad."

For this new India project, the research group will use the methodology and technology they have been developing over the years, such as the SkyTEM and MRS.

"We have now carried out surveys that, at that time, we never thought possible ten years ago because of interferences with people living in the area – our measurements get very disturbed by power lines and cables, but we've found ways to handle such obstacles," says Auken.

"We now plan to use such tools to produce mapping of fresh water resources in more and more complicated geological environments."

"It's something we'd like to pursue more because we know we can make a big difference to the lives of many people," he adds.

At a glance

Project Information

Project Title:
HyGEM: Integrating geophysics, geology, and hydrology for improved groundwater and environmental management

Project Objective:
The objective is to create tools for direct and automatic integration of geophysical and geological data into geological and hydrological models for water resources and environmental management.

Project Duration and Timing:
3 years, April 2012 to March 2015

Project Funding:
The Danish Council for Strategic Research, 2.07 mill Euro form the council, 3.70 mill Euro in total.

Project Partners:
3 Danish research institutions, 3 Danish private companies, 1 water supply company, United States Geological Survey, TNO Holland and CSIRO Australia.

Prof. E Auken

Prof. E Auken is an experienced geophysicist who heads a large research group of hydrogeophysicists, engineers and technicians. He manages a number of research project centred around geophysical methods for mapping of ground water resources and shallow geology.
The group develop everything from instrumentation to software and implementation of results.

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