Long-time resistivity monitoring of a freshwater/saltwater transition zone using vertical electrode systems

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In September 2009 two vertical electrode systems (CLIWAT 1 and CLIWAT 2) were installed in the water catchment areas Waterdelle and Ostland at the North Sea island Borkum to monitor possible changes of the transition zone between the freshwater lens and the underlying saltwater in depths between 44 m and 65 m below ground level. The installation and the first measurements were carried out in the framework of the EU Interreg project Climate & Water (see http://cliwat.eu/ and Sulzbacher et al., 2012).

Each of the two vertical electrode systems is about 20 m long and includes 78 stainless steel ring electrodes; the spacing between adjacent electrodes is 0.25 m. These systems are used for DC multi-electrode measurements. The measurements are carried out automatically several times per day using a modification of the commercial resistivity meter 4point light 10W (see www.l-gm.de). The power is supplied by batteries recharged by solar panels. Since December 2009 the data are regularly transmitted to Hannover by telemetry.

For the measurements the Wenner-alpha array is used. Each multi-electrode measurement includes 975 different four-point arrays. In the beginning the measurements were strongly influenced by moisture effects and showed a lot of outliers, but the use of newly developed active electrode switchboxes increased the quality of the data very much. In recent years a maintenance of the system at the surface was necessary once to twice a year only.

At both locations the data show a clear decrease of the apparent resistivity from about 80-90 Ωm in depths around 45 m to about 1-2 Ωm around 65 m depth (spacing a = 0.25 m). This decrease indicates the transition zone between freshwater and saltwater. The depth of the transition zone as well as the kind of decrease of the apparent resistivity is very stable since 2010. Only within the first year large changes occurred, but these were caused by the readjustment of the local conditions (disturbed by drilling) to the undisturbed situation.

Temporal changes are only visible if single depths are considered. They are especially large in CLIWAT 2 (Ostland) in depths around 55 m. Here a sand layer confined by clay layers is found. In 2015 Miriam Ibenthal used a vertical 2D density-dependent groundwater flow model to explain the long-term resistivity measurements and showed within her master thesis at the University of Göttingen that these temporal changes can be explained by variations of the groundwater level, changing groundwater recharge rates and changing pumping rates of the nearby located drinking water supply wells (Ibenthal, 2015).

REFERENCES

Ibenthal, M. (2015): A 2D density-dependent groundwater flow model to explain vertical distribution of electrical conductivity measurements and hydraulic heads of Borkum Island. – Master Thesis, Georg August University Göttingen.

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