Geoelectrical long-term monitoring with the SAMOS system using vertical electrode sections

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The Leibniz Institute for Applied Geophysics (LIAG, www.leibniz-liag.de) is carrying out long-term geoelectric measurements with vertical electrode sections at currently five different sites at the North Sea coast of Lower Saxony (Germany): The measurements with the SAMOS system are carried out on the North Sea island of Borkum in the two water catchment areas Waterdelle and Ostland (installation within the framework of the EU project CLIWAT, www.cliwat.eu/), on the North Sea island of Spiekeroog in the dunes as well as directly on the beach (project go-CAM, https://bmbf-grow.de/de/go-cam and DFG project DynaDeep, https://uol.de/icbm/verbundprojekte/dynadeep), and on the mainland near Abickhafe (project go-CAM). The objective is always to record changes in the transition zone between fresh water and salt water.

The monitoring started on Borkum island in 2009 in cooperation with Stadtwerke Borkum (two systems). The third and the fourth system were installed near Abickhafe in 2018 and on Spiekeroog in 2020 together with the Oldenburg East Frisian Water Association (OOWV). The last SAMOS station was recently installed (2022) at the shore of Spiekeroog as part of a multi-sensor monitoring approach to investigate physical and biogeochemical processes at high-energy beaches. The vertical electrode sections, each with about 80 electrodes, cover the depth range 44-65 m below terrain on Borkum, 35-55 m below terrain in Abickhafe and 29-53 m below terrain in the dunes of Spiekeroog. The system at the beach of Spiekeroog covers the depth range between terrain and about 21 m depth. The spacings between adjacent electrodes are 0.25 m or 0.30 m respectively. A 4 point light 10W is used to carry out measurements with different arrays (Wenner-alpha, dipole-dipole, Wenner-beta). The data transfer, which previously took place automatically to a server in LIAG, has already been converted to a cloud solution at Abickhafe.

The measuring system allows the detection of resistivity changes of less than 1 Ωm. Up to now the temporal resistivity variations are generally small. Major seasonal changes in some depths at Borkum (Ostland) are attributed to changes in production rates in neighbouring wells as well as to changes in the groundwater recharge rate. In longer time-series (Borkum) resistivity decreases lasting for several years as well as resistivity increases (due to reduced water demand as a result of the pandemic?) can be observed. The small variations also make differences between different measuring equipment visible. Temperature effects are small at greater depths as expected and are only of greater importance for the measurements at the shore of Spiekeroog. The measurements directly after installation can be disturbed by the drilling process at small electrode distances and show a gradual re-alignment with the natural environmental conditions. Using an inversion algorithm that takes the correct geometry into account the near-borehole and undisturbed resistivity can be separated. By monitoring the transition zone between salt water and fresh water the SAMOS system serves the waterworks as an early warning system for possible salt water upconing in groundwater extraction areas.