Geoelectrical Monitoring of freshwater/saltwater interactions at the high-energy beach of Spiekeroog (DynaDeep)

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Subterranean estuaries are hidden connective zones between inland aquifers and the open sea where meteoric freshwater and circulating seawater mix and undergo major biogeochemical changes. Hence, they are considered powerful biogeochemical reactors affecting elemental net fluxes to the sea. In particular, at high-energy beaches undergoing significant changes even at short time scales, the effect of hydro- and morphodynamics on subsurface flow and transport is yet unclear and related consequences on biogeochemical reactions and microbial habitat characteristics have not been investigated. The recently started research unit DynaDeep studies the groundwater flow patterns as a function of hydro- and morphodynamics, together with investigating rates of biotic and abiotic transformation of organic matter and related redox processes. Furthermore, the project assess the transformation and fractionation of trace metals and metal isotopes as well as microbial interactions with organic matter. The DynaDeep project focused on the beach of the north-sea barrier island of Spiekeroog.

Investigating the dynamics of the saltwater/freshwater interface presents an ideal target for geoelectrical monitoring. We collect ERT data in the intertidal zone in a regular six-week interval and support them by direct-push measurements, pore water sampling and the installation of a vertical electrode chain SAMOS (Ronczka et al., 2018) starting summer 2022. ERT data set have been collected repeatedly since 12/2021 investigating the current state of the upper saline plume (UPS) and freshwater discharge tube (FDT), the two main features defining the fresh/saltwater interface.

We conduct all ERT measurements using the ABEM Terrameter LS2, 2.5 m electrode spacing and a gradient array. We use up to four chains of electrodes with 32 electrodes each. The main profile is oriented south north from the dunes to the North Sea, i.e. crossing the east-west oriented beach. The actual length of the profiles depend on the current beach and tidal conditions affecting the mean low-water line. We invert the ERT data using the pyGIMLi framework (Rücker et al., 2017) and using geostatistical regularization (Jordi et al., 2018). The geostatistical regularization parameter are mesh independent and more likely to remain stable, when the topography is changing with time.

In the following three years, the monitoring will help to get an understanding of how topography changes in this high-energy environment are affecting the USP and FDT as well as the origin and behavior of temporal freshwater discharge locations known as runnel. Once we monitored a full hydrogeological year, the focus can shift to distinguish effects of seasonal origin or caused by storm events in general.

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