Bridging the gap between the optimistic and conservative salinization map: Steps towards unification

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The salinization map of Flanders, Belgium, shows the depth of the interface between fresh and salt groundwater in the coastal and polder area. It serves as a diagnostic tool for the presence of 'fossil' salty groundwater and as an exploratory tool to examine the potential of groundwater projects that improve freshwater availability in the shallow subsurface. Flanders environment agency published an updated map in 2019, based on airborne time-domain electromagnetic induction data [1,2]. Flanders is one of the first regions in the world to apply this innovative method for large-scale hydrogeological mapping, which means there is still room for methodological improvements. This results in two maps for the fresh-saltwater interface, an optimistic and a conservative one, potentially concealing interesting features.

Via an inverse problem, the electromagnetic induction data can be mapped onto a conductivity profile, which serves as a proxy for salinity via petrophysical laws. The inverse problem is ill-posed and regularization improves the stability of the inversion. A smoothing constraint is typically used with a very large number of thin layers. However, the salinity profiles in the Belgian coastal plains are often sharp, impeding the correct estimation of the fresh-saltwater interface. An alternative is to use a blocky inversion which yields sharp contrasts. In practice, however, the real underground might be either blocky or smooth, or somewhere in between. Those standard constraints are thus not always appropriate.

With a novel wavelet-based inversion scheme [3,4], the original data can be re-interpreted in a flexible fashion. In simple terms, a wavelet function can be seen as a building block and a simple model is one that can be built with a few building blocks of various sizes. Our proposed inversion scheme adds a regularization term that limits the number of building blocks to make sure only the necessary complexity is retrieved. The scheme is tuned by only one additional parameter (which determines the shape of the building block) and can recover blocky, intermediate, and smooth structures. It is also capable of recovering high amplitude anomalies in combination with globally smooth profiles, a common problem for smooth inversion, and an essential feature to accurately predict salinity.

The remaining step is to determine the optimal parameter that determines the sharpness of the transition from fresh to salt water. This parameter depends on the subsurface discretization and the hydrogeological circumstances. We present a calibration procedure to determine the tuning parameter for the inversion of the airborne TDEM data using additional high-resolution ground-based geophysical data. By choosing the appropriate tuning parameter and discretization, we can obtain a more reliable sharpness in the transition from fresh to saltwater, eliminating the need for two different salinity maps (optimistic and conservative).

Acknowledgements

The research leading to these results has received funding from VLIZ / De Zee als Goed Doel, sponsored by Antea Group Belgium and FWO (Fund for Scientific Research, Flanders, grant 1113020N).

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Keywords

Salinization; Geophysics; Inversion; Wavelets; Electromagnetics; Modelling