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# Assessing freshwater plumes, offshore freshened groundwater and the risk of salt intrusions in urbanised karstic groundwater systems using combined resistivity methods

**Jasper Hoffmann**[1,2], Ercan Erkul[3], Irfan Yolcubal[4], Amir Haroon[5], Pritam Yogeshwar[6], Simon Fischer[3], Elif Sen[6], Wolfgang Rabbel[3], Ahmet Sener[7], Jens Schneider von Deimling[3], Bülent Tezkan[6], Ertan Peksen[7], Aaron Micallef[1,8], Elnur Gasimov[7], Ismail Kaplanvural[7], Felix Gross[3], Lasse Sander[2], and Serif Baris[7]

[1]University of Malta, Marine Geology and Seafloor Surveying, 37, Triq ta' Xmiexi, Msida, Malta
[2]Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research, Wadden Sea Station, List, Germany
[3]Kiel University, Institute of Geosciences, Otto-Hahn-Platz 1, 24118 Kiel, Germany
[4]İstanbul Technical University, Mining Faculty, Department of Geological Engineering, 34469 Maslak İstanbul
[5]Geomar - Helmholtz Centre for Ocean Research, Kiel, Germany
[6]University of Cologne, Institute of Geophysics and Meteorology,50923 Cologne, Germany
[7]Kocaeli University, Engineering Faculty, Department of Geophysical Engineering, Umuttepe Campus, 41380, Kocaeli, Turkey
[8]Monterey Bay Aquarium Research Institute, Moss Landing, CA, United States

Groundwater acts as a critical link between onshore and offshore environments, connecting freshwater systems to saline oceans. With 40% of the world's population residing along coastlines, understanding coastal groundwater reserves is paramount. One open question involves the vital role of submarine groundwater springs in global hydrology, and how the distribution and groundwater flux can be better constrained across the coastline to better predict both groundwater discharge into the ocean and saltwater inflow into coastal aquifers. Especially urban areas pose unique challenges where water demand is high and groundwater exploration problematic since geophysical remote sensing techniques often interfere with surface and subsurface constructions (e.g. cables, pipelines etc.), making innovative approaches for groundwater exploration crucial for sustainable groundwater management.

In this study, we aim to address the complex dynamics of coastal karstic groundwater systems in urban regions, where meteoric waters discharge into the ocean through coastal and submarine freshwater springs, while concurrently facing the risk of saltwater intrusions. Our investigations in the bay of Antalya (Turkey) aim to provide a comprehensive understanding of the land-ocean transition zone in the karstic groundwater systems and provide new tools for future groundwater monitoring in coastal regions.

We employ advanced hydroacoustic and resistivity methods, combining onshore and offshore electrical resistivity tomography with electromagnetic measurements to bridge the gap between

onshore and offshore domains. This integration of geophysical datasets enables us to (1) delineate karstic groundwater flow pathways from land to ocean, (2) identify coastal and submarine freshwater springs, and (3) assess the risk of saltwater intrusions along the coastline.

The study showcases the potential of offshore geoelectric measurements as a tool for groundwater investigations in urbanized coastal regions. The proposed approach will facilitate exploration efforts for groundwater in urbanised karstic areas, but much more importantly will facilitate monitoring strategies to avoid intrusions of saltwater into freshwater aquifers. Our findings contribute valuable insights for water management strategies in Antalya, with implications for safeguarding todays and future freshwater resources.