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Structural characterization of a coastal aquifer using time-lapse electrical resistivity tomography

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The coastal areas of the Yucatan Peninsula typically present a zone of transition from coast to continent that represents a change from submerged sandbars to mangroves and lagoons, and into short tropical forest (deciduous and evergreen). Adequate characterization of the lithological contacts and the subsurface structure is critical for an adequate hydrogeological modeling of the coastal aquifer; especially as such transition zones are subject to a more dynamic interaction between the influences of the marine dynamics (e.g., tides) and the discharge from the regional aquifers than the inland regions of the Peninsula. Hence, we propose here the application of electrical resistivity tomography to solve for the lithological changes and identify the main hydrogeological units in the subsurface. Furthermore, in this work, we present time-lapse imaging results for ERT monitoring data collected at two different regions: (i) a one year monitoring period of the backshore and dunes of Sisal beach to investigate changes in the groundwater flow and salinity in a shallow aquifer and their correlation with variations in the vegetation cover as measured through a video-monitoring station; as well as (ii) a shorter but denser monitoring dataset collected at the coastal lagoon of La Carbonera to investigate the interactions between the sea and the coastal aquifer during spring high tide by means of ERT monitoring measurements collected every three hours.
Electrical images reveal clear changes in the electrical properties of the subsurface linked with variations in the salinity associated with interactions between sea- and groundwater. In the case of the Sisal beach, the seasonal changes in the vegetation cover seem to be related to the near-surface values in the electrical parameters. In the data collected at La Carbonera lagoon, the increase in the electrical resistivity is linked to groundwater recharge to the shallow aquifer accompanying tides. Our results provide insights into the hydrologic dynamics of the coastal aquifer and yield important information on its role in the stabilization of the subaerial beach (through the vegetation cover) and on the role of the average quality of the water for human consumption for the settlements along the Yucatan coast.