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Application of transient electromagnetic to understand infiltration in farmlands in karst areas of Yucatan, Mexico

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Rising temperatures as well as accompanying changes in precipitation rates and periods due to climate change demand an efficient use of water resources for farming. The Yucatan peninsula (Mexico) is not only affected by the climatic changes per se but also by their consequences, such as the deepening of the groundwater table and seawater intrusion, enhanced by population growth. These threats call for the development of efficient irrigation methods to maintain farming activities. Moreover, the management of water resources needs to consider irregular water infiltration as well as groundwater flow and storage due to the presence of fractures, caves and low permeable limestone associated to the karstic geology of the peninsula. We evaluate the application of the transient electromagnetic (TEM) method to gain information about subsurface architecture, in particular to identify the presence of unknown cavities that may act as preferential flow paths. The TEM is a geophysical method well suited for hydrogeological investigations in karst environments as it resolves the subsurface electrical conductivity without galvanic contact with the ground and with a higher spatial resolution compared to borehole data. The TEM survey was planned for a depth of investigation of ca. 60 m across a citrus farm on the Yucatan peninsula where treated wastewater is used for irrigation. While such practice minimizes the exploitation of groundwater, some concerns have been raised about the possible contamination of the aquifer due to with the use of treated wastewater. The difference in the electrical conductivity between the treated wastewater and the groundwater due to their different chemical composition renders the TEM as a suitable method to delineate pathways of the irrigation water within the subsurface as well as hydraulic connections with the aquifer. In a first step, the TEM soundings were inverted independently to enhance the spatial variability associated to the complexity of the karst system. Interpretation of the resulting electrical models in terms of the aquifer geometry and preferential flow paths took into account the existing information from boreholes and irrigation points. We also conducted a sensitivity analysis of the resolved model parameters after the inversion of the data, to better evaluate the interpretation of our results. In a second step, we conducted a stochastic analysis of the TEM data to quantify the uncertainty of our results, in particular, regarding the resolved geometry of the aquifer. Our results reveal changes in the electrical conductivity at different depths and across the farmland. High conductivity values, which were

observed close to the surface, are related to the infiltration of the treated wastewater. Deeper variations in electrical conductivity reveal the presence of caves and other preferential flow paths for groundwater. Areas revealing high resistivity values are associated with less karstified rocks that may act as hydraulic barriers.