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Advanced processing of airborne FDEM data for improved imaging of groundwater conduits and sea water layering near Tulum, Mexico

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The study presented herein is part of a series of international research cooperations, started in the year 2006 and still ongoing, which have the general objective to develop and test new approaches of data acquisition and modelling methods for studying a complex ground/seawater regime and its interaction. The study area is located at the Yucatan Peninsula, Mexico, and comprises the northern most part of the Sian Ka'an biosphere reserve, a coastal wetland of international recognition, as well as the town of Tulum and part of the worlds second largest barrier reef. In the subsurface, and below the city, the whole area is nerved by a complex network of underwater caves. The upper most fresh water layer of the karstic aquifer actually represents the only significant fresh water resource in the region.

In principle, karst aquifers are characterized by the presence of two distinct flow domains: the limestone matrix and the karst conduits. A flow model of karst aquifers requires detailed, spatially distributed information on the characteristics of the two domains. Electromagnetic methods determining the distribution of the electrical resistivity within the subsurface can provide such information. To explore the applicability of airborne electromagnetics, several airborne surveys in the area were conducted in 2007, 2008, and 2015 by the Geological Survey of Austria, covering an area of some 300 square kilometres in total. Above the reef, data has been acquired along distinct flight lines. Adapted and new processing techniques retrieved increased resolution of apparent electrical resistivity anomalies. These can be interpreted as vast complex conduit network inland partially confirmed by explored cave systems. Consequentely, a 3d-model of the network as well as complex halocline table and further aquifer structures have been derived. Furthermore, advanced processing of offshore lines delivered improved resolution of seawater layering primarily due to variation in temperature and/or salinity down to depths below skin depth. This recommends the AEM-method also for oceanographic studies concerning the most significant upper ocean layer and ocean/atmospheric interaction. Advanced data processing and numerical simulations show the opportunities of a common airborne FDEM system without specific hardware adaptions in hydrogeological studies encouraging further development including decoupled transmitter/receiver configuration as well as squid-sensors and adapted data processing.