# Spatiotemporal variability of SGD as indicated by UAV based thermal infrared measurements

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## ABSTRACT

Submarine groundwater discharge is highly variable in spatial and temporal terms due to interplay of several terrestrial and marine processes. In contrast to discrete in-situ measurements, remotely sensed thermal infrared radiation has proven to reveal horizontal SGD variability in a spatially continuous context. Yet, it lacks temporal information that is crucial to understand highly dynamic systems as represented by coastal environments. Here we report the results of temporal continuous Unmanned Aerial Vehicle (UAV)-based measurements of thermal radiances at the Dead Sea exploiting the UAV ability to observe predefined locations by hovering above.

For focused SGD spots the so obtained high temporal and spatial resolution show influences of crossflows and interaction of nearby SGDs on the final thermal radiance pattern, horizontal pattern shifts of ~0.42-1.40 m for certain periods and even pattern size variation between 19-55%.

The thermal radiance pattern induced by likewise encountered diffuse discharge constantly influences a fringe along the coastline of ~1.30 m width, which extends periodically at intervals of 20-78 seconds to a width of up to 4.55 m. The significant periodicity denotes a non-random process, which we attribute to small-scale hydrogeological karst conditions and associated effects at the investigation site.

Yet, the facts are: 1. If combined with in-situ measurements, the derived pattern, independent of focused or diffuse discharge, provide a sound possibility of discharge quantification from TIR data especially if patterns are integrated over time and 2. The high temporal resolution (4Hz) of the presented UAV-based approach may even mean asset for discharge and process understanding, which is well below the temporal resolution of classical in-situ measurements.

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