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Optimal design of an hydrogeophysical monitoring system of compacting volcanic aquifers (Tenerife Island)

Pablo J. Gonzalez[1,2], Maria Charco[3], Antonio Eff-Darwich[4], Anthony Lamur[1], Rayco Marrero[5], and Silvio De Angelis[1]
[1]COMET. Department of Earth, Ocean and Ecological Sciences, University of Liverpool, Liverpool, United Kingdom (pjgonzal@liverpool.ac.uk)
[2]Volcanology Research Group, Department of Life and Earth Sciences, Instituto de Productos Naturales y Agrobiologia (IPNA-CSIC), Tenerife, Canary Islands, Spain
[3]Instituto de Geociencias (IGEO, CSIC, UCM), Madrid, Spain
[4]Universidad de La Laguna, Tenerife, Spain
[5]Instituto Volcanologico de Canarias (INVOLCAN), Tenerife, Spain

Groundwater in volcanic islands is usually the main source of freshwater, and it is essential for sustainable development. In Tenerife Island, groundwater extraction occurs by drilling horizontal water tunnels, called water galleries, as well as numerous coastal wells. Since around 1900, but especially since the 1960s, hundreds of water tunnels have been drilled for agriculture and freshwater supply. This has resulted in a sustained extraction of groundwater larger than the natural recharge, leading to a general water table decline, locally up to 200 m of down drop. Since 2000, satellite radar interferometry (InSAR) applied to measure surface deformation has located several subsidence bowls (e.g., Fernandez et al., 2009). The localized surface deformation patterns have been correlated with water table changes and hence aquifer compaction. However, no further investigations have been carried out to confirm which characteristics (chemical composition, texture, porous network, alterations, etc.) of the volcanic materials can control compaction process, and to which extent porous volcanic units, the most abundant material in Tenerife, can compact to explain the observed surface deformation. This lack of knowledge might affect the effectiveness of water management policies.

To investigate the compaction processes affecting the volcanic aquifer, we propose to set up a passive hydrogeophysical monitoring network composed of geodetic and seismological instruments. However, considering logistic constrains it is desirable to have as low as possible number of observation sites, whist maximizing the detection and characterization of the aquifer dynamics. Here, we explore different network configurations to maximize the spatial and temporal characterization of the compaction processes using machine learning methods (low-rank matrix techniques). We pose the network design as an optimization process with the aim to parsimoniously have as fewer as possible ground station sites, and have a low error on reconstructing spatiotemporal land subsidence observations. Land subsidence rates were estimated using Sentinel-1 radar interferometric observations from October 2014 to December 2020. This method allows for an optimal network configuration, with respect to the dual penalty

function, which facilitate the decision making. Nevertheless, this type of network design should be regarded as proposals because some station site conditions are a priori unknown. Although, one could modify the penalty function to optimize the network considering additional types of information, e.g., geological materials, groundwater table time series, etc.

Fernandez, J., et al. (2009), Gravity-driven deformation of Tenerife measured by InSAR time series analysis, Geophys. Res. Lett., 36, L04306, doi:10.1029/2008GL036920.