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Mass and stress balance continuous monitoring in volcanic geothermal fields: integrated observational approach for exploration drilling

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In volcanic and hydrothermal geosystems, mass and stress changes follow processes that we want to understand, as they provide us with better volcanic hazard assessment to mitigate the risk and a better estimation of geothermal resources to sustain our energy needs. Although it is not always straightforward to estimate such changes on active volcanic systems, the exploitation of geothermal volcanic systems modifies mass and stress distributions in and around the hydrothermal reservoir with better constrained boundary conditions.

The combined continuous recording of the gravity field and ground motion with sufficient accuracy in active volcano-tectonic setting allows a better understanding of the mass and stress transfer mechanisms, that produce short term gravity changes and local seismic activity. We aim at a better understanding of geothermal systems processes by addressing short term mass changes within geothermal reservoirs in relation with external solicitations such as anthropogenic (reservoir exploitation) and natural forcing (local and regional earthquake activity and earth tides). This contributes in knowing the reservoir properties, structure and long-term behavior. The expected amplitudes are small (e.g., <1 to 100s μgal, 1 μgal=10e-8 m.s-2). We therefore use high performance and up-to-date instrumentation such as broadband seismometers and superconducting gravity meters; we also measure all other parameters that may affect the records (deformation, hydrological parameters, pressure, temperature, snow height...). To achieve those goals, we deployed in December 2017 a network of gravimeters (3 iGrav superconducting gravimeters and 2 gPhone spring-meters), supplemented with additional instruments, such as tilmeters, GNSS receivers (complemented with InSAR analysis), hydro-meteorological stations, snow height observation instruments, piezometers in shallow boreholes, ... In particular, In order to monitor and remove the instrumental drift and calibrate each relative gravimeter, we performed also absolute gravity measurements (FG5) at each location, and in order to increase the spatial coverage of the gravity changes, a repetition gravity network was set-up in summer 2017.

Theistareykir (Northeast Iceland) is the chosen site for this unique experiment; this geothermal system is at the very beginning of its exploitation providing us with the initial mass and stress status. After being used for power production (45 MW since November 2017) all extracted fluids are re-injected at a single location. We present here the site, the infrastructure, the instruments deployed and the first results.

A remote telecommunication and operation system has also been set-up, which allows us to monitor, control and analyze recorded data from everywhere on Earth. Data are also sent via wifi and mobile phone system to the Telegrafenberg at GFZ, where we perform analysis and interpretation. Our goal is to demonstrate that we can monitor and interpret integrated high quality data for a better understanding of magmatic and hydrothermal reservoirs in order to prepare their future highly challenging exploration by drilling.