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Analysis of the applicability of ambient noise based techniques on the monitoring of deep geothermal reservoirs by numerical modelling

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A challenge in deep geothermal projects based on the Enhanced Geothermal System (EGS) is to ensure their successful development and the durability of the operation of deep underground heat exchangers while controlling the risk of inducing potentially seismic events. The management of these risks calls for the development of monitoring methods which could contribute to recognize an unexpected reservoir dynamic. Recently, the development of seismic noise correlation methods has contributed to the use of Coda Wave Interferometry (CWI) to compare daily stacked ambient noise cross-correlation functions (or ANCFs). The application of such ambient noise-based monitoring techniques opened perspectives to follow the fine-scale evolution of complex geological structures. In particular, the methods have been applied to the ambient seismic noise recorded since 2012 in the vicinity of the Rittershoffen deep geothermal power plant. The measurements highlight an annual variability repeated from year to year, but the trend is still not well understood as the physical process at the origin of the measurements are not well identified. Surface phenomena, such as annual temperature variations or changes in the water table elevation, are among the natural processes unrelated to the reservoir evolution, that could explain the annual variability but also potentially bias the monitoring of the reservoir changes.

Our study aims first at a better understanding of the processes deduced from the measurements. Second, we study the applicability of passive monitoring techniques based on the ambient noise to support the management of the reservoir in various geotechnical contexts and to monitor unexpected evolutions. To this purpose, we developed a 2D numerical model that describes the signature of annual surface temperature and water table elevation variations, on the interferometry measurements. By modelling the contribution of a local evolution in the reservoir, we investigate whether if the contribution to the measurements of surface perturbations could shadow the one of a local change in the reservoir.

Our measurements show that the annual variability measured from the ambient seismic noise recorded in the vicinity of Rittershoffen is retrieved in the numerical measurement. The time-serie of the ANI is correlated to the water table elevation variation. We show that the transient deformation introduced in the medium at depth has a clear impact on the measurements. The numerical modelling of the effects highlighted infield opens perspectives for the removing of unwanted effects related to natural surface processes in the monitoring of the deep geothermal reservoir.

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