Geophysical Research Abstracts
Vol. 17, EGU2015-11321, 2015
EGU General Assembly 2015

Deep geothermal reservoir imaging using ambient seismic noise interferometry

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The Rhine graben is known to be a suited region for the exploitation of deep geothermal resources. In this study, we focus on the area of northern Alsace (France) where two Enhanced Geothermal System (EGS) have been established in Soultz-sous-Forêts (GEIE-EMC) and Rittershoffen (ECOGI project). Our objective is to assess the use of the tomographic methods based on ambient seismic noise interferometry to characterize the structure of the upper crust hosting the geothermal reservoir ($\sim$10 km2 large / 3 km deep). Over the past 10 years, a vast amount of studies have shown that correlation of seismic noise between seismic receivers can be used to infer the medium properties and follow their evolution in time. Conversely to the use of individual micro seismic events, ambient seismic noise interferometry can be applied anywhere with a sufficiently dense and long-operating seismic network. In northern Alsace, a large dataset is now available. Firstly, a long-term sparse network of 18 permanent and temporary seismic stations has been installed in a radius of 15 km around the two EGS sites and has already produced continuous recordings for several months to several years. Secondly, a short term dense network of more than 250 stations (EstOf-250 project) has been installed for one month in september 2014 to increase the network coverage. In this study we apply the method of ambient noise correlation to both datasets. The considered frequency range (0.2 to 5Hz) is constrained by the scale of the structures to be observed, and therefore includes seismic noise sources having various origins and properties. It appears that the non-uniform distribution of the seismic noise sources is a limiting factor to the reliability of the method and this effect is strengthen by the small size of the networks. Based on a careful analysis of the noise properties combined with a modeling of the noise correlation functions, we propose a preliminary surface wave tomographic map of the area using both datasets. We also discuss the strengths and weaknesses of a long-term sparse network with respect to a short-term dense network for the application of ambient noise tomography to the exploration of deep geothermal resources.