spatial gradients had a diameter of only 10 meters. Results from f-k analyses and gradiometry are generally in agreement. We demonstrate the principles of gradiometry and discuss potential reasons for the remaining deviations between the different techniques. Finally, we give an outlook for future investigations at that site, including the use of rotational sensors.

ESC2018-S33-438

AMBIENT VIBRATIONS MEASUREMENTS TO STUDY ROCK SLOPE INSTABILITY IN THE ETNA AREA

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We show the results of an integrated study of geologic surveys and seismic site response in the southern segment of the Acireale fault (eastern flank of Mt.Etna), where creep phenomena and landslides play an important role. We performed ambient noise measurements using the Horizontal to Vertical Spectral Ratio (HVSR) technique, in order to infer the occurrence of directional amplification effects in the fault zone.The fractures surveyed in this study take place along a fault segment belonging to a wider NNW-SSE system, locally known as Timpe, which displaces a large part of the Etna eastern flank. Along this part of the fault system, stickslip motion, producing seismic sequences of low magnitude (M<4.9) earthquakes, and aseismic displacements take place. Literature data about creep rates, obtained from analysis of historical records and field surveys, indicate significant movements varying from 0.5 to 2.3 cm/year. HVSR analysis was performed on ambient noise recorded in 30 sites, using a 3-component seismometer (Tromino). Time series of ambient noise were recorded with a sampling rate of 128 Hz,divided in different time windows of 20 s, following the guidelines suggested by the SESAME project (2004). Spectra of each window were smoothed and then HVSRs were calculated in the frequency range 0.5-20.0 Hz. Experimental spectral ratios were also calculated after rotating the horizontal components of motion by steps of 10 degrees starting from 0° (north) to 180° (south). This approach has been used for ambient noise signals by several authors to identify site response directivity in the presence of faults. In the present study we also applied the time-frequency (TF) polarization analysis described by Burjánek et al. (2012 and reference therein). This technique provides quite robust results, overcoming the bias that could be introduced by the denominator spectrum in the HVSR calculation. Polarization parameters obtained all over the time series analysed are then cumulated and represented using polar plots, together with ellipticity vs. frequency diagrams.The HVSR measurements were performed near the cliff edge, where the fractures are more evident, and moving towards its inner parts. The results point out a clear seismic site effect very marked in the neighbourhood of the fractures, in the eastern part of the studied area, and a decrement moving towards West. In particular, the HVSRs show a tendency to increase the amplitude, in the frequency range 1.5-4.0 Hz, with a clear "eye shape" (Castellaro and Mulargia, 2009) in the FFT. The presence such a characteristic allowed us to exclude anthropic disturbances on HVSR results. The rotated spectral ratios show a broadband frequency effect with several adjacent peaks pointing out a preferential direction with angles of about 80°-90°. Furthermore, the TF results set into evidence the presence of a significant horizontal polarization at the measurement sites along and across the investigated faults. The ambient noise is sharply polarized in a narrow frequency band (1.0-4.0 Hz), following a roughly east-west trend that is almost perpendicular to the fault strike. The results of ambient noise measurements performed along the studied fault segment therefore pointed out the presence of directional amplifications, also confirmed by the results of the time–frequency analysis, with the largest amplification occurring at high angle to the fault strike. The nature of the observed site effects is highly complex as a number of different mechanisms, such as near-surface structures and slow gravitational deformations, contribute. Consequently, the shear wave velocities could be lower with respect to the values typical of lava formations. Measurements performed some hundreds meters away from the fault zone show a reduction of the observed directional effects that may be ascribed to the fault fabric. We relate the polarization effects to compliance anisotropy in the fault zone, where the presence of predominantly oriented fractures makes the normal component of ground motion larger than the transversal one. Such findings corroborate the hypothesis that the observed landslide movements can be related to creep movements along the investigated fault.

ESC2018-S33-452

ARRAY DESIGN FOR SITE CHARACTERIZATION MEASUREMENTS IN THE SWISS STRONG MOTION NETWORK RENEWAL PROJECT

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The most important parameter to understand amplification effects at a given site is the shear-wave velocity profile of the underground, which can be obtained by performing site characterization measurements. There is a large variety of tools which can be used for this purpose. Many of them are analyzing ambient seismic noise, which has the advantage that the signals do not have to be generated artificially, but are present at all times. In contrast to active seismic experiments, we cannot control the sources of the signal to be analyzed. Therefore, the different seismic wave types which are present in the signal, mainly surface waves, have to be separated by appropriate methods. Using arrays of seismic sensors, we can observe the propagation of the different wave types across the array and deduce their velocity, i.e. the dispersion curves. The design of a seismic array is not a trivial issue and needs to be adapted to the techniques which are supposed to be used for the analysis. There are other issues to be considered. The available space in urban areas is very limited compared to measurements in agricultural landscapes. Lateral variations and varying geology also influence the array response. Furthermore, costs for the instruments, the manpower and the necessary workforce to analyze the data should be taken into account. The Swiss Seismological Service started to renew and extend its strong motion network (SSMNet) in 2009. The project is ongoing and is scheduled to be finished in 2020 with the installation of the 100th new station. For all of these stations, site characterization measurements are systematically carried out. The measurement techniques vary from site to site. At most of the sites, array measurements of ambient seismic vibrations are performed. The data are analyzed using different techniques such as SPAC, 3-component high-resolution FK and WaveDec (wavefield decomposition). We optimize our arrays for these measurements to be able to measure dispersion curves of Love and Rayleigh waves in a wide frequency range in a limited time with a limited number of participants. Additional constraints are that the planning of the arrays and their implementation in the field should be easy. The optimization of an array of seismic sensors is a nontrivial issue. Maranò et al. (2014) optimized array designs by minimizing the side-lobes of the array response in a given wavenumber range. The resulting arrays depend on the number of sensors used, but most of them have a design which can be mainly described by a three-fold rotational symmetry. Another approach is to optimize the array for the use with SPAC. The original SPAC method (Aki, 1957) is based on seismic stations installed on a circle. It can be shown that a limited number of stations on the circle are sufficient for a good measurement, but the number has to be odd. Three or five stations are sufficient. Other frequency ranges can be covered by adding rings with larger or smaller radius. Even if advanced SPAC techniques such as M-SPAC do not necessarily require a strict station positioning on rings, it is still advantageous to plan the array with such a configuration. For our measurements, we generally use 16 sensors connected to 12 dataloggers and set them in five rings with three stations each around a central station, increasing the radii of the rings from about 8 m to over 200 m. In this way, dispersion curves can be measured over a wide frequency range with only one array. We will present which steps we take to plan such an array for a given site, compare the array response of different array designs and analyze which radii and rotation angles between the different rings give the best array response.

ESC2018-S33-462

SEISMIC WAVE-FIELD ANALYSIS FROM DENSE SEISMIC ARRAYS AND IMPLICATIONS FOR SITE EFFECTS IN CEPHALONIA, GREECE

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Site-specific characteristics of the observed ground motions are considered important for the