# Array Analyses of Low-Frequency (0.1-0.5 Hz) Ambient Noise in Central Italy.

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In the framework of the seismological studies related to the activity of the Alto Tiberina Fault (ATF), a seismic array composed by 9 stations was deployed in the vicinity of Gubbio, central Italy (Fig. 1).

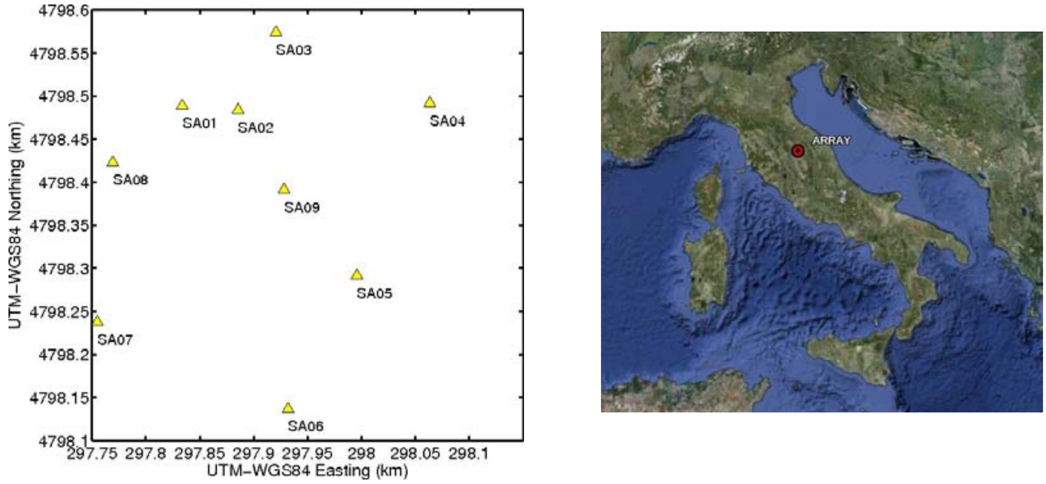

Fig. 1 – (left) Map of the array. To the right, the location of the deployment with respect to Italy.

The array operated from November, 2009, through the end of March, 2010, and consisted of Lennartz LE3D-5s sensors connected to Reftek 130 digital stations recording in continuous mode. While the analysis of the large earthquake data set collected during this time frame is still undergoing, in this work we present preliminary results from multichannel measurements of the microseismic noise of marine origin recorded over the 0.1-0.6 Hz frequency band. At frequencies below 1 Hz, the time-frequency transforms (spectrograms) of our data evidence a complicate pattern, dominated by shifting peaks centered at frequencies between 0.1 Hz and 0.5 Hz (see example in Fig. 2). In order to determine the kinematic properties of the microseismic wavefield, we use a frequency-domain array processing technique based on the separation of the multichannel spectra into the noise and coherent signal subspaces (MUSIC, Multiple Signal Classification; Schmidt, 1986). In our processing procedure, array recordings are first corrected for the instrument response, low-pass filtered at 1 Hz, and eventually resampled at 50 samples/s. These data are then segmented into 10-minute-long time windows overlapping by 50% of their width, tapered and Fourier transformed. For each time segment, we calculate an array-averaged spectrum, and select the peak of largest amplitude. The spatial covariance of the signal is then derived for a narrow (0.018 Hz) frequency band encompassing that peak. From the eigenvector associated with the principal eigenvalue of that matrix, we eventually derive the two components of the horizontal slowness vector which permit determination of the propagation azimuth and ray parameter for a plane-wave crossing the array in that time frame.

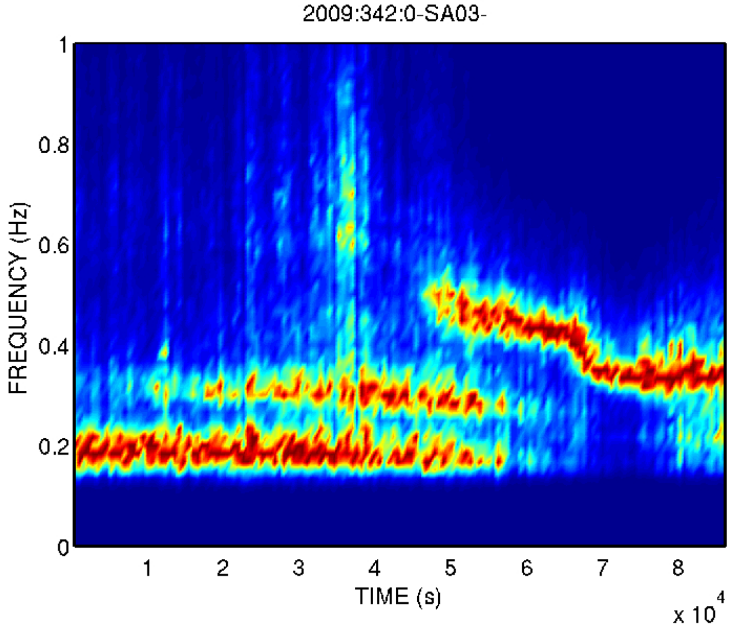

Fig. 2 – Time-frequency transform (spectrogram) for one day (December 8, 2009) of continuous recording at station SA03 of the array in Fig.1. The spectrogram has been obtained by calculating the Fourier transform of the signal over consecutive, not-overlapping 10-minute-long windows of signal. Before plotting, spectra from the different time frames have been individually normalised to their maximum amplitude.

Results from 6 consecutive days of analysis (3-8 December, 2009) indicate that the distinct frequencies evidenced by spectral analysis (Fig. 3a) are sourced from different locations (Fig. 3b-d) and propagate with different velocities. The energy at frequency ~0.2 Hz propagates from backazimuths of about 300°N with ray parameters between 0.3 s/km and 0.8 s/km (Fig. 3b), corresponding to apparent velocities spanning the 3 km/s – 1.25 km/s range. These low velocity values are consistent with surface (Rayleigh) waves. Conversely, most of the energy at frequency ~0.3 Hz comes from a wide azimuthal range, which span both the NE and SE quadrants. These waves propagate at much higher velocities, (3-10 km/s), and they are most likely representative of body waves. At even higher frequencies (~0.4 Hz), the propagation parameters are suggestive of body waves (apparent velocities ~4 km/s) sourced from the NE direction. Additional constraints on the location of the noise sources will be gained through triangulation methods applied to subsets of stations from the Centralised National Seismic Network (RSNC), and by correlating the observed directional data with the significant wave heights modeled for the Mediterranean Sea (e.g., Marzorati and Bindi, 2008). Though preliminary, however, the above results evidence the marked directional properties of the noise wavefield at frequencies below 1 Hz, thus suggesting that care must be taken once using correlation-based noise travel-times for determining velocity structures (e.g., Shapiro et al., 2004).

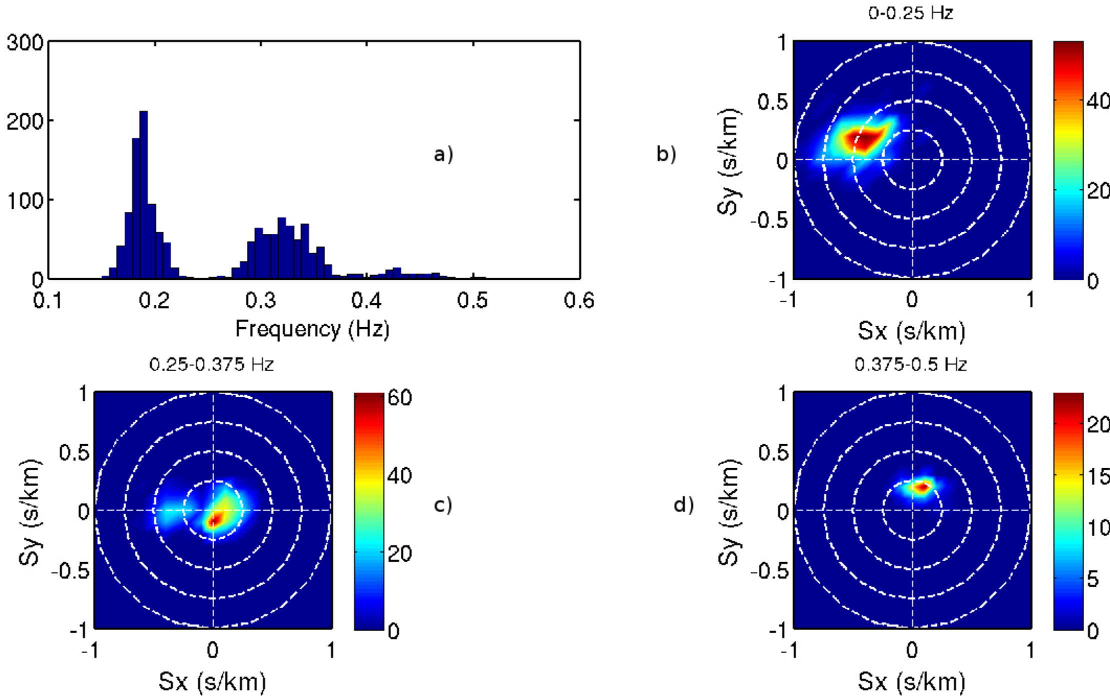

Fig. 3 – (a) Histogram of peak frequencies for 5 days of analysis. (b-d) Multivariate distributions of the two components of slowness for different frequency bands. The two components are reversed in sign, so that the slowness vector points to the direction of arrival (backazimuth). Dashed contours are ray parameter isolines, spaced by 0.25 s/km.

## References

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