Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04301, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04301
EGU General Assembly 2008

Principal component analysis of VLF radio signals and pre-seismc anomaly associated with august 22, 2005 earthquake

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In this study we applied principal component analysis (PCA) to extract any VLF signature associated with earthquakes. In radio signal processing, PCA takes its starting point from analyzing the length of the samples located in some suitable part of the signal. By varying the length of the samples, we are able to locate when earthquake occurred. The signal sample is represented by the column vector x_i=[x_i(1),....., x_i(N)]^T, where x_i(j)$\in$R^n is the signal we are investigating, T means transpose and N is the number of samples we analyze. In our study, N stands for the number of hours in the day we collected the signal. So doing, the entire radio signal is represented by N$\times$M data matrix X=[x_1,x_2,.....,x_M]. The sample covariance matrix R and its eigenvalue decomposition of R=VΛV^T have been performed. We investigated the variations of eigenvalues λ_i and eigenvectors v_i.

In this paper we applied PCA to VLF radio signals signals transmitted by GB (f=16 kHz, United Kingdom), FR (f=20.9 kHz, France), GE (f=23.4 kHz, Germany), IC (f=37.5 kHz, Island) and IT (f=54 kHz, Sicily, Italy) monitored with a 5s sampling rate. In order to manage the huge amount of data we analysed the time series of 10 minutes means, that is one datum each 10 minute averaged between the raw data 5 minutes before and 5 minutes after the datum. We set N=24,12,6,3,2, 1 hours and by the analysis of eigenvalues and principal components, we found and located the day and then the hours of peak values, on August 19. Since this behaviour can be found in FR both intensity and phase data collected during the 2005 and the same data of

other radio signals, we can associate this anomaly to the earthquake with M= 4.6 occurred in the Anzio (central Italy) offshore area, on August 22, 2005. The earthquake epicenter is close enough to some of the radio paths and this explains how only some data provide useful information related to signal anomaly. A further proof of the previous highlighted anomaly was also confirmed by wavelet analysis, as we presented in this Assembly. The duration of the anomaly fits with perturbations in the ionosphere related to Atmospheric Gravity Waves produced during the preparation of the earthquake.