SYNAPSE SCIENCE CENTER

S N D A

SEISMIC NETWORK DATA ANALYSIS

Part 2

DESCRIPTION OF THE PROCESSING ALGORITHMS FOR ANALYSIS OF SEISMIC DATA FROM SMALL APERTURE ARRAYS AND LOCAL NETWORKS

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1. PROGRAM PACKAGE FOR 1-COMPONENT SEISMIC ARRAY DATA ANALYSIS

1.1. Program MARMAMO: multidimensional ARMA modelling of seismic array data

DESCRIPTION OF ALGORITHM

The program calculates parameters of autoregressive-moving average (ARMA) model for a multidimensional (vector) random time series. The ARMA model of vector time series $\boldsymbol{x}(t)=(x_1(t),...,x_M(t))^T$, $t=1,...N$, is a new random vector time series $\boldsymbol{y}(t)=(y_1(t),...,y_M(t))^T$ which satisfies the following finite difference equation:

$$\boldsymbol{y}(t) = \sum_{j=1,p}\{\boldsymbol{A}(l)\boldsymbol{y}(t-l)\} + \sum_{j=0,q}\{\boldsymbol{B}(l)\boldsymbol{e}(t-l)\}, \quad t=1,..,N, \qquad (1)$$

where $\boldsymbol{e}(t)=(e_j(t),...,e_m(t))^T$, $t=1,2,...,N$, is a zero-mean Gaussian random vector time series with zero correlation between $\boldsymbol{e}_k(t)$ $\boldsymbol{e}_j(s)$ for different s,t and variances equal 1 for all s,t; $\boldsymbol{A}(j)$, $j=1,...,p$ and $\boldsymbol{B}(j)$,are $(M\times M)$ matrices: AR and MA matrix parameters of time series $\boldsymbol{x}(t)$. These parameters are estimated to provide a fit of the statistical characteristics of model y(t) to the same characteristics of time series $\boldsymbol{x}(t)$. The matrices $\boldsymbol{A}(j)$, $j=1,...,p$ and $\boldsymbol{B}(j)$, $j=1,...,q$ are the output data of the program and are saved to disc files with specified names.

The particular cases of ARMA modelling are autoregressive (AR) modelling and moving average (MA) modelling. In the first case, one has $\boldsymbol{B}(j)=0$ for $j=1,...,q$, and $\boldsymbol{B}(0)\neq 0$. In the second case, $\boldsymbol{A}(j)=0$ for $j=1,...,p$. The program has several calculation modes providing different particular cases of ARMA modelling and different methods for calculation of AR and MA matrix parameters.

The program incorporates a subroutine for LOW-PASS filtering of input components (channels) $x_j(,t)$, $j=1,M$ by the Chebyshev filter (the same filter is applied to all channels). The frequency response of the filter is calculated inside the program for given parameters: cut off frequency, frequency response lope and resampling factor. Preliminary LOW-PASS filtering and resampling improves the fit of a time series by a multidimensional ARMA model in the case where the high frequency part of data spectrum (starting from some cut off frequency) contains much less power than the low frequency part. This case is a common one for applications in seismology. The resampling factor after filtering has to be chosen to provide a new Nyquist frequency of data to be as close as possible (but greater) than the filter cut of frequency.

The input vector time series x(t) are read into the program from the SNDA stack. An arbitrary sequence of channels can be chosen for subsequent processing.