NORSAR

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VII.5   Interactive analysis program for use with NORESS data

We have completed a flexible analysis program for processing the NORESS data in an interactive manner. This code will be used in coming months to assess the performance of the new regional array and to examine a variety of aspects of wave propagation in the region.

The program provides basic file manipulation and plotting functions. Data can be read into the program from standard NORESS tapes or from disk file images of the tapes. The program also has the capability of writing and reading data to disk files in its own format for temporary storage. The data storage part of the program is organized as a signal stack, that is, it is a first-in first-out push down stack, where entries on the stack are signals. Signals may be popped off of the top of the stack into the local-format files, or pushed onto the stack from those files.

The top of the stack is the reference point for all commands. The default operand for all unary operations is the top signal on the stack, and for binary operations the default operands are the top two signals. Usually, a command can be extended to apply to any number of operations, such as scaling, absolute value, square root, are provided as well as binary operations like addition, subtraction, multiplication, division of signals. These are pointwise operations. Basic filtering, spectral analysis, and array processing functions, such as stacking and FK calculations, are also incorporated.

Several canned plotting routines are available to plot trace data, array response patterns and FK spectra as contour maps or perspective drawings, power spectra, and maps of array geometry (Fig. VII.5.1 and VII.5.2). To a limited extent, the plots can be titled and labeled. The viewing window for the trace data plotting command is under cursor as well as keyboard control. This provides for convenient zooming on a

particular window and also for cursor selection of the analysis window for analysis functions that operate on some restricted domain of interest.

The code is command driven, rather than menu driven, to enhance the speed of interaction. A help command has been provided to list the available command options and syntax. A primitive macro facility exists as well, permitting groups of commands to be stored in external files and accessed with a single macro call (Fig. VII.5.3). Macro calls can be nested to a maximum depth of four, but may not be recursive.

A facility for storing temporary numerical and character values has been implemented. We have called this facility the "blackboard", although it is far from a blackboard in the expert system sense of the term. Blackboard entries are named, and they may be referred to by name as arguments to all of the commands in the program. Simple arithmetic and string manipulations can be performed on blackboard entries as well.

The purpose of the blackboard is to facilitate automatic processing of large amounts of data. Blackboard entries are useful for passing arguments to macros, effectively turning the macros into subroutines. This approach makes it possible to build up extensive and fairly sophisticated signal processing and measurement capabilities from the primitive operations supplied in the program. Our intent was to provide a flexible "breadboard" for trying new ideas that would also have the capability for production work with a new method, once that method had proved useful.

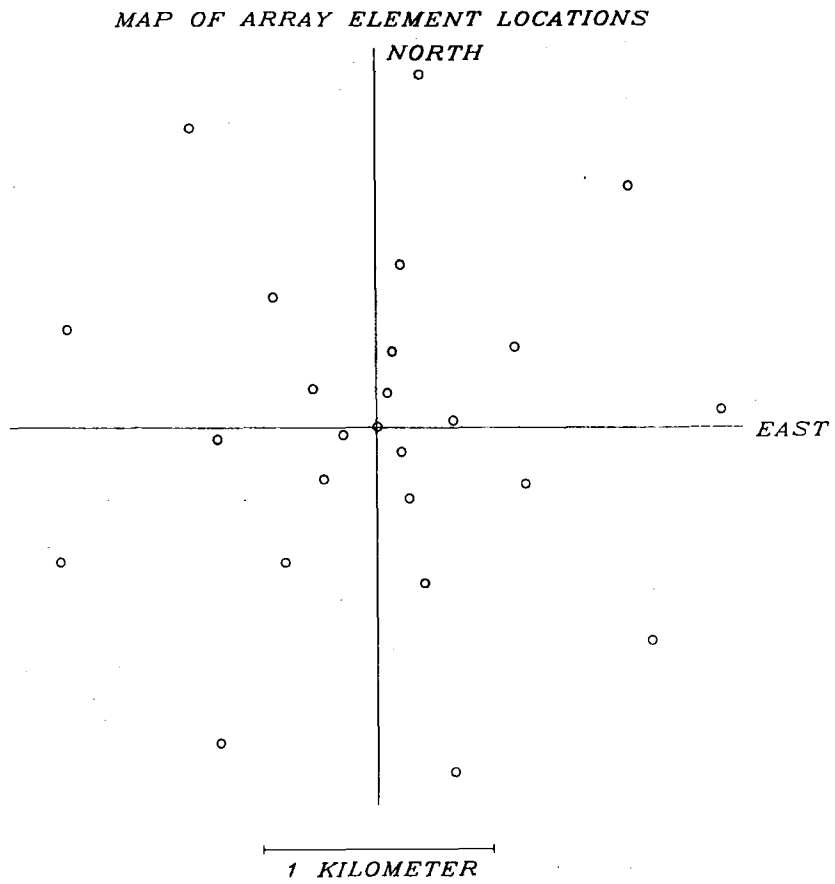D.B. Harris, Lawrence
Livermore Ntl. Laboratory
T. Kværna

MAP OF ARRAY ELEMENT LOCATIONS

Fig. VII.5.1 a) Locations of the vertical instruments of the NORESS
array.

THEORETICAL BEAMPATTERN
CONTOURS GIVEN IN DECIBEL BELOW MAX. PEAK
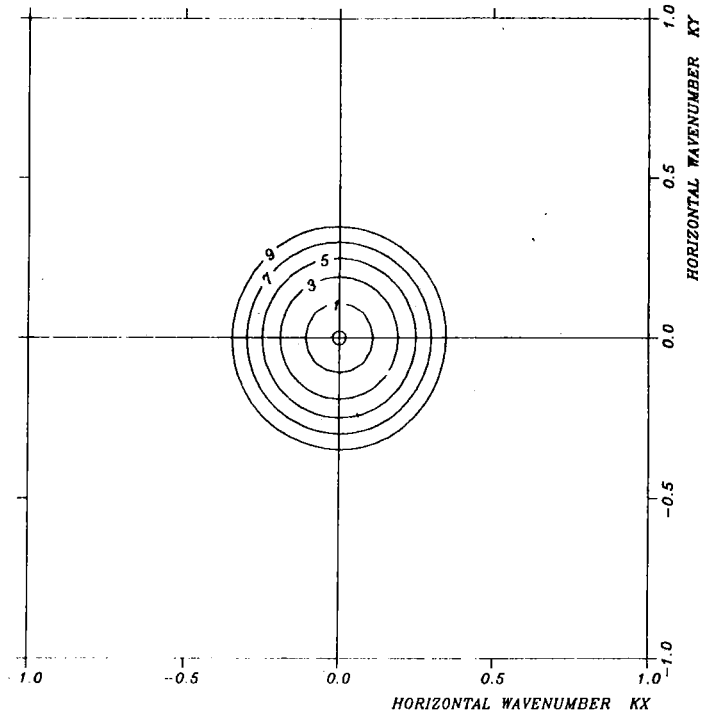

Fig. VII.5.1   b)   Theoretical beam pattern of the NORESS array.

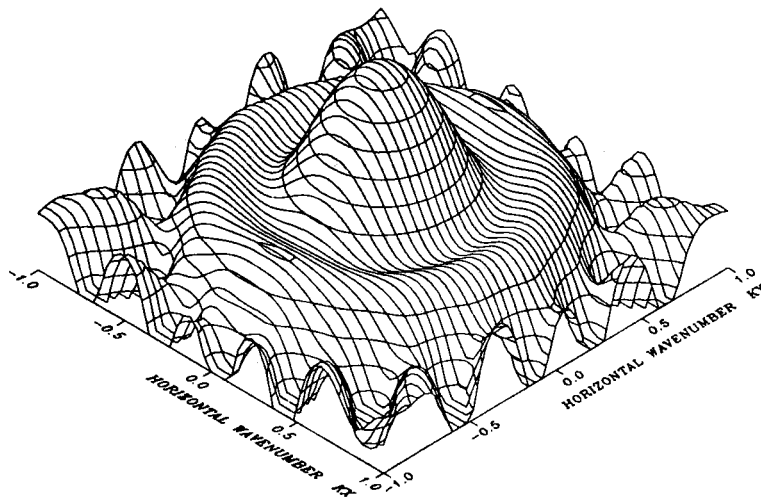THEORETICAL BEAMPATTERN
CONTOURS GIVEN IN DECIBEL BELOW MAX. PEAK

Fig. VII.5.1   c)   Perspective view of the theoretical beam pattern of the NORESS array.
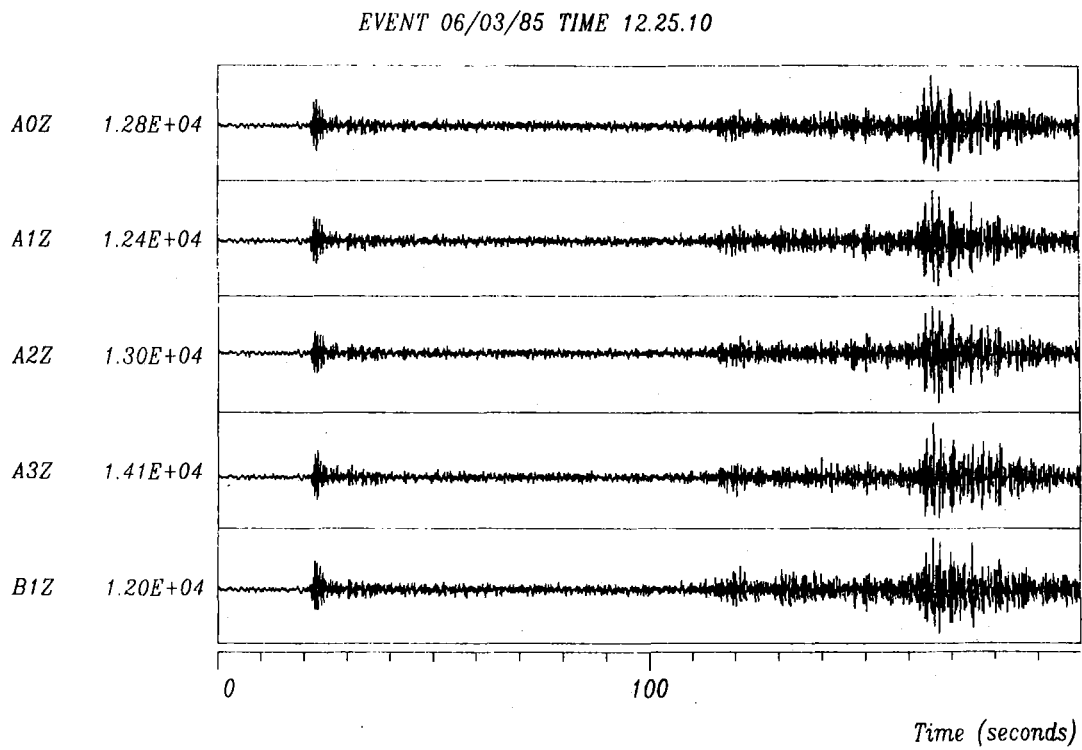
EVENT 06/03/85 TIME 12.25.10

AOZ   1.28E+04

A1Z   1.24E+04

A2Z   1.30E+04

A3Z   1.41E+04

B1Z   1.20E+04

0   100

Time (seconds)

Fig. VII.5.2 a) Example of regional event.

MONOCHROMATIC F-K ANALYSIS
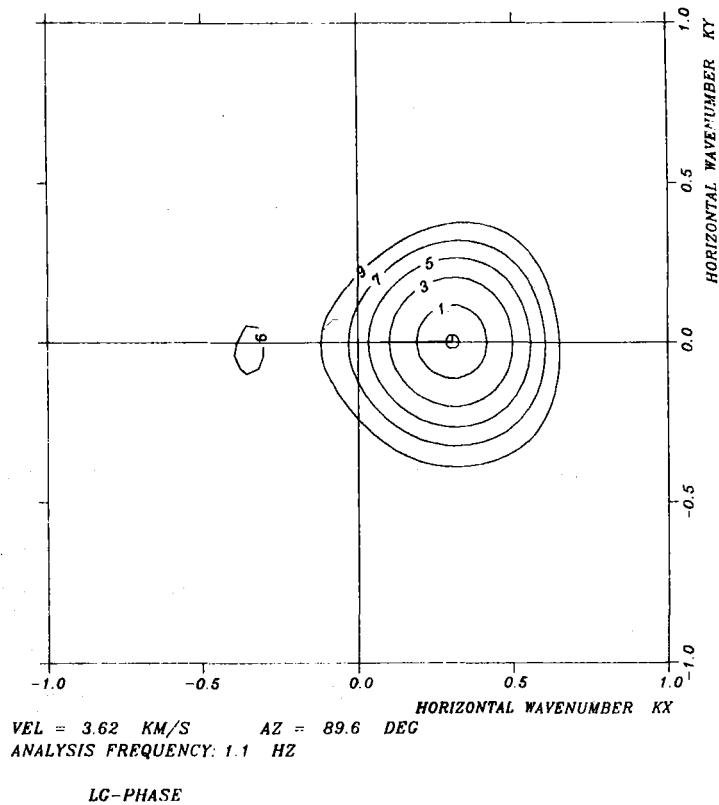CONVENTIONAL RESOLUTION
CONTOURS GIVEN IN DECIBEL BELOW MAX PEAK

VEL = 3.62 KM/S   AZ = 89.6 DEG
ANALYSIS FREQUENCY: 1.1 HZ

LG-PHASE

Fig. VII.5.2 b) F-k solution of the Lg phase of the event in Fig. VII.5.2 a).

SPECTRA FOR P, LG AND NOISE
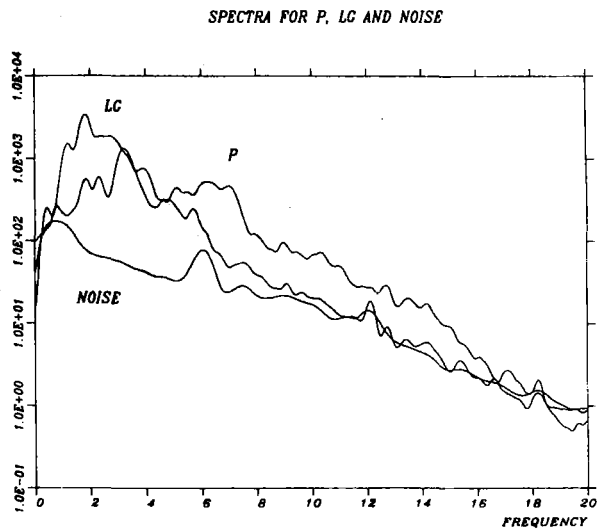
Fig VII.5.2 c) Spectra for noise preceding the P phase, the P phase and the Lg phase of the event shown in Fig. VII.5.2 a).

"   PW-SPECT   "

" MACRO TO PREWHITEN TOP STACK SIGNAL AND CALCULATE ITS SPECTRUM WITH "
"   THE EFFECTS OF PREWHITENING COMPENSATED FOR.   EFFECTIVELY   "
"   FLUSHES THE TOP STACK SIGNAL.   SPECTRUM ON TOP OF STACK.   "

```
 1
 2    PREWHITEN .
 3    SWAP .
 4    SETW ON :SIGNAL-START :SIGNAL-STOP .
 5    CUT .
 6    SETW OFF .
 7    WINDOW COSINE .
 8    PAD TO 1024 .
 9    FFT .
10    SQR 2 .
11    ADD .
12    SWAP .
13    FLUSH .
14    SWAP .
15    FFT .
16    SQR 2 .
17    ADD .
18    SWAP .
19    FLUSH .
20    SWAP .
21    DIVIDE .

22    TERMINAL .
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LOGIC OF THE PW-SPECT MACRO

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1 SIGNAL ON TOP OF THE STACK
  STACK: SIGNAL
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Fig. VII.5.3   PW spectra (page 1 of 3).

2 PREWHITEN .
   PREWHITEN THE THE TOP SIGNAL AND PUT THE PREWHITENING FILTER ON
   TOP OF THE STACK (1024 POINTS).
   STACK: PREWHITENING FILTER, SIGNAL

3 SWAP .
   SWAP THE TWO FIRST SIGNALS
   STACK: SIGNAL, PREWHITENING FILTER

4 SETW ON :SIGNAL-START :SIGNAL-STOP .
   SET ANALYSIS WINDOW ON THE SIGNAL TRACE . THE VALUES OF SIGNAL-START
   AND SIGNAL-STOP ARE CALLED FROM THE BLACKBOARD .
   STACK: SIGNAL, PREWHITENING FILTER

5 CUT .
   STORE THE PART OF THE SIGNAL WITHIN THE ANALYSIS WINDOW, ERASE THE
   REST .
   STACK: SIGNAL (NOW SHORTER), PREWHITENING FILTER

6 SETW OFF .
   SET ANALYSIS WINDOW OFF THE SIGNAL TRACE .
   STACK: SIGNAL, PREWHITENING FILTER

7 WINDOW COSINE .
   WINDOW THE TOP SIGNAL WITH A COSINE WINDOW .
   STACK: SIGNAL, PREWHITENING FILTER

8 PAD TO 1024 .
   INCREASE THE LENGTH OF THE SIGNAL TO 1024 POINTS BY ADDING ZEROS .
   NECESSARY TO MAKE IT COMPARABLE TO THE PREWHITENING FILTER.
   STACK: SIGNAL, PREWHITENING FILTER

9 FFT .
   TAKE THE FFT OF THE TOP SIGNAL AND STORE THE REAL AND IMAGINARY
   PART ON TOP OF THE STACK.
   STACK: SPECTRUM (REAL), SPECTRUM (IMAGINARY), SIGNAL, PREWHITENING
          FILTER

10 SQR 2 .
   SQARE THE TWO TOP SPECTRA .
   STACK: SPECTRUM (REAL), SPECTRUM (IMAGINARY), SIGNAL, PREWHITENING
          FILTER

11 ADD .
   ADD THE TWO TOP SPECTRA .
   STACK: ENERGY DENSITY SPECTRUM, SIGNAL, PREWHITENING FILTER

Fig. VII.5.3 PW spectra (page 2 of 3).

12 SWAP .
   SWAP THE TWO FIRST SIGNALS .
   STACK: SIGNAL, ENERGY DENSITY SPECTRUM , PREWHITENING FILTER

13 FLUSH .
   FLUSH OFF THE TOP SIGNAL .
   STACK: ENERGY DENSITY SPECTRUM , PREWHITENING FILTER

14 SWAP .
   SWAP THE TWO FIRST SIGNALS .
   STACK: PREWHITENING FILTER, ENERGY DENSITY SPECTRUM

15 FFT .
   TAKE THE FFT OF THE TOP SIGNAL AND STORE THE REAL AND IMAGINARY
   PART ON TOP OF THE STACK.
   STACK: SPECTRUM (REAL), SPECTRUM (IMAGINARY), PREWHITENING FILTER,
        ENERGY DENSITY SPECTRUM

16 SQR 2 .
   SQARE THE TWO TOP SPECTRA .
   STACK: SPECTRUM (REAL), SPECTRUM (IMAGINARY), PREWHITENING FILTER,
        ENERGY DENSITY SPECTRUM

17 ADD .
   ADD THE TWO TOP SPECTRA .
   STACK: ENERGY DENSITY SPECTRUM (PREWHITENING FILTER), PREWHITENING
        FILTER, ENERGY DENSITY SPECTRUM

18 SWAP .
   SWAP THE TWO FIRST SIGNALS .
   STACK: PREWHITENING FILTER, ENERGY DENSITY SPECTRUM (PREWHITENING
        FILTER), ENERGY DENSITY SPECTRUM

19 FLUSH .
   FLUSH OFF THE TOP SIGNAL .
   STACK: ENERGY DENSITY SPECTRUM (PREWHITENING FILTER), ENERGY DENSITY
        SPECTRUM

20 SWAP .
   SWAP THE TWO FIRST SIGNALS .
   STACK: ENERGY DENSITY SPECTRUM, ENERGY DENSITY SPECTRUM
        (PREWHITENING FILTER)

21 DIVIDE .
   DIVIDE THE TWO TOP SPECTRA POINT BY POINT TO ACCOUNT FOR THE EFFECT
   OF PREWHITENING.
   STACK: ENERGY DENSITY SPECTRUM

22 TERMINAL .
   RETURN FROM THE MACRO MODE .

Fig. VII.5.3 PW spectra (page 3 of 3).