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VII.5 NORESS noise spectral studies - system description

The NORESS noise spectral recording system has been developed to run unattended on the NORESS data recording computer, in parallel with the RONAPP processor (IBM 4341 with VM/CMS).

The idea behind the system is to systematically observe noise frequency spectra in order to determine characteristic features of noise over short and long periods of time. Moreover, the system will be able to observe noise beam suppression for different array configurations.

After some initial testing it was decided to use one minute of NORESS SPZ data to estimate noise spectrum and beam suppression, and to conduct the estimation on an hourly basis. As a procedure for spectral estimation we adopted the method described by Kværna et al in NORSAR Scientific reports nos. 2-84/85 and 1-85/86. The background for this was discussed in NORSAR Sci. rep. no 2-85/86.

A number of programs and procedures has been developed for this purpose. Overall, the spectral recording system is divided into 4 steps :

1. Search for one minute of noise data at a specified time.
This involves checking NORESS recording status, NORESS recording gap statistics and RONAPP event processing results.
2. Calculate spectra for individual channels and selected beams, and record the results.
3. Analyze the observed data and compile statistics.
4. Do regular backup of the observed data on tape.

Step 1. Search for noise intervals

To be sure to find a one-minute data interval of noise without interfering signals or data errors, 5 programs (CMS procedure language REXX) have been developed.

NORREC - reports NORESS recording time intervals. It may also be used to see whether a wanted time interval has been recorded.

NRSINT - reports NORESS current recording statistics and RONAPP processing times. It is also used to see whether a wanted time interval has been processed by RONAPP.

NORGAP - reports NORESS recording gaps. Gaps are of typical length 1 to 4 seconds. It is here used to see whether a wanted time interval has any recording gaps.

NORDET - reports RONAPP processing results, and detection lists. It is here used to see whether a wanted time interval has any reported detections. If so, the time is adjusted to avoid such signals.

NORSTL - reports NORESS communication statistics and other data quality statistics. It is used to see whether any individual channels should be avoided for a given time interval.

NRSONLIN is the main driving procedure. The previous time of spectral computation is read and is used to find a new time interval, one hour later, and on the hour. All the procedures above are then run to see whether the data interval is acceptable. If not, the selected time is incremented by three minutes, and the tests are run over again. When a time interval has been found, all the necessary inputs to the spectral system are created, and the procedure NRSSPC is executed. If the tests result in incrementation of time passed current RONAPP processed time, then the NRSONLIN procedure go to 'sleep' for a preset number of hours. When the wait time has elapsed, the procedure resumes all the checking procedures. The NRSONLIN procedure is programmed to either find noise after these

criteria, or detections. It has also been used to control programs that execute on detected signals only.

Step 2 . Calculate power spectra

NRSSPC is developed for calculation of power spectra for individual NORESS SPZ channels or beams. The calculation of spectra using the method of Kværna et al is performed in practice by linking the NRSSPC and DISPAT programs together. DISPAT is the interactive analysis program described by Harris and Kværna in NORSAR Sci.rep. No 2-84/85. The DISPAT program includes the use of macros to do specific calculation procedures. This has been adopted by the spectral system in such a way that data is presented to DISPAT together with name of the macro to be used for spectrum estimation. In this way we obtain flexibility in the calculation process.

The input to the spectral system program is mainly start time of analysis, length of data (one minute), channels and/or beams to use. An input file is easily set up to define the actual beam configurations. Velocity and azimuth may be given, and the velocity used so far is 999.9 km/sec which give zero delays (vertical beam or direct sum). The input file may give a name to each beam configuration, and list the channels to use. The beams currently used are as follows:

- BRING - 9 sensors, AOZ plus A-ring instruments plus B-ring SPZ instruments.
- CRING - 13 sensors, AOZ plus B-ring plus C-ring.
- TELEV - 17 sensors, AOZ plus C-ring plus D-ring.
- HIFRQ - 16 sensors, AOZ plus A-ring plus B-ring plus C-ring.
- INTER - 22 sensors, AOZ plus B-ring plus C-ring plus D-ring.
- ALLV - 25 sensors, All SPZ instruments.

Before doing any calculations, NRSSPC inspects whether the NRSONLIN process reported any channel as bad. If so, the configurations are automatically adjusted, leaving out possible bad data channels. Thereafter RMS is calculated for each individual SPZ channel. The individual values are compared to the mean value, and if a channel is more than two standard deviations from the mean, then that channel is excluded from analysis. The next step is estimating power spectra for each individual SPZ. The arithmetic average of all accepted SPZ channel spectra is called 'MEANZ'. The individual spectra are compared to the mean spectrum point for point (total 512 points in one spectrum). If 250 of the values for one channel is outside two standard deviations from the mean, then that channel is declared an outlier, and a new MEANZ is calculated. An outlier channel is also excluded from the beamforming. This technique of data quality control successfully masks outliers due to near-field weak events, bad data due to electronics failures and channels with numerous spikes. A channel with one spike (or few single spikes) will not be detected by this procedure, which has been in effect since day 154/1986.

After the masking procedure has been performed, all the selected beams are formed and spectra calculated. The program then record the data on disk files. The disk file names follow the general NORSAR rules for data files, where the name of the file defines both the content of the file and the time and date of the data. NORESS spectra files are denoted for example by SPC86277 1201350, where SPC identifies the content as spectra data, and the data were observed day 277, 1986 at 12.01.35.0.

During some time periods the borehole instrument FOZ has been used instead of AOZ. Until day-of-year 176, 1986 we recorded all the individual spectra. At present (november 1986), only MEANZ spectrum plus the beam spectra are recorded. In addition, spectra of the high frequency system NORESS HFSE, and the three component stations A0, C4 and C7 are recorded.

Step 3. Analyze the observed data and compile statistics

To find the characteristics of the data we have developed the program SPC. This program allows the analyst to plot any of the spectra for any time interval, and calculate noise suppression. Noise suppression is defined as the function $BEAM/MEANZ$, where BEAM is the spectrum of the actual beam.

All measurements are here reported in dB relative to one quantum unit squared, as sampled by the NORESS system. No corrections are done to determine ground motion, since the features we want to extract are the relative noise variations over time and beam noise suppression.

To report the content of this data, a standard procedure has been adopted. For every week we plot the following data, where the term 'versus time' mean that we plot exactly one week of data , and x-axis is 7*24 hours. The standard plots are:

- 1 Average noise RMS for NORESS SPZ instruments versus time.
- 2 NORESS HUB temperature versus time.
- 3 NORESS HUB average wind speed and maximum wind speed over one hour, plotted versus time.
- 4 MEANZ for selected frequencies versus time. Frequency bands are 0.4 - 0.6 Hz, 1.9 - 2.1 Hz, 5.9 - 6.1 Hz, 9.9 - 10.1 Hz, 14.9 - 15.1 Hz.
- 5 MEANZ for selected frequencies versus time. Frequency bands are 0.9 - 1.1 Hz, 2.9 - 3.1 Hz, 6.9 - 7.1 Hz, 11.9 - 12.1 Hz, 16.9 - 17.1 Hz.
- 6 BRING noise suppression versus frequency. All observations within week. BRING noise suppression average and standard deviation.
- 7 CRING noise suppression versus frequency. All observations within week. CRING noise suppression average and standard deviation.
- 8 CRING noise suppression for frequencies within 3.4 - 3.7 Hz versus time.
- 9 TELEV noise suppression versus frequency. All observations within week. TELEV noise suppression average and standard deviation.
- 10 TELEV noise suppression versus frequency. Only observations from 00 GMT.
- 11 TELEV noise suppression versus frequency. Only observations from 08 GMT.
- 12 TELEV noise suppression for frequencies within 1.9 - 2.1 Hz versus time.
- 13 INTER noise suppression versus frequency. All observations within week. INTER noise suppression average and standard deviation.
- 14 HIFRQ noise suppression versus frequency. All observations within week. HIFRQ noise suppression average and standard deviation.
- 15 ALLV noise suppression versus frequency. All observations within week. ALLV noise suppression average and standard deviation.

- 16 All HFZ power spectra for the week.
- 17 All HFN power spectra for the week.
- 18 All HFE power spectra for the week.
- 19 HFZ power spectra for 00 GMT hours only.
- 20 HFZ power spectra for 12 GMT hours only.
- 21 HFZ for selected frequencies versus time. Frequency bands are 4.8 - 5.2 Hz, 14.8 - 15.2 Hz, 47.3 - 47.6 Hz.
- 22 HFZ for selected frequencies versus time. Frequency bands are 5.8 - 6.2 Hz, 17.8 - 18.2 Hz.
- 23 HFZ for selected frequencies versus time. Frequency bands are 29.4 - 29.7 Hz, 19.9 - 20.2 Hz.
- 24 HFZ for selected frequencies versus time. Frequency bands are 0.8 - 1.1 Hz, 11.8 - 12.1 Hz, 34.9 - 35.2 Hz.
- 25 HFZ for selected frequencies versus time. Frequency bands are 0.3 - 0.7 Hz, 24.9 - 25.2 Hz.
- 26 HFZ for selected frequencies versus time. Frequency bands are 41.9 - 42.1 Hz, 2.9 - 3.2 Hz.
- 27 HFZ for selected frequencies versus time. Frequency bands are 49.8 - 50.1 Hz, 3.9 - 4.2 Hz.

The selected frequency bands have been chosen as a representative set.

Backup

Standard procedures for VM/CMS disk file backup are used to store the observed data on tapes.

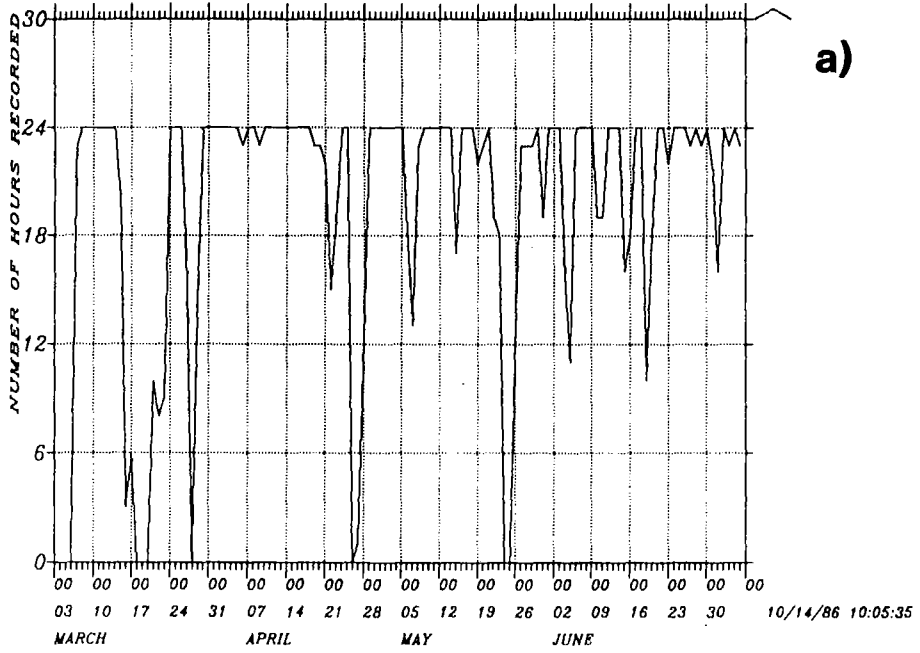
The NORESS noise spectral recording system as described here, has now been running since March 7, 1986.

Figs. VII.5.1a&b show the recording statistics for the spectral system.

J. Fyen

NORESS Spectral Recording Statistics

Days 62 - 187 1986



Days 181 - 278 1986

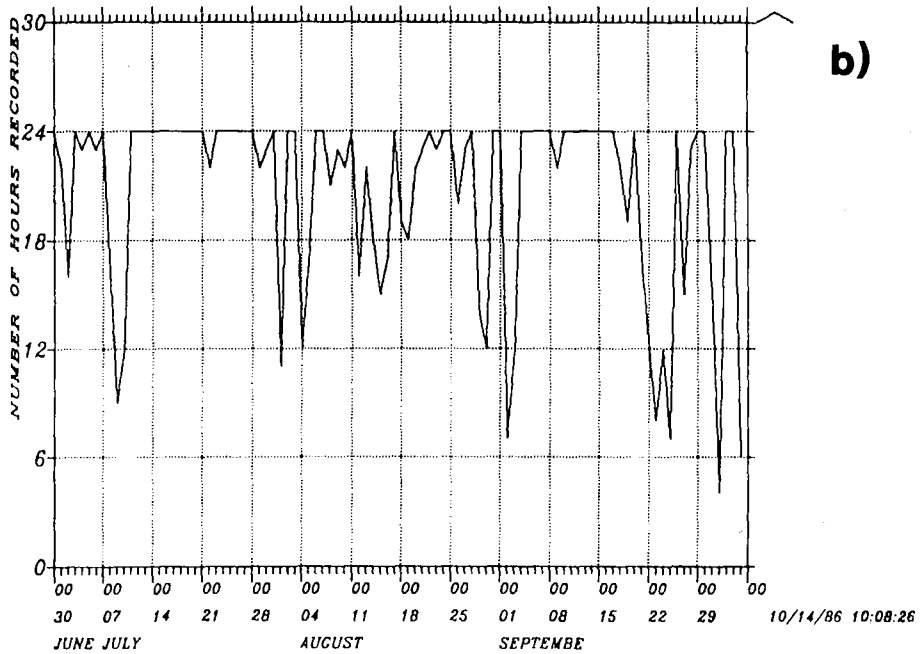


Fig. VII.5.1 NORESS noise spectral system recording statistics. The points plotted are number of hours recorded per day.