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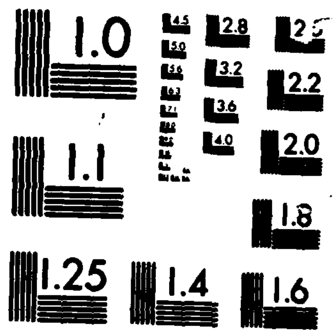

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AD-A166 394

Technical Report C86-02

March 1986

QUARTERLY TECHNICAL REPORT

FOR 1 APRIL 1985 - 30 JUNE 1985

Center Staff

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This report covers results from an international seismic data exchange test sponsored by the Group of Scientific Experts, U.N. Conference on Disarmament. It also reports on computer program development at the Center for Seismic Studies, on m_b bias as deduced from Soviet seismograms, and on noise levels and detection thresholds of seismic stations that particapated in the data exchange experiment. Keywords:

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1. FOREWORD

Commencing about December 1983, and continuing through the period covered by this report, the Center for Seismic Studies was heavily involved in planning, preparing for, and conducting the major part of the United States' technical activities associated with an International Seismic Data Exchange experiment. As described in previous reports, virtually all work conducted under this project by the scientific staff of the Center was devoted to this project, known as the Group of Scientific Expert's Technical Test, or GSETT. The main period of operational activities for the GSETT was 15 October 1984 through 15 January 1985, and the major descriptive documentation of the Center's activities was completed by March 1985. The reader is referred to the proceding quarterly report for more detail on Center-specific activities, and to the forthcoming report of the Group of Scientific Experts, UN Conference on Disarmament, for information on the test as a whole.

During this quarter work continued on documentation of the GSETT and on performing certain routine assessments, as will be described in Section 2 of this report. However, with the reduction in demands by the GSETT it was possible to direct a portion of the technical staff's efforts towards other objectives, as described in Sections 3 and 4 of this report. Section 3 outlines steps taken by Mike Tiberio to make the SUN 2 computers at the Center more useful for conducting seismic analysis. Section 4 gives abstracts of research conducted by members of the staff in two areas. Alan Ryall's short report on m_b bias at Soviet seismic stations documents work initiated at the University of Nevada and completed at the Center as a visiting scientist and later as a member of the staff. Hans Israelsson's short report on noise levels and detection thresholds at GSETT stations represents the initial steps of a larger research project directed toward exploiting the excellent GSETT database for research on a variety of problems of interest to nuclear test monitoring. Both of these topics are the subject of separately published detailed reports, C86-03 and C86-04.

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2. GSE TECHNICAL TEST (GSETT)

2.1 Summary of Activities

The GSETT was completed in a formal sense during the previous quarter (on 15 January 1985), and rather complete reports describing the experiment and its major results were prepared for use by the U.S. delegation at the March meeting of the Group of Scientific Experts (GSE). However, a number of follow-up activities continued throughout this quarter that can be considered either as part of the experiment itself, or as part of the documentation of the experiment. Some activities of this nature were initiated in response to needs of the GSE in preparing its formal report to the Conference on Disarmament, and some were initrated by the Center and DARPA technical staffs as part of the process of conducting more thorough evaluations of the experiment. Highlights of these activities included:

- A tape was received from the Experimental International Data Center in Stockholm, Sweden, containing the complete set of Level I data messages received during the GSETT. Programs were written to merge this new data with that received at the Center (after purging duplicates). The new consolidated data set was then parsed and installed in an Ingres database.

- Using this combined database, analyses were conducted of the reported noise levels from the participating GSETT stations. Individual station "spectra" (average noise amplitudes at each period) were prepared. These results were then supplied to Dr. Robert North, Energy, Mines and Resources Canada, for inclusion in the GSE report.

- Logs of data messages received at the Moscow Experimental International Data Center were obtained. The information contained therein, together with the tape from Stockholm, provided a complete list of all messages received at the combined EIDCs.

- Analyses were conducted of the combined Level I database to produce statistics on transmission effectiveness of the Global Telecommunications System of the World Meteorological Organization. These statistics showed the numbers of messages received on the first transmission, as well as those received after retransmission, from each participating country. Programs were also written to determine the total amount of seismological data received, based on "begin" and "end" statements contained in the messages.

- Studies were initiated to evaluate the adequacy of the automatic event detection (the "DP" and "PDP") programs employed by the Center during the GSETT. As part of these studies, programs were written to "window" waveform segments containing P-Waves, to scale them arbitrarily in amplitude, and to blend signal and noise samples.

- Preliminary analyses of the detection threshold of individual stations and of the total GSETT network were conducted.

Details on several of these and other activities are contained in the following portion of Section 2 of this report.

2.2 Routine Data Processing Software Developed for GSETT

During the GSETT experiment the Center was run for the first time as a fully operational seismic data processing center. While most of the basic modules necessary to perform the required technical analysis had been developed over the years, many scripts had to be written for managing and preprocessing the data for proper input to the analysis programs and to insure a smooth operation. In addition to these scripts, some new software had to be written to handle those aspects that were unique to the test (i.e., Level I parameters). This report outlines those scripts and programs that were written solely for the test, and explains how they fit into the data flow and how they work.

The following table identifies these scripts and programs and provides an indication as to where, why and how each was used.

NAME	?DC	SCRIPT	MACHINE	FUNCTION
SUN3	ndc	yes	vax	capture wf's, run llp build tapes
cutarr	ndc	yes	vax	eliminate RSNT and RSCP from flow
reqsun	ndc	yes	vax	build archive tape request for sun
arr2sunreq	ndc	yes	vax	generate sp/mp request from arrivals
lpreq	ndc	yed	vax	generate continous lp request
sunarc	ndc	no	vax	write archive tape in SUN integers
llp	ndc	no	vax	generate Level I parameters
setup	ndc	yes	sun	make directories and get arrivals
dmparc	ndc	yes	sun	check disc arrivals, run sundmp
GPM	ndc	yes	sun	drives gpm program
gpm	ndc	no	sun	graphical parameter measurement
ppp	ndc	no	sun	post parameter processing
send	ndc	no	sun	generate wmo messages
PRS	idc	yes	vax	check for unparsed msgs, run parser
CHK	idc	yes	vax	check quality of parser output
MAD	idc	yes	vax	make a script to load parsed data
OTH	idc	yes	vax	find and parse telex messages
MAA	idc	yes	vax	make a script to load telex data

To function as a "National Data Center" it was necessary to tap into our routine archives to obtain data. SUN3 is a very large script that performs many functions. First it logs the standard continous data archive tapes. This allows the data to be segmented later. Once the detector and post detector processing has been completed, the data can be segmented. This requires that the segments be obtained from the continous archive tapes. Data from two of the five seismic stations received on-line at the Center, RSCP and RSNT, were not analyzed during the test and the cutarr script removed them from the "dearchive" arrival file. The reqsun script builds this dearchive request. Reqsun calls arr2sunreq which turns the detector calls into requests for short period (sz,sn,se) and mid-period (mz,mn,me) data. The long-period data is not segmented, and lpreq builds a request for the continuous lp data. These segments are then written to an archive tape using a special version of the archiver (sunarc) that writes SUN integers on the tape rather than VAX integers. This saves the SUN from having to do it, and reduces the total amount of time, overall, for the data transfer. Lastly, before the segments are removed from the VAX, the Level I parameter processor (llp) is run. This program supplements the standard arrival file with records indicating estimates of M1X, M2X, NSZ etc. After this step the data is removed from the VAX and the data tapes carried to the SUN. The analyst, before reading the tapes, would run the script setup in order to retrieve, over the net from the VAX, the necessary arrival files. Setup would also build the proper directory tree structure so that when the tapes are read, directories will exist for the data. Once the tapes were mounted on the SUN tape drive, the analyst ran the script dmparc. Dmparc, before reading the tape, would check and make sure that sufficient room existed on the disc. Once the disc space checked out, dmparc would run the program sundmp, which would actually build the waveform database on the SUN. Once the database is built, GPM can be run. GPM the script runs gpm the program, taking care of some bookeeping along the way. After analysis, ppp, the post parameter processor, was run, insuring that the work performed conformed to normal seismic rules and also that it conformed to rules set out by the GSE concerning their special parameters. Once checked out, the script send, which calls the program wmo, generated messages WMO/GTS format from the Center database files.

To function as an "International Datacenter", numerous large parameter files had to be manipulated. What follows is a detailed description of the scripts written to handle these files. PRS is a script that would allow the user to parse incoming WMO seismic messages, either interactively or in batch mode. Normally the user would run the files through in batch mode, which would allow all the error free files to be parsed and would leave all the files containing errors unparsed. The user would then parse the erroneous files interactively, editing out the errors so that the files would parse. PRS would first search for messages with invalid or missing arrival files. This list of undone messages was then processed. After all the messages were parsed, the script CHK would check the arrival file produced by the parser for common errors. Non-unique arrival identification numbers or non standard record lenghts are sufficient to corrupt the database and thus were not allowed to pass.

Any messages producing such files were corrected and reparsed. Once all the files checked out it was necessary to load the files into the database. The script MAD produced a script to do that. Special scripts to handle telex messages and those messages whose headers were so corrupted that they could not be classified, were needed. OTH and MAA perform tasks similar to PRS and MAD.

M. A. Tiberio

2.3 Formation of the Combined WashIDC/StocIDC GSETT Database

A new database called GSETT was created to store seismic parameters reported during the experiment. The database as it presently stands consists of a number of tables that contain the parsed equivalents of the WMO messages received during the experiment. It was necessary to use four tables to hold the data contained in the GSETT messages. They are stalog, arrival, feature and extra. Initially the GSETT database contained only the data that was received by the Washington Experimental International Data Center (WashIDC). Also, only those messages that were deemed to be non-duplicates were loaded into the database. Messages received prior to a cutoff time of 0600 UTC on the date that a Preliminary Epicenter List (PEL) was to be calculated were parsed once daily and loaded into the database. Thus at the end of the experiment, the GSETT database contained all the WashIDC contributions. It was noticed that when message coverage was compared between the WashIDC and StocIDC, there were a number of messages received by only one data center. The following table shows how many messages were unique to each IDC and how many were jointly received. These numbers reflect total numbers received, not unique messages received.

	# messages total	# duplicated	# unique
WASHIDC	3023	3019	4
STOCIDC	3330	3152	178

One can see that Stockholm received 174 more messages than did Washington. In order to make a more complete GSETT database, the Stockholm dataset was obtained and distributed into a directory tree that paralleled the one used during the experiment.

Once the missing messages were identified, the duplicates within this list were removed, resulting in 98 unique new messages being parsed and loaded into the GSETT database. Most of the messages received by Stockholm but not by Washington were from SEAG (Argentina), SEAU (Australia), SECN (Canada), SEIN (India) and SEZB (Zambia).

M. A. Tiberio

2.4 Upgrades to the International Seismic Code

An important aspect of the GSETT was the design and implementation of many new procedures. Conventional procedures for measuring signal parameters were refined and new ones were added. Also, new message conventions were needed for reporting these data (Conference Room Paper 134/Rev .1, Procedures for the GSE Technical Test, 1984). Many of the specially designed procedures used during the test have application to conventional seismological practice. This section reports one such example, namely improved message conventions for reporting seismic data.

Following the GSETT, Drs Gerald Frazier from the Center for Seismic Studies and Peter McGregor, the test coordinator from Australia, met with the Working Group on Telegraphic Formats, Subcommission on Data Exchange of the IASPEI Commission on Seismological Practice to upgrade standard message conventions, i.e., the International Sesmic Code (ISC). The 1985 version of the ISC resulted from this meeting, subsequent correspondence and the considerable efforts of Jerry Dunphy and his colleagues at the U.S.G.S. National Earthquake Information Center who prepared the actual code documentation. This new code accommodates essentially all of the special GSE parameters and includes the benefit of further refinements identified during the test.

The special procedures used for encoding GSETT messages were derived from the then current convention, ISC version 1979. The GSE message conventions were developed in an attempt to specify unambiguous message formats in a way that was not easily misunderstood, and to make provisions for all relevant data. To minimize conflicts with the current conventions, several of the GSE extensions were implemented as comments, isolated from the formatted data by double sets of parentheses. These unobtrusive extensions to the message convention included such relevant data as: message identification (i.e., GSETT), message originator, identification of special message types (i.e., bulletins), time interval covered by each station report, data outages during this interval, and the analyst's interpretation of recorded events. With the exception of the analyst's interpretation of recorded events, the 1985 version of the ISC now accommodates the above information in the formatted portion of the message rather than in comments as was done in the GSETT. Concern was expressed that the particular set of GSE key words that were used to enter the analyst's interpretations could lead to omissions of relevant measurements, and this procedure was not adopted.

In preparation for the test, new phase identifiers were defined for encoding non-standard data, and provisions were made for identifying the recording channel from which the data were extracted. Special effort was required to provide meaningful, unambiguous identifier names. Among the alternatives that were considered was an attempt to append letters to the conventional phase identifiers to explicitly specify the recording channel, i.e., the instrument response band (S,M,L) and the directional component (Z,N,E). However, we found that, when these two-letter combinations (SZ,SN,SE,MZ,ME,LZ,LN,LE) are appended as suffixes to the common phase identifiers (P or S), over half of the resulting three-letter combinations coincide with one of the many station abbreviations. This particular scheme was abandoned in favor of an alternate procedure that avoided these ambiguities. Special characters have now been defined in the new ISC to completely specify the channel, both the frequency band (i.e., instrument class: SP,LP,MP,BP,UP) and the directional component (Z,N,E).

Further ambiguities with station abbreviations were noted. Half of the three-letter abbreviations used to denote the month-of-year coincide with a station abbreviation, and message context is required to distinguish the two. The 1985 version of the ISC has mostly alleviated such ambiguities by requiring:

> "A colon (:) must be prepended to a station or net abbreviation whenever the abbreviation is identical to a phase code or symbolic identifier used in the International Seismic Code."

This action will simplify the computer task of decoding messages and enhance the reliability of data exchange. Added reliability could have been achieved by requiring that a colon be prepended to all station names. However, such a requirement was not made in the new ISC so as to maintain compatibility with messages prepared according to the earlier 1979 code, which has no provisional characters for identifying stations apart from their unique abbreviations.

The desirability of special characters (e.g., : or /) and message delimiters was recognized during the planning stage of the test, and some provisions were made. Again, to minimize conflicts with the current conventions, no special characters were used, but spaces, carriage returns and double carriage returns plus station abbreviation and date were required to separate parameters, phases, and events, respectively.

Execution of the test enabled us to evaluate the special message conventions and to identify further improvements. An average of about 50 messages were decoded per day using an interactive computer parser developed at the Center in preparation for the test (see the preceding quarterly technical report). The parser was designed to perform a sequence of tests to verify the identification of parameters in the message. When problems were encountered, the parser displayed the message contents in the near vicinity of the problem, identified the discrepancy, and placed the analyst's keyboard in an edit mode with the screen cursor positioned on the apparent error. Otherwise, the parser proceeded to decode messages and write the data in database-formatted files, operating in a fully automatic mode.

To resolve non-unique constructs the parser was equipped with numerous context flags to portray recognizable information before and after the ambiguous data. The required spaces, carriage returns and station delimiters proved quite useful for identifying local context and to aid in resolving potential ambiguities. Overall, the messages were well formatted, and the participants should be commended for the care that was taken to implement the new procedures. Nevertheless, nearly half of the messages contained an irregularity that required analyst intervention to fix. The large majority of these computer-identified problems were resolved either by accepting the algorithmic assumptions or by implementing obvious fixes, e.g., dropped or substituted characters (e.g., an"I" used for a one or an "O" used for a zero). About two hours of an analyst's time was generally required each day to decode the messages depending on the number of irregularities that were encountered and the computer load from other jobs.

Pathological cases were encountered that were not easily resolved, and added levels of sophistication were implemented during the test to handle some of the peculiar constructs. Spaces, inserted or omitted at unusual places within the message, posed a particular challenge. To automatically decode such data is cumbersome and unreliable, and correcting this data involves experienced human judgement. It became apparent that much of this awkward dilemma could have been avoided through the use of special characters to delimit sub-message constructs.

The 1985 ISC has taken important steps to improve the message formats used for exchanging data. In addition to the extensions already noted, the new code specifies spaces and carriage returns to delimit several types of data, and a comma (,) is now used to separate first motion parameters measured on short period and long period channels. Special characters have been designated to delimit reported events (BEGEV, ENDEV and /). Several new phases have been defined, akin to the GSE parameters, including maximum signal amplitude and pre-signal measurements of ground noise.

Overall it appears that the GSETT has provided valuable information for upgrading the standard ISC message conventions. Although many of the new features are optional, their universal adoption would greatly simplify the task of message decoding and provide improved reliability for exchanging seismic data.

G. Frazier

2.5 Further Analysis of Level I Data Transmissions Received over WMO/GTS

The preceding quarterly technical report contained rather complete reports of GSETT messages received over the Global Telecommunications System of the World Meteorological Organization (WMO/GTS). While useful for generating statistics on transmission efficiencies, these reports did not give a clear picture of a crucial aspect of the test: how much seismic data was actually available at the Experimental International Data Centers (EIDC) for use in detecting seismic . events?

To investigate this question, programs were written to determine, for each contributing station, the time intervals for which data was received by one or more of the EIDCs. Station outages of less than 6 hours were not counted as missing for purposes of this study. The results were then used to determine the percentage of time during the test for which data were received from each station, as well as the percentage of data received for each day during the test.

The attached table gives the percentage of time for which data reported from a participating station was received over the WMO/GTS at any of the three EIDCs. For over one half of the stations participating in the GSETT, reports were received which covered at least 95% of the time of the test. As expected, there is a strong correlation between those stations having a large fraction of their station data missing and the less efficient circuits of the WMO/GTS as revealed in the study included in the preceding quarterly technical report. The effective transmission rates for South America, Africa and New Zealand never exceeded 20%, even accounting for retransmission which had an insignificant effect on these circuits. Loss of this data is of particular concern in view of the sparsity of seismic stations in these regions. The combined effect was a relatively poor signal detection capability for these regions during the GSETT.

Figure A is a chart of the overall availability of the combined set of data from the GSETT network received at one or more of the EIDCs. The daily average availability of data from the stations in the whole GSETT network was 72% during the Test. The data on which these statistics are based was compiled at the conclusion of the GSETT; thus the percent availability indicated represents a maximum after retransmission and is not indicative of the amount of data available for calculation of the Preliminary and Final Event Bulletins, which may have been considerably less. A surprising result is that the overall availability of data at the EIDCs did not improve during the GSETT. This lack of improvement is indicative of chronic problems with certain WMO/GTS circuits during the test due to either poor connections with national facilities or poor quality communication circuits.

LEVEL I DATA FROM STATIONS
(VIA WMO/GTS COMMUNICATIONS)
October 27 - December 14, 1984

Country/Station	No. of Days of Level I Data	Percent Coverage	Country/Station	No. of Days of Level I Data	Percent Coverage
ARGENTINA			INDIA		
BAA	5.0	10	GBA	47.2	96
LPA	10.5	21	INDONESIA		
AUSTRALIA			AAI	26.5	54
ASPA	49.0	100	JAY	7.7	16
CTAO	48.2	98	KSI	6.0	12
MAW	48.2	98	KUG	14.0	29
NWAO	47.7	97	PSI	17.7	36
AUSTRIA			TRT	15.5	32
KBA	49.0	100	IRELAND		
BELGIUM			DKM	47.2	96
DOU	47.5	97	ITALY		
UCC	46.2	94	MNS	46.5	95
BRAZIL			RMP	46.5	95
BDF	17.5	36	JAPAN		
BULGARIA			MAT	48.2	98
VTS	42.7	87	NETHERLANDS		
CANADA			DBN	49.0	100
GAC	49.0	100	ENN	49.0	100
MBC	49.0	100	NEW ZEALAND		
YKA	49.0	100	RAR	6.5	13
COLOMBIA			SBA	6.2	13
BOG	0.7	1	WEL	2.5	5
CZECHOSLOVAKIA			NORWAY		
KHC	49.0	100	NAO/NB2	49.0	100
PRU	49.0	100	PERU		
DENMARK			NNA	28.2	58
COP	41.7	85	ROMANIA		
DAG	41.0	84	MLR	19.7	39
GDH	28.5	58	SWEDEN		
EGYPT			HFS	49.0	100
HLW	4.2	9	APO	49.0	100
FINLAND			SLL	49.0	100
NUR	49.0	100	TBY	49.0	100
SUF	49.0	100	U. S. S. R.		
FRANCE			OBN	49.0	100
LOR	44.0	90	U. K.		
PMO	11.7	24	EKA	48.0	98
GERMAN DEM. REP.			U. S. A.		
MOX	47.5	97	LAC	49.0	100
GERMANY, FED. REP.			LTX	48.0	98
GRF	49.0	100	FBAS/FBAL	49.0	100
HUNGARY			RSNY	49.0	100
BUD	45.2	92	RSON	49.0	100
JOS	45.2	92	RSSD	49.0	100
PSZ	45.2	92	ZAMBIA		
			LSZ	37.2	76

Outages within message periods are not included.

Total Level I data from each station based on data set combined from all EIDC's at conclusion of GSETT.

There was an appreciable difference in the average transmission effectiveness of the WMO/GTS circuits in the Northern Hemisphere as compared to those in the Southern Hemisphere. This is directly reflected in the availability of data at the EIDCs from stations located in these areas. Figures B and C show the overall data availability, after accounting for retransmission, at one or more of the EIDCs from stations in the Northern Hemisphere and the Southern Hemisphere respectively. It is seen that, on the average, 89% of the data from stations in the Northern Hemisphere were received by at least one EDIC. For stations in the Southern Hemisphere, the average data availability was only 44%. By contrast, those national facilities from which more than 95% of the messages were received were almost exclusively in the Northern Hemisphere. Australia was the only exception to this. The efficiency of the WMO/GTS and the high density of stations in North America and Europe resulted in a relatively good signal detection threshold for these regions.

L. Huszar
C. Romney

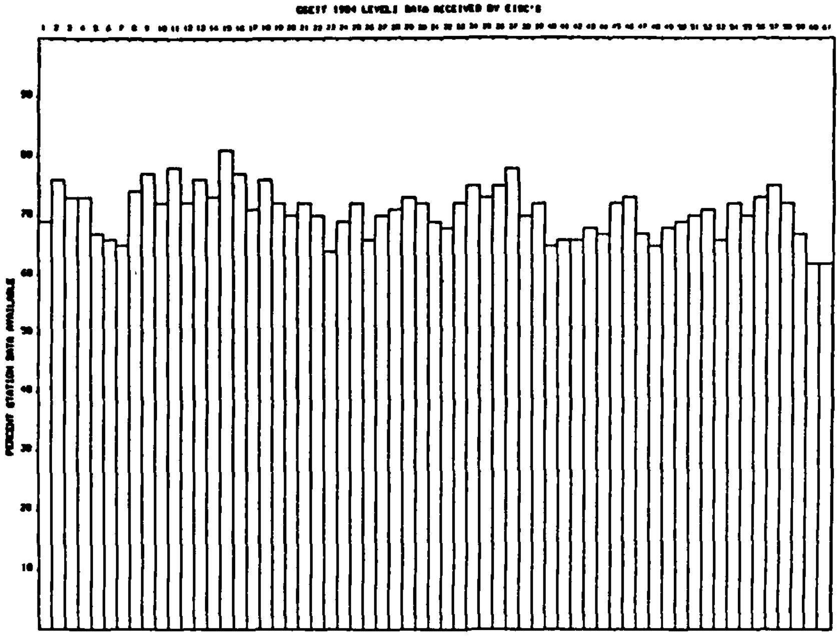

Figure A Overall Network Data Availability of Combined EIDCs. Vertical columns indicate the percentage of participating stations whose reports were received during each day of the GSETT.

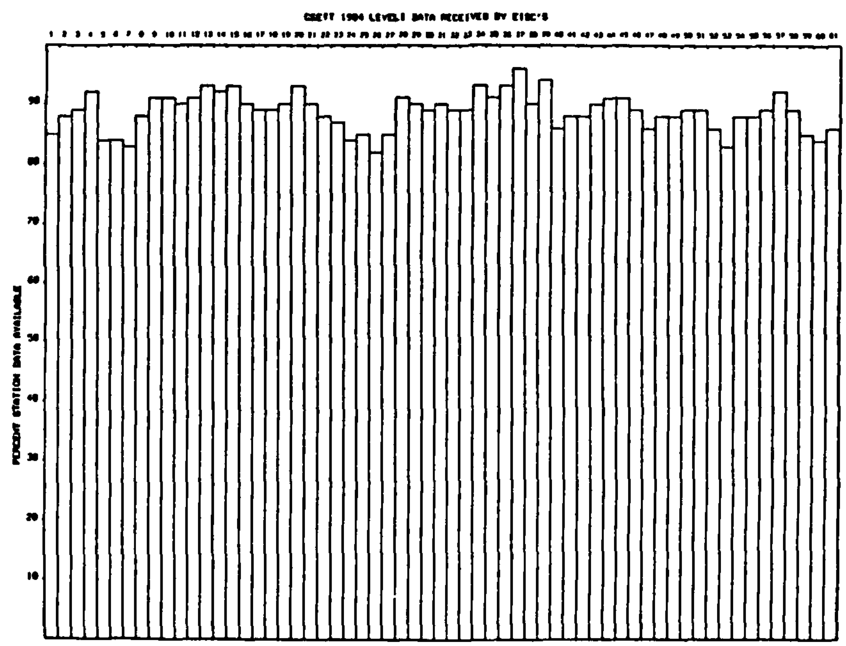

Figure B Data Availability of Combined EIDCs from Northern Hemisphere Stations (excluding Bogota).

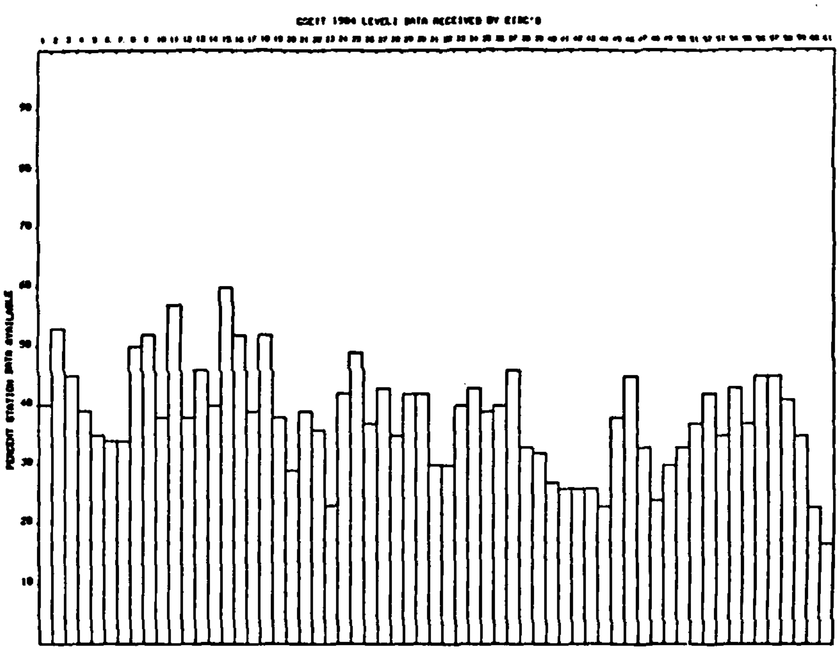

Figure C Data Availability of Combined EIDCs from Southern Hemisphere Stations (including Bogota).

2.6 GSETT Network Detection Threshold Inferred from Earthquake Recurrence Curves

Final Epicenter Bulletins from the Experimental International Data Center (EIDC) in Washington, Stockholm and Moscow were calculated and transmitted to all participants during the GSE Technical Test (GSETT). According to the GSETT instructions, all EIDCs should have used a common program for associating the events reported by the participating stations and for calculating the formal parameters of located events. Given the same data reports, the calculated epicenter lists should have been identical. Some of the associated reports would have resulted in spurious "events" because of imperfections in the Automatic Association (AA) program, but with coordination among the three EIDCs, presumably these could have been weeded out, and identical final epicenter lists would have been produced.

In practice, there were differences in the analysis programs among all EIDCs (although programs used by Washington and Stockholm differed in only minor ways), and the EIDCs were unable to reconcile final bulletins throughout most of the test because of the heavy workload involved. Hence, there were substantial differences between final epicenter lists produced by Moscow and the other EIDCs, and fewer (but still significant) differences between those produced by Washington and Stockholm. Perhaps the most notable difference was in the total numbers of events located -- Moscow located appoximately 450 whereas Washington and Stockholm located somewhat more than 900 events.

While further analyses are needed prior to drawing firm conclusions, the numbers of located events as a function of magnitude appear to be sufficient to give a first estimate of the detection threshold of the GSE network, as it operated during the test. Forming the earthquake recurrence curves in the conventional way (see figure D) it may be seen that for magnitudes in the range above about $m_b = 5$:

$$\log N_c = a + b\, m_b, \text{ and}$$
$$\log N_i = c + b\, m_b$$

where N_c is the cumulative number of events larger than a given magnitude and N_i is the incremental number of events at a given magnitude. The slope, b, is near -1 as usual. The detection threshold is indicated by the magnitude at which the observed numbers of events depart from the formulas above.

As inferred from Figure D, the detection threshold for worldwide events during the GSETT was slightly above m_b 4.5,including all effects of seismic station noise conditions, reporting practices at the stations, data transmission losses, and analysis programs and procedures in use at the Washington and Stockholm EIDCs. Using programs and procedures in effect at the Moscow EIDC, the threshold was slightly above m_b 4.8.

C. Romney

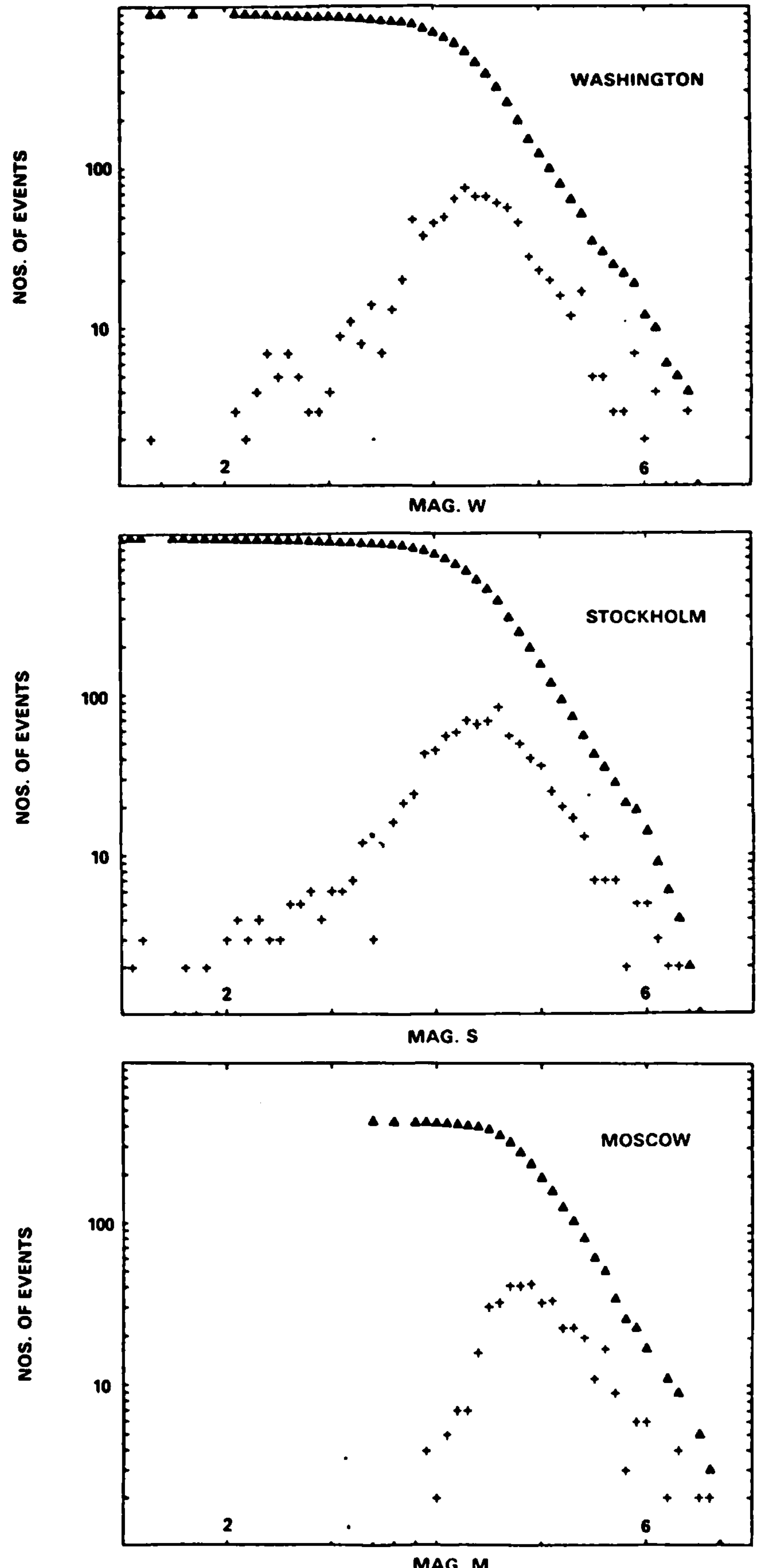

Fig. D
INCREMENTAL AND CUMULATIVE RECURRENCE CURVES FOR GSETT.

3. SUN SYSTEM DEVELOPMENT

3.1 New data Retrieval Software Available on the SUN Microsystem

In an attempt to take advantage of the latest developments in UNIX networking, we have developed the software necessary to allow, from our SUN computer, access to resources normally available only from a VAX computer. One limitation of the moderately priced SUN systems is the lack of high density drives which allow reading of Center archive tapes. Libraries exist that permit a program on the SUN to use tape drives on another machine on the same local area network. However, before tapes can be read, data requests must be built and to do so requires access to databases. These databases are normally available to users while logged into the computer that is host to the database. Through the use of the rsh (remote shell) command we can access these databases and retrieve data across the local area network.

One script and one program have been developed to handle these tasks. The script, described in simplified form below, builds a dearchive request from a given database (RSTN84) for a given event (ekaz.origin) both specified by the user. In the following example we will assume the user is attempting to build a local database ekaz.

```
(get the date for the event from the first column of the origin file)
set DATE = "awk"§print $1† "ekaz.origin"

(retrieve wftape records from RSTN84 on hugo into file ekaz.wftape)
rsh hugo cpout RSTN84 wftape "w.date=$DATE" >ekaz.wftape

(predict arrivals and make waveform request files)
predar -aw -s ekaz.segrules -p ekaz -t ekaz

(compress waveform request)
cmpreq ekaz ekaz

(build dearchive request)
dareq ekaz ekaz
```

When the above script is completed the most important file created will be ekaz.wdareq. This file drives the program which dearchives the data. This new program, rdetwo (for Remote DETWO), is a version of detwo with subroutine calls to the remote tape library replacing the calls to the normal tape library. The program has the same command line syntax as detwo, except that when a remote tape drive is desired, the device name must be preceeded by a machine name. For example: rdetwo -i hugo:/dev/rmt0 -r ekaz. The above command line when issued on the SUN will build a waveform database ekaz from data read from drive zero on HUGO.

Since the VAX and the SUN have different representations for 32 bit integers it is necessary to convert the data words before they are written onto disc. Rdetwo handles this automaticaly and silently. The end result of this session is a suite of files that comprise a local official Center database. The suite of files includes a number of ".w" files, that is, files with names like ekaz.1.w, ekaz.2.w, etc. An index for the waveforms exists in ekaz.wfdisc, while the predicted arrivals are found in ekaz.arrival. Ekaz.assoc links the arrivals to ekaz.origin. The arrivals were predicted and waveforms segmented based on the content of ekaz.segrules. Ekaz.wftapes contains indexes to all the waveforms archived for the day the event falls on, while ekaz.wfreq and ekaz.wdareq are waveform request files, desired and doable respectively. At this point the database is ready to be used by any number of official Center programs.

M. A. Tiberio

3.2 Center Standard Software Now Available on the Sun Microsystem

With the acquisition of new SUN Microsystems Computers, the processing of seismic data can now be downloaded from the VAX to the SUN. Since both machines share a 32 bit data word and both run Berkeley UNIX version 4.2, transfering programs is not as difficult as it would be to, say, move the same programs to a 16 bit PDP 11. Long integers and floating point numbers have different formats on the VAX and SUN, so any data files in binary need to be converted. Of course the two machines have different instruction sets so it is necessary to recompile all programs to their binary executables. With these facts firmly in hand we undertook the task of moving a selected subset of official Center for Seismic Studies software from the VAX to the SUN.

Deemed most necessary were programs that aid the seismologist, not routine data processers. Since the floating point performance of the SUN2 is poor in comparison to the VAX, no programs that perform large numbers of floating point operations, such as detectors, filters and spectral programs, were ported. Certain libraries of seismic routines that support the wanted programs were, of course, also moved. Along with the Center official programs we moved many shell scripts that we have written that aid in working with Center official databases. Below is a description of those programs, scripts and libraries now available on the SUN.

PROGRAMS;

fmt.arrival	prints format of arrival file
fmt.assoc	prints format of assoc file
fmt.origin	prints format of origin file
fmt.wfdisc	prints format of wfdisc file
dareq	creates dearchive request from waveform request
predar	predicts arrivals
rdetwo	remotely dearchives waveforms
rdmparc	remotely dumps an archive tape
trix	gives possible origins from three arrivals
locit	relocates an event using multi phase algorithm
dlaz	gives distance and azimuth between two points
reg	gives region number or name
sta	gives station location, etc.
tt	gives travel times

SCRIPTS:

AAWK	reformats arrival file
OAWK	reformats origin file
WAWK	reformats wfdisc file
ORI	allows interactive input of origin info.
arrival.awk	awk template for arrival file
assoc.awk	awk template for assoc file
origin.awk	awk template for origin file
wfdisc.awk	awk template for wfdisc file
wftape.awk	awk template for wftape file
getr	gets dearchive request from database
getw	gets waveforms from archive tapes
putw	archives waveforms onto tapes
makesegrules	makes a segmentation rules file for predar
tapes	tells what tapes are needed for dearchive request

LIBRARIES:

libextf	external files handling routines
librtap	remote tape handling routines
libseis	various seismic routines (travel times, dist, az)
libtap	native tape handling routines
libtime	epoch time handling routines
libwfa	wfdisc/wftape manipulation routines

M. A. Tiberio

4. RESEARCH

4.1 Preliminary Study of m_b Bias at Selected Soviet Seismic Stations

Magnitude m_b was determined for five earthquakes on 25 and 27 may 1980, from recordings at eight Soviet seismic stations on a 4,300 km-long profile from eastern Kazakh to eastern Siberia. The records were hand-digitized, and magnitudes were determined from traces corrected for instrument response as well as the uncorrected traces. Four of the five earthquakes were at Mammoth Lakes, California, in the western Great Basin; the fifth was at Tonga in the south Pacific. Magnitude residuals with respect to network-averaged m_b listed in the ISC Bulletin were postive for stations at Yakutsk and Seymchan in Siberia, negative for raypaths through the Baikal rift zone, and slightly positive for a station at Semipalatinsk, about 100 km from the East Kazakh test site. A comparison of tabulated magnitude residuals for Soviet seismic stations from previous work of Ringdal (1985), North (1976) and Vanek et al. (1978, 1980) shows excellent agreement between these studies. Our results are slightly more scattered but in good agreement with previous work. Recalculation of m_b for 83 events recorded on granite at the Nevada Test Site provided a determination of magnitude bias(m_b= -0.10±0.35) for the NTS granite site site with respect to ISC magnitudes. Comparison of this value with m_b for the Soviet stations provides a direct measure of the magnitude bias of the NTS area relative to areas in the USSR in which the stations are located. This bias reflects only differences in attenuation, and does not account for other effects such as differences in coupling, focusing, tectonic release, and instrumental effects. The magnitude bias due to attenuation differences between the NTS granite site and the station at Semipalatinsk is -0.20. Details are shown in the following table. The complete report is published as Center Technical Report C86-04.

A. Ryall

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Ringdal, F. (1985). Study of Magnitudes, Seismicity and Earthquake Detectability Using a Global Network, Center for Seismic Studies Rept., in press

Vanek, J. and 32 others (1978). Station corrections for longitudinal waves in the Uniform Magnitude System of the Eurasian continent, Akad. Nauk SSSR, Izvestiya Earth Phyics, 14, Amer. Geophys. Un., 169-178

Vanek, J., N.V. Kondorskaya, I.V. Federova and L. Khristoskov (1980). Optimization of amplitude curves for longitudinal seismic waves for purposes of development of a uniform magnitude system for seismic obervations on the Eurasian continent, Doklady Akad. Nauk SSSR, 250, 834-838, transl. by Scripta Publ. Co.

Comparison of Station Residuals and δm_b(OB2-NV)						
Sta	*Ringdal*	*North*	*Vanek*[1]	δm_b[2]	δm_b[3]	$\delta m_b(OB2-NV)$[4]
BKR	+0.38±0.33		+0.30			-0.44
BOD	-0.02±0.34			-0.05	+0.10	-0.11
CLL	+0.16±0.26	+0.20±0.32	+0.09			-0.25
ELT	+0.15±0.34			-0.01	+0.15	-0.20
FRU	+0.35±0.33		+0.36			-0.46
ILT	+0.08±0.32		+0.03			-0.16
IRK	-0.03±0.31			-0.32	-0.06	-0.04
KHC	+0.03±0.26	+0.10±0.26	+0.08			-0.17
KHE	+0.37±0.31		+0.31			-0.44
KRA	+0.32±0.29	+0.22±0.29	+0.22			-0.35
KZL				-0.06	+0.14	-0.14
MOX	+0.07±0.25	+0.02±0.27	+0.01			-0.13
OBN	+0.39±0.33		+0.39			-0.49
PET	+0.24±0.36		+0.35			-0.40
PRU		+0.04±0.24	-0.06			-0.09
SEI				+0.25	+0.28	-0.37
SEM			+0.07	+0.10	+0.12	-0.20
TIK	+0.03±0.37		+0.00			-0.12
UST				-0.12	-0.10	+0.01
YAK	+0.43±0.34			+0.33	+0.42	-0.49
YSS	+0.20±0.41		+0.02			-0.21
ZAK	-0.11±0.33		-0.03			-0.03

1 -- Given by authors as Δm_b corrections relative to base station OBN. Sign reversed and all values increased by 0.39 for comparison with Ringdal (1985).

2 -- Mean of δm_b for Tonga earthquake plus average δm_b for four Mammoth Lakes events from Table 9. Uncorrected data.

3 -- Mean of δm_b for Tonga earthquake plus average δm_b for four Mammoth Lakes events from Table 10. Corrected data.

4 -- Average residual (-0.10±0.35) for OB2-NV with respect to ISC *Bulletin* minus average station residual.

4.2 Noise Values and Detection Thresholds of GSETT Seismological Stations

Seismic noise levels and detection thresholds for short period teleseismic P waves and long period Rayleigh waves have been estimated for seismological stations participating in the Technical Test of the Ad Hoc Group of Scientific Experts carried out in the fall of 1984 (GSETT). The estimates are primarily based on noise and amplitude measurements reported from the stations to the Experimental International Data Center operated at the Center for Seismic Studies during the GSETT.

The measurements at the stations of short period noise, (NSZ), consisted of the maximum trace amplitude at a frequency between 1.0 and 5.0 Hz or at a frequency close to that of a detected signal together with the associated period within 30 seconds before the signal onset. In many instances it was, however, not possible to measure the noise amplitudes at these specified frequencies.

<u>Analysis of Data From Six U.S. Stations</u>.

Mean values of short period amplitude measurements at participating U.S. stations (i.e., the stations: FBA, LAC, LTX, RSNY, RSON, RSSD) are plotted in Fig.E as amplitude/period ratios and as a function of frequency (i.e., the reciprocal of period). The plotted values can be thought of as approximate "spectra". An amplitude roll-off inversely proportional to frequency has been drawn for each station for comparison and the "spectra" follow this roll-off over some frequency band for all the stations except for LTX and RSSD. The "spectra" drop from lower frequencies systematically up to some frequency between 1 and 3 Hz beyond which a flattening of the amplitude occurs. Statistical testing suggests that measured noise amplitudes for a given period follow approximately normal distributions and the variation of the amplitudes are compatible with a standard deviation equal to the commonly used value of 0.2 regardless of period.

Long period noise was usually only measured at the GSETT stations when associated with a detected short period P wave. The long period noise parameters, (N2LZ), consisted of the largest trace amplitude with a period between 10 to 30s measured on the vertical component within 5 minutes preceding the initial P wave. Mean amplitude values plotted as a function of frequency are shown in Fig. F for the six U.S. stations. The "spectra" usually have a pronounced minimum around the 20s period (or 0.05 Hz).

The noise amplitudes for the short and long period bands varies with frequency and in order to determine an operational noise level that represents the station detection capability it is, therefore, necessary to take the frequency distribution of signal amplitudes into account. The empirical distributions of the period of small short period teleseimic amplitudes are shown in Fig. G at each of the six U.S. stations. For most of the stations the distribution peaks between 1 and 2 Hz. In order to represent each station with one single noise amplitude the empirical distributions of the wave period as shown in Fig. G have been combined with the mean noise amplitudes shown in Fig. E as a function of period. These weighted mean values or "operational" noise amplitudes are drawn as horizontal lines in Fig. G and are generally lower than the mean amplitudes at 1 Hz.

Plots of the cumulative number of recorded earthquake signals against the logarithm of the short period amplitude/period ratio are given in Fig.H for the U.S. stations. These plots, which taper off at low values of the amplitude/period ratio, resemble recurrence curves for earthquake magnitudes and can be used to estimate the amplitude detection thresholds independently of the noise levels. Both the "operational" noise levels and the estimated amplitude thresholds are drawn in the figure as vertical lines and the gap between the two represents the minimum signal-to-noise ratio below which the station will not detect signals. The following values were obtained for the U.S. stations:

Station code	Noise		Ampl.Thres.		SNR
	Mean (nm/s)	Std	Mean (nm/s)	Std	
-		-		-	
FBA	2.2	0.20	3.3	0.18	1.5
LAC	1.6	0.30	11.5	0.34	7.3
LTX	1.0	0.18	3.2	0.18	3.2
RSNY	4.5	0.19	12.0	0.16	2.6
RSON	3.8	0.19	10.0	0.22	2.6
RSSD	2.1	0.16	4.7	0.18	2.2

The values of the signal-to-noise ratio, SNR, which in the table are defined as the ampltiude threshold divided by the "operational" noise level, are all equal to or larger than the commonly assumed value of 1.5. Similar results were obtained for several other GSETT stations. This indicates that 1.5 may be low as a standard value for the "average" station even if there may be stations that operate at minimum signal-to-noise ratios around this value.

Analysis of Data From Other GSETT Stations

The analysis of noise and signal amplitude data illustrated above for the six participating U.S. stations was applied to as many participating GSETT stations as possible in order to compile an updated list of station noise and detection thresholds for the entire GSETT network. Short and long period noise data reported during the GSETT was used for 48 and 26 of the stations respectively and estimates published in the seismological literature were used for the remaining stations. These updated noise values have been transformed into magnitude thresholds, from a standard magnitude formula assuming a constant Q value (3.73 and 3.19 for short and long period respectively) corresponding to average values of Q in the interval 30 to 85 degrees. The distribution of the thresholds are shown in the bar chart of Fig.I. The M_s thresholds of long period Rayleigh waves have been given in equivalent m_b values for earthquakes using the relation: m_b=0.62 M_s+2.03.

In summary, the following general conclusions can be drawn from the analysis of the noise and amplitudes at the GSETT stations.

The revised noise values differ significantly from the preliminary values assumed before the GSETT. The revised short period values are either significantly lower or significantly higher than the preliminary values for most of the stations. The revised long period values are generally much higher than the preliminary values.

The GSETT stations constitute a global network with large variation in noise and detection characteristics among the individual stations. The median value of the m_b detection threshold as defined above is 4.9 which is a rather high value. Most of the stations have a significantly higher detection capability of teleseismic short period P waves than of long period Rayleigh waves for earthquakes. The variation in short period detection capability among the stations is well over a magnitude unit whereas the long period detection capability has less variation among the stations. The network of GSETT stations also has a clearly non-uniform geographical distribution with most of the stations concentrated in the Northern Hemisphere and in Europe in particular. The stations in the Northern Hemisphere have also generally lower magnitude thresholds than stations in the Southern Hemisphere and more than half of the most sensitive GSETT stations were located in Europe.

A more complete report on the results summarized above is published as Center Technical Report C86-03.

H. Israelsson

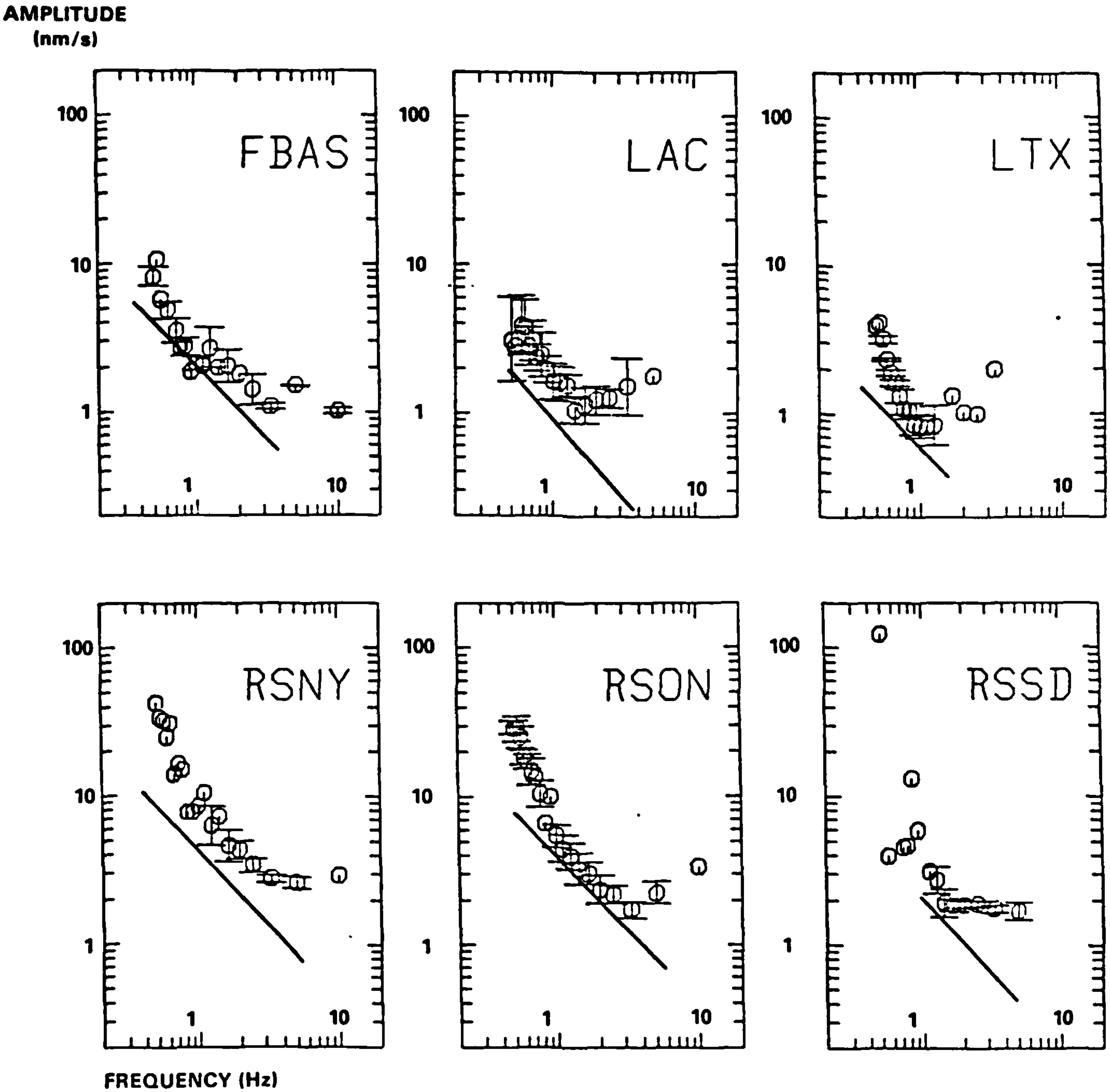

FIGURE E ESTIMATED MEAN VALUES OF NOISE AMPLITUDES (AMPLITUDE/PERIOD) AS A FUNCTION OF FREQUENCY. THE 95% CONFIDENCE LIMITS ARE INDICATED BY HORIZONTAL BARS IN CASES WITH SUFFICIENT NUMBERS OF OBSERVATIONS. THE SLOPING LINES CORRESPOND TO AN AMPLITUDE ROLL-OFF PROPORTIONAL TO FREQUENCY SQUARED.

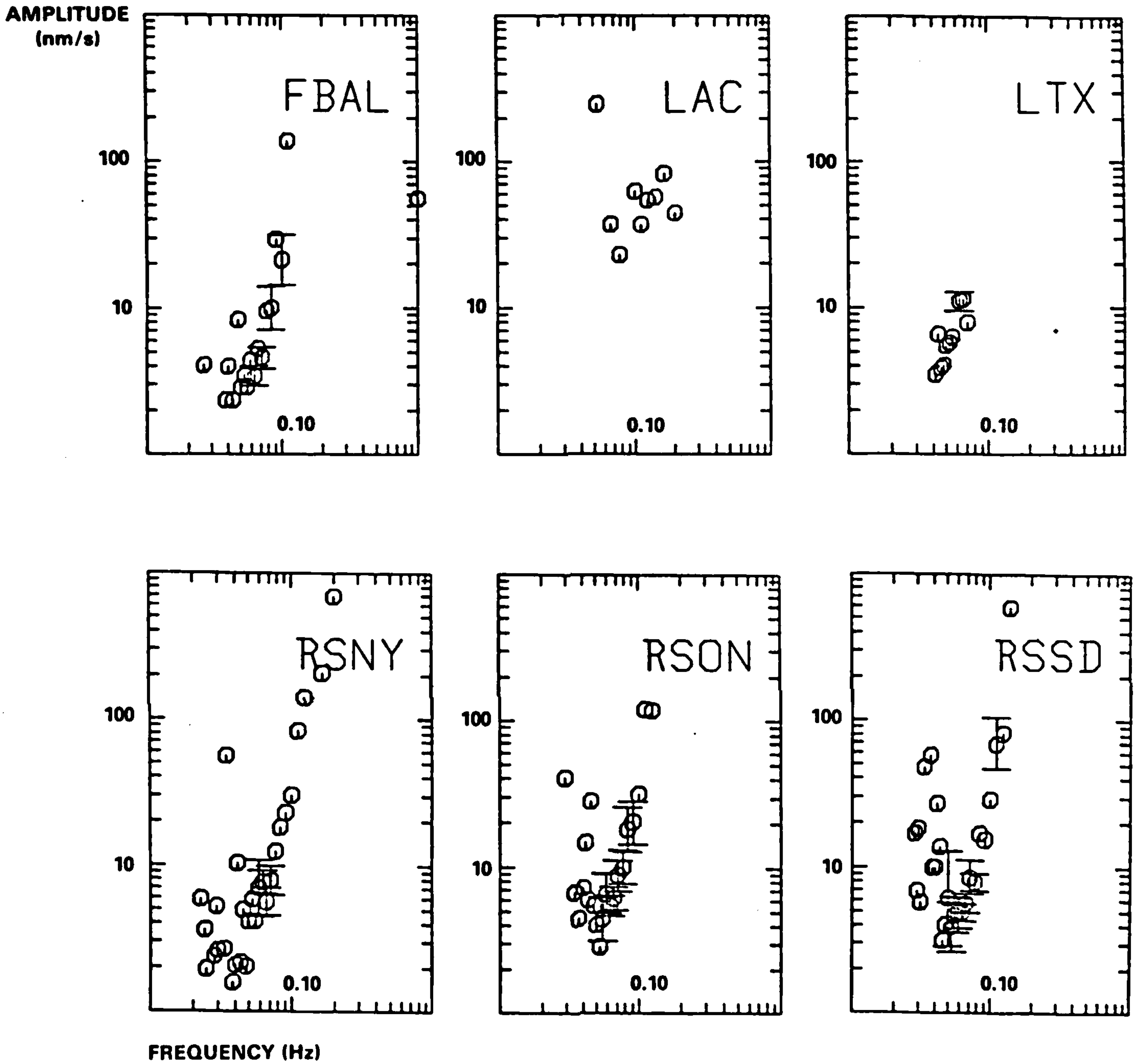

FIGURE F ESTIMATED MEAN VALUES OF NOISE AMPLITUDES (AMPLITUDE/PERIOD) AS A FUNCTION OF FREQUENCY. THE 95% CONFIDENCE LIMITS ARE INDICATED BY HORIZONTAL BARS IN CASES WITH SUFFICIENT NUMBER OF OBSERVATIONS.

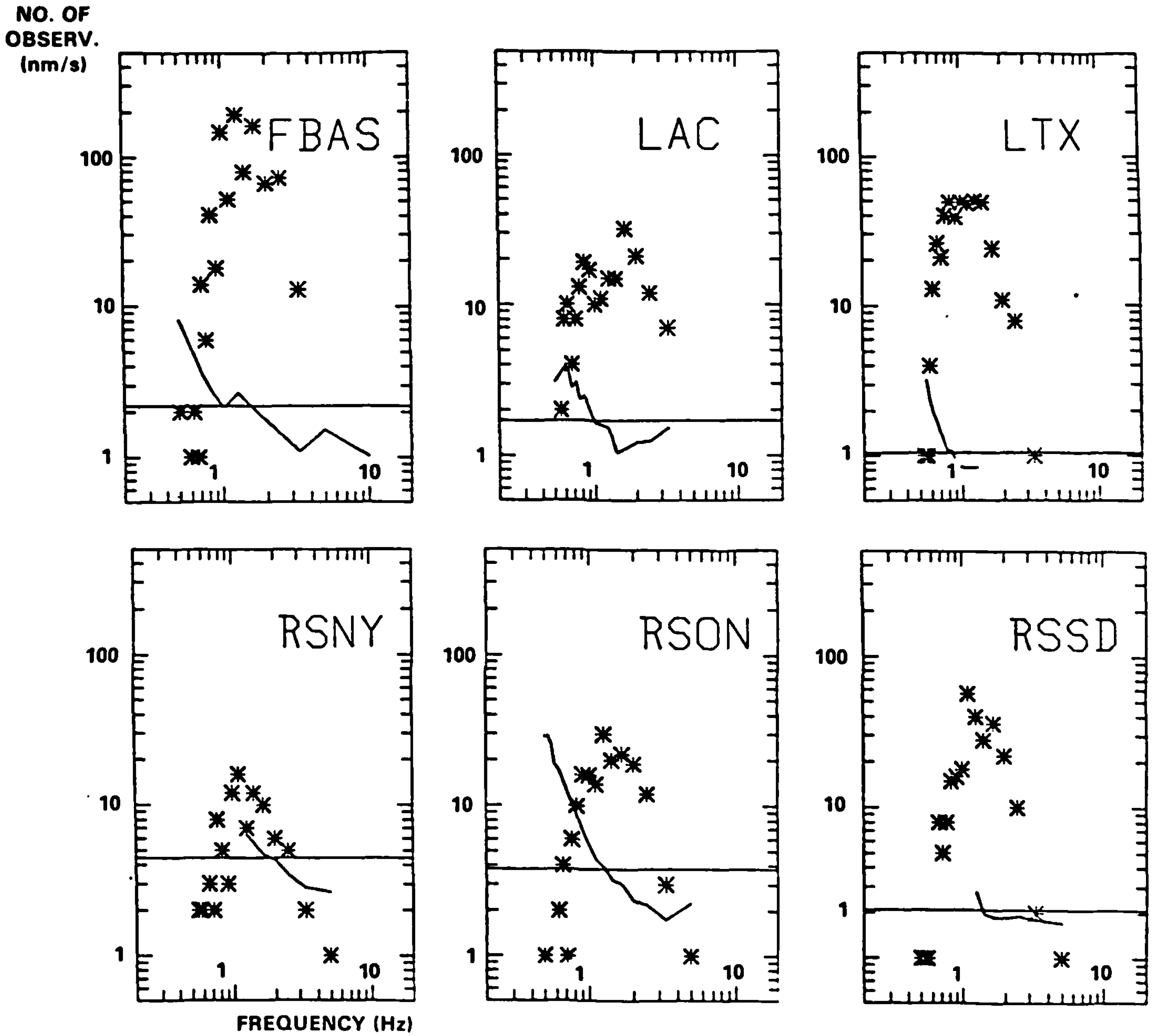

FIGURE 6 NUMBER OF DETECTED SHORT PERIOD TELESEISMIC P-WAVES WITH SMALL AMPLITUDES AS A FUNCTION OF MEASURED DOMINANT FREQUENCY. THE MEAN NOISE LEVELS HAVE BEEN DRAWN FOR COMPARISON, AND ESTIMATED 'OPERATIONAL' NOISE LEVELS AS DEFINED IN SECTION 6.1 ARE DRAWN AS HORIZONTAL LINES.

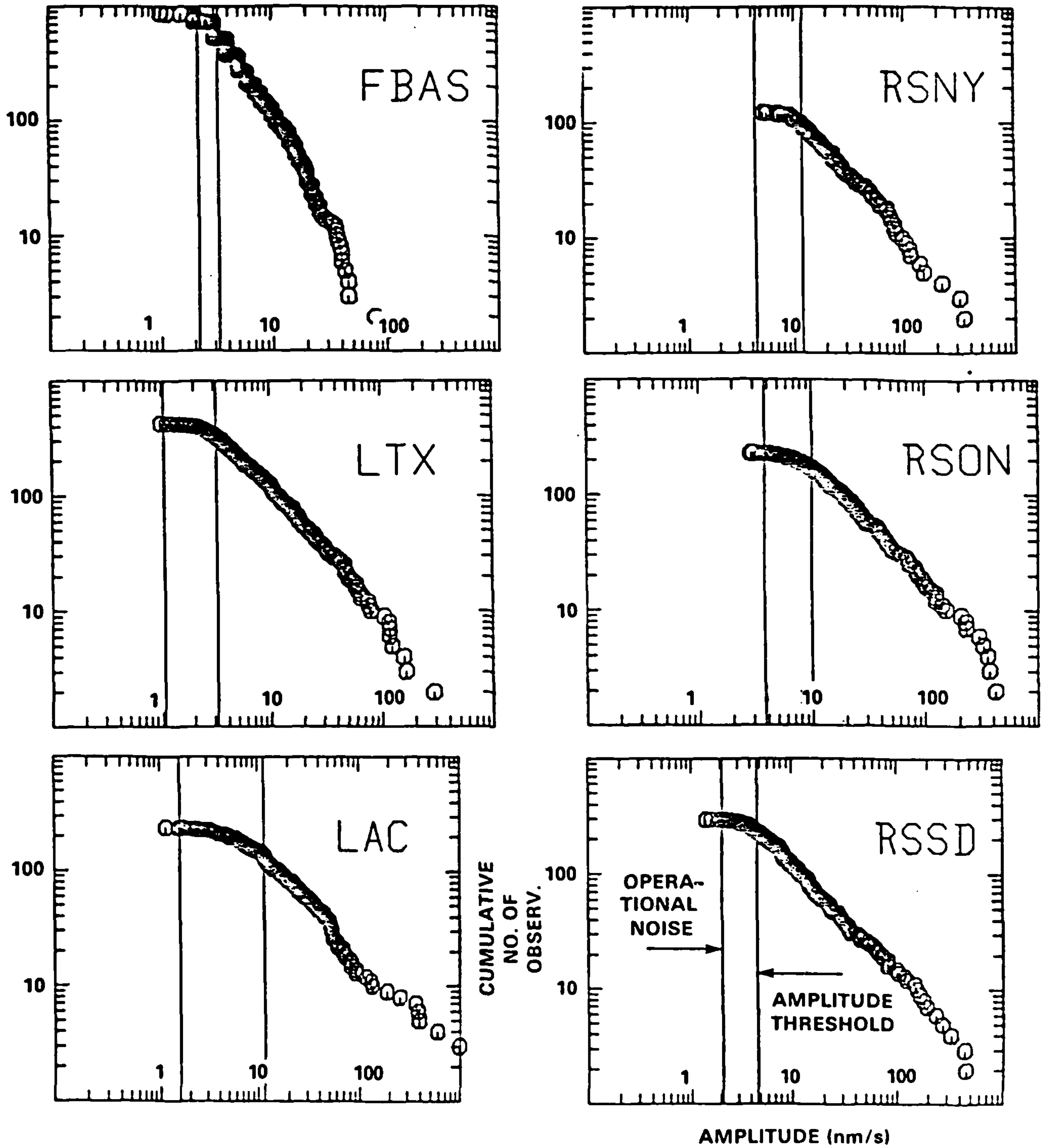

FIGURE H CUMULATIVE NUMBER OF DETECTED SHORT PERIOD TELESEISMIC P-WAVES AS A FUNCTION OF THE AMPLITUDE PERIOD RATIO. ESTIMATED AMPLITUDE DETECTION THRESHOLDS AND 'OPERATIONAL' NOISE LEVELS AS DEFINED IN SECTIONS 6 AND 8 ARE DRAWN AS VERTICAL LINES FOR COMPARISON.

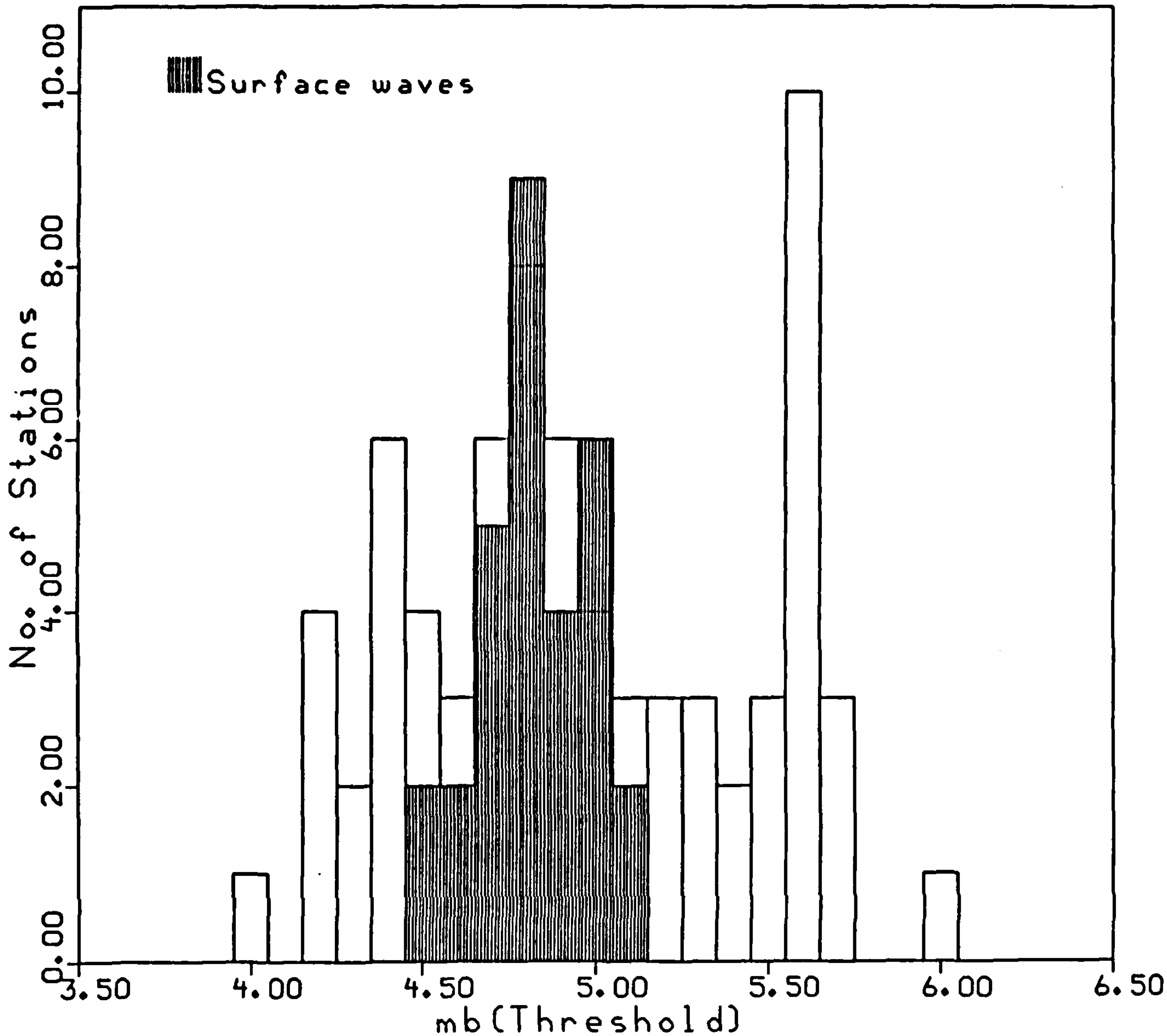

Fig.1 **Magnitude detection thresholds for the GSETT stations for short period P waves and long period Rayleigh waves.**

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