United States Department of the Interior
Geological Survey

NATIONAL EARTHQUAKE INFORMATION CENTER
SEMI-ANNUAL TECHNICAL REPORT
VOLUME 1 NUMBER 1

Open-File Report 88-384
1988

National Earthquake Information Center
U.S. Geological Survey
Denver, Colorado

TABLE OF CONTENTS

INTRODUCTION

This is the first of a series of publications that will report on current seismological research being conducted at the National Earthquake Information Center (NEIC) of the U.S. Geological Survey, Department of the Interior, in Golden, Colorado. General information on data services available from the NEIC will also be included in a separate Operations section that will incorporate progress reports and updates of the various seismograph networks supported by the USGS. Initially, the report will appear on a semi-annual basis, but will be published more often if it becomes necessary.

This first issue contains several short articles describing some of the studies currently in progress at the NEIC. One of the articles, which was contributed by G. Choy and J. Boatwright, describes the estimation of the source parameters for the Nahanni earthquakes from an analysis of the teleseismic digital broadband data and the near-source strong ground motions recorded for the events. Another entry, by C. Mendoza and S. Hartzell, describes the linear inversion of strong-motion velocity records to infer the distribution of coseismic slip during the 1985 Michaoacan, Mexico, earthquake. In addition, D. Gordon reports on the isoseismal data available for a large historic earthquake in the eastern U.S.

Descriptions of the seismological services available from the NEIC are also included in this issue. These are presented in the Operations section together with a discussion of current procedures being utilized by the NEIC for analyzing broadband seismograms and a report of NEIC seismicity maps currently available. In addition, the digital-data information previously contained in the NEIC newsletter will be presented in this section under the heading "Global Digital Seismic Data". In future issues, the Operations section of this report will continue to provide information pertinent to NEIC operations, including status information and updates on the digital-data services available from the NEIC.

Carlos Mendoza

RESEARCH AND DEVELOPMENT

TELESEISMIC AND NEAR-FIELD ANALYSIS OF THE NAHANNI EARTHQUAKES IN THE NORTHWEST TERRITORIES, CANADA

G. L. Choy and J. Boatwright

The analysis of the Nahanni earthquakes of October 5, 1985 (M_S 6.6) and December 23, 1985 (M_S 6.9) will have important implications for the assessment of seismic hazards in intraplate environments. To maximize the information available to seismic engineers, broadband data recorded teleseismically are analysed jointly with strong-motion data recorded in the near field. The time-domain analysis of teleseismic data yields the source mechanisms, depths and complexities of rupture of each earthquake. Both earthquakes occurred as shallow thrusts with centroid depths (6-7 km) and shallowly dipping fault planes that correspond well with the aftershock distributions obtained from a local survey run by the Canadian Geological Survey. The shallow nodal plane for the October 5 earthquake dips 30° to the WSW, while the shallow nodal planes of the subevents for the December 23 earthquake dip an average of 23° to the WSW. The October 5 earthquake has an impulsive initial rupture, followed by a weak subevent of longer duration but smaller moment release. The December 23 earthquake exhibits more complexity, being comprised of three subevents of similar size. The subevent delays derived from the teleseismic analysis are used to help interpret arrivals in records of ground velocity recorded in the near field of the December 23 earthquake. The rupture geometries inferred from the joint near- and far-field analysis suggests that the rupture processes were unusually complicated and that the $2g$ peak that occurs late in one of the near-field records could be a localized phenomenon. Spectral analyses of the teleseismic P waves yield the following source parameters for the October 5 and December 23 earthquakes, respectively: the seismic moments are 1.2 and 1.8×10^{19} Nm, the radiated energies are 1.8 and 2.8×10^{14} Nm, and the dynamic stress drops are 65 and 50 bars. The acceleration source spectra of both earthquakes exhibit an intermediate slope ($|\ddot{u}_\alpha(\omega)| \propto \omega$) from 0.03 to 0.3 Hz, suggesting that the earthquakes represent the failure of asperities. Extrapolating the teleseismic P-wave spectra to estimate the near-field S-wave spectra yields good fits to the acceleration spectra from two strong motion records, but underestimates the spectra from a third strong motion record with the strongest, but possibly localized, accelerations.

INVERSION OF STRONG-MOTION DATA FOR FAULT-SLIP DISTRIBUTION DURING THE 1985 MICHOACAN, MEXICO, EARTHQUAKE

C. Mendoza and S. H. Hartzell

The strong-motion data recorded for the 19 September 1985 (8.1 M_S) Michoacan, Mexico, earthquake has been presented by Anderson et al. (1986). We have analyzed selected velocity records from this data set to recover the distribution of coseismic slip on the fault using the point-by-point inversion method of Hartzell and Heaton (1983). Initially, we fixed the strike and dip of the fault plane at 300°and 14°, respectively, and then divided the fault into 120 subfaults of equal size. Assuming a radial propagation of rupture at a constant velocity away from a fixed hypocenter, synthetic ground motions were then computed for each subfault at each strong-motion site for uniform strike-slip and dip-slip displacements. We then inverted for the amounts of strike-slip and dip-slip displacement required of each subfault to reproduce the observed velocity records. These slip values were subsequently contoured to obtain a map of the slip variation on the fault.

The distribution of slip bears a strong resemblance to the slip model previously obtained from an inversion of the teleseismic P waveforms (cf. Mendoza and Hartzell, 1988). Both the strong-motion and teleseismic data require the failure of at least three different large asperities distributed within a 180-km segment of the Cocos-North American plate boundary. As in the teleseismic result, the strong-motion model shows mainly dip-slip displacement with a small and relatively insignificant component of right-lateral strike-slip motion. The dip-slip components of displacement for the two models are shown in Figure 1. A notable difference in the two distributions is the major source located near the hypocenter. This source is farther down-dip of the hypocenter in the strong-motion model than in the teleseismic model. This difference could be due either to a lack of resolution in the down-dip direction for the teleseismic data or to large errors in the timing of the strong-motion records. A simultaneous inversion, incorporating both the teleseismic waveforms and the near-source ground motions, should provide additional constraints on the variation of slip across the fault for the Michoacan earthquake.

REFERENCES

Hartzell, S.H. and T.H. Heaton, 1983, Inversion of strong ground motion and teleseismic waveform data for the fault rupture history of the 1979 Imperial Valley, California, earthquake, Bull. Seism. Soc. Am., v. 73, p. 1553-1583.

Anderson, J.G., P. Bodin, J.N. Brune, J. Prince, S.K. Singh, R. Quaas, and M. Onate, 1986, Science, v. 233, p. 1043-1049.

Mendoza, C. and S.H. Hartzell, 1988, Inversion for slip distribution using teleseismic P waveforms: North Palm Springs, Borah Peak, and Michoacan earthquakes, Bull. Seism. Soc. Am., v. 78, p. 1092-1111.

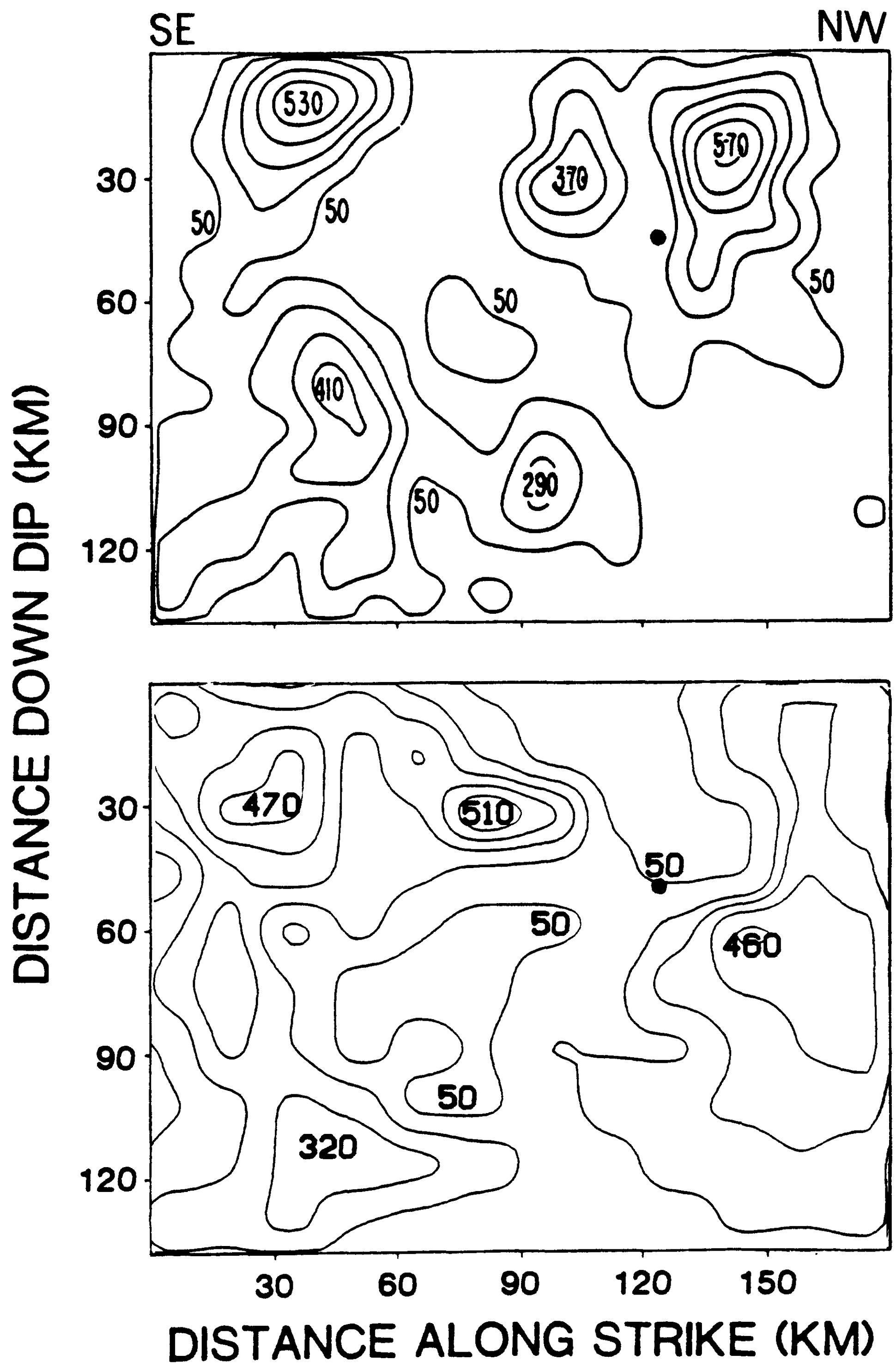


Figure 1. Distribution of coseismic dip-slip (90°rake) displacement computed for the 1985 Michoacan, Mexico, earthquake using teleseismic data (Top) and selected strong-motion velocity records (Bottom). Slip is contoured at 100-cm intervals beginning at the 50-cm level. The filled circle, which represents the hypocenter, is at a depth of 17 km.

THE FIRST ISOSEISMAL MAP OF A UNITED STATES EARTHQUAKE

D. W. Gordon

The National Earthquake Information Center (NEIC) retains a keen interest in the historical development of earthquake seismology. The accompanying map (Figure 2) may represent the first, contemporary isoseismal map of an earthquake in the United States. These isoseismals, which were compiled by Rockwood (1885), correspond to an earthquake near the New York-New Jersey border on August 10, 1884.

Drawn on the basis of a 6-element intensity scale of Professor Rockwood's design, the isoseismals represent over 200 intensity observations. The outermost isoseismal encloses the total felt area. The innermost isoseismal surrounds an elliptically shaped area, about 300 km long and 100 km wide, where ground motion cracked plaster and threw bricks down from chimneys. The innermost isoseismal also exhibits the northeast-southwest elongation that characterizes more recent shocks in the area.

The isoseismals of the 1884 shock engender more than scientific curiosity. The possible effects of a repeat of the 1884 earthquake must be considered relative to the fact that over 20 million people now reside in the area of light architectural damage (MM VI to VII) associated with the 1884 shock. Furthermore, since early Colonial times, about 10 earthquakes with maximum intensity as high or higher than the 1884 shock have occurred in the urban corridor between Boston and Washington, D.C. A shock similar to the 1884 event would affect a large number of people were it to occur anywhere along this corridor.

REFERENCES

Rockwood, C. G., 1885, Notes on American earthquakes: American Journal of Science (Third Series), v. 29, p. 425-437.

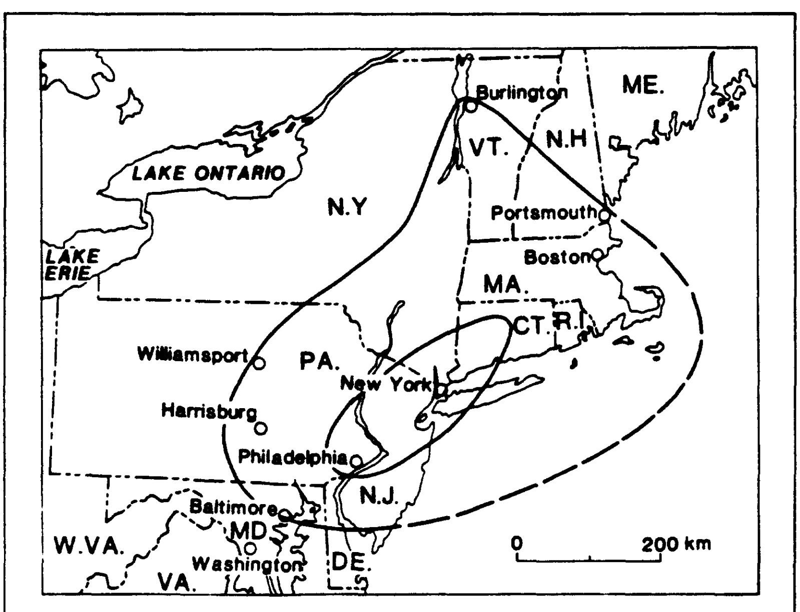


Figure 2. Isoseismals of the New York - New Jersey earthquake of August 10, 1884. The outer isoseismal surrounds the felt area and the inner isoseismal encloses the area characterized by light damage, cracked plaster and bricks thrown from chimneys (modified from Rockwood, 1885).

OPERATIONS

NATIONAL EARTHQUAKE INFORMATION SERVICE

The National Earthquake Information Service (NEIS) forms a major part of the operational responsibilities of the National Earthquake Information Center (NEIC). The NEIS is the foremost collector of rapid earthquake information in the world and has two basic responsibilities: the Earthquake Early Alerting Service (EEAS) and the publication and dissemination of earthquake data.

The EEAS is a 24-hour-a-day service which requires the NEIS to determine the location and magnitude of significant earthquakes in the United States and around the world as rapidly and accurately as possible and to communicate this information to interested persons or groups. The information is given to federal and state government agencies who are responsible for emergency responses, to government public information channels, to national and international news media, to scientific groups including groups planning aftershock studies, and to private citizens who request information. In the case of a damaging earthquake in a foreign country, the information is passed to the staffs of the American embassies and consulates in the affected countries and to the United Nations Disaster Relief Organization (UNDRO).

The EEAS is activated by an alarm in the NEIC office, triggered when recorded ground motion exceeds a threshold level at four seismograph stations in the western United States. Signals from the stations are telemetered to the NEIS operations center in Golden. The alarm is triggered by an earthquake that registers at least 4.5 on the Richter Scale in the contiguous United States, 5.5 in Alaska, Latin America, and Japan, and 6.5 anywhere else in the world. The service can also be invoked upon visual observation of an incoming seismic signal on the recorders in the instrument room or by a felt report telephoned to the NEIC headquarters by the news media, by government-agency personnel, or by private citizens. The service also collaborates with the Pacific and Alaska Tsunami Warning Service.

When an earthquake occurs and the alarm is triggered, the geophysicists on standby duty are notified. After entering the operations center, the geophysicists scale arrival times of "P" waves at selected stations of the U.S. Seismic Network. A preliminary epicenter, magnitude and origin time are computed from the network data using NEIS computer programs. The geophysicists then prepare a "release" on the earthquake send it via several telecommunications networks to the news media, other government agencies, disaster relief organizations, and foreign governments. Key civil defense agencies are notified by telephone over the National Warning System, and telephone calls from the news media and other interested persons are answered.

The NEIS relies on a variety of seismic reporting networks throughout the world to gather data. The most rapid data to arrive are from the approximately 100 stations of the U.S. Seismic Network. which are recorded in the Golden operations center as the events actually occur. The U.S. Seismic Network includes stations spread across the contiguous United States, Alaska, Hawaii, and Norway. Signals are transmitted to Golden via telephone line and satellite. An arrangement with the European-Mediterranean Seismological Centre (CSEM) in Strasbourg, France, enables the NEIS to receive rapid data telegraphically from additional stations located in Europe. Data from these stations and additional networks and stations associated with governments and universities throughout the world, including the People's Republic of China and the USSR, arrive at the NEIS via computer link, telecommunications networks, and airmail. More than 3,000 stations report data to the NEIS; some report regularly and some report only occasionally or for local events.

Additionally, raw seismic data (seismograms) from around the world are received by mail from the Worldwide Standardized Seismographic Network (WWSSN) and the Global Digital Seismograph Network (GDSN) managed by NEIC's Albuquerque Seismological Laboratory (ASL). These networks include about 130 stations operating in 60 countries. The raw data from these networks provide an invaluable complement to the data reports and are distributed by the NEIC to interested scientists. The digital data are routinely subjected to sophisticated computer analysis to determine details of the most important events each month.

The second responsibility of the NEIS is the publication of earthquake data. The NEIS publications are the principal sources of current earthquake information for thousands of seismologists around the world for use in fundamental research and in the evaluation of earthquake hazards. At the present time, the NEIS staff locates and publishes approximately 12,000 earthquakes on a yearly basis. These include only the most important of the many million earthquakes which are estimated to occur each year.

The "Quick Epicenter Determinations" (QED), a very preliminary list of earthquakes, is computed daily and is available for computer access by telephone line. The "Preliminary Determination of Epicenters" (PDE) is published and distributed weekly to those agencies contributing data to the NEIS. The PDE "Monthly Listing" is published monthly and is available to the general public on a subscription basis through the Superintendent of Documents in Washington, D.C. The "Earthquake Data Report," also a monthly publication, provides additional and more detailed information and is intended for the use of seismologists on a data-exchange basis. The Monthly Listing and the EDR each contain about 900 to 1200 events each month.

Waverly J. Person

BROADBAND SEISMOGRAM ANALYSIS

Since October 1985, the Monthly Listings of the PDE have published estimates of depth from broadband seismograms. Occasionally, the Comments in the Monthly Listings have also included remarks on the complexity of earthquake rupture. It is the purpose of this section to describe in greater detail than is possible within the Monthly Listings the features on the seismograms from which depth and rupture complexity have been inferred. In each issue of this Semi-Annual Report, this section will be devoted to the discussion of selected earthquakes.

The NEIS routinely interprets broadband data from the GDSN and other networks that contribute to the Event Tape. The advantages of using broadband records for teleseismic analysis have been discussed by Choy and Boatwright (1981). As a result of the broad bandwidth in the data, there is often sufficient resolution in the waveforms to distinguish source functions and depth phases by direct inspection. Methods of interpretation have been described by Choy et al. (1983) and Choy and Engdahl (1987). An example is shown in Figure 3 for a deep earthquake from the Sea of Okhotsk. Three representations of the P wave recorded at station KEV are shown. The top trace shows the raw short-period record. The next two traces show broadband displacement and velocity. Depth phases are evident only in the broadband records. Moreover, rupture complexity can be inferred from the double trough in the direct P wave. The inversion of differential travel times of P-pP and P-sP from 10 stations yielded a depth from broadband records of 542 km. A depth obtained from broadband analysis is identified in the Monthly Listings by the phrase: "Depth from broadband displacement seismograms".

The NEIS will not assign a broadband depth to an earthquake if phases cannot be clearly identified. This is often the case for waveforms from large complex ruptures. Such waveforms cannot be interpreted without the assistance of synthetic seismograms. Nevertheless, the broadband data often reveal direct information on crucial features of the rupture process which may have some impact on the seismological and tectonic assessment of an earthquake. An example is the large (M_S 7.6) earthquake that occurred in the Gulf of Alaska on 18 May 1987. The description in the Monthly Listings for this earthquake states that it was "a complex event, with major subevent occurring about 15 seconds after the onset of the foreshock, observed on broadband displacement seismograms." Figure 4 illustrates the basis for this comment. In the top two traces of Figure 4, a typical short-period record generated by the main shock is shown at two magnifications. The entire P wave appears to be an undistinguished cascade of 1 Hz energy that monotonically changes in amplitude over the next minute. The initial arrival would normally be considered the onset of the main shock. (Note that the signal from a foreshock of m_b 4.5 is too small to be seen on this record.) However, as seen in the broadband displacement and velocity records, the P wave is composed of two parts. The initial part is relatively insignificant compared to the major release of moment and energy that arrives 16 s later (or 20 seconds after the foreshock). Following the convention of Choy and Dewey (1988), we have labeled the initial small burst of energy as the ms or minor subevent of the main shock. The major subevent is identified as MS. The arrival of MS could be clearly identified on the broadband records from 9 stations. The differential times between MS and ms, ranging from 11 s to 17 s, appeared to show a systematic variation with azimuth. As seen in the velocity records, the energy of the *ms* arrival is substantially smaller than the energy in the large *MS* arrival. This relationship would not be discernable if based entirely on measurements from bandlimited short-period data. The radiated energy, as computed from the broadband data using the method of Boatwright and Choy (1986), is $2.7 \pm 0.5 \times 10^{17}$ Nm.

George L. Choy
Bruce W. Presgrave

REFERENCES

Boatwright, J. and G. L. Choy, 1986, Teleseismic estimates of the energy radiated by shallow earthquakes, J. Geophys. Res., v. 91, p. 2095-2112.

Choy, G. L. and J. Boatwright, 1981, The rupture characteristics of two deep earthquakes inferred from broadband GDSN data, Bull. Seismol. Soc. Am., v. 71, p. 691-711.

Choy, G.L., J. Boatwright, J.W. Dewey, and S.A. Sipkin, 1983, A teleseismic analysis of the New Brunswick earthquake of January 9, 1982, J. Geophys. Res., v. 88, p. 2199-2212.

Choy, G. L. and E. R. Engdahl, 1987, Analysis of broadband seismograms from selected IASPEI events, Phys. Earth and Planet. Int., v. 47, p. 80-92.

Choy, G.L. and J.W. Dewey, 1988, Rupture process of an extended earthquake sequence: Teleseismic analysis of the Chilean earthquake of 3 March 1985, J. Geophys. Res., v. 93, p. 1103-111.

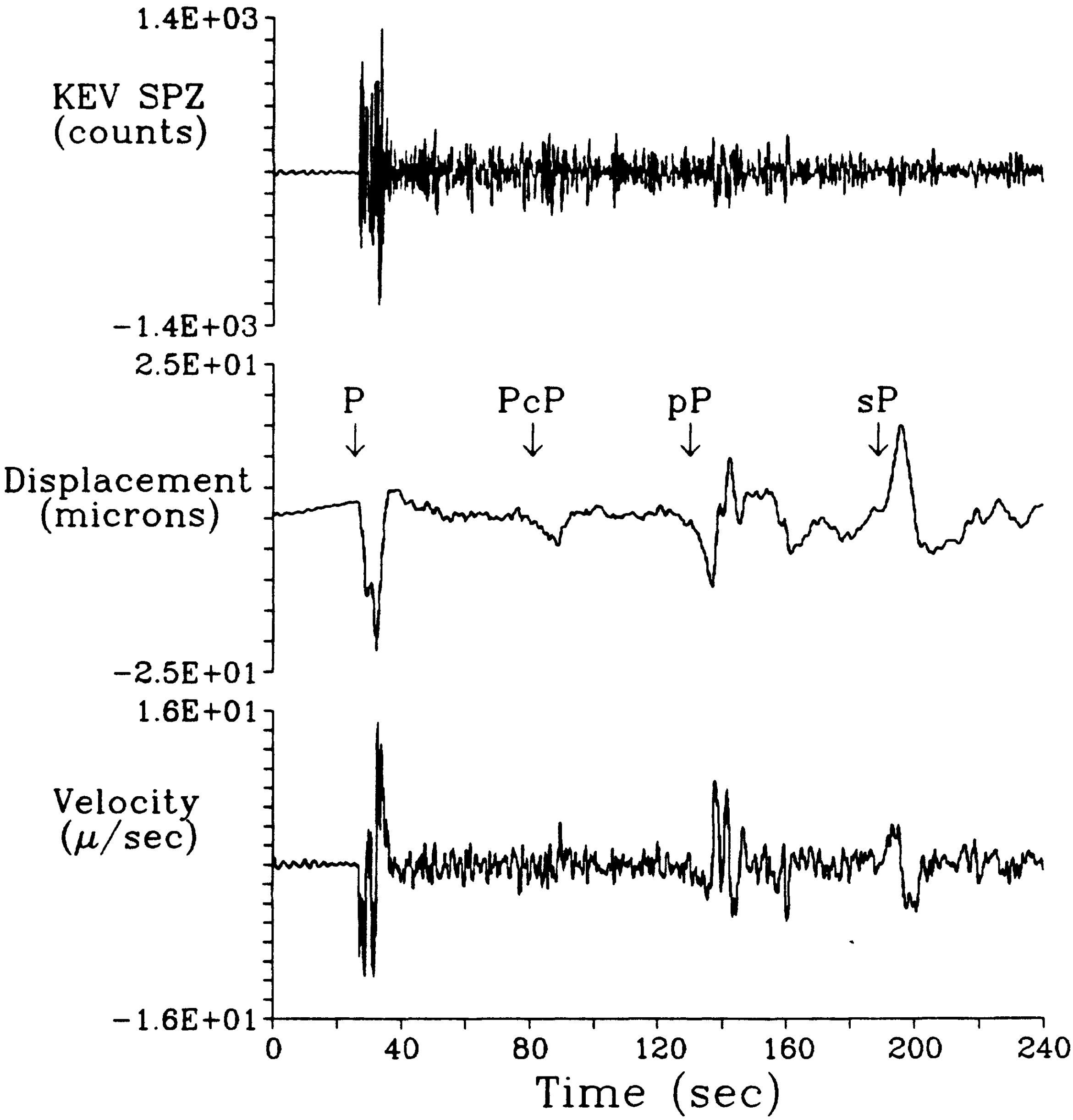


Figure 3. P-wave data recorded at KEV from the deep Sea of Okhotsk earthquake of 18 May 1987 (NEIC origin time 03h 07m 34.1s; 49.282°N, 147.693°E; m_b6.1; broadband depth 542 km). (Top) The raw short-period record. (Middle) The corresponding broadband displacement record. (Bottom) The corresponding broadband velocity record.

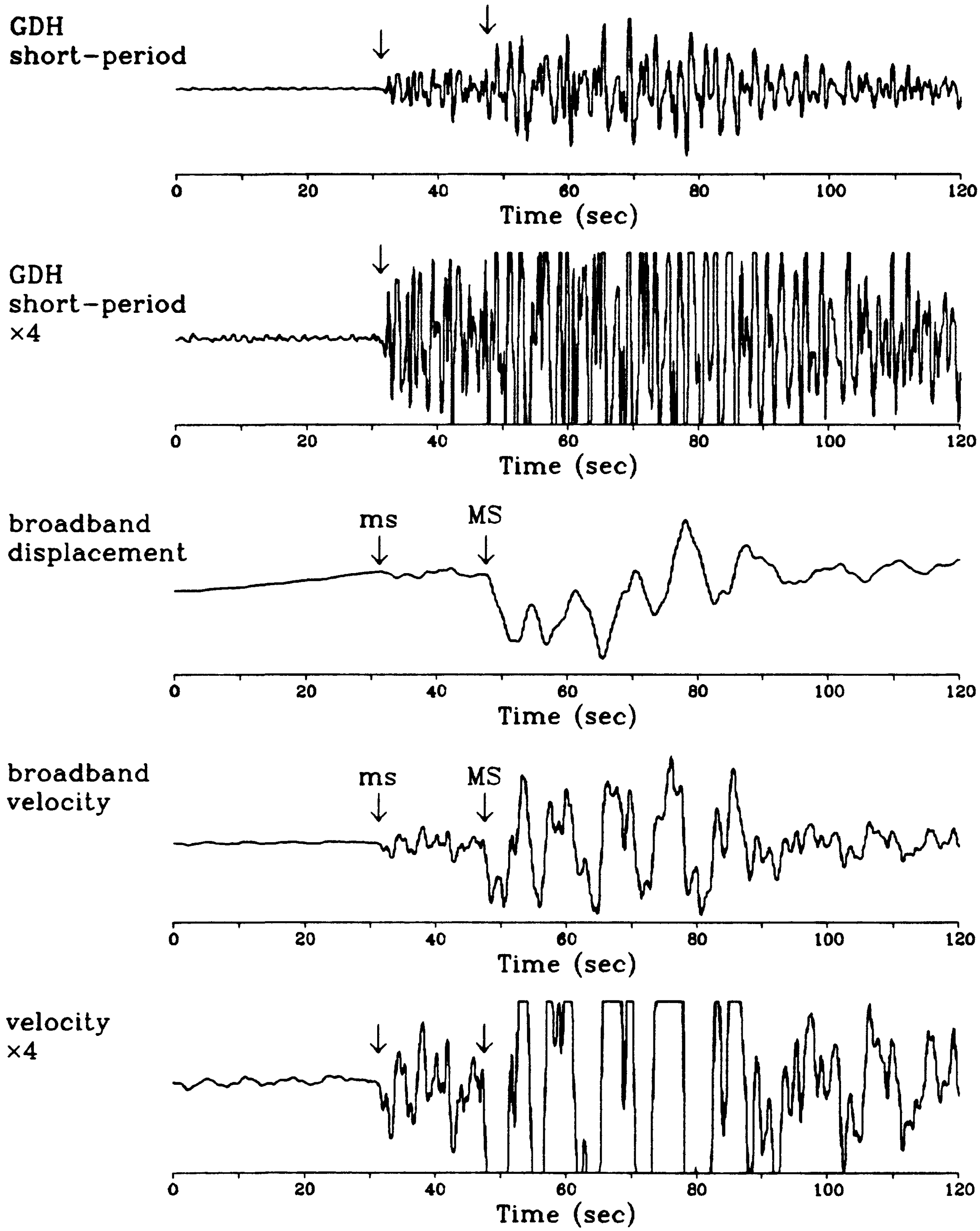


Figure 4. The P-wave data recorded at GDH for the large Gulf of Alaska earthquake of 30 November 1987 (NEIC origin time 19h 23m 19.5s; 58.679°N, 142.786°W; m_b 6.7, M_S 7.6). (Top) The short-period P wave from GDH. (Second trace) The short-period P wave magnified four times. (Third trace) The broadband displacement record. The event *ms* is relatively small compared to the *MS* event that arrives 11 s later. (Fourth trace) The broadband velocity record. (Bottom) The velocity record magnified 4 times.

SEISMICITY MAPS

The National Earthquake Information Center (NEIC) has published a set of three global seismicity maps in the Geophysical Investigation Series of the U.S. Geological Survey (USGS). One of the maps (GP-989) contains the global distribution of seismicity for the years 1977 to 1986. The other two maps include focal-mechanism data for large earthquakes that occurred in the years 1981 to 1985. One of the focal-mechanism maps (GP-990) contains first-motion fault-plane solutions determined by the NEIC. The other mechanism map (GP-991) contains the NEIC moment-tensor source mechanisms. The maps can be obtained from the Map Sales section of the U.S. Geological Survey. In addition, microfiche and photographic slides (35-mm) of the maps have been produced. These, as well as a limited number of the wall-size maps, are available from Susan Goter, National Earthquake Information Center, U.S. Geological Survey, Box 25046, MS 967, Denver, Colorado, 80225.

Susan K. Goter

UNITED STATES EARTHQUAKES PROJECT

This project, which was first begun by the U.S. Government in 1928, is concerned with the publication of hypocenters, magnitudes, and damage/effects of earthquakes within the 50 states. The hypocenters and magnitudes are computed in conjunction with the National Earthquake Information Service (NEIS); the damage and effects are compiled from various sources. The principal source is questionnaires mailed to U.S. Postmasters, police departments, fire departments, and volunteers. The information is published in the annual publication, "United States Earthquakes", which contains tables of earthquake data, seismicity and isoseismal maps, activities of other organizations, and strong-motion data. These data are primary to the study of seismic risk in the United States.

Another important source of information is the seismic history of the United States. The U.S. Earthquakes Project compiles and publishes a list of all the known hypocenters, magnitudes, and intensities of earthquakes located within the boundaries of each state. These data are updated annually from the "United States Earthquakes" publication. The data are available in three formats: maps, published lists, and computer lists from a search on the Earthquake Data System. The Earthquake Data System consists of two parts. The first part is a data base of worldwide earthquakes compiled from 64 seismic catalogs from the United States and from other countries around the world. It contains entries of approximately 500,000 earthquakes covering the period 2000 B.C. to present and is continuously being updated from new catalogs and from data published by the NEIS. The second part is a computer program that conducts a search of the data base and outputs the earthquake lists. The computer lists can be in three formats: printed output, magnetic tape, or floppy disk. A unique feature of this system is that a user may access the data base via any computer terminal equipped with a modem and telecommunication software.

Carl W. Stover

NATIONAL SEISMOGRAPH NETWORK

The frequency of occurrence, geographical distribution, and magnitude of earthquakes are important parameters for assessing the seismic hazard of a region and for establishing the design and construction criteria for critical facilities. These parameters are known collectively as the seismicity of a region and can only be determined through the operation of seismic networks. For many years, scientists and government agencies have recognized the need for a high-quality National Seismograph Network through a cooperative effort between the U.S. Geological Survey (USGS) and the Nuclear Regulatory Commission (NRC). The network is being installed and will be operated by the USGS. The NRC is providing funds to the USGS for the completion of the network east of the Rockies. Funding for the network west of the Rockies is currently under negotiation.

The network will consist of approximately 150 seismic stations distributed across the lower 48 states and across Alaska, Hawaii, Puerto Rico, and the Virgin Islands. This network should provide the capability to detect, locate, and quantify the energy release of earthquakes of magnitude 2.5 and larger in all states except possibly part of Alaska. This capability to characterize earthquakes will be greater than exists today in most parts of the United States. However, the U.S. network will not, even when complete, eliminate the need for additional very dense networks of seismic stations in certain specific locations. Such dense local networks exist today in areas within the United States (for example, in parts of California, Utah, and around the city of St. Louis). The purpose of these dense local networks is to detect earthquakes down to very low magnitude levels (below the magnitude 2.5 threshold of the national network) and to achieve very high location accuracy. The dense, local networks are thus targeted against a few specific identified seismic risk areas with the objective of acquiring data important for research in subjects such as earthquake prediction and ground motion estimation.

Data from the National Network will be of very high quality and will provide, for the first time, near uniform coverage to fairly low magnitude levels for the entire country. All future seismic studies of the United States, including those studies using data from the very dense local networks, can be expected to rely very heavily on the high-quality data base obtained from the National Network. The relationship between the National Seismograph Network and the dense local seismic networks can, therefore, be considered complementary in nature.

Robert P. Masse

GLOBAL DIGITAL SEISMIC DATA

Earthquake data recorded by stations of the Global Digital Seismograph Network (GDSN) are routinely collected by the National Earthquake Information Center (NEIC) and made available to the seismological community through various Regional Data Centers located at several universities in the United States and in several other countries. The GDSN network includes Seismic Research Observatory (SRO), abbreviated SRO (ASRO) instruments. and Worldwide Standardized Seismograph Network stations that have been converted to digital recording (DWWSSN). In addition, stations of the Regional Seismic Test Network (RSTN) form part of the digital network, but these stations are currently closed on a temporary basis. The NEIC also collects digital data contributed by other worldwide networks such as the China Digital Seismograph Network (CDSN) and the Network of Autonomous Recording Stations (NARS) and Gräfenburg (GRF) Arrays in western Europe.

In this section, status information pertaining to the digital-data collection program is presented. This information was formerly included in the National Earthquake Information Center Newsletter, which is no longer being published. However, the same general format previously used in the Newsletter is kept here. For example, a current list of the worldwide digital stations that contribute to the network-day and event tapes is included. In addition, a discussion of current modifications to the collection program and recent problems associated with the various digital stations is presented. This includes a comprehensive listing containing information on all stations that have had problems and/or modifications to date. This list will be periodically updated in future publications of this report. This issue also contains detailed information on the Gräfenburg Array, which has not been previously described.

CURRENT GDSN STATIONS

SRO STATIONS	*CODE*	*ID*	*INSTALLED*
Albuquerque, New Mexico	ANMO	30	01 Sep 1974
Ankara, Turkey	ANTO	31	01 Aug 1978
Bogota, Colombia	BOCO	32	13 Mar 1978
Chiang Mai, Thailand	CHTO	33	01 Jul 1977
Bar-Giyyora, Israel	BGIO	34	15 Apr 1986
Guam, Mariana Islands	GUMO	35	01 Dec 1975
Bangui, Central African Republic	BCAO	37	12 Jun 1979
Mundaring (Narrogin), Australia	NWAO	38	01 Apr 1976
Gräfenberg, Germany	GRFO	39	01 Oct 1978
Taipei, Taiwan	TATO	41	13 May 1976
Wellington (South Karori), New Zealand	SNZO	42	15 Mar 1976
ASRO STATIONS			
Charters Towers, Australia	CTAO	50	09 Oct 1976
La Paz (Zongo), Bolivia	ZOBO	51	10 Sep 1976
Matsushiro, Japan	MAJO	53	15 Jun 1977
Kongsberg, Norway	KONO	54	01 Sep 1978
DWWSSN STATIONS			
State College, Pennsylvania	SCP	61	29 Jan 1981
College, Alaska	COL	62	06 Jan 1982
Longmire, Washington	LON	63	01 Oct 1980
Columbia College, California	CMB	64	11 Nov 1986
Honolulu, Hawaii	HON	66	21 Mar 1983
Kevo, Finland	KEV	67	14 Oct 1981
Afiamalu, Western Samoa	AFI	69	15 May 1981
Godhavn, Greenland	GDH	70	26 Aug 1982
Silverton, South Africa	SLR	71	24 Oct 1981
Brasilia, Brazil	BDF	72	08 Jun 1982
Toledo, Spain	TOL	73	03 Nov 1981
Hobart, Tasmania	TAU	74	10 Jun 1981
Lembang, Indonesia	LEM	76	02 Jun 1982
Kingsbay (Svalbard), Norway	KBS	79	02 Oct 1985

CURRENT CONTRIBUTING STATIONS

CDSN STATIONS			*START*
Beijing, China	BJI	101	Oct 1986
Lanzhou, China	LZH	102	Oct 1986
Kunming, China	KMI	104	Oct 1986
Urumqi, China	WMQ	107	Oct 1986
Hailar, China	HIA	108	Mar 1987
Mudanjiang, China	MDJ	109	Oct 1986

NARS Array			*START*
Goteborg, Sweden	NE01	201	Sep 1985
Monsted, Denmark	NE02	202	Sep 1985
Logumkloster, Denmark	NE03	203	Sep 1985
Witteveen, Netherlands	NE04	204	Sep 1985
Dourbes, Belgium	NE06	206	Sep 1985
Villiers-Adam, France	NE07	207	Sep 1985
Les-Eyzies, France	NE09	209	Sep 1985
Arette, France	NE10	210	Sep 1985
Ainzon, France	NE11	211	Sep 1985
Puertollano, Spain	NE13	213	Sep 1985
Granada, Spain	NE14	214	Sep 1985
Valkenburg, Netherlands	NE15	215	Sep 1985
Clermont-Ferrand, France	NE16	216	Sep 1985
Toledo, Spain	NE17	217	Sep 1985

OTHER STATIONS			*START*
Glen Almond, Quebec, Canada	GAC	43	26 Apr 1982
NORESS array site A0	NRA0	301	Sep 1985
Haidhof, Germany	GRA1	302	Sep 1985
Bruennthal, Germany	GRB1	303	May 1986
Eglofsdorf, Germany	GRC1	304	May 1986

IRIS-1 STATIONS			*START*
Harvard, Massachusetts	HRV	510	1 Jan 1988
Pasadena, California	IPAS	511	3 Apr 1988

THE GRÄFENBERG ARRAY

The Gräfenberg (GRF) array is a 13-station digital broadband array in the Federal Republic of Germany that extends over a length of approximately 100 km on the Franconian Jura. Three of the stations (GRA1, GRB1, GRC1) have three components, while the remainder are vertical-component only. The configuration of the array is shown in Figure 5. The system consists of a Streckeisen STS-1 seismometer, an anti-aliasing filter, and a gain-ranging amplifier. The output is then converted with a 15-bit analog-to-digital converter and transmitted to the Seismologisches Zentralobservatorium Gräfenberg (SZGRF), the Gräfenberg Central Seismological Observatory. The broadband output is proportional to ground velocity, with a response that is flat from approximately 0.05 to 5.0 Hz, and is sampled at a rate of 20 sps. The transfer function is shown in Figure 6.

The GRF array was completed and began operation in 1980. The SZGRF is a part of the Bundesanstalt fur Geowissenschaften und Rohstoffe (BGR), the Federal Institute of Geosciences and Natural Resources. The array was built by the BGR with the financial support of the Deutche Forschungsgemeinshaft, the German Research Association.

The data available on the NEIC Network Event Tapes and CD-ROM's are event data from the three 3-component stations that have been windowed according to event size and event-station distance. Continuous data and/or data from the vertical-component stations may be obtained directly from the SZGRF by writing to the Seismologisches Zentralobservatorium, Krankenhausstraße 1-3, D-8520 Erlangen, Federal Republic of Germany.

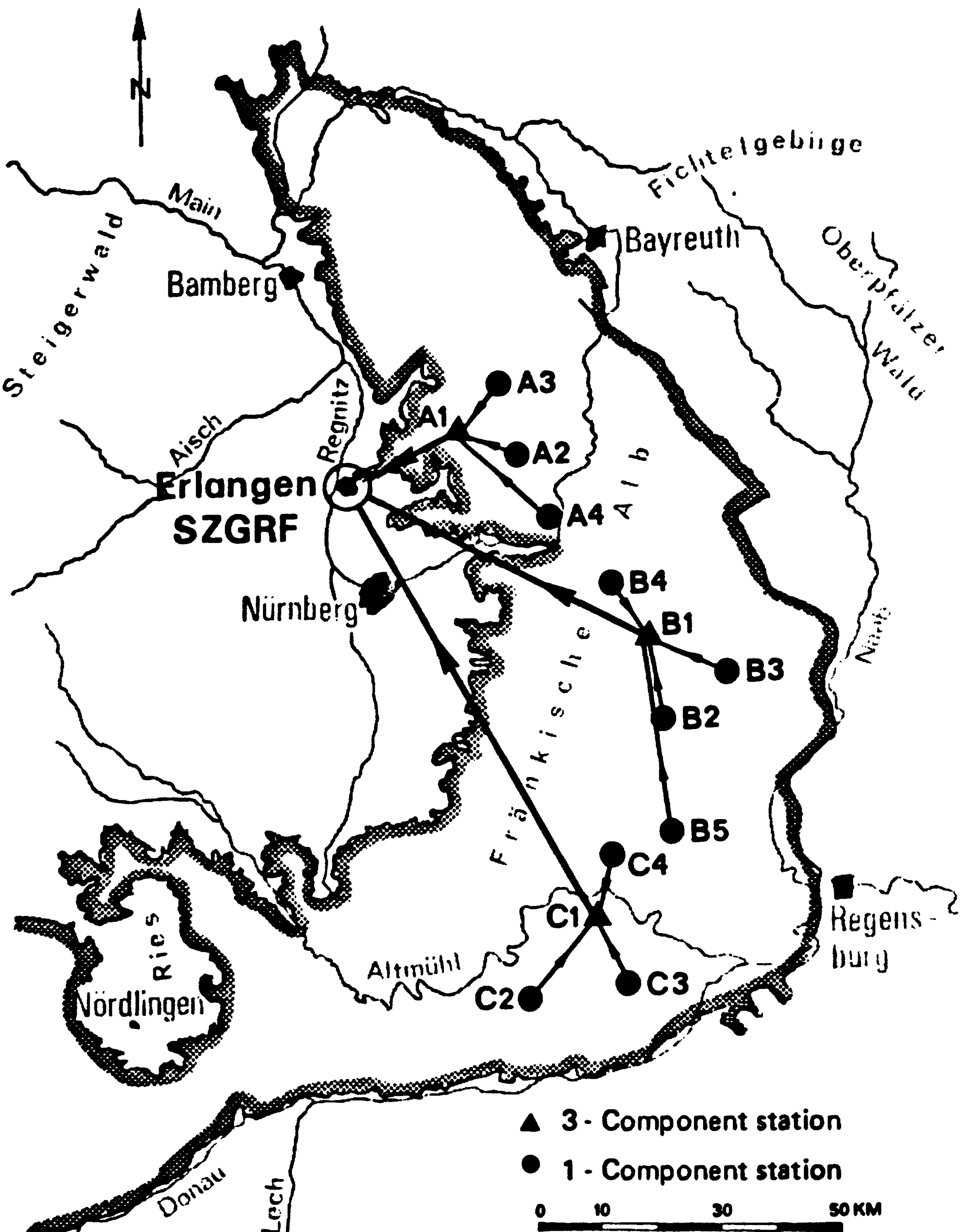


Figure 5. Locations of the seismometer stations and data flow of the Gräfenburg Array.

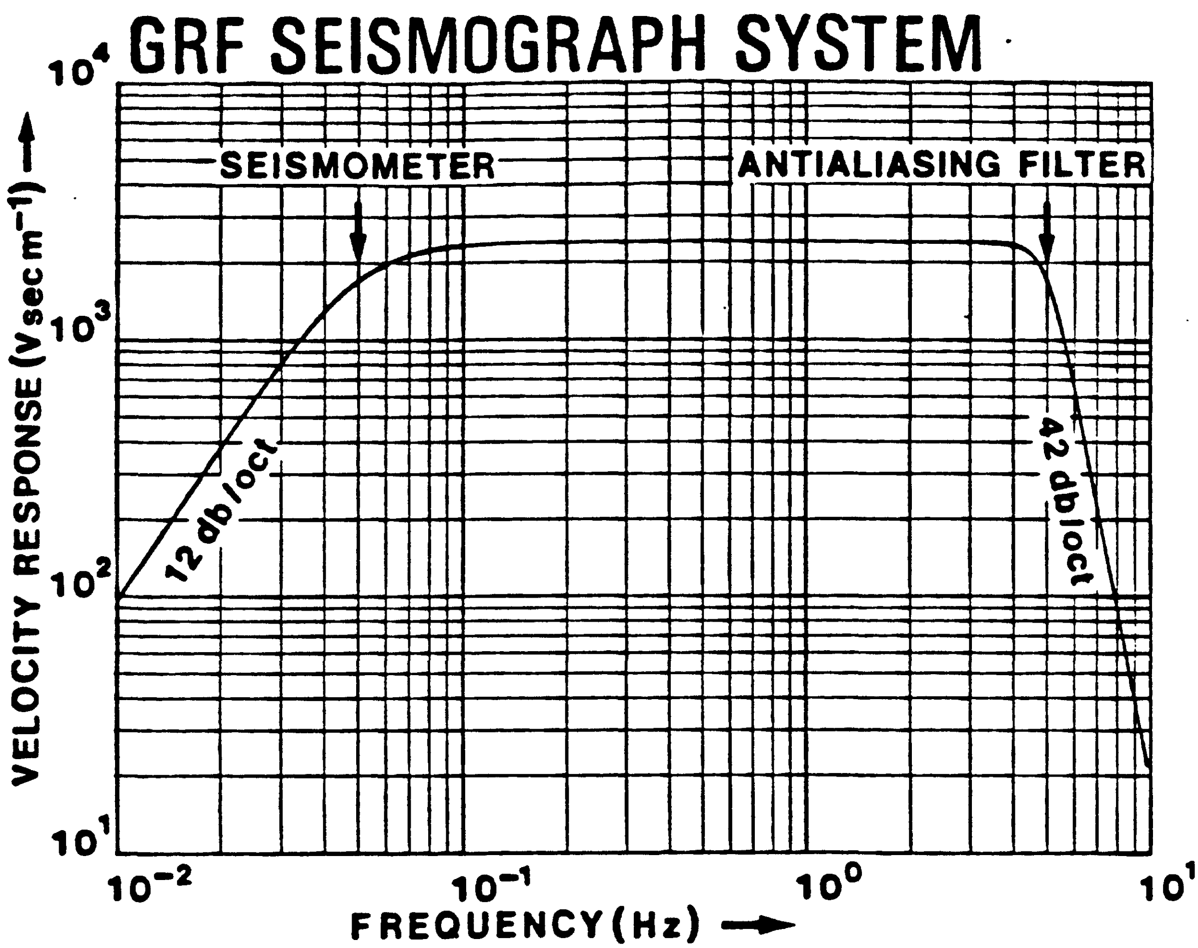


Figure 6. Ground velocity transfer function of the GRF broadband seismometer system.

MODIFICATIONS AND PROBLEMS

A new digital-data format became effective on January 1, 1988. This format is more portable, provides more information, is expandable, and can be used both for recording field data and for distribution in the form of network-day and event tapes. A new format was introduced at this time due to the start of the Global Seismic Network (GSN), which will ultimately comprise 50 or more seismograph stations developed under the direction of the Incorporated Research Institutions for Seismology (IRIS). Installation for most of this network will not begin until 1989. However, several preliminary stations, referred to as IRIS-1 stations, started recording data in early 1988. These stations include one in Harvard, Massachusetts, and one in Pasadena, California. Three more IRIS-1 stations will be installed during the next few months in Missouri, Hawaii, and Alaska. These stations will produce long-period data at 1 sample per second (sps), broadband data at 20 sps and very long period data at 0.1 sps. The Pasadena station will also include an event-detected, low-gain, three-component, strong-motion recording system at 100 sps. All of these data are continuous and, to reduce storage media, will be distributed in a compressed data format. The addition of these five IRIS-1 stations will increase the amount of data to be processed at the Data Collection Center in Albuquerque, New Mexico, from approximately 30 megabytes per day to more than 60 megabytes per day. Therefore, all Network-Day Tapes dated January 1, 1988, or later will be recorded at a density of 6250 bpi. New software is presently under development to assist the seismic research community in accessing these data.

The new format has been discussed in detail with both data users and network operators from this country and from overseas. Their reaction has been very positive. There was a strong consensus that a universal format for recording and distributing digital seismic data would be a significant advance for the seismological community. A report explaining this format in complete detail has been assembled. Anyone wishing copies of the report please contact the Albuquerque Seismological Laboratory, Building 10002, Kirtland AFB-East, Albuquerque, New Mexico 87115.

The following entries describe current updates and/or problems associated with the various digital stations and contributing networks.

AFI: All digital data was one day (24 hours) in error from May 1 through May 13, 1987. The date on the digital data is 24 hours ahead; therefore, one day should be subtracted from the header data.

TOL: Streckeisen seismometers were installed effective October 5, 1987.

CTAO: Streckeisen seismometers were installed effective September 27, 1987.

RSNY: Seismometer orientation was in error by 17°clockwise for all Network-Day Tape data distributed for this station.

ZOBO: The LPN and LPE polarities have been reversed since approximately January 20, 1987.

LZH: The horizontal components for both long-period and short-period data had reverse polarity from original installation date until October 24, 1987.

CDSN SP AND BB DATA: The field tapes from the CDSN stations are forwarded to Beijing where they are copied. The copies are shipped to the Albuquerque Seismological Laboratory (ASL) where the data are included in the Network-Day Tapes. During May and June 1987, a problem with the tape copy system in Beijing resulted in occasional two-minute jumps in the SP and BB data. Most of these jumps were correctable at the ASL. However, when the skips occurred at the beginning of a triggered event, it was not possible to make any correction. Therefore, for the CDSN stations listed below, it is possible for a triggered event to start two minutes late during the time period indicated.

BJI: 29 Apr - 03 Aug 1987
LZH: 24 May - 20 Jul 1987
KMI: 27 Apr - 20 Jul 1987
WMQ: 13 Apr - 18 Jul 1987
HIA: 27 Apr - 20 Jul 1987

STATION PROBLEMS AND MODIFICATIONS

Station	Date	Description
AFI	15 May 1981	Station installed.
	27 April 1987	Streckeisen seismometers installed.
	01 May 1987 thru 13 May 1987	Date was 24 hours ahead. To obtain the correct date, one day should be subtracted in the tape header.
ANMO	01 Sep 1974	Station installed.
	09 Dec 1975	4-pole Bessel filters replaced 4-pole Butterworth anti-aliasing filters (long-period signals).
	24 Jul 1978 thru 31 Jul 1978	Multiplexing errors occurred from 24 Jul 16:45:57.0 through 31 Jul 15:57:56.0. Channel sequence is N, E, Z.
	23 Oct 1978	Single-pole low-pass sections cornered at 16 Hz in short-period channels removed.
	30 Jul 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	13 May 1981	Clip detectors installed.
	05 Apr 1983	Horizontal short-period components installed.
	24 May 1983	The six second notch filter was removed, as were two single pole high-pass corners on the ANMO long-period filters. Pole 1 was moved from 250 seconds to 1200 seconds, and pole 2 was moved from 670 seconds to 1200 seconds.
	19 Mar 1984	22 Feb 1984 software installed. Calibration procedure revised.
	01 Oct 1984	During the first three weeks of October 1984, a new borehole was drilled close to the existing ANMO borehole. The long-period channels at ANMO became saturated during drilling operations. Drilling hours varied between 1500 and 2300 hours UTC.
	20 Feb 1985	Both short-period horizontal components were removed from the ANMO recording system to facilitate testing of a modified borehole seismometer. The SPZ component will be included with the ANMO data for the next few months.
	09 Dec 1985 thru 08 Jan 1986	Polarity reversed on the LPE channel.
ANTO	01 Aug 1978	Station installed.
	26 Feb 1979	The 4-pole Bessel anti-aliasing filter on the N-S component failed and was temporarily replaced with a 4-pole Butterworth filter on February 26, 1979. The Butterworth filter was replaced with a new Bessel filter on October 10, 1979. This was the N-S component only.

	03 Oct 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	27 Jul 1984 thru 07 Sep 1984	The time was exactly one hour fast. To obtain the correct time, one hour should be subtracted from the time listed in the tape header.
	19 Oct 1984 thru 16 Nov 1986	The time was exactly one hour fast from 16 Oct 07:40 through 19 Nov 1984 00:00 UTC. To obtain the correct time, one hour should be subtracted from the time listed in the record header.
BCAO	12 Jun 1979	Station installed.
	12 Jun 1979 thru 26 Apr 1980	Polarity reversals on both horizontal components.
	25 Sep 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	Nov 1981	The BCAO system was damaged by lightning during November 1981. When repairs to the system were completed, including a new borehole seismometer, it was found that the seismometer cable was damaged at the point where it connects to the seismometeer. Only the long-period vertical component was affected, and the station has been in operation since 01 Mar 1982 withhout that component. On 07 Sep 1982 the cabling connections were replaced and all components are now recording data.
	29 Feb 1984	The 6 sec. notch was removed, and two single-pole high-pass corners were moved from 250 and 670 seconds to 1200 seconds.
	03 Mar 1984	Long-period transfer functions changed by removing the six second notch filters and by moving the two single-pole high-pass corners. Pole 1 was moved from 250 seconds to 1200 seconds, and pole 2 was moved from 670 seconds to 1200 seconds.
	14 Aug 1984	22 Feb 1984 software installed. Calibration procedure revised.
	14 Aug 1984	Horizontal short-period components installed.
	14 Aug 1984	Clip detectors installed.
BER	10 Aug 1981	Station installed.
	01 Sep 1984	Station closed. The digital recording system moved to Kingsbay, Svalbard (KBS).
BGIO	10 Jul 1986	Station installed.
	10 Jul 1986 thru 25 Jul 1986	Longitude incorrectly listed as 35.08 West instead of East.
BOCO	13 Mar 1978	Station installed.
	24 Oct 1978 thru 28 Oct 1978	Multiplexing errors occurred from 24 Oct 13:48:16.0 through 28 Oct 00:45:56.0. Channel sequence is N, E, Z.

	21 Nov 1978 thru 07 Dec 1978	Multiplexing errors occurred from 21 Nov 18:33:03.0 through 07 Dec 15:34:06.0. Channel sequence is E, Z, N.
	08 Mar 1979	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
CHTO	01 Jul 1977	Station installed.
	04 Feb 1979	Single-pole low-pass sections cornered at 16 Hz in short-period channels removed.
	06 Jul 1979	4-pole Bessel filters replaced 4-pole Butterworth anti-aliasing filters (long-period signals).
	10 Dec 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	May 1983	After being inoperative for more than 1 year, CHTO came on line in early May 1983 after the installation of a new power system.
	22 May 1983 thru 7 Jan 1984	Polarity reversed on all long- and short-period channels.
	21 May 1984	2-22-84 software installed. Calibration procedure revised.
	24 May 1984	Long-period transfer functions changed by removing the six second notch filters and by moving the two single-pole high-pass corners. Pole 1 was moved from 250 seconds to 1200 seconds, and pole 2 was moved from 670 seconds to 1200 seconds.
	24 May 1984	Horizontal short-period components installed.
	21 Sep 1984	Clip detectors installed.
COL	06 Jan 1982	Station installed.
	05 Feb 1987	Streckeisen seismometers installed.
CTAO	09 Oct 1976	Station installed.
	01 Jan 1980 thru 01 May 1981	A pole was not included in the original long-period transfer function listings on the network-day tapes. The pole which should be added is (-0.159E+00, -0.594E+00).
	29 Dec 1980	Long-period sensitivities changed: Z = 9000 counts, N-S = 10000 counts, and E-W = 11000 counts per micrometer of ground motion at a period of 25 seconds.
	03 Jun 1983	Short-period sensitivity was reduced from 10^5 to 10^6 counts per micrometer at one second.
	27 Sep 1987	Streckeisen seismometers installed.
GRFO	01 Oct 1978	Station installed.

	03 Nov 1978 thru 11 Dec 1978	Vertical component recorded simultaneously on channels 1 and 2 from 3 Nov 1978 at 05:41 through 11 Dec 1978 at 14:53. Channel sequence is Z, Z, E.
	19 Jun 1979	Single-pole low-pass sections cornered at 16 Hz in short-period channels removed.
	08 Mar 1980 thru 03 Apr 1980	Long-period channels multiplexed incorrectly. Channel sequence is E, Z, N.
	18 Oct 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
GUMO	01 Dec 1975	Station installed.
	27 Apr 1976	Short-period sensitivity reduced from 2,000,000 to 2,000 digital counts per micrometer of ground motion at a period of 1 second. The *RESPONSE TO EARTH DISPLACEMENT* table located in the short-period data log was modified beginning on Day 326, 1981. Changes in the values for the relative amplitudes average 2%-3%. Changes in the phase angle values are more significant, averaging between 5%-10%.
	19 Dec 1979	4-pole Bessel filters replaced 4-pole Butterworth anti-aliasing filters (long-period signals).
	29 Jul 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	08 Jan 1985 thru 11 Apr 1985	Station closed on 8 Jan 1985 for replacement of the Model KS36000 borehole seismometer with the Streckeisen Model STS-I surface seismometer. New transfer functions and sensitivites are included in station and data logs. GUMO became fully operational on 11 Apr 1985.
	15 Jan 1985	22 Feb 1984 software installed. Calibration procedure revised.
	15 Jan 1985	Clip detectors installed.
JAS	01 Oct 1980	Station installed.
	26 Jun 1984	Station closed. Seismograph system moved to a new location. The new station code is JAS1.
JAS1	03 Jul 1984	Station installed.
	27 Jul 1984	Digital data included on network-day tapes.
	06 Nov 1986	Station closed. Seismograph system was moved to a new location. The new station code is CMB.
KAAO	10 May 1977	Station installed.
	12 Sep 1978 thru 13 Sep 1978	Multiplexing errors occurred from 12 Sep 18:32:15.0 through 13 Sep 07:33:28.0. Channel sequence is N, E, Z.
	08 Dec 1978 thru 10 Dec 1978	Multiplexing errors occurred from 08 Dec 06:02:59.0 through 10 Dec 06:10:28.0. Channel sequence is N, E, Z.

	11 Dec 1978 thru 24 Dec 1978	Time is 330 seconds fast from 11 Dec 1978 through 24 Dec 1978 at 0:700.
	01 Jan 1980 thru 01 May 1981	A pole was not included in the original long-period transfer function listings on the network-day tapes. The pole which should be added is (-0.159E+00, -0.594E+00).
	20 Jan 1981 thru 17 Feb 1982	The EW and Z components were switched.
	30 Jul 1982	Last data received. Station closed.
KEV	14 Oct 1981	Station installed.
	15 Mar 1982 thru 26 Mar 1982	The network-day tape data starting 15 Mar 1982 through 26 Mar 1982 at 06:00 UTC is approximately 15 to 20 minutes fast.
	12 Mar 1987	Streckeisen seismometers installed.
KONO	01 Sep 1978	Station installed.
	01 Jan 1980 thru 01 May 1981	A pole was not included in the original long-period transfer function listings on the network-day tapes. The pole which should be added is (-0.159E+00, -0.594E+00).
	12 Oct 1980	Long-period sensitivities changed: Z = 9000 counts, N-S = 10000 counts, and E-W = 11000 counts per micrometer of ground motion at a period of 25 seconds.
	30 May 1983	Short-period sensitivity was reduced from 10^5 to 10^6 counts per micrometer at one second. Calibration procedure for SRO/ASRO was revised.
LON	01 Oct 1980	Station installed.
	06 Apr 1981 thru 18 Jan 1982	All digital short-period vertical component data during this time frame has reversed polarity.
MAIO	14 Oct 1975	First data distributed on Station Tape.
	24 Nov 1977 thru 27 Nov 1977	Multiplexing errors occurred from 24 Nov 7:35:30.0 through 27 Nov 5:20:59.0. Channel sequence is N, E, Z.
	11 Oct 1978	Last data received. Station closed.
MAJO	15 Jun 1977	Station installed.
	20 Nov 1977 thru 21 Nov 1977	Multiplexing errors occurred from 20 Nov 05:39:24.0 through 21 Nov 00:54:23.0. Channel sequence is N, E, Z.
	01 Jan 1980 thru 01 May 1981	A pole was not included in the original long-period transfer function listings on the network-day tapes. The pole which should be added is (-0.159E+00, -0.594E+00).

	03 Aug 1980	Long-period sensitivities changed: Z = 9000 counts, N-S = 10000 counts, and E-W = 11000 counts per micrometer of ground motion at a period of 25 seconds.
	03 Mar 1983	Short-period sensitivity was reduced from 10^5 to 10^6 counts per micrometer at one second.
NWAO	01 Apr 1976	Station installed.
	20 Mar 1977 thru 21 Mar 1977	Multiplexing errors occurred from 20 Mar 17:25:27.0 through 21 Mar 03:00:57.0. Channel sequence is N, E, Z.
	01 Aug 1977 thru 3 Aug 1977	Multiplexing errors occurred from 1 Aug 03:23:46.0 through 3 Aug 23:49:31.0. Channel sequence is E, Z, N.
	01 Dec 1977	Single-pole low-pass sections cornered at 16 Hz in short-period channels were removed.
	05 May 1978 thru 6 May 1978	Multiplexing errors occurred from 5 May 06:30:00.0 through 6 May 07:38:59.0. Channel sequence is E, Z, N.
	13 Jun 1978 thru 14 Jun 1978	Multiplexing errors occurred from 13 Jun 07:04:14.0 through 14 Jun 04:29:30.0. Channel sequence is E, Z, N.
	30 Dec 1978	4-pole Bessel filters replaced 4-pole Butterworth anti-aliasing filters (long-period signals).
	01 Aug 1979 thru 21 Aug 1979	Long-period channels multiplexed incorrectly. Channel sequence is N, E, Z.
	24 Dec 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	21 Jan 1982 thru 01 Feb 1982	The network-day tape data starting 21 Jan 16:23 UTC through 01 Feb 00:31 UTC is 7 hours 52 minutes slow.
RSCP	12 Dec 1982	Data included on Network-Day Tapes. (V1N2)
	13 May 1985	Station has been modified to make the transfer functions and sensitivities identical to other RSTN stations.
	01 Apr 1985	The short-period horizontal components have been switched from the KS36000 to the S-750 borehole seismometer.
	22 Oct 1986	RSTN network temporarily closed.
RSNT	12 Dec 1982	Data included on Network-Day Tapes.
	15 Feb 1983 thru 01 Mar 1984	The short-period vertical transfer function included four incorrect poles plus the wrong sign for A0. The incorect poles were P03, P04, P05 and P06.
	01 Apr 1985	The short-period horizontal components have been switched from the KS36000 to the S-750 borehole seismometer.
	22 Oct 1986	RSTN network temporarily closed.

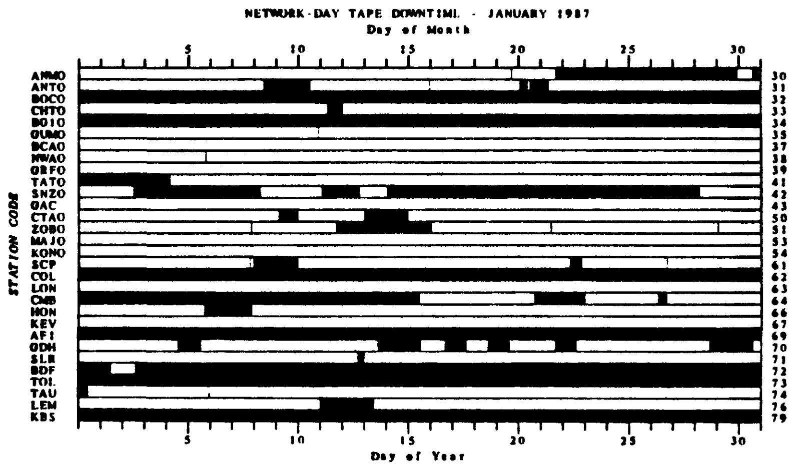
RSSD	12 Dec 1982	Data included on Network-Day Tapes.
	15 Feb 1983 thru 08 Jul 1984	The short-period vertical transfer function included four incorrect poles plus the wrong sign for A0. The incorect poles were P03, P04, P05 and P06.
	01 Apr 1985	The short-period horizontal components have been switched from the KS36000 to the S-750 borehole seismometer.
	22 Oct 1986	RSTN network temporarily closed.
RSNY	12 Dec 1982	Data included on Network-Day Tapes.
	12 Dec 1982 thru 02 Mar 1984	The short-period horizontal transfer functions have listed an incorrect A0 constant plus a missing zero (Z01).
	15 Feb 1983 thru 01 Mar 1984	The short-period vertical transfer function included four incorrect poles plus the wrong sign for A0. The incorect poles were P03, P04, P05 and P06.
	01 Apr 1985	The short-period horizontal components have been switched from the KS36000 to the S-750 borehole seismometer.
	12 Dec 1982 thru 22 Oct 1986	Seismometer orientation was in error 17°clockwise.
	22 Oct 1986	RSTN network temporarily closed.
RSON	01 Jul 1978	Station installed.
	12 Dec 1982 thru 02 Mar 1984	The short-period horizontal transfer functions have listed an incorrect A0 constant plus a missing zero (Z01).
	15 Feb 1983 thru 01 Mar 1984	The short-period vertical transfer function included four incorrect poles plus the wrong sign for A0. The incorect poles were P03, P04, P05 and P06.
	01 Apr 1985	The short-period horizontal components have been switched from the KS36000 to the S-750 borehole seismometer.
	22 Oct 1986	RSTN network temporarily closed.
SHIO	01 Jul 1978	Station installed.
	01 Aug 1978 thru 26 Sep 1978	Polarity reversals on both horizontal components.
	14 Sep 1978 thru 21 Sep 1978	Multiplexing errors occurred from 14 Sep 06:31:06.0 through 21 Sep 09:39:35.0. Channel sequence is E, Z, N.
	14 Sep 1978 thru 21 Sep 1978	Long-period channels multiplexed incorrectly. Channel sequence is E, Z, N.
	25 Mar 1980 thru 28 Mar 1980	Long-period channels multiplexed incorrectly. Channel sequence is E, Z, N.

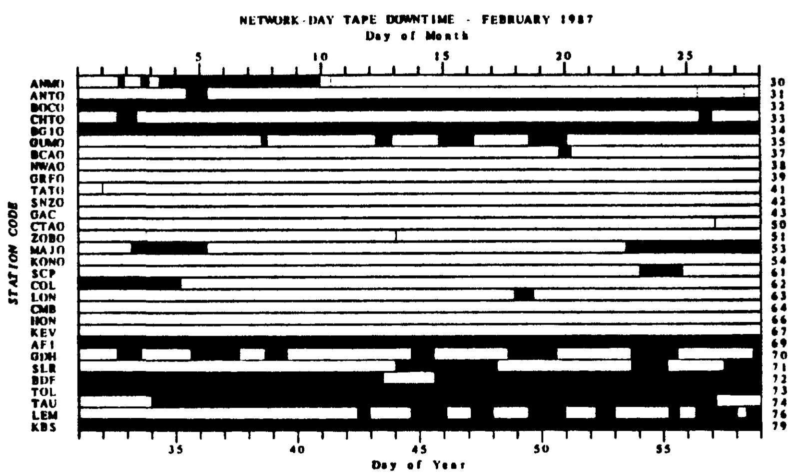
	30 Nov 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
	19 Feb 1984	Long-period transfer functions changed by removing the six second notch filters and by moving the two single-pole high-pass corners. Pole 1 was moved from 250 seconds to 1200 seconds, and pole 2 was moved from 670 seconds to 1200 seconds.
	31 Mar 1985	22 Feb 1984 software installed. Calibration procedure revised.
	31 Mar 1985	Horizontal short-period components installed.
	31 Mar 1985	Clip detectors installed.
	27 May 1985 thru 18 Aug 1985	Station tapes arrived at the Albuquerque Seismological Laboratory after the network-day tapes had been written. Station day tapes have been produced containing data from SHIO only in day tape format for this period.
	03 Mar 1986	Last data received. Station closed.
SLR	24 Oct 1981	Station installed.
	14 Feb 1986 thru 01 May 1986	All data is in error by exactly 24 hours starting at 14 Feb at 04:00 until 1 May at 00:00 UTC. The data is one day late. After a power outage on 14 Feb 1986 the clock was incorrectly reset to 15 Feb 1986.
SNZO	15 Mar 1976	Station installed.
	15 Mar 1976	Short-period sensitivity reduced from 2,000,000 to 2,000 digital counts per micrometer of ground motion at a period of 1 second. The *RESPONSE TO EARTH DISPLACEMENT* table located in the short-period data log was modified beginning on Day 326, 1981. Changes in the values for the relative amplitudes average 2%-3%. Changes in the phase angle values are more significant, averaging between 5%-10%.
	10 Nov 1978	4-pole Bessel filters replaced 4-pole Butterworth anti-aliasing filters (long-period signals).
	10 Nov 1978	Single-pole low-pass sections cornered at 16 Hz in short-period channels removed.
	07 Jan 1981	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
TATO	13 May 1976	Station installed.
	13 May 1976	Short-period sensitivity reduced from 2,000,000 to 2,000 digital counts per micrometer of ground motion at a period of 1 second. The *RESPONSE TO EARTH DISPLACEMENT* table located in the short-period data log was modified beginning on Day 326, 1981. Changes in the values for the relative amplitudes average 2%-3%. Changes in the phase angle values are more significant, averaging between 5%-10%.
	16 Sep 1977 thru 17 Sep 1977	Multiplexing errors occurred from 16 Sep 03:12:04.0 through 17 Sep 04:02:34.0. Channel sequence is N, E, Z.

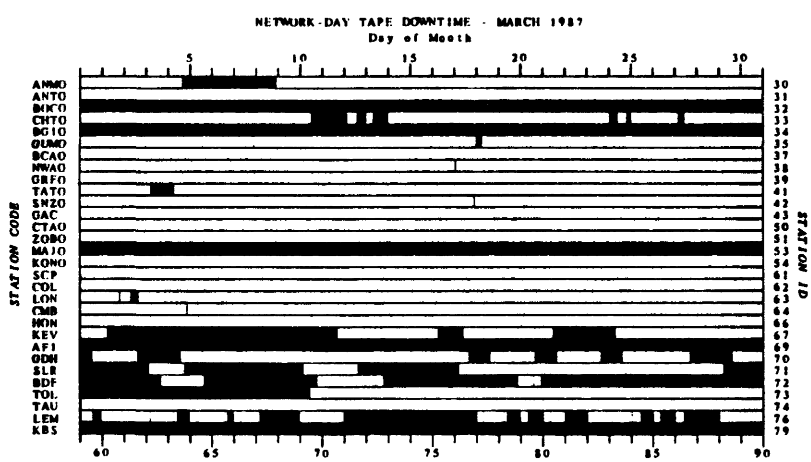
	06 Sep 1978 thru 07 Sep 1978	Multiplexing errors occurred from 06 Sep 03:24:17.0 through 07 Sep 05:37:16.0. Channel sequence is N, E, Z.
	30 Nov 1978	Single-pole low-pass sections cornered at 16 Hz in short-period channels removed.
	25 Jan 1979	4-pole Bessel filters replaced 4-pole Butterworth anti-aliasing filters (long-period signals).
	14 Sep 1979 thru 26 Aug 1980	Polarity reversals on both horizontal components.
	22 Aug 1980	Long-period sensitivities changed: Z = 4500 counts, N-S = 5000 counts, and E-W = 5500 counts per micrometer of ground motion at a period of 25 seconds.
TOL	03 Nov 1981	Station installed.
	05 Oct 1987	Streckeisen seismometers installed.
ZOBO	10 Sep 1976	Station installed.
	27 Dec 1977 thru 28 Feb 1978	The E-W channel was down. The N-S and E-W channels were temporarily switched from 10 Feb 1978 through 14 Feb 1978.
	10 Feb 1978 thru 11 Feb 1978	Multiplexing errors occurred from 10 Feb 16:41:06.0 through 11 Feb 12:51:05.0. Channel sequence is N, E, Z.
	06 Jun 1978 thru 14 Jun 1978	Multiplexing errors occurred from 06 Jun 18:48:02.0 through 14 Jun 14:48:33.0. Channel sequence is N, E, Z.
	18 Sep 1978	During recalibration of the LPN and LPE components, incorrect motor constants were used, resulting in a sensitivity setting of 10000 digital counts per 1.4 microns of ground motion at a period of 25 seconds. LPN and LPE calibrations since that date are for an equivalent ground motion of 1.4 microns. The actual calibration for 1 micron of ground motion is approximately 7150 digital counts. The station log in the network-day tapes contained the following statement in the comment section: 'Long-period horizontal calibration values should be increased by 27%'. This statement should read: 'Long-period horizontal calibration values should be divided by 1.4'. The log comments were corrected on 10 Jun 1981. The average calibration values on the network-day tapes for the long-period horizontal components were changed on 30 Jun 1981 to their correct values (approximately 7150 counts).
	01 Jan 1980 thru 01 May 1981	A pole was not included in the original long-period transfer function listings on the network-day tapes. The pole which should be added is (-0.159E+00, -0.594E+00).
	11 May 1982	The station was recalibrated, and motor constants corrected. Also, the sensitivities were adjusted to coincide with those at other ASRO stations, which are Z = 9000, N-S = 10000, and E-W = 11000 digital counts per micrometer of ground motion at a period of 25 seconds.

	11 Aug 1983	During a maintenance visit, the long-period sensitivities for all channels were incorrectly adjusted. The long- period sensitivities are LPZ = 10,900, LPN = 9,900, LPE = 10,100 digital counts per micron of ground motion at a period of 25 seconds.
	11 May 1984	22 Feb 1984 Software installed. Calibration procedure revised.
	02 Jan 1987	Polarity reversed on LPN and LPE components.
BJI	Oct 1986	Data included on Network-Day Tape.
	29 Apr 1987 thru 03 Aug 1987	Due to a problem with the Tape Copy System in Beijing, events triggered on the short-period and broadband records may start 2 minutes late.
HIA	Oct 1986	Data included on Network-Day Tape.
	27 Apr 1987 thru 20 Jul 1987	Due to a problem with the Tape Copy System in Beijing, events triggered on the short-period and broadband records may start 2 minutes late.
KMI	Oct 1986	Data included on Network-Day Tape.
	27 Apr 1987 thru 20 Jul 1987	Due to a problem with the Tape Copy System in Beijing, events triggered on the short-period and broadband records may start 2 minutes late.
LZH	Oct 1986	Data included on Network-Day Tape.
	Oct 1986 thru 24 Oct 1987	Polarity reversals on long- and short-period horizontal components.
	24 May 1987 thru 20 Jul 1987	Due to a problem with the Tape Copy System in Beijing, events triggered on the short-period and broadband records may start 2 minutes late.
WMQ	Oct 1986	Data included on Network-Day Tape.
	13 Apr 1987 thru 18 Jul 1987	Due to a problem with the Tape Copy System in Beijing, events triggered on the short-period and broadband records may start 2 minutes late.

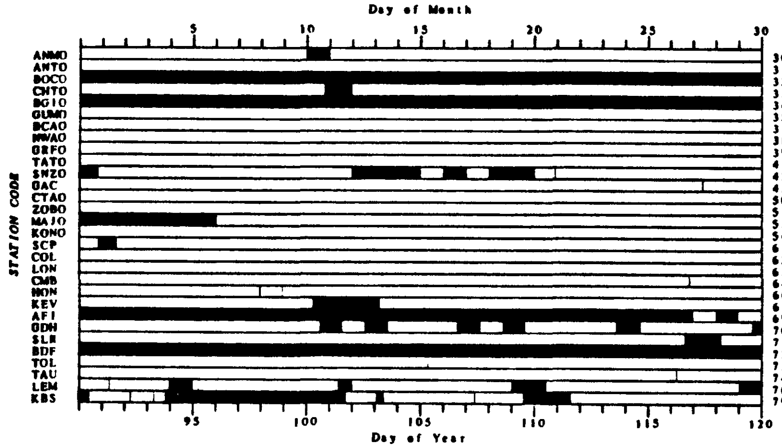
APPENDIX A
NETWORK-DAY TAPE DOWNTIME, 1987


NETWORK-DAY TAPE DOWNTIME - JANUARY 1987
Day of Month
Day of Year
STATION CODE
STATION ID
ANMO
ANTO
BOCO
CHTO
BGIO
GUMO
BCAO
NWAO
GRFO
TATO
SNZO
GAC
CTAO
ZOBO
MAJO
KONO
SCP
COL
LON
CMB
HON
KEV
AFI
GDH
SLR
BDF
TOL
TAU
LEM
KBS

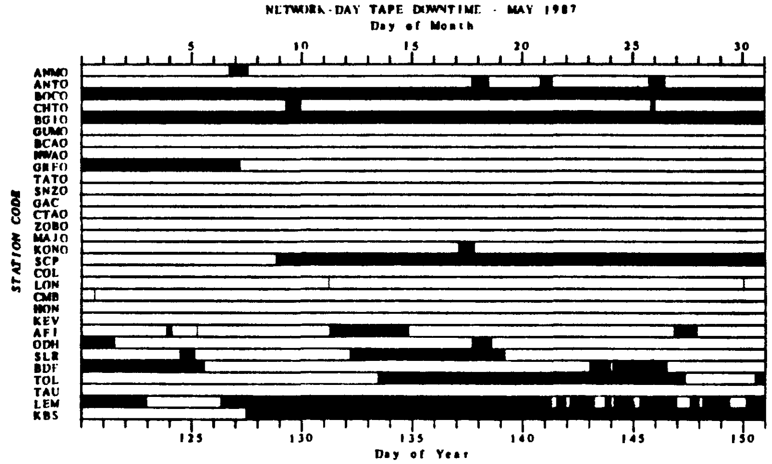

NETWORK-DAY TAPE DOWNTIME - FEBRUARY 1987
Day of Month
Day of Year
STATION CODE
STATION ID


NETWORK-DAY TAPE DOWNTIME - MARCH 1987
Day of Month
Day of Year
STATION CODE
STATION ID

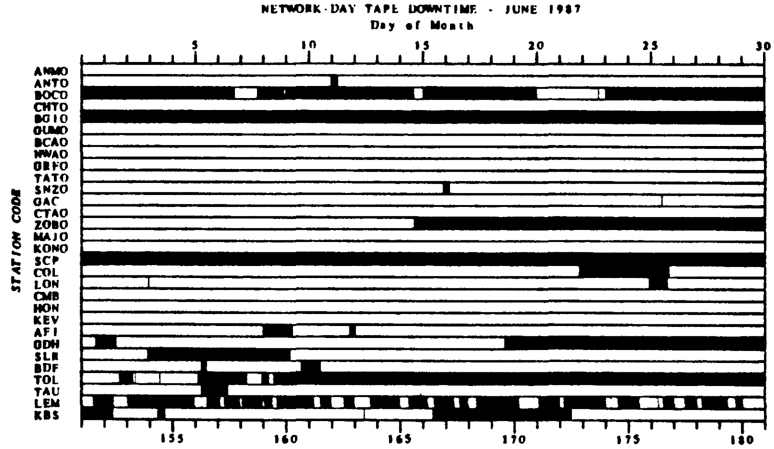
NETWORK-DAY TAPE DOWNTIME - APRIL 1987



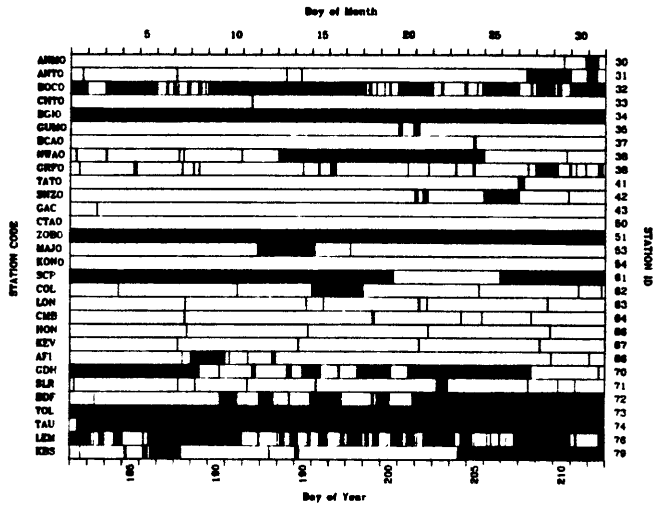
NETWORK-DAY TAPE DOWNTIME - MAY 1987



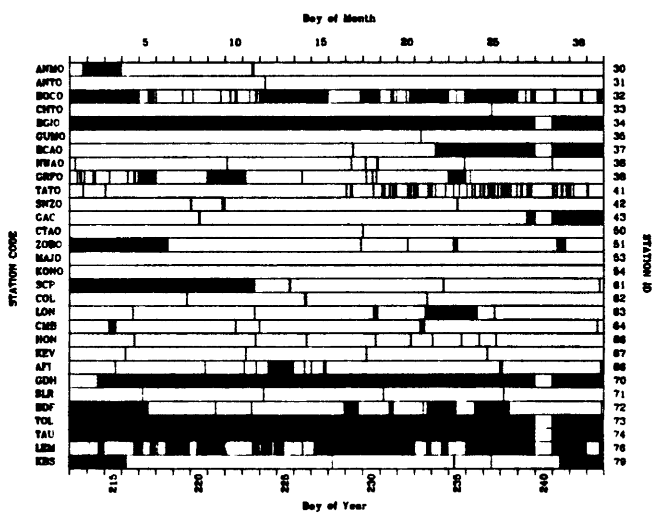
NETWORK-DAY TAPE DOWNTIME - JUNE 1987



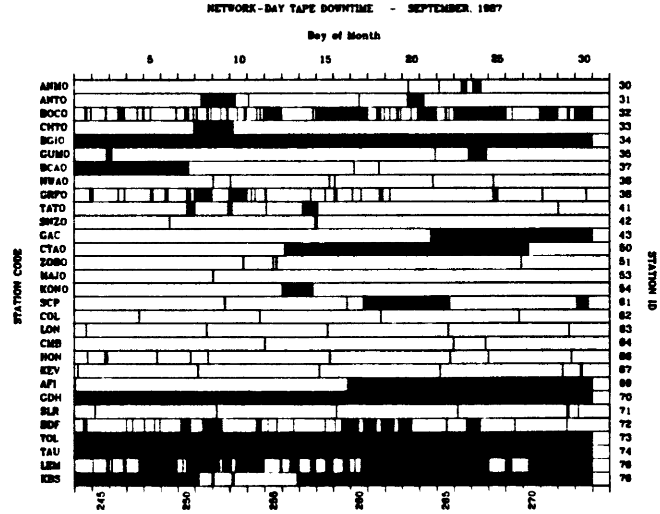
NETWORK-DAY TAPE DOWNTIME - JULY, 1987

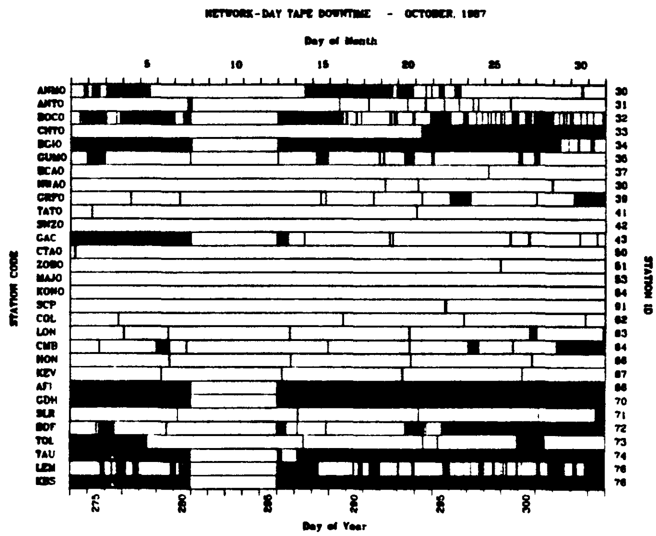


NETWORK-DAY TAPE DOWNTIME - AUGUST, 1987

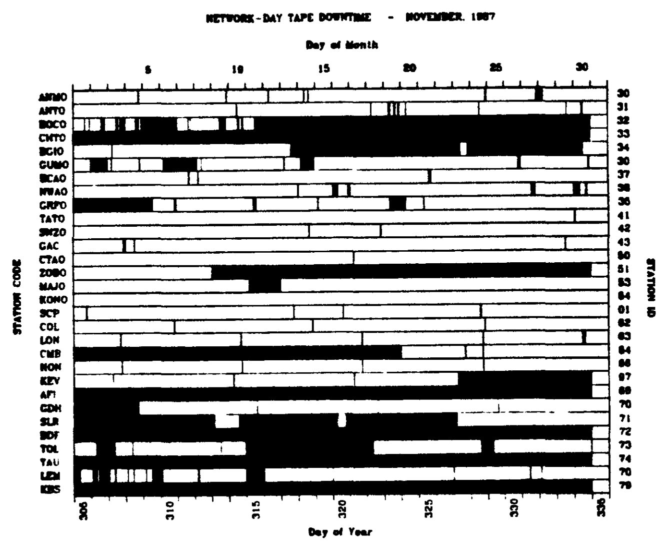


NETWORK-DAY TAPE DOWNTIME - SEPTEMBER, 1987

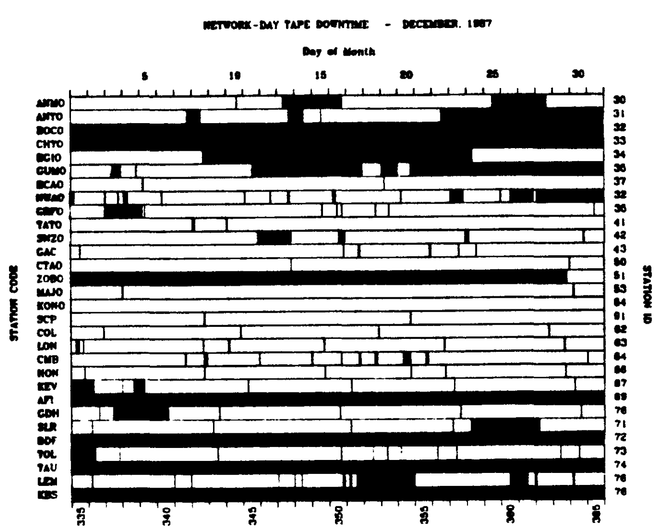




NETWORK-DAY TAPE DOWNTIME - OCTOBER, 1987
Day of Month
STATION CODE
STATION ID
Day of Year



NETWORK-DAY TAPE DOWNTIME - NOVEMBER, 1987
Day of Month
STATION CODE
STATION ID
Day of Year



NETWORK-DAY TAPE DOWNTIME - DECEMBER, 1987
Day of Month
STATION CODE
STATION ID
Day of Year

APPENDIX B
SIGNIFICANT EARTHQUAKES OF THE WORLD, 1987

Earthquakes of magnitude 6.5 or greater or ones that caused fatalities, injuries or substantial damage.
BRK--Berkeley. PAS--Pasadena. FIR--Florence, Italy. FUR--Fuerstenfeldbruck, FRG. GRF--Graefenberg, FRG.
KBA--Barrage Koelnbrein, Austria. KRA--Krakow, Poland. LDG--Laboratoire de Detection et de Geophysique, France.
PMR--Palmer, Alaska. RIV--Riverview, Australia. ROM--Rome, Italy. SLM--St. Louis, Missouri. TRI--Trieste, Italy.
TTG--Titograd, Yugoslavia. VKA--Vienna-Kobenzl, Austria.

DATE	ORIGIN TIME UTC HR MN SEC	GEOGRAPHIC COORDINATES LAT	LONG	DEPTH	MAGNITUDES GS MB	Msz	SD	NO. STA USED	REGION, CONTRIBUTED MAGNITUDES AND COMMENTS
JAN 03	22 04 04.8	14.998 S	167.929 E	15 G	6.0	6.5	1.1	266	VANUATU ISLANDS. Ms 6.7 (BRK), 6.6 (PAS). Complex rupture. Depth from broadband displacement seismograms, based on dominant second event.
JAN 05	12 11 55.7	52.448 N	169.381 W	33 N	6.1	6.7	1.1	361	FOX ISLANDS, ALEUTIAN ISLANDS. Ms 6.5 (BRK), 6.3 (PAS). Complex rupture. Felt (V) at Unalaska and (III) at False Pass. Also felt strongly at Nikolski.
JAN 05	22 52 46.5	41.964 N	81.319 E	17 G	5.9	5.8	1.0	338	SOUTHERN XINJIANG, CHINA. Several people injured and damage in the Baicheng area. Felt in the Aksu-Kuqa-Wushi area. Depth from broadband displacement seismograms.
JAN 09	06 14 44.8	39.895 N	141.677 E	68 G	6.4		1.0	485	HONSHU, JAPAN. mb 6.8 (PAS), 6.6 (BRK). Minor damage (V JMA) in the Morioka-Ofunato area. Felt (IV JMA) at Hachinohe, Ishinomaki, Miyako, Sakata and Sendai; (III JMA) in the Tokyo-Yokohama area and as far north as Kushiro, Hokkaido. Two events about 3 sec. apart. Depth from broadband displacement seismograms, based on the first event.
JAN 09	08 01 35.9	19.469 S	176.538 W	33 N	5.9	6.6	1.1	171	FIJI ISLANDS REGION. Ms 6.8 (BRK), 6.7 (PAS).
JAN 11	12 31 26.0	29.969 N	51.788 E	10 *	4.9	4.1	1.5	53	SOUTHERN IRAN. Three hundred houses damaged in the Doshman Ziari area.
JAN 14	11 03 48.7	42.565 N	142.850 E	102 G	6.5		1.1	521	HOKKAIDO, JAPAN REGION. mb 6.6 (BRK). Six people injured. Felt (V JMA) at Kushiro; (IV JMA) at Hiroo, Nemuro, Obihiro and Urakawa. Also felt (IV JMA) at Hachinohe and Morioka, Honshu. Felt (II JMA) in the Tokyo-Yokohama area, Honshu. Depth from broadband displacement seismograms.
JAN 22	05 10 51.1	43.515 N	10.154 E	22			1.1	62	CENTRAL ITALY. ML 4.2 (KBA), 3.9 (LDG). MD 4.1 (FIR). Two people died of heart attacks. Felt in the Livorno area.
JAN 24	08 09 21.3	41.529 N	79.318 E	29 D	5.9	5.9	1.2	254	KIRGHIZ-XINJIANG BORDER REGION. At least 417 houses damaged in the Wushi area, China. Felt (IV) in the Alma Ata-Przhevalsk area and (III) in the Frunze-Naryn area, USSR.
JAN 26	11 11 41.8	35.964 N	1.374 E	10 G	4.9	4.3	1.2	146	ALGERIA. One person killed, 7 injured and 629 homes damaged in the Mohammadia area. Felt at Oued Fadda and Tissemsilt.
JAN 30	22 29 42.0	60.063 S	26.916 W	48 D	6.2	7.0	1.4	172	SOUTH SANDWICH ISLANDS REGION. Ms 6.9 (BRK), 6.8 (PAS).
FEB 06	13 16 17.8	36.988 N	141.689 E	48	6.1	6.3	1.0	455	NEAR EAST COAST OF HONSHU, JAPAN. Ms 6.5 (PAS), 6.3 (BRK). Felt (V JMA) at Onahama and (IV JMA) at Mito, Sendai, Tokyo, Utsunomiya and Yokohama. Felt from Hikone and Wajima, Honshu to Kushiro, Hokkaido. Also felt on Oshima and Hachijo-jima. Local tsunami recorded with maximum wave heights 12 cm at Onahama; 8 cm at Ishinomaki; 7 cm at Ofunato. Two events about 4 seconds apart, observed on broadband displacement seismograms.
FEB 08	18 33 58.3	6.088 S	147.689 E	55		7.4	1.3	290	EAST PAPUA NEW GUINEA REGION. Ms 7.6 (BRK), 7.0 (PAS). Three people killed by a landslide and some damage (VI) on the Huon Peninsula. Several hundred people homeless and moderate damage (VII), landslides and ground cracks on Umboi Island. Liquefaction occurred in some sands on Malai Island. Felt (VI) in the Cape Gloucester area, New Britain. Felt (III) as far away as Wewak and Port Moresby, New Guinea and Rabaul, New Britain. Multiple event, observed on broadband displacement seismograms.
FEB 11	07 56 12.9	15.834 S	167.355 E	24 G	5.9	6.4	1.2	310	VANUATU ISLANDS. Ms 6.6 (BRK), 6.4 (PAS). Depth from broadband displacement seismograms.
FEB 13	07 18 29.0	0.670 N	126.167 E	32	6.2	6.5	1.3	344	MOLUCCA PASSAGE. Ms 6.4 (PAS). Felt on Ternate and at Manado, Sulawesi.
FEB 17	06 16 12.1	32.793 S	179.304 W	10 G	5.9	6.6	1.2	294	SOUTH OF KERMADEC ISLANDS. Ms 6.5 (BRK), 6.4 (PAS).
FEB 27	08 31 54.4	53.470 N	167.291 W	10 G	6.2	6.7	1.1	428	FOX ISLANDS, ALEUTIAN ISLANDS. Ms 6.8 (BRK), 6.5 (PAS). Minor damage at Dutch Harbor and Unalaska. Felt (V) at Akutan, (III) at Cold Bay and False Pass and (II) at Sandpoint.

DATE	ORIGIN TIME UTC HR MN SEC	GEOGRAPHIC COORDINATES LAT	LONG	DEPTH	MAGNITUDES GS MB	Msz	SD	NO. STA USED	REGION, CONTRIBUTED MAGNITUDES AND COMMENTS
MAR 02	01 42 34.1	37.965 S	176.765 E	19 G	5.9	6.6	1.5	198	NORTH ISLAND, NEW ZEALAND. Ms 6.8 (BRK), 6.4 (PAS). One person died from a heart attack, 25 injured and extensive damage (X) in the Edgecumbe-Kawerou-Whakotane area. Felt throughout much of North Island. Landslides and sandblows occurred. A southwest trending fault scarp 6 km. long had extension openings of up to 1 m. and as much as 1.5 m. of downthrow on the northwest side. Peak ground acceleration of 0.33 g. was recorded within 15 km. of the epicenter. Depth from broadband displacement seismograms.
MAR 05	09 17 05.2	24.388 S	70.161 W	62 G	6.5	7.3	1.2	303	NEAR COAST OF NORTHERN CHILE. Ms 7.2 (BRK), 7.0 (PAS), mb 6.8 (PAS). One person killed and damage (VI) in the Antofagasta area. Felt (VI) at Chuquicamata; (V) in the Taltal-Toconao-Calama area; (IV) at Arica; (III) at Vallenar. Felt (II) at Arequipa, Peru. Also felt at La Paz, Bolivia. Local tsunami generated with maximum wave heights 22 cm. at Caldera, 20 cm. at Coquimbo, 14 cm. at Valparaiso and 18 cm. at Arica. Depth from broadband displacement seismograms.
MAR 06	01 54 50.4	0.048 N	77.653 W	14 G	6.1	6.1	0.9	354	COLOMBIA-ECUADOR BORDER REGION. Ms 6.2 (BRK). One old building collapsed in Quito, Ecuador. Felt throughout northern Ecuador, central and southwestern Colombia, and northern Peru. Depth from broadband displacement seismograms.
MAR 06	04 10 41.9	0.151 N	77.821 W	10 G	6.5	6.9	1.2	344	COLOMBIA-ECUADOR BORDER REGION. Ms 7.0 (BRK), 6.7 (PAS). Approximately 1,000 people killed, 4,000 missing, 20,000 homeles, extensive damage, landslides and ground cracks in Napo Province and in the Quito-Tulcan area, Ecuador. About 27 km. of the oil pipeline in Ecuador, between Lago Agrio and Balao, were destroyed or badly damaged. Landslides occurred in the Pasto-Mocoa area, Colombia. Felt (IV) at Iquitos, Peru. Felt strongly in many parts of Ecuador and southwestern Colombia. Also felt in central Colombia and northern Peru.
MAR 12	23 07 48.7?	51.37 N	20.21 E	10 G			0.1	5	POLAND. ML 2.6 (KRA). Three people killed and three injured in the Slask Mine at Ruda Slaska.
MAR 18	03 36 30.3	32.034 N	131.837 E	54 D	6.4		1.2	534	KYUSHU, JAPAN. Ms 6.7 (BRK), 6.6 (PAS). One person killed; also one person died from a heart attack and five people were injured. Damage (V JMA) and landslides in the Miyazaki area. Felt (IV JMA) in the Kumamoto-Nobeoko-Oita-Saga area; (III JMA) in the Fukuoka-Kagoshima area and on southwestern Shikoku. Felt (I JMA) from Naze, Ryukyu Islands to Mito, Honshu. Seven cm. tsunami recorded along the coast of Kyushu.
APR 07	00 40 43.4	37.363 N	141.796 E	29 G	6.4	6.6	1.0	545	NEAR EAST COAST OF HONSHU, JAPAN. Ms 6.4 (PAS), 6.2 (BRK). Minor damage (V JMA) in the Onahama-Watari area. Felt (IV JMA) at Fukushima, Sendai and Tokyo; (III JMA) at Niigata, Maebashi, and Yokohama; (II JMA) at Hachinohe and Ajiro, Honshu and Obihiro, Hokkaido. Felt (I JMA) from Shizuoka, Honshu to Kushiro, Hokkaido and on Hachijo-jima. Depth from broadband displacement seismograms.
APR 11	02 26 23.6	41.639 N	12.606 E	18			1.2	68	SOUTHERN ITALY. MD 4.1 (FIR), 3.8 (ROM). One person injured slightly and minor damage in the Genzano di Roma-Velletri area. Felt at Rome.
APR 22	20 13 23.1	37.155 N	141.573 E	30 G	6.1	6.6	1.1	505	NEAR EAST COAST OF HONSHU, JAPAN. Ms 6.6 (PAS), 6.4 (BRK). Slight damage (V JMA) at Shirakawa. Felt (IV JMA) at Fukushima, Mito and Onahama; (III JMA) from the Tokyo-Kofu-Tateyama area to Miyako and Morioka; (II JMA) in the Maebashi-Niigata-Akita area and at Kushiro, Hokkaido. Felt (I JMA) on Hachijo-jima and Oshima and from Shizuoka, Honshu to Hakodate and Urakawa, Hokkaido. Depth from broadband displacement seismograms.
APR 25	19 22 07.2	2.244 N	98.866 E	11 D	5.9	6.6	1.3	284	NORTHERN SUMATERA. Ms 6.3 (PAS). Two people killed, 22 injured and more than 300 buildings damaged in the Tarutung-Lake Toba area. A hot spring in the area stopped flowing but resumed later. Felt in the Sibolga-Berastagi area. Also felt in the Kuala Lumpur area, Malaysia.
APR 29	14 27 35.7	19.013 S	177.736 W	385 G	5.9		1.1	441	FIJI ISLANDS REGION. mb 6.5 (PAS), 6.2 (BRK). Depth from broadband displacement seismograms.

DATE	ORIGIN TIME UTC HR MN SEC	GEOGRAPHIC COORDINATES LAT	LONG	DEPTH	MAGNITUDES GS MB	Msz	SD	NO. STA USED	REGION, CONTRIBUTED MAGNITUDES AND COMMENTS
MAY 02	20 43 53.0	44.818 N	10.723 E	10 G	4.8		1.3	204	NORTHERN ITALY. ML 5.2 (FUR), 5.0 (LDG), 5.0 (TTG). One person died from a heart attack at Parma. Several people injured and slight damage (VII) in the Reggio nell'Emilia-Modena area. Felt from Lucca and Genoa to Milan, Verona and Padova.
MAY 06	04 06 14.1	51.272 N	179.898 W	20 G	6.3	6.4	1.0	477	ANDREANOF ISLANDS, ALEUTIAN IS. ML 6.1 (PMR), Ms 6.5 (BRK), 6.2 (PAS). Felt (V) on Adak. Depth from broadband displacement seismograms.
MAY 07	03 05 49.1	46.736 N	139.232 E	430 G	6.0		0.9	653	NEAR E. COAST OF EASTERN USSR. mb 6.6 (BRK), 6.5 (PAS). Felt (IV) in parts of the Sikhote-Alin mountain range. Felt (II JMA) at Aomori, Hachinohe, Morioka and Miyako; (I JMA) at Akita, Takada, Tokyo and Yokohama, Honshu. Felt (II JMA) at Kushiro and Urakawa; (I JMA) at Wakkanai, Rumoi and Asahikawa, Hokkaido. Two events about 4 seconds apart. Depth from broadband displacement seismograms, based on first event.
MAY 12	01 30 25.0	7.090 N	126.701 E	25 G	6.2	6.4	1.1	455	MINDANAO, PHILIPPINE ISLANDS. Ms 6.5 (BRK), 5.9 (PAS). Felt (II RF) at Cagayan de Oro. Also felt at Palo, Leyte. Depth from broadband displacement seismograms.
MAY 18	07 27 00.2	8.302 N	125.362 E	16 *	5.5	5.9	1.3	82	MINDANAO, PHILIPPINE ISLANDS. One person killed in Bukidnon Province. Felt (III RF) at Cagayan de Oro. Also felt in the Davao area.
MAY 23	17 09 04.4	8.047 N	125.410 E	32	5.1	5.2	1.2	99	MINDANAO, PHILIPPINE ISLANDS. One person was killed, two people injured and damage in the Talakag-Malaybalay area. Felt (II RF) at Cagayan de Oro and (I RF) at Butuan and Surigao.
MAY 29	06 27 50.7	34.076 N	48.266 E	41	4.9	4.6	1.2	147	WESTERN IRAN. Two people killed, 50 injured and damage in the Nahavand-Hamadan-Tuysarkan area.
JUN 10	23 48 54.8&	38.713 N	87.954 W	10	4.9	4.4		173	SOUTHERN INDIANA. <SLM-P>. mbLg 5.1 (SLM), Ms 4.6 (BRK). One person injured and minor damage (VI) at Lawrenceville, Illinois. Minor damage also reported at Bridgeport, Mt. Carmel and Olney, Illinois; Bloomfield and New Albany, Indiana; and Louisville, Kentucky. Felt in parts of 21 states from Kansas to Pennsylvania and from South Carolina to Minnesota. Also felt in southern Ontario, Canada.
JUN 17	01 32 53.7	5.577 S	130.791 E	67 G	6.6		1.1	523	BANDA SEA. Ms 6.8 (BRK), 6.5 (PAS). mb 6.3 (PAS). Felt on Banda and Ambon. Depth from broadband displacement seismograms.
JUN 18	10 01 07.3	17.291 N	121.356 E	43	5.5	6.0	1.4	165	LUZON, PHILIPPINE ISLANDS. Eight people killed, five injured, one missing and five houses damaged from landslides. Felt (V RF) in the epicentral area; (IV RF) at Baguio; (III RF) at Manila and Cagayan; (II RF) at Santo and Tuguegarao.
JUN 20	00 37 55.8	51.472 N	16.126 E	13	4.9		1.2	64	POLAND. ML 4.9 (GRF), 4.9 (VKA), 4.7 (KBA). At least three people injured in a mine in the Lubin area.
JUN 24	03 30 30.7	21.179 S	173.581 E	33 N	5.7	6.4	1.3	204	VANUATU ISLANDS REGION. Ms 6.7 (BRK), 6.4 (PAS).
JUN 24	15 04 57.8	33.436 S	150.131 E	40	4.4		1.0	21	NEAR S.E. COAST OF AUSTRALIA. ML 4.2 (RIV). Damage (VII) at Lithgow and slight damage at Sydney and Newcastle. Felt at Bathhurst, Katoomba and Moss Vale.
JUN 27	00 17 04.6	2.164 S	138.170 E	21 G	5.7	6.5	1.3	231	WEST IRIAN. Ms 6.5 (BRK). Depth from broadband displacement seismograms.
JUL 06	02 49 42.7	14.074 S	167.828 E	48	5.9	6.6	1.0	304	VANUATU ISLANDS. Ms 7.1 (BRK), 6.5 (PAS). Felt strongly on the Banks Islands. A small local tsunami was reported.
JUL 15	07 16 13.5	17.522 N	97.153 W	67 D	5.9		1.1	392	OAXACA, MEXICO. mb 6.5 (BRK), 5.9 (PAS). Felt in Oaxaca, Guerrero and in the Mexico City area.
AUG 02	09 07 35.5	24.924 N	115.608 E	29 *	4.9		1.0	97	NEAR SOUTHEASTERN COAST OF CHINA. Eighty-four people injured and about 37,000 houses damaged in the Ganzhou-Xunwu area. Felt (IV) at Hong Kong. Also felt at Canton and Macao.

DATE	ORIGIN TIME UTC HR MN SEC	GEOGRAPHIC COORDINATES LAT	LONG	DEPTH	MAGNITUDES GS MB	Msz	SD	NO. STA USED	REGION, CONTRIBUTED MAGNITUDES AND COMMENTS
AUG 08	15 48 56.7	19.022 S	69.991 W	70 G	6.4	6.9	1.1	379	NORTHERN CHILE. mb 6.3 (BRK). Five people killed, 112 injured and more than 1,000 houses destroyed (VII) in the Arica area. Several landslides occurred along the Chile-Peru border. Damage (VI) at Iquique. Felt (V) at Tocopilla and (III) at Calama and Antofagasta. Felt (III) at La Paz, Bolivia. Felt strongly at Tacna, Moquegua and Lima, Peru. Appears to be two events about 5 seconds apart. Depth from broadband displacement seismograms, based on first event.
AUG 13	15 23 06.9	17.897 S	70.931 W	37 G	6.1	6.4	1.2	310	NEAR COAST OF PERU. Ms 6.2 (BRK). One person killed, one injured and additional damage (V) at Arica, Chile. Felt (IV) at Arequipa and Tacna, Peru. Depth from broadband displacement seismograms.
AUG 14	06 24 04.6	43.734 N	20.413 E	14	5.0		1.2	198	YUGOSLAVIA. ML 4.7 (TTG). Two people injured and damage (VII) in the Kraljevo-Bogutovacko Banja area. Felt (III) at Belgrade and in northern Montenegro. Felt (IV) in the Sofia-Pernik-Vidin area, Bulgaria.
SEP 03	06 40 13.9	58.893 S	158.513 E	33 N	5.9	7.3	1.0	292	MACQUARIE ISLANDS REGION. Ms 7.7 (BRK), 6.9 (PAS).
SEP 03	08 01 36.2	59.538 S	159.005 E	33 N	6.1	6.8	1.2	275	MACQUARIE ISLANDS REGION
SEP 04	16 42 49.1	43.242 N	13.874 E	19	5.1	4.6	1.2	225	CENTRAL ITALY. ML 4.7 (VKA), 4.7 (LDG), 4.7 (TRI). MD 5.1 (TTG), 4.8 (KBA). Two people injured and damage (VIII) in the Porto San Giorgio-Fermo-Pedaso area. Some damage in the Civitanova Marche-Porto Recanati area. Felt from Pesaro to Campobasso.
SEP 07	11 57 09.4	31.089 S	177.968 W	33 N	5.8	6.7	1.3	249	KERMADEC ISLANDS REGION. Ms 6.7 (BRK).
SEP 22	13 43 37.6	0.978 S	78.050 W	10 G	6.1	6.2	1.0	306	ECUADOR. Ms 6.1 (BRK). At least two people killed, twelve injured, several houses destroyed or seriously damaged and landslides in the Ambato area. Minor damage in the Latacunga and Riobamba area. Felt in southern Colombia and northern Peru.
SEP 22	16 21 35.1	1.082 S	78.127 W	10 G	5.9	5.6	1.1	221	ECUADOR. Additional damage in the Ambato area. Felt strongly in the Latacunga area. Felt in southern Colombia and northern Peru.
SEP 28	11 47 08.6	18.411 S	168.058 E	31 D	5.7	6.8	1.3	199	VANUATU ISLANDS. Ms 6.7 (BRK), 6.7 (PAS). Felt.
SEP 28	13 46 13.9	18.546 S	168.161 E	25 D	5.8	6.5	1.1	254	VANUATU ISLANDS
OCT 01	14 42 20.0&	34.060 N	118.080 W	10	5.8	5.7		292	SOUTHERN CALIFORNIA. <PAS-P>. ML 5.9 (PAS), 6.1 (BRK). Eight people killed, many injured, about 2,200 homeless and more than 10,400 buildings damaged in the Los Angeles-Whittier-Pasadena area. The earthquake caused 358 million dollars in property damage. Maximum intensity (VIII) at Whittier. Felt strongly in much of southern California. Felt as far away as Las Vegas, Nevada.
OCT 02	22 27 55.8	8.143 S	77.954 W	20 *	5.4	5.1	1.0	144	PERU. Three people killed and several homes damaged at Santiago de Chuco. Felt (IV) at Trujillo and (III) at Chimbote.
OCT 04	10 59 38.1&	34.070 N	118.100 W	8	5.2	4.8		151	SOUTHERN CALIFORNIA. <PAS-P>. ML 5.3 (PAS), 5.6 (BRK). One person died from a heart attack. Some injured and additional damage in the Pasadena-Alhambra-Whittier area. Felt from Ventura County to San Diego to Palm Springs.
OCT 06	04 19 06.0	17.940 S	172.225 W	16 G	6.7	7.3	1.0	455	TONGA ISLANDS REGION. Ms 7.3 (BRK), 7.2 (PAS). Felt at Nukualofa. Felt on American Samoa. Twenty-five cm. tsunami recorded at Pago Pago, American Samoa.
OCT 12	13 57 04.7	7.288 S	154.371 E	25	6.3	6.8	1.1	363	SOLOMON ISLANDS. Ms 6.8 (BRK), 6.7 (PAS). Felt (V) at Arawa and Panguna, Bougainville. Felt (III) at Rabaul, New Britain. Eight cm. tsunami recorded at Rabaul.
OCT 16	20 48 01.6	6.266 S	149.060 E	48 G	5.9	7.4	1.2	345	NEW BRITAIN REGION. Ms 7.7 (BRK), 7.0 (PAS). Damage (VIII) at Kandrian. Felt (V) at Kimbe and Hoskins, (IV) at Bialla and (III) at Rabaul. Felt (V) at Finschhafen and also felt at Port Moresby, New Guinea. Felt (IV) on Bougainville. Local tsunami generated with 30 meter runup reported at Kandrian. Thirteen cm. tsunami recorded at Rabaul. Multiple event.
OCT 25	16 54 05.6	2.323 S	138.364 E	33 N	6.2	7.0	1.1	290	WEST IRIAN. Ms 6.7 (BRK), 6.7 (PAS). Felt at Jayapura.

DATE	ORIGIN TIME UTC HR MN SEC	GEOGRAPHIC COORDINATES LAT	LONG	DEPTH	MAGNITUDES GS MB	Msz	SD	NO. STA USED	REGION, CONTRIBUTED MAGNITUDES AND COMMENTS
NOV 17	03 40 08.9	12.534 N	87.030 W	76 D	5.8		1.2	392	NEAR COAST OF NICARAGUA. mb 6.2 (PAS). Three people injured and damage in the Chinandega-Leon-El Viejo area, Nicaragua. Felt throughout Nicaragua and (IV) at San Salvador, El Salvador. Also felt in Honduras, Guatemala and northern Costa Rica.
NOV 17	08 46 53.3&	58.586 N	143.270 W	10 G	6.6	6.9		581	GULF OF ALASKA. <AGS-P>. ML 7.0 (PMR). Ms 7.0 (BRK), 6.8 (PAS). Complex event. Felt (V) at Anchorage, Haines, Seward, Trapper Creek, Valdez and Yakutat. Felt (IV) throughout much of southern Alaska from Juneau to Anchorage. Also felt (IV) at Whitehorse, Yukon Territory. Felt at Kodiak, Alaska and Carcross and Haines Junction, Yukon Territory. Ten cm. tsunami recorded at Yakutat.
NOV 24	01 54 14.5&	33.083 N	115.775 W	5	5.7	6.2		237	SOUTHERN CALIFORNIA. <PAS-P>. ML 5.8 (PAS), 6.5 (BRK). Two people killed in an earthquake-related automobile accident about 80 km. east of Mexicali, Mexico. Slight damage (VI) at Calipatria, El Centro, Heber and Westmorland. Felt throughout much of southern California from San Diego and Los Angeles to Las Vegas, Nevada and Yuma, Arizona. Also felt at Mexicali, Tijuana and Ensenada, Mexico.
NOV 24	11 23 16.9	32.658 N	59.105 E	41	5.3	4.4	1.1	163	IRAN. About 485 buildings damaged in 15 villages west of Birjand. Felt at Birjand and Qaen.
NOV 24	13 15 56.4&	33.010 N	115.840 W	2	6.0	6.6		327	SOUTHERN CALIFORNIA. <PAS-P>. ML 6.1 (PAS), 6.7 (BRK). Multiple event. At least 94 people injured and an estimated 4 million dollars damage in Imperial County. Additional injuries and damage occurred in the Mexicali area, Mexico, with an estimated 3,000 people temporarily homeless. Maximum intensities (VI-VII) at El Centro and Westmorland, (VI) at Brawley, Calexico, Calipatria, Heber, Holtville, Imperial and Seeley. Felt throughout much of southern California from San Diego and Los Angeles to Las Vegas, Nevada and Tempe, Arizona. Also felt at Tijuana and Ensenada, Mexico. Surface fault rupture and afterslip were mapped by California Division of Mines and Geology along a 23 kilometer segment of the Superstition Hills fault. A maximum of 65 centimeters of right-lateral displacement with a few centimeters of vertical displacement was measured. Strong-motion records indicate peak accelerations of 0.21g at Westmorland and 0.36g at El Centro.
NOV 26	01 43 14.0	8.247 S	124.155 E	33 N	5.8	6.5	1.3	158	TIMOR. Ms 6.3 (BRK), 6.3 (PAS). At least 37 people killed, 108 injured and 237 buildings damaged on Pantar Island. Landslides also occurred on the island. Mount Sirung started erupting on December 2.
NOV 27	08 26 43.7	32.691 N	59.100 E	33 N	4.7		0.7	50	IRAN. ML 4.4 (MHI). Two hundred forty-three buildings damaged in the Birjand area.
NOV 30	19 23 19.5&	58.679 N	142.786 W	10 G	6.7	7.6		584	GULF OF ALASKA. <SPEC>. Ms 7.7 (BRK), 7.4 (PAS). ML 7.1 (PMR). Mo=1.2*10**20 Nm (BRK). Held to foreshock location. Damage (VI) at Yakutat from earthquake and tsunami. Felt (V) at Anchorage, Copper Center, Gakona, Haines, Homer, Juneau, Levelock, Petersburg, Seward and Skwentna. Also felt (V) in sections of Whitehorse, Yukon Territory, Canada. Felt (IV) throughout southern Alaska from the Ketchikan area to Glennallen and Kodiak Island and (III) as far away as Bethel and Fairbanks. Also felt at Sand Point and (II) at Anaktuvuk Pass. Some damage caused to 2 ships at sea in the epicentral area; felt strongly on 3 other ships in the area. Tsunami generated with wave heights (peak to trough) 85 cm. at Yakutat and 25 cm. at Sitka, Alaska; 15 cm. at Hilo, 12 cm. at Nawiliwili and 5 cm. at Honolulu, Hawaii; and 5 cm. at Presidio, California. Complex event, with major subevent occurring about 15 seconds after onset of the foreshock, observed on broadband displacement seismograms.
DEC 07	12 26 11.7	13.632 S	167.393 E	48	5.7	6.2	1.0	201	VANUATU ISLANDS. Ms 6.7 (BRK).
DEC 07	13 14 34.9	13.559 S	167.454 E	33 N	5.8	6.3	1.0	230	VANUATU ISLANDS. Ms 6.7 (BRK).
DEC 17	02 08 19.9	35.362 N	140.214 E	63 D	6.0		1.0	535	NEAR EAST COAST OF HONSHU, JAPAN. Ms 6.4 (BRK). Two people killed, 66 injured and damage in Chiba Prefecture and the Tokyo area. Felt (V JMA) at Choshi, Chiba and Katsuura; (IV JMA) in the Tokyo-Yokohama-Mito-Kumagaya area; (III JMA) in the Onahama-Shizuoka-Iida area and on Oshima and Hachijo-jima. Felt (I JMA) from Tottori to Sendai.
DEC 17	20 22 58.3	9.169 S	114.610 E	46 G	5.7	5.5	1.1	234	SOUTH OF BALI ISLAND. Twenty people injured on Bali. Felt (III) on Lombok and in eastern Java. Depth from broadband displacement seismograms.

Compiled by: Waverly J. Person