Seismic Network Operations in Alaska

#1434-95-A-01310

Final Technical Report

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Element I-N

The Alaska Earthquake Information Center (AEIC) and Alaska Volcano Observatory (AVO) jointly operate, record and analyze data from several networks comprising over 300 channels of seismic data throughout Alaska. Part of the operation and maintenance of the network is supported by USGS/NEHRP. The USGS/NEHRP funded network contains numerous short-period (SP) seismic stations , 14 Strong motion accelerometers (SMA) and the associated receiving and telemetry systems. Many of these stations are in very remote areas with extreme climatic conditions and can only be reached by helicopter, late in the summer after the snow has melted. During the contract period four additional stations were added in the vacinity of Anchorage; two SP stations, and two broadband stations. The major thrust of this work is to provide the continued operation of the south Alaska seismic network together with the routine analysis of the combined network data. The AEIC monitors earthquakes in Alaska, provides rapid information on felt earthquakes, and disseminates information about earthquakes and seismic hazards to government officials, the media, the public, and the earth-science community worldwide. Six types of reports are issued regularly by the AEIC: 1) Information Release -- a one-page release issued within one-half hour of the occurrence of any shock with magnitude > 4.0; 2) Weekly Seismicity Report; 3) Earthquakes in Alaska -- this multi-page monthly report (12 issues/yr) issued about seven months following the close of a particular month; 4) Alaska Earthquakes and AEIC Seismic Network Operations -- annual report; 5) Catalog of Alaska Earthquake Focal Mechanisms -- Annual catalogs of focal mechanisms; 6) Submission of our monthly earthquake listings to the Council of the National Seismic System catalog.

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The SMAs are designed with a two-year routine site visit schedule, they were serviced in summers of 1996 and 1998. The SP stations have varying maintenance schedules from two to five years or more depending upon power source, and equipment failures. Throughout the contract period, all sites were serviced to repair improperly functioning equipment.

We have been attempting to increase our emphasis on monitoring the seismicity in the vicinity of Anchorage and the upper Cook Inlet, and had proposed six new sites to be installed during the contract period. As stated above, we have managed to accomplish four of these installations, including two broadband stations. Over 50% of the State's population and much of its economic base are located in the extended Anchorage region. The 1964 earthquake demonstrated the threat that great earthquakes pose to this region. What is not clear is the threat that smaller, but perhaps closer, earthquakes pose. Potentially damaging events might originate in the subduction zone near the top of the subducting Pacific Plate, in the overriding plate, as well as on the interplate megathrust. Crustal seismicity located in the Cook Inlet area by our seismic network since 1971 suggests that the fold belt that traverses upper Cook Inlet immediately west of Anchorage might be a serious seismic hazard, capable of generating significant earthquakes on buried thrust faults similar to the recent Northridge earthquake in Southern California. A northerly trend of diffuse seismicity extending from upper Cook Inlet to the Denali Fault along the Susitna River, which may be a zone of NW-SE compression, may also pose a significant hazard. Shallow historical earthquakes as large as magnitude 7.4 have occurred within 100 km of Anchorage, but it is not clear on what

structures these events occurred or whether they all originated in the upper plate. Enhanced monitoring of this region will provide better constrained hypocenters and earthquake source types with which to resolve active seismic structures and modes of deformation in the extended Anchorage region. Such information is critical to assess earthquake exposure in the region.

Seismicity

For the period from May 1, 1995 to May 1, 1998 the AEIC located nearly 17000 earthquakes within the combined seismic network. A plot of these events is shown in Figure 1 illustrating the magnitude and depth distribution for the central parts of Alaska. The abrupt decline in seismicity to the southwest toward the Alaska Peninsula and to the southeast is primarily due to the lack of seismic stations. Such areas are supplemented by teleseismic locations in cooperation with the NEIC.

More detailed information on seismicity parameters can be found in the NEHRP report by Wyss and Hansen, 1998 titled "Seismicitiy Parameters for Seismic Hazard Assessment in Alaska." (USGS Grant Number 1434-HQ-97-GR-03073). Here we illustrate the spatial magnitude of completeness and temporal homogeneity for earthquake reporting throughout the large region of Alaska.

During the contract period, the Alaska Earthquake Information Center has released the following documents and publications on a regular basis:

Weekly Seismicity Reports:

Weekly releases include summary listings of all located earthquakes in or near Alaska for the previous week (usually 100 to 120 events), with date and time of origin, latitude, longitude and hypocentral depth, magnitude, solution quality parameters and a brief comment regarding approximate region, alternate magnitudes and any felt information. Each weekly listing also includes an epicenter map of the whole state (including the Aleutian Islands), a close-up map focusing on the central and south-central part of the state which is most heavily populated, and a brief verbal summary of largest or most significant earthquakes to have occurred during the week.

The seismicity maps and earthquake summary are available over the Worldwide Web, updated on a weekly basis.

Monthly Earthquake Catalogs

Approximately seven months after the end of each month, AEIC issues "Earthquakes in Alaska," a monthly catalog of earthquakes in and near Alaska. The catalogs include full-state seismicity maps, central/ south-central seismicity maps, cross-sections through the two Wadati-Benioff Zones which exist beneath Alaska, a comprehensive listing of the month's earthquakes with additions from the National Earthquake Information Center, the Alaska Tsunami Warning Center, and data from the Geological Survey of Canada where appropriate. A "Highlights" section discusses in detail several of the month's most interesting or significant earthquakes, each of which is presented with an individual map and, when available, its focal mechanism. Detected and located mine and quarry blasts are also itemized in the monthly catalogs.

During the contract period, AEIC has completed many of the remaining back issues of catalogs. Further back issues are being completed as time and resources permit, while maintaining current status on present deadlines.

Beginning with the January 1995, we implemented many modifications and improvements

to the graphical presentation used in the earlier catalogs.

Information Releases

As a part of the 24-hour earthquake monitoring carried out by AEIC, any earthquake whose magnitude is large enough to be considered significant, or an earthquake which was felt by locals, will have a formal "Information Release" issued. The Information release is sent out in two forms: electronic mail is broadcast to a suite of recipients, with a text message providing location, magnitude and any other pertinent information; also, a FAX release is transmitted which includes all the above information as well as a map illustrating the epicenter of the earthquake. These email and FAX releases are sent to numerous state, local and federal government agencies, news media, utilities, other seismic observatories and interested parties.

Monthly Newspaper Map

A seismicity map of the state of Alaska is printed each month in the Fairbanks Newspaper, showing the previous month's seismic activity throughout the state. Accompanying this map is a short column discussing the activity and enlarging on some aspect of seismology for the public's information.

Finger quake

The widely used finger quake utility (finger quake@giseis.alaska.edu) is available on our machines for anyone to view the most recent 100 events located by AEIC. This utility is updated on an hourly basis.

CNSS Catalog contribution

We have implemented regular submission of our earthquake catalogs to the Council of the National Seismic System. This feature was added in February of 1997, so that all catalogs from February 1997 to the end of the grant period, April 1998, have been delivered to the CNSS. Catalogs are submitted several days after completion of each month. In addition, we have retroactively submitted all catalogs from July 1988 through February of 1997, meaning that the catalogs from the full period of this grant, May 1995 through the end of April 1998, have been submitted to the CNSS.

Outreach and Education

During the contract period, seismologists provided an average of two invited lectures each month to various audiences including University departments, community organizations such as the Rotary and Kiwanis clubs, meetings of engineers and public safety officials as well as guest lectures at area elementary and high schools. Among these were two heavily attended (200 people) lectures given in Fairbanks and Anchorage as part of the annual "Science for Everyone" public lecture series, and one as a regular part of the State Division of Emergency Services continuing education class for teachers, "Quake and Shake." Several television news appearances and taped radio interviews were made during the year. AEIC participated in Earth Day activities with an earthquake booth, providing educational demonstrations and materials on earthquakes and earthquake preparedness. An earthquake and seismology booth was set up and maintained during the Tanana Valley State Fair; this was heavily attended and much literature was disbursed regarding earthquakes and earthquake preparedness.

Tours are routinely conducted in the seismology laboratory; on average, two groups per

week are provided with lab tours and talks; these groups range from emergency providers and visiting professionals to tourists and school children.

AEIC routinely exchanges e-mail with citizens worldwide who are seeking information about Alaska earthquakes, or seismology in general, and has provided verbiage and graphics for engineering reports, newspaper articles and school textbooks this year. Public Radio International's "Earth and Sky" series has contacted us on three occasions for help in crafting responses to their listeners' questions about earthquakes.

Public schools throughout the state of Alaska are beginning to incorporate seismology into their science curriculum through their access to our data via the Internet. Further, we are working closely with selected schools to maintain seismic instruments at their location and encourage hands-on participation among students and teachers in the routine scanning and transfer of seismic data; our efforts are modeled on our participation with the Princeton Earth Physics Project (PEPP) approach for bringing schools into the seismic network both as a means to enhance science and mathematics education, as well as to augment our own network coverage and capabilities.

Development of a Real-Time Monitoring System in Alaska (IceWorm)

We joined two software projects to create a near-real-time earthquake monitoring system that writes directly to a relational-database. The Earthworm system acquires seismic data from a network, detects and locates seismic events, and provides support for alarms and emergency-response actions in near-real-time [Dietz et al. 1995]. The Datascope software package developed by the IRIS JSPC combines a relational databasing system for seismic data with a host of processing and analysis tools. The combination is a powerful tool for quickly analyzing and responding to seismic events. Relational databases of Earthworm's intermediate and final outputs allow comprehensive study of its performance. All automatic picks can be reviewed with a graphical waveform viewer, both picks that are associated with hypocenters and picks that remain unassociated, allowing evaluation of the quality of automatic picks and the types of errors that occur. Tentative hypocenters put out by the associator modules can be entered into the database, and the movement of hypocenters as they are updated, as well as the varying associations of picks with evolving hypocentral locations, can be tracked. Picks can be reassigned, removed, or added, and the hypocenters can be relocated by hand for comparison to the automatic solutions. Hypocenters can be interactively watched, mapped, and re-analyzed immediately as they are posted by the Earthworm event associator.

The combination of the Earthworm and Datascope software packages provides a flexible platform for near-real-time analysis of and response to seismic events. It allows graphical, intuitive review of earthquake information well-suited to emergency response. Our relational database of picks, hypocenters and waveforms allows straightforward additions of other post-processing tools, such as alternate location algorithms and a variety of magnitude-estimation routines, as well as examination and transport of the results across the Internet.

We have written an alarm, display, and response script, called wormwatch, that takes advantage of these capabilities. The program displays a map of a monitored region on a Sun workstation. Within minutes of the occurrence of earthquakes, symbols appear on the map to denote their locations. The most recently detected earthquake is highlighted, and its coordinates are displayed. Display of the coordinates for other recently detected earthquakes can be requested by pointing to the event of interest with a cursor. Clicking on a symbol brings up a response menu that allows several actions: creation of a subset database for the event; graphical

display of the corresponding waveforms and editing of the automatic picks; and entry into an analyst-review station for re-location of the event.

The Tatalina River, Alaska, Earthquake of October 6, 1995

On October 6, 1995, at 05:23:19 UT an ML 6.2 earthquake occurred 34 km northwest of Fairbanks, Alaska. This event was felt widely in the region and stimulated renewed public interest in seismic activity within interior Alaska. Intensity reports were solicited via the Fairbanks newspaper, E- mail, and telephone interviews; 1,185 responses were obtained. A complex distribution of effects was produced by the shock in Fairbanks, which had the highest assigned intensity (MM VI), based on minor structural damage. The earthquake was reported felt as far away as Valdez, 465 km to the southeast. Over-flights of the area failed to identify any sign of surface rupture or other surficial effects. Seismicity in the Fairbanks area defines three northeast-southwest trending bands of activity. These are named, from southeast to northwest, the Salcha, Fairbanks, and Minto Flats seismic zones. The Salcha and Fairbanks seismic zones have been the most studied because of their location nearer to Fairbanks and more even distribution of seismic stations, while the Minto Flats seismic zone has received less attention due more difficult access and poorer station coverage. The October 1995 event was located at the northeastern end of the Minto Flats seismic zone and was the largest event to occur within 100 km of Fairbanks since the M7.2 earthquake of 1947 about 80 km south-southeast of the city. While earthquakes up to magnitude 5.9 have subsequently occurred, most of the infrastructure of the region that could be vulnerable to earthquake damage has been built since 1947. The Minto Flats seismic zone, as defined by regional network epicenters determined since 1982, is approximately 150 km long and 50 km wide. Although epicentral uncertainty is clearly a contributing factor, the great width is attributed to the activation of a zone of sub-parallel faults rather than a single through-going fault. To enhance our ability to determine the orientation, extent, and depth of the fault plane and to obtain better constrained focal mechanisms, seven portable PDAS seismic stations were installed, including three that were deployed by helicopter in the immediate epicentral region. In the two-week period following the mainshock, about 4,000 aftershocks were detected, many of which could be located. Preliminary estimates of both p and b values (1.0 and 0.8 respectively) are consistent with other Alaska interior earthquakes, such as the 1968 Rampart and the 1985 Dall City earthquakes. Nine of the ten focal mechanism determinations available for earthquakes in the Minto Flats zone since 1991 are consistent with those of the mainshock and the over 40 aftershocks (M >= 2.3) studied to date. These mechanisms imply left-lateral strike-slip motion on a NNE-striking, steeply dipping fault plane.

Reports and Articles

Reports

Earthquakes in Alaska (Periodical Series, 12 issues/year, author list varies including B. Hammond, K. Fogleman, R. Tam, N. Macgregor-Scott, C. Stephens, and J. Lahr from USGS, and L. Rao, C. Rowe, R. Hansen, and D. Mcnamara from UAFGI):

Month/Year	Alaska State Seismologist Report No.
September 1991	91-01-09
October 1991	91-01-10
November 1991	91-01-11
December 1991	91-01-12
January 1992	92-01-01

February 1992	92-01-02
March 1992	92-01-03
April 1992	92-01-04
May 1992	92-01-05
June 1992	92-01-06
July 1992	92-01-07
August 1992	92-01-08
September 1992	92-01-09
October 1992	92-01-10
November 1992	92-01-11
December 1992	92-01-12
January 1993	93-01-01
February 1993	93-01-02
March 1993	93-01-03
April 1993	93-01-04
May 1993	93-01-05
June 1993	93-01-06
July 1993	93-01-07
August 1993	93-01-08
September 1993	93-01-09
October 1993	93-01-10
November 1993	93-01-11
December 1993	93-01-12
January 1994	94-01-01
February 1994	94-01-02
March 1994	94-01-03
April 1994	94-01-04
May 1994	94-01-05
June 1994	94-01-06
July 1994	94-01-07
August 1994	94-01-08
September 1994	94-01-09
November 1994	94-01-11
December 1994	94-01-12
January 1995	95-01-01
February 1995	95-01-02
March 1995	95-01-03
April 1995	95-01-04
May 1995	95-01-05

Fogleman, K.A., Rowe, C.A., and Hammond, W.R., 1995. Alaska Earthquakes - 1994, in Moore, Tom, and Dumoulin, Julie, eds, The U.S. Geological Survey in Alaska, Accomplishments during 1994, U.S. Geol. Survey Bull. 2152.

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Lindquist, K.G. and Hansen, R.A. 1995. A Local Magnitude Scale for Alaska. IUGG General

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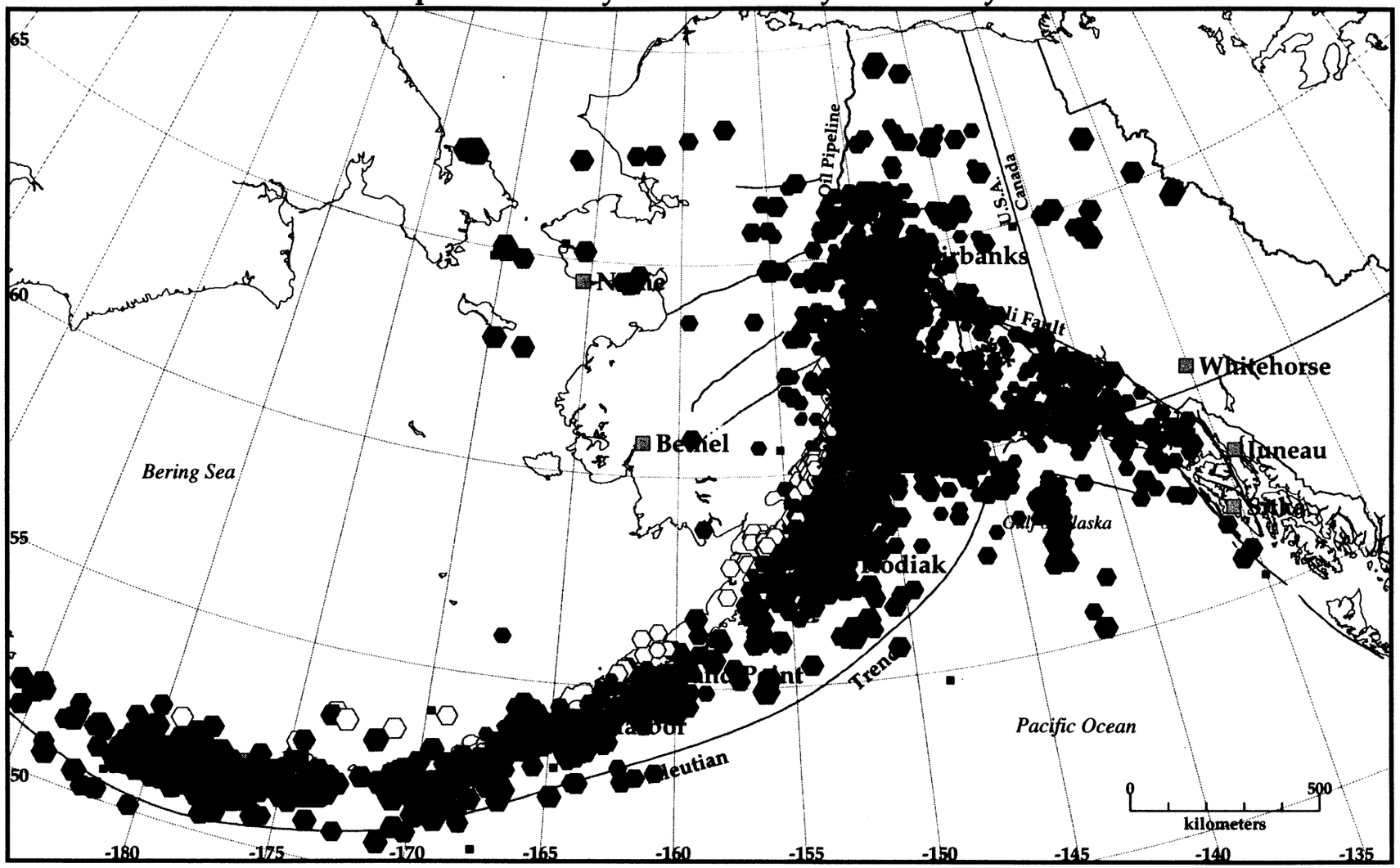
McNutt, S.R. and J. Benoit, D. Christensen, S. Estes, G. Tytgat, S. Stihler, S. Wiemer, A. Jolly, M. Robinson, R. Hansen, K. Lindquist, M. Garces, J. Lahr, R. Hammond, J. Paskievitch, J. Power (1997). "Broadband Seismology at the Alaska Volcano Observatory," 1993-1997, *Eos Trans. Amer. Geophys. U.*, **78**, No. 46, p. F429.

Lindquist, K. (1998). PhD Thesis. Seismic array processing and computational infrastructure for improved monitoring of Alaskan and Aleutian seimicity and Volcanoes, University of Alaska, Fairbanks, 255 pp.

Earthquake Activity in Alaska May 1995 - May 1998



16516 events plotted
- Depth <= 30
- 30 < Depth <= 75
- 75 < Depth <= 125
- Depth > 125

Alaska Earthquake Information Center
UAF Geophysical Institute
U.S. Geological Survey

Figure 1

- No M
- M = 2.0
- M = 3.0
- M = 4.0
- M = 5.0