SEISMIC NETWORK OPERATIONS IN ALASKA

Final Project Report

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Abstract

AEIC and AVO jointly operate, record and analyze data from ~800 channels of seismic data throughout Alaska. Part of the operation and maintenance of the network is supported by USGS/NEHRP. At the end of the reporting period, the real-time network contained numerous short-period seismic stations, 37 accelerometers, 46 broadband stations, and the associated receiving and telemetry systems. Many of these stations are in remote areas with extreme climatic conditions and can only be reached by helicopter, after the snow has melted. The major thrust of this work is to provide continued operation of the south Alaska seismic network together with the routine analysis of the combined network data.

Investigations Undertaken

The Alaska Earthquake Information Center (AEIC) and Alaska Volcano Observatory (AVO) jointly operate, record and analyze data from several networks comprising about 800 channels of seismic data throughout Alaska. Part of the operation and maintenance of the network is supported by this USGS/NEHRP cooperative agreement.

The USGS/NEHRP funded network contains numerous short-period (SP) seismic stations, 13 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. The SMAs are designed with a two-year routine site visit schedule, 9 were serviced in the summer of 2003. 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, the majority of the sites were serviced to repair improperly functioning equipment.

At the end of the reporting period, there were a total of 46 broadband digital stations operating in Alaska. Three of these are IRIS stations, nine are installed by AVO on volcanoes, three are operated by WC/ATWC, and the rest were installed by AEIC.

Installation of the Fairbanks Strong Motion Network

As an add on to this cooperative agreement, ANSS funds were leveraged in partnership with AVO and AEIC/Geophysical Institute to establish a 10 station strong motion network in Fairbanks. Sites were chosen and approved by NSMP at 4 fire stations, 3 schools, a borough maintenance facility, the University of Alaska campus, and the State of Alaska Department of Natural Resource offices. AEIC personnell then built the vaults and installed the equipment at all the sites. Each of these sites represents a reference site type of installation. Guralp cmg-5TD instruments were selected for installation, and were telemetered in real time using Wi-Lan IP type spread spectrum radios that form a network cloud throughout the Fairbanks area. The data is recieved at AEIC with a central receiving radio, and integrated into the AEIC recording and processing system. Utilities were then established for use of the data within our Shakemap production, and also for automatic detection of earthquakes of interest for relaying data in near real time to USGS/ NSMP in Menlo Park, CA.

Seismicity

For the period from May 1, 2001 to April 30, 2004 the AEIC reported a total of 65,500 events within the combined seismic network. The seismicity in the western Aleutian arc and Bering sea is supplemented by teleseismic locations in cooperation with NEIC. A map of these events is shown in Figure 1. Figure 2a shows seismicity in the south-central Alaska with two cross-sections presented in Figure 2b. There were 1102 events with magnitude 4.0 or above (~30 events per month on average) and 47 events with magnitude 5.0 or above (~4 events per month on average). The largest earthquake occurred on November 3, 2002 on the Denali fault in the central region of Alaska (M_W 7.9). The second major event within this time period occurred on November 17, 2003 in the Rat Islands region of the Aleutian Islands (M_W 7.8). The AEIC located ~26,600 aftershocks of the Denali Fault earthquake (~11,000 within the 1st month and ~7,000 within the 2nd month alone) and ~500 aftershocks of the Rat Islands event through the end of the reporting time interval. The cumulative number of processed events is shown in Figure 3. Due to the large number of Denali fault event aftershocks, the AEIC analyzed so far only events with M>=3.0 between January 10 and April 25, 2003. We are currently working on finishing processing within this gap. Figure 4 illustrates the frequency-magnitude relation for the earthquakes located in the mainland

Alaska. From this relation, the magnitude of completeness of the AEIC catalog for this time period within the network core area is estimated to be 1.4.

Earthquake Sources

The AEIC routinely determines P-wave first motion focal mechanisms for earthquakes with M_L>=3.5 located within the network core area. There are 384 first motion focal mechanisms for this time period (see map in Figure 5a). Regional seismic moment tensors are determined for earthquakes with M_W>= 3.8 in the mainland Alaska and M_W>=4.0 in the Aleutians. The AEIC determined a total of 120 moment tensors for this time period with the largest event a M_W=6.7 on the Denali fault in central Alaska which preceded the M7.9 November 3, 2002 event by ten days (see map in Figure 5b).

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

Weekly Seismicity Reports

Weekly reports include summary listings of all located earthquakes in or near Alaska for the previous week, 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 four 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, 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 Pacific Coast and 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.

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 (M>=3.5 in the mainland Alaska and M>=4.0 in the Aleutians), 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. In addition, all Information Releases are now available on the Web.

ANSS Catalog contribution

We have implemented regular submission of our earthquake catalogs to the ANSS system at UC Berkeley. Catalogs are submitted several days after completion of each month. In addition, we have retroactively submitted all catalogs from July 1988 until present, meaning that the catalogs from the full period of this grant have been submitted to the ANSS.

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.

We have a Web page for the Seismology group at the Geophysical Institute that incorporates the activities of the ASN and the AEIC. Within this web site are descriptions of personnel, network topology, network processing, earthquake occurrence, research activities, and links to a variety of related sites. Examples of related links include the USGS Alaska Hazard Maps, publications on hazard preparedness, and a customized version of the Community Internet Intensity Map (CIIM) in collaboration with David Wald. In addition, we are supplying near-real-time earthquake information to both the CIIM and the web based seismicity maps through the QDDS system. We have implemented dbrecenteqs, a web-based application to display detected earthquakes on the web as they are detected in near-real-time.

Lastly, we have updated and published the pamphlet titled “Are you prepared for the next big Earthquake in Alaska” in collaboration with FEMA, DHS&EM, ADGGS, WC/ATWC, Conoco Phillips, and USGS. This publication was distributed in various Alaska newspapers on the 40th anniversary of the 1964 M9.2 earthquake. Many copies are available to each of the collaborators for supplement outreach distribution.

Significant events:

The M_W 7.9 Denali Fault Earthquake of November 3, 2002

At 1:12 p.m. AST on Sunday afternoon, November 3, 2002, a major earthquake (M_W=7.9) occurred in the central region of Alaska. The epicenter of this earthquake was situated ~150 km (94 miles) south of Fairbanks, the second largest population center in Alaska. It ruptured three different faults resulting in a total rupture length of ~330 km. It started on the previously unrecognized Susitna Glacier Thrust fault, a splay fault south of the main strand of the Denali fault. Then the rupture transferred onto the main strand of the Denali fault and continued as a right-lateral strike-slip event for ~220 km until it reached the Totschunda fault near 143^{o}W longitude. At that point, it right-stepped onto the more south-easterly trending Totschunda fault and stopped after rupturing nearly 70 km of it. A team of geologists surveyed the total length of the ruptured faults and reported maximum vertical offsets on the Susitna Glacier Thrust of 4 m and maximum horizontal offsets of 8.8 m west of the Denali and Totschunda fault junction. While the fault rupture lasted for approximately 100 sec from its initiation to the arrest, its distal effects were felt for many days and months. Of the population centers, the hardest hit were the villages of Mentasta and Northway, located at the eastern end of the rupture zone. This event caused significant damage to the transportation systems in central Alaska. The Trans-Alaska Pipeline suffered some damage, but no oil spills occurred. Multiple land slides and rock avalanches occurred in the Alaska Range with the largest slide on the Black Rapids Glacier. The Denali Fault event was felt as far as Washington and caused seiches in pools and lakes as far as Texas and Louisiana. There were reports of triggered seismicity in volcanic and geothermal centers in Washington and California and regional seismicity in Utah. The M7.9 Denali Fault event was preceded by the magnitude 6.7 Nenana Mountain event on October 23, 2002. Its epicenter was located on the Denali fault 22 km east of the M 7.9 event epicenter. In response to the magnitude 6.7 and 7.9 events, the Alaska Earthquake Information Center (AEIC) staff installed a network of temporary instruments for the aftershock monitoring. At its peak of operation it contained a mixture of 26 broadband and strong motion instruments. The temporary network was dismantled in June, 2003.

The AEIC reported ~26,600 aftershocks of the Denali Fault earthquake through the end of the report time (~11,000 within the 1st month and ~7,000 within the 2nd month). The magnitude of completeness of the aftershock catalog varies along the ruptured fault and reflects the station distribution. The threshold is the lower (~M1.1) within the epicentral region and higher (~M1.8) near the eastern end of the rupture. Due to a large increase in the processing load immediately following the mainshock, the AEIC so far has processed only events with the magnitudes~3.0 and above between January 10 and April 25, 2003.

The M_W 7.8 Rat Islands Earthquake of November 17, 2003

At 9:43 p.m. AST (06:43 11/17 UTC) on Sunday evening, November 16, 2003, a major earthquake (M_W=7.8, CMT) occurred in the Rat Islands region of the Aleutian Islands. This earthquake was situated 95 kilometers (59 miles) south-southwest of Amchitka. It was the largest event to occur in the Aleutian Islands since the June 1996 magnitude 7.9 Adak earthquake. The AEIC located over 500 aftershocks of the M7.8 event through the end of the reported time period. The magnitude of completeness of the aftershock catalog is 3.5. The largest aftershock occurred at 10:50 p.m. AST on November 17 (7:50 UTC, 11/18) and had a moment magnitude of 5.7. The

main shock generated a small tsunami of about 50 cm (1.64 ft) at Shemya and 12 cm (0.39 ft) at Adak (Alaska Tsunami Warning Center).

The M 7.8 earthquake occurred on the convergent boundary between the subducting Pacific and overriding North American crustal plates. This region, where the two plates are being forced directly into one another, is one of the world's most active seismic zones. Over one hundred earthquakes of magnitude seven or larger have occurred along this boundary in the past hundred years. The 1965 M 8.7 Rat Islands earthquake ruptured an ~600 km-long portion of the plate boundary. In the 2003 M7.8 earthquake, the easternmost part of the 1965 zone failed again.

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Figure 1: May 1, 2001 -- April 30, 2004

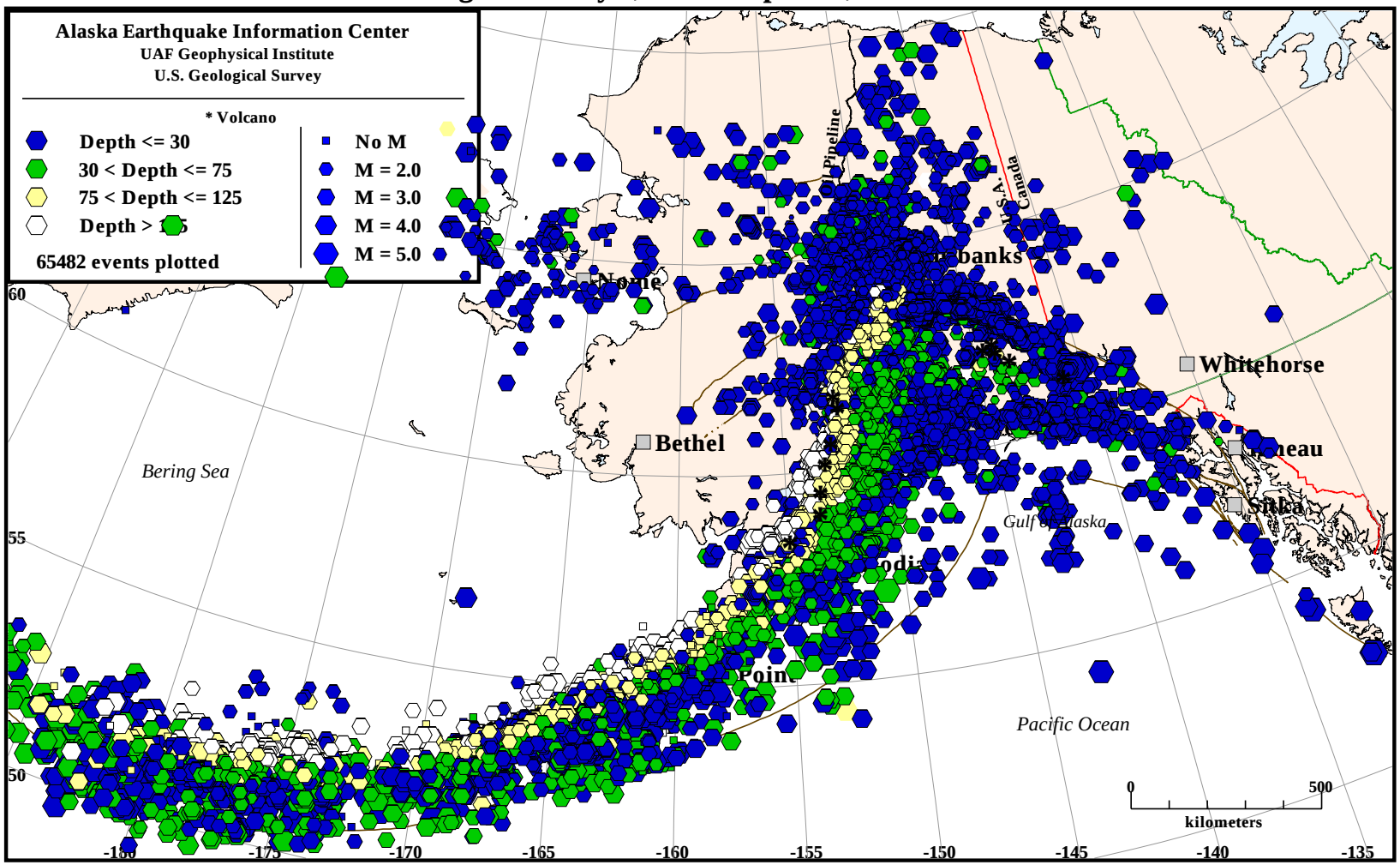


Figure 1. AEIC earthquake catalog from May 1, 2001 - April 30, 2004.

Figure 2a: May 1, 2001 -- April 30, 2004

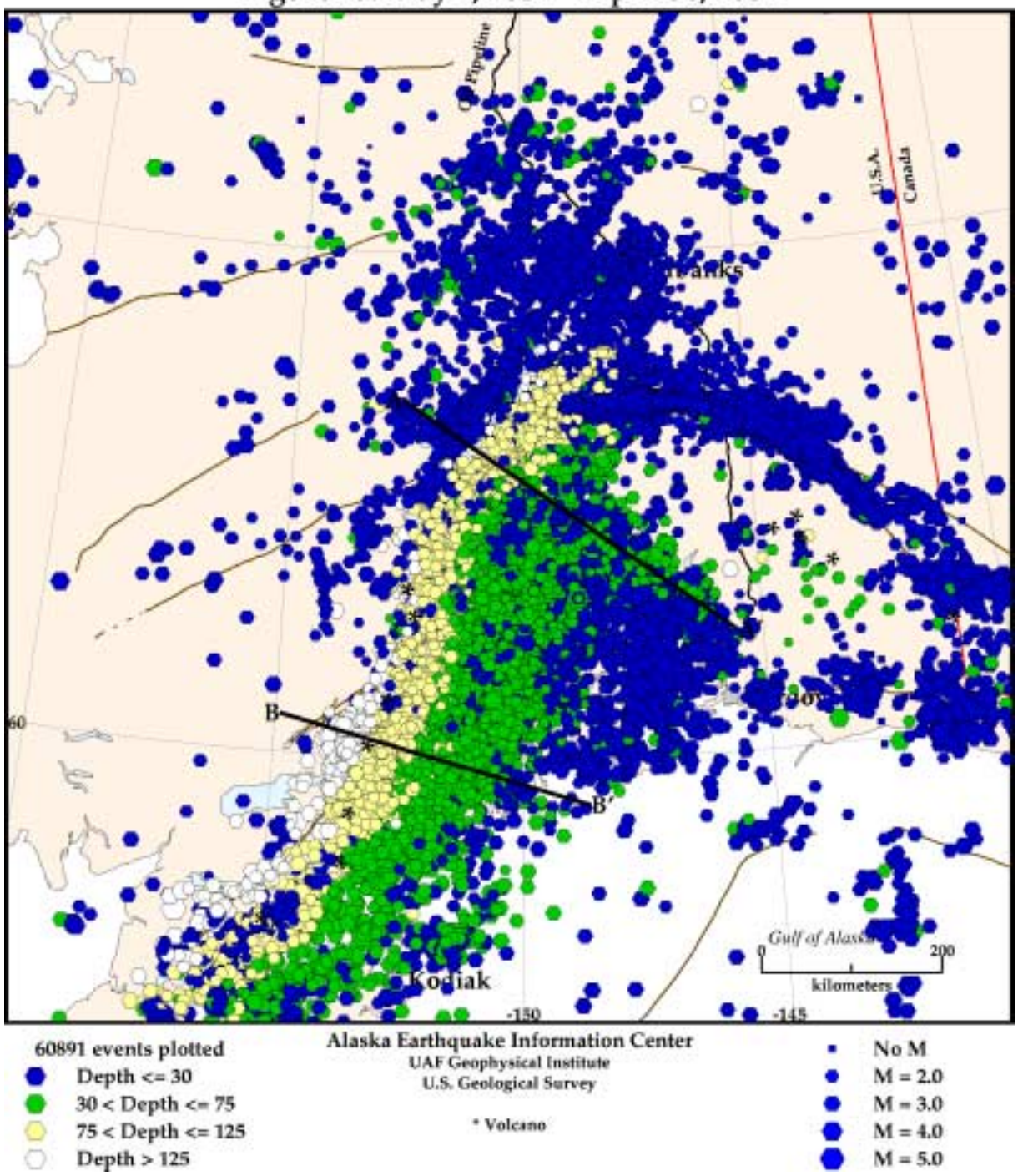
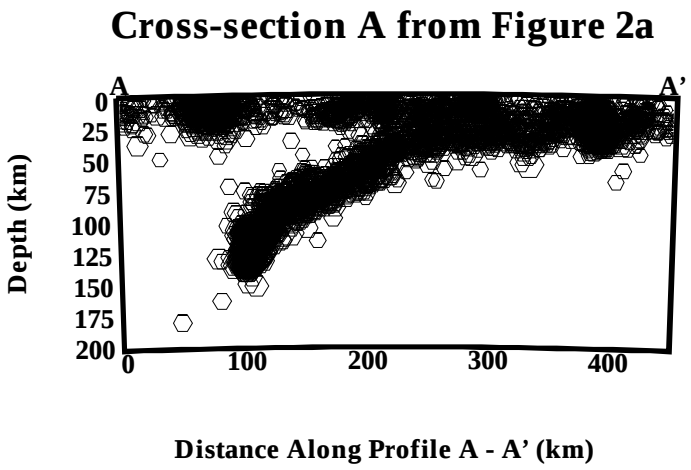


Figure 2a. The AEIC earthquake catalog for south-central Alaska May 1, 2001 - April 30, 2004.



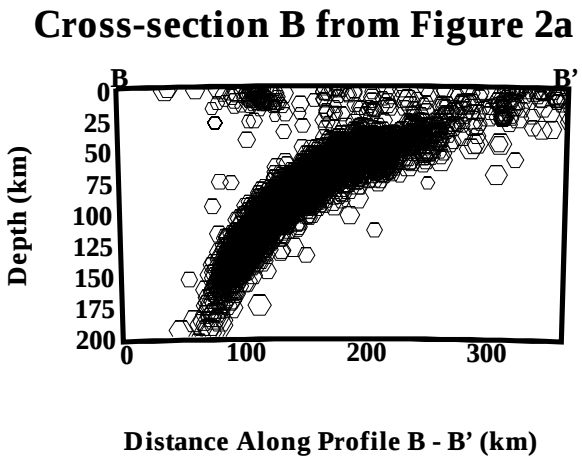


Figure 2b. Cross-sections from Figure 2a.

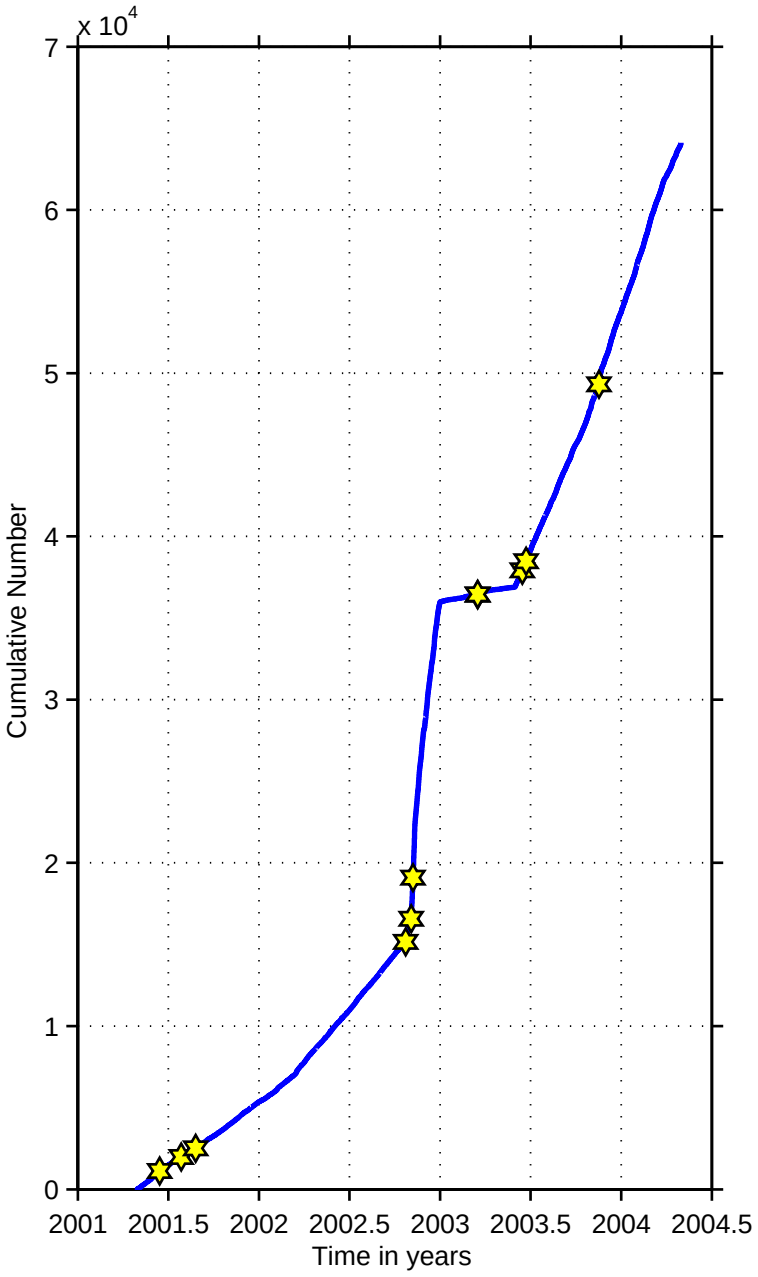


Figure 3. Cumulative plot of events from the AEIC earthquake catalog from May 1, 2001 - April 30, 2004. Stars are events with the magnitudes 6.0 and larger.

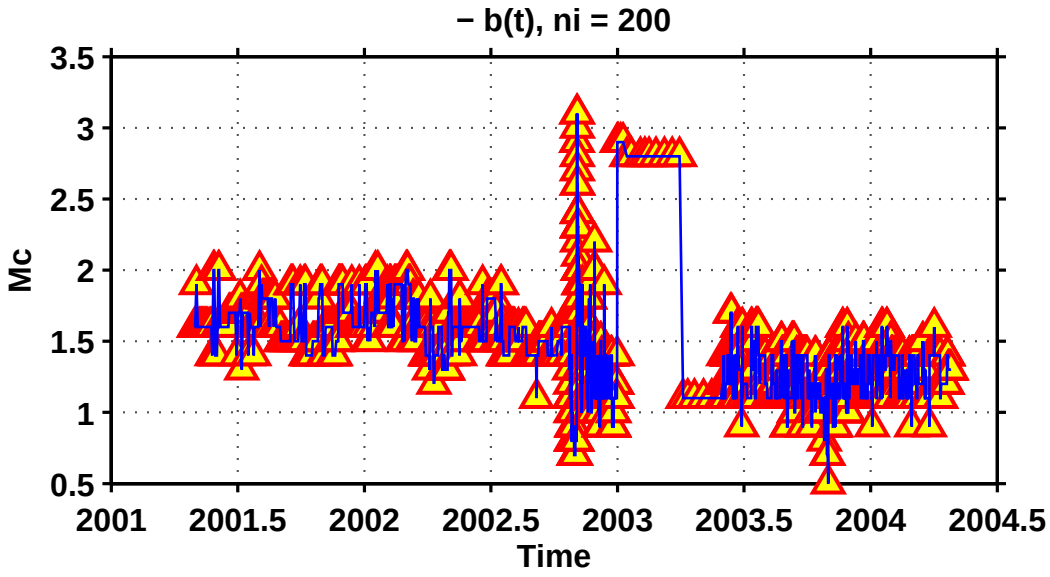


Figure 4. Magnitude of completeness (Mc) with time for the mainland Alaskan events from the AEIC earthquake catalog from May 1, 2001 - April 30, 2004. The magnitude of completeness decreases towards the end of the time period from 1.5-2 in the beginning to 1-1.5 at the end. There is an increase in Mc for several hours immediately following the M7.9 Denali Fault earthquake of November 3, 2002 due to a large number of overlapping aftershocks. The second, prolonged increase corresponds to the 4-months processing gap.

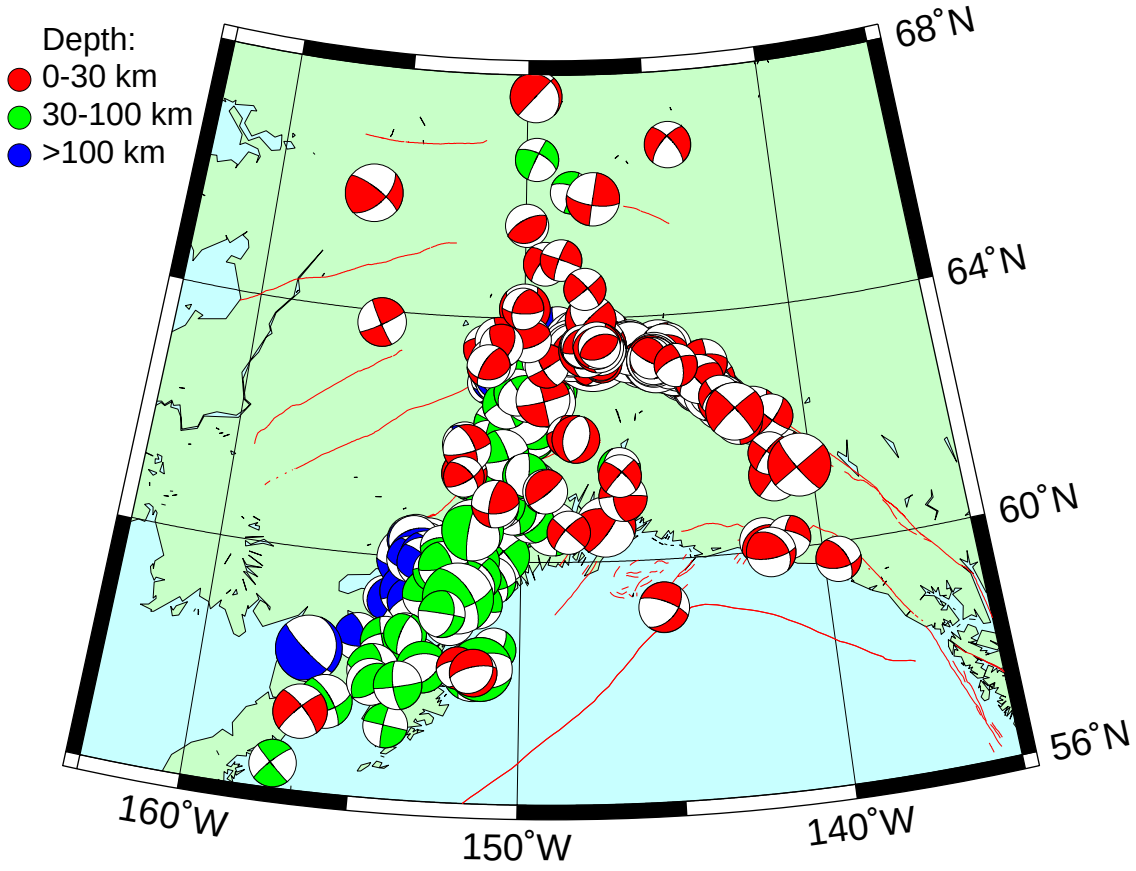


Figure 5a. P-wave first motion focal mechanisms from the AEIC earthquake catalog (May, 2001-April, 2004).

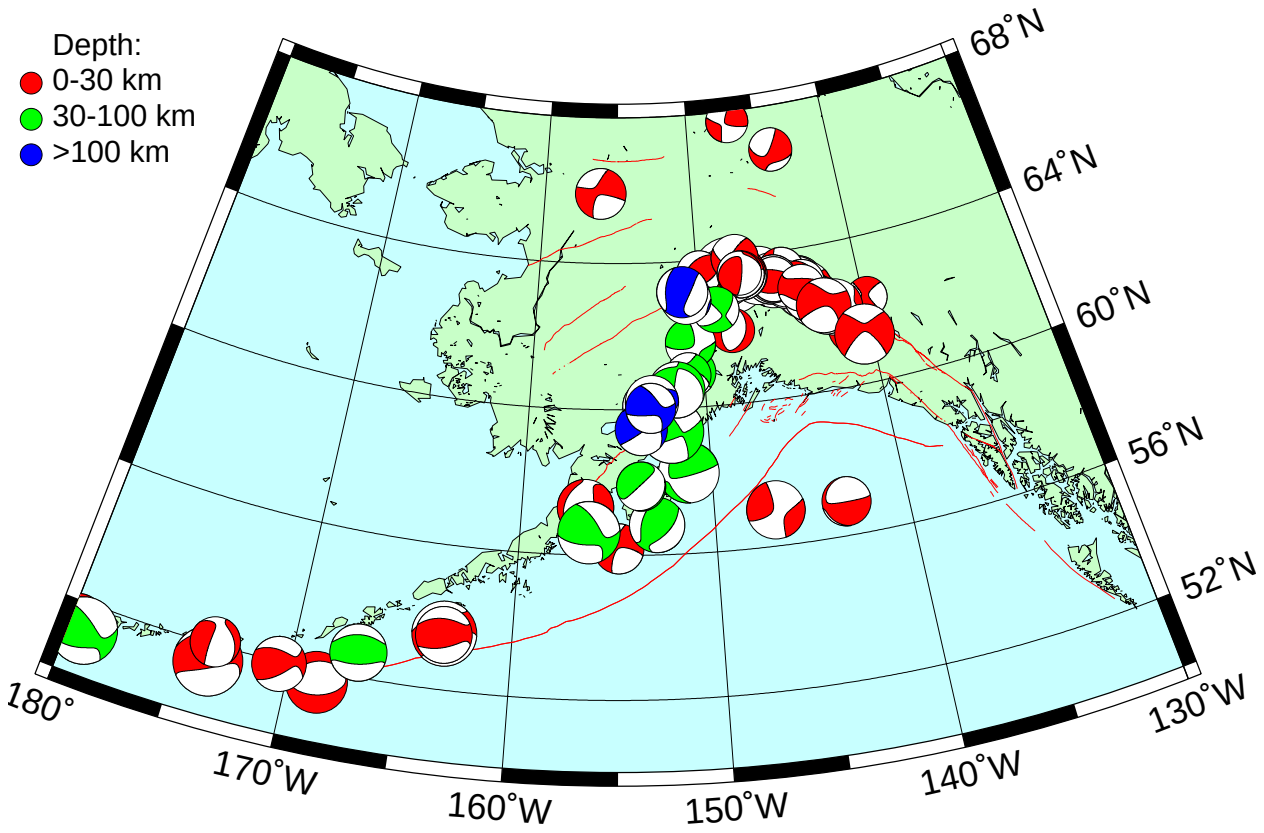


Figure 5b. Regional moment tensors from the AEIC earthquake catalog (May, 2001-April, 2004).