Catalog of Earthquake Hypocenters at Alaskan Volcanoes: January 1 through December 31, 2006

By James P. Dixon, U. S. Geological Survey, Scott D. Stihler, University of Alaska Fairbanks, John A. Power, U. S. Geological Survey, Cheryl Searcy, Science Applications International Corporation

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By James P. Dixon[1], Scott D. Stihler[2], John A. Power[1], Cheryl Searcy[3]

Abstract

Between January 1 and December 31, 2006, AVO located 8,666 earthquakes of which 7,783 occurred on or near the 33 volcanoes monitored within Alaska. Monitoring highlights in 2006 include: an eruption of Augustine Volcano, a volcanic-tectonic earthquake swarm at Mount Martin, elevated seismicity and volcanic unrest at Fourpeaked Mountain, and elevated seismicity and low-level tremor at Mount Veniaminof and Korovin Volcano. A new seismic subnetwork was installed on Fourpeaked Mountain. This catalog includes: (1) descriptions and locations of seismic instrumentation deployed in the field during 2006, (2) a description of earthquake detection, recording, analysis, and data archival systems, (3) a description of seismic velocity models used for earthquake locations, (4) a summary of earthquakes located in 2006, and (5) an accompanying UNIX tar-file with a summary of earthquake origin times, hypocenters, magnitudes, phase arrival times, location quality statistics, daily station usage statistics, and all files used to determine the earthquake locations in 2006.

Introduction

The Alaska Volcano Observatory (AVO), a cooperative program of the U.S. Geological Survey, the Geophysical Institute at the University of Alaska Fairbanks, and the Alaska Division of Geological and Geophysical Surveys, has installed and maintained seismic monitoring networks at many historically active volcanoes in Alaska since 1988 (fig. 1). The primary objectives of the AVO seismic program are the real-time seismic monitoring of active, potentially hazardous, Alaskan volcanoes and the investigation of seismic processes associated with active volcanism. This catalog includes: (1) descriptions and locations of seismic instrumentation deployed in the field during 2006; (2) a description of earthquake detection, recording, analysis, and data archival systems; (3) a description of seismic velocity models used for earthquake locations; (4) a summary of earthquakes located in 2006; and (5) an accompanying UNIX tar-file with a summary of earthquake origin times, hypocenters, magnitudes, phase arrival times, location quality statistics, daily station usage statistics, and all HYPOELLIPSE (Lahr, 1999) files used to determine the earthquake locations in 2006.

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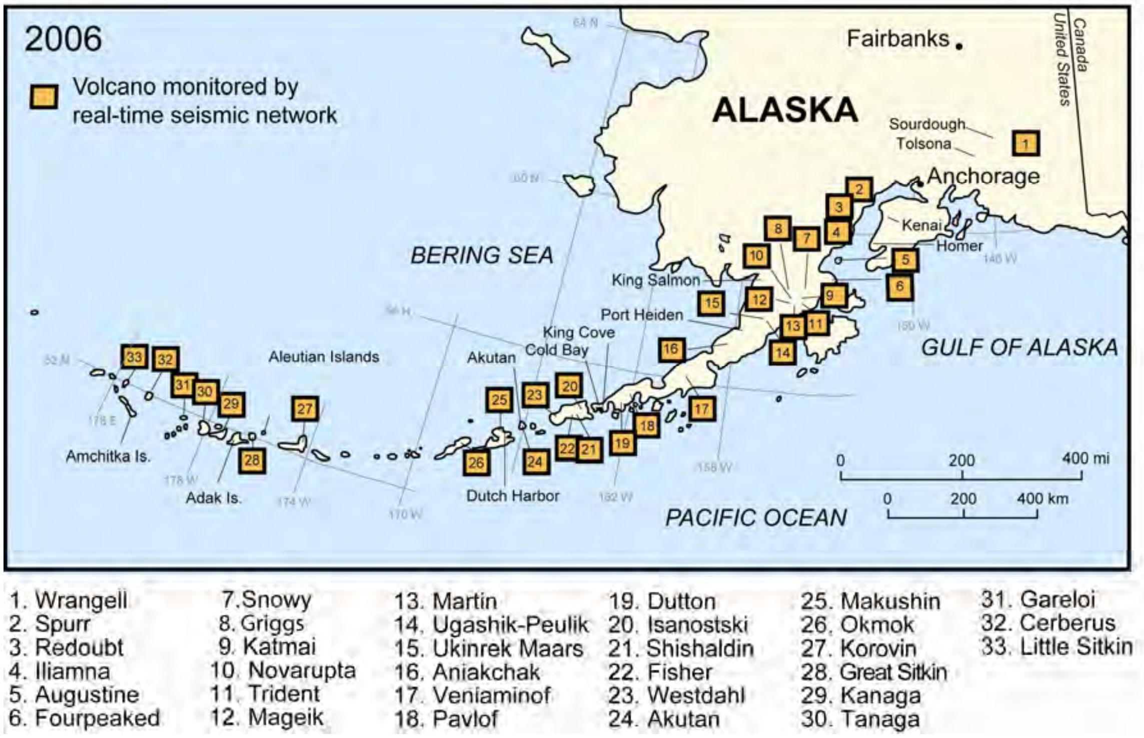


Figure 1. Location of Alaskan volcanoes seismically instrumented by AVO in 2006.

The AVO seismograph network was used to monitor seismic activity at 33 volcanoes within Alaska in 2006, an increase from 32 with the addition of a subnetwork to monitor Fourpeaked Mountain. Three volcanic centers, Fourpeaked, Little Sitkin Volcano, and Mount Cerberus have not yet been formally added to the list of permanently monitored volcanoes in the AVO weekly update as of the end of 2006. To be included in the list of monitored volcanoes in the AVO weekly update, the seismic network on the volcano must be in place long enough so that the background seismicity is known and have no station outages that prevent the AVO analysts from locating earthquakes on the volcano. A minimum of 6 months without significant station outages is typically needed before a volcano is added to the list of monitored volcanoes. More time is needed to determine the background seismicity at Fourpeaked and telemetry issues with the Rat Island subnetworks have prevented Little Sitkin and Cerberus from being added. In 2006, AVO located 8,666 earthquakes (table 1). Maps of calculated hypocenters at each monitored volcano are presented in appendix A.

Monitoring highlights in 2006 include: (1) the eruption of Augustine Volcano, (2) an explosion of ash, gas and steam and associated seismicity at Fourpeaked starting in September and continuing into 2007, (3) a volcanic-tectonic earthquake swarm at Mount Martin in January, (4) volcanic tremor and seismicity related to low-level strombolian activity at Mount Veniaminof throughout the year, (5) short periods of elevated seismicity at Korovin and Kliuchef Volcanoes throughout the year, and (6) seismicity at Mount Spurr returning to background levels from elevated unrest that started in February 2004 (table 2).

Table 1. Number of earthquakes located per year by AVO for the last 17 years.

Year	Number of earthquakes located per year	Volcanoes monitored by the AVO seismograph network
1990	3,285	4
1991	1,119	4
1992	2,184	4
1993	697	4
1994	441	4
1995	850	4
1996	6,466	15
1997	2,930	17
1998	2,873	19
1999	2,769	21
2000	1,551	21
2001	1,427	23
2002	7,242	24
2003	3,911	27
2004	6,928	28
2005	9,012	32
2006	8,666	33

Table 2. Highlights of Alaskan volcanic seismicity in 2006.

Dates	Volcano	Event
January-August	Augustine	Eruption
September-December	Fourpeaked	Increased seismicity
January	Martin	VT earthquake Swarm
March-December	Veniaminof	Minor ash bursts recorded in seismic data
July-December	Korovin	Elevated seismicity and volcanic tremor
January-April	Spurr	Elevated seismicity

Instrumentation

In 2006, the AVO seismograph network was expanded from 187 to 192 permanent seismograph stations. The AVO seismograph network is composed of 24 subnetworks with 4 to 20 seismograph stations per subnetwork and eight regional seismograph stations. The only new subnetwork during 2006 was installed in September to monitor Fourpeaked Mountain. This subnetwork is composed of one existing station (CDD) and four new stations. A single temporary broadband station (FP01) was installed prior to the start of the installation of a permanent network and removed after the first few stations were installed.

In response to the increased seismicity associated with the 2006 eruption of Augustine Volcano, three new permanent stations (AUSE, AUNW, and a strong motion station initially named AU20) were installed on Augustine Island. The sensors at AUSE and AUNW are short-period vertical seismometers and at AU20 is a strong motion seismometer. The seismometer at AU20 was later moved to a new location and renamed AU22. A second strong motion seismometer (AU21) was installed and destroyed before any data could be recovered. Five out of eight stations

(AUH, AUL, AUP, AUR, and AUS) on Augustine Island were destroyed or disabled by eruptive activity during 2006 of which three (AUH, AUL, AUP) were eventually repaired or replaced. Six non-telemetered temporary broadband stations (AU10, AU11, AU12, AU13, AU14, and AU15) were deployed on Augustine Island in December 2005 and removed at various times throughout 2006. At the end of 2006, nine stations were operating on Augustine Island.

Of the 192 permanent seismograph stations (274 different components) operated by AVO, 153 were short-period vertical-component seismograph stations. All these stations were equipped with either Mark Products L4 or Teledyne-Geotech S13 seismometers with a one-second natural period. AVO also operated 23 three-component, short-period instruments during 2006. The instruments used at sites with three component sensors were Mark Products L22 seismometers with a 0.5-second period, Mark Products L4-3D seismometers with a 1-second period, and Teledyne-Geotech S13 seismometers with a 1-second natural period. Fifteen broadband stations were operated with either Guralp CMG-40T seismometers (frequency range: 0.033 Hz to 50 Hz) or Guralp CMG-6TD seismometers (frequency range: 0.033 Hz to 50 Hz). The Augustine strong motion station used a REFTEK 130-ANSS/02 strong motion sensor (frequency range: DC to 500 Hz).

The majority of the short-period stations were digitized at 100 samples/second (sps). The Cerberus and Little Sitkin subnetworks were recorded at 50 sps due to limitations in the VSAT telemetry between the recording hub located on Amchika Island and Anchorage. Broadband stations were digitized at 50 sps with the exception of AUL, which is recorded at 100 sps. Typical calibration curves for short-period and broadband seismometers used in the AVO seismograph network are shown in figures 2-6.

Data from short-period seismograph stations were telemetered using voltage-controlled oscillators (VCOs) to transform the signals generated by the seismometer in response to ground velocity from a voltage to a frequency-modulated carrier suitable for transmission over a radio link or telephone circuit. AVO primarily used McVCO VCOs (McChesney, 1999) to modulate signals in the field. In rare cases, other VCO models were used instead of the McVCO VCO, but these are being replaced with McVCO VCOs as stations are visited. Signals were transmitted via UHF and VHF radio to communication hubs located in Adak, Akutan, Amchitka Island, Anchorage, Cold Bay, Dutch Harbor, Homer, Kenai, King Cove, King Salmon, Port Heiden, Sourdough, and Tolsona (fig. 1). Data were then digitized at the Adak, Amchitka Island, Dutch Harbor, Homer, Kenai, and King Salmon communication hubs and directed to AVO offices via high speed digital circuits. From all other hubs, analog signals were relayed via leased telephone circuits to AVO offices in Anchorage and Fairbanks where the signals were subsequently digitized. Data from broadband seismograph stations were digitized at the seismograph station site and transmitted digitally using spread spectrum radios to communication hubs in Akutan, Anchorage, Dutch Harbor, Homer, and King Salmon. These data were forwarded to AVO offices in Fairbanks and Anchorage via high speed digital circuits.

Locations and descriptions for all AVO stations operated during 2006 are contained in appendix B. Maps showing the locations of stations with respect to individual volcanoes are contained in appendix C. Estimates of each station's operational status for the catalog period are shown in appendix D. Other station information, such as calibration information contained in the file CALDATA.PRM, is available within the associated compressed UNIX tar-file.

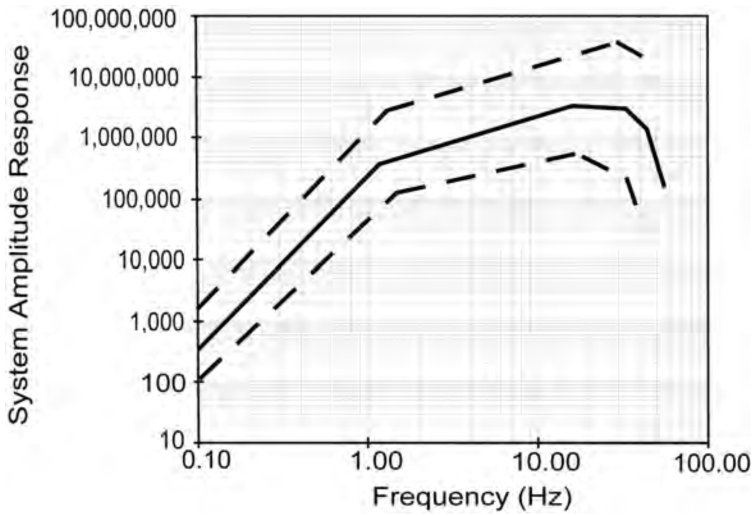


Figure 2. A log-log plot of representative displacement response curves for the short-period stations using a Mark Products L4 or L4-3D seismometer. The solid line illustrates the typical calibration curve and the dashed lines show the range of calibration curves for all AVO stations using an L4 or L4-3D seismometer.

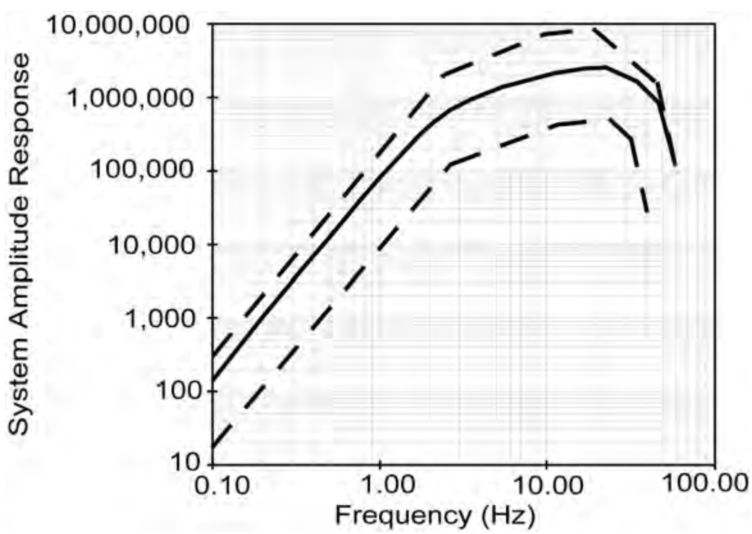


Figure 3. A log-log plot of representative displacement response curves for the short-period stations using a Mark Products L22 seismometer. The solid line illustrates the typical calibration curve and the dashed lines show the range of calibration curves for all AVO stations using an L22 seismometer.

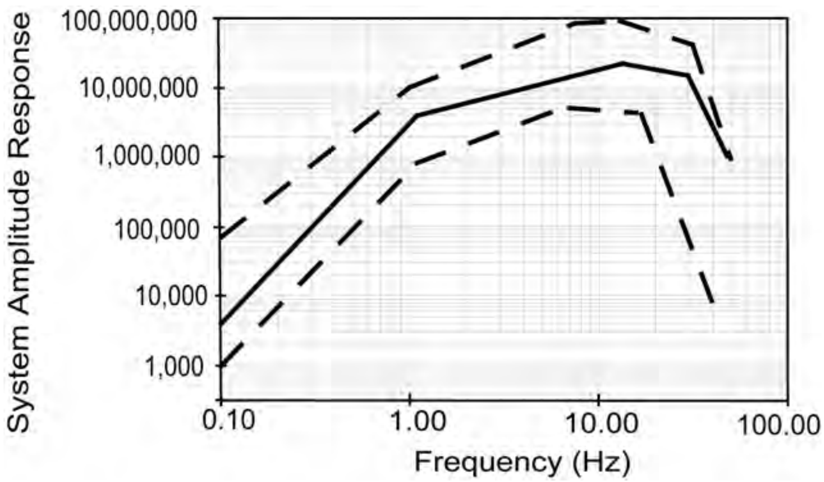


Figure 4. A log-log plot of representative displacement response curves for the short-period stations using a Teledyne-Geotech S13 seismometer. The solid line illustrates the typical calibration curve and the dashed lines show the range of calibration curves for all AVO stations using an S13 seismometer.

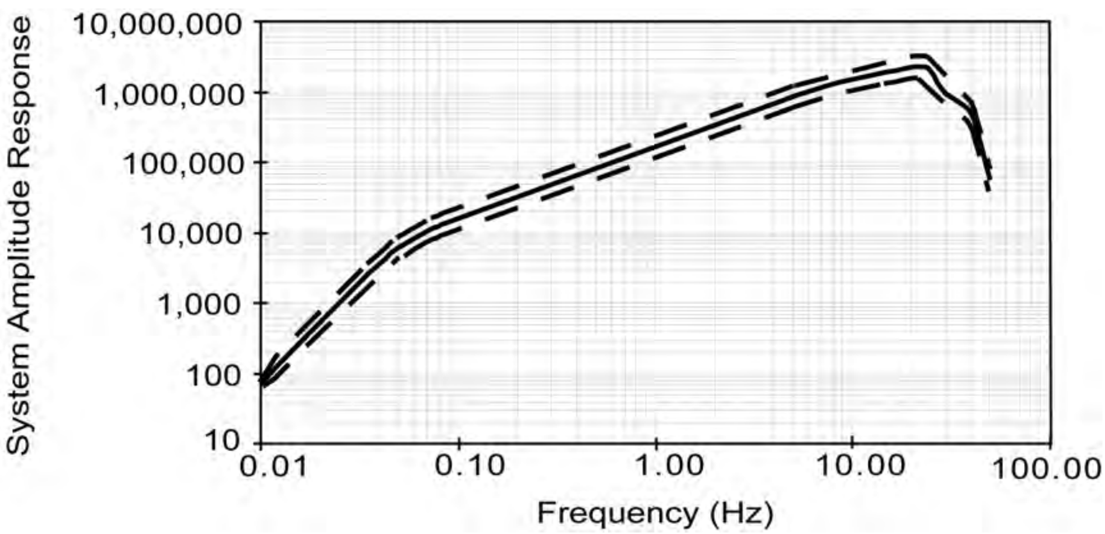


Figure 5. A log-log plot of representative displacement response curves for the broadband stations using a Guralp CMG-40T seismometer. The solid line illustrates the typical calibration curve and the dashed lines show the range of calibration curves for all AVO stations using a Guralp CMG-40T seismometer.

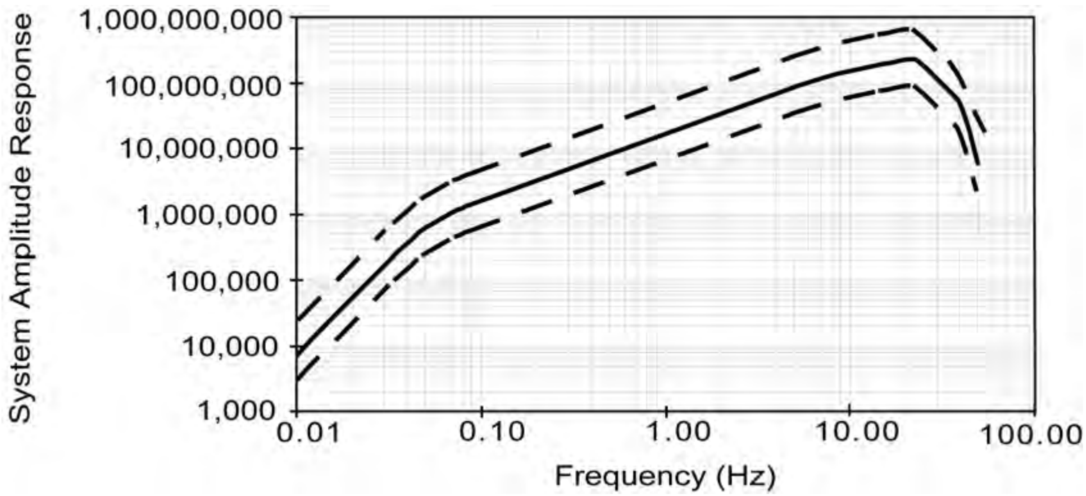


Figure 6. A log-log plot of representative displacement response curves for the broadband stations using a Guralp CMG-6TD seismometer. The solid line illustrates the typical calibration curve and the dashed lines show the range of calibration curves for all AVO stations using a Guralp CMG-6TD seismometer.

Data Acquisition and Processing

Data acquisition for the AVO seismograph network was accomplished with duplicate EARTHWORM systems (Johnson and others, 1995) located in Anchorage and Fairbanks. Data were recorded in both continuous and event detected modes. Event detected data were collected using the EARTHWORM modules, 'Carlstatrig' and 'Carlsubtrig'. The 'Carlstatrig' parameters were set as follows: Long-term-average (LTA) time = 8 seconds, Ratio = 2.3, and Quiet = 4. 'Carlsubtrig' was modified such that a two-letter code was appended to the filename of each trigger to identify the first subnetwork that triggered. If four or more subnetworks triggered on the same event, all data were saved in a single trigger and tagged as a regional event. These network codes are summarized in table 3. All data are saved in SAC (Seismic Analysis Code) format (Goldstein and others, 1999). Event triggers were processed daily using the interactive seismic data analysis program XPICK (Robinson, 1990) and the earthquake location program HYPOELLIPSE (Lahr, 1999). Each event trigger was visually inspected and false triggers were deleted. Each subsequent event was identified by a classification code (Table 4) and stored as a comment in the event location pick file. This classification system was modeled after that described by Lahr and others (1994). Earthquakes with a P-wave and S-wave separation of greater than five seconds on the closest station were assumed to come from non-volcanic sources and were typically discarded. Each hypocenter was checked using a computer algorithm that identified events that did not meet the following minimum parameters: three P-phases, two S-phases, and standard hypocentral errors (as defined in the HYPOELLIPSE manual) less than 15 km. If upon revaluation, the minimum parameters could not be met, the event was removed from the final catalog listing. For all the 2006 earthquakes in the AVO catalog, the average root-mean-square travel-time error was 0.122 seconds and the average hypocentral errors ERZ and ERH were 1.43 km and 2.22 km respectively. Data from seismographs operated by the West Coast and Alaska Tsunami Warning Center (two seismograph stations) and Alaska Earthquake Information Center (28 seismograph stations) were routinely utilized in event detection and location. Station parameters for the West Coast and Alaska Tsunami Warning Center and Alaska Earthquake Information Center stations used by AVO are found in appendix B.

Table 3. Volcano Subnetwork Designators.

[The volcanoes shown in figure 1 are monitored by the subnetwork of the same name with the following exceptions. Snowy Mountain, Mount Griggs, Mount Katmai, Novarupta, Trident Volcano, Mount Mageik and Mount Martin are monitored by the Katmai subnetwork. Ugashik-Peulik and Ukinrek Maars are monitored by the Peulik subnetwork. Isanotski Peaks is monitored by the Shishaldin subnetwork and Fisher is monitored by a combination of the Westdahl and Shishaldin subnetworks]

Volcano Subnetwork	Network Code
Akutan	ak
Aniakchak	an
Augustine	au
Cerberus	ce
Dutton	dt
Iliamna	il
Fourpeaked	fo
Gareloi	ga
Great Sitkin	gs
Kanaga	ki
Katmai	ka
Korovin	ko
Little Sitkin	ls
Makushin	ma
Okmok	ok
Pavlof	pv
Peulik	pl
Redoubt	rd
Regional Event	rg
Shishaldin	sh
Spurr	sp
Tanaga	ta
Veniaminof	vn
Westdahl	we
Wrangell	wa

Table 4. Classification codes.

Event Classification	Classification Code
Volcano-Tectonic (VT)	a
Low-Frequency (LF)	b
Hybrid	h
Regional-Tectonic	E
Teleseismic	T
Shore-Ice	i
Calibrations	C
Other non-seismic	o
Cause unknown	x

Problems encountered in 2006 included timing issues for the subnetworks that are digitized in King Cove and Dutch Harbor. In both cases, it was the absolute timing that was incorrect. The relative timing for the stations digitized at each hub was internally consistent thus allowing earthquakes to be located provided data from within a single subnetwork was used. The timing problem at King Cove, first noted in September, was corrected in late October by installing updated equipment drivers on the digitizer. The timing problems at Dutch Harbor, typically lasting less than a day, occurred infrequently (3-4 times a year). A resetting of the clock resolved these intermittent clock failures. Other problems with the data were corrected immediately when identified.

Seismic Velocity Models

During 2006, AVO employed 11 local volcano-specific seismic velocity models and one regional seismic velocity model to locate earthquakes at Alaskan volcanoes. All velocity models were one-dimensional models utilizing horizontal layers to approximate the local seismic velocity structures. Each model, with one exception, assumed a series of constant velocity layers. The single exception was the Akutan velocity model (Power and others, 1996), which had a velocity gradient in a layer overlying a half-space of constant velocity.

One or more vertical cylindrical volumes were used to model the volcanic source zones for all volcanoes where a local velocity model was used. Earthquakes within these cylindrical volumes were located with a local model and earthquakes outside of the cylindrical volumes were located with the regional model. All cylindrical volumes had a radius of 20 km with the exception of the cylinders centered on Shishaldin Volcano and Mount Veniaminof. The cylinder centered on Shishaldin had a radius of 30 km in order to encompass Fisher Caldera and Isanotski Peaks. The cylinder centered on Veniaminof also had a radius of 30 km because of the large size of the volcanic edifice. The top of each cylinder is set at 3 km above sea level and the bottom is set at a depth of 50 km with respect to sea level.

The Akutan, Augustine (Power, 1988), Iliamna (Roman and others, 2001), Tanaga (Power, oral commun., 2005), Veniaminof (Sánchez, 2005), and Westdahl (Dixon and others, 2005) velocity models were used to locate hypocenters that fell within cylindrical volumes described above, centered on each respective volcano. The Cold Bay velocity model (McNutt and Jacob, 1986) was used to locate earthquakes that fell within single cylindrical volumes centered on Mount Dutton and Pavlof Volcano. Earthquakes on Fisher, Isanotski, and Shishaldin that fell within the cylindrical regions centered on Shishaldin Volcano were also located using the Cold Bay velocity model. Five overlapping cylinders defined the area in which the Spurr velocity model (Jolly and others, 1994) was used, four overlapping cylinders defined the area in which the Redoubt velocity model (Lahr and others, 1994) was used, and four overlapping cylinders defined the area in which the Katmai model (Searcy, 2003) was used. The Andreanof velocity model, modified from that in Toth and Kisslinger (1984), was used to locate earthquakes within a volume defined by three cylinders centered on Kanaga Volcano, Mount Moffet, and Great Sitkin Volcano. Specific velocity models for Aniakchak Crater, Mount Gareloi, Korovin Volcano, Makushin Volcano, Okmok Volcano, Mount Peulik, and Mount Wrangell were not available in 2005 and the regional velocity model (Fogleman and others, 1993) was used to locate earthquakes near these volcanoes. The cylindrical model parameters, regional velocity model, and volcano-specific models used to locate earthquakes in this report are summarized in appendix E. Figures showing the volcanic source zones modeled by multiple cylinders are shown in appendix F.

Seismicity

The 8,666 earthquakes located in 2006 represents the second highest annual total determined by AVO in the last decade and a decrease from the 9,012 earthquakes located in 2005 (Dixon and others, 2006). Of the earthquakes located in the last 2 years, a total of 8,146 earthquakes in 2005 and 7,782 earthquakes in 2006 were located within 20 km of an active volcanic center. The numbers of located events at volcanic centers in the last two years, listed by seismograph subnetwork, are shown in table 5.

Table 5. Number of earthquakes located for each seismograph subnetwork in 2005 and 2006 within 20 km of the volcanic centers in each subnetwork.

[The totals for 2006 are broken into three event types: volcanic-tectonic (VT), low-frequency (LF) and other (all other possible event types shown in table 4). Magnitude of completeness (Mc) for AVO seismograph subnetworks used the 2006 data]

Volcano Subnetwork	Earthquakes located in 2005	Earthquakes located in 2006	2006 VT	2006 LF	2006 Other	2006 Mc
Akutan	100	101	94	7	0	0.4
Aniakchak	33	30	14	16	0	1.7
Augustine	1,204	1,452	1,441	7	4	0.0
Cerberus	6	37	32	5	0	1.2
Dutton	13	34	34	0	0	0.9
Fourpeaked	n/a	178	178	0	0	0.7
Gareloi	580	1,058	212	845	1	1.0
Great Sitkin	51	59	59	0	0	0.6
Iliamna	979	234	228	6	0	-0.4
Kanaga	42	56	56	0	0	1.2
Katmai Cluster	1,084	2,125	2,105	19	1	0.5
Korovin	74	447	441	6	0	0.8
Little Sitkin	15	99	99	0	0	0.6
Makushin	135	139	135	4	0	1.0
Okmok	71	100	94	6	0	0.9
Pavlof	32	20	6	14	0	0.7
Peulik	48	25	25	0	0	0.9
Redoubt	70	34	32	2	0	0.1
Shishaldin	208	130	73	57	0	0.5
Spurr	2,317	1,129	1,050	74	5	0.2
Tanaga	925	140	140	0	0	1.1
Veniaminof	24	10	6	4	0	1.5
Westdahl	27	9	4	5	0	0.6
Wrangell	106	136	26	110	0	0.9
Totals	8,146	7,782	6,585	1,187	11	0.6

Typically only 2 percent of the earthquakes in the AVO catalog are low-frequency events deeper than 10 km (table 6). These earthquakes have been linked to the movement of magma in the mid- to lower-crust and uppermost mantle (Power and others, 2004) and are our primary tool in detecting magma flux at depth.

Using the 2006 earthquake catalog, the magnitude of completeness (Mc) for each subnetwork was calculated (table 5). The Mc ranged from -0.4 to 1.7 for the individual subnetworks. Mc, the lowest magnitude at which we are reasonably certain that all events with a magnitude greater than or equal to the Mc were detected, was determined using a maximum likelihood estimate of the inflection point in the frequency magnitude distribution using the seismology analysis software ZMAP (Weimer, 2001).

Table 6. Number of deep (depth>10 km) low-frequency earthquakes located by seismograph subnetwork in 2005 or 2006 within 20 km of a volcanic centers in each subnetwork.

Volcano Subnetwork	Deep low-frequency earthquakes in 2005	Deep low-frequency earthquakes in 2006
Akutan	1	6
Aniakchak	26	14
Cerberus	0	4
Gareloi	40	30
Iliamna	1	0
Katmai	4	9
Korovin	1	3
Makushin	2	4
Pavlof	12	6
Okmok	5	4
Spurr	57	14
Tanaga	3	0
Veniaminof	0	4
Westdahl	0	3
Wrangell	14	31
Total for all subnetworks	166	132

Seismicity Highlights

Six volcanoes seismically monitored by AVO, Augustine Volcano, Fourpeaked Mountain, Mount Martin, Mount Veniaminof, Korovin Volcano, and Mount Spurr, showed significant unrest in 2006, and for each the Volcano Activity Alert Level was above normal for all or part of 2006. Augustine erupted in early 2006 and most of the located events at Augustine were related to the eruption. In 2006, the four summit stations (AUH, AUP, AUR, and AUS) were not operational for long periods of time (see appendix D), and their loss significantly degraded the network's ability to detect and reliably calculate earthquake hypocenters (Power and others, 2006). As the summit stations stopped working, there was an apparent deepening of earthquake hypocenters. Conversely when the summit stations were reestablished, there was an apparent shallowing of hypocenters. By the end of the year, only two of these summit stations (AUH and AUP) had been repaired. The loss of two summit stations resulted in an increase in Mc from 0.0 to 0.9. This is nearly a full unit of magnitude higher than the Mc calculated for Augustine in 2005 (Dixon and others, 2006).

On September 17, 2006, an explosion of ash, gas, and steam occurred at Fourpeaked and was accompanied by increased seismicity detected by neighboring subnetworks. A new subnetwork was established in response to the increase in activity. Because this subnetwork has only been in place during the period of unrest at Fourpeaked, no comparison to background is possible at this time. The increase in seismicity at the Katmai subnetwork is the result of a VT earthquake swarm at Martin in January (Dixon and others, 2007). At Veniaminof, the seismic activity is dominated by intermittent non-locatable tremor and low-frequency events. Unrest at Korovin, which included ash and steam emissions, was accompanied by a six-fold increase in the number of located earthquakes and periods of intermittent tremor which continued into 2007. The number of located earthquakes at Spurr continued to be elevated for the first 4 months in 2006. In early April, there was a swarm of activity accompanied by two M_L>2.0 earthquakes. By May, the number of located earthquakes at Spurr returned to background levels signifying the end of the volcanic unrest that began in mid-2004 (Power, 2004).

At Dutton and Gareloi, there was an apparent increase in seismic activity as determined by the number of located earthquakes. The seismicity at Dutton in 2006 is similar to that in 2004 and is believed to reflect the background rate of seismicity. The reported increase in seismicity at Gareloi is a result of lowered microseismic activity caused by storms. As shown in figure 7, although the number of earthquakes located in 2006 is much greater than in 2004 or 2005, the number of earthquake > 1.0 (Mc) has not significantly changed since recording begun in 2003.

The number of located earthquakes at Tanaga declined in 2005. There was an episode of volcanic unrest in 2005 and the seismicity in 2006 showed a return to background levels. Detected seismicity at Iliamna, Redoubt, Shishaldin, and Westdahl in 2006 also declined compared to that in 2005. Significant stations outages for the subnetworks at these volcanoes, shown in appendix D, were the likely cause for this apparent decrease in seismicity.

Seismicity rates at the Wrangell, Peulik, Aniakchak, Pavlof, Akutan, Makushin, Okmok, Great Sitkin, Kanaga, and Great Sitkin subnetworks, were similar to that in 2005. The Cerberus and Little Sitkin subnetworks were established in 2005 and no comparisons could be made for these subnetworks.

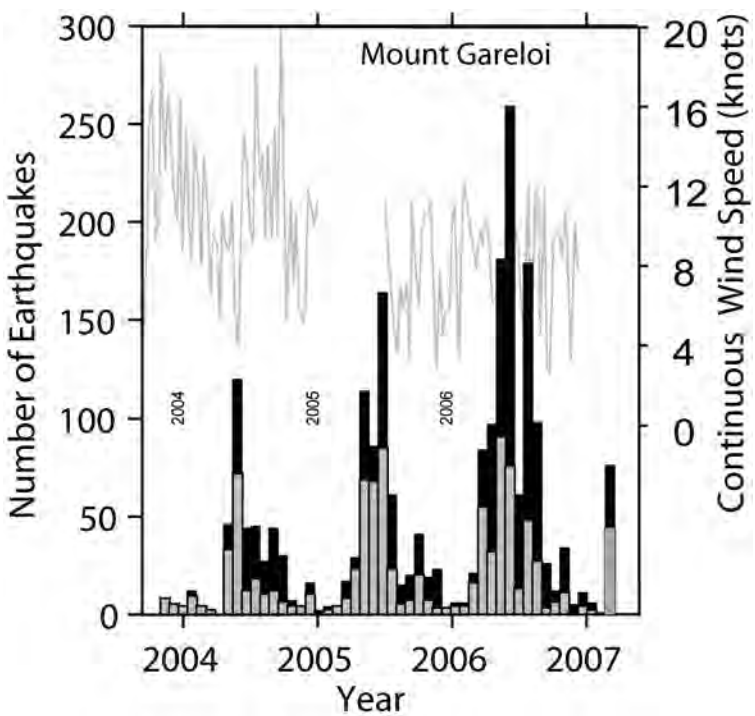


Figure 7. Number of earthquakes located within 20 km of Mount Gareloi since recording begun. Black bars represent all earthquakes located and gray bars represent those earthquakes above the 1.0 Mc in table 5. Wind data (gray line) is from National Data Buoy Center Station 46035 in the Bering Sea, 570 km north of Adak, Alaska.

Summary

Between January 1 and December 31, 2006, AVO located 8,666 earthquakes of which 7,783 occurred at or near volcanoes in Alaska. Monitoring highlights in 2006 include: the eruption of Augustine Volcano, the VT earthquake swarm at Mount Martin, the elevated seismicity and volcanic unrest at Fourpeaked Mountain, and elevated seismicity and low-level tremor at Mount Veniaminof and Korovin Volcano. A new seismic subnetwork was installed on Fourpeaked Mountain.

Available for download with this report is a compressed Unix tar-file containing a summary listing of earthquake hypocenters and all the necessary HYPOELLIPSE input files to recalculate the hypocenters including station locations and calibrations, seismic velocity models, and phase information. The reader should refer to Lahr (1999) for information on file formats and instructions for configuring and running the location program HYPOELLIPSE. Archives of waveform data are maintained on DVD-ROM at AVO offices in Fairbanks and Anchorage.

A list of AVO earthquake catalogs for the years 1989–2005 can be found in appendix G. A list of selected papers published in 2006 that utilized AVO seismic data is found in appendix H.

Acknowledgments

The contents of this report reflect a great deal of hard work by a large number of people including AVO, Alaska Earthquake Information Center (AEIC), and USGS personnel and various students, interns, and volunteers. We thank the AEIC and the West Coast and Alaska Tsunami Warning Center for the use of their data. We thank John Ewert and Matt Haney for formal reviews of the text and figures.

References Cited

Dixon, J.P., Power, J.A., and Stihler, S.D., 2005, Seismic Observations of Westdahl Volcano and Western Unimak Island Alaska: 1999-2005 [abs.]: Eos Transactions of the American Geophysical Union, v. 86, no. 52, Fall Meeting Supplement, Abstract S11b-0169.

Dixon, J.P., Stihler, S.D., Power, J.A., Tytgat, G., Estes, S., and McNutt, S.R., 2006, Catalog of Earthquake Hypocenters at Alaskan Volcanoes: January 1 through December 31, 2005: U.S. Geological Survey Open-File Report 2006-1264, 78 p.

Dixon, J.P., Prejean, S., and Power, J.A., 2007, The January 2006 Volcanic-Tectonic Earthquake Swarm at Mount Martin, Alaska [abs.]: Seismological Research Letters, v. 78, p. 255.

Fogleman, K.A., Lahr, J.C., Stephens, C.D., and Page R.A., 1993, Earthquake locations determined by the southern Alaska seismograph network for October 1971 through May 1989, U.S. Geological Survey Open-File Report 93-309, 54 p.

Goldstein, P., Dodge, D., and Firpo, M., 1999, SAC2000: Signal processing and analysis tools for seismologists and engineers, in International Handbook of Engineers and Engineering Seismology, Lee W.H.K., Kanamori, H., Jennings, P.P., Kisslinger, C., eds., v. 81B, Academic Press, San Diego, CA, p. 1613-1614.

Johnson, C.E., Bittenbinder, A., Bogaert, D., Dietz, L., and Kohler, W., 1995, EARTHWORM: A Flexible Approach to Seismograph network Processing: Incorporated Research Institutions for Seismology Newsletter, v. 14, no. 2, p. 1-4.

Jolly, A.D., Page, R.A., and Power, J.A., 1994, Seismicity and stress in the vicinity of Mt. Spurr volcano, south-central Alaska: Journal of Geophysical Research, v. 99, p. 15305-15318.

Lahr, J.C., Chouet, B.A., Stephens, C.D., Power, J.A., and Page, R.A., 1994, Earthquake classification, location, and error analysis in a volcanic environment: Implications for the magmatic system of the 1989-90 eruptions at Redoubt Volcano, Alaska: Journal of Volcanology and Geothermal Research, v. 62, p. 137–152.

Lahr, J.C., 1999, HYPOELLIPSE: A Computer Program for Determining Local Earthquake Hypocentral Parameters, Magnitude, and First Motion Pattern: U.S. Geological Survey Open-File Report 99-23, 116 p.

McChesney, P.J., 1999, McVCO Handbook 1999: U.S. Geological Survey Open-File Report 99-361, 48 p.

McNutt, S.R., and Jacob, K.H, 1986, Determination of large-scale velocity structure of the crust and upper mantle in the vicinity of Pavlof volcano, Alaska: Journal of Geophysical Research, v. 91, p. 5013-5022.

Power, J.A., 1988, Seismicity associated with the 1986 eruption of Augustine Volcano, Alaska: Fairbanks, University of Alaska Fairbanks, Masters thesis, 149 p.

Power, J.A., Paskievitch, J.F., Richter, D.H., McGimsey, R.G., Stelling, P., Jolly, A.D., and Fletcher, H.J., 1996, 1996 seismicity and ground deformation at Akutan Volcano: EOS Transactions of the American Geophysical Union, v. 77, p. F514.

Power, J.A., Stihler, S.D., White, R.A., Moran, S.C., 2004, Observations of deep long-period (DLP) seismic events beneath Aleutian arc volcanoes; 1989-2002, Journal of Volcanology and Geothermal Research, v. 138, p. 143-266.

Power, J.A., 2004, Renewed unrest at Mount Spurr Volcano, Alaska: EOS Transactions of the American Geophysical Union, v. 85, p. 434.

Power, J.A., Nye, C.J., Coombs, M.L., Wessels, R.L, Cervelli, P.F., Dehn, J., Wallace, K.L., Freymueller, J.T., Doukas, M.P., 2006, The reawakening of Alaska's Augustine Volcano: EOS Transactions of the American Geophysical Union, v. 87, p. 373 and 377.

Robinson, M., 1990, XPICK users manual, version 2.7: Seismology Lab, Geophysical Institute, University of Alaska Fairbanks, 93 p.

Roman, D.C., Power, J.A., Moran, S.C., Cashman, K.V., Stihler, S.D., 2001, Unrest at Iliamna Volcano, Alaska in 1996, Evidence for a magmatic intrusion [abs.]: EOS Transactions of the American Geophysical Union, v. 82, F1329.

Sánchez, J.J., 2005, Volcano Seismology from around the World: Case Studies from Mount Pinatubo (Philippines), Galeras (Columbia), Mount Wrangell and Mount Veniaminof (Alaska), Fairbanks, University of Alaska Fairbanks, Ph.D. Dissertation, 208 p.

Searcy, C.K., 2003, Station Corrections for the Katmai Region Seismograph network: U.S. Geological Survey Open-File Report 03-403, 16 p.

Toth, T., and Kisslinger, C., 1984, Revised focal depths and velocity model for local earthquakes in the Adak seismic zone: Bulletin of the Seismological Society of America, v. 74, p. 1349-1360.

Wiemer, S., 2001, A software package to analyze seismicity: ZMAP: Seismological Research Letters, v. 72, p. 373-382.

Appendix A: Maps showing the locations (datum NAD27) of the earthquake hypocenters calculated for monitored volcanoes in 2006.

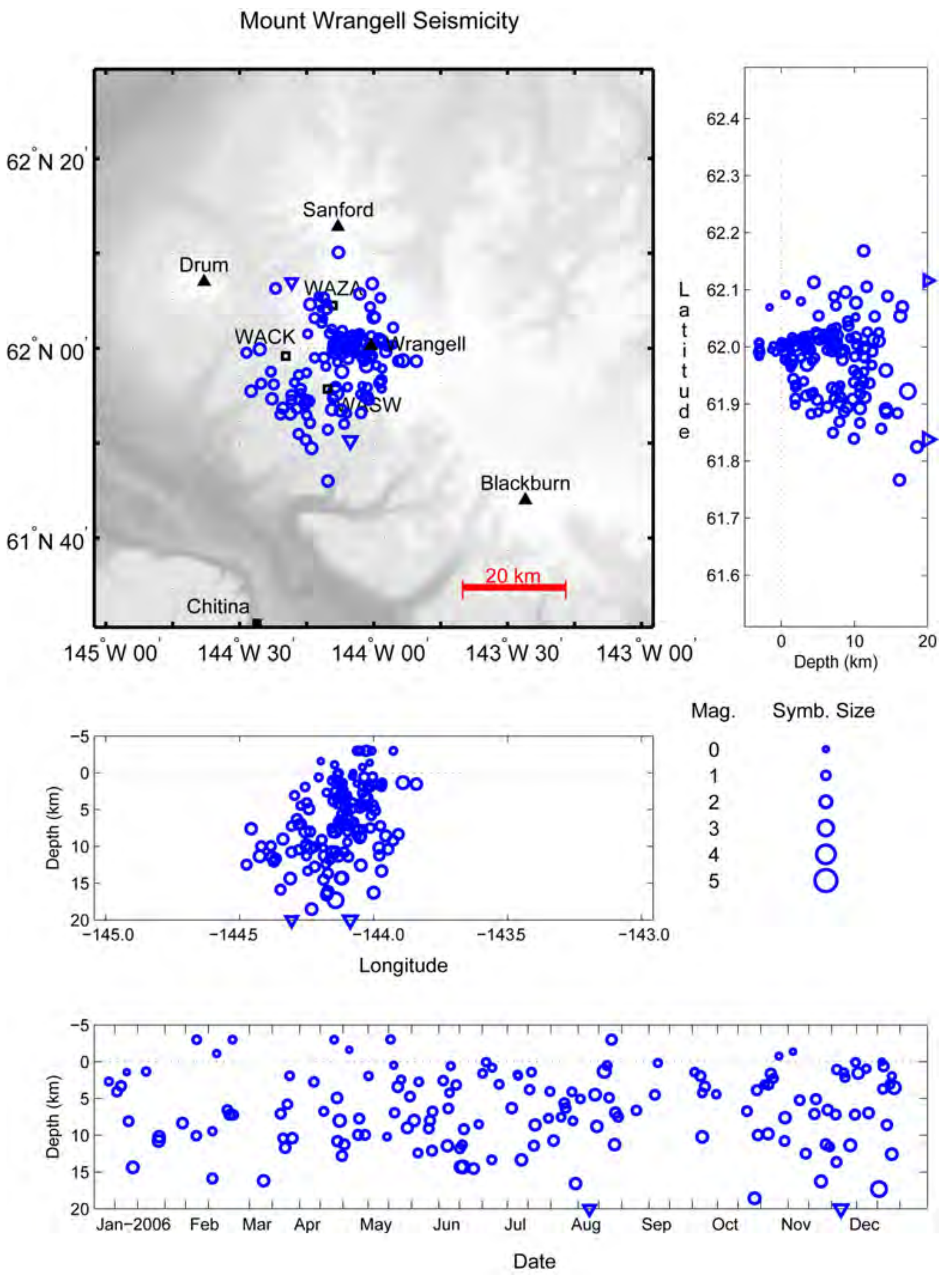


Figure A1. Summary plots of earthquakes located near Mount Wrangell in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

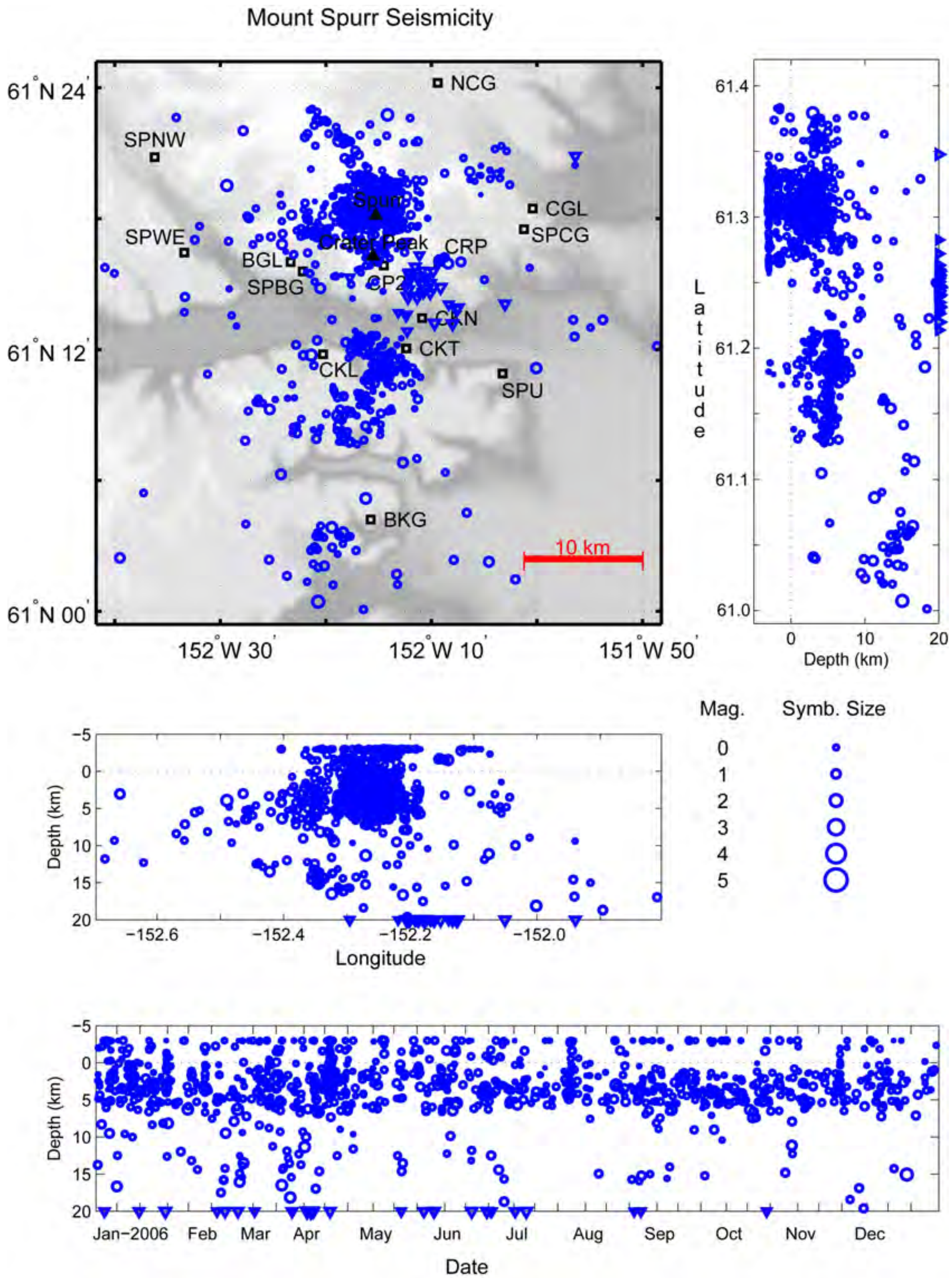


Figure A2. Summary plots of earthquakes located near Mount Spurr in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

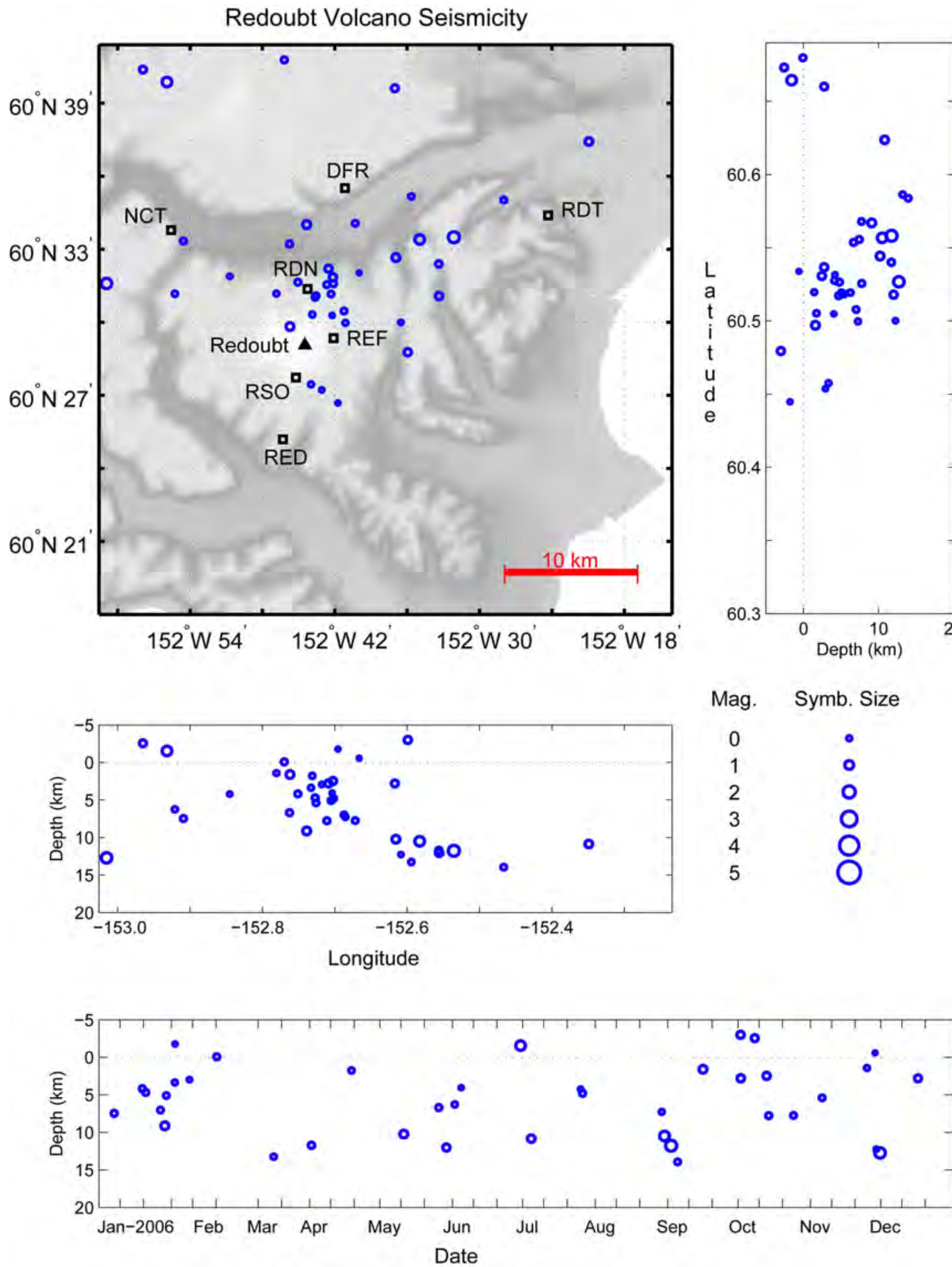


Figure A3. Summary plots of earthquakes located near Redoubt Volcano in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

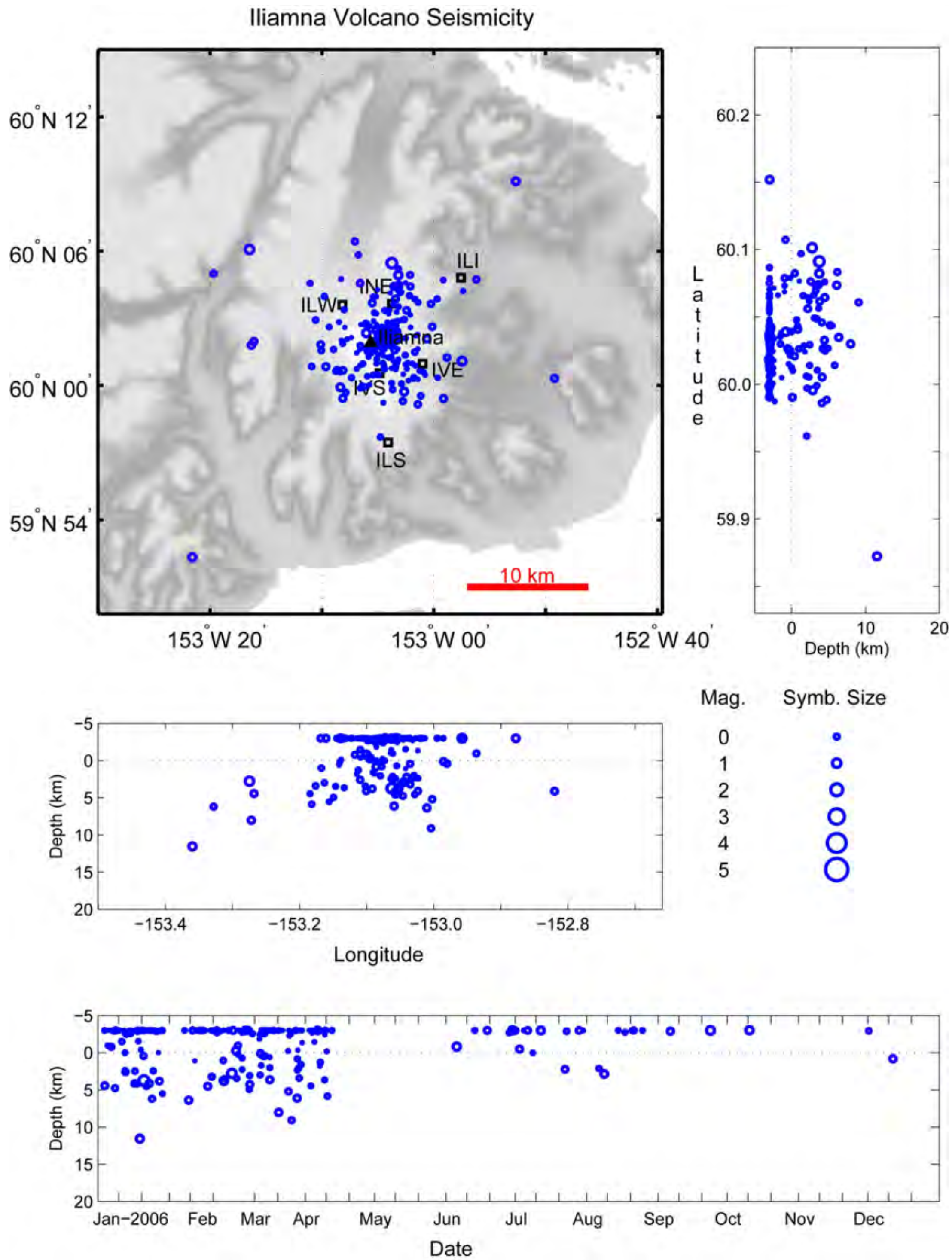


Figure A4. Summary plots of earthquakes located near Iliamna Volcano in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

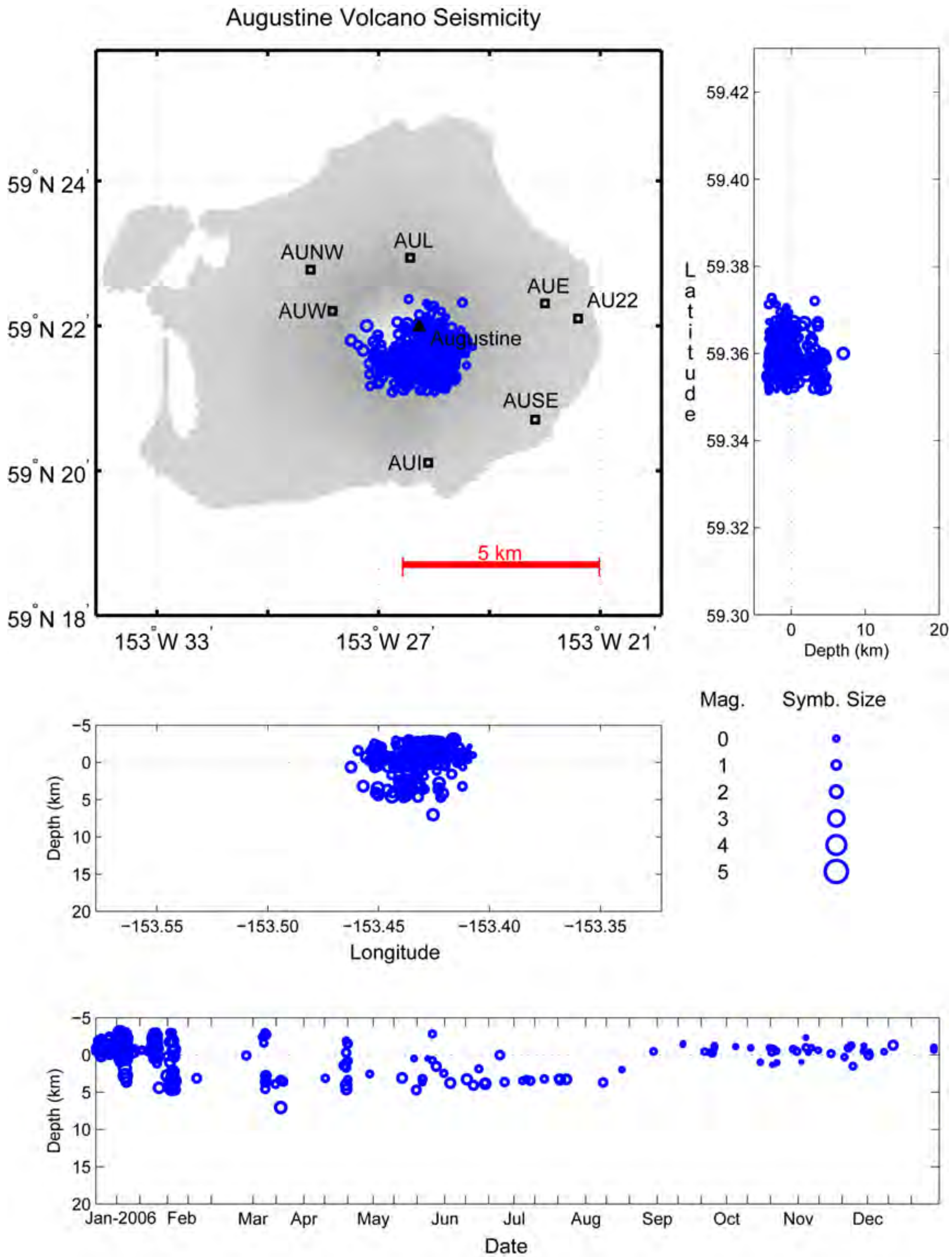


Figure A5. Summary plots of earthquakes located near Augustine Volcano in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information. See text for a discussion on hypocenter depths.

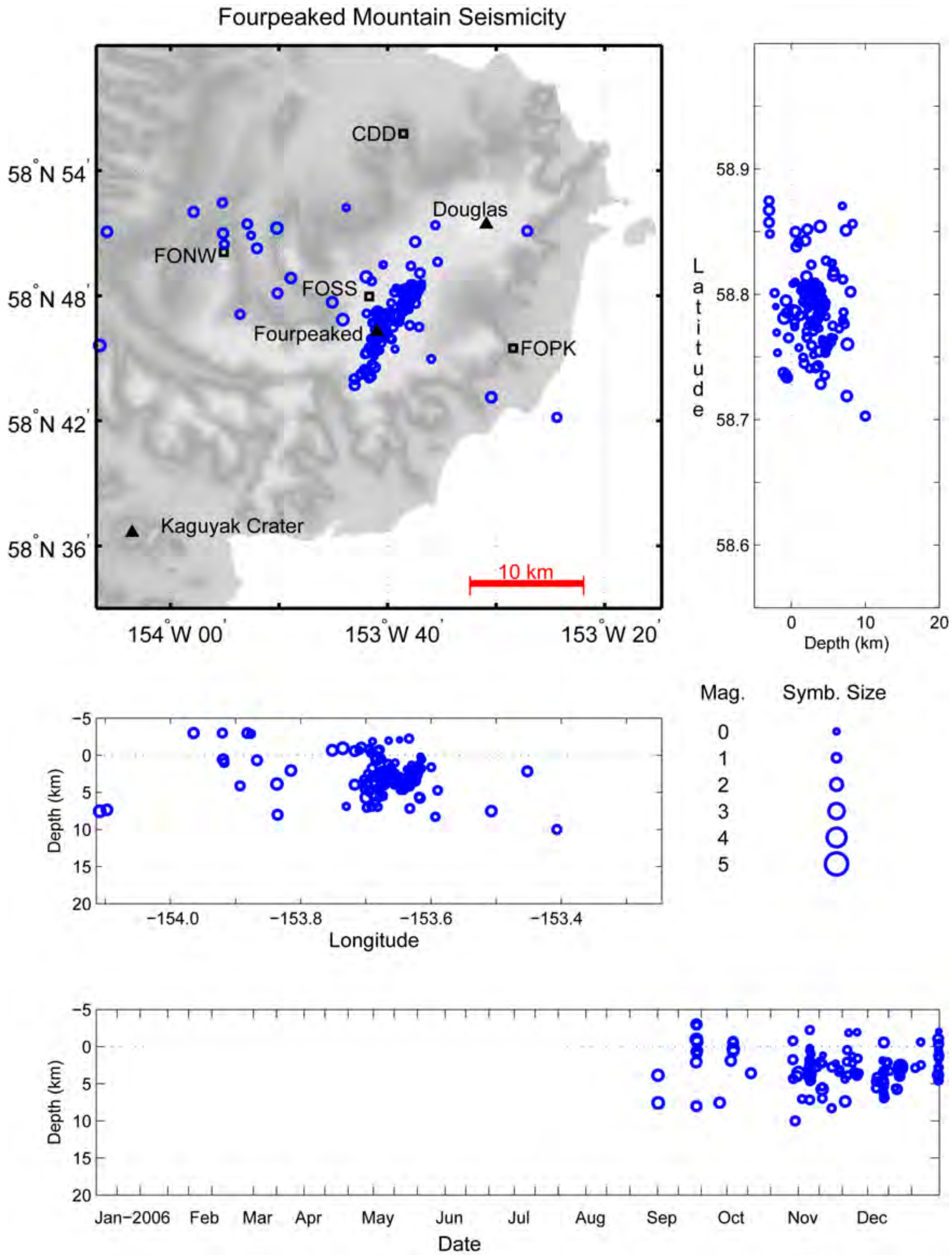


Figure A6. Summary plots of earthquakes located near Fourpeaked Mountain in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

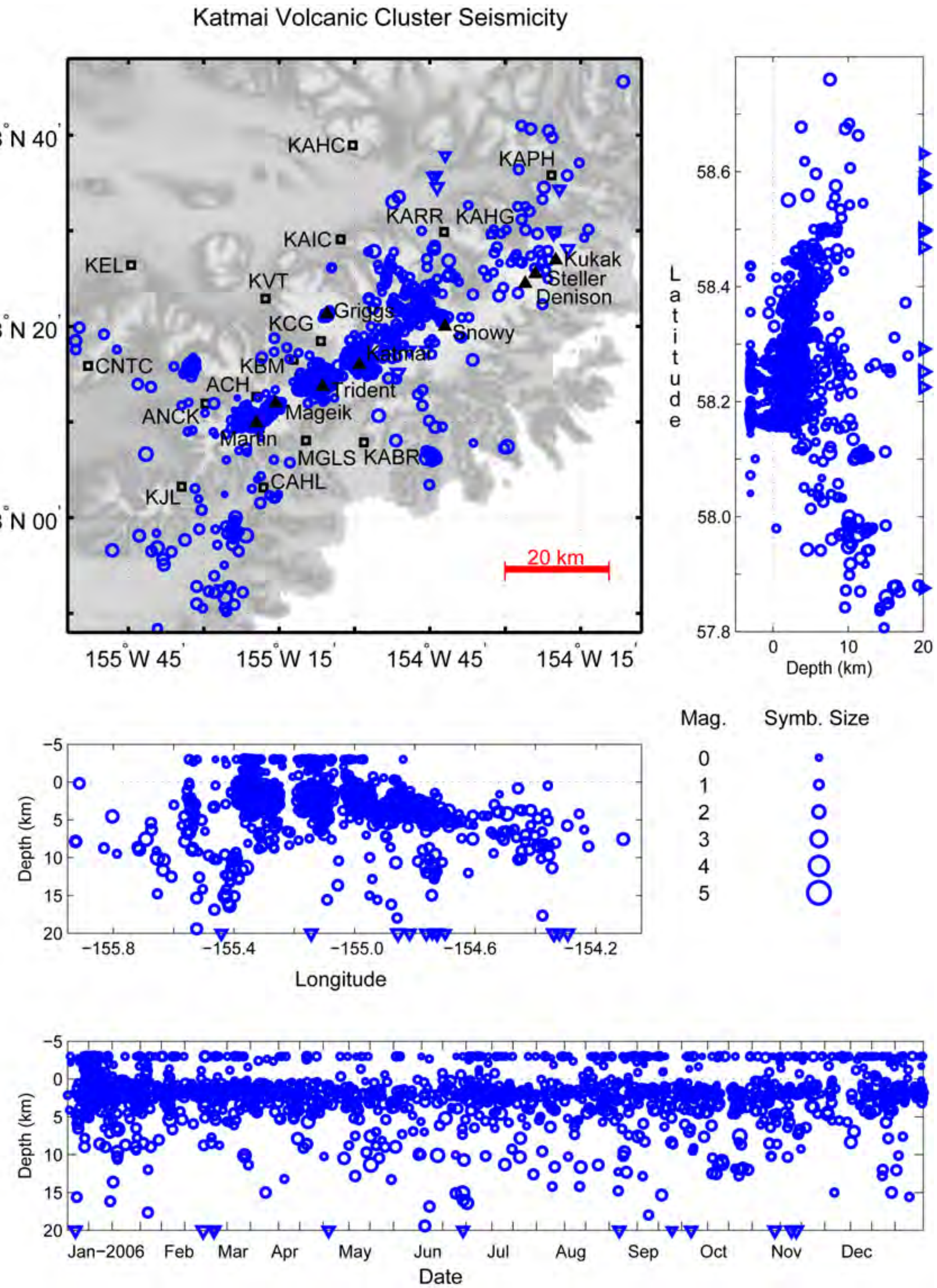


Figure A7. Summary plots of earthquakes located near the Katmai volcanic cluster in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

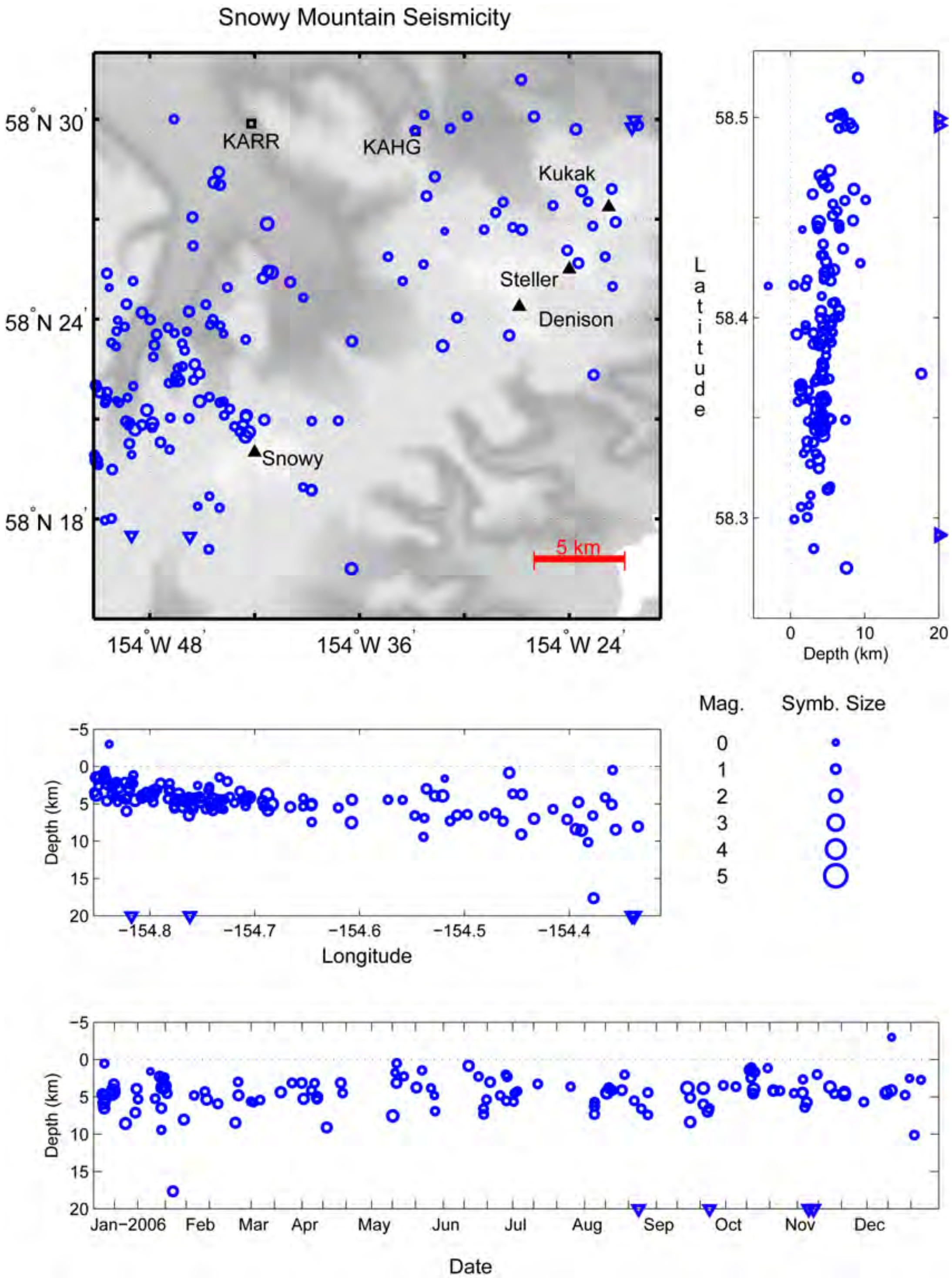


Figure A8. Summary plots of earthquakes located near Snowy Mountain in the Katmai volcanic cluster in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

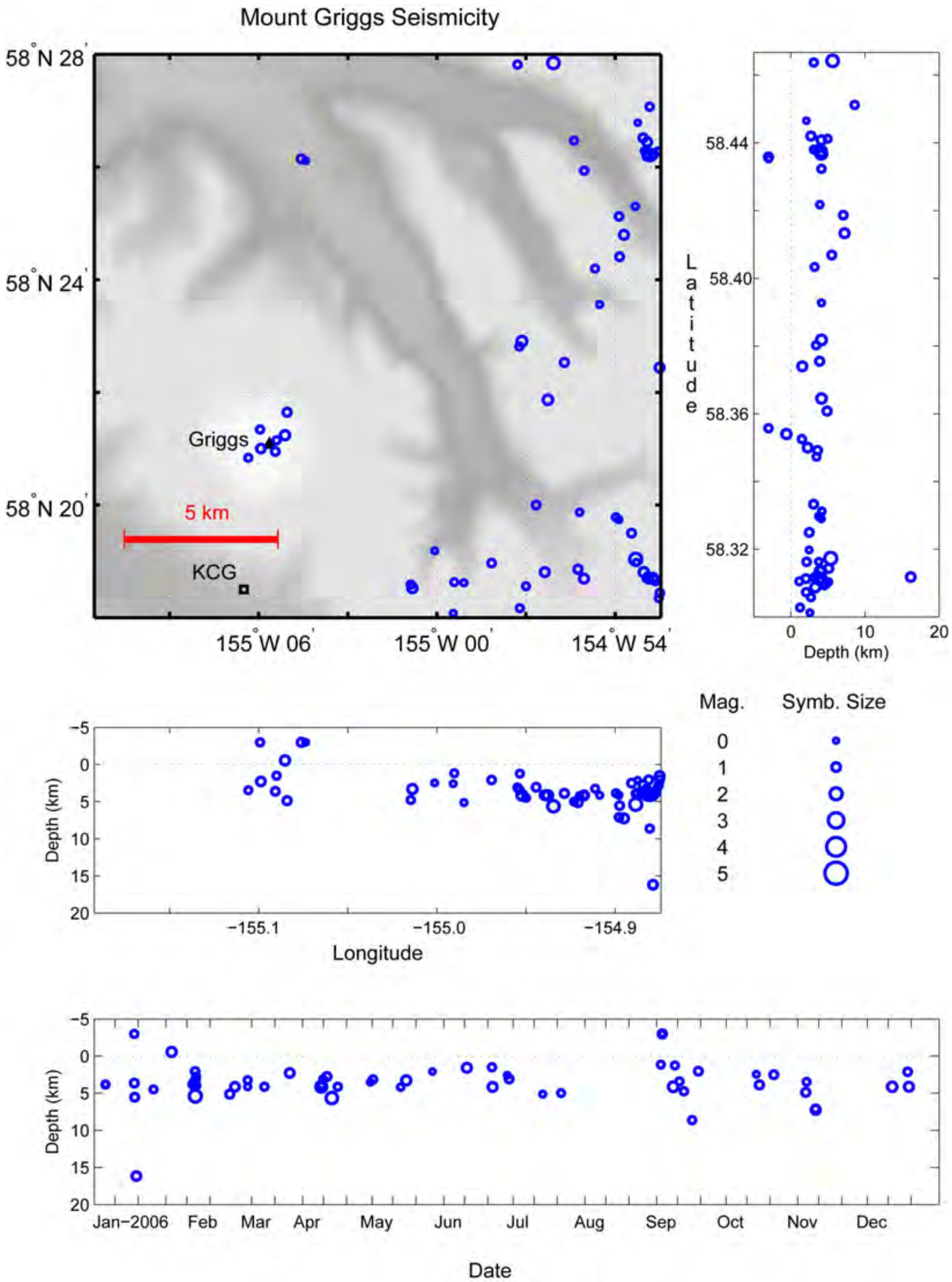


Figure A9. Summary plots of earthquakes located near Mount Griggs in the Katmai volcanic cluster in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers and solid squares are used to show other points of interest. See appendix B for station information. Several earthquakes that appear on this figure appear on other figures.

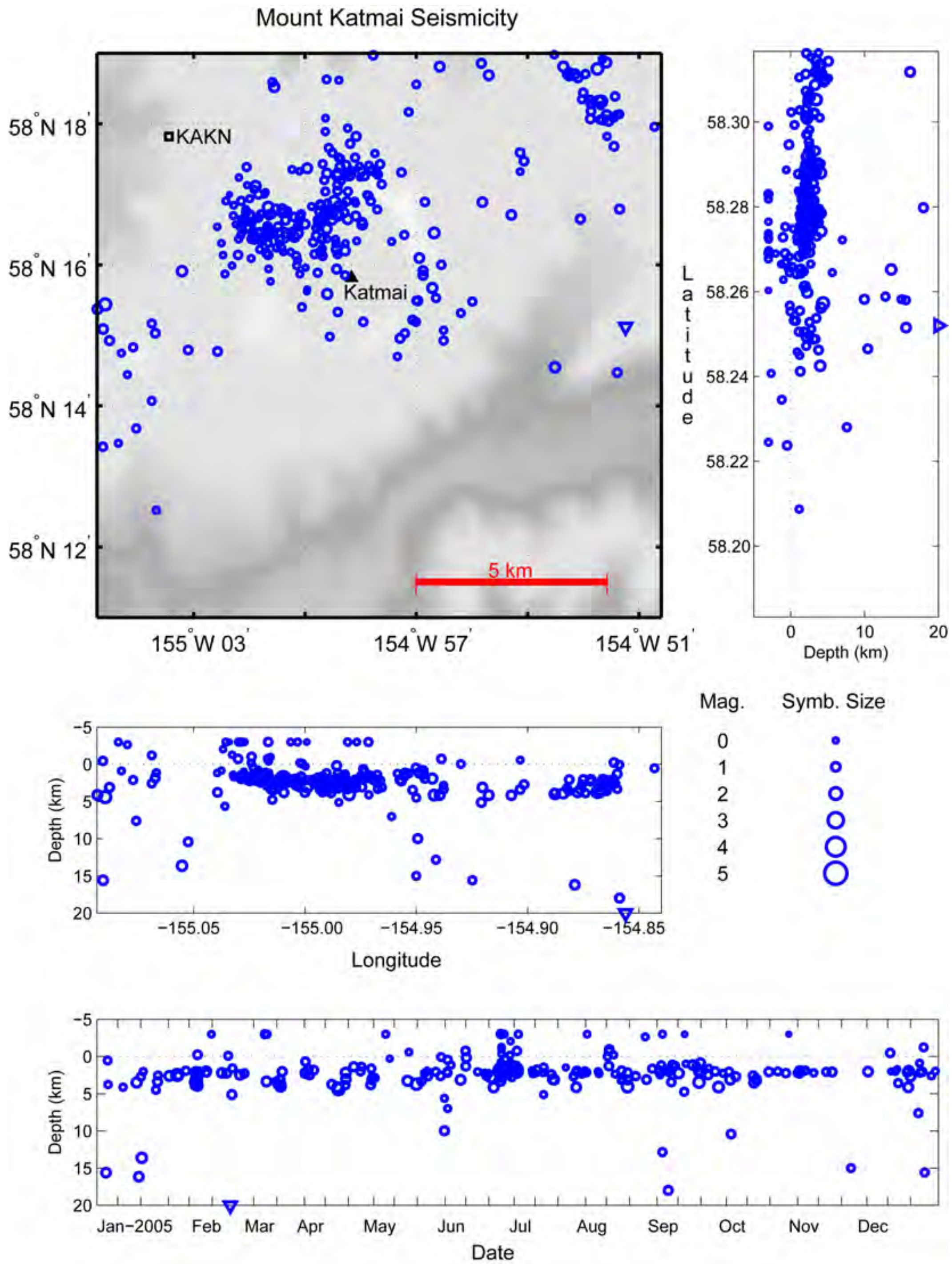


Figure A10. Summary plots of earthquakes located near Mount Katmai in the Katmai volcanic cluster in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information. Several earthquakes that appear on this figure appear on other figures.

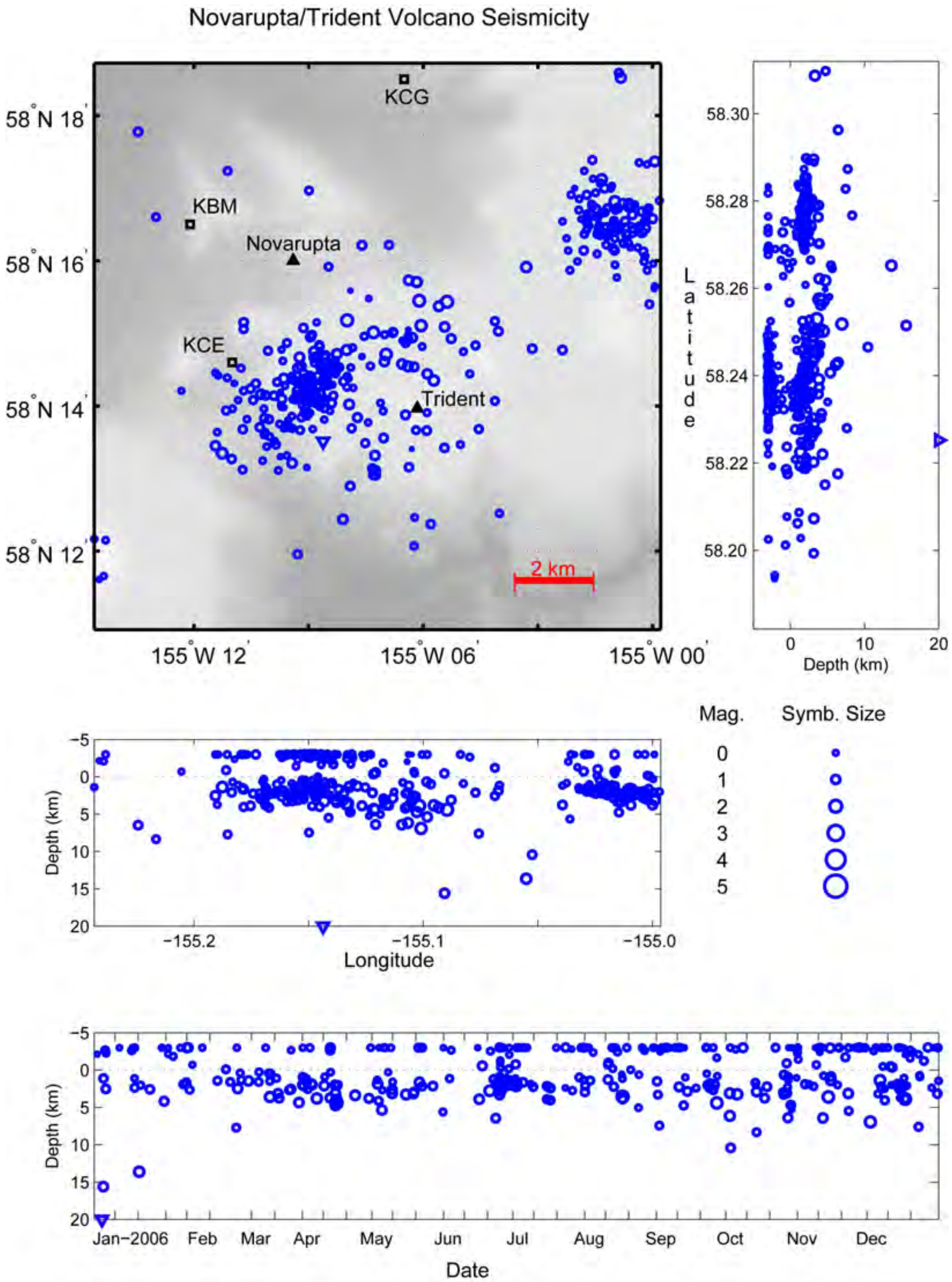


Figure A11. Summary plots of earthquakes located near Novarupta and Trident Volcano in the Katmai volcanic cluster in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information. Several earthquakes that appear on this figure appear on other figures.

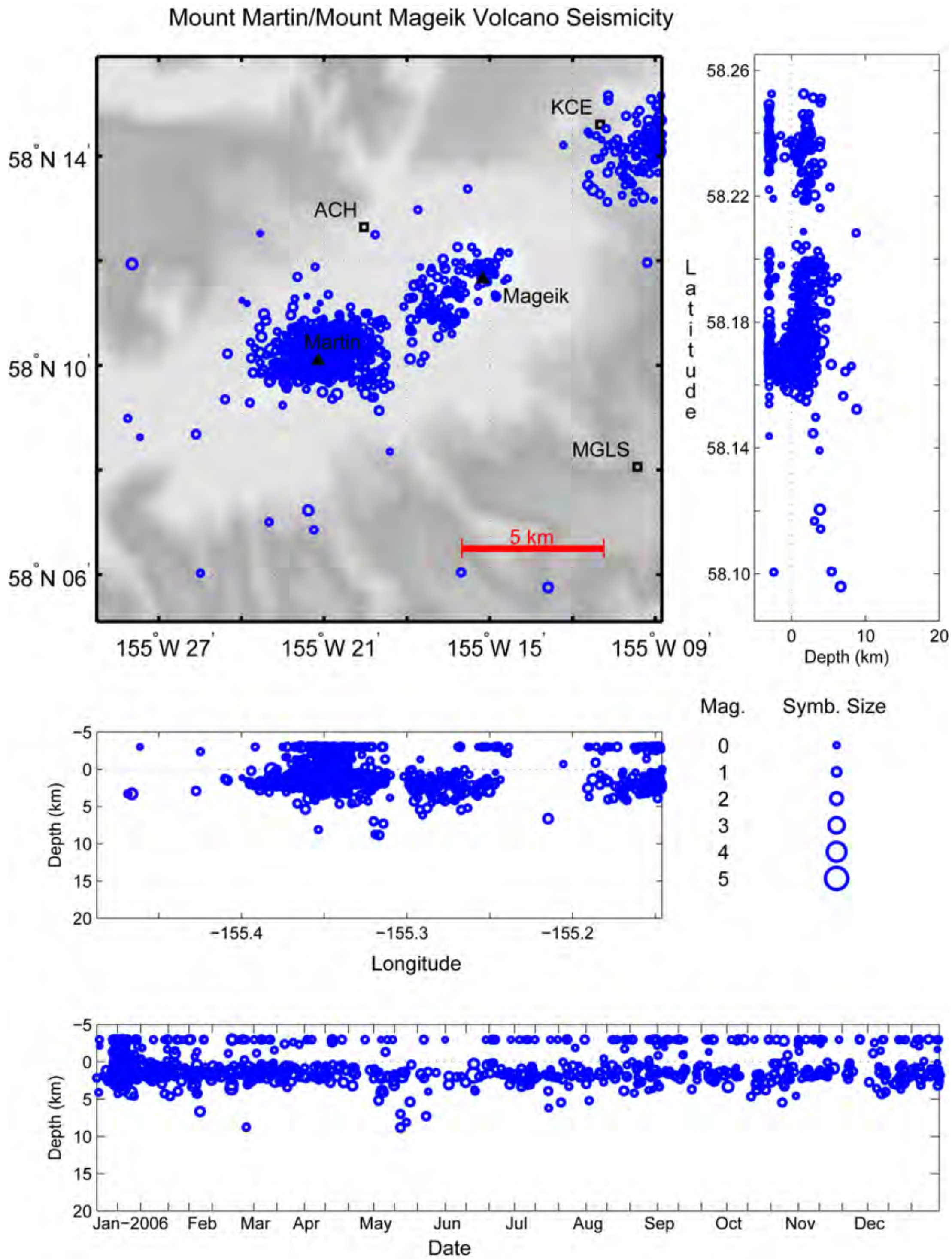


Figure A12. Summary plots of earthquakes located near Mount Mageik and Mount Martin in the Katmai volcanic cluster in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information. Several earthquakes that appear on this figure appear on other figures.

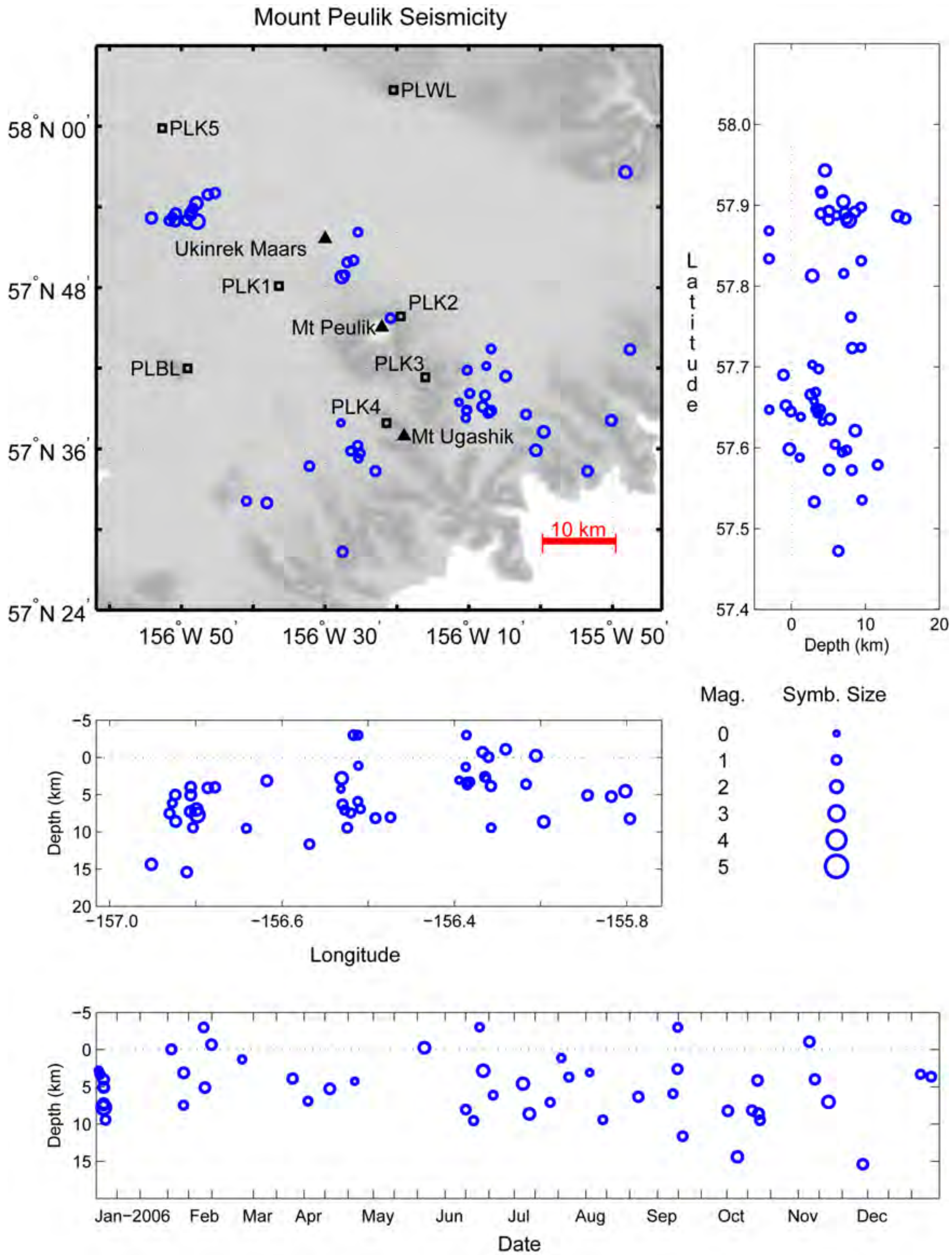


Figure A13. Summary plots of earthquakes located near Mount Peulik in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

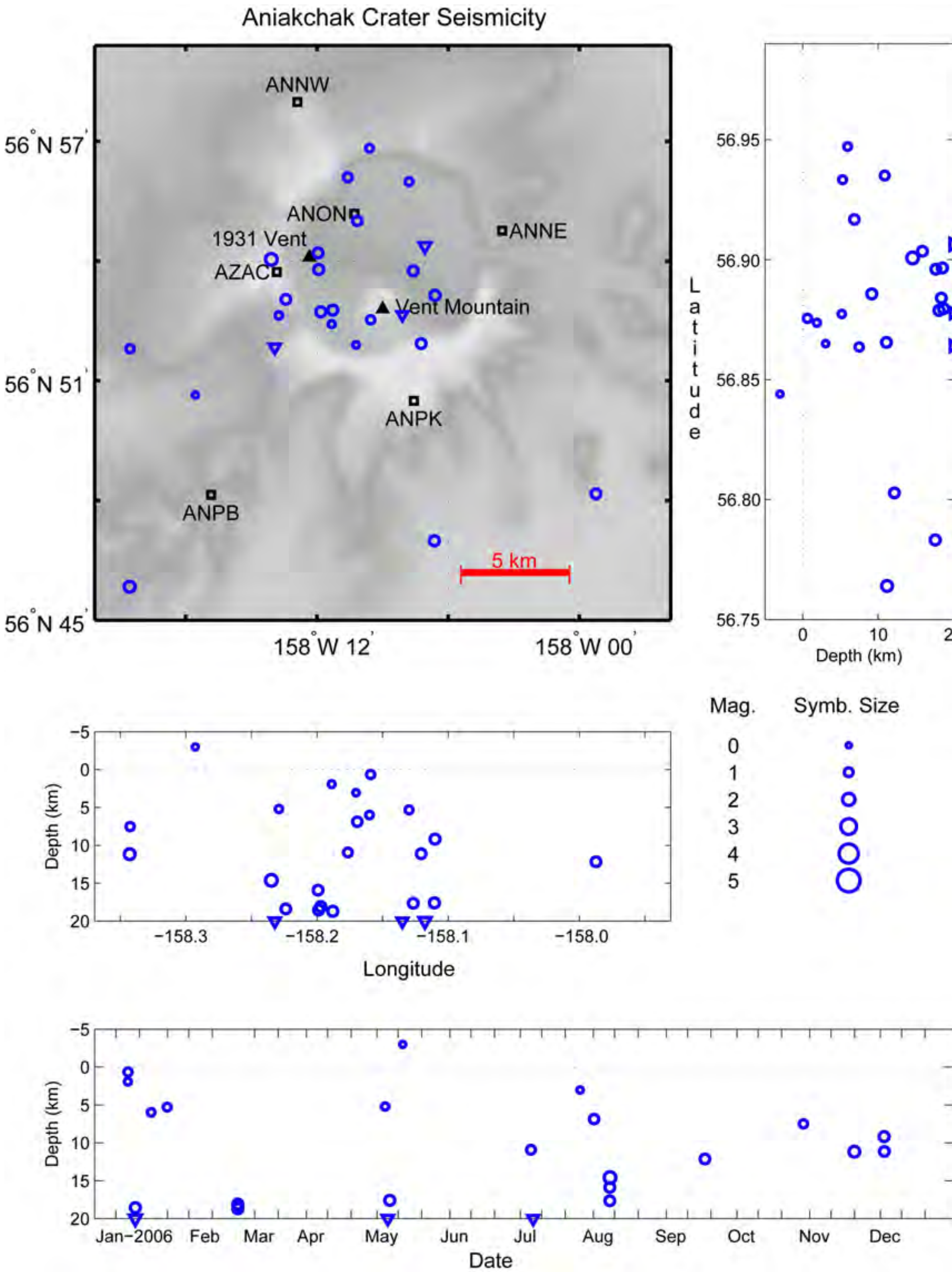


Figure A14. Summary plots of earthquakes located near Aniakchak Crater in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

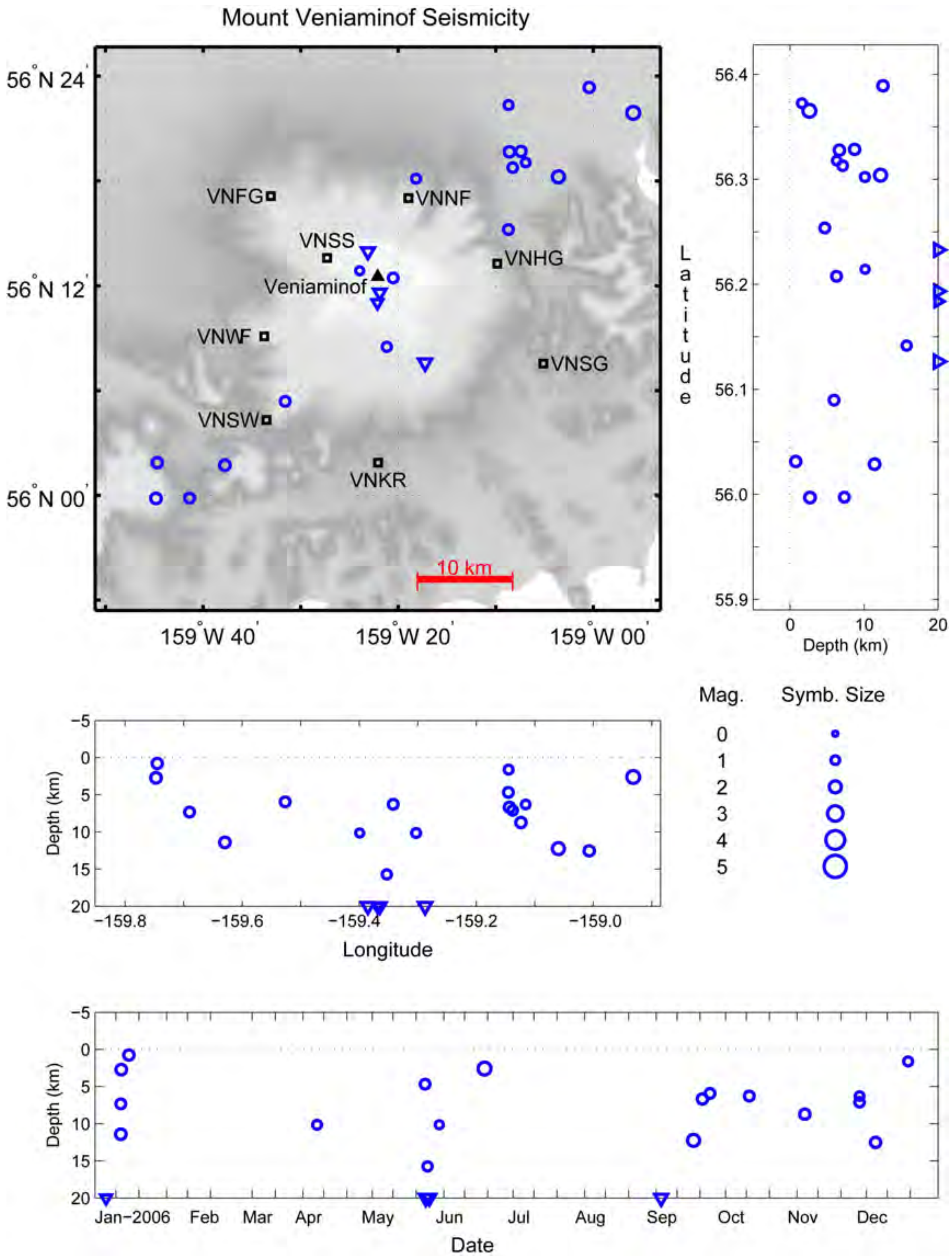


Figure A15. Summary plots of earthquakes located near Mount Veniaminof in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

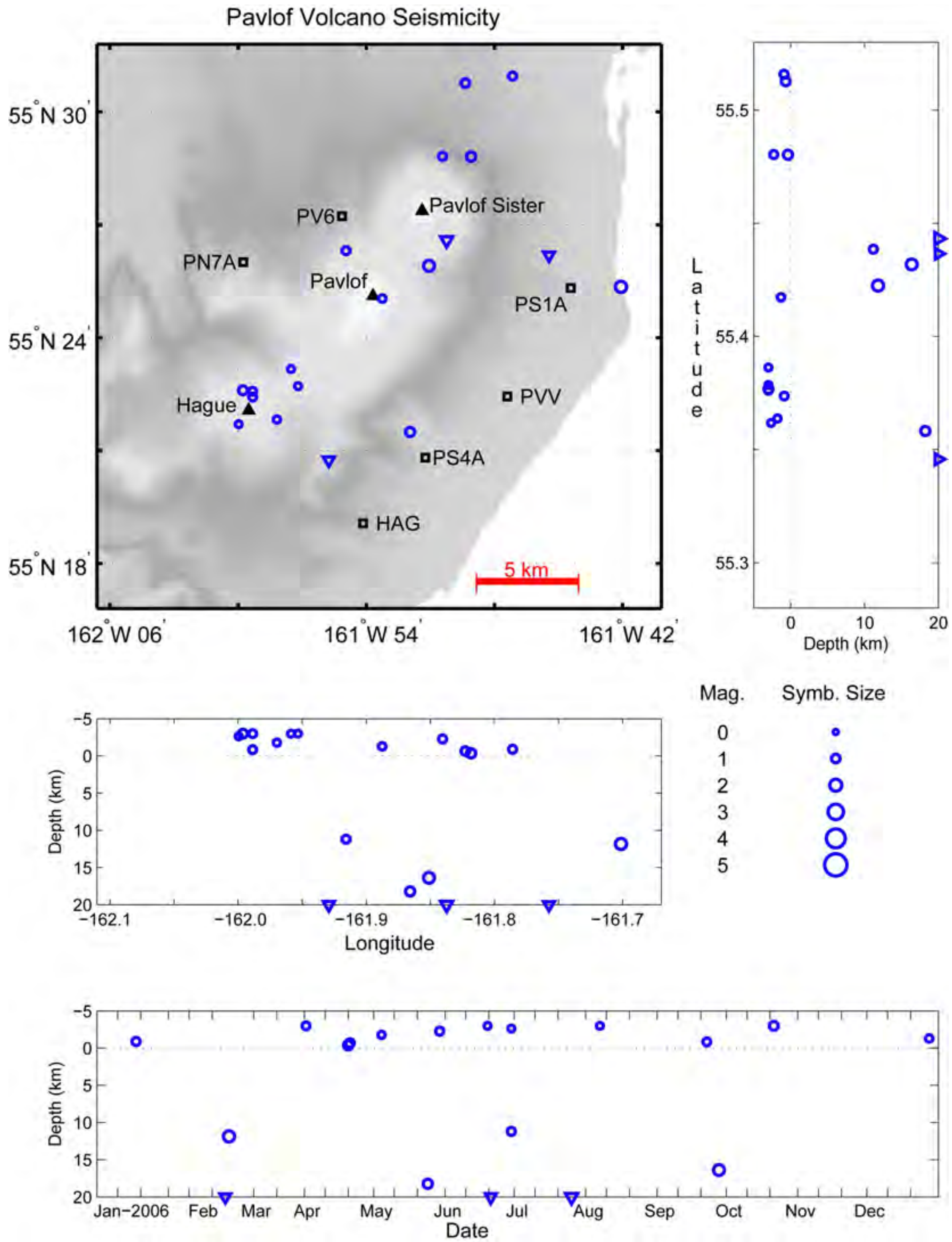


Figure A16. Summary plots of earthquakes located near Pavlof Volcano in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

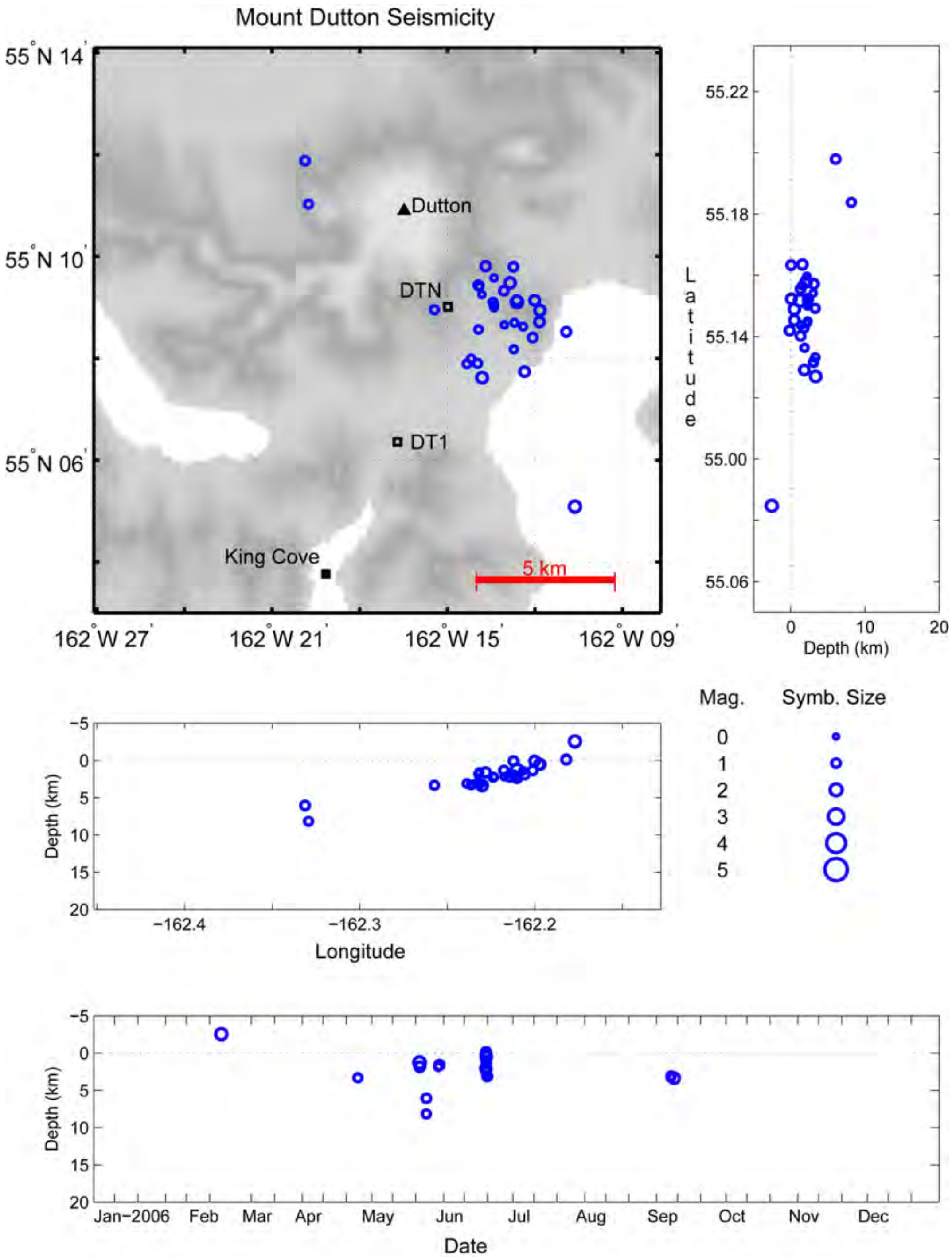


Figure A17. This summary plot shows earthquakes located near Mount Dutton in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers and solid squares are used to show other points of interest. See appendix B for station information.

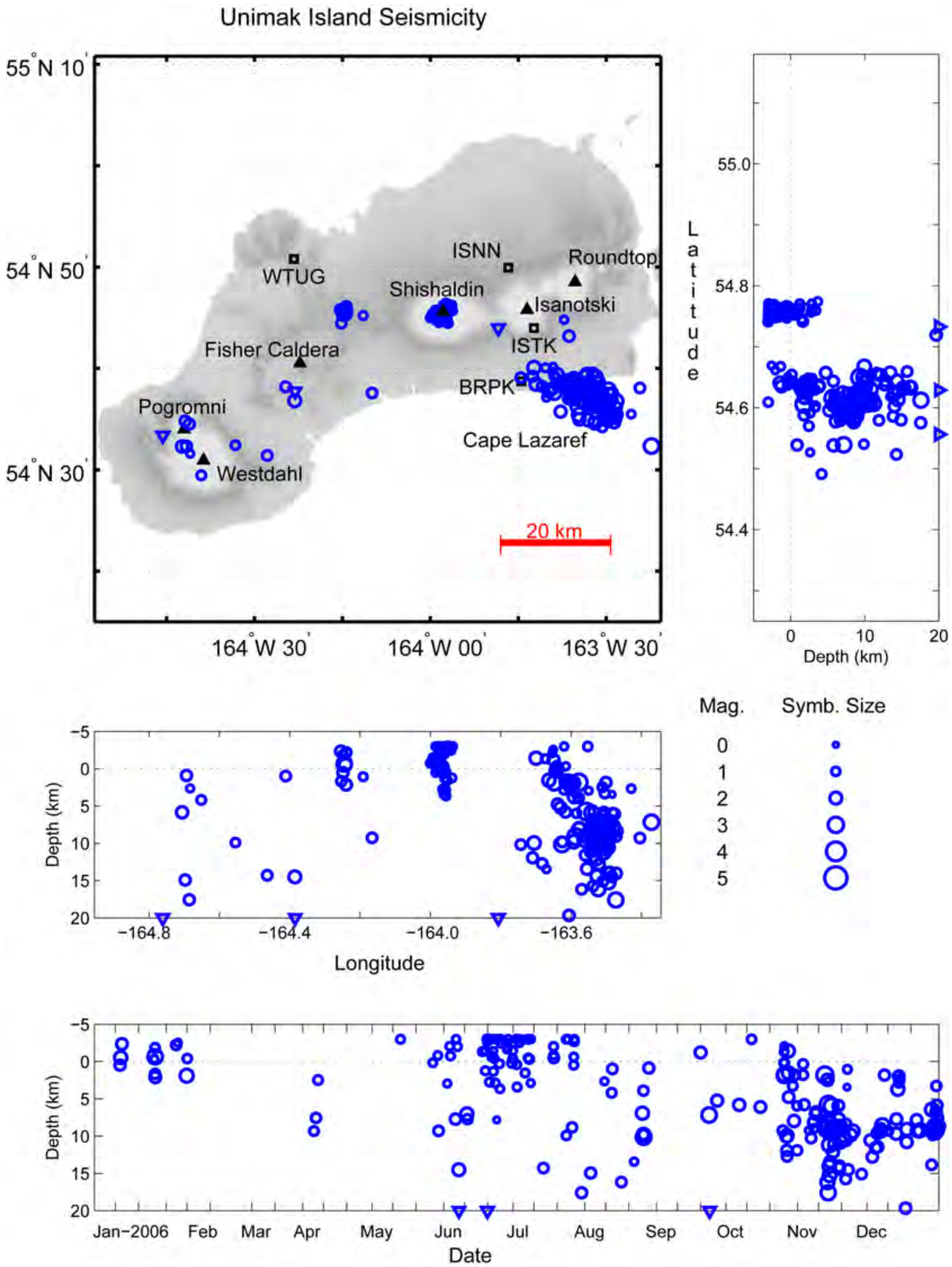


Figure A18. Summary plots of earthquakes located near Unimak Island in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

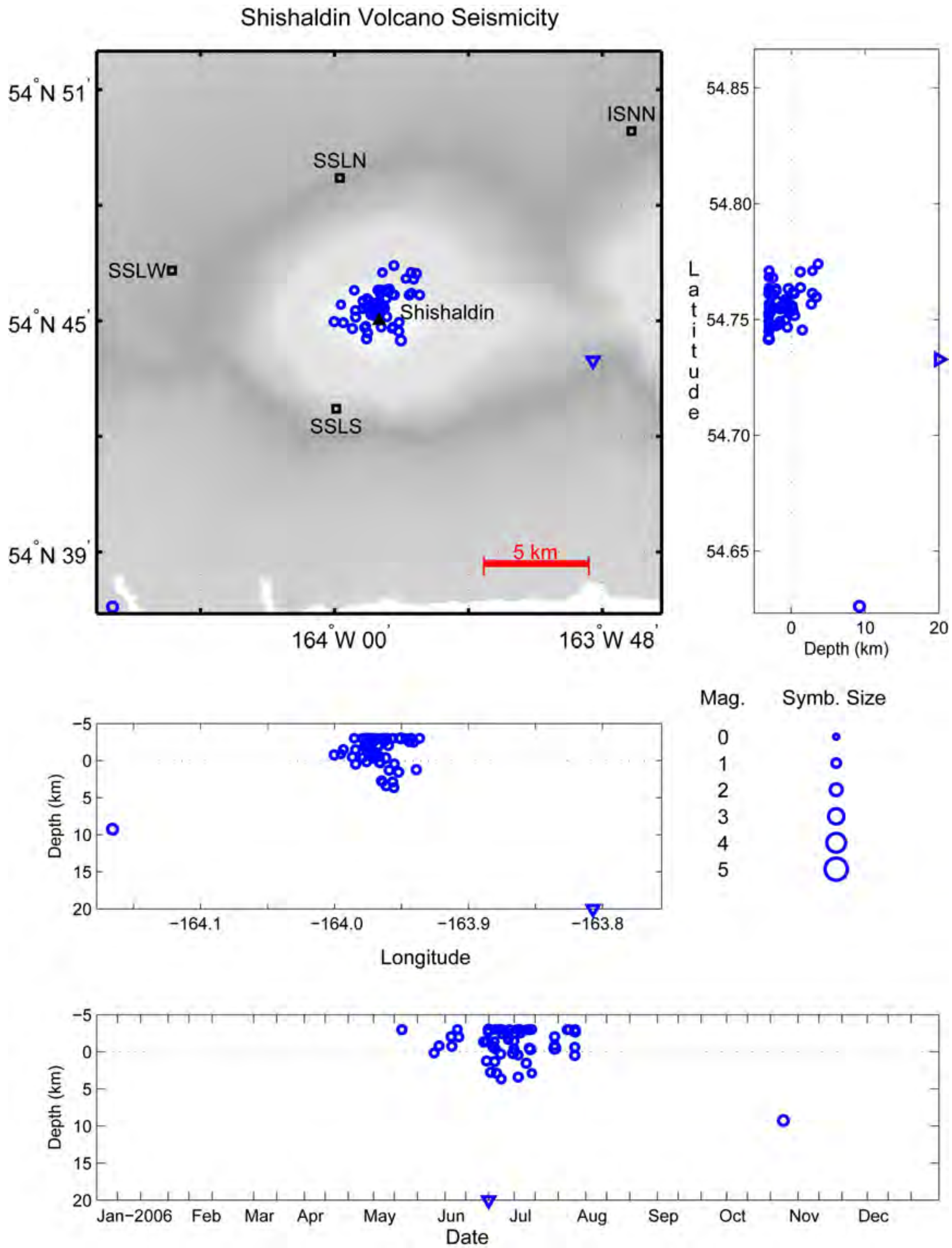


Figure A19. Summary plots of earthquakes located near Shishaldin Volcano in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

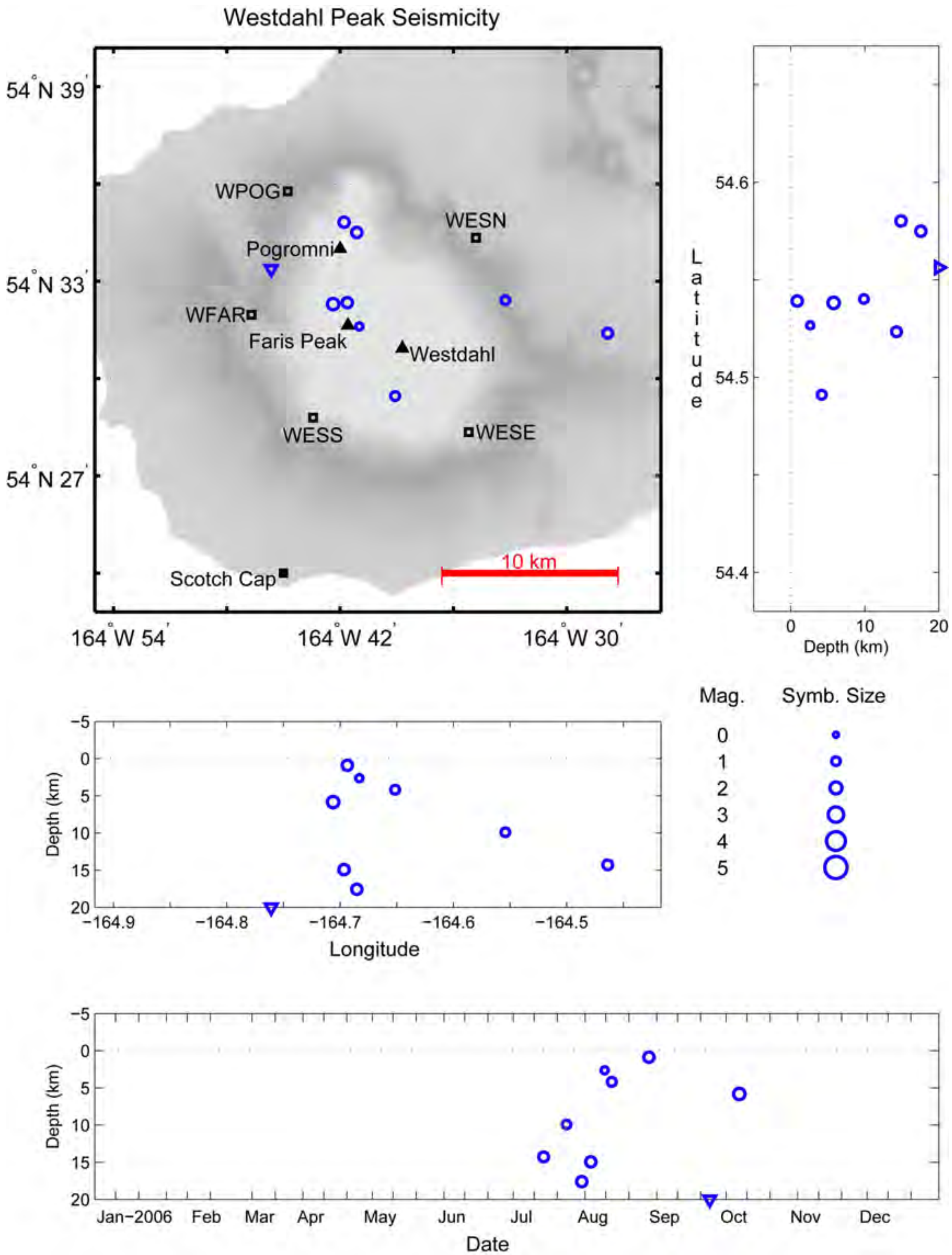


Figure A19. Summary plots of earthquakes located near Westdahl Peak in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers and solid squares are used to show other points of interest. See appendix B for station information.

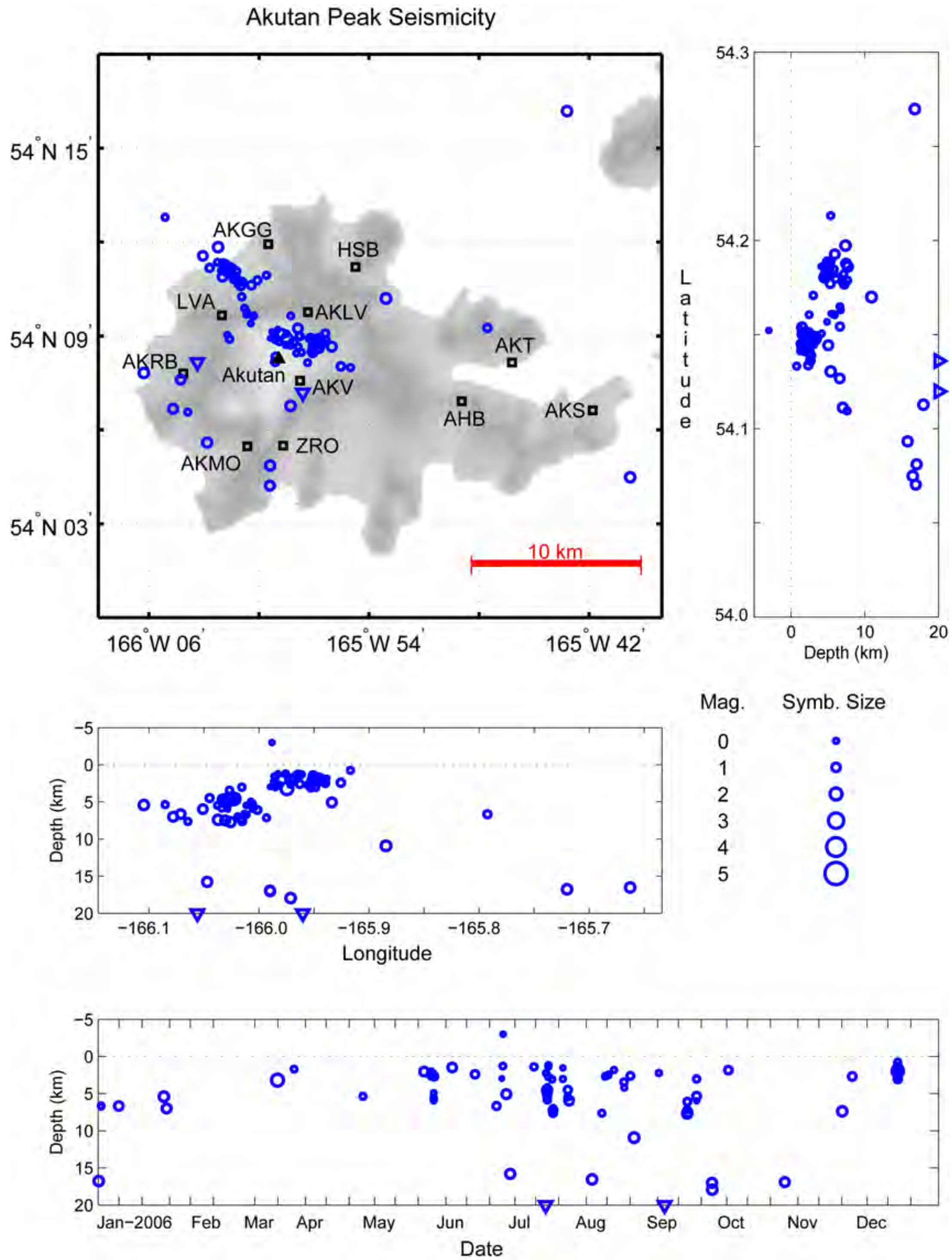


Figure A21. Summary plots of earthquakes located near Akutan Peak in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

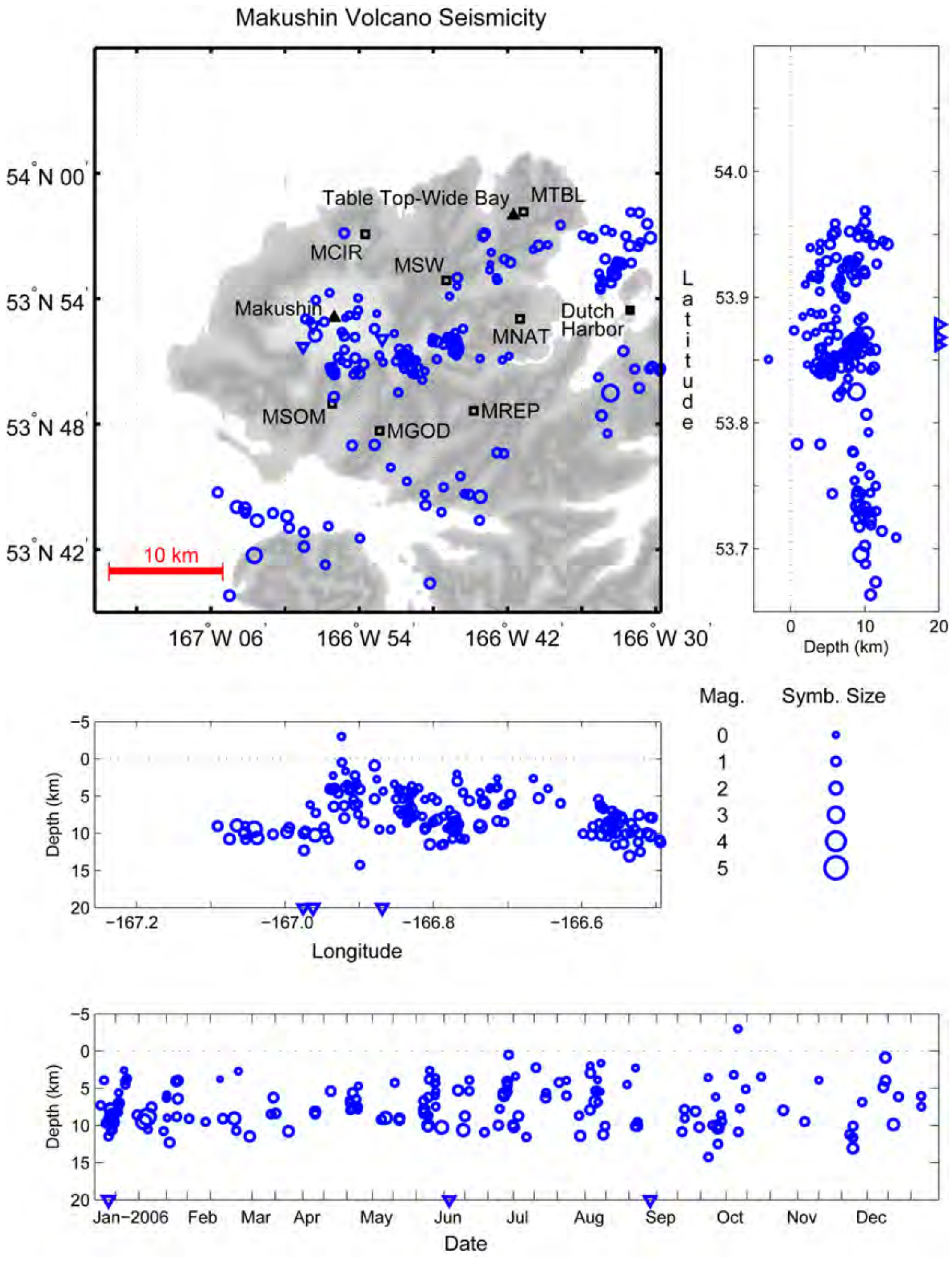


Figure A22. Summary plots of earthquakes located near Makushin Volcano in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers and solid squares are used to show other points of interest. See appendix B for station information.

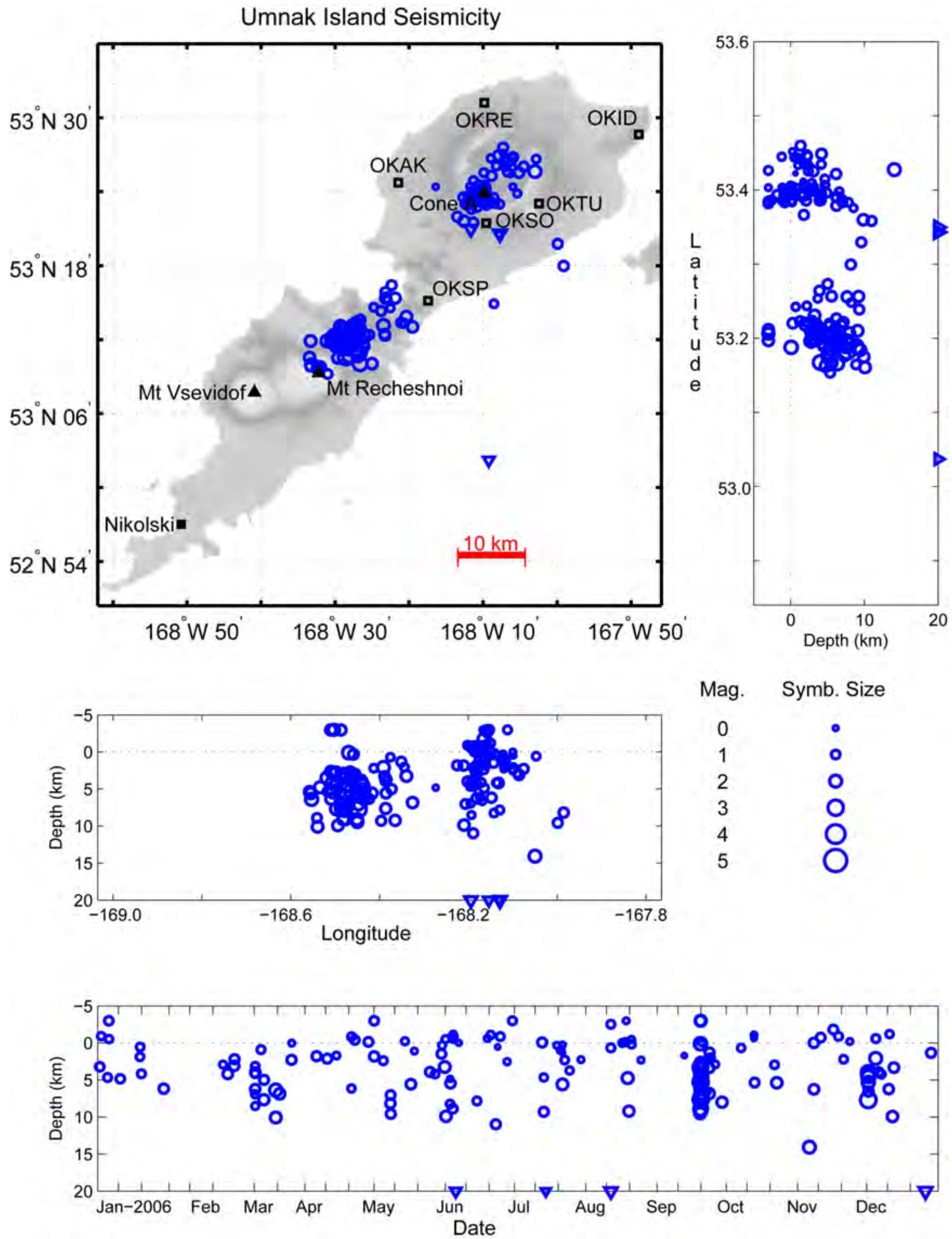


Figure A23. Summary plots of earthquakes located on Umnak Island in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers and solid squares are used to show other points of interest. See appendix B for station information.

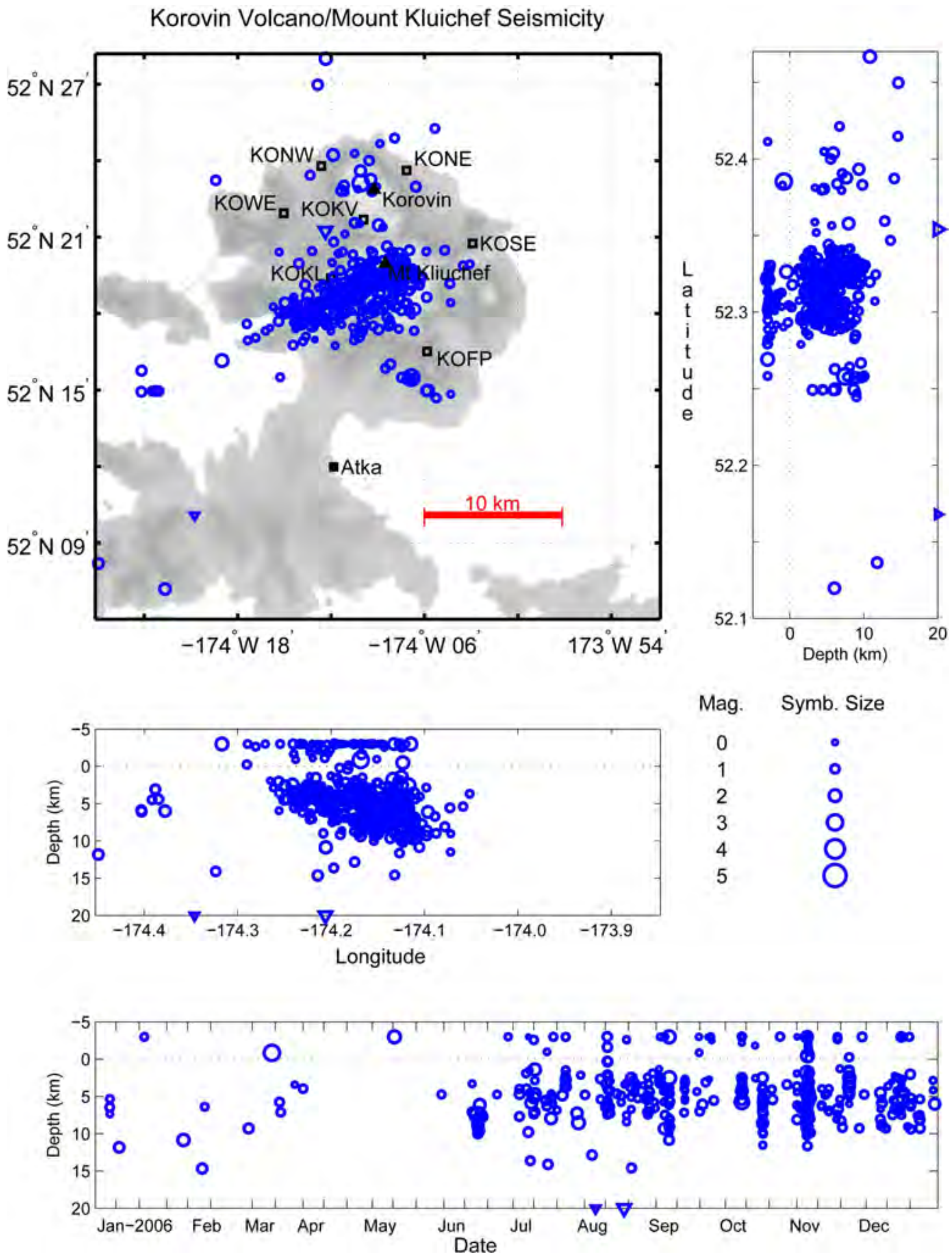


Figure A24. Summary plots of earthquakes located near Korovin Volcano and Mount Kliuchef in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers and solid squares are used to show other points of interest. See appendix B for station information.

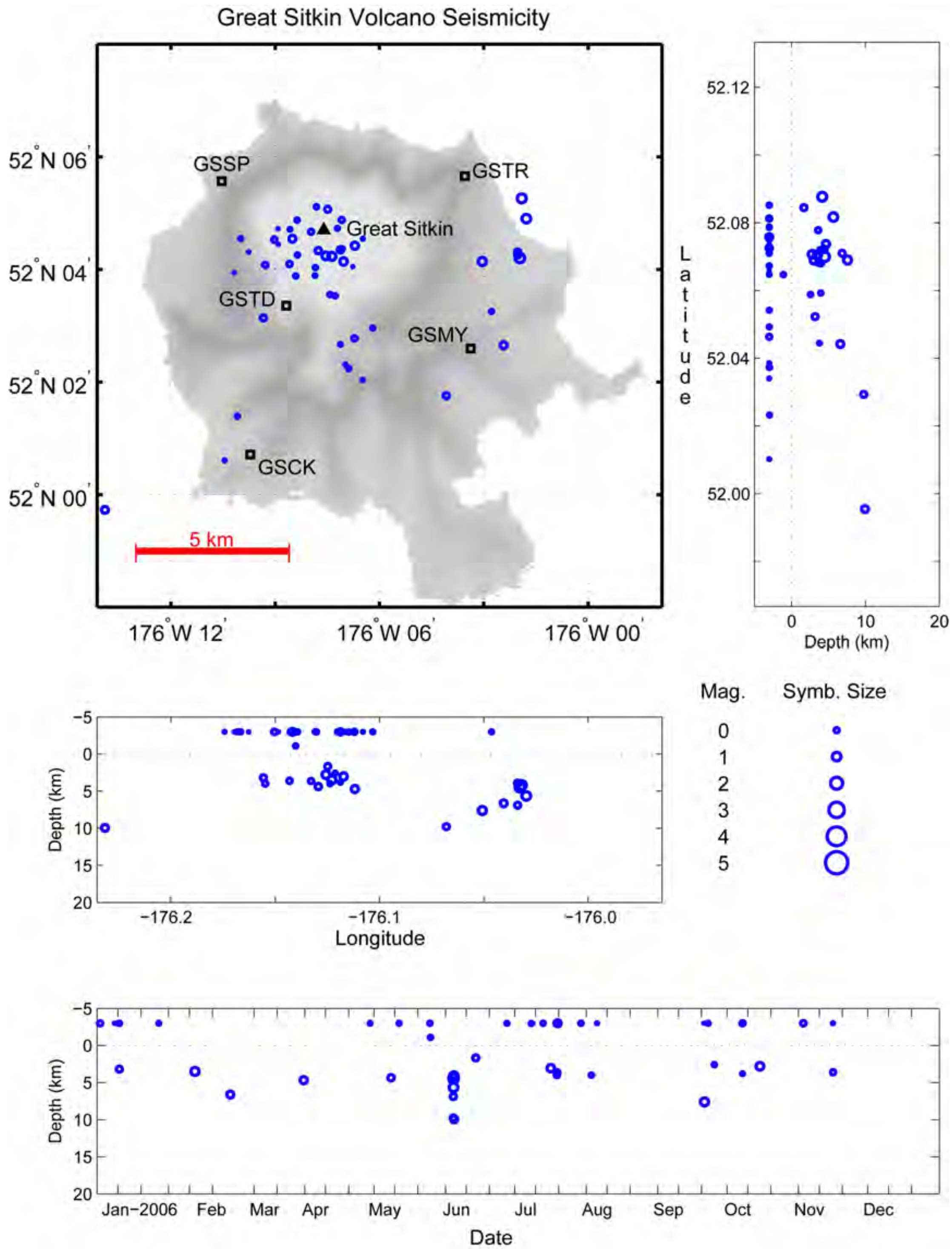


Figure A25. Summary plots of earthquakes located near Great Sitkin Volcano in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

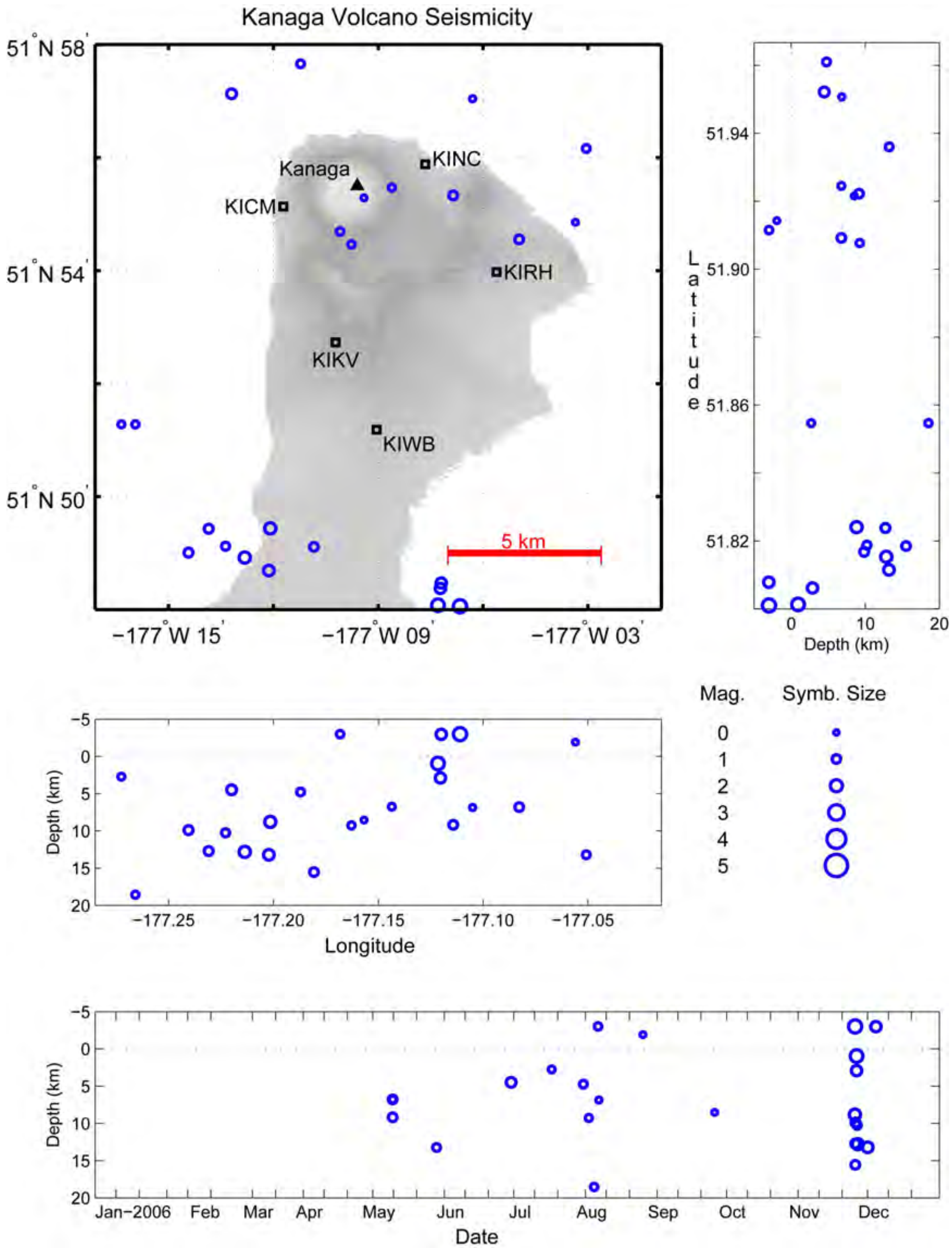


Figure A26. Summary plots of earthquakes located near Kanaga Volcano in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

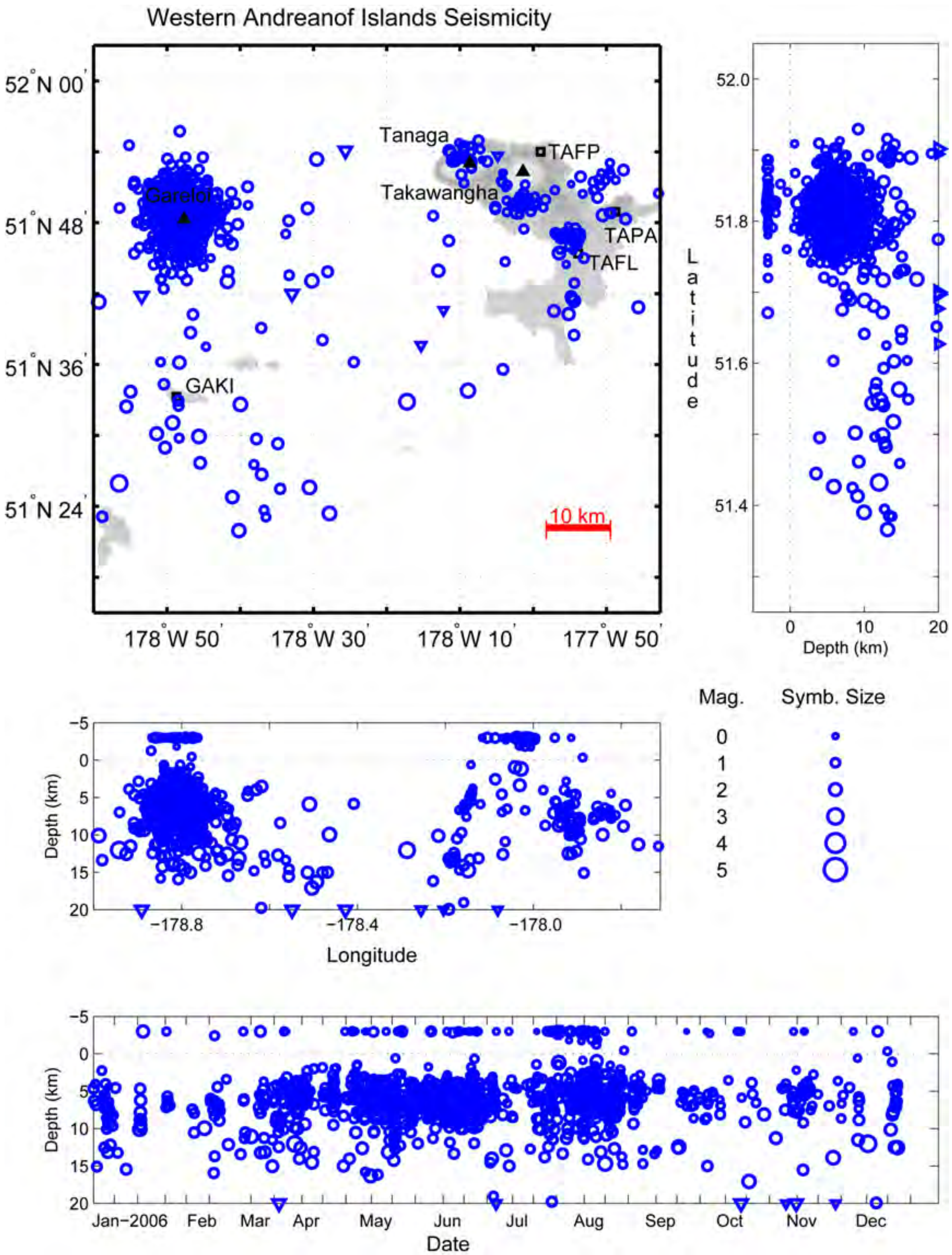


Figure A27. Summary plots of earthquakes located in the Western Andreanof Islands in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

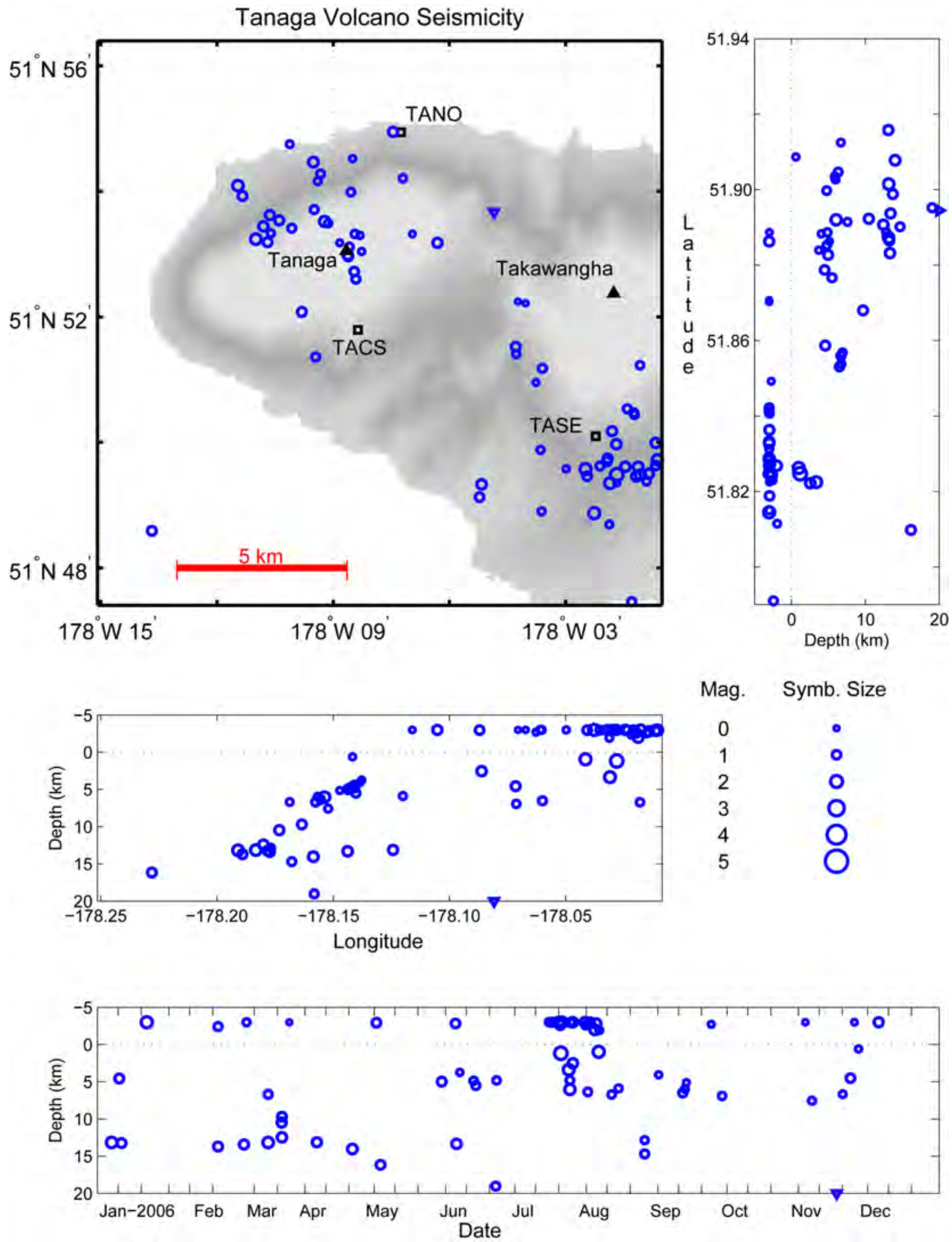


Figure A28. Summary plots of earthquake located near Tanaga Volcano in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

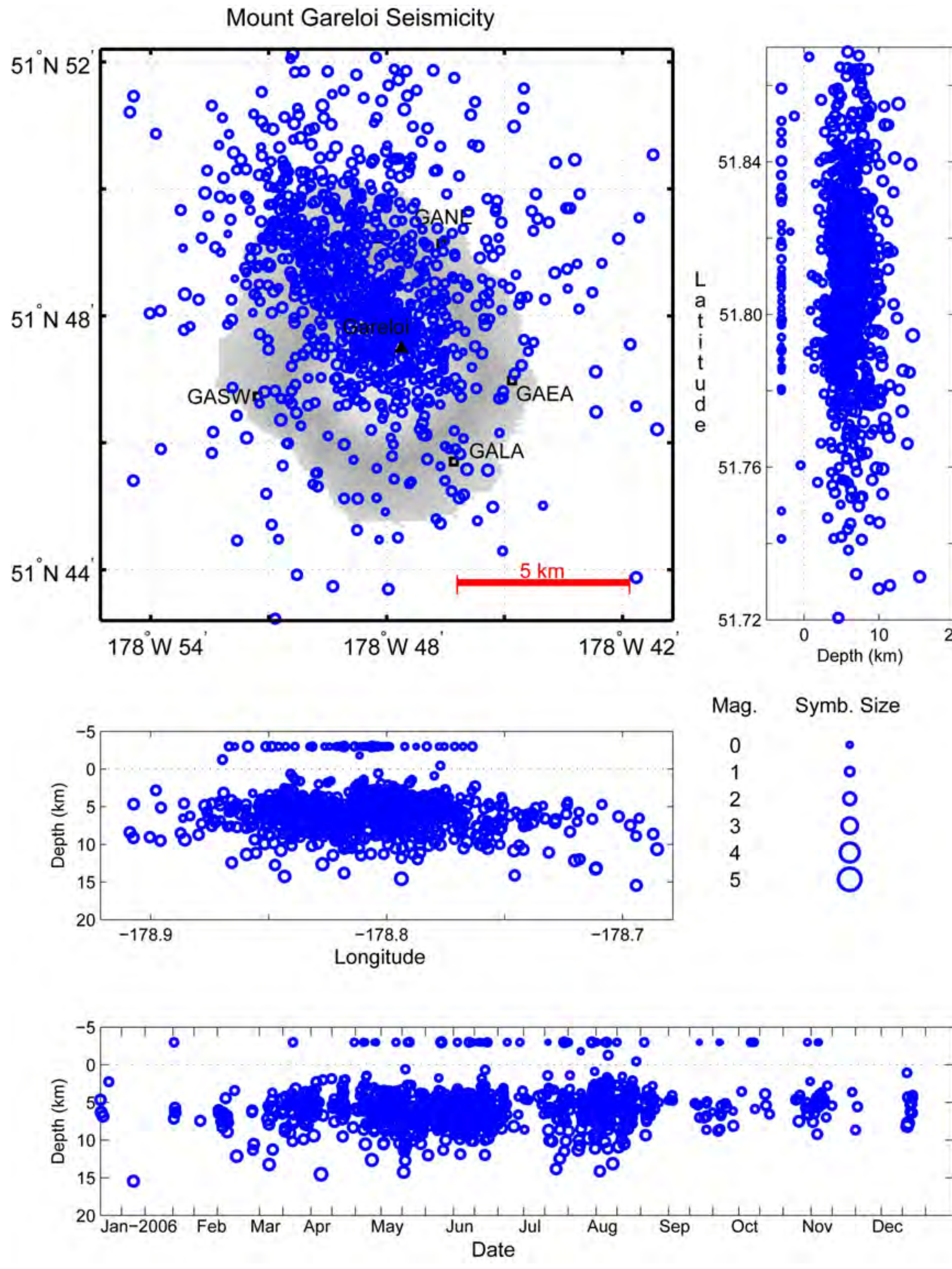


Figure A29. Summary plots of earthquakes located near Mount Gareloi in 2006. Open circles scaled with magnitude show hypocenter locations. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

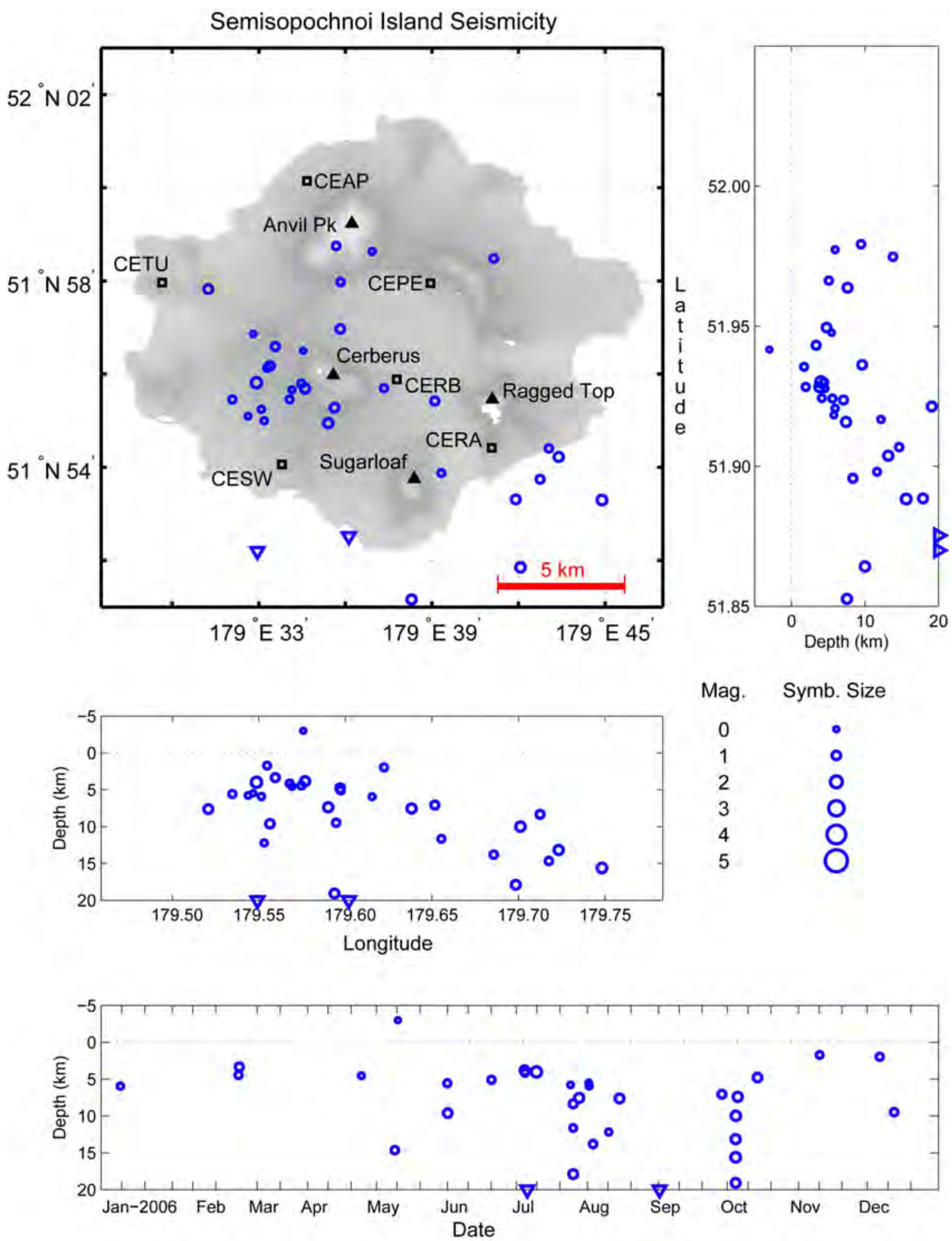


Figure A30. Summary plots of earthquakes located on Semisopochnoi Island in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

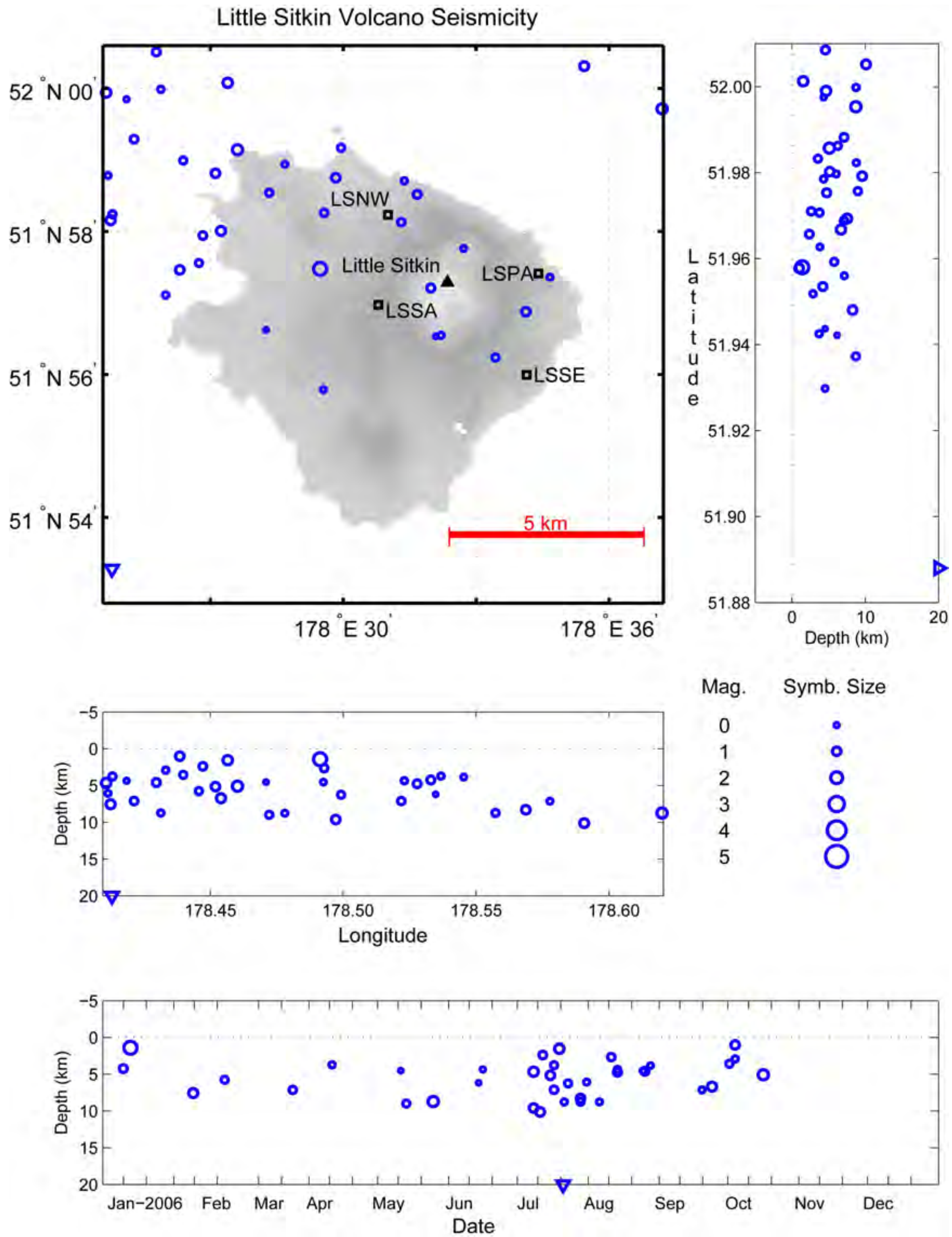


Figure A31. Summary plots of earthquakes located near Little Sitkin Volcano in 2006. Open circles show hypocenter locations shallower than 20 km and open triangles show hypocenters with depths of 20 km and deeper. Hypocenter symbols are scaled with magnitude. Permanent seismograph stations are shown by open squares and labeled by station code. Solid triangles are used to show volcanic centers. See appendix B for station information.

Appendix B: Parameters for AVO seismograph stations (datum NAD27) in 2006. Included in this list are the station parameters for seismograph stations operated by the Alaska Earthquake Information Center (AEIC) and the West Coast-Alaska Tsunami Warning Center (WC-ATWC) that were used to locate earthquakes in the AVO catalog.

Station	Latitude (N)	Longitude (E)	Elevation (m)	Seismometer	Open date	Close date
Akutan Peak subnet (11 stations - 23 components)						
AHB	54 06.916	-165 48.943	447	L4	1996/07/24	-
AKBB	54 05.905	-165 55.907	310	CMG-6TD	2005/07/05	-
AKGG[3]	54 11.930	-165 59.495	326	CMG-6TD	2003/06/27	-
AKLV[3]	54 09.762	-165 57.336	551	CMG-6TD	2003/07/02	-
AKMO[3]	54 05.471	-166 00.634	277	CMG-6TD	2003/06/25	-
AKRB[3]	54 07.803	-166 04.125	334	CMG-6TD	2003/06/29	-
AKS[3]	54 06.624	-165 41.803	213	L22	1996/07/24	-
AKT[3]	54 08.15	-165 46.2	12	CMG-40T	1996/03/18	-
AKV	54 07.571	-165 57.763	863	L4	1996/07/24	-
HSB	54 11.205	-165 54.743	497	L4	1996/07/24	-
LVA	54 09.654	-166 02.025	457	L4	1996/07/24	-
ZRO	54 05.494	-165 58.678	446	L4	1996/07/24	-
Aniakchak Crater subnet (6 stations - 8 components)						
ANNE	56 54.763	-158 03.534	705	L4	1997/07/18	-
ANNW	56 57.986	-158 12.895	816	L4	1997/07/18	-
ANON[3]	56 55.188	-158 10.293	445	L22	2000/07/10	-
ANPB	56 48.141	-158 16.847	658	L4	1997/07/18	-
ANPK	56 50.499	-158 07.572	972	L4	1997/07/18	-
AZAC	56 53.727	-158 13.841	1,057	L4	2003/07/12	-
Augustine Volcano subnet (Permanent Stations Only: 9 stations - 18 components)						
AU11[3]	58 21.576	-153 28.818	234	CMG-6TD	2005/12/20	2006/02/12
AU12[3]	58 23.009	-153 27.114	210	CMG-6TD	2005/12/20	2006/01/30
AU13[3]	58 20.781	-153 26.046	518	CMG-6TD	2005/12/20	2006/05/30
AU14[3]	58 22.268	-153 23.811	303	CMG-6TD	2005/12/21	2006/08/07
AU15[3]	58 21.042	-153 29.134	168	CMG-6TD	2005/12/21	2006/08/10
AU20[R]	59 22.216	-153 21.245	102	SM	2006/01/09	2006/09/01
AU22	59 22.247	-153 21.301	105	SM	2006/09/01	-
AUE[3]	59 22.308	-153 22.504	168	S13	1980/10/29	-
AUH	59 21.833	-153 26.591	890	S13	1978/12/01	-
AUI[3]	59 20.11	-153 25.66	293	S13	1978/04/06	-
AUL	59 22.937	-153 26.142	360	S13	1980/10/29	-
AUL[3]	59 22.937	-153 26.142	360	CMG-6TD	1997/08/27	-
AUNW	59 22.694	-153 28.609	160	L4	2006/03/15	-
AUP	59 21.805	-153 25.210	1,033	S13	1977/09/22	-
AUR[R]	59 21.766	-153 25.876	1,225	L4	1995/11/01	2006/01/11
AUS[R]	59 21.599	-153 25.840	1,226	L4	1990/09/01	2006/01/11
AUSE	59 20.481	-153 23.850	152	L4	1990/09/01	-
AUW	59 22.205	-153 28.249	276	S13	1976/10/17	-

Station	Latitude (N)	Longitude (E)	Elevation (m)	Seismometer	Open date	Close date
Mount Cerberus Subnet (6 stations - 8 components)						
CEAP	52 00.146	179 34.667	244	L4	2005/09/17	-
CEPE	51 57.949	179 38.950	335	L4	2005/09/17	-
CERA	51 54.419	179 41.074	305	L4	2005/09/26	-
CERB[3]	51 55.886	179 37.783	305	L4-3D	2005/09/18	-
CESW	51 54.060	179 33.800	238	L4	2005/09/18	-
CETU	51 57.965	179 29.651	335	L4	2005/09/22	-
Mount Dutton subnet (5 stations - 5 components)						
BLDY	55 11.670	-162 47.018	259	L4	1996/07/11	-
DOL	55 08.960	-161 51.683	442	L4	1996/07/11	-
DRR3	54 58.014	-162 15.665	457	L4	1996/07/11	-
DT1	55 06.427	-162 16.859	198	L4	1991/06/21	-
DTN	55 08.744	-162 15.419	396	S13	1988/07/16	-
Fourpeaked subnet (Permanent Stations Only: 4 stations - 7 components)						
CDD	58 55.771	-153 38.558	622	S13	1981/08/17	-
FONW*	58 50.086	-153 55.102	905	L-4	2006/10/19	-
FOPK*	58 45.480	-153 28.433	546	L4	2006/09/25	-
FOSS*	58 47.965	-153 41.699	1268	L-4	2006/10/10	-
FP01[3]	58 48.814	-153 45.360	844	CMG-6TD	2006/09/24	2006/10/08
Gareloi Volcano subnet (6 stations - 8 components)						
GAEA	51 46.980	-178 44.810	326	L4	2003/08/30	-
GAKI	51 33.267	-178 48.725	99	L4	2003/09/01	-
GALA	51 45.704	-178 46.292	315	L4	2003/08/30	-
GANE	51 49.135	-178 46.603	322	L4	2003/09/02	-
GANO	51 49.220	-178 48.230	451	L4	2003/09/02	-
GASW[3]	51 46.731	-178 51.276	248	L22	2003/08/30	-
Great Sitkin Volcano subnet (6 stations - 8 components)						
GSCK	52 00.712	-176 09.718	384	L4	1999/09/15	-
GSIG	51 59.181	-175 55.502	407	L4	1999/09/03	-
GSMY	52 02.594	-176 03.376	418	L4	1999/09/03	-
GSSP	52 05.566	-176 10.541	295	L4	1999/09/15	-
GSTD[3]	52 03.356	-176 08.685	873	L22	1999/09/03	-
GSTR	52 05.655	-176 03.546	536	L4	1999/09/03	-
Iliamna Volcano subnet (6 stations - 8 components)						
ILI	60 04.877	-152 57.502	771	L4	1987/09/15	-
ILS	59 57.454	-153 04.083	1,125	S13	1996/08/28	-
ILW	60 03.585	-153 08.222	1,646	S13	1994/09/09	-
INE	60 03.65	-153 03.75	1,585	S13	1990/08/29	-
IVE[3]	60 01.014	-153 00.981	1,173	S13,L22	1996/09/19	-
IVS	60 00.55	-153 04.85	2,332	S13	1990/08/29	-
Kanaga Volcano subnet (6 stations - 6 components)						
KICM	51 55.136	-177 11.718	183	L4	1999/09/15	-
KIKV	51 52.730	-177 10.223	411	L4	1999/09/15	-
KIMD	51 45.697	-177 14.093	183	L4	1999/09/15	-
KINC	51 55.884	-177 07.657	198	L4	1999/09/15	-
KIRH	51 53.976	-177 05.611	309	L4	1999/09/03	-
KIWB	51 51.183	-177 09.049	244	L4	1999/09/03	-

Station	Latitude (N)	Longitude (E)	Elevation (m)	Seismometer	Open date	Close date
Katmai Volcanic Cluster subnet (20 stations - 30 components)						
ACH[3]	58 12.64	-155 19.56	960	L22	1996/07/25	-
ANCK	58 11.93	-155 29.64	869	L4	1996/07/25	-
CAHL	58 03.15	-155 18.09	807	L4	1996/07/25	-
CNTC	58 15.87	-155 53.02	1,158	L4	1996/07/25	-
KABR	58 07.87	-154 58.15	884	L4	1998/08/12	-
KABU[3]	58 16.225	-155 16.934	1,065	CMT-6TD	2004/08/01	-
KAHC	58 38.94	-155 00.36	1,250	L4	1998/10/12	-
KAHG	58 29.64	-154 32.78	923	L4	1998/10/12	-
KAIC	58 29.10	-155 02.75	734	L4	1998/10/12	-
KAKN[3]	58 17.819	-155 03.668	1,049	CMG-6TD	2004/08/01	-
KAPH[3]	58 35.81	-154 20.81	907	L22	1998/10/12	-
KARR	58 29.87	-154 42.20	610	L4	1998/10/12	-
KAWH	58 23.02	-154 47.95	777	L4	1998/10/12	-
KBM	58 16.50	-155 12.10	732	L4	1991/07/22	-
KCE	58 14.60	-155 11.00	777	L4	1991/07/22	-
KCG[3]	58 18.457	-155 06.684	762	L22	1988/08/01	-
KEL	58 26.401	-155 44.442	975	L4	1988/08/01	-
KJL	58 03.24	-155 34.39	792	L4	1996/07/25	-
KVT	58 22.90	-155 17.70	457	L4	1988/08/01	-
MGLS	58 08.06	-155 09.65	472	L4	1996/07/25	-
Korovin Volcano subnet (7 stations - 9 components)						
KOFP	53 57.08	-166 53.51	662	L4	2004/07/02	-
KOKL	53 47.68	-166 52.35	758	L4	2004/07/05	-
KOKV[3]	53 53.03	-166 41.00	776	L22	2004/07/05	-
KONE	53 48.629	-166 44.736	253	L4	2004/07/10	-
KONW	53 48.978	-166 56.187	334	L4	2004/07/04	-
KOSE	53 54.88	-166 46.96	625	L4	2004/07/07	-
KOWE	53 58.16	-166 40.71	527	L4	2004/07/06	-
Little Sitkin subnet (4 stations - 6 components)						
LSNW	51 58.232	178 31.011	290	L4	2005/09/30	-
LSPA[3]	51 57.413	178 34.405	335	L4-3D	2005/09/30	-
LSSSA	51 56.973	178 30.793	549	L4	2005/09/28	-
LSSE	51 55.993	178 34.139	335	L4	2005/09/27	-
Makushin Volcano subnet (7 stations - 9 components)						
MCIR	53 57.086	-166 53.529	800	L4	1996/07/25	-
MGOD	53 47.683	-166 52.561	650	L4	1996/07/25	-
MNAT	53 53.028	-166 41.016	397	L4	1996/07/25	-
MREP	53 48.629	-166 44.736	785	L4	2002/01/01	-
MSOM	53 48.978	-166 56.187	146	L4	1996/07/25	-
MSW[3]	53 54.929	-166 47.186	418	L22	1996/07/25	-
MTBL	53 58.136	-166 40.760	810	L4	1996/07/25	-
Okmok Volcano subnet (13 stations - 21 components)						
OKAK	53 24.740	-168 21.465	165	L4	2005/07/11	-
OKCD[3]	53 25.818	-168 06.737	459	CMG-6TD	2003/01/09	-
OKCE[3]	53 25.622	-168 09.858	515	CMG-6TD	2003/01/09	-
OKCF	53 23.749	-168 08.175	685	L4	2003/01/09	-
OKER	53 27.278	-168 02.960	956	L4	2003/01/09	-
OKFG[3]	53 24.702	-167 54.568	201	CMG-6TD	2003/01/09	-

Station	Latitude (N)	Longitude (E)	Elevation (m)	Seismometer	Open date	Close date
Okmok Volcano subnet (continued)						
OKID	53 28.645	-167 48.972	437	L4	2003/01/09	-
OKRE	53 31.215	-168 09.846	422	L4	2003/01/09	-
OKSO[3]	53 21.447	-168 09.591	460	CMG-6TD	2004/09/01	-
OKSP	53 15.156	-168 17.431	608	L4	2003/01/09	-
OKTU	53 23.035	-168 02.466	646	L4	2003/01/09	-
OKWE	53 28.328	-168 14.388	445	L4	2003/01/09	-
OKWR	53 26.084	-168 12.333	1,017	L4	2003/01/09	-
Pavlof Volcano subnet (7 stations - 9 components)						
BLHA	55 42.227	-162 03.907	411	L4	1996/07/11	-
HAG	55 19.068	-161 54.150	503	L4	1996/07/11	-
PN7A	55 26.020	-161 59.713	838	L4	1996/07/11	-
PS1A	55 25.321	-161 44.425	293	L4	1996/07/11	-
PS4A	55 20.811	-161 51.233	322	L4	1996/07/11	-
PV6[3]	55 27.217	-161 55.112	747	L22	1996/07/11	-
PVV	55 22.438	-161 47.396	161	L4	1996/07/11	-
Mount Peulik subnet (7 stations - 9 components)						
PLBL	57 41.990	-156 49.131	461	L4	2004/08/01	-
PLK1	57 48.114	-156 36.433	78	L4	2004/08/01	-
PLK2	57 45.852	-156 19.458	401	L4	2004/08/01	-
PLK3[3]	57 41.320	-156 16.044	494	L22	2004/08/01	-
PLK4	57 37.928	-156 21.464	1,031	L4	2004/08/01	-
PLK5	57 59.864	-156 52.662	49	L4	2004/08/01	-
PLWL	58 02.696	-156 20.479	585	L4	2004/08/01	-
Redoubt Volcano subnet (7 stations - 12 components)						
DFR	60 35.514	-152 41.160	1,090	L4	1988/08/15	-
NCT	60 33.789	-152 55.568	1,079	L4	1988/08/14	-
RDN	60 31.377	-152 44.273	1,400	L4	1988/08/13	-
RDT	60 34.394	-152 24.315	930	L4	1971/08/09	-
RED[3]	60 25.192	-152 46.308	1,064	L4	1990/08/30	-
REF[3]*	60 29.35	-152 42.10	1,801	L22	1992/07/27	-
RSO	60 27.73	-152 45.23	1,921	L4	1990/03/01	-
Shishaldin Volcano subnet (6 stations - 8 components)						
BRPK	54 38.730	-163 44.449	393	L4	1997/07/27	-
ISNN	54 49.937	-163 46.706	466	L4	1997/07/27	-
ISTK	54 43.929	-163 42.376	704	L4	1997/07/27	-
SSLN	54 48.709	-163 59.756	637	L4	1997/07/27	-
SSLS[3]	54 42.718	-163 59.926	817	L22	1997/07/27	-
SSLW	54 46.307	-164 07.282	628	L4	1997/07/27	-
Mount Spurr subnet (15 stations - 23 components)						
BGL	61 16.012	-152 23.340	1,127	L4	1989/08/13	-
BKG	61 04.21	-152 15.76	1,009	L4	1991/07/01	-
CGL	61 18.46	-152 00.40	1,082	L4	1981/09/22	-
CKL	61 11.782	-152 20.268	1,281	L4	1989/08/05	-
CKN	61 13.44	-152 10.89	735	L4	1991/08/19	-
CKT	61 12.05	-152 12.37	975	L4	1992/09/16	-
CP2	61 15.85	-152 14.51	1,981	L4	1992/10/23	-
CRP[3]	61 16.02	-152 09.33	1,622	L4	1981/08/26	-
NCG	61 24.22	-152 09.40	1,244	L4	1989/08/06	-

Station	Latitude (N)	Longitude (E)	Elevation (m)	Seismometer	Open date	Close date
Mount Spurr subnet (continued)						
SPBG[3]	61 15.583	-152 22.194	1,087	CMG-6TD	2004/09/09	-
SPCG[3]	61 17.512	-152 01.228	1,329	CMG-6TD	2004/09/08	-
SPCR[3]	61 12.051	-152 12.409	984	CMG-6TD	2004/09/08	-
SPNW	61 20.826	-152 36.236	1,040	L4	2004/08/17	-
SPU	61 10.90	-152 03.26	800	L4	1971/08/10	-
SPWE	61 16.441	-152 33.410	1,233	L4	2004/08/18	-
Tanaga Volcano subnet (6 stations - 8 components)						
TACS	51 51.792	-178 08.363	918	L4	2003/08/28	-
TAFL	51 45.396	-177 53.867	186	L4	2003/08/28	-
TAFP[3]	51 54.003	-177 58.997	440	L22	2003/08/27	-
TANO	51 54.942	-178 07.249	269	L4	2003/08/24	-
TAPA	51 48.932	-177 48.770	640	L4	2003/08/27	-
TASE	51 50.099	-178 02.222	682	L4	2003/08/24	-
Mount Veniaminof subnet (9 stations - 9 components)						
BPBC	56 35.383	-158 27.153	584	L4	2002/10/03	-
VNFG	56 17.140	-159 33.066	1,068	L4	2002/02/06	-
VNHG	56 13.267	-159 09.853	966	L4	2002/02/06	-
VNKR	56 01.871	-159 22.068	620	L4	2002/02/06	-
VNNF	56 17.022	-159 18.961	1,153	L4	2002/06/20	-
VNSG	56 07.549	-159 05.121	761	L4	2002/02/06	-
VNSS	56 13.600	-159 27.290	1,733	L4	2002/02/06	-
VNSW	56 04.317	-159 33.508	716	L4	2002/06/20	-
VNWF	56 09.104	-159 33.733	1,095	L4	2002/02/06	-
Westdahl Peak subnet (6 stations - 8 components)						
WESE	54 28.389	-164 35.038	953	L4	1998/08/28	-
WESN	54 34.600	-164 34.703	549	L4	1998/10/17	-
WESS[3]	54 28.828	-164 43.333	908	L22	1998/08/28	-
WFAR	54 32.029	-164 46.567	640	L4	1998/08/28	-
WPOG	54 35.837	-164 44.606	445	L4	1998/10/17	-
WTUG	54 50.847	-164 23.117	636	L4	1998/10/17	-
Mount Wrangell subnet (4 stations - 6 components)						
WACK[3]	61 59.178	-144 19.703	2,280	L22	2000/07/31	-
WANC	62 00.189	-144 4.195	4,190	L4	2000/07/31	-
WASW	61 55.692	-144 10.346	2,196	L4	2001/08/03	-
WAZA	62 04.506	-144 9.132	2,531	L4	2001/08/03	-
AVO Regional stations (8 stations - 8 components)						
ADAG	51 58.812	-176 36.104	286	L4	1999/09/15	-
AMKA	51 22.70	179 18.11	116	Tri-40	2005/10/14	-
BGM	59 23.56	-155 13.76	625	L4	1978/09/08	-
BGR	60 45.45	-152 25.06	985	L4	1991/07/01	-
ETKA	51 51.712	-176 24.351	290	L4	1999/09/15	-
MMN	59 11.11	-154 20.20	442	S13	1981/08/22	-
OPT	59 39.192	-153 13.796	634	S13	1974/00/00	-
PDB	59 47.27	-154 11.55	305	S13	1978/09/09	-
STLK	61 29.926	-151 49.963	945	L4	1997/09/01	-

Station	Latitude (N)	Longitude (E)	Elevation (m)	Seismometer	Open date	Close date
WC-ATWC stations						
AKUT	54 8.112	-174 11.730	55	STS-2	2002/10/03	-
MENT	62 56.280	-143 43.164	702	L4	2004/10/20	-
AEIC stations						
ADK	51 53.022	-176 41.064	116	STS-1	1966/01/01	-
ATKA	52 12.162	-174 11.730	55	CMG-3ESP	2002/10/03	-
BAL	61 02.172	-142 20.652	1541	L4	1973/08/24	-
BMR	60 58.092	-144 36.180	842	CMG-40T	1979/08/19	-
CNP	59 31.550	-151 14.088	564	L4	1983/07/01	-
CUT	62 24.282	-150 16.164	168	L4	1986/07/18	-
DIV	61 07.782	-145 46.368	939	CMG-3ESP	1999/01/07	-
FALS	54 51.438	-163 24.930	46	CMG-3ESP	2002/06/19	-
FIB	61 09.972	-150 10.518	62	CMG-40T	1996/01/04	-
GHO	61 46.326	-148 55.446	1041	L4	1984/09/12	-
GLB	61 26.508	-143 48.630	853	L4	1973/08/25	-
HARP	62 24.456	-145 09.300	601	CMG-40T	2002/11/09	-
HOM	59 39.498	-151 38.592	198	L4	1981/01/01	-
KDAK	57 46.968	-152 35.010	152	KS-54000	1997/06/09	-
KLU	61 29.580	-145 55.236	1021	L4	1972/07/23	-
KNK	61 24.750	-148 27.336	595	L4	1973/08/11	-
KTH	63 33.192	-150 55.254	1172	L4	1988/05/08	-
MSP	60 29.328	-149 21.666	168	L4	1973/08/05	-
NIKO	52 56.328	-168 52.002	80	CMG-3ESP	2002/11/22	-
NKA	60 44.580	-151 14.274	100	L4	1971/09/13	-
PAX	62 58.224	-145 28.056	1130	STS-2	1969/07/01	-
RC01	61 05.376	-149 44.208	383	CMG-40T	1998/08/07	-
SAW	61 48.456	-148 36.104	782	CMG-3ESP	1973/08/31	-
SCM	61 50.004	-147 19.644	1039	S13	1966/06/01	-
SWD	60 06.294	-149 27.042	68	CMG-40T	2001/06/02	-
TRF	63 27.060	-150 17.232	1717	CMG-3ESP	1989/08/15	-
UNV	53 50.790	-166 30.120	67	CMG-3ESP	1999/02/19	-
VLZ	61 07.920	-146 20.076	23	L4	1971/09/02	-

Station Codes:

- [3] Three-component station
- [R] Station removed or moved in 2006
- * Seismic station has a low-gain vertical component.

Seismometer Codes:

CMG-40T	Guralp CMG-40T three-component broadband seismometer
CMG-6TD:	Guralp CMG-6TD three-component broadband seismometer
CMG-3ESP:	Guralp CMG-3ESP three-component broadband seismometer
L4, L4-3D:	Mark Products L4 or L4-3D single-component short-period seismometer
L22:	Mark Products L22 three-component short-period seismometer
S13:	Teledyne Geotech S13 single-component short-period seismometer
SM:	Ref Tek 130-ANSS/02 strong motion seismometer
STS-1:	Streckeisen STS-1H/VBB broadband seismometer
STS-2:	Streckeisen STS-2 broadband seismometer

Tri-40: Nanometrics Trillium 40 three-component broadband seismometer

Appendix C: Figures showing the locations (datum NAD27) of the AVO seismograph stations in 2006.

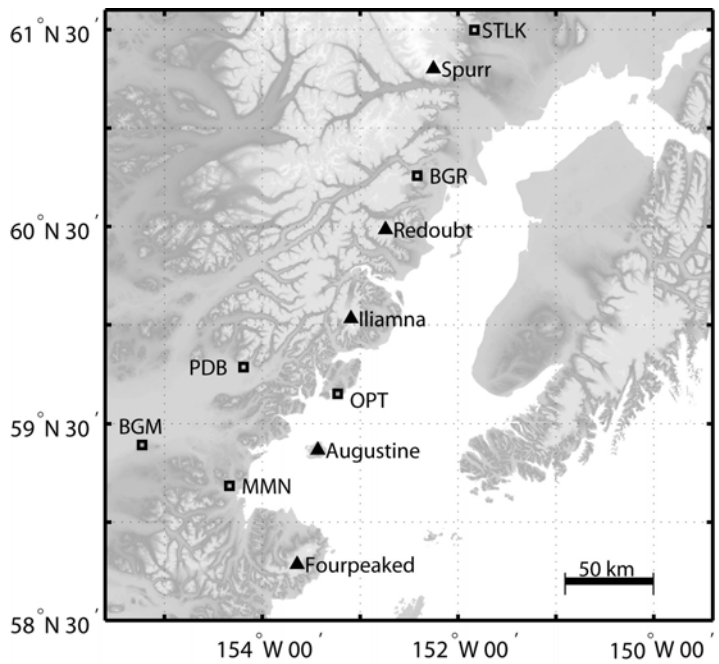


Figure C1. Regional AVO seismograph stations in Cook Inlet. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

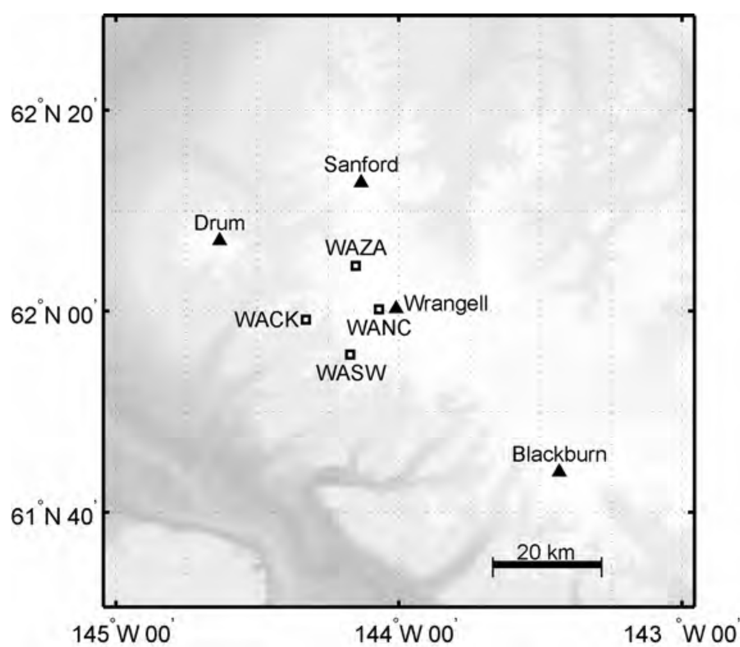


Figure C2. AVO seismograph stations near Mount Wrangell. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

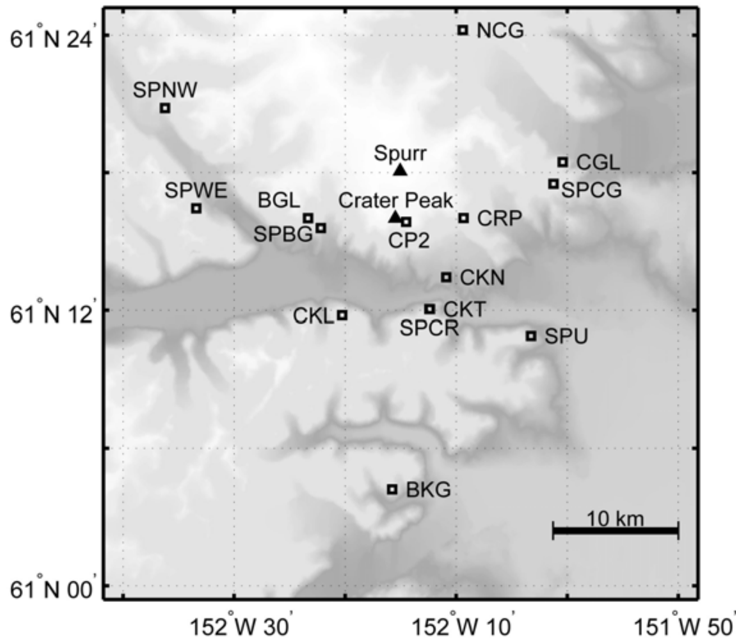


Figure C3. AVO seismograph stations near Mount Spurr. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

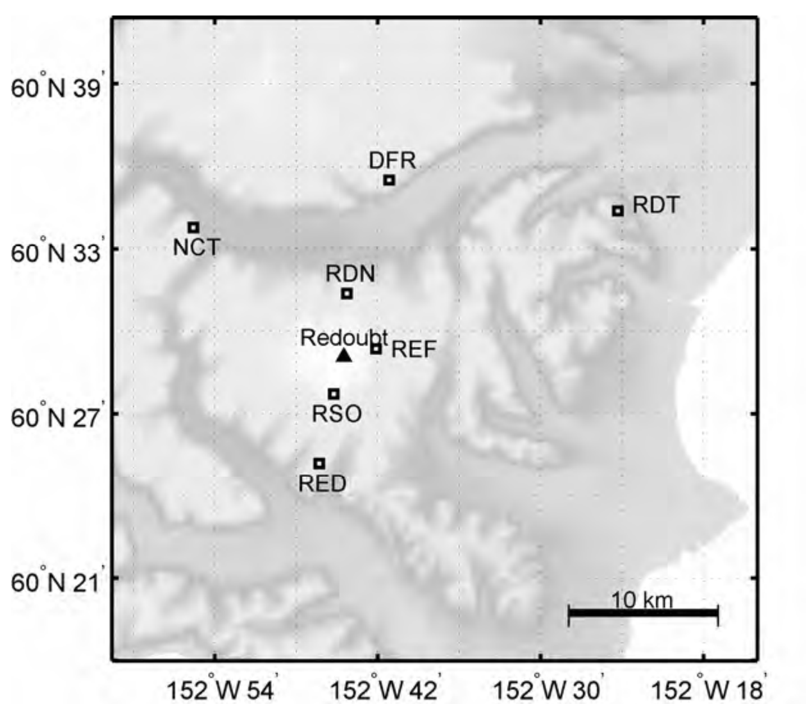


Figure C4. AVO seismograph stations near Redoubt Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

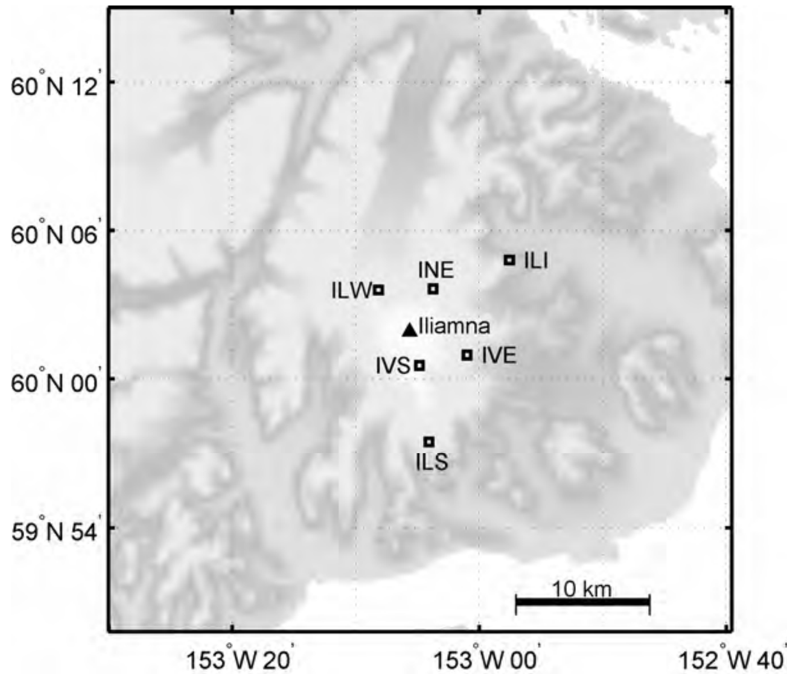


Figure C5. AVO seismograph stations near Iliamna Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

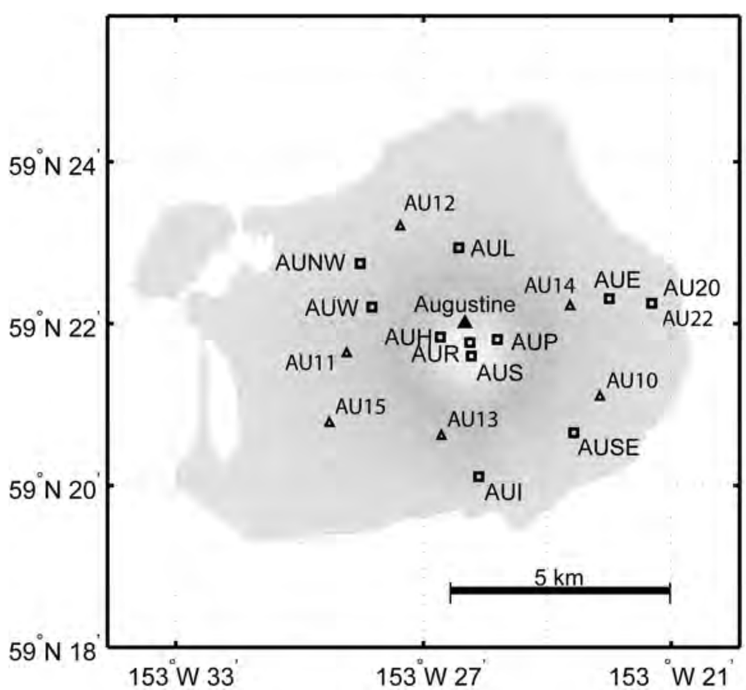


Figure C6. AVO seismograph stations near Augustine Volcano. Permanent seismograph stations are shown by open squares. Temporary broadband stations are shown by open triangles. Closed triangles show volcanic centers.

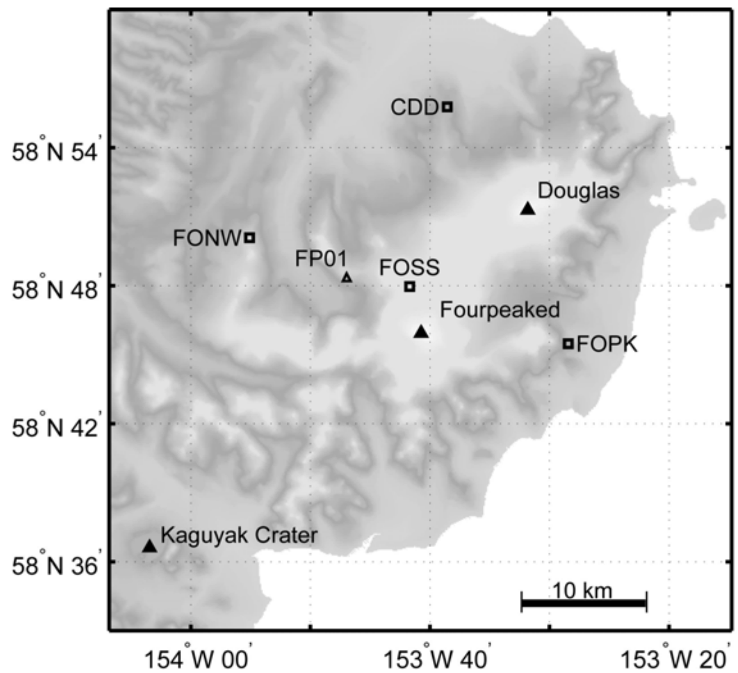


Figure C7. AVO seismograph stations near Fourpeaked Mountain. Permanent seismograph stations are shown by open squares. The temporary broadband station is shown by an open triangle. Closed triangles show volcanic centers.

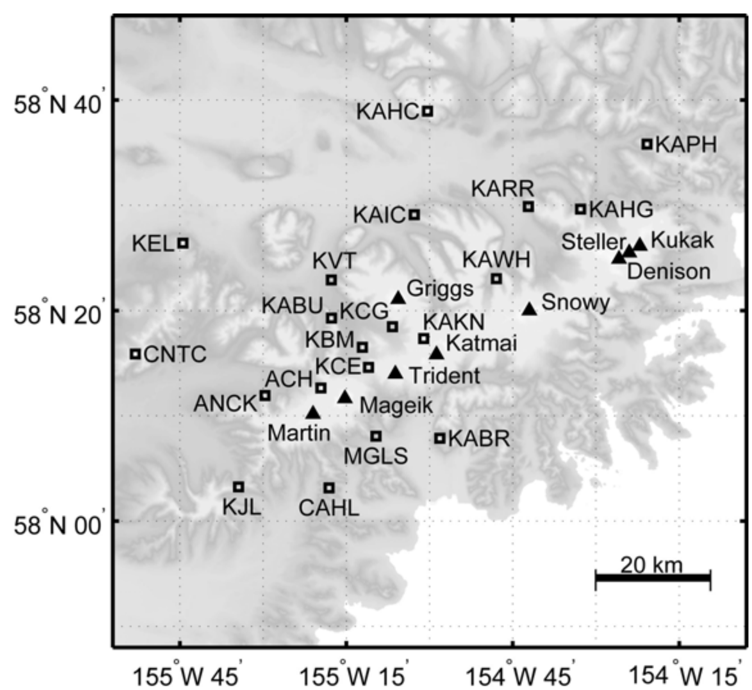


Figure C8. AVO seismograph stations near the Katmai volcanic cluster. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

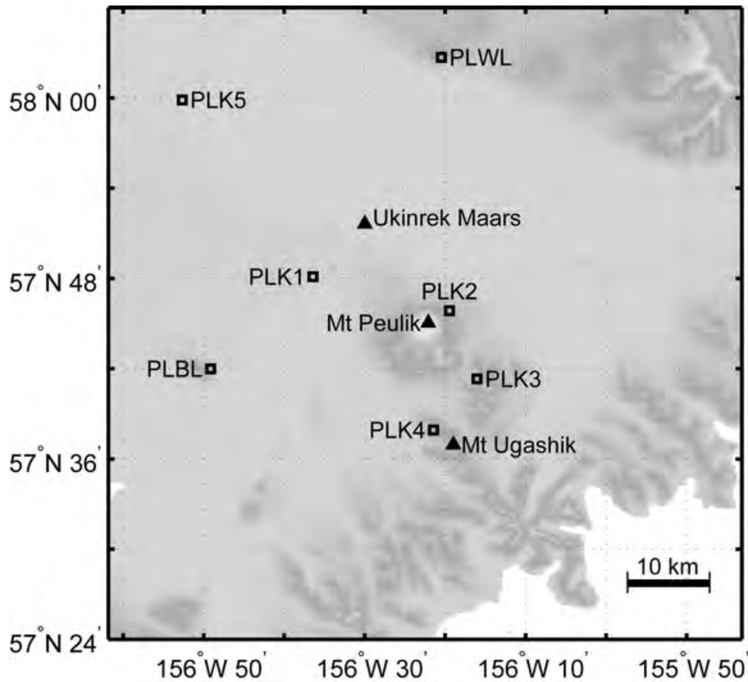


Figure C9. AVO seismograph stations near the Mount Peulik. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

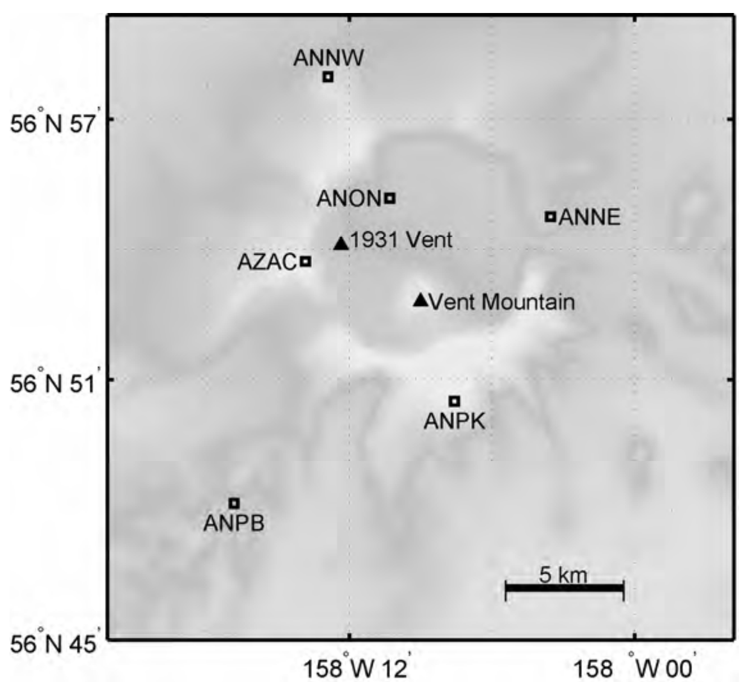


Figure C10. AVO seismograph stations near Aniakchak Crater. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

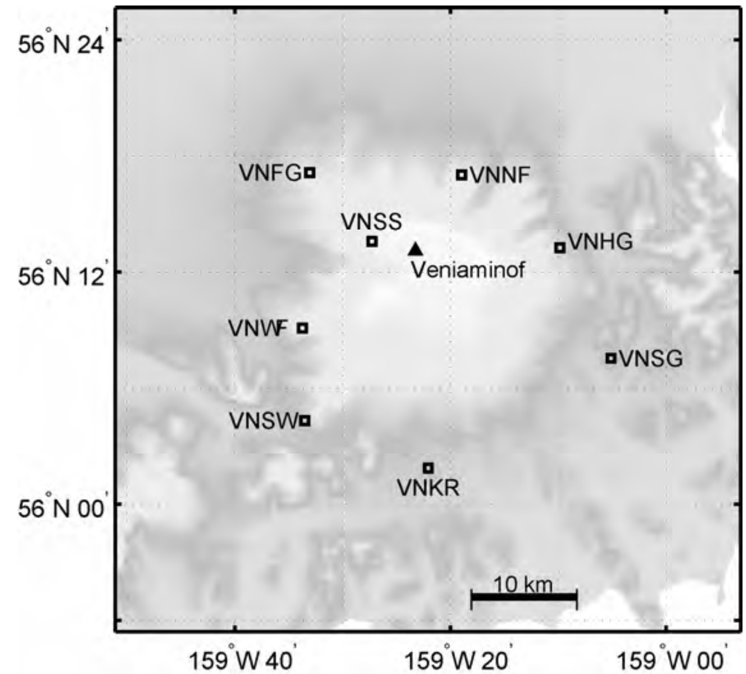


Figure C11. AVO seismograph stations near Mount Veniaminof. Seismograph station BPBC is not shown and is located 70 km northeast of Mount Veniaminof. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

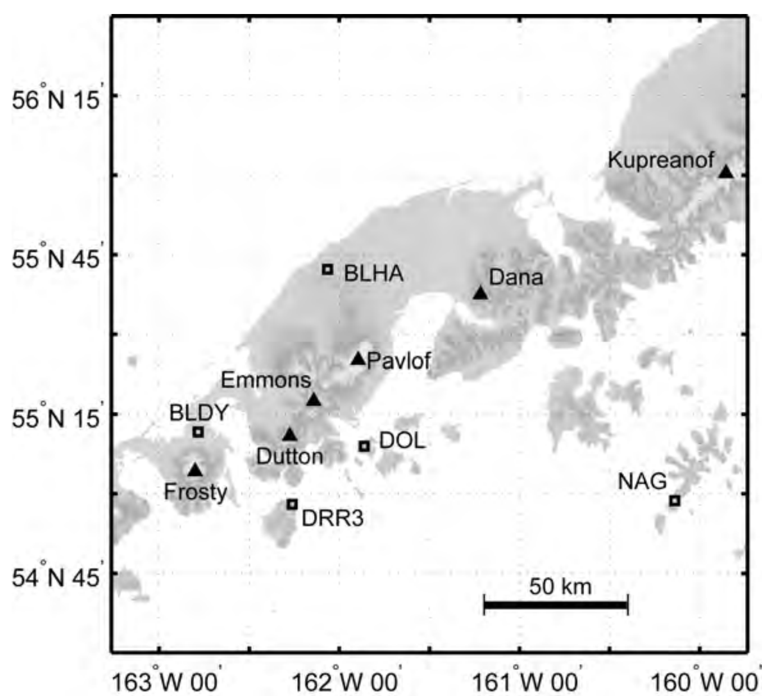


Figure C12. Regional AVO seismograph stations on the western end of the Alaska Peninsula. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

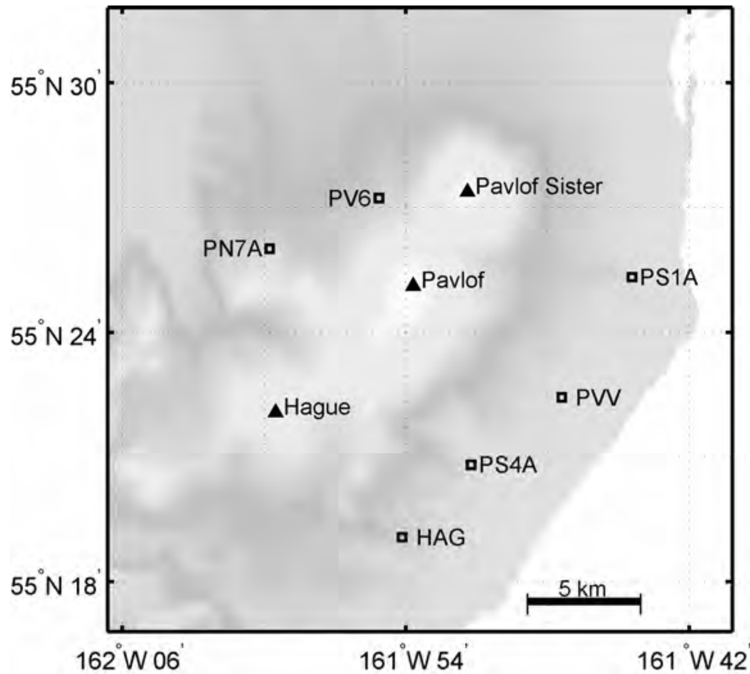


Figure C13. AVO seismograph stations near Pavlof Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

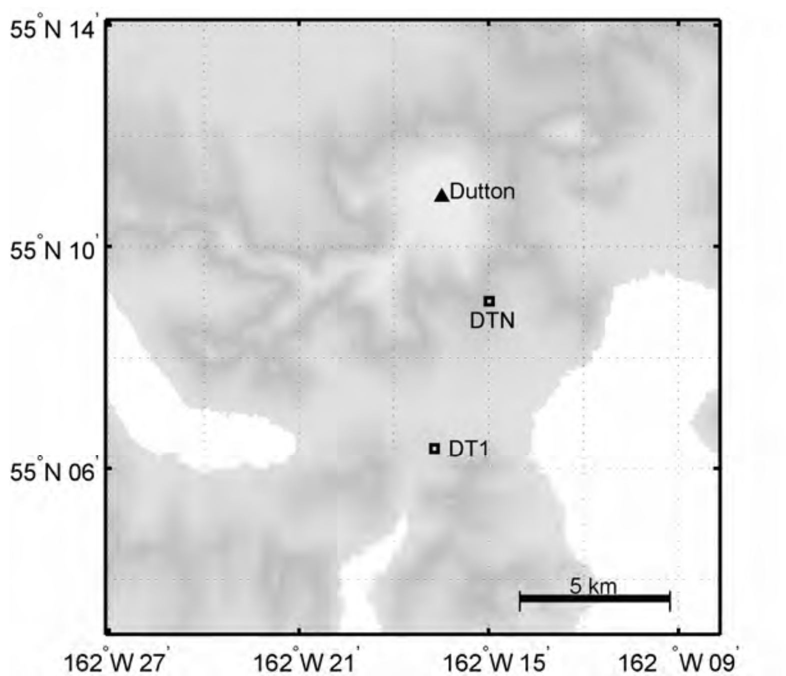


Figure C14. AVO seismograph stations near Mount Dutton. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

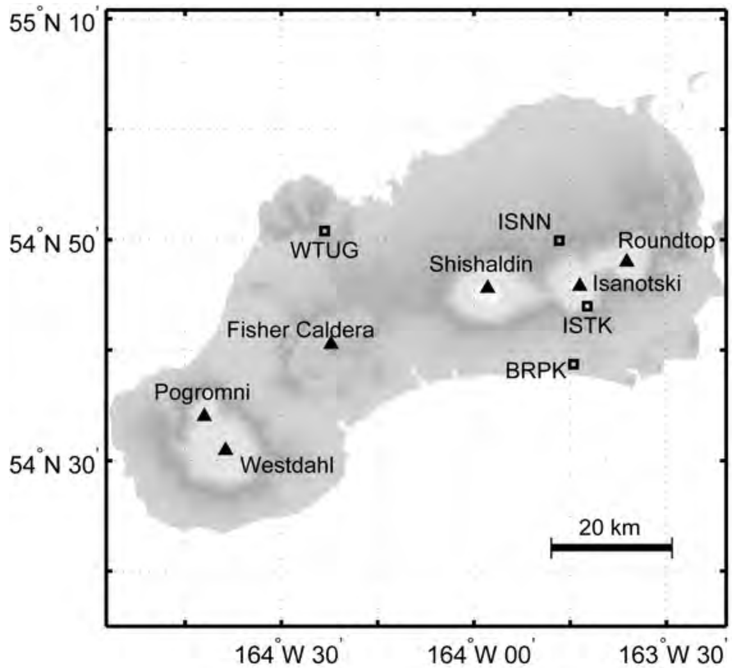


Figure C15. Regional AVO seismograph stations on Unimak Island. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

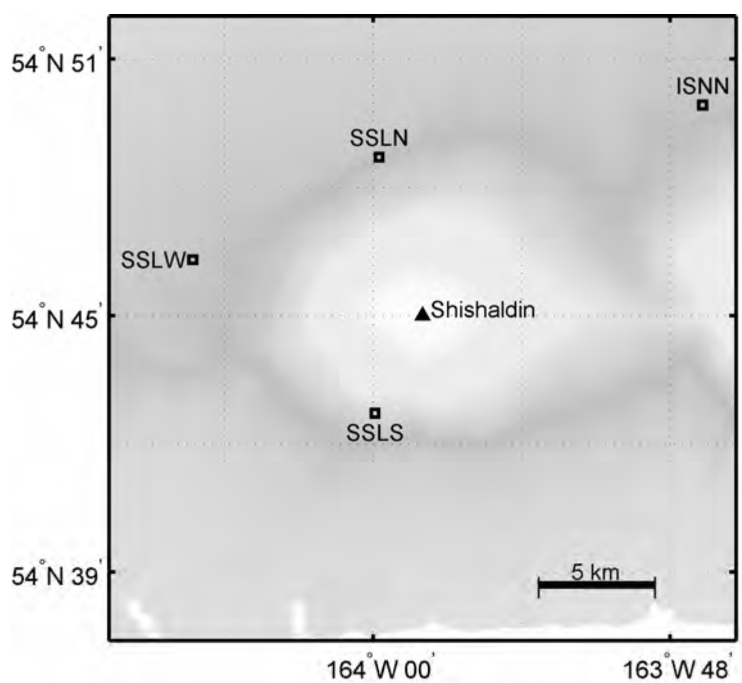


Figure C16. AVO seismograph stations near Shishaldin Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

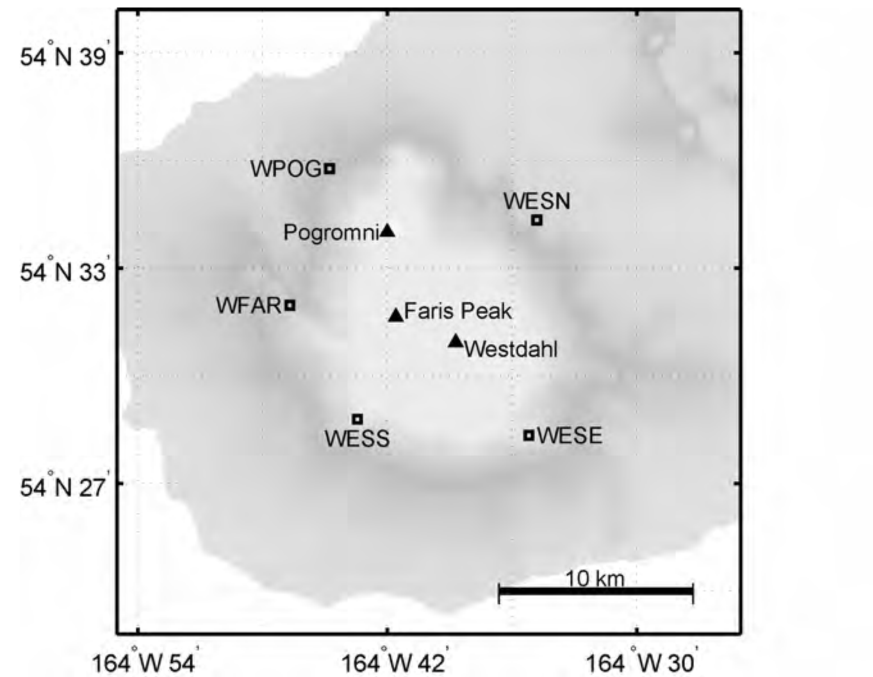


Figure C17. AVO seismograph stations near Westdahl Peak. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

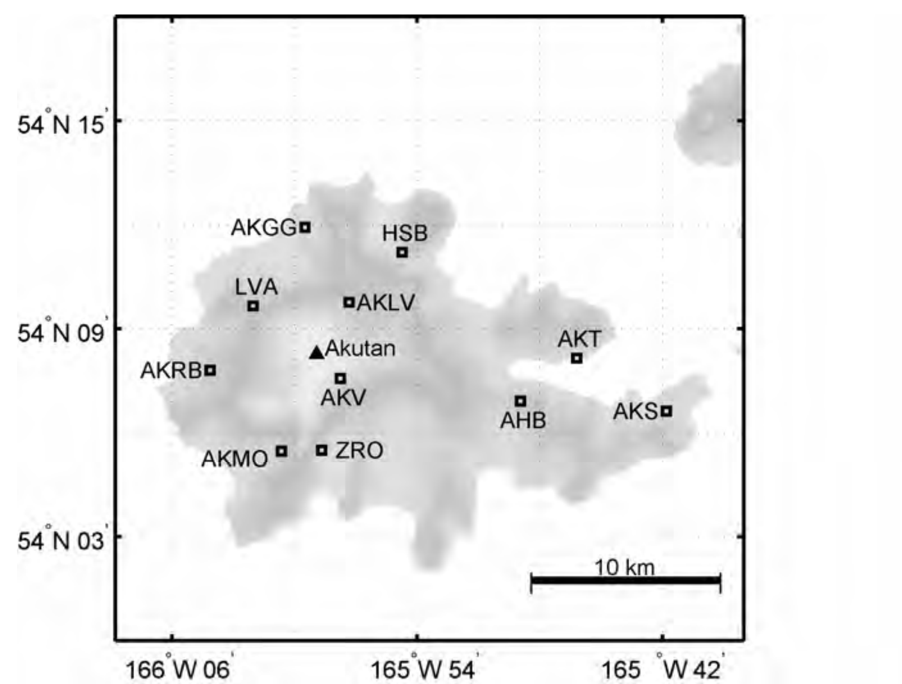


Figure C18. AVO seismograph stations near Akutan Peak. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

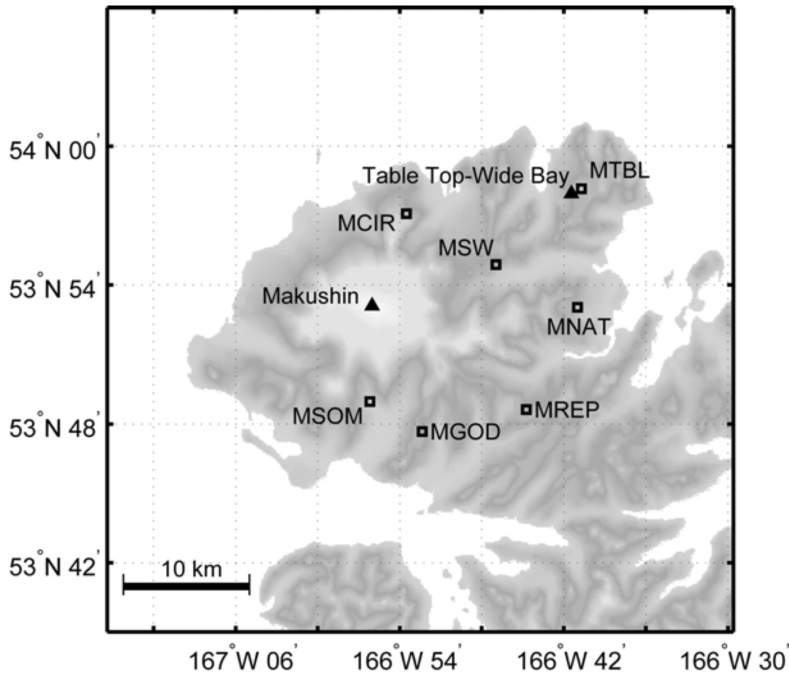


Figure C19. AVO seismograph stations near Makushin Volcano. ermanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

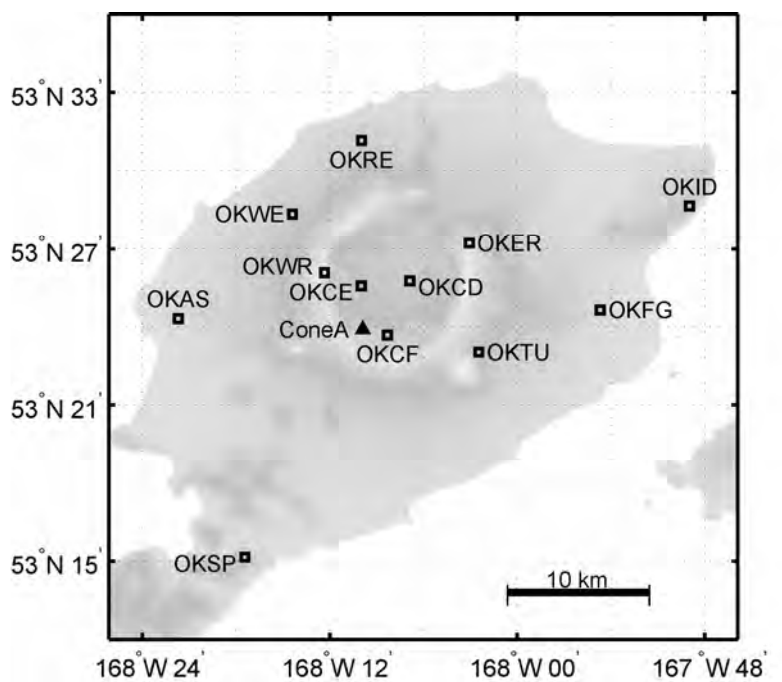


Figure C20. AVO seismograph stations near Okmok Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

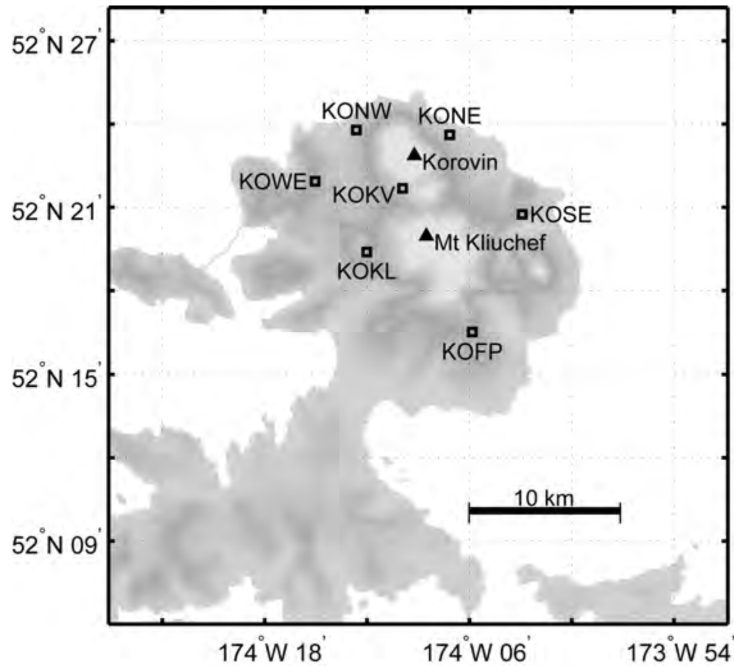


Figure C21. AVO seismograph stations near Korovin Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

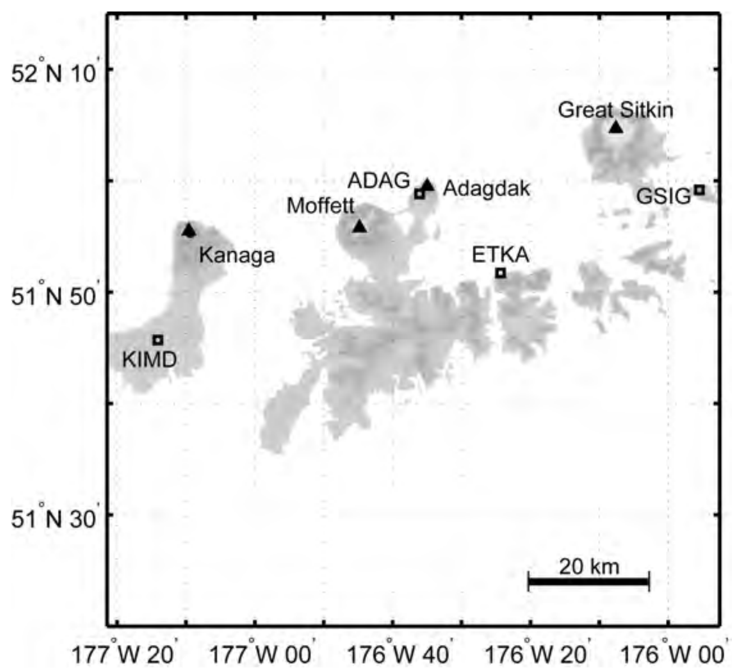


Figure C22. Regional AVO seismograph stations around Adak Island. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

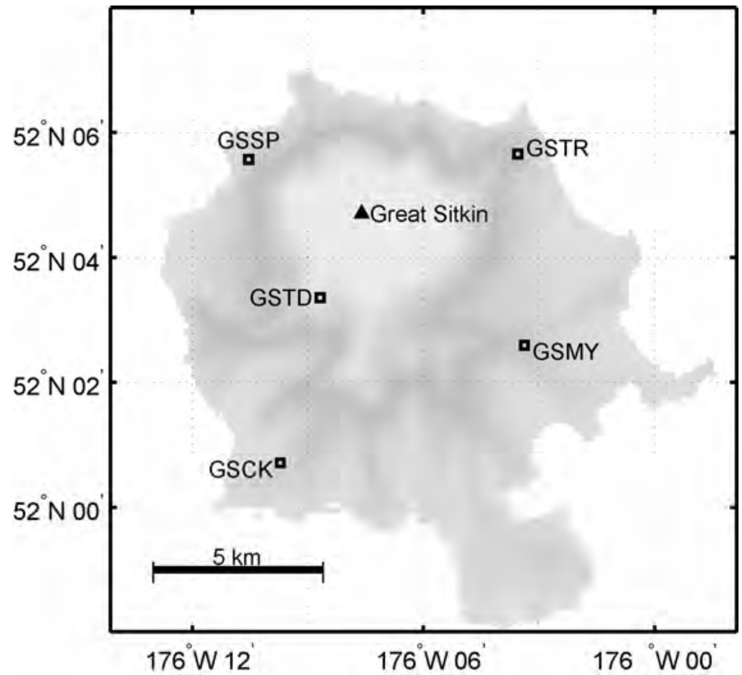


Figure C23. AVO seismograph stations near Great Sitkin Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

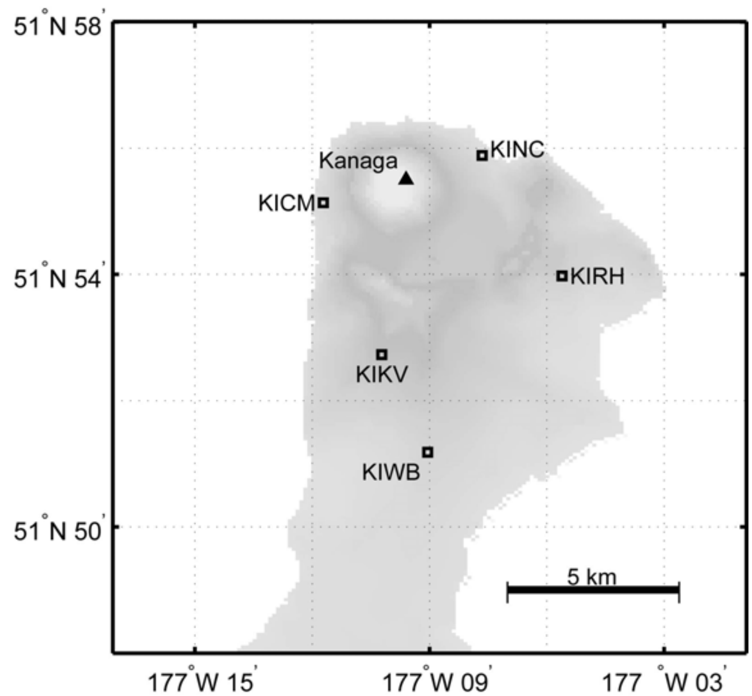


Figure C24. AVO seismograph stations near Kanaga Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

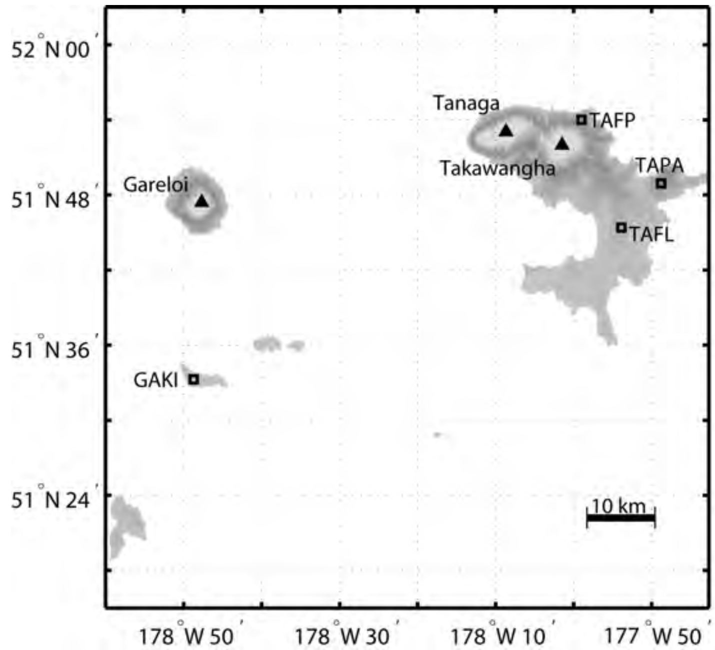


Figure C25. Regional AVO seismograph stations around Tanaga Volcano and Mount Gareloi. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

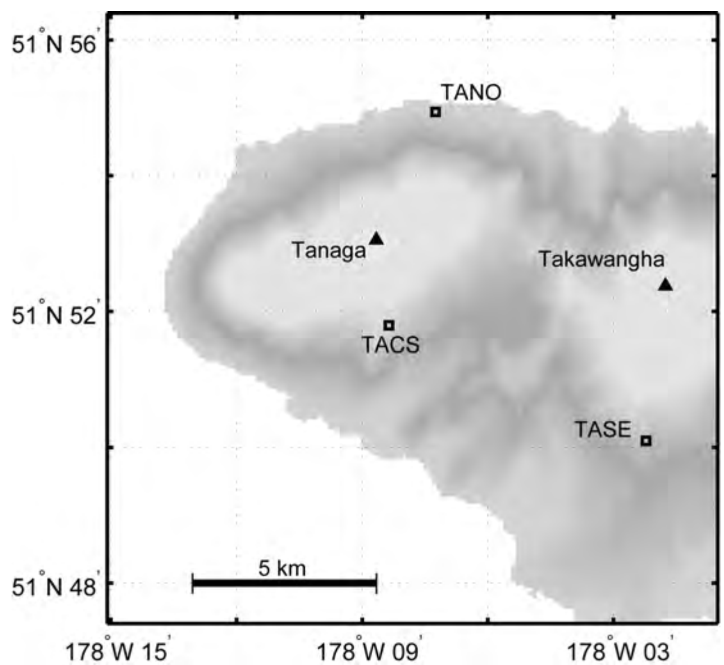


Figure C26. AVO seismograph stations near Tanaga Volcano. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

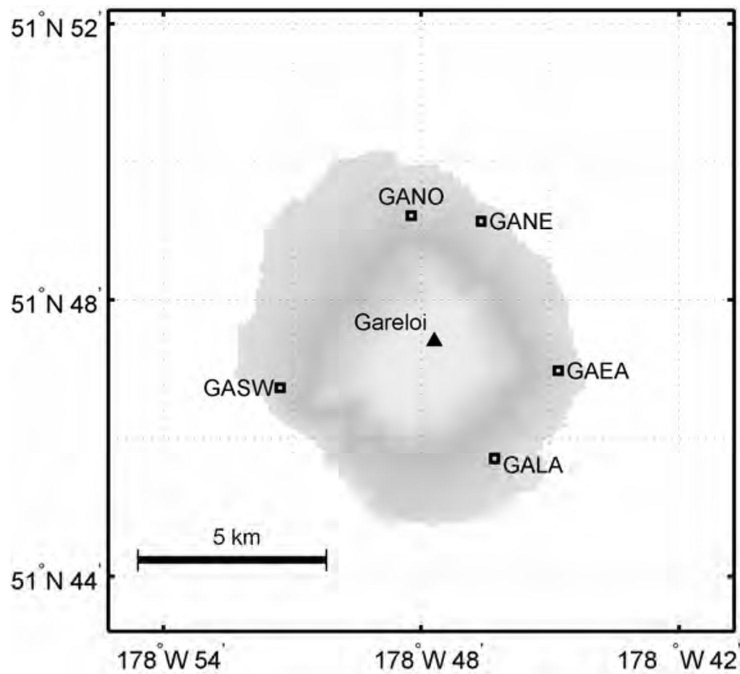


Figure C27. AVO seismograph stations near Mount Gareloi. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

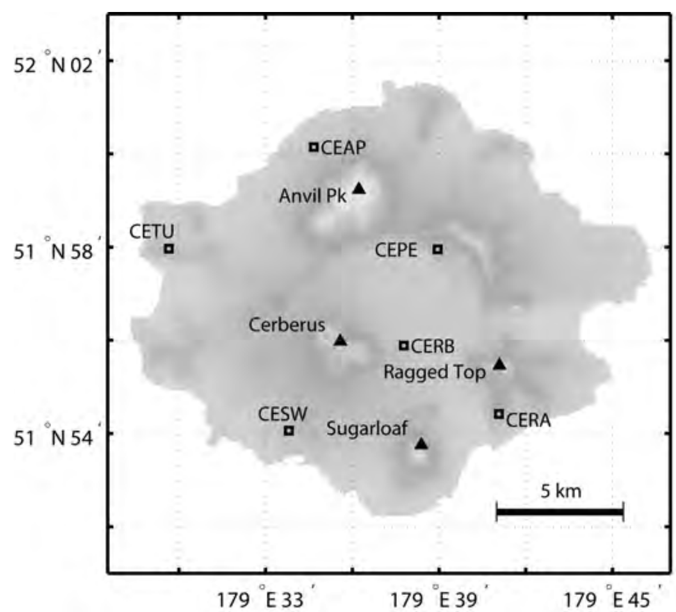


Figure C28. AVO seismograph stations on Semisopochnoi Island. Seismograph station AMKA is not shown and is located 65 km south-southwest of Mount Cerberus. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

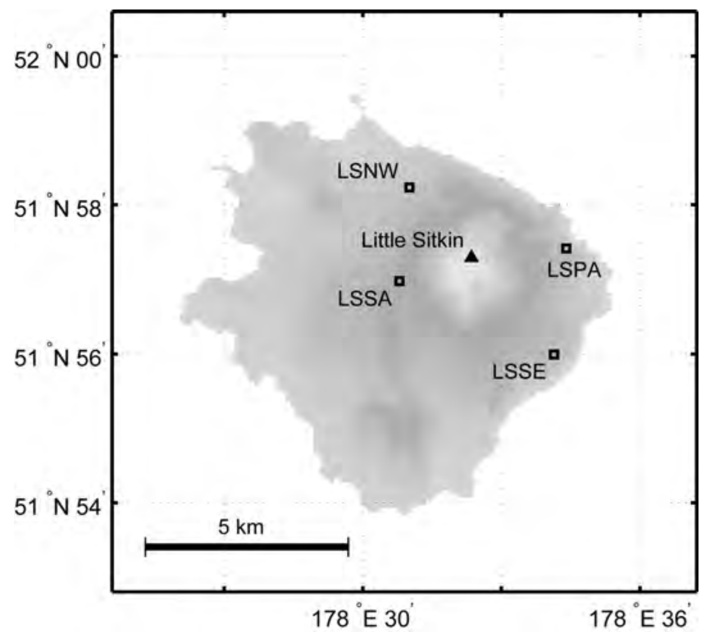
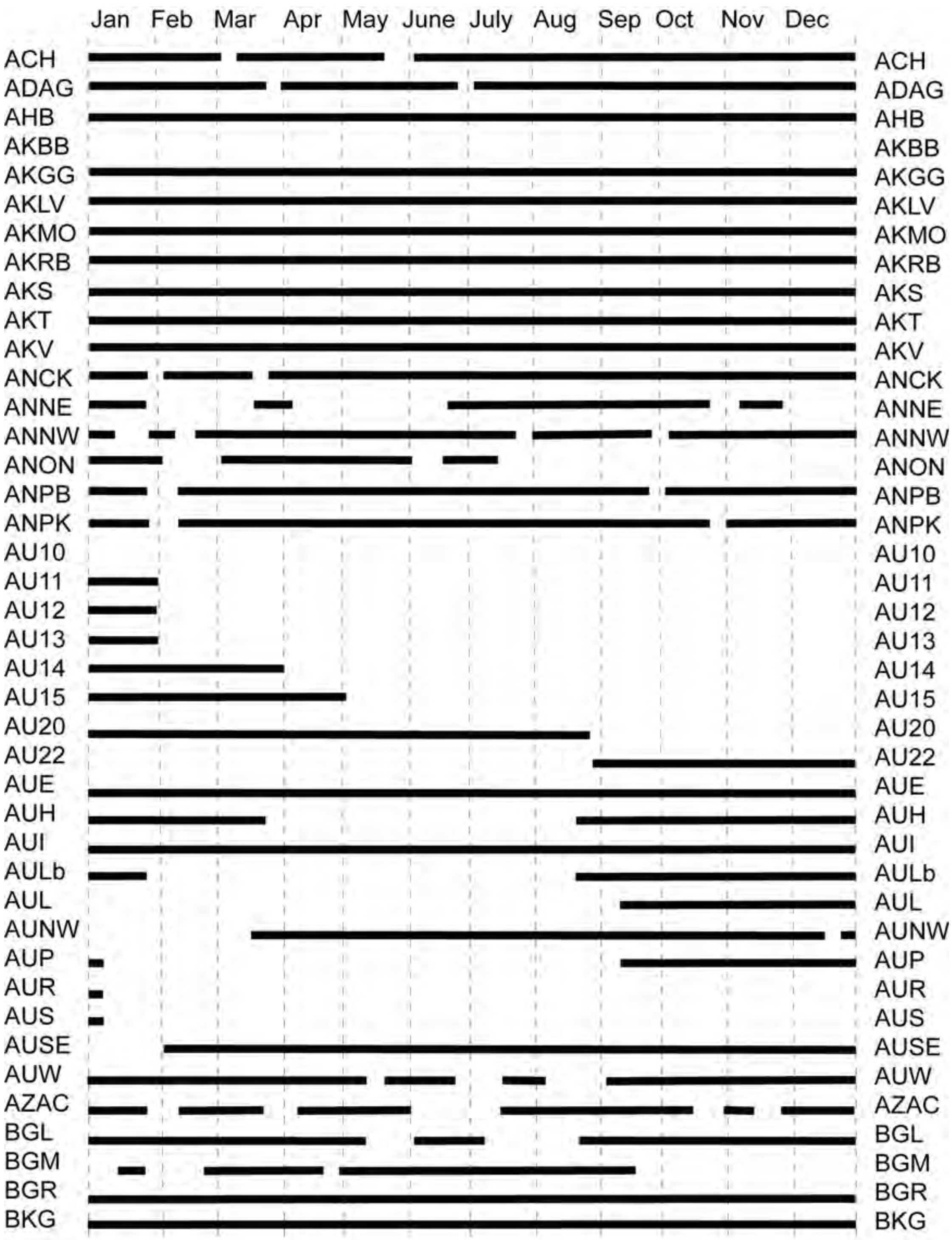
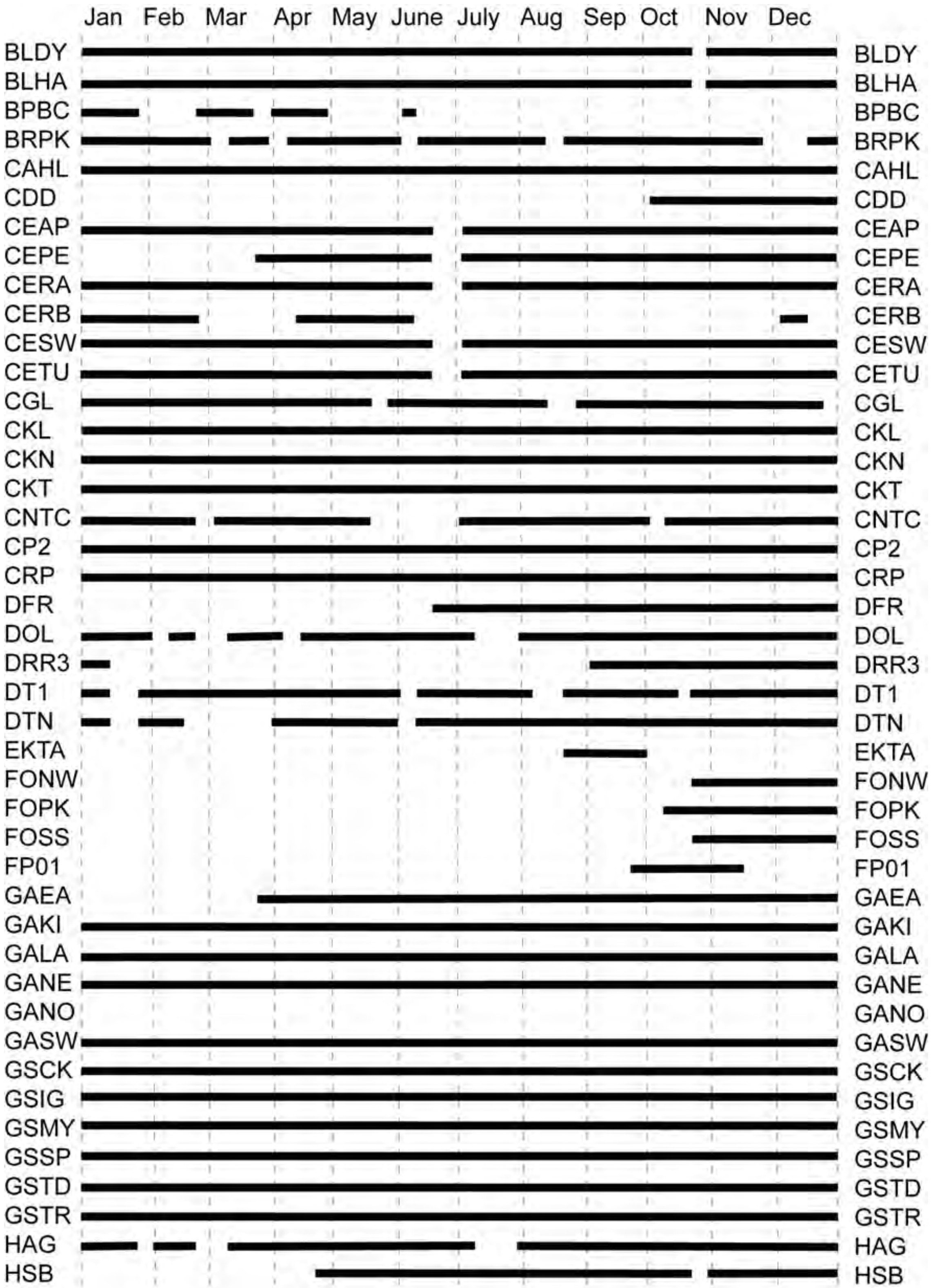
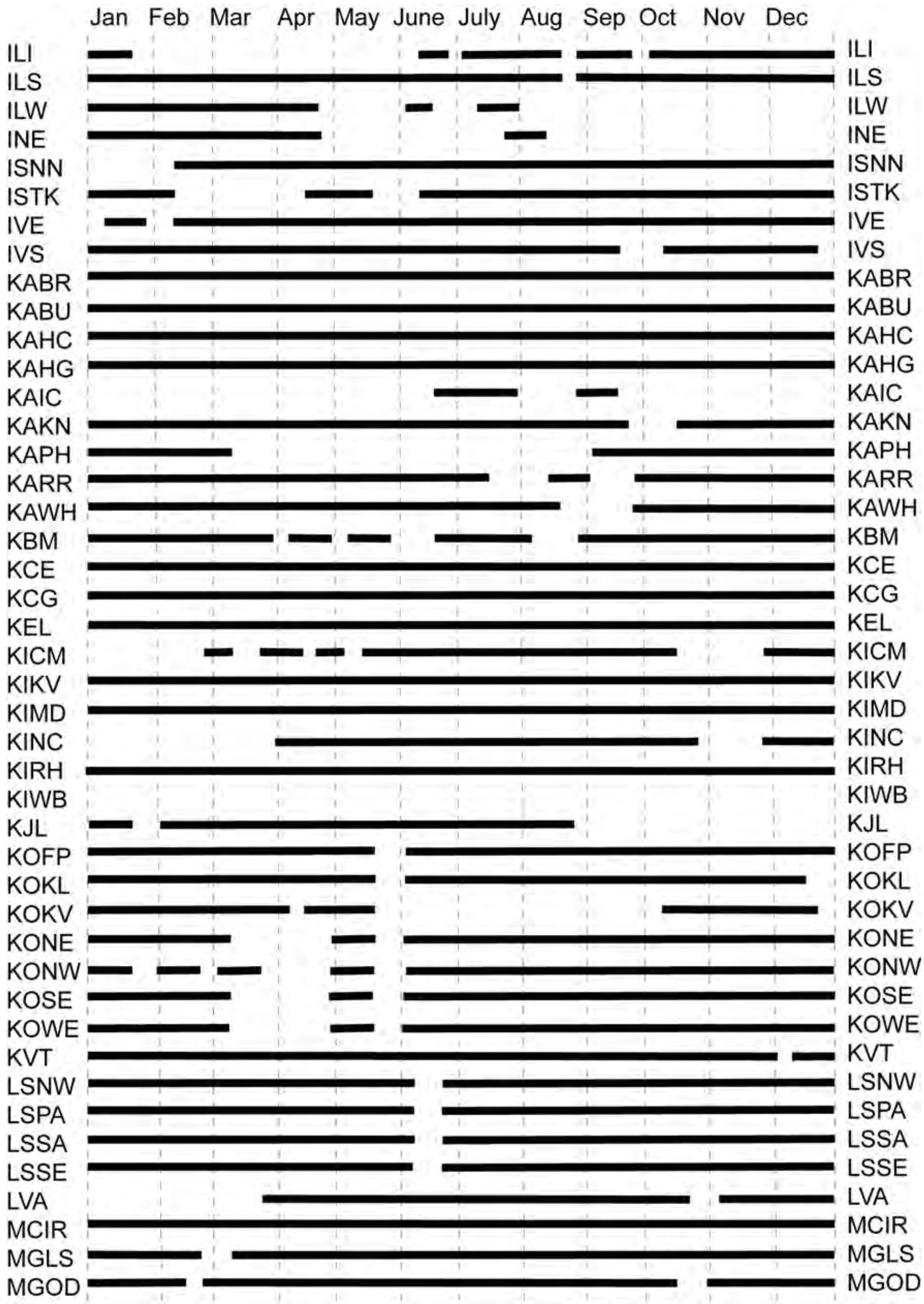


Figure C29. AVO seismograph stations on Little Sitkin Island. Permanent seismograph stations are shown by open squares. Closed triangles show volcanic centers.

Appendix D: Operational status for AVO stations in 2006. A solid bar indicates periods of time a station was operational based on station use plots and weekly checks. Dashed vertical lines show the beginning/end of each month.




Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
BLDY
BLHA
BPBC
BRPK
CAHL
CDD
CEAP
CEPE
CERA
CERB
CESW
CETU
CGL
CKL
CKN
CKT
CNTC
CP2
CRP
DFR
DOL
DRR3
DT1
DTN
EKTA
FONW
FOPK
FOSS
FP01
GAEA
GAKI
GALA
GANE
GANO
GASW
GSCK
GSIG
GSMY
GSSP
GSTD
GSTR
HAG
HSB


Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
ILI
ILS
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ISNN
ISTK
IVE
IVS
KABR
KABU
KAHC
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KAIC
KAKN
KAPH
KARR
KAWH
KBM
KCE
KCG
KEL
KICM
KIKV
KIMD
KINC
KIRH
KIWB
KJL
KOFP
KOKL
KOKV
KONE
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KOSE
KOWE
KVT
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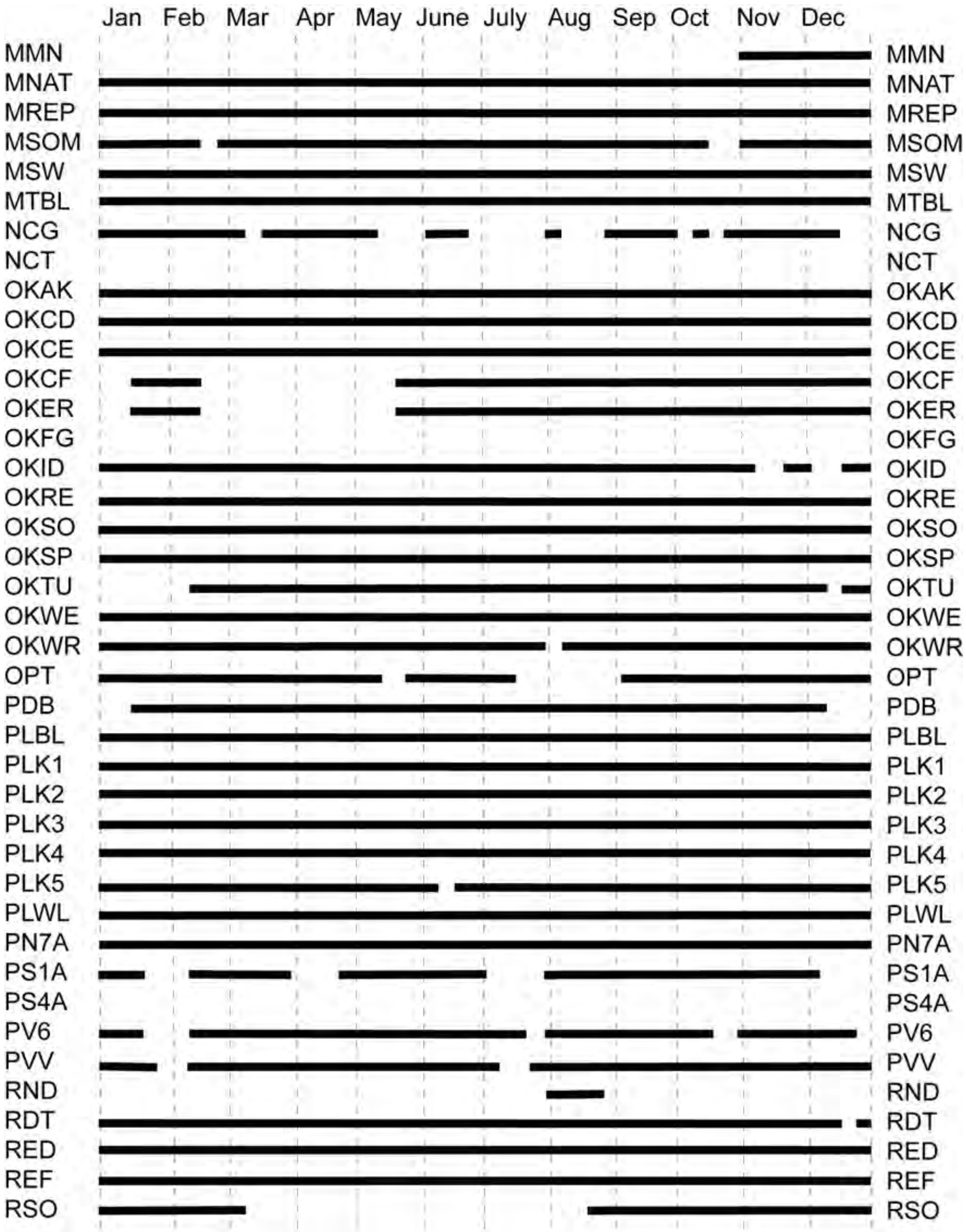
LSPA
LSSA
LSSE
LVA
MCIR
MGLS
MGOD


Jan
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MMN
MNAT
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NCG
NCT
OKAK
OKCD
OKCE
OKCF
OKER
OKFG
OKID
OKRE
OKSO
OKSP
OKTU
OKWE
OKWR
OPT
PDB
PLBL
PLK1
PLK2
PLK3
PLK4
PLK5
PLWL
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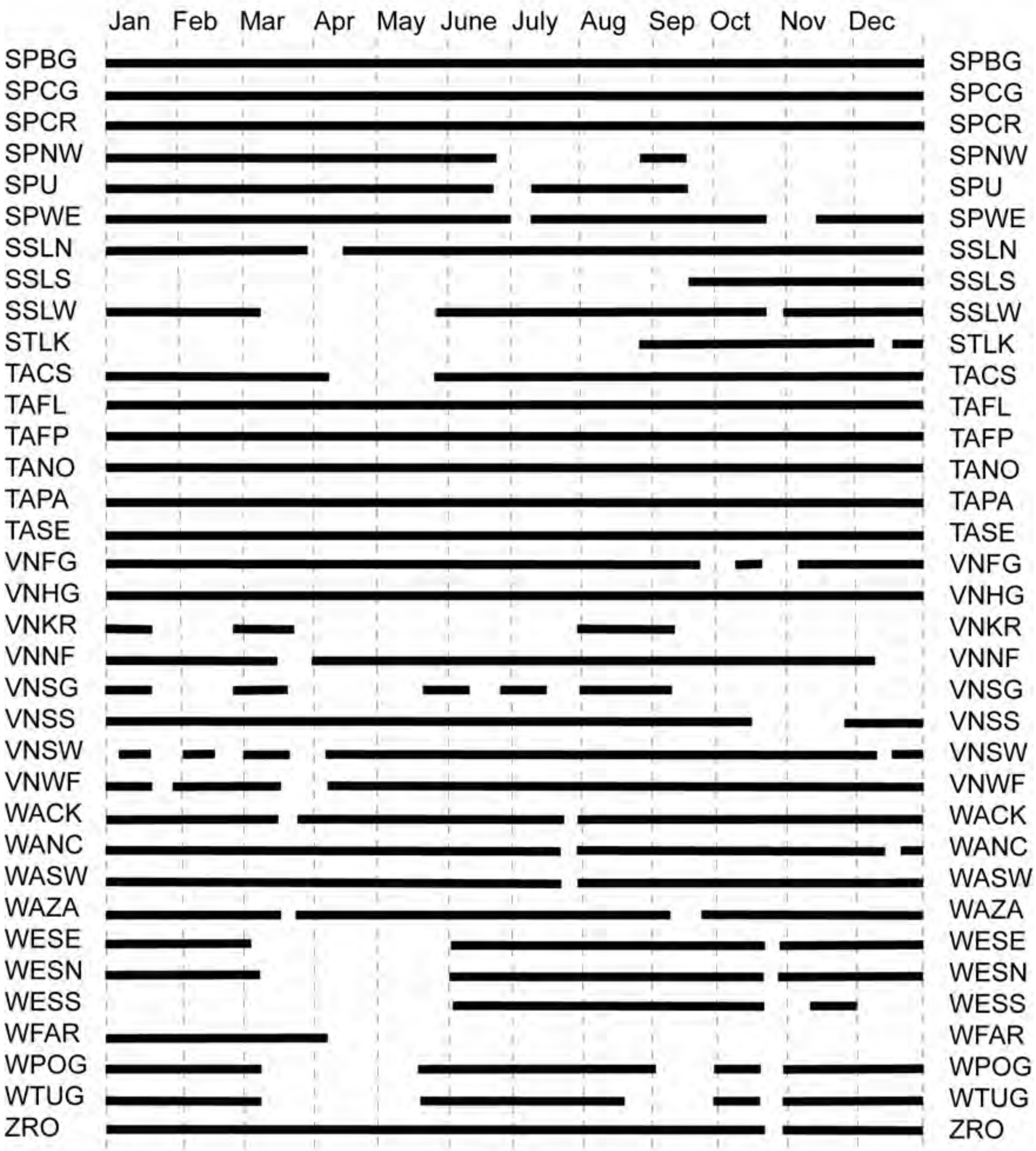
PS4A
PV6
PVV
RND
RDT
RED
REF
RSO



Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
SPBG
SPCG
SPCR
SPNW
SPU
SPWE
SSLN
SSLS
SSLW
STLK
TACS
TAFL
TAFP
TANO
TAPA
TASE
VNFG
VNHG
VNKR
VNNF
VNSG
VNSS
VNSW
VNWF
WACK
WANC
WASW
WAZA
WESE
WESN
WESS
WFAR
WPOG
WTUG
ZRO

Appendix E: Seismic velocity models used in locating the earthquakes described in this report. Following the name of each velocity model is a list of volcano subnetworks for which the model is used. Depths are referenced to sea level, with negative values reflecting height above sea level.

Cylindrical Model Parameters (Latitude and Longitude are the center of the model)

Velocity Model	Latitude (°N)	Longitude (°E)	Radius (km)	Top (km)	Bottom (km)
Spurr	61.60	-152.40	20	-3	50
Spurr	61.47	-152.33	20	-3	50
Spurr	61.33	-152.25	20	-3	50
Spurr	61.17	-152.35	20	-3	50
Spurr	61.00	-152.45	20	-3	50
Redoubt	60.83	-152.55	20	-3	50
Redoubt	60.66	-152.66	20	-3	50
Redoubt	60.49	-152.75	20	-3	50
Redoubt	60.34	-152.86	20	-3	50
Redoubt	60.19	-152.98	20	-3	50
Redoubt	59.87	-153.17	20	-3	50
Redoubt	59.70	-153.25	20	-3	50
Redoubt	59.53	-153.34	20	-3	50
Iliamna	60.03	-153.09	20	-3	50
Augustine	59.36	-153.42	20	-3	50
Katmai	58.17	-155.35	20	-3	50
Katmai	58.29	-154.86	20	-3	50
Katmai	58.35	-155.09	20	-3	50
Katmai	58.43	-154.38	20	-3	50
Veniaminof	56.18	-159.38	30	-3	50
Cold Bay	55.42	-161.89	20	-3	50
Cold Bay	55.18	-162.27	20	-3	50
Cold Bay	54.76	-163.97	30	-3	50
Westdahl	54.52	-164.65	20	-3	50
Akutan	54.15	-165.97	20	-3	50
Andreanof	52.08	-176.13	20	-3	50
Andreanof	51.93	-176.75	20	-3	50
Andreanof	51.92	-177.17	20	-3	50
Tanaga	51.89	-178.15	20	-3	50

Regional Velocity Model (for all areas south of 62.5°N not covered by a volcano specific model): Aniakchak, Gareloi, Korovin, Little Sitkin, Makushin, Okmok, Peulik, Semisopochnoi, and Wrangell (Fogleman and others, 1993).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	5.3	-3.0	1.78
2	5.6	4.0	1.78
3	6.2	10.0	1.78
4	6.9	15.0	1.78
5	7.4	20.0	1.78
6	7.7	25.0	1.78
7	7.9	33.0	1.78
8	8.1	47.0	1.78
9	8.3	65.0	1.78

Akutan Velocity Model: Akutan (Power and others, 1996).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	2.30 +0.37 km/sec for each km of depth	-3.0	1.80
2	6.30	7.0	1.80

Andreanof Velocity model: Great Sitkin, and Kanaga (Toth and Kisslinger, 1984).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	3.50	-3.0	1.73
2	3.88	-2.8	1.73
3	4.25	-2.6	1.73
4	4.62	-2.4	1.73
5	5.00	-2.2	1.73
6	5.50	-2.0	1.73
7	5.62	-1.0	1.73
8	5.74	0.0	1.73
9	5.86	1.0	1.73
10	5.98	2.0	1.73
11	6.10	3.0	1.73
12	6.60	4.0	1.73
13	6.68	5.0	1.73
14	6.80	8.0	1.73
15	6.92	11.0	1.73
16	7.04	14.0	1.73
17	7.16	17.0	1.73
18	7.28	20.0	1.73
19	7.85	23.0	1.73
20	8.05	37.0	1.73

Augustine Velocity Model: Augustine (Power, 1988).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	2.3	-3.0	1.80
2	2.6	-0.7	1.80
3	3.4	0.0	1.80
4	5.1	1.0	1.80
5	6.3	9.0	1.78
6	8.0	44.0	1.78

Cold Bay Velocity Model: Dutton, Pavlof, and Shishaldin (McNutt and Jacob, 1986).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	3.05	-3.00	1.78
2	3.44	0.00	1.78
3	5.56	1.79	1.78
4	6.06	3.65	1.78
5	6.72	10.18	1.78
6	7.61	22.63	1.78
7	7.90	38.51	1.78

Iliamna Velocity model: Iliamna (Roman and others, 2001) .

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	4.8	-3.0	1.78
2	6.1	-1.6	1.78
3	6.2	1.7	1.78
4	6.3	2.9	1.78
5	6.4	3.1	1.78
6	7.1	16.5	1.78

Katmai Velocity Model: Katmai (Searcy, 2003).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	5.05	-3.0	1.78
2	5.10	1.0	1.78
3	5.41	2.0	1.78
4	5.49	3.0	1.78
5	5.65	4.0	1.78
6	5.67	5.0	1.78
7	5.69	6.0	1.78
8	5.76	7.0	1.78
9	5.80	8.0	1.78
10	6.00	9.0	1.78
11	6.04	10.0	1.78
12	6.08	12.0	1.78
13	6.30	15.0	1.78
14	6.73	20.0	1.78
15	7.54	25.0	1.78
16	7.78	33.0	1.78

Redoubt Velocity Model: Redoubt (Lahr and others, 1994) .

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	2.90	-3.0	1.80
2	5.10	-1.7	1.80
3	6.40	1.5	1.72
4	7.00	17.0	1.78

Spurr Velocity Model: Spurr (Jolly and others, 1994).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	5.1	-3.00	1.81
2	5.5	-2.00	1.81
3	6.3	5.25	1.74
4	7.2	27.25	1.78

Tanaga Velocity Model: Tanaga (Power, personal communication, 2005) .

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	4.0	-3.0	1.78
2	4.5	-1.2	1.78
3	5.0	0.0	1.78
4	5.6	4.0	1.78
5	6.9	10.0	1.78
6	7.2	15.0	1.78
7	7.8	20.0	1.78
8	8.1	33.0	1.78

Veniaminof Velocity Model: Veniaminof (Sánchez, 2005) .

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	4.82	-3.0	1.73
2	5.23	4.0	1.88
3	5.23	10.0	1.38
4	6.49	15.0	1.65
5	6.52	20.0	1.51
6	8.18	25.0	1.89
7	8.21	33.0	1.90
8	8.21	47.0	1.80
9	8.30	65.0	1.78

Westdahl Velocity Model: Westdahl (Dixon and others, 2005).

Layer number	Vp (km/sec)	Top of layer (km)	Vp/Vs
1	3.03	-3.0	1.71
2	3.18	0.0	1.71
3	5.03	2.0	1.71
4	5.70	8.0	1.71
5	6.30	10.0	1.71
6	6.82	16.0	1.71
7	7.17	26.0	1.71
8	8.16	38.0	1.71

Appendix F: Maps showing the location of volcanic zones modeled using multiple cylinders.

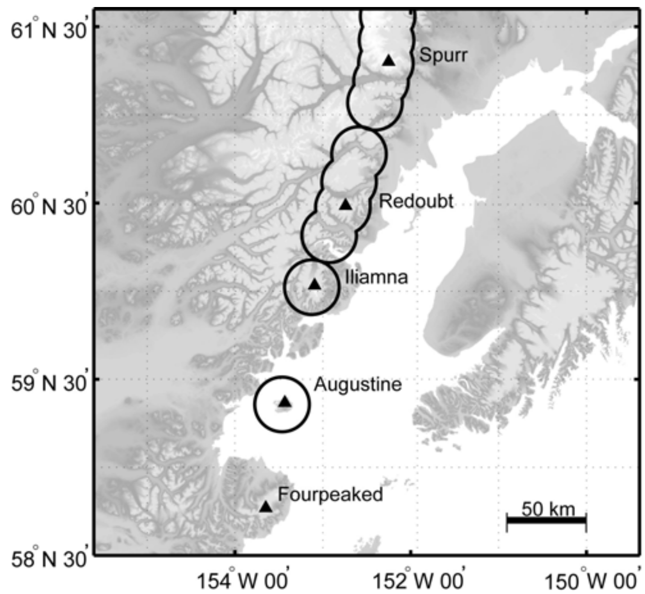


Figure F1. Volcanic zones for the Cook Inlet Volcanoes. Five overlapping cylinders model the Spurr volcanic zone. Four overlapping cylinders model the Redoubt volcanic zone. Single cylinders model the Iliamna and Augustine volcanic zones.

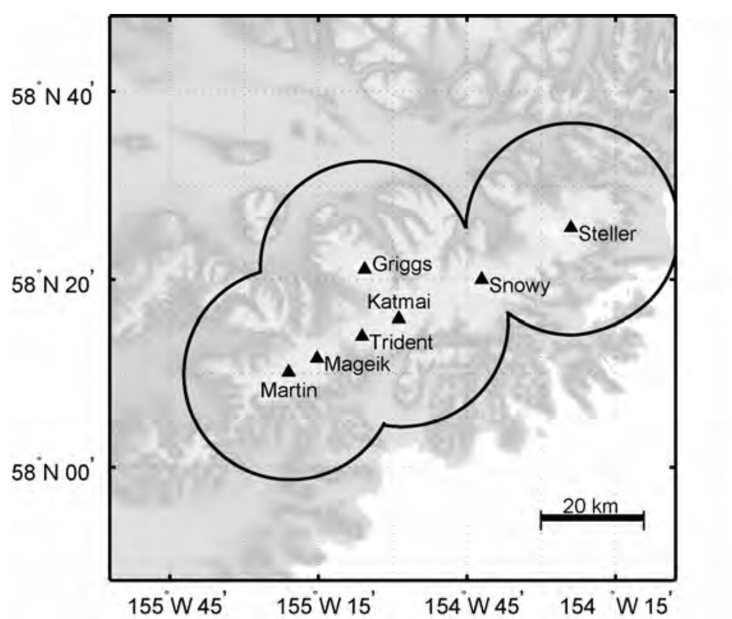


Figure F2. Volcanic zone for the Katmai volcanic cluster. The volcanic zone is modeled using four overlapping cylinders centered on Mount Martin, Mount Katmai, Mount Griggs, and Mount Steller.

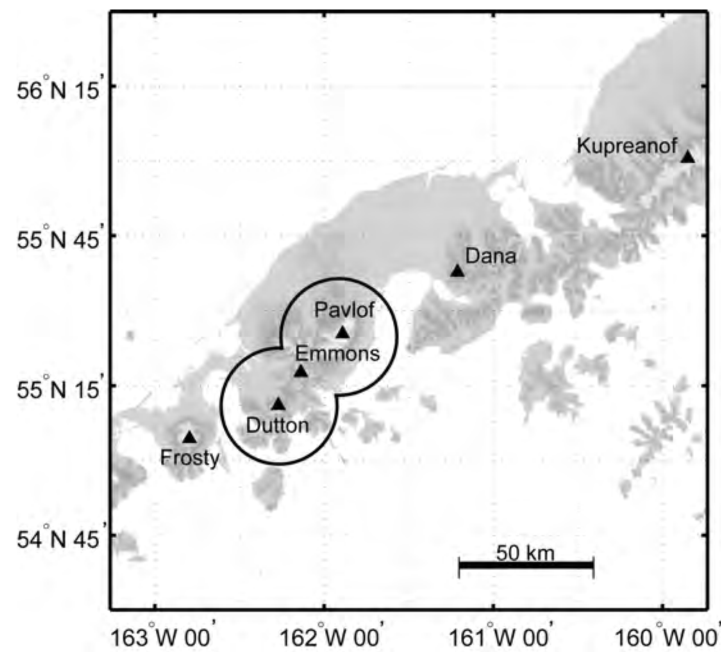


Figure F3. Volcanic zones for Pavlof Volcano and Mount Dutton. The volcanic zone is modeled using two overlapping cylinders centered on Mount Dutton and Pavlof Volcano.

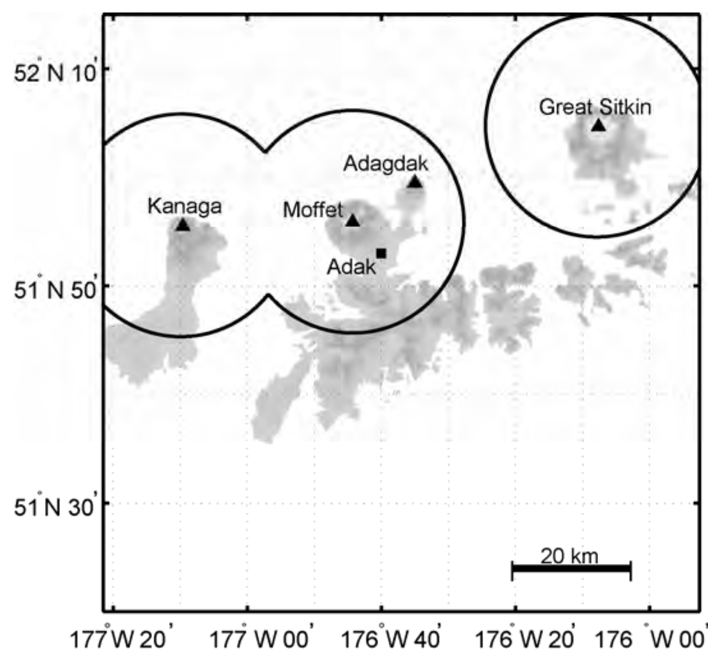


Figure F4. Volcanic zones in the Adak region. The volcanic zones are modeled using cylinders centered on Kanaga Volcano, Mount Moffet, and Great Sitkin Volcano.

Appendix G: Previous AVO Earthquake Catalogs. Earthquake catalog for 1994-present are available from the USGS on the World-Wide-Web.

1989-90: Power, J.A., March, G.D., Lahr, J.C., Jolly, A.D., and Cruse, G.R., 1993, Catalog of earthquake hypocenters at Redoubt Volcano and Mount Spurr, Alaska: October 12, 1989 - December 31, 1990: U.S. Geological Survey Open-File Report 93-685-A, 57 p.

1991-93: Jolly, A.D., Power, J.A., Stihler, S.D., Rao, L.N., Davidson, G., Paskievitch, J., Estes, S., and Lahr, J.C., 1996, Catalog of earthquake hypocenters for Augustine, Redoubt, Iliamna, and Mount Spurr Volcanoes, Alaska: January 1, 1991 - December 31, 1993: U.S. Geological Survey Open-File Report 96-70, 90 p.

1994-99: Jolly, A.D., Stihler, S.D., Power, J.A., Lahr, J.C., Paskievitch, J., Tytgat, G., Estes, S., Lockhart, A.B., Moran, S.C., McNutt, S.R., and Hammond, W.R., 2001, Catalog of earthquake hypocenters at Alaskan Volcanoes: January 1, 1994 - December 31, 1999: U.S. Geological Survey Open-File Report 01-189, 202 p. URL: http://geopubs.wr.usgs.gov/open-file/of01-189/

2000-01: Dixon, J.P, Stihler, S.D., Power, J.A., Tytgat, G., Estes, S., Moran, S.C., Paskievitch, J., and McNutt, S.R., 2002, Catalog of Earthquake Hypocenters at Alaska Volcanoes: January 1, 2000 - December 31, 2001: U.S. Geological Survey Open-File Report 02-342, 56 p. URL: http://geopubs.wr.usgs.gov/open-file/of02-342/

2002: Dixon, J.P., Stihler, S.D., Power, J.A., Tytgat, G., Moran, S.C., Sánchez, J.J., Estes, S., McNutt, S.R., and Paskievitch, J., 2003, Catalog of Earthquake Hypocenters at Alaska Volcanoes: January 1 - December 31, 2002: U.S. Geological Survey Open-File Report 03-267, 58 p. URL: http://geopubs.wr.usgs.gov/open-file/of03-267/

2003: Dixon, J.P., Stihler, S.D., Power, J.A., Tytgat, G., Moran, S.C., Sánchez, J.J., Estes, S., McNutt, S.R., and Paskievitch, J., 2004, Catalog of Earthquake Hypocenters at Alaska Volcanoes: January 1 - December 31, 2003: U.S. Geological Survey Open-File Report 2004-1234, 59 p. URL: http://pubs.usgs.gov/of/2004/1234/

2004: Dixon, J.P., Stihler, S.D., Power, J.A., Tytgat, G., Estes, S., Prejean, S., Sánchez, J.J., Sanches, R., McNutt, S.R., and Paskievitch, J., 2005, Catalog of Earthquake Hypocenters at Alaskan Volcanoes: January 1 through December 31, 2004: U.S. Geological Survey Open-File Report 2005-1312, 74 p. URL: http://pubs.usgs.gov/of/2005/1312/

2005: Dixon, J.P., Stihler, S.D., Power, J.A., Tytgat, G., Estes, S., and McNutt, S.R., 2006, Catalog of Earthquake Hypocenters at Alaskan Volcanoes: January 1 through December 31, 2005: U.S. Geological Survey Open-File Report 2006-1264, 78 p. URL: http://pubs.usgs.gov/of/2006/1264/

Appendix H: Selected AVO papers published in 2006

Cervelli, P.F., Fournier, Tom, Freymueller, J., and Power, J.A., 2006, Ground deformation associated with the precursory unrest and early phases of the January 2006 eruption of Augustine Volcano, Alaska: Geophysical Research Letters: v. 33, p. 5, doi: 10.1029/2006GL027219.

Petersen, T., Caplan-Auerbach, J., and McNutt, S.R., 2006, Sustained long-period seismicity at Shishaldin Volcano Alaska: Journal of Volcanology and Geothermal Research, v. 151, p. 365-381.

Petersen, T., De Angelis, S., Tytgat, G., and McNutt, S.R., 2006, Local Infrasound Observations of Large Ash Explosions at Augustine Volcano, Alaska, During January 11-28, 2006: Geophysical Research Letters, v. 33, L12303, doi:10.1029/2006GL026491.

Petersen, T. and McNutt, S.R., 2006, Seismo-acoustic signals associated with degassing explosions recorded at Shishaldin Volcano, Alaska: Bulletin of Volcanology, doi: 10.1007/s00445-006-0088-z.

Power, J.A., Nye, C.J., Coombs, M.L., Wessels, R.L, Cervelli, P.F., Dehn, J., Wallace, K.L., Freymueller, J.T., Doukas, M.P., 2006, The reawakening of Alaska's Augustine Volcano: EOS Transactions of the American Geophysical Union, v. 87, p. 373 & 377.

Wilson, C.R., Olson, J.V., Szuberla, C.A.L, McNutt, S., Tytgat, G., and Drob D.P., 2006, Infrasonic Array Observations at I53US of the 2006 Augustine Volcano Eruptions: Inframatics, no. 13, p. 11-25.